Smart Siting: The First Step in Mitigating Impacts of Wind Energy for Wildlife

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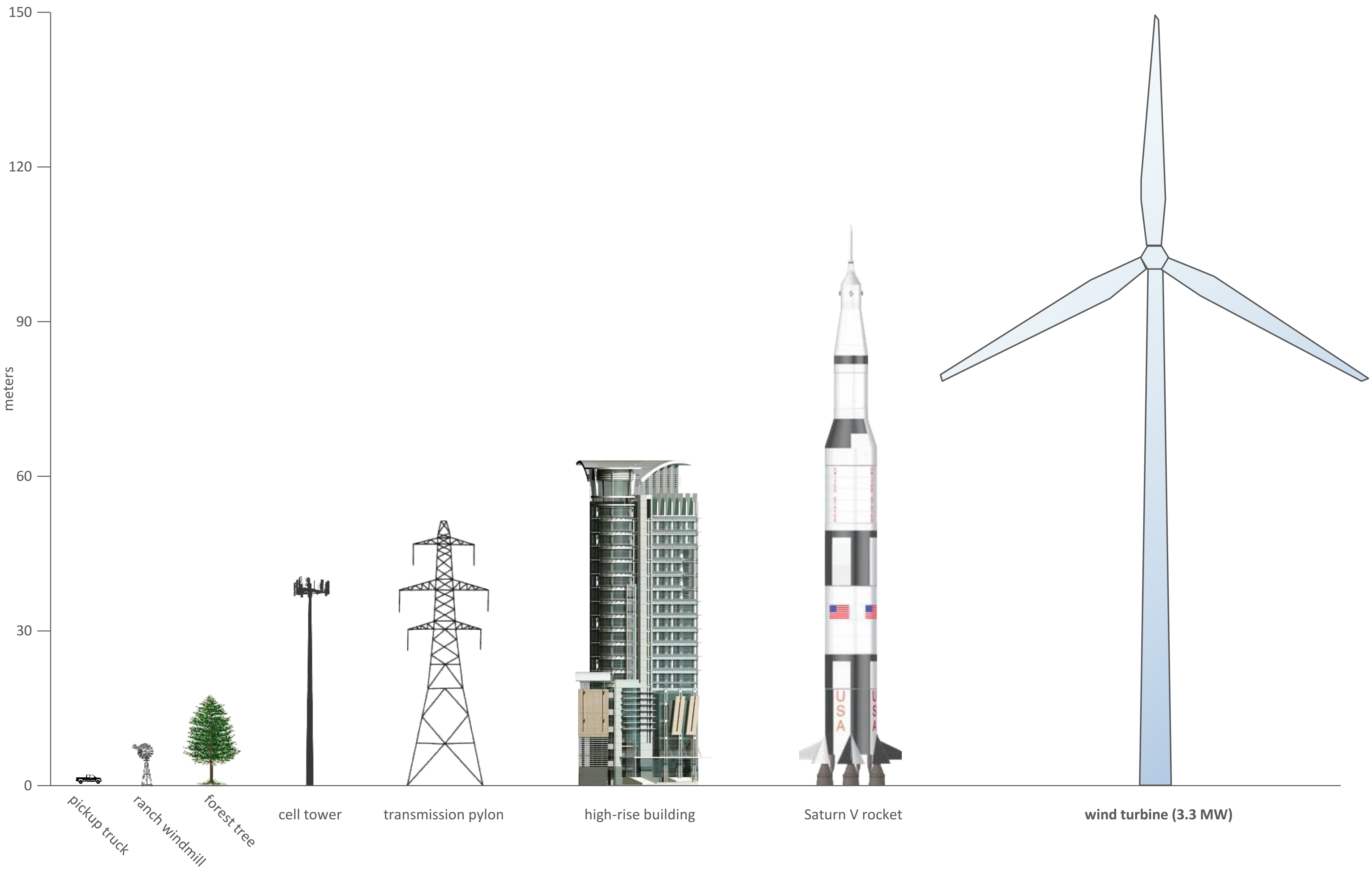
Holly Copeland, TNC Wyoming
Chris Hise, TNC Oklahoma

UW Wind Energy Forum, Laramie, WY
October 3, 2017

Height comparison




VIC'S

A hypothetical 80 turbine wind energy facility

- 210 acre physical footprint* (facilities, roads)
- 1,600 acres land area[†] (200 acres/turbine)
- Potential **much larger** ecological footprint[‡]

* - 5% of land area of wind farm, following: National Renewable Energy Laboratory. 2008. 20% wind energy by 2030: increasing wind energy's contribution to U.S. electricity supply.

[†] - Minimum convex polygon bounding an 80 turbine wind facility in Harper County, Oklahoma.

[‡] - Calculated from wind turbine avoidance distance in Horton etal 2010.

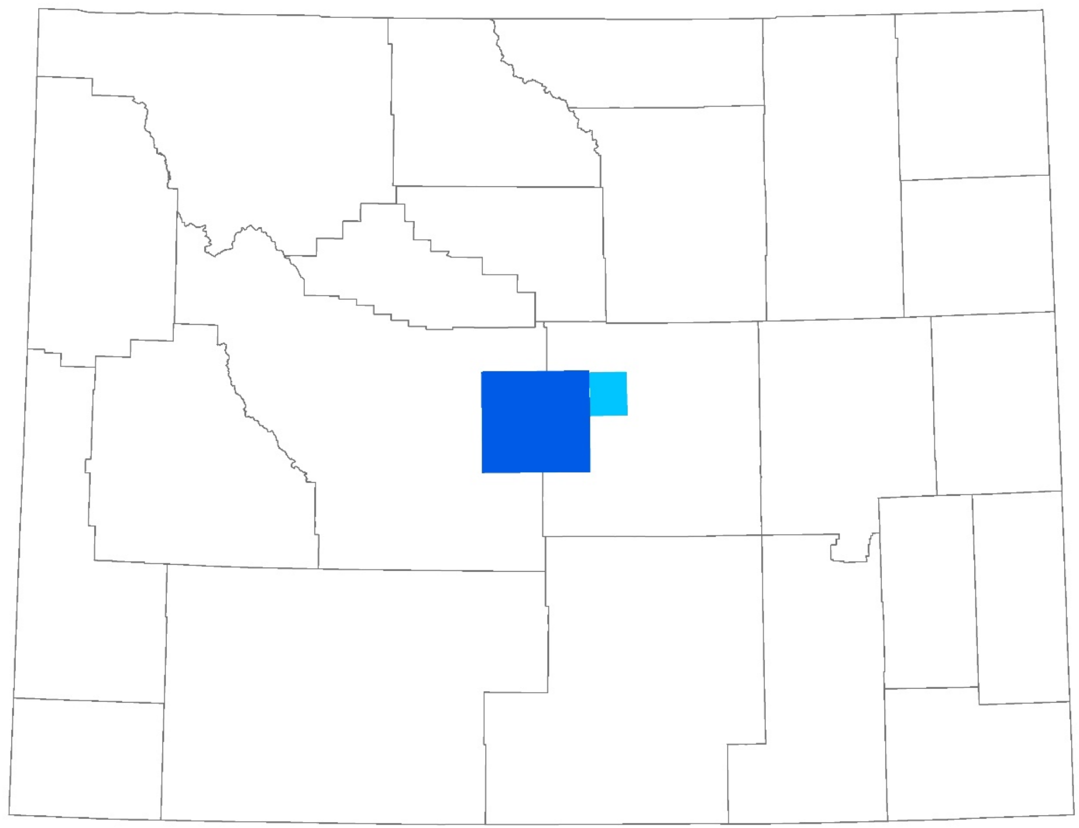
PROPOSED WIND DEVELOPMENT IN WYOMING

Current Installed: 1,500 MW (10% of WY electric production)
Proposed: 8,000+ MW (4,000 turbines, 800,000 acres)
NREL Technical Potential: 350,000 MW (110 meter hub height)

Wind energy spatial footprint

(~200 acres/turbine)

<u>Wyoming</u>
Installed capacity[1] – 1,4
U.S. rank[1] - 15th
Land area[2] - **492 km^2**



[1] NREL Q4 2016 installed wind capacity maps (http://energy.gov/eere/wind/windexchange)
[2] calculated; 0.33 km^2/MW (Denholm etal 2009)

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RESEARCH ARTICLE

Energy Sprawl Is the Largest Driver of Land Use Change in United States

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

Abstract

Energy production in the United States for domestic use and export is predicted to rise 27% by 2040. We quantify projected energy sprawl (new land required for energy production) in the United States through 2040. Over 200,000 km^2 of additional land area will be directly impacted by energy development. When spacing requirements are included, over 800,000 km^2 of additional land area will be affected by energy development, an area greater than the size of Texas. This pace of development in the United States is more than double the historic rate of urban and residential development, which has been the greatest driver of conversion in the United States since 1970, and is higher than projections for future land use change from residential development or agriculture. New technology now places 1.3 million km^2 that had not previously experienced oil and gas development at risk of development for unconventional oil and gas. Renewable energy production can be sustained indefinitely on the same land base, while extractive energy must continually drill and mine new areas to sustain production. We calculated the number of years required for fossil energy production to expand to cover the same area as renewables, if both were to produce the same amount of energy each year. The land required for coal production would grow to equal or exceed that of wind, solar and geothermal energy within 2–31 years. In contrast, it would take hundreds of years for oil production to have the same energy sprawl as biofuels. Meeting energy demands while conserving nature will require increased energy conservation, in addition to distributed renewable energy and appropriate siting and mitigation.

Introduction

By 2040, energy produced in the U.S. for domestic use and export is predicted to rise 27% to support both domestic and international demand [1]. The challenge of meeting energy demands while minimizing damaging climate change is widely recognized [2,3], but there is an additional challenge that also warrants attention–the land use implications of growing energy demand. The growing land use footprint of energy development, termed 'energy sprawl,' will likely cause significant habitat loss and fragmentation with associated impacts to biodiversity

Table 2. Range of land use efficiency for each energy source.

