Final Memo 2-C

Northern Basin and Range and Snake River Plain Ecoregion Rapid Ecoregional Assessment

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Northern Basin and Range and Snake River Plains Ecoregions Rapid Ecoregional Assessment

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This document was submitted for review and discussion to the Bureau of Land Management and does not reflect BLM policies or decisions

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Acronyms

ACEC	Areas of Critical Environmental Concern
AML	Appropriate Management Level
AMT	Assessment Management Team
ARD	Acid Rock Drainage
ATV	All-Terrain Vehicle
BLM	Bureau of Land Management
CA	Change Agent
CE	Conservation Element
cm	centimeter
DPS	Distinct Population Segment
ESA	Endangered Species Act
FLPMA	Federal Land Policy and Management Act
GSG	Greater Sage Grouse
GYE	Greater Yellowstone Ecosystem
HMA	Herd Management Area
IDFG	Idaho Department of Fish and Game
IHN	Infectious Hematopoietic Necrosis
IPNV	Infectious Pancreatic Necrosis Virus
km	kilometer
LANDIS	Landscape Disturbance and Succession
MQs	Management Question
NBR	Northern Basin and Range and Snake River Ecoregions
NCA	National Conservation Area
NDOW	Nevada Department of Wildlife
NLCS	National Landscape Conservation System
NM	National Monument
NPS	National Park Service
NRCS	National Resources Conservation Service
NWR	National Wildlife Refuge
ODFW	Oregon Department and Fish and Wildlife
OHV	Off Highway Vehicle
PADS	Protected Areas Database
REA	Rapid Ecoregional Assessment
RSF	Resource Selection Functions
SAD	Sudden Aspen Death
SDA	Specially Designated Area
SRP	Snake River Plain
USACE	US Army Corps of Engineers
USBR	US Bureau of Reclamation
USDA	US Department of Agriculture
USFS	US Forest Service
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
WA	Wilderness Areas
WNS	White-nosed Syndrome
WNV	West Nile Virus
WSA	Wilderness Study Area
WSR	Wild and Scenic River
WSID	White Sturgeon Iridovirus Disease
WSSR	Wild and Scenic Study River

1 Introduction

This memo presents the results of Phase 1 Task 2 of the Northern Basin and Range and Snake River Ecoregions (NBR) Rapid Ecoregional Assessment (REA). Phase 1 Task 2 includes the development of graphical presentations of conceptual models for the NBR conservation elements (CEs). The results of this memo include guidance from and collaboration with the NBR Assessment Management Team (AMT) and reviewers, which is made up of Bureau of Land Management (BLM) and other state, federal, and stakeholder scientists and planners.

1.1 The REA Process

The BLM is currently evaluating a wide variety of environmental challenges to western ecosystems. These challenges transcend land ownership and administrative jurisdictions, and necessitate a landscape-scale approach to evaluation of these ecosystems. The REA process is the BLM's first step toward a broader initiative to systematically develop and incorporate landscape-scale information into the evaluation, and eventual management, of public land resources.

REAs look across an ecoregion to more fully understand ecological conditions and trends; natural and human influences; and opportunities for resource conservation, restoration, and development. They seek to identify important resource values and patterns of environmental change that may not be evident when managing smaller, local land areas. REAs describe and map areas of high ecological value. REAs then gauge the potential of these values to be affected by environmental change agents (CAs). REAs are called "rapid" assessments because they synthesize existing information, rather than conduct research or collect new data, and are generally completed within 18 months.

REAs are organized into various phases, with specific tasks in each phase (Table 1-1). Phase I is the pre-assessment, and includes four tasks including finalization of the management questions (MQs), CAs, and CEs that the REA will attempt to answer. In a departure from the order of tasks in previous REA efforts, Phase I Task 2 (the subject of this memorandum), includes development of conceptual models to understand the process framework of the CEs. Geo-processing models, work-flows, and applied data tools will be developed under Phase I Task 3. The final task under Phase I will include the preparation of the REA Work Plan (Task 4).

Table 1-1. REA Phases and Tasks

Phase	Task #	Product
I. Pre-assessment	1	Refine MQs (completed)
	2	**Identify, Evaluate, and Recommend Conceptual Models (the subject of this memorandum)**
	3	Identify, Evaluate, and Recommend Geoprocessing Models, Methods, and Tools
	4	Prepare REA work plan
II. Assessment	1	Compile and Generate Source Datasets
	2	Conduct analyses and generate findings
	3	Prepare REA report, maps, and supporting documents

Phase II is the assessment, and includes an analysis of the data relative to the identified CAs and CEs, documentation of the results, and culminates in the REA document, which will guide BLM and other land managers in developing and prioritizing planning and management strategies.

1.2 Document Contents and Organization

The objectives of tasks under the NBR REA Phase I Task 2 are to identify, evaluate, and recommend various conceptual models for assessing the current status of CEs, assessing the potential for future change to status, and answering the ecoregion MQs. This final memorandum (2-c) document provides the foundation for the AMT to consider the suitability of specific conceptual model depictions and evaluate the interactions between NBR CEs and identified CAs following the decisions made at the focused two-day AMT Workshop 2 held 10-11 January 2012 in Boise, Idaho.

The creation of conceptual models requires an understanding of the ecological requirements of each of the selected CEs and an understanding of which CAs have the potential to significantly affect the CEs. These conceptual models serve as a snapshot in time to determine what the current ecological condition is and what is projected to occur based on various scientific literatures available.

This memo is organized to most easily facilitate a review of core concepts and analyses developed by SAIC as well as provide a framework for the deliberative process that occurred at Workshop 2. Chapter 2 includes fine-filter and coarse filter CEs conceptual models specific to the NBR ecoregion and a discussion of the associated reasoning that went into developing these models based on best scientific information and the deliberative process that occurred at the workshop. Chapter 3 contains information on Specially Designated Areas (SDAs) and Appendix A contains a description of each SDA. Appendix B includes a presentation of specific relationships between CEs and CAs and other resources that was presented at the AMT Workshop #2. Appendix C lists the most recent version of the MQs. As the MQs may change throughout the REA process, listing them in each memo will allow the readers to see the most recent updates to the MQs.

2 Graphical Presentation of Conceptual Models

2.1 Introduction

Conceptual models are to be used to (1) provide a science-based context as to how conservation elements interact with one another and how they may be driven to change by change agents; (2) identify if the management questions are missing critical ecosystem attributes; (3) capture the best available understanding about ecological functioning and essential ecological attributes; and (4) depict the status (state) of conservation elements and the interactions among conservation elements and the change agents that drive ecological system (BLM 2011a).

Natural systems are complex and many factors influence ecological processes. Conceptual models are useful for describing functional relationships among structure components of ecological systems (biotic, abiotic, and local- and landscape-level), and the effects of natural and human-influenced CAs (Miller *et al.* 2005). Well-constructed conceptual models provide a scientific framework and justification for the choice of indicators intended for use in assessing ecological integrity in landscape reporting units. Several types of conceptual models were considered for use in this REA, including control models and stressor models. Control models depict, in a mechanistic way, the actual controls, feedback, and interactions responsible for system dynamics (Gross 2003). Control models sometimes consist of sets of models that illustrate functional subsystems such as soils, fire, or nutrient flow. Stressor models depict relationships between stressors and ecosystem components, and often include indicators of the responses to stressors. Stressor models do not depict feedbacks and usually illustrate only a subset of system components (e.g., selected CEs in an REA). Since the purpose of these models is to illustrate sources of stress or disturbance in a system and the responses of system components of interest, they generally do not present relationships in a mechanistic manner. Stressor models are an appropriate choice for CEs in this REA because they are better suited to illustrating the linkages between CAs and system components relied upon by the particular CE.

For the purposes of the REA, conceptual models should

- provide scientific context and basis for answering MQs;
- be able to use reliable and available existing data;
- be easy to understand;
- meet REA constraints on schedule and cost; and
- be applicable and informative for BLM managers.

There are a variety of ways to present conceptual models. In this memo we provide the current versions of conceptual models for fine-filter and coarse-filter CEs chosen for the NBR. For each fine-filter CE we present a system-level conceptual model that depicts the CE and the actions of CAs upon it, and if applicable, both on landscape and local scales.

2.2 Fine-filter CEs

Introduction

We present conceptual models for each fine filter CE included in this REA that depicts the CE and the actions of CAs upon it. For some of the CEs (e.g., greater sage-grouse, bats, and spotted frog) that occupy different habitat types during the year, we incorporated life cycle requirements into the system model based on work of Parrish *et al.* (2003). This focus on species' life cycle needs complements the CA relationships shown in the system-level models. We explored the usefulness of separate life-cycle models, which are intended to highlight the relationship between the attributes of ecological integrity (landscape context, size, and condition [Unnasch *et al.* 2009]) and the life cycle needs of the CE species. We found the life-cycle models easy to grasp because of their simplicity but found that they do not incorporate another major element of the REA, the CAs, and therefore are generally less informative than the system-level models as presented in this memo. We also discovered that life-cycle models don't lend themselves well to all fine-filter CEs or to coarse-filter CEs. However, for the fine-filter CEs mentioned above, by incorporating a life cycle depiction into the system models the variety of required local habitat elements by seasons of use (or life-cycle stage) can be illustrated as well as a tie-in made with appropriate CAs that may affect them. For example, in addition to the overall landscapes bats require to meet their needs, bat species in the NBR ecoregion use caves, mines, rock crevices, trees, and buildings to fulfill special needs such as for hibernation, summer roosts, and for maternity colonies. It is important to include these specific habitat needs when analyzing potential environmental and human-caused effects to this species. Each of these models is discussed in detail by fine filter CE in the following sections.

For those CEs where it was deemed appropriate, grazing was included as a CA under development because effects from grazing are as variable as those from the other development CAs and can be controlled by human actions. The simple fine-filter models do not depict whether effects from each CA are positive or negative on the landscape or local scale because we recognize that these relationships are complex and can change with particular circumstances. For example, in grasslands dominated by invasive species, grazing can be used in a positive manner to reduce seed spread and fuels for potential wildland fires. If applied too heavily or for too long a season, grazing can also reduce fitness of native grasslands and affect habitat components such as decreasing nesting cover for greater sage-grouse (DeLong *et al.* 1995).

2.2.1 Greater Sage-grouse

2.2.1.1 Rationale for being a CE

The greater sage-grouse (GSG) is considered an umbrella species for sagebrush-associated vertebrates (Rowland *et al.* 2006, Hanser and Knick 2011). Indirect effects of sagebrush habitat loss, fragmentation, and degradation are thought to have caused the extirpation of the GSG from approximately 50 percent of its original range (Connelly and Braun 1997, Connelly *et al.* 2004, Schroeder *et al.* 2004), leading to a finding by the US Fish and Wildlife Service (USFWS) in 2010 that GSG warranted listing the Endangered Species Act (ESA).

2.2.1.2 Factors Related to the Distribution of the CE

The system model for GSG incorporates a life cycle model that indicates the major components of sagebrush ecosystems that are used during the course of the year (Connelly *et al.* 2011a) (Figure 2.2-1). There is considerable variation among populations with respect to migration distances, but some migratory populations move relatively large distances (often >20 kilometers [km]) between different seasonal habitats, and occupy large home ranges (>600 kilometers [km sq.]). Life cycle components related to habitat (Connelly *et al.* 2011b) include: (1) Lek sites, which are typically located in natural or man-made openings within sagebrush communities. Sagebrush immediately surrounding lek sites (generally within 0.6 miles) is used for feeding, resting and cover from weather and security from predators when the birds are not on leks; (2) Nesting habitat, which requires a sagebrush canopy that provides cover from predation during the growing season; (3) Early brood-rearing habitat, which is characterized by the chicks' requirements for escape cover (sagebrush canopy) and food resources (primarily arthropods and forbs); (4) Summer and late brood-rearing, during which sage-grouse may shift to areas that support green vegetation, such as

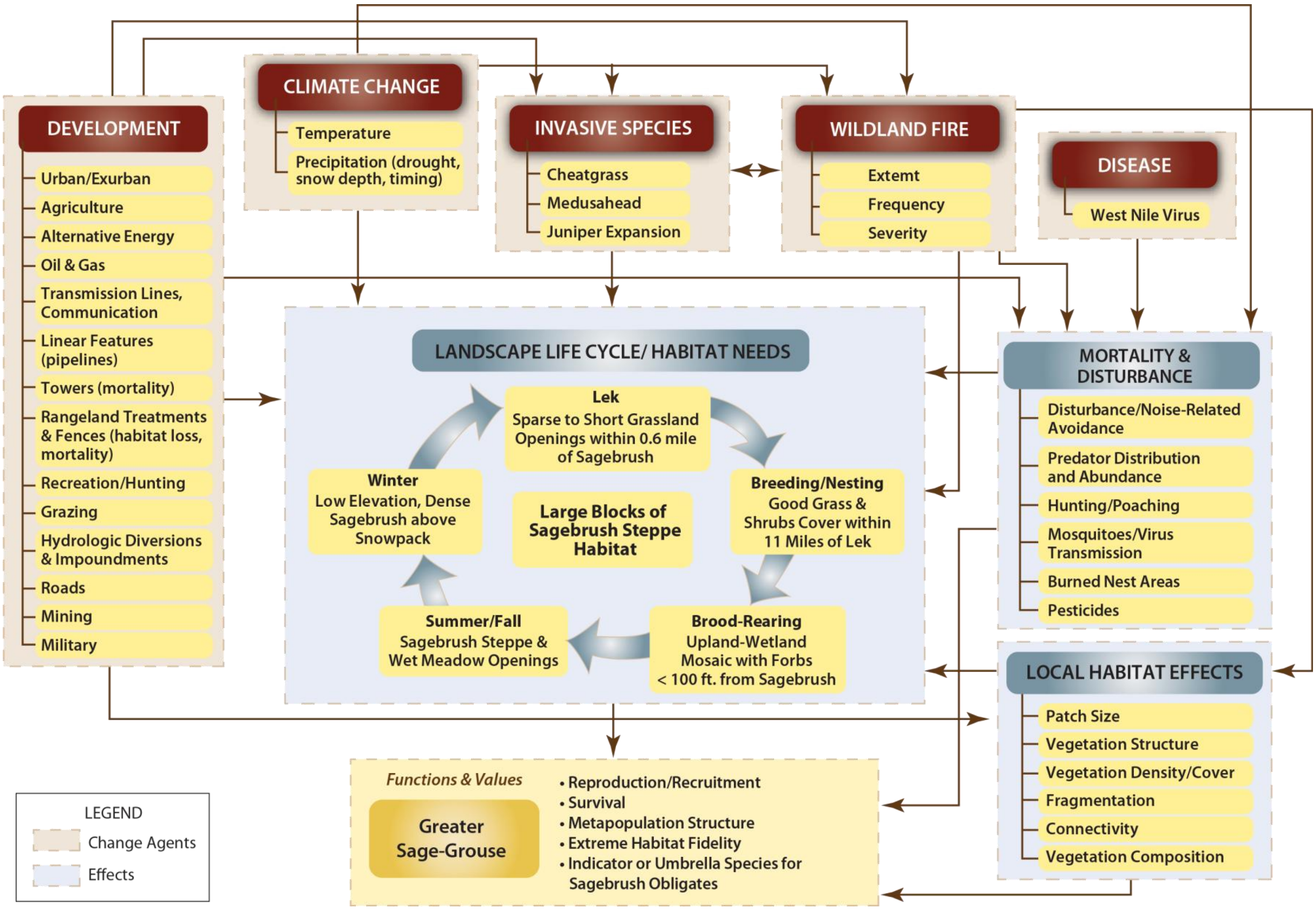


Figure 2.2-1. Greater Sage-grouse System Model

riparian habitats, springs and seeps, and agricultural croplands, irrigated hayfields and high elevation meadows; (5) Winter habitat, in which the primary requirement is sagebrush exposed above the snow. Exposed sagebrush is used for feed and cover; sage-grouse feed almost exclusively on sagebrush in the winter.

At the landscape scale, GSG require large, interconnected expanses of sagebrush ecosystems, with varying density and height of sagebrush cover, age and moisture regimes (Doherty *et al.* 2008). Sagebrush steppe vegetation types are generally not considered resilient to frequent and substantial disturbance (Davies *et al.* 2009). Many semiarid systems are characterized by alternate stable states (vegetation conditions) resulting from different disturbance events, as described in greater detail in the Coarse Filter vegetation models (Section 2.3.1). Altering a native disturbance regime (e.g., fire frequency or grazing intensity) may drive a sagebrush community across a threshold to another stable state (e.g., woodland). Because these details of transitions between sagebrush vegetation states are presented in a later section, they are not repeated in the GSG model. However, the GSG system model does indicate the relationships between the change agents that act upon the species' habitat needs.

2.2.1.3 Key Change Agents

Development

In the last few decades, developments including infrastructure expansion (roads, pipelines, and transmission lines), oil and gas exploration and development, mining, and establishment of wind farms in proximity to GSG leks and in winter habitat have directly reduced the amount of suitable habitat available for GSG and introduced noise and human presence that may also have adverse effects (Hollaran 2005; Kaiser 2006; Aldridge and Boyce 2007; Doherty *et al.* 2008; Naugle *et al.* 2009; Harju *et al.* 2010). Historic conversion of sagebrush to pasture, cropland or irrigated hayfields, also has been widely recognized as a dominant factor in the decline of GSG populations. Rangeland vegetation treatment practices formerly removed sagebrush, with adverse effects on GSG habitat, but current practices attempt to maintain adequate shrub cover while rejuvenating the understory component. Grazing affects GSG habitat because livestock tend to deplete understory forbs, which are also consumed by GSG, but has less effect on shrub cover. Changes to the stand size or density of sagebrush, especially in winter habitat, reduce the suitability for GSG. On the landscape scale, reducing the land cover of sagebrush communities below 25 percent of a 30 km radius (i.e., the mean home range size) has been suggested as a strong predictor of GSG local extinctions (Aldridge *et al.* 2008) and landscapes with less than 60 percent are likely to have persisting GSG populations.

Climate Change, Wildland Fire, and Invasive Species

Climate effects are expressed primarily as a range of suitable precipitation (Wisdom *et al.* 2011) and the frequency and duration of drought (Aldridge *et al.* 2008). Evers (2010) suggested that under projected climate change, cooler and moister sagebrush communities (i.e., nesting and brood rearing habitat) would decrease substantially. Under natural conditions, moderate fire return intervals and low intensity fires promoted the mixed composition of sagebrush communities for lekking, nesting and brood rearing.

However, the ecological role of fire has changed significantly. In conjunction with climate change and the expansion of invasive annual species, wildland fire now covers larger areas more frequently, reducing habitat quality and quantity for sage-grouse (Connelly and Braun 1997, Connelly *et al.* 2000, Nelle *et al.* 2000, Fischer *et al.* 1996). On lower elevation drier sites more frequent wildfire covering a larger extent has contributed to vegetation type conversion from sagebrush to invasive grass monocultures. Elsewhere fire suppression has promoted expansion of juniper woodland into sagebrush sites. The predominant impacts of wildland fire are expected to occur at the vegetation community level, as sagebrush sites shift from one state to another with changes in disturbance regimes.

Invasive species occurrences and fire history are often linked, as shown in the coarse filter sagebrush model, and have been estimated to contribute to an increase in pinyon-juniper woodlands (Miller and Tausch 2001) which are avoided by GSG. In Wyoming big sage communities, invasion by annual grasses or weeds (e.g., cheatgrass, medusahead) is the greatest threat, because these fuels increase the fire frequency from greater than100 years to less than 10 years (Whisenant 1990). Tree establishment within sagebrush communities generally decreases forb availability due to moisture depletion (Bates *et al.* 2000).

Mortality and Disturbance

The GSG system model also depicts CA effects related to direct mortality and disturbance. Direct loss of habitat was discussed under Development above. In addition, GSG habitat adjacent to developed areas may be avoided by breeding GSG due to noise and disturbance, thereby further reducing suitable habitat availability in proximity to human developments (Holleran 2005; Doherty *et al.* 2008; Harju *et al.* 2010). Abandonment of GSG leks in response to power lines has been documented (Ellis 1987; Hall and Haney 1997; Braun 1998), presumably due to an increase in the number of raptors and ravens by offering them new or alternative nesting/perching structures (Gilmer and Wiehe 1977; Steenhof *et al.* 1993). Collision of GSG with transmission lines during flight is also a known source of mortality (Beck *et al.* 2006). Similar to power lines, collision with fencing has been shown to contribute to sage-grouse mortality (Christiansen 2009, Gruver 2009) and wood fence posts may provide additional perches for avian predators. Predation has been shown to be a major cause of nest failure in poor habitats (Moynahan *et al.* 2007).

Disease

West Nile virus (WNV), an important new source of mortality in GSG since its introduction in 1999, has the greatest potential for population-level effects among all parasites and infectious diseases identified in GSG (Christiansen and Tate 2011): West Nile virus has been identified in GSG populations in 10 states and may result in at persistent low-level mortality and possibly severe outbreaks leading to local and regional population declines (Walker and Naugle 2011). Its incidence is probably related to the increase in available surface water (breeding sites for the WNV mosquito vector) associated with energy development and livestock tanks and ponds.

2.2.2 Golden Eagle

2.2.2.1 Rationale for being a CE

The golden eagle is one of the most widely distributed of raptor species, but western U.S. populations are believed to be in decline (Kochert and Steenhof 2002). The status of golden eagles in the NBR reflects local factors determining breeding territory occupancy, nesting success, and survival. Any agent of change that positively or negatively influences these factors has the potential to influence golden eagle distribution and population levels in the region.

2.2.2.2 Factors Related to the Distribution of the CE

The golden eagle occurs primarily in association with open habitats including shrublands and grasslands, although hunting may be conducted also over open woodlands (Kochert *et al.* 2002, Stahlecker *et al.* 2010). They avoid heavily forested areas (Poole and Bromley 1988). During the breeding season most golden eagles are found where cliffs, canyon walls, and rock outcrops provide nest sites. Less often, golden eagles will nest in tall trees or man-made structures such as telecommunication towers. In eastern Utah, Bates and Moretti (1994) found active eagle nests in four habitats: in trees on saltbush flats or low elevation riparian areas, on cliffs and escarpments in pinyon-juniper and talus, and in prominent trees in the aspen-conifer zone. The golden eagle has a broad prey base, though it relies primarily on mammals including rabbits and ground squirrels (Olendorf 1976, Kochert *et al.* 2002). Prey species are closely associated with open vegetation types. The system model for golden eagle (Figure 2.2-2) indicates the landscape features that are most closely associated with this species including nest sites, habitats that support its terrestrial prey, and foraging perch availability. The feature that most significantly affects the distribution of the golden eagle is vegetation type because suitable vegetation supports prey species availability and abundance; thus, vegetation type and condition indirectly drive the distribution, productivity, and survival of golden eagles. Changes caused by development and resource use, climate change, and altered fire regime affect eagle habitat primarily through their effects on prey habitats.

2.2.2.3 Key Change Agents

Development

The golden eagle system model depicts the change agents that will be evaluated in this REA, of which habitat destruction through human development and direct mortality are the most important. The golden eagle is threatened by development on a variety of levels. Large-scale population declines have followed urban growth, and agricultural activities (Kochert and Steenhoff 2002). Land use change and agriculture affect golden eagle distribution via affecting the prey base, as described above (Marzluff *et al.* 1997, Beecham and Kochert 1975, Smith and Murphy 1973, McGahan 1968). The primary prey species of the golden eagle inhabit predominantly natural areas of shrub-steppe and other open vegetation types. Agricultural conversion of these lands severely reduces prey species habitat quality, and thus indirectly reduces use by golden eagles. Vegetation degradation from shrub-steppe to annual grass and forb-dominated types also reduces habitat value for prey species.

With regard to direct mortality, there are a number of development-related threats to golden eagles. Collision with vehicles (as eagles feed on road-kill), overhead transmission lines and other structures, and electrocution at power poles are major causes of mortality of golden eagles (Franson *et al.* 1995, Harness and Wilson 2001). Fatalities due to collision with wind turbines also contribute significantly to eagle mortality in areas where wind farms are situated in corridors used by golden eagles (Smallwood and Thelander 2007, Hunt 2002, Stahlecker *et al.* 2010). Siting of wind farms is a significant issue in the NBR ecoregion because of the substantial number of migrant golden eagles during winter months (Kochert *et al.* 2002, McIntyre *et al.* 2008). Golden eagles are killed by secondary poisoning after consuming prey that have ingested rodenticides and herbicides, or that may be contaminated by lead shot.

The effect of human disturbance on golden eagle nesting remains largely understudied. Coal mining activities have been found to affect breeding populations of golden eagles (Platt 1984), and other types of mining activities could potentially affect breeding behavior and distribution of the species. Roads lead to collisions of eagles with vehicles but affect eagle distribution because golden eagles avoid nesting in areas with high densities of roads.

Climate Change

The role that climate change will play in golden eagle distribution is also unclear. Potentially climate change may affect shrub-dominated habitats through altered fire regimes and increased occupation by invasive plants, leading to reduced small mammal populations. Also, temperature affects golden eagle reproduction in concert with prey abundance (Steenhof *et al.* 1993). In a long-term study in southwestern Idaho, the percentage of eagle pairs that laid eggs was limited by black-tailed jackrabbit abundance and winter severity influenced how much eagle reproduction declined. In addition, brood size at fledging was positively affected by rabbit abundance and inversely related to the number of hot days in spring. Although these results show a relationship between weather factors and reproductive success, the long-term implications with respect to the effects of climate change on golden eagle distribution are unclear.

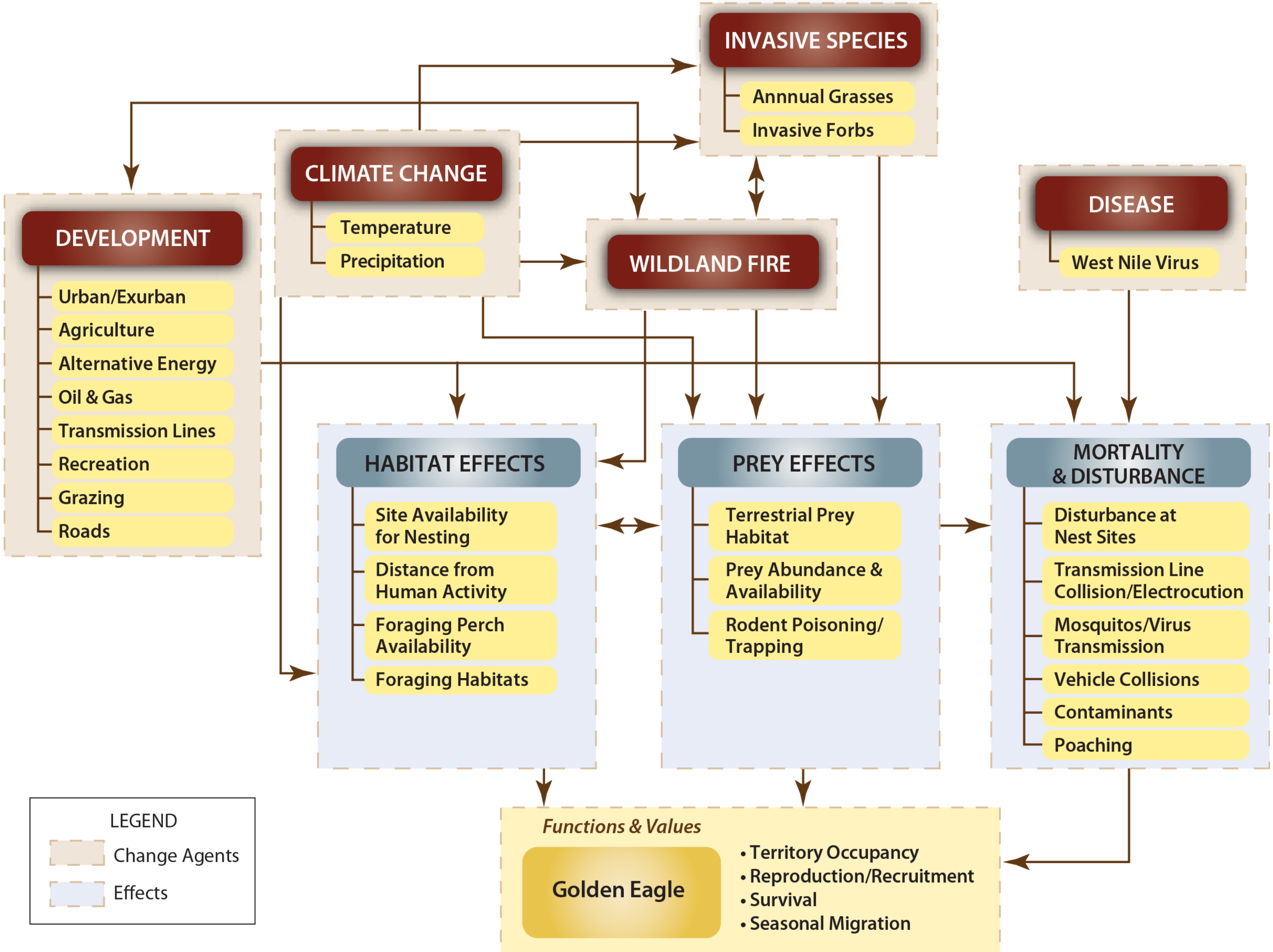


Figure 2.2-2. Golden Eagle System Model

Invasive Species and Fire

The relationship of fire with golden eagles is complex under the historic ranges of variability in frequency, extent, and severity, in part because this is a generalist species that occupies a wide range of vegetation types. Wildfires in the western states reduce the shrub layer and can promote vegetation types dominated by invasive annual grasses, affecting prey populations such as the black-tailed jackrabbit. For example, the loss of shrub habitat due to wildfires in southwestern Idaho reduced golden eagle reproductive success for several years (Kochert *et al.* 1999). However, fire in forested areas may create clearings that promote the prey base and improve hunting efficiency of eagles. Although fire plays a part in short-term effects on breeding populations, there is no clear correlation between fire and long-term effects on golden eagles.

2.2.3 Bald Eagle

2.2.3.1 Rationale for being a CE

Bald eagles are widespread in North America in association with marine shorelines and large bodies of water where there is significant forest cover nearby to provide nesting, roosting, and foraging perch sites. The number of resident pairs in the Snake River Plain is largest in the upper river above Idaho Falls (GYE/Idaho Bald Eagle Research Project 2004). Bald eagle numbers increase greatly along the Snake River system in winter due to an influx of migrants coming into the region from Canada, northern Idaho and Montana (Buehler 2000). The distribution and numbers of bald eagles in this ecoregion reflect a complex pattern of migration dependent on age of the individual (immature or adult), location of breeding sites (north vs. south, interior vs. coastal), severity of climate at breeding sites during winter, and food availability. Most immatures migrate and may move nomadically, presumably because they are not tied to defense of a nest site, but it is difficult to distinguish between true migration (seasonal movements between breeding and wintering grounds) in immatures and dispersal. Adult birds, in contrast, migrate as needed when food becomes unavailable (Buehler 2000).

2.2.3.2 Factors Related to the Distribution of the CE

Factors related to availability of nesting sites and suitable wintering habitat play a major role in determining the distribution and abundance of the species (Swenson *et al.* 1986, Buehler 2000). Nest sites are limited to forest stands with suitable large nest trees. Vegetation types that offer the best nesting opportunities include forest stands located in proximity to lakes or reservoirs that are dominated by Douglas-fir and/or lodgepole pine, and occasionally cottonwood-dominated gallery forests. A stable food source (most often fish) that is available from early spring through the end of the nesting period in late summer is an important factor in breeding area selection (Swenson *et al.* 1986). Overwintering bald eagles exploit available food supply, following salmon runs (Swenson *et al.* 1986, McClelland *et al.* 1994) and concentrating near dams along the Snake River where open water and fish are available (Steenhof *et al.* 1980, Brown *et al.* 1989, Kaltenecker *et al.* 1998). Adults in some northern populations may not migrate but instead move locally to food sources such as mammalian carrion or waterfowl during winter (e.g., Greater Yellowstone Ecosystem [GYE]) (Swenson *et al.* 1986). Wintering bald eagles congregate at communal roosts located in conifer forest stands in close proximity to foraging areas (Stalmaster 1987, Buehler *et al.* 1991).

Factors related to reproductive success and survival of immature and adult bald eagles are also important in determining distribution and abundance of bald eagles (Swenson *et al.* 1986). Productivity of bald eagle populations is regulated by the percentage of adults that breed and the relative success of those attempts (Buehler 2000). The percentage of adults that are able to breed is determined in part by competition for limited supply of suitable breeding sites (Swenson *et al.* 1986). The success of breeding attempts is limited by food availability and weather, among other factors. For example, weather effects explained 63 percent of variation in reproductive output in GYE, with reduced output in cold, wet springs

(Swenson *et al.* 1986). However, in terms of long-term population dynamics, survival rates of bald eagles have a greater effect than reproductive rates (Grier 1980, Harmata *et al.* 1999). Lifespan, rather than clutch size and number of young fledged, often accounts for most of the variance of lifetime reproduction in long-lived birds (Newton 1979) such as the bald eagle. Thus, factors related to availability of nesting sites, reproductive success, and survival of immature and adult bald eagles play a major role in determining the distribution and abundance of the species.

2.2.3.3 Key Change Agents

The system model for bald eagles focuses on CA effects on habitats used by bald eagles: nest site availability, winter roost availability, and foraging site availability and condition (Figure 2.2-3). In addition, CA effects on habitats of terrestrial and aquatic prey and other factors that determine prey abundance and availability are included in the model. CAs that are associated with direct mortality and disturbance of bald eagles comprise a third set of effects.

Development

Development-related change agents may involve hydrologic changes that create foraging opportunities, such as impoundments on the Snake River and its tributaries with natural or stocked fish populations, water withdrawals and diversions that affect seasonal flow, and runoff of sediments and contaminants into aquatic habitat. All of these CAs may affect the fish and waterfowl prey base for bald eagles. Land use changes, such as urban/exurban development, hydrologic changes, and agriculture may result in loss of foraging sites including gravel bars and perch trees along rivers, lakes and reservoirs, and loss of conifer forest stands used for roosting.

