Managing and Monitoring Utah's Wildlife:
Strategies and Tools for Success

THE HEINZ CENTER

Wildlife Conservation Program

Managing and Monitoring Utah's Wildlife: Strategies and Tools for Success

Report and Workshop Summary

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Prepared by:
The H. John Heinz III Center for Science Economics and the Environment

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Report produced by:
The H. John Heinz III Center for Science, Economics and the Environment
900 17th Street NW, Suite 700
Washington, D. C. 20006
(202) 737-6307
www.heinzcenter.org

1.0 Report Overview

This report introduces the concept of an integrated wildlife monitoring program for the state of Utah. The report highlights the steps required to develop an integrated monitoring approach, from conceptual modeling and indicator selection to sampling design and data management. It also includes information about existing monitoring programs in the state of Utah that are capturing important information about key species and ecosystems of management interest.

Throughout the report, the concepts presented are supported by examples drawn from the Heinz Center's Pioneering Performance Measures workshop, which was held from September 9-10, 2010 in Salt Lake City, Utah and September 13-15, 2010 in Price, Utah.

The workshop, co-hosted with the Bureau of Land Management and the Utah Division of Wildlife Resources, gathered wildlife and land stakeholders from throughout the state and helped build consensus on shared priorities and common conservation targets. Results from the workshop, including conceptual models for target ecosystems such as Sage communities, lists of candidate indicators for the target ecosystems, and lists of existing monitoring programs, can be found in the appendices. Information and ideas shared by the workshop participants provide an important foundation for the development of integrated monitoring approaches for wildlife and ecosystems in the state of Utah.

2.0 Introduction to Monitoring and Assessment

There is a long history of wildlife and ecosystem monitoring in Utah, ranging from the Division of Wildlife Resources' efforts to track big game populations, to Bureau of Land Management efforts to monitor rangeland health, to USDA Forest Service inventories of forest condition and forest stands. In recent years, monitoring activities have also focused on determining the status and trends of at-risk or imperiled wildlife species. Wildlife assessment activities, including surveys and monitoring, have been essential in guiding management activities for wildlife resources in Utah, ranging from harvestable deer and elk populations to imperiled fishes and desert tortoises.

While wildlife monitoring was once a matter of an ongoing census of Utah's rich game species diversity, it now includes an increasing obligation to survey for and assess the status and trends of an ever-growing list of protected wildlife species. Today the unprecedented challenges of monitoring game and protected wildlife species are placing significant demands on the resources of the department and its partners. Emerging concerns about the responses of Utah's wildlife to directional environmental change pose further challenges for the state's wildlife monitoring programs.

Historically in Utah, as in its neighboring states, wildlife management and conservation planning has focused on sustaining wildlife species in their current habitats. However, a diverse landscape that is increasingly experiencing (and will continue to experience) rapidly changing environmental conditions requires that planning, management, and monitoring under the Comprehensive Wildlife Conservation Strategy (CWCS) must take new dynamic and anticipatory approaches. Managers will need to be creative in addressing future challenges, using existing conservation tools in new and innovative ways. This is especially true for monitoring and evaluation programs, where there are exciting new opportunities for scientists and program managers to coordinate and collaborate across agency and jurisdictional boundaries in order to provide society with the information needed to manage our rapidly changing environment.

2.1 Setting Performance Measures

The process of setting performance measures for the Utah CWCS must take into account a range of information from diverse sources: data about key threats and stressors to wildlife and ecosystems in the state; information about the existing management activities of the Utah Division of Wildlife Resources and partners; and in-depth information about the underlying monitoring designs and data collection activities for the programs that currently track wildlife and ecosystems in Utah.

Identifying key threats and stressors helps to frame management questions and helps clarify how monitoring programs could collect data about the effects of threats and stressors. Identifying the full suite of current management activities helps to focus monitoring attention on the short- and long-term outcomes of conservation actions. And reviewing the set of existing monitoring programs is the first step towards better collaboration and integration across programs and among partners. Such integration has clear practical benefits, including efficiencies in data collection as well as the ability to make comparisons across complementary data sets (for example, comparisons between wildlife population trends and vegetation condition at the same sites or areas).

2.1.1 Monitoring Design

For wildlife management planning to be informed effectively, the monitoring schemes and performance measures that service the state's CWCS need to consider the full breadth of environmental changes that will directly and indirectly affect desired species over both shorter and longer terms. Recognizing the diverse types of potential environmental changes and anticipating wildlife responses, the CWCS acknowledges the need to:

- **Integrate ongoing monitoring efforts** that have historically provided essential population status and trend data to wildlife managers;
- Place ongoing monitoring efforts into an **adaptive management framework**; and
- **Enhance sampling and survey designs** to increase the possibility of picking up signals from local ecosystem responses to environmental disturbances that put Utah's desired wildlife at risk for extirpation, extinction, or population decline.

Adaptive management -- also known as "learning by doing" -- under the CWCS will not only require well-designed monitoring schemes, it will also require integration of those assessment activities with information gathered from directed research and from species and ecosystem models. Integrated monitoring will in many circumstances need to be initiated as pilot studies, with initial sampling programs amended sequentially as accruing data are used to resolve uncertainties in the monitoring design.

2.1.2 Types of Monitoring

Monitoring in support of the CWCS may continue to proceed in the following three categories:

1. ***Implementation monitoring***, which is the monitoring of management actions in relation to planned activities; cataloguing the completion of wildlife management projects or habitat restoration activities as they were designed; and documenting compliance with environmental regulations and mitigation obligations in project implementation.
2. ***Effectiveness monitoring***, which assesses the effectiveness of management actions in achieving desired wildlife responses and improved habitat conditions.
3. ***Status and trend monitoring***, which documents the status and trends of targeted wildlife, their essential habitats and resources, and environmental agents that cause change in both. Status and trend monitoring is the principal data gathering effort that informs management planning about overall environmental and resource conditions relative to established environmental objectives and thresholds. Typically, this type of monitoring serves to track the condition of indicators selected to represent a set of conditions pertinent to environmental objectives in the CWCS.

2.1.2.1 Monitoring for Environmental Change

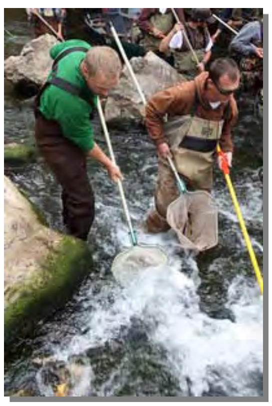
In order for monitoring to capture environmental change, a new approach is needed that will require adjustments to monitoring programs, including:

- Sustaining ongoing data collection efforts that target desired game and fish species, species that are listed as threatened or endangered, and other valued species, including species that might be useful as early-warning indicators of environmental change.

- Incorporating concurrent data collection of appropriate environmental variables that are known or expected to contribute to landscape occupancy and habitat use by desired wildlife species.
- Sampling widely for wildlife and environmental variables across those geographic and vegetation gradients that provide the template upon which wildlife species distributions and abundances will adjust in response to shifting physical and biological conditions.

2.1.3 Choosing Indicators

The Utah Division of Wildlife Resources currently fields a diverse group of survey, monitoring, and assessment programs. In combination with other data sets on land cover, soils, climate, and hydrology, data from these programs are being used to help inform ongoing and future management of wildlife and other key natural resources within the state.



In particular, analyses of time-series data for species and environmental variables can link changes in population trends to changes in candidate environmental variables. By linking changes in population trends to broader environmental variables, wildlife species have the potential to serve as "indicators" of habitat quality and ecosystem integrity. Wildlife species of particular interest for such analyses include: taxa which are associated with vegetation communities and land-cover types that are limited in geographic extent, taxa associated with highly fragmented ecological communities, and taxa found along the upper limits of elevational gradients. Monitoring of these species will focus attention on ecological indicators that clearly allow cause-effect interpretations of signal changes in the indicator status or trend.

Ultimately, integrated and synthetic monitoring schemes can be implemented in the most extensive vegetation communities and land-cover types, and in highly restricted and at-risk communities and associations. In these locations, prospective sampling will use designs that maximize the likelihood that deterministic changes in wildlife status and trends will be observed and identified, and the environmental determinants of those changes can be assigned.

2.1.4 Indicators and Adaptive Management

To be successful, monitoring under the Utah CWCS needs to be highly structured and form part of an integrated adaptive management program for wildlife species and habitat features. Such a program can be informed by and designed around a series of requisite elements, including:

- Articulation of **explicitly defined management options** for targeted wildlife species and their habitats;
- Use of **ecological models** that characterize the relationships between desired wildlife or habitat conditions, environmental indicators, and environmental threats and stressors;
- **Data collection in monitoring schemes** that anticipate the application of the information gathered in identifying and directing candidate management actions and prioritizing those actions; and
- Rigorous **evaluation of assessment outcomes**.

A stressor-based approach is one way to meet monitoring program requirements and to identify performance measures under the CWCS.

3.0 A Stressor-Based Approach to Wildlife Conservation and Wildlife Monitoring

One of the essential elements in the Utah CWCS is a discussion of the threats and stressors that affect wildlife and ecological communities in the state. Threats and stressors obviously have considerable importance for wildlife managers; in fact, Aldo Leopold (1933) traces the development of modern wildlife management back to very early concerns about poaching and the illegal harvesting of game and fish species. Since Leopold's time, advances in ecological science have provided managers with important new understandings of threats and stressors such as invasive species, habitat fragmentation, and drought.

In this report, we follow a stressor-based approach in order to develop a framework for monitoring the condition of wildlife resources and the effectiveness of wildlife conservation activities in the state of Utah. The conceptual models in the appendices focus on the interactions between individual threats and stressors and a particular conservation target. The models show causal pathways by which individual threats and stressors affect the target, and show how particular conservation activities are intended to reduce, eliminate, or ameliorate particular threats or stressors. The models thus differ from other ecosystem models that show interactions among individual components (as in food web diagrams) or flows of energy or nutrients through a system.

3.1 The Value of a Stressor-based Approach

For wildlife managers, there are several practical justifications for adopting a stressor-based approach to management and monitoring.

- Much of traditional wildlife management has focused on reducing or ameliorating threats and stressors to individual species or vegetation communities. Methods for controlling many of the most pervasive threats and stressors have been developed (e.g., fire management, invasive species control, erosion control, mine reclamation).
- Threats and stressors are often anthropogenic in nature. It stands to reason that if human activities are responsible for creating the threat or stressor in the first place, then humans may be able to reduce or even undo the adverse effects of the threat or stressor.
- Funding from state and federal government agencies is often focused on specific threats or stressors, such as invasive species, new energy development, or climate change.

3.2 Stressors and Threats in Utah

The general list of threats and stressors for Utah – as with every state – is necessarily broad and comprehensive. Beyond a general discussion of these threats, it is also important to understand how specific threats and stressors are affecting the individual Species of Greatest Conservation Need (SGCN) and the specific ecosystems of conservation interest within the state. In this report on the Utah Comprehensive Wildlife Conservation Strategy, detailed information about known or potential threats and stressors is listed for each species and community of conservation interest. Such details are critically important for wildlife managers who must then develop more detailed management prescriptions and monitoring frameworks for individual species and ecological communities.

During the workshop, five threats / stressors were repeatedly identified as common to many of the key target habitat systems. Below are descriptions of these five main stressors, followed by the list of stressors and threats identified by workshop participants:

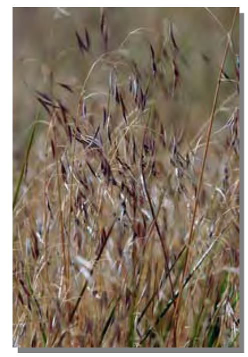
3.2.1 Energy Development

Eastern Utah has coal, natural gas, and oil reserves, including some of the nation's largest oil and natural gas fields. Energy development, including fossil fuel extraction, puts considerable pressure on wildlife habitats. Well pads, power lines, and roads all result in loss of habitat as well as habitat fragmentation. According to the Utah CWCS, energy development particularly affects several of the key habitats identified throughout the workshop, including lowland riparian areas, shrubsteppe, flowing waters, and wetlands. Multiple extraction sites scattered throughout the landscape fragment habitat and disrupt wildlife. In addition, renewable energy development in Utah is expected to increase in the future, and will bring with it additional impacts to plant and wildlife species. The state of Utah is participating in the Western

Governors Association's Wildlife Corridors and Crucial Habitat Initiative, collaborating with other states to build a mapping tool that can be used to balance energy development with minimal wildlife impact (WGA 2010).

3.2.2 Invasive Species

The CWCS highlights several invasive species, including carp and aquatic mollusks, cowbirds, cheatgrass, and tamarisk. Nearly all of the key habitats identified throughout the workshop are significantly affected by the presence of invasive species. Wildfires that occurred during 2007, including the catastrophic Milford Flat Fire, were fueled by the widespread presence of invasive cheatgrass in the wildfire areas, particularly in shrubsteppe habitats. As a result, in 2008 the Utah legislature declared a "war on cheatgrass," passing legislation that established an Invasive Species Mitigation Fund worth $2 million (UDAF 2011). The Utah Division of Natural Resources, Bureau of Land Management, Utah Conservation Commission, and a variety of other agencies have implemented several cheatgrass control and habitat restoration projects under this fund.



3.2.3 Altered Fire Regimes

Non-native species such as cheatgrass contribute to alteration of the frequency and intensity of natural fires. In addition, fire suppression and lack of disturbance also play a role in altered fire regimes. Of the key habitats identified in the workshop, this issue is of particular concern in aspen, lowland riparian, and shrubsteppe habitat systems. In aspen systems, fire suppression allows other conifer species to replace aspen stands that are typically maintained by regular fire cycles. In lowland riparian areas, invasive plant species such as salt cedar outcompete native plant species such as Fremont cottonwood and desert willow – salt cedar can increase fire frequency in riparian areas. In shrubsteppe areas, pinyon-juniper forests (which are not burned frequently) slowly replace sagebrush and other native vegetation normally found in the area under historically typical fire cycles.

3.2.4 Altered Hydrology

Both drought and water development activities contribute to altered hydrological conditions. A significant drought affected Utah in the first half of the past decade, although since 2005 Utah has experienced relatively average precipitation (DWRe 2011). Water development activities, such as stream channelization, storage, pumping and diversion for irrigation and other human uses, and similar activities, reduce the amount of water available for wildlife in their native habitat. These activities are particularly impactful in lowland riparian, flowing waters, and wet meadows and wetland areas. Given that Utah is considered the second driest state in the nation, water use will naturally continue to be a concern into the future.

3.2.5 Improper Recreation Uses

The Utah CWCS cites improper Off-Highway Vehicle (OHV) use, including illegal trail pioneering and proliferation, as an important stressor on lowland riparian, shrubsteppe, flowing water, and wet meadow systems. On designated public land trails and roads, OHV use can provide unique recreation opportunities and access to hunting areas. Off-trail OHV use compresses the soil in wet meadow areas, which disrupts plant growth and wildlife. When riders come too close to rivers and streams, OHV use can cause soil degradation and run-off into the adjacent streams. In shrubsteppe systems, OHV use can damage plants, spread invasive species, and disturb wildlife.

3.2.6 Other Stressors and Threats

Participants were asked to list their agency or program's top three to five state-specific stressors and threats (local to regional to state-level). The full list included:

- ATV use
- Climate variability
- Connectivity, barriers to migration
- Disease (e.g., plague in prairie dog)
- Disruption of natural processes that maintain the landscape
- Entitlement (e.g., predator-free landscape)
- Fire (changes in frequency – catastrophic in lowland, lack of fire in high elevations)
- Flood control
- Grazing
- Habitat fragmentation
- Insect invasions
- Irrigated lands and wetlands
- Juniper encroachment
- Land conversion (from "natural" to agricultural)
- Limited stream flows
- Limited water supply – driven by background natural state but exacerbated by human activity water withdrawals)
- Loss of agricultural lands
- Non-native/Invasive species (e.g., cheatgrass, tamarisk, knappweed, carp, New Zealand mud snail, mosquito fish, brown and rainbow trout, catfish)
- Oil and gas development

- Renewable energy development (solar, wind)
- Residential developments
- Roads, associated with energy or other uses
- Urban encroachment
- Water diversions

4.0 Shared Priorities for Conservation and Monitoring

4.1 The Challenge of Multiple Conservation Targets

The word "target" is used in many different ways by wildlife and natural resource managers. A "target" can be a desired population size, a land protection goal, a financial or budgetary objective, or the species or area that is itself the focus of management.

