Sensitive Species Assessment of Vulnerability to Climate Change on San Juan Public Lands, Colorado

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INTRODUCTION

This report was prepared by Mountain Studies Institute for Bureau of Land Management, Tres Rios Field Office and San Juan National Forest, to assess the relative impact of predicted shifts associated with climate change on selected sensitive terrestrial vertebrate species utilizing the System for Assessing the Vulnerability of Species (SAVS v.2.0) tool published by the U.S. Forest Service. This report presents the methodology used for the analysis, brief introduction to climate variability for southwest Colorado region and the projected habitat responses for key ecosystems, the results of SAVS analysis for each species evaluated, and a discussion of the rationale and species life history supporting the SAVS scores from the analysis.

The climate in southwestern Colorado has shown a 2°F increase in annual mean temperature over the past three decades, a trend that parallels the statewide climate (Ray et al. 2008). Warmer temperatures and drier conditions can have a host of impacts on ecosystems and wildlife, some of which are already being observed. The impacts of climate change on wildlife species is of growing concern to citizens, scientists, and land managers. Although many wildlife species have evolved to deal with a variable climate, the rate of global warming is shifting climate regimes outside of their historic range of variability. Predicting how species will respond to these changes is of great importance if land managers want to maintain biodiversity and preserve vulnerable species. The Bureau of Land Management (BLM) Tres Rios Field Office (TRFO) and San Juan National Forest (SJNF) have identified over 70 sensitive species within their management areas, including birds, fish, reptiles, amphibians, mammals, insects, and plants. Species response to climate change will vary in both direction (positive or negative response) and magnitude (degree to which a species is impacted). The purpose of this report is to highlight those sensitive species that may be the most vulnerable to a changing climate and to help land managers focus management activities to help maintain habitat and reduce stressors for those species that are vulnerable.

Predicting wildlife species response to climate change in southwestern Colorado is a challenging task because the magnitude of climate change is still uncertain and climate effects are hard to predict in mountainous terrain. Characteristics associated with exposure, sensitivity, and adaptive capacity can be used as indicators (Glick and Stein 2011, IPCC 2007). In the context of wildlife, exposure describes the character, magnitude and rate of change that a species will experience, sensitivity is the degree to which a species can tolerate those changes, and adaptive capacity is the ability of a species to reduce exposure or sensitivity (Glick and Stein 2011). Our goal was to perform a qualitative vulnerability assessment for a number of designated sensitive species of the San Jan National Forest and Tres Rios Field Office of the BLM. We utilized the System for Assessing Vulnerability of Species (SAVS v.2.0), a management tool developed by the U.S. Forest Service (USFS) Rocky Mountain Research Station (RMRS) (Bayne et al 2011). This tool provides a relative score of either vulnerability or resilience to climate change. The tool does not make specific predictions of how a species will respond to changing conditions; rather, it provides insight into which species might be most affected by change and therefore may require increased attention or specific management actions to preserve populations.

METHODS

Methodology: System for Assessing Vulnerability of Species

The System for Assessing the Vulnerability of Species (SAVS v.2.0, available online at http://www.fs.fed.us/rm/grassland-shrubland-desert/products/species-vulnerability) uses a questionnaire system to translate the anticipated response of terrestrial vertebrate species to climate change into a relative score that indicates vulnerability or resilience. The questions and multiple choice responses are divided into four broad categories: habitat, physiology, phenology, and biotic interaction. SAVS questions were developed using predictive criteria that indicates a species response to climate change. For example, under the habitat category, one question asks "What is the potential for this species to disperse?" If a species is highly mobile, it will presumably have a greater capacity to relocate in response to habitat shifts and would be considered more resilient than a species whose dispersal capabilities are limited by physical, behavioral, or physiological barriers. The full set of questions, responses, and associated scores can be found in Appendix A. Information from published literature, online resources, agency documents specific to the target region, and consultation with local specialists were used to complete the questionnaire.

Responses to the questionnaire generate a cumulative score which indicates a species' relative vulnerability (positive score, maximum of 20) or resilience (negative score, minimum of -20) to climate change (Appendix B). This creates a standard for comparison among species in a target region, in this case, the TRFO/SJNF management area. Scores should not be considered quantitative; rather, they provide a qualitative ranking of vulnerability.

This assessment process considers only factors related to predicted changes associated with climate change. It does not consider other factors, such as current population status, that could work in concert with climate-related shifts. For more detailed information on the predictive criteria, scoring methodology and rationale behind the SAVS tool, see "A System for Assessing Vulnerability of Species to Climate Change" (Bagne et al 2011), available online at www.fs.fed.us/rm/pubs/rmrs_gtr257.html.

Evaluation of Uncertainty

It is important to recognize the limitations and difficulties inherent in efforts to predict species vulnerability or resilience to climate change and to view the results of this assessment in the context of that uncertainty. Here, we are concerned with two levels of uncertainty: 1) limitations of climate scenario predictions, and 2) difficulty predicting species response to climate changes. Table 1, which summarizes biotic response to climate change for vegetation communities, addresses uncertainty by indicating a qualitative level of confidence (low, moderate, or high) based upon agreement of climate models and published studies or on the general availability of such information. The SAVS tool similarly addresses uncertainty, so that responses to each question are rated as either having adequate information or having information that is not adequate or conflicting. The uncertainty responses for each question are calculated as a percentage and perhaps should be viewed as a confidence interval indicating the degree to which the vulnerability score could potentially deviate higher or lower from the indicated score. It should be emphasized that a high uncertainty score does not negate the inference of the vulnerability rating. Rather, it indicates areas where additional research may be necessary or where a more complex assessment may be required to more confidently predict the vulnerability of an individual species to climate change.

Species Selected for Assessment

Through consultation with TRFO/SJNF wildlife biologists, a total of 41 species were initially identified for possible evaluation. Ultimately, 32 species were fully evaluated through this assessment and are included in this report. Based on guiding recommendations offered in the assessment protocol (Bagne et al 2011), some species were omitted from evaluation immediately. Long-distance migrants that only spend a small portion of their annual cycle in the target area are not good candidates for this particular assessment tool. These species are unlikely to be highly influenced by local conditions in the SJNF/TRFO or would not be considered a priority for management. This eliminated the white-face ibis, northern harrier, and short-eared owl. The western yellow-billed cuckoo was eliminated because its presence in the region has not been confirmed. Species with a lack of information, either on their life history or how climate change will affect their habitat are also not good candidates for evaluation because there would be high uncertainty: this eliminated the American bittern, black tern, ferruginous hawk, Allen's big-eared bat, and big-free-tailed bat. Appendix C provides a full list of the species that were considered for this assessment and rationale for inclusion or exclusion from the study.

CLIMATE VARIABILITY AND CHANGE: OBSERVATIONS AND PROJECTIONS

Mountain Studies Institute, in cooperation with TRFO/SJNF and other local organizations, has been working to summarize the impacts of climate change in southwestern Colorado. The information presented here incorporates findings on changes in temperature and precipitation, hydrology, plant phenology, vegetation ranges, and disturbances such as wildfire. Projections of future climate scenarios are based on the work of authorities such as the Intergovernmental Panel on Climate Change (IPCC), U.S. Climate Change Science Program, Western Water Assessment, and many individual scientists and institutions. Climate models represent a multitude of interactions and feedbacks among land, water, oceans, and atmosphere as numerical representations at different scales. Given the complexity of the system being modeled, projected impacts from climate change should not be viewed as explicit predictions, but as a plausible future condition within a range of scenarios. The information summarized here was initially compiled by the Mountain Studies Institute in the more comprehensive report: "Climate Change Assessment for the San Juan Mountain Regions, Southwestern Colorado, USA: A Review of Scientific Literature" (Nydick et al. 2012).

Impacts of climate change on wildlife can be viewed as direct (e.g. heat or drought stress, loss of habitat, alteration in resource availability or quality) or indirect (e.g. alteration of environmental cues such as snowmelt, increase in disease or pest outbreaks, shifts in timing of critical events such as pollination). The following information sheds light on the range of conditions that sensitive species may encounter in the future. As much as possible, the information is specific to southwestern Colorado and can be applied to the TRFO/SJNF management area.

Physical Conditions

Temperature and Precipitation

Southwestern Colorado has seen rapid warming since the mid-1990's, with an observed increase of about 1°C (Rangwala and Miller 2010). This rate of warming is the same as for western Colorado, but greater than the western United States, or any other region of the United States except Alaska. Temperatures are likely to increase by an additional 0.8°C to 1.9°C by 2025 and 1.4°C to 3.1°C by 2050 (Ray et al. 2008). Rangwala et al (2012) also project that minimum and maximum temperatures will increase by more than 2°C by mid-21st century, with large increases in winter minimum temperatures and summer maximum temperatures. The climate of the mountains is projected to migrate upward in elevation and the climate of the desert Southwest to progress up into the valleys (Figure 7, Ray et al. 2008). As a result of increased temperatures, the rate at which water is evaporated from water bodies, soil, and vegetation will very likely increase. This will make the environment drier and reduce the growing capacity of the land, even if precipitation stays the same.

The San Juan Mountain region is difficult to model for precipitation because of complex topography and natural variability in precipitation patterns. Due to this complexity projections of change for the region are not in complete consensus. Some models project more variable precipitation patterns with a greater frequency of extreme events. Some studies suggest only slight decreases in annual precipitation, while others project an increase in the winter (Ray et al 2008). Even if the amount of annual precipitation remains relatively constant, more precipitation in the lower elevations may fall as rain, compared to current conditions

Snowpack and Streamflow

Warming temperatures are projected to have significant effects on snowpack, timing of snowmelt, and streamflow even without a decrease in precipitation. From 1978 to 2004, snowmelt shifted about two weeks earlier in western Colorado and has shifted even earlier in the Pacific Northwest and Northern California (Clow 2010). In Colorado, dust deposition is also a contributor to early snowmelt (Painter et al. 2007). A dominant source of dust for the San Juan Mountain region is the Colorado Plateau, where warming temperatures, livestock grazing, gas and oil development, off-road vehicle use, and military training activities are all contributing to increased wind-driven transport of dust (Lawrence et al. 2010, Neff et al. 2008, Rhoades et al. 2010, Field et al. 2010). Biological consequences of early snowmelt include changes in the timing of plant growth and flowering, increased susceptibility to freezing, altered species interactions, changes in aquatic habitat and earlier emergence of hibernating mammals (Steltzer et al. 2009, Inouye et al. 2000). In addition, nutrient loading can occur in water bodies and soils where dust is deposited (Field et al. 2010, Neff et al. 2008).

It is likely that this trend in earlier snowmelt and earlier peak streamflow will continue into the future. A 2006 study by Christensen and Lettenmaier predicts that snow water equivalent will be 70% of its historical values by 2070-2098 throughout Colorado, with the greatest decreases occurring in southern Colorado. However, the extent to which potential precipitation changes in the future may impact these findings is unclear. Changes in timing of snowmelt and runoff affect reservoir operations, water rights, flood risks, wildfire risks, and the ecology of forests and woodlands (Clow 2010). The watershed hydrology and physical structure of critical riparian corridors will be affected by earlier spring peak discharge. High elevation streams will likely experience lower and warmer base flows in summer.

Disturbance Patterns

Western forests are at great risk of large-scale stand-replacing fires or disease and/or insect epidemics due to warmer temperatures and dry conditions (Fule et al. 2002, Fule et al. 2009, Keane et al. 2002, Mast et al. 1999, Wiedinmyer and Hurteau 2010). Climate can influence flammability of living and dead biomass seasonally, through early spring snowmelt and associated mid-summer drought (Bigler et al. 2005, Westerling et al. 2006). Drought at the time of, or recently after, bark-beetle outbreaks may also increase wildfire risks and severity (Bigler et al. 2005, Kulakowski and Veblen 2006, 2007). Burn severity is influenced by pre-fire disturbance, species composition, stand structure, topography, and climate (Bigler et al. 2005). Heterogeneity in a landscape increases its resilience to severe disturbances such as wildfire, so some systems are able to recover from wildfire, whereas others are likely to convert to non-forest systems (Schoennagel et al. 2008). With climate change, landscapes may not be able to return to their pre-disturbance state if tree species and genotypes are outside their climatic niche (Baron at al. 2009), pre-disturbance species are replaced with successional or vegetatively-reproducing species (Bigler et al. 2005), or tree seedlings are out-competed by exotic or native herbaceous and woody plant species (Crawford et al. 2001, Griffis et al. 2000).

Under warmer climate scenarios, insect outbreaks may continue to occur and possibly become more intensive, resulting in adverse consequences to forests (Janetos et al. 2008, Kliejunas et al. 2008). Specifically, mountain pine beetle, spruce beetle, and piñon ips beetle are predicted to have more frequent and extensive outbreaks (Hicke et al. 2006, Kliejunas et al. 2008, Ryan et al. 2008). Warmer temperatures not only make trees more susceptible to outbreaks through moisture stress, they can also increase survival of insects, such as the mountain pine beetle, which have larger spring populations when minimum winter temperatures are higher (Regniere and Bentz 2007).

Ecosystems

Climate change can influence plant communities directly, by changing temperature and moisture regimes, or indirectly, by changing disturbance regimes like wildfire or insect and disease outbreaks. Vegetation patterns, range and diversity of ecosystems depend on physical factors such as topography, seed dispersal distance, temperature, and precipitation (Anderson and Feiler 2009, Coats et al. 2008, Perfors et al. 2003). Trends of warming and drying are projected to continue in the West, and it is predicted that by the end of the century, only half of the current climate regimes and their associated plant communities will be maintained (Rehfeldt et al. 2006). Table 1 summarizes the impacts of climate change on biotic communities found in the San Juan region.

Shrublands & Woodlands

Sagebrush shrublands are currently under threat from encroachment by other woody plant, exotic plant invasion, as well as land-use activities (Aldridge et al. 2008, Neilson, Lenihan, et al. 2005). Increased temperatures may promote seedling establishment, growth rate, and increased biomass of sagebrush communities, but this potential for sagebrush expansion may be offset by elevated carbon dioxide (CO_2) levels that will also accelerate woodland encroachment (Neilson, Lenihan, et al. 2005). Sagebrush communities have a fire-return interval estimated at 35 to 80 years in productive sites and 100 to 200 years in unproductive sites, with a slow recovery time. A trend of more frequent and intense fires is predicted for sagebrush communities, and research suggests that many of these communities will experience conversion to exotic-dominated grasslands with short fire-return intervals (Keane et al. 2008, Bradley 2009, Bradley et al. 2009). In areas with cheatgrass invasion, conversions from sagebrush-dominated communities to annual grassland have already occurred. Gambel oak communities are predicted to increase in elevational range and shift upwards in elevation by up to 300 meters (Figure 1, Rehfeldt et al. 2006). Piñon-juniper woodlands (Figure 2) have been known to move up and down along elevational and latitudinal gradients as a result of climate variation (Barger et al. 2009). Drought, which leads to declines in growth and may trigger insect or disease outbreaks, may strongly impact piñon-juniper communities (Allen 2009, Breshears et al. 2005). Additionally, piñon-juniper woodlands have a fire-return interval of over 200 years, and stand-replacing fires are often associated with severe drought (Keane et al. 2008, Romme et al. 2008). Model predictions of the future range of piñon-juniper vary depending on whether elevated CO_2 levels are included. A possible scenario is that juniper will stay about the same while piñon declines, which would alter woodland habitat composition.

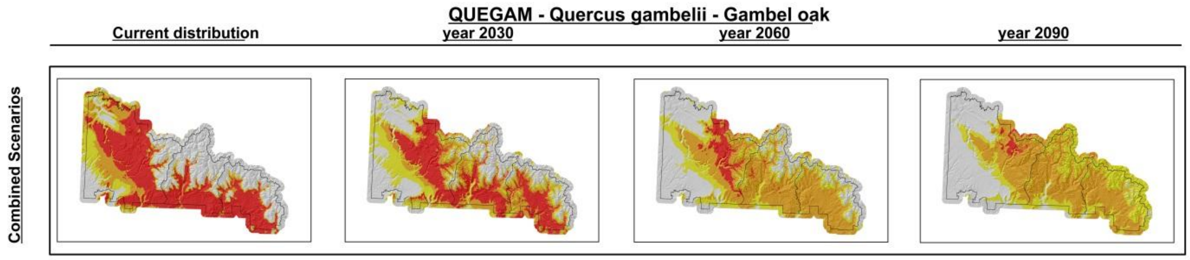


Figure 1: Modeled projections of future *Quercus gambelii* distribution, combining 3 models and 7 scenarios. Colors represent probability of occurrence, where Yellow=0.25-0.50, Orange=0.50-0.75, and Red=0.75-1.00. Maps prepared in cooperation with the Columbine Ranger District of the San Juan National Forest by Jiri Doskocil; based on plant-climate relationships developed by Rehfeldt et al. 2006. (Gerald E.Rehfeldt, A Spline Model of Climate for the Western United States, RMRS-GTR-165, 2006)

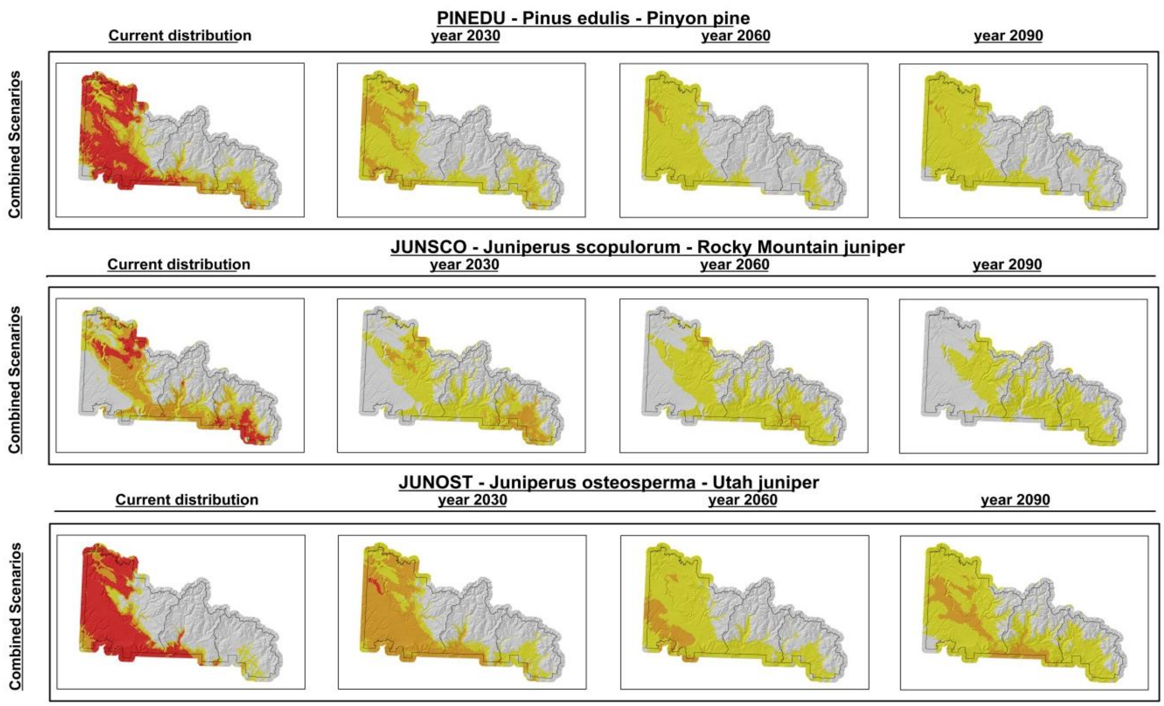


Figure 2: Model projections of future piñon-juniper community species, combining 3 models and 7 scenarios. Colors represent probability of occurrence, where Yellow=0.25-0.50, Orange=0.50-0.75, and Red=0.75-1.00. Maps prepared in cooperation with the Columbine Ranger District of the San Juan National Forest by Jiri Doskocil; based on plant-climate relationships developed by Rehfeldt et al. 2006. (Gerald E.Rehfeldt, A Spline Model of Climate for the Western United States, RMRS-GTR-165, 2006)

Forests

Bioclimatic modeling suggests variability in how forest types will respond to climate change, although many forest types will shift upwards in elevation (Rehfeldt et al. 2006). Ponderosa pine forests are predicted to decrease or have little change in overall area; however, there is high potential for stand-replacing fires, which would decrease habitat for a variety of pine-associated wildlife species (Figure 5, Rehfeldt et al. 2006, Bachelet and Neilson 2000, Fule 2008, Keane et al. 2008). Douglas-fir and mixed-conifer forests in general are predicted to not change in overall area, although warm-dry mixed conifer forest types are at higher risk of wildfires (Rehfeldt et al. 2006, Bachelet and Neilsen 2000). Subalpine spruce-fir forests, including subalpine fir and Englemann spruce tree species, are likely to decrease in area and shift upwards in elevation (Figure 3, Rehfeldt et al. 2006, Westerling et al. 2006). Moisture stress will likely play a big role in determining future composition and distribution of forests. In one study, subalpine fir was more strongly negatively affected by drought than Engelmann spruce (Bigler et al. 2007, Rehfeldt et al. 2006). Figure 5 indicates that white fir may increase in area, while blue spruce decreases. Aspect may also play an important role in the upwards shifts of subalpine forests, due to moisture limitations on south-facing slopes (Elliott and Kipfmueller 2010).

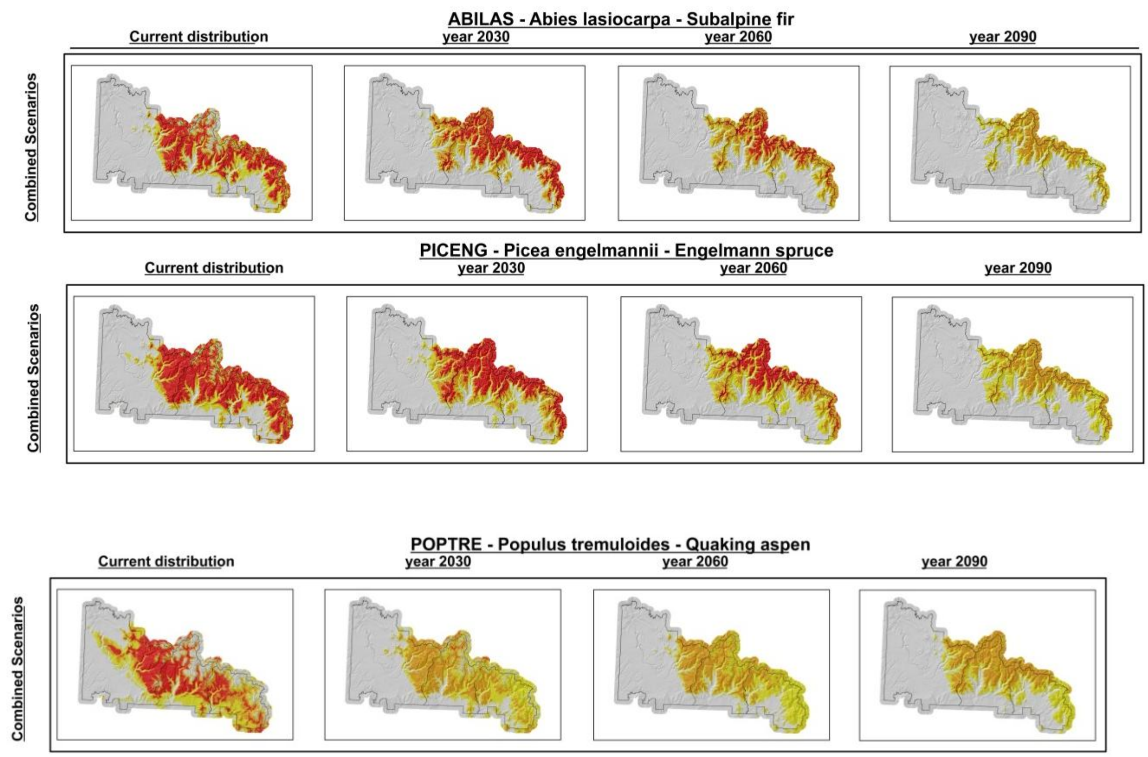


Figure 3 and 4: Model projections of future spruce-fir community species and future aspen communities respectively, combining 3 models and 7 scenarios. Colors represent probability of occurrence, where Yellow=0.25-0.50, Orange=0.50-0.75, and Red=0.75-1.00. Maps prepared in cooperation with the Columbine Ranger District of the San Juan National Forest by Jiri Doskocil; based on plant-climate relationships developed by Rehfeldt et al. 2006. (Gerald E.Rehfeldt, A Spline Model of Climate for the Western United States, RMRS-GTR-165, 2006)

Drought has been associated with the decline of aspen forests in lower elevation habitats (Rehfeldt et al. 2009, Worrall et al. 2008). However, other factors also contribute to sudden aspen decline (SAD), such as the location and density of stands, and higher-than-normal populations of insects or cankers (Worrall et al. in press). Recent outbreaks of insects in Colorado are attributable to a combination of climatic factors, and outbreaks have occurred at higher elevations and latitudes than previously recorded (Romme et al. 2006, Hansen et al. 2010). Future warmer temperatures are predicted to lead to similar and possibly more intensive outbreaks than those experienced in the last decade (Janetos et al. 2008).

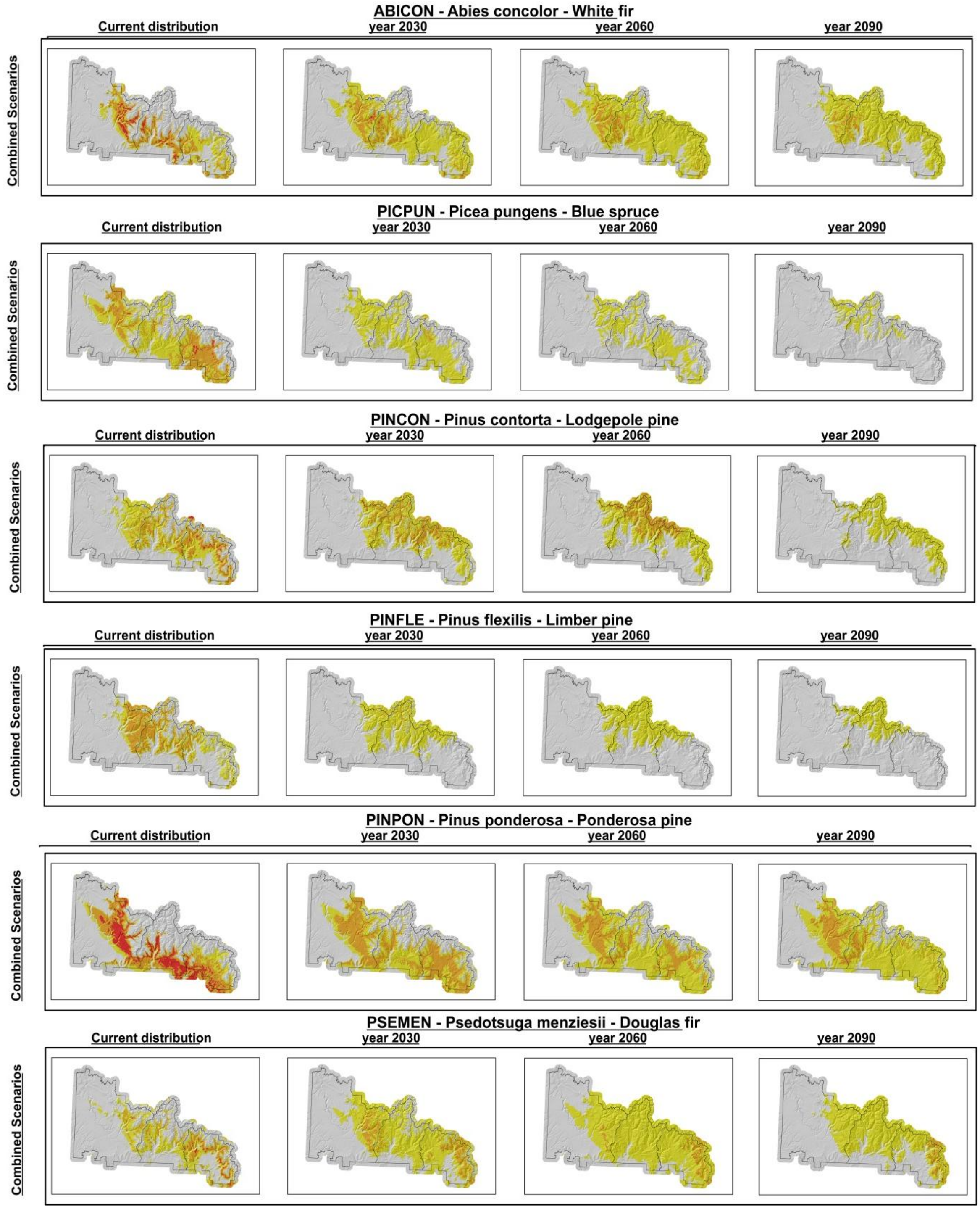


Figure 4: Model projections of future mixed-conifer forest species, combining 3 models and 7 scenarios. Colors represent probability of occurrence, where Yellow=0.25-0.50, Orange=0.50-0.75, and Red=0.75-1.00. Maps prepared in cooperation with the Columbine Ranger District of the San Juan National Forest by Jiri Doskocil; based on plant-climate relationships developed by Rehfeldt et al. 2006. (Gerald E.Rehfeldt, A Spline Model of Climate for the Western United States, RMRS-GTR-165, 2006)

Wetlands & Riparian Areas

Long-term persistence of wetlands can be impacted by changes in summer temperatures, length of growing season, annual snowpack snow water equivalent, timing of snowmelt, and alterations in the frequency and strength on monsoon rainstorms. Projections of drier conditions in the future indicate that water table depths in fens and wet meadows will be low for longer periods of time, and may result in drying, decomposition, and vegetation shifts in these ecosystems (Chimner and Cooper 2003a, 2003b, Chimner et al. 2002).

Changes in timing of snowmelt, which have already shifted two weeks earlier in Colorado, will likely affect riparian areas as peak stream discharge occurs earlier (Clow 2010, Hultine et al. 2007). Changes in timing and amount of precipitation will also affect riparian areas, although direction and magnitude of change for precipitation is uncertain. Native riparian tree species, such as cottonwood and willow, may respond differently to late-season drought, although hot dry summers have been linked to the decline of both of these species in Canada and the Sierra Nevada (Glenn and Nagler 2005). Also playing a role in the future composition of riparian communities are invasive shrub species, including tamarisk and Russian olive, which are already widespread throughout the southwest, and as drought-tolerant species, are expected to expand their range (Bradley et al. 2009, Nagler et al. 2011).

Alpine

Overall contraction of alpine ecosystems is expected in the future (Figure 6), due to changes in snow cover and vegetation. Snow cover is predicted to decrease in extent and duration in the future, with cover elevated upslope up to 400m in some regions (Burkett and Kusler 2000). Shrub line is expected to move up in elevation and the interactions between alpine forbs and pollinators are changing. This will result in nitrogen tolerant, drought tolerant, freeze tolerant and pollinator generalist species becoming dominant at the expense of other alpine species (Bowman, W. D., et al. 2006, Inouye, D. W. 2008, Johnson, D. R., et al. 2011). Subalpine herbaceous species have also been observed moving upslope, and subalpine forests are encroaching into alpine areas (Elliot and Baker 2004, Elliot and Kipfmueller 2010).