Development change agents also affect bald eagles by disturbing them at nest sites, foraging sites and communal roosts and interfering with the reproductive cycle and survival. Causes of mortality associated with human development and activities include collisions with power lines and vehicles, electrocution at power poles, and illegal shooting (Buehler 2000). Other anthropogenic mortality agents include contaminants in the environment and prey species such as lead shot. Bald eagles ingest lead pellets from waterfowl carcasses and deer carcasses, leading to lead poisoning (Neumann 2009). Secondary poisoning of bald eagles due to ingestion of organophosphorus insecticides used in feedlots (Henny *et al.* 1987), where the eagles fed on cow carcasses.

Climate Change and Wildland Fire

The role of climate change and wildland fire in bald eagle distribution and abundance is unclear and is likely associated with hydrologic changes affecting fish populations. These effects, including direct effects on fish species reproduction and survival as well as effects on aquatic habitats, are described in the system models for fish species (Sections 2.2.10 through 2.2.12) and are not repeated here.

2.2.4 Pronghorn

2.2.4.1 Rationale for being a CE

Pronghorn are an important part of the grassland-sagebrush steppe food chain and iconic symbol of open spaces in the West. These ungulates require vast open landscapes to meet their life cycle requirements over each season. Many types of anthropogenic land disturbances have interrupted, changed, reduced, or blocked pronghorn access to habitats and movement patterns, adversely affecting this species across its historic range. This is especially true of fast-growing industries such as oil and gas development, alternative energy, and suburban to exurban residential housing with their accompanying roads and utilities corridors. Pronghorn were also chosen as a CE because of their status as an important game species in all of the NBR states.

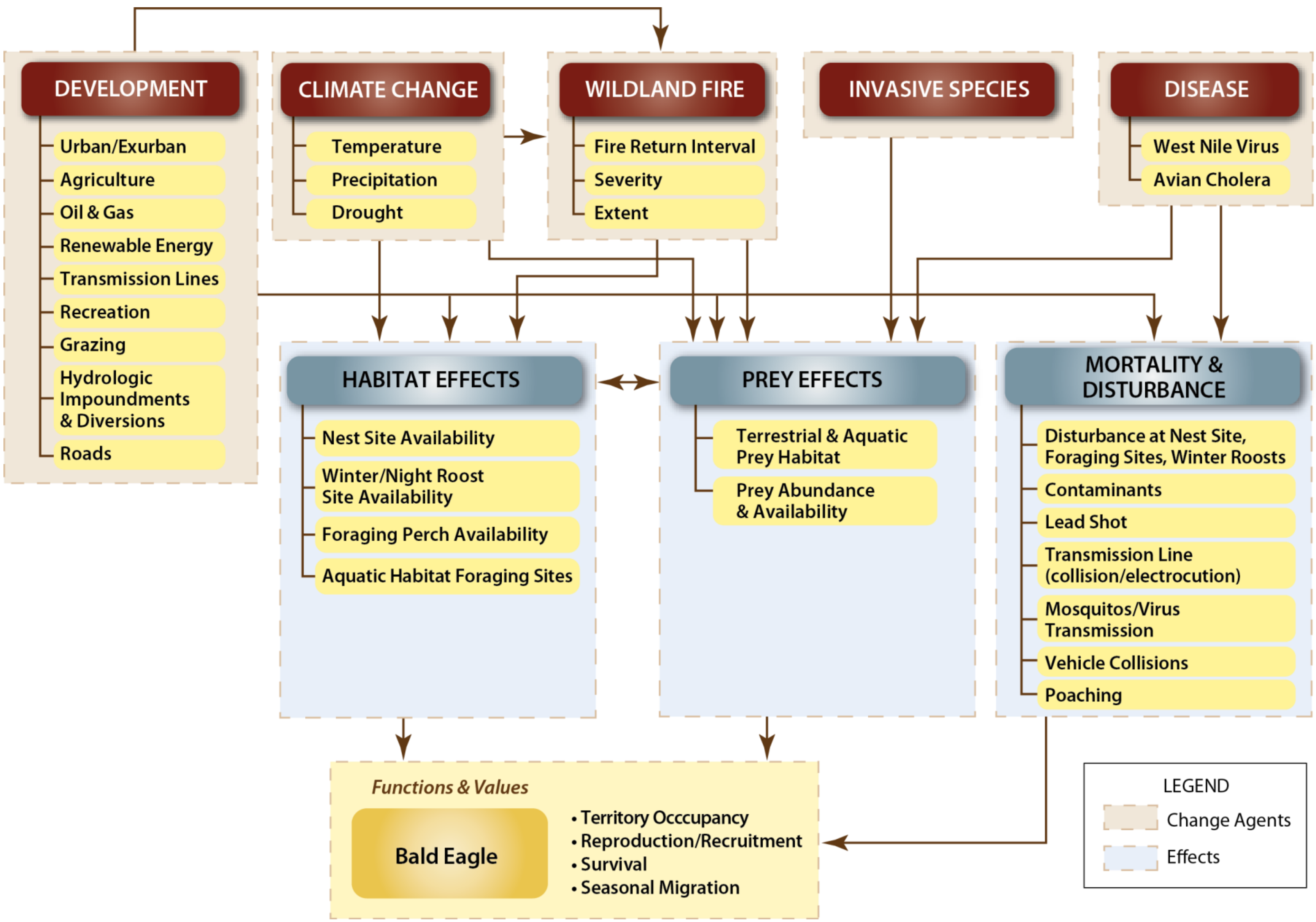


Figure 2.2-3. Bald Eagle System Model

2.2.4.2 Factors Related to the Distribution of the CE

Due to the topographic relief and vegetation variability of the ecoregion, most ungulates exhibit seasonal shifts among different habitats to obtain the resources they need. Areas that will be delineated for analysis of pronghorn encompass a diversity of habitats including those used for critical periods such as migration, winter and parturition. For those fine-filter CEs that require larger home ranges (mule deer, bighorn sheep, pronghorn), the conceptual models depict effects on two scales, on the landscape level and at the local habitat/terrain scale. This allows the model to be able to focus on site–level CA effects to certain CE habitat needs that may differ from landscape level effects. Examples of some of these critical, local terrain or habitat types recognized in the conceptual model presented in this memo include winter range, water sources, and areas with high visibility (Figure 2.2-4).

Pronghorn migration distances are the longest known for terrestrial animal species in the 48 contiguous states (Feeney *et al.* 2004). Radio-telemetry studies have confirmed that pronghorn migrate as much as 274 km between the Grand Teton National Park and the Green River Basin in Wyoming (Sawyer and Lindzey 2000, Sawyer *et al.* 2005). Not all pronghorn populations migrate these distances; non-migratory individuals have been documented in other studies (Hoskinson and Tester 1980, White *et al.* 2007). Adult pronghorn in the vicinity of the Idaho National Energy Laboratory in the eastern Snake River Plain (SRP) overwinter at the lower end of valleys on the edge of the SRP, moving variable distances (up to 64 km) up the valleys during spring migration (Hoskinson and Tester 1980). Pronghorn in northeastern California may migrate between summer and winter range up to 150 km (California Department of fish and Game 2000). Pronghorn summer and winter ranges have been identified in other portions in the NBR ecoregion (e.g., reported in BLM 2004, BLM 2007), and state fish and game agencies will likely provide additional sources of distribution data for this CE.

Typically, transitional migration habitat for pronghorn consists of habitat used in winter and characterized by relatively flat, open native sagebrush and grassland habitats free of encroaching trees, fragmenting infrastructure (roads, fences, and oil and gas development) and other anthropogenic disturbances. Slope is also an important indicator of pronghorn migration habitat. Studies suggest that pronghorn avoid slopes of greater than 20 percent and apparently prefer areas where the slopes are less than 10 percent (Yoakum 2004a, Longshore and Lowrey 2007). Snow depth above 15 inches (38 centimeters [cm]) appears to limit pronghorn use of winter range in some areas. A variety of studies are currently in progress to evaluate pronghorn migration routes relative to the potential impact of oil and gas exploration and production. Beckmann *et al.* 2006 suggest that both snow depth and land fragment size explain threshold levels for use by pronghorn within or adjacent to gas fields.

2.2.4.3 Key Change Agents

Development

Pronghorn evolved in open landscapes without vertical barriers. Fences often severely impede pronghorn movements (Spillet *et al.* 1967, Oakley and Riddle 1974, Mitchell 1980, Barrett 1982, Pyrah 1978, Hailey 1979); unlike deer species pronghorn rarely jump over fences. There is strong evidence that, if prevented from seasonal migration by obstacles, pronghorn may experience massive die-offs (Ryder *et al.* 1984). Other CAs that are important to analyze for effects to pronghorn that are included in the "Development" box include roads (Figure 2.2-4). Roads may also impair pronghorn access and use of winter range and seasonal movements. In southwestern Wyoming (Sheldon 2005) and in Arizona (Van Riper *et al.* 2001) unfenced roads appeared not to be a barrier to pronghorn movement, but the combination of heavy traffic volume (Buechner 1950) and fences along roads can be considerable barriers to movement (Ockenfels *et al.* 2007). Divided, interstate, and other high-volume (i.e., > 2,000 average annual daily traffic) highways are usually fenced to restrict pronghorn movements to designated crossing structures however, Yoakum (2004b) speculated that pronghorn behavior may prevent the use of under- and overpasses of high-volume highways.

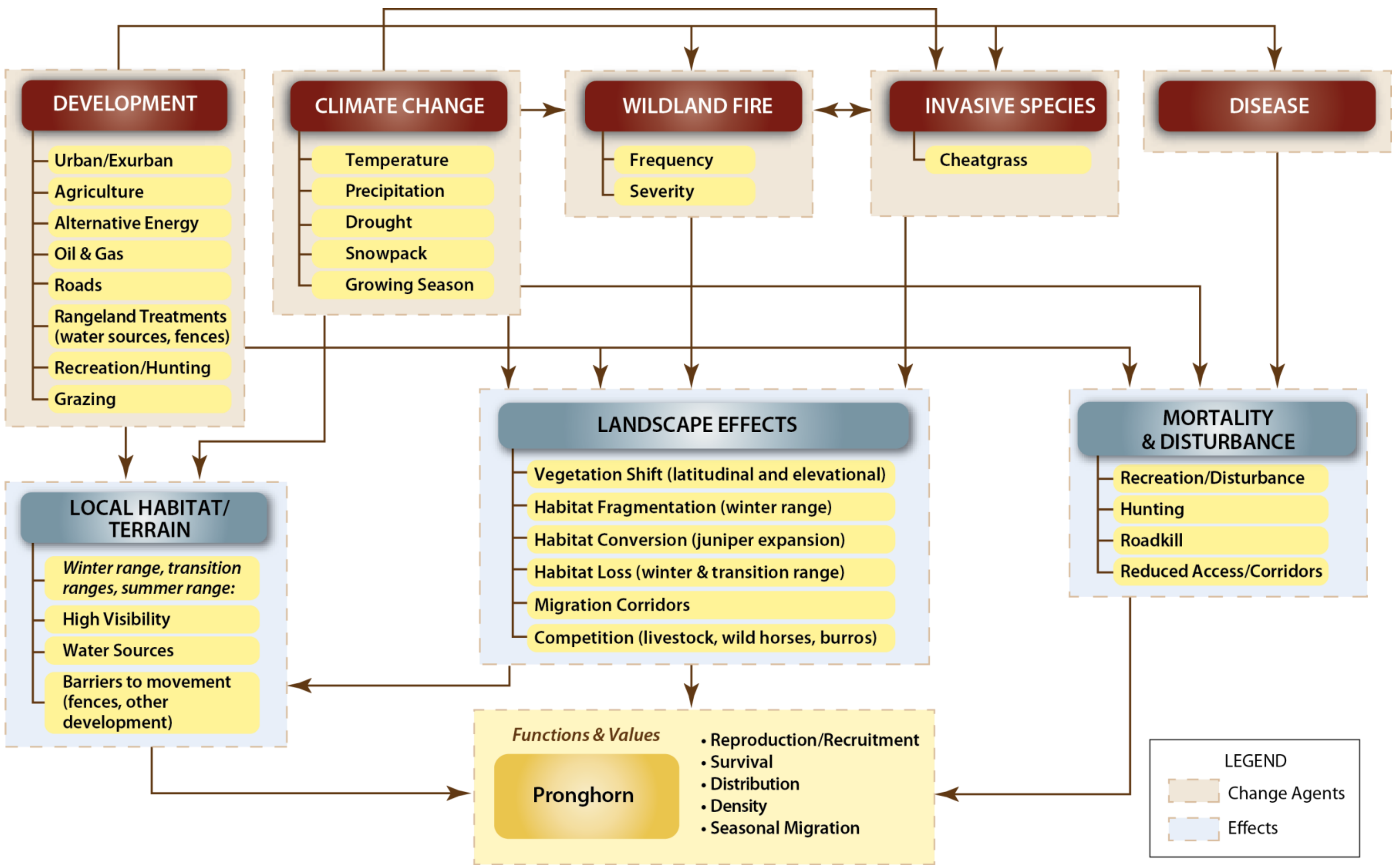


Figure 2.2-4. Pronghorn Conceptual Model

The recent expansion of energy development in the West has the potential to have serious impacts to pronghorn and their migration corridors (Hebblewhite 2008). Berger *et al.* (2006) showed that some pronghorn continued to use areas that were heavily developed, whereas other animals showed strong avoidance to such areas. Energy development resulted in avoidance of heavily developed areas by pronghorn and the total abandonment of the Jonah Field in Wyoming, which had previously been important winter transition range. Avoidance distances reported for pronghorn range from 0.25 miles (0.4 km) (Autenrieth 1984) to 0.6 miles (0.96 km) (Easterly *et al.* 1991) from sources of disturbance. Pronghorn tended to avoid foraging in the habitat near well pads, even at night when human disturbance was reduced. Areas within 100 meters of gas wells were also consistently avoided. Sawyer *et al.* (2002) suggested that energy development could sever migrations corridors for pronghorn and could influence the distribution of pronghorn on winter ranges.

Climate Change

Generally, changes in climatic and vegetative conditions trigger the onset and length of seasonal movements for pronghorn. If global climate change has an effect on timing of seasonal temperature changes, this may affect initiation of migration. Also, precipitation amounts and spatial distribution play a role in pronghorn fitness and reproductive success. Numerous studies have reported positive associations between pronghorn fawn survival and both the previous growing season precipitation and current season precipitation (Byers and Hogg 1995, Fairbanks 1994, Gregg *et al.* 2001). The greater the winter severity, the farther individuals and herds travel to areas with less snow (Creek 1967, Yoakum 1978, Guenzel 1986, Raper *et al.* 1989, Sawyer and Lindzey 2000) to avoid mortality that is often associated with snow depths exceeding 15 inches (38 cm) (Yoakum *et al.* 1996). Winter precipitation, specifically snow depth, also may affect recruitment (Smyser 2006).

Wildland Fire

Wildland fire is considered one of the key factors affecting pronghorn migration and winter habitat. Moderate fire return intervals and low intensity fires are necessary to maintain the mixed composition of sagebrush communities that provide the forage and open migration habitat pronghorn require. The biggest threat to maintaining pronghorn habitat is fire suppression that causes “decadent” sagebrush conditions with excessive shrub heights, tree encroachment and loss of the open character of the landscape. Pronghorn generally avoid trees and woodland habitats within 100 m (Ockenfels *et al.* 1994, Yoakum 2004a).

Invasive Species and Disease

It is not certain at this point in the REA if invasive species and disease, which are included in the model, will play an important role in analyses for pronghorn. These types of CAs can be explored in more detail and refined as the REA process moves forward.

2.2.5 Mule deer

2.2.5.1 Rationale for being a CE

Over the past century, mule deer populations throughout their range have fluctuated widely; however, recent trends indicate that populations are declining throughout the West. Much of this decline can be attributed to direct habitat loss (mainly winter range), a loss of browse species and deteriorating forage base, and weather extremes including large-scale droughts and severe winters (Heffelfinger and Messmer 2003). Mule deer are also an important game species in the NBR states.

2.2.5.2 Factors Related to the Distribution of the CE

The Mule Deer Working Group (2005) has mapped the entire range of mule deer in North America and has identified two types of winter range: that which is used as the part of the overall range where 90 percent of the individuals are located during the average five winters out of ten from the first heavy snowfall to spring green-up, or during a site-specific period of winter, and "severe winter range" used where 90 percent of the individuals are located when annual snow pack is at its maximum and/or temperatures are at a minimum in the two worst winters out of ten. In addition to identifying and mapping distribution, habitat classification factors that limit habitat quality for mule deer were also identified by the Working Group. Mule deer migratory behavior is similar to that described for pronghorn. However, mule deer show distinctly different habitat requirements, and are generally more tolerant of a wider range of habitat conditions. Unlike pronghorn, mule deer are more habitat generalists and their seasonal requirements all fit into a landscape level effect analysis (Figure 2.2-5). Also differing from both pronghorn and bighorn sheep, mule deer do not require open, high-visibility areas but rather will escape danger by retreating into dense cover of shrub and woodland communities.

2.2.5.3 Key Change Agents

Development

Roads are widely recognized by the scientific community as having a range of direct, indirect, and cumulative effects on wildlife and their habitats (Trombulak and Frissell 2000, Gaines *et al.* 2003, Wisdom *et al.* 2004). Roads are usually included with many of the development types included in the model (Figure 2.2-5) including urban/exurban, agriculture, oil and gas, and recreation/hunting areas. Mule deer show avoidance of roads, with behavior dependent on vehicle travel volume and roadside cover habitat available. In a wildlife tracking study near a highway in Colorado, only about half (53%) of mule deer that approached the highway actually crossed, and mule deer comprised 77 percent of species tracked (Barnum 2001). In a Montana highway study, mule and white-tailed deer comprised the largest percentage of species killed as a result of vehicle collisions (62%) (Craighead *et al.* 2001). Being good jumpers, fences are less of a constraining factor to mule deer movements than to pronghorn, unless they are bordered by game-proof fences.

Mule deer are occasionally perceived as a problem on agricultural crops, especially alfalfa and haystacks during fall and winter. Efforts to fence or haze deer from these agricultural areas may result in increased energy expenditure and loss of body condition in winter. Conflicts on agricultural lands are often resolved by issuing kill permits and conducting depredation hunts. Thus, agricultural areas within traditional migration and or wintering areas are considered a risk factor to mule deer.

Increasingly, studies are demonstrating many of the negative effects on wildlife specific to oil and gas development (Wyoming Game and Fish Department 2004, Holloran 2005, Sawyer *et al.* 2006, Berger *et al.* 2006). Oil and gas development creates a complex network of roads, well pads, pipelines, pumping stations, and other infrastructure across the landscape. Direct impacts include the loss of habitat to well pads, access roads and pipelines. Indirect impacts may include changes in distribution, access, or deer activities caused by increased human disturbances associated with energy development (e.g., traffic, noise, human use). Sawyer and Nielsen (2010) found at the Pinedale Anticline Project Area in western Wyoming that mule deer avoided areas close to well pads, and did not habituate to presence of well pads. Lower predicted probabilities of use within 2.7 to 3.7 km of well pads suggested indirect habitat losses may be substantially larger than direct habitat losses (Sawyer *et al.* 2006). Overall, energy development at this site reduced mule deer abundance to its lowest level since energy development begun (Sawyer and Nielsen 2010).

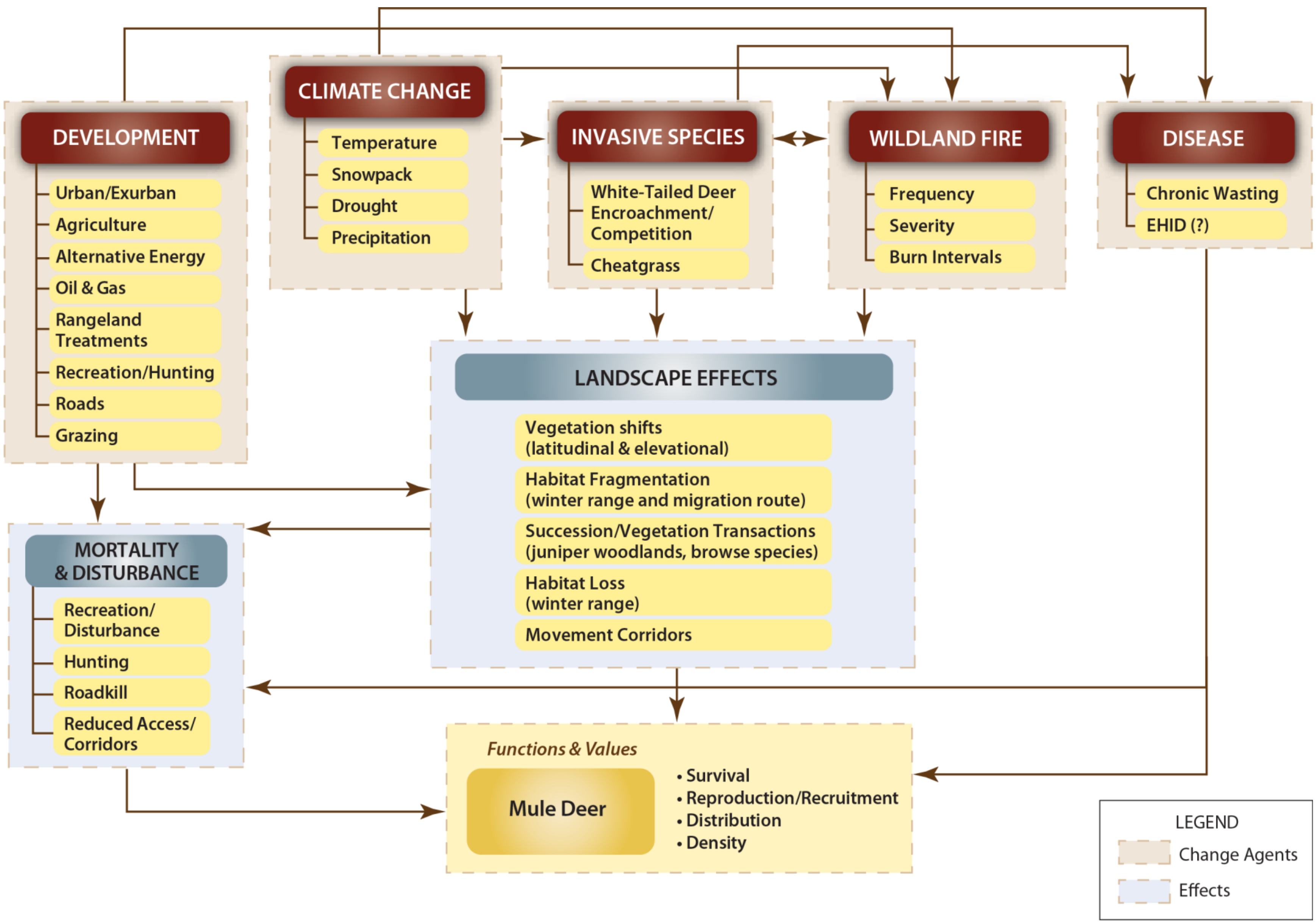


Figure 2.2-5. Mule Deer Conceptual Model

Wisdom *et al.* (2004) found that movement rates increase in response to some recreational off-road activities. Taylor and Knight (2003) noted that mule deer showed a 96 percent probability of flushing within 100 m of hikers or mountain bikers located off trails and suggested that the area around existing trails that may be impacted by recreationists was a 200-m "area of influence". These kinds of disturbances increase mule deer energy expenditures, which can be especially adverse during winter and breeding season.

Climate Change

The primary impact of climatic conditions on mule deer and their habitat are through (a) effects of the moisture and temperature regime on availability of forage resources (i.e., productivity, species composition, and nutrient content are affected by drought, late frosts, etc.), and (b) snow depth on winter ranges and migration corridors. Mule deer are less affected by severe cold weather than by high levels of snow cover, which restrict access to forage. Gilbert *et al.* (1970) stated that snow depth over 18 inches precluded use of winter range by deer, but energy costs of locomotion for mule deer increase significantly at 10 in (25 cm), regardless of the density of snow (Parker *et al.* 1984). Lower snowfall amounts are projected to occur in much of western North America as a result of climate change, which may reduce the importance of, or change locations of, winter ranges for mule deer. However, global warming patterns are projected to lead to loss of sagebrush winter ranges and increasing coniferous communities, which will reduce habitat quality of winter range (Lutz *et al.* 2003). In addition, climate-induced changes could begin to expose native plant communities to invasive weed species or exacerbate current invasive weed problems, which may alter range forage quality and fire regimes. Generally, ecoregional differences in the impact to mule deer populations are expected to occur as climate change progresses (deVos and McKinney 2007).

Mule deer autumn migration is highly variable and likely associated with patterns of winter weather (cold and snow); whereas spring migration seems to be coincident with decreasing snow depth and advances in plant phenology. The likely association between seasonal migration and weather conditions provides evidence that those migratory patterns may be altered by global climate change. Climate change is thought to negatively affect abundance and distribution of mule deer in hotter and drier ecoregions, while in ecoregions where extreme winters presently limit these populations in some years, short-term effects on abundance and distribution may be positive, but long-term effects are uncertain.

Wildland Fire and Invasive Species

The effects of fire on mule deer habitat are widely varied and well documented in the literature. Fire generally has a beneficial impact on mule deer habitat, by stimulating earlier greenup the following spring, which increases availability and nutritional quality of forage and more herbaceous plants. However, fire can also facilitate invasion by cheatgrass, which has low value as mule deer forage, and reduce shrub cover. The absence of fire for 50 years or more, with subsequent conifer encroachment, canopy closure, and deterioration of herbaceous and shrub understories has resulted in deterioration of mule deer habitat in some areas of the West. Fire suppression results in thickening of pine stands and, therefore, decreases in secondary stages of plant succession, which are important to mule deer. Mule deer generally seem to prefer recently burned areas that create mosaics of forage and cover, as long as herbaceous vegetation and re-sprouting browse species remain viable and nutritious (Hobbs and Spowart 1984). Regrowth that follows burned sagebrush communities can result in significant increases of herbaceous plants favored by mule deer. However, when sagebrush is the only cover, its complete removal can be detrimental to mule deer, especially on winter range. There is some concern that white-tailed deer are moving into mule deer habitat in some areas and are better competitors, therefore displacing habitat and resources. White-tailed deer distribution in the NBR will be explored on this subject as the REA progresses.

Disease

Several diseases that affect mule deer may increase in presence and result in effects on populations in the NBR (e.g., chronic wasting disease, bluetongue, epizootic hemorrhagic disease, etc). However, none are thought to be directly associated with habitat alterations or anthropogenic changes to habitat quality at this time, but the topic will continue to be examined.

2.2.6 Bighorn Sheep

2.2.6.1 Rationale for being a CE

Two subspecies of bighorn sheep, the California (*Ovis canadensis californiana*) and Rocky Mountain (*O.c. canadensis*) inhabit portions of the NBR. Westward expansion of human populations, the accompanying hunting of wildlife, use and conversion of native habitats and exposure to domestic livestock disease spread led to bighorn sheep extirpation from Oregon by the mid 1940's (Oregon Department of Fish and Wildlife 2003). Land use changes have rendered much of the original wild sheep ranges unsuitable for occupancy. Present populations in Oregon are the result of reintroductions from California and occupy only a small percentage of historic ranges. Drastic population declines followed the arrival of homesteaders and other settlers in the late 1800s and early 1900s in Idaho as well (IDFG 2010). Concerns about disease spread to bighorn sheep led to developing a plan to keep domestic sheep separate from bighorns in Idaho (IDFG 2007). This plan states that “bighorn sheep are historically, culturally and economically valuable to the citizens of the State of Idaho and Tribes.” Bighorn sheep remain a sought-after game species.

2.2.6.2 Factors Related to the Distribution of the CE

The California bighorn sheep populations that are present in the NBR are found throughout the steeper terrain of southeast Oregon, and the non-timbered portions of the Deschutes and John Day River drainages below 8,000 feet with the timbered regions of the Blue and Umatilla mountains separating them from Rocky Mountain bighorn sheep in the northeastern portion of Oregon (Oregon Department of Fish and Wildlife 2003). In Oregon, most California bighorn herds are non-migratory, preferring rugged, open habitats with high visibility of their surroundings. Survival is positively correlated with amount of cliffrock, rimrock, and rocky outcroppings, particularly important for lambing and escape from predators (Oregon Department of Fish and Wildlife 2003). Habitats used include alpine and sub-alpine, open grasslands, shrub-steppes, and canyons among low elevation steep bunchgrass slopes interspersed with rock rims. Important habitat requirements are depicted in the conceptual model for Local Habitat/Terrain (Figure 2.2-6). These include “High Visibility” areas that indicate how bighorn sheep tend to avoid areas that have visual obstructions, such as trees or tall shrubs. The Rocky Mountain subspecies in Idaho also relies on the proximity of steep, rocky escape terrain, especially when lambs are young. During the lambing season, ewes select steep inaccessible cliffs to give birth. Beyer (2008) reported that landscape ruggedness, aspect (favorable sun exposure for higher solar radiation index, more snow melt, and forage exposure) were important winter ranges habitat characteristics that affected population stability. Seasonal migrations occur in most populations, and open grasslands and shrublands typically provide winter ranges. Diets are diverse and can include grasses and sedges, browse, or forbs; forbs often contribute the greatest number of plant species eaten (Shackleton *et al.* 1999).

2.2.6.3 Key Change Agents

Development

Specific development types that may limit bighorn health and habitat access include anywhere domestic sheep are grazed, mining, and military use of steep terrain and low level overflights. Helicopters have been shown to have an adverse effect on mountain bighorn sheep movements, habitat use, and foraging efficiency (Bleich *et al.* 1994). However, Krausman *et al.* (1993) found no long-term detrimental effects to penned desert bighorn sheep from jet overflights conducted about 125 m above ground level in Nevada.

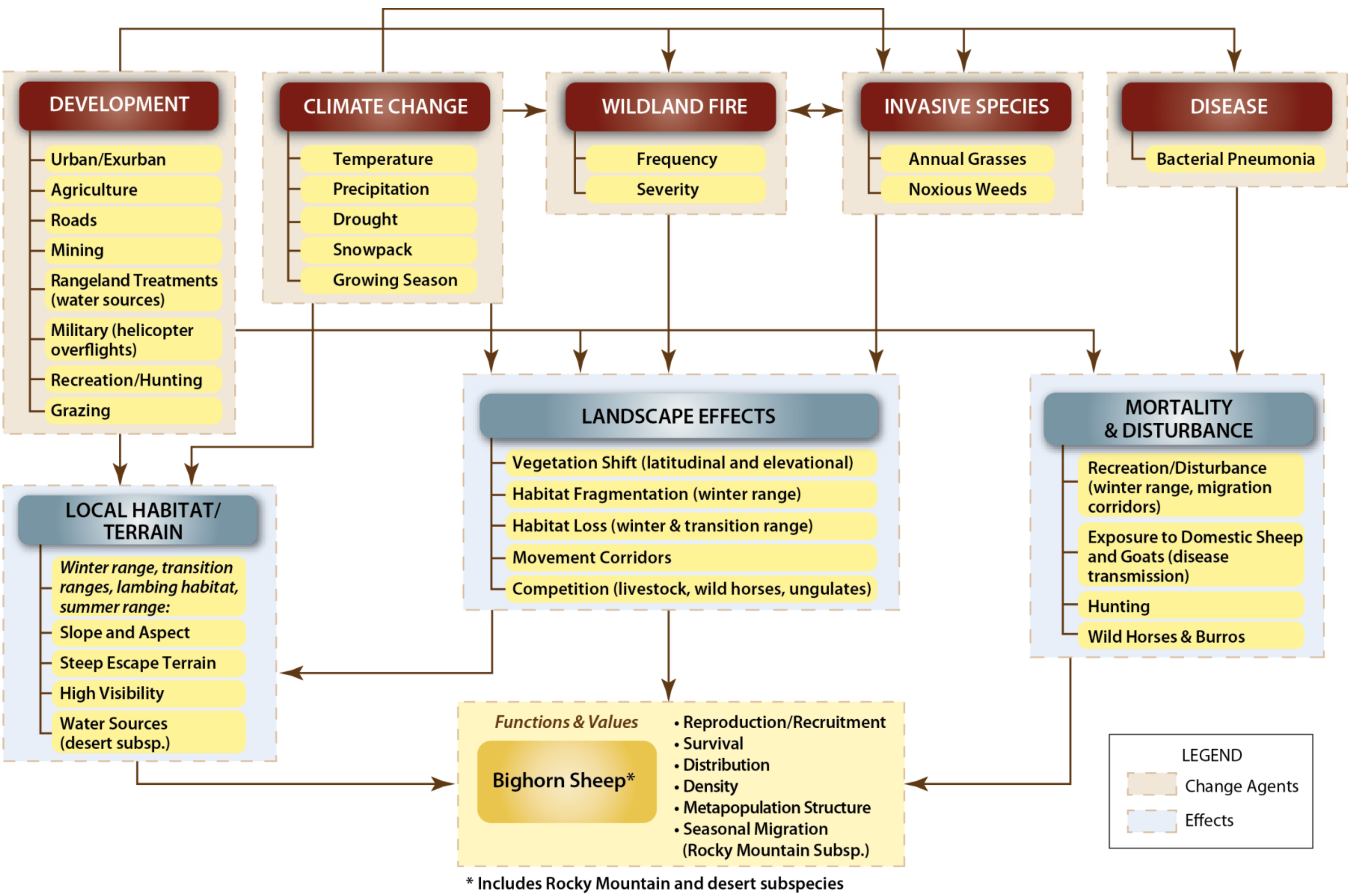


Figure 2.2-6. Bighorn Sheep Conceptual Model

Few studies of road effects on bighorn sheep have been conducted. Similar analyses for other western big game suggested that road densities above one mile of road per square miles (mi/mi$^{2)}$ reduced habitat effectiveness by 25 percent for some big game species (Lyon 1979). At road densities of 2 mi/mi^{2,} effective habitat decreased by 50 percent, and at road densities of 6 mi/mi^2 elk use of suitable habitat declined by 75 percent. Coe *et al.* (2011) developed resource selection functions (RSFs) to estimate and predict spatial distributions and resource use by elk in Oregon in which distance to traffic, slope, and percent forest cover figured prominently. A commonly used minimum patch size for security habitat is 250 contiguous acres more than 0.5 miles from an open road (Christensen *et al.* 1993, Leege 1984).

