EXHIBIT K

July 19, 2023

Tarpon Towers III, LLC
8916 77th Terrace East Suite 103
Lakewood Ranch, FL 34202

Attention: **Mr. Keith Coppins**

Subject: **Avian Resource/Migratory Bird Impact Analysis**
Proposed 165-Foot Monopole Telecommunications Structure
(Overall Height with Appurtenances)
Tarpon Towers Site - South Windsor (CT1207)
99 Dart Hill Rd
South Windsor, Hartford County, Connecticut
Latitude: N 41° 50' 49.6" Longitude: W 72° 31' 12.7"
ECA Project Number: 22-004208

Dear Mr. Coppins

Environmental Corporation of America (ECA) is pleased to provide this Avian Resource/Migratory Bird Impact Analysis.

Background

ECA understands that a proposed 165-foot tall (overall height) monopole telecommunications structure would be constructed within a proposed 100-foot by 100-foot lease area. The proposed lease area would be accessible by a proposed approximate 16,773-square-foot access/utility easement.

Purpose

The purpose of this letter is to provide you with documentation of our investigations and findings relative to potential impacts to migratory birds in conjunction with the FCC NEPA Environmental Checklist.

Review of Available Documentation

Action Area

The Action Area includes the proposed leased area, proposed access/utility easement, and adjacent areas that may be impacted directly or indirectly by construction and/or ongoing maintenance. The Action Area consists of undeveloped wooded land adjacent to existing overhead utilities.

Migration Flyway/Corridor & Important Bird Areas

The proposed facility is located within the Atlantic Flyway, one of four North American major migratory flyways or routes which birds travel as they migrate between nesting and wintering areas.

However, the proposed Action Area is not located within any Important Bird Areas (IBA), which consists of biologically diverse habitats suitable for migratory bird species to utilize throughout all stages of migration.

Breeding Bird Survey

ECA reviewed the USGS North American Breeding Bird Survey (BBS) and identified the Willimantic route (#18007) as being approximately 3.4 miles from the proposed telecommunications facility location at its closest point. However, due to the design of the tower (165 feet in height with no lighting or guy wires), as well as the distance between the proposed facility and the Willimantic route, the proposed project is not anticipated to adversely impact migratory birds identified as utilizing this route.

Hawk Watch

ECA reviewed data from HawkWatch International to determine impacts to raptor species. The nearest research and data collection site, Beelzebub Street, is located 2.3 miles south of the proposed facility. Data Inventory for the Beelzebub Street site is available for the years 1977 and 1980-1990 (12 years). A review of the inventory indicated that 10 known raptor species and five unknown raptor species were observed from this data collection site in the aforementioned observation years. Of the raptor species observed at this site, five are currently identified by the Connecticut Department of Energy and Environmental Protection (DEEP) as being endangered, threatened, or a species of concern. These species include: the sharp-shinned hawk (*Accipiter striatus*) and northern harrier (*Circus hudsonius*) which are state-listed endangered; the bald eagle (*Haliaeetus leucocephalus*) which is state-listed threatened; and the broad-winged hawk (*Buteo platypterus*) and American kestrel (*Falco sparverius*) which are considered a species of concern. However, due to the design of the proposed tower, as well as the distance between the proposed facility and the Beelzebub Street site, the proposed project is not anticipated to adversely impact raptor species.

Bald Eagle Survey Route

The Bald and Golden Eagle Protection Act (BGEPA; 16 U.S.C. 668-668d) prohibits the "taking" of bald and golden eagles without a permit issued by the Secretary of the Interior. Additionally, as defined within the USFWS 2007 National Bald Eagle Management Guidelines, the USFWS recommended buffer for bald eagle nests is 660 feet. ECA reviewed the Midwinter Bald Eagle Count to identify any bald eagle (*Haliaeetus leucocephelaus*) nests in the vicinity of the proposed tower location. We found that the nearest survey route, *Route 66 to Route 291* (*Survey Station: 01A*), is located 6.4 miles west of the proposed facility. Data was collected at this survey station between 1995 and 2005, with the most recent survey year observing a total of three bald eagles from this location. However, due to the design of the proposed tower, the distance between the proposed facility and the location of the previously observed bald eagles, as well as lack of observed nests within the vicinity of the proposed project area, the proposed project is not anticipated to adversely impact bald eagles.

<u>Waterfowl/Waterbird/Landbird National Priority Areas</u>
Based on a review of the North American Wetlands Conservation Act (NAWCA) online mapper, ECA found that the proposed tower location is not located within a Waterfowl Priority Area, but is located within a Waterbird Priority Area and immediately adjacent to a Landbird Priority Area. However, there are no suitable waterbird habitats located at or near the proposed tower location, and although tree clearing would be required as part of the construction of the proposed facility, impacts to potential nesting habitat for landbird species in anticipated to be minimal.

<u>Connecticut Department of Energy and Environmental Protection (DEEP)</u>
ECA also reviewed the Connecticut Department of Energy and Environmental Protection's (DEEP) county report for endangered, threatened, and special concern species list and the National Diversity Database (NDDB) map dated June 2023. Based on our review, no known locations of state and federally listed species or critical habitats were recorded within the project area or in the immediate vicinity of the proposed facility, with the nearest known location of state and federal listed species being located approximately 0.5 miles north of the proposed tower location.

Additionally, we reviewed the CT DEEP migratory waterfowl online mapper and determined that there are no concentration areas in the immediate vicinity of the proposed project location. However, the nearest concentration area, Hockanum River, Vernon, is located 1.5 miles east of the proposed location. Due to the design of the proposed tower, as well as the distance between the proposed facility and the concentration area, and the lack of suitable waterfowl nesting habitat within the proposed project area, adverse impacts to waterfowl known to occur at Hockanum River, Vernon are not anticipated.

<u>USFWS Protected Bird Species (Threatened, Endangered) and Critical Habitat</u>

ECA utilized the United States Fish and Wildlife Service (USFWS) Information for Planning and Consultation (IPac) online project review tool to identify any federally-listed or migratory bird species occurring within the project vicinity and found that there are no federally threatened or endangered birds known to occur near the proposed tower location. Additionally, ECA reviewed the USFWS Critical Habitat for Threatened & Endangered Species online mapper to determine that there are no critical habitats in the vicinity of the proposed tower facility.

Impact Minimization Measures

The USFWS provides guidance on best practices for telecommunication tower design and construction to avoid and reduce the risk of avian mortality. The FWS's recommendations and our findings are indicated below.

1. Any company/applicant/licensee proposing to construct a new communications tower should be strongly encouraged to collocate the communications equipment on an existing communication tower or other structure (e.g., billboard, water tower, or building mount). Depending on tower load factors, from 6 to 10 providers may collocate on an existing tower.
   The proposed tower height is required to meet operational and service coverage objectives for Tarpon Towers, LLC, which are not available through existing communications towers within the vicinity of the proposed Action Area. Additionally, the tower will also subsequently accommodate future antenna collocations, thereby reducing the need for future towers in the immediate vicinity.

2. If collocation is not feasible, and a new tower or towers are to be constructed, communications service providers should be strongly encouraged to construct towers no more than 199 feet above ground level (AGL), using construction techniques which do not require guy wires (e.g., use a lattice structure, monopole, etc.). Such towers should be unlighted if Federal Aviation Administration regulations permit.
   The proposed facility will consist of a 165-foot monopole tower with no guy wires or lighting.

3. If constructing multiple towers, providers should consider the cumulative impacts of all of those towers to migratory birds and threatened and endangered species as well as the impacts of each individual tower.
   This proposed project consists of the construction of one communications tower.

4. If at all possible, new towers should be sited within existing "antenna farms" (clusters of towers). Towers should not be sited in or near wetlands, other known bird concentration areas (e.g., state or Federal refuges, staging areas, rookeries), in known migratory or daily movement flyways, or in habitat of threatened or endangered species. Towers should not be sited in areas with a high incidence of fog, mist, and low ceilings.
   The proposed tower is located within the Atlantic Flyway and the proposed tower is not located within what could be considered by the FCC as a "cluster of towers". ECA also reviewed online resources maintained by the USFWS to identify any species that are federally-listed under the Endangered Species Act (ESA) as either endangered or threatened, and that are known to occur within the project vicinity. Based on our research, no federally-protected (i.e. endangered, threatened) bird species are known to occur within the project vicinity. Further, based on a review of the USFWS online Critical Habitat

Portal, the proposed communications facility is not located within designated critical habitat.

The proposed facility is not located within any state or Federal refuge, staging area, or rookeries.

Further, ECA reviewed of the USFWS National Wetlands NWI map and did not identify any wetlands within the Action area.

5. If taller (>199 feet AGL) towers requiring lights for aviation safety must be constructed, the minimum amount of pilot warning and obstruction avoidance lighting required by the FAA should be used. Unless otherwise required by the FAA, only white (preferable) or red strobe lights should be used at night, and these should be the minimum number, minimum intensity, and minimum number of flashes per minute (longest duration between flashes) allowable by the FAA. The use of solid red or pulsating red warning lights at night should be avoided. Current research indicates that solid or pulsating (beacon) red lights attract night-migrating birds at a much higher rate than white strobe lights. Red strobe lights have not yet been studied.
   Not Applicable (The proposed facility will consist of a 165-foot monopole tower with no lighting).

6. Tower designs using guy wires for support which are proposed to be located in known raptor or waterbird concentration areas or daily movement routes, or in major diurnal migratory bird movement routes or stopover sites, should have daytime visual markers on the wires to prevent collisions by these diurnally moving species.
   Not Applicable (The proposed facility will not utilize guy wires).

7. Towers and support facilities should be sited, designed and constructed so as to avoid or minimize habitat loss within and adjacent to the tower "footprint." However, a larger tower footprint is preferable to the use of guy wires in construction. Road access and fencing should be minimized to reduce or prevent habitat fragmentation and disturbance, and to reduce above ground obstacles to birds in flight.
   The proposed tower and facility will be partially accessible via an existing gravel road, and will also be partially located within an existing overhead utility corridor. Additionally, no guy wires are planned.

8. If significant numbers of breeding, feeding, or roosting birds are known to habitually use the proposed tower construction area, relocation to an alternate site should be recommended. If this is not an option, seasonal restrictions on construction may be advisable in order to avoid disturbance during periods of high bird activity.
   The tower is to be located within the Atlantic Flyway. Spring migration takes place from approximately April 1st through approximately May 31st. The breeding season takes place

from approximately June 1st through approximately August 15th. The majority of fall migration takes place from August 15th through November 15th. However, due to the limited amount of suitable nesting habitat, the design and lighting of the proposed tower, and the lack of identified protected bird species known to occur within the immediate vicinity of the proposed facility, there are no recommended construction timeframes and work may proceed at any time.

9. In order to reduce the number of towers needed in the future, providers should be encouraged to design new towers structurally and electrically to accommodate the applicant/licensee's antennas and comparable antennas for at least two additional users (minimum of three users for each tower structure), unless this design would require the addition of lights or guy wires to an otherwise unlighted and/or un-guyed tower.

   The design of the proposed tower will be sufficient to support future collocations; however, information regarding the total space available for future collocations is currently undetermined as it is dependent upon the engineering requirements of such collocations.

10. Security lighting for on-ground facilities and equipment should be down-shielded to keep light within the boundaries of the site.

    Not applicable (There will be no lighting so no need for down shielding).

11. If a tower is constructed or proposed for construction, Service personnel or researchers from the Communication Tower Working Group should be allowed access to the site to evaluate bird use, conduct dead-bird searches, to place net catchments below the towers but above the ground, and to place radar, Global Positioning System, infrared, thermal imagery, and acoustical monitoring equipment as necessary to assess and verify bird movements and to gain information on the impacts of various tower sizes, configurations, and lighting systems.

    USFWS and research personnel associated with the Communication Tower Working Group will be permitted to access to the tower site (excluding the fenced equipment compound area) in order to study the effects of the proposed tower on migratory birds.

12. Towers no longer in use or determined to be obsolete should be removed within 12 months of cessation of use.

    This project involves the proposed construction of a new tower. If this tower is determined to be obsolete it will be removed within 12 months of cessation of use.

Conclusions

Based on the information reviewed, ECA has found no evidence that any migratory bird species potentially occurring within the project area vicinity would be impacted by the proposed telecommunications facility. Additionally, the proposed project would not affect any designated critical habitat and would not result in the destruction or adverse modification of proposed critical habitat.

While the proposed telecommunication facility, will be located within the Atlantic Flyway, the proposed tower will not be located in any Important Bird Areas or Waterfowl or Landbird NAWCA Priority Areas, and is not anticipated to adversely impact any migratory birds, nesting habitats or critical habitats. Further, the proposed facility will not utilize any lighting or guyed wires. Therefore, it is ECA's opinion that the proposed facility will not significantly impact migratory birds.

Environmental Corporation of America

Sierra Webster
Project Manager

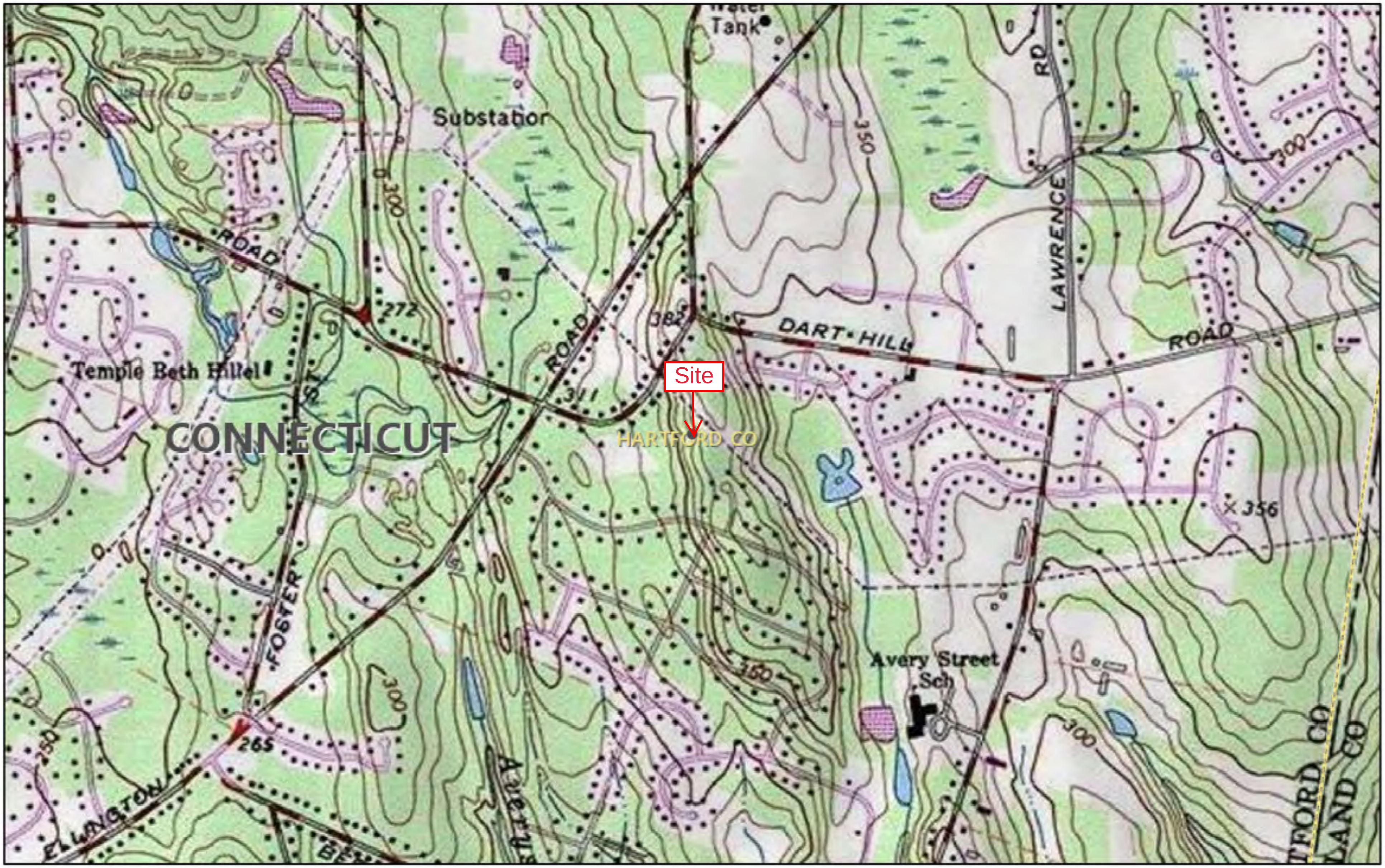
Eric Johnson
Principal Scientist

Hazel Errett
Principal Biologist

Attachment A

Figures

The National Map Advanced Viewer



4/18/2023, 5:07:32 PM

US Fish & Wildlife Service
National Forest
County or Equivalent
National Wilderness
National Park
State or Territory Large-Scale

1:18,056

0 0.1 0.2 0.4 mi

0 0.17 0.35 0.7 km

Copyright:© 2013 National Geographic Society, i-cubed, USGS The National Map: National Boundaries Dataset. Data Refreshed April, 2023.

USGS

2021 USGS

Attachment B

Drawings

VICINITY MAP

SCALE: N.T.S

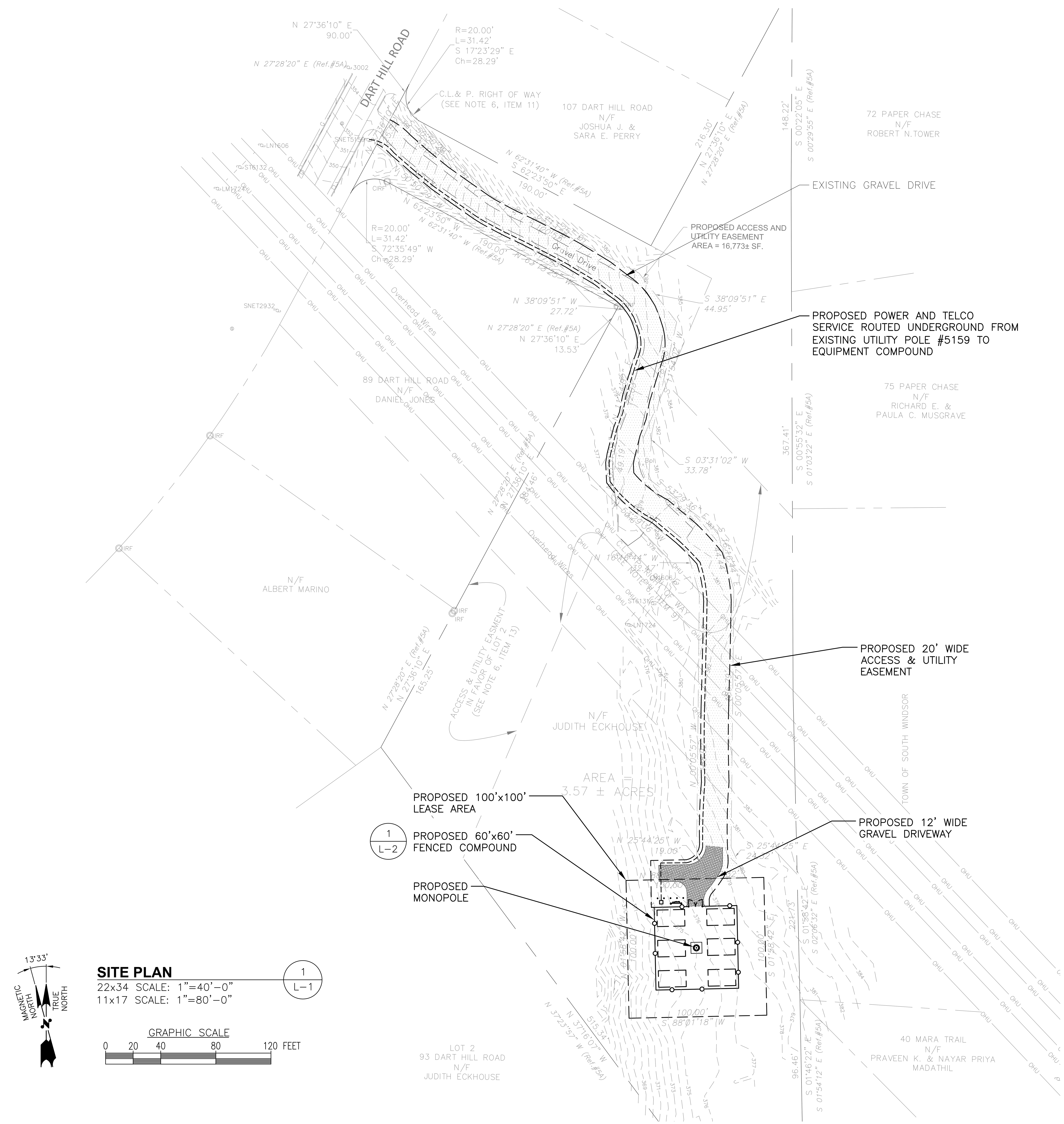
CENTER OF STRUCTURE COORDINATES:	LAT:	N41° 50' 49.55"
	LONG:	W72° 31' 12.67"

LEASE EXHIBIT

THIS LEASE PLAN IS DIAGRAMMATIC IN NATURE AND IS INTENDED TO PROVIDE GENERAL INFORMATION REGARDING THE LOCATION AND SIZE OF THE PROPOSED WIRELESS COMMUNICATION FACILITY. THE SITE LAYOUT WILL BE FINALIZED UPON COMPLETION OF SITE SURVEY AND FACILITY DESIGN.