Flowering Plants

Across the western United States, snowmelt and plant flowering time for many species have come earlier in the past 40 years (Cayan et al. 2001, Forrest et al. 2010, Forrest and Thomson 2010, Miller-Rushing and Inouye 2009). Predicted warming and drying from climate change could advance flowering time of subalpine meadow species up to 11 days for each two weeks earlier of snowmelt, or for a 2°C (3.6°F) increase in average spring/summer soil temperature (Dunne et al. 2003). Earlier flowering time can result in fewer flowers per plant (Inouye et al. 2002), fewer plants flowering (Saavedra et al. 2003), and increased (Dunne et al. 2003) or decreased (Inouye et al. 2002) flowering period. However, response to climate change varies by species, and individual response must be understood before predictions about communities can be made (Inouye 2008, Inouye et al. 2002, Lambrecht et al. 2007). Although a species may have the ability to survive periods of variable climate, depending on time and evolution, decreases in flowering and seed set can have serious repercussions (Inouye et al. 2003, Inouye et al. 2002). If climate change occurs too quickly, species could be at risk of extirpation or extinction.

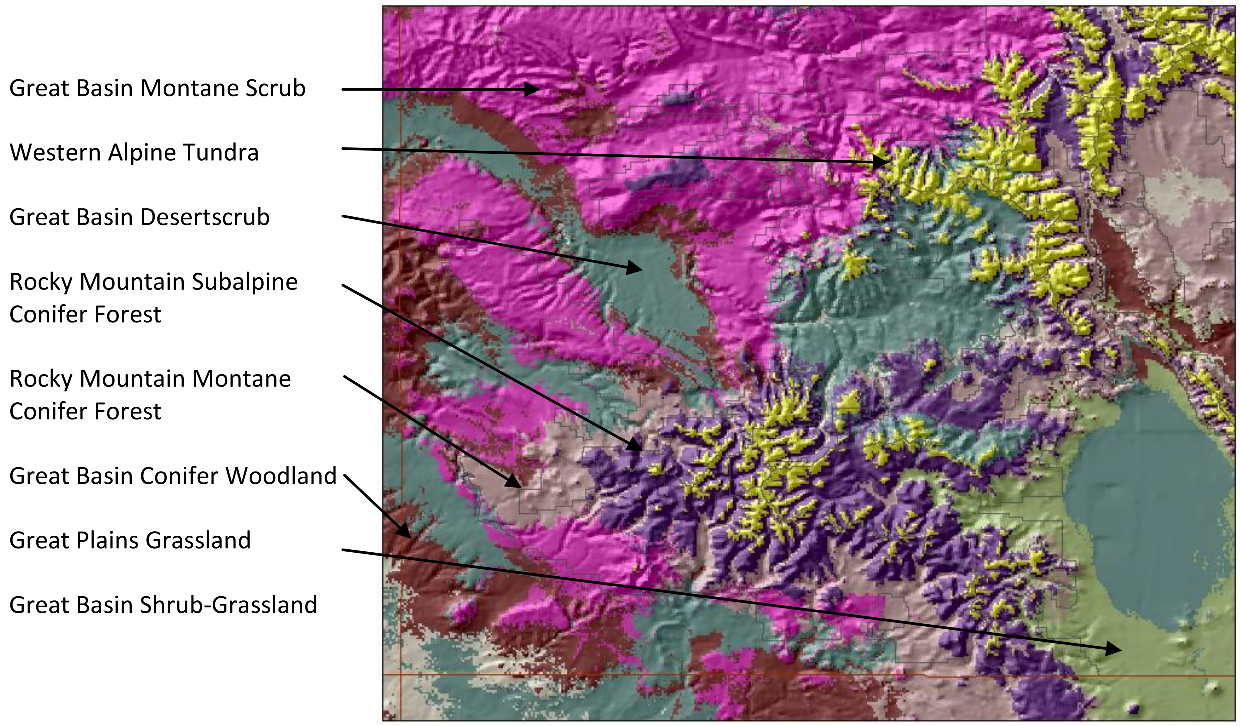


Figure 5: Current biome distribution of southwestern Colorado. From "Climate Change Implications on Forest Structure and Composition" by Nicholas L. Crookston et al. Presentation to TRFO/SJNF on January 18, 2011.

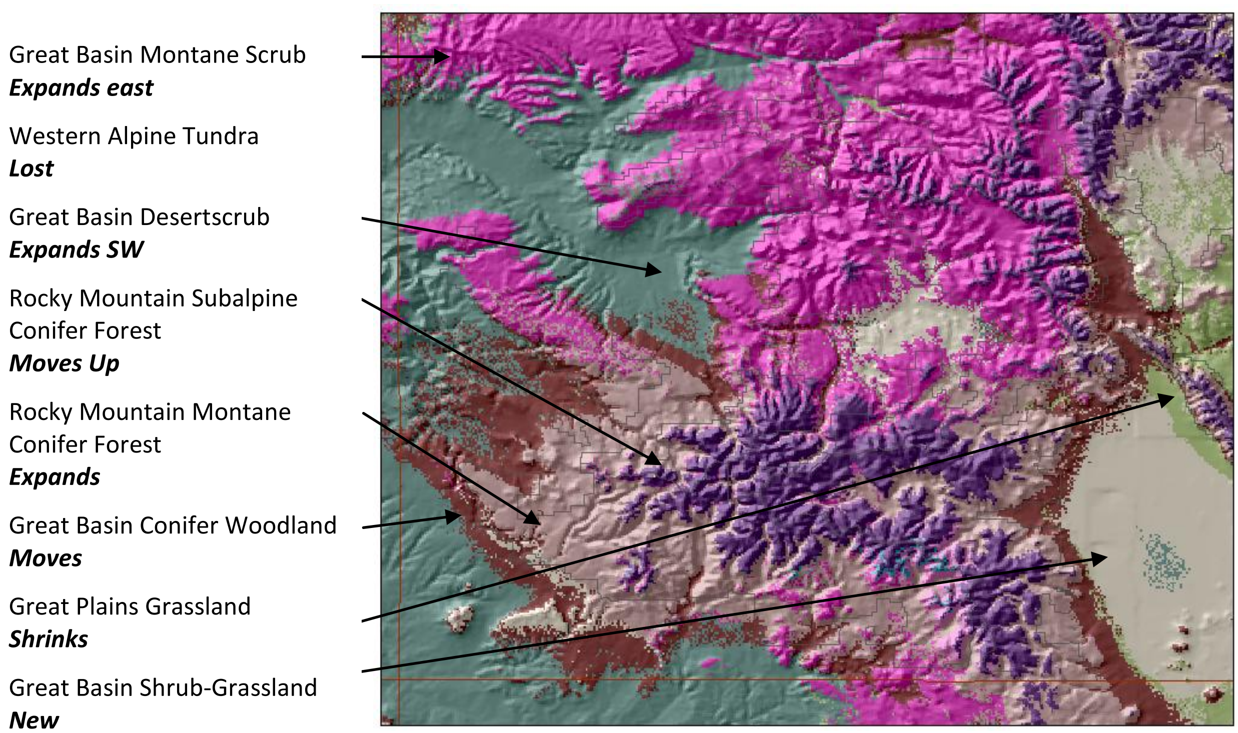


Figure 6: Predicted biome distribution map for 2060. In general, species shift upwards in elevation, with some lower elevation shrublands and grasslands expanding into the region. From "Climate Change Implications on Forest Structure and Composition" by Nicholas L. Crookston et al. Presentation to TRFO/SJNF on January 18, 2011.

Table 1: Summary of projected changes for biotic communities

General Change Expected	Specific Change Projected Over the Next Century	Observed Changes	Information about Seasonal or Patterns of Change	Confidence	Source(s) and Context
Sagebrush					
Increase in area based on climate models; **decrease** due to exotic species and fire	Increase in elevation; loss of populations on edge of distribution; loss to catastrophic fire could be high	Current sagebrush fire return intervals are 20 times shorter than historic intervals and fires are more severe	Historically expanded range during warm climatic periods; historically did not have high-severity fire and is slow to recover	**Low** confidence –climate literature suggests increases in range with warming, however habitat literature suggests causes of present decline are expected to prevail in the future	Harte and Shaw 1995; Keane et al. 2008; Perfors et al. 2003
Montane Shrubland (Gambel Oak)					
Increase in area based on climate models; **increase** following stand-replacing fire	Increase range; increase elevation by up to 300 meters	In recent catastrophic fires in the southwest, some ponderosa pine forests were replaced with re-sprouting shrub species	Following stand-replacing fire in ponderosa pine forests, gambel oak may re-sprout and shift from forest to shrubland	**Moderately High** confidence –single reference regarding climate plus high potential for post-fire succession into this community type	Neilson and Wullstein 1983; Rehfeldt et al. 2006
Piñon-Juniper Woodlands					
Decrease or **increase in area** based on two models; **decrease** with expected future disturbances	Loss of two needle piñon and Utah juniper and reduced co-occurrence of these two species; increases in elevation of 500 and 100 meters, respectively	Landscape scale changes in this community occurred as a result of recent regional drought; more drought-tolerant junipers were also affected	Historically two needle piñon expanded in wet climatic periods; historic fires were stand-replacing and infrequent; fires today are within this range of variability	**Moderately High** confidence –climate literature suggests both an increase and a decrease; decrease also expected given future disturbance potential	Anderson and Feiler 2009; Keane et al. 2008; Rehfeldt et al. 2006; Romme et al. 2008

Table 2: Summary of projected changes for biotic communities, continued

General Change Expected	Specific Change Projected Over the Next Century	Observed Changes	Information about Seasonal or Patterns of Change	Confidence	Source(s) and Context
Ponderosa Pine Forests					
Decrease or **little change in area** based on climate models; **decrease** following stand-replacing fire	Elevation increase up to 500 meters	Recent increases in small-diameter trees and loss of large-diameter trees; chance for catastrophic fire is high	Historic fires were low-severity and frequent; restoration to fewer young trees and less accumulated fuel will decrease chance of stand-replacing fire and large, short-term (decades to 100 years) carbon losses	**Moderately High** confidence –climate literature suggests both a decrease and no change; potential for stand-replacing fires in untreated forests is high	Bachelet and Neilson 2000; Fulé 2008; Keane et al. 2008; Rehfeldt et al. 2006
Mixed-Conifer Forests					
No change in area based on climate models; **decrease** in dry mixed-conifer forests from stand-replacing fire	Elevation increase up to 500 meters	Recent increases in small-diameter trees and loss of large-diameter trees; chance for catastrophic fire in dry mixed-conifer is high	Historic fires in dry mixed-conifer were similar to ponderosa pine forests and similar restoration measures are suggested; historic fires in mesic mixed-conifer was variable	**Moderate** confidence–climate literature predicts no change, yet potential for stand-replacing fires in untreated dry mixed-conifer forests is high	Bachelet and Neilson 2000; Rehfeldt et al. 2006
Aspen Forests					
Decrease in area and **shift upslope** in elevation	Elevation increase up to 1,000 meters	Recent loss of 17% of the aspen cover type across Colorado (SAD) in marginal habitat at lower elevations, in open stands, on south- and west-facing slopes, and on drought-prone soil—poor regeneration in these sites	At higher elevations in spruce-fir forests, aspen is successional following stand-replacing disturbance; loss of aspen at lower elevations expected from drought	**Moderate** confidence–climate references suggest decrease; high potential for post-fire succession into this community type in higher elevation forests	Elliott and Baker 2004; Rehfeldt et al. 2009; Worrall et al. 2008; Worrall et al. in press

Table 3: Summary of projected changes for biotic communities, continued

General Change Expected	Specific Change Projected Over the Next Century	Observed Changes	Information about Seasonal or Patterns of Change	Confidence	Source(s) and Context
Subalpine Forests					
Decrease in area based on climate models; **decrease** with expected future disturbances	Elevation increase up to 300 meters; changes in species composition	Recent increases in small-diameter trees and loss of large-diameter trees; infrequent catastrophic disturbance is normal in this system	Historic fires were stand-replacing and infrequent; fires today are within this range of variability	**High** confidence –climate literature suggests decrease; decrease also expected given future disturbance potential	Bigler et al. 2005; McKenzie et al. 2004; Noss et al. 2006; Rehfeldt et al. 2006; Schoennagel et al. 2004; Westerling et al. 2006
Alpine					
Decrease in area based on climate models; **decrease** from subalpine invasion	Elevation increase in alpine snow cover up to 400 meters	Shifts in species composition have been documented worldwide in recent decades	Subalpine plant establishment upslope reduces available alpine habitat; no movement upslope for alpine species is possible; alpine plants are gradually replaced by subalpine plants	**High** confidence –climate and habitat literature suggest decrease	Bachelet and Neilson 2000; Burkett and Kusler 2000; Diaz and Eischeid 2007; Dirnböck et al. 2003; Elliott and Baker 2004; Elliott and Kipfmueller 2010
Riparian					
Decrease in area based on climate models and from human disturbance	Earlier spring runoff; reduced summer flows; more evapotranspiration; drier conditions; reduced obligate riparian species	Reduction in cottonwood, willow, and alder; changes in riparian plant community structure; loss of female cottonwood, willow, and boxelder; earlier spring runoff, lowering of water tables, and increased exotic species competition	Reduction in species health; alteration in plant community composition and structure	**High** confidence –climate literature suggests decrease; decrease also expected given future degradation potential	Cayan et al. 2001; Glenn and Nagler 2005; Hultine et al. 2007; Worrall, Adams, and Tharp in press; Worrall et al. 2008

Table 4: Summary of projected changes for biotic communities, continued

General Change Expected	Specific Change Projected Over the Next Century	Observed Changes	Information about Seasonal or Patterns of Change	Confidence	Source(s) and Context
Wetlands					
Decrease	Drier conditions may result in long-term drying and shifts from hydrophilic vegetation to mesic upland species (fens become wet meadows, wet meadows become dry meadows)	The first study of climate change effects on wetlands of the region began in 2010	San Juan Mountain wetlands are very sensitive to the amount and timing of snowmelt and summer monsoon rains	**Moderate** confidence– the first study is being conducted this summer	Chimner and Cooper 2003a,b; Chimner et al. 2010; Cooper et al. 1998

VULERNABILITY RESULTS FOR SELECT SPECIES

Summary of Vulnerability Scores

Under the SAVS scoring system, the range of possible scores is from -20 to 20, with -20 indicating maximum resiliency and 20 indicating maximum vulnerability. Of the thirty-two species examined in this assessment, scores ranged from -2.73 for the American three-toed woodpecker to 8.18 for the Yuma myotis, white-tailed ptarmigan, and Gunnison's sage grouse (Figure 8, Appendix B). Overall, scores fell within the mid-range of possible variability. Again, the scores do not represent a quantitative measure of vulnerability, but provide insight into the relative vulnerability of species in relation to each other.

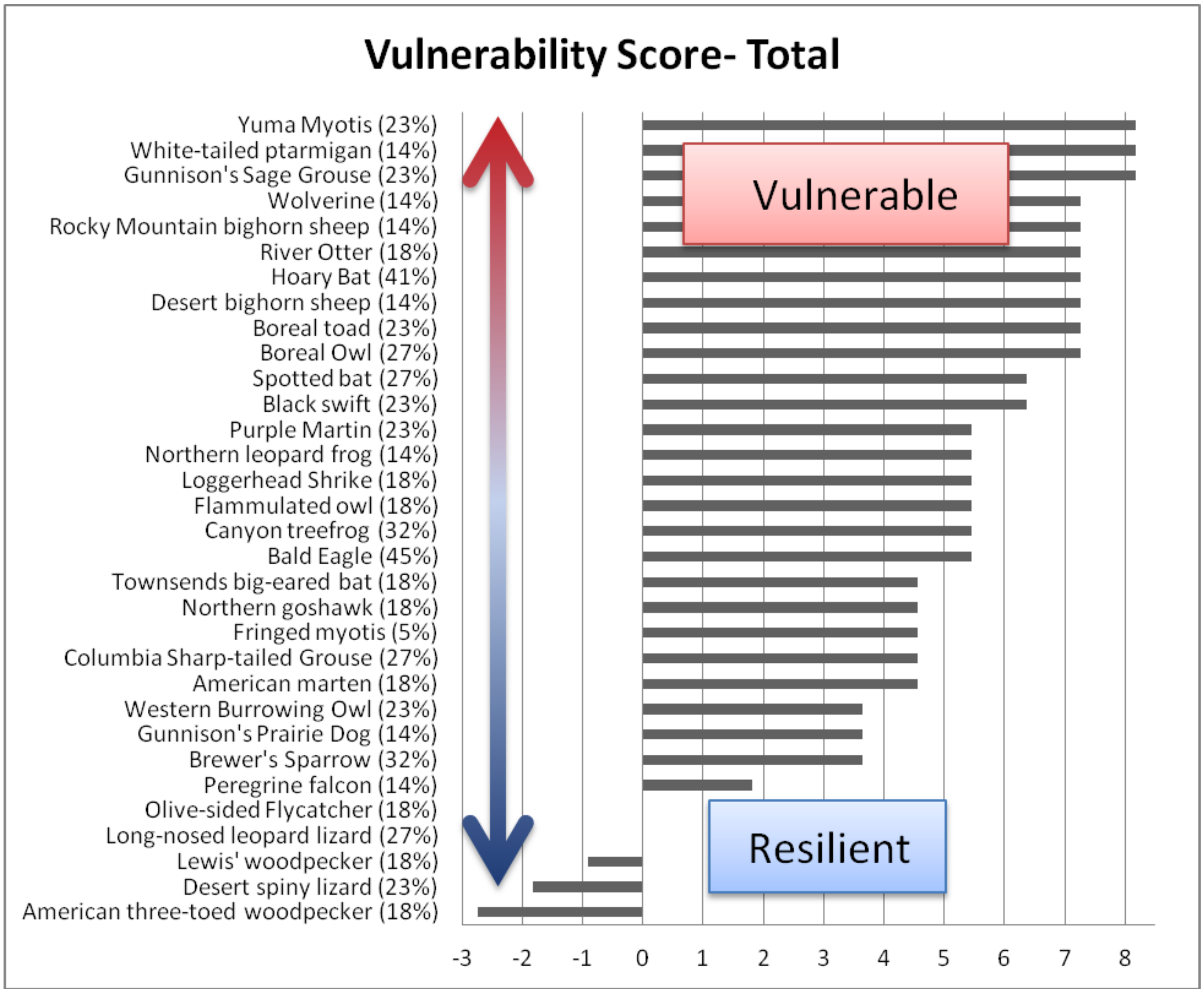


Figure 7: Summary of vulnerability scores for all species. The possible range of maximum to minimum scores is -20 to 20. The number in parenthesis after the species name is the uncertainty score for that species. The Yuma myotis, Gunnison's sage grouse, and white-tailed ptarmigan were predicted to be the most vulnerable species to climate change in this evaluation, while the two species of woodpecker and desert spiny lizard were the least vulnerable.

The mean score for all species was 4.72, indicating that, generally, sensitive species in this region appear to be more vulnerable to climate change than resilient. Even those species that had some resilience were not far from a neutral score, and a low level of resilience may not be enough to offset the effects of climate change, particularly when considering other non-climate related factors that may limit, confound or control population factors.

Of the species that were found to be vulnerable, there were 11 mammals, 13 birds, and 3 amphibians. Five species were neutral or resilient, including three bird and two reptile species. The two bird species found to be somewhat resilient were Lewis' woodpecker and American three-toed woodpecker. These species share a similar life history characteristic, in that they prefer recently disturbed habitats (i.e. burned areas) and have adapted to utilize ephemeral forest types. The olive-sided flycatcher, which had a neutral vulnerability score, also has a preference for disturbed, or at least, somewhat fragmented habitats. This characteristic may allow these species to more easily adapt to changing conditions. The reptiles evaluated share similar habitats: desert or semi-desert. Since this habitat type will likely expand in the region, it is expected that these species will likely fare better under future conditions.

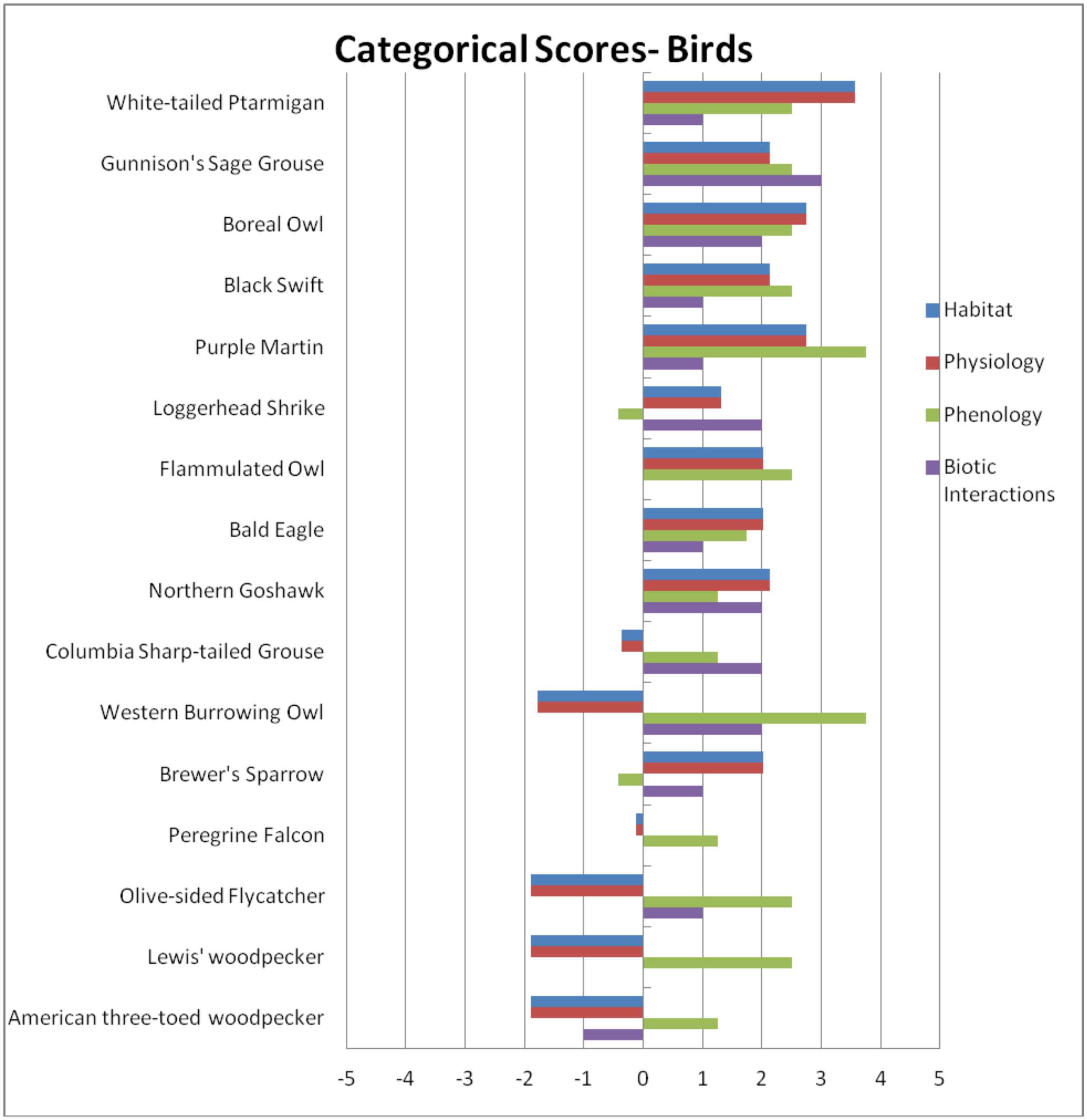
Uncertainty scores for individual species are reported in the species accounts; overall, scores ranged from 5% to 45% (bald eagle) with an average of 21.4%. Sources of uncertainty were most often related to a paucity of information on certain aspects of a species' life history (e.g., dispersal ability), or a lack of information on how climate might affect certain aspects of a species' habitat (e.g., future structural components of mixed-conifer forests). A high uncertainty score should not discount the level of concern for a species with a predicted high vulnerability to climate change. However, it does indicate that more information may be needed to confidently predict the degree to which that species may respond to these changes.

Summary of Categorical Scores

Figures 9, 10, 11 and 12 show the breakdown of categorical scores for all species evaluated. The four broad categories in which vulnerability is assessed are habitat, physiology, phenology, and biotic interactions (Appendix A). The habitat category asks questions about change for a species' overall habitat range, breeding and non-breeding habitat components, habitat quality, and dispersal ability. The physiology category addresses limiting temperature or moisture conditions, limitations to daily activity, reactions to inclement weather, and life history strategies. Query items regarding phenology examine whether a species would likely experience mismatches between important life history events (e.g., breeding, emergence from hibernation, migration) and availability of resources (e.g., food, breeding sites). Finally, the biotic interactions questions ask about possible changes in the species' relationship with other animals, including prey, competitors, and symbiotic relationships.

For the species examined in this assessment phenology and habitat were the most important contributing categories to vulnerability. Phenology contributed the greatest (37%) to the average total vulnerability score (4.71) across the species, followed by habitat (31%), biotic interactions (16%), and physiology (16%). When considering only species that fell into the vulnerable range, phenology contributed 34% to the average vulnerability score (5.79), followed by habitat (33%), biotic interactions (17%), and physiology (15%). Phenology scores tended to be highest in medium to long-distance migratory avian species (as well as the migrating hoary bat). This was generally associated with the potential for mismatches, such as prey availability during migration or on arrival at breeding sites (Bagne et al. 2011). Species that hibernate, including most bats, amphibians and reptiles, are also at risk for mismatches when cues for emergence from hibernation do not coincide with peaks in resource availability. In this assessment all of the hibernating amphibians and the Gunnison's prairie dog, a hibernating mammal, appeared to be vulnerable to mismatched cues. However, this did not appear to be a serious issue with the examined reptiles or local (non-migratory) hibernating bats. High scores in the habitat category frequently contributed to a high overall score across the examined species, suggesting that changes in habitat will be one of the key drivers for species' vulnerability in this region. Reptiles, which showed the highest resilience out of all animal groups, had negative (resilient) scores in the habitat category, since desert-like environments are likely

to



expand in the region.

Figure 8: Categorical scores for all bird species.
Note- Scores range from -5 to 5. A score of zero (0) will be even with the line and will not be visible.

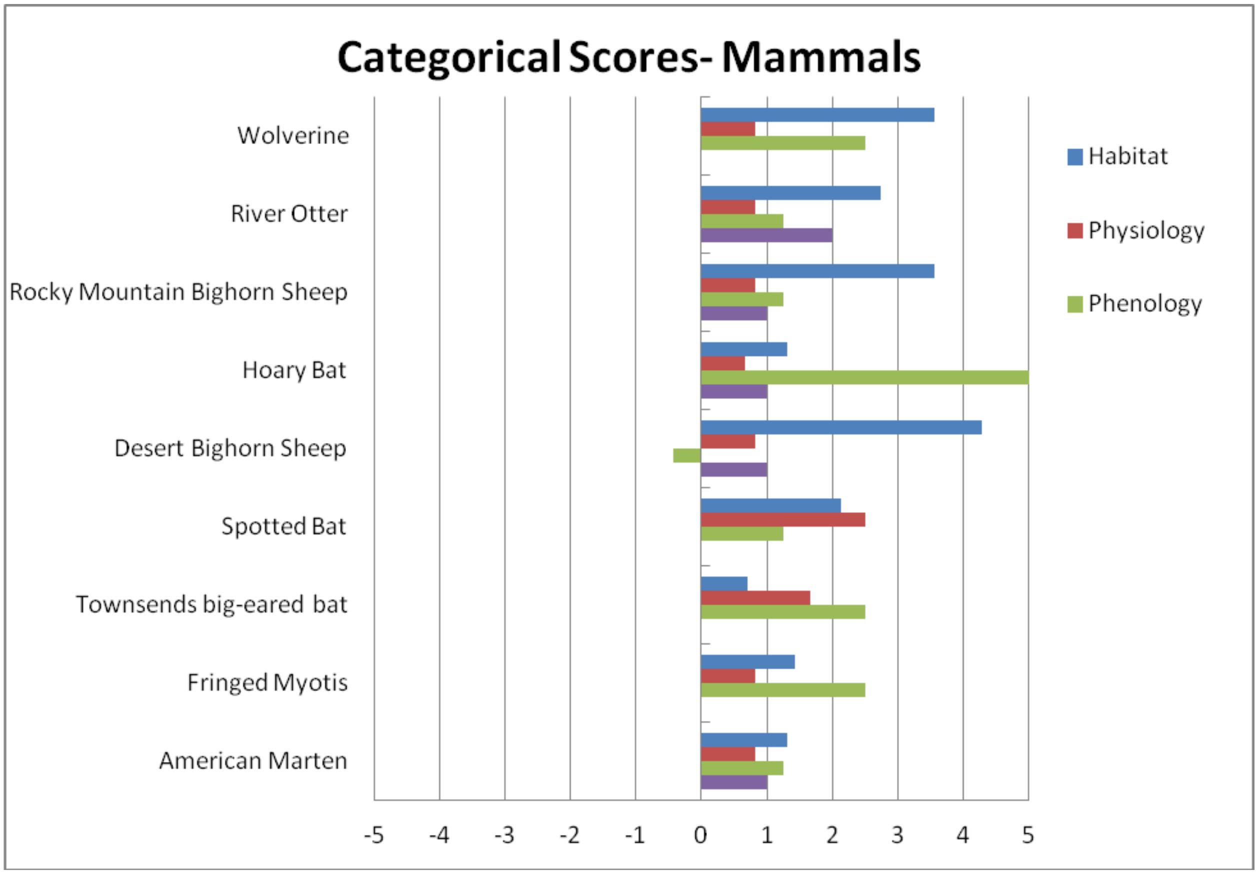


Figure 10: Categorical scores for all mammal species.

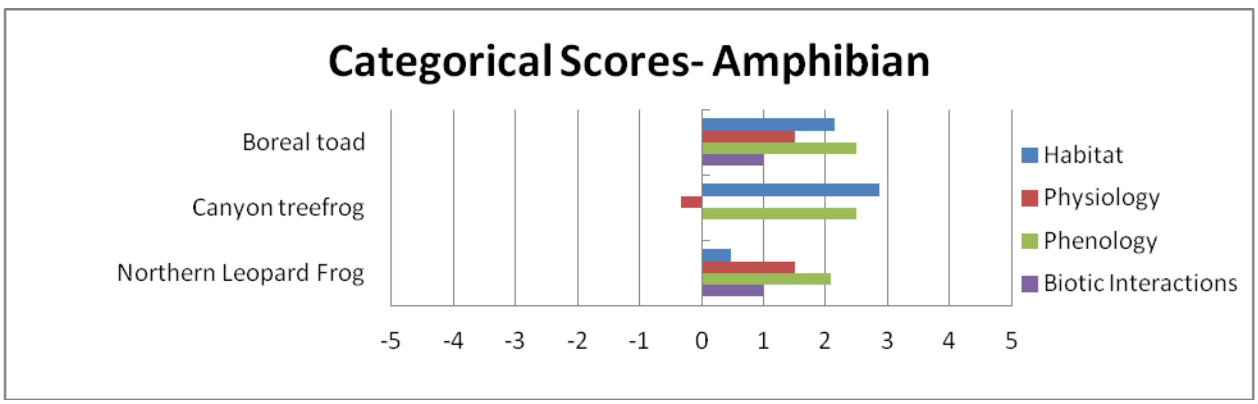


Figure 9: Categorical scores for all amphibians.

