# CHALLENGES IN WILDLIFE MANAGEMENT

Nevada is uniquely challenged in approaching effective wildlife conservation, in part because of its generally arid climate, geography, and relative scarcity of water resources, which has created a unique endemic biota easily subject to threats and stressors. Beyond these inherent conditions, however, human factors including a long history of land use activities altering natural habitats, recent intense urban development, and the widespread occurrence of invasive plant and animal species must be addressed to ensure the effectiveness of conservation actions and the maintenance of wildlife and their habitats into the future. When coupled with natural stressors such as periodic, but unpredictable, drought conditions from short-term climatic variation human related stressors can create a compounding effect which significantly influences the ability of habitats to maintain wildlife diversity on a landscape scale. Although some of these anthropogenic stressors, such as urban development and large-scale modification of hydrologic systems for water supply and flood control, may not be reversible and are necessary costs associated with human settlement and needs, others can be managed or corrected in ways that reduce negative effects or positively assist in implementing conservation.

Although Nevada's unique landforms and natural history are important elements in understanding and addressing the challenges inherent in developing this strategy to comprehensively conserve our wildlife resources, it must be understood that challenges for species and habitats across Nevada are closely tied to anthropogenic land use activities. Any strategy for addressing these challenges and effective conservation must include a definition and attempt to understand the stress on species and their habitats. In the broad sense, the sources of stress can be categorized into actions related to agriculture, hydrology, recreation, natural resources extraction, development, military activities, and a few additional actions which do not fall into these general areas.

Although organized agricultural activities are not a significant broad-scale stressor in Nevada, where they do occur, land-use actions such as agricultural and pasture conversion can influence wildlife through loss of native vegetation communities and species diversity, changes in vegetative structure characteristics, and increased disturbance to wildlife. Improper agricultural practices have the potential for significant local impacts; water and soil pollution can occur from improper waste management in intensive agriculture operations such as feedlots; and improper application of pesticides and herbicides can cause incidental mortality of non-target sensitive species and disruption of physiological processes, including reproduction. Improper soil conservation practices cause soil erosion and sedimentation of streams and floodplains, and the improper application of fertilizers can result in nutrient loading of streams and contamination of animal tissues.

## Animal Disease

The principles of disease in wildlife are adherent to the epidemiological triad which states that disease results from the interaction between the host, the environment, and the disease agent (pathogen or chemical). Each of these components (host, environment, and agent) can influence the others and factors within each component may change the contribution of the component to the development of disease. Critical factors which affect the host component include age, sex, genetics, nutritional, physiological and immune status, and prior exposure to pathogens. Environmental factors influencing the host include climate, habitat, and interactions with other species, host densities and aggregation indexes.

The occurrence of disease in wildlife can be a natural phenomenon or anthropogenically driven. Human generated influences that have been tied to wildlife disease events have been broadly divided into three categories; environmental change, climate change, and ecological change. Factors within each of these categories alter other physical and biological processes thus affecting the epidemiological triad and increasing the risk and/or incidence of disease events in wildlife populations across Nevada's eco-regions.

### *Environmental Change and Disease*

- Electromagnetic fields (characterized by low intensity, variety of signals, and long term duration cell phone towers, etc.): Studies of electromagnetic field exposure on wildlife indicate that there may be impacts to behavior, reproductive success, growth and development, physiology and endocrinology, and oxidative stress potentially increasing carcinogenesis.

- Exposure to and accumulation of pollutants (which may lead to reduced habitat quality): Reported and predicted effects include impaired reproduction, impacts to the immune system (primarily a decrease in effectiveness) resulting in an increased incidence of infectious disease or carcinogenesis. Pollutants found in water may be of greatest importance to species within Nevada and toxicity from heavy metals, salts and petrochemicals found in evaporation ponds associated with the mining and energy industry and toxic algal blooms have been documented.

- Ozone depletion: An increase in exposure to UV radiation has been reported to have a detrimental impact on species of amphibians. Negative effects included abnormal development or decreased hatching success due to cellular damage, depression of the immune responses and an increase in cancer development. Impacts appear to vary between species and life stages. It is suspected that the effects of increasing UV radiation will be an additional stressor to taxa that are already in decline due to the impacts of habitat loss and emerging infectious diseases (Chytrid fungus, ranavirus).

### *Climate Change and Disease*

Climate change predictions, such as thermal extremes and weather disasters, can contribute to:

- Changes in vector and pathogen distribution
- Pathogen emergence
- Altered habitats
- Droughts

The interaction between climate change and disease dynamics in wildlife is complex and as yet poorly understood. Vector borne or environmentally transmitted disease pathogens appear to provide the most convincing evidence that a warming climate may be facilitating their spread. Insect vector species can be sensitive to temperature and precipitation fluctuations and these climatic factors are known to impact life-cycle completion times, biting and feeding rates and overwintering survival of important disease vector species. Expanding ranges allow these vectors to encounter native host populations. Parasites that have a free-living life stage may have their development times and transmission windows impacted by increasing temperatures.

There is an increasing trend of novel or introduced pathogens occurring worldwide. This is significant in part because they can result in rapid and devastating population declines that often pose a greater threat to conservation efforts than habitat loss. Global population declines and extinctions have impacted amphibian species due to the chytrid fungus; white nose syndrome caused by the fungus, *Geomyces destructans,* is threatening the persistence of the little brown bat (*Myotis lucifugus)* in eastern North America; and pneumonia complex in bighorn sheep has caused all age die-offs leading to local collapse and extinction of meta-populations across the western states.

Nutritional stress (decreased calories, protein, vitamins, and other essential nutrients) and dehydration can occur secondary to thermal extremes or drought and may decrease the effectiveness of the immune system thereby lowering disease resistance to known or emerging pathogens. Immunodeficiency resulting from malnutrition has been well documented in humans and is strongly related to increased incidence of infectious diseases and infant mortality worldwide. Nutritional stress may impact other physiological processes in addition to immunity such a growth rate and reproduction leading to potential population impacts in vulnerable species.

### *Ecological Change and Disease*

Ecological changes or shifts caused by climate change, such as land degradation and habitat fragmentation, can cause:

- Decreased food/nutrient availability may have a direct effect such as starvation, dehydration, or nutritional deficiencies may secondarily impact physiological processes resulting in an increased susceptibility to infectious disease.

- Restricted movement of animals due to loss of habitat corridors may isolate populations leading to decreased gene flow, inbreeding, and loss of genetic diversity. This may impact immune system responses and reproductive rates within these isolated populations.