LEGEND:

- PROPERTY LINE – SUBJECT PARCEL
- PROPERTY LINE – ABUTTERS
- EXISTING BUILDING
- WETLAND BOUNDARY LINE



SITE PLAN

22x34 SCALE: 1"=40'-0"
11x17 SCALE: 1"=80'-0"

1 / L-1

GRAPHIC SCALE

0 20 40 80 120 FEET

LEASE EXHIBIT

TARPON TOWERS

TARPON TOWERS II, LLC
1001 3rd AVENUE WEST, SUITE 420
BRADENTON, FL 34205

DOUGLAS J. ROBERTS ARCHITECT
110 Washington Avenue
Fourth Floor
North Haven, CT 06473

Tel: 203.234.6368
Email: droberts - architect@outlook.com

CHECKED BY: DJR

APPROVED BY: DJR

SUBMITTALS

REV.	DATE	DESCRIPTION	BY
0	10/13/2022	ISSUED FOR REVIEW	KAM

SITE NAME:

SOUTH WINDSOR

SITE ADDRESS:

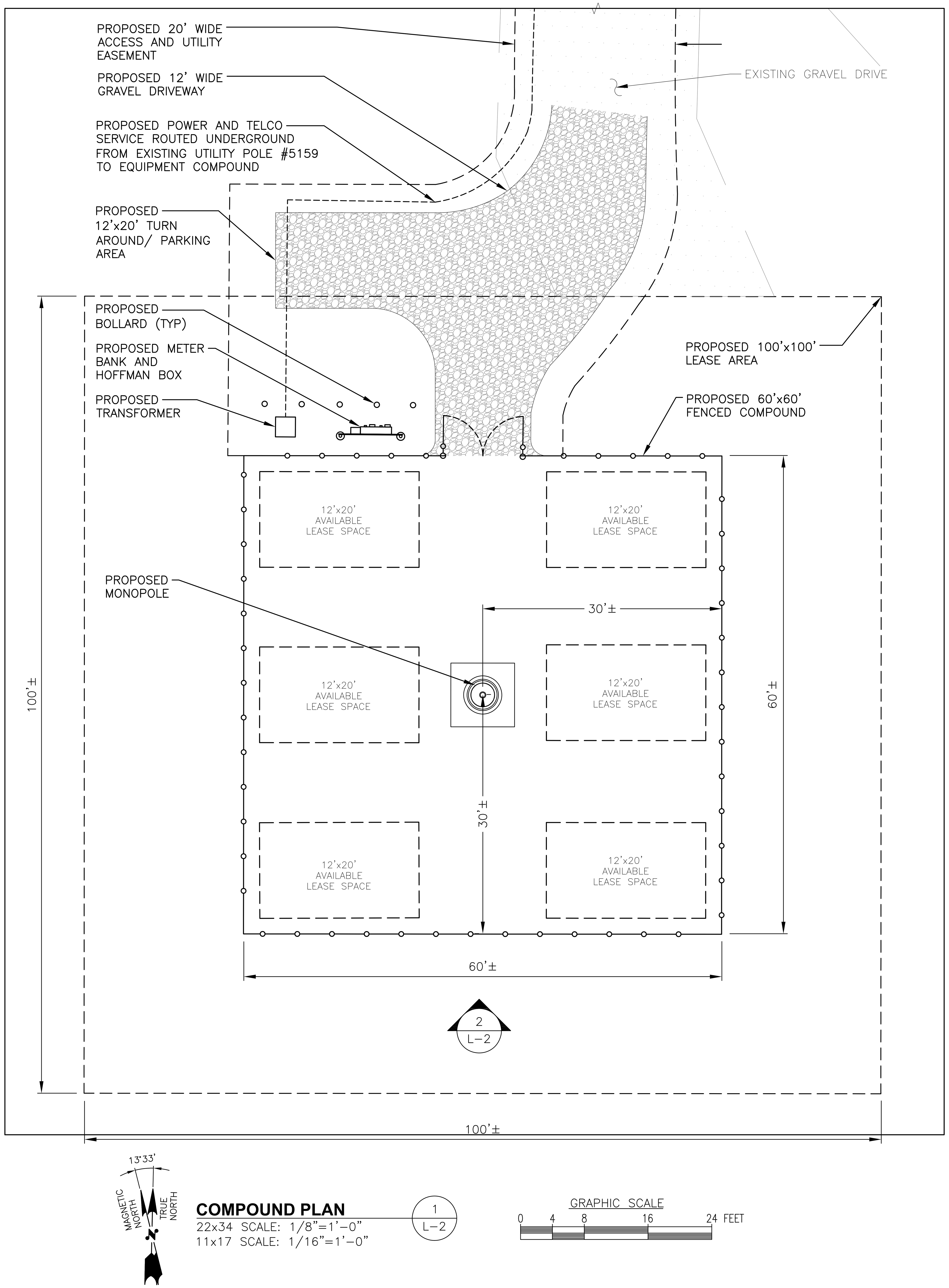
99 DART HILL ROAD
SOUTH WINDSOR, CT 06074

SHEET TITLE

SITE PLAN

SHEET NUMBER

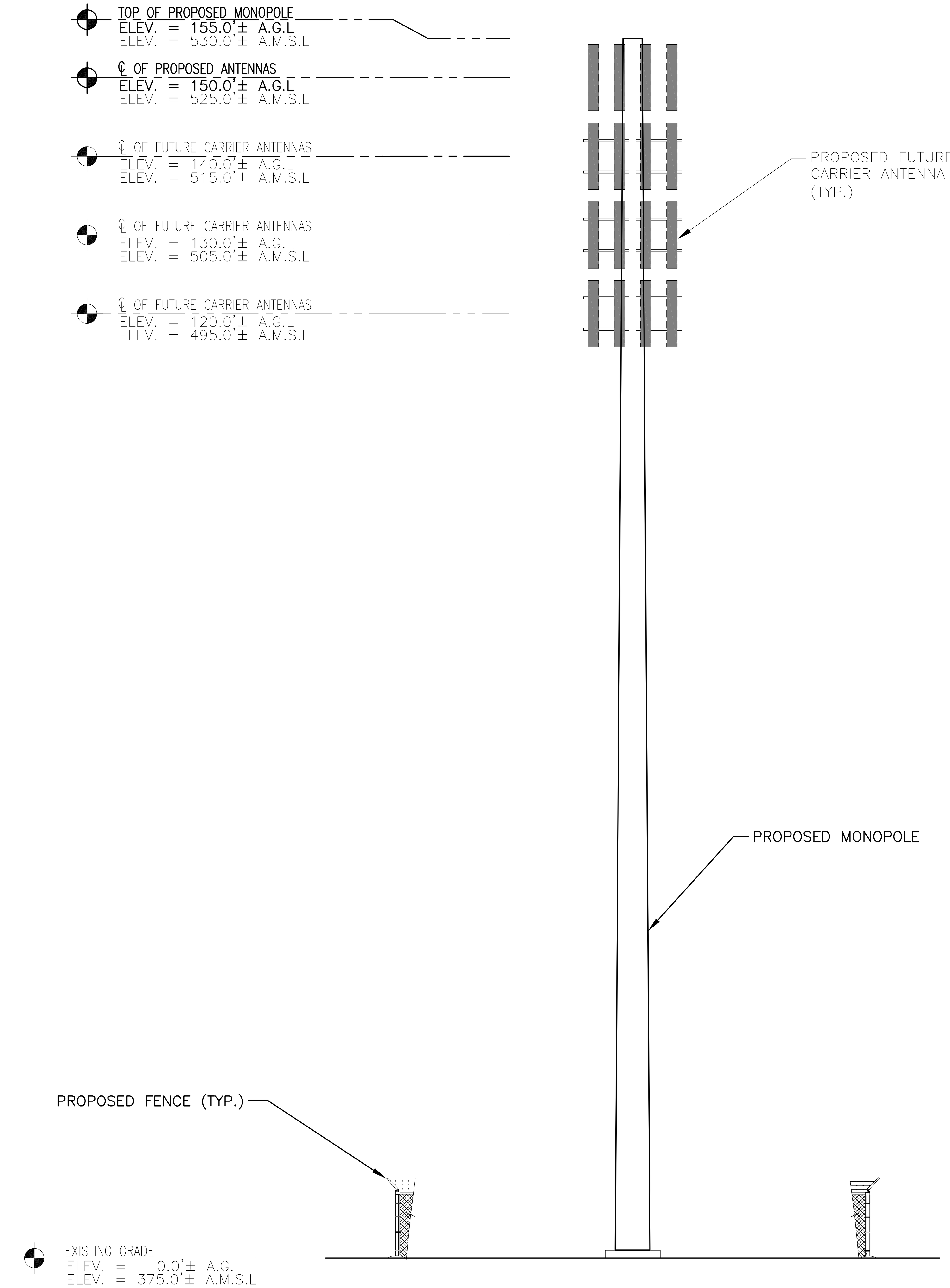
L-1



COMPOUND PLAN (1 / L-2)

22x34 SCALE: 1/8"=1'-0"
11x17 SCALE: 1/16"=1'-0"

GRAPHIC SCALE: 0 4 8 16 24 FEET



NORTH ELEVATION (2 / L-2)

22x34 SCALE: 1"=10'-0"
11x17 SCALE: 1"=20'-0"

GRAPHIC SCALE: 0 5 10 20 30 FEET

LEASE EXHIBIT

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LEASE EXHIBIT

TARPON TOWERS

TARPON TOWERS II, LLC
1001 3rd AVENUE WEST, SUITE 420
BRADENTON, FL 34205

DOUGLAS J. ROBERTS ARCHITECT
110 Washington Avenue
Fourth Floor
North Haven, CT 06473

Tel: 203.234.6368
Email: droberts - architect@outlook.com

CHECKED BY: DJR

APPROVED BY: DJR

SUBMITTALS

REV.	DATE	DESCRIPTION	BY
0	10/13/2022	ISSUED FOR REVIEW	KAM

SITE NAME:

SOUTH WINDSOR

SITE ADDRESS:

99 DART HILL ROAD
SOUTH WINDSOR, CT 06074

SHEET TITLE

COMPOUND PLAN

SHEET NUMBER

L-2

Attachment C

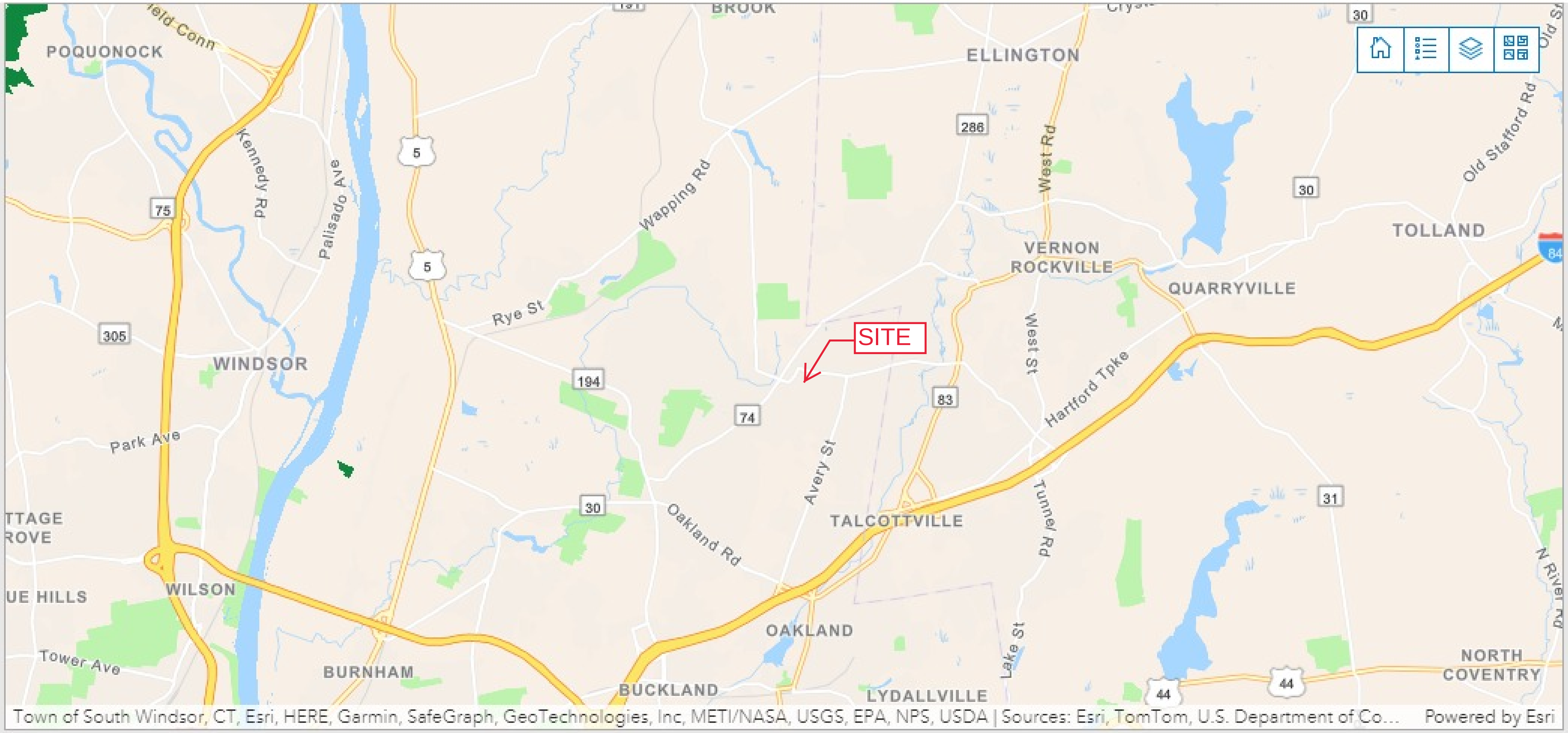
Supporting Documents

Sign In

Important Bird Areas - National Audubon Society

Audubon

Home | IBA Explorer | Public Reports



IBA Sites

Site Name: Northwest Park
Site ID: 741
Status: Recognized
Priority: State
eBird Link: View
State: Connecticut
Download Site Report: View

Site Name: Station 43 Marsh/Sanctuary
Site ID: 832
Status: Recognized
Priority: State
eBird Link: View
State: Connecticut
Download Site Report: View

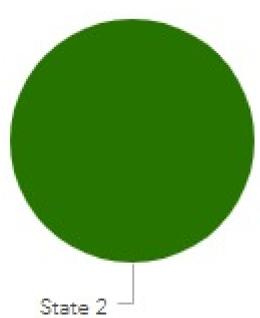
Total IBAs

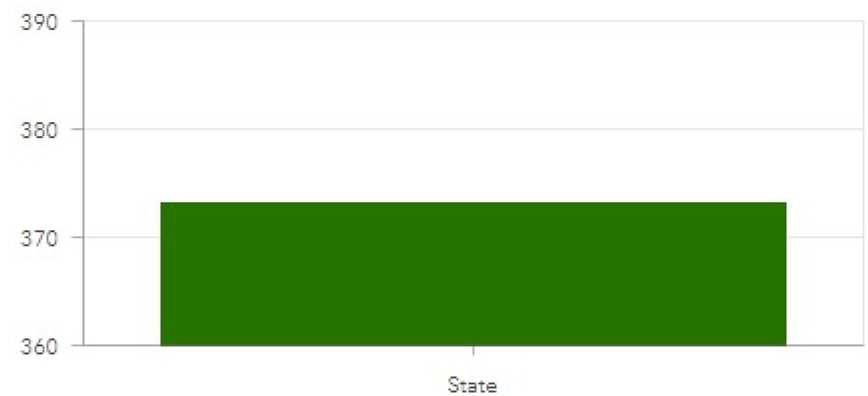
2

Total Acres

373.1

IBAs by Priority Level





Available Routes for 2023 Field Season

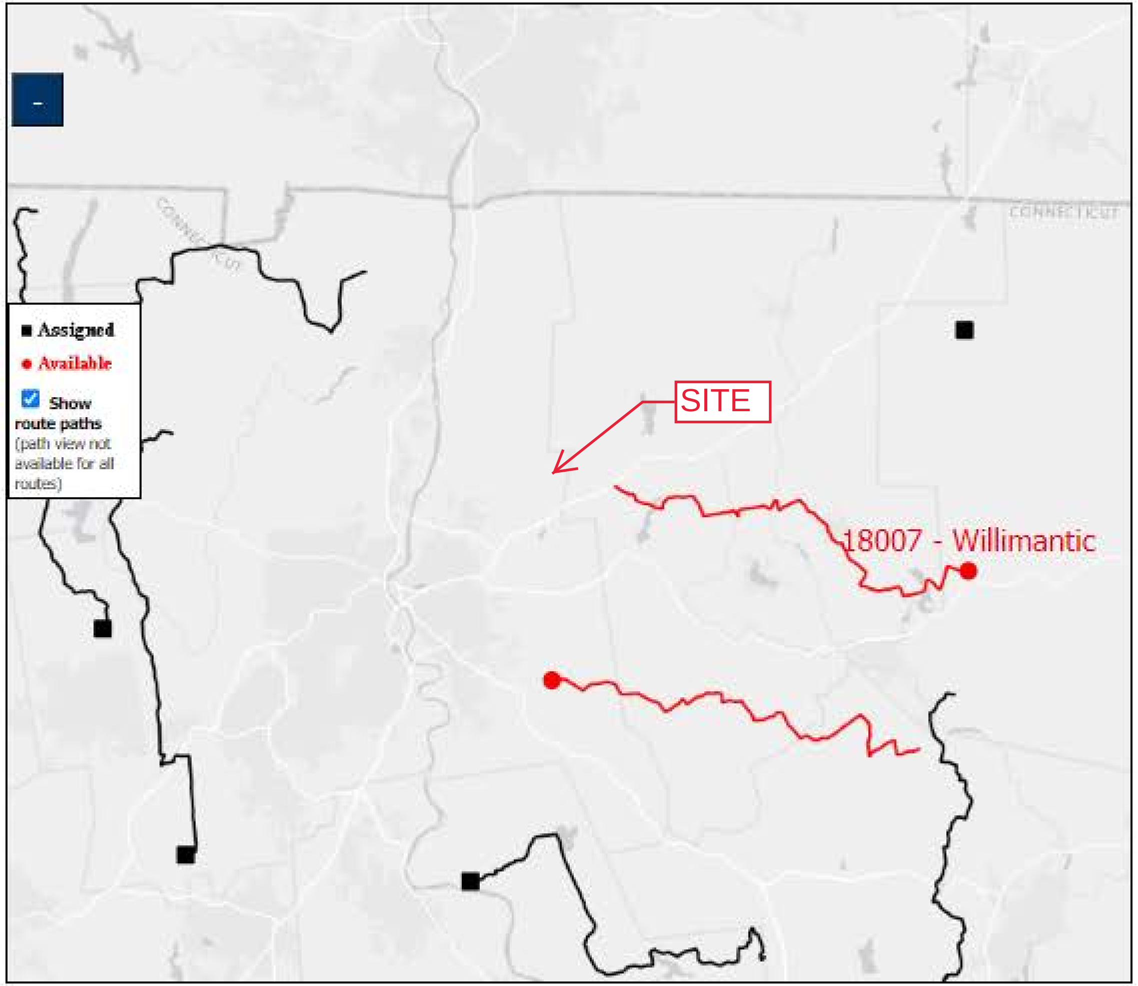
Please Select Your Country and State Below

Country: United States

State: Connecticut

5 Available Routes

Zoom to:	Details:
18001 - Mystic	Info
18003 - Buckingham	Info
18004 - Uncasville	Info
18006 - Westbrook	Info
18007 - Willimantic	Info
18008 - No Woodbury	Info
18009 - Sherman	Info
18010 - Greenwich	Info
18011 - Danbury	Info
18013 - Long Hill	Info
18014 - Mid Haddam	Info
18015 - Southington	Info
18102 - New Hartford	Info
18105 - Woodstock 2	Info
18112 - Warren 2	Info
18116 - Granby	Info



Search Search [Search]

Eastern Ecological Science Center (formerly Patuxent Wildlife Research Center) (EESC) Migratory Bird Research (MBR) Comments/FAQ(comments)

