Fire Effects and Fuels Management in Blackbrush (*Coleogyne ramosissima*) Shrublands of the Mojave Desert
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Final Report
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Preface
JFSP project 00-2-32 began in FY00 as a fuels management study of invasive annual grasses in the Mojave Desert, with an original title of, "Control of Invasive Annual Grasses in the Mojave Desert," authored by Matt Brooks and Richard Franklin. However, five years of low rainfall from 2000-2004 failed to produce the appropriate fine fuel conditions to treat non-native annual grasses with the herbicides or other management prescriptions described in the original proposal. We therefore shifted the focus of this project to another major fire and fuel management concern in the Mojave, one which involved both native and non-native fuels associated with blackbrush (*Coleogyne ramosissima*) shrublands. We started this new effort in FY01 as a possible alternative in case drought conditions persisted and prevented the implementation of the original plan, and fully adopted it in FY03 after three successive years of low rainfall. During FY03 we requested and were granted permission from the JFSP Board of Directors for our new plan and for a no-cost extension through the end of FY05. The title of this final report for JFSP project 00-2-32 reflects this revised focus on fire effects and fuels management in blackbrush shrublands of the Mojave Desert.

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Background and Justification

The blackbrush vegetation type occurs at the bioregional transition between the Mojave and Great Basin deserts, from California through Nevada, Arizona, and Utah (Bowns 1973). In the Mojave Desert, blackbrush occupies the elevational zone from approximately 1220 to 1525 m, above the zone dominated by creosote bush (*Larrea tridentata*) and below the zone dominated by sagebrush (*Artemisia* spp.)(Bradley and Deacon 1967, Randall 1972, Beatley 1976). This project was focused on blackbrush in the Mojave Desert ecoregion as defined by Bailey (1995). For clarity in this report, I refer to the vegetation type as blackbrush, and the type species as *Coleogyne ramosissima.*

Blackbrush is characterized by relatively high cover (50%) of low statured (~50cm tall) evergreen woody shrubs dominated by the type-species (*Coleogyne ramosissima*), which can comprise 90 to 95% of the total plant cover (Shreve 1942). Cover of *Coleogyne ramosissima* is highest in late seral stands on shallow, sandy soils with strong pretrocalcic (caliche) horizons, where it is the primary dominant plant species. Cover of *Coleogyne ramosissima* is lowest in deeper, silty soils, or at its upper or lower ecotones, where it is co-dominant with other native species such as *Larrea tridentata*, *Juniperus* spp., *Prunus fasciculata*, *Lycium andersonii*, *Yucca brevifolia*, *Salazaria mexicana*, *Achnatherum* spp., and *Pleuraphis* spp.

Due in part to relatively high plant cover, blackbrush is one of the most flammable vegetation types in the Mojave Desert (Brooks et al. 2003, Brooks and Minnich in press), and many fires have occurred in this vegetation type since the 1980s (Brooks and Esque 2002). As a result, blackbrush is considered to be a hazardous fuel and there have been local efforts at wildland-urban interface areas to reduce its cover, primarily by using fire (Brooks and Minnich in press). In many cases these management actions have been challenged, primarily based on the increased dominance by non-native annual plants, decreased diversity of native plants, and increased fine fuels from invasive grasses and potential for increased fire frequency that is thought to occur during the first few decades after blackbrush stands burn (Jenson et al. 1960, West 1983, Bates 1984, Callison et al. 1985). The merits of these concerns are difficult to evaluate because very little information is currently available on the ecological effects of fire or the effects of management actions to reduce landscape flammability in blackbrush shrublands. This project was designed to help fill this information gap.

Project Objectives

1. Evaluate the effects of fire on plant community structure and dominance by invasive annual grasses.

2. Evaluate the effects of mechanical fuels treatments on fire behavior, plant community structure, and dominance by invasive annual grasses.

3. Establish at least one demonstration study site where the effects of fire and fuels management can be observed in the field.

4. Develop educational materials summarizing the current state-of-knowledge of fire effects and fuels management in blackbrush shrublands.

Approach and Accomplishments

We focused on three study sites located from the northeast to the southwest Mojave Desert, in the middle of the blackbrush zone between the upper and lower ecotones within each region. The Beaver Dam site (37°11′17″ N, 113°56′39″ W, 1230 m) was in the Bureau of Land Management, St. George Field Office region of southwestern Utah. The Spring Mountain site (36°01′40″ N, 115°33′10″ W, 1470 m) was in the Spring Mountain National Recreation Area of the Humboldt-Toiyabe National Forest in southern Nevada. The Joshua Tree site (34°03′23″ N, 116°19′45″ W, 1370 m) was located at Joshua Tree National Park in southern California. Each site consisted of mature blackbrush and an adjacent burned area located on similar soils and topography. Burned areas were created by a wildfire in 1995 at the Beaver Dam site, a wildfire in 1987 at the Spring Mountains site, and a prescribed fire in 1993 at the Joshua Tree site (Table 1).

Table 1. Project overview.