Studies of recreation disturbance effects on bighorn sheep are few. Research on similar species found that elk responded in 65 percent of all cases with flight when a human disturbance was at close range (under 500 m); beyond 500 m, the probability of animal flight declined for hiking and horseback riding, but remained high for all-terrain vehicle (ATV) and mountain biking until distance increased to 1,500 m (Wisdom *et al.* 2004). Movement rates also increased during ATV and mountain bike presence (Wisdom *et al.* 2004). These types of studies may be applicable to investigating potential effects from recreation on bighorn sheep populations in the NBR.

Climate Change

Climate change effects on big game species are primarily related to changes in vegetation communities, fire regimes, plant productivity, water availability (in arid environments), and the amount and persistence of snow pack affecting winter range. Rapid changes in climate have been documented to have adverse effects on bighorn sheep. Epps *et al.* (2004) investigated how climate change affected bighorn sheep in southern California and concluded that increased temperature and decreased precipitation in the late 1900s was an important factor in bighorn sheep population extirpations in California. These findings may apply to understanding the direction and role of climate change on the California bighorn sheep in Oregon within the ecoregion.

Invasive Species and Wildland Fire

Direct effects of invasive vegetation species are concentrated on competition with bighorn sheep preferred forage and reduction of native forage species. In addition, some invasive species (especially *Bromus* spp.) can alter fire regimes and thus affect entire landscapes and their communities by increasing fire frequency, extent and severity. As for the other big game species, wildland fire threats to bighorn sheep are generally related to short-term loss of forage. Depending on fire severity and the size and timing of fires, bighorn sheep may need to migrate out of affected areas. However, within one to two seasons, forage conditions are generally improved over pre-fire conditions and these effects may last for several years, depending on the vegetation community. Vegetation transitions across ecological thresholds following wildfires are often associated with loss of important habitat resources and functions for wildlife, such as foraging areas, parturition areas or winter ranges. Thus, vegetation state and fire frequency and severity are important indicators for habitat stability.

Disease

Bighorn sheep have experienced die-offs caused by pneumonia, which results from contracting *Pasteurella haemolytica* from domestic sheep (Foreyt 1989). Domestic sheep allotments in or near active bighorn sheep habitat are a major risk factor for this species. In Idaho, bighorn population declines as a result of contracting bacterial pneumonia from domestic sheep have been serious enough that the governor asked the state to write a plan to keep domestic and wild sheep separate (IDFG 2007).

2.2.7 Pygmy Rabbit

2.2.7.1 Rationale for being a CE

The pygmy rabbit (*Brachylagus idahoensis*) is the smallest rabbit species in North America and occupies sagebrush-steppe communities within the Great Basin and adjacent Intermountain West. The distribution of the species is widespread but populations are disjunct within a large geographic range that roughly stretches from southwestern Oregon, through central Nevada, to western Utah, into southern Idaho. Along with natural factors, effects from anthropogenic factors have generated concern for the status and conservation of pygmy rabbit populations throughout most of its range. Its current distribution is much reduced from historic locations and recent concern has prompted interest in the species. In addition, populations are susceptible to rapid declines due to local isolation of small populations and increased disturbances from fire and agricultural/ranching interests. Little assessment of effects of fragmentation on pygmy rabbit habitat use and population dynamics has been done (Hagar and Lienkaemper 2007, Gabler *et al.* 2001).

2.2.7.2 Factors Related to the Distribution of the CE

The pygmy rabbit is a sagebrush obligate and relies on big sagebrush (*Artemisia tridentata* spp.) for food (51–99% of the diet) and cover from thermal extremes and predators (Crawford 2008, Gabler *et al.* 2001). Several investigators have identified the presence of taller, denser stands of big sagebrush, relative to surrounding unused areas, as an essential feature of pygmy rabbit habitat (Crawford 2008, Larrucea and Brussard 2008, Hagar and Lienkaemper 2007, Gabler *et al.* 2001). This is depicted as the Landscape Effects box in the conceptual model (Figure 2.2-7). Suitable habitat selection appears to be based on a complex of vegetation and soil characteristics (Gabler *et al.* 2001). Important vegetative characteristics include composition (i.e., sagebrush), shrub cover, and shrub height (greater than 65 cm) (Hagar and Lienkaemper 2007). Deep (greater than 61 cm), friable soils are required for the species to dig their burrows. Soil texture is also important, usually comprised of greater sand and less clay content in an optimal balance to provide ease of burrow excavation and minimize burrow collapse (Hagar and Lienkaemper 2007).

2.2.7.3 Key Change Agents

Development and Invasive Species

As for other sagebrush CEs, many development CAs have affected the suitable habitat quality and availability for the pygmy rabbit (Figure 2.2-7). These include urban/exurban expansion, agriculture (when land conversion occurs), alternative and traditional energy exploration and development, linear features (especially pipelines that disrupt vegetation and soil structure), and rangeland treatments that reduce sagebrush habitat amounts. Grazing is also included in the Development category of the model.

Important pygmy rabbit habitat requirements listed in the Local Habitat Effects box from Figure 2.2-7 that may be affected by development include patch size, density, and cover reductions, changes to vegetation height or composition, fragmentation of interconnected suitable patches, and any changes to soil type. Large, land-intensive development types especially affect the natural patchy distribution of sagebrush communities resulting in changes to pygmy rabbit behavior, movements, and feeding habits (Crawford 2008). As indicted by the Mortality and Disturbance box (Figure 2.2-7, competition with other species has been identified as an issue for pygmy rabbits and suitable habitat occupancy decreased with presence of cottontails (Larrucea and Brussard 2008). These researchers also found that an increase in cheatgrass (invasive grass) reduced pygmy rabbit occupancy.

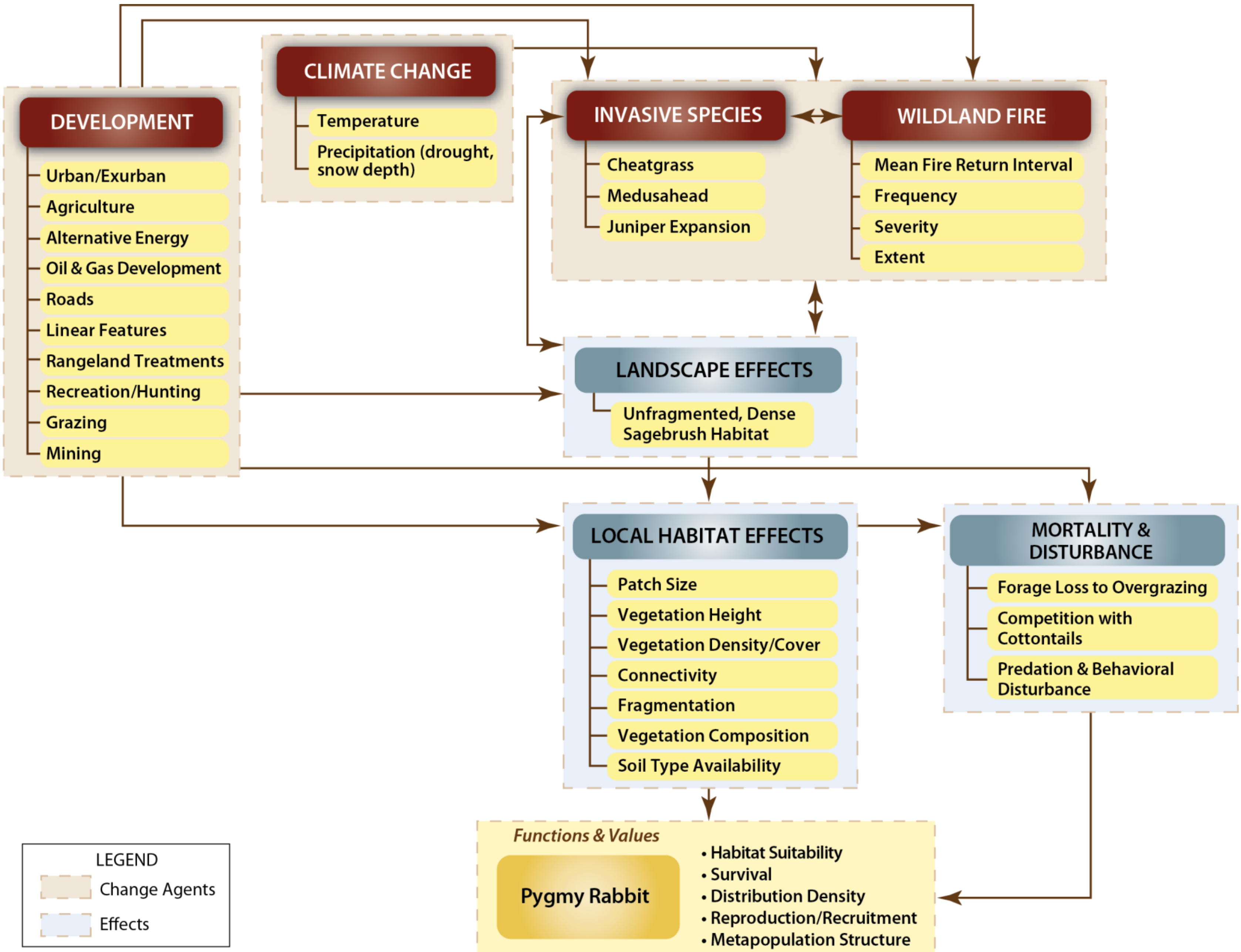


Figure 2.2-7. Pygmy Rabbit Conceptual Model

Maintaining connectivity between patches of adequate size was found to be of great importance for pygmy rabbit populations studied in southwest Idaho (Burak 2006). Any of the CAs that fragment habitat patches and limit successful rabbit dispersal among patches would have adverse effects, potentially leading to local extirpations. However, little information is currently available, especially at the landscape level, to assess effects of fragmentation on pygmy rabbit habitat use and population dynamics, including genetic analysis of metapopulations (Hagar and Lienkaemper 2007). For this reason, the model includes several local habitat effects factors that can be evaluated to determine effects to pygmy rabbits (Figure 2.2-7).

Pygmy rabbit habitat is affected by livestock grazing when it is severe enough to affect sagebrush cover or the nutritional quality of forage (Hagar and Lienkaemper 2007). Refer to the sagebrush coarse filter effects analysis Section 2.3.1.1 and Figure 2.3-3 for a complete discussion on CAs that affect this vegetation type.

Wildland Fire and Climate Change

The increase in fire frequency in the West within this century also poses serious threats to pygmy rabbit habitat (Gabler *et al.* 2001). Understanding of the pygmy rabbit is relatively new and climate change studies on the species were not found. The treatment of climate change effects to sagebrush ecosystems is well reviewed under the sagebrush and greater sage-grouse sections (Sections 2.2.1 and 2.3.1) and implications can readily be applied to predictions for this species.

2.2.8 Bats

2.2.8.1 Rationale for being a CE

The bat species assemblage in the Northern Great Basin and SRP ecoregions includes 14 vespertilionid species in eight genera, including seven *Myotis* species. Other species that have been reported in the ecoregions on occasion will not be included because these records are outliers, or were on the extreme periphery of the species' range. Bats in this assemblage exhibit a wide variety of adaptations characterized by 1) roost preference, 2) foraging behavior/preferred habitats, and 3) migratory vs. year-round occurrence (Table 2.2-1). In these ecoregions resident status implies the need to hibernate during winter months; thus, bat species may also be characterized by 4) hibernation site preference. Two species that are widespread in the ecoregions but are migratory are the silver-haired bat and the hoary bat (Cryan 2003, Miller *et al.* 2005a, Bradley *et al.* 2006). All of the other species are known to hibernate in these ecoregions, or are likely to do so (Perkins *et al.* 1990, Miller *et al.* 2005a, Bradley *et al.* 2006). Migration corridors and winter habitats of the migratory species in these ecoregions are unknown.

2.2.8.2 Factors Related to the Distribution of the CE

Availability of suitable roosts is critical to all bat species and influences species distribution, diversity and abundance (Kunz 1982, Humphrey 1975). Roost types used during spring through fall include day roosts, night roosts, maternity roosts, and bachelor (males and non-reproductive females) roosts. Some species are associated with a particular type of roost; for example, Townsend's big-eared bat is strongly associated with caves and mines, while the big brown bat is associated with buildings (Kunz *et al.* 2003). Crevice-dwelling is a prevalent feature of vespertilionid bats in arid and semiarid regions (Kunz 1982); the spotted bat and canyon bat are strongly associated with crevices in rocky outcrops and cliffs (Barbour and Davis 1969, Pierson and Rainey 1998). However, although bat species may have preferences among available roost sites, most will actually utilize a wide variety of roost sites depending on microclimate conditions within the roosts, the life stage of the individual, and proximity to preferred foraging areas and water (Kunz 1982, Bogan *et al.* 2003, Baker and Lacki 2006). Hibernacula used in winter months have very different requirements, with a much narrower range of sites (generally caves and underground mines) providing the cold moist conditions required to promote winter torpor (Tuttle 1997). Many bat species must make

Table 2.2-1. Roost and Foraging Site Preferences of Bat Species that occur in the Northern Great Basin/Snake River Plain Ecoregions

Species	Roosting Habitat				Foraging Habitat			Hibernacula		
	Caves & Mines	Cliffs, Crevices, Talus	Trees	Buildings & Bridges	Aquatic Habitats[2]	Forest, Woodland & Riparian	Xeric & Shrub Habitats[3]	Cave, Mine	Rock Crevice	Buildings
Cave and Mine Roosting Species										
Townsend's big-eared bat *Corynorhinus townsendii*	Primary	Secondary	Secondary	Secondary		Primary	Secondary	Primary		
Cliff-Roosting Species										
Spotted bat *Euderma maculatum*	Secondary	Primary		Secondary		Secondary	Primary		?	
Canyon bat *Parastrellus hesperus*	Secondary	Primary		Secondary			Primary	Primary	Primary	
Tree-Roosting Species										
Silver-haired bat *Lasionycteris notivagans*			Primary			Primary		Migratory species		
Hoary bat *Lasiurus cinereus*			Primary			Primary		Migratory species		
Multiple Roost Types										
Pallid bat *Antrozous pallidus*	Primary	Primary	Secondary	Primary			Primary	Primary	Primary	Secondary
Big brown bat *Eptesicus fuscus*	Secondary	Secondary	Secondary	Primary	Primary	Primary		Primary		Primary
California myotis *Myotis californicus*	Primary	Secondary	Primary	Secondary	Secondary	Primary	Secondary	Primary		Secondary
Western small-footed myotis, *Myotis ciliolabrum*	Primary	Secondary	Primary			Secondary	Primary	Primary	Primary	
Long-eared myotis *Myotis evotis*	Secondary	Secondary	Primary	Secondary		Primary		?		
Little brown bat *Myotis lucifugus*	Secondary	Secondary	Primary	Primary	Primary	Primary		Primary		
Fringed bat *Myotis thysanodes*	Primary	Secondary	Primary	Secondary		Secondary	Primary	?		
Long-legged myotis *Myotis volans*	Secondary	Secondary	Primary	Secondary		Primary		Primary		
Yuma myotis *Myotis yumanensis*	Primary	Secondary	Secondary	Primary	Primary	Primary		?		

Legend: Primary Association (dark green) | Secondary Association (light green)

Notes:

1. Roost types include day roost, night roost, maternity roost.
2. All bats drink water; this column indicates species that frequently forage over water.
3. Xeric and shrub habitats include salt desert scrub, shrub-steppe, grasslands.

Sources: Bradley *et al.* 2006, Miller *et al.* 2005a, Oliver 2000, ODFW 2011, Western Bat Working Group 2007, Harvey *et al.* 2011, Maser and Cross 1981.

seasonal movements, which are poorly understood, in order to access suitable sites. Bats frequently display a high degree of philopatry to maternity roosts and hibernacula and may concentrate there in large numbers, making the identification and protection of these sites especially important.

Although all bat species in this assemblage are insectivorous they nonetheless exhibit differences in prey selection, foraging method, and foraging habitat (Table 2.2-1). Insectivorous bats are adapted to the ephemeral life cycles of their prey and readily travel to exploit insect hatches (Richardson 2002).

The system-level model for the bat assemblage illustrates the effects of the change agents, on the primary habitat requirements of resident (non-migratory) species in this assemblage, and the role of change agents as sources of mortality and disturbance (Figure 2.2-8). Central to the model is a simplified life cycle schematic that depicts roost site requirements in three stages of the life cycle of resident (non-migratory) species. The model does not depict bachelor summer roosts or transitional roosts used by bats during the fall mating period, or while transiting between summer roosts and hibernacula. Transitional roosts are poorly documented in these ecoregions, but they likely do not have the same microclimate requirements as maternity roosts. Application of the model to the migratory species would involve substitution of migratory corridors and winter habitats, which are largely unknown in this region, for hibernation sites.

2.2.8.3 Key Change Agents

The most important actual and potential CAs with direct effects on this assemblage involve human development, climate change, and disease.

Development

As discussed above, availability of suitable roost sites is critical to all bat species and loss of roost sites is a significant threat to bat populations. Therefore, the model links human development to life cycle/roost site requirements. Bat Conservation Plans recently developed by sections of the Western Bat Working Group in several western states (Miller *et al.* 2005a, Bradley *et al.* 2006) cite a number of anthropogenic threats that directly affect roost site availability, including closure of abandoned mines, re-opening of historic mines (Brown 1995), highway and bridge construction and maintenance, and timber harvest (Barclay and Brigham 1996).

Disturbance of bats at roost sites, leading to death of bats, reproductive failure, and/or abandonment of roosts are shown in the model as related to recreational caving, although disturbance at other types of roosts such as buildings and bridges may also contribute. Other sources of mortality are related to the use of pesticides (which reduce insect prey availability and may directly poison bats), toxic waste impoundments at mines, collisions with wind turbines (Arnett *et al.* 2008, Cryan and Barclay 2009), and the potential spread of white nose syndrome (see *Disease* below) by humans to hibernacula.

The model depicts anthropogenic and naturally-occurring change agents that affect prey availability and foraging habitat availability. These effects are shown as direct effects of development on foraging habitats and prey availability, such as loss of habitats used by prey species and reduced prey numbers due to pesticide use in agricultural areas. Grazing practices and rangeland management may alter the vegetative community, especially riparian habitats (Swift 1984), affecting the insect prey base. Manmade hydrologic changes such as ground water pumping or development for livestock use, and large-scale water diversion can alter or reduce the amount of natural vegetation available as foraging habitat.

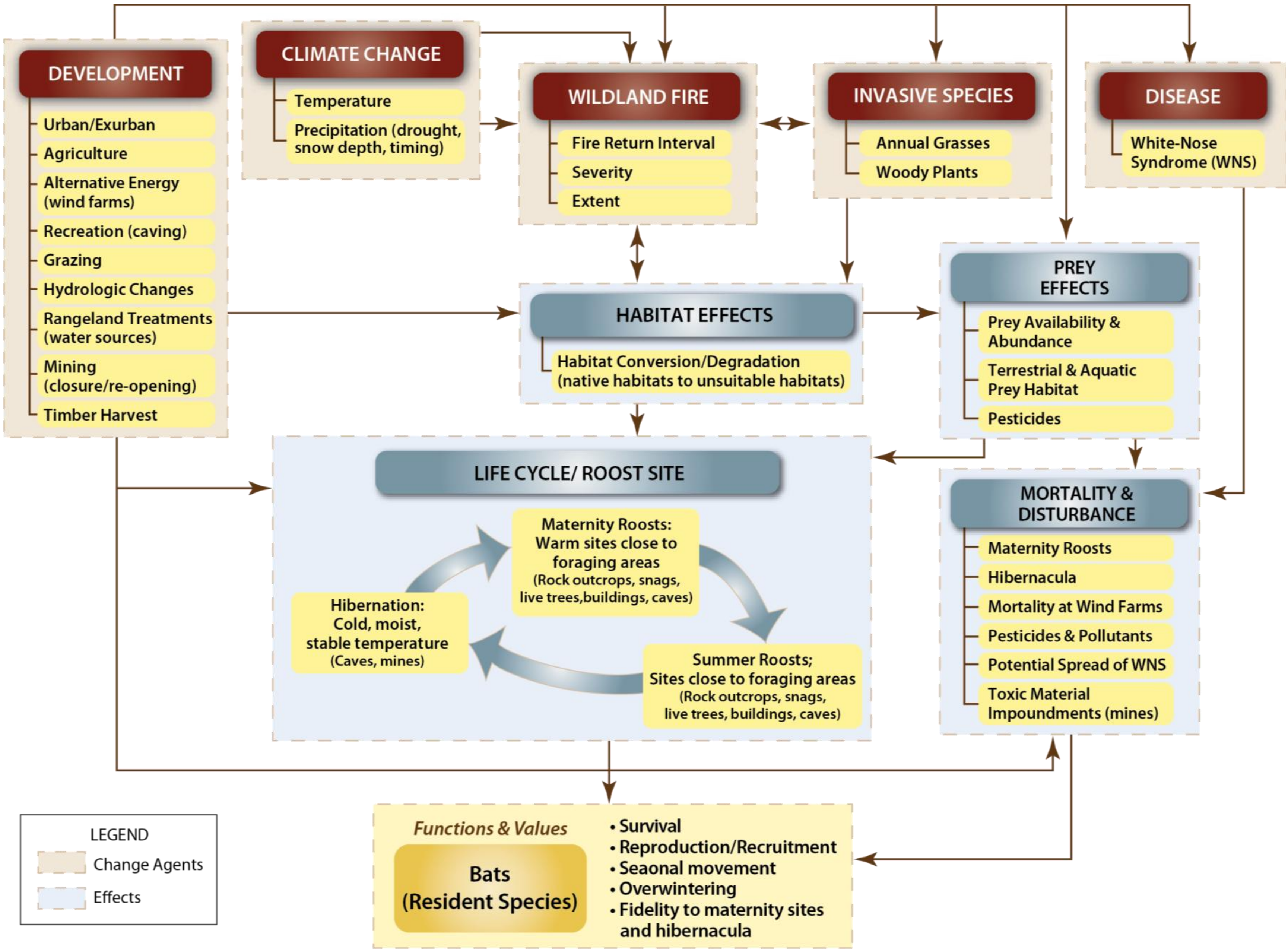


Figure 2.2-8. Bats System Model

Climate Change

Climate change is shown in the model as acting indirectly in concert with wildland fire and invasive species to result landscape-level effects involving conversion of native habitats used by foraging bats to less productive habitats. Loss of native shrub steppe and juniper habitats, through the agents of wildland fire, livestock grazing, and rangeland manipulation, have been converted to exotic grasslands. Many prey species such as moths which are present in shrub- and tree-dominated communities do not occur in grasslands; thus, habitat conversion is linked to foraging habitat/prey availability. Landscape-level effects are linked to the life cycle of bat species because habitat conversion may limit the ability of bats to move among the various sites they require in different seasons.

Disease

White-nosed syndrome (WNS) is included as a disease-related CA in the system model because it has the potential become a significant source of mortality of bat species in the NBR/SRP ecoregions. White-nosed syndrome (*Geomyces destructans*) is a fungal disease that has devastated hibernating bats in eastern North America since it was first identified in 2006 (USFWS 2011b). Eleven cave-hibernating species in eastern states and provinces have been affected by or are potentially at risk from WNS, including several species that also occur in the NBR/SRP ecoregions. By the end of the 2010-2011 hibernating season, WNS had not been identified in any bats or substrate in hibernacula in any western state or province. However, given its rapid spread to date it is possible that hibernacula in these ecoregions may be affected in the future through transmittal of the organism by infected bats or humans who enter hibernacula with contaminated caving/mining clothing or equipment.

2.2.9 Spotted Frog

2.2.9.1 Rationale for being a CE

Columbia spotted frog populations in the Northern Basin and Range ecoregion represent the southernmost extent of the species' range. Columbia spotted frogs in northern Nevada, southwestern Idaho, and most populations in southeastern Oregon are geographically separate and genetically distinct from the remainder of the species (Engle and Munger 2003). These populations are small, exhibit low genetic variation, and are highly vulnerable to the threats faced by most small isolated populations: susceptibility to stochastic events, reduced genetic diversity, inbreeding effects, and high probability of local extinction (Funk *et al.* 2008). Sites at which frogs become locally extinct have a small probability of reoccupation due to overall low levels of migration. Thus, major concerns for this widely-distributed landscape species are isolation of populations and concern over persistence of local populations (USFWS 2011a).

2.2.9.2 Factors Related to the Distribution of the CE

Columbia spotted frog are strongly associated with clear, slow-moving or ponded surface waters with little shade, and relatively constant water temperatures (Munger *et al.* 1996, Reaser and Pilliod 2005, Bull 2005, Wilson 2006). Selected breeding/larval rearing sites provide a variety of herbaceous emergent, floating, and submergent vegetation (Bull 2005, Pearl *et al.* 2007). Although they are known to use temporary bodies of water for breeding in more mesic parts of their range, in more arid portions of the ecoregion breeding sites are predominantly associated with springs or other permanent water sources such as shallow ponds, and shorelines of streams and lakes (Pearl *et al.* 2007, Wilson 2006). A variety of change agents, discussed below, affect the availability and condition of spotted frog habitats.

Anuran habitats must provide the major resources for the annual cycle: reproduction, foraging, hibernation/estivation (Sinisch 1990). These life cycle stages are central in the system model (Figure 2.2-9). In some circumstances, these resources may be located in the same habitat patch (e.g., a

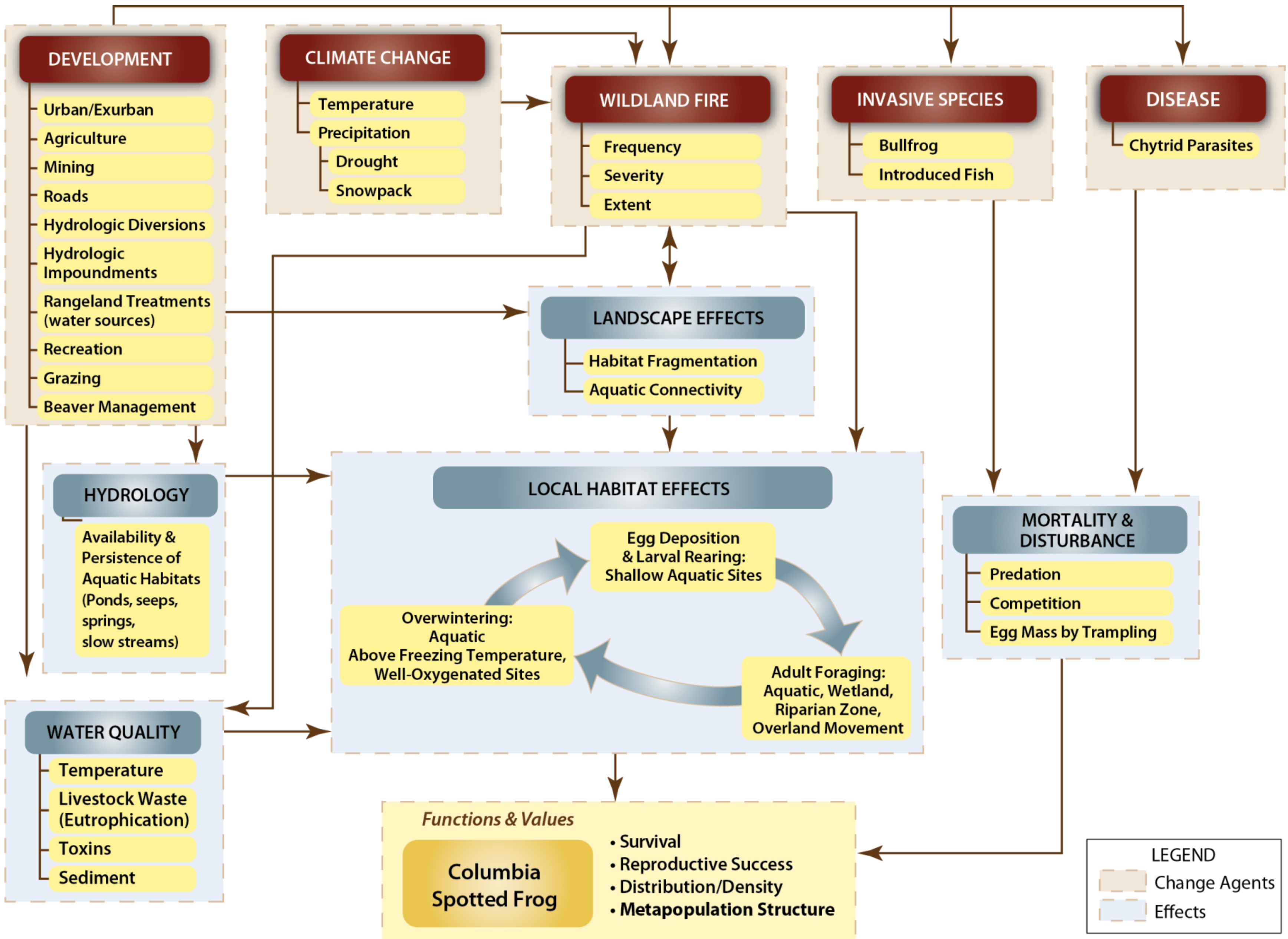


Figure 2.2-9. Spotted Frog System Model

breeding pond with adequate summer and winter habitat) but for many Columbia spotted frogs, some or all of these resources are spatially separated, requiring seasonal migrations among different, sometimes distant, water bodies (Pilliod *et al.* 2002). For example, up to 50 percent of adult female Columbia spotted frogs migrated between aquatic breeding and summer habitats separated by 500 m or more of dry coniferous forests in high elevation montane sites (Pilliod *et al.* 2002). Bull and Hayes (2001) found that pond size, proximity to other permanent water, and water temperature were associated with frog movements. Presence of predators and food supply are important of breeding and summer habitats (Bull and Hayes 2001, Pilliod *et al.* 2010). Post-breeding travel frequently follows streams and riparian corridors (Turner 1960), but movement across dry, grazed grasslands and sagebrush uplands has been documented (Reaser and Pilliod 2005, Bull and Hayes 2001). Spotted frog migrations often appear to follow shortest-distance travel routes through dry open forest even when stream corridors were available nearby (Pilliod *et al.* 2002). Columbia spotted frog overwintering habitats are different from breeding and summer habitats, and are primarily related to availability of a silt or muck layer for hibernation and sufficient oxygen levels beneath frozen pond surfaces (Bull and Hayes 2002, Pilliod *et al.* 2002, Bull 2005, Reaser and Pilliod 2005). Thus, conservation concerns include protecting not only suitable aquatic habitats for breeding/larval rearing, summer, and winter life cycle stages but also the stream, riparian, and overland corridors that connect these habitats. Pilliod *et al.* (2002) recommended protecting diverse water bodies and surrounding uplands within 1 km of breeding ponds in high elevation sites. Bull and Hayes (2001) recommended protecting permanent ponds and river and stream habitat within at least 500 m of breeding ponds in northeastern Oregon.

2.2.9.3 Key Change Agents

Development

Many anthropogenic and natural change agent effects determine the availability and condition of suitable spotted frog habitats and the distribution and persistence of spotted frog populations. Habitat loss, degradation, and fragmentation is a combined result of past and current human development influences related to agriculture, livestock grazing, hydrologic diversions, urbanization, mining, and climate change (USFWS 2005). Most of the development change agents depicted in the system model (Figure 2.2-9) affect hydrology and water quality in spotted frogs' habitats. Urbanizing areas, for example, tend to increase impervious surface, putting increased demands on existing wetlands and streams to carry runoff. Stream dredging and straightening lead to floodwaters rising and falling at an increased rate. Spotted frog breeding habitat at the margins of shallow wetlands and ponds can be affected by more pronounced and rapid water level fluctuations: eggs laid during or immediately following late winter rains are often left exposed to freezing and desiccation by rapidly dropping water levels (Richter and Azous 1995). Water diversions and impoundments for agriculture, urban/exurban development, and rangeland management are included in the system model to indicate many other direct and indirect effects on spotted frog habitat, including lost or reduced surface and groundwater flow, flooding of desirable shallow-water habitat, changes in water temperatures, and increased habitat for predatory fish.

In semi-arid areas, springs represent a stable permanent source of water for breeding, feeding, and overwintering frogs (Patla and Peterson 1996, Munger 2003); diversion of springs for livestock watering can lead to a the loss of associated riparian habitats and wetlands. Livestock grazing affects riparian and stream ecosystems throughout the range of the Columbia spotted frog (Minshall *et al.* 1989, Munger *et al.* 1996, Reaser 1997, Engle 2002), but the magnitude of this threat in terms of frogs' reproductive success and survival is uncertain in the literature (reviews in USFWS 2005, Patla and Keinath 2005). Management of beaver populations is an important element affecting the availability of suitable spotted frog habitat (Reaser 1997, NDOW 2006, ODFW 2006), and past beaver and beaver dam removal practices have negatively influenced spotted frog habitat (USFWS 2005). The effects of mining on water quality and quantity in general, and amphibians in particular include addition of toxic substances into streams (such as methylmercury and other trace metals), altered stream morphology, and effects on groundwater and aquifers (Nelson *et al.* 1991, USFWS 2008, NDOW 2010). Aquatic habitat loss and degradation have had both local and landscape-level effects on Columbia spotted frogs, as shown in the system model. Loss of connectivity between aquatic habitats and fragmentation of habitat patches have contributed to the isolation of remaining spotted frog populations with implications for the long-term persistence of populations.

Climate Change

Spotted frogs are highly vulnerable to natural drought events which sometimes cause local extirpations of populations (Turner 1962, Munger *et al.* 2002, Wilson 2006). The role of climate change beyond historic variations in temperature and precipitation has been considered in the amphibian literature but measurable effects have not been well documented. In the western states, documented warming trends will produce large hydrological changes due to reduced snowpack and earlier melting. Direct effects on spotted frogs may include loss of some ponds due to higher summer temperatures with reduced survival during overland migration, earlier reproduction and more rapid larval development, and shorter hibernation periods, (Corn 2003, Corn 2005, Patla and Keinath 2005), but the net effect is currently difficult to predict.

