**Table E-3 Species Recorded during the Last 10 Years of the Plattsburgh Christmas Bird Count (1995-2005 excluding 1997 when surveys were not conducted)**

| Common Name | Listed Species | Year | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1995 | 1996 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | |
| American Kestrel | | 2 | 1 | - | - | 2 | - | 1 | - | 1 | - | 7 |
| Merlin | | - | - | - | - | 1 | - | - | - | - | - | 1 |
| Peregrine Falcon | E | - | - | - | - | - | - | 1 | - | - | - | 1 |
| American Coot | | - | 4 | - | - | - | - | - | - | - | 1 | 5 |
| American Woodcock | | - | - | - | - | 1 | - | - | - | - | - | 1 |
| Bonaparte's Gull | | - | 2 | - | - | - | - | 15 | - | - | - | 17 |
| Ring-billed Gull | | 758 | 635 | 121 | 580 | 977 | 260 | 482 | 360 | 389 | 451 | 5,013 |
| Herring Gull | | 254 | 164 | 156 | 431 | 335 | 130 | 97 | 89 | 35 | 60 | 1,751 |
| Glaucous Gull | | - | - | - | - | - | 6 | - | - | - | - | 6 |
| Great Black-backed Gull | | 235 | 231 | 30 | 57 | 47 | 62 | 20 | 35 | 132 | 45 | 894 |
| Rock Pigeon | | 302 | 883 | 663 | 446 | 369 | 462 | 681 | 1,061 | 743 | 573 | 6,183 |
| Mourning Dove | | 306 | 453 | 186 | 159 | 157 | 270 | 571 | 325 | 599 | 531 | 3,557 |
| Great Horned Owl | | - | - | 1 | - | - | - | - | 2 | - | - | 3 |
| Barred Owl | | 1 | 1 | 1 | 1 | - | - | - | 2 | - | - | 6 |
| Short-eared Owl | E | - | - | - | - | - | - | - | 1 | - | - | 1 |
| Belted Kingfisher | | 1 | - | - | 1 | 1 | 1 | - | - | - | - | 4 |
| Downy Woodpecker | | 45 | 43 | 57 | 30 | 41 | 24 | 46 | 46 | 67 | 50 | 449 |
| Hairy Woodpecker | | 30 | 26 | 35 | 14 | 18 | 9 | 35 | 33 | 37 | 45 | 282 |
| Northern Flicker | | 1 | 1 | - | - | - | - | - | - | 2 | - | 4 |
| Pileated Woodpecker | | 12 | 5 | 7 | 3 | 8 | 4 | 10 | 9 | 3 | 11 | 72 |
| Northern Shrike | | - | 6 | 2 | 2 | - | 1 | - | 3 | - | 2 | 16 |
| Blue Jay | | 216 | 274 | 269 | 55 | 124 | 98 | 200 | 177 | 173 | 138 | 1,724 |
| American Crow | | 533 | 1,390 | 1,223 | 727 | 692 | 780 | 1,243 | 638 | 675 | 2,587 | 10,488 |
| Common Raven | | - | 6 | 2 | 3 | 5 | - | 3 | 2 | 1 | 3 | 25 |
| Horned Lark | SC | - | 48 | 5 | - | - | - | 120 | 6 | - | 70 | 249 |
| Black-capped Chickadee | | 500 | 737 | 754 | 374 | 460 | 327 | 415 | 430 | 678 | 631 | 5,306 |
| Tufted Titmouse | | - | 3 | 9 | 1 | 8 | 4 | 6 | 2 | 2 | 24 | 59 |
| Red-breasted Nuthatch | | 23 | 13 | 76 | 27 | 36 | 24 | 12 | 8 | 9 | 22 | 250 |
| White-breasted Nuthatch | | 32 | 54 | 83 | 36 | 58 | 29 | 77 | 51 | 64 | 63 | 547 |
| Brown Creeper | | 2 | 1 | 3 | 4 | 3 | 1 | 2 | 5 | - | 4 | 25 |

Table E-3 Species Recorded during the Last 10 Years of the Plattsburgh Christmas Bird Count (1995-2005 excluding 1997 when surveys were not conducted)

| Common Name | Listed Species | Year | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1995 | 1996 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | |
| Carolina Wren | | - | 1 | - | - | - | - | - | - | - | 1 | 2 |
| Golden-crowned Kinglet | | 5 | - | - | - | 1 | 2 | - | 7 | - | - | 15 |
| Eastern Bluebird | | 6 | - | 3 | - | 11 | 7 | - | 15 | 16 | - | 58 |
| American Robin | | 77 | 4 | 9 | 11 | 16 | 31 | 29 | 44 | 1 | 12 | 234 |
| Northern Mockingbird | | - | - | 1 | 2 | 1 | - | 3 | 2 | 3 | 2 | 14 |
| European Starling | | 1,210 | 360 | 1,153 | 694 | 667 | 918 | 1,027 | 2,018 | 754 | 1,169 | 9,970 |
| Bohemian Waxwing | | - | 103 | - | - | 12 | - | 70 | - | - | - | 185 |
| Cedar Waxwing | | 128 | 142 | 78 | - | 88 | 24 | 50 | - | - | - | 510 |
| American Tree Sparrow | | 69 | 129 | 25 | 16 | 36 | 17 | 41 | 34 | 178 | 79 | 624 |
| Chipping Sparrow | | - | - | - | - | - | - | 2 | 2 | - | - | 4 |
| Fox Sparrow | | - | 1 | - | - | - | - | - | - | - | - | 1 |
| Song Sparrow | | 1 | - | 2 | 1 | 1 | - | 1 | - | 1 | - | 7 |
| White-throated Sparrow | | 1 | 3 | - | 1 | 9 | - | - | - | 2 | 6 | 22 |
| Dark-eyed Junco | | 79 | 131 | 87 | 69 | 50 | 44 | 100 | 67 | 193 | 137 | 957 |
| Lapland Longspur | | - | 5 | - | - | - | - | - | - | - | - | 5 |
| Snow Bunting | | - | 40 | 20 | - | 12 | 1 | 18 | 3 | 4 | 439 | 537 |
| Northern Cardinal | | 29 | 78 | 27 | 16 | 22 | 15 | 53 | 33 | 89 | 58 | 420 |
| Red-winged Blackbird | | - | - | - | 1 | - | - | 1 | - | - | - | 2 |
| Common Grackle | | - | 7 | - | - | - | - | 3 | 1 | 1 | 3 | 15 |
| Brown-headed Cowbird | | 15 | - | 11 | - | 30 | 100 | - | 5 | 40 | 11 | 212 |
| Pine Grosbeak | | 5 | 302 | 24 | - | - | - | 41 | - | - | - | 372 |
| Purple Finch | | 35 | 13 | 29 | 24 | 20 | 11 | 4 | 26 | 18 | 24 | 204 |
| House Finch | | 461 | 303 | 151 | 83 | 153 | 46 | 90 | 63 | 56 | 114 | 1,520 |
| White-winged Crossbill | | - | - | 31 | - | - | - | 5 | - | - | - | 36 |
| Common Redpoll | | - | 2 | 242 | - | 212 | - | 71 | - | 55 | - | 582 |
| Pine Siskin | | 34 | 12 | 152 | 2 | - | 16 | 5 | 2 | 15 | 1 | 239 |
| American Goldfinch | | 483 | 141 | 56 | 165 | 128 | 198 | 91 | 152 | 386 | 332 | 2,132 |
| Evening Grosbeak | | 33 | 221 | 93 | - | 5 | 8 | 32 | - | 18 | 8 | 418 |
| House Sparrow | | 272 | 421 | 213 | 213 | 260 | 307 | 365 | 150 | 231 | 183 | 2,615 |

**Table E-3 Species Recorded during the Last 10 Years of the Plattsburgh Christmas Bird Count (1995-2005 excluding 1997 when surveys were not conducted)**

| Common Name | Listed Species | Year | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1995 | 1996 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | |
| **Grand Total** | | 8,367 | 9,979 | 8,749 | 7,903 | 9,791 | 5,763 | 11,707 | 7,565 | 8,330 | 10,152 | 88,306 |
| **Species Total** | | 56 | 61 | 55 | 50 | 60 | 49 | 59 | 58 | 57 | 55 | 88 |

Source: National Audubon Society 2006.

Key:
E = Endangered
SC = Special Concern
T = Threatened

**Table E-4 Species Recorded during the Last 10 Years of the St. Timothee Christmas Bird Count (1996-2005)**

| Common Name | Listed Species | Year | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | |
| Snow Goose | | - | - | - | 8 | 2 | - | 18 | 2 | 7 | - | 37 |
| Canada Goose | | 3 | 76 | 1 | 424 | 1,817 | 5 | 285 | 262 | 117 | 35 | 3,025 |
| Brant | | - | - | - | - | - | - | - | - | 1 | - | 1 |
| Tundra Swan | | - | - | - | 11 | - | - | - | - | - | - | 11 |
| Gadwall | | - | - | - | - | 10 | 1 | 13 | - | - | - | 24 |
| American Wigeon | | - | - | - | 1 | 1 | - | 3 | - | 5 | - | 10 |
| American Black Duck | | 50 | 126 | 61 | 109 | 66 | 81 | 18 | 25 | 101 | 61 | 698 |
| Mallard | | 110 | 200 | 65 | 202 | 402 | 121 | 159 | 141 | 248 | 464 | 2,112 |
| Northern Pintail | | - | - | - | 1 | 1 | - | - | - | - | - | 2 |
| Green-winged Teal | | - | - | - | - | - | - | - | - | - | 2 | 2 |
| Redhead | | - | - | - | 1 | - | - | - | - | - | - | 1 |
| Ring-necked Duck | | 1 | - | - | - | - | - | 31 | 1 | - | - | 33 |
| Greater Scaup | | - | 1 | 1 | 5 | 0 | 1 | 6 | 1 | 13 | - | 28 |
| Lesser Scaup | | 1 | 50 | 1 | 10 | 68 | - | 41 | 1 | 1 | - | 173 |
| Surf Scoter | | - | - | 1 | - | - | - | - | - | - | - | 1 |
| White-winged Scoter | | - | - | 1 | 4 | 1 | - | 2 | - | - | - | 8 |
| Black Scoter | | - | 1 | - | - | - | - | - | - | - | - | 1 |
| Long-tailed Duck | | - | - | - | - | 4 | - | - | - | 2 | - | 6 |
| Bufflehead | | - | - | - | 1 | - | - | - | 12 | - | - | 13 |
| Common Goldeneye | | 125 | 59 | 19 | 61 | 261 | 13 | 103 | 90 | 40 | 32 | 803 |
| Hooded Merganser | | - | 2 | - | - | 7 | 2 | 5 | 1 | 1 | 1 | 19 |
| Common Merganser | | 71 | 12 | 98 | 79 | 26 | 40 | 12 | 80 | 102 | 86 | 606 |
| Red-breasted Merganser | | - | - | - | - | 2 | - | - | - | - | - | 2 |
| Gray Partridge | | 0 | 5 | - | - | - | - | - | - | - | 6 | 11 |
| Ring-necked Pheasant | | - | - | 1 | 1 | - | - | - | - | - | - | 2 |
| Ruffed Grouse | | 1 | 1 | 14 | 7 | 12 | 16 | 4 | 8 | 5 | 1 | 69 |
| Wild Turkey | | - | - | 15 | - | 1 | 17 | 8 | 29 | 6 | 7 | 83 |
| Common Loon | SC | - | 1 | - | - | - | - | - | - | 1 | 1 | 3 |
| Double-crested Cormorant | | - | 1 | - | 8 | 1 | 1 | 1 | 1 | 3 | 1 | 17 |
| Great Blue Heron | | 1 | 2 | 1 | 1 | 2 | - | - | 1 | - | 1 | 9 |

**Table E-4 Species Recorded during the Last 10 Years of the St. Timothee Christmas Bird Count (1996-2005)**

| Common Name | Listed Species | Year | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | |
| Northern Harrier | T | 0 | - | - | - | 1 | 1 | - | - | - | - | 2 |
| Sharp-shinned Hawk | SC | 2 | 0 | 0 | 3 | 2 | 1 | 2 | - | - | - | 10 |
| Cooper's Hawk | SC | 1 | 1 | 2 | 0 | 1 | 3 | 1 | 3 | 1 | 0 | 13 |
| Northern Goshawk | SC | - | - | - | 1 | - | - | 1 | - | - | - | 2 |
| Red-tailed Hawk | | 11 | 6 | 4 | 12 | 14 | 8 | 10 | 5 | 6 | 2 | 78 |
| Rough-legged Hawk | | 2 | - | - | 1 | 2 | 6 | 2 | 2 | 2 | 1 | 18 |
| American Kestrel | | 3 | 4 | - | 2 | 6 | 2 | - | 1 | - | - | 18 |
| Merlin | | - | - | - | - | - | 1 | - | - | 1 | - | 2 |
| Peregrine Falcon | E | - | - | - | - | 1 | 1 | - | - | 1 | 1 | 4 |
| Ring-billed Gull | | 18 | 14 | 27 | 145 | 131 | 4 | 37 | - | 58 | - | 434 |
| Herring Gull | | 52 | 19 | 36 | 6 | 9 | 26 | 4 | 45 | 38 | 19 | 254 |
| Great Black-backed Gull | | 68 | 3 | 9 | 6 | 10 | 7 | 2 | 9 | 16 | 11 | 141 |
| Rock Pigeon | | 1,972 | 1,356 | 1,226 | 1,160 | 1,240 | 1,645 | 1,512 | 2,465 | 1,110 | 889 | 14,575 |
| Mourning Dove | | 155 | 236 | 83 | 213 | 262 | 540 | 756 | 322 | 93 | 250 | 2,910 |
| Eastern Screech-Owl | | - | 2 | 0 | 1 | 2 | 2 | 2 | 2 | - | - | 11 |
| Great Horned Owl | | 0 | - | - | - | - | - | - | - | - | 1 | 1 |
| Snowy Owl | | 2 | - | - | - | - | - | - | - | - | - | 2 |
| Short-eared Owl | E | - | - | - | - | - | - | 1 | - | - | - | 1 |
| Belted Kingfisher | | 0 | - | - | - | - | - | - | 1 | - | - | 1 |
| Downy Woodpecker | | 24 | 23 | 25 | 3 | 40 | 29 | 26 | 15 | 12 | 13 | 210 |
| Hairy Woodpecker | | 5 | 6 | 13 | 5 | 14 | 12 | 5 | 3 | 4 | 1 | 68 |
| Northern Flicker | | - | - | - | - | 1 | - | - | - | - | - | 1 |
| Pileated Woodpecker | | 1 | - | - | 2 | 2 | 3 | - | 2 | - | 1 | 11 |
| Northern Shrike | | 6 | 1 | 1 | 1 | 2 | 4 | - | - | 2 | 2 | 19 |
| Blue Jay | | 136 | 68 | 93 | 35 | 137 | 77 | 109 | 43 | 77 | 52 | 827 |
| American Crow | | 166 | 167 | 382 | 66 | 105 | 213 | 121 | 163 | 147 | 115 | 1,645 |
| Common Raven | | - | - | 1 | 1 | 2 | - | - | - | - | 2 | 6 |
| Horned Lark | SC | 32 | 0 | 13 | 23 | 6 | 35 | 136 | - | - | 45 | 290 |
| Black-capped Chickadee | | 186 | 82 | 176 | 90 | 290 | 144 | 126 | 113 | 98 | 122 | 1,427 |
| Tufted Titmouse | | 1 | - | - | - | - | - | - | - | - | 2 | 3 |
| Red-breasted Nuthatch | | - | 1 | - | 3 | - | 2 | 1 | - | - | 4 | 11 |

## Table E-4 Species Recorded during the Last 10 Years of the St. Timothee Christmas Bird Count (1996-2005)

| Common Name | Listed Species | Year | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | |
| White-breasted Nuthatch | | 11 | 17 | 20 | 9 | 24 | 17 | 15 | 23 | 5 | 8 | 149 |
| Brown Creeper | | 2 | 1 | 4 | 5 | - | 1 | - | - | - | - | 13 |
| Golden-crowned Kinglet | | - | 1 | - | 2 | 1 | 2 | - | - | - | - | 6 |
| American Robin | | - | 1 | 1 | - | 3 | 5 | 1 | - | - | 1 | 12 |
| Northern Mockingbird | | - | 1 | - | - | - | - | - | - | - | - | 1 |
| European Starling | | 671 | 1,192 | 1,192 | 1,243 | 2,141 | 2,450 | 2,426 | 1,783 | 1,175 | 747 | 15,020 |
| Bohemian Waxwing | | 1 | - | 5 | - | 22 | - | - | - | - | - | 28 |
| American Tree Sparrow | | 72 | 62 | 92 | 26 | 46 | 29 | 55 | 29 | 129 | 45 | 585 |
| Savannah Sparrow | | - | - | - | - | - | - | 1 | - | - | - | 1 |
| Song Sparrow | | - | 1 | - | 1 | - | 3 | 3 | 2 | 2 | 0 | 12 |
| White-throated Sparrow | | 2 | - | - | - | - | - | - | - | - | - | 2 |
| Dark-eyed Junco | | 25 | 41 | 30 | 8 | 6 | 6 | 32 | 1 | 56 | 27 | 232 |
| Lapland Longspur | | - | - | - | - | - | - | 1 | - | - | - | 1 |
| Snow Bunting | | 34 | - | 1,017 | 291 | 60 | 314 | 296 | - | - | 347 | 2,359 |
| Northern Cardinal | | 35 | 1 | 3 | 1 | 7 | 8 | 16 | 3 | 1 | 14 | 89 |
| Dickcissel | | - | - | - | - | - | - | 1 | - | - | - | 1 |
| Red-winged Blackbird | | 0 | 1 | 19 | 1 | - | 0 | - | - | - | 102 | 123 |
| Rusty Blackbird | | - | 0 | - | - | - | - | - | - | - | 1 | 1 |
| Common Grackle | | 2 | 5 | 1 | 4 | - | 1 | 1 | - | - | - | 14 |
| Brown-headed Cowbird | | - | 302 | 516 | 419 | 38 | 196 | 13 | 11 | 185 | 54 | 1,734 |
| Pine Grosbeak | | 11 | - | 11 | - | - | - | - | - | - | - | 22 |
| Purple Finch | | 7 | - | - | - | - | - | - | - | - | 1 | 8 |
| House Finch | | 34 | 86 | 7 | 39 | 113 | 32 | 124 | 35 | 17 | 17 | 504 |
| Common Redpoll | | 14 | - | 595 | - | 179 | - | 715 | - | 131 | 115 | 1,749 |
| Pine Siskin | | - | 3 | - | - | 1 | - | - | - | - | - | 4 |
| American Goldfinch | | 13 | 97 | 43 | 47 | 90 | 105 | 67 | 44 | 102 | 82 | 690 |
| Evening Grosbeak | | 25 | - | - | - | 3 | - | - | - | - | - | 28 |
| House Sparrow | | 1,652 | 1,141 | 561 | 655 | 866 | 773 | 1,320 | 503 | 709 | 1,133 | 9,313 |

Table E-4 Species Recorded during the Last 10 Years of the St. Timothee Christmas Bird Count (1996-2005)

| Common Name | Listed Species | Year | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | |
| **Grand Total** | | 5,817 | 5,479 | 6,487 | 5,464 | 8,564 | 7,006 | 8,650 | 6,283 | 4,831 | 4,925 | 63,506 |
| **Species Total** | | 52 | 51 | 48 | 56 | 60 | 51 | 53 | 42 | 44 | 50 | 89 |

Source: National Audubon Society 2006.

Key:
E = Endangered
SC = Special Concern
T = Threatened

# F

# E & E Bird Survey Tables

Table F-1

## Noble Windpark in Chateaugay and Bellmont Project Area
## Spring Migratory Bird Survey by Location

Totals From One Survey

| Species | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | ZA | ZB | ZC | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mallard | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Northern Harrier | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **1** |
| American Kestrel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | **1** |
| Killdeer | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| Wilson's Snipe | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **1** |
| Mourning Dove | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **6** |
| Yellow-bellied Sapsucker | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Hairy Woodpecker | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Northern Flicker | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **3** |
| Pileated Woodpecker | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Least Flycatcher | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **3** |
| Eastern Phoebe | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **4** |
| Blue-headed Vireo | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Warbling Vireo | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **2** |
| Red-eyed Vireo | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Blue Jay | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | **14** |
| American Crow | 0 | 2 | 0 | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 2 | 2 | 1 | **18** |
| Purple Martin | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **1** |
| Barn Swallow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | **7** |
| Black-capped Chickadee | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **5** |
| Red-breasted Nuthatch | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| White-breasted Nuthatch | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| [illegible]stern Bluebird | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | **1** |
| [illegible]mit Thrush | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Wood Thrush | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **3** |
| American Robin | 2 | 3 | 0 | 2 | 0 | 4 | 1 | 0 | 0 | 3 | 2 | 1 | 3 | 1 | 2 | 0 | 0 | 2 | 1 | 3 | 2 | 2 | 3 | 0 | 1 | 1 | 2 | 4 | **45** |
| Brown Thrasher | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | **2** |
| Nashville Warbler | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **3** |
| Yellow Warbler | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | **13** |
| Chestnut-sided Warbler | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | **13** |
| Black-throated Blue Warbler | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| Yellow-rumped Warbler | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **1** |
| Black-thr. Green Warbler | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **2** |
| Black-and-white Warbler | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | **3** |
| American Redstart | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **3** |
| Ovenbird | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | **8** |
| Northern Waterthrush | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Common Yellowthroat | 0 | 1 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | **12** |
| Scarlet Tanager | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **3** |
| Chipping Sparrow | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | **4** |
| Savannah Sparrow | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 1 | 1 | **13** |
| Song Sparrow | 3 | 2 | 0 | 3 | 1 | 2 | 3 | 0 | 0 | 1 | 3 | 1 | 2 | 1 | 1 | 1 | 3 | 3 | 1 | 1 | 2 | 1 | 2 | 2 | 0 | 0 | 1 | 2 | **42** |
| White-throated Sparrow | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 1 | 1 | 1 | 0 | 0 | 1 | **12** |
| Rose-breasted Grosbeak | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | **4** |
| Bobolink | 0 | 3 | 3 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 0 | 0 | **20** |
| Red-winged Blackbird | 3 | 4 | 0 | 0 | 3 | 5 | 2 | 0 | 0 | 3 | 3 | 1 | 2 | 0 | 3 | 4 | 3 | 4 | 3 | 2 | 2 | 0 | 0 | 0 | 2 | 1 | 2 | 3 | **55** |
| Eastern Meadowlark | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **5** |
| Common Grackle | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **13** |
| [illegible]wn-headed Cowbird | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | **4** |
| [illegible]timore Oriole | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | **9** |
| Purple Finch | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| House Finch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |

| Species | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | ZA | ZB | ZC | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| American Goldfinch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 1 | 2 | 0 | 0 | 13 |
| **Total Birds:** | **16** | **18** | **10** | **17** | **13** | **22** | **13** | **6** | **5** | **13** | **11** | **15** | **18** | **3** | **12** | **8** | **15** | **21** | **13** | **14** | **12** | **17** | **19** | **16** | **17** | **13** | **14** | **18** | |
| **Species Count:** | **10** | **9** | **8** | **13** | **7** | **10** | **7** | **4** | **5** | **9** | **5** | **11** | **11** | **3** | **7** | **4** | **10** | **10** | **9** | **10** | **9** | **12** | **13** | **13** | **12** | **10** | **11** | **12** | |
| **Total Species:** | **53** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Table F-2

## Noble Windpark in Chateaugay and Bellmont Project Area
## Breeding Bird Survey by Date

| **Species** | **6/08/2006** | **6/20/2006** | **Total** |
|---|---|---|---|
| Mallard | 0 | 1 | **1** |
| [illegible]at Blue Heron | 1 | 0 | **1** |
| Wilson's Snipe | 0 | 2 | **2** |
| Mourning Dove | 11 | 0 | **11** |
| Hairy Woodpecker | 0 | 1 | **1** |
| Northern Flicker | 0 | 1 | **1** |
| Alder Flycatcher | 1 | 2 | **3** |
| Least Flycatcher | 1 | 0 | **1** |
| Eastern Kingbird | 2 | 3 | **5** |
| Blue-headed Vireo | 1 | 0 | **1** |
| Red-eyed Vireo | 6 | 7 | **13** |
| Blue Jay | 1 | 10 | **11** |
| American Crow | 12 | 12 | **24** |
| Common Raven | 0 | 1 | **1** |
| Barn Swallow | 3 | 6 | **9** |
| Veery | 1 | 1 | **2** |
| Wood Thrush | 0 | 1 | **1** |
| American Robin | 16 | 16 | **32** |
| Brown Thrasher | 0 | 2 | **2** |
| Cedar Waxwing | 3 | 22 | **25** |
| Nashville Warbler | 0 | 1 | **1** |
| Yellow Warbler | 2 | 4 | **6** |
| Chestnut-sided Warbler | 4 | 6 | **10** |
| Blackburnian Warbler | 1 | 0 | **1** |
| Black-and-white Warbler | 1 | 1 | **2** |
| American Redstart | 1 | 1 | **2** |
| [illegible]enbird | 5 | 4 | **9** |
| Mourning Warbler | 0 | 1 | **1** |
| Common Yellowthroat | 5 | 7 | **12** |
| Scarlet Tanager | 0 | 1 | **1** |
| Chipping Sparrow | 1 | 3 | **4** |
| Savannah Sparrow | 10 | 7 | **17** |
| Song Sparrow | 30 | 20 | **50** |
| White-throated Sparrow | 4 | 7 | **11** |
| Rose-breasted Grosbeak | 2 | 0 | **2** |
| Indigo Bunting | 0 | 2 | **2** |
| Bobolink | 0 | 2 | **2** |
| Red-winged Blackbird | 8 | 14 | **22** |
| Eastern Meadowlark | 0 | 1 | **1** |
| Common Grackle | 5 | 2 | **7** |
| Brown-headed Cowbird | 4 | 3 | **7** |
| American Goldfinch | 8 | 2 | **10** |
| **Total Birds:** | **150** | **177** | **327** |
| **Species Count:** | **29** | **36** | |
| **Total Species:** | **42** | | |

Table F-3

## Noble Windpark in Chateaugay and Bellmont Project Area
## Breeding Bird Survey by Location

| Species | A | B | C | D | E | F | G | H | I | J | K | L | M | N | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mallard | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Great Blue Heron | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **1** |
| Wilson's Snipe | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| Mourning Dove | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | **11** |
| Hairy Woodpecker | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **1** |
| Northern Flicker | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **1** |
| Alder Flycatcher | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | **3** |
| Least Flycatcher | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Eastern Kingbird | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | **5** |
| Blue-headed Vireo | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Red-eyed Vireo | 2 | 2 | 0 | 0 | 1 | 3 | 1 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | **13** |
| Blue Jay | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 1 | 3 | 0 | 1 | 1 | 0 | **11** |
| American Crow | 3 | 0 | 0 | 0 | 3 | 1 | 1 | 0 | 1 | 1 | 0 | 2 | 1 | 11 | **24** |
| Common Raven | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Barn Swallow | 0 | 2 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | **9** |
| Veery | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| Wood Thrush | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| American Robin | 6 | 2 | 1 | 4 | 3 | 0 | 0 | 6 | 0 | 0 | 3 | 2 | 2 | 3 | **32** |
| Brown Thrasher | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | **2** |
| Cedar Waxwing | 2 | 0 | 0 | 0 | 1 | 0 | 8 | 6 | 5 | 0 | 0 | 0 | 0 | 3 | **25** |
| Nashville Warbler | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Yellow Warbler | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | **6** |
| Chestnut-sided Warbler | 1 | 1 | 2 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | **10** |
| Blackburnian Warbler | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Black-and-white Warbler | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **2** |
| American Redstart | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **2** |
| Ovenbird | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | **9** |
| Mourning Warbler | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Common Yellowthroat | 3 | 0 | 0 | 2 | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | **12** |
| Scarlet Tanager | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Chipping Sparrow | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | **4** |
| Savannah Sparrow | 0 | 2 | 0 | 0 | 0 | 7 | 0 | 3 | 2 | 0 | 2 | 0 | 1 | 0 | **17** |
| Song Sparrow | 4 | 6 | 1 | 1 | 3 | 4 | 3 | 4 | 6 | 4 | 4 | 3 | 1 | 6 | **50** |
| White-throated Sparrow | 2 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **11** |
| Rose-breasted Grosbeak | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **2** |
| Indigo Bunting | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| Bobolink | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| Red-winged Blackbird | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 6 | 4 | 4 | 0 | 2 | 0 | 2 | **22** |
| Eastern Meadowlark | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Common Grackle | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 5 | 0 | 0 | **7** |
| Brown-headed Cowbird | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | **7** |
| American Goldfinch | 1 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | **10** |
| **Total Birds:** | **32** | **25** | **12** | **21** | **17** | **28** | **22** | **46** | **27** | **21** | **14** | **20** | **10** | **32** | **327** |
| **Species Count:** | **17** | **11** | **11** | **9** | **8** | **13** | **9** | **11** | **11** | **11** | **7** | **10** | **8** | **10** | |
| **Total Species:** | **42** | | | | | | | | | | | | | | |

# G Work Plan for Post-construction Bird and Bat Mortality Monitoring

*002270_NP17_08-B2091*

# Work Plan for Bird and Bat Post-construction Studies at the Chateaugay and Bellmont Windparks Towns of Chateaugay and Bellmont, Franklin County, New York

**January 2007**

**Prepared for:**

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**Prepared by:**

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# List of Abbreviations and Acronyms

| | |
|---|---|
| asl | above sea level |
| E & E | Ecology and Environment, Inc. |
| FAA | Federal Aviation Administration |
| FEIS | Final Environmental Impact Statement |
| kV | kilovolt |
| MW | megawatt |
| Noble | Noble Chateaugay Windpark, LLC and Noble Bellmont Windpark, LLC |
| NWCC | National Wind Coordinating Committee |
| NWS | National Weather Service |
| NYPA | New York Power Authority |
| NYSDEC | New York State Department of Environmental Conservation |
| ROW | right-of-way |
| SEQRA | State Environmental Quality Review Act |
| USACE | U.S. Army Corps of Engineers |

# 1 Project Background and Study Area

## 1.1 Project Overview and Definitions

Noble Chateaugay Windpark, LLC and Noble Bellmont Windpark, LLC (Noble) propose to install and operate a wind energy facility (the Project) in Northeastern New York State primarily located in the Towns of Chateaugay and Bellmont, Franklin County (see Figure 1-1 of the DEIS). The Project will have the capability of producing approximately 129 megawatts (MW) of power.

The Project consists of the following:

- Installation and operation of 14 wind turbines within an approximate 920-acre area in the Town of Bellmont and installation and operation of 72 wind turbines within an approximate 7,447-acre area in the Town of Chateaugay;
- Construction and use of approximately 22 miles of access roads that will connect each wind turbine to a Town road, County road, or State highway to allow equipment and vehicle access for construction and subsequent maintenance of the facilities as well as access by emergency services, if needed. The majority of the access roads will be located in the Towns of Chateaugay and Bellmont, with approximately 900 feet of new turbine access road located in the Town of Ellenburg;
- Construction and use of an electrical collection system that will allow delivery of electricity to a previously permitted substation in the Town of Clinton, Clinton County, where the electricity will tie into an existing 230-kilovolt (kV) New York Power Authority (NYPA) Plattsburgh – Willis line that will provide access to the grid. The electrical collection system will primarily be constructed in the Towns of Chateaugay and Bellmont. Three miles of new collection line will traverse Noble-controlled parcels in the Town of Clinton. The electrical collection system will be partially buried and partially aboveground and, where practicable, will be installed along the same right-of-way (ROW) corridor as the access roads;
- Addition of equipment within the previously approved substation located on Ryan Road in the Town of Clinton necessary to accommodate the additional

power from the Project. This substation work will be engineered, reviewed, and approved by NYPA to accept the generated power while minimizing the number of taps into the existing 230-kV lines;

- The use of existing equipment laydown areas located on Irona Road in Irona and Joe Woods Road in Mooers. These laydown areas were identified and approved for the Clinton County Noble Windpark projects. An additional laydown area of approximately 20 acres may be utilized at the new Chateaugay Business Park located in the Town of Chateaugay. Utilization of this additional area will involve construction of a short gravel road that will be extended from an existing gravel road and utilization of an open field without major disturbance. The site was reviewed and cleared by necessary authorities and given a "shovel ready" status by Empire State Development in April 2006; and

- Use of parking areas for the Project that were previously considered in the evaluation of the Clinton County Noble Windpark projects. These areas are summarized in Sections 2.21 and 2.22, Traffic and Transportation.

The wind turbines that will be installed at the Chateaugay and Bellmont Windparks will be General Electric 1.5 MW, Model 1.5sle, MTS, T-Flange wind turbine generators with an 80-meter tower.[1] The turbine is a three-bladed, upwind, horizontal-axis wind turbine with a rotor diameter of 77 meters (253 feet). The nacelle is located at the top of each tower and contains the electrical generating equipment. The turbine rotor and the nacelle are mounted on top of a tubular tower giving a rotor hub height of 263 feet (80 meters) (see Figure 1-2 of this report). The maximum height for the turbine is 389 feet (118.5 meters) when a rotor blade is at the top of its rotation. Once installed, each wind turbine will occupy a round, slightly exposed base area approximately 18 feet (5.47 meters) in diameter.

## 1.2 Permitting Requirements

This work plan for bird and bat post-construction mortality studies was prepared by Ecology and Environment, Inc. (E & E) to address anticipated requirements that will be incorporated into the New York State Department of Environmental Conservation (NYSDEC), Article 15 and Article 24 permitting and U.S. Army Corps of Engineers (USACE), Section 404 and Section 10 permitting for the Project. It should be noted that NYSDEC is likely to require an overarching adaptive management strategy for evaluating actual impacts associated with the operation of the Project. As such, the methodology as outlined here is a pilot study of

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[1] 1.5MW refers to the production capacity of the turbine, which is 1.5 megawatts. The nomenclature "sle" is used to designate that the diameter size of the turbine rotor is 77 meters. 80 Meter refers to the height of the tower. MTS (Modular Tower System) designates the type of tower configuration, and T-Flange designates the type of flange used to connect the tower directly to the foundation.

methods to be used in subsequent years of the post-construction studies. The scope may be revised to either increase or reduce the scope of the study, based on the number of carcasses retrieved in relation to the actual number of hours/days searched, weather conditions, carcass removal rates, searcher efficiencies, or other parameters viewed as relevant following yearly review of the data.

# 2

# Study Objectives

Given the concern for bird and bat resources associated with wind energy facilities, quantifying the direct collisions with turbines is the key component of the studies. The studies are a compliment to pre-construction radar studies and field surveys that were conducted in the spring and fall of 2006 and are designed to quantify the bird and bat collision impacts from the Chateaugay and Bellmont Windparks during migratory periods.

The proposed plan of study has the following objectives:

1. Collect quantitative collision data on birds and bats from the Chateaugay and Bellmont Windparks during migratory seasons. Estimates of numbers of fatalities will be determined for both bird and bats, both collectively, and on a species-by-species basis.

2. Collect information on the occurrence of bat species in the Project Area during migratory seasons.

3. Evaluate the data and identify potential adaptive management strategies if the collision impacts are significant.

# 3 Methodology

To date, there is no consensus regarding methodologies for post-construction mortality monitoring studies at Windparks, nor are there any formally accepted practices. Noble anticipates that NYSDEC will be issuing more defined guidance for post-construction monitoring requirements to standardize sampling between the various projects that are under construction or being proposed within the State. While the guidance has not yet been published, it is the understanding of Noble that the guidance will be made available early in 2007, and as such, will be able to modify approaches, as appropriate, prior to the Chateaugay and Bellmont Windparks becoming operational. The methodologies proposed by Noble follow standard procedures now used at communication towers and which have been applied to wind turbines in various locations in the United States. Noble has also integrated comments from ongoing discussions with NYSDEC bird and bat biologists.

## Task 1: Post-construction Bird and Bat Mortality Study

This post-construction study will estimate the magnitude of bird and bat collisions associated with the Chateaugay and Bellmont Windparks based on field surveys and statistical extrapolation. The study will be conducted over three successive years and focus on the migration periods for birds and bats. The results of this study will be useful to determine the collision impacts on migratory birds and bats and identify whether the results are comparable with the estimated mortality rates included in the DEIS for this project.

**Study Area.** When constructed, the Chateaugay and Bellmont Windparks will consist of 86 1.5-MW turbines within an approximately 8,620-acre Project Area in the Towns of Bellmont and Chateaugay, Franklin County, with a small portion traversing Clinton County, in the Towns of Clinton and Ellenburg. Clinton County will be traversed for construction of 3 miles of collection line and 900 feet of access road. The turbines will be distributed in loose clusters throughout the Project Area. The surface elevation of the Project Area ranges between 898 and 1,556 feet above sea level (asl) with a total turbine height, from ground surface to full rotor blade extension, of approximately 389 feet (1,287 to 1,945 feet asl). The Windpark will be lighted in accordance with Federal Aviation Administration (FAA) guidelines. No guy wires will be associated with the turbines and there are also no locations suitable for perching or nesting by birds on the turbines. Access roads will connect to each turbine, allowing for vehicular access to conduct this study.

**Search Area.** Previous mortality studies at wind projects indicate that most fatalities are typically found within half of the maximum distance from the tip height to the ground (Erickson and Kerns 2005). With a tip height of 118.5 meters (389 feet), direct visual observations will be conducted within a 120-meter (394-foot) diameter plot from the turbine. The search area will be further separated into survey transect lines at 10-meter (33-foot) intervals, with 12 transects sited for each turbine surveyed. The transects will be located using GPS and/or in field flagging to assure consistency between searchers and turbine sites.

Searches will be conducted at approximately one-third of the total turbines. Therefore, 29 turbines will be searched for this study at the Chateaugay and Bellmont Windparks. Although the turbines to be searched would be selected randomly, the selection process will involve a stratification by habitat. In other words, all habitats present (hayfield/grasslands, brushlands, forested land, and proximity to wetland complexes) would be represented so that differences in fatality rates among habitats could be evaluated via statistical analysis following data collection.

**Search Interval.** Based on discussions with NYSDEC as well as on information generally available for other wind projects, Noble proposes to further divide the 29 turbines into three subsets. Daily searches will be conducted at 10 turbines, searches would be conducted twice a week (every third day) at 10 turbines, and the remaining 9 turbines would be searched weekly. Adjustments may be necessary based on severe weather.

Although largely dependent on weather, Noble proposes that search efforts will extend from April 15 through October 15. Winter bird use of the project site is comparatively low, and risk is considered minimal during this season. Although bird migration begins in late March and can extend into November, the proposed time frame encompasses the peak of spring and fall passerine migration and the entire breeding season. Based on preliminary data being collected at other constructed wind projects, much of the mortality that is being noted is bat mortality, and it is occurring as specific events throughout the summer. Therefore, while bird mortalities would be associated primarily with spring and fall migration, the impacts on bats, specifically tree roosting species, will require mortality monitoring throughout the summer.

Prior to initiating the annual survey effort, each of the 29 turbine sites will be searched to locate residual carcasses that may have accumulated since the Project began operating.

**Field Search Methodology.** Each field surveyor will be trained in the search protocol in advance of his or her first fatality search. The 12 transect lines within each search area will be slowly walked, with surveys conducted by a team of two biologists. A search time of approximately 30 to 45 minutes per turbine is anticipated, although the time will vary based on habitat and terrain. Field modification of transect lines may be necessary to avoid unwalkable areas (e.g., dense forest, pit, steep slope). Prior to the commencement of sampling, the search areas beneath turbines (except forested areas) would be cleared of vegetation to facilitate the searchers' efforts. Except in agricultural areas, additional clearing would occur at monthly intervals throughout the duration of monitoring year.

All carcass observations, which may include feathers or portions thereof, will be mapped on a data sheet as to its location relative to specific transect lines. Additional information to be collected shall include the date; time; observer; identification of bird or bat species; whether the carcass was intact, scavenged, or there were feather spots; and photographic documentation of the carcass and its location. Daily searches will commence near sunrise and proceed until all searches for the day are completed. Searches will be temporarily delayed if severe weather or safety conditions occur.

**Identification of Carcasses.** Any bird carcasses observed during the survey effort will be left undisturbed for use in the scavenging loss analysis. In the case of bat carcasses, final (confirmatory) identification would be by an expert (e.g., Al Hicks, NYSDEC). Based on discussions, all bat carcasses are to be collected and forwarded to NYSDEC for identification and storage. Noble will continue to coordinate with NYSDEC regarding possible on-site storage of certain bat carcasses and use for scavenging and efficiency trials.

Each carcass will be mapped on a data sheet in reference to its distance and bearing from the specific turbine. Photographic documentation will be collected for each observation. The field surveyor will attempt to identify each carcass to species. The photographic documentation will be reviewed to confirm the proper identification.

NYSDEC has requested that specific carcasses be submitted for stable radioisotope analysis to determine genetic diversity within local bat populations and, possibly, the origin of individual bats. Based on recent information collected at the National Wind Coordinating Committee (NWCC) annual meeting, Dr. Nancy Simmons, with the American Museum of Natural Science, will be undertaking a nationwide genetic analysis of tree-roosting bats to assess the genetic/population stability of these species. To support this effort, Noble will commit to submitting approximately 10 specimens of the following species per year toward this effort: Hoary Bat (*Lasiurus cinereus*), Eastern red Bat (*L. borealis*), and Silver-haired Bat (*Lasionycteris*). Final details of this portion of the carcass analysis, specifically collection protocols and cost, will be coordinated with NYSDEC.

**Weather.** Weather conditions from the night prior to each survey day will be collected from local sources and supplemented by National Weather Service (NWS) data. During each morning's carcass search, weather observations will be documented on all data sheets and will include, at a minimum, cloud cover, temperature, and wind direction and speed. Night visibility will be characterized by estimating the percent of cloud cover to the nearest quarter percent and by recording the presence or absence of fog. Precipitation records will also be gathered from NWS data sources.

**Scavenging Loss Estimations.** The proportion of bird and bat carcasses removed from the search area by other wildlife (scavengers) will be estimated based on the information collected. The number of days until scavenging removal occurs will be tracked for each bird and bat carcass found in the search area. The degree of scavenging prior to carcass removal will be documented during each search.

Additional carcasses will occasionally be placed at random locations within the search area, based on bird and bat carcass availability. Placement of these "test carcasses" will be used primarily to determine searcher efficiency (see section below), but they will also be tracked for scavenging loss. Test carcasses will be those found from other locations, such as roadway or building collisions.

The estimates for scavenging loss will be factored in to the estimates for the total number of bird and bat fatalities during the study period.

**Searcher Efficiency.** To correct for detection bias, searcher efficiency will be estimated. Additional test carcasses will occasionally be placed at random locations within the search area, based on bird and bat carcass availability. The test carcasses will be placed either one day before or on the day of the survey to reduce the potential for predation. The date, time, and location of the test-carcass placement will be documented. Someone besides the searchers will place the test carcasses; the presence of test carcasses will not be known by the searchers. The percentage of test carcasses found will be determined based on review of the data collected by the searchers.

**Mortality Estimation.** The mortality estimate for the Chateaugay and Bellmont Windparks will be calculated separately for birds and bats. Scavenging loss estimations, searcher efficiency, and the proportion of turbines searched will be used to adjust the total number of carcasses found during the searches.

To calculate the total number of fatalities for the period of time in which searches would be conducted (April to October), the estimator proposed in Erickson, Jeffrey, Kronner, and Bay (2003) would be used. For most of the species concerned, this time period would be an annual measurement of mortality. The rationale for this conclusion is that most species of birds and bats are not active or present during the period November through March, so there is no risk of fatalities for those species during this time period. The point estimates for the fatality rates would be calculated for each season by the formula (or an appropriate variation of the formula):

$$m = \left(\frac{N * C}{k * t * p}\right)\left(\frac{e^{I/t} - 1 + p}{e^{I/t} - 1}\right)$$

where $N$ is equal to the total number of turbines, $C$ is the total number of carcasses detected for the period of study, $I$ is the interval between searches (in days), $t$ is the mean carcass removal time (in days), $p$ is the detection probability, and $k$ is the number of turbines sampled. This formula assumes correctness of the estimates for $t$ and $p$, i.e., sampling error in those estimates is not considered. Fatality estimates for the entire period of study (April through October) would be calculated by summing the seasonal estimates.

**Utilization – Mortality Estimation.** The post-construction mortality estimation will be compared to the number of estimated collisions presented in the DEIS and to pre-construction radar study passage rates.

### Task 2: Acoustical Monitoring for Bats (Summer/Fall)

Acoustical monitoring via AnaBat equipment will be conducted during the summer/fall migratory period (approximately August 1 through September 30) of the first year of the study. AnaBat monitoring equipment will be installed on a meteorological tower, wind turbine, or other structure located in the Project Area. One monitoring unit will be installed as high on the structure as possible, while the other unit will be installed midway between that unit and the ground. It is anticipated that the monitoring units will be deployed within a guy wire system and pointed in the direction of anticipated migration (facing north). Bat echolocation data will be recorded digitally and analyzed for species or species-group identification.

AnaBat detectors will be used for the duration of this study. AnaBat detectors are frequency-division detectors, dividing the frequency of ultrasonic calls made by bats so that they are audible to humans. Frequency division detectors will be used based upon their widespread use for this type of survey, their ability to be deployed for long periods of time, and their ability to detect a broad range of frequency, which allows detection of all species of bats that could occur in New York. Data from the AnaBat detectors will be logged onto compact flash media and downloaded to a computer for analysis. Detectors will be programmed to record data from 7:00 p.m. to 7:00 a.m. every night.

Call files will be extracted from data files using appropriate software, with default settings in place. Call files will be visually screened to remove files caused by wind, insect noise, and other static so that only bat calls remain. Nightly tallies of detected calls will be compiled for each detector and each night. Detection rates indicate only the number of calls detected and do not necessarily reflect the number of individual bats in an area.

Call files will be examined visually and assigned to species categories, based on comparison to libraries of known bat reference calls. This is possible only when clear calls are recorded and only with certain species. The tree-roosting bats are typically easy to identify to species while those of the genus *Myotis* are not. Call rates by species as well as total detections and trends in species' presence in the data set will be reported. Comparisons between call rates and species composition will also be compared between the detectors.

The results of the acoustical monitoring study will be compared to the mortality study results and weather data to identify if any temporal similarities occurred between abundance and mortality.

### Task 3: Post-construction Study Report and Adaptive Management Review

A preliminary report will be prepared evaluating the results from the post-construction bird and bat mortality study and acoustical monitoring study based on the first year of data. Potential adaptive management measures will be identified if significant adverse impacts occur. The mortality study methodology will also be evaluated in this preliminary report and, if necessary, changes identified for implementing the second year of the mortality study. A similar preliminary report will be prepared after the second year of the study and a final report evaluating all of the data collected during the study will be prepared after the third year of the study.

Noble will continue to coordinate with NYSDEC regarding the adequacy of survey methodologies following review of annual reports. The need for adaptive management strategies will be assessed based on the results of the previous year's surveys.

# 4

# References

Erickson, W., J. Jeffrey, K. Kronner, and K. Bay. 2003. Stateline Wind Project Wildlife Monitoring Annual Report, results for the period July 2001 – December 2002. A technical report to FPL Energy, Oregon Office of Energy, and Stateline Technical Advisory Committee.

Erickson, W., and J. Kerns. 2005. Bat Mortality at Wind Energy Facilities during Fall Migration: A Proposal for Intensive Mortality Searches. Appendix V in E. B. Arnett, technical editor, Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Bat Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas.

# Draft
# Environmental Impact Statement for the Noble Wethersfield Windpark

## Towns of Wethersfield and Eagle
## Wyoming County, New York

## Volume III

**February 2007**

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Date Public Comments Due: April 30, 2007

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# F

# Bird and Bat Risk Assessment

002270_NP19_08-B2090

# Bird and Bat Risk Assessment
# Noble Wethersfield Windpark
# Towns of Wethersfield and Eagle, Wyoming County, New York

January 2007

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# List of Tables

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# List of Figures

# List of Abbreviations and Acronyms

| | |
|---|---|
| ABR | ABR, Inc. |
| agl | above ground level |
| amsl | above mean sea level |
| BBRA | bird and bat risk assessment |
| BBS | breeding bird surveys |
| BCA | bird conservation area |
| BCI | Bat Conservation International |
| BOS | Buffalo Ornithological Society |
| CBC | Christmas bird count |
| CHI | CHI Energy |
| DEIS | Draft Environmental Impact Statement |
| E & E | Ecology and Environment, Inc. |
| Enel | Enel North America |
| FAA | Federal Aviation Administration |
| GAO | (United States) Government Accountability Office |
| GE | General Electric |
| HMANA | Hawk Migration Association of North America |
| HSS | hourly sampling session |
| IBA | important bird areas |
| km | kilometer |
| kV | kilovolt |

## List of Abbreviations and Acronyms (cont.)

| | |
|---|---|
| kW | kilowatt |
| MHz | megaHertz |
| MTS | modular tower system |
| MW | megawatt |
| NHP | National Heritage Program |
| NWCC | National Wind Coordinating Committee |
| NWI | National Wetland Inventory |
| NYSDEC | New York State Department of Environmental Conservation |
| NYSOA | New York State Ornithological Association |
| ROW | right-of-way |
| USFWS | United States Fish and Wildlife Service |
| USGS | United States Geological Survey |
| WMA | wildlife management area |

# 1 Introduction

## 1.1 Project Description

Noble Wethersfield Windpark, LLC (Noble) proposes to install and operate a wind energy facility (Project) in the Towns of Wethersfield and Eagle, Wyoming County, located in western New York State (see Figure 1-1).

### 1.1.1 Wethersfield Project Area

The Project consists of the following:

- Installation and operation of 85 wind turbines with a capacity of 127.5 megawatts (MW) within an approximate 9,151-acre area in the Towns of Wethersfield and Eagle (Windpark);
- Construction and use of approximately 20 miles of access roads that will connect each wind turbine to a Town or County roadway to allow equipment and vehicle access for construction and subsequent maintenance of the facilities; and
- Construction and use of an electrical collection system that will allow delivery of electricity to a new substation to be constructed in the Town of Wethersfield as part of Noble's proposed Wethersfield to Orangeville 230-kilovolt (kV) Transmission Project. The collection system will consist of a total of 30 miles of underground collection and 0.5 mile of overhead collection will be installed. Where practical, the electrical collection system will be installed underground along the same right-of-way (ROW) corridor as the access roads.

### 1.1.2 Turbine Description

The wind turbines that will be installed at the Windpark will be General Electric (GE) 1.5-MW, Model sle, 80-meter, modular tower system (MTS), T-Flange wind turbine generators[1]. The turbine is a three-bladed, upwind, horizontal-axis wind

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[1] 1.5MW refers to the production capacity of the turbine, which is 1.5 megawatts. The nomenclature "sle" is used to designate that the diameter size of the turbine rotor is 253 feet. 80-meter refers to the height of the tower. MTS (Modular Tower System) designates the type of tower configuration, and T-Flange designates the type of flange used to connect the tower directly to the foundation.

turbine with a rotor diameter of 253 feet (77 meters) (see Figure 1-2). The nacelle is located at the top of each tower and contains the electrical generating equipment. The turbine rotor and nacelle are mounted on top of a tubular tower, giving a rotor hub height of 263 feet (80 meters) (see Figure 1-2). The maximum height for the turbine is 389 feet (118.5 meters) when a rotor blade is at the top of its rotation. Once installed, each wind turbine will occupy a round, slightly exposed base approximately 18 feet (5.5 meters) in diameter.

Section 1.3 of the Draft Environmental Impact Statement (DEIS) describes the process used to select turbine site locations. A number of factors, including proximity to wetlands were evaluated in determining where to locate turbines. A specific discussion of impacts to wetlands is found in Section 2.8 of the DEIS. The proposed turbine sites represent a balancing of the site selection criteria.

## 1.2 Project Background

In order to provide supporting documentation for the environmental assessment, Noble has undertaken this study to assess the potential for impacts to birds and bats associated with the Project. Noble conducted bird and bat studies in the Project Area through its consultant, Ecology and Environment, Inc. (E & E). The study had the following objectives:

1. Collect information on the occurrence and distribution of birds in the Project Area during migratory and breeding seasons.

2. Collect baseline information on flight directions, passage rates, and flight altitudes of nocturnal targets (migratory birds and bats).

3. Collect information on the occurrence of bat species in the Project Area during migratory seasons.

4. Analyze the baseline data and other available studies and data to evaluate the potential impacts to birds and bats from the Project.

The findings in this report are based on information obtained from the literature and site surveys, comparing data collected at this site with data collected at operating wind facilities at other locations, and by reviewing site features and geography with local bird and bat distribution and use (see Section 2 for methodology).

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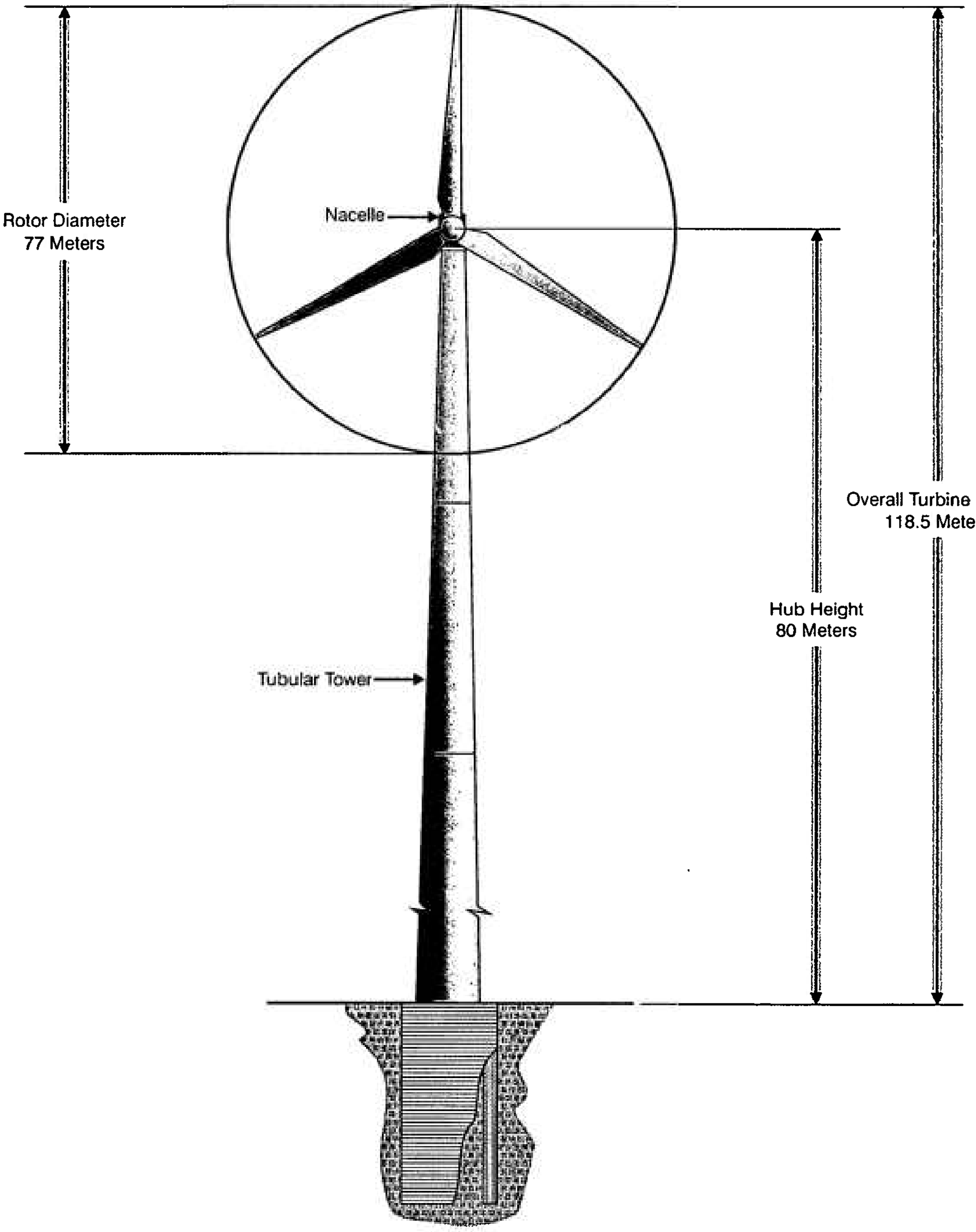


Figure 1-2 Generalized Wind Turbine Layout

# 2 Methodology

The methodology for this bird and bat risk assessment (BBRA) includes the following components:

- Performing a habitat assessment;
- Conducting a literature review and contacting agencies to gather background data for birds and bats in the Project Area;
- Conducting field studies; and
- Evaluating the potential impacts to birds and bats from the Project.

## 2.1 Habitat Assessment

The habitat and topography of the Project Area were evaluated based on site visits, interpretation of aerial photography, and through United States Geological Survey (USGS) land use and land cover figures. The general description developed is useful to understand the existing environment for birds and bats.

## 2.2 Literature Review

A literature review was conducted to obtain existing information about the occurrence and distribution of birds and bats in the Project Area. Sources of bird information that were reviewed included a nocturnal radar and visual study conducted at the nearby Wethersfield facility (preconstruction), the New York State Breeding Bird Atlas project, USGS breeding bird surveys, National Audubon Society Christmas Bird Counts (CBCs), regional publications and records databases, the Audubon New York Important Bird Areas program, and bird studies conducted for other proposed wind energy projects in Wyoming County. Sources of bat information that were reviewed include publications of the New York State Department of Environmental Conservation (NYSDEC), the United States Fish and Wildlife Service (USFWS), Bat Conservation International (BCI) and other reference sources, and bat studies conducted for other proposed wind energy projects in Wyoming County. In addition to conducting a literature review, requests were made to NYSDEC and USFWS for information on threatened and endangered species in the Project Area.

## 2.3 Field Studies

### 2.3.1 Nocturnal Radar and Visual Study

Mobile marine radar and visual techniques were employed to assess migratory bird and bat activity in the Project Area during spring and fall migratory periods. This integrated visual and radar study of bird and bat movements provided site-specific information on passage rates, behavior, and flight altitudes. ABR, Inc. (ABR) conducted the nocturnal radar and visual study through coordination with E & E (see Appendix A and Appendix B).

One radar unit, located in the Town of Wethersfield, was used to conduct sampling during a 45–night period during the spring migration season (April 15, 2006 through May 30, 2006; see Figure 2-1). Each night, ABR conducted nocturnal radar and visual observations at the survey site. Sampling began at sunset and concluded at sunrise as per the recommendation of the NYSDEC. Each of the 60-minute nocturnal radar sampling periods consisted of: one 10-minute session to collect weather data and adjust radar to surveillance mode; one 10-minute session with the radar in surveillance (i.e., horizontal) mode at 1.5-kilometer (km)-range collecting information on passage rates of nocturnal targets; one 15-minute session with the radar in surveillance mode at 1.5-km-range collecting information on ground speed and flight direction; one 10-minute session to collect weather information and adjust radar to vertical mode; and one 15-minute session in the vertical mode at 1.5-km-range to collect information on flight altitudes of nocturnal targets below 1,500 meters (4,921 feet). The following weather data were collected at the beginning of each hour session: wind speed, wind direction, cloud cover, ceiling height, visibility, precipitation, and air temperature (degrees Celsius).

For approximately seven hours each night, a second observer conducted 50 minutes per hour of visual sampling with night-vision goggles and infrared spotlights to identify low-flying targets (i.e., birds vs. bats) and to help assess insect activity levels. During night-vision sampling, the observer was stationed near the radar sampling station and used night-vision equipment to make visual observations of birds, bats, and insects along two vertically oriented spotlights (fitted with infrared filters). For each session, the observer recorded the number, species group (to lowest possible taxonomic unit), altitude (if possible), and primary flight directions of any bats and birds that were observed flying through the beam (up to approximately 492 feet [150 meters] above ground level (agl), beyond which small birds and bats cannot be effectively detected.)

The mobile radar lab consisted of a marine radar mounted on a vehicle. The radar was X-band, transmitting at 9,410 megaHertz (MHz) with peak power output of 12 kilowatts (kW). A similar radar lab is described in Cooper et al. (1991) and the vertical radar setup is described by Harmata et al. (1999). For night-vision equipment, 1x power Generation III night-vision goggles were used. Spotlights were 2-3 million candlepower lights.

The sampling location was selected in the field during a tour of the Project Area (see Figure 2-1). The site provided an unobstructed view of the surrounding area.

The results of the spring nocturnal radar and visual study include:

- Baseline information on flight altitude, passage rates, and flight direction of migratory birds and bats;
- An estimate of the relative proportions of birds vs. bats within 492 feet (150 meters) agl (based on visual estimates);
- An estimate of the number of birds and bats that flew at heights within the proposed turbine zone during spring 2006; and
- The amount of among-night and within-night variation in passage rates and flight altitudes of nocturnal targets (bats/birds).

A nocturnal radar study was also conducted during the fall migratory period (August 16 through October 14, 2006). A nocturnal visual study complemented the radar study for the period of approximately August 16 through October 9, 2006. The same mobile marine radar and visual techniques were employed to assess migratory bird and bat activity in the Project Area as during the spring study period.

For more complete information on the radar study methodology, see ABR's spring and fall reports in Appendices A and B.

### 2.3.2 Migratory Raptor Surveys

Migratory raptor surveys were conducted in the Project Area for three days during the spring migratory season and for six total days during the fall raptor migratory season. The duration of the surveys (i.e., minimum of three days per season) was consistent with the request from NYSDEC that three days of raptor surveys be undertaken for proposed wind project areas in the spring and fall migratory periods. Raptor migration areas in New York State are well documented (see further discussion in Section 3.2.1.1). Additional days of raptor surveys were unnecessary because the Project Area is not located in an area known to have increased raptor migration.

The sampling location was selected during a field visit. With an agreeable land owner, a good view of the surrounding area, and proximity to the proposed turbine locations, the met tower site was selected as the sampling location (see Figure 2-1). Field data collected on migrating raptors included species identification, number of individuals, flight direction, and estimated flight altitude (above or below 400 feet agl). Birds that were observed flying in a non-northerly direction during fall migration (or flying in a non-southerly direction during spring migration) were assumed to be migrating; whereas, birds observed flying north in fall (or south in spring) or hunting near the ground were considered to be local birds.

The surveys were conducted between 9:00 a.m. and 4:00 p.m. on days of preferable raptor migration weather to the extent possible. Favorable weather conditions in spring include little or no precipitation, warmer than average temperatures, and light or southerly winds. Scheduling of surveys in the fall was attempted for days following the passage of cold fronts and/or the presence of light or northerly winds, with little or no precipitation. The same sampling location and protocol were used for both the spring and the fall surveys.

Migratory raptor surveys were conducted on three days (21 hours) in the spring (April 22, 27, and 29, 2005), three days (21 hours) in the fall of 2005 (September 13, 15, and 18), and three days in the fall of 2006 (September 21 and 29 and November 1) in the Project Area.

### 2.3.3 Spring Migratory Bird Surveys

E & E conducted baseline migratory bird surveys in the Project Area on May 10 and 18, 2006, during the spring (migratory) season. The effort included conducting reconnaissance surveys to document bird species and searching for threatened and endangered species and appropriate habitat.

Twenty-four sampling points were selected prior to field activities based on the proposed turbine locations, viewing distances, a variety of habitats, and areas suited for avian occurrence (see Figure 2-1). The observer documented all birds (except the unprotected Rock Pigeons, European Starlings, and House Sparrows) identified by sight or sound in 5-minute periods at selected survey points. Because avian activity is greatest in the morning, the survey was conducted during the morning hours. To maximize the number of points visited during the morning hours, these surveys were conducted along roadsides.

This survey supplements the information collected in the spring radar study, especially with regard to species-related data. Data from this survey were used to document the occurrence and distribution of bird species in the Project Area and help identify the presence/absence of listed species and areas of higher/lesser bird activity.

### 2.3.4 Breeding Bird Surveys

Breeding bird surveys were conducted in the Project Area during the primary breeding season. Two surveys were conducted on June 5 and 22, 2006, and were performed using USFWS Breeding Bird Survey techniques with an observer recording all birds identified by sight or sound in 3-minute periods at each survey point (USGS 2006). Survey points were selected based on proposed turbine locations, accessibility, and a variety of habitats (see Figure 2-1). The number of survey points was limited to 15 points so that all of the surveys were conducted between sunrise and 11:00 a.m.; however, on both mornings of the survey, only 14 points were surveyed (June 5: points A through C and E through O and June 22: A through G and I through O). Species observed during other site visits and surveys in the Project Area were also documented as was breeding behavior.

Data from these surveys was used to document the occurrence and distribution of breeding bird species in the Project Area and help identify the presence/absence of listed species and areas of higher/lesser bird activity.

### 2.3.5 Bat Habitat Surveys

E & E conducted initial habitat-level surveys during various visits to the Project Area in the spring, summer, and fall of 2006 to determine if any habitat within the Project Area is suitable for bat species, particularly habitats required for endangered and threatened species. Habitats were documented based on species composition and general landscape position with particular emphasis placed on forested riparian, floodplain, and wetland areas, which tend to be preferable roost and foraging locations for the endangered Indiana Bat. These areas were assessed through a combination of aerial and topographic map interpretation and site visits during migration and summer roosting periods. The survey assessed the potential for bat species to frequently utilize the Project Area. Rock outcroppings, potential dwellings, or other hibernacula where bats may roost were examined from field visits and desktop level of reviews for the surrounding region.

### 2.3.6 Acoustical Monitoring for Bats

Acoustical monitoring via bat echolocation detectors (i.e., AnaBat equipment) was conducted during the spring migratory period (April 6 through June 7, 2006) and the fall migratory period (July 25 through October 9, 2006). AnaBat monitoring equipment was installed on a meteorological tower located in the Project Area (see Figures 2-2 and 2-3). In the spring, one monitoring unit was installed as high on the tower as possible at approximately 69 feet (21 meters) agl, while the other unit was installed midway between that unit and the ground at approximately 33 feet (10 meters) agl. In the fall, the detectors were mounted at 98 feet (30 meters) and 49 feet (15 meters). The monitoring units were deployed within a guy wire system and pointed in the direction of anticipated migration (facing south in spring and north in fall). Bat echolocation data was recorded digitally and analyzed for species or species-group identification. The acoustical monitoring study was conducted by Woodlot Alternatives, Inc. (Woodlot) with project coordination provided by E & E. Woodlot's spring and fall reports are attached in Appendices C and D.

AnaBat detectors were used for the duration of this study. AnaBat detectors are frequency-division detectors, dividing the frequency of ultrasonic calls made by bats so that they are audible to humans. Frequency division detectors were selected based upon their widespread use for this type of survey, their ability to be deployed for long periods of time, and their ability to detect a broad range of frequencies, which allows detection of all species of bats that could occur in New York State. Data from the AnaBat detectors were logged onto compact flash media using a CF ZCAIM (Titley Electronics Pty Ltd.) and downloaded to a computer for analysis. Detectors were programmed to record data from 7:00 p.m. to 7:00 a.m. every night.

Call files were extracted from data files using CFCread© software, with default settings in place. Call files were visually screened to remove files caused by wind, insect noise, and other static so that only bat calls remain. Call files were examined visually and assigned to species categories, when possible, based on comparison to libraries of known bat reference calls. The categorization of calls was possible only when clear calls were recorded and only with certain species. Due to similarity of call signatures between several species, all classified calls were categorized to the lowest possible taxonomic level and then were grouped into one of four guilds established by Gannon et al. (2003) (Woodlot 2006 a, b):

- **Big Brown, Silver-haired, and Hoary Bat –** This guild will also be referred to as the big brown guild. These species' call signatures commonly overlap and have, therefore, been included as one guild in this report;

- **Red Bat and Pipistrelle** – Eastern Red Bats and Eastern Pipistrelles. Like so many other northeastern bats, these two species can produce calls distinctive only to each species. However, significant overlap in the call pulse shape, frequency range, and slope can also occur;

- **Myotid –** Bats of the genus Myotis. While there are some general characteristics believed to be distinctive for several of the species in this genus, these characteristics do not occur consistently enough for any one species to be relied upon at all times when using AnaBat recordings; and

- **Unknown** – Call sequences with too few pulses (less than seven) or of poor quality such as indistinct pulse characteristics or background static.

Grouping calls in this way is considered a conservative approach to bat call identification.

Once the data were classified, nightly tallies of detected calls were compiled for each detector and each night. Detection rates indicate only the number of calls detected and do not necessarily reflect the number of individual bats in an area, because a single individual can produce one or many call files recorded by the bat detector, and the bat detector cannot differentiate between individuals of the same species. Call rates by species, guild, as well as total detections and trends in species' presence in the data set were reported. Comparisons between call rates and species composition were also compared between the detectors.

For more complete information on the acoustical monitoring study methodology, see Woodlot's spring and fall reports in Appendices C and D.

**Figure 2-2** AnaBat Detector Attached to Guy Wires of the Meteorological Tower

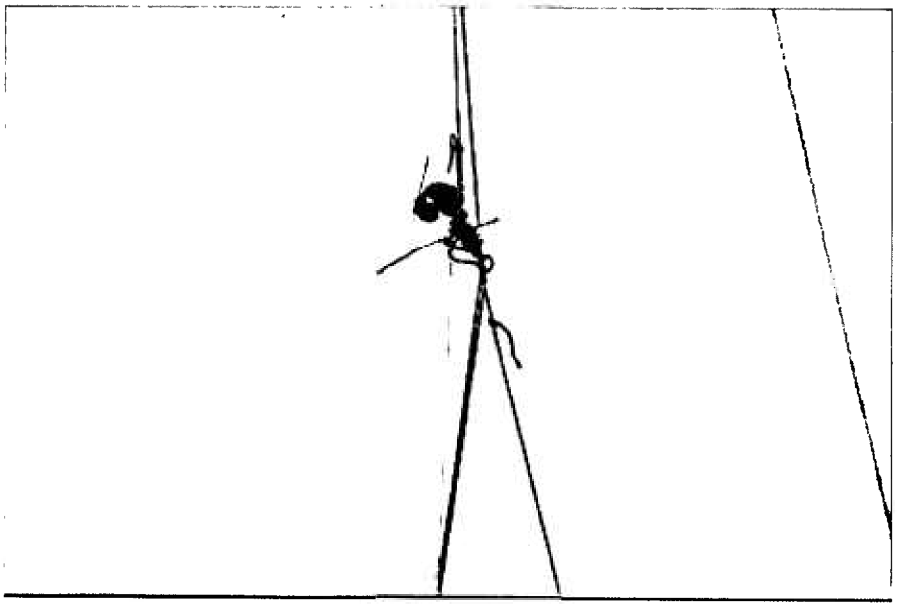


**Figure 2-3** Acoustical Monitoring Equipment (AnaBat Detectors)

# 3 Results

## 3.1 Habitat and Topography Description

The Windpark is located within an area of approximately 9,151 acres in the Towns of Wethersfield and Eagle, Wyoming County, New York. Land uses within the Project Area are predominantly a mixture of agricultural (5,447 acres), forested land (3,625 acres), and some developed land (8 acres). Additionally, there are 356 acres of NYSDEC mapped wetlands and 606 acres of National Wetland Inventory (NWI) mapped wetlands, within the Project Area. Current agricultural use includes a mixture of row crops (e.g., corn), hay production, and pasture. Forested land within the Project Area varies from successional northern hardwood forest to beech-maple mesic forest. Current and historic silviculture is evident throughout the Project Area.

The Project Area is located in the Appalachian Uplands physiographic province of New York State. The Appalachian Uplands are bordered to the west by the Portage Escarpment and to the north by the Alleghany Plateau. The escarpment forms the boundary between the Appalachian Uplands and the Erie-Ontario Lowlands physiographic province to the north and west. The shale, siltstone, and sandstone bedrock in the region has been tilted slightly to the south. Sandstone and siltstone layers form this escarpment due to their greater resistance to erosion than the shale layers above and below them. Since the deposition and subsequent tilting of the bedrock, glaciation, and erosion have carved the hilly upland present today (New York State Museum 1991). Within the Project Area, elevations range from less than 1,546 feet to a county-high elevation of slightly greater than 2,096 feet above mean sea level (amsl).

The Project Area is characterized by agricultural fields (pasture/hay and some row crops), and deciduous and mixed forest; scattered residential and developed uses, and wetlands/open water. Active agricultural areas are scattered throughout the Project Area with larger, contiguous tracts of active agricultural land located in the northeast portion of the Project Area along Route 78. Corn and potatoes are the predominant row crops in the area. Inactive agricultural areas are in successional stages, including old-field and shrub communities. The dominant woodland communities are successional northern hardwood forest, beech-maple mesic forest, and hemlock-northern hardwood forest. Timbering activities occur throughout the area. Residential land use within the Project Area is typical of rural areas, with scattered residences located along the major roadways. Residential use in the Project Area is primarily a mixture of active farmsteads and seasonal residences. Most of the residences are located south of Route 78.

The mosaic of uplands and wetlands within the Project Area offers a variety of habitats and ecozones beneficial to a broad wildlife assemblage. Numerous streams and ponds are also interspersed throughout the Project Area. Eleven general ecological communities were identified in the Project Area: beech-maple mesic forest; hemlock-northern hardwood forest; maple-basswood rich mesic forest; pine plantation; successional northern hardwood forest; successional shrubland; successional old field; cropland/row crops; cropland/field crops; pasturelands; and mowed land. The community structure found within the Project Area is typical of other western New York areas with similar significant agricultural production, ranging from woodlots to old fields. Wildlife associated with these communities throughout the Project Area is typical of what would be found throughout much of western New York State.

## 3.2 Literature Review

### 3.2.1 Birds

### 3.2.1.1 Regional Avian Overview

#### Migrating Birds (Spring and Fall)

The primary bird migration seasons in the Project Area are spring and fall. Typical of New York State and the northeast United States in general, the migrations of certain bird groups are as follows:

- Raptors (e.g., hawks, falcons, eagles, and vultures) migrate primarily between mid-March and mid-May and then between September and early November;
- Passerines (i.e., songbirds) primarily migrate between mid-April through May and between late August through October; and
- Waterbirds (e.g., waterfowl, herons, and shorebirds) migrate primarily between March and mid-May and then between September and mid-November.

Raptor migration areas in New York State are well documented and locations where large numbers (thousands to tens of thousands) of migrating raptors occur are already known. There are 13 sites in New York State that regularly report results to the Hawk Migration Association of North America (HMANA) database (HawkCount 2007). Most of these prime raptor migration locations are along the Great Lakes (in spring) and in the lower Hudson Valley (in fall). In spring, raptor migration is concentrated along the southern shores of the Great Lakes as raptors avoid crossing large bodies of water. Migratory raptors are also found in concentrated numbers along prominent ridgelines. There are no raptor monitoring locations (i.e., "hawk watches") in Wyoming County (HawkCount 2007; Zalles and

Bildstein 2000). The closest hawk watch is near the Lake Erie shoreline in Hamburg, approximately 31 miles northwest of the Project Area, where thousands are tallied each spring. As the Project Area is not proximate to the shorelines of the Great Lakes, large bodies of water, or lengthy ridgelines, raptor migration is diffuse and without regularly occurring concentration points. There are no geographical or topographical features in the Project Area that attract or concentrate large numbers of migrating raptors.

Unlike most migrating raptors, migrating passerines (i.e., songbirds) do not generally avoid crossing large bodies of water or migrate in concentrated numbers along ridgelines. However, they do concentrate in stopover points following nocturnal migration. These stopover points are often along geographical or topographical features (i.e., shorelines of large lakes or oceans) or isolated patches of habitat. No geographical or topographical features in the Project Area that attract or concentrate migrating passerines in greater numbers than elsewhere in the region were identified. Outside of such concentration areas, passerine migration is typically diffuse over a broad front. Two nocturnal radar studies in proximity to the Project Area were conducted previously (i.e., an ABR study in Wethersfield in fall 1998 and spring 1999 and a limited study by Marine Services Diversified LLC in Eagle over eight nights in fall 2005) and were evaluated in the BBRA along with a nocturnal radar study conducted for this Project in 2006 (see Sections 3.2.1.8 and 3.3.1).

There are no large waterbodies or extensive wetlands with open water in the Project Area to attract substantial numbers of waterbirds (i.e., waterfowl or shorebirds) during migration. Other than some small inland lakes and reservoirs (e.g., Attica Reservoir, Cuba Lake, Silver Lake) that attract lesser numbers of migrant waterfowl, the closest area to the Project Area with wetland habitat conducive for large concentrations of migrant waterfowl is the Iroquois National Wildlife Refuge complex (to the north and west of the Project Area); however, the refuge is approximately 30 miles away and does not result in strong passage of waterfowl or shorebirds through the Project Area. There is no strong passage of waterbirds in or near the Project Area, primarily because of the habitat and lack of large water bodies in the Project Area.

### Breeding Birds (Late Spring and Summer)

Late spring and summer is the primary season for avian breeding in the Project Area. Breeding activity in and/or near the Project Area has been documented by several sources described in the sections below (see Sections 3.2.1.2 and 3.2.1.3) and E & E conducted two breeding bird surveys in the Project Area in June 2006 (see Section 3.3.4). Typical for Wyoming County, a good diversity of breeding species is associated with the area, primarily in forested areas.

### Wintering Birds

Large concentrations of birds do not winter in the Project Area and diversity is low because of the harsh climate and lack of sufficient food sources. Most species present in other seasons (e.g., warblers, flycatchers, and thrushes) migrate south for the winter, leaving only year-round species that are not seasonally displaced (e.g., Great Horned Owl, Pileated Woodpecker) and some species (e.g., American Tree Sparrow, Rough-legged Hawk) that travel south from more northern climates to winter in western New York. Regional CBC data provide an overview of species that would be anticipated to occur in the Project Area during the winter in appropriate habitat (see Section 3.2.1.4).

#### 3.2.1.2 Breeding Bird Atlas Projects

The New York State Breeding Bird Atlas (Atlas 2000) project (NYSDEC 2006a) was an extensive survey to determine the current distribution of breeding bird species in New York State. Volunteer birders recorded evidence of breeding bird species throughout the state within 5-km by 5-km blocks. The data provide evidence of breeding composition and, in general, quality of breeding habitat. A total of 76 species was considered the approximate average species diversity per block across the state during the first atlas conducted between 1980 and 1986 (Andrle and Carroll 1988). Surveys for the Atlas 2000 project (2000 through 2005) were recently completed, allowing a comparison to the results of the first atlas to see how the distribution of breeding birds has changed. Draft data from the Atlas 2000 project and final data from the 1980 to 1986 Atlas project are available for review on NYSDEC's Atlas 2000 web site (http://www.dec.state.ny.us/website/dfwmr/wildlife/bba/index.html). Depending on the breeding evidence observed, species were classified as possible, probable, or confirmed breeders.

The Project Area is located within six New York State Breeding Bird Atlas blocks (2271B, 2272B, 2272C, 2272D, 2372A, and 2372C; see Figure 3-1). Draft data for the species totals in these blocks through the 2005 season are included in Table 3-1. The totals for these atlas blocks are greater than the state average of 76, indicating good atlas observer effort and a good diversity of breeding species in the area.

**Table 3-1 Total Species Identified in New York State Breeding Bird Atlas Blocks in the Project Area**

| Atlas Block | Total Species |
|---|---|
| 2271B | 89 |
| 2272B | 96 |
| 2272C | 95 |
| 2272D | 88 |
| 2372A | 93 |
| 2372C | 93 |

Source: NYSDEC 2006a.

A combined total of 119 species was identified in the six atlas blocks; see Appendix E, Table E-1, for the species identified in each block. The species identified in these six blocks are generally consistent with regularly occurring nesting species for the region.

Several state-listed species were included among the species documented in these blocks during the Atlas 2000 project. Two state-threatened species, the Northern Harrier and the Upland Sandpiper, were documented. Northern Harrier was categorized as a confirmed breeder in block 2271B and a possible breeder in blocks 2272C and 2372C. Upland Sandpiper was categorized as a possible breeder in block 2272C. Species of special concern documented in the atlas blocks included Sharp-shinned Hawk (blocks 2272D and 2372C), Red-shouldered Hawk (blocks 2271B, 2272B, 2272C, and 2372C), Horned Lark (blocks 2272C, 2272D, 2372A, 2372C), Vesper Sparrow (blocks 2271B, 2272B, and 2372A), and Grasshopper Sparrow (block 2372C).

### 3.2.1.3 Breeding Bird Surveys

Breeding bird surveys (BBSs) are conducted annually by skilled volunteers during the peak nesting season (June) as part of a long-running, widespread monitoring program implemented by the USGS. All birds heard or observed are documented using a specified protocol. Surveys are conducted for three minutes at 50 locations, one-half mile apart, starting 30 minutes before sunrise. The BBS data provide a valuable source of information on bird population numbers and trends over time in given areas, both locally and nationally.

There are four BBS routes (East Java, Gainesville, Centerville, and Castile) where at least of portion of the route is within 10 miles of the Project Area (see Figure 3-2). The species identified on these BBSs (see Appendix E, Table E-2) are similar to those observed during the Atlas 2000 project and are generally consistent with regularly occurring nesting species for the region. Several state-listed species were included among the species documented in these BBSs. Table 3-2 includes the New York State-listed species that were identified at least once during the BBS between 1966 and 2005 and the number of birds per route (Sauer et al. 2005). No federally listed species were identified during these surveys.

**Table 3-2 State-Listed Species Identified during East Java, Gainesville, Centerville, and Castile BBSs**

| Species | East Java (Birds/ Route) | Gainesville (Birds/ Route) | Centerville (Birds/ Route) | Castile (Birds/ Route) | New York State Status |
|---|---|---|---|---|---|
| Pied-billed Grebe | NR | NR | NR | 0.33 | Threatened |
| American Bittern | NR | 0.17 | NR | 0.08 | Special Concern |
| Osprey | 0.03 | NR | NR | NR | Special Concern |
| Northern Harrier | 0.03 | 0.45 | 0.29 | 0.14 | Threatened |
| Sharp-shinned Hawk | 0.09 | 0.07 | NR | 0.11 | Special Concern |
| Cooper's Hawk | 0.06 | 0.07 | NR | 0.06 | Special Concern |
| Red-shouldered Hawk | 0.20 | NR | 0.13 | 0.06 | Special Concern |

## Table 3-2 State-Listed Species Identified during East Java, Gainesville, Centerville, and Castile BBSs

| Species | East Java (Birds/ Route) | Gainesville (Birds/ Route) | Centerville (Birds/ Route) | Castile (Birds/ Route) | New York State Status |
|---|---|---|---|---|---|
| Upland Sandpiper | 0.89 | 1.93 | 0.10 | NR | Threatened |
| Common Nighthawk | NR | NR | 0.03 | NR | Special Concern |
| Red-headed Woodpecker | 0.03 | 0.17 | 0.03 | 0.33 | Special Concern |
| Horned Lark | 0.83 | 5.03 | 1.26 | 9.42 | Special Concern |
| Golden-winged Warbler | NR | NR | NR | 0.03 | Special Concern |
| Vesper Sparrow | 0.20 | 4.69 | 0.52 | 4.36 | Special Concern |
| Grasshopper Sparrow | 0.40 | 1.48 | 0.39 | 0.19 | Special Concern |
| Henslow's Sparrow | 0.23 | 0.24 | 0.13 | NR | Threatened |

Source: Sauer et al. 2005.

Key:
NR = Not recorded.

The East Java BBS (#61057) is a west-to-east route from the Town of Boston to the Town of Arcade 18 miles east, Wyoming County; this route is approximately 3 miles west of the Project Area. A total of 113 species have been recorded over the duration of the East Java BBS, which was conducted every year between 1967 and 2005 except 1972 and 1979 (USGS 2006).

The Gainesville BBS (#61055) is a south-to-north route from the Town of Gainesville (Wyoming County) to the Town of, Bethany (Genesee County) 23 miles north. The BBS route is 1.5 miles from the Project Area at its closest point. A total of 107 species have been recorded over the duration of the Gainesville BBS, which was conducted every year between 1967 and 2001, except for 1991, 1994, and 1996, no surveys were conducted from 2002 to 2005 (USGS 2006).

The Centerville BBS (#61060) is an "L"-shaped route from the Town of Centerville, approximately 12 miles east then 11 miles south to the Town of Angelica, Allegany County. This route is approximately 7 miles south of the Project Area. A total of 113 species have been recorded over the duration of the Centerville BBS, which was conducted every year between 1967 and 2005 except six years (USGS 2006).

The Castile BBS (#61058) is a north-to-south route, from the Town of Middlebury to the Town of Gainesville, approximately 15 miles south. This route is approximately 4 miles from the Project Area at its closest point. A total of 107 species have been recorded over the duration of the Castile BBS, which was con ducted every year between 1967 and 2003, no surveys were conducted in 2004 or 2005 (USGS 2006).

### 3.2.1.4 Christmas Bird Counts

The primary objective of the National Audubon Society's CBC is to monitor the status and distribution of wintering bird populations across the Western Hemisphere. The CBC is an all-day census of early winter bird populations within 15-mile diameter survey areas. The results are compiled into the longest running database in ornithology, representing over a century of unbroken data on trends of early winter bird populations across the Americas (National Audubon Society 2004). The CBCs are conducted mostly by volunteer birders. The CBC data provide a good overview of the species that occur regionally in early winter in similar habitat. Data are available from a National Audubon Society web site (http://audubon2.org/birds/cbc/hr/count_table.html). Birds observed during CBCs conducted near the Project Area provide information on birds likely occurring in the Project Area during the winter months in similar habitat. However, past observations of bird species during the CBC does not mean that such species are currently present on or near the Project Area.

One CBC is conducted in a portion of the Project Area. The Beaver Meadow CBC is centered on the Beaver Meadow Audubon Center in East Java, approximately three miles from the Project Area. Given that a 15-mile diameter area is surveyed, the western half of the Project Area is included in this count. The Beaver Meadow CBC is typically conducted on the third Saturday of December.

A total of 90 species were identified during the last 31 (December 1975 through December 2005) of this CBC (National Audubon Society 2006). The number of species counted each year ranged from a minimum of 26 species in 1975 to 55 species in 1990 for an average species count during that time period of 46 species. See Appendix E, Table E-3, for the data from the last 10 years of the Beaver Meadow CBC. Table 3-3 includes the New York State-listed species that were identified at least once during the Beaver Meadow CBC between 1975 and 2005 and the maximum count during that period (National Audubon Society 2006). No federally listed species were identified during this period.

**Table 3-3 State-Listed Species Recorded during Beaver Meadow Christmas Bird Count (1975 through 2005)**

| Species | Number of Years Observed | Maximum Count (Year[1]) | New York State Status |
|---|---|---|---|
| Northern Harrier | 15 out of 31 years | 8 (1988) | Threatened |
| Sharp-shinned Hawk | 26 out of 31 | 7 (1998) | Special Concern |
| Cooper's Hawk | 26 out of 31 | 8 (2000) | Special Concern |
| Northern Goshawk | 9 out of 31 | 2 (1979, 1983) | Special Concern |
| Red-shouldered Hawk | 6 out of 31 | 3 (2005) | Special Concern |
| Short-eared Owl | 14 out of 31 | 12 (1989) | Endangered |
| Horned Lark | 25 out of 31 | 266 (2002) | Special Concern |

[1] Year(s) that the maximum count was observed.

Source: National Audubon Society 2006.

### 3.2.1.5 Regional Reports

E & E reviewed the Region 1, Niagara Frontier, quarterly reports in *The Kingbird,* a publication of the New York State Ornithological Association (NYSOA). NYSOA Region 1 includes Niagara, Erie, Chautauqua, Cattaraugus, Allegany, and the western portion of Wyoming, Genesee, and Orleans counties. All reports since 1995 were reviewed for bird sightings in the Towns of Wethersfield and Eagle.

The Buffalo Ornithological Society (BOS) maintains a database of avian records dating back to 1964 for NYSOA Region 1 and adjacent Ontario. E & E reviewed the database for bird sightings in the Towns of Wethersfield and Eagle.

*The Birds of Wyoming County, New York* (1967), by Richard C. Rosche, was also reviewed by E & E. This book describes the occurrence and distribution of 232 bird species recorded in Wyoming County. Although the book is somewhat dated, there is still some relevant material regarding species. Rosche (1967) mentions Wethersfield Springs as one of 12 areas that contain habitat of chief importance to birds in Wyoming County. Wethersfield Springs, a pond that was used as a reservoir for the Village of Warsaw, is adjacent to the Project Area in the northeast corner of the Town of Wethersfield.

Records of threatened/endangered species from these and other sources were reviewed and information obtained is included in Table 3-12.

### 3.2.1.6 Important Bird Areas

There are no important bird areas (IBAs) as identified by Audubon New York within the Project Area. There is one IBA, Letchworth State Park, within 10 miles of the Project Area, and is the only IBA in Wyoming County. Letchworth State Park is located in multiple towns in Livingston and Wyoming counties 7.5 miles east of the Project Area (see Figure 3-3). Letchworth is a 14,000-acre park offering recreational activities associated with the Genesee River gorge. The park is approximately 15 miles long and 2 miles wide. Deep gorges, dense forests, and numerous grasslands create multiple habitats within the park boundaries, offering a diverse array of breeding bird species. The IBA criteria for the site are met for eight Audubon bird species at risk, including large breeding populations of American Woodcock, Willow Flycatcher, Wood Thrush, Blue-winged Warbler, Cerulean Warbler, Canada Warbler, and Yellow-breasted Chat, plus large migratory numbers of Rusty Blackbird. There are several state-listed bird species that occur in the park, including Bald Eagle (one nesting pair), Northern Harrier (breeds), Cooper's Hawk, Northern Goshawk, Red-shouldered Hawk, Short-eared Owl (winters regularly), Upland Sandpiper (breeds), Red-headed Woodpecker, Golden-winged Warbler, and Henslow's Sparrow (breeds) (Burger and Liner 2005).

There is one other IBA within 20 miles of the Project Area. Keeney Swamp Forest in Birdsall, Allegany County is a 3,300-acre area of private, state, and county lands approximately 20 miles from the Wethersfield Project Area. The area includes extensive wetlands, diverse forests, and some surrounding grasslands that collectively offers a high diversity of birds and other wildlife. Several state-listed bird species regularly occur at this IBA, including Northern Harrier, Pied-billed Grebe, and Upland Sandpiper.

Although Letchworth State Park IBA and Keeney Swamp Forest IBA contain habitats unique to the area and/or habitats that are not degraded or heavily impacted by humans (Burger and Liner 2005), neither of these IBAs is proximate to the Project Area. Therefore, the IBAs are unlikely to be impacted by the Project.

#### 3.2.1.7 Other Protected Areas

There are three Wildlife Management Areas (WMAs) (Carlton Hill, Harwood Lake, and Hanging Bog) near the Wethersfield Project Area, besides the Keeney Swamp Forest mentioned above.

Carlton Hill WMA is located in Middlebury, Wyoming County, 12 miles north of the Wethersfield Project Area. This WMA is a 2,580-acre NYSDEC multiple-use recreational area consisting of wetland and upland complexes that offers hiking trails, scenic vistas, winter use (snowshoeing and cross-country ski), and hunting. Carlton Hill WMA is managed largely for hunting activities and grassland habitat. Many species utilizing grassland habitats are present, including the Northern Harrier, Grasshopper Sparrow, Henslow's Sparrow, and Vesper Sparrow.

Harwood Lake WMA is a 298-acre area offering bird watching, fishing, and hunting. The WMA is located near the Town of Farmersville in Cattaraugus County and is approximately 13 miles to the south of the Wethersfield Project Area.

Hanging Bog WMA, a 4,571-acre NYSDEC multiple-use recreational area, is located in New Hudson, Allegany County, approximately 18 miles south of the Wethersfield Project Area. This WMA consists of wetland and upland complexes that offers hiking trails, scenic vistas, winter use (snowshoeing and cross-country ski), and hunting.

There are no bird conservation areas (BCAs) within 20 miles of the Wethersfield study area at this time. However, NYSDEC has proposed designating Keeney Swamp, currently an IBA, as a BCA (NYSDEC 2006b). Keeney Swamp meets a number of criteria for listing as a BCA including: has large numbers of waterfowl, migratory species, individual species, diverse species, and possibly shorebirds; and supports a significant population of species at risk.

Although not officially designated as an IBA, Beaver Meadow Audubon Center is considered an important avian resource area. It is approximately 3.7 miles west of the Wethersfield Project Area on Welch Road in North Java. Beaver Meadow Audubon Center is a well-known 324-acre wildlife preserve, offering hiking, wildlife viewing, and outdoor education programs. Habitats within the preserve include glacial kettle ponds, wetlands, and wooded uplands. A variety of avian studies are conducted here, including a yearly CBC.

#### 3.2.1.8 Recent Bird Studies in Proximity to the Project Area

Several bird studies were conducted recently in proximity to the Project Area as part of the permitting process for other proposed wind energy projects. A summary of the bird study results for each proposed project is included in this section. The general project areas for the proposed Noble Bliss Windpark, Noble Centerville Windpark, High Sheldon Wind Farm (Horizon), Dairy Hills Wind Farm (Invenergy), and the existing Wethersfield wind farm, are identified on Figure 3-4.

#### Noble Bliss Windpark Study

Bird surveys were conducted for the proposed Noble Bliss Windpark in the Town Eagle, Wyoming County, New York in the spring and fall of 2005 (E & E 2006a; Figure 3-4). This proposed Windpark is adjacent to the south of the Wethersfield Project Area.

A limited nocturnal radar study was conducted in fall 2005 as part of the permitting effort for Noble Bliss Windpark. Marine Services Diversified, LLC conducted the study between September 9 and October 31, 2005, for a total of eight nights of study (one night per week for eight weeks) at a site in the Town of Eagle. The mean passage rate for fall 2005 was 440 targets/km/hr with a range of 52 to 1,392 targets/km/hr. The mean flight altitude was 1,348 feet (411 meters) agl and approximately 13% of all nocturnal targets in fall 2005 flew below 125 meters (410 feet) agl. The mean direction of movement was to the southwest. Although the sample size was small, weather appeared to play a role in nocturnal movements, where, in general: migration passages rates decreased with strong headwinds and precipitation; migration passages rates increased with strong tailwinds; and targets that occurred at altitudes less than 656 feet (200 meters) agl were associated with strong headwinds, low ceilings, and advancing precipitation shields.

Three raptor surveys were conducted by Noble in the Bliss Project Area in April 2005 and three raptor surveys were conducted by Noble in September 2005. During the spring six migratory raptors and 19 locally foraging raptors were observed including Red-tailed Hawk, Rough-legged Hawk, Broad-winged Hawk, and Turkey Vultures. In the fall, no raptors were observed.

During the migratory bird surveys conducted by E & E on May 12, 18, and 26, 2005, at 28 roadside points, a total of 1,644 birds of 87 species were recorded, all of which were expected based on the habitat, location, and time of year. The most numerous species recorded were Red-winged Blackbird, Bobolink, and American Robin. There was no evidence that the Project Area served as an increased migratory corridor or stopover point for passerines or other bird species.

Two breeding bird surveys were conducted by E & E at or near nine of the proposed turbine locations in June 2005. During the two breeding bird surveys, a total of 294 birds of 54 species were recorded. The most numerous species recorded were Bobolink and Song Sparrow. The species identified during the breeding bird survey, including others identified on that day outside of the three-minute survey intervals, were generally consistent with those species expected for the geographic area. No threatened or endangered species were identified.

The bird and bat risk assessment indicated that the potential impacts on birds and bats were anticipated to be within the range of national and eastern fatality rates from other wind projects and not biologically significant (E & E 2006a).

**Bird/Bat Mortality Study.** In addition, as part of the permitting effort for the Noble Bliss Windpark, a bird/bat mortality study was conducted to determine the magnitude of bird and bat collisions associated with the existing wind generating facility located in Wethersfield, New York (E & E 2006a). The existing Wethersfield Wind Farm is north of an adjacent to the proposed Noble Wethersfield Windpark Project Area (see Figure 3-5). The Wethersfield Wind Farm has been operational for approximately six years with 10 Vestas V47, 660-kilowatt (kw) wind turbines that are supported by steel monopole towers. The towers are aligned as two northwest-to-southeast trending strings on a high point within a grassland community surrounded by dense deciduous shrub and forest habitats. The surface elevation of the site is approximately 2,070 feet asl with a total windmill height, from ground surface to full rotor blade extension, of 290.35 feet (2,360.35 feet asl). Each tower structure is lighted in accordance with Federal Aviation Administration (FAA) guidelines. There are no guy wires associated with the turbines and there are also no locations suitable for perching or nesting by birds. Enel North America (Enel) is the owner and operator of the wind turbines and provided access to E & E to conduct this study.

Field searches were conducted at least three times per week in spring (May 9, 2005, through June 3, 2005) and from late summer to fall (August 15, 2005, through October 14, 2005). At each of the 10 wind turbines, direct visual observations were conducted within a 100-foot radius from the turbine centerline (see Figure 3-5). The search areas were further separated into survey transect lines which ran perpendicular to the tower string at 10-foot intervals. Spring searches commenced from the southernmost turbine and progressed north, while the autumn searches started from the northernmost turbine and headed south. Searches commenced near dawn and took approximately 30 to 45 minutes to slowly walk each established transect line. All carcass observations, including feathers or portions thereof, were mapped on a datasheet as to its location relative to the individual turbine. Additional information collected included the species identification of the bird or bat (to species or family if possible) and if the carcass was intact, scavenged, or feather spots. Carcasses observed were left undisturbed for use in the scavenging loss analysis.

Bird carcasses (test birds) were occasionally placed at random locations by the searchers within the study limits. Each location was mapped and entered into the field logbook as to the turbine identification, date and time of test bird placement, and the bird's orientation within the study plot. Routine searches for each test bird were incorporated with each day's carcass searches to determine when and if any test birds were scavenged, along with any identifiable scavenger evidence. The relative proportion of birds or bats that may have been removed from the study area by other wildlife (scavengers) was estimated based on the information collected.

**Spring 2005 Surveys.** Twelve surveys were conducted at the existing Wethersfield Wind Farm between May 9, 2005, and June 3, 2005, approximately one survey every other day. No dead or injured birds or bats were found during the spring study.

Weather during the spring survey period was cooler and drier than average according to data from the National Weather Service in Buffalo. There were few nights with an increased risk of collisions (e.g., nights with low cloud ceilings, rain/mist, or fog). The most notable night with conditions conducive to an increased risk of collisions was the night of May 14, 2005, when rain, fog, and favorable (southwest) winds occurred. No dead birds or bats were found on the survey the next day.

Four test birds (road- or window-killed) were placed at the site on various days to see how long they remained before being scavenged or removed. Two test birds placed in the southern portion of the wind farm (T-6) remained a minimum of six and two days before disappearing. Two test birds placed in the northern portion of the wind farm (T-2) disappeared after less than two days. Therefore, there was a greater risk of scavenging (and of missing birds) near the northern turbines than near the southern turbines. Additionally, E & E observers indicated there was more evidence (e.g., tracks, scat, and sightings) of potential scavengers near the northern turbines than near the southern turbines. Based on evidence observed, potential scavengers included coyote, fox, raccoon, deer, and crows.

The average length of stay for the test birds, taken collectively, was a minimum of two days. Therefore, the sampling schedule of every other day was consistent with the scavenging rate, and it is highly unlikely that a large mortality event (i.e., more than 10 birds/bats) was missed in spring.

**Fall 2005 Surveys.** Thirty surveys were conducted at the existing Wethersfield Wind Farm between August 15, 2005, and October 14, 2005, approximately one survey every other day. No dead or injured birds and four dead bats were found during the summer/fall study. Small bats were found dead from apparent collision with turbine blades during surveys on August 23, September 17, September 23, and October 10, 2005, (see photos on Figure 3-6). The first two bats found were identified as Little Brown Bats, a very common local species. The other two bats were similar in appearance to the Little Brown Bats but could not be conclusively identified. They are likely among the small bat species common in the area, Little Brown Bat or Eastern Pipistrelle.

All four bats were found at the two northernmost turbines (T-1 and T-2). Southward-bound migrants are likely to first encounter the northernmost turbines in this linear string. However, there is more vegetation in the area surrounding the northern turbines and possibly greater foraging potential for insects. Based on the species identification for two of the bats as Little Brown Bats, they are considered local and not migratory. It is uncertain if the two unidentified bats were migratory or local.

Weather during the survey period was warmer than average according to data from the National Weather Service in Buffalo. There were several nights with an increased risk of collisions, e.g., nights with low cloud ceilings, rain/mist, or fog. The most notable nights with conditions conducive to an increased risk of collisions were the nights of August 20; September 3, 11, 16, 22, and 24; and October 6, 11, and 13 when rain, fog, and/or favorable (north) winds occurred. No dead birds or bats were found on the surveys following these nights.

Eight test birds (road-killed) were placed at the site on various days to see how long they remained before being scavenged or removed. The four dead bats found during the mortality study were left in place and tracked as well. Among the 12 samples, the minimum number of days before disappearance ranged from 0 to 32, with an average of 6.3 days. However, besides one bat (23 days) and one placed bird (32 days), the other 10 samples all disappeared between 0 and 4 days. Consistent with the spring study results, there was a greater risk of scavenging (and of missing dead birds/bats) near the northern turbines than near the southern turbines. The averages for the minimum days before disappearance in six northern turbine samples and six southern turbine samples were 5.0 and 6.3 days, respectively.

As with any mortality study, it is possible that some dead birds and bats were missed due to scavenging uptake prior to conducting a survey. However, based on the frequency of surveys, the numbers potentially missed are considered low. It is highly unlikely that a large mortality event (i.e., more than 10 birds/bats) was missed in spring or fall.

- Extrapolated estimates of bird fatalities based on scavenger uptake and searcher efficiency could not be calculated because zero dead birds were found in spring and fall. An extrapolated estimate of bat fatalities could be calculated for fall based on scavenger uptake but not based on searcher efficiency as no test bats were searched for. The fall scavenger uptake factor for bats was 0.5, based on two of the four dead bats disappearing in less time than the search interval (2 days). Therefore, the extrapolated estimate of bat fatalities during the fall 2005 search period based on scavenger uptake is eight.

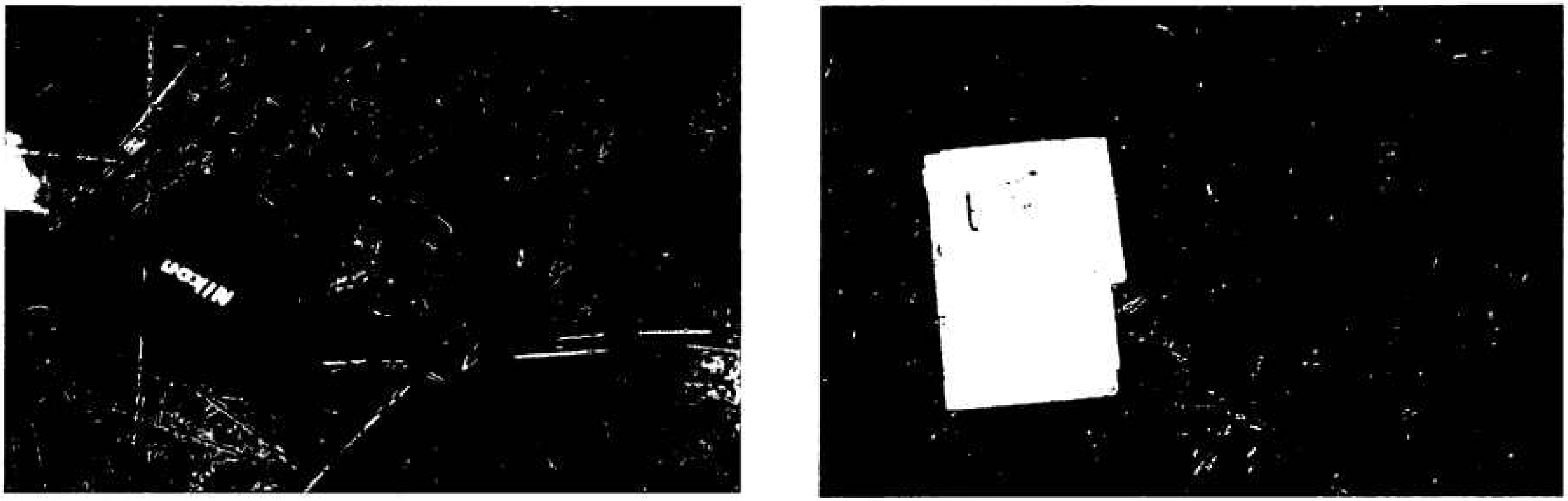
### Noble Centerville Windpark Study

Noble is considering development of a Windpark in the Town of Centerville, Allegany, New York. An Environmental Impact Statement (EIS) will be forthcoming in 2007 if development proceeds. Bird surveys were conducted at the proposed Noble Centerville Windpark in the spring and fall of 2006 (E & E 2006b; Figure 3-4). This proposed Windpark is approximately 4 miles south of the Wethersfield Project Area.

A nocturnal radar and visual study was conducted in spring and fall 2006 as part of the permitting effort for Noble Centerville Windpark. ABR conducted the study between April 16 and May 30, 2006, and between August 16 and October 14, 2006, at a site in the Town of Centerville. The mean passage rates for spring 2006 and fall 2006 were 290±35 targets/km/hr and 259±27 targets/km/hr, respectively (Mabee et al. 2006a, b). The mean flight direction in the spring was 22° and in the fall was 208 °. The mean flight altitudes for spring 2006 and fall 2006 were 351±2 meters (1,152±7 feet) agl and 350±2 meters (1,148±7 feet) agl, respectively. Approximately 16% of all nocturnal targets in spring 2006 and approximately 12% of all nocturnal targets in fall 2006 flew below 125 meters (410 feet) agl. The proportions of birds and bats observed with night-vision goggles and spotlights below an approximate altitude of 150 meters (492 feet) agl were 84% birds and 16% bats in spring 2006, and 86% birds and 14% bats in fall 2006 (Mabee et al. 2006 a, b).

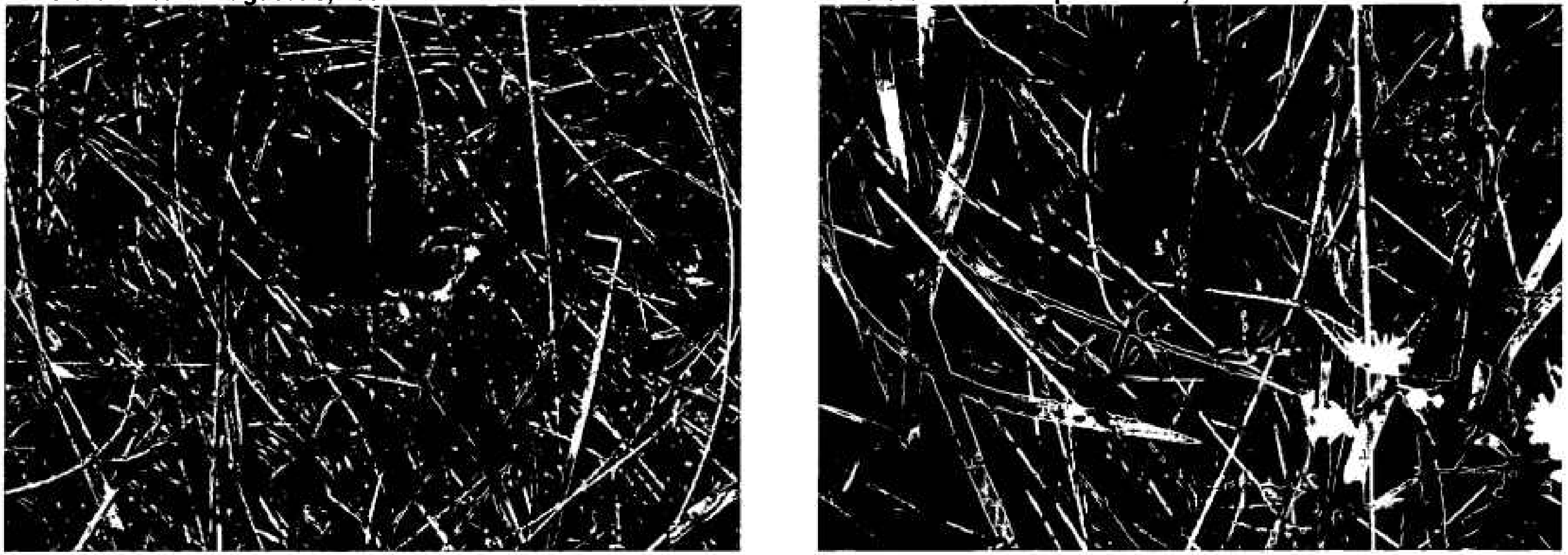
Three raptor surveys were conducted by E & E in the Centerville Project Area in April 2006 and three raptor surveys were conducted by E & E in September and October 2006. In the spring, 68 of the 73 raptors observed during raptor surveys were thought to be migrants. In the fall, 73 of the 103 birds observed were thought to be migrants. Turkey Vultures were the most prevalent species in the spring and fall.