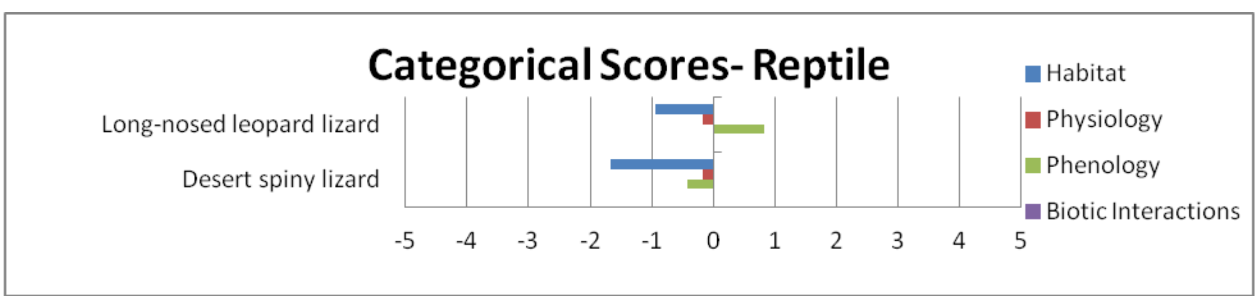


Figure 10: Categorical scores for reptile species.

Note- Scores range from -5 to 5. A score of zero (0) will be even with the line and will not be visible.

Vulnerability Scores by Habitat

A summary of vulnerability by habitat type is presented in Figure 13. The numbers shown are an average of the SAV scores for the wildlife species examined in each habitat category. Although the SAVS assessment tool does not specifically evaluate habitats, the scores for wildlife may infer, at some level, a relationship between habitat types and species vulnerability. For example, all of the species associated with alpine tundra had relatively high scores (Table 2). Those species that use moister environments (wetland/riparian) as primary habitat, or as a component of primary habitat, also consistently indicated relatively high vulnerability scores. Species that occupy the middle montane forest systems (aspen, mixed-conifer) trended toward a higher vulnerability than those that occupy lower elevation forest and woodland systems. It might be expected that most species in semi-arid environments, such as sagebrush and lower elevation grasslands would have a higher resilience to climate change. However, this does not appear to always be the case. Many of these species depend on specific components or structural characteristics within these drier habitats that could be altered by climate shifts. An example is the Gunnison's sage grouse, which is an obligate of sagebrush shrublands. While core habitat for this species is sagebrush, mesic areas and riparian corridors play an important role in brood-rearing and non-fragmented to lightly fragmented sagebrush habitats are critical for courtship and over-wintering. These situations are predicted to decline with increased frequency of drought, shortened fire intervals, and increasing presence of non-native plant species, such as cheatgrass. Species that occupy multiple habitats might be expected to fare better with changing climate; however, this was also not demonstrated in this assessment. Of species that occupy three or more habitat types, all were found to be vulnerable. Interestingly, habitat specialists (occupy only one habitat) were found at both extremes of the vulnerability scale.

While there may be some predictable relationship between habitat type and risk of vulnerability, it should be cautioned that reliable generalizations in this regard would require a more extensive evaluation of a range of wildlife species in each of the individual habitat categories.

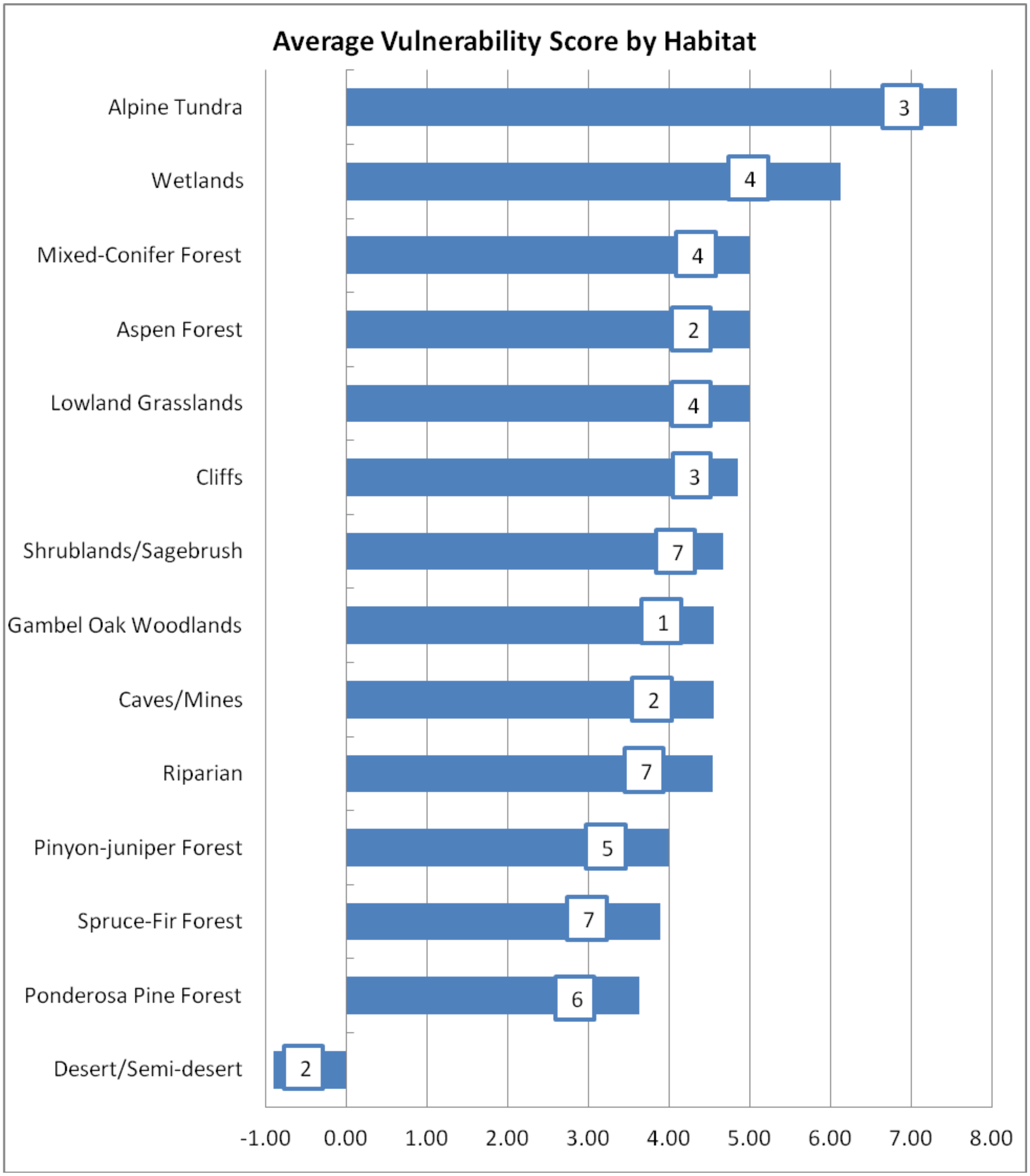


Figure 11: Average species vulnerability score by habitat type. Number of species evaluated for each habitat is shown in the inset boxes. The X-axis shows the average score for all the species found in that particular habitat; does not indicate a level of vulnerability for the habitat type. *Note: some species may have been included in more than one habitat type.*

Table 5: Summary of scores with species' habitat association. [1]

Species	Total Score	Ponderosa Pine Forest	Spruce-Fir Forest	Mixed-Conifer Forest	Alpine Tundra	Piñon -Juniper Forest	Cliffs	Riparian	Caves/Mines	Wetland	Aspen Forest	Montane Shrubland	Lowland grassland	Sagebrush Shrubland	Desert/ Semi-desert
Yuma Myotis	8.18							P							
White-tailed ptarmigan	8.18				P										
Gunnison's Sage Grouse	8.18													P	
Boreal Owl	7.27		P												
Desert bighorn sheep	7.27												P		
Hoary Bat	7.27							P							
Rocky Mountain bighorn sheep	7.27				P										
River Otter	7.27							P							
Wolverine	7.27				P										
Boreal toad	7.27									P					
Black swift	6.36						P								
Spotted bat	6.36						P								
Bald Eagle	5.45							P							
Loggerhead Shrike	5.45												P		
Northern leopard frog	5.45									P					
Canyon treefrog	5.45									P					
Flammulated owl	5.45	P													
Purple Martin	5.45										P				
Fringed myotis	4.55	P				P									
Northern goshawk	4.55	P									P				
Townsends big-eared bat	4.55								P						
Columbia Sharp-tailed Grouse	4.55													P	
American marten	4.55		P												
Brewer's Sparrow	3.64													P	
Western Burrowing Owl	3.64												P		
Gunnison's Prairie Dog	3.64												P		
Peregrine falcon	1.82						P								
Long-nosed leopard lizard	0													P	
Olive-sided Flycatcher	0		P												
Lewis' woodpecker	-0.91	P						P							
Desert spiny lizard	-1.82														P
American three-toed woodpecker	-2.73		P												

[1] *Scores are color coded from most vulnerable (red) to somewhat resilient (blue); primary habitat for each species is indicated by a "***P***", other habitat are listed that might be requisite during other parts of its life.*

Individual Species Assessments

This section provides the results of the individual species' assessments and a discussion of the salient aspects of the species life history as it relates to the scoring items in the assessment. The explanation presents how the species' habitat is likely to change over time and explains significant sources of uncertainty in the scores. Additional scoring rationale is shown in Appendix D, which contains the completed questionnaires and an explanation of the responses to the individual query items, where appropriate.

Birds

American Three-toed Woodpecker (Picoides dorsalis)

Species Status: not currently listed					
American three-toed woodpecker	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	-1.90	-1.00	1.25	-1.00	-2.73
Uncertainty	14%	17%	50%	60%	32%

Populations of the American three-toed woodpecker, a cavity nester, benefit when suitable habitat such as dead and downed trees is available (Wiggins 2004b). Although overall habitat for the three-toed woodpecker may decrease in area and move upwards in elevation (spruce-fir, mixed conifer), patches of improved habitat for nesting and foraging will increase with more frequent wildfires and outbreaks of bark and wood-boring beetles. However, population increases following disturbance events are temporary, so it is less certain how long-term population dynamics may be affected. The woodpeckers' dispersal ability will play a role in how well it utilizes newly disturbed patches, but there is a lack of information on adult and juvenile dispersal and how it may be limited by fragmented habitat.

Small-scale irruptions of movement have been observed for the three-toed woodpecker (Wiggins 2004b), a strategy that adds to the overall resilience score. To fully understand how three-toed woodpecker populations will respond to changing habitat and resources, more information is needed on competitive interactions, effect of predators on population dynamics, and how diseases and parasites will respond to a changing climate. These questions are reflected in the high uncertainty score in the biotic interactions category.

Bald Eagle (Haliaeetus leucocephalus)

Species Status: FS-sensitive, BLM-sensitive, State-threatened					
Bald Eagle	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	2.02	1.67	1.25	0.00	5.45
Uncertainty	43%	33%	75%	40%	45%

Much of the bald eagle's vulnerability is related to its strong association with aqueous environments for both its breeding and non-breeding habitats (Buehler 2000). This includes rivers and riparian corridors, lakes and reservoirs, and their forested surroundings. In the arid west these environments represent less than 1% of the total landscape. Climate change has the potential to further reduce the availability of these areas through more frequent droughts and lower rates of annual precipitation and runoff. In a Colorado study, 75% of eagle nests were in cottonwoods (Winternitz 1998). Mature cottonwoods are likely to decline and future recruitment of new trees will likely be affected by changing flow patterns in rivers and more frequent drought, as well as competition from exotic shrubs (Perry et. al. 2012). The greatest source of nest failure in a Colorado/Wyoming study was destruction of the nest and nest trees from heavy winds (Kralovec et al. 1992). Severe spring winds associated with climate change could accelerate these losses.

The eagle's preference for water-rich environments is related, to a large degree, to its strong affinity for fish throughout the year, particularly during the breeding season. Availability of food can affect nestling survivorship and can also affect the age at which females begin breeding (Gerrard et al. 1992, Buehler 2000). This resource can be affected by climate-related disturbances in several ways. Smaller water bodies will generally support lower overall fish numbers and are more susceptible to heating, which reduces available dissolved oxygen. Increased fire frequency in the watersheds can reduce water quality in lakes and streams through increased sedimentation and turbidity from runoff, which can cause direct and indirect impacts to mature fish and interfere with fish reproduction.

Eagles migrate along narrow pathways, using habitats similar to those on their breeding and non-breeding grounds. It is suspected that they time their movements to specific resource events (i.e., fish runs) along their migration routes (Buehler 2000). While fish are generally important throughout the year, eagles also rely on other resources, such as scavenging, particularly in winter, when the water surfaces of fishing areas may be frozen. Winter-killed deer and elk are an important scavenging resource. Milder winters could lead to higher survivorship of these species, and thus, fewer animals to scavenge. Additionally, poor range conditions, especially on their wintering grounds, may significantly reduce overall herd sizes over the long term (deVos & McKinney 2007). However, it should be noted that milder winters may prove to be less of a stressor to eagles and could make aqueous foraging areas more available through much of the winter months.

Both sexes of eagles have the ability to disperse, when facing resource shortages. However, eagles have strong breeding site fidelity and alternative territories for dispersal that feature aqueous environments and adequate forage are relatively uncommon across the landscape. Bald eagles have essentially no alternate strategies for coping with resource fluctuations or to respond to low population levels. They breed only once a year and nest productivity is a naturally low 1.2-1.6 fledglings/year (Buehler 2000). Additionally, juveniles do not begin breeding until roughly their 5th year and may postpone breeding even longer during periods of scarce resources (ibid.).

There are two subspecies of bald eagle, distinguished primarily by size and breeding range. The larger subspecies (H.l. alascanus) breeds roughly north of 40°N latitude, while the smaller subspecies (H.l.

leucocephalus) breeds south of that latitude (Buehler 2000). It is assumed that both subspecies occur locally, although H.l. alacanus is probably primarily a winter resident. It is likely that the local breeding population would be most susceptible to climate-related changes occurring in southwestern Colorado

Black Swift (Cypseloides niger)

Species Status: FS-sensitive, BLM-sensitive					
Black Swift	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	2.14	0.83	2.5	1	6.36
Uncertainty	43%	0%	25%	20%	23%

The black swift has unique habitat requirements and life history characteristics that increase its vulnerability to climate change. Black swifts nest high on cliffs, in close proximity to waterfalls. Reduced snow water equivalent in the snowpack and drier summers may reduce flows in waterfalls that are part of nesting swift habitat. Reduced flows may lead to declines in number of nesting swifts (Wiggins 2004a). It may also be important that flows are sustained throughout late summer, because the swifts are relatively late nesters (Wiggins 2004a). Earlier snowmelt, which has already been observed in Colorado and is exacerbated by dust-on-snow events, may further affect nesting birds by shifting the timing of peak flows to earlier in the spring and additionally reducing flows in late summer (Clow 2010). Little is known about the swifts' winter range, so it is uncertain how climate may affect non-breeding habitat area and quality. Also, little is known about the swifts' dispersal ability, which adds to the high uncertainty score in the habitat category.

The black swift is a relatively long-lived species with a low reproductive rate, long breeding season, and high nest fidelity (Wiggins 2004a). These characteristics make individuals less able to cope with changing resources, so the overall population is likely to be more vulnerable. As a long-distance migrant, there is potential for mismatch with important food resources (winged ants, termites, flying insects) because timing of migration to breeding sites is initiated far from where the timing of resource pulses is taking place. Additionally, drought conditions that will be more frequent in a drier climate may negatively affect the numbers of flying insects available for swift forage (Wiggins 2004a).

Boreal Owl (Aegolius funereus richardsoni)

Species Status: FS-sensitive					
Boreal Owl	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	2.74	-0.17	2.50	2.00	7.27
Uncertainty	14%	33%	0%	60%	27%

In Colorado, the boreal owl exhibits a strong preference for mature spruce-fir forests (Palmer 1986) with mesic forest conditions being favored over drier situations. This association is due, in part, to the owl's primary prey, southern red-backed vole, which also occurs in its highest abundance in mesic spruce-fir forests. Clutch size, fledging success and number of birds breeding in any one year are directly related to prey abundance (Hayward 1989). Mesic mature spruce-fir forests would be expected to decline with climate change due to rising temperatures, smaller snow packs, insect infestations and periodic drought. Fire intervals in all spruce-fir forest are also expected to decrease, favoring a shift to younger forests structures. Since the boreal owl uses these habitats during both the breeding and non-breeding seasons, a decline in mature, mesic subalpine forests would have implications to both nesting productivity and post-fledging survival. This species breeds only once a year and, therefore, has limited ability to respond to population declines associated with periodic scarcities of resources. However, both sexes can disperse to other areas during periods of resource failure (Hayward and Verner 1994).

The boreal owl also shows an affinity for cooler micro-sites during the summer, apparently indicating a need for thermoregulation (Hayward & Verner 1994). Hayward (1997) suggests that these micro-sites could be a significant limiting factor in warmer parts of the owl's range. Winter foraging could also be affected as a result of warming temperatures through snow-crusting (Hayward & Verner 1994). A key foraging technique in winter involves detecting prey aurally and diving though the surface of the snow to capture prey. Crusting associated with thawing and refreezing of the snow surface could interfere with this foraging approach and could effectively limit foraging success during critical times of the year.

As a secondary cavity nester, the boreal owl depends on flickers for cavities for nesting sites. However, it also competes with this species, as well as saw whet owls for cavities (Hayward & Hayward 1993). Northern flickers populations are likely to increase across the range of forest ecosystems as a result of climate-associated disturbances. This would increase the potential availability of cavities for the boreal owl, but since flickers occasionally use existing cavities, they may compete with owls for this limited breeding resource (ibid.). Whether this would be an offsetting relationship is unclear. American martens are both a predator to and a competitor of the boreal owl. Martens also prey heavily on red-back voles, and thus compete directly with the boreal owl for core prey (Hayward and Hayward 1993). While marten populations are not expected to increase with climate change, predation on the owls and their nests by martens could increase during periods of low vole abundance and the competition for limited prey could impact owl reproductive productivity and survival.

Brewer's Sparrow (Spizella breweri)

Species Status: FS-sensitive, BLM-sensitive

Brewer's Sparrow	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	2.02	-0.17	-0.42	1.00	3.64
Uncertainty	57%	17%	25%	20%	32%

The Brewer's sparrow nesting grounds are highly associated with sagebrush shrublands. Similar habitats are also used during migration and on their wintering grounds (Holmes & Johnson 2005). There are conflicting opinions on whether sagebrush ecosystems will expand and move upward in elevation or contract due to increasing frequency of severe drought, decreasing fire intervals, and invasion of non-native plant species (Harte and Shaw 1995; Keane et al. 2008; Perfors et al. 2003). Shrublands infested with cheatgrass are 20 times more likely to burn than those without cheatgrass (Whisenant 1990). Large scale and more frequent fires in sagebrush occurring during the breeding season can result in direct impacts to Brewer's sparrow nesting populations. These fires can also result in fragmentation that may potentially reduce the overall functionality of these habitats for this species (Holmes & Johnson 2005). The health and structure of sagebrush patches and individual plants may also decline due to less favorable moisture regimes. The major cause of nest failure in this species is nest predation (Rotenberry et al. 1999) and studies suggest that nests in fragmented habitats are more prone to predation.

The Brewer's sparrow chooses healthier stands of shrub and healthier, taller, and fuller individual plants for nest placement. This is also thought to be, at least partly, a response to predation. Some studies suggest that high winter precipitation rates in the preceding winter on the sparrow's breeding grounds results in a positive reproductive response (Rotenberry and Wiens 1989). However, the specific component(s) in the sparrow's breeding requisites that benefit from this moisture were not identified. As a long distance migrant, the Brewer's sparrow risks mismatches between environmental cues and critical events on its breeding grounds. However, both sexes of the Brewer's sparrow are capable of dispersal, which should allow it to relocate to other areas during periods of low resources.

Columbia Sharp-tailed Grouse (Tympanuchus phasianellus columbianus)

Species Status: BLM-sensitive

Columbia Sharp-tailed Grouse	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	-0.36	1.67	1.25	2.00	4.55
Uncertainty	43%	17%	0%	40%	27%

The Columbian sharp-tailed grouse (CSTG) uses a mix of sagebrush and mountain shrublands during the breeding and non-breeding seasons. Mountain shrublands are predicted to increase and move upslope; however, there is uncertainty regarding the expansion or contraction of sagebrush shrublands (Rehfeldt et al. 2006, Lenihan, et al. 2005, Bradley et al. 2009, Hoffman & Thomas 2007). The CSTG does not use oak-dominated shrub unless it is highly fragmented and contains a significant serviceberry component (Hoffman & Thomas 2007). While the general cover type used by this species may be increasing, the overall quality of this habitat is expected to decline due to drought and fires, especially on (but not limited to) drier sites (Miller & Freeman 2001). CSTG nesting success is associated with nesting areas having high horizontal and vertical cover. Brood success is highly associated with high forb cover (Hoffman & Thomas 2007). Both of these elements are likely to decline with drying conditions and increased fire frequency (ibid.). During the winter months the CSTG favors riparian areas with diverse shrub cover, along with mountain shrub habitats. Riparian habitats are also likely to decline with drying conditions and lower stream flows (Theobold et al. 2010).

Primary food sources for CSTG in the non-winter months include forbs, insects, and berries. Forbs are particularly important for chicks. The availability of these resources could decline with drought, more frequent fire and conversion to non-native herbaceous cover (Miller & Freeman 2001). The CSTG tends to feed early and later in the day and seeks cover during the middle of the day. This may indicate some sensitivity to warmer conditions, which could affect foraging dynamics during the summer months. In the winter the grouse feeds on buds from shrub protruding from the snow. It roosts beneath the snow to escape extreme winter temperatures and weather, as well as predators. It has been suggested that warmer winters could result in snow crusting as the snow thaws during the day and refreezes at night. This process could interfere with “snow roosting” exposing grouse to temperature extremes and predation (Hoffman & Thomas 2007).

The CSTG has only one brood per year but will re-nest due to nest failure, particularly if the nest is lost early in the season. Nearly all females attempt to nest, even in the first year. CSTG have no specific strategies for addressing varying resources over multiple years. However, while nest sizes are large (8-10 eggs) and hatching rates high (90%), nest success is below 50% (Hoffman & Thomas 2007). This suggests that CSTG has the potential to respond to poor years by increasing nest productivity in years of more favorable resources.

Flammulated Owl (Otus flammeolus)

Species Status: FS-sensitive					
Flammulated Owl	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	2.02	-1.00	2.50	0.00	3.64
Uncertainty	29%	17%	25%	20%	23%

In this region, the flammulated owl prefers open, mature ponderosa pine forests and some warm-dry mixed conifer forests (Hayward and Verner 1994). Ponderosa pine forests are predicted to decrease in area and shift upward in elevation, and warm-dry mixed conifer will likely stay the same or decrease due to higher risk of catastrophic wildfires (Rehfeldt et al 2006). Even if the overall area of habitat remains relatively constant (assuming warm-dry mixed conifer may convert to ponderosa pine), shifts to earlier successional stand structures would negatively affect the species. Wintering grounds for the flammulated owl are undetermined, so there is a significant element of uncertainty in how climate change may affect overall populations.

The Technical Conservation Assessment for the USFS suggested that the flammulated owl may be vulnerable to habitat change because it has a conservative life history characterized by small broods and a long lifespan. Additionally, a super abundance of food resources does not appear to lead to increased fertility (Hayward and Verner 1994). These same characteristics make the species vulnerable to climate change, since it could not quickly respond to population declines associated with periodic resource declines. More information is needed to understand how primary prey species, particularly moths, will respond to climate change. A mismatch in timing of arrival of flammulated owls to breeding grounds and timing of prey availability could leave owls vulnerable to decline and starvation, especially in early spring.

Gunnison's Sage Grouse (Centrocercus minimus)

Species Status: BLM-sensitive, Federal-candidate					
Gunnison's Sage Grouse	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	3.57	0.83	2.50	3.00	10
Uncertainty	29%	33%	25%	40%	32%

The Gunnison's sage grouse (GSG) is an obligate to sagebrush shrublands. There is some disagreement in the research on whether the sagebrush communities used by this species will expand to higher elevations or decrease in area through conversion to arid and semi-arid grasslands (Harte and Shaw 1995; Keane et al. 2008; Perfors et al. 2003). However, there does seem to be consensus that sagebrush communities are likely to become more fragmented and the overall habitat quality is likely to decline through climate-related disturbance regimes, such as more frequent droughts, fire and invasions of non-native plants, particularly cheatgrass (Connelly et al. 2004). Fragmentation of sagebrush habitats has been cited as a primary cause for the decline of sage-grouse populations (ibid.). It may be important to view potential climate effects in context to other disturbance regimes that could have synergistic negative effects to this species and its habitats, especially human-related disturbances. Oyler-McCance et al. (2001) noted that GSG habitats in southwest Colorado have been impacted more than anywhere else in the state.

Although the adult GSG has some flexibility in its diet, sage leaves provide an important component throughout the year and are critical in winter, when it comprises most of the adult diet. Areas with taller sagebrush are important, since these shrubs will be available even when snow accumulations are deep. Drier moisture regimes during the growing season and shorter fire intervals could favor the development of shorter stands of sagebrush that may be unavailable for browsing during heavy snow years (Connelly et al. 2004). Sage grouse have a low rate of nesting success (ibid.) and scarcity of forbs has been offered as a major contributing factor by several researchers (Barnett & Crawford 1994, Greg et al. 1994, Delong 1995). Young chicks depend on a variety of forbs and insects during early development. Brood-rearing shifts from the sage-dominated nesting sites to more mesic habitats during the early and mid-summer, where these foraging resources are more abundant (Connelly et al. 2004). Mesic sites are likely to become less available through drought and more frequent fire could result in a declining forb layer or conversions to short-lived, non-native annuals (ibid.).

GSG has few alternative strategies to deal with resource or population declines. Both sexes of the sage grouse can disperse to colonize new areas and respond to resource declines. However, dispersal is somewhat local and may not allow a sufficient level of movement to reach areas less affected by climate- related disturbance regimes (Dunn & Braun 1985). Annual nesting success is low and the species breeds only once per year (it may re-nest as a result of nest failure). Many females do not nest until their second year of adulthood and a significant number may not breed in any one year (Connelly et al. 2004). These factors could interfere with the species ability to respond to population declines.

Predation has an important influence on the population dynamics of GSG by reducing nesting success and increasing mortality in juveniles and breeding-aged birds. This species has many predators, and primary predators may vary by region. While the full impact of predation is not well-understood, most researchers agree that habitat fragmentation will significantly increase the rate of predation through higher exposure of nest and brood sites, as well as exposure of individuals moving between fragmented patches of suitable habitat (Connelly et al. 2004, Greg 1994). GSG has an identified susceptibility to a number of parasites and diseases; however, the impact of this on population dynamics has not been thoroughly researched. Birds in poor condition due to scarce resources may be more vulnerable to disease and parasitic infestations (Connelly et al. 2004)

Lewis' woodpecker (Melanerpes lewis)

Species Status: FS-sensitive					
Lewis' woodpecker	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	-1.90	-1.00	2.50	0	-0.91
Uncertainty	29%	0%	25%	0%	14%

Lewis' woodpecker will likely see decreases in its preferred habitat on the SJNF/TRFO, which include ponderosa pine forest and deciduous riparian forests (Bachelet and Neilson 2000; Fulé 2008; Keane et al. 2008; Rehfeldt et al. 2006). However, an increase in wildfires could offset overall habitat loss by creating patches of burned ponderosa pine forest, which is ideal nesting habitat for the woodpecker (Abele et al. 2004, NatureServe 2011). Non-breeding habitat, which includes mature oak woodlands, such as gambel oak, may increase in area and expand upwards in elevation (Rehfeldt et al. 2006). Additionally, Lewis' woodpecker has a demonstrated use of a variety of forest types and a high dispersal ability (Abele et al. 2004), which will provide a measure of resilience to shifting habitats.

Timing of breeding for Lewis' woodpecker is most likely tied to insect availability, which is affected by local temperature and precipitation conditions (Abele et al. 2004). With warmer and drier conditions, timing of this resource availability could shift. In general, however, Lewis' woodpecker is opportunistic and has a variety of prey resources in summer and winter (NatureServe 2011). This characteristic will help the species cope with changing resource conditions.

Loggerhead Shrike (Lanius ludovicianus)

Species Status: FS-sensitive					
Loggerhead Shrike	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	1.31	1.67	-0.42	2.00	5.45
Uncertainty	29%	0%	0%	40%	18%

The loggerhead shrike, in unaltered landscapes, uses grassland/shrub and open sagebrush shrublands for breeding and non-breeding. It is unclear whether these habitats will contract or expand, perhaps varying regionally (Finch et al. 2012, Keane et al. 2008, Bradley 2009). In areas where sagebrush is important, the predicted fragmentation may benefit the shrike by creating more open habitats. While it is unclear whether the broad vegetation cover types may increase or decrease, habitat quality is likely to decline. On its breeding grounds important habitat components for nest placement and forage perches include tall (relative to other vegetation) shrubs and small trees, which could be lost to drought or more frequent fire (Wiggins 2005). In the eastern Colorado grasslands these components have already declined in some areas due to drought (Wiggins 2005). While hunting perches could also be lost on non-breeding grounds, shrikes would have more flexibility in moving to areas with better foraging structure. Drought and invasion from non-native species, particularly cheatgrass, could impact the overall quality of prey habitat, which would have important implications to nesting success for the shrike (Wiggins 2005). Loggerhead shrike migrates in winter and is found from southern Colorado and Utah to Mexico; however, the origin of wintering Colorado birds is not clear. In migration this species depends on habitats similar to its breeding and wintering grounds. As a migratory species it is vulnerable to mismatch cues between its initiation of spring migration and resources occurring along its migratory pathways and breeding grounds.

Shrike nests are highly susceptible to intense storms, and severe weather in the spring and summer can result in the loss of clutches or broods, as well as reduced food supply (Yosef 1996). Nestlings may also be susceptible to late spring frost (Wiggins 2005). The shrike will re-nest if the first nest is lost and is known to occasionally attempt a second clutch (ibid.). The literature mentions no alternate strategies to deal with varying resources over multiple years. However, the shrike does have relatively large clutch sizes and a typical low fledging rate of slightly over 50% (Yosef 1996). This may indicate that shrikes have the capacity for higher fledging rates in years of plentiful resources.

Nests are subject to high rates of predation from a variety of predators. One Colorado study determined that most nest failures were attributed to magpie predation (Yanishevsky & Petring-Rupp. 1998). As year-round residents, magpie populations may benefit from milder winters and lower rates of winter mortality.

Northern goshawk (Accipiter gentiles)

Species Status: FS-sensitive, BLM-sensitive					
Northern Goshawk	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	2.14	-1.00	1.25	2.00	4.55
Uncertainty	14%	0%	25%	40%	18%

The northern goshawk occurs in a variety of forested habitat types and will nest in ponderosa pine forests, mixed conifer forests, and deciduous forests including aspen (Barrett 1998). Climate change will impact different forest types differently (e.g. no change in area of mixed conifer vs. decrease in area of aspen); however, overall area of suitable forest types is likely to decrease or shift upwards in elevation. Although it nests and forages in a variety of habitats, the size of nests and nature of their prey base requires large tracts of habitat (Barrett 1998). Projected increases in the frequency of wildfires as well as widespread insect outbreaks have a high potential to impact populations if large blocks of habitat are destroyed. Wildfires will likely affect some forest types more than others, but large fires in any of the suitable forest types would reduce overall habitat quality by decreasing canopy closure and favoring a shift to early successional forests with dense understory. Decreased canopy closure would be detrimental to fledgling survival because it increases incoming solar radiation and heat stress; fledglings prefer a cool microenvironment.

Goshawks are known to periodically have irruptions of movement southward which appear to be influenced by prey availability (Kennedy 2003, NatureServe 2011). This strategy may provide some resiliency to climate change. In the Northern Goshawk Technical Conservation Assessment, it is noted that forest reduction and fragmentation may favor early successional competitors such as red-tailed hawks and great-horned owls (Kennedy 2003).

