BLOWING SAND MOUNTAINS

Initial Conservation Assessment and Strategies

The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

March 2004

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Executive Summary

The Nature Conservancy, Department of Defense – Naval Air Station Fallon, Bureau of Land Management – Carson City Field Office, Walker River Paiute Tribe and Fallon Paiute Shoshone Tribe have embarked on a partnership to examine the ecology and land management of the area we have chosen to call *Blowing Sand Mountains*. This area encompasses what appears to be an ancient sand movement corridor that began on the shores of Walker Lake approximately 11,000 years before present and terminates in the dune field at Sand Mountain, southeast of Fallon, Nevada. The Blowsand Mountains are another significant sand dune system located midway in the sand corridor.

This area includes two significant areas of conservation interest, as identified in a Great Basin ecoregional assessment by The Nature Conservancy (TNC). Both Sand Mountain and Blowsand Mountain were identified as areas supporting noteworthy biodiversity and viable examples of representative Great Basin systems, such as playa, greasewood shrubland, and sand dune systems. Several western Great Basin endemic species are found within the Blowing Sand Mountains area, such as the Sand Mountain blue butterfly (*Euphilotes pallescens arenamontana*), Hardy's scarab beetle (*Aegialia hardyi*) and Tonopah milkvetch (*Astragalus pseudiodanthus*).

TNC facilitated this conservation assessment using funding from the Department of Defense Legacy Resource Management Program. The Blowing Sand Mountains area was analyzed for appropriate conservation management strategies using TNC's conservation area planning methodology, the *Five-S Framework.* The Five-S Framework for conservation planning addresses the viability of the representative native species and ecological systems at a site, identifies the stresses to these species and systems and the actions that are the sources of stress, and finally, develops a suite of potential strategies and success measures to allow for adaptive management of the area.

The Five-S Framework was applied to the Blowing Sand Mountains area during a series of facilitated workshops. This workshop series allowed for all participating land management agencies and tribal governments to appoint representatives to a conservation assessment team, to work through the Five-S Framework for the Blowing Sand Mountains area. The conservation assessment team for the Blowing Sand Mountains area also participated in field trips to the area and gathered additional input from additional resource experts. The outcome of this workshop series was a peer-reviewed assessment of conservation potential for the Blowing Sand Mountains area.

CONSERVATION ASSESSMENT FOR BLOWING SAND MOUNTAINS

To facilitate assessment of the conservation potential of the Blowing Sand Mountains area, the conservation assessment team chose representative ecological systems as units of analysis. The systems chosen to represent the biodiversity at Blowing Sand Mountains are described below in table ES-1. Each system captures a group of ecological entities on the ground with common natural processes, threats to the system's viability, or likelihood of a common response to land management strategies. Each of these systems also captures species of interest to land managers. It is presumed that actions directed to protect the functioning of these natural systems will also protect the native species of interest within the Blowing Sand Mountains area.

Table ES-1. Conservation target ecological systems for the Blowing Sand Mountains area.

Ecological Systems	Description	Key Species or Ecological Processes Nested within System
Salt Desert Scrub	Composed of four-wing saltbush, shadscale or Bailey's greasewood dominated vegetation. Matrix communities that surround all other systems.	Bailey's greasewood Altered fire regime or large-scale weed invasions here would effect other systems.
Greasewood Shrubland	Composed of relictual (not active within past 150 years) dunes and deep sand deposits throughout the sand movement corridor.	Potential future movement corridors for dune species.
Blowsand Mountains Dunes	Active and dormant (active in past 150 years) sand dunes with shrub and herbaceous vegetation. Includes much of the Bravo-19 bombing range, Naval Air Station, Fallon.	Kearney buckwheat (last seen 1981) Watson's oxytheca Lahontan indigobush sand cholla Hardy's scarab beetle Sand dune formation processes
Sand Mountain Dunes	Active and dormant (active in past 150 years) sand dunes with shrub and herbaceous vegetation. Includes much of Sand Mountain Recreation Area.	Sand Mountain blue butterfly Kearney buckwheat Sand cholla Hardy's scarab beetle Sand dune formation processes
Playas	Dry lakebeds that flood during periods of high surface water flows.	Important for sand flow to both dune systems.
Springs	Spring sources, outflows and associated riparian communities. Springs in this area are rare, and often geothermal and/or with high conductivity levels due to dissolved minerals and salts.	Important forage areas for herbivores and insectivores (bats). Changes in groundwater will likely be seen here first.

Table ES-2 summarizes the conservation assessment team's findings relative to the viability of the selected ecological systems. The Five-S Framework process revealed that the Blowing Sand Mountains area has an overall good viability due to the good status of landscape processes, the naturally large extent of many of these systems, and the minimal fragmentation of this site.

Table ES-2. Viability rankings for conservation targets in the Blowing Sand Mountains area.

System	Size	Condition	Landscape Context	Summary viability score
Salt Desert Scrub	Very Good	Good	Very Good	Very Good
Greasewood Shrubland	Very Good	Good	Very Good	Very Good
Blowsand Mountains	Good	Good	Very Good	Good
Sand Mountain	Good	Fair	Very Good	Good
Playas	Very Good	Good	Good	Good
Springs	Good	Fair	Good	Good
Overall Site Viability				Good

In general, the viability criterion that responds most readily to land management activities is condition. Four of the six systems were found to be in good condition. However, two systems were found to be in only fair condition; springs and Sand Mountain dunes. The spring systems received a fair condition rank due to a decrease in extent of riparian vegetation, invasion by tamarisk, and an alteration of some stream brook segments. Sand Mountain dunes received a fair rank for condition due to extensive shrub and herbaceous vegetation mortality as a result of crushing by vehicles. These findings, and an analysis of the threats to the area revealed a few key challenges for land managers.

A threat is defined as the combination of a stress and its source. Stated another way, a threat is a combination of an activity that is damaging an area, natural system or species, and the damage that activity is causing. The Five-S Framework guides participants through a detailed analysis of the actual and likely stresses that would decrease the viability of systems or species within the next ten years, and the relative contributions and degree of damage from each stress. The stress analysis is then expanded to identify the most proximate source or cause of each stress, and the relative contributions each source makes to the overall expression of the stress. In this way the Five-S Framework reveals the most critical sources of stress that require action to maintain or improve the system or species viability in the long term. Threats rankings for the conservation targets in the Blowing Sand Mountains area are summarized in table ES-3.

Table ES-3. Threat rankings for conservation targets in the Blowing Sand Mountains area.

Active Threats Across Systems	Salt Desert Scrub	Greasewood Shrubland	Blowsand Mountain Dune System	Sand Mountain Dune System	Playas	Springs	Overall Threat Rank
Vehicular abuse	Low	Low	-	High	Medium	-	Medium
Vehicular use	-	-	-	High	-	-	Medium
Invasive/alien species	Medium	Medium	-	Medium	Low	-	Medium
Mining practices	Medium	-	-	Low	Medium	-	Medium
Responsible use of paved roads	Medium	Medium	-	Low	-	-	Medium
Current Grazing	Low	Low	-	Low	-	Medium	Low
Excessive groundwater withdrawal	-	-	-	-	Medium	Low	Low
Construction of ditches, dikes, drainage or diversion systems	-	-	-	-	-	Medium	Low
Ordnance drops	-	-	Medium	-	-	-	Low
Ordnance removal-invasive transport	-	-	Medium	-	-	-	Low
Ordnance removal-UXO detonation	-	-	Medium	-	-	-	Low
Rights-of-Way and ROW Corridors	Low	Low	-	-	Low	-	Low
Recreational use of springs	-	-	-	-	-	Low	Low
Historical Sources Across Systems							
Past Grazing	Low	Low	-	-	-	-	Low

Strategies to address critical threats to the Blowing Sand Mountains area were developed by the conservation assessment team during the workshop series and field trips to the site. The conservation assessment team further refined the strategies based on conversations with knowledgeable persons including resource managers, agency staff and tribal members. The strategies presented here are not intended to be a directive to any of the land management agencies or tribal governments, but are a suite of possibilities recommended by the conservation assessment team for consideration by land managing agencies and tribal governments. Also, this suite of strategies is not intended to be all-inclusive, and assumes that current best practices will be continued.

Each strategy was scored for direct benefits to all systems in the site, and then ranked through an analysis of the feasibility and relative cost of each strategy recommendation, as well as an analysis of the *leverage* value of each strategy. Leverage value was defined as the degree to which a particular strategy facilitates the successful implementation of another strategy. The final top ten strategies are listed below in table ES-4.

Table ES-4. Strategy highlights for the Blowing Sand Mountains area.

Strategy	Priority Rank
Increase BLM law enforcement presence at Sand Mountain Recreation Area to increase user compliance with rules and use area restrictions.	Very High
Restrict vehicular traffic to unvegetated dunes and designated roads and trails to reduce damage to vegetated dunes at both Sand Mountain Dune System and Blowsand Mountain Dune System. Land management agency staff, Unexploded Ordnance Removal personnel and Emergency Response personnel excluded.	High
Continue requirement for spark arrestor devices on off-highway vehicles.	High
Implement actions that allow Bureau of Land Management management of 86 acre Navy parcel at the entrance to Sand Mountain Recreation Area	High
Evaluate current livestock grazing levels on Bureau of Land Management and Tribal allotments.	High
Restrict vehicle access to Sand Mountain Recreation Area via the Dixie Valley road in order to protect northern vegetated dunes.	High
Station a campground host at Sand Mountain Recreation Area to assist in interpretation of rules and use restrictions.	Medium
Establish and enforce a use threshold at which Sand Mountain Recreation Area is full, and no additional users are admitted during that period.	Medium
Fence spring riparian areas to exclude livestock and allow recovery of spring habitats.	Medium
Require procedures to minimize soil disturbance and reduce weed invasions during rights-of-way construction and maintenance.	Medium

Because strategies which lend leverage to the successful implementation of other strategies were ranked higher in this analysis, and expensive or less-feasible strategies were downgraded during this analysis, some strategies designed to address highly ranked threats did not automatically rank highly. For example, strategies to address the highly ranked threats from mining operations/exploration did not rank as highly as some of the more leveraged strategies. Evaluating current livestock grazing levels to detect adverse effects to native species and their habitats, and continuing the spark arrestor requirement for all off-highway vehicles were both found to be feasible, low-cost strategies, and thus ranked fairly high in the final strategy analysis.

Measuring the success of management activities is increasingly critical for land managers. The cost of land management activities is scrutinized by the public, supervisors and stakeholders. The Five-S Framework provides the basis for using quantitative measures where possible, with predetermined threshold values at which management activities can either be considered successful or in need of adjustment. Measures of success can then be directly related to the viability of species and systems of concern whenever possible, or designed to track increases or decreases in threats to these species and systems. The conservation assessment team suggested several measures of success for the Blowing Sand Mountains area, and a few are listed below in table ES-5.

Table ES-5. Measures of success highlights for the Blowing Sand Mountains area.

Measure	Indicator Species / System or Threat
Monitor abundance, distribution and recruitment of Kearney buckwheat in and around Sand Mountain Recreation Area	This important resource for many animals in the Sand Mountain dune system is expected to experience increased plant recruitment and decreased mortality if vehicular misuse decreases.
Monitor user compliance with vehicle use restrictions in Sand Mountain Recreation Area	Increased perennial plant recruitment and decreased dune plant mortality are expected to be correlated with an increase in user compliance with vehicular use restrictions.
Conduct remote sensing surveys of vehicular effects throughout the Blowing Sand Mountains assessment area.	The threat of vehicular misuse is expected to decrease with an increase in law enforcement and/or presence of a campground host at Sand Mountain Recreational Area.
Conduct surveys for invasive weed species throughout the Blowing Sand Mountains assessment area	Detection of emerging weed invasions / localized increases in weed distribution may indicate a need to alter land management practices.
Monitor abundance, distribution and recruitment of sensitive species in Blowing Sand Mountains assessment area	Long term decreases in these species' populations may indicate a decrease in the overall viability of the dune system at Sand Mountain Recreation Area.

The conservation assessment team's analysis of the Blowing Sand Mountains area revealed that the potential for conservation success in this area is high due to the current good viability ranking of the systems, including both sand dune systems, and the high proportion of public lands within the assessment area. However, continuing management actions will be vital to maintaining the viability of this site. The existence of several invasive weed species in the area, threats from increasing off-highway vehicle use and potential pressures for additional or expanded mining operations compound the likelihood of additional weed invasions and fire regime alterations.

This initial conservation assessment of the Blowing Sand Mountains area resulted in a comprehensive evaluation of the character and status of the biological resources in this endemic-rich area. The conservation assessment team recommends this analysis of the area's viability, threats and conservation strategies should be updated periodically to assess the effectiveness of management practices and to detect new or changing threats to the system. Due to the trend toward increasing threats to native habitats in the area, a three year review cycle is recommended. It is the conservation assessment team's hope that the bulk of recommended very highly and highly ranked strategies and success measures will be implemented and evaluated in an adaptive manner, allowing land managing agencies and governments the best opportunity for conservation success at Blowing Sand Mountains.

Acknowledgements

This conservation assessment effort would not have been possible without the active involvement of a number of dedicated professionals. Members of the Blowing Sand Mountains conservation assessment team provided their professional expertise and personal knowledge of this area. For their tireless efforts, I am indebted to Donna Cossette, Gary Cottle, Cliff Creger, Rochanne Downs, Claudia Funari, Sherry Lash, Bruce Lund, Gary Ryan, Dean Tonenna and Tad Williams. Additional expertise was provided by Richard Rust, Libby Powell, Jan Nachlinger, Dennis Murphy, Christine Miller, Nicholas Lancaster, Karen Kelleher, Cameron Barrows, George Austin and Rebekah Andrus.

Many military and civilian staff of Naval Air Station Fallon provided support in various ways, and their efforts are greatly appreciated. The expertise and data shared by members of the Bureau of Land Management's Carson City Field Office were invaluable to this conservation assessment. The knowledge contributed by the members of both the Fallon Paiute Shoshone Tribe and the Walker River Paiute Tribe informed the conservation assessment team's understanding of the history of human involvement with and use of the dunes, as well as providing a unique perspective on how these dynamic sand dune systems function within the context of the surrounding geology, hydrology and ecosystems. I am deeply grateful for the hospitality shown to the conservation assessment team by the Fallon Paiute Shoshone Tribal Council during our team field trips to the area.

During two workshops, facilitated by Greg Low, other conservation assessment teams reviewed our team's progress and assumptions. The peer review provided by members of other teams at this early stage of the Blowing Sand Mountains assessment was profoundly helpful. The superb facilitation and strategic thinking provided by Greg Low was invaluable, and we thank him.

Access to maps and geographic data was provided by the Walker River Paiute Tribe, Naval Air Station Fallon, and Bureau of Land Management Photos to enhance the conservation assessment team's assessment and the final document were graciously provided by Cliff Creger, Bruce Lund, Jan Nachlinger, Richard Rust and Dean Tonenna. In addition to the insightful reviews provided by the conservation assessment team, several Nature Conservancy colleagues provided clarifying comments to improve the final assessment document. For this I thank Jan Nachlinger, Janet Bair, Hazel Wong, Jim Moore, and Elaine Evans. I also thank Elaine Evans for her assistance with the graphics. For the accompanying maps and underlying data I thank Brian McMenamy.

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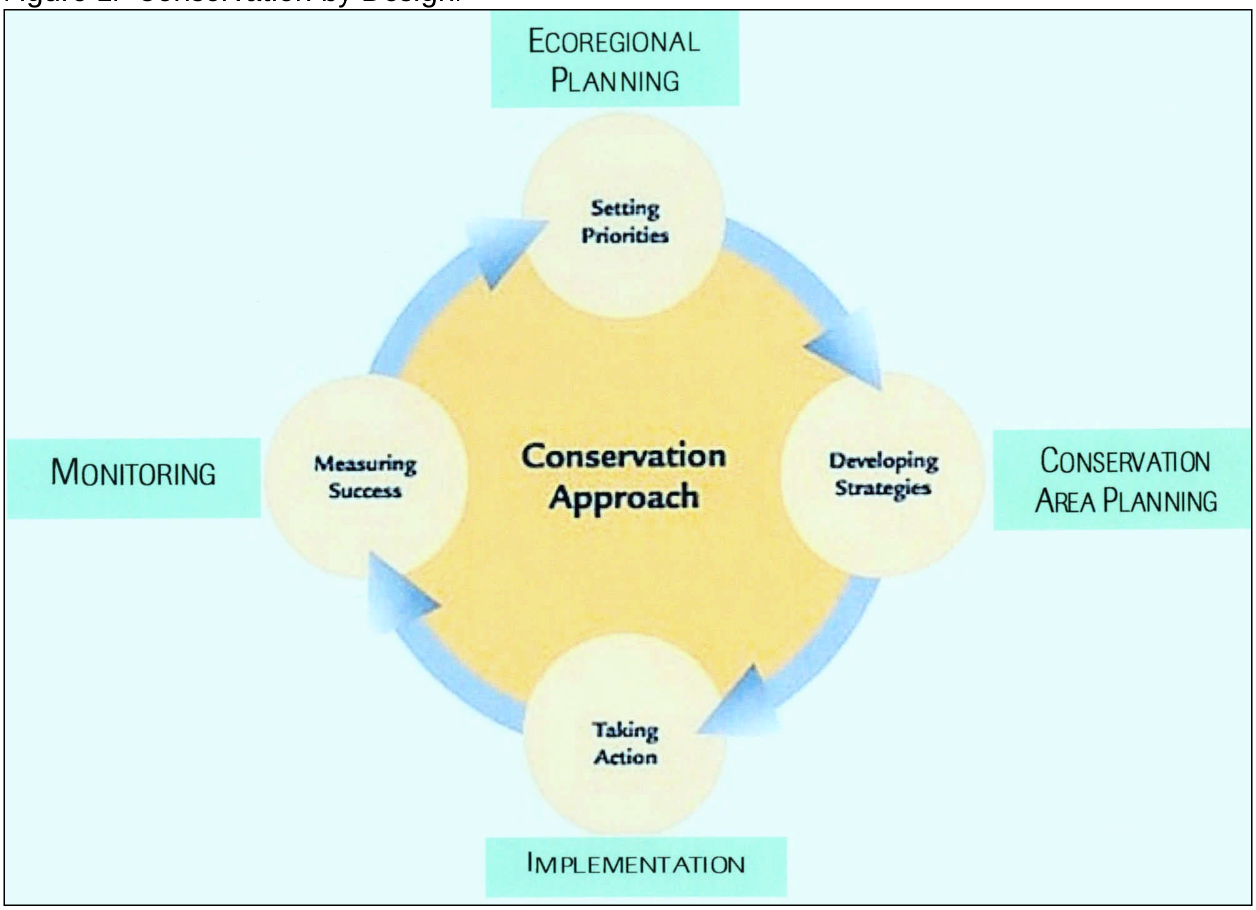
Background

GREAT BASIN CONSERVATION INITIATIVE

The Legacy Resource Management Program of the Department of Defense (DoD) has supported a number of conservation initiatives led by The Nature Conservancy (TNC) primarily on large military installations in the U.S. Among the various southwestern efforts is the Great Basin Conservation Initiative, which began in December 1999, and supports TNC of Nevada's effort as part of an organization-wide conservation approach called *Conservation by Design*.

TNC's *Conservation by Design* approach includes four fundamental components which are illustrated in figure 1.

Figure 1. Conservation by Design.



The four components of *Conservation by Design* include setting **priorities** through the ecoregional planning process; developing **strategies** to conserve both single and multiple areas via conservation area planning; taking direct conservation **action**; and **measuring** conservation success through monitoring and other means. The latter component of measuring success provides adaptive feedback loops for setting new conservation priorities and developing additional strategies as situations evolve over time.

With funding support from the Legacy Program, TNC of Nevada completed a first iteration of a conservation assessment for the Great Basin ecoregion in May 2001, thus helping TNC set conservation priorities in the Great Basin (Nachlinger and others 2001). The Great Basin Ecoregional Blueprint identifies a network of 358 conservation areas that collectively represent the ecological systems, natural communities, and species that are characteristic of the 72 million acre desert ecoregion. The 358 conservation areas were selected to complement one another by including different assemblages of conservation targets—rare species, plant communities, and ecological systems that are either unique to or representative of the Great Basin. Simultaneously, they were selected to provide maximum efficiency by building from already protected core areas and incorporating the least area possible.

Two types of conservation areas were selected in the conservation assessment, Functional landscape areas and functional sites. **Functional landscape** areas seek to conserve a large number of ecological systems, natural communities and species at several geographic scales. Functional landscapes have a high degree of ecological intactness and have most of their key components, patterns and ecological processes intact or in a restorable condition. These areas tend to be larger, have more habitat, more habitat diversity and larger populations of known and unknown species (Poiani and others 2000). Ninety four of the 358 conservation areas identified in the Great Basin Ecoregional Blueprint (26% of areas) are functional landscapes.

On the other hand, many of the conservation areas identified in the Great Basin Ecoregional Blueprint are less complex, yet still capture viable examples of most of their target species, communities and ecological systems. These areas are **functional sites**, and are designed to protect a smaller number of targets, often at smaller, more local geographic scales. Often the targeted species, communities and ecological systems within a functional site require the proper functioning of similar ecological processes (Poiani and others 2000). Of the 358 conservation areas in the Great Basin Ecoregional Blueprint, 74% are functional sites.

The network of 358 conservation areas encompasses about 28.5 million acres of land and water, which is just under 40% of the Great Basin ecoregion. Approximately 5% of the acreage identified for conservation is land managed by DoD. In addition, the associated military air space, or military operation area (MOA) is substantially larger than the DoD land footprint and accounts for another 10% of the conservation area acreage. Management of land in the shadow of the MOA is administered by various governmental agencies (U.S. Department of the Navy 2000), primarily the Bureau of Land Management (BLM) within the Great Basin.

In the Great Basin ecoregional assessment, five conservation areas were identified that overlap with land units managed by the Navy: Carson Sink, Sand Mountain, Blowsand Mountains-Barnett Hills, Dixie Valley, and Stillwater Range-Dixie Valley (appendix A, map 2).

Another 29 conservation areas occur within the shadow of the MOA. Each conservation area is described in the following sections, but eight deserve special mention.

Conservation areas that contain the only known occurrence of an ecoregional target are said to have unique values. Eight of the conservation areas in the Naval Air Station (NAS) Fallon MOA have unique values (table 1), including two areas (Carson Sink and Sand Mountain) that overlap Navy lands. The two areas with the highest biological contributions to conservation value for NAS Fallon are the Carson Sink wetlands and the sand dune systems in the MOA (Rahn and Rust 2000). Sand systems are found at the Carson Sink, Blowsand Mountains-Barnett Hills, and Sand Mountain conservation areas as defined in the Great Basin Ecological Blueprint (Nachlinger and others 2001).

Table 1. Great Basin ecoregional conservation areas within NAS Fallon MOA that contribute unique biodiversity values.

Conservation Area Name	Acres	Conservation Area Type	Number of Conservation Targets	Number of Great Basin Endemics
Augusta Mountains	15,409	Functional Site	11	3
Carson Sink	936,872	Functional Landscape	74	12
Fly Ranch Geyser-Granite Range	120,290	Functional Landscape	16	1
Reese River	111,958	Functional Landscape	19	6
Sand Mountain	58,614	Functional Landscape	30	11
Shoshone Range-Carico Lake Valley	52,621	Functional Landscape	16	3
Toiyabe Range-Big Smoky Valley	508,369	Functional Landscape	59	18
Toquima Range-Monitor Valley & Range	979,084	Functional Landscape	74	20

Naval Air Station Fallon Installation Conservation Areas

NAS Fallon's primary mission is to provide training facilities for carrier air wings, Marine air groups, tenant commands, and individual units participating in training events including joint and multinational exercises. NAS Fallon also houses the Naval Strike and Air Warfare Center. The installation operates and maintains a complete airfield facility to provide visiting squadrons and air wings with ordnance, fuel, air traffic control, berthing and messing and all other aspects necessary for accomplishing the training mission. NAS Fallon manages several disjunct land units to support its training mission (appendix A, maps 1 and 2). These ranges are used for a variety of activities, including laser ranging and targeting, inert and live air-to-ground ordnance delivery training using bombs and rockets, and small arms training.

As previously mentioned, five conservation areas were identified that overlap with land units managed by the Navy: (appendix A, map 2). **Carson Sink** is a large functional landscape area that overlaps Navy land and extends into the MOA. A small portion (3.7%) of this area overlaps the Navy installation, while approximately 45% of it is beneath the MOA. The Carson Sink area has very high biological diversity, containing 74 aquatic and terrestrial conservation targets. The wetlands support a diverse resident bird population, as well as large concentrations of migratory birds. Many of the migratory bird populations are experiencing a declining trend. The area is a functional landscape with 12 Great Basin endemic species and 16 taxa of limited distribution, in addition to its wetland values. The majority of rare species within this area are plants and invertebrates that are restricted to sand systems of the Lahontan Basin. Carson Sink is a unique, irreplaceable site for a narrowly endemic, sand obligate dermestid beetle (*Novelsis sabulorum*). One of two known occurrences of an endemic tui chub (*Gila bicolor* ssp. 9) are found in the Carson Sink. Several mammals with limited distributions or habitat requirements, including sagebrush vole, occur in this conservation area. Carson Sink is also known for its importance to the inland portion of the Pacific Flyway.

The **Sand Mountain** conservation area is adjacent to the Carson Sink, and is also a functional landscape area with unique values. There are 11 known Great Basin endemic species within this area, five of which are known only from Sand Mountain. An additional 14 taxa with limited distributions can be found in the Sand Mountain conservation area. Approximately ¾ of the sand dune ecological system in this area falls within the Sand Mountain Recreation Area, which has been used for primarily vehicular recreation. A portion (50 acres) of Sand Mountain Recreation Area has been designated a limited use area, which provides some protection to the species adapted to the low dunes within this portion of the area. Long-term protection of the deeper, vegetated sand dunes, surrounding shrub systems, and dune-building processes is essential to the persistence of the 19 restricted invertebrates and several psammophytic (sand-loving) plants found in the Sand Mountain conservation area.

Blowsand Mountains – Barnett Hills is another functional landscape area that harbors 10 species endemic to the Great Basin; 2 plants and 8 invertebrates. Three scarab beetles and a sand obligate bee are more narrowly restricted, and are known to occur only at Blowsand Mountains-Barnett Hills and Sand Mountain. The Blowsand Mountains sand dune system harbors an additional 15 sand-obligate invertebrates that are both habitat restricted and limited in distribution. The Blowsand Mountains overlap the Bravo-19 range of the NAS Fallon complex, and a portion is used for military live-ordnance training purposes. However, the Blowsand Mountains-Barnett Hills area clearly is significant for its contribution to dune biodiversity (Rahn & Rust 2000).

Two additional conservation areas overlap with NAS Fallon installation land units. Both are functional sites. **Dixie Valley** was selected for five lower elevation representative systems and a viable population of desert bighorn sheep, and the **Stillwater Range – Dixie Valley** area was selected for a Great Basin endemic plant and good examples of seven representative systems.

Naval Air Station Fallon Military Operation Area Conservation Areas

An additional 29 conservation areas identified in the Great Basin assessment overlap the NAS Fallon MOA (appendix A, map 2) and are listed below. Nine of the 29 conservation areas are functional landscape areas. Nineteen of these conservation areas harbor taxa endemic to the Great Basin. Areas such as Trail Canyon provide opportunities to protect endemic species (Big Smoky Valley tui chub) as well as conserve or enhance representative sagebrush vegetation. Opportunities such as this could offer new partnerships for NAS Fallon with local groups and coalitions (Governor's Sage Grouse Task Force, for example) in addition to other land managing agencies.

Functional landscapes that overlap the MOA are listed below.

Black Rock Desert – Smoke Creek Desert is a functional landscape that contains vast playas with ephemeral wetlands, salt desert shrub systems, and the ecological processes that maintain them.

Desatoya Mountains is a functional landscape that has numerous representative systems (three aquatic and 11 terrestrial systems). Two species of rare and geographically limited bees, occurrences of Lahontan cutthroat trout in good condition, and habitat for three declining birds occur in the diverse shrublands.

Fly Ranch Geyser – Granite Range is a large functional landscape that occurs mostly within the MOA, but extends beyond onto unrestricted public land. This is an irreplaceable site for a unique endemic springsnail. It has high diversity of terrestrial and aquatic systems. Habitat for Greater Sage Grouse occurs in surrounding sagebrush steppe.

New Pass, in the Desatoya Mountains, is a functional landscape with viable examples of seven representative systems, as well as a Great Basin endemic plant, Northern Goshawks, and Lahontan cutthroat trout.

Reese River is a large, functional landscape with high biological diversity. It includes habitat for six Great Basin endemic species (plants and invertebrates), along with two bird species with declining trends.

Shoshone Range-Carico Lake Valley is an irreplaceable functional landscape with unique conservation targets. There are three springsnails endemic to the Great Basin and habitat for a declining bird, the Greater Sage Grouse. Two of the springsnails are known only from Carico Lake. In addition, several terrestrial and aquatic systems common to basin bottoms and lower mountain slopes are represented in the site.

Simpson Park Mountains – North Toiyabe Range is a functional landscape selected both for rare or declining species and representative terrestrial and aquatic systems. The site houses a rare solitary bee with a limited range, and five birds with declining population trends.

The **Toiyabe - Big Smoky Valley** site is a large, functional landscape that extends beyond the MOA. It has unique conservation targets, high endemism, and a very diverse landscape from valley bottoms to alpine environments. There are eleven rare Great Basin endemic plants, populations of Lahontan cutthroat trout, Toiyabe spotted frog, and two Great Basin endemic butterflies that occur in the site within the MOA. Additional species of concern occur in this site, but are well beyond the MOA shadow. This is an irreplaceable site for six unique conservation targets and four of them occur within the MOA—Ophir rockcress, Rollins clover, Big Smoky wood nymph, and Toiyabe spotted frog.

The **Toquima Range - Monitor Valley - Monitor Range** is a functional landscape with unique conservation targets, 21 species endemic to the Great Basin and highly diverse aquatic and terrestrial systems. Within the MOA, there are populations of two geographically limited rare bees, one butterfly, and two rare plants. The majority of the MOA site was delineated by experts for Greater Sage Grouse habitat and good condition riparian woodlands. A large portion of the habitat and species diversity is located outside of the MOA, which is also where the unique species occur.

