BLM

United States Department of the Interior
Bureau of Land Management

Programmatic Cheatgrass Management Environmental Assessment
Farmington Field Office

DOI-BLM- NM- F010- 2009- 430 - EA

09/19/2010

Location:
The proposed treatments would be done within the boundaries of the Farmington Field Office. The treatments would be done on areas that have infestations of cheatgrass and few native grass species. The planning area, located in the northwestern New Mexico, encompasses over 2,000,000 acres of Bureau of Land Management administered lands within the FFO, and includes lands in all of San Juan County, most of McKinley County, western Rio Arriba County and northwestern Sandoval County.

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1.0 INTRODUCTION

This Environmental Assessment (EA) has been prepared to disclose and analyze the environmental consequences of treating cheatgrass (*Bromus tectorum*) and discusses the impacts of the proposed action and alternatives for managing cheatgrass. This EA will analyze the impacts of the proposed action and alternative actions in improving watershed conditions, rangeland health, ecosystem function, and reducing fire hazard within the Bureau of Land Management Farmington Field Office (FFO) (see location map, Figure 1.).

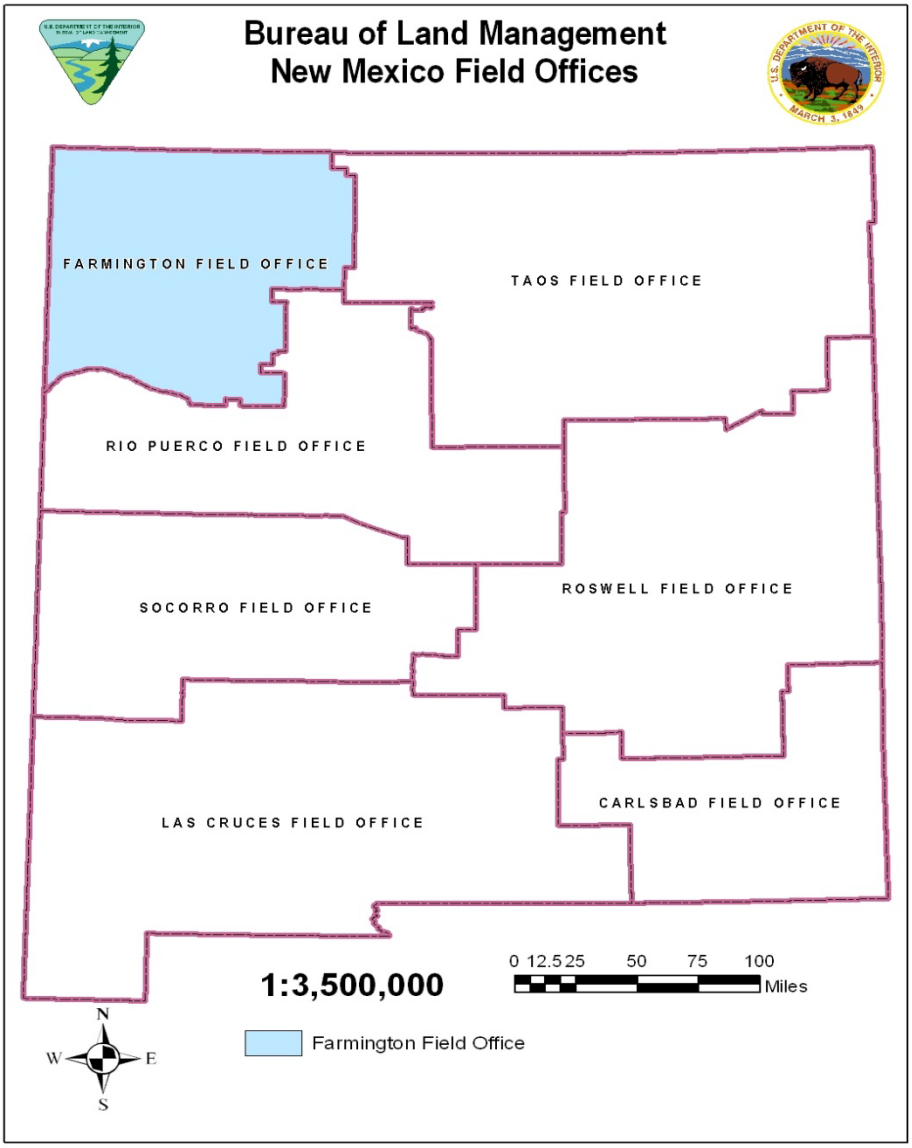

Figure 1. Location map of the Bureau of Land Management Field Offices in New Mexico. Only the Farmington Field Office is covered by this EA.

1.1 Purpose and Need for the Proposed Action

In 2007 the Secretary of the Interior launched the Healthy Lands Initiative (HLI) to accelerate land restoration, increase productivity, and improve the health of public lands in the western United States. Goals of HLI include: removal of exotic plant species and reversal of the expansion of invasive shrubs, restoration of native habitat for fish, wildlife, and special-status species and to reduce the impacts of catastrophic fire (BLM 2009).

Cheatgrass is a non-native invasive annual grass which out-competes native perennial grasses. Cheatgrass creates a large amount of fine, dead fuel, and jeopardizes the shrub-land steppe ecosystem by increasing the size and extent of wildfires that remove shrubs from the landscape (BLM 2008a). Eighty percent of the counties in New Mexico have cheatgrass present, with the heaviest infestations occurring in San Juan and Rio Arriba counties, both of which lie within or partially in the FFO.

The Bureau of Land Management's New Mexico Cheatgrass Management Plan (BLM 2008a) outlines the extent of infestation and a strategic plan for the "eradication" of cheatgrass. Objectives of the Cheatgrass Management Plan include reducing the amount of cheatgrass in the current invaded areas by 50% in 5 years. The New Mexico BLM has targeted cheatgrass as a priority in the Healthy Lands Initiative Restore New Mexico Partnership. This Partnership focuses on restoring grasslands and watersheds dominated by exotic and invasive species to a healthier and more productive condition.

The purpose of the proposed action is to apply a treatment for the removal and control of cheatgrass. The need is to improve soil and vegetative function on upland areas, and improve overall watershed function within the project area to a condition that meets the fundamentals of rangeland health as described in 43 CFR 4180.1.

1.2 Conformance with BLM Land Use Plan(s), Statutes and Regulations

The proposed action is in conformance with, and within the constraints of, the December 2003 Farmington Resource Management Plan (RMP) (BLM 2003). Goals of the RMP are to promote healthy sustainable rangeland ecosystems; accelerate restoration and improvement of public rangeland to properly functioning condition; promote the orderly use, improvement, and development of the public lands; and protect and enhance the vegetation resources on public land in San Juan and Rio Arriba counties by initiating a program of more intensive grazing management.

The proposed action is consistent with:

1. The Colorado Salinity Control Act of 1974 (as amended in 1984 and 1995) directing the Secretary of Interior to "undertake research and development of salinity control projects for minimizing salt contributions to the Colorado River from Bureau-administered land" (BLM 2003, 2-20).

2. The FFO Integrated Weed Management objectives to "determine the best methods for the integrated approach to weed management and implement on-the-ground operations" (BLM 2003, 2-24).

3. The FFO Rangeland Management objectives to "promote healthy sustainable rangeland ecosystems; to accelerate restoration and improvement of public rangeland to [a] properly

functioning condition" and with the guidelines of the "Livestock Grazing Management Practices" (BLM 2003, 2-35 and 2-36).

4. The FFO Integrated Weed Management Plan to "take action to prevent the spread of invasive plant species", and "use best management practices for vegetation management when and where feasible" and to "integrate the use of all available tools…to reduce, eliminate, [and] prevent [the] establishment of, or lead to better management of, problem plant species (BLM 2008c,15-16).

5. The BLM Standards for Public Land Heath (BLM 2001).

6. The BLM NM Cheatgrass Management Plan (BLM 2008b).

7. The BLM Healthy Lands Initiative, New Mexico (BLM 2009).

8. The BLM Integrated Vegetation Management Handbook (H-1740) (BLM 2008d).

This EA is tiered to the "Fire and Fuels Management Plan Amendment and Environmental Assessment for Public Land in New Mexico and Texas" (BLM 2004b) and "Farmington Field Office Fire Management Plan" (FFO-FMP) signed September 2004 (BLM 2004a). The FFO-FMP analyzed and authorized multiple treatments of fuels including prescribed burns and chemical and mechanical vegetation fuels treatments. Both of these documents allow for wildland fire use for resource benefit as long as ecological, social and political constraints are considered.

This EA is also tiered to the Vegetation Treatments Using Herbicides on BLM Land in 17 Western States Environmental Impact Statement, Programmatic EIS Volumes 1 & 2 (BLM 2007). The EIS analyzed the effects of using herbicides for treating vegetation on public lands in the western U.S. (including Alaska), and the effects of herbicide use on humans, plants, animals and other environmental and social resources associated with public lands. The Record of Decision for the EIS authorized a variety of treatment methods to achieve desired vegetative conditions on public lands, including the application of certain herbicides, the use of prescribed fire, the use of mechanical equipment, the use of biological agents, and manual methods of control.

The New Mexico Department of Game and Fish's Comprehensive Wildlife Conservation Strategy (CWCS) was considered in the development of the proposed action and alternatives. Objectives of the CWCS relative to wildlife species of Greatest Conservation Need are considered.

2.0 PROPOSED ACTION AND ALTERNATIVES

2.1 Alternative A – No Action (Current Management):

The No Action Alternative, or continuation of current management, is considered and analyzed to provide baseline for comparison of the Proposed Action. Selection of this alternative would mean there would not be any implementation of any treatments in an attempt to control and reduce cheatgrass within the Field Office.

2.2 Alternative B – Proposed Action:

This alternative presents an integrated treatment approach using chemical application *(see note below), prescribed fire and seeding. This alternative is proposed because it is an efficient approach to managing cheatgrass, and has the potential to improve watershed function and rangeland health and to improve soil and vegetative conditions within the Field Office.

Prescribed burning would be used to remove the above ground vegetation and the surface litter layer, permitting effective seeding and use of approved herbicides. The desired burn conditions would be at a Fire Intensity Level (FIL) of 3, with flame lengths between 4.1 to 6.0 feet (BLM 2004a). The burning would preferably occur during mid to late summer, after monsoon rains (generally August to September) to mimic "natural" ignition and burning conditions. Early fall would be an acceptable alternative time to conduct the burn and still meet objectives. Drill seeding would be carried out post-burn, (timing may differ depending on objectives or opportunity (weather, approved burn conditions, etc).

Cheatgrass phenology allows the seeds to germinate as early as September and as late as December, depending on temperature, moisture and snow cover. Therefore pre germination chemical treatment with imazapic (or other federally approved chemical) is proposed to kill germinating cheatgrass and supply a residual component to the soil. If germination of cheatgrass occurred in the spring the area would be spot treated with imazapic and/or glyphosate (or other federally approved chemical), which would kill germinated cheatgrass and supply a residual component to the soil to stop further germination or growth of cheatgrass.

Additionally, there will be a need to apply prescribed burning during the late spring, just when the cheatgrass has cured and gone to seed. The desired burn conditions would be at FIL of less than 3, with flame lengths between 0 to 4 feet (BLM 2004a). Burning at this time would be done in order to burn as much cheatgrass seed as possible, and to remove litter to prepare the site for seeding and herbicide applications. Drill seeding would occur post-burn and would incorporate residual carbon from the burn into the soil. In the fall (September) the burn would be treated with imazapic, allowing its pre-emergent action to prevent germination of cheatgrass in the fall and subsequent spring. Cheatgrass may be spot-treated in the spring with imazapic and/or glyphosate for its pre and post-emergence effects.

For both stages label application rates would be adhered to so as not to affect the germination of already established and desired seeded species. At approved rates, perennial vegetation is expected to show some minor effects of the chemical, however risk of mortality is low. Herbicide treatments may be applied by either truck, UTV, or aerially.

Seeding of the project area would be done using a rangeland drill. The FFO has determined this method to be the most effective for establishing desired species. The proposed seed mix includes intermediate wheatgrass (*Agropyron intermedium)*, slender wheatgrass, (*Elymus trachycaulus*), western wheatgrass

(*Agropyron smithii*), bottlebrush squirreltail (*Elymus elymoides*), sand dropseed (*Sporobolus cryptandrus*), crested wheatgrass (*Agropyron cristatum*) and small burnet (*Sanguisorba minor)*. In inaccessible areas broadcast seeding or aerial seeding may be implemented. Seed mixes may occasionally be modified depending on goals, however, only certified weed free seed would be used.

Prescribed fire objectives include: 1) Removal of 80% or more of the standing aboveground fine dead fuel and, 2) attempt to expose 90% of bare mineral soil to allow for the chemical to penetrate the bare soil (per manufacturer's guidance). Monitoring will determine the need for re-treatment. All chemical use will be under the guidance of a certified pesticide applicator, and will be used in accordance with the manufacturer's label.

** note: Currently the following chemicals approved for use by the BLM under NEPA approval are as follows: 2, 4-D and 2, 4-DP, asulam, atrazine, bromacil, chlorsufuron, clopyralid, dicamba, diuron,diquat, diflufenzopyr, flurideone, fosamine, glyphosate, hexazinone, imazapyr, imazapic, metsulfuron methyl, picloram, sulfometuron methyl, tebuthiuron, triclopyr, mefluidide, and simazine (Appendix B). The use of these chemicals has been analyzed in the Vegetation Treatments Using Herbicides on BLM Lands in 17 Western States Environmental Impact Statement (EIS). This EA (Programmatic Cheatgrass Management) is intended to analyze the effects of the proposed action to the resources, not the environmental effect of individual chemicals. Refer to the aforementioned EIS for more information on the chemicals analyzed. Only those chemicals that have been approved in an appropriate NEPA document will be used for treating cheatgrass in the FFO. Additional chemicals may be included in the proposed action once they have been approved for use by the BLM.*

2.3 Alternatives Considered But Eliminated From Detailed Analysis

<u>Seeding only</u>

Aerial/broadcast seeding exclusively was considered as an alternative. However, current vegetative and soil conditions are not conducive to the germination and establishment of herbaceous plants following aerial seeding. Existing vegetative communities include decadent grass materials that cover the soil, inhibiting the penetration of seeds for germination.

Floyd et al. (2006) found that seeding without concomitant use of herbicide did not change cheatgrass density. Seeding mitigation post-wildfire likewise did not prevent the spread of cheatgrass. They recommended the use of chemicals in conjunction with seeding.

Carpenter and Murray (1999) stated that lasting control of cheatgrass requires a combination of chemical, physical, vegetative, and livestock management for effective control. Cheatgrass requires two- to three-year combinations of treatment in order to reach objectives. Therefore, the option of seeding alone, without other measures, is unlikely to be effective, and this alternative will not be analyzed further.

<u>Biological Control</u>

As part of the BLM Restore New Mexico initiative, the strategic plan for cheatgrass recognizes that additional research needs to be conducted to successfully control cheatgrass in the long term. Furthermore, this strategy depends on adaptive management. Thus, the Bureau would participate in, and assist with, research to help establish the best management practices and treatments for controlling cheatgrass in New Mexico.

Currently, the use of biological control organisms (fungal endophytes) is being conducted under Cheatgrass Fungal Pathogens Research Treatment Environmental Assessment (DOI-BLM-NMF010-2009-253-EA) for the FFO. As these results are not yet available, and would be addressed in the Cheatgrass Fungal Pathogens EA, this alternative will not be further analyzed here.

Mechanical Control

This alternative proposes to improve watershed function by improving soil and vegetative conditions within the project areas by implementing the chaining, tilling or mowing of cheatgrass.

Mattise and Scholten (1994) explored various means of mechanical control for undesirable annual plants, including cheatgrass. Chaining or cabling may effectively control cheatgrass; however, control often requires several tillages. Tillage should be 4 to 6 inches deep to bury the undesirable plants and seed bank to prevent their growth or germination. Furthermore, chaining or cabling greatly increases erosion unless there is a deep soil profile.

Tu et al. (2001) stated that mechanical control methods can be successful, but work best if the cheatgrass population is relatively small.

Chaining and mowing require an extensive amount of surface disturbance, and in turn would require extensive archeological survey and clearance. Areas which have a greater degree of slope or rocky outcrops are much harder to implement chaining and mowing in, due to inaccessibility for the equipment. In addition to the surface disturbance and accessibility issues, operation of the required equipment, along with the costs for archeological survey, can be uneconomical. As a consequence, this alternative will not be analyzed further.

Target Grazing

Mosley and Roselle (2006) described the benefits of grazing in controlling and reducing the negative impacts of invasive species, including cheatgrass. Grazing can disrupt fine fuel continuity, reduce fuel loads, and increase the length of fire intervals. Grazing during the winter can reduce the buildup of annual grasses and promote perennial grasses seeding. However, perennial grasses may be adversely affected if spring grazing is conducted two or more years in a row. Mosley and Roselle noted that the benefits of grazing tend to be localized and that grazing, in conjunction with restoration techniques such as prescribed burning, herbicides, and seeding, can be more successful in restoration of range lands than grazing alone.

Target grazing would require close monitoring of livestock use. Establishment of temporary electric fences and the movement of livestock would be cost-and time-prohibitive. Consequently, this alternative will not be analyzed further.

Prescribed Fire without Chemicals or Seeding

Keeley and McGinnis (2007) looked at the timing of prescribed fire in controlling cheatgrass, and found that altering burning season to coincide with seed maturation (usually during spring) was not successful in controlling cheatgrass, due to the sparse fuel loads generating low fire intensity. Rasmussen (1994) noted that since cheatgrass thrives when burned, prescribed burning should only be used as a means of seed bed preparation for re-vegetation methods. Prescribed burning alone is not anticipated to achieve the project objectives without combining it with some other range improvement practice, such as seeding, and therefore will not be analyzed further.

3.0 AFFECTED ENVIRONMENT

Introduction and General Setting

The landscape administered by the FFO in northwest New Mexico occupies a transitional zone between the Rocky Mountains of southwest Colorado and the Colorado Plateau of New Mexico. The transitional nature of the area gives it its unique character and diversity, as evidenced by the richness of archaeological, mineral, biological and recreation resources.

Topographically, the area is characterized by fractured sandstone and shale uplifts varying in elevation from 5,000 to 8,000 feet, with annual precipitation ranging from 8 to 14 inches. Growing conditions are difficult with clayey and shallow soil types and fluctuations between drought and rain saturations. Spring snowmelt and summer thunder showers provide the majority of growing season moisture. Vegetative succession tends toward domination by woody species when natural disturbances, such as fire, are restricted. As a shrub/tree canopy becomes denser the herbaceous understory tends to decrease, causing the soil surface to become exposed.

There are 167 grazing allotments managed by the FFO with 351 grazing authorizations that permit cattle, sheep and horse grazing within the resource area. Of the 351 grazing authorizations, 317 are permitted under Section 3 of the Taylor Grazing Act. Of the 167 grazing allotments, there are four authorizations issued under Section 15 of the Taylor Grazing Act to the Navajo Tribe that authorize grazing on 35 sub-allotments. There are an additional 30 Section 15 authorizations that permit grazing on allotments in the Lindrith, New Mexico area.

Recreation on public lands administered by the FFO is diverse. Opportunities exist for a variety of recreation activities including horseback riding, mountain biking, hunting, fishing, camping, off-road vehicle use, rafting, hiking, sightseeing, and photography. The FFO administers several recreation areas, a wilderness area, a wilderness study area and a research natural area.

Critical Elements of the Affected Environment

Certain critical environmental components require analysis under BLM policy. These items are marked with an asterisk (*) below in Table 1. Following the table, only those resources of the environment that have the potential to be affected by the proposed action, or any alternative to the proposed action, are described.

Table 1. Potentially Affected Resources

Resources	Potentially Affected	No Effect	Included in EA Text	Comment
*Air Quality / Climate	x		x	
*Cultural Resources	x		x	
Fuels Management	x		x	
Invasive, Non-native Plant Species	x		x	
Range/Grazing	x		x	
*Native American Religious Concerns	x		x	

Resources		Potentially Affected	No Effect	Included in EA Text	Comment
Paleontology		x		x	
*T&E Species/Special Status Species/Migratory Birds		x		x	
Recreation		x		x	
*Socioeconomic/Environmental Justice		x		x	
Soils		x		x	
Vegetation		x		x	
*Water Quality/Surface/Ground		x		x	
Wildlife		x		x	
*Riparian Zone/Wetlands		x		x	
*Floodplains		x		x	
Congressional or Administrative Designations	*ACECs	x		x	
	*Wilderness	x		x	
	*Wild and Scenic Rivers		x		There are no Wild and Scenic River designations within the FFO administrative area
*Hazardous or Solid Waste Materials			x		None of the alternatives involve the production/use of hazardous or solid waste.
*Farmlands, Prime or Unique			x		None of the FFO area is considered prime/unique farmland.

