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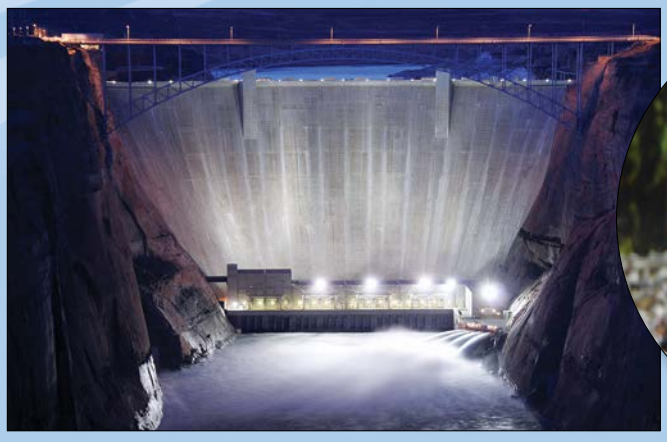
U.S. Geological Survey—Energy and Wildlife Research Annual Report for 2017








Circular 1435

U.S. Department of the Interior
U.S. Geological Survey

Cover. Top: Wind energy facility in White Pine County, Nevada (Alan M. Cressler, U.S. Geological Survey [USGS]), and bats flying at night (Ann Froschaue, U.S. Fish and Wildlife Service). Middle: Utility-scale solar array on Moapa Band of Paiutes Indian land, southern Nevada (U.S. Department of Energy), and desert tortoise near Palm Springs, California (Jeffrey Lovich, USGS). Bottom: Glen Canyon Dam hydroelectric facility at night, Arizona (Thomas Ross Reeve, Bureau of Reclamation), and razorback sucker (Melanie Fischer, U.S. Fish and Wildlife Service).

U.S. Geological Survey—Energy and Wildlife Research Annual Report for 2017

Edited by Mona Khalil

Agave plants at a U.S. Department of Agriculture experimental plot site near Phoenix, Arizona. The U.S. Geological Survey, in collaboration with the U.S. Department of Agriculture Arid Land Agricultural Research Center and Ohio University, is conducting tests for the potential production of agave biofuel. Photograph by Sasha Reed, U.S. Geological Survey.

Circular 1435

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
RYAN K. ZINKE, Secretary

U.S. Geological Survey
William H. Werkheiser, Acting Director

U.S. Geological Survey, Reston, Virginia: 2017

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Contents

Abbreviations

ABR	auditory brainstem response
AEA	Alaska Energy Authority
BCI	Bat Conservation International
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
BOR	Bureau of Reclamation
BSEE	Bureau of Safety and Environmental Enforcement
CRM	Collision Risk Model
DART	disturbance automated reference toolset
DNA	deoxyribonucleic acid
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DRECP	Desert Renewable Energy Conservation Plan
EIA	U.S. Energy Information Administration
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FSC	floating surface collector
GIS	geographic information system
GOM	Gulf of Mexico
GoMMAPPS	Gulf of Mexico Marine Assessment Program for Protected Species
GPS-GSM	Global Positioning System-Global System for Mobile Communications
NABat	North American Bat Monitoring Program
NMFS	U.S. National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
OCS	Outer Continental Shelf
PacOCS	Pacific Outer Continental Shelf
PCR	polymerase chain reaction
PPR	Prairie Pothole Region
SCB	Southern California Bight
UOG	unconventional oil and gas
URTD	upper respiratory tract disease
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UV	ultraviolet
WEC	wave energy conversion
WLCI	Wyoming Landscape Conservation Initiative
WNS	white-nose syndrome

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Science to Understand Risks, Measure Impacts, and Inform Solutions

Terrestrial and aquatic ecosystems provide valuable services to humans and are a source of clean water, energy, raw materials, and productive soils. The Nation's food supply is more secure because of wildlife. For example, native pollinators enhance agricultural crops, and insect-eating bats provide pest control services worth billions of dollars to farmers annually. Fish and wildlife are also vital to a vibrant outdoor recreation and tourism industry. Recreational activities, such as hunting, shooting, boating, and angling, generated $1.1 billion in excise taxes paid to State wildlife agencies in 2017. National parks, wildlife refuges, and monuments accounted for $35 billion in economic output and 318,000 jobs nationwide in 2016 (Cullinane and Koontz, 2017). Additional economic benefits are generated from the use and enjoyment of wildlife in State-owned lands and waters.

Although the United States is rich in natural resources, human activity continues to place new pressures on fish and wildlife and the habitats they rely on. The United States became the world's top producer of petroleum and natural gas products in 2012, surpassing Russia's natural gas production levels in 2009 and Saudi Arabia's petroleum production in 2013 (U.S. EIA, 2017a). The U.S. Energy Information Administration projects that the demand for liquid fuel, natural gas, and renewable energy will show strong growth in the next 20 years (U.S. EIA, 2016). Wind energy has demonstrated consistent growth since 2007 with now more than 53,000 wind turbines contributing to power grids in 41 States, Guam, and Puerto Rico (American Wind Energy Association, 2017). Solar energy has seen rapid growth since 2013 and made up nearly one-third of the total electricity generation additions in 2016 (U.S. EIA, 2017b). Yet as our Nation works to advance energy security and sustain wildlife, some conflicts have surfaced. Impacts of an expanding energy infrastructure include fragmentation and loss of habitat as well as mortality of birds, bats, fish, and other animals from interactions with energy generation facilities. Because energy development can often occur in wildlife habitats, ecological science can help guide project siting and operational decisions to areas that present the lowest risk to wildlife and energy developers.

To address these challenges and make the most of new opportunities, the U.S. Geological Survey (USGS) is producing innovative science to develop workable solutions that can help sustain wildlife and the habitat they rely upon, while allowing informed development.

USGS Mission

The USGS provides science about the natural hazards that threaten lives and livelihoods; the water, energy, minerals, and other natural resources we rely on; the health of our ecosystems and environment; and the impacts of climate and land-use change. USGS scientists work to develop new methods and tools to supply timely, relevant, and useful information about the Earth and its processes.

Partners

To meet the Nation's most pressing science needs and deliver timely and relevant information related to energy development and wildlife, USGS scientists work with other Federal, State, and local government agencies; Tribal nations; academic institutions; and nongovernmental and private organizations. Partners include more than 20 Federal agencies, 25 State agencies, 5 Tribal Nations and Commissions, 20 nongovernmental organizations, 10 industry partners, and more than 50 academic institutions.

Energy and Wildlife Science Strategy

USGS scientists provide information and science-based options that land and resource managers and private industries can use to make decisions regarding allowing access to energy resources while protecting the health of ecosystems and environments. This information can be used to avoid, minimize, or mitigate the impacts of energy infrastructure on fish and wildlife. This information can also inform areas where development may be best suited on the basis of merging economic, social, and ecological information. Research goals range from identification of a specific local issue, and options for management, to development of tools or techniques to address nationwide concerns. This science furthers our understanding of impacts and creates workable solutions. The three goals guiding activities concerning the investigation of wildlife and energy development are:

- Understand risks by identifying when, where, and how fish and wildlife share space with energy facilities
- Measure direct and indirect impacts to species
- Inform feasible and cost-effective solutions to minimize impacts through technological fixes, management, and mitigation

Updates to the Annual Report

This year's report features ongoing projects and new publications on energy development impacts and solutions for addressing risks to birds, bats, and other animals. We have updated the sections on bats, birds, desert tortoise, pollinators, and impacts to fish and wildlife habitats with new projects and publications. The report has an expanded section featuring science related to the management of hydropower effects on fish and aquatic resources, describing studies based in multiple regions, including the Pacific Northwest, the Northeast, the Southwest, and the mid-Atlantic regions. A new section listing projects focused on wildlife and energy development issues in Alaska has also been added. In the "Conservation and Energy Development Planning Tools" section, we feature science-based tools and approaches to assist resource managers in prioritizing areas for future energy development and for improving existing strategies for restoration following development. The final two sections focus on methods for fatality estimation, risk assessment, and other management support tools.

Figure 1. Three interrelated goals guiding USGS science in addressing energy and wildlife.

List of Projects

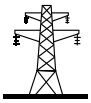
Regulatory and management issues associated with energy development are often focused on the impacts on legally protected species and (or) other species and habitats of concern. The USGS science efforts highlighted in this report are organized by species or groups of species, habitats, and other topics considered most relevant to the U.S. Fish and Wildlife Service (USFWS), Bureau of Land Management (BLM), Bureau of Ocean Energy Management (BOEM), and other Federal and State agencies responsible for permitting energy projects, conserving or managing species and habitats, and monitoring operations of renewable or conventional energy facilities.

Energy Icons

Each project is associated with a type of energy production or transmission. Types of energy production or transmission are represented by the following icons:


Biofuels


Electric generation


Electric transmission lines


Geothermal energy


Hydropower


Mining/coal production


Oil and gas extraction


Solar energy

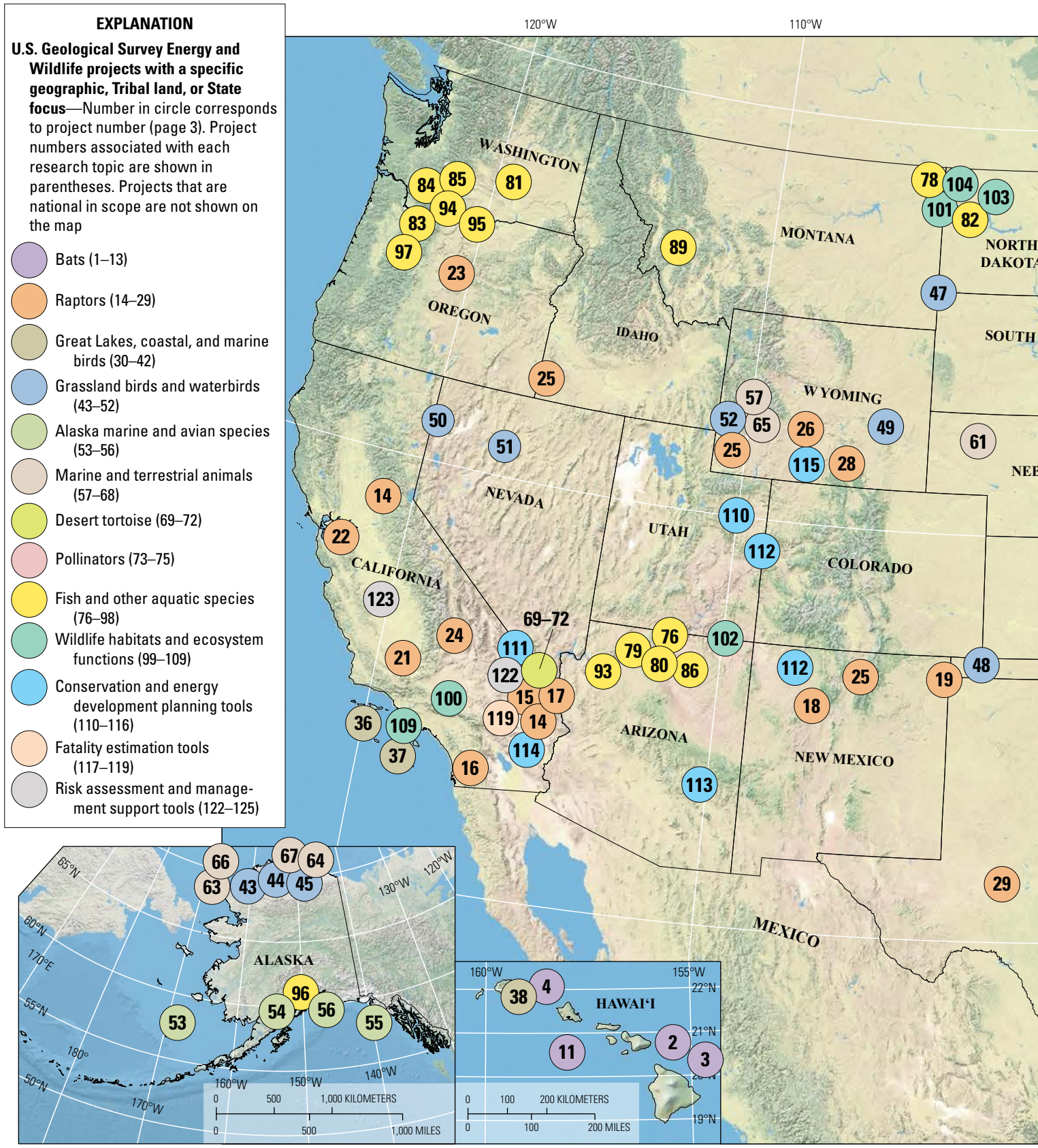

Wave/tidal energy


Wind energy

Icons modified from BSGStudio, all-free-download.com. Geothermal energy icon modified from VisualPharm, http://www.visualpharm.com/free_icons.html.

This oil rig in Wyoming is an example of long directional drilling, which can limit the amount of surface disturbance due to the rig's long reach. Photograph by Bureau of Land Management.

Study Locations




100°W
90°W
80°W
70°W
40°N
30°N
CANADA
UNITED STATES
MINNESOTA
DAKOTA
BRASKA
IOWA
WISCONSIN
MICHIGAN
ILLINOIS
INDIANA
OHIO
KANSAS
MISSOURI
KENTUCKY
WEST VIRGINIA
VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
VT
NH
MA
CT
RI
NJ
MD
DC
DE
OKLAHOMA
ARKANSAS
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
MISSISSIPPI
ALABAMA
GEORGIA
LOUISIANA
TEXAS
FLORIDA
105–106
0 100 200 300 400 500 KILOMETERS
0 100 200 300 400 500 MILES

Antelope Valley, White Pine Canyon, Nevada.
Photograph by Alan M. Cressler, U.S. Geological Survey.

Project Descriptions

Photograph by Paul Cryan, U.S. Geological Survey.

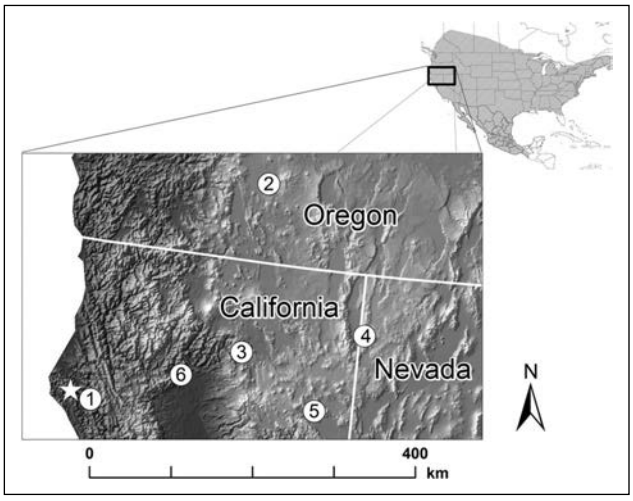
Bat colony flying at dusk.

Bats

Understand Risks

1. Understanding and Reducing Bat Fatalities Associated With Wind Turbines

Migratory bat species that roost in trees, or tree bats, are disproportionately affected by wind turbines, in part because they appear to be attracted to these structures. USGS science has led to new discoveries about these species, such as the consistent patterns in the way tree bats approach and dangerously interact with turbines at night (for example, making extremely close approaches on the downwind side of these structures), and identified areas of the continent where risk might be higher (such as the Great Plains, the Great Lakes region, and areas adjacent to coastal wintering areas). Working from this foundation, current USGS science aims to apply understanding of bat behaviors, seasonal distribution, and perception toward efficient and effective ways of reducing bat interactions with wind turbines.



Locations of a free-ranging hoary bat recorded using a miniature Global Positioning System tag in October 2014 (from Weller and others, 2016).

Contact

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Publications

O'Shea, T.J., Cryan, P.M., Hayman, D.T.S., Plowright, R.K., and Streicker, D.G., 2016, Multiple mortality events in bats—A global review: Mammal Review, v. 46, no. 3, p. 175–190, https://doi.org/10.1111/mam.12064.

Weller, T.J., Castle, K.T., Liechti, Felix, Hein, C.D., Schirmacher, M.R., and Cryan, P.M., 2016, First direct evidence of long-distance seasonal movements and hibernation in a migratory bat: Scientific Reports, v. 6, no. 34585, https://doi.org/10.1038/srep34585.

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Hayes, M.A., Cryan, P.M., and Wunder, M.B., 2015, Seasonally-dynamic presence-only species distribution models for a cryptic migratory bat impacted by wind energy development: PLOS ONE, v. 10, no. 7, e0132599, https://doi.org/10.1371/journal.pone.0132599.

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Cryan, P.M., Gorresen, P.M., Hein, C.D., Schirmacher, M.R., Diehl, R.H., Huso, M.M., Hayman, D.T.S., Fricker, P.D., Bonaccorso, F.J., Johnson, D.H., Heist, Kevin, and Dalton, D.C., 2014, Behaviors of bats at wind turbines: Proceedings of the National Academy of Sciences of the United States of America, v. 111, no. 42, p. 15126–15131, https://doi.org/10.1073/pnas.1406672111.

Cryan, P.M., Stricker, C.A., and Wunder, M.B., 2014, Continental-scale, seasonal movements of a heterothermic migratory tree bat: Ecological Applications, v. 24, no. 4, p. 602–616, https://doi.org/10.1890/13-0752.1.

2. Vocalization Behavior of Bats

A common assumption of bat studies is that species capable of echolocation will consistently call during flight. Scientists with the USGS and the University of Hawai'i at Hilo are using synchronized thermal video imagery and acoustic recordings of the endangered Hawaiian hoary bat to observe bat flight and echolocation behavior. The study found that bats in flight may often forgo echolocation or do not always vocalize in a way that is detectable with common sampling methods. Silent flight behavior may be more prevalent in echolocating bats than previously appreciated and has profound implications for ecological research and population monitoring. Given the current trend toward reliance on acoustic detection as part of bat conservation and management actions, an increased understanding of vocalization behavior clearly is needed, particularly for vocalization rates of bats flying near wind turbines. Identifying silent behavior by bats may improve monitoring methods and focus management actions.

Photograph by Paul Cryan, U.S. Geological Survey.

Bats that roost in trees, or tree bats, are more likely to interact with wind turbines, leading some scientists to speculate that they may be visually mistaking wind turbines as trees.

Contact

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Publication

Gorresen, P.M., Cryan, P.M., Montoya-Aiona, Kristina, and Bonaccorso, F.J., 2017, Do you hear what I see? Vocalization relative to visual detection rates of Hawaiian hoary bats (*Lasiurus cinereus semotus*): Ecology and Evolution, prepublication early view, https://doi.org/10.1002/ece3.3196.

3. Modeling Foraging Habitat Suitability of the Hawaiian Hoary Bat

Quantitative measures of habitat use by tree-roosting bat species have frequently faced the difficulty of detecting sparsely distributed and vocally cryptic individuals at locations where samples often yield low encounter rates. The current study by the USGS and the University of Hawai‘i at Hilo will concurrently apply thermal videography and echolocation sampling to more directly determine the occurrence and activity of the endangered Hawaiian hoary bat than previous approaches that have relied solely on acoustic detection or bat capture. Foraging habitat suitability will be related to bat occurrence, the frequency of feeding events, and insect abundance using multistate occupancy models, which can be more informative than simple models of presence and assumed absence. This approach may allow managers to evaluate the relative importance of different areas to foraging bats and track the effects of habitat restoration efforts over time.

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4. Detecting and Understanding Bat Fatalities

A USGS study conducted on north O‘ahu, Hawai‘i, simultaneously monitored bats at turbines with thermal and near-infrared cameras and nacelle-mounted acoustic detectors. Bats were more likely to be found near turbines when barometric pressure was low but rising, as well as during periods of low wind and warmer temperatures. Nightly insect and bat detections were significantly and positively correlated. This correlation between bat and insect presence may be a relatively simple predictor of bat activity and could help refine operational mitigation strategies.

Contact

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Publication

Gorresen, P.M., Cryan, Paul, Huso, Manuela, Hein, Cris, Schirmacher, Michael, Johnson, Jessica, Montoya-Aiona, Kristina, Brinck, Kevin, and Bonaccorso, Frank, 2015, Behavior of the Hawaiian hoary bat (*Lasiurus cinereus semotus*) at wind turbines and its distribution across the North Ko‘olau mountains, O‘ahu: Hilo, Hawai‘i, University of Hawai‘i at Hilo, Technical Report HCSU–064, 68 p., http://hdl.handle.net/10790/2585.

