Elk Migration © J Burrell, WCS

Spectacular Migrations in the Western U.S.

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INTRODUCTION

Wildlife migration is a spectacular biological phenomenon that can be witnessed by people around the world. It resonates with our own human history and the migration of people across continents and time. The regular migration of animals, especially birds, has aroused the curiosity of humans since our African genesis. All hunting and gathering societies certainly have known about and perhaps depended upon the movement of animals across land or water. Many cave paintings of animals relay ancient knowledge of animal movements. There are several early written references to the periodic movement of birds in the Bible, and other recorded observations of animal migration date back nearly 3,000 years to the times of Homer, Herodotus, and Aristotle. Humanity has long been aware of the spectacle of animal migration but, until now, had limited understanding of the biological and ecological significance of these migrations. Even today, despite diminished connections between man and nature, the annual synchronized movement of millions of animals captivates the public imagination like few other wildlife phenomenon (Berger 2008).

Migration is the seasonal movement of animals (individuals, populations) across land or seascapes that may differ by sex, age, or environmental conditions: yet the core pattern of movement returns to a central area, either by individuals or across generations (Berger et al 2010). It is a complex behavior that is governed by a number of traits that have varying degrees of genetic control and context sensitivity (Bolger et al 2007). This constellation of traits includes navigation, timing of migration, site fidelity, social behavior, and morphological and physiological adaptations for migration (Bolger et al 2007).

Migration behavior has both cost and benefit for animals and defining the exact nature of the tradeoffs has proven elusive (Bolger et al 2007). This balance is delicate, however, and changes in land use or other external environmental factors can easily tip the balance for or against migration. Pending changes in climate and increased human occupancy of natural landscapes are significant factors influencing the persistence of migration behaviors.

Even though migration is a spectacular biological event we should never lose sight of its even greater ecological significance. Migrants serve as seasonally abundant predators (many raptor species) grazers/browsers (caribou, elk and deer), prey (many ungulates and birds), pollinators (bats, birds and insects), and seed dispersers (many ungulates, bat and bird species). The migrant and its habitats are delicately co-evolved to this seasonal movement and important services that one species provides to another in the ecological system.

There is a growing concern that populations of migratory animals are declining globally (Wilcove 2007). Conservationists have long argued the importance of protecting migratory corridors and dispersal of wildlife (Grzimek and Grzimek 1961, Kelasal 1968, Schaller 1988, Berger 2004). However, long distance migration in terrestrial vertebrates has become a highly fragile ecological phenomenon (Berger et al 2006). Long distance migration events are quietly disappearing due to human population growth and the habitat degradation and fragmentation caused by land use changes (Berger et al 2006).

In this report we identify spectacular migrations in need of conservation that we believe will resonate with our society. We do not mean to imply other migrations are not important but rather attempt to profile flagship examples in order to increase public support for the conservation of wildlife migration phenomena. Our geographic focus is the western United States and our taxonomic focus is mammals and birds.

METHODS

Fish and wildlife biologists from 11 western states including Alaska, Washington, Oregon, Idaho, Montana, Nevada, Wyoming, Colorado, Utah, Arizona and New Mexico were asked to nominate spectacular bird and mammal migration corridors in need of conservation. These biologists were asked to consider the biological phenomenon of migration as well as the urgent need for conservation action. We also consulted terrestrial and aerial migration experts to help evaluate our list of migrations. The migrations nominated through our survey and expert opinions were divided into two groups for analysis and prioritization including terrestrial mammal (land-based) and aerial (flight-based) migrations. We determined that each group should be evaluated through different rule-based filters, based on a set of selection criteria.

Elk Migration, Montana *©Unknown*

Using this survey information and expert opinions of terrestrial ecologists with the Wildlife Conservation Society (WCS) we identified 24 terrestrial mammal migrations in the western United States needing conservation (Map 1). For a full list of nominated corridors and associated data, see Appendix A. We supplemented the survey results for aerial migrations provided by wildlife practitioners with expert opinion from WCS avian ecologists to craft a list of spectacular bird migrations. We identified 17 spectacular aerial migrations needing conservation in the western United States (Map 2, Appendix B).

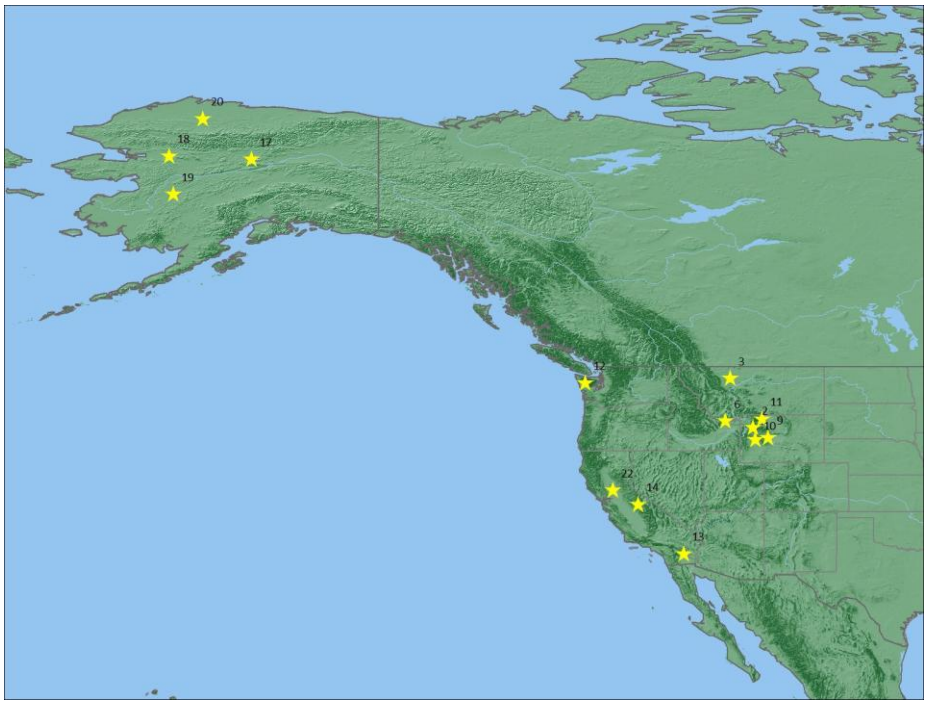
Defining a Spectacular Migration Corridor: Categories and Filter Criteria

In our process, we established a set of five independent evaluation categories for prioritizing these migration spectacles. These categories were designed to discriminate desirable features of a priority migration based on the biological characteristics, conservation status and social significance of each migration. Our purpose was to identify migrations that are not only biological phenomena, but are immediately threatened, demonstrate charismatic qualities (Value for marketing conservation), exhibit a level of stakeholder engagement, and can be conserved in the near future (feasibility). Each category represented a different lens by which to view priority migrations.

We applied two criteria to describe each of the 5 categories to discriminate the relative priority of each migration spectacle (Table 1). For example, two criteria that we used to discriminate biological phenomenon were the distance animals migrated and the number of animals involved in this annual migration. We evaluated the threat level of each migration from the identified number of threats reported in the existing literature and the level of threat reported by experts.

Sandhill Crane Migration *©Steve Zack*

We eventually excluded two filter categories from the aerial migrant prioritization process because they were not very useful in prioritizing these migrations. We found that stakeholder involvement is consistent across bird migration routes and dependent upon scale of that migration. Aerial migrations typically cross many states or even countries and involve stop-over sites along the migration pathway. As birds and even bats use common flyways and pathways that are consistent across land or water, this filter did not help us discriminate among the migrants in our list. We also discovered that conservation feasibility was primarily driven by the migration distance and complexity of jurisdictions that a migrant crossed. Like the stakeholder filter category all aerial migrants crossed multiple jurisdictions depending upon migration scale (i.e. whether local, national, or continental in scale) and therefore this filter did not aid us in discriminating among candidate aerial migrations since most were long distance.



Map 1. General locations of 24 spectacular terrestrial mammal migrations

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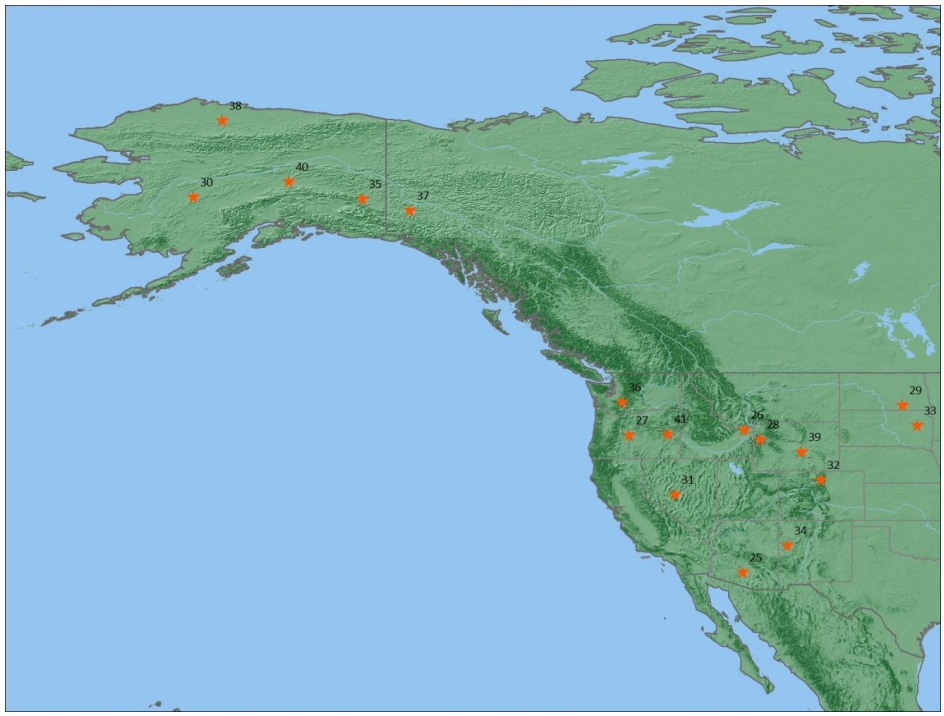


Map 2. General location of 17 spectacular aerial migrations (1 Mammal-16 Birds).

Table 1. Evaluation categories filter criteria, and desirable conditions used for the terrestrial filter. The three highlighted in gray were also used for the aerial filter.

Category	Criteria	Description	Condition Rules
Stakeholder Influence	Number of Stakeholders	Total number of stakeholders engaged.	Higher number of stakeholders is better.
	Distribution of Stakeholders	Ratio of government to non-government organizations.	Lower ratio indicates more public involvement which is better.
Story Telling Value	Charisma based on corridor scale	Local, regional, national or international scale of audience.	A larger audience is better for marketing the value of migration.
	No. animals/Distance migrated	Size of populations divided by the one-way migration distance.	The higher value is better. More animals moving a longer distance is best story.
Threat Complexity and Urgency	Number of Threats	Tally of the number of threats reported by experts and in literature.	Complex threats are more difficult. Fewer is better.
	Level of Threats	Level of threat reported by local experts. A measure of the ability to convince public of urgency.	High threat urgency is important.
Conservation Feasibility	No. Management Jurisdictions	The number of land jurisdictions crossed during migration.	Lower number of jurisdictions is better.
	Migration Distance	Length of the migration in miles. Shorter migrations may be easier to conserve.	Shorter migrations increase the likelihood of conservation success. Longer migrations are more difficult.
Biological Phenomenon	Population of Migrants	Reports on the size of migrant populations	Larger populations are better.
	Maximum Distance	Reported one-way distance of the migration	Long distance migration is more phenomenal.

The Quadrant Approach

For both the terrestrial and aerial filters, a quadrant approach was used to rank the list of spectacular migrations. In this approach, desirable conditions for a priority corridor were determined for each criteria (Table 2). Those corridors which met the desirable conditions for both criteria were put into the top quadrant for that category (Quadrant I). Those meeting desirable conditions for only one of the two criteria in said category were placed into one of two intermediary categories (Quadrants II & III). Those corridors which did not meet desirable conditions for either filter criteria were placed into the bottom quadrant (Quadrant IV) (Diagram 1). This was done for each of the five evaluation categories for the terrestrial filter and for three categories in the aerial migrant filter.

Diagram 1. Example of criteria-based quadrant design using "stakeholder influence" category.

Category: Stakeholder Influence			No. of Stakeholders	
			Worse	Better
			<6	≥6
Stakeholder Distribution	Better	≤1	II	I
	Worse	>1	IV	III

Using Filters and Rules for Prioritizing Spectacular Migrations

For the terrestrial mammal migrations group, the nominated migrations were passed through a two-step filter process. Those terrestrial mammal migrations meeting the optimal set of condition rules for the five evaluation categories (Table 2) were selected as first filter migration spectacles. To further prioritize this set we ran them through a second filter based on an additional rule set. Under this second filter, the rules required that top priority migrations must fall into the top quadrant (Quadrant I) for Biological Phenomenon. Those terrestrial mammal migrations which met the condition rules for this second filter, as well as rules for the first filter, were considered the best choice terrestrial migration corridors for conservation.

Table 2. Rules for migrations to pass through first filter in selecting best choice terrestrial mammal migrations in need of conservation.

Filter 1: Top choice mammal migrations must meet one of the four following conditions:	
1	Falls into the top quadrant (Quadrant 1) in at least three of five evaluation categories
2	Rank is intermediate (Quadrant II and III) or higher for at least four of the five categories
3	Classed in the top quadrant in two of the five evaluation categories but never ranks in the lowest
4	Ranked at least once in the top quadrant and is ranked intermediate for at least three of five evaluation categories.

The 17 aerial migrations were filtered using only three evaluation categories. Those aerial migration corridors which met the condition rules for these evaluation categories (see Table 3), were selected as priority aerial migrations for conservation.

Table 3. Rules for aerial migrations to pass through first filter in selecting best choice aerial migrations in need of conservation.

Filter: Top choice aerial migrations must meet all of the three following conditions:	
1	Fall into top quadrant (Quadrant 1) in at least two of the three categories
2	Must never be ranked in the lowest quadrant (Quadrant IV)
3	May be ranked in intermediate quadrants (Quadrant II or III) once.

A View Through Different Lenses

The prioritization of each migration spectacle when viewed through different evaluation lenses provided unique arrangement of priorities. There is confidence that conservation of most mammal migrations is feasible in the near future. We found that, through expert opinion, only three of these mammal spectacles were viewed as highly threatened and those in the Rocky Mountains where human population growth and land use conflicts are high. The greatest conservation challenge may be saving large scale caribou migrations where significant energy exploration is predicted during the next few decades and climate change is a potential impact. On the other hand most of the aerial migrations were viewed as threatened because international cooperation is necessary to conserve these phenomena. We identified several important migrations with great story telling power that can be profiled to market the conservation of animal migration.

Table 4. Priorities for terrestrial mammal migrations as viewed through different evaluation lenses.

Migration	Stakeholder Engagement	Story Telling	Threat	Feasibility	Biological Phenomenon
HD Mountains-CO/NM					
Pinedale Anticline-WY					
National Elk Refuge-WY					
Sonoran Pronghorn-AZ/NM					
Desert Bighorn CA/NV					
Teshekpuk Caribou-AK					
Porcupine Caribou-AK					
Sun River Elk-MT					
N. Yellowstone Elk-MT/WY					
Piceance Corridors-CO					
Olympic Peninsula Elk-WA					
W. Arctic Caribou-AK					
Central Arctic Caribou-AK					
Forty Mile Caribou-AK					
Paunsegaunt Kaibab-UT/AZ					
Interstate Antelope-CA/NV					
Sun River Bighorn-MT					
Salmon River Corridor-ID					
Sierra Nevada Bighorn-NV					
Loyalton-Truckee Deer-CA/NV					

Table 5. Priorities for spectacular aerial migrations as viewed through different evaluation lenses.

