

Mapping Migration

Important places for Wyoming's migratory birds

Executive Summary

Wind development poses a potential threat to Wyoming's migratory birds. Potential impacts could be avoided by siting turbines in areas away from important migratory pathways or stopover habitat. Knowledge of bird migratory behavior is incomplete. However, by synthesizing existing information into maps, land managers and developers can identify critical areas for these birds. This report is based on a study that synthesized knowledge of migration behaviors for four functional groups of migrating birds: wetland birds, riparian birds, raptors and sparse grassland birds¹. These groups represent a majority of migrating species in Wyoming, including many species of conservation concern. We combined important migration areas for each of the four groups into one



map and found that 73% of these areas were exposed to potential wind development. However, 27% of the lands with high potential for wind development have lower importance for migrating birds. By focusing development here, impacts to migrating birds could be avoided or reduced.

Migratory bird conservation needs



Many birds migrate each spring and fall between their summer and winter habitats. During these journeys birds often concentrate at stopover sites to rest and forage. Effective migratory bird conservation requires protection of summer (breeding), winter, and migration habitats. Energy expended each migration

can impact the persistence of individuals and even populations, making conservation of migration habitat crucial to conserving species. Migration is a poorly understood component of a bird's annual activities; in particular, there are limited data on the locations of stopover sites and movement pathways. Although some organizations have worked to identify individual stopover sites deemed critical to migrating birds, maps showing important migratory areas across entire landscapes are lacking, particularly in the Rocky Mountain region. By mapping information synthesized from migration literature and experts, conservationists can gain a clearer picture of where important bird migration habitat is throughout the region. These migratory concentration maps could facilitate proactive planning related to wind farms or other infrastructure developments and better target conservation efforts for migratory birds.

Study Objectives

- Synthesize existing knowledge about bird migration in Wyoming
- Use this knowledge to create maps showing where birds likely concentrate during migration
- Identify the overlap between important areas for both migration and wind development

Migratory bird groups

This study considered four functional groups of bird species known to migrate through Wyoming: wetland birds, riparian birds, raptors and sparse grassland birds. Functional groups were used because the species within each group have similar migration behaviors and insufficient data is available for most individual species. These groups represent a majority of migrating species in Wyoming, including many species of conservation concern. All groups represent

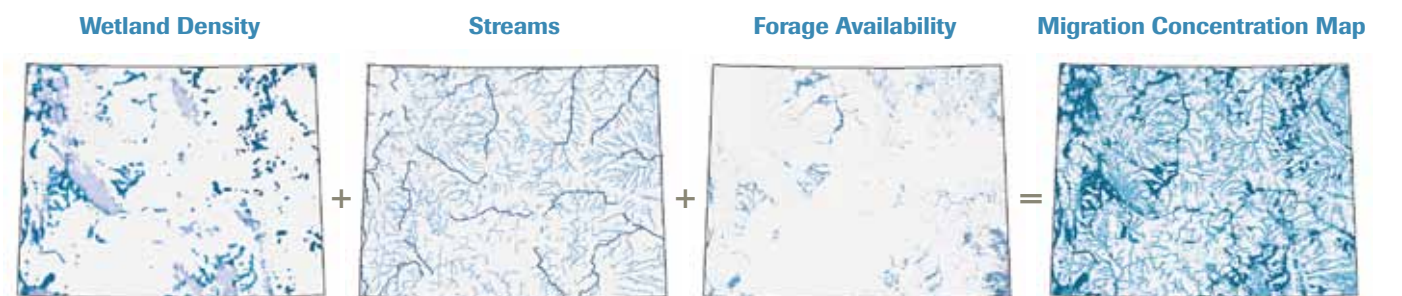


CLOCKWISE McCown's Longspur (sparse grassland bird) © John Carlson; Sharp-shinned Hawk (raptor) © Michael Wickens; Snowy Egret (wetland bird) © Kathy Lichtendahl; Yellow-breasted Chat (riparian bird) © Bob Griffith

species that concentrate during migration, except sparse grassland birds, which were included because many of these species are declining. Some of the maps better represent either spring or fall migration patterns, as described for each bird group.