3.1 Air Resources

The proposed project is located in San Juan Basin located in Northwestern New Mexico. Additional general information on air quality in the area is contained in Chapter 3 of the RMP (BLM 2003). In addition to the air quality information in the RMP cited above, new information about greenhouse gases (GHGs), and their effects on national and global climate conditions has emerged since that RMP was prepared. On-going scientific research has identified the potential impacts of GHG emissions such as carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); water vapor; and several trace gases on global climate. Through complex interactions on a global scale, GHG emissions may cause a net warming effect on the atmosphere, primarily by decreasing the amount of heat energy radiated by the earth back into space. Although GHG levels have varied for millennia (along with corresponding variations in climatic conditions), industrialization and the burning of fossil fuels have caused GHG concentrations to increase measurably, and may contribute to overall climatic changes, typically referred to as global warming.

The 2003 RMP discussed ozone in the Baseline Air Quality and Impact Assessment sections. The National Ambient Air Quality Standard (NAAQS) at the time was 0.084 ppm. In March of 2008, the Environmental Protection Agency (EPA) announced a new primary 8-hour standard of 0.075 ppm.

In addition, the Environmental Protection Agency (EPA), on October 17, 2006, issued a final ruling on the lowering of the National Ambient Air Quality Standard (NAAQS) for particulate matter ranging from 2.5 micron or smaller particle size. This ruling became effective on December 18, 2006, stating that the 24-

hour standard for PM2.5, was lowered to 35 ug/m³ from the previous standard of 65 ug/m³. This revised PM2.5 daily NAAQS was promulgated to better protect the public from short-term particle exposure.

Air quality and climate are the components of air resources, which include applications, activities, and management of the air resource. Therefore, the BLM must consider and analyze the potential effects of BLM and BLM-authorized activities on air resources as part of the planning and decision making process.

The Environmental Protection Agency (EPA) has the primary responsibility for regulating air quality, including seven nationally regulated ambient air pollutants. Regulation of air quality is also delegated to some states of which New Mexico is one. Air quality is determined by atmospheric pollutants and chemistry, dispersion meteorology and terrain, and also includes applications of noise, smoke management, and visibility. Climate is the composite of generally prevailing weather conditions of a particular region throughout the year, averaged over a series of years. Greenhouse gases and the potential effects of GHG emissions on climate are not regulated by the EPA, however climate has the potential to influence renewable and non-renewable resource management.

3.1.1 Air Quality

The area of the proposed action is considered a Class II air quality area (NMED AQB 2005). A Class II area allows moderate amounts air quality degradation. The primary sources of air pollution are dust from blowing wind on disturbed or exposed soil and exhaust emissions from motorized equipment.

Air quality in the area near the proposed project is generally good and is not located in any of the areas designated by the Environmental Protection Agency as “non-attainment areas” for any listed pollutants regulated by the Clean Air Act. During the summers of 2000 through 2002, ozone levels in San Juan County were approaching non-attainment. Additional modeling and monitoring was conducted by Alpine Geophysics, LLC and Environ International Corporations, Inc., in 2003 and 2004. Results of the modeling suggest the episodes recorded in 2000 through 2002 were attributable to regional transport and high natural biogenic source emissions. The model also predicted that the region will not violate the ozone NAAQS through 2007 and that the trends in the 8-hr ozone values in the region will be declining in the future. At the present time, the San Juan County is classified as in attainment with the revised federal ozone standard of 0.075 ppm. Rio Arriba County is unclassified because of there are no ozone monitors sited in Rio Arriba County.

Greenhouse gases, including carbon dioxide (CO_2) and methane (CH_4), and the potential effects of GHG emissions on climate, are not regulated by the EPA under the Clean Air Act. However, climate has the potential to influence renewable and non-renewable resource management. The EPA’s Inventory of US Greenhouse Gas Emissions and Sinks found that in 2007, total U.S. GHG emissions were over 7 billion metric tons and that total U.S. GHG emissions have increased by 17% from 1990 to 2007. Emissions increased from 2006 to 2007 by 1.4 percent (99.0 Tg CO2 Eq.). The following factors were primary contributors to this increase: (1) cooler winter and warmer summer conditions in 2007 than in 2006 increased the demand for heating fuels and contributed to the increase in the demand for electricity, (2) increased consumption of fossil fuels to generate electricity and (3) a significant decrease (14.2 percent) in hydropower generation used to meet this demand (EPA 2009).

The levels of these GHGs are expected to continue increasing. The rate of increase is expected to slow as greater awareness of the potential environmental and economic costs associated with increased levels of GHG's result in behavioral and industrial adaptations.

3.1.2 Climate

Global mean surface temperatures have increased nearly 1.0°C (1.8°F) from 1890 to 2006 (GISS 2007). However, observations and predictive models indicate that average temperature changes are likely to be greater in the Northern Hemisphere. Without additional meteorological monitoring and modeling systems, it is difficult to determine the spatial and temporal variability and change of climatic conditions; what is known is that increasing concentrations of GHGs are likely to accelerate the rate of climate change.
In 2007, the Intergovernmental Panel on Climate Change (IPCC) predicted a warming of about 0.2°C per decade for the next two decades, and then a further warming of about 0.1°C per decade. The National Academy of Sciences (2006) supports these predictions, but has acknowledged that there are uncertainties regarding how climate change may affect different regions. Computer model predictions indicate that increases in temperature would not be equally distributed, but are likely to be accentuated at higher latitudes. Warming during the winter months is expected to be greater than during the summer, and increases in daily minimum temperatures are more likely than increases in daily maximum temperatures.

A 2007 US Government Accountability Office (GAO) Report on Climate Change found that, "federal land and water resources are vulnerable to a wide range of effects from climate change, some of which are already occurring. These effects include, among others: 1) physical effects such as droughts, floods, glacial melting, and sea level rise; 2) biological effects, such as increases in insect and disease infestations, shifts in species distribution, and changes in the timing of natural events; and 3) economic and social effects, such as adverse impacts on tourism, infrastructure, fishing, and other resource uses." It is not, however, possible to predict with any certainty regional or site specific effects on climate relative to the proposed action and subsequent actions (US Government Accountability Office 2007).

3.2 Cultural Resources

The project is located within the archaeologically rich San Juan Basin of northwestern New Mexico. In general, the prehistory of the San Juan Basin can be divided into five major periods: PaleoIndian (ca. 10000 B.C. to 5500 B.C.), Archaic (ca. 5500 B.C. to A.D. 400), Basketmaker II-III and Pueblo I-IV periods (A.D. 1-1540), and the Historic (A.D. 1540 to present), which includes Native American as well as later Hispanic and -American settlers. Detailed description of these various periods and select phases within each period, as well information regarding the BLM cultural resources program is provided in the 2003 RMP and will not be reiterated here. Additional cultural resources information is also included in an associated document, Cultural Resources Technical Report (CRTR) (SAIC 2002).

The CRTR is a comprehensive analysis and summary of cultural resources by watersheds. At the time the CRTR was prepared, over 37,000 cultural resource sites were on record within the FFO. As of March 2009, there were approximately 43,000 sites on record, and of those approximately 12,100 (28%) are located on Public Lands. The highest number of sites occurs in the Chaco watershed, but this is in part because the watershed is so large and has seen some of the most extensive archaeological research over the years. Following Chaco are the Navajo Reservoir, Upper Puerco, Upper and Middle San Juan, and Largo watersheds, which combined with Chaco, contain over 70% of the recorded sites in the area.

These sites represent everything from simple artifact scatters of the PaleoIndian and Archaic cultures to complex and large prehistoric architectural sites of the Basketmaker/ Pueblo culture. Rock art sites are also particularly common in the area, representing thousands of years of history. Also found in the area are the greatest concentrations of early Navajo sites in the American Southwest, dating from the 15th– 18th centuries. Historic non-Native American sites include early settlement by Hispanic and Anglo homesteaders/ranchers, as

well as early trails of exploration and commerce, such as the Old Spanish Trail. The area is also populated by landscapes that are of traditional significance to Native Americans, such as Huerfano Mesa.

The FFO requires site-specific surveys in advance of ground-disturbing activities. In some cases, existing inventory data can be used in evaluating potential effects to cultural resources. Seldom will existing surveys be sufficient to completely negate the need for field inspections. Compliance with Section 106 of the National Historic Preservation Act is adhered to by following the BLM New Mexico State Historic Preservation Office (SHPO) protocol agreement, which is authorized by the "National Programmatic Agreement between the BLM, the Advisory Council on Historic Preservation, and the National Conference of Council of State Historic Preservation Officers."

3.3 Fuels Management

Fuels within areas infested with cheatgrass can be characterized as either Fuel Model GR2 (102) Low Load, Dry Climate Grass or Fuel Model GS1 (121) Low Load, Dry Climate Grass-Shrub. The primary carrier in GR2 is grass, though small amounts of fine dead fuel may be present. Approximate fuel load is 1.1 tons/acre. If the area is grazed for short periods during the summer, utilization is very low due to the lack of palatability of the brome species. (Scott and Burgan 2005).

Areas infested with cheatgrass can be classified as being in historic Fire Regime III where fire intervals historically would have been between 35-100 years and of mixed severity (Schmidt et al. 2002). However, the current Fire Regime Condition Class (FRCC) or degree of departure from the historical fire regime is in Condition Class 2. Condition Class 2 attributes include:

1. Fire regimes are moderately altered from historical range.
2. The risk of losing key ecosystem components has increased to moderate.
3. Fire frequencies have departed from historical frequencies resulting in changes to fire size, frequency, intensity, severity, or landscape patterns.
4. Vegetation attributes have been significantly altered from their historical range.

Cheatgrass (*Bromus tectorum*) is the predominant non-native grass. The predominant brush is Wyoming big sage (*Artemisia tridentata wyomingensis*). It is believed that the presence of shrubs would only have a slight influence on fire behavior.

3.4 Invasive / Non-native Species

Invasive, non-native species are a major concern within the boundaries of the FFO. Besides cheatgrass, other noxious species of concern include Russian knapweed, spotted knapweed, leafy spurge, yellow toadflax, camelthorn, hoary cress, yellowstar thistle, musk thistle, Canada thistle, scotch thistle, black henbane, jointed goatgrass, and halogeton. Another specie of concern which is non-native, but naturalized, is Russian thistle. All of these species are invasive and pose a concern any time there is surface disturbance. Activities that create bare ground, even temporarily, are potential host sites for one or several of the above listed species.

Project planning associated with the proposed treatment of cheatgrass will increase the possibility of increasing noxious and invasive weeds within treatment areas if revegetation efforts are not actively implemented. However, leaving existing stands of cheatgrass is also a major concern since this species is is currently displacing native vegetation and continues to expand its range throughout the FFO.

3.5 Range/Grazing

The proposed treatment of cheatgrass being analyzed in this EA would occur within the boundaries of the FFO. The majority of grazing allotments in the resource area are for winter and spring use. Prior to application of any treatment type, cooperative agreements would be made with each permittee to ensure that two years of grazing deferment in the treatment areas during the growing season (April 1st thru September 30th) would occur.

The BLM has used the NEPA process for renewing term grazing permits since 1998. NEPA analysis requires that assessments be done on allotments whose permits are expiring, prior to renewal. In some cases assessments revealed range areas that did not meet the Fundamentals of Rangeland Health (USDI, Bureau of Land Management 2001). For this reason, livestock management has been modified to ensure that the majority of livestock grazing occurred during the non-growing season in areas that did not meet the criteria in Fundamentals of Rangeland Health. In addition, stipulations were incorporated into the terms and conditions of all the permits to improve soil, vegetative, and hydrologic attributes within each allotment. These included: requiring permittees to place salt and/or mineral supplement (if used) a minimum of ¼ mile away from all water sources or riparian areas, limiting utilization levels of key forage species to proper use factors for the individual plant species, and requiring permittees to maintain assigned range improvements to a standard that ensures continued effectiveness.

After grazing deferment in cheatgrass treatment areas and monitoring the success or shortcomings of treatment, the BLM would allow grazing to continue within the terms and conditions of the permit, or modify grazing use to implement further treatments to correct the shortcomings. Grazing permittees will be kept informed of project status and the BLM will cooperate with permittees to implement treatments.

3.6 Native American Religious Concerns

"Traditional Cultural Prosperities" (TCPs) is a term that has emerged in historic preservation management and the consideration of Native American religious concerns. TCPs are places that have cultural values that transcend, for instance, the values of scientific importance that are normally ascribed to cultural resources such as archaeological sites. The National Park Service has defined TCPs as follows:

> A traditional cultural property can be defined generally as one (a property) that is eligible for the National Register because of its association with cultural practices or beliefs of a living community that (a) are rooted in that community's history, and (b) are important in maintaining the continuing cultural identity of the community. (National Register Bulletin 38)

Native Americans are the "communities" most likely to identify TCPs, although TCPs are not restricted to these groups. Some TCPs are well known, while others may only be known to a small group of traditional practitioners, or otherwise vaguely known.

There are several pieces of legislation or Executive Orders that should be considered when evaluating Native American religious concerns. These govern access to and use of sacred sites, possession of sacred items, protection and treatment of human remains, and the protection of archaeological resources ascribed with religious or historic importance. These include the following:

- The American Indian Religious Freedom Act of 1978 (AIRFA; 42 USC 1996, P.L. 95-431 Stat. 469).
- Executive Order 13007 (24 May 1996).
- The Native American Graves Protection and Repatriation Act of 1990 (NAGPRA; 25 USC 3001, P.L. 101-601).
- The Archaeological Resources Protection Act of 1979 (ARPA; 16 USC 470, Public Law 96-95).

TCPs or other places of significance are identified primarily by literature review and Tribal consultation. There is a vast body of existing information for the FFO area, both published and un-published "gray literature" that addresses this subject. Some literature is extensive and covers large areas while others are very project-specific in the areas examined. Consultation, both written and verbal, is used to identify places that are of concern. Some TCPs have no material evidence and would not normally be identifiable by archaeologists, so consultation with knowledgeable Native people is often necessary. These consultations can take place at the executive tribal levels or at the local levels, such as with Navajo chapters or individual land users, such as grazing allottees.

TCPs may include but not be limited to the following kinds of places: medicinal plant gathering areas, graves, archaeological sites, prayer offering locations, springs, landscape elements associated with important events, antelope traps, ceremonial grounds, mineral collecting areas, and so forth.

3.7 Paleontology

The proposed San Juan Basin of northern New Mexico is paleontologically rich. The BLM uses the Potential Fossil Yield Classification (PFYC) system to identify areas with a high potential to produce significant fossil resources (IM 2008-009). This system has designated all lands within the FFO management area as Class 5. Class 5 designations are described as being Very High Potential paleontological resource areas, thus requiring an assessment at the project level (IM 2008-011).

Site-specific treatments would be assessed individually based on BLM's PFYC system, known paleontological locality information, existing reports and data for the area. If preliminary analysis indicates that the proposed treatment has a high probability of impacting paleontological resources, additional surveys, reporting and stipulations would be required. Paleontological Specially Designated Areas (SDAs), like Areas of Critical Environmental Concern (ACECs) are not addressed in this EA.

The Nacimiento Formation, found within the proposed project area, has the potential to contain several important vertebrate fossils. The San Jose Formation found within the proposed project area is not known to contain any paleontological resources.

3.8 Recreation

BLM lands within the FFO are popular for recreational use in a variety forms, including hunting, hiking, ATV use, mountain bike riding, and horseback riding. Wildlife viewing and photography are also popular pastimes engaged in on BLM lands. None of the proposed treatments would take place in specially designated recreation areas, but recreational use is by no mean confined to these areas alone. The FFO administers several recreation areas, a wilderness area, a wilderness study area, and a research natural area.

3.9 Threatened and Endangered Species / Special Status Species / Migratory Birds

There are 15 federally listed threatened, endangered, proposed or candidate for listing species that are known to, or have the potential to, occur within San Juan, Rio Arriba, Sandoval and McKinley Counties (see Table 2). Federally listed and proposed species that have the potential to occur within the area but have not been specifically identified include the black-footed ferret, the least tern, the New Mexico jumping mouse, and the Zuni fleabane.

A complete Biological Evaluation for all currently listed species has not been completed for the proposed action and the alternatives. Any treatment activity will be analyzed for the potential to affect federally-listed species. Any affect on federally-listed species will be analyzed before any treatments are conducted. Any action that could impact federally-listed species will undergo consultation under Section 7 of the Endangered Species Act

In accordance with BLM Manual 6840, the FFO of the Bureau of Land Management (FFO) has prepared a list of special management species to focus species management efforts toward maintaining habitats under a multiple use mandate, called FFO Special Management Species (SMS). The BLM manages certain sensitive species not federally listed as threatened or endangered in order to prevent or reduce the need to list them as threatened or endangered in the future. The authority for this policy and guidance is established by the Endangered Species Act of 1973, as amended; Title II of the Sikes Act, as amended; the Federal Land Policy and Management Act (FLPMA) of 1976; and Department of Interior Manual 235.1.1A. FFO SMS are listed in Table 2 below.

Table 2: Special Management Species in the BLM/FFO

Species Name	Conservation Status		Habitat Associations
	BLM/FFO	New Mexico	
Birds			
Golden Eagle (*Aquila chrysaetos*)	SMS		In the West, mostly open habitats in mountainous, canyon terrain. Nests primarily on cliffs and trees.
Ferruginous hawk *(Buteo regalis)*	SMS		Open, arid country or grasslands with piñon-juniper plant associations. Nests on ledges or cliff sites, may use the ground.
Prairie falcon *(Falco mexicanus)*	SMS		Arid, open country, grasslands or desert scrub, rangeland; nests on cliff ledges, trees, power structures.
Mountain plover *(Charadrius montanus)*	SMS		Semi desert, grasslands, open arid areas, bare fields, breeds in open plains or prairie.
Yellow-billed cuckoo *(Coccyzus americanus*)	SMS		Low to mid-elevation riparian woodlands, deciduous woodlands, and abandoned farms and orchards. Rare in the San Juan River valley.
American peregrine falcon (*Falco peregrinus anatum*)	SMS	NM-T	Open country near lakes or rivers with rocky cliffs and canyons. Tall city bridges and buildings also inhabited.
Bald eagle (*Haliaeetus leucocephalus)*	SMS	NM-T	Near lakes, rivers and cottonwood galleries. Nests near surface water in large trees. May forage terrestrially in winter

Species Name	Conservation Status		Habitat Associations
	BLM/FFO	New Mexico	
Burrowing owl *(Athene cunicularia)*	SMS		Associated with prairie dog towns. In dry, open, short-grass, treeless plains
Plants			
Brack's hardwall cactus (*Sclerocactus cloveriae* ssp. *brackii*)	SMS	NM-E	Sandy clay of the Nacimiento Formation in sparse shadscale scrub (5,000-6,000 ft).
Aztec gilia (*Aliciella formosa*)	SMS	NM-E	Salt desert scrub communities in soils of the Nacimiento Formation.

3.9.1 Migratory Birds of Conservation Concern

There are slightly over 350 avian species in the area administered by the Bureau of Land Management's FFO. While all migratory songbirds are protected by law, certain species have been determined to be at greater risk than others. Data collected through breeding bird surveys coordinated by the U.S. Fish & Wildlife Service (USFWS), as well as other private sector efforts, have provided the basis for the organization Partners in Flight (PIF) to develop bird "Watch Lists" and the USFWS "Birds of Conservation Concern List". The focus of the Proposed Action is primarily on two of the habitat types addressed in these documents: Great Basin Desert Shrub (Sage/Grass) and Pinon/Juniper habitat. A sampling of some of the birds listed as "Highest Priority" by the PIF group includes the gray vireo, gray flycatcher, sage sparrow and sage thrasher. The USFWS' list of "Birds of Conservation Concern" includes the gray vireo and sage sparrow. In addition, the New Mexico Department of Game and Fish's "Comprehensive Wildlife Conservation Strategy" lists the sage sparrow, sage thrasher and Bendire's thrasher as species of "Greatest Conservation Need" within the Intermountain Basins Big Sagebrush Shrubland habitat type. All of the bird species noted above (and others) occur in the areas affected by the Proposed Action and are analyzed under the "Impacts" section.

3.10 Socioeconomic/Environmental Justice

The Bureau of Land Management is required to conduct its programs, policies, and activities that substantially affect human health or the environment in a manner that ensures that no person is subjected to discrimination due to their race, color, or national origin, or excluded from participation therein, or denied the benefit thereof on these bases. Executive Order 12898 requires federal agencies to assess their projects to ensure they do not result in disproportionately high and adverse environmental health or safety effects on minority and low-income populations.

3.11 Soils

The soils in the San Juan Basin fall into the general soil order called Aridisols. These soils are found in arid regions and are associated with dry or semi-dry climates and with desert vegetation types. It is not uncommon to find Entisols inclusions associated with Aridisol regions. These soils are well oxidized, low in organic matter and lack free iron oxide movement. The most observed feature with this soil order is a layer of carbonate accumulation commonly referred to as caliche. These carbonate layers are formed when calcium bicarbonate ($CaCO3$) moves down the soil profile and is precipitated when the percolation of

moisture stops and moisture is lost through transpiration. Another common feature is salic horizons (salt accumulations) and nitric (sodium-affected) horizons. Their formation is favored by periodic accumulations of water, as in or near broad seasonal lakes called playas or locally in areas of seepage similar to springs sites. Aridisols are commonly low in nitrogen but often contain larger amounts of fertility elements such as potash derived from feldspars and mica. Supplies of micronutrients are usually abundant but are generally not available because of the high pH associated with this soil order.