- Increased rates of contact with humans or domestic animals can lead directly to increased pathogen transmission. If domestic species and wildlife are competing for the same decreasing resources at certain periods during the year this may place wildlife at an increased risk of disease. Most domestic livestock receive supplemental feed during part of the year thus their nutritional and physiological needs are met. Wildlife species competing on the range for limited resources may already be in a negative nutritional state with a compromised immune status and thus more vulnerable to disease transmission.

Determining the effects of anthropogenic influences, in particular climate change, on host–pathogen interactions is a challenge as these relationships are already complex. The impact of increasing population densities coupled with decreasing habitat resources are generally felt to facilitate disease transmission; however, some diseases have shown increasing incidence with decreasing population density and, with some interactions, it is believed that host population isolation secondary to the effects of climate change may lead to pathogen extinctions. Isolation of populations of desert bighorn sheep produced by herds moving to higher elevations across their range (as lower elevations are no longer habitable due to a warmer and drier landscape) has been hypothesized as a model of the effects of climate change, leading to a decline in population viability in the face of decreasing disease transmission. Initial concentration of individuals may increase the incidence of disease within the population; however, as metapopulations become increasingly isolated the chance of disease spread between populations declines and certain diseases may not persist.

With the possible exception of desert tortoises and bighorn sheep, extensive surveillance for and documentation of diseases in Nevada's wildlife has not been conducted. Extrapolations from studies conducted on species with ranges that overlap into Nevada (primarily those species along the Sierra Nevada) contribute to the current body of information; however, further efforts are needed to establish a baseline of health data within the state's wildlife populations. Such a baseline of data would assist wildlife managers in defining which components of the epidemiological triad currently influence disease distributions and prevalence in Nevada's wildlife thus increasing the our understanding of which components, impacted by a changing climate, may influence future disease events.

## Climate Change

A growing body of evidence has linked changing climate with observed changes in fish and wildlife and their habitats. Climate change has likely increased the size and number of wildfires, insect outbreaks, disease outbreaks and tree mortality in the interior West and Southwest. In the aquatic environment, evidence is growing that higher temperatures are negatively impacting cold and cool water fish populations across the country (USFWS, 2010).

Climate is changing at an accelerated rate and science strongly support the findings that the underlying cause of these changes are largely the result of human–generated greenhouse gas concentration in the atmosphere caused by increasing human development and population growth (USFWS, 2010). Global temperatures are expected to continue to rise through the $21^{st}$ century, dependent on the continued accumulation of heat-trapping gas emissions and the sensitivity of regional climates.

Average air temperature worldwide has risen steadily over several decades and dramatically since the 1950s. The first decade of the $21^{st}$ century has proven to be the hottest decade since scientists began recording global temperatures in the 1880s, with the 1990s following close on its heels as the second hottest. In September, 2011, the polar ice cap set a new record low for area frozen at the end of summer, a trend that has been on a downward track for over a decade. Reports from all over the world of glacier melt, disrupted plant community phenological cycles, and disrupted bird migrations continue to mount. The average rate of sea level rise has doubled in just the last 20 years, and projections made just five years ago are already out of date, with actual change more accelerated than predicted.

Rainfall patterns around the world will be affected. Rising temperature causes water to evaporate faster, resulting in more water in the atmosphere. While scientists predict that global average annual precipitation will increase as a result, the increases will not be distributed evenly across the globe. Rainfall in many regions will increase in range of variability. Rain storms will become more intense but less frequent. Also, in some areas snowfall will shift to rain, with major implications for streamflows and seasonal availability of water for wildlife, fish, and people.

As the concern for climate change and its impact grows, federal, state, and local agencies and conservation organizations have been developing guidance documents for wildlife-related climate response. The USFWS developed the document: "*Rising to the Urgent Challenge: A Strategic Plan for Responding to Accelerating Climate Change*", in 2010. The Western Governors' Association published the document, *"Climate Adaptation Priorities for the Western States: Scoping Report",* in 2010. Very recently, the USDA Forest Service released the publication, "*Responding to Climate Change in National Forests: A Guidebook for Developing Adaptation Options"*. In 2011, The National Wildlife Federation published "*Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment"*. In addition, a team of federal, state and tribal nations have developed the Public Review Draft of the "*National Fish, Wildlife and Plants Climate Adaptation Strategy",* which should be completed in 2012.

The AFWA/FWS document, "*Voluntary Guidance for States to Incorporate Climate Change into State Wildlife Action Plans & Other Management Plans*", includes recommended steps for developing and implementing adaptation strategies in the face of climate change:

1. Engage diverse partners and coordinate across state and regional boundaries.

2. Take action on strategies effective under both current and future climates.
   - Managers should focus on conservation actions likely to be beneficial regardless of future climate conditions. This can include reducing non-climate stressors, managing for ecological function and protection of diverse species assemblages, and maintaining and restoring connectivity.

3. Clearly define goals and objectives in the context of future climate conditions.
   - Goals and objectives should address whether they aim to resist the impacts of climate change, promote resilience, and/or facilitate changing conditions.

4. Consider appropriate spatial and temporal scales.

5. Consider several likely/probable scenarios of future climate and ecological conditions.

6. Use adaptive management to help cope with climate change uncertainty.

The documents and principles listed above were used as guidance in the development of this revision of the WAP. NDOW also serves on the AFWA and Western Association of Wildlife Agencies (WAFWA) Climate Change Committees to stay updated on national and regional wildlife issues related to climate change.

### *Climate Change in Nevada*

Primarily using the climate change predictive tools available through the Climate Wizard (www.climatewizard.org), the Revision Team led by The Nature Conservancy's vegetation modeling team settled on the A2 Emissions Scenario from the *Climate Change 2007: Impacts, Adaptation, and Vulnerability* report (IPCC, 2007) for climate change modeling. The general deductions made from following the A2 scenario were that Nevada would increase in temperature about 3° C with greater greenhouse gas concentration, but with the same total amount of average precipitation. This prediction is highly dependent on the influence of the Pacific Ocean. The greatest uncertainty for future climate forecasting (high divergence among Global Circulation Models) will be for a western shift of the western boundary for the monsoonal effect (i.e., summer precipitation). For the purposes of modeling vegetation response, it was assumed that the eastern Nevada regions would experience a greater amount of summer precipitation and therefore less drought.