During migratory bird surveys conducted by E & E on May 9 and 26, 2006, at 28 roadside points, a total of 1,139 birds of 85 species were recorded and the species observed were all expected based on the habitat, location, and time of year. The most numerous species recorded were Red-winged Blackbird, American Robin, American Crow, and Bobolink. There was no evidence from this survey that the Project Area served as an increased migratory corridor or stopover point for passerines or other bird species.



Little brown bat – August 23, 205

Little brown bat – September 27, 2005



Unidentified small bat – September 23, 2005

Unidentified small bat – October 10, 2005

**Figure 3-6** Dead Bats Found During Fall Mortality Study at Existing Wethersfield Wind Farm

Two breeding bird surveys were conducted by E & E at or near proposed turbine locations: 14 locations on June 6 and 13 locations on June 23, 2006. During the two breeding bird surveys, a total of 629 birds of 55 species were recorded during the two breeding bird surveys. The most numerous species recorded were Red-winged Blackbird, Bobolink, and American Crow. The species identified during these surveys were generally consistent with those species expected for the geographic area. No threatened or endangered species were identified.

## High Sheldon Wind Farm Study

Bird surveys were conducted for Invenergy Wind's (Invenergy) proposed High Sheldon Wind Farm in the Town of Sheldon, Wyoming County, New York (Figure 3-4). This proposed wind project is approximately 5 miles northwest of the Wethersfield Project Area.

A nocturnal radar study was conducted in the spring and fall of 2005 by Woodlot between April 15 and May 30, 2005, and September 1 and October 15, 2005, respectively, at a site in the Town of Sheldon. The mean passage rate for spring 2005 was 112±20 targets/km/hr and for fall 2005 was 197±24 targets/km/hr (Woodlot 2006c). The mean flight direction in the spring was 25 ° and in the fall was 213 °. The mean flight altitudes for spring was 418±45 meters (1,371±148 feet) agl and for fall was 422±12 meters (1,385±39 feet) agl. Approximately 6% of all nocturnal targets in spring and 3% of targets in fall flew below 120 meters (394 feet) agl. Woodlot (2006c) concluded that this area was not a migration corridor and that the majority of targets migrating in this area flew above the height of the proposed wind turbines.

Raptor surveys were conducted from two locations in the Project Area by Tetra Tech EC, Inc. (2006a) in the spring (April and May 2005) and in fall (August, September, and November 2005). Surveys were conducted on seven days (37 hours of observation) in spring. A total of 119 raptors of seven species were observed. The number of raptors per hour was approximately 3.2. Three state-listed species were observed: Northern Harrier (threatened), Cooper's Hawk (special concern), and Red-shouldered Hawk (special concern). In the fall, eight surveys were conducted (53.5 hours of observation). A total of 168 raptors of nine species were observed for an average of 4.1 raptors per hour. In fall, four state-listed species were observed: Northern Harrier (threatened), Northern Goshawk (special concern), Sharp-shinned Hawk (special concern), and Cooper's Hawk (special concern). Turkey Vultures were the most abundant species in the spring and fall.

Two breeding bird surveys were conducted by Tetra Tech EC, Inc. (2006a) at or near proposed turbine locations for a total of 41 survey points. A total of 1,562 birds of 55 species were observed. The total number of birds per point ranged between six and 33.5, with an overall average per point of 19.05. The average number of species per point ranged from seven to 17 with an average of 11.1. The most abundant species recorded were the Red-winged Blackbird, European Starling, American Robin, Song Sparrow, Common Grackle, and American Crow.

The more abundant species were habitat generalists, compared to the less abundant species that were observed in more specialized habitat not commonly occurring in the survey area. Listed species observed during surveys include the Northern Harrier (threatened) and Horned Lark (species of concern).

Kerlinger (2004) indicated in a bird and bat risk assessment for High Sheldon that there was little indication, from a literature search, site visits, and interviews, biologically significant impacts would result to birds from collision with the wind turbines.

### Dairy Hills Wind Farm Study

Bird surveys were conducted by WEST Inc. at Horizon Wind's (Horizon) proposed Dairy Hills Wind Farm, which is located in the Towns of Perry, Warsaw, and Covington, Wyoming County, New York, in the spring and fall of 2005 (Young et al. 2006; Figure 3-4). This proposed wind project is approximately 8 miles northeast of the Wethersfield Project Area.

A nocturnal radar study was conducted in the spring between April 15 and May 31, 2005, and fall between August 15 and October 15, 2005, at a site in the Town of Perry. The mean passage rate for spring 2005 was 117±9 targets/km/hr and for fall 2005 was 64±3 targets/km/hr. The mean flight direction in the spring was 14 ° and in the fall was 180 °. The mean flight altitudes for spring was 1,302±7 feet (397±2 meters) agl and for fall was 1,529±7 feet meters (466±2) agl. Approximately 15% of all targets in spring and 10% of targets in fall were observed at altitudes less than 410 feet (125 meters).

Raptor surveys were conducted at four points in the study area. In the spring, each point was surveyed five times for a total of 20 surveys, during which a total of 50 raptors were observed in 34 groups. In the fall, each point was surveyed four times for a total of 16 surveys. A total of 48 raptors in 24 groups were observed. In the spring and fall, Turkey Vulture was the most commonly seen raptor.

For breeding bird surveys, 30 points were established at proposed turbine locations, and were visited twice in June 2005. A total of 747 birds of 58 species were observed during the breeding bird surveys. The most abundant species recorded were the Red-winged Blackbird, American Crow, and Savannah Sparrow. Three Northern Harriers (state-threatened), Horned Lark (species of concern), and Vesper Sparrow (species of concern) were observed during surveys (Young et al. 2006).

Young et al. (2006) concluded that the Dairy Hills area was not a migration corridor for raptors, did not support large or unusual populations of resident breeding birds, and that this project would not significantly impact state-listed bird species.

## Wethersfield Wind Farm Study

In 2000, an avian assessment report was completed for the then-proposed Wethersfield Wind Farm project by ABR for Niagara Mohawk Power Corporation (Cooper and Mabee 2000). The wind farm has since been constructed and is approximately 1 mile north of the proposed Project Area. The project consists of 10 Vestas V47 660-kW turbines that are 290 feet high at the maximum extent of the blades.

ABR conducted a nocturnal radar and visual study between September 2, 1998, and October 1, 1998, and between April 20, 1999, and May 14, 1999. Daily sampling included 2 to 4 hours of nocturnal radar, 4 to 7 hours of daytime visual observations, and 0 to 2 hours of daytime radar (Cooper and Mabee 2000). Nocturnal radar mean passage rates were 168 targets/km/hr in fall 1998 and 41 targets/km/hr in spring 1999 (Cooper and Mabee 2000). Nocturnal passage rates were highly variable from night to night. The overall passage rates were very low in spring and low-to-average in fall compared with other locations in New York State where similar studies were conducted by ABR. Diurnal mean passage rates (see Table 3-4) were much lower than the nocturnal mean passage rates listed above, in both spring and fall.

**Table 3-4 Diurnal Mean Passage Rates at ABR Wethersfield Study (1998 to 1999)**

| Bird Group | Fall 1998 | Spring 1999 |
|---|---|---|
| Waterbirds | 6.9 birds per hour | 1.8 birds per hour |
| Raptors | 2.4 birds per hour | 3.6 birds per hour |
| Landbirds | 9.3 birds per hour | 12.3 birds per hour |

The mean nocturnal flight altitudes based on vertical radar sampling less than 4,921 feet (1,500 meters) agl were 154 ± 3 meters (505±10 feet) agl and 178 ± 4 meters (584±13 feet) agl in fall 1998 and spring 1999, respectively and were variable throughout the study periods (Cooper and Mabee 2000). However, since the time of the Wethersfield radar study (1998 to 1999), ABR has refined its protocol for vertical radar data collection and removal of insect interference. ABR advises to not compare altitude data from older studies, such as Wethersfield, to more recent sites because the older data is no longer reliable and is biased low. ABR indicates that passage rate and flight direction data from the older studies are still valid and comparable to recent studies. Therefore, it is more appropriate to evaluate the altitude data from the 2006 radar studies in Wethersfield (see Section 3.3.1).

The mean flight direction of targets observed on nocturnal radar was 179° in fall 1998 and 21° in spring 1999 (Cooper and Mabee 2000). This indicates that the predominant flight direction was northerly in spring and southerly in fall, which is consistent with the expected seasonal migration flight directions.

The diurnal visual surveys by ABR resulted in the identification of 31 bird species in fall 1998 and 45 species in spring 1999. Three state-listed species were identified during the diurnal visual surveys. ABR identified four Ospreys, 19 Northern Harriers, and one Peregrine Falcon in the fall and eight Ospreys and eight Northern Harriers during the spring surveys (Cooper and Mabee 2000).

Mortality surveys were also conducted by ABR at a 130-foot meteorological tower to determine collision and scavenging rates. No dead birds or bats resulting from collisions with the tower were recorded during the survey (Cooper and Mabee 2000). The lack of mortality was attributed to the small number of flights in the area and likely avoidance of the structure. Scavenging studies were conducted by placing dead birds, or chicken parts, around structures to simulate collision mortality. These areas were then surveyed on a daily basis to determine how long it took for scavengers to remove the carcass. Scavenging rates were determined to be insignificant based on the low rates of removal observed during the study.

ABR concluded that the Wethersfield study area did not exhibit the characteristics of a major migration corridor. The area was considered to be included within the broad front of migration in New York as opposed to a more concentrated migration corridor (e.g., along the Great Lakes shorelines).

### 3.2.2 Bats

#### 3.2.2.1 Regional Overview

This section discusses general bat ecology and habitat preference for bat species found in New York State. Very limited information specific to the Project Area was identified during the literature review. Nine species of bats have been identified as potentially utilizing the various landscapes found in the State of New York (see Table 3-5).

Table 3-5 Bat Species of New York, Habitat Types, and Abundance

| Common Name | Scientific Name | Average Body Size (inches) | Preferred Habitats: Summer | Preferred Habitats: Winter | Abundance |
|---|---|---|---|---|---|
| Small-footed Myotis | *Myotis leibii* | 2.9-3.2 | Hemlock stands, rock crevices, tree bark, urban structures | Regional hibernacula, rock outcropping | Uncommon; state species of special concern |
| Indiana Bat | *Myotis sodalis* | 2.9-3.9 | Exfoliating bark, cavities, dead trees in riparian corridors | Regional Hibernacula | Uncommon; federally endangered |
| Little Brown Bat | *Myotis lucifigus* | 2.4-4.0 | Tree cavities, urban structures | Regional Hibernacula | most common |
| Eastern Long-eared Bat | *Myotis septentriônalis* | 3.2-3.8 | Tree cavities, exfoliating bark, barns, eves, shingles | Regional Hibernacula | Uncommon to common |

Table 3-5 Bat Species of New York, Habitat Types, and Abundance

| Common Name | Scientific Name | Average Body Size (inches) | Preferred Habitats: Summer | Preferred Habitats: Winter | Abundance |
|---|---|---|---|---|---|
| Eastern Pipistrelle | *Pipistrellus subflavus* | 3.0-3.6 | Tree foliage, leaf litter | Regional Hibernacula | Uncommon to common |
| Eastern Red Bat | *Lasiurus borealis* | 3.6-4.6 | Dense riparian tree foliage | Migrates outside region? | Uncommon (status uncertain in New York); most common tree roosting bat |
| Hoary Bat | *Lasiurus cinereus* | 5.1-5.9 | Tree foliage | Migrates outside region? | uncommon (status uncertain) |
| Silver-haired Bat | *Lasionycteris noctivagans* | 3.6-4.6 | Tree cavities, exfoliating bark in coniferous forested stands, and rock crevices | Migrates outside region? | Uncommon (status uncertain) |
| Big Brown Bat | *Eptesicus fuscus* | 3.4-5.4 | Tree cavities, exfoliating bark, urban structures | Regional hibernacula, buildings, urban structure | Common |

Source: NYSDEC 2006c, Williams et al 2002, Curtis and Sullivan 2001.

Habitats utilized by these species include wetlands, agricultural and reverting fields, forests, and cities with a variety of micro-habitats used for foraging, roosting, and maternity roosting. Bats thrive in these various habitats as they are proficient predators of insect populations. Generally bats are solitary outside of mating, hibernation periods, and rearing of young, although some colonial roosting does occur. The most common species of bats (e.g., Little Brown Bat, Eastern Pipistrelle, Big Brown Bat, and Red Bat) have adapted to a multitude of habitat types including human-altered landscapes. As such, these species are assumed to utilize the Project Area.

The remaining bat species tend to be found only in densely forested stands and are not expected to be found regularly in the Project Area. The Indiana Bat, which is federally protected, and the Eastern Small-footed Myotis, a state species of concern, have not been identified in the Project Area and are not expected to be present. These species are habitat specialists and their preferred habitats are not present in the Project Area. General habitats for these two species are wintering hibernacula, forested riparian corridors for foraging and maternity roosts, and rocky outcroppings for daily roosting.

Specialized habitats required for bats include winter hibernacula, where bat species congregate during hibernation periods (November through March). Identified hibernacula include limestone caves, old mines, and old well shafts. Most bats require a moderated constant temperature and humidity provided by the hibernacula to survive over the winter. Measures have been taken by state and federal agencies in the last decade to protect important bat hibernacula habitats, as any disturbances during critical hibernation periods can be detrimental to large populations of bats, as well as individual bat species. Bats return in fall to established hibernacula. Some New York bats migrate relatively short distances to these locations, and some winter in small hibernacula near their summer roosting areas. Others migrate further south to warmer climates following foraging sources, where shorter periods of hibernation may occur.

Summer roosts are generally daytime or nighttime roosts, where bats will spend the entire day resting or portions of the night resting. Day roosts for New York bats can vary and include buildings, exfoliating bark, tree cavities, rock piles, and caves depending on species-specific preferences. No roosting areas were identified in the Project Area during site visits or as indicated in the literature.

No threatened or endangered bat species were specifically identified by the National Heritage Program (NHP). Although no significant bat communities were identified within the Project Area, the NHP identified one bat colony within 10 miles of the Project Area at Letchworth State Park in the Town of Portage, Livingston County (Ketcham 2005, Seoane 2006). Indiana Bats were not identified by NHP at this hibernaculum.

#### 3.2.2.2 Recent Bat Studies in Proximity to the Project Area

Several bat studies were conducted recently in proximity to the Project Area as part of the permitting process for other proposed wind energy projects. A summary of the bat study results for each proposed project is included in this section, which provides some of the only local bat data from the region outside of that collected for this Project. The general project areas for the proposed Noble Bliss Windpark, Noble Centerville Windpark, High Sheldon Wind Farm, and Dairy Hills Wind Farm, are identified on Figure 3-4.

##### Noble Bliss Windpark Study

Acoustical monitoring was conducted for the proposed Noble Bliss Windpark in the Towns of Eagle, Wyoming County, New York in the spring and fall of 2005 (E & E 2006a; Figure 3-4). This proposed Windpark is adjacent to the south of the Wethersfield Project Area. Acoustical monitoring was conducted in Bliss by Ecological Specialties, LLC using two AnaBat II bat detectors placed at different heights (50 and 100 feet) on an agricultural silo to record the unique echolocation calls of bats for 54 nights in the spring (April 20 through June 13, 2005) and 55 nights in the fall (August 15 through October 9, 2005).

A total of 9,757 bat call sequences were recorded in the spring and fall sampling periods. There were more sequences (6,032 to 3,725) detected during the spring study period of April 20 through June 13, 2005 (54 nights) than during the fall study period of August 15 through October 9, 2005 (55 nights). A greater number of calls (6,500 to 3,257) were recorded at the 100-foot detector than at the 50-foot detector. A total of 2,384 calls were unidentified and may have been attributed to noise from roosting pigeons at the site. Calls were detected most frequently between the hours of 8:00 p.m. and 2:00 a.m. Four bat species were detected, both in the spring and fall: the Red Bat (2,662 call sequences), Hoary Bat (41 sequences), Big Brown Bat (1,140 call sequences), and Little Brown Bat (3,530 call sequences). These species are found throughout New York State. The Little Brown Bat is considered to be the most common species in the state, and it was recorded with the most frequency.

### Noble Centerville Windpark Study

Acoustical monitoring was conducted at the proposed Noble Centerville Windpark in the Town of Centerville, Allegany County, New York in the spring and fall of 2006 (E & E 2006b; Figure 3-4). This proposed windpark is approximately 4 miles southeast of the Wethersfield Project Area. Acoustical monitoring was conducted by Woodlot using two AnaBat bat detectors placed on a meteorological tower to record the unique echolocation calls of bats. In spring, the two detectors were at 10 meters (33 feet) and 25 meters (82 feet) and were deployed from April 6 to June 8, 2006. In fall, the two detectors were at 15 meters (49 feet) and 30 meters (98 feet) and were deployed from July 25 to October 10, 2006.

A total of 275 bat call sequences were recorded in the spring and fall sampling periods. There were more sequences detected during the spring study period (270 call sequences in 126 detector-nights) than during the fall study period (five call sequences in 90 detector-nights). A similar number of calls were recorded at the both of the detectors in the spring and fall. A total of 110 calls in the spring and one call in the fall were unidentified due to call sequences that were too short to identify, poor call signature formation, of static interference. In the spring, most of the calls were in the myotis guild (89 call sequences). Forty-seven call sequences were classified to the big brown guild, and 24 call sequences were classified as the Red Bat/Eastern Pipistrelle guild. Three bat species were detected in the spring: the Red Bat (22 call sequences), Hoary Bat (21 sequences), and Big Brown Bat (six call sequences). In the fall, four call sequences were in the big brown guild. These species are found throughout New York State.

### High Sheldon Wind Farm Study

Acoustical monitoring was conducted prior to construction at Invenergy's proposed High Sheldon Wind Farm in the Town of Sheldon, Wyoming County, New York in the spring, summer, and fall of 2005 (Woodlot 2006c; Figure 3-4). This proposed wind project is approximately 5 miles northwest of the Wethersfield Project Area. Acoustical monitoring was conducted using two AnaBat bat detectors placed at two different heights on a meteorological tower in Sheldon to record the unique echolocation calls. In the spring, a detector was placed at 98 feet. In the summer, sampling was both passive, where one AnaBat detector was mounted on the meteorological tower, and active, where an additional AnaBat detector was carried by hand near field edges, hedgerows, roadsides, streams, and wet areas. In the fall, bat detectors were 7, 33, and 66 feet above the ground. Detectors were programmed to record from 7:00 p.m. to 7:00 a.m.

In the spring, monitoring was conducted from April 21 to May 30, 2005, for a total of 36 nights of sampling. A total of six bat call sequences were recorded in the spring sampling period, all of which were recorded by May 10. Due to the low number of calls, passage rates were not calculated. Four of the calls were from bats of the *Myotis* genus, the other two were Eastern Pipistrelle and Silver-haired Bat.

During the summer sampling period (July 13 through 15, 21 through 31 and August 1, 2005), a total of 763 bat call sequences were recorded: 133 bat call sequences were detected during passive sampling and 630 bat call sequences were detected during active sampling. Active sampling detected bats at nearly five times the rate (39 calls per hour) of passive sampling (0.8 calls per hour). Five bat species were detected in the project area, including the Big Brown Bat (587 call sequences), myotids (394 call sequences), Hoary Bat (16 call sequences), Eastern Red Bat (eight call sequences), and Silver-haired Bat (two call sequences), all of which are found throughout New York State. Twenty-seven calls could not be classified by species.

In the fall, from August 1 to October 4, 2005, 172 detector nights of sampling were conducted yielded a total of 6,007 bat call sequences. More calls were detected using the hand-held equipment (5,535 calls) that the lower (335 calls) or higher (137) passive detectors. Most of the calls (91%) were of myotids, but Big Brown Bat, Eastern Red Bat, Hoary Bat, Silver-haired Bat, and Eastern Pipistrelle were also detected. Surveys indicate that activity levels were greatest mid-August and again mid-September. No definitive determination of the presence or absence of rare bats could be made from these surveys, and, in general, myotids were the most frequently detected species (Woodlot 2006c).

### Dairy Hills Wind Farm Study

Acoustical monitoring was conducted prior to construction at Horizon's proposed Dairy Hills Wind Farm, which is located in the Towns of Perry, Warsaw, and Covington, Wyoming County, New York, in the spring (April 15 to June 2), summer (June 25 to 27, July 8 to 10, and July 23 to 25), and fall (August 16 to October 14) of 2005 (Young et al. 2006; Figure 3-4). This proposed wind project is approximately 8 miles northeast of the Wethersfield Project Area. Acoustical monitoring was conducted using AnaBat bat detectors placed at on a meteorological tower in Perry to record the unique echolocation calls. The detectors were at ground level, 82 feet (25 meters) and 164 feet (50 meters). In spring, only one detector, at ground level, was used. In the summer and fall, bat detectors were at ground level and 164 feet (50 meters) above the ground; detectors were programmed to record from 8:00 p.m. to 6:00 a.m. In the summer, a third detector was mounted at 82 feet (25 meters) and hand-held surveys were conducted.

The total number of calls in spring (one detector, 10 nights) was 27 calls, in summer (three detectors, 24 nights) was 21 calls, and in fall (two detectors, 84 nights) was 302 calls. Five species of bats were positively identified at the met tower location including Big Brown Bat, Eastern Red Bat, Hoary Bat, Myotis species, and Eastern Pipistrelle. Summer sampling with the mobile AnaBat unit recorded 1,138 calls in nine nights. The most common species based on number of call recorded were Big Brown Bat, Eastern Red Bat, and Little Brown Bat.

### 3.2.3 Threatened and Endangered Species (Birds and Bats)

Federally listed threatened and endangered plant and animal species are protected by the Endangered Species Act of 1973, which is administered by the USFWS. State-listed threatened and endangered plant and animal species are protected by the New York State Environmental Conservation Law, Article 9 and Article 11, which is administered by NYSDEC.

The USFWS and the NYSDEC NHP were consulted to determine the potential occurrence of federally and state-listed endangered and threatened species and significant natural communities and habitats within the Project Area (see EIS Appendix C).

The USFWS and NHP provided data detailing the known occurrences of threatened, endangered, and species of special concern within the Project Area. Species of special concern are wildlife species found by NYSDEC to be at risk of becoming either endangered or threatened in New York State. Species of special concern do not qualify as either endangered or threatened at this time, as defined in Part 182.2(g) and 182.2(h), and are not subject to the provisions of Part 182. Species of special concern are listed in Part 182.6(c) for informational purposes only. For more information, see Section 2.9 of the EIS.

#### 3.2.3.1 NYSDEC Natural Heritage Program

In addition to the standard analysis of project areas for potential occurrences of threatened or endangered plant and animal species, the NHP has developed specific criteria for wind power projects. NHP now reports all records of avian species occurring within a 10-mile radius of identified project areas (Ketcham 2005, Seoane 2006). Records of bat colonies and bat species of concern occurring within a 40-mile radius are also reported.

No listed bird or bat species or significant communities were identified by NHP within the Project Area. Six bird species, the Bald Eagle (*Haliaeetus leucocephalus*), Northern Harrier (*Circus cyaneus*), Short-eared Owl (*Asio flammeus*), Upland Sandpiper (*Bartramia longicauda*), Pied-billed Grebe (*Podilymbus podiceps*), and Henslow's Sparrow (*Ammodramus henslowii*), and one bat species, the Eastern Small-footed Myotis (*Myotis leibii*), were identified by NHP within, or slightly beyond, 10 miles of the Project Area (Ketchum 2005, Seoane 2006). Short-eared Owl is considered an endangered species within New York State while Bald Eagle, Northern Harrier, Upland Sandpiper, Pied-billed Grebe, and Henslow's Sparrow are considered threatened species within New York State. The Eastern Small-footed Myotis is considered a species of special concern.

According to NHP, a Bald Eagle nest has been located along the Genesee River in the Town of Mount Morris, Livingston County approximately 12 miles east of the Project Area. Northern Harrier has been observed in the Towns of Portage, Mount Morris, and Nunda in Livingston County along River Road, approximately 10 to 15 miles away and in the Town of Middlebury on Bank Road 5 miles northeast in Wyoming County. Short-eared Owl has been observed in the Town of Hume, Allegany County, approximately 5 miles from the Project Area and in the Towns of Sheldon and Warsaw in Wyoming County, approximately 7 and 6 miles, respectively, from the Project Area. Upland Sandpiper has been observed in the Town of Centerville, Allegany County, approximately 5 miles from the Project Area; in the Town of Sheldon, Wyoming County, approximately 4 miles from the Project Area; in the Town of Orangeville, Wyoming County, approximately 2 miles from the Project Area; and in the Towns of Portage, Mount Morris, and Nunda, approximately 10 to 15 miles away. Pied-billed Grebe has been observed at the Route 39 pond in the Town of Pike, Wyoming County, approximately 2 miles from the Project Area. Henslow's Sparrow has been observed in the Town of Attica, approximately 5 miles north and in the Town of Middlebury on Bank Road five miles northeast, both in Wyoming County. They have also been observed in Livingston County near the Towns of Portage, Mount Morris, and Nunda, approximately 10 to 15 miles away. Eastern Small-footed Myotis occurs at a tunnel in Letchworth State Park in the Town of Portage, Livingston County, approximately eight miles from the Project Area.

Dates and seasonal occurrence were not provided in the 2005 or 2006 NHP letters. The occurrence of these bird species in the vicinity of the Project Area and their habitat requirements are described in more detail in Table 3-12 and Section 4.3.3.

Although no significant communities were identified within the Project Area, NHP identified one bat hibernaculum within 40 miles of the Project Area (Ketcham 2005, Seoane 2006). The hibernaculum is located approximately 8 miles from the Project Area at a tunnel in Letchworth State Park in the Town of Portage, Livingston County. No threatened or endangered bat species were specifically identified by NHP as associated with this hibernaculum. NHP identified the Little Brown Bat, Big Brown Bat, Eastern Long-eared Bat, Eastern Pipistrelle, and Eastern Small-footed Myotis at this hibernaculum.

#### 3.2.3.2 USFWS

According to the USFWS, except for transient individuals, no federally listed or proposed endangered or threatened animal species are known to occur in the Wethersfield Project Area (Stilwell 2005, Stilwell 2006). In addition, no federally designated or proposed "critical habitat" exists within the Project Area. The USFWS has expressed concern pertaining to the potential for wind projects, in general, to impact migratory birds and threatened or endangered bat species (such as the Indiana Bat [*Myotis sodalis*]). An assessment of potential impacts to birds and bats is provided in Section 4 of this report.

## 3.3 Field Studies

### 3.3.1 Nocturnal Radar and Visual Study

ABR conducted a nocturnal radar and visual study between April 16 and May 30, 2006, and between August 16 and October 14, 2006, to analyze the nocturnal migration of birds and bats over the Project Area. The results of the study, including nocturnal radar passage rates, flight altitude, flight direction, weather influence, turbine passage, and visual findings, are summarized in this section. Refer to ABR's reports in Appendices A and B for full details.

#### Passage Rates

Nocturnal radar observations indicate that passage rates in spring 2006 were 324 ± 27 targets/km/hr. Nocturnal passage rates were highly variable from night to night, ranging from 41 to 907 targets/km/hr (see Figure 6b in Appendix A). Passage rates had some variation throughout the night and the lowest mean rates occurred during the first hour after sunset (see Figure 7c,d in Appendix A).

Nocturnal radar observations indicate that passage rates in fall 2006 were 256 ± 20 targets/km/hr. Nocturnal passage rates were variable from night to night, ranging from 31 to 701 targets/km/hr (see Figure 6b in Appendix B). Passage rates had some variation throughout the night and the lowest rates occurred during the first hour of sampling (between crepuscular and nocturnal hours) and near sunrise; whereas the highest rates occurred near the third or fourth hour of sampling (see Figures 7d, e, and f in Appendix B).

The overall mean passage rates in spring and fall were above average, but well within the range of historical results from similar radar studies in the northeast (see Tables 3-6 and 3-7). The spring 2006 passage rate was above average compared to these other studies and was higher than the radar studies conducted in the same county (Wyoming County) in 1999 and 2005 (see Table 3-6). The fall 2006 passage rate was high compared to these other studies and was higher than the three radar studies conducted in the same county: one in 1998 and two in 2005.

#### Flight Altitude

The mean nocturnal flight altitude based on vertical radar sampling less than 4,921 feet (1,500 meters) agl in spring 2006 was 1,165±7 feet (355 ± 2 meters() agl, with a range among nights of 318 to 1,801 feet (97 to 549 meters) agl. The mean nocturnal flight altitude based on vertical radar sampling less than 4,921 feet (1,500 meters) agl in fall 2006 was 1,129±3 feet (344 ± 1) meters agl, with a range among nights of 725 to 1,873 feet (221 to 571 meters) agl. The spring and fall results are very similar, and they are consistent with similar radar studies conducted in the northeast (see Tables 3-6 and 3-7) and existing literature regarding the flight of nocturnal migrants (Kerlinger 1989; Mabee et al. 2006a, b;

## Table 3-6 Comparison of Spring Mean Passage Rates, Mean Flight Altitudes, Average Flight Directions, and Percentage of Targets at Altitudes Less than 410 Feet (125 Meters)

| Location | Year | Mean Passage Rate[1] (Targets/ km/hr) | Mean Flight Altitude (Meters agl [feet]) | Average Flight Direction (Degrees) | Percentage of Targets at Altitudes <125 Meters | Reference |
|---|---|---|---|---|---|---|
| Wethersfield, Wyoming Co., NY | 1999 | 41 | -[2] | 21 | -[2] | Cooper and Mabee 2000 |
| Western Maine | 1994 | 99 | - | - | - | Northrop, Devine, and Tarbell, Inc. 1995 in Woodlot 2006c |
| Ellenburg, Clinton Co., NY | 2005 | 110 ± 19 | 338 ± 3 (1,109 ± 10) | 30 | 20 | Mabee et al. 2006 |
| Perry, Wyoming Co., NY | 2005 | 117 ± 9 | 397 ± 2 (1,302 ± 7) | 14 | 15 | Young et al. 2006 |
| Carthage, Jefferson Co., NY | 1994 | 159 | -[2] | NA | -[2] | Cooper et al. 1995 in Cooper et al. 2004a |
| Prattsburgh-Italy, Steuben Co., NY | 2005 | 170 + 35 | 319 + 2 (1,047 + 7) | 18 | 18 | Mabee et al. 2005c |
| Clinton, Clinton Co., NY | 2005 | 254 ± 45 | 422 ± 54 (1,385 ± 177) | 40 | 11 | Woodlot 2006h |
| Prattsburgh, Steuben Co., NY | 2006 | 277±52 | 370±41 (1,214±135) | 22 | 16 | Woodlot 2005h |
| Centerville, Allegany Co., NY | 2006 | 290 ± 35 | 351 ± 2 (1,152 ± 7 | 22 | 16 | Mabee et al. 2006a |
| **Wethersfield, Wyoming Co., NY** | **2006** | **324 ± 27** | **355 ± 2 (1,165 ± 7)** | **12** | **19** | **Mabee et al. 2006a** |
| Chateaugay, Franklin Co., NY | 2006 | 360 ± 37 | 409 ± 26 (1,342 ± 85) | 48 | 18[3] | Woodlot 2006d |
| Cohocton, Steuben Co., NY | 2005 | 371 | 609 (1,198) | 28 | 12 | Woodlot 2006d |
| Westfield, Chautauqua Co., NY | 2003 | 395 ± 69 | 528 ± 3 (1,732 ± 10) | 29 | 4 | Cooper et al. 2004a |
| Searsburg, Bennington Co., VT | 2005 | 404 | 523 (1,716) | 69 | 4 | Woodlot 2005b in Woodlot 2006d |
| Jordanville, Herkimer Co., NY | 2005 | 409 | 371 (1,217) | 40 | 21 | Woodlot 2006d |

## Table 3-6 Comparison of Spring Mean Passage Rates, Mean Flight Altitudes, Average Flight Directions, and Percentage of Targets at Altitudes Less than 410 Feet (125 Meters)

| Location | Year | Mean Passage Rate[1] (Targets/ km/hr) | Mean Flight Altitude (Meters agl [feet]) | Average Flight Direction (Degrees) | Percentage of Targets at Altitudes <125 Meters | Reference |
|---|---|---|---|---|---|---|
| Howard, Steuben Co., NY | 2006 | 440 ± 68 | 426 ± 24 (1,398 ± 79) | 27 | 13 | Woodlot 2006e |
| Franklin, Pendleton Co., WV | 2005 | 457 | 492 (1,614) | 53 | 11 | Woodlot 2006d |
| Cape Vincent, Jefferson Co., NY | 1995 | 473 | -[2] | 18 | -[2] | Cooper et al. 1995 in Kerlinger and Guarnaccia 2006 |
| Fairfield, Herkimer Co., NY | 2005 | 509 | 419 (1,375) | 44 | 20 | Woodlot 2006d |

[1] There are a number of factors that can influence the mean passage rate including: weather, sampling methodology, equipment, study duration, site location, experience of firm/staff, etc. Therefore, this summary is intended to show a general comparison of passage rates of radar studies conducted in the northeast and it should not be used as a direct comparison between listed sites without additional evaluation.

[2] ABR does not believe it is appropriate to compare flight altitudes with studies conducted before 2001 because of different equipment that probably resulted in a low altitude bias (Mabee et al. 2006A).

[3] <120 meters (394 feet)

Key:

NA = Not available.

## Table 3-7 Comparison of Fall Mean Passage Rates, Mean Flight Altitudes, Average Flight Directions, and Percentage of Targets at Altitudes Less than 410 Feet (125 Meters)

| Location | Year | Mean Passage Rate[1] (Targets/ km/hr) | Mean Flight Altitude (Meters [Feet] agl) | Average Flight Direction (Degrees) | Percentage of Targets at Altitudes <125 Meters | Reference |
|---|---|---|---|---|---|---|
| Perry, Wyoming Co., NY | 2005 | 64 ± 3 | 466 ± 2 (1,529 ± 7) | 180 | 10 | Young et al. 2006 |
| Sheffield, Caledonia Co., VT | 2004 | 114 | 566 (1,857) | 200 | 1 | Woodlot 2006g in Woodlot 2006f |
| Harrisburg, Jefferson Co., NY | 1998 | 122 | -[2] | 181 | -[2] | Cooper and Mabee 2000 |
| Clinton, Clinton Co., NY | 2005 | 152 ± 16 | 438 ± 15 (1,437 ± 49) | 193 | 5* | Woodlot 2006i |
| Flat Rock Wind Power, Lewis Co., NY | 2004 | 158 | 415 (1,362) | 184 | 8 | Mabee et al. 2005a |
| Wethersfield, Wyoming Co., NY | 1998 | 168 | -[2] | 179 | -[2] | Cooper and Mabee 2000 |
| Casselman, Somerset, Co., PA | 2004 | 174 | 448 (1,470) | 219 | 7 | Plissner et al. 2005 in Young et al. 2006 |
| Searsburg, Bennington Co., VT | 2004 | 178 | 556 (1,824) | 203 | 4 | Roy and Pelletier 2005 in Young et al. 2006 |
| Martindale, Lancaster, Co., PA | 2004 | 187 | 436 (1,430) | 188 | 8 | Plissner et al. 2005 in Young et al. 2006 |
| Prattsburgh, Steuben Co., NY | 2004 | 193 ± 21 | 516±17 (1,692±148) | 188 | 2.6 | Woodlot 2005f |
| Sheldon, Wyoming Co., NY | 2005 | 197 ± 24 | 422 ± 12 (1,385 ± 39) | 213 | 3[3] | Woodlot 2006c |
| Ellenburg, Clinton Co., NY | 2005 | 197 ± 37 | 333 ± 1 (1,093 ± 3 | 162 | 12 | Mabee et al 2006 |
| Prattsburgh-Italy, Steuben Co., NY | 2004 | 200 ± 12 | 365 ± 3 (1,198 ± 10) | 177 | 9 | Mabee et al. 2005b |
| Carthage, Jefferson Co., NY | 1995 | 225 | -[2] | NA | -[2] | Cooper et al. 1995 in Cooper et al. 2004a |

## Table 3-7 Comparison of Fall Mean Passage Rates, Mean Flight Altitudes, Average Flight Directions, and Percentage of Targets at Altitudes Less than 410 Feet (125 Meters)

| Location | Year | Mean Passage Rate[1] (Targets/ km/hr) | Mean Flight Altitude (Meters [Feet] agl) | Average Flight Direction (Degrees) | Percentage of Targets at Altitudes <125 Meters | Reference |
|---|---|---|---|---|---|---|
| Franklin, Pendleton Co., WV | 2004 | 229 | 583 (1,913) | 175 | 8 | Woodlot 2004 in Woodlot 2006f |
| Westfield, Chautauqua Co., NY | 2003 | 238 ± 48 | 532 ± 3<br>(1,745 ± 10) | 199 | 4 | Cooper et al. 2004a |
| Mount Storm, Grant Co., WV | 2003 | 241 | -[2] | 184 | -[2] | Cooper et al. 2004b in Mabee et al. 2006b |
| **Wethersfield, Wyoming Co., NY** | **2006** | **256 ± 20** | **344 ± 1<br>(1,129 ± 3)** | **203** | **11** | **Mabee et al. 2006b** |
| Centerville, Allegany Co., NY | 2006 | 259 ± 27 | 350 ± 2<br>(1,148 ± 7) | 208 | 12 | Mabee et al. 2006b |
| Jordanville, Herkimer Co., NY | 2005 | 380 | 440 (1,444) | 208 | 6 | Woodlot 2005d in Woodlot 2006f |
| Howard, Steuben Co., NY | 2005 | 481 ± 52 | 491 ± 14<br>(1,611 ± 46) | 185 | 2[4] | Woodlot 2005a |
| Mars Hill, Aroostook Co., ME | 2005 | 512 | 424 (1,391) | 228 | 8[3] | Woodlot 2005e in Woodlot 2006f |
| Western Maine | 1994 | 551 | NA | NA | NA | Northrop, Devine, and Tarbell, Inc. 1995 in Woodlot 2006c |
| Chateaugay, Franklin Co., NY | 2006 | 643 ± 63 | 431 ± 17<br>(1,414 ± 56) | 212 | 8[3] | Woodlot 2006f |
| Fairfield, Herkimer Co., NY | 2005 | 691 | 516 (1,693) | 198 | 4 | Woodlot 2005c in Woodlot 2006f |

[1] There are a number of factors that can influence the mean passage rate including: weather, sampling methodology, equipment, study duration, site location, experience of firm/staff, etc. Therefore, this summary is intended to show a general comparison of passage rates of radar studies conducted in the northeast and it should not be used as a direct comparison between listed sites without additional evaluation.

[2] ABR does not believe it is appropriate to compare flight altitudes with studies conducted before 2001 because of different equipment that probably resulted in a low altitude bias (Mabee et al. 2006a).

[3] <120 meters (394 feet).

[4] <91 meters (299 feet).

Key:

NA = Not available.

Smithsonian Migratory Center 2006). Mean flight altitudes were variable throughout the study periods (see Figure 8b in Appendices A and B). There was no significant pattern as to the timing of the lowest altitudes (see Figure 9c and d in Appendix A and 9d, e, and f in Appendix B). Approximately 19% of all nocturnal targets in spring 2006 and approximately 11% of all nocturnal targets in fall 2006 flew below 410 feet (125 meters) agl, a close approximation to the maximum turbine height.

These percentages are consistent with similar radar studies conducted in the northeast United States.

The mean flight altitude in the spring was 775.9 feet (236.5 meters) higher than the maximum turbine height (388.8 feet [118.5 meters]) but in general, was in the middle of the range of mean flight altitudes from other studies (see Table 3-6). In the fall, the mean flight altitude was 739.8 feet (225.5 meters) higher than the maximum turbine height but slightly lower than at the other locations in the east where similar studies have been conducted (see Table 3-7). In both spring and fall, the majority of migration occurred well above the height of the proposed turbines.

### Flight Direction

The mean flight direction of targets observed on radar was 22° in spring (mean vector length = 0.59; median = 19°; n = 14,524 targets) and 203° in fall (mean vector length = 0.32; median = 205°; n = 16,470 targets). This indicates that the predominant flight direction was northerly in spring and southerly in fall, which is consistent with the expected seasonal migration flight directions. See Figure 5b in Appendices A and B for compass rose figures showing the flight directions of targets.

### Weather Influence

The ABR study examined the influence of various weather conditions on the results for passage rates and flight altitudes using statistical methods. ABR investigated the importance of a number of parameters including weather (i.e., wind direction, wind speed, ceiling height [including fog], daily barometric pressure change, synoptic weather [days since favorable migration—passage rate models only]), lunar illumination, and date on both the passage rates and flight altitudes of nocturnal migrants. This was done by building a series of models using combinations of the various weather variables and date, and then using a model-selection technique to quantify the statistical strength of those models. Refer to Appendices A and B for a discussion of the methodology.

In spring, passage rates decreased when there was fog, low ceiling heights (<1,640 feet [500 meters] agl), and with increasing barometric pressure. In fall, passage rates increased with tailwinds, calm conditions, and during eastern crosswinds. Flight altitudes were not strongly associated with any of the parameters, indicating no strong patterns for flight altitudes in spring. In fall, flight altitudes increased when a high pressure system entered the area creating favorable winds and when ceiling height was less than or equal to 1,640 feet (500 meters) agl. Flight altitudes decreased when birds were north or west of a cold front and when wind speeds increased.

## Turbine Passage

The ABR study estimated the turbine passage rate (i.e., the rate of migrants passing within the area occupied by each turbine) for bird/bat migrants in both seasons under existing conditions (i.e., without turbines). The turbine passage rate takes into account the (1) number of targets flying less than 410 feet (125 meters) agl; (2) turbine area that migrants would encounter when approaching turbines from the side or from the front; (3) number of nights during the migration period; and (4) number of hours of migration/night, which is number of nocturnal hours (see Appendices A and B for the methodology and assumptions). Passage rates are an index of the number of migrants flying past a given location. This rate can be used to assess the relative bird/bat use an area and make comparisons to other sites. This rate does not take into account avoidance behaviors; thus, it is a conservative value. Further, there is not a proven connection between increased abundance during preconstruction studies and fatality rates following construction.

The turbine passage rate in spring was estimated at 3.3 to 22.9 migrants per/turbine per day. In fall, the turbine passage rate was estimated at 2.1 to 14.3 migrants per turbine per day. The turbine passage rate in Wethersfield was slightly higher than the few other studies conducted by ABR where an estimated passage rate was developed. The turbine passage rate in spring during a study at Prattsburgh-Italy, New York, was 1.7 to 12.1 migrants/turbine/day (Mabee et al. 2005c). The turbine passage rates in fall at the proposed Flat Rock project was 0.7 to 4.6 migrants/turbine/day (Mabee et al. 2005a), at Prattsburgh-Italy was 1.1 to 8.0 migrants/turbine/day (Mabee et al. 2005b), and at Ellenburg, New York was 1.6 to 11.1 migrants/turbine/day (Mabee et al. 2006). Other nocturnal radar studies reviewed do not provide this metric.

## Nighttime Visual Study

Based on visual sampling to an approximate altitude of 492 feet (150 meters) agl with night-vision goggles and spotlights, a total of 356 birds and 80 bats were observed in the spring and 758 birds and 87 bats in the fall. From these totals, the proportions of birds and bats below 492 feet (150 meters) agl were:

- Eighty-two percent birds and 18% bats in spring 2006; and
- Ninety percent birds and 10% bats in fall 2006.

Due to the extreme difficulty in the speciation of bats through nocturnal visual surveys, bat targets that could be identified were categorizes as small or large bats, allowing the surveyor to discriminate the larger (approximately greater than 2 inches) bats (e.g., Hoary, Eastern Red, Big Brown and Silver-haired bats) from the smaller (approximately less than 2 inches) bats (e.g., *Myotis* sp.) of the region.

Nightly visual rates for bats (the number of bat targets observed per hour) was less variable compared to bird target rates during spring and fall observation. Overall, fewer bats (80 in spring and 87 in fall for a total of 167) were identified in comparison to bird targets (356 in spring and 758 in fall for a total of 1,114) during visual observations in spring and fall 2006. Although a similar number of bats were observed during spring (80 bats) and fall surveys (87 bats), nearly twice as many birds were observed in the fall (758 birds) compared to the spring (356 birds). Small bats dominated the two survey periods, as 52 of 80 bats in spring and 56 of 87 bats in fall were identified as small bats, with lesser numbers of large bats and unidentified bats. See Table 6 in Appendix A and Table 8 in Appendix B for more details.

## 3.3.2 Migratory Raptor Surveys

### 3.3.2.1 Spring Raptor Surveys

Spring migratory raptor surveys were conducted on April 22, 27, and 29, 2005, for a total of 21 survey hours. Migrants were determined as those raptors with a non-southerly flight path. Locally foraging raptors were also counted but not included in the migrant totals. Weather conditions on the survey days were generally favorable for raptor migration with south winds, only brief precipitation, and below average to average temperatures.

A total of five raptors of three species were identified during spring 2005 raptor surveys, two of which were considered to be migrants (see Table 3-8). The migratory passage rate was 0.1 raptors per hour. For comparison, at the Hamburg Hawk Watch in Hamburg, New York over two of the three survey days (surveys were not conducted in Hamburg on one of the days), 346 raptors were tallied with a passage rate of 29.5 raptors/hour. The findings are consistent with the knowledge of spring raptor migration in New York State, as the birds concentrate in higher numbers along the Great Lakes and are relatively diffuse elsewhere. There is no evidence of a pronounced spring migratory raptor corridor in the Project Area. Spring surveys were not conducted in 2006.

**Table 3-8 Spring Raptor Survey Results**

| | Species | 4/22/05 | 4/27/05 | 4/29/05 | Grand Total |
|---|---|---|---|---|---|
| Local | Turkey Vulture | 0 | 0 | 1 | 1 |
| | Red-tailed Hawk | 2 | 0 | 0 | 2 |
| **Total Locals** | | **2** | **0** | **1** | **3** |
| Migrant | Red-tailed Hawk | 0 | 1 | 0 | 1 |
| | Rough-legged Hawk | 0 | 1 | 0 | 1 |
| **Total Migrants** | | **0** | **2** | **0** | **2** |
| | **Grand Total** | **2** | **2** | **1** | **5** |

### 3.3.2.2 Fall Raptor Surveys

Fall migratory raptor surveys were conducted by Noble on September 13, 15, and 18, 2005, for a total of 21 survey hours. Migrants were determined as those raptors with a non-northerly flight path. Locally foraging raptors were also counted but not included in the migrant totals. Weather conditions on the survey days were generally favorable for fall raptor migration with northerly winds, no precipitation, and average to above average temperatures. No raptors were observed during the three surveys conducted.

Raptor surveys were also conducted by E & E on September 21 and 29 and November 1, 2006, using the same methodology as the fall 2005 surveys. Weather conditions on the survey days were generally favorable for fall raptor migration with northerly winds on two days and mild southwest winds on one day, only brief precipitation, below average to average temperatures, and following cold front passages.

During Project surveys in fall 2006, E & E observed a total of 231 raptors including 203 migrants and 28 local raptors of 11 species (see Table 3-9). The migratory passage rate was 9.7 raptors/hour. A hawk watch is not conducted at the Hamburg site or other regional hawk watches in the fall; therefore, no comparison could be made for the fall. No concentrated flight paths were identified. Turkey Vultures and Red-tailed Hawks were the most prevalent raptor species seen. Many of the Turkey Vultures identified were likely local birds exhibiting back and forth foraging flights; however, all birds observing flying in a non-northerly direction were considered potential migrants. Approximately 27% of the migratory raptors flew below 400 feet agl at some point during observation. The primary flight direction of migratory raptors was due south and no concentrated flight paths were identified.

**Table 3-9 Fall Raptor Survey Results**

| | Species | 9/21/06 | 9/29/06 | 11/1/06 | Grand Total |
|---|---|---|---|---|---|
| Local | Turkey Vulture | 3 | 5 | 0 | 8 |
| | Red-tailed Hawk | 1 | 4 | 4 | 9 |
| | Northern Harrier | 2 | 1 | 2 | 5 |
| | Sharp-shinned Hawk | 1 | 0 | 0 | 1 |
| | Unidentified Accipiter | 0 | 1 | 0 | 1 |
| | Unidentified Eagle | 1 | 0 | 0 | 1 |
| | American Kestrel | 1 | 1 | 1 | 3 |
| **Total Locals** | | **9** | **12** | **7** | **28** |
| Migrant | Turkey Vulture | 55 | 94 | 12 | 161 |
| | Osprey | 2 | 1 | 0 | 3 |
| | Northern Harrier | 0 | 0 | 1 | 1 |
| | Cooper's Hawk | 3 | 1 | 0 | 4 |
| | Red-shouldered Hawk | 0 | 0 | 1 | 1 |
| | Broad-winged Hawk | 7 | 0 | 0 | 7 |

**Table 3-9 Fall Raptor Survey Results**

| | Species | 9/21/06 | 9/29/06 | 11/1/06 | Grand Total |
|---|---|---|---|---|---|
| | Red-tailed Hawk | 10 | 6 | 1 | 17 |
| | Rough-legged Hawk | 0 | 0 | 1 | 1 |
| | Unidentified Buteo | 1 | 2 | 0 | 3 |
| | American Kestrel | 4 | 0 | 0 | 4 |
| | Merlin | 0 | 1 | 0 | 1 |
| **Total Migrants** | | **82** | **105** | **16** | **203** |
| | **Grand Total** | **91** | **117** | **23** | **231** |

The findings are consistent with the knowledge of fall raptor migration in the region, as raptors do not concentrate in large numbers and movements are relatively diffuse. There is no evidence of a pronounced fall migratory raptor corridor in the Project Area.

### 3.3.3 Spring Migratory Surveys

A total of 1,291 birds of 67 species was recorded during migratory bird surveys conducted at 24 points on May 10 and 17, 2006 (see Appendix F, Table F-1 for totals and F-2 for each survey). Total species identified decreased from 61 species on May 10 to 47 species on May 17, likely attributed to occasional occurrences of light rain on May 17. The averages for total birds and species per survey location are indicated in Table 3-10.

**Table 3-10 Spring Migratory Survey Results**

| | May 10 | May 17 |
|---|---|---|
| Total Species on Survey | 61 | 47 |
| Average Total Birds per Location | 28.3 | 25.5 |
| Average Number of Species per Location | 12.4 | 10.3 |

The most numerous species recorded were Red-winged Blackbird (256 birds), American Crow (133 birds), and Bobolink (116 birds). The species observed were generally expected based on the habitat, location, and time of year.

The total number of birds per point ranged between eight and 52 birds, with an overall average of 26.9 birds per point. Points E, K, and M had the highest number of birds with averages over 39 birds and points P, V, and X held the lowest number of total birds with averages under 14 birds.

The species richness per point ranged between six and 21 species, with an overall average of 11.4 species per point. Survey points A, E, H, and M had more than 16 species, while survey points K, Q, V, and W had fewer than eight species.

The survey points with the highest number of birds and species richness, generally, have a mix of habitats. The survey points with the lowest number of birds and species richness, generally, were without a mix of habitats and/or had poor lines-of-sight.

Most of the birds tallied during the spring migratory survey were likely local breeders rather than migrants, as most species identified were within their population breeding range. There was no evidence from the surveys or other time spent in the Project Area during the spring season that the Project Area serves as an increased migratory corridor or stopover point for passerines or other bird species.

### 3.3.4 Breeding Bird Surveys

Three-minute breeding bird surveys were conducted in 2006 at 14 points on June 5 (points A through C and E through O) and June 22 (points A through G and I through O; see Figure 2-1). A total of 408 birds of 54 species were identified during the two surveys (see Appendix F, Table F-3 for totals and F-4 for each survey). Forty-eight species were identified on the June 5, 2006, survey for a total of 215 birds. Forty-two species and a total of 193 birds were identified on the June 22, 2006 survey. The most numerous species recorded were Bobolink (48 birds), Red-winged Blackbird (37 birds), and Song Sparrow (36 birds).

Total birds per point ranged from three to 32 birds, with averages of 15.4 birds on June 5 and 13.8 birds on June 22. Total species per survey location ranged from two to 15 species, with averages of 9.0 species on June 5 and 6.4 species on June 22. Survey points D, H, and N averaged (for the two survey days) less than 10 birds per location and low species diversity (less than four species per location); whereas points I, G, and K averaged greater than 18 birds and relatively higher species diversity (six or more species per location).

The species composition was generally consistent with what was anticipated for the habitat and location and was generally consistent with those species regularly found in or near Wyoming County during the New York State Breeding Bird Atlas (2000 through 2005) and USGS breeding bird surveys. There is a high diversity of breeding bird species in the area. The survey points are generally in locations (i.e., agriculture fields, open fields) that typically have decreased diversity as compared with forested or edge habitats. No threatened or endangered species were identified during E & E breeding bird surveys.

### 3.3.5 Bat Habitat Surveys

Habitat surveys of the Project Area were conducted during various field efforts throughout spring, summer, and fall 2006. Surveys identified no major rock outcroppings, cave dwellings, or hibernacula where bats may roost within the Project Area. Based on the mosaic of habitat types found throughout the Project Area, suitable habitat was identified for the most common bat species that would be expected to occur in the Project Area. The acoustical monitoring surveys (see Section 3.3.6) confirmed their presence in the Project Area.

In order to determine the potential for state- and federally endangered Indiana Bats to occur in the Project Area, the suitability of the Project Area to support the Indiana Bat was evaluated. Although bat species are found in many environments throughout New York State, the Indiana Bat has very specific habitat requirements, and the range of the Indiana Bat in New York State is primarily in the eastern part of the state. No known Indiana Bat hibernacula were documented by NYSDEC or USFWS within 40 miles of the Project Area (Seoane 2006; Stilwell 2006).

Specific habitats targeted as potentially indicative of Indiana Bat habitat include well developed riparian corridors along streams and mature timber stands containing larger trees generally with exfoliating bark or cavities (Menzel et al. 2001). These bats react well to habitat disturbances and are known to forage in non-riparian woodlands and open farmlands (USDI FWS 1999).

Summer maternity habitats for Indiana Bats require dead/dying, large diameter trees, with exfoliating bark or cavities, located in upland forests, exposed to direct sunlight. Generally, Indiana Bat habitat requires streams/riparian areas (or some water source) harboring forage material. Dominant preferred tree species that provide suitable habitat for the Indiana Bat include Hickory (*Carya* spp.), Elm (*Ulmus* spp.), Oaks (*Quercus* spp.), and Cottonwood (*Populus deltoides*). Other tree species have been documented as "acceptable" tree habitat; however, these trees require very specific conditions to attract Indiana Bats. These secondary "acceptable" choices of tree species include common trees where size, the presence of cavities, exfoliating bark, or dead "snag" portions occurs. This flexibility in tree use suggests that preference may not be determined by tree species; so much as it may be the condition of the potential roost site (Menzel et al. 2001).

Female Indiana Bats spend a majority of the summer in breeding nurseries, generally located around water resources (i.e., streams, ponds, and wetlands). Male Indiana Bats spend most of their time foraging in close proximity to hibernacula and along watercourses, locating preferred food sources of flying insects. In late summer and early fall (late May through November), these bats begin to move back to wintering hibernacula. Surveys in 2003-2004 in New York State found Indiana Bats that were radio-tagged in regional wintering hibernacula were later found rearing young in breeding colonies along the southern portion of the Lake Champlain floodplain (NYSDEC 2003). The closest known Indiana Bat hibernacula to the Project Area are located in Onondaga and Jefferson counties. Figure 3-7 identifies six known counties that (Albany, Essex, Warren, Jefferson, Onondaga and Ulster counties) that Indiana Bat hibernacula have been located by NYSDEC and shows their proximity to the Project Area (NYSDEC 2003, NYNHP 2006). Outside of New York, there are also known Indiana Bat hibernacula that are located in central and southern Pennsylvania, which are farther away than Onondaga County, New York.

No suitable hibernacula were identified within the Project Area, nor were any areas found meeting the specific summer roost and maternity roost habitats, for the state- and federally endangered Indiana Bat. The Project Area does not contain significant timber stands of the necessary age or species composition to provide suitable habitat for this species. Silvicultural and agricultural practices have eliminated contiguous tracts of mature timber (with cavities and exfoliating bark). These current land use practices coupled with the lack of defined water courses largely eliminates the potential for suitable habitat to exist within the Project Area. Based on the known locations of Indiana Bat hibernacula and the distance that separates the hibernacula from the Project Area, migration through the Project Area is unlikely.

### 3.3.6 Acoustical Monitoring for Bats

Woodlot conducted an acoustical monitoring study in the spring and fall of 2006. The results of their study, including mean detection rate, species composition, and the relationship of the number of call sequences to weather variables, are summarized in this section. The reports prepared by Woodlot are in Appendices C and D.

#### 3.3.6.1 Spring 2006 Study

Two detectors were deployed at different heights in a met tower in the Project Area from the night of April 6 to the night of June 7, 2006, yielding a total of 126 detector-nights of recordings (63 nights with two detectors). The met tower was located in an open agricultural field with some nearby woodlands (see Figure 2-1). A total of 192 bat call sequences were recorded during the spring sampling. The mean detection rate of all detectors was 1.5 call sequences per detector-night. More than twice as many call sequences were recorded by the lower detector (132 call sequences), which was 10 meters (33 feet) above the ground, than by the upper detector (60 call sequences), which was 21 meters (69 feet) above the ground. The number of call sequences varied considerably from night to night. In general, the most calls were recorded over a few nights in late April to early May and over a few nights between late May to early June (see Figure 6 in Appendix C). The maximum number of call sequences occurred on April 30, 2006, when 14 call sequences were recorded at the low detector and on June 6, 2006, with nine call sequences at the high detector.

A large proportion (40% or 76) of the call sequences were identified simply as "unknown" due to poor call quality or too few call pulses on which to base identification. Approximately 32% of the calls were identified as myotids; 26% as the "Big Brown" guild that includes the Big Brown Bat, Silver-haired Bat, and Hoary Bat; and only 3% were that of the guild including Eastern Red Bat and Eastern Pipistrelle. Several of the recorded call sequences were distinct enough to identify to species, rather than just to guild. Five bat species were identified in this manner during the spring surveys, including the Little Brown Bat (24 calls), Hoary Bat (eight calls), Silver-haired Bat (seven calls), Eastern Red Bat (six calls), and Big Brown Bat (four calls). The 37 other call sequences in the myotid group could not be identified to species because the call sequences were too indistinct, and the 30 other calls in the Big Brown guild were either that of the Big Brown Bat or Silver-haired Bat, but definitely not from the Hoary Bat. All five species are found throughout New York State. The survey results (detections and species) were generally consistent, although slightly higher, than similar studies conducted in the spring in the northeast (see Table 5 in Appendix C).

Woodlot determined that there was not a significant relationship between weather variables and the number of bat call sequences. However, very few call sequences were detected when wind speeds were high (>23 feet [7 meters] per second) and greater numbers of call sequences were detected when temperatures were warmer (>10 °C; see Appendix C).

For more complete results and discussion on the AnaBat surveys conducted in the spring, see the Woodlot report in Appendix C.

#### 3.3.6.2 Fall 2006 Study

Detectors were deployed at different heights on the same met tower used during the spring 2006 study. Surveys were conducted from the night of July 25 to the night of October 9, 2006, yielding a total of 80 detector-nights of recordings (some nights of data were lost as a result of detector failure, which is common during remote studies). A total of 22 bat call sequences were recorded during the fall sampling. The mean detection rate for both detectors was 0.3 call sequences per detector-night. All 22 call sequences were detected by the upper detector, which was positioned 98 feet (30 meters) above the ground. No call sequences were recorded by the lower detector, which was 49 feet (15 meters) above the ground. The number of call sequences varied and no calls were detected on a number of nights; consequently, no seasonal trends were observed (see Figure 5 in Appendix D). The maximum number of call sequences occurred on August 1, 2006, when three call sequences were recorded at the high detector.

The highest proportion (77% or 17 calls) of the recorded call sequences were labeled as unknown due to short call sequences, poor call signature formation, or static interference. Woodlot estimated that approximately 80% of the unknown calls were likely from the Myotis group. The composition of bat call sequences were two in the Big Brown guild, two in the Myotis guild, and one in the red bat/eastern pipistrelle guild. Only the Eastern Red Bat could be identified to species rather than just to guild. This species is found throughout New York State.

There was not a significant relationship between bat call sequence detections and weather variables. In general, more calls were detected when wind speeds were low (see Figures 6 and 7 in Appendix D).

The detection rates in fall 2006 were lower than in spring 2006 at this site, which was not anticipated as bat activity is often greater in the late-summer and fall, based on previous studies conducted in the northeast. Too few calls were recorded in the fall to make any conclusions about species presence. More bats were observed in fall 2006 during ABR's visual survey (87) than bat call sequences were recorded by Woodlot at the same survey site in fall 2006. The fall survey results (detections and species) were generally much lower than similar studies conducted in the fall in the northeast (see Table 6 in Appendix D).

For more complete results and discussion on the AnaBat surveys conducted in the fall, see the Woodlot report in Appendix D.

### 3.3.7 Bird Species List and Threatened/Endangered Species

During the bird surveys and other activities in the Project Area, E & E identified a total of 106 bird species in the Project Area (see Table 3-11).

**Table 3-11 Bird Species Identified during E & E Surveys and Site Work in the Wethersfield Project Area**

| Common Name[1] | | |
|---|---|---|
| Canada Goose | Alder Flycatcher | Yellow Warbler |
| Wood Duck | Willow Flycatcher | Chestnut-sided Warbler |
| American Black Duck | Least Flycatcher | Magnolia Warbler |
| Mallard | Eastern Phoebe | Black-throated Blue Warbler |
| Ring-necked Pheasant | Great Crested Flycatcher | Yellow-rumped Warbler |
| Ruffed Grouse | Eastern Kingbird | Black-throated Green Warbler |
| Wild Turkey | Blue-headed Vireo | Blackburnian Warbler |
| Great Blue Heron | Warbling Vireo | American Redstart |
| Green Heron | Red-eyed Vireo | Ovenbird |
| Turkey Vulture | Blue Jay | Northern Waterthrush |
| Osprey (SC) | American Crow | Mourning Warbler |
| Bald Eagle (T) | Common Raven | Common Yellowthroat |
| Northern Harrier (T) | Horned Lark (SC) | Hooded Warbler |
| Sharp-shinned Hawk (SC) | Purple Martin | Scarlet Tanager |
| Cooper's Hawk (SC) | Tree Swallow | Eastern Towhee |
| Red-shouldered Hawk (SC) | Northern Rough-winged Swallow | Chipping Sparrow |
| Broad-winged Hawk | Cliff Swallow | Field Sparrow |
| Red-tailed Hawk | Barn Swallow | Savannah Sparrow |
| American Kestrel | Black-capped Chickadee | Song Sparrow |
| Merlin | Tufted Titmouse | White-throated Sparrow |
| Killdeer | White-breasted Nuthatch | Dark-eyed Junco |
| Ring-billed Gull | House Wren | Northern Cardinal |
| Rock Pigeon | Golden-crowned Kinglet | Rose-breasted Grosbeak |
| Mourning Dove | Ruby-crowned Kinglet | Indigo Bunting |
| Barred Owl | Eastern Bluebird | Bobolink |
| Northern Saw-whet Owl | Veery | Red-winged Blackbird |
| Chimney Swift | Hermit Thrush | Eastern Meadowlark |

**Table 3-11 Bird Species Identified during E & E Surveys and Site Work in the Wethersfield Project Area**

| Common Name[1] | | |
|---|---|---|
| Ruby-throated Hummingbird | Wood Thrush | Common Grackle |
| Belted Kingfisher | American Robin | Brown-headed Cowbird |
| Red-bellied Woodpecker | Gray Catbird | Baltimore Oriole |
| Yellow-bellied Sapsucker | Brown Thrasher | Purple Finch |
| Downy Woodpecker | European Starling | House Finch |
| Hairy Woodpecker | Cedar Waxwing | American Goldfinch |
| Northern Flicker | Blue-winged Warbler | House Sparrow |
| Pileated Woodpecker | Tennessee Warbler | |
| Eastern Wood-Pewee | Nashville Warbler | |

[1] Endangered (E) and threatened (T) species and species of special concern (SC) are noted with parenthesis after the common name.

NYSDEC maintains a list of bird species that are considered endangered (nine species), threatened (10 species), or of special concern (19 species) within the state of New York, inclusive of several federally listed species. Information was obtained from various sources, including E & E field surveys, Breeding Bird Atlas projects, BOS database of avian records, and Wyoming County birding references to determine the potential occurrence of endangered, threatened, or special concern species in the Project Area. Table 3-12 lists these species along with notes of possible or confirmed occurrence within the Project Area.

**Table 3-12 Potential Occurrence of Endangered, Threatened, or Species of Special Concern within New York State at the Wethersfield Project Area**

| Listed Species[1,2] | Notes |
|---|---|
| **Endangered Species** | |
| Golden Eagle | It is considered extirpated as a breeder in New York State. It is likely a very rare transient or migrant over the Project Area. |
| Peregrine Falcon | No nests are known to occur in or near the Project Area. It is likely an uncommon migrant over the Project Area. ABR observed one migrant during their visual surveys in fall 1998. One was observed in Wethersfield in October of 2005 (BOS 2006). |
| Spruce Grouse | Its New York State range is limited to the Adirondacks, where rare. Location/habitat is not suitable in Project Area. |
| Black Rail | It is extremely rare in New York. There are no records of occurrence in Wyoming County. Location/habitat is not suitable in Project Area. |
| Piping Plover | It is federally endangered in the Great Lakes region. It is very rare in western New York. Location/habitat is not suitable in the Project Area. There are no records of occurrence in Wyoming County. |
| Roseate Tern | It is federally endangered. Its New York State range is limited to coastal Long Island. Location/habitat is not suitable in the Project Area. |

**Table 3-12 Potential Occurrence of Endangered, Threatened, or Species of Special Concern within New York State at the Wethersfield Project Area**

| Listed Species[1,2] | Notes |
|---|---|
| Black Tern | Location/habitat in the Project Area is not suitable for breeding or foraging. There are no records of occurrence in the Project Area. |
| Short-eared Owl | It is a very rare breeder in western New York. There are no records of breeding in Wyoming County. As evidenced by Beaver Meadow CBC data, it regularly winters in the county and may occur in the Project Area. As reported by the NHP, this species was observed in the Towns of Sheldon and Warsaw in Wyoming County and in the Town of Hume in Allegany County (Seoane 2006). |
| Loggerhead Shrike | It is very rare in New York State and declining. There are no records of occurrence in the Project Area. |
| **Threatened Species** | |
| Pied-billed Grebe | It is an uncommon breeder in Wyoming County. NYSDEC indicated it has bred within 10 miles of the Project Area in Town of Pike (Seoane 2006). There are no records of occurrence in the Project Area. |
| Least Bittern | Location/habitat within Project Area is not suitable for breeding. There are no records of occurrence in the Project Area. |
| Bald Eagle | It is classified as federally threatened but it is currently in the de-listing process. This increasing species occurs as a migrant and transient over the Project Area. Location/habitat within Project Area is not ideal for breeding. E & E observed an unidentified eagle during a fall raptor survey on September 21, 2006, that was likely this species. Noble observed an immature Bald Eagle flying over the Project Area in April 2006. E & E observed one immature flying high above Pattridge Road in the Town of Eagle, approximately 3 miles south of the Project Area on May 26, 2005. |
| Northern Harrier | It has bred in a number of locations in Wyoming County. It was confirmed as a breeder in atlas block 2271B and a possible breeder in blocks 2272C and 2372C all in or near the Project Area. E & E staff observed this species on several occasions during E & E migratory surveys and on at least one other occasion in fall 2006 within the Project Area. |
| King Rail | It is extremely rare in upstate New York. There are no records of occurrence in Wyoming County. Location/habitat in the Project Area is unsuitable for breeding. |
| Upland Sandpiper | It has bred in a number of locations in Wyoming County (Rosche 1967); however, it has decreased over the last few decades. There is some habitat (pasturelands) suitable for breeding in the Project Area. The NHP reported that it has been observed in the Towns of Sheldon and Orangeville in Wyoming County (Seoane 2006). One was observed in Eagle in June 2002 (BOS 2006). Targeted searches in the Project Area could not find this species in May or June 2006. |

Table 3-12 Potential Occurrence of Endangered, Threatened, or Species of Special Concern within New York State at the Wethersfield Project Area

| Listed Species[1,2] | Notes |
|---|---|
| Common Tern | It is rare in Wyoming County. Location/habitat in the Project Area is unsuitable for breeding or foraging. |
| Least Tern | Its New York State range is limited to coastal Long Island. Location/habitat is not suitable in the Project Area. |
| Sedge Wren | There are no records of occurrence in the Project Area. There is some potentially suitable habitat in the Project Area. |
| Henslow's Sparrow | The NHP reported that this species was observed near Gouinlocks Pond in the Town of Attica, Wyoming County and in fields near Bank Road in the Town of Middlebury, Wyoming County (Seoane 2006). Although they were not detected during the 2000-2005 BBA, they were listed as possible breeders in block 2271B during the 1980-1985 BBA. There is some potentially suitable habitat in the Project Area. Several birds were found approximately 3 miles outside of the Project Area along the Eagle-Pike Town Line in 2002, but they were not found again in the following years as the field matured. Targeted searches in the Project Area could not find this species in May or June 2006. |
| **Species of Special Concern** | |
| Common Loon | Location/habitat in the Project Area is not suitable for breeding. It is likely a rare migrant over the Project Area. |
| American Bittern | Location/habitat within the Project Area is not suitable for breeding. There are no records of occurrence in the Project Area. |
| Osprey | It is a migrant and transient over the Project Area. E & E observed this species during the September 21 and 29, 2006, fall raptor surveys. Location/habitat within the Project Area is not suitable for breeding. |
| Sharp-shinned Hawk | It is considered fairly common in Wyoming County. Location/habitat in the Project Area is suitable for breeding. It was confirmed breeding in BBA blocks 2272D and 2372C. One was observed in May 2006 in the Project Area. One was observed in the Project Area on September 21, 2006, during fall raptor surveys and was thought to be local. |
| Cooper's Hawk | It is considered fairly common in Wyoming County. Location/habitat in the Project Area is suitable for breeding. Four were observed during 2006 fall raptor surveys. |
| Northern Goshawk | It is considered a rare breeder in western New York. Location/habitat in the Project Area is suitable for breeding. It was not observed during E & E surveys or field work. Two Northern Goshawks were observed in Wethersfield in May 1998; one was observed in Wethersfield Springs in December 1998; one young and one adult were observed in July 1998, two were observed in May 1999, and one in June 1999 in Eagle (BOS 2006). |

## Table 3-12 Potential Occurrence of Endangered, Threatened, or Species of Special Concern within New York State at the Wethersfield Project Area

| Listed Species[1,2] | Notes |
|---|---|
| Red-shouldered Hawk | It is considered fairly common in Wyoming County. It was considered a probable breeder in block 2272B, and considered a possible breeder in blocks 2271B, 2272C, and 2372C. E & E observed one on November 1, 2006, in the Project Area. |
| Black Skimmer | Its New York State range is restricted to coastal Long Island. Location/habitat is not suitable in the Project Area. |
| Common Nighthawk | It is a rare and declining breeder in western New York. Site location/habitat is likely unsuitable for breeding. It is likely an occasional spring and late summer migrant over the Project Area. There are no records of occurrence in the Project Area. |
| Whip-poor-will | It is a very rare breeder and migrant in western New York. Location/habitat in the Project Area is likely unsuitable for breeding. There are no records of occurrence in the Project Area. |
| Red-headed Woodpecker | It is an uncommon and declining breeder in western New York. Location/habitat in the Project Area is possibly suitable for breeding. There are no records of occurrence in the Project Area. |
| Horned Lark | It is a regular, often common, species in winter throughout New York State. It likely breeds in low numbers in plowed fields within and near the Project Area. It was listed as a probable breeder in BBA blocks 2272C, 2272D, and 2372A. Eight were identified during E & E migratory surveys and fall raptor surveys in agricultural fields and as flyovers. |
| Bicknell's Thrush | Its New York State range is restricted to the Adirondacks and Catskills, where it breeds in stunted fir forests above 3,000 feet. Location/habitat in the Project Area is unsuitable for breeding. |
| Golden-winged Warbler | Location/habitat in the Project Area is possibly suitable for breeding. There are no records of occurrence in the Project Area. |
| Cerulean Warbler | Location/habitat in the Project Area is possibly suitable for breeding. None were observed during E & E surveys or site work. |
| Yellow-breasted Chat | It is an uncommon breeder in western New York. Location/habitat in the Project Area is suitable for breeding. None were observed during E & E surveys or site work. E & E identified one in the Town of Eagle in June 2005 during a breeding bird survey for the adjacent Noble Bliss Windpark. |
| Vesper Sparrow | Location/habitat in the Project Area is suitable for breeding. It was listed as a probable breeder in BBA block 2372A and a possible breeder in blocks 2271B and 2272B. One was observed in May 2003 in Wethersfield (BOS 2006). None were observed during E & E surveys or site work. |

### Table 3-12 Potential Occurrence of Endangered, Threatened, or Species of Special Concern within New York State at the Wethersfield Project Area

| Listed Species[1,2] | Notes |
|---|---|
| Grasshopper Sparrow | Location/habitat in the Project Area is suitable for breeding. None were observed during E & E surveys or site work. E & E identified one in the Town of Eagle in June 2005 during a breeding bird survey for the adjacent Noble Bliss Windpark. |
| Seaside Sparrow | Its New York State range is restricted to coastal Long Island. Location/habitat in the Project Area is unsuitable for occurrence. |

[1] All species are state-listed. Federally listed species are indicated in the notes column.

[2] Special concern species are not afforded protection under state and/or federal endangered species acts.

# 4

# Risk Assessment

## 4.1 Wind Energy and Bird and Bat Issues

### 4.1.1 Overview

There are a number of positive impacts on bird populations that would result from an increased use of renewable energy, including wind energy. Air emissions and global climate change have been cited as serious concerns for North American bird populations (see *A Birdwatcher's Guide to Global Warming by the National Wildlife Federation and American Bird Conservancy* [Price and Glick 2004]). Increased renewable energy use will slow down the negative impacts of global climate change and air emissions on people and wildlife. In addition to the positive impacts noted above, operation of wind energy facilities also has the potential to result in some adverse impacts by causing injury or death to birds through collisions and resulting in habitat loss, degradation, or displacement. While studies have shown that these negative impacts have occurred at a few sites, the results from numerous studies and reviews of impacts on birds from wind energy facilities in North America and Europe indicate that mortality rates are low (Erickson et al. 2001; NWCC 2004; GAO 2005).

In November 2004, the National Wind Coordinating Committee (NWCC), a consortium of wind energy developers, researchers, proponents, opponents, and agencies, issued the second edition of a fact sheet, "Wind Turbine Interactions with Birds and Bats: A Summary of Research Results and Remaining Questions" (2004). The following, taken from the fact sheet, is part of an overview on the status of bird and bat issues at wind energy facilities that aptly describes the current understanding:

> "Wind energy's ability to generate electricity without many of the environmental impacts associated with other energy sources (air pollution, water pollution, mercury emissions, and greenhouse gas emissions associated with global climate change) can significantly benefit birds, bats, and many other plant and animal species. However, the direct and indirect local and cumulative impacts of wind plants on birds and bats continue to be an issue."

In a September 2005 report to congressional requesters, the United States Government Accountability Office (GAO) reviewed the impacts on wildlife from wind power. The GAO report concluded that outside of the Altamont site in northern California, the research to date has not shown bird kills in alarming numbers (GAO 2005). The GAO review of post-construction mortality studies found that bird fatalities ranged from 0 to 7.28 birds per turbine per year. Similarly, the 2004 NWCC fact sheet shows an average of 2.3 birds per turbine per year (3.1 birds per MW per year) are killed at facilities outside of California. For eastern wind farms, the average was 4.3 birds per turbine per year (3.0 birds per MW per year).

The research regarding bats and wind turbines is much more limited. As of 2004, no known collisions of federally endangered or threatened bat species have been documented in conjunction with wind turbines (BCI 2006). Although this report only extends through 2004, anecdotal information from the most recent NWCC conference in November 2006 indicated that this conclusion is still valid. Collisions involving other bat species are typically on the same order as expected for birds with 3.4 bat kills per turbine per year as national average although much higher rates were found during some studies in the Appalachian Mountains (NWCC 2004; GAO 2005). The significance of localized bat mortality from collisions on a population as a whole is largely not understood, and current research is being aimed at addressing this issue.

The USFWS, state agencies, NWCC, and BCI are currently trying to determine the biological significance of the large bat kills at the Mountaineer Wind Energy Center in West Virginia in 2003 and 2004. More recently, additional reports of sizeable bat mortalities have been recorded at the Meyersdale facility in Pennsylvania, the Maple Ridge Project in northern New York, and the Summerview Wind Farm in southern Alberta, Canada. However, there is no generally accepted understanding of the interaction of bats and wind turbines. To date, there has been no confirmed correlation between habitat availability and specific atmospheric or seasonal conditions that result in increased mortality, although preliminary data seem to indicate that mortalities occur during periods of lower wind speed and that temperature, precipitation, and humidity may also be contributors. Because of the general lack of understanding regarding the interaction of bats and wind turbines, the expectation is that continued monitoring and data analysis associated with operational and proposed windparks will contribute to the database regarding bat species and that windpark operators will need to implement management strategies that will evolve throughout the lifespan of windparks as more defined information is developed. As the breadth of knowledge regarding bat/turbine interactions increases, specific mitigation strategies can be developed to allow for the continued operation of windparks as a critical aspect of a global renewable energy approach, while reducing the potential impact on bats.

### 4.1.2 Bird Collisions

There is a potential that direct collisions with the wind turbine rotors or tower can result in injury or mortality to birds and bats. However, the data from numerous post-construction mortality studies at wind turbine projects, particularly newer facilities, demonstrate that avian mortality rates are low. The low mortality rates are primarily due to three factors:

- Most migrating birds fly at altitudes higher than the maximum turbine height;
- A very high percentage of birds flying toward wind turbines will detect and avoid them; and
- Of those birds that do not alter their flight path in time to avoid the rotor swept area of a turbine, a majority will still avoid a collision.

#### Migration Flight Altitude

Birds migrate at varying altitudes, with most in the following ranges (Smithsonian Migratory Bird Center 2006):

- Songbirds: 500 to 6,000 feet, with 75% of songbirds migrating between 500 and 2,000 feet;
- Shorebirds: 1,000 to 13,000 feet;
- Waterfowl: 200 to 4,000 feet; and
- Raptors: 700 to 4,000 feet.

Given these ranges, only a small percentage of migrating birds are expected to be flying lower than the maximum turbine height and be at risk of collision with turbine rotors. Weather conditions such as precipitation, low cloud ceilings, and strong opposing winds will usually lower the altitude of migrating birds, although fewer birds typically migrate under such unfavorable conditions.

#### Turbine Avoidance

Various studies of birds approaching wind turbines have demonstrated that most birds detect the presence of wind turbines and react by altering their flight path to avoid them (Sterner 2002; BirdLife 2003; Desholm and Kahlert 2005). In comparison of flight behavior, one study in Spain found that migrating birds flew at higher average altitudes (>328 feet [100 meters] versus 197 feet [60 meters]) over wind turbines than over areas without wind turbines (Janss 2000). In a study in the Netherlands, Winkelman (1994) observed that at 984 feet (300 meters) from wind turbines, the change in flight behavior was five times more horizontal than vertical and that 75% of the reactions occurred 328 feet (100 meters) from the turbines. Kahlert et al. (2003) showed some avoidance of an offshore wind farm by birds but emphasized that not enough data had been collected to determine whether the wind farm had or did not have negative effects on migrating bird populations. Desholm and Kahlert (2005) indicated that the radar studies demonstrated a substantial avoidance by migrating waterbirds to a large offshore wind farm with less than 1% flying close enough to the turbines to be at risk of collision.

In the Netherlands, Winkelman (1994) found that 1.2% of birds flying at the maximum turbine height were killed. In Belgium, Everaert et al. (2002) calculated the chance of a gull colliding with a turbine to be 0.05% and for a tern 0.2% (BirdLife 2003). At three wind turbine facilities in the United States, Erickson (2003) estimated that more than 99.99% of birds exhibited behavioral avoidance. Because of site-specific differences in turbines, wind farm layout, weather, and bird species, these results cannot be universally applied; however, they demonstrate strong avoidance behavior.

#### Rotor Avoidance

For birds that do not alter their flight path when approaching a turbine, studies have documented low collision rates for birds flying through the rotor swept area (the area of the rotating turbine blades). In a direct visual study, Winkelman (1994) observed that 84% of the birds passing through a rotor swept area were not killed. Although there are no empirical data that predict a bird's ability to pass safely through the rotor swept area (but see Desholm et al. 2006 for methods to investigate this behavior), there is a hypothetical model (Tucker 1996). Predictive models based on physics indicate that more than half of the birds passing through a rotor swept area will survive (Tucker 1996) because so little space is occupied by the rotating rotors in relation to the speed of the bird's flight.

### 4.1.3 Habitat Loss, Degradation, or Displacement

There is also a potential that habitat disturbance from wind turbines may result in habitat loss, habitat degradation through fragmentation (i.e., the loss of quality or quantity of habitat), or result in behavioral displacement from habitats. These impacts have occurred in certain instances at wind turbine facilities (e.g., Leddy et al. 1999, Spaans et al. 1998, and Winkelman 1992a in BirdLife 2003). The disturbances can be temporary (i.e., during construction) or permanent. Some studies have documented decreased breeding densities, primarily in grassland-nesting songbirds, in proximity to wind turbines (Leddy et al. 1999). However, other studies have documented little impact on nesting birds and that some birds or species groups habituate to the areas around the turbines (e.g., Winkelman 1992b, Brown and Shepherd 1993 in BirdLife 2003; NWCC 2004).

## 4.2 Potential Impacts on Birds and Bats from Construction

Construction-related activities (i.e., clearing for road construction, infrastructure construction, equipment noise, and increased vehicle traffic) can potentially impact birds and bats. Displacement from habitat is the primary concern with construction-related impacts. However, potential impacts from construction are generally only temporary in nature.

### 4.2.1 Potential Impacts on Migratory Birds

Significant adverse impacts on migratory bird populations including raptors, passerines, and waterbirds are not expected as a result of construction of the Project. The Project Area is not located along a major migratory corridor for birds. Most species are expected to avoid the area of construction, both during the day when turbines are visible and at night, as birds tend to fly at higher elevations at night, during the active construction period. Upon completion of construction, it is anticipated that migratory birds would resume use of the area during migration.

### 4.2.2 Potential Impacts on Breeding Birds

Breeding bird populations are not expected to be adversely affected significantly by construction of the Project. If construction begins before the breeding season, it is anticipated that breeding birds will likely avoid areas during the active construction period. If construction begins during the breeding season, because many breeding birds have been exposed to similar disturbance such as farming and logging, they will either be accustomed to disruption of this nature or they will relocate to other adjacent suitable habitat. Indirect impacts on breeding birds will occur as a result of habitat alteration in association with construction of the Project; however, these impacts are not expected to be significant because similar disturbances occur in the Project Area. Further, habitat loss should be minimal because of site planning (i.e., the placement of turbines in agricultural areas). Outside of localized construction disturbance, no significant adverse impacts on breeding birds are anticipated.

### 4.2.3 Potential Impacts on Threatened and Endangered Species

Based on consultation with the USFWS and NHP, except for transient individuals, no threatened or endangered species or communities were identified within the Project Area. This conclusion was supported by the field surveys. During field surveys, several threatened species including Bald Eagle (federally and state-threatened) and Northern Harrier (state-threatened), and state species of concern, including Osprey, Sharp-shinned Hawk, Cooper's Hawk, Red-shouldered Hawk, and Horned Lark, were observed in the Project Area; all in low numbers. Only limited use of the Project Area is anticipated by endangered, threatened, and special concern species during construction as most of any occurrences would be related to migration or transient (i.e., limited) use. Therefore, no significant adverse impacts on these species are expected during construction. The potential impacts on individual species listed by USFWS and NYSDEC on the NHP reports are discussed in detail in Section 4.3.3.

If construction takes place in suitable nesting habitat for endangered or threatened species in the spring to early summer - during breeding season - the work area will be surveyed and cleared by an environmental monitor in advance of construction. If nesting threatened or endangered species are found in the immediate proximity of a construction area, Noble will coordinate with the USFWS and/or NYSDEC to develop a mitigation plan to address site-specific occurrences of species of concern. Measures that may be implemented include delaying construction until the young have fledged from the nest or continual monitoring during the initial construction period to ensure that the birds are not impacted. With implementation of monitoring activities, no significant adverse impacts from construction on threatened or endangered species are anticipated.

### 4.2.4 Potential Impacts on Bats

Significant adverse impacts on bat populations are not expected as a result of construction of the Project. Some potential indirect impacts on bats may occur as a result of habitat alteration or loss in association with construction of the Project; however, these impacts are not expected to have a significant adverse affect on bat populations. In addition, the potential impacts on habitat are consistent with activities and conditions that currently occur throughout the Project Area such as ground disturbance and tree removal associated with farming and logging activities. It is anticipated that bats in the Project Area would return to temporarily disturbed areas upon completion of construction.

## 4.3 Potential Impacts on Birds and Bats from Operation of the Project

Operation of the wind turbines can potentially impact birds and bats through collisions with the rotors and towers, displacement from habitat, or influence on migration, etc. Collisions are typically the primary concern with operation-related impacts. Potential impacts can vary among different bird and bat populations and groups.

### 4.3.1 Potential Impacts on Migratory Birds

The dynamics of migration and the potential impacts from the operation of wind turbines differ among groups of birds. Therefore, this section contains separate discussions of potential impacts on the migration of raptors, passerines, and waterbirds. The majority of passerines migrate during the night while raptors migrate almost exclusively during the day. Waterbirds migrate during the day and night (Richardson 1998).

#### Raptors

Raptor migration is diffuse in the region. There are no geographical or topographical features in the Project Area that attract or concentrate migrating raptors. The Project Area is not proximate to the recognized raptor migration pathways in New York State (i.e., near shorelines of the Great Lakes in spring or select mountainous ridges in fall). Results of the migratory raptor surveys demonstrate that migratory raptor use of the Project Area is low. No concentrated flight paths were identified in either spring or fall and the findings were consistent with the existing knowledge of the bird resources in the region. Therefore, low numbers of migrant raptors are anticipated in the Project Area.

Concerns about raptor impacts from wind turbines persist from the continued fatalities occurring at the Altamont Pass in California and other older wind farms in that state. However, several site-specific features at Altamont Pass contribute to the number of raptor deaths including older turbines that allow raptors to perch and nest on lattice structures; the large number of turbines (over 5,000); and an abundant source of prey, all of which contribute to a large number of raptors in the area (GAO 2005). Large numbers of raptor kills have not occurred at wind farms elsewhere in the United States outside of California, and raptor fatalities have ranged from 0 to 0.07 raptors per turbine per year (GAO 2005).

As raptor use in the Project Area is low and the likelihood of turbine avoidance is high, the potential for impacts is very low. No biologically significant adverse impacts on migrant raptors are anticipated from operation of the Project.

### Passerines

A collision risk exists for nocturnal migrant passerines at all tall structures, including wind turbines. Nocturnal migrant passerines comprised the greatest number of bird fatalities (34% to 59%) in a review of post-construction mortality studies by Erickson et al. (2001). However, there have been no documented large fatality events of nocturnal migrants at wind energy facilities, with the largest limited to 27 songbirds at a floodlit substation and nearby turbines in West Virginia on a May night with heavy fog (NWCC 2004).

No dead or injured birds were found during the mortality study at the existing Wethersfield wind farm conducted in 2005 during the spring and fall migration periods. While it is possible that a few birds were consumed by scavengers prior to the surveys, it is highly unlikely that a large mortality event was missed. The results demonstrate that migrant passerines were not substantially impacted by the Wethersfield wind farm wind turbines.

While the mortality study results are very important in the evaluation of the potential for avian mortality at the Noble Wethersfield Windpark, there are several additional factors that must be considered:

- Wethersfield turbines (289 feet [88 meters] agl) are approximately 98 feet (30 meters) smaller than the turbines proposed by Noble at the Noble Wethersfield Windpark (388.8 feet [118.5 meters] agl);
- The Wethersfield Wind Farm has been in operation for 6+ years (and therefore, local birds may have become habituated to avoiding the turbines); and
- The Wethersfield Wind Farm turbines are aligned in northwest-to-southeast string while the Noble Wethersfield Windpark turbines would be scattered.

Considering these caveats, it is likely that the Noble Wethersfield Windpark turbines will pose a slightly higher risk to migrating passerines than the existing Wethersfield turbines.

There are no geographical or topographical features in the Project Area that attract or concentrate nocturnal migrant passerines. The Project Area is not proximate to any large water bodies where nocturnal migrants tend to concentrate at stopover areas. Outside of such concentration areas, passerine migration is typically diffuse over a broad front. Results of the nocturnal radar study are generally consistent with this assessment. The migratory passage rates over the Project Area in spring and fall 2006 were above average but within the values of studies conducted at other locations.

The mean flight altitudes were 777 feet (237 meters) and 742 feet (226 meters) higher than the maximum turbine height in spring and fall 2006, respectively; therefore, the majority of nocturnal migration occurs well above the height of the proposed turbines. The mean flight altitude in spring was similar to other locations studied and in fall was slightly lower than at the other locations in the east where similar studies have been conducted. Approximately 19% of all nocturnal targets in spring 2006 and approximately 11% of all nocturnal targets in fall 2006 flew below 410 feet (125 meters) agl, a close approximation to the maximum turbine height. These findings are within the range of results from other radar studies in the northeast.

There are conditions when nocturnal migrants will be more susceptible to collision. There is an increase for potential impacts when adverse weather conditions cause birds to fly at lower altitudes. Studies have shown that bird collisions with communication and television towers (much taller than wind turbines) are increased during low cloud ceilings, heavy fog, and precipitation.

It is likely that nocturnal migrant passerines will make up the majority of bird kills from the Project. However, the potential mortality risk to migrant passerines is considered low based on the Project location, the results of the mortality study at the Wethersfield wind farm, the passage rate and altitude data from the radar studies (and other regional radar studies), and the avoidance behavior of passerines typically exhibited at wind energy facilities. No biologically significant adverse impacts are anticipated for any species from operation of the Project.

### Waterbirds

The Project Area is not located in an area where there are large numbers of migratory waterbirds or local movements. Post-construction studies at existing wind energy facilities have shown that waterfowl are less susceptible to collision than other species groups (Erickson et al. 2002; BirdLife 2003). Therefore, the potential risk for waterbird mortality from the Project is estimated to be very low.

### 4.3.2 Potential Impacts on Breeding Birds

Given the various habitats in the Project Area and site geography, there is a fairly high diversity of breeding species; however, most turbines will be sited in agricultural fields and open areas which already have a relatively low species diversity and density. There is some degree of habitat fragmentation already in the Project Area. By minimizing the Project footprint near wetlands and mature forests, potential impacts on resident birds have been reduced.

Much of the Project will be constructed in agricultural and young woodland areas, and breeding birds in these habitats may demonstrate temporary displacement. Long-term displacement in wooded areas is unlikely as breeding species are anticipated to habituate to the turbines. The habituation of grassland-nesting species in agricultural areas is less certain, although displacement may be limited to the immediate area of each turbine. While habituation of grassland-nesting species is uncertain and, therefore, the potential impacts of displacement are unknown, any potential impacts are anticipated to be much less than the impacts from existing hay mowing and pesticide practices in the same area.

There is a low risk of any substantial negative impact on habitat through loss, degradation, or displacement of breeding birds. No significant adverse impacts on breeding birds are anticipated from operation of the Project.

### 4.3.3 Potential Impacts on Threatened and Endangered Species

Based on consultation with the USFWS and NHP, except for transient individuals, no threatened or endangered species or communities were identified within the Project Area. This conclusion was supported by the field surveys. During field surveys, two threatened species, including Bald Eagle (federally and state-threatened) and Northern Harrier (state-threatened), were observed in the Project Area (in low numbers). Only limited use of the Project Area is anticipated by endangered, threatened, and special concern species. Therefore, no significant adverse impact on these species is expected during operations. The potential impacts on these species and those listed by USFWS and NYSDEC on the NHP reports (i.e., Short-eared Owl, Upland Sandpiper, Pied-billed Grebe, Henslow's Sparrow, and Eastern Small-footed Myotis) within 10 miles of the Project Area are discussed in detail below.

Bald Eagle was identified by NHP as occurring near the Project Area. E & E observed an unidentified eagle during a fall raptor survey on September 21, 2006, that was likely this species. Noble observed an immature Bald Eagle flying over the Project Area in April 2006. E & E observed one immature flying high above Pattridge Road, approximately 5 miles south of the Project Area on May 26, 2005. There is no suitable habitat for breeding in the Project Area. Although a nest has been documented along the Genesee River approximately 12 miles east of the Project Area, the foraging potential is considered very low given the absence of any large bodies of water in the Project Area. There are no activities pertinent to the life cycle of the Bald Eagle that would regularly bring it to the Project Area except as a migrant or an occasional transient. With such low utilization of the Project Area, the potential direct mortality or injury of eagles colliding with wind turbines is considered remote. Similarly, as there is not suitable breeding or foraging habitat in the Project Area, the potential for harassment, displacement, or habitat impacts are also remote. Therefore any potential impacts to Bald Eagle are considered remote.

Northern Harrier was identified by NHP, was included in local BBRA data, and was observed on several occasions in the Project Area. It is a regular occurrence in Wyoming County, just like in many other areas of New York State. Various wetland and upland habitats, including cattail marshes, wet meadows, and hayfields, are used for nesting. Unlike most raptors, it is a ground nester. It is highly visible in all seasons and has a large hunting range (Andrle and Carroll 1988). Because there is ample suitable nesting habitat in and near the Project Area, the potential risk of displacement is low. Very low Northern Harrier mortality has been documented from wind turbines, even at sites that have relatively high use by this species (Erickson et al. 2002). It is anticipated that local Northern Harriers will habituate to the presence of wind turbines; however, the collision risk is considered low-to-moderate because of the species' frequency of occurrence in the Project Area.

Short-eared Owl was listed by NHP in Sheldon and Warsaw in Wyoming County and Hume in Allegany County. These locations are assumed to be wintering locations rather than breeding areas, because breeding areas are very scarce in the state, and there are no breeding records from the 1980-1985 or 2000-2005 BBA in Wyoming or Allegany counties. During the 1980-1985 BBA, one block in Livingston County west of Wyoming County had a probable breeding pair of Short-eared Owls and four blocks had possible breeding, but during the 2000-2005 BBA, only two blocks had possible breeding. These blocks are associated with the Nations Road Grasslands IBA, approximately 22 miles northeast of the Project Area. This species is categorized as endangered in New York State because of its rare breeding status. Unlike breeding birds, wintering Short-eared Owls are not rare. Suitable habitat occurs throughout much of Wyoming County, including the Project Area, for wintering Short-eared Owls. Although this species was not observed during field surveys, it is suspected that a few birds may forage in the Project Area in some winters. Given the unlikelihood of breeding birds in the Project Area, the potential impact to this species is considered low.

Upland Sandpiper was listed by the NHP in the Town of Centerville, Allegany County, in the Towns of Sheldon and Orangeville in Wyoming County, and in the Towns of Portage, Mount Morris, and Nunda, Livingston County. There are also scattered BBA reports in Wyoming County, including in blocks near the Project Area. The Upland Sandpiper is considered a threatened species within New York State. The Wyoming County NHP listings were less than three miles from the Project Area, which is within the foraging range for breeding birds. However, this species was not observed in the Project Area, despite searching for it on two occasions in June 2006. The potential impact to this species is considered low.

Pied-billed Grebe, a threatened species in New York State, was listed by the NHP based on birds at a large pond in Pike, southeast of the Project Area. Habitat requirements include a combination of open water along with an abundance of emergent aquatic vegetation. Habitat in the Project Area is not suitable for foraging or breeding. The Pied-billed Grebe is secretive during the breeding season except for its loud call. It spends most of its time on the water and is rarely seen in flight. Assuming a pair breeds in the Pike area, it is unlikely fly to other locations to forage given the suitable habitat near the nest. Therefore, the potential risk of collision is considered remote. Similarly, the potential risk of displacement is considered very low because the suitable habitat will not be altered.

Henslow's Sparrow was listed by the NHP for historical occurrences in the Towns of Attica and Middlebury, Wyoming County and in the Towns of Portage, Mount Morris, and Nunda, Livingston County. Henslow's Sparrow is a habitat specialist that uses undisturbed pastures and meadows, timothy hayfields, tallgrass prairies, pine savannas and uncultivated fields, generally preferring mesic or wet habitats with relatively tall and dense, but also somewhat sparse and patchy vegetation (Wisconsin Department of Natural Resources 2003; National Audubon Society 2002). Habitat is considered a limiting factor for this species, and there is some potentially suitable habitat in the Project Area. During the 1980-1985 BBA, a number of confirmed, probable, and possible breeders were identified in Wyoming County, but during the 2000-2005 BBA, only two blocks in Wyoming County had probable breeding Henslow's Sparrows. They were not detected during E & E surveys even though searches were conducted in May and June 2006. Therefore, the potential risk of collision to this state-threatened species is considered remote. Similarly, the potential risk of displacement is considered low-to-moderate because suitable habitat in the Project Area may be altered.

Eastern Small-footed Myotis, a species of special concern in New York State, was listed by NHP as historically occurring at a tunnel in Letchworth State Park in the Town of Portage, Livingston County, approximately 8 miles from the Project Area. During the summer, this species is roosts in hollow trees, beneath the loose bark of trees, in crevices of cliffs, in rock piles, or in man-made structures such as buildings or along the undersides of bridges; during winter, these bats are found in colonies in caves or abandoned mines (Williams et al. 2002). This species is a habitat specialist and the preferred habitats are not present in the Project Area. Although Myotids were detected by Woodlot during the spring and fall AnaBat surveys, many of these calls could not be categorized to species and of the calls that could be categorized, Eastern Small-footed Myotis was not identified. The potential risk of collision is considered low for this species. Similarly, the potential risk of displacement is considered low because suitable habitat is not available Project Area.

Only limited use of the Project Area is anticipated by endangered, threatened, and special concern bird species; therefore, the overall risk to threatened and endangered bird species from operation of the Project is considered low.

### 4.3.4 Potential Impacts on Bats

Based on the habitat within the Project Area, acoustical monitoring studies performed in and near the Project Area, and the limited post-construction data associated with other similar projects, the potential for significant adverse impacts on bats from operation of the Project is considered low-to-moderate. Although these studies suggest that the potential adverse impacts on bats are not significant, uncertainty still remains regarding the affect of wind farms on bats. The greatest concern would be to transient individuals, especially tree-roosting bat species (Hoary Bat, Eastern Red Bat, and Silver-haired Bat) colliding with wind turbines. Preliminary data collected at sites in the eastern United States as well as the Canadian prairie seem to indicate that these species are susceptible to collisions with wind turbines. It is anticipated that there would be much lower risk to the resident/summering populations occurring in the Project Area than to migrants.

New York State is not recognized as containing federal designated priority one critical habitat, or for containing large populations of the federally protected Indiana Bat. Within New York State, the Indiana Bat is known to winter only in isolated hibernacula mostly within the eastern portion of the state. Based on the known locations of hibernacula in New York counties (Albany, Essex, Warren, Jefferson, Onondaga, and Ulster Counties), coupled with the lack of recognized habitat for the Indiana Bat in the Project Area, it is unlikely that Indiana Bats would be found residing in the Project Area, and, therefore, any potential impacts are considered remote.

## 4.4 Bird and Bat Fatality Approximations

### 4.4.1 Birds

NWCC compiled regional and overall bird fatality rates based on 12 post-construction mortality studies that were conducted for a minimum of three seasons and where scavenging and searcher efficiency biases were incorporated into the estimates (NWCC 2004). The overall national average is 2.3 birds/turbine/year, ranging from 0.6 to 7.7 birds/turbine/year. The eastern regional average, based on only two studies, is higher at an average of 4.3 birds/turbine/year.

No wind energy facilities in New York State were included in the NWCC compilation; however, mortality studies have been conducted at several facilities in the region:

- A one-year post-construction mortality study at the Madison County facility (seven turbines, 11.6 MW) found four dead birds, at a fatality rate of 0.42 birds/turbine/year (Kerlinger and Guarnaccia 2006).

- No dead birds were found at the Wethersfield wind farm, Wyoming County, facility (10 turbines at 290 feet agl, 6.6 MW) during a post-construction mortality study conducted by E & E in 2005.

- No dead birds were found during a 6-month mortality study at the Searsburg, Vermont facility (11 turbines, 6 MW) (Kerlinger and Guarnaccia 2006).

- The Huron Wind site, five turbines located along Lake Huron in Ontario, Canada, has had only one known bird mortality since 1995 (Huron Wind 2006).

- Only two dead birds were found during a mortality study at a single turbine in the city of Toronto, Canada, along the Lake Ontario waterfront (James and Coady 2003).

- The Maple Ridge Project (formerly known as the Flat Rock Power project) is the closest constructed project in proximity of the Project Area. It is located in the Towns of Martinsburg, Lowville, Watson, and Harrisburg in Lewis County, approximately 95 miles southwest of the Project Area. Project review was conducted by the Towns, NYSDEC, and USFWS among other agencies and approval was granted to proceed with the project. Construction was initiated in 2005 and, when completed, the project will consist of 195 1.65-MW turbines for a total of 322 MW. A preconstruction nocturnal radar and visual study was conducted at the site in fall 2004 by ABR (see Section 3.3.1 for comparison of results). A post-construction mortality study was initiated in 2006 (Kerlinger 2006). Approximately 90 bird fatalities of a mix of species were documented during the 2006 mortality study conducted at 50 turbines (draft and anecdotal evidence provided by Al Hicks of NYSDEC). More information on bird fatalities including a site fatality rate and an estimate of the total number of fatalities based on extrapolations for project size, scavenger uptake, and searcher efficiency will be provided in a report to NYSDEC in winter 2007. Based on the anecdotal evidence available, it is anticipated that the bird fatality rates at Maple Ridge will be within range of the national and eastern results.

It is anticipated that the bird fatality rates for the Project will be near the national average and within the range of the national and eastern results. This prediction is based on the results of the bird studies, literature review, and because there are no features in the Project Area that attract or concentrate large numbers of migrating birds. Multiplying the national average and eastern fatality rates for bird kills with the proposed number of turbines provides an approximate number of bird fatalities for the Project (see Table 4-1). These are only estimates and there can be considerable variation in fatality rates. The number of bird fatalities can only be determined with post-construction mortality studies; however, this estimate allows an evaluation of the potential impacts.

Table 4-1 Approximate Number of Bird Fatalities Based on Average National and Eastern Fatality Rates

| Project | Number of Turbines | Approximate Bird Fatalities Per Year Based on Average National Rate[1] | Approximate Bird Fatalities Per Year Based on Average Eastern Rate[2] |
|---|---|---|---|
| Noble Wethersfield | 85 | 196 | 366 |

[1] 2.3 birds/turbine/year (NWCC 2004).
[2] 4.3 birds/turbine/year (NWCC 2004).

### 4.4.2 Bats

Historically the average number of bat kills from wind turbines has varied from facility to facility and was considered a function of a number of factors including the proximity to hibernacula, known migration corridors, and topography. Until the Mountaineer site bat kills in 2003 and 2004, the average had remained low, approximately fewer than three bats/turbine/year killed (BCI 2006). To date, the average has grown to approximately 3.4 bats/turbine/year with the inclusion of the Mountaineer results of 47 bats/turbine/year (NWCC 2004) and this average is likely to increase as more post-construction mortality study results become available (e.g., Maple Ridge site).

No wind energy facilities in New York State were included in the NWCC compilation; however, mortality studies have been conducted at several facilities in the northeast:

- Four dead bats (two Little Brown Bats and two unidentified bats) were found at the Wethersfield wind farm, Wyoming County, facility (10 turbines at 290 feet agl) during a post-construction mortality study conducted by E & E (2006a) in 2005.
- Approximately 400 bat fatalities of a mix of species were documented during the 2006 mortality study conducted at 50 turbines (draft and anecdotal evidence provided by Al Hicks of NYSDEC). More information on bat fatalities including a site fatality rate and an estimate of the total number of fatalities based on extrapolations for project size, scavenger uptake, and searcher efficiency will be provided in a report to NYSDEC in winter 2007. Based on the anecdotal evidence available, it is anticipated that the bat fatality rate at Maple Ridge will be higher than the national average.

It is anticipated that the bat fatality rates for the Project will be near the national average. This prediction is based on the results of the bird and bat studies and because there are no features in the Project Area that attract or concentrate large numbers of bats. Multiplying the national average bat kill rate with the proposed number of turbines provides an approximate number of bat fatalities for the Project (see Table 4-2). However, this is only an estimate and the number of bat fatalities could be substantially higher or lower, as it is difficult to predict whether large scale fatality events will occur at a specific site based on preconstruction studies and there can be considerable variation in bat fatality rates. The number of bat fatalities can only be determined with post-construction mortality studies; however, this estimate allows an evaluation of the potential impacts.

**Table 4-2 Approximate Number of Bat Fatalities Based on National Average Fatality Rate**

| Project | Number of Turbines | Approximate Bat Fatalities Per Year Based on National Average Rate[1] |
|---|---|---|
| Noble Wethersfield | 85 | 289 |

[1] 3.4 bats/turbine/year (low = 0.7; high= 47) (NWCC 2004).

## 4.5 Potential Cumulative Impacts on Birds and Bats from Regional Projects

The proposed Wethersfield Project is evaluated in this Bird and Bat Risk Assessment. The proposed Noble Bliss Project site was evaluated in a bird and bat risk assessment prepared in 2006. This section evaluates the impacts of those Projects with the High Sheldon, Dairy Hills, and Noble Centerville Projects, and the existing Wethersfield wind farm.

An approximate range of bird fatalities for the Project was identified in Section 4.4.1 by multiplying the national average and eastern fatality rates for bird kills with the proposed number of turbines provides (see Table 4-1). Likewise, an approximate number of bat fatalities for the Project was identified in Section 4.4.2 by multiplying the national average bat kill rate with the proposed number of turbines (see Table 4-2). The same calculations are included for the four other currently proposed wind projects in Wyoming County and adjacent Allegany County and the existing Wethersfield wind farm in order to demonstrate the potential cumulative impacts on birds and bats in the region (see Tables 4-3 and 4-4). These are only estimates and there can be considerable variation in fatality rates, especially for bats. The number of bird and bat fatalities can only be determined with post-construction mortality studies; however, this estimate allows an evaluation of the potential cumulative impacts.

**Table 4-3 Approximate Number of Bird Fatalities Based on Average National and Eastern Fatality Rates**

| Project | Number of Turbines | Approximate Bird Fatalities Per Year Based on National Average Rate[1] | Approximate Bird Fatalities Per Year Based on Average Eastern Rate[2] |
|---|---|---|---|
| **Noble Wethersfield** | **85** | **196** | **366** |
| Noble Bliss | 67 | 154 | 288 |
| Noble Centerville | 70 | 161 | 301 |

**Table 4-3 Approximate Number of Bird Fatalities Based on Average National and Eastern Fatality Rates**

| Project | Number of Turbines | Approximate Bird Fatalities Per Year Based on National Average Rate[1] | Approximate Bird Fatalities Per Year Based on Average Eastern Rate[2] |
|---|---|---|---|
| Horizon Dairy Hills | 86 | 198 | 370 |
| Invenergy High Sheldon | 75 | 173 | 323 |
| Wethersfield (existing) | 10 | 23 | 43 |
| **Total** | **393** | **905** | **1,691** |

[1] 2.3 birds/turbine/year (NWCC 2004).
[2] 4.3 birds/turbine/year (NWCC 2004).

**Table 4-4 Approximate Number of Bat Fatalities Based on National Average Fatality Rate**

| Project | Number of Turbines | Approximate Bat Fatalities Per Year Based on National Average Rate[1] |
|---|---|---|
| **Noble Wethersfield** | **85** | **289** |
| Noble Bliss | 67 | 228 |
| Noble Centerville | 70 | 238 |
| Horizon Dairy Hills | 86 | 292 |
| Invenergy High Sheldon | 75 | 255 |
| Wethersfield (existing) | 10 | 34 |
| **Total** | **393** | **1,336** |

[1] 3.4 bats/turbine/year (low = 0.7; high= 47) (NWCC 2004).