			Land-use Efficiency (km^2/TWhr)		
Energy Product	Energy Source		Area of Direct footprint (lower-upper estimates)		Landscape-level Impact*
Electricity	Nuclear		0.13	(0.02–0.24)	0.13
	Natural Gas	Shale Gas	0.19	(0.12–0.48)	5.08
		Tight Gas	0.24	(0.13–0.89)	4.01
		Coalbed Methane	0.63	(0.28–0.81)	8.11
		Conventional	0.95	(0.82–0.951)	2.86
	Coal	Underground	0.64	(0.24–1.51)	0.64
		Surface	8.19	(4.69–16.42)	8.19
	Renewables	Wind	1.31	(0.34–1.37)	126.92
		Geothermal	5.14	(2.14–10.96)	5.14
		Solar Photovoltaic	15.01	(12.30–16.97)	15.01
		Hydropower	16.86	(6.45–86.95)	16.86
		Solar Thermal	19.25	(12.97–27.98)	19.25
		Biomass	809.74	(557.93–1254.028)	809.74
Liquid Fuel	Oil	Tight Oil	0.38	(0.23–0.88)	8.19
		Conventional	0.56	(0.48–0.66)	2.86
	Biofuel	Corn	236.59	(192.69–259.00)	236.59
		Sugarcane	274.49	(229.24–342.05)	274.49
		Soybean	295.91	(235.54–313.33)	295.91
		Cellulose	565.39	(125.67–826.49)	565.39

* Energy sources without spacing requirement have the same value for direct and landscape-level impacts.

doi:10.1371/journal.pone.0162269.t002

Species impacts:

- Between 368,000 birds are killed annually by wind development or 3.35 small passerine birds/MW/Year (Erickson et al. 2014)
  - ~5,000 passerine birds/year in WY
- Displaces 7 of 9 grassland bird species within 300 meters of towers (Shaffer and Buhl 2015)
- Sage-grouse – selection impacts on summer, brood-rearing within 1.2 km (LeBeau et al. 2017)
- Eagles -85 reported eagle deaths from wind turbine collisions 1997-2012 (Patel et al. 2013)
- Bats: 6 bat deaths per MW/year (Arnett et al. 2013)
  - ~ 9000 bats/year in WY

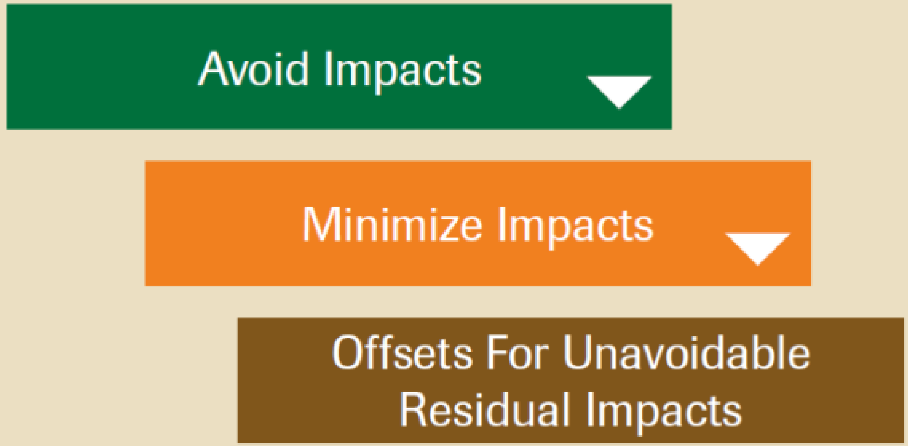
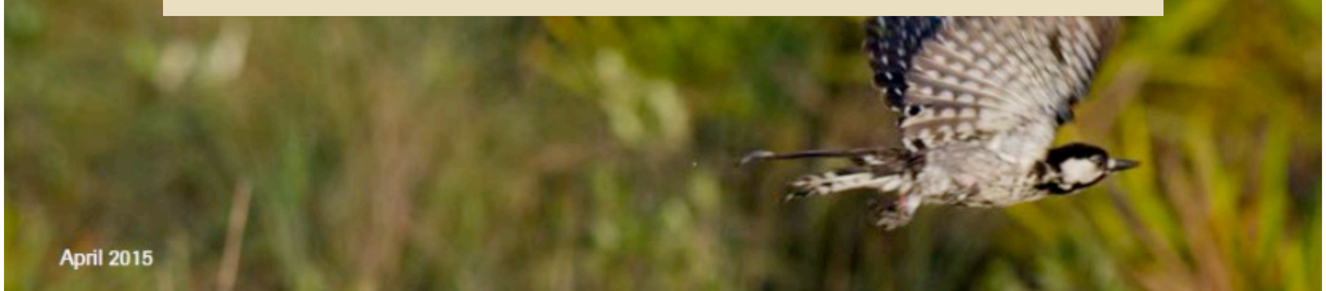


FIGURE 1: THE MITIGATION HIERARCHY

The three-step process of the mitigation hierarchy – avoid impacts, minimize impacts (including restoration on-site and other actions), and provide offsets for remaining unavoidable impacts (also often referred to as compensatory mitigation) – may be applied to achieve policy goals for biodiversity, ecosystem services, or other resources and values.



Mitigation Measures Classification

Planning & Siting	Macro Siting	▷ Use Areas of Low Spatial Resistance ▷ Avoid Sensitive Areas
	Micro Siting	▷ Turbine Arrangement & Placement
	Facility Characteristics	▷ Facility Design & Size ▷ Increased Visibility
Construction	Noise Reduction	▷ Sound Barriers
	Absence of Animals	▷ Restrictions During Specific Periods ▷ Physical Barriers ▷ Deterrence
Operation	Avoid Attraction	▷ Temporal & Spatial Land Management ▷ Lighting Intensity
	Luring	▷ Habitat Enhancement ▷ Habitat Replacement
	Deterrence	▷ Acoustic, Visual & Electromagnetic
	Curtailment & Cut-in Speed	▷ During High Abundance ▷ During High Risk of Collision
Decommissioning	Decommissioning	▷ Dismantling & Restoration
	Repowering	▷ Dismantling & Relocation ▷ Phased Development

Gartman et al. 2016 Journal of Environmental Assessment and Policy

Win-Win for Wind and Wil

Sustainable Development

Wind and Wildlife in the N

Identifying Low-Impact Are

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PLoS one

Development by Design: Mitigating Wind Development's Impacts on Wildlife in Kansas

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Abstract

Wind energy, if improperly sited, can impact wildlife through direct mortality and habitat loss and fragmentation, in contrast to its environmental benefits in the areas of greenhouse gas, air quality, and water quality. Fortunately, risks to wildlife from wind energy may be alleviated through proper siting and mitigation offsets. Here we identify areas in Kansas where wind development is incompatible with conservation, areas where wind development may proceed but with compensatory mitigation for impacts, and areas where development could proceed without the need for compensatory mitigation. We demonstrate that approximately 10.3 million ha in Kansas (48 percent of the state) has the potential to provide 478 GW of installed capacity while still meeting conservation goals. Of this total, approximately 2.7 million ha would require no compensatory mitigation and could produce up to 125 GW of installed capacity. This is 1,648 percent higher than the level of wind development needed in Kansas by 2030 if the United States is to get 20 percent of its electricity from wind. Projects that avoid and offset impacts consistent with this analysis could be awarded "Green Certification." Certification may help to expand and sustain the wind industry by facilitating the completion of individual projects sited to avoid sensitive areas and protecting the industry's reputation as an ecologically friendly source of electricity.

Citation: Obermeyer B, Manes R, Kiesecker J, Fargione J, Sochi K (2011) Development by Design: Mitigating Wind Development's Impacts on Wildlife in Kansas. PLoS ONE 6(10): e26698. doi:10.1371/journal.pone.0026698

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

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Introduction

Concerns over fossil fuel dependence and climate change have accelerated the development and deployment of renewable energy technologies in the United States. The U.S. Department of Energy (DOE) predicts that 20 percent of the nation's electricity could be generated from wind by 2030 [1]. Although wind energy is a relatively low-carbon source of energy, wind turbines have, per unit of energy produced, a larger terrestrial footprint than most other forms of electricity production [2]. Modern wind energy development requires approximately 20 28 ha per megawatt (MW) of installed capacity [1], and the ecological footprint of wind energy development can be even larger.

Depending on siting, wind energy may cause adverse impacts on wildlife, resulting in direct mortality to birds and bats, as well as habitat loss and fragmentation [3,4,5]. Although direct habitat losses from turbine footings and roads typically entail less than five percent of a wind energy project area, the habitat values of adjacent lands may be significantly diminished. Fragmentation is widely acknowledged to be detrimental to both the integrity of ecological systems and the long-term viability of associated wildlife [6,7], and may act synergistically with climate change and other factors to magnify deleterious effects to species and ecosystems by limiting the ability of species to adapt or migrate [8,9].

Wind development projects may also result in fragmentation on a more local scale. At the 150-MW Elk River Wind Project near Beaumont, Kansas, nearly 30 km of new, improved roads were built across native tallgrass prairie to service the facility (Figure 1). Roads effectively fragment the habitat, restricting movement for many animals, possibly leading to population level impacts and genetic effects [10]. Edges of habitat caused by roads may also create an avenue for predators and invasive weeds and may affect fire behavior [11,12]. While some bird species seem minimally affected by the presence of wind turbines [13], certain waterfowl, shorebird, and songbird species are known to avoid them. Grassland and shrubland-nesting birds are of particular concern, because these species are sensitive to human infrastructure and activity and may be evolutionarily disposed to avoid nesting and brood-rearing activities near vertical structures such as wind turbines [4]. Ongoing population declines for greater and lesser prairie-chickens and the intersection of their remaining distribution with some of the continent's prime wind generation regions compound the concern.

