Appendix C – Species Conservation Elements

Organization of Appendix C

For each conservation element, we provide some background information, a conceptual model, description of the analytical process (including source data) and/or a Process Model for each management question, and results in the form of maps and other supporting graphics.

Species Conceptual Models

Conceptual models attempt to organize and articulate the relationship between the various change agents and natural drivers for each conservation element. Not all of the relationships identified lend themselves well to measurement or monitoring, but they are still important to include, as they add to our general understanding of complex interactions.

All conceptual models include a series of change agents (depicted with yellow boxes) and natural drivers (cyan boxes). Specifics regarding some of the factors are presented in blue text. Arrows represent relationships between the various change agents and natural drivers on the community overall and, where appropriate, on the dominant species more directly. More specific information is provided by the orange text. Thicknesses of the arrows **DO NOT** represent degree of importance. Rather, bold lines represent those factors that are tracked or modeled to varying degrees of certainty throughout the REA analysis.

Species Process Models

Two basic management questions were addressed for each species conservation element. The first question pertained to current distribution and status. The second question referred to potential impact on the species from near-term (2025) future change, impact from potential energy development, and finally long-term potential-for-change (2060) from climate change. The basic method for each species was similar, but, in the case of current distribution, input data varied in source and quality. Source data for each is provided in the introduction for each species. Current status was determined by overlaying current distribution against terrestrial landscape intactness (Chapter 4) for terrestrial species and aquatic intactness (Appendix E) for the fishes.

For potential future condition, current distribution was evaluated in a similar fashion against potential energy development (Chapter 5, Section 5.2), near-term (2025) terrestrial landscape intactness (Chapter 5, Section 5.3), and climate change model results (Chapter 5, Section 5.4).

Black-footed Ferret – *Mustela nigripes*

Black-footed ferrets are the only extant ferret species native to North America. The species reached near extinction by the 1980s and it has been sustained only through captive breeding and reintroduction efforts. The connection between black-footed ferrets and prairie dogs is inextricable—from habitat to food to shelter (USFWS 2008). Historically, ferret habitat coincided with the North American shortgrass and mixed-grass prairie lands associated with that of the Gunnison's, white-tailed, and black-tailed prairie dogs (Biggins et al. 1997, USFWS 2008). Currently, less than 2% of the ferrets' original geographic distribution remains occupied, and wild black-footed ferrets can only be found at reintroduction sites (Black-footed ferret Recovery Program). As of 2010, the number of individuals living in the wild is estimated to be around 1,000 – all in states where releases have occurred – and another 300 in captive breeding facilities (Black-footed Ferret Recovery Implementation Team 2012).

Black-footed ferrets are highly specialized predators and rely almost completely on prairie dogs for food. The species spends the majority of its time in vacated prairie dog burrows, coming above ground mostly at night to look for prey (Black-footed Ferret Recovery Program 2012). Prairie dogs comprise over 90% of the ferrets' diet (Houston et al. 1986, Biggins et al. 1993). While the most common predators of the black-footed ferret are owls, coyotes, and badgers, the greatest threats they face are habitat loss and the loss of their prairie dog prey base from sylvatic plague infestations and/or intentional poisoning of prairie dog colonies by humans (USFWS 2008). Large expanses of native prairie grasslands were converted to farmland with Euro-American settlement (U.S. Fish and Wildlife Service Report, 2008). The sylvatic plague, a non-native disease introduced to the Americas in the early 1900's, affects black-footed ferret populations directly through infestation and high mortality rates (up to 90% in some populations) in prairie dog colonies (USFWS 2008). With the decline of all prairie dog species in the U.S., there has been a concurrent and predictable decline of black-footed ferret populations (Hoffmeister 1986, USFWS 2008).

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
prey	Prairie dog density	<3.63/ha	3.63–5/ha	5–7/ha	>7/ha	Houston et al. (1986), Biggins et al. (1993)
prey	Area prairie dog colonies	<800 ha	800–1,900 ha	1,900–3,000 ha	>3,000 ha	Houston et al. (1986), Biggins et al. (1993)
dispersal	Prairie dog inter-colony distance	>4.3 km	3.2–4.3 km	2.1–3.2 km	<2.1 km	Minta and Clark (1989)

References Cited

Biggins, D.E., B.J. Miller, L.R. Hanebury, B. Oakleaf, A.H. Farmer, R. Crete and A. Dood. 1993. A technique for evaluating black-footed ferret habitat. Pages 73–88 *in* Oldemeyer, J.L., D.E. Biggins, B.J. Miller, and R. Crete (eds.), Proceedings of the symposium on management of prairie dog complexes for the reintroduction of the black-footed ferret, Biological Report 13, U. S. Fish and Wildlife Service, Washington, D.C.

Biggins, D.E., B.J. Miller, T.W. Clark, and R.P. Reading. 1997. Management of an endangered species: The black-footed ferret. Pages 420–424 *in* Meffe, G.K., and C.R. Carroll (eds.), Principles of Conservation Biology, 2nd edition, Sinauer Associates, Sunderland, Massachusetts.

Black-footed Ferret Recovery Implementation Team 2012. www.blackfootedferret.org

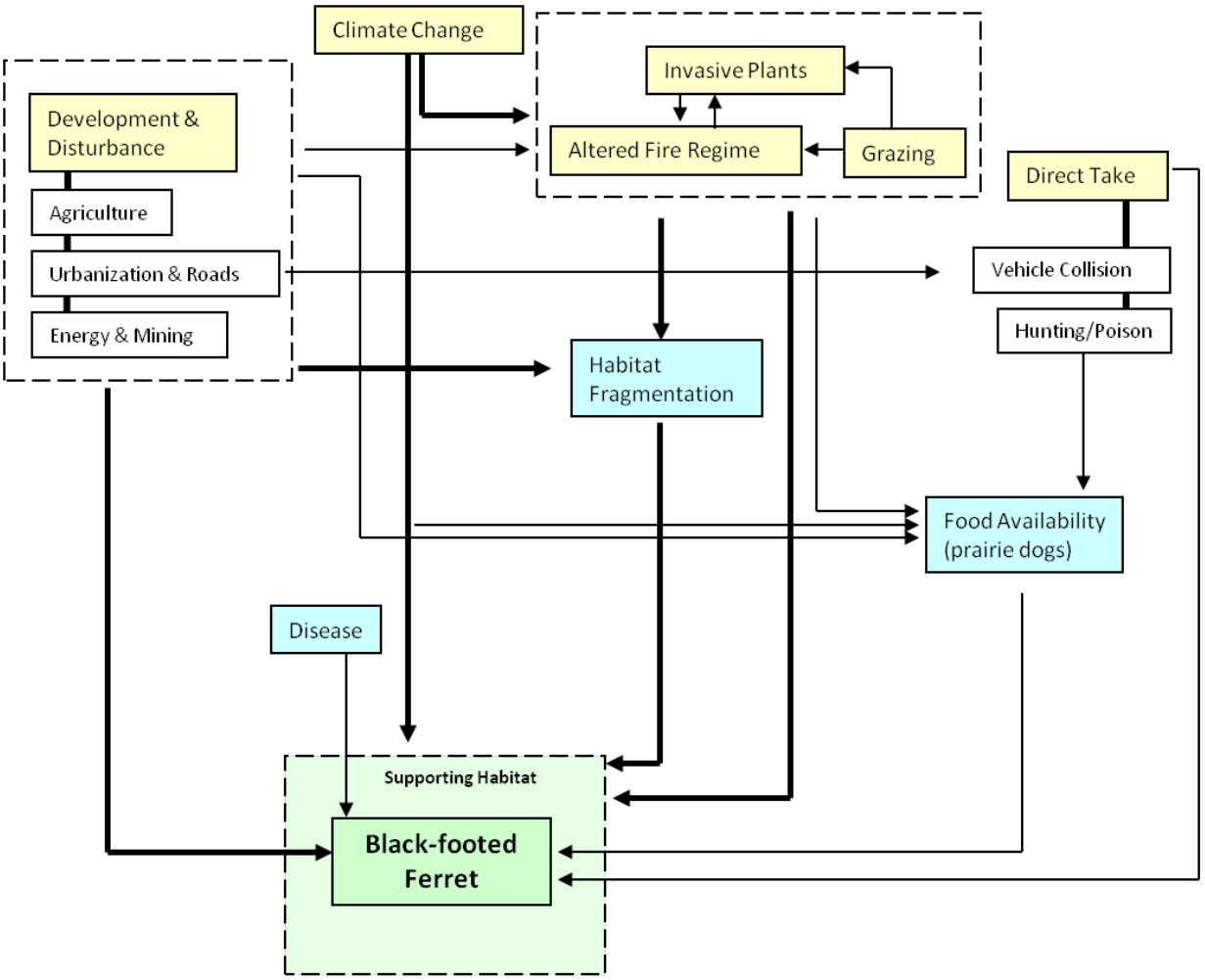
Hoffmeister, D.F. 1986. Mammals of Arizona. University of Arizona Press and Arizona Game and Fish Department, Tucson.

Houston, B.R., T.W. Clark, and S.C. Minta. 1986. Habitat suitability index model for the black-footed ferret: A method to locate transplant sites. *Great Basin Naturalist Memoirs* 8: 99–114.

Minta, S.C., and T.W. Clark. 1989. Habitat suitability analysis of potential translocation sites for black-footed ferrets in north central Montana. Pages 29–45 *in* Clark, T.W., D. Hinckley, and T. Rich (eds.), The prairie dog ecosystem: Managing for biological diversity. Montana BLM Wildlife Technical Bulletin No. 2, Bureau of Land Management, Billings, Montana.

USFWS (U.S. Fish and Wildlife Service). 2008. Black-footed ferret five year status review: Summary and evaluation. USFWS, South Dakota Field Office, Pierre, South Dakota.

Black-Footed Ferret Conceptual Model



Thick arrows denote components with available spatially explicit data – NOT importance

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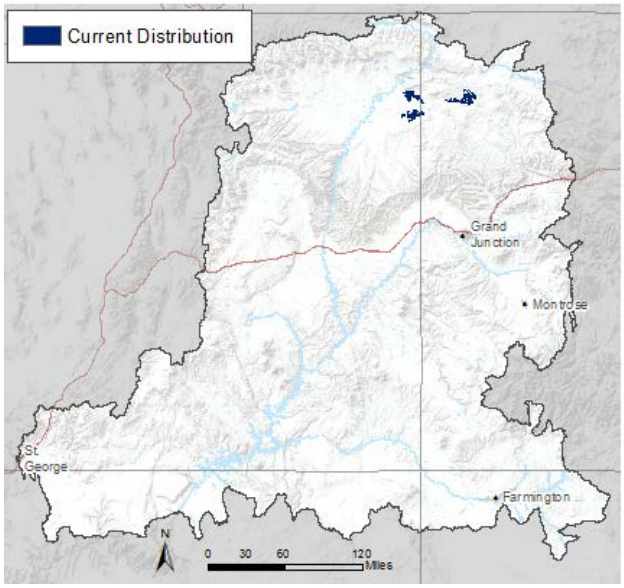
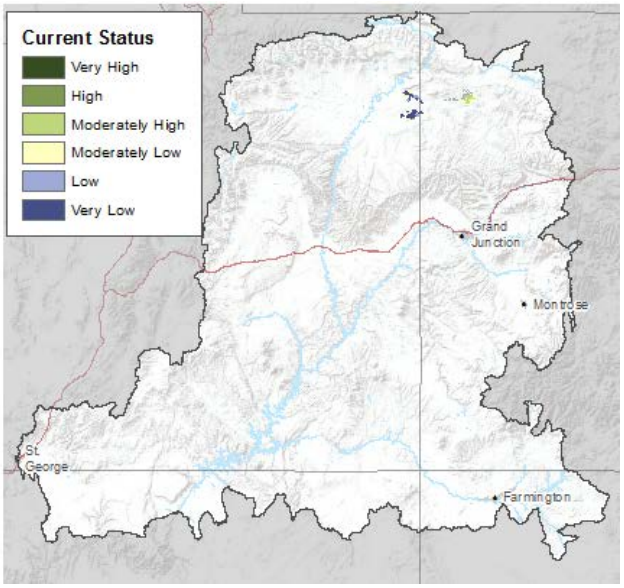
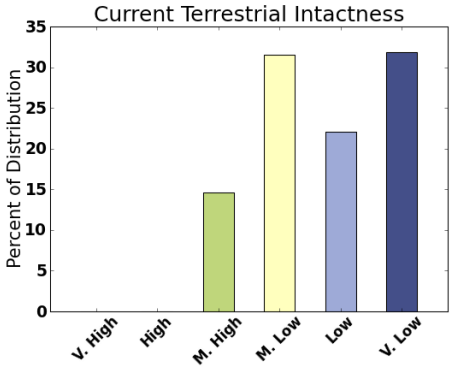




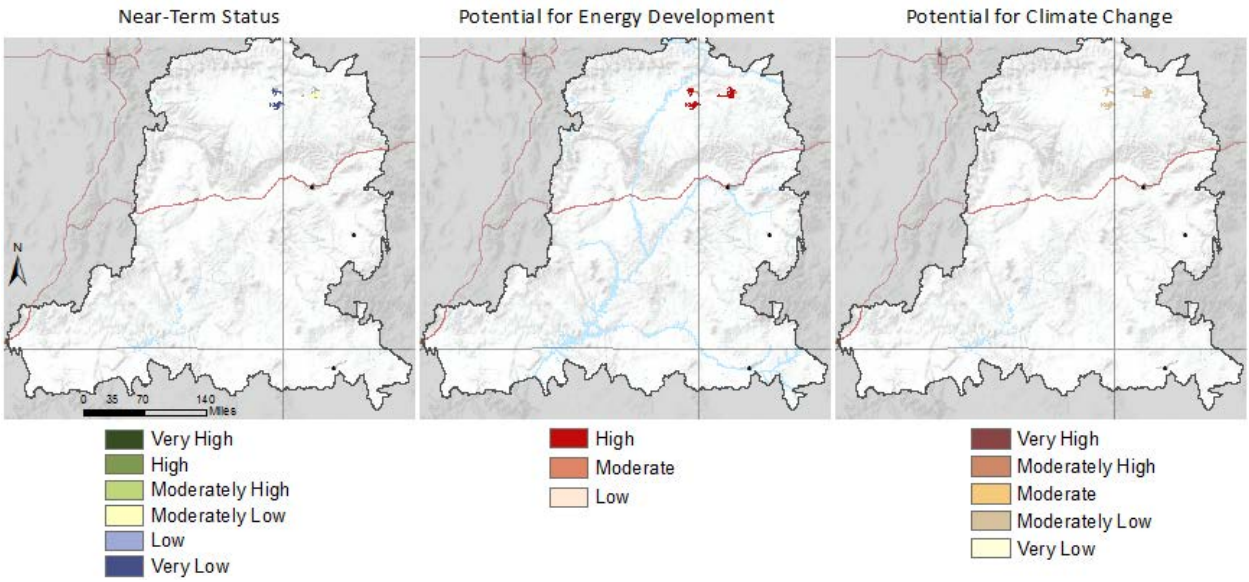
Data Sources:

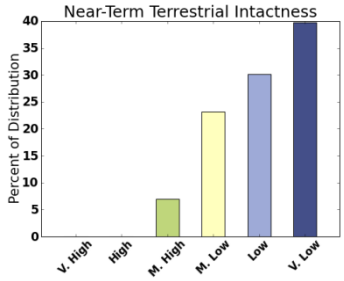
Black-footed ferret: polygons of white-tailed prairie dog selected out based on natural heritage element occurrences and reintroduction sites referenced in http://www.blm.gov/nstc/library/pdf/TN426.pdf

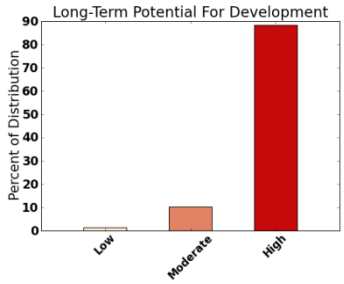


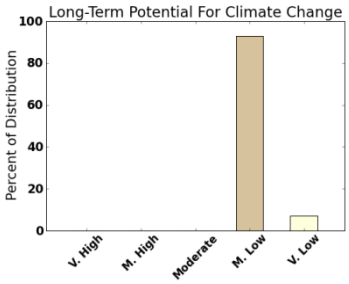
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Black-Footed Ferret Potential for Change

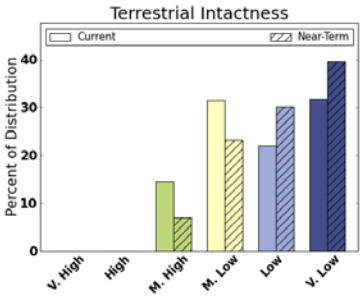








Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Desert Bighorn Sheep – *Ovis canadensis nelsoni*

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Habitat	Cover & terrain	Forest/thick brush; lack of precipitous escape terrain			Visually open with steep, rocky slopes	Sierra Nevada Bighorn Sheep Foundation; Beecham et al 2007
Disease	Proximity to domestic livestock				A minimum of 13.5 km between sheep & domestic livestock	Beecham et al, 2007; Singer et al, 2001
Habitat	Habitat fragmentation	Increased human disturbance			Little to no human disturbance	Beecham et al, 2007; King 1985
Climate	Effect on vegetation	Higher temperatures - decreased precipitation			Normal to higher levels of rainfall	Beecham et al, 2007

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Beecham, J.J. Jr., C.P. Collins, and T.D. Reynolds. 2007. Rocky Mountain bighorn sheep (*Ovis canadensis*): A technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/rockymountainbighornsheep.pdf

Graham, V.K. 1997. Desert bighorn sheep plan, Colorado Division of Wildlife Desert Bighorn Sheep Management Plan. 17pp.

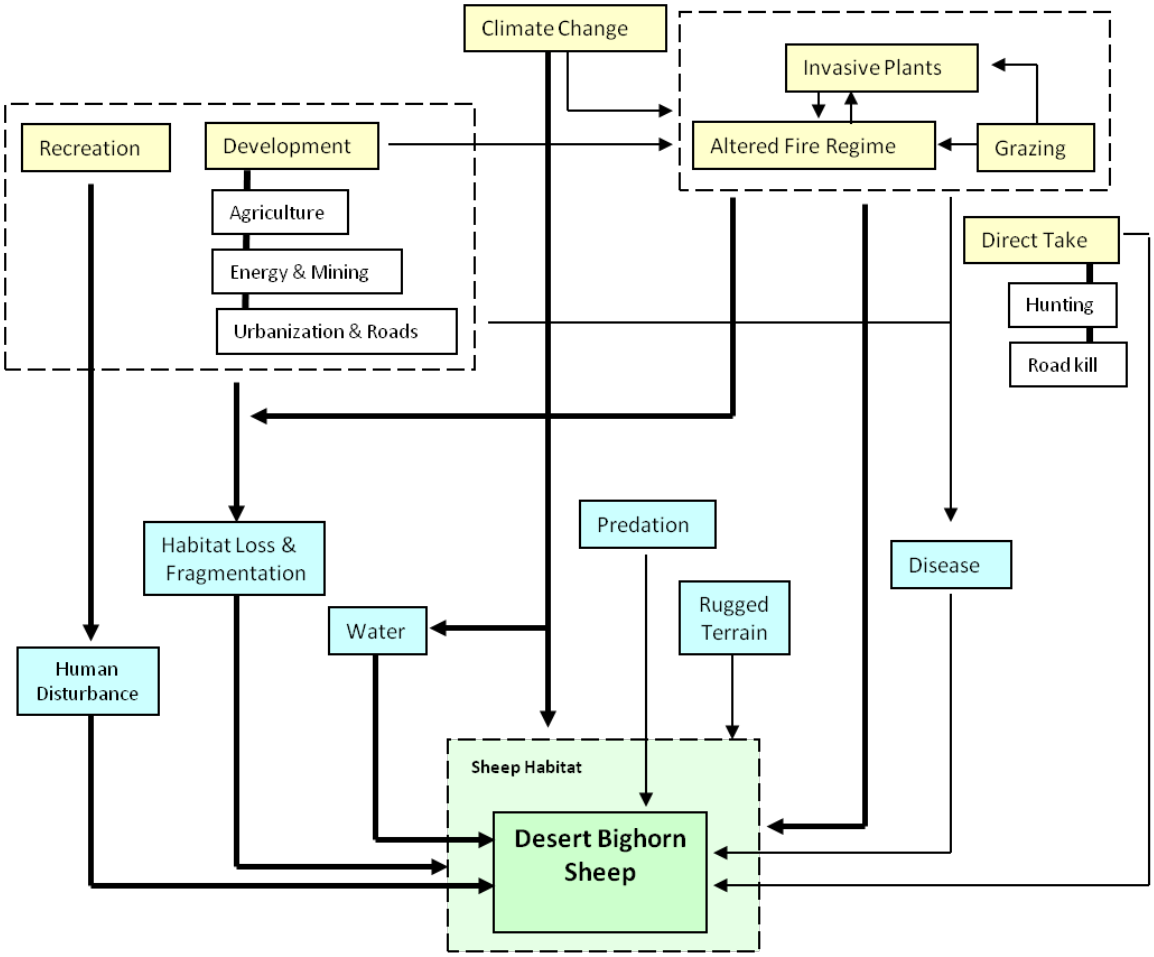
King, M.M. and G.W. Workman. 1985. Response of desert bighorn sheep to human harassment: Management implications. *Transactions of the 51st North American Wildlife and Natural Resources Conference* 51: 74–85.

Sierra Nevada Bighorn Sheep Foundation; http://www.sierrabighorn.org/Pages/S-NHistory.htm

Singer, F.J., L.C. Zeigenfuss, and L. Spicer. 2001. Role of patch size, disease, and movement in rapid extinction of bighorn sheep. *Conservation Biology* 15(5): 1347–1354.

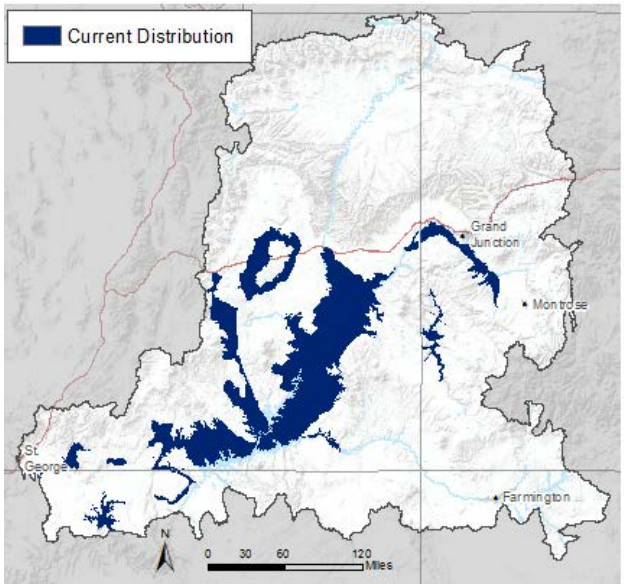
UDWR (Utah Division of Wildlife Resources). 2008. Utah Bighorn Sheep Statewide Management Plan, Utah Division of Wildlife Resources, Salt Lake City, Utah. 25pp.

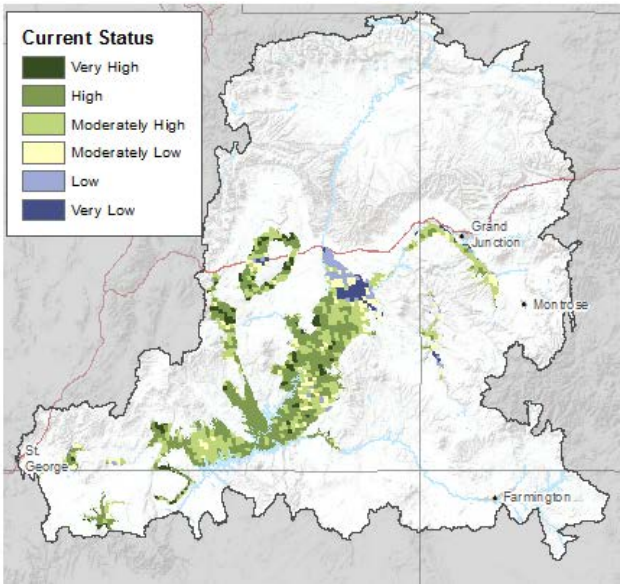
Desert Bighorn Sheep Conceptual Model



Thick arrows denote components with available spatially explicit data – NOT importance

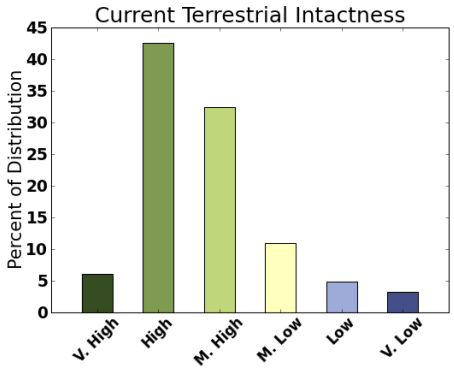
MQ D1. What are the current distribution and status of desert bighorn sheep (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?





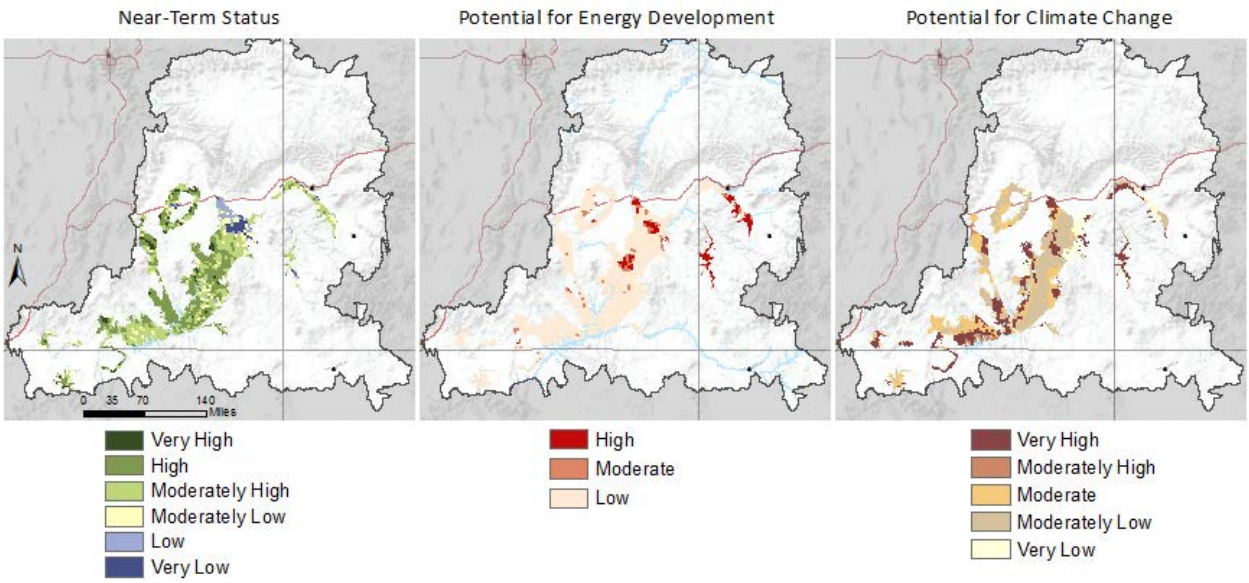
Data Sources:

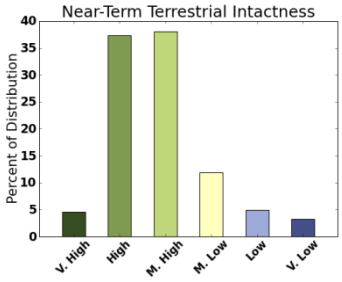
Desert bighorn sheep: Arizona Department of Fish & Game, Utah Division of Wildlife Resources, and reintroduction sites w/in polygons mapped by Colorado Division of Wildlife

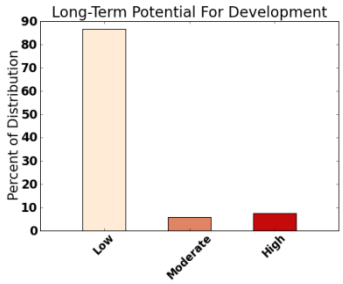


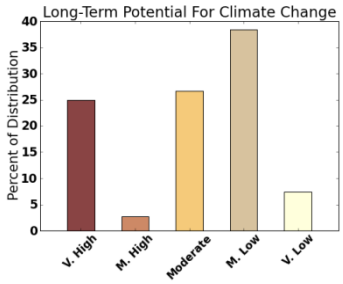
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Desert Bighorn Sheep Potential for Change

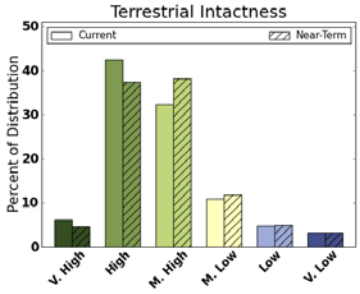








Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Gunnison's Prairie Dog – *Cynomys gunnisoni*

Gunnison's prairie dogs reside in both grasslands and (montane) high-desert scrub (Linzey et al. 2008, Lupis et al. 2007). The species typically burrows on slopes or in hummocks and prefers elevations of 1,550–3,660 meters (Longhurst 1944, Pizzimenti and Hoffman 1973, Linzey et al. 2008). They require well drained, deep soils for burrow construction and, because the species hibernates, they rely on placement of hibernacula below the frost line (Linzey et al. 2008). Grasses are, by far, the species' most important food item, though forbs, insects, and shrubs are consumed occasionally (Shalaway and Slobodchikoff 1988, Linzey et al. 2008).

Gunnison's prairie dogs are considered a keystone species of the sagebrush and prairie ecosystems because they are a top prey species and they also create habitat and keep soil and plant communities healthy (Lupis et al. 2007). They are one of five prairie dog species considered to be critical to the structure and function of their native ecosystems (Kotliar et al. 1999). Gunnison's prairie dog burrows provide homes for a host of animals including snakes, cottontail rabbits, burrowing owls, beetles, and salamanders. In addition, they are prey for numerous species including the black-footed ferret (*Mustela nigripes*), one of the most endangered mammals in North America (Rocke 2011 that depends on the Gunnison's prairie dog (as well as the black-tailed and white-tailed prairie dogs) for food and burrows. Population numbers for the Gunnison's prairie dogs have been drastically reduced from historic levels, resulting in the near extinction of the black-footed ferret (Rocke, 2011). In 1916, colonies of Gunnison's prairie dogs covered 24 million acres—currently they occupy less than 500,000 acres (Lupis et al. 2007). In Utah, Gunnison's prairie dogs inhabited 100,000 acres of habitat in 1961 that has declined to only 3,687 acres by 2002 (Lupis et al. 2007). The major threat to colonies of Gunnison's prairie dogs is their high susceptibility to outbreaks of plague. Specifically, sylvatic plague, a bacterial disease transferred by fleas and common among mammals, is a serious mortality threat to the species (Rocke 2011). The sylvatic plague is not native to North America, and, as a consequence, native mammals have no immunity and quickly succumb to the disease. Prairie dogs seem to be particularly susceptible to the disease and suffer very high mortality rates, up to 90% during outbreaks (Rocke 2011, Linzey et al. 2008).

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Forage	Available foods	shrubs	insects	forbs	grasses	Shalaway and Slobodchikoff (1988)
Habitat	Elevation	<4,500 ft or >11,000 ft	4,500–5,000 ft or 10,000–11,000 ft	5,000–6,000 ft or 8,500–10,000 ft	6,000–8,500 ft	Longhurst (1944), Pizzimenti and Hoffman (1973)
Disease	Sylvatic plague	exposed			no exposure	Linzey et al. (2008)
Habitat	Slope	>15%	5–15%	2–5%	0–2%	Fitzgerald and Lechleitner (1974)

References Cited

Fitzgerald, J.P., and R.P. Lechleitner. 1974. Observations on the biology of Gunnison's prairie dog in central Colorado. *American Midland Naturalist* 92:146–163.

Kotliar, N.B., B.W. Baker, A.D. Whicker, and G. Plumb. 1999. A critical review of assumptions about the prairie dog as a keystone species. *Environmental Management* 24: 177–192.

Linzey, A.V., Mabee, T., Cannings, S. & Hammerson, G. 2008. *Cynomys gunnisoni in* IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. www.iucnredlist.org

Longhurst, W. 1944. Observations on the ecology of the Gunnison prairie dog in Colorado. *Journal of Mammalogy* 25: 24–36.

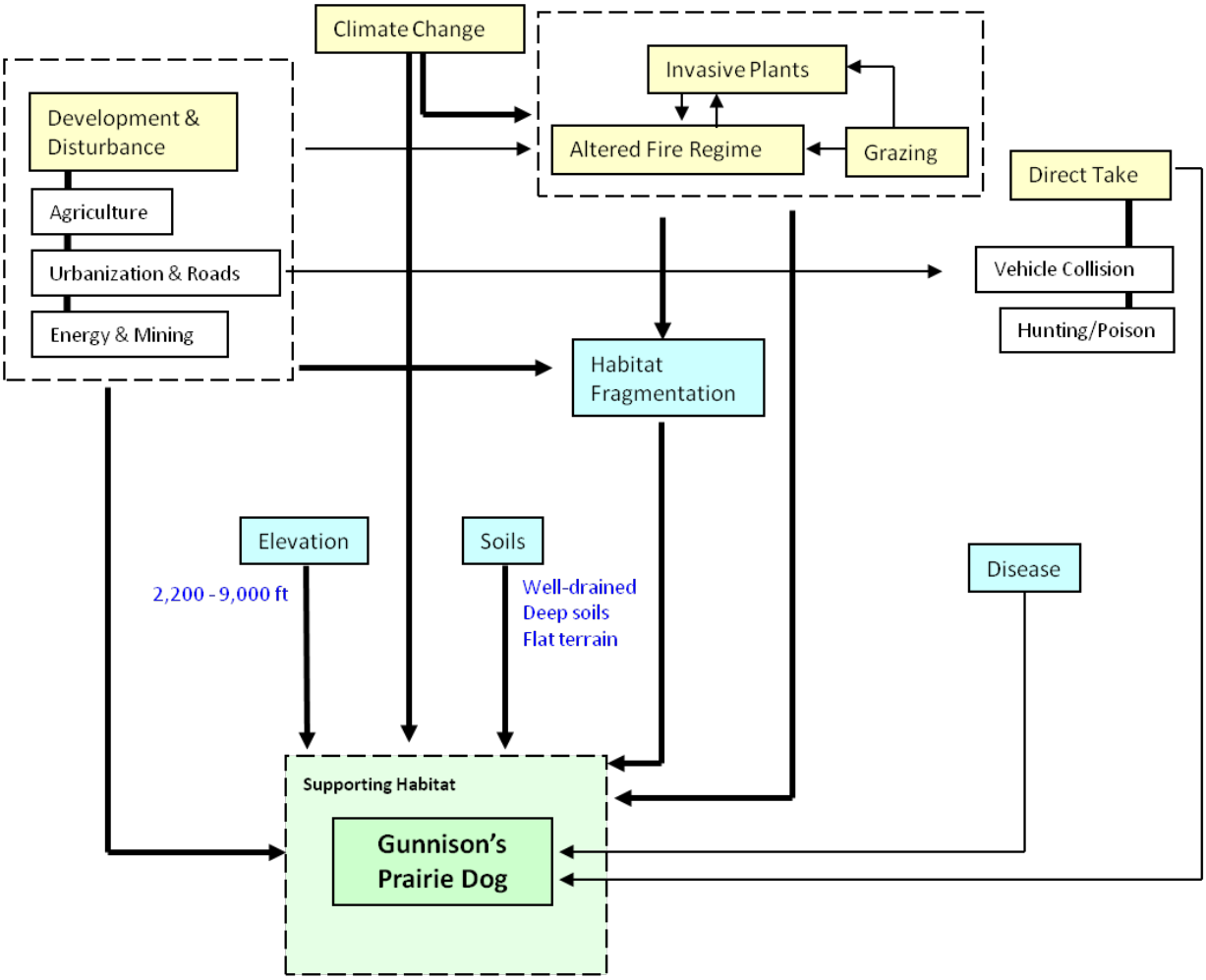
Lupis, S.G., K.D. Bunnell, T.A. Black, and T.A. Messmer. 2007. Utah Gunnison's prairie dog and white-tailed prairie dog conservation plan: Draft #5. Utah Division of Wildlife Resources, Salt Lake City, Utah.