Soils in the San Juan Basin were formed primarily from two kinds of parent material: alluvial sediment and sedimentary rock. The alluvial sediment is material that was deposited in river valleys and on mesas, plateaus, and ancient river terraces. The material has been mixed and sorted in transport and has a wide range of mineralogy and particle size. Sedimentary parent material consists mainly of sandstone and shale bedrock. These shale and resistant sandstone beds form prominent structural benches, buttes and mesas bounded by cliffs.

The proposed project area consists of two general soil mapping units; Torriorthent/Torrifluvent groups and Torriorthent/Ustorthent groups. The Torriorthent/Torrifluvent groups are derived from sandstone, shale, siltstone and mudstone. The majority of the soils are alkaline with depths ranging from 20 to 60 inches. These soils extend over gently sloping valley floodplains, benches, mesas and steep foothills. The Torriorthent/Ustorthent groups are derived from sandstone and shale. This map unit contains a significant proportion of shallow soils (less than 20 inches thick) that are alkaline with light colored surface layers. The unit is present in canyonlands, mountain slopes, valleys, rock outcrops and shale badlands.

The soil maps and a description of each of the soil units can be found in the Soil Survey of McKinley County and Parts of Cibola and San Juan Counties (2005), and Juan County, Eastern Part (1980), Parts of Rio Arriba and Sandoval Counties (2008) (USDA Natural Resources Conservation Service http://soils.usda.gov/survey/online_surveys/new_mexico/).

3.12 Vegetation

As described in the Soil Survey Manuals, the soil types where proposed cheatgrass treatment would predominantly occur can feature a wide range of native plant species. These include Indian ricegrass (*Spartina anglica)* blue grama (*Bouteloua gracilis)*, galleta (*Hilaria jamesii)*, needle-and-thread (*Stipa comate*), alkali sacaton (*Sporobolus airoides)*, western wheatgrass (Pascopyrum smithii), sand dropseed (*Sporobolus cryptandrus)*, fourwing saltbush (*Atriplex canescens*), winterfat (*Eurotia lanata)*, globemallow (*Sphaeralcea munroana*), greasewood (*Sarcobatus vermiculatus)*, and big sagebrush (*Artemisia tridentata)*. As the potential plant community deteriorates, the proportion of preferred forage plants (grasses) decreases and the proportion of less desirable plant species (sagebrush, rabbitbrush [*Chrysothamnus nauseosus*] and cheatgrass) increases. Cheatgrass is found occasionally and to a lesser degree in Pinyon-juniper (*Pinus edulis- Juniperus spp.)* woodlands as well. Areas where woodlands occur are generally in shallower soils and are less conducive to growing perennial or annual grasses. The potential plant community on shallow soils sites is generally Pinyon-juniper, Mountain mahogany (*Cercocarpus ledifolius*), antelope bitterbrush (*Purshia tridentata*), Prairie Junegrass (*Koeleria macrantha*), and various forbs. Most proposed treatments would be prioritized in sagebrush grassland range sites; however, there may be future need to do cheatgrass treatments in woodland areas.

The current vegetative composition of the areas proposed for treatment includes, in order of dominance: big sagebrush, cheatgrass, annual forbs, and few perennial grasses such as sand dropseed, Indian

ricegrass, blue grama, galleta, and needle-and-thread. In the pinyon/juniper communities there is potential for other browse species such as mountain mahogany, antelope bitterbrush, oak brush (*Quercus gambelii)*, service berry *(Amelanchier alnifolia)*, and Fendler bush (*Fendlera falcate*). The current vegetation composition is imbalanced to the degree that the biotic standard of rangeland health is fundamentally at risk. Currently, trees and woody shrubs are allowed at 5% of the potential natural plant community, where 15-50% is currently present on the sites analyzed.

3.13 Water Quality

Surface waters are mainly tributary to the San Juan River. Perennial flows occur in the San Juan and Animas Rivers. Ephemeral flows occur in a number of major drainages, including the La Plata, Chaco, Largo, and Gobernador. The numerous washes and arroyos usually flow only during spring snow melt and after summer thunderstorms. Summer thunderstorms can be very intense but usually highly localized. They can create increased stream flows in the wash channels with flash flooding.

The soil and vegetation type and amount have a major effect on the amount of precipitation that becomes surface runoff. Storms and annual surface runoff vary with the amount of bare soil and amount of vegetation liter. Surface runoff increases as vegetation and litter decreases. Increased runoff causes higher velocities and initiates more erosion and more water that transports sediment.

Topographic features and soil conditions that result in the formation and continual development of canyons, arroyos, and gullies are contributing to the production of very poor water quality from many ephemeral flows. Key components that influence water quality are highly erosive and saline soils, sparse vegetative cover, and rapid runoff. Surface runoff usually consists of greater than 10,000 ppm of suspended sediment and more than 1,000 ppm of total dissolved solids (TDS). Limited salinity data indicates that moderately saline water (1,000 to 2,000 ppm TDS) are predominate for lands under the jurisdiction FFO.

The major aquifers associated with the FFO are Quaternary gravels, the San Jose, Nacimento, Ojo Alamo, Gallup, Morrison, Entrada, and San Andreas formations. Recharge into the ground water aquifers is slight to moderate, depending on the porosity and permeability of each aquifer, amount of rainfall, snow melt, etc. Conductivities of the ground water aquifers are variable and can be both laterally and vertically discontinuous, depending on geology.

3.14 Wildlife

Wildlife habitat within the FFO area is dominated for the most part by the pinyon *pine (Pinus edulis)/* Utah juniper (*Juniperous osteopserma)* and Wyoming big sagebrush (*Artemisia tridentata wyomingensis)*/perennial grass habitat types with lesser interspersions of ponderosa pine (*Pinus ponderosa)/*Gambel's oak (*Quercus gambellii*) and riparian areas. Overall, the area is considered to be part of the Colorado Plateau high desert and is probably best characterized as a mesic environment. The land supports a broad spectrum of plant and animal species. Large mammals endemic to the area include mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and pronghorn antelope (*Antilocapra americana*). Because of variations in habitat type and quality these species are not uniformly distributed within the field office area. Resident mule deer and elk typically occur in greatest numbers in the pinyon/juniper/sage areas of the Largo, Carrizo and Rattlesnake Canyon watersheds. These populations are temporarily augmented each winter as animals from the surrounding higher elevation areas migrate to avoid the snow and cold temperatures. In addition, the Thomas Canyon, Carracas Mesa and Rosa Mesa SDAs also receive a large influx of migratory winter deer, primarily from southern Colorado.

There are also a number of mammalian carnivores that fill important niches within the San Juan Basin ecosystem. Included in these are the black bear (*Ursus americanus*), mountain lion (*Felis concolor),* coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*) and bobcat (*Lynx rufus*). Each of these species affects a somewhat different trophic level. Mountain lions are considered a keystone species as they play a significant role in keeping the deer and elk populations in check. Black bears (which also consume large quantities of vegetation, nuts, berries and insects) and coyotes, to a lesser degree, also affect this trophic level by preying upon fawns and calves. The smaller carnivores (gray fox and bobcat) impact smaller mammals such as mice (*Peromyscus spp*.), desert cottontail rabbits (Sylvilagus auduboni), black-tail jackrabbits (*Lepus californicus*), ground squirrels, such as rock squirrels) (*Citellus variegatus*), spotted ground squirrels (*Citellus spilosoma)* and antelope squirrels (*Ammospermophilus leucurus*), Gunnison's prairie dog (*Cynomys gunnisoni*) and birds such as Merriam's turkeys (*Meleagris gallopavo merriami*).

Reptiles commonly observed in the field office area include the collared lizard (*Crotaphytus collaris*) , short-horned lizard (*Phrynosoma douglassii*), western prairie rattlesnake (*Crotalus viridis viridis*) and gopher snake (*Pituophis melanoleucus*). Habitat for amphibians, while less abundant, does exist in the form of earthen tanks, sumps, ephemeral streams and perennial rivers such as the San Juan and Animas. Representative species include Woodhouse's toad (*Bufo woodhousii woodhousii*), bullfrog (*Rana catesbeiana*) and tiger salamander (*Ambystoma tigrinum nebulosum).*

A search of the New Mexico Department of game and Fish's Bison-M Data Base revealed 271 extant avian species in San Juan County. This group includes species found in both aquatic and upland habitat types. A representative sample of these was listed previously, under Migratory Birds of Conservation Concern.

3.15 Wetlands / Riparian Zones

The BLM defines a riparian area as "a form of wetland transition between permanently saturated wetlands and upland areas. The areas exhibit vegetation or physical characteristics that reflect the influence of permanent water sources or subsurface water" (BLM 1992). To protect these rare and important areas, the 2003 RMP designated approximately 7,500 acres of riparian habitat in the Ephemeral Wash Riparian Area SDA (Specially Designated Area). One of the management prescriptions for the SDA states: "vegetation management must benefit the values for which the SDA was established" (BLM 2003a).

An additional 2,150 acres was designated in the 2003 RMP as the River Tract ACEC's to maintain, restore, improve, protect and expand riverine habitat so they it is in proper functioning condition for their productivity, biological diversity and sustainability. Management prescriptions call for analysis of "invasive, non-native vegetation for the development of vegetation manipulation projects to improve the native riparian vegetation community" (BLM 2003).

Although there has been no systematic inventory for cheatgrass in riparian areas, it is known to have a scattered presence. There are few, if any, large monoculture areas of cheatgrass, thus riparian rehabilitation efforts focus on removal of saltcedar (tamarisk), Russian olive, thistles and knapweed.

3.16 Floodplains

Executive Order 11988 requires federal agencies to consider and evaluate potential effects that a proposed action may have on floodplains. Where applicable, actions should reduce the risk of flood loss, minimize the impact of floods on human safety and restore and preserve the natural and beneficial values served by

floodplains. The best available floodplain information for the Farmington Field Office resource area is the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM). These maps define zones according to varying levels of flood risk; the zones reflect the severity or type of flooding in the area. The FEMA maps display high risk areas, generally describing them as areas with a 1% or greater chance of annual flooding, either in the form of ponding, sheet flooding, or overbank flooding (FEMA 2009). There are approximately 190,000 acres delineated within a high risk area in the FFO administrative area.

3.17 ACECs / Wilderness

The 2003 RMP designated 150 Areas of Critical Environmental Concern (ACECs) throughout the FFO administrative area. ACEC's are a special designation for areas that meet certain relevance and important criteria, which calls for specific management to protect and prevent irreparable damage to important natural resources and processes. Table 3 summarizes the target resource that is protected by the ACEC designation.

Table 3: ACEC Designations

Number of ACECs designated to protect a particular resource type.

Resource	*Anasazi Communitites (Non-Chacoan)*	*Chacoan Outlier*	*Chacoan Road*	*Early Navajo Defensive Site*	*Historic Site*	*Petroglyph and Pictograph Site*	*Traditional Use and Sacred Area*	*Geologic Formation*	*Special Recreation Value*	*Bald Eagle*	*Riverine Habitat*	*Vegetation*	*Critical Habitat*
Cultural	5	18	3	30	9	12	3						
Geology								1					
Recreation									1				
River Tracts											30		
T&E Species										36		1	1

Cultural

The cultural ACECs ensure the long-term protection of important cultural resources for future generations of researchers, public enjoyment, and for preservation of Native American sacred sites. All but four of the Cultural ACEC's (Cedar Hill, La Jara, San Rafael Canyon and parts of Superior Mesa) have management prescriptions that close them to vegetation manipulation. This could limit the ability of BLM to control noxious weeds or conduct other activities, which may be necessary to improve public land health. Exceptions to this prescription will be allowed when site-specific environmental analysis indicates such treatments are necessary to maintain or improve public land health or control noxious weeds and when it can be demonstrated such treatments will not adversely impact the resources for which the SDA was created. The four ACEC's which allow vegetation modification must also be approved on a case-by-case basis by the cultural staff.

Geology

The geology ACEC provides protection and preservation of a unique geologic feature (it appears as the shape of an angel with one uplifted wing) and associated scenic values. Management prescriptions state that vegetative treatments must benefit recreation and visual experiences managed for.

Recreation

The Recreation ACEC contains 3,928 acres which are managed to provide opportunities for the public to enjoy a variety of semi-primitive recreational activities and challenges, including fishing, hiking, backpacking, wildlife viewing, camping and cultural interpretation. Management prescriptions state that vegetation treatments must benefit recreation experiences.

T&E

The T&E ACECs protect 10,367 acres for plants that are rare or endemic to New Mexico; 2,758 acres of designated critical habitat for the Mexican Spotted Owl; and 4,141 acres of important bald eagle wintering habitat. The main goal of the River Tract ACEC is to protect and rehabilitate the riparian and wetland habitat, which supports potential habitat for endangered and sensitive species. Management prescriptions for each ACEC allow for vegetation treatments, with ranging emphasis:

- Mexican Spotted Owl: emphasis on protection of ponderosa pine and mixed conifer stands from man-caused disturbance and catastrophic wildfires
- The Hogback: includes invasive weed management prescriptions
- Bald Eagle: states that any vegetative management must benefit the purpose of the ACEC (protecting bald eagle wintering habitat)
- River Tracts: states that vegetation manipulation projects should be developed to improve the native vegetation community.

Wilderness

The FFO also manages one congressionally designated wilderness area (Bisti/De-na-zin, 44,608ac) and one wilderness study area (Ah-shi-sle-pah, 6,653ac). These areas have been designated to preserve important natural landscapes in the FFO area that are uncommon in the region, including remote wind-eroded sandstone and shale badlands, striking geologic features with high scenic value, petrified wood, cultural resources, significant paleontological resources, wildlife and solitude. They also provide recreational, educational, and scientific opportunities for local, in-state, out-of-state, and international visitors. Management prescriptions for both the Wilderness and Wilderness Study Area state that vegetation treatments may occur in accordance with existing laws.

4.0 ENVIRONMENTAL IMPACTS

4.1 Air Resources

No Action Alternative

Under the No Action Alternative, the potential exists for serious, though short-term, impacts to air quality in the event of a large cheatgrass-fueled wildfire. Particulate matter emission from fires has a great potential for causing air pollution because of the amount of particulate matter produced, the effect on visibility due to the amounts of sub-micrometer sized particles, and the high organic content. Particulate matter less than or equal to 10 micrometers in diameter (PM 10) is the size which can penetrate the inner recesses of the human lung, potentially causing health problems.

Currently five primary air toxins are being assessed relative to the exposure of humans to smoke from both prescribed fire and wildfires. These toxins are: acrolein, formaldehyde, carbon monoxide, particulates, and benzene. Currently, little is known of the long-term health impacts these toxins have on humans, as they are found in smoke from vegetation. Modeling to predict concentrations of air toxins downwind from a prescribed burn or wildfire does not exist. Due to dilution of these toxins with fresh air, exposure is less harmful the farther away an individual is from the source of the smoke.

Although both toxins and particulate matter are released from both wildfires and prescribed burns, prescribed burns are generally smaller, and would be timed to ensure that winds would promote high-altitude mixing (which dilutes concentrations) and also carry smoke away from populated areas.

Proposed Action Alternative

First Order Fire Effects (FOFEM) computer model (Version 5.11) was used to predict the amount of particulate matter PM2.5 (particulate matter 2.5 microns in diameter or smaller) and PM10 (particulate matter 10 microns in diameter or smaller) produced by prescribed burning (see Table 4).

The people that will be impacted the most by the effects of prescribed burning would be those personnel directly involved with the project. The areas surrounding the project area (especially areas downwind) may be impacted when some of these burns are implemented. Prescribed burning would be conducted at times when there is both good predicted ventilation and mixing height (the height above the surface through which relatively vigorous vertical mixing occurs). During these times, smoke and smoke particles would be dispersed in a manner that would be tolerable to healthy people living downwind. Thus, smoke impacts would be monitored, limited and of short duration.

Air quality would temporary be directly impacted with pollution from smoke from controlled burns, internal combustion engine exhaust emissions and dust that would be caused by the motorized equipment use of access roads to the project sites. Smoke is expected to disseminate from winds that frequent the area. Dust and pollution from motorized equipment would continue for a short period after vehicles pass. The winds that frequent the northwestern part of New Mexico generally disperse dust and emissions rapidly. Other factors that currently affect air quality in the area include dust from livestock herding activities, recreational use, and from use of roads for vehicular traffic. Due to the amount of bare soil exposed to aeolian erosion from natural causes (in washes, sparsely-vegetated ground, etc.) dust from natural sources can, depending on weather conditions, be a significant source of air pollution. The proposed action would

temporarily increase the potential for pollution of this nature. In the long term, however, the increased perennial vegetation cover would reduce this source of pollution.

The NAAQS are set for the most common and widespread pollutants. The standards are concentrations of air pollution above which the EPA has determined that serious health and welfare consequences could occur. If the concentrations are below the NAAQS, there are no expected adverse effects to humans and the environment (EPA 2009).

The assessment of GHG emissions and quantifying their impact on climate change is in its formative phase. It is currently not feasible to know with certainty the net impacts from the proposed action on climate. The inconsistency in results of scientific models used to predict climate change at the global scale, coupled with the lack of scientific models designed to predict climate change on regional or local scales, limits the ability to predict potential future impacts of decisions made at this level. When further information on the impacts to climate change is known, such information would be incorporated into the BLM's planning and NEPA documents as appropriate.

Mitigation Measures

The FFO has been a participant of the Four Corners Air Quality Task Force (FCAQTF) since its inception in 2002, when it was known as the Four Corners Ozone Task Force. Because of the unanswered questions raised by these modeling efforts, the FCAQTF has continued to look at air quality issues in the Four Corners region. The FCAQTF is comprised of a broad base of representatives including federal, state, Indian, and local governments, as well as industry, interest groups, and concerned community members. The FCAQTF has several working groups, which worked on the development of a mitigation options report (Four Corners Air Quality Task Force 2007), to serve as a resource and guide to the regulatory agencies. The responsible agencies may use the report as the basis for developing air quality management plans for the region. This may include developing new, and revising existing, regulations, supporting new legislation, developing new outreach and information programs, and developing and/or expanding voluntary programs for emission reductions.

The proposed burns would meet all of the State of New Mexico's smoke management guidelines. Burns will meet all guidelines for SMP II smoke permit (New Mexico Environmental Department's Air Quality Bureau 2005). The Air Quality Bureau (AQB) would be notified of burns 24 hrs prior to first ignition. If there are more than ten complaints; ignition would cease and the burn will be re-evaluated. If it is decided to continue ignition, an additional ten complaints would halt all ignitions until mixing conditions improve.

If visibility becomes a hazard for driving, the burn boss would determine which, if any, of the following steps should be taken:

1. Posting of vehicles equipped with emergency lighting on roads.
2. Ignition would slow.
3. Ignition would halt if number one and two do not mitigate the situation.
4. Rapid mop-up as needed.

If residual smoke becomes a problem after ignition, mop-up would be initiated to reduce the smoke.

Prescribed fire managers would also utilize local techniques for limiting the amount of smoke production, such as scheduling burning when weather conditions are favorable, limiting the amount of burning in adjacent areas and using higher fuel moisture and/or relative humidity levels to limit the amount of duff and

fine fuel consumption. The smoldering phase of a prescribed fire can contribute greatly to the duration and amount of smoke produced.

Table 4: Estimated particulate matter emissions for the Proposed Action using the FOFEM computer model.

Emissions			
Region:	Interior West		
Cover Type:	FCC-Grass-Mature-Low		
Fuel Type:	Natural		
•	Flaming lbs/acre	Smoldering lbs/acre	Total lbs/acre
PM 2.5	1	27	28
PM 10	1	32	33

4.2. Cultural Resources

No Action Alternative

Under the No Action Alternative the potential exists for negative impacts upon cultural resources through increased erosion (see the discussion on Soil Resources, below) which could expose and destroy archaeological sites. Likewise, uncontrolled, cheatgrass-fueled wildfires have the potential to severely damage cultural resources, particularly wooden historic and late prehistoric archaeological structures. . Fire also has the potential to destroy or seriously compromise the preservation of rock art when fuel loads are naturally concentrated at or near the base of cliff faces or other rock exposures.

Proposed Action Alternative

Drill seeding and burning have the potential to directly and adversely affect cultural resources. Drill seeding would affect sites by disturbing the upper surface of the sites and compromising fragile features and artifacts. Burning likewise has the potential to compromise fragile features and artifacts, and could destroy wooden archaeological remains, such as hogans or antelope traps. Fire also has the potential to destroy or seriously compromise the preservation of rock art when fuel loads are naturally concentrated at or near the base of cliff faces or other rock exposures.

Mitigation Measures

Prior to burning and surface disturbing actions such as drill seeding, a Class III cultural resource inventory would be conducted on a project-by-project basis. All FFO/BLM cultural resources stipulations would be followed as indicated in the Cultural Resource Records of Review for any specific project. These stipulations may include, but are not limited to temporary fencing or other physical barriers, monitoring of earth disturbing activity, project area reduction and/or specific avoidance zones, and employee education. Any significant resources would be avoided.