Migration mapping methods

1. Gathered information on migration behavior and ecology from literature and bird experts.
2. Identified the most important factors for migration and additional variables that modify factor importance in certain locations. Developed conceptual models based on these factors and modifiers.
3. Translated each important factor for migration into a Geographic Information System (GIS) layer.
4. Combined GIS layers to represent each group's conceptual model and create a migration concentration map.
5. Tested accuracy of the final maps using 1) expert ratings on a 5-point scale ranging from very poor (-1) to very good (1), and 2) statistical associations between map predictions and documented migratory bird observations, as measured by the Boyce Index (range -1 to 1).



Example of combining GIS map layers for individual factors important for migration into a final map representing relative importance for migration concentration.



Migration Stopover Concentrations

The wetland bird group includes both waterfowl (e.g., ducks, geese, pelicans) and shorebirds (e.g., gulls, wading birds) and targets spring migration, when this group is most concentrated. Wetland birds generally migrate at night, stopping and feeding during the day. They tend to migrate along large perennial streams and use marshes, wetlands, lakes, reservoirs, and other water bodies for stopover sites²⁻⁸. Larger lakes and wetlands, as well as clusters of wetlands in close proximity, can support large groups of migrating waterfowl and shorebirds and provide safety from predators. Agricultural lands, especially those close to water, can provide important foraging areas for migrating wetland birds⁹. Ducks and geese often forage in corn, wheat, and other grain fields while shorebirds will sometimes feed in irrigated

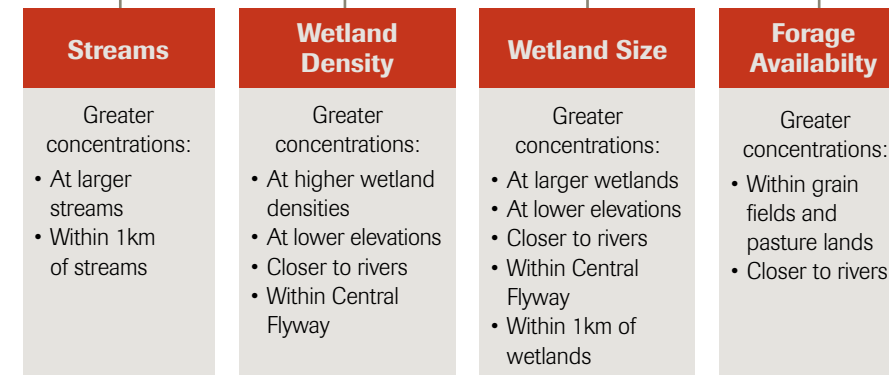
pastures and hay meadows. Eastern Wyoming overlaps the Central Flyway, a major migration route for waterfowl, and thus tends to have higher concentrations of migrating ducks and geese than the western portion of the state.

Although wetland birds attain some of the highest altitudes during migration, generally flying well above the height of wind turbines, many have large bodies relative to their wing span, necessitating long take-off and approach distances at stopover sites^{3,10}. Thus, wetland birds are most at risk from collisions with wind turbines while ascending from or descending to stopover and foraging sites^{11,12}. Wetlands and streams were buffered in our model to account for long take-off and approach distances¹³.

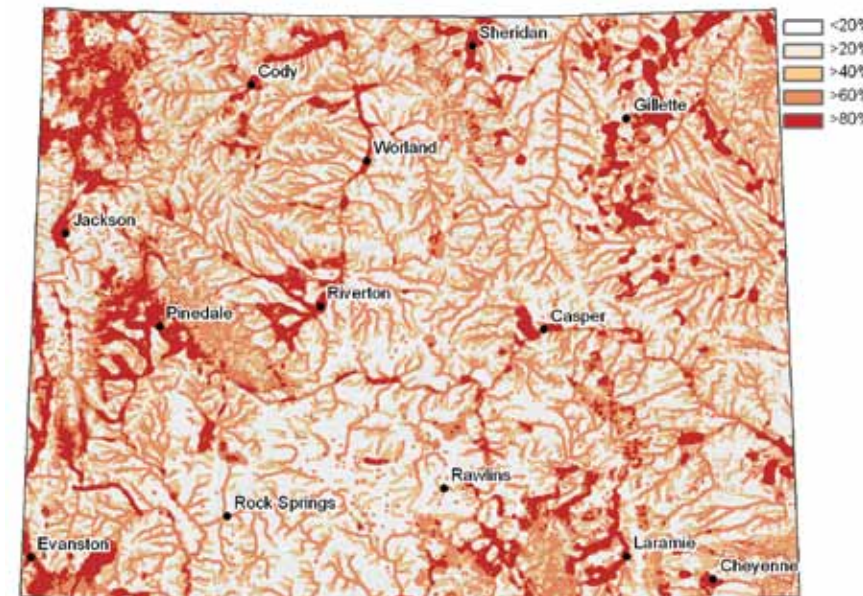
THIS PAGE TOP TO BOTTOM American Avocets © Kathy Lichtendahl; American White Pelican © Ian Abernethy; Canada Geese © Ian Abernethy

We modeled spring wetland bird stopover concentrations as a function of streams, wetland size and density (modified by elevation, proximity to rivers, and migratory flyway) and forage availability (modified by proximity to rivers).