Olive-sided Flycatcher (Contopus cooperi)

Species Status: FS-sensitive					
Olive-sided Flycatcher	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	-1.90	-1.17	2.50	1.00	0.00
Uncertainty	14%	0%	50%	20%	18%

The assessment indicates a neutral response to climate change for the olive-sided flycatcher. This species breeds predominantly in the upper montane and sub-alpine forest zones. It also uses forest structures typically associated with disturbance (i.e., fire, insect infestations, drought), such as forest edges and snags. It would, therefore, likely benefit from some of the structural changes that are predicted to occur in these forest systems through climate change (Kotliar et. al 2007). The olive-sided flycatcher is a long-distance migrant that over-winters in Central and South America. There are concerns that climate change could interfere with the re-establishment of forests in areas within its winter range that have been heavily logged (Altman & Sallabanks 2000, Petit et al. 1995). As a long-distance migrant the olive-sided flycatcher must use alternate habitats when in transit. However, it is known to use a variety of forests and woodlands and is not restricted to the upper elevation zones during migration. This diversity in habitat use during migration should help insulate the species from any localized resource deficits occurring between its breeding and wintering grounds.

The olive-sided flycatcher is sensitive to inclement weather on its breeding grounds and periods of cold, wet weather can disrupt nest-building and foraging activities, both of which can affect reproductive success (Altman & Sallabanks 2000). Under a climate change scenario these periods of inclement weather would likely occur less frequently. Warmer weather may also extend the length of the flycatcher's daily foraging activities, which could also benefit its nesting success.

The predicted changes to this flycatcher's habitat could also benefit competitors that may use similar habitats (e.g., western woods peewee, Townsend's solitaire, mountain bluebird). There is little in the literature to indicate that this would have significant impact on the olive-sided flycatcher. However, this species is aggressively territorial and defends relatively large territories on its nesting grounds (Kotliar, et. al 2007), suggesting that competition may play at least some role in breeding success.

Peregrine Falcon (Falco peregrinus)

Species Status: FS-sensitive, BLM-sensitive					
Peregrine Falcon	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	-0.12	0.83	1.25	0.00	1.82
Uncertainty	0%	17%	25%	20%	14%

Peregrine falcons are widespread throughout the United States, and use a variety of habitat types; in Colorado, breeding sites can be associated with ponderosa pine, piñon-juniper, or shrublands (Craig and Enderson 2004). Shifts in vegetation types are unlikely to strongly affect falcon nesting sites, because nests are located on high cliffs (NatureServe 2011, Craig and Enderson 2004). Preferred nesting site components are associated with cliff situation rather than surrounding vegetation, so climate impacts on habitat appear to be minimal.

Peregrine falcons may be less vulnerable to climate change because they have a varied prey base, can inhabit a range of environmental conditions, and breeding is not strongly cued by temperature. The falcon is able to replace lost clutches, however, this is not considered to be a factor contributing to resiliency (Bagne et al 2011, Craig and Enderson 2004). More information is needed on how prey populations may be affected by climate change; specifically, how changes in weather patterns may affect the arrival of migratory birds, since timing and success of nesting appears to be linked to this resource availability.

Purple Martin (Progne subis)

Species Status: FS-sensitive					
Purple Martin	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	2.74	-2.17	3.75	1.00	5.45
Uncertainty	29%	0%	50%	20%	23%

Purple martin is an aspen obligate in Colorado and most often occurs in low to mid-elevation aspen stands (Gillihan & Levad 2002). Aspen at lower elevations is likely to decline and the aspen cover type is predicted to shift upward in elevation. It is not clear how the martin would adjust to this shift into higher elevation areas. A key component in breeding habitat selection is proximity to open water. This important element to foraging would be expected to decline in availability through drought and warmer temperatures. While the martin will re-nest in the event of nest failure, it is not known to "double clutch" or breed more than once a year (Wiggins 2005). This reduces the species ability to quickly recover from population declines that might occur in years of poor resource availability or unusual weather conditions. As a long-distance migrant the martin has the potential to experience a mismatch between its initiation in movements and key resource events occurring on its distant breeding or wintering grounds.

Diseases in martins were not well-explored in the literature. However, it is known that martins are highly susceptible to a number of parasites. Parasite infestations can reduce nesting success or result in total nest failure. In extreme cases, entire colonies have been abandoned as a result of high parasite levels (Ehrlich et. al. (1988). Some research suggests that ecto-parasitic activity may be greater during warmer and drier years (Merino & Potti. 1996). Since martins re-use cavities in successive years, warmer winters could also create a potential for a higher parasite "carry-over" into the following nesting season, especially in nests with residual nesting material (Rendell & Verbeek 1996).

There are aspects of climate change that could offer resilience to purple martins. Martins do not forage during periods of inclement weather and extended periods of poor weather can affect nesting productivity or cause total nest failure. These periods of unfavorable weather during the nesting season would likely occur less frequently under a climate change scenario. Martins also do not forage when temperatures are below 9ºC. Warmer temperatures could potentially extend the daily foraging period, which could be particularly important early in the nesting season. As a secondary-cavity nester the martin is dependent on woodpeckers for cavities. Climate change, through such forest disturbance mechanisms as drought, fires, and insect infestations, would likely result in increased populations of these primary cavity-nesters and indirectly benefit the purple martin through a greater availability of nesting sites.

White-tailed Ptarmigan (Lagopus leucura)

Species Status: FS-sensitive					
White-tailed Ptarmigan	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	3.57	0.83	2.50	1.00	8.18
Uncertainty	14%	17%	0%	20%	14%

The White-tailed ptarmigan had one of the highest vulnerability scores of all species assessed. Contributing strongly to this high score is overall loss of suitable habitat. As an alpine obligate the ptarmigan already has a limited range. Climate change is predicted to shift treeline upward in elevation, further reducing the total amount of alpine area. In addition to reductions in total available habitat, encroachment of treeline may mean a loss of area of shrubby willow in some locations. Willow is essential to ptarmigan populations, as it serves as the primary food source in winter, as well as an important component of breeding and non-breeding habitat (Hoffman 2006). Some alpine shrubs have expanded or are predicted to expand with increased levels of carbon dioxide. Yet, willows are sensitive to changes in soils, hydrology, temperature, diseases, and competition from other plants (Cooper et al. 2006, Kaczynski and Cooper 2013). In summary, there is some controversy as to how willow will respond in a warming climate. Availability of snow-free areas is also an important factor related to the timing of nesting, and there may be increased temporal variation due to changes in weather and snow cover (Hoffman 2006). Early snowmelt would therefore potentially change the timing of nesting.

Western Burrowing Owl (Athene cunicularia)

Species Status: FS-sensitive, BLM-sensitive, State-threatened					
Western Burrowing Owl	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	-0.95	0.83	3.75	2	4.55
Uncertainty	43%	17%	0%	40%	27%

The western burrowing owl breeds in arid to semi-arid grasslands, a vegetation cover type that is likely to expand as a result of changing climate conditions. Therefore, landscape level availability of this habitat should not be a limiting factor to the burrowing owl (McDonald et al. 2004, Andrews and Righter 1992). Colorado breeding birds migrate from the state during the non-breeding season and little is known about their winter habitats or migratory pathways (Haug et al. 1993). While burrowing owls prefer low grass or bare ground around their burrows, they prefer a mosaic of vegetation with patches of shortgrass in their surrounding foraging grounds. The increased "edge" associated with these patches presumably provides increased numbers of arthropod and mammalian prey (McDonald et al. 2004). Climate-driven shifts (e.g., fire, cheatgrass invasion) could reduce the availability of these patches, potentially affecting foraging resources.

The burrowing owl depends on prairie dog burrows for its nesting sites (McDonald et al. 2004) and the availability of active prairie dog colonies is considered a key limiting factor for this species (Andrews and

Righter 1992). In Colorado 80 percent of surveyed burrowing owls were associated with prairie dog colonies (VerCauteren et al. 2001). In areas where prairie dog colonies have become inactive, owls will discontinue their use when grass reaches six inches in height (Jones 1998). (The Gunnison's prairie dog was found to have a moderate level of vulnerability to climate change in this assessment study; however, it is unclear how other species of prairie dog might be affected.) Prairie dogs also play a role in predation dynamics, providing both alarm calls in response to encroaching predators and alternative prey to those predators (McDonald et al. 2004). However, it is not clear that relationships with specific predators would be altered through climate change. While there is fidelity to the breeding grounds, both sexes can disperse to other areas. It has been suggested that the fragmented distribution of prairie dog colonies may represent population "sinks" for this owl (ibid.).

Burrowing owls return to their breeding grounds earlier at lower latitudes than at higher latitudinal zones (ibid.), suggesting that temperature could be a cue to breeding initiation. However, this may also be a function of a greater travel distance between wintering and breeding grounds. As a moderate-long distance migrant, this species has the potential of mismatched cues between its wintering and breeding grounds. The burrowing owl appears to be adapted to warmer environments, and being mostly crepuscular or nocturnal, is not likely to be overly sensitive to potential increases in daytime temperatures associated with climate change. The owl does not have any alternative strategies to address variable resource conditions or population declines. It breeds only once per year, and while clutch sizes can be relatively large, fledging success and juvenile survival appears to be low (Haug et al. 1993). It has been argued (but not confirmed in research) that the large clutch sizes would allow owls to increase populations during years of resource abundance (McDonald et al. 2004).

Mammals

American Marten (Martes americana)

Species Status: FS-sensitive

American Marten	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	1.31	0.83	1.25	1.00	4.55
Uncertainty	29%	0%	0%	40%	18%

The American marten primarily occupies spruce-fir and occasionally cool-moist mixed conifer forests in the San Juan region. Martens generally prefer mesic conditions and mature to late successional forest structures (Buskirk and Ruggiero 1994). These forest types are generally predicted to move upwards in elevation and/or decrease in total area (Bachelet and Neilsen 2000, Rehfeldt et al 2006). These shifts in forest elevational ranges will be accompanied by changes in structure, as well as moisture regimes. Increased frequency of wildfires and insect outbreaks, especially at higher elevations, could decrease marten habitat as the availability of late successional forests decline and as canopy closure is lost. However, high levels of coarse woody debris, another component of preferred marten habitat, is predicted to increase with these disturbances.

This association of martens with mature mesic spruce-fir forests is due, in part, to the southern red-backed vole, which is a primary prey of the marten and occurs in highest abundance in this forest type. The mesic conditions provide optimal habitat for fungal species on which the vole depends. The boreal owl, another vole-dependent species, may compete with the marten for a declining resource. However, since the marten also preys on boreal owls, decreasing vole availability may result in increased predation by martens on owl nests.

Martens have a conservative life history strategy, with long life spans and small litter sizes, which suggests that they may not be able to respond quickly to dramatic environmental changes (Buskirk 2002). More information on how competitive species might be affected by climate change would improve the uncertainty score for the biotic interactions category; interference competition may play an important role in marten community structure (Buskirk 2002).

Desert Bighorn Sheep (Ovis canadensis nelsonii)

Species Status: FS-sensitive, BLM-sensitive

Desert Bighorn Sheep	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	4.29	0.83	-0.42	1.00	7.27
Uncertainty	29%	0%	0%	20%	14%

A study of desert bighorns in California has shown that this species is highly vulnerable to climate change (Epps et al. 2004). This assessment has a similar result, with vulnerability primarily related to the drying of lowland grassland areas that the sheep inhabit. Reduction of water sources in a drier climate will directly affect this important component of desert bighorn habitat (Graham 1997). Drought can cause increased mortality and affect recruitment dynamics (Epps et al. 2004). Another effect of drought will be increased competition for water sources, potentially increasing the spread of disease, especially if desert bighorns come into contact with domestic sheep more frequently. Desert bighorns also have overall low dispersal rates, which limits their ability to utilize new habitat (Beecham et al 2007, Epps et al 2004).

The desert bighorn does have a slightly resilient score in the phenology category, due to its non-seasonal reproductive pattern. Beecham et al (2007) state that this may be an adaptive strategy to ensure lamb survival during periods of unpredictable forage. In general, desert bighorns will forage opportunistically, with spatial and temporal variation based on precipitation and soil moisture patterns.

Fringed Myotis (Myotis thysanodes)

Species Status: FS-sensitive, BLM-sensitive					
Fringed Myotis	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	1.43	0.83	2.50	0.00	4.55
Uncertainty	14%	0%	0%	0%	5%

Like other bats, the fringed myotis needs access to water as part of its habitat requirements, and loss of water sources due to a warmer and drier climate could certainly reduce suitable habitat. It will roost in a variety of forest types, including oak, piñon-juniper, and ponderosa pine, and it has been found in grasslands and deserts (Keinath 2004). The presence of loose snags and low canopy cover is associated with preferred habitat (Keinath 2004), but it is uncertain how changing climate would alter the presence of these elements over multiple forest types. Fringed myotis appear to be mobile, which would benefit the species in the event of shifting habitat, but they show strong roost site fidelity, so it is uncertain how well they would take advantage of new habitat.

Fringed myotis prey on a variety of species, usually including beetles and moths (Keinath 2004), and the ability to feed somewhat opportunistically will be a benefit in the event of changing resources. However, more information on exactly how insect populations will change with shifting plant communities would improve the understanding of how this species will respond to climate change.

Gunnison's Prairie Dog (Aegolius funereus richardsoni)

Species Status: FS-sensitive, BLM-sensitive					
Gunnison's Prairie Dog	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	-0.95	-0.17	3.75	2.00	3.64
Uncertainty	14%	17%	0%	20%	14%

The Gunnison's prairie dog (GPD) inhabits grassland/shrub, a vegetation type that is predicted to expand with climate change. Since it uses these habitats throughout its life, this would be expected to offer some resiliency during both the breeding and non-breeding periods. The GPD appears to prefer more mesic conditions than other prairie dogs, and while total available habitat may increase, habitat quality could decrease with drying site conditions associated with the elements of climate change (NMG&F 2008). GPD reproductive success is highly dependent on quality forage (ibid.), which would be expected to decrease with more frequent and longer duration droughts. Recovery of browsed vegetation around the colony would likely be less robust, and exotics, such as cheatgrass, would be expected to replace perennial grasses in many situations. Cheatgrass represents a significant threat, since it matures early in the year and provides no nutritional benefit later in the year as animals are building stores for winter (Lupis et al. 2007). Both sexes of GPD disperse, which would allow them to colonize new areas in response to changing resource conditions. However, dispersals are generally limited to relatively short-distances and most dispersals involve the movement of males to established neighboring colonies.

The GPD hibernates during the winter, creating a potential for mismatched cues with its changing environment. For example, female GPDs are sexually receptive for only a single day during the breeding season each year (Hoagland 1999). As mentioned, species reproductive success is dependent on available forage. This is normally most available in early summer, coinciding with the later stages of reproduction (Knowles 2002). Under the warming conditions of climate change this peak could occur earlier and with lesser magnitude during years of lower precipitation. How this might affect individual or colony productivity is not well described in the literature. GPD tends to be most active during the cooler parts of the day, suggesting some sensitivity to high diurnal temperatures (Seglund & Schnurr 2010). Rising diurnal temperatures could decrease the amount of time spent foraging during the summer breeding season, which could also affect reproductive productivity. However, these effects could be balanced by extending early and late season foraging. While the GPD has the ability to aestivate in response to declining resources later in the season, it is not clear how this may affect winter mortality or future reproductive success. . The GDP appears to have enhanced rates of reproduction when populations have been impacted by disease or episodic resource declines (Knowles 2002). This may offer it some resiliency to periodic climate-related effects.

Sylvatic plague is a major factor in individual mortality and colony failure in the GPD. Poor physical condition of individuals related to low forage availability could contribute to higher susceptibility to the disease. The lower forage availability could also increase the rate of dispersal of individuals to other colonies, which could also increase the chances of infected individuals transferring the disease to uninfected colonies (Seglund & Schnurr 2010).

Hoary Bat (Lasiurus cinereus)

Species Status: FS-sensitive					
Hoary Bat	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	1.31	0.67	5.00	1.00	7.27
Uncertainty	43%	50%	50%	20%	41%

The hoary bat assessment indicates a high level of vulnerability to climate change; albeit, with a relatively high degree of uncertainty. Many aspects of the bat's life history remain unclear or are poorly researched. This species forages in a range of habitats including juniper scrub, riparian forests, wetlands, and desert scrub (Shump & Shump 1982, Oliver 2000). While males seem to prefer conifers for roosting, females use the dense foliage of deciduous trees for the maternity roosts. Deciduous trees in much of its range in the southwest may be limited to cottonwood trees. Due to the broad range of habitats used for foraging, it was assumed in this assessment that overall availability of habitat would remain stable on both the breeding and non-breeding grounds. However, riparian habitats, an important component of foraging (and likely nesting) are predicted to decline (Theobold et al. 2010). Apparently, both sexes can disperse to other areas to address resource needs. As a migratory species it requires additional habitats during migration and has been observed foraging along riparian corridors during spring migration. It apparently must also use upland areas because members of the species are often killed by wind turbines, an increasing threat as more wind farms are created to provide alternative energy (Cryan 2011). Hoary bats represent 50% of reported bat fatalities at wind facilities.

Generally, hoary bats have limited strategies to address resource shortfalls over multiple years. It breeds only once per year. It does produce more offspring (mean=2, up to 4) than non-migratory bats, which typically have only one pup/year. This could allow for higher reproductive productivity in years of above average resources. As a migratory species, the hoary bat has the potential for mismatched environmental cues relative to critical resources. It is speculated that migration through New Mexico's riparian corridors is timed to coincide with peak moth abundance (Valdez and Cryan 2009). This species consumes a variety of prey but prefers soft-bodied insects, especially moths. Populations of this favored prey group could decline through factors associated with climate change (Singer and Parmesan 2010).

Hoary bats have high metabolism during foraging and in migration; however, they likely have much slower rates on the roost. Females can induce prolonged torpor during cold and wet weather and can postpone birthing until conditions improve (Willis et al. 2006). Adults can apparently fly in a wide range of temperatures. Growth rates and development of young are correlated to ambient temperatures (Cryan 2003), which could offer some benefits to reproductive productivity under the warming conditions of climate change.

River Otter (Lontra Canadensis)

Species Status: FS-sensitive, State-threatened

River Otter	Habitat	Physiology	Phenology	Biotic Interactions	Total Score
Vulnerability Score	2.74	0.83	1.23	2.00	7.27
Uncertainty	0%	50%	0%	20%	18%

Much of the river otter's vulnerability in this assessment was attributable to its close association with aqueous environments throughout its life history. In the western United States this species inhabits rivers, lakes and reservoirs within a broad range of ecosystems from semi-desert shrublands to montane and sub-alpine forests. However, these surface waters must be permanent and of relatively high water quality. They must also offer abundant fish or crustacean prey (Boyle 2006). Climate change, through predicted lower precipitation and drought, has the potential to significantly diminish the availability and functionality of currently suitable habitats. Some streams and other surface waters may become too small to support prey. Water quality that supports the fishery may also be affected (Ficke et. al 2007). Smaller water bodies and warmer ambient air temperatures will likely result in rising water temperatures, which tends to lower dissolved oxygen levels in water. Increased sedimentation and turbidity from runoff associated with higher-frequency and larger fires could also have a detrimental effect on fish populations. Temperature fluctuations and sedimentation can also affect crayfish populations, another often important food resource for the otter in lower elevation streams (Holdich 2002). Otters can disperse moderate distances to colonize new areas or respond to temporary resource scarcities. However, while otters can disperse as a response to resource needs, they may be challenged in their ability to move outside of the zone of influence of disturbance events, such as extended periods of drought, which tend to be regional rather than local.

Otters require high quality, complex riparian structures along the shorelines of their aqueous habitats (Boyle 2006). This structure offers security cover from predators during their daily activities and areas within their territories that lack these features have low levels of utilization (ibid.).   Stretches of streams with poorly developed riparian habitat can also interfere with dispersal. These riparian conditions are predicted to decline through changing climate conditions (Theobold et. al 2010).

Beavers are important symbionts of the river otter. Otters use beaver dens extensively for natal structures, resting areas, and latrine sites. The quiet waters of beaver ponds and marshes, appear to be important areas for raising young (Melquist and Hornocker 1983) and beaver-modified environments are also important in Region 2 for coping with severe winters (Boyle 2006). A study in Nevada suggests an extremely high level of vulnerability of the mountain beaver to climate change (Young et. al 2009).

River otters do not appear to have strategies to allow it respond to fluctuating resources over time. Female adult survival is the most important population characteristic for population viability (Boyle 2006). The otter breeds only once per year, litter sizes are relatively small and a low percentage of females produce litters in consecutive years (Toweill and Tabor 1982). These factors would make it difficult for otters to respond to population declines associated with periodic resource failures.

Rocky Mountain Bighorn Sheep (Ovis canadensis canadensis)

Species Status: FS-sensitive					
Rocky Mountain Bighorn Sheep	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	3.57	0.83	1.25	1.00	7.27
Uncertainty	14%	17%	0%	20%	14%

Habitat loss and fragmentation may strongly impact the Rocky Mountain Bighorn Sheep, a species that had large population declines in the 19th century and is still vulnerable to competition from domestic livestock and disease (Beecham et al. 2007). As a result of climate change, alpine meadows and tundra may decrease in area as subalpine forests shift upslope (Elliot and Baker 2004, Elliot and Kipfmueller 2010, Moir et al. 1999). Woody plant encroachment may also decrease suitable habitat for the bighorn sheep, which requires open areas with high visibility for predator detection (Neilson et al. 2005, Rehfeldt et al. 2006).

Rocky Mountain Bighorn Sheep populations are susceptible to widespread outbreaks of disease; most often associated with contact with domestic sheep populations (Beecham et al 2007). It is uncertain how climate change might affect domestic sheep populations or grazing practices. However, wild populations that are more crowded from loss of habitat will come into contact more frequently and increase spread of pathogens (Bagne et al 2011, Beecham et al 2007).

Spotted Bat (Euderma maculatum)

Species Status: FS-sensitive, BLM-sensitive					
Spotted Bat	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	2.14	2.50	1.25	0.00	6.36
Uncertainty	29%	0%	75%	20%	27%

Spotted Bat populations may suffer if permanent water sources are reduced or lost, which is likely due to warmer temperatures, earlier snowmelt, and overall drier conditions in arid regions such as southwestern Colorado. The Spotted Bat requires a unique habitat combination of cliff sites for roosting in close proximity to water sources for drinking and foraging (Luce and Keinath 2007). The presence of water is essential because of the bats' high metabolism, and because their preferred prey, noctuid moths, are associated with water (Luce and Keinath 2007). There is a moderate level of uncertainty in the habitat category because not much is known about the bats' dispersal ability and seasonal movements. More information on these could affect how the species responds to climate change. For example, if the spotted bat is able to disperse widely and moves seasonally to different roosts, it may be able to shift its range upward in elevation where water sources are more readily available, assuming appropriate roosting sites are also available.

There is a very high level of uncertainty in the phenology category because of a lack of information on breeding biology, influences on adult and juvenile survivorship, and seasonal movements.

Townsend's Big-eared Bat (Corynorhinus townsendii)

Species Status: FS-sensitive, BLM-sensitive					
Townsend's Big-eared Bat	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	0.71	1.67	2.5	0.00	4.55
Uncertainty	14%	17%	25%	20%	18%

As long as appropriate roost sites (caves, abandoned mines) are available for Townsend's Big-eared Bat, shifts in associated vegetation ranges may not greatly impact the species, which uses a wide variety of habitats (Gruver and Keinath 2006). However, the species has limited dispersal ability and shows high fidelity to roost sites, which makes it more sensitive to loss of habitat (Gruver and Keinath 2006).

Townsend's big-eared bat scored positively in the phenology category because it is a hibernator and environmental cues, including temperature, determine when it emerges from hibernation (Gruver and

Keinath 2006). This could lead to a trophic mismatch with its primary prey base, moths. However, it is uncertain how timing or abundance of moth populations will be affected by climate change.

Wolverine (Gulo gulo)

Species Status: FS-sensitive, Federal-candidate					
Wolverine	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	3.57	0.83	2.50	0.00	7.27
Uncertainty	29%	17%	0%	0%	14%

The North American Wolverine breeding habitat in Colorado is limited to alpine tundra and sub-alpine forests (Banci 1994). Sub-alpine forests are expected to shift upwards, and overall area of alpine tundra is expected to decrease. Overall loss of habitat contributes to a high vulnerability score for this species. Not only will overall area of suitable habitat decrease, there will be less connectivity between habitat, limiting dispersal and population persistence (Banci 1994). There is a lack of information on what components make up suitable forest habitat, so there is a slightly higher uncertainty score in the habitat category. Readily available prey is an important association of wolverine habitat as well, and this question is addressed in the biotic interactions category. Since the wolverine has a wide prey base, a neutral score was given here (i.e., prey availability will not be positively or negatively affected by climate change).

Earlier snowmelt in Colorado will also affect possible wolverine persistence. Snow cover that persists into spring has been linked to successful reproduction, since alpine den sites are usually tunnels in the snowpack (Banci 1994, McKelvey et al 2011, Ruggiero et al 2007). Wolverines, which are already considered rare in the San Juan Mountains, seem unlikely to maintain a stable population in this area with the increasing effects of climate change.

Yuma Myotis (Myotis yumanensis)

Species Status: No current listing					
Yuma Myotis	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	2.02	1.67	3.75	1.00	8.18
Uncertainty	14%	17%	50%	20%	23%

While the Yuma myotis inhabits or utilizes, to some degree, a range of vegetation types, it is most often found in dry shrublands in association with riparian habitats (Oliver 2000). It was assumed in this assessment that, due to the range of habitats used by this species on both its breeding and non-breeding grounds, overall habitat availability would likely remain stable. However, riparian situations, a key component in habitat, are predicted to decline with climate change, becoming less available or less functional through drought and reduced stream flows (Theobold 2010). These habitats appear to play an important role in foraging (CP &W 2012, Oliver 2000) and insect prey associated with these areas would likely decline with shifts in moisture regimes and vegetation structures. Yuma myotis roosts beneath the bark of cottonwoods found in riparian habitats, which could be important in unaltered habitats where man-made structures are unavailable (Chung-MacCoubrey 1999). The Yuma myotis also requires the free water associated with these habitats due to its poor urine concentration ability and high rate of metabolism, when foraging (Oliver 2000). Both sexes are capable of dispersing to new habitats to address resource declines. However, since riparian habitats represent a very small proportion of the total landscape, dispersing individuals may be challenged in finding suitable alternative areas for relocation. They would still be constrained by the need for suitable hibernacula, which could affect their flexibility in choosing new breeding or wintering grounds. As a migratory species, this bat will require additional habitats to sustain it along its migration pathways and may be vulnerable to mismatched cues associated with critical resources at its destinations or along its migration routes. Based on studies with other bat species, Yuma myotis may depend on a combination of stored reserves and foraged prey to fuel its migration (Voight et al. 2012).

Mating occurs only once per year and only one offspring is produced. As a result Yuma myotis has a limited capacity to respond to population declines. It does have two characteristics that could help in overall survival and reproduction. It is reportedly a very efficient forager and usually completes its foraging activities during the summer months in less than two hours and sometimes in less than 15 minutes after dark (AG&FD). It also is known, in more southern latitudes, to leave hibernacula to forage during warmer periods in winter, which would supplement its winter stores (Oliver 2000).

There are a number of diseases that might affect Yuma myotis but this area of its life history has not been well-researched. Any species that congregates in relatively tight quarters, such as bats, has the potential to spread disease throughout significant numbers of individuals. Animals in poor condition from resource scarcity would likely be more susceptible to infection and less capable of coping with it. Of particular concern, at present is white-nose syndrome, which infects bats in cave roosts and hibernacula. Yuma myotis has not been identified as having been affected by this disease, but it could be an issue in the future. Some research has suggested that warm micro-sites within cave habitats may be associated with lower levels of infection and some bats tend to gravitate toward these warmer areas in infected caves (Boyles & Willis 2009). Climate change could potentially help reduce this pathogen's effects by creating warmer micro-sites within cave structures.

Amphibians

Boreal Toad (Bufo boreas boreas)

Species Status: FS-sensitive, BLM-sensitive, State-endangered

Boreal Toad	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	2.14	1.50	2.50	1.00	7.27
Uncertainty	29%	0%	25%	40%	23%

Boreal toads are found in high-elevation wetlands and are associated with forests or shrubby habitats when they are not breeding (Keinath and McGee 2005). This species will likely be less affected by shifting forest habitat than by drying of wetlands. In general, wetlands are likely to decrease in overall area, and loss of small patches of wetlands may be additionally detrimental to the boreal toad as this will reduce habitat connectivity. Droughts and wildfires, which are predicted to increase in frequency, may cause direct mortality to the larval or juvenile stages of the toad (Keinath and McGee 2005). Uncertainty in the habitat category comes from (1) a lack of information on how microhabitat that is used for thermal regulation will be affected by climate change, and (2) from heterogeneity in the summer habitats used by individual toads, which makes it difficult to predict an overall direction of change for this component.

The temperature of water in breeding ponds directly affects the timing and duration of larval development (Keinath and McGee 2005). Higher temperatures may not have a negative effect if waters at the upper elevation limit warm earlier, lengthening the amount of time for larvae to develop. However, breeding normally coincides with snowmelt, so there is a potential for mismatch if snow melts early but temperatures are still below an acceptable range. The boreal toad hibernates below the frost line in underground chambers (e.g., rodent borrows) and depend on adequate snow cover to insulate their hibernacula (FWS 2001). Decreasing snow depths may leave some toads susceptible to freezing or reduce the availability of suitable wintering habitat. The chytrid fungus has been implicated in the loss of toad populations in the Southern Rockies. However, there is little information regarding how this fungus, and the toad's susceptibility to the fungus, could be influenced by climate change. Some researchers suggest, based on responses of other amphibian species, that some aspects of climate change, could reduce the immunity of boreal toads to pathogens, such as the chytrid fungus (Blaustein et al.1994).

Canyon Treefrog (Hyla arenicolor)

Species Status: BLM-sensitive

Canyon Treefrog	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	2.86	-0.33	2.50	0.00	5.45
Uncertainty	29%	17%	25%	60%	32%

The Canyon treefrog is able to use a variety of terrestrial habitats, including piñon-juniper, semi-arid grassland, or pine-oak woodlands (NatureServe 2011), so the overall amount of non-breeding habitat may stay relatively constant for this species. However, they are also closely associated with permanent or intermittent streams in canyon bottoms (NatureServe 2011), which they use as breeding pools. These types of water bodies are susceptible to drying up in a warmer climate, which would significantly affect this species by reducing suitable breeding habitat and reducing habitat connectivity. Canyon treefrogs are adapted to arid environments, and are able to extend their breeding period in years of low rainfall, a strategy that may help them cope with more frequent dry years.

There is fairly high uncertainty in the biotic interactions category, which stems from a lack of information on predators, competitors, and effects of disease on this species. Although diseases such as chytridiomycosis are a concern for amphibians in general in a warmer climate, there was little information that linked this disease specifically to the canyon treefrog.

Northern Leopard Frog (Rana pipiens)

Species Status: FS-sensitive, BLM-sensitive

Northern Leopard Frog	Habitat	Physiology	Phenology	Biotic Interactions	Total Score
Vulnerability Score	0.48	1.5	2.08	1.00	5.45
Uncertainty	14%	17%	0%	20%	14%

The Northern Leopard Frog shows a relatively high vulnerability to climate change, driven by positive scores in all categories. Effects on leopard frog habitat were difficult to evaluate because the frog occupies a variety of habitats at different life stages. In general, leopard frog habitat at all life stages will be strongly impacted by warmer temperatures. Breeding ponds and moist upland foraging habitat at lower elevations may become too warm or dry up, reducing overall habitat. The northern leopard frog requires a specific temperature range for breeding ponds, and timing of egg deposition and therefore reproductive success is strongly affected local temperatures (Smith and Keinath 2007). At high elevations, breeding areas may warm earlier, increasing reproductive success. The frog also requires dispersal habitat from breeding sites to upland areas and for natal dispersal from breeding ponds (Smith & Keinath 2007). There is not enough information on what type of dispersal habitat is required, but frogs have been observed dispersing through areas with no aquatic connections (Smith & Keinath 2007), which may help in a drier climate.