Invasive Species

At the level of effects on individual survival and reproductive success, shown as mortality and disturbance in the system model, the primary change agents are invasive predatory fish species (salmonids and bass) and bullfrogs (Monello and Wright 1999, Pilliod and Peterson 2001, Munger *et al.* 1996) and disease (chrytridiomycosis [chytrid] and ranavirus). Chytrid has not been associated with any large die-off of Columbia spotted frogs (Rollins-Smith *et al.* 2005, Adams *et al.* 2010) but monitoring of its occurrence and a better understanding of how it affects this species is needed (Russell *et al.* 2010). Malformations of frogs, which generally lead to higher mortality rates, are a common problem in Columbia spotted frog populations outside the Great Basin Distinct Population Segment (DPS) (Johnson *et al.* 2002). These malformations are associated with the presence and abundance of trematodes (*Ribeiroia*) and parasitic snails (*Planorbella*) in anthropogenic wetlands and stock ponds. The level of malformations in the Great Basin DPS of Columbia spotted frogs is currently not significant but the range extension of *Planorbella* into the ecoregion may result in a greater threat.

2.2.10 Bull Trout

2.2.10.1 Rationale for being a CE

Bull trout, an ESA threatened species, currently occurs in less than half of their historic range. Of all salmonids, due to their sensitivity to environmental conditions, bull trout are considered excellent indicators of water quality. Habitat alteration/loss, habitat fragmentation, riparian condition, climate change, environmental effects of mining and hybridization with introduced trout species are also factors affecting bull trout status and distribution over its this range (Rieman and McIntyre 1993, USFWS 2002, Andonaegui 2003, Dunham *et al.* 2003a). The reduction of suitable habitat conditions by CAs will further constrict the range over which bull trout can occur. Decreases in habitat connectivity also isolate individual populations and decrease the sustainability of the metapopulation. The system level conceptual model (Figure 2.2-10) illustrates the interactions between the CAs and the primary habitat functions for bull trout in this ecoregion.

2.2.10.2 Factors Related to the Distribution of the CE

Bull trout have the most specific habitat requirements of salmonids, including the “Four Cs”: Cold, Clean, Complex and Connected habitat. Bull trout require colder water temperature than most salmonids, very clean stream substrates for spawning and rearing, complex and connected habitats, including streams with riffles and deep pools, undercut banks and lots of large logs, for rearing and annual spawning and feeding migrations.

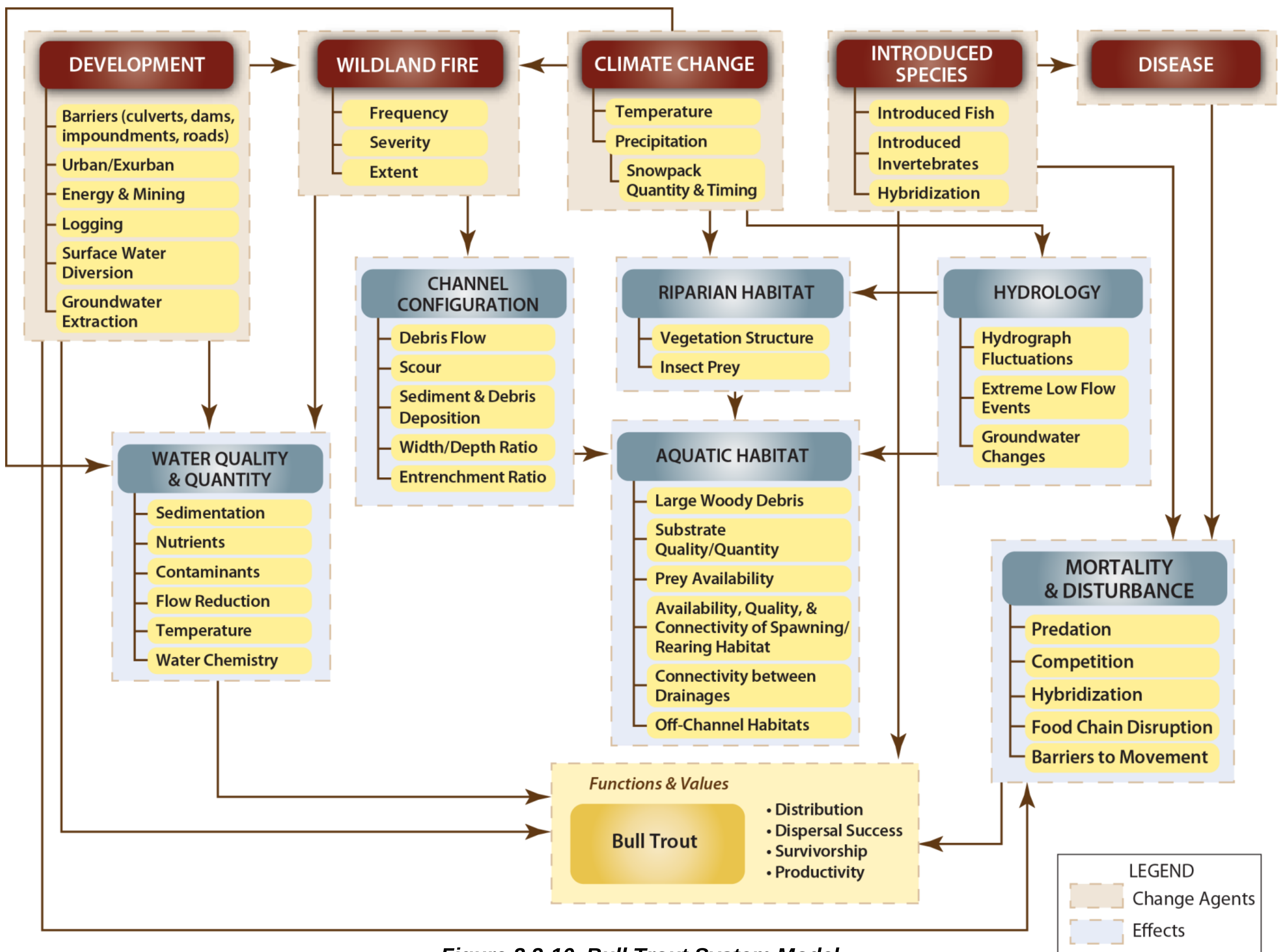


Figure 2.2-10. Bull Trout System Model

2.2.10.3 Key Change Agents

Development

Past human development activities have adversely affected the Four-C's in many ways. As depicted in the model for Bull Trout (Figure 2.2-10), within drainages of this ecoregion dams, logging, urban/exurban development, road construction, and mining have resulted in streambank erosion, sedimentation, adverse changes to channel configuration, reductions in water quality, and loss of riparian habitat which provides shading and a source of insect prey for aquatic habitats. In addition to increased sedimentation, water chemistry can be degraded by contaminants and nutrients in runoff from adjacent developments and mining. As discussed in more detail for coldwater fish in Section 2.2.11, in areas of past mining activity, metals such as zinc, copper, and iron have adversely affected the ecological function of these systems, and have the potential to lead to fish death.

Migrational barriers such as dams, improperly placed culverts, and irrigation diversions, among other migration barriers, have negatively affected bull trout and have interfered with metapopulation dynamics as well as spawning adult fish access to limited suitable spawning habitats within this ecoregion. Degradation of riparian vegetation in headwater streams can negatively impact bull trout habitat use through reductions in large woody debris contribution, shade, available food resources with this vegetation (e.g., insects), and the protection of water and sediment quality during precipitation events.

Climate Change

As addressed in more detail for coldwater fish (Section 2.2.11), reduced snowpack, water temperature changes, precipitation changes, and greater fluctuations in stream hydrographs will likely be significant stressors on native coldwater fish species that result from climate change. Due to a greater dependence on cold water than the coldwater fish assemblage, a reduction in cold waters represents an even greater risk of reducing suitable habitat conditions for bull trout in the ecoregion. RA reduced snowpack increases stream temperature variability. In addition, under climate change the snowpack will be replaced by periodic rain events as the climate gets warmer. These events would contribute to warmer instream temperatures, and increase fine sediment contribution to stream small tributaries. As bull trout have a narrow thermal tolerance range (Dunham *et al.* 2003a) particularly during early winter spawning periods, a reduction in snowpack will increase the range of instream temperatures, effectively decreasing the suitability of the limited number headwater streams as bull trout spawning habitat. The input of finer-grained sediments can bury eggs and fry and reduce the oxygenation of bull trout eggs, effectively decrease bull trout egg survivability. As populations are already isolated by migrational barriers, maintaining suitable spawning habitat is essential to avoid additional declines and local bull trout extinctions (Rieman *et al.* 1997).

Invasive Species

The introduction of non-native fishes in the waters occupied by bull trout, would result in competition with, and predation by, non-native fish species, and are among the primary concerns for persistence of bull trout throughout their range. Hybridization with introduced brook trout many times leads to sterile offspring (Leary *et al.* 1993). Introduced fish species such as channel catfish, smallmouth bass, and walleye likely influence population dynamics and distribution of bull trout.

Wildland Fire

Wildland fire effects on bull trout and their habitat are anticipated to be similar to those described for the coldwater fish assemblage, and are not repeated here.

Disease

Although all species of trout and salmon may become infected with the parasite responsible for whirling disease (*Myxobolus cerbralis*), an introduced disease agent that was first identified in the United States in 1956 and is now present in Idaho (Idaho Fish and Game 2007), bull trout appear to be somewhat resistant of the disease (Lorz *et al.* 2002). The significance of disease as a change agent for bull trout is unknown at present but it is included in the conceptual model due to the potential for spread of pathogens from hatchery facilities into habitats of wild salmonid populations and those pathogens potentially introduced from outside sources.

2.2.11 Coldwater Fish Assemblage

2.2.11.1 Rationale for being a CE

The coldwater fish assemblage for the NBR ecoregions includes redband trout, mountain whitefish, Lahontan cutthroat trout, and Yellowstone cutthroat trout. The system level conceptual model (Figure 2.2-11) illustrates the interactions between the CAs and the primary habitat functions for coldwater fish species in this ecoregion. These species were selected to represent the assemblage due to their sensitivity to changes in water and habitat quality, in addition hybridization and predation pressures associated with introduced species. System level components modeled for this assemblage include habitat loss, fragmentation of current habitat, isolation of existing populations, and introduced species are primary factors that affecting coldwater fish status and distribution within this ecoregion.

2.2.11.2 Factors Related to the Distribution of the CE

For species such as redband trout, hybridization with other salmonids has contributed to its decline (Thurow *et al.* 2007). Many of the species in this assemblage require well–oxygenated water; clean, well–sorted gravels with minimal fine sediments for successful spawning; temperatures <21 C (<70 F), and a complexity of instream habitat structure such as large woody debris and overhanging banks for cover. The reduction of these habitat conditions by CAs will constrict the range over which these species can occur.

2.2.11.3 Key Change Agents

Development

Past human development activities and land use have adversely affected native coldwater fish species in many ways. Habitat loss and degradation have been primary causes of depressed populations in Idaho (McIntyre and Rieman 1995, Zoellick and Cade 2006, Thurow et al 2007, Gresswell 2011). Within drainages of this ecoregion, dams, logging, grazing, urban/exurban development, road construction, and mining have resulted in streambank erosion, sedimentation, adverse changes to channel configuration, reductions in water quality, and loss of riparian habitat, which provides shading and a source of insect prey for aquatic habitats. In addition to increased sedimentation, water chemistry can be degraded by contaminants and nutrients in runoff from adjacent developments and mining. Within the upper Snake River, climate change has altered snowpack timing and extent, which has corresponded into increases in acid rock drainage (ARD). ARD, which can be increased in areas of previous mining activity, dissolves metals such as zinc, copper, and iron, which have increased in some drainages with adverse effects on instream organisms, including fish and the foodwebs upon which they are dependent. In laboratory studies on cutthroat trout, dissolved metals have been shown to reduce feeding activity, and decrease kidney function, with effects likely expressed as reduced growth and survival of fish in the wild (Farag *et al.* 1999).

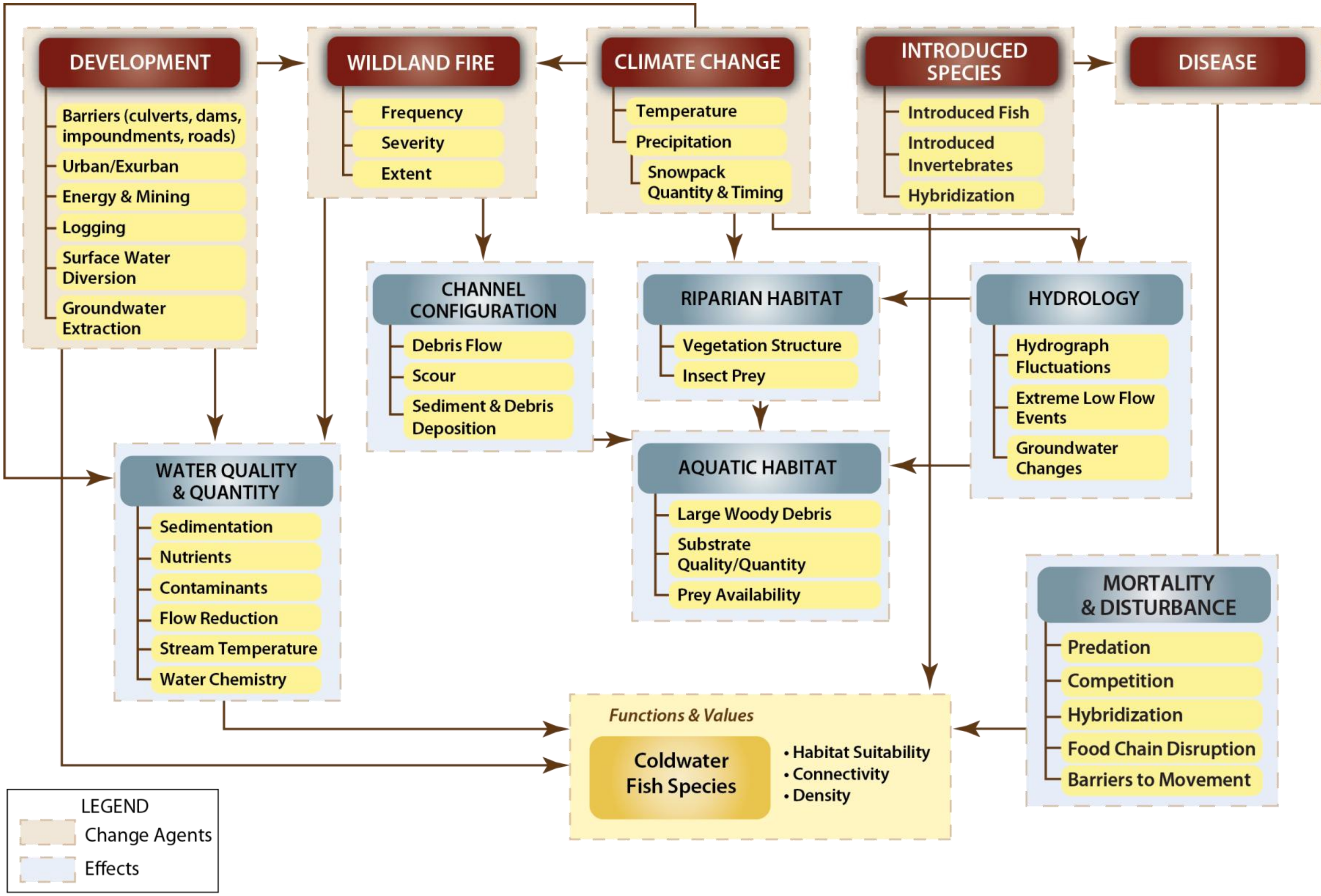


Figure 2.2-11. Coldwater Fish Assemblage System Model

Dams, improperly placed culverts, irrigation diversions, and other migration barriers have negatively affected individuals and habitat and likely have interfered with metapopulation dynamics. As a result, populations have become increasingly fragmented. Surface and groundwater extraction for urban and exurban populations, agricultural irrigation, and industrial development adversely affect native coldwater fish populations. Diversion of water for hydroelectric and agriculture uses has exacerbated persistent drought conditions, and requires mitigated flow management of the dams by the US Army Corps of Engineers (USACE). Degradation of riparian vegetation can negatively impacted fish habitat through reductions in large woody debris contribution, shade, available food resources with this vegetation (e.g., insects), and the protection of water and sediment quality during precipitation events.

Climate Change

Reduced snowpack, water temperature changes, precipitation changes, and greater fluctuations in stream hydrographs will likely be significant stressors on native coldwater fish species that result from climate change. The USBR(2010) suggests that future climate conditions will feature less snowfall and more rainfall, less snowpack development, and earlier snowmelt runoff. The report also suggests that warming will lead to more intense and heavy rainfall that will tend to be interspersed with longer relatively dry periods. USBR (2010) reported evaluations of potential future changes to Pacific Northwest climate relative to the ability of the Columbia River reservoir system to meet regional resource objectives. The report predicted decreased summer streamflows of up to 26 percent relative to the historic average. This reduction, if realized, would amplify competition between water users, and the required mitigation for USACE mandated flows for fish. Climate change is likely to eliminate some habitat directly through water quantity and temperature changes (USBR 2010) and indirectly through water quality changes. Water quantity issues associated with climate change include effects of persistent severe drought and impacts on recruitment due to sudden runoff events during hatching and emergence of larvae (USBR 2010). Conversely, extreme low flows during severe drought decrease survival of adults due to increased water temperatures, increased susceptibility to predation, and diminished habitat volume. Under current climatic patterns, in drought years water temperatures have surpassed lethal limits for all salmonid species, these conditions would occur more frequently under climate change.

Invasive Species

The introduction of non-native fishes in the waters occupied by native salmonid populations, hybridization between trout species such as redband trout and cutthroat trout, competition with, and predation by, non-native fish species, are among the primary concerns for persistence of native populations. The impact of hybridization of redband trout has become so problematic that it has necessitated monitoring of genetic purity within systems in which pure redband trout still occur. Introduced fish species such as channel catfish, smallmouth bass, and walleye likely contribute influence population dynamics and distribution of the coldwater fish assemblage.

Wildland Fire

Wildland fire affects aquatic habitats and biota through water quality changes including sedimentation and debris flows. Climate change will increase the likelihood of wildfires in the presence of fuels and ignition sources in relation to the timing of snowmelt (Haak *et al.* 2010). Dunham *et al.* (2003b) indicated that an increase in wildland fire prevalence would likely result in a corresponding decrease of riparian habitat function and benefit to the associated stream or river system, and has been considered as a disturbance that may provide an ecological advantage for introduced fish species.

Disease

All species of trout and salmon may become infected with the parasite responsible for whirling disease (*Myxobolus cerbralis*), an introduced disease agent that was first identified in the United States in 1956 and is now present in Idaho (Idaho Fish and Game 2007). The presence of the parasite does not always cause dramatic population losses, but can be a serious problem in hatcheries and has had severe impacts on some wild trout populations (Whirling Disease Initiative 2011). Infectious hematopoietic necrosis virus (IHN) and other pathogens affect salmonids, and other hosts, and require continued monitoring within hatchery systems. The significance of disease as a CA for native coldwater fishes is unknown at present but it is included in the conceptual model due to the potential for spread of pathogens from hatchery facilities into habitats of wild salmonid populations.

2.2.12 White Sturgeon

2.2.12.1 Rationale for being a CE

White sturgeon, sensitive to changes in environmental conditions, are dependent on cold, clean waters of suitable depth and flow to allow reproductive-sized adult fish access to suitable spawning habitats (IDFG 2008, Israel *et al.* 2009). Eggs and larvae require clean substrates, and cool waters to ensure healthy egg survival and larval development (Israel *et al.* 2009). Introduced species have been shown to limit their survival through alteration in foodwebs, and direct predations on larval and juvenile white sturgeon. Other factors that have limited white sturgeon abundance in the NBR ecoregions include harvest, regional population isolation, loss of habitat connectivity, and loss of flowing water habitats by dams.

2.2.12.2 Factors Related to the Distribution of the CE

Natural reproduction and occurrence of white sturgeon populations throughout the NBR may not be sustainable under current conditions. Their current distribution and abundance is dependent upon the intervention of resource managers. Therefore, as white sturgeon require hatchery production for their continued presence in the NBR, white sturgeon recruitment may not be as responsive to outside CAs as species that are not dependent on resource management for sustainability. Due to poor recruitment of naturally-spawned white sturgeon within the NBR, these populations may require ongoing aquaculture of and reach-specific releases of juveniles and the translocation of adults (IDFG 2008).

The system level conceptual model (Figure 2.2-12) illustrates the interactions between the CAs and the primary habitat functions for sturgeon. The most important CAs for white sturgeon are climate change, development, and invasive species, but wildland fire and disease are also included in the model due to their potential to affect water quality and habitat. Although white sturgeon have not experienced regional population impacts comparable to whirling disease in salmonids, the affects that introduced diseases have had on other fish species highlight the potential regional effects introduced diseases could have on regional white sturgeon populations.

2.2.12.3 Key Change Agents

Development

A variety of human development projects affect white sturgeon and the habitats upon which they are dependent. Within the NBR these include roads, mining, logging, dams, culverts, diversions, impoundments and reservoirs (Figure 2.2-12). Development projects such as dams have also necessitated associated development projects such as fish hatcheries, roads, and transmission lines.

Logging, mining, roads, water diversions and impoundments, and urban/exurban development can result in sedimentation, adverse changes to channel configuration, loss of riparian habitats, reductions in large woody debris, shade, available food resources, and adverse impacts to water and sediment quality associated with precipitation events and reservoir needs (review in Johnson *et al.* 1995, Israel *et al.* 2009). In addition, human population growth and development can lead to degradation of water quality from roads and agricultural runoff, mining, and municipal wastes.

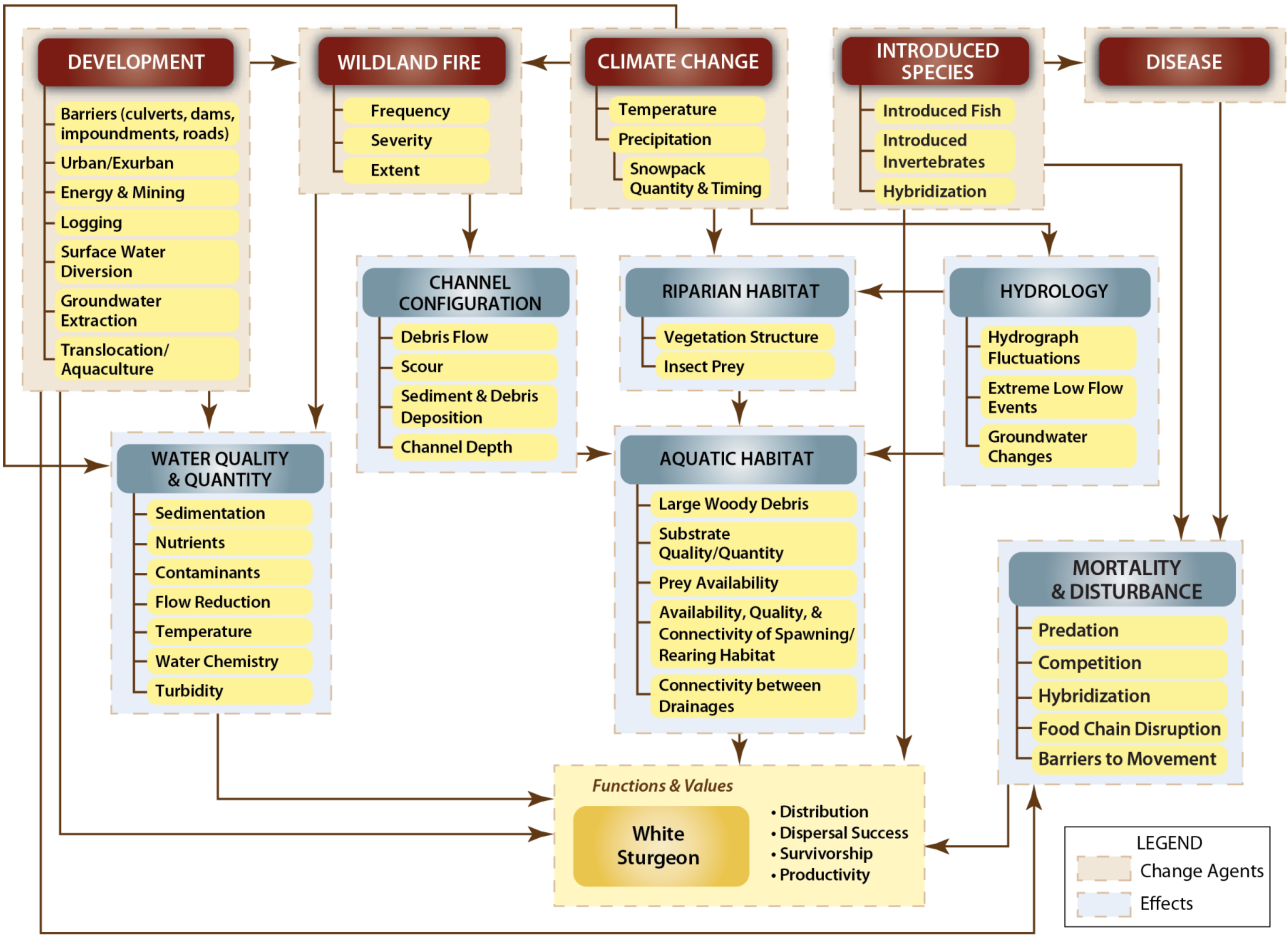


Figure 2.2-12. White Sturgeon System Model

Impoundments, such as those along the Snake River (Hell's Canyon Dam and upstream), alter and fragment riverine habitats, and limit fish movements between upstream and downstream reaches (Lepla 2003). Within river systems impeded by dams, the reservoir levels and associated flows require seasonal adjustment by the USACE, which is mandated to facilitate fish access to and use of habitats, as well as maintaining suitable instream temperatures during critical life history periods of these fish (Lepla 2003, Rust and Wakkinen 2008).

Climate Change

As with other regions where the species is distributed, potential threats to white sturgeon attributable to climate change include the decrease of flows due to changing precipitation regimes and the potential increase of riverine and reservoir water temperatures (Lepla 2003, Israel *et al.* 2009). In general, white sturgeon favor moderate to fast water and can be found in deeper mid-channel areas. Sufficient seasonal flows are required for successful spawning. Within highly studied systems, successful white sturgeon spawning is tightly correlated with wetter water years (Israel *et al.* 2009). A reduction in these events reduces the number of years in which conditions are favorable for successful spawning and recruitment events. In addition, drier water years can amplify the water quality degradation from agricultural runoff and municipal wastes. Increases in nutrient loads can reduce dissolved oxygen, which can lead direct mortality or decreased fitness due to a reduction and feeding activity (Lepla 2003, Israel *et al.* 2009). Reductions in flow not only reduce velocity, but alter sediment distribution, island development, water depth and channel morphology, as well as increase the risk of colonization of riparian habitats by non-native riparian vegetation (Johnson *et al.* 1995).

Invasive Species

The establishment and introduction of non-native fishes in waters occupied by white sturgeon likely affects this species by increasing competition with and predation by these species. Within the Snake River above Hell's Canyon Dam, there is very poor recruitment of new year classes of white sturgeon, even though older, reproductive-aged fish are present (Lepla 2003). Poor survival of younger age classes within this portion of the Snake River may be due to predation by other fish, including non-native species. Along the Pacific coast, a number of white sturgeon populations have shown indications that younger age class survivability may be limited due to predation by non-indigenous fish species (Israel *et al.*, 2009). Non-native species generally prey on eggs, larvae and younger juveniles (< year 2-3) before juvenile sturgeon growth is sufficient to provide them a size refuge from fish predation pressures (Israel *et al.* 2009). A number of non-native species introduced into Snake River systems, such as channel catfish, smallmouth bass, and walleye, may play a role in limiting the survivability and recruitment of naturally-spawned white sturgeon. With repeated recruitment failures, this species appears to be nearing complete dependence on artificial propagation to sustain their existence in this portion of the Snake River system.

Wildland Fire

Wildland fire affects aquatic habitats and associated biota through a reduction in riparian vegetation. Climate change has the potential to increase the prevalence of wildfires in the presence of fuels and ignition source in relation to the timing of snowmelt (Haak *et al.* 2010). An increase in wildland fire prevalence would likely result in a corresponding decrease of riparian habitat function and benefit to the associated stream or river system, and has been considered as a disturbance that may provide an ecological advantage for non-native species introductions of fish species (Dunham *et al.* 2003).

Disease

White sturgeon appear to be resistant to whirling disease and also to other salmonid diseases including infectious pancreatic necrosis virus (IPNV) and IHN, and do not appear to be carriers of these diseases (Canadian Columbia River Inter-Tribal Fisheries Commission 2005, LaPatra *et al.* 2011). However, white sturgeon are at risk for other diseases, including white sturgeon iridovirus disease (WSID), due to the dense population required by a species dependent on aquaculture and hatchery transplants due to failing natural recruitment (LaPatra *et al.* 1996). These risks associated with dense populations are likely greater than would occur in an undisturbed environment. WSID is more prevalent in dense populations, and can become more rampant in hatchery populations (LaPatra *et al.* 1996, Drennan *et al.* 2005).

2.3 Coarse-filter Model Examples

2.3.1 Vegetation Coarse Filter Models

Most of the Northern Basin and Range and SRPs Ecoregion is dominated by shrubland and woodland vegetation, with forested vegetation only along rivers and in montane environments. Along an elevational gradient going from low to higher elevations in upland environments one would encounter Salt Desert Shrub, Sagebrush, Juniper Woodland, and Montane Coniferous Forest as major vegetation types. Deciduous aspen woodlands or forests would be present on certain slopes and exposures in the montane environment. Riparian woodlands would follow streams and in valleys multilayered Gallery Forests dominated by cottonwood may occur along major river systems.

In contrast to many other shrubland and woodland dominated ecosystems, frequent fire does not appear to have been a characteristic part of salt desert shrub, sagebrush, and juniper dominated ecosystems in the Intermountain West and the dominant species, including junipers, most species of sagebrush, and saltbushes lack adaptations facilitating regeneration after fire. Most of these species die outright after fire. For species that do not resprout after fire, establishment must be from seed. Distance from surviving seed bearing plants becomes a major factor in recovery of predisturbance vegetation for those species whose seed is short-lived in the soil. Figure 2.3-1, which is adapted from the Landscape Disturbance and Succession (LANDIS) model of disturbance and succession, provides a depiction of establishment through mortality of dominant plant species that is applicable to shrubland and woodland communities in the ecoregion. Changing fire regimes as a result of human related changes is a very important factor shaping shrubland and woodland ecosystems over most of the ecoregion.