Wetland Bird Migration Concentration



Conceptual model of wetland bird migration concentrations. Factors are shown in colored boxes, with modifiers appearing below.



Continuous modeled values were binned into five quantiles representing relative importance for migration concentration. Darker colors represent areas with greater importance, where >80% represents areas more important than those found across 80% of the state.

Map accuracy: Experts rated this map as Very Good (Score = 0.88). There was also strong agreement between the map and migrating bird records (Boyce Index = 0.95).

SPECIES REPRESENTED

Over 40 wetland bird species are represented by the map, including:

- Common Loon (*Gavia immer*)
- Clark's Grebe (*Aechmophorus clarkii*)
- American Bittern (*Botaurus lentiginosus*)
- Snowy Egret (*Egretta thula*)
- Black-crowned Night-Heron (*Nycticorax nycticorax*)
- White-faced Ibis (*Plegadis chihi*)
- Northern Pintail (*Anas acuta*)
- Lesser Scaup (*Aythya affinis*)
- Canvasback (*Aythya valisineria*)
- Redhead (*Aythya americana*)
- Barrow's Goldeneye (*Bucephala islandica*)
- Virginia Rail (*Rallus limicola*)
- Sandhill Crane (*Gras canadensis*)
- Franklin's Gull (*Leucophaeus pipixcan*)
- Caspian Tern (*Hydroprogne caspia*)
- Black Tern (*Chlidonias niger*)
- Forster's Tern (*Sterna forsteri*)

Did you Know?...

Sandhill Cranes have been documented migrating at up to 3600 m (11,800 ft) above sea level, though most migration flights occur at much lower elevations.¹⁴



THIS PAGE LEFT TO RIGHT Sandhill Crane © Russ Schnitzer; Red-necked Phalaropes © Scott Copeland



Riparian Birds



Migration Stopover Concentrations

Riparian birds include cuckoos and certain species of songbirds and flycatchers. These birds breed in vegetation along stream and river corridors and seek similar habitat while migrating. We modeled stopover habitat during spring migration, when species in this group are most concentrated. During migration, riparian birds concentrate along perennial rivers and streams where structurally-diverse riparian trees and shrubs are present¹⁵⁻¹⁹. Riparian migrants are most likely to use larger, north-south oriented rivers or streams to guide migration^{18,19}, and cottonwood and willow-dominated riparian areas are used more frequently than other vegetation types¹⁹. Isolated oases of riparian habitat are often found around large permanent wetlands and are important to riparian migrants, especially in arid

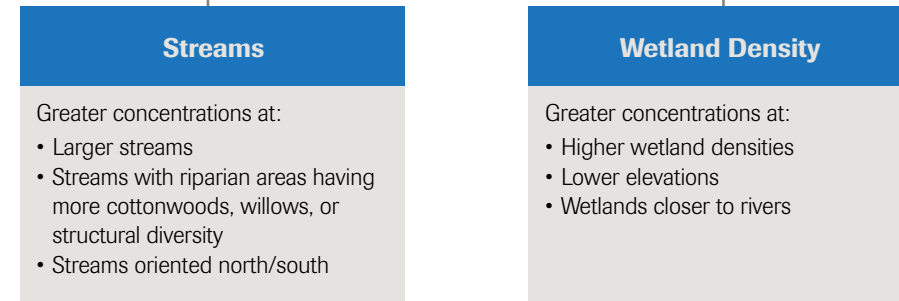
landscapes like much of Wyoming^{18,19}. Wetlands are more likely to be used when they are located near the streams followed by migrants, and lower elevation riparian corridors tend to be used by a greater number of species^{17,20}. Some migrants use different routes in spring and fall, preferring lower elevation riparian corridors in spring, when higher elevation riparian and forested areas and the food that they provide are still buried under snow^{19,21,22}.