Predicted early snowmelt may result in more extreme flooding events in spring, which could directly impact frog populations if eggs or larvae are disturbed (Smith & Keinath 2007). Also, amphibians in general are vulnerable to the spread of diseases, including chytridiomycosis, which is strongly influenced by climate and weather factors (Alford 2011).

Reptiles

Desert Spiny Lizard (Sceloporus magister)

Species Status: BLM-sensitive

Desert Spiny Lizard	Habitat	Physiology	Phenology	Biotic Interactions	Total Score
Vulnerability Score	-1.67	-0.17	-0.42	0.00	-1.82
Uncertainty	14%	17%	25%	40%	23%

Unlike the majority of species evaluated here, the habitat range for the desert spiny lizard will likely increase in this region. Much of the population is found to the south and west of the Four Corners (NatureServe 2011), a hotter and more arid environment, so as climate and associated vegetation moves upward, so will the range of this species. However, no information was found on dispersal ability, which will influence the opportunity to utilize expanding habitat.

The diet of the desert spiny lizard fluctuates seasonally and annually, so it may be well equipped to take advantage of resources when they are available (Vitt et al. 1981). It is able to produce two clutches per season, increasing the chances that one set of offspring will be able to take advantage of temporally variable food resources (Tinkle 1976). The lower metabolism of this ectothermic species also contributes to its overall resiliency to climate change; aestivators in general may benefit because they are able to withstand hotter, drier conditions (Bagne et al 2011). More information is needed on competitors and symbionts for this species.

Long-nosed Leopard Lizard (Gambelia wislizenii)

Species Status: BLM-sensitive					
Long-nosed Leopard Lizard	**Habitat**	**Physiology**	**Phenology**	**Biotic Interactions**	**Total Score**
Vulnerability Score	-0.95	-0.17	0.83	0.00	0.00
Uncertainty	14%	17%	25%	60%	27%

Similar to the desert spiny lizard, the overall habitat range for the long-nosed leopard lizard is expected to increase as warmer and drier climate regimes move upward in elevation. Habitat components for breeding are unlikely to change, since the lizards lay their eggs in burrows (NatureServe 2011). However, this species prefers areas with a moderate amount of shrubs and low grass cover (Schorr et al. 2011). Climate change is expected to favor the expansion of invasive species such as cheatgrass (*Bromus tectorum*), which persists in the landscape and would reduce habitat quality for the leopard lizard.

Hibernating species whose emergence is primarily cued by temperature are more likely to experience a mismatch with resource availability, which results in a slightly positive score in the Phenology category here (Bagne et al. 2011). However, the positive score is balanced by a negative score in the Physiology category, a result of the benefits from being ectothermic and producing multiple clutches per season (NatureServe 2011). More information is needed on climate effects on predators, symbiotic species, diseases, and competitors.

CONCLUSIONS

We assessed 32 wildlife species designated as sensitive for the TRFO in the context of climate change, using the System for Assessing Vulnerability of Species management tool developed by the Rocky Mountain Research Station. Out of the 32 species assessed, all but five were found to be vulnerable to climate change with an average SAVS score of 4.71.

This assessment infers that, while habitat is a key indicator of population health, other factors may play important roles in population viability including those that may be affected by climate change. Phenology appears to be a key contributing element to vulnerability, particularly for long-distance migratory species and hibernating species (with the exception of desert reptiles). Loss of extent and quality of habitat will also be a key driver of vulnerability for many species. This was most apparent for alpine species, which are already at the upper limits of their range and will have nowhere to disperse with changing conditions. It seemed apparent, as well, for species that depend on water-rich environments for some or all of their life requisites. In some cases, it was not only a general decrease in habitat area, but changes in structural attributes that contributed to vulnerability. For species that prefer the attributes of mature forests (e.g., northern goshawk, flammulated owl), vegetation range shifts may have a compounding effect as species lose overall habitat and as structural components change with new successional stages. Other species that will be highly vulnerable are those that have strong requirements for consistent water sources throughout the year. Desert bighorn sheep, river otter, bald eagle, northern leopard frog, and spotted bat are all examples of wildlife species that require access to water for population persistence. In a warmer and drier climate, water will be scarcer, which directly limits access and increases competition. While physiology and biotic interactions did not appear to be as important a contributor to the individual species' climate-related vulnerability, the cumulative impact of these factors along with phenology and habitat should not be ignored.

The relative levels of vulnerability indicated by the SAVS scores should provide land managers guidance in the allocation of resources in the management of its wildlife species of conservation concern. From a management perspective there will be little that can be done to address species' climate-related sensitivities to physiology or phenology, and only minimal opportunities to intercede in biotic interactions. It is likely that habitat management will provide the best opportunities for mitigating predicted species' vulnerabilities to climate change. Many of the habitats used by the species examined in this assessment have already been substantially altered by past management practices, which likely contributed to their status as sensitive species. Some mitigation is currently being implemented through such actions as alpine habitat protection, noxious plant control, protection and restoration of wetlands and riparian corridors, maintenance of late successional forests, and management of rangelands. However, with the shifts predicted to occur with climate change, managers may find it necessary to expand these efforts to effectively manage for viable local populations of sensitive wildlife species. In some cases, this may require difficult choices between wildlife and other management priorities, such as livestock management, energy development, fuels management, timber harvesting and water management.

In the process of completing this assessment, a number of critical information gaps for the San Juan Mountain region became apparent. While there are projections of change for many forest types and -tree species (ponderosa pine, mixed-conifer forest, aspen, etc.), there are fewer specific projections for other habitat types, specifically wetlands, riparian areas at different elevations, and lower elevation grasslands. While some conclusions can be drawn about these habitat types (e.g., wetlands in general will be drier and decrease in area), more specific predictions about the type and magnitude of change are needed to better understand how wildlife species will respond. There is also considerable uncertainty in understanding how specific aspects of forest structure will change as ranges shift. Changes in forest structure will affect important habitat components (e.g., understory composition, amount of coarse woody debris) for many wildlife species, and a better understanding of these changes will improve relative predictions of vulnerability. Insect populations are highly significant as prey for a number of bird and bat species. More information on how the insect prey base will respond to climate change would improve the vulnerability assessments for many of the species discussed here. For the most vulnerable species, a more detailed assessment tool may be useful to better understand the drivers of vulnerability.

Finally, it is important to remember that the SAVS assessment tool does not consider the current overall status of the individual species examined or consider factors unrelated to climate change that might be exerting influences on population dynamics of these species. These factors, in association with climate change, could have compounding effects so that even slight impacts related to climate change may push species that are already being negatively influenced by other stressors beyond their threshold limits of tolerance. The results of this assessment may also have implications for other wildlife species that use similar habitats or have similar life histories to those species examined here. It may be advisable to apply this or some other assessment tool to a broader range of species that have not been yet been identified as species of conservation concern.

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APPENDIX A- System for Assessing Vulnerability of Species (v.2.0): Questions, Responses and Points

Habitat

H1. Area and distribution: breeding. Is the area or location of the associated vegetation type used for breeding activities by this species expected to change? Specific habitat elements and food resources are considered in other questions.

a. Area used for breeding habitat expected to decline or shift from current location (SCORE = 1)
b. Area used for breeding habitat expected to stay the same and in approximately the same location (SCORE = 0)
c. Area used for breeding habitat expected to increase and include the current location (SCORE = -1)

H2. Area and distribution: non-breeding. Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?

a. Area used for non-breeding habitat expected to decline or shift from current location (SCORE = 1)
b. Area used for non-breeding habitat expected to stay the same in approximately the same location (SCORE = 0)
c. Area used for non-breeding habitat expected to increase and include the current location (SCORE = -1)

H3. Habitat components: breeding. Are specific habitat components required for breeding expected to change within the associated vegetation type?

a. Required breeding habitat components expected to decrease (SCORE = 1)
b. Required breeding habitat components unlikely to change OR habitat components required for breeding unknown (SCORE = 0)
c. Required breeding habitat components expected to increase (SCORE = -1)

H4. Habitat components: non-breeding. Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?

a. Required non-breeding habitat components expected to decrease (SCORE = 1)
b. Required non-breeding habitat components unlikely to change OR habitat components required for breeding unknown (SCORE = 0)
c. Required non-breeding habitat components expected to increase (SCORE = -1)

H5. Habitat quality. Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?

a. Projected changes are likely to negatively affect habitat features associated with improved reproductive success or survival (SCORE = 1)
b. Projected changes are unlikely to affect habitat features associated with improved reproductive success or survival (SCORE = 0)
c. Projected changes are likely to positively affect habitat features associated with improved reproductive success or survival (SCORE = -1)

H6. Ability to colonize new areas. What is the potential for this species to disperse?

a. Low ability to disperse (SCORE = 1)
b. Mobile, but dispersal is sex-biased (only one sex disperses) (SCORE = 0)
c. Very mobile, both sexes disperse (SCORE = -1)

H7. Migratory or transitional habitats. Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?

a. Additional habitats required that are separated from breeding and non-breeding habitats (e.g., most migratory species) (SCORE = 1)
b. No additional habitats required that are separated from breeding and non-breeding habitats (e.g., most resident species and short-distance migrants) (SCORE = 0)

Physiology

PS1. Physiological thresholds. Are limiting physiological conditions expected to change?

a. Projected changes in temperature and moisture are likely to exceed upper physiological thresholds (e.g., activities occur in very hot climates, amphibians in drier climates, species with narrow thermal range) (SCORE = 1)

b. Projected changes in temperature or moisture will primarily remain within physiological thresholds OR species is inactive during limiting conditions (e.g., species with moderate thermal range, aestivators that avoid hot/dry conditions) (SCORE = 0)

c. Projected changes in temperature or moisture will decrease current incidents where lower thresholds are exceeded (e.g., species active in very cold climates, amphibians in wetter climates, species with very broad thermal range) (SCORE = -1)

PS2. Sex ratio. Is sex ratio determined by temperature?

a. Yes. (SCORE = 1)

b. No. (SCORE = 0)

PS3. Exposure to weather-related disturbance. Are disturbance events (e.g., severe storms, fires, floods) that affect survival or reproduction expected to change?

a. Projected changes in disturbance events will likely decrease survival or reproduction (SCORE = 1)

b. Survival and reproduction are not strongly affected by disturbance events OR disturbance events are not expected to change (SCORE = 0)

c. Projected changes in disturbance events will likely increase survival or reproduction (SCORE = -1)

PS4. Limitations to daily activity period. Are projected temperature or precipitation regimes that influence activity period of species expected to change?

a. Duration of daily active periods likely to be reduced (e.g., heliotherms in hot climates, terrestrial amphibians in drier climates) (SCORE = 1)

b. Duration of daily active periods unchanged or not limited by climate (species in habitats buffered from extremes, nocturnal species, primarily aquatic amphibians) (SCORE = 0)

c. Duration of daily active periods likely to increase (e.g., heliotherms in cool climates, terrestrial amphibians in wetter climates) (SCORE = -1)

PS5. Survival during resource fluctuation. Does this species have flexible strategies to cope with variation in resources across multiple years?

a. Species has no flexible strategies to cope with variable resources across multiple years (SCORE = 1)

b. Species has flexible strategies to cope with variable resources across multiple years (e.g., alternative life forms, irruptive, explosive breeding, cooperative breeding) (SCORE = -1)

PS6. Energy requirements. What is this species' metabolic rate?

a. Very high metabolic rates (e.g., shrews, hummingbirds) (SCORE = 1)

b. Moderate (e.g., most endotherms) (SCORE = 0)

c. Low (i.e. ectotherms) (SCORE = -1)

Phenology

PH1. Mismatch potential: Cues. Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g., hibernation, migration, breeding)?

a. Species primarily uses temperature or moisture cues to initiate activities (e.g., some hibernators, aestivators, rainfall breeders) (SCORE = 1)

b. Species does not primarily use temperature or moisture cues OR no cues to predict or initiate activities (e.g., photoperiod or circadian rhythms, resource levels) (SCORE = 0)

PH2. Mismatch potential: Event timing. Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g., food, breeding sites) that are expected to change?

a. Species' fitness is tied to discrete resource peaks that are expected to change (SCORE = 1)

b. Species' fitness is tied to discrete resource peaks that are NOT expected to change (SCORE = 0)

c. No temporal variation in resources or breeds year-round (SCORE = -1)

PH3. Mismatch potential: Proximity. What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?

a. Critical resource occurs far in advance or in distant locations from cues or initiation of activity (SCORE = 1)

b. Critical resource does NOT occur far in advance or in distant locations from cues or initiation of activity (SCORE =0)

c. Species initiates activities directly from critical resource availability (e.g., opportunistic breeders) (SCORE = -1)

PH4. Resilience to timing mismatch. Does this species have more than one opportunity to time reproduction to important events?

a. Species reproduces once per year or less (SCORE = 1)

b. Species reproduces more than once per year (SCORE = -1)

Biotic Interactions

B1. Food resources. Are important food resources for this species expected to change?

a. Primary food source(s) are expected to be negatively impacted by projected changes (SCORE = 1)

b. Species consumes variety of prey/forage species OR primary food resource(s) not expected to be impacted by projected changes (SCORE =0)

c. Primary food resource(s) expected to be positively impacted by projected changes (SCORE = -1)

B2. Predators. Are important predator populations for this species expected to change?

a. Primary predator(s) are expected to be positively impacted by projected changes (SCORE = 1)

b. Preyed upon by a suite of predators OR the primary predator is not expected to be impacted by projected changes (SCORE = 0)

c. Species has no predators (SCORE = 0)

d. Primary predator(s) expected to be negatively impacted by projected changes (SCORE = -1)

B3. Symbionts. Are populations of symbiotic species expected to change?

a. Symbiotic species populations expected to be negatively impacted by projected changes (SCORE = 1)

b. Symbiotic species populations not expected to be impacted by projected changes(SCORE = 0)

c. No symbionts (SCORE =0)

d. Symbiotic species populations expected to be positively impacted by projected changes (SCORE = -1)

B4. Disease. Is prevalence of diseases known to cause widespread mortality or reproductivefailure in this species expected to change?

a. Disease prevalence is expected to increase with projected changes (SCORE = 1)

b. No known effects of expected changes on disease prevalence (SCORE = 0)

c. Disease prevalence is expected to decrease with projected changes (SCORE = -1)

B5. Competitors. Are populations of important competing species expected to change?

a. Major competitor species are expected to be positively impacted by projected changes (SCORE = 1)

b. Species has a variety of competitive relationships OR no expected impacts of projected changes in major competitor species (SCORE = 0)

c. Competing species are expected to be negatively impacted by projected changes(SCORE = -1)

APPENDIX B- Scoring Summary Table

Table: Summary of species with categorical scores:

Species	Scientific Name	Overall Score	Categorical Scores				Overall Uncertainty
			Habitat	Physiology	Phenology	Biotic Interactions	
American three-toed woodpecker	Picoides dorsalis	-2.73	-1.9	1	1.25	-1	18%
Desert spiny lizard	Sceloporus magister	-1.82	1.67	0.17	-0.42	0	23%
Lewis' woodpecker	Melanerpes lewis	-0.91	-1.9	-1	2.5	0	18%
Olive-sided Flycatcher	Contopus cooperi	0	-1.9	1.17	2.5	1	18%
Long-nosed leopard lizard	Gambelia wislizenii	0	0.95	0.17	0.83	0	27%
Peregrine Falcon	Falco peregrinus	1.82	0.12	0.83	1.25	0	14%
Brewer's Sparrow	Spizella breweri	3.64	2.02	0.17	-0.42	1	32%
Western Burrowing Owl	Athene cunicularia hypugaea	3.64	1.79	0.83	3.75	2	23%
Gunnison's Prairie Dog	Aegolius funereus richardsoni	3.64	0.95	0.17	3.75	2	14%
American Marten	Martes americana	4.55	1.31	0.83	1.25	1.00	18%
Columbia Sharp-tailed Grouse	Tympanuchus phasianellus columbianus	4.55	0.36	1.67	1.25	2	27%
Fringed Myotis	Myotis thysanodes	4.55	1.43	0.83	2.5	0	5%
Northern Goshawk	Accipiter gentilies	4.55	2.14	-1	1.25	2	18%
Townsends big-eared bat	Corynorhinus townsendii	4.55	0.71	1.67	2.5	0	18%
Flammulated Owl	Otus flammeolus	5.45	2.02	-1	2.5	0	18%
Bald Eagle	Haliaeetus leucocephalus	5.45	2.02	1.67	1.25	0.0	45%
Loggerhead Shrike	Lanius ludovicianus	5.45	1.31	1.67	-0.42	2	18%
Purple Martin	Progne subis	5.45	2.74	2.17	3.75	1	23%
Northern Leopard Frog	Rana pipiens	5.45	0.48	1.5	2.08	1	14%
Canyon treefrog	Hyla arenicolor	5.45	2.86	0.33	2.5	0	32%
Black Swift	Cypseloides niger	6.36	2.14	0.83	2.5	1	23%
Spotted Bat	Euderma maculatum	6.36	2.14	2.5	1.25	0	27%
Boreal toad	Bufo boreas boreas	7.27	2.14	1.5	2.5	1.00	23%
Desert Bighorn Sheep	Ovis canadensis nelsonii	7.27	4.29	0.83	-0.42	1	14%
Hoary Bat	Lasiurus cinerus	7.27	1.31	0.67	5	1	41%
Rocky Mountain Bighorn Sheep	Ovis canadensis canadensis	7.27	3.57	0.83	1.25	1	14%
River Otter	Lontra Canadensis	7.27	2.74	0.83	1.25	2	18%
Wolverine	Gulo gulo	7.27	3.57	0.83	2.5	0	14%
Boreal Owl	Aegolius funereus	7.27	2.74	0.17	2.5	2	27%
Yuma Myotis	Myotis yumanensis	8.18	2.02	1.67	3.75	1	23%
Gunnison's Sage Grouse	Centrocercus minimus	8.18	2.14	0.83	2.5	3	23%
White-tailed Ptarmigan	Lagopus leucurus	8.18	3.57	0.83	2.5	1	14%

APPENDIX C- Sensitive Wildlife Species Considered for Evaluation

Species	**Evaluation Status**
Birds	
American Bittern *(Botaurus lentiginosus)*	Species eliminated-lack of relevant information
American Three-toed Woodpecker (Picoides dorsalis)	Species examined in detail
Bald Eagle *(Haliaeetus leucocephalus)*	Species examined in detail
Black Swift *(Cypseloides niger)*	Species examined in detail
Black Tern ***(Chlidonias niger)***	Species eliminated-lack of relevant information
Boreal Owl (*Aegolius funereus richardsoni)*	Species examined in detail
Brewer's Sparrow (Spizella breweri)	Species examined in detail
Columbia Sharp-tailed Grouse *(Tympanuchus phasianellus columbianus)*	Species examined in detail
Ferruginous Hawk *(Buteo regalis)*	Species eliminated-lack of relevant information
Flammulated Owl *(Otus flammeolus)*	Species examined in detail
Gunnison's Sage Grouse *(Centrocercus minimus)*	Species examined in detail
Lewis' woodpecker *(Melanerpes lewis)*	Species examined in detail
Loggerhead Shrike *(Lanius ludovicianus)*	Species examined in detail
Northern goshawk *(Accipiter gentiles)*	Species examined in detail
Northern Harrier *(Circus cyaneus)*	Species eliminated-Low priority-management unlikely to influence
Olive-sided Flycatcher *(Contopus cooperi)*	Species examined in detail
Peregrine Falcon *(Falco peregrinus)*	Species examined in detail
Purple Martin *(Progne subis)*	Species examined in detail
Short-eared Owl *(Asio flammeus)*	Species eliminated-Low priority-management unlikely to influence
Western Burrowing Owl (Athene cunicularia)	Species examined in detail
Western Yellow-billed Cuckoo *(Coccyzus americanus)*	Species eliminated-presence not confirmed
White-faced Ibis *(Plegadis chihi)*	Species eliminated-Low priority-management unlikely to influence
Mammals	
Allen's Big-eared Bat *(Idionycteris phyllotis)*	Species eliminated-lack of relevant information
American Marten *(Martes americana)*	Species examined in detail
Big Free-tailed Bat ***(Nyctinomops macrotis)***	Species eliminated-lack of relevant information
Desert Bighorn Sheep *(Ovis canadensis nelsonii)*	Species examined in detail
Fringed Myotis *(Myotis thysanodes)*	Species examined in detail
Gunnison's Prairie Dog (Aegolius funereus richardsoni)	Species examined in detail
Hoary Bat *(Lasiurus cinereus)*	Species examined in detail
River Otter *(Lontra Canadensis)*	Species examined in detail
Rocky Mountain Bighorn Sheep (Ovis canadensis canadensis)	Species examined in detail
Spotted Bat *(Euderma maculatum)*	Species examined in detail
Townsend's Big-eared Bat *(Corynorhinus townsendii)*	Species examined in detail
Wolverine *(Gulo gulo)*	Species examined in detail
Yuma Myotis *(Myotis yumanensis)*	Species examined in detail
Amphibians & Reptiles	
Boreal Toad *(Bufo boreas boreas)*	Species examined in detail
Canyon Treefrog *(Hyla arenicolor)*	Species examined in detail
Northern Leopard Frog *(Rana pipiens)*	Species examined in detail
Desert Spiny Lizard *(Sceloporus magister)*	Species examined in detail
Long-nosed Leopard Lizard *(Gambelia wislizenii)*	Species examined in detail

APPENDIX D- Completed Questionnaires and Explanation of Responses

Scoring response numbers correspond to a rating of vulnerable, neutral, or resilient, where: -1=Resilient, 0=Neutral, 1=Vulnerable. Uncertainty response numbers correspond to a level of uncertainty, where: 0=Information adequate, 1=Information not adequate or conflicting. Sources generally refer to species information, rather than climate effects, which are fully referenced in the 'Climate Projections' section of this document. Species are arranged in alphabetical order.

AMERICAN MARTEN (*Martes americana*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	0	breeding habitat in spruce-fir and coll-moist mixed conifer forests; more spruce forest lost than added; doug fir about the same; in general, spruce-fir and mixed con move up in elevation (Buskirk and Ruggiero 1994, Rehfeldt et al. 2006)
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	1	0	breeding and non-breeding habitat essentially the same (associated vegetation type)
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	0	1	characteristics of mid-late successional forests are important, with complex physical structures near the ground; but uncertain exactly how these characteristics will shift with shifting veg ranges; higher frequency of wildfires would have detrimental impact; insect outbreaks may have negative short-term effects but improve habitat over a longer time period (Buskirk and Ruggiero 1994)
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	1	again, complex physical structures near the ground important for protection from predators, hunting, and protective thermal environment; uncertain how climate change will impact this habitat component; see H3 (Buskirk and Ruggiero 1994)
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	marten are sensitive to changes in habitat, esp. timber harvest, snag removal, firewood collection; so shifts in veg ranges might change forest structural components that increase fitness (Finch 1992)
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	0	few studies, but long distance movements have been reported (Buskirk and Ruggiero 1994, NatureServe 2011)
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	0	does not migrate (NatureServe 2011)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

AMERICAN MARTEN (*Martes americana*)				
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	no evidence that physiological thresholds will be exceeded
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	0	wildfire or other disturbances would affect martens indirectly, by changing habitat (Buskirk and Ruggiero 1994)
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	dusk and dawn in summer, daytime in winter (NatureServe 2011)
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	no known alternative strategies; conservative breeding strategy (Buskirk 2002)
PS6. Energy requirements	What is this species' metabolic rate?	0	0	Moderate
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	0	active gestation cued by photoperiod (Buskirk and Ruggiero 1994)
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	0	fitness tied to prey availability, but has a variety of prey, so no discrete resource peak (Buskirk 2002)
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	species is not a long distance migrant; resources available throughout year
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	Once per year
BIOTIC INTERACTIONS				

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

AMERICAN MARTEN (*Martes americana*)				
B1. Food resources	Are important food resources for this species expected to change?	1	0	While the marten depends on a variety of prey species, the red-backed vole represents an important species that occurs in highest abundance in mesic, mature spruce-fir forests (Buskirk 2002). The late successional forests and mesic conditions within those forest types are predicted to decline with climate change.
B2. Predators	Are important predator populations for this species expected to change?	0	0	predators include coyote, bobcat, lynx, fisher and more (Buskirk 2002)
B3. Symbionts	Are populations of symbiotic species expected to change?	-1	0	no known symbionts (NatureServe 2011, Buskirk 2002)
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	1	no known expected increase in diseases, but little information found
B5. Competitors	Are populations of important competing species expected to change?	0	1	variety of carnivorous competitors; competition plays important role in community structure of martens; not enough info on how competitors may be affected by climate change (Buskirk 2002)

AMERICAN THREE-TOED WOODPECKER (*Picoides dorsalis*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	0	according to Crookston maps, more spruce forest lost than added; doug fir about the same; in general, spruce-fir and mixed con move up in elevation
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	1	0	see H1
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	-1	0	important breeding habitat components are snags, expected to increase after fires, which are projected to increase in frequency; however, increase in populations post-fire is temporary (Wiggins 2004b)
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	-1	0	same as breeding, but dead or infested trees are also important components of non-breeding habitat (for foraging) (Wiggins 2004b)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

AMERICAN THREE-TOED WOODPECKER (*Picoides dorsalis*)				
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	-1	0	disturbances associated with climate change (insect outbreaks, fires) are likely to improve habitat quality by creating snags and dead or infested trees
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	1	The black-backed woodpecker lives in an environment that is unpredictable and/or ephemeral and its dispersal ability is well developed in order to occupy such a niche (Dixon and Saab 2000).; this could apply to TTW as well; however, Wiggins repeatedly states need for more information on dispersal ability and how fragmented habitat may limit it
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	0	non-migratory (NatureServe 2011)
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	inhabits a range of temperature and precipitation regimes; drier and warmer climate may limit habitat range but not physiology (NatureServe 2011)
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	1	although disturbances such as fire will indirectly benefit populations by creating habitat, there is not enough information on direct effects of the disturbance on populations
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	habitat buffered from extremes (NatureServe 2011)
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	-1	0	have displayed irruptions due to changing resources- small-scale (Wiggins 2004b)
PS6. Energy requirements	What is this species' metabolic rate?	0	0	Moderate (NatureServe 2011)
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	1	phenology of breeding events poorly known (Wiggins 2004b)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

AMERICAN THREE-TOED WOODPECKER (*Picoides dorsalis*)				
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	1	phenology of breeding events poorly known; Wiggins says reproductive success appears to depend on food resources (Wiggins 2004b)
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	influenced by availability of habitat and food resources, both local (Wiggins 2004b)
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	Once per year (NatureServe 2011)
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	-1	0	primary food resource are bark and wood-boring beetles; outbreaks of these insects are strongly related to drought, which is predicted to increase with climate change (Hansen et al. 2010)
B2. Predators	Are important predator populations for this species expected to change?	0	1	some goshawk predation- goshawk populations unlikely to strongly decline due to climate change; susceptible to small mammal predation on nests; not enough info on how much predators affect population dynamics (Wiggins 2004b)
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	no known symbionts (Wiggins 2004b)
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	1	no systematic studies of parasites or disease on TTW (Wiggins 2004b)
B5. Competitors	Are populations of important competing species expected to change?	0	1	competes with other woodpeckers (black-backed, hairy, flicker, sapsuckers) for resources; not enough info on how all these populations might be affected (Wiggins 2004b)

BALD EAGLE (Haliaeetus leucocephalus)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

BALD EAGLE (Haliaeetus leucocephalus)				
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	0	The bald eagle uses trees around the margins of surface waters that offer an abundance of prey potential. Climate change is predicted to shrink water bodies (with commensurate declines in fish) and will also affect the tree component around these water bodies over the long term, particularly when that component is comprised of cottonwoods. Buehler, D.A. 2000.
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	0	1	Non-breeding habitat is somewhat similar to breeding habitat and would be expected to decline. Buehler, D.A. 2000.
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	0	Nest trees, particularly cottonwoods within narrow riparian corridors, can be expected to decline. Also, the size, and ultimately functionality of waterbodies in relation to forage potential is also expected to decline with climate change. Buehler, D.A. 2000.
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	1	0	Winter concentration areas and roost sites comprised of cottonwood trees and galleries (e.g., Disappointment Creek) would be expected to decline. Buehler, D.A. 2000.
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	90% of eagles nest near water sources and depend on fish as a major part of their foraging base during the nesting season. The quality of fish and fish populations are expected to decline as a result of climate change.
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	1	While this species does have the ability to disperse, dispersal is confined to a narrow pathway of suitable habitats. Also, strong site fidelity may also interfere with effective dispersal to other favorable habitats.

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

BALD EAGLE (Haliaeetus leucocephalus)				
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	1	Eagles are dependent on similar habitats during migration comparable to habitats used on their breeding and winter grounds. Buehler, D.A. 2000.
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	1	1	In a study of nesting eagles in Colorado and Wyoming between 1981 and 1989, the greatest source of nest failure was destruction of the nest trees resulting from heavy winds. Spring high wind events, such as have been experienced in the SW in recent years, could increase with climate change. However, the relationship between these winds and climate change have not been completely substantiated.
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	1	Winter foraging activities are reported to be affected by temperature and eagles are more active in foraging when temps are higher. However, it is unclear if this would be a significant aspect of winter survival. Grubb and Kennedy (1982)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

BALD EAGLE (Haliaeetus leucocephalus)				
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	No, They breed only once a year and nest productivity is a naturally low 1.2-1.6 fledglings/year. Additionally, juveniles do not begin breeding until roughly their 5th year and may postpone breeding even longer during periods of scarce resources (Buehler 2000). These factors would make it difficult for species to recover from population declines.
PS6. Energy requirements	What is this species' metabolic rate?	0	0	
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	1	No reference in the literature regarding cues related to temperature or moisture.
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	1	
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	1	While migration cues are not well understood, it has been suggested that fall migration in some populations moving southward are initiated to coincide with fish spawning events. Buehler, D.A. 2000.
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	The bald eagle will re-nest as a result of nest failure but does not double clutch. Buehler, D.A. 2000.
BIOTIC INTERACTIONS				

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

BALD EAGLE (Haliaeetus leucocephalus)				
B1. Food resources	Are important food resources for this species expected to change?	1	0	Food resources related to fish could be impacted by drought with shrinking streams and reservoirs, increased sedimentation due to fire, and increasing water temperatures. Winter forage relating to scavenging could be impacted as warmer winters produce fewer winter kills of deer and elk. Buehler, D.A. 2000.
B2. Predators	Are important predator populations for this species expected to change?	0	0	Most predation occurs at the nest and is perpetrated by a host of nest predators. Buehler, D.A. 2000.
B3. Symbionts	Are populations of symbiotic species expected to change?	-1	0	Eagles have frequent interactions with other species in attempts to steal captured prey (e.g., osprey). Whether a decline in this species (which has a similar life history to eagles) would have a significant impact to the bald eagle is possible but not likely.
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	1	A number of diseases are reported in eagles but do not appear to have a significant impact on mortality. Marine Coastal Information System (1996)
B5. Competitors	Are populations of important competing species expected to change?	0	1	Bald eagles and osprey have somewhat similar habitat and foraging characteristics and compete for food and nesting sites. Osprey are likely to be negatively affected by climate change, especially on their breeding grounds. Since osprey may be more impacted by bald eagles than the other way around, it is not really known if a decline in osprey would have a meaningful positive response in eagles. Ogden's study in Florida doesn't suggest that it would. Ogden, J.C. (1975)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

BLACK SWIFT (*Cypseloides niger*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	0	0	Breeding habitat occurs in close proximity to waterfalls; there are highly specific components for nesting sites, but overall area and distribution of cliff sites unlikely to change. (Wiggins 2004)
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	0	1	Inadequate information on winter range in general; consequently, inadequate information on climate effects for non-breeding habitat (NatureServe 2011)
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	0	0	specific required habitat components are close proximity to waterfalls, high relief, no direct sunlight, inaccessibility to predators, unobstructed flyways, niches in rocks, availability of moss for nests; none of these are expected to change due to climate change; effect of change in water flows is addressed in H5 (Wiggins 2004)
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	1	Inadequate information on winter range in general; consequently, inadequate information on climate effects for non-breeding habitat components (NatureServe 2011)
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	In montane areas, years with poor snowfall and little summer rain not only reduce the number of available waterfalls, but also reduce the flow at existing falls, which may lead to declines in the number of nesting swifts; In addition, the timing of water flows appears to be important, as black swifts are relatively late nesters and thus rely on continued water flow during the mid and late summer periods. (Wiggins 2004). Climate predictions include drier summers, increased dust-on-snow events that reduce late season flows, and reduced snowpack.
H6. Ability to colonize new areas	What is the potential for this species to disperse?	1	1	No studies on juvenile dispersal. High nest site fidelity has been demonstrated (Wiggins 2004a)
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	1	0	Long-distance migrant (NatureServe 2011)
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	Moderate thermal range.
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No.

