Threats and Stressors to SAR and Ecological Systems, Practical Implications, and Management Strategies for Installations in Colorado and the Western U.S.

Abstract

Species and ecological systems face continued pressure from a variety of inter-related threats, including expanding urbanization, habitat degradation, climate change, and others. As threats to biodiversity continue, the Department of Defense (DoD) could find its installations shouldering more conservation responsibility in the future. To better understand evolving management challenges, the project team conducted an analysis of current and potential future threats to three ecological systems and five species-at-risk (SAR) on Fort Carson, Piñon Canyon Maneuver Site (PCMS), and the U.S. Air Force Academy (USAFA).

In consultation with installation personnel, the project team identified the following ecological systems and species as the focus of the study:

- Pinyon-juniper woodlands
  - pinyon jay (*Gymnorhinus cyanocephalus*)
  - gray vireo (*Vireo vicinor*)
- Shortgrass prairie
  - burrowing owl (*Athene cunicularia*)
- Cliffs and canyons (including outcrops and pine barrens)
  - golden eagle (*Aquila chrysaetos*)
- Preble's meadow jumping mouse (*Zapus hudsonius preblei*)

Key components of the study included: 1) synthesizing the most current information on distribution, status, ecological processes and life history for each species and ecosystem; 2) calculating potential impact from incompatible land uses for each ecosystem using existing spatial data layers; 3) evaluating existing models of potential distribution shift in response to climate change for both ecological systems and species, and 4) considering potential impacts from military training.

Project Specifics

Description of geographic setting: Ecological systems assessed in this study represent the major land cover types for Fort Carson and Piñon Canyon Maneuver Site. Species assessed were selected by these two installations and the U.S. Air Force Academy. All three installations are in Colorado, at or near the ecotone between shortgrass prairie plains and the Rocky Mountain front. Ecological systems were evaluated across their distribution: Central and Southern Shortgrass Prairie ecoregions for shortgrass prairie and cliffs/canyons/outcrops, and portions of Colorado, Utah, Arizona, and New Mexico for pinyon-juniper (i.e., the distribution of two-needle pinyon pine, *Pinus edulis*). Species were assessed at two scales: Colorado and western U.S.

Principal investigators: Lee Grunau (Colorado Natural Heritage Program) and Dave Jones (Center for Ecological Management of Military Lands); both organizations are units of Colorado State University.

Partners: None.

Service branch: Army, Air Force

Project location: Colorado and the western U.S.

Installation size: Fort Carson (approximately 138,000 acres), Piñon Canyon Maneuver Site (approximately 235,000 acres), and U.S. Air Force Academy (approximately 18,500 acres).

Installation primary mission: Training

Project dates: October, 2014 – January, 2017

Project point of contact: Lee Grunau, Colorado Natural Heritage Program, Campus Delivery 1475, Colorado State University, Fort Collins, CO, 80523, lee.grunau@colostate.edu.

Purpose/Need

DoD lands support more federally listed species than those of any other major federal agency, and harbor more imperiled species than lands managed by either the National Park Service or U.S. Fish and Wildlife Service. Thus, DoD installations carry significant responsibility for conservation of the Nation's sensitive biological resources. Species and ecological systems face continued pressure from the effects of expanding urbanization, invasive species, habitat degradation, and other evolving threats. Understanding, anticipating, and responding to an increasingly complex array of issues is a significant challenge for our military's natural resource managers. The purpose of the project was to provide installation managers with a comprehensive and integrated understanding of issues and opportunities for resource stewardship in a regional context.

