FINAL REPORT

Response of Birds, Butterflies, and their Habitats to Management of Wildland Fuels and Fire Regimes

JFSP # 05-2-1-94

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Abstract

Natural and anthropogenic processes are causing extensive and rapid ecological changes across the Great Basin. Fire regimes have been altered; the frequency, severity, and spatial extent of fires are increasing. Rapid invasion of non-native annual grasses like cheatgrass (*Bromus tectorum*) in many parts of the region has resulted in an annual grass–fire cycle and conversion of native shrublands and woodlands to homogenous annual grasslands with little ecological or economic value. We examined associations among abiotic factors, pre-burn vegetation, and post-burn vegetation on post-fire cover of sagebrush (*Artemisia tridentata*) and cheatgrass. We also investigated the effects of prescribed fire in pinyon–juniper woodlands and ponderosa pine forests on birds and their habitats. In addition, we identified drivers and quantified the expansion of pinyon–juniper woodlands in the central Great Basin since the mid 1980s.

Pre-fire canopy cover of trees was inversely correlated with post-fire cover of sagebrush. Invasion of cheatgrass post-fire was most likely on sites that were relatively dry, had high pre-burn canopy cover, or were relatively distant from unburned patches. We identified specific biotic and abiotic covariates associated with detection, occupancy, local colonization, and local extinction of multiple species of songbirds. We found that bird species that use similar abiotic and biotic resources cannot be assumed to serve as surrogates for each other. Because species within presumed guilds may have different responses to environmental and habitat variables, the effects of a given management action may vary among species.

Analysis of a series of Landsat TM images suggested that across the central Great Basin, increases in conifer cover and density between 1986 and 2005 were most likely to occur at elevations below 2000 m and on south facing slopes, whereas overall cover and density of woodlands tended to be greatest at elevations between 2200 and 2600 m. Climate change may arrest current expansion of pinyon–juniper woodlands at relatively low elevations in the Great Basin, rendering human intervention to constrain undesirable expansion less necessary.

Background and Purpose

Land cover across the Great Basin is changing as a result of expansion of native singleleaf pinyon (*Pinus monophylla*) and Utah and western juniper (*Juniperus osteosperma*, *J. occidentalis*) trees; invasion by cheatgrass (*Bromus tectorum*), a fire-adapted species, and other non-native plants; and human land uses such as agriculture, grazing by domestic livestock, energy extraction, and exurban infrastructure. Further, climate change already is affecting water availability, disturbance regimes, and species distributions across the region.

Fire regimes both respond to and drive changes in land cover. During the past few decades, the frequency, severity, and spatial extent of fires in the Great Basin has increased dramatically. For example, a single wildfire in 2007 burned more than 2600 km^2 in Nevada and Idaho. Rapid invasion of cheatgrass in many parts of the region has resulted in an annual grass–fire cycle and conversion of native shrublands and woodlands to homogenous annual grasslands with little ecological or economic value.

Prescribed fire and other fuels management treatments have been suggested as mechanisms to slow expansion of pinyon and juniper woodlands while minimizing potential expansion of non-native plants. These treatments also may reduce the probability of extreme fire events, which can have undesirable effects on social, economic, cultural, and ecological values. However, relatively little information exists to predict how alternative fire management strategies will affect native species and communities. Understanding biological responses not only to current fuels treatments but to longer-term environmental changes is critical to development of practical tools for ecological restoration and maintenance.

Resource agencies across the Intermountain West are concerned with the effects of fire and fire management on wildlife as well as on vegetation. Around the world, birds frequently are monitored because they have regulatory protection or to assess biological consequences of management of specific land-cover types and disturbances. For example, concerns about impacts to the status of individual species of birds, in potential violation of the Migratory Bird Treaty Act, can constrain implementation of prescribed fire during the spring. Monitoring of carefully-selected taxonomic groups and their habitats across large areas and over many years helps us to evaluate whether environmental changes are modifying critical natural resources, whether management strategies are meeting their objectives, and the extent to which biological responses to management are likely to vary as a function of the spatial and temporal scales of management actions. Data from areas that have not been subject to fuels treatments, for instance, increase our ability to assess whether changes in wildlife diversity result from the treatment or simply reflect background variability.

Study Description and Location

We conducted our study in four adjacent mountain ranges with similar biogeographic and human land-use histories: the Shoshone Mountains, Toiyabe Range, Toquima Range, and Monitor Range (Lander, Eureka, and Nye counties, Nevada). The area bounding the ranges is about 125 x 125 km, centered near 39˚ N latitude and 117˚ W longitude. Canyons, many of which have perennial or ephemeral streams, drain the east and west slopes of the ranges.

Vegetation

To collect information on community-level and watershed-level responses of vegetation to prescribed fire in pinyon-juniper woodlands, we initially anticipated working in a Demonstration Watershed (Underdown Canyon, Shoshone Mountains) that was established to illustrate the feasibility and ecological effects of large-scale prescribed fire in pinyon-juniper woodlands to managers, researchers, and the public. In 2002, ~20 ha of the watershed were treated with fire; in 2004, an additional 375 ha were treated.

We ultimately decided to work in Wall Canyon (Toiyabe Range), in which a 2800-ha wildfire occurred in high-density pinyon-juniper woodland in 2000. The spatial extent of the burned area in Wall Canyon was more conducive to robust research than the relatively localized treated areas in the Demonstration Watershed.