Forest and shrubland birds may also use areas identified by our riparian model^{15,17,19,23}. This is because riparian areas offer more concentrated resources when snow is still on the ground in the spring, especially in the upland forests.

THIS PAGE TOP TO BOTTOM Willow Flycatcher © Michael Wickens; MacGillivray's Warbler © Michael Wickens; Blue Grosbeak © Catherine Nishida

We modeled spring riparian bird stopover concentrations as a function of streams (modified by orientation and riparian vegetation) and wetland density (modified by elevation and proximity to large rivers).

Riparian Bird Migration Concentration



Conceptual model of riparian bird migration concentrations. Factors are shown in colored boxes, with modifiers appearing below.



Continuous modeled values were binned into five quantiles representing relative importance for migration concentration. Darker colors represent areas with greater importance.

Map accuracy: Experts rated this map as Very Good (Score = 0.97). There was also strong agreement between the map and migrating bird records (Boyce Index = 0.91).

Did you Know?...

The riparian corridor just below Fontenelle Dam on the Green River is a hotspot for migrating riparian and forest birds in Wyoming. Nine species of riparian-obligate birds and dozens of forest-dwelling bird species are regularly documented in this narrow riparian strip during spring and fall migration.²⁴

THIS PAGE TOP TO BOTTOM Yellow-billed Cuckoo © Catherine Nishida; Riparian corridor along the Green River © Holly Copeland

SPECIES REPRESENTED

- Black-billed Cuckoo (*Coccyzus erythrophthalmus*)
- Yellow-billed Cuckoo (*Coccyzus americanus*)
- Willow Flycatcher (*Empidonax traillii*)
- Yellow Warbler (*Setophaga petechia*)
- Northern Waterthrush (*Parkesia noveboracensis*)
- MacGillivray's Warbler (*Geothlypis tolmiei*)
- Wilson's Warbler (*Cardellina pusilla*)
- Yellow-breasted Chat (*Icteria virens*)
- Blue Grosbeak (*Passerina caerulea*)
- Song Sparrow (*Melospiza melodia*)
- Lincoln's Sparrow (*Melospiza lincolni*)
- Orchard Oriole (*Icterus spurius*)
- Bullock's Oriole (*Icterus bullockii*)





Raptors

Fall Migration Concentrations

The raptor group includes diurnal birds of prey (e.g., hawks, eagles). Unlike many other migrants, most raptors do not maintain high altitudes during migration. Instead, they conserve energy by gaining lift from updrafts and thermals and gliding long distances, slowly losing altitude, to the next updraft or thermal^{10,25,26}. Therefore, instead of concentrating at stopovers, raptors concentrate in areas that provide the best updrafts and thermals, especially during fall migration, to which this model pertains.

Ridges and mountain ranges oriented perpendicular to prevailing winds produce the strongest updrafts. Although some ridges consistently provide strong updrafts, the location of updrafts can vary daily with local wind and weather conditions. As a result, when updrafts are not available, raptors will adjust their

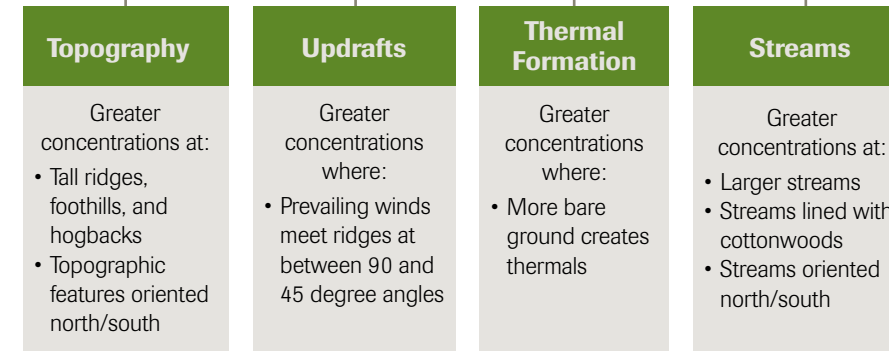
migration routes to take advantage of thermals, which form over surfaces that heat up the air faster (e.g. rock, sand, bare ground, pavement)^{25,26}. Raptor movements also are guided by linear landscape features including tall ridges and rivers^{25,27} oriented in the direction of migration.