Approach

For ecological systems, the project team synthesized current understanding of physical and biological factors, ecological processes, and condition from published and gray literature and expert opinion. For each system, the team's landscape ecologist conducted a GIS analysis to calculate vulnerability to potential effects of incompatible land uses across its range and for the system as it occurs within or near Colorado DoD installations. The distributions of ecological systems were derived from the GAP Land Cover v2.2 (USGS 2013). For shortgrass prairie, the analysis included prairie vegetation within the Central Shortgrass Prairie and Southern Shortgrass Prairie ecoregions. Pinyon-juniper was mapped based on the current distribution of two-needle pinyon pine (*Pinus edulis*). The cliffs, canyons, and outcrops ecosystem was not well depicted by the GAP dataset, so steep slope areas (slope $\geq$35 degrees) from a slope raster derived from the National Elevation Dataset was added.

Potential land use impacts were assessed by calculating the number of acres and percentage of total ecosystem area located within one mile of:

- Residential and commercial development (high intensity and low intensity)
- Cropland

- Energy (oil and gas, wind)
- Transportation (major roads and minor roads)

To estimate the degree to which climate change may constitute a threat to shortgrass prairie and cliff/canyon systems within the western Great Plains, a model (previously developed by the authors) of future climate conditions for Colorado was adapted and expanded to cover the Central and Southern Shortgrass Prairie ecoregions. In brief, the model was created using the following inputs:

- an ensemble average of 34 climate models
- two greenhouse gas emissions scenarios: increasing emissions over time, and emissions stabilize shortly after 2100
- a 30-year analysis timeframe (i.e., 2035 – 2064).

For the pinyon-juniper ecosystem, potential future distribution models were available from other ongoing work (by the authors of this project) in the San Juan region of southwestern Colorado. In the interest of providing installation managers with as much information as possible, that model was expanded statewide to include the portion of pinyon-juniper distribution on Colorado's eastern slope. In brief, the Colorado distribution of pinyon-juniper was overlaid onto two plausible future climate scenarios – "hot and dry" and "warm and wet." Each scenario is represented by a single climate model rather than an ensemble average. These climate models, which were selected in consultation with a research scientist at the North Central Climate Science Center, represent potential future climate conditions above (i.e., worse case) and below (i.e., better case) the multi-model ensemble mean for temperature and precipitation.

For species, current information on distribution, conservation status, select life history requirements, threats, and management recommendations from peer reviewed literature, State Wildlife Action Plans, and other references and planning documents were compiled and synthesized. In addition, a preliminary climate change vulnerability assessment for each target species using NatureServe's Climate Change Vulnerability Index and distribution shift modeling efforts by others, as reported in the literature, were included.

Results

All three ecological systems have significant potential for adverse impacts from incompatible land uses, based on geographic proximity to semi-permanent or permanent infrastructure. Across the distribution of pinyon-juniper, only 11% of this system is further than one mile from at least one mappable incompatible land use. That number is 7% for shortgrass prairie, and 8% for cliffs and canyons. Not surprisingly, the land use with the greatest acreage of potential impact for all systems is roads. For example, see Figure 1, which shows the distribution of pinyon-juniper in relation to major and minor roads.

Future vulnerability to climate change can only be projected at this point. Available information suggests that future conditions are likely to be very challenging for pinyon pine, but potentially beneficial for juniper species under some scenarios. For example, Figure 2 shows modeled future suitable conditions for pinyon pine and one-seed juniper under hotter/drier and warmer/wetter climate scenarios. A variety of vulnerability assessment methods have been applied to shortgrass prairie, all with the same result:

highly vulnerable. Cliffs and canyons are expected to experience climate effects similar to shortgrass prairie, though potentially with fewer impacts where they are sparsely vegetated. However, altered hydrology could affect rare canyon ferns. Assessments of vulnerability to climate change produced variable results for all of the species, with the exception of Preble's meadow jumping mouse, which was ranked as extremely vulnerable.