The twenty remaining conservation areas are functional sites, and are listed below by geographic location in a generally east to west order (appendix A, map 2). In the Toquima Range, **West Northumberland Canyon** supports one Great Basin endemic plant and has small examples of three terrestrial ecological systems. **Stoneberger Basin**, also in the Toquima Range, was selected for eleven representative systems and several rare species. The area supports one population of a rare plant endemic to the Great Basin, a sagebrush obligate small mammal, and two bird species with declining trends.

Augusta Mountains is an irreplaceable site that harbors three endemic springsnails unique to this mountain range. Springsnails are indicators of persistent spring systems and serve as surrogates for unknown aquatic fauna. **Home Station Wash** is another conservation area in the Augusta Mountains, and was selected for seven representative terrestrial systems and populations of two Great Basin endemic plants.

Reese River Valley was selected for three rare solitary bees, one endemic to the Great Basin and the other two with limited distribution beyond the Great Basin. **Railroad Grade**, along the Reese River, was selected for viable populations of two plants endemic to the Great Basin. **Railroad Pass**, located south of these two areas in the Shoshone Range, was selected for the presence of a rare solitary bee. Somewhat northwest of these areas, **White Sage Flat** in Antelope Valley was selected for one Great Basin endemic plant. This conservation area also includes small examples of four upland ecological systems.

Trail Canyon is a small functional site in the Toiyabe Range that supports one fish endemic to the Great Basin and has examples of five terrestrial systems. **Barrett Canyon**, in the Shoshone Range, contains populations of two plants endemic to the Great Basin. It includes representative montane riparian shrublands and surrounding upland systems. **Mudhole Spring**, also in the Shoshone Range, was primarily selected for a population of a Great Basin endemic plant and for Northern Goshawk, a bird species that is widespread in distribution but experiencing declining trends in population size.

Bolivia is a functional site in the Stillwater Range. It harbors representative examples of desert riparian woodlands and populations of two Great Basin endemic plants. **Topier Canyon** in the Paradise Range provides habitat for a diversity of bat species that are experiencing declining population trends and examples of four terrestrial ecological systems.

Broken Hills was selected for intact examples of representative salt desert scrub systems. **Fairview Peak** is a functional site with three representative systems and a population of a rarer Great Basin endemic plant. **Fairview Valley** was selected for viable examples of two representative systems, sagebrush steppe and salt desert scrub.

East Gabbs Valley contains viable populations of two Great Basin endemic plants in salt desert scrub systems. **Finger Rock Wash** in Stewart Valley contains excellent examples of lower elevation terrestrial systems, as well as populations of five rare plants endemic to the Great Basin. **Monte Cristo Mountains** is a functional site that contains three representative systems and a population of one globally rare plant of limited distribution. **West Gabbs Valley** supports a Great Basin endemic plant and examples of two terrestrial systems.

The Legacy Resource Management Program continues to support *Conservation by Design* in the current phase of the Great Basin Conservation Initiative which involves developing conservation strategies at priority sites to guide implementation. Naval Air Station Fallon is one DoD installation in the Great Basin where we are currently developing potential conservation strategies with multiple partners. This report outlines an initial assessment and recommended conservation strategies for two important conservation areas identified at Naval Air Station Fallon by the Great Basin ecoregional assessment. These two areas (Sand Mountains and Blowsand Mountain-Barnett Hills) are combined and assessed as one unit within the Blowing Sand Mountains area.

Introduction

LONG-TERM VISION

The Department of the Navy is committed to sound management of the natural resources within its area of operations (U.S. Department of the Navy 1994). Sound management of existing natural resources and compliance with environmental regulations is critical to continuing the military mission's access to large tracts of public land, and thus is a vital part of national security (U.S. Department of Defense 2000). The Department of the Navy has recognized that sound natural resource conservation and compliance contribute to a high quality of life for present and future generations of Americans (U.S. Department of Defense 1999).

Through participation in this assessment effort, the Department of the Navy, Walker River Paiute Tribe, Fallon Paiute Shoshone Tribe, Bureau of Land Management, and The Nature Conservancy are demonstrating their commitment to continuing and improving cooperative natural resources management in this biologically, geologically and culturally important area.

DESCRIPTION OF THE ASSESSMENT AREA

Location

The conservation assessment area is composed of two major Great Basin sand dune systems southeast of Fallon, Nevada and covers approximately 187,000 acres (75,500 hectares; appendix A, map 3). The Blowsand Mountains are located 52 km southeast of Fallon, NV, and Sand Mountain is approximately 46 km east-southeast of Fallon. Both sand dunes are situated within the Lahontan Basin section of the Great Basin in western Nevada. This assessment area captures two functional landscape conservation areas identified in the Great Basin Ecoregional Blueprint; Sand Mountain and a portion of Blowsand Mountains-Barnett Hills (Nachlinger and others 2001). Because there is no common place name for this consolidated landscape, the conservation assessment team choose to call this larger area the *Blowing Sand Mountains*.

Ecological Overview

It is thought that these two dune systems once shared a common sand source along the Walker River (Eissmann 1990). When Lake Lahontan began to recede approximately 11,000 years ago, several sub-basins emerged including Pyramid Lake, Black Rock, Carson Desert and Walker Lake basins (Morrison 1964). As the warming and drying trend continued, these sub-basins continued to dry, exposing large deposits of pluvial sediments. Sands originating from the Sierra Nevada had been accumulating in a large delta of the Walker River near present day Sunshine Flat. Sediment deposits, such as this delta, were transported by the prevailing winds during the past 6,000 years, and formed several sand dune systems in northwestern Nevada (Morrison 1964). It appears that the primary historical sand source for both Blowsand Mountains and Sand Mountain was the sand delta near Sunshine Flat (Eissmann 1990).

As large quantities of sand flowed in a northeasterly direction from Sunshine Flat, those plants and animals adapted to the unique conditions provided by active sand dunes moved with the sand. Over the last 6,000 years, this sand flow has been split into two dune systems separated by some 25 km (appendix A, map 3). Both sand dune systems are associated with playas, and it is likely that sand is continually circulated between each playa and dune system via wind and rain action (Nicholas Lancaster, personal communication 2002). Additional inputs of sand and sediment have likely contributed to these systems. Both sand dune systems are heavily influenced by surrounding topography, and have been temporarily trapped by local landforms. However, some sand continues to blow from the Sand Mountain system over the Stillwater Mountains and into Dixie Valley. Sand deposits on the northeast side of Blowsand Mountains suggest a similar long-term deposition pattern.

These two dynamic sand systems are quite similar in species composition, but the overlap is not complete. For instance, the narrowly endemic Sand Mountain blue butterfly (*Euphilotes pallescens arenamontana*, figure 3) has been found only on the Sand Mountain dunes, although it's host plant, Kearney buckwheat (*Eriogonum nummulare*, figure 2) was seen in small numbers on the eastern edge of the Blowsand Mountains in 1981 (Dr. Richard Rust, personal communication 2003, Rust 1986), and in other sand dunes across the Great Basin. There are two rare plant and three rare insect species found on Blowsand Mountains that are not known from Sand Mountain and a total of six rare plants and insects found on Sand Mountain that are not known from the Blowsand Mountains, including the Sand Mountain blue. Additionally, some level of genetic divergence has been detected between the Blowsand Mountains and Sand Mountain populations of Hardy's aegialian scarab beetle, *Aegialia hardyi* (Porter and Rust 1997). It appears that the geographic distance between these two dune systems is not adequately bridged by less vagile species, and populations on the two systems may experience additional divergence in the future. Many Great Basin endemic species are found on these sand dunes, and it is clear that each dune system contributes significantly to the biodiversity of the Great Basin (Rahn and Rust 2000).

Figure 3. Sand Mountain blue butterfly. © The Nature Conservancy

Figure 2. Kearney buckwheat on Sand Mountain dune system. © The Nature Conservancy

The plant communities on both dune systems are sparsely vegetated, and are dominated by dalea shrubs (including Nevada dalea, *Psorothamnus polydenius*, and Lahontan indigobush, *P. kingii*,) and ricegrass (*Achnatherum hymenoides*). Several plant species restricted to sand dunes and sand substrates occur in these systems. Tonopah milkvetch (*Astragalus pseudiodanthus*) and Watson's oxytheca (*Oxytheca watsonii*) are Great Basin endemic plants found on Blowsand Mountains, while Nevada oryctes (*Oryctes nevadensis*) is found on Sand Mountain. Sand cholla (*Opuntia pulchella*) and desert sunflower (*Helianthus deserticola*) are found on both dune systems. Several insects endemic to the Great Basin and restricted to sand substrates are found at these dune systems, such as Hardy's aegialian scarab beetle, Sand Mountain pygmy scarab (*Coenonycha pygmaea*) and Sand Mountain serican scarab (figure 4, *Serica psammobunus*). Several sand obligate, ground nesting, solitary bees also are known from these dune systems.

Figure 4. Sand Mountain serican scarab
© Richard Rust

Surrounding the two dune systems are numerous deposits of sand and several stabilized, relict dune communities. On the relictual dunes and deeper sand deposits, big greasewood (*Sarcobatus vermiculatus*) dominates a significant portion of a greasewood shrubland system. Springs are found within the assessment area, but they are uncommon, and most have high temperatures and high mineral contents which make them less valuable as a watering source. However, they support riparian vegetation and invertebrate life, which provide important resources to wildlife in desert systems. Salt desert scrub forms a matrix system throughout the assessment area within which all other systems are imbedded. Bailey's greasewood (*Sarcobatus baileyi,* at one time considered a variety of big greasewood, but now recognized as a different species), a Great Basin endemic shrub, dominates a distinctive, but common plant community in the salt desert scrub matrix system.

Management and Land Uses

The Blowing Sand Mountains assessment area is owned and managed in part by NAS Fallon (~10%), the Walker River Paiute Tribe (~25%), and the Bureau of Land Management (~65%; appendix A, map 3).

NAS Fallon lies in Churchill County, approximately 107 km (66 miles) east of Reno. NAS Fallon administers 8,261 acres (3,343 ha) of land at the NAS Fallon Main Station, and an additional 232,456 acres (94,072 ha) of non-contiguous land associated with the Fallon Range Training Complex (FRTC). The FRTC Military Operation Area (MOA), is a 26 million acre (~10.5 million ha) area of operations for the Naval Strike and Air Warfare Center which includes the Navy Fighter Weapons School, more commonly known as Top Gun. The MOA overlies parts of Washoe, Lyon, Churchill, Pershing, Mineral, Nye, Lander, and Eureka counties. The majority of lands under the MOA air shadow is administered by BLM, with lesser acreage managed by the U.S. Forest Service, U.S. Fish and Wildlife Service, State of Nevada, or are privately owned. The northern half of the Blowing Sand Mountains assessment area is beneath the FRTC MOA.

Most of NAS Fallon facilities are in a large, remnant drainage depression known as Lahontan Valley or the Carson Sink. Rocks exposed in adjacent mountain ranges are mostly Tertiary sedimentary and volcanic rocks (U.S. Department of the Navy 2001). The valleys are underlain by unconsolidated alluvial and playa deposits. Widespread and active faulting has occurred on many of the mountains and valleys in recent time. A non-contiguous air space lies over the Black Rock Desert, which was designated as the Black Rock Desert - High Rock Canyon Emigrant Trails National Conservation Area in 2000 (BLM Winnemucca District).

The militarily restricted land occurs within four hydrographic basins, with the Carson Desert Basin receiving a substantial quantity of water from irrigation and return flows. Regional hydrologic features include the Lahontan, Sheckler, and Stillwater reservoirs, Carson Lake, various ephemeral playa lakes, irrigation canals, ephemeral streams, and springs.

Vegetation varies from barren alkali playas to greasewood-shadscale shrublands and pinyon-juniper woodlands. Much of the land in withdrawn areas has been disturbed by both military and civilian activities. Some sites are dominated by non-native species, *e.g*. salt cedar at water sources. Wildlife includes native and game fishes, birds and mammals. Migrating shorebirds, waterfowl, and marsh birds in the Lahontan Valley account for 70% of the avifauna migrating through Nevada's wetlands. The area surrounding NAS Fallon (largely within the FRTC MOA) provides critical wetland and riparian habitats for water birds.

Dune systems support several species that have been utilized by Native Americans for thousands of years, such as ricegrass and various beetle larvae. Sand Mountain is a known area of spiritual significance to the Fallon Paiute Shoshone Tribe. Sand Mountain's dunes are managed by BLM and many, but not all, are included in the designated Sand Mountain Recreation Area (SMRA). Off-highway vehicle (OHV) use predominates in SMRA, but other forms of recreation occur as well. A portion of Sand Mountain is designated as a Desert Study Area, which affords some level of protection to some of the sand-obligate invertebrates and their shrub habitat within this portion of SMRA. The sand dunes and other areas outside of the SMRA boundary are not closed to OHV use. The Bureau of Land Management has recently implemented a voluntary avoidance area within the vegetated dunes in and around the SMRA. A system of trails has also been established at SMRA and signed as "encouraged routes" of travel for motorized vehicles.

The active dunes on the Blowsand Mountains have been used by NAS Fallon for training exercises for more than 40 years. A portion of the Blowsand Mountains dune system is used for inert and live air-to-ground ordinance drops. Much of the Blowsand Mountains area is not open to public access, and therefore is not used for off-highway vehicle recreation or livestock grazing.

The more stabilized sand deposits and surrounding salt desert scrub are used for cattle grazing and recreational off-highway vehicle use. Several mines dot the landscape, including a significant salt mining operation in the Salt Wells Basin.

Methods

The Nature Conservancy's Great Basin ecoregional assessment, produced via a collaborative process, revealed that both Blowsand Mountains and Sand Mountain contributed significantly to the biodiversity of the Great Basin ecoregion (Nachlinger and others 2001; appendix A, map 2). With funding from the DoD Legacy Resource Management Program, TNC and a group of experts from tribal governments and land management agencies formed a team to analyze the conservation potential of these areas. Ultimately the conservation assessment team combined the two units and analyzed them as one conservation area, called the Blowing Sand Mountains assessment area.

TNC's Five-S Framework for Conservation Area Planning

The conservation assessment team followed the process defined in "The Five-S Framework for Site Conservation: A Practitioner's Handbook for Site Conservation Planning and Measuring Conservation Success" (The Nature Conservancy 2000). The "Five-S Framework" process includes identifying the following:

- ***Systems*** – species and natural systems occurring at a site, and the natural processes that maintain them: the focus of conservation assessments
- ***Stresses*** – the types of degradation and impairment afflicting the systems at a site
- ***Sources*** – the agents generating the stresses
- ***Strategies*** – the types of conservation activities that may be deployed to abate sources of stress (threat abatement) and persistent stresses (restoration)
- ***Success*** – measures of biodiversity health and threat abatement at a site, *i.e.* monitoring

The Five-S Framework is the product of over 20 years of experimentation, innovation, and thought by TNC staff. The framework is accompanied by an automated Excel® workbook tool containing a number of tables to facilitate and document the assessment process. The completed workbook for the Blowing Sand Mountains area is presented in many of the following tables, and in appendix B.

Efroymson Workshop Facilitation

The Five-S Framework was applied to the Blowing Sand Mountains area during a series of two facilitated workshops (February 19-21 and May 14-16, 2002). Four other conservation areas were also analyzed during this workshop series; Mount Grant, Jumbo Grade, Pine Nut Mountains, and the Amargosa River, a Mojave Desert ecoregional conservation area. This workshop series allowed all participating land management agencies and tribal governments to appoint representatives to work through the Five-S Framework for each assessment area. Each conservation assessment team involved six or more individuals who brought a breadth and depth of knowledge about the resources, conservation issues and opportunities at their site. The conservation assessment team for the Blowing Sand Mountains area is listed in table 2.

Table 2. Members of the Blowing Sand Mountains area conservation assessment team.

Name	Affiliation
Donna Cossette	Fallon Paiute Shoshone Tribe
Gary Cottle	Naval Air Station Fallon
Cliff Creger	Naval Air Station Fallon
Rochanne Downs	Fallon Paiute Shoshone Tribe
Claudia Funari	Bureau of Land Management
Dean Tonenna	Bureau of Land Management
Sherry Lash	Naval Air Station Fallon
Bruce Lund	The Nature Conservancy
Gary Ryan	Bureau of Land Management
Susan Wainscott	The Nature Conservancy
Tad Williams	Walker River Paiute Tribe

During the workshops, participants from each area's conservation assessment team followed exercises outlined in the Five-S Framework and entered key information into the Excel © tool. This workshop series was facilitated by TNC's Greg Low and co-sponsored by the BLM and TNC's Efroymson Fellowship program. The BLM Carson City Field Office co-sponsored this series of workshops because four of the five conservation areas addressed in the workshop series fall within its jurisdictional boundaries and the agency is supportive of collaborative, multi-scale approaches to land management. The five areas analyzed were Blowing Sand Mountains (managed primarily by NAS Fallon and BLM) and Mount Grant (managed primarily by Hawthorne Army Depot), as well as three areas primarily managed by BLM; Jumbo Grade, Pine Nut Mountains and Amargosa River.

During each workshop in the series, conservation assessment teams worked concurrently, and periodically gathered to present each area assessment to the larger group (~40 people total) for peer review. The larger group reviewed and critiqued each conservation assessment team's product, which resulted in improved outcomes. The participatory process elicited and produced clear conservation goals, obstacles to goals, strategies for success, and draft implementation plans for the individual areas. Each conservation assessment team also met informally between the two workshops to discuss their analyses and incorporate additional input from experts and scientific literature.

The outcome of this workshop series was a peer-reviewed analysis of conservation potential for each of the five areas, including an analysis of the Blowing Sand Mountains. This initial analysis has resulted in a first iteration of an ecologically-defined conservation assessment for Blowing Sand Mountains. This document should be used to assist land and resource managers as they develop activity-based, adaptive management plans that are soundly grounded on current conservation biology theory and practice as well as a base of peer-reviewed, scientific literature.

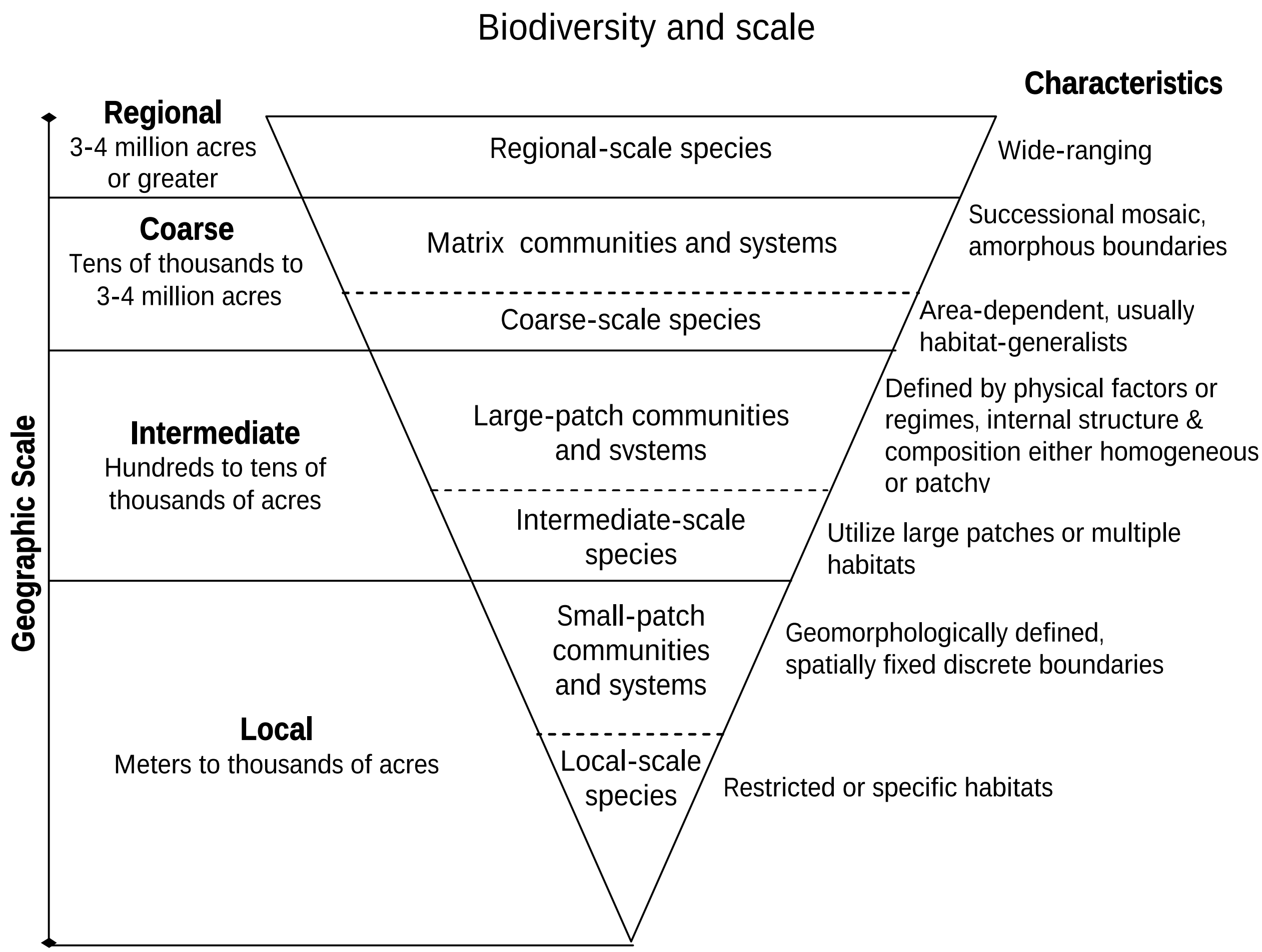
Conservation Targets: Natural Systems, Species and Viability

The first step in the Five-S Framework is to identify conservation targets for analysis. Conservation targets may be species, communities or ecological systems. Because the single-species approach to conservation is often expensive to implement and becomes unwieldy for a large group of species spread over a wide geographic area, this assessment used a coarse-filter / fine-filter approach to proactive, adaptive management in the Blowing Sand Mountains area (Franklin 1999; Kintsch and Urban 2002; Poiani and others 2000). The coarse-filter approach assumes that most species can be managed effectively if the ecological system they live in functions within its normal range of variability or is managed to simulate key ecological processes (*e.g*., prescribed burning). Species of special interest that do not require specific attention and that can be managed as part of a larger ecological system are called "nested targets." The fine-filter approach addresses the species whose ecological requirements do not match those of broader ecological systems in which they are spatially nested. These species would need to be specifically considered in a conservation assessment so that their special management needs are more fully addressed. No species requiring a fine-filter approach was identified in the Blowing Sand Mountains area. Even the Sand Mountain blue butterfly was found to have ecological requirements and management needs that "nested" within the Sand Mountain dune system's normal range of natural variability. The nested species for conservation target systems are listed in appendix C.

There are many species living in the assessment area that were not selected as conservation targets in this assessment. Several of these species, while not listed as conservation targets or nested targets, are important to land managers and may serve vital functions in the larger ecosystem. These species are discussed in the description of each system target.

To adequately capture ecosystem processes at a site, different geographic scales should be represented by the conservation targets (Poiani and others 2000; figure 5). A conservation target that occurs at a larger geographic scale, such as the salt desert scrub system (appendix A, map 4), serves as a matrix ecosystem with other species or plant community targets contained within its local distribution. Ecosystems that occur at a local geographic scale, such as small-patch spring systems, are ecological islands within matrix systems, and rely on different ecosystem processes to persist.

Figure 5. Geographic scales of potential conservation targets (after Poiani and others 2000).



The representative ecological systems were selected based upon their ability to meet one or more of the following criteria:

- their contribution to describing the overall biotic and abiotic character of the assessment area,

- their relevance to specific conservation mandates in the overarching management plans of the region (Carson City Field Office Consolidated Resource Management Plan (BLM 2001), Naval Air Station Fallon Integrated Natural Resources Management Plan / Resource Management Plan Amendment (U.S. Department of the Navy 2001) and Sand Mountain Recreation Area Management Plan (BLM 1985)),

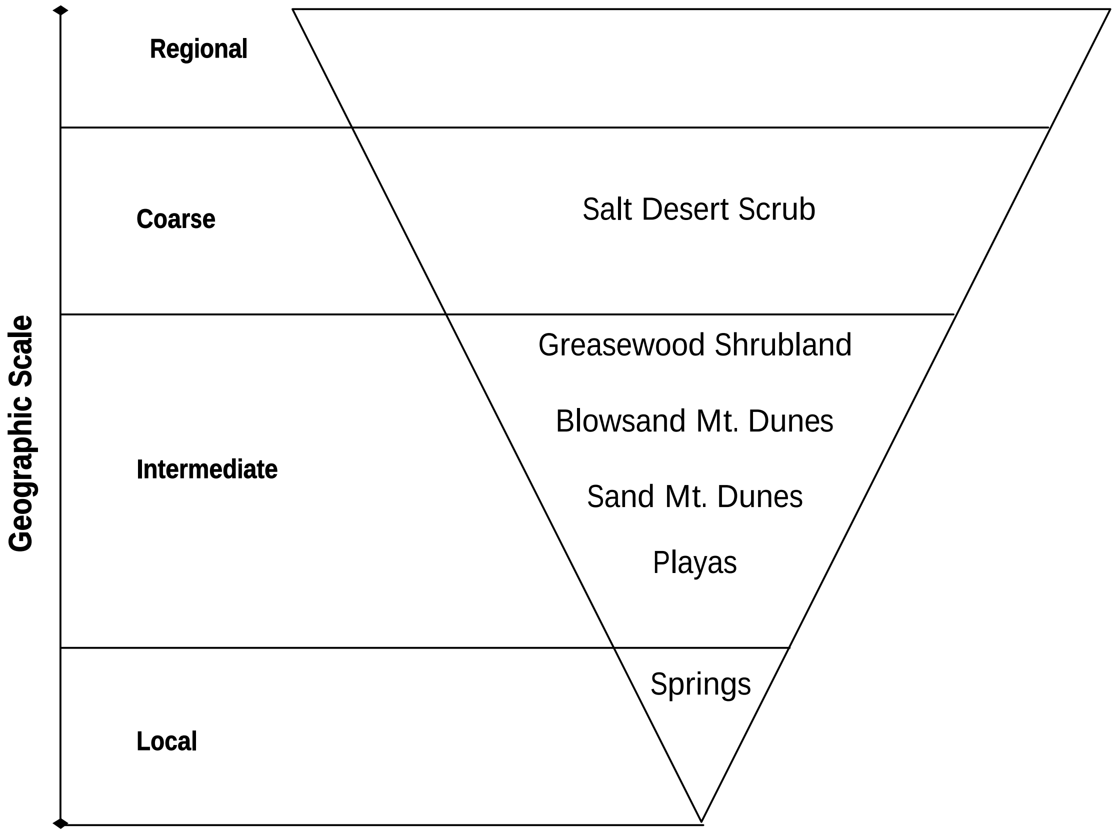
- their ability to inform management, protection, and restoration efforts at appropriate scales, and

- their value as indicators for gauging effectiveness of management actions in achieving conservation objectives.

Land managers need to take a single-species, fine-filter conservation approach for extremely rare or imperiled species, or for those species where specific conservation activities are required by law or mandate. However, proactive management for larger scale conservation targets should be considered to compliment these intensive, single-species approaches. Without conservation of landscape scale processes that maintain or create habitat of the species of concern, heroic and likely more expensive measures to artificially create and maintain habitat will be necessary. When landscape scale processes cannot be directly conserved or restored, the artificial maintenance of habitat carries great uncertainty of successful conservation of species and their habitats. One example of such heroic measures is a recent attempt to artificially create active dune habitat for the Coachella Valley fringe-toed lizard, a federally listed species in the Coachella Valley, California, where several sand sources for the dune habitat were disconnected from the dune system by urban development (Barrows 1996). Protection of the sand sources and transport corridor would likely have been less expensive in the long run, and would have had a greater likelihood of conservation success (Cameron Barrows personal communication 2002).

Six ecological systems were chosen to capture the biodiversity and landscape level processes at Blowing Sand Mountains: salt desert scrub, greasewood shrubland, Blowsand Mountains dune system, Sand Mountain dune system, playas, and springs (appendix A, map 5). Each system has several species or plant communities, some of which are also conservation targets identified in the Great Basin ecoregion assessment, nested within its geographic extent. The geographic scale of each selected system is shown in figure 6.

Figure 6. Geographic scale of selected conservation targets in Blowing Sand Mountains assessment area.



CONSERVATION TARGET NATURAL SYSTEMS AND SPECIES

Salt Desert Scrub:

Salt Desert Scrub is a common sight in the Great Basin, and forms a matrix within which many other systems are found (figure 7, appendix A, maps 4 and 5). Within this assessment area, the most common salt desert communities are dominated by Bailey's greasewood (figure 8, *Sarcobatus baileyi*), which is found on essentially all of the alluvial fans in the area. These communities occur on less alkaline soils compared with salt desert communities on valley bottoms. Bailey's greasewood is a western Great Basin endemic species that is limited to the rainshadow of the Sierra Nevada (Billings 1945). No other predominant salt desert plant community is dominated by a shrub with as restricted of a global distribution as Bailey's greasewood.

Figure 7. Salt desert scrub matrix system.
© The Nature Conservancy

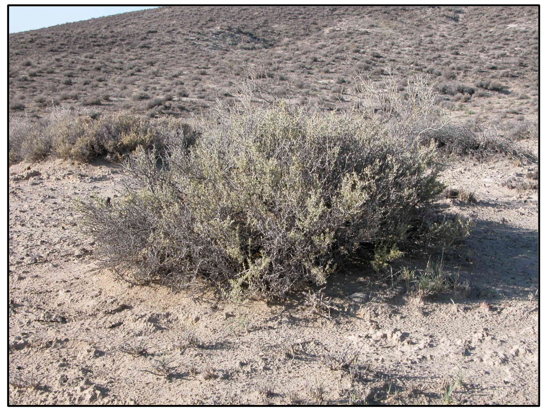


Figure 8. Bailey's greasewood.
© The Nature Conservancy

The connectivity of habitat and integrity of the salt desert scrub system is critical to inhibit exotic weed invasions, alterations to the fire regime and soil erosion patterns throughout the Blowing Sand Mountains area. Significant alterations to these ecological processes would negatively effect other, less extensive, conservation targets in the Blowing Sand Mountains area. For instance, biological soil crusts, which naturally inhabit open soil between shrub canopies in the salt desert scrub system, provide two critical ecosystem functions: soil stability and nitrogen fixation (West and Young 2000). Biological soil crusts are composed of several types of organisms, including fungi, lichens, mosses, algae, and cyanobacteria. These crust components form a complex web of filaments and aggregates that entangle soil particles. This greatly reduces the potential for wind transport (i.e. wind erosion) of the particles (Belnap and Gillette 1997).