North American Breeding Bird Survey

3.35 miles from site

Species List

Route WILLIMANTIC

Species	Birds/route	Route Change(Loess) Estimate (Yrs)	Route Change(EEQ) Est | Pval | Nyrs | Var | AvgCnt
Canada Goose *Branta canadensis*	7.50	9.16 (1969-2016)	-0.94 | 0.85871 | 47 | 5.2808 | 2.55 single site analysis - variance may not be valid
Wood Duck *Aix sponsa*	0.12	6.76 (1969-2016)	32.68 | 0.09498 | 47 | 19.5702 | 0.34 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Mallard (all forms) *Anas platyrhynchos*	0.12	-7.20 (1969-2016)	-4.88 | 0.20454 | 47 | 3.8428 | 1.02 single site analysis - variance may not be valid
American Black Duck *Anas rubripes*	0.00	-0.22 (1969-2016)	NA NA
Northern Bobwhite *Colinus virginianus*	0.00	-6.11 (1969-2016)	-9.26 | 0.00926 | 47 | 3.5595 | 0.62 single site analysis - variance may not be valid
Ring-necked Pheasant *Phasianus colchicus*	0.00	7.01 (1969-2016)	4.10 | 0.56870 | 47 | 7.1998 | 0.11 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Ruffed Grouse *Bonasa umbellus*	0.00	-2.24 (1969-2016)	NA NA
Wild Turkey *Meleagris gallopavo*	0.38	-5.86 (1969-2016)	-6.49 | 0.61693 | 47 | 12.9806 | 0.23 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Rock Pigeon *Columba livia*	0.00	-1.48 (1969-2016)	-8.13 | 0.01596 | 47 | 3.3710 | 2.74 single site analysis - variance may not be valid
Mourning Dove *Zenaida macroura*	23.88	0.26 (1969-2016)	-0.09 | 0.90071 | 47 | 0.7212 | 24.11 single site analysis - variance may not be valid
Yellow-billed Cuckoo *Coccyzus americanus*	0.88	-0.45 (1969-2016)	-7.00 | 0.30583 | 47 | 6.8403 | 0.43 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Black-billed Cuckoo *Coccyzus erythropthalmus*	0.12	-9.02 (1969-2016)	-13.93 | 0.00029 | 47 | 3.8185 | 1.43 single site analysis - variance may not be valid
Eastern Whip-poor-will *Androstomus vociferus*	0.00	-1.03 (1969-2016)	NA NA
Chimney Swift *Chaetura pelagica*	5.00	0.45 (1969-2016)	-3.58 | 0.13903 | 47 | 2.4193 | 5.64 single site analysis - variance may not be valid
Ruby-throated Hummingb *Archilochus colubris*	0.50	5.70 (1969-2016)	27.11 | 0.13435 | 47 | 18.1014 | 0.19 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Killdeer *Charadrius vociferus*	0.12	0.82 (1969-2016)	-5.61 | 0.20891 | 47 | 4.4635 | 0.66 single site analysis - variance may not be valid
American Woodcock *Scolopax minor*	0.00	2.56 (1969-2016)	NA NA
Spotted Sandpiper *Actitis macularius*	0.00	-1.89 (1969-2016)	NA NA
Ring-billed Gull *Larus delawarensis*	0.38	4.99 (1969-2016)	NA NA
Herring Gull *Larus argentatus*	0.00	-1.73 (1969-2016)	NA NA
Double-crested Cormora *Phalacrocorax auritus*	0.12	-0.12 (1969-2016)	NA NA
Great Blue Heron (all *Ardea herodias*	0.38	4.47 (1969-2016)	13.73 | 0.20150 | 47 | 10.7496 | 0.17 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Green Heron *Butorides virescens*	0.00	4.66 (1969-2016)	1.24 | 0.79875 | 47 | 4.8725 | 0.32 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Turkey Vulture *Cathartes aura*	0.25	4.94 (1969-2016)	22.05 | 0.35599 | 47 | 23.8836 | 0.11 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Cooper's Hawk *Accipiter cooperii*	0.00	2.56 (1969-2016)	NA NA
Red-shouldered Hawk *Buteo lineatus*	1.38	5.43 (1969-2016)	5.77 | 0.53848 | 47 | 9.3836 | 0.38 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Broad-winged Hawk *Buteo platypterus*	0.75	6.17 (1969-2016)	2.25 | 0.73131 | 47 | 6.5430 | 0.26 single site analysis - variance may

Species	Birds/route	Route Change(Loess) Estimate (Yrs)	Route Change(EEQ) Est | Pval | Nyrs | Var | AvgCnt
			not be valid,low relative abundance species - view results with caution!
Red-tailed Hawk (all *Buteo jamaicensis*	0.50	2.74 (1969-2016)	-0.44 | 0.94600 | 47 | 6.4841 | 0.19 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Great Horned Owl *Bubo virginianus*	0.00	-1.77 (1969-2016)	NA NA
Barred Owl *Strix varia*	0.25	3.69 (1969-2016)	46.69 | 0.41751 | 47 | 57.5902 | 0.06 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Belted Kingfisher *Megaceryle alcyon*	0.62	-4.37 (1969-2016)	-6.77 | 0.21380 | 47 | 5.4426 | 0.26 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Red-bellied Woodpecker *Melanerpes carolinus*	8.75	4.73 (1969-2016)	9.63 | 0.00115 | 47 | 2.9675 | 3.43 single site analysis - variance may not be valid
Downy Woodpecker *Picoides pubescens*	11.62	-0.28 (1969-2016)	-0.50 | 0.77845 | 47 | 1.7752 | 6.49 single site analysis - variance may not be valid
Hairy Woodpecker *Picoides villosus*	1.25	-7.60 (1969-2016)	-9.70 | 0.00134 | 47 | 3.0260 | 1.38 single site analysis - variance may not be valid
Pileated Woodpecker *Dryocopus pileatus*	1.62	-1.02 (1969-2016)	4.22 | 0.55570 | 47 | 7.1571 | 0.34 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
American Kestrel *Falco sparverius*	0.00	-7.01 (1969-2016)	-20.21 | 0.01731 | 47 | 8.4916 | 0.15 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Great Crested Flycatch *Myiarchus crinitus*	1.75	1.80 (1969-2016)	0.59 | 0.61935 | 47 | 1.1863 | 4.04 single site analysis - variance may not be valid
Eastern Kingbird *Tyrannus tyrannus*	3.50	-0.58 (1969-2016)	-3.47 | 0.02963 | 47 | 1.5947 | 4.77 single site analysis - variance may not be valid
Eastern Wood-Pewee *Contopus virens*	5.25	3.33 (1969-2016)	-0.52 | 0.76026 | 47 | 1.7014 | 3.72 single site analysis - variance may not be valid
Alder & Willow Flycatc *Empidonax spp.*	0.00	-5.11 (1969-2016)	-10.24 | 0.04986 | 47 | 5.2240 | 0.28 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Least Flycatcher *Empidonax minimus*	0.12	-7.21 (1969-2016)	-5.25 | 0.00570 | 47 | 1.8970 | 1.55 single site analysis - variance may not be valid
Eastern Phoebe *Sayornis phoebe*	8.50	-1.86 (1969-2016)	-0.22 | 0.84996 | 47 | 1.1408 | 8.02 single site analysis - variance may not be valid
White-eyed Vireo *Vireo griseus*	0.00	-1.94 (1969-2016)	-8.17 | 0.27026 | 47 | 7.4058 | 0.04 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Yellow-throated Vireo *Vireo flavifrons*	3.88	0.40 (1969-2016)	-3.64 | 0.04572 | 47 | 1.8240 | 2.02 single site analysis - variance may not be valid
Warbling Vireo *Vireo gilvus*	4.62	5.60 (1969-2016)	5.20 | 0.00786 | 47 | 1.9541 | 3.34 single site analysis - variance may not be valid
Red-eyed Vireo *Vireo olivaceus*	25.88	1.22 (1969-2016)	-1.64 | 0.07193 | 47 | 0.9106 | 16.34 single site analysis - variance may not be valid
Blue Jay *Cyanocitta cristata*	13.12	-11.39 (1969-2016)	-3.88 | 0.00027 | 47 | 1.0693 | 15.96 single site analysis - variance may not be valid
American Crow *Corvus brachyrhynchos*	39.00	-0.61 (1969-2016)	0.99 | 0.18041 | 47 | 0.7379 | 39.23 single site analysis - variance may not be valid
Fish Crow *Corvus ossifragus*	0.62	-2.62 (1969-2016)	-16.02 | 0.59047 | 47 | 29.7731 | 0.11 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Common Raven *Corvus corax*	0.00	-1.71 (1969-2016)	-14.65 | 0.36934 | 47 | 16.3130 | 0.04 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Purple Martin *Progne subis*	0.00	0.93 (1969-2016)	NA NA
Tree Swallow *Tachycineta bicolor*	2.62	-1.71 (1969-2016)	0.14 | 0.96730 | 47 | 3.5216 | 2.98 single site analysis - variance may not be valid
Northern Rough-winged *Stelgidopteryx serripennis*	0.12	-4.77 (1969-2016)	-3.45 | 0.34025 | 47 | 3.6151 | 0.62 single site analysis - variance may not be valid
Bank Swallow *Riparia riparia*	0.00	4.21 (1969-2016)	8.74 | 0.28151 | 47 | 8.1135 | 0.06 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Barn Swallow *Hirundo rustica*	10.88	-1.49 (1969-2016)	-4.71 | 0.02639 | 47 | 2.1216 | 6.77 single site analysis - variance may not be valid

Species	Birds/route	Route Change(Loess) Estimate (Yrs)	Route Change(EEQ) Est | Pval | Nyrs | Var | AvgCnt
Black-capped Chickadee *Poecile atricapillus*	22.88	0.31 (1969-2016)	0.34 | 0.74856 | 47 | 1.0535 | 18.85 single site analysis - variance may not be valid
Red-breasted Nuthatch *Sitta canadensis*	0.00	-1.72 (1969-2016)	NA NA
White-breasted Nuthatc *Sitta carolinensis*	15.88	2.58 (1969-2016)	0.97 | 0.50304 | 47 | 1.4528 | 7.49 single site analysis - variance may not be valid
Brown Creeper *Certhia americana*	0.00	-5.66 (1969-2016)	-6.32 | 0.06579 | 47 | 3.4314 | 0.43 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
House Wren *Troglodytes aedon*	16.88	-2.36 (1969-2016)	-2.13 | 0.01012 | 47 | 0.8288 | 14.89 single site analysis - variance may not be valid
Carolina Wren *Thryothorus ludovicianus*	6.00	9.32 (1969-2016)	13.17 | 0.00220 | 47 | 4.3050 | 2.19 single site analysis - variance may not be valid
Blue-gray Gnatcatcher *Polioptila caerulea*	2.38	1.20 (1969-2016)	4.04 | 0.31475 | 47 | 4.0183 | 1.66 single site analysis - variance may not be valid
Eastern Bluebird *Sialia sialis*	2.50	1.57 (1969-2016)	5.10 | 0.33384 | 47 | 5.2762 | 1.17 single site analysis - variance may not be valid
Veery *Catharus fuscescens*	9.75	0.31 (1969-2016)	-1.15 | 0.31725 | 47 | 1.1454 | 9.68 single site analysis - variance may not be valid
Hermit Thrush *Catharus guttatus*	0.00	-3.22 (1969-2016)	-36.46 | 0.02397 | 47 | 16.1498 | 0.06 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Wood Thrush *Hylocichla mustelina*	4.62	-11.03 (1969-2016)	-2.92 | 0.00187 | 47 | 0.9365 | 13.53 single site analysis - variance may not be valid
American Robin *Turdus migratorius*	45.12	-1.59 (1969-2016)	-1.34 | 0.01696 | 47 | 0.5628 | 40.91 single site analysis - variance may not be valid
Gray Catbird *Dumetella carolinensis*	50.12	2.83 (1969-2016)	2.13 | 0.00295 | 47 | 0.7160 | 31.70 single site analysis - variance may not be valid
Brown Thrasher *Toxostoma rufum*	0.00	-7.82 (1969-2016)	-7.31 | 0.00104 | 47 | 2.2280 | 1.43 single site analysis - variance may not be valid
Northern Mockingbird *Mimus polyglottos*	2.38	9.07 (1969-2016)	1.10 | 0.51004 | 47 | 1.6622 | 6.51 single site analysis - variance may not be valid
European Starling *Sturnus vulgaris*	18.75	-14.00 (1969-2016)	-5.54 | 0.00001 | 47 | 1.3313 | 43.60 single site analysis - variance may not be valid
Cedar Waxwing *Bombycilla cedrorum*	10.00	-9.42 (1969-2016)	-0.33 | 0.89616 | 47 | 2.5067 | 6.64 single site analysis - variance may not be valid
House Sparrow *Passer domesticus*	21.12	0.83 (1969-2016)	0.20 | 0.85782 | 47 | 1.0959 | 23.23 single site analysis - variance may not be valid
House Finch *Haemorhous mexicanus*	10.12	12.28 (1969-2016)	8.80 | 0.00013 | 47 | 2.2746 | 13.77 single site analysis - variance may not be valid
Purple Finch *Haemorhous purpureus*	0.00	-2.75 (1969-2016)	-9.24 | 0.04191 | 47 | 4.5404 | 0.55 single site analysis - variance may not be valid
American Goldfinch *Spinus tristis*	23.38	-0.59 (1969-2016)	0.44 | 0.76650 | 47 | 1.4809 | 12.91 single site analysis - variance may not be valid
Eastern Towhee *Pipilo erythrophthalmus*	3.38	-11.05 (1969-2016)	-6.91 | 0.00000 | 47 | 0.9719 | 8.98 single site analysis - variance may not be valid
Chipping Sparrow *Spizella passerina*	36.00	2.86 (1969-2016)	2.79 | 0.00166 | 47 | 0.8862 | 25.11 single site analysis - variance may not be valid
Field Sparrow *Spizella pusilla*	0.25	-9.88 (1969-2016)	-11.03 | 0.00000 | 47 | 1.5881 | 3.02 single site analysis - variance may not be valid
Savannah Sparrow *Passerculus sandwichensis*	0.00	-5.50 (1969-2016)	-10.03 | 0.00893 | 47 | 3.8328 | 0.60 single site analysis - variance may not be valid
Song Sparrow *Melospiza melodia*	20.88	-3.74 (1969-2016)	-2.01 | 0.00105 | 47 | 0.6145 | 21.98 single site analysis - variance may not be valid
Swamp Sparrow *Melospiza georgiana*	0.00	-6.31 (1969-2016)	-12.68 | 0.00066 | 47 | 3.7204 | 0.53 single site analysis - variance may not be valid
Bobolink *Dolichonyx oryzivorus*	0.00	2.71 (1969-2016)	15.74 | 0.04809 | 47 | 7.9645 | 0.23 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Eastern Meadowlark *Sturnella magna*	0.00	-9.24 (1969-2016)	-14.41 | 0.00001 | 47 | 1.9989 | 1.83 single site analysis - variance may not be valid
Orchard Oriole *Icterus spurius*	0.00	-2.73 (1969-2016)	5.29 | 0.33893 | 47 | 5.5321 | 0.17 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Baltimore Oriole *Icterus galbula*	4.88	-11.02 (1969-2016)	-4.89 | 0.00001 | 47 | 1.1262 | 11.45 single site analysis - variance may

Species	Birds/route	Route Change(Loess) Estimate (Yrs)	Route Change(EEQ) Est | Pval | Nyrs | Var | AvgCnt
			not be valid
Red-winged Blackbird *Agelaius phoeniceus*	20.38	-3.59 (1969-2016)	-6.73 | 0.00001 | 47 | 1.3106 | 40.40 single site analysis - variance may not be valid
Brown-headed Cowbird *Molothrus ater*	12.25	-0.58 (1969-2016)	0.67 | 0.61752 | 47 | 1.3463 | 9.72 single site analysis - variance may not be valid
Common Grackle *Quiscalus quiscula*	17.50	-2.06 (1969-2016)	-0.22 | 0.87453 | 47 | 1.4084 | 20.83 single site analysis - variance may not be valid
Ovenbird *Seiurus aurocapilla*	11.00	-0.81 (1969-2016)	0.62 | 0.56928 | 47 | 1.0871 | 10.51 single site analysis - variance may not be valid
Worm-eating Warbler *Helmitheros vermivorum*	1.00	-2.50 (1969-2016)	-0.09 | 0.99068 | 47 | 7.8577 | 0.26 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Louisiana Waterthrush *Parkesia motacilla*	1.50	1.91 (1969-2016)	5.91 | 0.30705 | 47 | 5.7829 | 0.64 single site analysis - variance may not be valid
Northern Waterthrush *Parkesia noveboracensis*	0.25	-2.63 (1969-2016)	9.71 | 0.31149 | 47 | 9.5889 | 0.19 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Golden-winged Warbler *Vermivora chrysoptera*	0.00	-3.12 (1969-2016)	NA NA
Blue-winged Warbler *Vermivora cyanoptera*	1.50	-2.43 (1969-2016)	-1.62 | 0.19952 | 47 | 1.2611 | 6.53 single site analysis - variance may not be valid
Black-and-white Warble *Mniotilta varia*	1.00	-9.53 (1969-2016)	-6.95 | 0.00002 | 47 | 1.4452 | 3.19 single site analysis - variance may not be valid
Common Yellowthroat *Geothlypis trichas*	15.50	-1.40 (1969-2016)	-2.27 | 0.00025 | 47 | 0.6168 | 17.32 single site analysis - variance may not be valid
American Redstart *Setophaga ruticilla*	3.12	10.46 (1969-2016)	3.29 | 0.13957 | 47 | 2.2254 | 3.28 single site analysis - variance may not be valid
Cerulean Warbler *Setophaga cerulea*	0.00	-1.53 (1969-2016)	NA NA
Northern Parula *Setophaga americana*	0.00	-1.90 (1969-2016)	NA NA
Blackburnian Warbler *Setophaga fusca*	0.00	5.73 (1969-2016)	-9.22 | 0.09331 | 47 | 5.4916 | 0.23 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Yellow Warbler *Setophaga petechia*	7.50	3.47 (1969-2016)	1.56 | 0.11646 | 47 | 0.9938 | 12.30 single site analysis - variance may not be valid
Chestnut-sided Warbler *Setophaga pensylvanica*	0.25	-8.53 (1969-2016)	-7.49 | 0.00035 | 47 | 2.1010 | 2.53 single site analysis - variance may not be valid
Pine Warbler *Setophaga pinus*	5.38	-0.26 (1969-2016)	2.22 | 0.47493 | 47 | 3.1131 | 1.94 single site analysis - variance may not be valid
Yellow-rumped Warbler *Setophaga coronata*	0.00	1.93 (1969-2016)	13.88 | 0.02570 | 47 | 6.2215 | 0.21 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Prairie Warbler *Setophaga discolor*	0.88	-3.77 (1969-2016)	-4.52 | 0.01360 | 47 | 1.8312 | 2.83 single site analysis - variance may not be valid
Black-throated Green W *Setophaga virens*	0.12	-3.62 (1969-2016)	NA NA
Canada Warbler *Cardellina canadensis*	0.00	3.03 (1969-2016)	-3.85 | 0.39752 | 47 | 4.5525 | 0.19 single site analysis - variance may not be valid,low relative abundance species - view results with caution!
Scarlet Tanager *Piranga olivacea*	2.62	-1.02 (1969-2016)	-1.57 | 0.28140 | 47 | 1.4603 | 5.19 single site analysis - variance may not be valid
Northern Cardinal *Cardinalis cardinalis*	43.38	0.69 (1969-2016)	1.27 | 0.04354 | 47 | 0.6288 | 25.91 single site analysis - variance may not be valid
Rose-breasted Grosbeak *Pheucticus ludovicianus*	2.00	-9.92 (1969-2016)	-8.48 | 0.00002 | 47 | 1.5037 | 3.60 single site analysis - variance may not be valid
Indigo Bunting *Passerina cyanea*	2.00	-11.55 (1969-2016)	-8.13 | 0.00106 | 47 | 2.4812 | 2.02 single site analysis - variance may not be valid

HawkCount

Hawk Migration Association of North America's Raptor Migration Database

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Hawkwatch Site Profile

Beelzebub Street

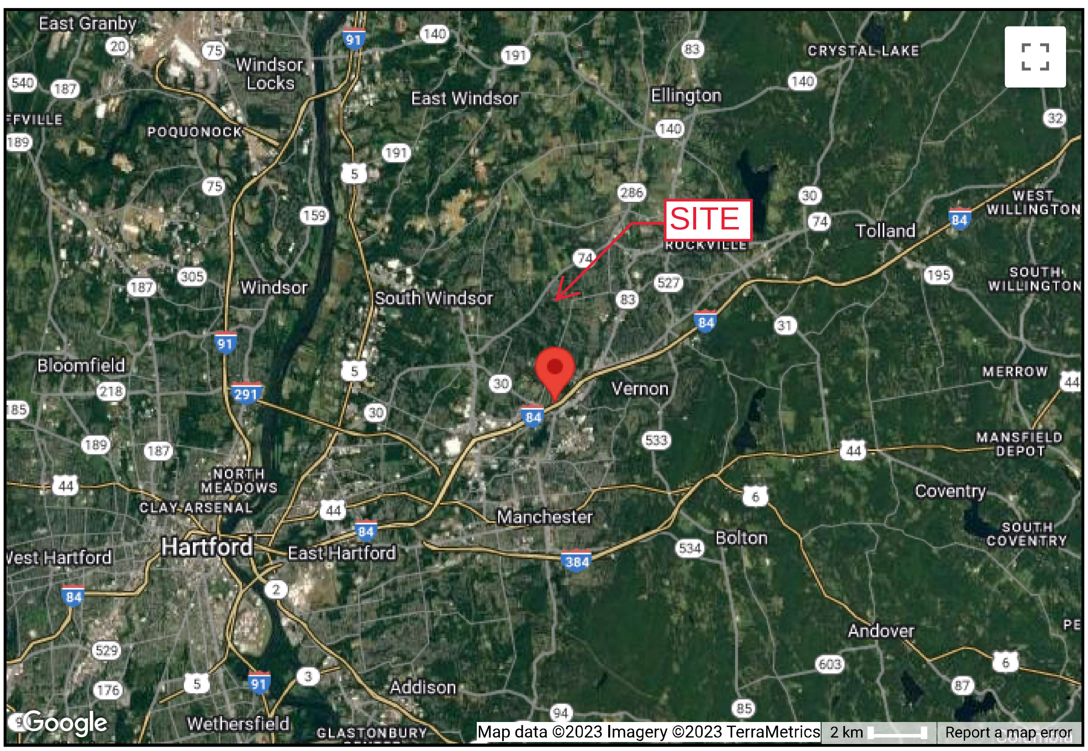
N 41° 48' 50.1",W -72° 31' 3.4"
(N 41.81392, W -72.51761)

South Windsor, Connecticut, USA

[Latest count data]

General | Data Inventory | Migration Timing | RPI Analysis

Map



Pan: Click and drag the map with the mouse pointer.
Zoom: Select the zoom level with the control at the left of the map.