Pizzimenti, J. J., and R.S. Hoffmann. 1973. *Cynomys gunnisoni*. *Mammalian Species* 25: 1–4.

Rocke, T.E. 2011. Protecting black-footed ferrets and prairie dogs against sylvatic plague. U.S. Geological Survey Fact Sheet 2008-3087, Revised 2011, 2p.

Shalaway, S., and C.N. Slobodchikoff. 1988. Seasonal changes in the diet of Gunnison's prairie dog. *Journal of Mammalogy* 69: 835–841.

Gunnison's Prairie Dog Conceptual Model



Thick arrows denote components with available spatially explicit data – NOT importance

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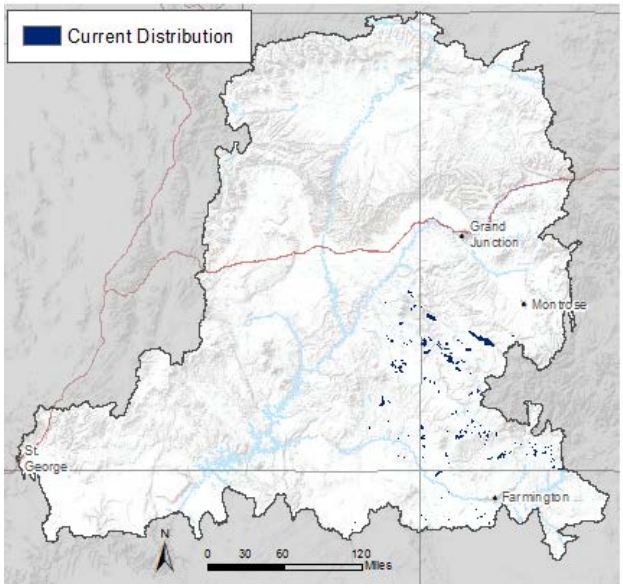
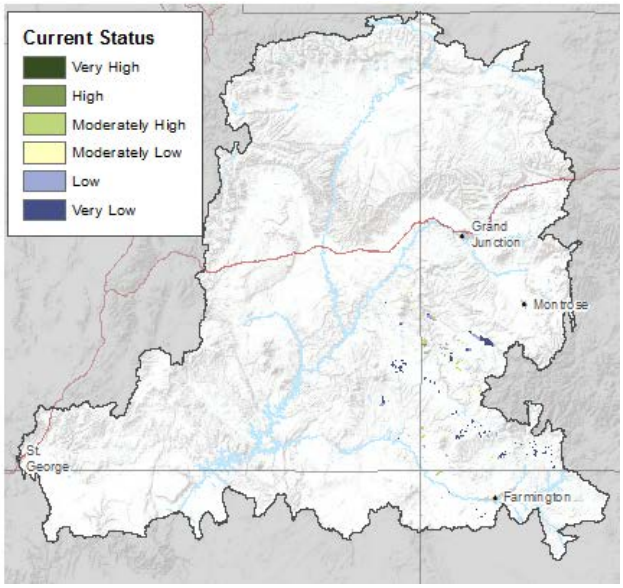
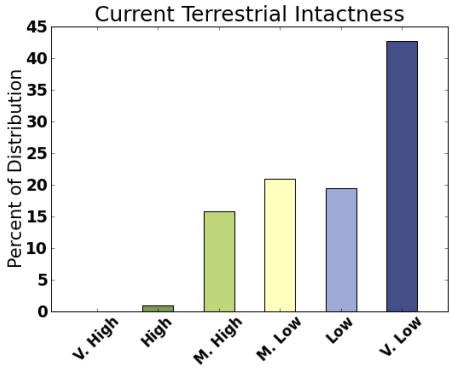




Data Sources:

Gunnison's Prairie Dog: Gunnison's Prairie Dog Colonies (2002) digitized from Seglund et al. (2005).

New Mexico Natural Heritage Program: Distributional analysis of Gunnison's Prairie Dog (*Cynomys gunnisoni*) on the Navajo Nation and Reservation of the Hopi Tribe (Johnson et al. 2010).

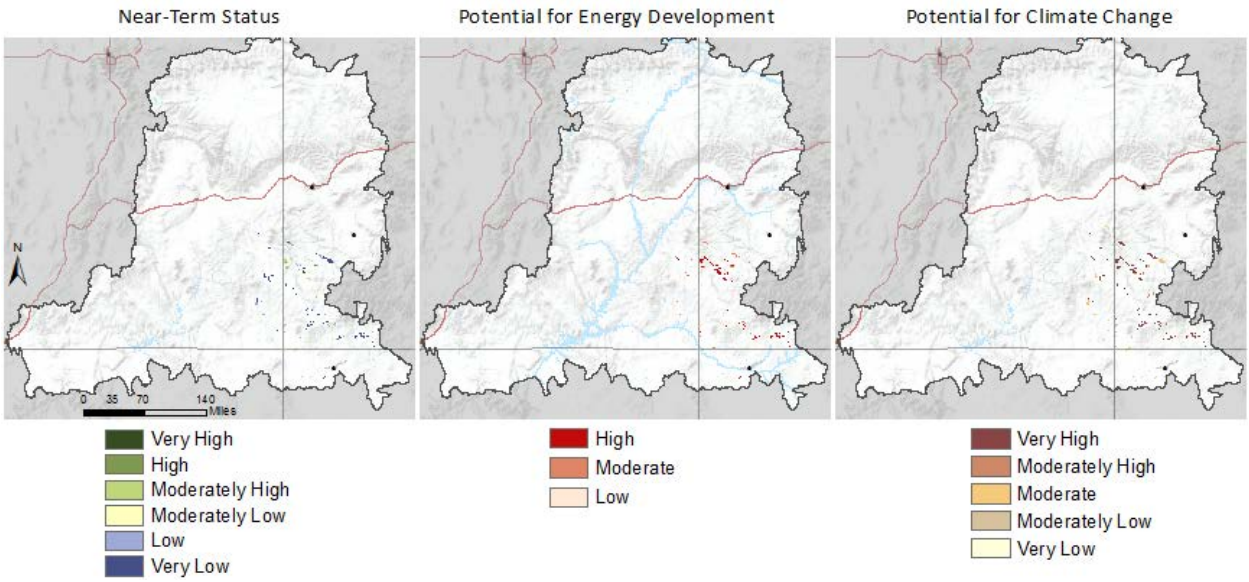


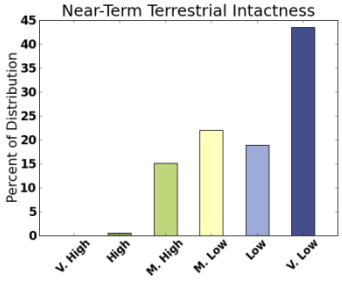
Johnson, K., T. Neville, D. Mikesic, and D. Talayumptewa. 2010. Distributional analysis of Gunnison's Prairie Dog (Cynomys gunnisoni) on the Navajo Nation and Reservation of the Hopi Tribe. Natural Heritage New Mexico Publ. No. 10-GTR-357. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM. 33 p.

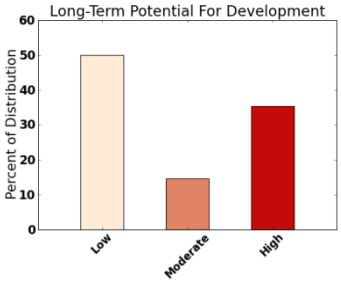
Seglund, A.E., A.E. Ernst, and D.M. O'Neill. 2005. Gunnison's prairie dog conservation assessment. Western Association of Fish and Wildlife Agencies. Laramie, Wyoming. Unpublished Report. 87 pp. (http://wildlife.state.co.us/SiteCollectionDocuments/DOW/WildlifeSpecies/Profiles/GPD_Assessment2005.pdf)

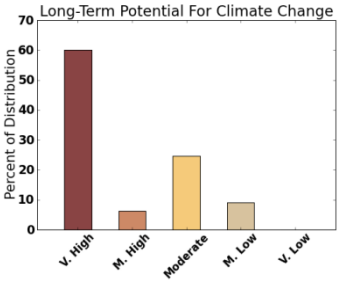
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Gunnison Prairie Dog Potential for Change

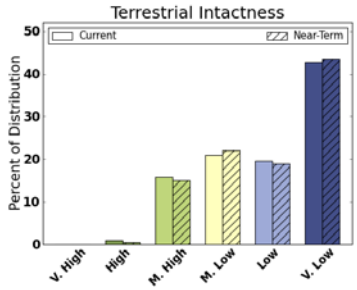








Current and Near-Term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Mountain Lion – *Puma concolor*

Mountain lions are habitat generalists that have adapted to a wide range of environmental conditions (Weaver et al. 1996). The three main components defining high quality mountain lion habitat are abundance of prey species (e.g., mule deer, elk, and bighorn sheep), steep, rugged terrain, and vegetative cover to allow for the successful stalking of prey (Hornocker 1970, Koehler and Hornocker 1991). Mountain lions can inhabit all elevations, but they prefer open mixed hardwood and coniferous forest vegetation zones below timberline. Terrain ruggedness is a better predictor than vegetation cover in some landscapes such as the Colorado Plateau, meaning that the species is fairly widespread throughout the ecoregion. However, availability of abundant prey (especially in winter) is the most important factor in supporting a strong lion population. Mountain lions are highly territorial, solitary predators that display a wide variability in home range sizes (males 25 to more than 500 sq mi and females 8 to more than 400 sq mi). Territory size, which often shifts seasonally, is determined by a number of ecological and allometric factors including abundance of prey—higher prey densities often result in smaller home ranges (Grigione et al. 2002). Hemker et al. (1984) reported some of the largest known home range sizes for mountain lions in southern Utah with males occupying up to 513 sq mi and females up to 426 sq mi. A typical mountain lion population consists of resident males and females in occupied territories, transient males and females moving across the landscape looking to establish their own territories, and dependent kittens of resident females (Lynch 1989).

At the ecoregion level, mountain lions require fairly large home ranges with ample food and cover (provided by vegetation cover and/or rugged terrain). They also require the ability to disperse widely in search of prey and new territories as this is important component of their life history. Mountain lions can tolerate significant human disturbance (Weaver et al. 1996); however, they do avoid developed and semi-developed areas unless dispersing to new territories, which is normally conducted at night when under more stressful circumstances (Beier 1995). The most important threat to mountain lions in the ecoregion is overall habitat degradation due to residential development, recreational development, and road building. For example, Van Dyke et al. (1986) reported road densities > 0.6 km/sq km as poor for mountain lion due to avoidance behavior and direct mortality through increased conflict with humans.

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Prey	Ungulate density	Low	Medium	High	Very high	Julander and Jeffrey (1964)
Habitat degradation	Road density	.6 km/sq km	0.4	0.2	0	Van Dyke et al. (1986)
Habitat	Cover & terrain	Very dense or open cover	-	-	Rugged terrain with mixed cover	Riley (1998)
Habitat	Human	Highly	Moderately	Minimally	No	Van Dyke et

degradation	development	developed	developed	developed	development	al. (1986)

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Julander, O. and D.E. Jeffrey. 1964. Deer, elk, and cattle relations on summer range in Utah. Transactions of the North American Wildlands and Natural resources Conference 29: 404–413.

Koehler, G.M., and M.G. Hornocker. 1991. Seasonal resource use among mountain lions, bobcats, and coyotes. *Journal of Mammalogy* 72: 391–396.

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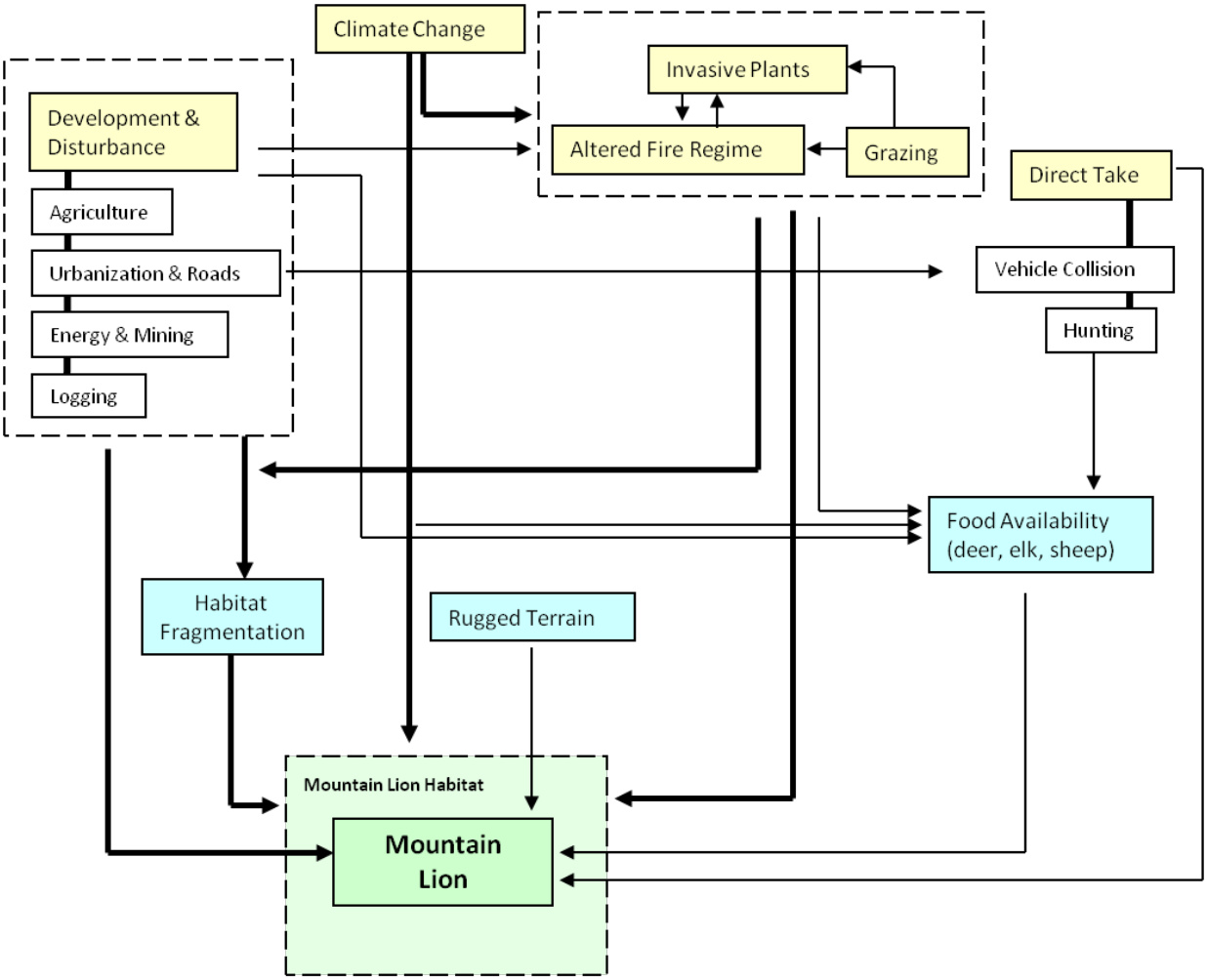
Mountain Lion Conceptual Model



Thick arrows denote components with available spatially explicit data – NOT importance

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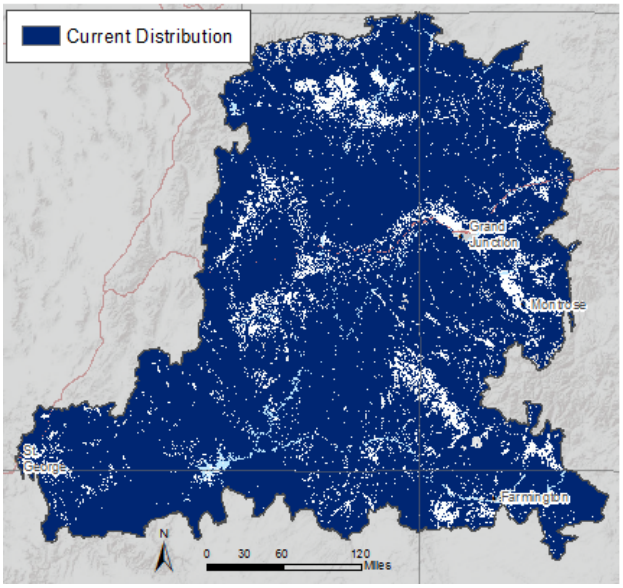
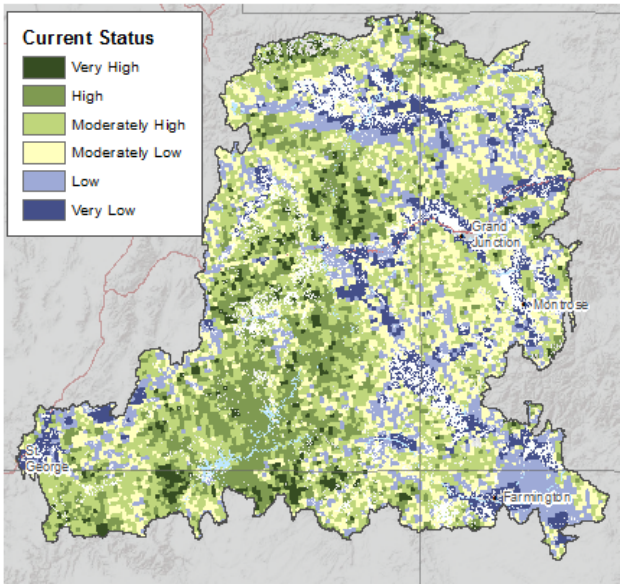
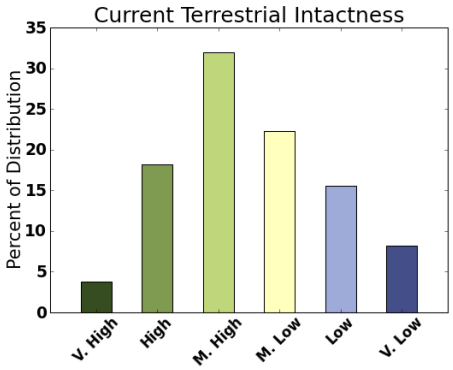




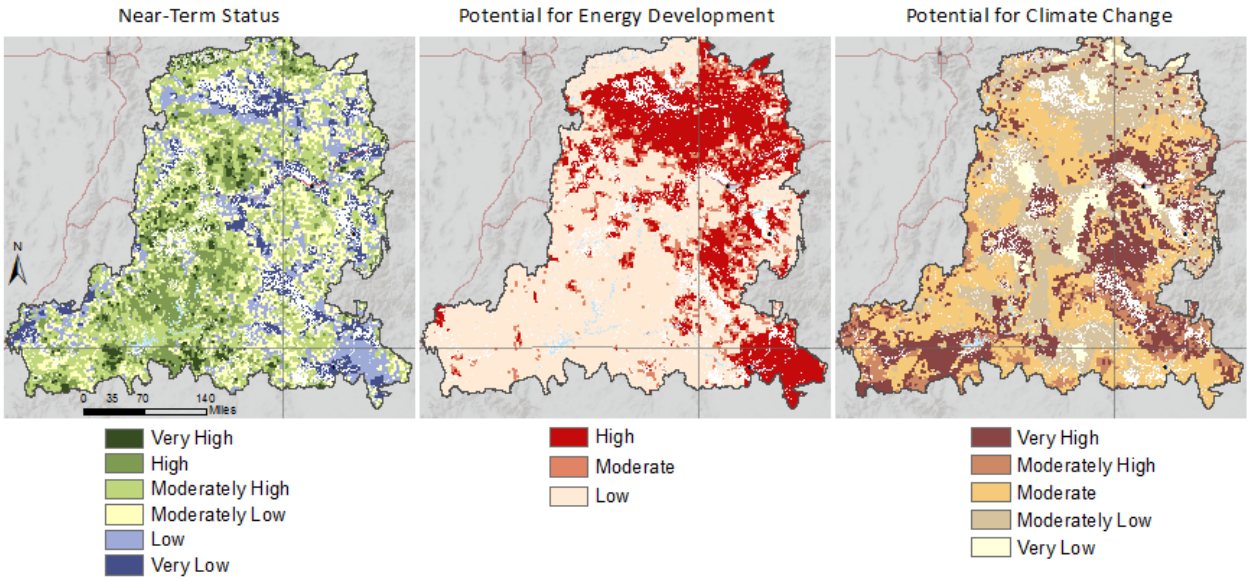
Data Source:

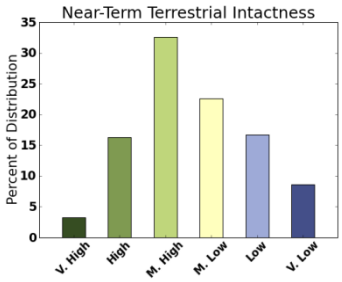
SW ReGAP (Southwest Regional GAP Analysis Project).

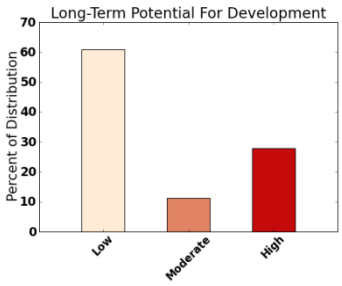


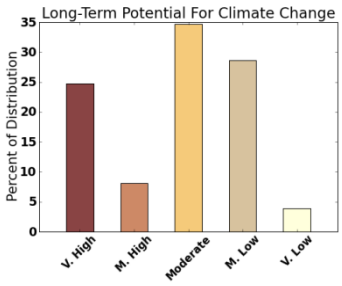
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Mountain Lion Potential for Change

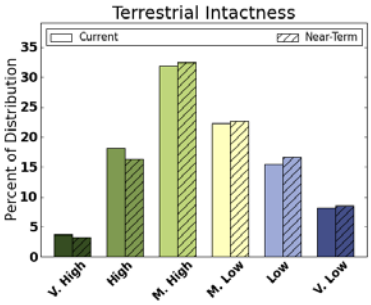








Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Mule Deer – *Odocoileus hemionus*

Mule deer have the ability to occupy a diverse set of habitats but are most commonly associated with sagebrush communities (Mule Deer Working Group 2003, Theodore Roosevelt Conservation Partnership 2011). Shrub communities are important to mule deer for food and shelter, and the connectivity of such seasonal habitats is critical to the survival of mule deer populations (Theodore Roosevelt Conservation Partnership 2011). Like most deer, mule deer are browsers that rely on a diverse range of plants for their nutrition. In late spring to early fall, mule deer eat mostly forbs and grasses, while in late fall they eat the leaves and stems of brush species, and in winter to early spring they must survive on just twigs and branches (Theodore Roosevelt Conservation Partnership 2011). So, while mule deer forage on a wide variety of plant species, they also have very specific seasonal foraging requirements, and variety and high nutritional content across seasons is imperative to the survival of populations (Watkins et al. 2007). Mountain lions are the top predators in the ecoregion.

Despite their adaptability, mule deer populations have been decreasing in numbers since the latter third of the 20th century. In Utah, the 2007 post-hunting season population was estimated to be 302,000 deer, well below the long-term management objective of 426,000 individuals (Utah Division of Wildlife Resources, Statewide Management Plan for Mule Deer 2008). There are a myriad of stressors on mule deer, but the most significant threats involve habitat fragmentation and conversion (Theodore Roosevelt Conservation Partnership 2011). The vegetative species composition has been modified extensively with the invasion of non-native plants such as cheatgrass (Watkins et al. 2007). Cheatgrass out-competes most native plant species in a moisture-limited environment and changes the site-specific fire ecology, resulting in a loss of important shrub communities (Watkins et al. 2007). Plant species composition has also changed due to livestock grazing, successional changes caused by fire suppression, and the disturbance and conversion of habitat (Watkins *et* al. 2007). In addition to the change in plant species composition, active fire suppression has changed the vegetation structure to result in the accumulation of unnaturally high fuel loads that can lead to more extensive fires (Watkins et al. 2007, Mule Deer Working Group 2011). Other factors that contribute to the decline of mule deer populations include habitat fragmentation due to gas, mineral, and oil exploration and increased competition with elk when habitat is poor or limited (Mule Deer Working Group 2011).

Oil and gas development is the main change agent presently affecting mule deer populations in the Colorado Plateau. Energy development results in direct loss of habitat, disturbance and displacement from foraging areas and migration routes, resulting loss of connectivity between seasonal habitats, contamination of water supplies, spread of invasive non-native vegetation, and stress-related energy expenditures, particularly in the winter months (Tessman et al. 2004). Watkins et al. (2007) have developed management guidelines for mitigating the impacts of energy development on mule deer populations.

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Habitat degradation	Distance from oil wells	<2.7 km	-	-	>3.7 km	Sawyer et al. (2006)
Habitat degradation	Well density	>16 wells or >80 acres disturbed per mile^2 section	5–16 wells and 20–80 acres disturbed per mile^2 section	1–4 wells and ≤20 acres disturbed per mile^2 section	No wells	Tessman et al. (2004)
Habitat degradation	Distance from roads	>200m	-	-	>500 m	
Habitat	Loss, fragmentation, drought, fire, low quality					http://www.ndow.org/wild/animals/facts/mule_deer.shtm
Habitat	Vegetation/food preference as associated with fire suppression	Large, hot fires	-	-	Small, frequent fires (early successional plants)	Mule Deer Working Group - Western Assoc. of Fish & Wildlife agencies, (2003)
Habitat	Variety of vegetation	Homogen-eous	-	-	Mosaic of early successional habitat (food) & tree-dominated habitats (cover)	Mule Deer Working Group, Western Assoc. of Fish & Wildlife agencies (2003)

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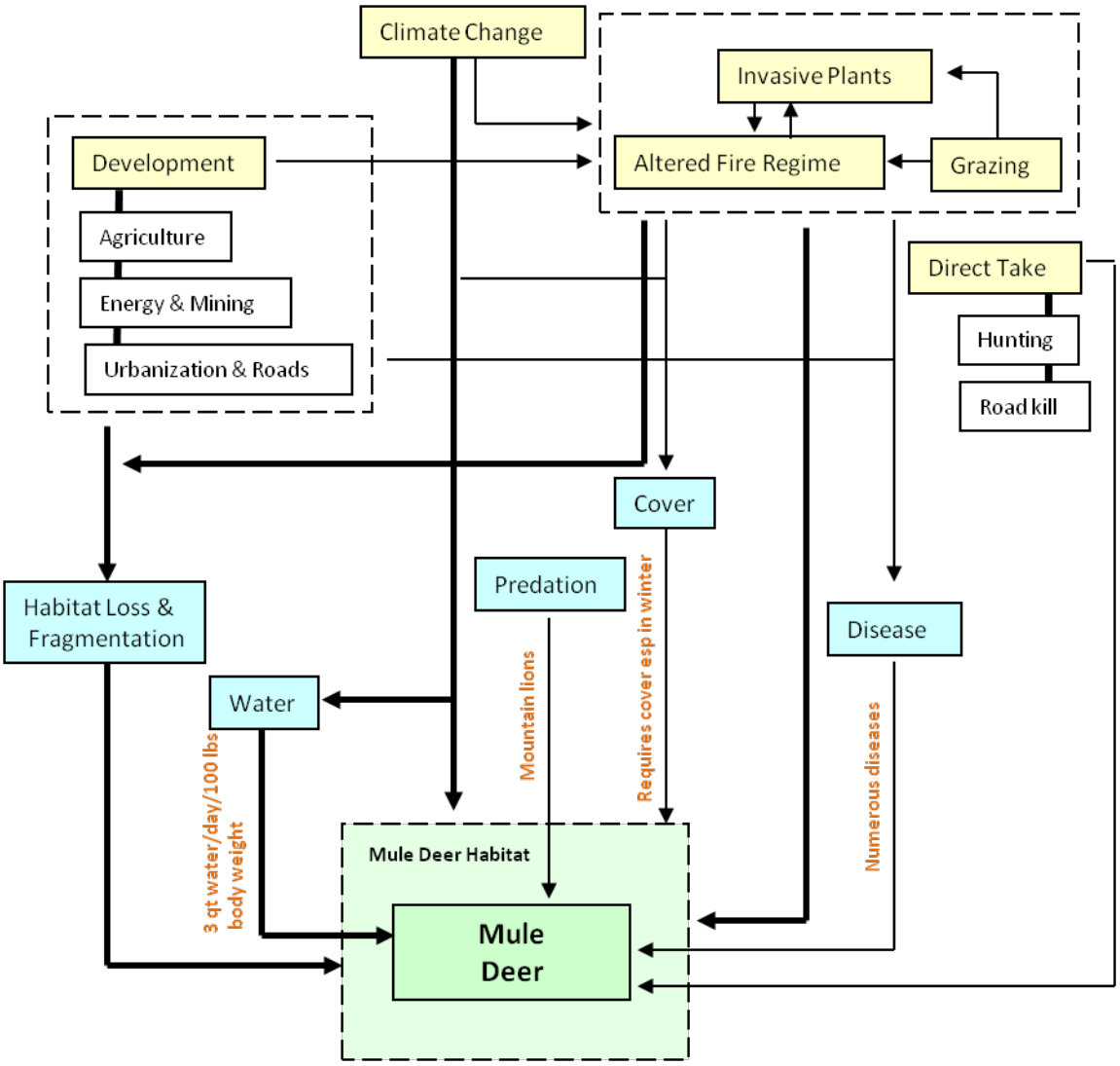
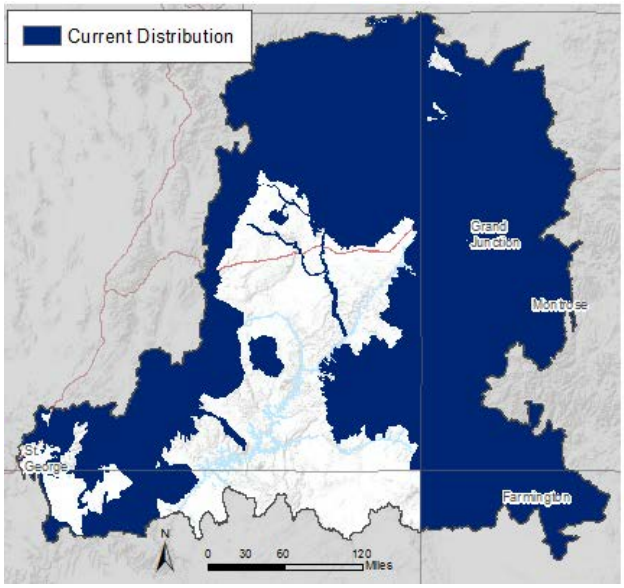
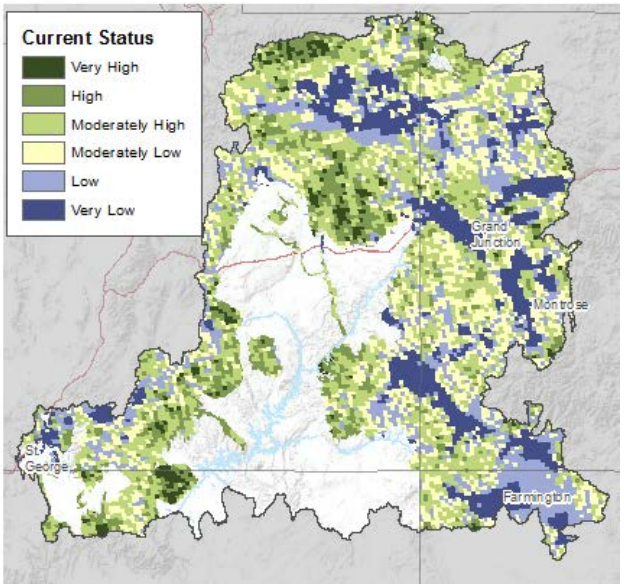
Mule Deer Conceptual Model



Thick arrows denote components with available spatially explicit data – NOT importance

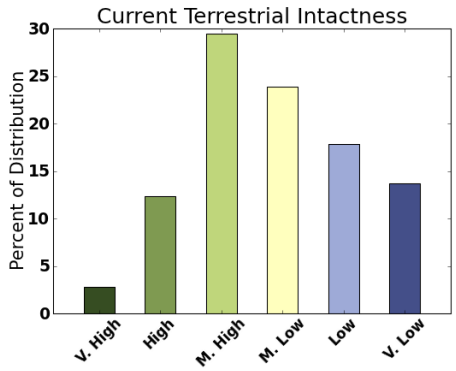
MQ D1. What are the current distribution and status of mule deer (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?