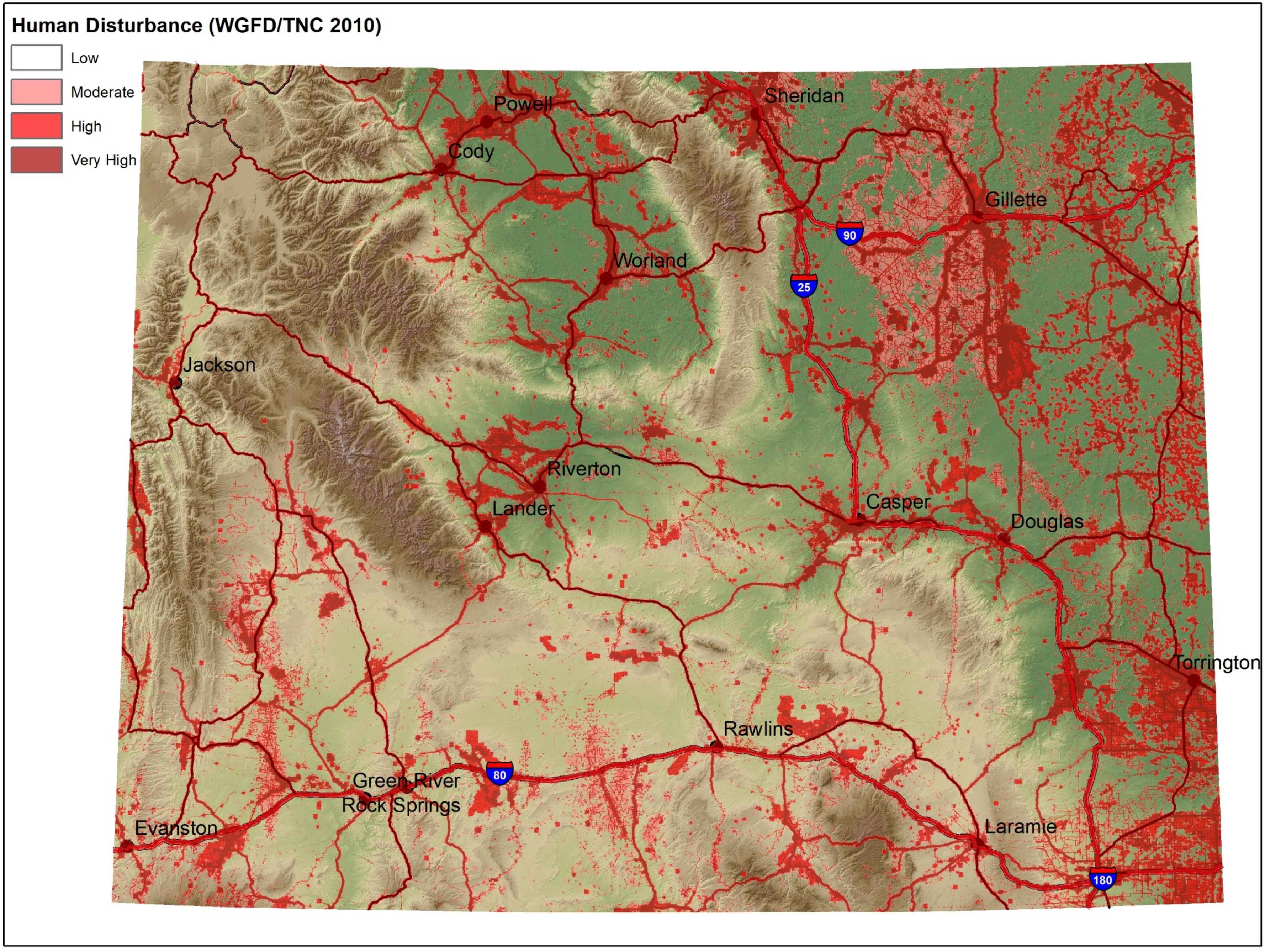
The DOE estimates that it will require about 5 million ha of land and nearly 18,000 km of new transmission lines in order for the U.S. to generate 20 percent of its electricity from wind [1]. Given the distribution of wind resources across the continental United States, certain states, such as Kansas, are likely to experience a disproportionate amount of development. According to DOE, however, wind energy production will require only about 3 percent of the land area with commercially viable wind resources in the continental U.S. This should allow ample opportunity to site wind energy development away from important and sensitive habitats.

Room for wind *and* wildlife

Over 3,500,000 MW can be generated on disturbed lands (lower 48)

14X US DOE Goal

Kiesecker et al. 2011. Win-win for wind and wildlife: A vision to facilitate sustainable development. PLoS One 6(4): e17566


Human Disturbance (WGFD/TNC 2010)
Low
Moderate
High
Very High
Powell
Sheridan
Cody
Gillette
90
Worland
25
Jackson
Riverton
Casper
Lander
Douglas
Torrington
Rawlins
80
Green River
Rock Springs
Evanston
Laramie
180

Modeling the Distribution of Migratory Bird Stopovers to Inform Landscape-Scale Siting of Wind Development

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Abstract

Conservation of migratory birds requires understanding the distribution of and potential threats to their migratory habitats. However, although migratory birds are protected under international treaties, few maps have been available to represent migration at a landscape scale useful to target conservation efforts or inform the siting of wind energy developments that may affect migratory birds. To fill this gap, we developed models that predict where four groups of birds concentrate or stopover during their migration through the state of Wyoming, USA: raptors, wetland, riparian and sparse grassland birds. The models were based on existing literature and expert knowledge concerning bird migration behavior and ecology and validated using expert ratings and known occurrences. There was significant agreement between migratory occurrence data and migration models for all groups except raptors, and all models ranked well with experts. We measured the overlap between the migration concentration models and a predictive model of wind energy development to assess the potential exposure of migratory birds to wind development and illustrate the utility of migratory concentration models for landscape-scale planning. Wind development potential is high across 15% of Wyoming, and 73% of this high potential area intersects important migration concentration areas. From 5.2% to 18.8% of each group's important migration areas was represented within this high wind potential area, with the highest exposures for sparse grassland birds and the lowest for riparian birds. Our approach could be replicated elsewhere to fill critical data gaps and better inform conservation priorities and landscape-scale planning for migratory birds.

Citation: Pocewicz A, Estes-Zumpf WA, Andersen MD, Copeland HE, Keinath DA, et al. (2013) Modeling the Distribution of Migratory Bird Stopovers to Inform Landscape-Scale Siting of Wind Development. PLoS ONE 8(10): e75363. doi:10.1371/journal.pone.0075363

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

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Introduction

Conservation of migratory birds requires an understanding of habitat, behavior and threats faced by birds during breeding, wintering, and migration. Migration is the most poorly understood of these annual activities, and of particular importance is understanding the distribution of stopovers and pathways used by migrating birds [1]. Recent technological advances, including telemetry devices, radar, stable isotope analysis, and genetic markers, permit the tracking of birds during migration [2]. Geographic Information System (GIS) modeling is also being used increasingly across large regions to evaluate conservation strategies and assess risks to migrating birds [3,4].

One risk to migrating birds is wind energy development, which is expected to increase substantially in the United States in the coming decades due to evolving policies aimed at increasing renewable energy production [5–7]. Wind development can negatively impact birds through direct mortality from turbine collisions, avoidance behavior, and indirect effects of habitat fragmentation [8–12]. The U.S. Fish and Wildlife Service, Partners in Flight, The Wildlife Society, and the American Bird Conservancy, among others, have raised concerns about the long-term impacts of wind energy on bird populations [9,13]. Mortality related to wind turbines could have especially great effects on declining species and long-lived species with low fecundity, such as raptors [14].

Wind development impacts to migratory birds may be reduced if facilities avoid major migration stopovers and flyways or if turbine operations are reduced in these areas during peak migration [13,15]. However, the lack of information on the distribution of migratory concentration areas, and their overlap with wind energy resources, impedes conservation and proactive development planning [16]. Several studies have examined bird migration patterns and modeled stopovers and pathways in the eastern U.S. [3,4], but much less is known about migration patterns in the western U.S. [17], especially in the Rocky Mountains. Limited regional information exists as incidental sightings [18], migration counts [19,20], local or species specific research reports, e.g. [21–23], and expert knowledge, but has not been synthesized.

We developed a deductive modeling approach based on a synthesis of literature and expert knowledge concerning bird migration, and represented through GIS datasets, to map migratory concentration areas across the state of Wyoming. We produced deductive models due to concerns regarding the quality and quantity of available occurrence data needed to generate

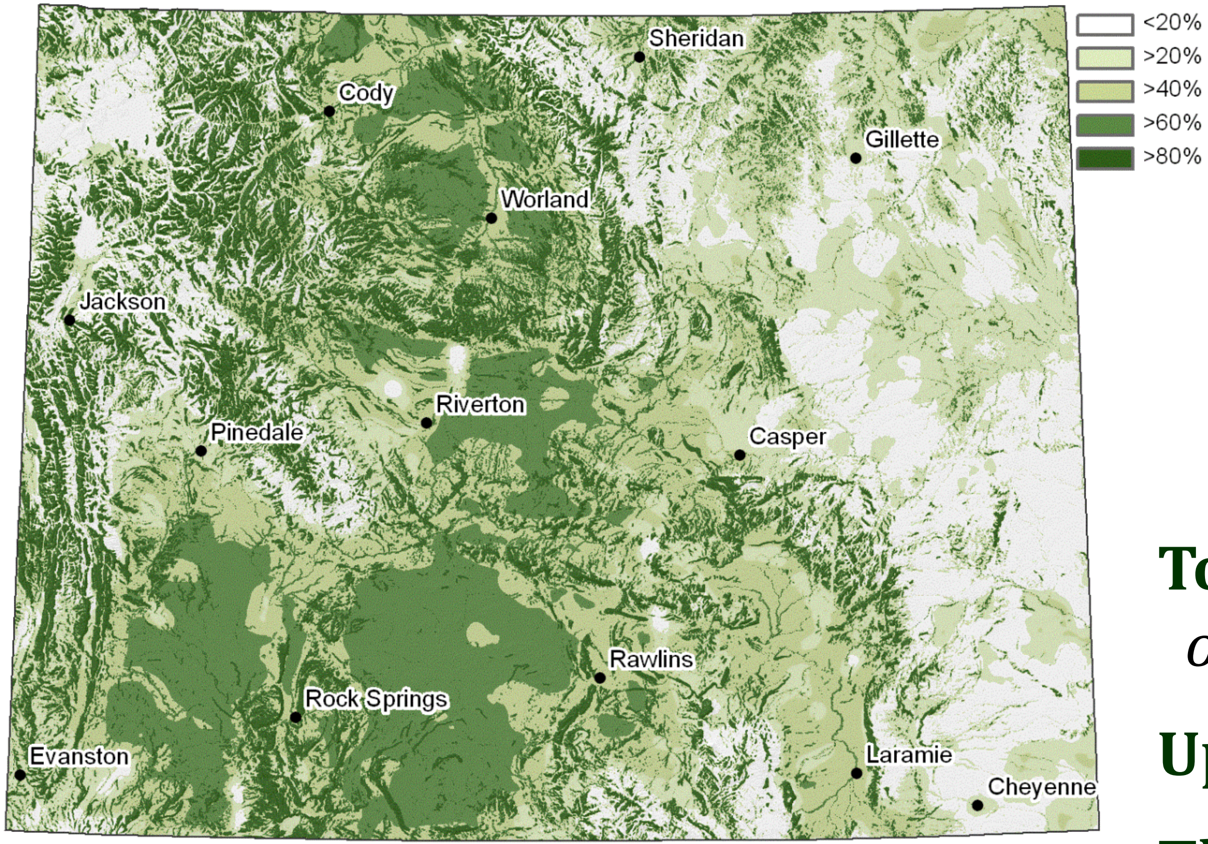
Migration mapping objectives

- Developed models predicting migratory concentration for 4 functional bird groups

- Raptors, riparian, wetland & sparse grassland birds

- How much exposure to future wind development?