The cumulative loss of approximately 900 to 1,700 birds per year is not considered to be biologically significant, especially in consideration of other sources of bird mortality. The USFWS estimates that a minimum of 10 billion birds breed in North America (USFWS 2002). There are many widespread sources of bird mortality. However, it is challenging to compare predicted mortality from a proposed wind site to other sources of mortality, because it is only a prediction and local mortality rates from other sources are rarely quantified to allow comparison. On a national scale, the annual bird mortality associated with wind energy facilities (estimated at 33,000 birds per year in 2002) is slight compared to other sources of mortality, such as vehicles (60 million or more deaths per year), building windows (97 to 976 million deaths per year), power and transmission lines (conservatively tens of thousands deaths per year, possibly closer to 174 million deaths per year), communication towers (conservatively 4 to 5 million deaths per year, possibly closer to 40 to 50 million deaths per year), electrocution (estimated tens of thousands per year), pesticides (at least 72 million deaths annually, likely far more), oil spills (hundreds of thousands of deaths per year), oil and wastewater pits (up to two million deaths per year), cats (hundreds of millions of deaths per year), agricultural practices (i.e., hay mowing), and hunting (Erickson et al. 2001; USFWS 2002). These sources of mortality are also present within the Project Area.

The bird kills would be from many different species. Nocturnal migrant passerines will likely make up the majority of bird kills. This is of concern because of the potential of neotropical migrants, many of which are considered in decline, to be among the fatalities. However, these are also among the species that are most harmed by global warming and air pollution (Price and Glick 2004). For example, recent research suggests that acid precipitation from air pollution is contributing to the steady decline of the Wood Thrush in New York (Hames et al. 2002), where numbers are dropping up to 5% per year. Therefore, there are impacts from both non-renewable energy production and from wind energy. Mr. John Flicker, the president of the National Audubon Society recently (December 14, 2006) commented on this perception issue in support of wind energy (at appropriate sites), saying "When you look at a wind turbine, you can find the bird carcasses and count them. With a coal-fired power plant, you can't count the carcasses, but it's going to kill a lot more birds" (Levesque 2006).

At the present time, the cumulative annual loss of approximately 1,350 bats is not considered to be biologically significant. However, there are increasing concerns about the cumulative impacts of bat fatalities to specific species as the number of wind projects increase and data from ongoing mortality studies are made publicly available. While bird fatalities have been studied and estimated, we are not aware of similar studies for bats and estimates for bat fatalities are not available.

# 5 Mitigation

## 5.1 Siting Approach

The primary mitigation to avoid or reduce potentially significant bird and bat impacts was Noble's approach to siting. Initially, a "fatal flaw" study was conducted to identify whether the Project Area held any potential issues related to birds and bats, among many other categories, that could result in unfavorable impacts. In the siting phase, Noble selected available and appropriate locations for turbines that minimized potential impacts on wetlands, habitat, and land use. These considerations will minimize potential impacts on birds and bats. See Section 1.3 of the DEIS for details on the siting approach and Project alternatives. .

## 5.2 Lighting and Structural Mitigation

During nights of inclement weather and/or poor visibility, passerines may fly at lower altitudes and may be attracted to lights, especially steady (i.e., not blinking) lights. While the reasons for this attraction to lights are not certain, it coincides with evidence from tall structures (e.g., communication/television towers and buildings) that events of increased bird collisions occur on nights with poor visibility at structures with steady light. In order to reduce this potential, turbines will be equipped with slow-blinking lights.

In addition, Noble will:

- Provide the minimum allowable lighting as per FAA requirements;
- Install slow-blinking red lights rather than steady lights or blinking white lights;
- Avoid using non-directional lighting at any structures on site or steady light sources near the turbines. Lighting required on site for safety or security reasons will be directed downward and to the extent practical technology, such as motion sensors will be used to minimize the use of steady light sources.
- Install modern turbines (i.e., solid tubular structures) that are designed to prevent birds from perching or nesting on them. No guy wires will be required for these turbines.

## 5.3 Post-construction Monitoring

Post-construction mortality monitoring will be implemented by Noble to evaluate the actual impacts of the Project on birds and bats. This will help assess the significance of the impacts and, potentially, what the weather or environmental conditions or other circumstances are that contribute to such impacts. Based on real-time, site-specific data collected during the post-construction mortality monitoring, Noble will coordinate closely with NYSDEC to identify and assess potential mitigation strategies that can be implemented to reduce potentially significant adverse impacts, if any. This approach will allow mitigation measures to be developed/modified during the course of Windpark operation that are responsive to site-specific conditions and to the growing and evolving database of information regarding bird/bat interactions with turbines. Noble's work plan for proposed post-construction bird and bat mortality studies is included in Appendix G.

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# A Nocturnal Radar and Visual Study, Spring 2006 (ABR, Inc.)

# A RADAR AND VISUAL STUDY OF NOCTURNAL BIRD AND BAT MIGRATION AT THE PROPOSED CENTERVILLE AND WETHERSFIELD WINDPARKS, NEW YORK, SPRING 2006

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## EXECUTIVE SUMMARY

- This report presents the results of a radar and visual study of bird and bat migration conducted during a 45 d period in spring (16 April–30 May 2006) at the proposed Centerville and Wethersfield Windparks, located in Wyoming and Allegany counties, western New York. Radar observations were conducted during the evening crepuscular period, the entire nocturnal period (~8–9 h/night), and the morning crepuscular period. Visual observations were conducted for ~ 7–8h/night during nocturnal hours only.
- The primary goal of this study was to collect information on the migration characteristics of nocturnally migrating birds, especially passerines, during the spring-migration period and to assess the extent of use of the area by bats. Specifically, the objectives of this study were to: (1) collect baseline information on migration characteristics (i.e., flight direction, migration passage rates, flight altitudes) of nocturnally migrating birds and bats; (2) visually estimate the relative proportions of birds and bats within the potential rotor-swept area of the proposed wind turbines; and (3) determine the number of birds and bats that may pass within the rotor-swept area of the proposed wind turbines during the migratory season.
- The mean flight direction of targets observed on radar was 22° at Centerville and 12° at Wethersfield.
- The mean nocturnal passage rate at Centerville was 290 ± 35 targets/km/h and ranged among nights between 25 and 1,140 targets/km/h. The mean nocturnal passage rate at Wethersfield was 324 ± 27 targets/km/h and ranged among nights between 41 and 907 targets/km/h. Passage rates at Centerville and Wethersfield varied among some hours of the night (especially between crepuscular and nocturnal hours). Overall, the lowest rates occurred during the first hour of sampling (evening crepuscular period) and were followed by increasing rates until the 4th or 5th hour of nocturnal sampling, with declining rates until sunrise.
- The mean nocturnal flight altitude at Centerville was 351 ± 2 m agl and ranged among nights between 114 to 512 m agl. The mean nocturnal flight altitude at Wethersfield was 355 ± 2 m agl and ranged among nights between 97 to 549 m agl. Mean flight altitudes varied among some crepuscular and nocturnal hours of the night at both sites, although, there were not strong differences among most hours. There was no strong pattern as to the timing of the lowest altitudes. Approximately 16% of all targets at Centerville and ~19% at Wethersfield were below the maximal height of the proposed wind turbines (125 m).
- During spring migration at Centerville, passage rates increased later in the season, after long periods of unfavorable weather, and under synoptic weather conditions favorable for migration (i.e., near the center or west of a high pressure system, south or east of a cold front, or south of a warm front). Passage rates decreased at both Centerville and Wethersfield when there was fog or low ceiling heights (<500 m agl) and with increasing barometric pressure (during unfavorable migration conditions).
- During spring migration at Centerville, flight altitudes increased with increasing barometric pressure and decreased with increasing wind speeds. At Wethersfield, flight altitudes were not strongly associated with any of the parameters, indicating no strong patterns with flight altitudes at this site.
- We used visual sampling methods to investigate low-altitude migration of birds and bats. We sampled with both night-vision goggles and spotlights to calculate the proportion of birds and bats below ~<150 m agl. In total, ~84% of our visual observations were birds and ~16% were bats at Centerville and ~82% of our visual observations were birds and ~18% were bats at Wethersfield.
- Assuming an average of 8 nocturnal h/d and 45 d in spring, we estimated a turbine passage rate of 111–825 nocturnal songbird/bat migrants passing within the area occupied by each proposed turbine at Centerville during our spring study period, equivalent to 2.5–18.3

migrants/turbine/d. Making the same assumptions, we estimated a turbine passage rate of 149–1,031 nocturnal songbird/bat migrants passing within the area occupied by each proposed turbine at Wethersfield during spring 2006, equivalent to 3.3–22.9 migrants/turbine/d.

- The key results of our study were: (1) the mean overall passage rate was 290 targets/km/h at Centerville and 324 targets/km/h at Wethersfield; (2) mean nightly passage rates ranged from 25 to 1,140 targets/km/h at Centerville and from 41 to 907 targets/km/h at Wethersfield; (3) the percentage of targets passing below 125 m agl was 15.7% at Centerville and 19.4% at Wethersfield; (4) the estimated turbine passage rate of nocturnal migrants passing within the airspace occupied by each proposed turbine was 2.5–18.3 migrants/turbine/d at Centerville and 3.3–22.9 migrants/turbine/d at Wethersfield; and (5) migrants flying below 150 m agl consisted of ~84% birds and ~16% bats at Centerville and ~82% birds and ~18% bats at Wethersfield.

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## ACKNOWLEDGMENTS

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# INTRODUCTION

Avian collisions with tall, manmade structures have been recorded in North America since 1948 (Kerlinger 2000), with neotropical migratory birds such as thrushes (Turdidae), vireos (Vireonidae), and warblers (Parulidae) seeming to be the most vulnerable to collisions during their nocturnal migrations (Manville 2000). Passerines sometimes collide with wind turbines (Osborn et al. 2000, Erickson et al. 2001, 2002), composing >80% of the fatalities at wind power developments; ~50% of the fatalities at windfarms involve nocturnal migrants (Erickson et al. 2001). Studies examining the impacts of windfarms on birds in the U.S. and Europe suggest that fatalities and behavioral modifications (e.g., avoidance of windfarms) occur in some, but not all, locations (Winkelman 1995, Anderson et al. 1999, Erickson et al. 2001). Both the documentation of bird fatalities at most wind power facilities studied in the US (i.e., ~2 avian fatalities per turbine per year; Erickson et al. 2001) and the paucity of general information on nocturnal bird migration have generated interest in conducting preconstruction studies of nocturnal migration at the many proposed wind power developments throughout the country. Consideration of potential wind power impacts on nocturnal bird migration is particularly important because more birds migrate at night than during the daytime (Gauthreaux 1975, Kerlinger 1995). In particular, passerines ("songbirds") may be more at risk of colliding with structures at night because these birds tend to migrate at lower altitudes than do other groups of birds (e.g., waterfowl, shorebirds; Kerlinger 1995).

Recent data from Appalachian ridgetops in the eastern U.S. (Erickson 2004, Kerns 2004) have indicated that substantial bat kills are also possible at wind power projects. Most of the bat fatalities documented at wind farms have been associated with migratory species during seasonal periods of dispersal and migration in late summer and fall and several hypotheses have been posited, but not tested, to explain bat/turbine interactions (Arnett 2006).

Although the precise relationship between nocturnal bird/bat use and fatality at wind power developments currently is unknown, the current radar study was undertaken to provide baseline information on nocturnal bird and bat migration at the proposed Centerville and Wethersfield Windparks during spring 2006.

Noble Environmental Power, LLC proposes to build the Centerville Windpark, a ~99-MW wind power development in Allegany County and the Wethersfield Windpark, an ~129-MW wind power development in Wyoming County in southwestern New York (Fig. 1). Each of the ~50–60 wind turbines (Centerville) and ~86 wind turbines (Wethersfield) will have a generating capacity of up to ~1.5–2.0 MW. The monopole towers will be ~78 m (256 ft) in height, and each turbine will have three rotor blades. The diameter of the rotor blades and hub will be ~80 m (262 ft), thus, the total maximal height of a turbine will be ~118 m (387 ft) with a blade in the vertical position. The proposed developments are located in the Appalachian Plateau physiographic province (USGS 2003). Although these physiographic areas contain well-documented migration corridors for some species of birds (Bull 1985, Bellrose 1976, Zalles and Bildstein 2000), the migratory pathways of most nocturnal migrants are poorly documented.

# OBJECTIVES

The primary goal of this study was to collect information on the migration characteristics of nocturnally migrating birds (especially passerines) and bats during spring migration. Specifically, the objectives of this study were to: (1) collect baseline information on migration characteristics (i.e., flight direction, migration passage rates, flight altitudes) of nocturnally migrating birds and bats; (2) visually estimate the relative proportions of birds and bats within the potential rotor-swept area of the proposed wind turbines; and (3) determine the number of birds and bats that would pass within the rotor-swept area of the proposed wind turbines during the migratory season. We also evaluated the influence of weather on migration passage rates and flight altitudes.

# STUDY AREA

The proposed Centerville and Wethersfield Windparks are located in the Appalachian Plateau region of southwestern New York, near the towns of Arcade and Warsaw in Allegany and Wyoming Counties, respectively (Fig. 1). This region is

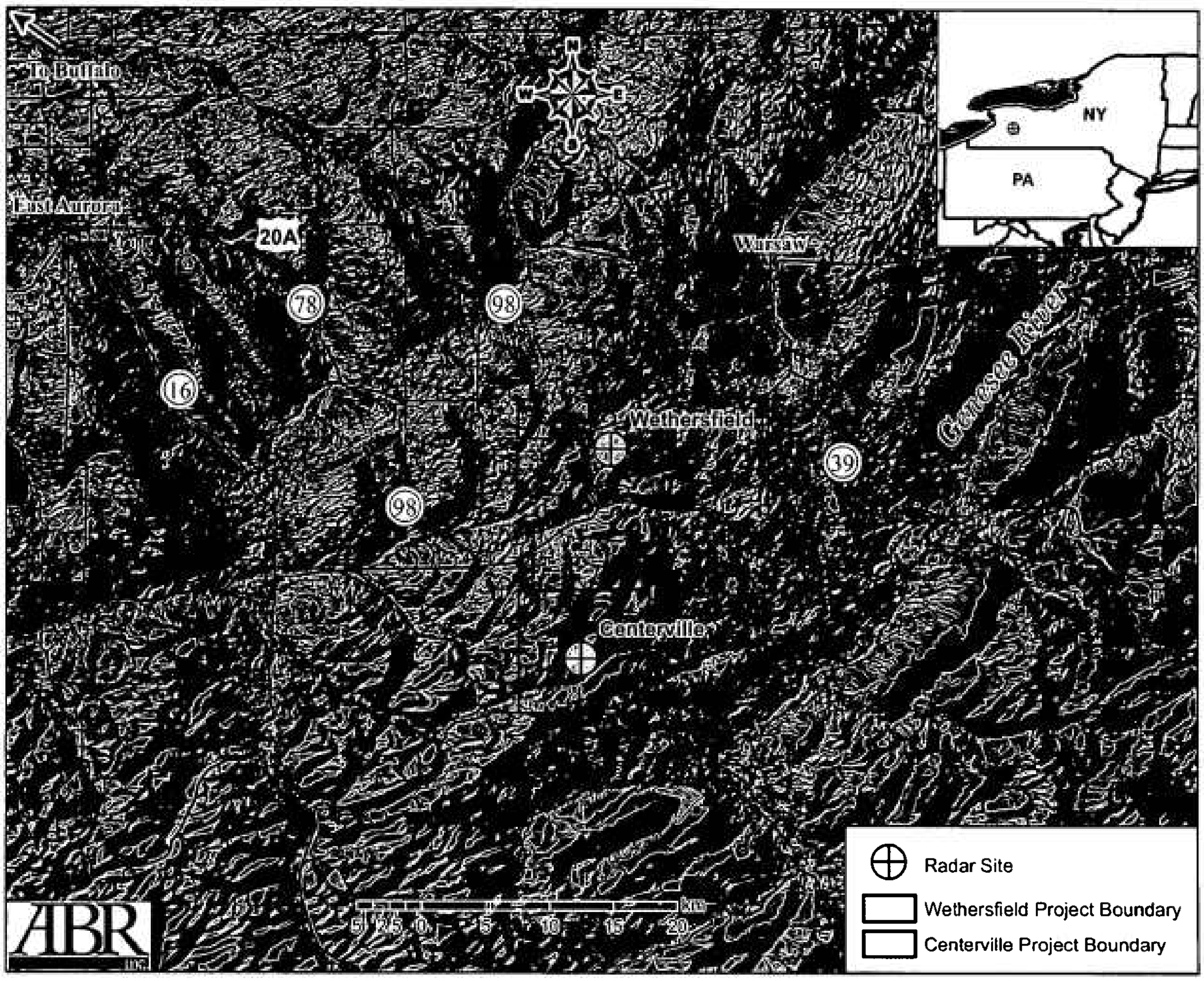


Figure 1. Map of the proposed Centerville and Wethersfield Windparks in Wyoming and Allegany Counties, New York.

characterized by rolling terrain with elevation ranging from ~1,312–1,969 ft (~400–600 m) above sea level (asl) and is part of the Appalachian Plateau physiographic province (USGS 2003). Both the proposed Noble Centerville and Wethersfield Windparks are located in rural locations with limited and dispersed residential development, in rolling terrain with a mix of woodlots, open farmland, dairy farms, and forested wetlands scattered throughout the project area. Virtually all of the land previously has been logged in both project areas.

The proposed Centerville development is located ~5 miles (~8 km) east of Arcade, NY, and the proposed Wethersfield development is located ~7 miles (~11 km) southwest of Warsaw, NY. Our Centerville radar sampling site (42°28'29"N, 78°15'52"W) was located ~ 2,133 ft (650 m) asl on a small ridge in the middle of the proposed project area overlooking the town of Centerville whereas the Wethersfield radar sampling site (42°36'54"N, 78°14'51"W) was located ~ 1,969 ft (600 m) asl in an open field near the center of the proposed project area (Fig. 1).

## METHODS

### STUDY DESIGN

We conducted radar and visual observations on 45 nights during spring (15 April to 30 May

2006) to overlap with the peak of passerine migration (Buffalo Ornithological Society 2002). We obtained useable data from radar observations during 42 nights at Centerville (42 nights for visual observations) and 44 nights for Wethersfield (43 nights for visual observations); on the remaining nights, we were unable to conduct radar observations because of inclement weather (rain or fog) or problems with our radar equipment. Each night, we conducted radar and visual surveys during the evening crepuscular period (sunset to ~ 45 min after sunset), the entire nocturnal period (~45 min after sunset to ~45 min before sunrise) and the morning crepuscular period (~45 min before sunrise to sunrise) between the hours of 1945 and 0630, for a total of ~10–11 h/night. Sampling during all crepuscular and nocturnal hours was done at the request of the New York Department of Environmental Conservation. This sampling schedule provides coverage before, during, and beyond the peak hours of nocturnal passerine migration within a night (Lowery 1951, Gauthreaux 1971, Alerstam 1990, Kerlinger 1995, Mabee et al., in press).

## RADAR EQUIPMENT

Our mobile radar laboratory consisted of a marine radar that was mounted on the roof of a van and that functioned as both a surveillance and vertical radar. When the antenna was in the horizontal position (i.e., in surveillance mode), the radar scanned the area surrounding the lab (Fig. 2), and we manually recorded information on flight direction, flight behavior, passage rates, and groundspeeds of targets. When the antenna was placed in the vertical position (i.e., in vertical mode), the radar scanned the area in an arc across the top of the lab (Fig. 3), and we manually measured flight altitudes of targets with an index line on the monitor. All data were recorded manually into a laptop computer. A description of a similar radar laboratory can be found in Gauthreaux (1985a, 1985b) and Cooper et al. (1991), and a similar vertical radar configuration was described by Harmata et al. (1999).

The radar (Furuno Model FR-1510 MKIII; Furuno Electric Company, Nishinomiya, Japan) is a standard marine radar transmitting at 9.410 GHz (i.e., X-band) through a 2-m-long slotted waveguide (antenna) with a peak power output of 12 kW. The antenna had a beam width of 1.23° (horizontal) × 25° (vertical) and a sidelobe of ±10–20°. Range accuracy is 1% of the maximal range of the scale in use or 30 m (whichever is greater) and bearing accuracy is ±1°.

This radar can be operated at a variety of ranges (0.5–133 km) and pulse lengths (0.07–1.0 μsec). We used a pulse length of 0.07 μsec while operating at the 1.5-km range. At shorter pulse lengths, echo resolution is improved (giving more accurate information on target identification, location, and distance), whereas, at longer pulse lengths, echo detection is improved (increasing the probability of detecting a target). An echo is a picture of a target on the radar monitor; a target is one or more birds (or bats) that are flying so closely together that the radar displays them as one echo on the display monitor. This radar has a digital color display with several scientifically useful features, including True North correction for the display screen (to determine flight directions), color-coded echoes (to differentiate the strength of return signals), and on-screen plotting of a sequence of echoes (to depict flight paths). Because targets plot every sweep of the antenna (i.e., every 2.5 sec) and because groundspeed is directly proportional to the distance between consecutive echoes, we were able to measure ground speeds of plotted targets to the nearest 5 mi/h (8 km/h) with a hand-held scale.

Energy reflected from the ground, surrounding vegetation, and other solid objects that surround the radar unit causes a ground-clutter echo to appear on the display screen. Because ground-clutter echoes can obscure targets, we minimized their occurrence by elevating the forward edge of the antenna by ~15° and by parking the mobile radar laboratory in locations that were surrounded by low trees or low hills, whenever possible. These objects act as a radar fence that shields the radar from low-lying objects farther away from the lab and that produces only a small amount of ground clutter in the center of the display screen. For further discussion of radar fences, see Eastwood (1967), Williams et al. (1972), Skolnik (1980), and Cooper et al. (1991).

Maximal distances of detection of targets by the surveillance radar depends on radar settings

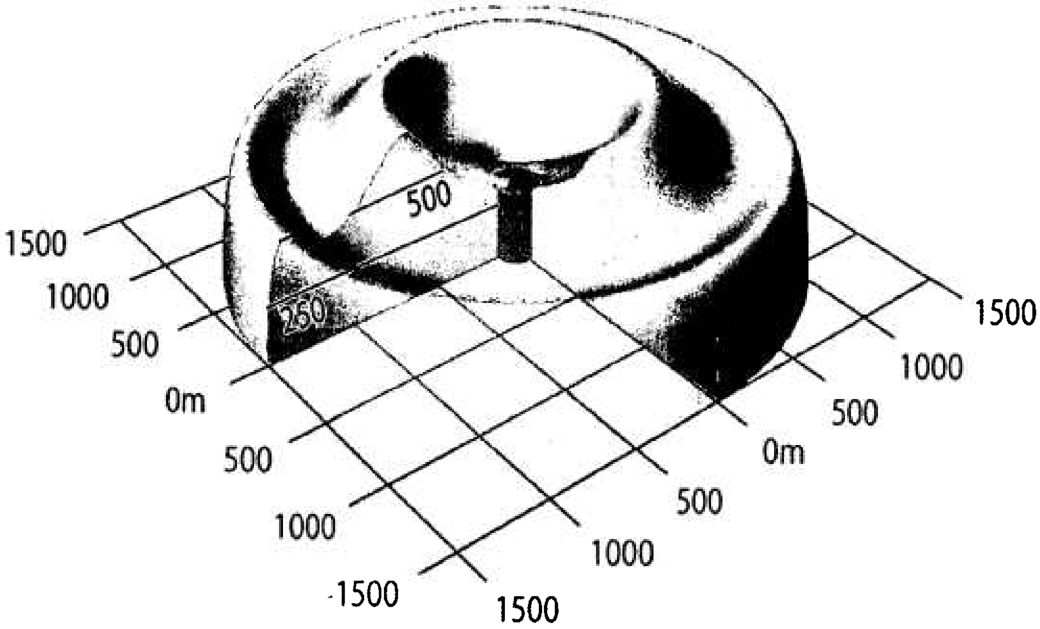


Figure 2. Approximate airspace sampled by Furuno FR–1510 marine radar when operating in the surveillance mode (antenna in the horizontal orientation) as determined by field trials with Rock Pigeons. Note that the distribution of the radar beam within 250 m of the origin (i.e., the darkened area) was not determined.

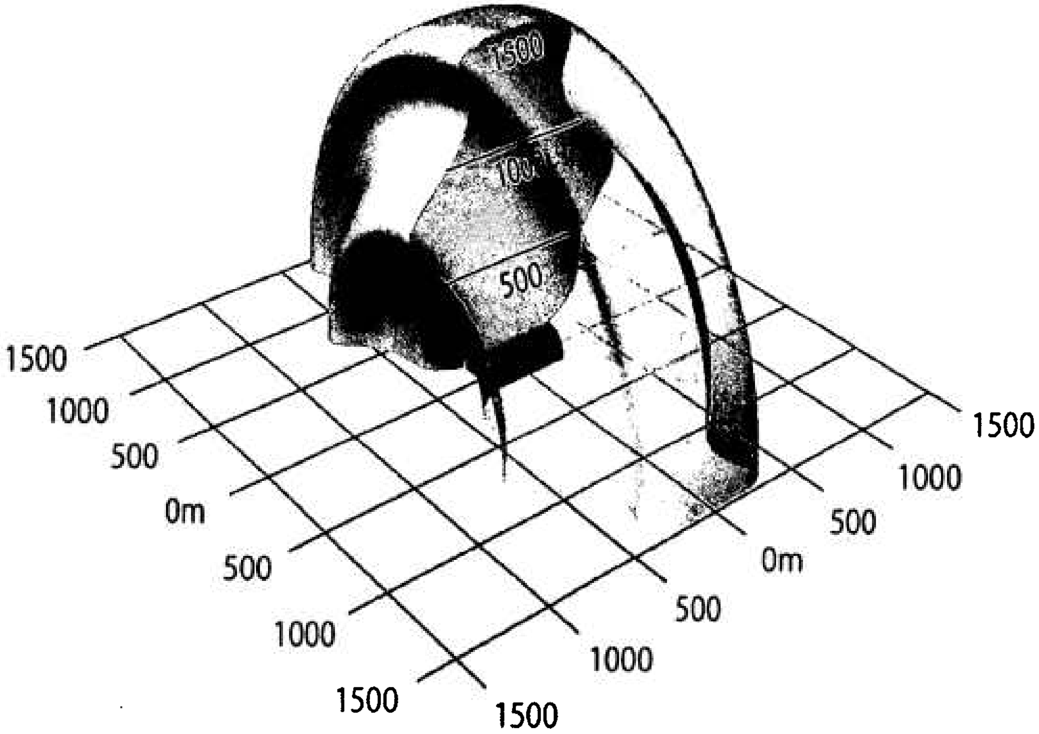


Figure 3. Approximate airspace sampled by Furuno FR–1510 marine radar when operating in the vertical mode (antenna in the vertical orientation) as determined by field trials with Rock Pigeons. Note that the distribution of the radar beam within 250 m of the origin (i.e., the darkened area) was not determined.

(e.g., gain and pulse length), target body size, flock size, flight profile, proximity of targets in flocks, atmospheric conditions, and, to some extent, the amount and location of ground clutter. Flocks of waterfowl routinely were detected to 5–6 km, individual hawks usually were detected to 2–3 km, and single, small passerines were routinely detected out to 1–1.5 km (Cooper et al. 1991).

## DATA COLLECTION

### TARGET IDENTIFICATION ON RADAR

The species composition and size of a flock of birds or bats observed on the radar usually was unknown. Therefore, the term "target," rather than "flock" or "individual," is used to describe animals detected by the radar. Based on the study period and location, it is likely that the majority of targets that we observed were individual passerines, which generally do not migrate in tight flocks (Lowery 1951, Kerlinger 1995); it also is likely that a smaller number of targets were migratory bats. Differentiating among various targets (e.g., birds, bats, insects) is central to any radar study, especially with X-band radars that can detect small flying animals. Because bat flight speeds overlap with flight speeds of passerines (i.e., are >6 m/s; Tuttle 1988, Larkin 1991, Bruderer and Boldt 2001, Kunz and Fenton 2003; Cooper and Day, ABR Inc., unpubl. data), it was not possible to separate bird targets from bat targets based solely on flight speeds. We were able to exclude foraging bats based on their erratic flight patterns; however, migratory bats or any bats not exhibiting erratic flight patterns were included in our data.

Of primary importance in target identification is the elimination of insect targets. We reduced insect contamination by (1) omitting small targets (the size of gain speckles) that only appeared within ~500 m of the radar and targets with poor reflectivity (e.g., targets that plotted erratically or inconsistently in locations having good radar coverage); and (2) editing data prior to analyses by omitting surveillance and vertical radar targets with corrected airspeeds <6 m/s (following Diehl et al. 2003). The 6 m/s airspeed threshold was based on radar studies that have determined that most insects have an airspeed of <6 m/s, whereas that of birds and bats usually is ≥6 m/s (Tuttle 1988, Larkin 1991, Bruderer and Boldt 2001, Kunz and Fenton 2003; Cooper and Day, ABR Inc., unpubl. data).

### SAMPLING DESIGN

We sampled during all nocturnal hours in this study to ensure that migration metrics from this study would be based on all possible hours and nocturnal conditions and, therefore, would be representative of the nocturnal period. We also sampled during dusk and dawn periods to determine if there were bird movements (e.g., taking off and landing) occurring within the height of the proposed wind turbines. This intensive sampling schedule (actually a census of all crepuscular and nocturnal hours) was done at the request of the New York Department of Environmental Conservation.

Each of the 10–11 one-hr crepuscular and nocturnal radar sampling sessions/night consisted of: (1) one 10-min session to collect weather data and adjust the radar to surveillance mode; (2) one 10-min session with the radar in surveillance mode (1.5-km range) for collection of information on migration passage rates; (3) one 15-min session with the radar in surveillance mode (1.5-km range) for collection of information on groundspeed, flight direction, tangential range (minimal perpendicular distance to the radar laboratory), transect crossed (the four cardinal directions—north, south, east, and west), species (if known), and the number of individuals (if known); (4) one 10-min session to collect weather data and adjust the radar to vertical mode; and (5) one 15-min session with the radar in vertical mode (1.5-km range) to collect information on flight altitudes, speed, and direction.

For each vertical radar session, the antenna was oriented parallel to the main axis of migration (determined by the modal flight direction seen during the previous surveillance radar session) to maximize the true flight speed of targets. True flight speeds of targets can be determined only for those targets flying parallel to the antenna's orientation because slower speeds are obtained when targets fly at an angle to this plane of orientation. During 6–30 May, we also examined the flight behavior of vertical radar targets during crepuscular and nocturnal hours by recording whether targets were ascending from the ground, ascending at a steep angle above ground (extrapolated flight path would have intersected the ground on the monitor), flying at a level altitude, descending at a steep angle (extrapolated flight path would have intersected the ground on the monitor), and descending to the ground.

Weather data collected twice each hour consisted of the following: wind speed (collected with a "Kestrel" anemometer in 5-mph [2.2-m/s] categories); wind direction (in ordinal categories to the nearest 45°); cloud cover (to the nearest 5%); ceiling height (in m agl; 1–50, 51–100, 100–150, 151–500, 501–1,000, 1,001–2,500, 2,501–5,000, >5,000); minimal visibility in a cardinal direction (in m; 0–50, 51–100, 101–500, 501–1,000, 1,001–2,500, 2,501–5,000, >5,000); precipitation level (no precipitation, fog, drizzle, light rain, heavy rain, snow flurries, light snowfall, heavy snowfall, sleet, hail); barometric pressure, and air temperature (measured with a thermometer to the nearest 1°C). We could not collect radar data during rain because the electronic filtering required to remove the echoes of the precipitation from the display screen also removed those of the targets of interest. We also obtained weather data (wind speed and wind direction) from a 50-m high meteorological tower located near the sites.

### VISUAL OBSERVATIONS OF LOW-ALTITUDE BIRDS AND BATS

We conducted visual observations with Generation 3 night-vision goggles with a 1X eyepiece (Model ATN-PVS7; American Technologies Network Corporation, San Francisco, CA) every night to assess relative numbers and proportions of birds and bats flying at low altitudes (≤150 m agl, the approximate maximal distance that passerines and bats could be discerned).

We used two 3 million-Cp spotlights with infrared lens filters to illuminate targets flying overhead while eliminating the attractiveness of the light to insects, birds, and bats. One "fixed" spotlight was mounted on a tripod with the beam oriented vertically, while a second, handheld light was used to track and identify potential targets flying through the "fixed" spotlight's beam. Two sampling sessions of ~20–25 min were conducted each hour, concurrent with radar surveys, during all nightly sessions. For each bird or bat detected visually, we recorded the taxon (to species when possible), flight direction, flight altitude, and behavior (straight-line, erratic, circling, hovering). Whenever possible, bats were classified as "small bats" or "large bats," in an attempt to discriminate the larger Hoary (*Lasiurus cinereus*), Eastern Red (*Lasiurus borealis*), Big Brown (*Eptesicus fuscus*), and Silver-haired (*Lasionycteris noctivagans*) bats from smaller species (e.g., *Myotis* spp.).

## DATA ANALYSES

### RADAR DATA

We entered all radar data into MS Access databases. Data files were checked visually for errors after each night and then were checked again electronically for irregularities at the end of the field season, prior to data analyses. All analyses were conducted with SPSS statistical software (SPSS 2005). For quality assurance, we cross-checked results of the SPSS analyses with hand-tabulations of small data subsets whenever possible. The level of significance ($\alpha$) for all statistical tests was set at 0.05.

Radar data were not corrected for differences in detectability with distance from the radar unit. Correcting for differences in target detectability is confounded by several factors, including but not limited to the following: (1) variation in target size (i.e., species) across the study period; (2) an assumption that there is an equal distribution of targets throughout the sampling area (which would be violated if migrants responded to landform or microsite features on the landscape); (3) variation in the shape and size of the effective radar-sampling beam (see our preliminary assessment of the shape of our radar beam under one set of conditions in Figures 2 and 3). Thus, our passage rate estimates (and other estimates derived from passage rates) should be considered an index of the actual number of birds and bats passing through the area, useful for comparisons with our previous studies and other radar studies that use similar equipment and methods.

Airspeeds (i.e., groundspeed corrected for wind speed and relative direction) of surveillance-radar targets were computed with the formula:

$$V_a = \sqrt{V_g^{\,2} + V_w^{\,2} - 2V_gV_w\cos\theta},$$

where $V_a$ = airspeed, $V_g$ = target groundspeed (as determined from the radar flight track), $V_w$ = wind velocity, and $\theta$ is the difference between the observed flight direction and the direction of the wind vector. Targets that had corrected airspeeds <6 m/s (6.4% and 3.3% of surveillance data at Centerville and Wethersfield, respectively), were deleted from all analyses.

We analyzed flight-direction data following procedures for circular statistics (Zar 1999) with Oriana software version 2.0 (Kovach 2003). The dispersion of flight directions is presented as the mean vector length (*r*), which varies from a value of 0 (maximal dispersion) to 1 (maximal concentration). Because flight directions of visual targets were recorded only in 45° increments, we only report median values of these directions, as mean values could be misleading. Migration passage rates are reported as the mean ± 1 standard error (SE) number of targets passing along 1 km of migratory front/h (targets/km/h ± 1 SE). Passage rates of targets flying <125 m in altitude were derived for each hourly period by multiplying passage rates recorded from surveillance radar by the percentage of targets on vertical radar having flight altitudes <125 m, correcting for the hypothetical maximal height of the surveillance radar beam. All flight-altitude data are presented in m agl (above ground level) relative to a horizontal plane passing through the radar-sampling site. Actual mean altitudes may be higher than those reported because an unknown number of birds fly above the 1.5-km range limit of our radar (Mabee and Cooper 2004).

For calculations of the daily patterns in migration passage rates and flight altitudes, we assumed that a day began at 0700 h on one day and ended at 0659 h the next day, so that a sampling night was not split between two dates. We used repeated-measures ANOVAs with the Greenhouse-Geisser epsilon adjustment for degrees of freedom (SPSS 2005), to compare passage rates and flight altitudes among hours of the night for nights with data collected during all sessions. Factors that decreased our sample size of the various summaries and analyses included insect contamination and precipitation. Sample sizes therefore sometimes varied among the different summaries and analyses.

## EFFECTS OF WEATHER ON MIGRATION PASSAGE RATES AND FLIGHT ALTITUDES

We modeled the hourly influence of weather and date separately on the dependent variables passage rates and flight altitudes. We obtained our weather data (i.e., wind speed and direction) from a 50-m meteorological tower located near the radar sampling sites. All wind categories except the calm category had a mean wind speed of ≥2.2 m/s (i.e., ≥5 mph) and were categorized as the following during spring: head winds WNW to ENE (i.e., 293°–068°), tail winds ESE to SSW (i.e., 113°–248°), eastern crosswinds (069°–112°), western crosswinds (249°–292°), and calm (0–2.2 m/s).

Prior to model specification, we examined the data for redundant variables (Spearman's $r_s$ >0.70) and retained eight parameters for inclusion in the passage rate model set and seven parameters in the altitude model set. We examined scatterplots and residual plots to ensure that variables met assumptions of analyses (i.e., linearity, normality, collinearity) and did not contain presumed outliers (>3 SE). We used a natural logarithm transformation on the dependent variables "passage rate" for both sites and used no transformation and a square root transformation on the dependent variable "flight altitude" at the Centerville and Wethersfield sites, respectively, to make the data normal. We specified 35 models for passage rates and 30 models for flight altitudes: a global model containing all variables and subset models representing potential influences of five small-scale weather variables (wind speed, wind direction, ceiling height (including fog), and daily barometric pressure change), one large-scale weather variable (synoptic —that reflected the position of pressure systems or frontal systems relative to our study site (Fig. 4), one variable reflecting the number of days between favorable migration conditions (i.e., the number of days since last tail wind, used only in passage rate models), one variable describing the percent of the moon illuminated on a given night, and date on migration passage rates and flight altitudes. Synoptic weather

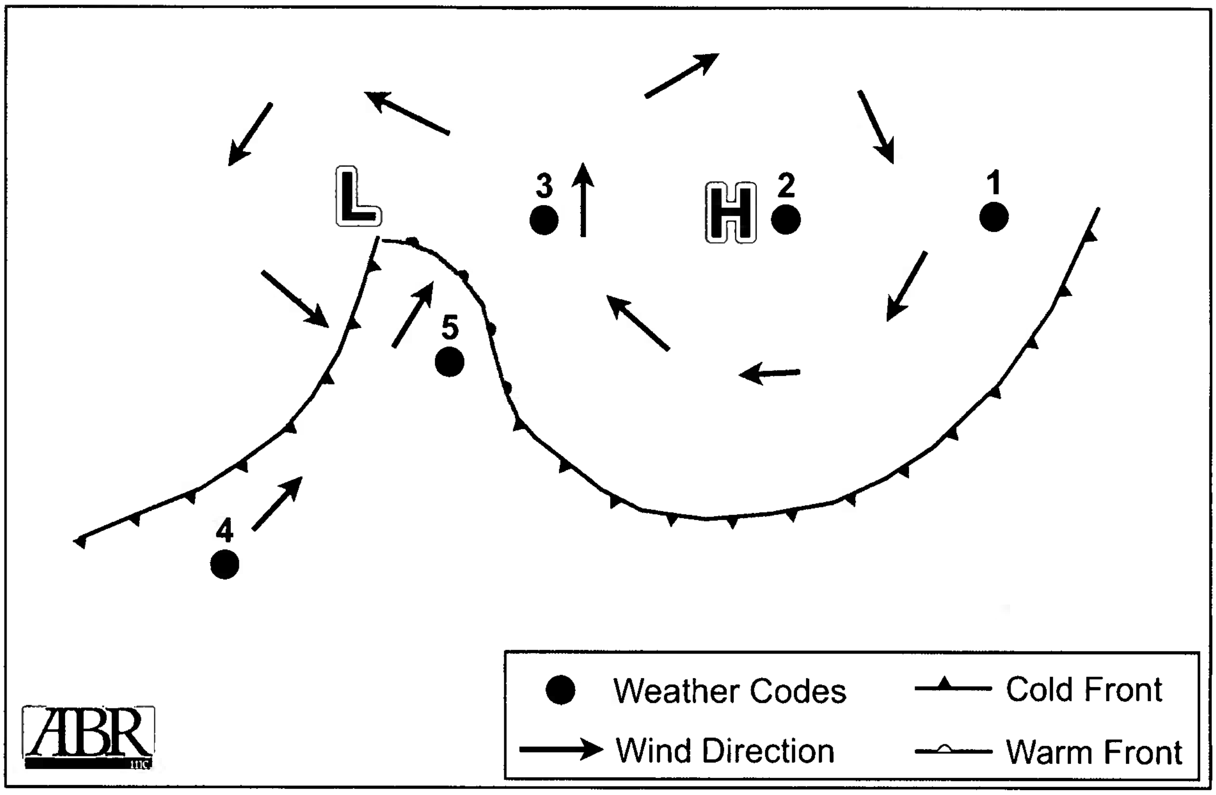


Figure 4. Synoptic weather codes used to depict the position of pressure systems or frontal systems relative to our study site. Code 1 = N or W of cold front, 2 = near center of high pressure system, 3 = W of high pressure system, 4 = S or E of cold front, 5 = S of warm front.

codes were based on Gauthreaux (1980) and Williams et al. (2001). We analyzed all model sets with linear mixed models that treated nights as subjects and hourly sessions within a night as the repeated measure. This treatment of the data allows the full use of hourly sessions while properly modeling the appropriate covariance structure for this variable. Because the hourly sessions within a night were temporally correlated, we used a first-order autoregressive structure with heterogeneous variances for the covariance structure for both the passage rate and altitude models.

Because the number of sampling sessions for both passage rates ($n = 327$ at Centerville, $n = 341$ at Wethersfield) and flight altitudes ($n = 288$ at Centerville, $n = 299$ at Wethersfield) was small relative to the number of parameters ($K$) in many models (i.e., $n/K < 40$), we used Akaike's Information Criterion corrected for small sample size ($AIC_c$) for model selection (Burnham and Anderson 2002). We ranked all candidate models according to their $AIC_c$ values and considered the best-approximating model (i.e., most parsimonious) to be that model having the smallest $AIC_c$ value (Burnham and Anderson 2002). We drew primary inference from models within 2 units of the minimal $AIC_c$ value, although models within 4–7 units may have some empirical support (Burnham and Anderson 2002). We calculated Akaike weights ($w_i$) to determine the weight of evidence in favor of each model (Burnham and Anderson 2002). All analyses were conducted with SPSS software (SPSS 2005).

## TURBINE PASSAGE RATE INDEX

To describe migration passage rates within the potential turbine area we developed the turbine passage rate index (the number of nocturnal migrants flying within the turbine area throughout the study period). The turbine passage rate index is comprised of several components, including: (1) *passage rate of targets flying < 125 m agl* (calculated by multiplying passage rates from surveillance radar by the percentage of targets on vertical radar with flight altitudes <125 m agl, correcting for the maximal height of the surveillance radar beam); (2) *turbine area* that migrants would encounter when approaching turbines from the side (parallel to the plane of rotation) or from the front (perpendicular to the plane of rotation); (3) *study period* (number of nights during the migration period); and (4) *number of hours of migration/night* (estimated as the number of nocturnal hours). These factors are combined as described in Appendix 1 to produce the turbine passage rate index.

We consider these estimates to be indices because they are based on several simplifying assumptions that may vary among projects. The assumptions for this specific project include: (1) minimal (i.e., side profile) and maximal (i.e., front profile, including the entire rotor-swept area) areas occupied by the wind turbines relative to the flight directions of migrants, (2) a worst-case scenario of the rotor blades turning constantly (i.e., used the entire rotor swept area, not just the area of the blades themselves), (3) a 45-d migration period (spring), and (4) an average of 8 nocturnal hours/day of migration during spring migration.

## RESULTS

### FLIGHT DIRECTION

At night, most radar targets were traveling in seasonally appropriate directions for spring migration (i.e., northerly), with a mean flight direction of 22° at Centerville (mean vector length = 0.55; median = 20°; *n* = 12,709 targets; Fig. 5a) and a mean flight direction of 12° at Wethersfield (mean vector length = 0.59; median = 19°; *n* = 14,524 targets; Fig. 5b). Most of the nocturnal

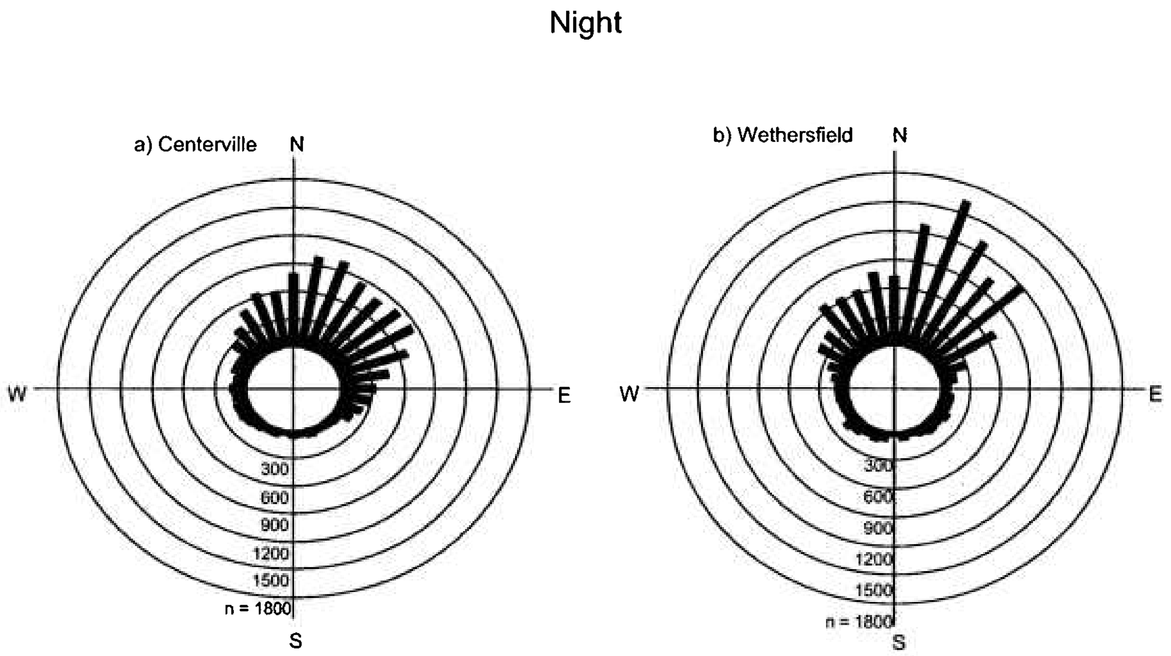


Figure 5. Flight directions of radar targets at the proposed (a) Centerville and (b) Wethersfield Windparks, New York, spring 2006.

targets were traveling in a northerly direction, between NW (315°) and NE (45°) at Centerville (50%) and at Wethersfield (59%).

## PASSAGE RATES

The mean nocturnal passage rate for the spring season during nocturnal hours was 290 ± 35 targets/km/h (*n* = 42 nights) at Centerville and was 324 ± 27 targets/km/h (*n* = 44 nights) at Wethersfield. Mean passage rates differed significantly between the Centerville and Wethersfield sites ($Z_{paired}$ = -2.182, *P* = 0.029, *n* = 42 paired nights). Overall mean nightly passage rates were highly variable among nights at Centerville (range = 25–1,140 targets/km/h; Fig. 6a) and at Wethersfield (range = 41–907 targets/km/h; Fig. 6b) and during different time periods of the migratory season (Appendix 2).

Passage rates varied significantly among crepuscular and nocturnal hours of the night for nights with 9 hours darkness/night at Centerville ($F_{4.5,\ 62.9}$ = 7.3; *P* < 0.001; *n* = 15 nights; Fig. 7a) and Wethersfield ($F_{4.5,\ 72.5}$ = 7.4; *P* < 0.001; *n* = 17 nights; Fig. 7c), and among nocturnal hours only at Centerville ($F_{4.3,\ 72.5}$ = 3.0; *P* = 0.020; *n* = 18 nights; Fig. 7a) but not Wethersfield ($F_{3.9,\ 62.4}$ = 2.4; *P* = 0.058; *n* = 17 nights; Fig. 7c). Passage rates varied significantly among all crepuscular and nocturnal hours of the night for nights with 8 hours darkness/night at Centerville ($F_{3.1,\ 36.9}$ = 9.0; *P* < 0.001; *n* = 13 nights; Fig. 7b) and Wethersfield ($F_{2.5,\ 35.5}$ = 8.9; *P* < 0.001; *n* = 15 nights; Fig. 7d), but not among nocturnal hours at Centerville ($F_{3.0,\ 47.5}$ = 0.4; *P* = 0.726; *n* = 17 nights; Fig. 7b) and Wethersfield ($F_{2.4,\ 41.6}$ = 1.7; *P* = 0.181; *n* = 18 nights; Fig. 7d). Overall, the lowest rates occurred during the first hour of sampling (evening crepuscular period) and were followed by increasing rates until the 4th or 5th hour of nocturnal sampling, with declining rates until sunrise.

## FLIGHT ALTITUDES

The mean nocturnal flight altitude for the entire spring season during nocturnal hours was 351 ± 2 m agl (*n* = 11,750 targets; median = 305 m agl) at Centerville and 355 ± 2 m agl (*n* = 15,291 targets; median = 296 m agl) at Wethersfield. Mean flight altitudes differed significantly between the Centerville and Wethersfield sites (Wethersfield 15 m > Centerville; $Z_{paired}$ = -2.093, *P* = 0.036, *n* = 41 paired nights). Mean flight altitudes observed on vertical radar (1.5-km range) were highly variable among nights ranging from 114 to 512 m agl at Centerville (Fig. 8a) and from 97 to 549 at Wethersfield (Fig. 8b). Flight altitudes were also variable during different portions of the migratory season (Appendix 2).

Mean flight altitudes varied among crepuscular and nocturnal hours of the night for nights with 9 hours darkness/night at Centerville ($F_{4.7,\ 79.5}$ = 2.8; *P* = 0.025; *n* = 18 nights; Fig. 9a) and at Wethersfield ($F_{3.8,\ 76.1}$ = 3.3; *P* = 0.016; *n* = 21 nights; Fig. 9c), but not among nocturnal hours only at Centerville ($F_{4.0,\ 80.0}$ = 1.1; *P* = 0.342; *n* = 21 nights; Fig. 9a) and at Wethersfield ($F_{3.4,\ 75.0}$ = 1.1; *P* = 0.371; *n* = 23 nights; Fig. 9c). Mean flight altitudes did not vary among crepuscular and nocturnal hours of the night only for nights with 8 hours darkness/night at Centerville ($F_{2.6,\ 18.1}$ = 1.7; *P* = 0.201; *n* = 8 nights; Fig. 9b) and Wethersfield ($F_{2.6,\ 20.5}$ = 1.7; *P* = 0.198; *n* = 9 nights; Fig. 9d), nor did they vary among nocturnal hours only at Centerville ($F_{2.2,\ 21.1}$ = 3.1; *P* = 0.059; *n* = 11 nights; Fig. 9b) and Wethersfield ($F_{2.3,\ 24.9}$ = 2.2; *P* = 0.133; *n* = 12 nights; Fig. 9d). Overall the lowest altitudes occurred at variable times of the crepuscular and nocturnal periods and no strong pattern was evident.

The overall distribution of targets in 100-m categories of nocturnal flight altitudes at Centerville varied from 20.2% in the 101–200 m agl interval to 0% in the 1,401–1,500 m agl interval and flight altitudes at Wethersfield varied from 20.3% in the 101–200 m agl interval to 0% in the 1,401–1,500 m agl interval (Table 1). A detailed examination of the percent of targets within 250 m agl (by 25-m categories) for both sites is provided in Appendix 3. We determined during nocturnal hours that 15.7% of all targets flew <125 m at Centerville and that 19.4% of all targets flew <125 m at Wethersfield, which is the approximate maximal height of the proposed wind turbines.

Observations of the flight behavior of targets during crepuscular and nocturnal hours showed that the vast majority of targets flew over the Centerville and Wethersfield sites at level flight altitudes (Fig. 10). We observed small percentages of birds taking off and landing as well as ascending

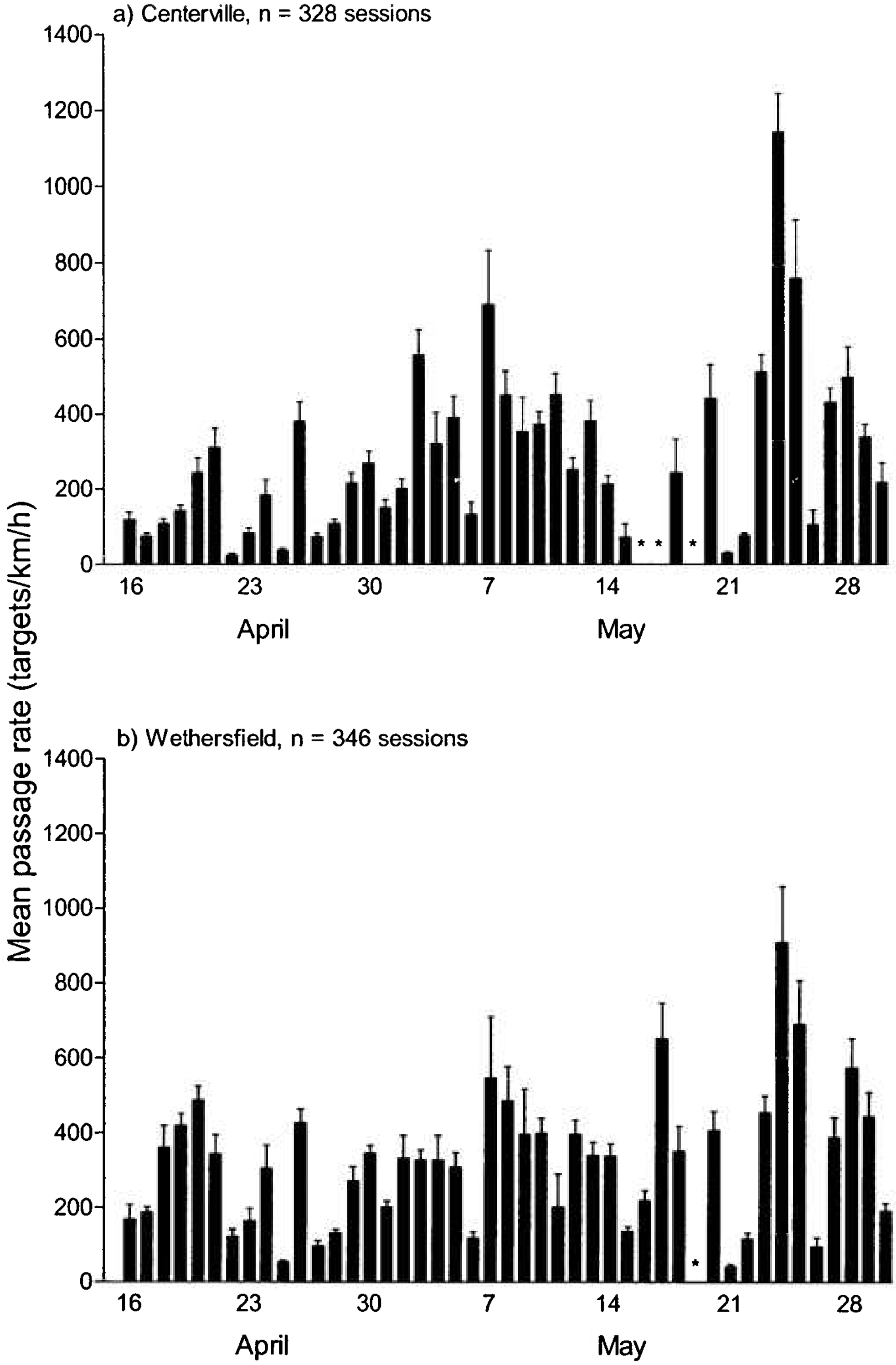


Figure 6. Mean ± 1 SE nightly passage rates (targets/km/h) at the proposed (a) Centerville and (b) Wethersfield Windparks, New York, spring 2006.

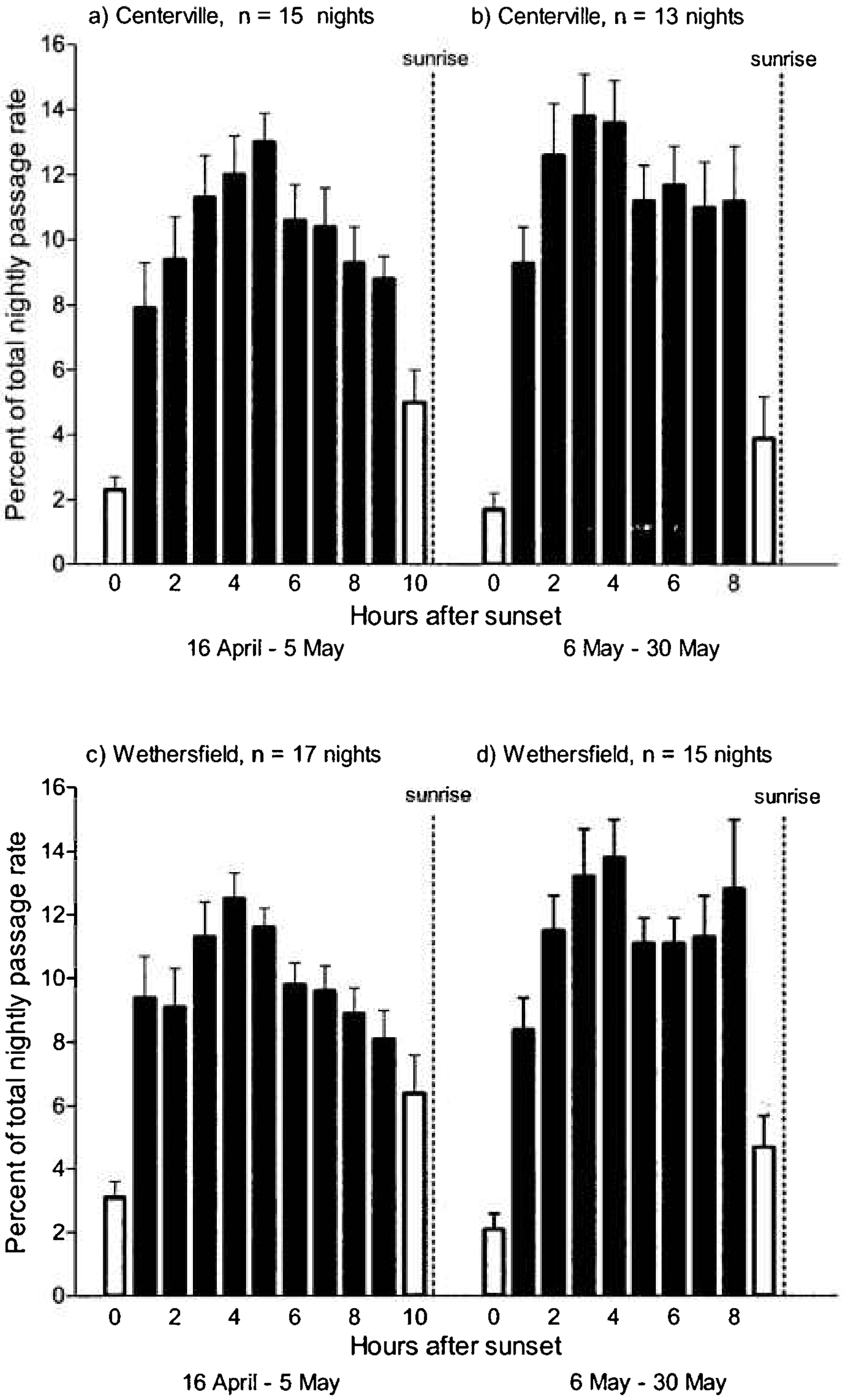


Figure 7. Percent of nightly passage rate (± 1 SE) relative to time past sunset for nights that had 9 hours of darkness/night at (a) Centerville and (c) Wethersfield and 8 hours of darkness/night (b) Centerville and (d) Wethersfield at the proposed Centerville and Wethersfield Windparks, New York, spring 2006. First and last hours are crepuscular periods.

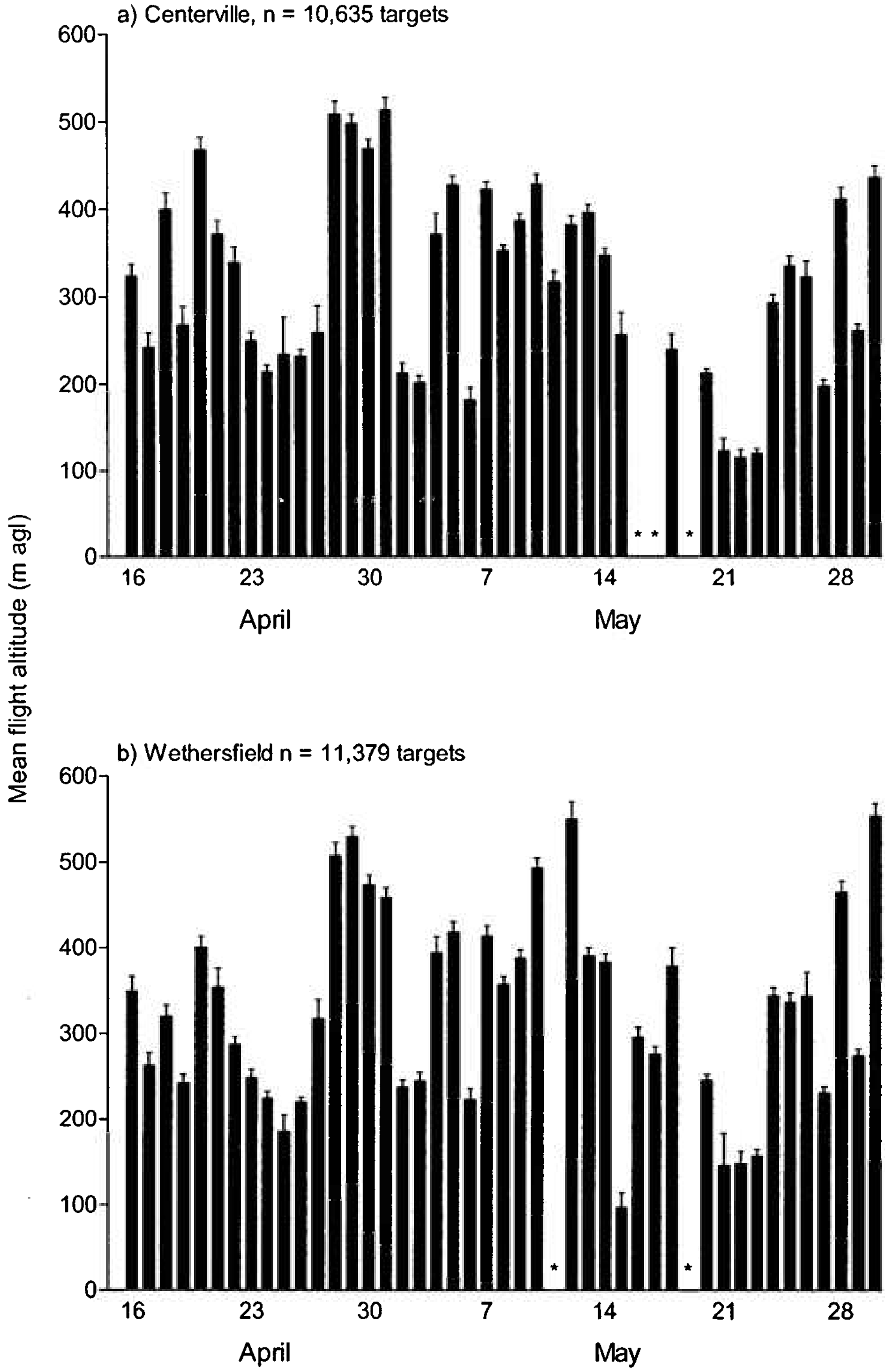


Figure 8. Mean ± 1 SE nightly flight altitudes (m agl) at the proposed (a) Centerville and (b) Wethersfield Windparks; New York, spring 2006.

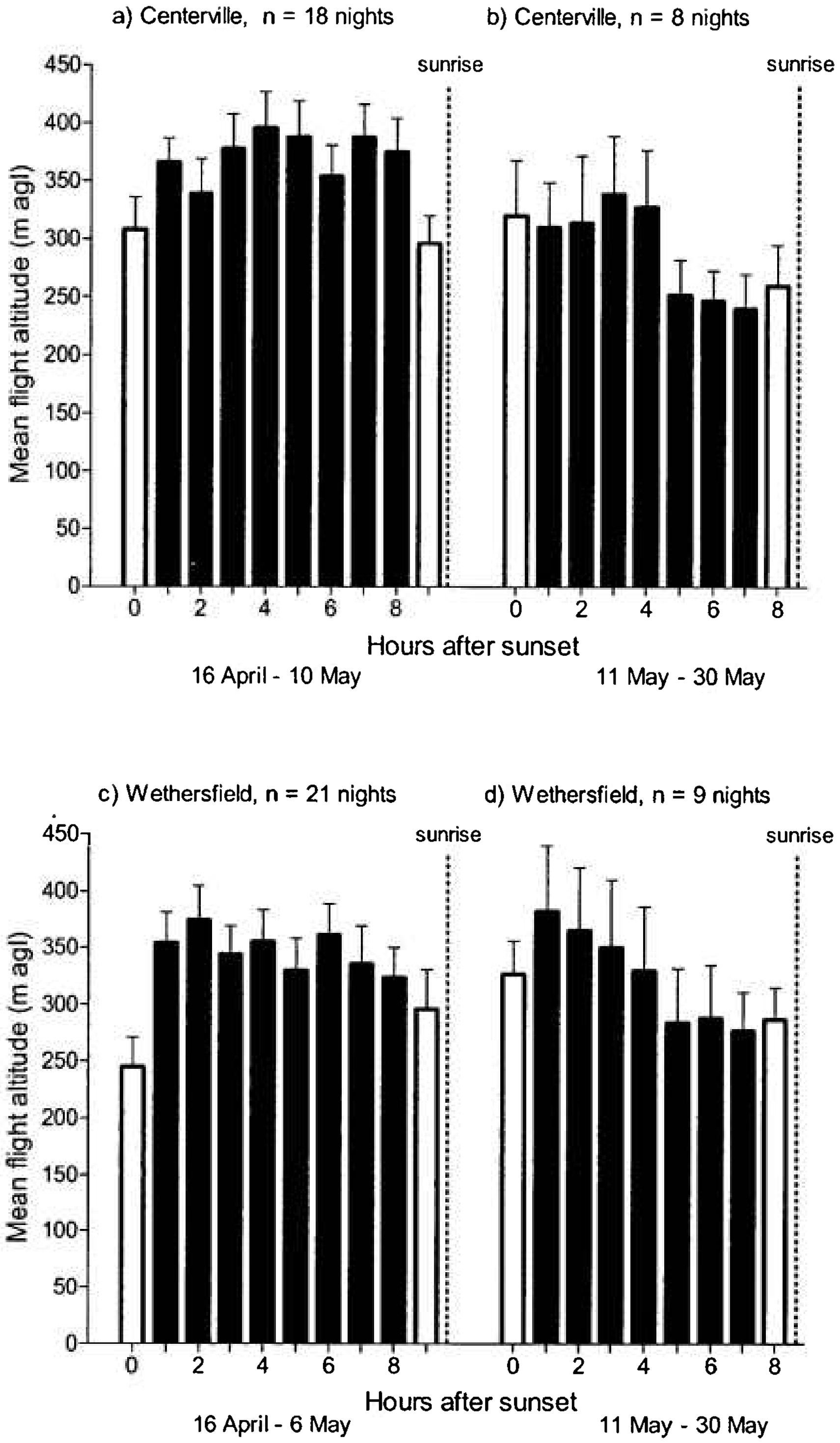


Figure 9. Percent of nightly flight altitude (± 1 SE) relative to time past sunset for nights that had 9 hours of darkness/night at (a) Centerville and (c) Wethersfield and 8 hours of darkness/night (b) Centerville and (d) Wethersfield at the proposed Centerville and Wethersfield Windparks, New York, spring 2006. First and last hours are crepuscular periods.

Table 1. Nocturnal flight altitudes of radar targets (% of all targets) detected at the 1.5-km range at the proposed Centerville and Wethersfield Windparks, NY, spring 2006, by flight-altitude category.

| | Percent of radar targets | |
|---|---|---|
| Flight altitude (m agl) | Centerville (n = 11,750 targets) | Wethersfield (n = 15,375 targets) |
| 0–100 | 10.6 | 13.8 |
| 101–200 | 20.2 | 20.3 |
| 201–300 | 18.6 | 17.0 |
| 301–400 | 15.7 | 13.3 |
| 401–500 | 12.6 | 11.3 |
| 501–600 | 8.3 | 8.1 |
| 601–700 | 5.3 | 5.6 |
| 701–800 | 3.5 | 3.9 |
| 801–900 | 2.5 | 2.7 |
| 901–1,000 | 1.3 | 2.2 |
| 1,001–1,100 | 0.8 | 1.1 |
| 1,101–1,200 | 0.4 | 0.5 |
| 1,201–1,300 | 0.1 | 0.3 |
| 1,301–1,400 | 0.1 | 0.1 |
| 1,401–1,500 | 0.0 | 0.0 |

steeply or descending steeply throughout most crepuscular and nocturnal hours at both the Centerville and Wethersfield sites (Fig. 10). The one exception to this general pattern was at the Wethersfield site during 6–10 May when a large percentage of targets were observed ascending steeply during the evening crepuscular hour (Fig. 10).

## EFFECTS OF WEATHER ON MIGRATION

We investigated the importance of weather (i.e., wind direction, wind speed, ceiling height [including fog], daily barometric pressure change, synoptic weather [days since favorable migration—passage rate models only]), lunar illumination, and date on both the passage rates and flight altitudes of nocturnal migrants by building a series of models (combinations of the various weather variables and date), and then using a model-selection technique (AIC) to quantify the statistical strength of those models. The AIC method allows one to (1) rank and identify the "best" model(s) (i.e., the most statistically supported models) from the full set of models, and (2) assess the statistical strength and relative importance of individual variables composing the "best" models.

### PASSAGE RATES

The best-approximating model explaining migration passage rates of nocturnal migrants during spring migration at Centerville was the global model containing the variables wind direction, ceiling height, days since favorable migration, synoptic weather, date, wind speed, , change in barometric pressure, and lunar illumination (Table 2). The second-best model contained the variables synoptic weather and date but was not well supported ($\Delta AIC_c = 11.47$; Appendix 4). The global model contained significant positive associations with date, the number of days since favorable migration, and synoptic weather conditions favorable for migration (Table 3). This indicates that passage rates increased later in the season, with an

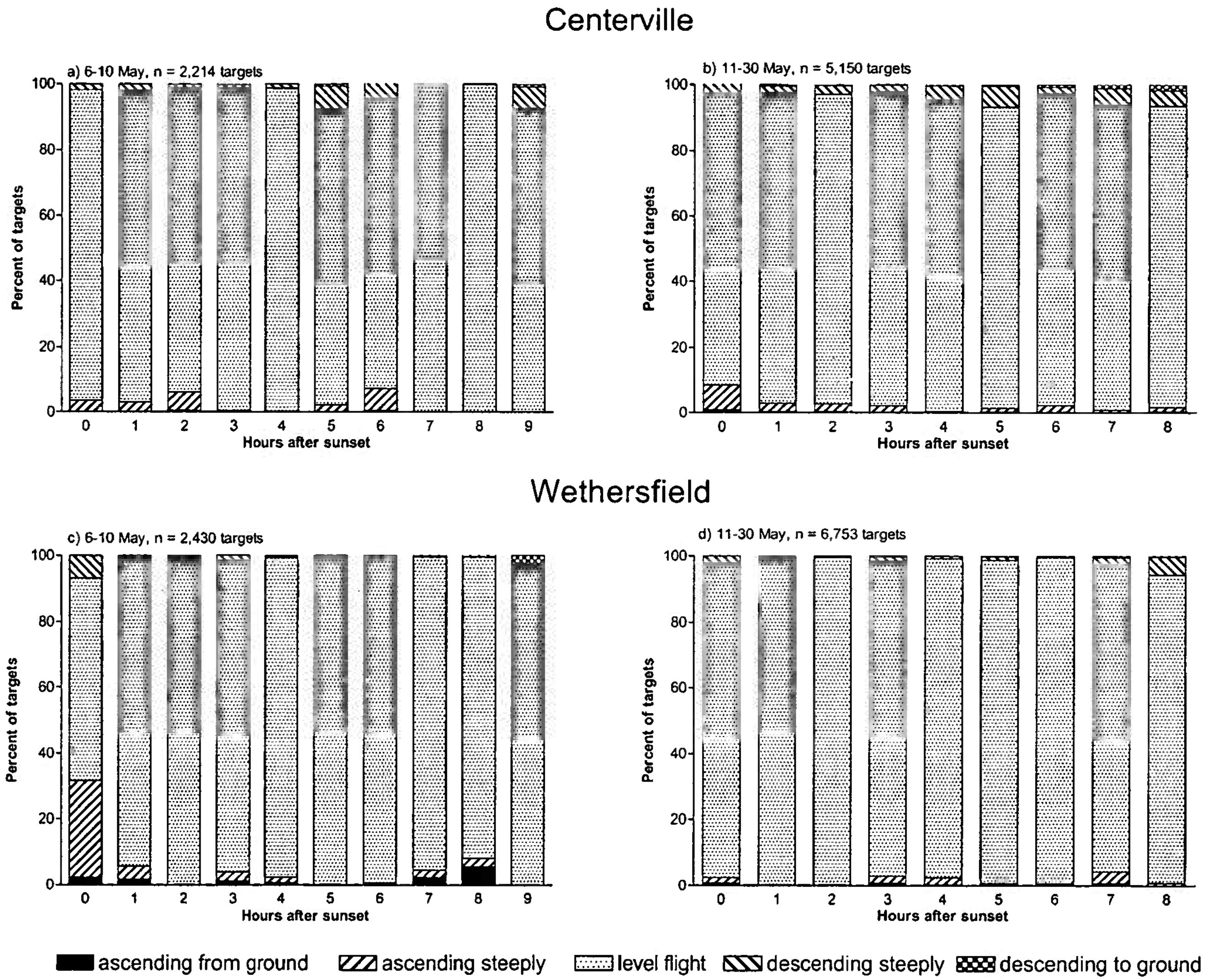


Figure 10. Flight behavior of targets (%) relative to time past sunset for nights that had 9 hours of darkness/night at (a) Centerville and (c) Wethersfield and 8 hours of darkness/night (b) Centerville and (d) Wethersfield at the proposed Centerville and Wethersfield Windparks, New York, spring 2006. First and last hours are crepuscular periods.

Table 2. Linear mixed model estimates from competitive models (Δ AICc ≤ 2) explaining the influence of environmental factors on passage rates of bird and bat targets on surveillance radar at the proposed Centerville and Wethersfield Windparks, NY, spring 2006 (Centerville, n = 327 sampling sessions; Wethersfield, n = 341 sampling sessions). Model weights (wi) were based on Akaike's Information Criterion (AIC).

| Station/Model | -2 Log Likelihood[a] | K[b] | $AIC_c$[c] | Δ $AIC_c$[d] | $w_i$[e] |
|---|---|---|---|---|---|
| Centerville | | | | | |
| Global: wind direction + ceiling height + favorable migration (d) + synoptic [f] + date + wind speed + change in barometric pressure [g] + moon | 490.88 | 25 | 545.20 | 0.00 | 0.99 |
| Wethersfield | | | | | |
| Favorable migration(d) + ceiling height | 457.34 | 14 | 486.63 | 0.00 | 0.36 |
| Barometric pressure change [f] + ceiling height | 457.81 | 14 | 487.10 | 0.47 | 0.28 |

[a] Calculated with the Maximum Likelihood method.

[b] Number of estimable parameters in approximating model (see methods for explanation).

[c] Akaike's Information Criterion corrected for small sample size.

[d] Difference in value between $AIC_c$ of the current model versus the best approximating model with the minimal $AIC_c$ value.

[e] Akaike weight—probability that the current model (i) is the best approximating model among those being considered.

[f] Synoptic weather

[g] Daily change in barometric pressure

Table 3. Model-averaged parameter estimates from competitive models ($\Delta$ AICc $\leq 2$) explaining the influence of environmental factors on passage rates of bird and bat targets at the proposed Centerville and Wethersfield Windparks, NY, spring 2006. Coefficients (B) of the categorical variables (ceiling height, synoptic weather, wind direction) were calculated relative to high ceiling conditions (> 500 m agl), unfavorable migratory conditions (N or W of cold front), and headwinds, respectively. Asterisks indicate 95% confidence intervals that do not overlap zero.

| Station/Parameter | B | SE |
|---|---|---|
| Centerville | | |
| Intercept | 3.990 | 0.240* |
| Barometric pressure change | -0.865 | 0.526 |
| Ceiling height = 0–50 m agl (fog) | -1.063 | 0.263* |
| Ceiling height = 51–500 m agl | -0.343 | 0.124* |
| Date | 0.034 | 0.006* |
| Favorable migration (d) | 0.104 | 0.029* |
| Lunar illumination | 0.032 | 0.151 |
| Synoptic Weather = (near center of high pressure system) | 0.535 | 0.184* |
| Synoptic Weather = (W of high pressure system) | 0.987 | 0.216* |
| Synoptic Weather = (S or E of cold front/S of warm front) | 0.708 | 0.187* |
| Wind direction = tailwind | -0.021 | 0.113 |
| Wind direction = calm | -0.320 | 0.188 |
| Wind direction = eastern crosswind | -0.127 | 0.101 |
| Wind direction = western crosswind | -0.143 | 0.094 |
| Wind speed | -0.037 | 0.021 |
| Wethersfield | | |
| Intercept | 5.422 | 0.240* |
| Barometric pressure change | -1.449 | 0.475* |
| Ceiling height = 0–50 m agl (fog) | -0.645 | 0.290* |
| Ceiling height = 51–500 m agl | -0.221 | 0.083* |
| Favorable migration (d) | 0.172 | 0.057* |

increasing number of days since a favorable migration event occurred, and when the study site was located near the center of a high pressure system, west of a high pressure system, south or east of a cold front, or south of a warm front. Ceiling height was associated negatively, indicating that passage rates decreased when ceiling height was 500 m agl. Passage rates were not related to daily barometric pressure change, lunar illumination, wind direction, or wind speed. The weight of evidence in favor of the "best" model ($w_{best}/w_{second\ best}$) was >99 times that of the second-best model (Burnham and Anderson 2002). The complete passage rate model set for Centerville can be found in Appendix 4 for the reader interested in examining all models and their associated statistical metrics.

The best-approximating model explaining migration passage rates of nocturnal migrants during spring migration at Wethersfield was the model containing the variables ceiling height and the number of days since favorable migration (Table 2). The second-best model containing the variables change in barometric pressure and ceiling height was also well supported ($\Delta AIC_c = 0.47$; Table 2), whereas the third best model containing the variables change in barometric pressure, ceiling height, and date ($\Delta AIC_c = 2.21$; Appendix 5) also received some empirical support. These models contained a significant positive association with the number of days since favorable migration indicating that passage rates increased with an increasing number of days since a favorable migration event occurred (Table 3). Change in barometric pressure and ceiling height were associated negatively, indicating that passage rates decreased with a drop in barometric pressure (creating unfavorable winds) and when ceiling height was <500 m agl. Passage rates were not related to wind direction, synoptic weather, date, wind speed, and lunar illumination. The weight of evidence in favor of the "best" model ($w_{best}/w_{second\ best}$) was 1.3 times that of the second-best model (Burnham and Anderson 2002). The complete passage rate model set for Wethersfield can be found in Appendix 5 for the reader interested in examining all models and their associated statistical metrics.

## FLIGHT ALTITUDES

The best-approximating model explaining flight altitudes of nocturnal migrants during spring migration at Centerville was the model containing the variable wind speed (Table 4). The second-best model contained the variables change in barometric pressure, wind direction, wind speed, and date; $\Delta AIC_c = 0.79$; Table 4), and a third model containing change in barometric pressure, wind direction, and wind speed ($\Delta AIC_c = 2.05$) also received some empirical support (Appendix 6). These models contained strong positive associations with barometric pressure change indicating that altitudes increased with increasing barometric pressure (Table 5). These models contained strong negative associations with wind speed indicating that flight altitudes decreased with increasing wind speeds. Flight altitudes were not related to wind direction, ceiling height, synoptic weather, date, or lunar illumination. The weight of evidence in favor of the "best" model ($w_{best}/w_{second\ best}$) was 1.5 times that of the second-best model (Burnham and Anderson 2002). The complete flight altitude model set for Centerville can be found in Appendix 6 for the reader interested in examining all models and their associated statistical metrics.

The best-approximating model explaining flight altitudes of nocturnal migrants during spring migration at Wethersfield was the model containing the variable wind speed (Table 4). The second-best model contained the variable lunar illumination; $\Delta AIC_c = 0.74$), and a third model containing lunar illumination, wind direction, and wind speed ($\Delta AIC_c = 2.08$) also received some empirical support (Appendix 7). These models did not contain strong positive or negative associations with any variables in these models, indicating no strong patterns with flight altitudes at this site (Table 5). The weight of evidence in favor of the "best" model ($w_{best}/w_{second\ best}$) was 1.4 times that of the second-best model (Burnham and Anderson 2002). The complete flight altitude model set for Wethersfield can be found in Appendix 7 for the reader interested in examining all models and their associated statistical metrics.

## TARGETS WITHIN THE PROPOSED TURBINE AREA

The mean passage rate of targets <125 m at Centerville was 54.5 ± 10.7 targets/km/h and at Wethersfield was 73.0 ± 7.3 targets/km/h. We made several assumptions to estimate the turbine passage rate (i.e., the number of targets that would pass within the area occupied by each proposed turbine): (1) the minimal area occupied by the wind turbine (i.e., side profile), (2) the maximal area occupied by the wind turbine (i.e., front profile, including the entire rotor-swept area), (3) a worst-case scenario of the rotor blades turning constantly, (4) 45 d in the study during spring, and (5) an average of 8 nocturnal hours/day across the 45-d spring period. If all migrants approached the turbines from the side, an estimated 111 migrants (Centerville) and 149 migrants (Wethersfield) would have passed within the area occupied by one turbine (Appendix 1). If all migrants approached the turbines from the front, an estimated 825 migrants (Centerville) and 1,031 (Wethersfield) would have passed within the area occupied by one

Table 4. Linear mixed model estimates from competitive models ($\Delta$ AICc $\leq 2$) explaining the influence of environmental factors on flight altitudes of bird and bat targets on surveillance radar at the proposed Centerville and Wethersfield Windparks, NY, spring 2006 (Centerville n = 288, Wethersfield n = 299 sampling sessions). Model weights (wi) were based on Akaike's Information Criterion (AIC).

| Station/Model | -2 Log Likelihood[a] | K[b] | $AIC_c$[c] | $\Delta AIC_c$[d] | $w_i$[e] |
|---|---|---|---|---|---|
| Centerville | | | | | |
| Wind speed | 3429.21 | 11 | 3452.17 | 0.00 | 0.32 |
| Barometric pressure change[f] + wind direction + wind speed + date | 3416.70 | 17 | 3452.96 | 0.79 | 0.22 |
| Wethersfield | | | | | |
| Wind speed | 1391.90 | 11 | 1414.82 | 0.00 | 0.21 |
| Lunar illumination | 1392.63 | 11 | 1415.55 | 0.74 | 0.15 |

[a] Calculated with the Maximum Likelihood method.

[b] Number of estimable parameters in approximating model (see methods for explanation).

[c] Akaike's Information Criterion corrected for small sample size.

[d] Difference in value between $AIC_c$ of the current model versus the best approximating model with the minimal $AIC_c$ value.

[e] Akaike weight—probability that the current model (i) is the best approximating model among those being considered.

[f] Daily change in barometric pressure

Table 5. Model-averaged parameter estimates from competitive models (Δ AICc ≤ 2) explaining the influence of environmental factors on flight altitudes of bird and bat targets at the proposed Centerville and Wethersfield Windparks, NY, spring 2006. Coefficient (B) of the categorical variable wind direction was calculated relative to headwinds. Asterisks indicate 95% confidence intervals that do not overlap zero.

| Station/Parameter | B | SE |
|---|---|---|
| Centerville | | |
| Intercept | 423.808 | 46.330* |
| Barometric pressure change | 981.278 | 455.261* |
| Date | -1.796 | 0.919 |
| Wind direction = tailwind | -3.395 | 20.705 |
| Wind direction = calm | 13.055 | 34.197 |
| Wind direction = eastern crosswind | 29.109 | 18.546 |
| Wind direction = western crosswind | -18.129 | 16.766 |
| Wind speed | -12.083 | 3.755* |
| Wethersfield | | |
| Intercept | 17.951 | 0.924* |
| Lunar illumination | 1.251 | 0.688 |
| Wind speed | -0.198 | 0.110 |

turbine during our spring study period (Appendix 1). An alternate way to look at this relationship is on a per day basis; these estimates would be equivalent to an estimate of 2.5–18.3 migrants at Centerville and 3.3–22.9 migrants at Wethersfield passing through the area of a single turbine each day (Appendix 1).

## VISUAL DATA

We collected visual data on birds and bats on 42 nights at Centerville and on 43 nights at Wethersfield. Most birds were traveling in seasonally appropriate directions for spring migration (i.e., northerly), at Centerville (Fig. 11c) and Wethersfield (Fig. 11d), with a median flight direction of 0° for birds (*n* = 411) at Centerville and 0° for birds (*n* = 356) at Wethersfield. Most bats were also traveling in a northerly direction during spring at both Centerville (Fig. 11a) and Wethersfield (Fig. 11b) with a median flight direction of 0° for bats (*n* = 77) at Centerville and 0° for bats (*n* = 80) at Wethersfield.

The mean nocturnal visual rates at Centerville for birds was 1.7 ± 0.3 targets/h (*n* = 42 nights) and for bats was 0.3 ± 0.05 targets/h (*n* = 42 nights) and at Wethersfield was 1.5 ± 0.3 targets/h (*n* = 43 nights) for birds and 0.3 ± 0.06 targets/h (*n* = 43 nights) for bats. Overall mean nightly visual rates were highly variable among nights for birds at Centerville (range = 0–8.7 targets/h) and at Wethersfield (range = 0–14.1 targets/h; Figs. 12a, 12b), but were less variable for bats at Centerville (range = 0–1.2 targets/h) and at Wethersfield (range = 0–2.0 targets/h; Figs. 12a, 12b). Birds were observed on most nights and peaked on 24 May at both Centerville and Wethersfield (Figs. 12a, 12b). Bats were observed in low numbers scattered throughout the spring season, with peak movement on 17 April at Centerville and on 19 April at Wethersfield; Figs. 12a, 12b).

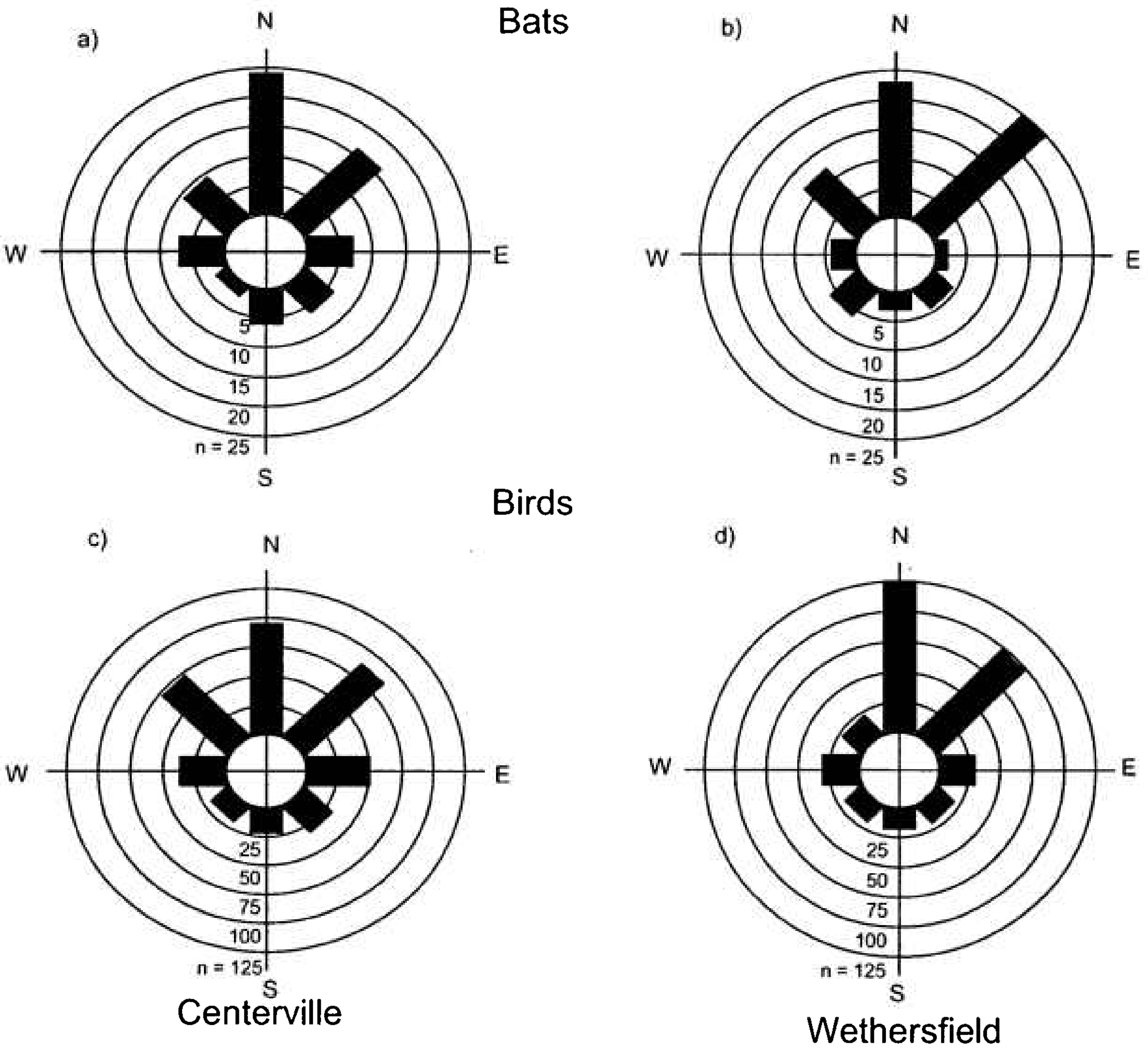
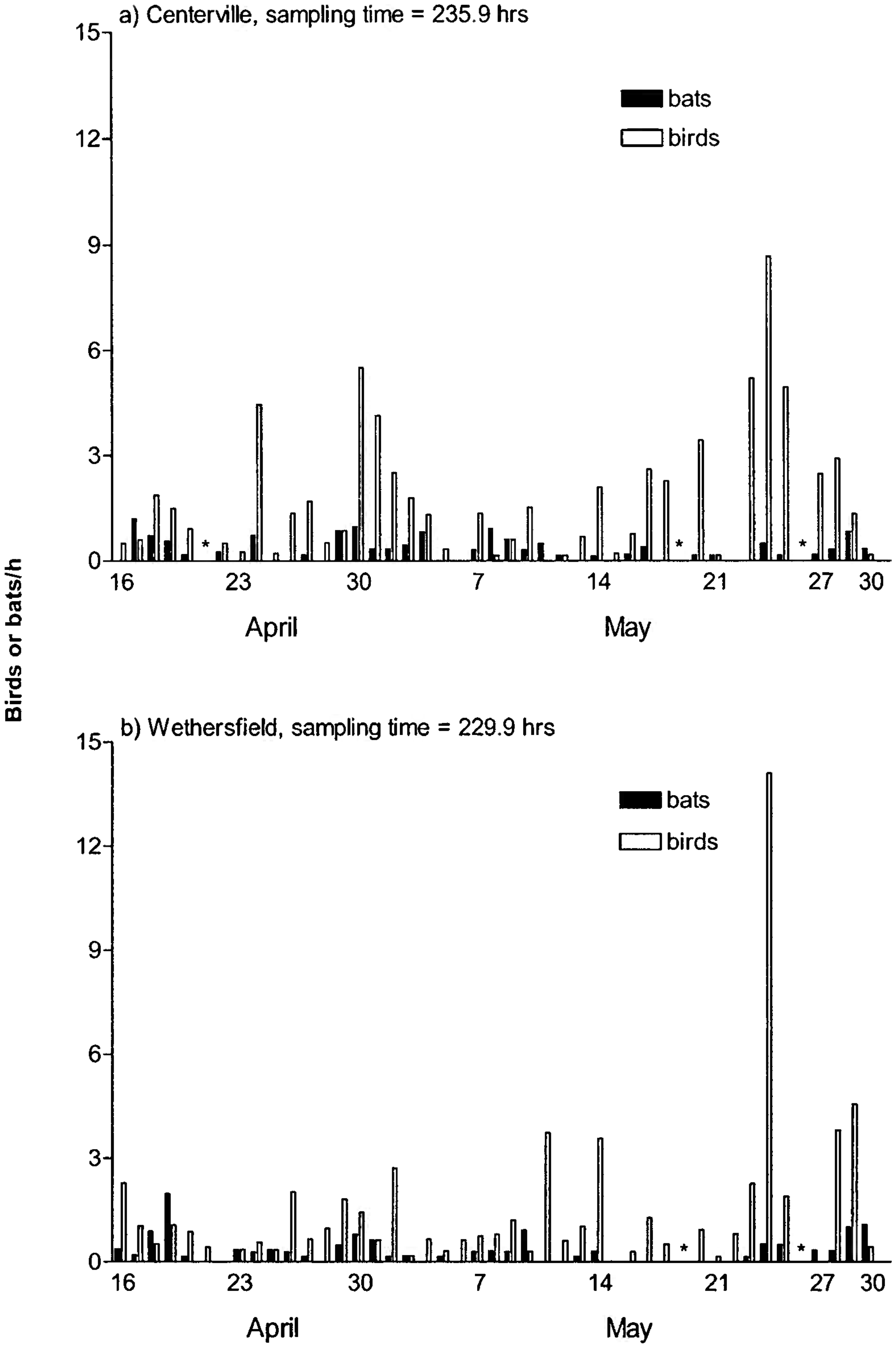


Figure 11. Flight directions of bats at (a) Centerville and (b) Wethersfield and birds at (c) Centerville and (d) Wethersfield observed during visual sampling at the proposed Centerville and Wethersfield Windparks, New York, spring 2006.

Visual rates did not vary among nocturnal hours of the night for nights with 7 hours of darkness sampled/night at Centerville for birds ($F_{2.2,\ 8.7}$ = 0.5; *P* = 0.657; *n* = 5 nights; Fig. 13a) or bats ($F_{1.7,\ 6.8}$ = 1.7; *P* = 0.245; *n* = 5 nights; Fig. 13a) or at Wethersfield for birds ($F_{2.8,\ 17.0}$ = 1.2; *P* = 0.333; *n* = 7 nights; Fig. 13c) or bats ($F_{2.5,\ 15.0}$ = 0.7; *P* = 0.549; *n* = 7 nights; Fig. 13c). Visual rates did vary among nocturnal hours of the night for nights with 8 hours of darkness sampled/night at Centerville for birds ($F_{3.6,\ 97.4}$ = 3.0; *P* = 0.026; *n* = 28 nights; Fig. 13b) and bats ($F_{3.8,\ 103.5}$ = 2.6; *P* = 0.045; *n* = 28 nights; Fig. 13b) and at Wethersfield for birds ($F_{1.9,\ 46.5}$ = 4.7; *P* = 0.015; *n* = 25 nights; Fig. 13d) but not bats ($F_{3.4,\ 81.5}$ = 1.2; *P* = 0.312; *n* = 25 nights; Fig. 13d). The highest rates for birds occurred


a) Centerville, sampling time = 235.9 hrs

b) Wethersfield, sampling time = 229.9 hrs

Figure 12. Mean number of birds/h or bats/h (± 1 SE) observed during visual sampling at the proposed (a) Centerville and (b) Wethersfield Windparks, New York, spring 2006. Asterisks denote nights not sampled because of rain or fog.

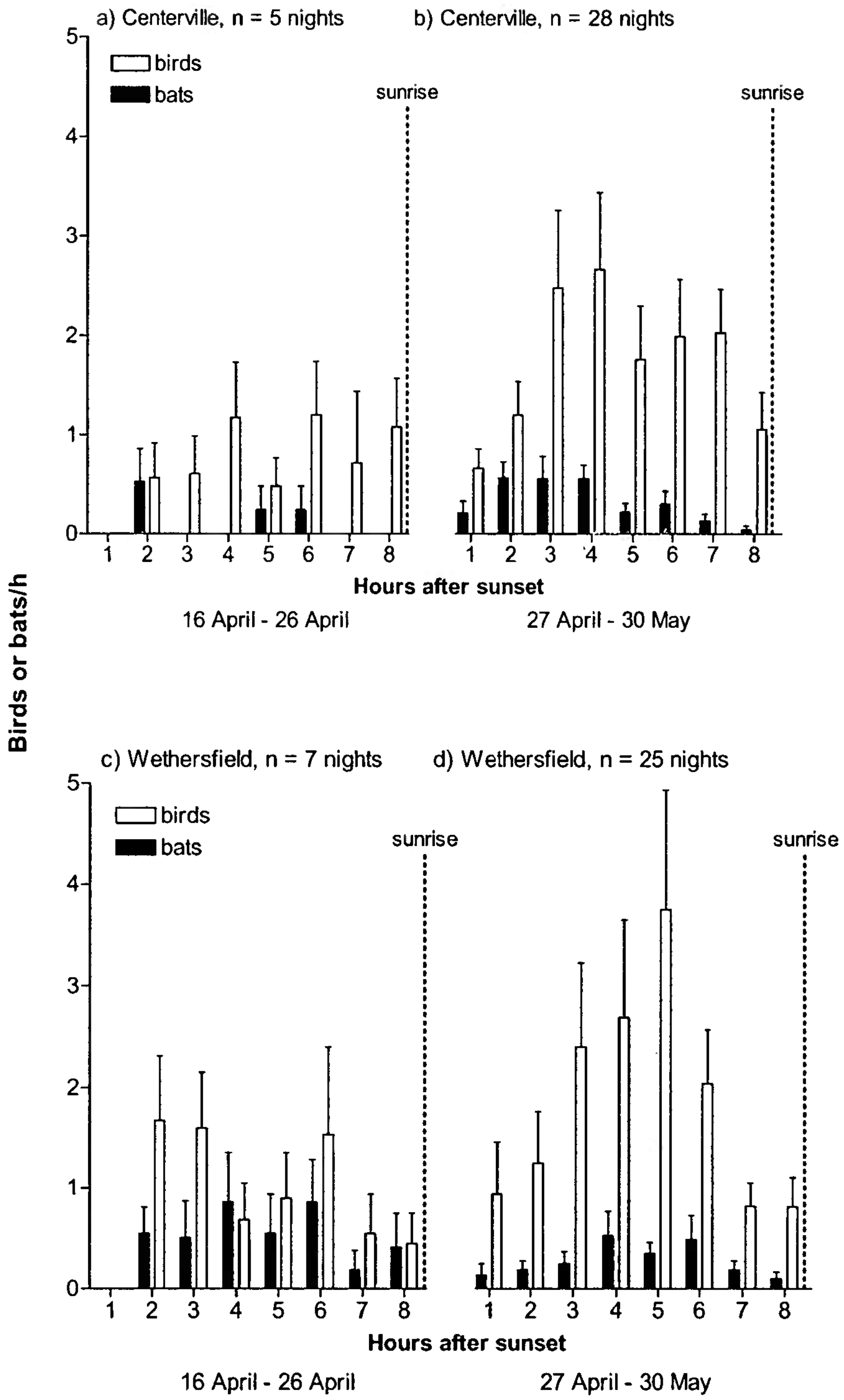


Figure 13. Mean number of birds/h or bats/h (± 1 SE) observed during visual sampling relative to time past sunset for nights that had 9 hours of darkness/night at (a) Centerville and (c) Wethersfield and 8 hours of darkness/night (b) Centerville and (d) Wethersfield at the proposed Centerville and Wethersfield Windparks, New York, spring 2006. First and last hours are crepuscular periods.

~3–7 h after sunset whereas the highest rates for bats occurred ~ 2–6 h after sunset (Fig. 13).

Passerines were the dominant type of species group for birds and small bats were the dominant type of species group for bats during spring at both sites (Table 6). The proportions of birds and bats flying <~150 m agl (our effective sampling distance with the night-vision goggles) were ~84% birds and ~16% bats at Centerville ($n$ = 488) and were ~82% birds and ~18% bats at Wethersfield ($n$ = 436; Table 6).

## DISCUSSION

Predictions of the effects of wind power development on migratory birds and bats are hampered by both a lack of detailed knowledge about patterns of the nocturnal migration and behavior of birds and bats around wind turbines and by the fact that the precise relationship between bird abundance and bird fatalities at wind turbines currently is unknown. In this study, we addressed the first of these issues and documented some of the key migration characteristics in order to describe some of the general properties of nocturnal bird migration at the proposed project site.

### TIMING OF MIGRATION

Understanding the timing of migration at multiple temporal scales (e.g., within nights, within seasons, and seasonally within years) allows the determination of patterns of peak migration that can be used with other information, especially weather, to develop predictive models of avian and bat use. Such models may be useful for both pre-construction siting decisions and for the consideration of operational strategies to reduce fatalities (if one makes the untested assumption that there is a correlation between bird abundance and fatality at wind turbines).

Within nights, spring passage rates at both Centerville and Wethersfield increased dramatically after sunset, peaked ~3–5 hours after sunset, then usually decreased until sunrise. Several studies have found a pattern similar to this, in which the intensity of nocturnal migration begins to increase ~30–60 min after sunset, peaks around midnight, and declines steadily thereafter

Table 6. Birds and bats observed during nocturnal visual sampling at the proposed Centerville and Wethersfield Windparks, NY, spring 2006. Percentages are relative to the total number of targets identifiable as birds or bats.

| | Centerville | | Wethersfield | |
|---|---|---|---|---|
| Species group | N | % | N | % |
| Passerines | 378 | 77.5 | 317 | 72.7 |
| Non passerines | 3 | 0.6 | 4 | 0.9 |
| Unidentified birds | 30 | 6.1 | 35 | 8.0 |
| Total birds | 411 | 84.2 | 356 | 81.7 |
| Small bats | 37 | 7.6 | 52 | 11.9 |
| Large bats | 16 | 3.3 | 16 | 3.7 |
| Unidentified bats | 24 | 4.9 | 12 | 2.8 |
| Total bats | 77 | 15.8 | 80 | 18.3 |
| Total birds and bats | 488 | 100.0 | 436 | 100.0 |

until dawn (Lowery 1951, Gauthreaux 1971, Kerlinger 1995, Farnsworth et al. 2004, Mabee et al., in press).

Within seasons, nocturnal migration often is a pulsed phenomenon (Alerstam 1990; Mabee and Cooper 2004, Mabee et al., in press). In this study, moderate–large mean nightly passage rates (>1 SD of seasonal mean [>514 targets/km/h at Centerville, >505 targets/km h at Wethersfield]) occurred on four nights at Centerville (3, 7, 24, 25 May) and on five nights at Wethersfield (7, 17, 24, 25, 28 May). Overall, spring migration peaked at 1,141 targets/km/h on 24 May at Centerville and at 907 targets/km/h on 24 May at Wethersfield. In general, most spring songbird migration in this part of New York occurs between ~mid–late April and ~mid–late May (Cooper and Mabee 2000, Cooper et al. 2004, Buffalo Ornithological Society 2002; W. Evans, Old Bird Inc., pers. comm.), so it is likely that our 2006 sampling window bracketed the period of peak songbird migration.

## PASSAGE RATES

Passage rates are an index of the number of migrants flying past a location; thus, they may be useful to assess the relative bird use of several sites being considered for wind power development. In this study we used our passage-rate data in two ways: (1) to examine the passage rate of all migrants passing over our study area, and (2) to examine the passage rate of migrants within the height of the proposed wind turbines (<125 m). Although both metrics are useful for comparing bird activity in the vicinity of wind farm sites, the second metric is especially well-suited for this comparison because of its altitude-specific nature.

Comparisons with passage rates from studies listed below can be categorized into two groups: (1) *direct comparisons*—studies where we used comparable radar equipment (i.e., the same type of radar and configuration) and methods (i.e., a speed-based criterion for removal of insects), which include the Clinton County (Clinton and Altona), Flat Rock, Prattsburgh–Italy, and Chautauqua projects in New York and the Mt. Storm project in West Virginia; and (2) *other comparisons*—studies where we used comparable equipment but different methods (i.e., a subjective criterion for removal of insects) which includes all studies conducted before 2001 in New York (Harrisburg, Wethersfield, Carthage), the Midwest, and the West (Stateline and Vansycle projects in Oregon and Washington). We believe the *other comparisons* are informative, as results from these studies may not have been substantially different from results obtained using our current methods if insect contamination was not a confounding factor in the study (e.g., spring studies where insects levels were minimal).

The overall passage rates in the project area were relatively high compared to four of five other locations in New York where we have conducted spring migration studies with similar equipment and methods. The mean spring nocturnal passage rate in this study was 290 targets/km/h at Centerville and 324 targets/km/h at Wethersfield compared with spring passage rates of 63 targets/km/h at a development near Wethersfield, NY, (located only 9 km from the current site; Cooper and Mabee 2000); 110 targets/km/h at the Clinton County Windparks (located ~ 20–40 km southeast of Malone, NY; Mabee et al. 2006), 117 targets/km/h at the Dairy Hills proposed development near Warsaw, NY, (Young et al. 2006), 159 targets/km/h at Carthage, NY (located ~10 km southeast of Watertown, NY; Cooper et al. 1995a), 170 targets/km/h at the proposed Prattsburgh–Italy wind development, NY (located ~35 km south of Canandaigua, NY; Mabee et al. 2005a) and 395 targets/km/h at Chautauqua, NY (located ~30 km northwest of Jamestown, NY; Cooper et al. 2004).

A detailed examination of our previous study at Wethersfield (Cooper and Mabee 2000) revealed a number of methodological differences that may help explain the large differences in passage rates between the two study periods (63 targets/km/h in 1999 vs. 324 targets/km/h at Wethersfield in 2006). These include 1) different sampling times (20 April–14 May 1999 vs. 15 April–30 May 2006); 2) different sampling intensities (3–4h/night during 1999 vs. 8–9h/night (all night) in 2006; 3) different insect removal criteria (subjective in 1999 vs. speed-based in 2006). We believe the difference in sampling times is the most important factor and it confounds the comparison between years for two reasons: 1) the full migration period was not sampled in 1999; and 2) passage rates may have peaked past the sampling dates in 1999 (e.g., passage rates peaked during late May 2006 in this study).

When we compare more similar time periods between the two studies, however, there still are higher rates in 2006 than in 1999: mean passage rates between 16 April–15 May 2006 ranged from 259–323 targets/km/h (Appendix 2), vs. 63 targets/km/h in 1999. Spring migration in New England during 1999 was characterized by unfavorable (northerly and easterly) winds during peak bird migration (Wood 1999) which led to passerine migration in New York that was spotty, with scattered areas of little or no migration activity (Burgiel et al. 1999). Although these on the ground assessments of bird migration are consistent with our radar observations during spring 1999, the other confounding factors mentioned above preclude us to determine unequivocally if annual variation existed between 1999 and 2006. Results from a recent study in Wyoming County, NY conducted using similar equipment, methods, and sampling duration, however, reported passage rates between those of our two spring studies (117 targets/km; Young et al. 2006) further suggesting that annual variation in passage rates occurs in this general area.

Our estimates of passage rates below the proposed turbine height in the project area during spring was 54.5 targets/km/h flying <125 m agl at Centerville and 73.0 targets/km/h flying <125 m agl at Wethersfield. Unfortunately, we only have comparable spring data for two other sites in New York during spring migration: 1) proposed Clinton County Windparks [25.7 targets/km/h flying <125 m agl] and 2) the proposed Prattsburgh-Italy wind development, [37.6 targets/km/h flying <125 m agl]).

## FLIGHT ALTITUDES

Flight altitudes are critical for understanding the vertical distribution of nocturnal migrants in the airspace. In general, passerines migrate at lower flight altitudes than do other major groups of over-land migrants such as shorebirds and waterfowl (Kerlinger 1995). Large kills of birds at tall, human-made structures (generally lighted and guyed communications towers; Avery et al. 1980) and the predominance of nocturnal migrant passerines at such kills (Manville 2000) indicate that large numbers of these birds fly <500 m agl on at least some nights.