Biological soil crusts also are a critical part of the nitrogen cycle in arid ecosystems. In the Great Basin, cyanobacteria play a major role in fixing atmospheric nitrogen to produce a form that is available to plants (Belnap 2002). Soil lichens also are important nitrogen fixers in cool deserts, such as the Great Basin (Belnap 2002).

Several species of interest to land managers are found in the salt desert scrub system. Bailey's greasewood (*Sarcobatus baileyi*), is endemic to the western portion of the Great Basin, although abundant in the Blowing Sand Mountains area. Burrowing owl (*Athene cunicularia*), kit fox (*Vulpes macrotis*), mule deer (*Odocoileus hemionus*) and pronghorn (*Antilocapra americana*) are all known from the area. No narrowly endemic plants or animals are known to inhabit the salt desert scrub system here, and no additional conservation targets are nested within this system target.

Greasewood Shrubland:

This conservation target (figure 9) is dominated by big or black greasewood (*Sarcobatus vermiculatus*) and occurs on stabilized sands and relictual dunes (stable longer than 150 years) and also on the lowlands of valleys and playa edges where heavy clay soils and salts accumulate and the groundwater is fairly shallow (West and Young 2000). Some of these sand deposits are also found on the edges of playas, where sand has been washed during periods when the playa is flooded and later blown into these deposits (appendix A, maps 4 and 5). Big greasewood communities are found throughout the western Great Basin in the vicinity of Pleistocene Lake Lahontan.

As in the salt desert scrub system, several species of interest to land managers are found in the greasewood shrubland system. Burrowing owl, kit fox, pale kangaroo mouse (*Microdipodops pallidus*), mule deer and pronghorn are all also known from this system. No narrowly endemic plants or animals are known to inhabit the greasewood shrubland system, and no additional conservation targets are nested within this system target. As in the salt desert scrub system, the biological soil crusts of greasewood shrubland are critical for soil stability and nitrogen fixation.

Figure 9. Greasewood shrubland system with Sand Mountain dunes in background.

Blowsand Mountains Dune System:

Blowsand Mountains is a 3571 acre (1446 hectare) sand dune system perched on and slowly climbing over a small mountain range north of Rawhide Flat (figure 10, appendix A, map 5). The wind and underlying topography have interacted to form both longitudinal and parabolic dunes (Eissmann 1990). This system includes not only unvegetated sand, but actively moving sands with sparse vegetation and vegetated dunes that likely have been mobile within the last 150 years. While the presumed historical sand source is Sunshine Flat along the Walker River, it is suspected that the current source is from the playa directly to the south, Rawhide Flats (Nicholas Lancaster personal communication, 2002). Sand and other materials are washed downhill out of Blowsand Mountains by rain events and are deposited in the internally draining playa. Other materials likely enter the playa from other sources, both water and wind driven. If enough water is held on the playa floor for wave action to develop, undissolved sediments may wash ashore and accumulate on the playa fringes. After the playa surface sediments have dried, these materials become available for wind transport to Blowsand Mountains. External sources of sand and sediment are likely important to these dunes as well.

Figure 10. Blowsand Mountain dune system. © The Nature Conservancy

The vegetated dunes on the periphery of the active dune area are dominated by big greasewood, Bailey's greasewood and rice grass (*Achnatherum hymenoides*) (Gary Cottle, personal communication December 3, 2003), and support a rich invertebrate community. A series of studies has documented the presence of 23 sand-obligate and endemic invertebrates in these dunes (appendix C; Rahn and Rust 2000, Hardy and Andrews 1987, Evans and Smith 1986, Rust 1986, Bechtel and others 1983, Rust and others 1983, Rust 1981). Perennial dune plants such as four-part horsebrush (*Tetradymia tetrameres*), rabbitbrush (*Chrysothamnus viscidiflorus*) and rice grass provide both above ground and subterranean habitat for many animals. Above ground, vegetation provides habitat for herbivorous beetles, such as the Sand Mountain serican scarab beetle (*Serica psammobunus*) and *Edrotes ventricosus* (Rust 1986, Bechtel and others 1983), the honey dune ant (*Myrmecocystus arenarius*) and for flower-visiting solitary bees such as *Andrena chrylismiae, Anthophora* sp. nov. 1, *Andrena* sp. nov. and *Colletes* sp. nov. 1(Hanks 1982, Rust and others 1983). Below the surface of the sand, root systems of the perennial dune vegetation provide habitat for several beetles. *Aegialia hardyi* (figure 11), *A. spinosa,* and *Serica psammobunus* in both larval and adult lifecycle stages were all found in the sand column aggregated near the root systems of perennial vegetation (Rust 1986). Another common psammophytic beetle, *Eusattus muricatus* (figure 12), was also commonly found on the Blowsand Mountains dune system (Rust 1986).

Figure 11. Hardy's aegialian scarab
© Richard Rust

Figure 12. Sand-obligate tenebrionid beetle (*Eusattus muricatus*)
© Richard Rust

Vegetation also provides more stable sands for the burrows of small mammals and other vertebrates. The most abundant small mammals on the Blowsand Mountains are pale kangaroo mouse, Great Basin kangaroo rat (*Dipodomys microps*), Ord kangaroo rat (*D. ordii*) and Merriam's kangaroo rat (*D. merriami*) (Gary Cottle, personal communication December 3, 2003). These animals in turn serve as prey for raptors, reptiles and larger wildlife, such as coyote (*Canis latrans*) and kit fox. For instance, the pale kangaroo mouse utilizes the perennial vegetation on the Blowsand Mountains dune system for burrow sites, in particular the bases of shadscale (*Atriplex confertifolia*) (Gary Cottle, personal communication May 6, 2002).

Of special note is the possible presence on the Blowsand Mountains dune system of a perennial dune plant, Kearney buckwheat, known to be the sole host plant for the rare Sand Mountain blue butterfly. This butterfly is currently known only from the nearby Sand

Mountain dune system. Kearney buckwheat was seen in low numbers on the eastern portion of the Blowsand Mountains dune system when Rust and others (1983) sampled for sand dune invertebrates in 1979-1981 (Richard Rust, personal communication January 22, 2004). However, recent attempts to relocate Kearney buckwheat on this dune system have failed (George Austin, Claudia Funari, Dennis Murphy, Jan Nachlinger, and Dean Tonenna personal communication August 17, 2003, Dean Tonenna personal communication February 2, 2004). In addition, NAS Fallon environmental staff have not encountered Kearney buckwheat during ecological and archaeological surveys of the area (Gary Cottle and Cliff Creger, personal communication December 3, 2003). While it is difficult to confirm the absence of any species in a dune system of this size, it can be said with certainty that Kearney buckwheat is not a widespread species on this dune system, nor was it listed as a dominant plant on the portion of Blowsand Mountains studied by Rust and others (1983).

There are several species of plants and animals nested within the Blowsand Mountains Dune System conservation target, listed in appendix C.

It has also been observed that during periods of drought, the more mesic conditions on many desert sand dunes allow for more robust production of floral resources than in the surrounding valleys (Rebekah Andrus personal communication May 14, 2003, Dean Tonenna personal communication February 4, 2003). Thus, in years of low rainfall, dune vegetation may act as temporary habitat for species that normally forage in the surrounding greasewood and salt desert scrub ecosystems.

One or more of the perennial dune plant species may also serve the role of a keystone species for the dune system. Keystone species are species that perform vital roles in the ecosystem, upon which many other species depend. Thus, the loss of a keystone species is predicted to effect several other species in a cascade of changes to the ecosystem. It may be that Kearney buckwheat fills this role in the sand dune system, as they both provide abundant floral resources for insects in the heat of summer, when other plant species are in a vegetative state. Additionally, the Hardy's aegialian scarab beetle (*Aegialia hardyi*) is known to aggregate around the root systems of Kearney buckwheat plants (Rust and Hanks 1982).

Three species found on Blowsand Mountains Dune system require special attention by land managers. The sand cholla (*Opuntia pulchella*), Sand Mountain serican scarab beetle (*Serica psammobunus*), and Hardy's aegialian scarab beetle require some degree of a species-specific conservation approach. Sand cholla is protected by Nevada state law (NRS §527.100), is fairly widespread throughout the Lahontan Basin, but is always in low abundance and all populations currently exhibit a declining trend. Land managers must follow procedures outlined in NRS §527 when activities are likely to result in mortality of sand cholla individuals. Sand Mountain serican scarab beetle and Hardy's aegialian scarab beetle are western Great Basin endemic species, and are BLM sensitive species in Nevada. While no specific actions are mandated by this category BLM sensitive species are generally given the same consideration as listed candidates under the federal Endangered Species Act.

Sand Mountain Dune System:

The Sand Mountain dune system is a 2581 acre (1044 ha) complex system nestled in a southern valley of the Stillwater Range (appendix A, maps 4 and 5). The largest dunes, with their linear, snake-like crests, are visually striking (figure 13), and are one of a very few booming or singing dunes in the Great Basin (Trexler and Melhorn 1986). However, the entire system is much larger than just these visually-striking dunes. Many smaller dunes surround the largest dunes, and some parabolic dunes are moving northeastward over the Stillwater Mountains into Dixie Valley (figure 14, Snyder 1984).

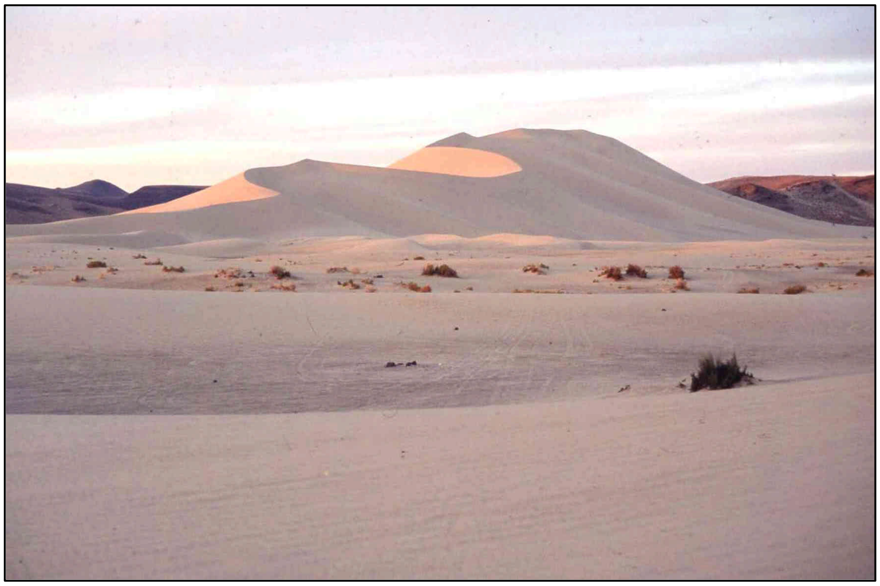


Figure 13. Sand Mountain dune system, active unvegetated dunes. © Bureau of Land Management

Figure 14. Parabolic dunes on northeast edge of Sand Mountain dune system. © The Nature Conservancy

Many of the dunes in the Sand Mountain system support vegetation, such as ricegrass (*Achnatherum hymenoides*), rabbitbrush (*Chrysothamnus viscidiflorus*), shadscale (*Atriplex confertifolia*), four-part horsebrush (*Tetradymia tetrameres*), desert sunflower (*Helianthus* *deserticola*), Kearney buckwheat (*Eriogonum nummulare*) and other psammophytic species. However, even the vegetated dunes are not static. Sand is constantly moving between ridges and swales within the vegetated mosaic surrounding the large, active dunes (figure 14). The native plants that inhabit these dunes have adaptations that allow them to grow out of the sand when shallowly buried (Brown 1997). The ridge-and-swale topography of the dunes provide several habitats that vary in degree of exposure to the winds that sweep sand and other sediments across the dunes. However, sand dunes of varying depths also provide a variety of habitats for sand dune biota. Many, if not most, of the endemic sand dune beetles spend much of their lives as larvae within the sand column, aggregating near the deep roots of perennial plants such as ricegrass, Kearney buckwheat, four-part horsebrush and rabbitbrush (Rust 1986).

The constant movement of sand creates slipfaces on the more active dunes, where windblown detritus gathers and is eventually buried by falling sand (figure 15). This detritus is then available to the many fungi, bacteria and invertebrates that live in the sand column. This detritus was found to be the main source of forage for several of the beetles of interest in this sand dune system, including *Eusattus muricatus* (figure 12, Rust 1986).

Figure 15. Sand Mountain dune system, wind blown sand burying detritus. © Bureau of Land Management

A wash along the west edge of the valley defines the western extent of the sand dune system. This wash traps sand and washes it back into the playa, where it may become available to wind action (Nicholas Lancaster personal communication 2002). This constant cycling of sand between the dunes and the Salt Wells Basin playa is likely a critical process in maintaining the larger active dunes as well as the smaller dune fields.

There are many species of interest nested within the Sand Mountain Dune System conservation target. These nested species are listed in appendix C. Five of the insect species are endemic to the Sand Mountain Dune System: Sand Mountain blue butterfly

(*Euphilotes pallescens arenamontana),* a click-beetle (*Cardiophorus ssp. nov*.), and three bees *(Hesperapis sp. nov. 2, Perdita sp. nov. 3, Perdita haigi).* While there is some overlap in species presence between the Sand Mountain Dune System and the Blowsand Mountain Dune System, each dune contributes uniquely to the biodiversity richness of the Great Basin ecoregion. A description of specific contributions of each dune system can be found in appendix D.

Several of the species in the Sand Mountain Dune system are of special interest to land managers, including the Sand Mountain serican scarab beetle (*Serica psammobunus*), Sand Mountain aphodius scarab beetle (*Aphodius sp. nov. 3*), Hardy's aegialian scarab beetle (*Aegialia hardyi*) and the Sand Mountain blue butterfly. All four of these species are BLM sensitive species in Nevada. While no specific actions are mandated by this listing, BLM sensitive species are generally given the same consideration by land managers as those species listed as candidates under the federal Endangered Species Act. Sand cholla is also present on the Sand Mountain dune system, and is protected by Nevada state law.

Described in 1998 by George Austin (NatureServe 2002), the Sand Mountain blue is a narrowly endemic, psammophytic butterfly known only from the Sand Mountain dune system. This small member of the Lycaenidae family is apparently dependent upon a single species of buckwheat for the larval phase of its lifecycle. Members of the *Euphilotes* genus are well known for their strict host plant relationships. Larvae of the Sand Mountain blue have only been found on some of the populations of Kearney buckwheat located on the peripheral, vegetated dunes in the Sand Mountain dune system. Surveys for the blue have been conducted by BLM staff, Dr. Dennis Murphy of the University of Nevada Reno and George Austin of the Nevada State Museum on several other dune systems in the area, and though some do support Kearney buckwheat, no other populations of the Sand Mountain blue have been located (Dean Tonenna, Claudia Funari, Dennis Murphy, George Austin, personal communication August 17, 2003). Surveys to detect the Sand Mountain blue on other dune systems are ongoing. (Dean Tonenna personal communication February 4, 2003). Many lycaenid butterfly larvae exhibit varying degrees of symbiotic relationships with ant species, ranging from commensalism (one species benefits while the other is unaffected) to mutualism (both species benefit) to parasitism (one species benefits while the other is harmed). Casual observations confirm a relationship between the Sand Mountain blue caterpillars and ants (Claudia Funari personal communication January 31, 2003; Dean Tonenna personal communication February 4, 2003). These observations suggest that the relationship is mutualistic, but this has not been firmly established (Claudia Funari personal communication January 31, 2003).

Playas:

The defining hydrologic characteristics of playas are that they function as a zone of discharge in the greater watershed, and they have a negative water balance where water depletion outpaces replenishment greater than 50% of the time (Rosen 1994). Globally, playas can be found in both hydrologically open and closed basins. In the Great Basin Desert, playas are found within internally draining basins. The two major playas in the

Blowing Sand Mountains area, Salt Wells Basin and Rawhide Flat (figure 16, appendix A, maps 4 and 5), were part of Pleistocene Lake Lahontan (Morrison 1964). Approximately 11,000 years before present, Lake Lahontan began to recede from its pluvial maximum and the sub-basin containing Rawhide Flat was separated from the Carson Sink sub-basin, which contains the present day Salt Wells Basin (Morrison 1964).

Playas contain high salt and silt concentrations deposited by the drying of ancient lakes and from materials washed in from the surrounding basin's rocks and soils. While playas may be periodically wet and productive (Nachlinger and others 2001), they are typified by flat, unvegetated expanses. The edges of the two playas in this area support typical playa vegetation, composed of alkali and salt tolerant (halophytic) plants, such as iodinebush (*Allenrolfea occidentalis*), big greasewood, and seepweed (*Suaeda calceoliformis*).

Figure 16. Rawhide Flats playa. © The Nature Conservancy

Playas have not been well studied in the Great Basin, but some general ecology is known. Playas with sufficient accumulated salts to support a brine layer can be particularly important and productive, yet ephemeral, sources of food for migrating birds and other wildlife, as numerous invertebrate populations may 'bloom' during periodic floods (Nachlinger and others 2001). In some instances, playas can sustain "algal mats" that persist in a desiccated form on the sediment surface, becoming photosynthetically active only when re-wetted by playa floods. Species, such as fairy shrimp (Order Anostraca) and brine flies (Family Ephydridae), respond quickly to available waters, reproduce and then form protective cysts that can persist in dry playa sediments for many years. Lindahl's fairy shrimp (*Branchinecta lindahli*) has been recorded from Rawhide Flats, and the Salt Wells Basin does flood during years of high precipitation runoff. There are no nested conservation targets in the playa systems, however the invertebrates and algae that bloom during wet periods may be important, though ephemeral, sources of forage for wildlife such as shore birds.

Salt Wells Basin and Rawhide Flats are probably critical to the long-term proper functioning of the two target sand dune systems (Nicholas Lancaster personal communication 2002). Rain events cause sand and other sediments to wash down the mountains into the playas. There they mix with local components and wash up to the shorelines with wave actions during periods when the playa holds water. Once deposited on the shores, sand becomes available for wind transport into the dunes. This cycling of sand materials may be critical to maintaining the active sand dune systems during the current, relatively more humid climatic period when sand in vegetated relictual dunes within the greasewood shrubland system is unavailable for transport.

Spring Systems:

In the Great Basin desert, sources of water and associated riparian habitats are restricted . In the Blowing Sand Mountains area, water sources are extremely rare, and there are only a few springs in the area (appendix A, map 5). These springs are generally thermal and have a high concentration of dissolved minerals or salts. This dissolved mineral concentration is expressed as a conductivity value, measuring the ease with which an electrical current travels through the spring water. Springs with higher conductivity values have higher concentrations of dissolved minerals and generally support only a few species that have adapted to this unusual environment. Thermal springs, such as those in the area, may contain several microclimates along the spring brook. As the water cools further from the spring source, the spring brook habitat becomes available for different aquatic species. No endemic or rare species are known to inhabit the springs in this assessment area, and no nested conservation targets are found in the spring systems.

When considering spring habitats, both the flowing waters in the spring brook and the moist soils in the riparian zone must be considered. While the high conductivity and temperatures of most of the springs in the assessment area appears to have reduced the diversity of the aquatic habitat, the riparian vegetation and more abundant insect life around these perennially flowing springs is of value to non-aquatic desert species. Bats, birds, and other wildlife may use these isolated riparian oases for forage, and the springs with lower conductivity may be of value as a last resort water source during drought periods when other water sources are less available.

VIABILITY

For each of the six conservation target systems, long term (>100 years) viability was ranked using information from the literature and expert opinion. Three components of viability were examined for each system: size, condition, and landscape context.

- *Size* is a measure of the area or abundance of the conservation target's occurrence.

- *Condition* is an integrated measure of the composition, structure, and biotic interactions that characterize the conservation target's occurrence. Factors include the presence of native versus exotic species, spatial distribution, predation and disease.

- *Landscape context* is an integrated measure of two factors: the dominant environmental regimes and processes that establish and maintain the conservation target occurrence, and connectivity. For example, dominant environmental regimes can include hydrologic, geomorphic, climatic, and fire regimes.

For each system guidelines were established for each viability measure, and will assist in future assessments of the systems to document change. Assessing the viability of system targets is challenging, and has been addressed in a variety of fashions by a number of authors (Anderson 1999; *biotic integrity* Karr 1991; *persistence* Pimm 1984, Holling 1973; and *resilience* Halpern 1988, Holling 1973). In general, system viability criteria in this assessment followed the Great Basin assessment (Nachlinger and others 2001) or the work of Anderson (1999). These guidelines are presented in table format for each system, and are based upon a literature search for minimum viable size for each system, and synthesis of expert opinion on how components of each measure effects long-term viability of the system.

The Blowing Sand Mountains assessment area has an overall good viability score (table 3) due to the good status of landscape processes, large extent of many of the systems, and minimal fragmentation. Successful long-term conservation of biodiversity in this area could be attained, with minimal alterations in land use, if appropriate management decisions and actions are fully implemented.

Of most concern is the fair score for condition of the Sand Mountain dunes and the spring systems. However, due to the good size scores and good or very good landscape context scores for both systems, actions that improve the condition of these two systems likely will improve the long-term viability of each.

The summary scores generated by the Five-S workbook are qualitative, but they represent the best available information, current expert opinion, and are based on explicit definitions. The criteria for each system's score are discussed in the text that follows. These scores are useful for detecting patterns over both space and time, in those characteristics that affect the viability of the target systems in the Blowing Sand Mountains assessment area.

Table 3. Blowing Sand Mountains conservation target systems viability ranking.

System	Size	Condition	Landscape Context	Summary viability score
Salt Desert Scrub	Very Good	Good	Very Good	Very Good
Greasewood Shrubland	Very Good	Good	Very Good	Very Good
Blowsand Mountains	Good	Good	Very Good	Good
Sand Mountain	Good	Fair	Very Good	Good
Playas	Very Good	Good	Good	Good
Springs	Good	Fair	Good	Good

Salt Desert Scrub:

The conservation assessment team ranked the size, condition and landscape context of this system as shown in table 4, and the Five-S Framework revealed that the viability of this system is very good overall. In other words, this system is likely to persist over the next 100 years if current threat levels remain the same or decrease. However, the condition of the community received only a good score because some exotic species known to alter landscape processes, such as cheatgrass (*Bromus tectorum*), are present. In addition, native bunchgrasses and other native plant species have decreased in abundance over the past 100 + years of livestock grazing (appendix A, map 6), particularly near water improvements (Matchett and others 2003). African rue (*Peganum harmala)*, halogeton (*Halogeton glomeratus*) and cheatgrass can be found within this system. Cheatgrass, in particular, is a significant threat to native communities, as it can build up a contiguous, fine fuel load that increases fire return intervals. An unnaturally frequent fire return interval can destroy non-fire-adapted shrubs, such as greasewood. After successive fires, cheatgrass out-competes native species, and is only replaced by other non-natives or more fire or disturbance-tolerant, invasive native species. In some localized areas, including the salt desert scrub communities directly northeast of the Sand Mountain dune system, the density of cheatgrass has increased to levels of concern to land managers. With cheatgrass present in the assessment area and no changes in land management practices, it is a matter of time before fire disturbance increases both density and spread of cheatgrass across threshold levels and creates a cheatgrass-dominated system in the future.

Table 4. Viability criteria for salt desert scrub with initial viability assessments highlighted in color.

	Size	Condition	Landscape Context
Very Good:	Greater than 50,000 acres	Few to no exotic/invasive plant species present	Fragmentation is only significant in 25% or less of extent. Natural surface and groundwater regimes are intact.
Good:	50,000 - 25,000 acres	Some exotics/invasives present, comprise less than 20% of total vegetative cover	Fragmentation is significant in 25-50% of extent. Natural surface and groundwater regimes are intact.
Fair:	25,000 - 17,000 acres	Exotics/invasives comprise 20-60% of total vegetative cover	Fragmentation is significant in over 50% of extent OR surface/ groundwater regimes are altered to the point of stand replacement in less than 25% of extent.
Poor:	Less than 17,000 acres	Exotics/invasives comprise greater than 60% total vegetative cover	Fragmentation is significant in over 50% of extent OR surface/ groundwater regimes are so altered that stand replacement is occurring in more than 25% of extent.

The size criteria for the viability assessment were set as reported in the Great Basin Ecoregional Blueprint, after a report by Young and others (1986) on salt desert scrub communities in Grass Valley, Nevada. Criteria for condition and landscape context were set using expert opinion.

Greasewood Shrubland:

Based upon the conservation assessment team's rankings (table 5), the overall viability rank for the greasewood shrubland system is very good. Greasewood shrubland is not currently affected by major threats, but several moderate threats are present. More palatable native species are less abundant than expected, and cheatgrass is fairly widespread, though not abundant. This change in composition is likely due to livestock grazing, and is likely to be more pronounced in areas where livestock seek water (Matchett and others 2003). This is the case within the Blowing Sand Mountains assessment area near the Walker River and livestock water improvements.

This system is also more sensitive than salt desert scrub to changes in groundwater levels, as many of the dominant species are tolerant of soils with high salt concentrations. If salt content of the soil were to decrease, as a result of long-term groundwater level changes, a gradual shift to less salt-tolerant species could occur.

Viability criteria for size of greasewood shrubland were adapted from the Great Basin Ecoregional Blueprint (Nachlinger and others 2001). Other viability criteria were adapted from expert opinion.

Table 5. Viability criteria for greasewood shrubland with initial viability assessments highlighted in color.

	Size	Condition	Landscape Context
Very Good:	greater than 2,000 ha	few to no invasive plant species present	Fragmentation is only significant in 25% or less of extent. Natural surface and groundwater regimes are intact.
Good:	2,000 – 1,700 ha	Some exotics/invasives present, comprise less than 20% of total vegetative cover	Fragmentation is significant in 25-50% of extent. Surface/ groundwater regimes are intact.
Fair:	1,700 – 1,200 ha	Exotics/invasives comprise 20-60% of total vegetative cover	Fragmentation is significant in over 50% of extent OR surface/groundwater regimes are altered to the point of stand replacement in less than 25% of extent.
Poor:	less than 1,200 ha	Exotics/invasives comprise greater than 60% total vegetative cover	Fragmentation is significant in over 50% of extent OR surface/groundwater regimes are so altered that stand replacement is occurring in more than 25% of extent.

Blowsand Mountains Dune System:

The conservation assessment team ranked the size of the Blowsand Mountains dune system as good, condition as good, and landscape context as very good (table 6), resulting in an overall system viability score of good. A portion of the central dunes are artificially mobilized by regular ordnance drops and detonations during military training activities based at Naval Air Station Fallon. The dunes in these areas likely would be naturally mobile due to local climatic conditions (Nicholas Lancaster, personal communication 2002, see also Bowers 1982). While individual organisms in the immediate vicinity of ordnance detonations are killed, it is uncertain if this artificial mobility has had a negative effect on the overall diversity or viability of sand-obligate species on Blowsand Mountains. No sensitive or rare species are known to inhabit the active portions of the Blowsand Mountains dune system. Thus, the conservation assessment team considered the current extent of artificial mobility in the active portion of the dune system to be neutral in effect on the greater Blowsand Mountains dune system.

Most importantly, it appears that the dunes are connected to their current sand source. This connectivity is critical for long term sand dune system viability. The size of the sand dunes system has not been artificially decreased; however, it is a bit smaller than desired for dunes that experience persistent artificial disturbance. The Great Basin Ecoregional Blueprint established a representative size of 500 hectares (1234 acres) for dune systems (Nachlinger and others 2001), which the Blowsand Mountains dune system exceeds. However, not all of the sand dune system can be considered viable habitat due to persistent artificial disturbance from training activities. Dune managers have found that the effects of artificial disturbance by OHV use can be detected more than one mile from the actual zone of use (Cameron Barrows personal communication 2002). It is reasonable to predict that live and inert ordnance drops and associated OHV use by unexploded ordinance (UXO) removal personnel would create a similar zone of effect.

Table 6. Viability criteria for Blowsand Mountains dune system with initial viability assessments highlighted in color.

	Size	Condition	Landscape Context
Very Good:	more than 1,000 ha outside of heavy effect zone required to withstand ongoing effects	no invasives present that artificially stabilize dune dynamics, no alterations to mobilized dune dynamics (vegetation mortality, artificial mobilization of stable sands), natural recruitment by key plant species	connection to current sand source(s) intact
Good:	1,000 - 500 ha of connected habitat outside of heavy effect zone	two of the above three conditions met: in this instance, no invasive plants present that stabilize dunes, and key plant species assumed to be experiencing natural recruitment	connection to current sand source(s) at least 70% intact
Fair:	500 – 200 ha	only one of the above three conditions met	current sand source(s) partly available, but only 30% permanently blocked
Poor:	less than 200 ha	none of the above conditions met	greater than 30% of current sand source(s) no longer available

An alternative means of evaluating dune system viability would compare dune acreage to some value of minimum dynamic area required to maintain dune formation processes. Estimating the minimum dynamic area for this dune system is complicated by the complex nature of the topography upon which the dune is located. Complex localized wind patterns generated by the underlying and surrounding landforms alter the dune topography.

Approximately one-third to one-sixth of the dunes in the Blowsand Mountains dune system are within the current effect zone for frequent ordnance drops however, a delineation of the actual zone of use for live ordnance drops was not available to the conservation assessment team. Thus, the team assumed that there was sufficient connected dune habitat (> 1234 acres) outside of the use area and associated zone of effect on the dunes peripheral to the large expanse of unvegetated sand to reach this minimum size criterion. This estimate of habitat size is conservative, and is based upon the assumption that none of the active sand area contributes habitat values to the species of interest because of a lack of vegetation.

Although the withdrawal of this area from public use has greatly reduced the occurrence of many types of artificial disturbance, some areas are very likely to have been altered by ordnance drops and detonation of unexploded ordnance. Higher densities of cheatgrass and Russian thistle have been observed in fire-scarred areas near objects apparently used as targets for live ordnance drops (Dean Tonenna personal communication January 7 2004). It is unclear how long ago the fires had occurred, and thus would be difficult to estimate the rate of spread of cheatgrass in the immediate area.