General Site Information

Site Contacts

Name	Role	Email	Phone
Neil W. Currie		nwcurrie23@yahoo.com	

Count Season

Fall: Sep 10 to Sep 22

Procedures/Protocols

Site History

Site Topography

Directions to Site

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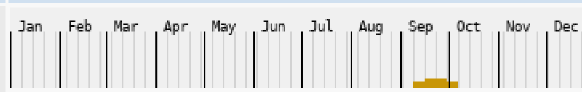
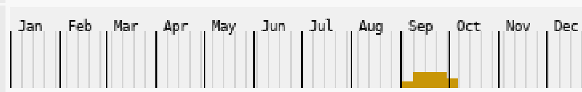
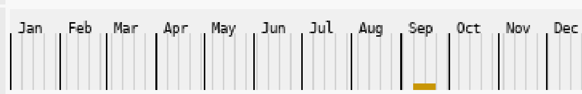
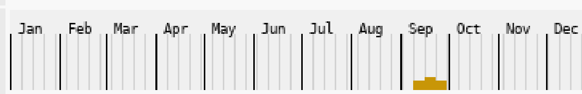
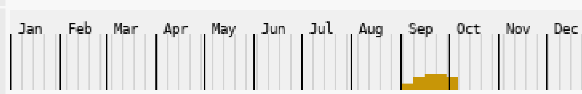
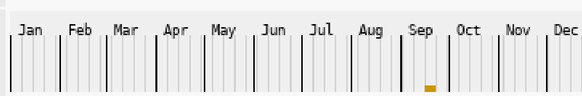
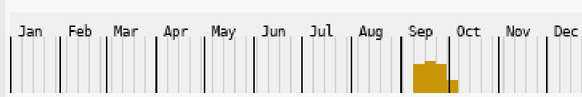
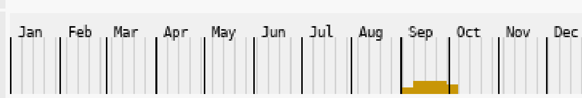
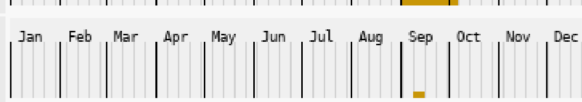
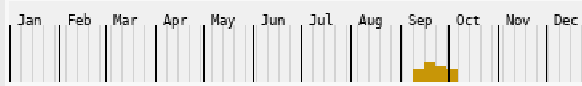
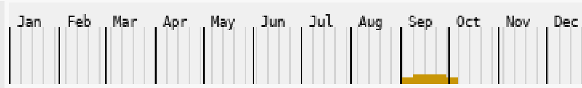
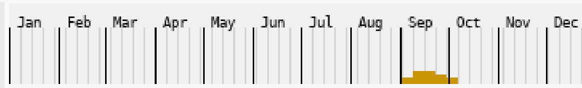
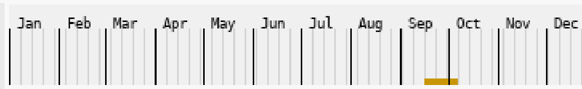
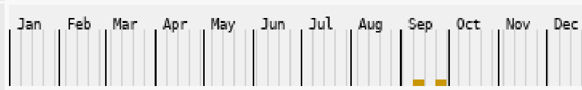
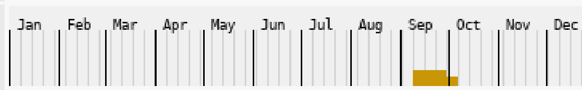
South Windsor, Connecticut, USA

[Latest count data]

General | Data Inventory | Migration Timing | RPI Analysis

Migratory Raptors Observed at Beelzebub Street

Species	Season Counts	Max. Daily Counts	Timing (Average spring / fall weekly counts)
Turkey Vulture *(Cathartes aura)*	**Average:** 2 **Max:** 6 (1988) **Min:** 1 (1987)	2 (Sep 24,1988) 2 (Sep 15,1986) 1 (Sep 17,1984)	
Osprey *(Pandion haliaetus)*	**Average:** 23 **Max:** 43 (1987) **Min:** 6 (1977)	13 (Sep 14,1988) 10 (Sep 17,1981) 10 (Sep 19,1987)	
Bald Eagle *(Haliaeetus leucocephalus)*	**Average:** 1 **Max:** 2 (1990) **Min:** 1 (1989)	1 (Sep 16,1986) 1 (Sep 13,1989) 1 (Sep 13,1990)	
Northern Harrier *(Circus hudsonius)*	**Average:** 5 **Max:** 7 (1980) **Min:** 2 (1982)	3 (Sep 21,1987) 3 (Sep 14,1988) 2 (Sep 09,1981)	
Sharp-shinned Hawk *(Accipiter striatus)*	**Average:** 31 **Max:** 93 (1986) **Min:** 3 (1982)	16 (Sep 23,1987) 15 (Sep 25,1986) 14 (Sep 20,1986)	
Red-shouldered Hawk *(Buteo lineatus)*	**Average:** 1 **Max:** 1 (1988) **Min:** 1 (1988)	1 (Sep 14,1988)	
Broad-winged Hawk *(Buteo platypterus)*	**Average:** 1731 **Max:** 3136 (1985) **Min:** 250 (1977)	2062 (Sep 14,1988) 1893 (Sep 13,1989) 1324 (Sep 21,1987)	
Red-tailed Hawk *(Buteo jamaicensis)*	**Average:** 10 **Max:** 22 (1988) **Min:** 2 (1983)	5 (Sep 24,1988) 4 (Sep 10,1990) 4 (Sep 17,1990)	
Rough-legged Hawk *(Buteo lagopus)*	**Average:** 1 **Max:** 1 (1987) **Min:** 1 (1987)	1 (Sep 12,1987)	

American Kestrel *(Falco sparverius)*	**Average:** 34 **Max:** 61 (1986) **Min:** 18 (1982)	17 (Oct 01,1986) 14 (Sep 15,1989) 13 (Sep 17,1981)	
Unknown Accipiter *(Accipiter sp.)*	**Average:** 3 **Max:** 9 (1981) **Min:** 1 (1989)	3 (Sep 25,1981) 3 (Sep 17,1981) 2 (Sep 12,1984)	
Unknown Buteo *(Buteo sp.)*	**Average:** 9 **Max:** 22 (1980) **Min:** 1 (1982)	5 (Sep 16,1986) 5 (Sep 08,1980) 5 (Sep 12,1989)	
Unknown Falcon *(Falco sp.)*	**Average:** 1 **Max:** 2 (1985) **Min:** 1 (1988)	2 (Sep 16,1985) 1 (Sep 21,1987) 1 (Sep 26,1988)	
Unknown Eagle *(eagle sp.)*	**Average:** 2 **Max:** 2 (1990) **Min:** 1 (1982)	1 (Sep 24,1982) 1 (Sep 10,1990) 1 (Sep 15,1990)	
Unknown Raptor *(Accipitridae sp.)*	**Average:** 31 **Max:** 68 (1980) **Min:** 8 (1989)	16 (Sep 25,1982) 16 (Sep 24,1980) 14 (Sep 09,1981)	

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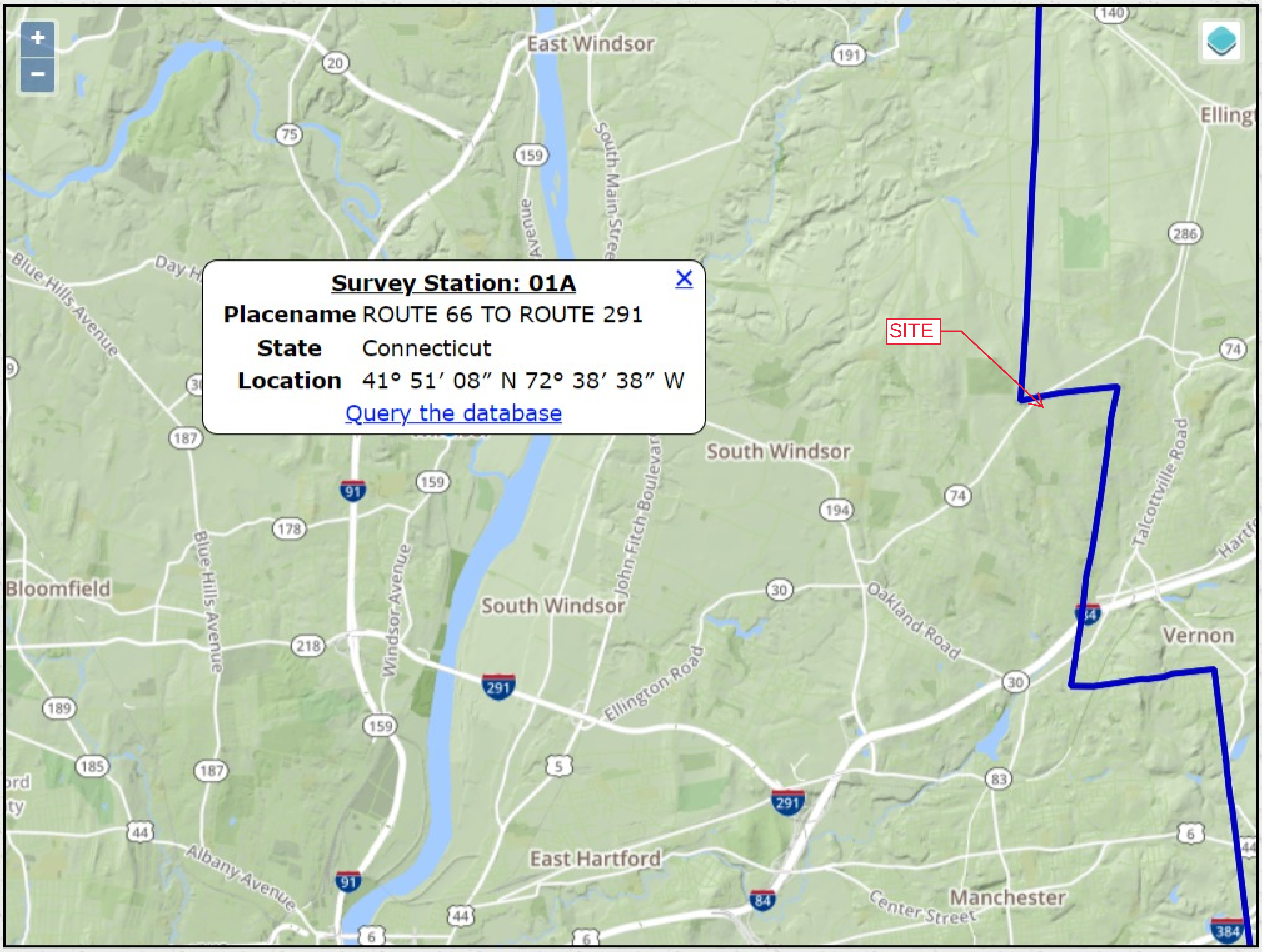
Query by Routes

This marker represents a cluster of sites in the general area. **Click** the marker to display a list of the sites contained within. **Zoom in** further to "break up" the cluster and display the individual yellow site markers within.

This marker indicates a survey site. **Click** the marker to display additional information, including a link that will allow you to query the database for records from that site.

NOTE: If you are experiencing loading or performance issues, please use another browser such as Firefox, Chrome, Edge, or Safari.



Midwinter Bald Eagle Count

Background/ History of the Survey
Summary Trend Information
How to Use This Site
Forms/ Instructions for Upcoming Surveys
Metadata
Site Map

Query by Routes

This marker represents a cluster of sites in the general area. **Click** the marker to display a list of the sites contained within. **Zoom in** further to "break up" the cluster and display the individual yellow site markers within.

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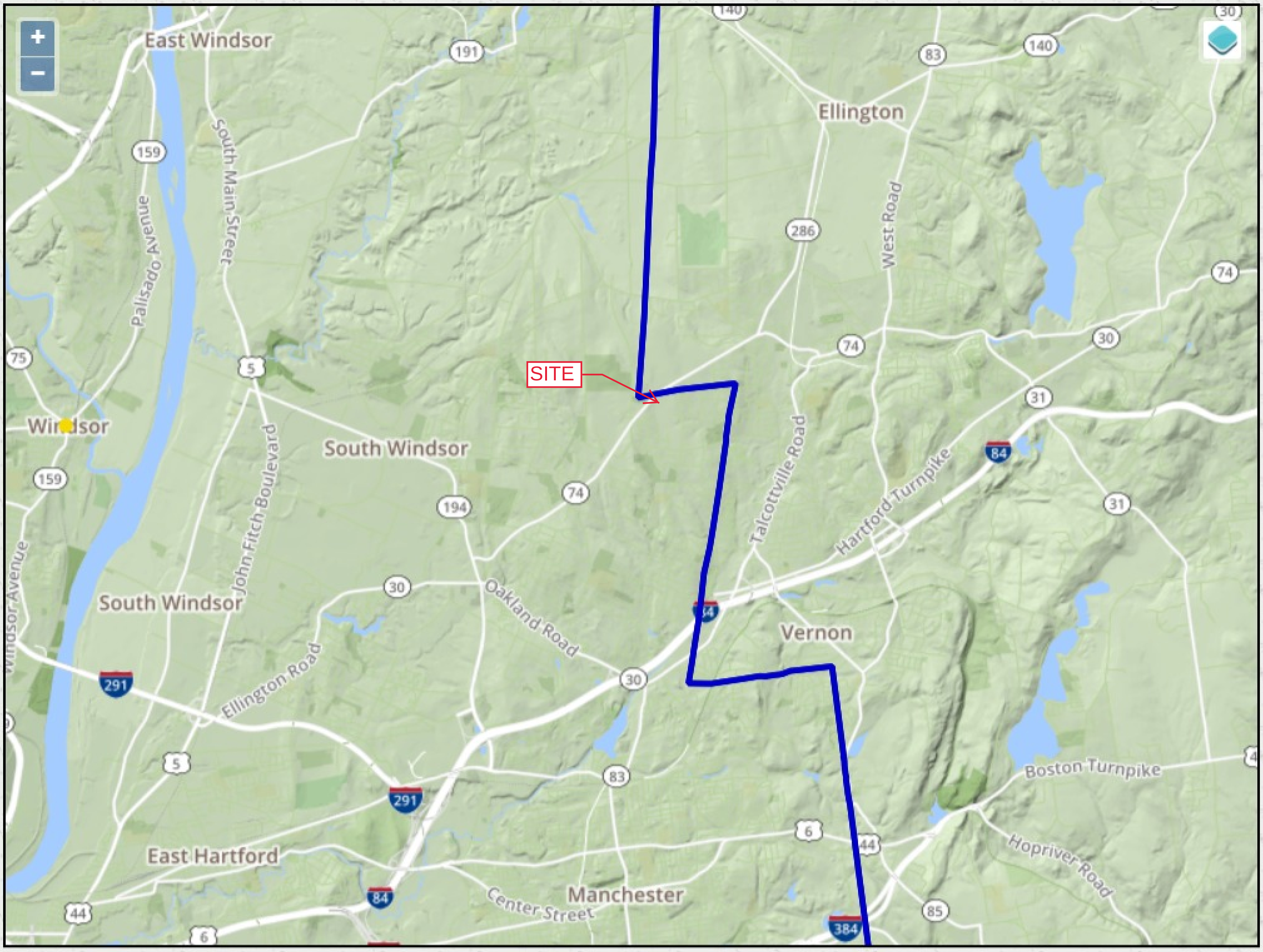
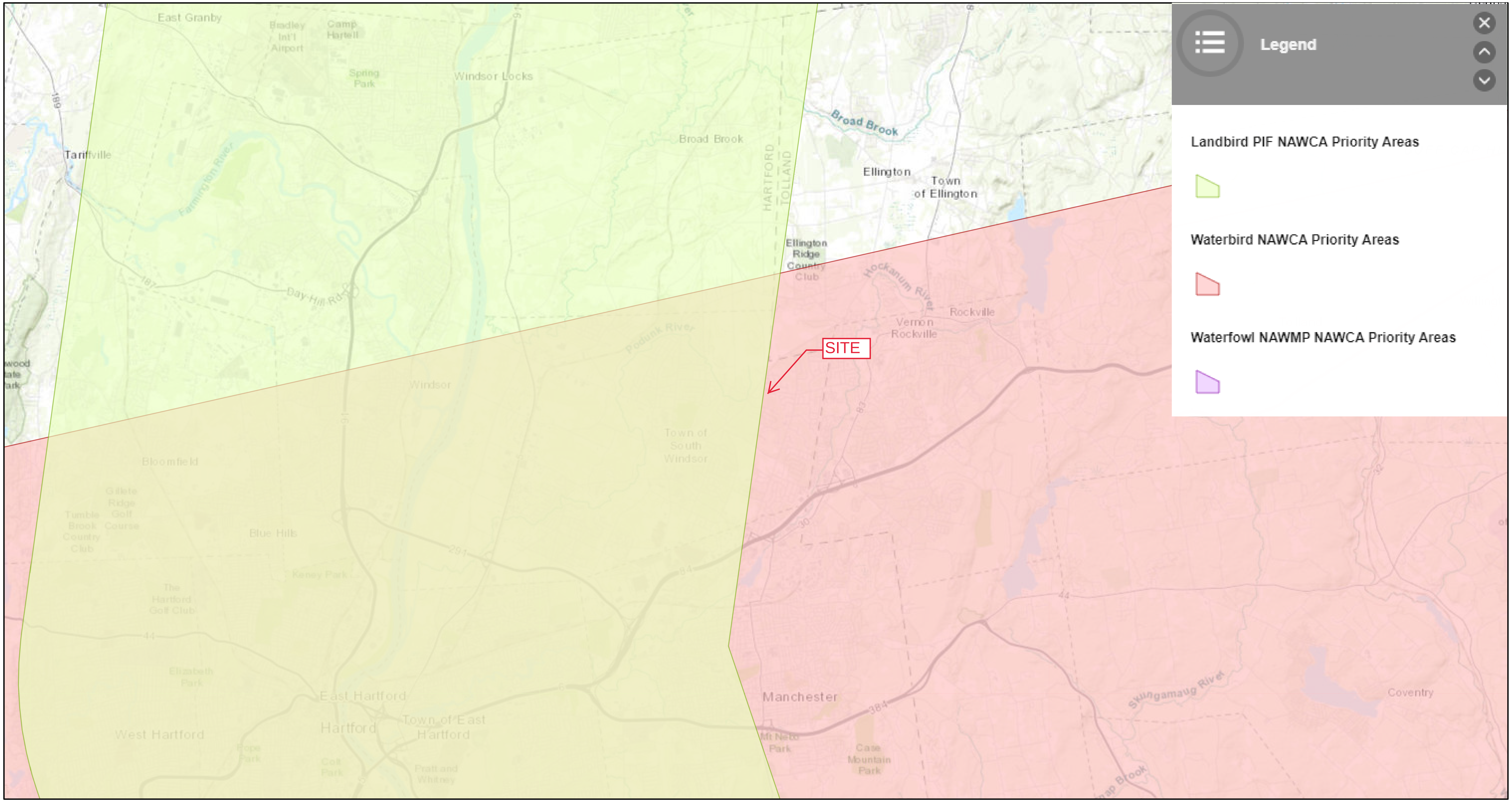


NAWCA all layers



July 12, 2023

1:144,448

0 1.25 2.5 5 mi

0 2 4 8 km

MassGIS, UConn/CTDEEP, Esri Canada, Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS

Natural Diversity Data Base Areas

SOUTH WINDSOR, CT

June 2023

- State and Federal Listed Species
- Critical Habitat
- Town Boundary

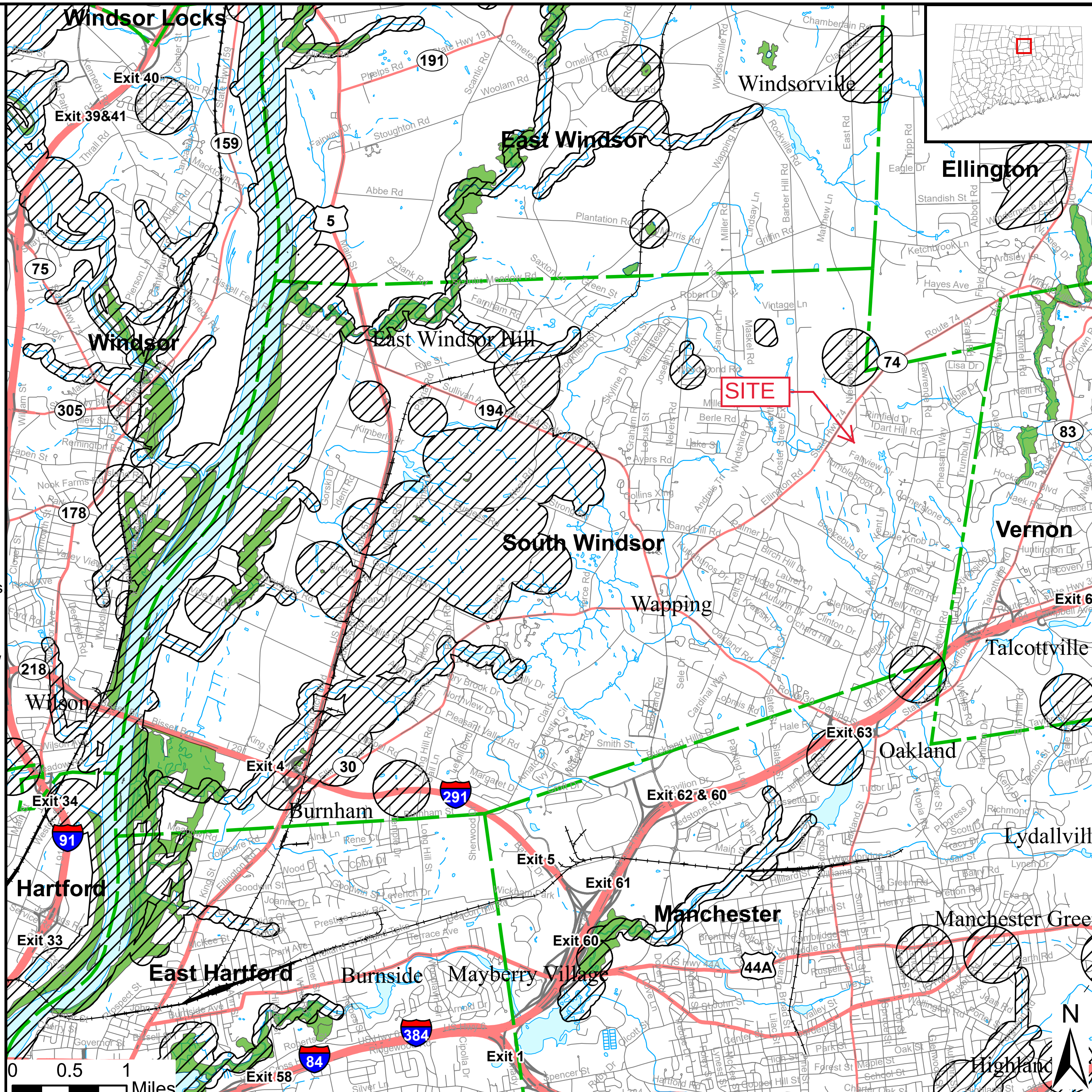
NOTE: This map shows known locations of State and Federal Listed Species and Critical Habitats. Information on listed species is collected and compiled by the Natural Diversity Data Base (NDDB) from a variety of data sources . Exact locations of species have been buffered to produce the generalized locations.