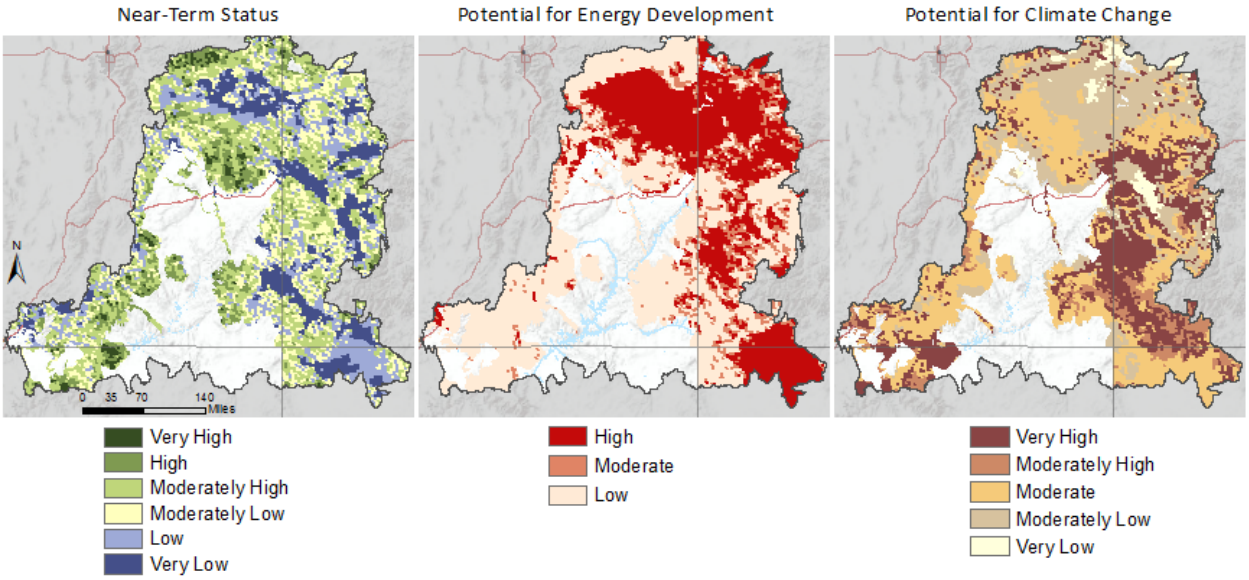
Data Sources:

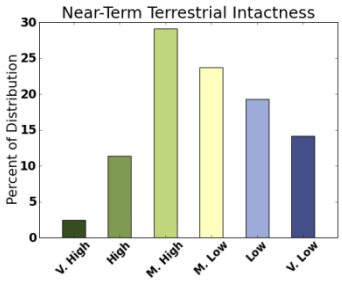
Colorado Division of Wildlife, Arizona Department of Fish & Game, Utah Division of Wildlife Resources, and "Mule Deer Habitat of North America"
Summer Habitat: Arizona Department of Fish & Game, Utah Division of Wildlife Resources, and "Mule Deer Habitat of North America"
Winter Habitat: Arizona Department of Fish & Game, Utah Division of Wildlife Resources, and "Mule Deer Habitat of North America"

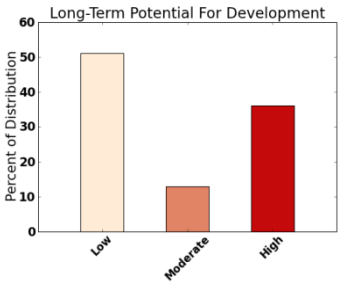


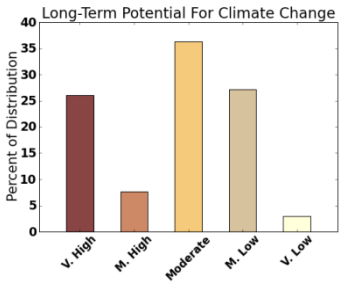
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Mule Deer Potential for Change

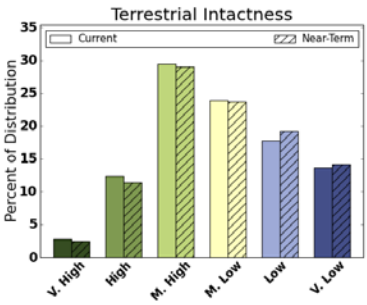






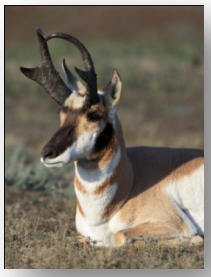


Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Pronghorn Antelope – *Antilocapra americana*



Pronghorns have specific habitat requirements necessary for the species to persist and thrive. Yoakum et al. (1996) and Jaeger and Fahrig (2004) defined the optimal habitat parameters for the North American pronghorn, the most critical of which are elevation, terrain, connectivity of habitat, distance from water, and vegetation. Peak concentrations of herds are located between 1200 and 1850 meters above sea level in open shrubland (Yoakum et al. 1996). In addition, for predator detection and escape, pronghorns require flat, open habitat, with rolling hills and slopes less than 30% to detect approaching predators (Yoakum et al. 1996). With speeds reaching 60 mph, pronghorns can easily outrun any predator once detected.

Some pronghorn populations migrate long distances between summer and winter feeding grounds. Fences form an especially significant barrier to pronghorn movement, as the species is averse to jumping fences and will typically choose to go under a fence (Yoakum et al. 1996, Jaeger and Fahrig 2004). Other barriers along the pronghorn migration include roads, railroads, urban sprawl, and gas fields (Sawyer et al. 2006). Additionally, pronghorns require ready access to water and they are usually found within 1.5-–6.5 km of a water source (Yoakum *et al*, 1996). Pronghorn also need a variety of vegetation for foraging; they select, in order of preference, forbs, shrubs, and grasses (Yoakum et al. 1996). Accessibility to a combination of both grasses and shrubs has been shown to be essential to fawn survival rate (Ellis, 1970). Throughout North America, pronghorn antelope populations have declined by as much as 95% from historic levels. In Utah, the current statewide population estimate is 12,000–14,000 (Utah Division of Wildlife Resources, Utah Pronghorn Statewide Management Plan, 2009). Oil and gas development in the Colorado Plateau is a major change agent affecting the future sustainability of pronghorn, particularly related to area needs for foraging and maintenance of seasonal migration routes. Heavy fragmentation of pronghorn habitat and migration blockages and bottlenecks from oil and gas development have been documented in western Wyoming (Sawyer et al. 2002, Berger 2003).

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Habitat	Distance to water	>6.5 km	4.5-6.5 km	4.5-1.5 km	<1.5 km	Yoakum et al. (1996)
Habitat	Fragmentation	<242 ha			large patch	Berger et al. 2006
Movement	Barriers	abundant	common	few	none	Jaeger and Fahrig (2004)
Habitat	Diet	woody vegetation	single food	somewhat mixed food	well-mixed food - forbs, grass, and shrubs	Yoakum et al. (1996), Martinka (1967)

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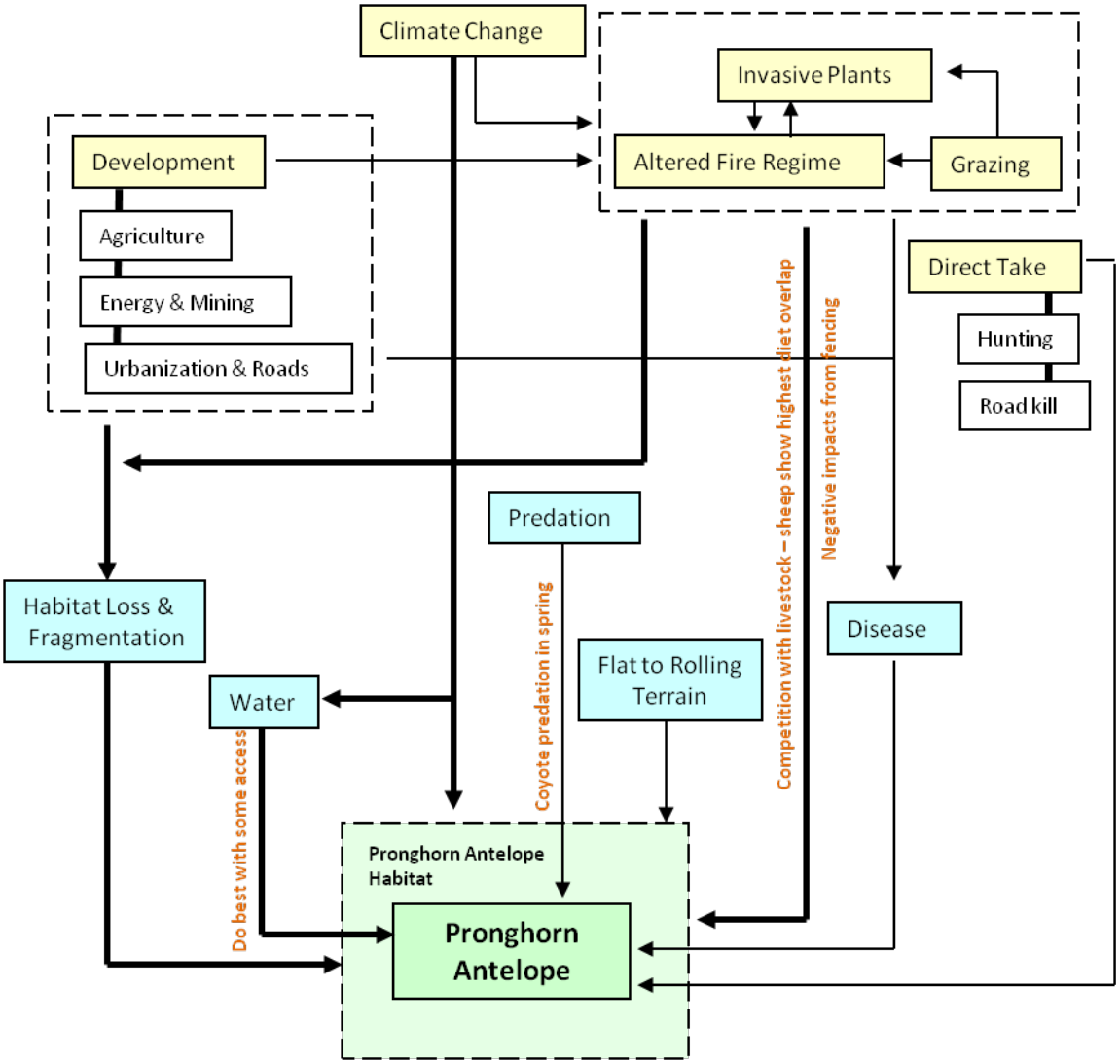
Sawyer, H. R.M. Nielson, F. Lindzey and L.L. McDonald. 2006. Winter habitat selection of mule deer before and during development of a natural gas field. *Journal of Wildlife Management* 70(2):396–403.

Utah division of wildlife resources, statewide management plan for pronghorn. 2009. http://wildlife.utah.gov/hunting/biggame/pdf/Statewide_prong_mgmt_2009.pdf

Yoakum, J.D., B.W. O'Gara, and V.W. Howard. 1996. Pronghorn on western rangelands. Pages 211–216 *in* Krausman, P.R. (ed.), Rangeland Wildlife, Society of Range Management, Denver, Colorado.

Pronghorn Antelope Conceptual Model



Thick arrows denote components with available spatially explicit data – NOT importance

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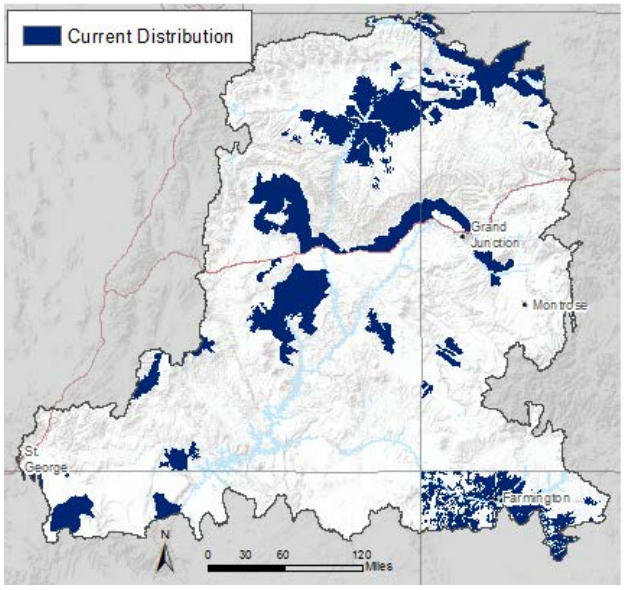
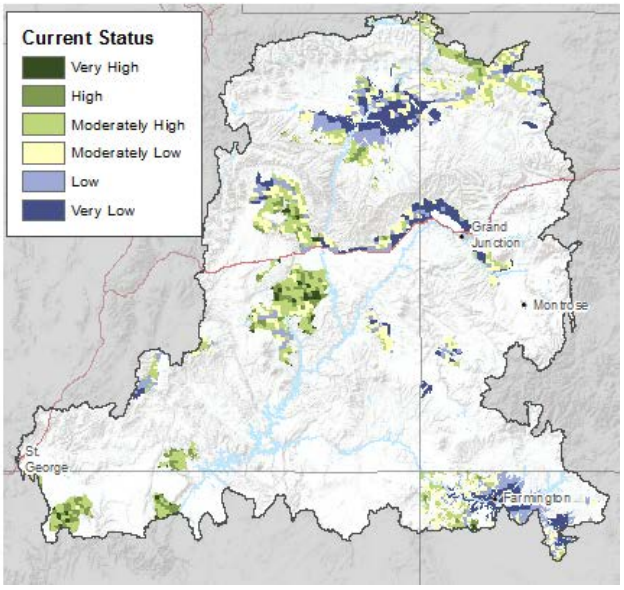
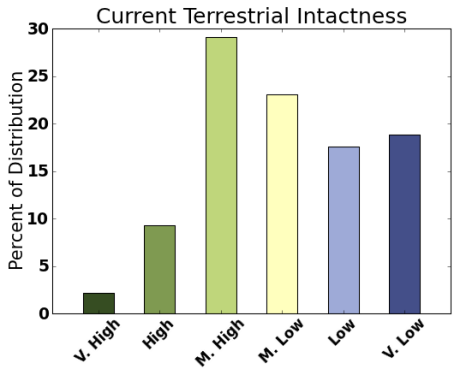




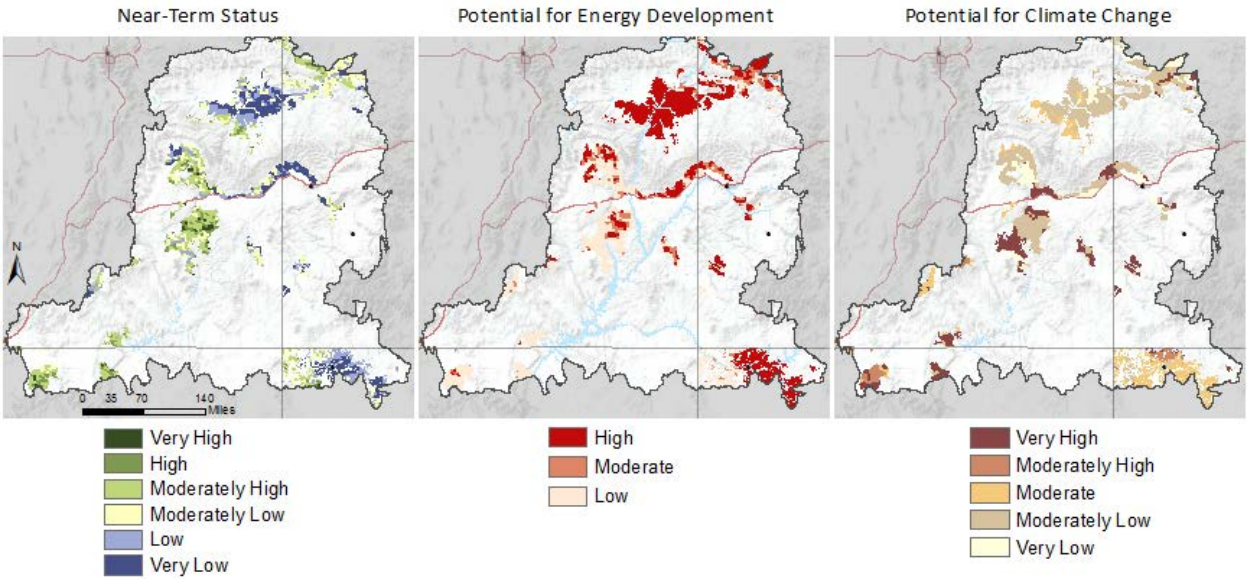
Data Source:

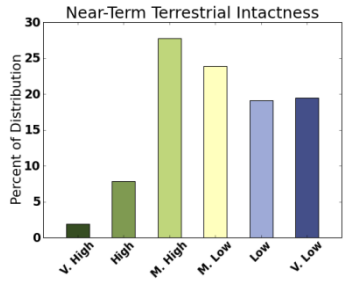
Colorado Division of Wildlife, Arizona Department of Fish & Game, Utah Division of Wildlife Resources, and NM GAP
Summer: Colorado Division of Wildlife, Arizona Department of Fish & Game, Utah Division of Wildlife Resources
Winter: Colorado Division of Wildlife, Arizona Department of Fish & Game, Utah Division of Wildlife Resources

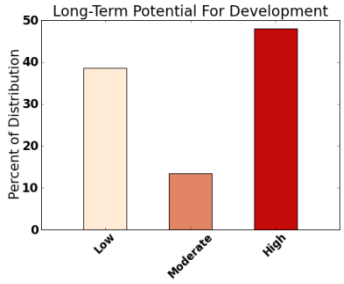


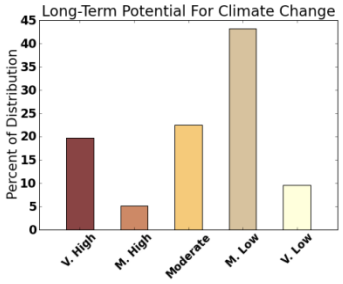
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Pronghorn Antelope Potential for Change

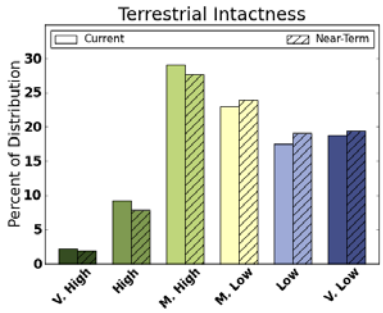








Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

White-tailed Prairie Dog – *Cynomys leucurus*

White-tailed prairie dogs thrive in dry, high elevation prairies (1700–3000 meters, Center for Native Ecosystems 2006, Goldbroch and Frost, 2008). Of the five prairie dog species found in the U.S., the white-tailed prairie dogs are the least social (Center for Native Ecosystems 2006, Goldbroch and Frost 2008). They have fairly specific habitat and diet preferences. Sage is an especially critical form of cover and an important component of their diet (Tileston and Lechleitner, 1966). In the springtime, after emerging from dormancy, they feed on sagebrush and saltbush while other food sources are still unavailable. As the season progresses, the species switches to foraging on forbs and grasses, such as western wheatgrass (Tileston and Lechleitner, 1966). White-tailed prairie dogs will also eat the mature seed heads of grasses, forbs, and sedges when available (Tileston and Lechleitner, 1966; Goldbroch and Frost, 2008).

Despite the severe decline of white-tailed prairie dog populations in recent times, they maintain a key ecological role in grassland and sagebrush ecosystems and they are considered a keystone species (Center for Native Ecosystems, 2006; Goldbroch and Frost, 2008). The species is prey for many grassland predators, including American badgers, golden eagles, foxes, and American minks. Additionally, the highly endangered black-footed ferret relies almost exclusively on prairie dogs for prey and shelter (Center for Native Ecosystems, 2006; Goldbroch and Frost, 2008). In addition to providing food and burrows for many species, white-tailed prairie dogs aerate and mix the soil through their burrowing, which provides better grazing for herbivores, including the American pronghorn (Goldbroch and Frost, 2008). Among the top threats contributing to the range-wide decline of white-tailed prairie dog populations are poisoning campaigns, the conversion of natural grasslands to agriculture and urban development, and the spread of sylvatic plague. The plague appears to be the single most critical factor influencing the abundance and distribution of the species; it is capable of inflicting 85–100 percent mortality in affected colonies (Pauli et al. 2006). The plague not only reduces colony size and prairie dog abundance, but it reduces the viability of entire colony complexes by increasing interannual variation in population size and the distances between colonies, which affects recruitment (Pauli et al., 2006).

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Habitat	Elevation	<4,160 ft or >9,630 ft	8,525–9,630 ft	7,640–8,525 ft	4,160–7,640 ft	Utah Natural Heritage Program
Habitat	Slope	>10 degrees	5–10 degrees	0–5 degrees	0 degrees	Collins and Lichvar (1986)
Disease	Sylvatic plague	exposed			no exposure	Center for Native Ecosystems
Habitat	Oil drilling and energy development	present			not present	Center for Native Ecosystems
Habitat	Max. vegetation height	>92 cm	62–92 cm	31–62 cm	<31 cm	Collins and Lichvar (1986)

References Cited

Center for Native Ecosystems, 2006; http://nativeecosystems.org/species/white-tailed-prairie-dog

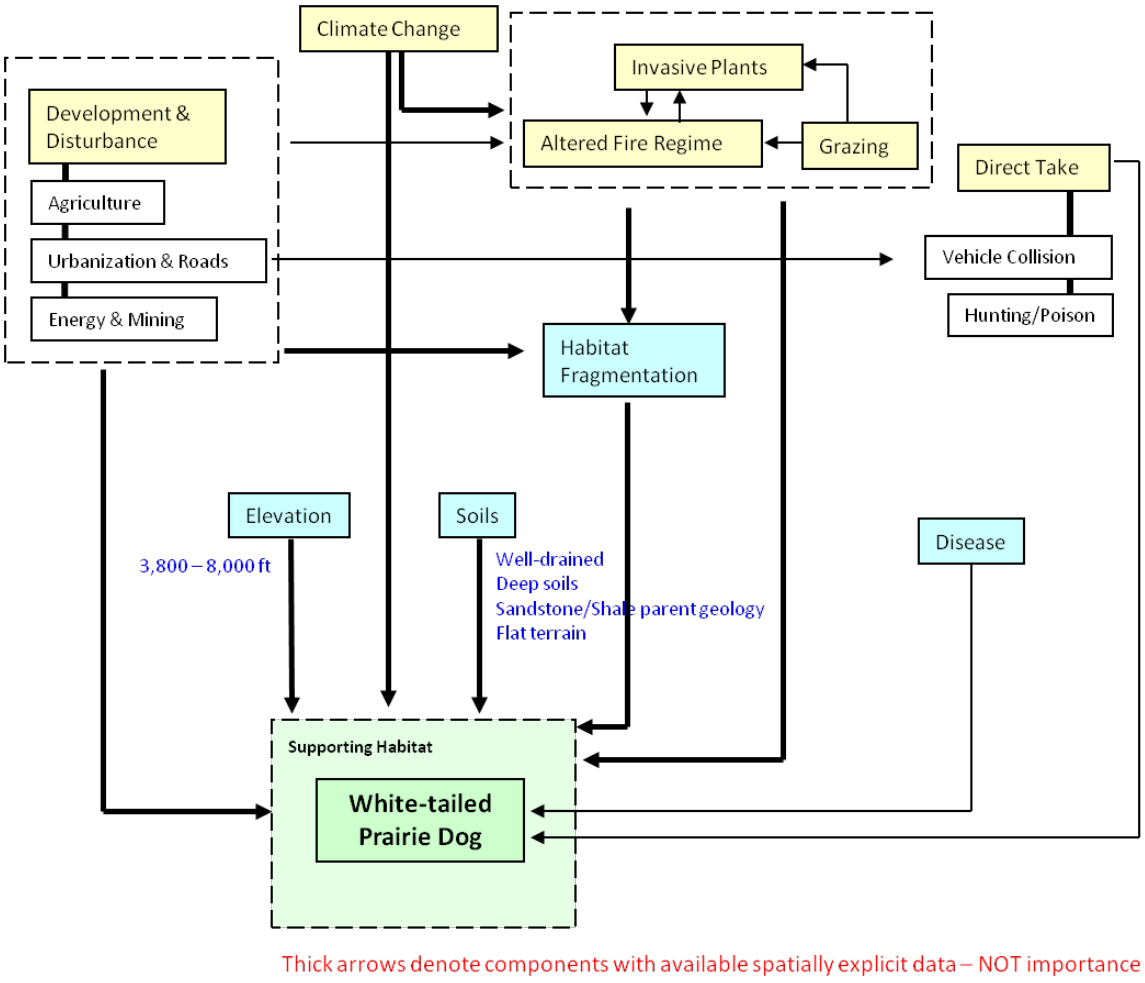
Collins, E. I., and R. W. Lichvar. 1986. Vegetation inventory of current and historic black-footed ferret habitat in Wyoming. *Great Basin Naturalist Memoirs* 8: 85–98.

Goldbroch, S. and S. Frost. 2008. "Cynomys leucurus" (On-line), Animal Diversity Web. Accessed January 14, 2012 http://animaldiversity.ummz.umich.edu/site/accounts/information/Cynomys_leucurus.html .

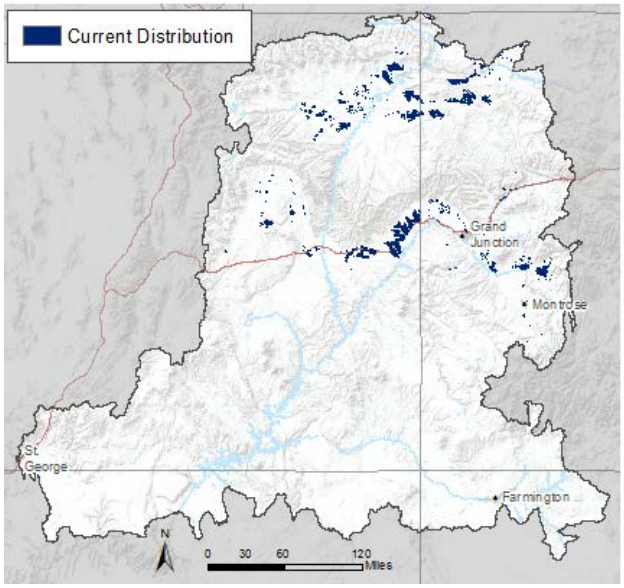
Pauli, J.N., R.M. Stephens, and S.H. Anderson. (2006, November 13). White-tailed Prairie Dog (*Cynomys leucurus*): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/whitetailedprairiedog.pdf

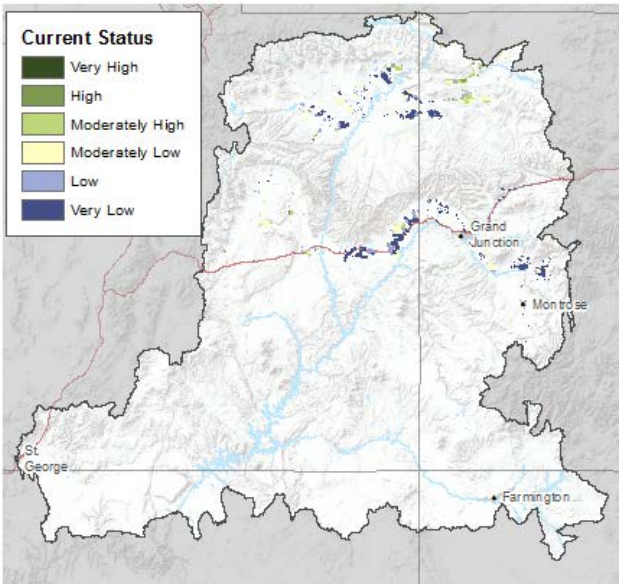
Tileston, J., R. Lechleitner. 1966. Some Comparisons of the black-tailed and white-tailed Prairie Dogs. *American Midland Naturalist* 75(2): 292–316.

White-Tailed Prairie Dog Conceptual Model



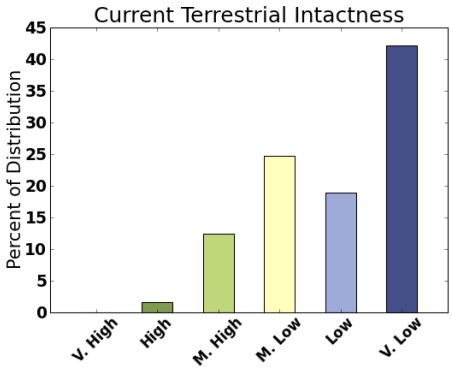
MQ D1. What are the current distribution and status of white-tailed prairie dog (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?





Data Source:

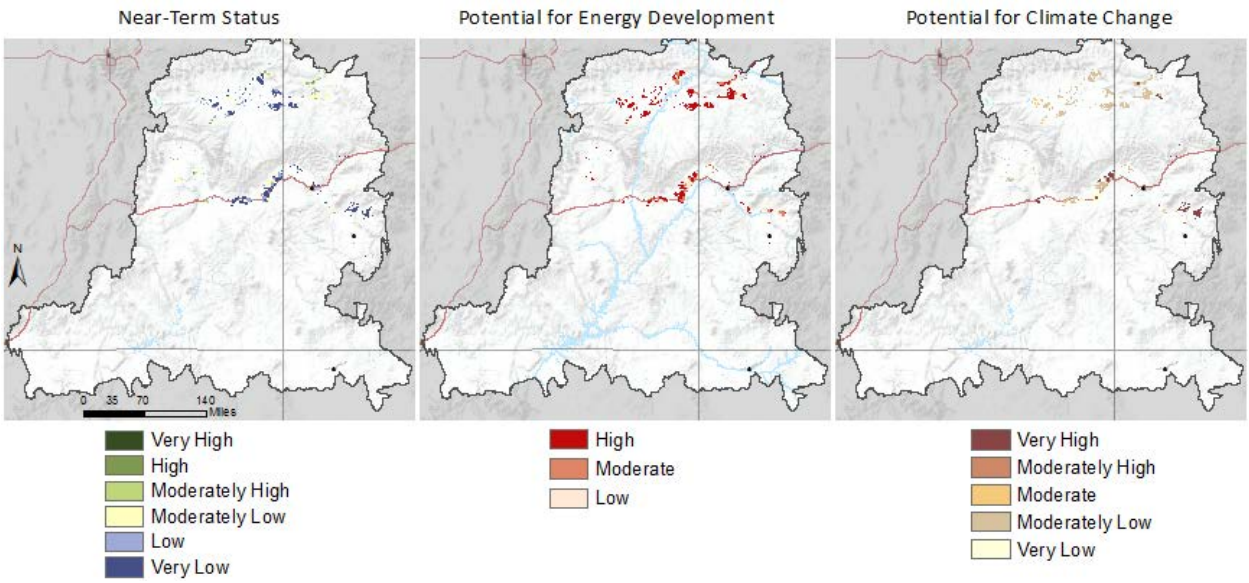
Digitized from Seglund et al. (2004)

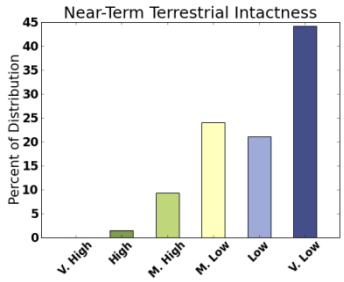


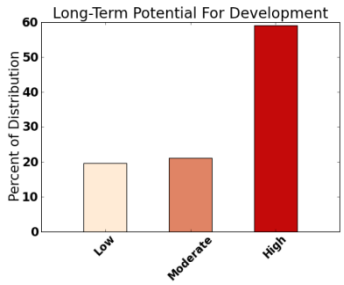
Seglund, A.E., A.E. Ernst, M. Grenier, B. Luce, A. Puchniak and P. Schnurr. 2004. White-tailed Prairie Dog Conservation Assessment.

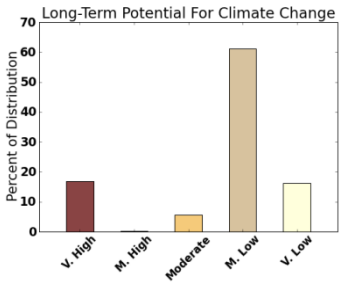
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

White-Tailed Prairie Dog Potential for Change

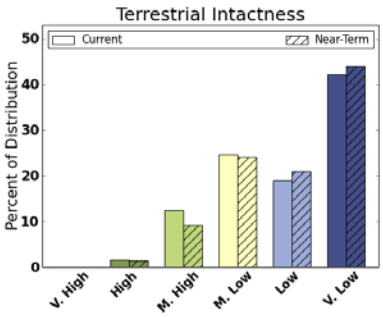






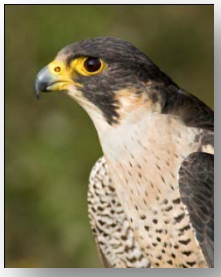


Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

American Peregrine Falcon – *Falco peregrinus*



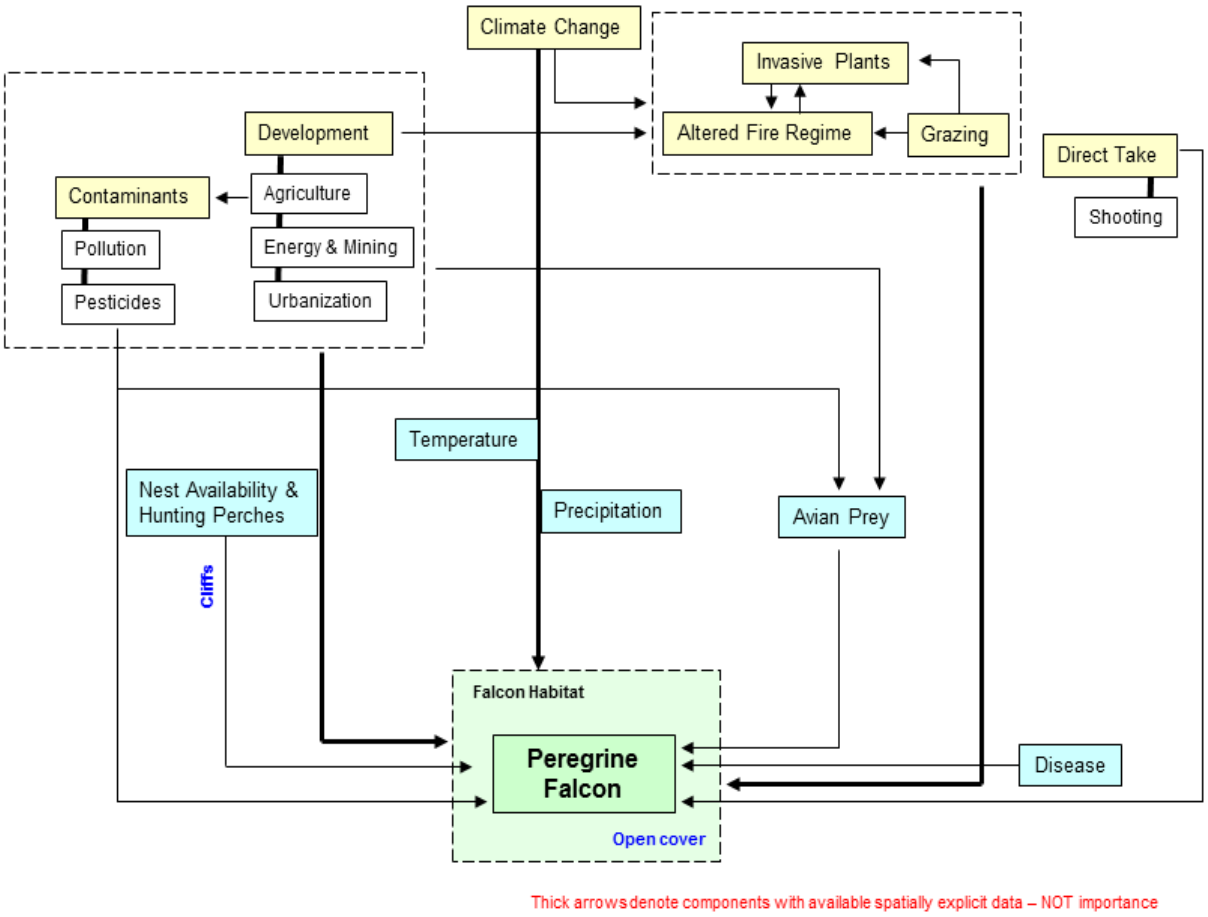
Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Breeding Habitats	Distance between nest sites			minimum distance = 1 km	3.3–5.6 km	Univ. of Michigan, Museum of Zoology; White et al. 2002
Breeding Habitats	Cliff height	<12m		200 m	200+ m	GBBO; Cornell Lab of Ornithology; White et al. 2002

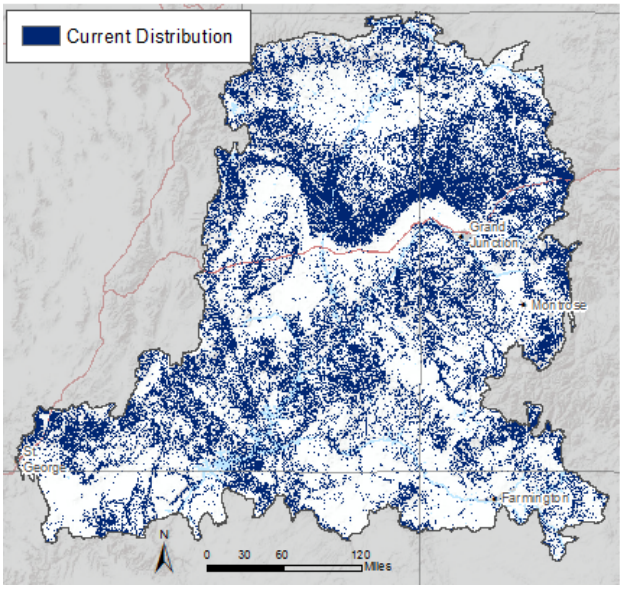
Cornell Lab of Ornithology http://www.allaboutbirds.org/guide/Peregrine_Falcon/lifehistory

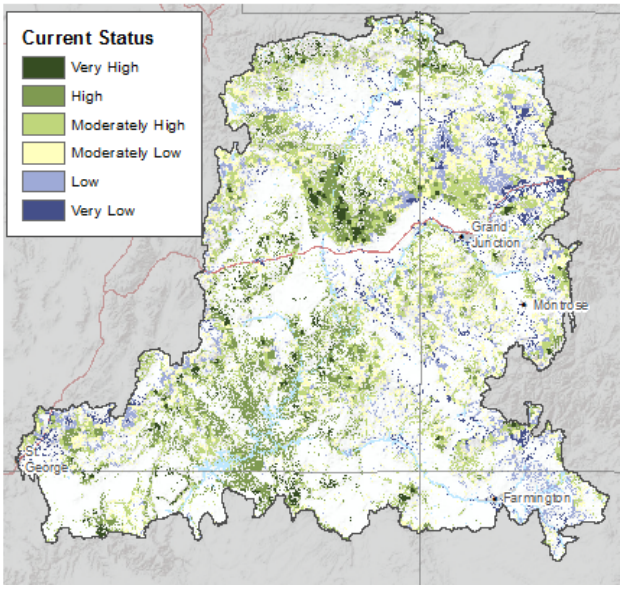
White, C., N. Clum, T. Cade, W. Hunt. 2002. Peregrine Falcon (Falco peregrinus). The Birds of North America, 660. http://bna.birds.cornell.edu/BNA/account/Peregrine_Falcon

Peregrine Falcon Conceptual Model



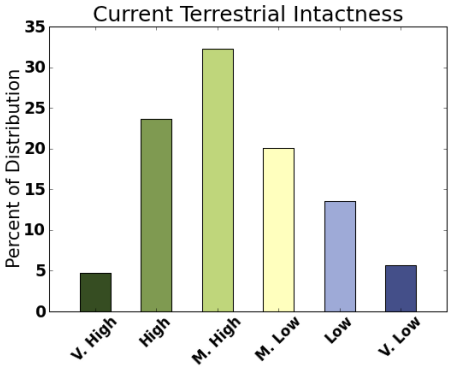
MQ D1. What are the current distribution and status of American peregrine falcon (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?