Flight altitudes of migratory bats are poorly known. Hoary bats (*Lasionycterus cinereus*), Eastern Red bats (*L. borealis*), and Silver-haired bats (*L. noctivagans*) are all long-range migrants that have been killed at wind power projects during their migratory periods, suggesting that at least some bats migrate below ~ 125 m agl. Allen (1939) observed bats migrating during the daytime near Washington, D.C. at 46–140 m agl, Altringham (1996) reported that at least some bats migrate well-above 100 m agl, and Peurach (2003) documented a hoary bat collision with an airplane at an altitude of 2,438 m agl over Oklahoma during October 2001.

Comparisons with flight altitudes from studies listed below can be categorized into three groups: (1) *direct comparisons*—studies where we used comparable radar equipment (i.e., the same type of radar and configuration) and methods (i.e., a speed-based criterion for removal of insects), including the Clinton County Windparks, Flat Rock, and Prattsburgh–Italy projects in New York and the Mt. Storm project in West Virginia; and (2) *other comparisons*—studies where we used comparable equipment but different methods (i.e., a subjective criterion for removal of insects), including Chautauqua, NY, and the Stateline and Vansycle projects in Oregon and Washington; and (3) *inappropriate comparisons*—studies where we used different radar equipment (i.e., a different radar and configuration) and different methods (i.e., a subjective criterion for removal of insects), including all studies conducted before 2001 in New York (Harrisburg, Wethersfield, Carthage) and in the Midwest. We believe that *other comparisons* are informative, as results from these studies may not have been substantially different from results obtained using our current methods if insect contamination was not a confounding factor in the study (e.g., spring studies where insects levels may be minimal) whereas *inappropriate comparisons* were not made in this report because the results should not be compared among these studies.

Mean flight altitudes at the proposed Centerville (351 m agl) and Wethersfield (355 m agl) sites were 230 m higher than the proposed turbine heights in these locations. The mean altitude at this study was similar to the spring mean flight altitude (319 m agl) at the proposed Prattsburgh–Italy wind power development (Mabee et al. 2005a), the proposed Clinton County Windparks (338 m agl; Mabee et al. 2006), the proposed Dairy Hills development in Wyoming County (397 m agl; Young et al. 2006) and lower than Chautauqua (528 m agl; Cooper et al. 2004).

Similar to our results, however, other published studies that used a variety of radar systems and analyses have indicated that the majority of nocturnal migrants fly below 600 m agl (Bellrose 1971; Gauthreaux 1972, 1978, 1991; Bruderer and Steidinger 1972; Cooper and Ritchie 1995). Kerlinger (1995) summarized radar results from the eastern US and concluded that three-quarters of passerines migrate <600 m agl.

In contrast to these results, other researchers have found that peak nocturnal densities extend over a broad altitudinal range up to ~2,000 m (Harper 1958, *in* Eastwood 1967; Graber and Hassler 1962, Nisbet 1963, Bellrose and Graber 1963, Eastwood and Rider 1965, Bellrose 1967, Blokpoel 1971; Richardson 1971, 1972; Blokpoel and Burton 1975). We suspect that differences between the two groups of studies are largely due to differences in location, species-composition of migrating birds, local topography, radar equipment used, and perhaps weather conditions. It has been suggested that limitations in equipment and sampling methods of some previous radar studies may have been responsible for their overestimation of the altitude of bird migration (Able 1970, Kerlinger and Moore 1989). For example, the radars used by Bellrose and Graber (1963), Blokpoel (1971), and Nisbet (1963) could not detect birds below 450 m, 370 m, and 180 m agl, respectively. In contrast, our vertical radar could detect targets down to ~10–15 m agl, allowing us to detect low-altitude migrants.

We also examined the percentage of targets below approximate turbine height (i.e., 125 m agl) during spring and estimated that 15.7% flew <125 m agl at Centerville and 19.4% flew < 125 m agl at Wethersfield, similar to 17.5% < 125 m agl at the proposed Prattsburgh–Italy wind project (Mabee et al. 2005a) and 19.7% <125 m agl at the proposed Clinton County Windparks (Mabee et al. 2006) but higher than Chautauqua, NY (3.8% <125 m agl; Cooper et al. 2004). The only other sites available for comparisons during spring are the Vansycle and Stateline wind power facilities in eastern Oregon (15–19% <125 m agl; Mabee and Cooper 2004). Variation in the percentage of targets below turbine height may vary for multiple reasons—including differences in weather conditions, date, and species composition of migrants.

Similar to our migration studies elsewhere (Cooper and Ritchie 1995; Cooper et al. 1995a, 1995b; Cooper and Mabee 2000; Mabee and Cooper 2004), we recorded large among-night variation in mean flight altitudes during the spring migration season, although mean flight altitudes generally were above the proposed turbine heights (mean altitudes <125 m agl on 3 of 42 nights at Centerville and at 1 of 43 nights at Wethersfield). Daily variation in mean flight altitudes may have reflected changes in species composition, vertical structure of the atmosphere, and/or weather conditions. Variation among days in the flight altitudes of migrants at other locations has been associated primarily with changes in the vertical structure of the atmosphere. For example, birds crossing the Gulf of Mexico appear to fly at altitudes where favorable winds minimize the energetic cost of migration (Gauthreaux 1991). Kerlinger and Moore (1989), Bruderer et al. (1995), and Liechti et al. (2000) have concluded that atmospheric structure is the primary selective force determining the height at which migrating birds fly.

## MODELING MIGRATION PASSAGE RATES AND FLIGHT ALTITUDES

### MIGRATION PASSAGE RATES

It is a well-known fact that general weather patterns and their associated temperatures and winds affect migration (Richardson 1978, 1990). In the Northern Hemisphere, air moves counterclockwise around low-pressure systems and clockwise around high-pressure systems. Thus, winds are warm and southerly when an area is affected by a low to the west or a high to the east and are cool and northerly in the reverse situation. Clouds, precipitation, and strong, variable winds are typical in the centers of lows and near fronts between weather systems, whereas weather usually is fair with weak or moderate winds in high-pressure areas. Numerous studies in the Northern Hemisphere have shown that, in fall, most bird migration tends to occur in the western parts of lows, the eastern or central parts of highs, or in intervening transitional areas. In contrast, warm fronts, which are accompanied by southerly (unfavorable) winds and warmer temperatures, tend to slow fall migration (Lowery 1951, Gauthreaux 1971; Able 1973, 1974; Blokpoel and Gauthier 1974, Richardson 1990). Conversely, more intense spring migration tends to occur in the eastern parts of lows, the western or central parts of highs, or in intervening transitional areas.

We examined the influence of weather (i.e., wind speed, wind direction, date, ceiling height, synoptic weather, daily barometric pressure change, and the number of days since favorable migration conditions), date, and lunar illumination on migration passage rates at both study sites. During spring migration at Centerville only, passage rates increased later in the season, after long periods of unfavorable weather, and under synoptic weather conditions favorable for migration (i.e., near the center or west of a high pressure system, south or east of a cold front, or south of a warm front). Passage rates decreased at both sites when there was fog or low ceiling heights (≤ 500 m agl) and with increasing barometric pressure (during unfavorable migration conditions on the east side of a high pressure system). The variables identified as important in this study generally are consistent with results of other studies (Lowery 1951, Gauthreaux 1971; Able 1973, 1974; Blokpoel and Gauthier 1974; Richardson 1990; Mabee et al. 2004).

### FLIGHT ALTITUDES

Radar studies have shown that wind is a key factor in migratory flight altitudes (Alerstam 1990). Birds fly mainly at heights at which head winds are minimized and tail winds are maximized (Bruderer et al. 1995). Because wind strength generally increases with altitude, bird migration generally takes place at lower altitudes in head winds and at higher altitudes in tail winds (Alerstam 1990). Most studies (all of those cited above except Bellrose 1971) have found that clouds influence flight altitude, but the results are not consistent among studies. For instance, some studies (Bellrose and Graber 1963, Hassler et al. 1963, Blokpoel and Burton 1975) found that birds flew both below and above cloud layers, whereas others (Nisbet 1963, Able 1970) found that birds tended to fly below clouds.

In this study during spring migration at Centerville, flight altitudes increased with increasing barometric pressure (perhaps to fly above the unfavorable winds of an approaching high pressure system) and decreased with increasing wind speeds. At Wethersfield, flight altitudes were not strongly associated with any of the parameters, indicating no strong patterns with flight altitudes at this site. Because fog occurred infrequently during this study (*n* = 7 of 288 sessions [Centerville], *n* = 7 of 299 sessions [Wethersfield]) and very low ceiling height (51–500 m agl) also occurred infrequently (*n* = 13 of 288 sessions [Centerville] and *n* =26 of 299 sessions [Wethersfield], their apparent lack of influence on flight altitudes may have been because of their infrequent occurrence at our sites this spring.

The need to understand how birds respond to fog and low ceiling height conditions is warranted, however, as the largest single-night kill for nocturnal migrants at a wind power project occurred on a foggy night during spring migration, when 27 passerines fatally collided with a turbine near a lit substation at the Mountaineer wind power development in West Virginia (Kerlinger 2003). Fatality events of this magnitude are rare at wind power developments, although large kills of migratory birds have sporadically occurred at other, taller structures (e.g., guyed and lighted towers >130 m high) in many places across the country during periods of heavy migration, especially on foggy, overcast nights in fall (Weir 1976, Avery et al. 1980, Evans 1998, Erickson et al. 2001).

## SPECIES COMPOSITION

Determination of species-specific risks to nocturnal migrants requires the identification of species migrating through the area of interest. Flight speeds observed on surveillance radar during spring at Centerville (mean = 13.5 ± 0.04 m/s) and Wethersfield (mean = 15.5 ± 0.04 m/s) suggested that most of the avian radar targets we observed during spring were passerines, although some faster-flying bird species such as shorebirds or waterfowl were likely present. Furthermore, our visual observations confirmed the dominance of passerines and the smaller numbers of nonpasserines and bats in the lower air layers (i.e., <150 m agl), with the percentage of birds at Centerville (84%) and Wethersfield (82%) dominating that of bats at Centerville (16%) and Wethersfield (18%) in the lower air layers.

Most (86%) of the bat fatalities at wind power developments and other tall structures occur during mid-July to mid-September and involve long-range migratory tree-roosting bat species such as Hoary (*Lasiurus cinereus*), Eastern Red (*Lasiurus borealis*), and Silver-haired (*Lasionycteris noctivagans*) bats (Erickson et al. 2002, Johnson et al. 2003, Johnson 2004). Fatalities of these same species during spring are uncommon (Johnson 2004). Of the 53 identified bats observed during spring at Centerville and 68 identified bats observed at Wethersfield, 43% and 31% of the bats were tree-roosting bats at Centerville and Wethersfield, respectively. In general, fatality rates of bats are much lower in the central and western US (Erickson et al. 2002, Johnson 2004) than at the few sites studied in the eastern US, where substantial bat kills have been observed at two wind energy facilities located along the same Appalachian ridgeline in West Virginia and Pennsylvania (Arnett 2006). Recent information, however, also shows that some of these same tree-roosting species (e.g., Hoary and Silver-haired bats) are killed at higher rates (~7.7 bats/turbine) than expected in the Canadian prairies of Alberta (News Canada 2006).

## TARGETS WITHIN THE PROPOSED TURBINE AREA

We estimated a turbine passage rate (nocturnal migrants/turbine/d) of 2.5–18.3 passing within the area occupied by each proposed turbine during spring at Centerville and 3.3–22.9 at Wethersfield. These estimates range higher than the proposed Clinton County Windparks (1.2–8.3) and the proposed Prattsburgh–Italy wind power development, NY (1.7–12.1). In addition, we calculated turbine passage rates for crepuscular periods for Centerville (0–0.3 dusk, 0.1–0.7 dawn) and Wethersfield (0.1–0.7 dusk, 0.2–1.6 dawn) showing that only a small number of birds would pass through the area occupied by each proposed turbine during these brief time periods.

It is possible to use estimated turbine passage rates as a starting point for developing a complete avian risk assessment; however, it currently is unknown whether bird use and fatality at wind power developments are strongly correlated. There are a variety of factors (especially weather) that could be more highly correlated with fatality rates than bird abundance. To determine which factors are most relevant, studies that collected concurrent bird use, weather, and fatality data would be needed to begin to determine whether bird use and/or weather conditions can be used to predict the likelihood of bird fatalities at wind power developments.

In addition to these questions about the unknown relationship between fatality, weather, and abundance, there also is very little data available on the proportion of nocturnal migrants that (1) do not collide with turbines because of their avoidance behavior (i.e., birds that alter either their flight paths or altitude to avoid colliding with turbines) and (2) safely pass through the turbine blades by chance alone — a proportion that will vary with the speed at which turbine blades are turning as well as the flight speeds of individual migrants. The proportion of nocturnal migrants that detect and avoid turbines is currently unknown in the US (but see Winkleman 1995 for studies in Europe), but detection of turbines could alter flight paths, passage rates, and flight altitudes of migrants that could reduce the likelihood of avian collisions. Although there are no empirical data that predict a species' ability to pass safely through the rotor-swept area of a turbine, there is a hypothetical model (Tucker 1996). We speculate, however, that the values are high for both the proportion of birds that avoid and safely pass through turbines, considering the relatively low avian fatality rates at wind power developments in the US (Erickson et al. 2002). Local information on avian and bat fatality rates at the 10 existing wind turbines ~9 km north of our Wethersfield radar sampling site corroborates this pattern, as no bird or bat fatalities were observed during spring migration of 2005 and no bird and only 4 bat fatalities during fall migration of 2005 (Ecology and Environment 2006).

## CONCLUSIONS

This study focused on nocturnal migration patterns and flight behaviors during the peak periods of passerine and bat migration during spring at the proposed Centerville and Wethersfield Windparks in New York. The key results of our study were: (1) the mean overall passage rate was 290 targets/km/h at Centerville and 324 targets/km/h at Wethersfield; (2) mean nightly passage rates ranged from 25 to 1,140 targets/km/h at Centerville and from 41 to 907 targets/km/h at Wethersfield; (3) the percentage of targets passing below 125 m agl was 15.7% at Centerville and 19.4% at Wethersfield; (4) the estimated turbine passage rate of nocturnal migrants passing within the airspace occupied by each proposed turbine was 2.5–18.3 migrants/turbine/d at Centerville and 3.3–22.9 migrants/turbine/d at Wethersfield; and (5) migrants flying below 150 m agl consisted of ~84% birds and ~16% bats at Centerville and ~82% birds and ~18% bats at Wethersfield.

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Appendix 1. Calculation of turbine passage rate indices (estimated number of targets passing within the area occupied by each proposed turbine) during crepuscular and nocturnal periods during spring 2006, at the proposed Centerville and Wethersfield Windparks, New York.

| | Centerville | | | Wethersfield | | |
|---|---|---|---|---|---|---|
| Calculation parameter | Dusk | Night | Dawn | Dusk | Night | Dawn |
| WIND-TURBINE CHARACTERISTICS | | | | | | |
| (A) Total turbine height (m) | 118.0 | 118.0 | 118.0 | 118.5 | 118.5 | 118.5 |
| (B) Blade radius (m) | 40.0 | 40.0 | 40.0 | 38.5 | 38.5 | 38.5 |
| (C) Height below blade (m) | 38.0 | 38.0 | 38.0 | 41.5 | 41.5 | 41.5 |
| (D) Approximate front-to-back width (m) | 6 | 6 | 6 | 6 | 6 | 6 |
| (E) Minimal (side profile) area ($m^2$) = A × D | 708 | 708 | 708 | 711 | 711 | 711 |
| (F) Maximal (front profile) area ($m^2$) = (C × D) + ($\pi \times B^2$) | 5,254.5 | 5,254.5 | 5,254.5 | 4,905.6 | 4,905.6 | 4,905.637 |
| PASSAGE RATE | | | | | | |
| (G) Mean rate below 125 m agl (targets/km/h) | 6.1 | 54.5 | 16.7 | 17.7 | 73 | 40.7 |
| (H) Area sampled below 125 m agl = 125 x 1,000 ($m^2$) | 125,000 | 125,000 | 125,000 | 125,000 | 125,000 | 125,000 |
| (I) Mean passage rate per unit area (targets/$m^2$/h) = G/H | 0.000049 | 0.000436 | 0.000134 | 0.000142 | 0.000584 | 0.000326 |
| TURBINE PASSAGE RATE INDEX | | | | | | |
| (J) Duration of study period (# nights) | 45 | 45 | 45 | 45 | 45 | 45 |
| (K) Mean number of hours of darkness (h/night) | 1 | 8 | 1 | 1 | 8 | 1 |
| (L) Minimum number of targets/km/h in zone of risk = E x I | 0.034692 | 0.308688 | 0.094589 | 0.100678 | 0.415224 | 0.231502 |
| (M) Maximum number of targets/km/h in zone of risk = F x I | 0.257471 | 2.290988 | 0.702009 | 0.694638 | 2.864892 | 1.597275 |
| (N) Minimum number of targets in zone/d = K x L | 0.0 | 2.5 | 0.1 | 0.1 | 3.3 | 0.2 |
| (O) Maximum number of targets in zone/d =K x M | 0.3 | 18.3 | 0.7 | 0.7 | 22.9 | 1.6 |
| (P) Minimum number of targets in zone of risk during 45-night study period = J x K x L | 2 | 111 | 4 | 5 | 149 | 10 |
| (Q) Maximum number of targets in zone of risk during 45-night study period = J x K x M | 12 | 825 | 32 | 31 | 1,031 | 72 |

Appendix 2. Mean passage rates and flight altitudes of nocturnal radar targets observed at the 1.5-km range during half-month periods of spring migration and over the full migratory season at the proposed Centerville and Wethersfield Windparks, NY, spring 2006.

| | Centerville | | | | Wethersfield | | | |
|---|---|---|---|---|---|---|---|---|
| | April | May | | Total | April | May | | Total |
| | 16–30 | 1–15 | 16–30 | | 16–30 | 1–15 | 16–30 | |
| Passage rate (targets/km/h) | 159 ± 27 | 333 ± 43 | 400 ± 91 | 290 ± 35 | 259 ± 35 | 323 ± 31 | 395 ± 67 | 324 ± 27 |
| Flight altitude (m agl) | 384 ± 4 | 372 ± 3 | 286 ± 4 | 351 ± 2 | 355 ± 4 | 392 ± 3 | 310 ± 3 | 354 ± 2 |
| Passage rate <125 m agl (targets/km/h) | 27 ± 7 | 40 ± 12 | 109 ± 32 | 55 ± 11 | 63 ± 11 | 58 ± 9 | 98 ± 19 | 73 ± 8 |
| Number of nights | 15 | 15 | 12 | 42 | 15 | 15 | 14 | 44 |

Appendix 3. Nocturnal flight altitudes of radar targets (% of all targets) detected at the 1.5-km range at the proposed Centerville and Wethersfield Windparks, NY, spring 2006, by flight-altitude category.

| | Cumulative % | |
|---|---|---|
| Flight altitude (m agl) | Centerville (n = 11,750 targets) | Wethersfield (n = 15,375 targets) |
| 1–25 | 0.4 | 0.3 |
| 26–50 | 2.5 | 2.6 |
| 51–75 | 6.2 | 8.0 |
| 76–100 | 10.6 | 13.8 |
| 101–125 | 15.7 | 19.4 |
| 126–150 | 20.7 | 24.6 |
| 151–175 | 26.1 | 29.5 |
| 176–200 | 30.8 | 34.1 |
| 201–225 | 35.7 | 38.4 |
| 225–250 | 40.2 | 42.7 |
| 251–1,500 | 100.0 | 100.0 |

Appendix 4. Linear mixed models explaining the influence of environmental factors on passage rates of bird and bat targets on surveillance radar at the proposed Centerville Windpark, NY, spring 2006 (n = 327 sampling sessions). Model weights (wi) were based on Akaike's Information Criterion (AIC).

| Model | -2 Log Likelihood[a] | K[b] | $AIC_c$[c] | $\Delta AIC_c$[d] | $w_i$[e] |
|---|---|---|---|---|---|
| Global: wind direction + ceiling height + favorable migration (d) + synoptic[f] + date + wind speed + barometric pressure change[g] + moon | 490.88 | 25 | 545.20 | 0.00 | 0.99 |
| Synoptic + date | 525.13 | 15 | 556.67 | 11.47 | 0.00 |
| Favorable migration(d) + date | 529.53 | 13 | 556.69 | 11.49 | 0.00 |
| Barometric pressure change + ceiling height + date | 527.15 | 15 | 558.69 | 13.50 | 0.00 |
| Date + ceiling height | 531.28 | 14 | 560.62 | 15.43 | 0.00 |
| Favorable migration(d) + wind direction + date | 525.24 | 17 | 561.22 | 16.02 | 0.00 |
| Lunar illumination + ceiling height + date | 531.25 | 15 | 562.80 | 17.60 | 0.00 |
| Wind direction + ceiling height + date + wind speed | 522.86 | 19 | 563.33 | 18.13 | 0.00 |
| Barometric pressure change + date | 536.19 | 13 | 563.35 | 18.16 | 0.00 |
| Date | 539.30 | 12 | 564.29 | 19.09 | 0.00 |
| Favorable migration(d) | 539.33 | 12 | 564.33 | 19.13 | 0.00 |
| Favorable migration(d) + ceiling height | 535.02 | 14 | 564.36 | 19.17 | 0.00 |
| Direction + date + ceiling height | 526.24 | 18 | 564.47 | 19.27 | 0.00 |
| Lunar illumination + date | 539.28 | 13 | 566.44 | 21.25 | 0.00 |
| Barometric pressure change + wind direction + wind speed + date | 528.66 | 18 | 566.88 | 21.68 | 0.00 |
| Barometric pressure change + wind direction + date | 531.65 | 17 | 567.64 | 22.44 | 0.00 |
| Wind direction + wind speed + date | 532.18 | 17 | 568.16 | 22.96 | 0.00 |
| Wind direction + date | 535.27 | 16 | 569.02 | 23.83 | 0.00 |
| Favorable migration(d) + wind direction | 535.96 | 16 | 569.71 | 24.52 | 0.00 |
| Synoptic | 540.66 | 14 | 570.01 | 24.81 | 0.00 |
| Lunar illumination + wind direction + wind speed + date | 532.18 | 18 | 570.40 | 25.20 | 0.00 |
| Lunar illumination + wind direction + date | 535.24 | 17 | 571.23 | 26.03 | 0.00 |
| Barometric pressure change + ceiling height | 542.40 | 14 | 571.75 | 26.55 | 0.00 |

Appendix 4. Continued.

| Model | -2 Log Likelihood[a] | $K^b$ | $AIC_c{}^c$ | $\Delta AIC_c{}^d$ | $w_i{}^e$ |
|---|---|---|---|---|---|
| Ceiling height | 544.75 | 13 | 571.91 | 26.72 | 0.00 |
| Wind speed | 547.35 | 12 | 572.34 | 27.14 | 0.00 |
| Barometric Pressure change | 547.45 | 12 | 572.44 | 27.25 | 0.00 |
| Lunar illumination + ceiling height | 544.69 | 14 | 574.04 | 28.84 | 0.00 |
| Lunar illumination | 549.40 | 12 | 574.39 | 29.20 | 0.00 |
| Wind direction + ceiling height | 541.14 | 17 | 577.12 | 31.93 | 0.00 |
| Barometric pressure change + wind direction + wind speed | 541.81 | 17 | 577.79 | 32.59 | 0.00 |
| Barometric pressure change + wind direction | 544.04 | 16 | 577.80 | 32.60 | 0.00 |
| Wind direction | 546.29 | 15 | 577.83 | 32.64 | 0.00 |
| Wind direction + wind speed | 544.08 | 16 | 577.84 | 32.64 | 0.00 |
| Lunar illumination + wind direction | 546.22 | 16 | 579.98 | 34.78 | 0.00 |
| Lunar illumination + wind direction + wind speed | 544.05 | 17 | 580.03 | 34.83 | 0.00 |

[a] Calculated with the Maximum Likelihood method.

[b] Number of estimable parameters in approximating model (see methods for explanation).

[c] Akaike's Information Criterion corrected for small sample size.

[d] Difference in value between $AIC_c$ of the current model versus the best approximating model with the minimal $AIC_c$ value.

[e] Akaike weight—probability that the current model (i) is the best approximating model among those being considered.

[f] Synoptic weather

[g] Daily change in barometric pressure

Appendix 5. Linear mixed models explaining the influence of environmental factors on passage rates of bird and bat targets on surveillance radar at the proposed Wethersfield Windpark, NY, spring 2006 (n = 341 sampling sessions). Model weights (wi) were based on Akaike's Information Criterion (AIC).

| Model | -2 Log Likelihood[a] | K[b] | $AIC_c$[c] | Δ $AIC_c$[d] | $w_i$[e] |
|---|---|---|---|---|---|
| Favorable migration(d) + ceiling height | 457.34 | 14 | 486.63 | 0.00 | 0.36 |
| Barometric pressure change[f] + ceiling height | 457.81 | 14 | 487.10 | 0.47 | 0.28 |
| Barometric pressure change + ceiling height + date | 457.36 | 15 | 488.84 | 2.21 | 0.12 |
| Global: wind direction + ceiling height + favorable migration (d) + synoptic[g] + date + wind speed + barometric pressure change + moon | 436.20 | 25 | 490.33 | 3.69 | 0.06 |
| Favorable migration(d) | 465.37 | 12 | 490.32 | 3.69 | 0.06 |
| Barometric Pressure change | 467.42 | 12 | 492.37 | 5.73 | 0.02 |
| Favorable migration(d) + date | 465.33 | 13 | 492.45 | 5.81 | 0.02 |
| Ceiling height | 465.92 | 13 | 493.03 | 6.40 | 0.01 |
| Lunar illumination + ceiling height | 464.50 | 14 | 493.79 | 7.15 | 0.01 |
| Favorable migration(d) + wind direction | 460.64 | 16 | 494.31 | 7.68 | 0.01 |
| Barometric pressure change + wind direction + wind speed | 458.50 | 17 | 494.39 | 7.76 | 0.01 |
| Barometric pressure change + date | 467.34 | 13 | 494.45 | 7.82 | 0.01 |
| Date + ceiling height | 465.79 | 14 | 495.08 | 8.45 | 0.01 |
| Barometric pressure change + wind direction | 461.50 | 16 | 495.18 | 8.55 | 0.01 |
| Synoptic | 466.02 | 14 | 495.30 | 8.67 | 0.00 |
| Lunar illumination + ceiling height + date | 464.43 | 15 | 495.91 | 9.28 | 0.00 |
| Favorable migration(d) + wind direction + date | 460.63 | 17 | 496.53 | 9.89 | 0.00 |
| Wind speed | 471.61 | 12 | 496.56 | 9.93 | 0.00 |
| Barometric pressure change + wind direction + wind speed + date | 458.45 | 18 | 496.58 | 9.94 | 0.00 |
| Barometric pressure change + wind direction + date | 461.50 | 17 | 497.39 | 10.76 | 0.00 |
| Synoptic + date | 465.98 | 15 | 497.46 | 10.82 | 0.00 |
| Lunar illumination | 472.66 | 12 | 497.61 | 10.98 | 0.00 |
| Wind direction + ceiling height | 461.87 | 17 | 497.77 | 11.14 | 0.00 |

Appendix 5. Continued.

| Model | -2 Log Likelihood[a] | K[b] | $AIC_c$[c] | $\Delta$ $AIC_c$[d] | $w_i$[e] |
|---|---|---|---|---|---|
| Date | 474.41 | 12 | 499.37 | 12.73 | 0.00 |
| Lunar illumination + date | 472.66 | 13 | 499.78 | 13.14 | 0.00 |
| Direction + date + ceiling height | 461.87 | 18 | 500.00 | 13.36 | 0.00 |
| Wind direction + ceiling height + date + wind speed | 459.92 | 19 | 500.29 | 13.66 | 0.00 |
| Wind direction + wind speed | 466.66 | 16 | 500.34 | 13.71 | 0.00 |
| Lunar illumination + wind direction + wind speed | 464.55 | 17 | 500.45 | 13.81 | 0.00 |
| Wind direction | 469.12 | 15 | 500.59 | 13.96 | 0.00 |
| Lunar illumination + wind direction | 467.01 | 16 | 500.69 | 14.06 | 0.00 |
| Wind direction + wind speed + date | 466.48 | 17 | 502.38 | 15.74 | 0.00 |
| Lunar illumination + wind direction + wind speed + date | 464.29 | 18 | 502.42 | 15.78 | 0.00 |
| Wind direction + date | 469.06 | 16 | 502.74 | 16.10 | 0.00 |
| Lunar illumination + wind direction + date | 466.90 | 17 | 502.79 | 16.16 | 0.00 |

[a] Calculated with the Maximum Likelihood method.

[b] Number of estimable parameters in approximating model (see methods for explanation).

[c] Akaike's Information Criterion corrected for small sample size.

[d] Difference in value between $AIC_c$ of the current model versus the best approximating model with the minimal $AIC_c$ value.

[e] Akaike weight—probability that the current model (i) is the best approximating model among those being considered.

[f] Daily change in barometric pressure

[g] Synoptic weather

Appendix 6. Linear mixed models explaining the influence of environmental factors on flight altitudes of bird and bat targets on surveillance radar at the proposed Centerville Windpark, NY, spring 2006 (n = 288 sampling sessions). Model weights (wi) were based on Akaike's Information Criterion (AIC).

| Model | -2 Log Likelihood[a] | K[b] | $AIC_c$[c] | $\Delta$ $AIC_c$[d] | $w_i$[e] |
|---|---|---|---|---|---|
| Wind speed | 3429.21 | 11 | 3452.17 | 0.00 | 0.32 |
| Barometric pressure change[f] + wind direction + wind speed + date | 3416.70 | 17 | 3452.96 | 0.79 | 0.22 |
| Barometric pressure change + wind direction + wind speed | 3420.21 | 16 | 3454.22 | 2.05 | 0.12 |
| Wind direction + wind speed + date | 3421.19 | 16 | 3455.20 | 3.03 | 0.07 |
| Barometric pressure change + date | 3430.76 | 12 | 3455.90 | 3.73 | 0.05 |
| Wind direction + wind speed | 3424.55 | 15 | 3456.31 | 4.14 | 0.04 |
| Lunar illumination + wind direction + wind speed + date | 3420.79 | 17 | 3457.06 | 4.89 | 0.03 |
| Barometric Pressure change | 3434.16 | 11 | 3457.12 | 4.95 | 0.03 |
| Lunar illumination + wind direction + wind speed | 3423.97 | 16 | 3457.98 | 5.81 | 0.02 |
| Barometric pressure change + wind direction + date | 3424.15 | 16 | 3458.16 | 5.99 | 0.02 |
| Wind direction + ceiling height + date + wind speed | 3419.78 | 18 | 3458.32 | 6.15 | 0.01 |
| Barometric pressure change + ceiling height + date | 3428.94 | 14 | 3458.47 | 6.30 | 0.01 |
| Date | 3435.61 | 11 | 3458.57 | 6.40 | 0.01 |
| Barometric pressure change + wind direction | 3427.34 | 15 | 3459.10 | 6.93 | 0.01 |
| Barometric pressure change + ceiling height | 3432.36 | 13 | 3459.68 | 7.51 | 0.01 |
| Lunar illumination + date | 3435.54 | 12 | 3460.68 | 8.51 | 0.00 |
| Wind direction + date | 3429.20 | 15 | 3460.96 | 8.79 | 0.00 |
| Date + ceiling height | 3433.84 | 13 | 3461.17 | 9.00 | 0.00 |
| Lunar illumination | 3438.71 | 11 | 3461.67 | 9.50 | 0.00 |
| Wind direction | 3432.24 | 14 | 3461.78 | 9.61 | 0.00 |
| Ceiling height | 3437.12 | 12 | 3462.25 | 10.08 | 0.00 |
| Lunar illumination + wind direction + date | 3429.00 | 16 | 3463.01 | 10.84 | 0.00 |
| Lunar illumination + ceiling height + date | 3433.78 | 14 | 3463.32 | 11.15 | 0.00 |

Appendix 6. Continued.

| Model | -2 Log Likelihood[a] | K[b] | AIC$_c$[c] | Δ AIC$_c$[d] | w$_i$[e] |
|---|---|---|---|---|---|
| Lunar illumination + wind direction | 3431.90 | 15 | 3463.66 | 11.49 | 0.00 |
| Synoptic[g] + date | 3434.18 | 14 | 3463.72 | 11.55 | 0.00 |
| Lunar illumination + ceiling height | 3436.91 | 13 | 3464.24 | 12.07 | 0.00 |
| Direction + date + ceiling height | 3427.99 | 17 | 3464.25 | 12.08 | 0.00 |
| Synoptic | 3436.98 | 13 | 3464.31 | 12.14 | 0.00 |
| Global: wind direction + ceiling height + synoptic + date + wind speed + barometric pressure change + moon | 3414.19 | 23 | 3464.37 | 12.20 | 0.00 |
| Wind direction + ceiling height | 3431.04 | 16 | 3465.05 | 12.88 | 0.00 |

[a] Calculated with the Maximum Likelihood method.

[b] Number of estimable parameters in approximating model (see methods for explanation).

[c] Akaike's Information Criterion corrected for small sample size.

[d] Difference in value between AIC$_c$ of the current model versus the best approximating model with the minimal AIC$_c$ value.

[e] Akaike weight—probability that the current model (i) is the best approximating model among those being considered.

[f] Daily change in barometric pressure

[g] Synoptic weather

Appendix 7. Linear mixed models explaining the influence of environmental factors on flight altitudes of bird and bat targets on surveillance radar at the proposed Wethersfield Windpark, NY, spring 2006 (n = 299 sampling sessions). Model weights (wi) were based on Akaike's Information Criterion (AIC).

| Model | -2 Log Likelihood[a] | K[b] | $AIC_c$[c] | $\Delta AIC_c$[d] | $w_i$[e] |
|---|---|---|---|---|---|
| Wind speed | 1391.90 | 11 | 1414.82 | 0.00 | 0.21 |
| Lunar illumination | 1392.63 | 11 | 1415.55 | 0.74 | 0.15 |
| Lunar illumination + wind direction + wind speed | 1382.97 | 16 | 1416.90 | 2.08 | 0.08 |
| Lunar illumination + wind direction | 1385.35 | 15 | 1417.05 | 2.23 | 0.07 |
| Lunar illumination + date | 1392.48 | 12 | 1417.57 | 2.75 | 0.05 |
| Barometric Pressure change[f] | 1394.80 | 11 | 1417.72 | 2.91 | 0.05 |
| Wind direction + wind speed | 1386.28 | 15 | 1417.98 | 3.16 | 0.04 |
| Date | 1395.27 | 11 | 1418.19 | 3.38 | 0.04 |
| Lunar illumination + ceiling height | 1390.98 | 13 | 1418.26 | 3.44 | 0.04 |
| Wind direction | 1389.02 | 14 | 1418.50 | 3.68 | 0.03 |
| Ceiling height | 1393.81 | 12 | 1418.90 | 4.08 | 0.03 |
| Lunar illumination + wind direction + wind speed + date | 1382.96 | 17 | 1419.14 | 4.33 | 0.02 |
| Lunar illumination + wind direction + date | 1385.34 | 16 | 1419.27 | 4.45 | 0.02 |
| Barometric pressure change + date | 1394.61 | 12 | 1419.70 | 4.88 | 0.02 |
| Synoptic[g] | 1392.47 | 13 | 1419.75 | 4.94 | 0.02 |
| Barometric pressure change + wind direction + wind speed | 1385.92 | 16 | 1419.85 | 5.03 | 0.02 |
| Wind direction + wind speed + date | 1386.26 | 16 | 1420.19 | 5.38 | 0.01 |
| Lunar illumination + ceiling height + date | 1390.85 | 14 | 1420.33 | 5.51 | 0.01 |
| Barometric pressure change + wind direction | 1388.67 | 15 | 1420.37 | 5.55 | 0.01 |
| Barometric pressure change + ceiling height | 1393.28 | 13 | 1420.56 | 5.74 | 0.01 |
| Wind direction + date | 1388.98 | 15 | 1420.67 | 5.86 | 0.01 |
| Date + ceiling height | 1393.63 | 13 | 1420.91 | 6.09 | 0.01 |
| Synoptic + date | 1391.88 | 14 | 1421.36 | 6.55 | 0.01 |

Appendix 7. Continued.

| Model | -2 Log Likelihood[a] | K[b] | $AIC_c$[c] | Δ $AIC_c$[d] | $w_i$[e] |
|---|---|---|---|---|---|
| Wind direction + ceiling height | 1387.75 | 16 | 1421.68 | 6.86 | 0.01 |
| Barometric pressure change + wind direction + wind speed + date | 1385.91 | 17 | 1422.09 | 7.27 | 0.01 |
| Barometric pressure change + wind direction + date | 1388.63 | 16 | 1422.56 | 7.75 | 0.00 |
| Barometric pressure change + ceiling height + date | 1393.12 | 14 | 1422.60 | 7.78 | 0.00 |
| Wind direction + ceiling height + date + wind speed | 1385.23 | 18 | 1423.67 | 8.86 | 0.00 |
| Direction + date + ceiling height | 1387.71 | 17 | 1423.89 | 9.08 | 0.00 |
| Global: wind direction + ceiling height + synoptic + date + wind speed + barometric pressure change + moon | 1379.62 | 23 | 1429.64 | 14.82 | 0.00 |

[a] Calculated with the Maximum Likelihood method.

[b] Number of estimable parameters in approximating model (see methods for explanation).

[c] Akaike's Information Criterion corrected for small sample size.

[d] Difference in value between $AIC_c$ of the current model versus the best approximating model with the minimal $AIC_c$ value.

[e] Akaike weight—probability that the current model (i) is the best approximating model among those being considered.

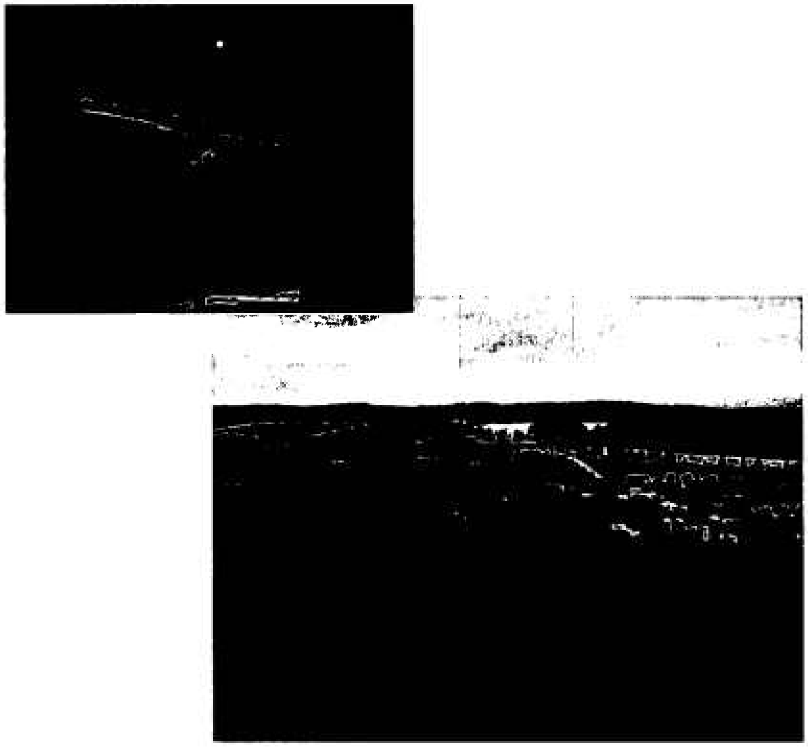
[f] Daily change in barometric pressure

[g] Synoptic weather

# B Nocturnal Radar and Visual Study, Fall 2006 (ABR, Inc.)

FINAL REPORT

# A RADAR AND VISUAL STUDY OF NOCTURNAL BIRD AND BAT MIGRATION AT THE PROPOSED CENTERVILLE AND WETHERSFIELD WINDPARKS, NEW YORK, FALL 2006



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# A RADAR AND VISUAL STUDY OF NOCTURNAL BIRD AND BAT MIGRATION AT THE PROPOSED CENTERVILLE AND WETHERSFIELD WINDPARKS, NEW YORK, FALL 2006

FINAL REPORT

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## EXECUTIVE SUMMARY

- This report presents the results of a radar and visual study of bird and bat migration conducted during a 60 d period in fall (16 August–14 October 2006) at the proposed Centerville and Wethersfield Windparks, located in Allegany and Wyoming counties, western New York. Radar observations were conducted during the evening crepuscular period, the entire nocturnal period (~9–11 h/night), and the morning crepuscular period. Visual observations were conducted for ~5–8h/night during nocturnal hours only.
- The primary goal of this study was to collect information on the migration characteristics of nocturnally migrating birds, especially passerines, during the fall migration period and to assess the extent of use of the area by bats. Specifically, the objectives of this study were to: (1) collect baseline information on migration characteristics (i.e., flight direction, migration passage rates, flight altitudes) of nocturnally migrating birds and bats; (2) visually estimate the relative proportions of birds and bats within the potential rotor-swept area of the proposed wind turbines; and (3) determine the number of birds and bats that may pass within the rotor-swept area of the proposed wind turbines during the migratory season.
- The mean nocturnal flight direction of targets observed on radar was 208° at Centerville and 203° at Wethersfield.
- The mean nocturnal passage rate at Centerville was 259 ± 27 targets/km/h and ranged among nights between 12 and 877 targets/km/h. The mean nocturnal passage rate at Wethersfield was 256 ± 20 targets/km/h and ranged among nights between 31 and 701 targets/km/h. Passage rates at Centerville and Wethersfield varied among some hours of the night (especially between crepuscular and nocturnal hours). Overall, the lowest rates occurred during the first hour of sampling (evening crepuscular period) and were followed by increasing rates until the 3rd or 4th hour of nocturnal sampling, with declining rates until sunrise.
- The mean nocturnal flight altitude at Centerville was 350 ± 2 m agl and ranged among nights between 207 to 586 m agl. The mean nocturnal flight altitude at Wethersfield was 344 ± 1 m agl and ranged among nights between 221 to 571 m agl. Mean flight altitudes varied among some crepuscular and nocturnal hours of the night at both sites, although, there were not strong differences among most hours. There was no strong pattern as to the timing of the lowest altitudes. Approximately 12% of all targets at Centerville and ~11% at Wethersfield were below the maximal height of the proposed wind turbines (125 m).
- During fall migration at Centerville, passage rates increased when a high pressure system entered the area and when winds were favorable, and decreased when ceiling height was ≤ 500 m agl and later in the season. During fall migration at Wethersfield passage rates increased with tailwinds, calm conditions, and during eastern crosswinds.
- During fall migration at Centerville, flight altitudes increased under favorable wind conditions and decreased with increasing wind speeds. At Wethersfield, flight altitudes increased when a high pressure system entered the area (creating favorable winds) and when ceiling height was ≤ 500 m agl and decreased when birds were north or west of a cold front and when wind speeds increased.
- We used visual sampling methods to investigate low-altitude migration of birds and bats. We sampled with both night-vision goggles and spotlights to calculate the proportion of birds and bats below ~150 m agl. In total, ~86% of our visual observations were birds and ~14% were bats at Centerville and ~90% of our visual observations were birds and ~10% were bats at Wethersfield.
- Assuming an average of 10 nocturnal h/d and 60 d in fall, we estimated a turbine passage rate of 130–966 nocturnal songbird/bat migrants passing within the area occupied by each proposed turbine at Centerville during our fall study period, equivalent to 2.2–16.1 migrants/turbine/d. Making the same

assumptions, we estimated a turbine passage rate of 124–857 nocturnal songbird/bat migrants passing within the area occupied by each proposed turbine at Wethersfield during fall 2006, equivalent to 2.1–14.3 migrants/turbine/d.

- The key results of our study were: (1) the mean overall passage rate was 259 targets/km/h at Centerville and 256 targets/km/h at Wethersfield; (2) mean nightly passage rates ranged from 12 to 877 targets/km/h at Centerville and from 31 to 701 targets/km/h at Wethersfield; (3) the percentage of targets passing below 125 m agl was 11.6% at Centerville and 10.9% at Wethersfield; (4) the estimated turbine passage rate of nocturnal migrants passing within the airspace occupied by each proposed turbine was 2.2–16.1 migrants/turbine/d at Centerville and 2.1–14.3 migrants/turbine/d at Wethersfield; and (5) migrants flying below 150 m agl consisted of ~86% birds and ~14% bats at Centerville and ~90% birds and ~10% bats at Wethersfield.

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## ACKNOWLEDGMENTS

We thank Noble Environmental Power, LLC., for funding this study and Patrick McCarthy, Dan Woods, Charles Readling, Michael Beckner, and Colin Kelly for helping with field logistics. We thank Mike Morgante (Ecology and Environment, Inc.) for coordinating field logistics and for information on bird migration in New York. At ABR, we thank Seth Ring, Peter Elstner, Rich Blaha, Corey Grinnell, Kris Tjernell Nick Haxton, Melinda Malek, Mike Davis, Jena Lemke, and Lauren Attanas for help with radar sampling; Rich Blaha for figure preparation, and Alex Prichard for statistical advice. We also thank Dr. Devin Johnson (University of Alaska Fairbanks) for reviewing the statistical methods used for our weather analyses.

## INTRODUCTION

Avian collisions with tall, manmade structures have been recorded in North America since 1948 (Kerlinger 2000), with neotropical migratory birds such as thrushes (Turdidae), vireos (Vireonidae), and warblers (Parulidae) seeming to be the most vulnerable to collisions during their nocturnal migrations (Manville 2000). Passerines sometimes collide with wind turbines (Osborn et al. 2000, Erickson et al. 2001, 2002), composing >80% of the fatalities at wind power developments; ~50% of the fatalities at windfarms involve nocturnal migrants (Erickson et al. 2001). Studies examining the impacts of windfarms on birds in the US and Europe suggest that fatalities and behavioral modifications (e.g., avoidance of windfarms) occur in some, but not all, locations (Winkelman 1995, Anderson et al. 1999, Erickson et al. 2001). Both the documentation of bird fatalities at most wind power facilities studied in the US (i.e., ~2 avian fatalities per turbine per year; Erickson et al. 2001) and the paucity of general information on nocturnal bird migration have generated interest in conducting preconstruction studies of nocturnal migration at the many proposed wind power developments throughout the country. Consideration of potential wind power impacts on nocturnal bird migration is particularly important because more birds migrate at night than during the daytime (Gauthreaux 1975, Kerlinger 1995). In particular, passerines ("songbirds") may be more at risk of colliding with structures at night because these birds tend to migrate at lower altitudes than do other groups of birds (e.g., waterfowl, shorebirds; Kerlinger 1995).

Recent data from Appalachian ridgetops in the eastern US (Erickson 2004, Kerns 2004) have indicated that substantial bat kills are also possible at wind power projects and have prompted researchers to develop methods for assessing bat use of proposed wind power projects (Reynolds 2006). Most of the bat fatalities documented at wind farms have been associated with migratory species during seasonal periods of dispersal and migration in late summer and fall and several hypotheses have been posited, but not tested, to explain bat/turbine interactions (Arnett 2005).

Although the precise relationship between nocturnal bird/bat use and fatality at wind power developments currently is unknown, the current radar study was undertaken to provide baseline information on nocturnal bird and bat migration at the proposed Centerville and Wethersfield Windparks during fall 2006.

Noble Environmental Power, LLC proposes to build the Centerville Windpark, a ~100 MW wind power development in Allegany County and the Wethersfield Windpark, a 127.5 MW wind power development in Wyoming County in southwestern New York (Fig. 1). Each of the 61–67 wind turbines (Centerville) and 85 wind turbines (Wethersfield) will have a generating capacity of up to ~1.5–2.0 MW. The monopole towers will be 80 m (263 ft) in height, and each turbine will have three rotor blades. The diameter of the rotor blades and hub will be 77 m (253 ft), thus, the total maximal height of a turbine will be 118.5 m (389 ft) with a blade in the vertical position. The proposed developments are located in the Appalachian Plateau physiographic province (USGS 2003). Although these physiographic areas contain well-documented migration corridors for some species of birds (Bull 1985, Bellrose 1976, Zalles and Bildstein 2000), the migratory pathways of most nocturnal migrants are poorly documented.

## OBJECTIVES

The primary goal of this study was to collect information on the migration characteristics of nocturnally migrating birds (especially passerines) and bats during fall migration. Specifically, the objectives of this study were to: (1) collect baseline information on migration characteristics (i.e., flight direction, migration passage rates, flight altitudes) of nocturnally migrating birds and bats; (2) visually estimate the relative proportions of birds and bats within the potential rotor-swept area of the proposed wind turbines; and (3) determine the number of birds and bats that would pass within the rotor-swept area of the proposed wind turbines during the migratory season. We also evaluated the influence of weather on migration passage rates and flight altitudes.

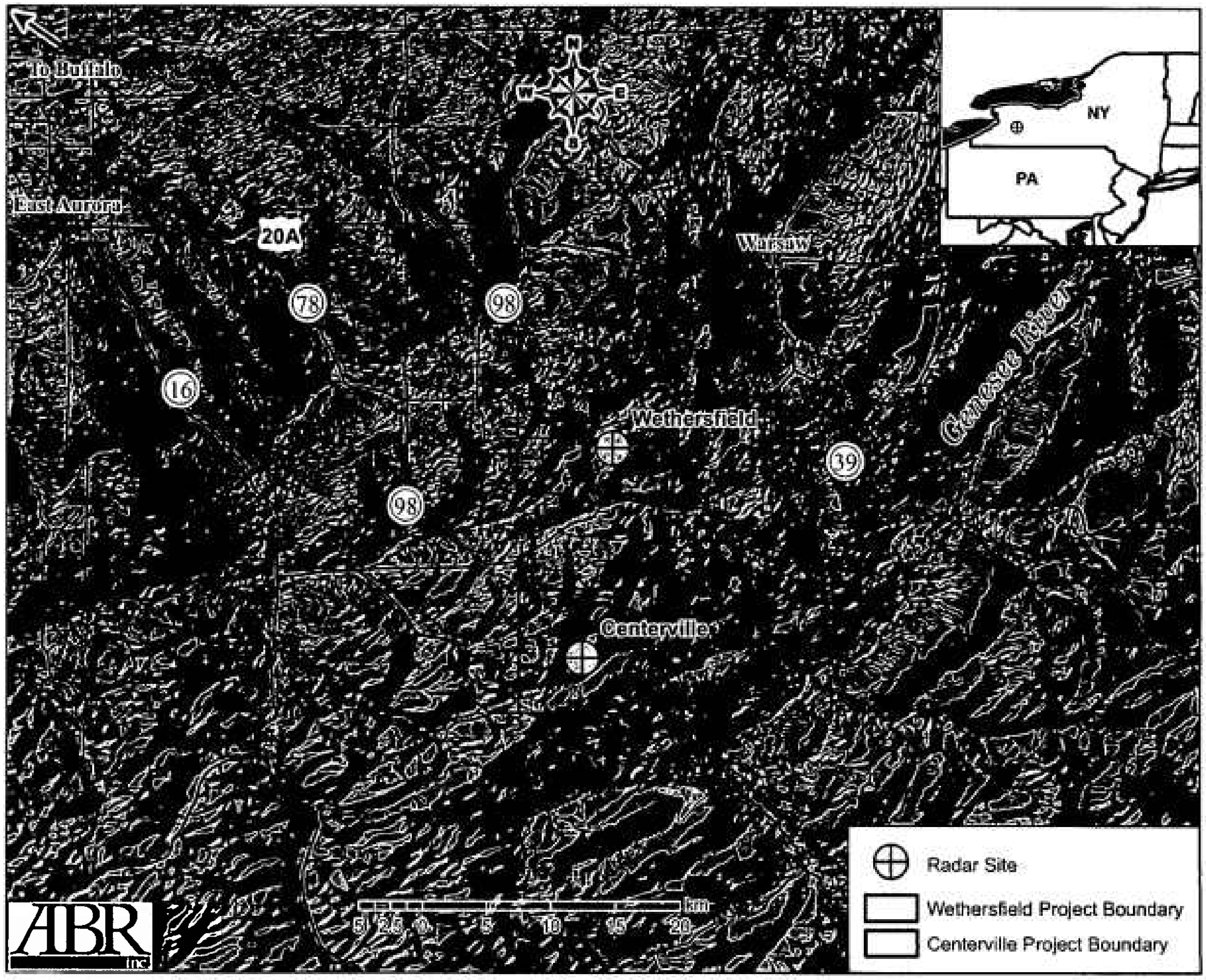

Figure 1. Map of the proposed Centerville and Wethersfield Windparks in Allegany and Wyoming Counties, New York.

## STUDY AREA

The proposed Centerville and Wethersfield Windparks are located in the Appalachian Plateau region of southwestern New York, near the towns of Arcade and Warsaw in Allegany and Wyoming Counties, respectively (Fig. 1). This region is characterized by rolling terrain with elevation ranging from ~1,312–1,969 ft (~400–600 m) above sea level (asl) and is part of the Appalachian Plateau physiographic province (USGS 2003). Both the proposed Noble Centerville and Wethersfield Windparks are located in rural locations with limited and dispersed residential development, in rolling terrain with a mix of woodlots, open farmland, dairy farms, and forested wetlands scattered throughout the project area. Virtually all of the land has been logged previously in both project areas.

The proposed Centerville development is located ~5 miles (~8 km) east of Arcade, New York, and the proposed Wethersfield development is located ~7 miles (~11 km) southwest of Warsaw, New York. Our Centerville radar sampling site (42°28’29”N, 78°15’52”W) was located ~ 2,133 ft (650 m) asl on a small ridge in the middle of the proposed project area overlooking the town of Centerville whereas the Wethersfield radar sampling site (42°36’54”N, 78°14’51”W) was located ~ 1,969 ft (600 m) asl in an open field near the center of the proposed project area (Fig. 1).

# METHODS

## STUDY DESIGN

We conducted radar and visual observations on 60 nights during fall (16 August to 14 October 2006) to overlap with the peak of passerine migration, (especially for warblers, thrushes, and vireos—the primary taxa of interest; Buffalo Ornithological Society 2002) and bat migration (Johnson 2005). We obtained useable data from radar observations during 57 nights at Centerville (48 nights for visual observations) and 56 nights for Wethersfield (56 nights for visual observations); on the remaining nights, we were unable to conduct radar observations because of inclement weather (rain or fog) or problems with our radar equipment. Each night, we conducted radar and visual surveys during the evening crepuscular period (sunset to ~ 45 min after sunset), the entire nocturnal period (~45 min after sunset to ~45 min before sunrise) and the morning crepuscular period (~45 min before sunrise to sunrise) between the hours of 1945 and 0630, for a total of ~11–13.5 h/night. Sampling during all crepuscular and nocturnal hours was done at the request of the New York State Department of Environmental Conservation. This sampling schedule provides coverage before, during, and beyond the peak hours of nocturnal passerine migration within a night (Lowery 1951, Gauthreaux 1971, Alerstam 1990, Kerlinger 1995, Mabee et al. 2006a).

## RADAR EQUIPMENT

Our mobile radar laboratory consisted of a marine radar that was mounted on the roof of a van and that functioned as both a surveillance and vertical radar. When the antenna was in the horizontal position (i.e., in surveillance mode), the radar scanned the area surrounding the lab (Fig. 2), and we manually recorded information on flight direction, flight behavior, passage rates, and groundspeeds of targets. When the antenna was placed in the vertical position (i.e., in vertical mode), the radar scanned the area in an arc across the top of the lab (Fig. 3), and we manually measured flight altitudes of targets with an index line on the monitor. All data were recorded manually into a laptop computer. A description of a similar radar laboratory can be found in Gauthreaux (1985a, 1985b) and Cooper et al. (1991), and a similar vertical radar configuration was described by Harmata et al. (1999) and Mabee et al. (2006a).

The radar (Furuno Model FR-1510 MKIII; Furuno Electric Company, Nishinomiya, Japan) is a standard marine radar transmitting at 9.410 GHz (i.e., X-band) through a 2-m-long slotted waveguide (antenna) with a peak power output of 12 kW. The antenna had a beam width of 1.23° (horizontal) × 25° (vertical) and a sidelobe of ±10–20°. Range accuracy is 1% of the maximal range of the scale in use or 30 m (whichever is greater) and bearing accuracy is ±1°.

This radar can be operated at a variety of ranges (0.5–133 km) and pulse lengths (0.07–1.0 µsec). We used a pulse length of 0.07 µsec while operating at the 1.5-km range. At shorter pulse lengths, echo resolution is improved (giving more accurate information on target identification, location, and distance), whereas, at longer pulse lengths, echo detection is improved (increasing the probability of detecting a target). An echo is a picture of a target on the radar monitor; a target is one or more birds (or bats) that are flying so closely together that the radar displays them as one echo on the display monitor. This radar has a digital color display with several scientifically useful features, including True North correction for the display screen (to determine flight directions), color-coded echoes (to differentiate the strength of return signals), and on-screen plotting of a sequence of echoes (to depict flight paths). Because targets plot every sweep of the antenna (i.e., every 2.5 sec) and because groundspeed is directly proportional to the distance between consecutive echoes, we were able to measure ground speeds of plotted targets to the nearest 5 mi/h (8 km/h) with a hand-held scale.

Energy reflected from the ground, surrounding vegetation, and other solid objects that surround the radar unit causes a ground-clutter echo to appear on the display screen. Because ground-clutter echoes can obscure targets, we minimized their occurrence by elevating the forward edge of the antenna by ~15° and by parking the mobile radar laboratory in locations that were surrounded by low trees or low hills,

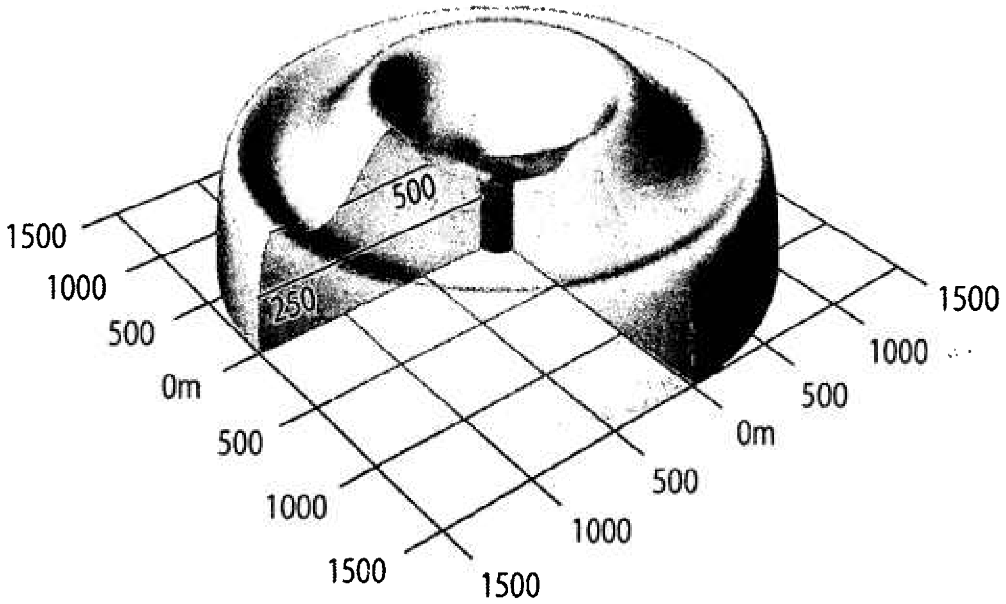

Figure 2. Approximate airspace sampled by Furuno FR–1510 marine radar when operating in the surveillance mode (antenna in the horizontal orientation) as determined by field trials with Rock Pigeons. Note that the distribution of the radar beam within 250 m of the origin (i.e., the darkened area) was not determined.

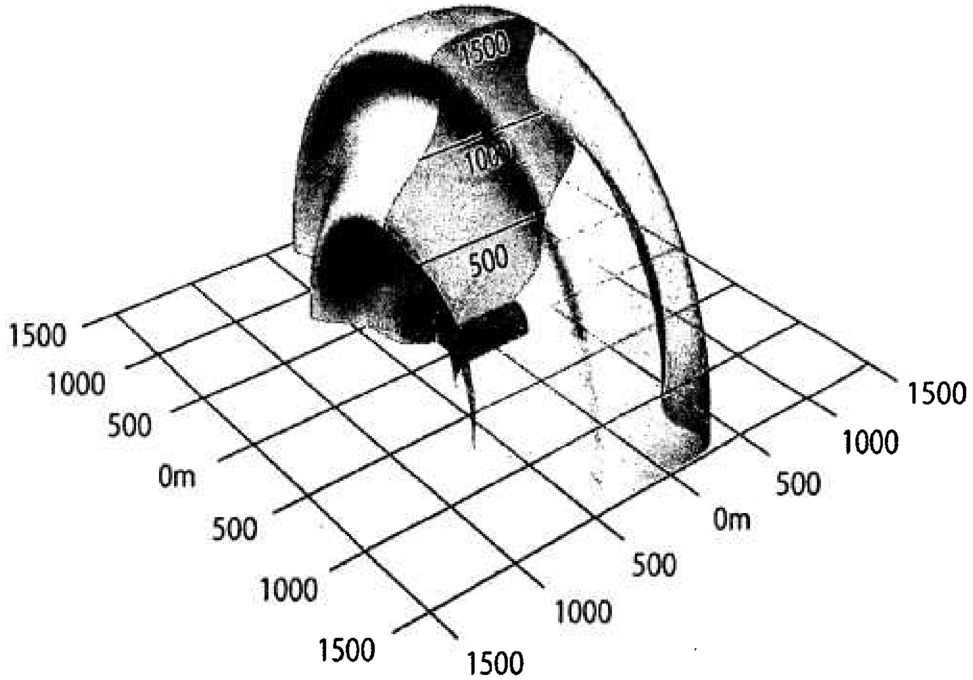

Figure 3. Approximate airspace sampled by Furuno FR–1510 marine radar when operating in the vertical mode (antenna in the vertical orientation) as determined by field trials with Rock Pigeons. Note that the distribution of the radar beam within 250 m of the origin (i.e., the darkened area) was not determined.

whenever possible. These objects act as a radar fence that shields the radar from low-lying objects farther away from the lab and that produces only a small amount of ground clutter in the center of the display screen. For further discussion of radar fences, see Eastwood (1967), Williams et al. (1972), Skolnik (1980), and Cooper et al. (1991).

Maximal distances of detection of targets by the surveillance radar depends on radar settings (e.g., gain and pulse length), target body size, flock size, flight profile, proximity of targets in flocks, atmospheric conditions, and, to some extent, the amount and location of ground clutter. Flocks of waterfowl routinely were detected to 5–6 km, individual hawks usually were detected to 2–3 km, and single, small passerines were routinely detected out to 1–1.5 km (Cooper et al. 1991).

## DATA COLLECTION

### TARGET IDENTIFICATION ON RADAR

The species composition and size of a flock of birds or bats observed on the radar usually was unknown. Therefore, the term "target," rather than "flock" or "individual," is used to describe animals detected by the radar. Based on the study period and location, it is likely that the majority of targets that we observed were individual passerines, which generally do not migrate in tight flocks (Lowery 1951, Kerlinger 1995); it also is likely that a smaller number of targets were migratory bats. Differentiating among various targets (e.g., birds, bats, insects) is central to any radar study, especially with X-band radars that can detect small flying animals. Because bat flight speeds overlap with flight speeds of passerines (i.e., are >6 m/s; Tuttle 1988, Larkin 1991, Bruderer and Boldt 2001, Kunz and Fenton 2003; Cooper and Day, ABR Inc., unpubl. data), it was not possible to separate bird targets from bat targets based solely on flight speeds. We were able to exclude foraging bats based on their erratic flight patterns; however, migratory bats or any bats not exhibiting erratic flight patterns were included in our data.

Of primary importance in target identification is the elimination of insect targets. We reduced insect contamination by (1) omitting small targets (the size of gain speckles) that only appeared within ~500 m of the radar and targets with poor reflectivity (e.g., targets that plotted erratically or inconsistently in locations having good radar coverage); and (2) editing data prior to analyses by omitting surveillance and vertical radar targets with corrected airspeeds <6 m/s (following Diehl et al. 2003). The 6 m/s airspeed threshold was based on radar studies that have determined that most insects have an airspeed of <6 m/s, whereas that of birds and bats usually is ≥6 m/s (Tuttle 1988, Larkin 1991, Bruderer and Boldt 2001, Kunz and Fenton 2003; Cooper and Day, ABR Inc., unpubl. data).

### SAMPLING DESIGN

We sampled during all nocturnal hours in this study to ensure that migration metrics from this study would be based on all possible hours and nocturnal conditions and, therefore, would be representative of the nocturnal period. We also sampled during dusk and dawn periods to determine if there were bird movements (e.g., taking off and landing) occurring within the height of the proposed wind turbines. This intensive sampling schedule (actually a census of all crepuscular and nocturnal hours) was done at the request of the New York State Department of Environmental Conservation.

Each of the ~11–13 one-hr crepuscular and nocturnal radar sampling sessions/night consisted of: (1) one 10-min session to collect weather data and adjust the radar to surveillance mode; (2) one 10-min session with the radar in surveillance mode (1.5-km range) for collection of information on migration passage rates; (3) one 15-min session with the radar in surveillance mode (1.5-km range) for collection of information on groundspeed, flight direction, tangential range (minimal perpendicular distance to the radar laboratory), transect crossed (the four cardinal directions—north, south, east, and west), species (if known), and the number of individuals (if known); (4) one 10-min session to collect weather data and adjust the radar to vertical mode; and (5) one 15-min session with the radar in vertical mode (1.5-km range) to collect information on flight altitudes, speed, and direction.

For each vertical radar session, the antenna was oriented parallel to the main axis of migration (determined by the modal flight direction seen during the previous surveillance radar session) to maximize the true flight speed of targets. True flight speeds of targets can be determined only for those targets flying parallel to the antenna's orientation because slower speeds are obtained when targets fly at an angle to this plane of orientation. We also examined the flight behavior of vertical radar targets during crepuscular and nocturnal hours by recording whether targets were ascending from the ground, ascending at a steep angle above ground (extrapolated flight path would have intersected the ground on the monitor), flying at a level altitude, descending at a steep angle (extrapolated flight path would have intersected the ground on the monitor), and descending to the ground.

Weather data collected twice each hour consisted of the following: wind speed (collected with a "Kestrel" anemometer in 5-mph [2.2-m/s] categories); wind direction (in ordinal categories to the nearest 45°); cloud cover (to the nearest 5%); ceiling height (in m agl; 1–50, 51–100, 100–150, 151–500, 501–1,000, 1,001–2,500, 2,501–5,000, >5,000); minimal visibility in a cardinal direction (in m; 0–50, 51–100, 101–500, 501–1,000, 1,001–2,500, 2,501–5,000, >5,000); precipitation level (no precipitation, fog, drizzle, light rain, heavy rain, snow flurries, light snowfall, heavy snowfall, sleet, hail); barometric pressure, and air temperature (measured with a thermometer to the nearest 1°C). We could not collect radar data during rain because the electronic filtering required to remove the echoes of the precipitation from the display screen also removed those of the targets of interest. We also obtained weather data (wind speed and wind direction) from a 50-m high meteorological tower located near the sites.

### VISUAL OBSERVATIONS OF LOW-ALTITUDE BIRDS AND BATS

We conducted visual observations with Generation 3 night-vision goggles with a 1X eyepiece (Model ATN-PVS7; American Technologies Network Corporation, San Francisco, California) every night to assess relative numbers and proportions of birds and bats flying at low altitudes (≤150 m agl, the approximate maximal distance that passerines and bats could be discerned).

We used two 3 million-Cp spotlights with infrared lens filters to illuminate targets flying overhead while eliminating the attractiveness of the light to insects, birds, and bats. One "fixed" spotlight was mounted on a tripod with the beam oriented vertically, while a second, handheld light was used to track and identify potential targets flying through the "fixed" spotlight's beam. Two sampling sessions of ~20–25 min were conducted each hour, concurrent with radar surveys, during all nightly sessions. For each bird or bat detected visually, we recorded the taxon (to species when possible), flight direction, flight altitude, and behavior (straight-line, erratic, circling, hovering). Whenever possible, bats were classified as "small bats" or "large bats," in an attempt to discriminate the larger Hoary (*Lasiurus cinereus*), Eastern Red (*Lasiurus borealis*), Big Brown (*Eptesicus fuscus*), and Silver-haired (*Lasionycteris noctivagans*) bats from smaller species (e.g., *Myotis* spp.).

## DATA ANALYSES

### RADAR DATA

We entered all radar data into MS Access databases. Data files were checked visually for errors after each night and then were checked again electronically for irregularities at the end of the field season, prior to data analyses. All analyses were conducted with SPSS statistical software (SPSS 2005). For quality assurance, we cross-checked results of the SPSS analyses with hand-tabulations of small data subsets whenever possible. The level of significance (α) for all statistical tests was set at 0.05.

Radar data were not corrected for differences in detectability with distance from the radar unit. Correcting for differences in target detectability is confounded by several factors, including but not limited to the following: (1) variation in target size (i.e., species) across the study period; (2) an assumption that there is an equal distribution of targets throughout the sampling area (which would be violated if migrants responded to landform or microsite features on the landscape); (3) variation in the shape and size of the effective radar-sampling beam (see our preliminary assessment of the shape of our radar beam under one set of conditions in Figures 2 and 3). Thus, our passage rate estimates (and other estimates derived from passage rates) should be considered an index of the actual number of birds and bats passing through the area, useful for comparisons with our previous studies and other radar studies that use similar equipment and methods.

Airspeeds (i.e., groundspeed corrected for wind speed and relative direction) of surveillance-radar targets were computed with the formula:

$$V_a = \sqrt{V_g^{\,2} + V_w^{\,2} - 2V_g V_w \cos\theta},$$

where $V_a$ = airspeed, $V_g$ = target groundspeed (as determined from the radar flight track), $V_w$ = wind velocity, and $\theta$ is the difference between the observed flight direction and the direction of the wind vector. Targets that had corrected airspeeds <6 m/s (12.2% and 8.4% of all surveillance data at Centerville and Wethersfield, respectively), were deleted from all analyses.

We calculated mean and median flight directions of radar targets to provide insight on the orientation of bird movements. Equally important, we presented a metric to describe the dispersion of flight directions. This metric, the mean vector length (r), varies from a value of 0 (maximal dispersion) to 1 (maximal concentration). Mean flight directions coupled with high r values indicate strong patterns in flight orientation whereas mean flight directions coupled with low r values indicate weak to no directionality in flight movements. Because flight directions of visual targets were recorded only in 45° increments, we only report median values of these directions, as mean values could be misleading. We analyzed flight-direction data following procedures for circular statistics (Zar 1999) with Oriana software version 2.0 (Kovach 2003).

Migration passage rates are reported as the mean ± 1 standard error (SE) number of targets passing along 1 km of migratory front/h (targets/km/h ± 1 SE). Passage rates of targets flying <125 m in altitude were derived for each hourly period by multiplying passage rates recorded from surveillance radar by the percentage of targets on vertical radar having flight altitudes <125 m, correcting for the hypothetical maximal height of the surveillance radar beam. All flight-altitude data are presented in m agl (above ground level) relative to a horizontal plane passing through the radar-sampling site. Actual mean altitudes may be higher than those reported because an unknown number of birds fly above the 1.5-km range limit of our radar (Mabee and Cooper 2004).

For calculations of the daily patterns in migration passage rates and flight altitudes, we assumed that a day began at 0700 h on one day and ended at 0659 h the next day, so that a sampling night was not split between two dates. We used repeated-measures ANOVAs with the Greenhouse-Geisser epsilon adjustment for degrees of freedom (SPSS 2005), to compare passage rates and flight altitudes among hours of the night for nights with data collected during all sessions. Factors that decreased our sample size of the various summaries and analyses included insect contamination and precipitation. Sample sizes therefore sometimes varied among the different summaries and analyses.

### EFFECTS OF WEATHER ON MIGRATION PASSAGE RATES AND FLIGHT ALTITUDES

We modeled the hourly influence of weather and date separately on the dependent variables passage rates and flight altitudes. We obtained our weather data (i.e., wind speed and direction) from a 50-m meteorological tower located near the radar sampling sites. All wind categories except the calm category had a mean wind speed of ≥2.2 m/s (i.e., ≥5 mph) and were categorized as the following during fall: tail winds WNW to ENE (i.e., 293°–068°), head winds ESE to SSW (i.e., 113°–248°), eastern crosswinds (069°–112°), western crosswinds (249°–292°), and calm (0–2.2 m/s).

Prior to model specification, we examined the data for redundant variables (Spearman's $r_s$ >0.70) and retained eight parameters for inclusion in the passage rate model set and seven parameters in the altitude model set. We examined scatterplots and residual plots to ensure that variables met assumptions of analyses (i.e., linearity, normality, collinearity) and did not contain presumed outliers (>3 SE). We used a natural logarithm transformation on the dependent variables "passage rate" for the Centerville site and a square root transformation for the Wethersfield site and used a natural logarithm transformation on the dependent variable "flight altitude" at both the Centerville and Wethersfield sites, to make the data normal. We specified 35 models for passage rates and 30 models for flight altitudes: a global model containing all variables and subset models representing potential influences of five small-scale weather variables (wind speed, wind direction, ceiling height (including fog), and daily barometric pressure change), one large-scale weather variable (synoptic —that reflected the position of pressure systems or frontal systems relative to our study site (Fig. 4), one variable reflecting the number of days between favorable migration conditions (i.e., the number of days since last tail wind, used only in passage rate models), one variable describing the percent of the moon illuminated on a given night, and date on migration passage rates and flight altitudes. Synoptic weather codes were based on Gauthreaux (1980) and Williams et al. (2001). We analyzed all model sets with linear mixed models that treated nights as subjects and hourly sessions within a night as the repeated measure. This treatment of the data allows the full use of hourly sessions while properly modeling the appropriate covariance structure for this variable. Because the hourly sessions within a night were temporally correlated, we used a first-order autoregressive structure with heterogeneous variances for the covariance structure for both the passage rate and altitude models.

Because the number of sampling sessions for both passage rates ($n = 488$ at Centerville, $n = 496$ at Wethersfield) and flight altitudes ($n = 444$ at Centerville, $n = 462$ at Wethersfield) was small relative to the number of parameters ($K$) in many models (i.e., $n/K < 40$), we used Akaike's Information Criterion corrected for small sample size ($AIC_c$) for model selection (Burnham and

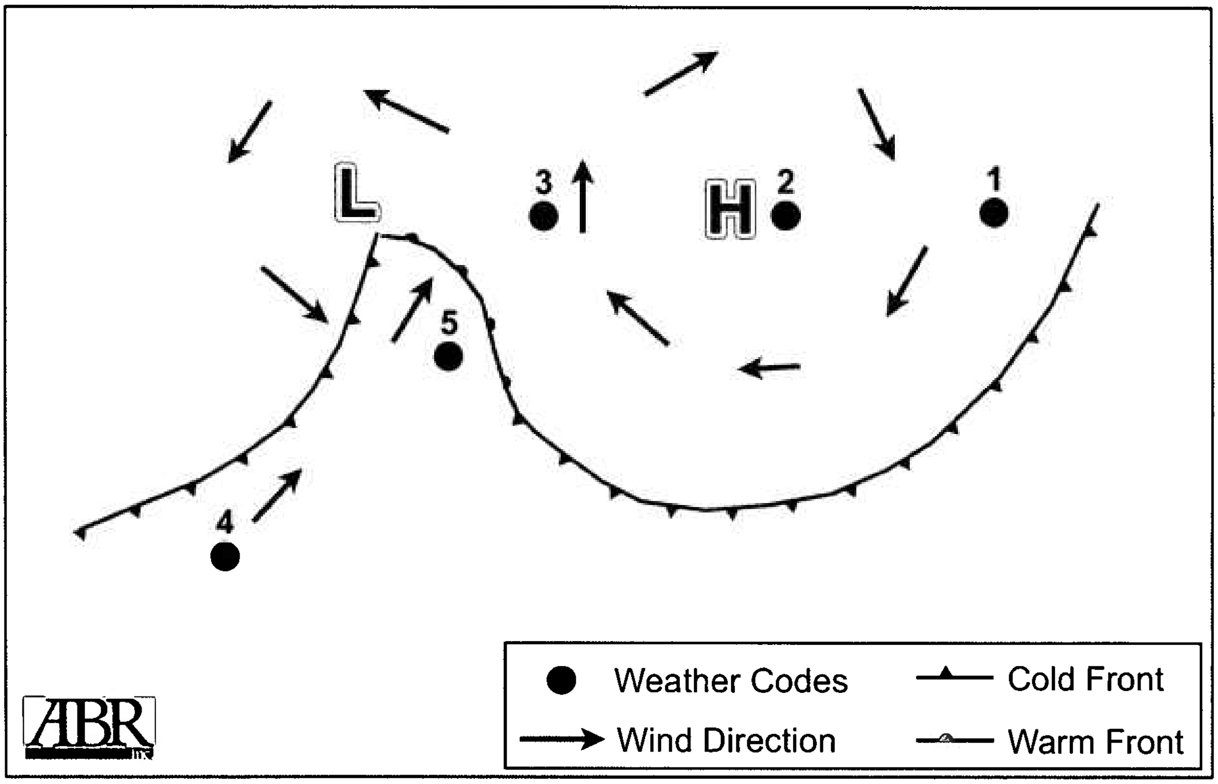

Figure 4. Synoptic weather codes used to depict the position of pressure systems or frontal systems relative to the study site. Code 1 = N or W of cold front, 2 = near center of high pressure system, 3 = W of high pressure system, 4 = S or E of cold front, 5 = S of warm front.

Anderson 2002). We ranked all candidate models according to their $AIC_c$ values and considered the best-approximating model (i.e., most parsimonious) to be that model having the smallest $AIC_c$ value (Burnham and Anderson 2002). We drew primary inference from models within 2 units of the minimal $AIC_c$ value, although models within 4–7 units may have some empirical support (Burnham and Anderson 2002). We calculated Akaike weights ($w_i$) to determine the weight of evidence in favor of each model (Burnham and Anderson 2002). All analyses were conducted with SPSS software (SPSS 2005).

### TURBINE PASSAGE RATE INDEX

To describe migration passage rates within the potential turbine area we developed the turbine passage rate index (the number of nocturnal migrants flying within the turbine area throughout the study period). The turbine passage rate index is comprised of several components, including: (1) *passage rate of targets flying <125 m agl* (calculated by multiplying passage rates from surveillance radar by the percentage of targets on vertical radar with flight altitudes <125 m agl, correcting for the maximal height of the surveillance radar beam); (2) *turbine area* that migrants would encounter when approaching turbines from the side (parallel to the plane of rotation) or from the front (perpendicular to the plane of rotation); (3) *study period* (number of nights during the migration period); and (4) *number of hours of migration/night* (estimated as the number of nocturnal hours). These factors are combined as described in Appendix 1 to produce the turbine passage rate index.

We consider these estimates to be indices because they are based on several simplifying assumptions that may vary among projects. The assumptions for this specific project include: (1) minimal (i.e., side profile) and maximal (i.e., front profile, including the entire rotor-swept area) areas occupied by the wind turbines relative to the flight directions of migrants, (2) a worst-case scenario of the rotor blades turning constantly (i.e., used the entire rotor swept area, not just the area of the blades themselves), (3) a 60-d migration period (fall), and (4) an average of 10 nocturnal hours/day of migration during fall migration.

## RESULTS

### FLIGHT DIRECTION

At night, most radar targets were traveling in seasonally appropriate directions for fall migration (i.e., southerly), with a mean flight direction of 208° at Centerville (mean vector length = 0.42; median = 210°; $n$ = 16,650 targets; Fig. 5a) and a mean flight direction of 203° at Wethersfield (mean vector length = 0.32; median = 205°; $n$ = 16,470 targets; Fig. 5b). Most of the nocturnal targets were traveling in a southerly direction, between SW (225°) and SE (135°) at Centerville (73%) and at Wethersfield (67%).

### PASSAGE RATES

The mean nocturnal passage rate for the fall season during nocturnal hours was 259 ± 27 targets/km/h ($n$ = 57 nights) at Centerville and was 256 ± 20 targets/km/h ($n$ = 56 nights) at Wethersfield. Mean passage rates did not differ significantly between the Centerville and Wethersfield sites ($Z_{paired} = -0.746$, $P = 0.456$, $n$ = 55 paired nights). Overall mean nightly passage rates were highly variable among nights at Centerville (range = 12–877 targets/km/h; Fig. 6a) and at Wethersfield (range = 31–701 targets/km/h; Fig. 6b) and during different time periods of the migratory season (Appendix 2).

Passage rates varied significantly among crepuscular and nocturnal hours of the night for nights with 9, 10, and 11 hours of darkness/night at both Centerville and Wethersfield (Fig. 7; Table 1). Similarly, passage rates varied significantly among nocturnal hours of the night for nights with 9, 10, and 11 hours of darkness/night at Centerville and most hours at Wethersfield (Fig. 7; Table 1). Overall, the lowest rates generally occurred during the first hour of sampling (evening crepuscular period) and were followed by increasing rates until approximately the 3rd hour of nocturnal sampling, with approximately stable rates for a few hours, and then with declining rates until sunrise.

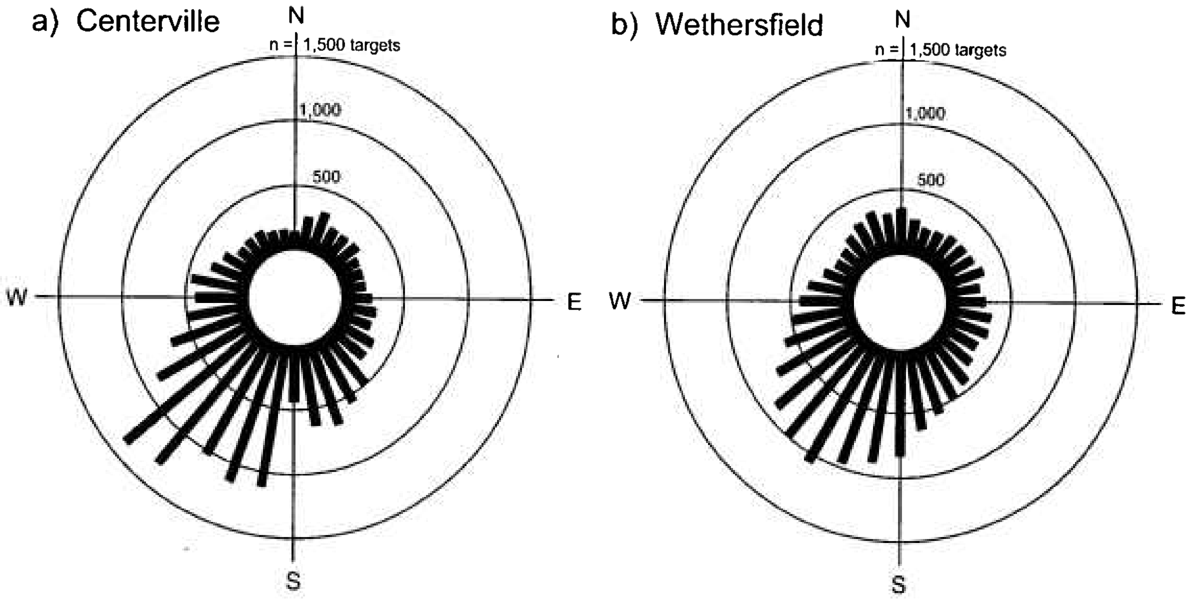

Figure 5. Flight directions of radar targets at the proposed (a) Centerville and (b) Wethersfield Windparks, New York, fall 2006.

## FLIGHT ALTITUDES

The mean nocturnal flight altitude for the entire fall season during nocturnal hours was 350 ± 1.6 m agl (*n* = 18,584 targets; median = 311 m agl) at Centerville and 344 ± 1.4 m agl (*n* = 20,531 targets; median = 309 m agl) at Wethersfield. Mean flight altitudes did not differ significantly between the Centerville and Wethersfield sites (Centerville 6 m > Wethersfield ; $Z_{paired}$ = -0.503, $P$ = 0.615, $n$ = 55 paired nights). Mean flight altitudes observed on vertical radar (1.5-km range) were highly variable among nights ranging from 207 to 586 m agl at Centerville (Fig. 8a) and from 221 to 571 at Wethersfield (Fig. 8b). Flight altitudes were also variable during different portions of the migratory season (Appendix 2).

Mean flight altitudes did not vary among crepuscular and nocturnal hours of the night for nights with 8, 9, or 10 hours of darkness/night at both Centerville and Wethersfield (Fig. 9; Table 1). Similarly, mean flight altitudes did not vary among nocturnal hours of the night during most hours of darkness/night at Centerville and Wethersfield (Fig. 9; Table 1). Overall the lowest altitudes occurred at variable times of the crepuscular and nocturnal periods and no strong pattern was evident.

The overall distribution of targets in 100-m categories of nocturnal flight altitudes at Centerville varied from 21.8% in the 201–300 m agl interval to 0% in the 1,301–1,400 and 1,401–1,500 m agl intervals and flight altitudes at Wethersfield varied from 22.9% in the 201–300 m agl interval to 0% in the 1,301–1,400 and 1,401–1,500 m agl intervals (Table 2). A detailed examination of the percent of targets within 250 m agl (by 25-m categories) for both sites is provided in Appendix 3. We determined during nocturnal hours that 11.6% of all targets flew <125 m at Centerville and that 10.9% of all targets flew <125 m at Wethersfield, which is the approximate maximal height of the proposed wind turbines.

Observations of the flight behavior of targets during crepuscular and nocturnal hours showed that the vast majority of targets flew over the Centerville and Wethersfield sites at level flight

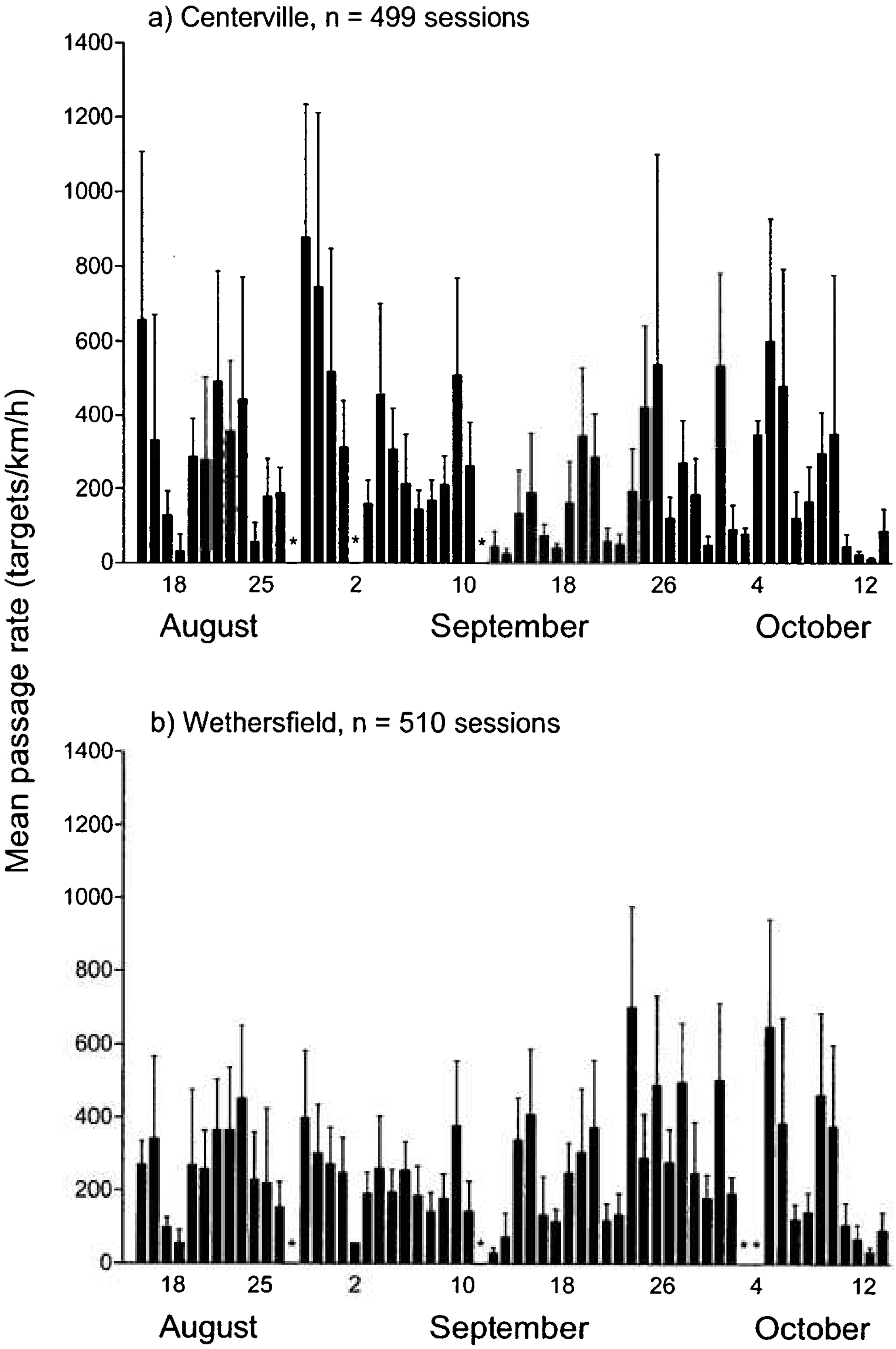

Figure 6. Mean ± 1 SE nightly passage rates (targets/km/h) at the proposed (a) Centerville and (b) Wethersfield Windparks, New York, fall 2006. Asterisks denote nights not sampled because of fog, rain, or snow.

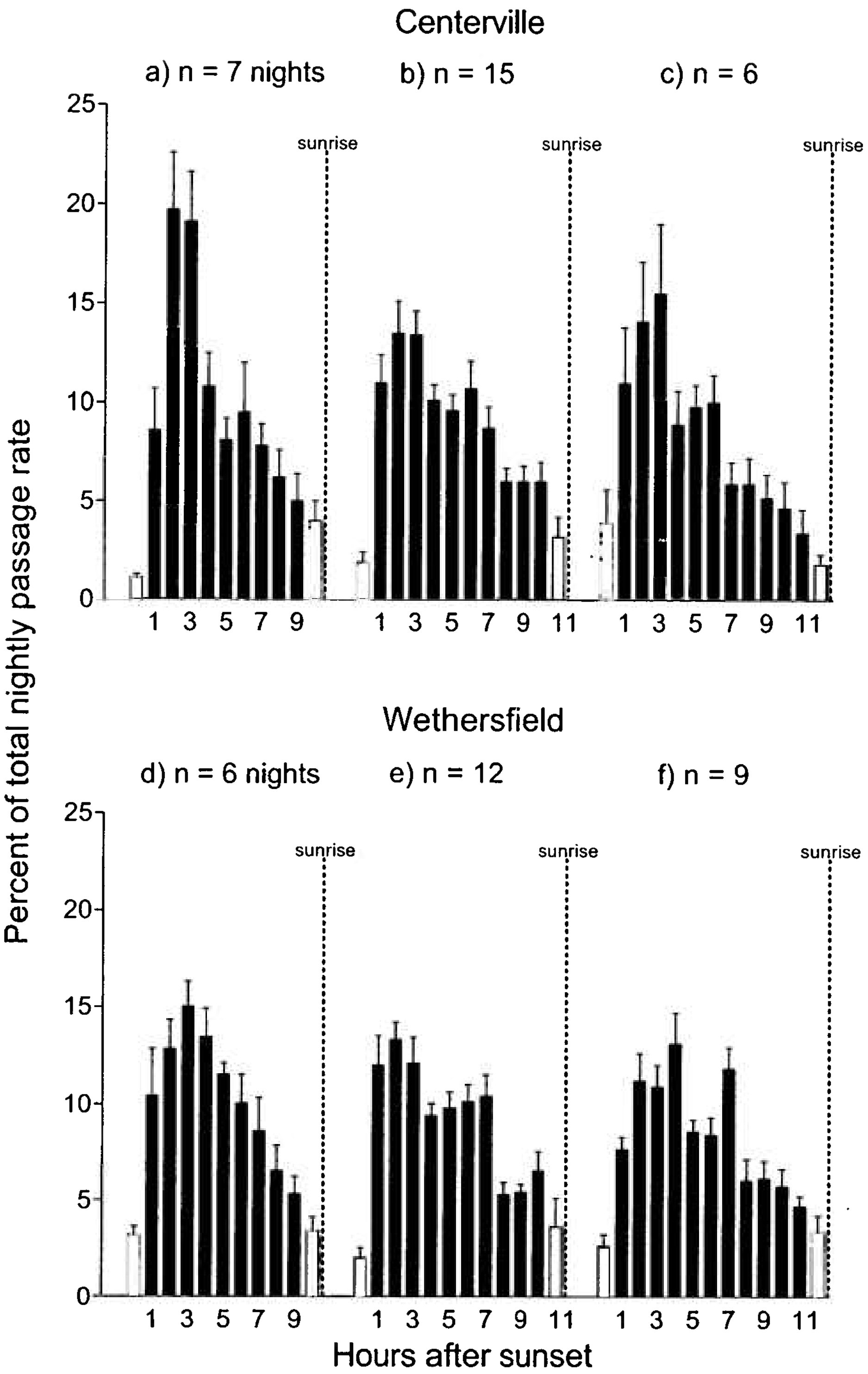

Figure 7. Percent of nightly passage rate (± 1 SE) relative to time past sunset for nights that had 9 hours of darkness/night at (a) Centerville and (d) Wethersfield, 10 hours of darkness/night at (b) Centerville and (e) Wethersfield, and 11 hours of darkness/night at (c) Centerville and (f) Wethersfield at the proposed Centerville and Wethersfield Windparks, New York, fall 2006. First and last hours are crepuscular periods.

Table 1. Hourly variation in passage rates and flight altitudes between crepuscular and nocturnal periods and among nocturnal hours at the proposed Centerville and Wethersfield Windparks, New York, fall 2006.

| | Crepuscular and Nocturnal | | | | Nocturnal | | | |
|---|---|---|---|---|---|---|---|---|
| Metric /site /hours > sunset | *df* | *F* | *P* | *n* | *df* | *F* | *P* | *n* |
| Passage rate (targets/km/h) | | | | | | | | |
| Centerville | | | | | | | | |
| 9 | 2.5, 15.1 | 9.4 | 0.001 | 7 | 2.6, 15.4 | 6.5 | 0.006 | 7 |
| 10 | 3.0, 42.2 | 11.1 | <0.001 | 15 | 2.5, 37.9 | 5.9 | 0.003 | 16 |
| 11 | 2.0, 10.2 | 4.7 | 0.036 | 6 | 2.1, 15.0 | 6.6 | 0.008 | 8 |
| Wethersfield | | | | | | | | |
| 9 | 2.2, 11.1 | 8.0 | 0.006 | 6 | 2.5, 17.5 | 2.5 | 0.098 | 8 |
| 10 | 3.8, 42.0 | 12.6 | <0.001 | 12 | 3.4, 51.3 | 9.8 | <0.001 | 16 |
| 11 | 2.8, 22.4 | 10.7 | <0.001 | 9 | 2.5, 19.7 | 7.2 | 0.003 | 9 |
| Flight altitude (m agl) | | | | | | | | |
| Centerville | | | | | | | | |
| 8 | 1.8, 3.6 | 2.9 | 0.175 | 3 | 1.9, 5.7 | 8.4 | 0.021 | 4 |
| 9 | 2.9, 14.7 | 2.7 | 0.084 | 6 | 3.0, 29.8 | 1.7 | 0.180 | 11 |
| 10 | 1.1, 2.2 | 2.3 | 0.261 | 3 | 1.8, 12.4 | 2.8 | 0.100 | 11 |
| Wethersfield | | | | | | | | |
| 8 | 3.1, 15.6 | 1.4 | 0.267 | 6 | 2.4, 12.1 | 1.8 | 0.205 | 6 |
| 9 | 3.7, 25.8 | 1.8 | 0.173 | 8 | 3.9, 35.5 | 1.1 | 0.374 | 10 |
| 10 | 2.3, 23.0 | 2.1 | 0.146 | 11 | 2.6, 33.6 | 2.3 | 0.100 | 14 |

altitudes (Fig. 10a and 10b respectively). We observed small percentages of birds taking off and landing during some crepuscular and nocturnal hours as well as ascending or descending steeply throughout most crepuscular and nocturnal hours at both sites (Fig. 10a and 10b respectively).

## EFFECTS OF WEATHER ON MIGRATION

We investigated the importance of weather (i.e., wind direction, wind speed, ceiling height [including fog], daily barometric pressure change, synoptic weather [days since favorable migration—passage rate models only]), lunar illumination, and date on both the passage rates and flight altitudes of nocturnal migrants by building a series of models (combinations of the various weather variables and date; Appendix 4), and then using a model-selection technique (AIC) to quantify the statistical strength of those models. The AIC method allows one to (1) rank and identify the "best" model(s) (i.e., the most statistically supported models) from the full set of models, and (2) assess the statistical strength and relative importance of individual variables composing the "best" models.

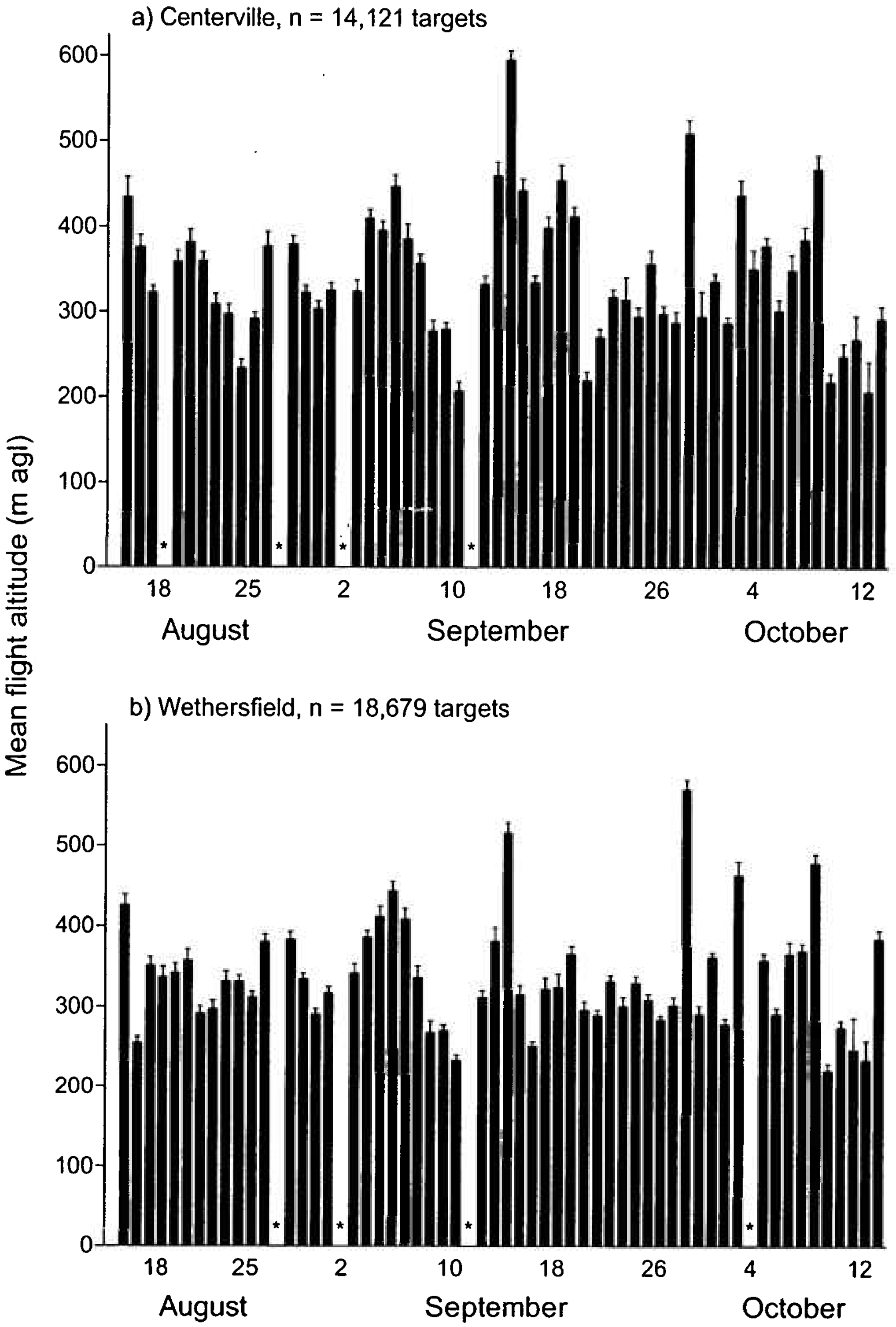

Figure 8. Mean ± 1 SE nightly flight altitudes (m agl) at the proposed (a) Centerville and (b) Wethersfield Windparks, New York, fall 2006. Asterisks denote nights not sampled because of fog, rain, or snow.

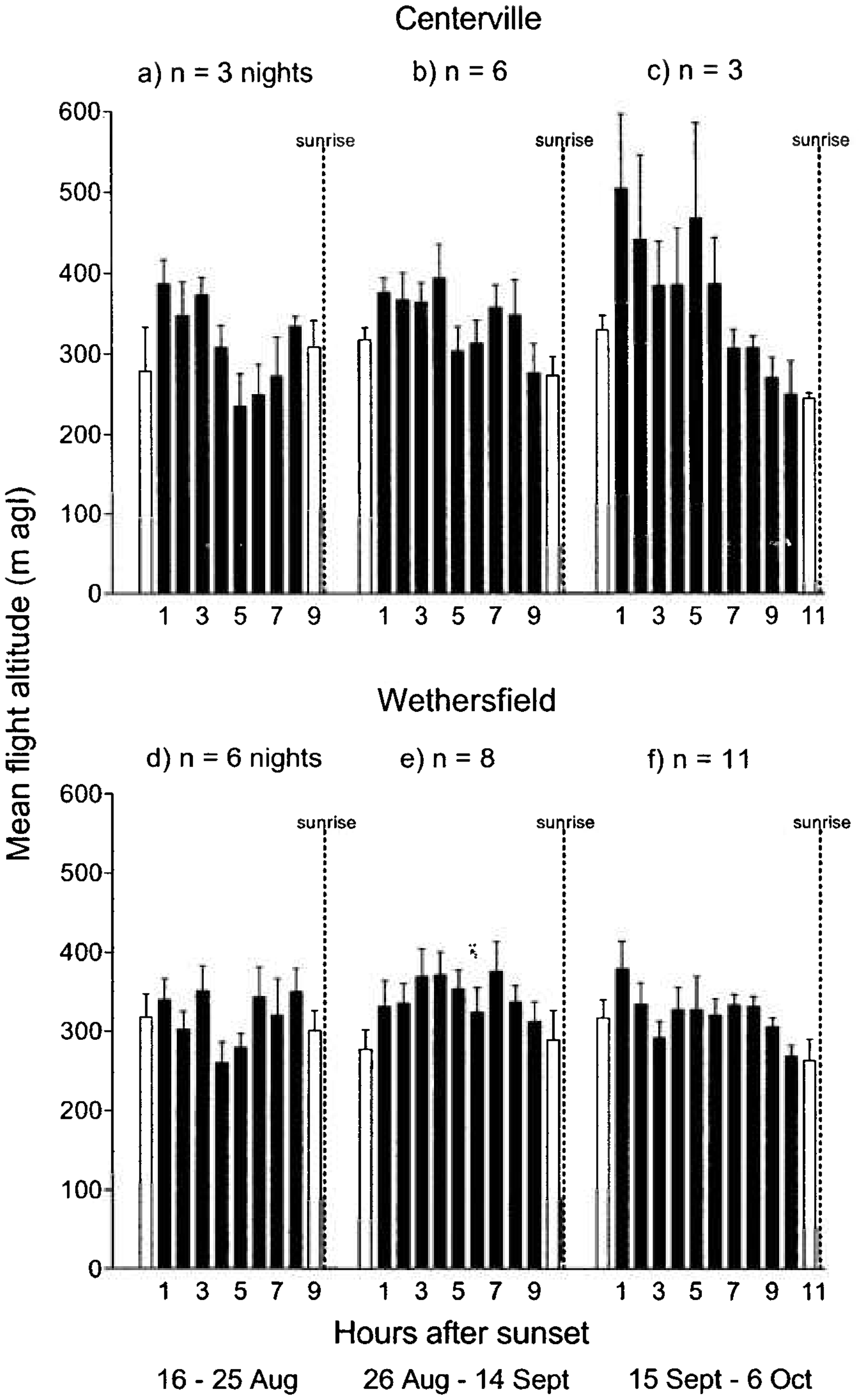

Figure 9. Percent of nightly flight altitude (± 1 SE) relative to time past sunset for nights that had 8 hours of darkness/night at (a) Centerville and (d) Wethersfield, 9 hours of darkness/night at (b) Centerville and (e) Wethersfield, 10 hours of darkness/night at (c) Centerville and (f) Wethersfield at the proposed Centerville and Wethersfield Windparks, New York, fall 2006. First and last hours are crepuscular periods. No figure for 7–14 October because of insufficient data.

Table 2. Nocturnal flight altitudes of radar targets (% of all targets) detected at the 1.5 km range at proposed Centerville and Wethersfield Windparks, New York, fall 2006, by flight-altitude category.

| | Percent of radar targets | |
|---|---|---|
| Flight altitude (m agl) | Centerville (n = 18,584 targets) | Wethersfield (n = 20,531 targets) |
| 0–100 | 7.8 | 7.1 |
| 101–200 | 18.1 | 18.2 |
| 201–300 | 21.8 | 22.9 |
| 301–400 | 19.2 | 19.4 |
| 401–500 | 13.3 | 13.7 |
| 501–600 | 8.4 | 8.4 |
| 601–700 | 4.5 | 4.4 |
| 701–800 | 2.8 | 2.3 |
| 801–900 | 1.8 | 1.5 |
| 901–1,000 | 1.0 | 1.1 |
| 1,001–1,100 | 0.7 | 0.5 |
| 1,101–1,200 | 0.5 | 0.2 |
| 1,201–1,300 | 0.1 | 0.1 |
| 1,301–1,400 | 0.0 | 0.0 |
| 1,401–1,500 | 0.0 | 0.0 |

## PASSAGE RATES

The best-approximating model explaining migration passage rates of nocturnal migrants during fall migration at Centerville was the global model containing the variables wind direction, ceiling height, days since favorable migration, synoptic weather, date, wind speed, change in barometric pressure, and lunar illumination (Table 3). The second-best model contained the variables barometric pressure change, ceiling height, and date but was not well supported ($\Delta AIC_c = 7.71$; Appendix 5). The global model contained significant positive associations with barometric pressure change and tailwinds indicating that passage rates increased when a high pressure system entered the area and when winds were favorable (Table 4). Ceiling height and date were associated negatively, indicating that passage rates decreased when ceiling height was $\leq 500$ m agl and later in the season (Table 4). Passage rates were not related to the number of days since favorable migratory conditions, lunar illumination, synoptic weather, or wind speed. The weight of evidence in favor of the "best" model ($w_{best}/w_{second\ best}$) was 49 times that of the second-best model (Burnham and Anderson 2002). The complete passage rate model set for Centerville can be found in Appendix 5 for the reader interested in examining all models and their associated statistical metrics.