More specific hypotheses of change that developed as a result of our analysis were:

- Increased dispersal of non-native species caused by $CO_2$ fertilization of plant growth during wetter than average years

- Decreased dispersal of non-native species during drier than average years regardless of $CO_2$ concentrations

- Higher tree mortality during longer growing season droughts

- Longer period of low flows caused by earlier snowmelt
- Greater severe flood variability due to greater frequency of rain-on-snow events, which would favor cottonwood and willow recruitment on currently regulated rivers and creeks
- Longer period of groundwater recharge during colder months with low evapotranspiration and greater percentage of rain *versus* snow (more effective recharge)
- More stable discharge (buffered from precipitation) for springs, seeps, wet meadows, creeks, and rivers on carbonate geology and, conversely, less stable discharge on non-carbonate geology
- More frequent, larger fires in forested systems
- Increased growth and recruitment of subalpine trees due to increased tree line temperature regardless of CO2 fertilization
- Longer fire return intervals in shrubland systems due to increased drought frequency preventing fine fuel build up
- Greater conifer and deciduous tree species recruitment and growth in wetlands/riparian due to drought and CO2 fertilization
- Impaired recruitment of willow and cottonwood due to descending peak flows occurring one month earlier and limited ability of these species to flower one month earlier in cold drainages; and
- Faster growth of fast-growing native tree species.

Compared to scenarios without climate change, the climate change effects predicted over the next 50 years yielded consistent differences that resulted in both detrimental and beneficial ecological responses that varied by region; therefore we were able to conclude that climate change would contribute specific impacts over and above the natural rate of change assisted by other human-induced impacts.

## Energy Development

The status of our current economy has had great influence upon land use within Nevada. Nevada with its large percentage of public land makes it a good choice for the purposes of developing an infrastructure for renewable energy. This development is being viewed as a means of diversifying our state's economy, a source for new job creation and as a native source for renewable energy production. Nevada has great potential for both solar and geothermal energy production and to a lesser degree, wind and biomass energy development. Each of these energy resources rely upon characteristics at a specific location (whether its sunlight intensity, consistent wind, or geothermal heat sources) that make a location desirable for development. The viability that makes these locations "work" for development includes its access, its proximity in relation to the electric grid, and the ease of which that site could be developed. That ease depends upon land ownership, zoning, or land designation for development and the ability to overcome or compensate for the environmental constraints of the site.

It has been well documented that energy projects have the potential to result in a loss of wildlife habitat (both permanent and temporary), habitat fragmentation and a host of indirect impacts such as disturbance created by human activity, vehicle traffic, noise, and noxious/invasive weed introductions. Technology has developed to treat many of these constraints and the success of reclaiming for the temporary loss of habitat has certainly made great advances. Yet the constraints are real, political decisions sometimes outweigh the need to make the best environmental decision and the challenges to wildlife conservation remain.

The best tool that land and resource managing agencies have is a detailed and current database of the resources that may be impacted by energy development. NDOW and NNHP have over the years worked on the development of GIS databases that provide spatial information on the resources. These data are used in a series of models that analyze management schemes and priorities for protection. In regards to energy development, the spatial information is used to aid in the siting of facilities and for comparing project alternatives.

Agencies have been stressing the importance of applying wildlife resource data in the siting of proposed facilities in an attempt to avoid high quality habitat and large undisturbed areas. The priority for land use would be to site on already disturbed ground, to site new facilities near existing facilities, and to avoid priority wildlife habitat. Unfortunately, not all projects request or use the resource data soon enough in the development of their plans to apply avoidance even though NEPA requires its application as the first effort in minimizing the impacts of development

### *Challenges for Wildlife Conservation*

- Encouraging developers to use wildlife resource data early enough in the process to influence facility siting to avoid high quality wildlife habitat
- Developing and updating best management practices as mitigation to address potential impacts from energy projects and their changing technology
- Conducting sufficient research and pre-construction monitoring to best assess the impacts of energy development on wildlife
- Identification of sufficient project location alternatives to avoid impacts of concern
- Identification of high value wildlife habitat for avoidance and to identify areas of low quality wildlife habitat as opportunities for development
- The ability to identify areas unaffected by future proposed projects for application of offsite mitigation
- Ability to receive compensation for the loss of habitat which could take many years (sometimes upward of 25 years in sagebrush habitat) to recover to pre-disturbance conditions
- Ability to prevent the establishment of invasive plant species, particularly noxious weeds, from becoming established in areas where soils have been disturbed
- Ability to prevent wildlife mortality, in toxic evaporation or cooling ponds and other water impoundments
- The ability to avoid habitat fragmentation caused by linear projects incorporating new roads, powerlines, or pipelines
- Planning for the closing, termination or cessation of energy projects, the removal of facilities, and other decommissioning actions and site restoration activities

***Actions Associated with Energy Projects to Advance Wildlife Conservation***

- Programmatic Environmental Impact Statements which have addressed the issues common to energy development on Public Lands in a general sense and have identified some of the issues which are common to those projects. Those documents include: Wind Energy Development PEIS, Geothermal Energy Development PEIS and the Solar PEIS
- Guidelines developed by the USFWS for the siting of Wind Energy Development Projects
- Guidelines, Recovery Plans, and Habitat Protection Plans developed for specific species or habitats to identify or require protection including: Guidelines for Golden Eagles, and Greater Sage Grouse, the Clark County Multiple Species Habitat Protection Plan, to name a few
- Issuance of the Standards for Energy Development in Sage Grouse Habitat by the Governor's Sage Grouse Committee
- Development of standards and best management practices to reduce predation by aerial predators utilizing high voltage electric transmission lines including application of anti-perching and anti-nesting devices
- Guy wire covers and other anti-collision devices which make guy wires and static wires more visible to reduce bird collisons
- Studies funded by project developers which increase the science of how wildlife reacts to energy developments. The Falcon to Gondor 345kV Project funded sage grouse study has provided some essential interaction and behavioral data

## Direct Human Effects

Another anthropogenic effect and source of stress is direct negative human interaction with wildlife, specifically, overexploitation of species through illegal activities such as poaching, illegal collection or killing, excessive harvest of species for commercial or scientific research purposes, and habitat destruction associated with collection activities. Although difficult to demonstrate in a quantitative sense, such activities have the potential to present significant threats at a local level, particularly for rare and geographically isolated Species of Conservation Priority.

## Grazing

Livestock grazing on the Nevada range has a long history and remains one of the state's important industries. Livestock managers make and implement grazing management decisions to achieve a variety of goals, including profitable livestock production, keeping working ranches and farms in the family, and wildlife habitat enhancement. Grazing management plays a pivotal role in the quality and extent of wildlife habitat. Livestock grazing is the most widespread activity overseen by federal land management agencies in Nevada and affects a large portion of the Nevada landscape.