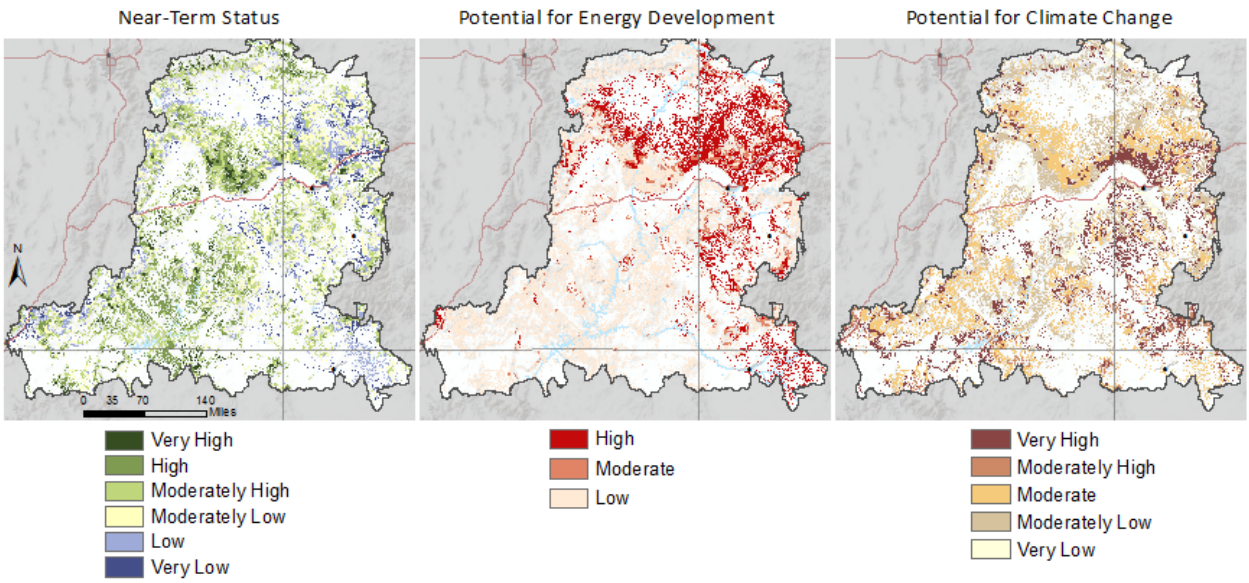
Data Source:

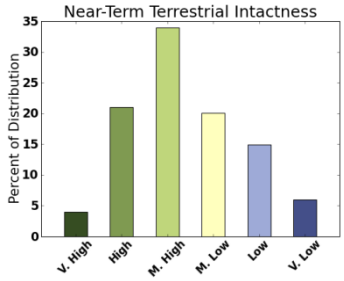
SW ReGAP (Southwest Regional GAP Analysis Project), limited to slopes >10 degrees

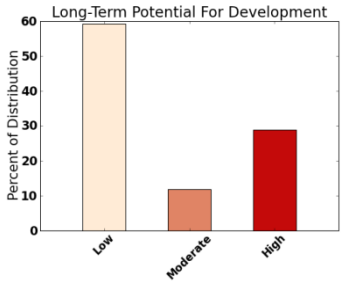


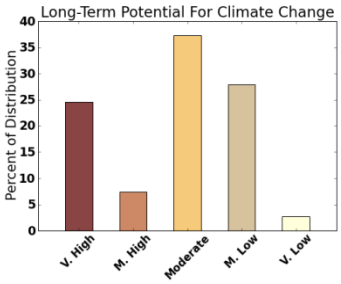
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

American Peregrine Falcon Potential for Change

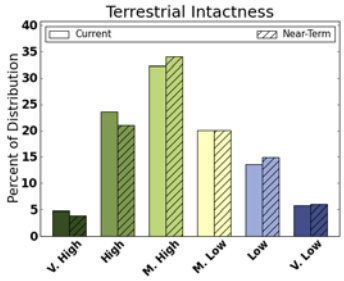






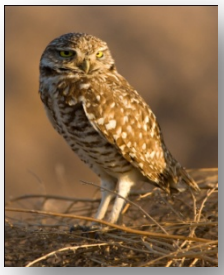


Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Burrowing Owl – *Athene cunicularia*

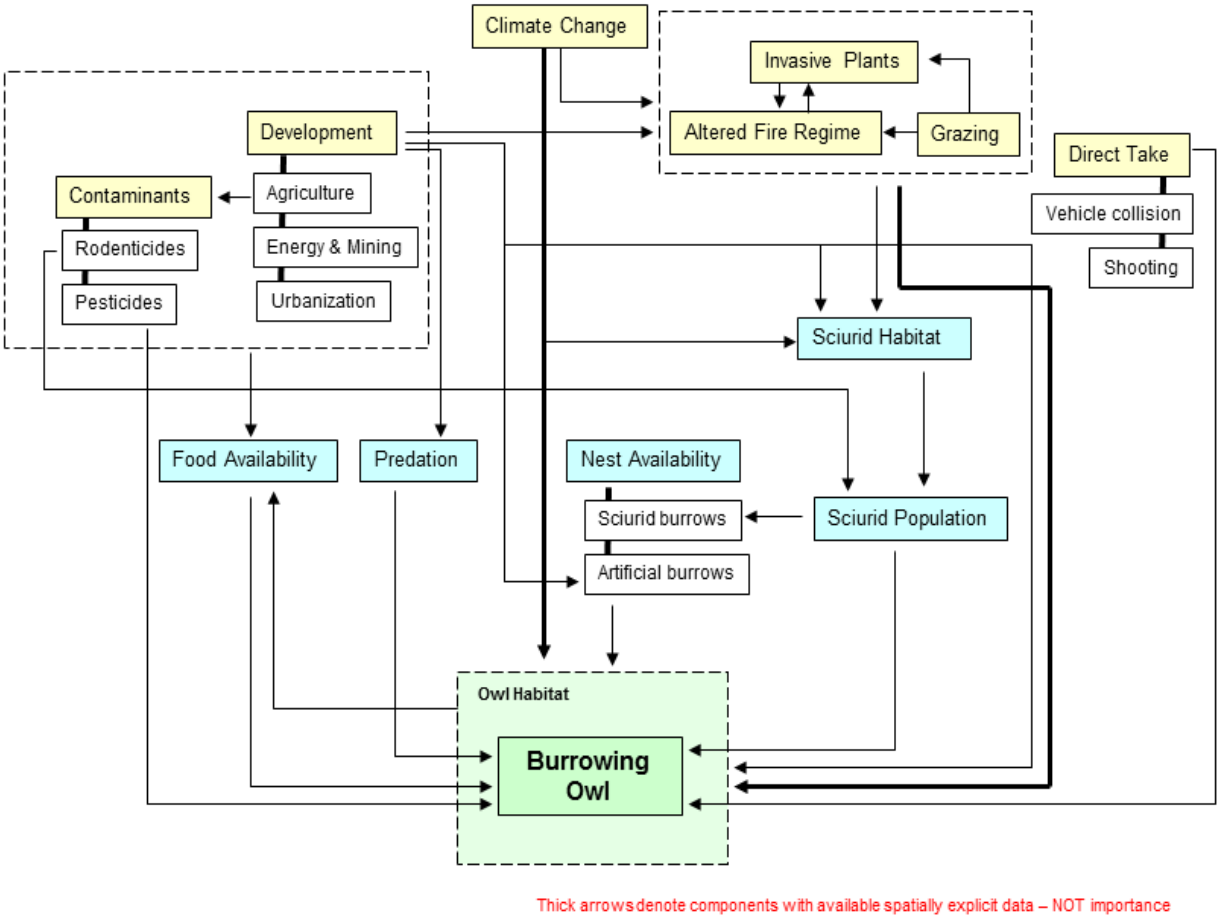


Attributes and Indicators

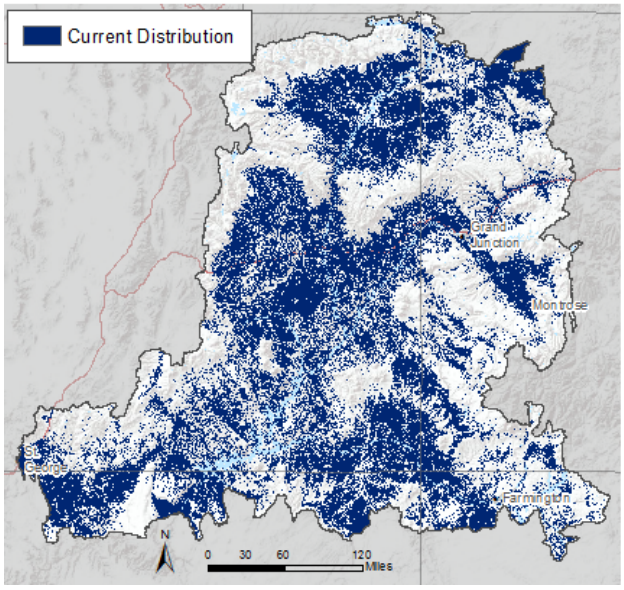
Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Thermal biology	Elevation	>9,000 ft	7,500–9,000 ft	5,500–7,500 ft	<5,500 ft	Utah Natural Heritage Program (2007)
Mortality	Proximity to roads	<0.5 mi	0.5–1.0 mi	1.0–1.5 mi	>1.5 mi	Haug et al. (1993)
Habitat	Aridity/openness of habitat	other	golf courses, fairgrounds & some ag land		dry, open short-grass prairies and steppes	Haug et al. (1993)

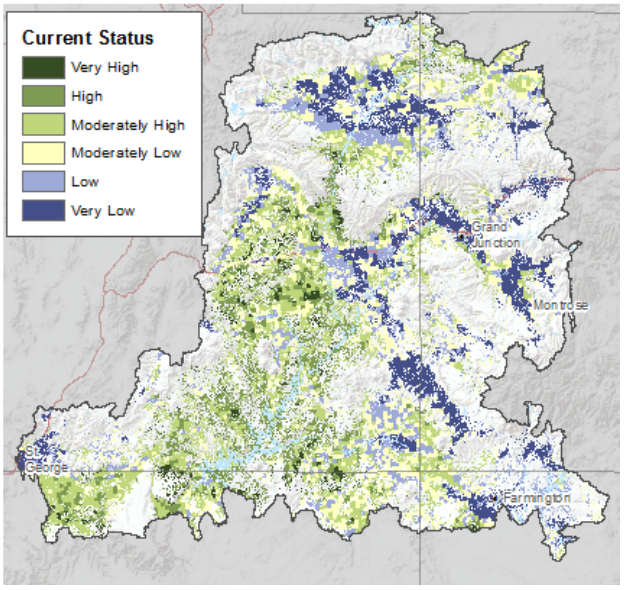
Haug, E. A., B. A. Millsap, and M. S. Martell. 1993. Burrowing owl. Birds of North America 61: 1–19.

Burrowing Owl Conceptual Model



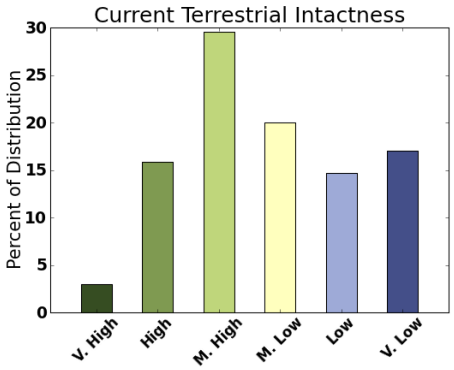
MQ D1. What are the current distribution and status of burrowing owl (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?





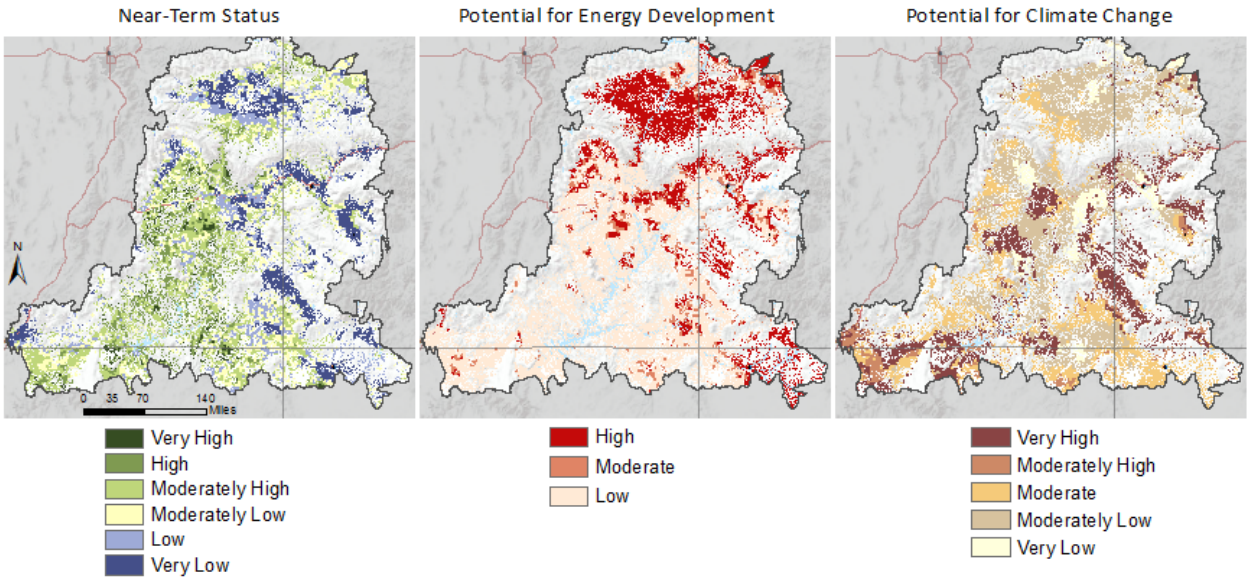
Data Source:

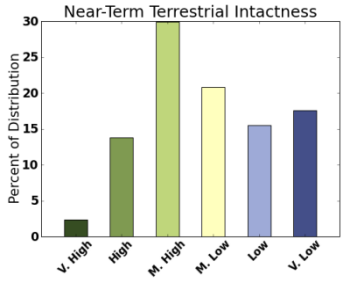
SW ReGAP (Southwest Regional GAP Analysis Project).

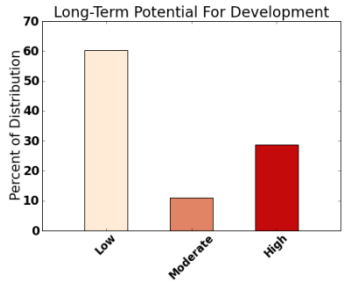


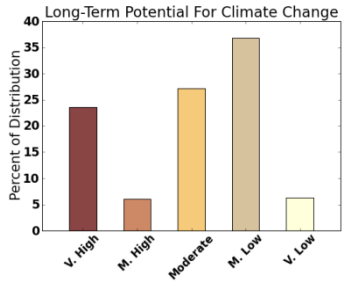
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Burrowing Owl Potential for Change

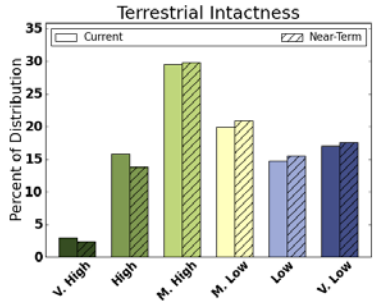








Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Ferruginous Hawk – *Buteo regalis*

The ferruginous hawk was selected as a wildlife species conservation element for the REA because it is a BLM species of concern and a representative of open grasslands and sage shrublands that are undergoing development pressures. It and a group of other conservation elements (burrowing owl, black-footed ferret, Gunnison's and white-tailed prairie dog) form an assemblage of species associated with prairie dog colonies. The species occurs throughout most of the Colorado Plateau ecoregion, although it is absent or sparsely distributed in parts of southeastern Utah and western Colorado. The southern edge of its breeding range extends to northwestern New Mexico and northern Arizona. Of the four states included in the REA, it is a state Species of Concern in Utah, Arizona, and Colorado and a federal (U.S. Forest Service and BLM) species of concern in New Mexico. The U.S. Forest Service listed the ferruginous hawk as a Management Indicator Species, defined as a "species selected because its welfare is presumed to be an indicator of the welfare of other species sharing similar habitat requirements", and "a species which reflects ecological changes caused by land management activities" (Collins and Reynolds 2005). Ferruginous hawks are very sensitive to disturbance during the nesting season (White and Thurow 1985). Entry into nesting areas is not advised for 99 days from egg laying and 68 days after hatching (Olendorff 1993).

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Abundance of main prey	Jackrabbit density	<10 per sq km	10-30 per sq km	30-50 per sq km	>50 per sq km	Howard and Wolfe (1976)
Habitat suitability	Size of contiguous cropland	>16 ha	8-16 ha	1-8 ha	none	Jasikoff (1982)
Habitat loss and degradation	Livestock density	present in large number	present in moderate numbers	present in small numbers	absent	Olendorff (1993)

References Cited

Collins, C.P., and T.D. Reynolds. 2005. Ferruginous Hawk (*Buteo regalis*): A technical conservation assessment. USDA Forest Service, Rocky Mountain Region, Golden, Colorado. http://www.fs.fed.us/r2/projects/scp/assessments/ferruginoushawk.pdf. [Accessed: 3-2012].

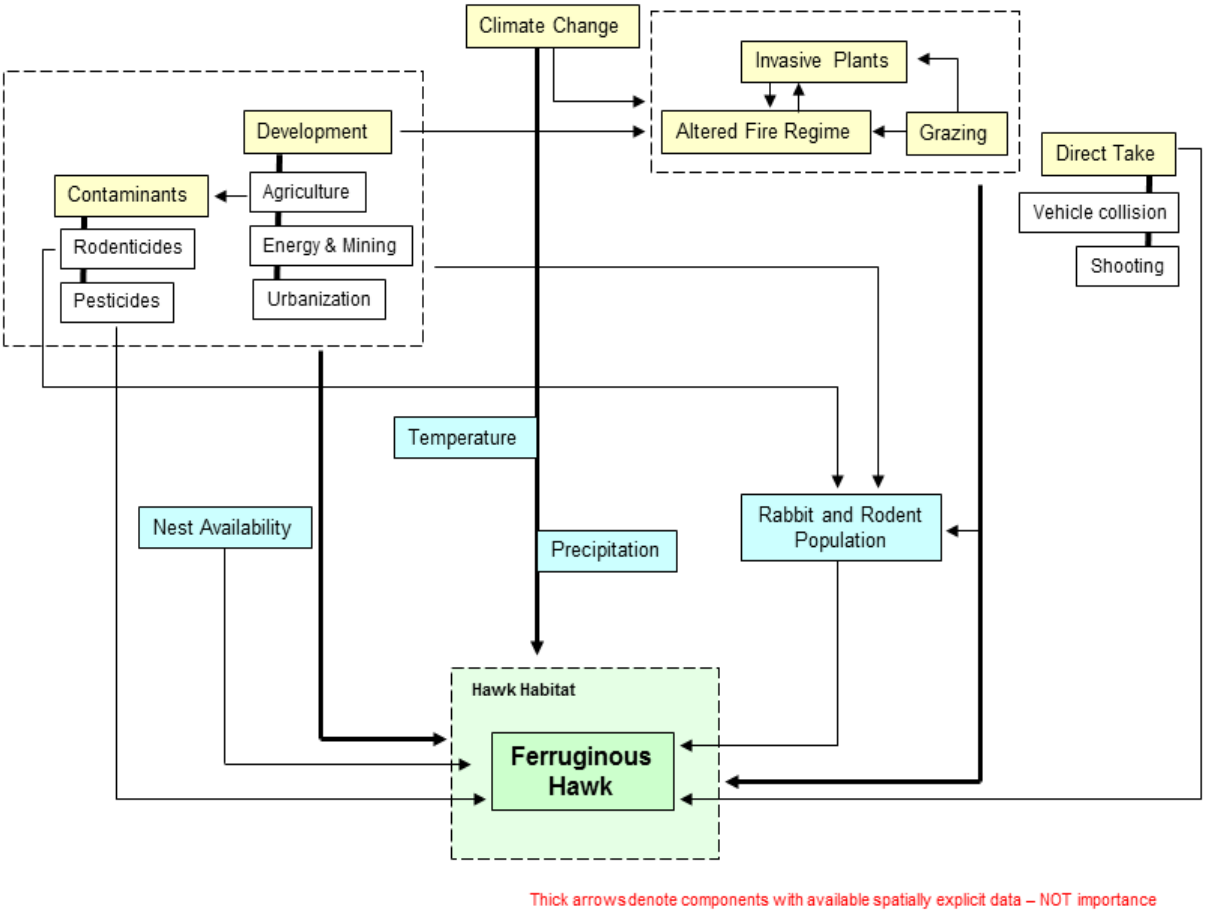
Howard, R. P., and M. L. Wolfe. 1976. Range improvement practices and ferruginous hawks. *Journal of Range Management* 29:33–37.

Jasikoff, T. M. 1982. Habitat suitability index models: Ferruginous hawk. Report FWS/OBS-82/10.10. U.S. Fish and Wildlife Service, Fort Collins, Colorado. vi + 18 pp.

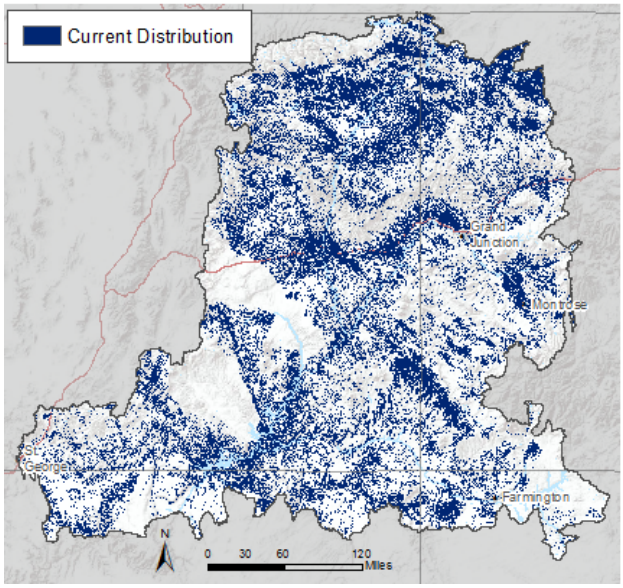
Olendorff, R.R. 1993. Status, biology, and management of ferruginous hawks: A review. Special report, Raptor Research and Technical Assistance Center, U.S. Bureau of Land Management, Boise, Idaho. 84 pp.

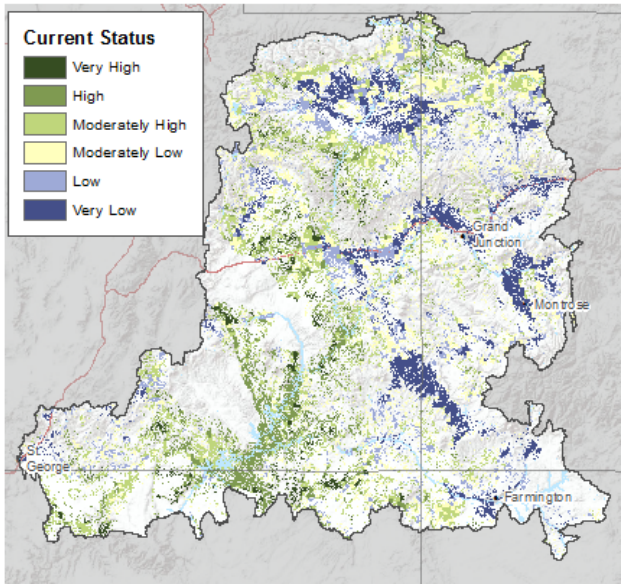
White, C. M. and T. L. Thurow. 1985. Reproduction of Ferruginous Hawks exposed to controlled disturbance. *The Condor* 87: 14–22.

Ferruginous Hawk Conceptual Model



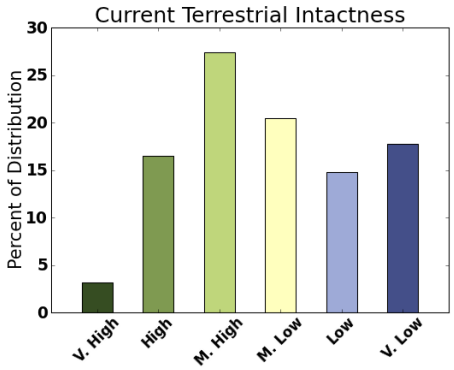
MQ D1. What are the current distribution and status of ferruginous hawk (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?





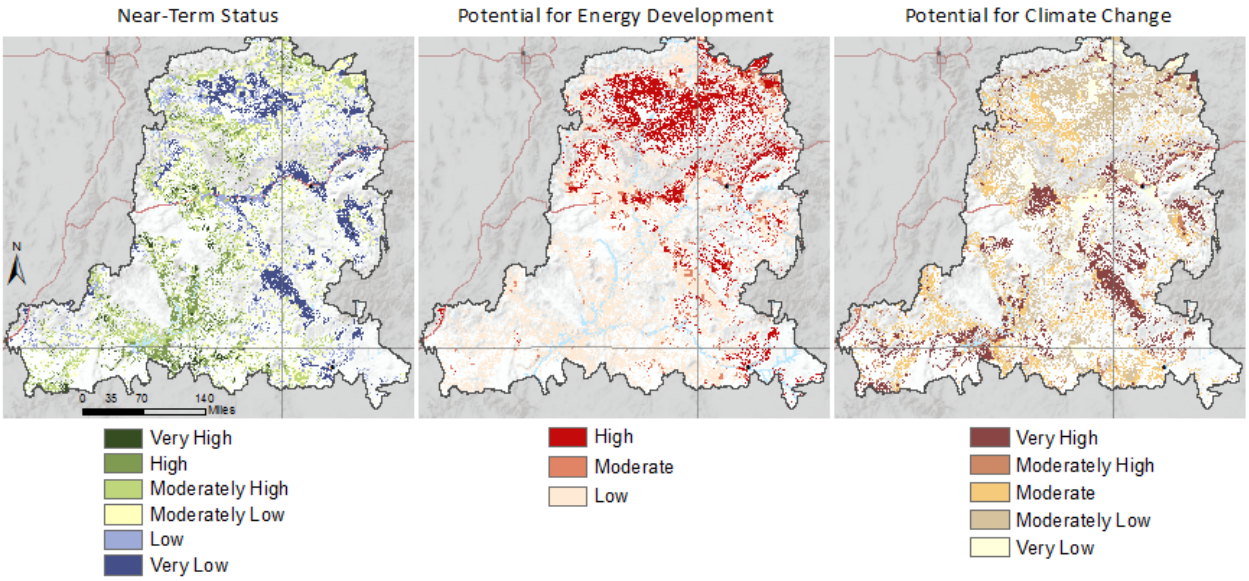
Data Source:

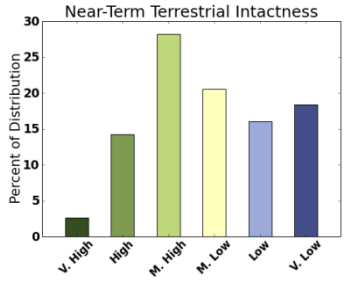
SW ReGAP (Southwest Regional GAP Analysis Project)

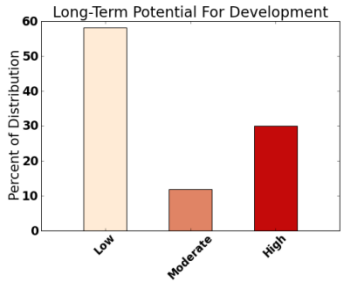


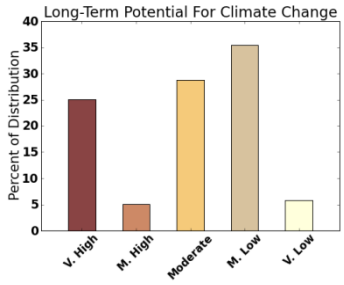
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Ferruginous Hawk Potential for Change

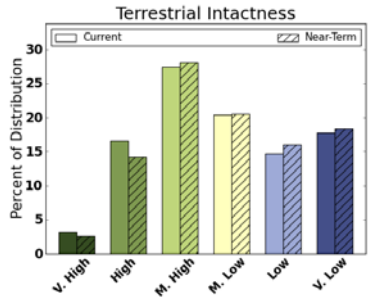








Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Golden Eagle – *Aquila chrysaetos*

Golden eagles hunt over open spaces in western North America, often in the vicinity of cliffs and ridges where the birds prefer to nest (Kochert et al. 2002). In two coal-mining counties in eastern Utah, Bates and Moretti (1994) found active eagle nests in four different habitats: on cliffs and escarpments in pinyon-juniper woodland and in trees on saltbush flats, in low elevation riparian areas, and in the aspen-conifer zone. The eagles feed primarily on small to medium-sized mammals, principally hares and rabbits (Olendorff 1976, Marzluff et al. 1997). Stahlecker et al. (2009), in their survey of 191 nests in the Four Corners region of the southwestern U.S., confirmed the preference for jackrabbit and noted that ravens were the most common avian prey.

Golden eagles benefit from the protection of large areas of intact desert and semi-desert habitat. Eagle home ranges are large, but they vary considerably in size depending on region, prey availability, and season from a few thousand to tens of thousands of hectares. In the Uinta Basin in the 1980s, average territory size per pair of eagles observed varied from 136 km^2 to 19 km^2 to 56 km^2 over the three years of the survey (Grant et al. 1991). Eagle management is inseparable from management of prey populations and their habitat, and shrub patch size is an important element; a management rule of thumb is to avoid fragmentation of shrub habitats below the mean patch size of 5000 ha shown to support healthy jackrabbit populations (Marzluff et al. 1997).

Although eagles and their nests have been protected since 1962 by the Bald and Golden Eagle Protection Act, long-term surveys indicate population declines in portions of the western U.S. (Kochert and Steenhof 2002). Eagles are vulnerable to environmental change, especially from human development and changes to habitat. Breeding Bird Survey trend results show a 1.3% yearly percentage decline for eagles in the Colorado Plateau-Southern Rockies for 1966–2009. However, these trend results carry substantial caveats since they reflect the detection difficulties and small sample size of a wide-ranging species with low abundance (Sauer et al. 2011). To reduce the speculation surrounding the estimates of golden eagle populations, the U.S. Fish and Wildlife Service in 2003 sponsored the first in a series of planned annual surveys of golden eagles across a broad area of the northwestern plains and the intermountain west (Good et al. 2004). The objective of the study is to use annual aerial surveys along systematic 100 km transects to detect golden eagle population changes ≥ 3% per year over a 20-year period. The survey over the Colorado Plateau-Southern Rockies Bird Conservation Region recorded 0.01 eagles/km^2 or an estimated abundance of 4998 birds across the entire region. The analysis was not stratified by habitat type, and results showed that "substantially" fewer eagles were observed in forested rugged habitats than in more open landscapes. The 0.01 eagles/km^2 estimate for the Colorado Plateau-Southern Rockies region is lower than the 0.017 eagles/km^2 estimated for the Great Basin (although the habitats covered in the Great Basin were more uniformly open).

The major reasons for the decline of golden eagles are direct take and habitat destruction through development. Humans cause over 70% of recorded deaths, either directly or indirectly, through collisions with vehicles, power lines, and wind turbines, electrocution on power poles, poisoning, and shooting (Franson et al. 1995). Although they are protected under the Bald and Golden Eagle Protection Act, golden eagles are sometimes illegally shot when suspected of killing livestock. Habitat destruction due to land development has led to large-scale population declines in some areas (Kochert and Steenhof 2002). Alteration of open shrubland habitats through development or conversion to agriculture has a negative effect on eagle populations because it reduces prey populations. Eagles will actively avoid agricultural areas when hunting (Marzluff et al. 1997). Eagles are often the victims of secondary poisoning when they consume prey

that have been killed or sickened by pesticides, herbicides, or rodenticides (Franson et al. 1995). Eagles may also survive with elevated blood-lead levels from consuming prey items that are contaminated with lead or from directly ingesting lead shot (Pattee et al. 1990, Kramer and Redig 1997). Wildfires affect golden eagles in sagebrush communities in the western U.S. through the loss of shrub habitat and resident prey. Large-scale shrub loss in sagebrush communities from wildfire in southwestern Idaho reduced golden eagle reproductive success for 4-6 years post-burn (Kochert et al. 1999). The eagles avoided hunting in previously burned areas and eagle fledging success declined with an increasing extent of burned area in the vicinity of the nest. Post-burn effects on golden eagle hunting and reproductive success would likely be similar in sagebrush communities of the Colorado Plateau.