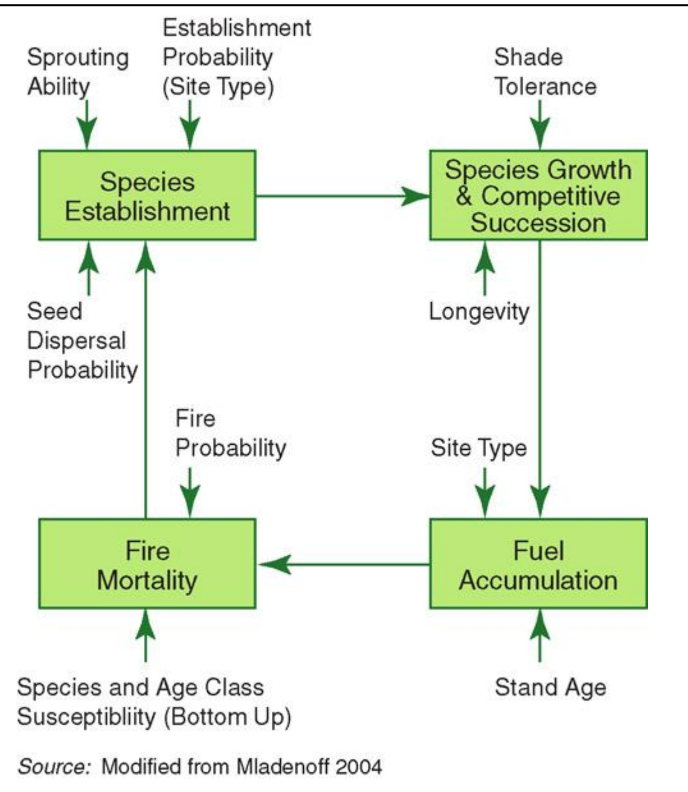


Figure 2.3-1. Succession and Disturbance Dynamics at a Given Site (Adapted from the LANDIS Model of Forest Disturbance and Succession [Mladenoff 2004])

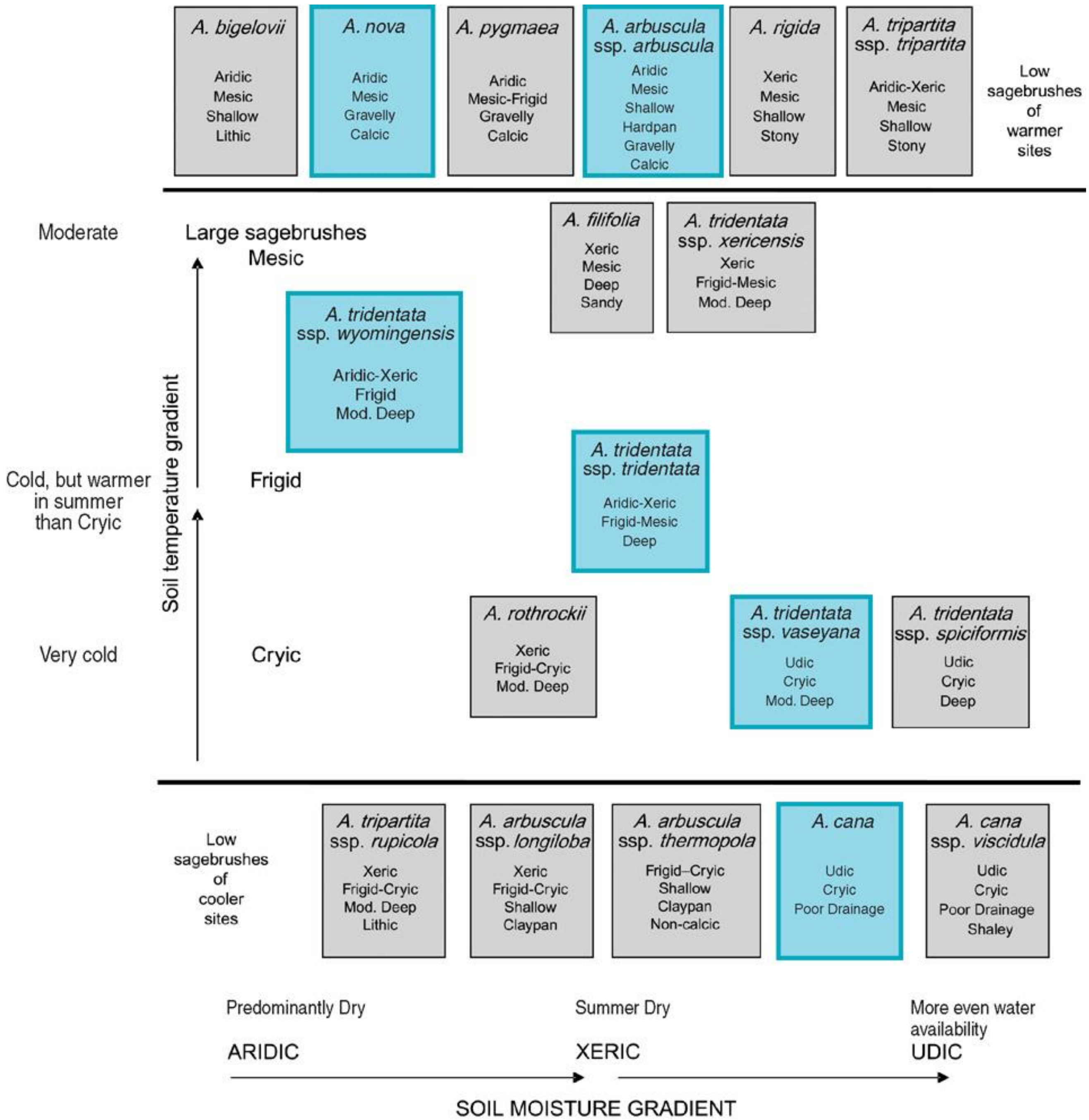
2.3.1.1 Sagebrush-steppe

Sagebrush-steppe ecosystems are dominated by species of sagebrush (*Artemisia* spp.) and perennial grasses. They are the focus of broad-based ecosystem conservation efforts (e.g., Davies et al. 2011; Knick and Connelly 2011; Great Basin Restoration Initiative 2012; Great Basin Consortium 2012). There are numerous species of sagebrush in the ecoregion that dominate different sites, generally assorting along soil temperature and moisture gradients. These species, their common names and an overview of their distribution in the states within the ecoregion are provided in Table 2.3-1. A schematic showing how these species tend to sort against these gradients soil moisture and temperature is shown in Figure 2.3-2 (adapted from Miller *et al.* 2011). The Y-axis shows increasing growing season soil temperature and the X-axis shows increasing soil moisture during the growing season. The three most important large sagebrush species, Wyoming big sagebrush, basin big sagebrush, and mountain big sagebrush, are highlighted in Figure 2.3-2. Shorter statured species important to sage-grouse within the ecoregion are also highlighted. These include black sagebrush, little sagebrush, and silver sagebrush (Miller *et al.* 2011).

Table 2.3-1. Common Names, Distribution, and Stature of Selected Sagebrush Taxa within States Included in the REA.

Scientific Name	Common Name	Distribution of Selected Sagebrush Taxa by State						Stature	
		CA	ID	OR	NV	UT	WY	Low	Tall
Artemisia arbuscula ssp. *arbuscula*	Gray low sagebrush (Little sagebrush)	✓	✓	✓	✓	✓	✓	✓	
A. arbuscula ssp. *longiloba*	Alkali sagebrush (Little sagebrush)		✓	✓	✓	✓	✓		
A. arbuscula ssp. *thermopola*	Little sagebrush	✓	✓	✓		✓	✓		
A. arbuscula ssp. *longicaulis*	Lahontan sagebrush (Little sagebrush)	✓		✓	✓				
A. bigelovii	Bigelow sage	✓			✓	✓			
*A. cana** ssp. *bolanderi*	Silver sagebrush	✓		✓	✓				
*A. cana** ssp. *cana*	Silver sagebrush						✓		
*A. cana** ssp. *viscidula*	Silver sagebrush		✓		✓	✓	✓		
A. nova	Black sagebrush	✓	✓	✓	✓	✓	✓		
A. pygmaea	Pygmy sagebrush				✓	✓			
A. rigida	Scabland sagebrush		✓	✓					
A. rothrockii	Timberline sagebrush	✓							
A. tridentata ssp. *spiciformis*	subalpine big sagebrush; snowfield sagebrush	✓	✓		✓	✓	✓		
A. tridentata ssp. *tridentata*	Basin big sagebrush	✓	✓	✓	✓	✓	✓		
A. tridentata ssp. *vaseyana*	Mountain big sagebrush	✓	✓	✓	✓	✓	✓		
A. tridentata ssp. *wyomingensis*	Wyoming big sagebrush	✓	✓	✓	✓	✓	✓		
A. tridentata ssp. *xericensis*	Xeric big sagebrush; foothill big sagebrush		✓						
*A. tripartita** ssp. *rupicola*	Wyoming threetip sagebrush						✓		
*A. tripartita** ssp. *tripartita*	Threetip sagebrush		✓	✓	✓	✓	✓		

Notes:
* *Artemisia cana* and *Artemisia tripartita* are capable of resprouting after fire; other species in the table are killed by fire and must regenerate from seed (Miller *et al.* 2011).
Sources:
Miller *et al.* (2011)
USDA Plants Profile http://plants.usda.gov/java/nameSearch
Tilley, *et al.* ND. NRCS Plant Guide: Big Sagebrush. http://plants.usda.gov/plantguide/pdf/pg_artrx.pdf



Source: Miller *et al.* 2011

Ordination of major sagebrush taxa in the Intermountain Region against gradients of soil temperature and soil moisture (adapted from West and Young 2000; with additions from Robertson *et al.* 1966, McArthur 1983, and this study). Sagebrush species not shown were prairie sagewort (*Artemisia frigida*), Owyhee sage (*A. paposa*), birdfoot sagebrush (*A. pedatifida*), and bud sagebrush (*Picrothamnus desertorum*).

Figure 2.3-2. Assortment of Various Sagebrush Species Along Gradients of Increasing Soil Temperature and Water Availability During the Growing Season (Adapted from Miller et al. (2011)). See Table 2.3-1 for common names of the sagebrush taxa.

A conceptual model of sagebrush-steppe ecosystems in the ecoregion is presented in Figure 2.3-3. It shows the general relationships among change agents including climate change, wildland fire, livestock grazing, invasive species, and insects and disease and the relationship of these change agents with the sagebrush steppe plant association. This model and the following discussion are based on many sources including West (1988); Miller et al. 2011; and Rosentreter (2005). Frequency, intensity, and areal extent of wildland fires are of greatest importance to this ecosystem and are in turn affected by characteristics of the vegetation (fuel characteristics) and livestock grazing (which affects vegetation and soils). As mentioned above, the dominant sagebrush species lack the ability to resprout after fire and tend to have short-lived seeds. Because of this, dispersal from surviving (unburned) individuals becomes very important in regeneration, making the areal extent of the fire and the completeness vs. patchiness of the burn critical factors in regeneration.

A key factor not shown in the model is the type of sagebrush and the characteristics of the ecological sites. Wyoming big sagebrush, which occurs at lower elevations on drier, less productive sites, is especially vulnerable to type conversion to cheatgrass monocultures after fire. In contrast, mountain big sagebrush, which occurs at higher elevations with higher precipitation, cooler conditions and more productive sites, is less vulnerable to cheatgrass invasion but is susceptible to juniper invasion under conditions of infrequent wildland fire (see Chambers et al. 2007; Miller et al., 2011; McIver et al. 2010). Both conditions can lead to increased wind and water erosion, especially on sloping ground and after fire, and can ultimately lead to permanent site degradation and inability to return the site to its original shrub steppe condition.

A conceptual model showing the relationship between fire return interval and site characteristics in sage-steppe sites is shown in Figure 2.3-4. The model shows that with longer periods between fires under comparatively moist cool conditions there is a high probability of woodland development in areas of grass or shrub dominated shrub steppe. State-and-transition models are shown in Figures 2.3-5 and 2.3-6 for more productive (12-14” precip.) and less productive (10-12” precip.) sage-steppe sites, respectively. The higher precipitation sites, exemplified by mountain big sagebrush, are more prone to juniper encroachment, whereas the lower precipitation sites, exemplified by Wyoming big sagebrush, are more prone to type conversion to cheatgrass (McIver et al. 2010).

2.3.1.2 Salt Desert Shrub

Salt Desert Shrub is a term that refers to shrub-dominated systems occupying extremely arid sites toward the bottom of basins where soils are generally salt-affected and where heat and aridity are locally the greatest. Key references consulted for this summary of salt desert shrub include Blaisdell and Holmgren (1984), West (1988), Brooks and Chambers (2011), Haubensak *et al.* (2009), and Dragt and Provencher (2005). With increasing elevation and decreasing soil salinity salt desert shrub systems give way to sagebrush dominated systems. The dominant shrubs in salt desert shrub may vary considerably from site to site and many sites are strongly dominated by a single shrub species. Generally, topographic gradients are very gentle in areas occupied by salt desert shrub. In basins, soils become progressively finer toward the bottom of the basin. Precipitation and productivity generally decrease with decreases in elevation.

The saltbush or goosefoot family (Chenopodiaceae) is extremely well represented by numerous species of saltbush (for example shadscale, *Atriplex confertifolia*), greasewood (*Sarcobatus* spp.), winterfat (*Krascheninnikovia lanata*), gray molly (*Kochia americana*) and hopsage (*Grayia spinosa*). Black sagebrush (*Artemisia nova*), budsage (*Picrothamnus* [*Artemisia*] *desertorum*), basin big sagebrush (*Artemisia tridentata* subsp. *tridentata*), and species of rabbitbrush (*Chrysothamnus viscidiflorus*) may be co-dominants or locally dominant, especially on less salt-affected soils. There are a variety of associated perennial grasses such as sand dropseed (*Sporobolus cryptandrus*), alkali sacaton (*Sporobolus airoides*), Indian ricegrass (*Achnatherum hymenoides*), galleta grass (*Pleuraphis jamesii*), and Great Basin wildrye (*Leymus cinereus*) on ranges in good condition. The primary use of Salt Desert Shrub has been for livestock grazing.

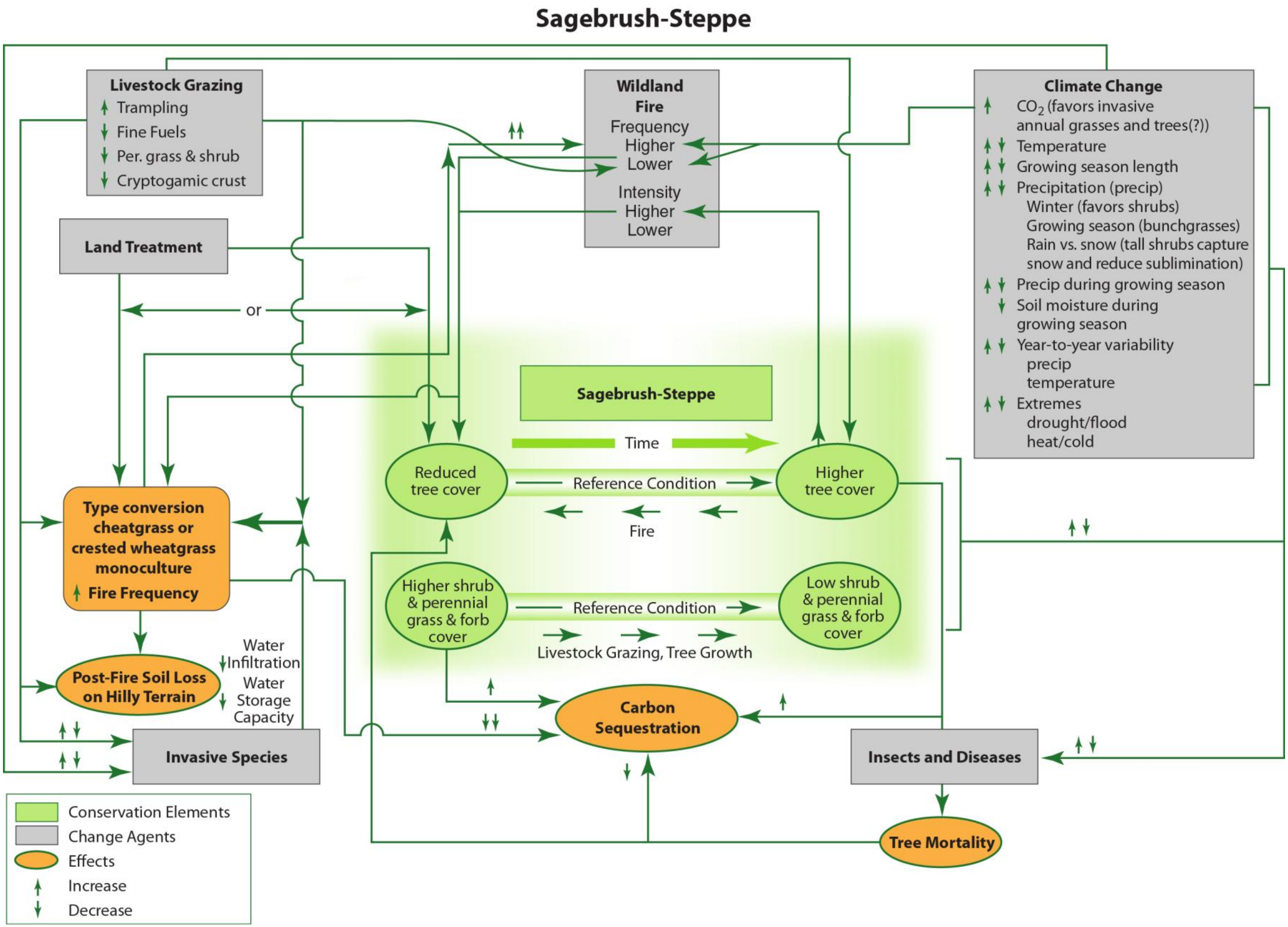


Figure 2.3-3. Conceptual Model Showing the Relationship Between Sagebrush Steppe Ecosystems and Change Agents Addressed in this REA

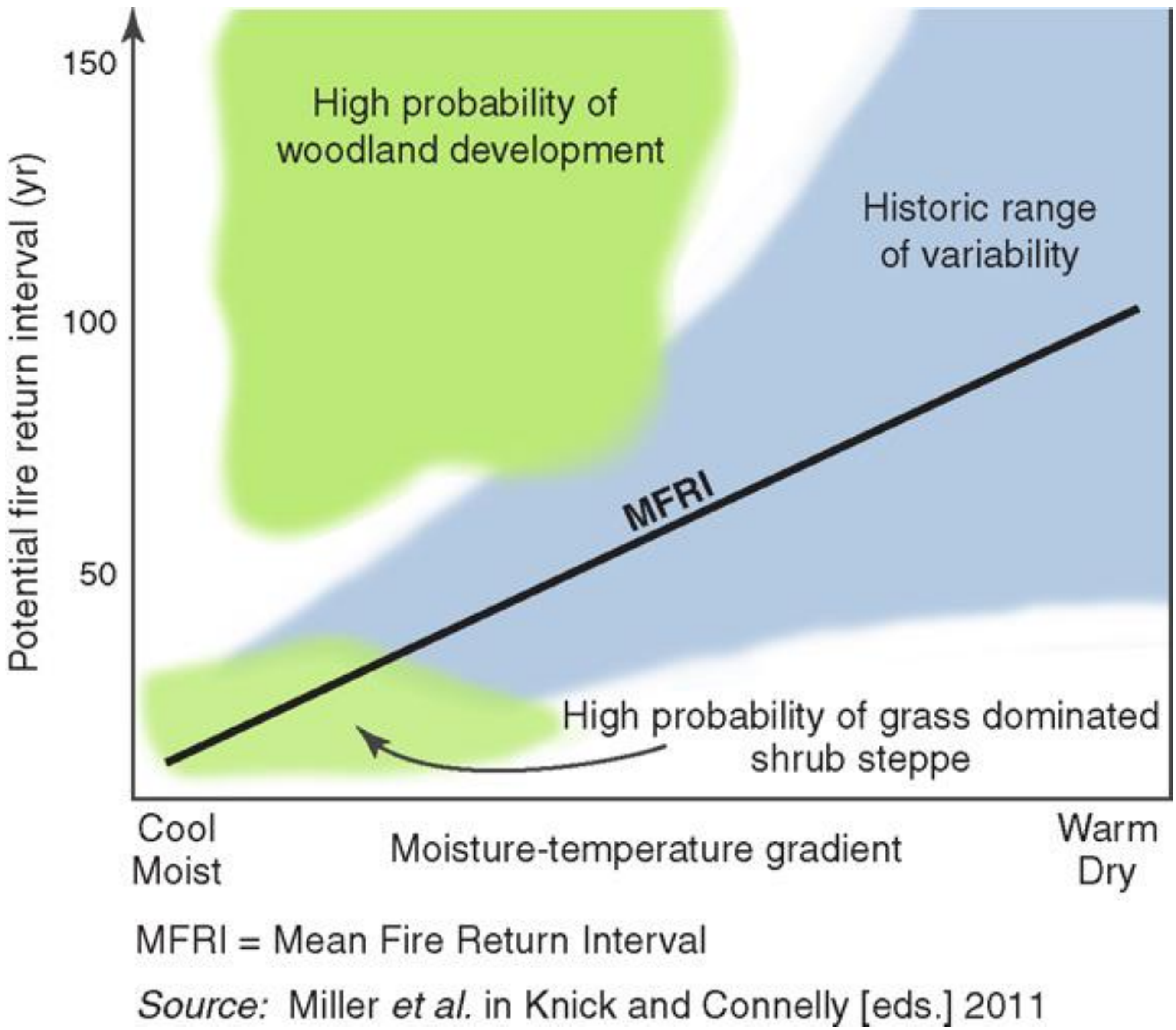
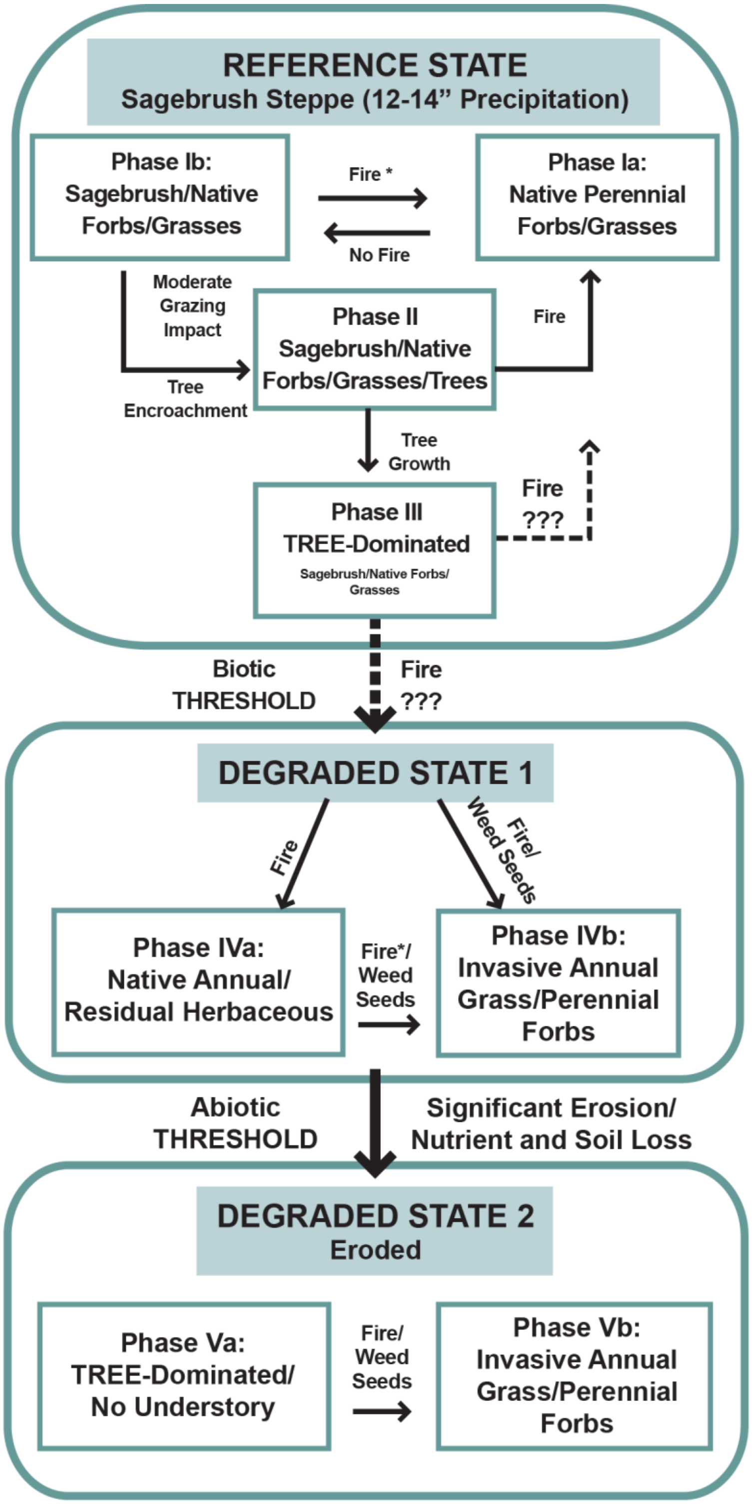


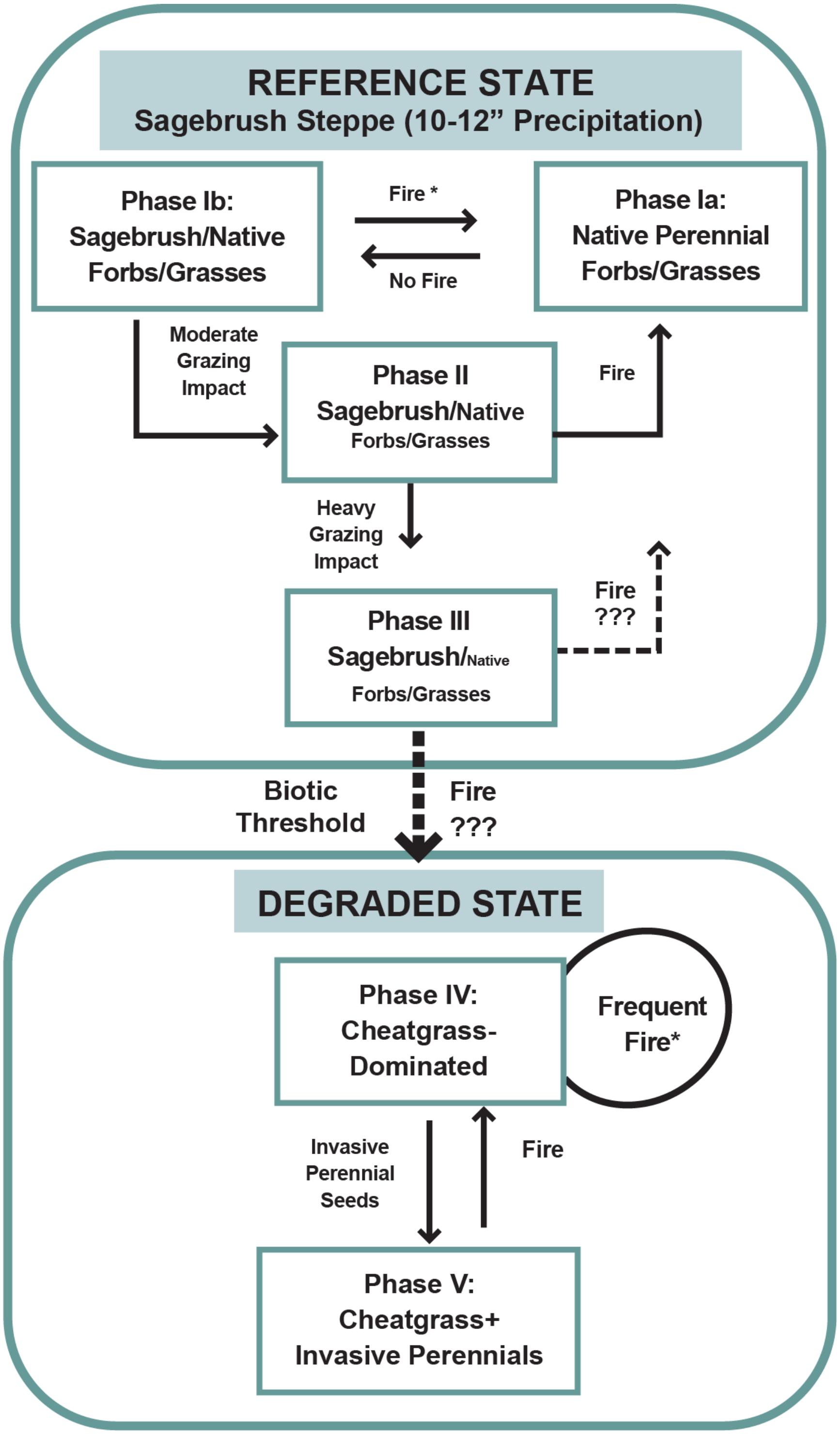
Figure 2.3-4. Conceptual Model Showing the Relationship between Potential Fire Return Interval (in years) and Moisture-temperature Gradient (Source: Miller et al. 2011)



Source: McIver *et al.* 2010

State-and-transition model for the woodland system (12- to 14-inch precipitation zone) focusing on vegetation only. Font size indicates relative dominance of vegetation life form within each phase.
*Fire is assumed to be severe enough to kill most of the woody vegetation.

Figure 2.3-5. State-and-Transition Model Applicable to High Productivity Sagebrush Steppe Sites (e.g., dominated by mountain big sagebrush), Which are Vulnerable to Invasion by Junipers, Including Utah Juniper and Western Juniper (from McIver et al. 2010, modified to remove cheatgrass from the reference state).



Source: McIver *et al.* 2010

State-and-transition model for the sage/cheat system (10- to 12-inch precipitation zone) focusing on vegetation only. Font size indicates relative dominance of vegetation life form within each phase. *Fire is assumed to be severe enough to kill most of the woody vegetation.

Figure 2.3-6. State-And-Transition Model for Low Productivity Sagebrush Steppe Sites (e.g., dominated by Wyoming big sagebrush), Which are Vulnerable to Invasion by Annual Grasses, Especially Cheatgrass (from McIver et al. 2010, modified to remove cheatgrass from the reference state).

Invasive species include cheatgrass (*Bromus tectorum*), halogeton (*Halogeton glomeratus*), Russian-thistle (*Salsola tragus; S. spp.*), and various mustards (Brassicaceae). Red brome (*Bromus madritensis* var. *rubens*) and North Africa grass (*Ventenata dubia*) have the potential to become more widespread and abundant in the region. Biological soil crusts (cryptogamic crusts) are important in soil stabilization. Revegetation is very challenging because of low and erratic precipitation and salt-affected soils. Because of the low productivity and low fuel availability and continuity in salt desert shrub communities, wildland fire was believed to be very infrequent under presettlement conditions. Wildland fire has become prevalent in recent years. The increase in wildfire is associated with the spread and increasing dominance of invasive annuals, particularly cheatgrass, which have altered vegetation composition and soil characteristics. A few shrubs (e.g., four-wing saltbush, sickle saltbush, black greasewood) are capable of post-fire resprouting, however, most of the native shrubs lack specialized adaptations for post-fire regeneration. In contrast, the invasive annual grasses increase in dominance after fire, capitalizing on nutrient release and greater availability of soil moisture. Additionally biological soil crusts regenerate slowly after fire, especially when dense stands of annual grasses emerge. Drill seeding of native grasses and shrubs after fire has shown some promise in reducing post-fire dominance of cheatgrass (Jessop and Anderson 2007).

A conceptual model for salt desert shrub is presented in Figure 2.3-7.

2.3.1.3 Western Juniper and Utah Juniper

Western juniper (*Juniperus occidentalis*) and Utah juniper (*J. osteosperma*) dominate large areas across the Intermountain Region including the Northern Basin and Range Ecoregion. In the ecoregion, western juniper is prevalent in Oregon, northeastern California, extreme northwestern California and southwestern Idaho. It is geographically replaced by Utah juniper to the south and east. Utah juniper has extensive distribution in Nevada and Utah and is present in southeastern Idaho. Where the two species overlap along the California-Nevada border, western juniper is represented by subspecies *australis* (known as Sierra juniper), which differs from subspecies *occidentalis* in being a large tree occurring in forested habitats at higher elevations, compared to typical western juniper (subspecies *occidentalis*), which occurs in woodlands in sagebrush-steppe. The ecological relationships of the Utah juniper and the typical western juniper are very similar and the conceptual model presented here (Figure 2.3-8) is applicable to both Utah juniper and western juniper.

Both junipers have expanded their distributions into sagebrush steppe since the mid-1800s and especially in the early 1900s. By reducing cover of competing perennial grasses and shrubs, livestock grazing historically made wildland fire less frequent and contributed to development of higher juniper cover (e.g., see Miller and Rose, 1999; Miller et al. 2008). Comparatively mild and wet conditions favorable to juniper establishment during the late 1800s and early 1900s probably contributed to the spread of junipers, which was rapid during that period of time (Miller et al 2008; Miller and Rose 1995). Juniper expansion has been documented in relict ungrazed areas as well as in grazed areas (Soule and Knapp 1999) suggesting that other factors could have contributed to the expansion, although the ungrazed site was probably not exposed to greater fire frequency than the grazed sites. Three phases of increasing juniper expansion into sagebrush steppe (Phase I-III) are recognized (Miller *et al.* 2005b). They are distinguished by characteristics including juniper cover on the site and the degree of annual leader growth on individuals (which declines as junipers age).

In expansion areas, as the junipers increase in cover, perennial grass and shrub cover decreases in the intervening spaces, which may lead to increased propensity to soil erosion especially on sloping sites after a fire (Figure 2.3-8). Juniper ecological sites, especially those with presettlement juniper, tend to be on rocky sites with very thin eroded soils, which are less subject to cheatgrass conversion or to severe erosion after wildland fire. Such sites would be too rocky for drill seeding to establish species such as crested wheatgrass.

