Colorado Sagebrush:
A Conservation Assessment and Strategy

BIO-Logic Environmental
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with Colorado Division of Wildlife

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Cover Photograph

Big sagebrush shrubland during autumn in the Gunnison Basin, Colorado (Reeder)

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ABSTRACT

Boyle, S. A.[1] and D. R. Reeder.[2] 2005. Colorado sagebrush: a conservation assessment and strategy. Grand Junction: Colorado Division of Wildlife.[3]

The Colorado Division of Wildlife (CDOW) is concerned with habitat needs and management of declining sagebrush-dependent wildlife. To address these concerns, we developed an assessment of sagebrush-dominated areas in central and western Colorado covering 2.2 million hectares, and a management strategy for declining (or potentially declining) sagebrush-dependent wildlife species not addressed by existing conservation plans. We used geographic information system (GIS) analysis of Southwest Regional GAP Analysis land cover data to estimate current and historic sagebrush distribution, analyze sagebrush patch size, and model the distribution and severity of threats to sagebrush from pinyon-juniper encroachment, weed encroachment, energy development, and residential development. We identified 11 wildlife species of concern (black-throated sparrow, Brewer's sparrow, green-tailed towhee, kit fox, lark sparrow, Merriam's shrew, northern harrier, sage sparrow, sage thrasher, sagebrush vole, and vesper sparrow) and used GIS to map their habitat and range and to assess threats to their sagebrush habitat. To provide a management framework we designated 3 species groups based on similarities in habitat requirements (in order of conservation priority: sagebrush obligates, arid shrubland/grassland species, and species of montane shrublands, woodlands, or edges). We mapped priority sagebrush areas for management based on sagebrush patch size, species of concern richness, level of modeled threats, and species group conservation priority. To guide CDOW management efforts for the species of concern, we provide goals, objectives, and strategies for protecting and enhancing sagebrush habitat, monitoring wildlife species, and conducting research.

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EXECUTIVE SUMMARY

The Colorado Division of Wildlife (CDOW) is concerned with habitat needs and management of declining sagebrush-dependent wildlife. CDOW funded the preparation of this document to provide 1) a regional assessment of current and historic Colorado sagebrush habitat, and 2) a multi-species regional conservation planning approach for wildlife species of concern.

Overview and Methodology

Chapters 1 through 4 constitute the regional sagebrush assessment. The assessment area encompasses the range of tall woody sagebrush (*Artemisia* spp.) in Colorado, consisting of the state's 39 contiguous western counties. In this assessment, we describe sagebrush ecosystems and use geographic information system (GIS) analyses of publicly available spatial datasets to map, and quantify current and historic sagebrush coverage in the assessment area, analyze patch size distribution, and model risks to sagebrush from four widespread threats: pinyon-juniper encroachment, invasive herbaceous plant encroachment, residential development, and energy development.

In Chapters 5 and 6 and the Appendix, we identify and describe the species of concern, map their ranges and habitat distributions, and estimate risks to their sagebrush habitats in the assessment area. Species of concern are declining or potentially declining sagebrush-dependent vertebrates without existing conservation, recovery, or management plans in the region. Species of concern are also limited to vertebrates whose large ranges and macro-habitat requirements are suited to regional-scale assessment, planning, and management efforts. Our species of concern selection process was to 1) identify species associated with sagebrush in the assessment area, 2) eliminate those species for which conservation planning or management exists or is underway, 3) determine which remaining species are experiencing population decline or potential decline, and 4) select from the remaining species those whose sagebrush habitat can be evaluated meaningfully on a regional scale. The 11 species of concern addressed in this document are black-throated sparrow, Brewer's sparrow, green-tailed towhee, kit fox, lark sparrow, Merriam's shrew, northern harrier, sage sparrow, sage thrasher, sagebrush vole, and vesper sparrow.

Chapter 7 provides a management framework for species of concern by designating 3 species groups based on similarities in habitat requirements. In order of conservation priority, the species groups are: Group 1 - sagebrush obligates (Brewer's sparrow, sage sparrow, sage thrasher, and sagebrush vole); Group 2 - arid shrubland/grassland species (black-throated sparrow, kit fox, northern harrier, and vesper sparrow); and Group 3 - montane shrubland, woodland, or edge species (green-tailed towhee, lark sparrow, and Merriam's shrew).