4.3 Fuels Management

No Action Alternative

Under the No Action Alternative, cheatgrass-infested areas would not be treated nor seeded with desirable grass and forbs species. In this situation, fuel conditions are expected to continue to deteriorate. This would continue to create the potential for extreme fire behavior conditions and create a high risk for the loss of key ecosystem components. Cheatgrass would continue to invade and increase within the project area. FRCC would progress from the current condition of 2, increasing to 3 resulting in a high departure from the natural (historical) regime of vegetation characteristics, fuel composition, fire frequency, severity, and pattern, and other associated disturbances.

Proposed Action Alternative

Treating areas infested with cheatgrass would create a more natural fuel condition. The replacement of the annual cheatgrass with desired perennial grasses and forbs would decrease fire behavior and lessen the chance of negative impacts caused by extreme fires on resources. FRCC would convert from condition class 2 to 1, where fuels would return to a natural range of variability of vegetation characteristics, fuel composition, fire frequency, severity and pattern. Fire behavior, effects and other associated disturbance would become similar to what occurred prior to fire exclusion. Ongoing monitoring of results would provide information to allow for adaptive management by determining the most effective means of treating cheatgrass.

Mitigation Measures

No measures other than those incorporated into the proposed action have been identified.

4.4 Invasive / Non-native Species

No Action Alternative

Under the No Action Alternative, cheatgrass would likely continue to spread and increase in the project area and its surroundings. If cheatgrass continues to increase in the project area, the potential exists for loss or a total replacement of desired native vegetation through competition, or if the fire regime periodicity increased due to the presence of cheatgrass. Soil stability, watershed function, wildlife habitat and livestock grazing could be negatively affected by the increase in invasive species.

Proposed Action Alternative

The proposed action would serve to correct an unbalanced vegetative community. By eliminating cheatgrass and restoring desired vegetation, treatment would serve to improve range condition and health, watershed function, wildlife habitat and potential use of the land. There is an increased potential for invasion by non-natives associated with treatment if reseeding is unsuccessful. Thus, subsequent attempts to reseed with chemical application may be needed.

Mitigation Measures

If seeding proves unsuccessful, reseeding may be necessary. An additional application of chemical may be necessary to coincide with reseeding. Monitoring would determine if the project is successful or if it would need further action. All seed used for seeding would be certified weed-free. Equipment would be washed prior to entering the project site.

4.5 Range/Grazing

No Action Alternative

Under the no action alternative there would be negative long-term impacts to livestock grazing operations. If cheatgrass continues to thrive and establish dominance on range sites, BLM grazing permits could be affected to the detriment of livestock grazing. The BLM cannot allow range to deteriorate to the point that it becomes unsuitable for livestock grazing. If rangelands became dominated by cheatgrass and did not meet the Fundamentals of Rangeland Health, the BLM could suspend grazing use of those lands until they were repaired or improved. By not addressing the cheatgrass problem, livestock grazing is at risk if cheatgrass were to dominate rangelands.

Proposed Action Alternative

The proposed action would have short-term negative impacts to the permitted livestock grazing operations in the form of deferment of grazing within the treatment areas. In the long term, if the proposed project is successful, grazing operations should benefit from the improved range conditions.

Grazing permittees will have to agree to grazing deferment in treatment areas and will have comply with the grazing deferment. This may cause some hardship in some cases as permittees may have to shorten the use of their allotments, or reduce the amount of livestock they run on the allotment, until the deferment period is over. The BLM will coordinate with permittees to develop grazing plans to allow deferment. If cases arise where the Fundamentals of Rangeland Health are severely affected by the presence or dominance of cheatgrass, the BLM may modify the terms of grazing permits annually to allow treatment of cheatgrass.

Mitigation Measures

Post-treatment grazing use should be curtailed until the desired plant community is fully established. This may require several years as evidenced by reclamation efforts on nearby gas well locations and pipeline rights of ways. Once livestock grazing is resumed on the project area it should be conducted in accordance with the principles of proper grazing use.

The grazing permittee would be briefed on the project and sign a cooperative agreement agreeing to defer grazing in the project area until its completion. Monitoring would reveal whether subsequent treatments would be needed if desired results are not being achieved.

4.6 Native American Religious Concerns

No Action Alternative

The No Action Alternative would not threaten the integrity of any known TCPs, prevent access to sacred sites, prevent the possession of sacred objects, or interfere with or otherwise hinder the performance of traditional ceremonies and rituals pursuant to AIRFA or EO 13007. There would be no threats to remains that fall within the purview of NAGPRA or ARPA. Uncontrolled cheatgrass-fueled wildfires would have the potential to severely damage cultural resources, particularly wooden historic and late prehistoric archaeological structures that may have religious or traditional significance ascribed to them. Additionally, the continued dominance of cheatgrass has the potential to reduce other native plant and forb species, including those necessary for the performance of certain Native American religious rituals.

Proposed Action Alternative

Direct effects normally include alterations to the physical integrity of the cultural resources. If a cultural resource is significant for other than its scientific information, direct effects may also include the introduction of audible, atmospheric, or visual elements that are out of character for the cultural site.

The proposed action is not known to currently physically threaten the integrity of any TCPs, prevent access to sacred sites, prevent the possession of sacred objects, or interfere or otherwise hinder the performance of traditional ceremonies and rituals pursuant to AIRFA or EO 13007. There are currently no known threats to remains that fall within the purview of NAGPRA or ARPA.

Mitigation Measures

Prior to burning or surface disturbing actions such as drill seeding a Class III cultural resource inventory would be conducted and issues regarding Native American Religious Concern addressed. Any significant resources would be avoided.

4.7 Paleontology

No Action Alternative

Under the No Action Alternative, increased erosion due to the absence of perennial grass and other plant species, and their replacement by cheatgrass, could result in negative impacts to paleontological resources. An increase in surface water flow and turbulence could result in further head-cutting of gullies and canyons, washing fossils out of their primary contexts and exposing them to the risk of unauthorized collection.

Proposed Action Alternative

Impacts to paleontological resources from the proposed project implementation could possibly occur. Direct impacts of the proposed project to fossil localities could result from the ground disturbing activities or the disturbance of the stratigraphic context in which they are located. This project could also create indirect impacts to areas by changing erosion patterns. Additionally there could be an increase in off-road vehicular access from the project area for recreational activities. An increase in human activity in the area could increase the possibility of unauthorized removal or other alterations to paleontological resources in the

area. Potential impacts to paleontological resources as a result of the proposed action would be low and long-term.

Mitigation Measures

All BLM/FFO paleontological resources stipulations would be followed as indicated in conditions of approval on a case by case basis. These stipulations may include, but are not limited to temporary or permanent fencing or other physical barriers, monitoring of earth disturbing construction, project area reduction and/or specific construction avoidance zones, and employee education. Upon review, a determination for final project clearance and stipulations shall be issued by the BLM/FFO.

If previously undocumented paleontological sites are encountered during construction, all activities shall stop in the vicinity of the discovery and the BLM would be immediately notified. The site would then be evaluated. Mitigation measures such as data recovery may be required by the BLM to prevent impacts to newly identified paleontological resources.

4.8 Recreation

No Action Alternative

Under the No Action Alternative, there would be negative impacts to recreational resources. Hunting is a significant recreational activity in the FFO. The increase in cheatgrass in the area, and the resultant negative impact on wildlife would reduce the potential for this type of recreation in the FFO. Additionally, the reduction in species diversity, both floral and faunal, would likewise negatively impact the appeal of the area for sightseeing, hiking, photography, and other recreational pursuits.

Proposed Action Alternative

Under the Action Alternative, there would be beneficial impacts to recreational resources. The increased carrying capacity of the land for large ruminants and game birds would increase the attraction of the area to hunters. Likewise, an overall increase in floral and faunal numbers and diversity would contribute to the appeal of BLM lands to hikers, campers, sightseers and photographers.

Mitigation Measures

No mitigation measures other than those incorporated into the proposed action have been identified.

4.9 Threatened and Endangered Species/Special Status Species/Migratory Birds

No Action Alternative

The potential for negative impact to T&E/special status species exists under the No Action Alternative, due both to the likely continued proliferation of cheatgrass, and also due to the threat of uncontrolled wildfires. Knowlton's cactus (*Pediocactus knowltonii)* and Mesa Verde cactus *(Sclerocactus mesae-verdae)* both occur in open grassland and sagebrush/grasslands, areas of the type that cheatgrass readily colonizes. Due to the limited populations of both of these species, uncontrolled wildfires in their areas of occurrence have the potential to wipe out or seriously reduce the numbers of these plants. Other threatened and

endangered species could potentially be affected by the No Action Alternative by the reduction of prey species. Invasive species could reduce the number of prey species including small mammals and insects.

Proposed Action Alternative

Under Section 7 of the Endangered Species Act of 1973 (as amended), the BLM is required to consult with the U.S. Fish and Wildlife Service on any proposed action which may affect federally listed threatened or endangered species, or species proposed for listing. The FFO would review and determine effects on any federally-listed species and special management species on a project-by-project basis. Any action that may impact federally-listed species would be subject to Section 7 consultation with the U.S. Fish and Wildlife Service. Any impacts to special management species would require mitigation measures that may include avoidance of habitat, seasonal restrictions, or other restrictions to protect these species and their habitat.

Mitigation Measures

Prior to surface disturbing actions, a biological analysis would be conducted on a project-by-project basis. The biological analysis may include a biological survey within appropriate habitat areas. Project activities would follow the BLM/FFO 2008 Special Management Species Policy. No projects would be undertaken without the authorization of a BLM/FFO biologist.

4.9.1 Migratory Birds of Conservation Concern

No Action Alternative

Under the No Action Alternative, migratory bird habitat would continue to deteriorate due to the presence and increase of cheatgrass. Desired herbaceous cover would not be established and it is expected that over time, desired vegetation would be replaced by cheatgrass. As a consequence, it is likely that cheatgrass would proliferate. Most migratory birds prefer a more diverse plant community for food and cover. A monotypic stand of cheatgrass would directly affect the number and diversity of migratory birds and other wildlife species.

Proposed Action Alternatives

The Proposed Alternative, if successful, would increase the overall biological diversity of the current plant and bird communities. This would benefit the ecosystem as a whole and, thus, benefit migratory birds.

Mitigation Measures

Any vegetation treatment over four acres of disturbance occurring from May 1- July 15 would require a biological survey by a BLM/FFO approved biologist to prevent any adverse impacts on nesting birds within the action area.

4.10 Socioeconomic/Environmental Justice

No Action Alternative

Under the No Action Alternative, there would be no impacts to Socioeconomic/Environmental Justice.

Proposed Action Alternative

Under the Action Alternative, there would be no impacts to Socioeconomic/Environmental Justice.

Mitigation Measures

No mitigation measures other than those incorporated into the proposed action have been identified.

4.11 Soils

No Action Alternative

Under the No Action Alternative, there would be increased negative impacts to soils and hydrological resources. Cheatgrass encroachment reduces the incidence of native grass and forb species, and leads to increased amounts of sagebrush, pinyon/juniper encroachment, and decreased soil cover. This, in turn, leads to increased surface erosion, due to exposure of the interstices in the sagebrush canopy to the action wind and water. The loss of surface soil layers also diminishes the water-holding capacity of the landscape, leading to increased runoff, and consequently to a further increase in erosion, creating a negative cycle.

The increased likelihood for large-scale, very hot wildfires in cheatgrass-dominated areas also has the potential to expose large areas to erosive forces, as the latent seed bank is reduced, and thus recovery periods are lengthened unless restorative measures are taken.

Proposed Action Alternative

Prescribed burning affects soil by consuming litter, organic soil layers, down, dead and woody fuels; and vegetative cover. Fire may alter the soil chemical properties, nutrient availability, microorganism populations and physical properties to name a few. However, the degree in which these properties are affected in the short and long term depends on the ignition technique, duration of burning and pre-burn fuel and vegetation conditions (USDI-BLM 1991a).

Some of the herbicide would be deposited on the soil. Removal of vegetation by chemical treatment may result in short term surface erosion that diminishes as vegetation reoccupies the site (UDSI-BLM 1991a). None of the herbicides used would result in severe effects to soil. Removing invasive species would improve soil productivity and reduce erosion in the long run (USDI-BLM 2007).

Impacts to soils would be short term for this proposed project. Nutrient cycling would be increased. Wind and water erosion would return to natural conditions once vegetation became reestablished (USDI-BLM 1991a).

Mitigation Measures

Minimizing soil erosion can be accomplished by timing burning with vegetative recovery, severity of precipitation events and slope. This project includes reseeding of vegetation timed with anticipated precipitation occurrence, which would reduce erosion potential.

4.12 Vegetation

No Action Alternative

Under the No Action Alternative, upland vegetation species and composition would continue to deteriorate due to the presence and increase of cheatgrass. Desired vegetation would not be established and it is expected that over time, desired vegetation would be replaced by cheatgrass.

Proposed Action Alternative

The proposed action is expected to reduce and/or eliminate the amount of cheatgrass in the project area. Seeding is being proposed to establish desired plant species for the purpose of improving rangeland health, wildlife habitat, soil and watershed function and to provide competition against invasive species such as cheatgrass. The research aspect of the project would also serve to provide information on the cost-effectiveness of varying treatments; information that would be beneficial when setting goals for restoration projects. There are desired plant species in the project area; the proposed action may have a slight impact on, or may stress, desired plant species but is not expected to kill or eliminate what is already present.

Mitigation Measures

The following mitigation measures would be implemented to mitigate potential impacts to the current vegetation population: use of certified weed free seed, washing all equipment prior to entering the site, using the recommended application rates of herbicides, and continuous monitoring of the projects. Grazing deferment during the growing season or until the seeding has had opportunity to establish itself would contribute to the establishment of desired vegetation.

4.13 Water Quality

No Action Alternative

Cheatgrass dominance creates a domino effect, including increased amounts of sagebrush, pinyon/juniper encroachment, decreased amounts of soil cover, decreased amounts of desirable plant species, and increased bare ground in the sagebrush/grassland habitats. These factors lead to increased surface erosion. Increased bare ground underneath and within the interstices in sagebrush canopy results where grazing, competition and allopathic influence have led to a loss of desired perennial plant species. The lack of desired plants and increased bare surface area contributes to greater amounts of soil erosion, which diminishes water quality. Rills, gullies and head cuts are evidence of soil loss through erosion. The soil thus lost through erosion is carried in surface runoff to local ephemeral and perennial streams, thereby decreasing water quality.

Proposed Action Alternative

The proposed action is anticipated to decrease the amount of cheatgrass, increase the density of desirable grass and forb species, decrease the amount of surface runoff, erosion, sedimentation and increase water infiltration into the soil. These factors would all reduce erosion and contribute to improved water quality.

Mitigation Measures

No mitigation measures other than those incorporated into the proposed action have been identified.

4.14 Wildlife

No Action Alternative

Under the No Action Alternative, the proposed actions would not be undertaken. As a consequence it is likely that cheatgrass would proliferate. The impacts of having a cheatgrass-dominated range on wildlife would vary depending upon the species, time of year and overall time frame (short term vs. long term). In the short term, big game such as deer and elk could derive some benefit from early season, high protein forage produced by the cheatgrass. However, this period lasts only a few weeks and the cheatgrass begins to cure out, producing sharp awns that can become hazardous to large herbivores as the awns can become embedded in their gums and mouth causing a condition known as actinomycosis or "lumpy jaw." In essence, cheatgrass becomes unpalatable to big game.

Once cheatgrass has cured out it becomes dry with little forage value; basically it is standing litter. In this state, other forms of wildlife such as small mammals (black-tailed jackrabbit, desert cottontail and mice), songbirds, reptiles and invertebrates are disadvantaged by a cheatgrass monoculture. Because of the usual density of cheatgrass, rodents and lizards (prey species) have difficulty moving through the vegetation. As a consequence they avoid this type of habitat, and because there is an absence of prey the number of snakes is also reduced. Conversely, mourning doves, which are endemic to the area, utilize the seed from cheatgrass. Other avian species, however generally prefer a more diverse plant community. This phenomenon may be a result of the probable reduced insect diversity and abundance, which would mean less food items available in the cheatgrass dominated area.

Overall, the No Action Alternative would allow much of the FFO to be increasingly dominated by cheatgrass, and therefore lacking in floral diversity which is a requirement of faunal diversity.

Proposed Action Alternative

The Proposed Action, if successful, would contribute to the diversification of the current plant community in the proposed burn areas. This vegetative diversity would affect every tropic level within this ecosystem in a positive way.

Mitigation Measures

The herbicide would be applied according to the manufacturer's recommended timeframes and in a manner so as to not impact wildlife foraging in the area.

4.15 Wetlands / Riparian Zones

No Action Alternative

Under the No Action Alternative, upland vegetation species and composition would continue to deteriorate due to the presence and increase of cheatgrass, which may lead to increased surface erosion. Excessive runoff and erosion from upland areas reduces the integrity of riparian areas, reducing their functionality of

buffering and protecting streams. In particular, sediment build up can restrict the flow of water moving through the riparian zone, causing more concentrated overland flow, as opposed to more dispersed surface flow. Concentrated flows move too quickly through the riparian zone for proper filtration to occur.

Proposed Action Alternative

This alternative would have a positive impact on wetland and riparian areas. Treatment of cheatgrass on uplands adjacent to wetlands/riparian zones should increase water infiltration into the upland soils, decreasing the volume of surface runoff, erosion, sedimentation that moves through the system.

Because of the scattered presence of cheatgrass, large scale projects will likely not take place in riparian areas. However, the knowledge that is gained from the treatments will allow successful treatments within riparian zones when deemed necessary. Short term impacts may include damage to native vegetation from overspray or drift.

Mitigation Measures

All herbicide will be applied in accordance with the manufacturer's label.

4.16 Floodplains

No Action Alternative

Impacts to floodplains would be directly related to the condition of the existing vegetation and soils. Both soil and vegetation components must have the ability to retain water and reduce energy as water flows through an area. Although the No Action Alternative would likely lead to an increase in cheatgrass coverage, vegetative cover is the important factor when considering flooding risk. There would be no change to the risk of flooding under this alternative.

Proposed Action Alternative

The objective of the burning and herbicide treatment is to obtain 90% bare mineral soil exposure. Prior to seed germination, these areas would be vulnerable to soil removal and subsequent damage caused by flooding. These risks would diminish as vegetation (regardless of species) reoccupies the site.

Mitigation Measures

The primary risk to floodplains would occur if, following the prescribed burn and herbicide application, seeding is unsuccessful. The exposed soil may then be susceptible to large amounts of soil erosion during rainfall events, potentially damaging (and essentially removing) the floodplain. To mitigate this risk, if seeding is unsuccessful and an area is identified to be at high risk for flooding, steps will be taken to minimize damage to exposed soil. This will be done by placing wattles or other similar features that will facilitate the slowing of the water moving across the surface.

4.17 ACECs / Wilderness

No Action Alternative

Under the No Action Alternative, the proposed actions would not be undertaken. As a consequence it is likely that cheatgrass would proliferate. This would conflict with the goals of many the ACEC designations (i.e., protect and prevent irreparable damage to important natural resources and processes).

Proposed Action Alternative

Impacts to ACEC's from the proposed actions would be similar to those described under the individual resources sections (Recreation, Cultural, Riparian and T&E) described above. Legal restraints would prohibit large scale projects within the wilderness boundaries.

Mitigation Measures

Refer to individual resource section for specific mitigation measures.

5.0 CUMULATIVE IMPACTS

No Action

The potential for large fires would increase, producing greater quantities of emissions than would be created during a prescribed burn. Cheatgrass would create shorter fire intervals and more extensive and more destructive fires. Soil erosion and loss would increase from the increased extent and severity of fires

Native species populations would continue to decrease and the ecosystem would continue to deteriorate with the potential for permanent loss of the shrub-steppe habitat type. Forage values would decrease at the expense of native shrub-steppe vegetative community being placed at risk of permanent loss

Rangeland health and forage conditions for livestock would continue to deteriorate, as well as nesting habitat quality for migratory birds. Wildlife species that depend on the native plant community would be negatively impacted by cheatgrass' increased spread and dominance. The lack of desired plants and bare ground due to the invasion of cheatgrass would increase soil erosion and runoff, which in turn decreases water quality

Long term impacts would include excessive runoff and erosion from upland areas, which would reduce the functionality of riparian zones. Consequently, this would cause additional soil erosion and loss, hindering the proper function of floodplains in the FFO area. The long term impacts of cheatgrass are proliferating. This would conflict with the goals and many of the ACEC designations (i.e., protect and prevent irreparable damage to important natural resources and processes).

Proposed Action

All prescribed burns would be scheduled so that no area would exceed Air Quality Standards or be impacted by smoke for prolonged period of time. Smoke mixing height and winds would be favorable for dispersion of smoke away from populated areas. Prescribed fires would not be conducted during inversions or when smoke would be expected to pool in populated areas.