We explored plant species distribution and community structure six years following the Wall Canyon fire. We examined post-fire establishment of a non-native annual grass, cheatgrass (*Bromus tectorum*), and a native shrub, mountain big sagebrush (*Artemisia tridentata vaseyana*). We used structural equation models to explore correlational and possibly causal relationships among abiotic factors, pre-fire canopy cover and cover of perennial herbaceous plants, proximity to unburned patches, and cover of sagebrush and cheatgrass. We also explored influences on vegetation succession following fire, emphasizing spatial factors that may decrease the probability of colonization by non-native plants. We used detrended correspondence analysis and variance partitioning to better understand the relative association of abiotic and biotic factors with post-burn species composition in pinyon–juniper woodland. We examined the influence of topographic and soil characteristics, pre-burn canopy cover, and proximity to unburned patches on species composition and colonization by invasive species following fire.

<u>Birds</u>

We surveyed birds during the breeding seasons (late May through June) of 2005–2009 using 75-m fixed-radius point counts. Our analyses capitalized on additional data from 2001—2004, which were collected with the same methods. We established 179 survey points in 2001, and added additional points annually in 2004–2008. In all, we have established 372 permanent survey points: 60 in the Shoshone Mountains, 168 in the Toiyabe Range, 75 in the Toquima Range, and 69 in the Monitor Range.

Most point centers were > 350 m apart. Points were located along the full elevational gradient of each canyon we sampled, typically with two or three points per 100 m vertical elevation change. We estimated the geographic coordinates of each point using a global positioning system and differential correction. We estimated the elevation at each point by intersecting its centroid with a 30-m (1:24,000) U.S. Geological Survey digital elevation model.

Points were positioned to sample, in approximate proportion to areal extent, the dominant land-cover types throughout the canyons: aspen, pinyon–juniper woodland, *Salix* spp. (willow), sagebrush and other montane shrubs [e.g. *Symphoricarpos albus* (snowberry), *Cercocarpus ledifolius* (mountain mahogany)], and mixed vegetation (combination of coniferous and deciduous trees, with variable understory). We did not attempt to classify land use because livestock grazing and human recreation, the ubiquitous dominant uses in this region, vary considerably through time.

We examined the relationship between individual species of breeding birds and biotic and abiotic attributes of their habitat. For example, we estimated multi-season patterns of occupancy, colonization, and local extinction for three obligate riparian species of songbirds species detected during the breeding seasons of 2001–2006: MacGillivray's Warbler (*Oporornis tolmiei*), Broad-tailed Hummingbird (*Selasphorus platycercus*), and Song Sparrow (*Melospiza melodia*). We used model selection and multi-model inference to identify functional relationships between the occupancy of each species and multiple habitat variables, including the structure and composition of riparian vegetation. Establishing these functional relationships between avifauna and vegetation is essential to predicting how land-cover change may affect the quality of different vegetation types from the perspective of birds.

We also examined the relationship of breeding birds to elevation across and within four adjacent mountain ranges. We focused on eight species that in this region are associated strongly with pinyon–juniper woodland: Gray Flycatcher (*Empidonax wrightii*), Mountain Chickadee (*Poecile gambeli*), Blue-gray Gnatcatcher (*Polioptila caerulea*), Black-throated Gray Warbler (*Dendroica nigrescens*), Green-tailed Towhee (*Pipilo chlorurus*), Spotted Towhee (*Pipilo maculatus*), Chipping Sparrow (*Spizella passerina*), and Brewer's Sparrow (*Spizella breweri*). In addition, we explored how the distribution of breeding birds may respond to potential changes in the extent and attributes of pinyon–juniper woodland by 2100. Our approach is applicable to diverse assemblages and ecosystems: we linked data on relationships between species and major environmental gradients with projected responses of land cover to environmental change, and then examined how species may respond to environmental change.

<u>Land-Cover Change</u>

We acquired Landsat images (path 41, row 33) from mid-October of 1986, 1995, and 2005. At this time of year, grasses, forbs, and deciduous trees are dormant, but pinyon and juniper are still photosynthetically active. We converted the images to reflectance using the radiometric gain and offset values associated with the Landsat TM satellite. After the Landsat images were geographically and spectrally aligned, we calculated the percentage of green vegetation in each pixel using spectral mixture analysis. Only the green vegetation component (i.e. fractional green cover as measured by the satellite, fG) was retained for each image. We used fG values to estimate the proportion of tree cover in 2005 and to identify changes in tree cover (DfG) between 1986 and 2005.

Based on the change analysis, we identified three categories: areas where fractional greenness had increased (positive DfG), areas where fractional greenness had decreased (negative DfG), and areas where no change occurred. A positive or negative DfG does not necessarily reflect an increase or decrease in greenness. The median DfG between years may be negative if, for example, productivity during the first year was particularly high. Hence, a local negative DfG value could actually correspond to an increase in fG if the median for the study region is lower than the local value. Similarly, a local positive DfG value could correspond to a decrease in fG if the median DfG value for the study region is greater than the local value.