Chapter 8 identifies and uses GIS analyses to map priority sagebrush areas for management based on sagebrush patch size, species of concern richness, level of modeled threats, and species group conservation priority. To guide CDOW management efforts for the species of concern, Chapter 8 provides goals, objectives, and strategies for protecting and enhancing sagebrush habitat, monitoring wildlife species, and conducting research. The conservation strategies presented in Chapter 8 have not been formally approved or adopted by CDOW, and timelines for completion have yet to be developed. Implementation of conservation strategies will be contingent upon adequate CDOW staffing and funding as well as agency priorities.

Assessment Key Findings

- Sagebrush-dominated shrublands cover 2.2 million hectares (ha), or 14 percent of the assessment area, and are the assessment area's second most abundant habitat type, behind upland forests. Just over half of all sagebrush-dominated areas are concentrated in northwestern Colorado, North Park-Middle Park, and the Gunnison Basin. These three areas should be considered cornerstones of sagebrush conservation in Colorado. However, widely scattered smaller concentrations account for nearly half of the sagebrush habitat in the assessment area and provide important landscape linkages. These patches are important for their species-habitat functions as well as ecosystem-level functions.
- We make the provisional, conservative estimate that approximately 13 percent of sagebrush shrublands in the assessment area has been lost to land use conversions (primarily agriculture) since pre-Euro-American settlement times (the actual percentage lost is likely greater).
- About 44 percent of the sagebrush in the assessment area occurs on private lands, 41 percent on U.S. Bureau of Land Management (BLM) lands, and 7 percent on U.S. Forest Service (USFS) lands. Private lands and BLM lands account almost equally together for 85 percent of sagebrush-dominated lands in the assessment area. Sagebrush conservation efforts should emphasize and involve these entities.
- The risk to sagebrush of pinyon-juniper encroachment is predicted to be high on nearly 400,000 ha (18 percent of sagebrush in the assessment area), and moderate or low on nearly 580,000 ha (27 percent), with moderate to high risk concentrated in the western counties of the assessment area but also in the San Luis Valley and Gunnison Basin.
- The risk to sagebrush of encroachment by invasive herbaceous plants is predicted to be high on about 510,000 ha (23 percent of sagebrush in the assessment area) and moderate on about 401,000 ha (18 percent). Nearly 58 percent of sagebrush in the assessment area is predicted to be at low risk, and less than 1 percent is predicted at no risk. Sagebrush areas at moderate or high risk are most concentrated in the western counties and elsewhere at lower elevations near human development.
- The predicted risk to sagebrush of energy development is predominantly moderate (1.27 million ha, 58 percent of sagebrush in the assessment area), with 165,000 ha, (7 percent) predicted at high risk. Substantial areas of sagebrush at moderate or high risk occur in the northwest counties, Paradox Basin, San Juan Basin, and other localized areas.
- The predicted risk to sagebrush of residential development is none on 1.2 million ha (56 percent of the assessment area, all on public lands), and moderate or high on about 85,000 ha (4 percent of sagebrush in the assessment area). Sagebrush areas at moderate or high risk are concentrated around cities and towns with increasing human populations and development. An important limitation is that a separate model predicting residential growth in 2020, on which our sagebrush threat model was based, underestimates development threat associated with some Colorado resort communities.
- Almost 1.8 million ha (81 percent) of sagebrush is predicted at moderate or high risk of all threats combined in the assessment area, and an insignificant amount is predicted at no risk. Sagebrush concentrations at high combined risk occur in the northwest counties, the Colorado River watershed, and southwestern counties bordering Utah and New Mexico with other areas at high risk scattered in the assessment area. Part of the Gunnison Basin forms the largest sagebrush area predicted to have low or no combined risk. An important limitation is that estimates of habitat at risk were generated from threats models whose performance has not been evaluated in the field.

