Clean Energy Compass

Methodology Paper

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Authored by Liz Kalies, North America Renewable Energy Lead Scientist; Chris Hise, Associate Director of Conservation, Oklahoma Four Canyon Preserve; Chris Brink, North America Senior GIS Analyst; Maya Batres, North America Senior Advisor, People and Climate; Melanie Bruce, GIS Web Developer; Julia Leopold, Associate Director of Communications, North America Renewable Energy; and Jessica Wilkinson, North America Renewable Energy Team Lead

Nathan Cummins

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Acronym Glossary

Acronym	Definition
3Cs	Climate, conservation and communities
AFT	American Farmland Trust
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
EPA	U.S. Environmental Protection Agency
EIS	Environmental impact statement
Esri	Environmental Systems Research Institute, Inc.
FRCN	Freshwater Resilient and Connected Network
GDE / GDEs	Groundwater-dependent ecosystem / groundwater-dependent ecosystems
GIS	Geographic information system
GLM	Generalized linear model
GRACE	Gravity Recovery and Climate Experiment
GRTS	Generalized Random-Tessellation Stratified
HLR	Hydrologic Landscape Region
HMI	Human Modification Index
HUC12	12-digit hydrologic unit code
LASSO	Least Absolute Shrinkage and Selection Operator
MCP	Minimum convex polygon
NABat	North American Bat Monitoring Program
NGDA	National Geospatial Data Asset
NHD	National Hydrography Dataset
NRCS	Natural Resources Conservation Service
PAD-US	Protected Areas Database of the United States
$PM_{2.5}$	Fine particulate matter with a diameter of 2.5 micrometers or less
PVR	Productivity, versatility, and resiliency
RCN	Resilient and Connected Network
SUI	Surface Water Supply Use Index
TNC	The Nature Conservancy
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTC	Coordinated Universal Time

WHSRN	Western Hemisphere Shorebird Reserve Network
XGBoost	Extreme Gradient Boosting

Introduction

The Clean Energy Compass is The Nature Conservancy's (TNC's) first-stop tool for clean energy planning. It is designed to inform—not determine—planning decisions.

The map can be used to identify potential **climate, conservation and community considerations (3Cs)** that may warrant further evaluation. It provides national-scale information to support early-stage planning and should be used alongside site-specific assessments, input from state and federal wildlife agencies, community engagement, Tribal consultation and other local analyses.

It is important to note that the presence of wildlife and habitat resources or community considerations does not necessarily preclude clean energy development, as many impacts can be avoided, minimized or addressed through thoughtful project design, operations and mitigation measures. The **Compass Resource Hub** helps the user navigate these considerations. Learn more www.nature.org/cleanenergycompass

The Clean Energy Compass Is:

- An interactive, national-scale map and accompanying resource hub that can be used to inform clean energy project planning.
- Intended to be used as a first-stop resource for early clean energy project planning. Its features are designed to support initial information-gathering before taking next steps.
- A map that includes more than 100 high-quality, national-scale data layers related to climate, conservation and community considerations—the 3Cs. The data flag where there are wildlife, habitat and community factors that may warrant additional consideration during early project planning.
- A Compass Resource Hub that offers vetted information about taking conservation values into consideration and practical suggestions to help clean energy project developers and decision makers engage with communities and Tribes.

The Clean Energy Compass Is Not:

- It is not a siting tool and is not intended to be used on its own to determine where clean energy should or should not be sited.
- It does not rank or score locations or certify projects for clean energy development on its own. The data in the tool can be used as part of a ranking or scoring system, along with other inputs.
- It is not a substitute for site-specific analysis or local decision-making. It complements—not replaces—site-level assessments, community input and consultation with local, state and federal agencies.

- It is designed to be used alongside state and local zoning, policies and planning frameworks. In some cases, it may highlight environmental and community considerations in areas already designated for clean energy development by state or local governments. This reflects the national-scale nature of the data and does not override state or local planning and decisions, which rely on more detailed and location-specific information.
- It provides a consistent national baseline of conservation and community considerations and is not a comprehensive assessment. Many states and local jurisdictions include consideration of additional or different conservation values that go beyond what is included in the Compass.
- It does not include data about technical feasibility of building clean energy projects. For example, it does not show where there is access to the transmission grid or provide information about the terrain.

Why Clean Energy Decision Makers Should Use the Clean Energy Compass

Clean energy projects often face opposition from communities concerned about environmental impacts. When tradeoffs are identified too late, projects can face costly delays, increased opposition and slower deployment. Addressing environmental and community considerations early in the clean energy planning process can help enable faster, more cost-effective development.

The Clean Energy Compass helps decision-makers better understand the factors that may matter most to a community. The map flags potential environmental and community considerations early in the project planning process, when projects are still flexible and adjustments are more feasible. It's national-scale dataset enables consistent, apples-to-apples comparison across differing geographies. The Compass also connects users to resources to help minimize tradeoffs and plan for projects that are better for nature and people—ideally allowing clean energy projects to move forward faster.

The intent of the Compass is to surface potential tradeoffs early, with the hope of enabling a faster, more efficient and more affordable clean energy buildout.

About This Methods Paper

The Clean Energy Compass brings together more than 100 national and regional datasets related to climate, conservation and community considerations. Because these datasets come from many different sources and were developed for different purposes, users may want additional information about what is included in the map and how the data should be interpreted.

This methods paper provides that additional context. For each Compass layer, we describe the data that are included, why those data were selected and how they can be used during early-stage clean energy planning. We also document the underlying data sources, summarize the processing methods used to create each layer and discuss key limitations that users should understand when interpreting the results.

Resolution, Accuracy and Uncertainty in Data Layers

Resolution, accuracy and uncertainty are related concepts, but they describe different aspects of a dataset. **Resolution** refers to the size of the map cells or pixels used to represent information. Most Clean Energy Compass layers are mapped at a 30 × 30-meter resolution, meaning the landscape is divided into relatively small areas that can capture local patterns and features. High resolution allows users to see finer spatial detail, but it does not automatically mean the information within each pixel is correct.

Accuracy describes how well the data represent real-world conditions. Many Compass wildlife layers are built from known species observations, documented occurrences, telemetry records, surveys or habitat models developed from actual species presence data. For example, a mapped whooping crane stopover area or a bat roost location is based on real observations, giving us confidence that the mapped feature reflects an actual conservation concern. However, **uncertainty** still exists because natural systems change through time. A whooping crane observed at one location may not be there every day or year. In other words, uncertainty reflects the limits of our knowledge about how species use the landscape across space and time, even when the underlying observations are accurate.

A useful example is the bat layer. We have accurate records showing where bats were detected or where known roosts occur. However, because those records only document locations that were surveyed, they do not necessarily tell us where bats are likely to occur elsewhere in the landscape. In that case, the data may have good resolution and high accuracy, but higher uncertainty when used to generalize beyond the observed locations. Conversely, the habitat suitability models used (in part) for the grouse layer may have greater uncertainty about any individual location but can provide broader insight into where a species is likely to occur across a region.

Conservation Values

Wildlife, habitats and ecosystems to consider during wind and solar planning

The Conservation Values category includes datasets representing wildlife, habitats, ecological systems and other natural resources that may warrant consideration during clean energy planning. Because potential interactions between energy infrastructure and conservation resources differ by technology, the Compass presents conservation data separately for solar, wind and floating solar projects. Selecting a technology automatically displays the conservation datasets most relevant to that technology. For example, some bird-related datasets are included for wind energy because of potential collision and displacement concerns, while certain terrestrial wildlife and habitat datasets are included for solar development because of potential land-use impacts. This approach helps users focus on the conservation considerations most likely to be relevant to the technology being evaluated.

Highly sensitive conservation data represents wildlife, habitats and ecological systems the Compass identifies as the highest priorities for minimizing conflict from wind and solar development. These datasets generally reflect areas with strong conservation significance, including protected lands, wetlands, biodiversity hotspots and habitat for particularly vulnerable species. **Moderately sensitive conservation data** provides additional ecological context that can inform siting decisions but may represent lower conservation priorities, greater uncertainty, broader habitat associations or datasets with varying levels of spatial precision. These layers help identify potential concerns and opportunities for further review but are typically less definitive indicators of conservation conflict than the highly sensitive datasets.

Highly Sensitive

Wildlife and ecosystems most sensitive to wind and solar development

Protected Areas

About the Data

This layer presents the U.S. Geological Survey's (USGS's) Protected Areas Database of the United States (PAD-US), a national inventory of U.S. terrestrial protected areas that are dedicated to the preservation of biological diversity and other natural, recreational and cultural uses, and are managed for these values through legal or other means. It includes federal, state and local lands that are protected or managed for conservation purposes, such as national parks, national wildlife refuges and Bureau of Land Management (BLM) lands with conservation designations (e.g., Areas of Critical Conservation Concern, National Monuments, Wilderness Areas, National scenic or Historic Trails, etc.). We also included the National Conservation Easement Database for additional areas protected by public agencies, private land trusts (including TNC preserves) and other organizations, and additional state-specific data as appropriate.

Why These Data Are Included

Development in these areas is generally restricted through legal protection. While renewable energy deployment is not always prohibited—for example, some projects may be permitted on federal lands with appropriate approvals (e.g., BLM's 11-state solar planning area; Department of Energy lands)—the regulatory complexity and high conservation value of these areas may present additional considerations or constraints for development.

Data Sources

National Data Sources

- U.S. Geological Survey (USGS) Gap Analysis Project. 2024. *Protected Areas Database of the United States (PAD-US) 4.1.* U.S. Geological Survey data release. https://doi.org/10.5066/P96WBCHS. https://www.usgs.gov/programs/gap-analysis-project/science/pad-us-data-download
  Note: We included Gap Status 1, 2, 3.
- National Conservation Easement Database. 2025. https://www.conservationeasement.us/
- TNC. *Secured Areas Dataset*. https://tnc.maps.arcgis.com/home/item.html?id=e033e6bf6069459592903a04797b8b07

State Data Sources

Colorado. Colorado Natural Heritage Program Protected Lands Database, including parks, refuges, preserves, conservation easements and other protected lands. https://comap.cnhp.colostate.edu/

Florida. Florida Natural Areas Inventory data and the Florida Managed Lands Database. Priority 1 and Priority 2 conservation lands were included. https://www.fnai.org/publications/gis-data

Maine. Protected lands were supplemented using a TNC-maintained protected lands dataset.

New Hampshire. Protected lands were supplemented using the New Hampshire Conservation and Public Lands dataset from New Hampshire GRANIT. https://new-hampshire-geodata-portal-1-nhgranit.hub.arcgis.com/datasets/NHGRANIT::new-hampshire-conservation-public-lands/about

New Jersey. Protected lands include the Pinelands Preservation Area District from the New Jersey Office of GIS. https://njogis-newjersey.opendata.arcgis.com/datasets/d94ed3f13d784a8ab57486b003c5478d_0/explore

New York. Protected lands were supplemented using a TNC-maintained protected lands dataset.

North Carolina. Protected lands were supplemented using the North Carolina Natural Heritage Program Managed Areas dataset.

Oklahoma. Protected lands were supplemented using a TNC-maintained protected lands dataset.

South Carolina. Protected lands were supplemented using a TNC-maintained protected lands dataset and South Carolina Conserved Lands. https://services.arcgis.com/F7DSX1DSNSiWmOqh/arcgis/rest/services/SC_Conserved_Lands_3_view/FeatureServer

Virginia. Protected lands include conserved lands and natural heritage conservation areas maintained by the Virginia Department of Conservation and Recreation. https://www.dcr.virginia.gov/natural-heritage/clinfo

Washington. Protected lands were supplemented using a TNC-maintained dataset representing lands and waters in which TNC has a legal conservation interest, including conservation easements and fee-owned properties.

Processing Methods

All data sources were converted to a single band, single value 8-bit raster image. The raster images were merged using ArcGIS to create a single, national protected area layer.

Limitations

Protected lands vary substantially in ownership, legal protections, management objectives and permitted land uses. The layer identifies areas where conservation objectives, legal protections, land-management priorities or administrative requirements may affect project feasibility and increase the likelihood of siting conflicts.

Floodplains, Wetlands and Groundwater-Dependent Ecosystems

About the Data

This layer identifies floodplains, rivers, open water and wetlands across the landscape. The data come from the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory and Fathom's modeled 1-in-20-year fluvial (river) and pluvial (rainfall-driven) floodplains. The layer also depicts groundwater-dependent ecosystems (GDEs) for the western U.S., which are often biodiversity hotspots that support rare species.

Why These Data Are Included

Together, these data highlight where water systems support areas of high biodiversity and ecological function. Floodplains, wetlands and groundwater-fed systems provide important habitat for fish and wildlife, support migratory birds and help reduce flood risk by slowly storing and releasing water (Mitsch & Gosselink, 2015; Opperman et al., 2024).

Development near wetland complexes and riparian corridors may alter water flow or fragment habitat. Groundwater-dependent ecosystems are particularly susceptible to development because land use changes can disrupt the natural water supply that supports these biodiversity hotspots (Rohde et al., 2024; Howard et al., 2023).

Data Sources

Floodplains

Floodplain data were derived from Fathom flood-hazard models representing both fluvial (riverine) and pluvial (surface-water) flooding.

- Fathom. Flood hazard data. 1-in-20 fluvial and pluvial floodplain model. https://www.fathom.global/flood-data/
- Fathom. Flood hazard data. 1-in-100 fluvial and pluvial floodplain model. https://www.fathom.global/flood-data/

Wetlands

The primary national wetlands dataset was the USFWS National Wetlands Inventory. State-specific wetland datasets were incorporated where available to improve representation of wetlands not fully captured by national sources.

- USFWS. National Wetlands Inventory. https://www.fws.gov/program/national-wetlands-inventory
- Massachusetts Department of Environmental Protection. MassGIS data: Massachusetts Department of Environmental Protection wetlands (2005). https://www.mass.gov/info-details/massgis-data-massdep-wetlands-2005

- New York State Department of Environmental Conservation. Freshwater wetlands and associated New York wetlands datasets.
- SanGIS. Vernal pool boundaries dataset, distributed through Data Basin. https://databasin.org/datasets/00fb0e88f5e04a7ebb5f5f80bf125790/

Groundwater-Dependent Ecosystems

The national dataset was supplemented by several state-level datasets.