Study Objective	**Study Sites**	**Treatment Years**	**Sampling Years**
Effects of fire on vegetation (Objective 1)	Beaver Dam (UT) Joshua Tree (CA) Spring Mtns. (NV)	Wildfire, Summer 1995 Wildfire, Summer 1993 Wildfire, Summer 1987	Spring 2001
Effects of fire on seedbanks (Objective 1)	Beaver Dam (UT) Joshua Tree (CA)	Wildfire, Summer 1995 Wildfire, Summer 1993	Fall 2002, 2003
Effects of fuels treatments on vegetation and seedbanks (Objective 2)	Beaver Dam (UT)	*Coleogyne* Thinning, Winter 2003 and 2004	Pre-treatment (from Obj. 1 sampling) Post-treatment Spring 2004, 2005, 2006; Fall 2005

Objective 1 was achieved by comparing vegetation and seedbank characteristics in burned and previously unburned areas. We collected detailed vegetation data to compare plant cover, species composition, and diversity in burned and unburned areas at all three sites during 2001 (Table 1). We also collected seedbank data to compare seedbank density, species composition, and diversity in burned and unburned areas at the Beaver Dam and the Joshua Tree sites in 2002 and 2003. These data have been analyzed and the results summarized in Brooks and Matchett (2001, 2003a, 2003b) and Brooks et al (in prep.a).

Objective 2 was addressed by implementing a mechanical thinning experiment to reduce cover of *Coleogyne ramosissima* at the Beaver Dam site during the winter months of 2003 and 2004 (Table 1). This experiment evaluated the effects of thinning treatments on total vegetation cover, species composition, diversity, and seedbank density, species composition, and diversity. Pre-treatment vegetation and seedbank data were collected in association with Objective 1 during 2001-2003 (Table 1). Implementation monitoring was done in spring 2004 to evaluate the total cover of *Coleogyne ramosissima* that was actually removed. Effectiveness monitoring was begun in spring 2005 to evaluate vegetation responses to the treatments. In July 2005 a wildfire swept through the entire study site burning all the study plots. We will survey these plots during fall 2005 to evaluate fuel consumption to infer fire intensities in thinned vs. unthinned plots, and in previously unburned and previously burned plots. This information, along with vegetation community data collected in spring 2005 and 2006, and seedbank data collected in fall 2005, will be presented and summarized in Brooks et al (in prep.a).

Objective 3 was achieved by establishing demonstration study sites at the three study areas. The most detailed and extensive information was generated at the Beaver Dam site, where vegetation and seedbanks were evaluated in burned, unburned, and mechanically thinned blackbrush. A field trip was conducted at the Joshua Tree site to describe the study to the Desert Managers Group, an interagency group of line officers who manage public lands within the Mojave Desert.

Objective 4 was addressed by summarizing the current state-of-knowledge of fire effects and management in blackbrush shrublands of the Mojave Desert. These summaries include the results from this project, and from past studies. Based on this information, we developed specific management recommendations. Documents that contain these syntheses include Brooks et al. (2003) and Brooks and Minnich (in press).

Overview of Blackbrush Management in The Mojave Desert.

This project resulted in a number of documents that are either published or pending publication (Brooks and Matchett 2001, 2003a, 2003b, Brooks et al. 2003, Brooks and Minnich in press, Brooks et al. in prep.a,b). These documents provide information that can be used by land managers to develop and implement fire management plans in blackbrush shrublands of the Mojave Desert. In this section, I synthesize the various results and management recommendations contained in these publications.

Plant Diversity Patterns in Unburned Blackbrush

High cover of *Coleogyne ramosissima* is thought to prevent the co-existence of many other plant species, thus maintaining this vegetation type in a state of low species diversity (Bowns 1973, Beatley 1976, Bowns and West 1976). Beatley (1976) states, "so nearly complete is the dominance of this shrub species that in areas that are not ecotonal there are only a few associated shrub species, and these occur usually as scattered plants in an otherwise pure stand of *Coleogyne*." Although 185 species of vascular plants have been found growing within blackbrush (Vasek and Barbour 1988), they are never very abundant except at upper and lower elevational ecotones (Bowns 1973, Beatley 1976, West and Young 2000). Thus, species richness and evenness of vascular plants is generally thought to be low in blackbrush compared to other vegetation types in western North America.