5. The North American Bat Monitoring Program (NABat)

North American bats are experiencing unparalleled population declines and face unprecedented risks from continuing and emerging threats including wind energy development. To better understand the ecological consequences of these declines, the USGS is leading the development and implementation of a multi-organizational North American Bat Monitoring Program (NABat). NABat is focused on the 46 species of bats common to Canada, the United States, and Mexico. NABat aims to help resource managers detect early signs of population declines, better estimate extinction risk, establish conservation priorities, and evaluate the effectiveness of conservation actions. Currently, data management for the NABat program is provided by the USGS. A NABat advisory committee is composed of representatives from the U.S. Forest Service, USFWS, USGS, National Park Service (NPS), Canadian Wildlife Service, Canadian Wildlife Health Cooperative, Bat Conservation International, (BCI), and Wildlife Conservation Society Canada. Since implementation in 2015, NABat monitoring is now occurring in more than 39 States and 10 Canadian provinces.

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6. Pre- and Post-Hibernation and Migratory Activity of Bats in the Central Appalachians

The USGS and Virginia Polytechnic Institute and State University are using fixed-site, long-term acoustical monitoring near cave systems and along mountain ridgelines and adjacent side slopes in Virginia and West Virginia to determine the timing of hibernation entry and exit and associated swarm-area habitat use for the endangered Indiana bat and threatened northern long-eared bat. Additionally, this project is being conducted to examine the timing and location of migratory pulses for eastern red bats. These data can be used to inform siting criteria for proposed wind energy facilities to lessen the potential impacts on migratory bats that use Appalachian ridges as their primary migration corridors as well as to understand the potential risks for myotid bats making short-distance movements to swarm habitats in the fall and post-hibernation and maternity habitats in the spring.

Contact

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Photograph by Mark Ford, U.S. Geological Survey Virginia Cooperative Fish and Wildlife Research Unit.

Northern long-eared bat, Rock Creek Park, Maryland.

7. Mid-Atlantic Coastal Bat and Acoustic Nano-Tag Study

The Virginia Department of Game and Inland Fisheries, USGS, and Virginia Polytechnic Institute and State University are studying migration timing and habitat use of eastern red bats in coastal areas of Virginia. With the move to develop coastal wind energy resources, there is a need to understand the potential for migration disruption and possible additive mortality of red bats and other migratory species. By understanding the timing of migration and offshore movements of these bats, it may be possible to design and implement wind energy mitigation measures, such as seasonal curtailment and (or) siting, to minimize interactions with bats. Red bats are being captured along the coast in Virginia, Maryland, and New Jersey prior to fall migration and in Virginia prior to spring migration and outfitted with very high-frequency nano-tags. Fixed sensor towers capable of tracking multiple bats simultaneously are being placed along the Virginia outer coast and in the Chesapeake Bay.

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Measure Impacts

8. Wind Energy Effects on the Indiana Bat

The USGS developed a quantitative framework for understanding the effects of wind energy development on migratory bats by developing migratory connectivity models for the endangered Indiana bat. Using USFWS data to determine model parameters, this framework provides insight into the effects of wind energy on migratory patterns and spatial dynamics of bats and also examines the synergistic effects of white-nose syndrome (WNS) on bat mortality. Wind energy development and WNS affect bat populations differently. Wind energy development disproportionately affects small overwintering populations, whereas WNS will more likely extirpate large overwintering populations. These findings illustrate the importance of considering changes among groups of populations when managing the Indiana bat.

Photograph by Sheryl Markham, U.S. Geological Survey.

Wind turbines in York Township, Elkhart County, Indiana.

Contact

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Publication

Erickson, R.A., Thogmartin, W.E., Diffendorfer, J.E., Russell, R.E., and Szymanski, J.A., 2016, Effects of wind energy generation and white-nose syndrome on the viability of the Indiana bat: PeerJ, v. 4, e2830, https://doi.org/10.7717/peerj.2830.

9. Using Genetic Tools to Examine the Biology of Summer-Roosting Indiana Bats

Photograph by Ann Forschauer, U.S. Fish and Wildlife Service.

Indiana bats.

Indiana bats are at risk from wind turbines, and wide-ranging populations of Indiana bats have declined by approximately half since 1967, when the species was listed as endangered under the Endangered Species Act (ESA). Traditional tracking techniques have not enabled scientists to regularly monitor individual bats throughout a field season. Recent advances in genetic techniques have made it possible to uniquely identify animals using deoxyribonucleic acid (DNA) in mark-recapture studies. Preliminary work by the USGS has shown that DNA can be extracted from Indiana bat fecal pellets collected beneath roost trees. It is now possible to explore the relatedness of Indiana bat-colony members using genetic information and to estimate population sizes using DNA. Accurate demographic and relatedness information can assist conservation managers in the management and recovery of the Indiana bat.

Contact

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Publication

Oyler-McCance, S.J., Fike, J.A., Lukacs, P.M., Sparks, D.W., O'Shea, T.J., and Whitaker, J.O., Jr., in press, Using non-invasive fecal DNA to investigate demographics of the endangered Indiana bat at summer roosts: Journal of Fish and Wildlife Management.

10. Post-White-Nose Syndrome Assessment of Bat Distribution in the Mid-Atlantic and Northeast

The USGS and Virginia Polytechnic Institute and State University, in cooperation with the USFWS, the National White-Nose Syndrome (WNS) Program, NPS, the U.S. Army, the U.S. Marine Corps, Virginia Department of Game and Inland Fisheries, and the National Council for Air and Stream Improvement are using multiyear acoustic data from more than 1,200 locations from the Appalachian Mountains to the Atlantic Coast, and from Virginia to New England, to determine post-WNS distribution and the community structure of bats. These data are being used to model current and future potential occupancy from individual forest to landscape level. Results can be used to inform managers and regulators of the likelihood that a rare, threatened, or endangered bat species will be found in or near wind energy development, surface mining, or oil and gas development activities on public lands. This project can also provide information on the level of effort required for acoustic monitoring of the endangered Indiana bat and threatened northern long-eared bat.

Contact

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Publications

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Powers, K.E., Reynolds, R.J., Orndorf, Wil, Ford, W.M., and Hobson, C.S., 2015, Post-white-nose syndrome trends in Virginia's cave bats, 2008–2013: Journal of Ecology and the Natural Environment, v. 7, no. 4, p. 56–64, https://doi.org/10.5897/jene2015.0507.

Inform Solutions

11. Ultraviolet Illumination as a Means of Reducing Bat Activity and Risk at Wind Turbines

Insectivorous bats are known for their ability to find and pursue flying insect prey at close range by using echolocation, but they also rely heavily on vision. Using a cue that only bats would perceive, the USGS is developing technologies to prevent bats from approaching wind turbines that might be mistaken for trees. In 2014, USGS scientists experimentally tested the ability of wild insectivorous bats to detect dim ultraviolet (UV) light and whether dim UV light could reduce bat activity. The scientists first confirmed that several species of bats were capable of detecting dim UV light. They then showed that Hawaiian hoary bat activity could be reduced in areas frequented by bats by illuminating trees with dim UV light. An operational turbine was subsequently illuminated with dim UV light prototypes and there was no indication of problems with the operations of the turbine when using this technique. Further research may determine whether dim UV light can reduce bat activity and fatality at operational wind farms, with the potential benefit of allowing operators to run turbines at maximum efficiency.

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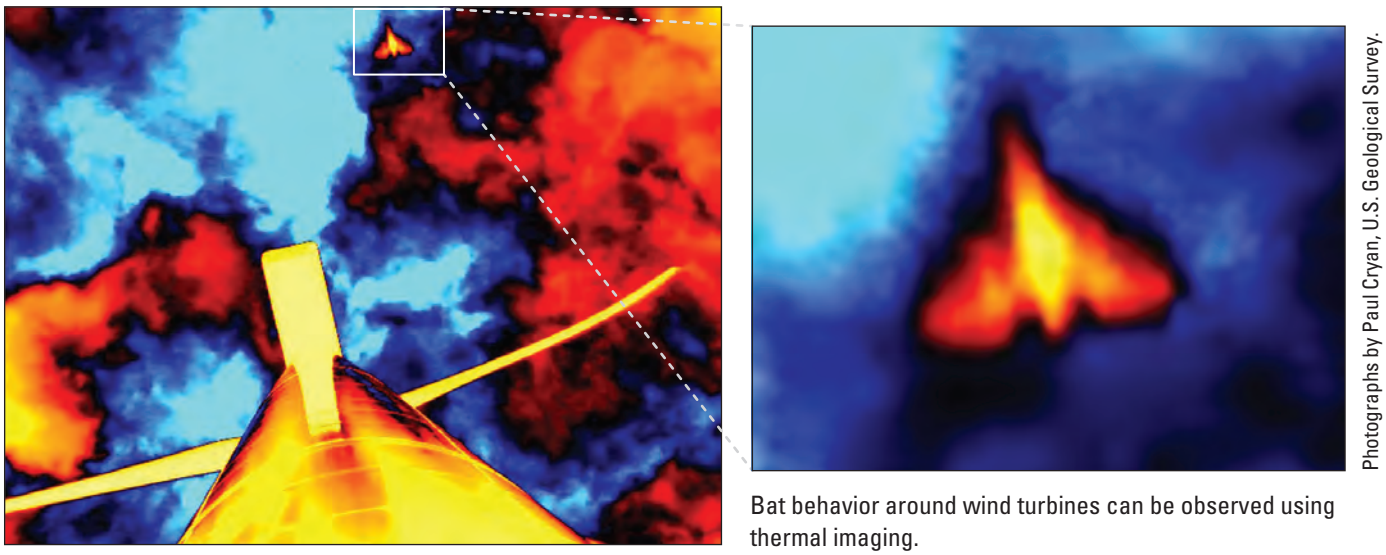

Photographs by Paul Cryan, U.S. Geological Survey.

Bat behavior around wind turbines can be observed using thermal imaging.

Publications

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12. Wind Turbine Curtailment Strategies to Reduce Bat Fatality

Wildlife fatalities due to collisions with wind turbines have sparked efforts to reduce the number of fatalities through operational management. Recent studies have shown that altering turbine operations when winds are below certain speeds can decrease the number of bat fatalities, but questions remain regarding optimal management. The USGS and colleagues are modeling the proportion of bat fatalities occurring under varying meteorological conditions at Avangrid Renewables' Blue Creek Wind Farm in Ohio to identify conditions that minimize both bat fatalities and energy production loss. The scientists are also investigating whether accurate and precise estimates of fatalities can be derived from carcass searches conducted at easily accessed areas, such as roads and pads beneath turbines.

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13. Comparing the Effectiveness of Acoustic Deterrents to Operational Curtailment in Reducing Bat Fatality

Independent studies have shown that both operational curtailment and ultrasonic acoustic deterrents can be effective in reducing bat fatalities at wind energy facilities. A primary goal of this USGS and BCI study is to directly compare the costs and benefits of the acoustic deterrents to operational curtailment. Fatality rates, when both curtailment and acoustic deterrents are applied singly and in combination, are being compared with fatality rates at untreated turbines to determine if one of these methods is more effective, if they are equally effective, or if they might act synergistically when employed simultaneously.

Photograph by Paul Cryan, U.S. Geological Survey.

Wind turbine bat fatality.

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Raptors

Understand Risks

14. Golden Eagle Migration and Habitat Use

The USGS is collecting information related to habitat use, home range, and population dynamics of golden eagles in the Central Appalachians, northeastern California, and the Mojave and Sonoran Deserts, using various methodologies including Global Positioning System-Global System for Mobile (GPS-GSM) communications telemetry, standard geographic information system (GIS) analyses, nest visits, and non-invasive genetic monitoring. The data collected have been used to model movement and to create risk models to assist resource management agencies in evaluating management options for this species. Results can inform resource managers about where and when eagles would be most at risk from disturbances associated with renewable energy structures. Data are being combined with datasets from other similar projects to create a framework and baseline to build an effective long-term golden eagle monitoring program in support of adaptive management.

Contact

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Publications

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Photograph by U.S. Geological Survey.

Golden eagle with a GPS backpack.

15. Assessing Eagle Use Frequency at Wind Energy Facilities

Operation of wind energy facilities can adversely affect eagles, among other wildlife. USFWS guidelines suggest wind facility operators or developers survey eagle use and calculate the risk to eagles across the project area; however, questions have arisen concerning the degree to which data from survey plots represent eagle use over an entire project area. The USGS is using existing telemetry data on golden eagles in the Mojave Desert, California, to help the USFWS compare eagle use within a plot to eagle use over an entire project area. Results can add to understanding of golden eagle activity and provide a context for interpreting survey data collected at potential wind energy facilities.

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Publication

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Photograph by Brian Millsap, U.S. Fish and Wildlife Service.

Golden eagle in flight.

16. Golden Eagle Movement and Conservation in Coastal Southern California

To evaluate the effects of human activities on golden eagles in coastal southern California, the USGS along with local agencies, State, and other Federal agencies began a multiyear golden eagle survey and tracking program in 2014. Thirty-seven golden eagles were captured in San Diego County, Orange County, and western Riverside County, California, and fitted with GPS backpack transmitters that send data over cellular networks, allowing scientists to track their movements. Movements ranged as far north as northern Nevada and southern Wyoming and as far south as the southern tip of Baja California, Mexico. By standardizing sampling designs and monitoring protocols with other ongoing studies of golden eagles in California, this work is expected to contribute to a broader understanding of the population status, demography, resource use, and genetic structure of golden eagles across a wide gradient of environmental conditions.

Photograph by Pete Bloom, Bloom Biological Inc.

A U.S. Geological Survey scientist releases a golden eagle with a solar-powered GPS transmitter, San Diego County, California.

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Publications

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17. Linking Habitat and Prey Availability to Golden Eagle Ecology

The USGS is helping managers in California and Nevada design conservation strategies for eagles by constructing predictive models that link prey availability and abundance with eagle productivity and survival across the Desert Southwest. In addition, because eagle demographics are linked to the abundance of rabbit populations, scientists conducted a review and synthesis of population status, demographic patterns, general ecology, and the ecological significance of certain rabbit species to golden eagles across the Western United States. The results of this work can be incorporated into monitoring plans for golden eagles and their habitats and can be used as inputs to ecological models of eagle populations as the work advances.

Photograph by U.S. Geological Survey.

Golden eagle feeding a chick in its nest on a cliff near Victorville, California.

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Publications

Longshore, K.M., Esque, T.C., Nussear, K.E., Johnson, Diego, Simes, Matthew, and Inman, R.D., 2017, An assessment of food habits, prey availability, and nesting success of golden eagles within the Desert Renewable Energy Conservation Plan Area: Prepared for California Energy Commission, Publication Number CEC–500–2017–003, 57 p., accessed September 5, 2017, at https://pubs.er.usgs.gov/publication/70190366.

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18. Golden Eagles in New Mexico

The BLM manages large areas in New Mexico that have a high potential for wind energy development. USGS science is helping assess the risk that proposed wind energy developments in southeastern and south-central New Mexico may have on resident and migratory golden eagles. The study is planned to assess habitat and space use of migratory and resident golden eagles; identify nest sites; estimate productivity and survival, origin, and migration patterns; and determine factors affecting golden eagle distribution. Results of the study may be used to inform the development of mitigation strategies that can reduce potential negative effects from proposed wind energy developments.

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19. Wintering Distribution of Golden Eagles in the Southern Great Plains

The Southern Great Plains, which comprises eastern New Mexico and the panhandles of Oklahoma and Texas, is experiencing rapid wind energy development. The region has traditionally been an important wintering area for golden eagles. The USGS is assessing the distribution and abundance of wintering golden eagles in relation to land-cover and land-use types across this region. The results of this study can provide industry managers with insight into whether landscape features pose potential conflicts between wind energy development and eagles.

Photograph by U.S. Geological Survey.

Dr. Clint Boal, Texas Cooperative Fish and Wildlife Research Unit, observing a golden eagle nest in the caprock canyon country of west Texas.

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20. Tracking Bald Eagles Near Wind Energy Facilities in the Central Great Plains

The Central Great Plains is an important focus area for the development of new wind facilities. The USGS is leading an effort to track bald eagles using GPS-GSM telemetry to acquire information that will help wildlife managers address potential conflict between bald eagles and wind turbines in Oklahoma and collaborate on similar work in Iowa and Illinois. Scientists are collecting information on topography, weather, and land cover to understand how environmental conditions may put eagles at risk from collisions with turbines.

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21. Condor Flight Behavior Near Wind Energy Facilities

California condor populations face numerous threats, including the development of wind energy facilities. Scientists from the USGS, USFWS, California Department of Fish and Wildlife, and BLM are tracking condor flight using high-frequency GPS-GSM telemetry to understand how flight behavior alters the risk for condors to interact with wind turbines. Project scientists plan to record movements of California condors to understand how their flight behavior, especially flight altitude, responds to variation in topography and weather. This information can be used to identify wind and topographic variables that may be preferentially used by condors and to predict risk to birds from existing and proposed turbines.

Photograph by Sue Haig, U.S. Geological Survey.

California condor at the Portland Zoo.

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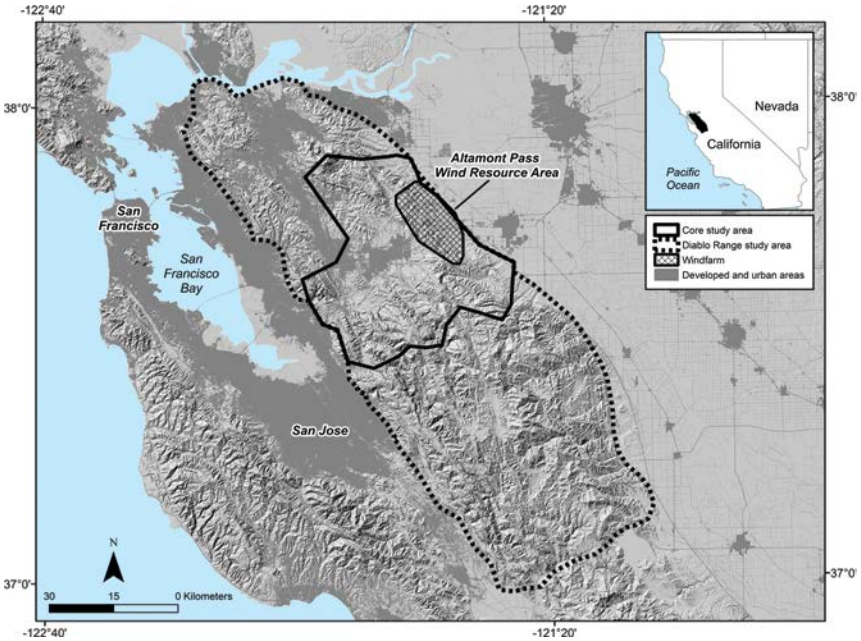
Measure Impacts

22. Population Demography of Golden Eagles Near the Altamont Pass Wind Resource Area, California

Wind turbines at the Altamont Pass Wind Resource Area in California have been estimated to kill as many as 28 to 68 golden eagles annually. This study investigates how estimated levels of turbine-related mortality and other environmental stressors may interact to affect the population demography of golden eagles in the broader landscapes surrounding the wind farm. The USGS and partners are using historic and current eagle data to assess territory occupancy, abundance, breeding success, survival, and habitat use of different age classes of golden eagles. This information has been used to quantify how the local population of golden eagles may respond to observed levels of turbine-related fatalities. Additionally, results from this study are providing detailed information on specific sites or breeding areas that contribute most to overall population growth, which permits land managers to identify and prioritize important areas for conservation.

High-quality nesting habitat for golden eagles in the Diablo Range, California (from Hunt and others, 2017).



Location of the Altamont Pass Wind Resource Area in the Diablo Range, California (from Hunt and others, 2017).

Contact

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Publications

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23. Using Drones to Detect Golden Eagle Carcasses

The USGS, in collaboration with Oregon State University and the Confederated Tribes of Warm Springs, is investigating the use of unmanned aircraft systems, or drones, to detect golden eagle carcasses at wind energy facilities. The objectives of the investigation are to use change-detection software to compare ground images taken by drones on separate flights over time to detect the timing of carcass appearance and to evaluate whether detection is affected by vegetation or carcass size.

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Photographs by Manuela Huso, U.S. Geological Survey.

Testing drones as a tool for detecting eagle carcasses.

Inform Solutions

24. Golden Eagle Monitoring Plan for the Desert Renewable Energy Conservation Plan Area

The Desert Renewable Energy Conservation Plan (DRECP) was developed to provide protection of Mojave and Colorado Desert ecosystems while allowing for the appropriate development of renewable energy projects. Research and monitoring of golden eagles are suggested to ensure that biological goals of the DRECP will be achieved while promoting compatible renewable energy development. The USGS and partners developed a research and monitoring plan for the DRECP that (a) profiles the ecology and status of golden eagles and their habitats in the area, (b) provides a range of potential sampling options to address monitoring needs, and (c) characterizes an iterative approach to monitoring golden eagles focusing on links between changes in human land-use, nesting, and foraging habitat conditions and population dynamics. The monitoring plan outlines a process for collecting and analyzing data on territory occupancy, reproduction, survival, and population size that can provide regulatory agencies with information to make conservation policy decisions regarding permitting and siting of renewable energy projects.