- Rohde, M.M.**,** C.M. Albano, X. Huggins, K.R. Klausmeyer, C. Morton, A. Sharman, E. Zaveri, L. Saito, Z. Freed, J.K. Howard, N. Job, H. Richter, K. Toderich, A. Rodella, T. Gleeson, J. Huntington, H.A. Chandanpurkar, A.J. Purdy, J.S. Famiglietti, M.B. Singer, D.A. Roberts, K. Caylor, J.C. Stella. 2024. Groundwater-dependent ecosystem map exposes global dryland protection needs. *Nature* 632: 101-107. https://www.nature.com/articles/s41586-024-07702-8
  Data source: https://codefornature.projects.earthengine.app/view/global-gde
- Nevada Division of Natural Heritage. *Nevada Indicators of Groundwater-Dependent Ecosystems (iGDE) Database*. Carson City, NV: Nevada Division of Natural Heritage. https://heritage.nv.gov/wetland-links
- Freed, Zach, Schindel, Michael, Ruffing, Claire and Scott, Shonene. 2022. Oregon Atlas of Groundwater-Dependent Ecosystems. https://doi.org/10.13140/RG.2.2.11817.98407
  Used to identify areas with high spring density and groundwater influence. The highest two natural-break classes of SpringDens were retained for inclusion.

Processing Methods

Floodplain, wetland, vernal pool and GDE datasets were converted to a single band, single value, 8-bit raster image. The raster images were then merged using ArcGIS.

Limitations

Hydrologic datasets differ substantially in mapping methods, spatial resolution, temporal coverage and ecological interpretation across jurisdictions. Some datasets represent observed features, while others represent modeled conditions or predicted habitat suitability. Consequently, mapped features should be interpreted as indicators of hydrologic sensitivity and ecological importance rather than precise delineations of wetland or GDE boundaries.

Biodiversity, Resilience and Flow

About the Data

TNC's Resilient and Connected Network (RCN) analysis depicts areas with recognized biodiversity value and high resilience that are important for sustaining species and natural wildlife habitats in a changing climate (Anderson et al. 2023a). These sites include representative geophysical environments and microclimates with relatively low levels of human modification, which comprise a network of lands most likely to retain biodiversity and ecosystem function in an altered climate. "Resilient, Biodiverse Areas" are sites with confirmed high levels of biodiversity that are resilient to climate change and may be valuable for connectivity. "Connectivity Pinch-points" are resilient but geographically restricted areas critical to facilitating the movement of species in response to changes in climate. "Coastal Migration Space" includes low-lying coastal land that is potentially suitable for supporting tidal habitats in the future as sea levels rise. We excluded diffuse areas without biodiversity as these sites may be suitable for renewable energy development (see the Resilient Land Mapper).

Why These Data Are Included

The RCN analysis identifies and prioritizes landscapes that are most likely to sustain biodiversity over time, not just today (Anderson et al. 2023a). As a result, they represent some of the highest priority landscapes for long-term biodiversity conservation. Focusing on areas that are both climate-resilient and well-connected helps ensure that species can persist and move in response to changing conditions. TNC prioritizes conservation investments in these areas to support biodiversity conservation not just now, but in the face of a changing climate. Wind and solar development in these areas may affect habitat connectivity and ecological function, disrupting their ability to support biodiversity over the long term (Clark et al. 2023; Wu et al. 2024).

Data Sources

National Resilient and Connected Network. The analysis integrates four core conservation principles: representation of geophysical diversity, climate resilience, ecological connectivity and recognized biodiversity value:

- Anderson, M.G., Clark, M., Olivero, A.P., Barnett, A.R., Hall, K.R., Cornett, M.W., Ahlering, M., Schindel, M., Unnasch, B., Schloss, C. and Cameron, D.R. 2023a. *A resilient and connected network of sites to sustain biodiversity under a changing climate. Proceedings of the National Academy of Sciences* 120(7): e2204434119. DOI: 10.1073/pnas.2204434119.
- Data can be found at: https://www.maps.tnc.org/resilientland/

The original RCN dataset contains multiple classes representing combinations of biodiversity value, climate resilience, ecological connectivity and coastal adaptation. For the Compass, these classes were consolidated into three categories that reflect the primary conservation attributes of the underlying analysis.

- *Resilient and Biodiverse Areas* are locations with recognized biodiversity value that also exhibit characteristics associated with climate resilience, including diverse geophysical settings, local climatic heterogeneity and relatively low levels of human modification. These landscapes are expected to provide opportunities for species and natural communities to persist under changing climate conditions (Anderson et al. 2023a; Anderson et al. 2023b).
- *Connectivity Pinch-points* are geographically constrained areas where ecological flows are concentrated and alternative movement pathways are limited. Because movement opportunities are restricted in these locations, they play a disproportionately important role in supporting species dispersal, migration and climate-driven range shifts across larger landscapes (Anderson et al. 2023a; Clark et al. 2023).
- *Coastal Migration Space* are low-lying coastal lands that may facilitate the inland migration of tidal wetlands and associated ecosystems as sea levels rise. These areas represent opportunities to maintain future coastal habitat extent and ecological function under projected sea-level rise scenarios (Anderson et al. 2023b).

Processing Methods

To improve interpretability for renewable energy planning applications, we retitled the layer "Biodiversity, Resilience and Flow" and consolidated multiple RCN classes into three user-facing categories representing biodiversity value, ecological connectivity and coastal adaptation potential.

Resilient and Biodiverse Areas (Green)

All RCN classes containing a recognized biodiversity designation were grouped into the Resilient and Biodiverse Areas category, namely:

- Resilient, Concentrated Flow (Climate Informed), Recognized Biodiversity
- Mostly Resilient, Concentrated Flow, Recognized Biodiversity
- Resilient, Diffuse Flow (Climate Informed), Recognized Biodiversity
- Resilient, Diffuse Flow, Recognized Biodiversity
- Resilient, Recognized Biodiversity

Because recognized biodiversity value was considered the primary conservation attribute, all classes containing a biodiversity designation were assigned to this category regardless of whether they also contained connectivity attributes.

Connectivity Pinch-points (Orange)

The Connectivity Pinch-points category includes concentrated flow classes that do not contain a recognized biodiversity designation, namely:

- Resilient, Concentrated Flow (Climate Informed)
- Resilient, Concentrated Flow
- Mostly Resilient, Concentrated Flow

These areas were retained because they represent ecologically important movement corridors where species movement and climate adaptation opportunities are concentrated.

Coastal Migration Space (Yellow/Tan)

The Coastal Migration Space category consists of:

- Resilient Coastal Migration Space

These areas identify lands with the potential to facilitate future inland migration of tidal habitats and associated coastal ecosystems as sea levels rise.

Excluded Classes

The following classes were excluded from the Compass:

- Resilient, Diffuse Flow (Climate Informed)
- Resilient, Diffuse Flow

These classes represent broad areas that contribute to landscape connectivity but do not contain recognized biodiversity designations. Although diffuse flow areas can support species movement and climate adaptation across large landscapes, ecological movement within these areas is generally distributed across multiple pathways rather than concentrated within geographically constrained corridors (Clark et al. 2023).

The decision to exclude diffuse flow classes reflects their lower sensitivity to localized development relative to concentrated flow areas. While widespread development throughout an entire diffuse flow region could reduce landscape connectivity, individual projects are less likely to disrupt ecological movement because alternative pathways typically remain available. In contrast, connectivity pinch-points represent locations where movement is concentrated and alternative routes are limited, making them substantially more vulnerable to the effects of habitat loss or fragmentation.

Limitations

The Biodiversity, Resilience and Flow layer is intended to support landscape-scale conservation planning and should not be interpreted as a site-specific assessment of ecological value. The analysis identifies areas expected to support biodiversity persistence and adaptation under changing climate conditions but does not directly evaluate local habitat quality, species presence or site-scale ecological conditions.

The underlying RCN analysis was developed at a national scale and may not capture all local conservation priorities, recently documented species occurrences, newly protected lands or regional connectivity assessments developed after publication of the source dataset. Users should consider complementary datasets and local expertise when evaluating potential project impacts.

Finally, because the analysis is designed to identify areas that can support biodiversity persistence and adaptation in the future, portions of the network may not currently exhibit the highest observed biodiversity values. The conservation significance of these areas derives from their expected long-term contribution to ecological resilience, connectivity and adaptive capacity under changing climatic conditions rather than solely from present-day species distributions.

Threatened and Endangered Species

About the Data

This layer depicts habitat for many terrestrial species that are federally listed as threatened or endangered under the Endangered Species Act (ESA), including critical habitat delineated by USFWS and NatureServe's "Areas of Unprotected Biodiversity Importance." Also shown are current/recent species distributions, modeled priority habitats and occurrence records for at-risk species that are known to be sensitive to wind and/or solar infrastructure (e.g., gopher tortoise, pygmy rabbit, dune sagebrush lizard). Note that whooping crane and grouse habitat are displayed in other layers, due to their high sensitivity to wind or solar development.

Why These Data Are Included

Imperiled species often occur in small, fragmented populations and depend on specialized habitats, making them particularly sensitive to habitat loss, fragmentation or disturbance (Wilcove et al., 1998; Crooks et al., 2017). This layer includes both broad indicators of threatened and endangered species, such as federally designated critical habitat and species diversity models, and selected datasets for species that are sensitive to the unique structural characteristics of wind or solar development, such as tall structures or large fenced areas. Additional land conversion and infrastructure can degrade or divide the limited habitats these species depend on (e.g., sandy uplands, intact shrublands or dune systems), further isolating populations and reducing their ability to persist (Haddad et al., 2015; Loss et al., 2013).

Data Sources

National Datasets

- USFWS. 2025. Federally designated critical habitat for species listed under the ESA. https://ecos.fws.gov/ecp/report/table/critical-habitat.html
- NatureServe. Areas of Unprotected Biodiversity Importance. https://www.arcgis.com/home/item.html?id=6a41c957ed584ce4be8ccb71a2131116#overview

Individual Species Data

Golden-cheeked Warbler (Setophaga chrysoparia) — Texas. Modeled habitat and priority conservation areas for the federally endangered golden-cheeked warbler from the Texas Parks and Wildlife Department.

Northern Spotted Owl (Strix occidentalis caurina) — Washington. Habitat conservation planning units and management units used to identify areas important for northern spotted owl conservation.

- Washington State Department of Natural Resources. Spotted Owl Management Units Dataset. https://data-wadnr.opendata.arcgis.com/maps/40a664ec4b72463dbcc33bcd1123a49d_4/about
- Washington State Department of Natural Resources. Habitat Conservation Plan Lands. Washington State Geospatial Open Data Portal. https://data-wadnr.opendata.arcgis.com/datasets/wadnr::habitat-conservation-plan-lands/about

Columbian White-tailed Deer (Odocoileus virginianus leucurus) — Washington and Oregon. Range and habitat data depicting current distribution and recovery areas for Columbian white-tailed deer.

- USFWS. http://tnc.maps.arcgis.com/home/item.html?id=8ff61284d56748de8f75ea4e8efe39b7

Piping Plover (Charadrius melodus) — Colorado. Production and foraging areas derived from Colorado Parks and Wildlife species datasets.

Preble's Meadow Jumping Mouse (Zapus hudsonius preblei) — Colorado and Wyoming. Occupied range and habitat information for the federally threatened Preble's meadow jumping mouse from Colorado Parks and Wildlife.

Multiple Species — Wyoming. Occurrence records and distribution models from the Wyoming Natural Diversity Database. https://wyndd.org/species_list/?pointerType=dataDownloadLinks

- Plains Pocket Gopher (*Geomys bursarius*)
- Pygmy Rabbit (*Brachylagus idahoensis*)
- Wyoming Toad (*Anaxyrus baxteri*)
- Blowout Penstemon (*Penstemon haydenii*)
- Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*)
- Regal Fritillary (*Speyeria idalia*)
- Monarch Butterfly (*Danaus plexippus*)

Baptisia spp. – Georgia. Occurrence records and/or habitat information for rare *Baptisia* plant species.

- Georgia Natural Heritage Inventory Program. 2023. Element Occurrence records for *Baptisia arachnifera*. Georgia Department of Natural Resources, Wildlife Resources Division, Wildlife Conservation, Social Circle, Georgia.

Eastern Indigo Snake (Drymarchon couperi) — Georgia. Occurrence data for eastern indigo snake only.

- Chandler, H.C., C.L. Jenkins and J.M. Bauder. 2022. Accounting for geographic variation in species-habitat associations during habitat suitability modeling. *Ecological Applications*: e2504. https://orianne.wpenginepowered.com/wp-content/uploads/2022/02/Chandler-et-al.-2022-Accounting-for-geographic-variation-in-species%E2%80%90habitat-associations-during-habitat-suitability-modeling.pdf

Gopher Tortoise (Gopherus polyphemus) — North Carolina, South Carolina, Georgia, Alabama, Mississippi and Florida. Regional habitat suitability and conservation datasets depicting potential gopher tortoise habitat across the southeastern United States.

- USGS. Gopher Tortoise Habitat Model. https://www.sciencebase.gov/catalog/item/5d0d4ba0e4b0941bde52a306
- Known occurrence locations supplementing the regional habitat model. From the Georgia Department of Natural Resources.

Florida Panther (Puma concolor coryi) — Florida. Florida Panther Consultation Areas.

- Florida Fish and Wildlife Conservation Commission. https://ca.dep.state.fl.us/arcgis/rest/services/Map_Direct/ESSA_Support/MapServer/13

Dune Sagebrush Lizard (Sceloporus arenicolus) — New Mexico and Texas. Habitat suitability and occurrence-based models depicting occupied and potentially suitable habitat.

- Laurencio, L.R., and L.A. Fitzgerald. 2010. Atlas of distribution and habitat of the dunes sagebrush lizard (*Sceloporus arenicolus*) in New Mexico. Texas Cooperative Wildlife Collection, Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843-2258. ISBN# 978-0-615-40937-5. https://www.bison-m.org/documents/25024_LaurencioandFitzgerald2010.pdf

Processing Methods

Datasets were converted to a single band, single value, 8-bit raster image. The raster images were merged using ArcGIS. Species-specific processing procedures varied by dataset type and source agency. Where applicable, habitat suitability datasets were filtered to retain the classes identified by data providers as most relevant for conservation planning. Additional processing steps used to standardize individual datasets are described in source documentation.