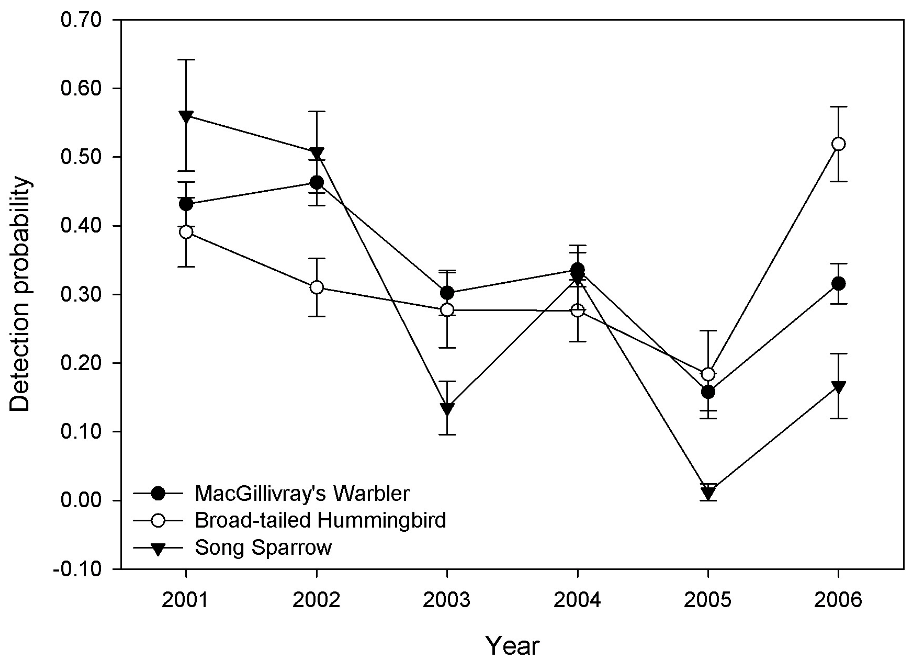
Key Findings

Pre-fire canopy cover of trees appeared to be inversely correlated with post-fire cover of sagebrush. We did not find a significant association between proximity to unburned areas (i.e., seed-dispersal distance) and sagebrush cover six years after wildfire. It is possible, as others have suggested, that a residual seed bank is masking an influence of distance to seed sources on post-fire establishment of sagebrush.

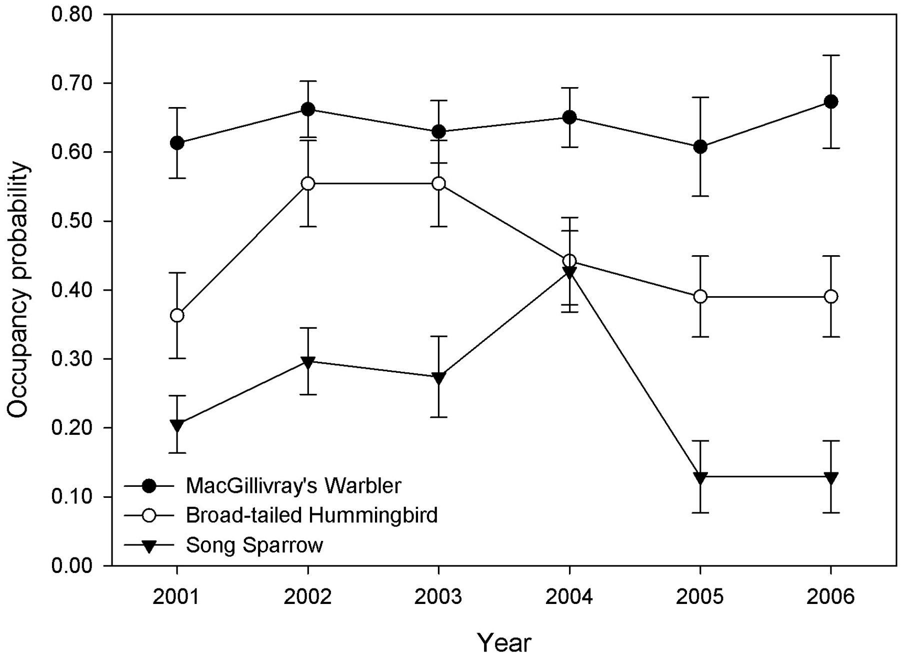
Post-fire cover of cheatgrass did not affect cover of sagebrush. Instead, cheatgrass cover primarily was associated with incident solar radiation (positive association) and post-fire cover of perennial herbaceous species (negative association). Sites with high solar radiation occurred on relatively steep slopes.

Species composition of plants six years after wildfire was most strongly correlated with incident solar radiation and soil pH. High values of these variables were associated with relatively high cover of non-native species, such as cheatgrass, prickly lettuce (*Lactuca serriola*), and Russian thistle (*Salsola tragus*). Cover of non-native species also was positively correlated with pre-burn tree canopy cover and distance to unburned patches. Cover of native perennial species was positively associated with pre-burn tree canopy cover when distance to unburned patches was relatively small, but not when distance to unburned patches was relatively great.

We observed considerable variability in probabilities of detection and occupancy within and among species of birds. For MacGillivray's Warbler, for example, the annual occupancy rates we estimated were relatively constant. Occupancy rates for Broad-tailed Hummingbird and Song Sparrow increased for three to four years (starting in 2001) and then decreased. Each species experienced its highest rate of local extinction during 2005. Our work suggests that factors other than changes in the habitat variables we measured—which included composition and structure of riparian vegetation—have contributed to differences in occupancy, colonization, and local extinction rates over space and time. Changes in quantity or quality of habitat could amplify the effects of other drivers, including weather conditions or disturbance events, on populations of riparian-obligate songbirds. Different components of riparian vegetation were good predictors of occupancy, colonization, and local extinction for each species. Typically, elevation and latitude also were strong predictors.



Annual estimates (± 1SE) of detection probability for MacGillivray's Warbler, Broad-tailed Hummingbird, and Song Sparrow in the central Great Basin (Nevada, USA).



Annual estimates (± 1SE) of occupancy for MacGillivray's Warbler, Broad-tailed Hummingbird, and Song Sparrow in the central Great Basin (Nevada, USA).

Of eight passerine species that in the central Great Basin are associated frequently with pinyon–juniper woodland, mean elevation of species' presence differed significantly among mountain ranges for all except *Spizella passerina* (Chipping Sparrow); all species except *S. breweri* (Brewer's Sparrow) occurred at highest mean elevation in the Toquima Range. Observed patterns were consistent with the elevational distribution of pinyon–juniper woodlands that provide nesting and foraging habitat for these species. Across the Great Basin, driven in part by climate change, pinyon–juniper woodland is increasing in density and expanding its distribution at lower elevations. However, breeding habitat for species dependent on mature trees may not be available in expansion woodlands for several decades, and increased tree densities may have negative effects on bird species that are dependent on shrubs within open pinyon–juniper woodlands. Responses of individual species to elevation differed from the response of assemblage-level patterns.