Livestock grazing now competes with more uses than it did in the past, as other industries and the general public look to public lands as sources of both conventional and renewable energy and as places for outdoor recreational opportunities, including off-highway vehicle use. This competition for land use is a sign of the times across the West, and debates over livestock and wildlife values should be placed within this broader context. Ranchers and wildlife conservationists know that debates over grazing and animal management units (AMUs) are of little importance if rangelands continue to be lost, degraded, or fragmented because of development, the dominance of exotic species, catastrophic wildfire, or restructuring of water allocations. Still, domestic grazing that reduces land values via reduced productivity and habitat quality can also lead to habitat conversion, alternative land uses, and suspension of permitted leases for not meeting minimum land health standards.

With increased use of public lands, wildlife is increasingly coming into contact with ranching and farming operations which may lead to neutral, beneficial or incompatible interactions depending on the type and magnitude of interaction.

Grazing management was initially designed to increase productivity and reduce soil erosion by controlling grazing through both fencing and water projects and by conducting forage surveys to balance forage demands with the land's productivity ("carrying capacity"). Over time, public expectations for the management of public lands continues to rise and includes new challenges such as: global climate change, severe wildfires, invasive plant species, and dramatic population increases, including associated rural residential development. These challenges add to the management challenges for both wildlife and livestock grazing.

Consequently, livestock grazing has shifted management objectives and priorities over the years to better manage and conserve specific rangeland resources, such as riparian areas, threatened and endangered species, sensitive plant species, and cultural or historical objects. Currently, grazing is managed with the goal of achieving and maintaining public land health using rangeland health standards and guidelines that were developed in the 1990s with input from citizen-based Resource Advisory Councils across the West.

Livestock facilities such as springs developments, water pipelines, and fencing have distributed livestock use over areas that were sporadically or lightly used prior to agricultural development. Distribution of livestock over a greater area, can also reduce impacts associated with concentrated livestock – trampling, soil compaction, eroding trails, etc. Water diversions (surface or excessive ground water withdrawal) are the most common threat to fish and other aquatic species in Nevada. Water diversions create functional changes in the spring system by decreasing water volume and reducing soil moisture. Riparian vegetation can be affected when excessive groundwater withdrawals lower the water table.

The loss of natural water resources threatens wildlife, but domestic livestock also require water to survive. Since the advent of commercial grazing on rangeland, ranchers have improved existing water supplies and developed new water systems for their livestock. Wildlife managers also develop water resources specifically for wildlife, and increasingly, livestock and wildlife water developments replace or augment diminishing natural sources in many areas and have become crucial for many species, especially during times of drought or unseasonably high temperatures. The presence of livestock water developments can also improve the quality of surrounding habitat, allowing wildlife species to expand into previously unoccupied areas. Pronghorn antelope generally require permanent water sources at intervals of less than five miles within their home range. Ranchers have become increasingly interested in, with the help of various federal programs, developing water systems that are wildlife friendly (e.g., wildlife escape ladders, using structures of different size, shape or position to enhance wildlife use). Strategically placed water developments that are managed to eliminate excessive diversion and that incorporate wildlife friendly features can be used to enhance rangeland for both livestock and wildlife.

Grazing has positive or negative effects depending on current and historic timing and intensity of grazing, soil conditions, precipitation, plant communities, and specific habitat (e.g. riparian) features under consideration.

Fortunately, habitat needs of many wildlife species are known and these requirements provide the "sideboards" necessary to develop guidance for grazing strategies for maintaining or enhancing wildlife. Food, cover, and space are habitat needs for both wildlife and livestock. Grazing management can be focused to managing livestock in a manner that supports these basic habitat elements while maintaining native plant community integrity – the plant communities to which native wildlife have adapted.

## Invasive Species

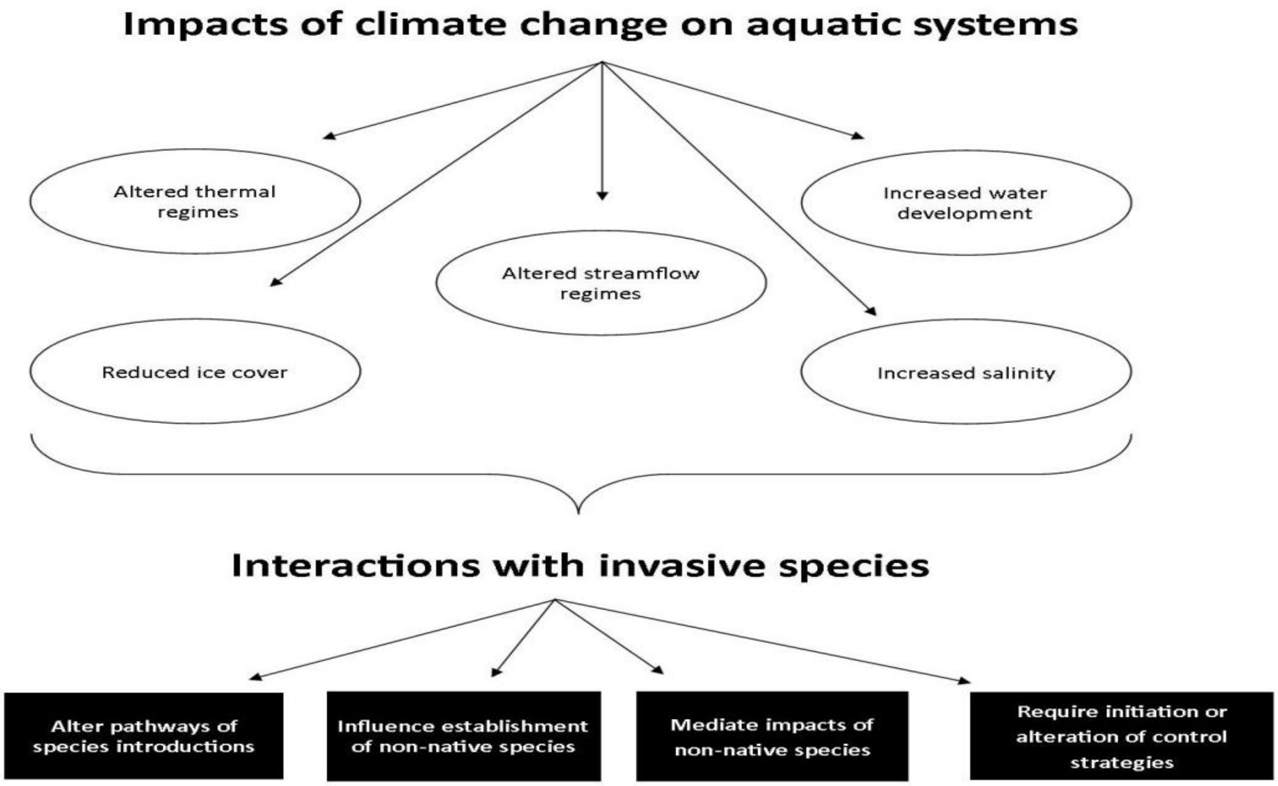
A number of other sources of stress for wildlife and habitats exist and are not well connected to land use per se, but are primarily of human origin. Invasive, exotic, and feral species are one of the most significant and difficult problems facing both terrestrial and aquatic species and habitats in Nevada. These non-native species, through their invasive natures can outcompete native species and decrease the complexity of the native ecological communities, thus contributing to localized loss of species and overall reductions in wildlife diversity. They can also alter natural ecological processes through changes in fire regime, resulting in self-sustaining exotic communities with little prospect of restoration back to natural communities or stability in naturally dynamic and changeable aquatic habitat substrates. The presence of exotic animal species can disrupt natural community dynamics through competition for resources, and can cause direct conflict and predation resulting in displacement, mortality and extirpation of native species. Invasive and exotic species can introduce alien diseases into non-resistant native populations.