Raptor species likely not well-represented by our model include Prairie Falcons (*Falco mexicanus*) and Peregrine Falcons (*Falco peregrinus*), which migrate at much higher altitudes than other raptors, resulting in more dispersed migration patterns. Bald Eagles (*Haliaeetus leucocephalus*) also have migration patterns that do not fit this model well due to their specific habitat needs. Ferruginous Hawks and Swainson's Hawks are better represented by the sparse grassland bird model due to their stopover habitat needs.

THIS PAGE TOP TO BOTTOM Golden Eagle © Joe Kiesecker; Golden Eagle © Chuck Preston; Swainson's Hawk © Scott Copeland

We modeled fall raptor migration concentrations as a function of topographical and hydrological leading lines, the suitability of slopes to produce updrafts, and surface layers likely to promote formation of thermals.

Raptor Migration Concentration



Conceptual model of raptor migration concentrations. Factors are shown in colored boxes, with modifiers appearing below.



Continuous modeled values were binned into five quantiles representing relative importance for migration concentration. Darker colors represent areas with greater importance.

Map accuracy: Experts rated this map as Good (Score = 0.45). There was no agreement between the map and migrating bird records (Boyce Index = -0.03); this may be because the model represents where raptors are moving during migration, and many birds are likely recorded while perching or foraging.

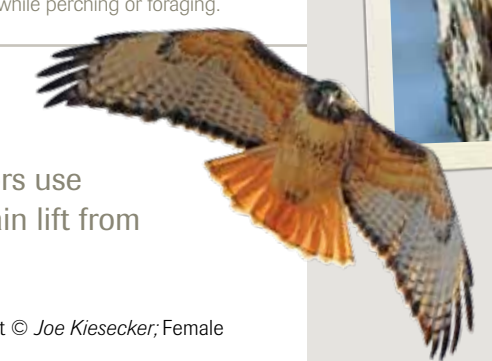
Did you Know?...

Each fall, an average of 3,880 migrating raptors use Commissary Ridge in western Wyoming to gain lift from the updrafts it provides.²⁸

THIS PAGE TOP TO BOTTOM Honeycomb Buttes in Wyoming's Red Desert © Joe Kiesecker; Female American Kestrel © Scott Copeland; Red-tailed Hawk © Keith Cauley

SPECIES REPRESENTED

- Cooper's Hawk (*Accipiter cooperii*)
- Sharp-shinned Hawk (*Accipiter striatus*)
- Northern Goshawk (*Accipiter gentilis*)
- Red-tailed Hawk (*Buteo jamaicensis*)
- Golden Eagle (*Aquila chrysaetos*)
- American Kestrel (*Falco sparverius*)
- Merlin (*Falco columbarius*)





Migration Stopover Concentrations



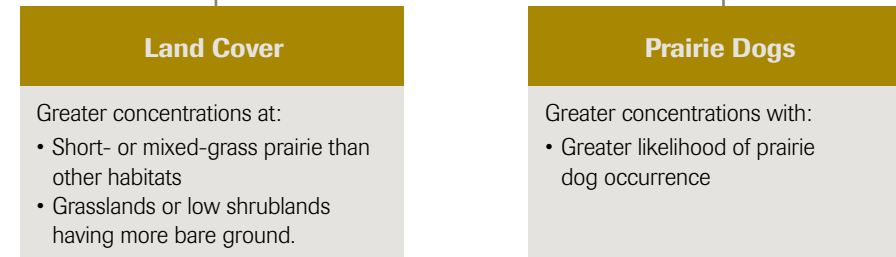
Sparse grassland birds tend to exhibit a more dispersed pattern during migration than other avian species, but we modeled this group because many

species represented are declining. Their populations are being monitored closely by various resource management agencies and conservation organizations. In Wyoming, the sparsely-vegetated grasslands and shrublands used by these birds during migration are relatively widespread. Sparse grassland birds prefer short-grass and mixed-grass prairie and/or low shrublands with plenty of bare ground²⁹⁻³³. Some species also will use heavily grazed, previously disturbed, or tilled land. Many sparse grassland birds, such as the Mountain Plover, are often associated with prairie dog (*Cynomys spp.*) colonies because of the close-cropped grass and high bare-ground components they provide³³⁻³⁶. Others, such as the Ferruginous Hawk, prey upon prairie dogs.