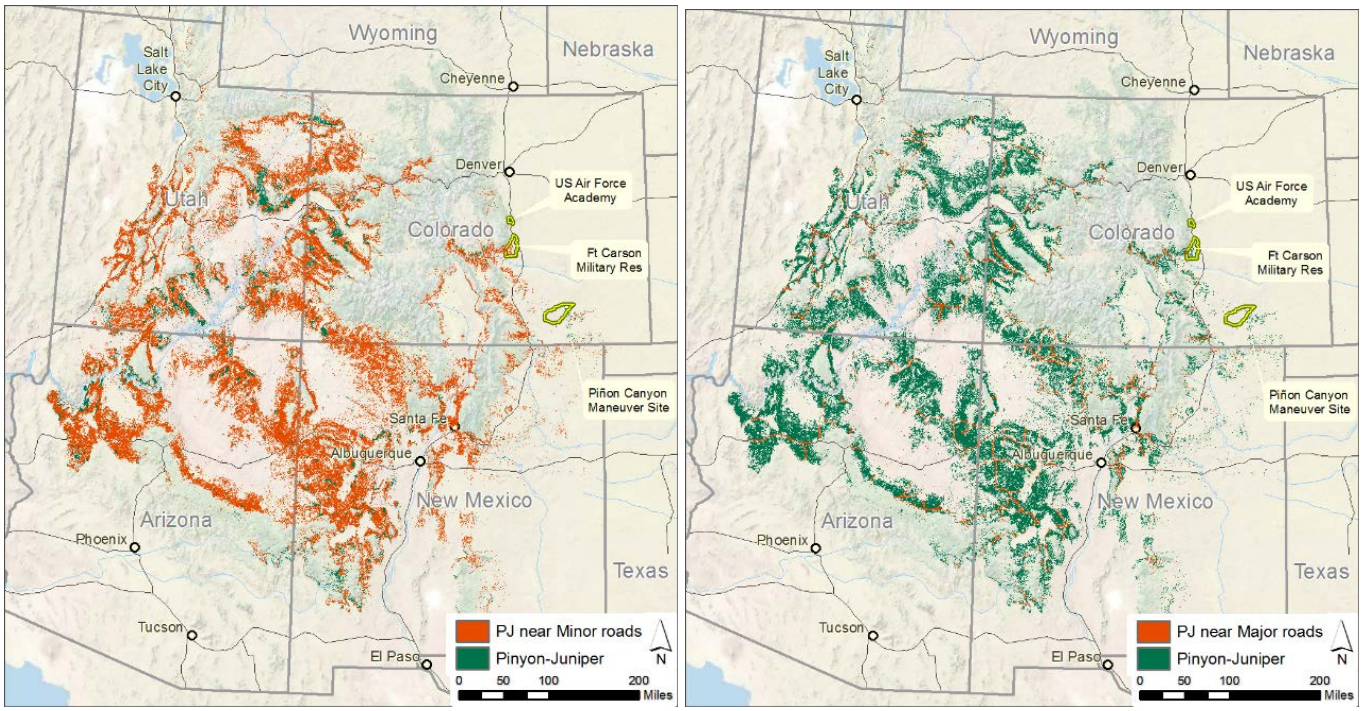

Figure 1. Distribution of pinyon-juniper within one mile of minor roads (left) and major roads (right).

For pinyon-juniper obligates, habitat has already been degraded by a host of factors, including historic rangeland "improvements," fire suppression and increasingly large wildfires, recent drought and Ips beetle damage, past and current attitudes of many land managers (target for removal, "grind-and-go" approach to restoration), and general confusion about the many variations of pinyon-juniper (e.g., when pinyon-juniper represents encroachment v. when it represents natural succession or recovery from past extreme events) – not to mention climate change. The current status of the gray vireo is unclear, but its future in the region may be favorable if climate projections for juniper expansion are correct. Pinyon jay, on the other hand, may be faced with increasing stress, even as its populations are showing significant declines in most parts of its range. Fort Carson and PCMS are near the edge of the current ranges for pinyon-juniper and pinyon jays. However, if ranges and distributions change (e.g., models predict that higher quality habitat for pinyon jays maybe move north and east), higher quality habitat may be closer to these installations. On the other hand, some models show these installations potentially losing suitability for pinyon pine.