Raptor fall movement concentration



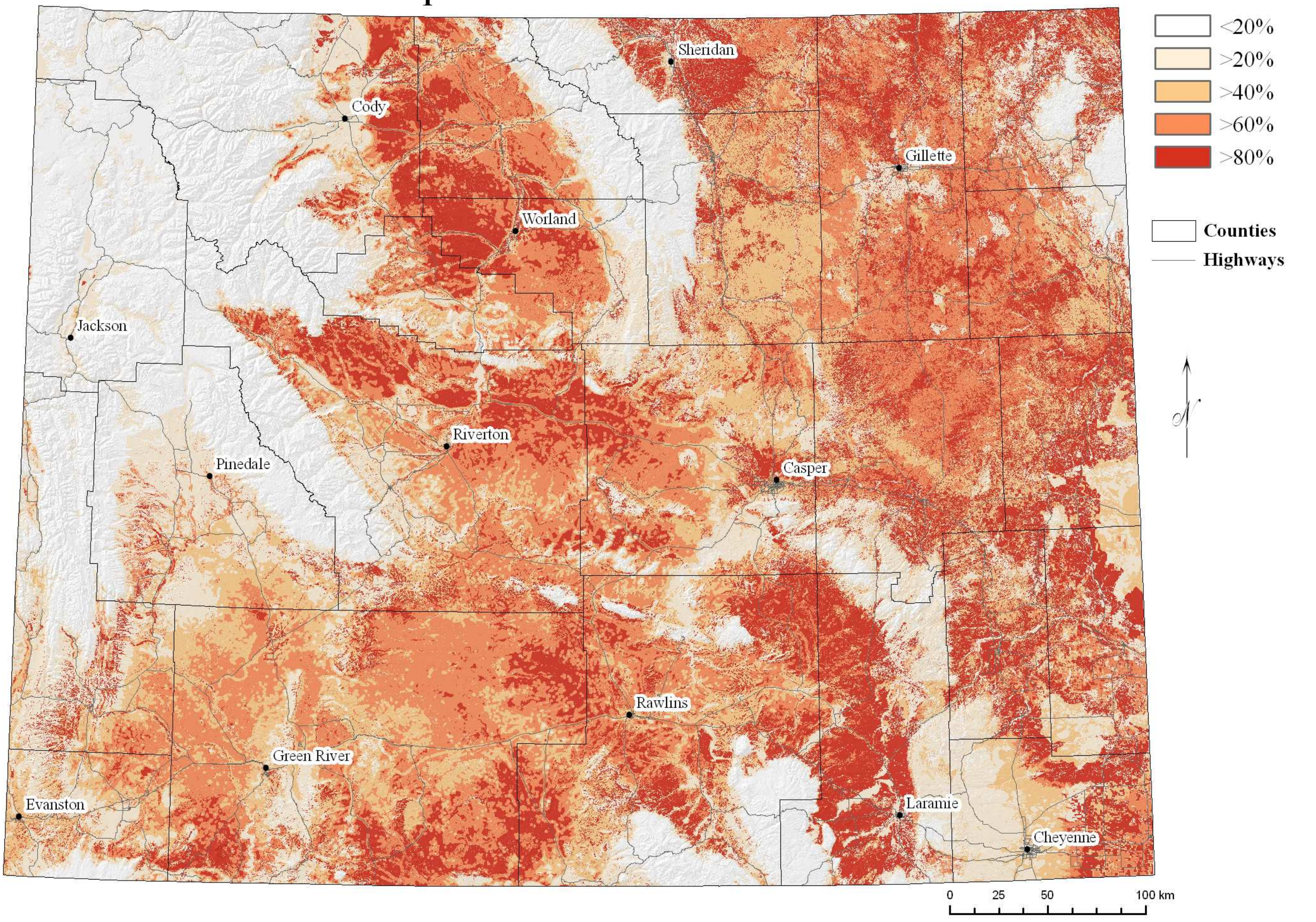
Topography
orientation

Updrafts

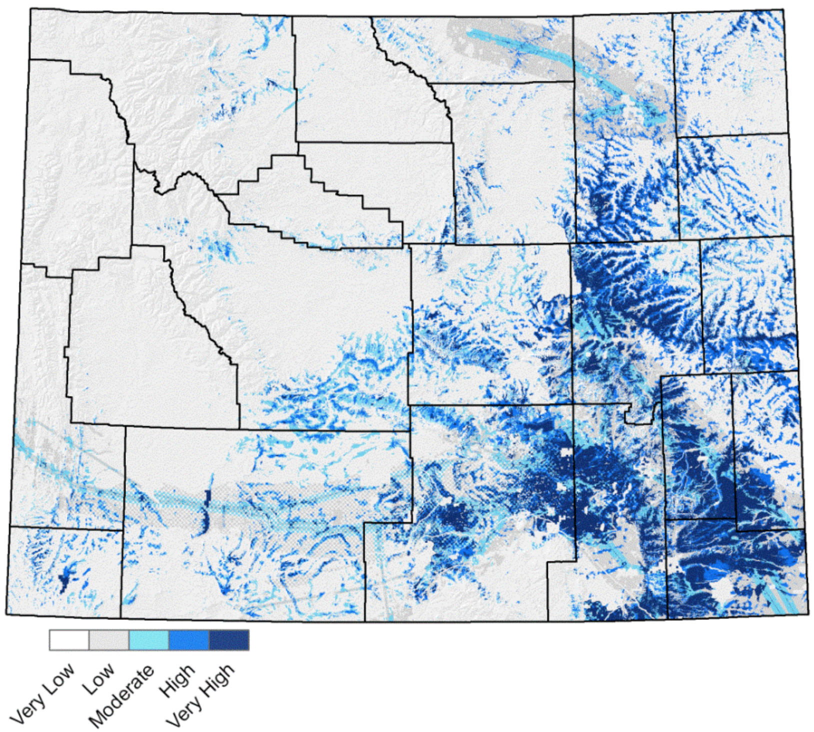
Thermal formation

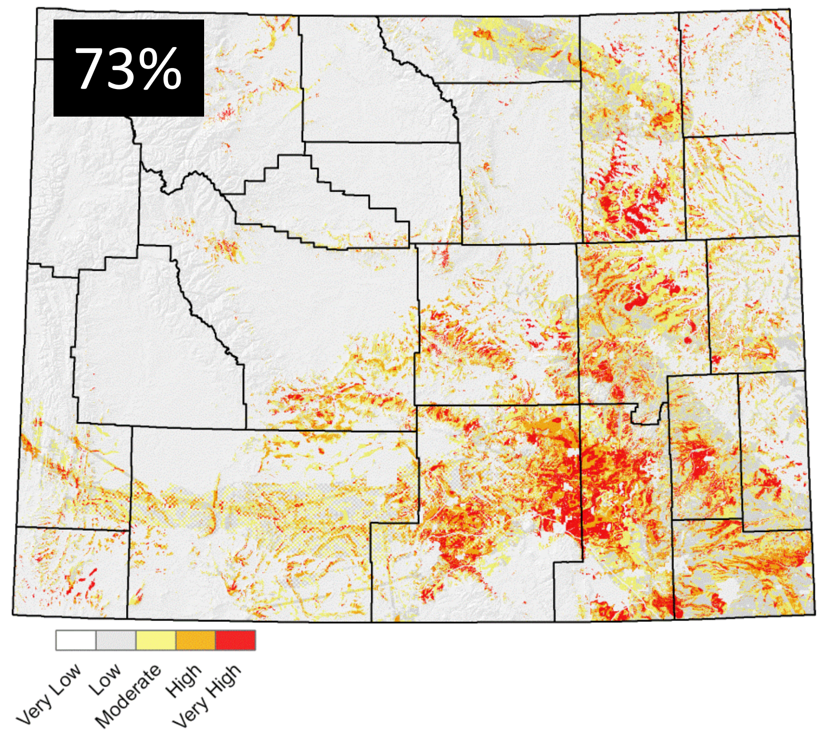
Streams
orientation, cottonwoods

Spring Migration Concentration
Sparse Grassland Birds

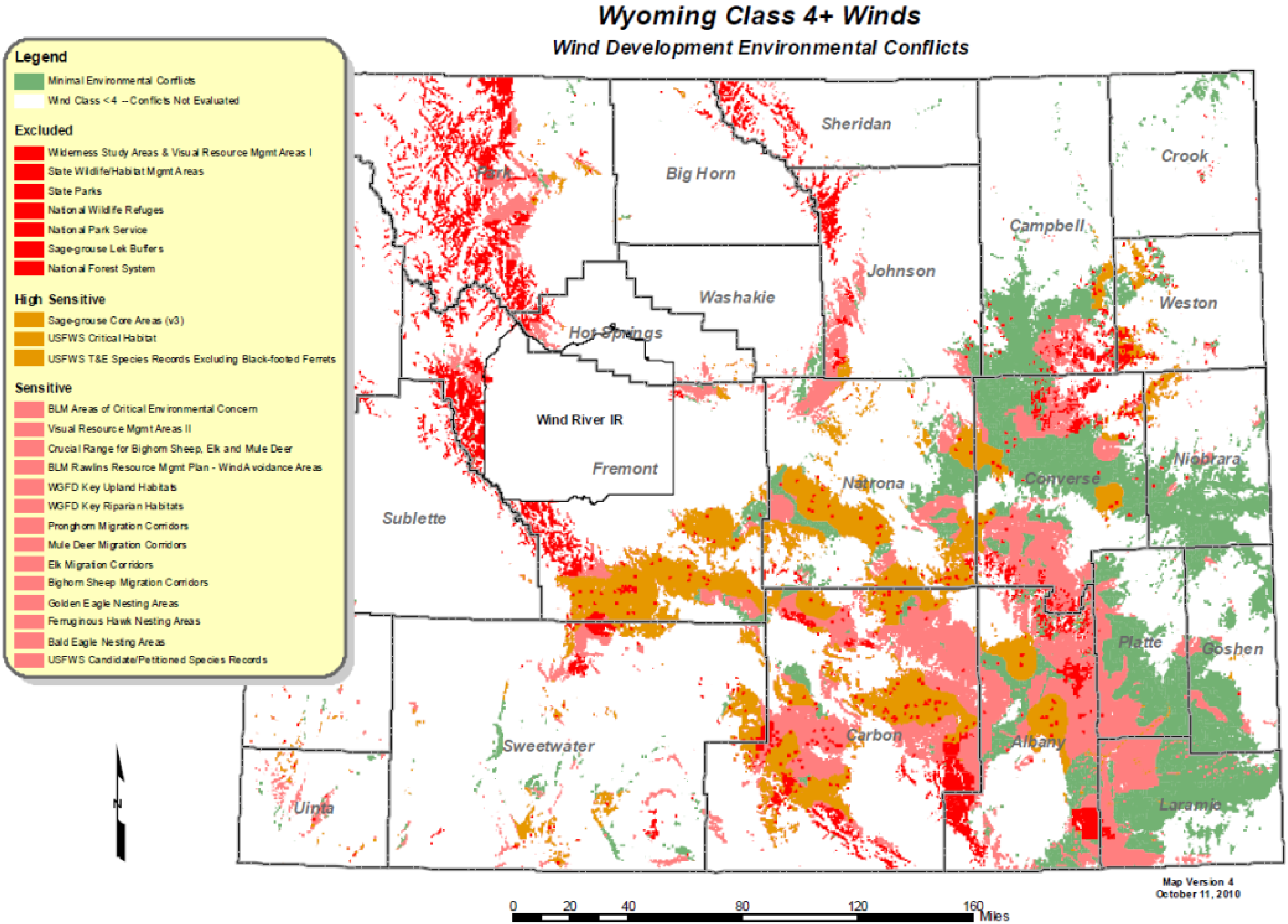


Exposure to wind development



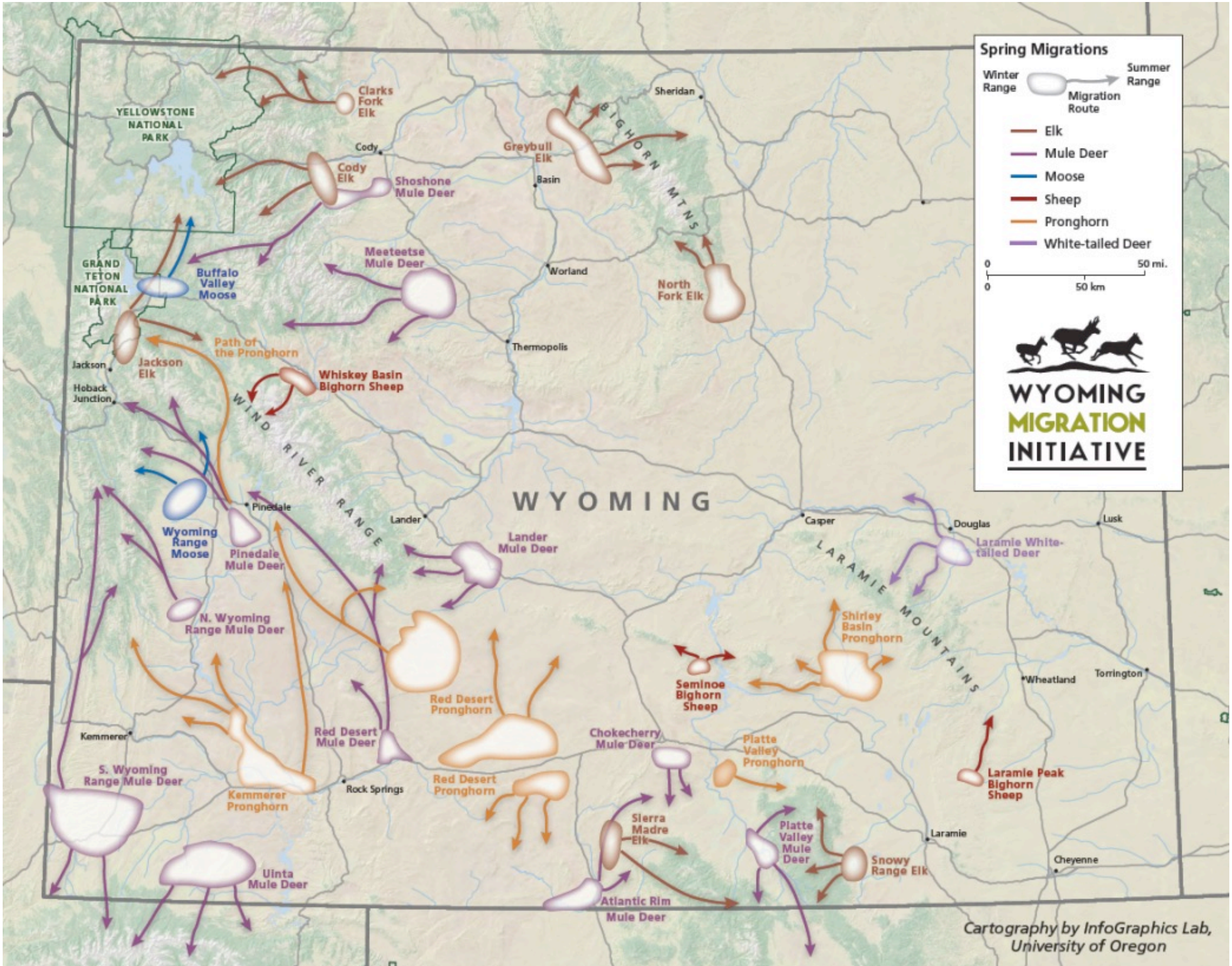


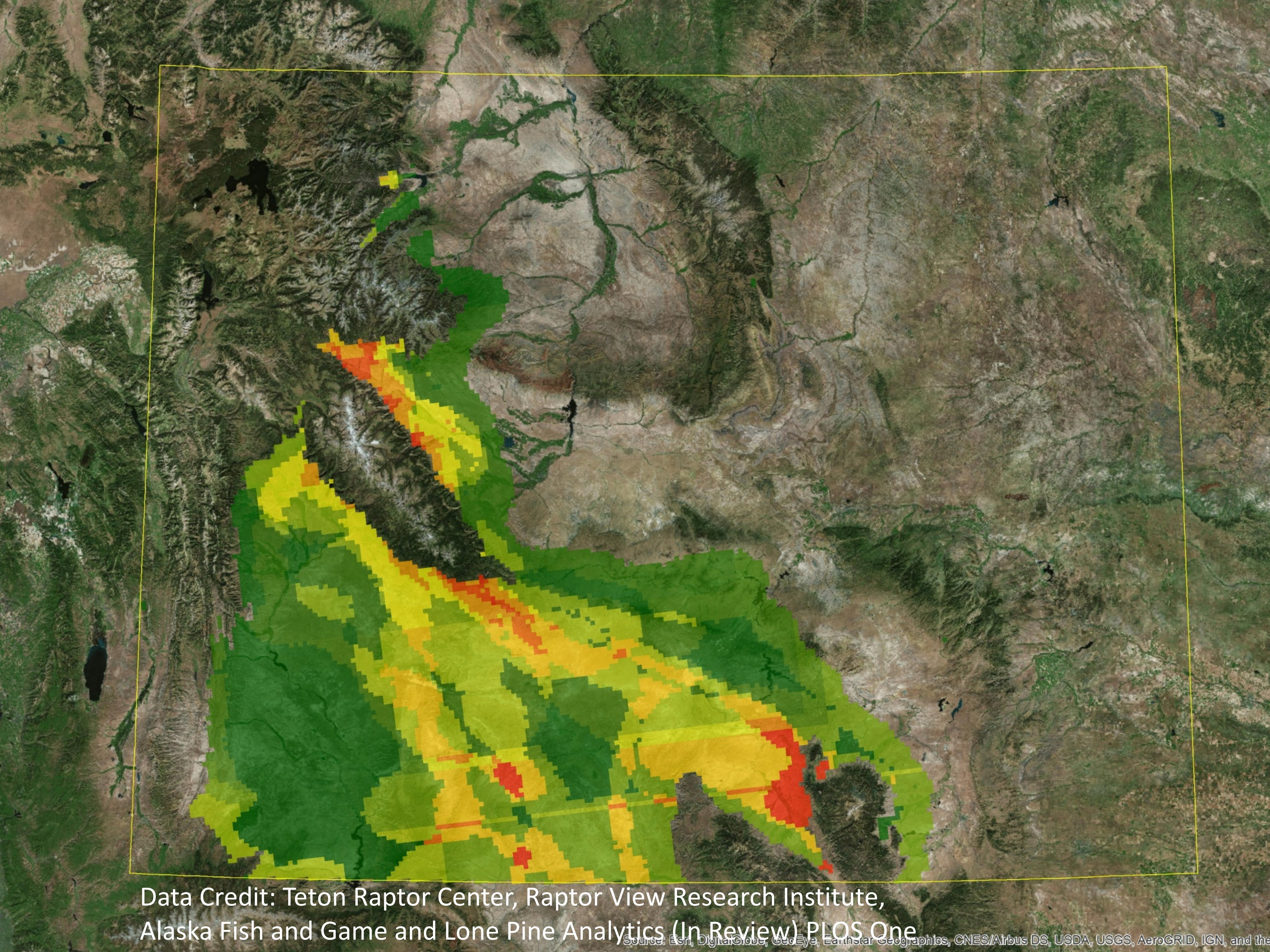
Highest 40% of wind potential has 73% overlap with highest 40% of migratory concentration (27% - no overlap)



Wyoming Class 4+ Winds
Wind Development Environmental Conflicts
Legend
Minimal Environmental Conflicts
Wind Class <4 -- Conflicts Not Evaluated
Excluded
Wilderness Study Areas & Visual Resource Mgmt Areas I
State Wildlife/Habitat Mgmt Areas
State Parks
National Wildlife Refuges
National Park Service
Sage-grouse Lek Buffers
National Forest System
High Sensitive
Sage-grouse Core Areas (v3)
USFWS Critical Habitat
USFWS T&E Species Records Excluding Black-footed Ferrets
Sensitive
BLM Areas of Critical Environmental Concern
Visual Resource Mgmt Areas II
Crucial Range for Bighorn Sheep, Elk and Mule Deer
BLM Rawlins Resource Mgmt Plan - Wind Avoidance Areas
WGFD Key Upland Habitats
WGFD Key Riparian Habitats
Pronghorn Migration Corridors
Mule Deer Migration Corridors
Elk Migration Corridors
Bighorn Sheep Migration Corridors
Golden Eagle Nesting Areas
Ferruginous Hawk Nesting Areas
Bald Eagle Nesting Areas
USFWS Candidate/Petitioned Species Records
Park
Big Horn
Sheridan
Crook
Campbell
Johnson
Washakie
Hot Springs
Weston
Wind River IR
Fremont
Natrona
Converse
Niobrara
Sublette
Platte
Goshen
Sweetwater
Carbon
Albany
Uinta
Laramie
N
0
20
40
80
120
160
Miles
Map Version 4
October 11, 2010