The results of this project suggest that species richness in unburned Mojave Desert blackbrush is not lower than other vegetation types in western North America (Brooks and Matchett 2003a; Brooks et al. in prep.a). We reported 11 total plant species/1 m^2, which is comparable to 7 species/1 m^2 reported in ponderosa pine and shortgrass steppe, 8 in tallgrass prairie, 9 in aspen, and 12 in mixed grasslands (Stohlgren et al. 1999a). We reported an average of 7 woody perennial species/100 m^2 (10 at Spring Mountain), which compares closely with 6 woody perennial species/100 m^2 reported in pinyon/juniper/sagebrush, 8 in creosote bush/bursage, and 8-10 reported for unburned blackbrush near our Spring Mountain study site (Lei and Walker 1995). We reported 47 total species/1000 m^2, compared to 38 species/1000 m^2 in chaparral (Schluter and Ricklefs 1993), 45 species in the Colorado Rocky Mountains (Stohlgren et al. 1999a), 50 species in Mediterranean regions with similar rainfall as the sites in the current study (150mm, Rosensweig and Abramsky 1993), and 65-70 species in semiarid grasslands and shrublands (Schluter and Ricklefs 1993). We also reported 46 native species and 3 non-natives species/1000 m^2, which compared favorably with 32 native species and 3 non-native species in Rocky Mountain grasslands (Stohlgren et al. 1999b). Thus, species richness of higher vascular plants, woody perennial species, and non-native species at our Mojave Desert blackbrush sites were comparable to other major vegetation types.

Species richness increased logarithmically between the 1- and 1000-m^2 scales, but this increase was much higher for natives than non-natives (Brooks and Matchett 2003). This pattern suggests that native richness was more closely related to increased environmental heterogeneity at successively larger spatial scales. Apparently, the spatial distribution of the few non-native species in this study was influenced more by environmental heterogeneity at the smaller scales, whereas the distribution of the many native species was affected more equitably by heterogeneity at all scales. The increase in richness at higher spatial scales also varied among plant life forms. Perennials increased proportionally more than annuals, indicating that the former were responding more to environmental variation at successively higher spatial scales. Heterogeneity at 1 m^2 was due to the shrub-intershrub gradient, and at 1000 m^2 by the microtopographic gradient from finer textures soils of rainfall runoff areas (hummocks) to coarser textures soils of run-on areas (washlets) (Brooks 1999). These results demonstrate that different spatial scales can produce different relative estimates of species richness between natives and non-natives, and among plant life forms in blackbrush.

Species evenness in unburned blackbrush appeared to be low, with *Coleogyne* dominating that landscape (Brooks and Matchett 2003a). However, comparisons with values from other studies were confounded by a wide range of evenness metrics and sampling designs, or insufficient published descriptions of the methods that were used. As a result, we were not able to include any reliable comparisons with other vegetation types in Brooks and Matchett (2003a).

Plant Diversity Patterns in Burned Blackbrush

Most previous accounts describing the dominance of *Coleogyne ramosissima* in blackbrush indirectly suggest that high cover of this species results in the competitive exclusion of other plant species (Bowns 1973, Beatley 1976, Bowns and West 1976). Removal of this cover by fire or other means may provide competitive release, which could lead to increase species diversity. However, a recent study indicates that species diversity in unburned blackbrush stands is not a low as previously thought, and can be comparable to other vegetation types in southwestern North America (Brooks and Matchett 2003; Brooks et al. in prep.a). These authors also reported that the short-term effects of fire (6–14 years post-fire) can decrease species richness, but increase species evenness by reducing cover of *Coleogyne ramosissima*. However, one must be careful with the spatial scales at which these effects are evaluated, because significant effects of fire were observed at 10, 100, and 1000 m^2 scales, but not at the smaller 1m^2 scale that approximates most ecological studies (Brooks and Matchett 2003a)(Fig. 1). In addition, seedbank studies are highly sensitive to environmental vagaries which may differentially effect measurements in different parts of the same landscape (Brooks, Matechett, and others< in prep).