Migration	Story Telling	Threats	Biological Phenomenon
Swainson's Hawk			
American Golden Plover			
Calliope Hummingbird			
Upland Sandpiper			
Desert Pollinator Bats			
Long-Billed Curlew			
Bristle -thighed Curlew			
Piping Plover			
Snowy Plover			
Western Snowgeese			
Sandhill Cranes			
Northern Pintail			

TERRESTRIAL MAMMAL MIGRATIONS IN THE WEST

Long distance mammal migrations are found throughout the western United States and are deemed critical to the viability of those populations. Unfortunately knowledge of many mammal migrations is low and human impacts on migrations are high (Harris et al 2009). We identify 24 spectacular terrestrial mammal migrations in this report but by no means imply that other migrations are not important and deserve conservation attention. We prioritize from our list to guide conservation efforts toward those known migrations that are most threatened based upon expert opinions. It was our intention to create this list so that conservation efforts may be directed toward migrations that can serve as examples of "how to conserve" this important ecological phenomenon.

Top 24 Spectacular Terrestrial Mammal Migrations

As a result of our survey of western states we have found 24 important land-based mammal migrations involving pronghorn, elk, mule deer, bighorn sheep, moose and caribou (Appendix A). These migrations represent a significant set of long distance migrations by terrestrial mammals that are important to ecosystems, economies and cultures. They present an enormous conservation opportunity to effect landscape management at local and regional scales.

Bighorn Migration ©Kevin Ellison

Setting Priorities for Conserving Land Migrations

Terrestrial Filter: Desirable criteria for each category: Based on the range of values for filter criteria, a selection threshold was chosen to discriminate our priority migrations (Table 4). In all criteria except Stakeholder Distribution[1] and Level of Threat, the mode of the values was used as a desirability threshold. When a criteria was not an actual numerical value and a mode calculation was not appropriate (i.e. Stakeholder Distribution and Level of Threat), expert opinion from the agency biologists and Wildlife Conservation Society staff was used to determine the level of threat and number/types of stakeholders engagement.

1 Range of ratio values is not available due to a third element in the criteria which was the involvement of a for-profit business. Presence of a business interest created a penalty to the desirability and created a non-numerical data set where mode could not be calculated.

Table 6. Range of criteria values and desirable conditions by category for the first terrestrial filter

Category	Criteria	Range	Desirable Condition Rule
Stakeholder Influence	Number of Stakeholders	4-17	≥6
	Distribution of Stakeholders	N/A	≤1
Story Telling Value	Charisma based on corridor scale from 1=local to 4=intercontinental	1-4	≤3
	No. animals/Distance migrated	2-5000	≥80
Threat Complexity and Urgency	Number of Threats	2-6	≤4
	Level of Threats	Low, Med., Med-High, High	Med-High, High
Conservation Feasibility	No. Management Jurisdictions	2-6	≤4
	Migration Distance	20-400	≤100
Biological Phenomenon	Population of Migrants	200-500,000	≥7,501
	Maximum Distance	20-400	≥100

Terrestrial Filter 1: Out of a possible 24 terrestrial wildlife migration corridors, 13 meet all criteria thresholds and rules. They exhibit a satisfactory combination of desirable conditions established by our first filter process. These corridors are listed below and represent a fairly wide range of species and geographies (Table 6).

Terrestrial Filter 2: Six of the 24 terrestrial mammal migrations ranked in Quadrant I for the Biological Phenomenon category. That is, they represent migrations of great distance involving large numbers of animals. We chose this specific second filter step to assure that we discriminate a set of migrations which are best examples of biologically spectacular long distance migrations of terrestrial mammals.

Caribou Migration, Alaska © Joe Liebezeit

The Best Five: Five of the 24 terrestrial mammal migrations we identified met the rules applied under *both* the first and second filters (Table 7). Of these five priority terrestrial mammal migrations, three are based on barren ground caribou populations and are located in Alaska. The remaining top migrations include one pronghorn migration located in northern Montana and one migration in western Wyoming involving elk, mule deer and pronghorn (Table 8). These represent our best choice for migrations needing immediate conservation action and that can serve as outstanding examples of mammal migrations.

Table 7. Terrestrial wildlife migration corridors meeting rules for first filter priority conditions. None of these migrations were classed in Quadrant 4, the least desirable condition.

Migration Spectacle	**Quadrant I**	**Quadrant II and III**
Northern Pronghorn-Montana, Sask., Alberta	0	4
HD Mountains Elk and Mule Deer –Colorado	1	3
Piceance Basin Elk and Mule Deer-Colorado	1	3
Path of the Pronghorn- Wyoming	1	3
Pinedale Anticline-Wyoming	2	2
Sonoran Pronghorn- Arizona	1	3
Sierra Nevada Bighorn-Nevada	1	3
Mojave Desert Bighorn-Californial, Nevada, Mexico	2	2
Western Arctic Caribou-Alaska	2	2
Central Arctic Caribou-Alaska	1	3
Porcupine Caribou-Alaska	2	2
Loyalton-Truckee Deer-California, Nevada	1	3
Interstate Antelope, California, Nevada	2	2

Table 8. Criteria values and quadrant rankings for top five spectacular terrestrial mammal migrations

	Stakeholder Influence			Marketing Value			Threat			Conservation Feasibility			Biological Phenomenon		
Migration Corridor	No	Distribution	Quad.	Charisma		Quad.	No.	Level	Qaud.	Jurisdictions	Migration Distance	Quad	Population	Migration Distance	Quad.
Northern Pronghorn	8	5:4:1	III	4	25	II	5	High	II	4	400	III	10,000	400	I
Pinedale Anticline	17	5:12	I	2	250	III	6	Med-high	II	4	100	I	25,000	100	I
Western Arctic Caribou	12	5:5:2	III	3	5000	I	1	Low	III	4	400	III	500,000	400	I
Central Arctic Caribou	8	4:3	III	3	558	I	1	Med	III	4	120	III	32,000	120	I
Porcupine Caribou	9	4:4	I	3	308	I	1	Low	III	4	400	III	169,000	400	I

Spectacular Mammal Migrations in Need of Conservation

Northern Pronghorn Migration-Montana, Alberta, and Saskatchewan: The Canary of the Prairie

The Migration Spectacle

Pronghorn, *Antilocarpa Americana*, the fastest land mammal in North America, once rivaled bison as a prominent feature of the American prairie. Prior to the arrival of Euro-Americans, there were 20-60 million pronghorn that ranged from Texas to southern Alberta and Saskatchewan Canada. Today there are about 1.2 million pronghorn surviving on the Great Plains and intermountain valleys of the west. Most of these pronghorn are a product of wildlife restoration efforts implemented by a new conservation ideal established in the early 20th century. As a result, pronghorn are again a prominent feature of intact prairies in many western states.

Recent research by state and provincial wildlife biologists has revealed an international pronghorn migration spectacle in Montana and Saskatchewan. Unlike the famous "Path of Pronghorn" that presents an invariant migration path in Wyoming, this migration is complex and illustrates multiple routes and patterns of movement across a human dominated landscape (Map 3).These pronghorn migrate through complicated obstacles to reach fawning areas to the north in Alberta and Saskatchewan and then return to wintering habitats in Montana and southern Alberta and Saskatchewan. On average the migration is 256 miles but some animals have migrated up to 515 miles. Spring migration starts the first week of March and takes 2-3 weeks until these pronghorn reach fawning areas. The fall migration follows the early signs of winter and is usually rapid to avoid being trapped by winter snows.

Extreme weather causes variation in this annual migration and drives the antelope to the south across the Missouri River and Fort Peck Reservoir where they occasionally are trapped during their spring return. In addition, extreme weather can cause winter aggregations along railroads and highways. In 2011 over 700 antelope were killed along the railroad line that crosses northern Montana.

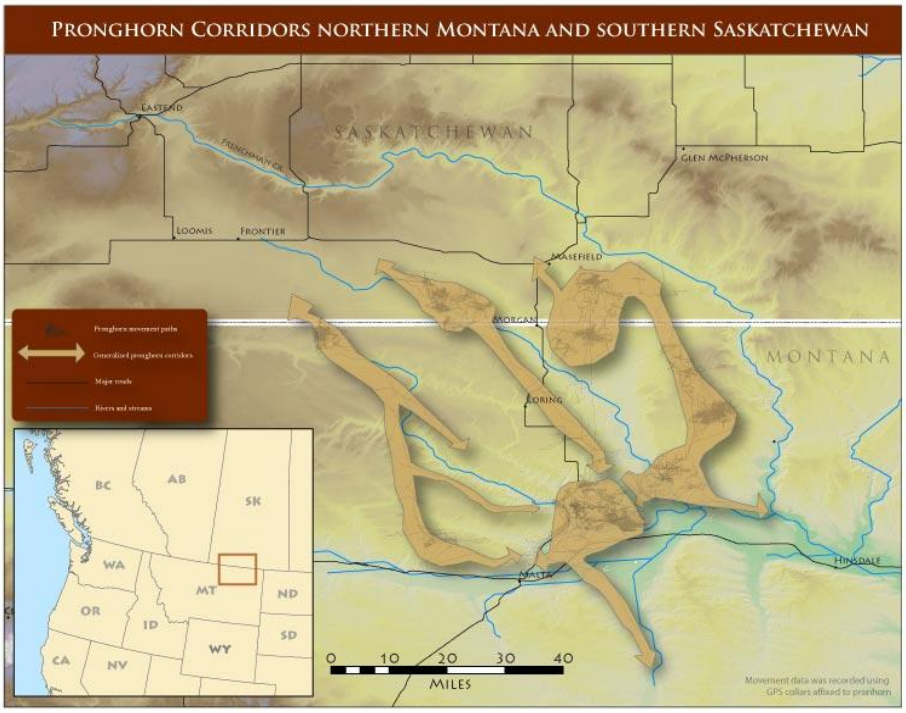
The Threats

Pronghorn could be considered the canary of the Prairie as they serve as great indicators of integrity of prairie habitats. They indicate the degree of fragmentation on prairie landscapes across the Great American Plains. Key threats to migrating pronghorn include agriculture (grazing and crop production), fencing, highways, railroads, housing development and energy development.

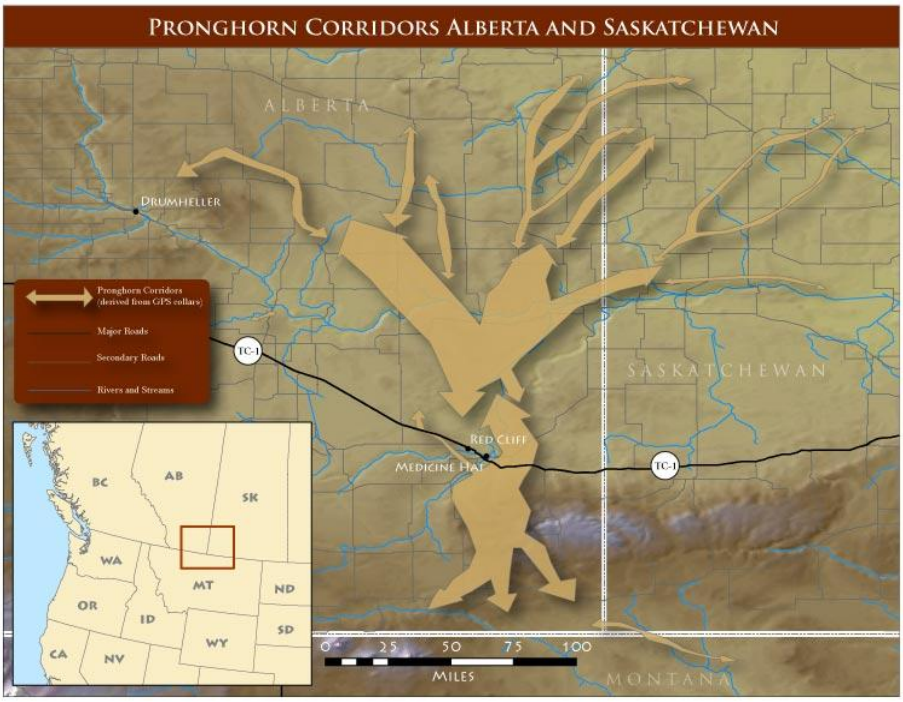
The existing prairie habitat in this geography is becoming increasingly fragmented by oil and gas development. Recent expansion of the Bowdoin oil and gas field and development of pipelines across the northern tier of Montana and in southern Saskatchewan and Alberta is threatening habitat within the remaining prairie blocks. A large proposed pipeline referred to as the Keystone pipeline will deliver Canadian crude oil to refineries in the U.S. Depending upon the route approved this pipeline could impact migrating pronghorn.

Conversion of native prairies to cropland and fencing to control livestock are creating key migration bottlenecks. Recent grain commodity prices and the expiration of Conservation Reserve contracts could lead to increased plowing of native prairie for cropland production. Much of the existing landscape is already fragmented by patches of wheat and barley production along the U.S. and Canada border. Few livestock producers are building or converting fencing to wildlife friendly types. There are several key bottlenecks in the migration route of these pronghorn that could be properly fenced to assure movement across these barriers.

Currently pronghorn migration routes are associated with islands of prairie grassland that serve as stopover points along the migration pathway. Residential development in and around Medicine Hat, Alberta is expanding into the migration corridors of pronghorn moving north into Central Alberta and Saskatchewan. This residential development has created serious bottlenecks impeding pronghorn movement through this region. Further expansion of residential homes around this prairie community could eliminate migrations far into the Suffield Airbase to the north of Medicine Hat.



Map 3. Pronghorn migration Montana border. Source: World Wildlife Fund



Map 4 Pronghorn migrations identified in southern Saskatchewan showing fragmented travel routes, migration into Montana and multiple bottlenecks in the migration. Source: World Wildlife Fund.

Pinedale Anticline-Western Wyoming: The Trail of Two Species

The Migration Spectacle

Wyoming Pronghorn Migration © Joel Berger

Western Wyoming is a vast region where some of the world's largest mule deer *Odocoileus hemionus* and antelope *Antilocarpa Americana* populations coincide with the some of the world's largest natural gas reserves (Sawyer et al 2009). This rim of majestic mountains (the Wind River and Wyoming Range) provides important summer habitats and surrounds the critical winter habitats in the lower elevations of the Green River Basin. As a result of conservation voices, portions of the Wyoming and Wind River Range have been protected through agency land use designations or were withdrawn from oil and gas leasing. Mule deer and pronghorn migrate back and forth between these summer and winter habitats (Map 5). Recent wildlife research completed by Joel Berger, WCS Conservation Scientist and Hal Sawyer, Research Biologist with Western Ecosystem Technologies, has revealed the importance of connections and migration pathways between these important seasonal ranges. Sawyer reports that 2,500-3,500 mule deer and 1,500-2,000 pronghorn in this area migrated 20-100 miles and 70-155 miles respectively between seasonal ranges. Sawyer and others (2009) report that mule deer migrations in this region may be the longest ever documented in the western states. Berger (2010) reports that the pronghorn migration from Grand Teton to the Green River Basin is the second longest migration second only to caribou migrations in Alaska. He and others identified and helped protect a unique migration pathway known as the "Path of the Pronghorn" which is an invariant long distance migration route in this region of Wyoming. In addition, Dr. Berger and others have also identified key bottlenecks and critical stop-over sites along these migration pathways that, if cut off, would seriously impede seasonal animal movements. The key transition and winter ranges in the Green River Basin are managed by the Bureau of Land Management (BLM) or are privately owned and are vulnerable to energy development and subdivision (Sawyer et al 2005). The mule deer and pronghorn in this region of Wyoming demonstrate how conservation planners must think large scale, manage across jurisdictions and consider multiple species when conserving the wildland character of a region.