Contact

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Publication

Wiens, J.D., Schumaker, N.H., Inman, R.D., Esque, T.C., Longshore, K.M., and Nussear, K.E., 2017, Spatial demographic models to inform conservation planning of golden eagles in renewable energy landscapes: Journal of Raptor Research, v. 51, no. 3, p. 234–257, https://doi.org/10.3356/JRR-16-77.1.

25. Eagle Surveys, Monitoring, and Distribution

The USGS reviewed the utility of the recommended golden eagle survey methodology given in the 2013 USFWS Eagle Conservation Plan Guidance with a goal of assessing the influence of different survey time intervals, sampling periods, and landscapes on detectability and occupancy estimates of golden eagles. Repeat 800-meter radius, 1-hour point-count surveys were conducted during two sampling periods at 50 sample points in three areas over breeding seasons in north-central New Mexico and southwestern Idaho during 2012 and 2013, and in southwestern Wyoming during 2013. A total of 1,500 hours of survey data were evaluated to determine the level of survey effort necessary to adequately evaluate eagle occurrence depending on area, season, and year. This study can help inform the temporal and spatial effort necessary to improve the efficacy of point-count surveys in evaluating golden eagle occurrence.

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Publication

Skipper, B.R., Boal, C.W., Tsai, J.-S., and Fuller, M.R., 2017, Assessment of frequency and duration of point counts when surveying for golden eagle presence: Wildlife Society Bulletin, v. 41, no. 2, p. 212–223, https://doi.org/10.1002/wsb.770.

26. Golden Eagle Late-Summer Occupancy in Wyoming

The USGS is developing golden eagle habitat-occupancy models to overlay with maps of potential energy development, including wind energy in Wyoming and other parts of the Western United States. Models and maps can be used to highlight biological strengths and weaknesses, or high- and low-quality habitat, across the landscape. Map overlays explicitly delineate opportunities for conservation—areas of high quality habitat where the energy-generating potential is low—and imminent threats—areas of high-quality habitat where the energy-generating potential is high. These tools can assist resource managers in their efforts with industry concerning siting for energy development and the identification of areas for off-site mitigation.

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Publications

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27. Predicting Golden Eagle Fatalities at Wind Facilities

The USGS, working with USFWS, has developed a predictive Bayesian Collision Risk Model (CRM) of golden eagle "take" at a given wind facility. The model is based on preconstruction eagle-use surveys and design considerations. The USFWS uses the model to work with facility applicants at the design and permitting stages to generate a predicted number of eagle fatalities for an incidental take permit. This model serves as the basis for compensatory mitigation, which may be needed. Scientists are also helping develop eagle population models at the regional level to evaluate the effect of the cumulative take on population

dynamics. Both efforts explicitly acknowledge uncertainty and, by doing so, permit risk analysis and the implementation of adaptive management.

Contact

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Publication

New, Leslie, Bjerre, Emily, Millsap, Brian, Otto, M.C., and Runge, M.C., 2015, A collision risk model to predict avian fatalities at wind facilities—An example using golden eagles, *Aquila chrysaetos*: PLOS ONE, v. 10, no. 7, e0130978, https://doi.org/10.1371/journal.pone.0130978.

28. Habitat Prioritization for Wyoming Raptors in Wyoming

The USGS is leading a project to develop predictive models of the association between the available habitat of raptors, such as golden eagle, ferruginous hawk, northern harrier, and prairie falcon, and their habitat use in Wyoming. This project is planned to create models and maps that can be used to identify priority habitat areas and assist resource managers with raptor conservation by providing information that can be used in the siting of wind power infrastructure and prioritization of locations for strategic and focused conservation efforts.

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Photograph by Todd Katzner, U.S. Geological Survey.

Ferruginous hawk in flight.

29. Potential Interactions of Migrating Raptors and Wind Energy Sites at the International Scale

Swainson's hawks are long-distance migratory raptors that breed across Western North America and migrate to Argentina for the winter. This annual round trip of approximately 20,000 kilometers (12,500 miles) takes the hawks over 12 countries, which all have interests in wind energy development. The USGS is using GPS transmitters to determine precise migration routes, which are then overlaid on maps of wind energy potential. This provides the means to identify high-risk areas for migrating raptors at the international scale. Analysis of 3 years of data for adult hawks is underway, and field data collection is now being shifted to include young hawks.

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Additional Publications About Raptors

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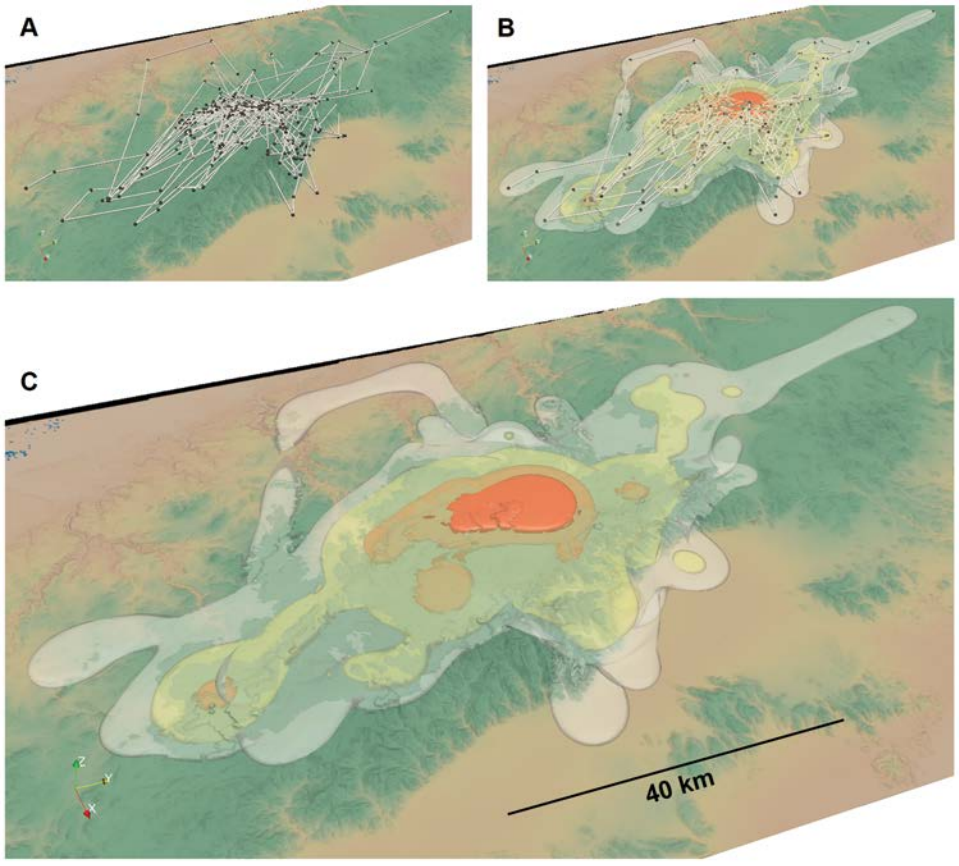

A movement-based kernel density estimator and computer visualization showing 3D home range for a California condor (from Tracey and others, 2014).

Great Lakes, Coastal, and Marine Birds

Atlantic Ocean

30. Potential Impacts of Offshore Wind Energy Projects on Endangered Roseate Terns

Offshore wind energy projects have been permitted for two coastal areas in Massachusetts and Rhode Island and have been proposed for offshore areas of New York. Fish-eating terns traveling through these offshore areas could be impacted by the construction and operation of wind turbines. The "Cape and Islands" area of southeastern Massachusetts is a particularly important area for the endangered northwest Atlantic roseate tern population because most of these terns congregate in this area for several months during the postbreeding staging period prior to fall migration. USGS scientists will examine long-term temporal variation in staging site use and survival of terns prior to the construction of offshore wind turbine operations. These data could be useful for evaluating the timing or risks to roseate terns from proposed offshore wind energy projects.

Photograph by Karli Rogers, National Park Service.

Endangered northwest Atlantic roseate tern.

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Publications

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31. Evaluating Acoustic Sensitivity of Diving Birds to Offshore Energy Development Activities

Construction and maintenance of wind turbines can increase in-air and underwater noise levels from pile driving, shipping of materials, turbine operation, and other activities. The USGS is testing whether diving bird species rely on auditory cues to orient or forage, by measuring in-air auditory thresholds in diving bird species, using behavioral and electrophysiological (auditory brainstem response [ABR]) techniques. At present these methodologies are being replicated in the underwater environment on long-tailed ducks, a pursuit diver of fish, and lesser scaup, which forage on sessile prey. These data may be the first evaluation of underwater hearing abilities of diving birds with the ultimate goal of evaluating the impacts of underwater noise activities on these species.

Contact

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Publication

Crowell, S.E., Wells-Berlin, A.M., Carr, C.E., Olsen, G.H., Therrien, R.E., Yannuzzi, S.E., and Ketten, D.R., 2015, A comparison of auditory brainstem responses across diving bird species: Journal of Comparative Physiology A, v. 201, no. 8, p. 803–815, https://doi.org/10.1007/s00359-015-1024-5.

Photograph by Jonathan Fiely, U.S. Geological Survey.

Diving long-tailed duck during hearing trials.

32. Satellite Tracking Offshore Habitat Use in Diving Bird Species

USGS scientists are using platform terminal transmitter satellite tracking tags to determine the occurrence and local movement patterns of red-throated loons, surf scoters, and northern gannets in Federal waters of the mid-Atlantic region of the United States during migration and winter. From 2012 to 2016, scientists tracked the movements of 75 gannets and 66 loons, and from 2001 to 2016, scientists tracked 217 scoters on their northward migration to their breeding colonies and on their southward migration back to and through the mid-Atlantic region. When published, data can inform siting, permitting, and regulation of future offshore wind development and provide important information on key habitat use and migration of a suite of species with different ecological niches.

Photograph by Jonathan Fiely, U.S. Geological Survey.

Northern gannet with a satellite tracking antenna.

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33. External GPS-GSM-Based Transmitters for Tracking Seabirds

USGS scientists are testing solar-powered GPS-GSM-based transmitters on seabirds to provide data with the necessary precision to capture fine-scale movement patterns. This new information may allow them to better relate the influence of weather, resource availability, and hazardous conditions for seabirds and thus predict conflict with offshore wind power facilities along the Atlantic coast. Preliminary data have corroborated previous platform terminal transmitter tracking data from these species and are also providing preliminary altitudinal data. The deployment of additional transmitters can be instrumental in modeling habitat use, mortality risk, and the impact of weather on flight behavior for these species in the face of multiple proposed offshore wind facilities along the Atlantic coast.

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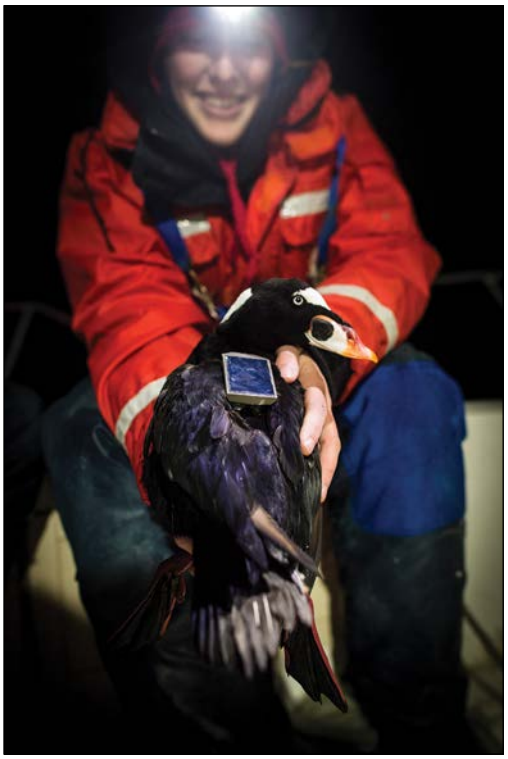

Photographs by Jonathan Fiely, U.S. Geological Survey.

Above, USGS field crew setting out to capture seabirds and attach solar-powered GSM transmitters to track bird movements offshore. At left, a scientist is holding a surf scoter with a GPS transmitter device.

34. The Atlantic Offshore Seabird Dataset Catalog

To assess the impacts of alternative energy on marine bird populations, large amounts of occurrence information are required along with biophysical data that influence species distributions. Before a model is constructed, data need to be retrieved, reconfigured, synthesized, and vetted. USGS scientists have created a catalog of more than 100 datasets, developed computer programs to facilitate comparisons between historic and recent surveys, and standardized survey sampling efforts for the Atlantic Outer Continental Shelf. This database is the single largest repository of marine bird information available for the western Atlantic. It includes information dating back to the 1970s and more than 350,000 seabird occurrence records from Florida to Maine, and one from Atlantic Canada.

Photograph by Alan M. Cressler, U.S. Geological Survey.

A variety of shore birds frequent Jekyll Island, Georgia.

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Publication

Wimer, Mark, and Benson, Abigail, 2016, USGS Patuxent Wildlife Research Center Seabirds Compendium, v. 1.1: U.S. Geological Survey occurrence dataset, https://doi.org/10.15468/w2vk7x.

35. Modeling of Atlantic Coast Seabird Distributions

To better understand the potential impacts of offshore energy development on Atlantic seabirds, the USGS initially used occurrence information from the Atlantic Seabird Compendium to develop hierarchical models and assess the distribution of marine avian populations. With the recent availability of robust survey information (repeat surveys), the USGS has developed dynamic occupancy models to refine those initial models and assess how seabird distributions vary over time and space. This effort is helping develop effective tools for estimating seabird habitat and distributions that can be used to inform siting of offshore energy development.

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Publication

Flanders, N.P., Gardner, Beth, Winiarski, K.J., Paton, P.W.C., Taber, Allison, and O'Connell, A.F., 2015, Key seabird areas in southern New England identified using a community occupancy model: Marine Ecology Progress Series, v. 533, p. 277–290, https://doi.org/10.3354/meps11316.

Pacific Ocean

36. Southern California Marine Bird and Mammal Surveys

The Southern California Bight (SCB) and the Pacific Outer Continental Shelf (PacOCS) biome off the central coast of California is the only region in California that supports breeding black storm-petrels, brown pelicans, Scripps's murrelets, and elegant terns. The area also contains nearly half of the world population of endemic ashy storm-petrels. The USGS plans to repeat aerial surveys to provide up-to-date information and a more robust longitudinal dataset from which to draw on for environmental analyses on the potential effects from proposed offshore energy development to seabirds and marine mammals. The study expects to (1) update understanding of the status and distribution of seabirds and marine mammals in areas where renewable energy projects may be proposed, (2) relate this new information to past surveys, and (3) augment data for numerically abundant and (or) indicator species, important area breeding and migratory species, and species with greatest vulnerability to offshore renewable energy development.

Photograph by Jonathan Felis, U.S. Geological Survey.

A sooty shearwater takes off just offshore of Capitola, California.

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Publications

Adams, Josh, Kelsey, E.C., Felis, J.J., and Pereksta, D.M., 2017, Collision and displacement vulnerability among marine birds of the California Current System associated with offshore wind energy infrastructure (ver. 1.1, July 2017): U.S. Geological Survey Open-File Report 2016–1154, 116 p., https://doi.org/10.3133/ofr20161154.

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37. Predictive Modeling of Marine Bird Spatial Distributions on the Pacific Outer Continental Shelf

The States of California, Oregon, and Washington are engaged with the BOEM in various ways to plan the siting of offshore energy projects within the territorial sea and OCS regions. The USGS and collaborators are using at-sea transect survey and individual tracking data throughout the PacOCS in addition to oceanographic and environmental data to develop predictive models on distribution and abundance and hotspot/coldspot areas and relative bird occurrence and abundance throughout a large region of the California Current System.

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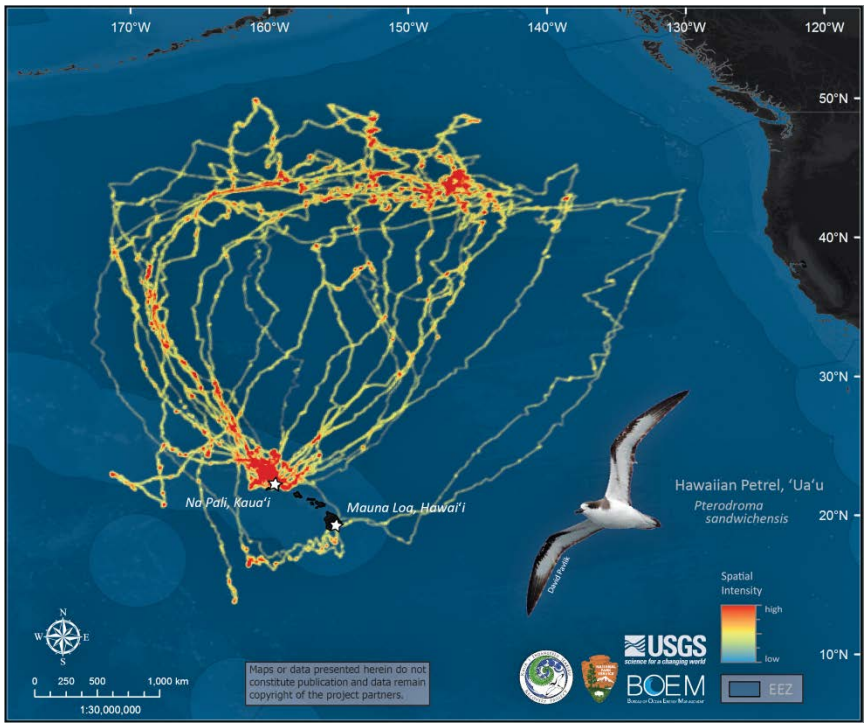
38. Main Hawaiian Islands Seabird Tracking

The main Hawaiian Islands and associated offshore areas provide substantial breeding habitat for more than 19 seabird species. The BOEM and the State of Hawai‘i have received proposals to develop offshore renewable energy-related projects within waters surrounding the main islands. These projects have the potential to negatively affect seabirds through interactions with wind-turbine structures, lighted facilities, elevated power lines on land, and lighted ships offshore. The USGS is continuing over-land and at-sea tracking studies of seabirds in this area to provide information to assess potential risks posed by proposed offshore energy developments and energy infrastructure. Information collected includes intra- and inter-seasonal and inter-colony differences in foraging behaviors, variability in at-sea habitat use, and ranging behaviors among seabird species including two species listed under the ESA, the Hawaiian petrel and Newell’s shearwater.



Hawaiian petrel at-sea movements from several breeding colonies in Hawai‘i (from USGS, https://www.werc.usgs.gov/ProjectSubWebPage.aspx?SubWebPageID=3&ProjectID=254).

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Gulf of Mexico

39. Spatial and Reproductive Ecology of Brown Pelicans in the Gulf of Mexico

Although the Gulf of Mexico contains a high density of oil infrastructure as well as a rich assemblage of seabirds, baseline data on at-sea distribution and habitat use of these species are poorly understood. Given its distribution patterns, behavior, and known sensitivity to chemical and oil contaminants exposure, the brown pelican is a focal species for investigations of risk exposure in the marine environment. The USGS is leading a study focusing on colony-specific movement patterns, habitat use at sea, and reproductive parameters for brown pelicans across the northern Gulf from Corpus Christi Bay to the Florida Panhandle. USGS scientists deployed GPS satellite tags on 85 adult pelicans breeding in the region to assess spatial ecology. Data were also collected on colony diet, behavior, and reproduction. Data may be used by the USFWS, BOEM, State agencies, and the Gulf Avian Monitoring Network to develop management plans and future research and monitoring efforts.

Photograph by Juliet Lamb, U.S. Geological Survey.

Brown pelican at breeding colony, Raccoon Island, Louisiana.

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Great Lakes

40. Monitoring and Mapping Avian Resources in Nearshore and Open Waters of Lake Michigan

USGS scientists have surveyed pelagic bird use in priority areas of Lake Michigan during fall and winter periods over a 4-year period to determine distribution patterns and abundance in nearshore and open water areas for the common loon, red-throated loon, white-winged scoter, black scoter, surf scoter, long-tailed duck, common merganser, red-breasted merganser, red-necked grebe, horned grebe, greater scaup, lesser scaup, and other waterbirds. Efforts are now focused on developing spatially explicit distribution models of selected waterbirds on Lake Michigan from aerial survey data.

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Photograph by John Tracey, U.S. Geological Survey.

Birds on the shore of Lake Michigan.