This map is intended for use as a preliminary screening tool for conducting a Natural Diversity Data Base Review Request. To use the map, locate the project boundaries and any additional affected areas. If the project is within a hatched area there may be a potential conflict with a listed species. For more information, use DEEP ezFile https://filings.deep.ct.gov/DEEPPortal/ to submit a Request for Natural Diversity Data Base State Listed Species Review or Site Assessment. More detailed instructions are provided along with the request form on our website.
https://portal.ct.gov/deep-nddbrequest

Use the CTECO Interactive Map Viewers at http://cteco.uconn.edu to more precisely search for and locate a site and to view aerial imagery with NDDB Areas.

QUESTIONS: Department of Energy and Environmental Protection (DEEP)
79 Elm St, Hartford, CT 06106
email: deep.nddbrequest@ct.gov
Phone: (860) 424-3011

Connecticut Department of Energy & Environmental Protection



A County Report of Connecticut's Endangered, Threatened and Special Concern Species

Hartford County

Amphibians

Scientific Name	Common Name	Protection Status
Ambystoma jeffersonianum	Jefferson salamander "complex"	SC
Ambystoma laterale	Blue-spotted salamander	E/SC
Gyrinophilus porphyriticus	Northern spring salamander	T
Necturus maculosus	Mudpuppy	SC
Rana pipiens	Northern leopard frog	SC

Birds

Scientific Name	Common Name	Protection Status
Accipiter striatus	Sharp-shinned hawk	E
Aegolius acadicus	Northern saw-whet owl	SC
Ammodramus henslowii	Henslow's sparrow	SC*
Ammodramus savannarum	Grasshopper sparrow	E
Asio flammeus	Short-eared owl	T
Asio otus	Long-eared owl	E
Bartramia longicauda	Upland sandpiper	E
Botaurus lentiginosus	American bittern	E
Buteo platypterus	Broad-winged hawk	SC
Caprimulgus vociferus	Whip-poor-will	SC
Circus hudsonius	Northern harrier (Circus cyaneus)	E
Cistothorus platensis	Sedge wren	E
Dolichonyx oryzivorus	Bobolink	SC
Empidonax alnorum	Alder flycatcher	SC
Eremophila alpestris	Horned lark	E
Falco peregrinus	Peregrine falcon	T

Hartford County

Birds

Scientific Name	Common Name	Protection Status
Falco sparverius	American kestrel	SC
Gallinula galeata	Common moorhen (Gallinula chloropus)	E
Gavia immer	Common loon	SC
Haliaeetus leucocephalus	Bald eagle	T
Ixobrychus exilis	Least bittern	T
Melanerpes erythrocephalus	Red-headed woodpecker	E
Passerculus sandwichensis	Savannah sparrow	SC
Podilymbus podiceps	Pied-billed grebe	E
Pooecetes gramineus	Vesper sparrow	E
Progne subis	Purple martin	SC
Setophaga cerulea	Cerulean warbler	SC
Sturnella magna	Eastern meadowlark	T
Toxostoma rufum	Brown thrasher	SC
Tyto alba	Barn owl	E

Fish

Scientific Name	Common Name	Protection Status
Acipenser brevirostrum	Shortnose sturgeon	E
Alosa aestivalis	Blueback herring	SC
Cottus cognatus	Slimy sculpin	SC
Enneacanthus obesus	Banded sunfish	SC
Lethenteron appendix	American brook lamprey	E
Lota lota	Burbot	E
Notropis bifrenatus	Bridle shiner	SC

Invertebrates

Scientific Name	Common Name	Protection Status
Agonum darlingtoni	Ground beetle	SC
Agonum mutatum	Ground beetle	SC

Hartford County

Invertebrates

Scientific Name	Common Name	Protection Status
Alasmidonta heterodon	Dwarf wedgemussel	E
Alasmidonta varicosa	Brook floater	E
Amara chalcea	Ground beetle	SC
Apodrepanulatrix liberaria	New Jersey tea inchworm	E
Bembidion carinula	Ground beetle	SC
Bombus terricola	Yellow-banded bumble bee	T
Brachinus cyanipennis	Bombardier beetle	SC
Brachinus medius	Bombardier beetle	SC
Callophrys irus	Frosted elfin	T
Cambarus bartonii	Common crayfish	SC
Chytonix sensilis	Barrens Chytonix	E
Cicindela formosa generosa	Big sand tiger beetle	SC
Cicindela lepida	Dune ghost tiger beetle	E
Cicindela puritana	Puritan tiger beetle	E
Cicindela purpurea	Purple tiger beetle	SC*
Cicindela tranquebarica	Dark-bellied tiger beetle	T
Cordulegaster erronea	Tiger spiketail	T
Erynnis horatius	Horace's duskywing	SC
Erynnis lucilius	Columbine duskywing	E
Euchlaena madusaria	Scrub euchlaena	T
Eumacaria latiferrugata	Brown-bordered geometer	T
Euxoa pleuritica	Fawn brown dart moth	SC
Euxoa violaris	Violet dart moth	SC
Exyra fax	Pitcher plant moth	T
Geopinus incrassatus	Ground beetle	SC
Gomphus descriptus	Harpoon clubtail	T
Gomphus fraternus	Midland clubtail	T
Gomphus quadricolor	Rapids clubtail	T

Hartford County

Invertebrates

Scientific Name	Common Name	Protection Status
Gomphus vastus	Cobra clubtail	SC
Gomphus ventricosus	Skillet clubtail	SC
Grammia phyllira	Phyllira tiger moth	E
Gyraulus circumstriatus	Disc gyro	SC
Harpalus erraticus	Ground beetle	SC
Hemileuca maia maia	Barrens buck moth	E
Hetaerina americana	American rubyspot	T
Hybomitra typhus	Horse fly	T
Lampsilis cariosa	Yellow lampmussel	E
Lapara coniferarum	Southern pine sphinx	T
Leptodea ochracea	Tidewater mucket	SC
Lethe eurydice	Eyed brown	SC
Leucorrhinia glacialis	Crimson-ringed whiteface	T
Ligumia nasuta	Eastern pondmussel	SC
Lycaena epixanthe	Bog copper	SC
Lycaena hyllus	Bronze copper	SC
Margaritifera margaritifera	Eastern pearlshell	SC
Scaphinotus viduus	Ground beetle	SC
Schinia spinosae	Spinose flower moth	SC
Speranza exonerata	Barrens itame	T
Speyeria atlantis	Atlantis fritillary butterfly	E
Stylurus amnicola	Riverine clubtail	T
Sympistis perscripta	Scribbled sallow moth	SC
Zale curema	Black-eyed zale	E
Zale obliqua	Oblique zale	SC
Zanclognatha martha	Pine barrens zanclognatha	T

Hartford County

Mammals

Scientific Name	Common Name	Protection Status
Lasionycteris noctivagans	Silver-haired bat	SC
Lasiurus borealis	Red bat	SC
Lasiurus cinereus	Hoary bat	SC
Myotis lucifugus	Little brown bat	E
Myotis septentrionalis	Northern long-eared bat	E
Perimyotis subflavus	Tri-colored bat	E

Plants

Scientific Name	Common Name	Protection Status
Acalypha virginica	Virginia copperleaf	SC
Agalinis acuta	Sandplain agalinis	E
Agastache nepetoides	Yellow giant hyssop	E
Agastache scrophulariifolia	Purple giant hyssop	E
Alopecurus aequalis	Short-awned meadow foxtail	T
Andromeda polifolia var. glaucophylla	Bog rosemary	T
Angelica venenosa	Hairy angelica	SC*
Aplectrum hyemale	Puttyroot	SC*
Arethusa bulbosa	Dragon's-mouth	SC*
Aristida longespica var. geniculata	Needlegrass	SC
Aristida purpurascens	Arrowfeather	E
Asclepias purpurascens	Purple milkweed	SC
Asplenium ruta-muraria	Wallrue spleenwort	T
Bidens beckii	Beck's water-marigold	SC
Blephilia ciliata	Downy wood-mint	SC*
Blephilia hirsuta	Hairy wood-mint	SC*
Calystegia silvatica	Short-stalked false bindweed	SC*
Calystegia spithamaea	Low bindweed	SC*
Carex aestivalis	Summer sedge	SC

Hartford County

Plants

Scientific Name	Common Name	Protection Status
Carex alata	Broadwing sedge	E
Carex barrattii	Barratt's sedge	E
Carex bushii	Bush's sedge	SC
Carex buxbaumii	Brown bog sedge	E
Carex collinsii	Collins' sedge	SC*
Carex cumulata	Clustered sedge	T
Carex davisii	Davis' sedge	T
Carex foenea	Bronze sedge	SC
Carex hitchcockiana	Hitchcock's sedge	SC
Carex limosa	Mud sedge	T
Carex oligocarpa	Eastern few-fruit sedge	SC
Carex oligosperma	Few-seeded sedge	SC*
Carex polymorpha	Variable sedge	E
Carex pseudocyperus	Cyperus-like sedge	E
Carex tuckermanii	Tuckerman's sedge	SC
Carex typhina	Cattail sedge	SC
Carex willdenowii	Willdenow's sedge	E
Celastrus scandens	American bittersweet	SC
Chamaelirium luteum	Devil's-bit	E
Coeloglossum viride	Long-bracted green orchid	E
Corallorhiza trifida	Early coral root	SC
Corydalis flavula	Yellow corydalis	T
Crocanthemum propinquum	Low frostweed	SC
Cuphea viscosissima	Blue waxweed	SC*
Cypripedium parviflorum	Yellow lady's-slipper	SC
Deschampsia cespitosa	Tufted hairgrass	SC
Desmodium glabellum	Dillenius' tick-trefoil	SC
Dicentra canadensis	Squirrel corn	SC

Hartford County

Plants

Scientific Name	Common Name	Protection Status
Dichanthelium ovale ssp. pseudopubescens	Stiff-leaved rosette-panicgrass	SC*
Dichanthelium scabriusculum	Tall swamp rosette-panicgrass	E
Dichanthelium xanthophysum	Pale-leaved rosette-panicgrass	SC*
Diplazium pycnocarpon	Narrow-leaved glade fern	E
Drymocallis arguta	Tall cinquefoil	SC
Dryopteris goldiana	Goldie's fern	SC
Echinodorus tenellus	Bur-head	E
Elymus wiegandii	Wiegand's wild rye	SC
Equisetum palustre	Marsh horsetail	SC*
Equisetum pratense	Meadow horsetail	E
Eriophorum vaginatum var. spissum	Hare's tail	T
Eurybia radula	Rough aster	E
Gaultheria hispidula	Creeping snowberry	SC
Gaylussacia bigeloviana	Dwarf huckleberry	T
Gentianella quinquefolia	Stiff gentian	E
Geranium bicknellii	Bicknell's northern crane's-bill	SC*
Goodyera repens var. ophioides	Dwarf rattlesnake plantain	SC*
Hottonia inflata	Featherfoil	SC
Houstonia longifolia	Longleaf bluet	T
Hydrastis canadensis	Goldenseal	E
Hydrophyllum virginianum	Virginia waterleaf	SC
Hypericum ascyron	Great St. John's-wort	SC
Isotria medeoloides	Small whorled pogonia	E
Liatris novae-angliae	New England blazing-star	SC
Linnaea borealis ssp. americana	Twinflower	E
Linum intercursum	Sandplain flax	SC*
Linum sulcatum	Grooved Yellow flax	E

Hartford County

Plants

Scientific Name	Common Name	Protection Status
Liparis liliifolia	Lily-leaved twayblade	E
Lipocarpha micrantha	Dwarf bulrush	T
Lygodium palmatum	Climbing fern	SC
Maianthemum trifolium	Three-leaved false Solomon's-seal	T
Malaxis unifolia	Green adder's-mouth	E
Milium effusum	Tall millet-grass	E
Moneses uniflora	One-flower wintergreen	E
Onosmodium virginianum	Gravel-weed	E
Ophioglossum pusillum	Northern adder's-tongue	E
Opuntia humifusa	Eastern prickly pear	SC
Orontium aquaticum	Golden club	SC
Orthilia secunda	One-sided pyrola	SC*
Oxalis violacea	Violet wood-sorrel	SC
Packera anonyma	Small's ragwort	E
Packera paupercula	Balsam groundsel	E
Panax quinquefolius	American ginseng	SC
Paronychia fastigiata	Hairy forked chickweed	SC*
Pedicularis lanceolata	Swamp lousewort	T
Pinus resinosa	Red pine	E
Piptatherum pungens	Slender mountain ricegrass	E
Plantago virginica	Hoary plantain	SC
Platanthera blephariglottis	White-fringed orchid	E
Platanthera ciliaris	Yellow-fringed orchid	E
Platanthera dilatata	Tall white bog orchid	SC*
Platanthera hookeri	Hooker's orchid	SC*
Platanthera orbiculata	Large round-leaved orchid	SC*
Polygala nuttallii	Nuttall's milkwort	T
Populus heterophylla	Swamp cottonwood	T

Hartford County

Plants

Scientific Name	Common Name	Protection Status
Prunus alleghaniensis	Alleghany plum	SC*
Ranunculus ambigens	Water-plantain spearwort	E
Ranunculus pensylvanicus	Bristly buttercup	SC
Rhododendron groenlandicum	Labrador tea	T
Rhynchospora scirpoides	Long-beaked beaksedge	E
Ribes glandulosum	Skunk currant	SC
Ribes triste	Swamp red currant	E
Rotala ramosior	Toothcup	T
Sagittaria cuneata	Northern arrowhead	E
Salix exigua	Sandbar willow	E
Salix pedicellaris	Bog willow	E
Salix petiolaris	Slender willow	SC
Scheuchzeria palustris ssp. americana	Pod grass	E
Schoenoplectus torreyi	Torrey bulrush	T
Scirpus longii	Long's bulrush	SC*
Scleria pauciflora var. caroliniana	Few-flowered nutrush	E
Scleria triglomerata	Whip nutrush	E
Scutellaria integrifolia	Hyssop skullcap	E
Senna hebecarpa	Wild senna	T
Silene stellata	Starry campion	T
Solidago latissimifolia	Elliott's goldenrod	SC*
Stachys hispida	Hispid hedge-nettle	T
Stachys hyssopifolia	Hyssop-leaf hedge-nettle	E
Stellaria borealis	Northern stitchwort	SC
Streptopus amplexifolius	White mandarin	T
Thuja occidentalis	Northern white cedar	T
Trichomanes intricatum	Appalachian gametophyte	SC

Hartford County

Plants

Scientific Name	Common Name	Protection Status
Trichostema brachiatum	False pennyroyal	E
Triosteum angustifolium	Narrow-leaved horse gentian	E
Triphora trianthophora	Nodding pogonia	E
Trisetum spicatum	Narrow false oats	E
Uvularia grandiflora	Large-flowered bellwort	E
Vaccinium vitis-idaea ssp. minus	Mountain cranberry	SC*
Valerianella radiata	Beaked corn-salad	SC*
Verbena simplex	Narrow-leaved vervain	SC*
Viola canadensis	Canada violet	SC
Viola selkirkii	Great-spurred violet	SC
Waldsteinia fragarioides	Barren strawberry	E
Xyris montana	Northern yellow-eyed grass	T

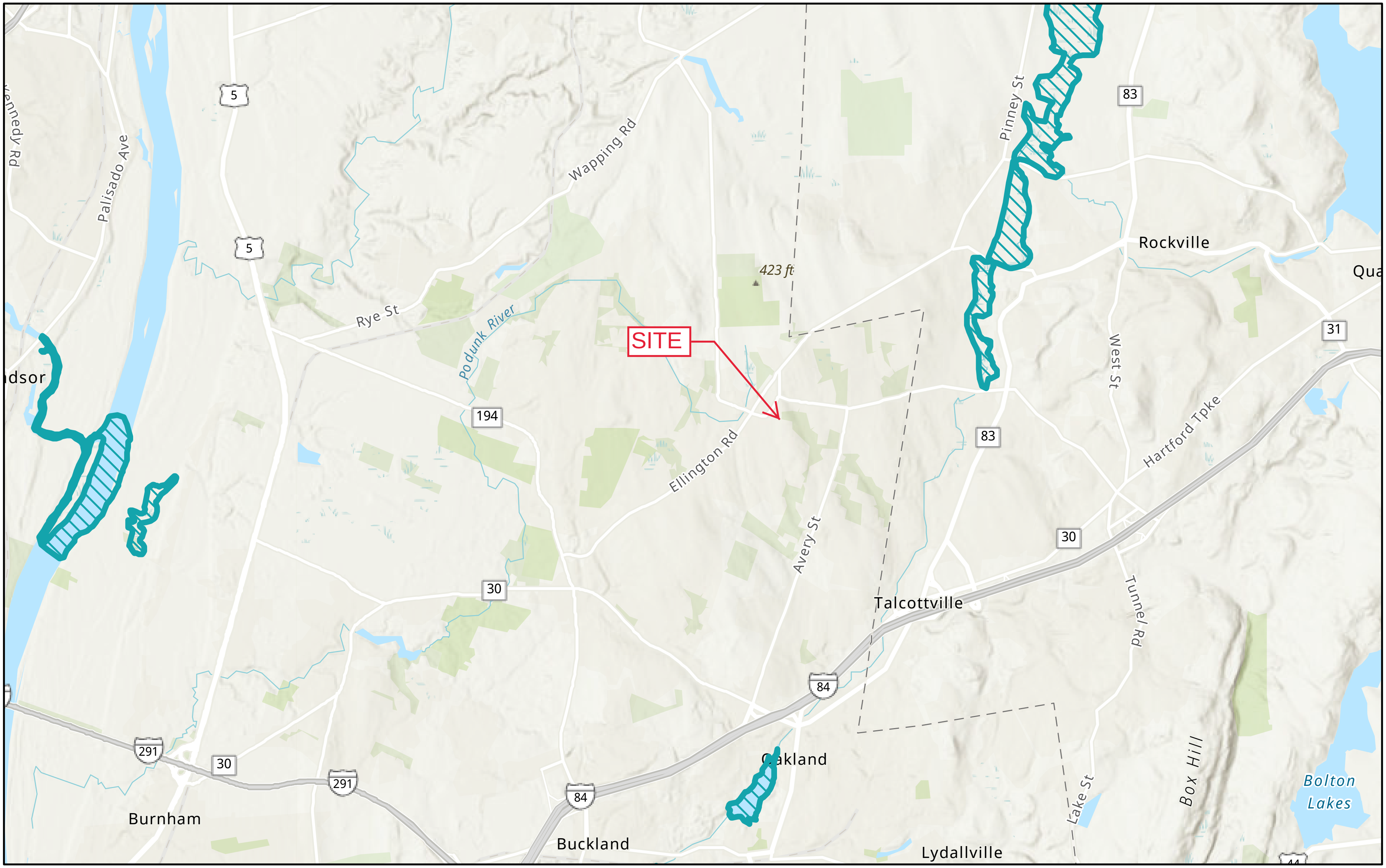
Reptiles

Scientific Name	Common Name	Protection Status
Clemmys guttata	Spotted turtle	SC
Crotalus horridus	Timber rattlesnake	E
Glyptemys insculpta	Wood turtle	SC
Heterodon platirhinos	Eastern hognose snake	SC
Opheodrys vernalis	Smooth green snake	SC
Plestiodon fasciatus	Five-lined skink	T
Terrapene carolina carolina	Eastern box turtle	SC
Thamnophis sauritus	Eastern ribbon snake	SC

E = Endangered, T = Threatened, SC = Special Concern, * Believed Extirpated

State of Connecticut
Department of Energy and Environmental Protection
Bureau of Natural Resources, Wildlife Division
79 Elm St., Hartford, CT 06106

Migratory Waterfowl - CT DEEP



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Esri, NASA, NGA, USGS, FEMA, Town of South Windsor, CT, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS,

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New England Ecological Services Field Office
70 Commercial Street, Suite 300
Concord, NH 03301-5094
Phone: (603) 223-2541 Fax: (603) 223-0104

In Reply Refer To: April 21, 2023
Project Code: 2023-0072386
Project Name: Tarpon Towers III, LLC Site – South Windsor (CT1207)

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

Updated 4/12/2023 - Please review this letter each time you request an Official Species List, we will continue to update it with additional information and links to websites may change.