Following the lead of groups like The Nature Conservancy and the World Wildlife Fund, many conservation organizations are adopting a more restrictive definition for the word "target" (Heinz Center 2008). By this definition, a "target" is a particular species, vegetation community, landscape, or defined geographic area which is the subject of conservation management. In this chapter the word "target" is used in this more restrictive sense to develop a preliminary set of performance indicators for the Utah Comprehensive Wildlife Conservation Strategy.

Even using the more restrictive definition of the word, the CWCS lists a significant number of potential conservation "targets" in the state of Utah. Conservation "targets" in the CWCS include all of the species of greatest conservation need and all of the ecosystems or vegetation communities of conservation interest within the state. Each species, ecosystem, and vegetation community listed is a worthy conservation target, deserving careful attention from wildlife and natural resource managers, scientists, and field biologists. At the same time, the state and its partners have limited resources available for conservation activities, making it unrealistic to focus on all the possible targets, and therefore some taxa will necessarily receive attention before others. This is especially true in the case of monitoring activities, where there are extremely limited resources available for monitoring individual species or ecosystem attributes.

Considerable resources are already dedicated to monitoring populations of species that are known to be of conservation interest, such as species listed under the U.S. Endangered Species Act. The monitoring of individual species is a complicated endeavor that requires considerable knowledge of a species' biology, development and testing of sampling protocols, and a firm understanding of the statistical basis for translating monitoring data into estimates of population trends and other information needed by wildlife and natural resource managers. Monitoring of individual species is both time- and labor-intensive, with significant commitments of staff and financial resources. In the current funding environment, support for new monitoring programs or projects that are focused on individual species is likely to be extremely limited for the foreseeable future.

In many cases, monitoring of **ecosystems or vegetation communities** may be more tractable than individual species monitoring. For many communities, such as grasslands, shrublands, and forests, there are readily available metrics of composition and structure that can be applied at the stand or plot level. Many of these same metrics can also be assessed using remote sensing imagery from satellites or aerial photographs. Focusing on ecosystems or vegetation communities as monitoring targets has the added benefit that the monitoring programs for individual species often fit geographically within particular large-scale ecosystem or vegetation types (for example, sage grouse monitoring efforts occur within sagebrush communities).

Furthermore, the presence or abundance of individual animal species can provide indirect measures of ecosystem function or vegetation condition (as in the case of species that are sensitive to fire or to the presence of certain invasive species).

Given the limited resources for monitoring species and ecosystems, it is often desirable to select a set of highest-priority species, ecosystems, or vegetation communities that can serve as foci for monitoring. In this initial approach for Utah, the focus is on large-scale vegetation communities or ecosystems as the primary set of conservation targets for collaborative, multi-agency, multi-jurisdictional monitoring. Each of these broad targets contains within it many individual species and sub-communities which are themselves potential targets of management and monitoring.

Monitoring efforts for individual species can help inform efforts to understand the status and trends of the larger system within which these species are embedded. Within a given ecosystem, individual species are often associated with particular habitat variables such as stand density or canopy cover. Such species could potentially serve as "indicators" of their associated aspects of habitat condition. Taken together, trends in the suite of species associated with a particular ecosystem or community can also help measure the overall ecosystem response to environmental stressors.

4.2 Exercise: Identifying Shared Priorities and Targets in Utah

At the Pioneering Performance Measures workshop, held in Utah in September 2010, Heinz Center staff facilitated a session to identify a manageable set of high-priority conservation targets shared by conservation partners across the state.

A group of diverse stakeholders representing state and federal agencies, academia, and non-profit organizations participated in the target selection exercise. Stakeholders are those who have direct management authority for wildlife and/or ecosystems within the state, or those who have direct responsibility for designing or implementing monitoring programs. Each stakeholder typically has their own set of priority conservation targets (i.e. species, ecosystems, vegetation communities, or areas of interest).

This exercise is designed to identify shared priorities among the set of stakeholders invited to the meeting. The goal is to identify targets that are viewed by the greatest number of stakeholders as top priorities for conservation and monitoring.

Each stakeholder was asked to identify their top five (5) ecosystem-scale conservation targets within the state. These lists were written on pieces of paper and collected by Heinz Center staff. The lists were then consolidated and presented to the group in rank order according to the number of times each prospective target was mentioned. The top 10 targets from this first round were then listed on poster paper and each participant was assigned 5 stickers with which to vote for their top 5 preferences. Participants were allowed to allocate their votes however they saw fit; voting 5 times for 1 prospective target and voting 1 time each for 5 prospective targets were both acceptable. The shared priority ecosystems selected by partners attending the workshop included: aspen; springs, springbrooks, and wetlands; flowing waters; sage communities; and lowland riparian zones.

4.3 Exercise Results: Overview of Utah Target Ecosystems

4.3.1 Aspen

Aspen forests cover 3.4% of Utah (or about 1.85 million acres), ranging from 5,600 to 10,500 feet in elevation. Numerous conifer species are also found in aspen forests, including: Engelmann spruce, blue spruce, sub-alpine fir, white fir, Douglas fir, lodgepole pine, and ponderosa pine. Snowberry and serviceberry shrubs are also found here. Species of particular conservation need in aspen forests include: the northern goshawk, Yavapai mountain snail, Mexican vole, and Williamson's sapsucker. In addition to seed generation, aspen trees can reproduce by sending out shoots along their roots, called clones. The "Pando" aspen clone can be found on Fishlake National Forest in southern Utah. This clone is considered by some to be the largest and oldest single living organism in the world.

The CWCS suggests that aspen forests are rapidly declining in Utah. Land development, alteration of the natural fire cycle, and improper grazing practices are noted as the most important threats and stressors to aspen forest systems.

4.3.2 Springs, Springbrooks, and Wetlands

While springs and springbrooks are not described specifically in the CWCS, it does define wetlands and wet meadows, which take up approximately 0.3% of the state of Utah (or just over 160,000 acres). Low elevation marsh and wetland areas occur at elevations less than 5,500 feet, while wet meadows occur between 3,300 – 9,800 feet. Cattail (*Typha latifolia*), bullrush (*Scirpus* spp.), and sedge (*Carex* spp.) are commonly found in marshes / wetlands. A wide variety of species can be found in wet meadows, including: sedges, rushes, reedgrass (*Calamagrostis* spp.), timothy (*Phleum* spp.), Alpine (*Poa* spp.), hairgrass (*Deschampsia cespitosa*), willowherb (*Epilobium* spp.), cinquefoil (*Potentilla* spp.), and saxifrage (*Saxifraga* spp.). Willow, honeysuckle (*Lonicera* spp.), and water birch are also associated with wet meadows. In marsh and wetland areas, common wildlife species that have been specifically identified by the Utah Division of Wildlife Resources as species of conservation need include: the Columbia spotted frog, least chub, Preble's shrew, western toad, desert springsnail, black-necked stilt, northern leopard frog, and the American avocet. In wet meadows, species of particular concern include: the Columbia spotted frog, bobolink, smooth green snake, and the common garter snake.

Wetland and wet meadow areas are in decline in Utah, and are subject to a number of threats and stressors. Land development, water development, drought, energy development, loss of adjacent habitats, pollution, invasive species, and improper grazing practices or OHV use all impact both the quantity and quality of remaining wetland and wet meadow habitat.

4.3.3 Flowing Waters

Flowing waters are described in the CWCS as "lotic" waters, including streams and rivers. Less than 0.1% of Utah (<54,000 acres) is considered covered by streams and rivers. Diverse wildlife species can be found in flowing waters. Species of particular concern include: the Colorado River and Bonneville cutthroat trout, bonytail, woundfin, razorback sucker, Desert sucker, Yellowstone cut-throat trout, leatherside chub, Utah sucker, and mottled sculpin. Snails, bivales, insects, and other invertebrates also inhabit flowing waters.

Threats and stressors include water loss (due to increasing human development), increased nutrients and sediments (due to farm runoff, inappropriate grazing or OHV use), pollution, and invasive species. Population increases in the state place pressure on already limited water resources, making it difficult to preserve intact natural habitats for wildlife.

4.3.4 Sage and Sagebrush Communities (including pinyon-juniper conversion areas)

According to Utah's Comprehensive Wildlife Conservation Strategy for 2005-2015, just over 13% (~7.3 million acres) of Utah is designated as shrubsteppe habitat, occurring from 2,500 – 11,500 feet in elevation. The dominant shrubs in this system include: big sagebrush (*Artemisia tridentata*), black sagebrush (*Artemisia nova*), low sagebrush (*Artemisia arbuscula*), and silver sagebrush (*Artemisia cana*). Here, juniper (*Juniperus* spp.) and pinyon trees (*Pinus* spp.) can also be found along with mountain mahogany (*Cerocarpus montanas*) and ponderosa pine (*Pinus ponderosa*). Gunnison and greater sage grouse are perhaps the most familiar wildlife species found in sagebrush systems, but a number of other important species live here, including: pygmy rabbits, sage thrasher, sage and Brewer's sparrows, olive-backed pocket mouse, and mule deer (particularly for winter habitat).

Workshop participants identified pinyon-juniper conversion areas as a particular area of interest within sagebrush systems.

The shrubsteppe system in Utah has become degraded due to a number of threats and stressors, including: drought, improper brush control activities, land development, energy development, fire cycle alteration, improper grazing practices, improper OHV use, and invasive plants. A number of partners across the state are working together to restore and protect shrubsteppe habitats.

4.3.5 Lowland Riparian Zones

Lowland riparian areas are identified in the CWCS as generally being found below 5,500 feet in elevation. Adjacent to rivers and streams, lowland riparian areas compose 0.2% of the area of Utah (nearly 110,000 acres). Plant species found in riparian areas include: Fremont cottonwood (*Populus fremontii*), salt cedar (*Tamarix pentandra*), netleaf hackberry (*Celtis reticulata*), velvet ash (*Fraxinus velutina*), desert willow (*Chilopsis linearis*), willow (*Salix* spp.), and squawbush (*Rhus trilobata*). Wildlife species of particular concern include: the yellow-billed cuckoo, southwestern willow flycatcher, Arizona toad, Allen's big-eared bat, black swift, cornsnake, western threadsnake, broad-tailed hummingbird, canyon tree frog, and the black-necked garter snake.

The primary threats and stressors that affect lowland riparian zones include: water development (e.g., channelization), land development, improper grazing practices and OHV use.

Because of the considerable diversity of wildlife in lowland riparian areas, these threats and stressors have the potential to impact an important segment of the state's overall wildlife diversity.

5.0 Conceptual Modeling

5.1 Introduction

Previous sections of this report have discussed how stakeholders can work together to identify priority conservation targets, and why adaptive management is essential to managing wildlife in an uncertain future. Once shared priority conservation targets have been identified, conceptual models can be used to show linkages between the targets, threats and stressors, and conservation actions. Such conceptual models can be important tools in conservation planning, in the development of assessment and monitoring programs, and in the identification of opportunities for future management and research activities.

Conceptual models describe in graphical or narrative form the ecological system subject to management, allowing inference about how that system works. A model of riparian vegetation function on the Colorado River, for example, describes the relationships between vegetation and the wildlife that depend on it, the hydrological and other physical processes that affect those relationships, and the role of human activities in disturbing and sustaining the system.

Conceptual models also document a specific version of the hypotheses about how wildlife survive and persist, and how the ecological systems that they depend on function. The Utah CWCS uses conceptual models to illustrate the relationships between ecosystems, threats, and actions that have been observed by state wildlife biologists and their conservation partners. The models thus represent the current status of knowledge among state wildlife managers regarding these conservation targets.

Conceptual models that explicitly link targeted wildlife species to essential resources and environmental stressors naturally lead to the identification of ecological factors that need to be targeted by management actions and candidate environmental parameters that should be measured by monitoring efforts. In the formulation of a conceptual model, the combinations of environmental influences that drive ecological systems often become apparent. This in turn allows planners to rank the importance of different attributes in determining system function, affecting the status and trends of wildlife populations. Using conceptual models helps us to assure that our current and future management actions target the correct ecosystem features and attributes, and to maximize the likelihood that management under the CWCS will produce desired outcomes.

In utilizing conceptual models, the CWCS seeks a clear articulation of what is known about wildlife and the ecological systems that support them, systems which are subject to management, assessment, and monitoring. These activities produce explicit descriptions of how the state's land and wildlife managers believe their targeted ecosystems and wildlife operate. The process of developing species- and ecosystem-specific conceptual models has proven to be an effective way of exposing differences of opinion regarding the essential relationships between desired wildlife species and the diverse environmental drivers that influence them, as well as the management actions that are intended to benefit them. The models also highlight interactions between species on the planning landscape.

Conceptual models serve to identify key system elements, including targeted species, the structure and composition of the ecosystem in which they exist, and the processes that link those species with other biotic elements and physical attributes of the system. The models describe how the system may be impacted by environmental stressors (e.g., disturbances, perturbations) generated by both natural and anthropogenic sources, and how management can intervene to reverse undesirable ecological conditions or wildlife population trends. These descriptions variously take one or more forms, which include box and arrow diagrams, cartoons that are accompanied by narrative descriptions, simple linear pathway illustrations, or straightforward text descriptions.

5.2 Core Principles

Several important principles were considered in the formulation of the conceptual models contained in this report.

First, because we do not fully understand how the ecosystems that support our wildlife operate, our models are nearly always incorrect in one or even a number of ways. Repeated refinement of our models is necessary as new information or new understandings of ecological interactions becomes available. Nonetheless, each iterative model tends to reduce uncertainties that confound our management efforts.

Second, as adaptive management efforts become increasingly effective, the conceptual models will improve. As we learn more about how systems function, our management will become more effective and efficient.

Finally, the conceptual models that we generate are essential tools to facilitate learning under the CWCS. The models and associated diagrams represent a common understanding of how Utah's natural systems work, providing opportunities for collaboration and coordination across existing conservation efforts. The models also help us to identify key areas of uncertainty, highlighting areas where more information is necessary to make better management decisions.

5.3 Exercise: Conceptual Modeling in Utah

5.3.1 Model Components: Threats, Stressors and Conservation Actions

During the September 2010 workshop, participating conservation partners used a simple exercise to develop a series of conceptual models for the set of high-priority monitoring targets that they had identified earlier (by consensus) from the Utah Comprehensive Wildlife Conservation Strategy.

For each target, workshop participants brainstormed lists of potential threats and stressors for that particular target. ***Threats*** are actions or processes that have the potential to cause direct harm to a particular target, while ***stressors*** are actions or processes that cause stress to the target.

Once identified, threats and stressors were sorted into two groups: ***direct threats and stressors***, which operate directly on the target; and ***indirect threats and stressors***, which operate on the target through an intermediary. For example, off-highway vehicles (OHVs) act directly on the landscape of Lowland Riparian Zones, and would therefore be considered a direct threat to Lowland Riparian Zones. By comparison, recreation policies and human attitudes towards the area would operate indirectly through their influence on OHV users, and thus would be seen as indirect. The stakeholder working groups agreed by consensus on the classification of individual threats and stressors into the direct or indirect categories.

Next, lists of potential ***conservation actions*** were brainstormed that either directly benefit the target or counter one or more of the threats and stressors.

The complete lists of threats, stressors, and conservation actions resulting from this exercise are found in Appendix 4.

5.3.2 Model Construction

For purposes of constructing the conceptual model, the threats and stressors were written on small "Post-It" notes and arranged around a central "Post-it" note listing the conservation target which was placed at the center of a large sheet of poster paper.

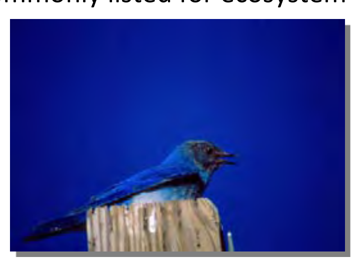
The next step was to draw arrows between threats/stressors and the conservation target, and between the various threats and stressors to show patterns of interactions between the threats/stressors and the target. The arrows indicate causal pathways, with the item on the blunt end of the arrow causing some form of change in the item on the pointed end of the arrow. Reciprocal relationships are possible (arrows pointing in both directions between two stressors, for example), as are loops. Arrows were drawn by the facilitators once the project stakeholders achieved consensus regarding the direction and placement of each arrow.

The group identified the three to five most significant threats/stressors for each target, recognizing that different threats and stressors operate at different temporal and spatial scales and that certain threats are likely to be more significant for particular conservation targets than others.

In the last step of model construction, the individual conservation activities were written on "Post-It" notes and these notes were added to the model, with arrows showing how those conservation activities would affect particular threats/stressors or the target itself. Most conservation activities map to one or more of the threats/stressors; a few map directly onto the target itself. An example of a conservation activity that addresses a threat or stressor would be the removal of invasive vegetation. An example of a conservation activity that addresses the target directly would be the augmentation of a population of a particular fish species through translocation, when the fish species itself is the target. Again, the arrows were drawn between conservation activities, threats/stressors, and the conservation target once the project stakeholders had achieved consensus on the direction and placement of each arrow.