The alteration of dunes from ordnance drops and UXO activities is also expressed as a greater area of actively mobile sands than might be expected under natural conditions. This shifts the species composition to favor those species that pioneer the active dunes, and away from species that require semi-stable dunes with vegetation or fully stable, vegetated dunes. If any invasive species have been introduced to this area via the vehicles used for UXO activities, or via wind or animal transport, they are likely to have invaded the edges of the active portions of the dunes. While the artificial mobility caused by continuing ordnance drops will keep any invasive plants from establishing within the active ordnance drop zone, any propagules present in this artificially mobilized sand area are a potential future source of stress to the system. Were the sands no longer perturbed artificially, invasive species would have an opportunity to colonize a large area in the center of this dune system. However, the conservation assessment team concluded that the overall condition of this target system is good. Although an increase in the area effected by live ordnance drops/other military training is not anticipated at this time, such an expansion would increase the amount of negative effects upon vegetation/fauna and would likely decrease the rank for this conservation target's condition.

After the conservation assessment team's analysis of the Blowing Sand Mountains area, including the Blowsand Mountains dune system, members of the team (Tonenna, Funari, Cottle, Ryan and Wainscott) were able to visit portions of the Blowsand Mountain dune system in August 2003 with other experts. It was observed that both Russian thistle and cheatgrass were present in low numbers in portions of the dune system. In future assessments of the Blowsand Mountains dune system, or the greater Blowing Sand Mountains area, particular attention should be paid to the extent of weed invasions and effects to species and habitats in the Blowsand Mountains dune system and surrounding ecological systems.

The conservation assessment team determined that the Blowsand Mountains dune system is currently connected to all of its sand sources, and ranked the landscape context as very good. Activities that significantly reduce the current rate of materials reaching the dune systems would decrease its extent and depth in the long term, and alter the extent of available habitat for psammophytic plants and animals in the more near term.

Sand Mountain Dune System:

The conservation assessment team ranked the size, condition and landscape context of this system as shown in table 7. The Five-S Framework revealed that the overall viability of this system is marginally good, but the rapid trend towards an increasingly degraded condition of this area is of considerable concern. Much of the dune system is within the BLM's Sand Mountain Recreation Area (appendix A, map 7). The designated Desert Study Area in the southern portion of the recreation area is restricted to foot traffic only, except for one designated access road, but there is evidence of continuing vehicular off-road use of the entire area. Vehicular use of the remainder of the dune system is increasing annually in and around this popular recreation area. In 1995 BLM estimated that there were 30,000 visitors annually to the recreation area, and by 2001 this number had jumped to 40,000 (Christine Miller personal communication 2002, Dean Tonenna personal communication February 4, 2003).

Table 7. Viability criteria for Sand Mountain dune system with initial viability assessments highlighted in color.

	Size	Condition	Landscape Context
Very Good:	more than 1,000 ha outside of heavy effect zone required to withstand ongoing effects	no invasives present that can artificially stabilize dune dynamics, no mobilizing alterations to dune dynamics (vegetation mortality, direct artificial mobilization of stable sands), natural recruitment by key plant species	connection to current sand source(s) intact
Good:	1,000 - 500 ha of connected habitat outside of heavy effect zone	two of the above three conditions met	connection to current sand source(s) at least 70% intact
Fair:	500 – 200 ha	only one of the above three conditions met: in this instance, no invasive plants known to stabilize dunes are present.	current sand source(s) partly available, but up to 30% permanently blocked
Poor:	less than 200 ha	none of the above conditions met	greater than 30% of current sand source(s) no longer available

The size of the entire dune system at Sand Mountain is smaller than desired for dunes that experience persistent artificial disturbance. Dune managers have found that the effects of artificial disturbance by vehicular use can be detected in native sand dune biota up to five miles from the actual area of use (Cameron Barrows personal communication 2002). In areas that experience intense vehicular use, a one to one-half mile wide “dead zone” can result, within which little to no native biota flourish, although they may still be present (Cameron Barrows personal communication 2002). For this conservation assessment, the size of the Sand Mountain dune system was evaluated using the criteria applied to the Blowsand Mountains dune system. The conservation assessment team assumed that the heavy effects from OHV use were occurring on the large, unvegetated dune in the center of the system, and that the effects on the majority of the vegetated dunes were moderate at the time of this assessment. Based upon this, the conservation assessment team rated the size of the less-effected dune habitats as good. However, some vegetated dune habitats within the Sand Mountain dune system are receiving much more use and appear to be more effected by this use than previously assumed. The increasing use of the vegetated dune areas for motorized recreation and the resulting effects on dune biota may soon require a review of how the size of the remaining, less negatively impacted habitat affects the dune system’s overall viability.

The condition of the Sand Mountain dune system has been effected primarily by vehicular recreation, and these effects are likely to increase as vehicular recreation levels at Sand Mountain Recreation Area continue to increase. Luckenbach and Bury (1983) studied the Algodones Dunes in the Mojave Desert (Imperial Sand Dunes Recreation Area) and found that areas with very high OHV usage had a lower overall volume of perennial vegetation than did areas closed to OHV recreation (see also Pianka 1967 for volume formula). This reduced volume of perennial vegetation in OHV use areas was strongly correlated with decreased numbers of both native rodents and lizards (Luckenbach and Bury 1983). Luckenbach and Bury (1983) also described lower numbers of beetle tracks detected in OHV recreation areas compared to areas closed to OHV recreation. From these data, it can be inferred that populations of perennial vegetation, small vertebrates and sand dune beetles have also declined to some degree on the vegetated dunes that receive vehicular use in and near the Sand Mountain Recreation Area. The lower use levels at Sand Mountain Recreation Area compared to the Imperial Sand Dunes Recreation Area, and the more remote location of some of the vegetated dunes might provide some protection from the effects of vehicular recreation. It must be remembered, however, that all of the dunes in this system are within less than half a day’s motorized travel from the main camping area at Sand Mountain Recreation Area. Indeed, analysis of remote sensing data and recent observations indicate much higher vehicular effect densities in these more remote dunes, both presently and in the past, than previously assumed by land managers (figure 17, Dean Tonenna, personal communication February 4, 2003).

Figure 17. Vehicle tracks in northern “remote” portion of Sand Mountain dune system.
© Bureau of Land Management

Preliminary data show what appear to be low recruitment rates of the stabilizing native plant species and increasing mortality of key perennial plants, such as Kearney buckwheat (Dean Tonenna personal communication, February 4 2003). This potential reduction in extent of dune vegetation, and of Kearney buckwheat in particular, is of great concern for land managers. Many of the endemic invertebrates found in the sand dune system aggregate around the root systems of perennial plants (Rust and Hanks 1982, Rust 1986). Kearney buckwheat is the sole host plant for the narrowly endemic Sand Mountain blue butterfly. Many other invertebrates are found in the sand column around the roots of this perennial shrub (Rust and Hanks 1982, Rust 1986). Kearney buckwheat is also important to other species, as its floral timing provides resources during the heat of summer lasting through fall, when other floral resources are scarce or ephemeral (Dean Tonenna personal communication, February 4, 2003).

At least two weed species of concern are present on the Sand Mountain dune system, Russian thistle and cheatgrass (figure 18), but neither are known to artificially stabilize sand movement. After the conservation assessment team's analysis of the Blowing Sand Mountains area, including the Sand Mountain dune system, was completed a few team members (Downs, Tonenna and Wainscott) were present on a field trip in May 2003 to the northern portion of the Sand Mountain dune system. The abundance of weed species observed on that trip was much higher than assumed by the conservation assessment team during the analysis, and it is possible that the condition of this dune system would have been downgraded to poor based upon this new information. Future assessments of this dune system and the greater Blowing Sand Mountains area should include a focused analysis of the distribution and abundance of weed species, and possible vectors of their spread.

Figure 18. Russian thistle (*Salsola* sp.) and cheatgrass (*Bromus tectorum*) on Sand Mountain dune system. © Bureau of Land Management

The landscape processes that maintain the sand dune system's mosaic of active and stabilized dunes appear to be intact at the present time. In addition, it appears that the sand transport corridor for this system is also intact. The main likely sand source for the Sand Mountain dune system appears to be the Salt Wells Basin. The conservation assessment team concluded that this playa is functionally connected to Sand Mountain, despite the presence of Highway 50. Also, it is likely that the recycling of sand from the dune system to the playa via the western wash continues with little disturbance. If destruction of native perennial dune vegetation continues, the artificial mobilization of the sand within these smaller dunes might reach a critical threshold of artificial activity. It is possible that artificially pushing the dune processes past this threshold of activity could cause mobilization of adjacent vegetated dunes, swamping or burying the remaining dune vegetation and causing a cyclical, chain reaction of artificial mobility.

If condition of the Sand Mountain dune system were improved, it is likely that the system and sand-obligate species nested within the system would be viable in the long-term, assuming that connectivity to current sand sources and the remainder of the sand transport corridor continues.

Playas:

The overall viability score for playas in the Blowing Sand Mountains area was good: a high likelihood of persistence for the next 100 years given current threat levels (table 8). Salt Wells Basin exceeds the minimum size for playas established by Nachlinger and others (2001); however Rawhide Flats and Bass Flats are within the size range for a rank of fair. Because each of the playas is at its natural extent, and the conservation assessment team determined that in general, all natural playa habitats within the Blowing Sand Mountains area were of a size likely to persist for the next 100 years and received a size rank of very good.

The condition and landscape context of the playas was ranked more conservatively by the conservation assessment team. The presence of salt-tolerant, invasive non-native plant species (salt cedar) and vehicular use of the playa edges for recreation, as well as the use of the playa floors for salt mining (Salt Wells Basin) and military activities (Rawhide Flats) has likely effected the native playa vegetation and any playa fauna present. Also, it is unclear how 100 years of shallow groundwater use by the salt mine in the Salt Wells Basin have effected the function of this playa. The native halophytic plants that inhabit the playa edges are dependent upon the periodic flooding of playas for seed germination (Ungar 1974), and if flooding of the playa were stopped for many years at a time, the native seed bank might become depleted, affording an advantage to non-native, invasive species such as tamarisk. Additionally, periodic flooding of the playas may be critical for liberating sand from the playa floor through wave action. Thus, the conservation assessment team ranked both condition and landscape context of the playa system as good.

Table 8. Viability criteria for playas with initial viability assessments highlighted in color.

	Size	Condition	Landscape Context
Very Good:	greater than 10,000 ha: minimum viable size (Nachlinger and others 2001)	minimum damage to playa invertebrates during periods of desiccation. Few to no exotics/invasives present.	Groundwater and surface water fluctuations within natural range of variation.
Good:	10,000 – 7,000 ha,	Some exotics/invasives present, comprise less than 30% of total vegetative cover	natural flooding rate decreased by 40% or less
Fair:	7,000 – 4,000 ha	Exotics/invasives comprise 30-80% of total vegetative cover	natural flooding rate decreased by greater than 40%
Poor:	less than 4,000 ha	Exotics/invasives comprise greater than 80% total vegetative cover	Natural flooding eliminated due to alterations in groundwater and/or surface water

Spring Systems:

The conservation assessment team ranked the size, condition and landscape context of this system as shown in table 9 and the overall viability rank of the spring systems was good. The possibility of alterations to the groundwater systems in this area, due to the proximity of potential future groundwater withdrawals for the City of Fallon and ongoing withdrawals by Huck Salt Mines, led the conservation assessment team to conservatively score the landscape context of the spring systems as good, rather than very good. However, future iterations of the assessment process for the Blowing Sand Mountains area may yield data that leads to a change in this rank. The size score for springs was ranked good, due to a decrease in the extent of riparian vegetation as a result of trampling by livestock and recreational users in the more moderately-thermal springs. The condition of the springs in the Blowing Sand Mountains area was scored as fair, due to a number of factors. Livestock grazing on the riparian vegetation has altered the composition of the vegetation community through changes to the relative abundance of species, trampling of plants, introduction of non-native and invasive plant species, as well as alterations to the nutrient levels in the soils and water via inputs of feces and urine. Invasive salt cedar (*Tamarix* spp.) is present at several of the springs in the assessment area.

Table 9. Viability criteria for springs with initial viability assessments highlighted in color.

	Size	Condition	Landscape Context
Very Good:	Spring brook length is intact. Riparian vegetation is at natural extent.	Less than 10% of riparian zone is non-native. AND No shifts in aquatic community due to unnatural alterations in chemical inputs from terrestrial zone due to animal wastes, soil erosion, human-added chemicals.	Groundwater supply is intact, spring flows are at natural levels.
Good:	Upper 50 meters of spring brook is intact. Riparian vegetation is at 100-80% of natural extent.	60-90% of vegetation in the riparian zone is native. AND No shifts in aquatic community due to unnatural alterations in chemical inputs from terrestrial zone.	Perennial springs retain flow year-round but flows are decreased. Ephemeral springs may be dry during seasons when would naturally flow.
Fair:	Upper 25 meters of spring brook is intact. Riparian vegetation is at 40-80% of natural extent.	20-60% of vegetation in the riparian zone is native. OR Unnatural alterations in chemical inputs from terrestrial zone have caused a shift to mainly pollution tolerant aquatic species.	Perennial springs retain flow year-round but flows are decreased, and aquatic species composition may shift. Ephemeral springs are dry during seasons or years when would naturally retain some flow.
Poor:	Less than 25 meters of upper spring brook is intact. Less than 40% of natural riparian vegetation extent is present.	Less than 20% of vegetation in the riparian zone is native. OR Unnatural alterations in chemical inputs from terrestrial zone have caused shift to only pollution tolerant aquatic species.	Perennial springs become ephemeral; aquatic community is lost.

Threats to Conservation Targets

A *threat* is defined as the combination of a *source* or agent that is damaging an area, natural system or species, and the *stresses* or damage the agent is causing. The Five-S Framework guides participants through a detailed analysis of the stresses that are currently decreasing, or likely to decrease, the viability of species or natural systems within the next ten years. The Five-S Framework also provides a mechanism to rank the relative contributions and severity of the damage caused by each stress. This stress analysis is then expanded to identify the most proximate source of each stress, and the relative contributions each source makes to the overall expression of the stress, as well as the degree to which the effects are reversible. In this way the Five-S Framework reveals the most critical threats that require action to maintain or improve the viability of the assessment area in the long term (table 10).

Table 10. Summary definitions of severity and scope of damage ranking for stresses, and contribution and irreversibility for sources of stress.

	Stresses		Sources	
	Severity of Damage	**Scope of Damage**	**Contribution to the Stress**	**Irreversibility of the Stress**
Very High	Likely to destroy or eliminate target within ten years	Likely to be very widespread or pervasive within ten years	Very large	Not reversible
High	Likely to seriously degrade target viability within ten years	Likely to be widespread within ten years	Large	Reversible, but not practically affordable
Medium	Likely to moderately degrade target viability within ten years	Likely to be localized within ten years	Moderate	Reversible with a reasonable commitment of additional resources
Low	Likely to only slightly impart target within ten years	Likely to be very localized and affect a limited portion within ten years	Low	Easily reversible at relatively low cost

Natural disturbance patterns are part of landscape processes that need to be maintained. Often, these natural disturbances are necessary to maintain a mixture of successional stages within a natural system. Thus, the natural flooding of a playa community is not a viability-reducing stress. However, a disturbance is considered to be a stress if it is artificially caused or outside the normal range of disturbance one would expect in the system, such as year-round standing water in a naturally ephemeral playa caused by impoundments. While many artificial stresses are acting upon these natural systems, only those stresses that are likely to reduce the viability of a natural system or species were analyzed. Additionally, only the most proximate sources of those stresses were assessed. Summaries of the conservation assessment team's threat assessment are presented in the following pages while detailed rankings are found in appendix B.

ECOREGIONAL CONTEXT

In the Great Basin ecoregional assessment (Nachlinger and others 2001) several threats were found to be widespread in the Great Basin. These threats included inappropriate grazing regimes, invasion by exotic species, hydrologic alterations, urban expansion, inappropriate recreation, and altered fire regimes. With the exception of urban expansion, all of these threats are of concern in the Blowing Sand Mountains area.

STRESSES TO ECOLOGICAL SYSTEMS AND SOURCES OF STRESS

Salt Desert Scrub

The conservation assessment team concluded that salt desert scrub communities within the Blowing Sand Mountains area were suffering a reduction in viability due to unnatural changes in the structure of the vegetation layer, alteration of the natural fire regime, habitat fragmentation and instances of severe soil compaction (table 11). The reduction in abundance of native bunch grasses and the presence of invasive non-native plant species, such as Russian thistle, halogeton, and cheatgrass, have altered the structure of the vegetation.

Table 11. Stresses and stress ranks for salt desert scrub in the Blowing Sand Mountains assessment area.

Stresses	Severity	Scope	Stress Rank
Alteration of natural fire regimes	Very High	Low	Low
Altered composition/structure	High	Medium	Medium
Habitat fragmentation	Medium	Medium	Medium
Soil Compaction	High	Low	Low

Widespread cheatgrass infestations impart an additional threat to salt desert scrub communities by altering the natural fire regime. Wildfires in more pristine desert shrublands tend to be small in scope, due to low cover of the native vegetation. Cheatgrass is a fine, flashy fuel. It is easily ignited, and can form a continuous carpet of fuel in disturbed areas. When the cheatgrass cover becomes dense enough to allow for a continuous fuel load in the naturally open, shrub dominated communities such as salt desert scrub, a dangerous threshold has been reached. When the density of cheatgrass is such that fire can carry much further and effect a greater proportion of the natural community, acres of desert scrub can be damaged, and long-lived, non-fire-adapted vegetation can be destroyed. Cheatgrass is also a very successful post-fire invader of these disturbed lands, and over time, the native vegetation can be replaced by cheatgrass and other invasive, fire-tolerant species.

The density of cheatgrass within the Blowing Sand Mountains area is not high enough at this time to warrant concern about alterations of the natural infrequent fire regime. However, continued invasion of cheatgrass, coupled with an increase in its density, could quickly lead to an increased fire cycle which is threatening much of the Great Basin's sagebrush and sage brush semi desert systems (Nachlinger and others 2001). The integrity of the salt desert scrub, a matrix system that surrounds the assessment area, is integral to the long term viability of all other conservation targets in the Blowing Sand Mountains area.

This ecological system is also likely to become more fragmented in the next ten years as road and trail networks proliferate. Finally, soil compaction is likely to occur in areas with moderate to high grazing or traffic loads, as well as in areas where heavy equipment operates, such as rights-of-way scheduled for expansion and maintenance in the next ten years. While effected areas are limited in geographic extent, soil compaction decreases the potential for germination of plants and re-establishment of native soil crusts after soil disturbance.

The conservation assessment team identified seven important sources of stress in the salt desert scrub system (table 12). Detailed rankings for the relative contributions and irreversibility of damage imparted by each source of stress are in appendix B. Both past and present grazing practices were identified as sources of ongoing stresses. Much of the area outside of Sand Mountain Recreation Area and the Bravo-19 Range is used as ephemeral grazing range for cattle (appendix A, map 6). Both the BLM and the Walker River Paiute Tribe manage allotments within the Blowing Sand Mountains area. Grazing levels have decreased on many of the Walker River Tribal allotments for economic reasons (Tad Williams personal communication 2002), but grazing levels have remained constant on BLM allotments.

Table 12. Sources of stress and final source rankings for the salt desert scrub system.

Source / **Stress**	Alteration of natural fire regimes	Altered composition/ structure	Habitat fragmentation	Soil compaction
Current grazing practices	-	LOW	-	-
Past grazing practices	-	-	-	LOW
Invasive species	LOW	MEDIUM	-	-
Misuse of vehicles	-	LOW	LOW	-
Responsible use of paved roads	LOW	-	MEDIUM	-
Rights-of-way management	-	LOW	-	-
Mining practices	-	MEDIUM	-	-

Past grazing has left compacted soils in heavily used portion of this ecological system. Current grazing practices continue to effect the relative abundances of native bunchgrasses as well as invasive non-native plant species. Populations or infestations of non-native invasive weed in the salt desert scrub system not only alter the composition and structure of the vegetation but also increase the fuel contiguity and potential frequency of fires. In addition, these established weed populations serve as seed sources for new infestations that may invade patches of disturbed soil.

The responsible use of paved roads increases the potential for fire starts when vehicles enter road shoulders while still hot from normal operation. The presence of these paved roads also causes fragmentation of this matrix system.

Vehicular recreation and use off of paved roads are common within the Blowing Sand Mountains assessment area and in the surrounding BLM lands. However, some forms of vehicle use are damaging to the resources. These forms of vehicular use will hereafter be referred to as *vehicular misuse*. Such vehicular misuse includes but is not limited to; driving vehicles off pavement at unsafe speeds, driving vehicles off pavement in excess of posted speed limits, creating new road incursions in vegetated areas, and driving vehicles over hummocks of perennial vegetation so as to use them as jump ramps in order to "catch air." Driving vehicles at unsafe speeds increases the likelihood of the vehicle straying from the established path, thus widening the existing trail or creating new road incursions.

It is important to note that with the exception of the Desert Study Area, all BLM lands in the Blowing Sand Mountains area are open to off-road and off-trail vehicular use (BLM 2001). However, damage to vegetation caused by off-road recreation has the potential to degrade the viability of the greasewood shrubland, salt desert scrub, and sand dune systems within the assessment area. Thus, all recreational use of vehicles off of designated roads or trails in vegetated areas are regarded in this report as vehicular misuse, regardless of current land use designations.

The creation of new road incursions in vegetated areas can not only destroy native vegetation, but can damage biological soil crusts, disrupt the upper soil levels, increase wind or water erosion of the soil, and introduce non-native or invasive plants along the incursion path (Defenders of Wildlife 2002). In desert ecosystems, soil crust organisms are responsible for producing the majority of fixed nitrogen. Belnap (2002) found that Great Basin biological soil crust nitrogen fixation was significantly reduced by vehicular traffic. Fixed nitrogen is the second most limiting factor for plant growth in desert soils, second only to water (Romey and others 1978). Disruption of the nitrogen cycle by alteration or destruction of the biological soil crust will reduce the levels of nitrogen available for vascular plant growth in localized areas.

The salt desert scrub system is also threatened by the possibility of invasion and spread of cheatgrass (*Bromus tectorum*) and other invasive weeds. Vehicles, hikers and animals can be vectors of weed seeds (Defenders of Wildlife 2002). In addition to natural transport mechanism such as water and wind erosion, actions such as vehicular use that disturb the soils while transporting weed seeds have a higher probability of successfully introducing weeds into the area.

Finally, the management of rights-of-way projects and mining practices both impart the risk of damage to perennial shrubs and the introduction of weeds to disturbed soils, thus altering the composition and structure of the salt desert scrub system. Within an established right-of-way (ROW) corridor (BLM 2001), a major powerline runs east to west across the Blowing Sand Mountains area. This powerline connects Fort Churchill Power Plant to Utah, and carries much of the power supply for northern Nevada. Although not required, it is likely that any future east to west ROW applications for buried lines would follow this corridor. ROW applications for above ground lines on towers over 50 feet high would likely be routed elsewhere due to concerns about conflicts with the military training mission for the Dixie Valley Electronic Warfare Training Range, NAS Fallon (BLM 2001).

Future construction and maintenance activities along this ROW or along alternative routes through the assessment area may destroy native vegetation, disturb or destroy soil crusts, increase soil erosion and /or encourage the introduction and spread of invasive plant species.

Greasewood Shrubland

Many stresses are effecting the viability of the greasewood shrubland, and are likely to continue to do so in the next ten years (table 13). The abundance of native bunch grasses and other species palatable to livestock is lower than expected, and cheatgrass is widespread though not abundant. As in the salt desert scrub system, this has resulted in changes in the composition and structure of the vegetation in the greasewood shrubland ecological system. The natural fire regime has also been altered to some extent, as in the salt desert scrub system. Additionally, the change in structure of the vegetation caused by increasing densities of weed species in the spaces between native perennial shrubs may be decreasing rates of sand transport within this system. In sand transport studies, it has been shown that sand movement does not occur in areas with greater than 15% vertical cover, typically from vegetation (Lancaster and Baas 1998).

Table 13. Stresses and stress ranks for greasewood shrubland in the Blowing Sand Mountains assessment area.

Stresses	Severity	Scope	Stress Rank
Altered composition/structure	High	Medium	Medium
Alteration of sand flow/dune dynamics	Medium	Medium	Medium
Alteration of natural fire regimes	Very High	Low	Low
Habitat destruction or conversion	Very High	Low	Low
Soil compaction	High	Low	Low
Direct mortality	High	Low	Low
Habitat fragmentation	Medium	Medium	Medium

There is a slight risk of habitat destruction or conversion of the greasewood shrubland system. Significant alterations in the groundwater levels in the Blowing Sand Mountains area could cause a shift in the extent and location of the greasewood shrubland community.

This community is found in areas where other desert vegetation cannot out-compete the more halophytic species (Ungar 1974), such as big greasewood. Any significant alteration in the water table, either an increase or decrease, might shift the areas in which such high concentrations of salts accumulate in the soils. This shift in salt deposition might temporarily increase the extent of the greasewood shrubland at the expense of salt desert scrub, or promote the invasion of non-native, salt tolerant species, such as tamarisk. Because the greasewood system is likely to be more sensitive to changes in groundwater levels, the potential stress of habitat destruction or conversion was assessed.

This system is fragmented by a network of both paved and unpaved roads which may serve as barriers to movement for some species of wildlife. Additionally, plants and animals inhabiting the greasewood shrubland system are killed by vehicles both on established roads and during the creation of new road incursions. Soil compaction decreases the potential for germination of plants and re-establishment of native soil crusts after soil disturbance. In a recent study, sandy soils disturbed by vehicular activity were found to be more susceptible to a decrease in nitrogen fixing activity, perhaps due to the higher likelihood of soil churning and deep burial of soil crust components (Belnap 2002). This stress is expected to be most pronounced along unpaved roads and in rights-of-way projects where heavy equipment is used for installation and maintenance.

The conservation assessment team identified and ranked six important sources of stress for the greasewood shrubland (table 14). Past grazing practices were found to have caused soil compaction as well as lingering changes in the composition and structure of the vegetation. Current grazing management also contributes to these stresses, and might also cause an alteration in the flow of sand in the system. Extreme overgrazing significantly decreases the vertical structure of native herbaceous vegetation, and this may artificially increase mobilization of sand via wind erosion. Alternatively, grazing levels and practices that encourage invasion of cheatgrass and other invasive plant species might artificially increase the vertical structure of the vegetation and completely halt the flow of sand through the greasewood shrubland system. The rates of natural sand transport through this ecological system are unknown, but worthy of further investigation by geologists.

Table 14. Sources of stress and final source rankings for the greasewood shrubland system.

Source / **Stress**	Altered composition/ structure	Alteration of sand flow/ dune dynamics	Alteration of natural fire regimes	Habitat destruction or conversion
Current grazing practices	LOW	LOW	-	-
Past grazing practices	LOW	-	-	-
Invasive species	MEDIUM	-	LOW	LOW
Misuse of vehicles	LOW	LOW	LOW	-
Responsible use of paved roads	-	-	LOW	-
Rights-of-way management	LOW	-	-	-

Table 14 (continued).

Source	Stress	Soil compaction	Direct mortality	Habitat fragmentation
Current grazing practices		LOW	-	-
Past grazing practices		LOW	-	-
Invasive species		-	-	-
Misuse of vehicles		LOW	LOW	LOW
Responsible use of paved roads		-	LOW	MEDIUM
Rights-of-way management		-	-	-

Vehicle use does pose a threat to native wildlife and plants that stray into, are attracted to, or burrow under established roads and trails. Some forms of native wildlife are attracted to the open spaces on roadways for basking, foraging, nesting, and other activities. In particular, reptiles may seek out roadways for basking and hunting, and have been found to be particularly vulnerable to roadway mortality (Rosen & Lowe 1994). Wildlife and plants that use road margins may also be harmed when vehicles stray slightly from roadways.

In contrast, other wildlife may avoid well established, barren patches of soil and roadways may thus become barriers to movement. Fragmentation of this sort can disrupt foraging, breeding, and other behavioral patterns (Defenders of Wildlife 2002). Wildlife in salt desert scrub and greasewood shrubland systems may not be well adapted to linear stretches devoid of vegetation. Unpaved roads and trails may be negatively effecting their viability.

The presence of invasive plant species alters the composition and structure of greasewood shrublands. As described earlier, localized areas near livestock water improvements and other available water sources have higher densities of cheatgrass. The invasive, non-native salt cedar has replaced greasewood shrubland in areas with more moisture, such as the banks of the Walker River, effectively reducing native plant cover.

The misuse of vehicles in the greasewood shrubland system also imparts threats similar to the salt desert scrub ecological system, with the additional stress of altered sand-flow dynamics via wind erosion in areas where vegetation is destroyed by repeated vehicular activities.

Blowsand Mountains Dune System

Four stresses to the Blowsand Mountain dune system were assessed by the conservation assessment team (table 15). An alteration of the sand flow and sand dune dynamics and potential reduction in the natural extent of sand dune vegetation in general is of concern to land managers, and was ranked a medium stress to the Blowsand Mountains Dune System. As mentioned above, it has been shown that sand movement occurs in areas with less than 15% vertical cover (Lancaster and Baas 1998). It is therefore reasonable to assume that artificially decreasing vegetative vertical structure below this threshold can artificially activate naturally vegetated, stable sand features. While active dunes are valuable habitat for specially adapted species, and are a critical part of the dynamic sand dune systems, stabilized dunes provide a unique habitat for yet another suite of specialized species (Richard Rust personal communication 2002). This alteration of the composition of the vegetated dune community and the resulting change in the overall structure of the vegetation was also ranked a medium stress. The direct loss of individual native plants and animals on the Bravo-19 bombing range was considered to be a severe stress to the ecological system, however the limited geographic extent of this stress caused the overall stress rank to the low. Additionally, the potential spot contamination of the dune system by incompletely detonated ordnance ranked as a low stressor.

Table 15. Stresses and stress ranks for the Blowsand Mountains dune system in the Blowing Sand Mountains assessment area.