About Official Species Lists

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Federal and non-Federal project proponents have responsibilities under the Act to consider effects on listed species.

The enclosed species list identifies threatened, endangered, proposed, and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested by returning to an existing project's page in IPaC.

Endangered Species Act Project Review

Please visit the "**New England Field Office Endangered Species Project Review and Consultation**" website for step-by-step instructions on how to consider effects on listed species and prepare and submit a project review package if necessary:

https://www.fws.gov/office/new-england-ecological-services/endangered-species-project-review

NOTE Please do not use the **Consultation Package Builder** tool in IPaC except in specific situations following coordination with our office. Please follow the project review guidance on our website instead and reference your **Project Code** in all correspondence.

Northern Long-eared Bat - (**Updated 4/12/2023**) The Service published a final rule to reclassify the northern long-eared bat (NLEB) as endangered on November 30, 2022. The final rule went into effect on March 31, 2023. You may utilize the **Northern Long-eared Bat Rangewide Determination Key** available in IPaC. More information about this Determination Key and the Interim Consultation Framework are available on the northern long-eared bat species page:

https://www.fws.gov/species/northern-long-eared-bat-myotis-septentrionalis

For projects that previously utilized the 4(d) Determination Key, the change in the species' status may trigger the need to re-initiate consultation for any actions that are not completed and for which the Federal action agency retains discretion once the new listing determination becomes effective. If your project was not completed by March 31, 2023, and may result in incidental take of NLEB, please reach out to our office at newengland@fws.gov to see if reinitiation is necessary.

Additional Info About Section 7 of the Act
Under section 7(a)(2) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to determine whether projects may affect threatened and endangered species and/or designated critical habitat. If a Federal agency, or its non-Federal representative, determines that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Federal agency also may need to consider proposed species and proposed critical habitat in the consultation. 50 CFR 402.14(c)(1) specifies the information required for consultation under the Act regardless of the format of the evaluation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

https://www.fws.gov/service/section-7-consultations

In addition to consultation requirements under Section 7(a)(2) of the ESA, please note that under sections 7(a)(1) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species. Please contact NEFO if you would like more information.

Candidate species that appear on the enclosed species list have no current protections under the ESA. The species' occurrence on an official species list does not convey a requirement to consider impacts to this species as you would a proposed, threatened, or endangered species. The ESA does not provide for interagency consultations on candidate species under section 7, however, the Service recommends that all project proponents incorporate measures into projects to benefit candidate species and their habitats wherever possible.

Migratory Birds

In addition to responsibilities to protect threatened and endangered species under the Endangered Species Act (ESA), there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts see:

https://www.fws.gov/program/migratory-bird-permit

https://www.fws.gov/library/collections/bald-and-golden-eagle-management

Please feel free to contact us at **newengland@fws.gov** with your **Project Code** in the subject line if you need more information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat.

Attachment(s): Official Species List

Attachment(s):

- Official Species List

OFFICIAL SPECIES LIST

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

New England Ecological Services Field Office
70 Commercial Street, Suite 300
Concord, NH 03301-5094
(603) 223-2541

PROJECT SUMMARY

Project Code: 2023-0072386
Project Name: Tarpon Towers III, LLC Site – South Windsor (CT1207)
Project Type: Communication Tower New Construction
Project Description: Proposed telecommunications facility
Project Location:

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@41.84762415,-72.52042232286234,14z

Counties: Hartford County, Connecticut

ENDANGERED SPECIES ACT SPECIES

There is a total of 2 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

MAMMALS

NAME	STATUS
Northern Long-eared Bat *Myotis septentrionalis* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9045	Endangered

INSECTS

NAME	STATUS
Monarch Butterfly *Danaus plexippus* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9743	Candidate

CRITICAL HABITATS

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

IPAC USER CONTACT INFORMATION

Agency: Environmental Corporation of America
Name: Hazel Errett
Address: 1340 Patton Avenue
Address Line 2: Suite K
City: Asheville
State: NC
Zip: 28806
Email hazel.errett@eca-usa.com
Phone: 8285050755

LEAD AGENCY CONTACT INFORMATION

Lead Agency: Federal Communications Commission

Home ▾ Critical Habitat for Threatened & Endangered Species [USFWS]

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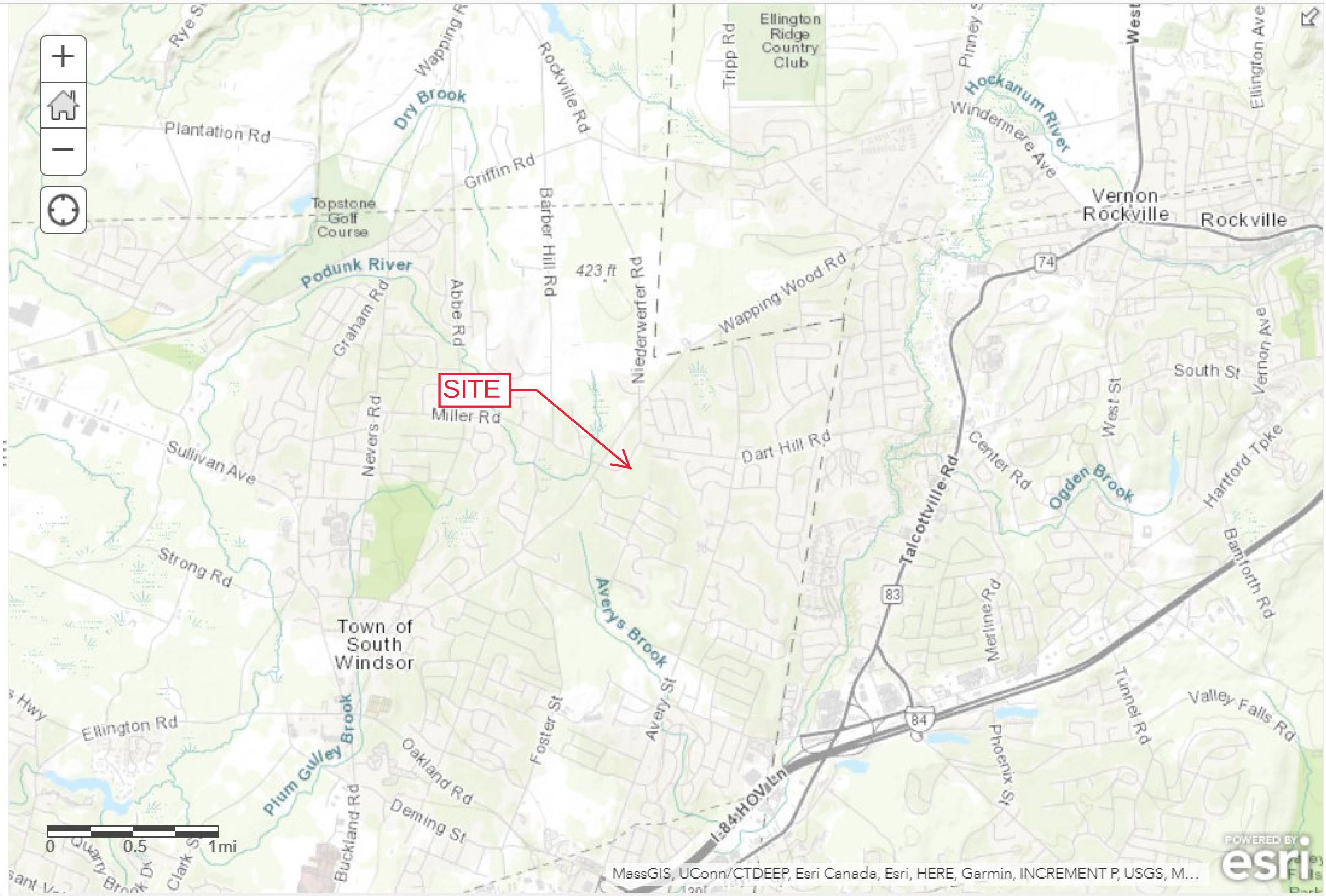
Legend

Final Polygon Features

Final Linear Features

Proposed Polygon Features

Proposed Linear Features



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PLoS One. 2012; 7(4): e34025.
Published online 2012 Apr 25. doi: 10.1371/journal.pone.0034025

PMCID: PMC3338802
PMID: 22558082

An Estimate of Avian Mortality at Communication Towers in the United States and Canada

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Martin Krkosek, Editor

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[4] Department of Geography, University of California Los Angeles, Los Angeles, California, United States of America,
[5] Department of Biological Sciences, Clemson University, Clemson, South Carolina, United States of America,
[6] National Wildlife Research Center, Florida Field Station, United States Department of Agriculture/Wildlife Services, Gainesville, Florida, United States of America,
[7] Thomasville, Georgia, United States of America,
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[9] Department of Forest and Wildlife Ecology, University of Wisconsin, Madison, Wisconsin, United States of America,
University of Otago, New Zealand
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Received 2011 Jul 28; Accepted 2012 Feb 20.

Abstract

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Avian mortality at communication towers in the continental United States and Canada is an issue of pressing conservation concern. Previous estimates of this mortality have been based on limited data and have not included Canada. We compiled a database of communication towers in the continental United States and Canada and estimated avian mortality by tower with a regression relating avian mortality to tower height. This equation was derived from 38 tower studies for which mortality data were available and corrected for sampling effort, search efficiency, and scavenging where appropriate. Although most studies document mortality at guyed towers with steady-burning lights, we accounted for lower mortality at towers without guy wires or steady-burning lights by adjusting estimates based on published studies. The resulting estimate of mortality at towers is 6.8 million birds per year in the United States and Canada. Bootstrapped subsampling indicated that the regression was robust to the choice of studies included and a comparison of multiple regression models showed that incorporating

sampling, scavenging, and search efficiency adjustments improved model fit. Estimating total avian mortality is only a first step in developing an assessment of the biological significance of mortality at communication towers for individual species or groups of species. Nevertheless, our estimate can be used to evaluate this source of mortality, develop subsequent per-species mortality estimates, and motivate policy action.

Introduction

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On the morning of September 11, 1948, "a good number of dead, dying, and exhausted birds" were found at the base of the WBAL radio tower in Baltimore, Maryland [1]. Reports of such avian mortality at communication towers in North America became common in the 1950s [2]–[7]. These observations were consistent with the long documented mortality of birds at lights, including lighthouses [8], light towers [9], buildings [1], [10], and ceilometers [1], [11]. Although initially dismissed as being of minor consequence [12], the ongoing and chronic mortality of nocturnally migrating birds at lighted structures has become a recognized conservation issue [7], [13]–[15]. Bats are also killed in collisions with tall towers in unknown numbers [16]–[18]. An estimate of the total number of birds killed at communication towers in the United States and Canada is particularly relevant because the current transition from analog to exclusively digital broadcasting in the United States is expected to lead to the construction of more tall towers and a similar trend will likely follow in Canada.

In 1979, Banks [13] developed a widely circulated estimate of avian mortality at television towers, which revised upward a previous estimate by Mayfield [12]. In Banks's assessment of various sources of human-caused avian mortality, he extrapolated the results of three studies at tall towers – two in Florida [19], [20] and one in North Dakota (for which he did not provide a citation but which was almost certainly [21]) – to all television towers. He calculated the average mortality at these three sites to be roughly 2,500 birds per year, and multiplied it by the number of television towers (1,010 in 1979). He then assumed that half of all television towers would cause a hazard to migrating birds. The resulting estimate of annual mortality was 1,250,000 [13]. Also in 1979, Avery [22] applied bird mortality results from seven towers that had been monitored for at least 10 years and derived an overall mortality estimate of 940,000/year for the United States. More recent estimates of total avian mortality at towers in the United States by the U.S. Fish and Wildlife Service (USFWS) in 2001 [14], [23] adjusted the Banks estimate by accounting for the increased number of towers since 1979. Application of Banks's method today results in an estimate of 4–5 million birds killed annually by tall towers, with Manville [15], [24] indicating a possibility of mortality an order of magnitude higher.

No estimate of avian mortality at communication towers has been made for the United States and Canada as a whole, and the only estimate for Canada was presented in a preliminary unpublished report preceding this paper. The bulk of species killed at towers in the United States and Canada are Neotropical migrants, i.e., birds that breed in Canada and the United States and spend the non-breeding period south of the U.S. border [13], [25]. Because the ranges of these species extend into Canada, mortality in both the United States and Canada contribute to their population dynamics.

In this paper we develop a new estimate of avian mortality at communication towers in the United States and Canada. This estimate derives from a review and re-analysis of tower mortality studies (following [26]). We improve on Longcore et al. [26] by adjusting mortality records at towers for sampling effort, search efficiency, and scavenging, and by incorporating additional studies. We produced a regression for avian mortality by tower height and then applied this regression to a geographic database of communication towers for the United States and Canada. This approach recognizes that taller towers kill more birds on average than do shorter towers [26]–[28], but also incorporates mortality estimates for lighted towers that are less than 600 ft (~180 m) above ground level (AGL), which have previously been left out of estimates of total avian mortality. These "shorter" (60–180 m) lighted towers, which constitute >95% of lighted towers, do regularly kill birds [28]–[30] and their sheer number argues against ignoring them. We do not, however, estimate mortality from collisions with other lighted structures. Attraction to light at night leads to avian mortality at buildings, monuments, cooling towers, bridges, offshore platforms, ships, lighthouses, and wind turbines [24], [31], [32], and the same group of species (Neotropical migrants) are especially susceptible.

Our goal is to improve upon past estimates, which relied on a very limited set of data and did not reflect current understanding of the tower height–mortality relationship. Because of the nature of the existing data on avian mortality at towers and the lack of a systematic continent-wide survey effort, additional field studies will be required to refine further our approach. Our results do, however, increase both the transparency and accuracy associated with the estimate of this source of avian mortality.

Methods

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We assigned average mortality values to tower height classes (every 30 m) using a regression of tower height by annual mortality (following [26]). Longcore et al. [26] identified reports of birds killed at 26 communication towers over at least two migratory seasons (e.g., spring and fall, two falls), consisting of a minimum of 10 total carcass-searching visits per site. We added figures from additional studies [33], [34], tested the sensitivity of the regression to inclusion of studies, and developed adjustments for sampling effort, search efficiency, and scavenging to produce estimates of mortality.

Sensitivity of Tower Height–mortality Regression

We collected as many studies of bird mortality at communication towers as possible from the literature and, when necessary, obtained raw data from study authors. Some studies had to be dropped from our analysis (e.g., [28]) because we were unable to obtain data from study authors and published reports did not allow us to assign mortality to specific towers. Because the number of tower studies available to us was finite, and because the choice of studies may have influenced our results, we tested the extent to which the regression was robust to sampling variation among the towers available for analysis. We used a randomization and resampling procedure to select random subsets of the 38 towers included in the analysis. To explore a range of plausible tower subsets that could produce a regression, we resampled subsets that included just under half of the available towers (18) up to those with one fewer than the complete dataset (37 towers) and re-iterated the sampling procedure 5,000 times. We used the natural logarithm of both the dependent and independent variables to normalize their distributions.

Adjustment for Scavenging and Search Efficiency

Loss of birds to scavengers and failure to detect all dead birds (search efficiency) are sources of error and variation in tower studies. Some authors have opted to apply searching and scavenging factors to final kill estimates (e.g., [28], [35]). Recognizing that search efficiency and scavenging losses are likely tower-specific, we opted to correct the number of kills at each tower before regressing these estimated losses against tower height.

We assumed that scavenging would be lower at a small tower that sporadically generates only a few mortalities compared with a well-established tall tower that kills birds reliably and therefore maintains scavenger interest [36]–[39]. This assumption is supported by high scavenging rates documented at tall towers such as WCTV in Florida [20], [36], [38] and rapid increases in scavenging when researchers provide carcasses [33]. Even with extensive scavenger control efforts, Stoddard estimated that he was losing at least 10% of bird carcasses to scavengers daily [40]. Therefore, we adjusted our scavenging rate by tower height.

We assumed that it is easier to find carcasses under a short tower because carcasses are likely to be less dispersed under shorter guy wires or in the absence of guy wires. Whether the area around the tower is bare or heavily vegetated will affect both scavenging and search rates [41]. Open habitats with little concealing vegetation are, predictably, more conducive to efficient searching for carcasses [41]. Scavengers detecting prey by sight can find the carcasses more easily as well. Notwithstanding the use of smell by some carnivores to find prey, dense cover makes it more difficult in general for both scavengers and searchers to find carcasses [42]. Support for our assumptions about the effect of cover on these rates is found in research on avian mortality caused by pesticides, power lines, and wind turbines [41]–[45]. We avoided attempts to calculate probability of detection by searchers that involved the "life expectancy" of carcasses because these methods are biased [46]. If a carcass was not found on the first search day, the probability that it will be found on subsequent days is considerably less than the average search rate would suggest. Therefore, for the purpose of this analysis, the likelihood that a carcass was found more than one day after it was generated is considered negligible. Removal of dead birds by scavengers at sites with regular mortality also follows an exponential decay model such that the probability of small dead birds remaining to be found falls quickly following the mortality event [45], [47].

We divided towers into height classes to which we could assign differential search and scavenging rates. Based on breaks in the raw tower mortality data, we chose to divide the towers into three height classes: 0–200 m, 201–400 m, and ≥401 m. To assign search and scavenging rates we relied on our published summaries of available rates from a range of carcass searching contexts (Table 1) [41], [42], other existing studies and reviews [37], [43], [44], [46], [48], and values reported at the towers in our dataset where these rates were measured [28], [33], [34], [49]. Taking into account patterns from these data, we used tower height as well as any information about cover as a way to assign search and scavenging corrections by height and cover class to the towers for which these rates had not been measured and reported by the authors (Table 2). All search and scavenging rates, both measured and assigned, are reported in Table 3.

Table 1

Average search and scavenging rates taken from pesticide impact studies [42].

Habitat	Body size	Search rate (# study plots)	Percentage lost to scavenging	Detection rates (studies combining search and scavenging rates)
Shrub/wood edge	Small-medium	41.0% (301)	20.9%	22.8% (94)
Shrub/wood edge	Large	67.6% (29)	-	-
Bare/open	Small-medium	64.6% (359)	28.4%	18.6% (56)
Bare/open	Large	88.1% (17)	-	-

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Search and detection rates are based on daily averages weighted by the number of study plots. Search rates represent the proportion of carcasses found over the total number still present at the time of search. Scavenging rates represent daily measurements averaged over all plots without regard for the number of placed carcasses.

Search rates are undoubtedly at the high end of that which is possible because the search procedures were optimized, always including trained lines of searchers spaced optimally for the habitat as well as the use of search dogs in some studies.

Table 2

Assumed rates for search efficiency and scavenger removal by tower height and habitat type when not provided by investigator.

Tower type and mortalityprofile	Habitat	Assumed proportion of small birds located by searcher	Assumed proportion ofsmall birds remainingafter scavenging	Combined rate of detection
Height class 1 (0–200 m), sporadic mortality, more localized	Open habitat	75%	80%	60%
	Brush and other visual obstructions	50%	85%	42%
Height class 2 (201–400 m), regular mortality, more dispersed	Open habitat	65%	55%	36%
	Brush and other visual obstructions	40%	70%	28%
Height class 3 (≥401 m),dependable mortality, carcasseswidely dispersed	Open habitat	55%	30%	16%
	Brush and other visual obstructions	30%	55%	16%

Table 3

Summary of factors used to develop the search and scavenging correction for bird mortality at communication towers.

Reference	Cover	Daily	Tower height (m)	Scavenger control	Scavenging measured	Search efficiency measured	Measured or assumed search rate	Measured or assumed scavenging rate	Ov det rate
[69]	burned spring, hayed fall	No	30.5	no	no	no	0.750	0.200	0.6
[49]	cleared periodically	No	60	yes	yes	yes	0.406	0.392	0.2
[34]	mowed at least once per season	Yes	60	no	yes	yes	0.294	0.076	0.2
[34]	mowed at least once per season	Yes	60	no	yes	yes	0.294	0.076	0.2
[34]	mowed regularly	Yes	79	no	yes	yes	0.294	0.076	0.2
[40]	Mowed	Yes	90	yes	no	no	0.750	0.100	0.6
[34]	mowed at	Yes	97.5	no	yes	yes	0.290	0.113	0.2

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We investigated the sensitivity of our final results to these assumptions about search efficiency and scavenging by recalculating our total mortality estimates while assigning the average search efficiency and scavenging rates reported from those studies that did estimate these rates. This approach tested the alternative assumption that studies from all towers where search efficiency or scavenging were not measured had the same search efficiency, scavenging rate, or both, as did studies at the towers where they were measured, regardless of the physical conditions at the tower or the height of the tower.