5.3.3 Desired Conditions for the Targets

For each target, the group developed a list of desired conditions through a brainstorming exercise. The description was aimed at field biologists who would need to be able to assess through site visits the relative condition of a particular site or area of conservation/management interest. Attributes that were commonly listed for ecosystem-scale targets include:



- Soil type and condition
- Characteristic vegetation (e.g., presence, composition, age structure, density, patchiness)
- Intact understory or herbaceous layer
- Full suite of associated vertebrate species, with emphasis on birds
- Absence of key stressors (e.g., invasives, roads, vehicle traffic)
- Disturbance regimes within expected parameters (e.g., fire, flooding, etc.)

5.4 Conceptual Models for Priority Ecosystems in Utah

Through the exercise described in section 5.3, five conceptual models were developed (Appendix 1, Figures 1-5), one for each target ecosystem identified by the group. As outlined, each model includes a target system, a suite of threats or stressors (direct and/or indirect), and possible conservation actions to alleviate the threats or stressors.

The conservation target is shown in a circle at the center of each model. Around the circle is a ring of boxes containing the names of stressors or threats affecting the system, and ovals containing possible conservation actions. The arrows indicate cause-and-effect relationships; the factor at the blunt end of the arrow affects the target or factor at the pointed end of the arrow.

A key to understanding components of the conceptual models:

- ***Direct stressors*** (square-shaped and typically placed closest to the target) have a solid arrow leading from them. The thickest arrowheads indicate the most impactful or priority stressors/threats to the target.
- ***Indirect stressors*** (square-shaped typically placed farther from the target) have a dashed line leading from them.
- ***Conservation actions*** (oval-shaped and typically placed on the outer ring of the circle) have a solid line with an open arrowhead leading from them.

Note that some stressors can have both *indirect* and *direct* effects. For example, in Figure 1 drought has a *direct* affect on the mixed conifer/spruce fir system as well as *indirect* affects through the stressors fire and insects/disease.

5.4.1 Aspen

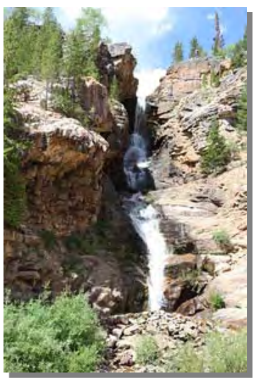
The first model (Figure 1) depicts the direct and indirect threats, as well as conservation actions for the aspen system. Before disbanding into smaller breakout groups, the full group worked together to create a sample conceptual model for this system. They brainstormed a list of eight threats and stressors, of which seven have direct impacts to the system, including: inappropriate grazing and browsing, spruce encroachment, lack of fire, disease, new road development, aspen regeneration, and recreation. Possible conservation actions were recommended for six of these threats/stressors, including: prescribed fires to address the lack of fire and aspen regeneration; fencing; game management; herd management to address inappropriate grazing and browsing; and recreation management to address issues from recreation such as OHV use.

5.4.2 Springs, Springbrooks, and Wetlands

Figure 2 illustrates the relationship between threat/stressors affecting spring, springbrook, and wetland ecosystems and possible conservation actions. All eight stressors identified have a direct impact on the system, and include eutrophication, horse and livestock use, and groundwater development (e.g., for irrigation, municipal water use, as a water source for cattle). Twelve conservation actions were identified to address these issues including water rights acquisition and protection, water policy, and herd management. Participants felt that two conservation actions - private landowner partnerships and incentives (such as technical assistance, cost shares, and easements), as well as land use planning - can help directly address all of the stressors identified for this system.

5.4.3 Flowing Waters

The third model (Figure 3) illustrates the complex relationship between flowing water systems, their major threats and stressors, and potential conservation actions. Workshop participants identified 17 threats to this system, approximately half of which are direct impacts, including: altered hydrology, inappropriate grazing, invasive species such as the New Zealand mud snail, agricultural runoff, and oil and gas development (especially oil shale). Indirect impacts include past beaver control, roads, and water management/development such as the gorge plan to divert water to Wyoming. Participants also discussed 17 conservation actions that are being taken or could be taken to ameliorate the threats/stressors ranging from best management practices to proactive watershed management and surface and drainage improvements



5.4.4 Sage and Sagebrush Communities

Participants in the sage and sagebrush community breakout group identified 15 threats and stressors on the ecosystem, shown in Figure 4, selecting a lack of natural disturbance as the number one problem. The remaining top five threats (in descending order) were: lack of age class diversity, pinyon-juniper encroachment, invasives, and urban/suburban development. Among invasives, introduced grass species – cheatgrass in particular – were cited as a major problem. The group considered climate change a significant indirect stressor, impacting the sage community through seven other stressors on the system. Plant disease and pathogens included insect infestations. Though it was not one of the top five stressors selected, "catastrophic" fire – and disturbance to the natural fire regime overall, as well as lack of resilience to fire – were cited as major problems for the sage community. Among the eleven conservation actions suggested were ecological restoration (including re-seeding), prescribed fire for pinyon-juniper areas, and water conservation. Education and outreach efforts were also suggested, as well as adaptation and mitigation, best management practices, and strategic zoning.

5.4.5 Lowland Riparian Zones

Figure 5 illustrates the 18 stressors on lowland riparian zones that were identified by the group. These included water diversion and groundwater development, as well as both terrestrial and aquatic invasives. Agriculture was also cited as a stressor, with a special focus on agricultural runoff. The group noted altered hydrologic regimes (such as diversions) and streambank stabilization/channelization as stressors. Fifteen conservation actions were suggested to address these stressors. They included regulation and enforcement of invasives and recreation/OHV use. Also discussed were restoration of native vegetation, strategic zoning, and best management practices for both agriculture and stormwater runoff. A note was made that it is important to consider terrestrial and aquatic systems together rather than considering them separately. This would encourage collaboration and interaction among the system managers.

6.0 Indicator Selection

6.1 Overview

The use of indicators to assess CWCS performance is not a shortcut – it is a necessity. Given resource constraints, only a relatively small number of wildlife species and ecosystem parameters can be monitored, assessed, or measured.

The default for monitoring efforts is data collection that targets a subset of the species, habitat attributes, and landscape features and vegetation conditions of conservation concern. Monitoring under the CWCS requires identification of a subset of candidate ecological features that are useful surrogates for, or indicators of, the greater array of organisms and other environmental attributes and processes that wildlife action planning seeks to manage. We are searching for reliable, cost-effective measures of the status or trend of wildlife and environmental phenomena that are scientifically or logistically challenging to measure directly.

An effective indicator species is recognized here as a species "so intimately associated with particular environmental conditions that its presence indicates the existence of those conditions" (see Patton 1987). Indicator species more generally meet the definition from Fleishman and Murphy (2009) as a "scientifically reliable, cost-effective measure of the status or trend of an environmental phenomenon, which is not scientifically or logistically tractable to measure directly."

Bringing necessary rigor to the indicator selection process is challenging; it requires a clear articulation of the purposes for identifying an indicator or indicators, the assumptions used in the indicator selection process, and the exacting circumstances for which the indicator will be used.

An emphasis on direct measures of wildlife abundances and habitat conditions will inevitably dominate monitoring in wildlife action planning. A comprehensive monitoring program will use some limited number of wildlife species for purposes of guiding management actions targeting a larger group of species. And, monitoring will include indicators that collectively measure compositional, structural, and functional attributes of vegetation and other components of ecological systems at a variety of spatial scales (see Lindenmeyer et al. 2000, Noon and Dale 2002). The monitoring parameters that are directly measured may include aspects of the demography, life history, or behavior of an indicator species. These indicator measures are prototypical “fine-filter” measures of ecosystem health or integrity (Hunter et al. 1988, Haufler et al. 1996, Noon 2003).

Some species selected for measurement are intended as "coarse-filters" -- or broad measures -- to provide insights into the status or trends of species that are not measured. ***Structure-based indicators*** are measured at local and landscape scales. Structure-based indicators include ecosystem elements, such as vegetation structural complexity, inter-patch heterogeneity, and connectivity at the landscape level. ***Function-based indicators*** rely on direct measures of processes and their rates, including primary productivity, nutrient cycling, water flows, and similar ecosystem process parameters. Both structure and function indicators serve as “coarse filter” measures of ecosystem condition.

6.2 Purpose

In service to the CWCS, indicators can be viewed as serving at least three purposes:

1) ***Early warning indicators***, which provide early warning of specific stressors that are impacting key ecosystem processes;
2) ***Population surrogate indicators***, drawn from species whose status and trends are indicative of the status and trends of other species; and
3) ***Biodiversity indicators***, a species or taxonomic group that serves as a surrogate for multiple other taxonomic groups.

Characteristics of effective indicator species include: sensitivity to environmental change, variability in responses, degree of ecological specialization, residence status, population dynamics, and more (Landres et al. 1988).

6.3 Process

Several sequential steps are necessary to inform a defensible indicator selection process, and are employed in developing a target-directed monitoring program:

1) Programmatic goals and planning criteria that are used to determine whether those goals are explicitly stated; from the overarching goals explicit, quantifiable objectives are identified.
2) Conceptual model(s) are built describing the target ecosystem and its wildlife, illustrating the species involved and the essential ecosystem attributes that affect those species, with an emphasis on stressors (both natural and human-generated) which impact the targeted species and their habitats and will require management responses.
3) Opportunities and options for management actions are listed.
4) A comprehensive candidate indicators list is drawn from the list of wildlife species that are supported by the targeted ecosystem, and from the landscape features and ecological attributes of the system that contribute to habitat for those species. Candidate indicators are drawn from available ecosystem attributes at multiple spatial scales. These are inclusive, such as physical environmental parameters and biotic parameters, including potential structural, compositional, and process variables.
5) Indicator measures are chosen using explicit criteria that are consistent with assessment goals. These measures are those for which a causal chain can be identified that link the parameter to the environmental phenomenon of immediate concern. Measures can be found in any component (e.g., drivers, linkages, outcomes, and endpoints) of the conceptual models.
6) Sampling schemes are developed using estimates of expected values (or trends) of selected performance measures to assess the state of those measures following management actions.

Monitoring program designers identify indicator measure values that will trigger management responses, and fully consider issues of spatial context (including heterogeneity), temporal resolution and extent, and sample size and units of measure. Monitoring design elements reference back to program and project goals, and conceptual models are necessary tools for developing a sampling scheme that will detect pertinent changes in performance measure and ecosystem attributes. Sampling frequency and replication needed to detect trends in indicators should be based on historical data where possible and power analyses that interrelate the percentage change that can be detected, variance of the parameter, and replication in space and time.

6.4 Exercise: Selecting Indicators in Utah

In this workshop exercise, Utah stakeholders identified potential indicators (e.g., key rates, states, or processes) that could be monitored by managers in “real time,” using the sagebrush community as an example. These indicators would allow managers to track the condition of each priority conservation target, the effects of the threats and stressors on the target, and the effectiveness of various conservation activities intended to benefit the target.

For each box in the conceptual model (i.e., targets, threat/stressors, actions), the stakeholder working groups brainstormed lists of potential indicators (e.g., metrics of status, trends, or key processes and rates). An initial question was posed to the group: "What would you want to know about this target/stressor/action in an ideal world?" This exercise resulted in a lengthy list of potential indicators (i.e., targets, threats/stressors, actions) for each of the boxes in the conceptual model.

For each of the potential actions, we also asked whether or not there was anyone in the state actually pursuing that course of action, and listed the names of agencies and/or programs engaged in the specific types of activities identified in the conceptual model.

For each potential indicator, participants had a brainstorming session to identify group(s) (e.g., state agencies, federal agencies, tribes, NGOs, or academic biologists) that are currently collecting pertinent data within the state at appropriate temporal and spatial scales to adequately inform land and wildlife managers about the condition of the target or the effects of stressors and the effectiveness of conservation activities. This first filter served as an important criterion for reducing the number of prospective indicators to a more manageable number.

The Heinz Center used information gathered during this brainstorming session to create a chart listing potential indicators for sagebrush communities (see Appendix 2).

The chart also includes information about monitoring programs that are currently collecting data associated with these indicators. By collecting and combining data from these various sources, the state of Utah will be able to develop a robust picture of overall ecosystem health in sage and sagebrush ecosystems.

7.0 Towards an Integrated Sampling Design

Because resources for monitoring are extremely limited within state and federal agencies, it is essential to attempt to derive as much benefit as possible from existing monitoring programs.

Current monitoring activities in the United States are a patchwork quilt of projects and programs, each of which has been designed to answer a specific set of questions at particular spatial and temporal scales. Monitoring programs run the gamut from satellite-based approaches that examine changes in continental-scale variables such as ecosystem extent and landscape pattern, to very small-scale approaches focused on a single species at a particular site.

At the state level, many of the existing monitoring programs are narrowly focused on individual species. Among other reasons, this narrow focus can be a result of legal mandates, funding constraints, or state and federal programmatic requirements. Given the limited nature of monitoring resources, managers at both state and federal levels must begin to ask pertinent questions such as:

- *How could we integrate and combine data across monitoring programs to tell us more about the factors affecting all species of conservation interest?*
- *What other variables could we add for little or no cost to our existing monitoring program that would give us extra insights into the species and ecosystems that we manage?*
- *How can we integrate data across multiple monitoring programs to provide us with a broader, large-scale picture of wildlife and ecosystem health?*

One approach to improve efficiency and effectiveness of monitoring is the concept of an integrated monitoring framework. This concept has already been pilot-tested at a variety of scales by the USDA Forest Service and other conservation agencies. An integrated monitoring framework combines data from multiple independent monitoring efforts that are focused on tracking a diversity of species as well as monitoring ecosystem attributes such as vegetation condition, climate, and hydrology. Such a framework can take a variety of different forms depending on the questions that it is intended to address and the spatial and temporal scales at which managers need data in order to make decisions.

7.1 Basic Building Blocks

Integrated monitoring approaches are built using existing monitoring or sampling activities as basic elements or "building blocks." Some of the elements that are commonly mentioned by wildlife managers and monitoring experts as essential components of an integrated monitoring approach include:

- Vegetation monitoring (composition, extent, structure)
- Monitoring of key vertebrate species, especially species that track important processes, states, and rates
- Monitoring of water quantity and quality (for aquatic systems)
- Monitoring of climatic variables
- Monitoring of the frequency and magnitude of disturbance events

Other building blocks can be added depending on the particular system of interest (e.g., a component measuring fluvial geomorphology could be added to monitoring efforts focused on riparian/riverine systems).

It is worth noting that information about animal populations, both vertebrate species as well as invertebrates, could potentially provide managers with data about any of the other basic "building blocks." Certain bird species, for example, only nest in areas that have a particular vegetation structure or species composition. Likewise, benthic macroinvertebrates are commonly used as indicators of the quality of aquatic systems, with certain species characteristic of intact systems while other species are characteristic of degraded systems.

Changes in the phenology or timing of life history events in animal species (and plant species too) are frequently discussed in the scientific literature as "early warning" indicators of global climatic change. And many animal species are sensitive to various forms of disturbance and are found in reduced numbers in disturbed areas. Similar arguments can also be advanced for plant species, many of which are also sensitive to various environmental threats and stressors.

7.2 Moving from Disparate Monitoring Efforts to Integrated Sampling

In Utah, the Division of Wildlife Resources and its partners already have a large number of individual species- or taxon-specific monitoring efforts deployed across the state. Such efforts could potentially serve as building blocks for an integrated approach. However, since these monitoring programs were generally designed to assess status and population trends in individual species or suites of closely related species, there may be incompatibilities between the individual monitoring programs (for example having different temporal or spatial sampling schemes) which could in turn lead to problems with comparing data across multiple monitoring programs. To build a more robust picture of ecosystem health and environmental condition, managers will want to improve coordination across the existing programs and move towards compatible data collection efforts.

7.2.1 Steps to Integrate Monitoring

Though improving coordination may seem like a daunting task to agencies already strained in their capacity, the process can be made easier by using systems already in place. The literature on integrated sampling suggests that the following series of steps can help integrate multiple disparate monitoring activities across a broad landscape.

- **Define the landscape of interest**. Generally the landscape of interest can be defined by a large-scale vegetation community, ecosystem, watershed, or by a unit of human geography such as a county, region, or major municipality.
- **Map the existing monitoring activities**. The agency and its partners can map the localities at which data are currently being collected using paper maps or, better yet, Geographic Information Systems (GIS). For each point, sampling transect, or sampling array, it is useful to know what data are being collected at that site and at what frequency.
- **Identify areas of overlap** where monitoring activities might be combined or integrated. Look for areas on the map where monitoring activities are already

occurring within close physical proximity. Determine whether or not there might be efficiencies in combining monitoring efforts at these sites.