Stresses	Severity	Scope	Stress Rank
Alteration of sand flow/dune dynamics	Very High	Medium	Medium
Altered composition/structure	Medium	Medium	Medium
Direct mortality	High	Low	Low
Toxins/contaminants	Low	Low	Low

Three main sources of stress were identified for the Blowsand Mountain dune system (table 16). The only activities that take place on this dune system are those related to the military training mission of NAS Fallon. Although the withdrawal of the Bravo-19 Range area from public access has reduced many types of disturbances, some areas have been significantly altered by ordnance drops. Approximately one-third to one-sixth of the dunes on Blowsand Mountains is within the current effect zone for frequent ordnance drops. When ordnance is dropped on the Bravo-19 Range, three things are possible: the ordnance may detonate completely, incompletely, or not at all. Complete detonation of ordnance causes a concussive blast or explosion and the release of heat energy. In such cases, little residue from either the internal chemical components or the outer shell remains. Thus, effects on biota of the dune system are localized but severe. It is unlikely that individual plants or animals survive the immediate explosion and the resulting sudden movement of large volumes of sand. Vegetation or animals within the immediate blast zone that survive the explosive event are likely to be buried deeply by mobilized sand. Any nearby animal burrows are likely to collapse, as well.

Table 16. Sources of stress and final source rankings for the Blowsand Mountains dune system.

Source	Stress	Alteration of sand flow/ dune dynamics	Altered composition/ structure	Direct mortality	Toxins/ contaminants
Ordnance drops		MEDIUM	-	LOW	LOW
Ordnance removal – invasive transport via OHV		MEDIUM	MEDIUM	-	-
Ordnance removal – UXO detonation		MEDIUM	LOW	LOW	LOW

Those non-native or invasive weed species present in this artificially disturbed dune system, such as cheatgrass and Russian thistle, may have formed seed banks that could rapidly expand if the artificial disturbances to Bravo-19 were to stop for any significant length of time. While the artificial mobility caused by continuing ordnance drops will temporarily keep invasive plants from establishing in large patches, any propagules present in this artificially mobilized sand area are a potential future source of stress to the system. Were the sands no longer perturbed artificially, invasive species would have an opportunity to colonize a large area in the center of this system. Due to the constant artificial disturbance and activation of the dunes in the target zone of the Bravo-19 Range, it is difficult to accurately assess the current extent of non-native or invasive weed propagules within the Blowsand Mountains dune system. In those locations where fires are started by either lightning, military activities or other means, dense areas of weed infestation may spread and increase in density. The conservation assessment team choose to estimate the geographic extent of the altered composition caused by weed infestation and artificial disturbance as medium in both severity and geographic scope.

Complete detonation of ordnance, when it occurs within the target area, may be the least threatening scenario for the biota of the Blowsand Mountains dune system. When ordnance fails to fully and properly detonate, the internal chemical components may enter the soil, and potentially leach into the water stored within the dune system. Also, incomplete and failed detonation of ordnance require clearance of the unexploded materials through explosive ordnance disposal (EOD) techniques.

Activities related to the destruction of unexploded ordnance (UXO) also impart stresses to the dune system. On the Bravo-19 Range, EOD techniques involve the entry of military personnel using off-highway vehicles to reach the unexploded ordnance. Explosive materials are placed on or near the UXO, and are then detonated from a safe distance. The detonation of the ordnance imparts stresses similar to the proper detonation of ordnance, but the use of vehicles for EOD purposes adds stresses of altering dune dynamics and the structure and composition of vegetated dune systems by potentially introducing and spreading invasive weed species.

Sand Mountain Dune System

The conservation assessment team identified and ranked six stresses for the Sand Mountain dune system (table 17). As described for the Blowsand Mountains Dune System, a reduction in the natural extent of sand dune vegetation and the resulting changes to the composition and structure of the vegetated dune communities, as well as the alteration of dune dynamics, are of concern to land managers.

Table 17. Stresses and stress ranks for the Sand Mountain dune system in the Blowing Sand Mountains assessment area.

Stresses	Severity	Scope	Stress Rank
Habitat disturbance	Medium	Medium	Medium
Direct mortality	High	High	High
Toxins/contaminants	Low	Medium	Low
Altered composition/structure	Medium	High	Medium
Habitat fragmentation	Medium	Low	Low
Alteration of sand flow/dune dynamics	Very High	Medium	Medium

The nearly constant presence of humans in this dune system led the conservation assessment team to consider the effects of habitat disturbance. Many species of wildlife alter their activity in the presence of humans, and this can result in disrupted breeding behaviors. The conservation assessment team considered this stress to be of moderate severity. Because the rates of direct mortality for key perennial shrub species appear to be increasing in and around this popular recreation area, the potential for pockets of remaining dune vegetation to become isolated within the next ten years was also assessed. The sand dune community is a dynamic system formed of vast stretches of unvegetated sands and smaller mosaics of shifting active and vegetated dunes. It is likely that native sand dune wildlife are adapted to patches of unvegetated soil, and thus the effects of fragmentation by unpaved roads and trails on sand dune wildlife is likely to be minor. Finally, the potential release of toxins and contaminants from the operation of vehicles and the burning of objects within the campground areas was identified as a low ranked stress to the Sand Mountain dune system.

Six sources of stress were identified and ranked for this dune system (table 18). Both vehicular use and misuse were ranked as high contributors to stresses in this system. Both contributed to habitat disturbance, direct loss of individuals, alteration in the structure of the vegetated communities and the release of toxins and contaminants. The misuse of vehicles, through creation of new tracks and destruction of perennial vegetation, also contributes to fragmentation of vegetated dune communities and the alteration of dune dynamics by removing vegetative vertical structure. Using vehicles at high speeds not only increases the likelihood of mortality for wildlife in the path of the vehicle, but endangers the user and other visitors as well (Defenders of Wildlife 2002). In addition, when vehicles are intentionally driven into and over perennial vegetation in an attempt to “catch air,” plants are damaged and with continued damage are eventually destroyed. The loss of individual plants is compounded by loss of the habitat provided by these large perennial shrubs, and the potential changes in sand activity and sand dune dynamics caused by the loss of stabilizing vegetation in an area.

Table 18. Sources of stress and final source rankings for the Sand Mountain dune system.

Source / Stress	Habitat disturbance	Direct mortality	Toxins/ contaminants
Vehicular use	MEDIUM	HIGH	LOW
Misuse of vehicles	MEDIUM	HIGH	LOW
Responsible use of paved roads	-	-	-
Invasive species	-	-	-
Current grazing practices	-	-	-
Mining practices	-	-	-

Table 18 (continued).

Source / Stress	Altered composition/ structure	Habitat fragmentation	Alteration of sand flow/ dune dynamics
Vehicular use	LOW	-	-
Misuse of vehicles	MEDIUM	LOW	MEDIUM
Responsible use of paved roads	-	LOW	-
Invasive species	MEDIUM	-	MEDIUM
Current grazing practices	LOW	-	-
Mining practices	-	-	LOW

As discussed earlier, many of the invertebrates that live in the sand column congregate around the roots of perennial plants (Rust and Hanks 1982; Rust 1986), including the Kearney buckwheat (*Eriogonum nummulare*). Also, such long lived shrubs may be over 20 years of age, and will take several years to replace. Preliminary observations at Sand Mountain Recreation Area show low levels of recruitment of this species (Dean Tonenna personal communication, February 4, 2003). Significant reductions in the Kearney buckwheat population would lead to an increased risk to the endemic Sand Mountain blue butterfly), which is specifically dependent upon this plant species. Additionally, other species of concern to land managers, such as the Hardy's aegialian scarab beetle, would suffer from habitat changes as a result of plant cover declines.

The threat of vehicular misuse in the Sand Mountain dune system is of particular concern (figure 19). Vehicular incursions continue to occur within the Desert Study Area, which has been closed to vehicular traffic since 1988, even though it is fenced and signed to indicate that the area is off limits to vehicles. Also, the use and misuse of the vegetated dunes on the periphery of the main dune system is more prevalent than previously believed (Dean Tonenna, personal communication, February 4, 2003). The entire dune system is within one half day's travel in an OHV from the designated parking area. Although it is likely that native sand dune wildlife are adapted to patches of unvegetated soil, another potential source of habitat fragmentation for some sand-obligate species may be the presence of Highway 50, which may isolate wildlife in the dunes along the eastern edge of the Salt Wells Basin playa.

Figure 19. Hill-climbing tracks on dune and in swale in western portion of Sand Mountain dune system. © Bureau of Land Management

Recreational vehicular use of Sand Mountain Recreation Area also poses threats to natural systems from contamination of the soil by oil and gas spillage, garbage that may attract opportunistic predators such as coyotes, unleashed dogs, and Common Ravens, as well as the potential for sewage contamination of the soils near the camping areas. Recent improvements to the camping area (increased garbage control and installation of pit toilets) by BLM (Christine Miller personal communication 2002) have reduced the threats posed by garbage accumulation and sewage contamination.

Soil compaction is not a key issue on these dune systems because of the high uniformity of size and the rounded shape of the sand grains in the Blowing Sand Mountains area (Eissmann 1990; Trexler and Melhorn 1986). However, the soils in the parking and camping areas at Sand Mountain that are heavily used by vehicles have been compacted. This compaction artificially stabilizes sand and precludes establishment of native vegetation. Additionally, in some heavily used portions of Sand Mountain Recreation Area, vehicular use has removed the vegetation and subsequent increases in wind erosion have removed the sand layer and exposed a clay layer that appears to underlie the entire dune system (Dean Tonenna personal communication, February 4, 2003). It is uncertain if this clay layer will be punctured by continued vehicular use or erosion, and what effect this might have on the hydrology of the dune system.

The presence of invasive species and current grazing practices that spread those weeds contribute to the alteration of the vegetated dune community. The southern camping areas and northeastern dunes of the Sand Mountain system support populations of cheatgrass and Russian thistle. Also, some invasive weeds may unnaturally stabilize the dunes, which eliminates the active sand/detritus burial critical for many endemic invertebrates' life cycles. In the Mojave Desert, it has been observed that stabilization of sand dunes by non-native *Schismus* sp. grasses can lead to a community dominated by a few non-native species, including Sahara mustard (*Brassica tournefortii*) (Libby Powell personal communication 2002). However, prolonged drought cycles may cause many of these invasive species to disappear from the area (Cameron Barrows personal communication 2002). It is unclear if any invasive species are capable of artificially stabilizing dune systems in the climate of the Great Basin.

Both the Sand Mountain and the Blowsand Mountains dune systems are dependent upon a flux between actively mobile and stable sands, and recycling of sands from the playa basins into the dune systems. Activities that impede this recycling of sand could significantly degrade the dynamics of these dune systems. As discussed in earlier sections of this document, vertical vegetative cover (structure) of greater than 15% has been shown to halt the movement of sand. Dense cheatgrass or other invasive plants within portions of the sand transport corridor between the dune systems and nearby playas could halt the flow of sand into the system. It is unclear how this might affect the form of the sand dunes at either dune system.

It may be that additional sources of sand are significant to the proper functioning of one or both of these sand dune systems. If this is determined to be the case, actions to protect the sand source and the current sand movement corridor(s) are critical to the conservation of native species of plants and animals dependent upon these dynamic systems. Modifications to existing paved road beds, or construction of new paved roads may interrupt sand dynamics critical to the functioning of these sand dune systems. In addition, the possibility of mineral material extraction in this dune system poses a threat to the dune dynamics in the local area of operations. Currently, 2760 acres within the Sand Mountain Recreation Area are closed to mineral entry (BLM 2001), and 1960 acres at Sand Mountain Recreation Area have been closed to both oil and gas leasing and geothermal leasing (BLM 2001).

Playas

Playa systems are driven by the local groundwater and surface water flows. Groundwater levels define the zonation commonly seen among playa edge communities (Ungar 1974) Significant changes in the groundwater level could cause a shift in this zonation, creating an opportunity for non-native species, such as salt cedar, to invade the disturbed natural communities. The level of the groundwater table also effects the occurrence and duration of floods in the playas. Because many of the halophytic species that populate the edges of desert playas are dependent upon periodic flooding for seed germination (Ungar 1974), long periods without natural playa flooding could lead to a depletion of the native seed bank. However, the importance of the seed bank in recovery from disturbance within these halophytic communities is not yet clear (Gul and Weber 2001).

Five stresses were identified and ranked for the playa systems in the Blowing Sand Mountains area (table 19). The conservation assessment team's analysis identified modification of both surface and groundwater processes as potential stresses to the viability of the playa systems in the Blowing Sand Mountains area.

Table 19. Stresses and stress ranks for playa systems in the Blowing Sand Mountains assessment area.

Stresses	Severity	Scope	Stress Rank
Groundwater depletion	High	Low	Low
Soil compaction	Medium	Medium	Medium
Salinity alteration	Medium	Medium	Medium
Modification of natural flow patterns	High	Medium	Medium
Alteration of sand flow/dune dynamics	Medium	Low	Low

The potential for significant alteration in salinity of Salt Wells Basin in the vicinity of the salt extraction operation was also identified as a stress in this assessment. The conservation assessment team also considered the possible effects to the ephemeral playa species of compacted soil layers and modification of natural surface water flows.

Finally, the potential for unnatural increases in the rate of sand transport into the playa systems from artificially activated dune systems was ranked as a moderately severe stress to playa communities, but was only likely to occur near the Sand Mountain dune system, in the Salt Wells Basin.

Five sources of stress were identified by the conservation assessment team (table 20). The salt extraction (or mining) operation in the Salt Wells Basin was identified as a potential source of localized groundwater depletion and alteration of salinity of the surrounding playa soils. Also, the evaporation ponds would likely alter playa flooding patterns, albeit in a localized fashion.

Table 20. Sources of stress and final source rankings for the playas system.

Stress / Source	Groundwater depletion	Soil compaction	Salinity alteration	Modification of surface water flow patterns	Alteration of sand flow/ dune dynamics
Mining practices	LOW	-	MEDIUM	MEDIUM	-
Excessive groundwater withdrawal	-	MEDIUM	-	-	-
Invasive species	LOW	-	MEDIUM	MEDIUM	-
Misuse of vehicles	-	-	-	-	LOW
Rights-of-way management	-	LOW	-	-	-

There is also a possibility that the local Salt Wells Basin groundwater table has been or will be depleted by withdrawals for the Huck Salt Mine or an expansion in groundwater use by the community of Fallon as it grows. However, no data were found to refute or support this potential source of stress.

The presence of salt cedar on the periphery of the playas posses the potential to decrease rates of sand transport from the playas to the sand dune system within the next ten years, but does not appear to be disrupting the sand flow at this time.

The Navy has investigated the environmental effects of installing a buried fiber optic line ROW running from highway 95 east to the facilities on the Bravo 19 Range (U.S. Department of the Navy 2000). This line would be used to support the training mission of Naval Air Station Fallon. If installed, this line would be placed along the existing access road to the Bravo 19 Range, requiring minimal additional surface disturbances in this ROW. Due to the minimal disturbance anticipated, and the localized nature of the project area, this was a low ranked potential source of stress.

The misuse of vehicles on playa systems is a common form of recreation in the desert southwest, but the stresses this activity and the resulting soil compaction imparts to the ephemeral playa communities is unknown at this time. The conservation assessment team ranked this activity as the greatest contributor to this stress, but more study of the effects to playa communities is warranted.

Springs

Five moderate to low stresses were identified for the few springs in the Blowing Sand Mountains area (table 21). The alterations to the vegetative component of the riparian and wetland communities were widespread and of moderate severity. Nutrient loading from livestock wastes alter the carbon, nitrogen and other chemical cycles in these systems, which can cause high rates of algal growth. Abundant algae can shade important aquatic habitats, and in some instances utilize all available dissolved oxygen. Additionally, emergent vegetation fertilized by these wastes can experience unnaturally lush growth and utilize all of the available water in spring brooks, thereby eliminating aquatic habitats.

Table 21. Stresses and stress ranks for springs in the Blowing Sand Mountains assessment area.

Stresses	Severity	Scope	Stress Rank
Altered composition/structure	Medium	Very High	Medium
Groundwater depletion	High	Low	Low
Salinity alteration	Medium	Low	Low
Nutrient loading	High	Medium	Medium
Modification of surface water flow patterns	High	Medium	Medium

Modifications to springbrooks can cause water flows to bypass seed banks for native species and lead to decreased diversity of native vegetation. Groundwater depletion can reduce available aquatic habitat and may lead to seasonally dry periods in formerly perennial spring systems. Changes in groundwater flow may also alter the concentrations of naturally occurring chemicals in solution within the spring waters, increasing salinity and conductivity levels and thus altering the habitat for native wildlife and plant species, many of which have differing tolerances.

Four main sources of stress were identified and assessed for spring systems (table 22). Grazing practices cannot only decrease the abundance of palatable plant species, but may allow introduction of non-native invasive species, such as salt cedar, that take advantage of disturbed soil in heavily trampled areas. Salt cedar also suppresses competition from other species by dropping leaves in which high concentrations of salts have accumulated, effectively inhibiting the germination of less salt-tolerant native species. Also, livestock allowed to congregate near spring habitats may input significant amounts of urine and feces, increasing nutrient levels in the local soils.

Table 22. Sources of stress and final source rankings for the springs system.

Source / **Stress**	Altered composition/ structure	Groundwater depletion	Salinity/ conductivity alteration	Nutrient loading	Modification of surface water flow patterns
Current grazing practices	LOW	-	MEDIUM	MEDIUM	-
Construction of ditches, dikes, etc.	-	MEDIUM	-	-	-
Excessive groundwater withdrawal	LOW	-	MEDIUM	MEDIUM	-
Recreational use of springs	-	-	-	-	LOW

Due to the generally high conductivity values of these springs, caused by high mineral content, few of the springs in the assessment area have been altered for livestock or potable water improvements. However, Sand Springs, in the southern portion of Sand Mountain Recreation Area, has been altered in the past for potable water at the Sand Springs Pony Express Station. The well constructed over Sand Springs in the late 1800s remains intact as part of an archaeological site in the Desert Study Area.

Modification of springbrooks for recreation or other reasons causes modification of surface water flows and alterations in vegetation composition and structure, as well as the potential for introduction of non-native invasive species, such as salt cedar. The use of thermal springs for soaking and other forms of recreation is common in the Great Basin. Users who do not understand the value of spring brooks as a resource for wildlife and native plants often modify the spring brook by creating pools, diverting a portion of the flow into bathtubs or other artificial “ponds”, and by removing vegetation and/or substrate to create seating opportunities. The effects of altering the spring brook have been addressed in a previous section. The damage to species, both aquatic and riparian, are considered in this section.

Destruction of individual plants and animals may occur via trampling, uprooting, burial or other activities as recreational users modify the environment in search of an improved recreational experience. These artificial disturbances not only directly decrease the populations of native species in these small and insular habitats, but also provide opportunities for invasive weed species to invade. Finally, excessive groundwater withdrawal is the sole identified potential future source of both groundwater alteration and altered salinity or conductivity.

Table 23 shows the threat ranking for all sources of stress to the Blowing Sand Mountains assessment area. Detailed tables showing rankings for all stresses and sources of stress may be found in appendix B.

Table 23. Threat summary for Blowing Sand Mountains.

Threats	Sand Mountain	Salt Desert Scrub	Playas	Blowsand Mountains	Greasewood Shrubland	Springs	Overall Threat Rank
Vehicular Misuse	High	Low	Medium		Low		Medium
Vehicle Use	High						Medium
Invasive Species	Medium	Medium	Low		Medium		Medium
Mining Practices	Low	Medium	Medium				Medium
Responsible Use of Paved Roads	Low	Medium			Medium		Medium
Grazing Practices	Low	Low			Low	Medium	Low
Excessive Groundwater Withdrawal			Medium			Low	Low
Spring Brook Alterations						Medium	Low
Ordnance Drops				Medium			Low
Ordnance Removal-Invasive Transport				Medium			Low
Ordnance Removal- UXO Detonation				Medium			Low
Rights-of-Way Installation and Maintenance		Low	Low		Low		Low
Recreational Use of Springs			Low				Low
Overall Threat Rank	High	Medium	Medium	Medium	Medium	Medium	MEDIUM

Conservation Strategies

The vision for the Blowing Sand Mountains assessment area is to conserve natural biodiversity of this endemic-rich landscape while continuing traditional and contemporary human uses. The geographic scope is intended to allow for an “unreserved matrix” (Franklin 1999), an area that will continue to support human activities such as recreation, mining, livestock grazing and military uses consistent with contemporary uses. Although many current activities appear to be happening at appropriate levels to maintain proper functioning of conservation targets, some alterations in the extent, intensity or timing of activities are recommended.

Federal designations such as *critical habitat* (Endangered Species Act of 1973 as amended) can restrict uses of public lands and impede the military’s ability to test and train on public land. Avoiding the listing of plant and animal species under the Endangered Species Act through proactive, adaptive management should allow federal land managers to minimize restrictions on the use of public lands. In particular, adaptive strategies that include measurements of the effects of species and habitat management techniques will help ensure that any use restrictions have the desired conservation results.

Well designed conservation actions that benefit representative communities or natural systems should also provide protect landscape scale processes that maintain them (Franklin 1999; Poiani and others 2000). By designing management and monitoring strategies that affect larger scale ecological systems, the natural variation in disturbance regimes will more likely be maintained in a functioning condition. The patchy nature of most natural disturbance is critical in maintaining the complete array of successional stages within each conservation target system. Monitoring the effects of management at the ecological system level will assist land managers in determining whether smaller-scale, more intrusive, management or restoration techniques are required to supplement successional stages critical to the viability of any of the species of interest.

Key to addressing long-term threats to rare species, their habitats, and important natural processes is the application of good science and expansion of open dialog among key stakeholders. Strong relationships among regulatory agencies, local governments, land managers, user groups, and other stakeholders will lead to strategies that allow land and resource managers to accomplish their missions and mandates without diminishing the viability of the Blowing Sand Mountains area.

The conservation analysis of the Blowing Sand Mountains explored the expected costs and benefits of various conservation strategies identified by the conservation assessment team. Only those strategies expected to benefit conservation targets are recommended in this document. Table 24 summarizes the expected direct benefits of each strategy recommendation to the affected target systems.

Table 24. Direct strategy benefit ranks to conservation target systems in the order of overall benefit rank

Strategies	Sand Mountain	Salt Desert Scrub	Playas	Blowsand Mountains	Greasewood Shrubland	Springs	Overall Benefit Rank
Eliminate vehicular traffic on vegetated dunes	Very High				Medium		High
Increase BLM law enforcement staff at SMRA	High				Low		Medium
Annual vehicular closure of SMRA for some period of time tied to needs of biota	High						Medium
Establish and enforce guidelines for user capacity at SMRA	High						Medium
Restrict access to SMRA via Dixie Valley road	High						Medium
Evaluate current grazing levels		Medium			Medium	Medium	Medium
Provide public vehicle cleaning station to reduce weed propagule transport	Medium	Low			Medium		Medium
Campground Host for SMRA	Low				Medium		Low
Continue requiring spark arrestors for all off-highway vehicles on BLM lands	Medium				Low		Low
Implement DoD vehicle cleaning procedure to reduce weed propagule transport				Medium			Low
Maintain or reduce extent of ordnance effect zone(s) on Bravo-19				Medium			Low
Fence spring riparian areas to exclude livestock						Medium	Low
Return spring brooks to natural stream bed, remove obstructions and modifications						Medium	Low

Table 24 (continued). Direct strategy benefit ranks to conservation target systems in order of overall benefit rank.

Strategies	Sand Mountain	Salt Desert Scrub	Playas	Blowsand Mountains	Greasewood Shrubland	Springs	Overall Benefit Rank
Minimize soil and vegetation disturbance during rights-of-way construction and maintenance			Low				Low
Facilitate BLM management of 86 acre DoD parcel at entrance to SMRA	Low						Low
Withdraw Blowing Sand Mountains area from all forms of mineral entry, subject to valid and existing claims.	Low						Low
Implement and expand volunteer clean-up events, monitoring programs and educational tours of SMRA and surrounding area	Low						Low

Each strategy was also ranked for its indirect costs and benefits to the entire Blowing Sand Mountains area. The indirect effects on the ease of implementing strategies or benefits from other strategies (*leverage*), feasibility of implementation, and the financial cost of each strategy in discretionary agency funds was assessed. Definitions for each ranking can be found in appendix E. The resulting scores reflect a cost/benefit analysis of each strategy for the Blowing Sand Mountains area. The strategies are grouped by responsible land management entity, and described at length below. At the end of this section, table 25 summarizes the results of the cost and benefit analysis for each strategy recommendation.

NAVAL AIR STATION FALLON

Facilitate BLM management of 86 acre DoD parcel at entrance to Sand Mountain Recreation Area: (Sand Mountain Dune System)

While none of the endemic plants or animals in the Sand Mountain dune system are known to occur on this parcel, consolidating management responsibility for the recreation area would indirectly benefit these species. Although BLM maintains a 3-mile buffer no-camping zone around Sand Mountain Recreation Area, it is possible that users may attempt to avoid BLM regulations and the use fee at Sand Mountain Recreation Area by camping on the DoD parcel and waiting to recreate on the dune system when BLM staff are not present. Minimizing future public confusion over acceptable uses of this parcel would allow BLM staff to focus on protecting those habitats on Sand Mountain that are known to harbor rare species.

Fence spring riparian areas to exclude livestock: (Springs)

While springs are rare in the general vicinity of the assessment area, they form isolated islands of riparian and aquatic habitat within a sea of salt desert scrub. Where cattle or other non-native ungulates are degrading spring vegetation or where their waste inputs are degrading water and soil chemistry, fencing some portion of the upper spring brook may be necessary. Installation of fencing at affected spring sites would result in recovery of the spring habitat, although the final strategy benefit ranking (Low) reflects the limited benefits this strategy can impart to the other five ecological systems within the assessment area.

Effective recovery of spring habitats is dependent upon a functional connectivity to the surrounding terrestrial habitats and wildlife that inhabit them. Management actions must take into account not only the connectivity of springs with the surface watershed and ground water basin, but also the connection with surrounding terrestrial areas (Baron and others 2002). To the extent possible, management actions that allow for native species of wildlife to access spring habitats are preferred. BLM's spring management guide (U.S. Department of the Interior 2001) suggests that restoration and protection activities at springs begin at the spring source, upper spring brook, and address any occurrences of endangered, threatened and sensitive species. Within the assessment area, no endangered, threatened or sensitive species are known from the spring habitats.

Minimize soil and vegetation disturbance during rights-of-way construction and maintenance: (Salt Desert Scrub, Greasewood Shrubland, Playas)

Rawhide Flat, the playa to the south of the Blowsand Mountains dune system, is currently crossed by a right-of-way for the potential future installation of a buried fiber optic cable to be used for communications at the Bravo-19 training range (U.S. Department of the Navy 2001). Installation of this cable would be along the existing access road to the Bravo-19 Range, but some local soil disturbance is possible. However, minimizing soil erosion and damage to vegetation could be accomplished with minimal cost, simply by setting reasonable guidelines for the area in which equipment would be staged and reducing unnecessary vehicular use of the surrounding playa area. Soil banking and implementation of soil erosion control measures are not recommended at this time.

Implement DoD vehicle cleaning procedures to reduce weed propagule transport: (Blowsand Mountains Dune System)

While not currently necessary due to a lack of invasive weeds known to stabilize sand dunes in the Great Basin, it is possible that, in the future, the spread of such invasive weeds surrounding the assessment area will warrant actions to reduce the creation of new weed populations via the transport of propagules on off-highway vehicles used for UXO. Public vehicle washdown stations have been installed in Queensland, Australia to stem the spread of noxious weeds. It is likely that other DoD installations have initiated vehicle washdown procedures to reduce weed spread. These models should be used to develop a procedure for NAS Fallon if washdown of EOD and other vehicles is warranted. Procedures as simple as dry-brushing of tires and under-carriages of vehicles entering the sand dune portion of the Bravo-19 Range might be sufficient.

Return spring brooks to natural stream bed, remove obstructions and modifications: (Springs)

Beginning at the upper spring brook reaches, modified stretches of the natural spring brook should be restored to a more natural state, to enhance riparian habitat for wildlife. Exotic plant species, and any invasive aquatic animal species should be removed to enhance recovery of native species. Land managers may refer to BLM's guide to spring restoration (BLM 2001) for the principles of spring aquatic and riparian habitat restoration.

Maintain or reduce extent of current ordnance effect zone(s) on Bravo-19: (Blowsand Mountains Dune System)

While the conservation assessment teams' analysis of the Blowing Sand Mountains area assumed that the viability of the sand dune species on Blowsand Mountains have not been significantly reduced following more than 40 years of ordnance drops, there are no quantitative data available to either support or challenge this assumption. Although the conservation assessment team assumed a limited zone of effect to the sand dune communities based upon current target zones, on a recent field visit to the Blowsand Mountain dune system some members of the team observed widespread invasive plant populations on the dunes, and this was of some concern (Claudia Funari, Dean Tonenna, personal communication August 17, 2003.) Coupled with the limited habitat acreage not already affected by past or current ordnance activities, it would be prudent to avoid expanding the area(s) of the Blowsand Mountains dune system negatively affected by the military training mission of NAS Fallon. As mentioned earlier, the Blowsand Mountains dune system does contribute to the biodiversity of the Great Basin (Rahn and Rust 2000), and is an important part of the Blowing Sand Mountains area. Analysis of remote sensing data coupled with field surveys should be used to evaluate the assumptions made by the conservation assessment team and allow for adaptive management of this dune system in the future.

BUREAU OF LAND MANAGEMENT

Increase Bureau of Land Management law enforcement staff at Sand Mountain Recreation Area (Sand Mountain Dune System)

It will be critical to the effective implementation of many of the following recommended strategies that BLM implement a sufficient level of law enforcement presence at Sand Mountain Recreation Area to increase user compliance to a level that adequately protects vegetated dunes and other resources. All strategies to reduce threats to the Sand Mountain dune system are predicated on active enforcement of regulations at Sand Mountain Recreation Area.

Eliminate vehicular traffic on vegetated dunes: (Sand Mountain Dune System)

Actions to eliminate or minimize vehicular traffic on all vegetated dunes are vital for the protection of the species dependent upon this habitat. The reduction in the natural extent of sand dune vegetation and the resulting changes to the composition and structure of the vegetated dune communities, as well as the alteration of dune dynamics, are of concern to land managers. While it might be possible to restore stable, vegetated dunes to the system, a different suite of species are "pioneers" on newly stabilized dunes, such as mustang clover (*Psoralidium lanceolatum*). Over many years, conditions on the newly stable dunes might become suitable for the establishment of a vegetation community that includes Kearney buckwheat and other species of concern, but restoration of this type of community has not been attempted, and it is uncertain if land managers would be able to artificially create or even restore a Kearney buckwheat dominated sand dune community. Thus, the conservation assessment team focused on strategies that would minimize threats to vegetated sand dune habitats.