- At least 73 sagebrush-associated vertebrates occur in the assessment area, 30 of which are known or believed to have stable populations. Of the 43 declining or potentially declining vertebrates, 14 are addressed by other conservation planning efforts, 11 are only weakly associated with sagebrush in the assessment area, and 7 are better suited to local-scale evaluation and management efforts. The remaining 11 species are the focus of our assessment.
- Significant knowledge gaps exist concerning population trends, biology, and ecology of all 11 species of concern in the assessment area. The majority of knowledge for each species of concern is derived from studies made outside Colorado, and in some cases, non-sagebrush habitats. Our species of concern selections were based on limited knowledge of habitat preferences and requirements, ranges, and population trends for Colorado vertebrates, underscoring the need for research and use of adaptive management principles in the conservation of these species.
- Among the widespread threats we modeled, risk of encroachment by invasive herbaceous plants is probably the most extensive sagebrush habitat threat across all species of concern (for example, with sagebrush habitat at high risk ranging from about 70 percent for kit fox to about 23 percent for Brewer's sparrow and green-tailed towhee). Threat of residential development in sagebrush habitats for species of concern is probably the least extensive sagebrush habitat threat overall, with less than 5 percent of sagebrush habitat at high risk and over 90 percent at none or low risk for all species. Risk of energy development is broadly moderate for sagebrush habitats of all species of concern, ranging from 58 to 78 percent of sagebrush habitat at moderate risk. For species of concern except kit fox, northern harrier, sage sparrow, and black-throated sparrow, risk of pinyon-juniper encroachment in more than half of their sagebrush habitat is none to low.
- Modeling of combined threats predicted some degree of risk in virtually all sagebrush habitat for each species of concern, underscoring the need for conservation action. Sagebrush habitats for the species of concern constitute an average of over half their total available habitats in the assessment area. The most serious long-term consequence of the modeled threats to all species of concern in the assessment area, especially to the sagebrush obligates, is habitat loss. Habitat fragmentation and habitat degradation have mixed effects on the species of concern. Limitations: Our threats models estimate risks to species' sagebrush habitats but do not account for species' responses to threats. Our threats models provide a generalized and fairly coarse estimate of the predicted risk, and each would benefit from refinement as funding and better datasets become available. Other widespread threats exist, but were not modeled; grazing and range treatments may cause widespread direct and indirect threats to sagebrush habitats for species of concern, but region-wide GIS coverages of range condition and range treatments are not yet available for modeling these threats across the assessment area. Finally, to gain a more complete understanding of threats and conservation needs of the species of concern in the assessment area, models for assessing risk of widespread threats to non-sagebrush habitat components are needed.
- Areas of maximum and near-maximum species richness in sagebrush habitat vary substantially among species groups. High species richness is concentrated for Group 1 (sagebrush obligates) in the northern counties, for Group 2 (arid shrubland/grassland species) in the southwestern counties, and for Group 3 (montane shrubland, woodland, or edge species) broadly throughout the assessment area.

Conservation Plan Summary

- This Conservation Plan (Chapter 8) is intended to provide resource managers with a conceptual and spatial framework for regional sagebrush conservation planning and management for the 11 species of concern. The overarching goal of the plan is to avert further decline of the species of concern within the assessment area. In the Conservation Plan, we 1) review the species groups, 2) identify and prioritize management emphasis areas for each species group, and 3) develop goals, objectives, and strategies for conservation of the species of concern with an integrated adaptive management approach. At the time of the publication of this document, the strategies presented in the Conservation Plan were not yet approved by the CDOW. In a separate process outside of this plan, the CDOW will analyze and prioritize recommended strategies, identify those to be considered during planning and budgeting processes, and develop timelines for their completion.