Photograph by Jonathan Fiely, U.S. Geological Survey.

Adult female surf scoter.

41. Documenting Movements, Habitat Use, and Foraging Patterns of Common Loons and Long-Tailed Ducks

USGS scientists are employing both satellite telemetry and archival geolocator tags to document the movements, habitat use, and foraging patterns of common loons across the Great Lakes during migration relative to future wind energy development. Additional work is underway to radiomark long-tailed ducks to determine local movement patterns while wintering on Lake Michigan. Data on waterbird seasonal movement patterns and core use areas based on aerial surveys and telemetry will be used to inform an environmental impact assessment of potential wind turbine placement and assist with identifying, evaluating, and suggesting alternative wind facility sites in the Great Lakes.

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Photograph by Judith Bloom, U.S. Geological Survey volunteer.

A juvenile common loon wearing a satellite transmitter antenna follows an adult at Tomahawk Lake, Wisconsin.

42. Airspace Use by Migrating Landbirds at Lake Erie

Interest is growing to develop wind energy capacity along Great Lakes shorelines both onshore and offshore. With this growth comes the consideration of potential impacts to the large concentrations of landbirds that use the southern Lake Erie shoreline during spring and fall migration. The USGS is using two marine radars operated simultaneously at shoreline and inland sites at 5 or 24 kilometers (3 or 15 miles). The data can be used to describe movement patterns of night-migrating landbirds, estimate ascent and descent flight profiles for night-migrating landbirds in relation to distance from the southwestern Lake Erie shoreline, and estimate intensity of nightly bird movements using radar and relate the results to data on banded birds.

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Photograph by J. Bartholmai, U.S. Geological Survey.

Radar is used to detect the movement patterns and other behaviors of flying animals at night and at distances far beyond the limits of human vision.

Grassland Birds and Waterbirds

Waterfowl in Alaska

43. Habitat Use of Molting Geese in the National Petroleum Reserve–Alaska

Photograph by Ryan Askren, U.S. Geological Survey.

Greater white-fronted geese flying near Chipp South field camp area, North Slope, Alaska.

Numerous greater white-fronted geese molt within the National Petroleum Reserve–Alaska, and proposed development in this area raises questions about possible impacts to molting geese and their habitats. The USGS used GPS transmitters to record fine-scale location data of white-fronted geese to assess patterns of movement and resource selection relative to vegetation class, year, and body mass at the time of capture. Results demonstrate that flightless white-fronted geese maintain fairly small home ranges across a gradient of habitats, suggesting that suitable habitat for this species is widely distributed. The only constraint documented was the apparent need to molt within 100 meters (328 feet) of a wetland, a potential escape habitat. Given the apparent widespread availability of suitable habitat in the National Petroleum Reserve–Alaska together with the total potential area available to molting geese, the effect of a limited number of localized displacements resulting from disturbance/development would not likely be measurable at the population level.

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44. Effects of Industrial and Investigator Disturbance on Arctic-Nesting Geese

Oil and gas development on the Arctic Coastal Plain of Alaska may have effects on Arctic-nesting birds. The USGS used digital cameras and periodic nest visits during 2013–14 to monitor nests of greater white-fronted geese at a disturbed site adjacent to manmade infrastructure and industrial cleanup activities, and a control site more than 2 kilometers (1.2 miles) from sources of industrial disturbance. Using nest photographs, scientists assessed variation in estimates of incubation constancy, nest survival, and predator behavior relative to site, year, and distance from industrial activity. Indirect vehicular and aircraft disturbance posed less risk to nest survival than direct encroachment by observers at nest sites. Therefore, USGS studies suggest that effects of industrial activities on avian productivity in the Arctic may be minimized through practices that limit direct encounters with nests.

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Publication

Meixell, B.M., and Flint, P.L., 2017, Effects of industrial and investigator disturbance on Arctic-nesting geese: Journal of Wildlife Management, prepublication early view, https://doi.org/10.1002/jwmg.21312.

45. Quantifying Shifts in Waterfowl and Their Habitat in the National Petroleum Reserve–Alaska

The Arctic Coastal Plain of northern Alaska has experienced a warming trend over the past 30 years, leading to reductions in sea ice and saltwater inundation of coastal habitats. Saltwater tolerant plants are now thriving in these areas. Since the 1970s, data collected by the USFWS have indicated a shift in the distribution of molting black brant geese in the Teshekpuk Lake Special Area. The USGS determined that black brant geese are using new molting areas on the coast, away from traditionally used large inland lakes. This shift in distribution is due to an increase in high-quality forage along the coast brought about by reduced sea ice. The USGS is developing forecasts of future habitat quality for geese that can assist management planning for potential development scenarios.

Photograph by Ryan Askren, U.S. Geological Survey.

A black brant goose on its nest, Colville field camp area, North Slope, Alaska.

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Publication

Flint, Paul, Whalen, Mary, and Pearce, John, 2014, Changing arctic ecosystems—Sea ice decline, permafrost thaw, and benefits for geese: U.S. Geological Survey Fact Sheet 2014–3088, 2 p., https://doi.org/10.3133/fs20143088.

Grassland Birds in Northern Prairie and Great Plains

Photograph by Kathleen Macek-Rowland, U.S. Geological Survey.

A meandering stream in North Dakota.

46. A Mitigation Tool for Estimating the Impact of Wind Energy Development on Grassland Birds in the Northern Great Plains

USGS scientists used results from a 10-year field study of the influence of wind facilities on breeding grassland birds to develop a tool to help wildlife agencies, conservation groups, and wind developers determine conservation measures that mitigate habitat lost to energy development. The study consisted of a before-after-control-impact assessment on three wind facilities in North and South Dakota and examined displacement or attraction one year after construction and the average displacement

or attraction 2–5 years after construction; scientists also tested for these effects overall as a function of distance from turbines for nine species. Using these results, the USGS developed a method for computing the displacement rate for grassland bird pairs and the amount of grassland needed to support these displaced pairs. Either the displacement rate or the grassland acreage can be applied to mitigation scenarios in situations where developers want to provide compensation for impacts.

Contact

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Publication

Shaffer, J.A., and Buhl, D.A., 2016, Effects of wind-energy facilities on grassland bird distributions: Conservation Biology, v. 30, no. 1, p. 59–71, https://doi.org/10.1111/cobi.12569.

47. Birds and the Bakken Formation: Integration of Oil Well, Land Cover, and Species Distribution Data to Inform Conservation

The USGS is leading a project to measure the effects of well development on birds in the Williston Basin in eastern Montana, western North Dakota, and South Dakota. Scientists plan to create maps that combine data on habitat conversion and species distribution to describe the effects of disturbance from oil well pads on biodiversity. Models are also being developed to display past and potential future effects of energy development on grassland birds. This information may assist managers with prioritizing areas for conservation in the Williston Basin.

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Photograph by Stephanie Gaswirth, U.S. Geological Survey.

A drill rig in the Bakken oil field in Stark County, western North Dakota.

48. Lesser Prairie-Chicken Population and Habitat Ecology

The lesser prairie-chicken currently occupies a range that includes portions of Colorado, Kansas, New Mexico, Oklahoma, and Texas. This species has experienced population declines due to both direct and indirect habitat loss, including conversion of native rangeland to cropland and disturbance from energy development. The USGS developed a population viability analysis (PVA) model to predict future population status of the lesser prairie-chicken in four ecoregions across the species' range. Studies by the USGS and collaborators predict habitat suitability for lesser-prairie-chicken leks by exploring lesser prairie-chicken occurrence in relation to landscape characteristics, drought, and anthropogenic effects, such as distance to active wells, roads, highways, transmission lines, and tall structures. Habitat suitability models, combined with other landscape information, form the basis of a habitat assessment tool that can be used to guide siting of development projects and targeting of areas for conservation.

Photograph by R. Ryan Hagerty, U.S. Fish and Wildlife Service.

Lesser prairie-chicken.

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Publications

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Birds in the Intermountain West

Photograph by Jeannie Stafford, U.S. Fish and Wildlife Service.

Greater sage-grouse.

49. Impacts of Oil and Gas Development on Greater Sage-Grouse Lek Attendance

The greater sage-grouse has experienced population declines over several decades attributable to a variety of disturbances, including oil and gas development. To better understand how male sage-grouse lek attendance is affected by oil and gas development, the USGS and Colorado State University analyzed changes in counts of male sage-grouse at leks in Wyoming from 1984 to 2008. The results showed that male sage-grouse lek attendance declined by approximately 2.5 percent per year. Increasing density of oil and gas wells was correlated with decreasing lek attendance. The effects of oil and gas development on lek attendance were observed up to 6 kilometers (4 miles) from leks, and attendance lagged for 4 years following development. Lek attendance was stable when no wells were present near a lek and began declining with the addition of the first well. This science can further assist resource managers in the active management of sagebrush habitats.

Contact

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Publication

Green, A.W., Aldridge, C.L., and O'Donnell, M.S., 2017, Investigating impacts of oil and gas development on greater sage-grouse: Journal of Wildlife Management, v. 81, no. 1, p. 46–57, https://doi.org/10.1002/jwmg.21179.

50. Effects of Energy Development on Greater Sage-Grouse and Their Predators

An increasing human footprint across ecosystems in the American West often results in disturbances to native vegetation and related changes that are favorable to generalist predator species. A large portion of the Great Basin consists of proposed and recently developed energy transmission lines and renewable energy sources (such as geothermal energy and wind). Further development could continue to fragment the contiguous sagebrush-steppe ecosystems that provide seasonal habitat for greater sage-grouse populations. The USGS, in collaboration with other Federal and State agencies and private industry, is working to understand how energy development and habitat loss influence predator-prey interactions between ravens and nesting sage-grouse. This science provides resource managers with information and tools to help develop guidelines for future energy-related projects to minimize adverse impacts on sage-grouse populations.

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Oil and gas exploration in the Intermountain West.

Photograph by U.S. Geological Survey.

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51. Implications of Anthropogenic Activities on Greater Sage-Grouse Populations in Nevada

The USGS has initiated a study at nine sites across Nevada to answer questions related to long-term and short-term effects of disturbance caused by wind turbines, gold mining, geothermal energy production, hydraulic fracturing for oil, and transmission line development on sage-grouse habitat selection, population vital rates, and movement patterns. This information can help managers develop guidelines that strive to minimize the negative effects of these activities on greater sage-grouse and their associated habitat.

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52. Breeding Sagebrush Songbird Responses to Gas Development: Patterns and Mechanisms

USGS research since 2008 in two natural gas fields, Pinedale Anticline and the Jonah Field, in western Wyoming has documented patterns in the abundance and nesting success of three sagebrush-obligate passerine birds—Brewer's sparrow, sagebrush sparrow, and sage thrasher—the populations of which are declining in many parts of their range. Abundance of the two sparrows decreased with increased density of natural gas wells, and all three songbird species experienced lower nest survival in areas with greater surrounding habitat loss due to natural gas infrastructure. The primary cause of nest failures in the study area is nest predation by rodents, which increased in abundance with natural gas development. The increased rodent abundance was not caused by a decrease in mesopredators. Current work is focused on the potential effects of altered herbaceous communities associated with reclaimed areas on rodent abundance, and the joint effects of climate variability and physical habitat loss due to energy development on songbird productivity.

Contact

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Publications

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Photograph by U.S. Geological Survey.

A male Brewer's sparrow singing from his sagebrush perch.

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Photograph by Todd Katzner, U.S. Geological Survey.

Horned lark.

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Alaska Marine and Avian Species

53. North Pacific Pelagic Seabird Survey Data

The USGS produced the North Pacific Pelagic Seabird Database, an online resource compiling the results of 40 years of surveys by biologists from the United States, Canada, Japan, and Russia. The database documents the abundance and distribution of 160 seabird and 41 marine mammal species over a 26-million-square-kilometer (10-million-square-mile) region of the North Pacific. This database offers a powerful tool for analysis and mitigation of anthropogenic effects on marine ecosystems of the Arctic and North Pacific, including the impacts of oil development and production, fisheries, and vessel traffic. It also creates an unprecedented opportunity to study the biogeography and marine ecology of dozens of species of seabirds and marine mammals throughout their range in Continental Shelf waters of the United States.

Contacts

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Publications

Renner, Martin, Salo, Sigrid, Eisner, L.B., Ressler, P.H., Ladd, Carol, Kuletz, K.J., Santora, J.A., Piatt, J.F., Drew, G.S., and Hunt, G.L., 2016, Timing of ice retreat alters seabird abundances and distributions in the southeast Bering Sea: Biological Letters, v. 12, no. 9, e20160276, https://doi.org/10.1098/rsbl.2016.0276.

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54. Status of Seabirds and Forage Fish in Cook Inlet, Alaska

Seabird densities in lower Cook Inlet are among the highest in Alaska, which is why seabird populations were decimated by the Exxon Valdez oil spill in 1989. Large resident and migratory seabird populations are sustained by locally abundant stocks of key forage fish species. Monitoring of seabird populations and forage fish stocks in potential oil and gas lease areas has been a BOEM priority, both to mitigate the impacts of development and to assess the impact of potential oil spills. Following intensive investigations of seabirds and forage fish in lower Cook Inlet during 1995–2000, the USGS initiated new studies in 2016 to update our knowledge in advance of potential lease sales and associated activities in Cook Inlet during 2017 and beyond. Ongoing studies are assessing changes in seabird and fish populations following the anomalous high temperatures in 2014–16.

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55. Gulf Watch Alaska Program for Quantifying Coastal Marine Ecosystem Change

Oil and gas development and transportation activities are major components of Alaska's economy, and some of that activity occurs along Alaska's coasts. The USGS is engaged in a collaborative marine monitoring program, Gulf Watch Alaska, which documents the status of coastal marine ecosystems, variation over time, and underlying drivers of observed change. This work quantifies abundance, distribution, and temporal variation in hundreds of marine species, including many of high interest to management agencies. This work provides context for understanding potential response of marine ecosystems to energy development relative to other sources of change.

Photograph by Sarah Schoen, U.S. Geological Survey.

Sea otter with pup in the Gulf of Alaska.

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Publications

Bowen, Lizabeth, Miles, A.K., Ballachey, Brenda, Waters, Shannon, Bodkin, James, Lindeberg, Mandy, and Esler, Daniel, in press, Gene transcription patterns in response to low level petroleum contaminants in *Mytilus trossulus* from field sites and harbors in southcentral Alaska: Deep Sea Research Part II—Topical Studies in Oceanography, corrected proof available online August 18, 2017, https://doi.org/10.1016/j.dsr2.2017.08.007.

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56. Long-Term Response of Wildlife to the Exxon Valdez Oil Spill in Alaska

The USGS has been heavily involved in studies documenting the effects and recovery of wildlife population from the 1989 Exxon Valdez oil spill in Alaska, particularly on sea otters and sea ducks. This work has resulted in a paradigm shift when considering the consequences of catastrophic oil spills, including appreciation that the effects for some species persisted well beyond the first weeks and months after the spill; for the most vulnerable species, effects were detectable for decades. Also, wildlife populations were affected by the Exxon Valdez spill through many different mechanisms, including the expected direct toxic effects, but also through more subtle, indirect pathways.

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Publications

Esler, Daniel, Ballachey, B.E., Matkin, C.O., Cushing, Daniel, Kaler, Robert, Bodkin, James, Monson, Daniel, Esslinger, G.G., and Kloecker, Kim, 2017, Timelines and mechanisms of wildlife population recovery following the Exxon Valdez oil spill: Deep Sea Research II— Topical Studies in Oceanography, corrected proof available online April 14, 2017, https://doi.org/10.1016/j.dsr2.2017.04.007.

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Marine and Terrestrial Animals

Understand Risks

57. Influence of Energy Development on Mule Deer Migrations

Migratory ungulates are often exposed to anthropogenic disturbance along their migration corridors. Understanding the influence of development on migratory behavior and phenology tracking (optimal foraging) is critical to successful planning and conservation. USGS scientists have used GPS collar data to evaluate the influence of development on behavior and phenology tracking of mule deer in western Wyoming. They found that deer increased movement rates under intense development conditions and shifted stopover areas away from development, but largely maintained fidelity to individual routes. Phenology tracking—the ability of deer to access the highest quality forage patches in the spring—declined over time in areas with rapidly expanding energy development. These results indicate that development in migration corridors may alter the behavior of migrating deer and diminish the foraging benefit of migration, with potential to cause long-term decline of migratory herds.

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Photograph by U.S. Geological Survey.

A scientist with the Wyoming Cooperative Fish and Wildlife Research Unit releases a collared mule deer.

58. Florida Manatee Movement and Habitat Use in the Northern Gulf of Mexico

The USGS is collecting data related to Florida manatee distribution and their use of habitat and travel corridors in the northern Gulf of Mexico (GOM). Manatees known to travel to the northern GOM are being captured for health assessment and tracked with GPS telemetry to acquire fine-scale habitat use and movement information. Field studies focus on characterization of local resources in areas with appropriate habitat or consistent manatee use. The data collected are being used to inform risk of interactions between manatees and vessels traveling through coastal areas to and from oil and gas structures.

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Photograph by Tom Scott, Florida Geological Survey, used with permission.

Florida manatee.

59. Gulf of Mexico Marine Assessment Program for Protected Species: Sea Turtles

The Gulf of Mexico Marine Assessment Program for Protected Species (GoMMAPPS) is a multiagency partnership between the BOEM, USFWS, National Oceanic and Atmospheric Administration (NOAA), and USGS with the goal of collecting broad-scale surveys for protected species to inform the distribution and abundance of marine animals across years and seasons. The USGS is leading efforts to provide information on abundance, distribution, and movement patterns of sea turtles. Some of the most severe gaps in knowledge of marine turtle ecology occur in areas of heavy oil and gas use, including BOEM's Central and Western Planning Areas. These data can be used in support of various BOEM/Bureau of Safety and Environmental Enforcement (BSEE) activities, including oil spill risk analysis, decommissioning of oil platforms, and movements of vessels.

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60. Sea Turtle Movements and Habitat Use in the Northern Gulf of Mexico

The USFWS and U.S. National Marine Fisheries Service (NMFS) identified that information on the distribution, seasonal movements, vital rates, and habitat use for all life stages of marine turtles is needed to recover these endangered species. The USGS is deploying satellite tags capable of logging dive data along with state-of-the-art acceleration data loggers on turtles to obtain fine-scale information on their dive profiles in the Gulf of Mexico. These data provide information on depth use, movement patterns, mortality risk, utilization of post-dredge sites, use of preferred thermal zones, and time spent near the vicinity of dredging activities which impacts mortality and entrainment risk of juveniles, sub-adults, and adult Kemp's ridleys, loggerheads, and green sea turtles. This study can directly address recovery and protection goals and provide information on in-water aggregations of sub-adult, juvenile, and adult marine turtles in the Gulf of Mexico.

Photograph by Thierry Work, U.S. Geological Survey.

Green sea turtle.

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61. Canid Distribution and the Potential Impacts of Energy Development in Nebraska

The USGS, in collaboration with the Nebraska Game and Parks Commission, the Nebraska Department of Roads, the Nebraska Environmental Trust, the U.S. Forest Service, Chadron State College, and the University of Nebraska, is implementing a comprehensive survey and monitoring plan for the swift fox across 67,000 square kilometers (26,000 square miles) of western Nebraska. The goal of the Nebraska Canid Project is to document the current distribution and ecological requirements of the swift fox and explore how infrastructure development may alter future habitat conditions and subsequently Nebraska's canid communities by creating and testing a series of predictive species distribution models. The resulting models can be used as a decision-support tool to assist policymakers and management agencies in future energy siting decisions.

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Photograph by U.S. Geological Survey Nebraska Cooperative Fish and Wildlife Research Unit.

Swift fox captured by a trail camera in western Nebraska.

62. Potential Effects of Wind Farms on Montane Carnivores in New England

With the increasing need for, and opportunities to site, wind farms in high-elevation New England forests, there is a need to understand the effects of the associated infrastructure on populations of animals otherwise expected to be impacted by climate change. A study by the USGS Northeast Climate Science Center was conducted to examine the effect wind farms would have on montane carnivores in New England with suggestions for siting, road construction, and minimized impacts on habitats considered climate refugia.

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Publication

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Measure Impacts

63. Quantifying Response of Pacific Walrus to Ocean Noise in the Arctic

Walruses spend the vast majority of their time in water. As with other marine mammals, their underwater acoustic environment enables them to communicate with one another and respond to disturbance. The USGS is using telemetry data and remote sensing information of sea ice and other environmental variables to study the effects of ocean noise from vessel traffic and offshore industrial activities on Pacific walrus activity patterns. Models are being developed to link levels of activity patterns to walrus energy expenditures and their potential effect on walrus rates of reproduction and survival. The results of these studies can be used to quantify the potential population-level impacts to walruses from offshore oil and gas development and associated support vessels off the coast of arctic Alaska.