### *Aquatic Invasive Species*

Non-native species that have been intentionally or unintentionally released into new environments can become aquatic invasive species, causing environmental, economic, and human health harm (EPA, 2007). The National Invasive Species Council defines an invasive species as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health." It should be noted, however, that not all non-native species are harmful or will become invasive. For example, it has been found that 28% of non-indigenous fishes have had beneficial effects (OTA, 1993; EPA, 2007). For those species that do become invasive and cause ecological and/or economic damage, their impact can be devastating to an ecosystem. Invasive species are considered a major cause of extinctions worldwide accounting for 25% of fish extinctions, 42% of reptile extinctions, 22% of bird extinctions and 20% of mammal extinctions (Cox, 1999; EPA, 2007). In the U.S., damage and losses from invasive species are estimated to be valued at approximately $120 billion annually (Pimentel et al., 2005). Aquatic invasive species (AIS), in particular, can have a wide range of ecological impacts including loss of native biodiversity, altered habitats, changes in water chemistry, altered biogeochemical processes, hydrological modifications, and altered food webs (EPA, 2007).

Evaluating the relationship between AIS resulting from changes in climate is relatively unknown and research needs to be conducted to clarify the impact. However, generally accepted changes are expected to impact aquatic systems in several major ways including increasing water temperatures, altering stream flow patterns, and increasing storm events (Poff et al, 2002). These changes will have profound impacts on aquatic ecosystems including altered thermal regimes, reduced ice cover, altered stream flow regimes, increased salinity and increased water development activities. Aquatic ecosystems and their respective organisms will be vulnerable to a changing environment and in many cases open the door for new introductions and increased spreading of AIS. Figure 3 (Rahel, Frank J. et al., 2008) depicts characteristics of aquatic systems that will be altered by climate change and how these changes will affect AIS.

**Figure 3**. Characteristics of aquatic systems that will be altered by climate change (Rahel, Frank J. et al., 2008)




Climate change is expected to alter the thermal regimes of much of the Earth's surface resulting in increased water temperatures. As the water warms, it is expected that warm-water aquaculture, tropical fish culture, and outdoor water gardens will expand providing new opportunities for unintentional AIS introductions that are capable of becoming established in historically colder water systems (Rahls, 2007). Suitable thermal habitat for warm-water fishes is predicted to increase by 31% across the U.S. due to climate change (Mohseni et al., 2003, Rahls et al., 2007). In addition, climate warming is predicted to allow for expansion of invasive coldwater species into new areas. For example, native bull trout have a competitive advantage over non-native brook trout in the "coldest" streams in the Rocky Mountains. As these streams warm, brook trout are expected to achieve competitive superiority and thus displace native bull trout from their habitat (Rahls et al., 2007).

Climate change is also expected to reduce the extent of ice cover on lakes which may influence the invasion process by increasing light levels for aquatic plants, reducing the occurrence of low oxygen conditions in winter, and thus exposing aquatic organisms to longer periods of predation from terrestrial predators (Rahl et al., 2007). In addition, the loss of winter hypoxia could also foster the expansion of quagga and zebra mussel populations in cold water lakes whereby the habitat would become more suitable for AIS establishment and rapid reproduction.

Climate driven changes to the flow regime is expected to influence the magnitude, frequency, duration, and timing of floods, droughts, and intermittent flows that are the primary drivers of ecological structure and function in aquatic ecosystem (Poff et al., 1997). Increases in flood conditions could increase the frequency of escapes from aquaculture during overflow events and also increase the dispersal of AIS through transportation through flooded streams (Havel et al., 2005; Rahl et al., 2007). During drought conditions, AIS (e.g., such as New

Zealand mud snails) can tolerate frequent and prolonged droughts and are tolerant of desiccation, thereby striving in harsh environments. Freshwater fish with opportunistic life-history strategies such as mosquito fish, guppies, and red shiners are also likely to increase in distribution and abundance (Olden et al., 2006; Rahl et al., 2007).

As the climate changes, arid regions are expected to experience increases in desiccation and alter the salinity of freshwater ecosystems (Seager et al., 2007). In addition, increases in water diversion and withdrawals that can provide new and altered pathways of introduction of AIS. Shifts are expected to occur due to salinity and increased water development activities that could lead to a decline of native fish species and the proliferation of invasive species that are salt and drought tolerant. Salt tolerant species such as red shiner, western mosquitofish, plains killifish, and invasive plant species (i.e, salt cedar) could successfully establish and dominate in the changed environment.

Identifying, preventing and eradicating AIS threats in a changing environment will require diligent state management and response plans that are capable of changing as the climate and AIS threats change. In addition, climate change impacts to existing or threatening AIS in Nevada will require additional research and site specific assessments. The ability of aquatic ecosystems to adapt to climate change is also limited in that expected rates of climate change are probably too great to allow adaptation through natural genetic selection and many types of habitat will be diminished or possibly lost entirely (Poff et al., 2002). In addition, human activities in response to climate change have the potential to severely modify many aquatic ecosystems. AIS species already established in Nevada, such as quagga mussels, Eurasian milfoil, Asian clams, and curly leaf pondweed, in addition to newer threats, such as Asian carp and other warm-water fish and plant species, will more than likely have the potential to spread into new habitat and regions within the state as water temperatures increase.