Human-made infrastructure such as power lines and wind turbines are also responsible for eagle mortality. In the Altamont Pass Wind Resource Area in west-central California, where there is an array of 5000 wind turbines on the ridgelines, Smallwood and Thelander (2008) estimated 67golden eagle fatalities per year from collisions with turbines; sub-adults and floaters appeared to be affected disproportionately (Hunt 2002). Golden eagle fatalities were correlated with turbine height, location, and topography with the majority of deaths associated with shorter turbines (e.g. Type 13), end of row and second from the end turbines, and favored aerial pathways through dips and notches in the topography (Curry and Kerlinger 1998, Hunt 2002). Although it has been reported that fatalities are much lower from newer wind farms with more recent turbine designs, there is no clear relationship between pre-construction risk assessment planning and reduced mortality (Lynn and Auberle 2009). While, on one hand, Smallwood and Karas (2009) estimated that newer turbines at Altamont could reduce mean annual fatality rates by 54% for raptors (while more than doubling annual wind-energy generation), eagle deaths tallied at a new (2 year old) wind farm north of Los Angeles, showed an annual death rate per turbine to be three times higher than at the older Altamont facility (Sahagan 2011). Potential risk assessments conducted prior to permitting wind facilities evaluate topography, weather patterns, and vegetation type, the presence of flyways and migration corridors, the numbers of birds potentially flying in the risk zones near the rotors, the possible presence of species of concern, the distance to important nesting areas and roost sites for birds and bats, and the potential for prey species such as ground squirrels to inhabit the site (Lynn and Auberle 2009). With the advent of renewable energy development in the Colorado Plateau ecoregion, planning for golden eagles should include protecting nest sites and minimizing activity in eagle nesting areas, eagle-sensitive turbine selection and placing (Curry and Kerlinger 1998, Hunt 2002, Smallwood and Thelander 2007), and raptor-safe electrical transmission lines and poles with widely spaced conductors, perch guards, or perches installed above the conductors (BLM 2005).

The potential consequences of climate change are related to how climate change may directly affect shrub and grassland habitats or indirectly affect them through altered fire regimes and distribution of invasive plants, both of which may affect prey populations. For example, if climate change leads to more widespread fire, this could lead to the loss of shrubs and a decline in small mammal populations which could negatively affect eagle populations in burned areas (Kochert et al. 1999). However, the golden eagle's broad latitudinal range in North America (from Mexico to the Arctic) and generalist habits make it a poor candidate to model the effects of climate change.

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Habitat loss or degradation	Urban development	present	--	minimal	absent	Kochert and Steenhof (2002)
Habitat degradation	Livestock grazing and agriculture	existing or planned	--	--	absent	Beecham and Kochert (1975)
Habitat degradation	Fire	>40,000 ha of shrublands burned	--	burned territory; adjacent vacant unburned	unburned territories	Kochert et al. (1999)
Habitat degradation	Mining and energy development	present	--	--	absent	Phillips and Beske (1990)
Habitat	Vegetation	disturbed areas, grasslands, agriculture			shrubland/open grassland	Marzluff et al. (1997), Peterson (1988)
Habitat/nest sites	Topography	--	--	--	cliffs within 7 km of shruband	Menkens and Anderson (1987), McGrady et al. (2002), Cooperrider et al. (1986)
Mortality	Infrastructure (roads, power lines, wind turbines	--	--	--	infrastructure absent	Franson et al. (1995)
Illness mortality	Poisoning from pesticides and other toxins	high levels of contaminants	--	--	low/no contaminants	Franson et al. (1995), Harmata and Restani (1995), Kramer and Redig (1997), Pattee et al. (1990)
Habitat loss or degradation	Urban development	present	--	minimal	absent	Kochert and Steenhoff (2002)

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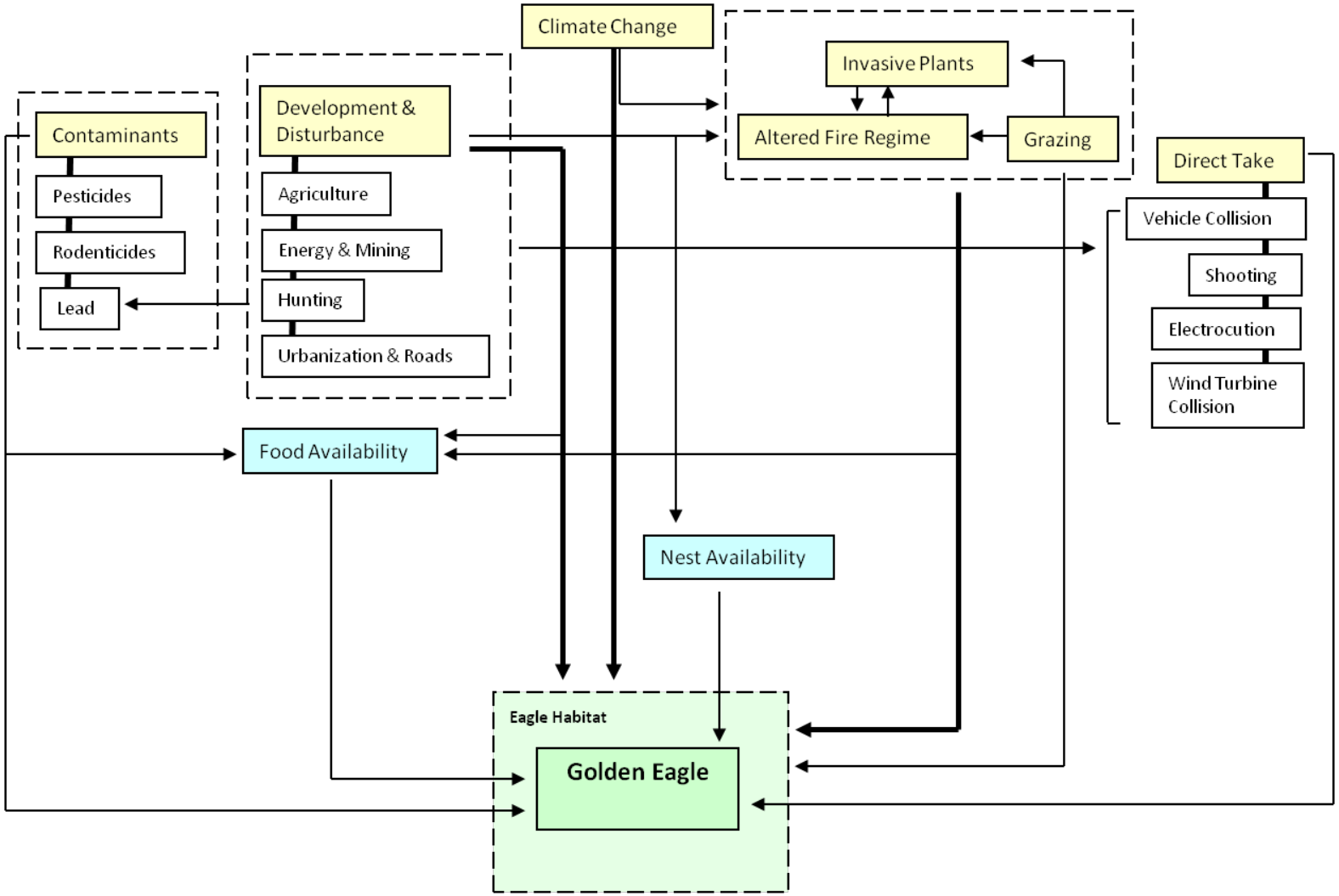
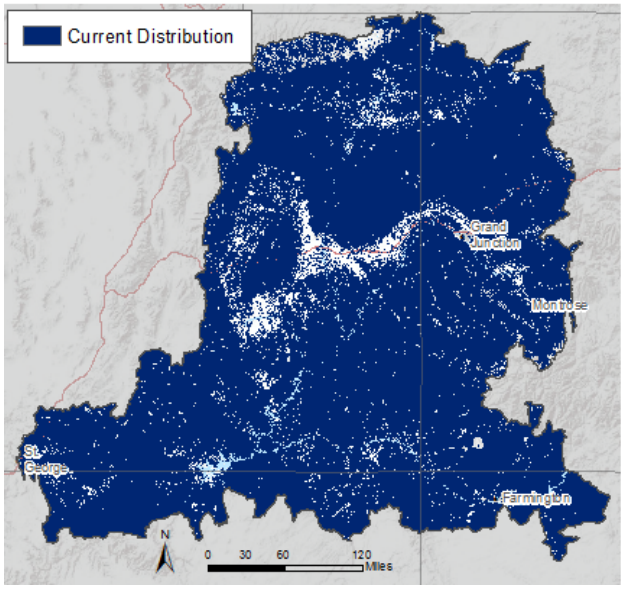
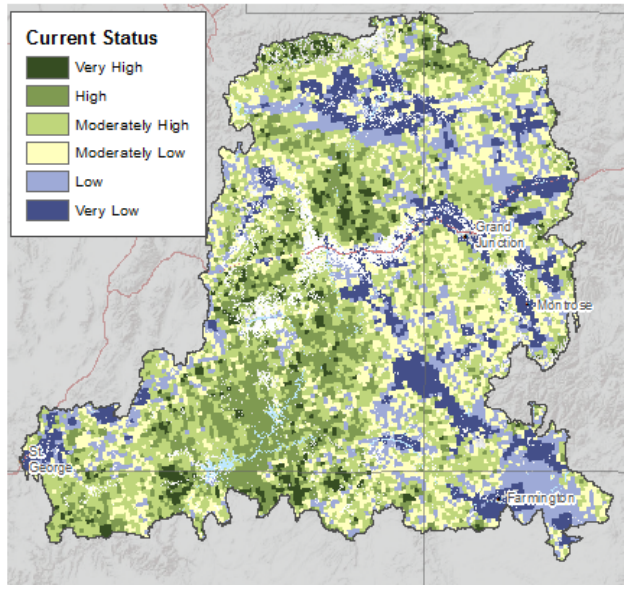
Golden Eagle Conceptual Model



Thick arrows denote components with available spatially explicit data – NOT importance

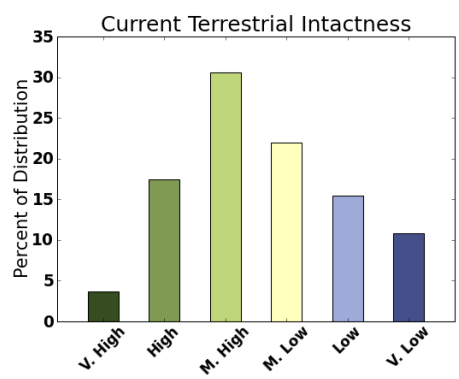
MQ D1. What are the current distribution and status of golden eagle (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?





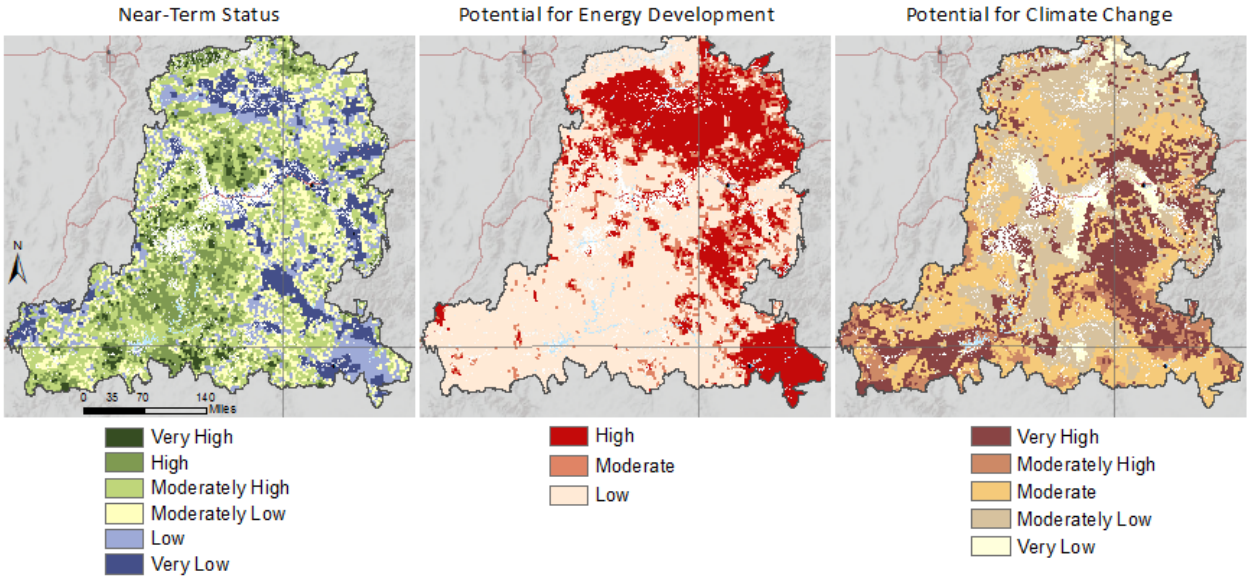
Data Source:

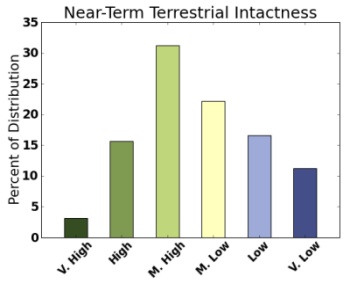
SW ReGAP (Southwest Regional GAP Analysis Project)

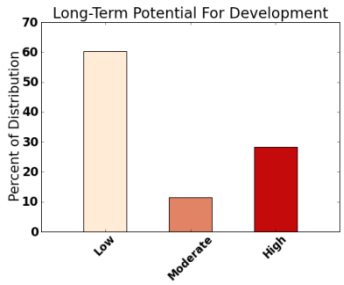


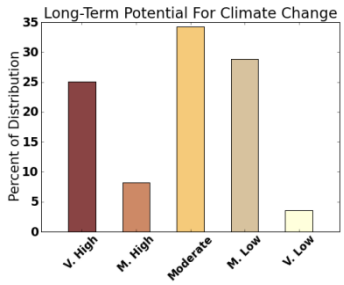
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Golden Eagle Potential for Change

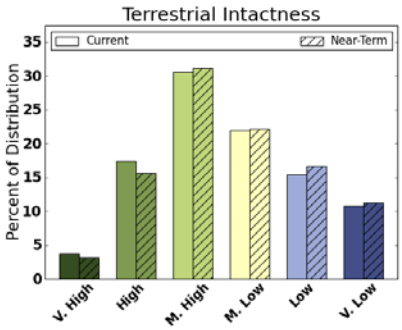








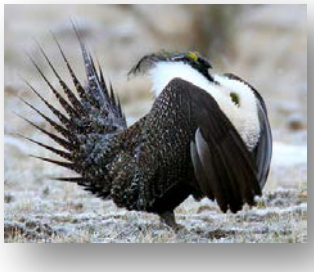
Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Greater Sage-Grouse – *Centrocercus urophasianus*

For full detailed account of Greater sage-grouse, see Sage Grouse Case Study Insert.



The sustainability of the greater sage-grouse (*Centrocercus urophasianus*) is entirely dependent on intact expanses of sagebrush. The sage-grouse is one of over 350 plant and animal species that are sagebrush obligates; a high proportion of these are endemic, threatened, or endangered, because the sagebrush community is one of the most-altered vegetation classes in the western states (Connelly et al. 2004). Over the last century, the sage-grouse has been reduced to 56% of its former range westwide. The U.S. Fish and Wildlife Service (USFWS) recently gave the greater sage-grouse candidate status rather than listing it as threatened or endangered—stating that it warrants protection, but that other species, facing greater and more immediate threats, take precedence (USFWS 2010). A court ruling in 2011 followed a number of law suits filed against the USFWS for delaying full Endangered Species Act protection for the grouse; it gave the USFWS until 2015 to decide the bird's status. In the interim, the BLM will review Resource Management Plans throughout the range of the greater sage-grouse and revise or amend them if necessary to incorporate sage-grouse conservation measures (BLM 2011a).

Across the species' range, trend results from research and monitoring of sage-grouse populations indicate general declines, but results vary depending on the region and the scale of the investigation. Breeding Bird Survey trend estimate data for the Southern Rockies-Colorado Plateau ecoregion showed a 7.1% per year decline for the period 1966–2009 and a 5.2% per year decline for the period 1999–2009 (Sauer et al. 2011). However, these trend results carry a caveat, since they reflect detection difficulties on existing Breeding Bird Survey routes and a small sample size (<14). Local trends differ when examined at a regional level. Utah and northwestern Colorado represent the southeastern-most extent of the species' current distribution, which has contracted to the north, based on evidence of historic distributions. Greater sage-grouse populations in northwestern Colorado still maintain some connectivity with sage-grouse strongholds in Wyoming and Montana. Colorado populations are relatively stable and have been increasing (about 1% per year) over the last 17 years (Connelly et al. 2004). Sage-grouse habitat in Utah connects to these northern populations through the Uinta Basin where sage habitats are heavily fragmented. Sage-grouse populations are small and scattered along the western border of the Colorado Plateau ecoregion, and several small populations have been recently extirpated from former leks in southern Utah (Connelly et al. 2004). Annual rates of change in Utah populations indicate a long-term decline from levels of the late 1960s and early 1970s, when populations were approximately 2-3 times higher than current numbers (Connelly et al. 2004). The number of males per lek has decreased significantly and lek size has also decreased since the late 1960s, although there was a gradual increase in number of males per lek between 1997 and 2005 (UDWR 2009). In an examination of available data, Connelly at al. (2004) determined that sage-grouse populations declined at an overall rate of 0.35% per year in Utah from 1965 to 2003.

Thousands of pages have been written about sage-grouse functional requirements and threats to their future productivity; for a detailed review of greater sage-grouse related population ecology, data, study results, and literature, see Connelly et al. (2004) and Knick and Connelly (2011). Sage-grouse need large contiguous patches of sagebrush habitat because their functional habitat requirements differ by season and are quite specific, based on percent sagebrush cover and height, percent herbaceous cover and height, distance to other seasonal habitat types, and topographic position (Connelly et al. 2000). Access to several types of seasonal habitats for lekking, nesting, brood-rearing, and wintering is important for reproductive success,

chick survival, and recruitment. Sagebrush patches used for nesting and brooding may be under 100 ha and located within a few kilometers of leks, but distances traveled by male grouse from lek to summer habitat and for all grouse between summer and winter ranges may be as much as 35–50 km (Connelly et al. 2004).

The species is sensitive and easily disturbed by land use activities that subdivide the landscape, disrupt the birds' site fidelity to traditional lekking and nesting areas, and ultimately isolate remnants of the population. Widespread degradation and conversion of sagebrush communities has occurred over the last century with broad scale agricultural conversion in irrigable areas, sagebrush treatments to increase forage for livestock on rangelands, the introduction of invasive annual species, and subsequent changes in fire regimes. In somewhat higher and more mesic areas, a cycle of grazing, leading to a decrease in fire frequency, has resulted in pinyon and juniper encroachment into sage grouse habitat and a reduction in ground cover perennials and forbs. Elsewhere, the invasion of cheatgrass (*Bromus tectorum*) and an associated increase in fire frequency has resulted in extensive loss of sagebrush stands that may take several decades to recover (Connelly et al. 2004, Crawford et al. 2004). Agricultural fields and irrigation canals affect 32% of sagebrush habitat in 9 western states (Connelly et al. 2004). In recent decades, exurban growth, expressed as rural small parcel development, has increased the fragmentation of sage habitat in former rangelands. The subsequent expansion of road networks, even low-volume secondary roads, negatively affects sage grouse. Recent studies have indicated that minimal road traffic (1–12 vehicles/day) reduces female grouse nest initiation (Lyon and Anderson 2003) and the number of breeding males displaying at leks (Holloran 2005). Powerlines and communications towers increase the pressure from predators and provide perches for raptors as do fences, which also cause direct mortality of sage grouse through collision and entanglement. Fences within 1.25 miles of active leks and fence densities > 1.6 miles/mile^2 of fence have been shown to increase risks for sage-grouse (thresholds listed in BLM [2011b], adopted from a study by Stevens [2011]).

Oil and gas drilling is the most pressing current and future threat to the sustainability of the sage-grouse in the Colorado Plateau. Increasing demand, a desire for energy security, favorable pricing, and recent extraction methods (e.g., fracking, see Section 4.1.4, Aquatic Resources of Concern) that retrieve oil and gas once thought too difficult and expensive to extract have created intense pressure to drill on public land in sagebrush habitats. Westwide, seven million hectares (~17,300,000 acres) of public lands—or 44% of the lands that the federal government controls for oil and gas development—have been authorized for drilling within distribution of the greater sage-grouse (Naugle et al. 2011).

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
General habitat	Cover type	cultivated fields	scrub-willow; sagebrush savannas	small sagebrush-forb mosaics	tall sagebrush	Schroeder et al. (1999) Connelly et al. (2004)
Disturbance	Oil and gas	>12 per 4 sq km x4sq km			none	Harju et al. 2010
Habitat	Invasive conifers (e.g. junipers)	abundant and encroaching	present but not encroaching	few and not encroaching	absent	Connelly et al. (2000)
Nest sites	Mean sagebrush canopy cover	<15% or >38%	15-23%	23-30%	30-38%	Connelly et al. (2000)

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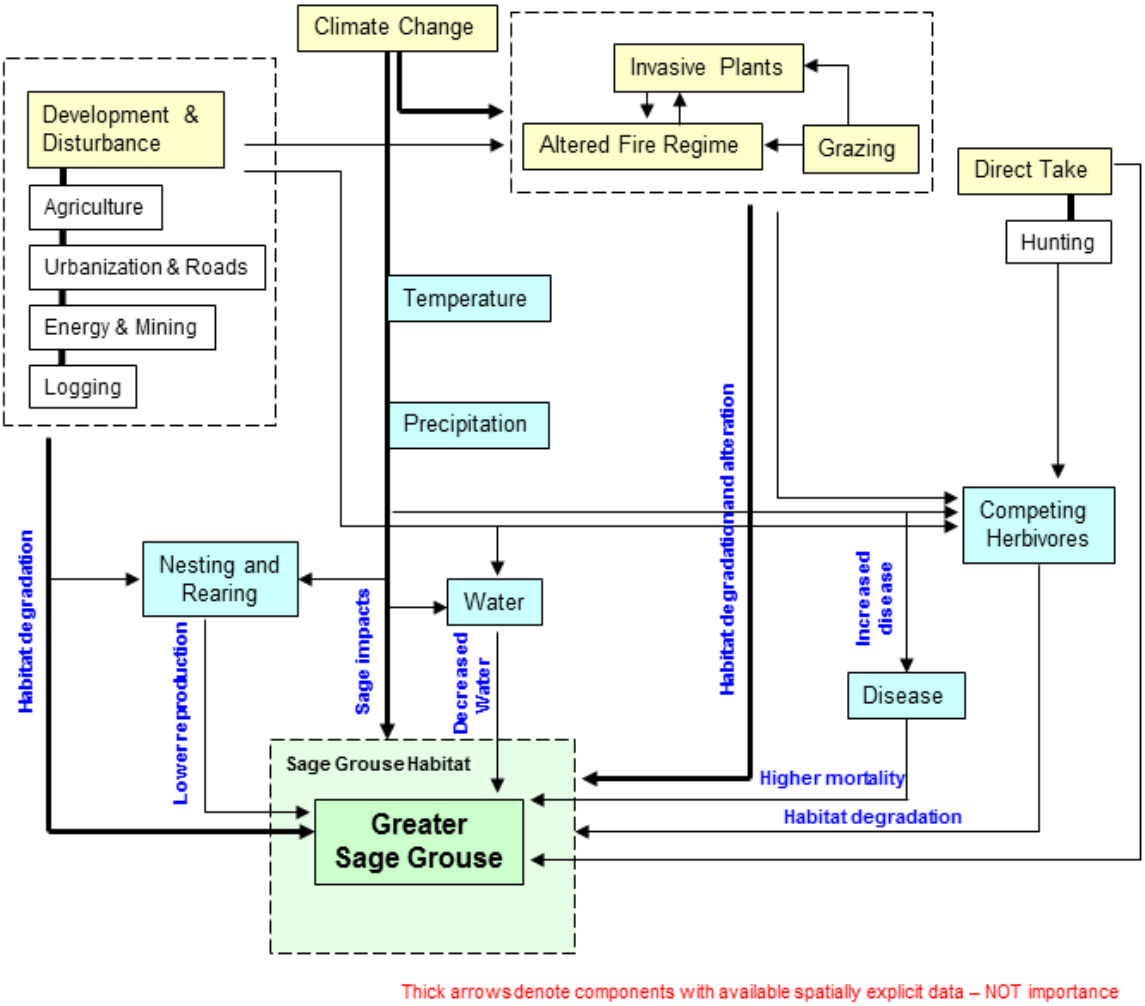
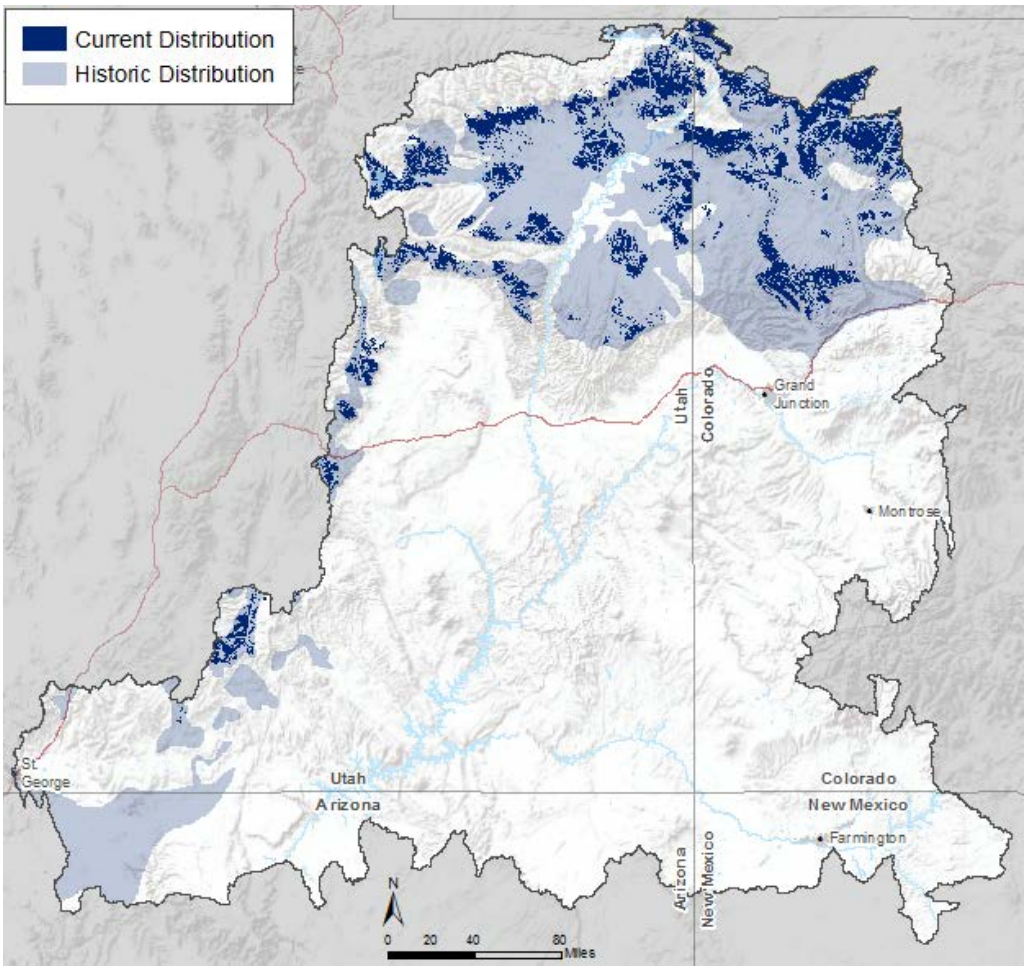


Greater Sage-Grouse Conceptual Model

MQ D1. What are the current distribution and status of greater sage-grouse (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?



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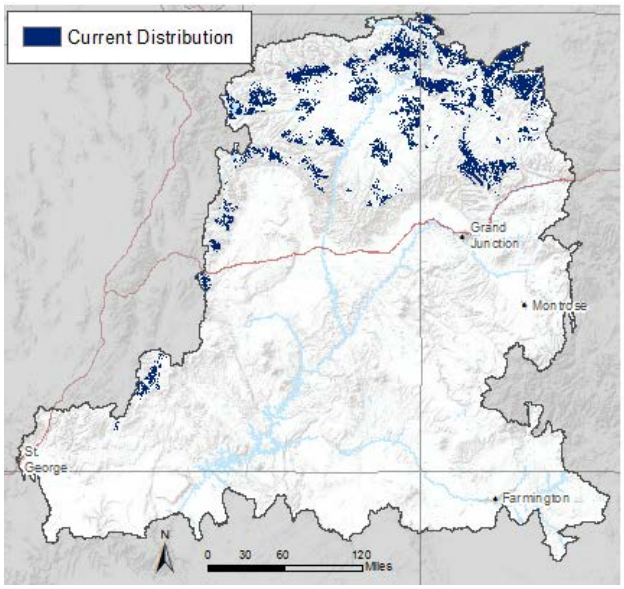
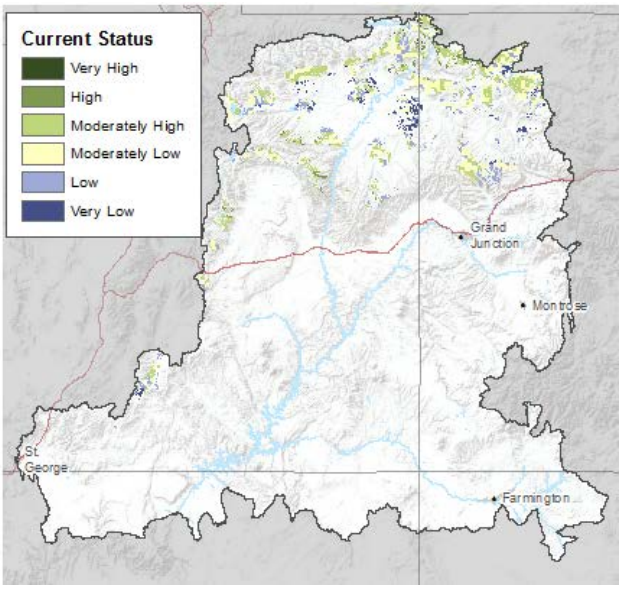
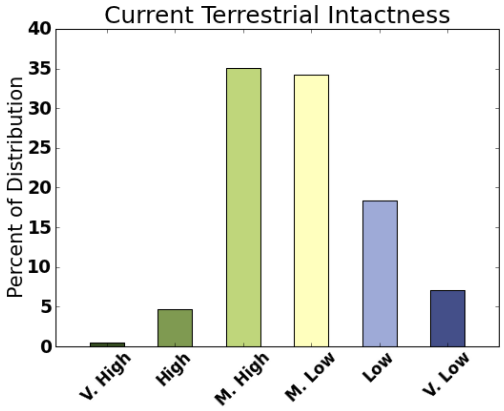




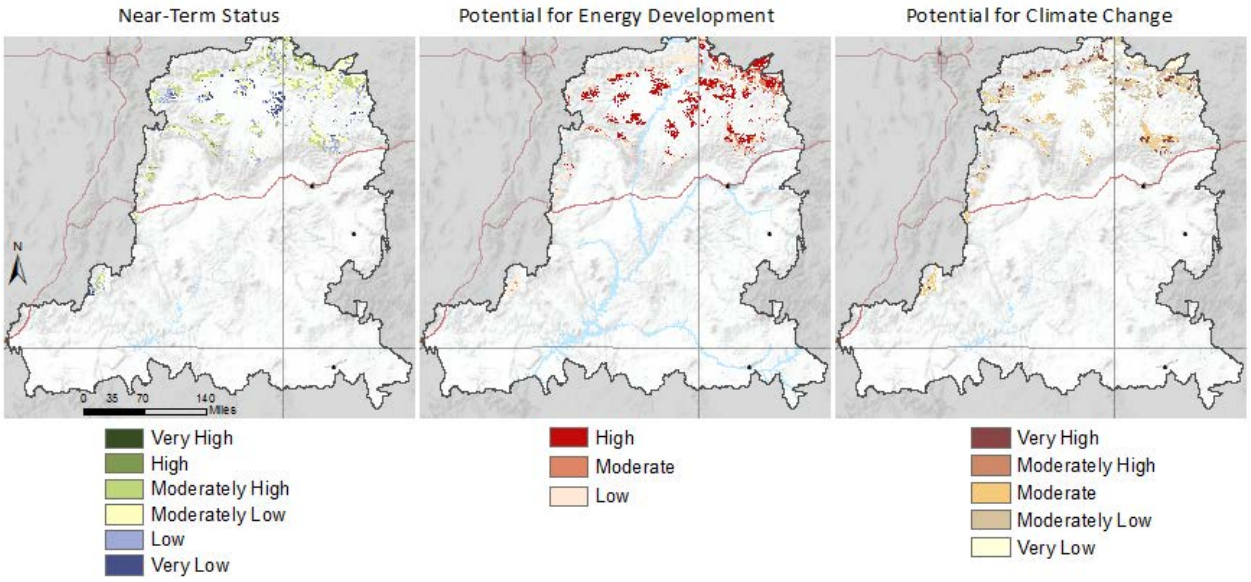
Data Sources:

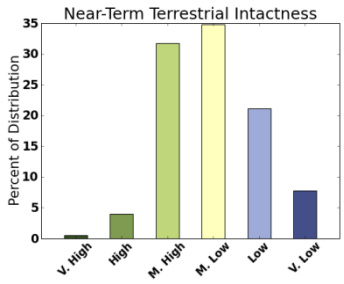
Greater Sage Grouse Occupied Habitat (BLM)
Nesting Habitat: Colorado Division of Wildlife and Utah Division of Wildlife Resources
Winter Habitat: Colorado Division of Wildlife and Utah Division of Wildlife Resources

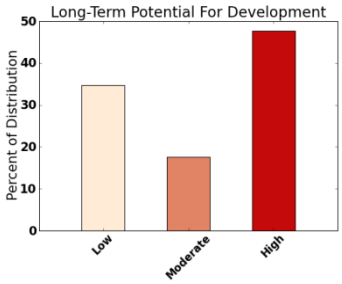


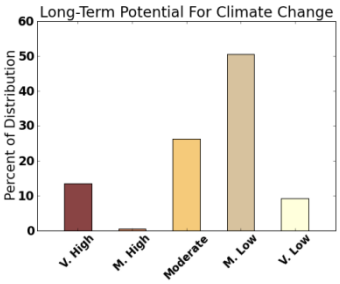
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Greater Sage-Grouse Potential for Change

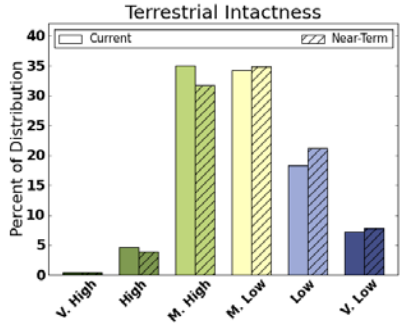








Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Gunnison Sage-Grouse – *Centrocercus minimus*

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Habitat	Plant communities (sagebrush obligate)	developed	agricultural fields	grasslands	sagebrush, riparian, wet meadows	Lupis (2005)
Habitat degradation	Sagebrush loss from leks	<0.6 mi of active lek	0.6-4.0 mi from active lek	4.0-6.0 mi from active lek	none in vicinity	GSRSC (2005)
Disturbance	Development footprint	<0.6 mi of active lek	0.6-4.0 mi from active lek	>4.0 mi from active lek	none in vicinity	GSRSC (2005)