- **Identify the desired temporal sampling frequency** and ideal spatial sampling density for each element, and for the system as a whole.
- Identify and take the specific steps needed in order to **bring activities into a standard temporal and spatial sampling frame**.

7.2.2 Steps in Action

7.2.2.1 Mapping Existing Monitoring in Utah

Mapping existing monitoring sites is a valuable contribution towards better integration across wildlife monitoring programs. Although the groups at the workshops in Salt Lake City and Price did not map existing locations of monitoring activities, these mapping exercises could easily be the focus of a follow-up workshop. The Utah Division of Wildlife Resources has mapped its existing bird and wildlife monitoring sites, and such maps could be combined with spatial data from other state, federal, academic, and private-sector monitoring programs using standard GIS technology. These maps could be compared against vegetation, land cover, and hydrological data layers to identify gaps in statewide monitoring and also identify areas where overlap between monitoring activities might exist. Mapping existing monitoring sites is the first step towards determining the degree of overlap between the existing monitoring programs and identifying portions of the landscape that are already being adequately sampled for key fish, wildlife, and plant resources.

7.2.2.2 Identifying Areas of Overlap

The next step involves determining whether any of these monitoring programs are in fact sampling at the same sites or same areas of the landscape, and whether it might make sense to integrate monitoring activities at these particular sites. Such comparisons can be done in the first approximation by simply inspecting the map of monitoring sites. Beyond this initial analysis, in-depth conversations are needed between program managers to discuss whether joint data collection activities are feasible.

Targeted meetings between the individual monitoring program managers in the state would be a valuable next step towards assessing the possibility of joint data collection by the staff of particular monitoring programs.

7.2.2.3 Identifying Desired Spatial and Temporal Scales

Since we are interested in making larger-scale inferences about the condition of key species and resources across broader landscapes, it is also necessary to determine whether the existing monitoring programs are collecting data at adequate spatial and temporal scales so that we can make these inferences. A statistical power analysis can be used to determine whether there are adequate numbers of sampling sites for each of the key species or ecosystem elements across a given landscape, and whether sampling is being conducted at appropriate temporal intervals in order to provide managers with the information they need.

In designing a spatially and temporally explicit sampling approach, managers are usually asked to start by identifying the degree or percentage of change they wish to detect, the level of error in measurements they are willing to accept, and also provide some basic information about the probability of detection for each species or resources.

Bayesian statistical analysis can then be used to specify the number of sampling sites and the frequency of sampling that is needed in order to achieve the level of precision in measurements that is desired. This form of analysis is helpful if an agency or its partners has the capacity to add additional monitoring sites. Such an analysis can also be useful even when additional sites cannot be added, because it can help managers determine exactly what magnitude of change in species, resources, and ecosystems can actually be detected by existing monitoring efforts. Assistance in designing and implementing such an analysis can be provided by statisticians or USGS wildlife biologists.

Even in the absence of a formal statistical analysis, managers can make significant strides towards integrating monitoring programs simply by increasing the communication and coordination between administrators of individual monitoring programs within a defined geographic area. Significant steps forward can be made with simple activities such as adopting a compatible temporal sampling frame for monitoring activities. By bringing the timing of monitoring programs into alignment, managers can compare population trends across multiple species and begin to investigate how factors such as drought or changes in weather patterns may be affecting entire suites of species.

Managers could also attempt to correlate patterns in species composition and abundance with the temporal and spatial distribution of known stressors. Such correlations can help identify the specific stressors that are directly or indirectly affecting species.

7.3 Putting the Elements Together: Site-specific Integrated Sampling Design for Multiple Taxa and Ecosystem Variables

Another way to combine multiple monitoring activities is to develop a site-based integrated "monitoring frame" that allows managers to collect data on a suite of species and ecosystem attributes at one site.

By combining multiple sampling activities at a single site, managers can directly compare data on species population trends across multiple taxa and compare these trends to other ecosystem attributes measured at the same site. The individual monitoring frames can also be deployed as repeated units using a statistically robust sampling approach (e.g., randomized design) across broader landscapes, which would allow managers to make inferences about changes in species and processes at the landscape or ecosystem scale. Monitoring frames can also be deployed intentionally across elevational and latitudinal gradients in order to investigate changes in species distribution and/or abundance that could be the result of climate change.

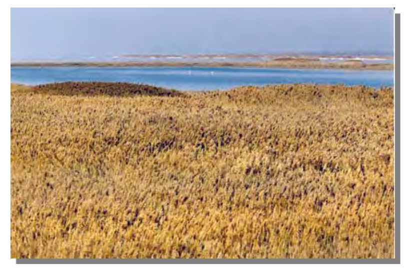


Figure 1 shows a simple integrated monitoring frame which was originally designed by staff at the Utah Division of Wildlife Resources for monitoring multiple wildlife species and ecosystem attributes in grassland or sagebrush communities in Utah. Although the frame was originally intended for a specific context [monitoring the effectiveness of watershed restoration activities], it could certainly be applied in other contexts such as climate-change monitoring or status monitoring of wildlife species and vegetation condition across broad landscapes.

The monitoring frame in Figure 1 incorporates a variety of data collection activities for different vertebrate taxa and different aspects of vegetation structure and composition at a single site. The green lines are vegetation sampling transects, based on the Bureau of Land Management's range assessment protocols which measure species composition, ground cover, and vegetation structure along a set of intersecting linear transects. The red lines are sampling transects for breeding birds and for large mammal scat sampling. The orange boxes are sites where Sherman live traps could be deployed for small mammal sampling. And the blue circles are large-diameter pitfall traps for live amphibian and reptile sampling.

With minor modifications, this sampling frame could be adapted for monitoring a wide variety of terrestrial ecosystems. In forest ecosystems, for example, managers may wish to incorporate traditional measures of stand density and forest structure as part of the vegetation monitoring component. Sampling for other taxa could also be added to the basic framework. For example, small-diameter pitfall traps could be added to sample ants and terrestrial beetles, or yellow pan traps for solitary bees and other pollinators.

Components of the monitoring frame could also be added to existing monitoring sites to complement ongoing data collection activities. For example, a vegetation monitoring component could be added at existing avian monitoring sites to examine how changes in vegetation structure and composition are associated with changes in the avifauna. Or riparian vegetation monitoring could be added at existing fish monitoring sites to examine how changes in riparian vegetation structure and density are associated with changes in fish populations. These additions would complement the existing data collection efforts and provide managers with the ability to draw broader inferences about the effectiveness of management activities from multiple data sources. Such comparisons are essential for drawing inferential causal linkages between management activities which focus on habitat restoration, changes in key habitat parameters such as vegetation structure and composition, and changes in the target fish and wildlife populations that are ultimately the focus of management.

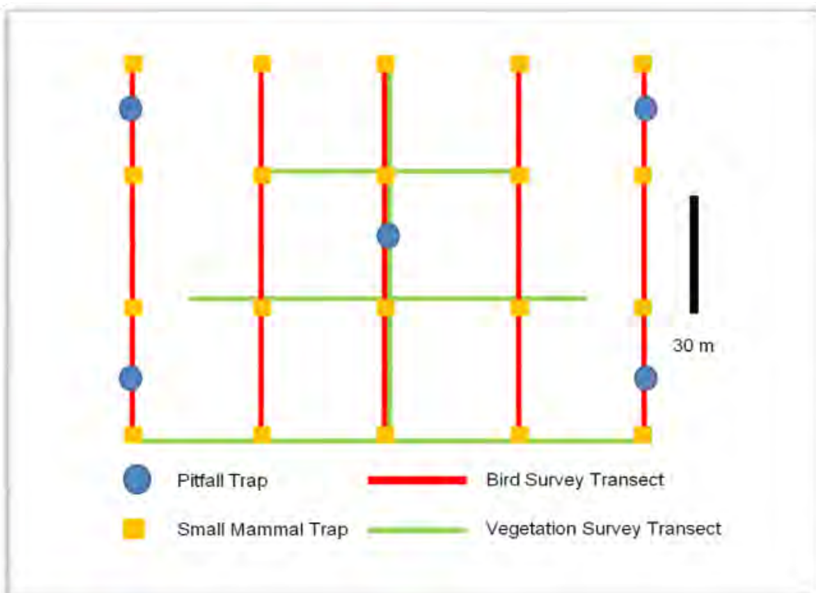


Figure 1: Integrated sampling design that includes sampling activities for multiple plant and animal taxa at a single site. This basic sampling unit may be replicated across broader landscapes or across elevational or latitudinal gradients in order to collect data at appropriate spatial and temporal scales necessary for answering particular questions related to wildlife and ecosystem management.

Workshop participants discussed some specific ways to build upon the UDWR sampling design in Figure 1. This included the possibility of overlaying additional information, such as BLM's Range Trend dataset, remote sensing data to observe effects of fragmentation, and/or presence/absence data for pygmy rabbits, mule deer, and sage grouse. The group also discussed stressors which may or may not be captured by these programs, and where such additional datasets might exist or be added. In particular they mentioned plant insects and pathogens (only large infestations are captured by the Range Trend study); energy development, recreational use, urban/suburban development; water development and groundwater mining (which may be available through the

Utah Division of Water Rights); and "uncharacteristic" fire data, which could be gathered through interagency first maps or potentially LANDFIRE data.

7.4 Strategies Towards More Robust Sampling

As monitoring programs in the state of Utah continue to develop and mature, program managers will undoubtedly have opportunities to build stronger connections with other monitoring programs at the state, federal, and local levels, thereby enhancing their own sampling efforts in a variety of ways. The literature on monitoring of wildlife and ecosystems provides a set of general guiding principles that are worth considering whenever the opportunity to improve a monitoring program arises. Managers should be encouraged to "think outside the box" and explore creative ways to enhance and expand existing monitoring efforts. The following activities are some practical suggestions for improvements from the literature on monitoring programs.

- **Identify opportunities for collaboration and coordination across existing monitoring programs.**

  Managers may be able to achieve efficiencies by identifying specific sites and areas where multiple taxa of management interest could be sampled by a single field crew. Training an existing field crew to collect additional data may be less expensive than deploying an entirely new field crew to sample the same sites. Under certain circumstances it may be possible to add simple yet informative monitoring protocols to existing data collection efforts which greatly improve the ability of managers to tell meaningful stories using their data. For example, protocols for assessing vegetation structure could be added to terrestrial bird monitoring efforts, or water quality monitoring could be added to existing fish sampling activities.

  Even the simple act of synchronizing the timing of data collection can be beneficial. By collecting samples at similar times, managers can compare responses of species to known stressors and determine which species are most strongly affected by particular stressors.

  Managers can also track the effects of management activities across multiple species and determine which management actions are most valuable for addressing the effects of particular stressors on particular species.

- **Use statistical methods to identify under-sampled areas within the broader landscape.**

  Statistical approaches can be used to identify areas of the landscape that are currently being under-sampled by existing monitoring programs. New monitoring activities for the species in question could then be directed towards sites in the under-sampled areas. Such sites could contribute important new data on species distributions and population size, and also enhance our ability to make inferences about one or more species across the broader landscape.

By adding additional sites, managers may be able to improve their ability to detect overall population trends, correlate species trends with trends in other environmental variables, and measure quantitatively the effectiveness of management activities. This form of analysis can be extremely valuable in identifying specific sites where new monitoring activities could take place if/when additional resources became available.

- **Add sites along elevational and latitudinal gradients, in order to track the effects of environmental change on wildlife and other important natural resources.**

Current projections suggest that the distributions of many wildlife species are expected to shift northward and upward along latitudinal and elevational gradients. By ensuring that a given sampling design includes sites distributed along these gradients, managers should be able to determine whether or not the distributions of species of management interest are in fact shifting, and what these shifts might be associated with.

- **Invest in permanent "sentinel sites" where long-term monitoring will occur.**

There is great value for wildlife and natural resource managers in establishing long-term monitoring programs that will give managers information about trends in species populations and key ecosystem variables. Long-term data sets have been very helpful in analysis of large-scale phenomena or changes in vegetation communities. Managers may wish to establish permanent "sentinel sites" in their state where a variety of monitoring data will be collected over long-term (decadal or longer) scales.

- **Add new monitoring targets sparingly and only when there is a clear management imperative or other compelling reason to do so.**

New monitoring programs are expensive and require significant investments of staff time and resources. Whenever possible, managers should look for efficiencies in existing monitoring programs. This means attempting to address new and emerging concerns using existing resources (staff time and funding).

8.0 Monitoring Programs

A variety of agencies and organizations use different methods for wildlife management and monitoring activities. The data captured through these activities is ideally meant to inform management in an adaptive management context. This chapter provides an overview of various data collection efforts described by

Utah workshop participants, as well as more specific discussions around monitoring activities in sage and sagebrush systems, lowland riparian zones, and flowing waters.

8.1 Review of Existing Monitoring Efforts in Utah

The workshop provided an opportunity for participants to discuss the monitoring programs their agencies engage in throughout the state which help meet the goals of the state Comprehensive Wildlife Management Strategy. Workshop participants were asked to describe the monitoring efforts within their agency or organization. Responses shared during this session are described below.

8.1.1 Utah Division of Wildlife Resources (UDWR)

The Utah DWR conducts a variety of monitoring activities statewide, including initiatives under the Partners in Flight, Big Game, Native Aquatics, and Sensitive Species Programs.

Partners in Flight Program

UDWR Partners in Flight program conducts or partners in a variety of monitoring programs. Of note is the integrated monitoring framework they are developing for habitat communities in the state, which is discussed in greater detail in Section 7.3. Other specific programs include regional surveys for passerines, colonial waterbirds, and regional shorebirds. Collaborative efforts include work with U.S. Fish and Wildlife Service-based regional surveys on the long-billed curlew, eagle, and plover. They also work with U.S. Department of Agriculture's Forest Service on regional surveys on goshawk, eagle, and owl. Additionally, they partner with the Forest Service's Inventory and Analysis program on regional vegetation surveys and the Southwest REGAP. Partners in Flight also participates in the USGS Breeding Bird Survey (BBS) and the Audubon Society's Christmas Bird Count (CBC), and submits data to the Institute for Bird Populations' Monitoring Avian Productivity and Survivorship (MAPS) program.

Nongame Bird Program

Monitoring of non-game bird species is well established in Utah and the Department has deployed bird monitoring activities throughout the state. A set of riparian bird population survey sites have been maintained since 1990. Bird monitoring has also been incorporated into the performance measures template for the statewide Watershed Restoration Initiative (see section 8.2.5). Monitoring sites for this initiative are intended to track the performance of specific watershed restoration projects. As such, their placement across the broader landscape is not statistically randomized; however, these sampling activities do take advantage of existing vegetative sampling sites and also incorporate data collection activities for small mammals. To give some idea of the scope and scale of the watershed management activities currently underway in Utah, there are 1,600 management projects varying in scale from 500 - 15,000 acres occurring in Utah's shrub-steppe areas alone. A crew of five collects data over a six-month period. Within each project site, there are 3-6 points; at larger sites this number increases to 7-10 points. Currently they have funding to sample 30-50 sites per year for birds, vegetation, and small mammals. The bird data that are being collected are focused on composition rather than species, however the program's managers are also strongly interested in detecting rare bird species as outlined in the SWAP. Vegetation sampling follows standard protocols developed by NRCS and BLM for rangeland assessment purposes. Small mammal traps and pitfall traps for shrews can also be deployed at the monitoring sites. Pellet counts for large mammals can also be incorporated into the design, however many of these larger-bodied species are abundant throughout the areas being monitored and thus pellet counts are of limited management value. A generalized version of the sampling design being used by this monitoring project is shown in Figure 1 (page 32).

For sage grouse, the Department has an ongoing lek count which includes three grouse dog teams.

Big Game Program

Utah's Big Game program captures data primarily on non-sensitive big game species, including:

Bear	For bears in the Camus area of Utah, UDWR has begun to gather DNA hair snares as part of a pilot study they intend to replicate statewide.
Bighorn Sheep	Bighorn sheep are monitored every two years through helicopter surveys. In addition, the department radio collars sheep for population estimates and survival data. Twelve GPS collars track sheep movements from their winter range through their migration routes, as well as their interactions with domestic sheep.
Bison	Bison are monitored through annual helicopter surveys and classification data projects. In 2011, the department will collar 80 animals as part of a research project to monitor species habitat use and survival.
Cougar	By collaring cougars, the Department obtains predator-prey interaction data (specifically related to deer).
Elk	UDWR gathered elk population trend data over the last 20 years through 3-year helicopter surveys. They also collect cow (female elk) productivity data via annual classification monitoring, as well as additional species data through localized projects (i.e., 2 monitoring units collared 30 animals to track their movements and habitat use).