### *Terrestrial Invasive Plants*

Invasive plants, such as noxious weeds, have become a major ecological and environmental concern throughout Nevada over the last couple decades. Noxious weed species are species that have been identified by the State of Nevada as plant species that are "injurious to the environment, economics, and public health." Some of more prevalent noxious weed species include tall whitetop (perennial pepperweed), tamarisk (salt cedar), yellow starthistle, various noxious thistles, several knapweed species, including Russian knapweed, and annual invasive grasses, such as medusahead rye. Other invasive plants, such as cheatgrass and red brome, are equally as threatening to native plant communities but are not officially designated as "noxious" because of these species prevalence and inability to achieve complete eradication.

Medusahead rye has increasingly expanded its range throughout northern Nevada over the last five years. Range landscapes, particularly in the Santa Rosa Range, Humboldt sink, Carson Range, and Washoe County, have become invaded with this species. Several factors make medusahead extremely competitive. It produces many seeds that germinate quickly year round. It also has roots that grow in winter. The plant litter is slow to decompose due to this plant's ability to uptake silica from the soil and this inhibits seedlings of other plants. This litter also creates fuel for intense, damaging fires.

There are many tools in the "integrated plant management" toolbox; however, one of the greatest tools that can be used against invasive plants is early detection, rapid response (EDRR). EDRR can be utilized by land and resource managers to quickly identify invasive plant expansion or newly invading plants. Once a species has been identified, immediate response (i.e., weed treatment or removal) shall be conducted to expeditiously eradicate and remove the plant from the location. Prevention is key to effective invasive species management; therefore, EDRR is an exceptional tool for the long-term management of invasive plants in Nevada.

## Land Development

Until recently, Nevada was one of the fastest growing states in the nation in human population, and both the Reno and Las Vegas metropolitan areas far exceeded average values for population growth, creating a concurrent need for additional development into existing open space and supporting urban infrastructure. Urban and suburban development, even when well controlled and regulated, cause permanent habitat loss and conversion; direct mortality of wildlife attributed to construction; habitat fragmentation and increased erosion; and sedimentation and nutrient or toxin loading associated with urban runoff. Right-of-way fences associated with roads interrupt wildlife movements and contribute to direct wildlife mortality. Important secondary effects of the urban/wildland interface can include increased local recreation from motorized and non-motorized sources, negative interactions between pets and wildlife, and increased potential for the spread of exotic species and illegal woodcutting. Existing landfills subject to the burdens of increased urban populations can result in local soil and groundwater contamination and unnatural support for generalist predators (e.g., corvids, gulls). Largely associated with urban and suburban development, industrial development creates many of the same potential stresses, including habitat loss and fragmentation, and soil or groundwater contamination from improper disposal and discharge of toxins and hazardous materials. To the degree that such impacts cannot be adequately regulated, airborne pollutants and nutrients can reduce habitat structure, composition, and quality.

Outside of areas of significant urban or suburban development and their wildland interfaces, effects associated with development have been and will continue to be problems for wildlife and habitats. Utility rights-of-way and associated developments such as wind energy farms can cause mortality through collisions and electrocutions. Habitat alteration follows facility and road construction, operation, and maintenance. Direct effects to wildlife may occur through disturbance and alteration of behavior and movement patterns. Infrastructure also provides more perch sites for avian predators in sensitive areas (e.g., desert tortoise habitat and sage grouse strutting grounds). Rights-of-way can serve as conduits for invasive species.

Road development, both in association with development projects and as a stand-alone independent effect, can cause habitat fragmentation, direct mortality, and disturbance of wildlife, and impacts from runoff including erosion, sedimentation, and contamination. The improper placement of road developments in riparian corridors and meadows can compound the core effects of this activity, and roads of any kind serve as conduits for invasive species.

## Military Activities

Nevada has a lengthy history of assistance to the nation's military and its mission, in particular because of the availability and access to broad areas of public lands for military training, maneuvers, and testing. Military installations in Nevada are closed to most non-defense related land uses (that have resulted in conservation of key habitats elsewhere), and thus serve as potential reference areas for ecological studies (e.g., Mt. Grant on the Hawthorne Army Depot, reptile studies on the Nevada National Security Site, formerly Nevada Test Site). Defense-related activities, however, also come with an associated cost and are potential sources of stress to wildlife habitats that may include habitat alteration at target sites and military training areas, habitat modification from facilities construction and maintenance, and soil or groundwater contamination from mission and infrastructure by-products. However, the exclusion of the public on military lands does allow for the property to act as a refuge for wildlife.

## Mining

Resource extraction for minerals and non-minerals has a rich history in Nevada and remains one of Nevada's premier industries. Historic mining predominantly involved the excavation of subterranean shafts, adits, and tunnels that left minimum impact on surface habitats, but opened up extensive new habitats underground. Dating as far back as the 1850s, these underground areas have been populated by wildlife, most notably used as roosts, maternity areas, and hibernacula for many of Nevada's bat species. Since their abandonment, the openings of these underground workings pose significant risk to human safety if left unprotected. To relieve the concerns of public safety, many mine openings have been closed with earthen fill. When this permanent closure technique is implemented without an assessment of the value of the underground wildlife resource, serious losses can occur.

Today's open-pit mining techniques leave a much more significant footprint on the surface landscape. The habitat present before a mine pit is excavated is lost temporarily or permanently and wildlife that lived on the site are temporarily or permanently displaced. Mining companies strive to implement the latest, most aggressive reclamation techniques, but even under the best of circumstances are often only able to stabilize the site in a permanently altered state. There remains considerable opportunity for collaboration between biologists and reclamation engineers to incorporate innovative, yet realistic wildlife goals and objectives into reclamation design based on each site's reclamation potential.

## Recreational Activities

The characteristics and extent of recreational activities vary tremendously across the spectrum of Nevada's wildlife habitats, dictated by factors such as access and proximity to urban development as well as the aesthetic appeal of individual habitat types to recreationists. Stresses include wildlife displacement, altered movements, decreased reproductive success, erosion, and direct habitat alteration and destruction. Recreational participants can act unknowingly as conduits for weed invasion. Motorized recreation, including off-highway vehicles, snowmobiles, watercraft, and other devices can result in noise disturbance to wildlife, thus affecting movements, behavior, and reproductive success. Improperly operated, these vehicles can accelerate erosion, and accelerate the invasion of weeds. In particular, improper operation in sensitive areas at the sensitive times of year (e.g., during the snowmelt season), or in desert washes, have potential to cause significant damage. Even non-motorized recreation, activities such as trail development, hiking, mountain biking, horse riding, cross-country skiing, rock-climbing, and spelunking, can cause habitat fragmentation and disturbance to wildlife. Although physical recreation development, for projects such as ski areas, snow parks, developed campgrounds and day-use areas, boat access, and organized event staging areas are likely not a large-scale source of stress across Nevada, these types of actions can cause localized disturbance from human activity and result in soil compaction and vegetation loss.