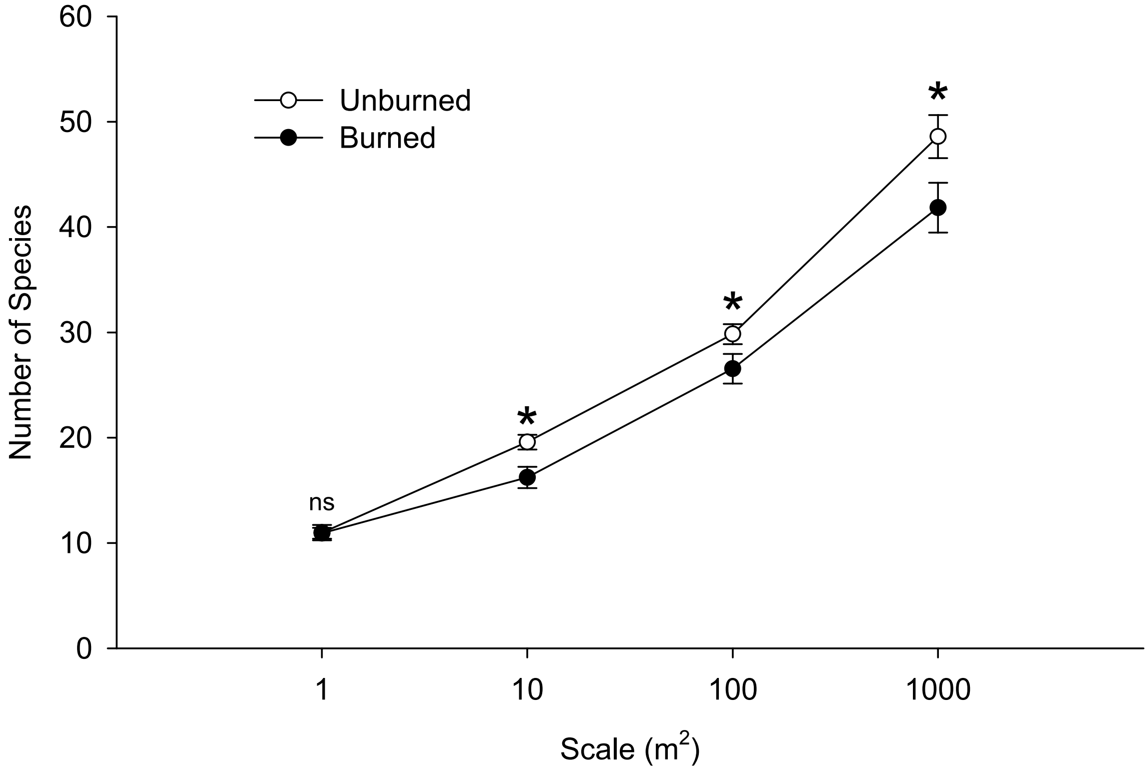

Figure 1. Total plant species richness (# of species) in burned and unburned areas averaged over the Beaver Dam, Joshua Tree, and Spring Mountains study sites.
*ns = not statistically significant, * = statistically significant*
Modified from Brooks and Matchett (2003a).

Fire removed virtually all *Coleogyne ramosisima* cover (Brooks and Matchett 2003), which is consistent with most other reports (Jenson et al. 1960, Bowns 1973, Beatley 1976, Callison et al. 1985, West and Young 2000). The loss of *Coleogyne ramosisima* as the single dominant species, and its replacement by 2 to 5 other co-dominant species 6–14 years postfire, resulted in increased species evenness, but decreased species richness. Decreased richness after *Coleogyne ramosisima* removal, and the finding that species richness in blackbrush was similar to other vegetation types, was not consistent with the assertion that *Coleogyne ramosisima* has a strong negative effect on the number of other coexisting species (Bowns 1973, Beatley 1976, Bowns and West 1976). Thus, the cover dominance of *Coleogyne ramosisima* may not prevent the coexistence of a wide range of other plant species.

Invasive non-native species respond rapidly to increased availability of limiting resources created by disturbances such as fire (Grime 1977, Chapin et al. 1986). It is therefore not surprising that fire increased non-native richness and cover (Brooks and Matchett 2003a) (Fig. 2). The one site where non-native richness, and cover of either *Bromus tectorum* or *Bromus madritensis* ssp. *rubens*, did not increase significantly after fire was at Beaver Dam, where moderate levels of past and current cattle grazing may have allowed non-natives to establish relatively high levels of richness and annual grass cover in unburned blackbrush. The other two sites had not been grazed by livestock for many decades, and had much lower levels of non-native richness and cover. These results suggest that relatively undisturbed blackbrush may be somewhat resistant to invasion by non-native species, and the effects of fire on previously disturbed blackbrush may not affect dominance of non-native annual plants if disturbance levels are already high.