New wildlife data are emerging daily from GPS technology

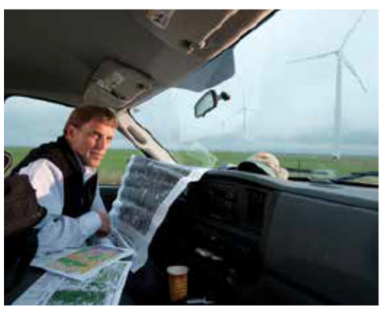

Spring Migrations
Winter Range
Migration Route
Summer Range
Elk
Mule Deer
Moose
Sheep
Pronghorn
White-tailed Deer
0 50 mi.
0 50 km
WYOMING MIGRATION INITIATIVE
YELLOWSTONE NATIONAL PARK
GRAND TETON NATIONAL PARK
Clarks Fork Elk
Cody Elk
Shoshone Mule Deer
Greybull Elk
BIGHORN MTNS
North Fork Elk
Meeteetse Mule Deer
Buffalo Valley Moose
Jackson Elk
Path of the Pronghorn
Whiskey Basin Bighorn Sheep
WIND RIVER RANGE
Wyoming Range Moose
Pinedale Mule Deer
N. Wyoming Range Mule Deer
Lander Mule Deer
WYOMING
LARAMIE MOUNTAINS
Laramie White-tailed Deer
Shirley Basin Pronghorn
Seminoe Bighorn Sheep
Red Desert Pronghorn
Red Desert Mule Deer
Chokecherry Mule Deer
Platte Valley Pronghorn
Laramie Peak Bighorn Sheep
S. Wyoming Range Mule Deer
Kemmerer Pronghorn
Red Desert Pronghorn
Sierra Madre Elk
Platte Valley Mule Deer
Snowy Range Elk
Uinta Mule Deer
Atlantic Rim Mule Deer
Cody
Basin
Sheridan
Worland
Thermopolis
Jackson
Hoback Junction
Pinedale
Lander
Casper
Douglas
Lusk
Wheatland
Torrington
Kemmerer
Rock Springs
Laramie
Cheyenne
Cartography by InfoGraphics Lab, University of Oregon


Data Credit: Teton Raptor Center, Raptor View Research Institute,
Alaska Fish and Game and Lone Pine Analytics (In Review) PLOS One
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the

WIND ENERGY & WILDLIFE:

Site it Right

Benefits for companies purchasing wind energy, wind energy developers and financiers, consumers, and wildlife.

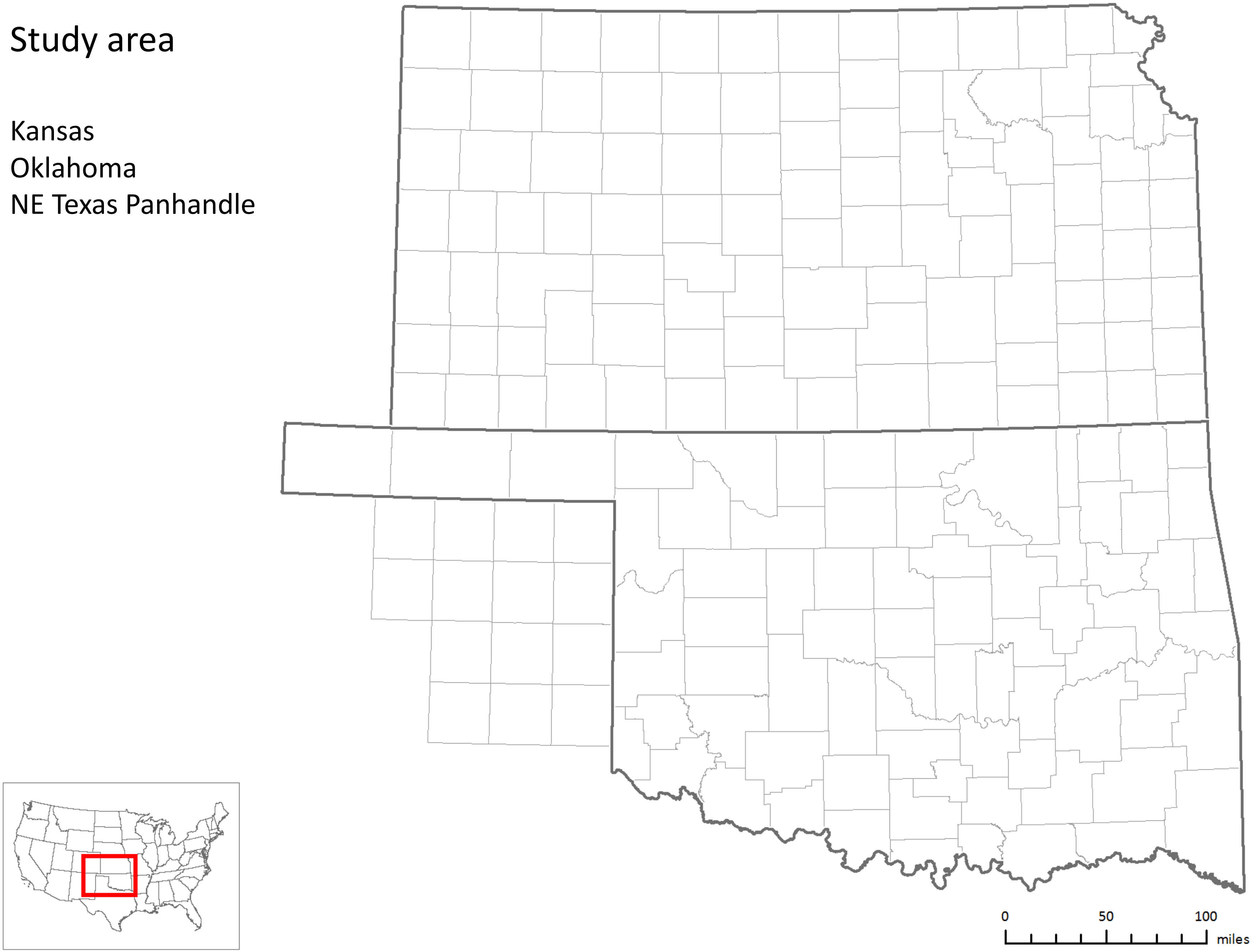


The Nature Conservancy
Protecting nature. Preserving life.

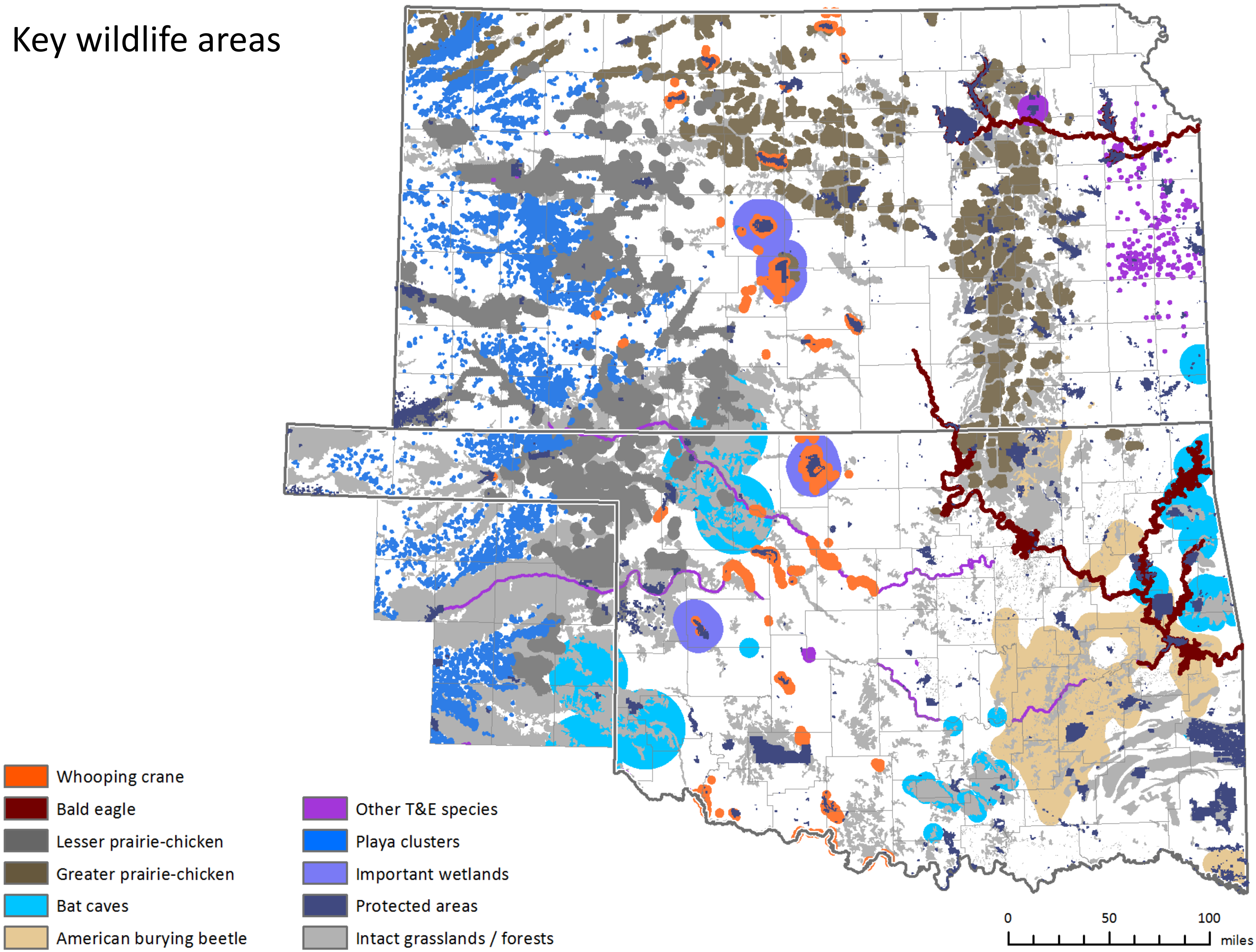
central great plains
grasslands
collaborating to conserve *America's most impacted habitat*