The FFO would benefit from the knowledge gained from this project in determining the most effective means of controlling cheatgrass. The cumulative effects on soil would be positive as cheatgrass would be controlled, reducing the frequency, extent, and severity of fires. As there would be greater control of the spread of cheatgrass, the upland vegetation and native shrub-steppe vegetative community would be at less risk for loss. Cheatgrass would be controlled and native species of grasses compositions would be reestablished and increase within the project area, along with nesting habitat for ground nesting birds would improve. There would be a decrease in soil erosion and runoff thus water quality would be improved. Wildlife species that depend on the native plant community would be positively impacted by cheatgrass removal.

Treatments around wetlands/riparian zones should increase water infiltration into the upland soils, decreasing the volume of surface runoff, erosion, sedimentation that moves through the system.
In the long term, it is anticipated to decrease the amount of cheatgrass, and increase the density of desirable grass and forb species. This would lead to increased biotic integrity, soil stability, and hydrologic function, enhancing the overall function of the floodplain.

6.0 MONITORING

Monitoring would meet the guidelines of BLM New Mexico Cheatgrass Management Plan (USDI, Bureau of Land Management 2008c) for monitoring management actions. The monitoring plan for this EA would address multiple variables for measuring overall success of the project.

Effectiveness monitoring would be conducted on projects implemented for the selected alternative. Two monitoring methods would be used: 1) an Interdisciplinary Team Fundamentals of Rangeland Health Assessment (USDI, Bureau of Land Management 2001) to be completed four years after the treatment would be performed, and 2) establishment of general rangeland cover/frequency treatment transects within treatment units following the procedures outlined in the 2008 Taos Field Office Fire Program Monitoring Protocol (USDI, Bureau of Land Management 2008d). Re-measurement of each transect would occur post-burn; post-seeding and post chemical application (see Table 5 for specifics).

This monitoring would allow the BLM to determine if the selected alternative and its implementation in each specific project are resulting in movement toward the desired future conditions. Monitoring is anticipated to continue up to four years following implementation of each project. Once all projects have been implemented a summary of monitoring results would be prepared.

Table 5: Possible schedule of treatments for the proposed action.

Block	Monitor	Burn	Monitor	Seed	Monitor	Chemical	Monitor	Chemical	Monitor
A	Pre-burn	8/1-9/15	post burn 9/15	10/7	10/15 for cheat	10/15 with Journey	5/1-6/15 for cheat and seeding	Fall spot or retreat with Plateau	Following mid-spring
B	Pre-burn	8/1-9/15	post burn 9/15	10/7	10/15 for cheat	nothing	5/1-6/15 for cheat and seeding	Fall spot or retreat with Plateau	Following mid-spring
C	Pre-burn	4/20-5/15 when cheat cures; target cheat	post burn 5/15	Pre-monsoon, late June	7/15 for cheat	nothing	5/1-6/15 for cheat and seeding	Fall spot or retreat with plateau	Following mid-spring
D	Pre-burn	4/20-5/15 when cheat cures; target cheat	post burn 5/15	Pre-monsoon, late June	7/15 for cheat	9/1 with Plateau	5/1-6/15 for cheat and seeding	Fall spot or retreat with Plateau	Following mid-spring

7.0 CONSULTATION & COORDINATION

7.1 List of Preparers

Name (and Agency, if other than BLM)	Title	Responsible for the Following Section(s) of this Document
Wendy Hall	Principal Preparer; Fuels Technician	Technical Coordination & Quality Control; Fuels Management; Socioeconomic/Environmental Justice; Vegetation
Barney Wegener	Natural Resource Specialist	Air Resources; Soils; Water Quality
Sherrie Landon	Environmental Protection Specialist/ Paleontology	Paleontology
Stanley Dykes	Rangeland Management Specialist	Invasive Weeds
Janelle Alleman	Outdoor Recreation Planner	Recreation; Wilderness
John Kendall	Wildlife Biologist	T&E/Special Status Species/Migratory Birds
Jim Copeland	Archaeologist	Cultural /Native American Religious Concerns
John Hansen	Wildlife Biologist	Wildlife
Jeff Tafoya	Rangeland Management Specialist	Range/Grazing
Sarah Scott	Natural Resource Specialist	Floodplains; Wetland/Riparian Zones; ACEC's

7.2 List of Persons Consulted

Name (and Agency, if other than BLM)	Title	Responsible for the Following Section(s) of this Document
Darlene Horsey	NEPA Coordinator, Farmington District	NEPA adequacy
EddyWilliams	Weeds and Restoration, New Mexico State Office, BLM	Overall Review
Shelia Williams	Botanist, New Mexico State Office, BLM	Overall Review
Leslie-lynne Sinkey	Public Information Clerk	Overall Review

8.0 APPENDICES

Appendix A: INTERDISCIPLINARY TEAM NEPA DOCUMENTATION TRACKING/REVIEW FORM

Programmatic Cheatgrass EA DOI-BLM-NM-F010-2009-430-EA	JULY 26, 2010

Divisions	Specialist Initials	Date Completed	Comments in document: YES/NO
Wildlife John Hansen	JH	8/27/10	No
T&E Plants/Mig. Birds John Kendall	JK	8/19/10	Yes – added to migratory bird section
Rec./Wild./VRM Janelle Alleman	JCA	8/20/10	no
Soil/Air/Water Barney Wegener	BW	8/19/10	Yes – made changes to Air Resources
Cult./Historic Resource Jim Copeland	JMC	7/26/10	no
Religious Concerns Jim Copeland	JMC	7/26/10	no
Range Jeff Tafoya	JT	9/23/2010	Yes- changes made
Inv./Non-Native Plants Stan Dykes	JT for SD	9/23/2010	NO
Paleo Sherrie Landon	SL	7/27/10	NO
L&RR Branch Chief Dale Wirth	DW	8/18/10	No
NEPA Coordinator Darlene Horsey	DEH	9/14/10	Yes: Rearranged and structured format.

Appendix B. Herbicide Active Ingredient NEPA coverage.

Adapted from Table 2-1 Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States PEIS (2007)

		Northwest Area Noxious Weed Control Program (1985)	California Vegetation Management (1988)	Vegetation Treatment on BLM Lands in 13 Western States (1991)	Western Oregon Program-Management of Competing Vegetation (1992)	17 Western States PEIS (2007)
1	2,4-D	Yes (Esternon-99 DMA-4)	Yes	Yes	Yes	
2	2,4-DP		Yes			
3	asulam		Yes		Yes	
4	atrazine		Yes	Yes	Yes	
5	bromacil		Yes	Yes		
6	chlorsulfuron			Yes		
7	clopyralid			Yes		
8	dicamaba	Yes (Banvel)	Yes	Yes	Yes	
9	diflufenzopyr					Yes
10	diflufenzopyr (in formulation with dicamba)					Yes
11	diquat				Proposed, but not evaluated	Yes
12	diuron		Yes	Yes	Proposed, but not evaluated	
13	fluridone					Yes
14	fosamine		Yes		Proposed, but not evaluated	
15	glyphosate	Yes (Rodeo)	Yes	Yes	Yes	
16	hexazinone		Yes	Yes	Yes	
17	imazapic					Yes
18	imazapyr			Yes		
19	mefluidide					
20	metsulfuron methyl			Yes		
21	picloram	Yes (Tordon 2K, Tordon22K)	Yes	Yes	Yes	
22	simazine		Yes	Yes		
23	sulfometuron methyl			Yes		
24	tebuthiuron		Yes	Yes		
25	Triclopyr	Yes (Esternon-99 DMA-4)	Yes	Yes	Yes	

Appendix C: CHEATGRASS LITERATURE REVIEW

1. History and Occurrence

Cheatgrass was introduced into the U.S. from Europe in the late 1800s from shipping ballasts, contaminated crop seed and packing material. By the early 1900s, cheatgrass had spread to its present range (Zouhar 2003, Stewart and Hull 1949).

Mack 1981 gives the chronology of cheatgrass spread across the United States. He documents cheatgrass entering British Columbia and the Washington/Utah area in 1889-1894 and spreading into Utah and Nevada by 1925. Heavy grazing that began in the 1880s reduced competition from native species and caused soil disturbance that allowed for cheatgrass invasion.

The introduction of cheatgrass to the western United States as early as the 1890s has changed the ecology of the Great Basin by shortening fire recurrence intervals and creating larger fires, which perpetuates cheatgrass expansion. As a result the Great Basin is now characterized by 1) large expanses of monotypic, highly flammable, annual grassland; 2) overly dense sagebrush stands with a meager understory of perennial grasses and forbs or annual exotics, and 3) greatly expanded pinon-juniper woodland with rapidly closing crown canopy and a non-existent understory of perennial grasses and forbs (Miller and Narayanan 2008).

Cheatgrass was first collected in New Mexico during the 1930s and is currently found in 80% of the state's counties. The New Mexico Cheatgrass Management Plan was prompted by an unprecedented surge of cheatgrass expansion in many parts of New Mexico during the spring of 2007 (USDI, BLM NM 2008a).

2. Life Form, Life Cycle, and Competitive Advantages

Cheatgrass is a winter annual that can act as a spring annual if there is little fall moisture (Finnerty, Klingman and Dayton 1962, Stewart and Hull 1949). Cheatgrass can germinate during the fall and is resilient to winter injury. After fall germination, numerous roots grow rapidly. Cheatgrass stops growing when snow comes and continues to grow in the spring. In 5 to 6 weeks, cheatgrass is fully grown. If there is not enough fall moisture, growth is delayed until spring, however growth is greatly reduced. When both fall and spring moisture are lacking, total growth may be only 2 to 3 inches. When both spring and fall are warm and with adequate moisture, growth may reach 24 inches or more (Stewart and Hull 1949).

Cheatgrass is predominately self pollinating (Hulbert 1955).The growth cycle continues through the spring until soil moisture becomes low. Plants turn a purplish-red, then straw yellow when cured.

Cheatgrass is able to adapt to varying precipitation patterns. In southern Idaho, if there is heavy late summer early fall moisture, cheatgrass will rapidly germinate and grow prior to winter dormancy. In southern Idaho, approximately two inches of concentrated rain is required for decent fall growth to occur. This type of rain pattern occurs only once every 3 to 8 years depending on the locations. The lack of fall moisture may prevent growth from starting until spring (Stewart and Hull 1949, Uresk et al. 1979).

If fall rains permit germination but not substantial growth, young plants will grow vigorously with spring moisture following winter dormancy. Late spring rains will cause cheatgrass growth even after the purple

phase (Hull and Pechanec 1947). During drought, cheatgrass will produce less herbage and produce a mature seed crop. When there is a rapid shortage of moisture or sharp drop in temperature, the inflorescence will take on a distinctly purple color. This purple color will fade with more favorable growing conditions or drying (Stewart and Hull 1949). In southern Nevada, germination of cheatgrass can occur with as little as ½ inch of rain compared to an inch that native annuals require (Hull and Pechanec 1947).

Germination typically occurs between October and December (Beatley 1966). Beatley (1966) observed in southern Nevada that when there was sparse moisture in the winter and thus sparse germination followed by substantial spring moisture, vigorous germination of cheatgrass occurred. Mature seeds require low temperatures for germination. Seeds do not germinate in the summer after occasional rains because of the lack of low temperatures. When autumn rains occur, germination is rapid. Emmerich et al. (1993) noted that during years of low precipitation, seedlings of native grasses seem to be favored over the cheatgrass seedlings. Chambers et al. (2005) found that in Nevada and Utah the potential for cheatgrass germination was greater in the spring than in the fall. Lower-elevation sites had greater cheatgrass germination than upper-elevation sites.

Gasch and Bigham (2006) found significant differences in storage duration and germination temperature among populations. These differences may indicate adaptive responses to local environments. Hulbert (1955) found in experiments that all or nearly all seeds will germinate under favorable conditions.

Evan and Young (1970), when investigating cheatgrass germination in western Nevada, observed that when litter was removed there was less moisture and conditions near the soil surface were less favorable for germination of seeds both in the soil and on the surface. They determined that litter that occurs in the later serial stages of succession is essential for establishment of cheatgrass.

Evans and Young (1984) noted that bare soil is not conducive to germination of cheatgrass. Bare ground is hotter and drier than when there is plant litter on the ground.

Evans and Young (1972), when investigating the differences in seed bed preparation for germinating cheatgrass, observed that seedling emergence and growth was favored by seed burial, pitting of the soil surface, and soil movement.

Complete germination of cheatgrass does not occur in one year. Species planted in cheatgrass areas will experience competition from cheatgrass unless all cheatgrass plants are killed and seed production is prevented during the year of seeding (Hull and Hansen 1974).

Mack and Pyke (1984) in eastern Washington observed that cheatgrass possesses attributes that allow the species to respond within seasonal variations in precipitation and temperature. Cheatgrass has the capacity to germinate in large numbers any time of year by capitalizing the on timing of available moisture. There are potentially five different periods that cheatgrass may emerge depending on moisture patterns: 1) initial germination may occur in late August following summer rains, or 2) emergence may occur during September/October following fall rains. On dry sites, 3) emergence may occur in November if moisture becomes present. On moist sites, 4) 30% of the recruitment may occur during the winter, January/February, if there is the absence of snow, and 5) with spring rains, plants can emerge as late as mid-May. Recruitment is concentrated in the late summer and autumn. Low death risk was observed in plants that germinated during fall-spring. Plants emerging in late summer were devastated during drought. Most plants survived to produce seed. Highest mortality occurred during September while temperatures

remained relatively high if no additional moisture occurred. Mortality rates declined during the cooler winter months (October to December) due to the decrease in evapotranspiration. Spring showed the lowest mortality rates due the cooler temperatures and greater soil moisture.

Meyer and Allen (1999a) and Meyer et al. (1997) studied germination response and possible genetic influence. Results indicated that seed germination regulation in this species is probably under strong genetic control, and that habitats with temporally varying selection are occupied by populations that tend to be more polymorphic in terms of their germination response patterns. Populations from extreme environments showed less variation among families than populations from less predictable cold desert, foothill and plains environments.

Rutledge and Mclendon (1996) noted several characteristics of cheatgrass and soils. Cheatgrass tends to grow on sandy or gravely soils and does not grow well on heavy soils, or soils with high salts. Cheatgrass is capable of creating in excess of 300 seeds/plant, and plants as small as 2.5 cm (1in) are capable of producing seed. Seeds may remain viable for 2 to 5 years.

Driscoll (1964) found that in the central Oregon juniper zone, cheatgrass was the most abundant species in the Juniperus/Purshia/Agropyron association and made up one-third of all vegetation cover, whereas for the Juniperus/Artemisia/Agropyron association, less than one percent of vegetative cover consisted of cheatgrass. He attributed the difference in cheatgrass abundance between the two associations to be related to soil characteristics and thus water availability. The Juniperus/Artemisia/Agropyron was associated with non-stony and clayey soils that restricted root penetration, thus stored water was as unavailable to cheatgrass compared to the coarser and stonier soils.

The roots of cheatgrass are able to penetrate caliche layers (layers of soil consisting of lime, calcium carbonate, and generally hard) providing a competitive advantage for soil moisture (Hulbert 1955).

Density of cheatgrass plants averages 600 plants per square foot and can be up to 1,400 plants per square foot (Hull and Pechanec 1947). Monocultures of cheatgrass have been observed with up to 900 plants per square foot (Young and Evans 1978).

Brown and Rowe (2004) found that at the high elevations of Rocky Mountain National Park germination response was adaptive. The higher elevation plants germinated at a higher percentage than lower elevation plants.

In Utah, Beckstead et al. (1995) collected seeds of cheatgrass and tested after-ripening temperatures of cheatgrass and squirreltail (*Elymus elymoides*) in dry storage. Study results showed that cheatgrass has an ecological advantage over native species with the ability to germinate with a higher after-ripening temperature (dormancy) requirement of 68-86 degrees Farenheit. This allows cheatgrass to geminate in the fall while native species need the cooler temperatures of winter.

The flower of cheatgrass is a panicle form with irregular flowering from individual stalks. These stalks will change color from green to purple as the plant reaches maturity. Spikelets have awns and can be up to two inches long and drooping. Leaves are light green and hairy. Mature plants range from 4 to 30 inches tall. Stems are erect, slender, glabrous, or slightly hairy. Roots are finely divided and reach up to 12 inches in depth (Colorado Weed Management 2009).

Cline et al. (1977) found that the bulk of the root mass for cheatgrass was in the top 4 to 8 inches of soil whereas the bulk of bluebunch wheatgrass (*Agropyron spicatum*) roots are in within 10 to 16 inches of soil depth. Because the bulk of the root mass for cheatgrass was shallow, cheatgrass was able to monopolize the moisture in the upper soil. Cheatgrass had most of its roots in the upper portions of the soil profile whereas the sagebrush-bunchgrass community had roots significantly lower into the profile. Consequently, during years of above average precipitation, the sagebrush-bunchgrass is able to exploit the moisture lower in the soil profile. Conversely cheatgrass, during years of below average precipitation, is able to exploit the limited soil moisture in the upper profile.

The roots of cheatgrass seedlings will continue to grow through the winter months while above-ground growth is dormant. In contrast the roots of perennial grasses, such as bluebunch wheatgrass (*Agropyron spicatum*) do not begin to germinate until spring (Harris 1977). Therefore, cheatgrass is able to out-compete perennial grasses because of rapid maturity and development of a deep root system (Hulbert 1955).

In northern Nevada, Melgoza and Nowak (1991) and Melgoza et al. (1990) studied root competition between cheatgrass and two native species, needle-and-thread grass (*Stipa comate*) and rabbitbrush (*Chrysothamnus viscidiflorus*) and found that cheatgrass' aggressive root system was able to out-compete the native species by utilizing soil resources that would otherwise be used by the native species.

Beatley (1966) found cheatgrass tends to grow predominately in deep sandy soils associated with big sagebrush (*Artemisia tridentata*) as well as shallow soils associated with the big sagebrush-pinyon-juniper woodlands. Cheatgrass thrives where there is disturbance, especially where new roads have been constructed.

Novak et al. (1991) conducted genetic analysis of cheatgrass populations across the United States. The results of their analysis suggest that cheatgrass more than likely was introduced on multiple occasions and more than likely from one of two sources: the western Mediterranean region or central Europe. Overall genetic diversity within populations was low due to the isolated nature of the populations. However, among the different populations, there was a higher level of genetic diversity. Although the overall genetic diversity for the cheatgrass populations was relatively low, this species has been able to adapt to a wide variety of arid environments.

3. Fuels Management and Fire Ecology

3.1. Fuel Models

Cheatgrass can be classified in the Scott and Burgan (2005) standard fire behavior fuels models as GR2 (102) Low Load, Dry Climate Grass and GR4 (104) Moderate Load, Dry Climate Grass (which represents cheatgrass without shrubs) or GS2 (122) Moderate Load, Dry Climate Grass-Shrub (which represents the cheatgrass-shrub fuel model).

3.2. Changes in Fuels

Brooks (1999) studied eight annual species and their influence on fire spread in the Mojave Desert. He found that cheatgrass was the only species, native or non-native, to become abundant enough in the

interspaces to promote fire spread and accumulation. Furthermore, litter accumulation led to hotter temperatures, longer flame residency, and more continuous burn patterns than other species during experimental burns.

Stewart and Hull (1949) noted that cheatgrass creates a fire hazard, not only when it is the dominant species, but also when it is interspersed with other vegetation. Cheatgrass matures and dries 4 to 6 weeks earlier in the summer than do the native perennials and creates conditions for burning into to the fall 1 to 2 months later. Cheatgrass changes in flammability as it changes color, from green to purple to straw indicating the stage of burning condition (Mutch 1967).

The annual characteristic and large quantity of above- and below-surface growth contributes quick additions of organic matter in the surface soil. Cheatgrass fires frequently spread into areas where there was no cheatgrass previously, creating conditions for its spread (Stewart and Hull 1949).

Link et al. (2006) performed a risk assessment of the Saddle Mountain National Wildlife Refuge in Washington State related to cheatgrass cover. They found that when cheatgrass cover was over 45%, fire risk was 100% when an ignition source was present.

Young and Evans (1978) sampled vegetation following three wildfires in serial big sagebrush/Thurber needlegrass north of Reno, Nevada. Cheatgrass was the most common herbaceous species the first season after the fire. Although the number of cheatgrass caryopses (seeds) was greatly reduced following the fire, those that remained responded vigorously to the open environment. With this response following the wildfires, cheatgrass is able to fuel its own fire dynamics by providing the accumulation of fine herbage that ignites and carries wildfire to the widely-spaced sagebrush plants.

3.3. Fire Regime

Cheatgrass in the Great Basin has changed the natural fire regime by increasing the fine dead fuel load. This increase has led to extensive and disastrous wildfires. The unintentional introduction of cheatgrass has led to ecosystem and fire regime changes that increase the size and potential for hazardous wildfires. These changes put the shrub steppe ecosystem at risk of being converted to unproductive annual grasslands with subsequent loss in native plant and animal diversity (Billings 1994).

Schmidt et al. (2002) describe how cheatgrass has changed the fire regime from a 35-100+ year frequency with mixed severity to a 0-35 year frequency, with a low severity, moderately altering conditions from the historic range.