- For each species group we identified geographic areas of sagebrush habitat to receive low, moderate, or high management emphasis (Figures 8-2, 8-3, and 8-4). To identify these sagebrush habitat areas and assign management emphases, we used GIS to analyze data sets developed in previous chapters (species richness, patch size analysis, and risks to sagebrush habitat from combined threats) against criteria presented in Figure 8-1. Generally, large patches of sagebrush habitat (>10,000 ha) with high species richness and high or moderate risk of combined threats were assigned high management emphasis, and smaller patches of sagebrush (<100 ha) with low species richness and low or no risk of combined threats were assigned low management emphasis. Moderate management emphasis was assigned to large patches with high species richness and low or no risk of combined threats, and to a range of patches (100 to 10,000 ha) with high or moderate risk of combined threats.
- We propose further prioritization of management emphasis areas by species group, with first priority given to Group 1, second priority given to Group 2, and third priority given to Group 3 (Figure 8-5). First priority for Group 1 species is due to their nearly complete reliance on sagebrush habitats. The protection of sagebrush habitat of suitable amounts and quality is the single biggest conservation issue for these species. Second priority for Group 2 is due to their partial dependence on sagebrush, and additional requirements for arid low shrublands that are susceptible to various land use threats including invasive herbaceous plants and residential development. Third priority for Group 3 species reflects their relatively low dependence on sagebrush or use of edge habitats, and common use of either more mesic mountain shrublands or pinyon-juniper shrublands/open woodlands. These other habitat types tend to be less ecologically brittle than the majority of Group 1 and Group 2 species habitats, and are generally less at risk from the combined modeled threats.
- The Conservation Plan is organized around three goals: 1) Maintain sagebrush habitat of adequate quantity, landscape arrangement, and quality for species of concern in the assessment area; 2) Maintain viable populations and avert further decline of species of concern in the assessment area; and 3) Conduct research to address knowledge gaps in sagebrush-dependent species of concern biology, ecology, and responses to habitat change.
- Under each goal, we establish a series of objectives, or specific benchmarks that would indicate progress toward or facilitate measurement of progress toward completion of a goal. Under each objective, we offer strategies (specific tasks, actions, or projects) to accomplish the objectives. Goal 1 objectives focus on minimizing sagebrush habitat loss and fragmentation, and reducing risks to sagebrush habitat from widespread threats identified in the assessment. Goal 2 objectives focus on further assessment and monitoring of individual species populations. Goal 3 objectives concern research needs for the conservation of sagebrush-dependent species of concern, including research that should be conducted prior to or during population monitoring, and research that may be suggested by the results of monitoring.

TABLE OF CONTENTS

List of Tables

List of Figures

ACRONYMS AND ABBREVIATIONS

%	percent
<	less than
>	greater than
≤	less than or equal to
≥	greater than or equal to
±	plus or minus
AZ	Arizona
BBA	Colorado Breeding Bird Atlas
BBS	North American Breeding Bird Survey
BIA	U.S. Bureau of Indian Affairs
BLM	U.S. Department of the Interior Bureau of Land Management
BLSP	black-throated sparrow
BRSP	Brewer's sparrow
ºC	degrees Celsius
CA	California
CDOW	Colorado Department of Natural Resources Division of Wildlife
CGS	Colorado Geological Survey
cm	centimeter
CNHP	Colorado Natural Heritage Program
CO	Colorado
COGCC	Colorado Oil and Gas Conservation Commission
CT	Connecticut
DDT	dichlorodiphenyltrichloroethane
DEM	Digital Elevation Model
DOD	U.S. Department of Defense
DOI	U.S. Department of the Interior
E	listed as endangered under the Endangered Species Act
ESA	Endangered Species Act
et al.	abbreviation for the Latin phrase meaning "and others"
ºF	degrees Fahrenheit
ft	foot
ft2	square feet
g	gram
G1, G2, G3, G4, G5	range of Natural Heritage rankings, where G1 indicates "globally critically imperiled" and G5 indicates "globally secure"
GIS	geographic information system
GTTO	green-tailed towhee
GSRSC	Gunnison Sage-grouse Regional Steering Committee
ha	hectare
IA	Iowa
ID	Idaho
IL	Illinois
in	inch
IN	Indiana
KIFO	kit fox
km	kilometer
km^2	square kilometer
LASP	lark sparrow

m	meter
MA	Massachusetts
MESH	Merriam's shrew
mi	mile
MO	Missouri
n	size of (or number of items in) a sample
NH	New Hampshire
NJ	New Jersey
NOHA	northern harrier
NRCS	Natural Resources Conservation Service (formerly SCS)
NY	New York
OR	Oregon
P	statistical probability (see Glossary for more information)
PIF	Partners in Flight
RA	relative abundance
RI	Rhode Island
S1, S2, S3, S4, S5	range of Natural Heritage rankings, where S1 indicates populations are "critically imperiled in the state" and S5 indicates populations are "secure in the state"
SASP	sage sparrow
SATH	sage thrasher
SAVO	sagebrush vole
SC	species of concern
SCS	U.S. Department of Agriculture Soil Conservation Service
SERGoM	Spatially Explicit Regional Growth Model
sp.	species (singular)
spp.	species (plural)
ssp.	subspecies
subsp.	subspecies
SW ReGAP	Southwest Regional GAP Project
T	listed as threatened under the Endangered Species Act
TN	Tennessee
TNC	The Nature Conservancy
USFS	U.S. Department of Agriculture Forest Service or U.S. Forest Service
USGS	U.S. Department of the Interior Geological Survey
USFWS	U.S. Department of the Interior Fish & Wildlife Service
UT	Utah
var.	variety
VESP	vesper sparrow
VT	Vermont
WA	Washington
WY	Wyoming