Additional interpretive signage that explains the importance of avoiding damage to the vegetation, signs around the vegetated avoidance areas, fencing, and law enforcement staff focus on those areas will all be necessary to achieve adequate protection of vegetative cover. Emergency administrative closure of the vegetated habitat for sensitive species should be implemented if population monitoring of key species suggests low population levels or substantial population declines. In addition, BLM should restrict vehicles to unvegetated areas and designated roads and trails within the Sand Mountain dune system in any future revisions of the management plan for the Sand Mountain Recreation Area (BLM 1985) and the Carson City Field Office Consolidated Resource Management Plan (BLM 2001). Emergency response personnel as well as land and resource management agency staff should be excluded from these restrictions.

Facilitate BLM management of 86 acre DoD parcel at entrance to Sand Mountain Recreation Area: (Sand Mountain Dune System)

Cooperative actions between NAS Fallon and the BLM will be required to implement this strategy. This strategy is discussed in detail under Naval Air Station Fallon.

Continue requiring spark arrestors on off-highway vehicles on BLM lands: (All target systems)

Continuation of this requirement is critical for minimizing the threat of accidental fire starts on public lands in the Blowing Sand Mountains area. The presence of cheatgrass and other non-native, invasive species in the salt desert scrub and greasewood shrubland compounds the threat of accidental fire ignitions.

Evaluate current grazing levels: (Salt Desert Scrub, Springs, Greasewood Shrubland)

The effects of current grazing levels and timing should be evaluated to ensure that they are sufficiently moderate to maintain the viability of the salt desert scrub and greasewood shrubland within the assessment area. Any increases in grazing pressure would increase both the likelihood of damaging alterations to the composition of native communities, and the spread and abundance of cheatgrass and other invasive plant species. Decreasing the grazing levels, as is occurring on several Walker River Tribal allotments due to economic factors, will allow native plants to increase in abundance and spread, but will likely not decrease existing levels of invasive species.

Restrict access to Sand Mountain Recreation Area via Dixie Valley road: (Sand Mountain Dune System, Salt Desert Scrub)

The official entry to Sand Mountain Recreation Area is via an access road from US Highway 50, but access can currently be gained on the north side of the dune system via a road into the Salt Wells grazing allotment. Measures to minimize use of this un-official egress point should be pursued to minimize conflicts with management of the overlapping grazing allotment and to decrease threats to the Sand Mountain dune system and surrounding salt desert scrub vegetation. Minimizing vehicular traffic in the northern most dune systems and the surrounding salt desert scrub will decrease the threat of vehicular misuse on these more isolated occurrences of Kearney buckwheat and Sand Mountain blue butterfly. Minimizing the introduction and spread of invasive plants in these areas will also maintain the integrity of the salt desert scrub in this area, thereby reducing the threat of an altered fire regime in this remote portion of the Blowing Sand Mountains assessment area.

Campground host for Sand Mountain Recreation Area: (Sand Mountain Dune System, Playas, Salt Desert Scrub, Greasewood Shrubland)

Initiating a campground host program for the Sand Mountain Recreation Area would assist BLM law enforcement staff in increasing user compliance with all rules and regulations. Additionally, the presence of a campground host will discourage the presence of “rowdy” users who tend to be more likely to violate rules, regulations and suggested use guidelines both in and around the recreation area. The presence of a campground host would also likely provide an indirect measure of protection to the surrounding area.

Establish and enforce guidelines for user capacity at Sand Mountain Recreation Area: (Sand Mountain Dune System, Playas, Salt Desert Scrub and Greasewood Shrubland)

Sand Mountain Recreation Area is a rather small dune system to support the current and projected future use levels for popular holiday weekends. To protect resources and facilities and for the safety of users, it may become necessary for recreation experts to establish a "carrying capacity" or maximum number of users who can use the recreational area at one time. It should be noted that turning away users when the recreation area has reached capacity may lead to increased use of the surrounding BLM lands, or other public lands in the vicinity. Many of the current users of the recreation area travel over 300 miles from home to recreate, and will be inclined to find alternative camping and recreational areas in the vicinity if turned away from Sand Mountain Recreation Area. Systems that might possibly be negatively effected by this "user diversion" include playas, salt desert scrub and greasewood shrubland.

Fence spring riparian areas to exclude livestock: (Springs)

This strategy is discussed in detail under Naval Air Station Fallon.

Minimize soil and vegetation disturbance during rights-of-way construction and maintenance: (Salt Desert Scrub, Greasewood Shrubland, Playas)

The current utility line within the designated ROW corridor that crosses the assessment area (BLM 2001) is likely to be expanded in the future as northern Nevada energy demands increase. Maintenance of this utility line is a certainty. Additional utility projects should be routed through the corridor as well. The Carson City Field Office Consolidated Resource Management Plan (BLM 2001) provides BLM the authority to require soil damage minimization and revegetation measures. Revegetation measures are to be implemented using seed mixtures and procedures at the discretion of the BLM. Because the designated ROW corridor runs through the Blowing Sand Mountains area, it is recommended that at a minimum, soil damage minimization measures be required of ROW projects to reduce the introduction and spread of invasive weeds. If an area within a ROW becomes an established source population for weed propagules that threaten the surrounding areas, BLM should strongly consider including revegetation measures for any additional activities in that portion of the corridor.

Provide a public vehicle cleaning station to reduce weed propagule transport: (Salt Desert Scrub, Greasewood Shrubland, Playas, Sand Mountain dune system)

While not currently necessary, it is possible that the spread of invasive weeds surrounding the assessment area will warrant actions to reduce the creation of new weed populations via the spread of propagules on off-highway vehicles, as previously discussed under Naval Air Station Fallon. Public vehicle washdown stations to stem the spread of noxious weeds should be established. Procedures as simple as dry-brushing of tires and under carriages of vehicles entering the Sand Mountain sand dune system might also be sufficient. Alternatively, educational materials might be provided to visitors to encourage proper cleaning of vehicles at commercial car wash facilities.

Annual vehicular closure of Sand Mountain Recreation Area for some period of time tied to needs of biota (Sand Mountain Dune System)

This strategy is suggested for consideration if other measures to reduce vehicular damage to key species are not successful. However, it is uncertain if annual short-term closure of the area would be sufficient for recovery of long-lived species such as Kearney buckwheat if damage to the vegetated habitat continues to occur during the remainder of the year. If short-term, annual vehicular closures are implemented, strict monitoring protocols should be developed and followed to determine whether this measure alone is sufficient for recovery of key species and their habitat. The timing of any proposed temporary vehicular closures should be determined by the key life-cycle events of the sensitive species (flowering, fruiting, germination or egg laying, hatching, feeding, metamorphosis) placed at risk by vehicular use/misuse of the Sand Mountain dune system.

Withdraw remainder of Blowing Sand Mountains area from all forms of mineral entry, subject to valid and existing claims: (all target systems)

As stated in Chapter 4 of this document, mining exploration, leasing and extraction activities could threaten most of the conservation target systems within the assessment area. Segregation and/or withdrawal of these areas from mineral entry and leasing should be accomplished via an amendment of the Carson City Field Office Consolidated Resource Management Plan (BLM 2001) or via federal legislation.

Implement, continue, and expand volunteer clean-up events, monitoring programs, and educational tours of Sand Mountain Recreation Area and surrounding area: (Sand Mountain dune system, Salt Desert Scrub, Greasewood Shrubland, Playas, Springs)

Educating the future users of the recreation area and the surrounding lands would indirectly benefit the biodiversity of the dune system and other target systems in the area. Participation of the Friends of Sand Mountain organization in volunteer clean-up events has already demonstrated to other users that these individuals value the resource. Other public land volunteer groups have been effective in interpreting the value of the natural resources within recreational areas to users (Karen Kelleher personal communication September 26, 2002). It is likely that continued and expanded volunteer clean-up events, educational tours and further user involvement in appropriate monitoring programs would influence a portion of the Sand Mountain Recreation Area users to comply with use guidelines, rules and regulations throughout the assessment area.

Return spring brooks to natural stream bed, remove obstructions and modifications: (Springs)

As described under Naval Air Station Fallon, beginning at the upper spring brook reaches, modified stretches of the natural spring brook should be restored to a more natural state, to enhance riparian habitat for wildlife. Exotic plant species, and any invasive aquatic animal species should be removed to enhance recovery of native species. Land managers may refer to BLM's guide to spring restoration (BLM 2001) for the principles of spring aquatic and riparian habitat restoration.

WALKER RIVER PAIUTE TRIBE

Evaluate current grazing levels: (Salt Desert Scrub, Springs, Greasewood Shrubland)

This strategy is discussed above under Bureau of Land Management. Grazing levels in Walker River Paiute Tribal allotments should also be evaluated to determine grazing levels consistent with conservation management goals.

ADDRESSING DATA GAPS

A large amount of data were amassed during this conservation area analysis. These data are available in the accompanying 5-S workbook tool and should be incorporated into future land use assessments. While the data are largely qualitative, they lay the groundwork for an ecologically based interpretation of the status of each of the biodiversity targets. However, gaps in data collection were inevitable. Refining the current information about the size, landscape context, condition, and threats to each natural system will be important for accurately reassessing the viability of the targeted natural systems. The effects of management actions should also be measured to determine whether they are sufficient to accomplish management goals.

Addressing the data gaps in our understanding of the Blowing Sand Mountains area may offer a mitigation option for the Department of Defense, should mitigation for proposed actions in the FRTC be necessary in the future. Using Legacy Program funds or other funding sources to fill in data gaps would also further understanding of representative Great Basin systems. Continuing species inventories on the two endemic-rich sand dune systems and similar sand dune systems in the Great Basin will enhance knowledge of distribution and habitat requirements for conservation targets. This information would allow land managers to better assess the relative contribution made to Great Basin biodiversity by the Sand Mountain and Blowsand Mountains dune systems. In addition, ecological studies of the species of concern and their habitats would inform management actions designed to enhance the viability of those species and persistence of their habitats. More detailed quantification and mapping of native and non-native vegetation utilizing both remote sensing data and field studies would allow land managers to better understand the extent of vegetation loss on the dune systems and the distribution of non-native invasive plant species throughout the Blowing Sand Mountains area. Finally, it would be extremely valuable for land managers to have better knowledge of local landscape processes such as sand dune dynamics, the importance of the clay layers within the dune systems, and the identification of contemporary sand sources for both dune systems, as well as a better understanding of the groundwater hydrology in the Salt Wells Basin, and fire regime alterations in the local salt desert scrub and greasewood shrubland systems.

Table 25. Strategy ranking in order of overall benefit rank after analysis of leverage/feasibility..

Strategies	Responsible resource management entity	"Raw" Benefit Rank	Leverage Gain for other Strategies	Feasibility (Staff Capacity)	Cost (from unrestricted funds)	Overall Benefit Rank
Increase BLM law enforcement staff at SMRA	BLM	Medium	High	Very High	Low	Very High
Eliminate vehicular traffic on vegetated dunes	BLM	High	High	Very High	High	High
Facilitate BLM management of 86 acre DoD parcel at entrance to SMRA	NAS Fallon, BLM	Low	Medium	High	Low	High
Continue requiring spark arrestors for all off-highway vehicles on BLM lands	BLM	Low	Low	Very High	Low	High
Evaluate current grazing levels	BLM, Walker Tribe	Medium	Medium	High	Low	High
Restrict access to SMRA via Dixie Valley road	BLM	Medium	High	Medium	Medium	High
Campground host for SMRA	BLM	Low	Low	High	Low	Medium
Establish and enforce guidelines for user capacity at SMRA	BLM	Medium	Medium	Medium	Medium	Medium
Fence spring riparian areas to exclude livestock	NAS Fallon, BLM	Low	Low	Medium	Low	Medium
Minimize soil and vegetation disturbance during rights-of-way construction and maintenance	NAS Fallon, BLM	Low	Low	Medium	Low	Medium
Provide public vehicle cleaning station to reduce weed propagule transport	BLM	Medium	Medium	Medium	Medium	Medium

Table 25 (continued). Strategy ranking in order of overall benefit rank after analysis of leverage/feasibility.						
Strategies	**Responsible resource management entity**	**"Raw" Benefit Rank**	**Leverage Gain for other Strategies**	**Feasibility (Staff Capacity)**	**Cost (from unrestricted funds)**	**Overall Benefit Rank**
Annual vehicle closure of SMRA for some period of time tied to needs of biota	**BLM**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**
Withdraw remainder of Blowing Sand Mountains area from all forms of mineral entry, subject to valid and existing claims	**BLM**	**Low**	**Low**	**High**	**Medium**	**Low**
Implement and expand volunteer clean-up events, monitoring programs, and educational tours of SMRA and surrounding area	**BLM**	**Low**	**Low**	**High**	**Medium**	**Low**
Implement DoD vehicle cleaning procedure to reduce weed propagule transport	**NAS Fallon**	**Low**	**Low**	**Medium**	**Medium**	**Low**
Return spring brooks to natural stream bed, remove obstructions and modifications	**NAS Fallon, BLM**	**Low**	**Low**	**Medium**	**Medium**	**Low**
Maintain or reduce extent of ordnance effect zone(s) on Bravo-19	**NAS Fallon**	**Low**	**Low**	**Low**	**Medium**	**Low**

Measures of Success

Implementation of conservation management strategies in the Blowing Sand Mountains area should be accompanied by an adaptive management approach to gauge effectiveness of management in conserving the targets and resources of concern. Adaptive management can be defined as a flexible and iterative approach to long-term resource management, directed over time by the results of ongoing monitoring activities to assure measurable success. Monitoring can include two types of measures: Effectiveness measures evaluate the status of the targets to gauge the effectiveness of management activities in conserving them, while compliance measures assure that the activities intended to be carried out are indeed completed as intended.

This section summarizes the effectiveness and compliance measures identified by the Conservation Assessment Team, while table 26 indicates those monitoring measures that would best assess the effectiveness of the strategies described in the previous section. To the extent practicable, lessons learned from an adaptive management approach to conservation in the Blowing Sand Mountains area should be shared with land managers responsible for similar resources elsewhere in the southwest U.S., through seminars and publications, including peer-reviewed journal articles.

EFFECT AND EFFECTIVENESS MEASURES

Survey for new weed invasions and monitor known populations

Surveys for new and known weed populations, coupled with monitoring of the composition of salt desert scrub and greasewood shrubland communities should be used to track the effects of management actions such as vehicle wash-down stations and grazing level changes on conservation target viability.

Monitoring of abundance, distribution and recruitment of sensitive species

The abundance and distribution of sensitive plant and animal species should be monitored to determine if reductions in vehicle use impacts are sufficient to allow for long-term viability of these species of concern. If feasible, more detailed monitoring of the recruitment of sensitive plant species would be beneficial to the understanding of effects to and recovery from vehicular use of the vegetated areas.

Monitoring of abundance, distribution and recruitment of Kearney buckwheat

Kearney buckwheat is the only known host plant for the narrowly endemic Sand Mountain blue butterfly, and forms an extensive root system that provides underground habitat for an entire suite of dune-obligate species. Monitoring the abundance, distribution and recruitment of this perennial plant species could provide trend data to inform management of vehicular and other uses in the vegetated portions of the Sand Mountain dune system.

Remote sensing to track trends in vegetated dune plant cover

The distribution of perennial dune plant species such as Kearney buckwheat should be monitored to determine if vehicle use effect reductions are sufficient to allow for long-term viability of these species of concern. Tracking the distribution of perennial dune vegetation via remote sensing will be an important measure for interpreting the results of species monitoring in dynamic dune systems such as the Blowsand Mountains and Sand Mountain dune systems. Measurements of perennial dune plant distribution should take place on both Sand Mountain dunes and on Blowsand Mountains dunes. Monitoring protocols should be comparable between the two dunes to allow for comparisons, although the measurements may be taken by BLM and DoD staff, respectively.

Remote sensing to track trends in vehicular effects and effect zone of vehicular activities

Remote sensing methods including satellite imagery and aerial photography, accompanied by field surveys, should be used to monitor vehicular effects to the Sand Mountain dune system, playas, greasewood shrubland system and salt desert shrub system. The effects of successfully implementing vehicular use reductions in the Sand Mountain dune system should also be monitored using remote sensing and field surveys to detect vehicle tracks. Remote sensing could also be used to determine whether surrounding areas begin to receive more vehicular effects when these restrictions are put into effect.

Track fire incident reports

Fire incidence reports should be tracked to determine whether the spark arrestor requirement for off-highway vehicles on Bureau of Land Management lands is abating the threat of fire starts.

Remote sensing to track effect zone of high-user-volume days at SMRA

Aerial photography and field surveys should be used to track the effect zone of high-visitor-volume days to determine if a temporary increase in law enforcement presence is required to adequately contain the public to designated camping and vehicular recreation areas.

Monitor composition of salt desert scrub and greasewood shrubland

Standard vegetation or rangeland monitoring protocols should be used to monitor the effect of grazing management, vehicle washing, and/or ROW corridor policies on these two target systems within the assessment area.

Monitor spring aquatic and riparian habitats.

Standard protocols for monitoring the extent and viability of both aquatic and wetland habitats associated with the spring systems should be implemented to allow for adaptive management of the springs within the Blowing Sand Mountains assessment area.

Remote sensing to track effect zone of training activities on Bravo-19

Measuring the effect of ordnance drops and other training activities on the Department of Defense lands in the assessment area, in particular the Bravo-19 bombing range on the

Blowsand Mountains dune system, is important for assessing the long term viability of the identified conservation targets that are found on that dune system and surrounding greasewood shrubland and playa systems. Aerial photography or other remote sensing techniques should be used to track changes in the effect zone.

COMPLIANCE MEASURES

Law enforcement activity reports

All strategies to reduce threats to the Sand Mountain dune system are predicated on user compliance with and active enforcement of regulations at Sand Mountain Recreation Area. Determining whether an effective level of law enforcement presence has been implemented should be measured by tracking law enforcement activity reports, coupled with public land user survey results.

Public land user surveys

Law enforcement activity reports and public land user surveys should be used to track user understanding of and compliance with restrictions on the use of vegetated dune habitats, changes in the allowed uses of springs, and other measure implemented in the assessment area. Some specific issues to address are knowledge of and attitudes toward vehicular use restrictions, resource values of plants and animals, degree of safety perceived while recreating at Sand Mountain, resource value of vegetated dunes and springs, problem of vehicles as a weed transport vector, and importance of spark arrestors.

Monitor user compliance with land management guidelines and policies.

Standard protocols for monitoring the percent of public land users who comply with land management guidelines and policies should be used to inform interpretation of the results of vegetation and habitat monitoring programs.

Table 26. Suggested monitoring measures for Blowing Sand Mountains.

X indicates a monitoring measure that will detect the strategy’s effect on the viability of at least one conservation target system.

O indicates a monitoring measure that will detect the degree to which the strategy has been successfully implemented, regardless of effects on conservation targets.

MONITORING MEASURES / **RECOMMENDED STRATEGIES**	Increase BLM law enforcement staff at SMRA	Eliminate vehicular traffic on vegetated dunes	Facilitate BLM management of 86 acre DoD parcel at entrance to SMRA	Continue requiring spark arrestors for all off-highway vehicles on BLM lands	Evaluate current grazing levels	Restrict vehicle access to SMRA via Dixie Valley road	Campground host at SMRA	Establish and enforce guidelines for user capacity at SMRA	Fence spring riparian areas to exclude livestock
Survey for new weed invasions and monitor known populations.		X			X	X			
Monitoring of abundance, distribution and recruitment of sensitive species.		X				X			
Monitor abundance, distribution and recruitment of Kearney buckwheat.		X				X			
Remote sensing to track trends in vegetated dune plant cover	X	X				X			
Remote sensing to track trends in vehicular effects and effect zone of vehicular activities.	X	X				X			
Track fire incident reports.				X					
Remote sensing to track effect zone of high-use-volume days at SMRA.	X	X						X	
Monitor composition of salt desert scrub and greasewood shrubland.					X				
Monitor spring aquatic and riparian habitats.					X				X
Remote sensing to track effect zone of training activities on Bravo-19.									
Law enforcement activity reports.	O	O	O	O		O	O	O	
Public land user surveys.	O	O		O			O	O	
Monitor user compliance with land management guidelines and policies.	O	O	O	O	O	O		O	O

Table 26 continued. Suggested monitoring measures for Blowing Sand Mountains.

X indicates a monitoring measure that will detect the strategy's effect on the viability of at least one conservation target system.

O indicates a monitoring measure that will detect the degree to which the strategy has been successfully implemented, regardless of effects on conservation targets.

MONITORING MEASURE \ RECOMMENDED STRATEGIES	Minimize soil and vegetation disturbance during rights-of-way construction and maintenance	Provide public vehicle cleaning station to reduce weed propagule transport	Annual vehicle closure of SMRA for some period of time tied to needs of biota	Implement DoD vehicle cleaning procedure to reduce weed propagule transport	Maintain or reduce extent of ordnance impact zone(s) on B-19	Return spring brooks to natural stream bed, remove obstructions and modifications	Withdraw remainder of Blowing Sand Mountains area from all forms of mineral entry	Implement and expand volunteer clean-up events, monitoring programs, and educational tours of SMRA and surrounding area
Survey for new weed invasions and monitor known populations.	X	X		X	X			
Monitor abundance, distribution and recruitment of sensitive species.			X					
Monitor abundance, distribution and recruitment of Kearney buckwheat.								
Remote sensing to track trends in vegetated dune plant cover			X		X			
Remote sensing to track trends in vehicular effects and effect zone of vehicular activities.			X				X	
Track fire incident reports.								
Remote sensing to track effect zone of high-use-volume days at SMRA								
Monitor composition of salt desert scrub and greasewood shrubland.	X	X						
Monitor spring aquatic and riparian habitats.						X		
Remote sensing to track effect zone of training activities on Bravo-19.					O			
Law enforcement activity reports.			O					
Public land user surveys.		O	O					O
Monitor user compliance with land management guidelines and policies.	O	O	O					

Conclusions and Next Steps

The Blowing Sand Mountains area contains various Great Basin ecoregion endemic species, and viable examples of salt desert scrub, greasewood shrubland, playa, dune, and spring ecosystems. Several Great Basin endemic species are found only on one or both of the two dune systems. While these two dune systems may share a common historic sand source, it is clear that each contributes uniquely to the biodiversity of the Great Basin ecoregion. Land managers responsible for management of sensitive species and representative Great Basin natural communities will need to consider the effects of both current and future human activities on each of these two heavily used and unique dune systems. The potential for conservation success in the Blowing Sand Mountains area is high due to the currently good viability ranking of the systems in this site, and high degree of public land management. However, due to ongoing threats to the area from invasive plant species and off-highway vehicle use of vegetated areas, continuing and adaptive management actions will be vital to maintaining the viability of this area.

Threats from continued and increasing off-highway vehicle use of vegetated dune habitat not only directly remove species of concern and reduce available habitat for other species of concern, but also compound the likelihood of weed invasions and artificial alteration of dune dynamics. Strategies that reduce the effects of vehicular use of the endemic-rich sand dune systems will directly benefit the overall viability of the Blowing Sand Mountains area, and the many species of concern that use these dune system for habitat. The few spring systems in the Blowing Sand Mountains area have been altered by livestock use, invasive plants and modifications made by recreating humans. Action to protect and restore the upper portions of the spring systems have a high likelihood of success, while still allowing human and livestock access to lower spring reaches.

Cooperation, partnership and involvement of all stakeholders will be vital to balanced and adaptive management of this unique area. If emergency, administrative actions are necessary to mitigate immediate threats to species viability, every effort should be made to educate the public and keep them informed of the results of monitoring these measures. The conservation assessment team recommends that all of the strategies and success measures described in this document be considered in future iterations of Resource Management Plans, Recreation Area Management Plans and Integrated Natural Resource Management Plans for the Blowing Sand Mountains area. A commitment to monitor the success of implemented conservation strategies will allow for adaptive management of the resources. This would afford all land managing agencies/governments the best opportunity for conservation success in the Blowing Sand Mountains.

This analysis of the Blowing Sand Mountains area's viability, threats and conservation strategies should be updated periodically to assess the effectiveness of management practices and to detect new or changing threats to the system. The conservation assessment team suggests a three year cycle of review by a multi-disciplinary team of experts,, given the potential for increased threats to the Sand Mountain sand dune system.

The potential exists in the Blowing Sand Mountains area for a balance to be reached among a multitude of uses and conservation of unique biological resources. Cooperative and adaptive management of the area will assure the long-term viability of the natural systems and native species as well as the sustainability of a wide variety of traditional and contemporary human uses.

Literature Cited

Anderson, Mark G. 1999. Viability and spatial assessment of ecological communities in the Northern Appalachian Ecoregion. PhD. Dissertation, University of New Hampshire. 224 pp.

Baron, Jill S., N. LeRoy Poff, Paul L. Angermeier, Clifford N. Dahm, Peter H. Gleick, Nelson G. Hairston Jr., Robert B. Jackson, Carol A. Johnston, Brian D. Richter and Alan D Steinman. 2002. Meeting ecological and societal needs for freshwater. Ecological Applications 12(5):1247-1260.

Barrows, Cameron 1996. An ecological model for the protection of a dune ecosystem. Conservation Biology 10(3):888-891.

Bechtel, R. C., L. M. Hanks and R. W. Rust. 1983. Coleoptera of Sand Mountain and Blow Sand Mountains, Nevada. The Southwestern Naturalist 28(4):473-478.

Belnap, J. and D. A. Gillette. 1997. Disturbance of biological soil crusts: impacts on potential wind erodibility of sandy desert soils in southeastern Utah. Land Degradation and Development 8:355-362.

Belnap, Jayne. 2002. Impacts of off-road vehicles on nitrogen cycles in biological soil crusts: resistance in different U.S. deserts. Journal of Arid Environments 52:155-165.

Billings, W. D. 1945. The plant associations of the Carson Desert Region, western Nevada. Butler University Botany Studies. 7:89-123.

Bureau of Land Management [BLM] 1985 Sand Mountain Recreation Area Management Plan, Revision. Carson City Field Office.

[BLM] 2001 Carson City Field Office Consolidated Resource Management Plan. Carson City Field Office.

Bowers, Janice E. 1982. The plant ecology of inland dunes in western North America. Journal of Arid Environments 5:199-220.

Brown, Jennifer F. 1997. Effects of experimental burial on survival, growth and resource allocation of three species of dune plants. Journal of Ecology 85(2):151-158.

Defenders of Wildlife. 2002. Out of Control: The Impacts of Off-Road Vehicles and Roads on Wildlife and Habitat in Florida's National Forests. Defenders of Wildlife. Washington DC. 121+ pp.

Eissmann, Linda J. 1990. Eolian sand transport in western Nevada: Applications of Landsat TM Imagery. MS Thesis. University of Nevada, Reno. 107pp + plates

Epps, Tammy M., Hugh B. Britten and Richard W. Rust. 2000. Allozyme variability, isolation and dispersal of *Eusattus muricatus* (Coleoptera: Tenebrionidae) within Silver State Dune complex, Great Basin, western North America. Western North American Naturalist 60(3):281-290

Evans, Arthur V. and Kirk A. Smith. 1986. Four new species of *Coenonycha* Horn from California and Nevada with an illustrated key to all species in the genus (Coleoptera: Scarabaeidae). The Coleopterists Bulletin 40(1):81-92.

Franklin, Jerry F. 1999. Preserving biodiversity: species, ecosystems, or landscapes? Ecological Applications 3(2):202-205.

Gul, Bilquees and Darrell J. Weber. 2001. Seed bank dynamics in a Great Basin salt playa. Journal of Arid Environments 49:785-794.

Halpern, C. B. 1988. Early successional pathways and the resistance and resilience of forest communities. Ecology 69(6):1703-1715.

Hanks, Lawrence Michael. 1982. The Pollinator Community of a Sand Dune Ecosystem. M. S. Thesis. University of Nevada Reno. 69 pp.

Hardy, Alan R. and Fred G. Andrews. 1987. Studies in the Coleoptera of western sand dunes. 3. Remarks upon *Serica* (Scarabaeidae) from some Nevada sand dunes with descriptions of two new taxa. The Coleopterists Bulletin 41(2):173-179.

Holling, C. S. 1973. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics 4:1-23.

Karr, J. R. 1991. Biotic integrity and water resources. Ecological Applications 1(1):66-84.

Kintsch, Julia A. and Dean L. Urban. 2002. Focal species, community representation and physical proxies as conservation strategies: a case study in the Amphibolite Mountains, North Carolina, U.S.A. Conservation Biology 16(4):936-947.

Lancaster, Nicholas and Andy Baas. 1998. Influence of vegetation cover on sand transport by wind: field studies at Owens Lake, California. Earth Surface Processes and Landforms 23:69-82.

Luckenbach, Roger A. and R. Bruce Bury. 1983. Effects of Off-Road Vehicles on the Biota of the Algodones Dunes, Imperial County, California. Journal of Applied Ecology. 20(1):265-286.

Matchett, J. R..,M. L. Brooks and K. H. Berry. 2003. Plant community structure associated with livestock watering sites in the Central Mojave Desert. 28th Annual Meeting and Symposium of the Desert Tortoise Council, February 21-23.

Morrison, R. B. 1991. Quaternary stratigraphic, hydrologic and climatic history of the Great Basin, with an emphasis on Lakes Lahontan, Bonneville, and Tecopa. Pages 283-371 *in* Morrison, R. B. ed., Quaternary nonglacial geology; Conterminous U.S.: Boulder, Colorado, Geological Society of America, The Geology of North America, v. K-2.

Nachlinger, J., K. Sochi, P. Comer, G. Kittel and D. Dorfman. 2001. Great Basin: an ecoregion-based conservation blueprint. The Nature Conservancy, Nevada. 160pp + appendices.

NatureServe Explorer: An online encyclopedia of life [web application]. 2001. Version 1.6. Arlington, Virginia, USA: NatureServe. Available: http://www.natureserve.org/explorer. (Accessed: January 25, 2004).

Pianka Eric R. 1967. On lizard species diversity: North American flatlands deserts. Ecology 48:333-351.