Fire Regime Condition Class (FRCC) is a quantitative measure of the degree of departure from historical fire regimes resulting in the alteration of key ecosystem components, including species composition, structural stage, canopy closure and fuel loadings. The invasion of cheatgrass creates a FRCC of 2 and is characterized by 1) fire regimes moderately altered from the historic range, 2) moderate risk of losing key ecosystem components, 3) fire frequencies that have departed from historical frequencies by one or more intervals, 4) vegetation attributes that have been moderately altered from their historical range, and 5) there is a potential for development to a FRCC of 3 to be created if shrub die-off occurs. Areas in a FRCC of 2 may need moderate levels of restoration treatments, such as fire use and hand or mechanical treatment to be restored (Schmidt et al. 2002, Hardy et al. 2001).

3.4. *Fire Interval*

Introduction of cheatgrass to Idaho's Snake River Plain in the Great Basin changed fire intensity and extent due to the increased fuel loads and distribution of fine dead fuels that cheatgrass creates. Fire intervals (time between fire occurrence) have shortened, changing the distribution of many species that depend on the shrub steppe ecosystem (Peters and Bunting 1994).

Roberts (1994) described the impacts that cheatgrass had on fuel bed, fire regime, and fire rehabilitation. He noted that in the Salt Lake District of the Bureau of Land Management, cheatgrass fires tended to be self-perpetuating. Fire created conditions favorable for cheatgrass invasion. Once an area was invaded, the uncharacteristically fine dead fuel bed that cheatgrass created increased fire hazard and decreased the interval between fires. The fine dead fuel bed also increased the extent of fire spread. Thus, with each fire occurrence, the size of area favorable for cheatgrass invasion increased. Areas that did not have the presence of cheatgrass prior to a burn did not require as extensive rehabilitation as areas that had cheatgrass present.

Whisenant (1990) described the changes in fire frequencies on the Snake River Plain. Fire-return intervals in the sagebrush-steppe historically varied between 60 and 110 years. However, with the invasion of cheatgrass and the creation of a more continuous fuel bed, much of the region now burns at intervals of less than 5 years.

4. Potential Impacts to Wildlife

Dobler (1994) conducted a range condition and bird species occurrence study in the Columbia Basin of eastern Washington. Study results showed that range condition was positively correlated with bird and plant diversity. In areas dominated by annual grasses (specifically cheatgrass) four bird species were negatively correlated (reduced in presence); brewer's sparrow (a federally listed species of concern), sage thrasher, sage sparrow, and brown-headed cowbird. Thus, management that reduces annual grasses such as cheatgrass will prevent the loss of important bird species.

Vander Haegen et al. (2000) compared abundance of bird species among soil types and range conditions in the shrub-steppe landscape. Where cheatgrass had invaded, replacing the perennial grass component, several songbird species became parasitized by brown-headed cowbirds.

Knick and Rotenberry (2000) found a negative correlation between bird species occurrence and the presence of cheatgrass. Bird habitat in the Great Basin and Upper Snake River Plains is undergoing large-scale change and loss of habitat because wildfires are changing shrub lands to exotic annual grasslands. There have been significant declines of bird species that depend on the shrubsteppe habitats such as horned larks, western meadowlarks, and Brewer's sparrows.

Roberts (1991) pointed out the indirect negative impact of cheatgrass invasion and loss of habitat on prey species available for eagles. When cheatgrass invades there is a subsequent loss of the shrub and forb component from the vegetative community. Prey species such as rabbits depend on these species as forage, and loss of this forage base negatively impacts the rabbit population. Bald eagles in the winter and golden eagles year round are thus negatively impacted with the loss of this valuable prey base.

5. Effective Control and Re-vegetation

Removal of cheatgrass during the early successional stages (where invasion is not extensive) prevents having to destroy large amounts of cheatgrass. Successive years of cheatgrass removal prevents dominance (Piemeisel 1951).

Carpenter and Murray (1999) state that lasting control of cheatgrass will require a combination of chemical, physical, vegetative, and livestock management for effective control. Cheatgrass will require two to three year combinations of treatment in order to reach objectives.

Rafferty and Young (2002) found that in the Great Basin some form of cheatgrass control is required for needlegrass establishment to succeed. Control has to be almost complete, rather than density reduction.

5.1. *Biological Controls*

Meyer et al. (2008) studied three potential biological control organisms 1) head smut pathogen (*Ustilago bullata*) 2) chestnut bunt pathogen (*Tilletia fusca*) and 3) black-fingers-of- death (*Pyrenophora semeniperda*). Head smut and chestnut bunt pathogen are host-specific whereas black-fingers-of-death does not appear to be host-specific. Both head smut and chestnut bunt infect at the seedling stage while black-fingers-of-death kills seeds in the seed bank. Meyer et al's results showed that a combination of all three pathogens showed promise at controlling cheatgrass.

Due to the competitive nature and adaptability of cheatgrass roots, Skipper et al. (1996) hypothesized that effective control of cheatgrass will require an agent that limits germination and root growth of cheatgrass seedlings.

Kennedy (1994) conducted experimental trials in Eastern Washington to evaluate the effects of inhibitory bacteria on cheatgrass. *Psedomonas fluoreces* strain D7 applied to the soil surface reduced seed production up to 64% and above-ground growth up to 50%. D7 slowed down root mass accumulation by cheatgrass and reduced its competitive ability. Kennedy (1994) further stated that a combination of a biological control agent and a herbicide may significantly reduce infestations of cheatgrass.

As part of the BLM Restore New Mexico initiative, the strategic plan for cheatgrass recognizes that further research needs to be conducted to successfully control cheatgrass in the long term. Furthermore, this strategy depends on adaptive management. Thus, the Bureau would participate in, and assist with research to help establish the best management practices and treatments for controlling cheatgrass in New Mexico.

5.2. *Browse Seeder-Scalper*

Giunta et al. (1975) explored the use of various browse seeder-scalpers to reseed four browse species in a dense stand of cheatgrass. They found that a 24 to 30 inch browse seeder-scalper proved successful in terms of survival of shrubs. The effect of scalping on cheatgrass density was most evident during the growing season immediately following planting. Scalping provided for release from competition during the critical first year of seedling growth.

5.3. *Burning*

Keeley and McGinnis (2007) looked at the timing of prescribed fire for controlling cheatgrass and found that altering burning season to coincide with seed maturation (usually during spring) did not control cheatgrass due to sparse fuel loads generating low fire intensity. However, Stewart and Hull (1949) pointed out that burning in the early spring allows for reseeding of perennial grasses.

Rasmussen (1994) noted that since cheatgrass thrives when burned; prescribed burning should only be used as a means of seed bed preparation for revegetation methods.

5.4. *Chemical Control*

Currently the following chemicals approved for use by the BLM under NEPA approval are as follows: 2, 4-D, 2, 4-DP, asulam, atrazine, bromacil, chlorsufuron, clopyralid, dicamba, diuron,diquat, diflufenzopyr, flurideone, fosamine, glyphosate, hexazinone, imazapyr, imazapic, metsulfuron methyl, picloram, sulfometuron methyl, tebuthiuron, triclopyr, mefluidide, and simazine (see table in Appendix B).

Only those chemicals that have been approved under the 17 Western States Programmatic Environmental Impact Statement (USDI, Bureau of Land Management, 2007) and by subsequent NEPA approval will be used for treating cheatgrass. The following is a summarization of the literature containing information on the use of herbicides to treat cheatgrass. Thus, information on herbicides that have not been approved for use in the BLM is presented as background information purposes only.

Plateau (Imazapic)

Plateau is a broad-spectrum herbicide discovered by BASF. Plateau selectively controls annual and perennial broadleaf and grass weeds, and may be applied at rates up to 0.188 lb a.e./A for control of invasive grass and broadleaf species such as cheatgrass (BASF 2006).

Plateau is an imidazolinone herbicide that is readily absorbed through leaves, stems, and roots and is translocated rapidly throughout the plant, with accumulation in the meristematic regions. Treated plants stop growing soon after spray application. Chlorosis spears first in the newest leaves, and necrosis spreads from this point. Chlorosis and tissue necrosis may not be apparent in some plant species for several weeks after application. Complete kill of plants may not occur for several weeks after application, and adequate soil moisture is important for optimum Plateau activity. When adequate soil moisture is present, Plateau will provide residual control of susceptible germinating weeds. Activity on established weeds will depend on the weed and rooting depth. Plateau will control annual and perennial grasses and broadleaf weeds and vine species. This product may be applied either pre-emergence or post-emergence. For maximum activity, weeds should be growing vigorously at the time of post-emergence application and the spray solution should include an adjuvant. Plateau may be applied in the dormant or growing season for weed control (Deneke et al. 2007, BASF 2004).

Plateau is a selective herbicide for both the pre and post-emergent control of some annual and perennial grasses and some broadleaf weeds. Plateau kills plants by inhibiting the production of branched-chain amino acids, which are necessary for protein synthesis and cell growth. Plateau is relatively non-toxic to terrestrial and aquatic mammals, birds, and amphibians. Plateau has an average half-life of 120 days in

soil, and is rapidly degraded by sunlight in aqueous solution, but is not registered for use in aquatic systems (Tu et al. 2001).

Plateau is the only herbicide to provide both pre-emergent and post-emergent control of annual invasive weeds as well as residual control of annual bromes. Since Plateau controls emerged seedlings and prevents new seedlings from germinating, Plateau effectively reduces re-infestation and re-treats. Plateau has shown up to 100 percent control of cheatgrass when applied in the fall (BASF 2003a).

Plateau is considered a "Smart Herbicide" that controls cheatgrass while allowing native plants to flourish. Plateau attacks a specific enzyme found only in plants to control growth, especially if used in conjunction with a competitive plant re-seeding program. Fall is the ideal season for proactive chemical treatment of cheatgrass, since it occurs before germination. It is recommended that Plateau be applied at 2 to 8 oz/acre, if burning has consumed the majority of the carbon residue, and prior to cheatgrass emergence. If cheatgrass has grown beyond the four leaf stage or is beginning to tiller, it is recommended that Plateau be applied at 6 oz/acre with a surfactant (such as glyphosate at 12 oz/acre). Cheatgrass must be actively growing to achieve acceptable results (BASF 2003b).

For annual weeds, post-emergent herbicides are more effective on newly-emerged seedlings. Plateau (imazapic) should be applied in the fall before cheatgrass germinates. Perennial grass tolerance varies. Best application of Plateau is during late summer to early fall before it perennial grasses have emerged (Dewey 2006).

Results from the first year and a half of treatments on the Kolob Fire restoration project indicated that 1) a significant reduction in brome biomass was found at the pinyon-juniper Kolob Terrance Road site from both the imazapic and native seed application, 2) although treatment with imazapic did not show a significant reduction in brome biomass at the Dalton Wash grass/shrub land site, there was significant reduction on all non-native biomass (Fuhrmann, personal communication 2008).

Vollmer and Vollmer (2008) found that the application of Plateau herbicide prior to annual brome germination at rates up to 8 oz/acre--with or without surfactant--gave acceptable annual brome reduction without adverse injury to true mountain mahogany.

Plateau is not a restricted use product and is only slightly toxic (PAN Pesticide Database). Plateau is a broad-spectrum herbicide that selectively controls annual and perennial broadleaf and grass weeds (BASF 2006).

Journey (Glyphosate and Imazapic)

Journey (glyphosate and imazapic) can be applied pre-emergence or during early post-emergence in the fall, and is designed for winter annuals. Journey is effective as a site preparation weed control prior to re-vegetation. Journey is very effective on cheatgrass (Dewey 2006).

Journey should be applied in late summer or fall before cheatgrass emerges and prior to planting desirable species. Journey cannot be used after newly seeded desirable species have begun to emerge. Spring applications of Journey can increase consistency in cheatgrass control (Menalled 2006).

Journey controls post-emergent activity, suppresses seed head production, and provides residual control of annual and perennial grasses and broadleaf weeds. It can be applied to post-emergence plants up to four inches tall (BASF 2008).

Journey is not a restricted use product and is only slightly toxic (PAN Pesticide Database).

Glyphosate +2,4 D and Quizalofop

Weise et al. (1995) performed experiments near Amarillo, Texas, to determine the most cost-effective means and the minimum application rate to obtain 95% or better control of three weedy species, including cheatgrass. For cheatgrass, quizalofop at 18 g ai/ha and glyphosate + 2,4 –D at 582 +950 g ae/ha was the minimum requirement to obtain at least 95% control.

Glyphosate is a broad-spectrum, nonselective systemic herbicide used to control annual and perennial plants. Glyphosate is moderately toxic and is an EPA toxicity class II (www.extoxnet.orst.edu)

2, 4 D is a selective herbicide that controls weeds (www.24d.org). 2, 4 D is a general use pesticide that controls many types of broadleaf weeds and in salt form is slightly toxic (Extension Toxicology Network).

Quizalofop is a general use pesticide used to control annual and perennial grass weeds. Quizalofop is a slightly toxic compound in EPA toxicity class III.

Glyphosate

Whitson and Koch (1998) conducted herbicide studies to control cheatgrass in Wyoming. They found that glyphosate, applied two consecutive years at 0.55 kg/ha and combined with intensive grazing, provided over 90% cheatgrass control. Grazing was necessary to remove seed heads.

Paraquat

Whitson and Koch (1998) also conducted herbicide studies on the use of paraquat to control cheatgrass in Wyoming. They found that paraquat, applied two consecutive years at 0.6 kg/ha and combined with intensive grazing provided over 90% control of cheatgrass. Grazing was necessary to remove seed heads.

Evans et al. (1967) found that applying paraquat at 0.5 lb/A and higher gave adequate and consistent control of cheatgrass allowing for establishment of perennial grasses. Seeding in furrows combined with paraquat spraying or disking gave best seedling establishment.

Paraquat is a restricted use pesticide and is a highly toxic compound in EPA toxicity Class I. It is used for broad leaf weed control. It is quick acting and a non-selective compound (Extension Toxicology Network, Pesticide Information Profiles).

Siduron and Pilcloram

Young and Evans (1970) found that, in field trials in Nevada and Northern California, pre-emergence applications of 3 lb/A of siduron and 0.3 lb/A of picloram sufficiently reduced cheatgrass competition so that intermediate wheatgrass (*Agropyron intermedium*) could successfully become established. The technique

was only successful on semi-arid range sites with above-average soil moisture and moderately dense stands of weed grasses.

Pilcloram is a systemic herbicide that controls a wide range of broad-leaved weeds. It is a restricted use pesticide and is slightly toxic (Extension Toxicology Network, Pesticide Information Profiles).

Chemical Fallow (Atrazine or Pilcloram)

Chemical fallow is a fallow system in which no tillage is practiced; herbicides are used for vegetation control.

Eckert and Evans (1967) found chemical fallow to be effective if 1) after fall application, the herbicide remains active in the soil to control weed species in late winter or early spring, and 2) at the time seeded species germinate (usually 1.5 years after treatment) the herbicide had either broken down or leached or both, and toxicity to perennial seedling is minimized. A desirable herbicide should control a broad spectrum of weeds and dissipate rapidly after weed control is accomplished.

Eckert et al. (1974) found that the degree of success of the atrzine-fallow technique for seeding perennial grasses on cheatgrass-infested rangelands depended on uniform application of herbicide, amount and timing of precipitation during the fallow and seedling years, weed population, site potential and depredation.

Evans and Young (1977) evaluated various chemical weed control techniques. They explored the use of 2, 4-D, atrazine, and picloram in controlling cheatgrass. The atrazine follow technique was successful at controlling pure stands of cheatgrass, but was not effective at controlling cheatgrass under shrubs. Using a broadleaf herbicide, such as picloram or 2, 4-D, in conjunction with atrazine was effective at controlling cheatgrass in shrub communities.

Atrazine is a restricted use pesticide used to control broadleaf and grassy weeds. Atrazine is toxicity class III, slightly toxic.

5.5. *Defoliation/Clipping*

Hempty-Mayer and Pyke (2008) found that the most effective defoliation treatment was clipping plants twice to a height of 2.5 cm (1 in.) once when plants were in the boot stage (the seed head is immature and still within the sheath) and again approximately two weeks later when the majority of plants were in pre-boot and post-boot stages. A single defoliation to 2.5 cm (1 in.) at purple stage is effective, but not when accomplished by grazing. While grazing, livestock cause disturbance that may disperse viable seeds, whereas when clipped the plants are collected removing the seeds.

5.6. *Mechanical*

Mattise and Scholten (1994) explored the various means of mechanical control for undesirable annual plants, including cheatgrass. Chaining or cabling may effectively control cheatgrass; however, control often requires several tillages. Tillage should be 4 to 6 inches deep to bury the undesirable plants and seed bank to prevent their growth or germination. Furthermore, chaining or cabling greatly increases erosion unless there is a deep soil profile.

Finnerty and Klingman (1962) mowed cheatgrass present in alfalfa and wheat fields as a control measure. They found that mowing of cheatgrass, for two successive years, approximately one week after the heads had emerged from the sheath (preventing seed production) effectively controlled cheatgrass. Cheatgrass plants can also be killed when mowed near the ground as soon as purple coloration began to develop in the inflorescences (Hulbert 1955).

Tu et al. (2001) stated that mechanical control methods can be successful, but work best if the population is relatively small.

5.7. *Grazing*

Emmerich et al. (1993) observed that on a private ranch where cheatgrass was deliberately grazed, winter grazing reduced excess cheatgrass herbage and the seed source of the dormant perennial grasses was protected. Hull and Pechanec (1947) found that continued over-grazing prevents seed production and reduces the number and height of plants. Spring growth is also slower.

Ruyle and Young (1997) found that during years of adequate precipitation, cheatgrass can be a valuable forage plant. Grazing should be concentrated during the active growing period. Cheatgrass has one-fifth of the digestible protein content of average alfalfa hay. Unless *heavily* grazed, cheatgrass will produce enough seed to assure a good stand the following year.

Mosley and Roselle (2006) described the benefits of grazing in controlling and reducing the negative impacts of invasive species, including cheatgrass. Grazing can disrupt fine fuel continuity, reduce fuel loads, and increase the length of fire interval. Grazing during the winter can reduce the buildup of annual grasses and promote perennial grasses reseeding. However, perennial grasses may be adversely affected if spring grazing is conducted two or more years in a row. They noted that the benefits of grazing tend to be localized and that grazing, in conjunction with restoration techniques such as prescribed burning, herbicides, and seeding, can be successful in restoration of range lands.

Taush et al. (1994) conducted simulated grazing in Nevada to determine potential impacts on cheatgrass production. Clipping was performed in fall and early spring, early spring only, and late spring. Cheatgrass production increased with fall clipping and decreased with both spring clippings, with the greatest reduction in density and biomass occurring with late spring clipping. The late spring clipping may have had the greatest impact on cheatgrass since clipping occurred just prior to complete seed maturation.

Tipton (1994) observed that on the T Quarter Circle Ranch, in areas that were on an intensive short-term rotational grazing system, cheatgrass was reduced and the preferred perennial vegetation was favored. In order for grazing to successfully reduce cheatgrass, pastures need to be uniform and adequately fenced, with adequate water distribution.

In the grasslands of southern interior British Columbia, Tisdale (1947) found that in overgrazed areas cheatgrass was dominant, whereas areas that were moderately grazed were occupied by native grasses of the Stipa-Poa-Agropyron association.

5.8. *Seeding Native and Non-native Species*

Several examples in the literature were found that provide evidence that planting of both native and non-native species are capable of successfully competing against cheatgrass.

Stumpf et al. (1996) analyzed restoration efforts at two national monuments. They found that formerly-cultivated areas that had been prescribed burned and then seeded with native species had significantly lower amounts of exotic cool season grasses, including cheatgrass, and that growth of native warm season grasses was promoted.

Hironaka and Tisdale (1963) noted that in order for conversion from cheatgrass to native perennial grasses to take place, several requirements must be met, including an ample seed supply of the native species. Species seeded also need to be able to withstand cheatgrass competition during seedling stage, and seedlings must be protected from livestock damage.

Klomp and Hull (1972) conducted experimental seeding of three perennial wheatgrasses; crested (*Agropyron desertorum*), fairway (*A. cristatum*) and Siberian (*A. sibiricum*) in southern Idaho. They tested numerous combinations of drilling methods, times of year, and cheatgrass germination stages. Results showed that deep furrow drilling in the fall gave the best stands, followed by fall cultivation and drilling and then by summer fallow and drilling.

Stewart and Hull (1949) stated that crested wheatgrass, when sown with a drill in furrows 1½ to 2 inches deep and covered with soil, germinated well. Once crested wheatgrass established itself it began to crowd out cheatgrass. Uniform stands of crested wheatgrass kept cheatgrass from establishing as long as the openings between plants were not more than 2 feet.

Ott et al. (2003) found that aerial seeding of grass and forb species, followed by chaining, successfully suppressed cheatgrass. Chaining was necessary as a modification of soil properties and for seed burial.

Palazzo et al. (2003) found that introduced grasses established more quickly at both the Yakima Training Center and Fort Drum military facilities when attempting to rehabilitate disturbed lands that have been invaded by cheatgrass. Introduced grasses in their study included crested wheatgrass (*Agropyron cristatum*), desert wheatgrass (*A. desertorum*), Siberian crested wheatgrass (*A. fragile*) and intermediate wheatgrass (*A. intermedium*). These introduced grasses established quicker than the native grasses and served as short-term ecological bridge to establish native species. The non-natives provided interim protections until the natives became established.