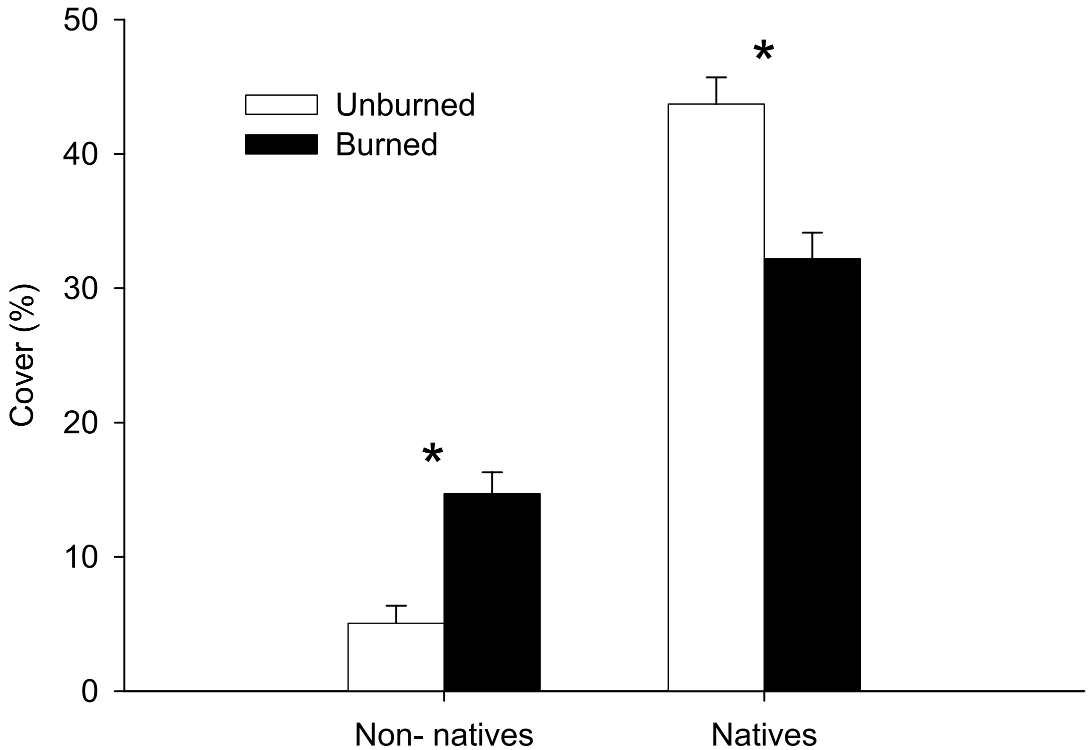

*Figure 2. Native and non-native cover in burned and unburned areas averaged over the Beaver Dam, Joshua Tree, and Spring Mountains study sites. * = statistically significant Modified from Brooks and Matchett (2003a).*

Effects of fire on blackbrush appear to be long-term. There is only one report of *Coleogyne ramosissima* resprouting after fire (Bates 1984), two reports of seedling establishment by *Coleogyne ramosissima* after fire (Ellison 1950, Lei 1999), and one report of autogenic succession back to blackbrush after fire (Thatcher 1975). In the latter case, fire intensity was likely very low and *Coleogyne ramosissima* survival very high, resulting in incomplete removal of *Coleogyne ramosissima* which allowed the direct reestablishment of the blackbrush vegetation type. Most studies report that blackbrush does not reestablish after fire (Bowns 1973, Beatley 1976, West and Young 2000), even after 37 (Callison et al. 1985) postfire years. A wide range of species can dominate after *Coleogyne ramosissima* is removed by fire (Jenson et al. 1960, Bowns 1973, Wright and Bailey 1982, Bates 1984, Callison et al. 1985). Annuals typically dominate during the first few postfire years, and early successional perennial plants dominate after the first few decades (Jenson et al. 1960, Bates 1983, Callison et al. 1985). Although the species composition can be highly variable (Bowns 1973), the non-native annual grasses red brome (*Bromus madritensis* ssp. *rubens*) and cheatgrass (*Bromus tectorum*) are often among the most common postfire species (Jenson et al. 1960, West 1983, Callison et al. 1985). Exceptions to this rule may occur during years of low rainfall when overall productivity of non-native grasses in low (Brooks and Matchett 2003a).

Non-native annual grasses can create a continuous cover of fine fuels that persists for years, thereby facilitating the spread of fire in the Mojave Desert (Brooks 1999). Recurrent fire may increase the cover and frequency of non-native annual grasses (Whisenant 1990, D'Antonio and Vitousek 1992), promoting additional fires and possibly replacing long-lived native species in the Mojave Desert (Brooks and Esque 2000, Brooks and Minnich in press). Slow recruitment rates of *Coleogyne ramosissima* should make this species particularly sensitive to the effects of recurrent fire. Although blackbrush produces the highest cover of all native vegetation types in the Mojave Desert (up to 51%, Beatley 1975), which is partly why it is considered the most flammable (Bowns 1973, Beatley 1976, West 1983), high cover and frequency of non-native annual grasses may create even more flammable fuel conditions (Holmgren 1960).

Historical Fuels and Fire Regimes in Blackbrush Shrublands

Coleogyne ramosissima is considered a poor livestock forage species, and ranchers noted that during the late 1930s and early 1940s wildfires increased production of livestock forage in blackbrush rangeland of southern Nevada and northwestern Arizona (Anonymous 1945). In an attempt to further increase forage production, ranchers and the Bureau of Land Management began a program of prescribed burning in the 1940s, during which time approximately 20% of the 400,000 acres of blackbrush were burned by prescribed fire or wildfire in southern Nevada (BLM, Las Vegas, Nevada, grazing district 5) (Croft 1950). Many blackbrush fires also occurred in northwestern Arizona during this time (BLM, Arizona Strip, Arizona, grazing district 2). Additional blackbrush burning likely occurred at least through the 1960s, because a policy review during that time by the Range and Forestry Officer of the Bureau of Land Management in Nevada recommended that blackbrush burning be continued to increase livestock forage (Dimock 1960). Before 1940, fires in these regions were relatively uncommon (Croft 1950). The long-term effects of these mid-century range burns are currently being evaluated using repeat photography of historical photos originally taken 5-10 years postfire and analyses of field reports, memos, and vegetation plot data collected during the late 1940s through the early 1960s by range conservationists and foresters from the Bureau of Land Management and the United States Forest Service, Intermountain Forest and Range Experiment Station (M. Brooks, unpublished data).