UNIT CONVERSION TABLES

Metric to U.S. Standard			U.S. Standard to Metric		
1 hectare (ha)	=	2.47 acres	1 acre	=	0.405 ha
1 kilometer (km)	=	0.621 mile (mi)	1 mi	=	1.61 km
1 meter (m)	=	3.28 feet (ft)	1 ft	=	0.305 m
1 centimeter (cm)	=	0.394 inch (in)	1 in	=	2.54 cm
1 gram (g)	=	0.04 ounce (oz)	1 oz	=	28.3 g
Celsius (ºC)	=	(Fahrenheit [ºF] – 32) * 5/9	ºF	=	(ºC * 9/5) + 32
Metric Conversions			**U.S. Standard Conversions**		
1 km^2	=	100 ha	1 acre	=	43,560 ft^2
1 km	=	1,000 m	1 mi	=	5,280 ft
1 m	=	100 cm	1 ft	=	12 in
1 kg	=	1,000 g	1 pound (lb)	=	16 oz

GLOSSARY

Abundance. The number of organisms in a population, combining “intensity” (density within inhabited areas) and “prevalence” (number and size of inhabited areas).[2]

Adaptive management. A management approach that periodically evaluates techniques in relation to goals, and responds with appropriate changes in management methods.

Argillic. A compact clay or claylike soil layer.

Biodiversity. The variety of life forms, especially number of species, but including number of ecosystem types and genetic variation within species.[1]

Carr. A wetland meadow, especially with willows.

Connectivity. A measure of how connected or spatially continuous a corridor, network, or matrix is. The fewer gaps, the higher the connectivity. Related to the structural connectivity concept; functional or behavioral connectivity refers to how connected an area is for a process, such as an animal moving through different types of landscape elements.[1]

Conspecific. Of or belonging to the same species.

Corridor. A strip of land differing from adjacent land on both sides—functioning as a conduit, barrier, or habitat.[1]

Distribution. The spatial range of a species, usually on a geographic but sometimes on a smaller scale; also the arrangement or spatial pattern of a species over its habitat.[2] An expression of presence or absence.

Disturbance. An event that removes organisms and opens up space which can be colonized by individuals of the same or different species.[2] An event that significantly alters the pattern of variation in the structure or function of a system (usually refers to a natural phenomenon).[1]

Diversity. See “Species Diversity”

Demography. The statistical science dealing with the distribution, density, and vital statistics of a population.

Endemic. Restricted to a particular locality; native to a particular region.

Forb. A non-grasslike herbaceous plant.

Fragmentation. The breaking up of a habitat, ecosystem, or land-use type into smaller pieces—one of several spatial processes in land transformation.[1] Reduction in average size of patches of a given natural habitat, increase in the distance between patches, decrease in the ratio or

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[1] (Forman 1995)
[2] (Begon et al. 1990)

interior to edge area within patches, and increase (at least initially) in the landscape diversity of an area through the creation of new patches of disturbances that may undergo succession.[4] In fragmented habitats, suitable area remains only as a remnant surrounded by unusable environment. Populations of obligate species decline because areas of suitable habitat decrease or because of lower reproduction or higher mortality in remaining habitats.[3] Species differ in their responses and sensitivity to habitat fragmentation. Habitat specialists generally occupy only a small portion of patch types in an area, and their range of patch occupancy will be further restricted to patches above a certain size if they specialize in patch interiors rather than edges. Larger organisms requiring bigger home ranges and having lower individual fecundity, and those in higher trophic positions, will be less abundant per unit area in suitable habitat patches. For species with short dispersal distances or low recruitment rates, colonization of patches created by local extinctions or habitat changes will be low. "Habitat specialization and low population densities further reduce patch colonization rates. All of these consequences—low abundance in occupied patches, low frequency of patch occupancy, and low rates of patch colonization—increase the probability that a population residing in a patch will suffer local extinction. With increasing fragmentation of a landscape, stochastic effects become more important and may enhance the likelihood of local extinctions further; with a reduction in the number of suitable patches in a region, regional extinction thus also becomes more probable."[4]

GIS (geographic information system). A computer application used to store, view, and analyze spatial or geographic data sets.