THIS PAGE TOP TO BOTTOM Horned Lark © Kathy Lichtendahl; Mountain Plover © Dave Showalter; Lark Bunting © Chuck Preston; Burrowing Owl © Ian Abernethy

We modeled sparse grassland bird stopover concentrations as a function of grassland or shrubland type, with more value given to locations with bare ground and prairie dog towns.

Sparse Grassland Bird Migration Concentration



Conceptual model of sparse grassland bird migration concentrations. Factors are shown in colored boxes, with modifiers appearing below.



Continuous modeled values were binned into five quantiles representing relative importance for migration concentration. Darker colors represent areas with greater importance.

Map accuracy: Experts rated this map as Good (Score = 0.69). There was also strong agreement between the map and migrating bird records (Boyce Index = 0.90).

Did you Know?...

The Swainson's Hawk has the second longest migration of any North American raptor. The species breeds in grasslands in the U.S. and Canada and winters in the South American pampas in central Argentina, a migration of over 10,000 km (> 6,000 miles)³⁷.



SPECIES REPRESENTED

- Swainson's Hawk (*Buteo swainsoni*)
- Ferruginous Hawk (*Buteo regalis*)
- Mountain Plover (*Charadrius montanus*)
- Burrowing Owl (*Athene cunicularia*)
- Horned Lark (*Eremophila alpestris*)
- Lark Bunting (*Calamospiza melanocorys*)
- Grasshopper Sparrow (*Ammodramus savannarum*)
- McCown's Longspur (*Rhynchophanes mccownii*)
- Chestnut-collared Longspur (*Calcarius ornatus*)



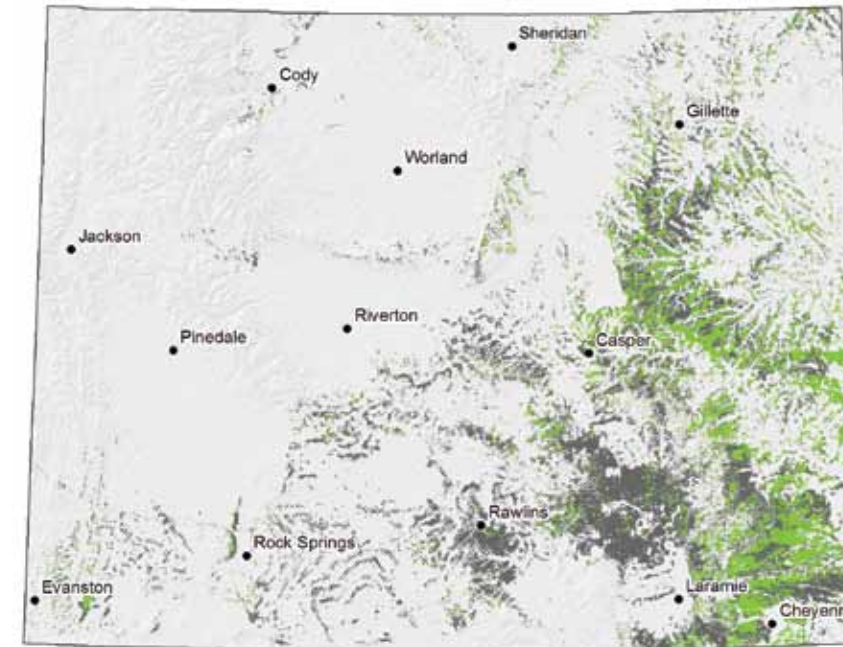
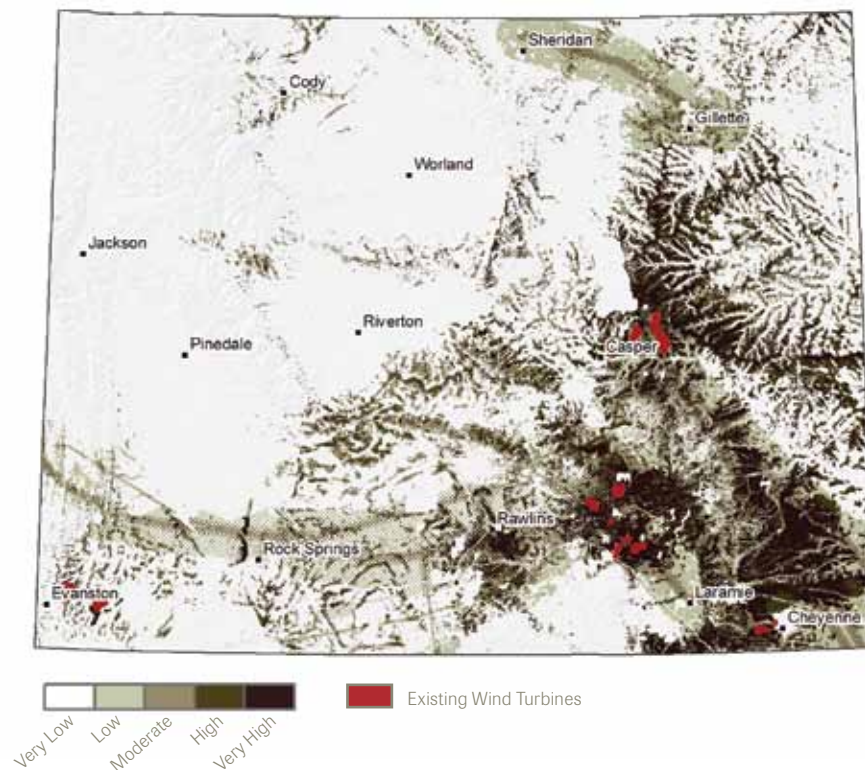
THIS PAGE TOP TO BOTTOM White-tailed Prairie Dog © Ian Abernethy; Grasslands at Hutton Lake National Wildlife Refuge © Ian Abernethy; Swainson's Hawk © Scott Copeland