Prior to European contact, late seral blackbrush stands were probably more extensive than they are today in the Mojave Desert. The vast expanses of blackbrush rangeland that were burned to improve livestock production during the mid-1900s are still dominated by early seral species and have been re-colonized only sporadically by *Coleogyne ramosissima* (M. Brooks, unpublished data). Blackbrush within the Desert Wildlife Range and Nevada Test Site in southern Nevada that has not been managed for livestock production since the 1930s, and likely was not burned for rangeland improvement, does not currently contain evidence of widespread historical burning (M. Brooks and T. Esque personal observations). It therefore appears that extensive burning to remove blackbrush must have created many of the vegetation stands where *Coleogyne ramosissima* is either absent or a sub-dominant species today.

The historical fuel complex in late seral blackbrush stands was probably similar to that observed in relatively undisturbed sites today, except for the current prevalence of *Bromus* spp. and *Erodium cicutarium* in many stands. Vegetation characteristics of these stands were characteristic of blackbrush Condition Class 1 described below. Shrub cover was likely comprised primarily of *Coleogyne ramosissima* at 30-50% total cover, and interspaces were probably mostly bare, even during years of high rainfall, due to root competition from *Coleogyne ramosissima*. Other species such as perennial grasses and early seral shrubs probably occurred sporadically, as they do today, along wash stringers and on steep hillslopes where cover of *Coleogyne ramosissima* is typically low.

Low amounts of fine fuels in interspaces probably limited fire spread to only extreme fire conditions, during which high winds, low relative humidity, and low fuel moisture led to high intensity stand-replacing crown fires. Historical fire return intervals appear to have been on the order of centuries (Webb et al. 1987), allowing late seral blackbrush stands to re-establish.

Current Fuels and Fire Regimes in Blackbrush Shrublands

Blackbrush is considered to be one of the most flammable native plant assemblages in the Mojave Desert. Many large fires have occurred in this vegetation type since the 1980s in the Spring Mountains and Mormon Mountains in Nevada, the Beaver Dam Mountains in Utah, the Black Mountains and Virgin Mountains in Arizona, and at Joshua Tree National Park in California (Brooks and Esque 2002). Although fire is generally no longer advocated as a tool for range improvement, ignitions from lightning and accidental ignitions along roads have been sufficient to burn significant acreage of blackbrush during the past few decades.

At Joshua Tree National Park in California, blackbrush was burned during the early 1990s to reduce woody fuel loads at the wildland-urban interface between Joshua Tree and the town of Yucca Valley. During the first few postfire years the landscape was dominated by native annual wildflowers, but by the fourth postfire year the non-native annual grasses *Bromus rubens* and *Bromus tectorum* became the dominant annual plants, and remained as such into the 2000s. The appearance of this new flashy fuelbed resulted in a change in fire management at Joshua Tree, putting a stop to the use of fire as a management tool until prescriptions could be identified that would not create continuous fuelbeds of non-native annual grasses. At the current rate of wildfire in blackbrush burning during 1980s and 1990s, managers estimate that all the blackbrush at Joshua Tree will burn within the next 15-20 years (Hank McCutchen, Chief of Resources, personal communication). This is a significant concern because the blackbrush stands at Joshua Tree are disjunct from the rest of the blackbrush range, and if all the stands were to burn it is very likely that *Coleogyne ramosissima* would not be able to re-establish.

The fuel complex in blackbrush appears to be more conducive to burning now than in the past. Non-native annual grasses currently occur in most blackbrush stands, facilitating the spread of fire after years of high rainfall. Postfire landscapes are even more dominated by these non-native grasses, raising concerns that they will promote recurrent fire and prevent the re-establishment of *Coleogyne ramosissima*. Interestingly, reports from the mid-1900s also acknowledge the role that non-native annual grasses, especially *Bromus rubens*, play in facilitating the spread of fire in blackbrush (Dimock 1960, Holmgren 1960, Jenson et al. 1960), although there was disagreement as to whether the burned landscapes were more or less susceptible than unburned landscapes to reburning. Jenson et al (1960) thought the chances of reburning were low because they observed low fine fuel levels in postfire landscapes, but their observations were made during the mid-century drought when fine fuel loads were on the low end of their possible range. In contrast, Holmgren (1960), who accompanied Jenson et al. on the same field visits, thought that the danger of accidental fire in blackbrush would be higher in areas that previously burned than in unburned areas, if high winter rainfall had produced more

Bromus rubens biomass and other fine fuels. Prior to the invasion of *Bromus rubens* and *Bromus tectorum* during the late 1800s to early 1900s (Brooks 2000, Young 2000), fine fuel loads were likely not as great in either burned or unburned blackbrush stands, resulting in fewer fires, and fewer reburns.

Fire Regime Condition Class Descriptions for Blackbrush Shrublands

Condition Class 1

Description – Condition Class 1 is characterized by vegetation and fire regime attributes within the historical range of variation. The risk of losing key ecosystem components such as high *Coleogyne ramosissima* cover and associated protection from soil erosion is low. Mature blackbrush stands fall into this condition class. These stands are typically late seral with occasional early seral patches created by small, infrequent, stand-replacing fires.