Limitations

Data sources vary considerably in geographic extent, age, spatial resolution, and methodology. Some datasets represent modeled habitat, while others represent known occurrences, conservation priority areas, or regulatory designations. Absence of mapped habitat or occurrence records should not be interpreted as absence of a species. Critical habitat designations do not encompass all habitat used by listed species, and species distributions may change as new information becomes available. Additional limitations specific to individual datasets are described in the original source documentation.

Prairie and Sage Grouse

About the Data

This layer depicts important habitat for the following prairie and sage grouse species:

- Attwater's prairie-chicken (Endangered; *Tympanuchus cupido attwateri*)
- Columbian sharp-tailed grouse (*T. phasianellus columbianus*)
- Greater prairie-chicken (*T. cupido*)
- Greater sage-grouse (*Centrocercus urophasianus*)
- Gunnison sage-grouse (Threatened; *C. minimus*)
- Lesser prairie-chicken (*T. pallidicinctus*)
- Plains sharp-tailed grouse (*T. phasianellus jamesi*)

Why These Data Are Included

Grouse species in the U.S. have experienced substantial population declines since the early 20th century and may be further threatened by improperly sited energy development (Vodehnal and Haufler 2007; Pruett et al. 2009). They rely on large, intact habitats and are sensitive to disturbance, often avoiding human activity and structures, including wind turbines and other tall structures (Vodehnal and Haufler 2007; McNew et al. 2014). Their breeding system makes them especially vulnerable because they gather at specific sites called leks year after year, and disturbance near these breeding areas can affect habitat use and population persistence (Winder et al. 2015).

Data Sources

The layer consists of priority habitats, production areas, winter range, conservation focal areas, lek buffers, core habitat areas, biologically significant units and other conservation areas identified by state, federal and partner conservation efforts. Habitat areas were selected to represent the most important breeding and conservation areas while excluding broad historical ranges and generalized habitat maps. Additional priority habitat management areas were incorporated across the western United States using BLM sage-grouse habitat datasets.

Attwater's Prairie-Chicken

Texas. Attwater's prairie-chicken occurrence records and the Refugio-Goliad Prairie Conservation Area.

- Texas Natural Diversity Database. 2021. Attwater's prairie-chicken element occurrence data export. Vector digital data. Wildlife Diversity Program, Texas Parks and Wildlife Department, Austin.
- TNC. 2009. Conservation action plan for the Refugio-Goliad Prairie Conservation Area. TNC, Austin, Texas.

Columbian Sharp-Tailed Grouse

Colorado. Production areas and winter range.

- Colorado Parks and Wildlife. 2015. Columbian sharp-tailed grouse production areas and winter range. Vector digital data. Colorado Parks and Wildlife, Fort Collins.

Greater Prairie-Chicken

Greater prairie-chicken habitat was identified using habitat models, production areas, conservation opportunity areas and priority habitat datasets across the Great Plains.

- *South Dakota*. Tier 1 and Tier 2 habitat models.
  Runia, T.J., A.J. Solem, N.D. Niemuth and K.W. Barnes. 2021. Spatially explicit habitat models for prairie grouse: implications for improved population monitoring and targeted conservation. *Wildlife Society Bulletin* 45(1): 36–54.
- *Kansas and Oklahoma*. Modeled optimal habitat.
  Hise, C., B. Obermeyer, M. Ahlering, J. Wilkinson and J. Fargione. 2022. Site Wind Right: identifying low-impact wind development areas in the central United States. *Land* 11(4): 462. https://doi.org/10.3390/land11040462
- *Colorado*. Production areas.
  Colorado Parks and Wildlife. 2015. Greater prairie-chicken production areas. Vector digital data. Colorado Parks and Wildlife, Fort Collins.
- *Missouri*. Grassland conservation opportunity areas.
  Missouri Department of Conservation. 2015. Missouri State Wildlife Action Plan.
- *Minnesota*. Priority habitat.
  Minnesota Department of Natural Resources. 2021. Greater prairie-chicken priority habitat. Vector digital data. Minnesota Department of Natural Resources, Aitkin.

Greater Sage-Grouse

Greater sage-grouse habitat was identified using biologically significant units, state-designated core and connectivity areas and priority habitat management areas across the western United States.

- *Western United States (CA, CO, ID, MT, NV, OR, UT, WY)*. Priority habitat management areas and other selected designations.
  BLM. 2022. Western U.S. greater sage-grouse records of decision habitat management areas (August 2022 version). Available through BLM Enterprise Geospatial Services.
- *Colorado*. Greater Sage Grouse overall range.
  Colorado Parks and Wildlife. 2013. Vector digital data.

- *Wyoming*. Core, connectivity and winter concentration areas.
  Wyoming Game and Fish Department. 2015. Sage-grouse core and connectivity areas, version 4. Vector digital data.
- *Wyoming*. Priority habitat management areas.
  BLM. 2024. Greater sage-grouse rangewide planning proposed resource management plan amendment and final environmental impact statement (EIS).
- *Wyoming*. Core area revisions.
  Wyoming Game and Fish Department. 2023. Vector digital data.
- *Montana*. Core areas.
  Montana Fish, Wildlife and Parks. 2016. Sage-grouse core areas. Vector digital data.
- *Idaho*. Proposed Habitat Management Area Amendments (2021).
  Bureau of Land Management. 2024. 2021 Greater Sage-grouse Rangewide Planning Effort.
- *Nevada*. Final EIS Proposed Habitat Management Areas (2024).
  BLM. 2024. 2021 Greater Sage-grouse Rangewide Planning Effort.

Gunnison Sage-Grouse

Colorado. Critical habitat, occupied range and lek locations.

- USFWS. 2025. Threatened and endangered species critical habitat polygons shapefile.
- Colorado Parks and Wildlife. 2023. Gunnison sage-grouse occupied range, production areas, brood areas and lek locations. Vector digital data. Colorado Parks and Wildlife, Fort Collins.

Lesser Prairie-Chicken

Colorado, Kansas, New Mexico, Oklahoma and Texas. Conservation focal areas and 6.8-km lek buffers.

- Southern Great Plains Crucial Habitat Assessment Tool. 2025. https://www.sgpchat.org/

Plains Sharp-Tailed Grouse

- *Colorado*. Production areas and lek locations with 5-km buffers.
  Colorado Parks and Wildlife. 2023. Plains sharp-tailed grouse leks and production areas. Vector digital data. Colorado Parks and Wildlife, Fort Collins.
- *South Dakota and North Dakota*. Tier 1 and Tier 2 habitat models.
  Runia, T.J., A.J. Solem, N.D. Niemuth and K.W. Barnes. 2021. Spatially explicit habitat models for prairie grouse: implications for improved population monitoring and targeted conservation. *Wildlife Society Bulletin* 45(1): 36–54.

- *Minnesota*. Priority habitat.
  Minnesota Department of Natural Resources. 2021. Sharp-tailed grouse priority habitat. Vector digital data. Minnesota Department of Natural Resources, Aitkin.

Whooping Cranes

About the Data

The federally endangered whooping crane (*Grus americana*) has a current population of approximately 800 individuals (International Crane Foundation 2026) and depends on wetlands in the central Great Plains during migration. In this layer, we display important whooping crane habitat including stopover sites, modeled suitable habitat, designated critical habitat, wintering areas and breeding sites. We delineated areas within 400 meters for solar development and 5 kilometers for wind development of whooping crane critical habitats and stopover sites as highly sensitive (*cf.* Baasch et al. 2019; Pearse et al. 2021).

Why These Data Are Included

Whooping cranes may be displaced from otherwise suitable habitat near wind and solar infrastructure as they avoid areas around turbines, effectively reducing available stopover sites along migration routes (Pearse et al. 2021). They may also face collision risk with tall structures during migration or while moving between roosting and foraging areas, particularly under low-visibility conditions (USFWS 2009). Although direct impacts of solar facilities on whooping cranes are less well understood, conversion or degradation of the limited wetlands and other stopover habitats they rely on may warrant additional consideration because of the species' dependence on these habitats during migration.

Data Sources

Central Flyway Migration Corridor (multi-state: MN, MT, ND, SD, NE, KS, OK, TX).

Documented stopover sites (locations with two or more confirmed whooping crane observations since 1985) and modeled suitable stopover habitat within the migration corridor. Modeled suitable habitat included contiguous areas >10 ha in size that meet all the following criteria: <100 m from a non-forested, non-rocky wetland or perennial stream or playa lake; <1 km from cropland; <3% primary and secondary road land cover within a 1 km^2 moving window; <10% urban land cover within a 1 km^2 moving window and intersected core intensity or extended use core intensity areas within a defined migration corridor.

- Austin, J.E. and A.L. Richert. 2001. A comprehensive review of observational and site evaluation data of migrant whooping cranes in the United States, 1943–99. USGS, Northern Prairie Wildlife Research Center, Jamestown, North Dakota.
- Baasch, D.M., P.D. Farrell, A.T. Pearse, D.A. Brandt, A.J. Caven, M.J. Harner, G.D. Wright and K.L. Metzger. 2019. Diurnal habitat selection of migrating whooping crane in the Great Plains. *Avian Conservation and Ecology* 14(1): 6.
- Belaire, J.A., B.J. Kreakie, T. Keitt and E. Minor. 2014. Predicting and mapping potential whooping crane stopover habitat to guide site selection for wind energy projects. *Conservation Biology* 28(2): 541-550.

- Esri (Environmental Systems Research Institute, Inc.). 2010. U.S. and Canada detailed streets. Vector digital data. Esri, Redlands, California.
- Fry, J., G. Xian, S. Jin, J. Dewitz, C. Homer, L. Yang, C. Barnes, N. Herold and J. Wickham. 2011. Completion of the 2006 National land cover database for the conterminous United States. *Photogrammetric Engineering and Remote Sensing* 77(9): 858-864.
- Pearse, A.T., D.A. Brandt, W.C. Harrell, K.L. Metzger, D.M. Baasch and T.J. Hefley. 2015. Whooping crane stopover site use intensity within the Great Plains. USGS Open-File Report 2015–1166. http://dx.doi.org/10.3133/ofr20151166
- Playa Lakes Joint Venture. 2015. Playa decision support system. http://pljv.org/playa-dss
- U.S. Census Bureau. 2016. Urban areas national shapefile (2010 census). Vector digital data. https://www.census.gov
- USFWS. 2010. Cooperative whooping crane tracking project GIS database. USFWS, Grand Island, Nebraska.
- USFWS. 2016. National wetlands inventory, version 2. http://www.fws.gov/wetlands/
- USFWS. 2025. Threatened & endangered species critical habitat polygons shapefile. https://ecos.fws.gov
- USFWS. 2021. Species profile for whooping crane (*Grus americana*). http://ecos.fws.gov

Nebraska. Whooping crane priority landscapes identified through the Nebraska Wind and Wildlife Working Group.

- Nebraska Wind and Wildlife Working Group. 2016. Guidelines for avoiding, minimizing, and mitigating impacts of wind energy on biodiversity in Nebraska. Nebraska Game and Parks Commission, Lincoln. https://wind-energy-wildlife.unl.edu/

Wisconsin. Breeding and use areas of the Eastern Migratory Population of whooping cranes.

- USFWS. 2021. Species profile for whooping crane (*Grus americana*). http://ecos.fws.gov

Texas. A minimum convex polygon (MCP) delineating the inland wintering area used by whooping cranes in southeastern Texas (primarily Colorado and Wharton counties). The inland MCP is based on winter location data compiled from International Crane Foundation telemetry and observation records, Phase 1 monitoring data and winter locations from December 2017 through March 2024.

- International Crane Foundation (Bradshaw, M., C. Crouch, et al.). 2024. Inland Texas whooping crane winter locations, December 2017–March 2024. Data were provided to TNC.
  Crouch, C.G., A.J. Caven, M.R. Bradshaw, K.M. Fernald, M.J. Butler and M.A. Kalisek. 2024. Space use and movements of inland wintering whooping cranes in the Aransas-Wood Buffalo population. *Avian Conservation and Ecology* 19(2):16. DOI: 10.5751/ACE-02746-190216.

Louisiana. Nighttime roost locations (Coordinated Universal Time [UTC] 04:00–10:00) of the reintroduced non-migratory Louisiana whooping crane population, collected 2023–2025. Data were filtered to remove single-night remote points and points falling on the White Lake Wetlands Conservation Area and National Wildlife Refuge boundaries prior to buffering.

- Louisiana Department of Wildlife and Fisheries. 2026. Louisiana non-migratory whooping crane nighttime roost locations, 2023–2025.

Processing Methods

Whooping crane critical habitat, stopover sites, modeled suitable habitat, Nebraska priority landscapes, Wisconsin breeding/use areas, the inland Texas wintering area and Louisiana non-migratory roost locations were merged into a single layer representing habitats important to the species. To account for the differing disturbance footprints of solar and wind development, two buffered outputs were generated:

- Solar: 400 m buffer applied around stopover sites, modeled suitable habitat and filtered Louisiana roost locations (following Baasch et al. 2019).
- Wind: 5 km buffer applied around stopover sites, modeled suitable habitat and the inland Texas wintering area MCP.

Buffered features were dissolved and retained alongside the underlying habitat polygons in the final layers for the Compass.

Limitations

Whooping crane stopover use is dynamic and can shift among years in response to water availability, wetland conditions, weather and land-use change along the migration corridor. Modeled suitable habitat and documented stopover locations represent our current understanding of where whooping cranes are most likely to occur but may not capture all sites used during migration. Mapped features should therefore be interpreted as indicators of elevated sensitivity for whooping cranes rather than as comprehensive representations of all habitat used by the species. The absence of mapped habitat should not be interpreted as evidence that whooping cranes are absent from a given location.