## Timber Harvest

Nevada's forest resources are not extensive and must be managed carefully to achieve the many objectives expected of them. Improper forestry practices and management can create significant stress from actions such as tractor logging on steep slopes, resulting in accelerated erosion and sedimentation; the alteration of wildlife habitat including insufficient habitat structure left after timber harvest (e.g., old growth stand characteristics, snags, dead and down woody material); loss of species and stand age diversity; increased vulnerability to insect outbreaks creating self-sustaining second-growth stand characteristics; inappropriate timber harvest in stream environment zones (subjecting these zones to modification processes); and unauthorized or excessive wood cutting.

## Water Management or Water Resources

Throughout Nevada, water is a scarce and valuable resource essential for both human needs and the maintenance of wildlife and their habitats, thus the development and alteration of hydrologic resources is a significant source of stress to wildlife resources. The development and operation of dams and impoundments at all scales, ranging from major reservoirs on the Colorado River to small-scale impoundments for water storage and flood control throughout the state, is an obvious human-induced change to the landscape. These structures modify hydrologic regimes and interrupt natural flow dynamics that result in modified channel and floodplain processes both upstream and downstream from dams and their impoundments. Dams play a key role in the fragmentation of aquatic habitats and modify the nature of both aquatic and terrestrial habitats through inundation upstream and de-watering downstream, frequently creating conditions more favorable to non-native plant and animal species.

Channel modification to lotic (flowing water) aquatic systems, through ditching, diking, and diversion is another significant source of stress to wildlife resources. The effect of these activities on aquatic and associated riparian habitats may include loss or modification of substrate diversity and structure, loss of streambank vegetation and increasing risk of erosion, loss of connectivity between channel and floodplain and within lotic systems by creating barriers to later movement by aquatic species; and actual dewatering and desiccation of aquatic habitats, which can cause direct mortality, reductions in habitat availability, and fragmentation or loss of connectivity within or between aquatic systems.

The development of springs and seeps, a common historic practice for livestock watering, domestic water supply and other purposes, is of concern, given the critical importance of spring resources widely distributed across Nevada's landscape as sources of surface water for terrestrial wildlife, and also because many springs and seeps of all sizes support unique endemic aquatic biota. The development and modification of spring sources and source pools directly alters or removes important aquatic habitats; modifications can limit access to remaining surface water by wildlife; and the diversion of water away from outflow channels can modify, reduce, or destroy associated riparian and wetland habitat, as well as limit or eliminate flowing water habitats for endemic species associated with springbrooks.

Although not directly related to the development and alteration of spring systems, groundwater development has been a historic source of stress for Nevada wildlife and habitats and continues to represent a significant ongoing problem. As demonstrated in areas such as Ash Meadows and Pahrump Valley in southern Nevada, excessive groundwater withdrawal can alter groundwater flow and recharge patterns, resulting in loss of connectivity between groundwater and surface water habitats and concurrent impacts to plant communities and surface flow of groundwater from springs and seeps. These effects are often not well understood and can vary considerably depending on local geology, the characteristics of groundwater development actions, and the nature of the groundwater resources being accessed.

## Wild Horse & Burro

### *Background*

In passing the Wild Free-Roaming Wild Horses and Burros Act of 1971 (WFRHBA) (Public Law 92-195), Congress found that "Wild-free roaming wild horses and burros are living symbols of the historic and pioneer spirit of the West." The WFRHBA further states that wild free-roaming wild horses are to be considered in the area where presently found, and as an integral part of the natural ecosystem.

At the time of the passage of the WFRHBA, herd areas (HA's) were established for BLM-managed lands with known populations of wild horses. Herd Management Areas, or HMAs, were established later for those HA's through a land use planning process that set the initial and estimated herd size that could be managed while still preserving and maintaining a thriving natural ecological balance and multiple-use relationships for the area. To be designated as an HMA, the area must have four essential habitat components including forage, water, cover, and space (BLM, 2010). The allocation of forage for wildlife, wild horses, and livestock was established, which set the Animal Unit Months (AUMs) for each category. An AUM is the amount of forage necessary to maintain one adult horse for one month (about 800 pounds of air dried forage) (BLM, 2010).

### *Management Actions and Constraints*

The Secretary of the Interior was directed to "manage wild free-roaming wild horses and burros in a manner that is designed to achieve and maintain a thriving natural ecological balance on the public lands." Program emphasis has recently shifted management from a removal of excess animals and adoptions to actions that include: increasing fertility control, reducing population growth rates, adjusting sex ratios and collecting genetic baseline data to support genetic health assessments.

The Wild Horse and Burro Program has also shifted management objectives and priorities over the years to better manage and conserve specific rangeland resources, such as riparian areas, habitats for threatened and endangered species, and sensitive plant species. Similar to requirements set forth for livestock grazing, HMAs are to be managed with the goal of achieving and maintaining public land health by achieving and maintaining rangeland health standards and guidelines.

NV BLM manages 85 HMAs covering 14.7 million acres for a statewide Appropriate Management Level (AML) of approximately 12,700 wild horses and burros. Nevada has a current population estimate of 19,000 to 21,000 wild horses and burros not including foals born in 2011. Over the last five years (2007-2011), NV BLM has maintained an average population size of roughly 17,000 wild horses and burros based on average annual removals of excess animals of nearly 3,800 statewide.

Within the program spending, the holding and care of excess wild horses and burros accounted for nearly 75% of that budget, with the balance directed at on-the-ground management, gathers and preparing horses and burros for adoption, sale, or placement on long-term grassland pastures.

Since 1971, approximately 230,000 wild horses and burros have been adopted. The number of animals that have been removed from the range for management purposes far outweigh adoption and sale demand. Last year, adoptions fell below 3,500 animals, down from an average of 6,300 per year in the 1990s. The decline in adoptions and sales can be contributed to the current weak economy and large numbers of available domestic horses as well as a shift towards a more urbanized culture.

### *On-the-Ground Management*

A variety of management practices have been in use since the passage of the WFRHBA. 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 the AML – the point at which wild horse and burro herd populations are consistent with the land's capacity to support them.

### 1. Population Inventory

The BLM needs population estimates to determine whether and where excess wild horses and burros exist, and, if there is an excess, how many animals need to be removed from public rangelands. Population estimates also guide the BLM in applying fertility control to mares and adjusting herd sex ratios in favor of stallions or geldings to reduce on-the-range births. The BLM works to ensure that horse populations are in balance with other rangeland resources and authorized uses of the public lands.