The fire regime for this condition class is active crown fire carried primarily by *Coleogyne ramosissima*, and perennial grasses (*Achnatherum* spp. and *Pleuraphis* spp.) on deep silty soils. Burns are complete and stand-replacing, fire intensity is high, and fire return intervals are >100 years. Long fire return intervals allow for the typically slow process of blackbrush re-establishment.

Recommendations – Suppress human-caused fires, but consider allowing lightning-caused wildfires to burn, unless significant populations of *Bromus rubens* or *Bromus tectorum* are present, or there are other reasons for suppression. Prescribed fires should not be conducted except for research burns designed to evaluate fire behavior, fire effects, and fire management techniques and treatments. Only apply fuel management treatments at the wildland urban interface to reduce fire hazard, or in wildland areas where fuel breaks are deemed necessary to achieve management goals. Realize that regular maintenance may be required to maintain these managed fuel zones, because fuel treatments that involve replacement of late seral woody fuels with early seral fine fuels will reduce fire intensity, but may increase susceptibility to ignition and rates of fire spread.

Condition Class 2

Description – Condition Class 2 is characterized by vegetation and fire regime attributes that have been moderately altered from their historical range. The risk of losing key ecosystem components such as high *Coleogyne ramosissima* cover and associated protection from soil erosion is moderate. Blackbrush stands with an intermix of late seral unburned patches and early seral burned patches are in this condition class. Blackbrush stands with patches that have been degraded by overgrazing, prescribed burning in the mid-1900s, or other forms of surface disturbance, also fall into this condition class. These disturbances reduce cover of *Coleogyne ramosissima*, and increase cover of early seral shrubs such as *Chrysothamnus* spp., *Gutierrezia* spp., and *Eriogonum fasciculatum*, early seral herbaceous perennials such as *Sphaeralcea ambigua* and *Astragalus* spp., and non-native annual plants such as *Bromus rubens*, *Bromus tectorum*, and *Erodium cicutarum*. Burned stands without livestock over-grazing, and situated on deep silty soils, can also have a large perennial grass component (*Achnatherum* spp. and *Pleuraphis* spp.).

Fires in late seral patches are active crown fires carried by *Coleogyne ramosissima*, perennial grasses (*Achnatherum* spp. and *Pleuraphis* spp.), and non-native annual grasses (*Bromus* spp.), burns are complete, and fire intensity is high. Fires within early seral patches are passive crown fires or ground fires, carried by perennial grasses and non-native annual grasses between the sparse cover of early seral shrubs, burns are patchy, and fire intensity is low to moderate.

Fire return intervals in Condition Class 2 stands are approximately 50-100 years. This shorter fire return interval, and over-grazing pressure from livestock, helps to maintain dominance by early seral species and may prevent re-establishment by *Coleogyne ramosissima*.

Recommendations – Suppress all wildfires, and prescribed fires should not be conducted except for research burns. Minimize livestock grazing and other surface disturbances on early seral stands, or where early seral and late seral stands are intermixed. Do not apply fuel management treatments on late seral stands, except possibly at the wildland urban interface to reduce fire hazards or in wildland areas where fuel breaks are deemed necessary to achieve management goals. Realize that regular maintenance may be required to maintain these managed fuel zones, because fuel treatments that involve replacement of late seral woody fuels with early seral fine fuels will reduce fire intensity, but may increase susceptibility to ignition, fire spread rates, and fire frequency. Fuel treatments on early seral stands dominated by non-native annual plants may include the use of grass-specific herbicides. Livestock grazing may reduce fine fuel loads temporarily, but may hinder the re-establishment of *Coleogyne ramosissima* and other late seral species, and thus may be counterproductive in the long-term.

Condition Class 3

Description – Condition Class 3 is characterized by vegetation and fire regime attributes that have been significantly altered from their historical range. The risk of losing key ecosystem components such as high *Coleogyne ramosissima* cover and associated protection from soil erosion is high. Blackbrush stands that burned during the 1900s, and have reburned at least once, fall into this condition class. These stands are typically dominated by non-native annuals and early seral perennials. Recurrently burned stands without livestock over-grazing can also have a large perennial grass component (*Achnatherum* spp. and *Pleuraphis* spp.).

The fire regime for this condition class is typically surface fire carried primarily by non-native annual plants, burns are patchy, fire intensity is low, and fire return intervals are <50 years. Re-establishment by *Coleogyne ramosissima* is unlikely under this fire regime.

Recommendations – Suppress all wildfires, and prescribed fires should not be conducted except for research burns. Extreme measures may be required in these stands. Revegetation with *Coleogyne ramosissima* and other late seral shrubs and perennial grasses, and exclusion of livestock grazing and other surface disturbances, may be necessary. Control of non-native annual grasses using herbicides or early season prescribed fire implemented immediately before revegetation treatments may improve initial establishment rates of revegetated plants.

Product Summary

The original proposal for JFSP project 00-2-32 called for deliverables to include: (1) a summary report describing the effects of management treatments; (2) at least one peer-reviewed manuscript; (3) educational fact sheets; (3) and presentations at symposia and workshops. The following summary indicates that we have more than achieved these product targets.