Study area

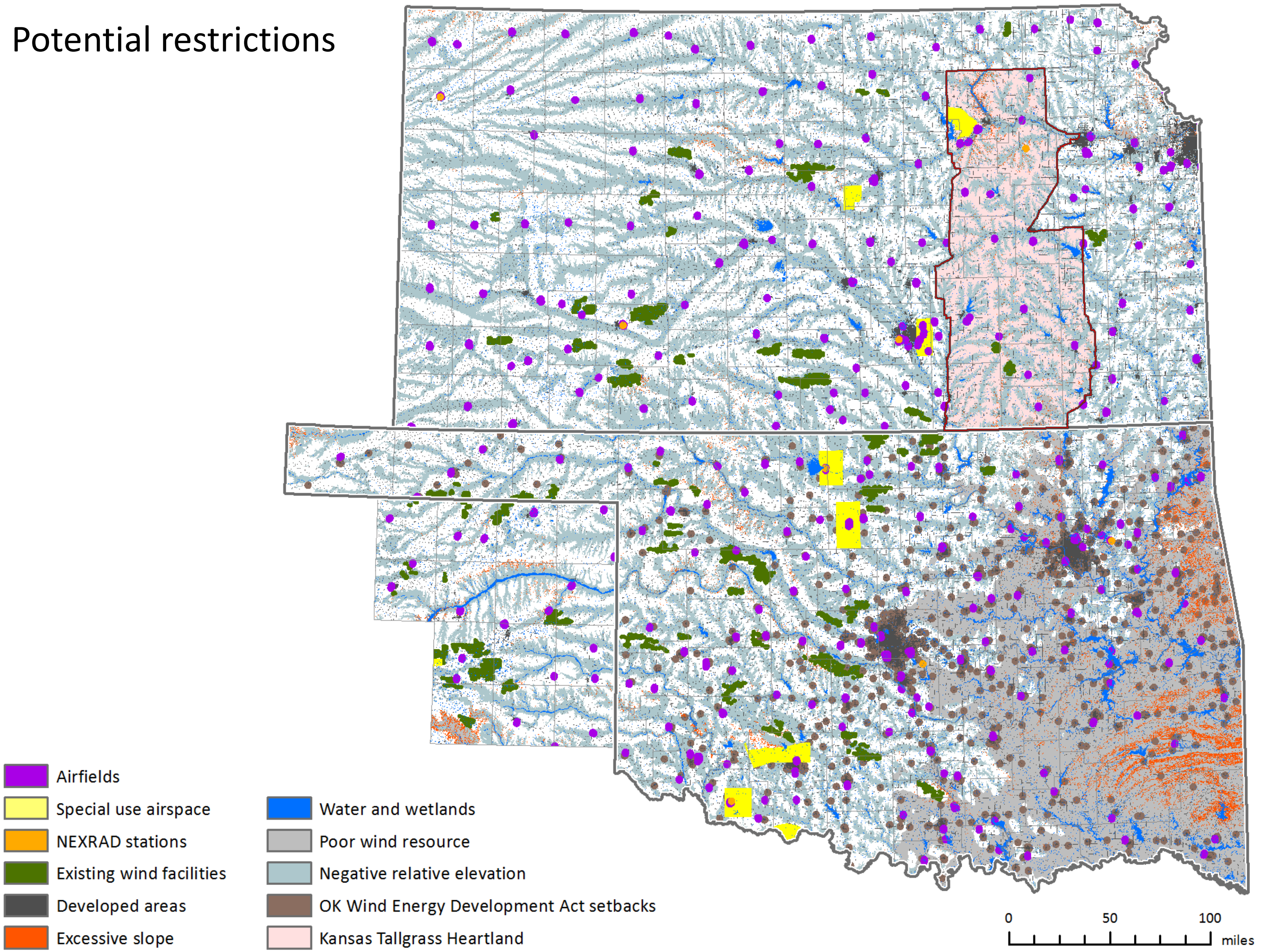
Kansas
Oklahoma
NE Texas Panhandle



Key wildlife areas



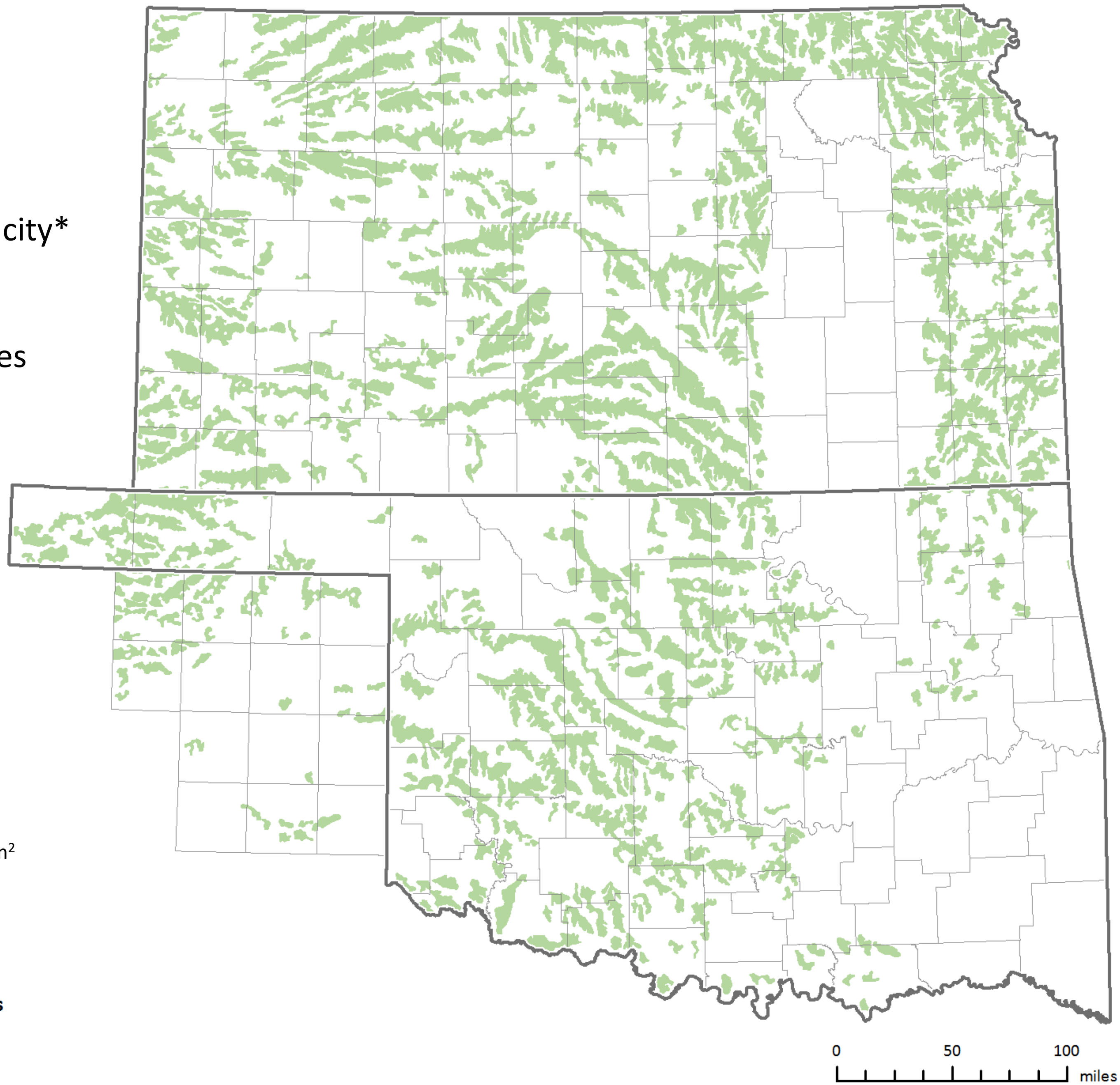
Potential restrictions



Results

190 GW of add'l capacity*

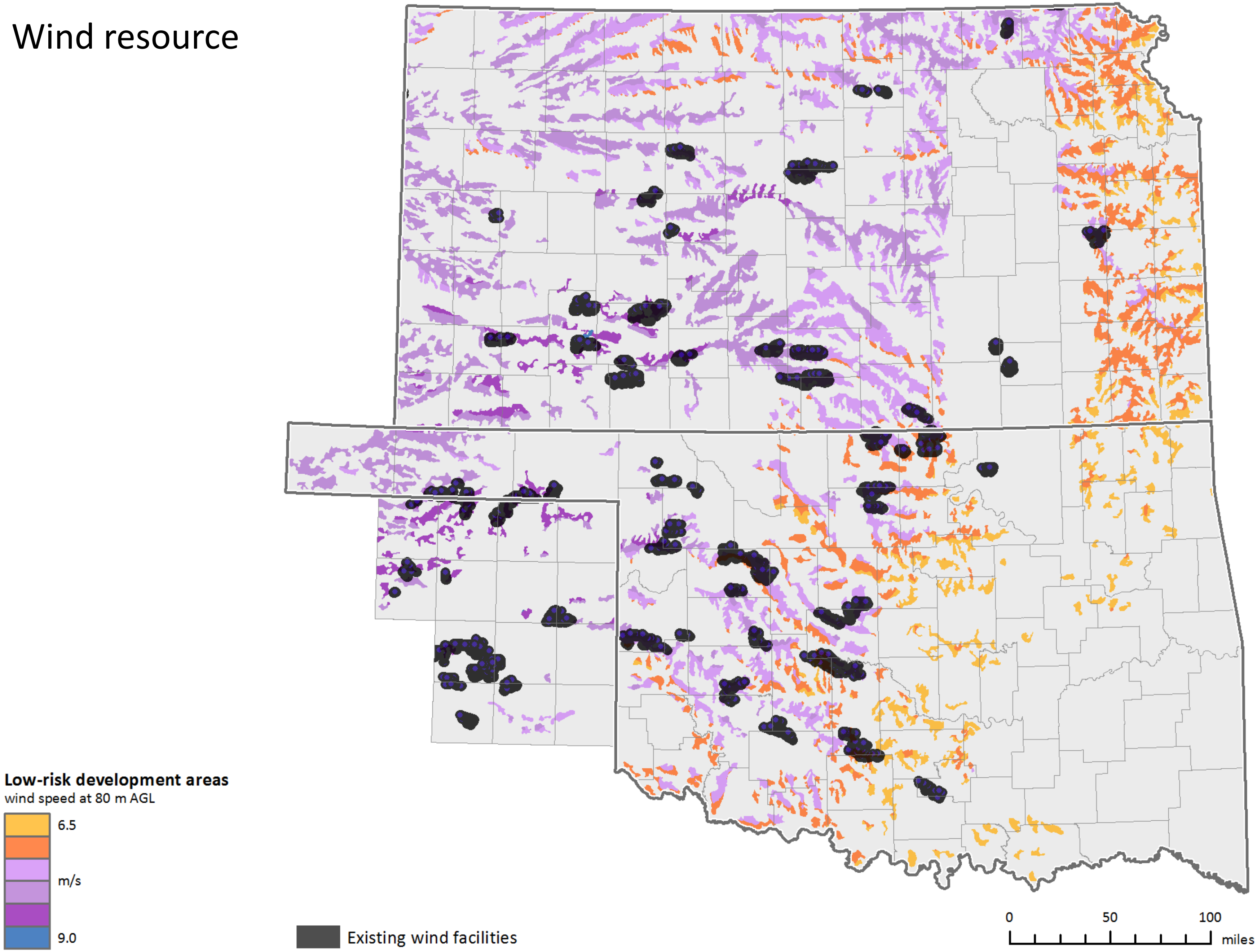
>20x DOE study figures



* Kansas and Oklahoma
calculated nameplate at 3 MW/km^2

Low-risk development areas

Wind resource

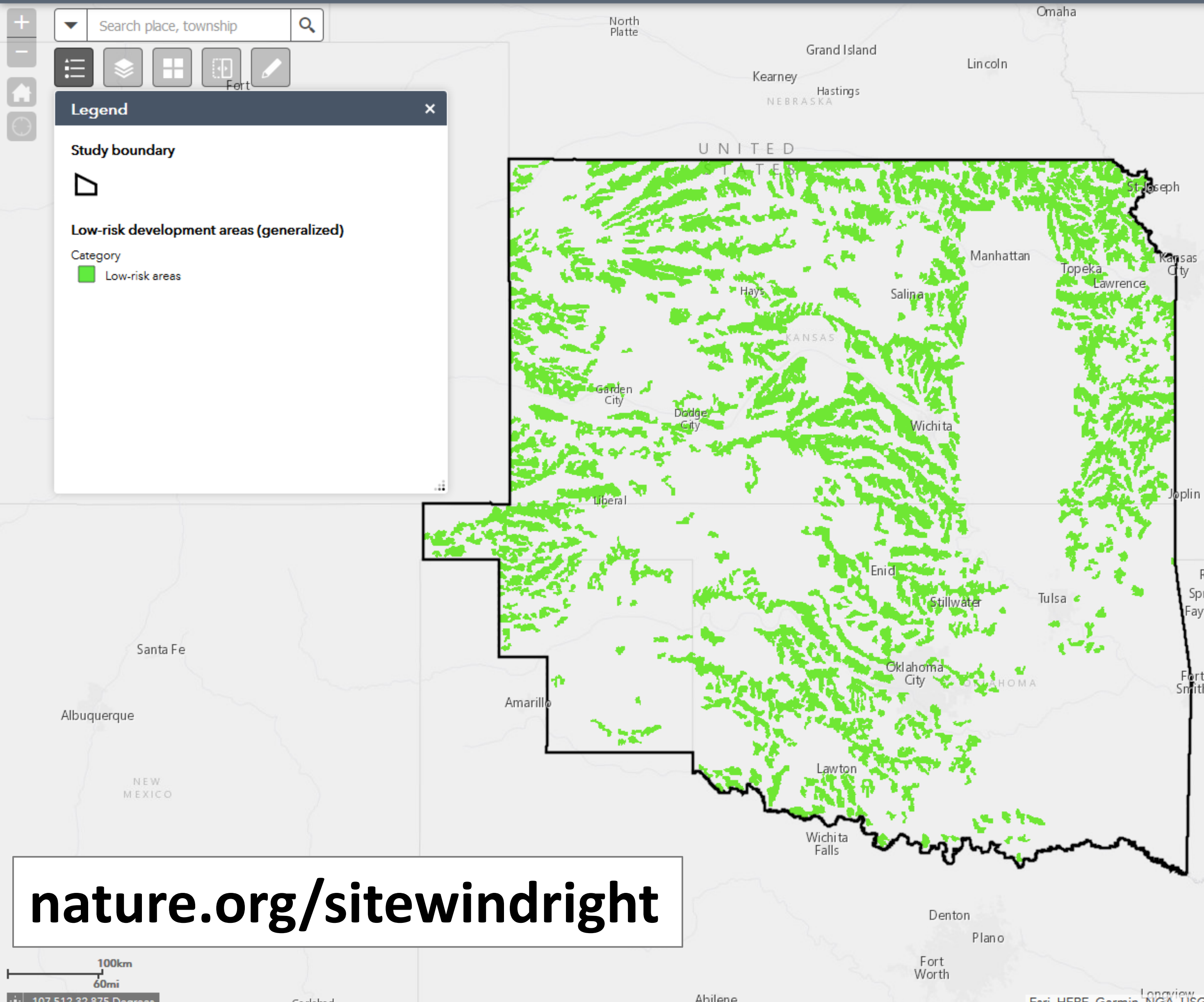


Central Plains Low-Risk Wind

tnc.maps.arcgis.com/apps/webappviewer/index.html?id=789aa65256b744ad9ccd54fb90130ba8

NOAA Mesonet

Central Plains Low-Risk Wind *revised 8/25/2017* nature.org/sitewindright



About

Power purchasers acquiring wind-generated electricity from the central Great Plains may meet their renewable energy objectives while protecting sensitive ecosystems by selecting projects sited in defined low-risk wind energy development areas.

This analysis identifies locations in Kansas, Oklahoma and a portion of Texas where conflicts between wind energy and wildlife are likely to be minimal. Importantly, the assessment factors engineering and land use constraints so that sites with low development potential are excluded.