The best-approximating model explaining migration passage rates of nocturnal migrants during fall migration at Wethersfield was the model containing the variables wind direction and date, although this models was not well supported ($\Delta AIC_c = 0.12$; Table 3). The second-best model containing the variables barometric pressure change, wind direction, and date was also not well supported ($\Delta AIC_c = 0.12$; Table 3). These models contained a significant positive association with wind direction indicating that passage rates increased with tailwinds, calm conditions, and during eastern crosswinds (Table 4). Passage rates were not related to barometric pressure change,

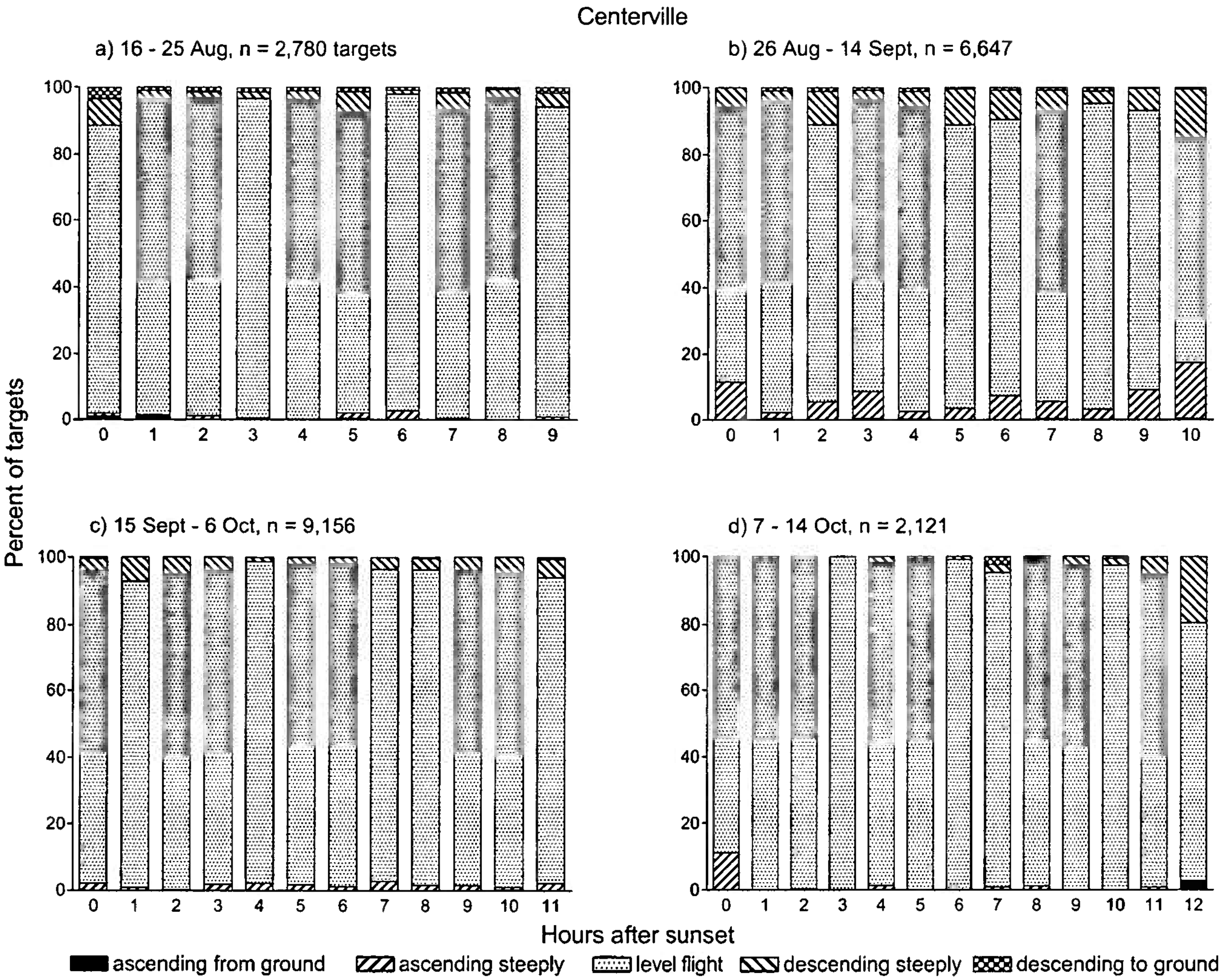

Figure 10a. Flight behavior of targets (%) relative to time past sunset for nights that had 8 hours of darkness/night (a), 9 hours of darkness/night (b), 10 hours of darkness/night (c), and 11 hours of darkness/night (d) at the proposed Centerville Windpark, New York, fall 2006. First and last hours are crepuscular periods.

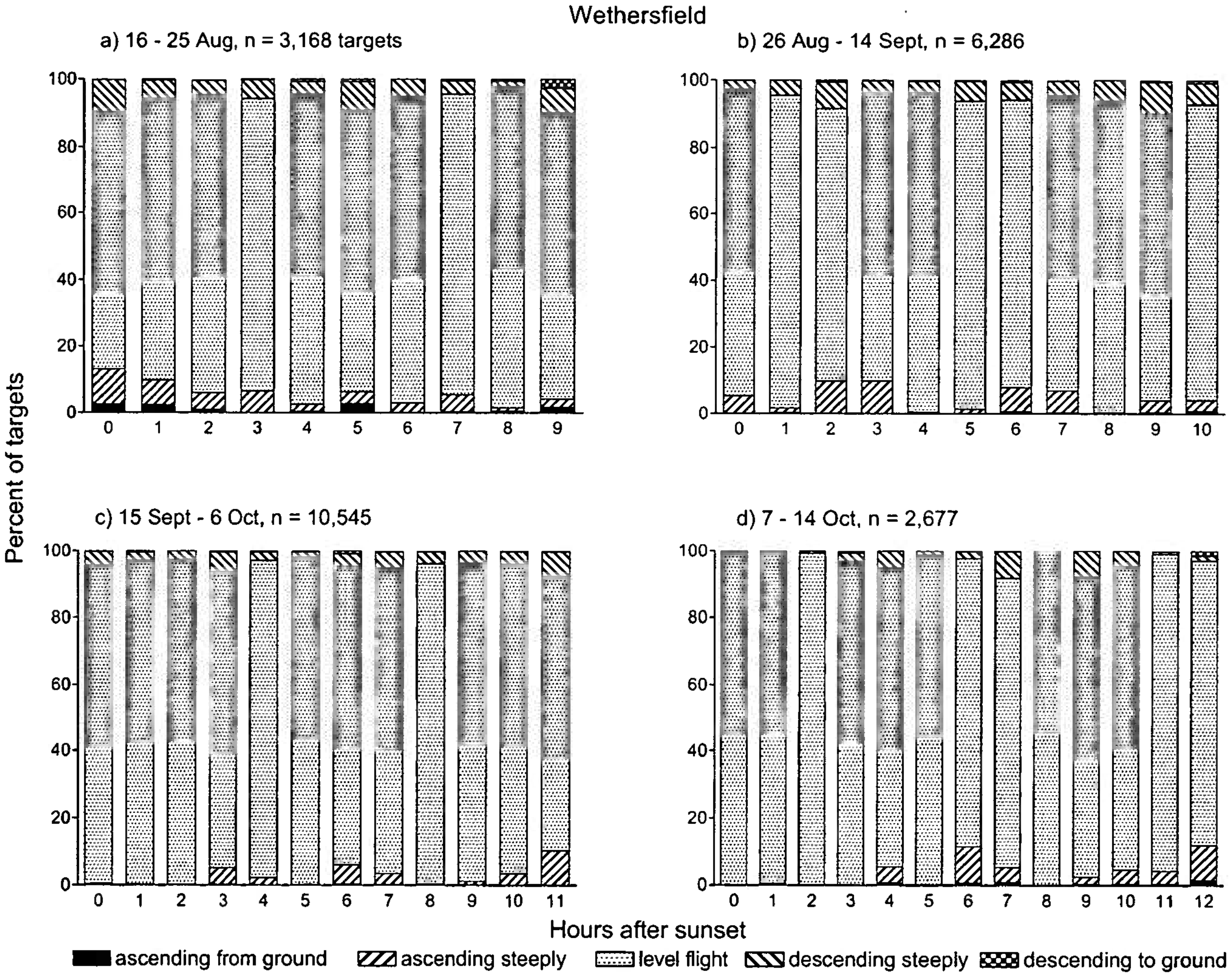

Figure 10b. Flight behavior of targets (%) relative to time past sunset for nights that had 8 hours of darkness/night (a), 9 hours of darkness/night (b), 10 hours of darkness/night (c), and 11 hours of darkness/night (d) at the proposed Wethersfield Windpark, New York, fall 2006. First and last hours are crepuscular periods.

Table 3. Linear mixed model estimates from competitive models (Δ AICc ≤ 2) explaining the influence of environmental factors on passage rates of bird and bat targets on surveillance radar at the proposed Centerville and Wethersfield Windparks, New York, fall 2006 (Centerville, n = 488 sampling sessions; Wethersfield, n = 496 sampling sessions). Model weights (wi) were based on Akaike's Information Criterion (AIC).

| Station/Model | -2 Log Likelihood[a] | K[b] | $AIC_c$[c] | Δ $AIC_c$[d] | $w_i$[e] |
|---|---|---|---|---|---|
| Centerville | | | | | |
| Global: wind direction + ceiling height + synoptic[f] + date + wind speed + barometric pressure change[g] + moon | 1051.069 | 28 | 1110.607 | 0.00 | 0.98 |
| Wethersfield | | | | | |
| Wind direction + date | 2686.661 | 18 | 2724.095 | 0.00 | 0.12 |
| Barometric pressure change + wind direction + date | 2684.579 | 19 | 2724.176 | 0.08 | 0.12 |
| Wind direction + wind speed + date | 2685.639 | 19 | 2725.235 | 1.14 | 0.07 |
| Lunar illumination + wind direction + date | 2685.672 | 19 | 2725.269 | 1.17 | 0.07 |
| Favorable migration(d) + wind direction + date | 2685.779 | 19 | 2725.375 | 1.28 | 0.07 |
| Barometric pressure change + wind direction + wind speed + date | 2683.829 | 20 | 2725.597 | 1.50 | 0.06 |
| Direction + date + ceiling height | 2684.108 | 20 | 2725.877 | 1.78 | 0.05 |

[a] Calculated with the Maximum Likelihood method.

[b] Number of estimable parameters in approximating model (see methods for explanation).

[c] Akaike's Information Criterion corrected for small sample size.

[d] Difference in value between $AIC_c$ of the current model versus the best approximating model with the minimal $AIC_c$ value.

[e] Akaike weight—probability that the current model (i) is the best approximating model among those being considered.

[f] Synoptic weather

[g] Daily change in barometric pressure

Table 4. Model-averaged parameter estimates from competitive models (Δ AICc ≤ 2) explaining the influence of environmental factors on passage rates of bird and bat targets at the proposed Centerville and Wethersfield Windparks, New York, fall 2006. Coefficients (B) of the categorical variables (ceiling height, synoptic weather, wind direction) were calculated relative to high ceiling conditions (> 500 m agl), unfavorable migratory conditions (S or E of cold front/S of warm front), and headwinds, respectively. Asterisks indicate 95% confidence intervals that do not overlap zero.

| Station/Parameter | B | SE |
|---|---|---|
| Centerville | | |
| Intercept | 5.347 | 0.540* |
| Barometric pressure change | 2.658 | 0.512* |
| Ceiling height = 0–50 m agl (fog) | -1.097 | 0.199* |
| Ceiling height = 51–500 m agl | -0.473 | 0.116* |
| Date | -0.014 | 0.005* |
| Favorable migration (d) | 0.061 | 0.035 |
| Lunar illumination | 0.192 | 0.140 |
| Synoptic Weather = (N or W of a cold front) | 0.240 | 0.484 |
| Synoptic Weather = (near center of high pressure system) | -0.294 | 0.503 |
| Synoptic Weather = (W of high pressure system) | -0.842 | 0.517 |
| Synoptic Weather = (S or E of cold front/S of warm front) | -0.049 | 0.483 |
| Wind direction = tailwind | 0.341 | 0.157* |
| Wind direction = calm | 0.145 | 0.190 |
| Wind direction = eastern crosswind | 0.483 | 0.174* |
| Wind direction = western crosswind | -0.146 | 0.124 |
| Wind speed | -0.024 | 0.028 |
| Wethersfield | | |
| Barometric pressure change | 4.241 | 2.768 |
| Ceiling height = 0–50 m agl (fog) | -0.983 | 0.901 |
| Ceiling height = 51–500 m agl | 0.280 | 0.835 |
| Date | -0.055 | 0.038 |
| Favorable migration (d) | 0.468 | 0.389 |
| Lunar illumination | -0.857 | 0.739 |
| Wind direction = tailwind | 1.885 | 0.707* |
| Wind direction = calm | 2.784 | 0.923* |
| Wind direction = eastern crosswind | 1.950 | 0.902* |
| Wind direction = western crosswind | 0.551 | 0.592 |
| Wind speed | -0.174 | 0.149 |

ceiling height, date, days since favorable migration, lunar illumination, synoptic weather, or wind speed. The weight of evidence in favor of the "best" model ($w_{best}/w_{second\ best}$) was 1.7 times that of the second-best model (Burnham and Anderson 2002). The complete passage rate model set for Wethersfield can be found in Appendix 5 for the reader interested in examining all models and their associated statistical metrics.

### FLIGHT ALTITUDES

The best-approximating model explaining flight altitudes of nocturnal migrants during fall migration at Centerville was the model containing the variable wind speed (Table 5). The second-best model contained the variables wind direction and wind speed ($\Delta AIC_c = 2.0$; Table 5). These models contained strong positive associations with tailwinds and crosswinds indicating that flight altitudes increased under these favorable wind conditions (Table 6). These models contained strong negative associations with wind speed indicating that flight altitudes decreased with increasing wind speeds. Flight altitudes were not related to barometric pressure change, ceiling height, date, lunar illumination, or synoptic weather. The weight of evidence in favor of the "best" model ($w_{best}/w_{second\ best}$) was 2.8 times that of the second-best model (Burnham and Anderson 2002). The complete flight altitude model set for Centerville can be found in Appendix 6 for the reader interested in examining all models and their associated statistical metrics.

The best-approximating model explaining flight altitudes of nocturnal migrants during fall migration at Wethersfield was the model containing the variable wind speed (Table 5). The second-best model contained the variables wind direction, ceiling height, date, and wind speed ($\Delta AIC_c = 0.16$; Table 5), and a third model containing all variables (global model; $\Delta AIC_c = 1.87$) also received some empirical support (Appendix 6). These models contained strong positive associations with barometric pressure and ceiling height indicating that flight altitudes increased when a high pressure system entered the area and when ceiling height was $\leq 500$ m agl (Table 6). These models contained strong negative associations with synoptic weather and wind speed indicating that flight altitudes decreased when birds were North or West of a cold front and when wind speeds increased. Flight altitudes were not related to barometric pressure change, date, lunar illumination, or wind direction. The weight of evidence in favor of the "best" model ($w_{best}/w_{second\ best}$) was 1.1 times that of the second-best model (Burnham and Anderson 2002). The complete flight altitude model set for Wethersfield can be found in Appendix 6 for the reader interested in examining all models and their associated statistical metrics.

## TARGETS WITHIN THE PROPOSED TURBINE AREA

The mean passage rate of targets 125 m at Centerville was 38 ± 5.5 targets/km/h and at Wethersfield was 36 ± 5.0 targets/km/h. We made several assumptions to estimate the turbine passage rate (i.e., the number of targets that would pass within the area occupied by each proposed turbine): (1) the minimal area occupied by the wind turbine (i.e., side profile), (2) the maximal area occupied by the wind turbine (i.e., front profile, including the entire rotor-swept area), (3) a worst-case scenario of the rotor blades turning constantly, (4) 60 d in the study during fall, and (5) an average of 10 nocturnal hours/day across the 60-d fall period. If all migrants approached the turbines from the side, an estimated 130 migrants (Centerville) and 124 migrants (Wethersfield) would have passed within the area occupied by one turbine (Appendix 1). If all migrants approached the turbines from the front, an estimated 966 migrants (Centerville) and 857 (Wethersfield) would have passed within the area occupied by one turbine during our fall study period (Appendix 1). An alternate way to look at this relationship is on a per day basis; these estimates would be equivalent to an estimate of 2.2–16.1 migrants passing through the area of a single turbine each day at Centerville and 2.1–14.3 migrants at Wethersfield (Appendix 1).

## VISUAL DATA

We collected visual data on birds and bats on 48 nights at Centerville and on 56 nights at Wethersfield. Most birds were traveling in seasonally appropriate directions for fall migration (i.e., southerly), at Centerville (Fig. 11c) and

Table 5. Linear mixed model estimates from competitive models (Δ AICc ≤ 2) explaining the influence of environmental factors on flight altitudes of bird and bat targets on vertical radar at the proposed Centerville and Wethersfield Windparks, New York, fall 2006 (Centerville n = 444, Wethersfield n = 462 sampling sessions). Model weights (wi) were based on Akaike's Information Criterion (AIC).

| Station/Model | -2 Log Likelihood[a] | K[b] | $\text{AIC}_c$[c] | Δ $\text{AIC}_c$[d] | $w_i$[e] |
|---|---|---|---|---|---|
| Centerville | | | | | |
| Wind speed | 131.288 | 13 | 158.134 | 0.00 | 0.50 |
| Wind direction + wind speed | 124.701 | 17 | 160.138 | 2.00 | 0.18 |
| Wethersfield | | | | | |
| Wind speed | -62.901 | 13 | -36.088 | 0.00 | 0.28 |
| Wind direction + ceiling height + date + wind speed | -77.834 | 20 | -35.930 | 0.16 | 0.26 |
| Global: wind direction + ceiling height + synoptic[f] + date + wind speed + barometric pressure change[g] + moon | -87.203 | 25 | -34.221 | 1.87 | 0.11 |

[a] Calculated with the Maximum Likelihood method.

[b] Number of estimable parameters in approximating model (see methods for explanation).

[c] Akaike's Information Criterion corrected for small sample size.

[d] Difference in value between $\text{AIC}_c$ of the current model versus the best approximating model with the minimal $\text{AIC}_c$ value.

[e] Akaike weight—probability that the current model (i) is the best approximating model among those being considered.

[f] Synoptic weather

[g] Daily change in barometric pressure

Table 6. Model-averaged parameter estimates from competitive models (Δ AICc ≤ 2) explaining the influence of environmental factors on flight altitudes of bird and bat targets at the proposed Centerville and Wethersfield Windparks, New York, fall 2006. Coefficients (B) of the categorical variables (ceiling height, synoptic weather, wind direction) were calculated relative to high ceiling conditions (> 500 m agl), unfavorable migratory conditions (S or E of cold front/S of warm front), and headwinds, respectively. Asterisks indicate 95% confidence intervals that do not overlap zero.

| Station/Parameter | B | SE |
|---|---|---|
| Centerville | | |
| Wind speed | -0.040 | 0.011* |
| Wind direction = tailwind | 0.121 | 0.058* |
| Wind direction = calm | 0.122 | 0.078 |
| Wind direction = eastern crosswind | 0.122 | 0.062* |
| Wind direction = western crosswind | 0.099 | 0.048* |
| Wethersfield | | |
| Intercept | 5.925 | 0.077* |
| Barometric pressure change | 0.254 | 0.148 |
| Ceiling height = 0-50 m agl (fog) | 0.190 | 0.066* |
| Ceiling height = 51-500 m agl | 0.006 | 0.052 |
| Date | 0.000 | 0.001 |
| Lunar illumination | -0.003 | 0.046 |
| Synoptic Weather = (N or W of a cold front) | -0.146 | 0.055* |
| Synoptic Weather = (near center of high pressure system) | -0.088 | 0.058 |
| Synoptic Weather = (W of high pressure system) | -0.139 | 0.075 |
| Wind direction = tailwind | 0.035 | 0.043 |
| Wind direction = calm | -0.073 | 0.059 |
| Wind direction = eastern crosswind | -0.010 | 0.049 |
| Wind direction = western crosswind | 0.041 | 0.036 |
| Wind speed | -0.034 | 0.008* |

Wethersfield (Fig. 11d), with a median flight direction of SW for birds ($n$ = 1,023) at Centerville and S for birds ($n$ = 830) at Wethersfield. Most bats were also traveling in a southerly direction during fall at Centerville (Fig. 11a) but were traveling in all directions at Wethersfield (Fig. 11b), with a median flight direction of SW for bats ($n$ = 194) at Centerville and SW for bats ($n$ = 95) at Wethersfield.

The mean nocturnal visual rates at Centerville for birds was 4.97 ± 1.14 targets/h ($n$ = 48 nights) and for bats was 0.70 ± 0.14 targets/h ($n$ = 48 nights) and at Wethersfield was 3.52 ± 0.54 targets/h ($n$ = 56 nights) for birds and 0.35 ± 0.08 targets/h ($n$ = 56 nights) for bats. Overall mean nightly visual rates were highly variable among nights for birds at Centerville (range = 0–43.0 targets/h) and at Wethersfield (range = 0–15.9 targets/h; Figs. 12a, 12b), but were less variable for bats at Centerville (range = 0–4.1 targets/h) and at Wethersfield (range = 0–3.4 targets/h; Figs. 12a, 12b). Birds were observed on most nights and peaked on 26 September at Centerville and on 25 September at Wethersfield (Figs. 12a, 12b). Bats

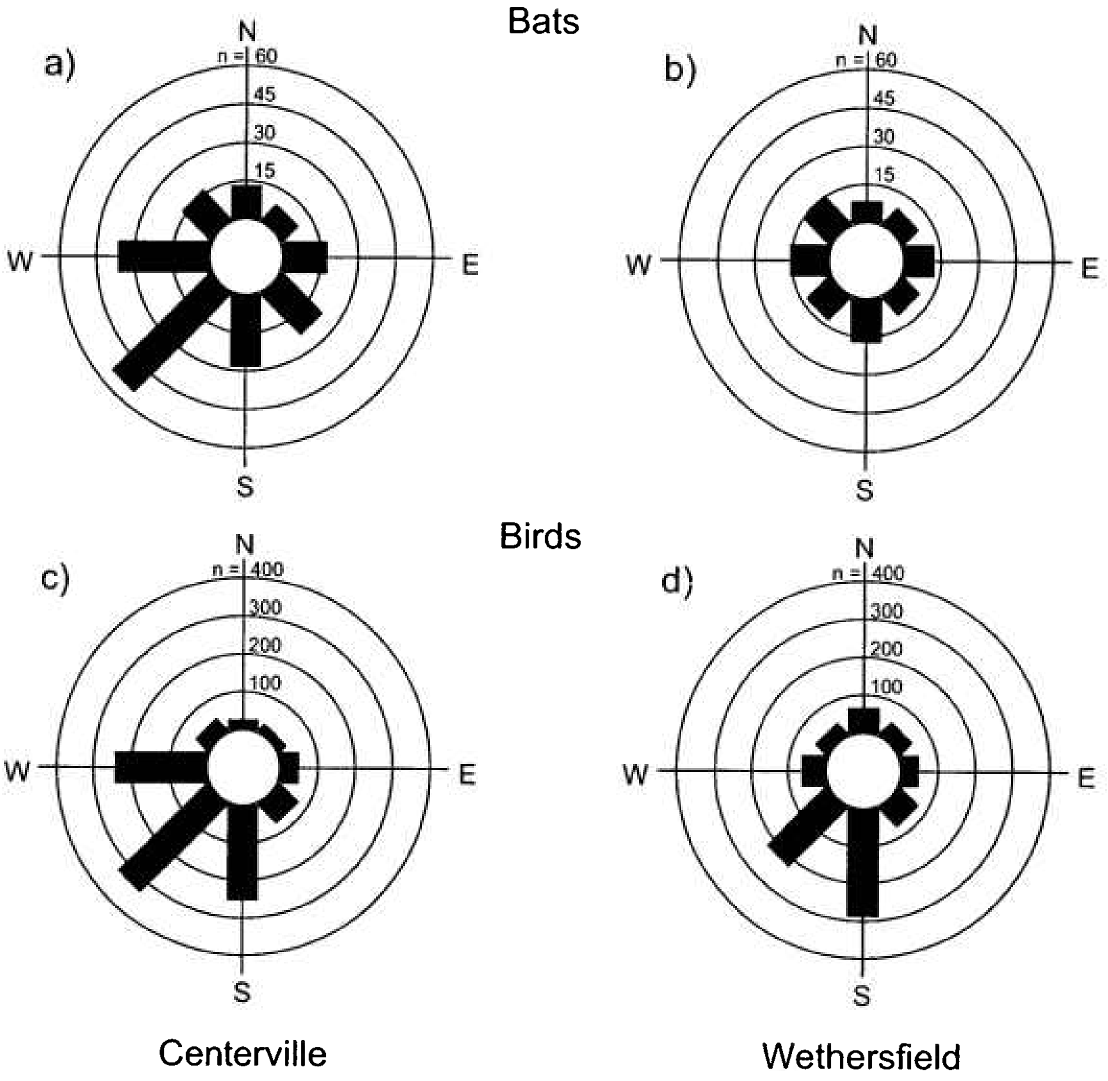

Figure 11. Flight directions of bats at (a) Centerville and (b) Wethersfield and birds at (c) Centerville and (d) Wethersfield observed during visual sampling at the proposed Centerville and Wethersfield Windparks, New York, fall 2006.

were observed in low numbers scattered throughout the fall season, with peak movement on 26 September at Centerville and on 22 August at Wethersfield; Figs. 12a, 12b).

Visual rates did not vary among nocturnal hours for nights with 8, 7, 6, or 5 hours of darkness sampled/night at both Centerville and Wethersfield for birds or bats (Fig. 13; Table 7). The highest rates for birds occurred ~2–5 h after sunset whereas the highest rates for bats occurred ~ 1–2 h after sunset (Fig. 13; Table 7).

Small passerines (e.g., warbler-sized birds) were the dominant type of species group for birds and small bats were the dominant type of species group for bats during fall at both sites (Table 8). The proportions of birds and bats flying <~150 m agl (our effective sampling distance with the night-vision goggles) were ~86% birds and ~14% bats at Centerville (*n* = 948) and were ~90% birds and ~10% bats at Wethersfield (*n* = 845; Table 8).

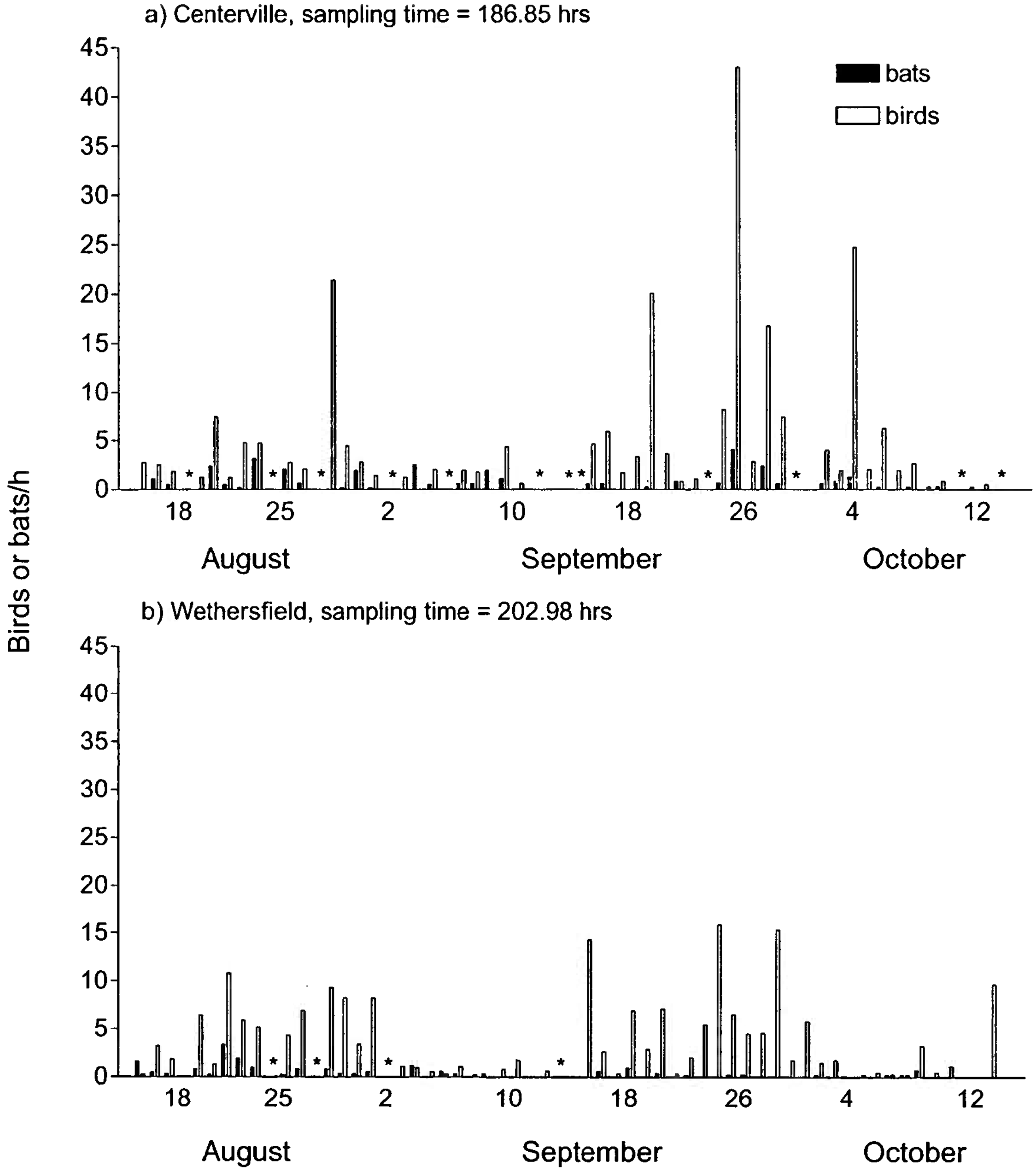

Figure 12. Mean number of birds/h or bats/h (± 1 SE) observed during visual sampling at the proposed (a) Centerville and (b) Wethersfield Windparks, New York, fall 2006. Asterisks denote nights not sampled because of fog, rain, or snow.

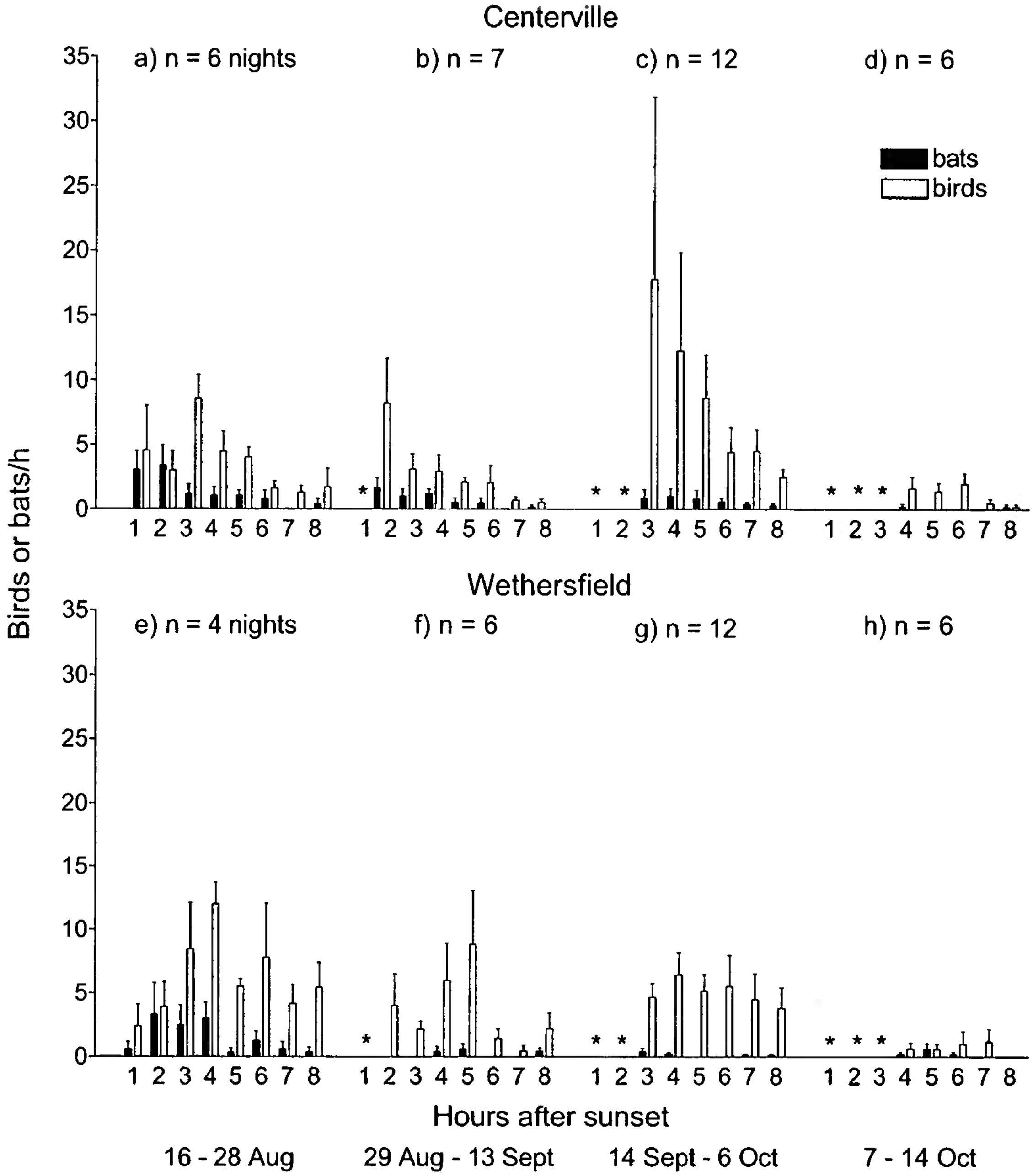

Figure 13. Mean number of birds/h or bats/h (± 1 SE) observed during visual sampling relative to time past sunset for nights that had 8 hours of darkness/night at (a) Centerville and (e) Wethersfield, 7 hours of darkness/night at (b) Centerville and (f) Wethersfield, 6 hours of darkness/night at (c) Centerville and (g) Wethersfield, and 5 hours of darkness/night at (d) Centerville and (h) Wethersfield at the proposed Centerville and Wethersfield Windparks, New York, fall 2006. First and last hours are crepuscular periods. Asterisks denote hours not sampled because of radar sampling.

Table 7. Hourly variation in bird and bat observation rates (targets/h) among nocturnal hours of visual sampling at the proposed Centerville and Wethersfield Windparks, New York, fall 2006.

| | Nocturnal | | | |
|---|---|---|---|---|
| Taxa / site / hours > sunset | *df* | *F* | *P* | *n* |
| Birds | | | | |
| Centerville | | | | |
| 8 | 2.1, 10.3 | 2.6 | 0.121 | 6 |
| 7 | 1.7, 10.0 | 3.0 | 0.102 | 7 |
| 6 | 1.1, 11.7 | 1.1 | 0.310 | 12 |
| 5 | 2.2, 11.1 | 2.3 | 0.142 | 6 |
| Wethersfield | | | | |
| 8 | 1.6, 4.8 | 2.2 | 0.209 | 4 |
| 7 | 1.6, 7.9 | 2.5 | 0.144 | 6 |
| 6 | 1.6, 17.5 | 0.4 | 0.605 | 12 |
| 5 | 1.4, 6.8 | 0.8 | 0.444 | 6 |
| Bats | | | | |
| Centerville | | | | |
| 8 | 2.3, 11.4 | 2.4 | 0.126 | 6 |
| 7 | 2.6, 15.3 | 2.6 | 0.093 | 7 |
| 6 | 1.4, 15.5 | 0.6 | 0.514 | 12 |
| 5 | 1.7, 8.4 | 0.7 | 0.493 | 6 |
| Wethersfield | | | | |
| 8 | 1.5, 4.5 | 1.2 | 0.372 | 4 |
| 7 | 1.9, 9.6 | 1.2 | 0.336 | 6 |
| 6 | 2.1, 23.4 | 1.2 | 0.334 | 12 |
| 5 | 1.4, 6.9 | 1.4 | 0.298 | 6 |

Table 8. Birds and bats observed during nocturnal visual sampling at the proposed Centerville and Wethersfield Windparks, New York, fall 2006. Percentages are relative to the total number of targets identifiable as birds or bats.

| | Centerville | | Wethersfield | |
|---|---|---|---|---|
| Species group | N | % | N | % |
| Small passerines | 380 | 40.1 | 318 | 33.5 |
| Large passerines | 203 | 21.4 | 171 | 18.0 |
| Unidentified passerines | 147 | 15.5 | 107 | 11.3 |
| *Total Passerines* | *730* | *77.0* | *596* | *70.5* |
| Unidentified waterfowl | 15 | 1.6 | 9 | 1.1 |
| *Total non-passerines* | *25* | *2.6* | *21* | *2.5* |
| *Total unidentified birds* | *62* | *6.5* | *141* | *16.7* |
| *Total birds* | *817* | *86.2* | *758* | *89.7* |
| Small bats | 62 | 6.5 | 56 | 6.6 |
| Large bats | 60 | 6.3 | 19 | 2.2 |
| Unidentified bats | 9 | 0.9 | 12 | 1.4 |
| *Total bats* | *131* | *13.8* | *87* | *10.3* |
| *Total birds and bats* | *948* | *100.0* | *845* | *100.0* |

## DISCUSSION

Predictions of the effects of wind power development on migratory birds and bats are hampered by both a lack of detailed knowledge about patterns of the nocturnal migration and behavior of birds and bats around wind turbines and by the fact that the precise relationship between bird abundance and bird fatalities at wind turbines currently is unknown. In this study, we addressed the first of these issues and documented some of the key migration characteristics in order to describe some of the general properties of nocturnal bird migration at the proposed project site.

### TIMING OF MIGRATION

Understanding the timing of migration at multiple temporal scales (e.g., within nights, within seasons, and seasonally within years) allows the determination of patterns of peak migration that can be used with other information, especially weather, to develop predictive models of avian and bat use. Such models may be useful for both pre-construction siting decisions and for the consideration of operational strategies to reduce fatalities (if one makes the untested assumption that there is a correlation between bird abundance and fatality at wind turbines).

Within nights, fall passage rates at both Centerville and Wethersfield increased dramatically after sunset, peaked ~3–5 hours after sunset, then usually decreased until sunrise. Several studies have found a pattern similar to this, in which the intensity of nocturnal migration begins to increase ~30–60 min after sunset, peaks around midnight, and declines steadily thereafter until dawn (Lowery 1951, Gauthreaux 1971, Kerlinger 1995, Farnsworth et al. 2004, Mabee et al. 2006a).

Within seasons, nocturnal migration often is a pulsed phenomenon (Alerstam 1990; Mabee and Cooper 2004, Mabee et al. 2006a). In this study, moderate–large mean nightly passage rates (>1 SD of seasonal mean [>458 targets/km/h at Centerville, >406 targets/km h at Wethersfield]) occurred on ten nights at Centerville (16, 22, 29, 30, 31 August; 10, 26 September; 1, 5, 6 October) and on eight nights at Wethersfield (16 August; 16, 24, 26, 28 September; 1, 5, 9 October). Overall, fall migration peaked at 877 targets/km/h on 29 August at Centerville and at 701 targets/km/h on 24 September at Wethersfield. In general, most fall songbird migration in this part of New York occurs between ~mid August and ~mid October (Cooper et al. 2004, Buffalo Ornithological Society 2002), so it is likely that our 2006 sampling window bracketed the period of peak songbird migration (especially for warblers, thrushes, and vireos—the primary taxa of interest).

## PASSAGE RATES

Passage rates are an index of the number of migrants flying past a location; thus, they may be useful to assess the relative bird use of several sites being considered for wind power development. In this study we used our passage-rate data in two ways: (1) to examine the passage rate of all migrants passing over our study area, and (2) to examine the passage rate of migrants within the height of the proposed wind turbines (<125 m). Although both metrics are useful for comparing bird activity in the vicinity of wind farm sites, the second metric is especially well-suited for this comparison because of its altitude-specific nature.

Comparisons with passage rates from studies listed below can be categorized into two groups: (1) *direct comparisons*—studies where we used comparable radar equipment (i.e., the same type of radar and configuration) and methods (i.e., a speed-based criterion for removal of insects), which include the Clinton County (Clinton and Altona), Flat Rock (Maple Ridge), Prattsburgh–Italy, and Chautauqua projects in New York and the Mt. Storm project in West Virginia; and (2) *other comparisons*—studies where we used comparable equipment but different methods (i.e., a subjective criterion for removal of insects) which includes all studies conducted before 2001 in New York (Harrisburg, Wethersfield, Carthage), the Midwest, and the West (Stateline and Vansycle projects in Oregon and Washington) or where other studies used comparable equipment but different methods (e.g., different radar settings; Young et al. 2006) or different data collection and analytical techniques (Woodlot Alternatives); and (3) *inappropriate comparisons*—studies where others used different radar methods (e.g., different radar settings and methods for data collection), including studies conducted in the nearby area by Yonker and Landon (2005). We believe that *other comparisons* are informative, as results from these studies may not have been substantially different from results obtained using our current methods if insect contamination was not a confounding factor in the study (e.g., spring studies where insect levels may be minimal) or if differences in methods were minimal. We did not make *inappropriate comparisons* in this report because of major differences in equipment or methodology, hence the results should not be compared among these studies.

The observed passage rates in the project area during fall were higher than most, but not all locations in New York where we or others have conducted fall migration studies. The mean fall nocturnal passage rate in this study was 259 targets/km/h (Centerville) and 256 targets/km/h (Wethersfield), compared with fall passage rates of 64 targets/km/h at the proposed Dairy Hills wind power development (Young et al. 2006), 122 targets/km/h at Harrisburg, New York (located ~35 km southeast Watertown, New York; Cooper and Mabee 2000); 158 targets/km/h at the proposed Flat Rock (i.e., Maple Ridge) wind power development, New York (located ~15 km southeast of Watertown, New York; Mabee et al. 2005c), 168 targets/km/h at Wethersfield, New York (Cooper and Mabee 2000); 197 targets/km/h at the proposed Clinton County Windparks (Mabee et al. 2006b), 200 targets/km/h at the proposed Prattsburgh–Italy wind power development (Mabee et al. 2005b); 225 targets/km/h at Carthage, New York (Cooper et al. 1995a), and 238 targets/km/h at Chautauqua, New York (Cooper et al. 2004), 481 targets/km/h at the proposed Howard wind project (Woodlot

2005), and 643 targets/km/h at the proposed Chateaugay Windpark (Woodlot 2006). Fall passage rates in other locations in the eastern US also were similar to what we recorded here (e.g., 199–241 targets/km/h at Mt. Storm, West Virginia; Mabee et al. 2004). In contrast, lower passage rates have generally been observed in the Midwest (e.g., 27–108 targets/km/h at four sites in South Dakota and Minnesota; Day and Byrne 1990) and the West (e.g., 19–26 targets/km/h at the Stateline and Vansycle wind power facilities in eastern Oregon; Mabee and Cooper 2004).

Our estimates of passage rate indices below the proposed turbine height in the project area during fall at Centerville (38.3 targets/km/h flying <125 m agl) and Wethersfield (36.4 targets/km/h flying <125 m agl) were greater than fall rates at the proposed Clinton County Windparks (27.5 targets/km/h flying <125 m agl; Mabee et al. 2006b), the proposed Prattsburgh–Italy wind power project (20.0 targets/km/h flying <125 m agl; Mabee et al 2005b), and the proposed Flat Rock wind power development (11.4 targets/km/h flying <125 m agl; Mabee et al. 2005c), and similar to those rates observed at the Mount Storm site along an Appalachian ridgeline in West Virginia (36.3 targets/km/h flying <125 m agl; Mabee et al. 2004).

## FLIGHT ALTITUDES

Flight altitudes are critical for understanding the vertical distribution of nocturnal migrants in the airspace. In general, passerines migrate at lower flight altitudes than do other major groups of over-land migrants such as shorebirds and waterfowl (Kerlinger 1995). Large kills of birds at tall, human-made structures (generally lighted and guyed communications towers; Avery et al. 1980) and the predominance of nocturnal migrant passerines at such kills (Manville 2000; Longcore et al. 2005) indicate that large numbers of these birds fly <500 m agl on at least some nights.

Flight altitudes of migratory bats are poorly known. Hoary bats (*Lasionycterus cinereus*), Eastern Red bats (*L. borealis*), and Silver-haired bats (*L. noctivagans*) are all long-range migrants that have been killed at wind power projects during their migratory periods, suggesting that at least some bats migrate below ~ 125 m agl. Allen (1939) observed bats migrating during the daytime near Washington, D.C. at 46–140 m agl, Altringham (1996) reported that at least some bats migrate well-above 100 m agl, and Peurach (2003) documented a Hoary bat collision with an airplane at an altitude of 2,438 m agl over Oklahoma during October 2001.

Comparisons with flight altitudes from studies listed below can be categorized into three groups: (1) *direct comparisons*—studies where we used comparable radar equipment (i.e., the same type of radar and configuration) and methods (i.e., a speed-based criterion for removal of insects), including the Clinton County Windparks, Flat Rock, and Prattsburgh–Italy projects in New York and the Mt. Storm project in West Virginia; and (2) *other comparisons*—studies where we used comparable equipment but different methods (i.e., a subjective criterion for removal of insects), including Chautauqua, New York, and the Stateline and Vansycle projects in Oregon and Washington or where other studies used comparable equipment but different methods (e.g., different radar settings and minor differences in methods; Young et al. 2006) or different data collection and analytical techniques (Woodlot Alternatives); and (3) *inappropriate comparisons*—studies where we used different radar equipment (i.e., a different radar and configuration) and different methods (i.e., a subjective criterion for removal of insects), including all studies conducted before 2001 in New York (Harrisburg, Wethersfield, Carthage) and in the Midwest, or where others used different radar methods (e.g., different radar settings and methods for data collection) including studies in the nearby area conducted by Yonker and Landon (2005). We believe that *other comparisons* are informative, as results from these studies may not have been substantially different from results obtained using our current methods if insect contamination was not a confounding factor in the study (e.g., spring studies where insect levels may be minimal) or if differences in methods were minimal. *Inappropriate comparisons* were not made in this report because of major differences in equipment or methodology, hence the results should not be compared among these studies.

Mean flight altitudes at the proposed Centerville (350 m agl) and Wethersfield (344 m agl) sites were 220 m higher than the proposed turbine heights in these locations. Mean flight altitudes at the proposed project site during fall were similar or lower than other sites studied in the fall in New York including the proposed Clinton County Windparks (333 m agl; Mabee et al. 2006b), the proposed Prattsburgh–Italy wind power development (mean = 365 m agl; Mabee et al. 2005b), Flat Rock (i.e., Maple Ridge) wind power development (mean = 415 m agl; Mabee et al. 2005c), the proposed Chateaugay Windpark (mean = 431 m agl; Woodlot 2006), the proposed Dairy Hills wind power development (mean = 466 m agl; Young et al. 2006), the proposed Howard wind project (mean = 491 m agl; Woodlot 2005), and Chautauqua, (mean = 532 m agl; Cooper et al. 2004). Mean flight altitudes were also lower than those in West Virginia (Mt. Storm, mean = 410 m agl). Similar to our results, however, other published studies that used a variety of radar systems and analyses have indicated that the majority of nocturnal migrants fly below 600 m agl (Bellrose 1971; Gauthreaux 1972, 1978, 1991; Bruderer and Steidinger 1972; Cooper and Ritchie 1995). Kerlinger (1995) summarized radar results from the eastern US and concluded that three-quarters of passerines migrate <600 m agl.

In contrast to these results, other researchers have found that peak nocturnal densities extend over a broad altitudinal range up to ~2,000 m (Harper 1958, *in* Eastwood 1967; Graber and Hassler 1962, Nisbet 1963, Bellrose and Graber 1963, Eastwood and Rider 1965, Bellrose 1967, Blokpoel 1971; Richardson 1971, 1972; Blokpoel and Burton 1975). We suspect that differences between the two groups of studies are largely due to differences in location, species-composition of migrating birds, local topography, radar equipment used, and perhaps weather conditions. It has been suggested that limitations in equipment and sampling methods of some previous radar studies may have been responsible for their overestimation of the altitude of bird migration (Able 1970, Kerlinger and Moore 1989). For example, the radars used by Bellrose and Graber (1963), Blokpoel (1971), and Nisbet (1963) could not detect birds below 450 m, 370 m, and 180 m agl, respectively. In contrast, our vertical radar could detect targets down to ~10–15 m agl, allowing us to detect low-altitude migrants.

We also examined the percentage of targets below approximate turbine height (i.e., 125 m agl) during fall and estimated that 11.6% flew <125 m agl at Centerville (10.9% flew <125 m agl at Wethersfield), within the range of those recorded at other proposed sites studied in the fall in New York including the Howard wind project (2% <91 m agl; Woodlot 2005), Chautauqua wind power development (4% <125 m agl; Cooper et al. 2004), Chateaugay Windpark (8% <120 m agl; Woodlot 2006), Prattsburgh–Italy wind power development (9.2% <125 m agl; Mabee et al. 2005b), Dairy Hills wind power development (9.8% flew <125 m agl; Young et al. 2006), Clinton County Windparks (12.1% flew <125 m agl; Mabee et al. 2006b), and the Mt. Storm, West Virginia, wind power development (13–16% flew <125 m agl (Mabee et al. 2006a). The only other sites available for comparisons during fall are the Vansycle and Stateline wind power facilities in eastern Oregon (3–9% <125 m agl; Mabee and Cooper 2004). Variation in the percentage of targets below turbine height may vary for multiple reasons—including differences in weather conditions, date, and species composition of migrants.

Similar to our migration studies elsewhere (Cooper and Ritchie 1995; Cooper et al. 1995a, 1995b; Cooper and Mabee 2000; Mabee and Cooper 2004), we recorded large among-night variation in mean flight altitudes during the spring migration season, although mean flight altitudes were always above the proposed turbine heights. Daily variation in mean flight altitudes may have reflected changes in species composition, vertical structure of the atmosphere, and/or weather conditions. Variation among days in the flight altitudes of migrants at other locations has been associated primarily with changes in the vertical structure of the atmosphere. For example, birds crossing the Gulf of Mexico appear to fly at altitudes where favorable winds minimize the energetic cost of migration (Gauthreaux 1991). Kerlinger and Moore (1989), Bruderer et al. (1995), and Liechti et al. (2000) have concluded that atmospheric structure is the primary selective force determining the height at which migrating birds fly.

## MODELING MIGRATION PASSAGE RATES AND FLIGHT ALTITUDES

### MIGRATION PASSAGE RATES

It is a well-known fact that general weather patterns and their associated temperatures and winds affect migration (Richardson 1978, 1990, Gauthreaux et al. 2005). In the Northern Hemisphere, air moves counterclockwise around low-pressure systems and clockwise around high-pressure systems. Thus, winds are warm and southerly when an area is affected by a low to the west or a high to the east and are cool and northerly in the reverse situation. Clouds, precipitation, and strong, variable winds are typical in the centers of lows and near fronts between weather systems, whereas weather usually is fair with weak or moderate winds in high-pressure areas. Numerous studies in the Northern Hemisphere have shown that, in fall, most bird migration tends to occur in the western parts of lows, the eastern or central parts of highs, or in intervening transitional areas. In contrast, warm fronts, which are accompanied by southerly (unfavorable) winds and warmer temperatures, tend to slow fall migration (Lowery 1951, Gauthreaux 1971; Able 1973, 1974; Blokpoel and Gauthier 1974, Richardson 1990, Gauthreaux et al. 2005). Conversely, more intense spring migration tends to occur in the eastern parts of lows, the western or central parts of highs, or in intervening transitional areas.

We examined the influence of weather (i.e., wind speed, wind direction, date, ceiling height, synoptic weather, daily barometric pressure change, and the number of days since favorable migration conditions), date, and lunar illumination on migration passage rates at both study sites. During fall migration at Centerville, passage rates increased when a high pressure system entered the area and when winds were favorable, and decreased when ceiling height was ≤ 500 m agl and later in the season. During fall migration at Wethersfield passage rates increased with tailwinds, calm conditions, and during eastern crosswinds. The variables identified as important in this study generally are consistent with results of other studies (Lowery 1951, Gauthreaux 1971; Able 1973, 1974; Blokpoel and Gauthier 1974; Richardson 1990; Mabee et al. 2004, Gauthreaux et al. 2005, Mabee et al. 2006b).

### FLIGHT ALTITUDES

Radar studies have shown that wind is a key factor in migratory flight altitudes (Alerstam 1990). Birds fly mainly at heights at which head winds are minimized and tail winds are maximized (Bruderer et al. 1995). Because wind strength generally increases with altitude, bird migration generally takes place at lower altitudes in head winds and at higher altitudes in tail winds (Alerstam 1990). Most studies (all of those cited above except Bellrose 1971) have found that clouds influence flight altitude, but the results are not consistent among studies. For instance, some studies (Bellrose and Graber 1963, Hassler et al. 1963, Blokpoel and Burton 1975) found that birds flew both below and above cloud layers, whereas others (Nisbet 1963, Able 1970) found that birds tended to fly below clouds.

In this study during fall migration at Centerville, flight altitudes increased under favorable wind conditions (tailwinds, crosswinds) and decreased with increasing wind speeds. At Wethersfield, flight altitudes increased when a high pressure system entered the area (creating favorable winds) and when ceiling height was ≤ 500 m agl (perhaps to fly above low-altitude clouds) and decreased when birds were North or West of a cold front (unclear why this occurred) and when wind speeds increased. Because fog occurred infrequently during this study ($n = 27$ of 444 sessions [Centerville], $n = 21$ of 462 sessions [Wethersfield]) its apparent lack of influence on flight altitudes may have been because of its infrequent occurrence at our sites this fall.

The need to understand how birds respond to fog and low ceiling height conditions is warranted, however, as the largest single-night kill for nocturnal migrants at a wind power project in the US occurred on a foggy night during spring migration, when 27 passerines fatally collided with a turbine near a lit substation at the Mountaineer wind power development in West Virginia (Kerlinger 2003). Fatality events of this magnitude are rare at wind power developments, although large kills of migratory birds have sporadically occurred at other, taller structures (e.g., guyed and lighted towers >130 m high) in many places across the country during periods of heavy migration, especially on foggy, overcast nights in fall (Weir

1976, Avery et al. 1980, Evans 1998, Erickson et al. 2001) and have occurred under similar conditions at an offshore platform in Germany (Huppop et al. 2006).

## SPECIES COMPOSITION

Determination of species-specific risks to nocturnal migrants requires the identification of species migrating through the area of interest. Flight speeds observed on surveillance radar during fall at Centerville (mean = 11.3 ± 0.02 m/s) and Wethersfield (mean = 12.1 ± 0.03 m/s) suggested that most of the avian radar targets we observed during fall were passerines, although some faster-flying bird species such as shorebirds or waterfowl were likely present. Furthermore, our visual observations confirmed the dominance of passerines and the smaller numbers of nonpasserines and bats in the lower air layers (i.e., <150 m agl), with the percentage of birds at Centerville (84%) and Wethersfield (90%) dominating that of bats at Centerville (14%) and Wethersfield (10%) in the lower air layers. See Appendices 7 and 8 for percentages and rates of birds and bats flying <150 m agl from additional studies in the eastern US.

Most (86%) of the bat fatalities at wind power developments and other tall structures occur during mid-July to mid-September and involve long-range migratory tree-roosting bat species such as Hoary (*Lasiurus cinereus*), Eastern Red (*Lasiurus borealis*), and Silver-haired (*Lasionycteris noctivagans*) bats (Erickson et al. 2002, Johnson et al. 2003, Johnson 2005). Fatalities of these same species during spring are uncommon (Johnson 2005). Of the 131 identified bats observed during fall at Centerville and 87 identified bats observed at Wethersfield, 46% and 22% of the bats were tree-roosting bats at Centerville and Wethersfield, respectively. In general, fatality rates of bats are much lower in the central and western US (Erickson et al. 2002, Johnson 2005) than at the few sites studied in the eastern US, where substantial bat kills have been observed at two wind energy facilities located along the same Appalachian ridgeline in West Virginia and Pennsylvania (Arnett 2005). Recent information, however, also shows that some of these same tree-roosting species (e.g., Hoary and Silver-haired bats) are killed at higher rates (~13–16 bats/turbine) than expected in the Canadian prairies of Alberta (Baerwald 2006).

## TARGETS WITHIN THE PROPOSED TURBINE AREA

We estimated a turbine passage rate of 2.2–16.1 and 2.1–14.3 nocturnal migrants/turbine/d to have passed within the area occupied by each proposed turbine at Centerville and Wethersfield, respectively. These rates are higher than fall data available from the Maple Ridge wind power development, New York (0.7–4.6 nocturnal migrants/turbine/d; Mabee et al. 2005c), from the proposed Prattsburgh–Italy windpower development (1.1–8.0 nocturnal migrants/turbine/d; Mabee et al. 2005b), and from the proposed Clinton County Windparks (1.6–11.1 nocturnal migrants/ turbine/d; Mabee et al. 2006b). In addition, we calculated turbine passage rates for crepuscular periods for Centerville (0–0.1 dusk, 0.1–0.4 dawn) and Wethersfield (0–0.3 dusk, 0.2–1.2 dawn) showing that only a small number of birds would pass through the area occupied by each proposed turbine during these brief time periods.

It is possible to use estimated turbine passage rates as a starting point for developing a complete avian risk assessment; however, it currently is unknown whether bird use and fatality at wind power developments are strongly correlated. There are a variety of factors (especially weather) that could be more highly correlated with fatality rates than bird abundance. To determine which factors are most relevant, studies that collected concurrent bird use, weather, and fatality data would be needed to begin to determine whether bird use and/or weather conditions can be used to predict the likelihood of bird fatalities at wind power developments.

In addition to these questions about the unknown relationship between fatality, weather, and abundance, there also is very little data available on the proportion of nocturnal migrants that (1) do not collide with turbines because of their avoidance behavior (i.e., birds that alter either their flight paths or altitude to avoid colliding with turbines) and (2) safely pass through the turbine blades by chance alone — a proportion that will vary with the speed at which turbine blades are turning as well as the flight speeds of individual migrants. The proportion of nocturnal migrants that detect and avoid turbines is currently unknown in the US (but see Winkleman 1995 and Desholm and Kahlert 2005 for studies of waterbirds in Europe) but detection of turbines could alter flight paths, passage rates, and flight altitudes of migrants that could reduce the likelihood of avian collisions. Although there are no empirical data that predict a species' ability to pass safely through the rotor-swept area of a turbine (but see Desholm et al. 2006 for methods to investigate this behavior), there is a hypothetical model (Tucker 1996). We speculate, however, that the values are high for both the proportion of birds that avoid and safely pass through turbines, considering the relatively low avian fatality rates at wind power developments in the US (Erickson et al. 2002, Strickland and Johnson 2006) and the high percentage of waterbirds that avoided an offshore windfarm in Denmark (Desholm et al. 2006). Local information on avian and bat fatality rates at the 10 existing wind turbines ~9 km north of our Wethersfield radar sampling site corroborates this pattern, as no bird or bat fatalities were observed during spring migration of 2005 and 0 bird and only 4 bat fatalities were recorded during fall migration of 2005 (Ecology and Environment 2006).

## CONCLUSIONS

This study focused on nocturnal migration patterns and flight behaviors during the peak periods of passerine and bat migration during spring at the proposed Centerville and Wethersfield Windparks in New York. The key results of our study were: (1) the mean overall passage rate was 259 targets/km/h at Centerville and 256 targets/km/h at Wethersfield; (2) mean nightly passage rates ranged from 12 to 877 targets/km/h at Centerville and from 31 to 701 targets/km/h at Wethersfield; (3) the percentage of targets passing below 125 m agl was 11.6% at Centerville and 10.9% at Wethersfield; (4) the estimated turbine passage rate of nocturnal migrants passing within the airspace occupied by each proposed turbine was 2.2–16.1 migrants/turbine/d at Centerville and 2.1–14.3 migrants/turbine/d at Wethersfield; and (5) migrants flying below 150 m agl consisted of ~86% birds and ~14% bats at Centerville and ~90% birds and ~10% bats at Wethersfield.

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Appendix 1. Calculation of turbine passage rate indices (estimated number of targets passing within the area occupied by each proposed turbine) during crepuscular and nocturnal periods during fall 2006, at the proposed Centerville and Wethersfield Windparks, New York.

| | Centerville | | | Wethersfield | | |
|---|---|---|---|---|---|---|
| Calculation parameter | Dusk | Night | Dawn | Dusk | Night | Dawn |
| WIND-TURBINE CHARACTERISTICS | | | | | | |
| (A) Total turbine height (m) | 118.0 | 118.0 | 118.0 | 118.5 | 118.5 | 118.5 |
| (B) Blade radius (m) | 40.0 | 40.0 | 40.0 | 38.5 | 38.5 | 38.5 |
| (C) Height below blade (m) | 38.0 | 38.0 | 38.0 | 41.5 | 41.5 | 41.5 |
| (D) Approximate front-to-back width (m) | 6 | 6 | 6 | 6 | 6 | 6 |
| (E) Minimal (side profile) area ($m^2$) = A × D | 708 | 708 | 708 | 711 | 711 | 711 |
| (F) Maximal (front profile) area ($m^2$) = $(C \times D) + (\pi \times B^2)$ | 5,254.6 | 5,254.6 | 5,254.6 | 4,905.6 | 4,905.6 | 4,905.6 |
| PASSAGE RATE | | | | | | |
| (G) Mean rate below 125 m agl (targets/km/h) | 2.9 | 38.3 | 9.4 | 8.6 | 36.4 | 31.2 |
| (H) Area sampled below 125 m agl = 125 x 1,000 ($m^2$) | 125,000 | 125,000 | 125,000 | 125,000 | 125,000 | 125,000 |
| (I) Mean passage rate per unit area (targets/$m^2$/h) = G/H | 0.000023 | 0.000306 | 0.000075 | 0.000069 | 0.000291 | 0.000250 |
| TURBINE PASSAGE RATE INDEX | | | | | | |
| (J) Duration of study period (# nights) | 60 | 60 | 60 | 60 | 60 | 60 |
| (K) Mean number of hours of darkness (h/night) | 1 | 10 | 1 | 1 | 10 | 1 |
| (L) Minimum number of targets/km/h in zone of risk = E x I | 0.016426 | 0.216931 | 0.053242 | 0.048917 | 0.207043 | 0.177466 |
| (M) Maximum number of targets/km/h in zone of risk = F x I | 0.121906 | 1.609997 | 0.395143 | 0.337508 | 1.428521 | 1.224447 |
| (N) Minimum number of targets in zone/d = K x L | 0.0 | 2.2 | 0.1 | 0.0 | 2.1 | 0.2 |
| (O) Maximum number of targets in zone/d =K x M | 0.1 | 16.1 | 0.4 | 0.3 | 14.3 | 1.2 |
| (P) Minimum number of targets in zone of risk during 60-night study period = J x K x L | 1 | 130 | 3 | 3 | 124 | 11 |
| (Q) Maximum number of targets in zone of risk during 60-night study period = J x K x M | 7 | 966 | 24 | 20 | 857 | 73 |

Appendix 2. Mean passage rates and flight altitudes of nocturnal radar targets observed at the 1.5-km range during half-month periods of fall migration and over the full migratory season at the proposed Centerville and Wethersfield Windparks, New York, fall 2006.

| Site / Metrics | August | September | | October | Total |
|---|---|---|---|---|---|
| | 16–31 | 1–15 | 16–30 | 1–14 | |
| Centerville | | | | | |
| Passage rate (targets/km/h) | 371 ± 65 | 227 ± 40 | 199 ± 39 | 231 ± 54 | 259 ± 27 |
| Flight altitude (m agl) | 334 ± 3 | 379 ± 3 | 339 ± 3 | 352 ± 3 | 350 ± 2 |
| Passage rate ≤125 m agl (targets/km/h) | 47 ± 12 | 29 ± 7 | 44 ± 14 | 31 ± 9 | 38 ± 6 |
| Number of nights | 15 | 13 | 15 | 14 | 57 |
| Wethersfield | | | | | |
| Passage rate (targets/km/h) | 270 ± 28 | 191 ± 27 | 301 ± 43 | 260 ± 59 | 256 ± 20 |
| Flight altitude (m agl) | 330 ± 2 | 374 ± 3 | 326 ± 3 | 352 ± 3 | 344 ± 1 |
| Passage rate ≤125 m agl (targets/km/h) | 32 ± 6 | 21 ± 4 | 55 ± 14 | 35 ± 10 | 36 ± 5 |
| Number of nights | 15 | 14 | 15 | 12 | 56 |

Appendix 3. Nocturnal flight altitudes of radar targets (% of all targets) detected at the 1.5-km range at proposed Centerville and Wethersfield Windparks, New York, fall 2006, by flight-altitude category. Flight altitudes and associated percentages are cumulative.

| | Cumulative % | |
|---|---|---|
| Flight altitude (m agl) | Centerville (n = 18,584 targets) | Wethersfield (n = 20,531 targets) |
| 1–25 | 0.4 | 0.3 |
| 26–50 | 1.8 | 1.5 |
| 51–75 | 4.5 | 3.8 |
| 76–100 | 7.8 | 7.1 |
| 101–125 | 11.6 | 10.9 |
| 126–150 | 16.2 | 15.5 |
| 151–175 | 21.0 | 20.3 |
| 176–200 | 25.9 | 25.4 |
| 201–225 | 31.1 | 30.9 |
| 225–250 | 37.0 | 37.0 |
| 251–1,500 | 100.0 | 100.0 |

Appendix 4. List of all models used to explain the influence of environmental factors on passage rates and flight altitudes of bird and bat targets on radar at the proposed Centerville and Wethersfield Windparks, New York, fall 2006. Asterisks denote models not used for flight altitudes.

| Model |
|---|
| Global: wind direction + ceiling height + synoptic + date + wind speed + barometric pressure change + moon |
| Wind direction |
| Wind speed |
| Wind direction + wind speed |
| Date |
| Wind direction + date |
| Wind direction + wind speed + date |
| Ceiling height |
| Wind direction + ceiling height |
| Date + ceiling height |
| Direction + date + ceiling height |
| Wind direction + ceiling height + date + wind speed |
| Synoptic |
| Synoptic + date |
| *Favorable migration(d) |
| *Favorable migration(d) + date |
| *Favorable migration(d) + wind direction |
| *Favorable migration(d) + wind direction + date |
| *Favorable migration(d) + ceiling height |
| Barometric pressure change |
| Barometric pressure change + date |
| Barometric pressure change + wind direction |
| Barometric pressure change + wind direction + date |
| Barometric pressure change + wind direction + wind speed |
| Barometric pressure change + wind direction + wind speed + date |
| Barometric pressure change + ceiling height |
| Barometric pressure change + ceiling height + date |
| Lunar illumination |
| Lunar illumination + date |
| Lunar illumination + wind direction |
| Lunar illumination + wind direction + date |
| Lunar illumination + wind direction + wind speed |
| Lunar illumination + wind direction + wind speed + date |
| Lunar illumination + ceiling height |
| Lunar illumination + ceiling height + date |

Appendix 5. Linear mixed models explaining the influence of environmental factors on passage rates of bird and bat targets on surveillance radar at the proposed Centerville and Wethersfield Windparks, New York, fall 2006 (Centerville, n = 488 sampling sessions; Wethersfield, n = 496 sampling sessions). Model weights (wi) were based on Akaike's Information Criterion (AIC) and models with wi = 0 were not presented in table.

| Model | -2 Log Likelihood[a] | K[b] | $\mathrm{AIC}_c$[c] | Δ $\mathrm{AIC}_c$[d] | $w_i$[e] |
|---|---|---|---|---|---|
| Centerville | | | | | |
| Global: wind direction + ceiling height + synoptic[f] + date + wind speed + barometric pressure change[g] + moon | 1051.069 | 28 | 1110.607 | 0.00 | 0.98 |
| Barometric pressure change + ceiling height + date | 1083.017 | 17 | 1118.319 | 7.71 | 0.02 |
| Wethersfield | | | | | |
| Wind direction + date | 2686.661 | 18 | 2724.095 | 0.00 | 0.12 |
| Barometric pressure change + wind direction + date | 2684.579 | 19 | 2724.176 | 0.08 | 0.12 |
| Wind direction + wind speed + date | 2685.639 | 19 | 2725.235 | 1.14 | 0.07 |
| Lunar illumination + wind direction + date | 2685.672 | 19 | 2725.269 | 1.17 | 0.07 |
| Favorable migration(d) + wind direction + date | 2685.779 | 19 | 2725.375 | 1.28 | 0.07 |
| Barometric pressure change + wind direction + wind speed + date | 2683.829 | 20 | 2725.597 | 1.50 | 0.06 |
| Direction + date + ceiling height | 2684.108 | 20 | 2725.877 | 1.78 | 0.05 |
| Lunar illumination + wind direction + wind speed + date | 2684.352 | 20 | 2726.120 | 2.02 | 0.05 |
| Favorable migration(d) + wind direction | 2688.849 | 18 | 2726.283 | 2.19 | 0.04 |
| Barometric pressure change + wind direction | 2688.974 | 18 | 2726.408 | 2.31 | 0.04 |
| Wind direction | 2691.337 | 17 | 2726.618 | 2.52 | 0.04 |
| Wind direction + wind speed | 2689.294 | 18 | 2726.728 | 2.63 | 0.03 |

Appendix 5. (Continued).

| Model | -2 Log Likelihood[a] | K[b] | AIC$_c$[c] | Δ AIC$_c$[d] | $w_i$[e] |
|---|---|---|---|---|---|
| Wind direction + ceiling height + date + wind speed | 2682.935 | 21 | 2726.885 | 2.79 | 0.03 |
| Barometric pressure change + date | 2695.887 | 15 | 2726.887 | 2.79 | 0.03 |
| Barometric pressure change + wind direction + wind speed | 2687.376 | 19 | 2726.972 | 2.88 | 0.03 |
| Date | 2696.113 | 15 | 2727.113 | 3.02 | 0.03 |
| Lunar illumination + wind direction + wind speed | 2687.665 | 19 | 2727.262 | 3.17 | 0.03 |
| Lunar illumination + wind direction | 2690.137 | 18 | 2727.571 | 3.48 | 0.02 |
| Wind speed | 2698.974 | 14 | 2727.847 | 3.75 | 0.02 |
| Wind direction + ceiling height | 2689.029 | 19 | 2728.626 | 4.53 | 0.01 |
| Lunar illumination + date | 2697.714 | 15 | 2728.714 | 4.62 | 0.01 |
| Favorable migration(d) + date | 2698.532 | 15 | 2729.532 | 5.44 | 0.01 |
| Barometric pressure change + ceiling height + date | 2694.614 | 17 | 2729.894 | 5.80 | 0.01 |

[a] Calculated with the Maximum Likelihood method.

[b] Number of estimable parameters in approximating model (see methods for explanation).

[c] Akaike's Information Criterion corrected for small sample size.

[d] Difference in value between AIC$_c$ of the current model versus the best approximating model with the minimal AIC$_c$ value.

[e] Akaike weight—probability that the current model (i) is the best approximating model among those being considered.

[f] Synoptic weather

[g] Daily change in barometric pressure

Appendix 6. Linear mixed models explaining the influence of environmental factors on flight altitudes of bird and bat targets on vertical radar at the proposed Centerville and Wethersfield Windparks, New York, fall 2006 (Centerville, n = 444 sampling sessions; Wethersfield, n = 462 sampling sessions). Model weights (wi) were based on Akaike's Information Criterion (AIC) and models with wi = 0 were not presented in table.

| Model | -2 Log Likelihood[a] | K[b] | $AIC_c$[c] | Δ $AIC_c$[d] | $w_i$[e] |
|---|---|---|---|---|---|
| Centerville | | | | | |
| Wind speed | 131.288 | 13 | 158.134 | 0.00 | 0.50 |
| Wind direction + wind speed | 124.701 | 17 | 160.138 | 2.00 | 0.18 |
| Barometric pressure change[g] + wind direction + wind speed | 123.882 | 18 | 161.491 | 3.36 | 0.09 |
| Lunar illumination + wind direction + wind speed | 124.440 | 18 | 162.050 | 3.92 | 0.07 |
| Wind direction + wind speed + date | 124.503 | 18 | 162.113 | 3.98 | 0.07 |
| Barometric pressure change + wind direction + wind speed + date | 123.650 | 19 | 163.443 | 5.31 | 0.03 |
| Lunar illumination + wind direction + wind speed + date | 124.076 | 19 | 163.869 | 5.73 | 0.03 |
| Wind direction + ceiling height + date + wind speed | 124.037 | 20 | 166.023 | 7.89 | 0.01 |
| Wind direction | 133.697 | 16 | 166.971 | 8.84 | 0.01 |
| Wethersfield | | | | | |
| Wind speed | -62.901 | 13 | -36.088 | 0.00 | 0.28 |
| Wind direction + ceiling height + date + wind speed | -77.834 | 20 | -35.930 | 0.16 | 0.26 |
| Global: wind direction + ceiling height + synoptic[f] + date + wind speed + barometric pressure change + moon | -87.203 | 25 | -34.221 | 1.87 | 0.11 |
| Wind direction + wind speed | -68.948 | 17 | -33.570 | 2.52 | 0.08 |
| Barometric pressure change + wind direction + wind speed | -70.587 | 18 | -33.043 | 3.05 | 0.06 |
| Barometric pressure change + ceiling height | -64.067 | 15 | -32.991 | 3.10 | 0.06 |
| Lunar illumination + wind direction + wind speed | -69.079 | 18 | -31.535 | 4.55 | 0.03 |
| Wind direction + wind speed + date | -68.980 | 18 | -31.436 | 4.65 | 0.03 |

Appendix 6. (Continued).

| Model | -2 Log Likelihood[a] | K[b] | AIC$_c$[c] | Δ AIC$_c$[d] | $w_i$[e] |
|---|---|---|---|---|---|
| Barometric pressure change + ceiling height + date | -64.417 | 16 | -31.194 | 4.89 | 0.02 |
| Barometric pressure change + wind direction + wind speed + date | -70.624 | 19 | -30.905 | 5.18 | 0.02 |
| Ceiling height | -58.499 | 14 | -29.559 | 6.53 | 0.01 |
| Lunar illumination + wind direction + wind speed + date | -69.082 | 19 | -29.363 | 6.73 | 0.01 |

[a] Calculated with the Maximum Likelihood method.

[b] Number of estimable parameters in approximating model (see methods for explanation).

[c] Akaike's Information Criterion corrected for small sample size.

[d] Difference in value between AIC$_c$ of the current model versus the best approximating model with the minimal AIC$_c$ value.

[e] Akaike weight—probability that the current model (i) is the best approximating model among those being considered.

[f] Synoptic weather

[g] Daily change in barometric pressure

Appendix 7. Percentage of birds and bats flying below ~150 m agl observed with night-vision goggles and infrared spotlights during nocturnal hours of spring and fall migration. N equals the total number of birds and bats observed per season.

| | | Sampling effort | | | Birds (%) | | | | Bats (%) | | | | Birds & bats | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project | Sampling dates | Nights | Hours | Min\h[c] | Passerines | Non-passerines | Other | Total | Small | Large | Other | Total | Total | n |
| Spring | | | | | | | | | | | | | | |
| Prattsburgh–Italy, NY | 4/24/05 - 5/23/05 | 28 | 16.0 | A | 57.4 | 0.0 | 38.7 | 96.1 | 1.9 | 1.3 | 0.7 | 3.9 | 100 | 155 |
| Clinton County, NY | 4/15/05 - 5/29/05 | 45 | 151.8 | B | 84.6 | 2.1 | 5.6 | 92.3 | 6.4 | 1.2 | 0.1 | 7.7 | 100 | 685 |
| Centerville, NY | 4/16/06 - 5/30/06 | 42 | 241.8 | B | 77.5 | 0.6 | 6.1 | 84.2 | 7.6 | 3.3 | 4.9 | 15.8 | 100 | 488 |
| Wethersfield, NY | 4/16/06 - 5/30/06 | 43 | 237.3 | B | 72.7 | 0.9 | 8.0 | 81.7 | 11.9 | 3.7 | 2.8 | 18.3 | 100 | 436 |
| Swallow Farm, PA | 4/13/05 - 5/27/05[b] | 22 | 74.8 | B | 83.8 | 0.2 | 5.5 | 89.5 | 6.1 | 1.2 | 3.2 | 10.5 | 100 | 493 |
| Fall | | | | | | | | | | | | | | |
| Maple Ridge, NY[a] | 8/5/04 - 10/3/04 | 50 | 195.9 | B[d] | 77.5 | 8.8 | 2.2 | 88.5 | 9.9 | 1.3 | 0.3 | 11.5 | 100 | 1,562 |
| Clinton County, NY | 8/15/05 - 10/13/05 | 53 | 242.7 | B | 75.2 | 3.4 | 3.2 | 81.8 | 11.3 | 5.7 | 1.2 | 18.2 | 100 | 829 |
| Centerville, NY | 8/16/06 - 10/14/06 | 43 | 205.8 | B | 77.0 | 2.6 | 6.5 | 86.2 | 6.5 | 6.3 | 0.9 | 13.8 | 100 | 948 |
| Wethersfield, NY | 8/16/06 - 10/14/06 | 56 | 235.8 | B | 70.5 | 2.5 | 16.7 | 89.7 | 6.6 | 2.2 | 1.4 | 10.3 | 100 | 845 |
| Swallow Farm, PA | 8/16/05 - 10/14/05 | 43 | 154.6 | C | 89.2 | 1.1 | 0.8 | 91.1 | 2.8 | 2.7 | 3.3 | 8.9 | 100 | 1,062 |
| Highland New Wind, VA | 8/16/05 - 10/14/05 | 49 | 159.4 | C | 79.1 | 1.4 | 5.8 | 87.1 | 4.2 | 1.4 | 7.3 | 12.9 | 100 | 1,541 |

[a] formerly known as Flat Rock

[b] alternate night sampling

[c] A = 5 min/h, B = 40–50 min/h, C = 40–50 min/h until ~1 Oct, then 5 min/h until end of study

[d] spotlight with red lens

Appendix 8. Seasonal mean rates (number/h ± 1 SE) of birds and bats flying below ~150 m agl observed with night-vision goggles and infrared spotlights during nocturnal hours of spring and fall migration. N equals number of nights sampled per season.

| Project | Sampling dates | Sampling effort | | | Birds (number/h)[e] | | Bats (number/h)[e] | | Total number birds & bats |
|---|---|---|---|---|---|---|---|---|---|
| | | Nights (n) | Hours | Min\h[c] | Mean | SE | Mean | SE | |
| Spring | | | | | | | | | |
| Prattsburgh–Italy, NY | 4/24/05 - 5/23/05 | 28 | 16.0 | A | 8.7 | 0.5 | 0.3 | 0.1 | 155 |
| Clinton County, NY | 4/15/05 - 5/29/05 | 45 | 151.8 | B | 4.2 | 0.6 | 0.4 | 0.1 | 685 |
| Centerville, NY | 4/16/06 - 5/30/06 | 42 | 241.8 | B | 1.7 | 0.3 | 0.3 | 0.1 | 488 |
| Wethersfield, NY | 4/16/06 - 5/30/06 | 43 | 237.3 | B | 1.5 | 0.3 | 0.3 | 0.1 | 436 |
| Swallow Farm, PA | 4/13/05 - 5/27/05[b] | 22 | 74.8 | B | 5.4 | 0.3 | 0.6 | 0.1 | 493 |
| Fall | | | | | | | | | |
| Maple Ridge, NY[a] | 8/5/04 - 10/3/04 | 50 | 195.9 | B[d] | 5.9 | 0.8 | 0.9 | 0.1 | 1,562 |
| Clinton County, NY | 8/15/05 - 10/13/05 | 53 | 242.7 | B | 2.9 | 0.4 | 0.6 | 0.1 | 829 |
| Centerville, NY | 8/16/06 - 10/14/06 | 43 | 205.8 | B | 5.0 | 1.1 | 0.7 | 0.1 | 948 |
| Wethersfield, NY | 8/16/06 - 10/14/06 | 56 | 235.8 | B | 3.5 | 0.5 | 0.4 | 0.1 | 845 |
| Swallow Farm, PA | 8/16/05 - 10/14/05 | 43 | 154.6 | C | 5.6 | 1.0 | 0.6 | 0.1 | 1,062 |
| Highland New Wind, VA | 8/16/05 - 10/14/05 | 49 | 159.4 | C | 8.2 | 2.0 | 1.4 | 0.2 | 1,541 |

[a] formerly known as Flat Rock

[b] alternate night sampling

[c] A = 5 min/h, B = 40–50 min/h, C = 40–50 min/h until ~1 Oct, then 5 min/h until end of study

[d] spotlight with red lens

[e] rates for subcategories of birds and bats were not calculated in original reports, nor can they be derived by applying seasonal percentage values from Appendix 7

# C

# Acoustical Monitoring Study, Spring 2006 (Woodlot Alternatives, Inc.)

# Spring 2006 Bat Detector Surveys at the Proposed Centerville and Wethersfield Windparks in Western New York

**Prepared For:**

Noble Environmental Power, LLC and
Ecology & Environment, Inc.

**Prepared By:**

Woodlot Alternatives, Inc.

September 2006

WOODLOT
ALTERNATIVES, INC.
ENVIRONMENTAL CONSULTANTS

# Executive Summary

During spring 2006, Woodlot Alternatives, Inc. (Woodlot) conducted field surveys as part of the planning process by Noble Environmental Power, LLC (Noble) for the proposed Centerville and Wethersfield Windparks in western New York. The field investigations included nighttime surveys of bats using bat echolocation detectors. These studies represent the first of two seasons of migration surveys undertaken at the sites.

Surveys were conducted from the night of April 6 to the night of June 7, 2006. The overall goal of the investigations was to document the presence of bats in the area, including the rate of occurrence and, when possible, species present during the spring migration period. The results of the field surveys provide useful information about site-specific migration activity and patterns in the vicinity of the proposed wind projects, especially when reviewed along with future results of the fall 2006 surveys that will be conducted in the same vicinity. This analysis is a valuable tool for the assessment of the potential risk to bats during migration through the area.

Bat call sequences were identified to the lowest possible taxonomic level. However, these were then grouped into four guilds based on similarity in call characteristics between some species and uncertainty in the ability of frequency division detectors to adequately provide information for this differentiation. The data reflect the species composition and relative abundance of bats in the area; however, it is important to consider the limitations of the equipment to sample large areas as well as sample at higher altitudes.

### *Centerville*

Two detectors were deployed at different heights in a meteorological measurement tower (met tower) site from the night of April 6 to the night June 7, yielding a total of 126 detector-nights of recordings. A total of 270 bat call sequences were recorded during the spring sampling. The mean detection rate of all detectors was 2.1 call sequences per detector-night. The detection rate was generally slightly higher than some other recent spring studies in New York and the region in the previous year. Habitat, landscape, location, and survey timing probably account for the observed differences between sites.

A large proportion (40%) of the call sequences were identified simply as 'unknown' due to poor file quality or too few call pulses on which to base an identification. Approximately 33 percent of the recorded call sequence were identified as myotid in origin; 17 percent as being from a guild of bat calls that includes the big brown bat (*Eptesicus fuscus*), silver-haired bat (*Lasionycteris noctivagans*), and hoary bat (*Lasiurus cinereus*); and only 9 percent were that of the eastern red bat (*Lasiurus borealis*) or eastern pipistrelle (*Pipistrellus subflavus*).

### *Wethersfield*

Two detectors were deployed at different heights in a met tower site from the night of April 6 to the night of June 7, yielding a total of 126 detector-nights of recordings. A total of 192 bat call sequences were recorded during the spring sampling. The mean detection rate of all detectors was 1.5 call sequences per detector-night. The detection rate was generally slightly higher than some other recent spring studies in New York and the region. Habitat, landscape, location, and survey timing probably account for the observed differences between sites.

A large proportion (40%) of the call sequences were identified simply as 'unknown' due to poor call quality or too few call pulses on which to base an identification. Approximately 32 percent of the calls were identified as myotids; 26 percent as the guild that includes the big brown bat, silver-haired bat, and hoary bat; and only 3 percent were that of the eastern red bat or eastern pipistrelle.

The number of call sequences was different between the two sites surveyed, although not substantially. There were very similar results from the site with respect to the timing of bat activity. In general, bat activity was greatest during periods with warm nightly temperatures and generally low wind. Both sites experienced a lapse in bat activity in the latter half of May, which was associated with cool, damp weather and nights with relatively high winds.

The species composition of the recorded call sequences at the two sites was also very similar. The species documented include most of the species expected to be present in this part of New York during the spring migration season. The species composition is also generally similar to other bat detector surveys conducted in the region recently.

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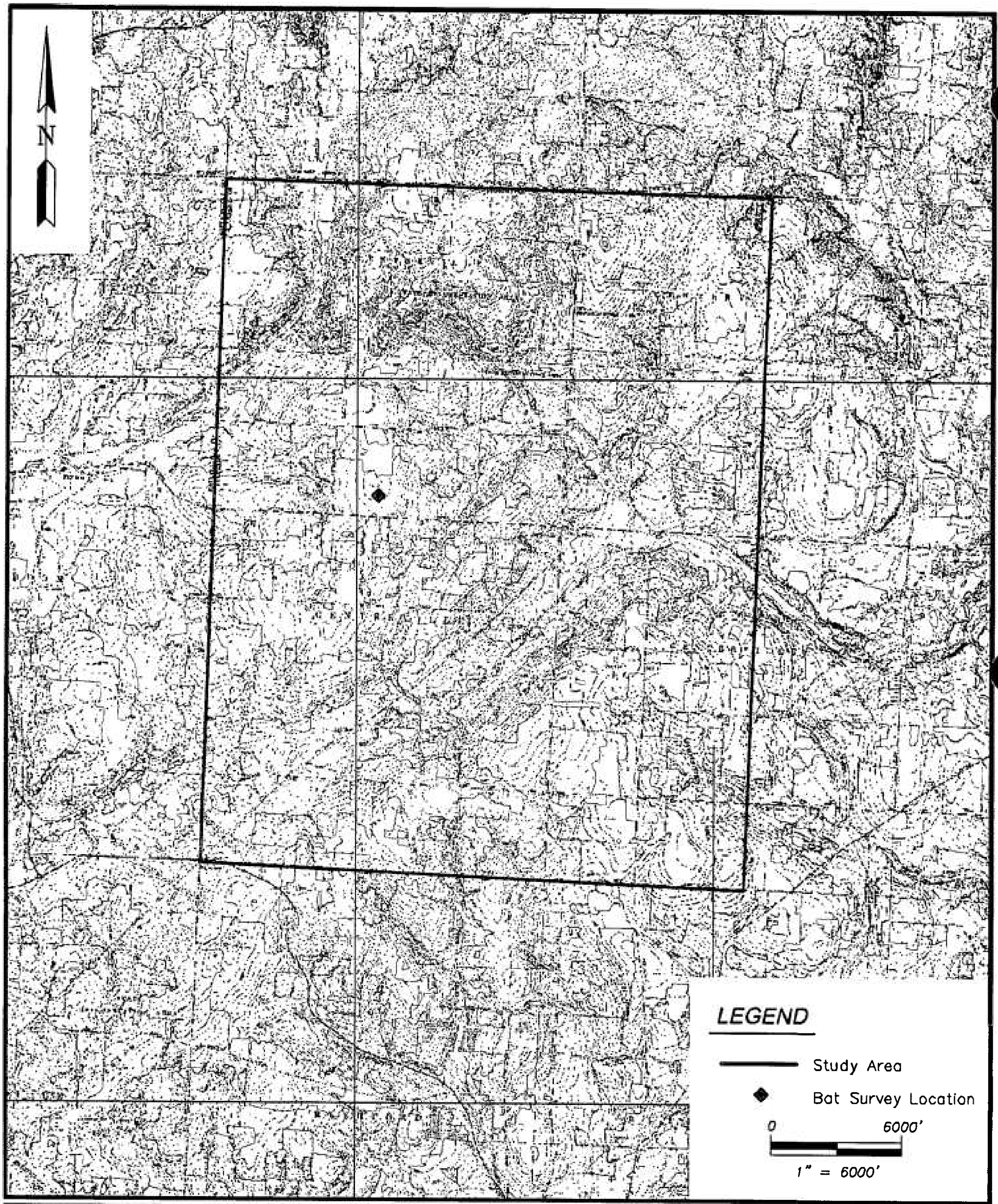
# 1.0 Introduction

Noble has proposed the construction of two wind developments in western New York. One project is located in Centerville, New York (Figure 1) and the other is located in Wethersfield, New York (Figure 2). Woodlot conducted field investigations for bat activity within the Centerville and Wethersfield project areas during the spring of 2006. The overall goals of the investigations were to document the presence of bats in the area, including the rate of occurrence and, when possible, species present during the spring migration period.

Wind projects have recently emerged as a potentially significant source of mortality for migrating bats following results of post-construction mortality surveys conducted at several operational wind farms in the southeastern United States (Arnett *et al.* 2005). While concerns about the risk of bat collision mortality were initially focused on forested ridgelines in the eastern United States, recent evidence from one facility on the prairies of Alberta indicate that bat mortality in those open habitats can be comparable to that observed along the forested ridgelines of the central Appalachian Mountains (Robert Barclay, unpublished data).

Two consistent patterns have emerged from mortality studies of bats at operating wind farms: the timing of mortality and the species most commonly found. The majority of bat collisions appear to occur consistently during the month of August, which is thought to be linked to fall migration patterns. The species most commonly found during mortality searches are the migratory tree bats, including eastern red bat, hoary bat, eastern pipistrelle, and silver-haired bat (Arnett *et al.* 2005). Bat collision mortality during the breeding season has been virtually non-existent, despite the fact that relatively large populations of some bat species have been documented in close proximity to some wind facilities that have been investigated. Available evidence indicates that most of the bat mortality at wind facilities in the United States involves migrant or dispersing bats in the late summer and fall, and that resident breeding bat populations are not currently impacted by wind facilities.

Nine species of bats occur in New York, based upon their normal geographical range. These are the little brown bat (*Myotis lucifugus*), northern long-eared bat, (*M. septentrionalis*), Indiana bat (*M. sodalis*), Eastern small-footed bat (*M. leibii*), silver-haired bat, eastern pipistrelle, big brown bat, eastern red bat, and hoary bat (Whitaker and Hamilton 1998). Of these, the Indiana bat is listed as federally endangered, and the small-footed bat is a state-listed species of special concern. According to the New York Department of Environmental Concern (NYDEC), eight Indiana bat hibernacula are present in New York and are located in Albany, Essex, Jefferson, Onondaga, Ulster, and Warren counties (NYDEC 2005). The proposed Centerville wind project is located in Allegany County and the Wethersfield wind project is located in Wyoming County, neither of which border any counties containing hibernacula. Additionally, no Indiana bat hibernacula are known from adjacent counties in Pennsylvania.

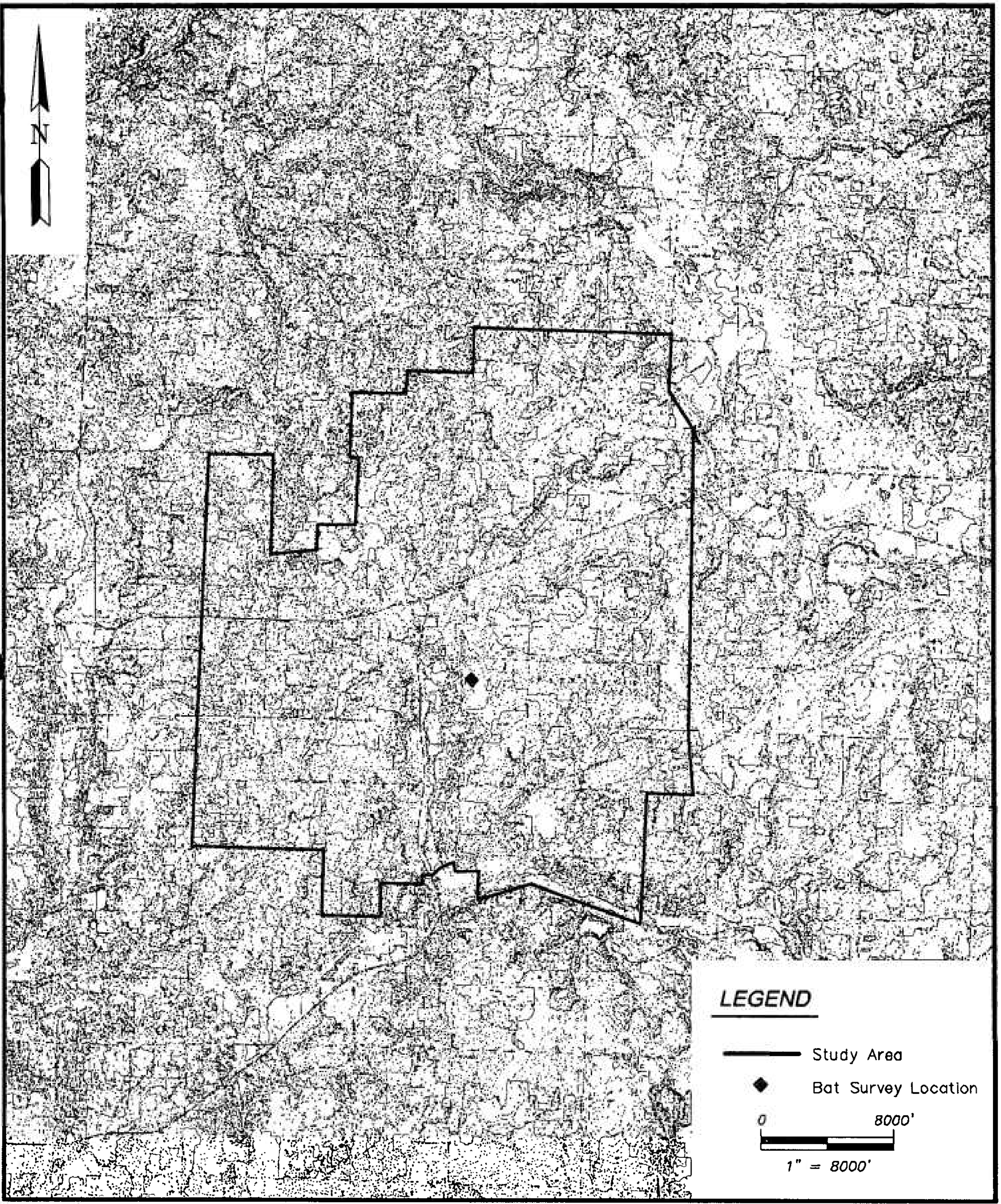


PREPARED BY:
**WOODLOT ALTERNATIVES, INC.**
ENVIRONMENTAL CONSULTANTS
106057-F001-BatDetector.dwg

SHEET TITLE:
Bat Detector Survey Location Map

PROJECT:
Proposed Noble Centerville Windpark
Centerville, NY

DATE: September 2008
SCALE: 1"=6000'
PROJ. NO.: 106057
FIGURE:
1



PREPARED BY:

**WOODLOT**
ALTERNATIVES, INC.
ENVIRONMENTAL CONSULTANTS
106058-F002-BatDetector.dwg

SHEET TITLE:

Bat Detector Survey Location Map

PROJECT:

Proposed Noble Wethersfield Windpark
Wethersfield, NY

DATE: September 2006
SCALE: 1"=8000'
PROJ. NO.: 106058
FIGURE:
2

# 2.0 Methods

*Field Surveys*

Anabat detectors are frequency-division detectors that divide the frequency of ultrasonic calls made by bats so that they are audible to humans. A factor of 16 was used in these studies. Frequency division detectors were selected based upon their widespread use for this type of survey, their ability to be deployed for long periods of time, and their ability to detect a broad frequency range, which allows detection of all species of bats that could occur in New York. Data from the Anabat detectors were logged onto compact flash media using a CF ZCAIM (Titley Electronics Pty Ltd.) and downloaded to a computer for analysis.

For each project, two detectors were deployed within the guy wire arrays at a single meteorological measurement tower (met tower) within each project area. These were passive surveys, as the detectors were placed at each site and left there for the duration of the study. At each site, the microphone of the first detector was attached to cables and raised as high as possible and the microphone of the second detector was deployed at approximately half the height of the first. Deployment in this fashion allowed sampling at different heights.

At Centerville, the microphones were deployed at heights of approximately 25 meters (m) (82') and 10 m (33') above the ground. At Wethersfield, microphones were deployed at heights of approximately 21 m (69') and 10 m (33') above the ground. At both sites, detectors were deployed on April 6 and retrieved on June 8, 2006. Detectors were programmed to record nightly from 7:00 pm to 7:00 am.

*Data Analysis*

Potential call files were extracted from data files using CFCread© software. The default settings for CFCread© were used during this file extraction process, as these settings are recommended for the calls that are characteristic of northeastern bats. This software screens all data recorded by the bat detector and extracts call files using a filter. The filter simply removes files created by noises other than bat calls based on the characteristics of the call file and the established characteristics of northeastern bat calls. Using the default settings for this initial screen also ensures comparability between data sets. Settings used by the filter include a maximum time between calls (TBC) of 5 seconds, a minimum line length of 5 milliseconds, and a smoothing factor of 50. The smoothing factor refers to whether or not adjacent pixels can be connected with a smooth line. The higher the smoothing factor, the less restrictive the filter is and the more noise files and poor quality call sequences are retained within the data set. A call is a single pulse of sound produced by a bat. A call sequence is a combination of two or more pulses recorded in a call file.

Following the initial screening, each file was visually inspected to ensure that files created by static or some other form of interference that were still within the frequency range of northeastern bats were not included in the data set. Call sequences were identified based on visual comparison of call sequences with reference libraries of known calls recorded by Woodlot during mist netting surveys in 2006 in New York and Pennsylvania and reference calls recorded from 2002 to 2005 provided by nationally recognized bat experts Lynn Robbins and Chris Corben. Mr. Corben is also the developer of the Anabat software. Bat calls typically include a series of pulses characteristic of normal flight or prey location. Bat calls capture periods (feeding 'buzzes') and visually look very different than static, which typically forms a solid line at either a constant frequency or with great frequency variation. Using these characteristics, bat call files are easily distinguished from non-bat files.

Qualitative visual comparison of recorded call sequences of sufficient length to reference libraries of bat calls allows for relatively accurate identification of bat species (O'Farrell *et al.* 1999, O'Farrell and Gannon 1999). A call sequence was considered of suitable quality and duration if the individual call pulses were clean (i.e., consisting of sharp, distinct lines) and at least seven pulses were included within the sequence. Call sequences were classified to species whenever possible, using the reference calls described above. However, due to similarity of call signatures between several species, all classified calls have been categorized into four guilds for presentation in this report. This classification scheme follows that of Gannon *et al.* (2003) and is as follows:

- Big brown/silver-haired/hoary bat (BBSHHB) – This guild will also be referred to as the big brown guild. These species' call signatures commonly overlap and have therefore been included as one guild in this report;
- Red bat/pipistrelle (RBEP) – Eastern red bats and eastern pipistrelles. Like so many of the other northeastern bats, these two species can produce calls distinctive only to each species. However, significant overlap in the call pulse shape, frequency range, and slope can also occur;
- Myotid. (MYSP) – All bats of the genus *Myotis*. While there are some general characteristics believed to be distinctive for several of the species in this genus, these characteristics do not occur consistently enough for any one species to be relied upon at all times when using Anabat recordings; and
- Unknown (UNKN) – All call sequences with too few pulses (i.e., less than seven) or of poor quality such as indistinct pulse characteristics or background static.

This guilding represents the most conservative approach to bat call identification. However, since some species do sometimes produce calls unique only to that species, all calls were identified to the lowest possible taxonomic level before being grouped into the listed guilds. Tables and figures in the body of this report will reflect those guilds. However, since species-specific identification did occur in some cases, each guild will also be briefly discussed with respect to potential species composition of recorded call sequences.

Once the call files were identified and placed into the appropriate guilds, nightly tallies of detected calls were compiled. Mean detection rates (number of calls/detector-night) for the entire sampling period were calculated for each detector and for all detectors combined. It is important to note that detection rates indicate only the number of calls detected and do not necessarily reflect the number of individual bats in an area. For example, a single individual can produce one or many call files recorded by the bat detector, but the bat detector cannot differentiate between individuals of the same species producing those calls. Consequently, detections recorded by the bat detector system likely over-represent the actual number of animals that produced the recorded calls.

### *Weather Data*

Nightly wind speed (meters per second [m/s]), direction (degrees from true North), and temperature (Celsius [C]) between 7:00 pm and 7:00 am were calculated for each night of the survey period. These weather measurements were obtained directly from the met towers in which the detectors were deployed. On some sampling nights, weather data from the met towers were not available. For the dates that were not available, weather data were obtained from the Dansville Municipal Airport (weatherunderground.com), which is approximately 35 miles to both Centerville and Wethersfield.

# 3.0 Results

## *3.1 Centerville*

Detectors were deployed at the Centerville site on April 6 and retrieved on June 8, 2006, for a total survey period of 63 nights. Combined, 126 detector-nights of bat echolocation data were recorded during the spring deployment period.

A total of 270 bat call sequences were recorded during the sampling period (Table 1). This was fairly evenly split between the two detectors, with 139 call sequences recorded by the upper detector and 131 by the lower detector. The number of call sequences recorded at each detector on any individual night ranged from 0 to 20 (May 24) at the low detector and 0 to 15 (April 30 and May 24) at the high detector. The mean detection rate for both detectors was 2.1 calls/detector night.

**Table 1.** Summary of bat detector field survey effort and results for Centerville - Spring 2006

| **Location** | **Dates** | **# Detector-Nights*** | **# Recorded sequences** | **Detection Rate **** | **Maximum # calls recorded ***** |
|---|---|---|---|---|---|
| High in met tower | April 6 - June 7 | 63 | 139 | 2.2 | 15 |
| Low in met tower | April 6 - June 7 | 63 | 131 | 2.1 | 20 |
| ***Overall Results*** | April 6 - June 7 | ***126*** | ***270*** | ***2.1*** | -- |

* Detector-night is a sampling unit during which a single detector is deployed overnight. On nights when two detectors are deployed, the sampling effort equals two detector-nights.

** Number of bat passes recorded per detector-night.

*** Maximum number of bat passes recorded from any **single** detector for a 12-hour sampling period.

Appendix A provides a series of tables with more specific information on the nightly timing, number, and species composition of recorded bat call sequences. Specifically, Appendix A Tables 1-2 provide information on the number of call sequences, by guild and suspected species, recorded at each detector and the weather conditions for that night. Appendix A Table 3 provides the actual data file information for each of the detectors. Included is the Analook file name for each of the 270 recorded call sequences, the night during which the call sequence was recorded, the time of night of the recording, and the species code that the call was given during analysis.

A total of 110 of the 270 (40%) recorded call sequences were labeled as unknown due to very short call sequences (i.e., less than seven pulses); poor call signature formation, likely due to a bat flying at the edge of the detection zone of the detector or flying away from the microphone; or static interference (Table 2). Of the calls that were identified to species or guild, myotids were the most common (33% of all call sequences), followed by the species within the big brown guild (17% of all call sequences). Fewer red bat/eastern pipistrelle call sequences (9% of all call sequences) were identified.

Within each guild, some individual call sequences were identified to species (Appendix A Tables 1-2). Call sequences within the guild of unknown bat calls were identified as such primarily due to too few pulses being included within the recorded call sequence. A vast majority of these call sequences (roughly 80%), however, had pulses that were steep and above 35-40 kilohertz (kHz). Most of these calls were probably those of the myotids. However, the characteristic of the upper portions of feeding buzzes for several other species extending above this frequency precludes making definitive identification of those call sequences to guild using call sequence files with so few pulses.

**Table 2.** Summary of the composition of recorded bat call sequences at Centerville - Spring 2006

| Detector | Guild | | | | Total |
|---|---|---|---|---|---|
| | Big brown guild | Red bat/ E. pipistrelle | Myotid | Unknown | |
| High | 25 | 9 | 49 | 56 | 139 |
| Low | 22 | 15 | 40 | 54 | 131 |
| *Total* | *47* | *24* | *89* | *110* | 270 |

Of the 89 call sequences in the myotid group, 48 (54%) were identified simply as *myotis* because the pulses in the call sequences were too indistinct. However, the remaining call sequences were identified as probably being little brown bat. Within the red bat/eastern pipistrelle guild, 22 of the 24 sequences were probably those of the red bat. Finally, of the 47 sequences in the big brown guild, 8 (17%) appeared to be distinctly that of the big brown bat, 6 (13%) the silver-haired bat, and 21 (47%) the hoary bat. The remaining sequences in this last guild were either that of the big brown bat or silver-haired bat and definitely not hoary bat (Appendix A Tables 1-2).

The nightly number of recorded call sequences, in general, varied considerably from night to night. Some trends were observed, however (Figure 3). Nightly call volume was low (i.e., only one or no recorded sequences) during the first two weeks of the survey period but began increasing in the latter half of April and through the first half of May. Call volume was also low around the middle of May but again increased around the end of the month.

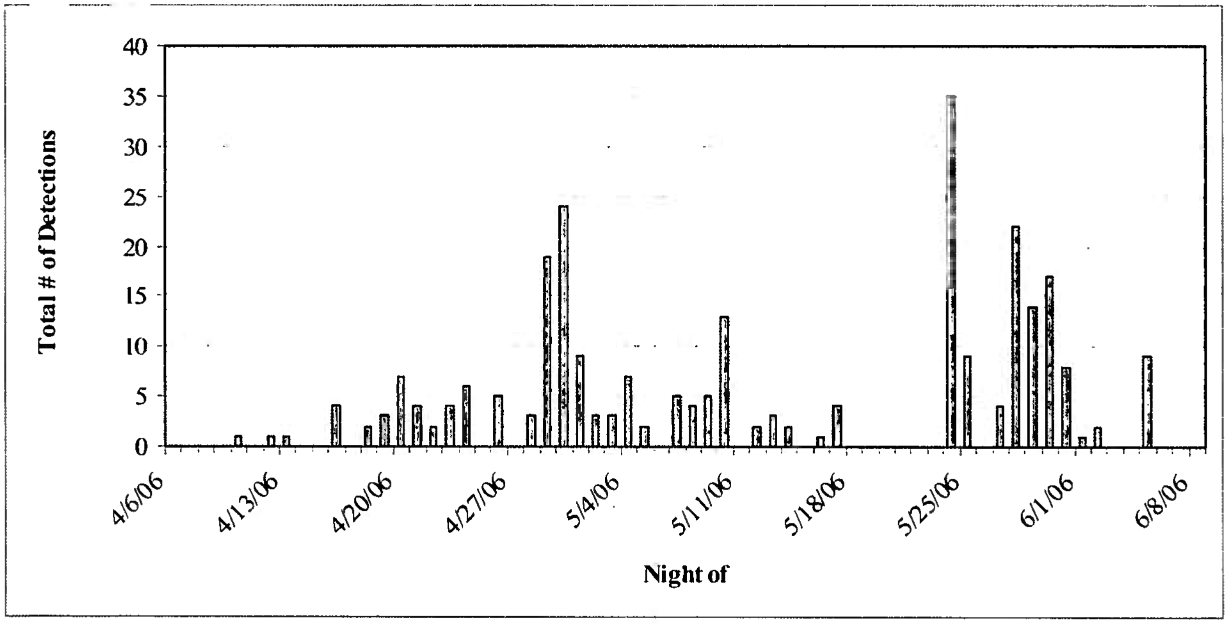


**Figure 3.** Nightly volume of recorded bat call sequences at Centerville.

*Weather Data*

Mean nightly wind speeds at the Centerville site varied between 1 and 11 m/s (Figure 4). Mean nightly temperatures varied between -3° C and 27° C (Figure 5). There appeared to be no strong relationship between either of these weather variables and bat call sequence detections. However, in general, no to very few call sequences were recorded on nights with the highest wind speeds (> 7 m/s), and nights with greater numbers of recorded call sequences were generally warmer (> 10 C).