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

BLACK SWIFT (*Cypseloides niger*)				
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	0	Projected increase in wildfires, but nesting sites on cliffs unlikely to be *directly* affected.
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	Diurnal (NatureServe 2011)
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	high nest fidelity, long-lived species with low reproductive rate; long breeding season (Wiggins 2004a)
PS6. Energy requirements	What is this species' metabolic rate?	0	0	Moderate
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	0	Given the large latitudinal range of black swifts, there is surprisingly little latitudinal variation in the timing of breeding (Wiggins 2004a); It is not yet known whether the unusually late breeding by black swifts is related to nest site conditions (e.g., low water flow), to food abundance, or to a combination of the two factors (Wiggins 2004a). Score indicating vulnerability reserved for species where change in climate leads to change in timing of a distinct cue.
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	1	feed primarily on winged ants and termites; apparent dependence on ephemeral, swarming prey likely responsible for aspects of breeding biology; not enough info on change in timing of insect pulses (Wiggins 2004a)
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	1	0	since species is a long distance migrant, food resource pulses available during breeding are spatially distant from where migration is initiated; resource is not available year-round (NatureServe 2011)
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	black swifts lay only a single egg and have a relatively long nesting period (and thus little chance to renest after failure) (Wiggins 2004a)
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	1	0	Drought conditions may also negatively affect the supply of flying insects, thereby reducing swift foraging and nesting success (Wiggins 2004a)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

BLACK SWIFT (*Cypseloides niger*)				
B2. Predators	Are important predator populations for this species expected to change?	0	0	Only known predator is peregrine falcon; nests are relatively inaccessible to predators (Wiggins 2004a)
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	No known symbionts (Wiggins 2004a)
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	1	Known parasites include 2 sp of feather mites and 2 sp of feather lice; no information about projected increase or decrease due to climate change (Wiggins 2004a)
B5. Competitors	Are populations of important competing species expected to change?	0	0	Because of their unique nest site preferences, black swifts have few known competitors for nest sites. In Region 2, the primary species that may compete for nest sites is the cordilleran flycatcher, which sometimes also nests on niches on cliffs. However, the extent to which any competition for nest sites occurs is unknown (Wiggins 2004a)

BOREAL OWL (Aegolius funereus)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	0	Habitat likely to decrease in area, migrate upslope or decline (e.g., beetles, increased incidence of fire, drought-related mortality, shifts from mesic to more xeric conditions).
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	1	0	Breeding and non-breeding habitats are the same general area. Hayward and Hayward 1993
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	1	The boreal owl nests primarily in dense, mature spruce-fir. Although not readily discussed in literature for breeding habitat, summer roosting habitat generally favors cooler micro-sites. One would assume that this is likely the case for breeding habitat, as well, since breeding occurs in summer. Many of these areas are likely to convert to more open, warmer sites through climate change. However, with increasing flicker populations the number of available caviites, another key component, may increase. Hayward, G. D. and J. Verner, tech. editors. 1994
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	1	0	Mesic spruce stands favorable to key forage species and cool summer micro-sites used for roosting are likely to decline in availability as a result of climate change. Hayward, G. D. and J. Verner, tech. editors. 1994

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	Nesting success in the BO is highly related to food resources. A key element in the forage base is the red-backed vole. With a likely decline in mesic SF forest there would be a commensurate decline in red-backed vole populations. Hayward, G. D. and J. Verner, tech. editors. 1994
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	0	Both sexes can and do re-locate in response to food availability. Hayward, G. D. and J. Verner, tech. editors. 1994
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	0	Generally, the same habitats are used year-round though there may be some seasonal shifts use within available forest structures. Hayward, G. D. and J. Verner, tech. editors. 1994
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	1	Literature suggests that the BO favors cooler micro-sites for roosting in summer for thermoregulation. However, little information on the degree of physiological sensitivity it might have to warm conditions. Hayward et al. (1993)
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	1	1	Some studies indicate that uncrusted snow facilitated the movement of prey to the snow surface where they are available to owls (ibid.). Additionally, hunting techniques of the boreal owl include diving through the snow surface to capture prey, an approach that would be impeded by crusted snow. Periodic warm weather during winter could lead to snow crusting and thus, reduce the overall availability of prey to the boreal owl. While not technically weather events this impact on foraging could affect winter survival. Hayward, G. D. and J. Verner, tech. editors. 1994
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	Literature suggests that the BO favors cooler micro-sites for roosting in summer for thermoregulation. However, little information on how this could affect overall daily activity, nest success, or survival. Since most activity is nocturnal, overall activity levels may not be seriously altered by warm conditions. Hayward et al. (1993)
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	0	0	The boreal owl has the ability to move relatively long distances when necessary to address reductions in prey. Hayward, G. D. and J. Verner, tech. editors. 1994
PS6. Energy requirements	What is this species' metabolic rate?	0	0	Moderate
PHENOLOGY				

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	0	Hayward, G. D. and J. Verner, tech. editors. 1994
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	1	0	Clutch size, hatching rate, fledging rate, number of breeding pairs) on an annual basis are directly related to prey availability. Red-back vole populations can be highly cyclic and highly influenced by factors affected by climate. Hayward and Verner 1994
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	Hayward et al. (1993)
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	Second clutch may be attempted if first attempt is a failure.
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	1	0	The red-backed vole is a primary prey of the BO. This vole occurs in mesic late successional forest conditions that support higher levels of hypogeous fungus. The availability of these types of forest conditions is likely to decline w/ climate change. Hayward et al. (1993)
B2. Predators	Are important predator populations for this species expected to change?	0	1	American marten, the primary predator to BO, was determined to be resilent to climate change, although overall predation in BO has not been well-studied. Hayward and Hayward 1993
B3. Symbionts	Are populations of symbiotic species expected to change?	-1	0	Since the boreal owl is a secondary cavity-nester one might expect increasing cavity availbility with increasing populations of primary cavity-nesters due to insect infestations, fires, drought-related tree mortality). Boreal owls appear highly dependant on northern flicker for cavities in Colorado. Palmer 1986
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	1	No information on disease in boreal owls found.
B5. Competitors	Are populations of important competing species expected to change?	1	1	Northern flicker, along with saw whet owls, appear to be major competitors with BO for cavities. Northern flicker populations are expected to increase. However, since they are also primary cavity-nesters the overall impact of this competion may balance out. Hayward and Hayward 1993

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

BOREAL TOAD (*Bufo boreas boreas*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	0	Primarily use wetland habitat, although are found in other habitats during dispersal; are seldom far from water; less common in dense forest; generally 7500 to 12000 ft elevation. Breeding habitat is typically shallow water (<20cm) where water is pooled or slow-moving; In general, drier conditions would reduce wetland habitat (Keinath and McGee 2005)
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	0	1	during summer, require terrestrial habitat with cover for foraging; can be a variety of forested and non-forested wet and dry habitats; lot of heterogeneity in individual preferences; use too wide a variety of habitat types to make a determination, neutral response (Keinath and McGee 2005)
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	0	1	temperature of breeding waters significant (usually ranges from 15 - 21 C) (Keinath and McGee 2005); and warmer spring and summer temperatures (as well as timing of snowmelt, see Phenology questions), could change this breeding component. However, direction of change may be neutral- if lower elevation ponds become too warm, higher elevation ponds may then be within an adequate range; neutral response but more information needed
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	1	1	use both warm and cool microhabitats for thermoregulation while dispersing, uncertain how climate change will affect this habitat component; toad requires adequate snowpack to insulate hibernacula. This is likely to decrease lower elevational sites and more exposed (i.e. southern exposure) sites
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	suitable habitat for dispersal includes forests, shrub habitat, or small wetlands; habitat connectivity essential for survival of the species (Keinath and McGee 2005). Warmer and drier climate could result in the loss of small wetlands, reducing habitat connectivity. Additionally, droughts or early freezes can cause larval and juvenile death (Keinath and McGee 2005)
H6. Ability to colonize new areas	What is the potential for this species to disperse?	0	0	Female toads more likely to disperse, and farther distances than males from breeding sites (Keinath and McGee 2005, Bull 2006)
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	0	seasonal movement from breeding sites to summer grounds, can travel relatively long distances (516 m^2); however, does not qualify as additional habitat because it is not distinctly different from summer habitat
PHYSIOLOGY				

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

BOREAL TOAD (*Bufo boreas boreas*)				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	use microhabitats to thermoregulate; assuming that suitable microhabitat can still be found, should not exceed physiological thresholds
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	temperature affects speed of development of larvae, but not sex ratio
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	1	0	Fires may cause high rates of mortality in forested environments, because toads are slow (Keinath and McGee 2005).
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	1	0	toads are primarily diurnal, but can be active at any time of day; hotter temperatures could reduce daytime activity,
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	no known alternative strategies
PS6. Energy requirements	What is this species' metabolic rate?	-1	0	
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	1	0	breeding occurs late May/early June, but may be later at high elevations and coincides with melting of snowpack (Keinath and McGee 2005)
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	1	uncertain how food resources are expected to change; neutral response
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	resources and cues for activity in same general location
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	breeds once per year or less; females do not produce eggs every year (Loeffler 2001)
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	0	wide variety of food; feed on abundant, easy-to-catch prey (Keinath and McGee 2005)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

BOREAL TOAD (*Bufo boreas boreas*)				
B2. Predators	Are important predator populations for this species expected to change?	0	0	wide variety of predators at all life stages, including birds, fish, snakes, and mammals (Keinath and McGee 2005)
B3. Symbionts	Are populations of symbiotic species expected to change?	0	1	toads have commensal relationship with some small mammals that create burrows (golden-mantled ground squirrel, for example), and beavers, which also contribute specific habitat components (Keinath and McGee 2005); not enough information on how climate change will affect these species; neutral response
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	1	boreal toads are susceptible to chytrid fungus, suspected in causing widespread population declines; no information on if/how climate change will increase/decrease fungal infection (Keinath and McGee 2005)
B5. Competitors	Are populations of important competing species expected to change?	0	0	neutral response; no known effects of competitor species

BREWER'S SPARROW (Spizella breweri)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	1	Some models suggest an increase in sagebrush through expantion into higher elevations, while others predict a decline as a result of decreasing fire intervals and cheatgrass invasions. Even if total area increases fragmentation caused by fire could reduce overall habitat functionality over large part of BS's range including Colorado. Harte and Shaw 1995; Keane et al. 2008; Perfors et al. 2003
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	0	1	The brewer's sparrow winters in similar habitats in Sonoran & Chihuahuan deserts. Unclear if these areas will be under the same influences and how important vs. breeding grounds.
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	1	The literature identifies a strong positive reproductive success response to preceding winters with higher precipitation on its breeding grounds. This must relate to a specific or combination of habitat components that are affected by winter moisture levels, although which is not clearly defined.
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	1	

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

BREWER'S SPARROW (Spizella breweri)				
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	The brewer's sparrow chooses healthier, taller, and fuller individual sages for nests, perhaps as a protection from predators, a major cause of nest failure. The structural quality of sage would likely decline through drying site conditions. Holmes, J.A. and M.J. Johnson (2005)
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	0	Holmes, J.A. and M.J. Johnson (2005)
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	1	0	Habitats used during migration are similar to breeding grounds. Holmes, J.A. and M.J. Johnson (2005)
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	The brewer's sparrow is adapted to hot, dry climates.
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	1	0	Large scale fires are likely to occur more frequently in the sagebrush type and would be most likely to occur during the breeding season. Holmes, J.A. and M.J. Johnson (2005), Harte and Shaw 1995
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	1	The brewer's sparrow is adapted to hot, dry climates and would likely accommodate warmer temps. Like most passerines it likely reduces foraging activity in the heat of the day. Whether the heat would extend this period of lower activity is not clear and none of this discussed in literature.
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	0	0	Unoccupied habitat in one year can be populated by numerous breeding pairs the next. This suggests a flexible response to resource fluctuations. Holmes, J.A. and M.J. Johnson (2005)
PS6. Energy requirements	What is this species' metabolic rate?	0	0	
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	0	

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

BREWER'S SPARROW (Spizella breweri)				
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	0	Literature indicates that BS has a broad foraging base and opportunistic in insects taken. However, the strong correlation between moist preceding winters higher reproductive rates suggests a possibility of resource peaks that have not yet been identified. Holmes, J.A. and M.J. Johnson (2005)
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	1	1	The brewer's sparrow is a long distance migrant, which creates the potential for a mismatched between cues and critical events on its breeding grounds. However, the literature does not speak of any specific relationships for this species.
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	0	0	The brewer's sparrow will re-nest in response to nest failure and is known to frequently double clutch. Holmes, J.A. and M.J. Johnson (2005)
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	0	Exploits a broad range of insect prey, which is supplemented by seed. Holmes, J.A. and M.J. Johnson (2005)
B2. Predators	Are important predator populations for this species expected to change?	1	0	The brewer's sparrow has a number of predators and nest predation is a major cause of nest failure. Climate change is expected to increase fragmentation of sagebrush habitats. The structural changes from large expanses of unbroken habitat to patchy distributions of habitat is expected to favor predators (ravens, magpies, small mammals, cowbird) in locating nest. Holmes, J.A. and M.J. Johnson (2005)
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	No symbionts
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	1	Some parasitic diseases were noted in literature but it was stated that diseases in this species are poorly understood. Holmes, J.A. and M.J. Johnson (2005)
B5. Competitors	Are populations of important competing species expected to change?	0	0	Literature mentions two competitors on nesting grounds (sage sparrow and sage thrasher). However, there appears to be no evidence that this competition plays any role in reproductive productivity. Holmes, J.A. and M.J. Johnson (2005)

CANYON TREEFROG (*Hyla arenicolor*)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

CANYON TREEFROG (*Hyla arenicolor*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	0	found in permanent or intermittent streams and pools in canyon bottoms (NatureServe 2011), found in Dolores River canyon; warmer and drier conditions could reduce the amount of temporary pools
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	0	0	terrestrial habitat includes p-j, semi-arid grassland, or pine-oak woodlands; may be shifts in habitat, but overall no decline if grasslands expand into currently forested area (NatureServe 2011)
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	0	loss of water bodies
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	1	uncertain; not enough information on specific components of terrestrial habitat; neutral response
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	loss of breeding pools; loss of habitat connectivity
H6. Ability to colonize new areas	What is the potential for this species to disperse?	1	0	not much info on dispersal ability, but suggested that they would be likely unable to disperse through hot, dry environments based on need to frequently rehydrate (FS Sensitive Species Evaluation, Barber 1999)
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	0	non-migratory (NatureServe 2011)
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	1	1	fits description of amphibian in dry climate; however, no direct information on physiological thresholds
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	0	flash floods may cause larval mortality, no projected direction of change (FS Sensitive Species Evaluation)
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	1	0	terrestrial amphibian in dry climate; higher temperatures likely to reduce activity period (NatureServe 2011)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

CANYON TREEFROG (*Hyla arenicolor*)				
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	0	0	can extend breeding period in years of low rainfall (AmphibiaWeb, http://amphibiaweb.org/cgi/amphib_query?where-genus=Hyla&where-species=arenicolor)
PS6. Energy requirements	What is this species' metabolic rate?	-1	0	
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	1	0	breeding can be cued by rainfall; hibernator/aestivator (NatureServe 2011)
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	1	not enough information on other activities related to increased fecundity/survival; neutral response
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	non-migratory, resources in same location as species
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	breeds once/year (NatureServe 2011)
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	0	variety of food sources as adult- ants, beetles, centipedes, spiders (NatureServe 2011)
B2. Predators	Are important predator populations for this species expected to change?	0	1	primary predator is garter snake, no info on impact of climate change (FS Sensitive Species Evaluation); neutral response
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	no known symbionts
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	1	although spread of disease such as chytridiomycosis widely implicated in amphibian declines, very little information found that connected this disease with the canyon treefrog; neutral response but with uncertainty
B5. Competitors	Are populations of important competing species expected to change?	0	1	no information found on competitive relationships; neutral response

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

COLUMBIA SHARP-TAILED GROUSE (Tympanuchus phasianellus columbianus)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	-1	-1	Mountain shrublands are expected to increase and move upslope. However, all oak woodlands are generally not used heavily by this species unless it is fragmented and has a significant serviceberry component. Riparian habitats used by this species are likely to decline. Also, sagebrush shrublands could potentially decrease or become highly fragmented as a result of persistent drought and fires. Rehfeldt et al. (2006),Lenihan, et al. (2005), Bradley et al. (2009), Hoffman & Thomas (2007)
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	-1	-1	See above
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	0	Brood rearing grounds must have high forb cover and high insect availability to provide forage for chicks. Forb cover is expected to decline, especially on drier sites and insect abundance is associated, to a degree, with forb density. Impacts are likely to be greatest in naturally dry habitats (e.g. sagebrush). Also, nest cover is a key predictor of nest success and the availability of areas with high grass and shrub cover would also be expected to decline. Hoffman & Thomas (2007)
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	1	1	CSTG also uses riparian habitats along with mountain shrub in winter. These areas would be expected to decline in availability and quality. CSTG uses snow for concealment and insulation during the winter. Cimate change could result in low snow levels, particularly at lower elevations that could interfere with "snow roosting". Snow crusting could also interfere with creating roost sites in the snow. Hoffman & Thomas (2007)
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	Hoffman & Thomas (2007)
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	0	Hoffman & Thomas (2007)
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	0	
PHYSIOLOGY				

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

COLUMBIA SHARP-TAILED GROUSE (Tympanuchus phasianellus columbianus)				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	Species seems moderately well-adapted to adjusting to extremes physiologically and strategically.
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	0	
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	1	1	CSTG avoids the hottest parts of the day in summer and tends to forage early in day and late in the afternoon. This could have implications in its warmer habitats (e.g. sagebrush). However, species will limit foraging during severe winter weather, which could ultimately affect winter survival in birds in poor condition. Severe winters are likely to be less frequent, which could be a positive for this species. However, literature does not indicate or at least address high winter mortality. Hoffman & Thomas (2007)
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	No flexible strategies mentioned in literature.
PS6. Energy requirements	What is this species' metabolic rate?	0	0	
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	0	Photo-period directly affects timing of nesting activities, but can be shifted up to 14 days (advanced or postponed) by climate conditions. Hoffman & Thomas (2007)
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	0	
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

COLUMBIA SHARP-TAILED GROUSE (Tympanuchus phasianellus columbianus)				
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	1	0	CSTG depends on forbs and insects on its brood-rearing grounds. These would be expected to decline as a result of climate change, particularly in lower elevational habitats, such as sagebrush. Also, species frequently uses riparian habitats in winter during high snow years since the shrub is more developed and extends above the snow level. Riparian habitat is likely to decline with climate change. Hoffman & Thomas (2007)
B2. Predators	Are important predator populations for this species expected to change?	0	1	CSTG has a large number of predators. Even though predation is a significant cause of nest failure, it is not considered a threat to this species as long as habitat is adequate. However, habitat quality is expected to decline and many of the mammalian predators are likely to respond favorably to milder winters. Hoffman & Thomas (2007)
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	No symbionts
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	1	1	CSTG has a large number of parasites and diseases. These have not been implicated in serious population effects. However, disease prevalence could increase in birds stressed by declining habitat conditions and parasites are likely to overwinter more effectively. Literature also mentions West Nile Virus as a possible concern. Mosquito season could be longer with warming conditions, however, breeding sites may be less available. Hoffman & Thomas (2007)
B5. Competitors	Are populations of important competing species expected to change?	0	0	Hoffman & Thomas (2007)

DESERT BIGHORN SHEEP (*Ovis canadensis nelsonii*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

DESERT BIGHORN SHEEP (*Ovis canadensis nelsonii*)				
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	1	prefer high-visibility habitat, often with steep, precipitous terrain; have abandoned traditional home ranges because fire suppression allowed vegetation to grow and obstruct visibility (Etchberger et al. 1989, Krausman et al. 1989, Etchberger et al. 1990 in Beecham et al 2007); in sw co, shrub/grass rangeland or lowland grassland vegetation types support desert bighorn populations, these veg types may shift upwards, decline with desertification- need more information
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	1	1	prefer high-visibility habitat, often with steep, precipitous terrain; have abandoned traditional home ranges because fire suppression allowed vegetation to grow and obstruct visibility (Etchberger et al. 1989, Krausman et al. 1989, Etchberger et al. 1990 in Beecham et al 2007); in sw co, shrub/grass rangeland or lowland grassland vegetation types support desert bighorn populations, these veg types may shift upwards, decline with desertification- need more information
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	0	for breeding and non-breeding, access and distance to water sources important factor in suitable habitat; in warmer and drier climate, water sources will become more scarce, increasing competition and negatively impacting desert bighorns (Graham 1997, Epps et al 2004)
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	1	0	for breeding and non-breeding, access and distance to water sources important factor in suitable habitat; in warmer and drier climate, water sources will become more scarce, increasing competition and negatively impacting desert bighorns (Graham 1997, Epps et al 2004); smaller home range in summer when they remain close to watering holes (Beecham et al 2007)
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	drought can cause increased mortality and affect recruitment dynamics (Epps et al 2004)
H6. Ability to colonize new areas	What is the potential for this species to disperse?	1	0	movements of desert bighorn from range to range more frequent than that of RM bighorn, but low overall dispersal rates (Beecham et al 2007, Epps et al 2004)
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	0	desert bighorn known to use distinct spring, summer, and fall-winter ranges; based on distribution of seasonal rainfall and forage conditions (Beecham et al 2007), but no additional habitats required
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	water is limiting factor, not temperature
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	no; sex ratio near unity (Beecham et al 2007)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

DESERT BIGHORN SHEEP (*Ovis canadensis nelsonii*)				
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	0	no known effect of disturbance events on populations
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	no known alternative strategies
PS6. Energy requirements	What is this species' metabolic rate?	0	0	
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	0	rut may last nine months and peak in Aug and Sept (Beecham et al 2007)
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	-1	0	non-seasonal reproductive pattern may be adaptive strategy to ensure lamb survival during periods of unpredictable forage production; plant production varies with temporal and spatial precipitation patterns (Beecham et al 2007)
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	critical resources occur in generally same location as breeding activities (Beecham et al 2007)
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	No, breeds once a year
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	0	in general, bighorn sheep forage opportunistically; seasonal use of different forages attributed to precipitation patterns and effect of soil moisture on vegetation (Brown et al. 1977, Krausman et al 1989 in Beecham et al. 2007)
B2. Predators	Are important predator populations for this species expected to change?	0	1	significant predation by mountain lions (responsible for transplant failures in Texas, Nevada, Utah; significant losses to transplanted herd in Colorado) (Beecham et al 2007); not enough info on how mountain lions will respond to climate change, neutral response

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

DESERT BIGHORN SHEEP (*Ovis canadensis nelsonii*)				
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	no known symbionts
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	1	0	sheep are susceptible to a variety of diseases that can cause widespread mortality, usually associated with exposure to domestic sheep; unclear how climate might directly impact spread of diseases, especially in highly managed populations; however, sheep populations that are stressed from reduced or fragmented habitat, drought, or severe winters would be more vulnerable to disease
B5. Competitors	Are populations of important competing species expected to change?	0	0	competition with domestic cattle important; no known expected change due to climate change; competition with domestic sheep and goats important- see B4

DESERT SPINY LIZARD (*Sceloporus magister*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	-1	0	associated vegetation types include desert shrubland and woodland, mequite-yucca grassland, juniper, shrubby areas, and cottonwood/willow riparian zones (NatureServe 2011). Currently found in few locations in extreme SW Colorado, generally below 5100 feet- habitat range on SJPL likely to expand as climate of desert and associated vegetation moves upward in elevation.
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	-1	0	non-breeding habitat not distinct from breeding habitat
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	0	0	eggs are laid in soil or underground (NatureServe 2011); no expected change
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	0	species is arboreal, so presence of trees/shrubs may be important; no expected direction of change; neutral response (Tinkle 1976, Vitt et al. 1981)
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	0	0	uses crevices in trees or rocks for thermal regulation; no expected direction of change (Tinkle 1976, Vitt et al. 1981)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

DESERT SPINY LIZARD (*Sceloporus magister*)				
H6. Ability to colonize new areas	What is the potential for this species to disperse?	0	1	no information found on dispersal ability; neutral response
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	0	non-migratory (NatureServe 2011)
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	hibernator/aestivator (NatureServe 2011); currently inhabits areas with higher temperatures than found here
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	sex ratio generally near 1:1 (Tinkle 1976)
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	1	no information found on sensitivity to weather events; neutral response
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	unlikely to change activity period
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	no known flexible strategies
PS6. Energy requirements	What is this species' metabolic rate?	-1	0	ectotherm
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	1	0	hibernator/aestivator that uses temperature to initiate emergence from hibernation (NatureServe 2011)
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	1	species' diet fluctuates seasonally and annually, in order to exploit temporally abundant insects (Vitt et al 1981); not enough information on direction of change for insect populations; neutral response
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	no separation in time or space

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

DESERT SPINY LIZARD (*Sceloporus magister*)				
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	-1	0	can produce two clutches per season (Tinkle 1976, NatureServe 2011), allows for more opportunity to time reproductive cycle to available resources
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	0	consumes variety of insects, possibly small lizards as well
B2. Predators	Are important predator populations for this species expected to change?	0	0	preyed on by larger lizards, including long-nosed leopard lizard, which is expected to have a relatively neutral response to climate change
B3. Symbionts	Are populations of symbiotic species expected to change?	0	1	no information found on symbiotic species; however, does use small mammal burrows as cool microhabitat; neutral response
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	0	no known effects of changes on disease prevalence
B5. Competitors	Are populations of important competing species expected to change?	0	1	inadequate info on competitve relationships; there may be competition for food resources as multiple species converge on abundant resources that vary temporally; or niche partitioning may reduce competition for resources (Vitt et al 1981)

FLAMMULATED OWL (*Otus flammeolus)*				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	0	primary habitat in this area is older ponderosa pine, projected to decrease in area and shift upward in elevation, and warm-dry mixed conifer, projected to stay the same or decrease due to high chance of catastrophic wildfire; Rehfeldt et al. 2006, Hayward and Verner 1994
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	0	1	neotropical migrant; no information on potential climate impacts in wintering grounds; Hayward and Verner 1994, NatureServe 2011
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	0	closely associated with large, mature trees for nesting, which provide abandoned cavities (also dependent on populations of primary cavity nesters); loss of mature forest as vegetation ranges shift and increased frequency of wildfires; NatureServe 2011

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

FLAMMULATED OWL (*Otus flammeolus)*				
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	1	see H2
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	old-growth ponderosa pine provides variety of lepidopteran prey, room for maneuvering while hunting; roosting sites in Colorado in large Doug fir or pines with spreading form that provide shade and protection from predators; any decline or shifts in old-growth ponderosa pine forests from changing moisture/temperature regimes or fire would decrease habitat quality; NatureServe 2011, Hayward and Verner 1994
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	0	long-distance natal dispersal and frequent inter-mountain dispersal; NatureServe 2011
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	1	0	long-distance migratory species; NatureServe 2011
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	1	limiting physiological conditions more likely limited by prey availability; owls can withstand cold temperatures as long as there is adequate prey; early spring snowstorms and cold temperatures may hurt populations if prey is not yet available; no clear predictions of temperature changes specific to early spring; Hayward and Verner 1994
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	no
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	0	see P1; exposure to spring snowstorms and extended periods of bad weather can result in decline and starvation of adults; unclear how climate change will affect early spring weather; Hayward and Verner 1994
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	nocturnal species; NatureServe 2011
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	-1	0	Irruptions; Stock et al. 2006
PS6. Energy requirements	What is this species' metabolic rate?	0	0	moderate, but nocturnal birds species in general have lower metabolic rates; van Woudenberg 1999

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

FLAMMULATED OWL (*Otus flammeolus)*				
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	0	egg laying begins in late May or June; likely initiated by a variety of environmental cues- no evidence that timing of breeding is strongly related to temperature or precipitation cues; Hayward and Verner 1994
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	1	variation in nesting success is low; fitness does not increase with increasing prey availability; however, lack of available prey would cause decline; Hayward and Verner 1994
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	1	0	long-distance migrant; shifts in prey availability in early spring could create potential for mismatch; Hayward and Verner 1994
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	one clutch per year; Hayward and Verner 1994
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	1	consumes only invertebrates, primarily moths in early spring (variety of species); unknown how prey poulations will respond to climate change; Hayward and Verner 1994
B2. Predators	Are important predator populations for this species expected to change?	0	0	predators include red squirrels and other rodents; accipiters, great-horned owls; Hayward and Verner 1994
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	no known symbiotic species
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	0	diseases unreported or rare for this species; Hayward and Verner 1994
B5. Competitors	Are populations of important competing species expected to change?	0	0	competes for food and nest sites; competitors include Abert's and red squirrel, bats, other cavity nesters; Hayward and Verner 1994, SJPL Species Profile

FRINGED MYOTIS (*Myotis thysanodes)*
HABITAT

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

FRINGED MYOTIS (*Myotis thysanodes*)				
Trait/Quality	Question	R*	U*	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	0	0	found in oak, piñon-juniper woodlands, ponderosa pine forests at middle elevations; mixed response to climate change for these types- some increase and some decrease or shift upwards; Keinath 2004
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	0	0	may move to higher or lower elevations for winter hibernacula, depending on thermal regime; foraging habitat same general forest type as breeding habitat, although different components required, see H4; Keinath 2004
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	0	1	abundance of large snags and low canopy cover; also roosts in buildings or abandoned mines; not enough information to predict how canopy cover and number of snags would change over multiple forest types; buildings and abandoned mines not affected by climate change; Keinath 2004
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	1	0	foraging areas chosen for prey availability, including insect abundance, water sources, and vegetative structure; uses forest interior and edges; drying of water sources expected; Keinath 2004, Bradley and Ports 1998
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	ideal area would include mosaic of roost sites, still water sources, and foraging habitat close to each other over a large enough area to accommodate shifts in local prey abundance; this combination of factors would be sensitive to climate change through drying of water sources or shifting vegetation regimes; Keinath 2004
H6. Ability to colonize new areas	What is the potential for this species to disperse?	0	0	mobile, but high breeding site fidelity, which limits dispersal; neutral response; Keinath 2004
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	0	movements not well understood, but not long distance migrant; Keinath 2004, NatureServe 2011
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	inhabit a wide range of thermal regimes, including desert; Keinath 2004
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	0	disturbance events that affect bats are primarily human caused; Keinath 2004

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

FRINGED MYOTIS (*Myotis thysanodes)*				
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	Nocturnal; NatureServe 2011
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	no known alternative strategies; NatureServe 2011, Keinath 2004
PS6. Energy requirements	What is this species' metabolic rate?	0	0	Moderate; Keinath 2004
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	1	0	Hibernator; NatureServe 2011
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	0	somewhat opportunistic feeder; will eat whatever prey is most abundant; no expected change in timing of availability of breeding sites; NatureServe 2011, Keinath 2004
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	little separation in time and space between breeding sites and resources
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	long-lives species, one young per year; Keinath 2004
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	0	see PH2; feeds on beetles, moths, and other insect prey; Keinath 2004
B2. Predators	Are important predator populations for this species expected to change?	0	0	variety of avian and small mammal predators; Keinath 2004
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	no symbiotic relationships, however, may share roosts with other bats, conferring some thermoregulatory and anti-predation advantage; Keinath 2004
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	0	subject to a variety of ectoparasites; these do not usually cause population level declines, but could be more important if populations are already stressed by other factors; Keinath 2004

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

FRINGED MYOTIS (*Myotis thysanodes)*				
B5. Competitors	Are populations of important competing species expected to change?	0	0	shares habitat with other bat species, but occupies unique niche by foraging in cluttered areas and gleaning prey directly from vegetation, reducing competitive pressures; Keinath 2004

GUNNISON'S PRAIRIE DOG (Aegolius funereus richardsoni)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	-1	1	While the vegetation type (grassland/shrub) is likely to increase, the GPD prefers less arid sites than other prairie dog species. Therefore, it is not clear that functional habitat will significantly increase. Knowles, C. 2002
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	-1	0	Breeding and non-breeding habitat is the same.
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	0	0	GPD has no specific habitat components other than forage.
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	0	
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	GDP reproductive success is highly dependent on quality forage. This would be expected to decrease with drier conditions. Recovery of browsed vegetation around colony would likely be less robust and exotics, such as cheatgrass, would be expected to replace perrenial grasses. Knowles, C. 2002
H6. Ability to colonize new areas	What is the potential for this species to disperse?	0	0	Males tend to disperse much more than females. Most dispersals are relatively short-distance to other existing colonies. Knowles, C. 2002, NMDGF 2008.
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	0	Year-round resident to colony except when dispersing.
PHYSIOLOGY				

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	0	
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	1	0	Several places in the literature mentioned activity highest earlier and later in the day, with GPD avoiding the hottest part of the day. Warmer days could reduce daily foraging duration. However, since this species hibernates, activity in the spring could begin earlier. Whether this would provide a biological advantage is not clear. Seglund, A.E. and P.M Schnurr. 2010.
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	0	0	GPD can estivate or cease above-ground activities when it can't meet its metabolic needs. Also, has higher reproductive productivity after population declines (e.g. plague). This probably related to high forage availability in relation to colony size. Seglund, A.E. and P.M Schnurr. 2010.
PS6. Energy requirements	What is this species' metabolic rate?	0	1	Generally, would be considered to have a moderate metabolic rate but can shift to low when needed (see above)
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	1	0	Seglund, A.E. and P.M Schnurr. 2010., Knowles, C. 2002.
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	1	0	Species reproductive success is dependent on available forage, which normally has its greatest availability in early summer. This coincides with the later stages reproduction. Under climate change the peak would likely occur at the same time or perhaps a little earlier, but the magnitude would be expected to be lower with lower precipitation. How this might affect individual or colony productivity is not well described.
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	
BIOTIC INTERACTIONS				
B1. Food	Are important food resources for this species	1	0	Lower precipitation rates and invasion of exotics such as cheatgrass are likely to

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

resources	expected to change?			negatively impact forage availability. Seglund, A.E. and P.M Schnurr. 2010.
B2. Predators	Are important predator populations for this species expected to change?	0	0	
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	No symbionts
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	1	1	The rate of dispersal to other colonies is higher when forage availability is lower, which would be expected occur more frequently under climate change conditions. This higher rate of dispersal activity would likely increase the rate at which plague is carried to uninfected colonies. Seglund, A.E. and P.M Schnurr. 2010., Knowles, C. 2002.
B5. Competitors	Are populations of important competing species expected to change?	0	0	GPD competes with a number of other herbivores for forage.