Pronghorn	Pronghorn counts conducted annually through fixed-wing trend flights. In the future they hope to use a distance sampling design.
Moose	Moose are currently monitored through health flights every three years. More intense monitoring may be conducted in the future in response to interest in climate change effects.
Mule deer	Mule deer information includes annual classification data going back to the 1950s, as well as recent survival data gathered by eight monitoring units state-wide from 30 collared does and 30 collared fawns.
Sage grouse	Annual lek counts are carried out at all known sage grouse and Gunnison grouse sites. A variety of research projects also take place to monitor the populations.

One monitoring partnership of note for UDWR's big game department is their Big Game Range Trend Studies Program, a collaboration between BLM, USDA Forest Service, and Utah DWR. All data and information from this program is available online (http://wildlife.utah.gov/range/), including maps, reference information, transact layouts, soil information, browse information, and herbaceous understory data. Data is collected at over 125 sites statewide during summer months and analyzed during winter months. Species data collected through the program include nested frequency plots, strip frequency from browse transects, canopy cover/line intercept approach, leader growth, pellet information, and browse characteristics including age class distribution, utilization, and condition. This program is a departure from the historical objective of monitoring only to determine target population size. Information gathered is much broader, as is seen in the desirable condition index developed for mule deer.

Utah is also participating in the Western Governor's Association Wildlife Corridors Initiative, which will create a new decision support tool for use in a variety of wildlife management situations in Utah and adjoining states.

Endangered Species Program

UDWR's endangered species program monitors basic distribution of species, starting with raptors, pygmy rabbits, curlews, and peregrine falcons. In the future they hope to add other lesser-known species to their monitoring scheme. Some occurrence data is available for other wildlife depending on the species within each region. In addition, baseline survey data exists for certain species, however they have been unable to conduct systematic surveys that cover an entire landscape.

Aquatics Program

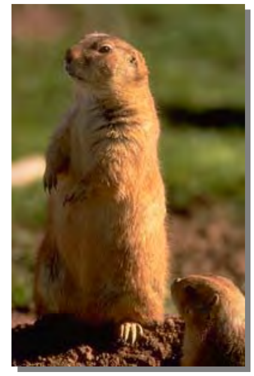
The state's aquatics monitoring program has a species focus through conservation agreements (e.g., suckers, roundtail chub). They conduct boreal toad monitoring, and in the future will incorporate other lesser-known species on a rotational basis (e.g., speckled dace). In terms of data management, the aquatics program is currently developing a database for the Upper Colorado River Recovery Program that will eventually contain over 20 years of data for three species of endangered fish throughout the Colorado River system. The program also submits data to the Utah Natural Heritage Program database (although on a limited basis). At the moment UDWR's sport fish program has its own separate database, however there is hope that collaboration between the two programs will improve in the future.

8.1.2 Utah Bureau of Land Management (UT BLM)

BLM offices throughout Utah are conducting a variety of monitoring efforts. During the workshop, participants focused on a few programs. A number of raptor studies are in process, such as raptor nest monitoring (including ten years of data on raptors in the west desert) through the BLM field office in Filmore, Utah. This project is run in conjunction with HawkWatch International and the Raptor Inventory Nest Survey (RINS). There is also a raptor geodatabase which uses new data and includes older data sets as they are digitized. In addition, roughly 12 to 15 years of data on winter raptor routes have been captured by the UT BLM. Other bird monitoring programs include: state-wide surveys for the Mexican Spotted Owl and Southwest Willow Flycatcher; a Western Hummingbird monitoring partnership, monitoring for the Breeding Bird Survey (BBS) in collaboration with USGS; and mid-winter bald eagle surveys.

Aquatic-related monitoring conducted through BLM offices includes a species-level fisheries project run in partnership with Utah State University (USU). Data on macroinvertebrate species collected by BLM and its partners is stored at USU's BugLab. In riparian areas, BLM conducts vegetation monitoring and also acquires project-specific data gathered through Proper Functioning Condition (PFC) assessments of these zones as well as other habitats throughout the state. BLM staff also attend training for the Multiple Indicator Monitoring: Monitoring the Effects of Management on Stream Channels and Streamside Vegetation (MIM) program, which advocates long-term monitoring techniques that can provide useful information about the effects of grazing management and the condition and trend of stream channels and streamside vegetation.

Other data collection efforts include BLM sensitive/key species monitoring, such as presence and absence studies of the pygmy rabbit. More in depth studies also occur, notably Utah prairie dog surveys consisting of 10 to 15 years of habitat monitoring data. White-tailed prairie dog distribution and presence studies are conducted through the Vernal, UT field office.



Big game species monitoring also occurs, through partnership efforts such as the Range Trend Studies program, which includes pre- and post-vegetation treatment and wildlife studies. Recently, there has been an effort to standardize range trend study data across field offices. Additionally, pellet group transect studies as well as species counts are being carried out on big game species.

BLM offices capture many data through their environmental permitting process, for instance those related to oil and gas development projects. Range Land Health data collection is also taking place, as well as data collected through multiple site-specific contractor surveys, although these are mainly presence and absence studies. At the moment, Land Health Assessments are the only data collection effort by BLM that amalgamates data in a central database.

Finally, while not a monitoring program per se, the Great Basin Restoration Initiative (GBRI) is a national project of BLM. State BLM offices that cooperate as Initiative partners include: Utah, Nevada, Oregon, Idaho, and California. GBRI's goal is to address the reduced ecological resilience of the Great Basin caused by cheatgrass, conifer encroachment, and invasives. Major activities include restoring areas of high value, and goals include reversing the cycle of wildfires and weeds. BLM specialists and managers are members of the GBRI team; they offer technical assistance and conduct public outreach/education efforts.

8.1.3 USDA Forest Service

The USDA Forest Service conducts forest-wide monitoring on Forest Service lands, including forest-level wildlife species tracking and plant species monitoring programs. Data collected through Forest Service monitoring efforts in Utah are consistent with those collected on all Forest Service lands country-wide under the agency's National Forest Inventory and Analysis Program (FIA) and National Forest Health Monitoring Program (FHM).

The Forest Service is also currently conducting a forest-wide assessment of Proper Functioning Condition (PFC) on National Forests in Utah. Aspen systems in particular are a priority focus for the agency, which is currently undertaking a rapid assessment of aspen ecosystems in the state, monitoring of aspen regeneration, as well as an aspen vegetation monitoring program.

Examples of Forest Service species-specific monitoring include projects occurring in the Manti National Forest, where migratory birds have been monitored for the past four years. Forest Service biologists have also conducted goshawk monitoring program for 10 years in areas of aspen and spruce, as well as a river cutthroat monitoring program carried out over the past four years.

In addition, the Forest Service has collected 10 years of data on benthic macroinvertebrate on National Forest System units throughout the state, which includes data mainly on flowing waters but also certain riparian habitat information. Forest Service staff also attended the BLM Multiple Indicator Monitoring: Monitoring the Effects of Management on Stream Channels and Streamside Vegetation (MIM) training program.

Most recently, the Forest Service has begun a new range trend analysis study using models on species and ground cover, which includes photo monitoring. Additionally, the Forest Service conducts a noxious weed inventory and performs treatment effectiveness monitoring at least annually. The agency has a fuels monitoring program (e.g., tons per acre, fuel moisture content) and monitors to capture stand level examination data.

The agency also engages in joint monitoring programs with federal and state agency partners. For instance, the Forest Service has run a sage grouse collaring program in partnership with the Utah Division of Wildlife Resources for the last three years. They also have a rare plant monitoring program in cooperation with UT BLM and the National Park Service (NPS) that tracks over 20 rare, sensitive, listed, and/or threatened and endangered plant species.

The Forest Service operates the Provo Shrub Sciences Lab, where scientists conduct original research and collaborate with researchers and managers from private and public universities and state, federal, and foreign agencies on aspects of shrub and shrubland biology, ecology, and management. Specific areas of research include: natural and human-caused fire regimes, invasives, genetics and genomics, and stability of montane and cold desert rangelands.

8.1.4 HawkWatch International

HawkWatch International carries out specialized data collection efforts focused on raptors as indicators of ecosystem health. Their Great Basin Raptor Nest Survey (GBRNS) project, in cooperation with BLM, provides 10 years of inventory data gathered in northwest Utah. GBRNS is currently undergoing review along with the Raptor Inventory Nest Survey (RINS) to determine feasibility of continued data collection. Another organization endeavor is their Legacy Project, done in cooperation with US Department of Defense, which tracks impacts of cheat grass on nesting species such as raptors, golden eagles, and ferruginous hawks. HawkWatch also gathers data through sporadic wintering raptor surveys. In the future, the organization aims to develop and test models of species' use of landscape, an activity undertaken in other states.

8.1.5 The Nature Conservancy (TNC)

TNC does not conduct much wildlife or habitat monitoring on their lands, however they do participate in site-specific projects run in conjunction with partners. For example, TNC is partnering with BLM at their Dugout Ranch site on rangeland ecological assessment. Additionally, near Moab they partner with BLM and the National Park Service to monitor tamarisk, including a project to observe the leaf beetle's effect on tamarisk. The organization is also working with UDWR on a Colorado cutthroat trout monitoring project.

TNC also performs Landscape Conservation Forecasting (LCF), which has its roots in the LANDFIRE program. LCF is a way to calculate the departure of current landscape condition from the natural range of variability. It is made of up maps, metrics and models. The biophysical settings (BpS) are mapped along with vegetation class. The LCF project has been tested in Fishlake National Forest and Dixie National Forest (both in Utah), and in other places across Utah and Nevada.

8.1.6 The Utah Watershed Restoration Initiative (UWRI)

A partnership of 17 conservation organizations, the Utah Watershed Restoration Initiative addresses "statewide issues of conserving, managing, and restoring Utah's vast and diverse watersheds by integrating the disciplines of soil, water, plants, and animals." Partners include UT DNR, BLM, USDA NRCS, US FWS, USFS, numerous state and federal agencies, and academic institutions. Actions include ecosystem restoration projects, administrative changes in land management, and promoting communication and increased cooperation between the public, stakeholders, and UWRI partner organizations.

8.2 Monitoring Efforts in Sage and Sagebrush Systems

The following sections list the monitoring programs identified by workshop participants during a group discussion on the sagebrush ecosystem, an extensive land cover type in Utah which has multiple agencies and funding sources involved in its protection and monitoring.

8.2.1 Utah Division of Wildlife Resources

UDWR has conducted a number of data collection projects in sage and sagebrush systems throughout the state. For instance, there is a three-year Milford Flat Fire study aimed at investigating distribution of plant species and measuring recruitment and re-establishment following a fire event. The study includes data collection on passerine birds, vegetation, pygmy rabbits, and large mammal pellet counts.

Sagebrush monitoring is also occurring at a county level. For instance, one four-year pilot project is monitoring experimental treatments on the landscape (pre- and post-evaluations). The treatments are intended to improve breeding habitat for sage grouse. Using 17 plots in a 16 kilometer range, this project carries out nest surveys, territorial mapping, and county-wide distribution and abundance monitoring on key sagebrush species such as the Brewer's Sparrow, Vesper Sparrow, Sage Sparrow, and Sage Thrasher. Regional-level data sets also exist, including maps of sagebrush vegetation communities, integrated basin data, remote sensing habitat condition data, cheat grass expansion maps, fire maps, and built or human infrastructure maps.

Several species-specific efforts were mentioned including monitoring of a bald eagle route through this vegetation type (Jim Parish); annual surveys of grouse, ferret, and pronghorn conducted by sensitive species biologists in the northeastern region of the state; and studies of sage connectivity and sage grouse using GIS (Mickey Frye). For this last project participants noted that there is a similar study being conducted simultaneously by the Wildlife Society. UDWR's mule deer survey in the sagebrush (run by Kent Hersey) was also discussed with specific interest in the monitoring design techniques and the vegetation data collection, including elements such as estimated canopy cover, percent cover for bare ground, litter, rock, and pavement. In addition to this study, UDWR has historically done pellet counts and animal collaring in these habitats. BLM has established a study agreement with UDWR to overlay range trend data with bird counts in areas occupied by sage grouse. This project is based on a six to seven year dataset and focuses on southwest Utah.

Lastly, participants suggested that an assessment tied to big game species monitoring might be useful. Specifically, they suggested that the program gather additional parameters, beyond species presence and absence data, to help gauge sagebrush system health.

8.2.2 Utah Bureau of Land Management (UT BLM)

UT BLM conducts many studies and field investigations that yield data about extent and condition of sage and sagebrush ecosystems. BLM's classic range trend studies have been conducted for many decades with the primary purpose of determining grazing livestock occurrences and trends. These studies are focused on key grassland and forage species, with sampling taking place every two to 10 years depending on the site. Within the agency, there has been an effort to standardize these studies across field offices. Vegetation data from these studies is also helpful in tracking long-term changes in sagebrush communities. In cooperation with UDWR, BLM also collects data on mule deer and elk winter ranges, which may include portions of the sagebrush ecosystem. In addition, the agency has conducted modified step point surveys in prairie dog habitat for approximately 10 years.

UT BLM also has rain cans positioned in some sage communities that are visited annually and climate stations that provide monthly data, as well as RAW (Remote Aerial Weather) stations positioned in sage/sagebrush areas that collect data as part of their fire program. The BLM state office has an air quality specialist who gathers data on information such as soil moisture, temperature, and humidity from a few dozen climate stations scattered across the state. In addition, BLM has established a set of long-term exclosure areas (although sporadically maintained) scattered throughout the state in sagebrush ecosystems which range in size from less than an acre to several acres ranging in size from less than an acre to larger. BLM also conducts invasive vegetation monitoring to treat and map noxious weeds. Additionally, the Intermountain Region office of BLM conducts PFC assessment studies of sagebrush region-wide.

8.2.3 USDA Forest Service

The Forest Service collects Forest Inventory and Analysis (FIA) data on vegetation cover in sage and sagebrush ecosystems. They also have some site-specific projects, for instance at the Ashley National Forest in northeast Utah there is a comprehensive trend monitoring program tracking species cover, bare ground percentage, and other factors (Sherel Goodrich). The Manti La Sal National Forest also conducts migratory bird counts, sage grouse counts, and maintains photo plots in treatment areas in sage and sagebrush ecosystems.

8.2.4 HawkWatch International

As mentioned in Section 8.1.4, HawkWatch's Great Basin Raptor Nest Survey (GBRNS) project is an extensive 10-year survey in northwest Utah that includes basic inventories of raptor species with some focused studies on golden eagle, ferruginous hawk, and burrowing owl. Although not specific to the sage system, they do look at densities of species in areas with cheat grass encroachment. Aerial photography and GIS vegetation data are both gathered as part of this study. In addition, they have a second project which looks at prey abundance across different vegetation systems including sagebrush.

8.2.5 Other Partners

Workshop participants mentioned several monitoring programs conducted by wildlife management partners not represented at the workshop. This includes climate data being collected daily by Utah State University's Utah Climate Center; pygmy rabbit studies conducted by Brigham Young University (BYU); a US Fish and Wildlife Service regional survey on long-billed curlew covering a few hundred plots statewide; and some USGS Breeding Bird Survey routes in sagebrush (with approximately 87 sites at least partially in sage). The Audubon Society's Christmas Bird Count may also have some sites in these habitats. Participants also noted that roadkill data is available, and suggested linking to ongoing genetic studies as an additional data source.

Much work specific to the monitoring of sage grouse is being conducted as well. Partners run approximately six to 12 grouse studies throughout the state investigating the treatment, survival, predation, reintroductions, population movements, and so on of the species. For example, BYU (Randy Larsen) examines sage grouse habitat modeling in northeast Utah. Sage grouse lek counts are also being conducted statewide.

Lastly, the state's Watershed Restoration Initiative has a number of study sites to monitor sagebrush wildlife and habitat in the state. WRI includes restoration activities (e.g., mechanical removal, reseeding) as well as monitoring. Typically they have 30 to 40 treated projects. The average project covers 1,000 acres, however some can span to over 500,000 acres. Their vegetation monitoring looks at nested frequency of plots down to a species level on every grass and forb area regardless of dryness, and also tracks species composition and canopy cover. Plots are set up on a five-year rotational cycle, with data collected once per cycle in each region.