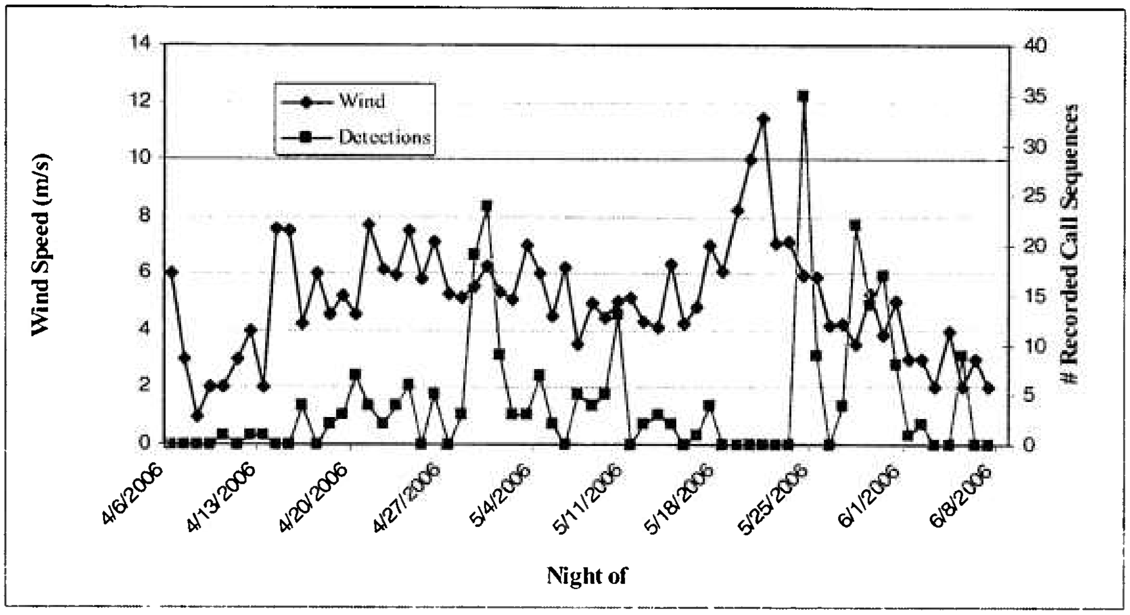


**Figure 4.** Nightly mean wind speed and nightly call sequence volume at Centerville.

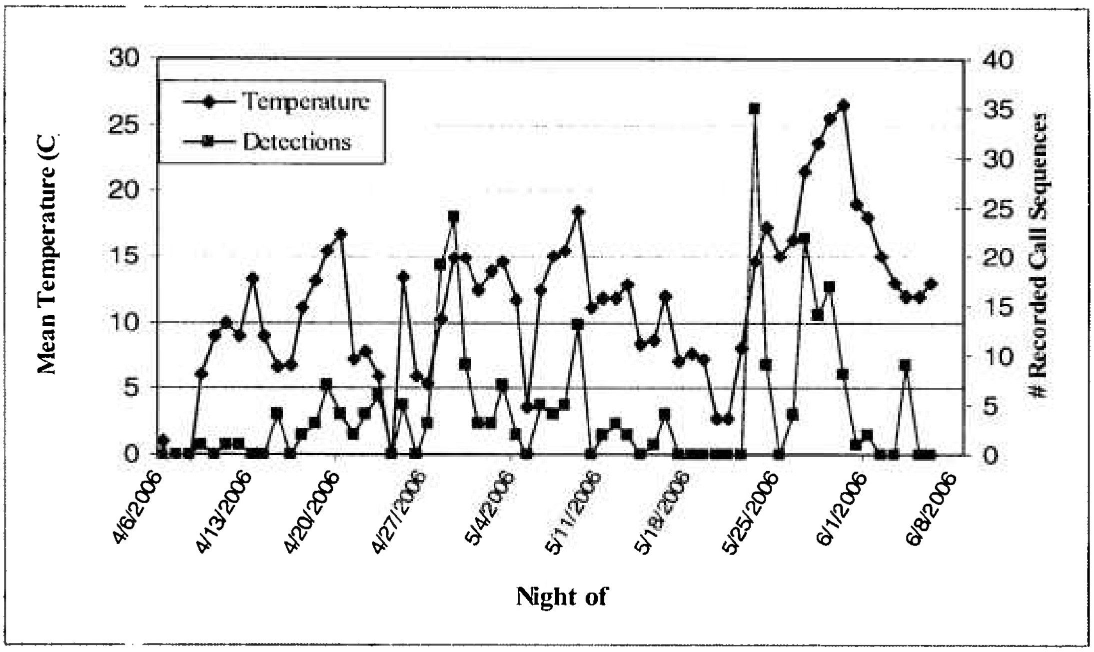


**Figure 5.** Nightly mean temperature and nightly call sequence volume at Centerville.

## 3.2 Wethersfield

Detectors were deployed at the Wethersfield site on April 6 and retrieved on June 8, 2006, for a total survey period of 63 nights. Combined, 126 detector-nights of bat echolocation data were recorded during the spring deployment period.

A total of 192 bat call sequences were recorded during the sampling period (Table 3). Slightly more than twice as many call sequences were recorded by the lower detector (132) than by the upper detector (60). The number of call sequences recorded at each detector on any individual night ranged from 0 to 14 (April 30) at the lower detector and 0 to 9 (June 6) at the upper detector. The mean detection rate for both detectors was 1.5 calls/detector night.

**Table 3.** Summary of bat detector field survey effort and results for Wethersfield - Spring 2006

| Location | Dates | # Detector-Nights* | # Recorded sequences | Detection Rate ** | Maximum # calls recorded *** |
|---|---|---|---|---|---|
| High in met tower | April 6 - June 7 | 63 | 60 | *1.0* | 9 |
| Low in met tower | April 6 - June 7 | 63 | 132 | *2.1* | 14 |
| ***Overall Results*** | ***April 6 - June 7*** | ***126*** | ***192*** | ***1.5*** | -- |

* Detector-night is a sampling unit during which a single detector is deployed overnight. On nights when two detectors are deployed, the sampling effort equals two detector-nights.

** Number of bat passes recorded per detector-night.

*** Maximum number of bat passes recorded from any **single** detector for a 12-hour sampling period.

Appendix B provides tables with more specific information on the nightly timing, number, and species composition of the recorded bat call sequences. Appendix B Tables 1-2 provide information on the number of call sequences, by guild and suspected species, recorded at each detector and the weather conditions for that night. Appendix B Table 3 provides the actual data file information for each detector, including the Analook file name for each of the 192 recorded call sequences, the night during which the call sequence was recorded, the time of night of the recording, and the species code that the call was given during analysis.

A total of 76 of the 192 (40%) recorded call sequences were labeled as unknown due to very short call sequences (i.e., less than seven pulses); poor call signature formation, likely due to a bat flying at the edge of the detection zone of the detector or flying away from the microphone; or static interference (Table 4). Of the calls that were identified to species or guild, myotids were the most common (32% of all call sequences), followed by the species within the big brown guild (26% of all call sequences). Fewer red bat/eastern pipistrelle call sequences (3% of all call sequences) were identified.

Within each guild, some individual call sequences were identified to species (Appendix B Tables 1-2). Call sequences within the guild of unknown bat calls were identified as such primarily due to too few pulses being included within the recorded call sequence. A majority of these call sequences (roughly 60%), however, had pulses that were steep and above 35-40 kHz. Most of these calls were probably those of the myotids. However, the characteristic of the upper portions of feeding buzzes for several other species extending above this frequency precludes making definitive identification of those call sequences to guild using call sequence files with so few pulses.

**Table 4.** Summary of the composition of recorded bat call sequences at Wethersfield - Spring 2006

| **Detector** | **Guild** | | | | **Total** |
|---|---|---|---|---|---|
| | **Big brown guild** | **Red bat/ E. pipistrelle** | **Myotid** | **Unknown** | |
| High | 17 | 2 | 9 | 32 | 60 |
| Low | 32 | 4 | 52 | 44 | 132 |
| ***Total*** | *49* | *6* | *61* | *76* | **192** |

Of the 61 call sequences in the myotid group, 37 (61%) were identified simply as *myotis* because the pulses in the call sequences were too indistinct. However, the remaining call sequences were identified as probably being little brown bat. Within the red bat/eastern pipistrelle guild, all 6 sequences were probably those of the red bat. Finally, of the 49 sequences in the big brown guild, 4 (8%) appeared to be distinctly that of the big brown bat, 7 (14%) the silver-haired bat, and 8 (16%) the hoary bat. The remaining 30 (61%) call sequences in this last guild were either that of the big brown bat or silver-haired bat and definitely not hoary bat (Appendix B Tables 1-2).

The number of recorded call sequences, in general, varied considerably from night to night, although some trends were observed (Figure 6). Nightly call volume was low (only one or no recorded sequences) during the first two weeks of the survey period but began increasing in the last week of April and through the first half of May. Call volume was also low around the middle of May but increased again around the end of the month.

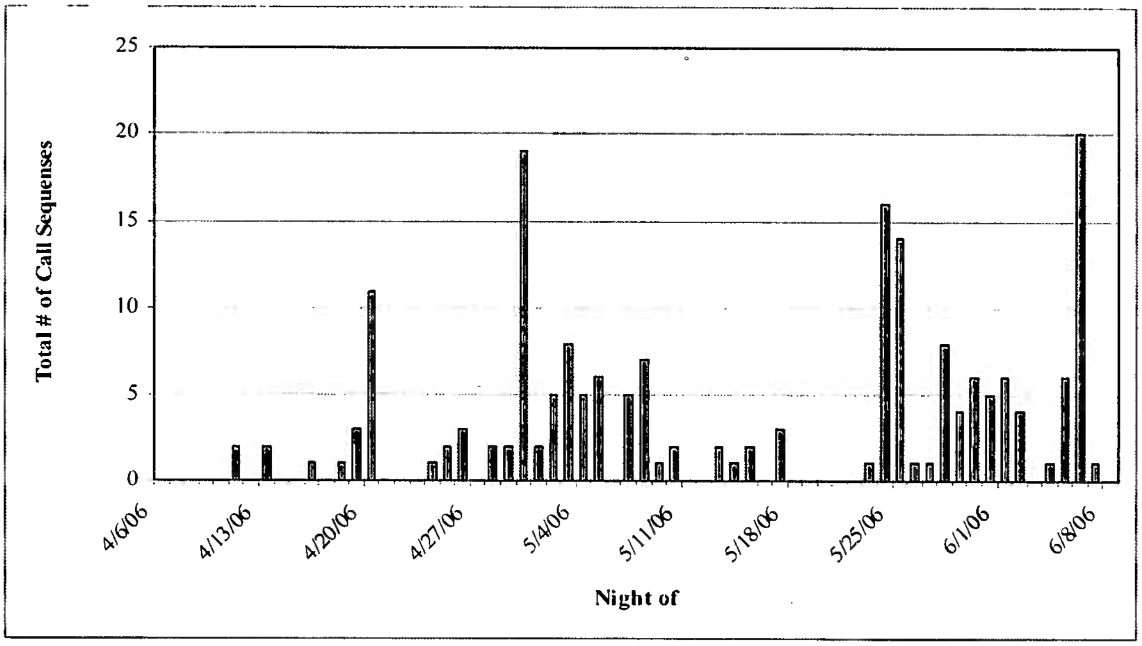


**Figure 6.** Nightly volume of recorded bat call sequences at Wethersfield.

*Weather Data*

Mean nightly wind speeds at the Wethersfield site varied between 1 and 11 m/s (Figure 7). Mean nightly temperatures varied between -3° C and 27° C (Figure 8). There appeared to be no strong relationship between either of these weather variables and bat call sequence detections. However, in general, no to very few call sequences were recorded on nights with the highest wind speeds (> 7 m/s), and nights with greater numbers of recorded call sequences were generally warmer (> 10 C).

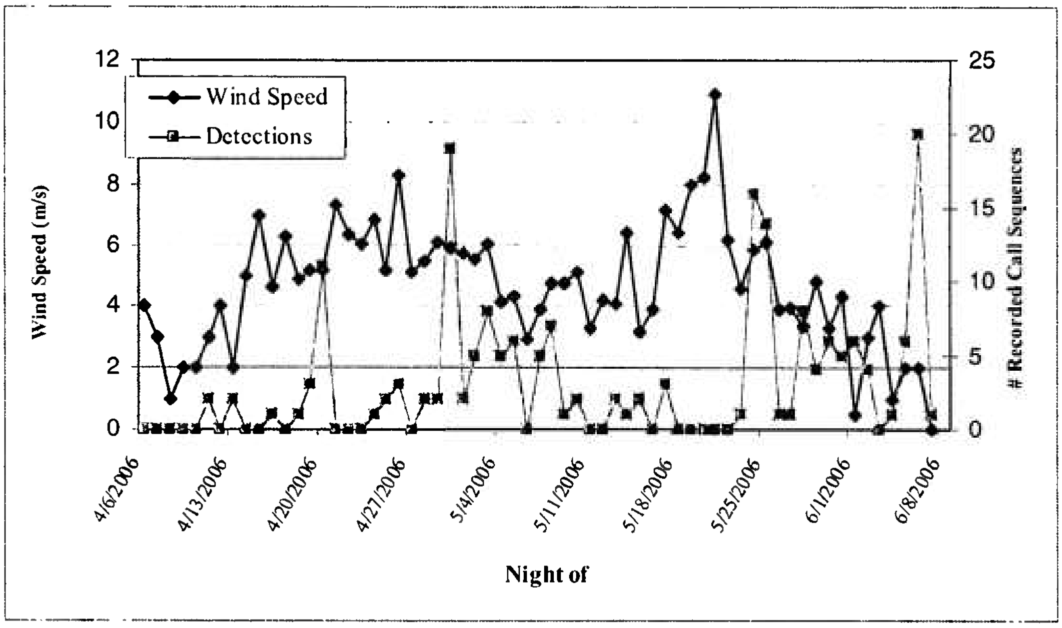


**Figure 7.** Nightly mean wind speed and nightly call sequence volume at Wethersfield.

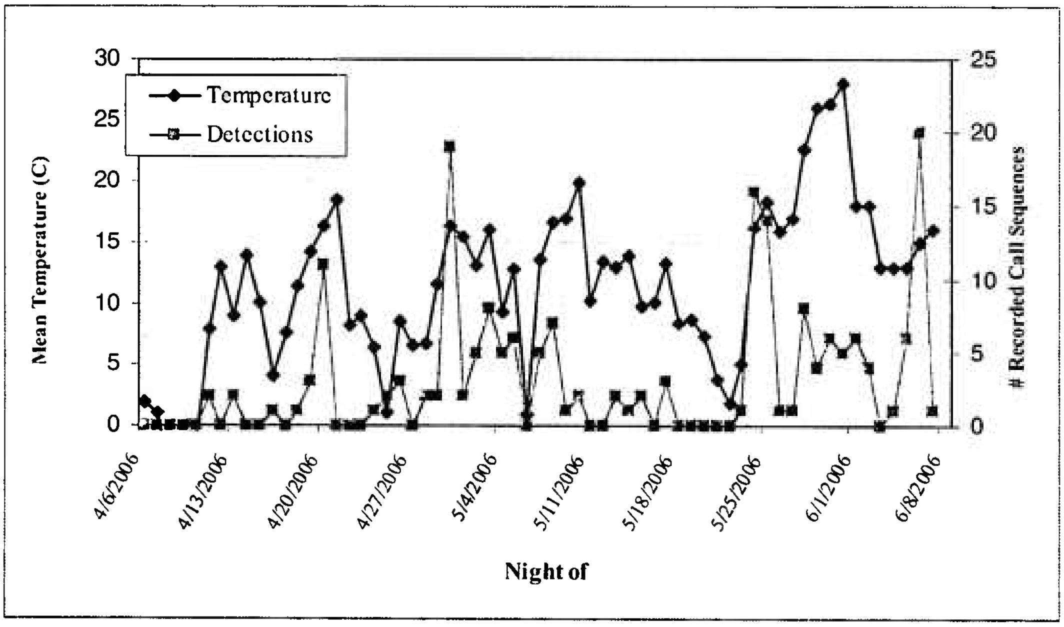


**Figure 8.** Nightly mean temperature and nightly call sequence volume at Wethersfield.

# 4.0 Discussion

Bat echolocation surveys in 2006 at the proposed Centerville Windpark and Wethersfield Windpark provide some insight into activity patterns, possible species composition, and timing of movements of bats in the project areas. The two met towers used for the deployment of the bat detectors at the two project sites were approximately 16 kilometers (10 miles) apart, and both sites were open agricultural fields dominated by pastures, hayfields, and silage corn. Results from the two sites show considerable similarity with respect to the timing and species composition at each site. Slight differences do occur, however, and are discussed below.

## *4.1 Comparison of the Two Sites*

The two sites differed with respect to the number of bat call sequences recorded over the course of the sampling period. The Centerville site documented approximately 40 percent more call sequences than the Wethersfield site over the same time period. Consequently, detection rates at the Centerville site were slightly higher than at the Wethersfield site. Habitat conditions, such as type and proximity of nearby forests and anthropomorphic roost sites (barns), were similar between the two sites. The difference between the two sites in the total number of recorded call sequences is likely due to natural variation in bat populations across the landscape, although in no way were attempts made during this study to document all habitat features that could affect bat density or activity.

The timing of the recorded call sequences at the two sites was quite similar and can be explained largely by weather conditions (Figure 9). Nightly tallies of recorded call sequences were fairly small throughout the first two weeks of the survey period and then increased during that last few days of April and the first two weeks of May. This time period was associated with progressively warmer nighttime temperatures that are typical of this time of year. The last two weeks of May, however, experienced colder and windier conditions, which resulted in a nearly week-long period when no call sequences were recorded at either of the sites. After this time period, the weather returned to seasonably typical patterns and bat activity resumed. Because the two sites were located so close to one another, weather likely affected bat activity similarly at both sites.

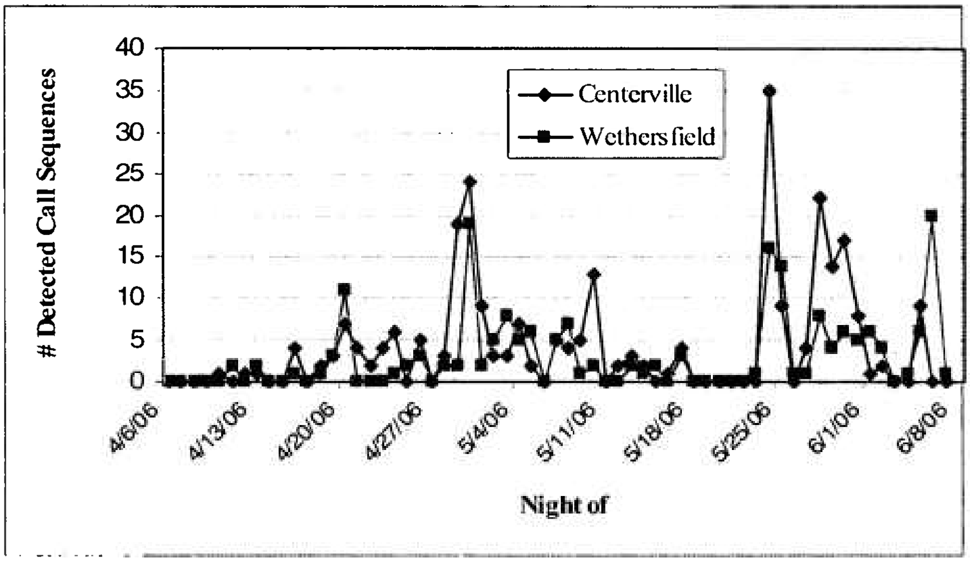


**Figure 9.** Nightly call volume at Centerville and Wethersfield.

Patterns in species (or guild) composition were also similar between the two sites. Figure 10 provides a summary of the composition of the recorded call sequences (identified to guild) at each detector and as a whole at both of the sites. As can be seen, after calls identified as unknown due to poor file quality or too few call pulses, calls of the myotids were generally the next most abundant group of call sequences. This was followed by call sequences within the big brown guild, which includes big brown bat, silver-haired bat, and hoary bat. Finally, calls of red bats and pipistrelles were the least abundant of all species and represented less than 10 percent of the calls at each site.

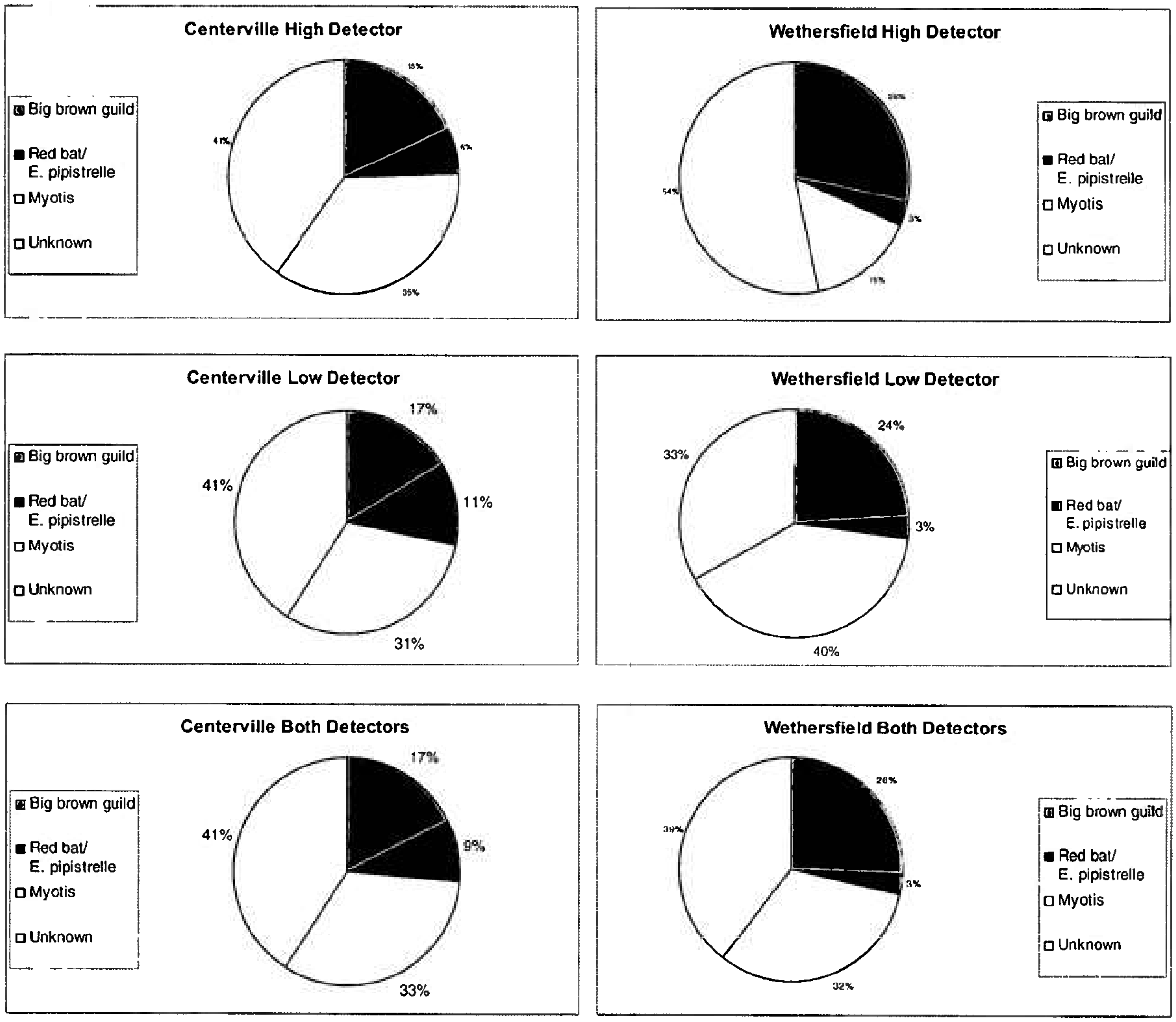


**Figure 10.** Comparison of species composition at each and all detectors at Centerville (left) and Wethersfield (right)

The overall results from the two survey sites were fairly similar. Considering the proximity of the two sites and the predominant land uses, it is likely that springtime bat migration activity at the two project sites is fairly similar. The use of individual locations for the placement of a limited number of bat detectors is occasionally identified as a potential limitation to on-site data at proposed wind power developments. While this deployment strategy may be limited in coverage across a proposed project area, the similarity of results at these two nearby sites indicates that the method may be capable of providing suitable data sets for use in comparison studies and as baseline data of bat activity at these sites.

## 4.2 Comparison with Other Regional Data Sources

The bat detectors deployed at both sites operated continuously throughout the 63-night sampling period and documented generally similar levels of bat activity. Those activity levels were higher, although not substantially higher, than those documented at a number of other sites across the northeast in the spring of 2005 (Table 5). These differences could be attributed to several potential factors. Initially, bat activity could be higher at the Centerville and Wethersfield sites than at other sites in the region due to habitat conditions or landscape-based concentrations in bat migration. This is unlikely, however, because many of the sites available for comparison occurred in very similar habitat, two of which were only approximately 72 kilometers (45 miles) east of the Centerville and Wethersfield sites.

**Table 5.** Summary of other available bat detector survey results

| Project | Location | Season | Calls per detector-night | Reference |
|---|---|---|---|---|
| Sheffield | Sheffield, VT | Spring 2005 | 0.17 | Woodlot 2006a |
| Deerfield | Searsburg, VT | Spring 2005 | 0.07 | Woodlot 2005a |
| Marble River | Churubusco, NY | Spring 2005 | 0.26 | Woodlot 2005b |
| Jordanville | Warren, NY | Spring 2005 | 0.5 | Woodlot 2005c |
| Cohocton | Cohocton, NY | Spring 2005 | 0.72 | Woodlot 2006b |
| Prattsburgh | Prattsburgh, NY | Spring 2005 | 0.28 | Woodlot 2005d |
| Liberty Gap | Franklin, WV | Spring 2005 | 0.50 | Woodlot 2005e |
| Centerville | Centerville, NY | Spring 2006 | 2.1 | this report |
| Wethersfield | Wethersfield, NY | Spring 2006 | 1.5 | this report |

The operation and number of detectors can also affect the overall results of a survey. At both sites, the bat detectors operated continuously and no nights of data were lost, which can be a typical occurrence when deploying detectors for long periods of time. Coincident with detector failure can be detector de-sensitivity from low battery voltage, among other things. That did not appear to occur at either of the two sites, and both detectors at both sites maintained their maximum sensitivity to detect bat echolocation calls through the duration of the survey.

Finally, the survey period for the spring 2006 surveys at Centerville and Wethersfield was slightly longer than in most of the of the other surveys identified in Table 5. Specifically, the survey period extended into June while the others concluded by the end of May. This extension likely includes activity levels associated with intense early summer feeding by bats that are not typical of spring migration activity. The other studies reported above do not include sampling from this same time period and it is possible that the longer survey period may be responsible for the slightly higher detection rates than other studies.

Results of acoustic surveys must be interpreted with caution. Considerable room for error exists in identification of bats based upon acoustic calls alone, especially if a site- or regionally-specific library of recorded reference calls is not available. Also, detection rates are not necessarily correlated with the actual numbers of bats in an area because it is not possible to differentiate between individual bats. Appendix A Tables 3 provide the time that each call file was recorded to help shed light on the nightly timing of bat activity and to identify potential repeat detections of individual bats, should that information be desired.

## 5.0 Conclusions

Detector surveys during the spring migration and early summer 2006 period have provided information on bat activity in the vicinity of the proposed Centerville and Wethersfield Windparks. The surveys documented the species that would be expected in the area based on the species' range and abundance, as well as the habitats in the project area.

The general similarity in detection rates, call volume, and species composition between the two sites likely reflects their proximity to one another and their predominant habitats and land uses. The results were generally consistent with other recent studies in the northeast, indicating that bat migration activity in the area wasn't particularly unique with respect to the level of bat activity or the species present.

## 6.0 Literature Cited

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## Appendix A

## Bat Detector Survey Data Tables - Centerville

**Appendix A Table 1.** Summary of species and weather during each survey night at the Centerville high detector (25 m) – Spring 2006

| Night of | BIG BROWN GUILD | | | | RBEP | | MYSP | | | | UNKN | Total | Mean Nightly Weather Conditions (7pm to 7am) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | big brown bat | hoary bat | silver-haired bat | silver-haired/big brown | eastern pipistrelle | eastern red bat | little brown bat | *Myotis* spp. | northern myotis | small-footed myotis | unknown | | Wind Speed (m/s) | Wind Direction (from) | Temp (C) |
| 4/6/2006* | | | | | | | | | | | | 0 | 6 | 135 | 2 |
| 4/7/2006* | | | | | | | | | | | | 0 | 3 | 315 | 1 |
| 4/8/2006* | | | | | | | | | | | | 0 | 1 | 135 | -3 |
| 4/9/2006* | | | | | | | | | | | | 0 | 2 | 135 | -1 |
| 4/10/2006* | | | | | | | | | | | | 0 | 2 | 135 | 6 |
| 4/11/2006* | | | | | | | | | | | | 0 | 3 | 135 | 9 |
| 4/12/2006* | | | | | | | | 1 | | | | 1 | 4 | variable | 10 |
| 4/13/2006* | | | | | | | | 1 | | | | 1 | 2 | 180 | 9 |
| 4/14/2006* | | | | | | | | | | | | 0 | 8 | variable | 13 |
| 4/15/2006 | | | | | | | | | | | | 0 | 8 | 295 | 9 |
| 4/16/2006 | | | | | | 1 | | | | | 2 | 3 | 4 | 170 | 7 |
| 4/17/2006 | | | | | | | | | | | | 0 | 6 | 44 | 7 |
| 4/18/2006 | | | | | | 1 | | | | | | 1 | 5 | 29 | 11 |
| 4/19/2006 | | | | | | | | 1 | | | 1 | 2 | 5 | 162 | 13 |
| 4/20/2006 | | | | | | 1 | 2 | 1 | | | | 4 | 5 | 153 | 15 |
| 4/21/2006 | | | | | | | | | | | 2 | 2 | 8 | 130 | 17 |
| 4/22/2006 | | | | | | | 1 | 1 | | | | 2 | 6 | 150 | 7 |
| 4/23/2006 | | | | | | | | 1 | | | 2 | 3 | 6 | 239 | 8 |
| 4/24/2006 | | | | | | | | 5 | | | 1 | 6 | 7 | 260 | 6 |
| 4/25/2006 | | | | | | | | | | | | 0 | 6 | 305 | 0 |
| 4/26/2006 | | | | | | | | | | | 3 | 3 | 7 | 250 | 13 |
| 4/27/2006 | | | | | | | | | | | | 0 | 5 | 240 | 6 |
| 4/28/2006 | | | | | | | | 2 | | | 1 | 3 | 5 | 53 | 5 |
| 4/29/2006 | | | | | | | 5 | | | | 4 | 9 | 6 | 75 | 10 |
| 4/30/2006 | 1 | | | 3 | | | 1 | 4 | | | 6 | 15 | 6 | 97 | 15 |
| 5/1/2006 | | | | | | | 4 | | | | 2 | 6 | 5 | 80 | 15 |
| 5/2/2006 | | | | | | | | | | | 2 | 2 | 5 | 75 | 12 |
| 5/3/2006 | | | | | | | 1 | | | | 1 | 2 | 7 | 289 | 14 |
| 5/4/2006 | 2 | | | | | | 1 | | | | 3 | 6 | 6 | 283 | 15 |
| 5/5/2006 | | | | | | | 1 | | | | 1 | 2 | 5 | 252 | 12 |
| 5/6/2006 | | | | | | | | | | | | 0 | 6 | 282 | 4 |
| 5/7/2006 | | | | | | 1 | | | | | 1 | 2 | 4 | 123 | 12 |
| 5/8/2006 | | | | | | | 1 | 1 | | | 1 | 3 | 5 | 150 | 15 |
| 5/9/2006 | | | | | | | 1 | | | | 2 | 3 | 4 | 91 | 15 |
| 5/10/2006 | | | | 2 | | 1 | 2 | | | | 3 | 8 | 5 | 100 | 18 |
| 5/11/2006 | | | | | | | | | | | | 0 | 5 | 166 | 11 |
| 5/12/2006 | | | | | | | | | | | | 0 | 4 | 247 | 12 |
| 5/13/2006 | | | | | | | | | | | 2 | 2 | 4 | 102 | 12 |
| 5/14/2006 | | | | 1 | | | | | | | | 1 | 6 | 92 | 13 |
| 5/15/2006 | | | | | | | | | | | | 0 | 4 | 128 | 8 |
| 5/16/2006 | | | | | | | | | | | | 0 | 5 | 237 | 9 |
| 5/17/2006 | | | | | | | | | | | 1 | 1 | 7 | 251 | 12 |
| 5/18/2006 | | | | | | | | | | | | 0 | 6 | 252 | 7 |
| 5/19/2006 | | | | | | | | | | | | 0 | 8 | 266 | 8 |
| 5/20/2006 | | | | | | | | | | | | 0 | 10 | 254 | 7 |
| 5/21/2006 | | | | | | | | | | | | 0 | 11 | 279 | 3 |
| 5/22/2006 | | | | | | | | | | | | 0 | 7 | 287 | 3 |
| 5/23/2006 | | | | | | | | | | | | 0 | 7 | 276 | 8 |
| 5/24/2006 | 1 | | | | | | | 8 | | | 6 | 15 | 6 | 262 | 15 |
| 5/25/2006 | | | | | | | | 1 | | | 2 | 3 | 6 | 196 | 17 |
| 5/26/2006 | | | | | | | | | | | | 0 | 4 | 281 | 15 |
| 5/27/2006 | | 1 | | | | | | | | | | 1 | 4 | 273 | 16 |
| 5/28/2006 | | | 2 | 2 | | 2 | | | | | 1 | 7 | 4 | 267 | 22 |
| 5/29/2006 | | | 2 | 2 | | | | | | | | 4 | 5 | 281 | 24 |
| 5/30/2006 | | 2 | | | | 1 | | | | | 5 | 8 | 4 | 255 | 26 |
| 5/31/2006 | | 1 | | | | | | 1 | | | | 2 | 5 | 276 | 27 |
| 6/1/2006* | | | | | | | | | | | | 0 | 3 | 160 | 19 |
| 6/2/2006* | | 1 | | | | | | | | | | 1 | 3 | 315 | 18 |
| 6/3/2006* | | | | | | | | | | | | 0 | 2 | 315 | 15 |
| 6/4/2006* | | | | | | | | | | | | 0 | 4 | 315 | 13 |
| 6/5/2006* | | 2 | | | | 1 | | 1 | | | 1 | 5 | 2 | 135 | 12 |
| 6/6/2006* | | | | | | | | | | | | 0 | 3 | 135 | 12 |
| 6/7/2006* | | | | | | | | | | | | 0 | 2 | 135 | 13 |
| **By Species** | 4 | 7 | 4 | 10 | 0 | 9 | 20 | 29 | 0 | 0 | 56 | 139 | | | |
| **By Guild** | 25 | | | | 9 | | 49 | | | | 56 | | | | |
| | BIG BROWN GUILD | | | | RBEP | | MYSP | | | | UNKN | Total | | | |

* Weather data from these nights were obtained online at www.weatherunderground.com

**Appendix A Table 2.** Summary of species and weather during each survey night at the Centerville low detector (10 m) - Spring 2006

| Night of | BIG BROWN GUILD | | | | RBEP | | MYSP | | | | UNKN | Total | Mean Nightly Weather Conditions (7pm to 7am) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | big brown bat | hoary bat | silver-haired bat | silver-haired/big brown | eastern pipistrelle | eastern red bat | little brown bat | *Myotis* spp. | northern myotis | small-footed myotis | unknown | | Wind Speed (m/s) | Wind Direction (from) | Temp (C) |
| 4/6/2006* | | | | | | | | | | | | 0 | 6 | 135 | 2 |
| 4/7/2006* | | | | | | | | | | | | 0 | 3 | 315 | 1 |
| 4/8/2006* | | | | | | | | | | | | 0 | 1 | 135 | -3 |
| 4/9/2006* | | | | | | | | | | | | 0 | 2 | 135 | -1 |
| 4/10/2006* | | | | | | 1 | | | | | | 1 | 2 | 135 | 6 |
| 4/11/2006* | | | | | | | | | | | | 0 | 3 | 135 | 9 |
| 4/12/2006* | | | | | | | | | | | | 0 | 4 | variable | 10 |
| 4/13/2006* | | | | | | | | | | | | 0 | 2 | 180 | 9 |
| 4/14/2006* | | | | | | | | | | | | 0 | 8 | variable | 13 |
| 4/15/2006 | | | | | | | | | | | | 0 | 8 | 295 | 9 |
| 4/16/2006 | | | | | | | 1 | | | | | 1 | 4 | 170 | 7 |
| 4/17/2006 | | | | | | | | | | | | 0 | 6 | 44 | 7 |
| 4/18/2006 | | | | | | | | | | | 1 | 1 | 5 | 29 | 11 |
| 4/19/2006 | | | | | | | | | | | 1 | 1 | 5 | 162 | 13 |
| 4/20/2006 | | | | | | | 1 | | | | 2 | 3 | 5 | 153 | 15 |
| 4/21/2006 | | | | | | | | | | | 2 | 2 | 8 | 130 | 17 |
| 4/22/2006 | | | | | | | | | | | | 0 | 6 | 150 | 7 |
| 4/23/2006 | | | | | | | | | | | 1 | 1 | 6 | 239 | 8 |
| 4/24/2006 | | | | | | | | | | | | 0 | 7 | 260 | 6 |
| 4/25/2006 | | | | | | | | | | | | 0 | 6 | 305 | 0 |
| 4/26/2006 | | | | | | | | | | | 2 | 2 | 7 | 250 | 13 |
| 4/27/2006 | | | | | | | | | | | | 0 | 5 | 240 | 6 |
| 4/28/2006 | | | | | | | | | | | | 0 | 5 | 53 | 5 |
| 4/29/2006 | | | | | | | 1 | 1 | | | 8 | 10 | 6 | 75 | 10 |
| 4/30/2006 | | | | 2 | | | 1 | | | | 6 | 9 | 6 | 97 | 15 |
| 5/1/2006 | | | | | | | 1 | | | | 2 | 3 | 5 | 80 | 15 |
| 5/2/2006 | | | | | | | 1 | | | | | 1 | 5 | 75 | 12 |
| 5/3/2006 | | | 1 | | | | | | | | | 1 | 7 | 289 | 14 |
| 5/4/2006 | | | 1 | | | | | | | | | 1 | 6 | 283 | 15 |
| 5/5/2006 | | | | | | | | | | | | 0 | 5 | 252 | 12 |
| 5/6/2006 | | | | | | | | | | | | 0 | 6 | 282 | 4 |
| 5/7/2006 | | | | | | | | | | | 3 | 3 | 4 | 123 | 12 |
| 5/8/2006 | | | | | | | | | | | 1 | 1 | 5 | 150 | 15 |
| 5/9/2006 | | | | | | | | 1 | | | 1 | 2 | 4 | 91 | 15 |
| 5/10/2006 | 1 | | | | | 1 | | 1 | | | 2 | 5 | 5 | 100 | 18 |
| 5/11/2006 | | | | | | | | | | | | 0 | 5 | 166 | 11 |
| 5/12/2006 | 1 | | | | 1 | | | | | | | 2 | 4 | 247 | 12 |
| 5/13/2006 | | | | | | | | 1 | | | | 1 | 4 | 102 | 12 |
| 5/14/2006 | | | | | | | | | | | 1 | 1 | 6 | 92 | 13 |
| 5/15/2006 | | | | | | | | | | | | 0 | 4 | 128 | 8 |
| 5/16/2006 | | | | | | | 1 | | | | | 1 | 5 | 237 | 9 |
| 5/17/2006 | | | | | | | 1 | | | | 2 | 3 | 7 | 251 | 12 |
| 5/18/2006 | | | | | | | | | | | | 0 | 6 | 252 | 7 |
| 5/19/2006 | | | | | | | | | | | | 0 | 8 | 266 | 8 |
| 5/20/2006 | | | | | | | | | | | | 0 | 10 | 254 | 7 |
| 5/21/2006 | | | | | | | | | | | | 0 | 11 | 279 | 3 |
| 5/22/2006 | | | | | | | | | | | | 0 | 7 | 287 | 3 |
| 5/23/2006 | | | | | | | | | | | | 0 | 7 | 276 | 8 |
| 5/24/2006 | 1 | | | | | | 7 | 6 | | | 6 | 20 | 6 | 262 | 15 |
| 5/25/2006 | | 1 | | | | | 1 | 2 | | | 2 | 6 | 6 | 196 | 17 |
| 5/26/2006 | | | | | | | | | | | | 0 | 4 | 281 | 15 |
| 5/27/2006 | | | | | | 1 | | 1 | | | 1 | 3 | 4 | 273 | 16 |
| 5/28/2006 | 1 | 6 | | | 1 | 2 | 1 | 2 | | | 2 | 15 | 4 | 267 | 22 |
| 5/29/2006 | | 5 | | | | | | 1 | | | 4 | 10 | 5 | 281 | 24 |
| 5/30/2006 | | 2 | | | | 5 | 1 | | | | 1 | 9 | 4 | 255 | 26 |
| 5/31/2006 | | | | | | 1 | 2 | 2 | | | 1 | 6 | 5 | 276 | 27 |
| 6/1/2006* | | | | | | | | 1 | | | | 1 | 3 | 160 | 19 |
| 6/2/2006* | | | | | | 1 | | | | | | 1 | 3 | 315 | 18 |
| 6/3/2006* | | | | | | | | | | | | 0 | 2 | 315 | 15 |
| 6/4/2006* | | | | | | | | | | | | 0 | 4 | 315 | 13 |
| 6/5/2006* | | | | | | 1 | 1 | | | | 2 | 4 | 2 | 135 | 12 |
| 6/6/2006* | | | | | | | | | | | | 0 | 3 | 135 | 12 |
| 6/7/2006* | | | | | | | | | | | | 0 | 2 | 135 | 13 |
| By Species | 4 | 14 | 2 | 2 | 2 | 13 | 21 | 19 | 0 | 0 | 54 | 131 | * Weather data from these nights were obtained online at www.weatherunderground.com | | |
| By Guild | 22 | | | | 15 | | 40 | | | | 54 | | | | |
| | BIG BROWN GUILD | | | | RBEP | | MYSP | | | | UNKN | Total | | | |

# Appendix B

## Bat Detector Survey Data Tables - Wethersfield

**Appendix B Table 1.** Summary of species and weather during each survey night at the Wethersfield high detector (21 m) – Spring 2006

| Night of | BIG BROWN GUILD | | | | RBEP | | MYSP | | | | UNKN | Total | Mean Nightly Weather Conditions (7pm to 7am) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | big brown bat | hoary bat | silver-haired bat | silver-haired/big brown | eastern pipistrelle | eastern red bat | little brown bat | *Myotis* spp. | northern myotis | small-footed myotis | unknown | | Wind Speed (m/s) | Wind Direction (from) | Temp (C) |
| 4/6/2006* | | | | | | | | | | | | 0 | 6 | 135 | 2 |
| 4/7/2006* | | | | | | | | | | | | 0 | 3 | 315 | 1 |
| 4/8/2006* | | | | | | | | | | | | 0 | 1 | 135 | -3 |
| 4/9/2006* | | | | | | | | | | | | 0 | 2 | 135 | -1 |
| 4/10/2006* | | | | | | | | | | | | 0 | 2 | 135 | 6 |
| 4/11/2006* | | | | | | | | | | | | 0 | 3 | 135 | 9 |
| 4/12/2006* | | | | | | | | | | | | 0 | 4 | variable | 10 |
| 4/13/2006* | | | | | | | | | | | 1 | 1 | 2 | 180 | 9 |
| 4/14/2006* | | | | | | | | | | | | 0 | 8 | variable | 13 |
| 4/15/2006 | | | | | | | | | | | | 0 | 8 | 295 | 9 |
| 4/16/2006 | | | | | | | | | | | | 0 | 4 | 170 | 7 |
| 4/17/2006 | | | | | | | | | | | | 0 | 6 | 44 | 7 |
| 4/18/2006 | | | | | | | | | | | 1 | 1 | 5 | 29 | 11 |
| 4/19/2006 | | | | | | | | | | | | 0 | 5 | 162 | 13 |
| 4/20/2006 | | | | | | 1 | 2 | 1 | | | 2 | 6 | 5 | 153 | 15 |
| 4/21/2006 | | | | | | | | | | | | 0 | 8 | 130 | 17 |
| 4/22/2006 | | | | | | | | | | | | 0 | 6 | 150 | 7 |
| 4/23/2006 | | | | | | | | | | | | 0 | 6 | 239 | 8 |
| 4/24/2006 | | | | | | | | | | | | 0 | 7 | 260 | 6 |
| 4/25/2006 | | | | | | | | | | | 1 | 1 | 6 | 305 | 0 |
| 4/26/2006 | | | | | | | | | | | | 0 | 7 | 250 | 13 |
| 4/27/2006 | | | | | | | | | | | | 0 | 5 | 240 | 6 |
| 4/28/2006 | | | | | | | | | | | 1 | 1 | 5 | 53 | 5 |
| 4/29/2006 | | | | | | | | | | | 1 | 1 | 6 | 75 | 10 |
| 4/30/2006 | | | | | | | | | | | 5 | 5 | 6 | 97 | 15 |
| 5/1/2006 | | | | | | | | | | | | 0 | 5 | 80 | 15 |
| 5/2/2006 | | | | | | | | | | | 1 | 1 | 5 | 75 | 12 |
| 5/3/2006 | | | | 2 | | 1 | | | | | | 3 | 7 | 289 | 14 |
| 5/4/2006 | | | | 1 | | | | | | | | 1 | 6 | 283 | 15 |
| 5/5/2006 | | | 1 | | | | | | | | 1 | 2 | 5 | 252 | 12 |
| 5/6/2006 | | | | | | | | | | | | 0 | 6 | 282 | 4 |
| 5/7/2006 | | | 1 | | | | | | | | | 1 | 4 | 123 | 12 |
| 5/8/2006 | | | | | | | | | | | 3 | 3 | 5 | 150 | 15 |
| 5/9/2006 | | | | | | | | | | | 1 | 1 | 4 | 91 | 15 |
| 5/10/2006 | | | | | | | | | | | | 0 | 5 | 100 | 18 |
| 5/11/2006 | | | | | | | | | | | | 0 | 5 | 166 | 11 |
| 5/12/2006 | | | | | | | | | | | | 0 | 4 | 247 | 12 |
| 5/13/2006 | | | | | | | | | | | | 0 | 4 | 102 | 12 |
| 5/14/2006 | | | | | | | | | | | | 0 | 6 | 92 | 13 |
| 5/15/2006 | | 2 | | | | | | | | | | 2 | 4 | 128 | 8 |
| 5/16/2006 | | | | | | | | | | | | 0 | 5 | 237 | 9 |
| 5/17/2006 | | | | | | | | | | | 1 | 1 | 7 | 251 | 12 |
| 5/18/2006 | | | | | | | | | | | | 0 | 6 | 252 | 7 |
| 5/19/2006 | | | | | | | | | | | | 0 | 8 | 266 | 8 |
| 5/20/2006 | | | | | | | | | | | | 0 | 10 | 254 | 7 |
| 5/21/2006 | | | | | | | | | | | | 0 | 11 | 279 | 3 |
| 5/22/2006 | | | | | | | | | | | | 0 | 7 | 287 | 3 |
| 5/23/2006 | | | | | | | | | | | 1 | 1 | 7 | 276 | 8 |
| 5/24/2006 | | | | | | | | | | | 4 | 4 | 6 | 262 | 15 |
| 5/25/2006 | | | | | | | 2 | 1 | | | 1 | 4 | 6 | 196 | 17 |
| 5/26/2006 | | | | | | | | | | | | 0 | 4 | 281 | 15 |
| 5/27/2006 | | | | | | | | | | | | 0 | 4 | 273 | 16 |
| 5/28/2006 | | | | | | | | | | | | 0 | 4 | 267 | 22 |
| 5/29/2006 | | | | | | | | | | | | 0 | 5 | 281 | 24 |
| 5/30/2006 | | | | | | | | | | | | 0 | 4 | 255 | 26 |
| 5/31/2006 | 1 | | | 1 | | | | | | | 1 | 3 | 5 | 276 | 27 |
| 6/1/2006* | | 1 | | | | | | | | | 2 | 3 | 3 | 160 | 19 |
| 6/2/2006* | | | 1 | 1 | | | | 1 | | | | 3 | 3 | 315 | 18 |
| 6/3/2006* | | | | | | | | | | | | 0 | 2 | 315 | 15 |
| 6/4/2006* | | | | | | | | | | | | 0 | 4 | 315 | 13 |
| 6/5/2006* | | | | 1 | | | | | | | | 1 | 2 | 135 | 12 |
| 6/6/2006* | | 2 | | 2 | | | 2 | | | | 3 | 9 | 3 | 135 | 12 |
| 6/7/2006* | | | | | | | | | | | 1 | 1 | 2 | 135 | 13 |
| **By Species** | 1 | 5 | 3 | 8 | 0 | 2 | 6 | 3 | 0 | 0 | 32 | 60 | * Weather data from these nights were obtained online at www.weatherunderground.com | | |
| **By Guild** | 17 | | | | 2 | | 9 | | | | 32 | | | | |
| | BIG BROWN GUILD | | | | RBEP | | MYSP | | | | UNKN | Total | | | |

**Appendix B Table 2.** Summary of species and weather during each survey night at the Wethersfield low detector (10 m) – Spring 2006

| Night of | BIG BROWN GUILD | | | | RBEP | | MYSP | | | | UNKN | Total | Mean Nightly Weather Conditions (7pm to 7am) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | big brown bat | hoary bat | silver-haired bat | silver-haired/big brown | eastern pipistrelle | eastern red bat | little brown bat | *Myotis* spp. | northern myotis | small-footed myotis | unknown | | Wind Speed (m/s) | Wind Direction (from) | Temp (C) |
| 4/6/2006* | | | | | | | | | | | | | | | |
| 4/7/2006* | | | | | | | | | | | | 0 | 3 | 315 | 1 |
| 4/8/2006* | | | | | | | | | | | | 0 | 1 | 135 | -3 |
| 4/9/2006* | | | | | | | | | | | | 0 | 2 | 135 | -1 |
| 4/10/2006* | | | | | | | | | | | | 0 | 2 | 135 | 6 |
| 4/11/2006* | 1 | | 1 | | | | | | | | | 2 | 3 | 135 | 9 |
| 4/12/2006* | | | | | | | | | | | | 0 | 4 | variable | 10 |
| 4/13/2006* | | | | | | | | | | | 1 | 1 | 2 | 180 | 9 |
| 4/14/2006* | | | | | | | | | | | | 0 | 8 | variable | 13 |
| 4/15/2006 | | | | | | | | | | | | 0 | 8 | 295 | 9 |
| 4/16/2006 | | | | | | | | | | | 1 | 1 | 4 | 170 | 7 |
| 4/17/2006 | | | | | | | | | | | | 0 | 6 | 44 | 7 |
| 4/18/2006 | | | | | | | | | | | | 0 | 5 | 29 | 11 |
| 4/19/2006 | | | | | | | 2 | 1 | | | | 3 | 5 | 162 | 13 |
| 4/20/2006 | | | | | | | 3 | | | | 2 | 5 | 5 | 153 | 15 |
| 4/21/2006 | | | | | | | | | | | | 0 | 8 | 130 | 17 |
| 4/22/2006 | | | | | | | | | | | | 0 | 6 | 150 | 7 |
| 4/23/2006 | | | | | | | | | | | | 0 | 6 | 239 | 8 |
| 4/24/2006 | | | | | | | | | | | 1 | 1 | 7 | 260 | 6 |
| 4/25/2006 | | | | | | | | | | | 1 | 1 | 6 | 305 | 0 |
| 4/26/2006 | | | | | | | | 2 | | | 1 | 3 | 7 | 250 | 13 |
| 4/27/2006 | | | | | | | | | | | | 0 | 5 | 240 | 6 |
| 4/28/2006 | | | | | | | | 1 | | | | 1 | 5 | 53 | 5 |
| 4/29/2006 | | | | | | 1 | | | | | | 1 | 6 | 75 | 10 |
| 4/30/2006 | | | | 2 | | 1 | 3 | 2 | | | 6 | 14 | 6 | 97 | 15 |
| 5/1/2006 | | | | 2 | | | | | | | | 2 | 5 | 80 | 15 |
| 5/2/2006 | 1 | | | 1 | | 1 | | | | | 1 | 4 | 5 | 75 | 12 |
| 5/3/2006 | | | | 2 | | 1 | | | | | 2 | 5 | 7 | 289 | 14 |
| 5/4/2006 | | | | 2 | | | | | | | 2 | 4 | 6 | 283 | 15 |
| 5/5/2006 | | | | 1 | | | 1 | 1 | | | 1 | 4 | 5 | 252 | 12 |
| 5/6/2006 | | | | | | | | | | | | 0 | 6 | 282 | 4 |
| 5/7/2006 | | | 1 | | | | 1 | | | | 2 | 4 | 4 | 123 | 12 |
| 5/8/2006 | | | 1 | | | | 1 | 1 | | | 1 | 4 | 5 | 150 | 15 |
| 5/9/2006 | | | | | | | | | | | | 0 | 4 | 91 | 15 |
| 5/10/2006 | | | | 2 | | | | | | | | 2 | 5 | 100 | 18 |
| 5/11/2006 | | | | | | | | | | | | 0 | 5 | 166 | 11 |
| 5/12/2006 | | | | | | | | | | | | 0 | 4 | 247 | 12 |
| 5/13/2006 | | | | 1 | | | | | | | 1 | 2 | 4 | 102 | 12 |
| 5/14/2006 | | | | | | | | 1 | | | | 1 | 6 | 92 | 13 |
| 5/15/2006 | | | | | | | | | | | | 0 | 4 | 128 | 8 |
| 5/16/2006 | | | | | | | | | | | | 0 | 5 | 237 | 9 |
| 5/17/2006 | | | | | | | | | | | 2 | 2 | 7 | 251 | 12 |
| 5/18/2006 | | | | | | | | | | | | 0 | 6 | 252 | 7 |
| 5/19/2006 | | | | | | | | | | | | 0 | 8 | 266 | 8 |
| 5/20/2006 | | | | | | | | | | | | 0 | 10 | 254 | 7 |
| 5/21/2006 | | | | | | | | | | | | 0 | 11 | 279 | 3 |
| 5/22/2006 | | | | | | | | | | | | 0 | 7 | 287 | 3 |
| 5/23/2006 | | | | | | | | | | | | 0 | 7 | 276 | 8 |
| 5/24/2006 | | | | | | | 2 | 9 | | | 1 | 12 | 6 | 262 | 15 |
| 5/25/2006 | | | | | | | 1 | 3 | | | 6 | 10 | 6 | 196 | 17 |
| 5/26/2006 | | | | | | | | | | | 1 | 1 | 4 | 281 | 15 |
| 5/27/2006 | | | | | | | | | | | 1 | 1 | 4 | 273 | 16 |
| 5/28/2006 | | | | | | | 2 | 4 | | | 2 | 8 | 4 | 267 | 22 |
| 5/29/2006 | | | | | | | 1 | 2 | | | 1 | 4 | 5 | 281 | 24 |
| 5/30/2006 | 1 | 1 | | 1 | | | 1 | | | | 2 | 6 | 4 | 255 | 26 |
| 5/31/2006 | | 1 | | 1 | | | | | | | | 2 | 5 | 276 | 27 |
| 6/1/2006* | | | | 1 | | | | 1 | | | 1 | 3 | 3 | 160 | 19 |
| 6/2/2006* | | | | 1 | | | | | | | | 1 | 3 | 315 | 18 |
| 6/3/2006* | | | | | | | | | | | | 0 | 2 | 315 | 15 |
| 6/4/2006* | | | | 1 | | | | | | | | 1 | 4 | 315 | 13 |
| 6/5/2006* | | | | | | | | 3 | | | 2 | 5 | 2 | 135 | 12 |
| 6/6/2006* | | 1 | 1 | 4 | | | | 3 | | | 2 | 11 | 3 | 135 | 12 |
| 6/7/2006* | | | | | | | | | | | | 0 | 2 | 135 | 13 |
| **By Species** | 3 | 3 | 4 | 22 | 0 | 4 | 18 | 34 | 0 | 0 | 44 | 132 | * Weather data from these nights were obtained online at www.weatherunderground.com | | |
| | 32 | | | | 4 | | 52 | | | | 44 | | | | |
| **By Guild** | BIG BROWN GUILD | | | | RBEP | | MYSP | | | | UNKN | Total | | | |

# Appendix C

## Bat Call Sequence File Data Tables

**Appendix C Table 1.** Summary of bat calls and their file names – Centerville, Spring 2006

| Filename | Date (night of) | Time | Height | Species | Guild |
|---|---|---|---|---|---|
| G4102359.49# | 4/10/06 | 23:59 | Low | LABO | RBEP |
| G4122326.19# | 4/12/06 | 23:26 | High | MYSP | MYSP |
| G4132224.04# | 4/13/06 | 22:24 | High | MYSP | MYSP |
| G4162321.13# | 4/16/06 | 23:21 | High | UNKN | UNKN |
| G4170058.39# | 4/16/06 | 0:58 | Low | MYLU | MYSP |
| G4170058.50# | 4/16/06 | 0:58 | High | LABO | RBEP |
| G4170126.07# | 4/16/06 | 1:26 | High | UNKN | UNKN |
| G4190054.52# | 4/18/06 | 0:54 | Low | UNKN | UNKN |
| G4190055.07# | 4/18/06 | 0:00 | High | LABO | RBEP |
| G4192210.12# | 4/19/06 | 22:10 | High | UNKN | UNKN |
| G4200016.15# | 4/19/06 | 0:16 | Low | UNKN | UNKN |
| G4200016.31# | 4/19/06 | 0:16 | High | MYSP | MYSP |
| G4202055.21# | 4/20/06 | 20:55 | Low | MYLU | MYSP |
| G4202055.41# | 4/20/06 | 20:55 | High | MYLU | MYSP |
| G4202154.34# | 4/20/06 | 21:54 | Low | UNKN | UNKN |
| G4202154.52# | 4/20/06 | 21:54 | High | MYLU | MYSP |
| G4210342.25# | 4/20/06 | 3:42 | Low | UNKN | UNKN |
| G4210342.43# | 4/20/06 | 3:42 | High | LABO | RBEP |
| G4210435.52# | 4/20/06 | 4:35 | High | MYSP | MYSP |
| G4212139.27# | 4/21/06 | 21:39 | Low | UNKN | UNKN |
| G4212246.53# | 4/21/06 | 22:46 | Low | UNKN | UNKN |
| G4212247.11# | 4/21/06 | 22:47 | High | UNKN | UNKN |
| G4212323.23# | 4/21/06 | 23:23 | High | UNKN | UNKN |
| G4222231.30# | 4/22/06 | 22:31 | High | MYLU | MYSP |
| G4230340.30# | 4/22/06 | 3:40 | High | MYSP | MYSP |
| G4232305.01# | 4/23/06 | 23:05 | Low | UNKN | UNKN |
| G4232305.23# | 4/23/06 | 23:05 | High | UNKN | UNKN |
| G4232322.48# | 4/23/06 | 23:22 | High | MYSP | MYSP |
| G4240134.26# | 4/23/06 | 1:34 | High | UNKN | UNKN |
| G4242246.34# | 4/24/06 | 22:46 | High | MYSP | MYSP |
| G4242252.45# | 4/24/06 | 22:52 | High | MYSP | MYSP |
| G4242335.31# | 4/24/06 | 23:35 | High | MYSP | MYSP |
| G4250006.41# | 4/24/06 | 0:06 | High | MYSP | MYSP |
| G4250024.02# | 4/24/06 | 0:24 | High | MYSP | MYSP |
| G4250237.19# | 4/24/06 | 2:37 | High | UNKN | UNKN |
| G4262229.27# | 4/26/06 | 22:29 | Low | UNKN | UNKN |
| G4262229.53# | 4/26/06 | 22:29 | High | UNKN | UNKN |
| G4270010.38# | 4/26/06 | 0:10 | High | UNKN | UNKN |
| G4270026.19# | 4/26/06 | 0:26 | High | UNKN | UNKN |
| G4270050.20# | 4/26/06 | 0:50 | Low | UNKN | UNKN |
| G4290016.33# | 4/28/06 | 0:16 | High | MYSP | MYSP |
| G4290039.19# | 4/28/06 | 0:39 | High | UNKN | UNKN |
| G4290042.58# | 4/28/06 | 0:42 | High | MYSP | MYSP |
| G4292108.11# | 4/29/06 | 21:08 | Low | MYSP | MYSP |
| G4292108.41# | 4/29/06 | 21:08 | High | MYLU | MYSP |
| G4292109.01# | 4/29/06 | 21:09 | Low | UNKN | UNKN |
| G4292109.30# | 4/29/06 | 21:09 | High | MYLU | MYSP |
| G4292129.02# | 4/29/06 | 21:29 | High | UNKN | UNKN |
| G4292237.23# | 4/29/06 | 22:37 | Low | UNKN | UNKN |
| G4292237.51# | 4/29/06 | 22:37 | High | UNKN | UNKN |
| G4292238.51# | 4/29/06 | 22:38 | Low | UNKN | UNKN |
| G4292239.19# | 4/29/06 | 22:39 | High | MYLU | MYSP |
| G4300012.22# | 4/29/06 | 0:12 | Low | MYLU | MYSP |
| G4300012.52# | 4/29/06 | 0:12 | High | MYLU | MYSP |
| G4300020.38# | 4/29/06 | 0:20 | Low | UNKN | UNKN |
| G4300021.05# | 4/29/06 | 0:21 | High | MYLU | MYSP |
| G4300035.26# | 4/29/06 | 0:35 | High | UNKN | UNKN |
| G4300112.45# | 4/29/06 | 1:12 | Low | UNKN | UNKN |
| G4300124.59# | 4/29/06 | 1:24 | Low | UNKN | UNKN |
| G4300125.29# | 4/29/06 | 1:25 | High | UNKN | UNKN |
| G4300203.17# | 4/29/06 | 2:03 | Low | UNKN | UNKN |
| G4300455.25# | 4/29/06 | 4:55 | Low | UNKN | UNKN |
| G4302052.55# | 4/30/06 | 20:52 | Low | UNKN | UNKN |
| G4302053.24# | 4/30/06 | 20:53 | High | UNKN | UNKN |
| G4302057.41# | 4/30/06 | 20:57 | Low | LE | BIG BROWN GUILD |
| G4302058.12# | 4/30/06 | 20:58 | High | LE | BIG BROWN GUILD |
| G4302108.14# | 4/30/06 | 21:08 | High | UNKN | UNKN |
| G4302148.20# | 4/30/06 | 21:48 | High | EPFU | BIG BROWN GUILD |
| G4302233.37# | 4/30/06 | 22:33 | High | UNKN | UNKN |
| G4302250.33# | 4/30/06 | 22:50 | Low | MYLU | MYSP |
| G4302257.23# | 4/30/06 | 22:57 | Low | UNKN | UNKN |
| G4302257.54# | 4/30/06 | 22:57 | High | MYSP | MYSP |
| G4302313.19# | 4/30/06 | 23:13 | High | UNKN | UNKN |
| G4302351.03# | 4/30/06 | 23:51 | High | MYSP | MYSP |
| G5010004.35# | 4/30/06 | 0:04 | High | UNKN | UNKN |
| G5010013.39# | 4/30/06 | 0:13 | Low | UNKN | UNKN |

*(continued)*

**Appendix C Table 1.** Summary of bat calls and their file names – Centerville Spring 2006 *(continued)*

| Filename | Date (night of) | Time | Height | Species | Guild |
|---|---|---|---|---|---|
| G5010014.10# | 4/30/06 | 0:14 | High | LE | BIG BROWN GUILD |
| G5010016.16# | 4/30/06 | 0:16 | High | MYSP | MYSP |
| G5010022.46# | 4/30/06 | 0:22 | Low | UNKN | UNKN |
| G5010023.16# | 4/30/06 | 0:23 | High | MYSP | MYSP |
| G5010035.43# | 4/30/06 | 0:35 | Low | UNKN | UNKN |
| G5010039.39# | 4/30/06 | 0:39 | Low | UNKN | UNKN |
| G5010040.05# | 4/30/06 | 0:40 | High | MYLU | MYSP |
| G5010123.05# | 4/30/06 | 1:23 | High | UNKN | UNKN |
| G5010124.45# | 4/30/06 | 1:24 | Low | LE | BIG BROWN GUILD |
| G5010125.19# | 4/30/06 | 1:25 | High | LE | BIG BROWN GUILD |
| G5012107.54# | 5/1/06 | 21:07 | High | MYLU | MYSP |
| G5012303.33# | 5/1/06 | 23:03 | High | UNKN | UNKN |
| G5012343.31# | 5/1/06 | 23:43 | High | UNKN | UNKN |
| G5020016.18# | 5/1/06 | 0:16 | Low | MYLU | MYSP |
| G5020016.50# | 5/1/06 | 0:16 | High | MYLU | MYSP |
| G5020323.49# | 5/1/06 | 3:23 | Low | UNKN | UNKN |
| G5020324.18# | 5/1/06 | 3:24 | High | MYLU | MYSP |
| G5020502.48# | 5/1/06 | 5:02 | Low | UNKN | UNKN |
| G5020503.19# | 5/1/06 | 5:03 | High | MYLU | MYSP |
| G5022345.20# | 5/2/06 | 23:45 | Low | MYLU | MYSP |
| G5022345.56# | 5/2/06 | 23:45 | High | UNKN | UNKN |
| G5030058.37# | 5/2/06 | 0:58 | High | UNKN | UNKN |
| G5032148.57# | 5/3/06 | 21:48 | Low | LANO | BIG BROWN GUILD |
| G5032223.59# | 5/3/06 | 22:23 | High | UNKN | UNKN |
| G5040117.52# | 5/3/06 | 1:17 | High | MYLU | MYSP |
| G5042101.06# | 5/4/06 | 21:01 | High | EPFU | BIG BROWN GUILD |
| G5042133.28# | 5/4/06 | 21:33 | High | MYLU | MYSP |
| G5042305.26# | 5/4/06 | 23:05 | High | UNKN | UNKN |
| G5042330.32# | 5/4/06 | 23:30 | High | UNKN | UNKN |
| G5042339.50# | 5/4/06 | 23:39 | Low | LANO | BIG BROWN GUILD |
| G5042340.27# | 5/4/06 | 23:40 | High | UNKN | UNKN |
| G5050029.23# | 5/4/06 | 0:29 | High | EPFU | BIG BROWN GUILD |
| G5060013.22# | 5/5/06 | 0:13 | High | UNKN | UNKN |
| G5060520.12# | 5/5/06 | 5:20 | High | MYLU | MYSP |
| G5072114.25# | 5/7/06 | 21:14 | Low | UNKN | UNKN |
| G5072120.35# | 5/7/06 | 21:20 | Low | UNKN | UNKN |
| G5072121.12# | 5/7/06 | 21:21 | High | LABO | RBEP |
| G5072346.18# | 5/7/06 | 23:46 | Low | UNKN | UNKN |
| G5072346.57# | 5/7/06 | 23:46 | High | UNKN | UNKN |
| G5082144.48# | 5/8/06 | 21:44 | High | MYLU | MYSP |
| G5082319.28# | 5/8/06 | 23:19 | Low | UNKN | UNKN |
| G5082320.08# | 5/8/06 | 23:20 | High | UNKN | UNKN |
| G5082359.40# | 5/8/06 | 23:59 | High | MYSP | MYSP |
| G5092131.39# | 5/9/06 | 21:31 | Low | UNKN | UNKN |
| G5092141.01# | 5/9/06 | 21:41 | High | UNKN | UNKN |
| G5092354.54# | 5/9/06 | 23:54 | Low | MYSP | MYSP |
| G5100007.44# | 5/9/06 | 0:07 | High | UNKN | UNKN |
| G5100446.29# | 5/9/06 | 4:46 | High | MYLU | MYSP |
| G5102106.08# | 5/10/06 | 21:06 | High | LE | BIG BROWN GUILD |
| G5102123.56# | 5/10/06 | 21:23 | Low | LABO | RBEP |
| G5102124.40# | 5/10/06 | 21:24 | High | UNKN | UNKN |
| G5102316.16# | 5/10/06 | 23:16 | High | MYLU | MYSP |
| G5102338.39# | 5/10/06 | 23:38 | Low | MYSP | MYSP |
| G5102339.24# | 5/10/06 | 23:39 | High | UNKN | UNKN |
| G5110014.01# | 5/10/06 | 0:14 | High | LABO | RBEP |
| G5110054.55# | 5/10/06 | 0:54 | High | MYLU | MYSP |
| G5110126.45# | 5/10/06 | 1:26 | Low | UNKN | UNKN |
| G5110127.28# | 5/10/06 | 1:27 | High | LE | BIG BROWN GUILD |
| G5110240.32# | 5/10/06 | 2:40 | Low | EPFU | BIG BROWN GUILD |
| G5110240.47# | 5/10/06 | 2:40 | Low | UNKN | UNKN |
| G5110241.15# | 5/10/06 | 2:41 | High | UNKN | UNKN |
| G5122139.42# | 5/12/06 | 21:39 | Low | EPFU | BIG BROWN GUILD |
| G5130100.32# | 5/12/06 | 1:00 | Low | PISU | RBEP |
| G5132053.11# | 5/13/06 | 20:53 | High | UNKN | UNKN |
| G5132053.18# | 5/13/06 | 20:53 | Low | MYSP | MYSP |
| G5132247.27# | 5/13/06 | 22:47 | High | UNKN | UNKN |
| G5142123.07# | 5/14/06 | 21:23 | High | LE | BIG BROWN GUILD |
| G5142215.13# | 5/14/06 | 22:15 | Low | UNKN | UNKN |
| G5162201.02# | 5/16/06 | 22:01 | Low | MYLU | MYSP |
| G5172323.31# | 5/17/06 | 23:23 | Low | UNKN | UNKN |
| G5180029.55# | 5/17/06 | 0:29 | High | UNKN | UNKN |
| G5180030.06# | 5/17/06 | 0:30 | Low | MYLU | MYSP |
| G5180113.41# | 5/17/06 | 1:13 | Low | UNKN | UNKN |
| G5242121.31# | 5/24/06 | 21:21 | Low | UNKN | UNKN |
| G5242122.02# | 5/24/06 | 21:22 | High | UNKN | UNKN |
| G5242122.22# | 5/24/06 | 21:22 | Low | MYSP | MYSP |
| G5242146.17# | 5/24/06 | 21:46 | Low | UNKN | UNKN |
| G5242216.19# | 5/24/06 | 22:16 | Low | MYSP | MYSP |

*(continued)*

**Appendix C Table 1.** Summary of bat calls and their file names – Centerville Spring 2006 *(continued)*

| Filename | Date (night of) | Time | Height | Species | Guild |
|---|---|---|---|---|---|
| G5242234.18# | 5/24/06 | 22:34 | High | UNKN | UNKN |
| G5242234.38# | 5/24/06 | 22:34 | Low | MYSP | MYSP |
| G5242308.04# | 5/24/06 | 23:08 | High | MYSP | MYSP |
| G5242308.23# | 5/24/06 | 23:08 | Low | MYLU | MYSP |
| G5242325.52# | 5/24/06 | 23:25 | High | MYSP | MYSP |
| G5242326.14# | 5/24/06 | 23:26 | Low | MYLU | MYSP |
| G5242328.09# | 5/24/06 | 23:28 | Low | UNKN | UNKN |
| G5242344.13# | 5/24/06 | 23:44 | High | UNKN | UNKN |
| G5242344.32# | 5/24/06 | 23:44 | Low | MYLU | MYSP |
| G5242352.16# | 5/24/06 | 23:52 | High | MYSP | MYSP |
| G5242352.39# | 5/24/06 | 23:52 | Low | MYLU | MYSP |
| G5250001.40# | 5/24/06 | 0:01 | High | UNKN | UNKN |
| G5250001.59# | 5/24/06 | 0:01 | Low | UNKN | UNKN |
| G5250029.15# | 5/24/06 | 0:29 | High | MYSP | MYSP |
| G5250029.38# | 5/24/06 | 0:29 | Low | MYLU | MYSP |
| G5250033.08# | 5/24/06 | 0:33 | High | MYSP | MYSP |
| G5250033.30# | 5/24/06 | 0:33 | Low | MYLU | MYSP |
| G5250104.28# | 5/24/06 | 1:04 | High | MYSP | MYSP |
| G5250104.49# | 5/24/06 | 1:04 | Low | MYLU | MYSP |
| G5250106.24# | 5/24/06 | 1:06 | High | MYSP | MYSP |
| G5250106.48# | 5/24/06 | 1:06 | Low | MYSP | MYSP |
| G5250108.17# | 5/24/06 | 1:08 | Low | UNKN | UNKN |
| G5250147.05# | 5/24/06 | 1:47 | High | UNKN | UNKN |
| G5250147.25# | 5/24/06 | 1:47 | Low | MYSP | MYSP |
| G5250225.53# | 5/24/06 | 2:25 | High | UNKN | UNKN |
| G5250226.15# | 5/24/06 | 2:26 | Low | UNKN | UNKN |
| G5250237.53# | 5/24/06 | 2:37 | High | MYSP | MYSP |
| G5250238.16# | 5/24/06 | 2:38 | Low | MYSP | MYSP |
| G5250429.38# | 5/24/06 | 4:29 | High | EPFU | BIG BROWN GUILD |
| G5250430.01# | 5/24/06 | 4:30 | Low | EPFU | BIG BROWN GUILD |
| G5252150.04# | 5/25/06 | 21:50 | High | UNKN | UNKN |
| G5252309.58# | 5/25/06 | 23:09 | Low | LE | BIG BROWN GUILD |
| G5252318.08# | 5/25/06 | 23:18 | Low | MYLU | MYSP |
| G5252324.48# | 5/25/06 | 23:24 | High | UNKN | UNKN |
| G5252344.58# | 5/25/06 | 23:44 | High | MYSP | MYSP |
| G5252345.21# | 5/25/06 | 23:45 | Low | MYSP | MYSP |
| G5260007.50# | 5/25/06 | 0:07 | Low | UNKN | UNKN |
| G5260023.02# | 5/25/06 | 0:23 | Low | UNKN | UNKN |
| G5260409.41# | 5/25/06 | 4:09 | Low | MYSP | MYSP |
| G5272254.03# | 5/27/06 | 22:54 | High | LACI | BIG BROWN GUILD |
| G5272317.22# | 5/27/06 | 23:17 | Low | LABO | RBEP |
| G5272350.59# | 5/27/06 | 23:50 | Low | UNKN | UNKN |
| G5280000.07# | 5/27/06 | 0:00 | Low | MYSP | MYSP |
| G5282214.58# | 5/28/06 | 22:14 | High | LABO | RBEP |
| G5282215.24# | 5/28/06 | 22:15 | Low | LABO | RBEP |
| G5282238.57# | 5/28/06 | 22:38 | High | LABO | RBEP |
| G5282239.23# | 5/28/06 | 22:39 | Low | LABO | RBEP |
| G5282336.32# | 5/28/06 | 23:36 | Low | PISU | RBEP |
| G5282356.19# | 5/28/06 | 23:56 | Low | MYSP | MYSP |
| G5290004.57# | 5/28/06 | 0:04 | High | UNKN | UNKN |
| G5290005.24# | 5/28/06 | 0:05 | Low | UNKN | UNKN |
| G5290020.09# | 5/28/06 | 0:20 | Low | UNKN | UNKN |
| G5290109.14# | 5/28/06 | 1:09 | High | LE | BIG BROWN GUILD |
| G5290109.34# | 5/28/06 | 1:09 | Low | EPFU | BIG BROWN GUILD |
| G5290112.23# | 5/28/06 | 1:12 | High | LE | BIG BROWN GUILD |
| G5290112.47# | 5/28/06 | 1:12 | Low | LE | BIG BROWN GUILD |
| G5290118.03# | 5/28/06 | 1:18 | High | LANO | BIG BROWN GUILD |
| G5290120.39# | 5/28/06 | 1:20 | Low | LE | BIG BROWN GUILD |
| G5290132.43# | 5/28/06 | 1:32 | Low | LE | BIG BROWN GUILD |
| G5290134.23# | 5/28/06 | 1:34 | Low | LE | BIG BROWN GUILD |
| G5290137.47# | 5/28/06 | 1:37 | High | LANO | BIG BROWN GUILD |
| G5290138.16# | 5/28/06 | 1:38 | Low | LE | BIG BROWN GUILD |
| G5290152.42# | 5/28/06 | 1:52 | Low | LE | BIG BROWN GUILD |
| G5290153.51# | 5/28/06 | 1:53 | Low | MYSP | MYSP |
| G5290308.17# | 5/28/06 | 3:08 | Low | MYLU | MYSP |
| G5292137.32# | 5/29/06 | 21:37 | Low | UNKN | UNKN |
| G5292154.00# | 5/29/06 | 21:54 | Low | UNKN | UNKN |
| G5292216.46# | 5/29/06 | 22:16 | High | LANO | BIG BROWN GUILD |
| G5292217.19# | 5/29/06 | 22:17 | Low | LE | BIG BROWN GUILD |
| G5292327.37# | 5/29/06 | 23:27 | High | LE | BIG BROWN GUILD |
| G5292328.08# | 5/29/06 | 23:28 | Low | UNKN | UNKN |
| G5292350.16# | 5/29/06 | 23:50 | Low | LE | BIG BROWN GUILD |
| G5300043.30# | 5/29/06 | 0:43 | Low | UNKN | UNKN |
| G5300100.44# | 5/29/06 | 1:00 | Low | LE | BIG BROWN GUILD |
| G5300109.19# | 5/29/06 | 1:09 | Low | MYSP | MYSP |
| G5300146.29# | 5/29/06 | 1:46 | High | LANO | BIG BROWN GUILD |
| G5300146.59# | 5/29/06 | 1:46 | Low | LE | BIG BROWN GUILD |
| G5300148.01# | 5/29/06 | 1:48 | High | LE | BIG BROWN GUILD |

*(continued)*

**Appendix C Table 1.** Summary of bat calls and their file names – Centerville Spring 2006 *(continued)*

| Filename | Date (night of) | Time | Height | Species | Guild |
|---|---|---|---|---|---|
| G5300148.29# | 5/29/06 | 1:48 | Low | LE | BIG BROWN GUILD |
| G5302137.46# | 5/30/06 | 21:37 | Low | MYLU | MYSP |
| G5302140.52# | 5/30/06 | 21:40 | High | LACI | BIG BROWN GUILD |
| G5302141.17# | 5/30/06 | 21:41 | Low | LACI | RBEP |
| G5302146.41# | 5/30/06 | 21:46 | Low | UNKN | UNKN |
| G5302237.36# | 5/30/06 | 22:37 | High | LACI | BIG BROWN GUILD |
| G5302238.05# | 5/30/06 | 22:38 | Low | LACI | RBEP |
| G5302332.12# | 5/30/06 | 23:32 | Low | LE | BIG BROWN GUILD |
| G5310141.57# | 5/30/06 | 1:41 | High | UNKN | UNKN |
| G5310142.27# | 5/30/06 | 1:42 | Low | LACI | RBEP |
| G5310205.42# | 5/30/06 | 2:05 | High | LABO | RBEP |
| G5310206.08# | 5/30/06 | 2:06 | Low | LABO | RBEP |
| G5310212.08# | 5/30/06 | 2:12 | Low | LE | BIG BROWN GUILD |
| G5310221.45# | 5/30/06 | 2:21 | High | UNKN | UNKN |
| G5310249.03# | 5/30/06 | 2:49 | High | UNKN | UNKN |
| G5310321.20# | 5/30/06 | 3:21 | High | UNKN | UNKN |
| G5310321.48# | 5/30/06 | 3:21 | Low | LACI | RBEP |
| G5310412.33# | 5/30/06 | 4:12 | High | UNKN | UNKN |
| G5312133.15# | 5/31/06 | 21:33 | High | MYSP | MYSP |
| G5312243.11# | 5/31/06 | 22:43 | Low | MYSP | MYSP |
| G5312246.58# | 5/31/06 | 22:46 | Low | LACI | RBEP |
| G5312310.38# | 5/31/06 | 23:10 | Low | MYLU | MYSP |
| G6010055.25# | 5/31/06 | 0:55 | Low | MYLU | MYSP |
| G6010157.28# | 5/31/06 | 1:57 | Low | MYSP | MYSP |
| G6010247.01# | 5/31/06 | 2:47 | High | LACI | BIG BROWN GUILD |
| G6010247.34# | 5/31/06 | 2:47 | Low | UNKN | UNKN |
| G6012221.41# | 6/1/06 | 22:21 | Low | MYSP | MYSP |
| G6022216.29# | 6/2/06 | 22:16 | High | LACI | BIG BROWN GUILD |
| G6022217.03# | 6/2/06 | 22:17 | Low | LACI | RBEP |
| G6052145.09# | 6/5/06 | 21:45 | High | LACI | BIG BROWN GUILD |
| G6052210.01# | 6/5/06 | 22:10 | Low | UNKN | UNKN |
| G6052336.33# | 6/5/06 | 23:36 | High | UNKN | UNKN |
| G6060010.23# | 6/5/06 | 0:10 | Low | UNKN | UNKN |
| G6060225.26# | 6/5/06 | 2:25 | High | LACI | BIG BROWN GUILD |
| G6060414.52# | 6/5/06 | 4:14 | High | MYSP | MYSP |
| G6060415.24# | 6/5/06 | 4:15 | Low | MYLU | MYSP |
| G6060439.07# | 6/5/06 | 4:39 | High | LABO | RBEP |
| G6060439.40# | 6/5/06 | 4:39 | Low | LABO | RBEP |

**Appendix C Table 2.** Summary of bat calls and their file names – Wethersfield Spring 2006

| Filename | Date (night of) | Time | Height | Species | Guild |
|---|---|---|---|---|---|
| G4112133.19# | 4/11/06 | 21:33 | Low | EPFU | BIG BROWN GUILD |
| G4120347.28# | 4/11/06 | 3:47 | Low | LANO | BIG BROWN GUILD |
| G4140325.15# | 4/13/06 | 3:25 | High | UNKN | UNKN |
| G4140325.17# | 4/13/06 | 3:25 | Low | UNKN | UNKN |
| G4170103.06# | 4/16/06 | 1:03 | Low | UNKN | UNKN |
| G4182135.56# | 4/18/06 | 21:35 | High | UNKN | UNKN |
| G4200029.07# | 4/19/06 | 0:29 | Low | MYSP | MYSP |
| G4192113.13# | 4/19/06 | 21:13 | Low | MYLU | MYSP |
| G4200444.55# | 4/19/06 | 4:44 | Low | MYLU | MYSP |
| G4210136.24# | 4/20/06 | 1:36 | High | LABO | RBFP |
| G4210058.31# | 4/20/06 | 0:58 | High | MYSP | MYSP |
| G4202141.42# | 4/20/06 | 21:41 | High | MYLU | MYSP |
| G4210018.48# | 4/20/06 | 0:18 | High | MYLU | MYSP |
| G4210212.56# | 4/20/06 | 2:12 | High | UNKN | UNKN |
| G4210227.35# | 4/20/06 | 2:27 | High | UNKN | UNKN |
| G4202141.42# | 4/20/06 | 21:41 | Low | MYLU | MYSP |
| G4210018.49# | 4/20/06 | 0:18 | Low | MYLU | MYSP |
| G4210227.34# | 4/20/06 | 2:27 | Low | MYLU | MYSP |
| G4210049.32# | 4/20/06 | 0:49 | Low | UNKN | UNKN |
| G4210213.03# | 4/20/06 | 2:13 | Low | UNKN | UNKN |
| G4250136.12# | 4/24/06 | 1:36 | Low | UNKN | UNKN |
| G4252202.59# | 4/25/06 | 22:02 | High | UNKN | UNKN |
| G4252203.01# | 4/25/06 | 22:03 | Low | UNKN | UNKN |
| G4262200.11# | 4/26/06 | 22:00 | Low | MYSP | MYSP |
| G4270031.37# | 4/26/06 | 0:31 | Low | MYSP | MYSP |
| G4261702.53# | 4/26/06 | 17:02 | Low | UNKN | UNKN |
| G4290133.52# | 4/28/06 | 1:33 | High | UNKN | UNKN |
| G4290133.56# | 4/28/06 | 1:33 | Low | MYSP | MYSP |
| G4292213.25# | 4/29/06 | 22:13 | High | UNKN | UNKN |
| G4300234.56# | 4/29/06 | 2:34 | Low | LABO | RBFP |
| G4302333.48# | 4/30/06 | 23:33 | High | UNKN | UNKN |
| G5010010.32# | 4/30/06 | 0:10 | High | UNKN | UNKN |
| G5010018.33# | 4/30/06 | 0:18 | High | UNKN | UNKN |
| G5010101.31# | 4/30/06 | 1:01 | High | UNKN | UNKN |
| G5010252.06# | 4/30/06 | 2:52 | High | UNKN | UNKN |
| G5010018.36# | 4/30/06 | 0:18 | Low | LABO | RBFP |
| G4302245.31# | 4/30/06 | 22:45 | Low | LE | BIG BROWN GUILD |
| G5010010.34# | 4/30/06 | 0:10 | Low | LE | BIG BROWN GUILD |
| G4302104.53# | 4/30/06 | 21:04 | Low | MYSP | MYSP |
| G4302156.39# | 4/30/06 | 21:56 | Low | MYSP | MYSP |
| G4302339.10# | 4/30/06 | 23:39 | Low | MYLU | MYSP |
| G5010101.35# | 4/30/06 | 1:01 | Low | MYLU | MYSP |
| G5010252.06# | 4/30/06 | 2:52 | Low | MYLU | MYSP |
| G4302116.02# | 4/30/06 | 21:16 | Low | UNKN | UNKN |
| G4302156.57# | 4/30/06 | 21:56 | Low | UNKN | UNKN |
| G4302212.36# | 4/30/06 | 22:12 | Low | UNKN | UNKN |
| G4302357.50# | 4/30/06 | 23:57 | Low | UNKN | UNKN |
| G5010101.34# | 4/30/06 | 1:01 | Low | UNKN | UNKN |
| G5010213.33# | 4/30/06 | 2:13 | Low | UNKN | UNKN |
| G5012222.45# | 5/1/06 | 22:22 | Low | LE | BIG BROWN GUILD |
| G5012223.30# | 5/1/06 | 22:23 | Low | LE | BIG BROWN GUILD |
| G5030202.59# | 5/2/06 | 2:02 | High | UNKN | UNKN |
| G5022311.11# | 5/2/06 | 23:11 | Low | EPFU | BIG BROWN GUILD |
| G5030203.04# | 5/2/06 | 2:03 | Low | LABO | RBFP |
| G5022109.34# | 5/2/06 | 21:09 | Low | LE | BIG BROWN GUILD |
| G5030212.22# | 5/2/06 | 2:12 | Low | UNKN | UNKN |
| G5040214.12# | 5/3/06 | 2:14 | High | LABO | RBFP |
| G5032102.21# | 5/3/06 | 21:02 | High | LE | BIG BROWN GUILD |
| G5032114.41# | 5/3/06 | 21:14 | High | LE | BIG BROWN GUILD |
| G5040214.18# | 5/3/06 | 2:14 | Low | LABO | RBFP |
| G5032102.26# | 5/3/06 | 21:02 | Low | LE | BIG BROWN GUILD |
| G5032114.45# | 5/3/06 | 21:14 | Low | LE | BIG BROWN GUILD |
| G5032114.44# | 5/3/06 | 21:14 | Low | UNKN | UNKN |
| G5032132.10# | 5/3/06 | 21:32 | Low | UNKN | UNKN |
| G5042115.20# | 5/4/06 | 21:15 | High | LE | BIG BROWN GUILD |
| G5042115.23# | 5/4/06 | 21:15 | Low | LE | BIG BROWN GUILD |
| G5042341.45# | 5/4/06 | 23:41 | Low | LE | BIG BROWN GUILD |
| G5042246.44# | 5/4/06 | 22:46 | Low | UNKN | UNKN |
| G5050025.56# | 5/4/06 | 0:25 | Low | UNKN | UNKN |
| G5052217.27# | 5/5/06 | 22:17 | High | LANO | BIG BROWN GUILD |
| G5052240.57# | 5/5/06 | 22:40 | High | UNKN | UNKN |
| G5052217.31# | 5/5/06 | 22:17 | Low | LE | BIG BROWN GUILD |
| G5052203.37# | 5/5/06 | 22:03 | Low | MYSP | MYSP |
| G5052240.59# | 5/5/06 | 22:40 | Low | MYLU | MYSP |
| G5060156.05# | 5/5/06 | 1:56 | Low | UNKN | UNKN |
| G5080305.30# | 5/7/06 | 3:05 | High | LANO | BIG BROWN GUILD |
| G5080305.36# | 5/7/06 | 3:05 | Low | LANO | BIG BROWN GUILD |

*(continued)*

**Appendix C Table 2. Summary of bat calls and their file names - Wethersfield Spring 2006** *(continued)*

| Filename | Date (night of) | Time | Height | Species | Guild |
|---|---|---|---|---|---|
| G5080113.20# | 5/7/06 | 1:13 | Low | MYLU | MYSP |
| G5080113.19# | 5/7/06 | 1:13 | Low | UNKN | UNKN |
| G5080411.19# | 5/7/06 | 4:11 | Low | UNKN | UNKN |
| G5082155.50# | 5/8/06 | 21:55 | High | UNKN | UNKN |
| G5082352.23# | 5/8/06 | 23:52 | High | UNKN | UNKN |
| G5090016.08# | 5/8/06 | 0:16 | High | UNKN | UNKN |
| G5082305.55# | 5/8/06 | 23:05 | Low | LANO | BIG BROWN GUILD |
| G5090015.13# | 5/8/06 | 0:15 | Low | MYSP | MYSP |
| G5082352.25# | 5/8/06 | 23:52 | Low | MYLU | MYSP |
| G5082216.08# | 5/8/06 | 22:16 | Low | UNKN | UNKN |
| G5100336.20# | 5/9/06 | 3:36 | High | UNKN | UNKN |
| G5102335.05# | 5/10/06 | 23:35 | Low | LE | BIG BROWN GUILD |
| G5110456.58# | 5/10/06 | 4:56 | Low | LE | BIG BROWN GUILD |
| G5140210.52# | 5/13/06 | 2:10 | Low | LE | BIG BROWN GUILD |
| G5132226.16# | 5/13/06 | 22:26 | Low | UNKN | UNKN |
| G5142350.21# | 5/14/06 | 23:50 | Low | MYSP | MYSP |
| G5152133.28# | 5/15/06 | 21:33 | High | LACI | BIG BROWN GUILD |
| G5160026.49# | 5/15/06 | 0:26 | High | LACI | BIG BROWN GUILD |
| G5180456.57# | 5/17/06 | 4:56 | High | UNKN | UNKN |
| G5180052.14# | 5/17/06 | 0:52 | Low | UNKN | UNKN |
| G5180457.06# | 5/17/06 | 4:57 | Low | UNKN | UNKN |
| G5232343.22# | 5/23/06 | 23:43 | High | UNKN | UNKN |
| G5250057.53# | 5/24/06 | 0:57 | High | UNKN | UNKN |
| G5250117.17# | 5/24/06 | 1:17 | High | UNKN | UNKN |
| G5250218.42# | 5/24/06 | 2:18 | High | UNKN | UNKN |
| G5250255.32# | 5/24/06 | 2:55 | High | UNKN | UNKN |
| G5242246.59# | 5/24/06 | 22:46 | Low | MYSP | MYSP |
| G5242324.25# | 5/24/06 | 23:24 | Low | MYSP | MYSP |
| G5250018.46# | 5/24/06 | 0:18 | Low | MYSP | MYSP |
| G5250058.01# | 5/24/06 | 0:58 | Low | MYSP | MYSP |
| G5250150.58# | 5/24/06 | 1:50 | Low | MYSP | MYSP |
| G5250210.31# | 5/24/06 | 2:10 | Low | MYSP | MYSP |
| G5250218.50# | 5/24/06 | 2:18 | Low | MYSP | MYSP |
| G5250246.48# | 5/24/06 | 2:46 | Low | MYSP | MYSP |
| G5250255.40# | 5/24/06 | 2:55 | Low | MYSP | MYSP |
| G5242251.05# | 5/24/06 | 22:51 | Low | MYLU | MYSP |
| G5250105.25# | 5/24/06 | 1:05 | Low | MYLU | MYSP |
| G5250116.33# | 5/24/06 | 1:16 | Low | UNKN | UNKN |
| G5252311.35# | 5/25/06 | 23:11 | High | MYSP | MYSP |
| G5252304.50# | 5/25/06 | 23:04 | High | MYLU | MYSP |
| G5252316.11# | 5/25/06 | 23:16 | High | MYLU | MYSP |
| G5252358.10# | 5/25/06 | 23:58 | High | UNKN | UNKN |
| G5252342.54# | 5/25/06 | 23:42 | Low | MYSP | MYSP |
| G5260059.50# | 5/25/06 | 0:59 | Low | MYSP | MYSP |
| G5260113.06# | 5/25/06 | 1:13 | Low | MYSP | MYSP |
| G5252311.44# | 5/25/06 | 23:11 | Low | MYLU | MYSP |
| G5252316.21# | 5/25/06 | 23:16 | Low | UNKN | UNKN |
| G5252329.14# | 5/25/06 | 23:29 | Low | UNKN | UNKN |
| G5252353.05# | 5/25/06 | 23:53 | Low | UNKN | UNKN |
| G5260008.40# | 5/25/06 | 0:08 | Low | UNKN | UNKN |
| G5260035.16# | 5/25/06 | 0:35 | Low | UNKN | UNKN |
| G5260405.26# | 5/25/06 | 4:05 | Low | UNKN | UNKN |
| G5270043.22# | 5/26/06 | 0:43 | Low | UNKN | UNKN |
| G5280143.46# | 5/27/06 | 1:43 | Low | UNKN | UNKN |
| G5282254.43# | 5/28/06 | 22:54 | Low | MYSP | MYSP |
| G5282329.08# | 5/28/06 | 23:29 | Low | MYSP | MYSP |
| G5290056.00# | 5/28/06 | 0:56 | Low | MYSP | MYSP |
| G5290059.30# | 5/28/06 | 0:59 | Low | MYSP | MYSP |
| G5282150.38# | 5/28/06 | 21:50 | Low | MYLU | MYSP |
| G5282215.13# | 5/28/06 | 22:15 | Low | MYLU | MYSP |
| G5282338.04# | 5/28/06 | 23:38 | Low | UNKN | UNKN |
| G5290023.38# | 5/28/06 | 0:23 | Low | UNKN | UNKN |
| G5292306.52# | 5/29/06 | 23:06 | Low | MYSP | MYSP |
| G5300000.47# | 5/29/06 | 0:00 | Low | MYSP | MYSP |
| G5292338.12# | 5/29/06 | 23:38 | Low | MYLU | MYSP |
| G5292324.41# | 5/29/06 | 23:24 | Low | UNKN | UNKN |
| G5310412.30# | 5/30/06 | 4:12 | Low | EPFU | BIG BROWN GUILD |
| G5302152.00# | 5/30/06 | 21:52 | Low | LACI | BIG BROWN GUILD |
| G5302210.55# | 5/30/06 | 22:10 | Low | LE | BIG BROWN GUILD |
| G5310450.44# | 5/30/06 | 4:50 | Low | MYLU | MYSP |
| G5302209.22# | 5/30/06 | 22:09 | Low | UNKN | UNKN |
| G5310355.33# | 5/30/06 | 3:55 | Low | UNKN | UNKN |
| G5312132.30# | 5/31/06 | 21:32 | High | EPFU | BIG BROWN GUILD |
| G5312217.34# | 5/31/06 | 22:17 | High | LE | BIG BROWN GUILD |
| G5312126.09# | 5/31/06 | 21:26 | High | UNKN | UNKN |
| G5312126.22# | 5/31/06 | 21:26 | Low | LACI | BIG BROWN GUILD |
| G5312217.39# | 5/31/06 | 22:17 | Low | LE | BIG BROWN GUILD |
| G6020126.12# | 6/1/06 | 1:26 | High | LACI | BIG BROWN GUILD |

*(continued)*

**Appendix C Table 2.** Summary of bat calls and their file names – Wethersfield Spring 2006 *(continued)*

| Filename | Date (night of) | Time | Height | Species | Guild |
|---|---|---|---|---|---|
| G6012149.41# | 6/1/06 | 21:49 | High | UNKN | UNKN |
| G6012209.47# | 6/1/06 | 22:09 | High | UNKN | UNKN |
| G6012210.01# | 6/1/06 | 22:10 | Low | LE | BIG BROWN GUILD |
| G6012146.06# | 6/1/06 | 21:46 | Low | MYSP | MYSP |
| G6020126.23# | 6/1/06 | 1:26 | Low | UNKN | UNKN |
| G6022212.32# | 6/2/06 | 22:12 | High | LANO | BIG BROWN GUILD |
| G6022214.30# | 6/2/06 | 22:14 | High | LE | BIG BROWN GUILD |
| G6030257.46# | 6/2/06 | 2:57 | High | MYSP | MYSP |
| G6022214.40# | 6/2/06 | 22:14 | Low | LE | BIG BROWN GUILD |
| G6050111.37# | 6/4/06 | 1:11 | Low | LE | BIG BROWN GUILD |
| G6060035.20# | 6/5/06 | 0:35 | High | LE | BIG BROWN GUILD |
| G6060006.13# | 6/5/06 | 0:06 | Low | MYSP | MYSP |
| G6060257.30# | 6/5/06 | 2:57 | Low | MYSP | MYSP |
| G6060330.16# | 6/5/06 | 3:30 | Low | MYSP | MYSP |
| G6052326.23# | 6/5/06 | 23:26 | Low | UNKN | UNKN |
| G6060035.30# | 6/5/06 | 0:35 | Low | UNKN | UNKN |
| G6062255.48# | 6/6/06 | 22:00 | High | LACI | BIG BROWN GUILD |
| G6070115.24# | 6/6/06 | 1:15 | High | LACI | BIG BROWN GUILD |
| G6070158.40# | 6/6/06 | 1:58 | High | LE | BIG BROWN GUILD |
| G6070334.41# | 6/6/06 | 3:34 | High | LE | BIG BROWN GUILD |
| G6070414.03# | 6/6/06 | 4:14 | High | MYLU | MYSP |
| G6070421.58# | 6/6/06 | 4:21 | High | MYLU | MYSP |
| G6062246.13# | 6/6/06 | 22:46 | High | UNKN | UNKN |
| G6070003.13# | 6/6/06 | 0:03 | High | UNKN | UNKN |
| G6070312.32# | 6/6/06 | 3:12 | High | UNKN | UNKN |
| G6070115.34# | 6/6/06 | 1:15 | Low | LACI | BIG BROWN GUILD |
| G6070334.53# | 6/6/06 | 3:34 | Low | LANO | BIG BROWN GUILD |
| G6070003.23# | 6/6/06 | 0:03 | Low | LE | BIG BROWN GUILD |
| G6070158.51# | 6/6/06 | 1:58 | Low | LE | BIG BROWN GUILD |
| G6070404.15# | 6/6/06 | 4:04 | Low | LE | BIG BROWN GUILD |
| G6070411.59# | 6/6/06 | 4:11 | Low | LE | BIG BROWN GUILD |
| G6070012.15# | 6/6/06 | 0:12 | Low | MYSP | MYSP |
| G6070312.37# | 6/6/06 | 3:12 | Low | MYSP | MYSP |
| G6070414.14# | 6/6/06 | 4:14 | Low | MYSP | MYSP |
| G6062210.49# | 6/6/06 | 22:10 | Low | UNKN | UNKN |
| G6062258.03# | 6/6/06 | 22:58 | Low | UNKN | UNKN |
| G6072311.59# | 6/7/06 | 23:11 | High | UNKN | UNKN |

# D

# Acoustical Monitoring Study, Fall 2006 (Woodlot Alternatives, Inc.)

# Fall 2006 Bat Detector Surveys at the Proposed Centerville and Wethersfield Windparks in Western New York

**Prepared For:**

Noble Environmental Power, LLC and
Ecology & Environment, Inc.

**Prepared By:**

Woodlot Alternatives, Inc.

December 2006

WOODLOT
ALTERNATIVES, INC.
ENVIRONMENTAL CONSULTANTS

# Executive Summary

During fall 2006, Woodlot Alternatives, Inc. (Woodlot) conducted field surveys as part of the planning process by Noble Environmental Power, LLC (Noble) for the proposed Centerville Windpark and Wethersfield Windpark in western New York. The field investigations included nighttime surveys of bats using bat echolocation detectors. These studies represent the second of two seasons of migration surveys undertaken at the sites.

Surveys were conducted from the night of July 25 to the night of October 10, 2006, at Centerville and from the night of July 25 to the night of October 9, 2006, at Wethersfield. The goal of the investigations was to document the presence of bats in the area, including the rate of occurrence and, when possible the species present, during the fall migration period. The results of the field surveys provide useful information about site-specific migration activity and patterns in the vicinity of the proposed windparks, especially when reviewed along with the results of the spring 2006 surveys. This analysis is a valuable tool for the assessment of the potential risk to bats during migration through the area.

Bat call sequences were identified to the lowest possible taxonomic level; these were then grouped into four guilds. Guilds were developed because of similarities in call characteristics between some species and uncertainty in the ability of frequency division detectors to adequately provide information for reliable species differentiation. Guilds, therefore, represent a conservative approach to reporting the results. The data reflect the species composition and relative abundance of bats in the area; however, it is important to consider the limitations of the equipment to sample large areas as well as sample at higher altitudes.

### *Centerville Project Area*

Two detectors were deployed at different heights in a meteorological measurement tower (met tower) site from the night of July 25 to the night of October 10, yielding a total of 90 detector-nights of recordings. A total of 5 bat call sequences were recorded during the fall sampling period. The mean detection rate of all detectors was 0.06 call sequences per detector-night. The detection rate was generally lower than some other recent fall studies in New York and the region in the previous year. Habitat, landscape, location, and survey timing and effort could account for the observed differences in detection rates between sites.

Four of the five recorded call sequences (80%) were identified as being from a guild of bat calls that includes the big brown bat (*Eptesicus fuscus*), silver-haired bat (*Lasionycteris noctivagans*), and hoary bat (*Lasiurus cinereus*). The remaining call was identified as unknown due to poor call quality.

### *Wethersfield Project Area*

Two detectors were deployed at different heights in a met tower site from the night of July 25 to the night of October 9, yielding a total of 81 detector-nights of recordings. A total of 22 bat call sequences were recorded during the fall sampling. The mean detection rate of all detectors was 0.3 call sequences per detector-night. The detection rate was slightly lower than some other recent fall studies in New York and the region in the previous year. Habitat, landscape, location, and survey timing probably account for the observed differences between sites.

A large proportion (77%) of the call sequences were identified as unknown due to poor file quality or too few call pulses on which to base identification. Approximately 9 percent of the recorded call sequences were identified as myotid in origin; 9 percent from a guild of bat calls that includes the big brown bat, silver-haired bat, and hoary bat; and 5 percent were that of either the eastern red bat (*Lasiurus borealis*) or eastern pipistrelle (*Pipistrellus subflavus*).

Overall, the number of call sequences recorded at the Centerville and Wethersfield project areas varied, although not substantially, and both sites had relatively low detection rates of bat echolocation calls. There were similar results at both sites with respect to the timing of bat activity, which would be expected considering the proximity of the two sites. In general, bat activity was greatest during periods with warm nightly temperatures and relatively low wind. The species composition of the recorded call sequences at the two sites was also somewhat similar to each other and to other recent studies in the region.

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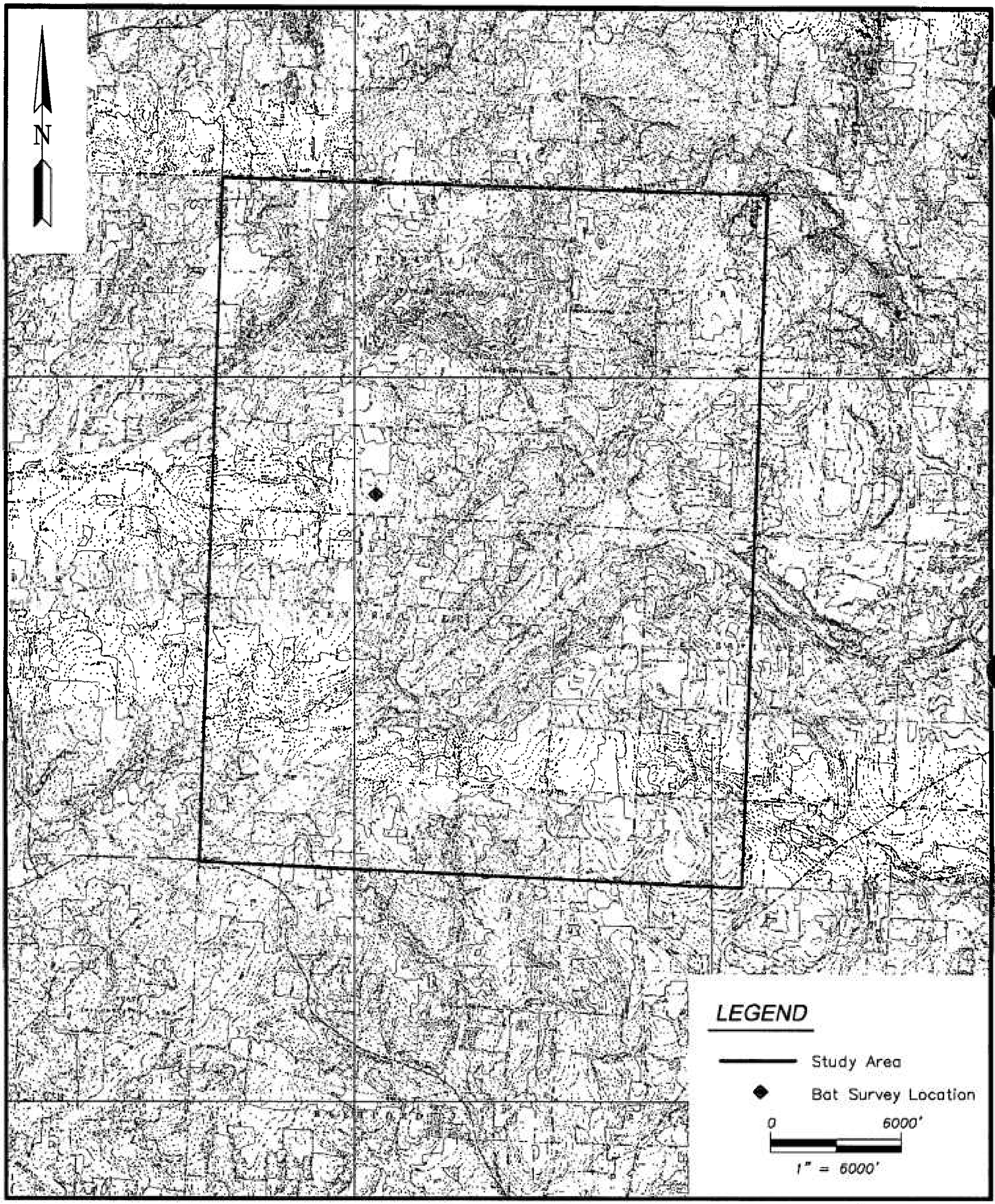
# 1.0 Introduction

Noble Environmental Power, LLC (Noble) has proposed the construction of two wind developments in western New York. One project is located in Centerville (Figure 1) and the other is located in Wethersfield (Figure 2). Woodlot conducted field investigations for bat activity within the Centerville and Wethersfield project areas during the fall of 2006. The overall goals of the investigations were to document the presence of bats in the area, including the rate of occurrence and, when possible, species present during the fall migration period.

Wind projects have recently emerged as a potentially significant source of mortality for migrating bats following results of post-construction mortality surveys conducted at several operational wind farms in the southeastern United States (Arnett *et al.* 2005). While concerns about the risk of bat collision mortality were initially focused on forested ridgelines in the eastern United States, recent evidence from one facility on the prairies of Alberta indicate that bat mortality in those open habitats can be comparable to that observed along the forested ridgelines of the central Appalachian Mountains (Robert Barclay, unpublished data).

Two consistent patterns have emerged from mortality studies of bats at operating wind farms: the timing of mortality events and the species most commonly found. The majority of bat collisions appear to occur during the month of August, which is thought to be linked to late-summer swarming activity and fall migration patterns. The species most commonly found during mortality searches are the migratory tree bats, including eastern red bat (*Lasiurus borealis*), hoary bat (*L. cinereus*), silver-haired bat (*Lasionycteris noctivagans*), and, to some extent, eastern pipistrelle (*Pipistrellus subflavus*) (Arnett *et al.* 2005). Bat collision mortality during the summer pup-rearing season has been very low, despite the fact that relatively large populations of some bat species have been documented in close proximity to wind facilities that have been investigated and that a fair number of sites have been monitored during that time period with no significant mortality events documented. Overall, the available evidence indicates that most of the bat mortality at wind facilities in the United States involves migrant or dispersing bats in the late summer and fall and that resident breeding bat populations are not currently impacted by wind facilities.

Nine species of bats occur in New York, based upon their normal geographical range. These are the little brown bat (*Myotis lucifugus*), northern long-eared bat, (*M. septentrionalis*), Indiana bat (*M. sodalis*), eastern small-footed bat (*M. leibii*), silver-haired bat, eastern pipistrelle, big brown bat (*Eptesicus fuscus*), eastern red bat, and hoary bat (Whitaker and Hamilton 1998). Of these, the Indiana bat is listed as federally endangered, and the small-footed bat is a state-listed species of special concern. According to the New York Department of Environmental Conservation (NYDEC), eight Indiana bat hibernacula are present in New York and are located in Albany, Essex, Jefferson, Onondaga, Ulster, and Warren counties (NYDEC 2005). The proposed Centerville wind project is located in Allegany County and the Wethersfield wind project is located in Wyoming County, neither of which borders any counties containing hibernacula.