Areas with high fractional greenness in 2005 were most likely to occur at elevations between 2200 and 2600 m. Increases in fractional greenness between 1986 and 2005 were most likely to occur at elevations below 2000 m and on south-facing slopes. However, relationships between elevation and increasing greenness for individual mountain ranges varied considerably from the average trend. Fractional greenness values measured by Landsat suggest that the majority of pinyon–juniper woodlands have not reached their maximum potential tree cover. Expansion of pinyon–juniper at low elevations and on south-facing slopes probably reflects increasing precipitation in the 20th century, higher water use efficiency caused by increasing atmospheric CO2 in the late 20th century, and livestock grazing at the interface between shrubland and woodland.

Management Implications

Both abiotic factors and pre-burn vegetation affect distributions of plant species following fire. The probability of cheatgrass colonization and severe fire is relatively low in locations with high primary productivity and relatively abundant perennial herbaceous species, which often are associated with early or intermediate stages of woodland expansion. The probability of post-fire recolonization by native species may increase when fire boundaries are irregular and there are remnants of unburned vegetation.

Restoration of relatively productive and mesic sites might increase overall resilience of mountain sagebrush communities to wildfire by increasing competition between native perennial shrubs and herbs and pinyon and juniper trees, and between native perennial shrubs and herbs and cheatgrass. Introducing disturbance to relatively xeric sites increases the probability of cheatgrass dominance. Invasion of cheatgrass post-fire is most likely on sites that are dry, have high pre-burn canopy cover, or are relatively distant from unburned patches. Cheatgrass invasion is less likely in relatively mesic locations with little canopy cover and a well-developed native understory pre-burn. Sites closer to unburned edges are more likely than those further away to be colonized by native perennial species such as snowberry (*Symphoricarpos oreophilus*) and woolypod milkvetch (*Astragalus purshii*).

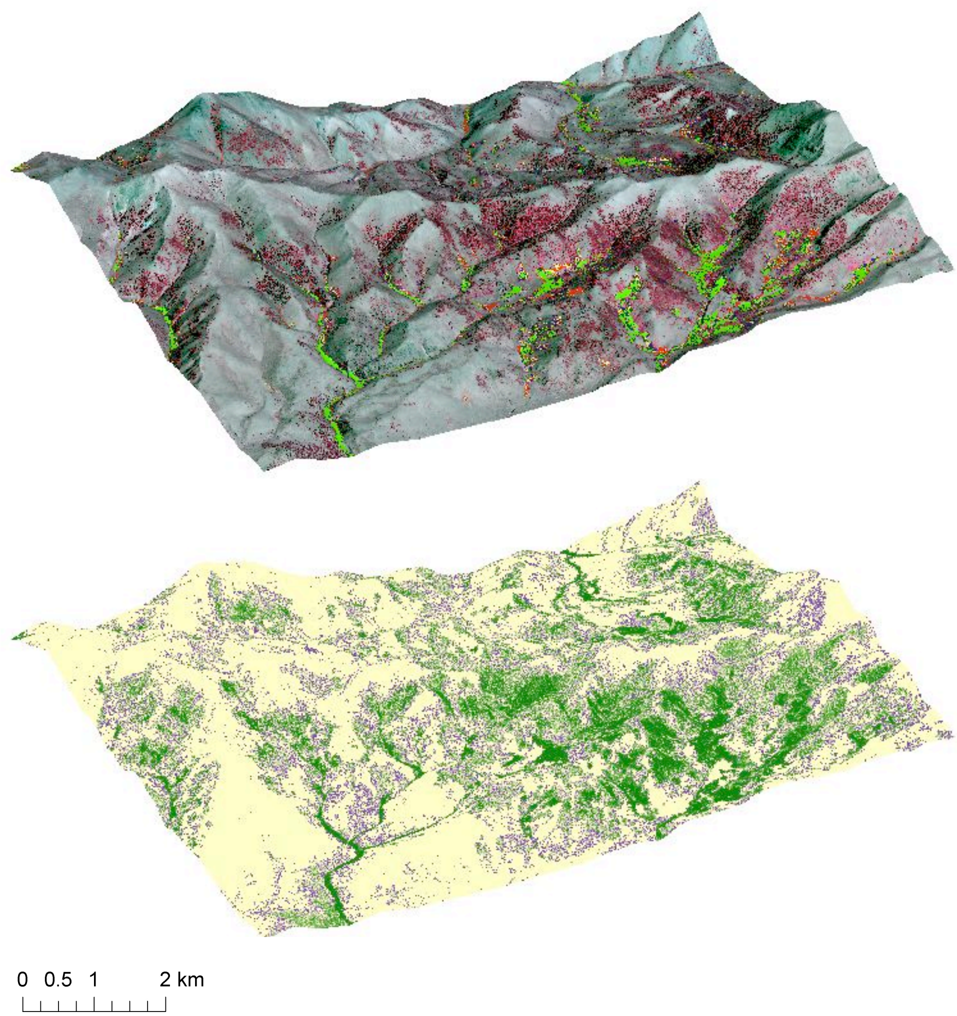
The occurrence of obligate riparian species of birds in the central Great Basin is strongly linked to multiple environmental and habitat variables, but the strength of these associations can differ by species. It cannot be assumed that annual patterns of avifaunal occupancy, colonization, extinction, or detection probability are similar among species with similar habitats. In other words, species with similar functional characteristics cannot be assumed to serve as surrogates for each other. Because species within functional groups (e.g., obligate riparian species) may have different responses to environmental and habitat variables, the effects of a given management action may vary among species. Moreover, it is unwarranted to assume that a bird species distributed widely across montane regions has similar local responses to elevation and other major environmental gradients. Habitat quality for obligate riparian species likely is enhanced by maintaining a complex vegetation structure that includes understory riparian shrubs.