8.2.6 Challenges

Several challenges to monitoring within the sage community were noted by workshop participants. Mapping of the extent and condition of current vegetation was identified as a key limiting factor to improved monitoring and management of sage and sagebrush ecosystems. Remote sensing data provide a relatively low-cost way to monitor extent of sagebrush cover, but interpretation of stand condition and suitability for wildlife species (particularly sage grouse) is problematic using remotely sensed data. With regards to ground-based monitoring, coverage of the sagebrush ecosystems of Utah is uneven, and some portions of this ecosystem receive more monitoring attention than others. Finally, participants noted the potential for improved collaboration and communication with neighboring states which also share sage and sagebrush communities with Utah.

8.3 Monitoring Efforts in Lowland Riparian Zones

Approximately 12 workshop participants took part in a small group discussion on the suite of monitoring programs relevant to lowland riparian systems in the state. Although the majority of the discussion centered around a review of ongoing data collection efforts, the group also discussed the identification and selection of appropriate indicators for ecosystem condition and function.

Group members felt that species should function as both targets of the monitoring programs, as well as potential indicators of ecosystem condition. Probably the most important measure of overall ecosystem health in Utah's lowland riparian systems is the diversity of species found in the system. Participants felt that wildlife managers should monitor species diversity and abundance over time for a suite of species (e.g., short distance migratory species, long distance migratory species, insectivores, etc.) in order to properly gauge riparian area health. This recommendation acknowledges the fact that our knowledge base is not robust enough to identify particular species as indicators for specific ecosystem parameters.

For the lowland riparian zones there are several well-designed sampling schemes that are currently being applied at sites around the state and could be used as the basis of a multi-taxa approach to monitoring. These include standard techniques for monitoring macroinvertebrates, as well as vegetation assessments and bird species monitoring. The riparian bird monitoring program that is currently being conducted by UDWR is a particularly robust sampling protocol around which other sampling efforts could be built.

The group discussion of indicators for monitoring riparian system health focused on such measures as overall species diversity or density of breeding birds, rather than individual indicator species. The group did discuss potential indicator bird species, recommending a combination of flagship species such as the Southwestern Willow Flycatcher, Yellow-billed Cuckoo, and Bell's Vireo, as well as more common bird species such as the Spotted Towhee, Warbling Vireo, Yellow Warbler, and others that are permanent, non-migratory residents and/or species which nest in riparian area. The group acknowledged the challenges associated with monitoring migratory birds, given the uncertainty introduced when birds are away from the study site on migration The lack of sampling for vegetation in riparian areas was noted and identified as a key "data gap."

The group discussed other data collection efforts that could be combined or integrated with data from the avian surveys. For instance, data on macroinvertebrates, water quality, and aquatic habitats are being collected by Utah State University's BugLab. There are also a number of ongoing fish surveys and inventories, as well as species-specific amphibian surveys. UDNR reports amphibian sightings in these areas when conducting monitoring for other species; however, such monitoring is necessarily opportunistic and limited.

Lastly, the group discussed data sharing between agencies, and the need to combine and compare data from different sources to improve our scientific knowledge of riparian systems as well as our understanding of how best to manage these systems. BLM's Proper Functioning Condition (PFCs) assessment program was cited as an important asset for data and mapping resources.

8.3.1 Challenges and Opportunities

The group was asked to consider hypothetically what the relationship between water quality monitoring, avian modeling, and vegetation modeling would look like in a riparian system. Members felt that integration of such monitoring was necessary for the system, however they also discussed a number of challenges including a lack of resources - specifically staff. They also discussed what scale, project, or program might be most appropriate for such an endeavor, noting that there are some challenges to imposing a broader scale monitoring scheme. Participants discussed the potential for a pilot project convening aquatic and habitat experts to demonstrate their monitoring successes, and connecting the pilot to management in a tractable way beyond standard annual reporting.

8.4 Monitoring Efforts in Flowing Waters

The group discussion on aquatic systems also included a consideration of the important ecological category of flowing waters. This conversation focused primarily on ongoing monitoring efforts.

Participants noted that the Utah Department of Water Quality (UT DWQ) conducts a variety of monitoring efforts in flowing waters. UT DWQ tracks macroinvertebrates at hundreds of sites statewide. These data are also shared with BLM's Bug Lab. Additionally, UT DWQ measures water quality, timing and volume in flowing waters throughout the state. They also conduct habitat monitoring using standard measures of water clarity and stream structure in flowing waters statewide.

In flowing waters, the US Forest Service surveys native and non-native fish through an annual presence/absence survey which investigates quality of stream habitats, non-native species, and specific native species like cut-throat trout. An overall inventory of the annual USFS surveys is in the initial stages.

The Utah Department of Natural Resources (UT DNR) was recognized as another source of ongoing monitoring information. UT DNR conducts population estimates and distribution surveys for fish species in flowing waters, tracking fish movement and recruitment. UT DNR has been removing non-native fish species for over 20 years, including northern pike (in 2001) and smallmouth bass (in 2004), along with other non-natives such as walleye and common carp. The agency is also active in monitoring sport fish, which they stock throughout the state.

UT DNR also monitors the upper Colorado River, which covers approximately one-fifth of the state.

Lastly it was noted that UT DNR monitors endangered fish and aquatic species. Variables that are tracked through this monitoring include fish movement, distribution, habitat use, and the age (juvenile vs. adult) of populations.

8.4.1 Integrated Sample Approach for Flowing Waters

After the discussion on monitoring efforts, the group brainstormed an integrated sampling approach that could be applied to flowing waters or riparian zones. Participants suggested it could be designed with four primary sources of existing data. First, it could incorporate the state of Utah's water quality monitoring data, which includes information about macroinvertebrate communities and water chemistry. State bird monitoring was cited as another source, in part because there are robust sampling protocols for birds and a sampling frame is already in place. Vegetation monitoring could be a third component, although it was acknowledged that there were fewer current vegetation monitoring activities in the state's riparian areas. Some data is already collected on vegetation in riparian zones, including at bird sites.

A fourth and final element of an integrated sampling approach could incorporate the wide spectrum of state and federal fish monitoring and assessment activities, which covers a broad range of listed, rare, and game species, as well as other aquatic taxa.

A workshop on monitoring of springs and springbrook ecosystems, to be held jointly between the states of Nevada and Utah, would be a potential venue for furthering discussions on the flowing waters systems discussed during the workshop.

9.0 Using Data in an Adaptive Management Context

The Utah workshop discussions highlighted a number of challenges and opportunities related to the actual use of wildlife and ecosystem data in an adaptive management context. Participants envisioned that UDWR habitat managers could work with BLM managers and other partners to develop projects together. Beyond state borders, they saw the possibility for an inter-state workshop between Nevada and Utah focused on springs and springbrooks habitat, to allow for collaboration between BLM, UDWR, and other partners. Participants also felt that an annual workplan containing information on all partner activities at the state level would be very useful.

In general, many of the challenges observed in Utah are widespread and systemic in agencies and organizations throughout the country. They range from lack of funding, lack of staff and lack of appropriate technology to a lack of understanding and support at higher levels within the organization.

Data is in itself a big part of the problem. Because our system of collecting data was not designed to incorporate our findings into decision making, much of the data collected through costly and labor-intensive monitoring efforts reaches a dead end in a single report. Not only are there no national standards for how to collect data (e.g., how frequently or in what units we measure), data is not systematically catalogued or uploaded into a database. To be relevant in a web-oriented world, data systems must be designed to make information easily accessible within an agency or organization and easily shared across platforms with conservation partners.

In the past, technological limitations and database incompatibilities prevented organizations and agencies from combining or sharing data sets. However, current developments in web and database technologies are reducing or eliminating these impediments. Advances in technology are creating exciting new opportunities for wildlife and natural resource managers to implement adaptive management approaches. As new projects are funded, all data could be housed in a central database, so that the information remains accessible beyond the life of individual projects. Such a database might include information about habitat, species, and human dimensions data (e.g., recreational surveys). Analyses could then be based on a cumulative body of information and apply cross-cutting data analysis techniques to best inform program planning.

Policy changes are also needed at higher levels outside of the state. For instance, the regulatory apparatus of the National Environmental Policy Act (NEPA) and the funding mechanisms of the North American Wetlands Conservation Act (NAWCA) do not require or pay for monitoring. Identifying dedicated streams of funding for wildlife monitoring, data archiving, and data analysis has the potential to benefit wildlife managers at local, state, and federal levels.

The extreme budget crisis facing all states today makes monitoring critically important for two essential reasons. First, states and agencies must be able to develop a strong narrative in support of their work in order to justify continued funding of their activities. It is in part because we are not able to explain what the data tell us or why it matters that monitoring funding is among the first to be reduced or eliminated. In a fiscal environment where no program is sacred, it is imperative that managers understand what information the decision-makers above them are most interested in and try to collect data - and deliver a strong message - that will meet those needs.

Secondarily, facing a future that is unlikely to include additional funding for monitoring - and a "best case" scenario of maintaining current funding - states and agencies must be able to efficiently utilize their existing financial and staff resources. This may mean making hard choices to abandon programs that are simply no longer relevant, pursuing new training or information systems, or partnering to leverage resources.

Our national system of natural resource management is like many of our iconic governmental systems: it is long overdue for an overhaul. It will take extraordinary leadership to help our wildlife and ecosystems survive the demands of increasing populations, volatile politics, and both environmental and human stressors.

Perhaps the best tool for natural resource managers in this struggle is one that they already have: the ability to collect scientifically credible data on the condition of wildlife and natural resources, and monitor the effectiveness of their conservation activities. In doing so they can learn “what works” from past conservation actions and finally connect this information to sound management actions and policies that will ensure the integrity of our resources for generations.

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Appendices

Appendix 1: Conceptual Models

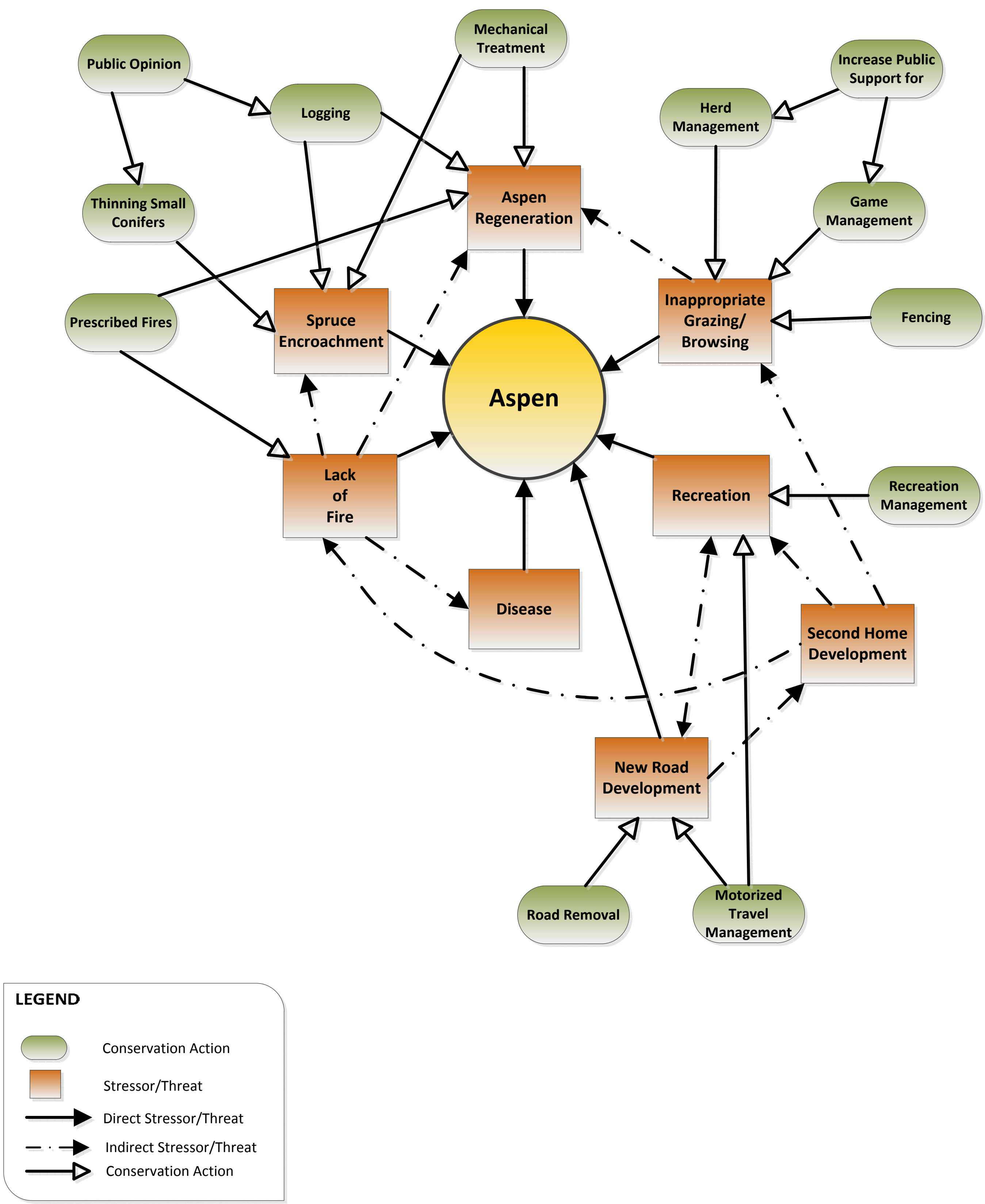
Appendix 2: Lists of Potential Indicators and Monitoring Programs in the Sagebrush Communities

Appendix 3: Workshop Participants List

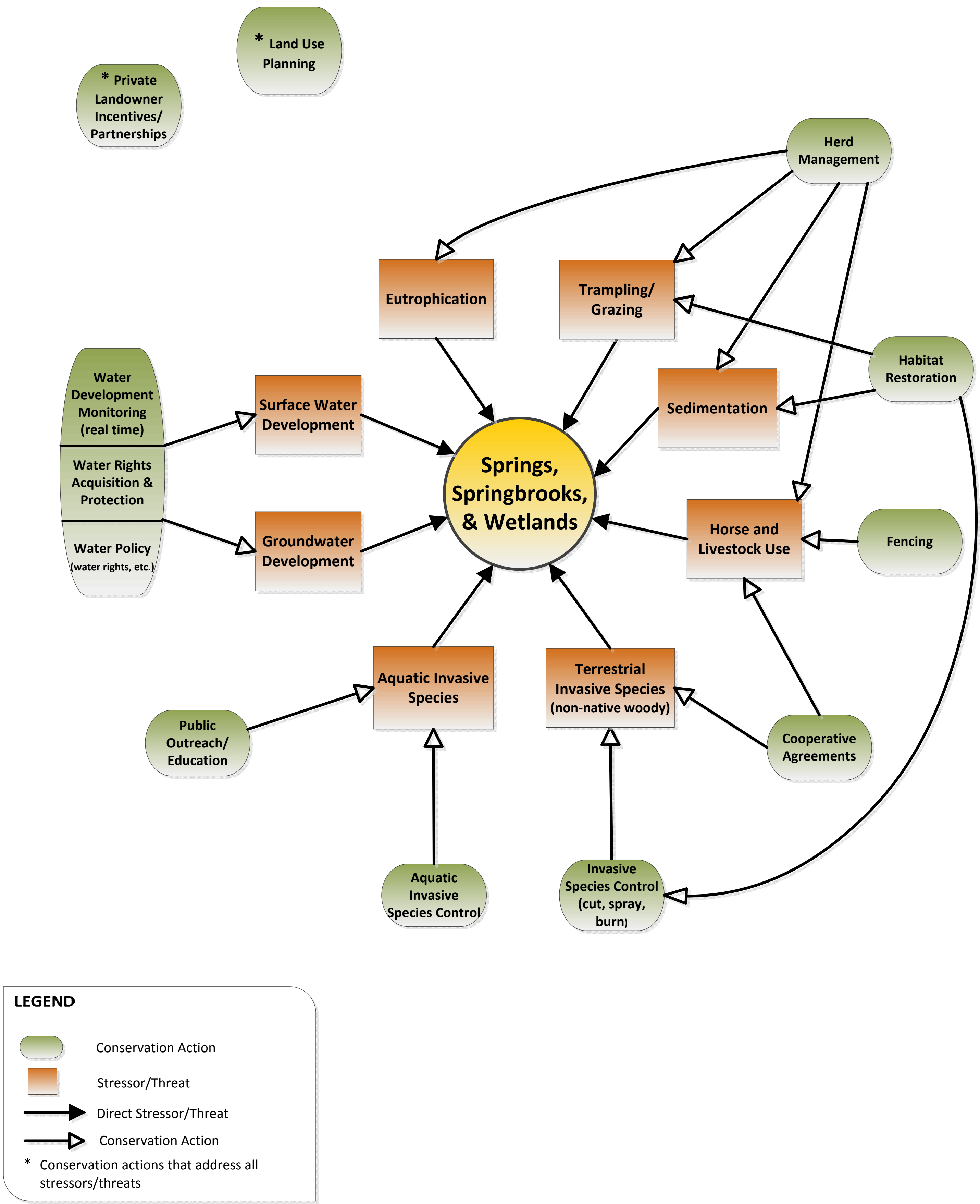
Appendix 4: List of Stressors, Threats, and Desired Conditions for Priority Ecosystems