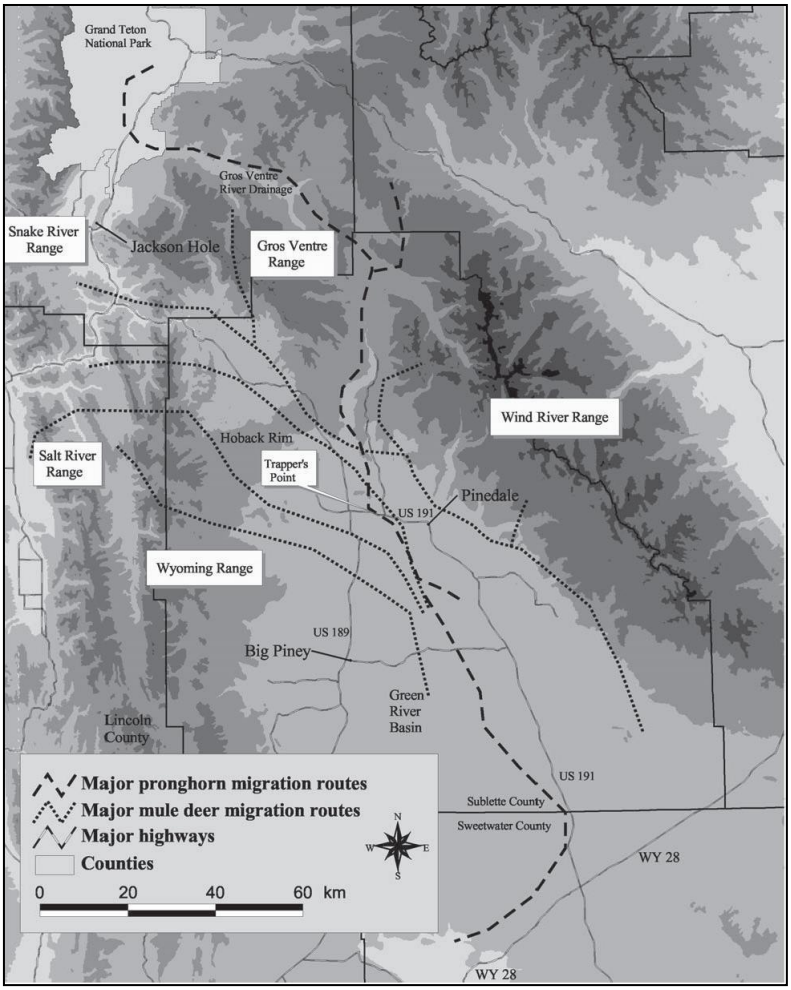
The Threats

Although major success has been achieved in saving the mountain habitats in the Wyoming and Wind River Ranges there has been limited success in conserving the important winter habitat and migration pathways for mule deer and pronghorn. Currently extensive energy exploration for oil, gas and coal bed methane are significantly impacting vast portions of the winter habitat used by all migratory ungulates in this portion of Wyoming. Although some efforts have been made to mitigate the impacts of energy development, there are significant cumulative effects from

multiple uses of these lands. Sawyer and others (2006) report a 46% decline in mule deer abundance with much of that likely due to development and recent harsh winters.

A major secondary impact associated with energy exploration is the intensive road and pipeline network necessary to reach drill sites and develop oil, gas and methane fields. This road and pipeline network sits on top of an existing road system designed to serve recreation, local residential access, and agriculture. This network of linear barriers includes U.S. Highway 191 which bisects the core winter habitats and creates a significant barrier to migrating ungulates. Although Wyoming Department of Transportation has begun a mitigation project and is implementing six highway crossing structures, this threat remains important and deserves continued attention by land managers. Several recent and numerous road kill events have highlighted the potential direct impacts of these road networks on migrating wildlife.

Also associated with expanding energy development, are increased housing developments for industry workers or new residents supporting that industry. New residential housing around Pinedale Wyoming has been slowly creeping into the migration paths that deer and antelope use. Several important bottlenecks in migrations pathways in the Green River Basin, such as Trappers Point, are being impacted by ever expanding housing (Sawyer et al 2005). Sawyer and others (2005) suggest greater attention should be given to manage these bottlenecks because they could sever established migration routes used by ungulates for over 6,000 years.

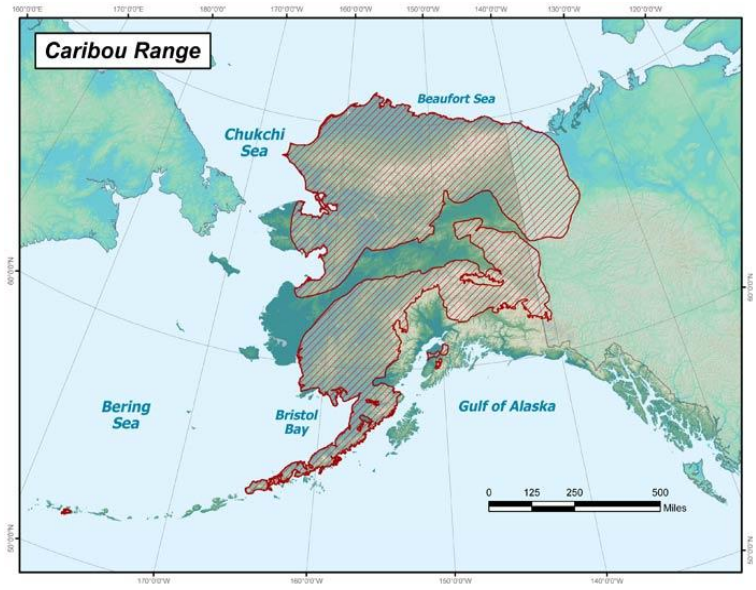


Map 5. Migration routes of mule deer and pronghorn in western Wyoming. Source: Sawyer and others 2005.

Another important impediment to ungulate migration in this landscape is the many fences that separate grazing pastures and cordon off human residential development. Recently, the Green River Valley Land Trust has been working with WCS and others to identify then replace or remove existing fences that are barriers to wildlife movement.

Buffalo of the Far North: Three Spectacular Arctic Caribou Migrations:

Caribou, *Rangifer tarandus,* are the most abundant large land mammal of the far North. No other large mammal in North America lives in such large social aggregations or embarks on such extensive migrations (Hummel and Ray 2008). Most caribou gather in herds of tens of thousands to more than one hundred thousand animals on their calving grounds in the brief Arctic summer, and scatter widely in small groups for the rest of the year. If there is one life cycle feature that characterizes the ecology of caribou it is survival through adaptive movements and migrations (Chapman and Feldhammer 1982). In a global analysis of 103 migratory mammal populations representing 29 species from all continents (except Australia) the greatest overall movement was performed by barren ground caribou (Harris et al 2009). They are the world's true long-distance overland migrator with some groups moving more than 1800 miles each year (Berger 2010). In Alaska, twenty five caribou herds totaling over 1 million animals, annually stream between wintering and calving grounds (Map 6, Gunn 1999). We selected 3 priority caribou migrations that represent spectacular animal migrations needing conservation (Map 7).



Map 6. Caribou Range in Alaska

During the summer, caribou feed on small tundra shrubs, including willow, and fatten themselves in preparation for the coming winter. The summer is also a crucial period for calving and lactation. Insect harrassment by mosquitoes and parasitic flies may significantly decrease foraging time. In particular insect harassment is associated with temperatures of 13 degrees Celsius or higher, and wind speeds of less than 6 meters per second. Insect harrassment prevents foraging and increases energy requirements.

In winter, caribou often dig through snow to find moss and lichen, a process called "cratering". In areas of shallow or patchy snow, it may take only a few minutes to expose enough food for the day. On the other hand, cratering may occur for approximately 2 hours per day where snow is deep or is covered with a crust of ice from freezing rain. Increased energy consumption while foraging during the winter and decreased food availability will increase winter starvation and decrease spring body fat, significantly reducing lactation and calf survival rates.

Biologists consider caribou a "keystone species' because they are integral to the Arctic ecology. Caribou are important prey for Arctic predators, especially the Arctic wolf and, on the calving grounds, grizzly bears, wolverines and golden eagles. Caribou are good indicators of regional conditions in the Arctic because of their migratory nature. Caribou may have substantial effects

Map 7.Spectacular Arctic Caribou herds in Alaska. Source: Hummel and Ray 2008.

on plant and lichen communities and by extension wildlife communities, either directly through browsing and grazing or indirectly through biogeochemical cycling. The large numbers of animals deliver nutrients across the land. They aerate the tundra with their sharp hooves and terrace the hillsides with braided trails. Other species, like the Lapland longspurs, line their nests with caribou hair and ground squirrels and lemmings gnaw on shed caribou antlers for calcium. Caribou provide much of the food for traditional northern societies, and their hides became clothing and material for tents and shelters. Today, Arctic peoples like the Gwich'in identify closely with caribou and are dependent on them for nutritious, affordable "country food" to supplement supplies imported from the south. Even the Inuit, while also hunters of marine mammals, often depend upon the caribou as their primary source of traditional food.

The Threat of Climate Change to Alaskan Caribou

All caribou populations of the far north are extremely vulnerable to pending changes in climate. The two key climate-related factors influencing caribou are snow and insects. Caribou, although usually successful in their harsh habitat, must often work hard to forage for the moss and lichen that is their main food source during the long Arctic winters, and must make the most of the small tundra shrubs they feed on during the brief summer. Almost all climate models project more precipitation in a greenhouse future, particularly in the Arctic. Models suggest that doubling the levels of greenhouse gases in the atmosphere would cause a 30 to 50 increase in Arctic snowfall. Any changes that make foraging more difficult on a consistent basis would threaten the herds. A deeper winter snow pack could also make caribou more vulnerable to wolf attack since lighter wolves can travel on snow crusts that caribou would sink through.

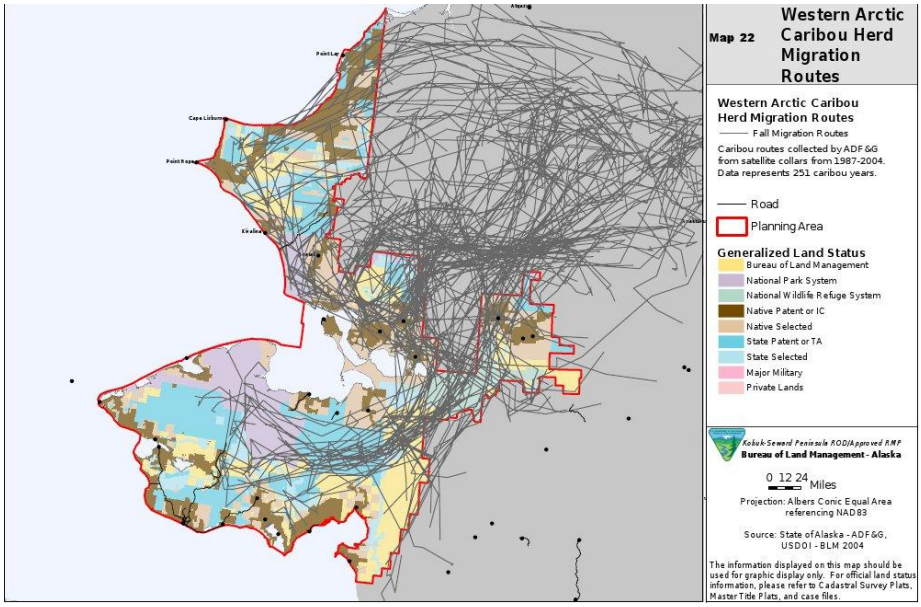
Climate change could result in warmer summers and more insect harassment, which could challenge caribou. The average temperature in the western Arctic in Canada and Alaska has been warming at a rate of at least 0.5 degrees per decade over the last 30 years, a rate 3-5 times faster than the planet as a whole. Most of this warming has occurred in the winter and spring, but warming has also occurred in the summer. Models also suggest a 2-4 week earlier period of snow melt. Caribou tend to frequent melting snow patches in the summer. Several reasons have been proposed for this, including decreased insect harassment because of lower air temperatures and higher wind speeds, or because of the availability of cotton grass. Cotton grass, an important food source for caribou, has its highest nutritional when it emerges from melting snow. Its nutritional value declines significantly within a few days following its emergence. Earlier snowmelt may reduce the availability of cotton grass in its most nutritious form if caribou migration is not timed accordingly. Increased insect harassment and decreased food quality because of earlier and more extensive snow melt would put increased stress on caribou herds.

Western Arctic Caribou Alaska: An Ecological and Cultural Icon

The Migration Spectacle

The Western Arctic Caribou Herd (WACH) in northwestern Alaska is one of the premier migrating caribou herds in Alaska covering a 140,000 mi^2 range. Throughout a single year these caribou will range across one-third of Alaska, an area the size of Montana. At an estimated population size of over 400,000 animals, the WACH is the largest in Alaska and a significant ecological force. The Western Arctic Caribou Herd is the second largest in North America.

The caribou's timeless, annual migration cycle begins in June with calving on the northern slopes of the Brooks Range. The spring migration lasts about five weeks and pregnant cows are the first to move north. The maximum straight line winter to summer range migration is over 400 miles. After calving, the herd forms into separate groups and disperses in search of relief from the summer's heat and pestering insects. As summer passes and the days grow shorter, the fall migration begins and caribou start the long journey through the passes of the Brooks Range and across the Noatak and Kobuk Rivers, heading to the wintering grounds in the south. Then again in late March and early April – following the long, Arctic winter – the caribou begin another spring migration, returning to the starting point of this age old cycle.



Map 8. Western Arctic caribou migrations in Alaska. Source: State of Alaska, ADF&G, USDOI – BLM 2004

The WACH has a substantial cultural impact in that the heritage and traditions of Native Alaskans in communities of the region have been shaped by the availability of these animals (Western Arctic Herd Working Group 2003). They provide a significant source of food and are part of an ancient culture for about 24,000 people from 40 villages. Caribou provide not only food but skins, sinew thread, bone and antler and a connection to nature that defines their traditional values and beliefs. When caribou become scarce the Native people of the western Arctic will lose more than a source of protein.

The Threats

The most significant threats to Western Arctic Caribou come from energy exploration, mining, road networks, domestic reindeer, and unregulated hunting. The Western Arctic is a region rich in oil and gas resources and since the 1960s there have been significant efforts to extract oil and gas from the area. Recently there has been interest in expanding energy exploration in the National Petroleum Reserve (NPR-A). Approximately 80% of this caribou herds calving grounds are within the NPR-A South Planning Area. In addition, the potential expansion of the Prudhoe Oil Field into the range of this herd is another potential threat. Although energy development is pending, some mitigation is possible and well planned conservation strategies are needed to limit the impacts. The most significant impact of energy development is the extensive transportation and pipeline networks necessary to support energy extraction.