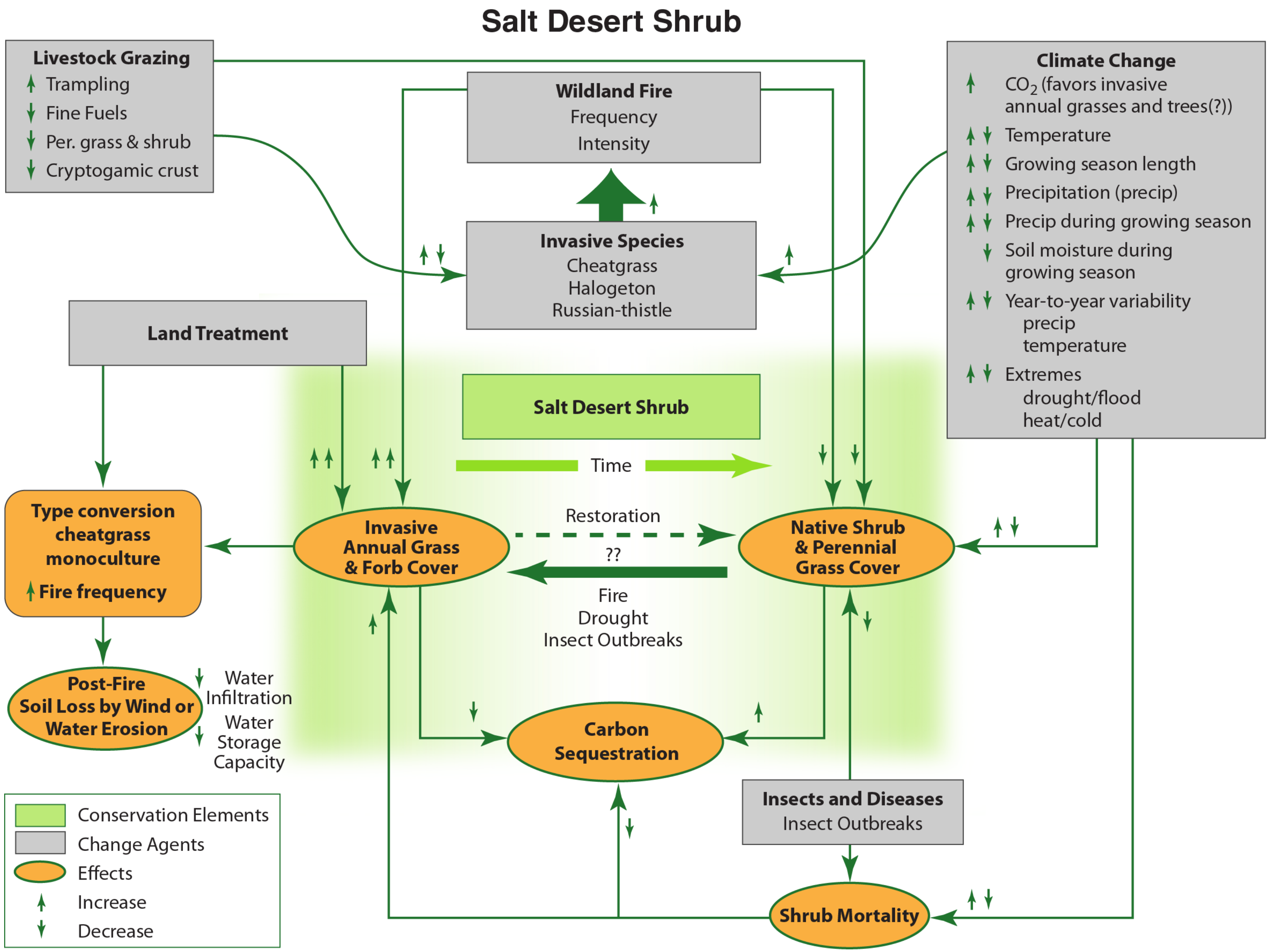


Figure 2.3-7 Salt Desert Shrub Conceptual Model

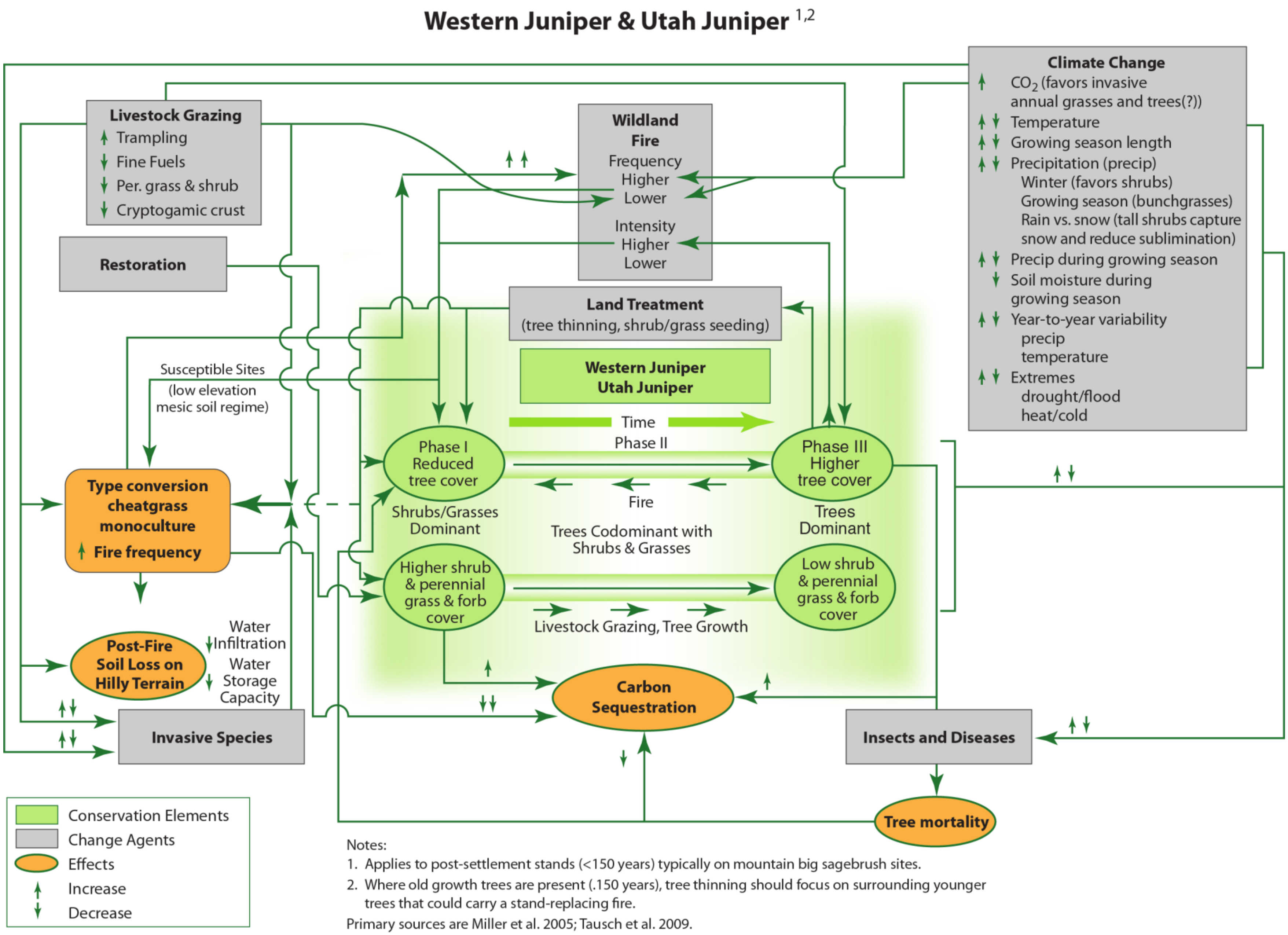


Figure 2.3-8 Western Juniper and Utah Juniper Conceptual Model

Avian species richness increases in the early phases of juniper expansion into sage steppe, peaks in Phase I to early Phase II and decreases in the later phases. Old growth junipers (established prior to about 1850), which have very irregular crowns and typically have an abundance of dead wood, support high numbers and densities of cavity nesting and tree nesting avian species. Several of these avian species occur in greater numbers in old growth (pre-settlement) woodlands compared to post-settlement woodlands (Miller *et al.* 2005b). Pre-settlement stands of western and Utah junipers typically occupied "fire-safe" sites such as rocky areas, which lack sufficient fuel to carry a damaging fire.

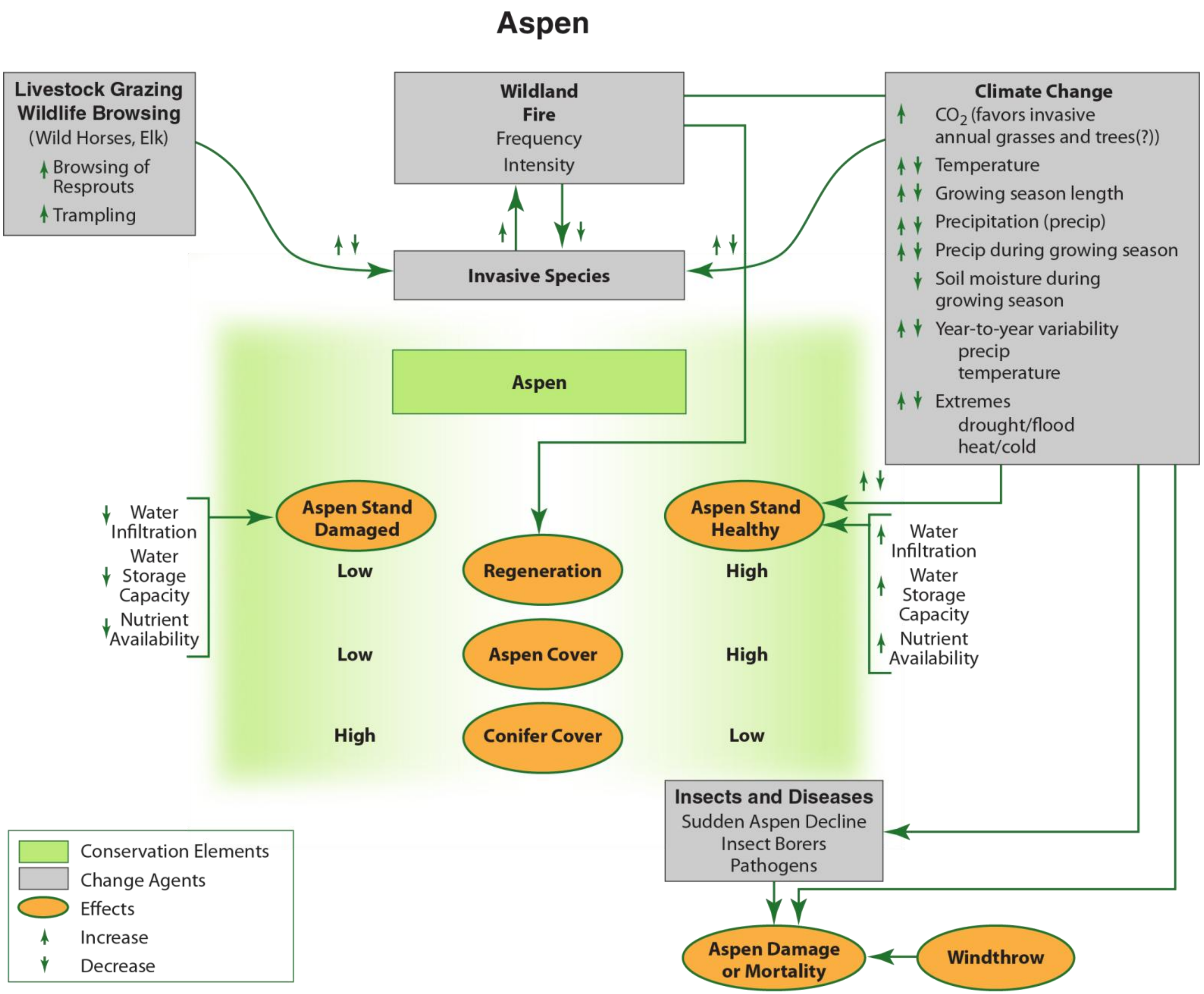
Except for large individuals in relatively fire safe sites, both Utah and western junipers are killed outright by fire and do not resprout. For these species to regenerate, seeds must survive a fire or disperse back into a burned area. Establishment typically takes place under a shrub (Miller *et al.* 2005b). All of this means that a certain amount of time must elapse to allow post-fire reestablishment of shrubs and seed dispersal of junipers to take place before western or Utah junipers can begin to reoccupy a burned site. Low elevation sites into which junipers have expanded are vulnerable to cheatgrass invasion which can ultimately lead to a type conversion and soil loss (please see Figure 2.3-5, above). Post-fire recovery of native vegetation in higher elevation stands is more rapid and these stands are less susceptible to cheatgrass invasion and type conversion (please see Figure 2.3-6, above).

Because of their aesthetic value and value as wildlife habitat, old growth stands of junipers are considered valuable and receive management attention. Restoration of western and Utah juniper stands is addressed in detail in Miller *et al.* (2005b), Miller *et al.* (2007) and Tausch *et al.* (2009), with special attention to analyzing the site and its potential. Restoration of stands in which junipers have increased to undesirable levels is possible and entails thinning of trees (often using chain saws) and possible reseeding of suitable native grass and shrub species. Combinations of cutting and fire may also be effective. Fire alone can be effective in Phase I and early Phase II stands if cover of native grasses is sufficient to support regeneration of grass cover. However, use of fire to thin post-settlement junipers that have infilled within or adjacent to an old-growth stand would have to be implemented with caution. This is because the increased tree density within or adjacent to old growth stands creates the potential to fuel stand-replacing wildfire, killing the old growth trees.

2.3.1.4 Aspen

Quaking aspens (*Populus tremuloides)* are one of the most widely distributed tree species in North America. Aspen stands provide habitat for a diversity of species and are one of the few broad-leaved trees that can grow at high elevations, though 80-90% of their historic stands have been lost and these woodlands are at risk of extinction. Increasing decline of the aspen populations was first noticed in Utah in the late 1990s (Huang and Anderegg 2012). In 2004, widespread branch dieback and mortality of whole portions of aspen stands occurred across Utah, Wyoming, Arizona and Colorado landscapes (Nijhuis 2008). This scale of aspen mortality had never been seen before and the phenomenon was named "sudden aspen decline," or SAD (Frey *et al.* 2004). Aspens grow in large clonal colonies that form from a single seedling and spread by root suckers. Natural disturbances such as wildfires or disease usually prompt clones to send up numerous fresh sprouts, but new growth is rare in SAD-affected stands. The cause of SAD is unknown and studies suggest that numerous factors are contributing to the rapid decline in aspen stands (Huang and Anderegg 2012). The increasing loss of aspen stands has resulted in the need for increased aspen management and restoration efforts.

A conceptual model of aspen ecosystems in the ecoregion is presented in Figure 2.3-9. Change agents of greatest importance to this CE are climate change, insect and diseases and wildland fire. Climate change, in particular hot and dry conditions, is thought to weaken the trees making them more vulnerable to insect attack, disease and at risk to SAD. Bronze poplar borer larva are known to weaken the trees and make the trees more susceptible to fungal infections and bark beetles cut off the tree's nutrient supply



Aspen health: Healthy = Full aspen crowns with little to no die-off (<25% overstory mortality, <25% conifer cover);
Damaged = Dead or dying aspen stands with considerable to full overstory die-off and/or foliage loss (25-100% overstory mortality, <25% conifer cover.
(*Source:* Oukrop et al. 2011).

Figure 2.3-9. Aspen Conceptual Model

(Nijhuos 2008). The physiological mechanisms of how drought induces SAD are currently being investigated (Huang and Anderegg 2012). Wildland fire suppression has reduced the cover of aspen. Aspen root systems can survive wildfire and the aspens regenerate from sucker sprouts. Post wildfires are optimal conditions for aspen regeneration, the open areas that receive high light allow root suckers to resprout. However encroachment by conifers creates a dense canopy that shades out aspens and reduces the ability for aspens to survive. Invasive species, livestock grazing and wildlife browsing by elk, deer, bison and horses are also factors that affect aspen health and cover. Wildlife and livestock browsing on resprouts in particular may retard regeneration. Aspen health is defined by Oukrop *et al.* (2011) as:

> **Healthy:** Full aspen crowns with little to no die-off (<25% overstory mortality, <25% conifer cover)
>
> **Damaged:** Dead or dying aspen stands with considerable to full overstory die-off and/or foliage loss (25-100% overstory mortality, <25% conifer cover

Future prediction of aspen distribution suggest the highest mortality will occur in the hottest and driest areas on south facing slopes and those trees at lower elevations are likely to disappear and those at higher elevations have been suggested as being weaker and sparser (Nijhuis 2008).

2.3.1.5 Other Conifers

Conifers are an integral component of forest communities at higher elevations in the Northern Great Basin. Common dominant species are Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*) and Engelmann spruce (*Picea engelmannii*). Conifers serve as an important food source and habitat for various fauna and are the main species used for timber harvest. Douglas fir and other conifers have been the focus of additional attention because of their ability to rapidly colonize and establish in sagebrush and aspen communities. A combination of overgrazing, changes in microenvironment, climatic patters and fire suppression may contribute to conifer encroachment (Adam *et al.* 2005). Conifer establishment is increasingly common and leads to new management decisions on existing stands and encroachment into sagebrush and aspen communities.

A conceptual model of conifer ecosystems in the ecoregion is presented in Figure 2.3-10. Change agents of greatest importance to this CE are climate change, insects and diseases, wildland fire and timber harvest. Climate change, in particular toward hotter and drier conditions, may alter their current distribution and is thought to weaken the trees making them more vulnerable to insect attack. Insects that infest conifers include Tussock moths (*Euproctis similis)*, western spruce budworms (*Choristoneura occidentalis*) and mountain pine beetles (*Dendroctonus ponderosae*), and diseases that infect trees are wood-rot basidiomycete fungus and white pine blister rust fungus. Bark beetle reproduction rates have rapidly increased in recent years. An increase in temperatures at high elevations is thought to be the reason that allows these insects to survive and reproduce at higher elevations than previously known to occur (Bentz 2008). Douglas fir can survive low intensity surface fires but are killed by moderate to high intensity fires and must regenerate from seed. Douglas fir is somewhat shade tolerant and can encroach into the understory of forested habitats (e.g., aspen, other conifers). In contrast, lodgepole pine and Engelmann spruce require open habitat for regeneration and regenerate from seed after a wildland fire. Fuel buildup in the understory is related to the cover of invasives, particularly knapweed (*Centaurea virgata*) and smooth brome (*Bromus inermis*) that invade conifer communities when openings exist. Fire frequency and intensity influences the cover of invasives. For example, smooth brome has been controlled with repeated, prescription burn treatments (Wilson and Stubbendieck 1997). Timber harvest, wildlife browsing and windthrow events are also important CAs. Older trees are generally more vulnerable to windthrow events (Steil *et al.* 2009). Timber harvest may initially reduce conifer cover however if harvest is conducted using sustainable methods, tree cover could increase. Wildlife and livestock browsing on resprouts, buds, needles and cambium may retard growth and regeneration.

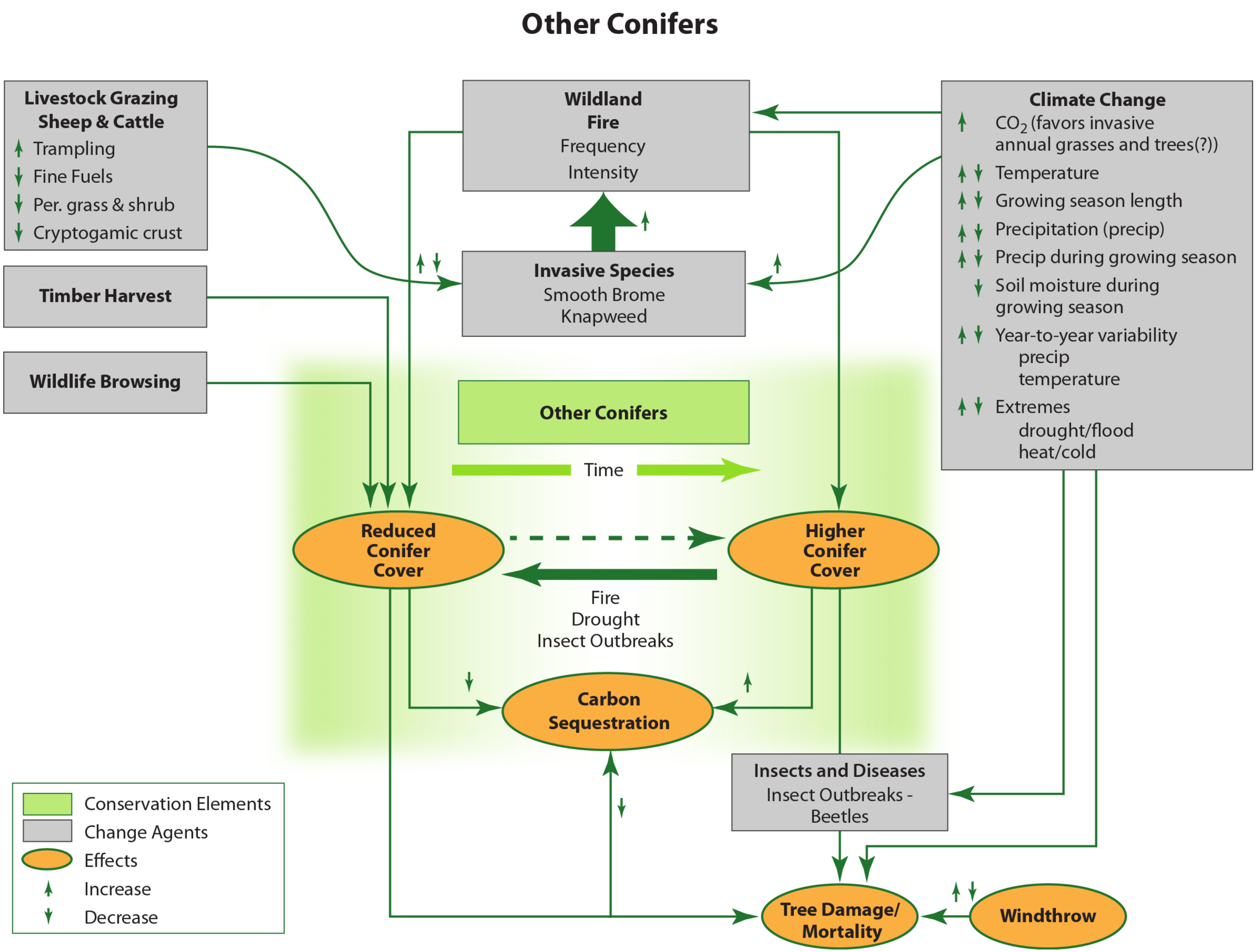


Figure 2.3-10. Other Conifer Conceptual Model

2.3.1.6 Vulnerable Soils

Vulnerable soils are defined as soils susceptible to wind or water erosion. Soil erosion caused by water and wind is a natural process; however human activities have accelerated the natural erosion process and can cause widespread soil degradation with ecosystem-level impacts. Vulnerable soils typically have fine texture (e.g., loess) and may be on sloping terrain or exposed to a long fetch in the direction of prevailing high winds. Lack of protective cover by vegetation, biological soil crust (cryptogamic crust), rock or gravel contributes to the vulnerability of soil to wind or water erosion.

A conceptual model of vulnerable soils in the ecoregion is presented in Figure 2.3-11. Change agents of greatest importance to this CE are livestock grazing, agriculture, large scale vegetation removal (including wildland fire), mining, off highway vehicles (OHVs) and climate change. Multiple change agents have the ability to accelerate soil erosion or lead to high soil loss. Livestock grazing may contribute through trampling and consumption of vegetation leading to soil compaction and reduced vegetative cover and cryptogamic crust. Agriculture and large scale vegetation removal have significant affects on the soil, not only changing the soil structure but also causing other forms of soil degradation including nutrient loss, compaction, and increased salinity. Mining can cause soils erosion and contaminate soils. Off highway vehicle can destroy cryptogamic crusts which are important for soil stabilization. All these factors will generally lead to a decrease in water infiltration, water storage capacity and nutrient availability contributing to high soil erosion.

Invasive species indirectly influence soil loss because an increasing dominance of invasive annuals produces fuel for wildland fire and facilitates short fire return intervals. Wildland fire can alter the habitat and create soil conditions vulnerable to invasion, particularly by cheatgrass and medusahead that will alter the fire regime and reduce persistent vegetation cover. Climate change will also indirectly effect soil erosion. A change in climatic patterns can influence insects and diseases which can cause vegetation damage and mortality potentially creating exposed soils that are vulnerable to erosion. Topographic gradients also effect soil erosion where high-gradient slopes are more vulnerable to soil erosion, especially by water, than low-gradient slopes.

Per an AMT recommendation, the authors plan to model wind erosion and water erosion separately during subsequent project phases. Figure 2.3-11. Vulnerable Soils Conceptual Model

2.3.2 Aquatic

Aquatic habitats are very limited and localized within the arid Northern Basin and Range and SRPs Ecoregion, which is characterized by extensive dryland habitats (shrublands and woodlands). The importance of aquatic habitats in the landscape is disproportionate to their limited area. Aquatic habitats contribute to the diversity of wildlife in the surrounding uplands (for example by providing water, nest/den/roost sites, seasonal refuges) as well as by contributing species that only exist where water is present. The scarcity of the water resource coupled with the high demands for water to support human uses makes aquatic habitats vulnerable to change.

2.3.2.1 Perennial Streams

Perennial Streams and rivers are natural watercourses that are closely related to their watershed. The source of water in a stream or river is generally collected from precipitation through a combination of surface runoff and groundwater inflows. Furthermore, the productivity of streams and wetlands is largely dependent on the growth of higher plants in the floodplain (Horne and Goldman 1994) and the community structure varies from the mouth to the headwaters. These dynamic systems incorporate many physical and biological processes and are the focus of management and restoration efforts.

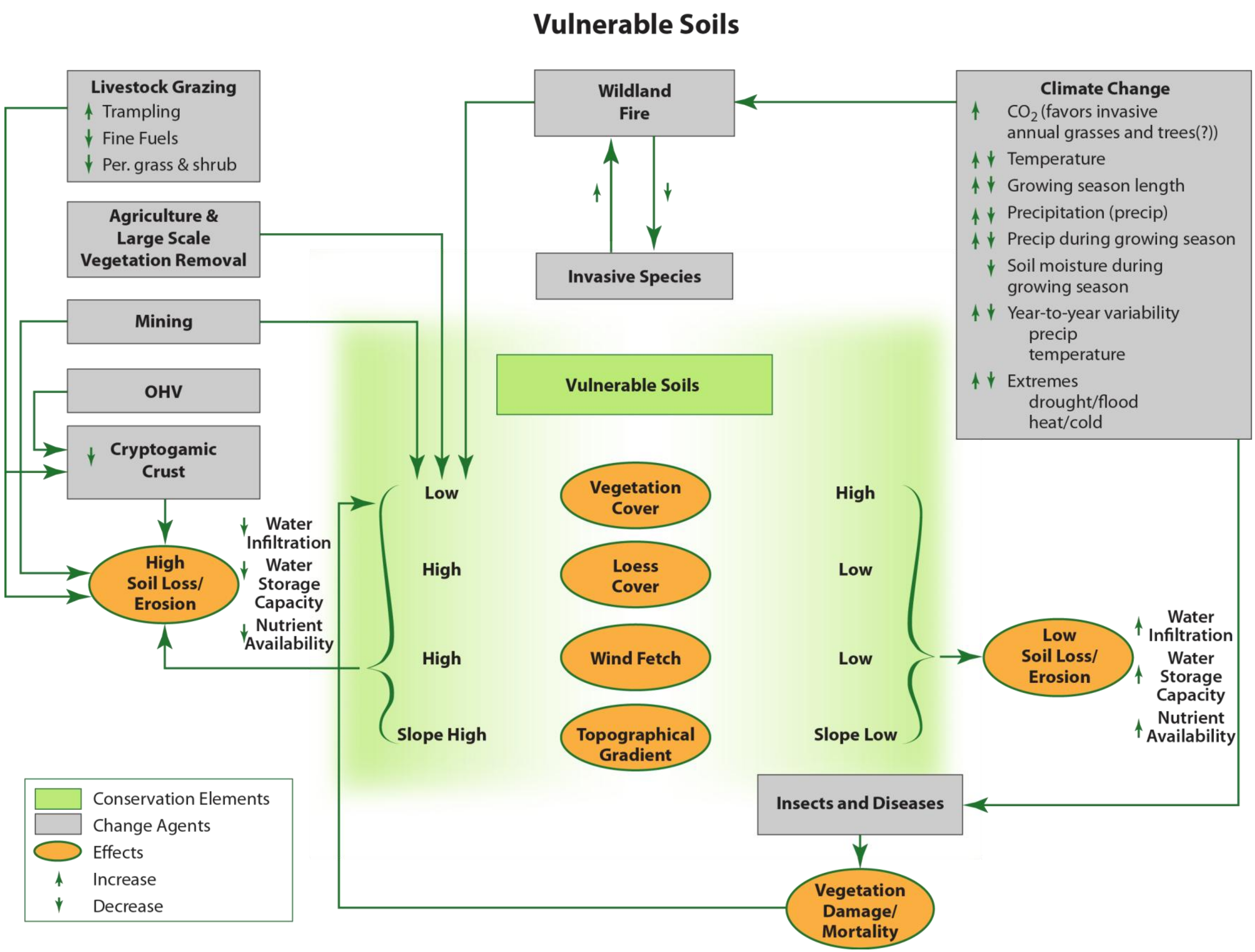


Figure 2.3-11. Vulnerable Soils Conceptual Model

A conceptual model of perennial streams and rivers ecosystems in the ecoregion is presented in Figure 2.3-12. Change agents that affect the hydrology, floodplain, cause erosion (and resulting sedimentation) or alter the riparian/aquatic biotic community are of greatest importance to this ecosystem. These change agents include agriculture, dams, groundwater pumping, development, wildland fire, livestock grazing invasive species, and insect and disease, and climate change. An increase in erosion and sedimentation runoff can be caused by development, wildland fire that occurs in the watershed and, more locally, by livestock grazing. Ultimately, an increase in erosion and sedimentation will directly affect the water quality. Climate change will influence perennial streams and rivers by shifting the timing, duration and amount of precipitation (and degree of snowpack and timing of snowmelt). Climate change may also affect the duration and frequency of wildland fires, species and extent of invasives, insects, diseases, and grazing. Invasive species, insects, diseases and grazing will influence the riparian/aquatic biotic community structure. The effects of the change agents mentioned above are interlinked and may be correlated. These effects include a) riparian/ aquatic biotic community structure including aquatic invertebrates, phytoplankton, zooplankton, bacteria, fungi viruses, fish, amphibians, birds, wildlife and vegetation; b) floodplain/channel, connectivity and fluvial dynamics; c) water flow including discharge, flooding frequency, timing of flooding event, water levels and groundwater depth and velocity; and d) water quality including water chemistry, temperature, dissolved oxygen, sediments and nutrients.

2.3.2.2 Springs and Seeps

Springs and seeps are known as biological hotspots, associated with unique aquatic ecosystems. Springs and seeps are small wetlands typically but not always found in sloping terrain and hydrologically supported by groundwater discharge. Discharge is from relatively deep groundwater flow systems that rise through a distinct hole from which shallow, broad flows move outward and create a saturated zone (Howard and Merrifield 2010). Springs and seeps can vary seasonally and tend to have a relatively constant concentration of dissolved minerals and water temperature which make them distinct from other wetlands and riparian surface-fed streams which vary in response to rainfall and snowmelt (Culver 2008).

A conceptual model of springs and seep ecosystems in the ecoregion is presented in Figure 2.3-13. Springs and seeps have the same key change agents and interlinked effects as mentioned above in wetlands. However, erosion and sedimentation are not considered to be an important effect on springs and seep systems. Change agents that affect the groundwater are of greatest importance to the springs and seeps ecosystem.

2.3.2.3 Wetlands

Wetlands are areas inundated or saturated by surface or groundwater and generally include swamps, marshes and bogs. This CE supports unique, biologically diverse communities and provides multiple functions to ecosystems such as preventing flooding, holding water, regulating flow and filtering water. For these reasons wetlands are valuable resources and important to resource managers.

A conceptual model of wetland ecosystems in the ecoregion is presented in Figure 2.3-14. Change agents that affect the hydrology are of greatest importance to this ecosystem. These include agricultural and other water uses, dams, diversions, and ground water pumping. Other factors that my influence wetlands are erosion and sedimentation that can be caused by wildland fire, development including the removal of vegetation in the watershed, and livestock grazing. Erosion and sedimentation will directly affect other physical and chemical processes that will influence habitat and other factors within a wetland system. In addition, climate change will influence wetlands by shifting the timing, duration and amount of precipitation which will also have an effect on wildland fires, invasive species and livestock grazing.