GUNNISON'S SAGE GROUSE (Centrocercus minimus)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	0	1	Arid and semi-arid grassland/shrublands are predicted to increase and there is disagreement on what direction sagebrush may go, the literature suggests that unfragmented & moderately fragmented sagebrush habitats favored by the GSG are likely to decrease as a result of drought, fire and exotic plant species (i.e., cheatgrass) Connnelly, et.al. (2004), Federal Register 2006.
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	0	1	See above. Winter grounds are similar to breeding grounds.
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	0	Several aspects of breeding habitat could be impacted by climate change. These include the quality of leks, which are typically characterized by openings surrounded by dense shrub cover. , A decline in the availability of mesic and moist meadows that are important for foraging areas for chicks and adults during the early-mid summer. Persistent droughts and rising temperatures would be the primary driver of these effects. Connnelly, et.al. (2004), Federal Register 2006.

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

GUNNISON'S SAGE GROUSE (Centrocercus minimus)				
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	1	0	Unfragmented to moderately fragmented sagebrush stands are predicted to decrease as a result of the above-mentioned factors. Sagebrush density, as well as, tall individual plants that extend above the snow during winter are also likely to decrease with recurring drought, shorter fire intervals, and other factors. Connnelly, et.al. (2004), Federal Register 2006.
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	Structural and forage-related quality of habitat is expected to decrease.
H6. Ability to colonize new areas	What is the potential for this species to disperse?	0	0	Both sexes are able to disperse over moderate distances to colonize new areas. However, this dispersal would still be in the context of same general locale with dispersal occurring within 10's of miles rather than 100's of miles. Therefore, the individual's dispersal may not be adequate to move it out of areas of compromised resources (drought, fire) that might have initiated dispersal.
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	1	1	Non-migratory species. Breeding and non-breeding habitats somewhat similar. While this species would not have migrational habitats it does have transitional habitats between breeding grounds and wintering grounds. During early autumn, in addition to sagebrush, habitats may include upland meadows, riparian areas, greasewood bottoms, alfalfa fields, and irrigated native hay pastures. Whether this is opportunistic or required as part of the seasonal cycles was not clear. Connnelly, et.al. (2004)
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	Species is adapted to warm, dry climates.
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	1	Nothing found in literature that speaks to weather-related mortality as an important factor in population dynamics.
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	Species generally adapted to warm, dry climates.
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

GUNNISON'S SAGE GROUSE (Centrocercus minimus)				
PS6. Energy requirements	What is this species' metabolic rate?	0	0	
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	1	0	Courtship at leks begins in March-May, depending on elevation. This suggests that the initiation of breeding activities at the leks is somewhat dependent on temperature. Federal Register 2006
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	0	No specific peaks were identified in literature.
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	Species nests only once/year.
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	1	0	Females with chicks tend to move to more mesic areas after eggs hatch because of higher levels of grasses, forbs and insects important to developing chicks. GSG also uses moist meadows during the middle of the summer for foraging. These areas are likely to become less available. Sagebrush, a primary food in winter, may be less available, particularly in high-snow winters where taller sagebrush above the snow is critical. Connnelly, et.al. (2004), Federal Register 2006.
B2. Predators	Are important predator populations for this species expected to change?	1	0	GSG is preyed upon by a number of species. Nest are particularly susceptible to nest predation by small mammals and coyotes, bobcats, weasels may prey on adults and chicks. Mammals typically experience greater mortality during "hard winters" and milder winters associated with climate change may result in higher populations of these predators. Also, structural changes to sagebrush in terms of density and height may make predation on GSG easier for both mammalian and avian predators. Connnelly, et.al. (2004), Federal Register 2006.

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

GUNNISON'S SAGE GROUSE (Centrocercus minimus)				
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	No symbionts
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	1	1	The literature describes a number of parasites and diseases to which GSG may be susceptible. The research on how these may affect populations of GSG is scant. It is suggested that, with increasing temperatures and poor physical conditions that might occur through declining forage quality, individuals might be more susceptible to these pathogens. West Nile Disease was specifically mentioned and described GSG as perhaps particularly at risk, since it tends to gravitate toward mosquito-rich wet meadows and mesic corridors during the summer. Connnelly, et.al. (2004)
B5. Competitors	Are populations of important competing species expected to change?	0	0	Literature doesn't identify any significant competitor unless you include cattle or other livestock.

HOARY BAT (Lasiurus cinerus)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	0	0	Species appears to use a variety of habitats. Oliver 2010
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	0	1	Little is known about wintering habitats. Cryan 2003
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	0	Hoary bat forages along riparian corridors and females establish maternity roost in cottonwood trees and other deciduous trees with full crowns. The extent and quality of these habitats could decline under climate shifts. Shump & Shump 1982, Oliver 2010, Theobold 2010
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	1	

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

HOARY BAT (Lasiurus cinerus)				
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	Insect prey, particularly moths, associated with foraging grounds is likely to decline due to drought, loss feeding substrate, mismatched synchronicity with host plants,etc. Deciduous trees with full crowns and foliage could become less available due to drought. Singer and Parmesan 2012.
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	1	Apparently both sexes are mobile but little info in literature.
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	1	Apparently a moderate to long-distance migrant. It is not known what requirements it may have along migrational pathways. It may also reportedly hibernate in its northern territories. Shrump & Shrump 1982
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	1	Species appears to have a fairly broad range of temps for foraging. However, does show some sensitivity to temperature at roost.
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	1	Species may have some sensitivity to prolonged periods of inclement weather but it is not clear that occasional periods of severe weather would not be balanced by reduced frequency of rainy weather related to climate change.
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	-1	0	Hoary bat is nocturnal and would not likely be influenced greatly by temperatures. Can forage in a broad range of temperature. However, growth rates and development of young is directly related to ambient temperatures and amount of rainy weather.
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	-1	1	Hoary bat usually has two, rather than one young, and may have as many as four. This might allow it to "fledge" larger numbers during years of high food abundance. Hoary bat can also induce torpor, early in season, in reponse to poor weather, and postpone birth until conditions are more favorable. Cryan 2003. Willis et al. 2006
PS6. Energy requirements	What is this species’ metabolic rate?	1	0	Metabolic rates are high during foraging and likely much lower during roosting periods.
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	1	1	Likely uses temperature to initiate migration or hibernation but not well discussed in lit.

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

HOARY BAT (Lasiurus cinerus)				
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	1	0	Literature suggests that hoary bats time their spring migration to coincide with moth peaks along their riparian migration pathways. Valdez & Cryan 2009.
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	1	0	As a migrating species it has the potential for mismatch cues related to foraging resources and weather along migrational routes and destination grounds.
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	1	While the hoary bat breeds only once a year it can reported delay implantation and birth for several weeks to respond to inclement weather on its breeding grounds.
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	1	0	
B2. Predators	Are important predator populations for this species expected to change?	0	0	
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	No symbionts
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	1	Species is known to have a high rate of incidence to rabies but it is not known if this would be influenced by climate shifts.
B5. Competitors	Are populations of important competing species expected to change?	0	0	

LEWIS' WOODPECKER (*Melanerpes lewis*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	1	breeding habitat is open mature ponderosa pine and cottonwood riparian forests; projections show decrease and shift upwards in elevation for ponderosa pine; no info on cottonwood/riparian areas with regard to climate change, although they are declining for other reasons (Abele et al. 2004, NatureServe 2011)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

LEWIS' WOODPECKER (*Melanerpes lewis*)				
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	-1	0	Non-breeding habitat is 'mature oak woodlands'; projections for gambel oak are increases and expansion upwards in elevation; projections for p-j are mixed (Abele et al. 2004, Rehfeldt et al. 2006)
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	-1	0	The Lewis' woodpecker requires specific structures and characteristics in its habitat, including relatively high snag densities with well decomposed snags to provide existing cavities or to construct new cavities; Wildfires and disturbance could increase snag densities (Abele et al. 2004)
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	1	They also require low-medium crown closures, well-developed shrub cover to supply insect prey, mast and berries, and caching sites.; Gambel oak habitat expected to increase, changes to specific habitat components unknown (Abele et al. 2004)
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	-1	0	Wildfires that increase snag density will positively affect nesting habitat. (Abele et al. 2004)
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	0	Strong dispersal ability (Abele et al. 2004)
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	1	0	Seasonal movements not well understood, but would require additional habitats (Abele et al. 2004)
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	Occupies wide range of thermal regimes (NatureServe 2011)
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	0	Wildfires may benefit woodpeckers through habitat creation, but no known direct effects
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	No specific information on activity period, but no evidence that it is strongly limited by daily temperature or precipitation
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	-1	0	Their foraging habits, which take advantage of superabundant local food supplies, suggest that nesting and wintering locations occur where insect prey and mast crops are readily available. Thus, migratory routes and timing may vary between years, and bird occurrence may vary year-to-year at any one location (Abele et al. 2004)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

LEWIS' WOODPECKER (*Melanerpes lewis*)				
PS6. Energy requirements	What is this species' metabolic rate?	0	0	Moderate
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	0	breeding and movements initiated by resource availability; see PH2 (Abele et al. 2004)
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	1	1	Because Lewis's woodpeckers feed on free-living adult insects, the timing of breeding may depend on local precipitation and temperature conditions affecting insect availability rather than changes in photoperiod (Bock 1970).; not enough info on how insect availability might change (Abele et al. 2004)
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	resource changes happen locally
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	Lewis's woodpeckers lay one clutch per year, which ranges in size from 5 to 11 eggs and averages between six and seven eggs (Abele et al. 2004)
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	0	described as opportunistic, has a variety of prey insects and consumes soft mast in winter (NatureServe 2011)
B2. Predators	Are important predator populations for this species expected to change?	0	0	nest predation by American kestrel, black bear, raven, mustelids, squirrels, snakes, etc; adult predation by Cooper's and Sharp-shinned, possibly red-tailed hawk (Abele et al. 2004)
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	0	
B5. Competitors	Are populations of important competing species expected to change?	0	0	Interactions between Lewis's woodpeckers and other avian species appear to revolve around the nest tree and not specific foraging locations (except possibly in the case of Lewis's and red-headed Woodpecker interactions), thus competition for food resources may be minimal (Abele et al. 2004)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

LOGGERHEAD SHRIKE (*Lanius ludovicianus*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	0	1	The broad vegetation type of grassland/shrub is predicted to increase. However, functional habitat, in regards to structure and prey, may decrease. Wiggins, D. (2005)
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	0	1	Same as above.
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	0	Components such as well-distributed woody vegetation for perching and full-crowned shrubs and small trees important for nest placement are likely to decrease. Wiggins, D. (2005)
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	0	Structural characteristics of non-breeding habitat are similar to breed habitat. Some structural components, such as hunting perches could decline as small trees and tall shrubs covert to predominantly grassland thru fires, cheatgrass invasion, etc. Wiggins, D. (2005)
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	Foraging perches are an important element to successful foraing which is directly related to nesting success. Wiggins, D. (2005)
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	0	Wiggins, D. (2005)
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	1	0	L.S. is most often a moderate-long distance migrant. Wiggins, D. (2005)
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	Nothing in literature suggests high sensitivity thermal physiological thresholds.
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

LOGGERHEAD SHRIKE (*Lanius ludovicianus*)				
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	1	0	LS nest appear to be highly vulnerable to severe storms. Nest are also susceptible to late spring frost. This might be important, particularly, if warmer springs initiate earlier nest starts.However, it is not substantiated in the literature that these occurences wll happen with greater frequency. Yosef 1996,Andrews and Righter 1992
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	Nothing in life history suggest that this would be the case. Wiggins, D. (2005)
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	
PS6. Energy requirements	What is this species' metabolic rate?	0	0	Wiggins, D. (2005)
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	0	Nothing found to suggest this is the case.
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	0	Species forages on a wide range of prey and is reported to apply a range hunting strategies thru the season to address changes in prey availability. Wiggins, D. (2005)
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	1	0	LS is a medium to long-distance migrant.
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	0	0	L.S. readily re-nests in response to nest fail and will commonly second clutch. Wiggins, D. (2005)
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	1	0	While LS has a variety of prey, arthropods are a primary food source. Periodic declines in populations of these species are expected with increase freqency of drought. Wiggins, D. (2005)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

LOGGERHEAD SHRIKE (*Lanius ludovicianus*)				
B2. Predators	Are important predator populations for this species expected to change?	1	1	One Colorado study found that most LS nest failure was related to magpie predation. Most LS predators are year-round residents to breeding areas would likely experience population increase through lower winter mortality due to milder winters. Yanishevsky, R., and S. Petring-Rupp. 1998
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	No symbionts Wiggins, D. (2005)
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	1	LS are susceptible to a number of diseases and parasites but nothing suggest that these play a large role in mortality or would increase with climate change. Yosef 1996
B5. Competitors	Are populations of important competing species expected to change?	0	0	LS has a number of competitors but this does not appear to have a significant impact on individuals or reproductive success. Wiggins, D. (2005)

LONG-NOSED LEOPARD LIZARD (*Gambelia wislizenii*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	-1	0	desert and semi-desert; sagebrush or other shrublands (NatureServe 2011); conflicting information on sagebrush direction of change; however, in general, a hotter and more desertlike climate will expand upwards in range, likely increasing overall habitat for this species
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	-1	0	no differentiation from breeding habitat
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	0	0	lay eggs in burrows (NatureServe 2011), no expected change
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	0	use burrows for hibernation and when inactive; no expected change

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

LONG-NOSED LEOPARD LIZARD (*Gambelia wislizenii*)				
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	prefer areas with moderate shrub and forb cover, and low grass cover for foraging, predator avoidance, and thermal regulation (Schorr et al 2011); climate change may favor expansion of invasive grasses such as cheatgrass, which would reduce preferred habitat components
H6. Ability to colonize new areas	What is the potential for this species to disperse?	0	1	long-distance movement by males observed (NatureServe 2011), no information on female dispersal- neutral response
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	0	non-migratory
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	aestivator; uses shade of shrubs to regulate temperature (NatureServe 2011)
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	1	no information found on effects of weather-related disturbance
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	unlikely to change activity period
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	no known flexible strategies
PS6. Energy requirements	What is this species' metabolic rate?	-1	0	
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	1	0	hibernator/aestivator that uses temperature to initiate emergence from hibernation (NatureServe 2011)
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	1	inadequate information found on relationship between resource availability and fitness or survival

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

LONG-NOSED LEOPARD LIZARD (*Gambelia wislizenii*)				
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	resources and breeding activities in same place/time
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	-1	0	can produce two clutches per season (NatureServe 2011), allows for more opportunity to time reproductive cycle to available resources
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	0	preys on variety of insects and smaller lizards (NatureServe 2011, Steffen and Anderson 2006)
B2. Predators	Are important predator populations for this species expected to change?	0	0	variety of bird and mammal predators
B3. Symbionts	Are populations of symbiotic species expected to change?	0	1	no information found on symbiotic species; neutral response
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	1	inadequate information on effects of disease on lizard populations
B5. Competitors	Are populations of important competing species expected to change?	0	1	inadequate information found on competitve species

NORTHERN GOSHAWK (*Accipiter gentiles*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	0	goshawk is considered at habitat generalist at large spatial scales and will use a wide variety of forest types for breeding, including ponderosa pine, aspen, mixed conifer, and spruce-fir; climate effects will vary by forest type, however all of these in the SJPL are predicted to stay the same, decrease, or shift upwards in area; Kennedy 2003, NatureServe 2011, Barrett 1998

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

NORTHERN GOSHAWK (*Accipiter gentiles*)				
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	0	0	non-breeding winter habitat requirements less well understood; however, has been observed using a wide variety of habitats, including woodlands, forests, shrublands, forested riparian strips; some of these may decrease (forests), while others increase (woodlands, shrublands), so overall neutral response; Kennedy 2003, NatureServe 2011
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	0	prefer mature forests with large trees, relatively closed canopies, and open understories; large wildfires would decrease these habitat components as well as diminishing size of large tracts of preferred habitat; Kennedy 2003, NatureServe 2011, Barrett 1998
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	1	some studies suggest tolerance for broad range of forest structures for foraging habitat; some suggest preference for forests with similar components to breeding habitat preferences; some studies indicate use of open areas and edges for hunting; conflicting information-neutral response; Kennedy 2003, NatureServe 2011
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	reduction of canopy closure would negatively affect goshawk nesting success; increased frequency of large wildfires would reduce canopy closure in all forest types, as well as creating patchier habitat; insect outbreaks would also decrease canopy closure; goshawks benefit from large tracts of undisturbed habitat; overall score vulnerable; Kennedy 2003, NatureServe 2011
H6. Ability to colonize new areas	What is the potential for this species to disperse?	0	1	lack of information on natal and breeding dispersal; neutral response; Kennedy 2003
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	1	0	limited information on movements indicate that goshawk is a short-distance or partial migrant; Kennedy 2003
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	inhabits wide range of thermal regimes; NatureServe 2011
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	0	wildfires are indirect disturbances on habitat, but do not directly affect populations; Kennedy 2003
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	diurnal; limiting conditions unlikely to change; NatureServe 2011

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

NORTHERN GOSHAWK (*Accipiter gentiles*)				
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	-1	0	has been known to have irruptive migrations in northern portion of range, likely in response to prey population crashes; NatureServe 2011, Kennedy 2003
PS6. Energy requirements	What is this species' metabolic rate?	0	0	
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	0	breeding season mid-Feb through April, not cued primarily by temperature or moisture conditions; Kennedy 2003
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	1	fitness can be influenced by prey abundance and availability; not enough information on how timing of prey populations may shift due to climate change; neutral response; Kennedy 2003
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	since they are a non-migrant or a short-distance migrant, resources and cues occur in generally the same time and space
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	one clutch per year, two to four eggs; NatureServe 2011
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	0	diet varies with region and seasonal availability; includes variety of small mammals and birds; NatureServe 2011, Kennedy 2003
B2. Predators	Are important predator populations for this species expected to change?	1	1	preyed upon by great-horned owls, eagles; nest predation by martens, fishers, raccoons; possible benefit to great-horned owl from climate change (see B5); NatureServe 2011
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	no known symbionts; Kennedy 2003
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	0	diseases documented in goshawk populations, but not believed to be strong threat to populations; Kennedy 2003
B5. Competitors	Are populations of important competing species expected to change?	1	1	reduction and fragmentation of habitat may favor early successional competitors such as red-tailed hawk and great-horned owls, need more information on this; Kennedy 2003

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

NORTHERN LEOPARD FROG

HABITAT

Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	0	breeding habitat is tied to various water sources; short or long term droughts that will become more frequent with climate change reduces habitat through drying of water sources; while more higher elevation ponds may become suitable because of warmer temperature, this expansion upwards will eventually be limited by treeline (Smith and Keinath 2007)
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	1	1	use moist upland habitats for summer feeding, may be a considerable distance from water sources in grasslands or wet meadows; not adequate info on how this type of habitat might be affected by climate change- likely drier, veg change? (Smith and Keinath 2007)
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	0	see H1- habitat components same as habitat in this case
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	0	includes components of adult upland habitat and overwintering habitat; upland habitat components unlikely to change, probably use bottom of streams and ponds that don't freeze overwinter (Smith and Keinath 2007)
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	-1	0	complex because of multiple habitat types; (1) warmer water temperatures accelerate development of eggs and tadpoles, this would improve reproductive success, particularly at high elevations; (2) oxygen saturation of wintering sites important; no known impacts of climate change on this aspect of habitat quality (Smith and Keinath 2007)
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	0	dispersal of adults from breeding sites to upland habitat, natal dispersal from breeding ponds; some young frogs found to disperse as far as 4km with no aquatic connections (Smith and Keinath 2007)
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	1	0	not well known what dispersal corridors are used for movement between breeding sites and upland habitat or for dispersal from breeding ponds (Smith and Keinath 2007)
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	1	could not find specific info on physiological thresholds, inhabits a wide range of thermal conditions; likely that temperature will adversely affect habitat before directly affecting the frog
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

NORTHERN LEOPARD FROG				
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	1	0	increased flooding in spring (due to early snowmelt runoff) could disturb eggs/larvae (Smith and Keinath 2007)
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	1	0	dry conditions may limit movement of adult frogs to and from upland areas (Smith and Keinath 2007)
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	no alternative life history strategies; although it is r-selected and can recover quickly from low population densities, it is also vulnerable to local extinctions (Smith and Keinath 2007)
PS6. Energy requirements	What is this species' metabolic rate?	0	0	Moderate
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	1	0	breeding is initiated by various environmental cues, including temperature; onset of breeding later at higher elevations (Smith and Keinath 2007)
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	1	0	reproductive success tied to appropriate temperature in breeding sites (shallow ponds); timing of this would change with early snowmelt and warmer temperatures (Smith and Keinath 2007)
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	-1	0	species will not initiate breeding activities until breeding sites are available (Smith and Keinath 2007)
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	No
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	0	larvae feed on free-floating algae; adults and sub-adults generalists (NatureServe 2011)
B2. Predators	Are important predator populations for this species expected to change?	0	0	variety of predators at all life stages (Smith and Keinath 2007)
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	did not find any mention of symbiotic species

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

NORTHERN LEOPARD FROG				
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	1	0	climate factors are widely cited in the spread and vulnerability of frogs to chytridiomycosis (Alford 2011)
B5. Competitors	Are populations of important competing species expected to change?	0	1	in region 2, frogs co-occur with tiger salamanders, but no studies of competition between the two have been completed; (Smith and Keinath 2007)

OLIVE-SIDED FLYCATCHER (*Contopus cooperi*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	-1	0	OSFC prefers patchy or open forest structures with snags and spike topped-trees in late successional stands. SF forest with these structural characteristics should increase with climate change, even though the amount of SF, overall, may decline. It does appear to adapt to disturbance regimes, such as fire and beetle epidemics. Altman and Sallabanks 2000
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	1	1	It has been suggested that habitat loss through logging on its winter grounds provides and explanation for decreasing populations.Climate change could interfere with forest re-establishment in traditional wintering sites.
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	0	0	Does not have any reported specific breeding habitat components. Altman and Sallabanks 2000
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	-1	0	Snags and spike-topped trees, important for sallying activites, should increase in availability. Altman and Sallabanks 2000
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	-1	0	Availability of more open stands and sallying perches should improve foraging activies which should have a commensurate postitive relationship to nesting success. Altman and Sallabanks 2000
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	?	OSFC is a long-distance migrant Altman and Sallabanks 2000

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

OLIVE-SIDED FLYCATCHER (*Contopus cooperi*)				
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	1	0	OSFC uses variety of wooded habitats including riparian corridors during migration between breeding and winter grounds. Altman and Sallabanks 2000
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	Nothing suggested in the literature re: physiological conditons. Kotliar, N.B. (2007, February 20)
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No. Nothing to suggest this and would be atypical for this
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	-1	0	Inclement weather can disrupt nest building and can interfere with foraging activities during the breeding season, both of which could have and effect of reproductive success. These weather patterns should be less frequent as a result of climate change. Altman and Sallabanks 2000
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	-1	0	Seems redundant to above.Reduced periods of inclement weather should allow for fewer disruptions in diurnal activities, particularly those related to foraging. Altman and Sallabanks 2000
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	OSFC have low reproductive rates and generally don't double clutch except in response to nest failure. Kotliar, N.B. (2007, February 20)
PS6. Energy requirements	What is this species' metabolic rate?	0	0	Nothing noted in literature. While this flycatcher probably has a higher metabolic rate than many other bird species (based on their energetic foraging habitats), it would not be at the level of species such as hummingbirds. Kotliar, N.B. (2007, February 20)
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	1	No information was found on cues that OSFC may use to initiated migration.
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	0	Any resource peak that could potentially affect this species would likely have to associated with foraging resources. Since OSFC preys on a broad variety of insect prey, it does not appear to depend on any specific peaks in prey availability. Kotliar, N.B. (2007, February 20)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

OLIVE-SIDED FLYCATCHER (*Contopus cooperi*)

PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	1	1	The OSFC is a long-distance migrant that uses a variety of habitats in its migratory pathways including riparian corridors. Critical resources may exists along these pathways on which this species depend. Climate change could alter the availability of these resources, particularly in riparian corridors, where insect "blooms" may be affected by such things as high-water run-off, early hatches, etc. However, no information was found in the literature. Altman and Sallabanks 2000
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	Olive-sided flycatchers have low nest productivity rates and, while it will re-nest in response to nest failure, it is not known to double clutch. Altman and Sallabanks 2000
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	0	Although some research suggests an affinity for honey bees in some areas and yellow-jackets in others, stomach-content surveys indicate a large variety of insects are taken. Kotliar, N.B. (2007, February 20)
B2. Predators	Are important predator populations for this species expected to change?	0	0	Due to its foraging approach, OSFC appears to be preyed upon by a variety of predators. Kotliar, N.B. (2007, February 20)
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	No known symbionts. Kotliar, N.B. (2007, February 20)
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	0	Disease has not been identified in any of the literature as a primary threat to this species.
B5. Competitors	Are populations of important competing species expected to change?	1	1	It is not clear that competition has a major influence on OSFC. However, the species is highly territorial and aggressive on both its breeding and wintering grounds, which may suggest that this is the case. Competitors that may benefit from structural changes brought about by climate change include western woods peewee, Townsend's solitare, and mountain bluebird. Kotliar, N.B. (2007, February 20)

PEREGRINE FALCON (*Falco peregrinus*)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

PEREGRINE FALCON (*Falco peregrinus*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	0	0	breeding sites found on cliff faces near water source; variety of associated vegetation types, including pj, ponderosa pine, shrublands; inhabits a wide range of habitat as long as suitable nesting sites are available; NatureServe 2011, Craig and Enderson 2004
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	0	0	uses a variety of habitats for foraging; and may or may not winter in the area; NatureServe 2011
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	0	0	specific habitat components required for breeding related to situation of nest ledges; these aspects unaffected by climate change; NatureServe 2011, Craig and Enderson 2004
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	0	perches for foraging important component of non-breeding activities; falcons hunt over a large area; also falcons will winter in a wide range of habitats; NatureServe 2011, Craig and Enderson 2004
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	0	0	reproductive success not associated with habitat features; Craig and Enderson 2004
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	0	both sexes disperse, however, females have been observed to disperse farther; Craig and Enderson 2004
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	1	0	migratory species; NatureServe 2011
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	moderate thermal range; NatureServe 2011
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	no
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	1	survival of nestlings can be impacted by exposure to bad weather; not enough information on direction of change for precipitation or severe weather events during critical time period

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

PEREGRINE FALCON (*Falco peregrinus*)				
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	no limitations to daily activity period; may hunt any time during the day; NatureServe 2011
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	no known instances of irruptions or other alternative strategies; NatureServe 2011
PS6. Energy requirements	What is this species' metabolic rate?	0	0	
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	0	Egg laying initiated primarily in April; no indication that breeding is cued by temperature or moisture alone; Craig and Enderson 2004
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	0	Prey availability important during breeding and nesting period; has a variety of prey species, so no evidence that resource peaks will change significantly; NatureServe 2011
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	1	Not enough information on migration movements of southwest Colorado birds; some may be short-distance migrants and can respond to prey levels at breeding sites, others may be distant from local cues
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	will replace lost clutches; in Colorado, clutches were removed by DOW while augmenting production and all pairs renested and laid second clutches; However… this doesn't count as being able to reproduce more than once per year according to SAVS document (NatureServe 2011, Craig and Enderson 2004)
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	0	Primarily preys on a variety of smaller avian species; sometimes small mammals; NatureServe 2011, Craig and Enderson 2004
B2. Predators	Are important predator populations for this species expected to change?	0	0	Nest predation by raccoons, red tailed hawks, red fox occurs; predation of young by golden eagles, great-horned owls, Cooper's hawks; SJPL Species Profile
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	No known symbionts
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	1	Not enough information on diseases affecting falcon populations.