Habitat. The ecosystem where a species occurs, or the conditions within that ecosystem.[1]

Hemiparasite. A plant such as mistletoe, which obtains some nourishment from its host but contains chlorophyll and photosynthesis nutrients.

Herbaceous. With the characteristics of herbs; not woody. Includes grass-like plants and forbs.

Herptiles. Collective term for reptiles and amphibians.

Heterogeneity. The uneven, non-random distribution of characteristics or objects.

Homogeneity. The even, non-random distribution of characteristics or objects.

Insolation. The radiation from the sun received by a surface, especially the earth's surface.

Landscape. A mosaic where a cluster of local ecosystems is repeated in similar form over a kilometers-wide area, generally with recognizable boundaries.[1]

Matrix. The background ecosystem or land-cover type in a mosaic.[1]

Mosaic. A pattern of patches, corridors, and matrix, each composed of smaller, similar aggregated objects.[1]

Multivariate analysis. A technique of statistical analysis that considers multiple variables simultaneously.

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[3] (Knick and Rotenberry 1995)

Neotropical migratory bird. Neotropical migratory birds are Western Hemisphere species in that breed north of the Tropic of Cancer and winter south of the Tropic of Cancer.

P. A statistical term meaning "probability." P is <0.05 is an indication of statistical significance of a test result (e.g., there is less than a 5 percent probability that a measured change was due to chance alone).

Passerine. A bird belonging to the order Passeriformes, the largest order of birds. Sometimes known as perching birds or, less accurately, as songbirds.

Patch. A relatively homogenous nonlinear area that differs from its surroundings (the internal micro-heterogeneity present is repeated in similar form throughout the area of a patch).[1] Corridors are linear patches.[2] The existence of patchiness offers organisms the opportunity to use patch structure in a non-random way. Non-random patterns of patch use are likely related to patch microclimate, predation pressures, and food availability or foraging efficiency.[4] There are 5 main causes or origins of vegetative patches:[1]

1. A disturbance patch (a disturbed area with different characteristics than its surroundings—for instance, patches of disturbed soil from burrowing rodents),
2. A remnant patch (appears when an area escapes disturbance),
3. An environmental patch (caused by patchiness of the environment, such as rock or soil type),
4. A regenerated patch (resembles the remnant, but has re-grown on a disturbed area), and
5. An introduced patch (caused by human activity—a parking lot or a wheat field, for example).

Patch dynamics. The concept of a mosaic of patches within which abiotic disturbances and biotic interactions proceed.[2] The event or agent causing a patch, and the species changes within a patch, over time. A large area containing many patches in various successional stages has been called a shifting mosaic—where patches appear and disappear over time. The balance between the rate of initiation of patches by disturbance and the rate of succession within them, determines both the rate and direction of change of the whole mosaic. Hence, the mosaic may be degrading or aggrading, slowly or rapidly, or may be in a steady state.[1]

Perforation. Openings created within continuous habitat (e.g., the transformed habitat is the patch and the natural habitat is the matrix)

Perturbation. The disruption of natural disturbance regimes.

Philopatry. The tendency of offspring to return to their natal home range to reproduce. Of or relating to species or groups that remain in or habitually return to their native regions or territories.

Polygyny. A breeding relationship in which one male is mated to two or more females.

Population. A group of individuals of one species in an area, though the size and nature of the area is defined, often arbitrarily, for the purposes of a study being undertaken.[2]

[4] (Wiens 1985)

Population dynamics. The variations in time and space in the sizes and densities of populations.[2]

Prevalence. The proportion or percentage of habitable sites or areas in which a particular species is present.[2]

Principal components analysis. A statistical analysis with the objective of reducing the number of variables, and detecting structure in the relationships between variables. The purpose of principal components analysis is to reduce the complexity of multivariate analysis data into the principal components that explain most of the variation in the original variables.

Range. The geographic spatial range of a species. An expression of presence or absence. Sometimes used synonymously with “species distribution.”