Pimm, S. L. 1984. The complexity and stability of ecosystems. Nature 307:321-326.

Poiani, Karen A., Brian D. Richter, Mark G. Anderson and Holly E Richter. 2000. Biodiversity conservation at multiple scales: Functional sites, landscapes, and networks. Bioscience 50(2):133-148.

Porter, Jennifer L. and Richard W. Rust. 1997 Phylogenetic relationships of North American Aegialia (Coleoptera: Scarabaeidae) as indicated by allozymes and morphology. Annals of the Entomological Society of America 90(3):302-315

Rahn, Matthew E. and Rust, Richard W. 2000. Nested Coleoptera and Orthoptera on sand dunes in the Basin and Range Province of western North America. Journal of Insect Conservation 4(1):33-43.

Romey, E. M., A. Wallace and R. B. Hunter. 1978. Plant response to nitrogen fertilization in the northern Mohave Desert and its relationship to water manipulation. *In* Neil E. West and John J. Skujins, eds. Nitrogen in Desert Ecosystems. Dowden, Hutchinson & Ross, Inc. Stroudsburg, PA United States/International Biological Program Synthesis Series 9.

Rosen, Philip C. and Charles H. Lowe. 1994. Highway mortality of snakes in the Sonoran Desert of southern Arizona. Biological Conservation 68:143-148.

Rosen, M. R. 1994. The importance of groundwater in playas: A review of playa classifications and the sedimentology and hydrology of playas. Pages 1 – 17 *in* M. R. Rosen, ed. Paleoclimate and Basin Evolution of Playa Systems. Boulder, Colorado, Geological Society of America Special Paper 289.

Rust, R. W. 1981. Unpublished report to Bureau of Land Management, Carson City District, Nevada: Sand Mountain and Blow Sand Mountains Arthropod Survey, Final Report. January 30, 1981.

Rust, R. W. and L. M. Hanks. 1982. Notes on the biology of *Aegialia hardyi* Gordon and Cartwright (Coleoptera: Scarabaeidae). Pan-Pacific Entomologist 58(4):319-325.

Rust, R. W., L. M. Hanks and R. C. Bechtel. 1983. Aculeata Hymenoptera of Sand Mountain and Blow Sand Mountains, Nevada. Great Basin Naturalist 43(3):403-408.

Rust, R. W. 1986. Seasonal distribution, trophic structure and origin of sand obligate insect communities in the Great Basin. Pan-Pacific Entomologist 62(1):44-52.

Snyder, Charles T. 1984. Sand Mountain. Pages 137-139 *in* Western Geological Excursions, Geological Society of America, Boulder, Colorado.

The Nature Conservancy 2000. The five-S framework for site conservation. A practioner's handbook for site conservation planning and measuring conservation success. Second edition. The Nature Conservancy, Arlington, VA. volumes 1 and 2.

Trexler, Dennis T. and Wilton N. Melhorn. 1986. Singing and Booming Sand Dunes of California and Nevada. California Geology 39(7):147-152.

U.S. Department of Defense. 1999. Technotes: Conserving Natural and Cultural Resources on Department of Defense Lands: Case Studies from the DoD Conservation Program. U.S. Department of Defense, Legacy Resource Management Program, Washington, D.C. 192 pp.

U.S. Department of Defense. 2000. Defense Environmental Quality Report to Congress. U.S. Department of Defense, Washington, D.C. 67 pp.

U.S. Department of the Interior. 2001. Riparian area management: A guide to managing, restoring, and conserving springs in the Western United States. Technical Reference 1737-17. Bureau of Land Management, Denver, Colorado. BLM/ST/ST-01/001+1737. 70 pp.

U.S. Department of the Navy. 2001. Integrated Natural Resources Management Plan / Resource Management Plan Amendment and Environmental Assessment, Naval Air Station Fallon, Nevada. Department of the Navy, Fallon, Nevada. Prepared by Tetra Tech, Inc. October 2001.

U.S. Department of the Navy. 2000. Final Environmental Impact Statement for the Proposed Fallon Range Training Complex Requirements Naval Air Station Fallon, Nevada. Prepared by Department of the Navy and Bureau of Land Management Carson City and Battle Mountain Field Offices. January 2000.

U.S. Department of the Navy. 1994. OPNAVINST 5090.1B N45. U.S. Department of the Navy, Office of the Chief of Naval Operations, Washington, D.C. November 1, 1994.

Ungar, Irwin A., 1974. Inland halophytes of the United States. *In* Robert J. Reimold and William Queen, eds. Ecology of Halophytes. Academic Press, New York, New York. 605 pp.

West, N. E. and J. A. Young. 2000. Intermountain valleys and lower mountain slopes. Pages 255-284 *in* M. G. Barbour and W. D. Billings, eds. North American terrestrial vegetation, 2nd edition. Cambridge University Press, Cambridge, UK.

Young, J. A., R. A. Evans, B. A. Roundy, and J. A. Brown. 1986. Dynamic landforms and plant communities in a pluvial lake basin. Great Basin Naturalist 46(1):1-21.

Experts Consulted

Andrus, Rebekah. May 14, 2003. Personal communication to Sue Wainscott regarding sand dunes, psammophytic bees and use of sand dunes by surrounding wildlife during drought years. Technician, U.S. Department of Agriculture/Agricultural Research Service Bee Biology and Systematics Lab, Logan, Utah.

Austin, George. August 17, 2003. Personal communication to Sue Wainscott regarding survey efforts for Kearney buckwheat and Sand Mountain blue butterfly. Biologist, Nevada State Museum.

Barrows, Cameron. March 4, 2002. Personal communication to Sue Wainscott regarding effect of off-highway vehicle recreation on sand dunes in the Mojave Desert and invasive species which stabilize sand dunes in the Coachella Valley dune system. Southern California Regional Director, Center for Natural Lands Management, Thousand Palms, California.

Cottle, Gary. December 3, 2003. Personal communication to Sue Wainscott regarding lack of Kearney buckwheat sightings on the Blowsand Mountains dune system by Gary Cottle. Wildlife Biologist, Naval Air Station Fallon, Nevada.

Cottle, Gary. May 6, 2002. Forwarded email from Michael Small, Contract Biologist, Southwestern Texas University, to Gary Cottle, regarding kit fox habitats in Blowing Sand Mountains area. Wildlife Biologist, Naval Air Station Fallon, Nevada.

Creger, Cliff. December 3, 2003. Personal communication to Sue Wainscott regarding lack of Kearney buckwheat sightings on the Blowsand Mountains dune system by Cliff Creger. Archaeologist, Naval Air Station Fallon, Nevada.

Funari, Claudia. August 17, 2003. Personal communication to Sue Wainscott regarding survey efforts for Kearney buckwheat and Sand Mountain blue butterfly. Wildlife Biologist, Bureau of Land Management, Carson City, Nevada.

Funari, Claudia. January 31, 2003. Personal communication to Sue Wainscott regarding wildlife at Sand Mountain Recreation Area. Wildlife Biologist, Bureau of Land Management, Carson City, Nevada.

Kelleher, Karen. September 26, 2002. Personal communication to Sue Wainscott regarding the effectiveness of interpretive signage in increasing recreational user compliance with land management policies and guidelines. Recreation Specialist, AZ BLM.

Lancaster, Nicholas. April 2, 2002. Personal communication to Sue Wainscott regarding sand dune dynamics and the Blowing Sand Mountains corridor in particular. Research Professor, Desert Research Institute, Reno, Nevada.

Miller, Christine. April 1, 2002. Personal communication to Sue Wainscott regarding visitor use and facilities at Sand Mountain Recreation Area. Recreation Specialist, Bureau of Land Management, Carson City, Nevada.

Murphy, Dennis. August 17, 2003. Personal communication to Sue Wainscott regarding survey efforts for Kearney buckwheat. Professor, University of Nevada Reno.

Nachlinger, Jan. August 17, 2003. Personal communication to Sue Wainscott regarding survey efforts for Kearney buckwheat. Director of Conservation Planning, The Nature Conservancy, Reno, Nevada.

Powell, Libby. November 5, 2001. Personal communication to Sue Wainscott regarding invasive plant species which stabilize sand dunes in Lake Mead National Recreation Area. Botanist, National Park Service, Lake Mead National Recreation Area, Boulder City, Nevada.

Rust, Richard. January 22, 2004. Personal communication to Sue Wainscott regarding location of Kearney buckwheat found on Blowsand Mountains dune system in 1979-1981. Professor, University of Nevada, Reno.

Rust, Richard. March 17, 2003. Personal communication to Sue Wainscott regarding presence of Kearney buckwheat on Blowsand Mountains dune system. Professor, University of Nevada, Reno.

Rust, Richard. July 2, 2002. Personal communication to Sue Wainscott regarding sand dunes and psammophytic invertebrates. Professor, University of Nevada, Reno.

Tonenna, Dean. February 2, 2004. Personal communication to Sue Wainscott regarding survey efforts for Kearney buckwheat on Blowsand Mountains dune system. Botanist, Bureau of Land Management, Carson City, Nevada.

Tonenna, Dean. January 7, 2004. Personal communication to Sue Wainscott regarding invasive plant species seen on Blowsand Mountain dune system and Sand Mountain dune system. Botanist, Bureau of Land Management, Carson City, Nevada.

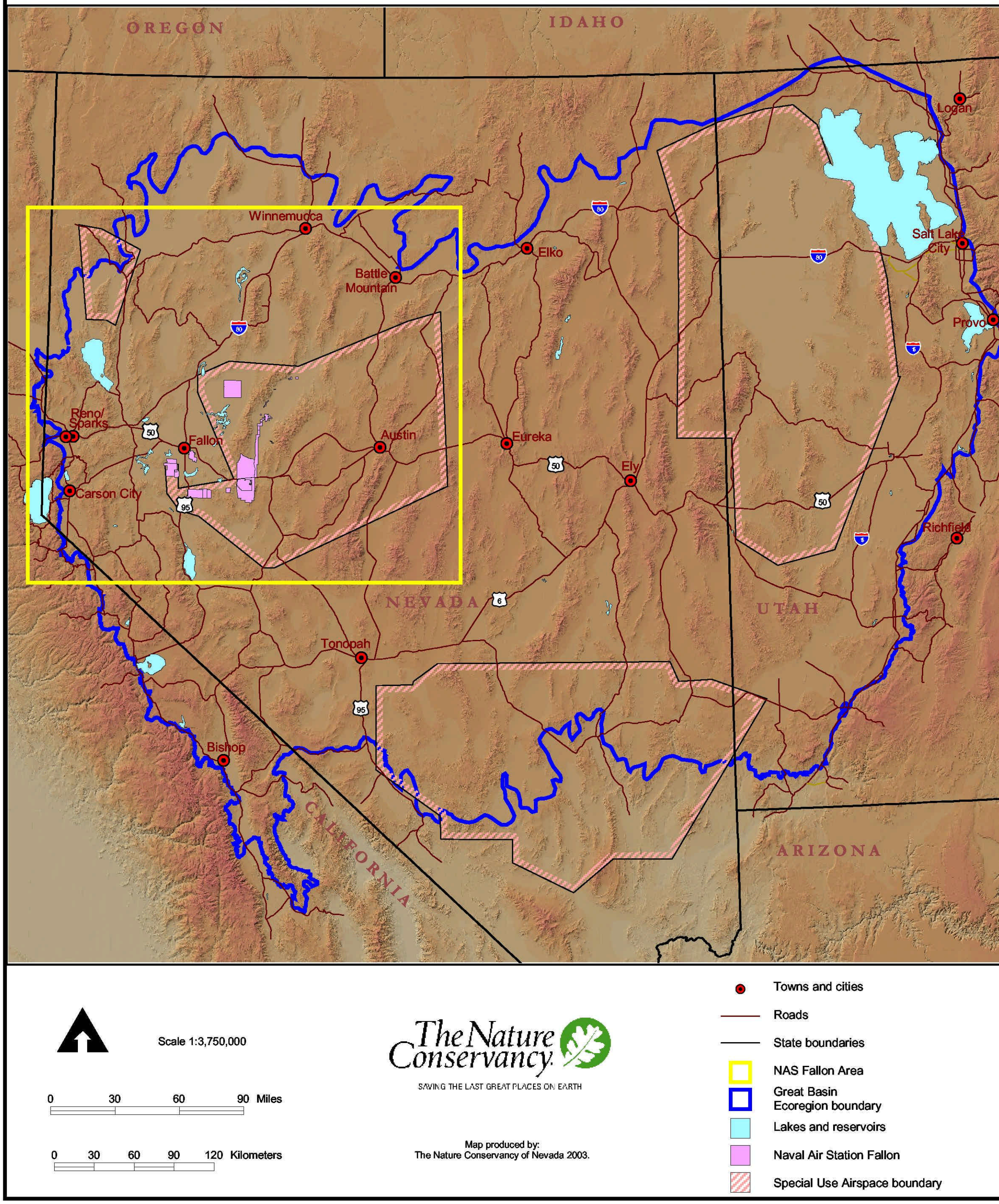
Tonenna, Dean. August 17, 2003. Personal communication to Sue Wainscott regarding survey efforts for Kearney buckwheat and Sand Mountain blue butterfly. Botanist, Bureau of Land Management, Carson City, Nevada.

Tonenna, Dean. February 4, 2003. Personal communication to Sue Wainscott regarding vegetation and wildlife at Sand Mountain Recreation Area. Botanist, Bureau of Land Management, Carson City, Nevada.

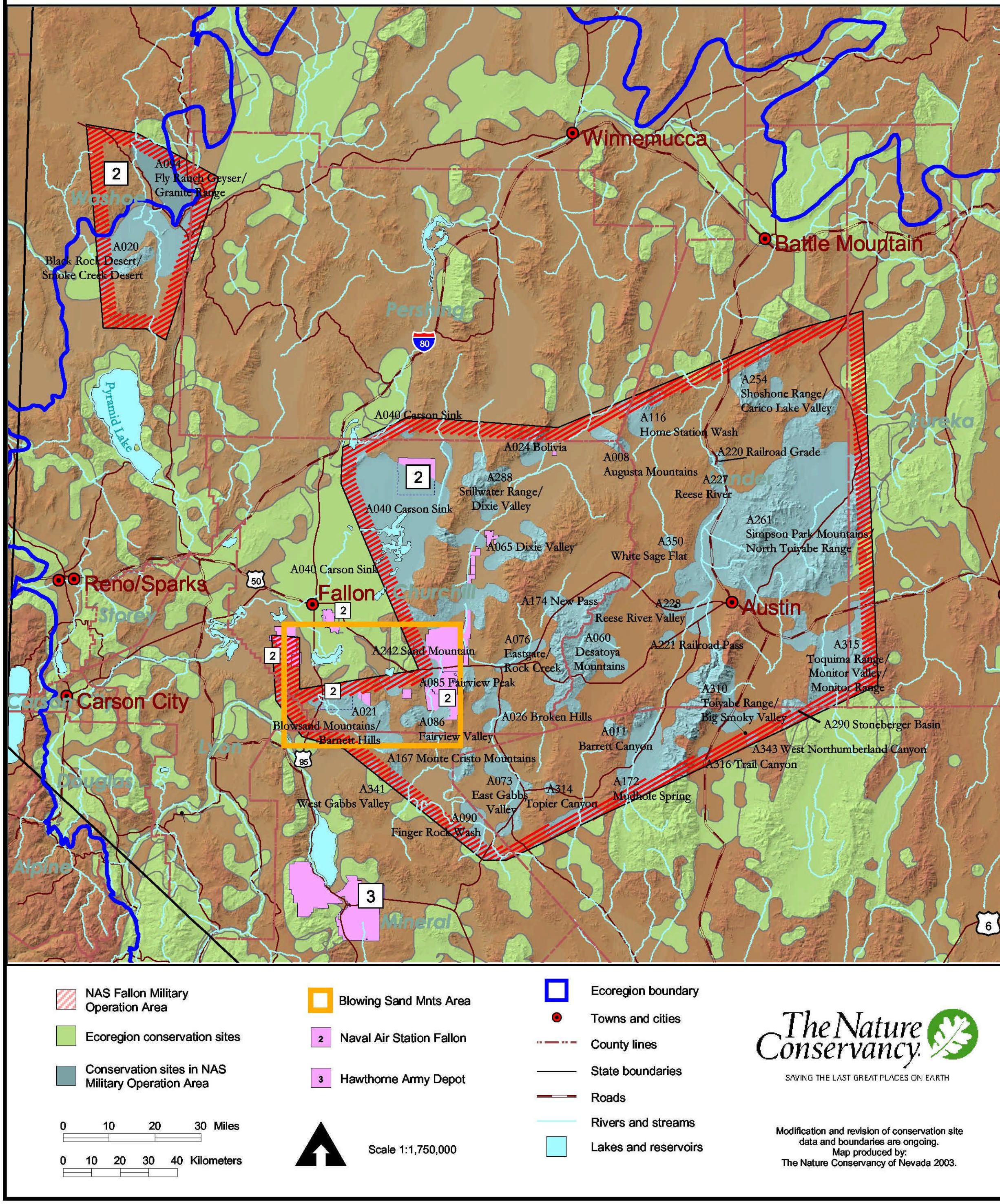
Williams, Tad. July 2, 2002. Personal communication to Sue Wainscott regarding current and past grazing allotment usage on Walker River Paiute Tribal Allotments. Environmental Director, Walker River Paiute Tribe, Schurz, Nevada

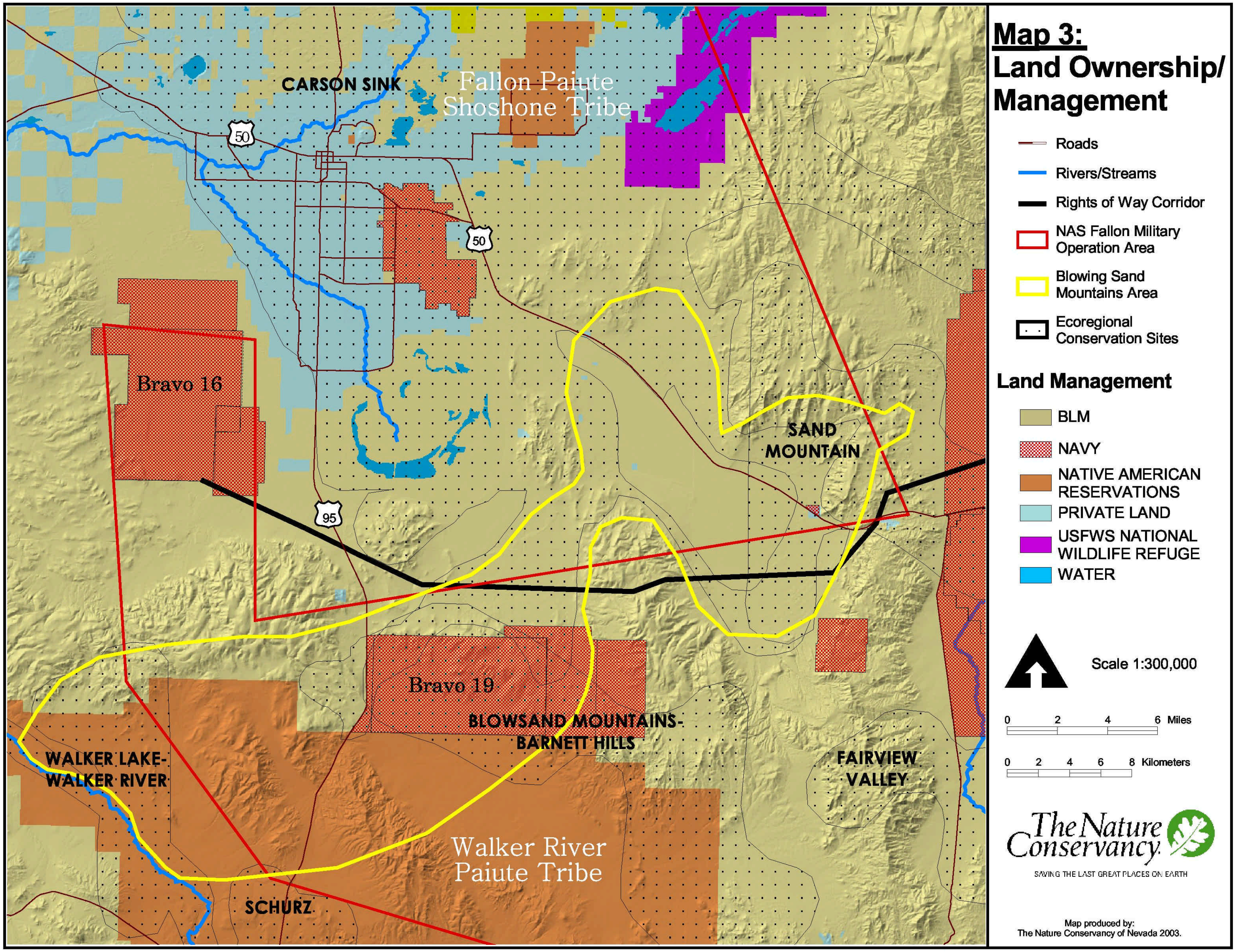
Appendix A. Maps

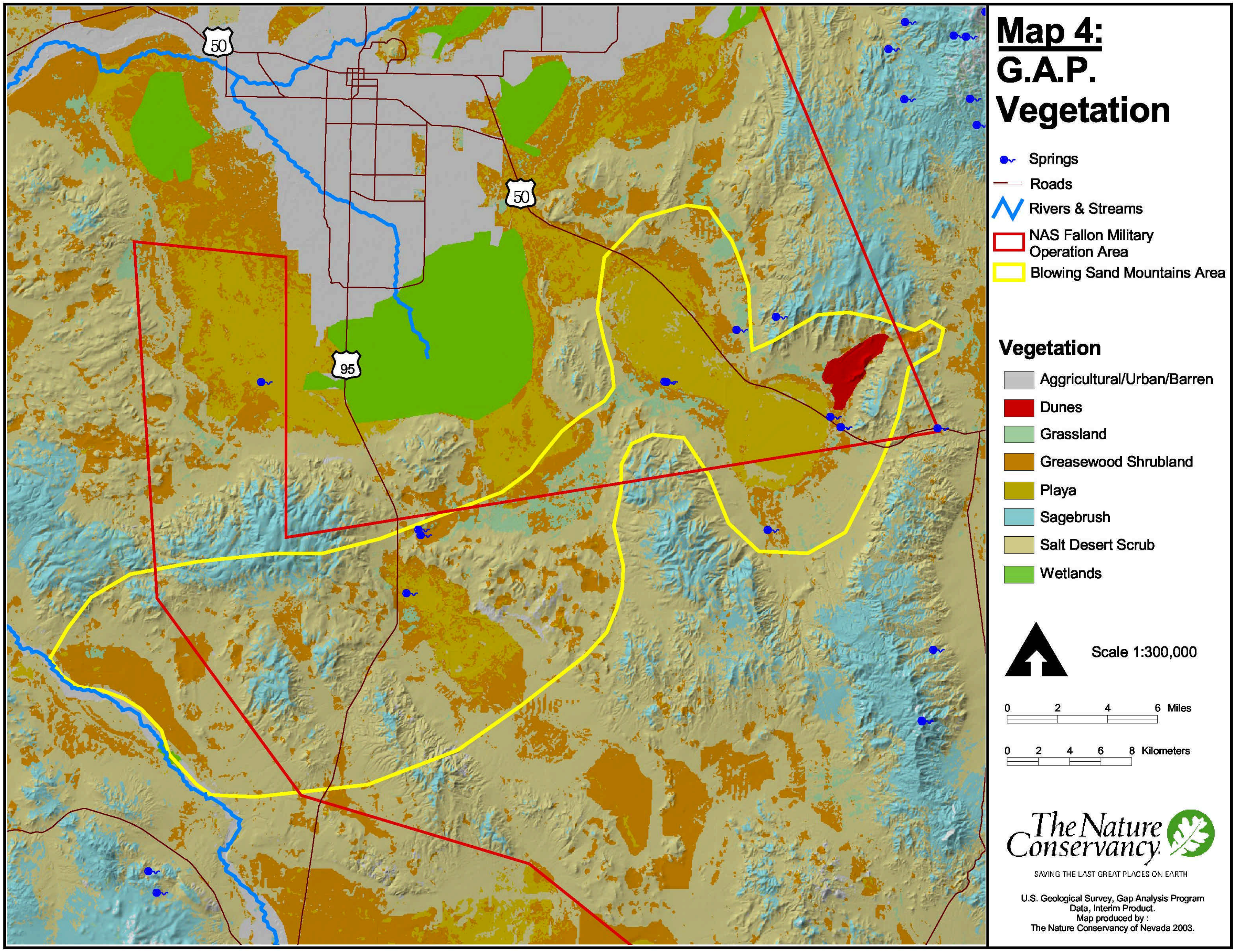
Map 1: Locator Map of Naval Air Station Fallon



Map 2: Locator Map of Blowing Sand Mountains




Map 3:
Land Ownership/ Management
Roads
Rivers/Streams
Rights of Way Corridor
NAS Fallon Military Operation Area
Blowing Sand Mountains Area
Ecoregional Conservation Sites
Land Management
BLM
NAVY
NATIVE AMERICAN RESERVATIONS
PRIVATE LAND
USFWS NATIONAL WILDLIFE REFUGE
WATER
Scale 1:300,000
0 2 4 6 Miles
0 2 4 6 8 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH
Map produced by:
The Nature Conservancy of Nevada 2003.
CARSON SINK
Fallon Paiute Shoshone Tribe
50
50
95
Bravo 16
SAND MOUNTAIN
Bravo 19
BLOWSAND MOUNTAINS-BARNETT HILLS
WALKER LAKE-WALKER RIVER
FAIRVIEW VALLEY
Walker River Paiute Tribe
SCHURZ