PREPARED BY:

**WOODLOT**
**ALTERNATIVES, INC.**
ENVIRONMENTAL CONSULTANTS
106057-F001-BatDetector.dwg

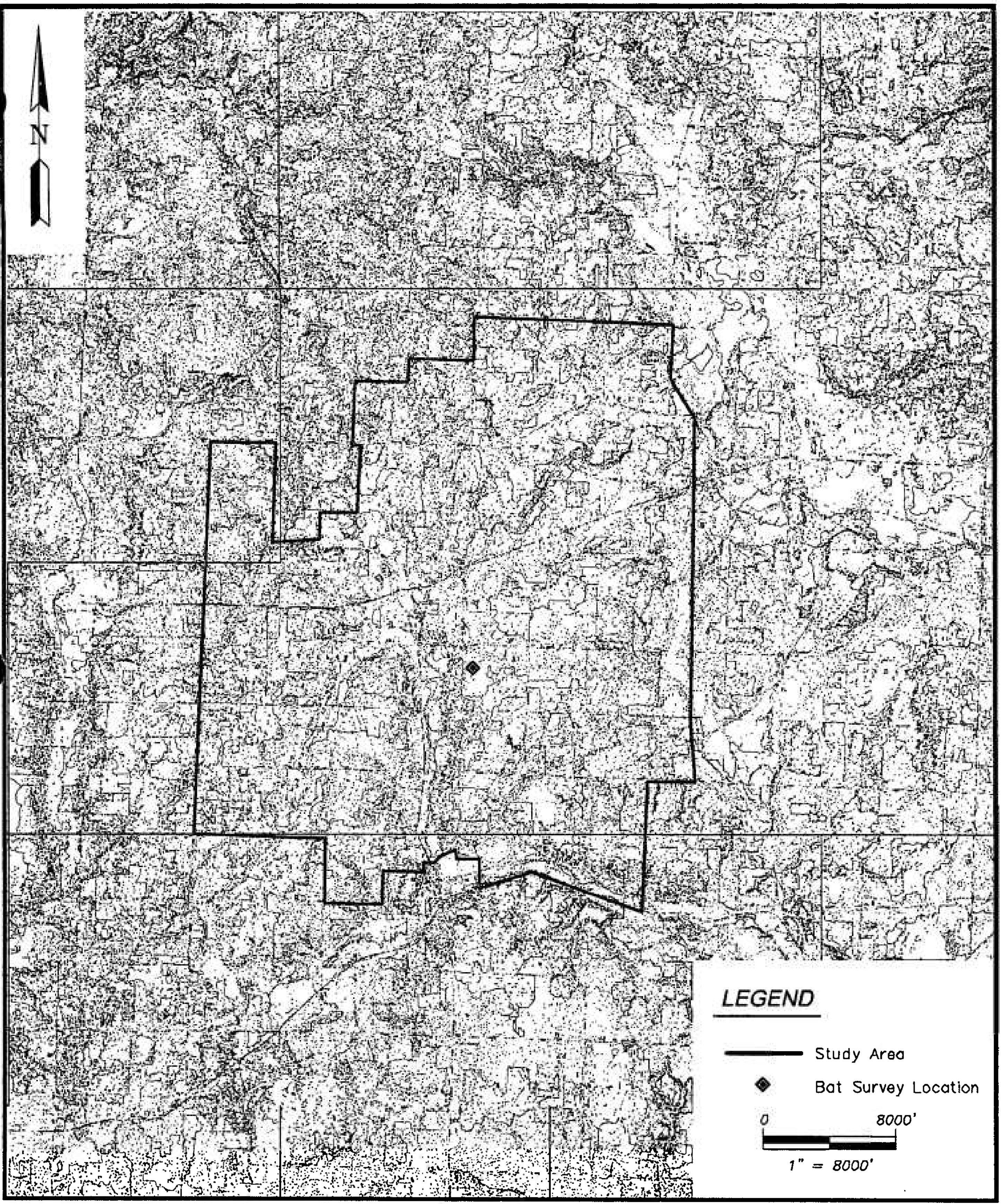
SHEET TITLE:

## Bat Detector Survey Location Map

PROJECT:

Proposed Noble Centerville Windpark
Centerville, New York

| | |
|---|---|
| DATE: | December 2006 |
| SCALE: | 1"=6000' |
| PROJ. NO: | 106057 |
| FIGURE: | 1 |



| | | |
|---|---|---|
| PREPARED BY:<br>**WOODLOT** ALTERNATIVES, INC.<br>ENVIRONMENTAL CONSULTANTS<br>106058-F002-BatDetector.dwg | SHEET TITLE:<br>Bat Detector Survey Location Map | DATE: December 2006<br>SCALE: 1"=8000'<br>PROJ. NO.: 106058 |
| | PROJECT:<br>Proposed Noble Wethersfield Windpark<br>Wethersfield, New York | FIGURE:<br>2 |

# 2.0 Methods

## 2.1 *Field Surveys*

Anabat detectors are frequency division detectors that divide the frequency of ultrasonic calls made by bats so that they are audible to humans. A factor of 16 was used in these studies. Frequency division detectors were selected based upon their widespread use for this type of survey, their ability to be deployed for long periods of time, and their ability to detect a broad frequency range, which allows detection of all species of bats that could occur in New York. Data from the Anabat detectors were logged onto compact flash media using a CF ZCAIM (Titley Electronics Pty Ltd.) and downloaded to a computer for analysis every other week.

Two detectors were deployed within the guy wire arrays at a single meteorological measurement tower (met tower) within each project area (see Figures 1 and 2). These were passive surveys, as the detectors were placed at each site and left there for the duration of the study. At each site, the microphone of the first detector was attached to cables and raised as high as possible and the microphone of the second detector was deployed at approximately half the height of the first. Deployment in this fashion allowed sampling at different heights, including the lower portion of the blade-swept area of the proposed turbines. The microphones were deployed at heights of approximately 35 meters (m) (115') and 15 m (49') at the Centerville project area and 30 m (98') and 15 m (49') at the Wethersfield project area. Detectors were deployed on July 25 and retrieved on October 10, 2006, at Centerville. At Wethersfield detectors were deployed on July 25 and retrieved on October 9, 2006. Detectors were programmed to record nightly from 7:00 pm to 7:00 am.

## 2.2 *Data Analysis*

Potential call files were extracted from data files using CFCread© software. The default settings for CFCread© were used during this file extraction process, as these settings are recommended for the calls that are characteristic of northeastern bats. This software screens all data recorded by the bat detector and extracts call files using a filter. The filter simply removes files created by noises other than bat calls based on the characteristics of the call file and the established characteristics of northeastern bat calls. Using the default settings for this initial screening also ensures comparability between data sets. Settings used by the filter include a maximum time between calls (TBC) of 5 seconds, a minimum line length of 5 milliseconds, and a smoothing factor of 50. The smoothing factor refers to whether or not adjacent pixels can be connected with a smooth line. The higher the smoothing factor, the less restrictive the filter is and the more noise files and poor quality call sequences are retained within the data set. A call is a single pulse of sound produced by a bat. A call sequence is a combination of two or more pulses recorded as a single file by the detector.

Following the initial screening, each file was visually inspected to ensure that files created by static or some other form of interference that were still within the frequency range of northeastern bats were not included in the data set. Bat calls typically include a series of pulses characteristic of normal flight or prey location and capture periods (feeding 'buzzes') and visually look very different than static, which typically forms a solid line at either a constant frequency or with great frequency variation. Using these characteristics, bat call files are easily distinguished from non-bat files. Call sequences were then identified based on visual comparison of the spectrograms of call sequences with reference libraries, including known calls recorded by Woodlot during mist netting surveys in 2006 in New York and Pennsylvania and reference calls recorded from 2002 to 2005 provided by nationally recognized bat experts Lynn Robbins and Chris Corben. Mr. Corben is also the developer of the Anabat software.

Qualitative visual comparison of recorded call sequences allows for relatively accurate identification of bat species (O'Farrell *et al.* 1999, O'Farrell and Gannon 1999). A call sequence was considered of suitable quality and duration if the individual call pulses were clean (i.e., consisting of sharp, distinct lines) and included at least seven pulses for species appearing to by in the genus *Myotis* and at least five pulses for non-myotids. Call sequences were classified to species whenever possible, using the reference calls described above. However, due to similarity of call signatures between several species, all classified calls were then categorized into four guilds for presentation in this report. This classification scheme follows that of Gannon *et al.* (2003) and is as follows:

- Big brown/silver-haired/hoary bat (BBSHHB) – This guild will also be referred to as the big brown guild. These species' call signatures commonly overlap and have therefore been included as one guild in this report;
- Red bat/pipistrelle (RBEP) – Eastern red bats and eastern pipistrelles. Like so many of the other northeastern bats, these two species can produce calls distinctive only to each species. However, significant overlap in the call pulse shape, frequency range, and slope can also occur;
- Myotid. (MYSP) – All bats of the genus *Myotis*. While there are some general characteristics believed to be distinctive for several of the species in this genus, these characteristics do not occur consistently enough for any one species to be relied upon at all times when using Anabat recordings; and
- Unknown (UNKN) – All call sequences with too few pulses (i.e., less than seven) or of poor quality such as indistinct pulse characteristics or background static.

This guilding represent a conservative approach to bat call identification. Tables and figures in the body of this report will reflect those guilds. However, since some species do sometimes produce calls unique only to that species, all calls were identified to the lowest possible taxonomic level before being grouped into the listed guilds. Consequently, the more specific composition of call sequences within each guild will also be briefly discussed.

Once the call files were identified and placed into the appropriate guilds, nightly tallies of detected calls were compiled. Mean detection rates (number of calls/detector-night) for the entire sampling period were calculated for each detector and for all detectors combined, per site. It is important to note that detection rates indicate only the number of calls detected and do not necessarily reflect the number of individual bats in an area. For example, a single individual can produce one or many call files recorded by the bat detector, but the bat detector cannot differentiate between individuals of the same species producing those calls. Consequently, detections recorded by the bat detector system likely over-represent the actual number of animals that produced the recorded calls.

## 2.3 Weather Data

Nightly wind speed (meters per second [m/s]), direction (degrees from true North), and temperature (Celsius [C]) between 7:00 pm and 7:00 am were calculated for each night of the survey period. These weather measurements were obtained directly from the met towers in which the detectors were deployed. On some sampling nights, weather data from the met towers were not available. For the dates that were not available, weather data were obtained from an online weather data archiving site[1] for the Dansville Municipal Airport, which is approximately 35 miles from both project areas.

---

[1] http://www.weatherground.com

# 3.0 Results

## *3.1 Centerville Project Area*

Detectors were deployed at the Centerville site on July 25 and retrieved on October 10, 2006, for a total survey period of 78 nights. Livestock in the field in which the detectors were deployed and repeated poor weather events caused damage to the detectors for several periods of varying length. Consequently, a total of 89 detector-nights of bat echolocation data were recorded during the fall deployment period.

A total of five bat call sequences were recorded during the sampling period (Table 1). This was fairly evenly split between the two detectors, with three call sequences recorded by the upper detector and two by the lower detector. The mean detection rate for both detectors was 0.1 calls/detector night.

**Table 1.** Summary of bat detector field survey effort and results for Centerville – Fall 2006

| **Location** | **Dates** | **# Detector-Nights*** | **# Recorded sequences** | **Detection Rate **** | **Maximum # calls recorded ***** |
|---|---|---|---|---|---|
| High in MET tower | July 25 to October 9 | 41 | 3 | 0.07 | 1 |
| Low in MET tower | July 25 to October 9 | 48 | 2 | 0.04 | 2 |
| ***Overall Results*** | | ***89*** | ***5*** | ***0.06*** | -- |

* Detector-night is a sampling unit during which a single detector is deployed overnight. On nights when two detectors are deployed, the sampling effort equals two detector-nights, etc.

** Number of bat passes recorded per detector-night.

*** Maximum number of bat passes recorded from any **single** detector for a 12-hour sampling period.

Appendix A Tables 1 and 2 provide information on the number of call sequences, by guild, and suspected species, recorded at each detector and the weather conditions for that night. Only one of the five (20%) recorded call sequences was labeled as unknown due to very short call sequences (i.e., less than seven pulses); poor call signature formation, likely due to a bat flying at the edge of the detection zone of the detector or flying away from the microphone; or static interference (Table 2). All calls that were identifiable to species or guild were categorized as part of the big brown bat guild (80% of all call sequences).

The call sequences in the big brown guild were either that of the big brown bat or silver-haired bat and definitely not hoary bat (Appendix A Tables 1 and 2). Call sequences within the guild of unknown bat calls were identified as such due to too few pulses being included within the recorded call sequence. The unknown call sequence had pulses that were steep and above 35 to 40 kilohertz (kHz), indicating that this call sequence was most likely myotid. However, the characteristics of the upper portions of feeding buzzes for several other (i.e., non-myotid) species extend above this frequency and preclude making definitive identification of this call sequence to guild using call sequence files with so few pulses.

**Table 2.** Summary of the composition of recorded bat call sequences at Centerville – Fall 2006

| Detector | Guild | | | | Total |
|---|---|---|---|---|---|
| | Big brown guild | Red bat/ E. pipistrelle | Myotis | Unknown | |
| High | 2 | 0 | 0 | 0 | 2 |
| Low | 2 | 0 | 0 | 1 | 3 |
| *Total* | *4* | *0* | *0* | *1* | 5 |

*Weather Data*

Mean nightly wind speeds at the Centerville site varied between 0.4 and 8.6 m/s (Figure 3). Mean nightly temperatures varied between 2.6° C and 25.5° C (Figure 4). There appeared to be no relationship between either of these weather variables and the few bat call sequence detections.

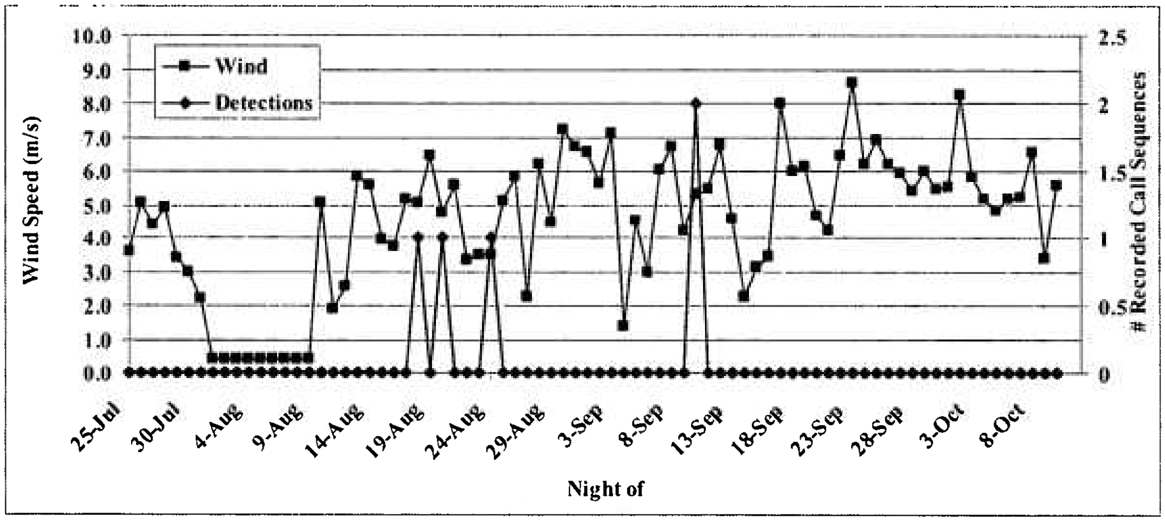


**Figure 3.** Nightly mean wind speed and nightly call sequence volume at Centerville – Fall 2006

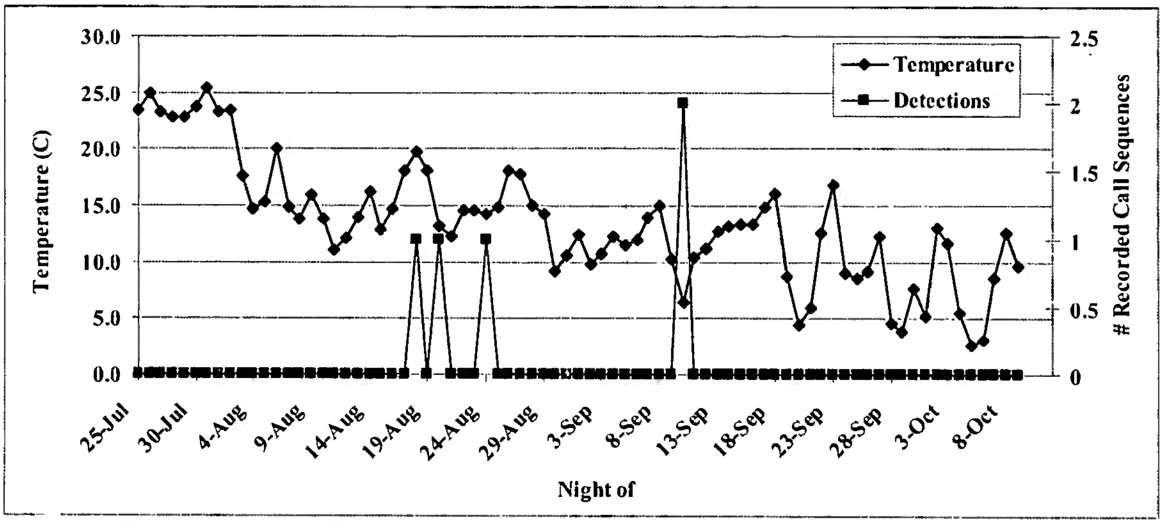


**Figure 4.** Nightly mean temperature and nightly call sequence volume at Centerville – Fall 2006

## 3.2 Wethersfield Project Area

Detectors were deployed at the Wethersfield site on July 25 and retrieved on October 9, 2006, for a total survey period of 77 nights. Due to periodic weather damage causing the detectors to power down or to become too desensitized, a total of 80 detector-nights of bat echolocation data were recorded during the fall 2006 deployment period.

A total of 22 bat call sequences were recorded during the sampling period (Table 3). This was not evenly split between the two detectors, as all 22 call sequences were recorded by the upper detector and 0 call sequences were recorded by the lower detector, despite the proper operation of the detectors the majority of the nights the detector was deployed. The number of call sequences recorded at the high detector on any individual night ranged from zero to three (August 1). The mean detection rate for both detectors was 0.3 calls/detector night.

**Table 3.** Summary of bat detector field survey effort and results for Wethersfield – Fall 2006

| Location | Dates | # Detector-Nights* | # Recorded sequences | Detection Rate ** | Maximum # calls recorded *** |
|---|---|---|---|---|---|
| High in MET tower | July 25 to October 9 | 26 | 22 | 0.8 | 3 |
| Low in MET tower | July 25 to October 9 | 54 | 0 | 0.0 | 0 |
| *Overall Results* | | ***80*** | ***22*** | ***0.3*** | -- |

* Detector-night is a sampling unit during which a single detector is deployed overnight. On nights when two detectors are deployed, the sampling effort equals two detector-nights, etc.

** Number of bat passes recorded per detector-night.

*** Maximum number of bat passes recorded from any **single** detector for a 12-hour sampling period.

Appendix B Tables 1 and 2 provide information on the number of call sequences, by guild, and suspected species, recorded at each detector and the weather conditions for that night. A total of 17 of the 22 (77%) recorded call sequences were labeled as unknown due to very short call sequences; poor call signature formation, likely due to a bat flying at the edge of the detection zone of the detector or flying away from the microphone; or static interference (Table 4). Of the calls that were identified to species or guild, myotids and species within the big brown guild were most common (9% of all call sequences, each). Fewer red bat/eastern pipistrelle call sequences (5% of all call sequences) were identified.

Within each guild, some individual call sequences were identified to species (Appendix B Tables 1 and 2). Call sequences within the guild of unknown bat calls were identified as such primarily due to too few pulses being included within the recorded call sequence. A vast majority of these call sequences (roughly 80%), however, had pulses that were steep and above 35 to 40 kHz, indicating that most of these calls were probably those of the myotids. As indicated earlier, however, the characteristics of the upper portions of feeding buzzes for several non-myotid species extending above this frequency precludes making definitive identification of those call sequences to guild using call sequence files with so few pulses.

**Table 4.** Summary of the composition of recorded bat call sequences at Wethersfield – Fall 2006

| **Detector** | **Guild** | | | | **Total** |
|---|---|---|---|---|---|
| | **Big brown guild** | **Red bat/<br>E. pipistrelle** | **Myotis** | **Unknown** | |
| High | 2 | 1 | 2 | 17 | 22 |
| Low | 0 | 0 | 0 | 0 | 0 |
| ***Total*** | *2* | *1* | *2* | *17* | 22 |

Within the red bat/eastern pipistrelle guild, the single call sequence was probably that of a red bat. Finally, of the two sequences in the big brown guild were either of the big brown bat or silver-haired bat and definitely not hoary bat (Appendix B Tables 1 and 2).

The nightly number of recorded call sequences, in general, varied somewhat from night to night. Some trends were observed, however (Figure 5). Call volume was higher (i.e., 2 to 3 calls per night) in late July and early August and low throughout most of the remainder of the survey period.

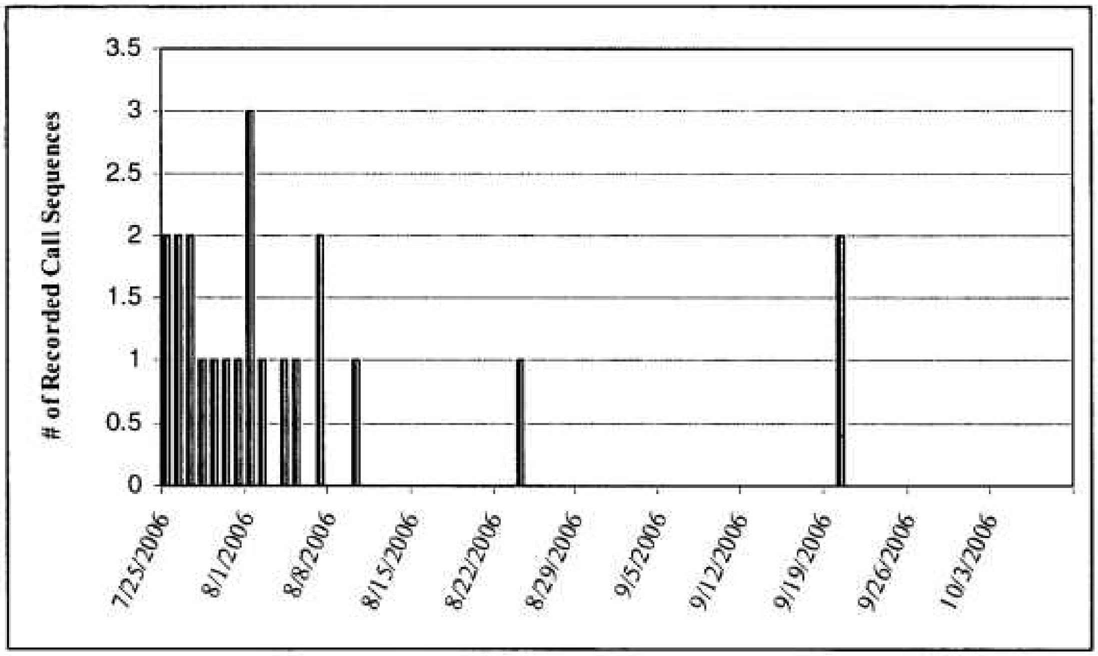


**Figure 5.** Nightly volume of recorded bat call sequences at Wethersfield – Fall 2006.

*Weather Data*

Mean nightly wind speeds at the Wethersfield site varied between 0.4 and 8.6 m/s (Figure 6). Mean nightly temperatures varied between 2.6° C and 25.5° C (Figure 7). There appeared to be no strong relationship between either of these weather variables and bat call sequence detections, although nights with the most detections typically included low wind speeds.

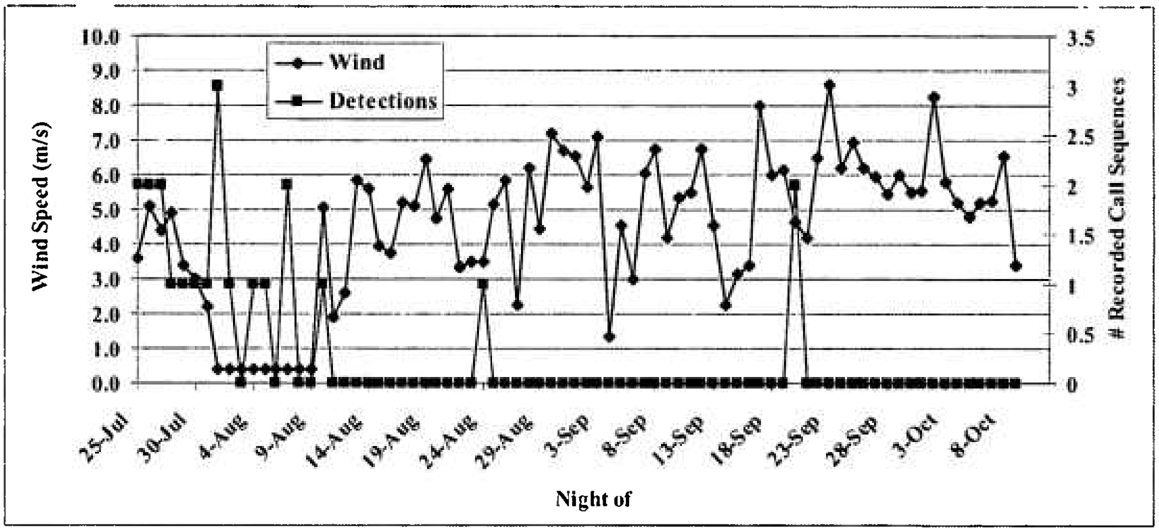


**Figure 6.** Nightly mean wind speed and nightly call sequence volume at Wethersfield – Fall 2006.

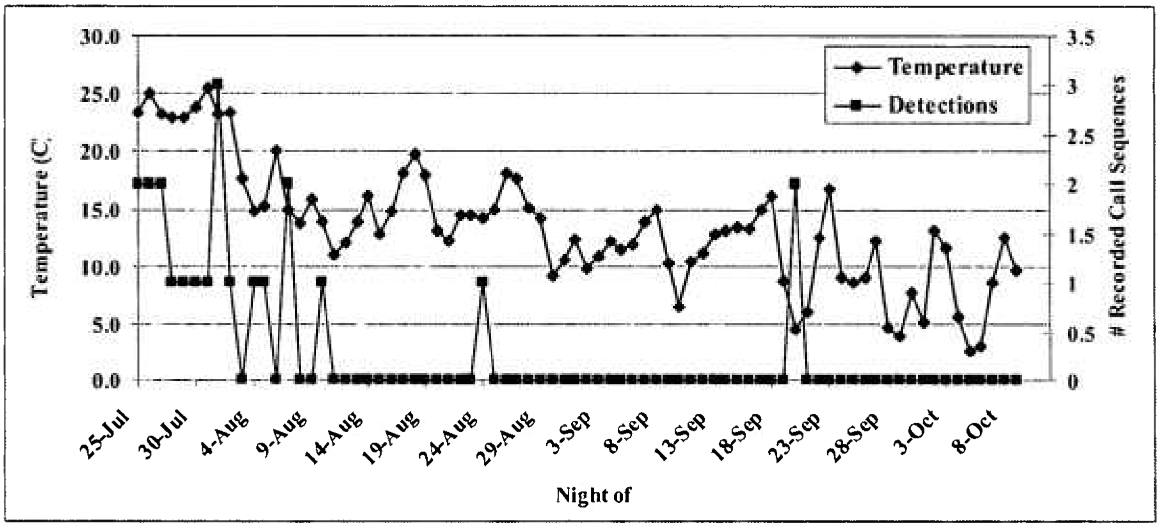


**Figure 7.** Nightly mean temperature and nightly call sequence volume at Wethersfield – Fall 2006.

# 4.0 Discussion

Bat echolocation surveys in 2006 at the proposed Centerville Windpark and Wethersfield Windpark provide some insight into activity patterns, possible species composition, and timing of movements of bats in the project areas. The two met towers used for the deployment of the bat detectors at the two project sites were approximately 26 kilometers (16 miles) apart, and both sites were open agricultural fields dominated by pastures, hayfields, and silage corn. Results from the two sites show some similarity with respect to an overall low rate of detection at each site.

## *4.1 Comparison of the Two Sites*

Although the two sites differed with respect to the number of bat call sequences recorded over the course of the sampling period, the detection rate was nearly identical and, overall, very few bat call sequences were recorded. Habitat conditions, such as type and proximity of nearby forests and anthropogenic roost sites (barns), were similar between the two sites. The difference between the two sites in the total number of recorded call sequences is likely due to natural variation in bat populations across the landscape. Equipment damage caused by cows and periods of sustained inclement weather also resulted in periods when one or both detectors at each site powered down, which affects the overall number of recorded call sequences.

Nightly tallies of recorded call sequences were consistently two or less per night throughout August and mid September and then decreased during late September and October (Figure 8). This time period was associated with progressively cooler nighttime temperatures, typical of this time of year. Because the two sites were located so close to one another, weather likely affected bat activity similarly at both sites.

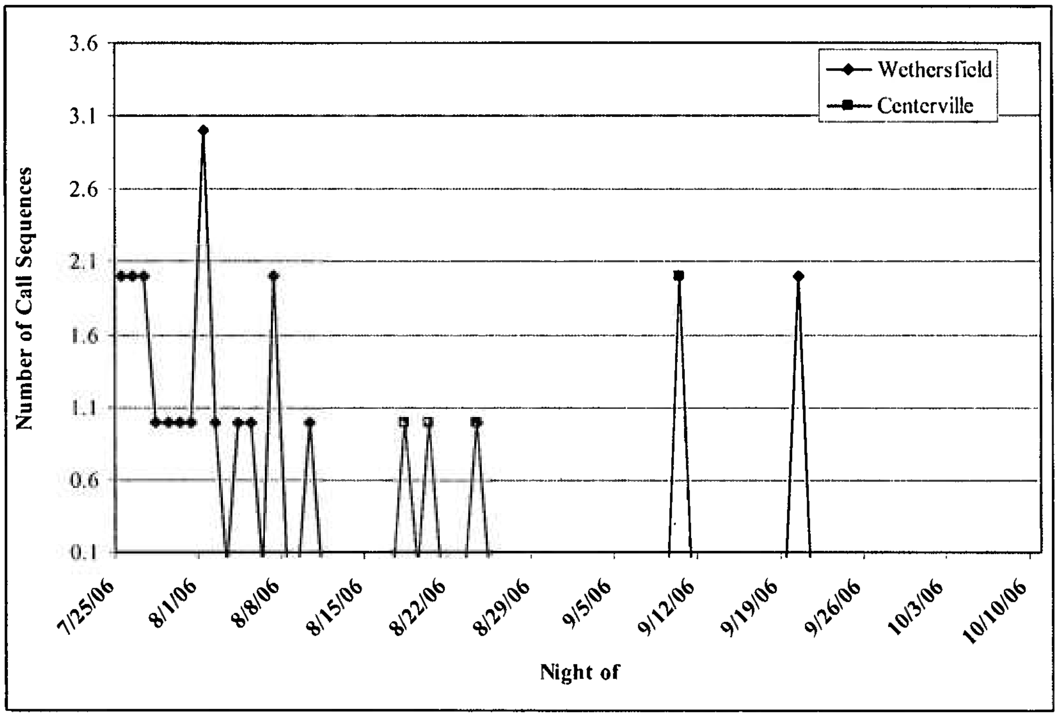


**Figure 8.** Nightly call volume at Centerville and Wethersfield – Fall 2006.

Patterns in species (or guild) composition were also somewhat similar between sites. Figure 9 provides a summary of the composition of the recorded call sequences (identified to guild) at the sites. Call sequences identified as unknown (due to poor quality or no definitive characteristics) were the most abundant calls recorded at Wethersfield, and made up 20 percent of calls recorded at Centerville. Of those call sequences that could be identified to guild, those of the big brown guild were generally the most abundant group (Centerville) or equally abundant as the myotids (Wethersfield). Finally, calls of red bats and eastern pipistrelles were the least abundant of all species and represented 5 percent of the calls at Wethersfield. This low percentage of call sequences attributable to red bat or eastern pipistrelle is a relatively common them among bat detector surveys.

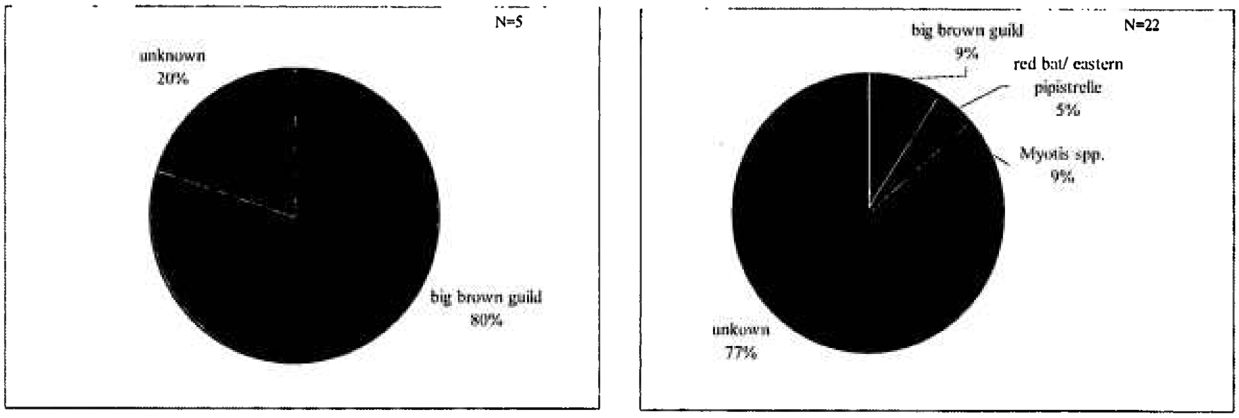


**Figure 9.** Comparison of species composition at all detectors at Centerville (left) and Wethersfield (right).

Considering the proximity of the two sites and the predominant land uses, it is likely that fall bat migration activity at the two project sites is similar. The use of a single met tower location for the placement of a small number of bat detectors may be a limitation to on-site data collection at any proposed wind energy development. However, no method has been proven to predict the number of fatalities that can occur at a proposed wind farm. The data collected in this survey simply represents information on the abundance and potential species composition of bats in the vicinity of the met towers during the period of operation. In addition, the use of met towers to deploy the bat detectors, provides the opportunity to document bat activity near the rotor zone of proposed turbines.

## 4.2 Comparison with spring 2006 Survey Results

The fall 2006 survey showed relatively low levels of bat activity within both the Centerville and Wethersfield project areas. Previous surveys conducted, using the same methods, during the spring of 2006 documented more bat activity at both project areas. The results of the Centerville fall survey yielded just 5 call sequences, while the spring survey yielded a total of 270 call sequences (Table 5). A similar decrease in recorded call sequences, and therefore detection rates, from spring to fall 2006 was seen in the Wethersfield surveys as well. This trend was unexpected, as bat activity is often much greater in the late-summer and fall than in the spring due to more animals being present in the population in the fall (i.e., recruitment) and the swarming behavior exhibited by bats in the late-summer and fall.

**Table 5.** Comparison of results for Centerville and Wethersfield – Spring and Fall 2006

| | **Centerville** | | | | **Wethersfield** | | | |
|---|---|---|---|---|---|---|---|---|
| | **SPRING** | | **FALL** | | **SPRING** | | **FALL** | |
| **GUILD** | **High** | **Low** | **High** | **Low** | **High** | **Low** | **High** | **Low** |
| Big brown guild | 25 | 22 | 2 | 2 | 17 | 32 | 2 | 0 |
| Red bat/eastern pipistrelle | 9 | 15 | 0 | 0 | 2 | 4 | 1 | 0 |
| *Myotis* | 49 | 40 | 0 | 0 | 9 | 52 | 2 | 0 |
| Unknown | 56 | 54 | 0 | 1 | 32 | 44 | 17 | 0 |
| Total by detector | *139* | *131* | *2* | *3* | *60* | *132* | *22* | *0* |
| # Nights | 63 | 63 | 41 | 48 | 63 | 63 | 26 | 54 |
| Total # of calls | *270* | | *5* | | *192* | | *22* | |
| **Detection rate*** | 2.2 | 2.1 | 0.07 | 0.04 | 1.0 | 2.1 | 0.8 | 0 |
| **Overall detection rate*** | **2.1** | | **0.6** | | **1.5** | | **0.3** | |

* Number of bat detections recorded per detector-night.

Reasons for these differences between spring and fall, and the fact that the trend in abundance is opposite of what is typically observed, are unknown. The differences could reflect local activity patterns of bats in this region of New York. They could also reflect year-to-year variation in bat population levels or regional migration and habitat use patterns. The fact that trends in the results from both projects in the spring and in the fall are similar indicates that a larger, landscape-level trend in bat activity is reflected in the data sets, rather than site-specific phenomena or limitations of the paired detectors.

## 4.2 Comparison with Other Regional Data Sources

The bat detectors deployed at both sites documented comparatively similar levels of bat activity. Those activity levels were lower than those documented at a number of other sites across the northeast in the fall of 2004 and 2005 (Table 6). These differences could be attributed to several potential factors. Initially, bat activity could be lower at the Centerville and Wethersfield sites than at other sites in the region during fall due to habitat conditions or landscape-based concentrations in bat migration. However, this seems unlikely since many of the sites available for comparison occurred in similar habitat. Year-to-year variation in population levels or, more likely, migration pathways could account for these observed differences.

**Table 6.** Summary of other available bat detector survey results

| Location | Landscape | Season | Calls Per Detector Night | Reference (bat only) |
|---|---|---|---|---|
| Cohocton, NY | Agric. plateau | Fall 2004 | 2.00 | Woodlot 2006a |
| Franklin, WV | Forested ridge | Fall 2004 | 9.24 | Woodlot 2004a |
| Prattsburgh, NY | Agric. plateau | Fall 2004 | 2.22 | Woodlot 2004b |
| Sheffield, VT | Forested ridge | Fall 2004 | 1.76 | Woodlot 2006b |
| Churubusco, NY | Agric. plateau / ADK foothills | Fall 2005 | 5.56 | Woodlot 2005a |
| Cohocton, NY | Agric. plateau | Fall 2005 | 1.57 | Woodlot 2006a |
| Fairfield, NY | Agric. plateau / ADK foothills | Fall 2005 | 1.70 | Woodlot 2005b |
| Jordanville, NY | Agric. plateau / ADK foothills | Fall 2005 | 4.79 | Woodlot 2005c |
| Mars Hill, ME | Forested ridge / Agric. plateau | Fall 2005 | 0.83 | Woodlot 2005d |
| Redington, ME | Forested ridge | Fall 2005 | 4.20 | Woodlot 2005e |
| Sheffield, VT | Forested ridge | Fall 2005 | 1.18 | Woodlot 2006b |
| Sheldon, NY | Agric. plateau | Fall 2005 | 34.92 | Woodlot 2005f |

The operation and number of detectors can also affect the overall results of a survey. At both sites, the bat detectors generally operated well. Although some nights of data were lost due to weather and livestock damage, this is often typical when remotely deploying detectors for long periods of time. Coincident with detector failure can be detector de-sensitivity from low battery voltage, among other things. That did not appear to occur at either of the two sites, and both detectors at both sites maintained their maximum sensitivity to detect bat echolocation calls during the periods when detectors were operating.

Results of acoustic surveys must be interpreted with caution. Room for error does exist in identification of bats based upon acoustic calls alone, especially if a site- specific or regionally specific library of recorded reference calls is not available. Also, detection rates are not necessarily correlated with the actual numbers of bats in an area because it is not possible to differentiate between individual bats.

## 5.0 Conclusions

Detector surveys during the 2006 fall migration period have provided information on bat activity in the vicinity of the proposed Centerville Windpark and Wethersfield Windpark. The surveys documented species that would be expected in the area based on the species' range and abundance, as well as the available habitat in the project area.

The general similarity in low activity levels and species composition between the two sites likely reflects their proximity to one another and their predominant landscape characteristics. The results were generally consistent with other recent studies in the northeast, indicating that bat migration activity in the area wasn't particularly unique with respect to the level of bat activity or the species present.

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# Appendix A

## Bat Detector Survey Data Tables – Centerville

**Appendix A Table 1.** Summary of species and weather during each survey night at the Centerville high detector (30 m) – Fall 2006

| | BIG BROWN GUILD | | | | RBEP | | MYSP | | | | JNK | Total | Mean Nightly Weather (7pm - 7am) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Night of** | **big brown bat** | **hoary bat** | **silver-haired bat** | **silver-haired/big brow** | **eastern pipistrelle** | **eastern red bat** | **little brown bat** | ***Myotis* spp.** | **northern myotis** | **small-footed myotis** | **unknown** | | **Wind Speed (m/s)** | **Wind Direction (degrees from true north)** | **Temperature ( c )** |
| **25-Jul** | | | | | | | | | | | | **0** | 3.6 | 180.0 | 23.4 |
| **26-Jul** | | | | | | | | | | | | **0** | 5.1 | 205.0 | 25.0 |
| **27-Jul** | | | | | | | | | | | | **0** | 4.4 | 205.0 | 23.3 |
| **28-Jul** | | | | | | | | | | | | **0** | 4.9 | 205.0 | 22.9 |
| **29-Jul** | | | | | | | | | | | | **0** | 3.4 | 270.0 | 22.9 |
| **30-Jul** | | | | | | | | | | | | **0** | 3.0 | 205.0 | 23.8 |
| **31-Jul** | | | | | | | | | | | | **0** | 2.2 | 135.0 | 25.5 |
| **1-Aug** | | | | | | | | | | | | **0** | 0.4 | 256.3 | 23.3 |
| **2-Aug** | | | | | | | | | | | | **0** | 0.4 | 251.0 | 23.4 |
| **3-Aug** | | | | | | | | | | | | **0** | 0.4 | 320.5 | 17.6 |
| **4-Aug** | | | | | | | | | | | | **0** | 0.4 | 290.7 | 14.7 |
| **5-Aug** | | | | | | | | | | | | **0** | 0.4 | 123.5 | 15.3 |
| **6-Aug** | | | | | | | | | | | | **0** | 0.4 | 239.0 | 20.0 |
| **7-Aug** | | | | | | | | | | | | **0** | 0.4 | 310.5 | 14.9 |
| **8-Aug** | | | | | | | | | | | | **0** | 0.4 | 98.5 | 13.7 |
| **9-Aug** | | | | | | | | | | | | **0** | 0.4 | 275.0 | 15.9 |
| **10-Aug** | | | | | | | | | | | | **0** | 5.1 | 69.0 | 13.8 |
| **11-Aug** | | | | | | | | | | | | **0** | 1.9 | 122.8 | 11.0 |
| **12-Aug** | | | | | | | | | | | | **0** | 2.6 | 191.1 | 12.1 |
| **13-Aug** | | | | | | | | | | | | **0** | 5.9 | 246.4 | 13.9 |
| **14-Aug** | | | | | | | | | | | | **0** | 5.6 | 275.2 | 16.2 |
| **15-Aug** | | | | | | | | | | | | **0** | 3.9 | 272.7 | 12.9 |
| **16-Aug** | | | | | | | | | | | | **0** | 3.8 | 99.1 | 14.7 |
| **17-Aug** | | | | | | | | | | | | **0** | 5.2 | 155.6 | 18.1 |
| **18-Aug** | | | | | | | | | | | | **0** | 5.1 | 207.5 | 19.8 |
| **19-Aug** | | | | | | | | | | | | **0** | 6.5 | 252.4 | 18.0 |
| **20-Aug** | | | | 1 | | | | | | | | **1** | 4.8 | 309.1 | 13.2 |
| **21-Aug** | | | | | | | | | | | | **0** | 5.6 | 253.9 | 12.3 |
| **22-Aug** | | | | | | | | | | | | **0** | 3.3 | 289.9 | 14.5 |
| **23-Aug** | | | | | | | | | | | | **0** | 3.5 | 177.0 | 14.5 |
| **24-Aug** | | | | 1 | | | | | | | | **1** | 3.5 | 146.7 | 14.2 |
| **25-Aug** | | | | | | | | | | | | **0** | 5.1 | 64.9 | 14.9 |
| **26-Aug** | | | | | | | | | | | | **0** | 5.8 | 160.4 | 18.0 |
| **27-Aug** | | | | | | | | | | | | **0** | 2.2 | 230.6 | 17.7 |
| **28-Aug** | | | | | | | | | | | | **0** | 6.2 | 60.0 | 15.1 |
| **29-Aug** | | | | | | | | | | | | **0** | 4.4 | 48.6 | 14.2 |
| **30-Aug** | | | | | | | | | | | | **0** | 7.2 | 67.0 | 9.2 |
| **31-Aug** | | | | | | | | | | | | **0** | 6.7 | 75.5 | 10.6 |
| **1-Sep** | | | | | | | | | | | | **0** | 6.6 | 75.6 | 12.4 |
| **2-Sep** | | | | | | | | | | | | **0** | 5.6 | 107.7 | 9.9 |
| **3-Sep** | | | | | | | | | | | | **0** | 7.1 | 265.0 | 10.8 |
| **4-Sep** | | | | | | | | | | | | **0** | 1.4 | 280.7 | 12.2 |
| **5-Sep** | | | | | | | | | | | | **0** | 4.5 | 265.7 | 11.5 |
| **6-Sep** | | | | | | | | | | | | **0** | 3.0 | 256.0 | 11.9 |
| **7-Sep** | | | | | | | | | | | | **0** | 6.0 | 231.5 | 13.9 |
| **8-Sep** | | | | | | | | | | | | **0** | 6.7 | 234.5 | 14.9 |
| **9-Sep** | | | | | | | | | | | | **0** | 4.2 | 63.9 | 10.3 |
| **10-Sep** | | | | | | | | | | | | **0** | 5.3 | 77.2 | 6.5 |
| **11-Sep** | | | | | | | | | | | | **0** | 5.5 | 132.3 | 10.4 |
| **12-Sep** | | | | | | | | | | | | **0** | 6.8 | 170.1 | 11.1 |
| **13-Sep** | | | | | | | | | | | | **0** | 4.6 | 180.0 | 12.8 |
| **14-Sep** | | | | | | | | | | | | **0** | 2.3 | 287.7 | 13.1 |
| **15-Sep** | | | | | | | | | | | | **0** | 3.1 | 58.7 | 13.4 |
| **16-Sep** | | | | | | | | | | | | **0** | 3.4 | 175.8 | 13.3 |
| **17-Sep** | | | | | | | | | | | | **0** | 8.0 | 215.8 | 14.9 |
| **18-Sep** | | | | | | | | | | | | **0** | 6.0 | 223.3 | 16.1 |
| **19-Sep** | | | | | | | | | | | | **0** | 6.2 | 257.0 | 8.7 |
| **20-Sep** | | | | | | | | | | | | **0** | 4.7 | 257.6 | 4.5 |
| **21-Sep** | | | | | | | | | | | | **0** | 4.2 | 193.0 | 6.0 |
| **22-Sep** | | | | | | | | | | | | **0** | 6.5 | 177.3 | 12.5 |
| **23-Sep** | | | | | | | | | | | | **0** | 8.6 | 219.2 | 16.8 |
| **24-Sep** | | | | | | | | | | | | **0** | 6.2 | 291.6 | 9.0 |
| **25-Sep** | | | | | | | | | | | | **0** | 6.9 | 267.3 | 8.6 |
| **26-Sep** | | | | | | | | | | | | **0** | 6.2 | 197.4 | 9.1 |
| **27-Sep** | | | | | | | | | | | | **0** | 6.0 | 193.5 | 12.2 |
| **28-Sep** | | | | | | | | | | | | **0** | 5.5 | 303.8 | 4.7 |
| **29-Sep** | | | | | | | | | | | | **0** | 6.0 | 208.1 | 3.9 |
| **30-Sep** | | | | | | | | | | | | **0** | 5.5 | 193.4 | 7.7 |
| **1-Oct** | | | | | | | | | | | | **0** | 5.5 | 277.6 | 5.2 |
| **2-Oct** | | | | | | | | | | | | **0** | 8.3 | 229.3 | 13.1 |
| **3-Oct** | | | | | | | | | | | | **0** | 5.8 | 226.8 | 11.6 |
| **4-Oct** | | | | | | | | | | | | **0** | 5.2 | 99.6 | 5.5 |
| **5-Oct** | | | | | | | | | | | | **0** | 4.8 | 54.7 | 2.6 |
| **6-Oct** | | | | | | | | | | | | **0** | 5.2 | 73.2 | 3.0 |
| **7-Oct** | | | | | | | | | | | | **0** | 5.2 | 174.0 | 8.6 |
| **8-Oct** | | | | | | | | | | | | **0** | 6.6 | 253.5 | 12.6 |
| **9-Oct** | | | | | | | | | | | | **0** | 3.4 | 241.5 | 9.7 |
| **By Species** | **0** | **0** | **0** | **2** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **2** | | | |
| **By Guild** | 2 | | | | 0 | | 0 | | | | **0** | | | | |
| | **BIG BROWN GUILD** | | | | **RBEP** | | **MYSP** | | | | **JNK** | **Total** | | | |

**Appendix A Table 2.** Summary of species and weather during each survey night at the Centerville low detector (15 m) – Fall 2006

| | BIG BROWN GUILD | | | | RBEP | | MYSP | | | | UNKN | | Mean Nightly Weather (7pm - 7am) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Night of | big brown bat | hoary bat | silver-haired bat | silver-haired/big brow | eastern pipistrelle | eastern red bat | little brown bat | *Myotis* spp. | northern myotis | small-footed myotis | unknown | Total | Wind Speed (m/s) | Wind Direction (degrees from true north) | Temperature ( c ) |
| 25-Jul | | | | | | | | | | | | 0 | 3.6 | 180.0 | 23.4 |
| 26-Jul | | | | | | | | | | | | 0 | 5.1 | 205.0 | 25.0 |
| 27-Jul | | | | | | | | | | | | 0 | 4.4 | 205.0 | 23.3 |
| 28-Jul | | | | | | | | | | | | 0 | 4.9 | 205.0 | 22.9 |
| 29-Jul | | | | | | | | | | | | 0 | 3.4 | 270.0 | 22.9 |
| 30-Jul | | | | | | | | | | | | 0 | 3.0 | 205.0 | 23.8 |
| 31-Jul | | | | | | | | | | | | 0 | 2.2 | 135.0 | 25.5 |
| 1-Aug | | | | | | | | | | | | 0 | 0.4 | 256.3 | 23.3 |
| 2-Aug | | | | | | | | | | | | 0 | 0.4 | 251.0 | 23.4 |
| 3-Aug | | | | | | | | | | | | 0 | 0.4 | 320.5 | 17.6 |
| 4-Aug | | | | | | | | | | | | 0 | 0.4 | 290.7 | 14.7 |
| 5-Aug | | | | | | | | | | | | 0 | 0.4 | 123.5 | 15.3 |
| 6-Aug | | | | | | | | | | | | 0 | 0.4 | 239.0 | 20.0 |
| 7-Aug | | | | | | | | | | | | 0 | 0.4 | 310.5 | 14.9 |
| 8-Aug | | | | | | | | | | | | 0 | 0.4 | 98.5 | 13.7 |
| 9-Aug | | | | | | | | | | | | 0 | 0.4 | 275.0 | 15.9 |
| 10-Aug | | | | | | | | | | | | 0 | 5.1 | 69.0 | 13.8 |
| 11-Aug | | | | | | | | | | | | 0 | 1.9 | 122.8 | 11.0 |
| 12-Aug | | | | | | | | | | | | 0 | 2.6 | 191.1 | 12.1 |
| 13-Aug | | | | | | | | | | | | 0 | 5.9 | 246.4 | 13.9 |
| 14-Aug | | | | | | | | | | | | 0 | 5.6 | 275.2 | 16.2 |
| 15-Aug | | | | | | | | | | | | 0 | 3.9 | 272.7 | 12.9 |
| 16-Aug | | | | | | | | | | | | 0 | 3.8 | 99.1 | 14.7 |
| 17-Aug | | | | | | | | | | | | 0 | 5.2 | 155.6 | 18.1 |
| 18-Aug | | | | | | | | | | | 1 | 1 | 5.1 | 207.5 | 19.8 |
| 19-Aug | | | | | | | | | | | | 0 | 6.5 | 252.4 | 18.0 |
| 20-Aug | | | | | | | | | | | | 0 | 4.8 | 309.1 | 13.2 |
| 21-Aug | | | | | | | | | | | | 0 | 5.6 | 253.9 | 12.3 |
| 22-Aug | | | | | | | | | | | | 0 | 3.3 | 289.9 | 14.5 |
| 23-Aug | | | | | | | | | | | | 0 | 3.5 | 177.0 | 14.5 |
| 24-Aug | | | | | | | | | | | | 0 | 3.5 | 146.7 | 14.2 |
| 25-Aug | | | | | | | | | | | | 0 | 5.1 | 64.9 | 14.9 |
| 26-Aug | | | | | | | | | | | | 0 | 5.8 | 160.4 | 18.0 |
| 27-Aug | | | | | | | | | | | | 0 | 2.2 | 230.6 | 17.7 |
| 28-Aug | | | | | | | | | | | | 0 | 6.2 | 60.0 | 15.1 |
| 29-Aug | | | | | | | | | | | | 0 | 4.4 | 48.6 | 14.2 |
| 30-Aug | | | | | | | | | | | | 0 | 7.2 | 67.0 | 9.2 |
| 31-Aug | | | | | | | | | | | | 0 | 6.7 | 75.5 | 10.6 |
| 1-Sep | | | | | | | | | | | | 0 | 6.6 | 75.6 | 12.4 |
| 2-Sep | | | | | | | | | | | | 0 | 5.6 | 107.7 | 9.9 |
| 3-Sep | | | | | | | | | | | | 0 | 7.1 | 265.0 | 10.8 |
| 4-Sep | | | | | | | | | | | | 0 | 1.4 | 280.7 | 12.2 |
| 5-Sep | | | | | | | | | | | | 0 | 4.5 | 265.7 | 11.5 |
| 6-Sep | | | | | | | | | | | | 0 | 3.0 | 256.0 | 11.9 |
| 7-Sep | | | | | | | | | | | | 0 | 6.0 | 231.5 | 13.9 |
| 8-Sep | | | | | | | | | | | | 0 | 6.7 | 234.5 | 14.9 |
| 9-Sep | | | | | | | | | | | | 0 | 4.2 | 63.9 | 10.3 |
| 10-Sep | | | | 2 | | | | | | | | 2 | 5.3 | 77.2 | 6.5 |
| 11-Sep | | | | | | | | | | | | 0 | 5.5 | 132.3 | 10.4 |
| 12-Sep | | | | | | | | | | | | 0 | 6.8 | 170.1 | 11.1 |
| 13-Sep | | | | | | | | | | | | 0 | 4.6 | 180.0 | 12.8 |
| 14-Sep | | | | | | | | | | | | 0 | 2.3 | 287.7 | 13.1 |
| 15-Sep | | | | | | | | | | | | 0 | 3.1 | 58.7 | 13.4 |
| 16-Sep | | | | | | | | | | | | 0 | 3.4 | 175.8 | 13.3 |
| 17-Sep | | | | | | | | | | | | 0 | 8.0 | 215.8 | 14.9 |
| 18-Sep | | | | | | | | | | | | 0 | 6.0 | 223.3 | 16.1 |
| 19-Sep | | | | | | | | | | | | 0 | 6.2 | 257.0 | 8.7 |
| 20-Sep | | | | | | | | | | | | 0 | 4.7 | 257.6 | 4.5 |
| 21-Sep | | | | | | | | | | | | 0 | 4.2 | 193.0 | 6.0 |
| 22-Sep | | | | | | | | | | | | 0 | 6.5 | 177.3 | 12.5 |
| 23-Sep | | | | | | | | | | | | 0 | 8.6 | 219.2 | 16.8 |
| 24-Sep | | | | | | | | | | | | 0 | 6.2 | 291.6 | 9.0 |
| 25-Sep | | | | | | | | | | | | 0 | 6.9 | 267.3 | 8.6 |
| 26-Sep | | | | | | | | | | | | 0 | 6.2 | 197.4 | 9.1 |
| 27-Sep | | | | | | | | | | | | 0 | 6.0 | 193.5 | 12.2 |
| 28-Sep | | | | | | | | | | | | 0 | 5.5 | 303.8 | 4.7 |
| 29-Sep | | | | | | | | | | | | 0 | 6.0 | 208.1 | 3.9 |
| 30-Sep | | | | | | | | | | | | 0 | 5.5 | 193.4 | 7.7 |
| 1-Oct | | | | | | | | | | | | 0 | 5.5 | 277.6 | 5.2 |
| 2-Oct | | | | | | | | | | | | 0 | 8.3 | 229.3 | 13.1 |
| 3-Oct | | | | | | | | | | | | 0 | 5.8 | 226.8 | 11.6 |
| 4-Oct | | | | | | | | | | | | 0 | 5.2 | 99.6 | 5.5 |
| 5-Oct | | | | | | | | | | | | 0 | 4.8 | 54.7 | 2.6 |
| 6-Oct | | | | | | | | | | | | 0 | 5.2 | 73.2 | 3.0 |
| 7-Oct | | | | | | | | | | | | 0 | 5.2 | 174.0 | 8.6 |
| 8-Oct | | | | | | | | | | | | 0 | 6.6 | 253.5 | 12.6 |
| 9-Oct | | | | | | | | | | | | 0 | 3.4 | 241.5 | 9.7 |
| By Species | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | | | |
| By Guild | 2 | | | | 0 | | 0 | | | | 1 | | | | |
| | BIG BROWN GUILD | | | | RBEP | | MYSP | | | | UNKN | Tota | | | |

n/o - indicates that detector was not operating on that night

# Appendix B

## Bat Detector Survey Data Tables – Wethersfield

**Appendix B Table 1.** Summary of species and weather during each survey night at the Wethersfield high detector (35 m) – Fall 2006

| | BIG BROWN GUILD | | | | RBFP | | MYSP | | | | UNKN | | Mean Nightly Weather (7pm - 7am) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Night of | big brown bat | hoary bat | silver-haired bat | silver-haired/big brow | eastern pipistrelle | eastern red bat | little brown bat | *Myotis* spp. | northern myotis | small-footed myotis | unknown | Total | Wind Speed (m/s) | Wind Direction (degrees from true north) | Temperature (c) |
| 25-Jul | | | | | | | | | | | 2 | 2 | 3.6 | 180.0 | 23.4 |
| 26-Jul | | | | | | | | 1 | | | 1 | 2 | 5.1 | 205.0 | 25.0 |
| 27-Jul | | | | | | 1 | | | | | 1 | 2 | 4.4 | 205.0 | 23.3 |
| 28-Jul | | | | | | | | | | | 1 | 1 | 4.9 | 205.0 | 22.9 |
| 29-Jul | | | | | | | | | | | 1 | 1 | 3.4 | 270.0 | 22.9 |
| 30-Jul | | | | | | | | | | | 1 | 1 | 3.0 | 205.0 | 23.8 |
| 31-Jul | | | | 1 | | | | | | | | 1 | 2.2 | 135.0 | 25.5 |
| 1-Aug | | | | | | | | | | | 3 | 3 | 0.4 | 256.3 | 23.3 |
| 2-Aug | | | | | | | | | | | 1 | 1 | 0.4 | 251.0 | 23.4 |
| 3-Aug | | | | | | | | | | | | 0 | 0.4 | 320.5 | 17.6 |
| 4-Aug | | | | | | | | | | | 1 | 1 | 0.4 | 290.7 | 14.7 |
| 5-Aug | | | | | | | | 1 | | | | 1 | 0.4 | 123.5 | 15.3 |
| 6-Aug | | | | | | | | | | | | 0 | 0.4 | 239.0 | 20.0 |
| 7-Aug | | | | 1 | | | | | | | 1 | 2 | 0.4 | 310.5 | 14.9 |
| 8-Aug | | | | | | | | | | | | 0 | 0.4 | 98.5 | 13.7 |
| 9-Aug | | | | | | | | | | | | 0 | 0.4 | 275.0 | 15.9 |
| 10-Aug | | | | | | | | | | | 1 | 1 | 5.1 | 69.0 | 13.8 |
| 11-Aug | | | | | | | | | | | | 0 | 1.9 | 122.8 | 11.0 |
| 12-Aug | | | | | | | | | | | | 0 | 2.6 | 191.1 | 12.1 |
| 13-Aug | | | | | | | | | | | | 0 | 5.9 | 246.4 | 13.9 |
| 14-Aug | | | | | | | | | | | | 0 | 5.6 | 275.2 | 16.2 |
| 15-Aug | | | | | | | | | | | | 0 | 3.9 | 272.7 | 12.9 |
| 16-Aug | | | | | | | | | | | | 0 | 3.8 | 99.1 | 14.7 |
| 17-Aug | | | | | | | | | | | | 0 | 5.2 | 155.6 | 18.1 |
| 18-Aug | | | | | | | | | | | | 0 | 5.1 | 207.5 | 19.8 |
| 19-Aug | | | | | | | | | | | | 0 | 6.5 | 252.4 | 18.0 |
| 20-Aug | | | | | | | | | | | | 0 | 4.8 | 309.1 | 13.2 |
| 21-Aug | | | | | | | | | | | | 0 | 5.6 | 253.9 | 12.3 |
| 22-Aug | | | | | | | | | | | | 0 | 3.3 | 289.9 | 14.5 |
| 23-Aug | | | | | | | | | | | | 0 | 3.5 | 177.0 | 14.5 |
| 24-Aug | | | | | | | | | | | 1 | 1 | 3.5 | 146.7 | 14.2 |
| 25-Aug | | | | | | | | | | | | 0 | 5.1 | 64.9 | 14.9 |
| 26-Aug | | | | | | | | | | | | 0 | 5.8 | 160.4 | 18.0 |
| 27-Aug | | | | | | | | | | | | 0 | 2.2 | 230.6 | 17.7 |
| 28-Aug | | | | | | | | | | | | 0 | 6.2 | 60.0 | 15.1 |
| 29-Aug | | | | | | | | | | | | 0 | 4.4 | 48.6 | 14.2 |
| 30-Aug | | | | | | | | | | | | 0 | 7.2 | 67.0 | 9.2 |
| 31-Aug | | | | | | | | | | | | 0 | 6.7 | 75.5 | 10.6 |
| 1-Sep | | | | | | | | | | | | 0 | 6.6 | 75.6 | 12.4 |
| 2-Sep | | | | | | | | | | | | 0 | 5.6 | 107.7 | 9.9 |
| 3-Sep | | | | | | | | | | | | 0 | 7.1 | 265.0 | 10.8 |
| 4-Sep | | | | | | | | | | | | 0 | 1.4 | 280.7 | 12.2 |
| 5-Sep | | | | | | | | | | | | 0 | 4.5 | 265.7 | 11.5 |
| 6-Sep | | | | | | | | | | | | 0 | 3.0 | 256.0 | 11.9 |
| 7-Sep | | | | | | | | | | | | 0 | 6.0 | 231.5 | 13.9 |
| 8-Sep | | | | | | | | | | | | 0 | 6.7 | 234.5 | 14.9 |
| 9-Sep | | | | | | | | | | | | 0 | 4.2 | 63.9 | 10.3 |
| 10-Sep | | | | | | | | | | | | 0 | 5.3 | 77.2 | 6.5 |
| 11-Sep | | | | | | | | | | | | 0 | 5.5 | 132.3 | 10.4 |
| 12-Sep | | | | | | | | | | | | 0 | 6.8 | 170.1 | 11.1 |
| 13-Sep | | | | | | | | | | | | 0 | 4.6 | 180.0 | 12.8 |
| 14-Sep | | | | | | | | | | | | 0 | 2.3 | 287.7 | 13.1 |
| 15-Sep | | | | | | | | | | | | 0 | 3.1 | 58.7 | 13.4 |
| 16-Sep | | | | | | | | | | | | 0 | 3.4 | 175.8 | 13.3 |
| 17-Sep | | | | | | | | | | | | 0 | 8.0 | 215.8 | 14.9 |
| 18-Sep | | | | | | | | | | | | 0 | 6.0 | 223.3 | 16.1 |
| 19-Sep | | | | | | | | | | | | 0 | 6.2 | 257.0 | 8.7 |
| 20-Sep | | | | | | | | | | | 2 | 2 | 4.7 | 257.6 | 4.5 |
| 21-Sep | | | | | | | | | | | | 0 | 4.2 | 193.0 | 6.0 |
| 22-Sep | | | | | | | | | | | | 0 | 6.5 | 177.3 | 12.5 |
| 23-Sep | | | | | | | | | | | | 0 | 8.6 | 219.2 | 16.8 |
| 24-Sep | | | | | | | | | | | | 0 | 6.2 | 291.6 | 9.0 |
| 25-Sep | | | | | | | | | | | | 0 | 6.9 | 267.3 | 8.6 |
| 26-Sep | | | | | | | | | | | | 0 | 6.2 | 197.4 | 9.1 |
| 27-Sep | | | | | | | | | | | | 0 | 6.0 | 193.5 | 12.2 |
| 28-Sep | | | | | | | | | | | | 0 | 5.5 | 303.8 | 4.7 |
| 29-Sep | | | | | | | | | | | | 0 | 6.0 | 208.1 | 3.9 |
| 30-Sep | | | | | | | | | | | | 0 | 5.5 | 193.4 | 7.7 |
| 1-Oct | | | | | | | | | | | | 0 | 5.5 | 277.6 | 5.2 |
| 2-Oct | | | | | | | | | | | | 0 | 8.3 | 229.3 | 13.1 |
| 3-Oct | | | | | | | | | | | | 0 | 5.8 | 226.8 | 11.6 |
| 4-Oct | | | | | | | | | | | | 0 | 5.2 | 99.6 | 5.5 |
| 5-Oct | | | | | | | | | | | | 0 | 4.8 | 54.7 | 2.6 |
| 6-Oct | | | | | | | | | | | | 0 | 5.2 | 73.2 | 3.0 |
| 7-Oct | | | | | | | | | | | | 0 | 5.2 | 174.0 | 8.6 |
| 8-Oct | | | | | | | | | | | | 0 | 6.6 | 253.5 | 12.6 |
| 9-Oct | | | | | | | | | | | | 0 | 3.4 | 241.5 | 9.7 |
| By Species | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 2 | 0 | 0 | 17 | 22 | | | |
| By Guild | 2 | | | | 1 | | 2 | | | | 17 | | | | |
| | BIG BROWN GUILD | | | | RBFP | | MYSP | | | | UNKN | Total | | | |

n/o - indicates that detector was not operating on that night

**Appendix B Table 2.** Summary of species and weather during each survey night at the Wethersfield low detector (15 m) – Fall 2006

| | BIG BROWN GUILD | | | | RBFP | | MYSP | | | | UNKN | Total | Mean Nightly Weather (7pm - 7am) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Night of | big brown bat | hoary bat | silver-haired bat | silver-haired/big brow | eastern pipistrelle | eastern red bat | little brown bat | *Myotis* spp. | northern myotis | small-footed myotis | unknown | | Wind Speed (m/s) | Wind Direction (degrees from true north) | Temperature ( c ) |
| 25-Jul | | | | | | | | | | | | 0 | 3.6 | 180.0 | 23.4 |
| 26-Jul | | | | | | | | | | | | 0 | 5.1 | 205.0 | 25.0 |
| 27-Jul | | | | | | | | | | | | 0 | 4.4 | 205.0 | 23.3 |
| 28-Jul | | | | | | | | | | | | 0 | 4.9 | 205.0 | 22.9 |
| 29-Jul | | | | | | | | | | | | 0 | 3.4 | 270.0 | 22.9 |
| 30-Jul | | | | | | | | | | | | 0 | 3.0 | 205.0 | 23.8 |
| 31-Jul | | | | | | | | | | | | 0 | 2.2 | 135.0 | 25.5 |
| 1-Aug | | | | | | | | | | | | 0 | 0.4 | 256.3 | 23.3 |
| 2-Aug | | | | | | | | | | | | 0 | 0.4 | 251.0 | 23.4 |
| 3-Aug | | | | | | | | | | | | 0 | 0.4 | 320.5 | 17.6 |
| 4-Aug | | | | | | | | | | | | 0 | 0.4 | 290.7 | 14.7 |
| 5-Aug | | | | | | | | | | | | 0 | 0.4 | 123.5 | 15.3 |
| 6-Aug | | | | | | | | | | | | 0 | 0.4 | 239.0 | 20.0 |
| 7-Aug | | | | | | | | | | | | 0 | 0.4 | 310.5 | 14.9 |
| 8-Aug | | | | | | | | | | | | 0 | 0.4 | 98.5 | 13.7 |
| 9-Aug | | | | | | | | | | | | 0 | 0.4 | 275.0 | 15.9 |
| 10-Aug | | | | | | | | | | | | 0 | 5.1 | 69.0 | 13.8 |
| 11-Aug | | | | | | | | | | | | 0 | 1.9 | 122.8 | 11.0 |
| 12-Aug | | | | | | | | | | | | 0 | 2.6 | 191.1 | 12.1 |
| 13-Aug | | | | | | | | | | | | 0 | 5.9 | 246.4 | 13.9 |
| 14-Aug | | | | | | | | | | | | 0 | 5.6 | 275.2 | 16.2 |
| 15-Aug | | | | | | | | | | | | 0 | 3.9 | 272.7 | 12.9 |
| 16-Aug | | | | | | | | | | | | 0 | 3.8 | 99.1 | 14.7 |
| 17-Aug | | | | | | | | | | | | 0 | 5.2 | 155.6 | 18.1 |
| 18-Aug | | | | | | | | | | | | 0 | 5.1 | 207.5 | 19.8 |
| 19-Aug | | | | | | | | | | | | 0 | 6.5 | 252.4 | 18.0 |
| 20-Aug | | | | | | | | | | | | 0 | 4.8 | 309.1 | 13.2 |
| 21-Aug | | | | | | | | | | | | 0 | 5.6 | 253.9 | 12.3 |
| 22-Aug | | | | | | | | | | | | 0 | 3.3 | 289.9 | 14.5 |
| 23-Aug | | | | | | | | | | | | 0 | 3.5 | 177.0 | 14.5 |
| 24-Aug | | | | | | | | | | | | 0 | 3.5 | 146.7 | 14.2 |
| 24-Aug | | | | | | | | | | | | 0 | 5.1 | 64.9 | 14.9 |
| 25-Aug | | | | | | | | | | | | 0 | 5.8 | 160.4 | 18.0 |
| 26-Aug | | | | | | | | | | | | 0 | 2.2 | 230.6 | 17.7 |
| 27-Aug | | | | | | | | | | | | 0 | 6.2 | 60.0 | 15.1 |
| 28-Aug | | | | | | | | | | | | 0 | 4.4 | 48.6 | 14.2 |
| 29-Aug | | | | | | | | | | | | 0 | 7.2 | 67.0 | 9.2 |
| 30-Aug | | | | | | | | | | | | 0 | 6.7 | 75.5 | 10.6 |
| 31-Aug | | | | | | | | | | | | 0 | 6.6 | 75.6 | 12.4 |
| 1-Sep | | | | | | | | | | | | 0 | 5.6 | 107.7 | 9.9 |
| 2-Sep | | | | | | | | | | | | 0 | 7.1 | 265.0 | 10.8 |
| 3-Sep | | | | | | | | | | | | 0 | 1.4 | 280.7 | 12.2 |
| 4-Sep | | | | | | | | | | | | 0 | 4.5 | 265.7 | 11.5 |
| 5-Sep | | | | | | | | | | | | 0 | 3.0 | 256.0 | 11.9 |
| 6-Sep | | | | | | | | | | | | 0 | 6.0 | 231.5 | 13.9 |
| 7-Sep | | | | | | | | | | | | 0 | 6.7 | 234.5 | 14.9 |
| 8-Sep | | | | | | | | | | | | 0 | 4.2 | 63.9 | 10.3 |
| 9-Sep | | | | | | | | | | | | 0 | 5.3 | 77.2 | 6.5 |
| 10-Sep | | | | | | | | | | | | 0 | 5.5 | 132.3 | 10.4 |
| 11-Sep | | | | | | | | | | | | 0 | 6.8 | 170.1 | 11.1 |
| 12-Sep | | | | | | | | | | | | 0 | 4.6 | 180.0 | 12.8 |
| 13-Sep | | | | | | | | | | | | 0 | 2.3 | 287.7 | 13.1 |
| 14-Sep | | | | | | | | | | | | 0 | 3.1 | 58.7 | 13.4 |
| 15-Sep | | | | | | | | | | | | 0 | 3.4 | 175.8 | 13.3 |
| 16-Sep | | | | | | | | | | | | 0 | 8.0 | 215.8 | 14.9 |
| 17-Sep | | | | | | | | | | | | 0 | 6.0 | 223.3 | 16.1 |
| 18-Sep | | | | | | | | | | | | 0 | 6.2 | 257.0 | 8.7 |
| 19-Sep | | | | | | | | | | | | 0 | 4.7 | 257.6 | 4.5 |
| 20-Sep | | | | | | | | | | | | 0 | 4.2 | 193.0 | 6.0 |
| 21-Sep | | | | | | | | | | | | 0 | 6.5 | 177.3 | 12.5 |
| 22-Sep | | | | | | | | | | | | 0 | 8.6 | 219.2 | 16.8 |
| 23-Sep | | | | | | | | | | | | 0 | 6.2 | 291.6 | 9.0 |
| 24-Sep | | | | | | | | | | | | 0 | 6.9 | 267.3 | 8.6 |
| 25-Sep | | | | | | | | | | | | 0 | 6.2 | 197.4 | 9.1 |
| 26-Sep | | | | | | | | | | | | 0 | 6.0 | 193.5 | 12.2 |
| 27-Sep | | | | | | | | | | | | 0 | 5.5 | 303.8 | 4.7 |
| 28-Sep | | | | | | | | | | | | 0 | 6.0 | 208.1 | 3.9 |
| 29-Sep | | | | | | | | | | | | 0 | 5.5 | 193.4 | 7.7 |
| 30-Sep | | | | | | | | | | | | 0 | 5.5 | 277.6 | 5.2 |
| 1-Oct | | | | | | | | | | | | 0 | 8.3 | 229.3 | 13.1 |
| 2-Oct | | | | | | | | | | | | 0 | 5.8 | 226.8 | 11.6 |
| 3-Oct | | | | | | | | | | | | 0 | 5.2 | 99.6 | 5.5 |
| 4-Oct | | | | | | | | | | | | 0 | 4.8 | 54.7 | 2.6 |
| 5-Oct | | | | | | | | | | | | 0 | 5.2 | 73.2 | 3.0 |
| 6-Oct | | | | | | | | | | | | 0 | 5.2 | 174.0 | 8.6 |
| 7-Oct | | | | | | | | | | | | 0 | 6.6 | 253.5 | 12.6 |
| 8-Oct | | | | | | | | | | | | 0 | 3.4 | 241.5 | 9.7 |
| 9-Oct | | | | | | | | | | | | 0 | 5.6 | 138.7 | 11.9 |
| By Species | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | |
| By Guild | 0 | | | | 0 | | 0 | | | | 0 | | | | |
| | BIG BROWN GUILD | | | | RBFP | | MYSP | | | | UNKN | Total | | | |

n/o - indicates that detector was not operating on that night

# Appendix C

## Bat Call Sequence File Data Tables

**Appendix C – Table 1.** Call sequence file data – Centerville

| Filename | Date (night of) | Time | Height | Species |
|---|---|---|---|---|
| G8210430.58# | 8/20/06 | 4:30 | 30 m | LE |
| G8242115.12# | 8/24/06 | 21:15 | 30 m | LE |
| G9102111.54# | 9/10/06 | 21:11 | 15 m | LE |
| G9110029.59# | 9/10/06 | 0:29 | 15 m | LE |
| G8182244.35# | 8/18/06 | 22:44 | 15 m | UNKN |

**Appendix C – Table 2.** Call sequence file data – Wethersfield

| Filename | Date (night of) | Time | Height | Species |
|---|---|---|---|---|
| G7272235.25# | 7/27/06 | 22:35 | 35m | LABO |
| G7312334.59# | 7/31/06 | 23:34 | 35m | LE |
| G8072300.03# | 8/7/06 | 23:00 | 35m | LE |
| G7270036.11# | 7/26/06 | 0:36 | 35m | MYSP |
| G8052346.22# | 8/5/06 | 23:46 | 35m | MYSP |
| G7252137.58# | 7/25/06 | 21:37 | 35m | UNKN |
| G7260445.08# | 7/25/06 | 4:45 | 35m | UNKN |
| G7262120.11# | 7/26/06 | 21:20 | 35m | UNKN |
| G7272335.44# | 7/27/06 | 23:35 | 35m | UNKN |
| G7282123.59# | 7/28/06 | 21:23 | 35m | UNKN |
| G7292218.47# | 7/29/06 | 22:18 | 35m | UNKN |
| G7310029.14# | 7/30/06 | 0:29 | 35m | UNKN |
| G8012127.06# | 8/1/06 | 21:27 | 35m | UNKN |
| G8012127.13# | 8/1/06 | 21:27 | 35m | UNKN |
| G8020255.05# | 8/1/06 | 2:55 | 35m | UNKN |
| G8030329.44# | 8/2/06 | 3:29 | 35m | UNKN |
| G8042338.49# | 8/4/06 | 23:38 | 35m | UNKN |
| G8072203.03# | 8/7/06 | 22:03 | 35m | UNKN |
| G8102135.34# | 8/10/06 | 21:35 | 35m | UNKN |
| G8250439.03# | 8/24/06 | 4:39 | 35m | UNKN |
| G9210710.34# | 9/20/06 | 7:10 | 35m | UNKN |
| G9210738.41# | 9/20/06 | 7:38 | 35m | UNKN |

# E

# Bird Data (BBA, BBS, CBC) Tables

**Table E-1 Bird Species and Their Breeding Status in New York State Breeding Bird Atlas Blocks in the Project Area**

| Common Name | Listed Species | Block | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2271B | 2272B | 2272C | 2272D | 2372A | 2372C |
| Canada Goose | | PO | C | PO | C | C | C |
| Wood Duck | | PR | C | PO | PR | PR | PO |
| Mallard | | PR | PR | PO | C | PR | PO |
| Hooded Merganser | | - | C | - | - | - | - |
| Northern Bobwhite | | - | - | - | - | - | PO |
| Ring-necked Pheasant | | PO | - | - | PO | PO | - |
| Ruffed Grouse | | PO | PR | PO | - | - | PO |
| Wild Turkey | | PO | C | PO | PO | PO | C |
| Great Blue Heron | | PO | C | PO | PO | PO | PO |
| Green Heron | | PO | C | PO | - | PO | PR |
| Turkey Vulture | | PO | PO | PO | PO | PO | PO |
| Northern Harrier | T | C | - | PO | - | - | PO |
| Sharp-shinned Hawk | SC | - | - | - | C | - | C |
| Red-shouldered Hawk | SC | PO | PR | PO | - | - | PO |
| Broad-winged Hawk | | PO | C | PO | - | PO | - |
| Red-tailed Hawk | | PO | PR | PR | PR | PO | PO |
| American Kestrel | | PO | - | PO | PO | C | PO |
| Virginia Rail | | - | - | - | - | PO | - |
| Killdeer | | PO | PO | PR | PR | PO | C |
| Spotted Sandpiper | | - | PO | - | - | - | - |
| Upland Sandpiper | T | - | - | PO | - | - | - |
| Wilson's Snipe | | - | - | PO | PR | PO | - |
| American Woodcock | | PO | PO | PO | PO | PO | PO |
| Rock Pigeon | | PO | C | C | C | C | PO |
| Mourning Dove | | C | C | PR | C | C | PR |
| Black-billed Cuckoo | | - | PO | PO | - | PO | - |
| Yellow-billed Cuckoo | | - | - | PO | PO | - | PO |
| Eastern Screech-Owl | | PO | PO | PO | PO | PO | - |
| Great Horned Owl | | - | PR | PO | PR | PO | - |
| Barred Owl | | PO | PR | PR | PO | PR | PR |
| Northern Saw-whet Owl | | - | PO | PO | PR | PO | PO |
| Ruby-throated Hummingbird | | PO | C | PR | PR | PO | PR |
| Belted Kingfisher | | C | C | PO | PO | - | - |
| Red-bellied Woodpecker | | - | PO | PO | PR | PO | - |
| Yellow-bellied Sapsucker | | PO | C | C | PR | C | C |
| Downy Woodpecker | | C | C | PR | PO | C | PO |
| Hairy Woodpecker | | C | C | PO | PO | C | PO |
| Northern Flicker | | PO | PR | PR | PR | C | C |
| Pileated Woodpecker | | PO | PR | PO | PO | PO | PR |
| Eastern Wood-Pewee | | PR | PR | PR | PO | PR | PR |
| Acadian Flycatcher | | - | PR | - | - | - | - |

## Table E-1 Bird Species and Their Breeding Status in New York State Breeding Bird Atlas Blocks in the Project Area

| Common Name | Listed Species | Block | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2271B | 2272B | 2272C | 2272D | 2372A | 2372C |
| Alder Flycatcher | | PO | PR | PR | PR | PO | PR |
| Willow Flycatcher | | PO | - | PR | PR | PO | PR |
| Least Flycatcher | | PR | PR | PO | PR | PO | PO |
| Eastern Phoebe | | PR | C | C | C | C | PR |
| Great Crested Flycatcher | | PR | PR | PR | C | PR | PR |
| Eastern Kingbird | | C | C | PR | PR | C | C |
| Blue-headed Vireo | | PO | PO | PR | - | - | PR |
| Warbling Vireo | | PR | - | PR | PR | PR | PR |
| Red-eyed Vireo | | PO | PR | PR | PR | C | C |
| Blue Jay | | PO | C | C | PR | C | PR |
| American Crow | | PO | C | C | C | C | PR |
| Horned Lark | SC | - | - | PR | PR | PR | PO |
| Tree Swallow | | C | C | C | C | C | C |
| Northern Rough-winged Swallow | | PR | - | - | PO | PR | - |
| Bank Swallow | | - | C | - | PO | - | - |
| Barn Swallow | | PO | C | C | C | C | PR |
| Black-capped Chickadee | | PR | C | PR | C | C | C |
| Tufted Titmouse | | - | - | PO | - | PO | PO |
| Red-breasted Nuthatch | | - | PR | PR | - | C | C |
| White-breasted Nuthatch | | PO | C | PR | PO | C | PR |
| Brown Creeper | | PR | PO | PR | - | PO | PR |
| House Wren | | C | C | PR | PR | C | PR |
| Winter Wren | | - | PR | - | - | - | PR |
| Golden-crowned Kinglet | | PO | PO | PO | - | PO | PR |
| Eastern Bluebird | | PR | C | PO | PR | C | PR |
| Veery | | C | PR | PR | PR | PR | PR |
| Hermit Thrush | | PR | PR | - | - | - | - |
| Wood Thrush | | PR | PO | PR | PO | PO | C |
| American Robin | | C | C | C | C | PR | C |
| Gray Catbird | | C | PR | C | PR | PR | C |
| Brown Thrasher | | PO | - | - | PR | PO | - |
| European Starling | | C | C | C | C | C | C |
| Cedar Waxwing | | - | C | PR | PR | PO | PR |
| Blue-winged Warbler | | C | PR | PR | PR | PR | C |
| “Brewster's” Warbler | | PO | - | - | - | - | - |
| Yellow Warbler | | C | PO | PR | PR | C | PR |
| Chestnut-sided Warbler | | PR | PR | PR | PR | C | C |
| Magnolia Warbler | | PO | PR | PR | PR | C | PR |
| Black-throated Blue Warbler | | - | - | - | - | - | C |
| Yellow-rumped Warbler | | PO | PR | PR | PR | PR | PR |

## Table E-1 Bird Species and Their Breeding Status in New York State Breeding Bird Atlas Blocks in the Project Area

| Common Name | Listed Species | Block | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2271B | 2272B | 2272C | 2272D | 2372A | 2372C |
| Black-throated Green Warbler | | PR | PR | PR | PR | PO | PR |
| Blackburnian Warbler | | PO | PO | PR | - | - | PR |
| Pine Warbler | | - | PR | - | - | - | C |
| Prairie Warbler | | PO | - | - | - | - | - |
| Black-and-white Warbler | | - | PR | - | - | - | - |
| American Redstart | | PO | PR | PO | PR | PR | PR |
| Ovenbird | | PO | PR | PR | PR | PR | PR |
| Northern Waterthrush | | - | PR | PR | - | - | - |
| Louisiana Waterthrush | | - | - | - | PO | - | - |
| Mourning Warbler | | PO | PR | PR | PR | C | C |
| Common Yellowthroat | | PR | PR | PR | C | PR | C |
| Hooded Warbler | | PO | PR | PR | PR | PR | C |
| Canada Warbler | | - | - | - | - | PR | C |
| Scarlet Tanager | | PR | PR | PR | PR | PO | PR |
| Eastern Towhee | | C | PR | PR | PR | PO | PR |
| Chipping Sparrow | | C | C | C | C | C | C |
| Field Sparrow | | C | PR | PO | PR | PO | PR |
| Vesper Sparrow | SC | PO | PO | - | - | PR | - |
| Savannah Sparrow | | PR | PR | C | C | C | PR |
| Grasshopper Sparrow | SC | - | - | - | - | - | PR |
| Song Sparrow | | C | PR | PR | C | C | C |
| Swamp Sparrow | | PO | PR | PR | C | PR | PO |
| White-throated Sparrow | | - | PO | - | - | - | - |
| Dark-eyed Junco | | C | C | C | PR | PR | C |
| Northern Cardinal | | PR | PR | PR | PR | PO | PR |
| Rose-breasted Grosbeak | | C | C | PR | PR | PO | C |
| Indigo Bunting | | PR | PR | PR | C | C | PR |
| Bobolink | | C | PO | C | PR | C | C |
| Red-winged Blackbird | | PR | C | C | C | C | C |
| Eastern Meadowlark | | - | - | - | PR | C | C |
| Common Grackle | | PO | C | C | C | C | PO |
| Brown-headed Cowbird | | PO | PR | PR | PR | PR | PR |
| Baltimore Oriole | | - | PR | C | PR | C | PR |
| Purple Finch | | PR | PR | PR | PR | C | PR |
| House Finch | | PO | - | C | PR | PO | - |
| Pine Siskin | | - | PR | - | - | - | - |
| American Goldfinch | | PR | PR | PR | PR | PR | PR |
| House Sparrow | | PO | C | C | C | C | C |

## Table E-1 Bird Species and Their Breeding Status in New York State Breeding Bird Atlas Blocks in the Project Area

| Common Name | Listed Species | Block | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2271B | 2272B | 2272C | 2272D | 2372A | 2372C |
| **Number of species reported as** | | | | | | | |
| **Possible Breeders** | | 45 | 17 | 30 | 19 | 34 | 21 |
| **Probable Breeders** | | 23 | 45 | 46 | 47 | 23 | 41 |
| **Confirmed Breeders** | | 21 | 34 | 19 | 22 | 36 | 31 |
| **Species Total** | | 89 | 96 | 95 | 88 | 93 | 93 |

Source: NYSDEC 2006

Key:

E = Endangered
SC = Special Concern
T = Threatened
PO = Possible
PR = Probable
C = Confirmed

### Table E-2 Bird Species Recorded During East Java, Gainesville, Centerville, and Castile Breeding Bird Surveys

| Common Name | Listed Species | Birds per Route | | | |
|---|---|---|---|---|---|
| | | East Java | Gainesville | Centerville | Castile |
| Canada Goose | | 3.00 | 1.24 | 0.29 | 3.42 |
| Wood Duck | | - | 0.07 | 0.16 | 1.19 |
| American Black Duck | | - | - | - | 0.11 |
| Mallard | | 1.77 | 6.03 | 0.29 | 6.31 |
| Blue-winged Teal | | - | - | 0.03 | 0.25 |
| Ring-necked Pheasant | | 1.60 | 8.48 | 0.81 | 8.25 |
| Ruffed Grouse | | 0.06 | - | 0.03 | 0.03 |
| Wild Turkey | | 0.20 | - | 0.03 | 0.11 |
| Pied-billed Grebe | T | - | - | - | 0.33 |
| American Bittern | SC | - | 0.17 | - | 0.08 |
| Great Blue Heron | | 0.69 | 1.48 | 1.35 | 1.28 |
| Green Heron | | 0.43 | 0.79 | 0.16 | 0.75 |
| Turkey Vulture | | 0.06 | 0.66 | 0.13 | 0.44 |
| Osprey | SC | 0.03 | - | - | - |
| Northern Harrier | T | 0.03 | 0.45 | 0.29 | 0.14 |
| Sharp-shinned Hawk | SC | 0.09 | 0.07 | - | 0.11 |
| Cooper's Hawk | SC | 0.06 | 0.07 | - | 0.06 |
| Red-shouldered Hawk | SC | 0.20 | - | 0.13 | 0.06 |
| Broad-winged Hawk | | 0.11 | - | 0.10 | - |
| Red-tailed Hawk | | 0.54 | 0.97 | 0.48 | 1.42 |
| American Kestrel | | 0.91 | 2.34 | 1.35 | 0.78 |
| Sora | | - | - | - | 0.03 |
| Common Moorhen | | - | - | - | 0.14 |
| American Coot | | - | - | - | 0.06 |
| Killdeer | | 9.26 | 15.31 | 5.81 | 12.67 |
| Spotted Sandpiper | | 0.14 | 0.17 | 0.23 | 0.17 |
| Upland Sandpiper | T | 0.89 | 1.93 | 0.10 | - |
| Wilson's Snipe | | 0.60 | 0.76 | - | 0.17 |
| American Woodcock | | 0.06 | 0.03 | - | - |
| Ring-billed Gull | | 8.74 | 0.28 | - | 5.06 |
| Herring Gull | | - | 0.03 | - | - |
| Rock Pigeon | | 21.37 | 38.45 | 10.19 | 43.25 |
| Mourning Dove | | 12.77 | 22.79 | 15.45 | 28.00 |
| Black-billed Cuckoo | | 0.31 | 0.72 | 0.52 | 0.47 |
| Yellow-billed Cuckoo | | 0.06 | 0.34 | 0.19 | 0.36 |
| Eastern Screech-Owl | | - | - | 0.06 | - |
| Great Horned Owl | | - | 0.17 | - | 0.19 |
| Barred Owl | | 0.03 | - | - | - |
| Common Nighthawk | SC | - | - | 0.03 | - |
| Chimney Swift | | 3.06 | 0.76 | 5.03 | 3.31 |
| Ruby-throated Hummingbird | | 0.17 | 0.21 | 0.61 | 0.36 |

## Table E-2 Bird Species Recorded During East Java, Gainesville, Centerville, and Castile Breeding Bird Surveys

| Common Name | Listed Species | Birds per Route | | | |
|---|---|---|---|---|---|
| | | East Java | Gainesville | Centerville | Castile |
| Belted Kingfisher | | 0.06 | 0.41 | 0.81 | 0.50 |
| Red-headed Woodpecker | SC | 0.03 | 0.17 | 0.03 | 0.33 |
| Red-bellied Woodpecker | | 0.03 | 0.14 | 0.10 | 1.06 |
| Yellow-bellied Sapsucker | | 0.23 | 0.86 | 0.06 | 0.64 |
| Downy Woodpecker | | 1.11 | 1.52 | 2.06 | 2.06 |
| Hairy Woodpecker | | 0.03 | 0.21 | 0.13 | 0.19 |
| Northern Flicker | | 1.71 | 2.93 | 2.74 | 3.11 |
| Pileated Woodpecker | | 0.17 | 0.10 | 0.06 | 0.33 |
| Eastern Wood-Pewee | | 1.20 | 2.34 | 1.68 | 2.78 |
| Alder Flycatcher | | 0.37 | 1.14 | 0.94 | 0.61 |
| Willow Flycatcher | | 3.86 | 6.07 | 1.65 | 5.64 |
| Least Flycatcher | | 1.80 | 3.93 | 3.87 | 3.67 |
| Eastern Phoebe | | 1.31 | 2.31 | 4.52 | 2.14 |
| Great Crested Flycatcher | | 1.49 | 1.00 | 1.58 | 2.72 |
| Eastern Kingbird | | 3.94 | 3.52 | 4.03 | 6.08 |
| Yellow-throated Vireo | | - | 0.03 | 0.03 | - |
| Blue-headed Vireo | | 0.09 | - | - | - |
| Warbling Vireo | | 1.29 | 4.07 | 3.52 | 4.42 |
| Red-eyed Vireo | | 7.43 | 5.97 | 7.39 | 4.31 |
| Blue Jay | | 5.63 | 2.93 | 8.35 | 4.17 |
| American Crow | | 46.17 | 54.17 | 48.74 | 56.67 |
| Common Raven | | - | - | 0.19 | - |
| Horned Lark | SC | 0.83 | 5.03 | 1.26 | 9.42 |
| Purple Martin | | 0.49 | - | 0.45 | 0.14 |
| Tree Swallow | | 6.37 | 4.72 | 4.52 | 4.89 |
| Northern Rough-winged Swallow | | 0.40 | 1.31 | 0.77 | 0.11 |
| Bank Swallow | | 0.17 | 2.07 | 0.61 | 1.22 |
| Cliff Swallow | | 0.11 | 0.10 | 0.23 | - |
| Barn Swallow | | 23.94 | 28.14 | 32.90 | 20.11 |
| Black-capped Chickadee | | 6.43 | 2.59 | 8.65 | 3.78 |
| Tufted Titmouse | | - | 0.03 | 0.10 | 0.22 |
| Red-breasted Nuthatch | | 0.11 | 0.03 | 0.13 | - |
| White-breasted Nuthatch | | 0.49 | 0.86 | 1.10 | 0.42 |
| Brown Creeper | | 0.14 | - | 0.06 | - |
| Carolina Wren | | - | - | 0.13 | 0.03 |
| House Wren | | 7.29 | 12.66 | 13.13 | 11.42 |
| Blue-gray Gnatcatcher | | - | 0.03 | - | - |
| Eastern Bluebird | | 1.09 | 0.34 | 1.58 | 1.03 |
| Veery | | 2.43 | 0.59 | 1.61 | 1.47 |
| Hermit Thrush | | 0.14 | - | 0.03 | - |
| Wood Thrush | | 4.63 | 5.24 | 3.29 | 5.75 |
| American Robin | | 58.40 | 70.97 | 90.81 | 93.81 |

## Table E-2 Bird Species Recorded During East Java, Gainesville, Centerville, and Castile Breeding Bird Surveys

| Common Name | Listed Species | Birds per Route | | | |
|---|---|---|---|---|---|
| | | East Java | Gainesville | Centerville | Castile |
| Gray Catbird | | 5.77 | 9.24 | 9.06 | 10.11 |
| Northern Mockingbird | | - | 0.03 | - | 0.22 |
| Brown Thrasher | | 0.69 | 0.62 | 1.10 | 0.56 |
| European Starling | | 97.57 | 168.14 | 121.90 | 211.31 |
| Cedar Waxwing | | 7.71 | 10.79 | 7.61 | 15.17 |
| Blue-winged Warbler | | 0.46 | 0.21 | 1.65 | 0.25 |
| Golden-winged Warbler | SC | - | - | - | 0.03 |
| Nashville Warbler | | - | 0.03 | 0.03 | - |
| Yellow Warbler | | 9.46 | 23.83 | 19.32 | 22.69 |
| Chestnut-sided Warbler | | 1.49 | 0.72 | 2.55 | 1.50 |
| Magnolia Warbler | | 0.14 | - | 0.19 | 0.03 |
| Black-throated Blue Warbler | | 0.03 | - | - | - |
| Yellow-rumped Warbler | | 0.06 | - | 0.19 | - |
| Black-throated Green Warbler | | 1.11 | 0.03 | 0.06 | - |
| Blackburnian Warbler | | 0.26 | - | - | - |
| Pine Warbler | | - | - | 0.03 | - |
| Prairie Warbler | | 0.06 | - | 0.29 | - |
| Black-and-white Warbler | | 0.03 | - | - | - |
| American Redstart | | 0.20 | 0.28 | 0.35 | 0.81 |
| Ovenbird | | 2.54 | 0.14 | 1.32 | 0.19 |
| Northern Waterthrush | | 0.20 | 0.03 | - | - |
| Louisiana Waterthrush | | - | - | 0.10 | 0.03 |
| Mourning Warbler | | 1.00 | 0.59 | 0.45 | 0.64 |
| Common Yellowthroat | | 11.17 | 16.97 | 16.97 | 11.11 |
| Hooded Warbler | | 0.37 | 0.14 | 0.39 | 0.58 |
| Canada Warbler | | 0.11 | - | - | - |
| Scarlet Tanager | | 1.03 | 0.62 | 0.65 | 0.97 |
| Eastern Towhee | | 1.66 | 0.90 | 2.81 | 1.19 |
| Chipping Sparrow | | 21.06 | 22.03 | 20.16 | 33.72 |
| Field Sparrow | | 5.00 | 5.17 | 11.23 | 4.42 |
| Vesper Sparrow | SC | 0.20 | 4.69 | 0.52 | 4.36 |
| Savannah Sparrow | | 19.94 | 47.34 | 11.35 | 32.64 |
| Grasshopper Sparrow | SC | 0.40 | 1.48 | 0.39 | 0.19 |
| Henslow's Sparrow | T | 0.23 | 0.24 | 0.13 | - |
| Song Sparrow | | 33.29 | 55.14 | 41.13 | 64.39 |
| Swamp Sparrow | | 0.80 | 0.59 | 0.06 | 0.97 |
| White-throated Sparrow | | 0.11 | - | - | 0.03 |
| Dark-eyed Junco | | 1.63 | 0.07 | 0.97 | 0.03 |
| Northern Cardinal | | 3.69 | 4.03 | 6.74 | 6.17 |
| Rose-breasted Grosbeak | | 1.77 | 3.17 | 1.71 | 3.50 |
| Indigo Bunting | | 4.06 | 5.21 | 8.68 | 5.28 |

**Table E-2 Bird Species Recorded During East Java, Gainesville, Centerville, and Castile Breeding Bird Surveys**

| Common Name | Listed Species | Birds per Route | | | |
|---|---|---|---|---|---|
| | | East Java | Gainesville | Centerville | Castile |
| Bobolink | | 30.00 | 27.14 | 33.35 | 20.53 |
| Red-winged Blackbird | | 114.37 | 155.48 | 122.87 | 176.42 |
| Eastern Meadowlark | | 16.57 | 25.97 | 19.00 | 13.86 |
| Western Meadowlark | | - | 0.03 | - | - |
| Common Grackle | | 71.66 | 76.24 | 50.87 | 103.00 |
| Brown-headed Cowbird | | 13.14 | 9.52 | 5.26 | 17.56 |
| Orchard Oriole | | - | - | 0.06 | - |
| Baltimore Oriole | | 4.77 | 6.93 | 6.55 | 8.00 |
| Purple Finch | | 2.11 | 0.21 | 0.48 | 0.25 |
| House Finch | | 2.49 | 2.38 | 3.90 | 5.36 |
| Pine Siskin | | - | 0.03 | - | - |
| American Goldfinch | | 16.11 | 28.83 | 22.39 | 35.44 |
| House Sparrow | | 30.17 | 55.66 | 39.90 | 90.06 |

Source: Sauer et al. 2005.

Key:

E = Endangered
SC = Special Concern
T = Threatened

**Table E-3 Species Recorded During the Last 10 Years of the Beaver Meadow Christmas Bird Count (1996-2005)**

| Common Name | Listed Species | Year | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | |
| Snow Goose | | - | - | - | - | - | - | - | - | 7 | - | 7 |
| Canada Goose | | - | 47 | 3 | 28 | 441 | 1 | 1,068 | 2 | 81 | 6 | 1,677 |
| Tundra Swan | | - | 20 | - | - | - | - | - | - | - | - | 20 |
| American Black Duck | | - | - | - | - | 4 | - | - | - | 2 | - | 6 |
| Mallard | | 3 | 4 | 29 | 52 | 47 | 21 | 68 | 43 | 14 | 18 | 299 |
| Hooded Merganser | | - | 0 | - | - | - | - | 1 | - | - | - | 1 |
| Ring-necked Pheasant | | 2 | - | 2 | 5 | - | 1 | 1 | 3 | - | 5 | 19 |
| Ruffed Grouse | | 1 | 5 | 4 | 2 | - | 2 | 2 | 2 | 5 | - | 23 |
| Wild Turkey | | 244 | 15 | 29 | 110 | 42 | 43 | 121 | 85 | 87 | 103 | 879 |
| Great Blue Heron | | 3 | 3 | 2 | - | 3 | 1 | 1 | 1 | 30 | 3 | 47 |
| Northern Harrier | T | - | - | - | 2 | 1 | - | 2 | - | - | - | 5 |
| Sharp-shinned Hawk | SC | 4 | 4 | 7 | 1 | 4 | 4 | 2 | 3 | 6 | 1 | 36 |
| Cooper's Hawk | SC | 1 | 4 | 4 | 5 | 8 | - | 7 | - | 7 | 6 | 42 |
| Northern Goshawk | SC | 0 | - | - | - | - | - | - | - | 1 | 1 | 2 |
| Red-shouldered Hawk | SC | - | - | - | - | - | - | - | - | 1 | 3 | 4 |
| Red-tailed Hawk | | 23 | 31 | 43 | 49 | 59 | 37 | 32 | 7 | 21 | 56 | 358 |
| Rough-legged Hawk | | 1 | - | - | 2 | 2 | 4 | 2 | - | 3 | 4 | 18 |
| American Kestrel | | 2 | 3 | 2 | 5 | 8 | 3 | 3 | - | - | - | 26 |
| Killdeer | | - | - | - | - | - | - | - | - | 1 | - | 1 |
| Ring-billed Gull | | - | 4 | 4 | 19 | - | 1 | 285 | - | 3 | - | 316 |
| Herring Gull | | 3 | - | - | - | 3 | 4 | 21 | - | 2 | 4 | 37 |
| Rock Pigeon | | 619 | 754 | 611 | 269 | 644 | 526 | 1,074 | 278 | 654 | 728 | 6,157 |
| Mourning Dove | | 149 | 268 | 265 | 270 | 894 | 212 | 464 | 134 | 497 | 252 | 3,405 |
| Eastern Screech-Owl | | 5 | 2 | 5 | 5 | 11 | 2 | 2 | 3 | 4 | 7 | 46 |
| Great Horned Owl | | 6 | 1 | 2 | 3 | 1 | 2 | - | - | 1 | 2 | 18 |
| Snowy Owl | | 1 | - | 1 | - | - | - | - | - | - | - | 2 |
| Barred Owl | | 3 | 2 | 1 | - | - | - | - | - | - | - | 6 |
| Short-eared Owl | E | 2 | - | - | 2 | 2 | - | - | - | 3 | - | 9 |
| Belted Kingfisher | | - | - | - | 1 | 1 | - | 1 | - | 1 | - | 4 |
| Red-bellied Woodpecker | | 7 | 4 | 4 | 8 | 6 | 4 | 14 | 4 | 22 | 28 | 101 |

## Table E-3 Species Recorded During the Last 10 Years of the Beaver Meadow Christmas Bird Count (1996-2005)

| Common Name | Listed Species | Year | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | |
| Yellow-bellied Sapsucker | | 1 | - | - | - | - | - | - | - | - | - | 1 |
| Downy Woodpecker | | 80 | 66 | 42 | 48 | 56 | 19 | 66 | 29 | 69 | 87 | 562 |
| Hairy Woodpecker | | 20 | 11 | 16 | 17 | 18 | 8 | 22 | 11 | 23 | 24 | 170 |
| Northern Flicker | | 3 | 2 | 3 | 1 | 8 | 1 | 5 | - | 2 | - | 25 |
| Pileated Woodpecker | | 5 | - | 1 | 5 | 3 | 1 | 4 | 2 | 3 | 2 | 26 |
| Eastern Phoebe | | 0 | - | - | - | - | - | - | - | - | - | 0 |
| Northern Shrike | | 4 | 3 | 3 | 4 | 12 | 4 | 3 | 1 | 1 | 5 | 40 |
| Blue Jay | | 162 | 278 | 144 | 306 | 314 | 344 | 153 | 199 | 352 | 275 | 2,527 |
| American Crow | | 898 | 1,020 | 510 | 1,224 | 990 | 793 | 808 | 381 | 1,637 | 940 | 9,201 |
| Common Raven | | 2 | - | - | - | - | - | - | - | - | - | 2 |
| Horned Lark | SC | 172 | 72 | 40 | 180 | 179 | 249 | 266 | - | 198 | 1 | 1,357 |
| Black-capped Chickadee | | 752 | 600 | 717 | 582 | 659 | 324 | 425 | 430 | 527 | 542 | 5,558 |
| Tufted Titmouse | | 20 | 8 | 8 | 4 | 7 | 5 | 18 | 7 | 38 | 34 | 149 |
| Red-breasted Nuthatch | | 15 | 11 | 10 | 7 | 9 | 7 | 15 | 7 | 22 | 9 | 112 |
| White-breasted Nuthatch | | 37 | 45 | 47 | 28 | 25 | 13 | 39 | 18 | 28 | 52 | 332 |
| Brown Creeper | | 8 | 5 | 2 | 2 | 1 | 4 | 5 | 6 | 6 | 1 | 40 |
| Carolina Wren | | - | - | - | - | - | 1 | - | - | - | - | 1 |
| Golden-crowned Kinglet | | 9 | 9 | 7 | 20 | 3 | 19 | 19 | 12 | 6 | 4 | 108 |
| Ruby-crowned Kinglet | | - | - | - | - | - | - | 1 | - | - | - | 1 |
| Eastern Bluebird | | - | 2 | - | - | 23 | 3 | - | 2 | - | - | 30 |
| American Robin | | - | 2 | - | 3 | 68 | 1 | 1 | 2 | 5 | 8 | 90 |
| Gray Catbird | | - | - | - | - | - | - | - | 1 | - | - | 1 |
| European Starling | | 2,299 | 1,147 | 2,913 | 1,556 | 2,672 | 1,544 | 4,197 | 387 | 1,286 | 3,858 | 21,859 |
| American Pipit | | - | - | - | - | 1 | - | - | - | - | - | 1 |
| Cedar Waxwing | | 2 | 20 | 258 | 26 | 62 | 82 | 167 | 74 | 50 | 14 | 755 |
| American Tree Sparrow | | 137 | 342 | 167 | 575 | 499 | 166 | 159 | 208 | 458 | 401 | 3,112 |
| Chipping Sparrow | | - | - | 1 | - | - | - | - | - | - | - | 1 |

**Table E-3 Species Recorded During the Last 10 Years of the Beaver Meadow Christmas Bird Count (1996-2005)**

| Common Name | Listed Species | Year | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | |
| Song Sparrow | | 3 | 7 | 4 | 9 | 3 | 1 | 2 | 3 | 5 | 6 | 43 |
| Swamp Sparrow | | - | - | - | 1 | - | - | - | - | 1 | - | 2 |
| White-throated Sparrow | | 3 | 15 | 3 | 6 | 3 | 3 | 9 | 16 | 19 | 12 | 89 |
| White-crowned Sparrow | | - | - | - | - | - | - | - | - | 1 | - | 1 |
| Dark-eyed Junco | | 155 | 651 | 227 | 515 | 477 | 300 | 272 | 325 | 501 | 591 | 4,014 |
| Lapland Longspur | | 3 | - | - | - | - | - | - | - | - | - | 3 |
| Snow Bunting | | 1,445 | 225 | - | 182 | 37 | 171 | 102 | - | 10 | 233 | 2,405 |
| Northern Cardinal | | 91 | 51 | 67 | 71 | 43 | 40 | 55 | 86 | 53 | 117 | 674 |
| Red-winged Blackbird | | - | - | - | - | 1 | 1 | 1 | 1 | - | - | 4 |
| Eastern Meadowlark | | 1 | - | - | - | - | - | - | - | - | - | 1 |
| Rusty Blackbird | | - | - | - | - | 1 | - | - | - | - | - | 1 |
| Common Grackle | | - | 1 | - | 1 | 1 | - | - | - | - | - | 3 |
| Brown-headed Cowbird | | - | - | 6 | 1 | 53 | 20 | 2 | - | 1 | 30 | 113 |
| Pine Grosbeak | | - | - | - | - | - | - | 1 | - | - | - | 1 |
| Purple Finch | | - | 1 | 2 | - | 7 | 9 | 2 | - | - | 25 | 46 |
| House Finch | | 141 | 166 | 153 | 190 | 148 | 110 | 231 | 118 | 207 | 98 | 1,562 |
| Common Redpoll | | 5 | - | - | - | 185 | - | 128 | - | - | - | 318 |
| Pine Siskin | | - | - | 1 | - | - | 1 | 3 | 1 | - | - | 6 |
| American Goldfinch | | 19 | 104 | 48 | 116 | 113 | 93 | 226 | 123 | 719 | 198 | 1,759 |
| Evening Grosbeak | | 130 | - | 130 | - | 102 | - | 4 | - | - | - | 366 |
| House Sparrow | | 539 | 434 | 333 | 402 | 359 | 459 | 390 | 134 | 225 | 519 | 3,794 |
| **Grand Total** | | **8,240** | **6,469** | **6,881** | **6,920** | **9,323** | **5,664** | **10,972** | **3,149** | **7,906** | **9,313** | **74,837** |
| **Species Total** | | **52** | **46** | **47** | **48** | **54** | **49** | **54** | **39** | **52** | **44** | **78** |

Source: National Audubon Society 2005

Key:

E = Endangered.
SC = Special Concern.
T = Threatened.