The Western Arctic Caribou also face threats from mining exploration and development. Recently significant coal developments have been introduced into this region. Vast, high-grade coal deposits have been discovered in a broad band beneath the northern foothills of the Brooks Range. This coal underlies virtually the entire WACH calving grounds. The Arctic Slope Regional Corporation began exploration in March 2007 to assess economic feasibility and expect to know if development is feasible by 2012. In operation since 1989, Red Dog Mine is a zinc-lead mine located in northwest Alaska, near Kotzebue is one of the world's largest producer of zinc concentrate. Teck Resources Ltd. and NANA Corp, the Inupiat company that owns the Red Dog property, are expanding the mine into an adjacent and relatively newly discovered ore body called Aqqaluk. With rising gold prices new gold mines are also being considered in several areas within the range of the Western Arctic Caribou Herd.

Roads represent a major barrier to movement and are being developed to reach mineral and oil and gas resources throughout the range of the Western Arctic Caribou Herd. This expanding road network sits on top of an existing road network connecting villages in this area. Additional roads in this pristine landscape will dramatically impact ecological integrity and could greatly impact caribou migration.

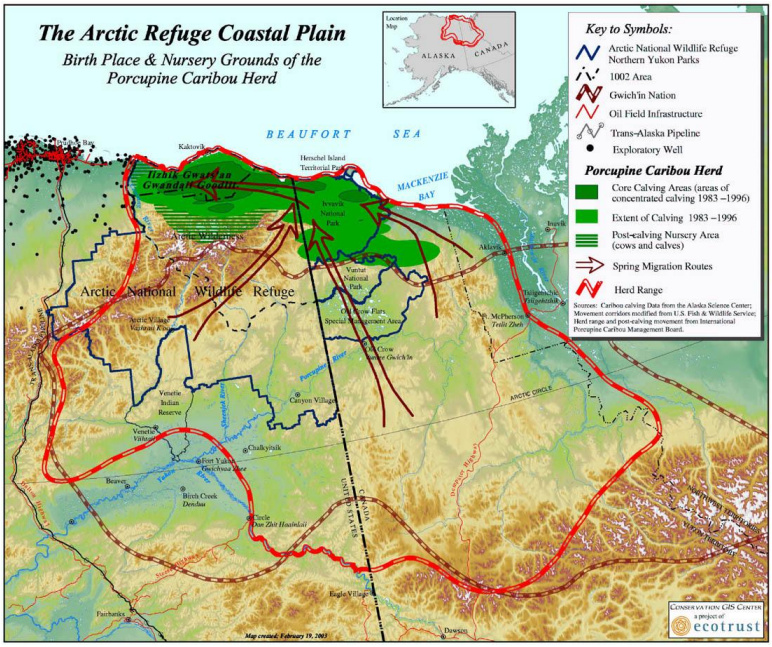
A major challenge to managing caribou populations and migration is maintaining the importance of this food resource to humans. Living off the land, as many Alaskans do, can be viewed as both a biological threat and management opportunity. Native Alaskans depend upon caribou and care very much about sustainability of this resource. However, cultural changes, industrial development and new transportation and hunting technologies have changed the relationship between these humans and their prey in the fragile Arctic. The introduction of snowmobiles, new technologies, and modern weapons has changed the efficiency of humans as a predator.

A subtle, but no less important, impact to Western Arctic Caribou is the management of domestic reindeer as a food resource. The threats from reindeer include disease transmission among the populations, hybridization, and competition for space and forage resources. Arctic managers are working to develop a plan with reindeer herders for responding to caribou migrations into reindeer areas and help hunters identify reindeer that are mixed with caribou.

Porcupine Caribou: Wilderness Wanderer

The Migration Spectacle

The Porcupine Caribou Herd numbers about 169,000 and ranges across 130,000 mi^2 of Arctic wilderness. Their range encompasses the eastern portions of the Arctic Slope, the Brooks Range, northeastern Interior Alaska, and Canada's Northwest Territories. These caribou winter in the southern portion of their range, including the Arctic National Wildlife Refuge, where they are an important resource for the Gwich'in people. The Porcupine herd both depends on and enhances the dynamic wilderness that defines the Arctic National Wildlife Refuge and the Yukon Territory. Porcupine caribou migrate between summer and winter ranges that are about 400 miles apart. In spring the Porcupine caribou herd migrates from winter ranges located south of the Brooks Range in Alaska, and from areas in Yukon Territory, to its traditional calving grounds on the Arctic National Wildlife Refuge's coastal plain and foothills. As part of the annual migration cycle the herd leaves the coastal plain by mid-July, heading back east and south toward its fall and wintering areas. Biologists have discovered, by using satellites to track Porcupine caribou, that the herds actually travel much farther than the straight-line distance between summer and winter ranges would indicate. They move to and fro over a wide area, adding many miles to their journeys and have been observed to travel over 3,000 miles per year.



Map 9. Range and movements of the Porcupine Caribou Herd. Source http://northern.org/media-library/maps/arctic/arctic-refuge-maps

Sometimes when migrating during spring, caribou arriving at the edge of the foothills find their summer range is still covered with snow. In this case, the cow caribou give birth in snow free or partially snow free areas to the south, near or in the mountain valleys. The herd will eventually continue north toward the traditional calving grounds after the young calves are able to travel. After calving, the cows and calves are joined by the bulls and yearlings. Almost every year, no matter where calving occurs, the caribou gather on the Refuge's coastal plain and foothills to feed on the abundant vegetation.

The Threats

The majority of the range of the Porcupine Caribou Herd is remote, roadless wilderness. However this herd typically calves on the coastal plan of the Arctic National Wildlife Refuge, which is also the most promising onshore petroleum prospect in the US. Recent discussions about energy exploration in the Arctic Wildlife Refuge indicate the looming potential for

development of this wilderness landscape. The Arctic National Wildlife Refuge is the largest unit in the National Wildlife Refuge System and America's finest example of an intact, naturally functioning community of arctic/subarctic ecosystems. Such a broad spectrum of diverse habitats occurring within a single protected unit is unparalleled in North America, and perhaps in the entire circumpolar north.

Most of the Arctic National Wildlife Refuge is withdrawn from oil and gas leasing. However, a small northern portion of the Refuge termed the 1002 area was leased for oil and gas exploration. The 1002 area provides significant habitat for caribou: while it is only one-fifth the size of the entire area used by the entire Central Arctic caribou herd, it supports six times as many caribou. In the Arctic Refuge, where the mountains are close to the coast, few alternative areas would be available for displaced cows. If the 1002 Area were developed, the associated pipelines, roads, and structures would potentially impact the Porcupine Caribou herd by:

- reducing the amount and quality of preferred forage available during and after calving,
- restricting access to important coastal insect-relief habitats,
- exposing the herd to higher predation, and
- altering an ancient migratory pattern, the effects of which we cannot predict.

A reduction in annual calf survival of as little as 5% would be sufficient to cause a decline in the Porcupine caribou population.

Since most of the Porcupine Caribou Herd range is not heavily roaded, travel is frequently by aircraft. Caribou can be affected in many ways by aircraft disturbance, including: direct injury or death, increased energy expenditures, and alienation from important habitat(s). Aircraft overflights have been identified as a significant disturbance to Porcupine caribou. Studies have shown that overhead aircraft flights may affect caribou by causing long term behavioral changes or increased energy expenditures.

Climate change has been identified as a particular threat to the migrating Porcupine caribou herd. A computer model of a Porcupine Caribou Herd female suggests that the combination of a deeper winter snow and increased insect harrassment could significantly decrease the female's body fat and reproductive success. Since there is a strong correlation between autumn body fat and successful spring births, climate change could reduce caribou birth rates by about 40 percent.

Central Arctic Caribou: Where Oil and Caribou Mix

The Migration Spectacle

The Central Arctic Caribou Herd (CACH) includes 32,000 caribou that range across the North slope of Alaska and into the Brooks Range. Their range encompasses about 25,787 mi^2 and represents a vast region known for its oil and gas resources, the Dalton Highway and the Trans Alaska Pipeline System (TAPS). Caribou in this herd travel 120 miles between favorite summer and winter ranges and appear to migrate north and south parallel to the TAPS and Dalton Highway. During their annual migration these caribou face many human modifications and obstacles to movement across this landscape including roads, oil and gas pads, and pipelines.

Despite these emerging barriers, the herd has persisted and their numbers remain stable. The crucial consideration for the future of Central Arctic Caribou is whether the cumulative impacts of human activities can be mitigated and migration sustained.

Caribou and Oil in Alaska © Joe Liebezeit

The oil fields in the Prudhoe Bay region of northern Alaska are the largest in North America and account for about 20% of U.S. domestic oil production. Caribou management and conservation have been a major consideration in exploring and developing these resources. During the 25-year history of oil development in Arctic Alaska, the Central Caribou Herd has been maintained and migration has persisted (Cronin et al 2000). Several studies have shown local impacts and development activities may displace caribou during calving seasons. However, the relative success of the Central Caribou Herd has demonstrated that careful management and mitigation strategies can reduce the impact of energy development on migrating ungulates.

The responses of CAH caribou to oil development are best described in a seasonal context. The two principal seasons when CAH caribou encounter oil development are the calving and insect seasons, which extend from late May to mid-June and from late June to mid-August, respectively. Calving activity by the western segment of the CAH traditionally has been concentrated in the area occupied by the Kuparuk and Milne Point oilfields. By the mid-1980s, studies by the Alaska Department of Fish and Game (ADFG) revealed a localized distributional shift within that area, as cows with newborn calves tended to avoid areas of human activity. The behavioral sensitivity of caribou cows with young calves is noticeable until the insect season, when harassment by insects during warm, calm weather becomes the dominant influence on caribou movements and behavior. Caribou respond to mosquito harassment by aggregating and moving toward the sea coast, where they find relief in the cooler, breezier conditions that prevail there.

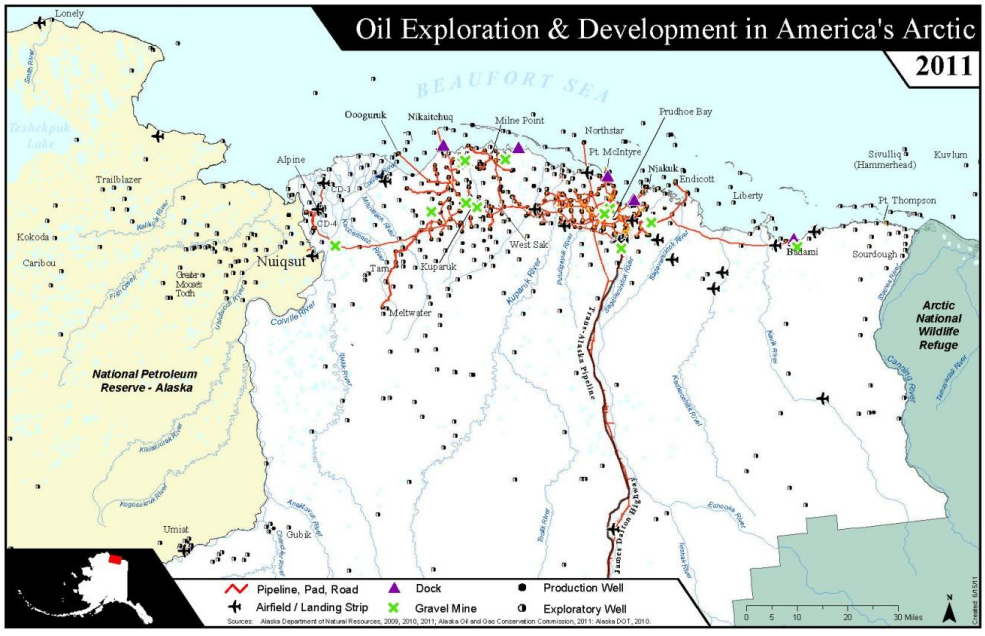
The Threats

Of the four herds of caribou that inhabit arctic Alaska, the Central Arctic Herd has experienced the most substantial contact with oil and gas development. This herd took the brunt of the Prudhoe development and associated pipelines and roads (including the opening of Dalton Highway) but generally increased due to cooperation between wildlife agencies, Tribes, and Conoco-Phillips on management of activities and restrictions on hunting from the highway. Nevertheless, the impact of new roads and highways cannot be overlooked. Caribou need to move freely over vast areas to forage, avoid predators, escape from harassing insects, and reach favorable summer and winter ranges. Structures such as highways may deflect caribou movements, and reduce their chances for survival. A single road within a caribou herd's range

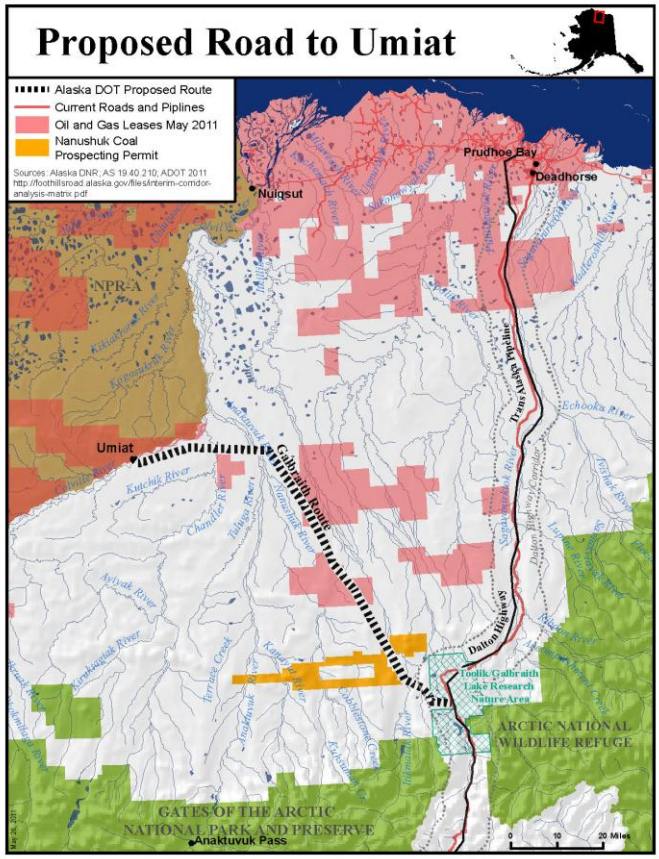
usually is not as serious as a system of many roads. It is quite common to find situations where caribou are reluctant to cross roads, berms, pipelines and other related obstacles. Researchers have learned there are many factors (traffic levels, time of year, degree of visual obstruction, reproductive status, etc.) which can influence caribou reactions to roads and other potential obstacles, and thus their chances of crossing successfully.

Unfortunately, the range of the Central Caribou Herd is slated for several new road projects and a network of transportation is emerging to connect Prudhoe Bay with the rest of the world. Experience and research in the oilfields has led to development of effective mitigation to counter some impacts on movements and behavior. In some instances, roads and pipelines can be constructed in ways that reduce problems for caribou. For example, a ramp may be built to direct caribou over a road, and a pipeline may have buried sections for caribou to pass over. Elevation of pipelines to 1.5 m above ground level, separation of pipelines from roads by 100m, traffic control measures, strategic placement of crossing structures, and careful design and layout of infrastructure all have proven effective.