Aguirre and Johnson (1991) studied planting seeds of Hycrest (a hybrid crested wheatgrass *Agropyron cristatum* X *A. desertorum*), Whitmar bluebunch wheatgrass (*Pseudoroegneria spicata*) and cheatgrass, at three planting densities to determine cheatgrass competition on seedling shoot and root development. Results showed that cheatgrass developed and elongated roots earlier and at colder temperatures (10/5 degrees C) than Hycrest or Whitmar. Hycrest had a greater absolute growth than Whitmar, thus Hycrest seedlings would compete earlier and more effectively than Whitmar seedlings.

Whitson and Kock (1998) measured the amount of cheatgrass control when perennial cool-season grasses were seeded in the spring and then received fall tillage. Three of the five species were effective in reducing the reestablishment of cheatgrass. Luna pubescent wheatgrass (*Thinopyrum intermedium*) controlled

cheatgrass 100%, Hycrest crested wheatgrass (*Apropyron cristatum X A. desertorum*) controlled cheatgrass 91%, and Sodar streambank wheatgrass (*Elymus lanceolatus*) controlled cheatgrass 85% of the time.

Brooks (2005) found that effectiveness of seeded species may not be apparent the first two post-treatment years. Disturbance from tilling the soil for seeding increased the presence of cheatgrass.

Robertson and Pearse (1945) looked at reseeding projects over a five year period in Utah, Nevada, and southern Idaho. Their study results indicated that sufficient disturbance (such as burning) to open the cheatgrass community was necessary for reseeding to be successful.

Floyd et al. (2006) found that seeding without herbicide did not change cheatgrass density. Seeding mitigation post-wildfire did not prevent the spread of cheatgrass, and suggested the use of chemicals with seeding.

Anderson et al. (1992) looked at the ability of mountain rye (*Secalse mantanum*) to suppress cheatgrass. Mountain rye significantly reduced growth and reproduction of cheatgrass during the first two growing seasons but did not persist in being effective at controlling it after the second year. When grown in competition, mountain rye growth during a six-week period exceeded both Hycrest crested wheatgrass and cheatgrass (Buman et al.1988).

Francis and Pyke (1996) conducted plant competition experiments to control cheatgrass. They found that Hycrest and desert wheatgrass (*Agropyron desertorum*) were able to compete with cheatgrass, with greater biomass and tiller production than cheatgrass.

Evans and Young (1978) evaluated several rehabilitation practices following a wildfire near Reno, Nevada, where cheatgrass had dominated the area prior to the wildfire. Results indicated that seeding crested or intermediate wheatgrass the first fall following the wildfire was successful at preventing cheatgrass from re-dominating the site.

Goodwin et al. (1996) found that Idaho fescue (*Festuca idahoensis*) seeds were slower to germinate than cheatgrass. As a consequence, Idaho fescue seedlings are very unlikely to out-compete cheatgrass seedlings. Harris (1967) found that cheatgrass out-competes bluebunch wheatgrass (*Agropyron spicatum)* by having a greater root-growth ability as a seedling. Due to its root-growth ability, cheatgrass is able to monopolize the available moisture. However, Harris and Wilson (1970) found that desert wheatgrass (*A. desertorum*) was able to outcompete cheatgrass with its root elongation ability.

Squirreltail (*Elymus elymoides*) is thought to be a promising species in the restoration of cheatgrass areas in cold deserts and semiarid habitats, based on its germination characteristics and rapid reproductive maturity, growth rates and fire tolerance. Second year seedlings of squaretail were able to effectively compete with cheatgrass (Humphrey and Schupp 2004). Ledger 2008 found that big squirreltail (*Elymus multisetus*) showed ability to compete on cheatgrass-invaded sites.

Prostrate kochia (*Kochia prostrate)* native to arid and semiarid regions of central Eurasia, is well adapted to the soils and climate of sagebrush communities in the western United States. Kochia successfully germinates regardless of method of seeding or season in monocultures of cheatgrass. Kochia competes well and can persist for many years in cheatgrass stands (Monaco et al. 2003).

6. Ecological Impacts

Cheatgrass has the potential to be detrimental to biological crusts by increasing the presence of live plants, litter, higher cover of plant material, shading the soil surface and increasing fire frequency which is detrimental to the bryophytes (Belnap et al. 2001). Deines et al. (2006) found that the maintenance of lichen-dominated biological soil crusts, compared to bare soil, reduced cheatgrass germination and root penetration by 85%.

The degree of disturbance determines the extent of cheatgrass's ability to invade and dominate a vegetative community. In habitats that are undisturbed, cheatgrass is a minor component of the plant community (Hulbert 1955). Pickford (1932) studied the percent cover of cheatgrass and other vegetative species in Utah near the Great Salt Lake. The influence of fire, grazing, fire combined with grazing, and natural (undisturbed) conditions on percent cover were compared. Results indicated that cheatgrass comprised 22% of the cover vegetation in the burned areas, 15% in the grazed, 38% of the burned and grazed, and only 4% in the natural areas. Changes in the plant cover due to fire and grazing have caused a reduction of over 50 percent in the grazing capacity of the spring-fall range. However, Hunter (1991) suggests that, due to the spread of cheatgrass at the Nevada Test Site (US Department of Energy) in the absence of disturbance, that cheatgrass is able to spread because it is biologically adaptable.

Conversion of native vegetation to cheatgrass-dominated annual grasses has been accelerated by un-controlled grazing and wildfires (Sparks et al. 1990). Recurrent fires and misuse destroy native sagebrush and grass communities and allow cheatgrass to invade and take over the plant community (Stewart and Hull 1949).

Cheatgrass invasion has been prompted by disturbance of soils and native vegetation. Bradford and Lauenroth (2006) modeled the role of disturbance on the influence of cheatgrass invasion. Their models indicated that the *frequency* of disturbance had a greater influence on cheatgrass invasion, more so than the *magnitude* of the disturbance.

Whittaker et al. (2008) studied the effects of disturbance on soil water availability and cheatgrass competition for soil moisture. They concluded that seasonal precipitation and weather conditions may be more important to cheatgrass invasion than disturbance.

Meyer et al. (2001) simulated grazing disturbance and the effects of cheatgrass invasion by clipping shrubs, trampling soil crusts, and a combination of both disturbances near Dugway Valley, Utah. Their results showed that disturbance had less of an effect on cheatgrass establishment during drier, less favorable, years. Where cheatgrass did not invade disturbance was limited and precipitation sporadic.

Cheatgrass is considered to be indirectly favored by overgrazing. Overgrazing of aerial shoots of perennials such as bluebunch wheatgrass causes the underground roots to become weak due to the lack of photosynthesis (Daubenmire 1940, 1942). If overgrazing persists, the plant dies off, allowing for invasive species such as cheatgrass to take over (Daubenmire 1940, Young and Evans 1973). Although heavy grazing prevents seed maturation of green cheatgrass, scattered clumps of cheatgrass will escape grazing, allowing the species to persist. During spring, when palatable, heavy grazing prevents cheatgrass from dominating (Pickford 1932, Daubenmire 1940). However, if heavy spring grazing ceases, cheatgrass will quickly dominate an area (Daubenmire, 1940).

On range lands that have experienced excessive grazing, cheatgrass appears as a biotic climax. The heaviest concentrations of cheatgrass were on abandoned fields, or on overgrazed areas. As areas become disturbed and cheatgrass invades, the shrub habitat becomes susceptible to loss due to the increased flammability and potential for the spread of fire through the shrub habitat. The pattern becomes cyclical: as cheatgrass increases so does the loss of shrub habitat by fire, until there is a conversion of the shrub habitat to annual grasslands (Knick and Rotenberry 1997). Large fires have fragmented shrub lands and accelerated the cheatgrass invasion process (Knick et al. 2003).

Young and Evans (1978) noted, following three wildfires in Nevada, that a site was subject to cheatgrass invasion unless there was a density of 2.5 perennial grass plants per square meter.

In the sagebrush and pinyon-juniper vegetation in west-central Utah, Ott et al. (2001) found that there was a shift from woody to herbaceous species, especially annual species such as cheatgrass, in burned areas. They found that cheatgrass increased the rate and direction of succession.

Areas that are degraded ecologically have increased risk of cheatgrass invasion (Chambers et al. 2007). In semiarid areas like the southwest, Gelbard and Belnap (2003) found that the cover of cheatgrass was three times as great in areas adjacent to improved roads compared to unimproved two-tracks.

Exotic annual grasses and noxious weeds now dominate roughly 1/3 of the land in the Great Basin and are spreading. During the 1999 fire season, cheatgrass contributed to the burning of 1.7 million acres in the Great Basin. Restoration efforts need to be conducted at a landscape level in order to have a measurable impact (USDI, Bureau of Land Management 1999). It is projected that, unless there is aggressive, well-planned restoration in the Great Basin, native vegetation will continue to decrease, allowing for exotic grasses and noxious weeds to invade, further putting the native plant community at risk of permanent loss. Watersheds will become unstable and water quality will suffer (USDI, Bureau of Land Management 2000).

Roberts (1994) pointed out the implications of the cheatgrass invasion if management efforts are not made to control and attempt to eradicate this exotic species. Impacts include 1) a shortened fire cycle and longer fire season, 2) increased susceptibility to drought and lowered sustained yield, 3) lack of diversity, 4) increased costs for fire suppression and rehabilitation, and 5) decreased land values.

According to Kaczmarski 2000, intense, immediate and long-term restoration of this region must be done to stop this downward spiral, or the whole region could eventually become a desert wasteland. Restoration will not happen, however, without millions of dollars from federal and regional agencies.

In the Great Basin, cheatgrass threatens the ecological and economic sustainability of both natural resources and people in the region. Expansion of this fire-prone invasive increases the risk of desertification of the region (Pellant et al. 2004).

Healthy plant communities are susceptible to being converted to exotic annuals within as few as two or three burns. Maintaining healthy communities is necessary to prevent the loss of native grass- and shrub lands (Rosentreter, 1994).

9.0 REFERENCES CITED

Aguirre, L., and D.A. Johnson. 1991. Influence of temperature and cheatgrass competition on seedling development of two bunchgrasses. J. Range Manage. 44:347–354

Anderson, Myron R., Depuit, Edward J.; Abernethy, Rollin H.; Kleinman, Larry H. 1992. Value of mountain rye for suppression of annual bromegrasses on semiarid mined lands. Journal of Range Management. 45: 345-351.

BASF. 2003a. Burning Issue: cheatgrass fuels rangeland fires. 12 pp.

BASF. 2003b. Cheatgrass: Non-native Cheatgrass Cheats Farmers and Ranchers Out of Their Land. Technical Bulletin. 8 pp.

BASF. 2004. Plateau Specimen Label. 16 pp. www.vmanswers.com

BASF. 2006 Plateau Herbicide: Toxicology, Ecotoxicology, and Environmental Fate Overview. 8 pp. www.vmanswers.com

BASF. 2008. Journey Speciment Label. 28 pp. www.vmanswers.com

Beatley, Janice, 1966. Ecological Status of Introduced Brome Grasses in Desert Vegetation of Southern Nevada. Ecology 47(4): 548-554.

Beckstead, Julie; Meyer, Susan E.; Allen, Phil S. 1995. Effects of afterripening on cheatgrass *(Bromus tectorum)* and squirreltail *(Elymus elymoides)* germination. In: Roundy, Bruce A; McArthur, E. Durant; Haley, Jennifer S.; Mann, David K. comps. Proceedings: Wildland Shrub and Arid Land Restoration Symposium; 1993 October 19-21; Las Vegas, NV. General Technical Report INT-GTR-315. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Research Station. 165-172.

Belnap, Jayne, Kaltenecker, Julie Hilty, Rosentreter, Roger, Williams, John, Leonard, Steve, and Eldridge, David. 2001. Biological Soil Crusts: Ecology and Management. Technical Reference 1730-2. Denver, CO: USDI, Bureau of Land Mangement. 110 pp.

Billings, W.D. 1994. Ecological impacts of cheatgrass and resultant fire on ecosystems in the western Great Basin. In: Monsen, Stephen B.; Kitchen, Stanley G. comps. Proceedings—Ecology and Management of Annual Rangelands; 1992 May 18-22; Boise, ID. General Technical Report INT-GTR-313. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Research Station: 22-30.

Bradford, John B.; Lauenroth, William K. 2006. Controls over invasion of *Bromus tectorum:* the importance of climate, soil, disturbance and seed availability. Journal of Vegetation Science 17: 693-704.

Brooks, Matthew L. 1999. Alien annual grasses and fire in the Mojave Desert. Madroño, Vol. 46(1): 13-19.

Brooks, Matthew L. 2005. Effectiveness of postfire seeding to reduce cheatgrass (*Bromus tectorum*) growth and reproduction in recently burned sagebrush steppe. Final Report for JFSP Project Number 01C-3-3-13. Delivered to the Joint Fire Science Program, National Interagency Fire Center, 3833 S. Development Ave., Boise, ID 83705-5354: 1-7.

Brown, Cynthia S.; Rowe, Helen. 2004. The unwelcome arrival of *Bromus tectorum* to high elevations. In: W.R. Keammerer and J. Todd, eds. Proceedings High Altitude Revegetation Workshop No. 16, March 2004, Fort Collins, Colorado. Colorado Water Resources Research Institute Information Series No. 99.

Buman, Robert A.; Monsen, Stephen B.; Abernethy, Rollin H. 1988. Seedling competition between mountain rye, 'Hycrest' crested wheatgrass, and downy brome. Journal of Range Management 41(1): 30-34.

Carpenter, A.T., and Murray, T.A., 1999. Element Stewardship Abstract for Bromus tectorum. Available from: http://tncweeds.ucdavis.edu/esadocs/documnts/bromtec.pdf [Accessed February 2009].

Chambers, Jeanne C.; Roundy, Bruce A.; Blank, Robert R.; Meyer, Susan E.; Whittaker, A. 2007. What makes Great Basin sagebrush ecosystems invasible by *Bromus tectorum*? Ecological Monographs 77(1): 117-145.

Cline, J.F.; D.W. Uresk; Rickard, W.H. 1977. Comparison of soil water used by a sagebrush-bunchgrass and a cheatgrass community. Journal of Range Management 30(3): 199-201.

Colorado State Parks. 2005. Weed Profile: Downy brome (cheatgrass) *Bromus tectorum* (L.) *Anisantha tectorum* (L.) Nevski. http://parks.state.co.us/NR/rdonlyres/4FB458D6-8C52-4AAA-AE3E-A3E16BE7FA4A/0/DowneyBrome.pdf

Daubenmire, Rexford F. 1940. Plant succession due to overgrazing in the *Agropyron* bunchgrass prairie of southeastern Washington. Ecology, Vol.21, No.1.

Daubenmire, R.F. 1942. An Ecological Study of the Vegetation of Southeastern Washington and Adjacent Idaho. Ecological Monographs, Vol.12, No. 1 pp.53-79.

Deines, L., R. Rosentreter, D.J. Eldridge, and M.D. Serpe. 2006. Germination and seedling establishment of two annual grasses on lichen-dominated biological soil crusts. PlantSoil 295:23-35.

Deneke, Darrell L.; Moechnig, Mike; Wrage, Leon J. 2007. Weed Control in CRP Plantings: 2007. Plant Science Extension: South Dakota State University, Plant Science Extension Brookings SD. 1-15.

Dewey, S.A, S.E. Enloe, F. Menalled, S. Miller, R. Whitesides, and L. Johnson (eds.) 2006. Weed Management Handbook 2006-2007. Montana, Utah, Wyoming. Cooperative Extension Services Press. Publication # EB0023, Bozeman, Mt. 272 pages.

Dobler, Frederick C. 1994. Washington state shrub-steppe ecosystem studies with emphasis on the relationship between non-game birds and shrub and grass cover densities. In: Monsen, Stephen B.; Kitchen, Stanley G. comps. Proceedings—Ecology and Management of Annual Rangelands; 1992 May 18-22; Boise, ID. General Technical Report INT-GTR-313. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Research Station: 149-161.

Driscoll, R.S. 1964. A relict area in the central Oregon juniper zone. Ecology 45:345-353.

Eckert, Richard E. Jr.; Asher, Jerry E.; Christensen, M. Dale; Evans, Raymond A. 1974. Evaluation of the Atrazine-fallow technique for weed control and seedling establishment. Journal of Range Management 27(4): 288-292.

Eckert, Richard E. Jr.; Evans, Raymond A. 1967. Chemical-fallow technique for control of downy brome and establishment of perennial grasses on rangeland. Journal of Range Management. 20(1): 35-41.

Emmerich, F.L.; Tipton, F.H.; Young, J.A. 1993. Cheatgrass: changing perspectives and management strategies. Rangelands. 15(1): 37-72.

Environmental Protection Agency, 2009. Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2007.Washington, D.C.: (http://www.epa.gov/climatechange/emissions/downloads09/Upfront.pdf)

Evans, Raymond A., Eckert, Richard E. and Kay, Burgess L. 1967. Wheatgrass establishment with parquat and tillage on downy brome ranges. Weed Science 15(1): 50-55.

Evans, Raymond A.; Young, James A. 1970. Plant litter and establishment of alien annual weed species in rangeland communities. Weed Science. 18(6): 697-703.

Evans, Raymond A.; Young, James A. 1972. Microsite requirements for establishment of annual rangeland weeds. Weed Science. 20(4): 350-356.

Evans, Raymond A.; Young, James A. 1977. Weed control-revegetation systems for big sagebrush-downy brome rangelands. Journal of Range Management 30(5): 331-336.

Evans, Raymond A.; Young, James A. 1978. Effectiveness of rehabilitation practices following wildfire in a degraded big sagebrush-downy brome community. Journal of Range Management. 31(3): 185-188.

Evans, Raymond A.; Young, James A. 1984. Microsite requirements for downy brome *(Bromus tectorum)* infestation and control on sagebrush rangelands. Weed Science. 32(Supplement 1): 13-7.

Federal Emergency Management Agency (FEMA). 2009. *Map Service Center: Definitions of FEMA Flood Zones Designations.* http://msc.fema.gov. Accessed August 5, 2009.

Finnerty, D.W.; Klingman, Dayton L. 1962. Life cycles and control studies of some weed brome grasses. Weeds. 10: 40-47.

Floyd, M. Lisa; Hanna, David; Romme, William H.; Crews, Timothy E. 2006. Predicting and mitigating weed invasions to restore natural post-fire succession in Mesa Verde National Park, Colorado, USA. International Journal of Wildland Fire. 15: 247-259.

Four Corners Air Quality Task Force. 2007. Report of Mitigation Options. 546pp. http://www.nmenv.state.nm.us/aqb/4C/Docs/4CAQTF_Report_FINAL.pdf

Francis, Mark G.; Pyke, David A. 1996. Crested wheatgrass-cheatgrass seedling competition in a mixed-density design. Journal of Range Management. 49(5): 432-438.

Fuhrmann, Kelly. 2008. Personal communications via email 11/28/2008. Program Manager, Resources Stewardship and Science Program, Bryce Canyon National Park, P.O. Box 640201, Bryce Canyon, UT. 84764.

Gasch, C. and Robin Bingham. 2006. A study of *Bromus tectorum* L. seed germination in the Gunnison Basin, Colorado. Bios 77(1):7-12.

Gelbard, Jonathan L.; Belnap, Jayne. 2003. Roads as conduits for exotic plant invasions in a semiarid landscape. Conservation Biology. 17(2): 420-432.

Giunta, Bruce C.; Christensen, Donald R.; Monson, Stephen B. 1975. Interseeding shrubs in cheatgrass with a browse seeder-scalper. Journal of Range Management. 28(5):398-402.

Goddard Institute for Space Studies. 2007. Annual Mean Temperature Change for Three Latitude Bands. Datasets and Images. New York, NY: GISS Surface Temperature Analysis, Analysis Graphs and Plots. (Available on the Internet: http://data.giss.nasa.gov/gistemp/graphs/Fig.B.lrg.gif.)

Goodwin, Jay R.; Doescher, Paul S.; Eddleman, Lee E. 1996. Germination of Idaho fescue and cheatgrass seeds from coexisting populations. Northwest Science. 70(3): 230-241.

Hardy, Colin C.; Schmidt, Kirsten M.; Menakis, James P.; Sampson, R. Neil. 2001. Spatial data for national fire planning and fuel management. International Journal of Wildland Fire. 10: 353-372.

Harris, Grant A. 1967. Some competitive relationships between *Agropyron spicatum* and *Bromus tectorum*. Ecological Monographs. 37(2): 89-111.

Harris, Grant A. 1977. Root phrenology as a factor of competition among grass seedlings. Journal of Range Management. 30(3): 172-177.

Harris, Grant A.; Wilson, A.M. 1970. Competition for moisture among seedlings of annual and perennial grasses as influenced by root elongation at low temperature. Ecology. 51(3): 530-534.

Hempty-Mayer, Kara; Pyke, David A. 2008. Defoliation effects on *Bromus tectorum* seed production: implications for grazing. Rangeland Ecology and Management 61(1): 116-123.