The burrowing owl is documented from a variety of habitats, but it is most often closely associated with prairie dog colonies. Thus, management for thriving prairie dog colonies is

the key to conservation for this owl. Though golden eagles are a wide-ranging species with a global distribution, they are vulnerable to a number of stresses. Key among these may be impacts from a changing climate on phenology, distribution, and response of their prey base. Similarly, there is potential for increasing impacts from wind energy infrastructure commensurate with increasing interest in development of renewable energy.

As an obligate of riparian systems, Preble's meadow jumping mouse is likely to be adversely impacted by a warming climate, which is expected to result in effectively drier conditions even if precipitation increases. These stresses, combined with increasing human population growth and demand for water resources, will certainly complicate management of western water-driven ecosystems. Of all the species evaluated in this report, the Preble's meadow jumping mouse is most in need of cross-boundary management for the benefit of its habitat.

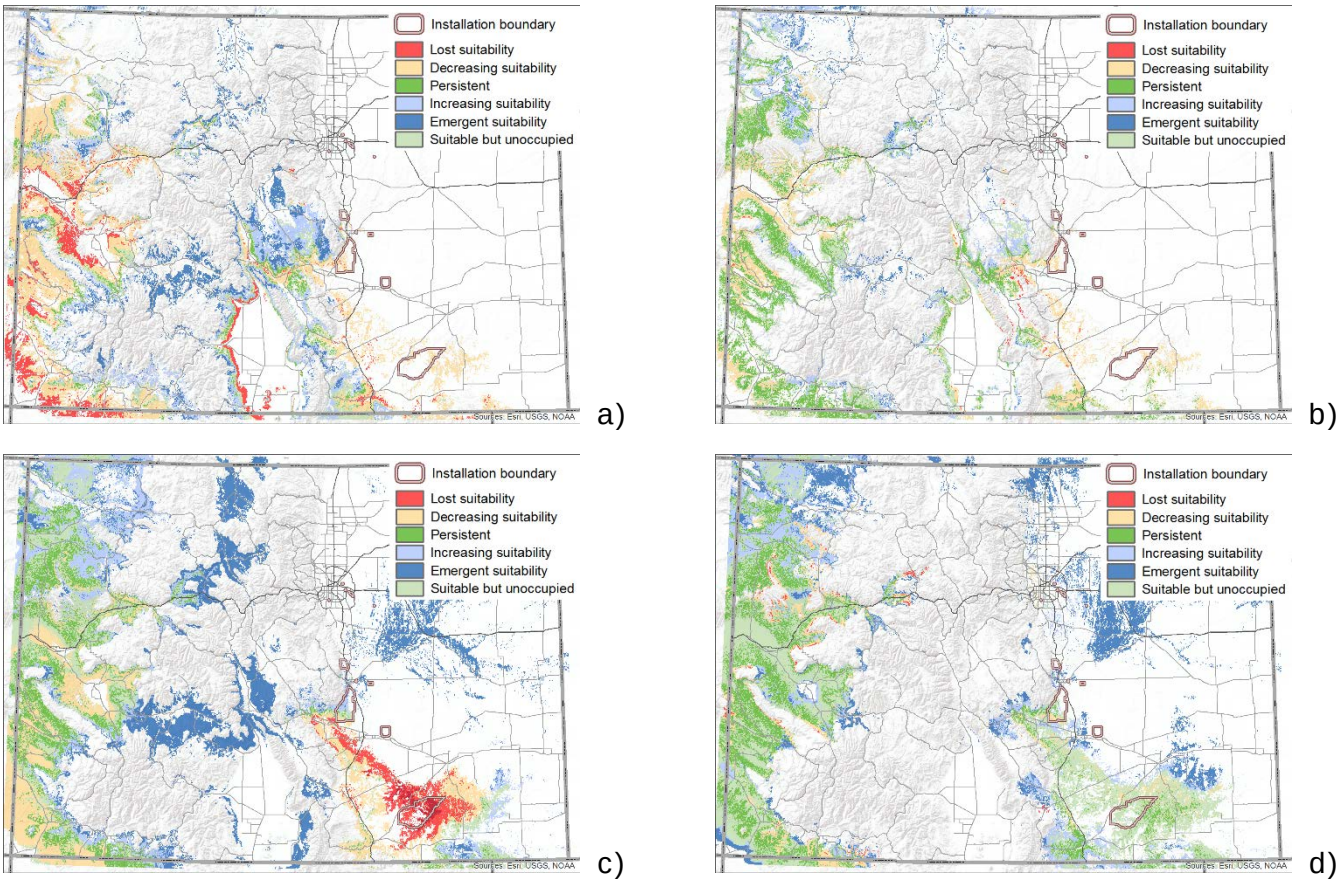

Figure 2. Projected habitat suitability changes across Colorado for pinyon pine (top) and one-seed juniper (bottom) under two climate scenarios at mid-century: a) pinyon pine under much hotter and drier conditions; b) pinyon pine under warmer, wetter conditions; c) juniper under much hotter and drier conditions; d) juniper under warmer, wetter conditions.

Benefit

This analysis addresses implications of multiple threats and stressors on the vulnerability of species and habitats, as well as potential changes to training environments. The findings can help managers understand implications of potential changes on range sustainability and resiliency at broad and installation-specific scales. Results have widespread

application for DoD installations in the western U.S., including the 26 Air Force, Army, Marine Corps, and National Guard installations that occur within the range of one or more of the targeted species and/or ecosystems. Analysis methods are readily transferrable across multiple DoD services and installations.

Recommendations/Lessons Learned