As with all the arctic caribou herds, climate change will dramatically impact the Central Caribou Herd. Increased winter snow depth and summer insect harassment are likely to reduce food availability, increase energy expenditure, and make caribou more vulnerable to predators such as wolves. These projected impacts suggest that continued climate change is likely increase stress on populations. Combined with increased energy development, the Central Caribou Herd might be one of the most vulnerable of all arctic caribou herds.



Map 10. Oil developments in the Prudhoe Bay area in the heart of Central Arctic Caribou range.



Map 11. The important linear man made features in the range of the Central Arctic Caribou Herd that may act as barriers to movement.

AERIAL MIGRATIONS ACROSS THE WEST

Western Snow Geese © Steve Zack

Long distance aerial migrations can involve birds, mammals or even insects. For this assessment we consider only bird and mammal cases as nominated by our survey respondents. Birds are more uniformly migratory than any other animal group so, as expected, were strongly represented in our survey. In fact, the only aerial mammal migrations we include are desert pollinator bats which are well known flying mammals that migrate.

Migratory birds comprise more than 80% of the avian diversity in temperate regions of the world (Martin et al 2007). In North America about 5 billion birds migrate each season

representing one of the most witnessed but underappreciated biological phenomenon. Each year more than 300 bird species leave the United States and Canada to winter in the West Indies, Central or South America.

Our understanding of aerial migration has only recently emerged with the advent of field science and new technologies. Years ago even renowned philosophers such as Aristotle thought that birds hibernated in the winter and others believed that smaller birds could not fly long distances so hitched rides on the larger birds. Despite our lack of understanding, humans have long contemplated the remarkable nature of migration by air. Even today, the annual migration of birds is a spectacular biological event that nearly all people recognize each spring and fall.

Top 17 Spectacular Aerial Migrations

We identified 17 spectacular aerial migrations in the western U. S. (Appendix B). These include 16 bird migrants and one mammal migrant (bats). This suite of aerial migrations represents only a small subset of many hundreds of migrating species. Again, we do not imply that these 17 aerial migrations are the only ones needing conservation but rather they represent some spectacular examples that are important, inspiring, and useful in promoting the need to protect long distance migrations. They present an enormous conservation opportunity to effect regional and even international conservation of lands and wildlife.

Setting Priorities for Conserving Aerial Migrations

Aerial Filter: Desirable criteria for each category: As mentioned previously in the methods we excluded two of the evaluation categories, Stakeholder Engagement and Conservation Feasibility, from the prioritization process for aerial migrations. This left three important filter categories to discriminate the most spectacular migrations from our candidate list (Table 9). Similar to the terrestrial filter, condition rules for selecting spectacular migrations were based on the range of values in each criterion. The mathematical mode was used to select migrations based upon the biological phenomenon filter category. For evaluating the marketing value and threat level categories we used the expert opinions of survey respondents and Wildlife Conservation Society staff. Out of a possible 17 aerial migration corridors, only three were selected as highest immediate priority (Table 10). In addition to these three priority examples we chose to profile three additional aerial migrations that express very unique migration stories.

Table 9 Range of criteria values and desirable conditions by category for the avian filter

Category	Criteria	Range	Desirable Condition Rule
Marketing Value	Species charisma based on scale of movements	2-4	$\geq$4
	No. Animals/Distance	5-2000	$\geq$66.67
Threat Complexity and Urgency	Number of Threats	1-6	$\leq$4
	Level of Threats	High, Medium, Low	Med or High
Biological Phenomenon	Population Size	4500-10,000,000	$\geq$700,000
	Maximum Migration Distance	500-12,500 mi.	$\geq$2,000

Table 10. Criteria values and quadrant rankings for spectacular aerial migrations.

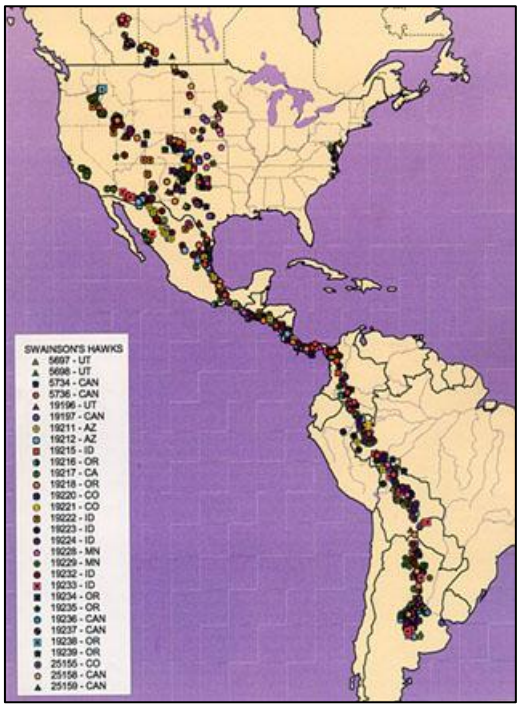
	Marketing Value					Threats			Biological Phenomenon		
Migration Title	Scale	No.	Dist. (mi.)	No./ Distance	Quad	No.	Level	Quad.	Population	Dist. (mi.)	Quad.
Swainson's Hawk	4	500,000	7,500	67	I	4	Med.	I	500,000	7,500	II
American Golden Plover	4	450,000	4,500	100	I	4	Med.	I	450,000	4,500	II
Upland Sandpiper	4	400,000	6,000	67	I	3	Med.	I	400,000	6,000	II

Spectacular Aerial Migrations in Need of Conservation

Swainson's Hawk: Bird of the Cowboys and Gauchos

The Migration Spectacle

Swainson's hawks have the second longest migration of all raptor species (second only to Arctic Peregrine Falcon). This species migrates over 6,000 miles every spring and fall between its temperate grassland breeding grounds in North America to its wintering grounds in the pampas of South America. Swainson's hawk is a broad-winged hawk that depends on the thermals produced over land to soar and hunt for food. When not breeding, Swainson's have an unusual diet among raptors - they feed mostly on insects. During summer they feed on ground squirrels, rodents reptiles and other small prey. This hawk will follow tractors or stay close to prairie fires in search of disturbed or fleeing prey.



Map 12. Swainson's Hawk Migrations: Source is USGS Snake River Field Station.

Swainson's hawks are highly gregarious and migrate and forage in flocks. Flocks of several hundred or even thousands will group together in late August and September to put on fat for their upcoming journey by gorging on grasshoppers. These flocks, called kettles, use northerly air currents and thermals to begin their flight south. Because they depend upon thermals to hunt and fly, they must stay over land to soar and therefore travel through the Isthmus of Panama. Their passage through Panama is an impressive sight with flocks sometimes numbering several hundred thousand birds. The migration is diurnal to take advantage of rising thermals. Each morning when the sun heats up the land a spectacle of enormous numbers of Swainson's hawks begin circling in newly-formed thermals, resembling a "cyclone" of soaring hawks.

Swainson's hawk populations declined around the turn of the century. They went from being repeatedly described as an abundant and even nuisance species in

the late 1800s to rare and obviously missing from the skies by the 1920s. The species is now reduced in numbers throughout its range and considered to be declining in Utah, Nevada, and Oregon. Swainson's hawks no longer breed along the southern California coast because it is too developed and they no longer occur in the Mojave Desert. Recent work has shown that reproductive success in Alberta and Saskatchewan is at a low point, most likely caused by a reduced prey base, decay of prairie trees, and plowing of grasslands. The main prey species for hawks in the western Canadian prairie, Richardson's ground-squirrel, is in decline, and is correlated with reduced reproductive rates in hawks.

The Threats

The primary threat to Swainson's hawk is the loss of native grassland habitats. Unfortunately, this bird is in decline in several areas of its range because of increased agriculture, habitat destruction, a reduction in its main prey species, and pesticide use. Their preferred habitat is gradually being converted to urban areas or to cropland that does not provide good foraging or nesting habitat. Since the bird depends upon two important grassland ecosystems, one in North America and another in South America it is also dependent upon international cooperation in conservation of native grassland habitats.

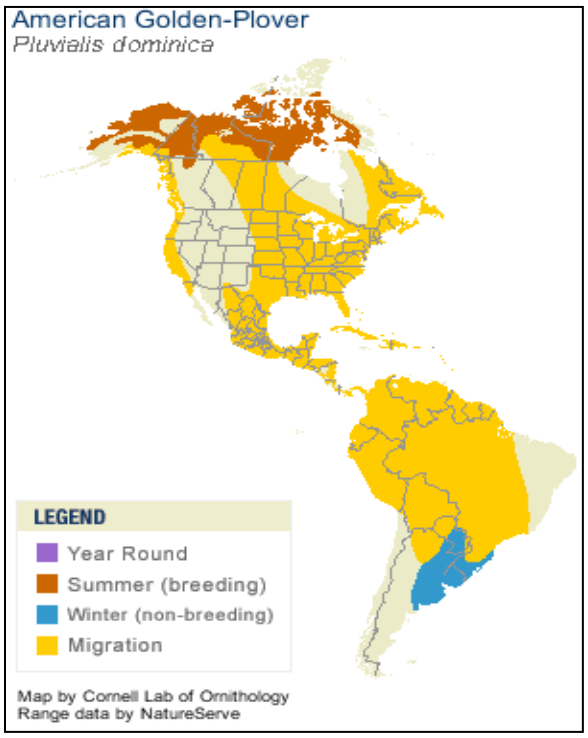
There is some evidence that this hawk is adapting to annual crop fields like alfalfa and hay fields where prey are abundant and the crops never get too high for foraging. Shelterbelts and tree plantings also provide roosting and sometimes nesting sites. However, large-scale agribusinesses do not have trees, and as small farms are incorporated into larger farms on both its summer and wintering grounds, it is likely that Swainson's will suffer. Pesticide use on alfalfa and sunflower fields in Argentina resulted in the death of some six thousand birds in 1995 and 1996. The alfalfa and sunflower fields were sprayed with organophosphate insecticides to kill grasshopper infestations. Hawks died immediately if they were sprayed directly while foraging in the fields or within several days after consuming the chemical-ridden grasshoppers.

The enormous distance that Swainson's hawks cover each year imposes various deadly threats including casual shooting, collisions with artificial constructions, and toxic poisoning. Banding returns have identified collisions with cars, trains, power lines and fences.

American Golden Plover: The Shorebird with Endurance and Speed

The Migration Spectacle

The American Golden Plover is a long distance migrant demonstrating world class speed and endurance. This small bird travels over 2,400 miles between North and South America each fall and spring, often in one-way continuous flights. These migrations are characterized as long, nonstop, often transoceanic flights that may be completed in just 48 hours. This remarkable feat is accomplished with the consumption of less than 2 ounces of body fat. This bird is also known for its unusual elliptical migratory pattern-offshore nonstop in the fall and a midcontinental flight in the spring where they cover up to 10,000 miles in each year. Weighing in at less than 0.5 pound, they are also considered the fastest flying shorebird, reaching speeds of 60 mph. Amazingly, these small plovers arrive at their destination without becoming utterly exhausted.



Map 13. Range and migrations of the American Golden Plover. Source: Cornell Lab of Ornithology

American Golden Plover nests in the arctic and subarctic of Canada and Alaska. It winters in South America on grasslands and coastal wetlands in temperate and tropical regions. Adults begin leaving breeding grounds in July and August with juveniles migrating later. The northward spring migration starts very early in February and lingers until April. The north migration coincides with the spring flooding cycle in Brazil. Arrival on the breeding grounds is influenced by latitude and annual variations in snowmelt.

The American Golden Plover diet consists mainly of mosquitoes, butterflies, other insects, small mollusks, and crustaceans. This diet makes them particularly vulnerable to the use of pesticides and toxins.

The Threats

Early declines in American Golden Plover populations were caused by excessive sport and market hunting during the nineteenth and early twentieth century's. Large numbers were killed in North America, especially during mid-continental spring migrations. This bird was also hunted on South American winter range. Populations have rebounded significantly after most hunting ended around turn of the last century. Loss of habitat, particularly on winter range has prevented any possibility of full recovery to pre-exploitation levels.

Arctic and subarctic breeding ranges of this plover are intact and relatively unexploited by humans. Energy exploration and mining pose some threat to nesting birds. Winter ranges and migratory routes are variously threatened by warming climate, and pressures from agriculture, ranching, reclamation, pollution, residential development, wind turbines (wind farms), and burgeoning human populations. Potentially harmful effects of wind farms are greatest for American Golden Plovers during migrations along continental flyways.

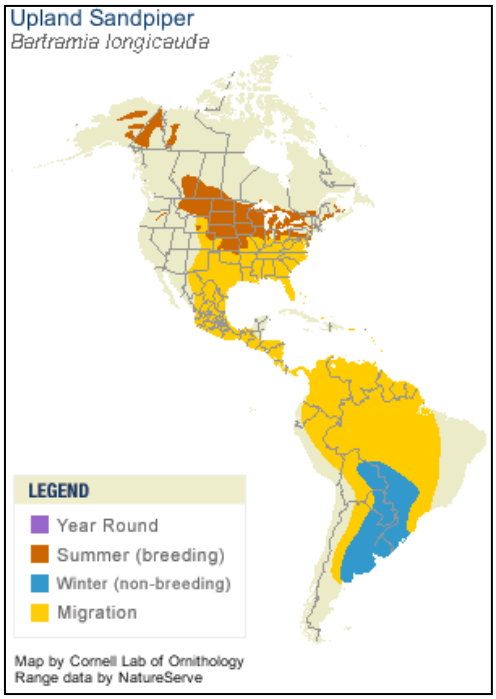
The negative impacts of climate change (low growth tundra replaced by taller vegetation, shifts in timing of insect emergence, etc.) loom as major threats to the stability of arctic and subarctic breeding grounds. In addition, rising sea levels would damage or eliminate large areas of wintering habitat for shorebirds.

Upland Sandpiper: Flying by Night

The Migration spectacle

The Upland Sandpiper, a little known Great Plains shorebird, is an obligate grassland species that spends most of its life away from water. This small shorebird is a long-distance migrant that makes the annual trip between breeding areas in southern Canada and northern U.S. and wintering areas in South America. A smaller subpopulation travels as far north as Alaska and Yukon Territory. It spends as little as 4 months on its main breeding grounds in Montana, Dakotas, Nebraska, and Kansas. The Upland Sandpiper begins southward migration unusually early, beginning in mid-July. It spends up to 8 months on its "wintering" grounds (during austral summer) in South America. It is capable of long flights, in stages, while migrating to South America, while individuals are known to wander to Guam, Australia, Tristan da Cunha, and Deception Island off Antarctica, and from inland North America to Europe. Birds arrive on wintering ground between August and October. Most migration routes follow the same narrow band through the Great Plains and Middle America. The upland sandpiper migrates largely at night. Prior to the advent of modern telemetry and radar, most large nocturnal migrations were detected by listening for calls during night passage. One early record of the nocturnal flight of Upland Sandpipers was reported over Iowa City, IA in 1878 and lasted more than an hour.

This unique shorebird exhibits distinctive grassland adaptations like cryptic coloration, ground-nesting, well-defined diversionary displays, flight song, and relatively short incubation and nestling periods. It typically requires 3 different but nearby habitats: during courting, it needs perches and low vegetation for visibility; during nesting, higher vegetation to hide its nest; and during supervision of young, lower vegetation. This bird depends upon a high degree of heterogeneity in grassland habitats which is increasingly difficult to find under current grassland management schemes. It feeds largely on a variety of invertebrates such as insects beetles, grubs, moths, ants, flies, centipedes, millipedes, spiders, earthworms and snails; occasionally waste grains and grass seeds. When disturbed, upland sandpipers will run a short distance and "freeze" in an attempt to blend into surrounding habitat and confuse a predator.