References Cited

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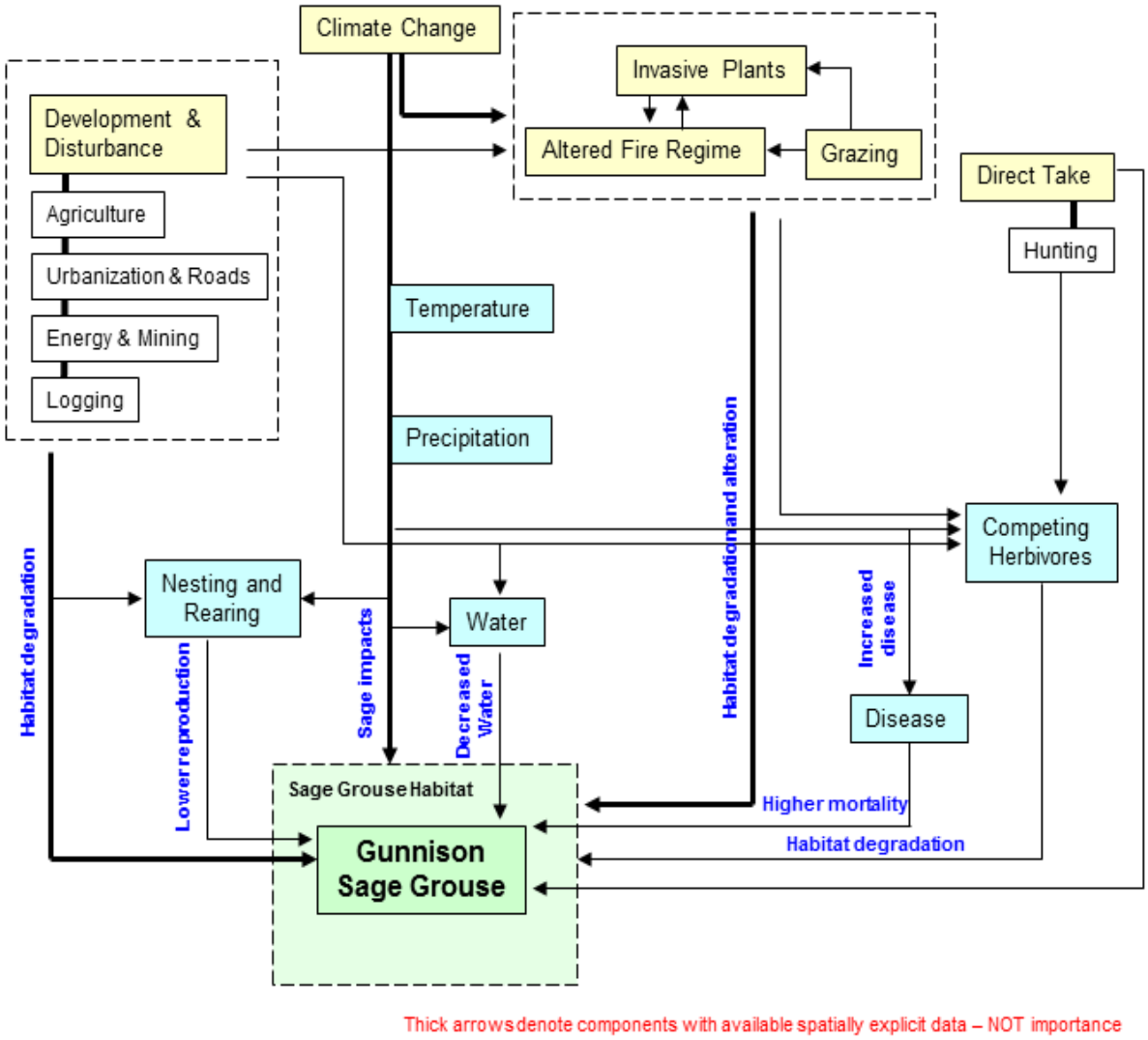
Gunnison Sage-Grouse Conceptual Model



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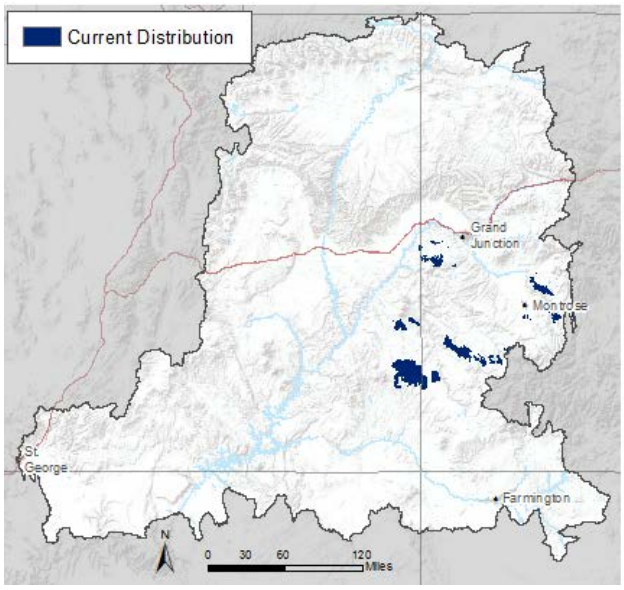
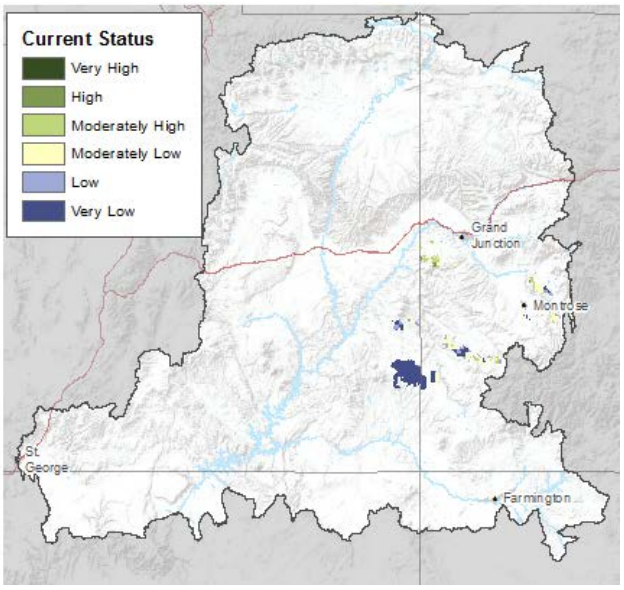
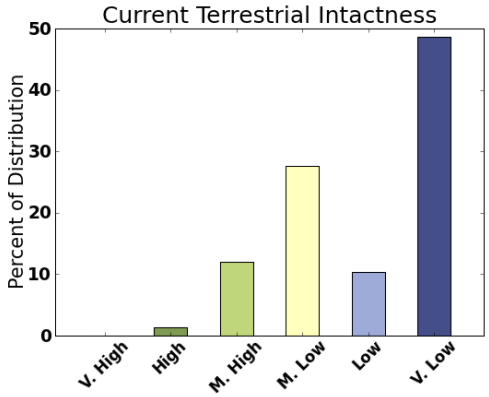




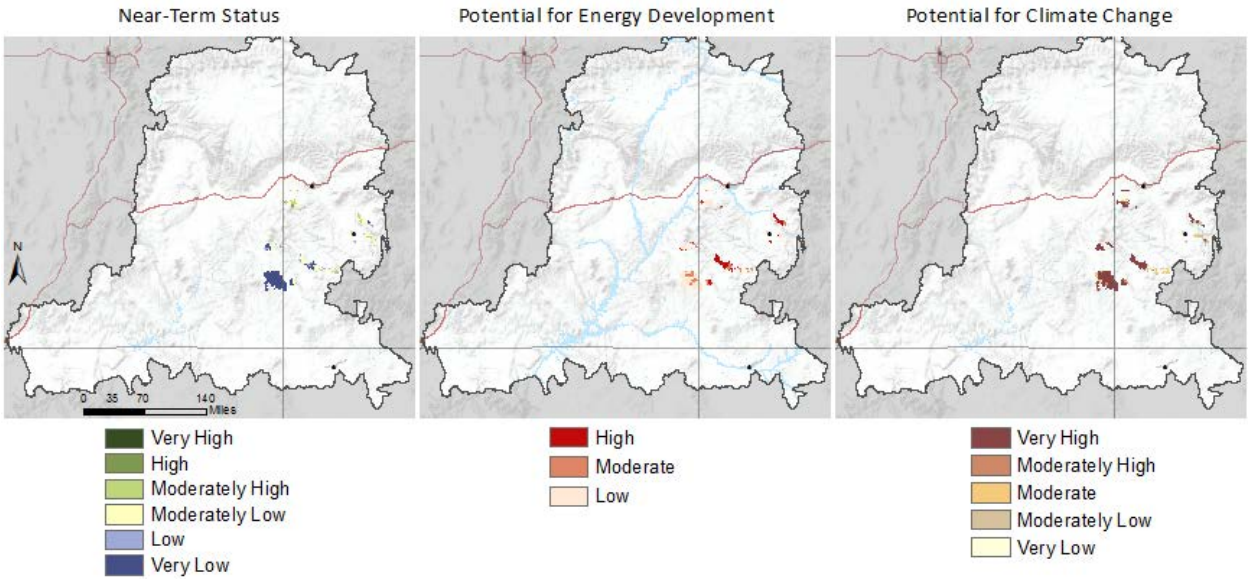
Data Sources:

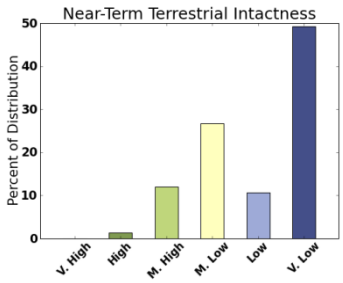
Colorado Division of Wildlife, Utah Division of Wildlife Resources
Nesting: Colorado Division of Wildlife, Utah Division of Wildlife Resources
Winter: Colorado Division of Wildlife, Utah Division of Wildlife Resources

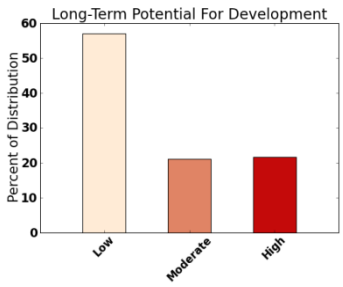


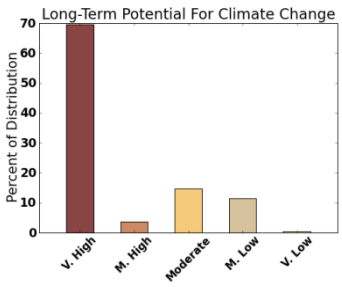
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Gunnison Sage Grouse Potential for Change

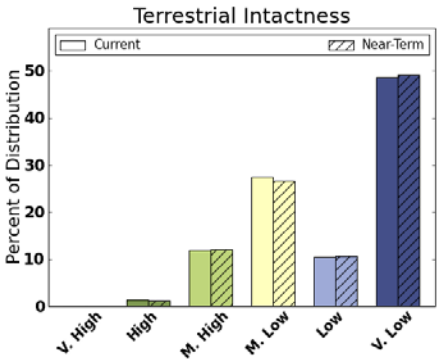








Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Mexican Spotted Owl – *Strix occidentalis lucida*

The Mexican spotted owl (*Strix occidentalis lucida*) was listed as threatened in 1993; the US Fish and Wildlife Service wrote the initial recovery plan in 1995 (USFWS 1995), designated areas of critical habitat in 2004 (USFWS 2004), and completed a revised recovery plan in 2011 (USFWS 2011). The characteristics of suitable habitat for Mexican spotted owl in the Colorado Plateau (specifically in southeastern Utah and the southwestern corner of Colorado) differ from occupied habitats encountered elsewhere in the owl's overall range; Mexican Spotted owls in this ecoregion use ledges and crevices in sheer sandstone canyons for nesting and roosting rather than larger trees within a forested matrix (Rinkevich and Gutiérrez 1996, Willey and van Riper 2007a). Prior to listing, extensive surveys were conducted in forested areas in southern Utah, but no breeding owls were detected outside of the canyonlands (LaRoe et al. 1995, USFWS 1995). Narrow, steep-walled tributary canyons offer the owl isolation, shade, water sources, and patches of riparian trees for alternate roost sites (USFWS 2011). The species' current distribution is naturally fragmented because owl habitat in the region depends on specific structural elements of canyon architecture.

The map of current distribution identifies known concentrations of Mexican spotted owls. Deeply incised canyon networks provide natural dispersal corridors joining occupied habitat islands and potentially suitable habitat (LaRoe et al. 1995). Identifying areas of potentially suitable habitat is critical to the expansion and recovery of the species. Willey et al. (2007b) developed a spatial model that predicts the potential distribution of Mexican spotted owl nesting and roosting habitat in the canyonlands of Utah using variables derived from optimal canyon morphology, relief, and rock type: for example, canyon widths < 1 km rim to rim extending for at least 1 km with cliff faces ≥ 90° and at least 15 m in height. Ledges and caves are also required, providing cool and shaded refugia. Their map of predicted habitat has a broader extent than the owl's current distribution map and can serve as a source to plan future owl surveys and protection areas. The National Park Service (using an earlier version of the Willey et al. [2007b] model) has been successful in locating Mexican spotted owls at over 90% of the areas surveyed that predicted owl occurrence (USFWS 2007).

Mexican spotted owls were listed as threatened in part because of concerns over even-age timber management and the threat of stand-replacing wildfire. Although canyon-dwelling spotted owls are not directly affected by either of these forest-related disturbances, they are sensitive and vulnerable to a number of other common regional disturbances such as road development, off-road vehicle use, oil and gas leasing, mineral exploration, canyon helicopter tours (Delaney et al. 1999b, USFWS 2007), grazing (USFWS 2011), and even low impact activities such as hiking, birding, and field research (Swarthout and Steidl 2001, Schelz et al. 2004). The structure of narrow, incised canyons magnifies noises and increases stress and startle responses when escape and avoidance routes are limited by confined roost and nesting areas within the canyon (USFWS 1995). In Canyonlands National Park, surveyors have observed that owls have abandoned canyons with higher recreation visitation (Schelz et al. 2004). Short of abandonment, owls will modify their behavior by flushing, perching in high locations on the canyon walls, being less attentive to their young, and altering the rate at which prey is delivered to the nest (Swarthout and Steidl 2001, Delaney et al. 1999a).

It goes without saying that if the Mexican spotted owl is sensitive enough to abandon an area too often frequented by hikers it will be more easily displaced from areas undergoing mineral development or exurban rural home expansion. Even if there is no direct loss of habitat, development near owl habitat increases the risk of disturbances from the expansion of road networks, incursions by offroad vehicles, changes in water table, increases in predator abundances, influx of invasive herbaceous species, and increases in human-

caused wildfire. Development peripheral to owl concentrations on federal land may also affect juvenile owl dispersal and adult winter range use outside of deep canyon habitats (USFWS 2011). Possible management actions to protect nesting owls include placing buffer zones (61m to 0.4 km) around known roosting and nesting sites (Swarthout and Steidl 2001, USFWS 2007) and limiting access or closing known nest areas to recreation during the nesting season (April–July, Schelz et al. 2004).

Grazing, if not carefully managed, affects owl habitat by altering stream channel morphology, depth to groundwater, and riparian plant species composition, density, and productivity. Changes in plant type, density, or height affect the availability and abundance of the owl's prey: woodrats (*Neotoma* sp.), deer mice (*Peromyscus maniculatus*), and voles (*Microtus* sp.). Grazers, domestic, feral, or wild, may also selectively browse riparian aspen, willow, or cottonwood seedlings and saplings, affecting long-term replacement of large roosting trees (USFWS 2011).

Drought also affects vegetation density and productivity, particularly the herbaceous plants that sustain the owl's preferred small mammal prey base. The species' reproductive success and recruitment are affected by drought because of drought-related reductions in the abundance of prey. The numbers of owls detected in surveys in Canyonlands National Park in the drought year of 2002 were alarmingly low; that year also saw the lowest vegetation production in 17 years of monitoring (Schelz et al. 2004). Most climate change scenarios predict increased drought in the region. Peery et al. (2012) modeled population dynamics and extinction risk for three Mexican spotted owl populations in Arizona and New Mexico over the next century under three climate change emissions scenarios. Their predicted changes in population growth rates indicated weather-induced changes in reproductive success; their results also indicated that owl populations were more sensitive to changes in temperature than reductions in precipitation amount. All three scenarios predicted a rapid decline in Mexican spotted owl abundances over the next century.

One could argue that the canyon-dwelling spotted owl has an advantage over members of the same species inhabiting late-seral stage forest because its preferred habitat includes the dramatic canyonlands that are revered as parklands by the American public. Owl strongholds exist in protected areas such as Canyonlands (Schelz et al. 2004), Capitol Reef, Grand Canyon, Mesa Verde, and Zion National Parks (Rinkevich and Gutiérrez 1996). Portions of these parks have been incorporated into the protected activity centers (PACs) developed for Mexican spotted owls; each PAC contains at least 600 acres of the best nesting and roosting habitat and includes 75% of the owls' foraging area (USFWS 2004). Management restrictions may be applied in PACs to protect Mexican spotted owls from disturbances, particularly during nesting season (April–July). Some find the concept of PACs for spotted owl management too limiting considering what is known (and not known) about the species' seasonal movements and home range size. Willey and van Riper (2007a) found that for 12 southeastern Utah owls tracked during breeding and non-breeding seasons, the non-breeding home range size was 49% larger than the breeding home range size. Winter ranges showed increased use of peripheral ranges (rolling mesas outside of narrow canyons) and more travel to distant use areas. Schelz et al. (2004) recommended that the PAC concept be more broadly defined to represent available habitat (as depicted in models of potential habitat) and to reflect more closely Mexican spotted owl movement patterns.

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Habitat	Canyon morphology	Closed canopy forest	-	-	Canyon width < 1 km rim to rim	Willey et al. (2007b)
Habitat	Canyon morphology	Closed canopy forest	-	-	Cliff faces ≥ 90° and at least 15 m in height	Willey et al. (2007b)
Habitat	Canyon morphology	Sheer walls, lack of perches and temperature refugia	-	-	Ledges and caves for perching and temperature refugia	Willey et al. (2007b)
Habitat	(Winter) physiography	-	-	Woodland mesas and benches	Narrow, steep-walled canyons	Schelz et al. (2004), Willey and van Riper (2007a)
Habitat	Riparian vegetation				Patches of riparian trees	USFWS (2011), Willey and van Riper (2007a)

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USFWS (U.S. Fish and Wildlife Service). 2011. Draft Recovery Plan for the Mexican Spotted Owl (*Strix occidentalis lucida*), First Revision. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 399 p.

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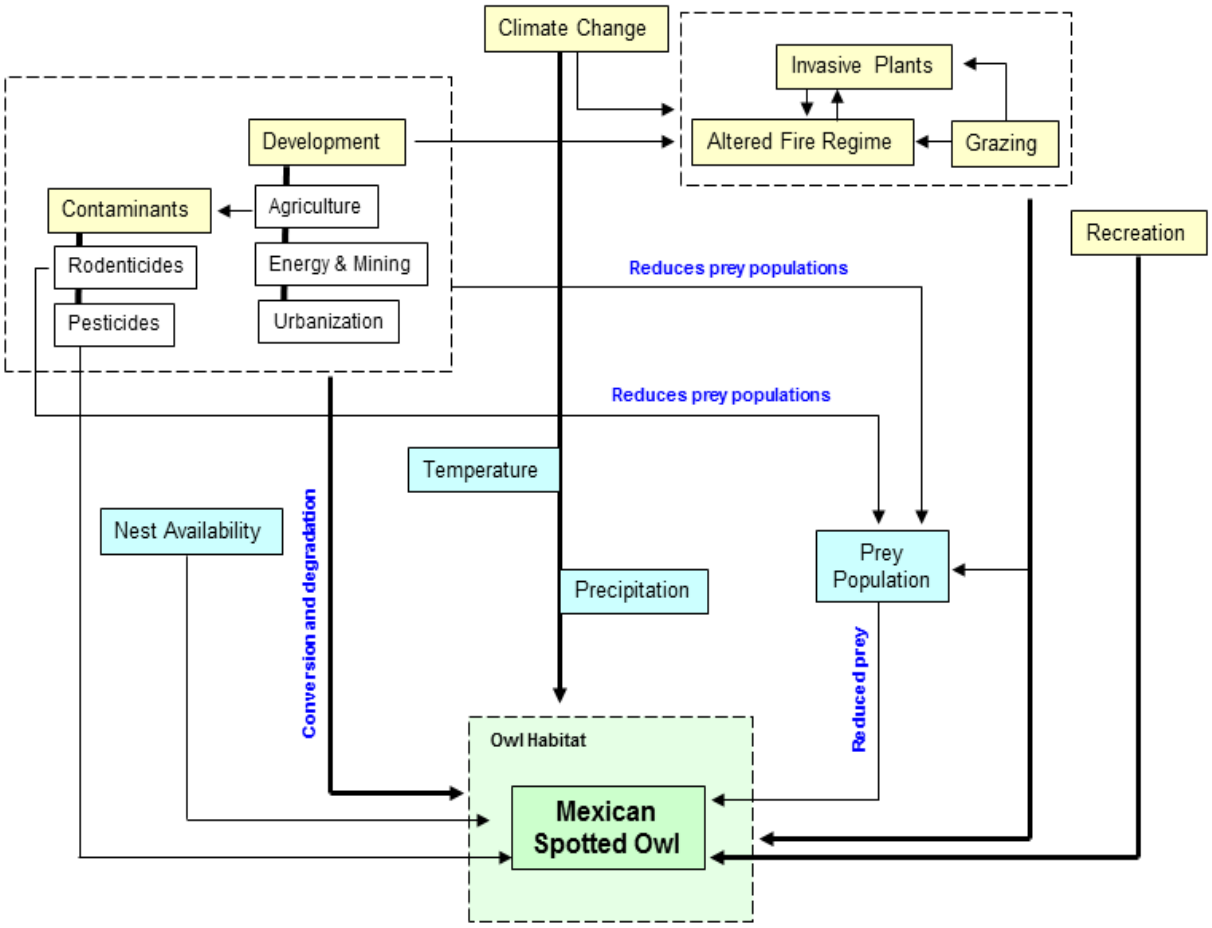
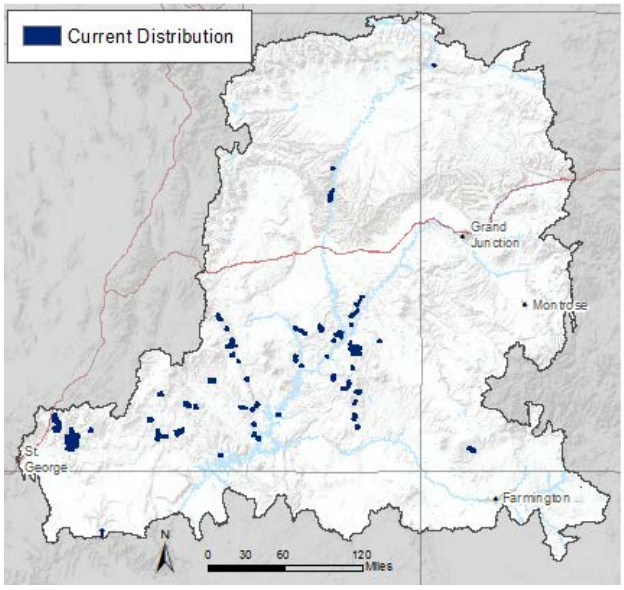
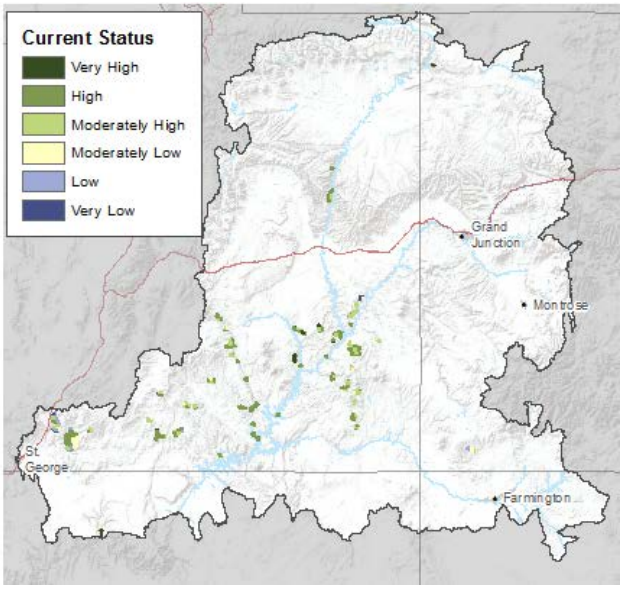
Mexican Spotted Owl Conceptual Model



Thick arrows denote components with available spatially explicit data – NOT importance

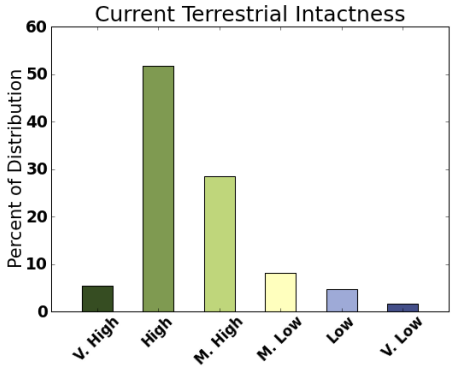
MQ D1. What are the current distribution and status of Mexican spotted owl (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?





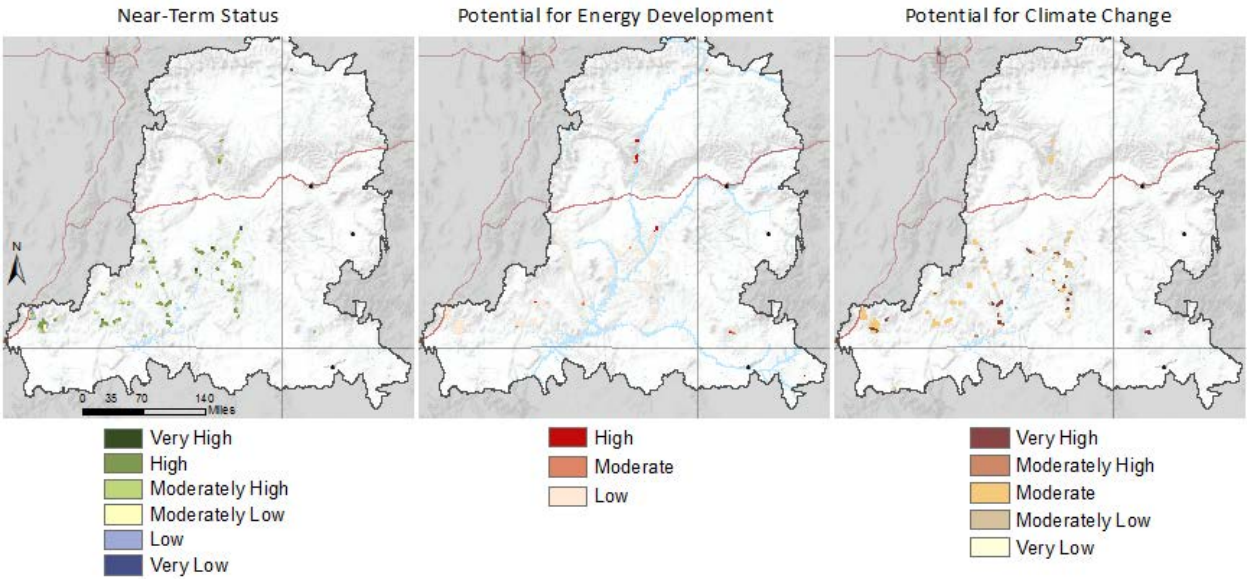
Data Sources:

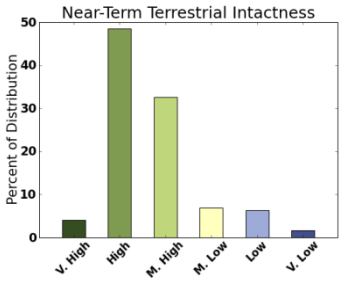
Carson National Forest Mexican Spotted Owl Management Areas, and Mexican Spotted Owl Areas identified in Draft Recovery Plan

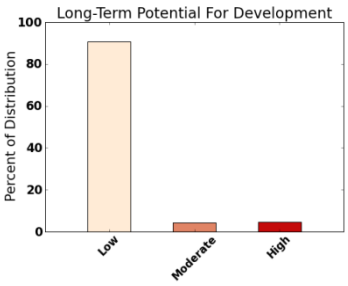


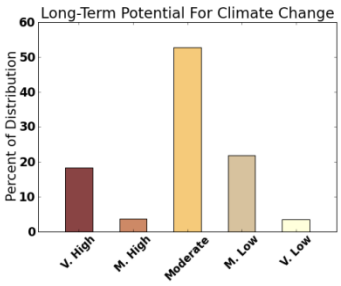
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Mexican Spotted Owl Potential for Change

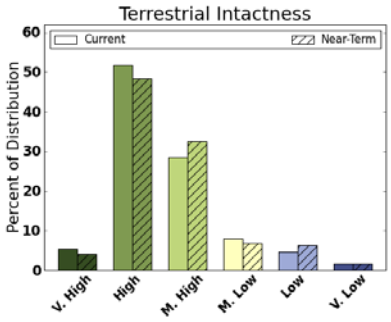








Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Yellow-breasted Chat – *Icteria virens*

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Habitat	Foliage/shrub density - Riparian shrub; Himalayan blackberry = especially preferred	low			high (1-3 m.)	Connor et al, 1983; Garrett and Dunn, 1981; Ricketts and Kus, 2000
habitat	Elevation			<1600 m		Gaines, 1992
Habitat	tree/shrub height (perching)			0.9-1.8 m	> 1.8 m (i.e. cottonwoods & alders)	Dunn and Garrett, 1997

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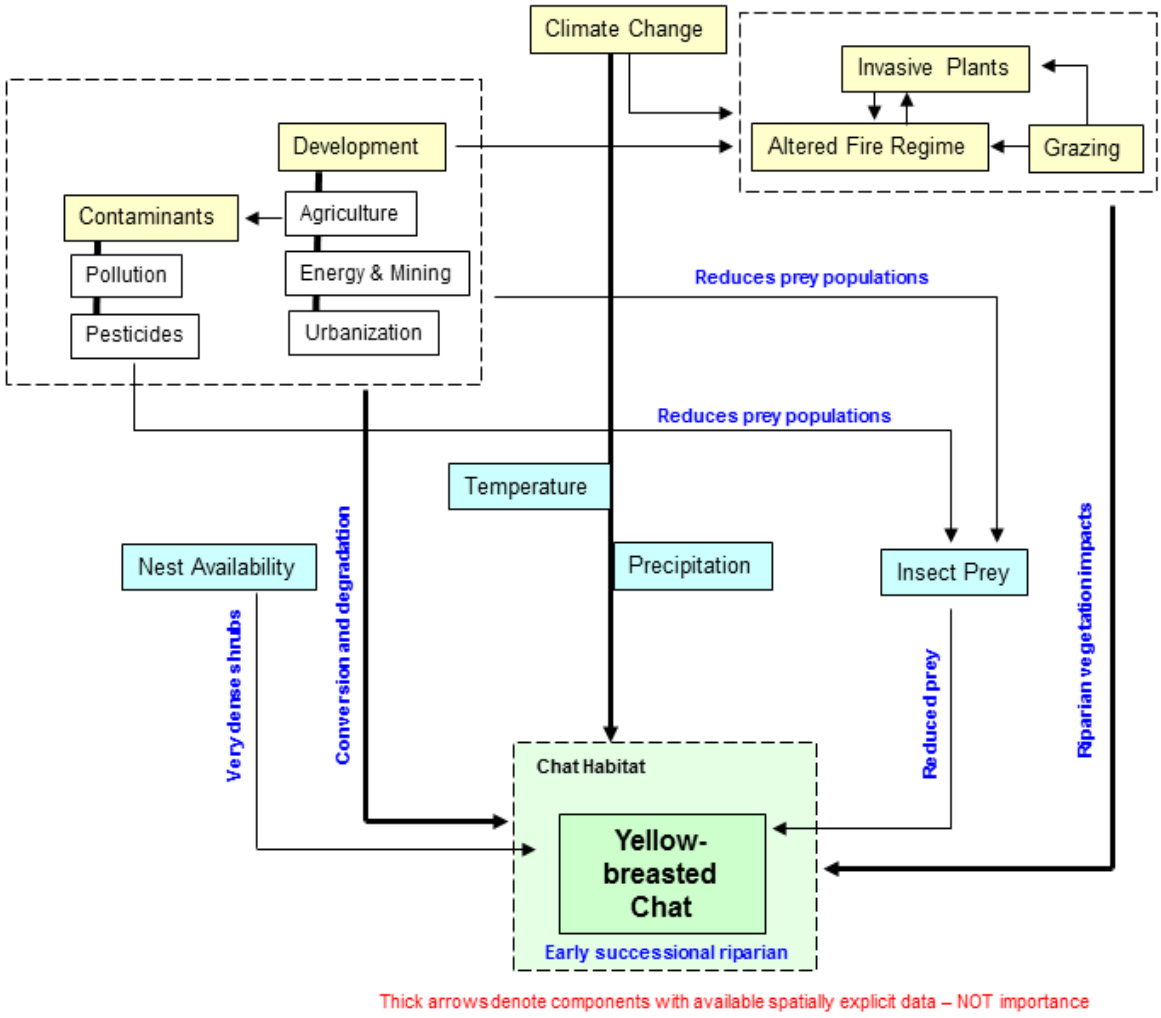
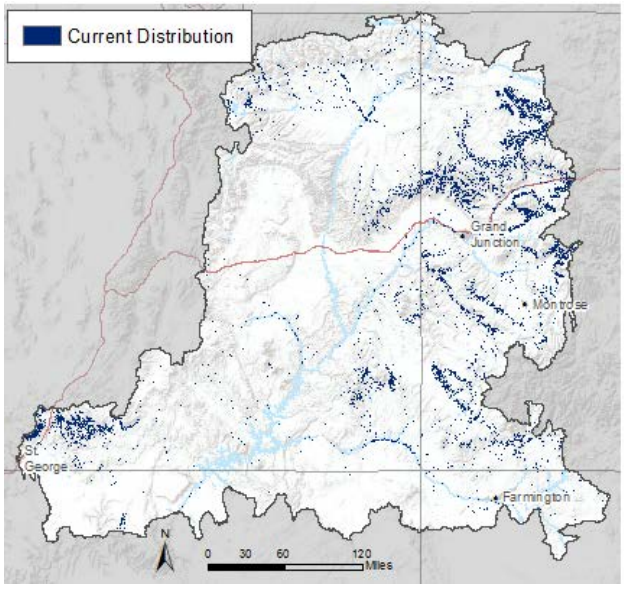
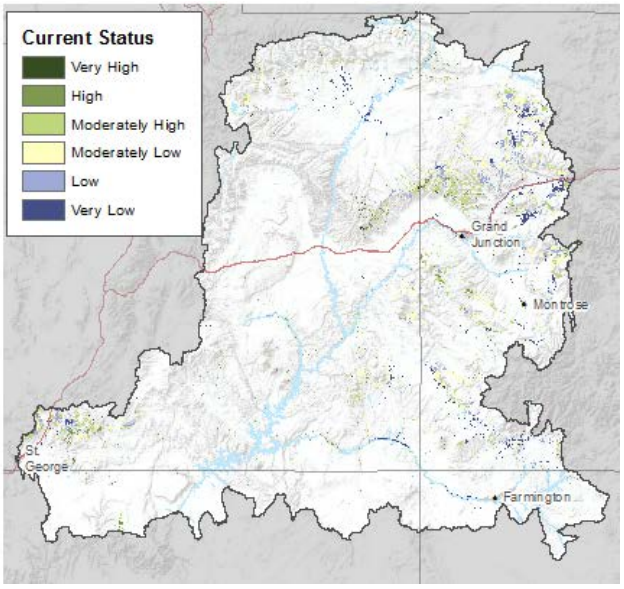
Yellow-Breasted Chat Conceptual Model



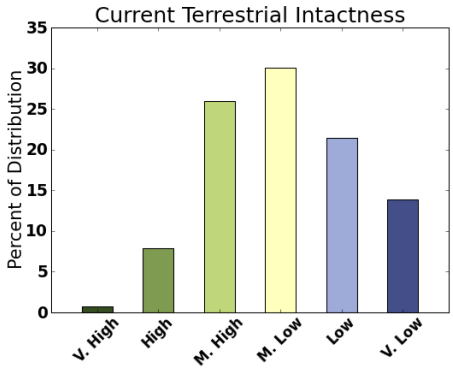
MQ D1. What are the current distribution and status of yellow-breasted chat (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?