Climate change may arrest current expansion of pinyon–juniper woodlands at relatively low elevations in the Great Basin, rendering human intervention to constrain the expansion less necessary. Climate change may create restoration opportunities on landscapes dominated by invasive plants if climate conditions become unsuitable for the invader. However, climate conditions may render these same areas unsuitable for native species that once occurred there, creating new challenges for restoration and management.

Bioclimatic envelope modeling can be used to identify locations where the current climate is most similar to the projected future climate of a given restoration target area in order to identify viable species for "transformative" restoration. Once potentially viable species are identified, landscape scale modeling and experimental work will be needed to evaluate species viability and establish restoration protocols. Integrated modeling, monitoring, and experimental work will be critical for effective restoration planning in the context of climate change.

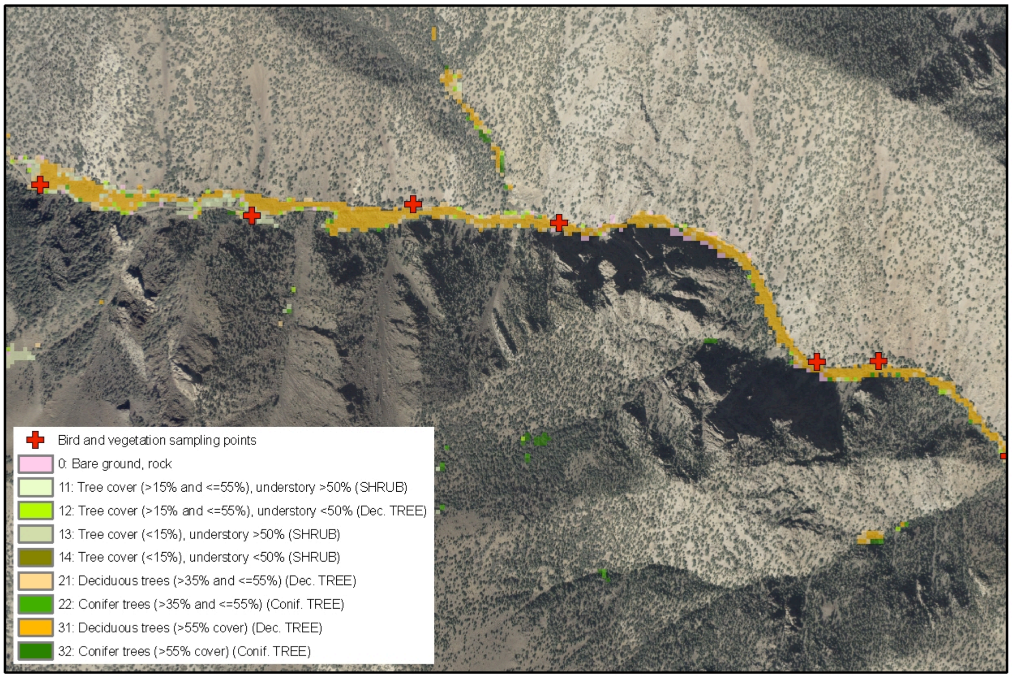
Relationship to Other Recent Findings and Ongoing Work

Relatively rapid changes in land cover across the Intermountain West suggest that efficient techniques are needed to assess and track environmental status across extensive areas. We have developed new methods to map riparian areas, other land-cover classes, and vegetation structure in the central Great Basin using high-resolution imagery and spatial models. These efforts are resulting in a database of digital information for a 15,000-km^2 pilot area in Lander, Nye, and Eureka counties, Nevada. The database includes color and color-infrared aerial photography (1-m resolution), orthorectified SPOT5 multispectral imagery (10-m resolution), and digital data products that characterize vegetation at multiple spatial scales. These data and products are easily accessed and integrated using common GIS platforms and tools.



Top image: Modeled location, derived from SPOT-5 data, of riparian vegetation (bright green, orange, and red) across 46 km^2 in the central Great Basin. Bottom image: percent cover of woodland (darker green = higher percent cover) across the same area.

These activities and outcomes build on many years of collaboration between researchers and managers affiliated with the USDA Forest Service, U.S. Geological Survey, Bureau of Land Management, University of California, Santa Barbara, Northern Arizona University, non-governmental groups, and other organizations. We continue to develop innovative techniques to model and map environmental features related to management of fauna, vegetation, and fire on public lands across the Great Basin. Because our approaches exploit new and freely available sources of information, our methods are easily transferable and repeatable. Our spatially explicit framework permits regional land-use stakeholders to integrate environmental objectives with feasible management responses.



SPOT-5-based model of vegetation along a 2-km canyon bottom in the Toiyabe Range of the central Great Basin.

Future Work Needed

With support from JFSP, we are developing a decision-support tool to assist in planning and implementing fire treatments in pinyon–juniper woodlands that will maximize maintenance of sagebrush systems, Greater Sage-grouse, and other sensitive species. Guidelines and tools for optimization of these treatments or to examine tradeoffs among management objectives in pinyon–juniper woodlands are either lacking or are difficult to apply. We will develop conceptual models that synthesize existing knowledge and present clear hypotheses about responses to fire treatments of (1) sagebrush and pinyon–juniper woodlands as functions of vegetation structure, understory composition, and topography and (2) Greater Sage-grouse and other species of sagebrush-associated birds as functions of vegetation structure and composition, topography, and connectivity of their habitats. We also will develop a spatially explicit decision-support tool based on ArcFuels (www.fs.fed.us/wwetac/arcfuels/) that optimizes fire treatments for multiple management objectives related to wildfire risk, sagebrush systems, Greater Sage-grouse, and other desired species and their habitats. Application of the decision-support tool will be evaluated with data from new prescribed burns on the Humboldt–Toiyabe National Forest.