Forecasting wind development potential

We measured the overlap between the maps of migratory concentration and wind development potential to assess the potential risk (exposure) of migratory birds to wind development.

Wind potential was represented by a GIS model that incorporated wind resource potential (wind speed, slope, topographic position) and near-term development indicators (met towers, land tenure, proposed transmission lines and wind farms). The model also excluded locations where development would be legally precluded, such as wilderness areas and airport runway space.



Where important bird migration and wind development areas overlap.
Where there is high potential for wind development and lower migratory concentrations.

Migration overlap with wind development

- Values for both migration and wind development were classified as high (60-80%) and very high (80-100%). We calculated the percent of overlap between these two types of important areas, as described below.
- We combined important migration areas for each of the four groups into one map and found that 73% of these areas were exposed to potential wind development. This higher overall exposure is due to little overlap in important migratory concentration areas among certain groups.
- The other 27% of the lands with high potential for wind development have lower importance for migratory birds. By focusing development in these areas, impacts to migrating birds might be avoided or reduced.
- Models indicated the greatest wind development exposure was for sparse grassland birds, which have the most dispersed migration concentration areas. Migration habitat for these species includes the southeastern portion of Wyoming, a region that also has some of the best wind resources.
- Potential exposure was most limited for riparian birds, which are the most concentrated of the migrants, clustered primarily along valleys that generally have lower wind development potential.

Migration map applications

- Provide an initial landscape-scale assessment highlighting important migration areas.
- Inform siting of wind developments and identify where mitigation may be needed.
- Assist in preliminary site evaluations recommended by the U.S. Fish and Wildlife Service, and support regional planning for development on public lands by land management agencies such as the Bureau of Land Management. These landscape-scale maps are not a substitute for pre-construction studies.
- Target conservation efforts: land protection, stopover habitat enhancements



Maps are available in GIS format through WYGISC at this link: <http://bit.ly/WYMigratoryBirds>



Advancing knowledge of bird migration in Wyoming

These landscape-scale maps of migratory concentration provide a starting point for understanding patterns of bird migration in Wyoming.

Migration stopover characteristics

Much of the information used to create these maps came from places outside Wyoming. More information is needed on migration in Wyoming, including habitat characteristics and effects of invasive species, development, or other factors on use of stopover sites. The migration concentration maps can suggest possible field sites for further studies.

Movement pathways

The migration concentration maps primarily identify stopover sites. There is still a need to “connect the dots” and determine where the primary migratory pathways are throughout the state. These studies have begun for some specific species and there is a need to expand these efforts to additional species through collection of new data and modeling.



Field validation of maps

Beginning in the spring of 2013, independent data will be collected specifically to validate, and possibly improve, the migration concentration maps created in this study. The maps provide a stratification that can target bird surveys in areas representing a range of predicted migration concentrations.

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THIS PAGE Sandhill Crane feather © *Russ Schnitzer*;
Sandhill Cranes © *Russ Schnitzer*

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