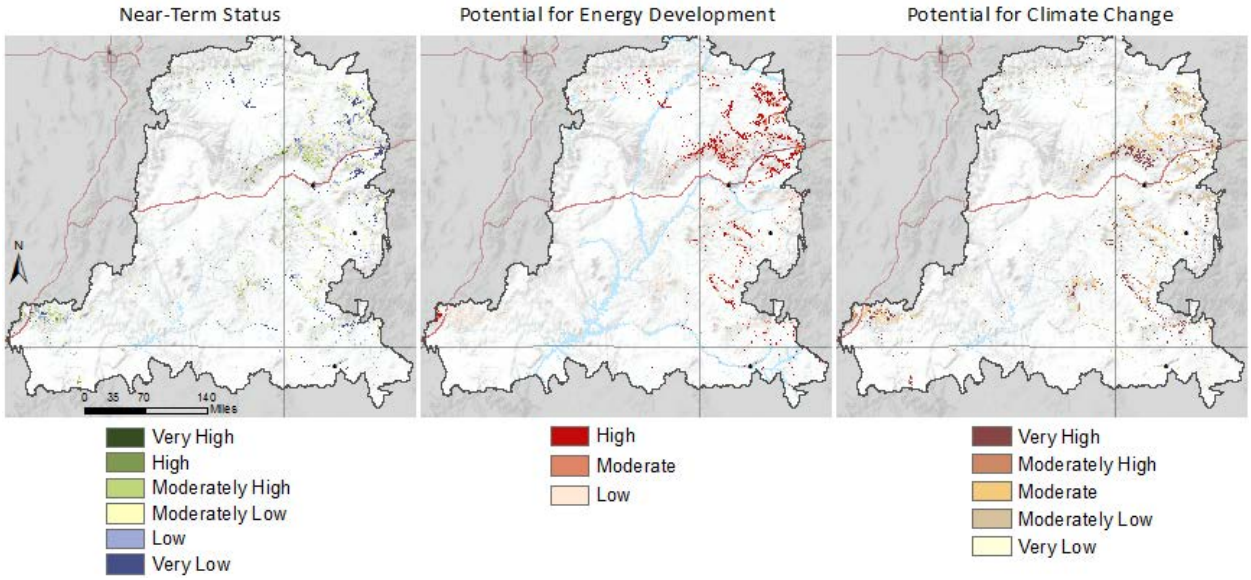
Data Sources:

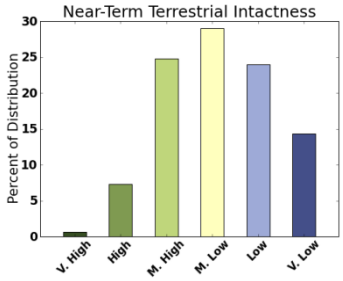
SW ReGAP (Southwest Regional GAP Analysis Project)

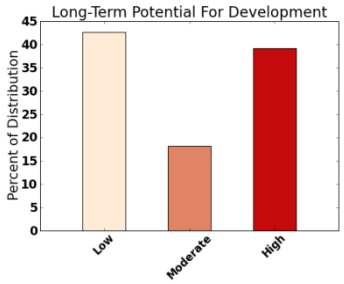


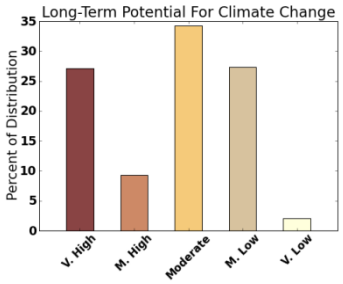
MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

Yellow-Breasted Chat Potential to Change

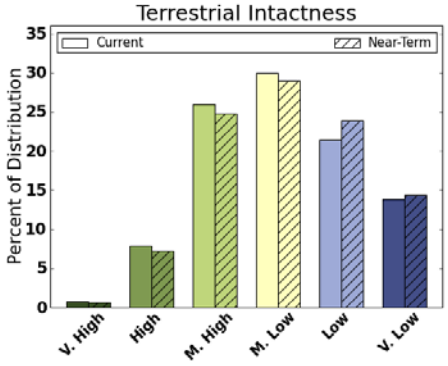








Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Colorado River Cutthroat Trout – *Oncorhynchus clarki*

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Habitat	Avg max water temperature	<4 degrees C or >20 degrees C	4-6.5 degrees C or 19-20 degrees C	6.5-12 degrees C or 14-19 degrees C	12-14 degrees C	Binns and Eiserman (1979), Hickman and Raleigh (1982)
Habitat	Avg min dissolved oxygen	<6.3 mg/L	6.3-7.2 mg/L	7.2-9 mg/L	>9 mg/L	Hickman and Raleigh (1982)
Flow regime	Avg daily base flow	<25%	25-37.5%	37.5-50%	>50%	Binns and Eiserman (1979), Hickman and Raleigh (1982)

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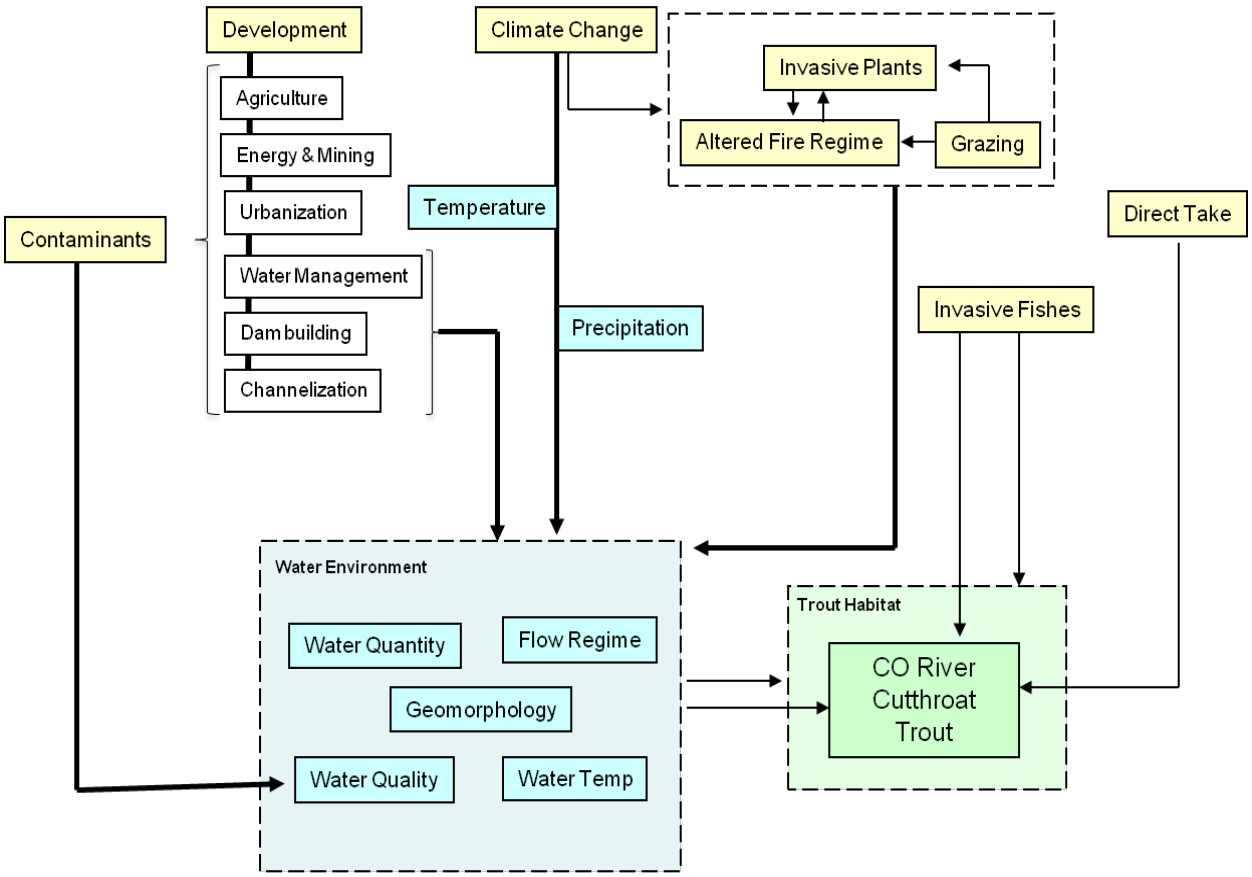
Binns, N. A., and F. M. Eiserman. 1979. Quantification of fluvial trout habitat in Wyoming. Transactions of the American Fisheries Society 108: 215–228.

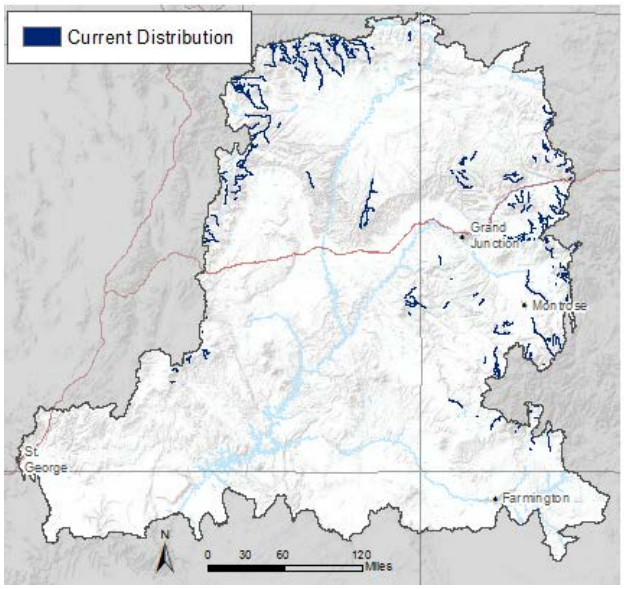
Hickman, T., and R. F. Raleigh. 1982. Habitat suitability models: cutthroat trout. U. S. D. I. Fish and Wildlife Service, Washington, D.C. FWS/OBS-82/10.5. vi + 38 pp.

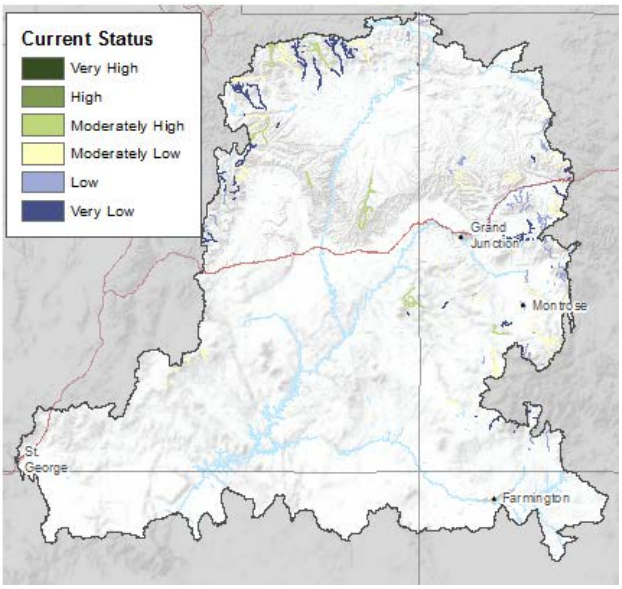
Colorado River Cutthroat Trout Conceptual Model



Thick arrows denote components with available spatially explicit data – NOT importance

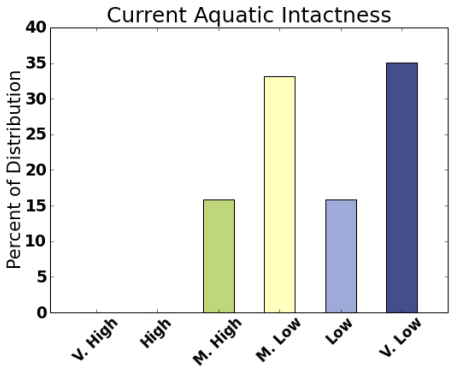
MQ D1. What are the current distribution and status of Colorado River cutthroat trout (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?





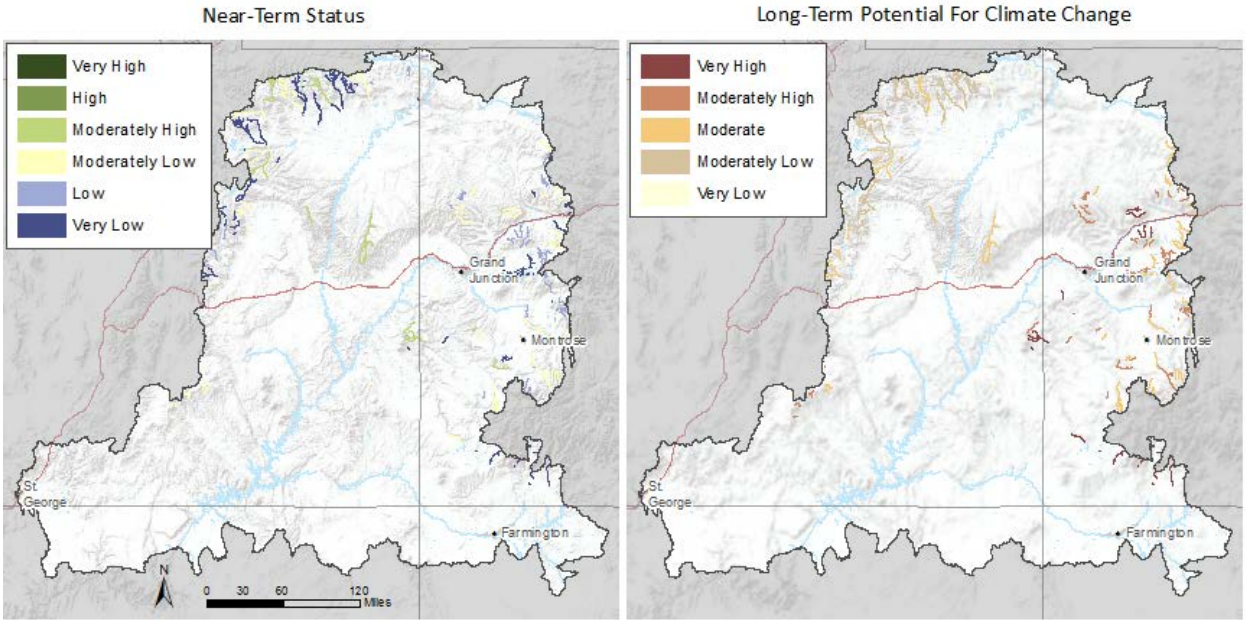
Data Source:

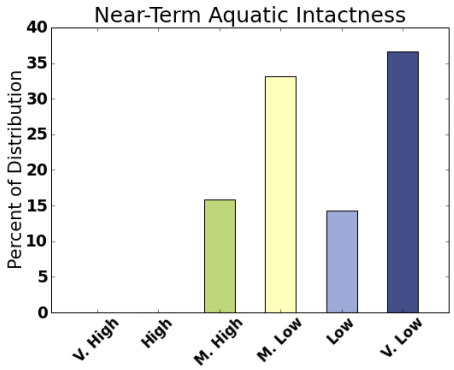
"Range-Wide Status of Colorado River Cutthroat Trout." (Hirsch, C.L., S.E. Albeke, T.P. Nesler 2006)

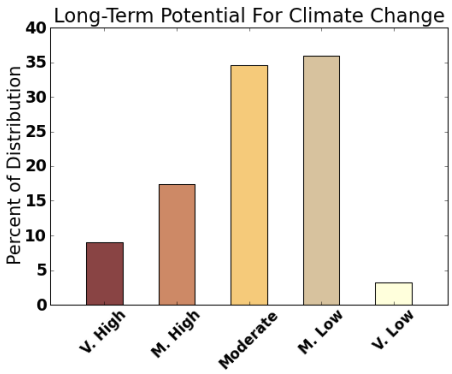


MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

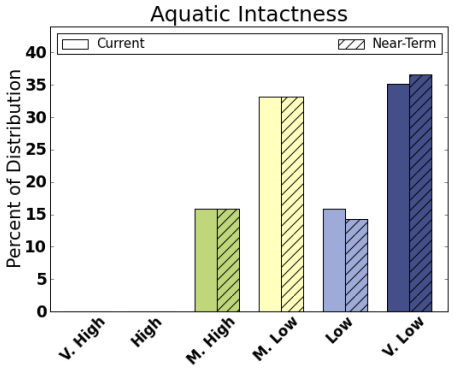
Colorado River Cutthroat Trout Potential for Change







Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Flannelmouth Sucker – *Catostomus latipinnis*

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Habitat	Summer water temperature	<10 degrees C or >30 degrees C	10-17.5 degrees C or 29–30 degrees C	17.5–25 degrees C or 27-29 degrees C	25–27 degrees C	Bezzerides and Bestgen (2002)
Habitat	Water depth	<0.5 m or >2.5m	0.5–1.0 m or 2.0-–2.5 m	1.5–2.0 m	1.0–1.5 m	Beyers et al. (2001)
Dispersal	Unblocked linear extent	<1.6 km	1.6–10 km	10–20 km	>20 km	Bezzerides and Bestgen (2002)

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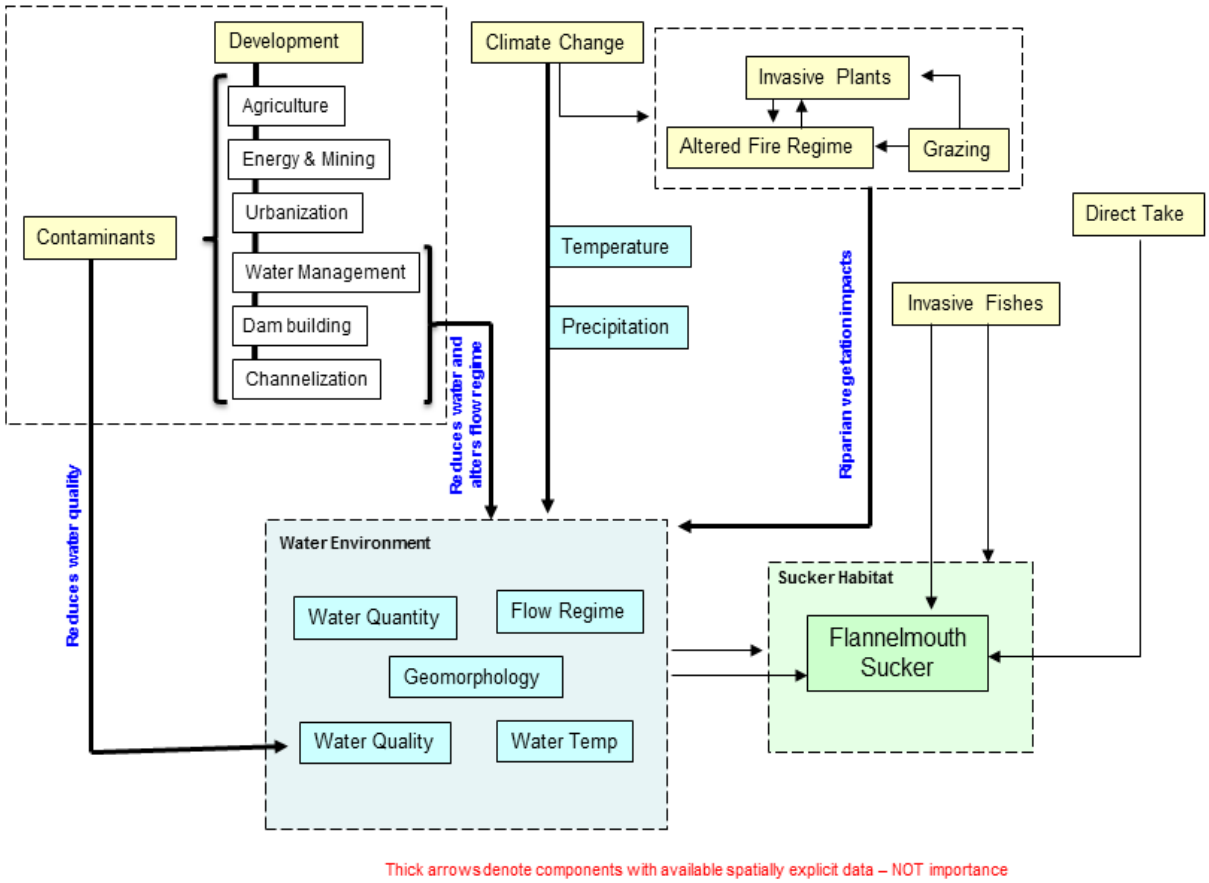
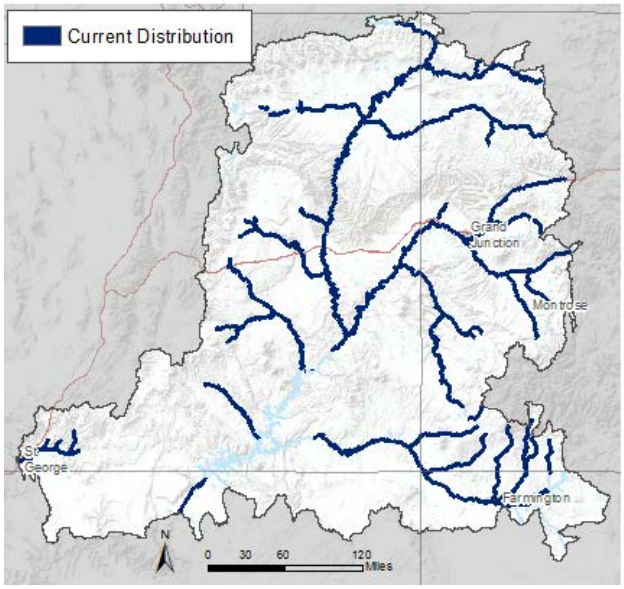
Beyers, D. W., C. Sodergren, J. M. Bundy, and K. R. Bestgen. 2001. Habitat use and movement of bluehead sucker, flannelmouth sucker, and roundtail chub in the Colorado River. Contribution 121, Larval Fish Laboratory, Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, Colorado. vi + 32 pp.

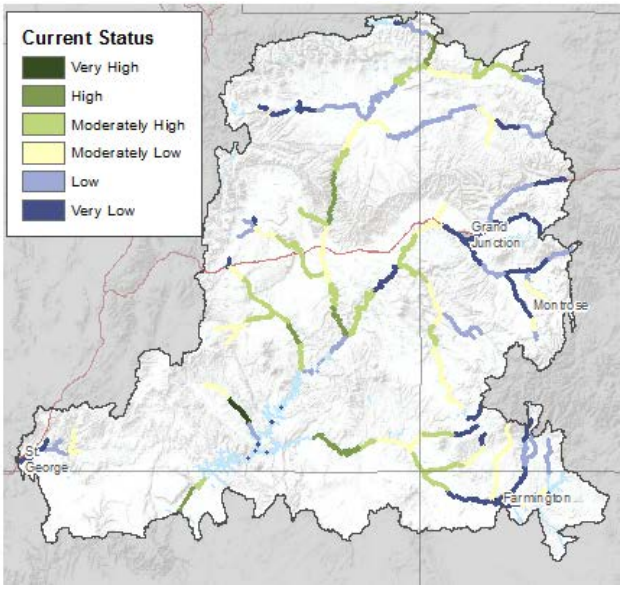
Bezzerides, N., and K. Bestgen. 2002. Status review of roundtail chub Gila robusta, flannelmouth sucker Catostomus latipinnis, and bluehead sucker Catostomus discobolus in the Colorado River basin. Contribution 118, Larval Fish Laboratory, Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, Colorado. x + 139 pp.

Flannelmouth Sucker Conceptual Model



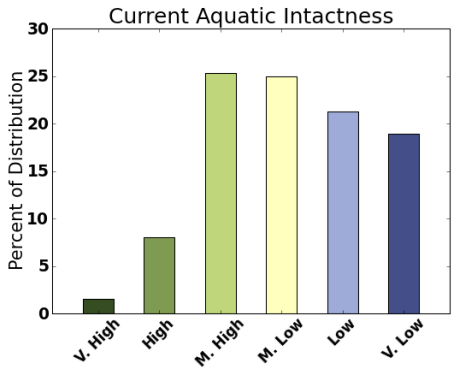
MQ D1. What are the current distribution and status of flannelmouth sucker (and historic occupied habitat if available), seasonal and breeding habitat, and movement corridors (as applicable)?



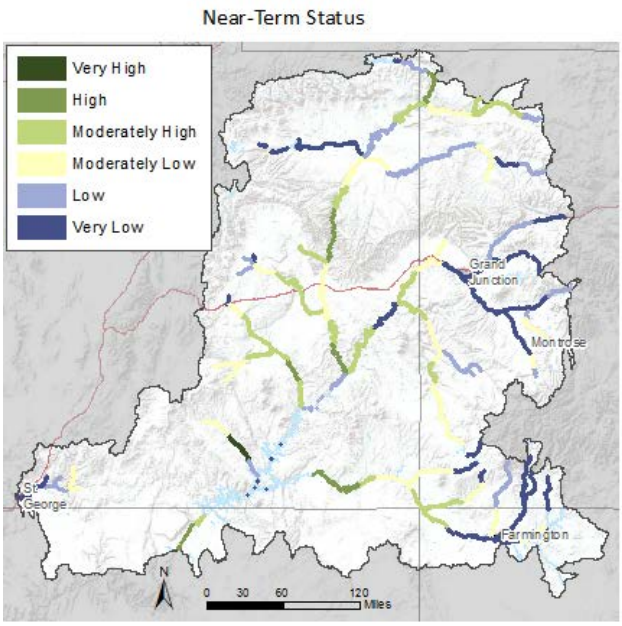


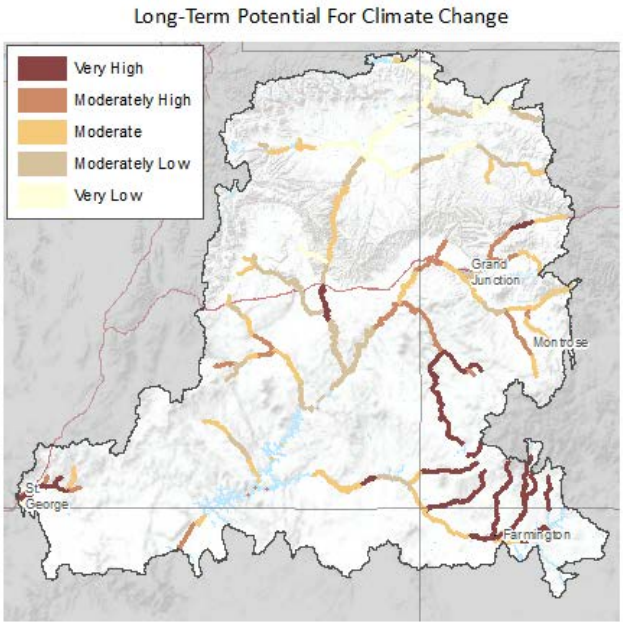
Data Sources:

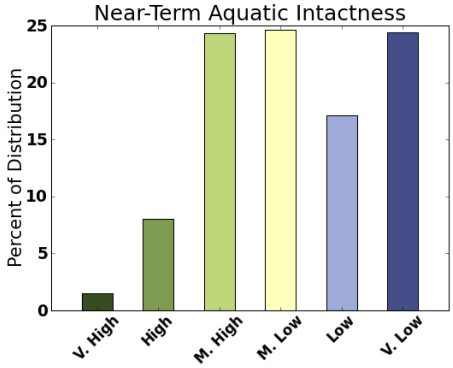
Selected features from NHD based on heritage occurrence data and survey points

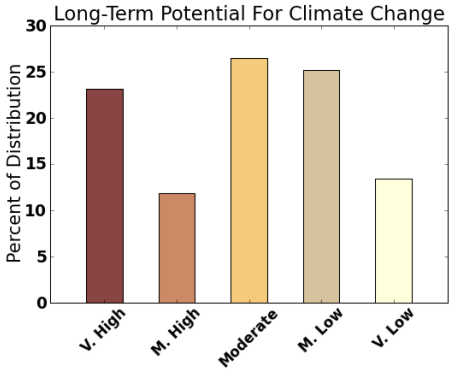


MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

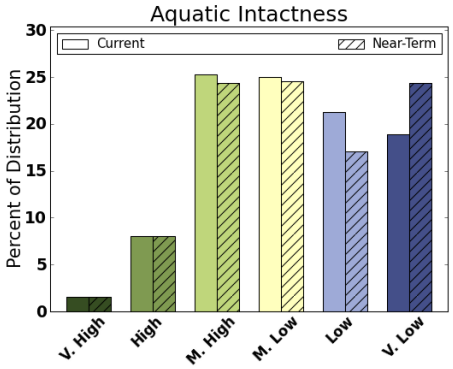








Current & Near-term Intactness



Current (solid color) and Near-term (cross-hatched) Intactness

Razorback Sucker – *Xyrauchen texanus*

The razorback sucker (also known as the humpback sucker or buffalo fish) was federally listed in 1991 as an endangered species (USFWS 1991, also IUCN Red-listed as Endangered, IUCN 2010). Endemic to and historically distributed throughout the Colorado and Gila River basins (Minckley et al. 1991, NatureServe 2010, Schooley and Marsh 2007), the species has been nearly extirpated from Arizona and now occurs naturally only in lakes Mohave and Mead (impoundments) and in small populations in the Yampa and Green rivers of Utah and Colorado (Lanigan and Tyus 1989, Minckley et al. 1991, Mueller et al. 2000, Tyus and Karp 1989). Hatchery-reared fish have been reintroduced into Lake Havasu, the Colorado River below Parker Dam, and the Verde River (Douglas and Marsh 1998, Modde et al. 1996, Minckley et al. 1991, Tyus and Karp 1989). Critical habitat was designated by the USFWS in 1994 and a Recovery Plan finalized by the USFWS in 1998. General habitat types currently utilized by razorback suckers include wetlands, permanent rivers, streams, creeks and lakes, artificial impoundments, and irrigation channels.

Given the relative interest in razorback sucker restoration in recent decades, there is a surprising paucity of quantitative razorback sucker models found in primary literature. However, numerous relationships between razorback suckers and various biological and physical parameters have been established in the literature. Some of these relationships have been incorporated into the conceptual and application/method models used in this REA.

Primary threats to the razorback sucker include interactions with non-native fishes and human alteration of riverine habitats. Dam operations continue to limit razorback sucker sustainability by restricting the amount of suitable habitat available for the species during multiple life stages. Alterations caused by dam-building and subsequent flow management trigger detrimental changes in timing, magnitude and duration of winter and spring flows, altered river temperatures (Clarkson and Childs 2000), reduced flooding (USFWS 1990, Hedrick et al. 2009), and abatement of sedimentation (Johnson and Hines 1999) and gravel bar accretion. Channelization for agricultural or highway projects further reduces the amount of gravel bar and slow backwater areas necessary for nesting and fry nurseries. Detailed changes to razorback sucker habitats are described in the USFWS proposal to federally list the species (1990) and in the recovery plan (USFWS 1998).

Recruitment of larvae and young has been very low (or absent), despite protracted hatchery intervention practices and costly habitat restoration projects (Hedrick et al. 2009). Besides a lack of recruitment from loss of backwater habitat, recruitment is also limited by the pervasiveness of predatory non-native fishes (Clarkson et al 2005, Jelks et al. 2008, Johnson et al. 1993, Marsh et al. 2003; see Table 1 in USFWS 1998 for a more detailed list). The presence of nonnative, invasive fish species can directly and indirectly influence razorback suckers by limiting the space available for razorback sucker to occupy (indirect), competing for razorback sucker food sources (prey; indirect), preying on eggs, larvae, and juvenile razorback suckers (direct), or exhibiting aggressive behavior toward razorback suckers (direct). Lenon et al. (2002) also noted that competition with and predation by non-native crayfishes may be a problem in some areas. Hybridization with other sucker species also occurs (Tyus and Karp 1989, Minckley et al. 1991).

In addition to human development and pressures from invasive species, climate change may have an additional impact on flow regimes that are so important to the razorback sucker. Climate change will have a direct impact on the type, amount, and timing of precipitation and spring runoff. Because stream flows are

closely related to precipitation patterns in the region (e.g., Christensen and Lettenmaier 2007, Hoerling et al. 2009), climate change will affect the aquatic environment through influencing the flow regimes, water quality, and water quantity, all of which are important drivers of razorback sucker populations.