Deliverables Crosswalk

The six deliverables identified in the proposal are listed below.

1. Expanded information from the Demonstration Watershed on community-level and watershed-level responses of vegetation to prescribed fire in pinyon-juniper woodlands.

Conference Presentation

Condon, L.A., P.J. Weisberg, and J.C. Chambers. 2007. Post-fire succession in a Great Basin pinyon-juniper woodland: importance of seed source availability and topographic heterogeneity. Joint meeting of the Ecological Society of America and Society for Ecological Restoration, San Jose, California.

Field Demonstration / Tour

2007 field tour of the JFSP Demonstration Area on ecosystem response to watershed-scale burns in Great Basin pinyon-juniper woodlands. Organized by J.C. Chambers. Included presentations by Chambers, E. Fleishman, and P. Weisberg.

M.S. Thesis

Condon, L.A. 2007. A landscape analysis of post-burn succession in a Great Basin pinyon-juniper woodland. M.S. Thesis, University of Nevada, Reno.

Posters

Board, D.I., J.C. Chambers, and J. Wright. 2007. Effects of prescribed fire in expanding pinyon-juniper woodlands on establishment of mountain sagebrush species. Society for Range Management, Reno, Nevada.

Condon, L.A., P.J. Weisberg, and J.C. Chambers. 2007. Post-fire succession in a Great Basin pinyon-juniper woodland: importance of seed source availability and topographic heterogeneity. Society for Range Management, Reno, Nevada.

Refereed Publication (in review)

Condon, L., P.J. Weisberg, and J.C. Chambers. In review. The effect of biological legacies and environment on Bromus tectorum invasion and post-fire recovery of *Artemisia tridentata*. International Journal of Wildland Fire.

2. Data on the response of birds (including Sensitive and priority species), butterflies, and their habitats to fuels management in pinyon-juniper woodlands and riparian woodlands.

We presented an organized oral session on the project at the 2007 joint meeting of the Ecological Society of America and Society for Ecological Restoration. Associated manuscripts were published in a special section of *Restoration Ecology* that was published in September 2009.

Data on butterflies in treated and control sites in the Demonstration Watershed (Underdown Canyon, Shoshone Mountains) and the canyon that served as the control for the watershed (Riley Canyon) will be archived with other project data (see Deliverable 6). Observations suggested that butterflies were moving relatively freely among treated and control areas, confounding our ability to infer treatment effects. Nevertheless, data on species composition of plants that were collected for related projects will allow us to project which species of butterflies theoretically could have colonized the treated sites, and to match those projections with field records. The latter analysis is in progress.

Invited Papers / Presentations

Bradley, B. 2007. Predicting future trajectories of plant invasion with climate change in the western United States. Presentation in the organized oral session Alternative futures for Great Basin Ecosystems. Joint meeting of the Ecological Society of America and Society for Ecological Restoration, San Jose, California.

Fleishman, E. and D. Dobkin. Predictive modeling of the distribution and habitat of birds in managed landscapes. USGS Forest and Rangeland Ecosystem Science Center, Snake River Field Station, Boise, Idaho.

Refereed Publications

Dickson, B.G., E. Fleishman, D.S. Dobkin, and S.R. Hurteau. 2009. Relationship between avifaunal occupancy and riparian vegetation in the central Great Basin (Nevada, U.S.A.). Restoration Ecology 17:722–730.

Dobkin, D.S., E. Fleishman, J. Thomson, and R. Mac Nally. 2007. Avian response to changes in structure and composition of riparian and upland land cover in the Great Basin. Presentation in the organized oral session Alternative futures for Great Basin Ecosystems. Joint meeting of the Ecological Society of America and Society for Ecological Restoration, San Jose, California.

Fleishman, E. and D.S. Dobkin. 2007. Response of avian species richness to elevation in the central Great Basin. Great Basin Birds 9:8–20.

Fleishman, E. and D.S. Dobkin. 2009. Current and potential future elevational distributions of birds associated with pinyon–juniper woodlands in the central Great Basin, U.S.A. Restoration Ecology 17:731–739.

Fleishman, E. and R. Mac Nally. 2006. Patterns of spatial autocorrelation of assemblages of birds, floristics, physiognomy, and primary productivity in the central Great Basin, USA. Diversity and Distributions 12:236–243.

3. Recommendations for monitoring the response of birds, butterflies, and their habitats to natural and anthropogenic environmental change.

We examined issues related to monitoring and evaluation in a broad sense as well as in the more specific context of fire management.

Conference Presentation

Fleishman, E., J.R. Thomson, and R. Mac Nally. 2005. Surrogate-based approaches for predicting species richness of multiple taxonomic groups. Society for Conservation Biology, Brasilia, Brazil.

Invited Paper / Presentation

Fay, J.P., E. Fleishman, D.S. Dobin, and J.C. Chambers. 2007. Linking spatial data and predictive models to forecast alternative options and futures in managed landscapes. Presentation in the organized oral session Alternative futures for Great Basin Ecosystems. Joint meeting of the Ecological Society of America and Society for Ecological Restoration, San Jose, California.