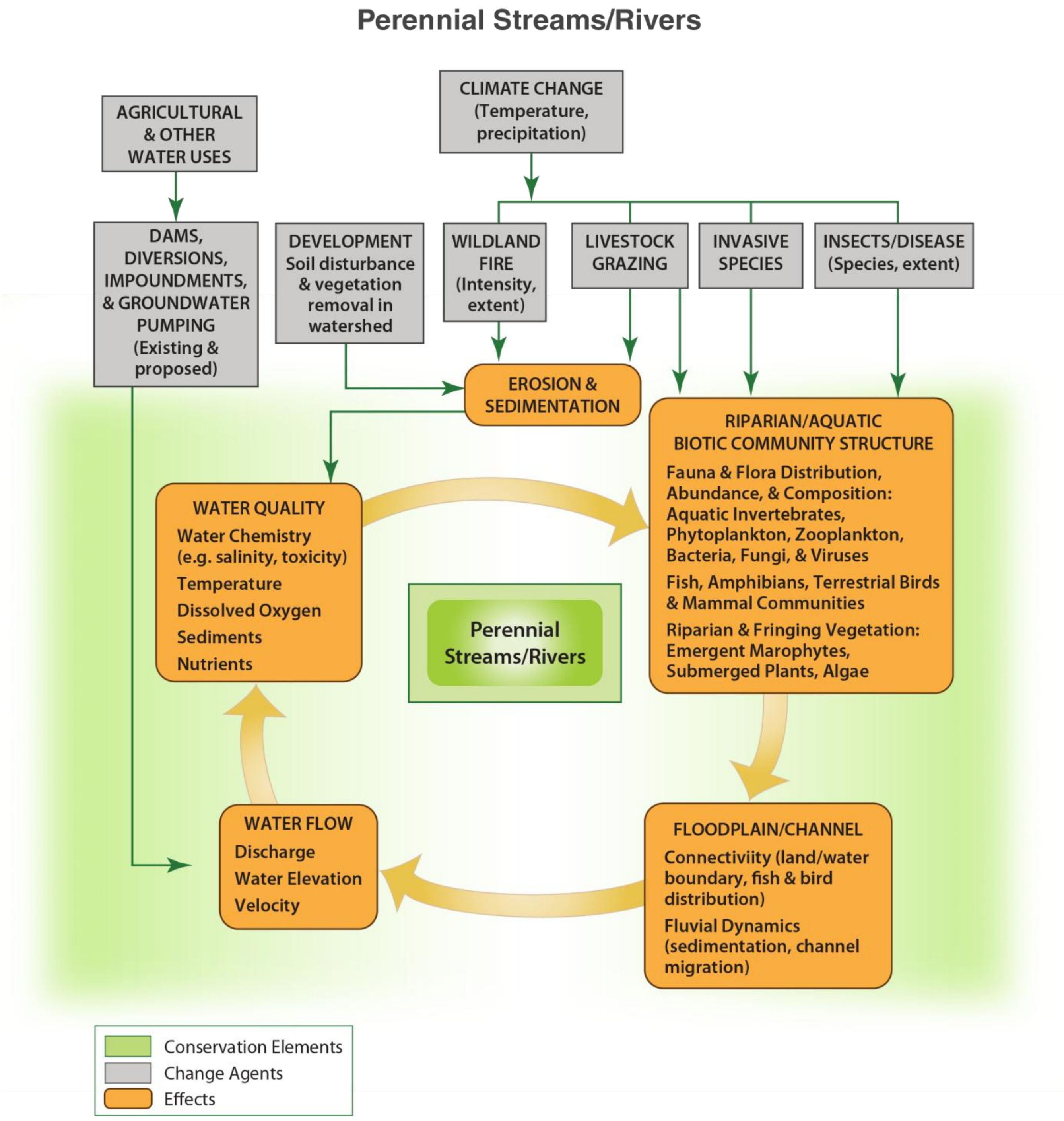


Figure 2.3-12. Perennial Streams Conceptual Model

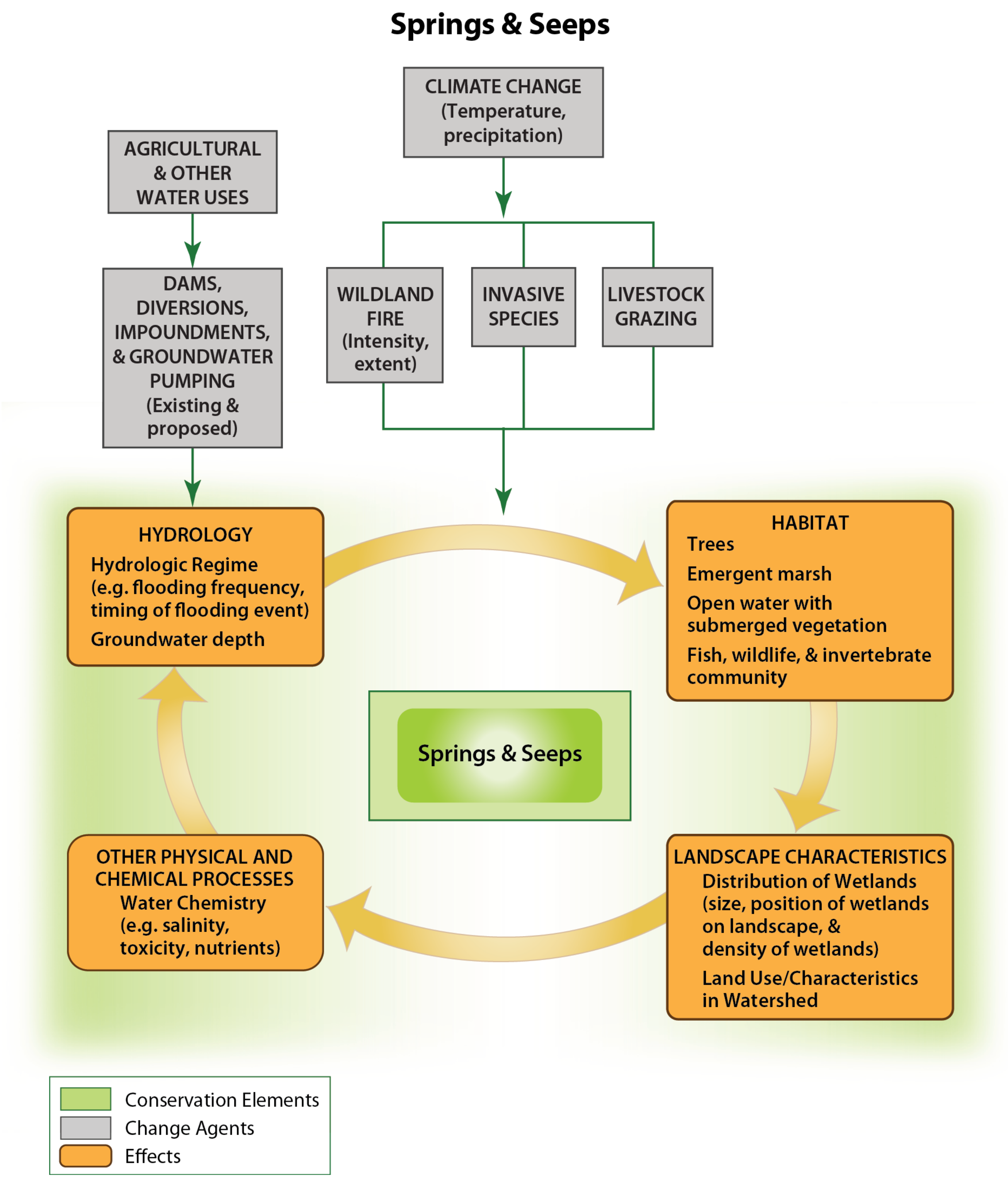


Figure 2.3-13. Springs and Seeps Conceptual Model

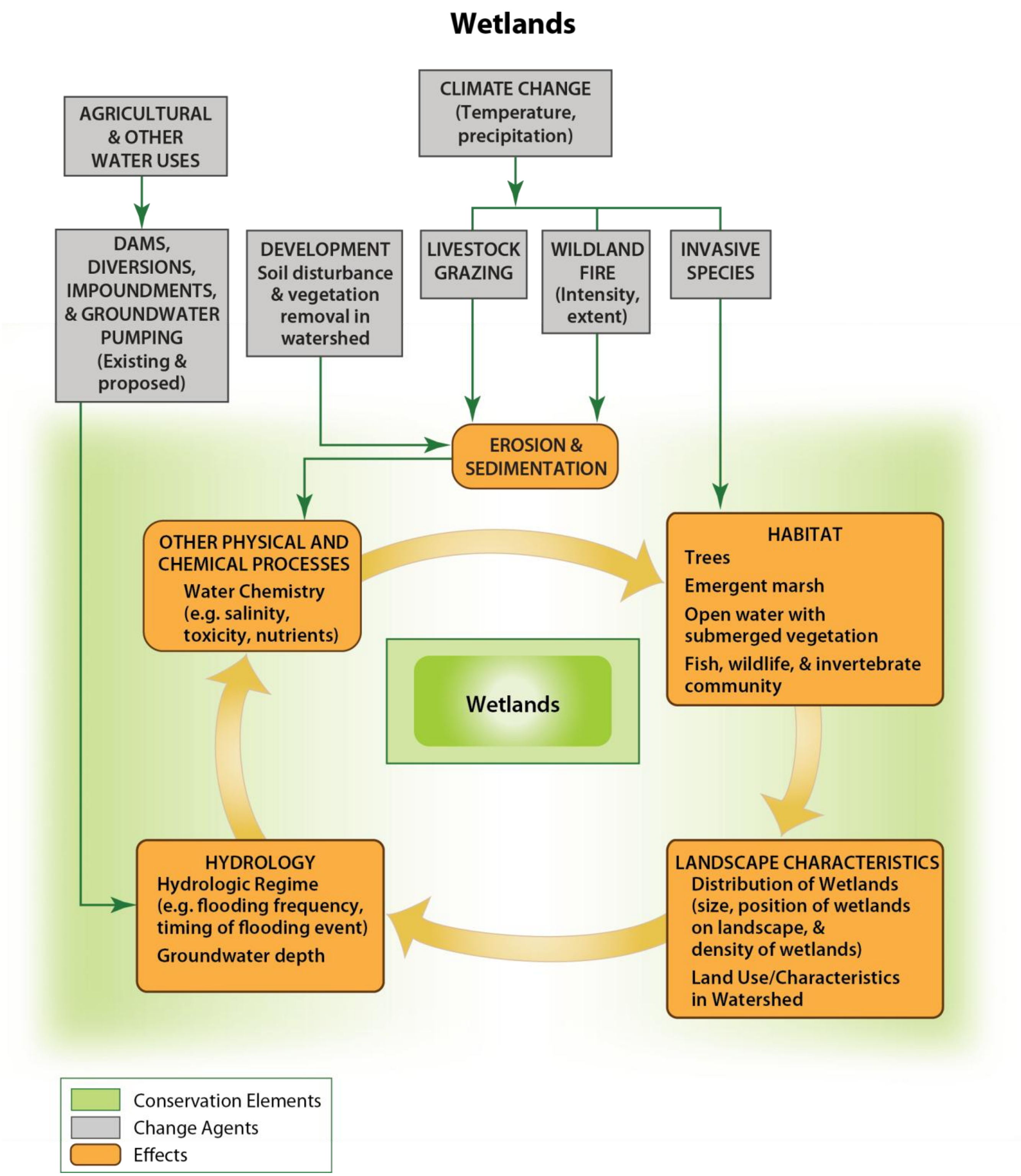


Figure 2.3-14. Wetlands Conceptual Model

The effects of the change agents mentioned above are interlinked and may be correlated. These effects include a) hydrology: including hydrological regime, flooding frequency, timing of flooding event and groundwater depth; b) habitat, the current vegetation cover and composition and biotic community (e.g. trees, emergent marshes and open water with submerged vegetation or suspended particles which are required for filter feeding organisms to survive, fish, wildlife and invertebrate community composition); c) landscape characteristics such as the distribution of wetlands on the landscape, and land use characteristics in the watershed; and d) other physical and chemical processes (e.g. water chemistry, salinity, toxicity and nutrients).

2.3.2.4 Open Water Habitat

Open water habitat areas include lakes, reservoirs and other water types (Copeland *et al.* 2010). These areas are often associated with wetlands and support diverse ecological communities with concentrated wildlife and also serve as critical habitats for migratory birds. The unique and diverse assemblage of species supported by open water habitats and associated wetlands has increased the need for wetland and open water habitat management and restoration efforts.

A conceptual model of open water habitats in the ecoregion is presented in Figure 2.3-15. Change agents that effect hydrology including agriculture, dams, groundwater pumping, development, invasive species, insect and disease, livestock grazing and climate change are of greatest importance to this ecosystem. Agriculture, dams, diversions and groundwater pumping will have a direct impact on the hydrology of an open water habitat. In addition, climate change can alter temperature patterns that are important for thermal stratification of the open water, sediment and nutrient transport (Horne and Goldman 1994). Stable thermal stratification is important in determining the distribution of dissolved chemicals, gases and biota. In addition, climate change has the potential to affect wildland fires, livestock grazing invasive species (e.g., carp; quagga mussel) and insects and diseases. Invasive species, insects and disease and livestock grazing will affect the riparian/aquatic biotic community structure. Wildland fires, livestock grazing and development will influence erosion and sedimentation that will directly affect hydrology in open water habitats which will affect the biotic community structure. The effects of change agents mentioned above are interlinked and are correlated. These effects include a) changes to morphometry and geomorphology including the shape of the open water habitat (e.g. deep steep banks or shallow banks) and its geologic origin; b) hydrological effects including water depth, time duration and frequency of flooding events, and chemical factors including chemistry, temperature, light, nutrients, toxins and decomposition and allochtonous material and c) riparian/aquatic biotic community structure, that includes invertebrates, phytoplankton, fish, amphibians, birds and mammals and riparian vegetation.

2.3.2.5 Cottonwood Galleries

Cottonwood galleries are unique landscape features that meander across the Northern Great Basin floodplain, lining the major streams of the foothills and adjacent semiarid lowlands. Dominated by cottonwood trees (*Populus fremontii*), these communities are central to the structure and ecosystem functioning of riparian forests. Providing various layers or strata of foliage from the tops of tall trees to ground level, cottonwood gallery forests are some of the most important types of habitat for migratory birds, providing habitat for a diversity of fish and wildlife species and have important ecological functions. Healthy riparian vegetation protects banks from erosion, influences in-channel aquatic habitats, maintains favorable water temperature for fish through shading, filters runoff, and provides nutrients. Human development (particularly dams, water diversions, conversion to agriculture, groundwater pumping and other land uses) have substantially altered the natural streamflow and diminished and threatened these riparian areas. An increase in knowledge about the ecological consequences related to the change in water flow has lead to further interest in restoring natural water flow and management of these ecosystems.

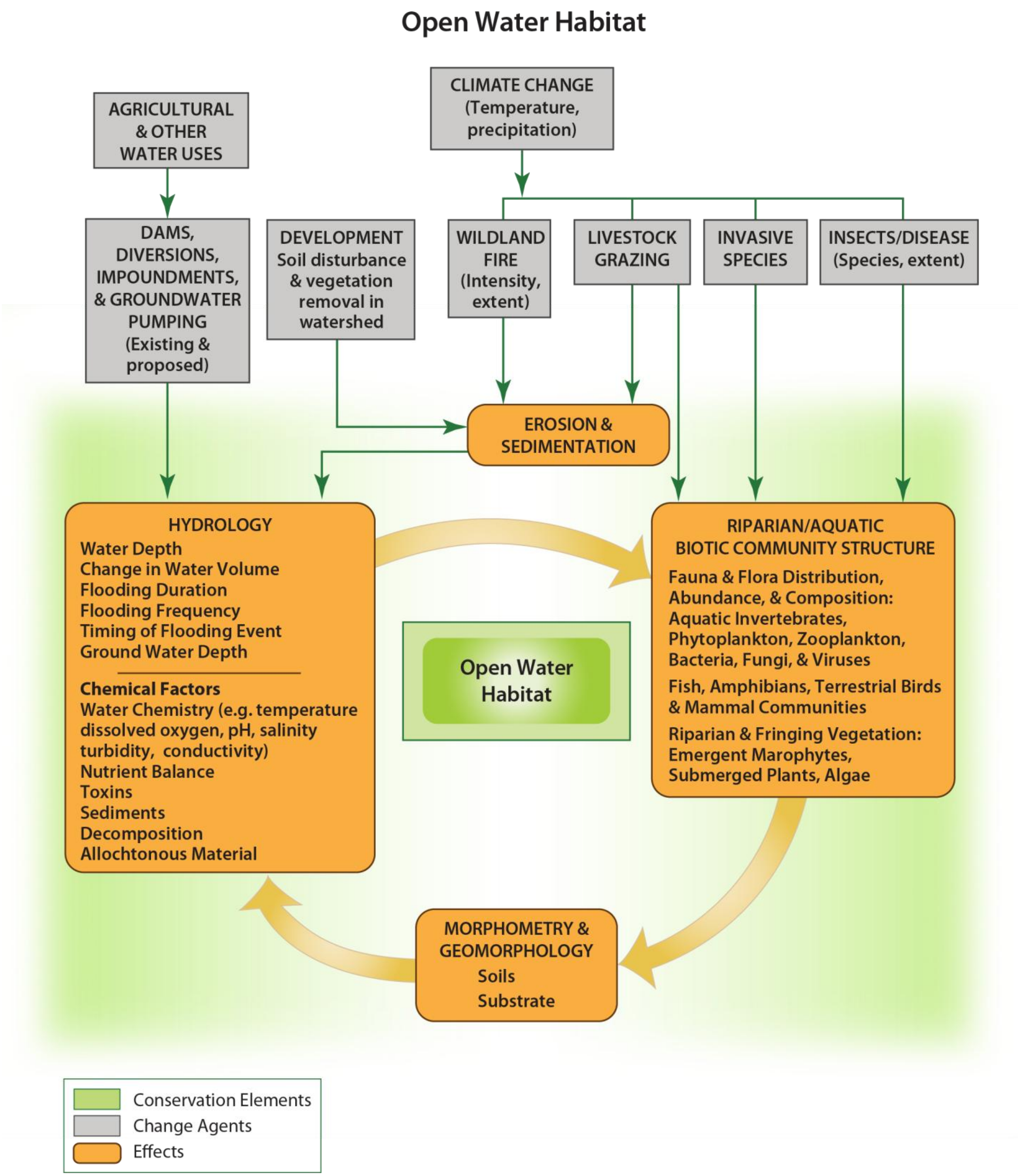


Figure 2.3-15. Open Water Habitat Conceptual Model

A conceptual model of cottonwood gallery ecosystems in the ecoregion is presented in Figure 2.3-16. Depending on the climatic setting and hydrologic regime, riparian wetlands receive varying proportions of their water from precipitation, ground water and surface flooding. Therefore, change agents or factors that affect hydrology including agricultural and other water uses, dams, diversions, and ground water pumping are of greatest importance to this ecosystem. Climate change is also a key in influencing the distribution of this community since changes in precipitation directly influence the hydrologic regime. Altered hydrology patterns and a shift in vegetation structure and wildlife habitat are the primary effects of the change agents. The vegetation type and structure that exists such as species occurrence, density and patch size of vegetation cover will influence this system in terms of fuel load, fire hazard and the wildlife and aquatic communities it supports. Vegetation types that occur within these riparian communities are based primarily upon dominant vegetation cover and defined by Burks-Copes and Webb (2009) as:

Mature riparian forests which have tall trees ranging from 50 to 60 feet in height or more, closed canopies, and well established (relatively dense) understory composed of saplings and shrubs.

Intermediate-aged Riparian Woodland/Savannahs which are characterized by open stands of midsized trees with widely scattered shrubs and sparse herbaceous growth underneath.

Meadows and Wet Marshes which are characterized by scattered plant growth composed of short shrubs (less than 5 feet in height), emergent macrophytes, seedlings, and grasses.

Cottonwood seeds require moist, bare soils for successful germination and water affects many morphological characteristics including wood formation and shoot growth; therefore flooding events are essential for stand renewal. Release of the very short-lived seeds is generally coincident with the receding flows following spring high water. In addition a variety of other change agents will influence the distribution of cottonwood galleries including: invasive species, insects and disease, livestock grazing, wildland fire, beavers, ungulates and other herbivores. Invasive species such as Russian-olive (*Elaeagnus angustifolia*) and salt cedar (*Tamarix* spp.) are common invasive trees along riparian areas and are known to consume similar amounts of water as cottonwoods and willows (Shafroth *et al.* 2010). Insects and diseases can affect vegetation structure, livestock grazing affects vegetation and soils, and intensity and frequency of wildland fires have the potential to alter to the vegetation structure and wildlife habitat. Beaver dams, ungulate browsing and other herbivores may also alter hydrology and vegetation structure in these systems.

2.3.2.6 Riparian Habitats

Similar to cottonwood galleries, riparian habitats are dynamic systems that are significantly important to diverse assemblage of wildlife, aquatic and plant species. Riparian habitats have the same factors related to distribution patterns and key change agents as mentioned above in cottonwood galleries.

A conceptual model of riparian habitat ecosystems in the ecoregion is presented in Figure 2.3-17. Riparian habitats differ from cottonwood galleries mainly in terms of vegetation composition that provide habitats for a variety of fish, wildlife and invertebrates. Riparian habitats vary from sparsely vegetated areas to dense forests. Vegetation distribution and composition is due to flood dynamics, and influenced by elevation, stream gradient, floodplain width, and flooding events. Riparian vegetation is mostly dominated by deciduous trees and shrubs, such as willows (*Salix* spp.), mountain alder (*Alnus viridis* ssp. *crispa*), aspen, cottonwood, and red-osier dogwood (*Cornus sericea*).

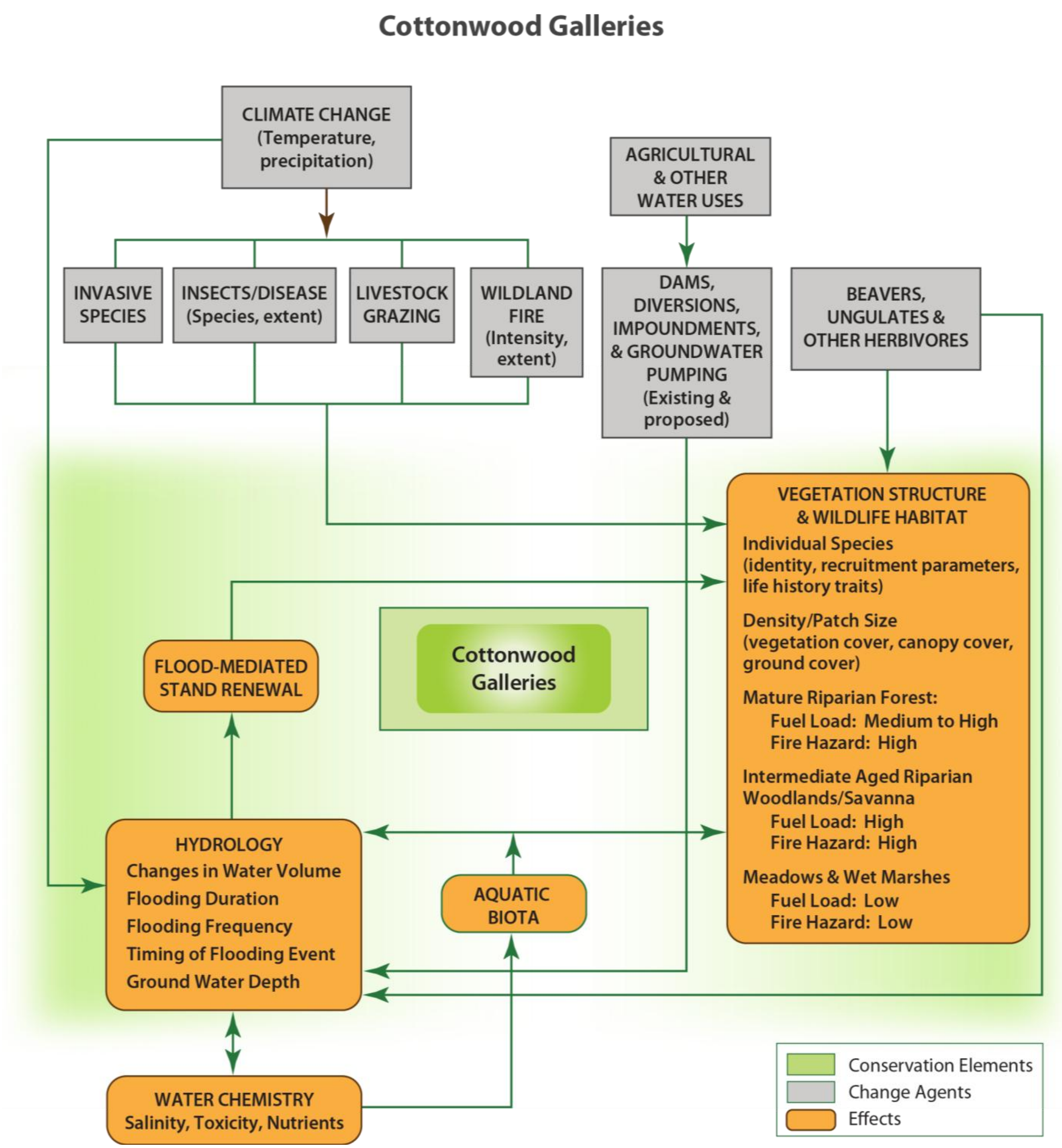


Figure 2.3-16. Cottonwood Galleries Conceptual Model

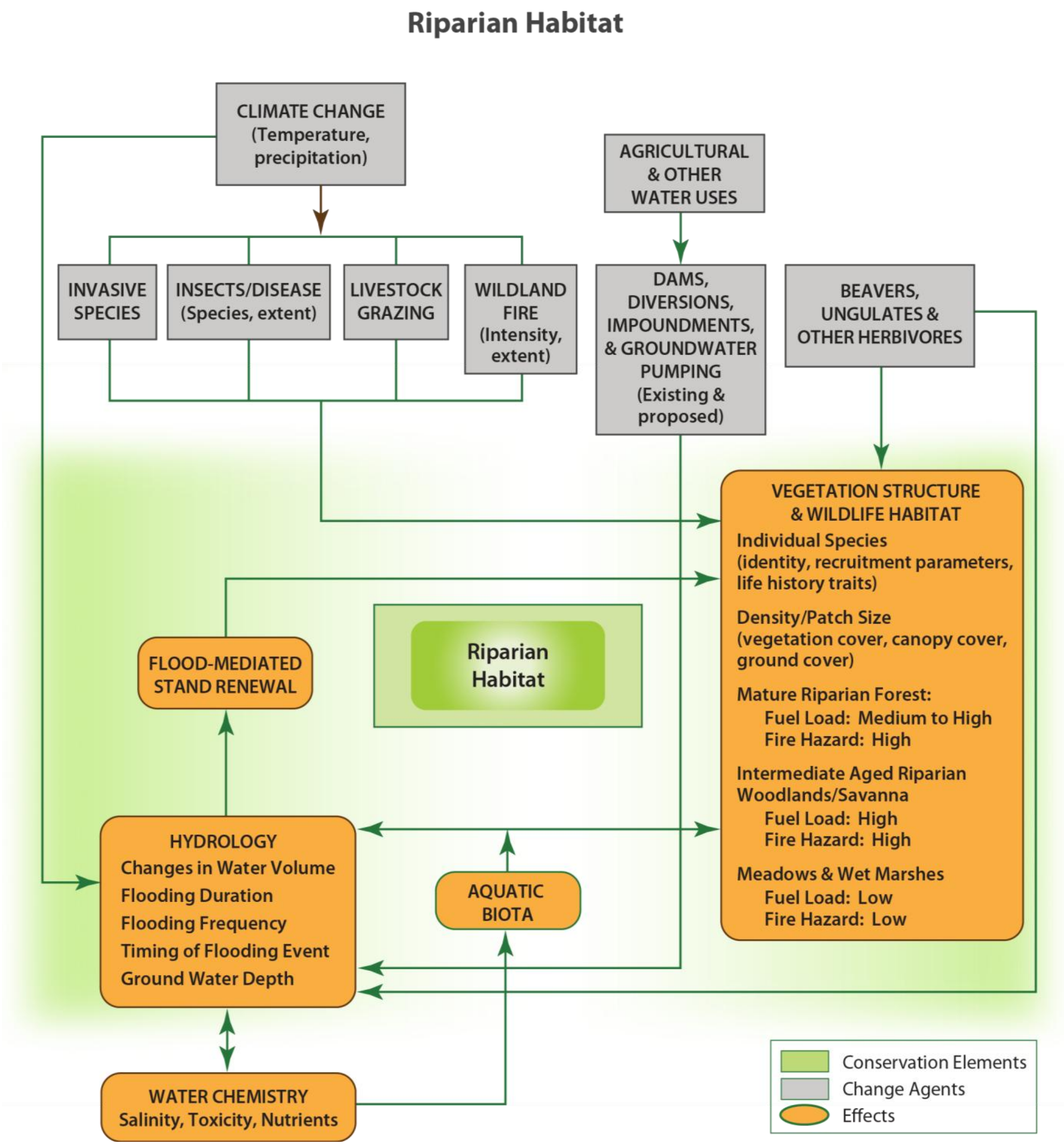


Figure 2.3-17. Riparian Habitats Conceptual Model

2.3.2.7 Groundwater

Across the landscape surface water, groundwater and geological characteristics control the flow of water and together with climate are the key variables that lead to development of ecological communities and control the available water supply. Groundwater withdrawal is mainly driven by agriculture and urban development. Throughout the Northern Great Basin, groundwater withdrawal is widespread and increasing. Forecasting changes likely to occur to the groundwater is of key interest to managers.

A conceptual model for groundwater in the ecoregion is presented in Figure 2.3-18. Change agents that affect the hydrology are of greatest importance to this system. These include dams, diversions, ground water pumping, agricultural and other water uses. Other factors that my influence groundwater are wildland fire that may lead to the removal of vegetation in the watershed, livestock grazing that may trample and consume vegetation that in time may alter the groundwater levels, and mining that could contaminate surface water and groundwater and also alter the groundwater levels. Climate change can influence groundwater directly or indirectly by altering the timing, duration and amount of available water in the form of snowmelt and rainfall. A portion of the available water is subject to evapotranspiration, which is influenced by solar radiation, topographic shading, vegetation density and cloudiness. The remaining available water, fed by mountain streams, springs and subsurface outflow consists of the surface runoff and groundwater discharge. Groundwater generally follows topography and flows from areas of high land-surface altitude to areas of lower land-surface altitude, creating a general pattern of flow from mountainous areas to lowlands (Figure 2.3-19), however, properties of the surface and underlying geology as well as hydraulic connections will influence surface runoff, recharge, and ground water discharge (USGS 2010). The amount of water removed from the system through dams, agricultural and groundwater pumping reduces the available water and the remaining water is groundwater storage.

2.3.3 Specially Designated Areas

SDAs Included in REA

Specially Designated Areas are natural areas (i.e., rivers, historic districts, etc.) of the United States' environment that have been, or have been proposed to be, designated by Congress to become federally protected entities (or by states for State Parks). SDAs have already been designated, or have been proposed to be designated, by Congress because these areas require special management attention to protect and prevent irreparable damage to important historic, cultural, scenic values and fish, wildlife resources or other natural systems or processes (BLM 2011b). There are many different SDAs that will be considered within the REA. Please see Table 2.3-2 below for a list of the SDAs.

Table 2.3-2. Specially Designated Areas and Abundance within the Ecoregion

Management/Land Protection:		Specially Designated Areas (SDAs)	Count	Source
	High	Wilderness Areas	27	Wilderness.net[1]
		Wilderness Study Areas	97	PADS 1.2[2]
		Wild and Scenic Rivers	21	Rivers.gov[3]
		Wild and Scenic Study Rivers	2	Rivers.gov[3]
		National Conservation Areas	79	PADS 1.2[2]
		National Wildlife Refuges	11	PADS 1.2[2]
		ACECs	61	PADS 1.2[2]
		National Monuments	4	PADS 1.2[2]
		Wild Horse & Burro Herd Mgmt Areas	49	BLM
		State Parks	8	PADS 1.2[2]
	Low	Historic Districts	43	PADS 1.2[2], NRHP[4]

Sources:
1. BLM 2012
2. USGS 2012
3. USFWS 2012
4. NPS 2011

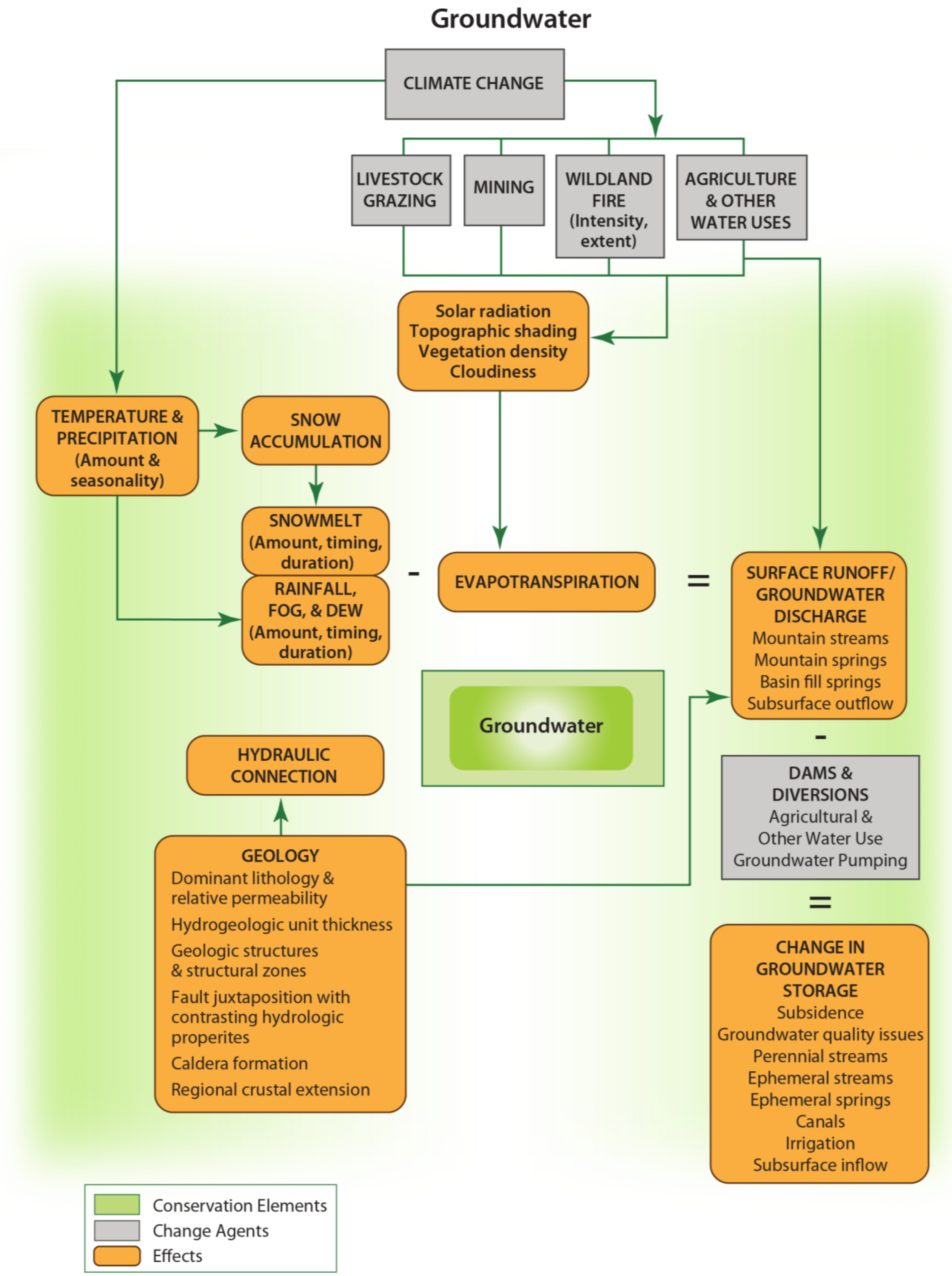


Figure 2.3-18. Groundwater Conceptual Model

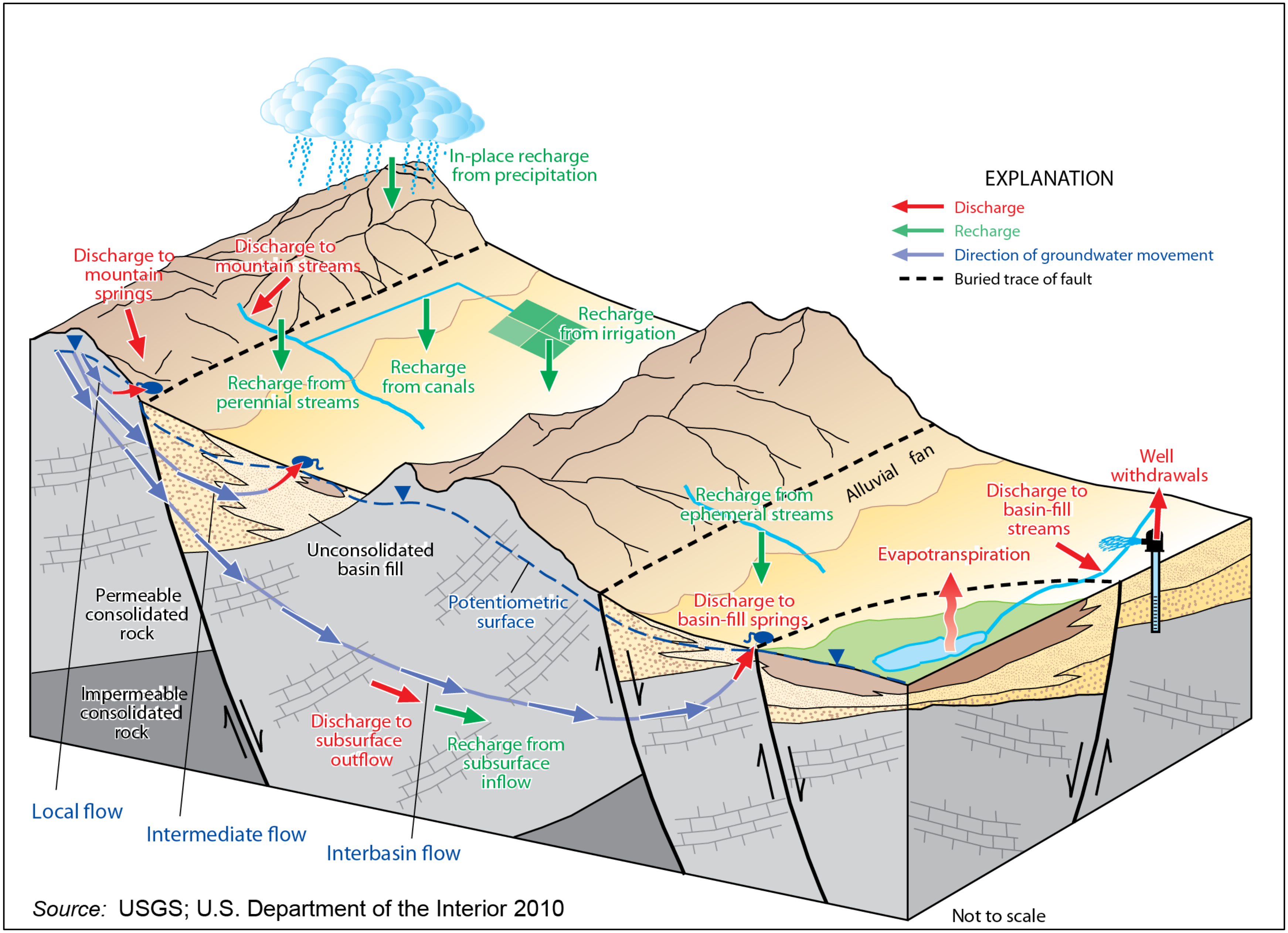


Figure 2.3-19. Schematic Diagram Showing Conceptualized Groundwater Flow in the Great Basin

Key Change Agents

Organizing the SDAs of ecological value into a table structured by which CAs (development, grazing, etc.) are allowed and/or prohibited in each and every CE in all of the states that are within the REA boundary, proved to be a difficult task. The only consistently regulated SDAs are wilderness areas (WAs) as these areas have the highest restrictions as mandated in the acts of Congress that created them. As one goes down the list of the other SDAs (Table 2.3-2), a distinction between what is allowed and not allowed for each type of area becomes very inconsistent. This is a result of the other ten SDAs being managed in numerous ways depending on the resources protected, the agency or state in charge and the provisions contained within acts of Congress or designations that created them (the Wilderness Act).