Big Game (Elk, Mule Deer, Moose and Pronghorn Antelope) (solar only)

About the Data

This layer shows mapped migration routes for elk, mule deer, moose and pronghorn antelope across the western U.S. It includes annual ranges, migration corridors, stopover areas and winter ranges from the USGS Western Migrations dataset, supplemented with additional data from wildlife agencies in Montana, New Mexico and North Dakota. Together, these data highlight the pathways and habitats that big game species rely on throughout the year. These data are not comprehensive, and wildlife agencies continue to collect tracking data for these migrating species.

Why These Data Are Included

Big game animals are an important part of a healthy, functioning ecosystem. They also play a significant role in local economies and cultures across the West. For many Tribal Nations, big game are also deeply connected to cultural traditions and ways of life (Middleton et al. 2020).

These animals depend on large, connected landscapes to move between seasonal habitats. These habitats provide the food, breeding areas and shelter they need to survive, including protection from harsh winter conditions. Impediments to migration, such as fencing around solar developments, can fragment the landscape and influence how these animals move (Sawyer et al. 2006; Sawyer et al. 2009). Over time, disruptions to movement can affect feeding, breeding and overall population health (Taylor et al. 2016).

Data Sources

Western Migrations Dataset

- USGS. Western Migrations Project. https://apps.usgs.gov/western-migrations/ Idaho data were not downloadable and thus missing from this layer.

State and Regional Datasets

- Montana Fish, Wildlife & Parks. 2010. Big Game Winter Range Habitat.
- Wyoming Game and Fish Department. 2011. Mule Deer and Pronghorn Crucial Winter Ranges.
- Colorado Parks and Wildlife. 2015. Mule Deer and Pronghorn Severe Winter Ranges.
- Western Electricity Coordinating Council. 2018. Environmental Data Viewer. (New Mexico data)
- North Dakota Game and Fish Department. 2021. Wind Energy Development in North Dakota Best Management Practices.
- Oregon Department of Fish and Wildlife. 2021. Oregon Pronghorn Essential and Limited Habitat. Salem, OR: Oregon Department of Fish and Wildlife. Oregon

Department of Fish and Wildlife Data Clearinghouse: https://nrimp.dfw.state.or.us/DataClearinghouse/default.aspx?p=202&XMLname=42052.xml and Oregon Explorer: https://hub.oregonexplorer.info/datasets/oregon-essential-pronghorn-habitat-2021/about

- Oregon Department of Fish and Wildlife. 2013. Oregon Department of Fish and Wildlife Deer and Elk Winter Range for Eastern Oregon (2012). Oregon Department of Fish and Wildlife Data Clearinghouse: https://nrimp.dfw.state.or.us/DataClearinghouse/default.aspx?p=202&XMLname=885.xml and Oregon Explorer: https://www.arcgis.com/home/item.html?id=a9eb523852a9440aabc457b2939487fb#overview

Processing Methods

The Big Game layer combines mapped migration corridors, seasonal ranges, stopover areas and winter ranges for elk, mule deer, moose and pronghorn antelope. Data were obtained from the USGS Western Migrations project and supplemented with additional habitat and migration datasets provided by state wildlife agencies. Datasets were standardized and merged into a single raster layer representing important habitats and movement pathways used by big game species across the western United States.

Limitations

The Big Game layer does not represent all populations or migration routes. Migration mapping depends on Global Positioning System (GPS) collar studies and other monitoring efforts that vary geographically, and many herds have not yet been studied. As a result, important migration routes or seasonal habitats may be absent from the dataset. Wildlife agencies continue to collect new movement data, and future updates may expand the geographic coverage and improve the representation of migratory populations. In addition, Idaho Department of Fish and Game does not share their data on the Western Migrations site, so that state appears blank.

Bats (wind only)

About the Data

This layer represents the presence of bats, using data on roost locations and acoustic detections from the North American Bat Monitoring Program (NABat). Also depicted are Indiana bat forest habitats, northern long-eared bat maternity roosts and/or hibernacula, bonneted bat habitat and maternity roosts for Mexican free-tailed bats. Species that are federally listed as threatened or endangered are shown in blue, while unlisted species are shown in gray.

Together, these data provide a broad picture of where bats have been observed to live, forage and migrate. They should be used in concert with other data layers in the Compass that depict intact wildlife habitat (e.g., Resilient and Connected Network, Landscape Intactness). Because the available bat data are presence-only, they don't tell us how likely bats are to occur in unsampled areas or how frequently they use a site, which makes it difficult to estimate true risk. A reliable, nationwide assessment that combines species occurrence, rarity and collision risk with wind turbines is not currently available.

Why These Data Are Included

Bats provide essential ecosystem benefits, including controlling insect populations, supporting agriculture and contributing to healthy ecosystems (Kunz & Fenton 2003; Boyles et al. 2011). Bats are vulnerable to wind energy development due to direct strikes, particularly because they gather in large numbers and may be attracted to turbines (Arnett & Baerwald 2013). Since bats have low reproductive rates, even small increases in adult mortality can have disproportionate population impacts (Kunz & Fenton 2003).

Data Sources

All Bats

Bat occurrence data were obtained through the North American Bat Monitoring Program (NABat) Partner Portal following approval of third-party data requests by participating data contributors. We thank the many state, federal, Tribal, academic, nonprofit and private partners who contributed monitoring data to NABat and approved data access for this project. Our request included acoustic detections, emergence counts and roost surveys (presence data).

- NABat. North American Bat Monitoring Program Database v8.0.21 (Provisional Release). USGS. NABat Request Number 523. https://doi.org/10.5066/P9UXA6CF
- NABat. North American Bat Monitoring Program Database v8.0.21 (Provisional Release). USGS. NABat Request Number 524. https://doi.org/10.5066/P9UXA6CF
- NABat. North American Bat Monitoring Program Database v8.0.21 (Provisional Release). USGS. NABat Request Number 525. https://doi.org/10.5066/P9UXA6CF

Gray Bat (*Myotis grisescens*) — federally endangered

- Indiana Natural Heritage Inventory Data Center. 2014. Indiana natural heritage database element occurrence records. Vector digital data. Indiana Department of Natural Resources, Indianapolis.
- TNC. 2026. Oklahoma Chapter GIS database. TNC, Tulsa, Oklahoma.
- TNC. 2003. Ozarks Ecoregional Conservation Assessment. TNC, Minneapolis, Minnesota.

Indiana Bat (*Myotis sodalis*) — federally endangered

- USFWS. 2016. Midwest wind energy multi-species habitat conservation plan (public review draft). http://www.midwestwindhcp.com/
- TNC and the National Audubon Society. 2010. Wind power development sensitive areas in Indiana. Vector digital data. TNC, Indianapolis, Indiana.
- Indiana Natural Heritage Inventory Data Center. 2014. Indiana natural heritage database element occurrence records. Vector digital data. Indiana Department of Natural Resources, Indianapolis.
- Cole, J. 2018. Notes from a March 7, 2018 meeting with USFWS staff at the Ecological Services Field Office in Columbia, Missouri. TNC, St. Louis.

Ozark Big-Eared Bat (Corynorhinus townsendii ingens) — federally endangered

- Graening, G.O., M.J. Harvey, W.L. Puckette, R.C. Stark, D.B. Sasse, S.L. Hensley and R.K. Redman. 2011. Conservation status of the endangered Ozark big-eared bat (*Corynorhinus townsendii ingens*) — a 34-year assessment. Publications of the Oklahoma Biological Survey 11: 1–16.
- TNC. 2026. Oklahoma Chapter GIS database. TNC, Tulsa, Oklahoma.

Northern Long-Eared Bat (Myotis septentrionalis) — federally endangered

- Minnesota Department of Natural Resources and USFWS. 2018. Townships containing documented northern long-eared bat maternity roost trees and/or hibernacula entrances in Minnesota. https://files.dnr.state.mn.us/

Mexican Free-Tailed Bat (Tadarida brasiliensis) — species of conservation concern

- Best, T.L. and K.N. Geluso. 2003. Summer foraging range of Mexican free-tailed bats (*Tadarida brasiliensis mexicana*) from Carlsbad Cavern, New Mexico. *The Southwestern Naturalist* 48(4): 590–596.
- Texas Speleological Survey. 2018. Known Bat Caves in Texas (Generalized to USGS Quadrangle). Texas Speleological Survey, Austin.
- TNC. 2026. Oklahoma Chapter GIS database. TNC, Tulsa, Oklahoma.

Florida Bonneted Bat (Eumops floridanus) — federally endangered

- Florida Natural Areas Inventory. Element occurrence and predicted habitat data for Florida bonneted bat (*Eumops floridanus*). Florida Natural Areas Inventory, Tallahassee, FL. Florida Natural Areas Inventory Biodiversity Matrix and Florida Natural Areas Inventory GIS. https://www.fnai.org/publications/gis-data

Multi-Species State-Level Bat Occurrence Data — Arkansas, Colorado, Illinois, Kansas, Montana, Nebraska, Missouri, Oklahoma and Texas

- Colorado Natural Heritage Program. 2017. Level 3 element occurrence records. Vector digital data. Colorado Natural Heritage Program, Colorado State University, Fort Collins.
- Kansas Biological Survey. 2015. Kansas natural resource planner occurrence records for bat caves. Vector digital data. Kansas Biological Survey, University of Kansas, Lawrence.
- Montana Natural Heritage Program. 2018. Species occurrence data for bats. Vector digital data. Montana Natural Heritage Program, Helena.
- Nebraska Wind and Wildlife Working Group. 2016. Guidelines for avoiding, minimizing and mitigating impacts of wind energy on biodiversity in Nebraska. Nebraska Game and Parks Commission, Lincoln. https://wind-energy-wildlife.unl.edu/
- Texas Speleological Survey. 2018. Known Bat Caves in Texas (Generalized to USGS Quadrangle). Texas Speleological Survey, Austin.
- TNC. 2026. Oklahoma Chapter GIS database. TNC, Tulsa, Oklahoma.
- TNC. 2003. Ozarks ecoregional conservation assessment. TNC, Midwestern Resource Office, Minneapolis, Minnesota.

Processing Methods

NABat records were joined with the NABat 5-km Knitted Grid via the Generalized Random-Tessellation Stratified (GRTS) Cell ID field and categorized by threatened and endangered species and non-listed ones. Threatened and endangered bat species take visual priority and grid cells with them might also contain non-listed species.

- USGS. (2025). *North American Bat Monitoring Program Knitted Grid and Multi-scale Grid Covariates framework*. USGS data release.

Species-specific processing follows the framework used in the previous assessment:

- *Gray bat:* 32-km buffers around priority 1 hibernacula, 16-km buffers around priority 2 hibernacula and 8-km buffers around other current and historical sites (following rationale for other endangered *Myotis* species; USFWS 2016).

- *Indiana bat:* 32-km buffers around priority 1 hibernacula, 16-km buffers around priority 2 hibernacula and 8-km buffers around other current and historical sites; Indiana bat forest habitat polygons retained as provided.
- *Mexican free-tailed bat:* 32-km buffers around maternity roosts in New Mexico, Oklahoma, Texas, and adjacent areas of Kansas.
- *Northern long-eared bat (Minnesota):* townships containing documented maternity roost trees and/or hibernacula entrances included as polygons.
- *Indiana bat (northeastern Missouri):* 12-county region near Sodalis Nature Preserve defined per coordination with USFWS.
- *Other bats:* 8-km buffers around roost point locations (if habitat polygons were unavailable).

Species- and state-level bat datasets described above, together with NABat presence data, were compiled into a single national bat sensitivity layer, attributed by federal listing status so that grid cells associated with federally listed species are symbolized distinctly from those associated only with unlisted species. All input layers were rasterized to a 30 × 30-m ground sample distance and merged into the final national bat layer.

Limitations

- *Presence-only data.* Available bat datasets, including NABat, are largely presence-only. They identify locations where bats have been detected but cannot indicate absence or estimate probability of occurrence in un-surveyed areas.
- *Variable survey effort and data-sharing elections.* NABat participation, survey intensity and each contributing project's data-sharing election vary substantially, so apparent gaps in coverage may reflect variation in survey effort or data-sharing decisions rather than variation in bat occurrence.
- *Non-latitude/longitude records.* NABat roost and emergence records are typically shared at coarser resolutions (up to 10-km grid cell) and must be interpreted at the GRTS Cell ID grid scale rather than as point locations.
- *No integrated risk model.* A publicly available, nationwide model that combines species occurrence, rarity, abundance and collision/barotrauma risk with wind turbines does not yet exist. This layer is intended as an interim indicator until such products are publicly available.
- *Migratory tree bats.* Hoary bat, eastern red bat and silver-haired bat mortality is a documented and significant concern at wind facilities (Arnett et al. 2016; Frick et al. 2017; American Wind Wildlife Institute 2018), but spatial data on migratory corridors and behavior are insufficient to inform site-specific screening across much of the country (Weller et al. 2016). Operational mitigation, including proven curtailment

strategies (Arnett et al. 2013) and smart curtailment (Hayes et al. 2019), remains the primary tool for reducing impacts to these species.

High-Quality Watersheds (floating solar only)

About the Data

This layer represents highly resilient and biodiverse watershed areas from TNC's Freshwater Resilient and Connected Network (FRCN) and terrestrial RCN analyses (Anderson et al. 2024). This area covers 20.6% of the conterminous United States. This layer is only provided for floating solar technology; for wind and solar, see the layer "Floodplains, Wetlands and Groundwater-fed Ecosystems" for relevant freshwater data.

Why These Data Are Included

Floating solar in highly resilient and biodiverse watershed areas could potentially alter habitat conditions and ecosystem processes in ways that may affect aquatic species (Nobre et al. 2023). However, these impacts are not well understood, and available evidence suggests that ecological responses are highly site-specific and variable (Cagle et al. 2025). Given this uncertainty and limited body of research, users may wish to carefully evaluate potential impacts in high-value watershed systems when considering floating solar development.