Managing for resilience is needed within the training environment as well as within the context of changing climate and other stressors. In many cases, understanding of exactly where the thresholds are between resilient and not resilient (e.g., the point at which some environmental variable moves from impairing to lethal) is poor. A plethora of research priorities exist, including better tracking of species distributions, phenology shifts, and changes in behavior, food preferences, and environmental tolerances. Additionally, improved means of housing, synthesizing, and sharing data and key messages continues to be needed.

Key recommendations include:

- Invest in planning and cross-boundary collaboration as a top priority.
- Enhance internal collaboration and communication on Best Management Practices and data sharing.
- Implement landscape-scale monitoring to support habitat management.
- Manage for resiliency of natural processes and systems dynamics, including prairie dogs as a keystone species, in the context of drought.

An important note in considering climate change vulnerability is that an assessment typically reports *relative* vulnerability rather than an absolute measure of risk. Results may vary based on inputs – e.g., which climate model(s), emissions scenarios, timeframes and scale are used in a given assessment. Given the nature of climate modeling and incomplete understanding of species and ecological systems, uncertainty in results is to be expected. However, sources of uncertainty should be adequately communicated to end users to avoid confusion arising from differing results. Climate projection data are constantly being refined and updated, and assessment results from the suite of possible climate model/emissions scenario combinations are highly variable, with some factors more reliably modeled than others. In particular, highly complex topography (e.g., of much of Colorado) makes precipitation predictions problematic at scales which are likely to be important to local vegetation types over the relatively short-time period typically encompassed by natural resource management plans. Incorporation of qualitative methods (i.e., expert input on species life history and ecology) is helpful in selecting some model inputs, but is also an additional source of uncertainty given often incomplete understanding.

Communications

In addition to the final report and fact sheet, a webinar through the DoD Natural Resources program and an article for the Natural Selections newsletter are being planned for 2018. For additional details, see the full technical report available at http://www.cnhp.colostate.edu/download/reports.aspx or contact Lee Grunau, Colorado Natural Heritage Program, at Lee.Grunau@colostate.edu.