Adjustment for Sampling Effort and Design

Studies included in the tower height–mortality regression varied in sampling design and duration. Following Longcore et al. [26], we required a minimum of 10 searches for a study to be included. Authors of most of the studies used in the regression assumed that most birds would be found by sampling during peak migration, on bad weather days preceding or following the passing of a cold front (e.g., J. Herron, pers. comm.), or both (Table 4). The logic behind this approach is that many high avian mortality days are correlated with these factors [31]. Nevertheless, "trickle kills" on fair weather days even outside the typical migration period can contribute substantially to overall mortality [40]. Substantial mortality during clear and calm weather during the migration season has also been documented [30], [50] (Figure 1). For these reasons we used raw data from two studies that carried out daily carcass searches – WCTV Florida tower data from 1956–1967 initiated by Herbert L. Stoddard and Tall Timbers Research Station [40] and North Dakota "Omega" tower [21], [51], [52] – as a baseline to develop estimates of the effectiveness of the various sampling designs for the 38 tower studies included in our dataset. The Florida estimates were averaged over the 10 years of sampling during which height of tower and predator control were the same; the North Dakota estimates are for two years of sampling. When the estimate was (partially) based on sampling outside the migratory period (as defined), we used the Florida dataset, which had continuous, year-round sampling. We did not, however, correct upward all kill estimates to account for the trickle of kills recorded in the non-migratory seasons. We believe, therefore, that our estimates are conservative. To control for differences between spring and fall migration we developed estimates for both spring and fall separately.

Table 4

Summary data with sampling efficiency correction for the 38 studies used to develop an estimate of bird mortality at communication towers.

Reference	Tower height (m)	Start year	End Year	Sampling days	Sampling correction	Sampling strategy	No. of years	Average correction sampling (spring)	Average correction sampling (fall)	Birds collect
[69]	30.5	1998	1999	25/year	yes	bad weather	1	0.44	0.36	0
[49]	60	2000	2004	average >70/year	yes	bad weather	4	0.50	0.50	15
[34]	60	2007	2008	45 spring, 45 fall	no	n/a	2	1.00	1.00	3
[34]	60	2007	2008	45 spring, 45 fall	no	n/a	2	1.00	1.00	1
[34]	79	2007	2008	45 spring, 45 fall	no	n/a	2	1.00	1.00	8
[40]	90	1998.5	2000	>330/year	no	n/a	1.5	1.00	1.00	21
[34]	109	2007	2008	45 spring, 45 fall	no	n/a	2	1.00	1.00	7
[34]	110	2007	2008	45 spring, 45 fall	no	n/a	2	1.00	1.00	6
[34]	110	2007	2008	45 spring, 45 fall	no	n/a	2	1.00	1.00	3
[70]	133	1958	1960	<60/year	no	n/a	2	1.00	1.00	267
[34]	142	2007	2008	45 spring, 45 fall	no	n/a	2	1.00	1.00	14
[34]	142	2007	2008	45 spring, 45 fall	no	n/a	2	1.00	1.00	5
[33]	152	2004	2006	>52/year	yes	bad weather + weekly	2	0.90	0.58	11
[71]	161	1980	1986	15.25/year average	yes	bad weather	6	0.44	0.36	700

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Number of years in each study may differ from the calendar years encompassed by the study because of the assumption that each fall constitutes 0.75 years of surveying and each spring constitutes 0.25 years of surveying. Studies in which surveys were conducted only during the fall or only sporadically during the spring will appear to be shorter than their calendar duration.

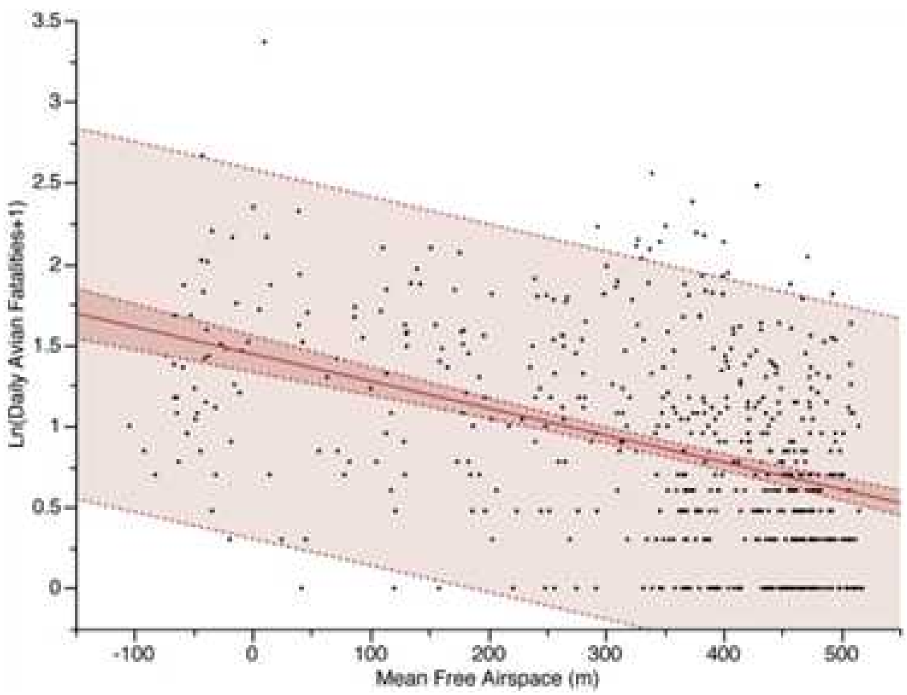

Figure 1

Relationship of bird fatalities to free airspace at WCTV Tower, 1956–1967.

Raw data from Crawford and Engstrom (2001) were used to plot daily bird fatalities against the mean free airspace between the top of the tower and the cloud ceiling each day. Days with maximum ceiling were excluded. Daily avian mortality increases significantly as free airspace decreases (Ln(Bird Fatalities +1)= 1.443928 – 0.0016667 · Mean Free Airspace (m), R^2=0.17, p<0.001).

To adjust for the kills between sampling days during the migratory seasons we resampled (with replacement) daily mortality data from the Florida and North Dakota datasets within each of the spring and fall migration periods by randomly selecting a subset of days and summing avian mortality for the selected days. We calculated average bird mortality for 5,000 iterations and then used the ratio of the average bird mortality from the 5,000 iterations to the total number of birds killed during either spring or fall migration or outside of the migration period to adjust mortality estimates for studies without daily sampling. We averaged estimates between the Florida and North Dakota datasets. This adjustment was applied to studies where researchers sampled on bad weather days (see below) and to those with weekly sampling outside the migration period.

For studies that did not provide complete details on their sampling design, we made simplifying assumptions (see below). If more than one sampling strategy was used, we developed estimates for each and used the sum as our overall estimate. For example, sampling may have been done weekly (regular sampling) outside of the migration period and also on "bad weather days" during the migration period.

We defined the spring and fall migration periods as a 60-day window before and after the migration peak for both spring and fall for each dataset, recognizing that for some recent studies (e.g., [28]) monitoring only occurred during the three-week peak of migration. We determined the peak for the Florida and North Dakota datasets by plotting the number of birds killed (from the raw data) against Julian date for all years of data combined and using negative exponential smoothing.

Some investigators reported the total number of days sampled during one or both migration periods and sometimes outside the migration periods. When the sampling interval (e.g., weekly) was identified in the study design, we constrained the resampling procedure to randomly select a day within that sampling interval. If no sampling interval was defined, selection was random.

Some investigators sampled on so-called "bad weather days" or following bad weather nights, i.e., overcast, often associated with advancing cold fronts and potentially including precipitation. Usually no other information was provided to define bad weather or the number of days when bad weather occurred. High bird mortality at communication towers is correlated with bad weather days [40], [50], [53]. This is shown by plotting ln(n+1)-transformed daily mortality data from the Florida tower dataset for the 1956–1967 fall migrations against the mean free airspace (distance between the top of the tower and the bottom of the cloud cover). Days where maximum free airspace was recorded were excluded from analysis because measurements did not vary for total ceiling greater than 610 m (2,000 ft). Mortality for days with mean ceiling at the maximum was 4.0–8.0 birds per day (95% C.I., n=871), while mortality for all days with less than the maximum ceiling was 16.0–33.5 birds per day (95% C.I., n=569). Considering these remaining points, a linear regression reveals a highly significant effect of mean free airspace, but also low explanatory power (Figure 1). Based on these data, we used days with mean free airspace equal to or below 335 m (1,100 ft) as an index of bad weather days because mortality was significantly lower on days with airspace greater than 335 m (10.3–17.8 birds per day, 95% C.I., n=387) compared with days with airspace below this threshold (21.5–73.3 birds per day, 95% C.I., n=182).

For some studies, the only information provided was the number of days sampled and the timing of sampling (during migration or all year). For these studies we assumed that researchers sampled on bad weather days during migration when large bird kills at communication towers were expected, given that this was the response obtained when we were able to contact researchers to ask about papers where this detail was not provided (e.g., J. Herron, pers. comm.).

Several researchers sampled only on days when so called "big kills" were reported. The definitions of "big kill" were not included. The typical daily trickle of dead birds for the Florida dataset over the 1956–1967 period was five. We therefore defined big kills as six or more birds located after any given night.

We investigated the sensitivity of our results to our assumptions about sampling effort by varying these assumptions for the 13 studies in our dataset that either did not indicate the number of days sampled or did not provide a definition of sampling design, or did neither. Some researchers had indicated that they had sampled on overcast or bad weather days or following bad weather days. For all of these studies and for those that did not mention anything specific, we made the conservative assumption that towers were sampled on bad weather days. We then recalculated the sampling adjustment and total mortality using three different scenarios: 1) researchers sampled on bad weather days and weekly during migration (e.g., [49]); 2) researchers sampled on bad weather days and weekly all year (e.g., [33]; excludes 5 of the 13 studies that clearly indicated they only sampled during migration); and 3) researchers sampled only following big kill days, about which they were notified by personnel at the tower (e.g., [5]).

Evaluation of Model Correction Factors

We plotted either raw carcass counts or mortality estimates corrected for either sampling effort or search efficiency and scavenging, or both, against tower height and looked for improvements in the regression coefficient as an indication that the corrections improved the model.

Description of Communication Towers and their Characteristics

We used a Geographic Information System (GIS) to extract the locations and characteristics of towers in the Antenna Structure Registration (ASR) database maintained by the U.S. Federal Communications Commission (FCC) and the NAV CANADA obstruction database. The FCC data are freely available and we purchased a license for the Canadian obstruction data for the limited purpose of this study. We compared and crosschecked these with the FCC's microwave tower database and the commercial TowerMaps database (also purchased, see http://www.towermaps.com/), which provides locations of cellular towers to potential lessees and incorporates both data for shorter towers and information that was not included in the FCC databases. We did considerable quality control on the tower data, confirming from independent sources that all towers greater than 300 m existed. This was necessary because the data were prone to multiple types of errors; for example, the FCC database included a record claiming to be located in the "Land of Oz" in Kansas, associated with geographic coordinates in Minnesota. Full details of the quality assurance are available from the authors.

The NAV CANADA database did not contain comprehensive information about either the presence of guy wires or the presence and type of lighting. We therefore relied on data from the FCC and TowerMaps datasets and assumed that lighting and guy wire use was similar in both countries for towers of the same height class, an assumption supported by the similarity in marking and lighting standards between the two countries. The U.S. Federal Aviation Administration requirements are found in the advisory circular AC 70/7460-1K. Those of Canada are found in Standard 621 of the Canadian Aviation Regulations.

Calculation of Annual Mortality

Avian mortality was estimated with the antilogarithm of the regression of the log transformed variables, which was adjusted for transformation bias using the smearing estimator after testing to confirm homoscedasticity of variance in the regression [54], [55]. Most recorded tower kill events take place at guyed towers, and steady-burning lights increase the probability of large tower kills [26], [28]. We assumed that unguyed towers caused 85% less mortality than guyed towers (midpoint of 69–100% estimate in [56]) and that towers without steady-burning lights caused 60% less mortality than towers with such lights (midpoint of 50–71% estimate in [28]). Following Longcore et al. [26], all estimates were calculated assuming that when both seasons were not measured, 75% of annual mortality occurred during the fall and 25% during the spring [40].

We overlaid locations of towers within each Bird Conservation Region (BCR) in the study area and calculated the number of towers in each 30 m height class for all towers ≥60 m. Bird Conservation Regions are divisions defined by habitat and topography that have been delineated for the purpose of bird conservation by the North American Bird Conservation Initiative and are endorsed by a range of bird conservation organizations and government agencies. BCRs are based on the North American ecoregions developed to promote international conservation efforts [57]. For each height class within each BCR we calculated the average number of birds killed per year, using the tower height–mortality regression adjusted for sampling effort, search efficiency, and scavenging as described above. For purposes of calculating total mortality we included all towers in the continental portions of the United States and Canada. Although most literature on tower mortality in North America describes studies from east of the Rocky Mountains, we included the West as well for purposes of estimating total mortality, a decision supported by records of tower mortality in Colorado [33], New Mexico [58], and Alaska [59], in addition to documented kills at lighthouses in California and British Columbia [60], [61]. We did not attempt to assign differential mortality for so-called flyways because radar studies and other observations strongly support the existence of "broad front" migration [62], [63]. To investigate this assumption, we plotted the residuals of the tower height–mortality regression by their geographic coordinates and calculated Moran's I as a measure of spatial autocorrelation. We acknowledge that local habitat factors may influence mortality at particular towers, but because only 18.4% of towers were originally selected for monitoring on the basis of knowledge of prior mortality (see below), it is unlikely that these variations would result in a systematic bias in the resulting mortality estimates.

To illustrate the contribution of each part of our adjustment to the final estimate of mortality, we calculated the extrapolated mortality estimates for the unadjusted mortality data, with the sampling correction only, with the search efficiency and scavenging corrections only, and corrected for all factors.

We do not report estimates of bird mortality at short (<60 m) towers in this paper because they contribute negligibly to overall annual bird mortality and are not usually illuminated unless located near an airport. We note, however, that single-night mortality events with several hundred identified dead birds at unlit <60 m towers have been reported, often related to lighting at adjacent infrastructure [30], which is consistent with reports from turbines and towers monitored at industrial wind facilities [64]. Our analysis therefore applies to towers ≥60 m.

Results

Go to:

Tower Height–mortality Regression

Towers used in the height–mortality regression were located throughout the eastern United States (Figure 2). We were able to confirm from original sources and personal communications that 68.4% of the towers were chosen for study with no prior knowledge of avian mortality; status is unknown for 13.2% of towers; and only 18.4% of towers were chosen with any knowledge of prior avian mortality. Log-transformed annual avian mortality, when adjusted for sampling effort, search efficiency, and scavenging, was significantly explained by log-transformed tower height in a linear regression (R^2= 0.84, $F_{1,36}$=191.62, p<0.0001) (Table 5; Figure 3).

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Figure 2

Bird Conservation Regions and locations of towers used for tower height–mortality regression.

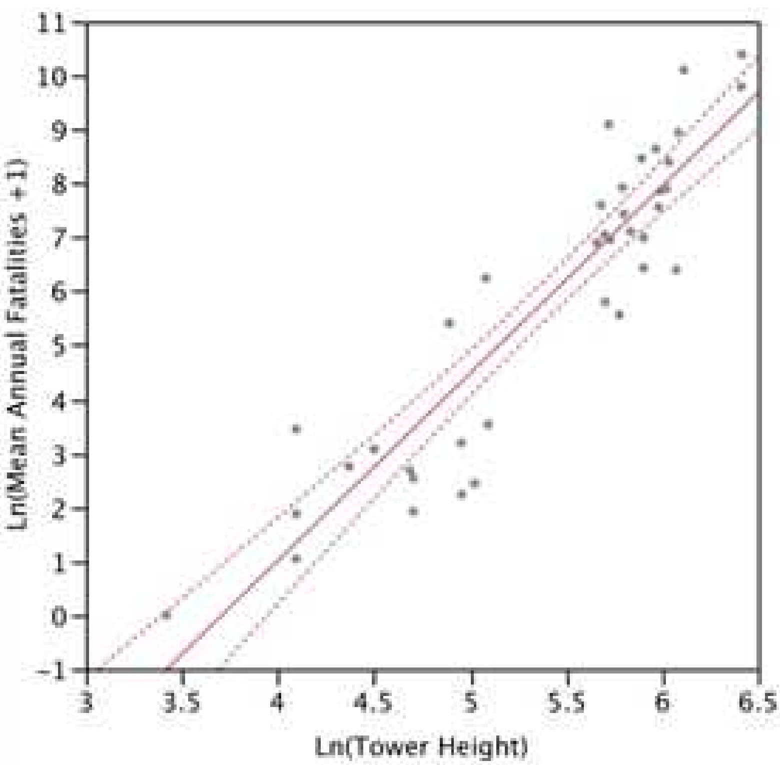

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Figure 3

Regression and 95% confidence intervals of annual avian fatalities by tower height.

Annual avian fatalities were adjusted for sampling effort, search efficiency, and scavenging and regressed by log-transformed tower height (Ln(Mean Annual Fatalities +1)=3.4684 · Ln(Tower Height) – 12.86, R^2 =0.84, p<0.0001).

Table 5

Regression results for mean annual fatalities by tower height, when unadjusted, corrected for sampling only, corrected for search efficiency and scavenging only, and corrected for both sampling and search efficiency/scavenging, with estimated annual fatalities after back transformation, adjustment for bias, and application to all towers in the United States and Canada.

	Slope	Intercept	R^2_{adj}	RMSE	F	P	Estimated annual fatalities (million)
No corrections	2.8257	–10.8626	0.78	1.110	133.5046	<0.0001	1.38
Sampling correction	3.0962	–11.9490	0.80	1.151	148.8302	<0.0001	2.06
Searcher/scavenging correction	3.2024	–11.8012	0.82	1.110	171.2329	<0.0001	4.31
Both corrections	3.4684	–12.8600	0.84	1.137	191.6163	<0.0001	6.80

Tower Height–mortality Regression Sensitivity to Study Inclusion

The median R^2 values of the resampled distributions are similar to those obtained from using all of the available studies (Figure 4, Table 6) and are not sensitive to the addition or elimination of a few or a set of studies. The results of the resampling procedure for subsets of 18 studies (a little under half of the studies) and for 37 studies (1 fewer than the total) show the range of influence that study inclusion could have on the regression line (Table 6).

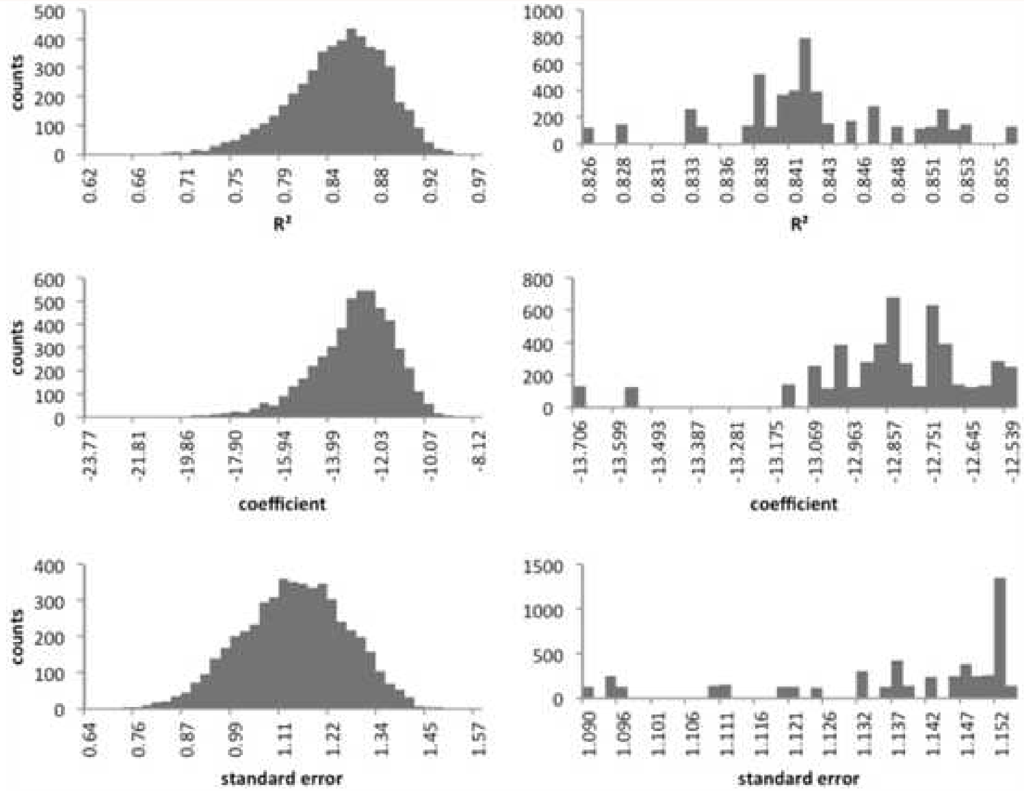

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Figure 4

Influence of study choice on tower height–mortality regression.

Distribution of counts for R^2 (adjusted), standard error, and coefficient for 5,000 iterations (subset=18 studies, left; subset=37 studies, right) for a linear regression between the natural logarithms of tower height (m) and mean annual fatalities.

Table 6

Confidence intervals and median values for model parameters using randomized subsets of 18 or 37 studies (5,000 iterations).

Subset	Parameter	5%	95%	Median
18 studies	R^2	0.765	0.906	0.847
	slope	3.087	4.061	3.474
	intercept	–16.205	–10.775	–12.882
	standard error	0.919	1.331	1.345
37 studies	R^2	0.828	0.853	0.841
	slope	3.414	3.591	3.465
	intercept	–13.556	–12.556	–12.845
	standard error	1.093	1.153	1.146

Evaluation of Model Adjustment Factors

Models using either sampling correction alone or the combination of sampling correction with the combined search efficiency and scavenging correction were found to be superior to the model using tower height alone at explaining annual kills (R^2=0.84 vs. R^2=0.79; Table 5). Correcting for search efficiency and scavenging losses appeared to provide the best improvement to the overall model (Table 5).