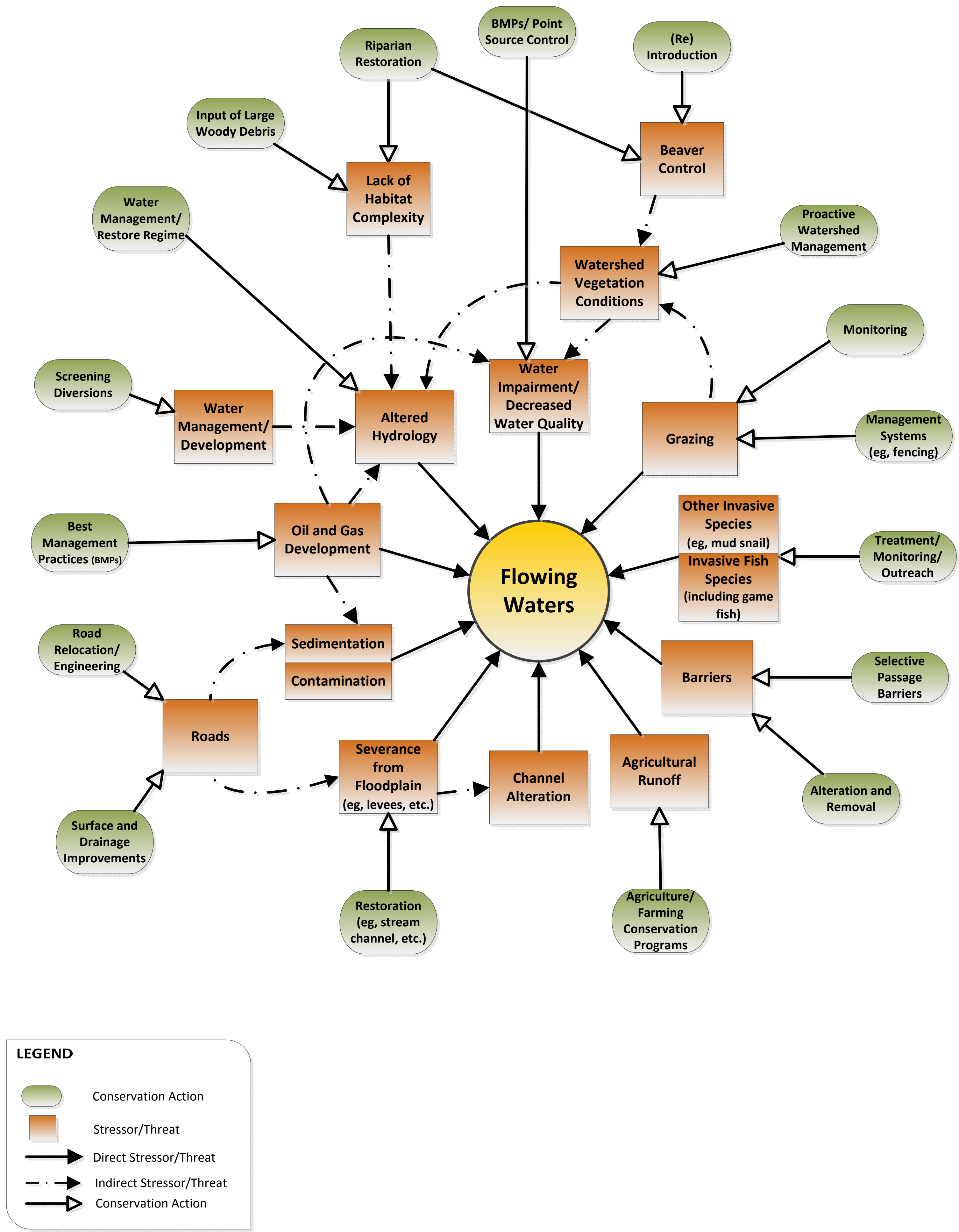
Appendix 1:

Conceptual Models

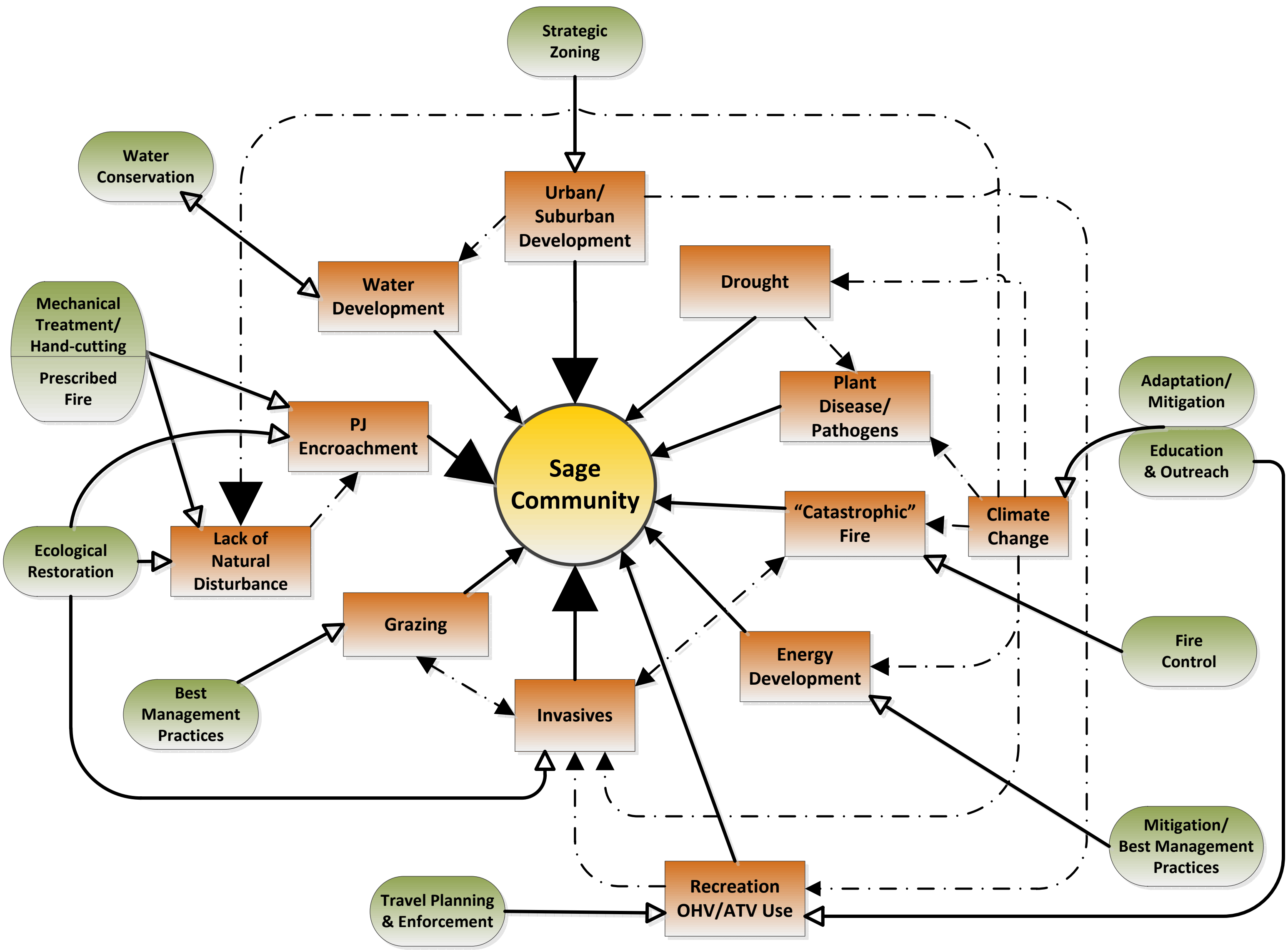


Public Opinion
Mechanical Treatment
Logging
Increase Public Support for
Herd Management
Thinning Small Conifers
Aspen Regeneration
Game Management
Prescribed Fires
Spruce Encroachment
Inappropriate Grazing/ Browsing
Fencing
Aspen
Lack of Fire
Recreation
Recreation Management
Disease
Second Home Development
New Road Development
Road Removal
Motorized Travel Management
LEGEND
Conservation Action
Stressor/Threat
Direct Stressor/Threat
Indirect Stressor/Threat
Conservation Action

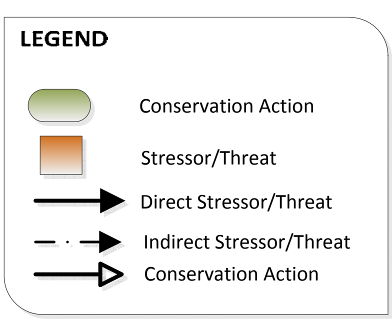

* Private Landowner Incentives/ Partnerships
* Land Use Planning
Herd Management
Eutrophication
Trampling/ Grazing
Habitat Restoration
Water Development Monitoring (real time)
Water Rights Acquisition & Protection
Water Policy (water rights, etc.)
Surface Water Development
Groundwater Development
Sedimentation
Springs, Springbrooks, & Wetlands
Horse and Livestock Use
Fencing
Aquatic Invasive Species
Terrestrial Invasive Species (non-native woody)
Public Outreach/ Education
Cooperative Agreements
Aquatic Invasive Species Control
Invasive Species Control (cut, spray, burn)
LEGEND
Conservation Action
Stressor/Threat
Direct Stressor/Threat
Conservation Action
* Conservation actions that address all stressors/threats



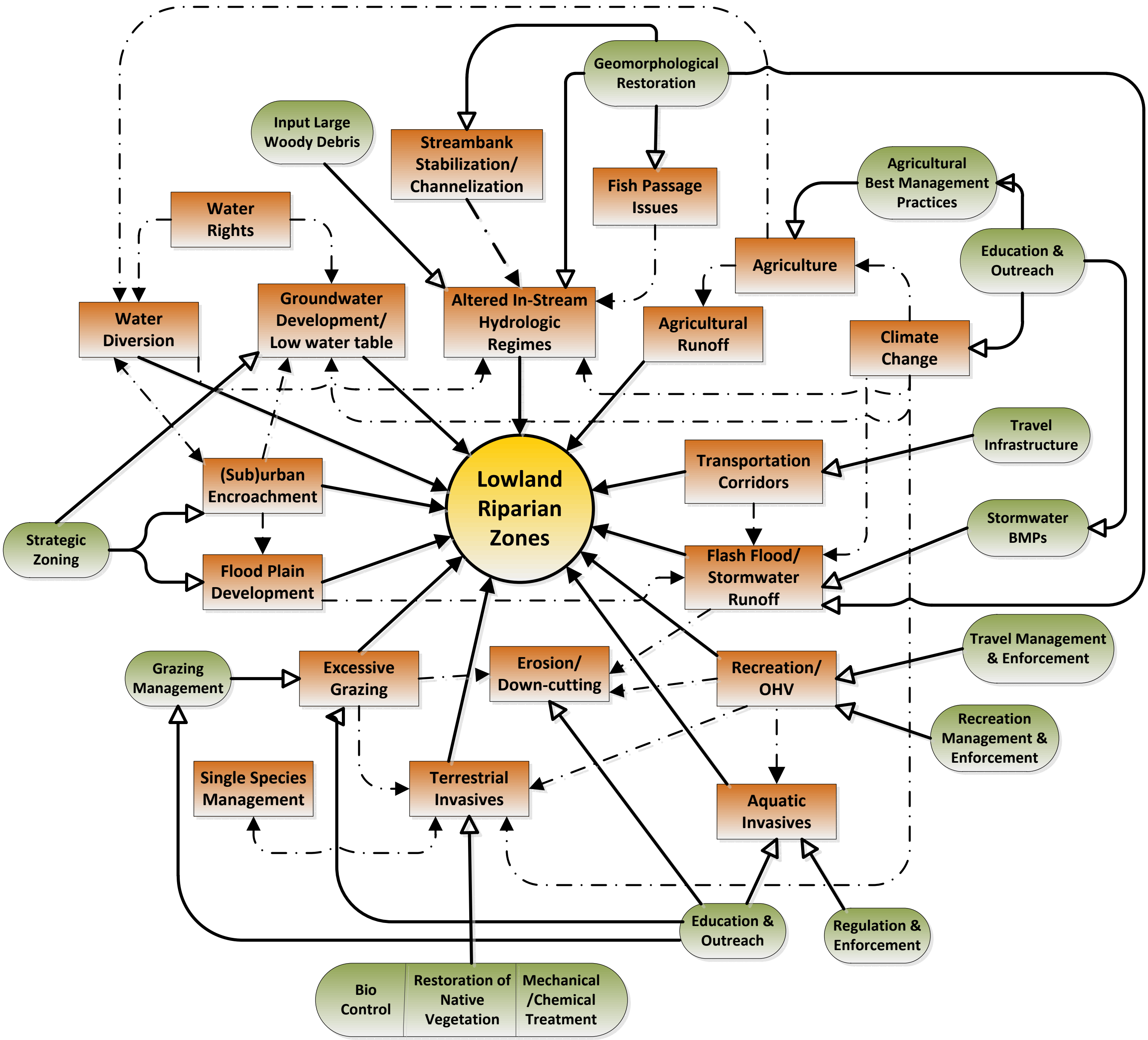
Flowing Waters
Riparian Restoration
BMPs/ Point Source Control
(Re) Introduction
Input of Large Woody Debris
Lack of Habitat Complexity
Beaver Control
Water Management/ Restore Regime
Watershed Vegetation Conditions
Proactive Watershed Management
Monitoring
Screening Diversions
Water Management/ Development
Altered Hydrology
Water Impairment/ Decreased Water Quality
Grazing
Management Systems (eg, fencing)
Best Management Practices (BMPs)
Oil and Gas Development
Other Invasive Species (eg, mud snail)
Invasive Fish Species (including game fish)
Treatment/ Monitoring/ Outreach
Road Relocation/ Engineering
Sedimentation
Contamination
Barriers
Selective Passage Barriers
Roads
Severance from Floodplain (eg, levees, etc.)
Channel Alteration
Agricultural Runoff
Alteration and Removal
Surface and Drainage Improvements
Restoration (eg, stream channel, etc.)
Agriculture/ Farming Conservation Programs
LEGEND
Conservation Action
Stressor/Threat
Direct Stressor/Threat
Indirect Stressor/Threat
Conservation Action



Strategic Zoning
Water Conservation
Urban/ Suburban Development
Water Development
Drought
Mechanical Treatment/ Hand-cutting
Prescribed Fire
PJ Encroachment
Plant Disease/ Pathogens
Adaptation/ Mitigation
Sage Community
Education & Outreach
"Catastrophic" Fire
Climate Change
Ecological Restoration
Lack of Natural Disturbance
Grazing
Energy Development
Fire Control
Best Management Practices
Invasives
Mitigation/ Best Management Practices
Travel Planning & Enforcement
Recreation OHV/ATV Use



LEGEND
Conservation Action
Stressor/Threat
Direct Stressor/Threat
Indirect Stressor/Threat
Conservation Action



LEGEND

Conservation Action

Stressor/Threat

Direct Stressor/Threat

Indirect Stressor/Threat

Conservation Action

Appendix 2:

List of Potential Indicators and Monitoring Programs in the Sagebrush Communities

List of Potential Indicators and Monitoring Programs:
Sagebrush Communities in Utah
September 15, 2010