Attributes and Indicators

Attribute	Indicator	Indicator Rating				
		Poor	Fair	Good	Very Good	Citation
Habitat	Water body	irrigation canals	small rivers, reservoirs	medium rivers	large rivers	Valdez et al. (2002)
Breeding habitat	River feature	rapids, riffles	slow runs, eddies	pools, off-channel flooded pits	backwaters	Osmundson et al. (1995)
Habitat	Summer water temperature	>29 degrees C or <12 degrees C	26.9–29 degrees C or 12-17.5 degrees C	24.8–26.9 degrees C or 17.5-22.9 degrees C	22.9–24.8 degrees C	Buckley and Pimentel (1983)

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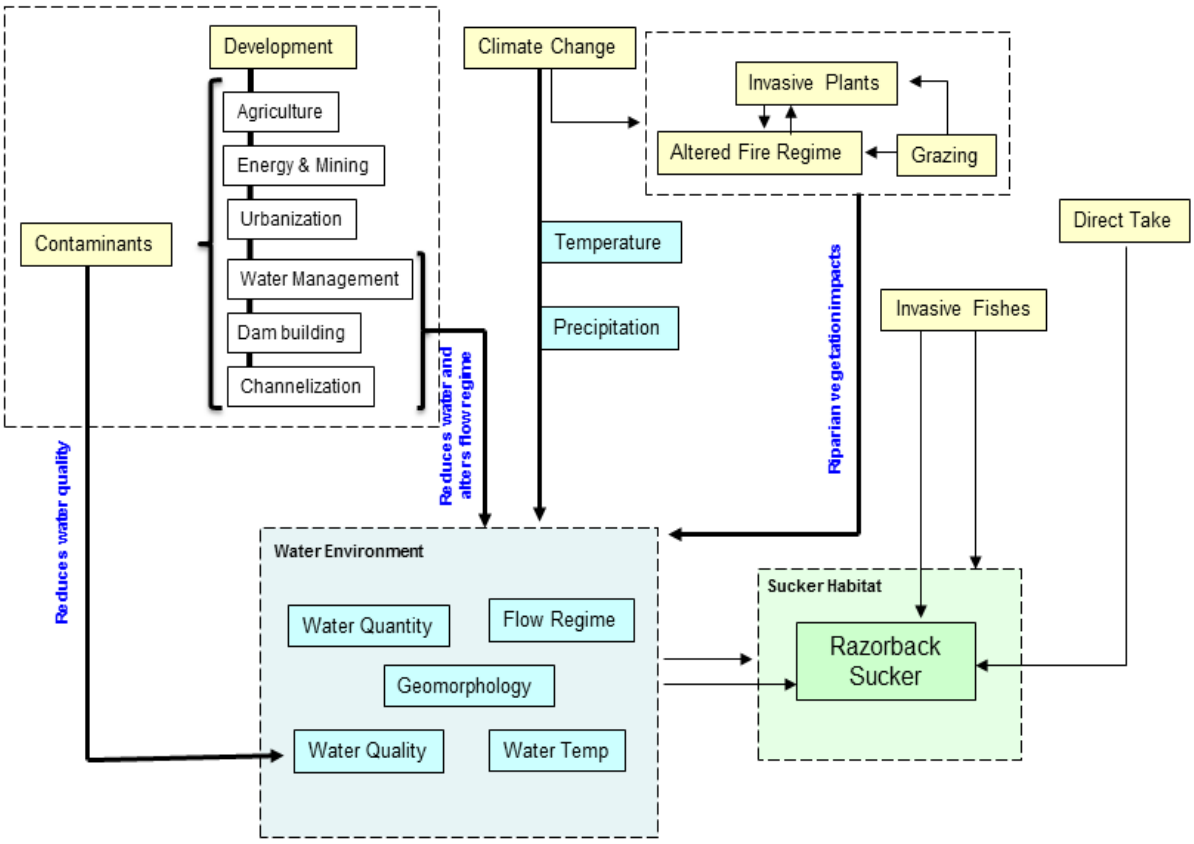
Razorback Sucker Conceptual Model



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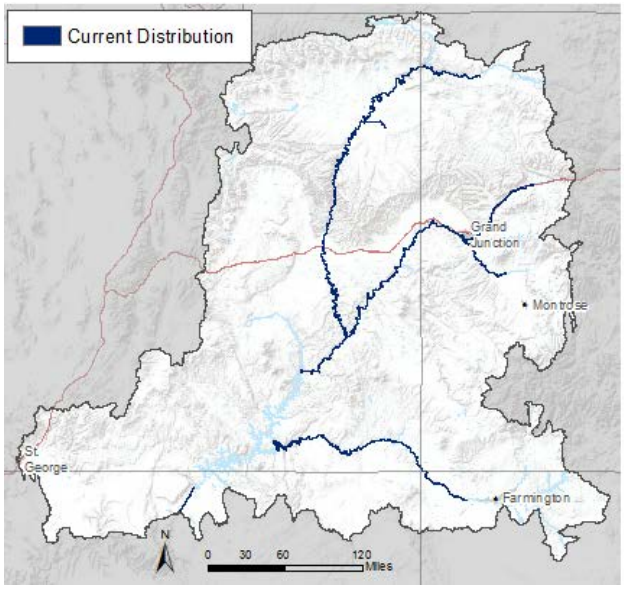
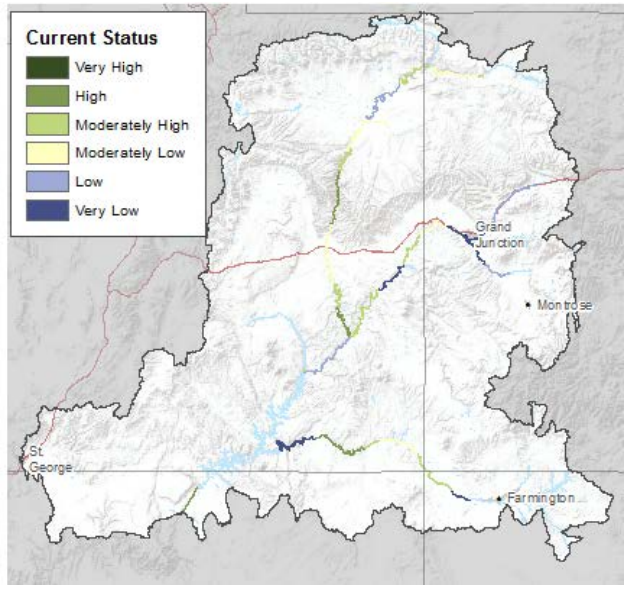
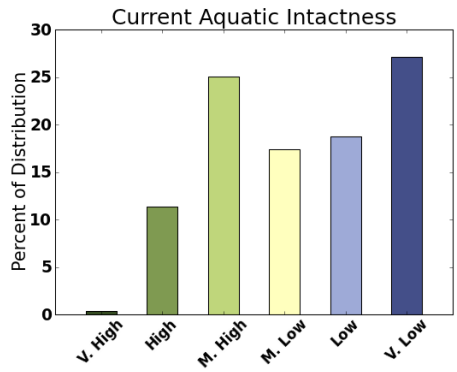




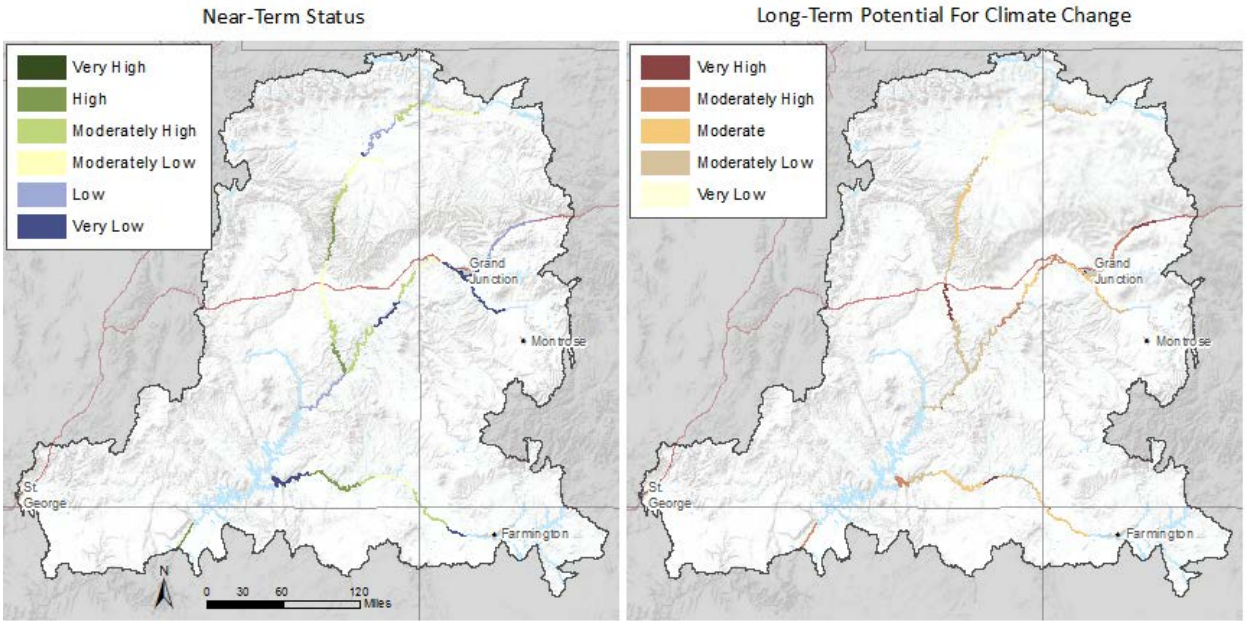
Data Sources:

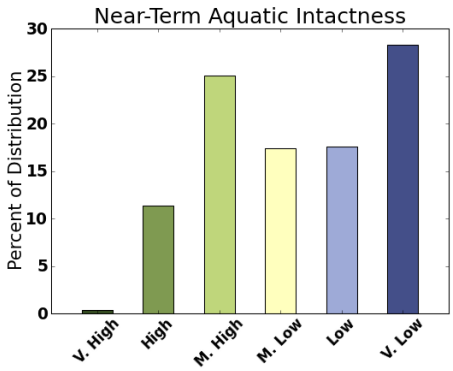
USFWS critical habitat

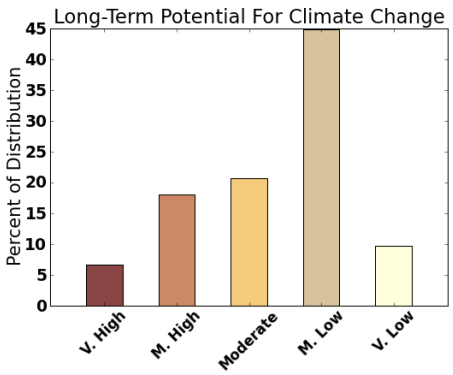


MQ D6. What sites and movement corridors are vulnerable to change agents in the near-term horizon, 2025 (development, fire, invasive species) and long-term change horizon, 2060 (climate change)?

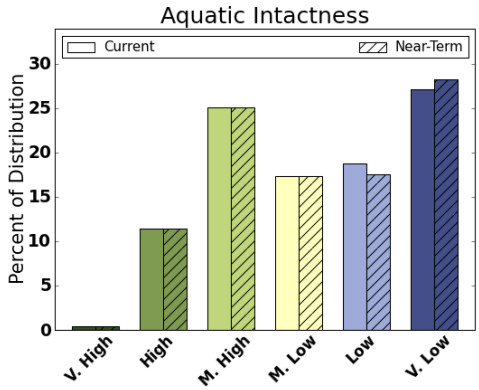
Razorback Sucker Potential for Change







Current & Near-term Intactness

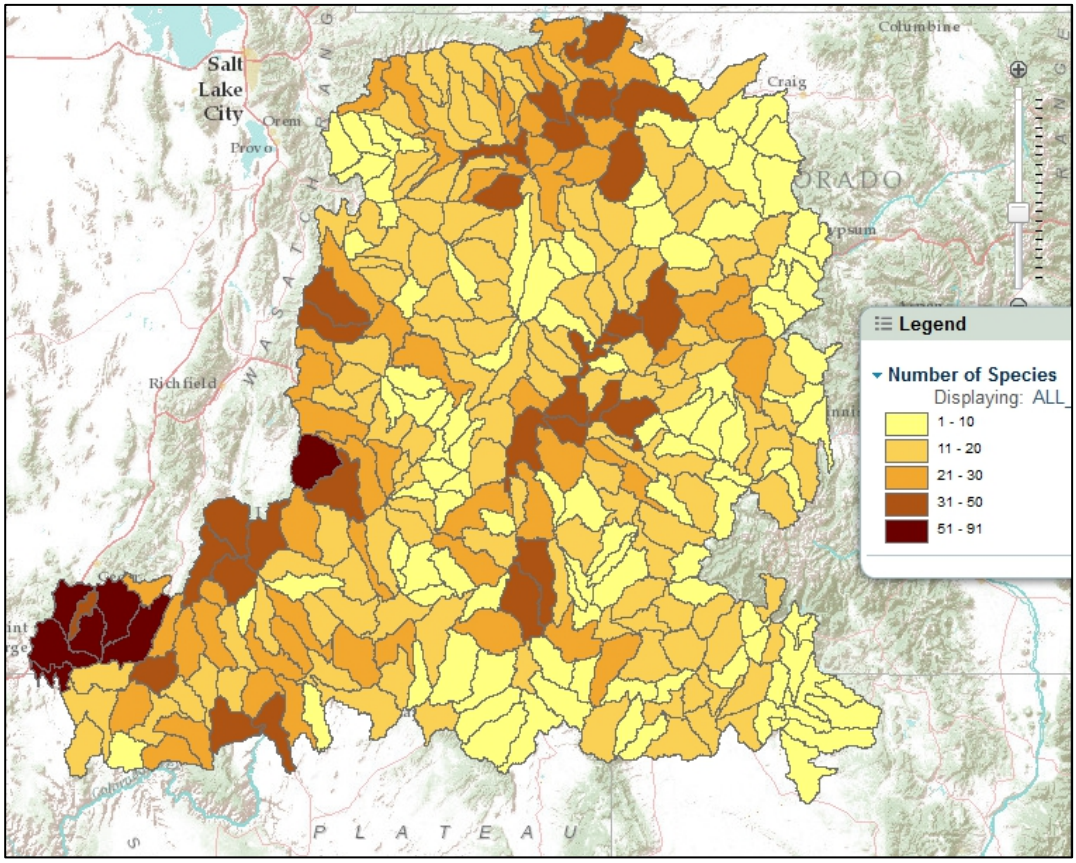


Current (solid color) and Near-term (cross-hatched) Intactness

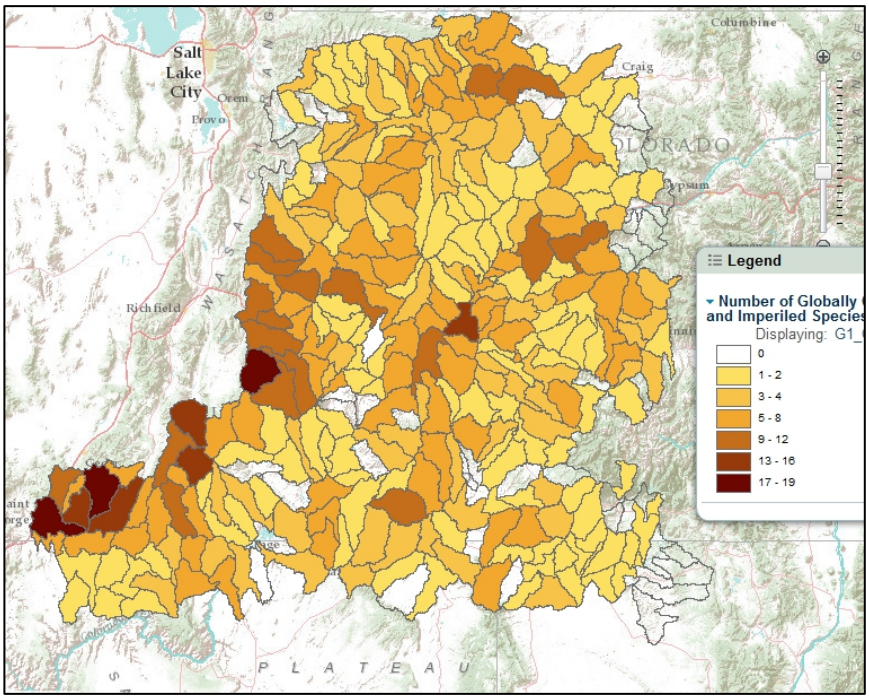
NatureServe Element Occurrence Data

BLM acquired species element occurrence data NatureServe Natural Heritage data enumerated by HUC for the REA. From the data, which was organized by 5th level HUC, four different map-based products were generated, including (1) number of all species, (2) number of globally critically imperiled and imperiled species (G1 and G2 species), (3) number of globally critically imperiled, imperiled, and vulnerable species (G1-G3 species), and (4) number of USFWS listed threatened and endangered species.

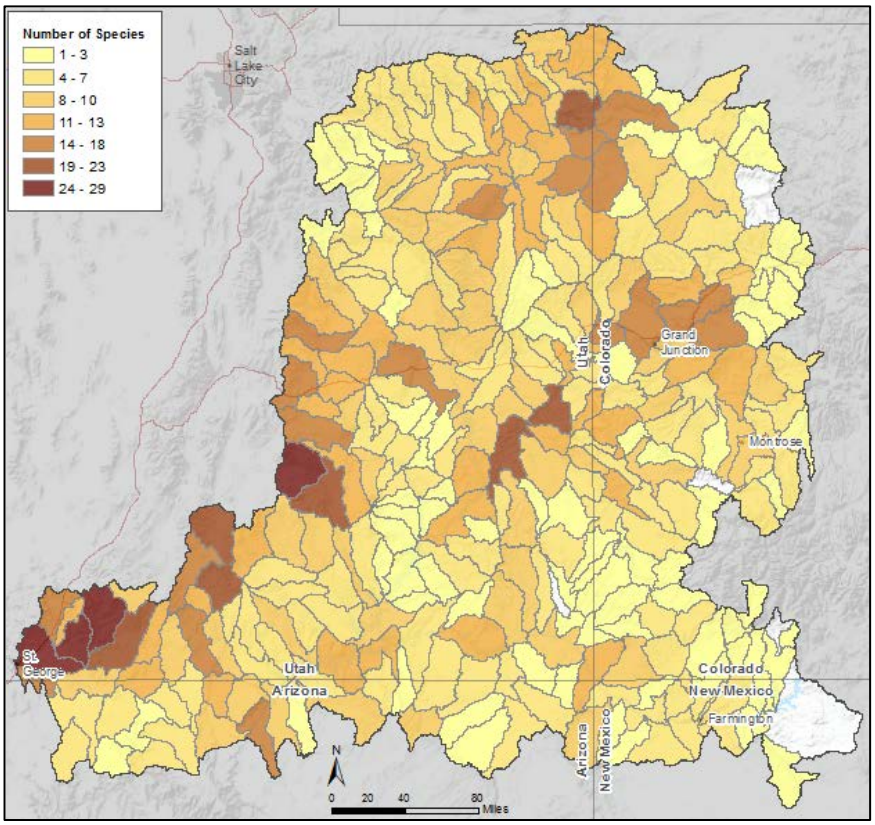
Number of All Species



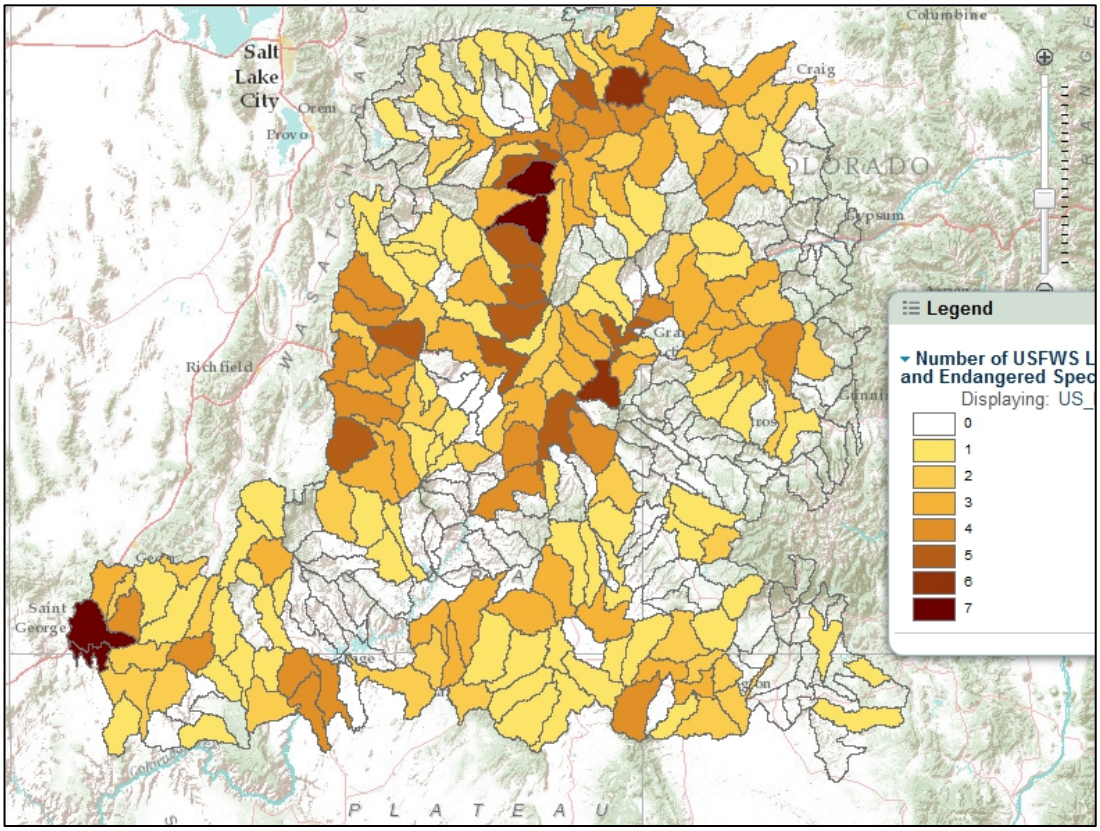
Number of G1 and G2 Species



Number of G1 – G3 Species



Number of USFWS Listed Species



Process

General landscape connectivity was assessed using a slightly modified version of a process developed for the State of California and presented below (Spencer et al. 2010). Procedure is outlined below with modifications highlighted in orange.

DATA BASIN SOURCES:

Easements

http://app.databasin.org/app/pages/datasetPage.jsp?id=99cae70ec0c94a16bc24fc704c2237fa

PAD-US 1.1

http://app.databasin.org/app/pages/datasetPage.jsp?id=305f2e83e5494609a2cfedaf3823e26c

BLM ground transportation

http://app.databasin.org/app/pages/datasetPage.jsp?id=7c3a671108b84051b74285795852e026

Fragmentation Classes

http://app.databasin.org/app/pages/datasetPage.jsp?id=c404f0f94740485d83c9b38abf8e3c48

LANDFIRE Existing veg type

http://app.databasin.org/app/pages/datasetPage.jsp?id=a124e55c66b24a339a8b7f6e4fa74ad8

REFERENCE:

Spencer, W.D., P. Beier, K. Penrod, K. Winters, C. Paulman, H. Rustigian-Romsos, J. Strittholt, M. Parisi, and A. Pettler. 2010. California Essential Habitat Connectivity Project: A Strategy for Conserving a Connected California. Prepared for California Department of Transportation, California Department of Fish and Game, and Federal Highways Administration.

This document and companion data files are available online at:
http://www.dot.ca.gov/hq/env/bio/program_efforts.htm
http://www.dfg.ca.gov/habcon
http://www.scwildlands.org

PROCESS:

A. Natural Landscape Blocks:

1. Reclassified Fragmentation Classes so that natural (1) had 1 but all others = 0 (new grid = natural)
2. Converted to polygon, calculated areas
3. Selected polygons with grid code = 1 and area >= 5000 acres and exported to new shapefile.

4. Converted output from 3 to grid. Expanded 17 cells (buffered the natural polygons by 510m). Converted back to shapefile.
5. Aggregated natural polygons ge 5000 acres within 1.2 km of each other: *spatial join with un-buffered polys ge 5000 acres(output from 3) as target and buffered polygons (output from 4) as join features to assign buffered ids to original polygons, dissolved on that id.*
6. Selected from BLM ground transportation and exported to new shapefile:
   CFF code: 103 highway, secondary, class 2
   MTFCC: S1100 Primary road; S1200 secondary road
   CFCC: A21 and A25 primary highways; A31 Secondary state and county highways
   This included some roads that clearly are not primary/secondary and omitted some sections of primary and secondary. Compared with Esri major roads (fcc interstate, primary us/state hwy, and secondary state/county) and added missing sections from BLM roads and deleted erroneous roads. Added all or sections of: CR 201, CR 25, SR 29, SR 122, SR 123, SR 124, SR264, SR 35, SR 44, SR 87, SR 96, SR 121, SR 12, SR 276, SR 163, SR 575, SR 330, SR 62, SR 90, SR 45, US 191.
7. Buffered output from 6 50m (**blm_prim_sec2_buf50.shp**)
8. Identity Output from 7 with output from 5, selected where outside the road buffer and exported. Exploded multipart into single part features. Assigned new id's to blocks broken up by primary/secondary road buffers. Dissolved on new ids. Calculated areas. Selected area ge 10000 acres = final blocks. (**final_blocks_ge_10k_acres.shp**)
   102 blocks ge 10000 acres
9. Used Feature to Point tool to create file of block centroids for connecting block pairs with least cost corridor modeling ().
10. Blocks contained many small islands of 'non-natural' habitat. For better visual display, eliminated these islands (dissolved into surrounding block; **blocks.shp**).

    Modifications: Selected natural vegetation from fragmentation classes. Converted to polygon and selected polygons greater than 5,000 acres (blocks1). Converted back to raster, expanded by 510 meters (buffer tool did not work) and converted back to polygon. Erased polygons using 50m buffer of road to create block neighborhoods. Used spatial join back to blocks1 to group blocks by neighborhood. Then selected blocks greater than 10,000 acres.

B. **<u>Sticks:</u>** Pairs of blocks to be connected are first represented as line segments or 'sticks' – placeholders showing which blocks need to be connected according to the following rules:

1. Each Natural Landscape Block was connected to its nearest neighbor (where nearness was defined edge to edge).
2. Each Natural Landscape Block was also connected to its second nearest neighbor if the second neighbor was < 15 km away (edge to edge)

Least cost corridor modeling is not necessary or appropriate for Road Fragmentation Areas, (where Natural Landscape Blocks are separated only by a road). Road fragmentation sticks were used to identify these areas: where the facing edges of two Natural Landscape Blocks were separated only by a road that may represent a barrier to wildlife movement. Rule = separated by road but within 1km = no corridor modeled (road stick). (For Roads - used output from Blocks step 6 above).

Created 89 corridor sticks and 52 road fragmentation sticks.

3. A group of two or more Natural Landscape Blocks connected by sticks is called a *constellation*. Once

all constellations were created by the above rules, each constellation was connected to its nearest neighboring constellation, if it was not already connected, starting with the smallest constellation. This added 1 corridor stick.

4. Collapsing corridor sticks: Where multiple sticks connected three or more Natural Landscape Blocks in a fairly linear configuration ("stepping stones"), they were consolidated by user judgment as one stick spanning the entire group between the centroids of the two farthest blocks, unless a least-cost corridor model between the two farthest blocks would be unlikely to connect all blocks in the group (in which case sticks were still drawn independently between the nearest-neighbor pairs as described above).

Resulted in 62 corridors (**sticks_corridors_collapsed.shp**) and 52 road fragmentation sticks (**sticks_rdfrag.shp**).

Modifications: Connected neighboring blocks using road sticks where they were only separated by a 500m buffer of major roads, or corridor stick if they were generally less than 15km apart edge-to-edge. Distances were obtained from the freehand measuring tool in ArcMap. In certain cases where least cost corridor modeling is still desirable, we connected blocks that were somewhat further part. For example, a block isolated from all neighbors by more than 15km was connected up to its nearest one or more neighbors (if multiple neighbors were roughly equidistant).

C. <u>Cost surface:</u>

1. Landcover Cost:
   a. Assigned costs to LANDFIRE Existing veg type following CALTRANS (see **landcover_cost.dbf**) and created grid lc_cost.
   b. Transportation: Primary and secondary roads (from blocks process above) were buffered by 25 m before conversion to a 30-m grid prim_sec_rd_c. Converted entire BLM ground transport to grid rds_cost. The grids of the 2 road types were combined into one, giving priority to primary/secondary roads (cost = 20) they overlapped other roads (cost = 18) using conditional: Con prim_sec_rd_c 20 rds_cost all_rds ""VALUE" = 20"
   c. The resulting transportation grid (rds_cost) was merged into the landcover grid, with higher cost overriding lower cost (combine lc_cost and rds_cost to create comb_rds_lc). Added f-cost to comb_rds_lc.vat. Selected rds_cost > lc_cost and calc f-cost = rds_cost. Switch selection and calc f-cost = lc_cost. Reclassify com_rds_lc.vat on f-cost to create lc_rd_cost.

2. Protection Status Cost:
   a. Added field 'new_gap' to PAD-US1.1. Assigned new_code per table below – with following exceptions gap_status = 'unknown' = new_code of 4, category = easements = new_gap of 2. Converted to grid on new_gap.

Resistance	GAP Protection Status
0	GAP1
1	GAP2
2	Conservation Easements
3	GAP3
4	GAP4

b. Converted Easements to grid with code =10 (added attribute 'code' to shapefile, calculated = 10, converted to grid on 'code'.
c. Added to output from a and reclassified: where gap status = 3 or 4 and easements are present (summed grid = 13 or 14) in easements database – calculated gapcost = 2; if overlap between gap status = 1 or 2 or PAD easements and easements, left gap cost as is (0, 1, 2).

3. Total Cost: Raster calculator: 1+ outputs from 1c and 2c . The final resistance surface was a 30-m grid with pixel scores ranging from 1 to 25 (Resistance = Landcover Score + Protection Score +1; **total_cost** (grid)).

D. <u>Least Cost Corridor Modeling:</u>

Least-cost corridor analysis was conducted between the centroids of each pair of Natural Landscape Blocks to be connected.

The analysis extent was defined by creating a 5-km buffer around the feature envelope of both Natural Landscape Blocks in a pair (select the pair of blocks for a corridor, 'feature envelope to polygon', calculate new id as 1, dissolve on new id, 'feature envelope to polygon' on dissolved, buffer envelope 5 km, convert to raster).

The cost-weighted distance was calculated from each of the two centroids for each pixel in the analysis extent. The two centroid-specific outputs were then summed to define the least-cost surface (see **corridor.aml**).

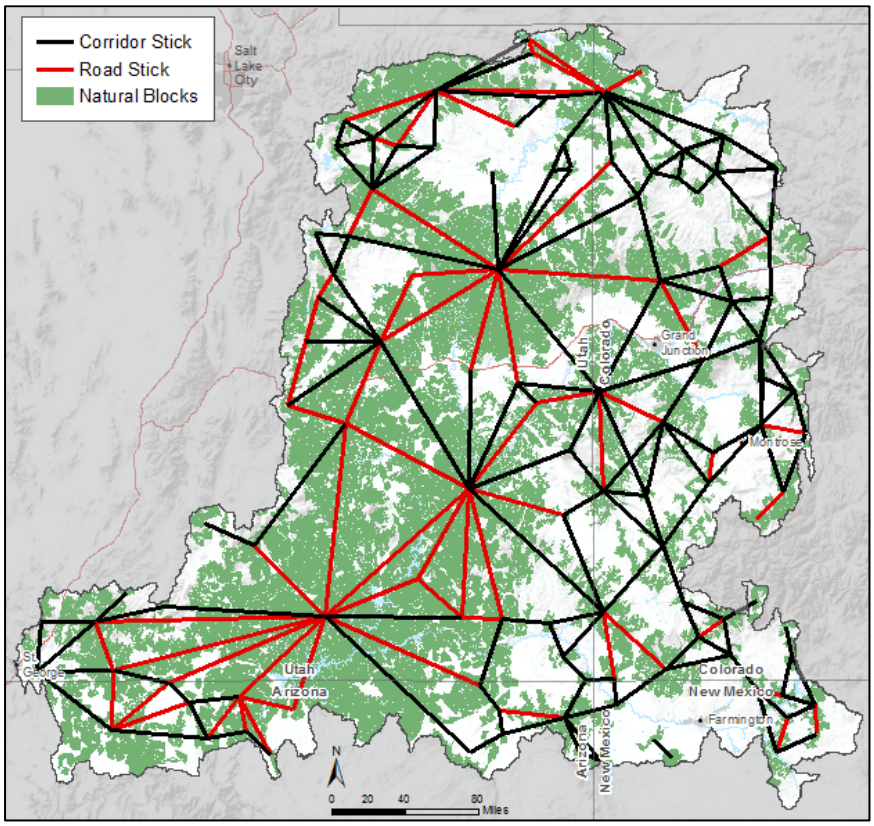
The continuous surface output was then sliced into equal-interval percentages to define the least-cost corridor. The top 5% least-cost corridor (i.e., the lowest-cost 5% of pixel values in the analysis window) was used to define the Essential Connectivity Areas (see **corridor2.aml**; **corridors.shp).**

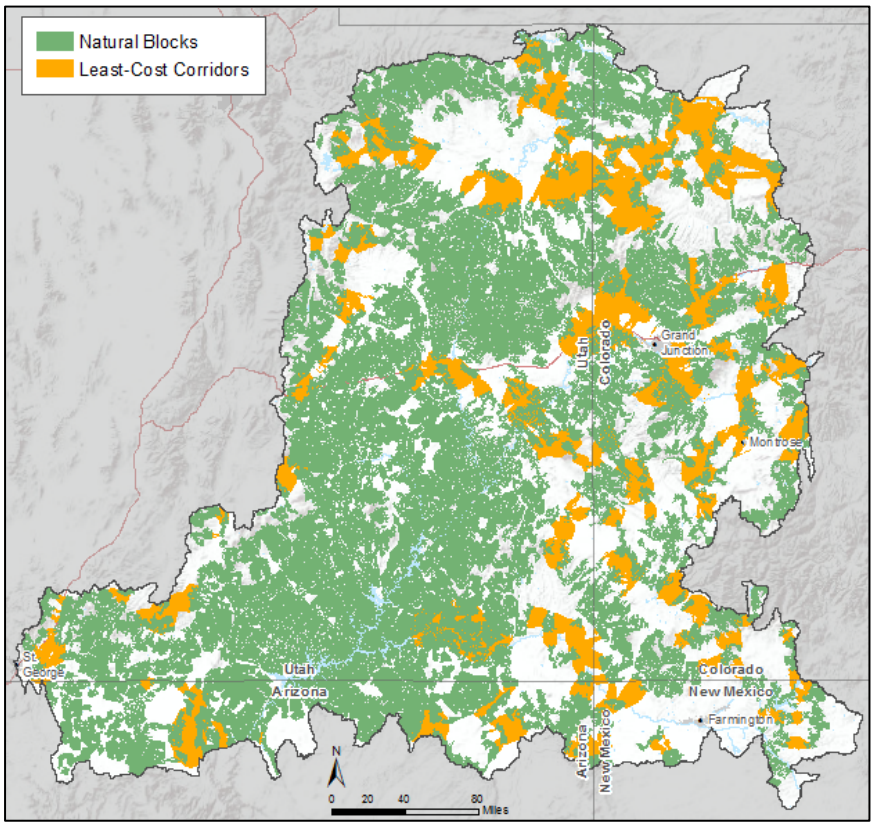
Modifications: For each pair of blocks connected by a corridor stick (road sticks were excluded from this analysis), we selected a 5 kilometer neighborhood around the extent of the pair for least-cost modeling. We clipped the cost surface to this extent, and then used the standard ArcGIS tool "Cost Distance" for each block in the pair. The results from each of these cost paths were then input to the "Corridor" ArcGIS tool. The corridor was then sliced into 20 equal width classes, and the lowest 5% of the cost corridor was extracted. This was then mosaicked across all pairs of blocks and converted to polygons.

The corridors were modeled between edges of blocks in the pair. Due to the way that the cost distance and corridor tools operate, least cost corridors did overlap with the natural landscape blocks. For display, it is recommended to overlay the blocks on top of this layer.

<u>Display note:</u>
Because each analysis was run from centroid to centroid, instead of from edge to edge of the Natural Landscape Block pair, a portion of the least-cost corridor output occurred within each Natural Landscape Block. To best display the Essential Connectivity Areas on a map, arrange in this order, top to bottom: sticks_corridors; sticks_rdfrag; blocks; corridors.

Results


Corridor Stick
Road Stick
Natural Blocks
Salt Lake City
Grand Junction
Montrose
Farmington
Utah
Colorado
Arizona
New Mexico
St. George
N
0 20 40 80
Miles


Natural Blocks
Least-Cost Corridors
Grand Junction
Montrose
Farmington
Utah
Colorado
Arizona
New Mexico
St. George
N
0 20 40 80
Miles