Nonrefereed Publication

Saab, V., L. Bate, J. Lehmkuhl, B.G. Dickson, S. Story, S. Jentsch, and W.M. Block. 2006. Changes in downed woody material and forest structure after prescribed fire in ponderosa pine forests. Pages 477–487 in P.L. Andrews and B.W. Butler, compilers. Fuels management—how to measure success. Conference proceedings, Portland, Oregon, 28–30 March, 2006. RMRS-P-41. USDA, Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado.

Refereed Publications

Buckland, S.T., R.E. Russell, B.G. Dickson, V. Saab, and W. Block. 2009. Analyzing designed experiments in distance sampling. Journal of Agricultural, Biological, and Environmental Statistics. DOI: 10.1198/jabes.2009.08030.

Chambers, J.C. and M.J. Wisdom. 2009. Priority research and management issues for the imperiled Great Basin of the western United States. Restoration Ecology 17:707–714.

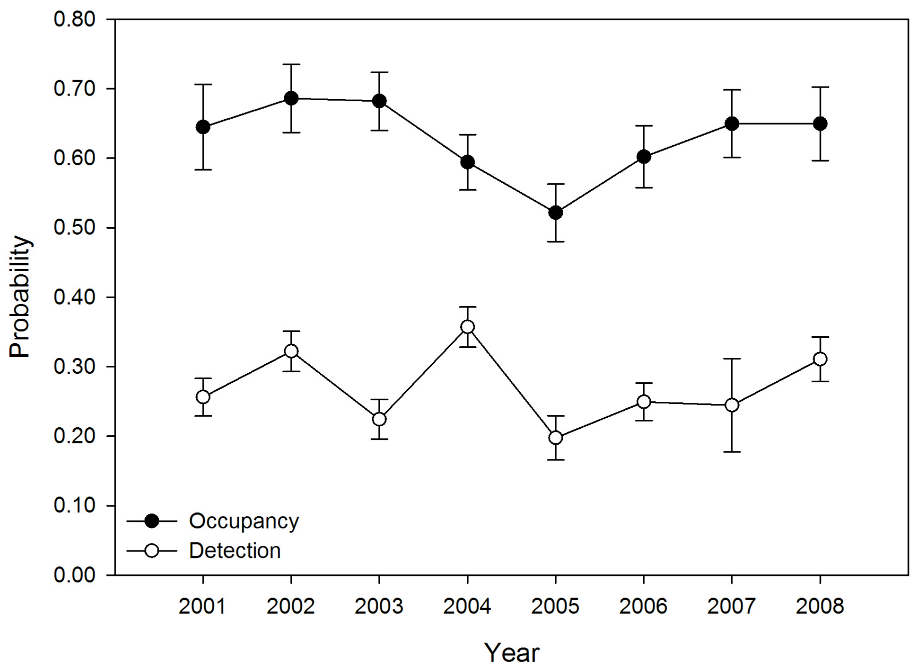
Fleishman, E. and D.D. Murphy. 2009. A realistic assessment of the indicator potential of butterflies and other charismatic taxonomic groups. Conservation Biology 23:1109–1116.

Mac Nally, R., E. Fleishman, J.R. Thomson, and D.S. Dobkin. 2008. Use of guilds for modeling avian responses to vegetation in the Intermountain West (U.S.A.). Global Ecology and Biogeography 17:758–769.

Thomson, J.R., E. Fleishman, R. Mac Nally, and D.S. Dobkin. 2007. Comparison of predictor sets for species richness and the number of rare species of butterflies and birds. Journal of Biogeography 34:90–101.

4. Information on the comparative response of birds to fuels treatments in pinyon-juniper woodlands and ponderosa pine forests (evaluation of predictable patterns of response across geographic regions and forest types).

We previously derived models of occupancy dynamics for 20 species of birds detected in the central Great Basin and on the Mogollon Plateau of northern Arizona during the breeding seasons of 2001–2006. We currently are deriving new models of occupancy dynamics for an additional six bird species detected in both regions during the breeding seasons of 2001–2008; a manuscript will follow. Many of these species occupy fire-affected locations in pinyon-juniper woodlands and ponderosa pine-dominated forests. We are deriving new information on the habitat of these species to describe quantitatively vegetation structure and composition in pre- and post-fire landscapes. For example, in response to pre-fire vegetation structure and topography, we have modeled detection probability and occupancy parameters for American Robin (*Turdus migratorius*) in the central Great Basin over an 8-year period.



Annual estimates (± 1SE) of multi-season occupancy and detection probability for American Robin in the central Great Basin (Nevada, USA).

This species is known to respond positively to prescribed fire and wildfire in woodland and forest. Our multi-season models provide baseline information that will permit us to use a priori hypotheses and an experimental approach to examine the post-fire magnitude and direction of response (e.g., proportion of area occupied) of this species to planned fire management activities.

Invited Paper / Presentation

Dickson, B.G., Y. Xu, H.M. Hampton, and T.D. Sisk. 2007. Relationship between initial vegetation structure and alternative management scenarios in southwestern woodlands and forests. Presentation in the organized oral session Alternative futures for Great Basin Ecosystems. Joint meeting of the Ecological Society of America and Society for Ecological Restoration, San Jose, California.

Dickson, B.G., Y. Xu., S.E. Sesnie, and J.M. Rundall. 2008. Mapping riparian land cover, corridors, and habitat for wildlife. Briefing for U.S Bureau of Land Management, Reno, Nevada.

Refereed Publication

Dickson, B.G., B.R. Noon, C.H. Flather, S. Jentsch, and W.M. Block. 2009. Quantifying the multi-scale response of avifauna to prescribed fire experiments in the Southwest. Ecological Applications 19:608–621.