The results indicate that over 6 million hectares of viable wind resource in Kansas and Oklahoma may be developed without significant negative impacts to wildlife. Collectively, this area is capable of yielding over 190 GW of electrical capacity, approximately 20 times greater than the combined state figures detailed in the U.S. Department of Energy's 20% by 2030 Wind Vision Study Scenario.

Visit nature.org/sitewindright for additional information.

The Nature Conservancy

nature.org/sitewindright

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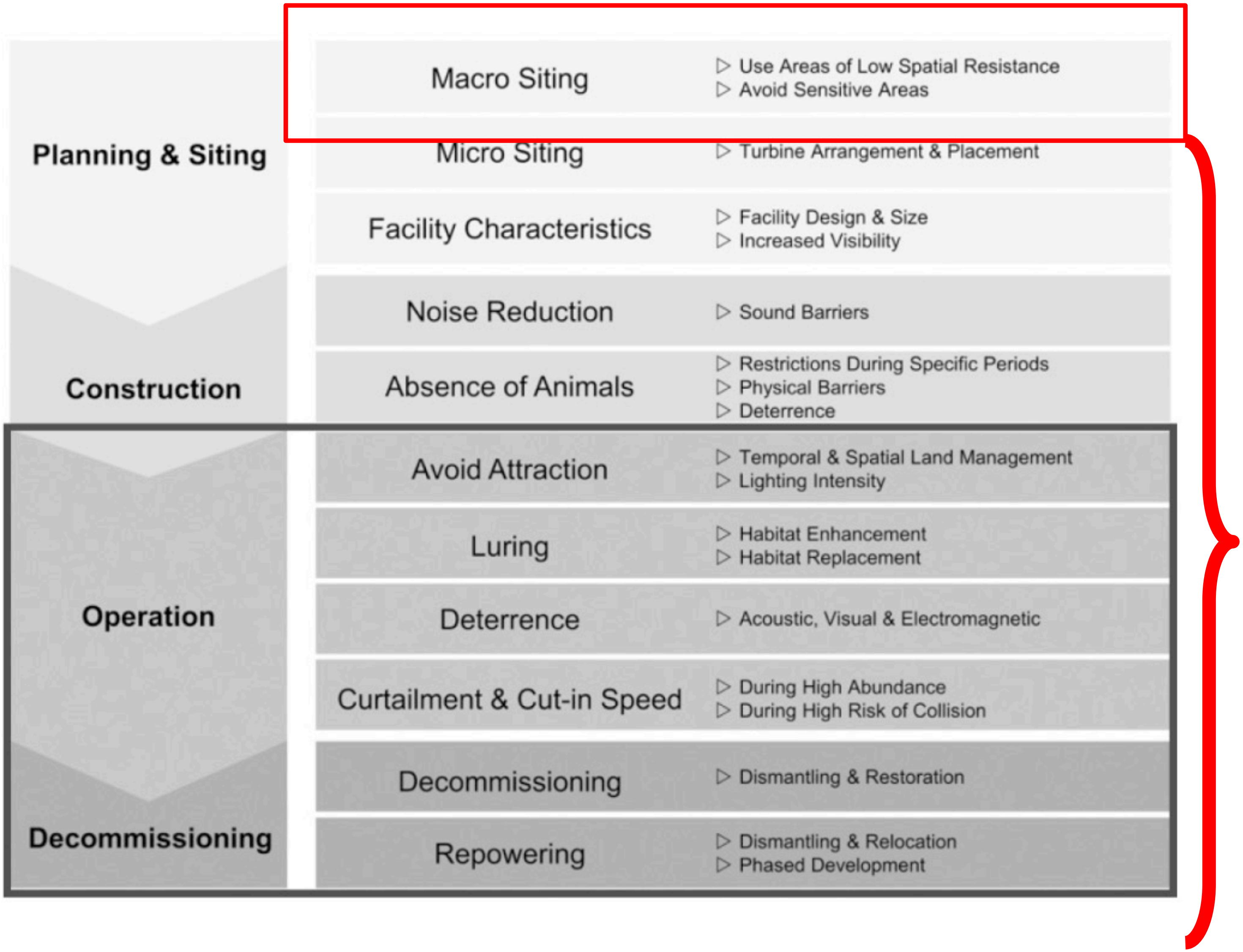
Mitigation Measures Classification



Gartman et al. 2016 Journal of Environmental Assessment and Policy

Summary

- Energy sprawl is a concern and footprint of wind development is high
- Analyses support development on existing disturbance
- Wyoming has world-class wildlife resources and open spaces. Maps for “smart siting” exist. New wildlife data are available and emerging to develop updated “lower risk” maps
- QUESTION: What, if any, opportunity exists to influence siting of future development, including proposed projects?