Data Sources

- Anderson, M.G., Olivero, A.P., Barnett, A.R., Khoury, M.L. and Martin, E.H. 2024. Mapping Freshwater Resilience across the Conterminous U.S. TNC, Center for Resilient Conservation Science. Newburyport, MA. https://www.conservationgateway.org/collections/freshwater/mapping-freshwater-resilience-across-the-conterminous-united-states/
- FRCN. 2024 update. TNC Center for Resilient Conservation Science. https://crcs.tnc.org/pages/frcn
- Terrestrial RCN. TNC Center for Resilient Conservation Science. https://crcs.tnc.org/pages/rcn

Processing Methods

The final geodataset was built by combining two components:

1. Freshwater Resilient and Biodiverse Small Watersheds — FRCN "Protect" Category (17.8% of conterminous U.S. area). This category includes greater-than-average resilient 12-digit hydrologic unit code (HUC12)-FRCN watersheds that overlap freshwater recognized biodiversity value areas, plus all very highly resilient HUC12-FRCN watersheds (greater than 1 standard deviation resilience score) even where they lack confirmed biodiversity overlap, because these extremely resilient watersheds are considered important strongholds for future freshwater biodiversity. Because the floating solar analysis focuses on lakes and ponds, the FRCN Protect set was further restricted within xeric freshwater ecoregions to remove watersheds that did not contain lakes and ponds mapped at 1:100,000 scale (National Hydrography Dataset [NHD] V2 medium resolution), per M. Anderson personal communication. In the extremely dry xeric ecoregions, most lakes and ponds are not natural or perennial features; the few verified large perennial saline lakes within the FRCN Protect category were retained.

2. Additional Biodiverse Lakes within Resilient Landscapes (2.8% of conterminous U.S. area). This component adds the local NHD catchments of lakes and ponds that meet all of the following criteria:

- Located within Freshwater Ecoregions or U.S. Forest Service (USFS) Ecomap subsections verified as having natural lake ecosystems (Anderson et al. 2024);
- Located within Freshwater Recognized Biodiversity value areas; and
- The majority of the lake or pond falls within the terrestrial RCN (>50% of the 100 m shoreline buffer within the terrestrial RCN).

This approach captures more naturally isolated small lake and pond systems (prairie potholes, kettle-hole ponds, etc.) that were excluded from the riverine freshwater resilience analysis due to their lack of natural connectivity to large stream networks, as well as some larger lakes disconnected from river-stream networks but embedded in highly resilient, intact terrestrial landscapes. It brings in important concentrations of prairie potholes, sandhill ponds, coastal plain ponds, the lake/pond/wetland-rich areas of southern Florida, south Texas Gulf coastal wetlands/potholes and northern kettle-hole lakes. In many eastern ecoregions, lakes and ponds were also originally removed from the terrestrial raster RCN, which included only land, so this process restored these important lakes and ponds that are surrounded by terrestrial RCN lands.

The two components were merged, and the final selection of 62,302 polygons was exported as the highly sensitive set.

Limitations

- *Resilience is inferred, not measured per waterbody.* The underlying resilience and RCN analyses did not evaluate resilience on a waterbody-by-waterbody basis. Rather, lakes and ponds are brought into the priority network based on their connectivity to highly resilient Freshwater RCN or Terrestrial RCN networks, and their resilience is inferred from that connectivity. All of these watershed areas do, however, have confirmed freshwater biodiversity value, given their overlap with published TNC freshwater ecoregional plan portfolio sites, State Wildlife Action Plan priority freshwater sites, and/or other federal, state or additional sources of high freshwater biodiversity value compiled for the freshwater resilience analysis

(Anderson et al. 2024). This dataset is best used as an initial screen; the ecological value of individual lakes and ponds within these areas should be further evaluated and verified on the ground.

- *Ecological effects of floating solar are poorly characterized.* The evidence base is limited, and documented responses are highly site-specific and variable.
- *Reservoirs vs. natural lakes are difficult to distinguish.* Some included waterbodies are likely man-made. Within the FRCN Protect category, reservoirs can form the terminal "end" of a network above a dam and thus be included. Across most of the U.S. it is difficult to impossible to separate wholly man-made reservoirs from natural lakes with a dam at the outlet, especially in regions where lakes are naturally part of the ecosystem and many natural lakes are also augmented in size by a terminal dam.

Moderately Sensitive

Wildlife and ecosystems with some sensitivity to development

Landscape Intactness

About the Data

To delineate discrete patches of relatively undisturbed natural landcover, we processed a human modification model (Theobald et al. 2025) using a 1-kilometer radius moving window and selected areas with index values less than 0.2. We then eliminated areas fragmented by oil and natural gas development, defined as sites with 1.5 active wells per square kilometer or greater. We also excluded lands in the Great Plains bioregion altered by past tillage or other landscape disturbances (Ostlie 2003) and forest plantations in the eastern U.S. managed for commercial timber harvest (LANDFIRE 2016). Finally, we added core forest and core wetland areas to capture additional functionally intact habitats in heavily cultivated ecoregions of Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio and Wisconsin (The Conservation Fund 2014).

Why These Data Are Included

Remaining intact landscapes provide the basis for long-term viability of many species of conservation concern (Comer et al. 2018). These areas support essential ecological processes, such as movement, gene flow and the pattern of fires, storms and other disturbances, that can be disrupted by wind and solar infrastructure, roads and transmission corridors (Naidoo et al. 2025). They also help maintain large, connected habitat blocks that are less fragmented and better able to absorb development pressures (Theobald et al. 2025), meaning siting energy projects in these areas can disproportionately reduce habitat quality and connectivity (Comer et al. 2018; Naidoo et al. 2025).

Data Sources

Human Modification Index. The layer was derived from the Human Modification Index (HMI) developed by Theobald and colleagues, which quantifies cumulative human impacts on natural systems across the United States. Areas of low human modification were used to identify landscapes that remain relatively intact despite widespread land-use conversion and fragmentation (Theobald et al. 2025).

To delineate discrete patches of relatively undisturbed natural landcover, the Human Modification Index was summarized using a 1-km moving window and areas with HMI values less than 0.2 were retained.

- Theobald, D.M., Oakleaf, J.R., Hall, K.R., Lawler, J.J., Anderson, M.G. and Eddy, D. 2025. A global map of terrestrial habitat types and human modification for use in climate, biodiversity and conservation assessments. *Scientific Data* 12:307. https://doi.org/10.1038/s41597-025-04892-2

Oil and Gas Development Screening. Areas fragmented by oil and natural gas development were subsequently removed, defined as locations with active well densities greater than or equal to 1.5 wells per square kilometer (following Wyoming Game and Fish Department 2010 guidance).

- Wyoming Game and Fish Department. 2010. Wyoming Game and Fish Department recommendations for wind energy development in Wyoming. Cheyenne, Wyoming.
- Arkansas Oil and Gas Commission. 2020. Oil and gas wells. Vector digital data.
- California Department of Conservation. 2025. All wells shapefile. Vector digital data.
- Colorado Oil and Gas Conservation Commission. 2018. Oil and gas wells. Vector digital data.
- Kansas Geological Survey. 2018. Oil and gas wells. Vector digital data.
- Louisiana Department of Conservation and Energy. 2025. Oil & gas wells. Vector digital data.
- Missouri Geological Survey. 2018. Oil and gas wells tabular data.
- Montana Department of Natural Resources and Conservation. 2018. Oil and gas wells. Vector digital data.
- Nebraska Oil and Gas Conservation Commission. 2018. Wells GIS shapefile. Vector digital data.
- New Mexico Energy, Minerals and Natural Resources Department. 2018. Oil and gas shapefile. Vector digital data.
- North Dakota Department of Mineral Resources. 2018. Wells shapefile. Vector digital data.
- Oklahoma Corporation Commission. 2018. Oil and gas wells tabular data.
- Pennsylvania Department of Environmental Protection. 2025. Conventional / unconventional oil gas locations. Vector digital data.
- South Dakota Department of Environment and Natural Resources. 2018. Records of oil and gas drilling. Vector digital data.
- Tennessee Department of Environment and Conservation. 2025. Division of Mineral and Geologic Resources data viewer. Vector digital data.
- Texas Railroad Commission. 2018. Oil and gas wells. Vector digital data.
- Utah Department of Natural Resources. 2025. Oil and gas wells. Vector digital data.
- West Virginia Department of Environmental Protection. Oil and Gas Wells, Vector digital data.

- Wyoming Oil and Gas Conservation Commission. 2018. All wells tabular data.
- FracTracker Alliance. 2016. US Oil and Gas Activity [for states not listed above].

Previously Disturbed Landscapes. Lands within the Great Plains bioregion that had been altered by historical tillage or other major landscape disturbances, and forest plantations in the eastern U.S. managed for commercial timber harvest, were excluded.

- Ostlie, W. 2003. Untilled landscapes of the Great Plains. TNC. Minneapolis, Minnesota.
- LANDFIRE. 2016. Existing Vegetation Type. Raster digital data. U.S. Department of Agriculture (USDA) Forest Service, USGS and TNC. https://landfire.gov/vegetation/evt

Core Forest and Core Wetland Additions. To improve representation of functionally intact habitats in heavily cultivated Midwestern landscapes, additional core forest and core wetland areas were incorporated into a limited set of highly fragmented Midwest ecoregions, including heavily cultivated ecoregions of Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri and Ohio. These supplemental datasets help capture ecologically important habitats that may not otherwise be retained in a human-modification analysis alone because of the extensive historical conversion and fragmentation of natural systems in these landscapes.

- The Conservation Fund. 2014. Midwest Wind Energy Multi-Species Habitat Conservation Plan Green Infrastructure Network. Raster digital data. http://tcfmidwestwind.conservationgis.com/

Processing Methods

1. Acquire the Human Modification Index dataset.
2. Apply a 1-km moving window to characterize surrounding landscape condition.
3. Retain areas with Human Modification Index values less than 0.2.
4. Remove areas fragmented by oil and gas development, defined as locations with active well densities greater than or equal to 1.5 wells per square kilometer.
5. Exclude Great Plains landscapes identified as previously altered through tillage or other major disturbance.
6. Incorporate core forest and core wetland datasets within selected highly fragmented Midwest ecoregions.
7. Merge outputs into a single national Landscape Intactness layer.

Limitations

The Landscape Intactness layer complements other conservation datasets included in the Clean Energy Compass, particularly the Biodiversity, Resilience and Flow layer. While

Biodiversity, Resilience and Flow identifies landscapes important for biodiversity conservation and climate adaptation, its classifications are standardized within ecoregions and based on statistical thresholds. As a result, some relatively intact habitats, particularly in regions with extensive natural land cover, may not be fully represented by resilience-based analyses alone. The Landscape Intactness layer provides an independent measure of cumulative human disturbance and highlights large areas where ecological condition remains comparatively intact. Together, these datasets provide a more complete picture of ecological sensitivity and conservation value.

The Landscape Intactness layer represents a broad-scale assessment intended to identify relatively undisturbed landscapes across large geographic areas. It should not be interpreted as a site-level assessment of habitat quality, ecological condition or species presence. Local ecological conditions and conservation values may differ from those represented in the underlying datasets.

Birds at Risk from Wind Development (wind only)

About the Data

We include golden eagle nest data, ferruginous hawk presence and prairie dog complexes to account for raptor presence. To represent waterbird presence, we include playas, prairie potholes and other wetlands important to birds (Western Hemisphere Shorebird Reserve Network (WHSRN) sites, Global Important Bird Areas, Ramsar Convention Wetlands). These datasets are best interpreted as indicators of important habitat, as many are based on expert delineation of habitat value rather than modeled or observed presence data.

Why These Data Are Included

Raptors, waterbirds and other large-bodied species may be particularly vulnerable to wind development due to both collision risk and sensitivity to disturbance. These species often fly at heights that overlap with the height of turbine blades or associated infrastructure, and their large size, flight behavior and limited maneuverability can increase the likelihood of collisions (Loss et al. 2013). Many also have long lifespans and low reproductive rates, so even small increases in adult mortality can have disproportionate population impacts (Waston et al. 2018). In addition, turbines can displace these species from otherwise suitable habitat, reducing available breeding, foraging or migratory stopover areas (Marques et al. 2021).

Data Sources

Raptors and Eagles

Golden Eagles – Western United States and Colorado. The layer includes areas corresponding to the highest modeled golden eagle densities in western ecoregions, active nest locations and state habitat datasets.

- Bedrosian, G., J.D. Carlisle, Z.P. Wallace, B. Bedrosian, D.W. LaPlante, B. Woodbridge and J.R. Dunk. 2018. Spatially explicit landscape-scale risk assessments for golden eagles in the western United States. Unpublished report prepared by the Western Golden Eagle Team, USFWS, Regions 1, 2, 6 and 8.
- Colorado Parks and Wildlife. 2013. Cooperative Raptor Database. Vector digital data. Colorado Parks and Wildlife, Fort Collins.
- Colorado Parks and Wildlife. 2025. High Priority Habitat Data (Terrestrial): Golden Eagle Active Nest Site. December 23, 2025 version. Colorado Geospatial Portal. https://geodata.colorado.gov/datasets/CPW::cpwhphterrestrialdata?layer=6

Peregrine Falcons – Colorado and Wyoming. Occupied peregrine falcon habitat and nesting areas buffered by 3.2 km.

- Colorado Parks and Wildlife. 2015. Peregrine Falcon Nesting Areas. Vector digital data. Colorado Parks and Wildlife, Fort Collins.
- Wyoming Game and Fish Department. 2004. Occupied Peregrine Falcon Habitat. Vector digital data. Wyoming Game and Fish Department, Cheyenne.

Ferruginous Hawks – Colorado, Washington and Wyoming. Ferruginous hawk nesting habitat and core use areas.

- Colorado Parks and Wildlife. 2025. High Priority Habitat Data (Terrestrial): Ferruginous Hawk Active Nest Site High Priority Habitat. Dataset updated December 23, 2025. Denver, CO: Colorado Parks and Wildlife GIS Unit. https://geodata.colorado.gov/datasets/CPW::ferruginous-hawk-active-nest-site-hphc
- Washington Department of Fish and Wildlife. Priority Habitat and Species Program Ferruginous Hawk Core Habitat Areas. Vector digital data. Washington Department of Fish and Wildlife, Olympia, Washington. Core areas with 3.2-km buffer. https://tnc.maps.arcgis.com/home/item.html?id=2a2e5052c319436fa182e5eb5743d076
- Wyoming ferruginous hawk habitat/core areas. Occurrence records and distribution models, Wyoming Natural Diversity Database. https://wyndd.org/species_list/?pointerType=dataDownloadLinks

Other Raptors – Colorado and Montana.