Most BLM field offices base their population estimates on the counting of each wild horse and burro actually seen during direct counts from either a helicopter or fixed-wing aircraft. In addition to collecting information about the location and condition of herds within HMAs, the BLM compiles basic data about the land, such as the amount and quality of forage and the availability of water.

### 2. Population Growth Suppression

Under the WFRHBA, the BLM is required to maintain herd populations at AMLs and protect the range from deterioration from overpopulation. The BLM is directed to determine whether AMLs should be achieved by removal or humane destruction of excess animals or other options (such as sterilization or natural controls on population levels). In order to reduce or limit population growth rates the BLM has begun investigating and researching several possible growth rate suppression techniques.

#### a. Contraception

The BLM has supported the development of an effective contraceptive agent for wild horses since 1978. Currently the most promising agent is a vaccine known as porcine zona pellucida (PZP) that was developed in the 1990s. The BLM uses PZP under an investigational new animal drug exemption issued by the Food and Drug Administration and held by The Humane Society of the United States (HSUS).

The most effective is a one-year liquid vaccine that must be re-administered annually. However, it is not feasible to gather wild horse herds every year to administer this form of the vaccine. The BLM uses the longer lasting 22-month pelleted PZP agent (PZP-22). Maximum effectiveness of PZP-22 is achieved when the mares are treated during a three- to four-month window prior to foaling.

Since 2004, the BLM has administered the pelleted PZP vaccine to more than 2,800 mares on 79 of its 179 HMAs, but significant reductions in the rate of population increase have not yet been apparent. Analysis of data from the McCullough Peaks herd, which was treated in 2004, indicates that treated mares had an average foaling rate of 32% in the two years following treatment, compared with a 75% foaling rate in untreated mares.

#### b. Sex Ratio Adjustment

One way to potentially slow population growth and extend the time between gathers in wild horse herds is to adjust herd sex ratios to include more males than females. BLM rangeland managers can use this option following a gather by releasing more stallions or geldings than mares back to the range. The larger proportion of males mean there will be fewer mares in the breeding population, resulting in fewer births. Sex ratio adjustment is mostly applicable to larger HMAs and is also most practical after the AML has been achieved.

#### c. Sterilization

Consistent with the WFRHBA's mandate and authority, the BLM can apply temporary or permanent sterilization to decrease herd growth rates while maintaining a herd's ability to sustain itself. When implementing this type of population growth suppression, animals can be captured, sterilized, and returned to the range. Castration (gelding) is a safe, effective, humane, and efficient method of sterilizing stallions. For this reason, the BLM is beginning to return geldings to HMAs in the place of mares to reduce the number of breeding mares within the population.

Spaying and other means of sterilizing mares are being considered by the BLM but has not been applied as a management tool on the range.

### *Impacts to Wildlife and their Habitat*

Wild horse and burro populations that have increased over the upper limit of the AML can have long-term adverse effects to wildlife resources. By achieving and maintaining appropriate population levels, the health of the rangeland resources used by wildlife would be protected from habitat degradation associated with wild horse overpopulation. Reduced competition for forage, water, cover, and space would provide diverse plant communities that meet applicable life cycle requirements for all wildlife species. Unfortunately, many of the herds currently exceed the upper limit of AML.

The overall impact wild horses and burros have on any type of ecosystem depends on intensity and duration of use, timing, and the health and resilience of the area. Plant diversity can decrease and habitat structure can be altered if the AML is exceeded over time and vegetation and water sources are over-utilized (Beever & Brussard, 2000). A less diverse plant community can be vulnerable to wildfire and invasive grasses such as cheatgrass. Cheatgrass displaces native perennial plants by germinating earlier and quicker. It is also adapted to frequent fires perpetuated by the fine fuels it creates. Beever et al. (2008) studied vegetation response to removal of wild horses and found sites without wild horses had greater shrub cover, total plant cover, plant species richness, and native grass cover than sites with wild horses.

Wild horses will use areas that have more grasses because they are primarily grazers. Sage-Grouse habitat can be adversely affected if grasses are over-utilized because horse populations are above the AML. Sage-Grouse require specific amounts of grass cover for optimal nesting habitat, an abundance of forbs for brood-rearing habitat, and water with sufficient vegetation to support insects and to provide cover (Connelly et al., 2000). Decreased cover and diversity of grasses and shrubs as well as decreased mammal burrow density have been documented at water sources used by wild horses (Beever & Brussard, 2000; Ganskop & Vavra, 1986). Small mammals are prey for many species and less prey could negatively affect raptors and carnivores that inhabit the area.

Nevada is the driest state in the U.S. and water resources are critical to the existence and management of all species. Year-round use of riparian areas by wild horses and burros can result in long-term or permanent habitat impacts through soil compaction and increased erosion as well as impacting water quality and quantity. Furthermore, wild horse and burro competition for limited water at seeps and springs during the critical hot summer months can have a significant impact on native wildlife. Wild horses and burros tend to have a dominant status within in the social interactions at these watering areas. Though there may not be aggressive behavior between wild horses and burros, deer, and bighorn sheep, their mere presence at these limited sources may affect the distribution of native species and their use of the habitat.

## Wildland Fire

Wildland fire is a natural process and plays an important role in the creation and maintenance of Nevada's terrestrial habitats and vegetative communities. Fire plays an important role in the restoration and management of those communities and habitats; however, fire management must be implemented with full consideration of all of its aspects and consequences. Improperly applied, fire suppression has altered natural ecological processes through the build-up of fuels; increased risk of catastrophic wildfire resulting in permanent loss of habitat values; accelerated conversion to alien plant communities; increased erosion and sedimentation; and increased fire frequency and spread of self-sustaining non-native communities. Further community-level effects can include the disruption of successional cycles; the unnatural maintenance of successional stages and vegetation structure and condition; and tree community encroachment into shrub and grassland habitats. Improper fire restoration policy can compound the effects of fires and fire suppression, through exotic plant introductions from seed mixes, improper early grazing access to restored areas, and inadequate response to post-fire restoration needs, including "no action" after a fire. Finally, while the application of prescribed fire to maintain habitat health is appropriate and necessary in certain situations, this land management technique must be applied with irrefutable knowledge of the fire history of the habitat type, its response mechanisms and fire return interval. Misapplication of prescribed fire in habitats where these characteristics are misinterpreted or not well-understood can have irrevocable impacts on the landscape. All in all, the discussion of applying prescribed fire to the landscape is a sensitive topic in Nevada and it is important that management theory, design, and implementation be carried forward by consensus with full participation of all stakeholders.

*Ruby Mountains* Photo Courtesy of R. Wilson