Tower Characteristics

Our database of ≥60 m towers included 70,414 towers in the continental United States and Canada after all quality assurance and quality control was done (Figure 5). Most towers in the United States dataset (31,486; 50.3%) were freestanding with steady-burning lights at night, while the fewest towers (4,898; 7.8%) were guyed with strobe lights at night. Some towers had strobe lights during the day but red flashing and red solid lights at night so these were included as having solid lights.

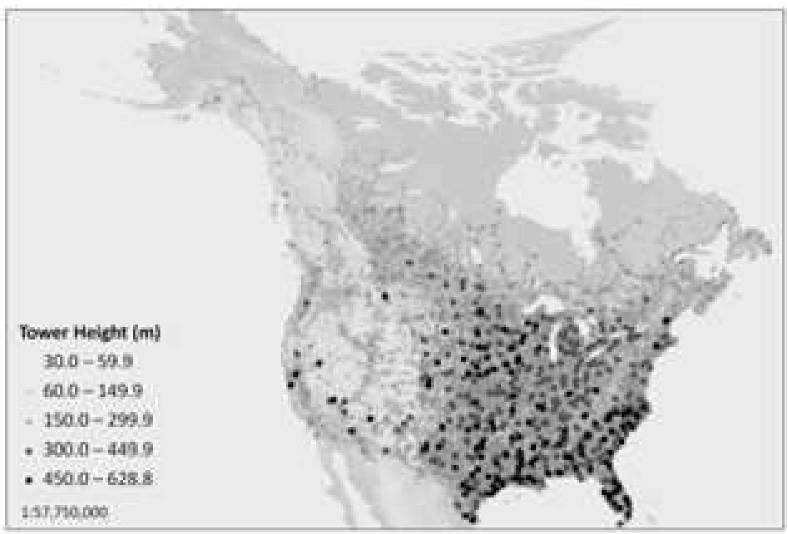

Figure 5

Map of communication towers in the United States and Canada by height class.

Data acquired from Federal Communications Commission, Towermaps.com, and NAV CANADA.

Total Mortality and Estimates by Bird Conservation Region

Combination of the tower height–mortality regression with estimates of reduced mortality at towers without guy wires or steady-burning lights produced a matrix of mortality by height class and tower characteristics. These estimates, already adjusted for sampling effort, search efficiency, and scavenging, ranged from zero for short unguyed towers to over 20,000 birds per year for the tallest guyed towers with steady-burning lights.

The back-transformed tower height–mortality regression, adjusted for bias (smearing estimator) and applied to towers in the continental United States and Canada, produced an annual mortality estimate of

6.8 million birds per year (Table 5). Extrapolation from the unadjusted data yielded an estimate of 1.4 million birds per year, meaning that our cumulative assumption is that searchers find only around 20% of the birds that are killed, because of search efficiency, scavenging, and incomplete sampling (Table 5).

These results are sensitive to the assumptions that were made about these factors. As an illustration, we calculated total mortality while assuming a constant search efficiency equal to the average of the measured search efficiency from those towers where this was measured (36.4%), which resulted in a total mortality estimate of 9.4 million birds per year. Applying the average scavenging rate (15.8%) to all towers resulted in a mortality estimate of 4.7 million birds per year. Using both averages (for scavenging and search efficiency) yielded an estimate of 6.4 million birds per year. For the sampling effort adjustments, recalculated mortality estimates for the three scenarios applied to studies with unknown sampling schemes were: 5.4 million birds per year for sampling only on big kill days, 5.7 million birds per year for sampling on bad weather days and weekly year round, and 6.2 million birds per year for sampling on bad weather days and weekly during migration only. Finally, if we recalculate mortality after omitting all towers selected with prior knowledge of any mortality on site (18.4% of our sample of towers), the estimate of total mortality declines to 5.5 million birds per year.

Over two-thirds of the estimated mortality is attributed to towers ≥300 m, of which only 1,040 were found in our database (1.6% of towers ≥60 m; Table 7). Fully 71% of mortality is attributed to the tallest 1.9% of towers. Shorter towers (60–150 m) contribute approximately 17% of all mortality because of their sheer numbers (Table 7).

Table 7

Number of communication towers ≥60 m by type and associated avian mortality estimates for Canada and the continental United States.

Country	Height class (m)	Guyed towers with steady-burning lights	Guyed towers with strobe lights	Unguyed towers with steady-burning lights	Unguyed towers with strobe lights	Annual fatalities	Percent of fatalities
United States	60–90	5,901	863	17,693	2,575	115,524	1.76%
	90–120	10,023	1,696	10,004	1,683	531,411	8.07%
	120–150	2,938	505	2,922	488	377,542	5.74%
	150–180	1,992	311	661	101	468,600	7.12%
	180–210	343	46	107	12	142,679	2.17%
	210–240	174	54	51	11	126,507	1.92%
	240–270	109	57	29	16	131,379	2.00%
	270–300	76	61	18	14	146,530	2.23%
	300–330	271	128	0	0	642,858	9.77%
	330–360	115	28	0	0	345,255	5.25%
	360–390	78	22	0	0	317,130	4.82%
	390–420	47	16	0	0	254,809	3.87%
	420–450	35	10	0	0	238,450	3.62%

Country	Height class (m)	Guyed towers with steady-burning lights	Guyed towers with strobe lights	Unguyed towers with steady-burning lights	Unguyed towers with strobe lights	Annual fatalities	Percent of fatalities
	450–480	66	23	0	0	579,458	8.80%
	480–510	25	10	0	0	277,580	4.22%
	510–540	24	8	0	0	319,300	4.85%
	540–570	8	9	0	0	165,120	2.51%
	570–600	18	15	0	0	410,068	6.23%
	600–630	38	27	0	0	991,745	15.07%
	Subtotal	*22,282*	*3,888*	*31,486*	*4,898*	*6,581,945*	*100.00%*
Canada [1]	60–90	627	323	1,880	968	13,980	6.34%
	90–120	1,295	284	1,295	284	69,981	31.72%
	120–150	251	55	251	55	32,797	14.86%

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[1]Tower attributes (guy wires, lighting type) for Canada are extrapolated from proportions in the United States because these attributes are not found in the NAV CANADA database.

Our estimates of mortality vary by region, influenced both by the size of the region and the number and height distribution of towers (Figure 6; Table 8). The number of towers in each BCR does not directly correlate with estimated annual mortality because of differing numbers and heights of towers. As a result, Peninsular Florida is associated with more mortality than all of Canada; even though fewer towers are reported in Peninsular Florida, they are on average much taller. The concentration of migrants resulting from Florida's geographic position would increase mortality even more, but this factor is not considered in our method because mortality rates for any given tower height are assumed to be constant across the continent. The Southeastern Coastal Plain BCR accounts for greater mortality than other BCRs, followed by Eastern Tallgrass Prairie, Oaks and Prairies, and Piedmont (Table 8). Canadian mortality accounts for only a fraction of the total (approximately 3.2%), because Canada has far fewer, and generally shorter, towers.

Figure 6

Estimated annual avian mortality from communication towers by Bird Conservation Region.

High mortality estimates in Peninsular Florida and Southeastern Coastal Plain reflect the more numerous and taller communication towers in these regions.

Table 8

Total estimated annual avian mortality at towers ≥60 m in the United States and Canada by Bird Conservation Region (BCR).

BCR	USA (lower 48 states)	Canada	Alaska	Total
1–Aleutian Bering Sea			0	0
2–Western Alaska			155	155
3–Arctic Plains and Mountains		542	83	625
4–Northwestern Interior Forest		288	2,228	2,516
5–Northern Pacific Rainforest	21,170	2,411	333	23,914
6–Boreal Taiga Plains		24,591		24,591
7–Taiga Shield and Hudson Plains		2,754		2,754
8–Boreal Softwood Shield		20,650		20,650
9–Great Basin	20,744	339		21,083
10–Northern Rockies	8,653	1,925		10,578
11–Prairie Potholes	265,244	63,032		328,276
12–Boreal Hardwood Transition	139,535	34,564		174,099
13–Lower Great Lakes/St. Lawrence Plain	83,185	51,175		134,360
14–Atlantic Northern Forest	36,469	18,378		54,847
15–Sierra Nevada	343			343

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Although we extended mortality estimates to all towers in Canada and the continental United States, few studies are available from the West (Figure 2). This may be a function of a higher number of nocturnal migrants in the East, different patterns of migration, different weather patterns, or it may simply reflect the fewer and shorter towers in the West as a whole. We investigated the effect of location on annual mortality by regressing the residuals of our height regression against longitude and also by testing the residuals for spatial autocorrelation. The resulting plot showed slightly higher mortality in the East, but the relationship was not significant and was largely driven by a single data point in Colorado. Residuals were not spatially autocorrelated using inverse Euclidean distance weighting (Figure 7; Moran's I=0.09, $z=0.23$, $p=0.816$). More comprehensive surveys of towers in the West are needed to see if the lower mortality at the site in Colorado represents an anomaly or a different pattern of mortality in the West. Pending such further analysis, extrapolation of mortality at towers in the western portions of the United States and Canada should be regarded as provisional.

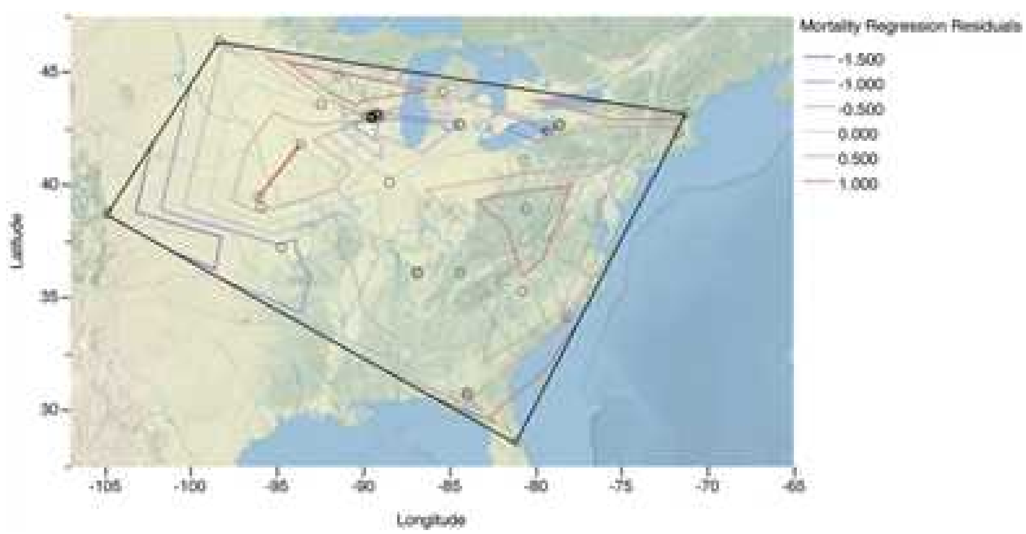

Figure 7

Distribution of residuals of tower height–mortality regression for 38 towers in the United States as adjusted for sampling effort, search efficiency, and scavenging.

Contour lines indicate regions above and below the regression line. Although exhibiting a geographically variable pattern, the residuals are not significantly spatially autocorrelated.

Discussion

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Our total mortality estimate of 6.8 million birds per year is ~50% greater than the current USFWS estimate of 4–5 million birds per year [14], [15], [23], [24]. Our results do not support the suggestion that mortality might be an order of magnitude higher [14], [15], which had been made before this type of synthetic analysis had been attempted. Our approach to estimating total avian mortality at towers uses far more data than previous efforts. For example, Banks's [13] estimate was based on mortality rates from only three tower studies and assumed that all towers caused the same rate of mortality, regardless of tower height. Our method incorporates evidence from 38 towers to establish the relationship between tower height and avian mortality. We accounted for the height distribution and physical characteristics of ~84,000 towers across the United States and Canada (including towers <60 m, which we mapped but did not include in our mortality estimates). Notwithstanding the sources of uncertainty in our estimate, the method improves previous efforts, is transparent, and can be revised in conjunction with additional field studies.

Although mortality at some towers has apparently declined over time [31], the influence of any such trend (if a true decline in mortality and not the result of increased scavenging) is offset by the large portion (>50%) of towers in the regression having survey end dates after 1990. If only these studies ending after 1990 are used in the regression, the total mortality estimate decreases to 4.8 million birds per year. The residuals of the tower height–mortality regression, however, are not significantly explained by the ending year of the survey (results not shown) so we did not exclude the older studies from our final regression. Even if the decline in number of birds killed at towers is a real phenomenon, the effect of these kills on sensitive species could still be substantial if populations have declined by a greater proportion.

Estimated tower mortality increases exponentially with tower height [26], which makes our results sensitive to the use of the height classes. For example, if we used the top of each height class rather than the middle to calculate total mortality, the estimate would increase by 25%. The use of the height classifications was necessary for ease of calculation and because attributes of the Canadian towers that were not known had to be assigned probabilistically. We used log transformations of both variables to normalize the distributions and because the total volume of airspace occupied by guy wires increases far more rapidly than does height. The increasing length of guy wires provides a mechanistic explanation for the exponentially increasing probability of avian collisions as tower height increases. Extremely tall towers also extend into the “normal” flight altitudes of many migrants so that mortality events can occur under clear skies and favorable migration conditions; this provides another plausible mechanism for the exponential increase in mortality rates observed by height. We also considered using separate regressions for towers less than and greater than 200 m, given the break in the data, but found that doing so had little effect on the overall estimate and we could not formulate a functional explanation why the tower height–mortality relationship should change in this manner.

Further research is needed on the mortality rates at the tallest towers (i.e., >500 m). These data are needed to confirm that the tower height–mortality relationship is exponential [26]. The nature of this relationship is important because it leads directly to a policy recommendation of focusing on the tallest towers first for mitigation. If more extensive tower datasets show a different relationship (e.g., logistic) then mitigation actions would be much different, requiring treatment of many more towers to address the same proportion of mortality.

Producing this estimate of avian mortality at towers required many assumptions, the implications of which we have explored to the degree possible with the data available. By undertaking this exercise, we have reaffirmed what elements should be included in tower studies going forward – explicit measurement of search efficiency, scavenging rates, and the effect of sampling schemes for any study, as well as investigation of geographic variation in mortality and inclusion of towers representative of the extremes of the height distribution. Such research will help refine our regionalized mortality estimates.

In 1989, the Exxon Valdez oil spill killed approximately 250,000 birds in what has become the benchmark for a major environmental disaster [65]. Our estimates show that communication towers are responsible for bird deaths equivalent to more than 27 Exxon Valdez disasters each year. Our estimate of the number of birds killed annually by communication towers is 2–4 times greater than the estimate for annual fatalities from lead poisoning before lead shot was phased out for hunting waterfowl [66].

Previous efforts (e.g., [25]) and our compiled database illustrate that most of the birds killed at communication towers are Neotropical migrants, which have suffered population declines and many of which are formally recognized as "Birds of Conservation Concern" [67], [68]. Data on per species mortality would provide even more clarity about the biological significance of avian mortality at communication towers. In a companion manuscript, we estimate species-specific losses based on total losses estimated here and species-specific casualty reports for Bird Conservation Regions following methods we developed previously [35]. But even without such estimates, the aggregate mortality numbers developed here should lead policymakers to pursue mitigation measures to reduce this source of chronic mortality.

Mitigation of avian mortality at communication towers could most practicably be achieved by implementing several measures: 1) concomitant with permission from aviation authorities, remove steady-burning red lights from towers, leaving only flashing (not slow pulsing) red, red strobe, or white strobe lights [24], [26], [28], [31]; 2) avoid floodlights and other light sources at the bases of towers, especially those left on all night [64]; 3) avoid guy wires where practicable [26], [28]; 4) minimize the number of new towers by encouraging collocation of equipment owned by competing companies; and 5) limit height of new towers when possible. Concentrating on removing steady-burning lights from the roughly 4,500 towers ≥150 m tall in the United States and Canada with such lights should be a top priority because, according to our model, it would reduce overall mortality by approximately 45% through remedial action at only 6% of lighted towers.

Acknowledgments

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The authors acknowledge the outstanding contribution of Herbert L. Stoddard and Tall Timbers Research Station in executing the long-term study of avian mortality at the WCTV tower. We thank Charles Francis for his help in extracting weather records used in Figure 1 and Martin Raillard for his support. We thank several anonymous reviewers for constructive criticisms and Gerald Winegrad, Caroline Kennedy, and Eugene A. Young for productive discussions about this research and access to unpublished reports.

Footnotes

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Competing Interests: The authors have declared that no competing interests exist.

Funding: Collaborators from The Urban Wildlands Group were supported in the early stages of this research by the American Bird Conservancy (www.abcbirds.org) and Defenders of Wildlife (www.defenders.org). The Canadian Wildlife Service (www.ec.gc.ca) purchased the NAV CANADA dataset. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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Attachment D

Resumes

Eric Johnson

Vice President of Operations/Principal Scientist
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EDUCATION

Florida State University Tallahassee, FL
Bachelors of Science, Environmental Studies & Sociology, 2008, *Cum Laude*

PROFESSIONAL EXPERIENCE

January 2009 – Present **Environmental Corporation of America** Alpharetta, GA
Position: Vice President of Operations/Principal Scientist
Responsibilities:

- Oversee day to day operations of ECA
- Principal review of Phase I Environmental Site Assessments
- Principal Review of NEPA Environmental Checklists/Documentation
- Regulatory Compliance for EPA/GA EPD Regulations involving hazardous air pollutants and volatile organic compounds

REPRESENTATIVE PROJECT EXPERIENCE - managed over 1,500 projects

T-Mobile Cell Towers **Various locations throughout the U.S.**
Principal Reviewer/Project Manager for Phase I Environmental Assessments, NEPA Checklists, and Section 106 compliance including archaeological surveys of the proposed tower site and access roads.

AT&T Cell Towers **Various locations through the Southeast and Midwest**
Principal Reviewer/Project Manager for Phase I Environmental Assessments, NEPA Checklists, and Section 106 compliance including archaeological surveys of the proposed tower site and access roads.

American Tower Cell Towers **Various locations in throughout Southeast, Midwestern, and Northwestern US**
Principal Reviewer/Project Manager for Phase I Environmental Assessments, NEPA Checklists, and Section 106 compliance including archaeological surveys of the proposed tower site.

SBA Network Cell Towers **Various locations throughout the MW, SE, and NE US**
Principal Reviewer/Project Manager for Phase I Environmental Assessments, NEPA Checklists, and Section 106 compliance including archaeological surveys of the proposed tower site.

Cell Tower Antenna Collocations/Acquisition Portfolios **Various locations in GA, IL, IN, KY, MO, PA, TX, and VA**
Project Manager for over a hundred Phase I Environmental Assessments for collocations on existing towers and buildings and acquisition portfolios.

Georgia Board of Regents **Various Locations in Georgia**
Conducted multiple GEPA and Phase I Environmental Assessments according to BOR Guidelines

Horton Homes, Inc. **Eatonton, GA**
Conducted annual and semi-annual reporting for compliance with EPA and Georgia EPD regulations related to hazardous air pollutants and volatile organic compound emissions and storm water pollution protection measures.

FEMA Grant Projects **AR, IL, IO, NE, MO, TN**
Compiled documentation and reports for NEPA screens for FEMA grant projects and completed FEMA Environmental Assessments where determined necessary.

Phase I Environmental Assessments **AL, FL, GA, SC, NC, TN**
Compilation and Principal review of Phase I Environmental Assessments for commercial real estate transactions across the southeast U.S. in accordance with ASTM E1527-13.

Hazel Errett
Senior Environmental Scientist/Program Manager
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EDUCATION

University of North Carolina at Asheville Asheville, NC
Bachelor of Science, Environmental Studies, December 2016

CURRENT EXPERIENCE

Environmental Corporation of America
May 2017 – Present Asheville, NC
Position: Project Scientist
Responsibilities:

- Preparation of FCC National Environmental Policy Act (NEPA) Checklist and Environmental Assessment (EA) evaluations for proposed telecommunications facilities
- Preparation of USFWS requests for technical assistance, Informal Biological Assessments (IBA), and species-specific surveys – Identify potential habitat that may or may not be located within a project area for species listed by the USFWS as "Threatened" or "Endangered"
- Osprey/Bald Eagle Nest Investigations to determine activity status of reported osprey or bald eagle nests on telecommunications towers
- Preparation of Phase I and Phase II Environmental Site Assessments (ESAs) to determine whether or not a "recognized environmental condition" (REC) is present in connection with the Property in accordance with ASTM E1527-13
- Section 106 Review Documentation/Archaeological Assessments for Telecommunications Projects

REPRESENTATIVE EXPERIENCE

Migratory Bird Nest Evaluation/Monitoring
Determine activity status of reported migratory bird nests to recommendations regarding timing and planning construction, installation, and/or maintenance activities can be made. Monitoring construction/maintenance activities in close proximity to occupied nests so actions are within applicable regulatory guidelines.

Phase I Environmental Site Assessments
Project Manager, Participation in Alabama, Florida, Indiana, Kentucky, Missouri, North Carolina, Oklahoma, South Carolina, and Tennessee

Section 106 Review
Project Manager, Participation in numerous Section 106 reviews in Alabama, Florida, Kentucky, Missouri, North Carolina, and Oklahoma.

Federal Communications Commission NEPA Assessments
Project Manager and/or Project Scientist, Participation in Alabama, Florida, Kentucky, Missouri, North Carolina, and Oklahoma.

Protected Species Evaluations/ USFWS and State Wildlife Agency Consultations
Project Manager and/or Project Scientist, Participation in numerous projects within the United States.