Map 14. Range and migration of the Upland Sandpiper. Source: Cornell Lab of Ornithology

The Threats

Abundant when settlers first arrived on the western plains, the Upland Sandpiper experienced severe pressures from settlers hunting adults and their eggs, and later from market hunters. Across the northern Great Plains the chronology of its decline suggests that an even more

detrimental factor was the loss of most of its breeding habitat as grasslands were converted to monoculture crops. Recent Breeding Bird Surveys suggest that declining trends have continued in all range states except North Dakota.

Loss of prairie habitat to agriculture continues to be the greatest threat facing the Upland Sandpiper. Plowing of native prairie for crops has adversely impacted this grassland specialist more than most other grassland species. Plowing of large areas on the Argentina pampas, with planting of alfalfa and grains, and wetland drainage continues to reduce wintering habitat. Intensive livestock grazing can also reduce the suitability of grasslands for this upland shorebird and has been found to reduce the number of nests in a field. Finally, in Platte River valley, NE, dewatering of river system has led to encroachment of woody vegetation into formerly wet prairie has had a negative impact on breeding habitat.

Some Upland Sandpiper habitats has been lost by expanding exurban development and residential housing. Former grasslands in the Spokane Valley of eastern Washington have been altered by housing developments, gravel pits, and the increase and spread of spotted knapweed (*Centaurea maculosa*), which is too tall and dense for Upland Sandpipers to nest in.

Altered fire regimes have probably influenced the quality and abundance of suitable habitat for Upland Sandpipers. Recent work has shown that controlled burns may benefit this species as they feed on low-growing plants and invertebrates that are more easily spotted after a fire. Returning prairie grasslands to a natural fire regime could significantly support the recovery of this species.

Unique Aerial Migrations to Consider as Conservation Priorities

As we reviewed our list of aerial migrations, we added three examples of unique aerial migrations in the west. After some review, we found these unique examples of migrations including: flying mammals (pollinator bats), the "champion" long distance migrant (arctic tern), and the smallest long distance migrant (calliope hummingbird). Each of these special cases represents a spectacular migration story and reveals story-telling power that captures our interest in the biological phenomenon of migration.

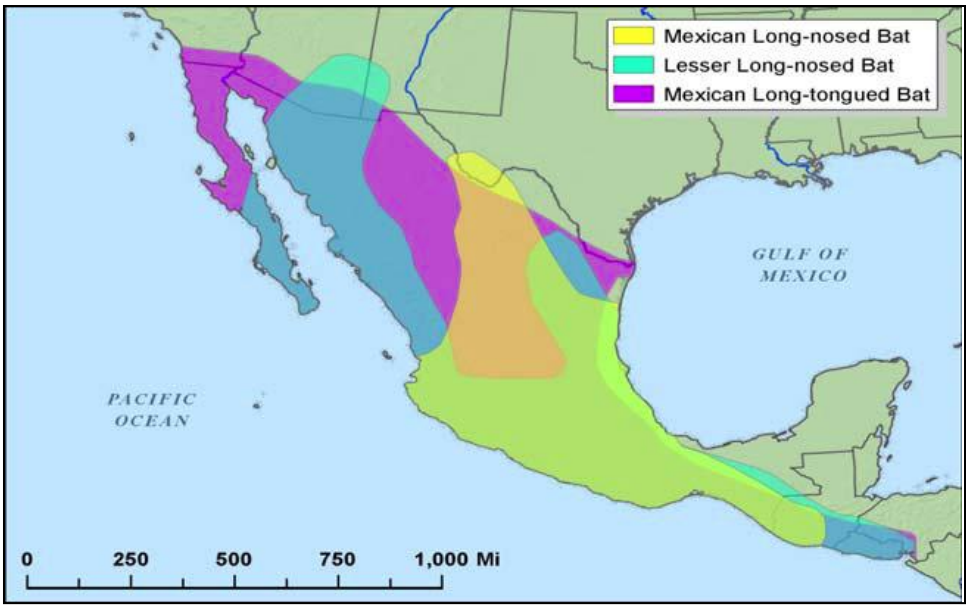
Pollinator Bats: International Ambassadors for Migration

The Migration Spectacle

Our review of migrations showed that when pollinator bats were viewed as a migrating mammal they were selected as top priority and as a biological phenomenon they rank well among mammal migrations. However, when prioritized among aerial migrants they dropped in ranking as they were pitted against many extraordinary bird migrants that moved great distances and were more abundant. They provide important ecosystem services and deserve high rank among the spectacular migrations in the west. In addition, we considered that 2011-2012 is the International Year of the Bat providing a unique time to profile this important migration.

The three desert pollinator bats that exhibit long distance migration include the Lesser Long-nosed Bat *(Leptonycteris yerbabuenae)*, Mexican Long-tongued Bat (*Choreonycteris Mexicana)*, and Mexican Long-nosed Bat *(Leptonycteris nivalis)*. Relatively few species of bats undergo long distance migrations. Instead of migrating to the tropics, most bats evade harsh winter conditions by hibernating. In North America, only five bats migrate substantial distances (up to 1,116 miles) from temperate-zone summer roosts into the neotropics for the winter. Of these species, the three nectarivores barely reach the United States after migrating north from central Mexico. *Leptonycteris curasoae* and *Choeronycteris mexicana* form maternity roosts in northern Sonora and southern Arizona in the spring, whereas *L. nivalis* sometimes occupies post-maternity roosts in southwestern New Mexico and Big Bend National Park, Texas, in the summer.

Unlike other migrant mammals, whose food supplies tend to be relatively uniformly distributed across habitats, migrating nectarivores depend on a food supply (nectar, pollen, and fruit) that can only be found at appropriate times. These migrants cannot search widely among habitats for food but exhibit foraging activities and migratory movements that are tightly associated with habitats and locations occupied by their food plants. Owing to the seasonal nature of most flower and fruit supplies, they must time their migrations to coincide with flowering of their food plants. Therefore, migrant nectarivores travel along "latitudinally broad paths of blooming plants" called nectar corridors (see Nabhan 2004). Pollinator mutualism between these bats and their food plants appears to vary latitudinally. Bats travel great distances at night to find large enough patches of nectar producing plants to sustain themselves and their young, and to prepare for the next leg of their journey. Thus, protection of foraging areas along this migration corridor is critical to the conservation of desert pollinator bats.



Map 15. Distribution of 3 pollinator bat species. From Berger et al 2010

The Threats

These three bat species are vital pollinators in desert systems and their distribution, in space and time, depends heavily on the phenology of desert plants, and are sensitive to the timing of rainfall as well as human activities such as agriculture. These vital pollinators migrate along corridors often referred to as nectar corridors (Nabhan 2004). These nectar corridors are threatened by destruction, degradation, and fragmentation due to land conversion, herbicides, pesticides, and exotic plant invasion. The principal threats to nectar corridors are wildland conversion to agriculture, ranches, and recreational and urban development. Fragmentation of these wildlands along the Mexican coast from Jalisco to Sonora is expected to increase and endanger flower-dependent bats as they migrate. Protecting critical food plants, especially columnar cacti and paniculate agaves, along bat migration routes is essential.

Another important threat facing pollinator bats is the increase in agave harvested for tequila production because agave are harvested before they have an opportunity to bloom—the commercial practice is to cut all flower buds. This practice creates a relatively barren (devoid of nectar sources) landscape for the bats. In certain locations and periods of the year, such a nectar source could be crucial, particularly during migration.

Lesser long-nosed bats are federally listed as an endangered species in both the U.S. and Mexico. Their migrations from south-central Mexico to the Sonoran Desert and other parts of southern Arizona are considered "endangered phenomena". Critical resources that need to be protected include safe roost sites and habitats containing adequate densities of food plants. Safe roost sites include caves (and mines) that provide protection from predators and human disturbance and that have acceptable microclimates. Fortunately, the mating cave in Jalisco and several of the major maternity roosts in the Sonoran Desert occur on federally protected lands. However, little is known about the locations and vulnerability of transient roosts used by Lesser Long-Nosed bats during migration. Some of these roosts likely are located in the states of Nayarit and Sinaloa in western Mexico, in areas that are difficult to explore because of their remoteness and drug activities.

In many areas of Mexico and elsewhere in Latin America bats that roost in cave or abandoned mines are often at risk as a result of misguided vampire bat eradication programs Vampire bats transmit rabies to large numbers of cattle and cause economic impacts to that industry. Because of the great loss of livestock to rabies, most Latin American countries have attempted to reduce vampire bat populations. Control methods included gassing, poisoning, dynamiting, and smoking bats out of caves.

The tight synchrony between bat migration and nectar availability of flowering plants makes these desert pollinators especially vulnerable to climate change. Any climate induced changes in the timing of flowering and distribution of nectar resources will have significant effects on pollinator bats. Changes in rainfall and temperature will likely influence these nectar resources forcing pollinators to adapt to these changes.

Calliope Hummingbird: The Smallest Long Distance Migrant

The Migration Spectacle

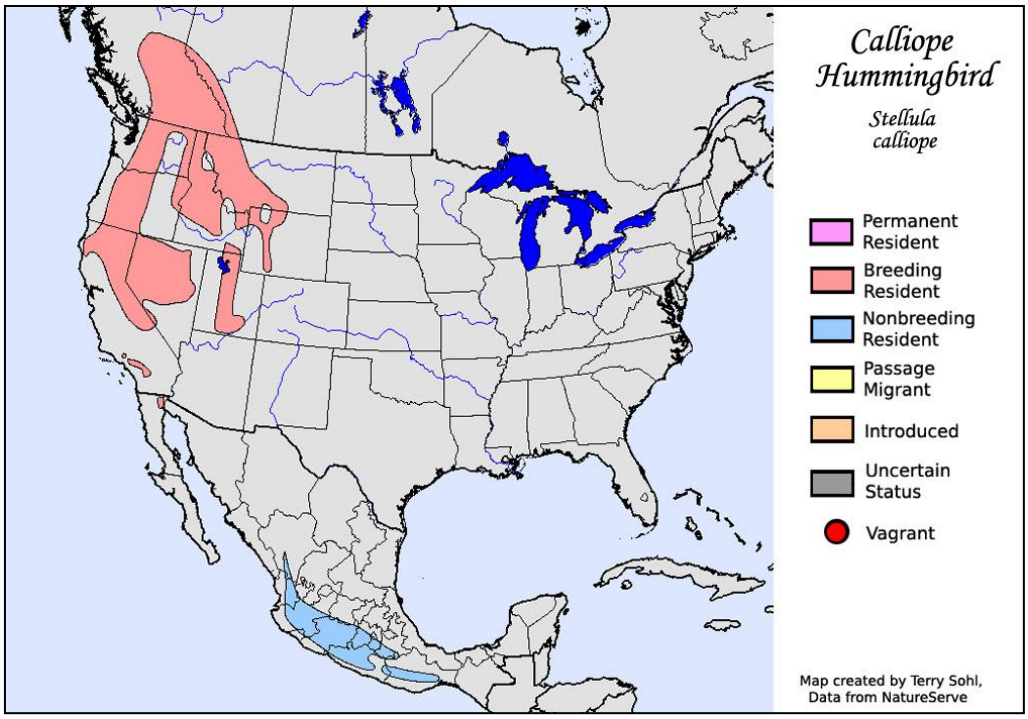
The ancient Mayans believed that hummingbirds were fashioned from tiny scraps left over from the making of larger birds. These small birds, made from those left-over scraps, comprise a unique avian family, *Trochilidae*, which is represented by more than 300 species. The family is found only in the New World, and is especially well-represented in Central and South America. Most species are between two and five inches and many weigh as little as a penny. Hummingbirds lose heat rapidly because they are so small, and expend an enormous amount of energy each day relative to their size. If a hummingbird were the size of a 150-pound person, it would require approximately 100,000 calories per day, or about 40 times a normal human diet.

Hummingbirds apply both migration and hibernations as survival strategies. To minimize the energy used at rest, many hummingbirds enter a sluggish, hibernation-like state called torpor each night, and at times throughout the day, where they lower their metabolism and body temperature significantly. Many hummingbirds also undertake long distance migrations. For example, Ruby-throated hummingbirds fly more than 500 miles across the Gulf of Mexico. Flying at approximately 60 miles per hour, it takes this tiny hummingbird eight hours of continuous flight to make the crossing. The birds need to eat nearly double their weight to fuel this migration.

Hummingbirds meet their energy needs by constantly feeding on high-calorie nectar and feed from flowers more than one thousand times a day. Many of these plants are specialized to rely on hummingbirds as pollinators, and sometimes their nectar is only available to a hummingbird's specifically shaped bill and extendable tongue. Protein-rich insects also account for a significant percentage of the diet in some species.

The Calliope hummingbird is the smallest long distance vertebrate migrant in the world. It is a common hummingbird of the western U.S. and represents the smallest North American breeding bird. Seasonal distribution records indicate that this bird must migrate over 4,500 miles each year. It ranges through western North America north to central British Colombia, and winters south to southwestern and south-central Mexico. Calliopes often turn up during winter in the south-central United States, as far east as Florida. The Calliope is primarily a montane species during the breeding season, found at elevations between 4,000 and 11,000 feet and nests in early successional habitats 8-15 years after logging. Its winter range in Mexico includes a variety of habitats, from dry thorn forest to humid pine-oak forest. Its numbers, as measured by the Breeding Bird Survey, have declined significantly at the limits of its breeding range, though hummingbird feeders may have bolstered populations of the species elsewhere.

The Calliope hummingbird is also an important pollinator of northwest forest flowers. Very little is known about the life history and its conservation and management needs. Forest practices probably have the most significant effect on this small migrant as it seems to select early shrub stages of forest succession.



Map 16. Range map information for Calliope hummingbirds obtained from Digital Distribution Maps of the Birds of the Western Hemisphere, version 1.0. NatureServe, Arlington, Virginia, USA.

The Threats

A serious threat to this species is the lack of knowledge about life history and population trends and status. Beyond general landscape preferences, specific habitat needs and threats are not well understood.

Habitat loss, due to agricultural growth and logging, is probably the most significant factor affecting Calliope hummingbird populations. Its small wintering range in Mexico also makes it vulnerable to major habitat changes there. There is a general lack of information on its conservation need on wintering habitats in Mexico.

Other threats may include use of insecticides and invasion of its habitat by alien plants. Insecticide use introduces toxic chemicals into the hummingbird food chain, since small insects are a major source of protein during some seasons. Invasive, alien plant species pose significant problems, since hummingbirds are so tightly coupled with native flowering plants.