5. Data on decadal changes in birds and woodlands in the central Great Basin

Ultimately, differences in sampling methods between the 1980s and 2000s did not allow us to make direct, quantitative inferences about decadal changes in distributions of birds in the central Great Basin. However, we successfully examined decadal changes in woodlands. Existing data from the 1980s, in conjunction with improved understanding of influences on occupancy of birds, may allow us to estimate past patterns of avian distribution in the region.

Refereed Publication

Bradley, B. and E. Fleishman. 2008. Relationships between expanding pinyon-juniper cover and topography in the central Great Basin, Nevada. Journal of Biogeography 35:951–964.

6. Electronic databases and associated metadata for use by land managers

Databases have been compiled. We are in the process of archiving project data with the Rocky Mountain Research Station. We are continuing to discuss with land managers the formats in which data and metadata are of greatest value.

7. Additional Deliverables

Book Chapter

Noon, B.R., K. McKelvey, and B.G. Dickson. 2008. Multispecies conservation planning on federal lands. Pages 51-84 in J.J. Millspaugh and F.R. Thompson, III, editors. Models for planning wildlife conservation in large landscapes. Elsevier, London.

Final Report

This document

Invited Papers / Presentations

Fleishman, E. 2005. Predictive approaches to managing public and private landscapes. Colorado State University, Fort Collins.

Fleishman, E. 2005. Surrogate-based approaches for predicting species richness of multiple taxonomic groups. Bowling Green State University, Bowling Green, Ohio.

Fleishman, E. 2005. Tradeoffs among alternative predictors of species distributions. Predictive modelling of species distributions: new tools for the 21st century. Universidad Internacional de Andalucia, Spain.

Fleishman, E. 2006. Conservation science in a polarized political world. Association of Environmental Professionals, Santa Barbara, California.

Fleishman, E. 2006. Predictive approaches to managing public and private landscapes. University of Maine, Orono.

Fleishman, E. 2007. Integration of science and management on public and private landscapes. Northern Arizona University.

Wisdom, M. and J.C. Chambers. 2007. Effective management for sagebrush ecosystems based on current trajectories. Presentation in the organized oral session Alternative futures for Great Basin Ecosystems. Joint meeting of the Ecological Society of America and Society for Ecological Restoration, San Jose, California.

Fleishman, E. 2009. Application of conservation science to management of public and private lands in the western United States. Carleton University, Ottawa, Ontario, Canada.

Nonrefereed Publications

Bradley, B.A. and E. Fleishman. 2008. Can remote sensing of land cover improve species distribution modelling? Journal of Biogeography 35:1158–1159.

Fleishman, E., J.C. Chambers, and M.J. Wisdom. 2009. Introduction to the special section on alternative futures for Great Basin ecosystems. Restoration Ecology 17:704–706.

Ph.D. Dissertation

Dickson, B.G. 2006. Multi-scale response of avian communities to prescribed fire: implications for fuels management and restoration treatments in southwestern ponderosa pine forests. Dissertation, Colorado State University, Fort Collins, Colorado.

Refereed Publications

Bradley, B.A. 2009. Regional analysis of impacts of climate change on cheatgrass invasion shows potential risk and opportunity. Global Change Biology 15:196–208.

Bradley, B.A. and D.S. Wilcove. 2009. When invasive plants disappear: transformative restoration possibilities in the western United States resulting from climate change. Restoration Ecology 17:715–721.

Bradley, B.A., D.S. Wilcove, and M. Oppenheimer. 2009. Climate change and plant invasion: restoration opportunities ahead? Global Change Biology 15:1511–1521.

Breece, C.R., T.E. Kolb, B.G. Dickson, J.D. McMillin, and K.M. Clancy. 2008. Prescribed fire effects on bark beetle activity and tree mortality in southwestern ponderosa pine forests. Forest Ecology and Management 255:119–128.

Dickson, B.G., J.W. Prather, Y. Xu, H.M. Hampton, E.N. Aumack, and T. D. Sisk. 2006. Mapping the probability of large fire occurrence in northern Arizona. Landscape Ecology 21:747–761.

Fleishman, E. 2008. Great Basin rare and vulnerable species. Pages 61–64 in J.C. Chambers, N. Devoe, and A. Evenden, editors. Collaborative Management and Research in the Great Basin—Examining the Issues and Developing a Framework for Action. General Technical Report RMRS-GTR-204, USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado.

Jentsch, S., R.W. Mannan, B.G. Dickson, and W.M. Block. 2008. Associations among breeding birds and Gambel oak in southwestern ponderosa pine forests. Journal of Wildlife Management 72:994–1000.

Pellet, J., E. Fleishman, D.S. Dobkin, A. Gander, and D.D. Murphy. 2007. An empirical evaluation of the area and isolation paradigm of metapopulation dynamics. Biological Conservation 136:483–495.

Sisk, T.D., J.W. Prather, H.M. Hampton, E.N. Aumack, Y. Xu, and B.G. Dickson. 2006. Participatory landscape analysis to guide restoration of ponderosa pine ecosystems in the American Southwest. Landscape and Urban Planning 78:300–310.

Xu, Y., B.G. Dickson, H.M. Hampton, T.D. Sisk, J. Palumbo, and J.W. Prather. 2009. Effects of mismatches of scale and location between predictor and response variables on forest structure mapping. Photogrammetric Engineering and Remote Sensing 75:313–322.

Xu, Y., J.W. Prather, H.M. Hampton, E.N. Aumack, B.G. Dickson, and T.D. Sisk. 2006. Advanced exploratory data analysis for mapping regional canopy cover. Photogrammetric Engineering and Remote Sensing 72:31–38.

Wisdom, M.J. and J.C. Chambers. A landscape approach for ecologically based management of Great Basin shrublands. Restoration Ecology 17:740–749.