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Publications

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64. Measuring Impacts of Industrial Activities on Polar Bears

The USGS is focused on characterizing changes in the abundance, distribution, and health of polar bears relative to human activities in the Arctic, with an emphasis on identifying critical habitats that are potentially at risk of disturbance from industrial activities along Alaska's arctic coast. This work has informed efforts of the Department of the Interior (DOI) agencies and industry when considering the consequences of oil spills and exposures to pollutants and actions to mitigate such occurrences. The USGS continues to work closely with its DOI and industry partners to identify circumstances in which industrial activities are likely to adversely affect polar bears. Future work is expected to focus on the potential for resource development activities on land and offshore to directly and indirectly affect polar bear behavior and health.

Photograph by U.S. Geological Survey.

Polar bear.

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Publications

McKinney, M.A., Atwood, T.C., Iverson, S.J., and Peacock, Elizabeth, 2017, Temporal complexity of southern Beaufort Sea polar bear diets during a period of increasing land use: Ecosphere, v. 8, no. 1, e01633, https://doi.org/10.1002/ecs2.1633.

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65. Pygmy Rabbit Presence and Abundance in Relation to Gas Field Development

Areas of the sagebrush steppe landscape, where gas field development is occurring, harbor 24 sagebrush-associated species of greatest conservation need. To examine the effects of gas field development density on pygmy rabbits, USGS scientists collected 3 years of survey data on pygmy rabbit site occupancy patterns at four major Wyoming gas fields. The study concluded that pygmy rabbits in southwestern Wyoming may suffer local population declines at lower levels of development than are allowed in existing plans and policies designed to conserve greater sage-grouse by limiting the surface footprint of energy development. Buried utilities, gas well pads, areas adjacent to well pads, and well pad access roads had the strongest negative correlation with pygmy rabbit presence and abundance. Minimizing the surface footprint of these elements may reduce negative impacts of gas energy development on pygmy rabbits.

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Publication

Germaine, S.S., Carter, S.K., Ignizio, D.A., and Freeman, A.T., 2017, Relationships between gas field development and the presence and abundance of pygmy rabbits in southwestern Wyoming: Ecosphere, v. 8, no. 5, e01817, 19 p., https://doi.org/10.1002/ecs2.1817.

Inform Solutions

66. Distribution and Abundance of Pacific Walrus in Relation to Offshore Development in Alaska

Increasing ice-free periods in the Arctic create greater opportunities for offshore oil and gas development in the Chukchi Sea, Alaska. These activities, and their reliance on onshore infrastructure and shipping, require information on the distribution of Pacific walrus and their habitats to identify ways for industry to operate effectively while meeting conservation goals set by government agencies. USGS scientists developed novel satellite radio tracking devices to map feeding areas used by walruses that were used by the U.S. Navy and by the U.S. Coast Guard for managing corridors of vessel transit. Scientists are now developing ways to use unmanned aircraft systems to estimate the abundance and distribution of Pacific walruses and their habitats in the Chukchi Sea. These studies have informed incidental take regulations and mitigation measures that can guide offshore development in minimizing their interactions with walrus foraging and resting areas.

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Publications

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Photograph by Tyrone Donnelly, U.S. Geological Survey.

Pacific walrus resting on a piece of sea ice in the Chukchi Sea.

67. Mitigating the Impacts of Energy Development on Polar Bears

USGS works closely with DOI agencies to identify science needs that inform mitigation actions from the impacts of energy development on polar bears. Science information collected by the USGS is used by (1) USFWS to guide regulations regarding the incidental take of polar bears by industry, (2) BLM to mitigate the effects of energy development on polar bears that den within the National Petroleum Reserve–Alaska, and (3) BOEM to guide decisions regarding permitting of offshore oil and gas exploration and extraction. Future USGS work is focusing on improving decision-making tools for these agencies to assess the relative importance of environmental and anthropogenic stressors to polar bear population persistence.

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Publications

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Photograph by Mike Lockhart, U.S. Geological Survey.

Aerial view of an industrial plant near the shore in Alaska, October 2009.

68. Effects of Changes in Coastal Florida Power Generation on Florida Manatees

The USGS, in collaboration with the Florida Fish and Wildlife Conservation Commission, completed a population viability analysis for the Florida manatee that included investigating threats to the persistence of the species. In coastal Florida, some manatees rely on warm-water effluents from power generation stations. These effluents are expected to disappear as plants reach the end of their operating lives, potentially exposing manatees to greater risk during the winter months. As part of the viability analysis, the USGS investigated the risk associated with different rates of loss of warm-water habitat for manatees associated with powerplant operations. The results suggested that, although loss of industrial warm-water effluent poses short-term risk to individual manatees, the long-term risk to the subspecies is small, producing only small increases in risk to the subspecies. In March 2017, the USFWS reclassified the West Indian manatee from endangered to threatened, based, in part, on the scientific analysis by the USGS.

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Publications

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Photograph by Bob Bonde, U.S. Geological Survey.

USGS researcher collects data on manatee in a Florida spring.

Photograph by Jeff Lovich, U.S. Geological Survey.

Desert tortoise with radio transmitter on a wind farm.

Desert Tortoise

69. Effects of Solar Development and Habitat Alterations on Desert Tortoises

The Ivanpah Valley in southeastern California and southern Nevada is a hotspot of genetic diversity and connectivity for Agassiz's desert tortoise that overlaps with utility-scale solar development. The USGS, University of Nevada at Reno, and partners are developing and applying novel tracking, genetic tagging, and biomarkers for assessing movement, health, and population connectivity in the valley relative to landscape features and renewable energy development that promote or impede population connectivity.

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Publications

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70. Interactions of Desert Tortoises With Wind Energy

From 1995 to 2013, the USGS has studied the ecology of a population of federally protected Agassiz's desert tortoises at a wind facility on land managed by the BLM near Palm Springs, California. To support recovery efforts for the species, almost 130 tortoises were marked between 1997 and 2000, providing a unique opportunity to examine the growth, demography, habitat selection, and survivorship of this long-lived species. Ongoing analyses of those data continue and are focused on the effects of turbine-induced fire on the ecology and behavior of tortoises, genetic characteristics of the population, and the apparent lack of significant recruitment into the population.

Contact

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Publications

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Photograph by U.S. Geological Survey.

A bobcat approaches a desert tortoise sleeping on the apron of her burrow. This image was taken with a motion-sensor camera placed facing the entrance of the burrow at a wind energy facility near Palm Springs, California.

Photograph by Jeff Lovich, U.S. Geological Survey.

Desert tortoise with a radio transmitter near Palm Springs, California.

71. Desert Tortoise Disease Risks Associated with Translocations

Renewable energy projects in southern California are frequently sited in desert tortoise habitat, creating the need to translocate tortoises to new areas. In a pre-translocation study of more than 1,000 desert tortoises in the central Mojave Desert, prevalence of upper respiratory tract diseases (URTD) was higher in tortoises living close to human settlements or towns. Bacterial-related URTD probably entered wild tortoise populations through released or escaped captive turtles and tortoises, in which such diseases are common. These findings have significant implications for wildlife and land management decisions regarding site selection for tortoise translocations.

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Publication

Berry, K.H., Coble, A.A., Yee, J.L., Mack, J.S., Perry, W.M., Anderson, K.M., and Brown, M.B., 2015, Distance to human populations influences epidemiology of respiratory disease in desert tortoises: Journal of Wildlife Management, v. 79, no. 1, p. 122–136, https://doi.org/10.1002/jwmg.816.

72. Shelter Choices for Tortoises During Temperature Extremes

Desert tortoises spend more than 90 percent of their lives underground in shelters that buffer the extremes of climate. To learn more about the characteristics of these shelters, USGS scientists monitored temperatures at 30 active burrows and dens used by adult desert tortoises in the Soda Mountains, California. Temperatures inside the shelters were largely influenced by tunnel length, width of the shelter openings, and soil cover. As tunnel length increased, the effects of temperature extremes were dampened and became more stable. With projected increasing temperatures, habitats with terrain and underlying surficial geology that sustain shelters with long tunnels and expanded openings could benefit desert tortoises. Managers may use these findings to make decisions about habitat for translocation, acquisition, connectivity, and other recovery efforts.

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Publication

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Photograph by Sarah Hanner, U.S. Geological Survey.

Adult male desert tortoise in central Mojave Desert, San Bernardino County, California.

Additional Publications About the Desert Tortoise

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Photograph by Shellie Puffer, U.S. Geological Survey.

A female Agassiz's desert tortoise, wearing a USGS radio, lounges in the entrance of her burrow at Joshua Tree National Park.

Pollinators

73. Impact of Biofuel Crop Production on Pollinators in the Northern Great Plains

The USGS, in cooperation with the U.S. Department of Agriculture (USDA), is quantifying how recent reductions in USDA conservation program enrollments affect pollinator habitat. Scientists are also developing a risk assessment model to identify what portions of the Northern Great Plains have undergone the most substantial land-use changes due to biofuel crop development while also supporting the highest density of commercial beekeepers. This study addresses several of the key information needs to better understand, minimize, and recover from pollinator losses.

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Publications

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Photograph by Sara Scott, U.S. Geological Survey.

Bee and musk thistle.

74. Taxonomic Characterization of Honey Bee Pollen Foraging

USGS scientists recently developed a genetic sequencing technique to identify pollen collected by foraging bees. The USGS is currently applying this technique to understand how land-use change and biofuel crop development affect forage for pollinators in agroecosystems. Together, this information can be used to evaluate specific plants that can be used in restoration programs for pollinators.

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Photograph by Marisa Lubeck, U.S. Geological Survey.

USGS Northern Prairie Wildlife Research Center partners with professional beekeepers in North Dakota to evaluate what plant species honey bees forage and when.

Publications

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75. Designing Conservation Seeding Mixes

USGS scientists are working closely with the USDA to quantify the benefits of USDA conservation lands for supporting healthy pollinator populations in the Northern Great Plains. In response to this need, the USGS developed the Pollinator Library (https://www.npwrc.usgs.gov/pollinator/), a tool for land managers to assist with conservation seeding mix design for land enhancement programs. This tool may be useful for restoring habitat for pollinators in areas where marginally productive lands are retired from biofuel crop production.

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Publications

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Fish and Other Aquatic Species

Understand Risks

76. Hydropower Effects on River Food Webs

A majority of river systems in the Western United States have been altered by the construction of hydroelectric dams that have created impoundments upstream and greatly altered the natural flow patterns downstream. USGS scientists developed a life history-hydrodynamic model to look at the effects of downstream regulated flow regimes on aquatic insect populations. Aquatic insects are a cornerstone of river food webs and can be a key indicator to the effects of altered flow regimes on the larger ecological river system. Modeled results show that flow regimes favoring hydroelectric-power generation create a scenario where many aquatic insects could be eliminated from downstream habitats.

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Publication

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Photograph courtesy of Dave Herasimtschuk, Freshwaters Illustrated.

Participants in a Grand Canyon Youth river trip deploy light traps along the banks of the Colorado River in the Grand Canyon (from Kennedy and others, 2016).

77. Vulnerability of Brook Trout Streams to Shale Gas Development in the Upper Susquehanna River Basin

The Upper Susquehanna River Basin drains portions of Pennsylvania and New York, and includes many high-quality and native brook trout streams. USGS and West Virginia University scientists are using spatial modeling approaches to assess the potential cumulative effects of unconventional oil and gas (UOG) development on high-quality brook trout streams in the Pennsylvania portion of the basin, which has experienced relatively recent, rapid increase in UOG development. Vulnerability models were developed that incorporate all stages of the UOG development process—infrastructure, drilling, spills, and water withdrawals—that may affect fish and other aquatic resources. These models incorporate measures of aquatic health and status to identify streams that are vulnerable to UOG development. This vulnerability framework can be applied to a variety of ecosystems or energy development scenarios.

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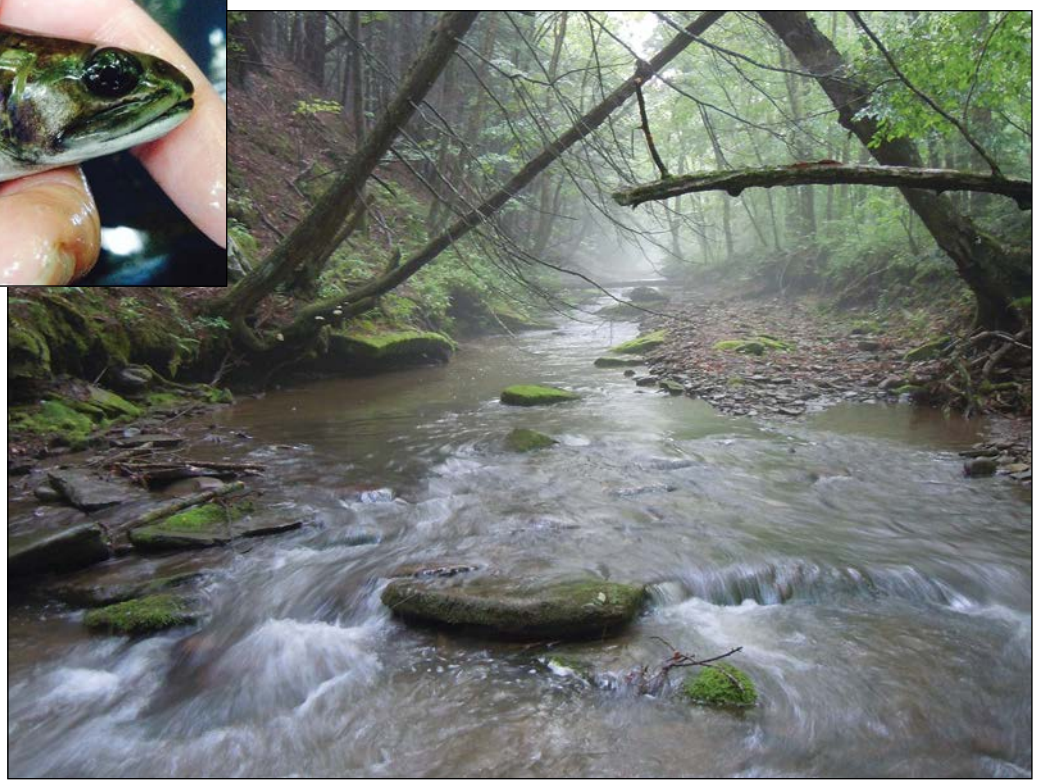
Photograph by Jeffrey Cole, U.S. Geological Survey.

Brook trout collected from a stream in Tioga County, Pennsylvania.



Photograph by Kelly Maloney, U.S. Geological Survey.

A brook trout stream during stormflow in Tioga County, Pennsylvania.

78. Legacy Brine Contamination From Oil Production Effects on Amphibian Survival

Historical oil production practices often released saline co-produced waters (brines) affecting wetland water quality directly or persisting in sediments in the Prairie Pothole wetlands in Montana and North Dakota. USGS scientists are using a combination of laboratory experiments and field surveys to (1) assess variation in survival of larval amphibians; (2) determine effects of brine contamination on amphibian distribution and abundance; (3) characterize microbial community structures in wetland sediments, water, and on amphibian skin (microbiome); and (4) measure persistence of contaminants (metals) in wetland sediments and amphibian tissues. Combined with other information on ecological community structure and function, the study results could help inform future practices for brine disposal and provide meaningful targets for habitat restoration.

Photograph by Blake Hossack, U.S. Geological Survey.

Northern leopard frog tadpole collected from a pond in North Dakota.

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Publication

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Photograph by Blake Hossack, U.S. Geological Survey.

Wetland near oil production site in the Prairie Pothole region of North Dakota.

Measure Impacts

79. Effects of Dam Operations on Tailwater Fisheries

Nonnative rainbow trout were introduced to the Colorado River downstream from Glen Canyon Dam in 1964 shortly after the dam was completed. The objective of this and other nonnative fish introductions was to create recreational sport fisheries. Dam operations can affect the growth, survival, and distribution of this important sportfish. USGS scientists conducted a large-scale mark-recapture study to determine the cause for long-term trends in rainbow trout growth and abundance as well as the effects of normal operations and experimental floods on downstream movement. High and steady flows resulted in large levels of recruitment while movement rates were low and unaffected by flows including experimental floods.

Photograph by Kyrie Fry, U.S. Geological Survey.

Colorado River downstream from the Glen Canyon Dam.

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Publications

Korman, Josh, Yard, M.D., and Kennedy, T.A., 2017, Trends in rainbow trout recruitment, abundance, survival, and growth during a boom-and-bust cycle in a tailwater fishery: Transactions of the American Fisheries Society, 53 p., https://doi.org/10.1080/00028487.2017.1317663.

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80. Effects of Dam Operations on Endangered Fishes

Glen Canyon Dam operations affect downstream environmental conditions of the Colorado River in Glen and Grand Canyons which, in turn, can affect resident aquatic species like fish. USGS scientists assessed the effects of temperature, turbidity (murkiness), food availability, flow variability, and nonnative fish abundance on endangered humpback chub. Growth models showed that environmental conditions like temperature and duration of turbidity best described growth in subadult humpback chub. Understanding the relative importance of various environmental factors on humpback chub allows managers to make informed decisions regarding the operation of Glen Canyon Dam and management actions intended to facilitate the recovery of this endangered species.

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Publication

Dzul, M.C., Yackulic, C.B., Korman, Josh, Yard, M.D., and Muehlbauer, J.D., 2016, Incorporating temporal heterogeneity in environmental conditions into a somatic growth model: Canadian Journal of Fisheries and Aquatic Sciences, v. 74, no. 3, p. 316–326, https://doi.org/10.1139/cjfas-2016-0056.

81. Fish Passage and Survival Through Diversion Dams

Diversion dams can negatively affect emigrating juvenile salmon populations because fish must pass through the impounded river created by the dam, negotiate a passage route at the dam, and emigrate through a riverine reach that has been affected by reduced river discharge. To quantify the effects of a main-stem diversion dam on juvenile Chinook salmon, USGS scientists used radio telemetry to understand how dam operations and river discharge downstream from the dam affected route-specific passage and survival.

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Publications

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82. Toxicity Associated With Produced Waters From Oil and Gas Activity in the Bakken Region

A significant spill related to oil and gas activity was reported on Blacktail Creek, Williams County, North Dakota, in late 2014. The USGS investigated potential effects on aquatic resources related to this spill by conducting in situ bioassays with newly hatched fathead minnows on Blacktail Creek in 2015 and 2016. Significant mortality was observed in 2015, but not during 2016. A laboratory toxicity test with reconstituted water mimicking the water quality in the contaminated site water indicated that elevated major ions in the contaminated surface water were toxic to fish and invertebrates. The USGS is also examining the effects of historic brine contamination related to oil and gas activity with waters collected from the Goose Lake National Wildlife Refuge in Montana. The effects of site waters on the growth of duckweed are being investigated as part of this study. Results can provide insight into the effects of oil brines on aquatic plants, an important rearing area for migratory waterfowl.

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Publication

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Photograph by Aïda Farag, U.S. Geological Survey.

Site of toxicity documented on Blacktail Creek, North Dakota, in 2016.

Inform Solutions

83. Behavioral Studies of Fish Routed Around a Hydroelectric Dam in the North Fork Reservoir

USGS scientists used acoustic cameras to assess the behavior and abundance of bull trout-size fish at the entrance to the North Fork Reservoir juvenile fish floating surface collector (FSC). The purpose of the FSC is to collect downriver migrating juvenile salmonids at the North Fork Dam and safely route them around the hydroelectric projects. The objective of the acoustic camera component of this study was to assess the behaviors of bull trout-size fish observed near the FSC and to determine if the presence of bull trout-size fish influenced the collection or abundance of juvenile salmonids.

Contact

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Publication

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84. Feasibility of Reintroducing Anadromous Salmonids to Reservoirs Above High-Head Dams

Reintroductions of anadromous salmonids above formerly impassable hydroelectric dams are being proposed to mitigate the loss of access to habitat and fish production due to blocked upstream passage. The USGS evaluated the carrying capacity in three hydropower reservoirs on the Lewis River in Washington to determine if they can support reintroduced populations of juvenile spring Chinook salmon and other salmonids by analyzing consumption demand and seasonal food availability. In addition, scientists evaluated the potential predation mortality to juvenile anadromous salmonids. These studies highlight the importance of quantitatively evaluating trophic interactions within reservoirs slated for reintroduction, because they serve both as functional migration corridors and offer profitable juvenile-rearing habitats despite hosting abundant predator populations. This information benefits fisheries managers and power operators by determining the net production potential of habitats proposed for reintroduction of fish species before major investments are committed. Moreover, this approach can identify options for design and operations of hydropower facilities that could satisfy power demand while minimizing impacts to aquatic resources.