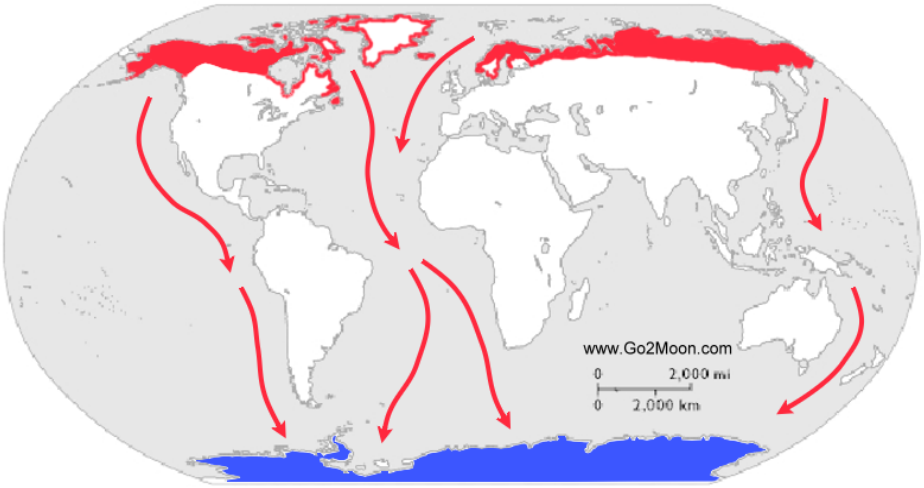
Due to their small size, temperature sensitivity and reliance on flowering plants the Calliope hummingbird is extremely vulnerable to climate change. Climate induced changes in temperature regimes and plant phenology will dramatically affect this and other hummingbirds across the west.

Arctic Terns: The Champion Migrant

The Migration Spectacle

Arctic Terns are the "champion migrant" and long distance flier traveling farther than any other animal migrant in the world. This bird nests as far north as the land extends in North America and winters in Antarctica. In just a few short months the bird flies over 10,000 miles across the entire globe, mostly over the ocean, from one pole to the other. It is reported by some that the round trip may be up to 24,000 miles each year. It is not exclusively a western bird as there are many routes across both the Atlantic and Pacific Oceans. This bird sees more sunlight than any other animal on the planet as the sun shines most of the day during breeding season in the North and during the winter in the south where daylight is also continuous as well.

The total global population of the Arctic Tern is around 500,000 pairs. This bird has a circumpolar distribution, breeding colonially in Arctic and sub-Arctic regions of Europe, Asia, and North America (as far south as Brittany and Massachusetts) and around the Arctic Ocean to the northern tip of Greenland. The breeding season is very short and lasts only 2-3 months. The birds begin heading south in August, soon after young are fledged. The Arctic Tern enjoys its second summer around the edges of the Antarctic ice pack and return again to breeding areas beginning in March. Arctic terns forage by plunge diving and surface dipping for a variety of small fish, crustaceans and other invertebrates. They also hawk for flying insects. This varied diet is primarily derived on or near the world's oceans.



Map 17. The migration routes of the Arctic Tern. Source: Downloaded from http://www.go2moon.com/image/Birds/Arctic-Tern/ArcticTernMigrationMap.html.

The Threats

Most of the winter and breeding habitat of the Arcitc Tern is very remote and uninhabited by humans. The major migration pathways are transoceanic. Key concerns are human occupancy and land use impacts on key stop-over sites and islands. Effects of increased human uses of barrier beaches and islands have not been adequately measured.

While nesting, Arctic Terns are vulnerable to predation because they nest upon the ground. Besides being a competitor for nesting sites, the larger Herring Gull steals eggs and hatchlings. Camouflaged eggs help prevent this, as do isolated nesting sites. While feeding, skuas, gulls, and other tern species will often harass the birds and steal their food

The Arctic Tern is a surface-feeder and spends most daylight hours foraging and must feed chicks frequently, so is especially sensitive to reductions in food availability. In the Northwest Atlantic, overfishing of groundfish stocks has led to changes in fish communities, but implications for Arctic Terns have not been critically examined.

Disturbance by humans, especially if accompanied by dogs, can prevent occupation of sites, promote desertions, or cause loss of eggs or chicks through overheating or chilling. All-terrain vehicles have led to increased disturbances, particularly of shores and beaches. A helicopter landing within an Alaskan colony caused complete abandonment, but colonies are known on airports. In Alaska, reindeer herding caused abandonment of sites. Terns generally tolerate vehicles, vessels, and aircraft, except when very close.

This champion migrant that uses habitats on both poles and depends upon ocean resources is likely to be dramatically impacted by climate change. The loss of an Antarctic ice pack and the flooding of arctic habitats will have dramatic impact on both the breeding and wintering habitat of this global traveler.

Meeting the Challenge of Conserving Spectacular Migrations

Over the past two centuries overhunting, anthropogenic barriers, and habitat loss have disrupted many animal migrations in North America (Bolger et al 2007). The specific threats to these migrations include differential hunting pressure, hydroelectric dams, energy development, mining, agriculture, human recreation, highways and roads, railroads, and urban/exurban development (Bolger et al 2007, Hebblewhite et al 2006, Harris et al 2009). The number and extent of long distance migrations in western North America are rapidly decreasing (Hebblewhite et al 2006). The few remaining migrations present a great conservation challenge because they often cross multiple jurisdictions and managers lack detailed knowledge about long distance migrations (Berger et al 2006). The effects of climate change can be expected to complicate the conservation picture even more.

Despite the great challenge there are also many conservation opportunities as we tend to the business of saving these remaining spectacular migrations. With the advent of new technologies (GPS collars and geolocators) our knowledge of animal movements has increased tremendously. Within the last decade we have developed superb tools to identify and map the detailed movements of even the smallest animals. As well as providing detailed scientific data, these tools impart great power to telling the migration stories. The conservation community is also meeting the challenge by forming complex partnerships. Inspired by the need to save animal migrations, new collaborations have been established like the Northern Sage Steppe Initiative to support the conservation of migrating wildlife like pronghorn, sagegrouse and even rattlesnakes on the northern prairies and the International Porcupine Caribou Board which is helping to manage an important wildlife resource across an international boundary. Large scale collaborations like

"Partners in Flight" are engaging in continental scale cooperation among wildlife agencies and NGO's to conserve bird migration. Finally, some innovative and ecologically based initiatives are emerging like recent efforts to protect nectar corridors that are not only important for animal movement but the ecological services provided (Nabhan 2004).

The success of these and future conservation initiatives will depend upon the ability to market migration to society and policy makers. From the 2003 film 'Winged Migration' which charmed the public, to recent trade and coffee-table books on great migrations (Wilcove 2008; Kostyal 2010), and the National Geographic series on "Great Migrations" the story of migration has been carried to an interested public. Via these media events, there is a strong and growing recognition that migration has tremendous cultural, economic, and biological value. The conservation community has a unique opportunity to build on the public appetite for migration stories and to keep sharing the spectacle of migration to gain support for on-the-ground and policy activities necessary to conserve this natural phenomenon.

Recently, WCS staff conducted a migrations workshop for the National Park Service and produced a new framework for conserving migrations in or near National Parks (Berger et al.2010). Although designed specifically for the National Park Service, this framework is applicable to the conservation of migration across many jurisdictions and consists of 6 essential actions including:

- Increased field research efforts to identify important migrations and migratory pathways
- Demonstrating successful conservation of migration on exemplars
- Increasing funding to support conservation of lands at key pinch points and bottlenecks
- Using a marketing approach to sell the value of migration to policy makers and public.
- Educating the public about the broader value of conserving ecological connectivity using migration spectacles as models.
- Improving jurisdictional cooperation across land and seascapes to protect migrations

WCS has already begun applying this framework to the conservation of migration. In this report we identified 31 spectacular migrations as the first step toward finding important exemplars to demonstrate the conservation of migration while maintaining human livelihoods. WCS has been active in conservation of one of these priority migrations in the Pinedale Anticline ("Path of the Pronghorn"). With support from the William and Flora Hewlett Foundation, WCS has begun to focus additional energy around conserving western nectar corridors in the southwestern U.S and Mexico. In this next year, we propose to convene an initial stakeholder workshop to identify key conservation needs and immediate actions that can be taken to conserve migration of pollinator bats in this desert environment. Our work in the Arctic has also positioned us to work on critical arctic migrants (bird and mammal) essential to ecosystems and human cultures in these cold environments.

In conclusion, we have identified many spectacular migrations with superb story-telling capacity and profile just a few of them. The next step is sharing these interesting stories to increase public interest in their conservation. We plan to profile these inspiring stories on websites and in print media to continue our conservation efforts to save spectacular migrations. WCS is working hard to save migration spectacles around the world and believes that these migrations serve as an awe-inspiring emblem for conservation.

Pronghorn Migration Wyoming *© J Burrell, WCS*

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Appendix A. Terrestrial Mammal Migrations Data Table

Nomin. #	Migration Title	Species	State/Prov.	Species Status	General Location	Population Number	Migration Distance	Geographic Scale	Threats	Jurisdictions	Stakeholders
1	Sun River Elk	Rocky Mountain Elk (Cervus elaphus)	MT	Common	Upper Sun River to Foothills	2,500	30 miles	2	Forest Management, livestock grazing, recreation, human development	Lewis and Clark NF. State of Montana, Private	Lewis and Clark NF, Grt Falls BLM, State of Montana (DNRC and MFWP), Private Landowners
2	Northern Yellowstone Elk	Rocky Mountain Elk (Cervus elaphus)	WY-MT	Common	Yellowstone to Paradise Valley	8,000	80 miles	3	Forest Management, recreation, disease (brucellosis), livestock grazing, human development	Gallatin NF, MTFWP, Private, YNP	Gallatin NF, Yellowstone National Park, BLM, State of Montana (DNRC and MFWP)
3	Northern Montana Pronghorn	Pronghorn Antelope (Antilocapra americana)	MT-AB-SK	Common	North Malta to southern Alberta- Also includes corner of Sask.	10,000	Up to 400 miles for some animals	4	Oil and Gas, habitat conversion, agriculture, Roads and Highways	BLM, Private, USFWS Refuge, Tribal	Malta-Glasgow BLM, State of Montana (DNRC and MFWP), Parks Canada, CMR Refuge, Alberta Conservation Association, Saskatchewan Environment, WWF, NCC, Energy Corporations (Encana, Fidelity)
4	Sun River Bighorn Sheep	Bighorn Sheep (Ovis Canadensis)	MT	Common	Bob Marshall Wilderness summer to Winter Range along Front	800	70 miles	2	Forest Management, livestock grazing, recreation, human development	USFS, State of Montana, Private	Lewis and Clark NF, Grt Falls BLM, State of Montana (DNRC and MFWP)
5	Salmon River Corridor	Bighorn Sheep (Ovis Canadensis)-600-650 sheep	ID	Common	Bighorn sheep moved from winter ranges to summer and lambing sites along the Salmon River and Tributories	650	25-30 miles	2	Federal Land Management (BLM and USFS), Disease, Domestic Sheep, human disturbance	Payett NF, BLM	Idaho Game and Fish, Payette National Forest, Wild Sheep Foundation, BLM, Nez Perce National Forest
6	HD Mountains	Elk (Cervus elaphus) 19,000 Mule Deer (Odocoileus hemionus) 25,000	CO-NM	Common	low elevation winter ranges on the Southern Ute Indian reservation, through the HD Mountains, to summer ranges in the rugged Weminuche Wilderness of the San Juan Mountains	34,000	Up to 50 miles	2	Forest Management, Highways, Energy Development	USFS, Private, State of Colorado, State of New Mexico, Ute Indian Reservation	CDOT, BLM, Forest Service – Public Lands Center, Southern Ute Tribe, CDOW, Colorado Wild, San Juan Citizens Alliance, WELC, La Plata County, Freedom to Roam
7	Piceance elk and mule deer migration corridor	Elk and Mule deer	North Western CO	Common	The Piceance Basin encompases 5 million acres of winter habitat in North western Colorado. The Roan Platueau forms the eastern third of the area.	50,000	Multiple migration routes of 20-30 miles Garrott reports up to 60 miles	2	Oil and Gas, Oil Shale, Forest management, Highways, livestock grazing and exurban development	USFS, BLM , State, Private. Over 75% is federally owned.	The Colorado Division of Wildlife, BLM, Audubon , Rocky Mountain Elk Foundation , Colorado Wildlife Federation, energy companies (Exxon Mobil)
8	Puansegaunt-Kaibab	Mule Deer (Odocoileus hemionus)- 6000-10,000	UT-AZ	Common	The Paunsaugunt Plateau in Utah to the winter range on the Kaibab Plateau in Arizona	8000	100 miles	2	Forest Management, livestock conflicts, Highways and Roads	USFS, BLM, private lands, State lands	Utah Division of Wildlife Resources, Utah State University, The Department of Defense, USFS, BLM, ADOT, UDOT, Arizona Game and Fish Department, WELC, Western Wildlife Conservancy, Round River Conservation Studies, Grand Canyon Wildlands Council, Sportsmen for Fish and Wildlife, Mule Deer Foundation, Arizona Deer Association
9	"Path of the Pronghorn" and other Sublette Co migrations	Pronghorn Antelope (Antilocapra americana) This is a subset of the Pinedale Anticline-Wyoming Range migrations below.	WY	Species of Concern	Jackson Hole to Green River Basin Other segments into the Basin from adjacent summer habitats	1000	100-150 miles	3	Forest Management, Agriculture, Ex-urban Development, Energy, fences, roads	USFS, BLM, State of WY, Private	Bridger Teton NF, Pinedale BLM, State of WY, Grand Teton NP, Green River Valley Land Trust, CF, WCS, Jackson Hole Alliance, NPCA, NFWF, TRCP, Energy Companies (Shell, Questar, Plains Exploration)
10	Pinedale Anticline-Wyoming Range	Mule Deer (Odocoileus hemionus) 20-30,000 and 10,000 Elk (Cervus elaphus)	WY	Common	The eastern slopes of the Salt River and Wyoming Range and southern slopes of the Wind River Range, Lower elevations are in the Green River Basin,	25,000	50-100 miles	2	Forest Management, Agriculture, Ex-urban Development, Energy Development, fences, roads	USFS, BLM, State of WY, Private It is over 90% publicly owned.	Pinedale BLM, Shoshone NF, Sublette Co., Pinedale Community, Energy Corporations (Shell, Questar, Plains Exploration), WY Game and Fish, Conservation Fund, Green River Valley Land Trust, Wildlife Conservation Society, Freedom to Roam, Wyoming Wildlife Federation, Citizens for the Wyoming Range, Sportsmen for the Wyoming Range, Mule Deer Foundation, RMEF, TRCP, NFWF