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

PEREGRINE FALCON (*Falco peregrinus*)				
B5. Competitors	Are populations of important competing species expected to change?	0	0	Compete for nesting sites with a variety of avian species, including prairie falcons, golden eagles, red-tailed hawks, ferruginous hawks, vultures, ravens; not known to what extent competition plays a role in regulating populations; SJPL Species Profile

PURPLE MARTIN (*Progne subis*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	0	Lower to mid-elevations are likely to decline as a result of increased drought occurrence or through disease such as SAD (Rehfeldt et al. 2009, Worrall et al. 2008)
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	1	0	Foraging is highly skewed to ponds and wet meadows in proximity to the colony sites. These would likely become more scarce with re-occurring drought and decreasing annual precipitation .Wiggins, D. (2005, March 31).
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	0	There may be an initial increase in breeding habitat (soft snags) as aspen begins to decline. However, this will be a relatively short-term positive effect as these breeding sites fall to the ground.
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	1	Purple Martins begin migration shortly after fledging. They generally remain near the nesting grounds until migration begins. Route taken to their winter grounds in South America are not well known. Brown mentions potential pesticide posioning on their winter grounds but no studies have been done Brown (1997)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

PURPLE MARTIN (*Progne subis*)				
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	1	Reduced quality of foraging habitat would likely have a negative outcome on nesting and ultimate fledging success rates. This may be expected with declines in open water and moist meadow habitats in proximity to colony sites.
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	0	While species is capable of dispersing to new areas, it's not clear, given the high specificity of breeding habitat, if suitable alternate areas will be available.
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	1	0	Species migrates via unknown routes to South American wintering grounds shortly after fledging. Specific habitats needed are not well-known. Wiggins, D. (2005, March 31).
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	-1	0	Periods suitable for foraging may increase. Martins don't forage during cold rainy weather or when temp. is below 9º C.Wiggins, D. (2005, March 31).
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	-1	0	Martins can experience nest failure or reduced nest success due to extended cold, rainy weather, which should be less prevalent with climate change. Wiggins, D. (2005, March 31).
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	-1	0	Periods suitable for foraging may increase. This is somewhat redundant to above. Martins don't forage during cold rainy weather or when temp. is below 9º C. Wiggins, D. (2005, March 31).
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	1	While the species as a whole exhibits a range of adaptability (shifts to urban areas, artificial nesting structures), this sub-species does not appear (yet) to show these traits.

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

PURPLE MARTIN (*Progne subis*)				
PS6. Energy requirements	What is this species' metabolic rate?	0	0	
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	1	No information was found that suggests there are .
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	1	1	Since purple martins choose nesting sites near and forage over open water, its plausible that insect abundance associated with these features may play a role in nesting success . A dependence of martins on specific peaks in insect populations is also plausible but not well discussed in literature. Wiggins alludes to it as a possibility. Wiggins, D. (2005, March 31).
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	1	0	Purple martins are long-distance migrants and could be sensitive to coordinaiton of cues on their winter grounds and critical resources on their breeding grounds. No discussion was found in literature.
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	Purple martins rarely have more than one clutch/year Wiggins, D. (2005, March 31).
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	1	1	Perhaps redundant. Foraging sources related to open water and moist meadows could be affected by climate impacts on these features.
B2. Predators	Are important predator populations for this species expected to change?	0	0	No evidence that predatory relationships will change. Wiggins, D. (2005, March 31).

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

PURPLE MARTIN (*Progne subis*)				
B3. Symbionts	Are populations of symbiotic species expected to change?	-1	0	Since martins are secondary cavity-nesters they should benefit by improving conditions for primary cavity-nesters (e.g., flickers, hairy woodpeckers). Increased mortality of trees in many forest types should result in increased populations of these species, thus increasing the abundance of potential nesting sites for martins.Wiggins, D. (2005, March 31).
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	1	0	While not a disease, martins are host to a large number of parasites at the nest that can signifcantly affect nest productivity and survival. Since these birds will re-use cavities in successive years this increase the chances that parasite infestations can carry over from year to year. With warmer winters the level of winter-kill of parasites would be expected to decrease. Wiggins, D. (2005, March 31),Brown (1997).
B5. Competitors	Are populations of important competing species expected to change?	0	0	Most discussion in literature re: competition is for cavities. While there would likely be an increase in primary cavity-nesters, and thus more cavities, species, such as flickers will re-use old cavities. Whether this competition balances out is hard to say. Wiggins, D. (2005, March 31).

RIVER OTTER (*Lontra Canadensis*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	0	The extent and quality of habitat is likely to change as small streams become too small for utilization or fish habitat. Cayan et al. (2001); Glenn and Nagler (2005); Hultine et al. (2007); Worrall, Adams, and Tharp in press; Worrall et al. (2008), Theobold, D.M., D.M. Merritt, and J.B. Norman, III. (2010)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

RIVER OTTER (*Lontra Canadensis*)				
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	1	0	River otter uses same habitat for breeding and non-breeding.
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	0	Beaver dens, particularly bank dens, are an important element since otters also use these dens for breeding. Beaver populations are likely to decline as fewer streams can accommodate them and shrinking riparian corridors accommodate them. S.Boyle (2006)
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	1	0	RO requires complex riparian vegetation along the shorelines of its aqueous habitats for movement and foraging cover. Lower water levels and highly fluctuating water levels would likely cause a decline in the overall riparian vegetation and would also tend to promote early successional stages of habitat. S.Boyle (2006), Theobold et.al. 2010)
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	Habitat quality for otters can be affected by low flows (fishery habitat), increased turbidity (fires), increased stream temperatures and altered flow regimes. Low stream flows could potentially eliminate ice-free stretches of stream during the winter. S.Boyle (2006); Fitzgerald, J. P., C. A., Meaney and D. M. Armstrong. (1994)
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	0	Otters can disperse moderate distances to colonize new areas of the same stream or new streams. It should be noted that while they can disperse as a response to resource needs they may not be able to disperse outside of the zone of influence of events, such as extended periods of drought. S.Boyle (2006)
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	0	
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	1	S.Boyle (2006)
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	1	Fires and increased turbidity could reduce fish populations but this seems covered in other items in the query.

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

RIVER OTTER (*Lontra Canadensis*)				
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	1	RO are reported to be more active at night and crepuscularly during the non-winter months and more diurnal during winter. This suggests a sensitivity to temperature but nothing found in literature. S.Boyle (2006)
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	
PS6. Energy requirements	What is this species' metabolic rate?	0	0	
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	0	
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	0	S.Boyle (2006)
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	Species does have delayed implantation that is variable and may be influenced by forage availability or condition of the female. However, not well-discussed in literature. S.Boyle (2006)
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1		
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	1	0	The primary food resource of RO is fish. The extent of fish habitat is likely to shrink with climate change and may affect traditional breeding areas. Water levels in streams are predicted to increase as a result of drought and turbidity and water temps are likely to increase. Increased sediment loading from fires could also affect gravel beds used for breeding. S.Boyle (2006); Ficke, Ashley D and C.A.Myrick (2007)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

RIVER OTTER (*Lontra Canadensis*)				
B2. Predators	Are important predator populations for this species expected to change?	0	0	Predation not thought to be a major source of mortality in RO. Mammalian predators including coyote, bobcat, and mountain lion and avian predators (golden eagle) could experience some benefits to milder winters but may have a commensurate decline in favored prey species as a result of habitat changes. S.Boyle (2006)
B3. Symbionts	Are populations of symbiotic species expected to change?	1	0	RO rely heavly on beavers for their natal and resting dens. Reductions in stream flows and degradation of riparian habiat due to low flows and drought are likely to affect beaver populations. S.Boyle (2006)
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	1	Although several diseases and parasites are mentioned in the literature it does not appear that disease plays an important role in population dynamics. S.Boyle (2006)
B5. Competitors	Are populations of important competing species expected to change?	0	0	Mink is the primary competitor for RO but this interaction is does not currently play a significant role in population or behavioral dynamics S.Boyle (2006)

ROCKY MOUNTAIN BIGHORN SHEEP				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	0	adapted to wide variety of habitats but current distribution is limited to open and often precipitous terrain, including alpine meadows, shrub-steppe, talus slopes, open grasslands, cliffs; alpine habitat may decrease in area due to invasion of subalpine shrub and tree species; they are not limited to alpine areas, but shrub encroachment in grasslands would also decrease suitable habitat (Beecham et al. 2007)
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	1	0	see H1 for description of habitat; breeding and non-breeding habitat similar, although breeding (winter) range is perhaps more limited to areas with low snow depth and sufficient forage cover (Beecham et al. 2007)
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	1	some climate projections include increased precipitation in the form of snow during the winter; a deeper snowpack would limit wintering range for sheep; however, there is not good agreement between models for precipitation predictions in Colorado (Ray et al. 2008)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

ROCKY MOUNTAIN BIGHORN SHEEP				
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	1	0	short vegetation or structure that maintains high visibility is important for detecting predators, and may be more important than composition; a variety of plant assemblages may serve habitat component requirements; however, subalpine plant species encroaching into alpine meadows or shrub expansion in grasslands would both reduce suitable habitat (Beecham et al. 2007)
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	0	0	escape terrain (cliffs, rocky outcrops, talus) is critical for lambing grounds, more so than forage quality; this would be unaffected by climate change (Beecham et al. 2007)
H6. Ability to colonize new areas	What is the potential for this species to disperse?	1	0	few studies but dispersal rates believed to be relatively low (Beecham et al. 2007)
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	0	not long-distance migrant (Beecham et al. 2007)
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	hypothetically, warmer temperatures at higher elevations would reduce thermal stress, especially on lambs that were born late; however, climate models predict that summers will warm more than winters, so uncertain that there would be any benefit here
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	1	inclement weather can cause mortality, especially in lambs; conflicting predictions on changes in frequency or severity of storms (Beecham et al. 2007)
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	diurnal; temperature and precipitation changes unlikely to change daily activity period (Beecham et al. 2007)
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	no known flexible strategies (Beecham et al. 2007)
PS6. Energy requirements	What is this species' metabolic rate?	0	0	Moderate (Beecham et al. 2007)
PHENOLOGY				

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

ROCKY MOUNTAIN BIGHORN SHEEP				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	0	breeding occurs over a range of winter months; movement between winter and summer ranges corresponds with greenup (influenced by temperature and moisture indirectly) (Beecham et al. 2007)
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	0	summer nutrient forage strongly correlated with winter lamb survival; early snowmelt and changes in precipitation may shift availability of various forbs; however, plant response to climate change will vary by species, and the bighorn sheep is an opportunistic grazer that will feed on a variety of plants; neutral response (Beecham et al. 2007)
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	winter breeding and summer resources occur in generally same location (Beecham et al. 2007)
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	usually single lamb; rarely twins (Beecham et al. 2007)
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	0	see PH2
B2. Predators	Are important predator populations for this species expected to change?	0	1	cougars main predator and can cause significant mortality; not enough info on how cougars will respond to climate change; neutral response (Beecham et al. 2007)
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	no known symbionts (Beecham et al. 2007)
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	1	0	sheep are susceptible to a variety of diseases that can cause widespread mortality, usually associated with exposure to domestic sheep; unclear how climate might directly impact spread of diseases; however, sheep populations that are stressed from reduced or fragemented habitat, drought, or sever winters would be more vulnerable to disease (Beecham et al. 2007)
B5. Competitors	Are populations of important competing species expected to change?	0	0	competition with domestic livestock has reduced carrying capacity; this is unrelated to climate change' no predicted impacts of climate change on livestock (Beecham et al. 2007)

SPOTTED BAT

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

SPOTTED BAT				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	0	0	roosting habitat is cliff faces in close proximity to water; associated vegetation may be piñon-juniper, desert shrub/sagebrush, or ponderosa pine; mixed increase and decrease in range and elevation for these types, so overall stay about the same (for example, if p-j moves out and sagebrush moves in, still suitable associated vegetation) (Luce and Keinath 2007)
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	0	0	foraging documented in a variety of habitats, including p-j, cliffs, riparian habitats, wetlands, meadows, old agricultural fields, open ponderosa pine forests; usually foraging takes place near or over water (function of prey availability) (Luce and Keinath 2007, NatureServe 2011)
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	0	heavy use of water sources for drinking and foraging, probably due to high water loss from respiratory demands of flight; drying of permanent water sources in arid regions would decrease negatively impact both breeding and non-breeding habitat components (Luce and Keinath 2007)
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	1	0	see H3
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	same as H3; loss or reduction of water sources would negatively impact reproductive success (Luce and Keinath 2007, Adams and Hayes 2008)
H6. Ability to colonize new areas	What is the potential for this species to disperse?	0	1	could not find any information on disperal ability; assigned a neutral score; not much information in general on seasonal movements
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	1	again, not much information on movement patterns; some support for seasonal movement to lower elevations (Luce and Keinath 2007)
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	1	0	reduction of water sources combined with high metabolism would make bats susceptible to exceeding upper physiological thresholds, especialy during droughts (Luce and Keinath 2007)
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

SPOTTED BAT				
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	0	No evidence that spotted bats are particularly vulnerable to disturbance events (Luce and Keinath 2007, NatureServe 2011)
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	nocturnal species (Luce and Keinath 2007, NatureServe 2011)
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	no known alternative strategies; low population densities and low reproductive rate make the species intrinsically vulnerable at a local level (Luce and Keinath 2007)
PS6. Energy requirements	What is this species' metabolic rate?	1	0	high metabolic rate associated with small body size and flight demands (Luce and Keinath 2007)
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	1	very little information on breeding biology of spotted bats; additionally, not all populations may hibernate; neutral rating (Luce and Keinath 2007)
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	1	very little information on population demographics and causes of survivorship for adults or juveniles; neutral rating (Luce and Keinath 2007)
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	1	again, not enough information on cues for breeding, or factors related to survival; also lack of information on seasonal movements, so unable to determine whether there would be a separation I time or space (Luce and Keinath 2007)
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	breeding period variable; evidence for single young (NatureServe 2011)
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	1	feed primarily on flying moths; uncertain what effects of climate change will be on these species; neutral rating (Luce and Keinath 2007)
B2. Predators	Are important predator populations for this species expected to change?	0	0	apparently low predation rates; possible predators are kestrel, peregrine falcon, red-tailed hawk, owls; peregrine falcon populations unlikely to be strongly impacted by climate change (Luce and Keinath 2007)
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	no known symbiotic species (Luce and Keinath 2007)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

SPOTTED BAT				
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	0	some evidence of external parasites or ticks, susceptible to rabies; however, spread of disease limited because of isolated nature of local populations (Luce and Keinath 2007)
B5. Competitors	Are populations of important competing species expected to change?	0	0	no known competitors; competition unlikely because of unique foraging and roosting habitats (Luce and Keinath 2007)

TOWNSEND'S BIG-EARED BAT				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	0	0	breeding habitat (abandoned mines and caves) may shift, but not due to climate change; inhabits a wide variety of habitats outside of roosting requirements- dry uplands to mesic coniferous forests and deciduous forests (Gruver and Keinath 2006)
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	0	0	uses a wide range of foraging habitats; does not stray far from roosts; in SJPL, non-breeding habitat includes shrublands, pj, and montane forests- these may shift upwards, but TBEB is able to use other vegetation types as well, provided appropriate roost sites are available (Gruver and Keinath 2006)
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	0	0	no, see H1
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	0	usually forages along forest edges and avoids open areas; variety of vegetation types; edge habitat would shift along with forests, but not decrease or increase (Gruver and Keinath 2006)
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	0	1	not enough info on specific aspects of habitat that provide improved reproductive success
H6. Ability to colonize new areas	What is the potential for this species to disperse?	1	0	limited dispersal (Gruver and Keinath 2006)
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	0	Doesn't migrate (Gruver and Keinath 2006)
PHYSIOLOGY				

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

TOWNSEND'S BIG-EARED BAT				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	are sensitive to temp changes with regard to roosting sites, but overall occupy a wide range of temperature regimes (semi-desert to high elevation coniferous forests) (Gruver and Keinath 2006)
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	1	1	Since the TBEB has a high site fidelity to roost sites it may be particularly sensitive or vulnerable to loss of these sites through natural (i.e., erosion, structure collapse, landslides) or human (i.e., mine closure, intrusion) causes. ; unsure exactly how climate change might increase natural disturbances- could be fire, floods (Gruver and Keinath 2006)
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	nocturnal species (NatureServe 2011)
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	no alternative strategies (Gruver and Keinath 2006)
PS6. Energy requirements	What is this species' metabolic rate?	0	0	moderate, metabolic rates reduced during hibernation (Gruver and Keinath 2006)
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	1	0	The daily and annual activity patterns of Corynorhinus townsendii mirror those of most other north-temperate species of bats and are dictated largely by daily cycles of light and dark and seasonal cycles of warm and cold. (Gruver and Keinath 2006)
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	1	high resource availability (moths) important; could be mismatch if emergence from hibernation does not match up with when moths are available in the spring; not enough information on how climate change might affect moths
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	resources and species in same location at same time
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	breeds once a year, one young (Gruver and Keinath 2006)
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	1	primary prey base is moths; uncertain what effect climate change will have on prey base (Gruver and Keinath 2006)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

TOWNSEND'S BIG-EARED BAT				
B2. Predators	Are important predator populations for this species expected to change?	0	0	preyed on by house cats, ringtails, spotted skunks, rat snakes… variety of predators, uncertain to what extent predation plays a role in populations (Gruver and Keinath 2006)
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	may share roosts, but no known symbiotic relationships (Gruver and Keinath 2006)
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	0	No
B5. Competitors	Are populations of important competing species expected to change?	0	1	may share roost sites or watering holes, but not enough information on competitive interactions (Gruver and Keinath 2006)

WESTERN BURROWING OWL (*Athene cunicularia hypugaea*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	-1	0	While the short-grass grasslands are predicted to increase, currently much of the structurally suitable habitat is unoccupied indicating that that in itself is not a primary population determinant. McDonald et al. (2004)
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	0	1	Not much is known about winter habitats for Colorado birds.
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	0	0	Habitat components, other than burrows, are likely to remain similar to current conditions. McDonald et al. (2004)
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	1	Not much is known about winter habitats for Colorado birds.
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	0	0	

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

WESTERN BURROWING OWL (*Athene cunicularia hypugaea*)				
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	0	While species has ability to disperse and does in 1st year individuals, they appear to often return to natal grounds. Also, dispersing owls do not necessarily select areas with quality resources to establish new territories. McDonald et al. (2004)
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	1	0	Little is known about transitional habitats. McDonald, D., N.M. Korfanta, and S.J. Lantz. (2004)
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	While this species is thought to be crepuscular, it can be observed active during a variety of periods and timing of activity may change through the season, at least on summer grounds. McDonald et al. (2004)
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	0	Species does not appear to be strongly affect by weather, although burrows may be occasionally flooding during heavy storms.
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	Although mostly crepuscular or nocturnal, BO has been reported active during all periods, indicating an overall low sensitivity thermal conditions that might be expected through climate change. McDonald, D., N.M. Korfanta, and S.J. Lantz. (2004)
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	1	BO has large clutch and brood sizes also high mortality to predation. It was speculated in literature that the large clutch would allow for higher fledged birds during better resource years but not necessarily confirmed. McDonald et al. (2004)
PS6. Energy requirements	What is this species' metabolic rate?	0	0	
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	1	0	Dates of nest initiation are latitudinally stratified with early initiation at lower latitudes. This suggests that nest initiation is being controlled to some degree by temperature. McDonald, D., N.M. Korfanta, and S.J. Lantz. (2004)
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	0	BO does not appear to depend on resource peaks such as food for overall fitness. Is adapted to a broad range of prey, which insulates the species forage related declines or episodic population failures. McDonald et al. (2004)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

WESTERN BURROWING OWL (*Athene cunicularia hypugaea*)				
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	1	0	Moderate to long distant migrant.
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	Not known to double clutch but will replace failed nest.
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	1	0	The BO preys on a range of species, although small mammals are very important to diet and reproductive success. Most of these species are herbivores and supporting vegetatable forage for these species is likely to declined due to drought and non-native invasions (e.g., cheatgrass).
B2. Predators	Are important predator populations for this species expected to change?	0	1	BO has a host of predators. Some studies suggest that badgers are a primary predator, which could be the case in this region. However, local info on predators or predation is sketchy. McDonald et al. (2004), Green (1983), Haug et al. (1993)
B3. Symbionts	Are populations of symbiotic species expected to change?	1	0	This analysis process indicated a decline in prairie dogs, as a result of climate change. Prairie dogs would be considered a primary symbiont of the BO. McDonald et al. (2004), Andrews and Righter (1992)
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	1	Literature note several parasites but not clear that these would increase with climate change. McDonald et al. (2004), USFS 1994 fr. Yanishevsky and Petring-Rupp 1998
B5. Competitors	Are populations of important competing species expected to change?	0	0	BO has several variety of potential competitors but no identified major competitor and no evidence that this competition influences productivity outcomes. McDonald et al. (2004)

WHITE-TAILED PTARMIGAN				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	0	primarily inhabits alpine tundra, above the treeline; upward encroachment of treeline will decrease available habitat (Hoffman 2006)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

WHITE-TAILED PTARMIGAN				
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	1	0	move from lower elevation wintering areas to mid-elevation breeding areas, but both are located in alpine, so response to H1 applies here as well
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	0	presence of willow important breeding habitat component; overall area of willow distribution likely to decrease with upward expansion of treeline (Hoffman 2006)
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	1	0	single most important habitat feature is willow; any activity that reduces the distribution and abundance of willow will have negative consequences (Hoffman 2006)
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	same as H1, 2, 3, 4; additionally, changes in snowpack would impact populations if snow continues to melt earlier (Hoffman 2006)
H6. Ability to colonize new areas	What is the potential for this species to disperse?	0	1	inadequate information on dispersal ability and movements (Hoffman 2006)
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	0	0	non-migratory, no additional habitats (Hoffman 2006)
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	will primarily remain within physiological thresholds; although increasing air temperatures in summer may cause heat stress
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	0	no direct impact on populations, although extreme weather in spring may affect nesting success (Hoffman 2006)
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	1	daily winter activity may increase with increasing snowfall (birds must travel more to forage); also movements increase during extreme weather; inadequate information on changes in daily weather due to climate change- some predict more severe winter storms and higher precipitation, which could mean more energy expenditure for ptarmigan; neutral response because of uncertainty (Hoffman 2006)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

WHITE-TAILED PTARMIGAN				
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	no known flexible strategies
PS6. Energy requirements	What is this species' metabolic rate?	0	0	moderate (low compared to other similar sized birds), but highly susceptible to heat stress due to low evaporative efficiency (Hoffman 2006)
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	0	nesting primarily determined by photoperiod, however, may be temporal variation based on weather and snow cover (Hoffman 2006)
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	1	0	presence of willow and availability of snow-free areas two most important factors influencing where ptarmigan breed (Hoffman 2006); see PH1 also, changes in timing of snowmelt would strongly influence timing of nesting activities
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	resources for breeding season (willow, breeding sites) not in distant location from wintering grounds
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	may be limited opportunity to re-nest, but only breed once a year (Hoffman 2006)
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	1	0	decrease in overall willow habitat also decreases food source, since ptarmigan browse on willow buds (and is most important food item in winter); summer diet is more diverse- includes insects, forbs, and grasses (Hoffman 2006) but alpine plant species composition may also change with climate change
B2. Predators	Are important predator populations for this species expected to change?	0	0	high predation rates from a variety of species, including falcons, eagles, weasels, fox, and coyote (Hoffman 2006)
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	no known symbionts
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	0	relatively low rates of disease and parasite infection (Hoffman 2006); no know consequences due to climate change
B5. Competitors	Are populations of important competing species expected to change?	0	1	competition with elk for willow browse (Hoffman 2006); inadequate information on how elk will respond to climate change, neutral response

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

WOLVERINE				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	1	0	in CO, wolverine habitat is generally alpine areas and subalpine coniferous forest; breeding occurs in the summer; overall area of subalpine forest likely to shift upwards and decrease (Banci 1994)
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	1	0	non-breeding area in general is also alpine and subalpine forests, same response as H1
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	1	deep snow drifts in alpine areas for den sites; physical structures in forested areas such as large cavities or coarse woody debris for den sites; changes in snowpack or forest structure from shifting ranges could decrease these components; need more information; also see H5
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	0	1	preferences for some cover types, aspects, slopes, or elevations are usually attributed to greater abundance of available food (Banci 1994); not enough information about these associations, neutral response; see B1 also
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	snow cover that persists into the spring (mid-May) is required for natal dens (tunnels); early snowmelt in CO could significantly reduce habitat suitability (Banci 1994, McKelvey et al. 2011)
H6. Ability to colonize new areas	What is the potential for this species to disperse?	0	0	females will generally establish residency near natal range, while young males disperse (Banci 1994)
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	1	0	in general, requires large tracts of wilderness (Banci 1994); dispersal corridors needed for population persistence; overall shrinking of alpine habitat will limit dispersal corridors and decrease habitat connectivity; however, they may disperse through atypical habitat (NatureServe 2011)
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	1	likely will remain within physiological thresholds, but there is evidence that wolverine avoid high temperatures (Banci 1994); higher summer temperatures in the alpine could cause heat stress
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No, sex ratio near 1:1 (Banci 1994)

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

WOLVERINE				
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	0	no evidence that survival and reproduction strongly affected by disturbances
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	primarily nocturnal (NatureServe 2011)
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	0	no known flexible strategies
PS6. Energy requirements	What is this species' metabolic rate?	0	0	moderate
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	0	0	breeds April-October (variable); delayed implantation until winter, which may correspond with higher carrion availability (Banci 1994); not primarily cued by temperature or moisture
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	1	0	successful natal dens related to duration of spring snow cover, which would change (Ruggiero et al 2007)
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	0	0	resources not distant from breeding areas
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	once per year (Banci 1994)
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	0	0	availability of large mammal carrion underlies distribution, survival, and reproductive success; consume a variety of prey and are described as opportunistic feeders in summer and scavengers in winter (Banci 1994)
B2. Predators	Are important predator populations for this species expected to change?	0	0	very few natural predators; cases of predation by wolves rare (Banci 1994, NatureServe 2011)
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	no known symbionts

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

WOLVERINE				
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	0	no evidence of effects of climate change on disease prevalence; in general, wolverine have low density populations that are less susceptible to disease
B5. Competitors	Are populations of important competing species expected to change?	0	0	no major competitors

YUMA MYOTIS (*Myotis yumanensis*)				
HABITAT				
Trait/Quality	Question	R	U	Scoring Rationale & Sources
H1. Area and distribution - breeding	Is the area or location of the associated vegetation type used for breeding activities by this species expected to change?	0	0	Y.M. is found in a variety of habitats, mostly associated with drier veg. types (e.g. sagebrush, P/J, mountain shrub). Some of these are expected to decline and other expand. Oliver 2000, CP&W,
H2. Area and distribution - non-breeding	Is the area or location of the associated vegetation type used for non-breeding activities by this species expected to change?	0	0	Non-breeding in Colorado similar to breeding habitat. Winter not clear but is not suspected of wintering in Colorado. It likely migrates to other lower latitudinal areas to hibernate, perhaps to extend the foraging season. Oliver 2000, CP&W,
H3. Habitat components - breeding	Are specific habitat components required for breeding expected to change within the associated vegetation type?	1	1	Yuma myotis is highly associated with riparian corridors and permanent water sources for foraging during the breeding season. The availability of these features is likely to decline during climate change as result of lower annual precips and extended droughts. CP&W
H4. Habitat components - non-breeding	Are other specific habitat components required for survival during non-breeding periods expected to change within the associated vegetation type?	1	1	YM uses similar habitats for foraging after the breeding season and it is likely that riparian and other water features play a role in their activities. No information on habitats that are used post-migration.
H5. Habitat quality	Within habitats occupied, are features of the habitat associated with better reproductive success or survival expected to change?	1	0	Species depends on riparian habitats for productive foraging. It also appears to use cottonwood trees for roosting, even as natal sites.
H6. Ability to colonize new areas	What is the potential for this species to disperse?	-1	0	Species has a high ability to disperse but successful dispersal would be contingent on availability of suitable roosts and hibernacula.

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

YUMA MYOTIS (*Myotis yumanensis*)				
H7. Migratory or transitional habitats:	Does this species require additional habitats during migration that are separated from breeding and non-breeding habitats?	1	0	The Yuma myotis migrates out of Colorado although its migrational pathways and destinations are not known.
PHYSIOLOGY				
PS1. Physiological thresholds	Are limiting physiological conditions expected to change?	0	0	Apparently will be within physiological thresholds. Generally active nocturnally or early evening. Day roost would be considered cool micro-sites.
PS2. Sex ratio	Is sex ratio determined by temperature?	0	0	No
PS3. Exposure to weather-related disturbance	Are disturbance events (e.g. severe storms, fires, floods, etc.) that affect survival or reproduction expected to change?	0	0	
PS4. Limitations to daily activity period	Are projected temperature or precipitation regimes that influence activity period of species expected to change?	0	0	Yuma myotis is mostly nocturnal
PS5. Survival during resource fluctuation	Does this species have alternative life history pathways to cope with variable resources or climate conditions?	1	1	No specifc strategies identified in literature.
PS6. Energy requirements	What is this species' metabolic rate?	1	0	Species has high metabolic rate when foraging but is able to dramatically reduce rate while roosting. Turbill et al. 2008, Voigt et al. 2012.
PHENOLOGY				
PH1. Mismatch potential - Cues	Does this species use temperature or moisture cues to initiate activities related to fecundity or survival (e.g. hibernation, migration, breeding)?	1	0	Timing of the daily temperature cycle affects the critical arousal temperature and energy expenditure in some bats including bats that roost beneath bark. Species will also forage during warmer periods of winter and temperature must be the cue for this activity. Turbill et al. 2008.
PH2. Mismatch potential - Event timing	Are activities related to species' fecundity or survival tied to discrete resource peaks (e.g. food, breeding sites) that are expected to change?	0	1	None identified in literature but it is known to opportunistically feed on swarms of flying ants. It is possible but insect swarms could be important at critical times.
PH3. Mismatch potential - Proximity	What is the separation in time or space between cues that initiate activities related to survival or fecundity and discrete events that provide critical resources?	1	1	As a migratory species the Yuma myotis has the potential for mismatched cues.

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)

YUMA MYOTIS (*Myotis yumanensis*)				
PH4. Resilience to timing mismatch	Does this species have more than one opportunity to time reproduction to important events?	1	0	
BIOTIC INTERACTIONS				
B1. Food resources	Are important food resources for this species expected to change?	1	0	
B2. Predators	Are important predator populations for this species expected to change?	0	0	
B3. Symbionts	Are populations of symbiotic species expected to change?	0	0	No symbionts
B4. Disease	Is prevalence of diseases known to cause widespread mortality or reproductive failure in this species expected to change?	0	1	Little information on disease in Yuma myotis. As a hibernator in caves it may be susceptble to white-nose syndrome. Some research suggests that warmer micro-sites in caves could inhibit growth of fungus and reduce metabolic expenditures associated with rousing from hibernation related to infection. Boyles & Willis 2009.
B5. Competitors	Are populations of important competing species expected to change?	0	0	

*R=Response (-1, 0, 1); U=Uncertainty (0, 1)