Peer-Reviewed Manuscripts Completed

Brooks, M.L. and J.R. Matchett. 2003a. Plant community patterns in unburned and burned blackbrush (*Coleogyne ramosissima*) shrublands in the Mojave Desert. Western North American Naturalist 63:283-298.

Publication Briefs/Fact Sheets Completed

Brooks, M.L. and J.R. Matchett. 2003b. Plant diversity and fire effects in blackbrush shrublands. USGS Publication Brief. Available online at www.werc.usgs.gov/pubbriefs/brookspbaug2003.html.

Non-peer-reviewed Reports Completed

Brooks, M.L., T.C. Esque, and T. Duck. 2003. Fuels and fire regimes in creosotebush, blackbrush and interior chaparral shrublands. Report for the Southern Utah Demonstration Fuels Project, USDA, Forest Service, Rocky Mountain Research Station, Fire Science Lab, Missoula, Montana. 17pp.

Brooks, M.L. and J.R. Matchett. 2001. Plant community patterns in unburned and burned blackbrush (*Coleogyne ramosissima*) shrublands in the Mojave Desert. Report prepared for the National Park Service, Pacific West Region, Fire Management, 1111 Jackson St. Suite 700, Oakland, CA 94607.

Peer-reviewed Manuscripts Pending.

Brooks, M. L. and R. A. Minnich. In press. Fire in the southeastern desert bioregion. Chapter 16 in: Sugihara, N. G., J. W. van Wagtendonk, J. Fites-Kaufman, K. E. Shaffer, and A. E. Thode (eds.). Fire in California ecosystems. University of California Press, Berkeley.

Brooks, M.L, et al. In prep.a. Annual plant seedbanks in unburned and burned blackbrush (*Coleogyne ramosissima* Torr.) shrublands in the Mojave Desert. Plant Ecology.

Brooks, M.L. et al. In prep.b. Effects of vegetation thinning in blackbrush shrublands.

Presentations (listed chronologically)

Brooks, M.L. 2004. Fire ecology zones of the Mojave Desert. Mojave Desert Science Symposium, 16-18 November, Redlands, CA.

Brooks, M.L. 2004. Fire and fuels management in the intermountain west. Bureau of Land Management, Idaho State Office, Science Seminar, 3 November, Boise, ID.

Brooks, T. Esque, T. Duck, and T. Patterson. 2004. Fire behavior, fire effects, and fuel management in blackbrush (*Coleogyne ramosissima*) shrublands and invasive annual grasslands of the Mojave Desert. National Fire Plan Conference 3-5 March, Reno, NV.

Brooks, M.L., T.C. Esque, T. Duck, and T. Patterson. 2003. Fire Behavior, Fire Effects, and Fuel Management in Blackbrush (Coleogyne ramosissima) Shrublands and Invasive Annual Grasslands of the Mojave Desert. Joint Fire Science Program Principal Investigator Workshop. 12 March, Phoenix, AZ.

Haines, D.F. T.C. Esque, L.A. DeFalco, S.J. Scoles, M.L. Brooks, and R.H. Webb. 2003. Blackbrush (*Coleogyne ramosissima*) habitat, fire and exotics in the Mojave Desert. Aridlands Restoration Workshop. 3-7 March, Palm Springs, CA.

Haines, D.F. T.C. Esque, S.J. Scoles, M.L. Brooks, and R.H. Webb. 2003. Do fire and exotics in the Mojave Desert cause irreversible change? A state-transition model for blackbrush (*Coleogyne ramosissima*) habitat. Aridlands Restoration Workshop. 3-7 March, Palm Springs, CA

Brooks, M.L., T.C. Esque, and J. D'Elia 2002. Fire Behavior in the Mojave Desert: Potential Effects of the El Nino/La Nina Cycle. Fire Conference 2002: Managing Fire and Fuels in the Remaining Wildlands and Open Spaces of the Southwestern United States. Co-hosted by the Association for Fire Ecology and the Western Section of the Wildlife Society. 2-5 December, San Diego, CA.

Matchett, J.R., and M.L. Brooks. 2002. Postfire successional patterns of blackbrush in the Mojave Desert. Fire Conference 2002: Managing Fire and Fuels in the Remaining Wildlands and Open Spaces of the Southwestern United States. Co-hosted by the Association for Fire Ecology and the Western Section of the Wildlife Society. 2-5 December, San Diego, CA.

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Brooks, M.L. 2002. Fire behavior, effects, and management in unburned and previously burned blackbrush (*Coleogyne ramosissima*) shrubland in the Mojave Desert. Poster presentation. Joint Fire Science Program 2001 Principal Investigator Workshop. 11-14 March, San Antonio, TX.

Brooks, M.L. and J.R. Matchett. 2001. Fire promotes exotic annual vegetation and reduces plant species richness in Mojave Desert blackbrush communities. 6th Biennial Conference of Research on the Colorado Plateau. Flagstaff, AZ.

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