11	National Elk Refuge	10,000 Rocky Mountain Elk (Cervus elaphus)	WY	Common	MIgrations from surrounding Forest to National Elk Refuge	10,000	60 miles	3	Roads, Subdivision	USFS, BLM, State, Private, Grand Teton NP.	Bridger-Teton NF, USFWS National Refuge, Jackson Hole-Alliance, WY Game and Fish, Grand Teton National Park, Park County, Community of Jackson Hole, WY Wildlife Fed., National Wildlife Refuge Association, Conservation Fund, RMEF
12	Roosevelt Elk of Olympic Peninsula	Roosevelt Elk (Cervus elaphus)	WA		IN and around Olympic National Park along the West Coast of Wash.	5000	50 miles	2	Residential and Commerical Development, Forest Management, roads	NPS, USFS Olympic NF, Private	NPS, State of Washington, USFS (forest), Ellawa KlallamTribal, RMEF, State Tribal working Group.
13	Sonoran Pronghorn	Pronghorn Antelope (Antilocapra americana)	AZ-MX	Endangered	The Sonoran Dester of Southwestern Arizona and northern Sonora, Mexico.	600	10-20 miles small shift in seasonal use but not able to migrate long distances any longer due to obstruction	4	Highways, Cities, Border Fences and Patro, climate change	Forty percent of the Sonoran pronghorn's home range in the United States is located within the Barry M. Goldwater Range (BMGR), The remaining 60% Cabeza Prieta National Wildlife Refuge (CPNWR), Organ Pipe Cactus National Monument (OPCNM), and Bureau of Land Management (Krausman et al. 2004) Most are in Mexico	Department of Defense, BLM, State of AZ, USFWS Many NGO's including Defenders of Wildlife, Antelope Gate Free Paradise, National Wildlife Federation. Western Regional Partnership. North Am Pronghorn foundation
14	Sierra Nevada Bighorn	SN Bighorn Sheep (O. c. californiana)	NV	Endangered	bighorn sheep from the Sierra Nevada are a distinct subspecies, qualifying them as an "evolutionary significant unit" (Moritz 1994).These bighorn sheep use habitatsranging from the highest elevations along the crest of the Sierra Nevada (4,000+meters [13,120+ feet]) to winter ranges at the eastern base of the range as low as 1,450 meters (4,760 feet).	250	50 miles	3	Domestic Sheep (disease), grazing, roads, human disturbance, mining, climate change	Los Angeles Department of Water and Power (LADWP), BLM, USFS,	NV and CA fish and Game, BLM, Sierra Nevada Bighorn Sheep Foundation, Foundation for North American Wild Sheep, Society for the Conservation of Bighorn Sheep, NPS, USFWS, USFS, Sierra Club, Bishop Paiute Tribe, N. A. Sheep and goat council
15	Desert Bighorn Mojave and Sonoran	Desert Bighorn (Ovis canadensis nelsoni)	CA NV-MX	Species of Concern	They exist in a barren, mostly waterless environment in the Mojave and Sonoran deserts. West Mojave, desert as 69 small, distinct populations, each of which depends on migrants from other populations to maintain genetic diversity. Sonoran desert includes the listed peninsular desert bighorn.	4000	20-50 miles	3	Roads and Highways, ORV activity, Human Development, Depr. Of Defense acdtivities, International Border, domestic livestock grazing, Water management, climate change	BLM, NPS, Dept. of Defense., USFWS national refuge	NV and CA game and Fish agencies, DOD, Blm, NPS, Foundation for N.A. Wildl Sheep, Society for the Conservation of Bighorn Sheep, Fraternity of the desert Bighorn, Desert Bighorn Council, AZ desert bighorn sheep society, National Wildlife Federation
16	St Anthony Sand Creek Elk Refuge	Rocky Mountain Elk (Cervus elaphus	ID	Common	Targhee forest lands to the Elk Refuge winter range in Sand Creek	2000	Up to 60 miles even some from YNP	2	Highways and Roads, Forest Management, exurban development, agricultural conflicts	Private, State, BLM, USFS, State of ID, YNP. Summer range is owned by the forest service (Targhee National Forest), YNP, and the state of Idaho (Harriman State Park)	State of Idaho, BLM, Targhee NF, Private Landowners
17	Alaskan Moose	Moose (Alces alces) N of the Brooks Range-Old Crow Flats area- 200	AK	Common	Moose migrate seasonally from Arctic Refuge in Alaska for winter habitat to the Yukon for summer.	200	up to 120 Miles	2	Roads, Fences	USFWS National Reguge, Yukon Territory, Aboriginal Settlement Lands	USFish and Wildlife Service, Yukon Terriroty, Vuntat NP-Parks Canada, Old Crow Setttlement, Alaska Moose Federation
18	Western Arctic Caribou	Tundra Caribou (Rangifer tarandus)	AK	Common	140,000 sq miles bound by Arctic Ocean, Yukon River, Trans Alaskan pipelin.	500,000	100 miles	3	Energy Exploration	USFWS,BLM,State of Alaska, NPS	USFWS, AKDFG, U of AK, BLM, NPS, CAFF, Rangifer network, ARCUS, Audobon, CARMA (CircumArctic Rangifer Monitoring and Assessment Network), Energy Industry (coal and oil), 40 Native Villages, Sportsmen
19	Teshekpuk Caribou	Tundra Caribou (Rangifer tarandus	AK	Common	North Slope Alaska...North on Arctic Coastal Plain above the Brooks Range	64,000	115 miles up to 240 miles recently	3	Energy Exploration	USFWS,BLM,State of Alaska, NPS, National petroleum Reserve	USFWS, AKDFG, U of A, North Slope Borrough, BLM, CAFF, Rangifer net, ARCUS, Audobon, CARMA
20	Central Arctic Caribou	Tundra Caribou (Rangifer tarandus	AK	Common	The Central Arctic herd roams between the Brooks Range and Beaufort Sea	67,000	120 miles	3	Energy Exploration	USFWS,BLM,State of Alaska, NPS	CAFF, USFWS, AKDFG, UofA, Rangifer net, ARCUS, CARMA, Native Americans
21	Porcupine Caribou	Tundra Caribou (Rangifer tarandus	AK	Common	Brooks Range north to the Beaufort Sea, and from the Colville River (the eastern border of NPR-A) east to the Canning River (the western edge of the Arctic National Wildlife Refuge).	123,000	400 miles	3	Energy Exploration	USFWS,BLM,State of Alaska, NPS	USFWS, AKDFG, UofA, Porcupine Caribou Management Board, CAFF, Rangifer network, ARCUS, CARMA, Native Americans

22	Loyalton-Truckee DH: The 2010 Interstate combined population estimate (Sierra Valley and Verdi subunits)	Mule Deer (Odocoileus hemionus) AND Columbian black-tailed deer (*Odocoileus hemionus columbianus*)	CA-NV	Common	The Lassen Washoe Deer Herd is an interstate, migratory, mule deer herd located astride the California-Nevada State line north and west of Reno, Nevada, The herd winters primarily in Lassen County, Cal and Washoe Co, NV with major summer ranges in Lassen, Plumas, Sierra, Nevada and Placer counties-all in California.	3,395	35 miles	2	Mostly residential and commercial development; highways and roads, livestock grazing	USFS, BLM, state and private	CA & NV game and fish depts, Caltrans, USFS, BLM, Mule Deer Foundation, Safari Club International, California Deer Association
23	Antelope: Intrastate herds Alturas, Bieber, Dorris, Likely Macdoel, Madeline, and Termo, CA	Pronghorn Antelope (Antilocapra americana)	CA-NV	Common	Northern California summer range to winter habitat in Northwestern Nevada.	4,500	50-100 miles	2	Fencing, development; highways; habitat loss	BLM, USFS, state and private	Almost exclusively federal and state agencies. Ca and NV game and fish depts, Caltrans, USFS, BLM North Am Pronghorn Foundation,
24	Forty Mile Caribou	Mountain Caribou (Rangifer tarandus granti)-30,000	AK-Yukon	Common	Border between Alaska and Yukon Territories Canada-Eastern Alaska and Yukon. Surrounding the Yukon River area	30,000	130 miles	3	Highway, Energy Development	BLM, Yukon Charley Preserve	State of AK, BLM, USFWS, NPS, USGS, and UofAK.

Appendix B. Aerial Migrations Data Table

Nomin #	Migration Title	Species	State/Prov.	Species Status	General Location	Population Number	Migration Distance	Geographic Scale	Threats	Jurisdictions
25	Desert Pollinator Bats	16,000 Lesser Long nosed Bat (Leptonycteris yerbabuenae), 100's of Mexican Long-tongued Bat (Choreonycteris mexicana), 3000 Mexican Long-nosed Bat (Leptonycteris nivalis)	Sothwest U.S. and Mexico	Endangered	Summer Ranges in Southwestern U.S. to winter habitats in California and Mexico	25,000	600-700 miles	4	Renewable energy, human developments, Agriculture, pesticides and herbicides, invasive species,	Mixed-BLM, U. S. Defense Department, NPS USFS, USFWS, private lands, Indian Reservations, Mexico
26	Sage Grouse	Greater Sage Grouse-(*Centrocercus urophasianus)*-Northern Great Plains region	Montana, Wyoming, Idaho, and N. Dakota, Alberta, Sask	Warranted but precluded in 2010	Recent studies detected long range movmenents across borders to and from winter ranges (e.g. Sask into Montana, ND into Montana, Id into Mt and Across Wyoming Mt Borders.	up to 200,000	up to 100 miles	2	Agriculture, fire, Energy development, W. Nile Virus, Roads, Fences, Invasive species, (see USFWS powerpoint)	Mixed-BLM, NPS, USFS, USFWS, private lands, Indian Reservations, Canadian Provinces
27	Western Snow Geese	Lesser Snow Goose (*Chen coerulescens coerulescens)* and Ross's (*Chen rossi)*	Pacific Flyway States	Common	Summer in the high Arctic while wintering as far south as the Texas.	500,000-700,000	2000-3000 miles	3	Overabundance Loss of Arctic grazing Habitat, Climate Change, Water mangement, land conversion on wintering areas	Mixed-BLM, NPS, USFS, USFWS, private lands, Indian Reservations, Canadian Provinces
28	Mountain Plover	Mountain Plover (*Charadrius montanus)*	Montana, Wy,CO and south to CA AZ, TX and Mexico	Threatened	Mountain plovers breed in the western Great Plains and Rocky Mountain States from the Canadian border to northern Mexico. Most breeding occurs in Montana, Wyoming, and Colorado. They winter in similar habitat in California, southern Arizona, Texas, and Mexico.	6000-10,000	1000-1500 miles	2	Agriculture, fire, Energy development, Roads, Fences, Invasive species,	Mixed-BLM, NPS, USFS, USFWS, private lands, Indian Reservations, Canadian Provinces
29	Curlew	Long-billed Curlew, (*Numenius americanus),* Largest NA shorebird	Northern Great Plains	Species of Concern	Migrate from Northern Great Plains states and provinces to Southern Ca	125,000	1000-1500 miles	2	Insecticide on wintering grounds, Agriculture, Livestock grazing , illegal harvest	Mixed-BLM, NPS, USFS, USFWS, private lands, Indian Reservations, Canadian Provinces
30	Curlew	Bristle-thighed Curlew (Numenius tahitienis)	Alaska and Oceania	Highly Imperiled	Breeding in Alaska and Yukon but winters in Oceania...Hawaii and other Pacific Islands.. Delayed migration until adulthood	17,000	4000-5500 miles	4	Insecticide on wintering grounds, Agriculture, Livestock grazing, habitat degradation on wintering grounds	Mixed-BLM, NPS, USFS, USFWS, Islands of Pacific
31	Swainson's Hawk	Swainson's Hawk (*Buteao swainsoni)*	All Western States and Provinces.	Species of Concern	Migration from Northern Argentina where they winter to areas across north American grasslands. Can form very large flocks of 5-10,000...a river of hawks.	400,000-500,000	3750-7,500 miles	4	Insecticide on wintering grounds, dimishing role of fire on grasslands, aspen and conifer encroachment, illegal harvest	Mixed-BLM, NPS, USFS, USFWS, private lands, Indian Reservations, Canadian Provinces, Mexico, South American countires
32	Sandhill Cranes	Sandhill	West and Midwestern States and Provinces	Common	Northern States and Provinces including Alaska wintering in New Mexico, CA, Az and Mexico.	600,000-700,000	1000- 2000 miles	3	Loss of wetlands in staging and wintering areas, Climate change	Mixed-BLM, NPS, USFS, USFWS, private lands, Indian Reservations, Canadian Provinces
33	Piping Plover	Piping Plover in Great Plains	Great Plains Region of their Range	Threatened or endangered	There are three locations where piping plovers nest in North America: the shorelines of the Great Lakes, the shores of rivers and lakes in the Northern Great Plains, and along the Atlantic Coast. Their nesting range has become smaller over the years, especially in the Great Lakes area. In the fall, plovers migrate south and winter along the coast of the Gulf of Mexico or other southern locations including Baja.....	2600-5000 birds-1300-2300 breeding pairs	500-1000 miles	2	Habitat loss and degradation, human disturbance, dams and water control, predation	Mixed-BLM, NPS, USFS, USFWS, private lands, Indian Reservations, Canadian Provinces
34	Snowy Plover	Pacific Coast Snowy Plover (*Charadrius alexandrius nivosus)*	Southwestern States to Mexico	Threatened	Breeding habitat in Southwestern states to Coastal regions of CA and Mexico	4000-4500	300-500 miles	2	Habitat loss and degradation, invasive species introduced predators near human developments	Mixed-BLM, NPS, USFS, USFWS, private lands, Indian Reservations, Dept. of Defense
35	American Golden Plover	Pacific and American Golden-Formerly Lesser Golden Plover	Alaska and Northern Canada	Species of Concern	Breeding in Alaska wintering on coast of California, Oceania (Hawaii) and as far south into Brazil and Argentina. Some as far south as Australia and Newzealand.	385000-450,000	3000-4500 miles	4	Climate change, agriculture, ranching energy (wind farms), residential development.	Mixed-BLM, NPS, USFS, USFWS, private lands, Canadian Provinces, Mexico and south America, Ocean Islands
36	Hummingbirds	Caliope-Smallest long distance migrant in the world	Pacific Northwest States to Mexico	Common	From Northwestern states and southern Canadian provinces to winter in southwestern Mexico. Sineaola, Oaxaca	1,000,000	4500 miles	4	Forestry and Climate change changes to stopover sites in migration	Mixed-BLM, NPS, USFS, USFWS, private lands, Indian Reservations, Canadian Provinces
37	Nighthawk	Common Nighthawk (*Chordeiles minor)*	Yukon to Argentina	Common	Migration is very long going from as far north as the Yukon to wintering habitats in Argentina, Paraguay and Brazil	10,000,000	2500-6800 miles	3	Insecticides, fire suppression, agriculture. Loss of habitat, introduced predators near human developments	Mixed-BLM, NPS, USFS, USFWS, private lands, Indian Reservations, Canadian Provinces

38	Arctic Terns	arctic tern (*Sterna paradisea)* Long lived and long distance migrant. Icons of migration	Arctic to antarctic	Species of Concern	Longest regular migration of any bird. Circumpolar travels on two main migration routes. From high Arctic to the antarctic….only in alaska then flying mostly over oceans…where are stopovers	200,000 in Alaska but poor information on populations. Worldwide 2-4,000,000	9,300 - 12,500	4	Loss of stopover habitat along coast, unregulated harvest, predation at nesting sights.(gulls), climate change	Mixed- USFWS, NPS, BLM, Alaskan Petroleum Reserve
39	Black Swift	Black Swift (*Cypseloides niger)* Little known long distance migrant	North America to South America	Species of Concern	North America from as far north as BC and SE Alaska migrating to South America as far south as Columbia.	80,000	1000-2000 miles	4	Human disturbance, life history is little known	Mixed-BLM, NPS, USFS, USFWS, private lands, Indian Reservations, Canadian Provinces, Mexic and south America
40	Upland Sandpiper	Upland Sandpiper	Alaska-Northern Great Plains	Species of Concern	Migrate from North America to south America as far as Argentina and Brazil.	200,000-400,000 Global population 386,000	2500-6000 miles	4	Loss of Habitat, Mowing, grazing, agriculture	Mixed-BLM, NPS, USFS, USFWS, private lands, Indian Reservations, Canadian Provinces
41	Northern Pintail	Northern Pintail	Across Western North America and Canada	Common	Migrate from Northern states and central canadian provinces to Gulf of Mexico and California. Some birds go to the Yucatan and central America	1.8-2.3 million	1000-2000 miles	3	Loss of wetlands, Climate Change, Agriculture, lead poisoning, pesticides	Mixed-BLM, NPS, USFS, USFWS, private lands, Indian Reservations, Canadian Provinces and Mexico