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Publications

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85. Informing Fish Passage Decisions at the Yale and Merwin Projects on the Lewis River

Fragmentation has been identified as one of the major factors limiting salmon populations; however, stream networks above hydropower facilities often represent suitable habitat for reintroductions, particularly in the context of habitat integrity and reaches with suitable thermal regimes. As such, numerous hydropower facilities continue to plan strategies to move salmon around hydropower facilities in the absence of volitional passage. Salmon reintroductions, however, represent a substantial resource commitment, and identifying the means to maximize the effectiveness and sustainability of salmon reintroductions is critical. Here, we conducted a suite of behavioral, habitat, demographic, and community-interaction studies to evaluate the potential risks and benefits of anadromous reintroductions in the Lewis River, Washington. In addition, we considered the risks to extant native populations of salmonids such as bull trout, which are currently listed under the ESA.

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Publication

Al-Chokhachy, Robert, Clark, Christopher, Sorel, Mark, and Beauchamp, David, 2015, Development of new information to inform fish passage decisions at the Yale and Merwin Projects on the Lewis River: Bozeman, Mont., U.S. Geological Survey Northern Rocky Mountain Science Center, 333 p., http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Hydro/Hydro_Licensing/Lewis_River/li/acc/LR_New_Inform_Progress_Report_August_2015.pdf.

86. Structured Decision Making for the Management of Glen Canyon Dam

The USGS, in cooperation with the U.S. Bureau of Reclamation (BOR), NPS, and Argonne National Laboratory, provided an analysis of the long-term management of water releases from Glen Canyon Dam in northern Arizona and associated management activities. Two primary decision analysis methods—multicriteria decision analysis and the expected value of information—were used to evaluate resource goals and the influence of uncertainty by the various alternative plans. This information was used by the BOR and NPS in their evaluation of management alternatives for the Glen Canyon Dam Environmental Impact Statement, and the decision analysis was included as an Appendix to the Environmental Impact Statement. In December 2016, the Secretary of the Interior signed a Record of Decision, choosing a 20-year management plan for Glen Canyon Dam.

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Publication

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87. Full-Scale Development and Evaluations of Fish Passage Structures and Fish Behavior

Many migratory fish species have been in decline worldwide due in large part to dams and poorly designed fishways that prevent fish from reaching spawning and feeding grounds. The USGS S.O. Conte Anadromous Fish Research Center laboratory's unique large-scale flume facility enables scientists and engineers to design and test full-scale upstream- and downstream passage structures under semicontrolled conditions with actively migrating test species. Working in collaboration with the USFWS, the NMFS, the U.S. Department of Energy (DOE), and State agencies, the USGS is improving and developing new fish passage designs and technologies, and also identifying behaviors and hydraulics that inform design criteria for successful passage. The goal of this work is to restore self-sustaining populations of migratory fish while maintaining a balance between energy production, water management, and ecosystem restoration.

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Photograph by Mona Khalil, U.S. Geological Survey.

Large-scale flume facility at the USGS S.O. Conte Anadromous Fish Research Center in Turner Falls, Massachusetts.

88. Biotelemetry Studies of Fish Behavior and Passage Through Dams

Understanding and quantifying fish behavior is essential for understanding fish passage problems and developing effective passage solutions across hydropower dams and other manmade barriers. Biotelemetry (radio and acoustic telemetry) has emerged as the method of choice for acquiring detailed, individual-based data for quantifying passage and underlying critical fish behaviors. Working in collaboration with the USFWS, the NMFS, the DOE, and State agencies, the USGS S.O. Conte Anadromous Fish Research Center laboratory has adapted and developed advanced telemetry technologies for studies of fish passage and developed advanced statistical methods for data analysis to expand the toolbox of available telemetry techniques used for fish passage evaluations. These advances maximize the return on these labor- and cost-intensive studies to improve efficiencies in integrating fish behavior with the hydraulic and physical characteristics of passage structures, thus improving passage design.

Photograph by Mona Khalil, U.S. Geological Survey.

Scientists remove American shad from a transport tank and tag each fish with a transmitter device to test their movement behavior in the flume facility.

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89. Risks and Benefits of Actively Managing a Small Bull Trout Population

Habitat fragmentation is one of the major factors contributing to the declines in distribution and abundance of many native salmonid species, including bull trout. Increasingly, managers are considering options to maintain and enhance the persistence of isolated local populations of bull trout through active management strategies. Understanding the ecological costs and benefits of such actions is a necessary step to achieve conservation goals. Here we used an individual-based model to evaluate population-level risks and benefits of an ongoing management program aimed at mitigating the anthropogenic fragmentation of the lower Clark Fork River in Montana due to hydropower facilities.

Photograph by Jonny Armstrong, used with permission.

Native Westslope cutthroat trout and bull trout swim in the cool waters of the Flathead River near Glacier National Park, Montana.

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Publication

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90. Optimizing Hydropower Operations to Reduce Eel Mortality and Turbine Shutdown

Hydroelectric dams are one of the contributing causes of freshwater eel declines by causing migratory delays and turbine mortality. An inherent tradeoff underlies turbine management where the competing demand for more hydropower comes at the expense of eel survival. A win-win solution exists when an option performs better on all competing demands compared to other options. Scientists with the USGS, USFWS, and North Carolina State University created a predictive model for silver American eels migration based on a recent telemetry study to develop decision rules for turbine management in the Shenandoah River system. The performance of alternative decision rules was compared to the status quo policy to search for win-win solutions. A range of cutoff probabilities resulted in a win-win situation with both reduced eel mortality and increased turbine operation relative to the current shutdown strategy. Monitoring of the implementation is needed to evaluate and update the predictive model and to refine the decision rule. Although the decision is framed for the Shenandoah River system, the analytical approach could be used to develop decision rules for turbine shutdown policy in other areas.

Photograph by Heather Galbraith, U.S. Geological Survey.

Young American eels, such as the one pictured here, are beginning to recolonize streams in Shenandoah National Park after the removal of a dam more than 145 kilometers (90 miles) downstream.

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Publications

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91. Using Genomics to Better Understand Habitat Use of the Atlantic Sturgeon

The Atlantic sturgeon is listed as endangered under the ESA. The BOEM requires information on the ecology of this species to understand the potential impacts from offshore energy development and fulfill obligations required under Federal laws including the National Environmental Policy Act, Magnuson-Stevens Fishery Conservation and Management Act, and ESA. Atlantic sturgeon use of coastal waters is poorly understood. The USGS is developing genomics tools aimed at providing a cost-effective, high-resolution approach for characterizing population structure and demographics. The USGS has assembled and annotated the complete mitochondrial genome of both the Atlantic and Gulf sturgeon which can now be used to detect Atlantic and Gulf sturgeon DNA sampled from water (referred to as environmental DNA or eDNA). These techniques can allow large numbers of sturgeon to be assigned to their river and distinct population segment of origin, and facilitate accurate assessments of impact

Photograph by Virginia State Parks staff, licensed under Creative Commons Attribution 2.0 Generic.

Altantic sturgeon.

on Atlantic sturgeon populations. These approaches are widely applicable to stock and impact assessments for a wide variety of imperiled or other species of management concern.

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92. Developing Selective Fish Passage to Block Invasive Sea Lamprey

The sea lamprey is an invasive, parasitic fish species in the Great Lakes, causing damage to recreational and commercial fisheries estimated at $7 billion annually. USGS scientists, in collaboration with the Great Lakes Fisheries Commission, University of Massachusetts, Michigan State University, and the University of Guelph, are evaluating velocity-based barriers, nonstick surfaces, and other strategies that take advantage of the relatively poor swimming abilities of lamprey. The goal is to develop selective fish passage that would block the passage of sea lamprey while allowing desirable fish species to pass through unharmed.

Photograph by Mona Khalil, U.S. Geological Survey.

Selective fish passage surfaces are tested in a flow device at the S.O. Conte Anadromous Fish Research Center to block sea lamprey movement across fish passageways.

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Publications

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93. Aquatic Invasive Species Control Efforts and Dam Operations

Nonnative fishes, some potentially invasive, have been introduced in impoundments throughout the United States to create recreational fishing opportunities. The passage of individual fish and other aquatic organisms through dams as part of hydropower operations can lead to invasions of unwanted species. USGS scientists are developing and testing the feasibility of using methods such as liquid ammonia, carbon dioxide, and sound to eradicate undesirable species upstream and downstream from dams. In one example, green sunfish were successfully eradicated from the Colorado River downstream from the Glen Canyon Dam, thus allowing managers to move forward with an experimental flood without the risk of further spreading an aquatic invasive species in the Colorado River. Current efforts focus on several fish and mollusks, including four species of nonnative Asian carp, Round Goby, and Dreissenid mussels (quagga mussels and zebra mussels).

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94. Natural Salmon Recolonization Following Condit Dam Removal

Condit Dam on the White Salmon River, Washington, was breached in 2011 and removed completely in 2012, allowing anadromous salmonids access to habitat that had been blocked for nearly 100 years. A multiagency workgroup concluded that the preferred salmonid restoration alternative was natural recolonization with monitoring to assess efficacy, followed by a management evaluation 5 years after dam removal. In 2016, USGS scientists, in cooperation with the Mid-Columbia Fisheries Enhancement Group, assessed juvenile salmonid diversity, distribution, and abundance. The 2016 efforts provided the first post-dam smolt and juvenile abundance estimates for coho salmon and steelhead as well as the first documentation of coho salmon juvenile production in tributaries upstream from the former Condit Dam site. This monitoring effort can help to better understand abundance trends, distribution, and life history patterns of recolonizing salmonids in the White Salmon River and assess efficacy of natural recolonization to inform management decisions.

Photograph by Steven Clark, Bureau of Land Management.

A spawning coho salmon with fins just above the water surface. Female coho select breeding sites on the basis of specific characteristics that offer protection and desired habitat for juveniles.

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Publication

Jezorek, I.G., and Hardiman, J.M., 2017, Juvenile salmonid monitoring in the White Salmon River, Washington, post-Condit Dam removal, 2016: U.S. Geological Survey Open-File Report 2017–1070, 34 p., https://doi.org/10.3133/ofr20171070.

95. Monitoring Total Dissolved Gas in Hydropower Dams Spills

Spill water from dams contains supersaturated dissolved gases. High dissolved gases increase mortality to fish below dams. The USGS, in cooperation with the U.S. Army Corps of Engineers (USACE), monitors total dissolved gas at USACE-owned dams in the Columbia and Willamette River systems. The data from the study are used in real time by USACE dam operators to ensure spills are within the acceptable range of total dissolved gas.

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Resources

USGS National Water Information System database
(https://waterdata.usgs.gov/or/nwis/current/?type=usacetdg&group_key=basin_cd);

USGS Oregon Water Science Center Lower Columbia River Dissolved Gas Monitoring Network
(https://or.water.usgs.gov/projs_dir/pn307.tdg/)

96. Maintenance of Instream Flows and Water Temperatures for Salmon Egg Incubation

The USGS, in cooperation with the Alaska Energy Authority (AEA), collects and analyzes streamflow, water temperature, and intragravel water temperature downstream from the Bradley Lake dam. To protect salmon egg incubation habitat during the winter, a minimum discharge of 1.3 cubic meters per second (40 cubic feet per second) in the lower river is maintained. This minimum flow determination was based on an open-water instream flow study that did not take into account the effects of ice formation, which is fatal to eggs. Data are collected to determine if below-freezing temperatures occur at depths 25 to 30 centimeters (10 to 12 inches) below the streambed. These data can be used to determine if the minimum instream flow is sufficient to maintain above-freezing temperature in the streambed and allow for salmon egg incubation.

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Photograph by U.S. Geological Survey.

Aerial view of the Elwha River upstream from the dam removal site.

97. Improving Stream Temperature With Modification to Hydropower Dam Operation

The USACE has more than 10 dams in the Willamette watershed. The Willamette Basin biological opinion requires the USACE to assess the feasibility of developing project-specific alternatives for achieving fish passage as well as improved long-term temperature control downstream from these dams. The USGS is using existing models to simulate the effects of structural and operational scenarios and follow the effects downstream. The USACE can use this information to determine the ways in which structural and (or) operational changes to dams can improve downstream water temperature and flow conditions for endangered fish species.

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Photograph by U.S. Army Corps of Engineers.

Dam operators for the Detroit Dam on the North Santiam River in Oregon use temperature sensors for direct operational feedback, altering dam operations to create a more-natural seasonal temperature pattern downstream for fish.

98. Land Use and Microhabitat Effects on Salamanders in the Central Appalachian Coalfields

The USGS, in cooperation with Virginia Polytechnic Institute and State University, is investigating the utility of using aquatic salamander surveys as a surrogate for costly and complex macroinvertebrate surveys to assess post-mining stream recovery and health in the Central Appalachian coalfields. Some salamander species are identified as tolerant to stream habitat and water-quality degradation while others are only found in streams with high biological integrity. These characteristics allow for a quicker, more cost effective way for scientists and managers to score aquatic health and determine watershed status. Scientists are also examining connections between spatial and land-use data with both salamanders and macroinvertebrates that may result in the development of a stronger watershed assessment tool using spatial imagery matched with water-quality parameters, such as conductivity and total dissolved solids, for large portions of the Central Appalachian coalfields.

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Publications

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Wildlife Habitats and Ecosystem Functions

99. Opportunities for Restoring Monarch Butterfly Habitat in the Midwestern United States

Monarch butterflies have declined by as much as 80 percent over the last 20 years, in large part because of declines in milkweed, the plant monarchs rely upon for breeding. The USGS, University of Arizona, and partners developed scenarios for incorporating approximately 1.6 billion new milkweed stems into the Midwestern U.S. landscape, the number needed to help restore the eastern migratory monarch population. Scientists evaluated five land-cover sectors to determine the current and potential future ability of the land to support milkweed, including utility and transportation rights-of-way land. They found that converting marginal cropland to monarch-friendly habitat provides the best opportunity for adding milkweed, but emphasize that planting milkweed in other types of lands, including protected areas and urban and suburban locations, is likely necessary to reach project goals.

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Publication

Thogmartin, W.E., López-Hoffman, Laura, Rohweder, Jason, Diffendorfer, Jay, Drum, Ryan, Semmens, Darius, Black, Scott, Caldwell, Iris, Cotter, Donita, Drobney, Pauline, Jackson, L.L., Gale, Michael, Helmers, Doug, Hilburger, Steve, Howard, Elizabeth, Oberhauser, Karen, Pleasants, John, Semmens, Brice, Taylor, Orley, Ward, Patrick, Weltzin, J.F., and Wiederholt, Ruscena, 2017, Restoring monarch butterfly habitat in the Midwestern U.S.—'all hands on deck': Environmental Research Letters, v. 12, no. 7, http://iopscience.iop.org/article/10.1088/1748-9326/aa7637.

Photograph by Alan M. Cressler, U.S. Geological Survey.

A monarch butterfly feeding on an aster in Pickens County, South Carolina.

100. Long-Term Recovery of Vegetation Along Utility Lines

Renewable energy development in the Mojave Desert involves the construction of transmission lines and other linear disturbances in Mojave and Sonoran vegetation. Recovery of habitat along linear disturbances requires decades, if not centuries. Although cover of shrubs, grasses, and annual plants in the Mojave Desert may occur relatively quickly several decades after disturbance, the composition of the plants does not, especially annual plants. Restoring the original composition and diversity remains a challenge to specialists and is likely to require more time when livestock graze a site, a road is adjacent, and with

increasing local temperatures. Knowledge about the pioneering roles of plant species, their association with other species (for example, nurse species), and successional stages can be applied to truncate the restoration and recovery process. The findings from these studies can be applied to restoration projects in disturbed creosote bush, tree yucca, and other vegetation alliances in the Mojave and other deserts.

Contact

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Publications

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101. Effects of Energy Development on Environmental Resources of the Williston Basin

Energy development within the Williston Basin, especially development focused on the Bakken Formation, has led to unprecedented natural, social, and cultural change across the Northern Great Plains. This development is expected to continue for at least the next 50 years as energy companies and scientists continue to discover new mineral-producing horizons and innovative technologies for extraction. The USGS developed a report in concert with the Bakken Federal Executive Group to review and synthesize the existing information about air, water, and wildlife resources that may be relevant in understanding the potential effects of oil and gas development in the Williston Basin.

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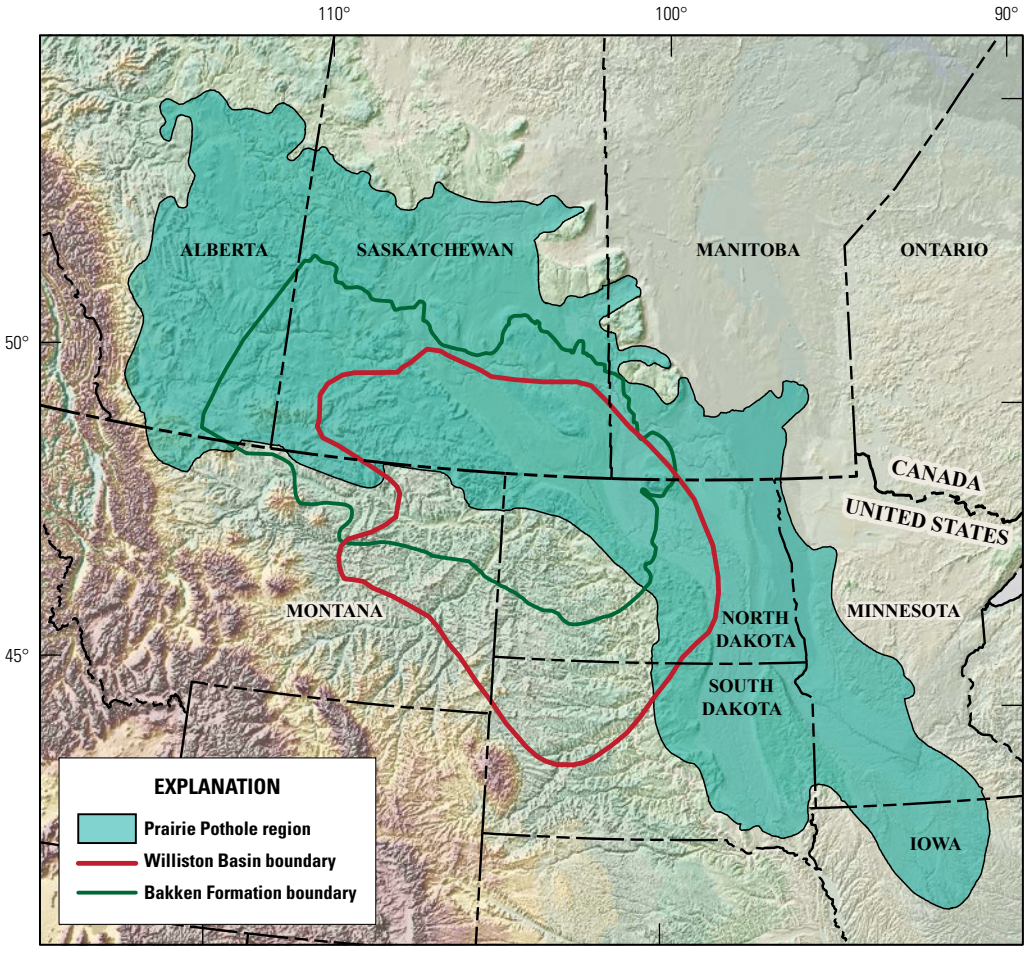

The Williston Basin of Montana and North Dakota is a leading source of domestic oil and gas (from Dennerline and Childs, 2017).

102. Evaluating Bioenergy Opportunities in the Southwest

The USGS is collaborating with the USDA Arid Land Agricultural Research Center and Ohio University regarding the potential for agave biofuel production to add to our national bioenergy portfolio in marginally productive lands. Agave may represent a highly efficient biofuel, even under nonirrigation conditions, but the ecosystem consequences of this development on drylands, including habitat and wildlife, remains unknown. The project aims to explore the potential benefits and drawbacks of biofuel production in the Southwest as an alternative energy source and strategy.

Photograph by Sasha Reed, U.S. Geological Survey.

Agave plants at a U.S. Department of Agriculture experimental plot site near Phoenix, Arizona.

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Publications

Tucker, C.L., and Reed, S.C., 2016, Low soil moisture during hot periods drives apparent negative temperature sensitivity of soil respiration in a dryland ecosystem—A multi-model comparison: Biogeochemistry, v. 128, nos. 1–2, p. 155–169, https://doi.org/10.1007/s10533-016-0200-1.

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Smith, W.K., Cleveland, C.C., Reed, S.C., Miller, N.L., and Running, S.W., 2012, Bioenergy potential of the United States constrained by satellite observations and existing productivity: Environmental Science and Technology, v. 46, no. 6, p. 3536–3544, https://doi.org/10.1021/es203935d.