One example of acts of Congress left open to interpretation is the Wild and Scenic Rivers (WSRs) Act of 1968 (Act). The language “generally”, “voluntarily”, “strives to”, and “with the goal of” have led to variations in prohibitions and management. Regardless of classification, each river in the National System is administered with the goal of protecting and enhancing the values that caused it to be designated. Designation neither prohibits development nor gives the federal government control over private property. Recreation, agricultural practices, residential development, and other uses may continue. Protection of the river is provided through voluntary stewardship by landowners and river users and through regulation and programs of federal, state, local, or tribal governments. In most cases not all land within boundaries is, or will be, publicly owned, and the Act limits how much land the federal government is allowed to acquire from willing sellers. Visitors to these rivers are cautioned to be aware of and respect private property rights (USFWS 2012).

Furthermore, the WSRs Act purposefully strives to balance dam and other construction at appropriate sections of rivers with permanent protection for some of the country's most outstanding free-flowing rivers. To accomplish this, it prohibits federal support for actions such as the construction of dams or other instream activities that would harm the river's free-flowing condition, water quality, or outstanding resource values. However, designation does not affect existing water rights or the existing jurisdiction of states and the federal government over waters as determined by established principles of law (USFWS 2012).

As one can see from these examples, organizing SDAs by the CAs (Table 2.3-3) that are allowed and/or not allowed within each and every SDA in all states within the ecoregion is not consistent enough to be put into a table. Descriptions of the individual SDAs are in Appendix A.

Table 2.3-3 Development Change Agents Affecting SDAs.

Change Agents
Alternative Energy
Wind Power
Solar Energy
Pumped Storage
Oil and Gas
Hydro Diversions/ Impoundment
Mining
Linear Features & Transportation
Fences
Transmission Lines
Roads, highways, freeways, etc.
Recreation
OHVs, mountain biking
Hunting, fishing
Hiking, camping
Agriculture
Rangeland Treatments
Grazing (Livestock, Wild Horse, Burro)
Urban/Exurban
Military

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Appendix A. Descriptions of Specially Designated Areas

Wilderness Areas (WAs)

WAs have been recognized as exhibiting outstanding ecological integrity where natural communities are essentially undisturbed. They retain a primeval character, without permanent improvements and generally appear to have been affected primarily by the forces of nature (BLM 2011c).

WAs are administered under authority of the Wilderness Act of 1964, and the key difference in on-the-ground management between a WA and a National Conservation Area (NCA) is how access is controlled. The Wilderness Act emphasizes management for wilderness values such as solitude and preservation, and therefore restricts motorized vehicle access. A WA is designated by law (BLM 2008).

WAs land and resource values are substantially protected and many of the change agents (CAs) listed in Table 2.3-2 are not allowed in WAs. Vehicle access, off-highway vehicle (OHV) use, and mountain biking, defined as motorized vehicles and mechanical transport, are recreational activities that are not allowed in WAs, as well as other types of motorized/mechanized equipment including wheeled game carriers and chainsaws. Other development CAs prohibited in WAs include roads, dams, and other permanent structures including wind farms; timber cutting as well as new mining claims, new mineral leasing, and new grazing permits (BLM 2008).

WAs do permit the following where such operations existed or were permitted prior to WA designation: the continuation of current mining operations, the continuation of livestock grazing, and the development of existing mineral leases. These uses are permitted to continue in WAs if they were already in existence when Congress declared the area a WA (also known as “grandfathered in”) (BLM 2008). There are currently 27 Wilderness Areas within the ecoregion (BLM 2012).

Wilderness Study Areas (WSAs)

A WSA is an administrative designation designed to allow these areas to be studied and considered by Congress for possible designation as a WA. Like WAs, WSAs are also managed under the Wilderness Act but unlike WAs, allow some use of motorized vehicles on trails or roads. WSAs possess the following mandatory characteristics identified in the Wilderness Act: 1) Size - roadless areas of at least 5,000 acres or of a manageable size, and roadless islands; 2) Naturalness - generally appears to have been affected primarily by the forces of nature; and 3) Opportunities - provides outstanding opportunities for solitude or primitive and unconfined types of recreation. Also, WSAs often are characterized by special qualities such as ecological, geological, educational, historical, scientific, and scenic values. A WSA is an administrative designation designed to allow these areas to be studied and considered by Congress for possible designation as Wilderness (i.e., a WA). WSAs are managed to prevent impairment of their suitability for Congressional designation as Wilderness (BLM 2011c).

In order for Congress to make a WSA a WA, each WSA is studied to determine if the area should be recommended to Congress as either suitable or unsuitable for WA designation. The BLM develops recommendations for each WSA by analyzing the environmental consequences of Congressional designation or non-designation as wilderness in a statewide environment impact statement. Furthermore, until Congress makes its decision about whether a WSA receives WA designation, Section 603 of the Federal Land Policy and Management Act (FLPMA) of 1976 requires the BLM to protect the wilderness character of each WSA regardless of its recommendation. Thus, WSAs are managed to prevent impairment of their suitability for Congressional designation as Wilderness (BLM 2011c).

The difference between a WSA and a designated WA is that a WA is designated by law and managed under the Wilderness Act. Although WSAs are highly protected/preserved areas they are not as protected as WAs are. By policy, management of WSAs is generally less restrictive than management of WAs, but activities that would impair wilderness suitability are prohibited (BLM 2011c).

Examples of activities that are allowed in WSAs are: hunting, fishing and trapping under state and federal laws; rock hounding; travel with motorized vehicles on most existing routes; camping, hiking and horseback riding; staking mining claims and prospecting by the public (without use of mechanized earth moving equipment, explosives or the use of vehicles off existing routes). In addition, existing mining and livestock grazing may continue in the "same manner and degree" as when FLPMA was passed. Some mineral lessees, mining claimants, or holders of right-of-ways have valid rights that must be honored, even if doing so impairs wilderness suitability. However, these activities must be conducted in a manner that avoids unnecessary impacts to wilderness resources (BLM 2011c). There are currently 97 Wilderness Study Areas in the ecoregion (USGS 2012).

Wild and Scenic Rivers (WSRs)

Congress created the National Wild and Scenic River System (National System) in 1968 to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. There are three categories of rivers in the National System: 1) Wild rivers, which are free of dams, generally inaccessible except by trail, and represent vestiges of primitive America; 2) Scenic rivers, which are free of dams, with shorelines or watersheds, still largely primitive, and shorelines are largely undeveloped but accessible in places by roads; and 3) Recreational rivers, which are readily accessible by road or railroad and may have been dammed in the past. Congress further states that the river, with its immediate environments, must possess outstanding scenic, recreational, geological, fish and wildlife, historic, cultural, or other similar values (BLM 2011d).

The BLM's National Landscape Conservation System (NLCS) provides national level management and policy guidance for these rivers and represents the BLM on the Interagency Wild and Scenic Rivers Coordinating Council. The evaluation of rivers on BLM lands takes place through the resource management planning process. In accordance with the provisions of the Wild and Scenic Rivers Act (Act), the evaluation is a sequential process: eligibility (inventory); tentative classification; and suitability for inclusion in the National System (BLM 2011d).

The main purpose of the Act is to preserve rivers in free-flowing condition and to 'protect and enhance' a river's "outstandingly remarkable values". Consequently, each river in the National System is administered with the specific goal of protecting and enhancing the values for which it was designated. The federal government is prohibited from supporting activities, such as dam construction, or any other activities that would harm the river's free-flowing condition, water quality, or "outstandingly remarkable values". Designation neither prohibits development nor gives the federal government control over private property (USFWS 2012a).

Mineral entry and mining laws applicable to federal lands are affected in the following ways under Section 9(a) of the Act: 1) Valid existing rights are not rescinded; 2) Ongoing mining and mineral leasing are subject to regulations issued by the Secretaries of the Interior and/or the Secretaries of Agriculture to protect water quality and scenic values; 3) Subject to valid existing rights, patents are issued for the minerals and surface use only; and 4) Rivers classified as "wild" are withdrawn from the mining and mineral leasing laws. Regarding #4, no new mining claims or mineral leases can be granted; however, existing valid claims or leases within the river boundary remain in effect, and activities may be allowed subject to regulations that minimize surface disturbance, water sedimentation, pollution, and visual impairment. The Interagency Wild and Scenic Rivers Council provides a summary of these mineral entry regulations for each river classification (USFWS 2012a).

Federal lands within the boundary of rivers that are designated and classified as ‘Scenic’ or ‘Recreational’ are not withdrawn from the mining and mineral leasing laws under the Act. Existing valid claims or leases within the river boundary remain in effect, and activities may be allowed subject to regulations similar to those for Wild Rivers that minimize surface disturbance, water sedimentation, pollution, and visual impairment. Reasonable access to mining claims and mineral leases is permitted. Mining claims, subject to valid existing rights, can be patented only as to the mineral estate and not the surface estate, subject to proof of discovery prior to the effective date of designation. For rivers designated as Scenic or Recreational, filing of new mining claims or mineral leases is allowed but is subject to reasonable access and environmental regulations that minimize surface disturbance, water sedimentation, pollution, and visual impairment (USFWS 2012a). There are currently 21 Wild and Scenic and/or Recreational rivers within the ecoregion (USFWS 2012a).

Wild and Scenic Study Rivers (WSSRs)

These are rivers that are pending Congress’ designation to WSRs in the future. Most rivers are added to the National System through federal legislation, after a study of the river’s eligibility and suitability for designation, which is usually a very lengthy process and is conducted by one or more of the four federal agencies responsible for WSRs. There are currently two study rivers within the ecoregion (USFWS 2012a).

National Conservation Areas (NCAs)

NCAs feature exceptional natural, recreational, cultural, wildlife, aquatic, archaeological, paleontological, historical, educational, and/or scientific resources. NCAs are designated by Congress to conserve, protect, enhance, and manage public land areas for the benefit and enjoyment of present and future generations. Unlike WAs or National WSR designations, there is not a single Congressional Act that guides the management of NCAs. Instead, the particular act which authorizes designation of each NCA identifies the unique values to be protected and any other specific management guidelines to be followed (BLM 2011e). In addition, NCAs differ tremendously in landscape and size, varying from the coastal beauty of California's 18-acre Piedras Blancas Light Station Outstanding Natural Area to the rugged desert vistas of Nevada's 1.2 million acre Black Rock Desert-High Rock Canyon Emigrant Trails NCA (BLM 2011f).

Although each NCA is administered under authority of the specific act that created it, the act that created each NCA does not specifically restrict activities allowed within the NCA. The act that created each NCA does however regulate how the BLM manages the NCA; how each NCA is regulated has to be in a manner consistent with the spirit and intent of the act that created the particular NCA. There are currently 79 NCAs within the ecoregion (USGS 2012).

National Monuments (NMs)

The Antiquities Act of 1906 grants the President authority to designate NMs in order to protect “objects of historic or scientific interest.” Historic landmarks, historic or prehistoric structures, or other objects of historic or scientific interest on public lands may warrant designation as a monument. While most NMs are established by the President, Congress has also occasionally established NMs protecting natural or historic features. Since 1906, the President and Congress have created more than 100 NMs. NMs are currently managed by agencies including the NPS, the USFS, the USFWS, or BLM(BLM 2011g).

There are currently four NMs in the ecoregion: Craters of the Moon, Hagerman Fossil Beds, Newberry National Volcanic Monument, and Minidoka Internment Camp (USGS 2012).

National Wildlife Refuges (NWRs)

The Refuge System maintains the biological integrity, diversity and environmental health of these natural resources for the benefit of present and future generations of Americans. Caring for fish, wildlife and plant populations and their habitat is the essence of the science of wildlife management as well as the newer disciplines of conservation biology and ecosystem management. The main recreational activities that go on in NWRs are hunting, fishing, wildlife observation, photography, environmental education, and interpretation (USFWS 2012b). The management of each NWR will vary depending on the resources being protected and wildlife managed. Some NWRs will grow crops for wildlife, conduct prescribed burns or manage invasive species. NWRs can allow telecommunications towers through a permitting similar to right-of-way permits. Oil and Gas extraction is not allowed but resource extraction such as gravel may be an allowed process (USFWS 2012c). There are currently 11 NWRs within the ecoregion (USFWS 2012b)

Areas of Critical Environmental Concern (ACECs)

An ACEC is a designation that highlights areas where special management attention is needed to protect and prevent irreparable damage to important historic, cultural and scenic values; fish, wildlife resources or other natural systems or processes; or to protect human life and safety from natural hazards. BLM establishes special management measures for these areas through land use planning. The designation is a record of significant values that must be accommodated when BLM considers future management actions and land use proposals (BLM 2011b).

ACECs differ from other special designations, such as WSAs, in that designation by itself does not automatically prohibit or restrict uses in the area. While WSAs are managed to a “non-impairment” standard that excludes surface-disturbing activities and permanent structures that would diminish the areas’ natural character, the management of ACECs is focused on the resource or a natural hazard of concern. This varies considerably from area to area, and in some cases surface disturbing actions may be allowed (BLM 2011b).

Since the BLM prescribes special management measures that are specific to the values for which the ACEC is designated, what can and cannot occur in different ACECs may vary dramatically. The activities that are allowed and/or prohibited in certain ACECs vary. Each ACEC is extremely unique and therefore has specific management measures. There are currently 61 ACECs within the ecoregion boundary (USGS 2012).

Wild Horse and Burro Herd Management Areas (HMAs)

The BLM protects, manages, and controls wild horses and burros under the authority of the Wild Free-Roaming Horses and Burros Act of 1971 to ensure that healthy herds thrive on healthy Western public rangelands as directed by Congress. The BLM manages these iconic animals on 26.9 million acres of BLM-managed Western rangeland as part of their overall multiple-use mission across 245 million acres of public lands (BLM 2011h).

Wild horse and burro herds, which have virtually no natural predators, grow at a rate of about 20 percent a year, which means herds can double in size every four years. As these animals populations grow at such a fast pace, there are many potential adverse impacts to public lands as a result of the overpopulated herds. In response to herd growth, the BLM must remove thousands of wild horses and burros from the range each year to protect public rangelands from the environmental impacts of herd overpopulation. Currently, the western rangeland free-roaming population of 38,500 horses and burros exceeds by nearly 12,000 the number that the BLM has determined can exist in balance with other public rangeland resources and uses. The health of ecosystems of public rangelands, which also provide habitat for wildlife and vegetation, is not sustainable and is not able to withstand the impacts resulting from overpopulated rapidly growing wild horse and burro herds (BLM 2011h).

The BLM's goal is to ensure and maintain healthy wild horse populations on healthy public lands. To do this, the BLM works to achieve what is known as the Appropriate Management Level (AML) – the point at which wild horse and burro herd populations are consistent with the land's capacity to support them. In the context of its multiple-use mission, AML is the level at which wild horses and burros can thrive in balance with other public land uses and resources, including vegetation and wildlife (BLM 2011i).

There are 71 Wild Horse and Burro Herd Areas and 49 Wild Horse and Burro Herd Management Areas within the ecoregion (USGS 2012).

State Parks

Of the eight state parks identified with the ecoregion, seven are in Idaho and one is within Oregon (USGS 2012). Since state parks are managed under state law, the level of protection given will vary with the state and the natural resources or recreation opportunities at each park.

Historic Districts

Historic Districts are locations with significant importance in American history, architecture, archeology, engineering, and culture. These can range from Archaeological Districts such as Guffey Butte / Black Butte (ID) to more recent historical locations such as the Oregon Trail Historic District. In conjunction with the Secretary of the Interior, all federal agencies establish their own historic preservation programs for the identification, evaluation, and protection of historic properties as mandated in Section 110 of the National Historic Preservation Act. These individual agency programs vary greatly in scope, depending on the degree to which the agency owns, controls, or affects historic properties (NPS 2011). There are currently 40 Historic Districts within the ecoregion (NPS 2011).

Appendix B. CE/Stressor (CA) Relationship Tables used as a reference in the pre-meeting memo (unchanged)

Introduction

The primary CAs addressed in this REA were refined through discussion with the AMT and summarized in Memo I-1. CAs may affect CEs in several ways; in this REA we focus primarily on adverse effects on CE species, assemblages, and systems, but recognize that some species may benefit from some CAs, such as rangeland improvements that include adding a water source that wildlife can also use. Direct and indirect adverse CA effects include mortality, illness or other reduced fitness, and behavioral disturbance or other effects leading to reduced individual fitness and/or reproductive success. Indirect effects also include reduction in quantity, quality, or availability of suitable habitat; habitat fragmentation; and loss of connectivity between habitat blocks, especially access to areas used on a seasonal basis for necessary winter resources or breeding opportunities. Some of the most vulnerable CEs, such as the greater sage-grouse, are expected to be affected by almost all of the CAs through combined direct and indirect effects on habitat availability and condition, individual survival, and reproductive success. Conversely, climate change is expected to affect virtually all CEs (as well as other CAs) through effects on extent, distribution, and connectivity of suitable habitats. One subtle but important effect of current research interest is in the timing of seasonal temperature variations (e.g., when warm-up in spring occurs) that changes blooming periods (phenology) of certain plant populations, which trickles down to affecting insect pollinators, seed production for birds, and many other species (Davis *et al.* 2010, Visser and Both 2005).

The following example involving wildland fire illustrates CA effects on CEs including some effects that may be synergistic with other CAs. Wildland fire is a key ecological process in western ecosystems (Baker 2009, Pyne 1992), and influences other ecosystem processes (Agee 1993, Dale *et al.* 2001) such as landscape patterns and species diversity (Swetnam and Betancourt 1997, Haire and McGarigal 2009), nutrient cycling, hydrology and erosion (Agee 1993), air quality (Sampson *et al.* 2000), plant ecology (Miller 2000), and wildlife habitats and biodiversity (Noss and Cooperrider 1994). Natural fire regimes are classified based on fire frequency and severity (Barrett *et al.* 2010). Departure from the historical fire regime, mostly due to human intervention in natural fire regimes, results in changes in the ignition frequency. In the Great Basin increased fire frequency is associated with replacement of native vegetation communities by invasive annual grasses, and decreased fire frequency leads to expansion of juniper-dominated communities. Moreover, changes in the severity of fire contribute to changes in distribution, composition, and structure of vegetation communities. This CA potentially affects most coarse-filter terrestrial CEs (vegetation types and ecological systems as well as specially designated areas) in the NBR ecoregion. Similarly, fine-filter CEs including greater sage-grouse and pygmy rabbit are directly affected by the wildfire CA due to the loss of their preferred mature growth sagebrush habitats and the time required for replacement. Aquatic species that are dependent upon existing in certain water temperatures and water quality conditions, like the coldwater fish and bull trout, are affected when fires remove shading riparian vegetation and water temperature and sedimentation increase.

Many CA synergies exist. Invasive species (exotic annual grasses) and livestock grazing are interwoven as grazing has been known to affect invasive annual grass spread. Amounts and types of fuels, such as invasive annual grasses, can affect frequency and intensity of fires. Fire is strongly influenced by climate and weather. Climate change and fire interactions include increased area burned (Flannigan *et al.* 2005), variability and frequency of extreme fire weather (Flannigan and Wotton 2001) and length of fire seasons (Wotton and Flannigan 1993). Insects and plant diseases contribute to the frequency and severity of fire by increasing fuel loads.

Relationships between CEs and CAs chosen for the NBR that are depicted graphically in the CE conceptual models (Section 2.X) are summarized in simple dot matrices (fine-filter CEs and coarse-filter CEs). Details of these relationships for individual CEs were discussed at AMT Workshop 2 and will be incorporated in the analyses that will occur in subsequent phases of the REA.

Fine-filter Conservation Elements – Change Agent Effects

	Fine-filter Conservation Elements											
Change Agents	Mule Deer	Greater Sage-grouse	Golden Eagle	Bald Eagle	Pygmy Rabbit	Bighorn Sheep	Pronghorn	Bull Trout	Coldwater Fish Assemblage	White Sturgeon	Bats	Spotted Frog
Wildland Fire	●	●		●	●		●	●	●	●		●
Climate Change	●	●	●	●	●	●	●	●	●	●	●	●
Invasives												
Annual Grasses/Forbs	●	●			●	●	●					
Juniper Expansion		●	●	●	●		●					
Aquatic Invasives				●				●	●	●	●	●
Development												
Traditional Energy		●			●		●					
Alternative Energy		●			●		●					
Pumped Storage		●			●			●	●	●	●	●
Linear Features	●	●	●	●	●		●	●	●	●		●
Urban/Exurban	●	●		●	●			●	●	●		●
Mining	●	●			●	●	●	●	●	●	●	●
Transportation	●	●		●	●		●	●	●	●	●	●
Recreation		●	●	●				●	●	●		●
Agriculture	●	●	●	●	●			●	●	●	●	●
Hydro Diversions	●	●		●	●	●	●	●	●	●	●	●
Hydro Impoundment	●	●		●	●	●	●	●	●	●	●	●
Military		●		●	●	●	●					
Rangeland Treatments		●			●		●					
Grazing (Livestock, Wild Horses, Burros)	●	●			●		●					

Coarse-filter Conservation Elements – Change Agent Effects

Change Agents	Coarse-filter Conservation Elements															
	Sagebrush	Salt Desert Shrub	Juniper	Aspen	Pinyon	Other Conifer	Vulnerable Soils	Carbon Sequestration Potential	High Biodiversity Areas	Perennial Streams/Rivers	Springs/Seeps	Wetlands	Open Water Habitat	Cottonwood Galleries	Riparian Habitat	Groundwater
Wildland Fire	●	●	●	●	●	●	●	●	●					●	●	
Climate Change	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Invasives																
Annual Grasses/Forbs	●	●	●				●	●	●	●	●	●		●	●	
Juniper Expansion	●	●	●		●		●	●	●							
Aquatic Invasives									●	●	●	●	●		●	
Development																
Traditional Energy	●	●	●		●		●	●	●		●					●
Alternative Energy	●	●	●		●		●	●	●		●					
Pumped Storage				●		●	●	●	●	●	●	●	●	●	●	●
Linear Features	●	●	●	●	●	●	●	●	●	●	●	●		●	●	
Urban/Exurban	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Mining	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Transportation	●	●	●	●	●	●	●	●	●	●	●	●		●	●	
Recreation	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Agriculture	●	●	●				●	●	●	●	●	●		●	●	●
Hydro Diversions									●	●	●	●	●	●	●	●
Hydro Impoundment									●	●	●	●	●	●	●	●
Military	●	●	●	●	●	●	●	●	●		●					●
Rangeland Treatments	●	●	●				●	●	●		●	●				
Grazing (Livestock, Wild Horse, Burro)	●	●					●	●	●	●	●	●		●	●	

Appendix C. Management Questions for the NBR

Table C-1. Management Questions for the NBR

MQ #	MQ Group	Final Management Question
		Questions Related to Conservation Elements (CEs)
1	Species	What is the current distribution of potential habitat for each species CE?
2	Species	Where are current locations of species CEs that are potentially affected by existing CAs (and thus potentially at risk)?
3	Species	What is the current distribution of suitable habitat, including seasonal habitat and movement corridors, for each landscape species and species assemblage CE?
4	Species	Where are existing CAs potentially affecting this current habitat and/or movement corridors, for landscape species and species assemblage CEs?
5	Species	Where are species CEs whose current locations or suitable habitats overlap with the potential future distribution of CAs (other than climate change)?
6	Species	Given current and anticipated future locations of CAs, which habitat areas remain as opportunities for habitat enhancement/ restoration?
7	Species	Where are potential areas to restore connectivity for landscape species and species assemblage CEs, based on current locations of CAs?
8	Species	Where will landscape species and species assemblage CEs experience climate outside their current climate envelope?
9	Native Plant Communities	Where are intact (i.e., minimally disturbed by human activities) CE vegetative communities located?
10	Native Plant Communities	Where are the likeliest current locations for high-integrity examples of each major terrestrial ecological system?
11	Native Plant Communities	Where are existing and potential future CAs (aside from climate change) likeliest to affect current communities?
12	Native Plant Communities	Where will current locations of these communities experience significant deviations from normal climate variation?
13	Terrestrial Sites of High Biodiversity	Where are sites identified as having high biodiversity characteristics? Which designated sites are protected?
14	Terrestrial Sites of High Biodiversity	Where will CAs (aside from climate change) potentially affect sites of high biodiversity?
15	Terrestrial Sites of High Biodiversity	Where will locations of these high biodiversity sites experience significant deviations from normal climate variation?
16	Aquatic Sites of High Biodiversity	What has been the general level of survey effort (ecoregion-wide, not site-specific) for spring snails and other species of concern?
17	Aquatic Sites of High Biodiversity	Where are areas representing unique aquatic lineages or assemblages or other areas of high aquatic biodiversity (considering both local [alpha] and regional [beta or gamma] diversity)?
18	Aquatic Sites of High Biodiversity	Where will these aquatic high biodiversity sites (as defined in MQ 17) be potentially affected by CAs (aside from climate change)?
19	Aquatic Sites of High Biodiversity	Where will current locations of these aquatic high biodiversity sites (as defined in MQ 17) experience significant deviations from normal climate variation?
20	Specially Designated Areas of Ecological Value	Where are specially designated areas of ecological or cultural value?
21	Wild Horse and Burro Management Areas	Where are the current wild horse and burro Herd Management Areas (HMAs)?
22	Wild Horse and Burro Management Areas	Where will CAs (excluding climate change) overlap HMAs, under each time scenario?
23	Wild Horse and Burro Management Areas	Which HMAs will experience climate outside their current climate envelope?
24	Grazing	Where are the current livestock grazing allotments?
25	Grazing	Where will CAs (excluding climate change) overlap grazing allotments under each time scenario?

Table C-1. Management Questions for the NBR

MQ #	MQ Group	Final Management Question
Questions Related to CEs (continued)		
26	Grazing	Which grazing allotments will experience climate change outside their current climate envelope?
27	Vulnerable Soils	Where are vulnerable (e.g., erodible, slickspot) soil types within the ecoregion?
28	Vulnerable Soils	Where will vulnerable soil types overlap with CAs (aside from climate change) under each time scenario?
29	Vulnerable Soils	Where will current vulnerable soil types experience significant deviations from normal climate variation?
30	Surface and Subsurface Water Availability	Where are current natural and man-made surface water resources, and which are perennial ephemeral, etc?
31	Surface and Subsurface Water Availability	What is the natural variation of monthly discharge and monthly base flow for streams and rivers?
32	Surface and Subsurface Water Availability	Where are the likely recharge areas within a HUC?
33	Surface and Subsurface Water Availability	Where will the recharge areas (relating to aquatic CEs) identified in MQ 32 potentially be affected by CAs?
34	Aquatic Ecological Function and Structure	What is the condition (ecological integrity) of aquatic CEs?
Questions Related to Change Agents (CAs)		
35	Fire History	What is the frequency, size, and distribution of wildfire on the landscape?
36	Fire Potential	What areas now have (high, medium, low) potential for fire based on fuels composition (e.g., invasive plants)?
37	Fire Potential	Where are areas that in the future will have high potential for fire?
38	Invasive Species	What is the current distribution of invasive species included as CAs?
39	Invasive Species	What areas are significantly affected by invasive species?
40	Invasive Species	Focusing on the distributions of terrestrial and aquatic CEs that are significantly affected by invasive species, which areas have restoration potential?
41	Invasive Species	Given current patterns of occurrence and expansion of the invasive species included as CAs, what is the potential future distribution of these invasive species?
42	Development	Where are current locations of development CAs?
43	Development	Where are areas of planned or potential development CAs?
44	Development	Where do development CAs cause significant loss of ecological integrity?
45	Development	Where do current locations of CEs overlap with development CAs?
46	Recreation	Where are areas with significant recreational use?
47	Recreation	Where have designated recreation areas, such as for off-highway vehicle (OHV) use, affected CEs and invasive species?
48	Recreation	Where are other areas of likely high OHV use [as determined by modeling] that may affect CEs and invasive species?
49	Oil, Gas, and Mining Development	Where are the current locations of oil, gas, and mineral extraction?
50	Oil, Gas, and Mining Development	Where will locations of oil, gas, and mineral extraction potentially exist by 2025?
51	Oil, Gas, and Mining Development	Where are the areas of potential future locations of Oil, Gas, and Mining (including gypsum) development (locatable, salable, and fluid and solid leasable minerals)?
52	Oil, Gas, and Mining Development	Where do locations of current CEs overlap with areas of potential future locations of non-renewable energy development?
53	Renewable Energy Development	Where are the current locations of renewable energy development (solar, wind, geothermal, transmission)?

Table C-1. Management Questions for the NBR

MQ #	MQ Group	Final Management Question
		Questions Related to CAs (continued)
54	Renewable Energy Development	Where are the areas identified by the National Renewable Energy Laboratory (NREL) as potential locations for renewable energy development?
55	Renewable Energy Development	Where are the areas of low renewable and non-renewable energy development that could potentially mitigate impacts to CEs from potential energy development?
56	Renewable Energy Development	Where do current locations of CEs overlap with areas of potential future locations of renewable energy development (MQ 65)?
57	Renewable Energy Development	Where will locations of renewable energy [development] potentially exist by 2025?
58	Groundwater Extraction and Transportation	Where will CAs potentially impact groundwater-dependent aquatic CEs?
59	Groundwater Extraction and Transportation	What is the present distribution of municipal and agricultural water use of groundwater resources in relation to the distribution of aquatic CEs?
60	Groundwater Extraction and Transportation	Where are the aquatic CEs showing degraded ecological integrity from existing groundwater extraction?
61	Surface Water Consumption and Diversion	Where are artificial water bodies including evaporation ponds, etc.?
62	Surface Water Consumption and Diversion	Where are the areas of potential future change in surface water consumption and diversion?
63	Surface Water Consumption and Diversion	Where are the CEs showing degraded ecological integrity from existing surface water diversion?
64	Climate Change: Terrestrial Resource Issues	Where will changes in climate be greatest relative to normal climate variability?
65	Climate Change: Terrestrial Resource Issues	Given anticipated climate shifts and the direction shifts in climate envelopes for CEs, where are potential areas of significant change in extent such as ecotones?
66	Climate Change: Terrestrial Resource Issues	Where are vegetation CEs that will experience significant deviations from normal climate variation?
67	Climate Change: Terrestrial Resource Issues	Where are wildlife CE habitats that will experience significant deviations from normal climate variation?
68	Climate Change: Aquatic Resource Issues	Where will aquatic CEs experience significant deviations from historic climate variation that potentially could affect the hydrologic and temperature regimes of these aquatic CEs?
69	Military Constrained Areas	Where are areas of planned expansion for military use?
70	Atmospheric Deposition	Where are areas affected by atmospheric deposition of pollutants, as represented specifically by nitrogen deposition, acid deposition, and mercury deposition?
71	Livestock Grazing	Where is structure of vegetation CEs affected by livestock grazing?
72	Livestock Grazing	Where can livestock grazing be used to reduce wildfire risk in areas with herbaceous fuel loads and proximity to high-probability ignition locations (roads, train tracks, lightning etc.)
73	Livestock Grazing	Where will livestock grazing have the potential to increase fire from vegetation cover type conversion (high, medium, low)?
74	Livestock Grazing	Where are areas in the landscape with various (low, medium, high) levels of resilience to livestock grazing (based upon ecological site and existing vegetation)?
75	Livestock Grazing	Where has the landscape been modified for purposes of livestock grazing and management (sagebrush elimination, fences, plantings, water sources, etc)?

Table C-1. Management Questions for the NBR

MQ #	MQ Group	Final Management Question
Questions Related to CAs (continued)		
76	Livestock Grazing	What areas of the landscape are low density vs. high density livestock grazed (streams, water developments, corrals, steep slopes, etc)?
77	Livestock Grazing	Where are areas best suited to potential livestock cattle and sheep grazing based on environmental factors (such as slope, aspect, water availability, wild ungulate grazing)?
78	Livestock Grazing	Where do grazing areas have the highest potential to increase invasive and/or noxious species occurrences?