# F

# E & E Bird Survey Tables

Table F-1

## Wethersfield Project Area
## Spring Migratory Bird Survey by Date

| Species | 5/10/2006 | 5/17/2006 | Total |
|---|---|---|---|
| Canada Goose | 30 | 52 | **82** |
| Wood Duck | 2 | 5 | **7** |
| Mallard | 14 | 6 | **20** |
| Ring-necked Pheasant | 3 | 3 | **6** |
| Wild Turkey | 5 | 4 | **9** |
| Green Heron | 2 | 0 | **2** |
| Turkey Vulture | 1 | 1 | **2** |
| Northern Harrier | 0 | 1 | **1** |
| Sharp-shinned Hawk | 1 | 0 | **1** |
| Red-tailed Hawk | 6 | 5 | **11** |
| Killdeer | 7 | 3 | **10** |
| Ring-billed Gull | 2 | 0 | **2** |
| Mourning Dove | 10 | 9 | **19** |
| Yellow-bellied Sapsucker | 8 | 2 | **10** |
| Downy Woodpecker | 2 | 1 | **3** |
| Hairy Woodpecker | 1 | 0 | **1** |
| Northern Flicker | 4 | 2 | **6** |
| Eastern Wood-Pewee | 1 | 0 | **1** |
| Least Flycatcher | 1 | 0 | **1** |
| Great Crested Flycatcher | 1 | 0 | **1** |
| Eastern Kingbird | 5 | 7 | **12** |
| Blue-headed Vireo | 1 | 0 | **1** |
| Red-eyed Vireo | 0 | 2 | **2** |
| Blue Jay | 10 | 4 | **14** |
| American Crow | 57 | 76 | **133** |
| Common Raven | 1 | 0 | **1** |
| Horned Lark | 8 | 0 | **8** |
| Tree Swallow | 19 | 8 | **27** |
| N Rough-winged Swallow | 3 | 1 | **4** |
| Cliff Swallow | 0 | 2 | **2** |
| Barn Swallow | 17 | 10 | **27** |
| Black-capped Chickadee | 8 | 3 | **11** |
| Tufted Titmouse | 4 | 2 | **6** |
| Golden-crowned Kinglet | 2 | 0 | **2** |
| Ruby-crowned Kinglet | 1 | 0 | **1** |
| Eastern Bluebird | 4 | 0 | **4** |
| Veery | 1 | 0 | **1** |
| Wood Thrush | 0 | 2 | **2** |
| American Robin | 59 | 48 | **107** |
| Gray Catbird | 3 | 5 | **8** |
| Brown Thrasher | 1 | 2 | **3** |
| Tennessee Warbler | 2 | 0 | **2** |
| Nashville Warbler | 4 | 0 | **4** |
| Yellow Warbler | 9 | 13 | **22** |
| Chestnut-sided Warbler | 1 | 19 | **20** |
| Magnolia Warbler | 2 | 2 | **4** |
| Yellow-rumped Warbler | 11 | 1 | **12** |
| Ovenbird | 2 | 1 | **3** |
| Mourning Warbler | 0 | 2 | **2** |
| Common Yellowthroat | 3 | 10 | **13** |
| Eastern Towhee | 1 | 0 | **1** |
| Chipping Sparrow | 13 | 13 | **26** |
| Field Sparrow | 1 | 0 | **1** |
| Savannah Sparrow | 23 | 10 | **33** |
| Song Sparrow | 17 | 19 | **36** |
| Northern Cardinal | 4 | 4 | **8** |
| Rose-breasted Grosbeak | 6 | 2 | **8** |

| Species | 5/10/2006 | 5/17/2006 | Total |
|---|---|---|---|
| Indigo Bunting | 0 | 1 | **1** |
| Bobolink | 59 | 57 | **116** |
| Red-winged Blackbird | 129 | 127 | **256** |
| Eastern Meadowlark | 1 | 0 | **1** |
| Common Grackle | 30 | 27 | **57** |
| Brown-headed Cowbird | 9 | 4 | **13** |
| Baltimore Oriole | 5 | 5 | **10** |
| Purple Finch | 3 | 0 | **3** |
| House Finch | 1 | 2 | **3** |
| American Goldfinch | 39 | 26 | **65** |
| **Total Birds:** | **680** | **611** | **1291** |
| **Species Count:** | **61** | **47** | |
| **Total Species:** | **67** | | |

Table F-2

## Wethersfiled Project Area
## Spring Migratory Bird Survey by Location

Totals From Two Surveys

| Species | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Canada Goose | 2 | 4 | 6 | 3 | 19 | 4 | 0 | 1 | 1 | 0 | 4 | 0 | 2 | 2 | 0 | 2 | 2 | 0 | 4 | 2 | 21 | 0 | 2 | 1 | **82** |
| Wood Duck | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **7** |
| Mallard | 0 | 0 | 4 | 0 | 2 | 0 | 2 | 4 | 3 | 0 | 0 | 0 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **20** |
| Ring-necked Pheasant | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **6** |
| Wild Turkey | 4 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **9** |
| Green Heron | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| Turkey Vulture | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| Northern Harrier | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Sharp-shinned Hawk | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | **1** |
| Red-tailed Hawk | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | **11** |
| Killdeer | 1 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | **10** |
| Ring-billed Gull | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **2** |
| Mourning Dove | 3 | 1 | 3 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 2 | 0 | 3 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | **19** |
| Yellow-bellied Sapsucker | 1 | 0 | 1 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | **10** |
| Downy Woodpecker | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **3** |
| Hairy Woodpecker | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Northern Flicker | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **6** |
| Eastern Wood-Pewee | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **1** |
| Least Flycatcher | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Great Crested Flycatcher | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **1** |
| Eastern Kingbird | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | **12** |
| Blue-headed Vireo | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Red-eyed Vireo | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **2** |
| Blue Jay | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 0 | 2 | **14** |
| American Crow | 3 | 2 | 8 | 8 | 3 | 8 | 4 | 7 | 13 | 6 | 5 | 5 | 9 | 4 | 4 | 3 | 6 | 7 | 7 | 11 | 3 | 1 | 5 | 1 | **133** |
| Common Raven | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Horned Lark | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **8** |
| Tree Swallow | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 4 | 2 | 0 | 4 | 0 | 4 | 1 | 1 | 1 | 3 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | **27** |
| N Rough-winged Swallow | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **4** |
| Cliff Swallow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| Barn Swallow | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 0 | 2 | 2 | 3 | 2 | 0 | 0 | 0 | 0 | **27** |
| Black-capped Chickadee | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | **11** |
| Tufted Titmouse | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | **6** |
| Golden-crowned Kinglet | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| Ruby-crowned Kinglet | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Eastern Bluebird | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **4** |
| Veery | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Wood Thrush | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| American Robin | 5 | 5 | 7 | 6 | 6 | 8 | 4 | 6 | 4 | 3 | 0 | 5 | 4 | 3 | 7 | 4 | 3 | 7 | 4 | 3 | 2 | 1 | 6 | 4 | **107** |
| Gray Catbird | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | **8** |
| Brown Thrasher | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **3** |
| Tennessee Warbler | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **2** |
| Nashville Warbler | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | **4** |
| Yellow Warbler | 4 | 0 | 0 | 1 | 1 | 0 | 1 | 3 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 2 | 1 | 0 | 2 | **22** |
| Chestnut-sided Warbler | 1 | 0 | 0 | 0 | 2 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 2 | 0 | 2 | 4 | 1 | **20** |
| Magnolia Warbler | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **4** |
| Yellow-rumped Warbler | 2 | 0 | 0 | 0 | 3 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | **12** |
| Ovenbird | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | **3** |
| Mourning Warbler | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | **2** |
| Common Yellowthroat | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 1 | **13** |
| Eastern Towhee | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Chipping Sparrow | 2 | 2 | 0 | 0 | 3 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 3 | 3 | 0 | 0 | 1 | 1 | 5 | 0 | 0 | 1 | **26** |

| Species | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Sparrow | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | [illegible] |
| Savannah Sparrow | 1 | 3 | 1 | 2 | 2 | 1 | 0 | 1 | 0 | 1 | 2 | 1 | 1 | 3 | 3 | 2 | 0 | 1 | 2 | 2 | 2 | 0 | 1 | 1 | 33 |
| Song Sparrow | 1 | 0 | 1 | 0 | 4 | 2 | 3 | 3 | 2 | 2 | 0 | 1 | 2 | 2 | 5 | 0 | 0 | 0 | 3 | 2 | 1 | 0 | 1 | 1 | 36 |
| Northern Cardinal | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 8 |
| Rose-breasted Grosbeak | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 8 |
| Indigo Bunting | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Bobolink | 3 | 4 | 3 | 2 | 1 | 2 | 2 | 4 | 5 | 4 | 22 | 5 | 24 | 18 | 0 | 0 | 6 | 5 | 6 | 0 | 0 | 0 | 0 | 0 | 116 |
| Red-winged Blackbird | 8 | 13 | 11 | 24 | 18 | 14 | 11 | 13 | 13 | 4 | 24 | 2 | 17 | 26 | 1 | 1 | 9 | 12 | 26 | 3 | 4 | 0 | 2 | 0 | 256 |
| Eastern Meadowlark | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Common Grackle | 0 | 5 | 6 | 4 | 3 | 0 | 5 | 2 | 5 | 0 | 0 | 3 | 5 | 3 | 4 | 2 | 0 | 6 | 2 | 1 | 0 | 0 | 1 | 0 | 57 |
| Brown-headed Cowbird | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 5 | 1 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 13 |
| Baltimore Oriole | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 10 |
| Purple Finch | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| House Finch | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| American Goldfinch | 10 | 0 | 1 | 1 | 5 | 6 | 0 | 1 | 1 | 1 | 0 | 6 | 1 | 1 | 9 | 0 | 0 | 4 | 4 | 1 | 6 | 2 | 1 | 4 | 65 |
| **Total Birds:** | **63** | **45** | **56** | **62** | **98** | **57** | **44** | **71** | **66** | **29** | **79** | **36** | **+02** | **66** | **48** | **28** | **36** | **54** | **74** | **36** | **66** | **16** | **29** | **28** | **1291** |
| **Species Count:** | **25** | **12** | **16** | **18** | **30** | **16** | **16** | **29** | **19** | **13** | **11** | **15** | **24** | **13** | **17** | **15** | **10** | **16** | **21** | **16** | **19** | **11** | **13** | **19** | |
| **Total Species:** | **67** | | | | | | | | | | | | | | | | | | | | | | | | |

Table F-3

## Wethersfield Project Area
## Breeding Bird Survey by Date

| **Species** | **6/05/2006** | **6/22/2006** | **Total** |
|---|---|---|---|
| Canada Goose | 12 | 0 | **12** |
| Ring-necked Pheasant | 1 | 0 | **1** |
| Broad-winged Hawk | 1 | 0 | **1** |
| Killdeer | 1 | 1 | **2** |
| Ring-billed Gull | 0 | 2 | **2** |
| Mourning Dove | 0 | 1 | **1** |
| Red-bellied Woodpecker | 1 | 0 | **1** |
| Yellow-bellied Sapsucker | 0 | 3 | **3** |
| Hairy Woodpecker | 1 | 0 | **1** |
| Northern Flicker | 1 | 1 | **2** |
| Eastern Wood-Pewee | 2 | 1 | **3** |
| Alder Flycatcher | 4 | 0 | **4** |
| Least Flycatcher | 1 | 1 | **2** |
| Eastern Phoebe | 2 | 0 | **2** |
| Great Crested Flycatcher | 2 | 0 | **2** |
| Eastern Kingbird | 1 | 4 | **5** |
| Warbling Vireo | 1 | 0 | **1** |
| Red-eyed Vireo | 13 | 6 | **19** |
| Blue Jay | 0 | 1 | **1** |
| American Crow | 12 | 19 | **31** |
| Barn Swallow | 4 | 2 | **6** |
| Black-capped Chickadee | 2 | 2 | **4** |
| White-breasted Nuthatch | 1 | 1 | **2** |
| House Wren | 1 | 1 | **2** |
| Veery | 4 | 3 | **7** |
| Hermit Thrush | 1 | 0 | **1** |
| Wood Thrush | 3 | 1 | **4** |
| American Robin | 15 | 9 | **24** |
| Gray Catbird | 2 | 1 | **3** |
| Cedar Waxwing | 12 | 11 | **23** |
| Blue-winged Warbler | 1 | 1 | **2** |
| Yellow Warbler | 12 | 1 | **13** |
| Chestnut-sided Warbler | 4 | 3 | **7** |
| Black-throated Blue Warbler | 1 | 0 | **1** |
| Black-thr. Green Warbler | 3 | 1 | **4** |
| American Redstart | 2 | 2 | **4** |
| Ovenbird | 5 | 3 | **8** |
| Mourning Warbler | 1 | 1 | **2** |
| Common Yellowthroat | 5 | 3 | **8** |
| Hooded Warbler | 1 | 2 | **3** |
| Scarlet Tanager | 1 | 1 | **2** |
| Eastern Towhee | 3 | 2 | **5** |
| Chipping Sparrow | 1 | 1 | **2** |
| Field Sparrow | 1 | 2 | **3** |
| Savannah Sparrow | 9 | 23 | **32** |
| Song Sparrow | 18 | 18 | **36** |
| Dark-eyed Junco | 0 | 1 | **1** |
| Indigo Bunting | 2 | 2 | **4** |
| Bobolink | 22 | 26 | **48** |
| Red-winged Blackbird | 13 | 24 | **37** |
| Eastern Meadowlark | 0 | 1 | **1** |
| Common Grackle | 2 | 2 | **4** |
| Brown-headed Cowbird | 3 | 0 | **3** |
| American Goldfinch | 4 | 2 | **6** |

| Species | 6/05/2006 | 6/22/2006 | Total |
|---|---|---|---|
| **Total Birds:** | 215 | 193 | 408 |
| **Species Count:** | 48 | 42 | |
| **Total Species:** | 54 | | |

Table F-4

## Wethersfield Project Area
## Breeding Bird Survey by Location

| Species | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Canada Goose | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 4 | 0 | 0 | 0 | 0 | **12** |
| Ring-necked Pheasant | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **1** |
| Broad-winged Hawk | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **1** |
| Killdeer | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| Ring-billed Gull | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **2** |
| Mourning Dove | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **1** |
| Red-bellied Woodpecker | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **1** |
| Yellow-bellied Sapsucker | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **3** |
| Hairy Woodpecker | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Northern Flicker | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | **2** |
| Eastern Wood-Pewee | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **3** |
| Alder Flycatcher | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **4** |
| Least Flycatcher | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | **2** |
| Eastern Phoebe | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| Great Crested Flycatcher | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **2** |
| Eastern Kingbird | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | **5** |
| Warbling Vireo | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **1** |
| Red-eyed Vireo | 1 | 1 | 3 | 0 | 0 | 4 | 2 | 1 | 0 | 1 | 2 | 0 | 2 | 2 | 0 | **19** |
| Blue Jay | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| American Crow | 0 | 1 | 3 | 0 | 1 | 3 | 2 | 0 | 11 | 1 | 1 | 0 | 2 | 1 | 5 | **31** |
| Barn Swallow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | **6** |
| Black-capped Chickadee | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | **4** |
| White-breasted Nuthatch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **2** |
| House Wren | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | **2** |
| Veery | 0 | 0 | 1 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | **7** |
| Hermit Thrush | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Wood Thrush | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **4** |
| American Robin | 0 | 5 | 5 | 0 | 0 | 3 | 1 | 0 | 2 | 6 | 2 | 0 | 0 | 0 | 0 | **24** |
| Gray Catbird | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **3** |
| Cedar Waxwing | 0 | 0 | 5 | 4 | 6 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 4 | 0 | 2 | **23** |
| Blue-winged Warbler | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **2** |
| Yellow Warbler | 4 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 1 | 0 | 0 | **13** |
| Chestnut-sided Warbler | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 1 | 0 | 0 | **7** |
| Black-throated Blue Warbler | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Black-thr. Green Warbler | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **4** |
| American Redstart | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | **4** |
| Ovenbird | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | **8** |
| Mourning Warbler | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| Common Yellowthroat | 2 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | **8** |
| Hooded Warbler | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **3** |
| Scarlet Tanager | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **2** |
| Eastern Towhee | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **5** |
| Chipping Sparrow | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| Field Sparrow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | **3** |
| Savannah Sparrow | 3 | 1 | 0 | 1 | 0 | 0 | 8 | 0 | 5 | 1 | 0 | 7 | 6 | 0 | 0 | **32** |
| Song Sparrow | 3 | 5 | 4 | 3 | 3 | 0 | 0 | 0 | 3 | 0 | 6 | 3 | 0 | 1 | 5 | **36** |
| Dark-eyed Junco | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Indigo Bunting | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | **4** |
| Bobolink | 1 | 4 | 0 | 3 | 0 | 0 | 10 | 0 | 7 | 1 | 0 | 10 | 9 | 0 | 3 | **48** |
| Red-winged Blackbird | 3 | 0 | 3 | 5 | 0 | 0 | 11 | 0 | 6 | 1 | 0 | 0 | 2 | 0 | 6 | **37** |
| Eastern Meadowlark | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Common Grackle | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | **4** |

| Species | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brown-headed Cowbird | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 |
| American Goldfinch | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 4 | 6 |
| **Total Birds:** | **20** | **32** | **31** | **16** | **31** | **25** | **37** | **5** | **56** | **23** | **39** | **23** | **32** | **8** | **30** | **408** |
| **Species Count:** | **10** | **17** | **13** | **5** | **16** | **13** | **9** | **4** | **14** | **15** | **21** | **6** | **12** | **7** | **10** | |
| **Total Species:** | **54** | | | | | | | | | | | | | | | |

# G Work Plan for Post-construction Bird and Bat Mortality Monitoring

002270_NP19_08-B2090

# Work Plan for Bird and Bat Post-construction Studies at the Wethersfield Windpark Towns of Wethersfield and Eagle, Wyoming County, New York

**January 2007**

**Prepared for:**

**Noble Environmental Power, LLC**
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Essex, Connecticut 06426

**Prepared by:**

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# Table of Contents

# List of Abbreviations and Acronyms

| | |
|---|---|
| asl | above sea level |
| DEIS | Draft Environmental Impact Statement |
| E & E | Ecology and Environment, Inc. |
| FAA | Federal Aviation Administration |
| GE | General Electric |
| kW | kilowatt |
| MTS | Modular Tower System |
| MW | megawatt |
| Noble | Noble Environmental Power, LLC |
| NWS | National Weather Service |
| NYSDEC | New York State Department of Environmental Conservation |
| ROW | right-of-way |
| USACE | United States Army Corps of Engineers |

# 1 Project Background and Study Area

## 1.1 Project Overview and Definitions

Noble Environmental Power, LLC (Noble) proposes to install and operate a wind energy facility (Project) in the Towns of Wethersfield and Eagle, Wyoming County, located in western New York State (see Figure 1-1).

The Project consists of the following:

- Installation and operation of 85 wind turbines with a capacity of 127.5 megawatts (MW) within an approximate 9,151-acre area in the Towns of Wethersfield and Eagle (Windpark) (see Figure 1-2);
- Construction and use of approximately 20 miles of access roads that will connect each wind turbine to a Town or County roadway to allow equipment and vehicle access for construction and subsequent maintenance of the facilities; and
- Construction and use of an electrical collection system that will allow delivery of electricity to a new substation to be constructed in the Town of Wethersfield as part of the transmission portion of the Project. Where practical, the electrical collection system will be installed underground along the same right-of-way (ROW) corridor as the access roads.

## 1.2 Turbine Description

The wind turbines that will be installed at the Windpark will be General Electric (GE) 1.5-MW, Model sle, 80-meter, Modular Tower System (MTS), T-Flange wind turbine generators[1]. The turbine is a three-bladed, upwind, horizontal-axis wind turbine with a rotor diameter of 253 feet (77 meters; see Figure 1-2). The nacelle is located at the top of each tower and contains the electrical generating equipment. The turbine rotor and nacelle are mounted on top of a tubular tower,

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[1] 1.5-MW refers to the production capacity of the turbine, which is 1.5 megawatts. The nomenclature "sle" is used to designate that the diameter size of the turbine rotor is 77 meters. 80-meter refers to the height of the tower. MTS (Modular Tower System) designates the type of tower configuration, and T-Flange designates the type of flange used to connect the tower directly to the foundation.

giving a rotor hub height of 263 feet (80 meters) (see Figure 1-3). The maximum height for the turbine is 389 feet (118.5 meters) when a rotor blade is at the top of its rotation. Once installed, each wind turbine will occupy a round, slightly exposed base approximately 18 feet in diameter.

Section 1.3 of the Draft Environmental Impact Statement (DEIS) describes the process used to select turbine site locations. A number of factors, including proximity to wetlands were evaluated in determining where to locate turbines. A specific discussion of impacts to wetlands is found in Section 2.8 of the DEIS. The proposed turbine sites represent a balancing of the site selection criteria.

## 1.3 Permitting Requirements

This work plan for bird and bat post-construction mortality studies was prepared by Ecology and Environment, Inc. (E & E) to address anticipated requirements that will be incorporated into the New York State Department of Environmental Conservation (NYSDEC), Article 15 and Article 24 permitting and United States Army Corps of Engineers (USACE) Section 404 and Section 10 permitting for the Project. It should be noted that NYSDEC is likely to require an overarching adaptive management strategy for evaluating actual impacts associated with the operation of the Project. As such, the methodology as outlined here, is a pilot study of methods to be used in subsequent years of post-construction studies. The scope may be revised to either increase the scope of the study, or reduce scope based upon the number of carcasses retrieved in relation to the actual number of hours/days searched, weather conditions, carcass removal rates, searcher efficiencies, or other parameters viewed as relevant following yearly review of the data.

# 2

# Study Objectives

Given the concern for bird and bat resources associated with wind energy facilities, quantifying the direct collisions with turbines is the key component of the studies. The studies are a compliment to preconstruction radar studies and field surveys that were conducted in the spring and fall of 2006 and are designed to quantify the bird and bat collision impacts from the Wethersfield Windpark during migratory periods (E & E 2006).

The objectives for the proposed plan of study are to:

- Collect quantitative collision data on birds and bats from the Wethersfield Windpark during migratory seasons. Estimates of numbers of fatalities will be determined for both bird and bats, both collectively, and on a species-by-species basis;

- Collect information on the occurrence of bat species in the Project Area during migratory seasons; and

- Evaluate the data and identify potential adaptive management strategies if collision impacts are significant.

# 3

# Methodology

To date, there is no consensus regarding methodologies for post-construction mortality monitoring studies at windparks, nor are there any formally accepted practices. Noble anticipates that NYSDEC will issue more defined guidance for post-construction monitoring requirements to standardize sampling between the various projects that are under construction or being proposed within the State. While the guidance has not yet been published, it is Noble's understanding that the guidance will be made available early in 2007, and as such, will be able to modify approaches, as appropriate, prior to the Wethersfield Windpark's operation. The methodologies proposed by Noble follow standard procedures currently used at communication towers and that have been applied to wind turbines in various locations in the United States. Noble has also integrated comments from ongoing discussions with NYSDEC bird and bat biologists.

### Task 1: Post-construction Bird and Bat Mortality Study

This post-construction study will estimate the magnitude of bird and bat collisions associated with the Wethersfield Windpark based on field surveys and statistical extrapolation. The study will be conducted over three successive years and focus on the migration periods for birds and bats. The results of this study will be useful to determine the collision impacts to migratory birds and bats and identify if the results are comparable with the estimated mortality rates included in the DEIS for this Project.

**Study Area.** When constructed, the Wethersfield Windpark will consist of 85 1.5-MW turbines within an approximate 9,151-acre area in the Towns of Wethersfield and Eagle, Wyoming County. The turbines will be distributed in loose clusters throughout the Project Area. The surface elevation of the Project Area approximately 2,070 feet above sea level (asl) with a total turbine height, from ground surface to full rotor blade extension, of approximately 389 feet. The Windpark will be lighted in accordance with Federal Aviation Administration (FAA) guidelines. No guy wires will be associated with the turbines, and there are also no locations suitable for perching or nesting by birds on the turbines. Access roads will connect to each turbine, allowing for vehicular access to conduct this study.

**Search Area.** Previous mortality studies at wind projects indicate that most fatalities are typically found within half the maximum distance from the tip height to the ground (Erickson and Kerns 2005). With a tip height of approximately 389 feet (118.5 meters), direct visual observations will be conducted within a 394-foot (120-meter) diameter plot from the turbine. The search area will be further separated into survey transect lines at 33-foot (10-meter) intervals, with 12 transects sited for each turbine surveyed. The transects will be located using a global positioning system and/or in field flagging to assure consistency between searchers and turbine sites.

Searches will be conducted at approximately one third of the total turbines. Therefore, 29 turbines will be searched for this study at the Wethersfield Windpark. Although the turbines to be searched would be selected randomly, the selection process will involve stratification by habitat. In other words, all habitats present (hayfield/grassland, brushland, forestland, and proximity to wetland complexes) would be represented so that differences in fatality rates among habitats could be evaluated via statistical analysis following data collection.

**Search Interval.** Based on discussions with NYSDEC, as well as on information generally available for other wind projects, Noble proposes to further divide the 29 turbines into three subsets. Daily searches will be conducted at 10 turbines, searches would be conducted twice a week (every third day) at 10 turbines, and the remaining nine turbines would be searched weekly. Adjustments may be necessary due to severe weather.

Although largely dependent on weather, Noble proposes that search efforts will extend from April 15 though October 15. Winter bird use of the Project Site is comparatively low and risk is considered minimal during this season. Although bird migration begins in late March, and can extend into November, the proposed time frame encompasses the peak of spring and fall passerine migration as well as the entire breeding season. Based on preliminary data collected at other constructed wind projects, much of the mortality that is noted is bat mortality and it occurs as specific events throughout the summer. Therefore, while bird mortalities would be associated primarily with spring and fall migration, the impacts to bats, specifically tree roosting species, will require mortality monitoring throughout the summer.

Prior to initiating the annual survey effort, each of the 29 turbine sites will be searched to locate residual carcasses that may have accumulated since the Project began operation.

**Field Search Methodology.** Each field surveyor will be trained in the search protocol in advance of his or her first fatality search. The 12 transect lines within each search area will be slowly walked, with surveys conducted by a team of two biologists. A search time of approximately 30 to 45 minutes per turbine is anticipated, although the time will vary based on habitat and terrain. Field modification of transect lines may be necessary to avoid unwalkable areas (e.g., dense forest, pit, steep slope). Prior to the commencement of sampling, the search areas beneath turbines (except forested areas) would be cleared of vegetation to facilitate the searchers' efforts. Except in agricultural areas, additional clearing would occur at monthly intervals throughout the duration of monitoring year.

All carcass observations, which may include feathers or portions thereof, will be mapped on a data sheet as to its location relative to specific transect lines. Additional information to be collected shall include the date; time; observer; identification of bird or bat species; if the carcass was intact or scavenged; if there were feather spots; as well as photographic documentation of the carcass and its location. Daily searches will commence near sunrise and proceed until all searches for the day are completed. Searches will be temporarily delayed if severe weather or safety conditions occur.

**Identification of Carcasses.** Any bird carcasses observed during the survey effort will be left undisturbed for use in the scavenging loss analysis. In the case of bat carcasses, final (confirmatory) identification would be by an expert (e.g., Al Hicks, NYSDEC). Based on discussions, all bat carcasses are to be collected and forwarded to NYSDEC for identification and storage. Noble will continue to coordinate with NYSDEC regarding possible on-site storage of certain bat carcasses and use for scavenging and efficiency trials.

Each carcass will be mapped on a data sheet in reference to its distance and bearing from the specific turbine. Photographic documentation will be collected of each observation. The field surveyor will attempt to identify each carcass to species. The photographic documentation will be reviewed to confirm the proper identification.

NYSDEC has requested that specific carcasses be submitted for stable radioisotope analysis to determine genetic diversity within local bat populations and possible the origin of individual bats. Based on recent information collected at the National Wind Coordinating Committee's annual meeting, Dr. Nancy Simmons, with the American Museum of Natural Science, will undertake a nationwide genetic analysis of tree-roosting bats to assess the genetic/population stability of these species. To support this effort, Noble will commit to submitting approximately 10 specimens of the following species per year toward this effort: Hoary Bat (*Lasiurus cinereus*), Eastern Red Bat (*L. borealis*), and Silver-haired Bat (*Lasionycteris noctivagans*). Final details of this portion of the carcass analysis, specifically collection protocols and cost, will be coordinated with NYSDEC.

**Weather.** Weather conditions from the night prior to each survey day will be collected from local sources and supplemented by National Weather Service (NWS) data. During each morning's carcass search, weather observations will be documented on all data sheets and will include, at a minimum, cloud cover, temperature, and wind direction and speed. Night visibility will be characterized by estimating the percent of cloud cover to the nearest quarter percent and by recording the presence or absence of fog. Additionally, precipitation records will also be gathered from NWS data sources.

**Scavenging Loss Estimations.** The proportion of bird and bat carcasses removed from the search area by other wildlife (scavengers) will be estimated based on the information collected. The number of days until scavenging removal occurs will be tracked for each bird and bat carcass found in the search area. The degree of scavenging prior to carcass removal will be documented during each search.

Additional carcasses will occasionally be placed at random locations within the search area based on bird and bat carcass availability. Placement of these "test carcasses" will be used primarily to determine searcher efficiency, but they will also be tracked for scavenging loss. Test carcasses will be those found from other locations, such as roadway or building collisions.

The estimates for scavenging loss will be factored in to the estimates for the total number of bird and bat fatalities during the study period.

**Searcher Efficiency.** To correct for detection bias, searcher efficiency will be estimated. Additional "test carcasses" will occasionally be placed at random locations within the search area based on bird and bat carcass availability. The test carcasses will be placed either one day before or on the day of the survey to reduce the potential for predation. The date, time, and location of test carcass placement will be documented. Someone besides the searchers will place the test carcasses and the presence of test carcasses will not be known by the searchers. The percentage of test carcasses found will be determined based on review of the data collected by the searchers.

**Mortality Estimation.** The mortality estimate for the Wethersfield Windpark will be calculated separately for birds and bats. Scavenging loss estimations, searcher efficiency, and the proportion of turbines searched will be used to adjust the total number of carcasses found during the searches.

To calculate the total number of fatalities for the period of time in which searches would be conducted (April to October), the estimator proposed in Erickson et al. (2003) would be used. For most of the species concerned, this time period would be an annual measurement of mortality. The rationale for this conclusion is that most species of birds and bats are not active or present during the period from November through March, so there is no risk of fatalities for those species during this time period. The point estimates for the fatality rates would be calculated for each season by the formula (or an appropriate variation of the formula):

$$m = \left(\frac{N * C}{k * t * p}\right)\left(\frac{e^{I/t} - 1 + p}{e^{I/t} - 1}\right)$$

where $N$ is equal to the total number of turbines, $C$ is the total number of carcasses detected for the period of study, $I$ is the interval between searches (in days), $t$ is the mean carcass removal time (in days), $p$ is the detection probability, and $k$ is the number of turbines sampled. This formula assumes correctness of the estimates for $t$ and $p$ (i.e., sampling error in those estimates is not considered). Fatality estimates for the entire period of study (April through October) would be calculated by summing the seasonal estimates.

**Utilization – Mortality Estimation.** The post-construction mortality estimation will be compared to the number of estimated collisions presented in the DEIS and to preconstruction radar study passage rates.

### Task 2: Acoustical Monitoring for Bats (Summer/Fall)

Acoustical monitoring via AnaBat equipment will be conducted during the summer/fall migratory period (approximately August 1 through September 30) of the first year of the study. AnaBat monitoring equipment will be installed on a meteorological tower, wind turbine, or other structure located in the Project Area. One monitoring unit will be installed as high on the structure as possible, while the other unit will be installed midway between that unit and the ground. It is anticipated that the monitoring units will be deployed within a guy wire system and pointed in the direction of anticipated migration (facing north). Bat echolocation data will be recorded digitally and analyzed for species or species-group identification.

AnaBat detectors will be used for the duration of this study. AnaBat detectors are frequency-division detectors, dividing the frequency of ultrasonic calls made by bats so that they are audible to humans. Frequency division detectors will be used based upon their widespread use for this type of survey, their ability to be deployed for long periods of time, and their ability to detect a broad range of frequency, which allows detection of all species of bats that could occur in New York. Data from the AnaBat detectors will be logged onto compact flash media and downloaded to a computer for analysis. Detectors will be programmed to record data from 7:00 p.m. to 7:00 a.m. every night.

Call files will be extracted from data files using appropriate software, with default settings in place. Call files will be visually screened to remove files caused by wind, insect noise, and other static so that only bat calls remain. Nightly tallies of detected calls will be compiled for each detector and each night. Detection rates indicate only the number of calls detected and do not necessarily reflect the number of individual bats in an area.

Call files will be examined visually and assigned to species categories based on comparison to libraries of known bat reference calls. Categorization of calls is possible only when clear calls are recorded and only with certain species. The tree-roosting bats are typically easy to identify to species while those of the genus

*Myotis* are not. Call rates by species, as well as total detections and trends in species' presence in the data set, will be reported. Comparisons between call rates and species composition will also be compared between the detectors.

The results of the acoustical monitoring study will be compared to the mortality study results and weather data to identify if any temporal similarities occurred between abundance and mortality.

### Task 3: Post-construction Study Report and Adaptive Management Review

A preliminary report will be prepared that will evaluate the results from the post-construction bird and bat mortality study and acoustical monitoring study based on the first year of data. Potential adaptive management measures will be identified if significant adverse impacts occur. The mortality study methodology will also be evaluated in this preliminary report. If necessary, changes will be identified for implementing the second year of the mortality study. A similar preliminary report will be prepared after the second year of the study and a final report that evaluates all of the data collected during the study will be prepared after the third year of the study.

Noble will continue to coordinate with NYSDEC regarding the adequacy of survey methodologies following review of annual reports. The need for adaptive management strategies will be assessed based on the results of the previous year's surveys.

# 4 References

Ecology and Environment, Inc., (E & E). 2006. *Work Plan for Avian and Bat Studies at Proposed Wethersfield Windpark, Towns of Wethersfield and Eagle, Wyoming County, New York.* Report prepared for Noble Environmental Power, LLC and provided to the New York State Department of Environmental Conservation and the United States Fish and Wildlife Service.

Erickson, W. and J. Kerns. 2005. Bat mortality at wind energy facilities during fall migration: A proposal for intensive mortality searches. Appendix V in E.B. Arnett, technical editor, Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International, Austin, Texas, USA.

Erickson, W., J. Jeffrey, K. Kronner, and K. Bay. 2003. *Stateline wind project wildlife monitoring annual report, results for the period July 2001 – December 2002.* Technical Report to FPL Energy, Oregon Office of Energy, and Stateline Technical Advisory Committee.

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# Visual Impact Assessment

- Noble Wethersfield Windpark, LLC. Visual Resources Assessment. Saratoga Associates. January 10, 2007.
- Noble Wethersfield Windpark, LLC. Supplemental Visual Resource Assessment – Cumulative Evaluation. Saratoga Associates. January 26, 2007.
- Noble Wethersfield Windpark, LLC. Shadow Analysis. Saratoga Associates. January 10, 2007.
- FAA Lighting Plan. Aviation Systems, Inc. December 8, 2006.

# Noble Wethersfield Windpark, LLC. Visual Resources Assessment

Saratoga Associates

January 10, 2007

SARATOGA
ASSOCIATES

# NOBLE WETHERSFIELD WINDPARK, LLC
# VISUAL RESOURCE ASSESSMENT

Prepared for:
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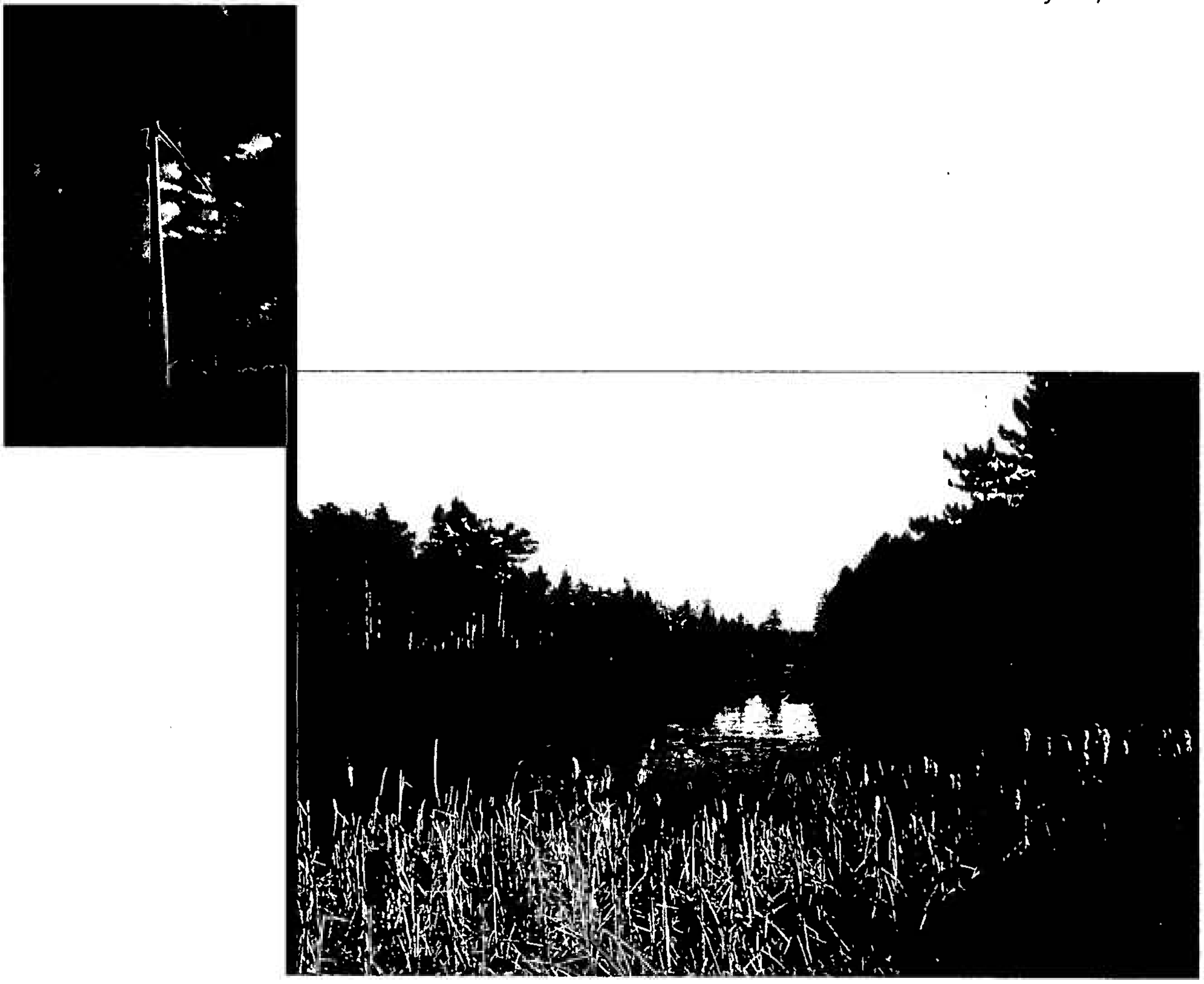
January 10, 2007



Landscape Architects, Architects,
Engineers and Planners, P.C.

#06-108

## Noble Wethersfield Windpark, LLC – Visual Resource Assessment

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# 1.0 INTRODUCTION

Noble Wethersfield Windpark, LLC (Noble) is proposing to develop a wind-powered generating facility consisting of 85 turbines with a capacity of approximately 127.5 megawatts (MW) in the Towns of Wethersfield and Eagle, Wyoming County, New York. The Noble Wethersfield Windpark (hereafter referred to as the "Project") will provide a viable means of generating electricity for use by customers in the New York State power pool.

To address issues of potential visual impact Noble has retained Saratoga Associates, Landscape Architects, Architects, Engineers, and Planners, P.C. to conduct a thorough and detailed Visual Resource Assessment (VRA) of the proposed Project. The purpose of this VRA is to identify potential visual and aesthetic impacts and to provide an objective assessment of the visual character of the Project, using standard accepted methodologies of visual assessment, from which agency decision-makers can render a supportable determination of visual significance.

This VRA does not include a comprehensive analysis of the Projects proposed transmission line. A petition for a Certificate of Public Convenience and Necessity (CPCN) will be filed for the generation portion of the Project, pursuant to Section 68 of the New York State Public Service Law, and an Application for a Certificate of Environmental Compatibility and Public Need has been filed for the transmission components, pursuant to Article VII of the NYS Public Service Law. A detailed description of the transmission line and an evaluation of its impacts can be found in the Article VII Application that will be submitted to the Public Service Commission in January 2007

## 1.1 METHODOLOGY

Consistent with Visual Resource Assessment (VRA) practice, this report evaluates the potential visibility of the proposed Project and objectively determines the difference between the visual characteristics of the landscape setting with and without the Project in place. The process used follows basic New York State Department of Environmental Conservation Program Policy "Assessing and Mitigating Visual Impacts" (NYSDEC 2000) (DEC Visual Policy) and State Environmental Quality Review (SEQRA) criteria to minimize impacts on visual resources. This process provides a practical guide so decision makers and the public can understand the potential visual impacts and make an informed judgment about their significance (aesthetic impact).

There are no specific Federal rules, regulations, or policies governing the evaluation of visual resources. However, the methodology employed herein is based on standards and procedures used by the U.S. Department of Agriculture (National Forest Service, 1974, 1995), U.S. Department of the Interior, Bureau of Land Management (USDOI, 1980), U.S. Department of Transportation, Federal Highway Administration (USDOT, 1981), NYS Department of Transportation (NYSDOT, 1988), and the NYS Department of Environmental Conservation (NYSDEC, July 31, 2000).

This evaluation includes both quantitative (how much is seen and from what locations; or visual impact) and qualitative (how it will be perceived; aesthetic impact) aspects of visual assessment.

The visual impact assessment includes the following steps:

- Define the existing landscape character/visual setting to establish the baseline visual condition from which visual change is evaluated;
- Conduct a visibility analysis (viewshed mapping and field investigations) to define the geographic area surrounding the proposed facility from which portions of the Project might be seen;
- Identify sensitive aesthetic resources to establish priority places from which further analysis of potential visual impact is conducted;
- Select key receptors from which detailed impact analysis is conducted;
- Depict the appearance of the facility upon completion of construction;
- Evaluate the aesthetic effects of the visual change (qualitative analysis) resulting from Project construction, completion and operation; and,
- Identify opportunities for effective mitigation.

Consistent with the DEC Visual Policy, the visual study area for this VRA generally extends to a 5-mile radius from the outermost turbines (hereafter referred to as the "five-mile radius study area" or "study area"). Beyond this distance it is assumed that natural conditions of atmospheric and linear perspective will significantly mitigate most visual impacts. However, considering the scale of the proposed Project and recognizing the proposed wind turbines will, at times, be visible at distances greater than five miles, site-specific consideration is given to resources of high cultural or scenic importance that are located beyond the typical 5-mile radius.

This VRA was prepared by a New York State registered Landscape Architect experienced in the specialized discipline of visual and aesthetic impact assessment.

## 1.2 PROJECT DESCRIPTION

The proposed Project area is located approximately 45 miles southeast of Buffalo, 25 miles south of Batavia, and 55 miles southwest of Rochester. The Project includes 85 energy-generating turbines arranged in clusters along a series of broad plateau-like ridgetops in the Towns of Wethersfield and Eagle (Wyoming County). Generally, the turbines extend from south of Wethersfield Road to north of NYS Route 39 and east of Younger Road to west of NYS Route 238/Sheppard Road. Turbines will be located on private land under lease agreement with property owners.

Each turbine will generally sit on an octagon shaped concrete pad (approximately 48' at its widest point) and be connected to the other turbines by a series of gravel access roads. Permanent access roads will typically be 12 feet wide. At a minimum, adjacent turbines will be spaced approximately 800-1,000 feet apart. Following construction of the Project, deforested areas will be maintained as grass/shrubs, while agricultural activities will resume up to the margins of turbine pads and access roads. Turbines will maintain a minimum setback of 1,320 feet from non-participated residential structure, 1,000 feet from the nearest participating residential structure and 500 feet from public roads and non-participating property lines.

The turbines themselves will each have a rated power of 1.5 MW, with a maximum capacity of 127.5 MW. Depending on final turbine selection, the turbine towers will be approximately 263 feet tall from ground to nacelle (hub). The tower will be approximately 16 feet wide at the base and eight (8) feet wide at the top. Each of the three turbine blades will be 123 feet in length with the apex of blade rotation reaching approximately 389 feet above ground elevation. The maximum rotation speed of the blades will be 17 revolutions per minute (rpm), or approximately one (1) revolution every three (3) seconds. The color of the blades, nacelle, and tower will be off-white. The towers will be a tubular shaped monopole.

A primarily underground interconnect will link the 85 proposed turbines. The windpark will be connected to an existing transmission line north of the site, via a proposed aboveground transmission line. The transmission line will include a switchyard and substation, and approximately 60 structures (ranging in height between 70 and 83.5 feet) along a 5.5-mile corridor through the Towns of Wethersfield and Orangeville. The transmission route will start at a proposed substation in the Town of Wethersfield (north of Devinney Road) and travel in a northeasterly direction for approximately 5.5 miles, where it will terminate at a proposed Orangeville switchyard (north of the Hermitage and Liberty Road intersection) and connect to the existing NYSEG 230 kV transmission line. The substation will be 200 feet by 300 feet and the switchyard will be 300 feet by 400 feet.

During construction, a construction equipment laydown and parking area will be located within the Project area. Construction is expected to begin in late 2007 and be completed in late 2008.

During operations, the wind generating facility requires very little active maintenance. It is anticipated that up to eleven staff members will be employed as a result of this Project. Typically, on-site personnel are not required on a daily basis. Under normal conditions, wind turbines operate automatically at a single speed. For the turbines Noble plans to use for this Project, a minimum wind speed of approximately 7 mph is required. High-speed shutdowns occur at approximately 55 mph. Each turbine has a computer which controls operations, monitoring of wind conditions, and provides report data.

### 1.2.1 Aviation Obstruction Marking and Lighting

According to the FAA, daytime lighting of wind turbines, in general, is not necessary. Turbines themselves, due to their solid (nonskeletal) construction, as well as their moving characteristics, provide sufficient warning to pilots during all daytime conditions and all documented terrain and sky conditions. Turbines should be painted either bright white, or a slight shade from white, to provide the maximum daytime conspicuity.

The FAA requires lighting at the outermost turbines in the linear string, as well as on interior turbines of a maximum gap between lit turbines of no more than ½ mile (2,640 feet). Based on these guidelines approximately 36 of the proposed turbines will be illuminated at night for aviation safety.

In accordance with FAA guidance, lighting is expecting to be slow flashing L-864 red lights. The FAA recommends red light emitting diode or rapid discharge style L-864 fixtures to minimize impacts on neighboring communities, as the fixtures' exposure time is minimal, thus creating less of a nuisance.

All light fixtures within the farm must flash in unison, thus delineating the farm as one large obstruction to pilots.[1]

The L-864 unit is a low intensity light emitting 2,000 candelas.[2] This compares to 120 candelas emitted by a 100-watt incandescent lightbulb[3] and vehicular daytime running lamps that produce up to 7,000 candela.[4]

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[1] U.S. Department of Transportation, Federal Aviation Administration, "*Development of Obstruction Lighting Standards for Wind Turbine Farms*" (DOT/FAA/AR-TN05/50, November 2005)

[2] Candela is the luminous intensity, in a given direction

[3] http://en.wikipedia.org/wiki/Candela

[4] http://en.wikipedia.org/wiki/Automotive_lighting

# 2.0 LANDSCAPE CHARACTER/VISUAL SETTING

Landscape character is defined by the basic pattern of landform, vegetation, water features, land use, and human development. This descriptive section offers an overview of the intrinsic visual condition of the study area and establishes the baseline condition from which to evaluate visual change.

The study area is decidedly rural and largely undeveloped. The population of the Town of Wethersfield is only 891 while the population of the Town of Eagle is 1,194. Broad tracts of agricultural land are either actively maintained or brush covered due to inactivity (fallow fields). Mature deciduous woodlands typically cover steep slopes, hilltops, ravines, stream corridors and other areas historically unsuitable for agricultural use. Other land cover includes yards, hedgerows, farmsteads low-density residential uses, streams, small lakes, and ponds. With the exception of the more developed Village of Gainesville, and hamlets of Bliss and North Java, built features typically include low-density single-family residential structures and farmsteads. Undulating hills and ridges rising more than 1,400 feet above Lake Erie, approximately 35 miles to the west, and Lake Ontario, approximately 45 miles to the north. These hills are the dominant landscape element and form the visible horizon.

## 2.1 TOPOGRAPHY

The proposed Project occupies a small portion of the northern edge of the Cattaraugus Hills, which is a subregion of the Appalachian Upland. This topographic feature rises slowly from the relatively flat bottom lands of the bordering Erie Lake and the Southern Ontario Plains, to a series of broad undulating ridge tops with deeply cut generally north-south aligned ravines and valleys. Although the surface of the plateau appears rather even when viewed from a distance, close examination reveals little level land. Valleys are numerous and narrow.

Uplands are relatively broad, undulating plateaus with elevations generally ranging between 1,600 feet to 2,050 feet above sea level. Terrain consists largely of undulating hills, ridges and areas of smaller rounded hillocks, often bisected by ravines.

## 2.2 VEGETATION

Dominant tree species within the study area are representative of the northern hardwood zone found throughout much of the Western New York Region. Species include beech, maple, ash, elm and hemlock. In addition to these deciduous climax species, isolated plantings of red and white pine are scattered throughout the study area. Coinciding with the mix of open field and woodlots is a significant amount of secondary growth edge habitat. For the most part, this secondary growth takes the form of hedgerows, wood borders, and old fields.

## 2.3 WATER FEATURES

Water features are not a major component of the visual landscape within the vicinity of the proposed Project. The most prominent water resources within the study area include Wiscoy Creek, Cattaraugus Creek, East Koy Creek, and Tonawanda Creek. With the exception of the Tonawanda Creek (which flows in a northwest direction), these waterways generally flow to the south and east. Additional notable resources within the study area include Faun Lake and Java Lake. Numerous private farm ponds, scattered wetlands, and small streams are also found in the study area.

## 2.4 TRANSPORTATION

The primary roadways that bisect the study area are New York State Route 78 (east-west), and New York State Routes 238 and 362 (north-south). New York State Route 78 is approximately 74 miles in length and extends from Gainesville to Olcott (New York State Route 18).[5] New York State Route 238 (Hermitage Road) is approximately 5.8 miles in length. The shortest New York State Route in the study area is Route 362, which is approximately 4 miles in length[6]. These major roadways are typically two-lane asphalt roadways. Several county designated routes and town roads traverse the study area. In addition, there are several seasonal roadways throughout the study area.

## 2.5 POPULATION CENTERS

Lowland Communities - Lowland communities include the Village of Gainesville, Java Center and hamlets such as North Java, North Gainesville, Southburg, East Arcade and Rock Glen. Generally, these communities are between 200 and 400 feet below the Project site.

The Village of Gainesville (pop. 304) is located along New York State Route 19. This lowland community is approximately five miles from the nearest proposed turbine and is more than 200 feet below the Project site. This Village is generally a residential community, however it does contain limited services such as small-scale manufacturing, commercial, and institutional uses. A variety of architectural periods/styles can be found within the Village. Development density drops sharply as one moves away from the center of the Village. Residential dwellings within this community tend to be older and well maintained with mature vegetation lining the roadways. Activities generally relate to business, residential, and local travel.

Additional lowland communities include Java Center and hamlets such as North Java, North Gainesville, Southburg, and East Arcade. In many instances, these communities could be considered cross-road hamlets as they are defined by a few residential structures at intersecting roadways. Generally, structures within these communities consist of low-density residential housing. Residential dwellings within these communities tend to be older and well maintained with mature vegetation lining the roadways. Little or no commercial centers exist and the organization of the hamlets are dictated largely by transportation corridors. Activities are generally related to business (including agricultural), residential, and local travel.

Upland Communities –Upland communities include the hamlets of Bliss, Hermitage, Smiths Corner, Halls Corner, Wethersfield Springs and Wing. Generally, these communities are roughly at the same elevation as the Project site.

The hamlet of Bliss, which is considered the larger of the communities within this group, is located north of the New York State Route 39 and 362 intersection. Bliss is generally a residential community,

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[5] http://www.answers.com/new%20york%20state%20route%2078
[6] http://www.answers.com/new%20york%20state%20route%20362

however it does contain recreational opportunities (e.g. fishing access, racetrack, and the Rita George Recreation Hall and Playground), and limited services such as commercial and institutional uses. Development density drops sharply as one moves away from the center of the hamlet. Residential dwellings within these communities tend to be older and generally well maintained. Activities within this community generally relate to business, recreation, residential, and local travel.

Additional upland communities include the hamlets of Hermitage, Smiths Corner, Halls Corner, Wethersfield Springs and Wing. In many instances, these communities could be considered crossroad hamlets as they are defined by a few residential structures at intersecting roadways. Generally, structures within these communities consist of low-density residential housing. Residential dwellings within these communities tend to be older and well maintained with mature vegetation lining the roadways. Little or no commercial centers exist and the organization of the hamlets are dictated largely by transportation corridors. Activities are generally related to business (agricultural), residential, and local travel.

Rural Residential Areas - Very low-density rural homes (a mix of old and new) and accessory structures (barns, garages, etc.) are scattered throughout the study area. Residences are often found in roadside locations, however many are located on isolated lots out of view of local roads. Rural homes range in quality from well maintained single-family frame construction to older housing stock in need of repair.

Seasonal homes, camps and cabins appear to be scattered throughout the study area. Most such residences are typically found in remote locations off of local roads and range in quality from well maintained fully insulated four season residences to uninsulated hunting cabins, mobile homes and recreational trailers.

## 2.6 WETHERSFIELD WIND FARM

The Wethersfield wind farm project is a 10 unit, 6.6-megawatt facility located in the Town of Wethersfield approximately one (1) mile north of the proposed Project. The Wethersfield wind farm project was constructed in 2000. Each wind turbine consists of 213-foot tall tubular steel tower, a 154-foot diameter three-bladed rotor connected to a gearbox and generator. The total turbine height is approximately 290 feet to the apex of blade rotation.[7]

Wyoming County actively promotes the clean energy Wethersfield wind farm.[8]

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[7] http://www.newwindenergy.com/windfarm_wethersfield.html
[8] http://www.wyomingcountyny.com/daytrips.php

# 3.0 VISUAL IMPACT ASSESSMENT

## 3.1 VIEWSHED MAPPING (ZONE OF VISUAL INFLUENCE)

### 3.1.1 Viewshed Methodology

The first step in identifying potentially affected visual resources is to determine whether or not the proposed Project would likely be visible from a given location. Viewshed maps are prepared for this purpose. Also known as defining the zone of visual influence, viewshed mapping identifies the geographic area within which there is a relatively high probability that some portion of the proposed Project would be visible.

The overall accuracy of viewshed mapping is dependent on the number and location of control points (study points representing proposed turbines) used in the viewshed calculation. To calculate the maximum range of potential turbine visibility, one control point was established at the turbine high point (i.e., apex of blade rotation) for each of the 85 proposed turbines. For these viewsheds a conservative height of 393 feet were used for the apex of blade rotation. The resulting composite viewshed identifies the geographic area within the 5-mile study radius where some portion of the proposed windpark (the apex of one or more turbine blades) is theoretically visible.

One viewshed map was prepared defining the area within which there would be no visibility of the Project because of the screening effect caused by intervening topography (See Figure 1 - Proposed Turbine Viewshed – Topography Only on page 17). This treeless condition analysis is used to identify the maximum potential geographic area within which further investigation is appropriate. A second map was prepared illustrating the probable screening effect of existing mature vegetation. This treed (leaf-on) condition viewshed, although not considered absolutely definitive, acceptably identifies the geographic area within which one would expect to be substantially screened by intervening forest vegetation (See Figure 2 - Proposed Turbine Viewshed – Vegetated on page 18).

Identified viewshed areas are further quantified to illustrate the number of turbines that may be visible from any given area. This cumulative degree of visibility is summarized on each map using the following groupings:

- 1-5 turbines visible;
- 6-10 turbines visible;
- 11-20 turbines visible;
- 21-30 turbines visible;
- 31-40 turbines visible;
- 41-50 turbines visible;
- 51-60 turbines visible;
- 61-70 turbines visible; and
- 71-85 turbines visible.

By themselves, the viewshed maps do not determine how much of each turbine is visible above intervening landform or vegetation (e.g., 100%, 50%, 10% etc. of total turbine height), but rather identify the geographic area within which there is a relatively high probability (theoretical visibility) that some portion of one or more turbines would be visible. Their primary purpose is to assist in determining the potential visibility of the proposed Project from the identified visual resources.

To develop each individual viewshed map, a digital base map was prepared using 1:24,000-scale NYSDOT Raster Quadrangle obtained through the NYS GIS Clearinghouse. In this evaluation, ArcGIS 9.1 and ArcGIS 3D Analyst software was used to generate a viewshed overlay map based on publicly available digital topographic and vegetation data sets. Viewshed overlays were created by first importing a digital elevation model (DEM) of the study area. This DEM, obtained through the United State Geologic Survey from its National Elevation Dataset, is based on the best available digital elevation data including the 1:24,000-scale USGS topographic maps (10-foot contour intervals) and is accurate to a 10-meter grid cell resolution. The computer then scanned 360 degrees across this DEM from each control point, distinguishing between grid cells that would be hidden from view and those that would be visible based solely on topography. Areas of the surrounding landscape were identified where each control point would be visible; areas in shadow would not be visible.

Vegetation data was extracted from the NOAA Coastal Services Coastal Change Analysis Program (C-CAP). The C-CAP dataset, produced by the NOAA Coastal Services Center, was developed from LandSat 7 Thematic Mapper (TM) imagery (2000) and is accurate to a 30-meter grid cell resolution.[9] The screening effect of vegetation was then incorporated by adding 40 feet in height to DEM grid cells that are completely forested (according to C-CAP dataset) and repeating the calculation procedure. Based on field observation, most trees in forested portions of the study area are significantly taller than 40 feet. This height thus represents a conservative estimate of the effect of vegetative screening.

It is important to note that the C-CAP dataset is based on interpretation of forest areas that are clearly distinguishable from multispecteral satellite imagery. As such, the potential screening value of site-specific vegetative cover such as small hedgerows and individual trees and other areas of non-forest tree cover may not be represented in the viewshed analysis. Furthermore, the NLDC dataset does not include the screening value of existing structures. This is a particularly important distinction in the populated areas including the Gainesville, Bliss, North Java, Java Center and other commercial and residential areas where existing structures are likely to provide significant screening of distant views. With these conditions, the viewshed map conservatively overestimates potential Project visibility in areas where the Project may be substantially screened from view.

It is noteworthy that untrained reviewers often misinterpret treeless condition viewshed maps to represent wintertime, or leafless condition visibility (i.e., Figure 1 - ). In fact, deciduous woodlands provide a substantial visual barrier in all seasons. Since the NLDC dataset generally identifies only larger stands of woodland vegetation that is clearly distinguishable from multispecteral satellite imagery, viewshed maps that include the screening value of existing vegetation are equally representative of both leaf-on and leaf-off seasons (i.e., Figure 2 - Proposed Turbine Viewshed –

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[9] Thirty-meter resolution is the smallest vegetative grid cell increment commonly available for the project region. This resolution provides an appropriate degree of accuracy for development of five-mile viewshed maps given the fairly broad patterns of existing land use in the area, as well as the accuracy of mapped topographic data (i.e., 1:24,000-scale USGS topographic maps with 10-foot contour intervals)

Vegetated). Treeless condition analysis is provided only to assist experienced visual analysts identify the maximum potential geographic area within which further investigation is appropriate. Such topography-only viewshed maps are not generally intended or appropriate for public interpretation of presentation.

Finally, the viewshed maps indicate locations in the surrounding landscape in which one or more turbine highpoints (i.e. apex of blade rotation) might be visible. These maps do not imply the magnitude of visibility (i.e., how much of each turbine is visible), the viewer's distance from each visible turbine or the aesthetic character of what may be seen. Such interpretation is the subject of the next phase of analysis (see sections 3.4 and 3.5 below).

### 3.1.2 Nighttime Visibility

A viewshed map (i.e. Figure 3 - Proposed FAA Viewshed – Vegetated) was created to assist in evaluating potential nighttime visibility. This map used the same methodology as described above, however, the map was created using the approximate height (265 feet) of the FAA required strobe lights as the control point for 36 turbines. These 36 turbines were selected based on a preliminary lighting plan prepared by Noble. The viewshed map took into account the screening potential of intervening topography and vegetation.

### 3.1.3 Verification of Viewshed Accuracy

Because the viewshed map identifies the geographic area within which one or more of the proposed turbines could theoretically be visible, but does not specify which of the 85 turbines would be within view, it is not readily feasible to field confirm viewshed accuracy. While it is common practice to field confirm viewshed maps prepared for a single study point through the use of balloon study or more intuitive means, the inability to field confirm viewshed accuracy is unique to analysis of multiple point Projects covering a large geography, such as wind farms.

To help determine the accuracy of the vegetation data used for viewshed development, the NLDC data set was overlaid on a color infrared aerial image (1994-1998) of the study area and reviewed for consistency. While minor inconsistencies were noted, including areas of recently cleared lands, areas of inactive/abandoned agricultural land showing a degree of pioneer species growth and areas of non-forest vegetative cover, the vast majority of woodland areas visible on the satellite image were highly consistent with the NLDC overlay.

### 3.1.4 Viewshed Interpretation

Table 1 indicates the degree of theoretical visibility illustrated on the viewshed maps within the 5-mile radius study area.

## Table 1 - Viewshed Coverage Summary

| | **Topography Only Viewshed**<br>(Figure 1 - Proposed Turbine Viewshed – Topography Only) | | **Vegetation and Topography Viewshed**<br>(Figure 2 - Proposed Turbine Viewshed – Vegetated) | |
|---|---|---|---|---|
| | **Acres** | **Percent Cover** | **Acres** | **Percent cover** |
| No Turbines Visible | 33,033 | 29.0 | 78,396 | 68.9 |
| 1-5 Turbine Visible | 9,580 | 8.4 | 7,544 | 6.6 |
| 6-10 Turbines Visible | 5,273 | 4.6 | 3,958 | 3.5 |
| 11-20 Turbines Visible | 9,687 | 8.5 | 6,350 | 5.6 |
| 21-30 Turbines Visible | 9,170 | 8.1 | 4,714 | 4.2 |
| 31-40 Turbines Visible | 7,305 | 6.4 | 3,183 | 2.8 |
| 41-50 Turbines Visible | 6,791 | 6.0 | 2,439 | 2.2 |
| 51-60 Turbines Visible | 6,336 | 5.6 | 2,209 | 1.9 |
| 61-70 Turbines Visible | 6,472 | 5.7 | 1,969 | 1.7 |
| 71-85 Turbines Visible | 20,101 | 17.7 | 2,986 | 2.6 |
| Total | 113,748 | 100.0 | 113,748 | 100.0 |

*Table 1 and Figure 1 - on page 17, illustrate that one or more turbine highpoints (i.e. apex of blade rotation) is theoretically visible from approximately 71 percent of the five-mile study radius. However, as discussed above, this unrealistic treeless condition analysis is used only to identify the maximum potential geographic area within which further investigation is appropriate. This viewshed is not representative of the anticipated geographic extent of visibility and is not intended for public interpretation. Acreage quantities in Table 1 and 2 are rounded to nearest whole number.

## **Table 2** – FAA Viewshed Coverage Summary

| | **Vegetation and Topography Viewshed**<br>Figure 3 - Proposed FAA Viewshed – Vegetated | |
|---|---|---|
| | **Acres** | **Percent cover** |
| No Turbine Lights Visible | 83,818 | 73.7 |
| 1-5 Turbine Lights | 12,658 | 11.1 |
| 6-10 Turbine Lights | 7,006 | 6.2 |
| 11-15 Turbine Lights | 3,841 | 3.4 |
| 16-20 Turbine Lights | 2,584 | 2.3 |
| 21-25 Turbine Lights | 1,980 | 1.6 |
| 26-30 Turbine Lights | 1,101 | 1.0 |
| 31-36 Turbine Lights | 760 | 0.7 |
| Total | 113,748 | 100% |

Table 1 and Figure 2 - Proposed Turbine Viewshed – Vegetated on page 18– Viewshed maps clearly indicate that one or more of the proposed structures will be theoretically visible from approximately 31 percent of the five-mile radius study area. Approximately 69 percent of the study area will likely have no visibility of any of the structures. Visibility is most common within the center of the study area. Visibility will be most evident in the agricultural uplands from cleared lands with down slope vistas in the direction of the proposed Project. Much of the hilltops and valley floors within the study area are cleared for agricultural use.

Views within the Village of Gainesville, which is approximately five (5) miles from the nearest turbine, will be partially screened by intervening vegetation and localized structures. Filtered or framed views are possible through foreground vegetation in isolated locations. Direct views are more prevalent on the outskirts of the village where localized structures (e.g. residential and commercial), street trees and site landscaping are less likely to provide a visual barrier. Overall, visual impacts from the Village of Gainesville should be substantially reduced by screening (e.g. structures and localized vegetation), the relatively long distance between the village and the Project, and the generally low/slim profile of the Project components.

Views within the hamlet of Bliss will also be available. Similar to the Village of Gainesville it is anticipated that many views will be partially screened by intervening vegetation and localized structures. However there will be open views of the Project along Main Street. With the exception of those attending a race or the Rita George Recreation Hall and Playground, views along Main Street appear to be relatively brief. For those with extended views, it is anticipated that the activity they are involved with will take precedence over the visibility of the turbines.

No views will occur behind the many hills and within ravines found throughout the study area. Where topography is oriented toward the turbine components, dense forest cover commonly prevents distant views.

Views of the Project will be available from elevated locations, along many of the major roadways (e.g. New York State Routes 78, 98, 238 (Hermitage Road) and 362), and county and local roadways (e.g. Hobday Road, Mote Road, and Murphy Road). Many of these views along the roadways may be long distant (background view) and fleeting as viewers pass in vehicles. However, these may be five (5) miles or more, and include current views the existing Wethersfield wind farm.

The area most directly affected by views of the Project will be the agricultural upland within immediate proximity of the Project. The rural areas along New York State Route 78, Mote Road, Maxwell Road, Hobday Road and other roads in these areas will experience a high degree of visibility. Residents and visitors will regularly encounter proximate views of one or more turbines within the foreground and near-middleground distances (e.g., ½ to 1 ½ miles); the distance where the visual contrast of the turbines will be greatest. Along portions of New York State Route 362 and roadways such as Maxwell, Hobday, Devinney, and West Hill turbines may be located both sides of the viewer. Within such close proximity, turbines frequently appear and disappear behind intervening foreground landform and vegetation as viewers move about the Project area. It is also important to note that within this area, there are often views of the existing Wethersfield wind farm

As illustrated in Table 2 and Figure 3 - Proposed FAA Viewshed – Vegetated, the viewshed map indicates that one or more of the 36 FAA required light sources will be theoretically visible from approximately 26 percent of the five-mile radius study area. Approximately 74 percent of the study area will likely have no visibility of any proposed light sources. Visibility will be most evident in the agricultural uplands from cleared lands with down slope vistas in the direction of the proposed Project, participating Project properties with lit turbines, and along roadways such as New York State Routes 78, 238 (hermitage Road) and 362, Mote Road, and Maxwell Road.

## 3.2 INVENTORY OF VISUALLY SENSITIVE RESOURCES

### 3.2.1 Inventory Criteria

Because it is not practical to evaluate every conceivable location where the proposed Project might be visible it is accepted visual assessment practice to limit detailed evaluation of aesthetic impact to locations generally considered by society, through regulatory designation or policy, to be of cultural and/or aesthetic importance. In rural areas where few resources of statewide significance are likely to be found, it is common practice to expand inventory criteria to include places of local sensitivity or intensity of use.

Resources of Statewide Significance - The DEC Visual Policy requires that all aesthetic resources of statewide significance be identified along with any potential adverse effects on those resources from the proposed Project. Aesthetic resources of statewide significance may be derived from one or more of the following categories:

- A property on or eligible for inclusion in the National or State Register of Historic Places [16 U.S.C. § 470a et seq., Parks, Recreation, and Historic Preservation Law Section 14.07];
- State Parks [Parks, Recreation, and Historic Preservation Law Section 3.09];
- Urban Cultural Parks [Parks, Recreation, and Historic Preservation Law Section 35.15];
- The State Forest Preserve [NYS Constitution Article XIV], Adirondack and Catskill Parks;
- National Wildlife Refuges [16 U.S.C. 668dd], State Game Refuges, and State Wildlife Management Areas [ECL 11-2105];
- National Natural Landmarks [36 CFR Part 62];
- The National Park System, Recreation Areas, Seashores, and Forests [16 U.S.C. 1c];
- Rivers designated as National or State Wild, Scenic, or Recreational [16 U.S.C. Chapter 28, ECL 15-2701 et seq.];
- A site, area, lake, reservoir, or highway designated or eligible for designation as scenic [ECL Article 49 or DOT equivalent and APA], designated State Highway Roadside;
- Scenic Areas of Statewide Significance [of Article 42 of Executive Law];
- A State or federally designated trail, or one proposed for designation [16 U.S.C. Chapter 27 or equivalent];
- Adirondack Park Scenic Vistas [Adirondack Park Land Use and Development Map];
- State Nature and Historic Preserve Areas [Section 4 of Article XIV of the State Constitution];
- Palisades Park [Palisades Interstate Park Commission]; and
- Bond Act Properties purchased under Exceptional Scenic Beauty or Open Space category.

Resources of Local Interest - Places of local sensitivity or high intensity of use (based on local context) were also inventoried, even though they may not meet the broader statewide threshold. Aesthetic resources of local interest were generally derived from the following general categories:

- Recreation areas including playgrounds, athletic fields, boat launches, fishing access, campgrounds, picnic areas, ski centers, and other recreational facilities/attractions;
- Areas devoted to the conservation or the preservation of natural environmental features (e.g., reforestation areas/forest preserves, wildlife management areas, open space preserves);
- A bicycling, hiking, ski touring, or snowmobiling trail designated as such by a governmental agency;
- Architectural structures and sites of traditional importance as designated by a governmental agency;
- Parkways, highways, or scenic overlooks and vistas designated as such by a governmental agency;
- Important urban landscape including visual corridors, monuments, sculptures, landscape plantings, and urban green space;
- Important architectural elements and structures representing community style and neighborhood character;
- An interstate highway or other high volume (relative to local conditions) road of regional importance; and
- A passenger railroad or other mass transit route.
- A residential area greater than 50 contiguous acres and with a density of more than one dwelling unit per acre.

Other Places for Analysis - Given the rural character of much of the study area, the inventory of aesthetic resources has been further expanded to be conservatively over-inclusive. In several cases, locations not rising to the threshold of statewide significance or local interest have been included to represent isolated pockets of visibility along sparsely populated rural roadways; most selected based on field observation of open vistas. Although possibly of interest to local residents, such locations are not considered representative of an aesthetically significant place and are, therefore, not typically heavily weighted or required to be reviewed in DEC guidelines for the evaluation of aesthetic impact.

Resources of statewide significance, resources of local interest and other places for analysis were identified though a review of published maps and other paper documents, online research, extensive windshield survey of publicly accessible locations.

### 3.2.2 Summary Characteristics of Inventoried Resources

Overall Population and Density of Development – This portion of New York State is quite rural with a very small population. Based on the 2000 census, the population in the Town of Wethersfield is 891 with a density of 45 persons per square mile. The Town of Eagle has a population of 1,194 with a density of 33 persons per square mile. This compares with a population density of 73 persons per square mile for Wyoming County and 402 persons per square mile for New York State as a whole. The total number of housing units contained in both Towns is only 977. Table 3 summarizes these demographics for other municipalities within the study area.

**Table 3 – Demographic Summary of Study Area Municipalities** (2000 Census)

| Municipality | Population | Population Density | Housing Units |
|---|---|---|---|
| *New York State* | | *402* | |
| *Wyoming County* | *43,424* | *73* | *16,940* |
| Arcade (t) | 4,184 | 89 | 1,854 |
| Eagle (t) | 1,194 | 33 | 535 |
| Gainesville (t) | 2,333 | 66 | 945 |
| Gainesville (v) | 304 | 357 | 122 |
| Java (t) | 2,222 | 47 | 1,035 |
| Middlebury (t) | 1,508 | 42 | 554 |
| Orangeville (t) | 1,301 | 37 | 602 |
| Pike (t) | 1,086 | 35 | 444 |
| Sheldon (t) | 2,561 | 47 | 973 |
| Warsaw (t) | 5,423 | 153 | 2,232 |
| Wethersfield (t) | 891 | 45 | 442 |

Highway Corridors - Due to its rural location and great distance from metropolitan destinations, highways within the study area are relatively lightly traveled. The primary east-west road through the study area is New York State Route 78. New York State Route 78 extends from Gainesville northward to Olcott (New York State Route 18). The primary north-south road is through the study area is a combination of New York State Routes 238 (Hermitage Road) and 362. Table 4 summarizes the average annual daily traffic (AADT) for-State highways within the study region.

**Table 4 - Annual Average Daily Traffic Volumes for Study Area Highways** (NYSDOT 2004)[10]

| Route | Section | AADT |
|---|---|---|
| NYS Rte 19 | End Rte 39 overlap to Rte 78 Gainesville | 1,557 |
| NYS Rte 19 | Rte 78 Gainesville to Rte 19A | 2,522 |
| NYS Rte 19 | Rte 19A to Mungers Mill Rd. | 4,790 |
| NYS Rte 39 | Rte 98 Overlap Arcade to Rte 362 Bliss | 2,022 |
| NYS Rte 39 | Rte 362 Bliss to Rte 19 Overlap Pike | 1,115 |
| NYS Rte 78 | Rte 19 North of Gainesville to CR 10 Hermitage | 1,514 |
| NYS Rte 78 | CR 10 Hermitage to Rte 362 West of Smiths Corners | 1,711 |
| NYS Rte 78 | Rte 362 West of Smiths Corners to Rte 98 Overlap Java Center | 1,228 |
| NYS Rte 98 | Rte 39 Overlap to Rte 77 / 78 Overlap | 1,948 |
| NYS Rte 98 | Rte 77 / 78 Overlap to End Rte 78 Overlap | 1,696 |
| NYS Rte 98 | End Rte 78 Overlap to Rte 20A Overlap | 1,935 |
| NYS Rte 98 | Rte 20A Overlap to End Rte 20A Overlap | 4,014 |
| NYS Rte 238 | Rte 20A to CR 39 | 1,611 |
| NYS Rte 362 | Rte 39 to Rte 78 (End 362) | 1,512 |
| NYS Rte 19 | End Rte 39 overlap to Rte 78 Gainesville | 1,557 |

These traffic volumes compare to over 17,100 vehicles per day (AADT) on US Route 20A in East Aurora, approximately 25 miles to the west of the study area, and more than 30,000 on US Route 20 in Depew, approximately 35 miles to the northwest.

Numerous county and local roads traverse the study area. Generally, these roads are lightly traveled.

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[10] http://www.dot.state.ny.us/tech_serv/high/tdr.html

Park, Recreation and Open Space Resources – The study area has relatively few recreational resources. Popular recreational activities within the study area include hiking, hunting, camping, biking, horseback riding, and snowmobiling. Other passive outdoor pursuits such as bird watching or a leisurely drive through the rural landscape are also common. Although numerous creeks flow through the study area, there is no evidence that significant fishing activities take place. There are few State designated recreational resources within the study area. Some of the more prominent recreational opportunities are discussed below.

Snowmobile trails may be found throughout the study area whether on public/private land or along roadways/seasonal roads. Snowmobiling is a popular activity in Western New York and is likely enjoyed by large numbers of participants within the study area during the winter months. State snowmobile trails that bisect the area include, but are limited to, S30, S34, S38, and C3. These trails are usually funded by the State, but are maintained by local snowmobile groups.

New York State Department of Environmental Conservation has identified East Koy Creek, Wiscoy Creek, Cattaraugus Creek and Trout Brook as public fishing streams. Public access (i.e. foot paths, vehicle parking lots) may occur at a variety of locations, and generally occur to the east, west and south of the proposed Project.

New York State Bike Route 19 extends 112 miles from the Lake Ontario State Parkway (Monroe County) to the Town of Angelica (Allegany County). The bike route runs in a north-south direction, along New York State Route 19 through the Village of Warsaw.

The Rose Acres Audubon Nature Preserve, located in the Town of Java, is a 53-acre nature preserve. The preserve has trails, a cabin, and hosts a variety of habitats including mixed upland woods, a small stream, a 5-acre beaver pond, and wildlife.[11]

Municipal park, recreational and open space resources includes the Gainesville Village Park, Veterans Park, the Rita George Recreation Hall and Playground, and other small community playgrounds and athletic fields that may be scattered throughout the study area. In addition, there are two County Forest parcels and a small portion of the Lost Nations State Forest within the study area.

Tourism and Population Centers – The study area is not generally known as a tourist destination. The existing Wethersfield wind farm is advertised as a destination by the Wyoming County tourism department.

Cultural Resources - Wyoming County contains few historic resources. Within the study area, only (1) resource listed on the State and National Register of Historic Places was identified. This resource, the Arcade and Attica Railroad, is located in the Town of Java.

There are no properties (within the study area) in the Towns of Sheldon, Warsaw, Gainesville, Pike, Eagle, and Arcade listed on the State and National Register of Historic Places. Historically significant properties within the study area that may be eligible will be identified as part of the studies

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[11] http://www.buffaloaudubon.com

being prepared for the State Historic Preservation Office (please see *Architectural Survey (Five Mile APE) For The Proposed Noble Wethersfield Windpark, Towns Of Wethersfield And Eagle, Wyoming County, New York* completed by Panamerican Consultants, Inc.).

### 3.2.3 Visibility Evaluation of Inventoried Resources

Each inventoried visual resource was evaluated to determine whether a visual impact might exist. This consisted of reviewing viewshed maps and field observation to determine whether or not individual resources would have a view of the proposed Project. Table 5 lists 69 (77 locations visited – multiple locations of four resources visited) visual resources located within the five-mile study area and identifies potential Project visibility. The location of these visual resources is referenced by numeric code within Figure 2 - Proposed Turbine Viewshed – Vegetated on page 18.

Of the original 69 visual resources, 21 would likely be screened from the proposed Project by either intervening landform or vegetation/structures and are thus eliminated from further study.

**Table 5 – Visual Resource Visibility Summary**

**Key**

● *Visibility Indicated*

○ *No Visibility Indicated*

▣ *Filtered View Through Trees Possible (field observed)*

| | | | | **Potential Visibility** | | |
|---|---|---|---|---|---|---|
| **Map ID** | **Receptor Name** | **Municipality, County** | **Inventory Type** | Theoretical View Indicated by Viewshed - Excluding Existing Vegetation (Figure 1) | Theoretical View Indicated by Viewshed - Including Existing Vegetation (Figure 2) | Actual View Likely Based on Field Confirmation of Existing Line-of-sight[12] |
| **Cultural Resources** | | | | | | |
| 45 | Arcade and Attica Railroad | Java, Wyoming | Statewide Significance | ● | ○ | NOT VISITED |
| **Tourist Resources** | | | | | | |
| 6 | Wethersfield wind farm | Wethersfield, Wyoming | Local Importance | ● | ● | ● |
| **Recreational Resources** | | | | | | |
| 31 | Cattaraugus Creek – NYS DEC Fishing Access | Arcade, Wyoming | Local Importance | ● | ○ | ○ |
| 34 | Good News Campground | Arcade, Wyoming | Local Importance | ○ | ○ | ○ |
| 22 | Wiscoy Creek - NYS DEC Fishing Access | Eagle, Wyoming | Local Importance | ● | ● | ▣ |
| 23 | Rita George Recreation Hall and Playground / Racetrack | Eagle, Wyoming | Local Importance | ● | ● | ● |
| 30 | Camp Deerwood Forest | Eagle, Wyoming | Local Importance | ● | ○ | ○ |
| 59 | Perry Wiscoy Haven Campground | Eagle, Wyoming | Local Importance | ● | ● | ● |
| 60 | Wiscoy Creek - NYS DEC Fishing Access | Eagle, Wyoming | Local Importance | ● | ● | ● |
| 9 | New York State Bike Route 19 / NYS Route 19 | Gainesville, Wyoming | Local Importance | ● | ● | ● |

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[12] Field confirmation of potential visibility was conducted on November 22, 2006. Refer to Section 3.4.1 for additional information.

## Table 5 – Visual Resource Visibility Summary

**Key**

● *Visibility Indicated*

○ *No Visibility Indicated*

▣ *Filtered View Through Trees Possible (field observed)*

| Map ID | Receptor Name | Municipality, County | Inventory Type | Potential Visibility | | |
|---|---|---|---|---|---|---|
| | | | | Theoretical View Indicated by Viewshed - Excluding Existing Vegetation (Figure 1) | Theoretical View Indicated by Viewshed - Including Existing Vegetation (Figure 2) | Actual View Likely Based on Field Confirmation of Existing Line-of-sight[12] |
| 11 | Gainesville Village Park | Gainesville, Wyoming | Local Importance | ● | ● | ● |
| 13 | East Koy Creek – NYS DEC Fishing Access | Gainesville, Wyoming | Local Importance | ● | ○ | ▣ |
| 14 | Goldenrod Campground | Gainesville, Wyoming | Local Importance | ● | ○ | ○ |
| 40 | Yogi Bear's Jellystone Campground (Entry) | Java, Wyoming | Local Importance | ● | ● | ● |
| 44 | Veterans Park (Entry) / NYS Route 78 | Java, Wyoming | Local Importance | ● | ○ | ○ |
| 53 | Rose Acres Audubon Nature Preserve | Java, Wyoming | Local Importance | ○ | ○ | ○ |
| 55 | Archie's Golf Course | Java, Wyoming | Local Importance | ● | ○ | ○ |
| 56 | Beaver Meadow Family Campground | Java, Wyoming | Local Importance | ● | ● | ● |
| 61 | Trout Brook NYS DEC Fishing Access | Pike, Wyoming | Local Importance | ● | ● | ● |
| 5 | Camp Weona YMCA | Wethersfield, Wyoming | Local Importance | ● | ○ | ○ |
| 51 | Wyoming County Forest | Wethersfield, Wyoming | Local Importance | ● | ○ | ○ |
| 57 | Bide-A-Bit Campground | Warsaw, Wyoming | Local Importance | ○ | ○ | ○ |
| 58 | Wyoming County Forest | Wethersfield, Wyoming | Local Importance | ● | ● | NOT VISITED |
| 29 | Lost Nation State Forest | Centerville, Allegany | Statewide Significance | ● | ○ | ○ |
| **Highway Corridors/Roadside Receptors** | | | | | | |
| 42 | NYS Route 98 | Arcade, Wyoming | Local Importance | ● | ● | ● |
| 19 | NYS Route 362 | Eagle, Wyoming | Local Importance | ● | ● | ● |
| 20 – 20c | NYS Route 39 | Eagle, Wyoming | Local Importance | ● | ● | ● |
| 21 | South Hillside Road | Eagle, Wyoming | Other place for analysis | ● | ● | ● |
| 25 | NYS Route 362 | Eagle, Wyoming | Local Importance | ● | ● | ● |
| 26 | Lyonsburg Road | Eagle, Wyoming | Other place for analysis | ● | ● | ● |
| 27 | Centerville Road | Eagle, Wyoming | Other place for analysis | ● | ● | ● |
| 28 | Wing Street | Eagle, Wyoming | Other place for analysis | ● | ● | ● |
| 32 | Caldwell Road | Eagle, Wyoming | Other place for analysis | ● | ● | ● |
| 33 | Telegraph Road | Eagle, Wyoming | Other place for analysis | ● | ● | ● |

## Table 5 – Visual Resource Visibility Summary

**Key**

● *Visibility Indicated*

○ *No Visibility Indicated*

◘ *Filtered View Through Trees Possible (field observed)*

| | | | | **Potential Visibility** | | |
|---|---|---|---|---|---|---|
| **Map ID** | **Receptor Name** | **Municipality, County** | **Inventory Type** | Theoretical View Indicated by Viewshed - Excluding Existing Vegetation (Figure 1) | Theoretical View Indicated by Viewshed - Including Existing Vegetation (Figure 2) | Actual View Likely Based on Field Confirmation of Existing Line-of-sight[12] |
| 35 | Flynn Road | Eagle, Wyoming | Other place for analysis | ● | ● | ● |
| 36-36a | Wilson Road | Eagle, Wyoming | Other place for analysis | ● | ● | ● |
| 7 | Wethersfield Road | Gainesville, Wyoming | Other place for analysis | ● | ● | ● |
| 9 | NYS Route 19/New York State Bike Route 19 | Gainesville, Wyoming | Local Importance | ● | ● | ● |
| 10 – 10c | NYS Route 78 | Gainesville/Wethersfield/ Java, Wyoming | Local Importance | ● | ● | ● |
| 16 | Sheppard Road | Gainesville, Wyoming | Other place for analysis | ● | ● | ● |
| 17 | School Road | Gainesville, Wyoming | Other place for analysis | ● | ● | ● |
| 43 | Pee Dee Road | Java, Wyoming | Other place for analysis | ● | ● | ● |
| 44 | NYS Route 78 / Veterans Park (Entry) | Java, Wyoming | Local Importance | ● | ○ | ○ |
| 46 | NYS Route 77 | Java, Wyoming | Local Importance | ● | ○ | ○ |
| 47 | Beaver Meadows Road | Java, Wyoming | Other place for analysis | ● | ● | ● |
| 50 | NYS Route 98 | Java, Wyoming | Local Importance | ● | ● | ● |
| 52 | Orangeville Center Road | Orangeville, Wyoming | Other place for analysis | ● | ● | ● |
| 18 | Murphy Road | Pike, Wyoming | Other place for analysis | ● | ● | ● |
| 1 | US Route 20A | Warsaw, Wyoming | Local Importance | ● | ○ | ○ |
| 2 | Centerline Road | Warsaw, Wyoming | Other place for analysis | ● | ● | ● |
| 4 – 4a | NYS Route 238 (Hermitage Road) | Wethersfield/Orangeville , Wyoming | Local Importance | ● | ● | ● |
| 8 | Wolcott Road | Wethersfield, Wyoming | Other place for analysis | ● | ● | ● |
| 37 | Hobday Road | Wethersfield, Wyoming | Other place for analysis | ● | ● | ● |
| 38 | Pleasant Valley Road | Wethersfield, Wyoming | Other place for analysis | ● | ● | ● |
| 62 | Mote Road | Wethersfield, Wyoming | Other place for analysis | ● | ● | ● |
| **Residential/Community Resources** | | | | | | |
| 67 | Hamlet of East Arcade | Arcade, Wyoming | Local Importance | ● | ○ | ○ |
| 24 | Hamlet of Bliss | Eagle, Wyoming | Local Importance | ● | ● | ◘ |
| 66 | Hamlet of Wing | Eagle, Wyoming | Local Importance | ○ | ○ | ○ |

## Table 5 – Visual Resource Visibility Summary

**Key**

● *Visibility Indicated*

○ *No Visibility Indicated*

▣ *Filtered View Through Trees Possible (field observed)*

| | | | | **Potential Visibility** | | |
|---|---|---|---|---|---|---|
| **Map ID** | **Receptor Name** | **Municipality, County** | **Inventory Type** | Theoretical View Indicated by Viewshed - Excluding Existing Vegetation (Figure 1) | Theoretical View Indicated by Viewshed - Including Existing Vegetation (Figure 2) | Actual View Likely Based on Field Confirmation of Existing Line-of-sight[12] |
| 3 | Quaker Settlement Cemetery | Orangeville, Wyoming | Other places for analysis | ● | ● | ● |
| 12 | Village of Gainesville | Gainesville, Wyoming | Local Importance | ● | ● | ▣ |
| 64 | Hamlet of North Gainesville | Gainesville, Wyoming | Local Importance | ● | ● | ● |
| 41 | Java Lake | Java, Wyoming | Other places for analysis | ● | ● | ● |
| 48 | Hamlet of North Java | Java, Wyoming | Local Importance | ○ | ○ | ○ |
| 49 | Wethersfield Road - Residential | Java, Wyoming | Other places for analysis | ● | ● | ● |
| 54 | Java Center | Java, Wyoming | Local Importance | ● | ● | ● |
| 68 | Hamlet of Southburg | Java, Wyoming | Local Importance | ○ | ○ | ○ |
| 69 | Hamlet of Halls Corner | Orangeville, Wyoming | Local Importance | ● | ○ | ○ |
| 15 | Hamlet of Hermitage | Wethersfield, Wyoming | Local Importance | ● | ● | ● |
| 39 | Faun Lake - Private | Wethersfield, Wyoming | Other places for analysis | ● | ● | ○ (Entry) |
| 63 | Hamlet of Wethersfield Springs | Wethersfield, Wyoming | Local Importance | ● | ● | ● |
| 65 | Hamlet of Smiths Corner | Wethersfield, Wyoming | Local Importance | ● | ● | ● |

### 3.2.4 Select Resources Beyond 5-Miles

In addition to those inventoried resources listed in Table 5, additional resources were identified outside the study area during the research completed for the VRA. Although not all-inclusive, the following resources were identified:

> Carlton Hill State Multiple-Use Area/Sulphur Springs Cooperative Hunting Area (located approximately 9.2 miles from the nearest proposed turbine);

> Letchworth State Park (located approximately 8.8 miles from the nearest proposed turbine); and

> Silver Lakes State Park (located approximately 7.5 miles from the nearest proposed turbine).

## 3.3 FACTORS AFFECTING VISUAL IMPACT

To bring order to the consideration of visual resources, the inventory of visual resources is organized into several recognizable elements, as follows:

### 3.3.1 Landscape Units

Landscape Units are areas with common characteristics of landform, water resources, vegetation, land use, and land use intensity. While a regional landscape may possess diverse features and characteristics, a landscape unit is a relatively homogenous, unified landscape of visual character. Landscape units are established to provide a framework for comparing and prioritizing the differing visual quality and sensitivity of visual resources in the study area. Discrete landscape units were identified through field inventory and air photo interpretation dividing the study area into zones of unique patterns and visual composition. Within the visual resources study area, three distinctive landscape units were defined. These landscape units, their general landscape character, and use are as follows:

<u>Village Center</u> - The primary land use of this unit is medium density residential activities. This unit consists of the Village of Gainesville. Built structures and streets dominate the landscape. Trees line many residential streets within the Village. The focal point of the Village of Gainesville appears to be the Village offices and adjacent land uses. Most buildings are one to two stories tall, including brick and wood frame structures. Buildings styles are an interesting mix of older architectural styles (e.g. Federal, Late Victorian, Italianate) interspersed with conventional mid- to late-20th century residences. Some of the older buildings are well maintained or restored while others are in various states of disrepair or alteration. Views are generally short distance and focused along the streetscape. Structures and trees generally block distant views, although filtered views to the surrounding hills are found. Development density drops sharply as one moves away from the central district as the Village Center landscape unit transitions to agricultural upland.

<u>Hamlet Centers</u> - This unit includes, but is not limited to, the hamlets of Bliss, North java, Java Center, Hermitage, North Gainesville, and Wethersfield Springs. The larger hamlets (Bliss, North Java, and Java Center) are characterized by a mix of residential, commercial, and limited small-scale industrial/manufacturing uses. Built structures and streets dominate. Buildings are typically one to two stories tall, and include brick commercial blocks and wood frame structures. The hamlets may be tree lined (formal or informal spacing) and are generally configured by the intersection of two roads whose linearity is reinforced with roadside residences. Buildings styles are an interesting mix of older architectural styles (e.g. Federal, Late Victorian, Italianate) interspersed with more modern utilitarian styles as well as pre-manufactured homes. Some of the older buildings located in these hamlets (e.g. North Java) are very well maintained or restored while others are in various states of disrepair or alteration. Views are generally short distance and focused along streets. Structures, background topography, and trees generally block distant views. The smaller crossroad hamlets are generally characterized by buildings at the intersecting corners with a few additional adjacent structures. Uses may include residential, commercial, and intuitional.

Views found within the Hamlet Center landscape unit may be considered to be of moderate visual quality depending on the character and composition of built and natural features within view.

Agricultural Uplands - This landscape unit is predominantly a patchwork of open land, including working cropland/pastures and successional old-fields transected by property-line hedgerows, and interspersed with woodlots (especially on hilltops and steeper slopes). The terrain itself consists largely of rolling hills and areas of smaller rounded hillocks, often bisected by steep sided ravines. In the vicinity of the Project, north-south (general direction) running valleys border the broad plateaus.

Population densities are very low and the building stock is sparsely located. This stock consists primarily of permanent homes and manufactured housing (both old and new) along with accessory structures (barns, garages, sheds, etc.). Uses are predominantly agricultural and very low-density residential.

Views are most often short distance, contained by foreground vegetation and surrounding hillsides. However, distant vistas are common from higher elevations across down slope agricultural lands. Narrow curving roads often provide an interesting series of short views of the rural landscape, but also force drivers to direct their attention to the road rather than the adjacent scenery.

### 3.3.2 Viewer/User Groups

Viewers engaged in different activities while in the same landscape unit are likely to perceive their surroundings differently. The description of viewer groups is provided to assist in understanding the sensitivity and probable reaction of potential observers to visual change resulting from the proposed Project.

Local Residents and Workers - These individuals would view the proposed Project from homes, businesses, and local roads. Except when involved in local travel, such viewers are likely to be stationary and could have frequent and/or prolonged views of the Project. They know the local landscape and may be sensitive to changes in particular views that are important to them. Conversely, the sensitivity of an individual observer to a specific view may be diminished over time due to repeated exposure.

Through Travelers - Commuters and through travelers would view the proposed Project from major highways. These viewers are typically moving and focusing on the road in front of them. Consequently, their views of the proposed facility may be peripheral, intermittent, and/or of relatively brief duration. Given a general unfamiliarity or infrequent exposure to the regional or local landscape, travelers are likely to have a lower degree of sensitivity to visual change than would local residents and workers.

Recreational Users - This group generally includes year-round and seasonal residents involved in outdoor recreational activities, as well as visitors who come to the area specifically to enjoy the recreational, and scenic resources and open spaces of the Western New York region.

The sensitivity of recreational users to visual quality is variable; but to many, visual quality is an important and integral part of the recreational experience. The presence of wind turbines may diminish the aesthetic experience for those that believe that the rural landscape should be preserved for agricultural, open space and similar uses. Such viewers will likely have high sensitivity to the visual quality and landscape character, regardless of the frequency or duration of their exposure to the proposed Project. For those with strong utilitarian beliefs, the presence of the proposed Project will have little aesthetic impact on their recreational experience.

While the scenic quality of the region is an important aspect of the recreational experience for most visitors, viewers will also be cognizant of various foreground details and developments and other visually proximate activities. Visitors and recreational users currently view existing low density roadside residential and commercial uses of varying aesthetic quality, as well as utility infrastructure, occasional hilltop communications towers and the existing Wethersfield wind farm.

Greater numbers of recreational users will be present in the region, when the weather is appropriate for the recreational activity (e.g. clear as compared to overcast, rainy days). In addition, more recreational users will be present on weekends and holidays than on weekdays.

Tourists – Generally, these individuals come to the area specifically to enjoy the recreational and scenic resources. Most tourists and seasonal residents would have high sensitivity to the visual quality and landscape character, regardless of the frequency or duration of their exposure to the proposed Project. This group may view the proposed facility while passing by the Project on major transportation corridors if traveling the area for the purpose of enjoying the scenic landscape.

### 3.3.3 Distance Zones

Distance affects the apparent size and degree of contrast between an object and its surroundings. Distance can be discussed in terms of distance zones, e.g., foreground, middleground and background. Distance zones established by the U.S. Forest Service and reiterated by the NYSDEC Visual Policy are used in this VRA. A description of each distance zone is provided below to assist in understanding the effect of distance on potential visual impacts.

Foreground (0-1/2 mile) - At a foreground distance, viewers typically have a very high recognition of detail. Cognitively, in the foreground zone, human scale is an important factor in judging spatial relationships and the relative size of objects. From this distance, the sense of form, line, color and textural contrast with the surrounding landscape is highest. The visual impact of the Project is likely to be considered the greatest at a foreground distance.

Middleground (1/2 mile to 3 miles) - This is the distance where elements begin to visually merge or join. Colors and textures become somewhat muted by distance, but are still identifiable. Visual detail is reduced, although distinct patterns may still be evident. Viewers from middleground distances characteristically recognize surface features such as tree stands, building clusters and small landforms. Scale is perceived in terms of identifiable features of development patterns. From this distance, the contrast of color and texture are identified more in terms of the regional context than by the immediate surroundings.

Background (3-5 miles to horizon) - At this distance, landscape elements lose detail and become less distinct. Atmospheric perspective[13] changes colors to blue-grays, while surface characteristics are lost. Visual emphasis is on the outline or edge of one landmass or water resource against another with a strong skyline element.

### 3.3.4 Duration/Frequency/Circumstances of View

The analysis of a viewer's experience must include the distinction between stationary and moving observers. The length of time and the circumstances under which a view is encountered is influential in characterizing the importance of a particular view.

Stationary Views - Stationary views are experienced from fixed viewpoints. Fixed viewpoints include residential neighborhoods, recreational facilities, historic resources and other culturally important locations. Characteristically, stationary views offer sufficient time, either from a single observation or repeated exposure, to interpret and understand the physical surroundings. For this reason, stationary viewers have a higher potential for understanding the elements of a view than do moving viewers.

Stationary views can be further divided to consider the effect of short-term and long-term exposure. Sites of long-term exposure include any location where a stationary observer is likely to be visually impacted on a regular basis, such as from a place of residence. Sites of short-term exposure include locations where a stationary observer is only visiting, such as recreational facilities. Although the duration of visual impact remains at the discretion of the individual observer, short-term impacts are less likely to be repeated for a single observer on a regular basis.

Moving Views - Moving views are those experienced in passing, such as from moving vehicles, where the time available for a viewer to cognitively experience a particular view is limited. Such viewers are typically proceeding along a defined path through highly complex stimuli. As the tendency of automobile occupants is to focus down the road, the actual time a viewer is able to focus on individual elements of the surrounding landscape may be a fraction of the total available view time. Obviously, a driver is most affected by driving requirements.

Conversely, the greater the contrast of an element within the existing landscape, the greater the potential for viewer attention, even if viewed for only a moment by a moving viewer. Billboards along a rural highway, designed to attract attention and recognition, are an example of this condition. Furthermore, an element is more likely to be perceived in greater detail by local residents to whom it is experienced on a daily basis than it is to passers-by.

### 3.3.5 Summary of Affected Resources

As listed in Table 5, of the original 69 inventoried visual resources, 21 would likely be screened from the proposed Project by either intervening landform or vegetation/structures and are thus eliminated

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[13] Atmospheric Perspective: Even on the clearest of days, the sky is not entirely transparent because of the presence of atmospheric particulate matter. The light scattering effect of these particles causes a reduction in the intensity of colors and the contrast between light and dark as the distance of objects from the observer increases. Contrast depends upon the position of the sun and the reflectance of the object, among other items. The net effect is that objects appear "washed out" over great distances.

from further study. Table 6 summarizes the factors affecting visual impact (landscape unit, viewer group, distance zone and duration/frequency/circumstances of view) described above for each visual resource determined to have a potential view of the proposed Project.

## Table 6 - Visual Resource Impact Summary

| | | | | | Factors Affecting Visual Impact | | | |
|---|---|---|---|---|---|---|---|---|
| **Map ID** | **Receptor Name** | **Municipality, County** | **Inventory Type** | **Number of Turbines Visible** (see Figure 2) | **Landscape Unit** | **Viewer/User Group(s)** | **Distance** (miles) **/Distance Zone** (nearest turbine) | **Moving/ Stationary** |
| 1 | US Route 20a | Warsaw, Wyoming | Local Importance | 0 | Ag. Uplands | Travelers, Local residents/workers | 4.8 / Background (T89) | Moving |
| 2 | Centerline Road | Warsaw, Wyoming | Other Place for Analysis | 18 | Ag. Uplands | Local residents/workers | 4.6 / Background (T89) | Moving |
| 3 | Quaker Settlement Cemetery | Orangeville, Wyoming | Other Place for Analysis | 0 | Ag. Uplands | Local residents/workers | 2.6 / Middleground (T89) | Stationary |
| 4 – 4a | NYS Route 238 (Hermitage Road) | Wethersfield/Orangeville, Wyoming | Local Importance | 45/43 | Ag. Uplands | Travelers, Local residents/workers | 2.4, 1.2 / Middleground (T89, T87) | Moving |
| 5 | Camp Weona | Wethersfield, Wyoming | Local Importance | 0 | Ag. Uplands | Recreational | 1.7 / Middleground (T84) | Stationary |
| 6 | Wethersfield wind farm | Wethersfield, Wyoming | Local Importance | 3 | Ag. Uplands | Tourists | 1.1 / Middleground (T84) | Stationary |
| 7 | Wethersfield Road | Gainesville, Wyoming | Other Place for Analysis | 85 | Ag. Uplands | Local residents/workers | 2.1 / Middleground (T89) | Moving |
| 8 | Wolcott Road | Wethersfield, Wyoming | Other Place for Analysis | 71 | Ag. Uplands | Local residents/workers | 0.4 / Foreground (T89) | Moving |
| 9 | NYS Route 19 / New York State Bicycle Route 19 | Gainesville, Wyoming | Local Importance | 7 | Ag. Uplands | Travelers, Local residents/workers, Recreational | 4.4 / Background (T89) | Moving |
| 10 – 10c | NYS Route 78 | Gainesville/Wethersfield/Java, Wyoming | Local Importance | 77/80/63/19 | Ag. Uplands | Travelers, Local residents/workers | 3.9, 3.0, 0.2, 1.1 / Foreground, Middleground, Background (T89, T62a, T1) | Moving |
| 11 | Gainseville Village Park | Gainesville, Wyoming | Local Importance | 2 | Village Center | Recreational | 4.5 / Background (T89) | Stationary |
| 12 | Village of Gainesville | Gainesville, Wyoming | Local Importance | 3 | Village Center | Travelers, Local residents/workers | 4.7 / Background (T89) | Stationary |
| 13 | East Koy Creek - NYS DEC Fishing Access | Gainesville, Wyoming | Local Importance | 0 | Village Center | Recreational | 4.5 / Background (T87) | Stationary |
| 14 | Goldenrod Campground | Gainesville, Wyoming | Local Importance | 0 | Ag. Uplands | Recreational | 4.4 / Background (T87) | Stationary |
| 15 | Hamlet of Hermitage | Wethersfield, Wyoming | Local Importance | 12 | Hamlet Center | Local residents/workers | 1.6 / Middleground (T82a) | Stationary |
| 16 | Sheppard Road | Gainesville, Wyoming | Other place for analysis | 56 | Ag. Uplands | Local residents/workers | 1.4 / Middleground (T69) | Moving |
| 17 | School Road | Gainesville, Wyoming | Other place for analysis | 85 | Ag. Uplands | Local residents/workers | 3.1 / Background (T69) | Moving |
| 18 | Murphy Road | Pike, Wyoming | Other place for analysis | 80 | Ag. Uplands | Local residents/workers | 2.8 / Middleground (T69) | Moving |
| 19 | NYS Route 362 | Eagle, Wyoming | Local Importance | 21 | Ag. Uplands | Travelers, Local residents/workers | 0.4 / Foreground (T33) | Moving |
| 20 – | NYS Route 39 | Eagle, Wyoming | Local Importance | 19/56/76/85 | Ag. Uplands | Travelers, Local | 1.6, 2.5, 3.3, 4.7 / | Moving |

## Table 6 - Visual Resource Impact Summary

| | | | | | | **Factors Affecting Visual Impact** | | |
|---|---|---|---|---|---|---|---|---|
| **Map ID** | **Receptor Name** | **Municipality, County** | **Inventory Type** | **Number of Turbines Visible** (see Figure 2) | **Landscape Unit** | **Viewer/User Group(s)** | **Distance** (miles) **/Distance Zone** (nearest turbine) | **Moving/ Stationary** |
| 20c | | | | | | residents/workers | Middleground, Background (T53a, T39, T23a)) | Stationary |
| 21 | South Hillside Road | Eagle, Wyoming | Other place for analysis | 15 | Ag. Uplands | Local residents/workers | 1.2 / Middleground (T51) | Moving |
| 22 | Wiscoy Creek - NYS DEC Fishing Access | Eagle, Wyoming | Local Importance | 23 | Ag. Uplands | Recreational | 1.4 / Middleground (T51) | Stationary |
| 23 | Rita George Recreation Hall and Playground / Racetrack | Eagle, Wyoming | Local Importance | 28 | Hamlet Center | Recreational | 1.3 / Middleground (T51) | Stationary |
| 24 | Hamlet of Bliss | Eagle, Wyoming | Local Importance | 22 | Hamlet Center | Local residents/workers | 1.1 / Middleground (T39) | Stationary |
| 25 | NYS Route 362 | Eagle, Wyoming | Local Importance | 34 | Ag. Uplands | Travelers, Local residents/workers | 1.3 / Middleground (T39) | Moving |
| 26 | Lyonsburg Road | Eagle, Wyoming | Other place for analysis | 63 | Ag. Uplands | Local residents/workers | 3.0 / Background (T53a) | Moving |
| 27 | Centerville Road | Eagle, Wyoming | Other place for analysis | 50 | Ag. Uplands | Local residents/workers | 2.9 / Middleground (T39) | Moving |
| 28 | Wing Street | Eagle, Wyoming | Other place for analysis | 33 | Ag. Uplands | Local residents/workers | 3.9 / Background (T39) | Moving |
| 29 | Lost Nation State Forest | Centerville, Allegany | Statewide Significance | 0 | Ag. Uplands | Recreational | 4.7 / Background (T39) | Stationary |
| 30 | Camp Deerwood Forest | Eagle, Wyoming | Local Importance | 0 | Ag. Uplands | Recreational | 2.6 / Middleground (T39) | Stationary |
| 31 | Cattaraugus Creek – NYS DEC Fishing Access | Arcade, Wyoming | Local Importance | 0 | Ag. Uplands | Recreational | 2.6 / Middleground (T17a) | Stationary |
| 32 | Caldwell Road | Eagle, Wyoming | Other place for analysis | 8 | Ag. Uplands | Local residents/workers | 3.5 / Background (T23a) | Moving |
| 33 | Telegraph Road | Eagle, Wyoming | Other place for analysis | 83 | Ag. Uplands | Local residents/workers | 2.3 / Middleground (T39) | Moving |
| 34 | Good News Campground | Arcade, Wyoming | Local Importance | 0 | Ag. Uplands | Recreational | 4.0 / Background (T23a) | Stationary |
| 35 | Flynn Road | Eagle, Wyoming | Other place for analysis | 17 | Ag. Uplands | Local residents/workers | 0.9 / Middleground (T39) | Moving |
| 36-36a | Wilson Road | Eagle, Wyoming | Other place for analysis | 61/36 | Ag. Uplands | Local residents/workers | 0.3, 0.2 / Foreground (T16, T33) | Moving |
| 37 | Hobday Road | Wethersfield, Wyoming | Other place for analysis | 58 | Ag. Uplands | Local residents/workers | 0.3 / Foreground (T7) | Moving |
| 38 | Pleasant Valley Road | Wethersfield, Wyoming | Other place for analysis | 65 | Ag. Uplands | Local residents/workers | 0.4 / Foreground (T7) | Moving<br>Stationary |
| 39 | Faun Lake - Private | Wethersfield, Wyoming | Other place for analysis | 19 | Ag. Uplands | Local residents/workers | 1.0 / Middleground (T55) | Stationary |
| 40 | Yogi Bear's Jellystone Campground (Entry) | Java, Wyoming | Local Importance | 11 | Ag. Uplands | Recreational | 1.4 / Middleground (T1) | Stationary |
| 41 | Java Lake | Java, Wyoming | Other places for analysis | 40 | Ag. Uplands | Local residents/workers. | 2.3 / Middleground (T1) | Stationary |