Region. An area composed of landscapes with the same macroclimate and tied together by human activities.

Road corridor. A linear surface used by vehicles plus any associated, usually vegetated, parallel strips.[1]

Semi-fossorial. Adapted for digging or burrowing.

Seral. Relating to the entire sequence of ecological communities successively occupying an area from the initial stage to the climax.

Shrubsteppe. In undisturbed sagebrush shrubsteppe, tall sagebrush species are typically co-dominant with native perennial bunchgrasses.

Sink. An area where input exceeds output.

Source. An area or reservoir where output exceeds input.

Species richness. The number of species.

Species diversity. An index of community diversity that takes in to account both species richness and the relative abundance of species.[2]

Stochastic effects. Random processes that affect community structure.

Trophic position. Describes an organisms feeding position in the food chain or web.

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COMMON AND SCIENTIFIC NAMES OF SPECIES

Common Name	Scientific Name
Birds	
American crow	*Corvus brachyrhynchos*
American kestrel	*Falco sparverius*
American robin	*Turdus migratorius*
Black-billed magpie	*Pica hudsonia*
Black-throated sparrow	*Amphispiza bilineata*
Brewer's sparrow	*Spizella breweri*
Brown-headed cowbird	*Molothrus ater*
Burrowing owl	*Athene cunicularia*
Cinnereous harrier	*Circus cyaneus cinereus*
Columbian sharp-tailed grouse	*Tympanuchus phasianellus columbiannus*
Common raven	*Corvus corax*
Cooper's hawk	*Accipiter cooperii*
Ferruginous hawk	*Buteo regalis*
Golden eagle	*Aquila chrysaetos*
Gray flycatcher	*Empidonax wrightii*
Great horned owl	*Bubo virginianus*
Greater sage-grouse	*Centrocercus urophasianus*
Green-tailed towhee	*Pipilo chlorurus*
Gunnison sage-grouse	*Centrocercus minimus*
Hen harrier	*Circus cyaneus cyaneus*
Horned lark	*Eremophila alpestris*
Lark sparrow	*Chondestes grammacus*
Loggerhead shrike	*Lanius ludovicianus*
Long-billed curlew	*Numenius americanus*
Long-eared owl	*Asio otus*
Northern goshawk	*Accipiter gentilis*
Northern harrier	*Circus cyaneus*
Peregrine falcon	*Falco peregrinus*
Prairie falcon	*Falco mexicanus*
Red-tailed hawk	*Buteo jamaicensis*
Greater roadrunner	*Geococcyx californianus*
Sage sparrow	*Amphispiza belli*
Sage thrasher	*Oreoscoptes montanus*
Sharp-shinned hawk	*Accipiter striatus*
Short-eared owl	*Asio flammeus*
Spotted towhee	*Pipilo maculatus*
Stellar's jay	*Cyanocitta stelleri*
Swainson's hawk	*Buteo swainsoni*
Timberline sparrow	*Spizella taverneri*
Vesper sparrow	*Pooecetes gramineus*
Western meadowlark	*Sturnella neglecta*
Herptiles	
Collared lizard	*Crotaphytus collaris*
Gopher snake	*Pituophis catenifer*
Great Basin spadefoot	*Spea intermontana*
Longnose leopard lizard	*Gambelia wislizenii*
Midget faded rattlesnake	*Crotalus viridis concolor*
Plateau striped whiptail	*Aspidoscelis [Cnemidophorus] velox*

Sagebrush lizard	*Sceloporus graciosus*
Short-horned lizard	*Phrynosoma hernandesi*
Southwestern black-headed snake	*Tantilla hobartsmithi*
Striped whipsnake	*Masticophis taeniatus*
Western terrestrial garter snake	*Thamnophis elegans*
Western whiptail	*Aspidoscelis [Cnemidophorus] tigris*