103. Land-Cover Changes Associated With Recent Energy Development in the Williston Basin

The Williston Basin in the Northern Great Plains has experienced rapid energy development since 2000. USGS scientists evaluated land-cover changes from recent (2000–15) development and found that the development had converted 12,990 hectares (50 square miles) of predominantly agricultural or prairie land and had disturbed an additional 12,121 hectares (47 square miles). Future land-cover changes are forecasted to be 2.7 times greater than the evaluated period based on the number of wells expected by 2050 as reported by the North Dakota Department of Mineral Resources in 2014 (https://www.dmr.nd.gov/oilgas/presentations/NDOGCPC091814.pdf). Although future development may result in substantial land-cover change, evolving industry practices and proactive siting decisions, such as development along energy corridors and placing pads in areas previously altered by human activity, have the potential to reduce the ecological effects of future energy development in the Williston Basin.

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Publication

Preston T.M., and Kim, Kevin, 2016, Land cover changes associated with recent energy development in the Williston Basin, Northern Great Plains, U.S.A.: Science of the Total Environment, v. 566–567, p. 1511–1518, https://doi.org/10.1016/j.scitotenv.2016.06.038.

104. Ecological Effects of Brine Contamination in the Prairie Pothole Region

Energy production in the Williston Basin results in the co-production of highly saline water, or brine. USGS researchers examined the effects of contamination from production waters derived from oil and gas development on macroinvertebrate communities and above-ground biomass and plant tissue chemistry of hardstem bulrush. Scientists sampled 10 wetlands across a contamination gradient in the Prairie Pothole Region (PPR) and collected samples to determine macroinvertebrate taxonomic richness, biomass, and plant tissue chloride concentrations. Across this gradient, a significant decrease in taxonomic richness and biomass of hardstem bulrush as well as an increase in plant tissue chloride concentration was documented with increased co-produced water contamination. These results can provide information on potential effects of production brine on primary productivity and benthic biota in PPR wetlands.

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Publication

Preston, T.M., and Ray, A.M., 2017, Effects of energy development on wetland plants and macroinvertebrate communities in Prairie Pothole Region wetlands: Journal of Freshwater Ecology, v. 32, no. 1, p. 29–34, https://doi.org/10.1080/02705060.2016.1231137.

Photographs by Rachel Harrington, U.S. Geological Survey.

Insect traps in a wetland in North Dakota's Prairie Pothole Region.

105. Shifts in Microbial Resistance Mechanisms in Surface Waters Impacted by Unconventional Oil and Gas (UOG) Wastewaters

The USGS and Rutgers University identified the environmental health impacts of UOG wastewater disposal activities using microbiomes as a proxy for ecological shifts. Microbiomes were assessed in stream samples at a West Virginia injection well disposal site, including sites upstream, on, and downstream from the disposal facility, and a background site in a separate drainage, by using metagenomics and quantitative polymerase chain reaction (PCR) for antibiotic resistance genes. Microbial communities and antibiotic resistance profiles shifted at impacted sites, and antibiotic resistance genes were found to be less abundant than in municipal wastewater. This study helps identify changes in the microbial community in an environment impacted by UOG wastewater. Shifts in microbial function can alter ecosystem processes, such as nutrient cycling, and can alter the resiliency of a community to perturbation.

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Publication

Fahrenfeld, N.L., Delos Reyes, Hannah, Eramo, Alessio, Akob, D.M., Mumford, A.C., and Cozzarelli, I.M., 2016, Shifts in microbial community structure and function in surface waters impacted by unconventional oil and gas wastewaters revealed by metagenomics: Science of the Total Environment, v. 580, p. 1205–1213, https://doi.org/10.1016/j.scitotenv.2016.12.079.

106. Biogeochemistry and Toxicology of a Stream Impacted by Unconventional Oil and Gas (UOG) Wastewater Disposal Operations

The USGS assessed the inorganic and organic chemistry and cell line toxicity in stream samples at a West Virginia injection well disposal site, including sites upstream, on, and downstream from the disposal facility, and at a background site in a separate drainage. Sites downstream from the UOG wastewater disposal facility contained inorganic and organic compounds in both water and sediments that were consistent with a source from UOG wastewater. Toxicological assays of human cell line exposures to water and sediment showed minimal effects. Results indicated that UOG wastewater had entered the stream; however, the contamination level was low and appeared to be restricted to sites immediately downstream from the disposal facility.

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Publications

Orem, William, Varonka, Matthew, Crosby, Lynn, Haase, Karl, Loftin, Keith, Hladik, Michelle, Akob, D.M., Tatu, Calin, Mumford, Adam, Jaeschke, Jeanne, Bates, Anne, Schell, Tiffany, and Cozzarelli, Isabelle, 2017, Organic geochemistry and toxicology of a stream impacted by unconventional oil and gas wastewater disposal operations: Applied Geochemistry, v. 80, p. 155–167, https://doi.org/10.1016/j.apgeochem.2017.02.016.

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107. Terrestrial Impacts of Mountaintop Mining

Ecological research on mountaintop mining has been focused on aquatic impacts because the overburden, or mountaintop, is disposed of in nearby valleys, which leads to a wide range of water-quality impacts on streams. Numerous impacts on the terrestrial environment from mountaintop mining also have been largely overlooked, even though they are no less wide ranging, severe, and multifaceted. USGS scientists are reviewing the impacts of mountaintop mining on the terrestrial environment by exploring six broad themes: the loss of topographic complexity, forest loss and fragmentation, forest succession and soil loss, forest loss and carbon sequestration, biodiversity, and human health and well-being. These studies can assist managers and regulators in evaluating the full impacts of mountaintop mining by complementing existing research focused on impacts to aquatic environments.

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Publications

Williams, J.M., Brown, D.J., and Wood, P.B., 2017, Responses of terrestrial herpetofauna to persistent, novel ecosystems resulting from mountaintop removal mining: Journal of Fish and Wildlife Management, prepublication early view, http://fwspubs.org/doi/abs/10.3996/102016-JFWM-079?code=ufws-site.

Wickham, James, Wood, P.B., Nicholson, M.C., Jenkins, William, Druckenbrod, Daniel, Suter, G.W., Strager, M.P., Mazzarella, Christine, Galloway, Walter, and Amos, John, 2013, The overlooked terrestrial impacts of mountaintop mining: BioScience, v. 63, no. 5, p. 335–348, https://doi.org/10.1525/bio.2013.63.5.7.

108. Bioenergy Production and Landscape Change in the Southeastern United States

The production of woody biomass for bioenergy has the potential to cause substantial landscape change and related effects on forest ecosystems, yet the landscape effects of alternative production scenarios have not been fully assessed. In a recent study, USGS researchers simulated landscape change from 2010 to 2050 under five scenarios of woody biomass production for wood pellets and liquid biofuels in North Carolina, a region that is a substantial producer of wood biomass for bioenergy and contains high biodiversity. Another USGS study used a forest economics model, spatially explicit state-and-transition simulation models, and species-habitat models to project change in habitat amount for 16 wildlife species from reaching a renewable fuel target and expected demand for wood pellets in North Carolina. These studies show that bioenergy feedstock portfolio decisions may affect landscape-scale impacts on wildlife habitat among species.

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Publications

Costanza, G.K., Abt, R.C., McKerrow, A.J., and Collazo, J.A., 2016, Bioenergy production and forest landscape change in the Southeastern United States: GCB Bioenergy, unpaginated, https://doi.org/10.1111/gcbb.12386.

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Photograph by Tanya Schoenhoff, U.S. Geological Survey.

Evening sunset over the mountains in Waynesville, North Carolina.

109. Predicting the Effects of Wave Energy Facilities on Nearshore Ecosystems

The USGS is investigating the possible effects of wave energy conversion (WEC) devices on nearshore ecosystems, such as kelp forests. WEC devices pull potential energy from the rise and fall or surge of open ocean swells and convert it into energy for human use. WEC devices can affect the local environment through noise, hazard, construction, anchoring, animal entanglement, turbulence, sedimentation, fouling, and reduction in wave height. Results from these studies can help BOEM determine the degree to which WECs affect currents and other physical features of the marine environment. BOEM anticipates receiving applications for WEC devices on the Pacific Outer Continental Shelf in the coming years.

Photograph by National Park Service.

Giant kelp forest near the Channel Islands.

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Conservation and Energy Development Planning Tools

110. Sensitive and Rare Plant Distributions and Energy Development in the Colorado Plateau

USGS scientists have developed optimization models to identify lands where management and conservation conflicts between energy development and sensitive and rare plant species could be minimized. As part of this effort, scientists organized existing data on 21 federally listed, rare and sensitive plant species in the Colorado Plateau. Scientists also are collecting new data on plant locations and developing distribution models, indicating the likelihood of plants being present in specified locations. The plant species distribution models are being analyzed in relation to existing and proposed renewable and oil and gas energy development in the Colorado Plateau. Results from this study can help decision makers select variable risk strategies depending on desired management and energy development goals.

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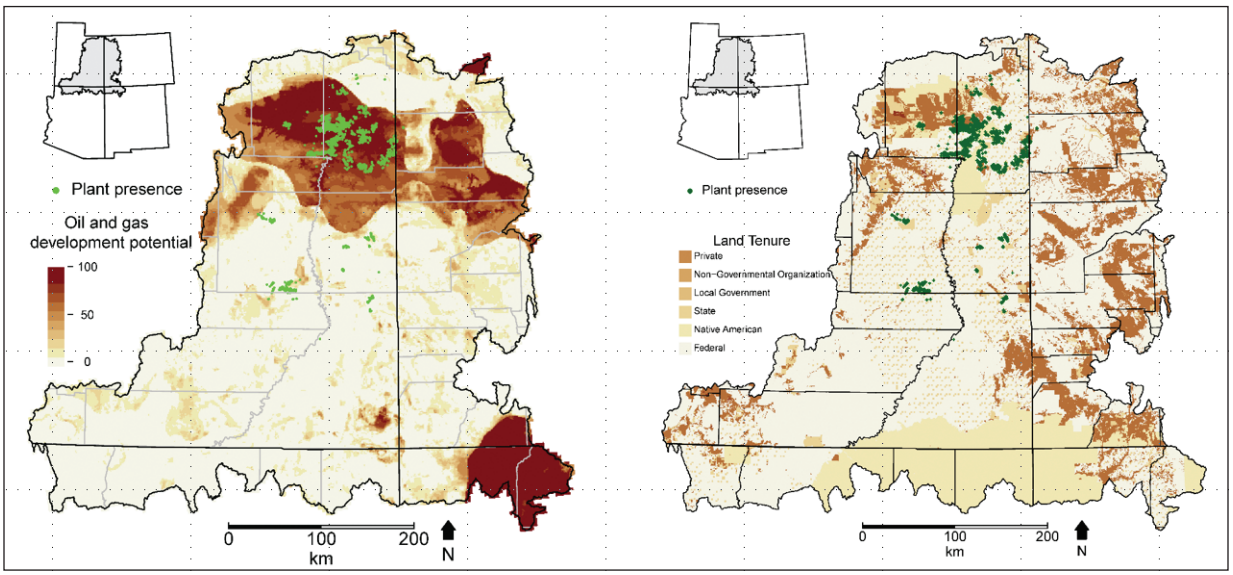

Locations of sensitive and rare plants and their overlap (shown in green) with areas of energy potential and land ownership.

Photograph by U.S. Fish and Wildlife Service.

Graham's beardtongue.

Photograph by U.S. Fish and Wildlife Service.

The Uinta Basin hookless cactus is listed as threatened by the ESA.

Photograph by John Spence, National Park Service.

The Jones cycladenia is only found on certain geologic formations in Utah and Arizona.

111. Ecological Restoration and Native Plant Development in Hot Desert Systems

Energy development across the Mojave and Sonoran deserts has increased the demand for more effective restoration techniques and appropriate plant materials for seeding and planting disturbed areas. In collaboration with Rancho Santa Ana Botanical Garden, Texas State University, BLM, and USFWS, the USGS developed seed-transfer zones at a resolution appropriate to guide seed-collection activities across the Mojave Desert. A network of experimental gardens incorporates research on germination, establishment, and survivorship with landscape genetics and physiology on a variety of key native plant species.

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Publications

Shryock, D.F., Havrilla, C.A., DeFalco, L.A., Esque, T.C., Custer, N.A., and Wood, T.E., 2016, Landscape genetic approaches to guide native plant restoration in the Mojave Desert: Ecological Applications v. 27, no. 2, p. 429–445, https://doi.org/10.1002/eap.1447.

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Photograph by U.S. Department of Energy.

Utility-scale solar array on Moapa Band of Paiutes Indian land, Nevada.

112. Evaluating Reclamation Success Following Oil and Gas Development

USGS scientists developed a new tool to provide regional assessments of land recovery following oil and gas drilling activities. This new tool was developed to help resource managers make informed decisions for future well pad development. The tool incorporates satellite imagery, digital soil mapping, predictive ecological modeling, and field assessments to evaluate vegetation recovery following well pad abandonment. Scientists used the tool to study 1,800 well pads in Utah, Colorado, and New Mexico. Satellite imagery was used to compare vegetation cover of the abandoned sites to surrounding undisturbed areas with roughly equivalent climate, soil, topography, and management histories. Findings showed that most abandoned oil and gas pads in the study were characterized by more bare ground and less vegetation than surrounding undisturbed areas, even more than 9 years after well abandonment. Differing recovery rates across environmental gradients and land stewardship suggest that these findings can be useful for identifying conditions that may promote or hamper pad recovery.

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Publications

Nauman, T.W., Duniway, M.C., Villarreal, M.C., and Poitras, T.B., 2017, Disturbance automated reference toolset (DART)—Assessing patterns in ecological recovery from energy development on the Colorado Plateau: Science of The Total Environment, v. 584–585, p. 476–488, https://doi.org/10.1016/j.scitotenv.2017.01.034.

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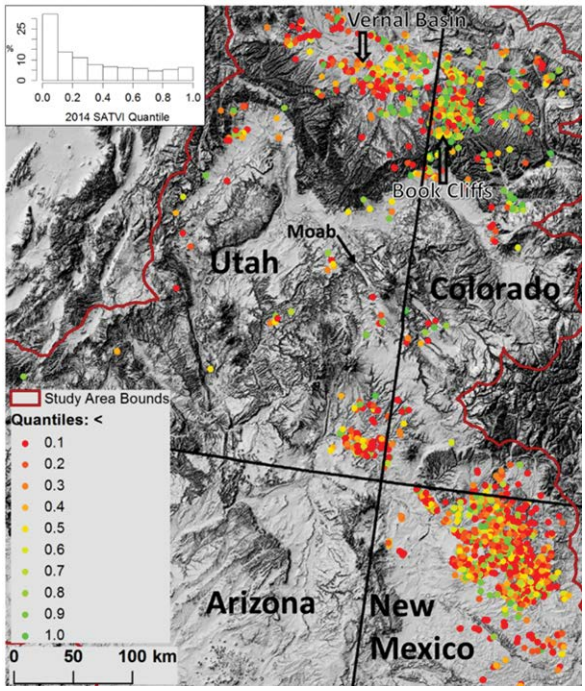
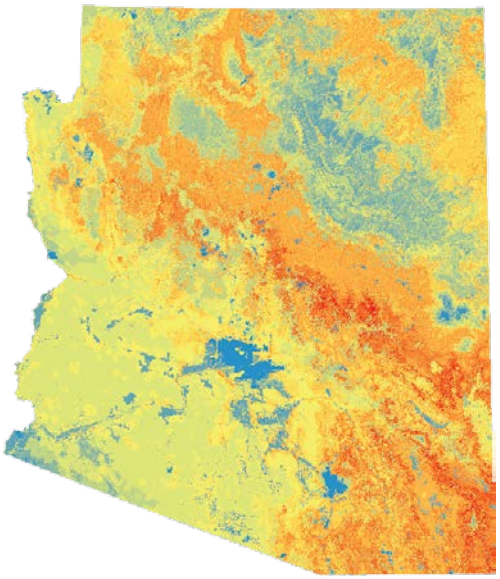


Photograph by Alan M. Cressler, U.S. Geological Survey.

Photograph by Mike Duniway, U.S. Geological Survey.

Map at upper left: Spatial distribution and histogram of well-pad recovery quantiles obtained using the disturbance automated reference toolset (DART). Points in red have lower vegetation cover signal and those in green have higher cover relative to reference areas (from Nauman and others, 2017). Upper right photograph: Shut in gas well on Bureau of Land Management lands in Grand County, Utah. Bottom photograph: View from Grand View Point in Canyonlands National Park.

113. Informing Energy Development Siting Decisions With Vertebrate Biodiversity Measures



USGS researchers are gathering information about vertebrate biodiversity needed by management agencies in Arizona to inform siting guidance for energy development on public lands. Siting guidance may help managers in identifying potential energy development conflicts with species of conservation concern. Scientists can use watershed-scale range models for vertebrate species developed through the USGS National Gap Analysis Program to illustrate how indices of biodiversity may be incorporated into renewable energy siting decisions.

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Map at left: Bat species richness in Arizona. The areas with the highest number of species (23 species) are shown in red, and the colors range down to the lowest number of species in blue. Image by Kathryn Thomas, U.S. Geological Survey.

114. Modeling of Cumulative Impacts for Conservation Planning and Renewable Energy Development in the Mojave Desert

USGS scientists developed analytical approaches, tools, and geospatial data to support conservation planning for renewable energy development in the California deserts. Research focused on geographical analysis to avoid, minimize, and mitigate the cumulative biological effects of utility-scale solar energy development. Researchers collected new data to model cumulative impacts for conservation planning applications. A model was created to map the relative degree of compatibility of new solar energy projects with current biological conservation values. Species distribution models were produced for 65 animal and plant species of potential conservation importance to the DRECP process. These models were used to map both historical and projected future habitat. A spatial decision support tool was created to aid in locating potential sites for offsetting project impacts on the basis of user-supplied conservation criteria. Finally, an analytical framework was designed to assess the potential cumulative impacts of multiple solar energy projects given background climate and land-use change.

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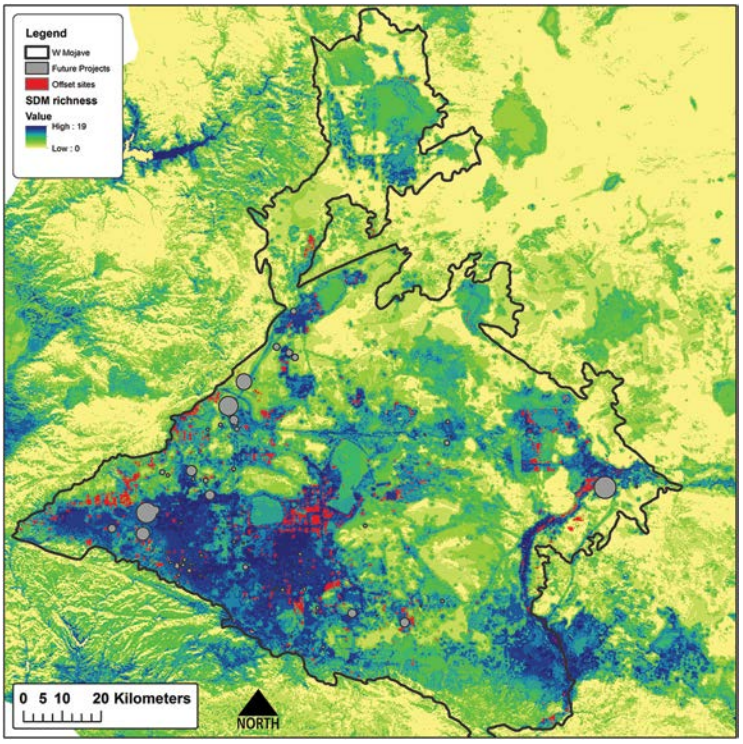

Solar offset map for the Desert Renewable Energy Conservation Plan (from Kreitler and others, 2015).

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Moore-O'Leary, K.A., Hernandez, R.R., Johnston, D.S., Abella, S.R., Tanner, K.E., Swanson, A.C., Kreitler, Jason, and Lovich, J.E., 2017, Sustainability of utility-scale solar energy—Ecological concepts: Frontiers in Ecology and the Environment, prepublication early view, https://doi.org/10.1002/fee.1517.

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115. Energy Futures for Wyoming

As part of the Wyoming Landscape Conservation Initiative (WLCI), the USGS is mapping the locations and extents of potential electricity-generating resources in Wyoming. This work includes mapping resources, such as natural gas, coal, wind, and hydropower, as well as transmission and transportation corridors. Results of this work can be used to inform the WLCI and other energy-related studies. More broadly, USGS researchers are developing an energy-assessment framework and methods that can be used in other regions.