Map 4:
G.A.P.
Vegetation
Springs
Roads
Rivers & Streams
NAS Fallon Military Operation Area
Blowing Sand Mountains Area
Vegetation
Agricultural/Urban/Barren
Dunes
Grassland
Greasewood Shrubland
Playa
Sagebrush
Salt Desert Scrub
Wetlands
Scale 1:300,000
0 2 4 6 Miles
0 2 4 6 8 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH
U.S. Geological Survey, Gap Analysis Program
Data, Interim Product.
Map produced by :
The Nature Conservancy of Nevada 2003.
50
50
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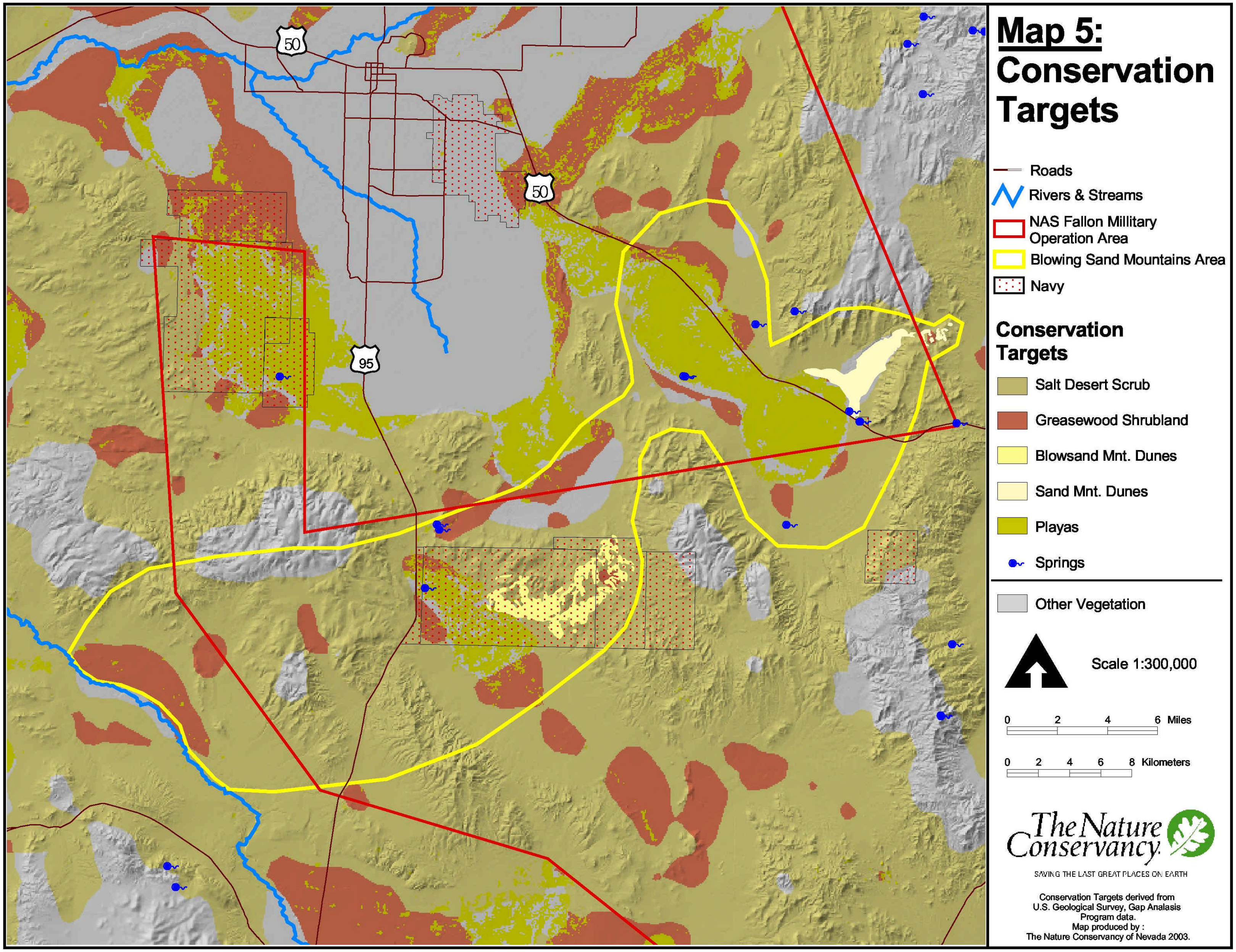
Map 5:
Conservation Targets
Roads
Rivers & Streams
NAS Fallon Millitary Operation Area
Blowing Sand Mountains Area
Navy
Conservation Targets
Salt Desert Scrub
Greasewood Shrubland
Blowsand Mnt. Dunes
Sand Mnt. Dunes
Playas
Springs
Other Vegetation
Scale 1:300,000
0 2 4 6 Miles
0 2 4 6 8 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH
Conservation Targets derived from U.S. Geological Survey, Gap Analasis Program data.
Map produced by :
The Nature Conservancy of Nevada 2003.
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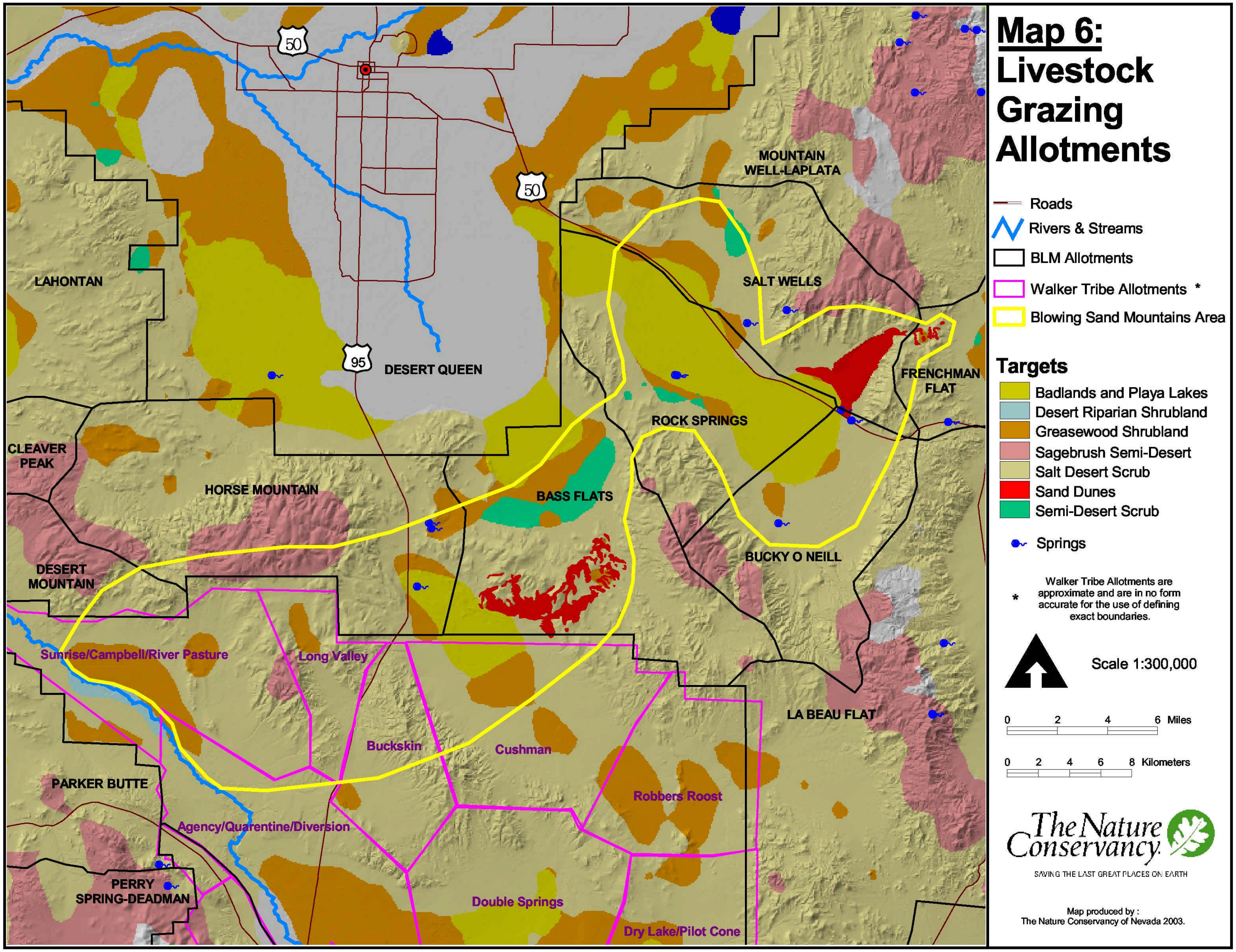
Map 6:
Livestock
Grazing
Allotments
Roads
Rivers & Streams
BLM Allotments
Walker Tribe Allotments *
Blowing Sand Mountains Area
Targets
Badlands and Playa Lakes
Desert Riparian Shrubland
Greasewood Shrubland
Sagebrush Semi-Desert
Salt Desert Scrub
Sand Dunes
Semi-Desert Scrub
Springs
* Walker Tribe Allotments are approximate and are in no form accurate for the use of defining exact boundaries.
Scale 1:300,000
0 2 4 6 Miles
0 2 4 6 8 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH
Map produced by :
The Nature Conservancy of Nevada 2003.
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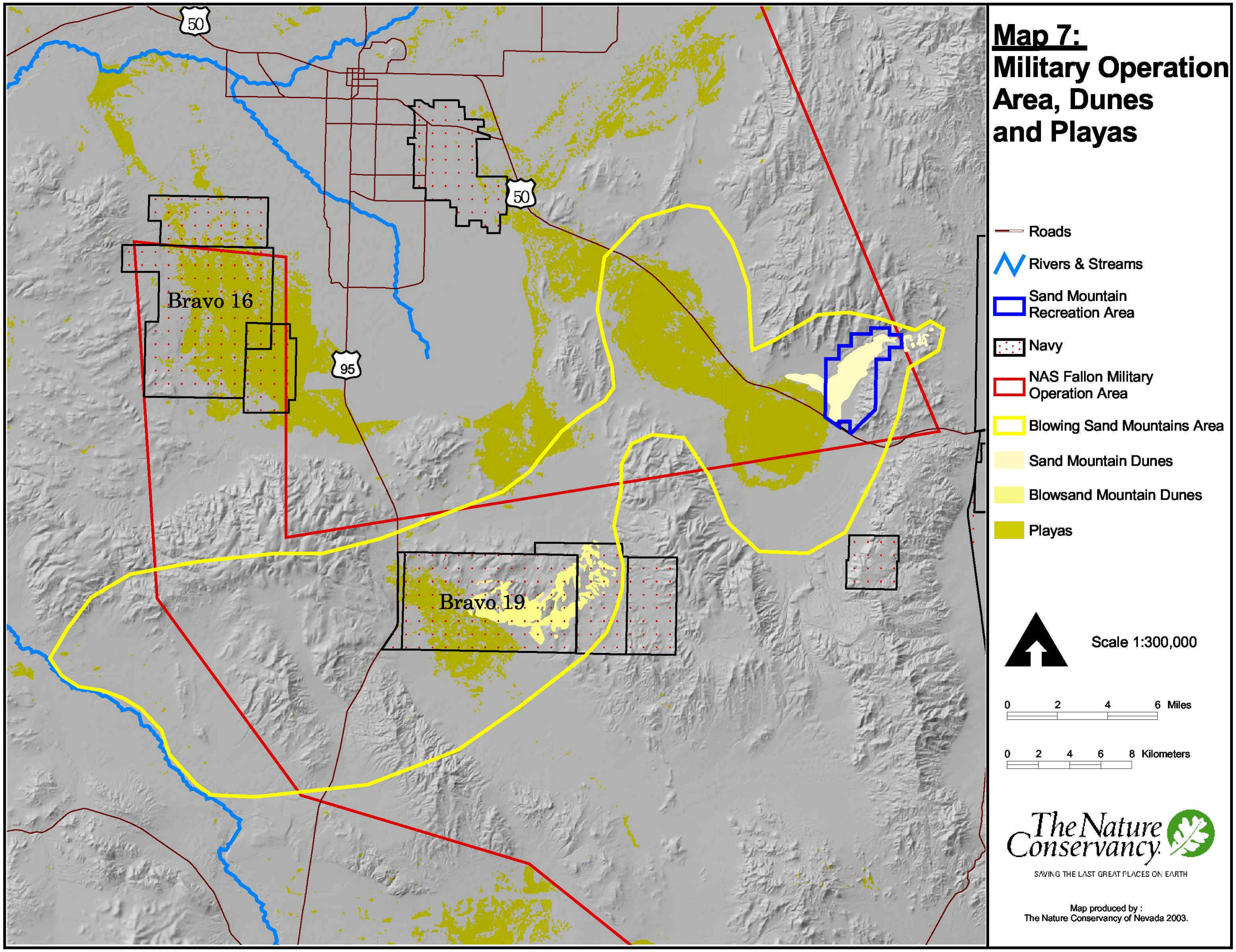
MOUNTAIN
WELL-LAPLATA
LAHONTAN
SALT WELLS
DESERT QUEEN
FRENCHMAN
FLAT
ROCK SPRINGS
CLEAVER
PEAK
HORSE MOUNTAIN
BASS FLATS
BUCKY O NEILL
DESERT
MOUNTAIN
Sunrise/Campbell/River Pasture
Long Valley
LA BEAU FLAT
Buckskin
Cushman
PARKER BUTTE
Robbers Roost
Agency/Quarentine/Diversion
PERRY
SPRING-DEADMAN
Double Springs
Dry Lake/Pilot Cone


Map 7:
Military Operation Area, Dunes and Playas
Roads
Rivers & Streams
Sand Mountain Recreation Area
Navy
NAS Fallon Military Operation Area
Blowing Sand Mountains Area
Sand Mountain Dunes
Blowsand Mountain Dunes
Playas
Scale 1:300,000
0 2 4 6 Miles
0 2 4 6 8 Kilometers
The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH
Map produced by :
The Nature Conservancy of Nevada 2003.
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Bravo 16
Bravo 19

Appendix B. Five-S Framework entries

Table B-1. Stress analysis for salt desert scrub.

Stresses	Severity	Scope	Stress
Alteration of natural fire regimes	Very High	Low	Low
Altered composition/structure	High	Medium	Medium
Habitat fragmentation	Medium	Medium	Medium
Soil compaction	High	Low	Low

Table B-2. Source of stress analysis for salt desert scrub.

Sources of Stress		Alteration of natural		Altered		Habitat fragmentation		Soil compaction		-		Threat to System
		Low		*Medium*		*Medium*		*Low*		-		
Current grazing practices	Contribution		-	High	Low		-		-		-	Low
	Irreversibility			Medium								
	Override											
	Source	-		Medium		-		-		-		
Invasive species	Contribution	Very High	Low	High	Medium		-		-		-	Medium
	Irreversibility	Very High		Very High								
	Override											
	Source	Very High		High		-		-		-		
Misuse of vehicles	Contribution		-	Medium	Low	Medium	Low		-		-	Low
	Irreversibility			Medium		Medium						
	Override											
	Source	-		Medium		Medium		-		-		
Responsible use of paved roads	Contribution	Medium	Low		-	Very High	Medium		-		-	Medium
	Irreversibility	Very High				Very High						
	Override											
	Source	High		-		Very High		-		-		
Mining practices	Contribution		-	Medium	Medium		-		-		-	Medium
	Irreversibility			Very High								
	Override											
	Source	-		High		-		-		-		
Past grazing practices	Contribution		-		-		-	Very High	Low		-	Low
	Irreversibility							Medium				
	Override											
	Source	-		-		-		High		-		
Rights of way management	Contribution		-	Low	Low		-	Low	-		-	Low
	Irreversibility			Low				Low				
	Override											
	Source	-		Low		-		Low		-		

Table B-3. Stress analysis for greasewood shrubland.

Stresses	Severity	Scope	Stress
Altered composition/structure	High	Medium	Medium
Alteration of dune dynamics	Medium	Medium	Medium
Alteration of natural fire regimes	Very High	Low	Low
Habitat destruction or conversion	Very High	Low	Low
Soil compaction	High	Low	Low
Direct mortalilty	High	Low	Low
Habitat fragmentation	Medium	Medium	Medium

Table B-4. Source of stress analysis for greasewood shrubland.

Sources of Stress		Altered		Alteration of dune		Alteration of natural		Habitat destruction or		Soil compaction		Direct mortalilty		Habitat fragmentation	
		Medium		Medium		Low		Low		Low		Low		Medium	
Current grazing practices	Contribution	High	Low	High	Low		-		-	Medium	Low		-		-
	Irreversibility	Low		Low						Medium					
	Override														
	Source	Medium		Medium		-		-		Medium		-		-	
Invasive species	Contribution	High	Medium		-	Very High	Low	Very High	Low		-		-		-
	Irreversibility	High				Very High		Very High							
	Override														
	Source	High		-		Very High		Very High		-		-		-	
Misuse of vehicles	Contribution	Medium	Low	Medium	Low	Medium	Low		-	High	Low	Medium	Low	Medium	Low
	Irreversibility	Medium		Medium		Medium				Medium		Medium		Medium	
	Override														
	Source	Medium		Medium		Medium		-		Medium		Medium		Medium	
Responsible use of paved roads	Contribution		-		-	Medium	Low		-		-	Very High	Low	Very High	Medium
	Irreversibility					Very High						Very High		Very High	
	Override														
	Source	-		-		High		-		-		Very High		Very High	
Past grazing practices	Contribution	High	Low		-		-		-	Medium	Low		-		-
	Irreversibility	Low								Medium					
	Override														
	Source	Medium		-		-		-		Medium		-		-	
Rights of way management	Contribution	Low	Low		-	Low	-	Low	-	Low	-	Low	-		-
	Irreversibility	Low				Low		Low		Low		Low			
	Override														
	Source	Low		-		Low		Low		Low		Low		-	

Table B-5. Stress analysis for Blowsand Mountains dune system.

Stresses	Severity	Scope	Stress
Alteration of dune dynamics	Very High	Medium	Medium
Altered composition/structure	Medium	Medium	Medium
Direct mortalilty	High	Low	Low
Toxins/contaminants	Low	Low	Low

Table B-6. Source of stress analysis for Blowsand Mountains dune system.

Sources of Stress		Alteration of dune *Medium*		Altered *Medium*		Direct mortalilty *Low*		Toxins/contaminants *Low*		- -		- -		Threat to System
Ordnance drops	Contribution	High	Medium		-	Very High	Low	Very High	Low		-		-	Medium
	Irreversibility	Very High				Very High		Very High						
	Override													
	Source	High		-		Very High		Very High		-		-		
Ordnance removal-invasive transport	Contribution	High	Medium	Very High	Medium		-		-		-		-	Medium
	Irreversibility	Very High		Very High										
	Override													
	Source	High		Very High		-		-		-		-		
Ordnance removal-UXO detonation	Contribution	Medium	Medium	Low	Low	Low	Low	Medium	Low		-		-	Medium
	Irreversibility	Very High		Very High		Very High		Very High						
	Override													
	Source	High		Medium		Medium		High		-		-		

Table B-7. Stress analysis for Sand Mountain dune system.

Stresses	Severity	Scope	Stress
Habitat disturbance	Medium	Medium	Medium
Direct mortality	High	High	High
Toxins/contaminants	Low	Medium	Low
Altered composition/structure	Medium	High	Medium
Habitat fragmentation	Medium	Low	Low
Alteration of dune dynamics	Very High	Medium	Medium

Table B-8. Sources of stress analysis for Sand Mountain dune system.

Sources of Stress		Habitat disturbance		Direct mortalilty		Toxins/contaminants		Altered		Habitat fragmentation		Alteration of dune		Threat to System
		Medium		*High*		*Low*		*Medium*		*Low*		*Medium*		
Responsible use of existing roads	Contribution	Very High	Medium	High	High	High	Low	Medium	Low		-		-	High
	Irreversibility	Medium		High		High		High						
	Override													
	Source	High		High		High		Medium		-		-		
Misuse of vehicles	Contribution	Very High	Medium	Very High	High	High	Low	Very High	Medium	Very High	Low	Very High	Medium	High
	Irreversibility	Medium		High		High		High		High		High		
	Override													
	Source	High		Very High		High		Very High		Very High		Very High		
Invasive species	Contribution		-		-		-	High	Medium		-	High	Medium	Medium
	Irreversibility							High				High		
	Override													
	Source	-		-		-		High		-		High		
Current grazing practices	Contribution		-		-		-	Low	Low		-		-	Low
	Irreversibility							Medium						
	Override													
	Source	-		-		-		Low		-		-		
Mining practices	Contribution		-		-		-		-		-	Low	Low	Low
	Irreversibility											High		
	Override													
	Source	-		-		-		-		-		Medium		
Responsible use of paved roads	Contribution		-		-		-		-	Medium	Low		-	Low
	Irreversibility									Very High				
	Override													
	Source	-		-		-		-		High		-		

Table B-9. Stress analysis for playas.

Stresses	Severity	Scope	Stress
Groundwater depletion	High	Low	Low
Soil compaction	Medium	Medium	Medium
Salinity alteration	Medium	Medium	Medium
Modification of natural flow patterns	High	Medium	Medium
Alteration of dune dynamics	Medium	Low	Low

Table B-10. Source of stress analysis for playas.

Sources of Stress		Groundwater		Soil compaction		Salinity alteration		Modification of natural		Alteration of dune		Threat to System
		Low		*Medium*		*Medium*		*Medium*		*Low*		
Mining practices	Contribution	Low	Low		-	Medium	Medium	Medium	Medium		-	Medium
	Irreversibility	High				Very High		Very High				
	Override											
	Source	Medium		-		High		High		-		
Misuse of vehicles	Contribution		-	Very High	Medium		-		-	Medium	-	Medium
	Irreversibility			High						Low		
	Override											
	Source	-		Very High		-		-		Low		
Excessive groundwater withdrawal	Contribution	Very High	Low		-	Very High	Medium	Very High	Medium		-	Medium
	Irreversibility	High				Very High		High				
	Override											
	Source	Very High		-		Very High		Very High		-		
Invasive species	Contribution		-		-		-		-	Medium	Low	Low
	Irreversibility									Very High		
	Override											
	Source	-		-		-		-		High		
Rights of way management	Contribution		-	Low	Low		-		-		-	Low
	Irreversibility			Low								
	Override											
	Source	-		Low		-		-		-		

Table B-11. Stress analysis for springs.

Stresses	Severity	Scope	Stress
Altered composition/structure	Medium	Very High	Medium
Groundwater depletion	High	Low	Low
Salinity alteration	Medium	Low	Low
Nutrient loading	High	Medium	Medium
Modification of natural flow pattern	High	Medium	Medium

Table B-12. Source of stress analysis for springs.

Sources of Stress		Altered *Medium*		Groundwater *Low*		Salinity alteration *Low*		Nutrient loading *Medium*		Modification of natural *Medium*		Threat to System
Current grazing practices	Contribution	Very High	Medium		-		-	Very High	Medium		-	Medium
	Irreversibility	Medium						Medium				
	Override											
	Source	High		-		-		High		-		
Construction of ditches, dikes, drainage or diversion systems	Contribution	Medium	Low		-		-		-	Very High	Medium	Medium
	Irreversibility	Low								Low		
	Override											
	Source	Low		-		-		-		High		
Excessive groundwater withdrawal	Contribution		-	Very High	Low	Very High	Low		-		-	Low
	Irreversibility			High		High						
	Override											
	Source	-		Very High		Very High		-		-		
Recreational use of springs	Contribution	Medium	Low		-		-		-	High	Low	Low
	Irreversibility	Medium								Low		
	Override											
	Source	Medium		-		-		-		Medium		

Appendix C. Nested conservation targets

Table C-1. Blowsand Mountains dune system nested species and alliances.

common name	scientific name	global natural heritage rank	comments
big greasewood community		not ranked	
Tonopah milkvetch	*Astragalus pseudiodanthus*	G2	Great Basin endemic
desert sunflower	*Helianthus deserticola*	G2Q	
Watson's oxytheca	*Oxytheca watsonii*	G2	limited distribution
Lahontan indigobush	*Psorothamnus kingii*	G3	Great Basin endemic
pale kangaroo mouse	*Microdipodops pallidus*	G3	
Hardy's aegialian scarab	*Aegialia hardyi*	G1	BLM sensitive species, endemic to Sand Mountain and Blowsand Mountains
scarab beetle	*Aegialia spinosa*	unknown, G?	limited distribution
sand-obligate tenebrionid beetle	*Chilometopon pallidium*	unknown, G?	limited distribution
Sand Mountain pygmy scarab beetle	*Coenonycha pygmaea*	G1	endemic to Sand Mountain and Blowsand Mountains
sand-obligate tenebrionid beetle	*Edrotes ventricosus*	unknown, G?	limited distribution
sand-obligate tenebrionid beetle	*Eusattus muricatus*	unknown, G?	widespread, sand-obligate specialist
sand-obligate anithicid beetle	*Mecynotarsus delicatulus*	unknown, G?	limited distribution
sand-obligate ptinid beetle	*Niptus ventriculus*	unknown, G?	limited distribution
predatory histerid beetle	*Philothris sp. nov.*	unknown, G?	limited distribution
sand-obligate carabid beetle	*Rhadine myrmecodes*	unknown, G?	limited distribution
Sand Mountain serican scarab beetle	*Serica psammobunus*	G1	BLM sensitive species, endemic to Sand Mountain and Blowsand Mountains
sand-obligate carabid beetle	*Tetragonoderus pallidus*	unknown, G?	limited distribution
sand-obligate tenebrionid beetle	*Trogloderus costatus*	unknown, G?	limited distribution
sand-obligate cricket	*Stenopelmatus ssp. nov.*	unknown, G?	endemic
dune honey ant	*Myrmecocystus arenarius*	G2?	endemic to Great Basin, in synonymy with *M. snellingii*
bee	*Andrena chrylismiae*	G1	endemic
bee	*Andrena taeniata*	G2	disjunct population
bee	*Andrena sp. nov.*	G1	endemic

bee	*Anthidium rodecki*	unknown, G?	limited to few ecoregions
bee	*Anthophora sp. nov. 1*	G1	endemic to Sand Mountain and Blowsand Mountains
red-legged beardtongue bee	*Atoposmia rufifemur*	unknown, G?	limited distribution
bee	*Colletes sp. nov. 1*	G1	limited to few ecoregions
bee	*Hesperapis kayella*	G1	limited distribution
bee	*Perdita hirticeps apicata*	unknown, G?	limited to few ecoregions

Table C-2. Sand Mountain dune system nested species and alliances.

common	scientific	G rank	comments
mottled milkvetch	*Astragalus lentiginosus var. kennedyi*	G5T3T4	Endemic to western Great Basin, locally abundant on dunes and sand flats
desert sunflower	*Helianthus deserticola*	G2Q	
Nevada oryctes	*Oryctes nevadensis*	G2	BLM sensitive species, limited to few ecoregions
Sand Mountain blue butterfly	*Euphilotes pallescens arenamontana*	G4T1	BLM sensitive species, endemic to Sand Mountain
Hardy's aegialian scarab beetle	*Aegialia hardyi*	G1	BLM sensitive species, endemic to Sand Mountain and Blowsand Mountains
Sand Mountain aphodius scarab beetle	*Aphodius sp. nov. 3*	G1?Q	BLM sensitive species
click beetle	*Cardiophorus ssp. nov.*	unknown, G?	Endemic to Sand Mountain
Sand Mountain pygmy scarab beetle	*Coenonycha pygmaea*	G1	Endemic to Sand Mountain and Blowsand Mountains
sand-obligate beetle	*Eusattus muricatus*	unknown, G?	widespread, sand-obligate specialist
Sand Mountain serican scarab beetle	*Serica psammobunus*	G1	BLM sensitive species, endemic to Sand Mountain and Blowsand Mountains
dune honey ant	*Myrmecocystus arenarius*	G2?	Endemic to Great Basin, in synonomy with *M. snellingii*
bee	*Anthidium rodecki*	unknown, G?	Limited to few ecoregions
bee	*Anthophora affabilis*	unknown, G?	Limited to few ecoregions
bee	*Anthophora sp. nov.1*	G1	Endemic to Sand Mountain and Blowsand Mountains
bee	*Calliopsis phaceliae*	unknown, G?	Limited to few ecoregions
bee	*Calliopsis sp. nov.*	unknown, G?	Limited to few ecoregions
bee	*Colletes stepheni*	unknown, G?	Disjunct
bee	*Colletes tectiventris*	unknown, G?	Disjunct
bee	*Colletes sp. nov. 1*	G1	Limited to few ecoregions

bee	*Hesperapis sp. nov. 2*	G1	Endemic to Sand Mountain
bee	*Perdita aridella*	unknown, G?	Limited to few ecoregions
bee	*Perdita chloris*	unknown, G?	Limited to few ecoregions
bee	*Perdita cleomellae*	unknown, G?	Disjunct
bee	*Perdita eucnides eucnides*	G2	Disjunct
bee	*Perdita haigi*	G1	Endemic to Sand Mountain
bee	*Perdita hirticeps apicata*	unknown, G?	Limited to few ecoregions
bee	*Perdita vesca*	unknown, G?	Limited to few ecoregions
bee	*Perdita sp. nov. 3*	G1	Endemic to Sand Mountain

Appendix D. Contributions of dune systems to Great Basin biodiversity

Comparison of Blowsand and Sand Mountains' endemic species and contribution to biodiversity within the Great Basin ecoregion

In the Lahontan Basin, several sand dune systems have developed. Blowsand Mountain and Sand Mountain were likely derived in part from the same sand source (Eissmann 1990, Morrison 1964), and are currently separated by only 26 km. These two dynamic sand communities are quite similar in species composition, but the overlap is not complete. There are several Great Basin endemic plant and insect species found on Blowsand Mountain that are not known from Sand Mountain. A study of the insect fauna of several larger Great Basin and Mojave sand dune systems, including Blowsand Mountain and Sand Mountain, found that each dune system contributed uniquely to sand dune biodiversity in the region, and that the sacrifice of any dune system would negatively impact biodiversity of dune ecosystems in the region (Rahn and Rust 2000).

Additionally, some level of genetic divergence has been detected between the Blowsand Mountain and Sand Mountain populations of one shared species, the Hardy's aegialian scarab beetle (*Aegialia hardyi*) (Porter and Rust 1997). While the level of genetic difference detected between the two populations was not sufficient to derive species, these two populations of the flightless beetle are unlikely to exchange genes between the two dune systems. It is not likely that the geographic distance between these two dune systems could be bridged by the smaller sand deposits between them. Epps and others (2000) have found that distances as great as 3 km may be traversed by a common, flightless sand dune beetle (*Eusattus muricatus*), but it has not been established that the sand deposits found between Blowsand Mountain and Sand Mountain form a series of linked sandy habitats that might potentially support a chain of gene flow for any of the sand-obligate species of interest to land managers. It is probable that the two populations of Hardy's aegialian scarab beetle will continue to experience additional divergence, increasing the uniqueness of each dune system.

In summary, a number of Great Basin endemic species are found only on one or both of these dune systems, and while they may share a common historic sand source, it is clear that each sand dune contributes uniquely to the biodiversity of the Great Basin Desert. Land managers charged with the conservation of sensitive species and / or representative Great Basin natural communities will need to consider the impacts of both current and future human activities on each of these two heavily used, unique dune systems.

Great Basin endemic species comparison of Sand Mountain and Blowsand Mountain, Nevada

Common Name	Scientific Name	Global Natural Heritage System Ranking	Site Name
(andrena bee)	*Andrena chrylismiae*	G1	Blowsand Mountain
(andrena bee)	*Andrena* sp. nov.	G1	Blowsand Mountain
(sand obligate cricket)	*Stenopelmatus* ssp. nov.	unranked	Blowsand Mountain
Tonopah milkvetch	*Astragalus pseudiodanthus*	G2	Blowsand Mountain
Lahontan indigobush	*Psorothamnus kingii*	G3	Blowsand Mountain
(click beetle)	*Cardiophorus* ssp. nov.	unranked	Sand Mountain
Sand Mountain blue butterfly	*Euphilotes pallescens arenamontana*	G4T1	Sand Mountain
(hesperapis bee)	*Hesperapis* sp. nov. 2	G1	Sand Mountain
(perdita bee)	*Perdita haigi*	G1	Sand Mountain
(perdita bee)	*Perdita* sp. nov. 3	G1	Sand Mountain
mottled milkvetch	*Astragalus lentiginosus* var. *kennedyi*	G5T3T4	Sand Mountain
Hardy's aegialian scarab beetle	*Aegialia hardyi*	G1	Blowsand Mountain & Sand Mountain
(anthophora bee)	*Anthophora* sp. nov.	G1	Blowsand Mountain & Sand Mountain
Sand Mountain pygmy scarab beetle	*Coenonycha pygmaea*	G1	Blowsand Mountain & Sand Mountain
dune honey ant	*Myrmecocystus arenarius*	G2?	Blowsand Mountain & Sand Mountain
Sand Mountain serican scarab beetle	*Serica psammobunus*	G1	Blowsand Mountain & Sand Mountain

Appendix E: Strategy ranking criteria

Table E-1. Leverage ranking criteria.

Very High	Immediate, visible, tangible results and high leverage towards another high impact strategy
High	Immediate, visible, tangible results or high leverage towards another high impact strategy
Medium	Moderate leverage
Low	No apparent leverage

Table E-2. Lead individual / institution ranking criteria.

Very High	A lead individual ("champion") with sufficient time, proven talent, substantial relevant experience and institutional support is reasonably available and committed to lead implementation of the strategy
High	An individual with sufficient time, promising talent, some relevant experience and institutional support is reasonably available and committed to lead implementation of the strategy
Medium	An individual with promising talent and sufficient time is reasonably available, but lacks relevant experience or institutional support
Low	No lead individual currently available

Table E-3. Ease of implementation ranking criteria.

Very High	Implementing the strategy is very straightforward; this type of strategy has been done often before
High	Implementing the strategy is relatively straightforward, but not certain; this type of strategy has been done before
Medium	Implementing the strategy involves a fair number of complexities, hurdles and/or uncertainties; this type of strategy has rarely been done before
Low	Implementing the strategy involves many complexities, hurdles and/or uncertainties; this type of strategy has never been done before

Table E-4. Overall cost ranking criteria.

Very High	Total cost of implementing the strategy – including staff time -- in unrestricted or discretionary dollars (i.e. dollars that might be applied to other purposes) is $1,000,000 or more
High	Total cost of implementing the strategy – including staff time -- in unrestricted or discretionary dollars (i.e. dollars that might be applied to other purposes) is $100,000 or more
Medium	Total cost of implementing the strategy – including staff time -- in unrestricted or discretionary dollars (i.e. dollars that might be applied to other purposes) is $10,000 or more
Low	Total cost of implementing the strategy – including staff time -- in unrestricted or discretionary dollars (i.e dollars that might be applied to other purposes) is $1,000 or more