Mammals

American badger	*Taxidea taxus*
American elk	*Cervus elaphus*
Big free-tailed bat	*Nyctinomops macrotis*
Black-footed ferret	*Mustela nigripes*
Black-tailed jackrabbit	*Lepus californicus*
Bobcat	*Lynx rufus*
Botta's pocket gopher	*Thomomys bottae rubidus*
Brazilian free-tailed bat	*Tadarida brasiliensis*
Canyon mouse	*Peromyscus crinitus*
Common porcupine	*Erethizon dorsatum*
Coyote	*Canis latrans*
Desert cottontail	*Sylvilagus audubonii*
Desert shrew	*Notiosorex crawfordi*
Golden mantled ground squirrel	*Spermophilus lateralis*
Gray fox	*Urocyon cinereoargenteus*
Great Basin pocket mouse	*Perognathus parvus*
Gunnison's prairie dog	*Cynomys gunnisoni*
Kit fox	*Vulpes macrotis*
Least chipmunk	*Tamias minimus*
Long-eared myotis	*Myotis evotis*
Long-tailed weasel	*Mustela frenata*
Merriam's shrew	*Sorex merriami*
Mountain lion	*Felis concolor*
Mule deer	*Odocoileus hemionus*
Nuttall's cottontail	*Sylvilagus nuttallii*
Olive-backed pocket mouse	*Perognathus fasciatus*
Ord's kangaroo rat	*Dipodomys ordii*
Pallid bat	*Antrozous pallidus*
Preble's shrew	*Sorex preblei*
Pronghorn	*Antilocapra americana*
Red fox	*Vulpes vulpes*
Rock squirrel	*Spermophilus variegatus*
Sagebrush vole	*Lemmiscus curtatus*
Spotted bat	*Euderma maculatum*
Spotted ground squirrel	*Spermophilus spilosoma*
Striped skunk	*Mephitis mephitis*
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*
Townsend's big-eared bat	*Corynorhinus townsendii*
Western pipistrelle	*Pipistrellus hesperus*
Western small-footed myotis	*Myotis ciliolabrum*
Western spotted skunk	*Spilogale gracilis*
White-tailed antelope squirrel	*Ammospermophilus leucurus*
White-tailed jackrabbit	*Lepus townsendii*
White-tailed prairie dog	*Cynomys leucurus*
Wyoming ground squirrel	*Spermophilus elegans*

Plants

Acacia	*Acacia constricta*

Aspen	*Populus tremuloides*
Big sagebrush	*Artemesia tridentata*
Bitterbrush	*Purshia tridentata*
Black sagebrush	*Artemesia nova*
Bluebunch wheatgrass	*Agropyron spicatum*
Bluegrass	*Poa* spp.
Bottlebrush squirreltail	*Elymus elymoides*
Cedar	*Thuja* sp.
Cheatgrass	*Anisantha* spp. or *Bromus tectorum*
Common chokecherry	*Prunus virginiana*
Creosote bush	*Larrea tridentata*
Crested wheatgrass	*Agropyron desertorum*
Douglas fir	*Pseudotsuga menziesii*
Dwarf sagebrush	*Artemesia cana*
Fringed sagebrush, fringed sage	*Artemisia frigida*
Gambel oak	*Quercus gambelii*
Greasewood	*Sarcobatus* spp.
Great Basin wild rye	*Elymus cinereus*
Hemlock	*Tsuga heterophylla*
Mesquite	*Prosopis* spp.
Horsebrush	*Tetradymia*
Idaho fescue	*Festuca idahoensis*
Indian ricegrass	*Achnatherum hymenoides*
Milkvetch	*Astragalus* spp.
Mountain mahogany	*Cercocarpus* spp.
Mustard species	Family Brassicaceae
Owl-clovers	*Orthocarpus* spp.
Paintbrushes	*Castilleja* spp.
Pinyon pine	*Pinus edulis*
Ponderosa pine	*Pinus ponderosa*
Rabbitbrush	*Chrysothamnus* spp.
Russian thistle	*Salsola* spp.
Sand sage	*Artemisia filifolia*
Sedge	*Carex* spp.
Serviceberry	*Amelanchier* spp.
Shadscale	*Atriplex confertifolia*
Snowberry	*Symphoricarpos* spp.
Spiny hackberry	*Celtis pallida*
Spiny hopsage	*Grayia spinosa*
Spruce	*Picea* spp.
Stiff sagebrush	*Artemisia rigida*
Tobosa	*Hilaria mutica*
Utah juniper	*Juniperus osteosperma*
Western needlegrass	*Achnatherum occidentale*
White fir	*Abies concolor*
Wild rose	*Rosa* spp.
Winterfat	*Krascheninnakovia lanata*

Note: see Chapter 5 Tables for additional species names.