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Publication

Bowen, Z.H., Aldridge, C.L., Anderson, P.J., Assal, T.J., Bartos, T.T., Chalfoun, A.D., Chong, G.W., Dematatis, M.K., Eddy-Miller, C.A., Garman, S.L., Germaine, S.S., Homer, C.G., Huber, C.C., Kauffman, M.J., Manier, D.J., Melcher, C.P., Miller, K.A., Norkin, Tamar, Sanders, L.E., Walters, A.W., Wilson, A.B., and Wyckoff, T.B., 2016, U.S. Geological Survey science for the Wyoming Landscape Conservation Initiative—2015 annual report: U.S. Geological Survey Open-File Report 2016–1141, 59 p., https://doi.org/10.3133/ofr20161141.

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Biewick, L.R.H., and Jones, N.R., 2012, Energy map of southwestern Wyoming, Part A—Coal and wind: U.S. Geological Survey Data Series 683, 18 p., 5 pls., https://pubs.usgs.gov/ds/683/.

116. Geographic Context in Wind Energy Land Transformation

Land transformation, measured as hectares of surface disturbance per megawatt, associated with wind facilities shows wide variation in its reported values. USGS scientists digitized land transformation at 39 wind facilities by using high-resolution aerial imagery and investigated how turbine size, configuration, land cover, and topography affected the levels of total land transformation. The results indicate that the geographic context in which facilities are installed affects the levels of land transformation associated with wind energy. For example, flat topographies had the lowest land transformation, while facilities on mesas had the largest. This information can assist managers with decisions on how to create opportunities for wind energy production that minimize land-cover change through effective siting. Scientists are now investigating the role of geographic context on road networks and how this affects habitat fragmentation around new facilities.

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Publication

Diffendorfer, J.E., Beston, J.A., Merrill, M.D., Stanton, J.C., Corum, M.D., Loss, S.R., Thogmartin, W.E., Johnson, D.H., Erickson, R.A., and Heist, K.W., 2017, A method to assess the population-level consequences of wind energy on bird and bat species, *in* Köppel, Johann, ed., Wind Energy and Wildlife Interactions—Presentations from the CWW2015 Conference: New York, Springer, p. 65–78, https://doi.org/10.1007/978-3-319-51272-3_4.

Additional Publications About Energy Planning Tools

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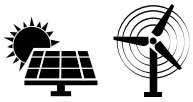
Fatality Estimation Tools



117. Advances in Estimating Fatalities From Collisions With Energy Infrastructure

Accurate estimates of bird and bat fatalities from collisions with energy infrastructure can be difficult because carcasses may not be detected or may be scavenged. These estimates, however, are critical to understanding the effects on species populations and devising effective methods to mitigate or minimize deaths. Accurate estimation is complicated because animals killed at facilities may go undetected when carcasses fall outside the search area, are removed by scavengers, or missed by searchers during surveys. The USGS and USFWS are working to develop new tools and improve existing tools to estimate actual bird and bat fatalities based on carcass searches near energy infrastructure. Factors such as fraction of turbines searched, time between searches, searchable area, imperfect carcass detection, and carcass persistence are being evaluated for inclusion. The software may enable resource managers and wind-facility developers to design monitoring protocols that can be optimized for different objectives.

Contact

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118. Evidence of Absence (version 2.0)

The USGS developed the "Evidence of Absence" statistical tool for estimating mortality of rare or endangered species where the loss of even one or two individuals may have a negative impact on the population. This tool helps resource managers design monitoring protocols that optimize detection probability at the lowest cost, evaluate whether permitted "take" rate is likely to have been exceeded, and project future take to inform adaptive management. Version 2.0 of "Evidence of Absence" further supports the conservation needs of USFWS by adding modules for (1) estimating searcher efficiency and carcass persistence from user-provided trial data, (2) streamlining the process for analyzing search data, and (3) providing guidance on interpreting data to signal when to initiate adaptive management. A multisession online training program is being developed to provide instruction on the use of the new features. The upgraded tool will help resources managers and wind energy industry representatives, as well as private consultants, respond to habitat conservation plans.

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Publications

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119. Fatality Monitoring Design and Estimation Software for Solar Power Facilities

The USGS, in collaboration with USFWS, is providing new methods for monitoring mortality at solar facilities on the basis of current wind-power facilities procedures adapted for unique conditions encountered at solar facilities. Case studies illustrate how distance-sampling techniques may improve overall detectability without substantially increasing monitoring costs. In addition, the USGS is modifying existing mortality estimation to produce unbiased estimates of fatalities and develop "Evidence of Absence" software for rare species at solar facilities. The approach accounts for searcher efficiency and carcass persistence as well as different sources of fatality at solar facilities. The software can assist the USFWS and the BLM, on whose lands much solar development is taking place, to analyze data on the effects of solar facilities on migratory bird mortality and on potential impacts to protected species.

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Publication

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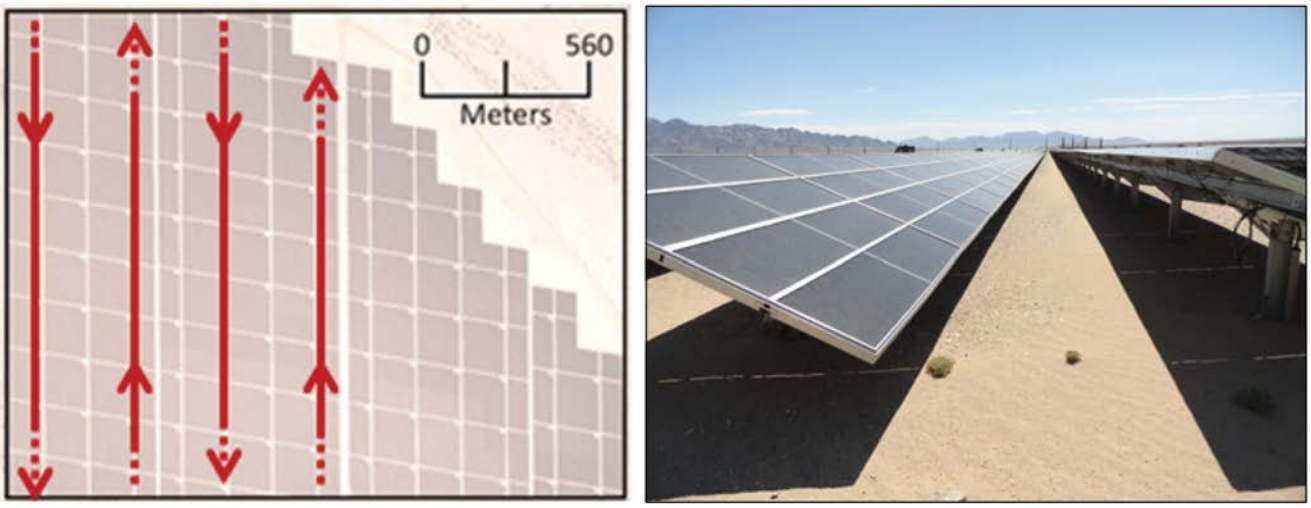

Transect pattern within photovoltaic panel array (from Huso and others, 2016).

Additional Publications About Fatality Estimation

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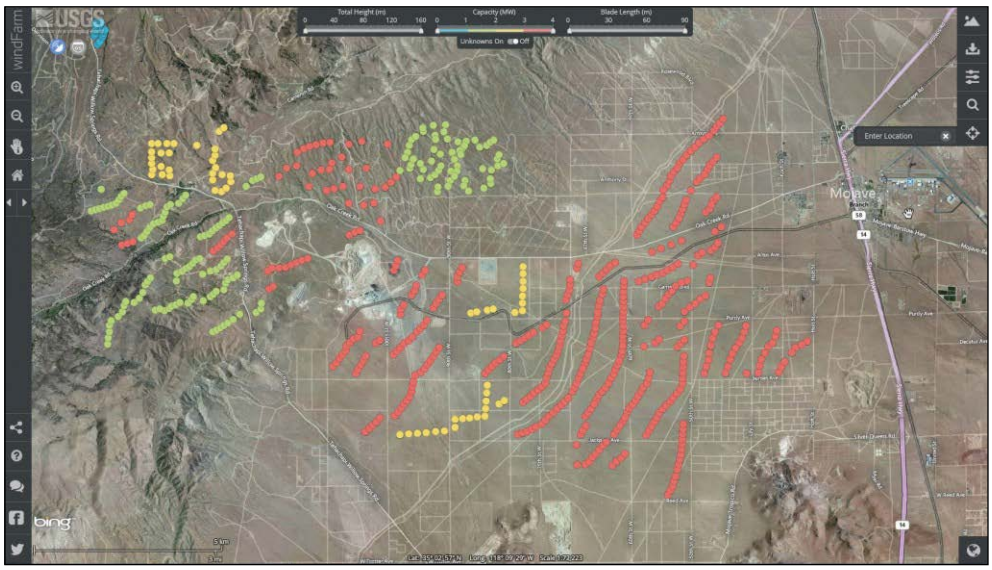
Risk Assessment and Management Support Tools

Understand Risks

120. Onshore Industrial Wind Turbine Locations



A screenshot from the USGS WindFarm mapping application showing locations and types of turbines in southern California.

The USGS updated a national dataset of onshore, industry-scale wind turbines in the United States through March 2014. Turbine locations were obtained from the Federal Aviation Administration (FAA) Digital Obstacle File; data are digitized and spatially verified. Turbines without FAA Obstacle Repository System numbers were obtained from publicly available facility datasets and were visually identified; point locations were added to the collection. Turbine position was verified using high-resolution aerial imagery with a final locational error of less than 10 meters (33 feet). Technical specifications, such as height, blade length, rotor swept area, model, and size, were attributed for the majority of turbines on the basis of a variety of sources. This map of onshore commercial scale wind turbines can assist scientists, regulatory agencies, nongovernmental organizations, and other decision makers in more easily assessing and planning for the effects of wind energy development on federally protected species.

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Publication

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121. Bird and Bat Risk From Wind Development

The USGS partnered with numerous nongovernmental and academic organizations in summarizing studies of raptor interactions with wind energy facilities from around the world, including case studies from Spain, Norway, Canada, United States, and southern Africa. Scientists also examined current pre-construction assessment risks to wildlife from wind turbines. Several shortcomings in methods used to assess the risk of fatality at turbines were noted, including the dearth of studies to offer evidence for an association between pre-construction surveys and post-construction fatality.

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Publications

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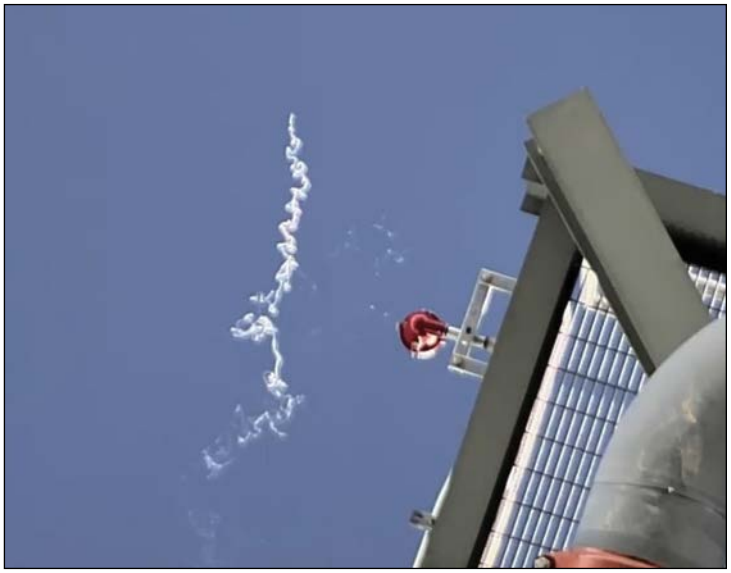
Measure Impacts

122. Advancing Wildlife Monitoring Technologies at Wind and Solar Facilities

USGS research in aeroecology relies on advancing radar and other kinds of remote sensing technology to understand the behavior and ecology of flying animals, especially in relation to new energy generation infrastructure. The USGS is using both historical and traditional technologies to observe wildlife behaviors in response to these changing habitats. In regions developing wind power, radar and thermal imagery are used to study bird and bat behavior in ways that contribute to the conservation and management of these species. USGS research has also expanded to examine how birds and bats respond to large-scale solar energy facilities, such as the Ivanpah Solar Electric Generating System facility in southern California. By working with the solar industry and other partners, the USGS is developing ways to mitigate the impacts on wildlife and preserve the ecological services and economic benefits provided by these animals. (For more information: https://www.usgs.gov/centers/norock/science-topics/aeroecology)



Erratic flight of insect burning in a solar flux field produced by a solar tower facility in the Mojave Desert, California (from Diehl and others, 2016).

Contact

Robb Diehl, USGS Northern Rocky Mountain Science Center, rhdiehl@usgs.gov, (406) 994–7481

Publication

Diehl, R.H., Valdez, E.W., Preston, T.M., Wellik, M.J., Cryan, P.M., and Mousseau, T.A., ed., 2016, Evaluating the effectiveness of wildlife detection and observation technologies at a solar power tower facility: PLOS ONE, v. 11, no. 7, e0158115, https://doi.org/10.1371/journal.pone.0158115.

123. Tools to Assess Energy Development Impacts on Sensitive Birds and Bats

A combination of tools is being used to understand how mortality at renewable energy facilities affects populations of sensitive bird and bat species in California. As part of this project, stable isotopes are being used to estimate the geographic scope of the population of birds or bats affected, and demographic modeling can forecast how individual fatalities affect the growth or decline of the species' populations. Development of analytical methods can aid in determining the best practices for conducting risk assessments and predicting mitigation outcomes. Field surveys design and protocols are also being developed and integrated with the developed tools. These tools can allow energy developers to more accurately estimate fatality rates and effects of mitigation techniques at wind and solar energy facilities, which may streamline permitting and ultimately reduce costs of energy development.

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Publication

Katzner, T.E., Nelson, D.M., Braham, M.A., Doyle, J.M., Fernandez, N.B., Duerr, A.E., Bloom, P.H., Fitzpatrick, M.C., Miller, T.A., Culver, R.C.E., Braswell, Loan, and DeWoody, J.A., 2017, Golden eagle fatalities and the continental-scale consequences of local wind-energy generation: Conservation Biology, v. 31, no. 2, p. 406–415, https://doi.org/10.1111/cobi.12836.

124. Detecting Population-Level Impacts of Wind Energy Development

The impact of wind energy generation on wildlife is commonly approached by monitoring the incidence of mortality resulting from turbine collisions. These mortality events may or may not scale up to observable impacts at a population level. USGS scientists are developing a framework for assessing population-level impacts of wind energy by using abundance time-series data and turbine location maps. The two-part approach first examines whether the timing and placement of turbines on the landscape are coincident with observed population trends at regional scales by using dynamic factor analysis. Next, localized impacts are examined by comparing population trends from sampling locations in close proximity to wind turbine development with relatively distant locations by using Bayesian structural time-series models. This research can assist conservation managers with wind energy project permitting and the use and interpretation of monitoring protocols for wind facilities.

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Publications

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125. Wind Energy Impacts Assessment Method

USGS scientists developed a method for evaluating national to regional impacts of wind energy on bats and birds. The method focuses primarily on the effects of collisions between wildlife and turbines. Primary uses of this method, which is complementary to and incorporates detailed studies and demographic models on key species, include (1) quantitative measuring of the potential impacts to species' populations through demographic modeling and the use of potential biologic removal methods; (2) ranking species in terms of their direct and indirect relative risk to wind energy development; (3) suggesting species for more intensive demographic modeling or study; and (4) highlighting species for which the effects of wind energy development on their populations are projected to be small. This method can be used to evaluate species for more or less intensive demographic modeling based on the projected impacts from wind energy development on the populations of the species.

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Publications

Diffendorfer, J.E., Beston, J.A., Merrill, M.D., Stanton, J.C., Corum, M.D., Loss, S.R., Thogmartin, W.E., Johnson, D.H., Erickson, R.A., and Heist., K.W., 2017, A method to assess the population-level consequences of wind energy on bird and bat species, *in* Köppel, Johann, ed., Wind Energy and Wildlife Interactions—Presentations from the CWW2015 Conference: New York, Springer, p. 65–76, https://doi.org/10.1007/978-3-319-51272-3_4.

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Photograph by Alan M. Cressler, U.S. Geological Survey.

Wind farm in Uinta County, Wyoming.

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List of Species

Common name	Scientific name
Agassiz's desert tortoise/desert tortoise	*Gopherus agassizii*
Agave	*Agave Americana*
American eel	*Anguilla rostrata*
American shad	*Alosa sapidissima*
Ashy storm-petrel	*Oceanodroma homochroa*
Atlantic roseate tern	*Sterna dougallii*
Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*
Bald eagle	*Haliaeetus leucocephalus*
Black brant goose	*Branta bernicla nigricans*
Black scoter	*Melanitta nigra*
Black storm-petrel	*Oceanodroma melania*
Bobcat	*Lynx rufus*
Brewer's sparrow	*Spizella breweri*
Brook trout	*Salvelinus fontinalis*
Brown pelican	*Pelecanus occidentalis*
Bull trout	*Salvelinus confluentus*
California condor	*Gymnogyps californianus*
Chinook salmon	*Oncorhynchus tshawytscha*
Coho salmon	*Oncorhynchus kisutch*
Common loon	*Gavia immer*
Common merganser	*Mergus merganser*
Duckweed	*Lemna minor*
Eastern red bat	*Lasiurus borealis*
Elegant tern	*Thalasseus elegans*
Fathead minnow	*Pimephales promelas*
Ferruginous hawk	*Buteo regalis*
Florida manatee	*Trichechus manatus latirostris*
Giant kelp	*Macrocystis pyrifera*
Golden eagle	*Aquila chrysaetos*
Graham's beardtongue	*Penstemon grahamii*
Greater sage-grouse	*Centrocercus urophasianus*
Greater scaup	*Aythya marila*
Greater white-fronted goose	*Anser albifrons*
Green sea turtle	*Chelonia mydas*
Green sunfish	*Lepomis cyanellus*
Gulf sturgeon	*Acipenser oxyrinchus*
Hardstem bulrush	*Schoenoplectus acutus*
Hawaiian hoary bat	*Lasiurus cinereus semotus*
Hawaiian petrel	*Pterodroma sandwichensis*
Hoary bat	*Lasiurus cinereus*

List of Species—Continued

Common name	Scientific name
Honey bee	*Apis mellifera*
Horned grebe	*Podiceps auritus*
Horned lark	*Eremophila alpestris*
Humpback chub	*Gila cypha*
Indiana bat	*Myotis sodalis*
Jones cycladenia	*Cycladenia humilis* var. *jonesii*
Kemp's ridley	*Lepidochelys kempii*
Lesser prairie-chicken	*Tympanuchus pallidicinctus*
Lesser scaup	*Aythya affinis*
Loggerhead	*Caretta caretta*
Long-tailed duck	*Clangula hyemalis*
Monarch butterfly	*Danaus plexippus*
Mule deer	*Odocoileus hemionus*
Musk thistle	*Carduus nutans*
Newell's shearwater	*Puffinus newelli*
Northern gannet	*Morus bassanus*
Northern harrier	*Circus cyaneus*
Northern leopard frog	*Lithobates pipiens*
Northern long-eared bat	*Myotis septentrionalis*
Pacific walrus	*Odobenus rosmarus divergens*
Polar bear	*Ursus maritimus*
Prairie falcon	*Falco mexicanus*
Rainbow trout	*Oncorhynchus mykiss*
Razorback sucker	*Xyrauchen texanus*
Red-breasted merganser	*Mergus serrator*
Red-necked grebe	*Podiceps grisegena*
Red-throated loon	*Gavia stellata*
Sagebrush sparrow	*Artemisiospiza nevadensis*
Sage thrasher	*Oreoscoptes montanus*
Scripps's murrelet	*Synthliboramphus scrippsi*
Sea lamprey	*Petromyzon marinus*
Sea otter	*Enhydra lutris*
Sooty shearwater	*Ardenna grisea*
Steelhead	*Oncorhynchus mykiss*
Surf scoter	*Melanitta perspicillata*
Swainson's hawk	*Buteo swainsoni*
Swift fox	*Vulpes velox*
Uinta Basin hookless cactus	*Sclerocactus wetlandicus*
West Indian manatee	*Trichechus manatus*
Westslope cutthroat trout	*Oncorhynchus clarki lewisi*
White-winged scoter	*Melanitta deglandi*

Wind turbine near trees. Photograph by Paul Cryan, U.S. Geological Survey.

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https://www2.usgs.gov/ecosystems/energy_wildlife

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