	Indicator	Monitoring Program		Notes
		Agency	Program Name	
Desired Condition				
Diverse age structure	Age class structure	DWR	Range Trend Studies	
Diverse understory (native)	Understory species diversity and extent	DWR	Range Trend Studies	
Native grasses/forbs	Grass/forb species diversity and extent	DWR	Range Trend Studies	
Inappropriate grazing/less ungulate use (domestic and wildlife)	Grazing/browsing metrics	DWR	? Range Trend Studies	Sampling under Range Trend Studies is too infrequent to assess effects of grazing/browsing
Fire frequency appropriate to sagebrush type	Fire frequency and vegetation response		Landfire	
Large unfragmented blocks with a structural mosaic	Vegetation patch size composition and diversity		Remote sensing imagery	
Diversity of dimensionality in sage community	Stand structure, plant species composition and age structure diversity	DWR	Range Trend Studies	Vertical height diversity is easier to monitor; TNC tool may be useful
Pygmy rabbits and Sage grouse	Presence/absence survey data (if possible, species abundance/ density data)	DWR	Existing and new survey and monitoring programs	Need to articulate different requirements of species in the sage. Pygmy rabbit should not be a sole indicator of sagebrush health, because of its variable presence in the sage; soil type/condition dependent, etc. It's included because it's a candidate for listing. Existing sage grouse monitoring focuses on leks.
Sagebrush obligate passerine birds	Diversity of species, presences/abundance of individual species	DWR	Existing bird monitoring	Opportunity to build on robust existing monitoring protocols.
Mule Deer	Presence/absence survey data (if possible, relative abundance)		Existing and new survey and monitoring programs	Opportunity to integrate with large-scale state big game monitoring programs.
Decreased percentage of invasive species	Percent cover invasive species; number of invasive species	DWR	Range Trend Studies	

List of Potential Indicators and Monitoring Programs:
Sagebrush Communities in Utah

September 15, 2010

	Indicator	Monitoring Program		Notes
		Agency	Program Name	
Stressors/Threats				
Climate change	Temperature, precipitation, other climate data	Weather agencies	Various	
Drought	Precipitation	Weather agencies	Various	
Plant disease/pathogen	Presence of Disease/Pathogen		Forest Health Inventory Database	Disease data base that covers the PJ community; unsure if covers sage
			Trend study	May be picked up if large enough outbreak Overall, no there is no large scale monitoring in the state for plant disease/pathogens.
Water development	Presence of altered water regime	Division of Water Rights	Water rights	Both surface and groundwater development are included here
Development (urban/suburban)	Extent of urban/suburban development		County and State planning offices	
Uncharacteristic Fire	Fire effects on vegetation		Landfire	Any fire more than 10 acres needs to be tracked via GPS
Inappropriate grazing	Grazing/browsing effects on vegetation	BLM/Forest Service	Land utilization tools	Not in Range Trend Studies Tracked on Federal Lands but not private
Introduced grass species	Presence of introduced grasses	DWR	Range Trend Studies	
Invasive species (cheatgrass)	Presence of invasive species	DWR	Range Trend Studies	
Lack of age class diversity	Age class structure	DWR	Range Trend Studies	
Lack of recruitment	Age class structure	DWR	Range Trend Studies	
Energy development	Presence of energy development and associated disturbances	State Div. of Oil, Gas, & Mining	State & Federal tracking efforts	Energy development stressors should also include fragmentation due to roads, power lines, etc.
Pinyon pine/Juniper encroachment	Pinyon pine-Juniper vegetation composition	DWR	Range Trend Studies	
Lack of natural disturbance	Vegetation structure and composition	DWR	Range Trend Studies	
Recreation and OHV/ATV use	Presence of OHV/ATV use; direct signs associated with use	DWR	Aerial photos	Photos can show OHV/ATV use
Insects	Damage to foliage	DWR	? Range Trend Studies	Sagebrush defoliators. Can cause extensive mortality or defoliation in some areas.

List of Potential Indicators and Monitoring Programs:
Sagebrush Communities in Utah
September 15, 2010

	Indicator	Monitoring Program		Notes
		Agency	Program Name	
Conservation Actions			**Conservation Program**	
Education and outreach				
* Climate change	n/a	None	None	
* Recreation & OHV/ATV use	Better informed recreation and OHV user; Reduced ATV impacts	Forest Service		Several programs focus on 4th graders. Successful audience with influence on families/parents. Outreach is part of their core curriculum.
		BLM		
		State DNR		
		DWR		
* Invasive species	Reduced spread of invasive species	BLM		
		Counties	Weeds program	
		Forest Service	Noxious weeds	
		BLM	Noxious weeds	
		DWR	Invasive species group	
Adaptation and mitigation				
* Climate change	n/a			NatureServe CCBI; Vulnerability assessments+E30 Rocky Mountain Research Station
Water conservation (awareness/action)	n/a	DNR		However, these programs are not directed towards wildlife
		Counties	Water Conservation Districts	
Strategic Zoning				
* Development (urban/suburban)	Design of development using wildlife conservation principles	Forest Service input to county planners	Wildlife Urban Interface	Federal agencies provide input to local decision-makers on development issues (e.g., Wasatch front). Participate in active discussions with counties regarding the issue.
Fire Management				
* Uncharacteristic fire	Fire frequency and intensity	DNR		
		BLM		
		Forest Service	Landfire	

List of Potential Indicators and Monitoring Programs:
Sagebrush Communities in Utah
September 15, 2010

	Indicator	Monitoring Program: Agency	Monitoring Program: Program Name	Notes
Best Management Practices (BMPs)				
* Grazing	Sage in mixed age classes supporting diverse wildlife	Forest Service	Forest Plant Standards, AMUs	
		BLM	Grazing standards on permits; Rangeland health	
Energy development mitigation and BMPs				
* Energy Development	Design of development using wildlife conservation principles, and minimized disturbance footprint	Forest service		
		BLM		
Ecological restoration (e.g., reseed)				
* Lack of natural disturbance, PJ encroachment, lack of recruitment, introduced grass species, invasive species (cheatgrass)	Sage in mixed age classes supporting diverse wildlife	DWR	Multiple programs	
		BLM	Multiple programs	
		Forest Service	Multiple programs	
		DNR	Multiple programs	
Prescribed Fires for PJ				
* Lack of natural disturbance	Sage in mixed age classes supporting diverse wildlife			
* PJ Encroachment	Reduced PJ density and appropriate age response	Forest Service		
		BLM		
Mechanical Treatment for PJ				
* Lack of natural disturbance	Reduced PJ density and appropriate age response	Forest Service		
		BLM		
* PJ Encroachment	Reduced PJ density and appropriate age response	Forest Service		
		BLM		
Travel Planning and Enforcement				
* Recreation & OHV/ATV use	Reduction in recreational disturbance			

Appendix 3:

Workshop Participants List

Jimi Gragg
Project Leader, Utah Wildlife Action Plan
Utah Division of Wildlife Resources

Steve Madsen
Wildlife Biologist
Bureau of Land Management
Utah State Office

Salt Lake City, UT

Carmen Bailey
Impact Analysis Coordinator
Utah Division of Wildlife Resources

Kevin Bunnell
Mammals Program Coordinator
Utah Division of Wildlife Resources

John Fairchild
Regional Supervisor
Utah Division of Wildlife Resources

Ashley Green
Division Lands and CUP Coordinator
Utah Division of Wildlife Resources

Betsy Herrmann
Habitat Conservation Supervisor
U.S. Fish and Wildlife Service
Utah Field Office

Justin Jimenez
Fisheries/Riparian Program Lead
Bureau of Land Management
Utah State Office

Chris Keleher
Recovery Programs Assistant Director
Utah Department of Natural Resources

Wayne Padgett
Colorado Plateau Native Plant Initiative Coordinator
Bureau of Land Management
Utah State Office

Verlin Smith
Branch Chief, Renewable Resources
Bureau of Land Management
Utah State Office

Bunny Sterin
Utah National Landscape Conservation System Coordinator
Bureau of Land Management
Utah State Office

Tyler Thompson
Habitat Conservation Coordinator
Utah Division of Wildlife Resources

Curtis Warrick
Utah Watershed Restoration Initiative Coordinator
Bureau of Land Management
Utah State Office

Price, Utah

Kim Asmus Hersey
Sensitive Species Biologist
Utah Division of Wildlife Resources
Central Region

Becky Bonebrake
Wildlife Biologist
Bureau of Land Management
Cedar City Field Office

Matt Breen
Native Aquatics Biologist
Utah Division of Wildlife Resources
Northeastern Region

Bob Campbell
Ecologist
Fishlake National Forest

Lisa Church
Wildlife Biologist
Bureau of Land Management
Kanab Field Office

Utah Workshop Participants

Kent Hersey
Big Game Project Leader
Utah Division of Wildlife Resources

Pam Jewkes
Forest Fisheries Biologist
Manti-La Sal National Forest

Markus Mika
Science Director
HawkWatch International

Russ Norvell
Utah Partners In Flight Coordinator
Utah Division of Wildlife Resources
Non-game Avian Program

Pamela Riddle
Wildlife Biologist
Bureau of Land Management
Moab Field Office

David Waller
Wildlife Biologist
Bureau of Land Management
Price Field Office

Joel Tuhy (Price session)
Conservation Science Director
The Nature Conservancy, Moab Project Office

Observers and Speakers:

Danielle Flynn (Salt Lake City and Price sessions)
Wildlife Program Lead
Division of Fish, Wildlife & Plant Conservation
Bureau of Land Management, Washington D.C. Office

Don Banks (Salt Lake City session)
Deputy State Director, Fire and Natural Resources
Bureau of Land Management, Utah State Office

Heinz Center Team:

Jonathan Mawdsley
Project Director

Sandra Grund
Project Coordinator

Dennis Murphy
Scientific Consultant

Caroline Sweedo
Workshop Coordinator

Stacia VanDyne
Project Communications Director

Appendix 4:

List of Stressors, Threats, and Desired Conditions for Priority Ecosystems

The following lists include the stressors/threats, desired conditions and conservation actions for the top five priority ecosystems identified by Utah workshop participants in September 2011.

1. SPRINGS, SPRINGBROOKS AND WETLANDS

Stressors/Threats

- Groundwater development (via irrigation, municipal use, cattle or inappropriate grazing, development as water source for cattle)
- Aquatic invasives (vegetative, mosquito fish)
- Terrestrial invasives (non-native woody)
- Trampling/grazing
- Excessive sedimentation
- Horse and livestock use
- Eutrophication
- Surface water development

Desired Conditions

- Surface water
- Native vegetation
- Native fish and snails
- Cattle/horses exclusions
- Migratory birds/breeding birds
- Native amphibians
- Stable areal extent
- Decrease is sedimentation

Conservation Actions

- Land use planning
- Private landowner incentives/partnerships
- Public outreach/education
- Aquatic invasive species control
- Invasive species control (cut, spray, burn)
- Cooperative agreements
- Fencing
- Habitat restoration
- Herd management
- Water development monitoring (real time)
- Water rights acquisition & protection
- Water policy

2. SAGE AND SAGEBRUSH COMMUNITIES

Stressors/Threats

- "Catastrophic" Fire
- Invasives (primarily plant, especially grass species)
- Drought
- Lack of natural disturbance
- Lack of age class diversity
- Lack of recruitment
- Inappropriate grazing
- Inappropriate/unregulated recreational use
- Plant disease/pathogens (defoliator moth)
- Energy development (renewable and non-renewable)
- Connectivity
- Climate change
- Groundwater mining
- Water development
- Urban/suburban development
- Recreation/OHV use
- Pinyon-juniper encroachment

Stressors/Threats on Sage-Steppe PJ Invasion Area (a Subset):

- Lack of disturbance (fire)
- Invasive species
- Catastrophic fire – if it happens, a large area is burned
- Increased soil loss
- Lack of understory
- Inappropriate recreational use
- Lack of structure

Desired Conditions

- Diverse age structure across landscape
- Developed understory
- Native grasses and forbs
- Lack of inappropriate grazing
- Recruitment demonstrated in population
- Pygmy rabbits present
- Low fire frequency – regular disturbance regime (fire freq. appropriate to sagebrush type)
- Large unfragmented blocks
- Big stands for age development
- Resilient stand (ability to reestablish itself after fire)
- Sage-obligate passerines
- Native birds
- Mule deer
- Good (high) production, linked to precipitation

- Low percentage of cheatgrass
- Large patches, but diverse
- Successional age structure

Conservation Actions

- Ecological restoration (e.g. reseed)
- Mitigation
- Best management practices
- Fire control
- Strategic zoning
- Water conservation
- Adaptation
- Mitigation
- Education and outreach
- Travel planning and enforcement
- Mechanical/hand-cutting
- Prescribed fire for pinyon-juniper

3. LOWLAND RIPARIAN ZONES

Stressors/Threats

- Inappropriate or excessive grazing
- Stream modification – downcutting
- Water rights
- Severe erosion
- Altered hydrologic regimes (diversions)
- Low water tables, groundwater development
- Recreation (OHV, ATV)
- Encroachment (urban and suburban)
- Urban development on the floodplain in particular
- Stormwater runoff/flash flooding
- Hardened structures/riprap/stabilization structures (flood control)
- Single species management (Endangered Species Act)
- Terrestrial and aquatic invasives [e.g., non-native forbs (e.g., pepperwhite), tamarisk, Russian olives]
- Agricultural runoff/nutrient loading
- Fish passage issues
- Streambank stabilization/channelization
- Transportation corridors (railways, highways)

Desired Conditions

- Sandbar willow
- Definitive green line
- Natural hydrology/flow regime, unaltered
- Streams with access to the floodplain
- Presence of native riparian species
- Diversity of species
- Presence of brushes and sedges
- Presence of cottonwoods and willows
- Healthy sediment transport
- Monitoring to document reproduction, nesting, of passerine and neotrop birds
- Native and sport fish "living in harmony"
- Healthy macroinvertabrate diversity and density
- Age class and recruitment diversity (e.g., multiple age classes of cottonwoods)
- Proper functioning and condition
- Connectivity among wildlife corridors (terrestrial and aquatic)

Conservation Actions

- Strategic zoning
- Grazing management
- Bio control (e.g. beetle)
- Restoration of native vegetation
- Mechanical/chemical treatment
- Management and enforcement for recreation/OHV uses

- Education and outreach
- Regulation and enforcement of invasives
- Travel infrastructure (e.g. bridges, roads)
- Travel management and enforcement
- Stormwater best management practices
- Agriculture best management practices
- Functional riparian geomorphology (restoration)
- Input large woody debris

4. FLOWING WATERS

Stressors/Threats

- Water consumption
- Diversion
- Barriers
- Water impairment/decreased water quality
- Impairment (agricultural, industrial, natural) – temperature and sedimentation
- Invasive fish species (including game fish)
- Altered hydrology
- Water management/development (e.g. gorge plan to divert water to Wyoming)
- Lack of habitat complexity
- Invasives (e.g. New Zealand mud snail)
- Unhealthy watershed condition
- Inappropriate grazing
- Agricultural runoff
- Beaver control
- Infrastructure constraints to flow (e.g., bridges that dictate river flow, culverts, overpasses)
- Severance from floodplain (floodplain development e.g. levees)
- Oil and gas development (especially oil shale)
- Sedimentation
- Contamination
- Roads

Desired Conditions

- Natural flow regime
- Connected to floodplain
- In-channel connectivity
- Healthy native riparian (i.e. complex habitat)
- Large woody debris (which provides complex habitat)
- Good fly fishing
- Beavers
- High density and diversity of macroinvertebrates
- Diversity and density (fish/mile) of native fish
- Appropriate geomorphology for the location on the landscape
- Native amphibians
- Appropriate water quality (temperature, turbidity, salinity, etc.)

Conservation Actions

- Best management practices/point source control
- Re-introduction
- Proactive watershed management
- Monitoring
- Management systems (e.g. fencing)
- Treatment/monitoring/outreach

- Selective passage barriers
- Alteration and removal
- Agriculture/farming conservation programs
- Restoration (e.g. stream channel)
- Surface and drainage improvements
- Road relocation/engineering
- Best management practices (BMPs)
- Screening diversions
- Water management/restore regime
- Input of large woody debris
- Riparian restoration

5. ASPEN

Stressors/Threats

- Aspen regeneration
- Lack of disturbance (fire)
- Inappropriate grazing/browsing (livestock and wildlife)
- Disease
- Second home development
- Lack of diversity in understory (due to grazing, spruce fir and subalpine fir replacing aspen)
- Spruce encroachment
- Recreation/ATV use
- New road development

Desired Conditions

- Multi-age class
- Seral vs. stable conservation
- Healthy fire regime
- Diverse understory
- Well-managed* grazing practices
- Well-managed* development
- Well-managed* recreation
- Take care of aspen-obligate wildlife (e.g., goshawk nesting sites)

Conservation Actions

- Logging
- Mechanical treatment
- Increase public support
- Herd management
- Game management
- Fencing
- Recreation management
- Motorized travel management
- Road removal
- Prescribed fires
- Thinning small conifers
- Public opinion

THE HEINZ CENTER

The H. John Heinz III Center for Science, Economics and the Environment

900 17th Street, NW, Suite 700, Washington, D.C. 20006
(202) 737-6307 • Fax (202) 737-6410 • www.heinzctr.org/wildlife