- Colorado Parks and Wildlife. 2013. Cooperative Raptor Database. Vector digital data. Colorado Parks and Wildlife, Fort Collins.
- Montana Natural Heritage Program. 2018a. Species Occurrence Data for Raptors. Vector digital data. Montana Natural Heritage Program, Helena.

Prairie Dog Complexes – Wyoming, Colorado, Montana and Texas. Prairie dog colonies were incorporated as indicators of important raptor foraging habitat because they often support elevated use by eagles, hawks, falcons and other avian predators.

- Wyoming Game and Fish Department. 2006. White-tailed Prairie Dog Towns. Vector digital data. Wyoming Game and Fish Department, Cheyenne.
- Colorado Parks and Wildlife. 2009. SPICE Habitat Model for Black-tailed Prairie Dog. Vector digital data. Colorado Parks and Wildlife, Fort Collins.
- Montana Natural Heritage Program. 2018b. Species Occurrence Data for White-tailed Prairie Dog and Black-tailed Prairie Dog. Vector digital data. Montana Natural Heritage Program, Helena.

- Texas Natural Diversity Database. 2021a. Prairie Dog Town Element Occurrence Data Export. Vector digital data. Wildlife Diversity Program, Texas Parks and Wildlife Department, Austin.

Waterfowl and Waterbirds

Breeding Waterfowl Habitat — Minnesota, North Dakota, South Dakota, Wisconsin, Texas and Louisiana

- USFWS. 2021c. Wetland Duck Pair Density for the Prairie Pothole Region. Raster digital data. USFWS Habitat and Population Evaluation Team, Bismarck, North Dakota.
- Shaffer, J., C. Loesch and D. Buhl. 2019. Estimating offsets for avian displacement effects of anthropogenic impacts. *Ecological Applications* 29(8). https://doi.org/10.1002/eap.1983
- Straub, J.N., M. Palumbo, J. Fleener, B. Glenzinski, D. Fowler, G. Kidd, K. Waterstradt and S. Hygnstrom. 2019. Wisconsin Waterfowl Habitat Conservation Strategy. Project #W-160-P-36; final report submitted to the Wisconsin Department of Natural Resources. Wisconsin Waterfowl Habitat Conservation Strategy.
- USFWS. 2023. West Gulf Coast Mottled Duck Nesting, Southeast Blueprint Indicator. Dataset available through the Southeast Blueprint geospatial portal.

Waterbird and Shorebird Habitat — Colorado, Kansas, Michigan, Nebraska, New Mexico, Oklahoma, Texas and National

These datasets identify wetlands, migratory stopover habitat, shorebird habitat and other landscapes that support regionally, nationally or internationally important concentrations of waterbirds and shorebirds.

- Playa Lakes Joint Venture. 2015. Playa Decision Support System. Playa Decision Support System.
- Obermeyer, B., R. Manes, J. Kiesecker, J. Fargione, and K. Sochi. 2011. Development by Design: Mitigating Wind Development's Impacts on Wildlife in Kansas. *PLoS ONE* 6(10): e26698.
- WHSRN. 2019. WHSRN Sites. WHSRN Sites.
- Ramsar Convention on Wetlands of International Importance. 2021. Ramsar Sites Information Service. https://rsis.ramsar.org/
- Ewert, D.N., J.B. Cole, and E. Gramm. 2011. Wind Energy: Great Lakes Regional Guidelines. Unpublished report to TNC, Lansing, Michigan.
- Battelle Memorial Institute. 2017. Great Lakes Coastal Wetlands. Vector digital data. Prepared for the EPA Great Lakes National Program Office. Battelle Memorial Institute, Columbus, Ohio.

Priority Bird Conservation Areas

Global Important Bird Areas identified by BirdLife International — United States

- WHSRN Executive Office. WHSRN Site Points and Polygons Boundary Digital Data Set. 2024. Western Hemisphere Shorebird Reserve Network. https://whsrn.org/whsrn-sites/map-of-sites/
  Audubon Important Bird Areas — Illinois, Indiana, Minnesota, Ohio, Wisconsin.

State-level sites identified as important for bird conservation — Iowa, Illinois, Indiana, Michigan, Minnesota, Ohio and Wisconsin

- National Audubon Society. 2018. Important Bird Areas. https://www.audubon.org/important-bird-areas
- Iowa Department of Natural Resources. 2017. Bird Conservation Areas in Iowa. https://geodata.iowa.gov
- Ewert, D.N. 1999. Great Lakes Bird Ecoregional Planning: A Final Report. TNC, East Lansing, Michigan.

Processing Methods

National and state bird datasets were combined into a single composite raster layer representing areas where wind energy development may create elevated risks for birds through collision, disturbance or habitat displacement. Source datasets include species-specific occurrence and nesting data, breeding habitat models, wetland systems, migratory bird sites and bird conservation priority areas.

Dataset-specific processing followed source-provider methodologies whenever possible.

WHSRN sites and Ramsar Wetlands of International Importance were incorporated directly from publicly available site boundaries. No additional buffering or modification of site boundaries was applied. Where source datasets included established conservation boundaries or management areas, those boundaries were retained.

Limitations

Bird datasets differ substantially in geographic extent, survey methods, conservation objectives, mapping approaches, spatial resolution and update frequency. Some datasets represent documented nest locations or species occurrences, whereas others represent habitat models, conservation planning areas, migratory stopover sites, wetland systems or areas supporting seasonally important concentrations of birds.

Many datasets included in this layer are intended to identify habitats or landscapes that are important for bird conservation rather than precise locations where birds are known to occur. Consequently, mapped features should be interpreted as indicators of elevated bird sensitivity and potential risk rather than comprehensive representations of species distributions.

Bird distributions and habitat use vary over time in response to migration, breeding activity, weather, hydrologic conditions, habitat quality and land-use change. Areas that support high concentrations of birds in one season may not support the same species or abundance at other times of year. Likewise, conservation priority areas may represent long-term habitat value rather than current bird occupancy.

Because data sources originate from multiple agencies, conservation organizations and research programs, methodologies and mapping objectives differ among datasets. As a result, data consistency, spatial precision and temporal coverage vary across regions and species groups.

The absence of a mapped feature should not be interpreted as evidence that bird resources are absent from a site. Numerous species and habitats are not represented by available national datasets, and local review may identify important bird resources that are not captured within this screening layer.

Migratory Bird Stopover (wind only)

About the Data

Stopover habitats are places birds feed and rest on their migratory routes. This layer highlights high-density distributions of migratory landbirds in stopover habitat across the U.S., derived from remote sensing observations of skyglow as a positive predictor of bird migration stopover density (Horton et al. 2023). Artificial light at night attracts and concentrates nocturnally migrating birds, drawing them toward illuminated, often peri-urban areas (McLaren et al. 2018). The resulting high-density areas therefore reflect where birds accumulate rather than where high-quality habitat necessarily exists, and these lit areas may even act as ecological traps that increase migration-related mortality (Horton et al. 2023).

Why These Data Are Included

Billions of migratory birds cross North America twice each year, concentrating movement along predictable flyways and stopover habitats where they are more exposed to wind energy infrastructure (Horton et al. 2019; Cohen et al. 2021). Because these species travel long distances and often fly at night or in low-visibility conditions, they face elevated collision risk with turbines and associated infrastructure (Horton et al. 2019; McLaren et al. 2018). In addition, disturbance or habitat loss at key stopover sites can reduce the availability of critical resting and refueling areas, potentially affecting migration success and population viability over time (Cohen et al. 2021; Guo et al. 2024).

Data Sources

Migratory landbird stopover density, contiguous United States (spring and fall):

Horton, K.G., J.J. Buler, S.J. Anderson, C.S. Burt, A.C. Collins, A.M. Dokter, F. Guo, D. Sheldon, M.A. Tomaszewska and G.M. Henebry. 2023. Artificial light at night is a top predictor of bird migration stopover density. *Nature Communications* 14: 7446. https://doi.org/10.1038/s41467-023-43046-z

Processing Methods

The high-density stopover areas (raster value of 2) were extracted from both the spring and fall stopover density layers and merged into a single combined layer representing important migratory landbird stopover habitat.

Limitations

Stopover use varies among years and seasons in response to weather, habitat conditions and land-use change, and the mapped high-density areas represent broad-scale patterns of concentrated use rather than a comprehensive inventory of sites used during migration. The absence of mapped stopover habitat should not be interpreted as evidence that migratory birds are absent from a given location.

Disturbed Lands

Former mining and contaminated sites that are less likely to encounter environmental and community concerns

Former Mine Lands

About the data

The mine lands layer uses the best available nationwide data on mine locations (USGS geospatial database). Users are advised that the data are of inconsistent quality and better data may be available from state mining agencies. Mines in the dataset include former coal mines, silica mines, iron pits, lignite pits, open pit mines, quarries and strip mines.

Why These Data Are Included

This layer identifies sites that operated as mines between 1977 and 2006, which may present an opportunity for renewable energy development after further site assessment and feasibility analysis, including evaluation of current wildlife value. Older mine sites may have recovered and could provide important conservation value, such as habitat for grassland birds. Previously disturbed lands such as former mine sites often have reduced ecological integrity and lower biodiversity compared to intact landscapes and may present opportunities for redevelopment (Su 2025). Siting wind and solar development on these lands may provide opportunities to meet energy goals while minimizing impacts to high-value habitats, avoiding additional fragmentation of intact ecosystems and supporting local economic development through job creation, tax revenue and investment in communities with a history of resource extraction (EPA 2026b).

Data Sources

The Former Mine Lands layer was derived from the USGS USMIN database, which compiles geospatial information on mines and mine-related features across the United States. The dataset includes locations of mine features digitized from historical USGS topographic maps and incorporates a wide variety of mining-related land uses.

- USGS. USMIN Mineral Deposit Database and Prospect- and Mine-Related Features from USGS Topographic Maps. USGS Mineral Resources Program. https://mrdata.usgs.gov/usmin/
- Horton, J.D., and San Juan, C.A. 2016 (ver. 10.0, May 2023). Prospect- and Mine-Related Features from USGS 7.5- and 15-Minute Topographic Quadrangle Maps of the United States. USGS Data Release. https://doi.org/10.5066/F78W3CHG

Processing Methods

The Former Mine Lands layer was incorporated from the nationwide USGS USMIN dataset without modification to its underlying classification. Mines selected from the USMIN dataset include former coal mines, silica mines, iron pits, lignite pits, open pit mines, quarries and strip mines; prospector and test pits were excluded

Limitations

The USMIN database was developed from historical USGS topographic maps and other available data sources and is not intended to represent a complete inventory of all mined lands in the United States. Coverage, completeness and positional accuracy vary geographically based on the availability and quality of source materials used in compilation. Users should consult state mining agencies and more recent local datasets where available.

Many mine features in the dataset reflect historical conditions and may not represent current land cover, site conditions, reclamation status or ecological value. Some former mine sites may have undergone extensive ecological recovery and now support important habitat or conservation resources, while others may remain disturbed. The dataset should therefore be interpreted as an indicator of historical mining activity rather than current site condition.

Brownfields over 10 acres

About the data

This layer depicts sites over 10 acres that are identified as brownfields by the U.S. Environmental Protection Agency (EPA), defined as abandoned, underused or idled commercial or industrial properties whose redevelopment or expansion may be complicated by the presence or potential presence of a hazardous pollutant. This data layer is a component of the EPA's RE-Powering America's Land Initiative data.

Why these data are included

Brownfields are contaminated or previously developed industrial lands that are often unsuitable for other uses and may provide little ecological value (EPA 2026a). These sites may present an opportunity for wind and solar development after further site assessment and feasibility analysis, including evaluation of current wildlife value. Siting wind and solar development on these lands may provide opportunities to meet energy goals while minimizing impacts to high-value habitats, avoiding additional fragmentation of intact ecosystems and supporting local economic development through job creation, tax revenue and investment in communities with a history of resource extraction and industrial use (EPA 2026b).

Data Sources

The Brownfields layer was derived from the EPA RE-Powering America's Land Initiative. The RE-Powering Mapper is a national geospatial screening tool that compiles contaminated lands, brownfields, landfills and mine sites from EPA program databases and state environmental programs to identify properties with potential for renewable energy redevelopment.

EPA. RE-Powering Mapper 3.0 and associated screening datasets.
https://geopub.epa.gov/repoweringApp/

Processing Methods

The Brownfields layer is a selection of sites from the EPA RE-Powering America's Land Initiative database of potentially contaminated and previously developed sites over ten acres.

Limitations

The EPA RE-Powering Mapper is a screening tool designed to identify sites that may have potential for renewable energy redevelopment. EPA explicitly notes that the data are not intended to identify the best development locations and that additional site-specific review is necessary before development decisions are made.

Brownfield designation does not indicate that a site lacks ecological value. Some sites may contain restored habitats, provide wildlife habitat, support rare species or contribute to local conservation objectives. Site conditions can vary substantially depending on prior land use, remediation status, age and surrounding landscape context. Any site over ten acres in the attribute table was selected with no additional criteria. Sites were not ground-truthed and the stated acreage might not be accurate or contiguous.

The underlying RE-Powering dataset includes information collected from both federal and state programs, resulting in variation in data completeness, update frequency and site characterization among states. Site boundaries, acreage estimates, contamination status and redevelopment potential may change over time as cleanup activities occur or additional information becomes available.

Agricultural Considerations

Areas where farmland is most productive, now and in the future

Highest Quality Farmland

About the data

It is anticipated that 90% of utility-scale solar capacity will be installed in rural communities, much of that on farmland (U.S. Department of Energy 2021). This layer identifies the top 50 to 75% of farm and ranchland in each state based on the land's productivity, versatility and resiliency (PVR) values, as defined by the American Farmland Trust (AFT). These data are based on soil productivity and capacity, land cover and use, crop type and length of the growing season (Farms Under Threat 2020).