Hironaka, M. and Tisdale. E.W. 1963. Secondary succession in annual vegetation in southern Idaho. Ecology 44(4) 810-812.

Hulbert, Lloyd C. 1955. Ecological Studies of *Bromus tectorum* and Other Annual brome grasses. Ecological Monographs: Vol. 25, No. 2, pp. 181-213.

Hull, A. C; Pechanec, Joseph F. 1947. Cheatgrass--A Challenge to Range Research Journal of Forestry, 45(8): 555-564.

Hull, A.C. Jr.; Hansen, Theron Jr. 1974. Delayed germination of cheatgrass seed. Journal of Range Management. 27(5): 366-368.

Humphrey, L. David; Schupp, Eugene W. 2004. Competition as a barrier to establishment of a native perennial grass (*Elymus elymoides*) in alien annual grass (*Bromus tectorum*) communities. Journal of Arid Environments. 58: 405-422.

Hunter, Richard. 1991. *Bromus* invasions on the Nevada Test Site: present status of *B. rubens* and *B. tectorum* with notes on their relationship to disturbance and altitude. Great Basin Naturalist. 5(2): 176-182.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: The Physical Basis (Summary for Policymakers). New York, NY.Cambridge University Press. (Available on the Internet: http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf)

Intergovernmental Panel on Climate Change (IPCC). Climate Change 2007, Synthesis Report. A Report of the Intergovernmental Panel on Climate Change New York, NY. Cambridge University Press, (Available on the Internet: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf).

Kaczmarski, Jennifer. 2000. Restoration Implications of *Bromus tectorum*-Infested Grasslands of the Great Basin. In: Restoration and Reclamation Review. Volume 6, Fall. St. Paul, MN: University of Minnesota.

Keeley, Jon E.; McGinnis, Thomas W. 2007. Impact of prescribed fire and other factors on cheatgrass persistence in a Sierra Nevada ponderosa pine forest. International Journal of Wildland Fire. 16:96-106.

Kennedy, Ann C. 1994. Biological control of annual grass weeds. In: Monsen, Stephen B.; Kitchen, Stanley G. comps. Proceedings—Ecology and Management of Annual Rangelands; 1992 May 18-22; Boise, ID. General Technical Report INT-GTR-313. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Research Station: 186-189.

Klomp, G. J.; Hull, A.C. Jr. 1972. Methods for seeding three perennial wheatgrasses on cheatgrass ranges in southern Idaho. Journal of Range Management. 25(4):266-268.

Knick, Steven T. 1999. Requiem for a sagebrush ecosystem? Northwest Science. 73(1): 53-57.

Knick, Steven T.; Dobkin, David S.; Rotenberry, John T.; Schroeder, Michael A.; Vander Haegen, W. Matthew; Van Riper, Charles III. 2003. Teetering on the edge or too late? Conservation and research issues for avifauna and sagebrush habitats. Condor 105:611-634.

Knick, Steven T.: Rotenberry, John T. 1997. Landscape characteristics of disturbed shrubsteppe habitats in southwestern Idaho. Landscape Ecology 12: 287-297.

Knick, Steven T.; Rotenberry, John T. 2000. Ghosts of habitats past: contribution of landscape change to current habitats used by shrubland birds. Ecology 81(1):220-227.

Leger, Elizabeth. 2008. Adaptive value of remnant native plants in invaded communities: an example from the Great Basin. Ecological Applications. 18(5):1226-1235.

Link, Steven O.; Keeler, Carson W.; Hill, Randall W.; Hagen, Eric. 2006. *Bromus tectorum* cover mapping and fire risk. International Journal of Wildland Fire. 15:113-119.

Mack, Richard N. 1981. Invasion of *Bromus tectorum* L. into western North America: an ecological chronicle. Agro-Ecosystems. 7:145-165.

Mack, R. N. and D. A. Pyke (1984). The demography of *Bromus tectorum*: The role of microclimate, predation and disease. Journal of Ecology 72: 731-748.

Mattise, Samuel N.; Scholten, Gerald. 1994. Mechanical control of undesirable annuals on the Boise Front, Idaho. In: Monsen, Stephen B.; Kitchen, Stanley G. comps. Proceedings—Ecology and Management of Annual Rangelands; 1992 May 18-22; Boise, ID. General Technical Report INT-GTR-313. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Research Station: 190-193.

Melgoza, Graciela; Nowak, Robert S. 1991. Competition between cheatgrass and two native species after fire: implications from observations and measurements of root distribution. Journal of Range Management. 44(1):27-33.

Melgoza, Graciela; Nowak, Robert S.; Tausch, Robin J. 1990. Soil water exploitation after fire: competition between *Bromus tectorum* (cheatgrass) and two native species. Oecologia. 83(1):7-13.

Menalled, Fabian. 2006. Management of cheatgrass on Conservation Reserve Program lands. http://www.montana.edu/cpa/news/nwview.php?article=4111

Meyer, Susan E.; Allen, Phil S.; Beckstead, Julie. 1997. Seed germination regulation in *Bromus tectorum* (Poaceae) and its ecological significance. Oikos. 78:475-485.

Meyer, Susan E.; Garvin, Susan C.; Beckstead, Julie. 2001. Factors mediating cheatgrass invasion of intact salt desert shrubland. In: McArthur, E. Durant; Fairbanks, Daniel J., compilers. Shrubland ecosystem genetics and biodiversity: proceedings; 2000 June 13-15, Provo, UT. Proc. RMRS-P-21. Ogden, UT: US Department of Agriculture, Forest Service, Rocky Mountain Research Station: 224-232.

Meyer, S. E. and P. S. Allen . 1999a. Ecological genetics of seed germination regulation in *Bromus tectorum* L. I. Phenotypic variance among and within populations. Oecologia 120:27–34.

Meyer, Susan E.; Nelson, David L.; Clement, Suzette; Beckstead, Juli e. 2008. Cheatgrass *(Bromus tectorum)* biocontrol using indigenous fungal pathogens. In: Kitchen, Stanley G.; Pendleton, Rosemary L.; Monaco, Thomas A.; Vernon, Jason, comps. Proceedings—Shrublands Under Fire: Disturbance and Recovery in a Changing World; 2006 June 6-8; Cedar City, UT. Proc RMRS-P-52. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 61-67.

Miller, E.; Narayanan, R. 2008. Background and overview. In: Miller, E. and Narayanan, R. editors. Great Basin Wildfire Forum: The Search for Solutions. Reno, NV: Nevada Agricultural Experiment Station, University of Nevada 41pp.

Mosley, Jeffrey C.; Roselle, Lovina. 2006. Targeted grazing to suppress invasive annual grasses. In: Launchbaugh, Karen, ed. Targeted Grazing: a Natural Approach to Vegetation Management and Landscape Enhancement. Centennial, CO: American Sheep Industry Association. 67-76.

Monaco, Thomas A.; Waldron, Blair L.; Newhall, Robert L.; Horton, W. Howard. 2003. Re-establishing perennial vegetation in cheatgrass monocultures. Rangelands. 25(2):26-29.

Mutch, Robert W. 1967. Cheatgrass coloration—a key to flammability? Journal of Range Management. 20(4):259-260.

National Academy of Sciences. 2006. Understanding and Responding to Climate Change: Highlights of National Academies Reports. Washington, DC: Division or Earth and Life Studies, National Academy of Sciences. (Available on the Internet: http://dels.nas.edu/basc/Climate-HIGH.pdf.)

New Mexico Environment Department Air Quality Bureau. 2005. New Mexico Smoke Management Program Guidance Document May 25, 2005. 25 pp. plus appendices. http://www.nmenv.state.nm.us/aqb/SMP/GuidanceDoc/SMP_052505.pdf

New Mexio Environment Department Air Quality Bureau, 2009. New Mexico Recommended Area Designaitons for the 2008 Revised Ozone NAAZS, March 12, 2009. 26. pp. plus appendices. http://www.nmenv.state.nm.us/aqb/OzoneRecommendation.htm

Novak, S.J.; Mack, R.N.; Soltis, D.E. 1991. Genetic variation in *Bromus tectorum* (Poaceae): population differentiation in its North American range. American Journal of Botany. 71:1150–1161.

Ott, Jeffery E.; McArthur, E. Durant; Roundy, Bruce A. 2003. Vegetation of chained and non-chained seedings after wildfire in Utah. Journal of Range Management. 56: 81-91.

Ott, Jeffrey E.; McArthur, E. Durant; Sanderson, Stewart C. 2001. Plant community dynamics of burned and unburned sagebrush and pinyon-juniper vegetation in west-central Utah. In: McArthur, E. Durant; Fairbanks, Daniel J. comps. Shrubland ecosystem genetics and biodiversity: proceedings; 2000 June 13-15; Provo, UT. Proc. RMRS P-21. Ogden, UT: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 177-191.

Palazzo, Antonio J.; Hardy, Susan E.; Jensen, Kevin B. 2003. Improved Native Grasses and Establishment Methods for Use on Military Training Lands. Hanover, NH: US Army Engineering Research and Development Center.

Pellant, Mike; Abbey, Bob; Karl, Sherm. 2004. Restoring the Great Basin desert, USA: integrating science, management, and people. Environmental Monitoring and Assessment. 99:169-179.

Peters, Erin F.; Bunting, Stephen C. 1994. Fire conditions pre- and post-occurrence of annual grasses on the Snake River plain. In: Monsen, Stephen B.; Kitchen, Stanley G. comps. Proceedings—Ecology and Management of Annual Rangelands; 1992 May 18-22; Boise, ID. General Technical Report INT-GTR-313. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Research Station: 31-36.

Pickford, G.D. 1932. The influence of continued heavy grazing and of promiscuous burning and spring-fall ranges in Utah. Ecology 13:159-171.

Piemeisel, Robert L. 1951. Causes affecting change and rate of change in a vegetation of annuals in Idaho. Ecology. 32(1):53-72.

Rafferty, Dawn L.; Young, James A. 2002. Cheatgrass competition and establishment of desert needlegrass seedlings. Journal of Range Management. 55:70-72.

Rasmuson , K.E. and J.E. Anderson. 2002. Salinity affects development, growth, and photosynthesis in cheatgrass, J. Range Manage. 55 (2002), pp. 80–87.

Roberts, Thomas C. Jr. 1991. Cheatgrass: management implications in the 90's. Rangelands. 13(2):70-72.

Roberts, Thomas C. Jr. 1994. Resource impacts of cheatgrass and wildfires on public lands and livestock grazing. In: Monsen, Stephen B.; Kitchen, Stanley G. comps. Proceedings—Ecology and Management of Annual Rangelands; 1992 May 18-22; Boise, ID. General Technical Report INT-GTR-313. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Research Station: 167-169.

Robertson, Joseph H.; Pearse, C. Kenneth. 1945. Artificial reseeding and the closed community. Northwest Science. 59(3): 58-66.

Rosentreter, Roger. 1994. Displacement of rare plants by exotic grasses. In: Monsen, Stephen B.; Kitchen, Stanley G. comps. Proceedings—Ecology and Management of Annual Rangelands; 1992

May 18-22; Boise, ID. General Technical Report INT-GTR-313. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Research Station: 170-176.

Rutledge, C.R., and T. McLendon. 1996. An Assessment of Exotic Plant Species of Rocky Mountain National Park. Department of Rangeland Ecosystem Science, Colorado State University. 97 pp. Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/othrda ta/Explant/explant.htm (Version 15DEC98).

Ruyle, G. B. and D. J. Young . 1997. Arizona range grasses: their description, forage value and grazing management. Tucson, AZ, USA University of Arizona Cooperative Extension. 152.

Schmidt, K.M. , Menakis, J.P. Hardy, C.C., Hann, W.J. Bunnell, D.L. 2002. Development of coarse-scale spatial data for wildland fire and fuel management. General Technical Report, RMRS-GTR-87, Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Science Applications International Corporation. 2002. Cultural Resources Technical Report. Background Information on Cultural Resources for the Farmington Draft RMP/EIS. Contract GS-10F-0076J.

Scott, Joe H.; Burgan, Robert E. 2005. Standard fire behavior fuel models: a comprehensive set for use with Rothermel's fire spread model. Gen. Tech. Rep. RMRS-GRT-153. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 72p.

Skipper, H.D., A.G. Ogg, and A.C. Kennedy. 1996. Root biology of grasses and ecology of rhizobacteria for biological control. Weed Technology 10:610-620.

Sparks, Steven R.; West, Neil E.; Allen, Edith B. 1990. Changes in vegetation and land use at two townships in Skull Valley, western Utah. In: McArthur, E. Durant; Romney, Evan M.; Smith, Stanley D.; Tueller, Paul T. comps. Proceedings—Symposium on Cheatgrass Invasion, Shrub Die-Off, and Other Aspects of Shrub Biology and Management; 1989 April 5-7; Las Vegas, NV. General Technical Report INT-276. United States Department of Agriculture Forest Service Intermountain Research Station. p.26-36.

Stewart, George; Hull, A.C. 1949. Cheatgrass (*Bromus tectorum* L.)—an ecologic intruder in southern Idaho. Ecology. 30(1):58-74.

Stumpf, Julie A.; Stubbendieck, James; Butterfield, Charles H.; Hiebert, Ronald D. 1996. Assessment of prairie restoration at two national monuments. In: Warwick, Charles, ed. Proceedings: Fifteenth North American Prairie Conference; 1996 October 23-26; St. Charles, IL. Bend, OR: Natural Areas Association. 234-243.

Tausch, Robin J.; Nowak, Robert S.; Bruner, Allen D.; Smithson, James. 1994 Effects of simulated fall and early spring grazing on cheatgrass and perennial grass in western Nevada. In: Monsen, Stephen B.; Kitchen, Stanley G. comps. Proceedings—Ecology and Management of Annual Rangelands; 1992 May 18-22; Boise, ID. General Technical Report INT-GTR-313. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Research Station: 113-119.

Tipton, F.H. 1994. Cheatgrass, livestock, and rangeland. In: Monsen, Stephen B.; Kitchen, Stanley G. comps. Proceedings—Ecology and Management of Annual Rangelands; 1992 May 18-22; Boise, ID. General Technical Report INT-GTR-313. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Research Station: 414-416.

Tisdale, E. W. 1947. The grasslands of the southern interior of British Columbia. Ecology 28:346-382.

Tu, Mandy; Hurd, Callie; Randall, John M. 2001. Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas. Need publication location: The Nature Conservancy.

U.S. Department of Agriculture, Natural Resources Conservation Service New Mexico Online Soil Survey Manuscripts http://soils.usda.gov/survey/online_surveys/new_mexico/

U.S. Department of Interior, Bureau of Land Management. 1991. Final Environmental Impact Statement Vegetation Treatment on BLM Lands in Thirteen Western States. Bureau of Land Management, Wyoming State Office, Casper Wyoming.

U.S. Department of the Interior, Bureau of Land Management.1992. *Procedures for Ecological Site Inventory with Special Reference to Riparian-Wetland Sites: Riparian Area Management.* BLM TR 1737-7. National Science and Technology Center, Denver, CO.

U.S. Department of Interior, Bureau of Land Management. 1999. Out of Ashes, An Opportunity. The Great Basin Restoration Initiative. Bureau of Land Management, National Office of Fire and Aviation. Boise, Idaho.. 28p.

U.S. Department of Interior, Bureau of Land Management. 2000. The Great Basin: Healing the Land. National Interagency Fire Center, Boise, ID. 36p.

U.S. Department of Interior. 2001. Rangeland Health Standards. Bureau of Land Management Handbook H-4180-1. Washington, DC

U.S. Department of Interior, Bureau of Land Management. 2003a. Farmington Resource Management Plan with Record of Decision. Farmington, NM: US Department of Interior, Bureau of Land Management, Farmington Field Office.

U.S. Department of Interior, Bureau of Land Management. 2003b. Farmington Proposed Resource Management Plan and Final Environmental Impact Statement. Vol's 1 & II. BLM-NM-PL-03-014-1610. Farmington, NM: US Department of Interior, Bureau of Land Management, Farmington Field Office.

U.S. Department of Interior, Bureau of Land Management. 2004a. Farmington Field Office Fire Management Plan. Farmington, NM: US Department of Interior, Bureau of Land Management, Farmington Field Office.

U.S. Department of Interior, Bureau of Land Management. 2004b. Fire and Fuels Management Plan Amendment and Environmental Assessment for Public Land in New Mexico and Texas. BLM-NM-PL-008-2824. Santa Fe, NM: US Department of the Interior, Bureau of Land Management, New Mexico State Office.

U.S. Department of Interior, Bureau of Land Management. 2007. Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States: Programmatic Environmental Impact Statement. Vol 1. Reno, NV: US Department of Interior, Bureau of Land Management, Rangeland Soils, Water, and Air Group.

U.S. Department of Interior, Bureau of Land Management. 2008a. BLM New Mexico Cheatgrass Management Plan: Strategic Plan for Cheatgrass (Downy Brome) Infestation Management on the New Mexico Public Lands. Santa Fe, NM: US Department of the Interior, Bureau of Land Management, New Mexico State Office.

U.S. Department of Interior, Bureau of Land Management. 2008b. Integrated Vegetation Management Handbook. Handbook 1740-2. US Department of Interior, Bureau of Land Management.

U.S. Department of Interior, Bureau of Land Management, 2008c. Integrated Weed Management Plan, Farmington Field Office, Farmington New Mexico.

United States Department of Interior, Bureau of Land Management 2008d. Monitoring Protocol for Prescribed Fire, Hazardous Fuels Reduction, and Forest/Range Restoration Activities. Fire and Fuels Management Program, Farmington District.

U.S. Department of the Interior, Bureau of Land Management. 2009 Healthy Lands Initiative, New Mexico, San Juan Basin www.blm.gov/style/medialib/blm/wo/Communications_Directorate/public_affairs/healthy_lands_initiative.Par.80058.File.dat/HLI-National_FY09.pdf 2pp.

U.S. Government Accountability Office. 2007. Report to Congressional Requesters. CLIMATE CHANGE: Agencies Should Develop Guidance for Addressing the Effects on Federal Land and Water Resources. 179pp. www.gao.gov/cgi-bin/getrpt?GAO-07-863.

Uresk, D.W.; Cline, J.F.; and Rickard, W.H. 1979. Growth rates of a cheatgrass community and some associated factors. Journal of Range Management. 32(3):168-170.

Vander Haegen, W. Matthew,; Dobler, Frederick C.; Pierce, D. John. 2000. Shrubsteppe bird response to habitat and landscape variables in eastern Washington, USA. Conservation Biology. 14(4):1145-1160.

Vollmer, Jennifer L.; Vollmer, Joseph G. 2008. Controlling cheatgrass in winter range to restore habitat and endemic fire. In: Kitchen, Stanley G.; Pendleton, Rosemary L.; Monaco, Thomas A.; Vernon, Jason, comps. Proceedings—Shrublands Under Fire: Disturbance and Recovery in a Changing

World; 2006 June 6-8; Cedar City, UT. Proc RMRS-P-52. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 57-60.

Whisenant, Steven G. 1990. Changing fire frequencies on Idaho's Snake River plains: ecological and management implications. In: McArthur, E. Durant; Romney, Evan M.; Smith, Stanley D.; Tueller, Paul T. comps. Proceedings—Symposium on Cheatgrass Invasion, Shrub Die-Off, and Other Aspects of Shrub Biology and Management; 1989 April 5-7; Las Vegas, NV. General Technical Report INT-276. United States Department of Agriculture Forest Service Intermountain Research Station. 4-10

Whittaker, Alison; Roundy, Bruce; Chambers, Jeanne; Meyer, Susan; Blank, Robert; Kitchen, Stanley G.; Korfmacher, John. 2008. Effect of herbaceous species removal fire, and cheatgrass *(Bromus tectorum)* on soil water availability in sagebrush steppe. In: Kitchen, Stanley G.; Pendleton, Rosemary L.; Monaco, Thomas A.; Vernon, Jason, comps. Proceedings—Shrublands Under Fire: Disturbance and Recovery in a Changing World; 2006 June 6-8; Cedar City, UT. Proc RMRS-P-52. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 49-56.

Whitson, Tom D. and David. W. Koch. 1998. Control of downy brome (*Bromus tectorum* L.) with herbicides and perennial grass competition. Weed Technology. Vol. 12, P. 391-396

Wiese, A. F. , C. D. Salisbury , and B. W. Bean . 1995. Downy brome (*Bromus tectorum*), jointed goatgrass (*Aegilops cylindrica*) and horseweed (*Conyza canadensis*) control in fallow. Weed Technology Vol. 9, P. 249–254.

Young, James A.; Evans, Raymond A. 1970. Weed control in wheatgrass seedbeds with Siuron and Picloram. Weed Science. 18(5): 546-549.

Young, James A.; Evans, Raymond A. 1973. Downy brome—intruder in the plant succession of big sagebrush communities in the Great Basin. Journal of Range Management. 26(6):410-415.

Young, James A.; Evans, Raymond A. 1978. Population dynamics after wildfires in sagebrush grasslands. 31(4):283-289.

Zouhar, Kris. 2003. *Bromus tectorum*. In: Fire Effects Information System [Onlline]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us./database/feis/ [March 20, 2008}