Why these data are included

Including these data helps decision-makers consider how siting decisions may intersect with farmland values, supporting an informed approach to wind and solar development. Agrivoltaics (co-location of solar and agriculture) and wind development on agricultural land may offer opportunities to maintain agricultural uses while supporting renewable energy generation (Smart Solar Principles), depending on local conditions and project design.

As with any large-scale analysis, on-the-ground verification is required. Sites mapped as high-quality based on current crop production and soil characteristics might become unproductive if they are water-stressed or contain highly erodible soils (Sonderegger and Pfister 2021). In these water-stressed areas, renewable energy projects, if designed intentionally, can reduce water use, improve soil stability and promote ecosystem recovery over time. For example, the California Energy Commission uses a Cropland Index Model to identify low-quality or water-limited agricultural lands (cropland suitability score < 7.7), which the California Energy Commission promotes as better suited for renewable energy development (California Energy Commission Land-use Screens). For this reason, we removed cropland with a California Energy Commission suitability score below 7.7 from the layer in California.

Data Sources

American Farmland Trust Farms Under Threat: Productivity, Versatility and Resiliency (PVR) dataset. The primary source for this analysis was the AFT Farms Under Threat PVR dataset (Conservation Science Partners 2020), which identifies agricultural lands best suited for long-term cultivation and food production. The PVR model integrates information on soil suitability, crop type and growing season length, and land cover/use to estimate agricultural land quality. Soil suitability is derived from Natural Resources Conservation Service (NRCS) Important Farmland designations and Land Capability Classes, while crop type information is derived from the USDA Cropland Data Layer and land cover information from national land-cover datasets. These factors are combined using weights developed through expert elicitation with agricultural specialists to generate a continuous PVR score for each location.

California Cropland Index Model. For California only, the California Energy Commission Cropland Index Model was used to identify agricultural lands with low productivity or substantial land-use constraints. The model incorporates soil characteristics, climate variables, slope and other agricultural suitability factors to generate a cropland suitability score for California agricultural lands. Areas with a suitability score below 7.7 were considered lower-quality agricultural land for purposes of this analysis and were excluded from the PVR analysis.

- American Farmland Trust. 2020. Farms Under Threat: The State of the States Productivity, Versatility and Resiliency (PVR) Analysis. Washington, DC. https://farmlandinfo.org/publications/farms-under-threat-the-state-of-the-states/
- California Energy Commission. Cropland Index Model (Classified). California Open Data Portal. https://data.ca.gov/dataset/cec-cropland-index-model-classified

Processing Methods

The AFT Farms Under Threat PVR dataset was used to identify high-quality agricultural lands across the continental United States. For each state, PVR values were ranked and classified using state-specific percentile thresholds (50th, 75th and 90th percentiles), producing four classes representing the bottom 50%, 50th-75th percentile, 75th-90th percentile and top 10% of agricultural lands within each state. Because agricultural conditions vary substantially across regions, state-specific rankings were used rather than a single national threshold.

In California, additional refinement was applied using the California Energy Commission Cropland Index Model. Agricultural lands with a cropland suitability score below 7.7 were removed from the high-quality farmland layer. This step was intended to exclude lands identified by the California Energy Commission as comparatively low-quality or water-limited agricultural areas that may be more appropriate for renewable energy development. The percentile thresholds were calculated using all California PVR values with areas below the California Energy Commission threshold masked from the final California output.

Limitations

The analysis relies on national-scale datasets describing soils, land cover, crop production and growing conditions and therefore may not capture local management practices, irrigation infrastructure, water availability, economic conditions or recent changes in land use. Agricultural productivity can also change over time due to drought, groundwater depletion, soil degradation or land management decisions.

Because state-specific rankings were used, PVR values are not directly comparable across state boundaries. A location identified as high-quality agricultural land in one state may not have the same absolute productivity or suitability as a similarly classified location in another state. Percentile thresholds were calculated independently for each state, and PVR values equal to percentile breakpoints may result in class sizes that differ slightly from the nominal percentile ranges (50%, 25%, 15% and 10%).

Limitations to Farmland

Abandoned Cropland

About the Data

This layer identifies croplands that were abandoned for at least 5 years between 1986 and 2018 (Xie et al. 2024). The dataset was developed using Landsat satellite imagery and machine-learning classification to map annual cropland extent and identify pixels that transitioned out of cultivation over time at a 30-meter resolution.

Why These Data Are Included

These areas are likely marginal for food production and therefore could be a suitable location for large-scale solar development, according to the American Farmland Trust. Repurposing abandoned or degraded agricultural lands may present opportunities for renewable energy development while reducing pressure to convert intact natural habitats or productive farmland (American Farmland Trust 2020; Næss et al. 2021). However, 20% of this area was enrolled in the Conservation Reserve Program as of 2020, and may be ecologically sensitive or susceptible to erosion, either of which could make these lands unsuitable for large-scale solar developments (Xie et al. 2024; Yang et al. 2020). The potential for grassland restoration should be closely evaluated.

Data Sources

Xie et al. (2024) developed a nationwide 30-meter resolution map of croplands abandoned between 1986 and 2018 across the conterminous United States. The dataset was derived from annual cropland maps created from Landsat imagery using automated machine-learning classification methods trained with the USDA Cropland Data Layer. The dataset identifies lands that transitioned out of cultivation for a period of at least five years and provides information on the timing and extent of cropland abandonment.

- Xie, Y., S.A. Spawn-Lee, V.C. Radeloff, H. Yin, G.P. Robertson and T.J. Lark. 2024. Cropland abandonment between 1986 and 2018 across the United States: spatiotemporal patterns and current land uses. *Environmental Research Letters* 19(4): 044009. https://doi.org/10.1088/1748-9326/ad2d12

Processing Methods

The Xie et al. (2024) abandoned cropland dataset was incorporated as a national representation of previously cultivated lands that had been abandoned for at least five years between 1986 and 2018. No additional state-specific modifications or reclassification were applied. The dataset was used as provided by the original authors.

Limitations

The abandoned cropland dataset is based on remotely sensed land-cover classifications and therefore inherits uncertainty associated with satellite imagery and land-use classification models. Xie et al. (2024) reported an overall accuracy of 0.91 for identifying the location of abandoned cropland but a lower accuracy (0.65) for identifying the timing of abandonment.

Because the dataset identifies historical abandonment through 2018, current site conditions may differ from those represented in the layer due to subsequent land-use change, restoration, revegetation or renewed agricultural production. Further, we can assume that cropland abandoned has continued since 2018, and therefore this layer should not be considered exhaustive. The dataset does not distinguish between lands that have been permanently removed from agricultural production and lands that may eventually return to cultivation. In addition, abandoned croplands can transition to ecologically valuable land covers such as grasslands, shrublands, forests or wetlands. As a result, not all abandoned cropland should be interpreted as suitable for renewable energy development. Site-specific conditions, restoration opportunities, conservation values and land-management objectives should be evaluated before siting decisions are made.

Water-limited Lands

About the data

This data layer combines information on surface and groundwater constraints. We defined areas as “surface water limited” when they are classified as moderately, highly or very highly limited in the USGS Water Limitation Surface Water Supply Use Index (SUI; ≥0.4). Groundwater constraints are based on an analysis in the arid western freshwater ecoregions of NASA's Gravity Recovery and Climate Experiment (GRACE) Shallow Groundwater Drought Indicator.

Why these data are included

Water-limited lands are areas where surface or groundwater resources are being depleted. This layer displays where water shortages could affect long-term agricultural viability and where alternative land-use options, including clean energy development, may be evaluated (Stets et al. 2025; Ingrao et al. 2023). Renewable energy projects have different water-use and land management implications than agricultural uses, depending on project design and local conditions. In these water-limited areas, renewable energy projects, if designed intentionally, can reduce water use, improve soil stability and support ecosystem recovery over time (Fernandez-Bou et al. 2023).

Data Sources

USGS Water Limitation Surface Water Supply Use Index (SUI)

Surface-water limitations were identified using the USGS Water Limitation Surface Water Supply Use Index (SUI), a watershed-scale indicator of the balance between surface-water availability and consumptive water use. The SUI expresses the fraction of long-term median water supply that is unavailable because of climatic variability or consumptive uses, including irrigation, thermoelectric power generation and public water supply. We used average decadal SUI conditions for water years 2010-2020 at the HUC12 watershed scale. Watersheds classified as moderately, highly or very highly water limited (SUI ≥ 0.4) were included in this analysis.

- Stets, E., M.J. Cashman, O.L. Miller and K.A. Powlen. 2025. Integrated Water Availability in the Conterminous United States, 2010-20. USGS Professional Paper 1894-F. USGS, Reston, Virginia. https://doi.org/10.3133/pp1894F

NASA GRACE Shallow Groundwater Drought Indicator

Groundwater limitations were identified using NASA's Gravity Recovery and Climate Experiment (GRACE) Shallow Groundwater Drought Indicator, which estimates departures from historical groundwater conditions by integrating ground- and satellite-based observations. The dataset provides weekly estimates of shallow groundwater conditions across the conterminous United States relative to a historical 1948-2012 baseline. Areas in arid freshwater ecoregions of moderate to high groundwater potential experiencing persistent severe groundwater depletion relative to historical conditions were incorporated into the final water-limitation analysis.

- Houborg, R., M. Rodell, B. Li, R. Reichle and B.F. Zaitchik. 2012. Drought indicators based on model-assimilated Gravity Recovery and Climate Experiment (GRACE) terrestrial water storage observations. *Water Resources Research* 48(7): W07525. https://doi.org/10.1029/2011WR011291

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Processing Methods

Surface-water limitations were mapped using the USGS Water Limitation Surface Water Supply Use Index. HUC12 watersheds with SUI values of 0.4 or greater, corresponding to the USGS moderate, high and very high water-limitation classes, were classified as surface-water limited. This analysis was based on average conditions from 2010-2020 and was applied across the conterminous United States.

Groundwater limitations were derived from a TNC analysis of NASA's GRACE Shallow Groundwater Drought Indicator in arid western freshwater ecoregions of moderate to high groundwater potential (Hydrologic Landscape Region [HLR] class moderate or high, Anderson et al. 2025). We focused our analysis on the months of February and March, the period of most complete groundwater recharge. We analyzed the weekly data for an 18-year period (2003-2021) relative to a 64-year average (1948-2012). We assigned each 12.5-km grid cell the most frequent percentile class relative to the historic period and classified cells as 'highly depleted' if, during this February and March 2003-2021 time period, the shallow groundwater was most frequently at 0-20% of its historic (64-year) level (Anderson et al. 2025). The area of each HUC12 watershed falling in this highly depleted class was then summarized. Those HUC12 watersheds with greater than or equal to 25% of their total area in this severe depletion class, representing the top 2 of a 3 class Jenk's natural break distribution, were highlighted as watersheds with groundwater limitation concerns.

The surface-water and groundwater datasets were combined into a single water-limitation layer.

Limitations

The Water-Limited Lands layer is intended to identify broad regional patterns of water stress and should not be interpreted as a site-specific assessment of water availability. Surface-water limitations are evaluated at the HUC12 watershed scale and may not capture local water-management practices, infrastructure, water rights, groundwater-surface water interactions or recent changes in water availability.

The groundwater component is based on relative changes in groundwater conditions compared to historical conditions and does not directly measure total groundwater volume, groundwater depth or available water supply. Areas with similar levels of groundwater change may differ substantially in the amount of groundwater available because background hydrogeologic conditions vary across regions. Groundwater conditions may also be influenced by climatic variability, land-use change and groundwater withdrawals.

Community Considerations

Community characteristics relevant to clean energy development

About the Data

These layers display census tracts, which are statistical areas determined by the U.S. Census Bureau once every ten years (2010). The data are organized into eight categories of burden. A community is highlighted as burdened if it is in a census tract that is at or above the threshold for one or more environmental, climate or other burdens.

If a tract is identified as burdened **and** the "Low Income Percentile" is 70% or greater (see pop-up box after clicking a tract), the tract is also considered "disadvantaged" for that category. For example, a census tract that is energy burdened **and** at the 80th low-income percentile is considered "energy disadvantaged."

Low Income Percentile: The percentage of people in a census tract who live in households with incomes at or below twice the federal poverty level, excluding college or university students.

Burden Categories

Climate Burdened: Communities are identified as climate burdened if they are in census tracts ranking at or above the 90th percentile nationally for one or more of the following indicators: expected agricultural loss rate, expected building loss rate, expected population loss rate, projected flood risk or projected wildfire risk.

Energy Burdened: Communities are identified as energy burdened if they are in census tracts ranking at or above the 90th percentile nationally for household energy costs or fine particulate matter ($PM_{2.5}$) concentrations.

Health Burdened: Communities are identified as health burdened if they are in census tracts ranking at or above the 90th percentile nationally for asthma prevalence, diabetes prevalence, heart disease prevalence or low life expectancy.

Housing Burdened: Communities are identified as housing burdened if they are in census tracts that experienced historic underinvestment (redlining risk score based on Homeowner's Loan Corporation maps) or rank at or above the 90th percentile nationally for housing cost burden, limited access to green space, lack of indoor plumbing or housing units with lead paint risk.

Pollution Burdened: Communities are identified as pollution burdened if they are in census tracts containing at least one abandoned mine land site, at least one Formerly Used Defense Site, or rank at or above the 90th percentile nationally for proximity to hazardous waste facilities, proximity to National Priorities List (Superfund) sites or proximity to Risk Management Plan facilities.

Transportation Burdened: Communities are identified as transportation burdened if they are in census tracts ranking at or above the 90th percentile nationally for diesel particulate matter exposure or for transportation barriers.

Water Burdened: Communities are identified as water burdened if they are in census tracts ranking at or above the 90th percentile nationally for underground storage tank releases or wastewater discharge impacts.

Workforce Burdened: Communities are identified as workforce burdened if they are in census tracts ranking at or above the 90th percentile nationally for linguistic isolation, low median income, poverty or unemployment and where more than 10% of residents age 25 or older have not earned a high school diploma.

Why These Data Are Included

Spatial data play a growing role in identifying and addressing community-level considerations. By including community and socioeconomic indicators such as income, climate vulnerability, energy burden and more, the Clean Energy Compass offers a starting point for understanding community characteristics. Burden indicators may provide insight into how people experience the benefits, burdens and opportunities associated with energy development in that place.

By bringing these datasets together, the Compass helps users identify places where additional engagement, partnership, benefit-sharing or project design considerations may be especially important. When used in combination with best practices on robust community engagement and benefit sharing, the data can support more informed community-centered siting decisions.

For deeper context, users are encouraged to explore the Compass Resource Hub at www.nature.org/cleanenergycompass.

Data Sources

Burden Indicator	Primary Data Source	Dataset	URL
Low Income Percentile	U.S. Census Bureau	America Community Survey	https://www.census.gov/programs-surveys/acs
Expected Agricultural Loss Rate	Federal Emergency	National Risk Index	https://hazards.fema.gov/nri/

	Management Agency		
Expected Building Loss Rate	Federal Emergency Management Agency	National Risk Index	https://hazards.fema.gov/nri/
Expected Population Loss Rate	Federal Emergency Management Agency	National Risk Index	https://hazards.fema.gov/nri/
Projected Flood Risk	First Street Foundation	Flood Factor®	https://firststreet.org/research-library/flood-model-methodology
Projected Wildfire Risk	First Street Foundation	Fire Factor®	https://firststreet.org/methodology/fire
Energy Cost	U.S. Department of Energy	Low-Income Energy Affordability Data Tool	https://www.energy.gov/scep/low-income-energy-affordability-data-lead-tool
$PM_{2.5}$ Concentration	U.S. Environmental Protection Agency	Downscaler Model for Air Quality Data	https://19january2017snapshot.epa.gov/air-research/downscaler-model-predicting-daily-air-pollution_.html
Asthma Prevalence	Centers for Disease Control and Prevention	PLACES: Local Data for Better Health	https://www.cdc.gov/places/
Diabetes Prevalence	Centers for Disease Control and Prevention	PLACES: Local Data for Better Health	https://www.cdc.gov/places/
Heart Disease Prevalence	Centers for Disease Control and Prevention	PLACES: Local Data for Better Health	https://www.cdc.gov/places/
Low Life Expectancy	Centers for Disease Control and Prevention	U.S. Small-Area Life Expectancy Estimates Project	https://www.cdc.gov/nchs/nvss/usaleep/usaleep.html
Historic Underinvestment (Redlining)	University of Richmond	Home Owners' Loan Corporation Redlining Maps-Mapping	https://dsl.richmond.edu/panorama/redlining/

		Inequality Project	
Housing Cost Burden	U.S. Census Bureau	American Community Survey	https://www.census.gov/programs-surveys/acs
Lack of Green Space	Multi-Resolution Land Characteristics Consortium	National Land Cover Database-based greenspace measure	https://www.mrlc.gov/
Lack of Indoor Plumbing	U.S. Census Bureau	American Community Survey	https://www.census.gov/programs-surveys/acs
Lead Paint Risk	U.S. Census Bureau	American Community Survey-Housing Age Data	https://www.census.gov/programs-surveys/acs
Abandoned Mine Lands	U.S. Office of Surface Mining Reclamation and Enforcement	Abandoned Mine Land Inventory System (e-AMLIS)	https://www.osmre.gov/programs/reclaiming-abandoned-mine-lands/inventory
Formerly Used Defense Sites	U.S. Army Corps of Engineers	Formerly Used Defense Sites Program	https://www.fuds.mil/
Proximity to Hazardous Waste Facilities	U.S. Environmental Protection Agency	Resource Conservation and Recovery Act Corrective Action Program	https://www.epa.gov/hwcorrectiveaction
Proximity to Superfund Sites	U.S. Environmental Protection Agency	Superfund National Priorities List	https://www.epa.gov/superfund/superfund-national-priorities-list-npl
Proximity to Risk Management Plan Facilities	U.S. Environmental Protection Agency	Risk Management Program Database	https://www.epa.gov/rmp

Diesel Particulate Matter Exposure	U.S. Environmental Protection Agency	National Air Toxics Assessment	https://www.epa.gov/national-air-toxics-assessment
Transportation Barriers	U.S. Department of Transportation	Transportation Disadvantaged Census Tracts	https://www.transportation.gov/grants/mpdg-areas-persistent-poverty-and-historically-disadvantaged-communities-1
Underground Storage Tanks and Releases	U.S. Environmental Protection Agency	Leaking Underground Storage Tanks Program	https://www.epa.gov/ust
Wastewater Discharge	U.S. Environmental Protection Agency	Discharge Monitoring Report datasets	https://echo.epa.gov/tools/data-downloads/icis-npdes-dmr-and-limit-data-set
Linguistic Isolation	U.S. Census Bureau	American Community Survey	https://www.census.gov/programs-surveys/acs
Low Median Income	U.S. Census Bureau	American Community Survey	https://www.census.gov/programs-surveys/acs
Poverty	U.S. Census Bureau	American Community Survey	https://www.census.gov/programs-surveys/acs
Unemployment	U.S. Census Bureau	American Community Survey	https://www.census.gov/programs-surveys/acs
Educational Attainment (< High School Diploma)	U.S. Census Bureau	American Community Survey	https://www.census.gov/programs-surveys/acs

Processing Methods

Individual burden categories are displayed as distinct map layers to allow users to explore different dimensions of community conditions independently. Low-income status is also provided as a stand-alone layer. No additional weighting, aggregation, or prioritization was applied.

Limitations

These data provide an important overview of community conditions but should not be interpreted as a complete representation of local circumstances. Because the data are summarized at the census tract level, they may mask substantial variation within communities and may not reflect neighborhood-scale conditions.

The indicators are derived from national datasets collected using different methods, spatial resolutions and update schedules. As a result, they may not capture recent changes in community conditions, local priorities, cultural values, community assets or lived experiences. Additionally, the use of threshold-based classifications means that communities falling just above or below a designated cutoff may experience similar conditions despite being categorized differently.

Most importantly, these layers do not replace the need to engage directly with communities. While they can help identify areas where cumulative challenges may exist and where additional consideration may be warranted, they cannot capture community aspirations, local knowledge or preferences regarding renewable energy development. The data should therefore be used as a starting point for inquiry and engagement rather than as a substitute for community participation in siting decisions. For practical guidance and resources to help navigate these considerations, visit the Compass Resource Hub at www.nature.org/cleanenergycompass.

Probability of Renewable Energy Buildout

Areas with a higher likelihood for future clean energy development

About the Data

The map was created using past siting trends to model the likelihood of solar development in the future. It also takes into consideration forward-looking information on planned transmission lines and substations to predict the likelihood of future solar development (Wu et al. 2026). Legally and technically unsuitable areas, e.g., protected areas, airports and areas prohibited by zoning ordinances (as of 2023) were excluded. Note that this map **is not a depiction of the forecasted footprint of solar energy buildout,** but rather the probability of solar development in different areas given site and state characteristics. The map shows the potential for more development than will be needed to meet U.S. demand.

Solar

The study supporting this data found that solar projects are more likely to be developed in areas with high infrastructure accessibility (proximity to roads, transmission lines and substations), higher population density, non-forested land cover, flatter terrain and lower environmental impacts (e.g., lower ecological sensitivity and less forested land). Solar locations are comparatively flexible and are influenced by a greater diversity of factors, indicating that they tend to be sited closer to load centers (Wu et al. 2026).

Wind

The study supporting this data found that wind projects are more commonly located in windier areas (higher capacity factor), on favorable land cover (agricultural and non-forested land), closer to transmission lines and on more sloped terrain. Wind siting is driven primarily by wind resource quality and agricultural land use. Land acquisition costs are also a statistically significant factor, although its effect size is small (Wu et al. 2026).

Why These Data Are Included

Early insight into where renewable energy buildout may occur can help communities identify areas suitable for wind energy and prepare for this development on their own terms. These data were included in direct response to feedback from 20 interviews conducted over a six-month period with energy experts, environmental justice community organizers, legal advocacy groups and coalition leads, in which interviewees identified potential buildout as useful information to help communities prepare for renewable energy projects.

Data Sources

Wu, G.C., Y. Min, R. Deshmukh, P. Cartwright, J. DeCesaro, D. Kerstan, D. Somasundaram and H. Strecker. 2026. Factors shaping the siting of utility-scale solar and wind projects in the United States. *Environmental Research Letters* 21(9): 094003. https://doi.org/10.1088/1748-9326/ae5faa

Wu, G., Y. Min, R. Deshmukh, P. Cartwright, J. DeCesaro, D. Kerstan, D. Somasundaram and H. Strecker. 2026. Utility-scale wind and solar project siting prediction surfaces for the United States. Zenodo. https://zenodo.org/records/19686722

Processing Methods

Wu et al. (2026) modeled the probability of utility-scale solar and wind siting across the contiguous U.S. using four modeling approaches — Least Absolute Shrinkage and Selection Operator (LASSO) regression, generalized linear model (GLM) logistic regression, random forest and XGBoost — applied within a robust sampling framework. Each model produced a continuous prediction surface with values ranging from 0 to 1, where higher values indicate a higher modeled probability of siting. Separate surfaces were generated for solar and wind under each of the four models (eight rasters in total).

The models were trained on the site and state characteristics associated with the locations of existing solar and wind projects. Among the candidate predictors, only planned transmission lines and substations were forward-looking; when generating the prediction surfaces, the authors combined planned transmission and substation locations with existing infrastructure (Wu et al. 2026). The analysis did not incorporate energy supply needs or a required generation footprint; it reflects the suitability of the land itself given the modeled factors (Wu et al. 2026). Legally protected areas were excluded from the analysis (Wu et al. 2026). For the Compass, the LASSO prediction surface is displayed for both solar and wind, prioritizing broader inclusivity of plausible future development locations over exclusive fit to existing project patterns.

Limitations

The maps show modeled *probabilities* of development given site and state characteristics, not a forecasted total footprint or a scenario of the generation needed to meet energy demand; they indicate more potential development than is likely to be built (Wu et al. 2026). Because the models are trained on historical siting patterns, they may not fully capture future shifts in technology, markets, policy or land-use practices. Aside from planned transmission and substations, the predictors reflect current conditions; most forward-looking drivers are not represented (Wu et al. 2026).

The LASSO model used in the Compass favors broader inclusivity of plausible future sites; models that reproduce existing project locations most accurately (random forest, XGBoost) may, by contrast, overfit current patterns and be less reliable for anticipating development in unexplored areas (Wu et al. 2026).

Indigenous Lands

Federally recognized Tribal lands and jurisdictions

About the Data

This layer displays locations of the Federally Recognized Tribal entities in the contiguous U.S. (National Geospatial Data Asset (NGDA) data from the U.S. Census Bureau) to acknowledge Tribal Nations' sovereignty status and jurisdiction. The data layer includes American Indian Reservations and Federally Recognized Tribal Entities, as identified by the Department of the Interior's Bureau of Indian Affairs (BIA), as well as other Tribal lands, including off-reservation trust lands, allotted lands, Oklahoma Tribal Statistical Areas, Tribal Designated Statistical Areas and State-Designated Tribal Statistical Areas.

This layer was selected based on a year-long process of listening to Indigenous energy experts across the country about what information would be appropriate to include in the tool, especially in the context of data sovereignty. The layer is intentionally greyed out when the map is opened to signal that respecting and upholding Tribal sovereignty, self-determination and authority to manage land, resources and data is the baseline for any responsible use of spatial information. The layer can be turned off so that Tribes and Indigenous People can access the information.

In addition to these layers, users should be aware of several additional resources reflecting Tribal land interests including:

- BIA Branch of Geospatial Support
- Esri GIS Sources for Native American Tribal Governments
- USFS's "Tribal Lands Ceded to the United States" dataset
- Native-Land.ca

Why These Data Are Included

Including data about Federally Recognized Tribal entities is a necessary component to understanding Tribal sovereignty, Tribal land interests and unique considerations when engaging Indigenous People and Tribal Nations. However, no map or dataset can or should be taken to represent cultural values, governance priorities or ecological significance of lands to Indigenous Peoples. All renewable energy planning that impacts Tribal lands must incorporate these considerations.

For deeper context, users are encouraged to explore the *Resource List: Indigenous Data & Energy Sovereignty* which provides additional resources on foundational frameworks and principles, legal context, evaluation and application of/on data and energy sovereignty. These resources can be found on the Compass Resource Hub at www.nature.org/cleanenergycompass.

Data Source

U.S. Census Bureau. NGDA Tribal Lands Dataset.
https://www.arcgis.com/home/item.html?id=1d6231f4358c4e3781557e702c319d9a#overview

Processing Methods

Federally recognized Tribal lands and jurisdictions were obtained from the NGDA dataset maintained by the U.S. Census Bureau. Relevant geographies were incorporated into the Compass and displayed as a reference layer available for user viewing.

Limitations

No map, dataset or polygon can fully represent the cultural significance, governance priorities, traditional knowledge, treaty rights, historical relationships or contemporary connections Indigenous Peoples maintain with land and natural resources. The boundaries presented in this layer represent only specific federally recognized geographic and jurisdictional designations and should not be interpreted as comprehensive representations of Indigenous homelands, cultural landscapes, areas of significance or areas of Tribal interest.

Users should not rely solely on mapped boundaries when assessing project impacts or opportunities. Renewable energy planning should incorporate meaningful engagement with Tribal governments and Indigenous communities and should respect Indigenous data sovereignty principles. Spatial information should be understood as one component of a broader process that centers Tribal rights, governance, leadership and self-determination.

The Compass team intentionally limited this layer to federally recognized Tribal geographies rather than incorporating broader datasets depicting ceded lands or other Tribal-interest areas. During development, project advisors noted that broader datasets can encompass much of the United States and raise additional considerations regarding Tribal consultation, representation and data sovereignty. Accordingly, the Indigenous Lands layer should be viewed as a resource that provides limited insights and context rather than a comprehensive representation of Indigenous relationships to place.

Tool Disclaimer

The Indigenous Lands layer is updated on an ongoing basis based on feedback from Tribal governments, Indigenous organizations and other partners. We welcome input regarding how this information is represented, including situations where Tribes wish to adjust, refine or remove reflected data. TNC can provide training on the use of the Compass for Indigenous energy experts and planners. Questions, feedback or requests related to this layer should be directed to maya.batres@tnc.org

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