Conservation Elements of and a Biodiversity Management Framework for the Barry M. Goldwater Range, Arizona
CONSERVATION ELEMENTS OF AND A BIODIVERSITY MANAGEMENT FRAMEWORK FOR THE BARRY M. GOLDFWATER RANGE, ARIZONA

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EXECUTIVE SUMMARY

This document provides the results from The Nature Conservancy’s site conservation planning process for the Barry M. Goldwater Range (BMGR), Arizona. The identification herein of conservation elements, and their subsequent use in the development of management goals and standards, serves as a biodiversity management framework that can be incorporated into the BMGR’s Integrated Natural Resources Management Plan (INRMP).

Contexts and Scope

The Military Lands Withdrawal Act of 1999 (Public Law 106–65) authorized the continued withdrawal of lands constituting the BMGR for 25 years. The Act, however, also stipulated a change in management authority for natural and cultural resources on BMGR withdrawn lands from the Department of the Interior to the Secretaries of the Navy (western portion of the range) and Air Force (eastern portion of the range). The Act further required the development of an INRMP specifically for the BMGR in accordance with the Sikes Act, as amended (Title 16, United States Code 670a et seq.), and other Withdrawal Act provisions. The Sikes Act directs the Secretary of Defense to carry out a program that provides for the conservation and rehabilitation of natural resources on military installations. To facilitate such a program, the Act requires the secretary of each military department to prepare and implement an INRMP at installations under their jurisdiction. Such plans ensure that natural resource conservation measures are integrated with military mission requirements and are consistent with federal stewardship requirements. The Navy and Air Force departments have decided to prepare a single INRMP for the BMGR.

In September 2000 the 56th Fighter Wing, Luke Air Force Base and The Nature Conservancy signed a Cooperative Agreement wherein both parties agreed to cooperate in the development and execution of an INRMP for the BMGR. In accordance with the Cooperative Agreement, Luke Air Force Base and The Nature Conservancy subsequently agreed to an initial project scope of work that supported development of the BMGR’s INRMP. The specific tasks identified for accomplishment reflected The Nature Conservancy’s expertise in the areas of ecoregional and site-level conservation planning.

Previous funding from the Department of Defense Legacy Resource Management Program enabled The Nature Conservancy and its conservation partners to develop an ecological basis for conservation throughout the Sonoran Desert Ecoregion, a 55 million-acre region of the Southwest within which the BMGR is located. The Sonoran Desert Ecoregion and the current and projected status of its biodiversity provide the appropriate ecological context for natural resources management planning on the BMGR and for assessing the relative significance of the BMGR to conservation and protection of the ecoregion’s biodiversity. The Nature Conservancy’s site conservation planning methodology uses a focal set of natural communities or species (conservation elements) to capture for planning and management purposes the overall native biodiversity of an area. The approach is modified herein to serve as a biodiversity management framework that addresses the scale and unique aspects of federal land management, especially in the context of the BMGR’s military training environment.

Overview and Benefits of the Biodiversity Management Framework

The biodiversity management framework for the BMGR described in this document provides for the following:
identifies a suite of conservation elements that when managed appropriately provides for the conservation and protection of biodiversity on the BMGR

uses broad expert input from the scientific community to evaluate the ecological characteristics and status of each conservation element

identifies major threats to the long-term viability of each conservation element

derives desired future ecological conditions for each conservation element to serve as element-specific management goals

identifies an initial set of monitoring objectives for each conservation element

identifies conservation-oriented management standards for spatially delineated land management categories that are based on the BMGR’s mission and other land uses, strategies appropriate to eliminate or minimize major threats, and presence and condition of conservation elements

identifies opportunities for cross-jurisdictional coordination of natural resources management with adjoining land administrators

The primary benefits of the biodiversity management framework and the process The Nature Conservancy used to develop it for the BMGR include:

provides a well-documented and science-based approach for making natural resource management decisions in the context of appropriate ecological boundaries, land management agency mandates, and land management unit land uses

provides access to regional scientific and agency experts that typically do not participate in agency planning processes thereby ensuring the best available and most contemporary scientific information can be integrated into the BMGR’s INRMP

can be used as an exportable model to raise the standards of biodiversity management across the Sonoran Desert Ecoregion (or at more local scales) to ensure an equitable distribution of management responsibility among jurisdictions and to facilitate an ecosystem approach to management

demonstrates to regulators and the public the ability to manage biodiversity through an informed decision-making process that leads to explicit management standards, which may result in a streamlining of environmental review and listed species consultation processes in the future.

Methods

The Nature Conservancy used a multi-step process to select conservation elements appropriate to the BMGR. Selected conservation elements were:

- representative of biodiversity within the Sonoran Desert Ecoregion
- relevant to natural resources management on the BMGR
- representative of the occurrence of biodiversity elements at different spatial scales, across taxonomic categories (for example, plants, birds, mammals, and so on), and across different levels of rarity
• inclusive of natural community and species conservation elements that had specialized management needs.

We used interviews, questionnaires, and workshops involving regional scientific and agency experts, as well as reviews of the applicable scientific literature, as the foundation of the entire process. We also made extensive use of geospatial data both as raw data (for example, species occurrence information) and as the components of analytical models (for example, to model the occurrence of natural communities).

The information gathered pertaining to ecological attributes and desired future conditions of individual natural community and species conservation elements was then considered in the broader contexts of the BMGR land management unit missions, land-use constraints and opportunities, landscape features, and cross-jurisdictional coordinated management opportunities. We assessed, delineated, and assigned individual land areas on the BMGR to an appropriate land management category based on the occurrence and condition of conservation elements, current land use, and principles of conservation biology. A primary consideration of the above assessment was to identify areas that qualify to be managed as Special Natural Areas, which is a Department of Defense designation for areas containing natural resources that warrant special conservation measures. These are areas that represent one type of land management category that share characteristics of high biodiversity value, low anthropogenic disturbance levels, and opportunities for coordinated management with one or more adjoining jurisdiction. Finally, we developed sets of recommended management standards corresponding to each land management category to ensure adequate management of the full extent and natural variation of the conservation elements.

Findings and Recommendations

Because of its size and east-west orientation the BMGR incorporates much of the diversity of landforms, rainfall, and elevation gradients that are present within the Sonoran Desert Ecoregion in Arizona and that contribute to this ecoregion’s biodiversity. To capture the resultant biodiversity we identified a total of 25 natural communities, species, and aggregates of ecologically similar species (guilds) that are proposed to serve as a focal set of conservation elements for the BMGR. The natural community conservation elements, when appropriately managed to ensure the long-term persistence of each community type on the BMGR, should provide a reasonable assurance that the majority of species associated with these communities will remain viable as well. The individual species and guilds are included as conservation elements, and identified for individual management attention, based on the assumption that management of the natural communities alone may not be sufficient to ensure their long-term persistence. They may already be rare, and deserving of focused management attention (such as a federally listed species), or they may have specialized habitat needs that are overlooked at the natural community level.

Based on the conservation elements and the other considerations outlined above, The Nature Conservancy developed four different land management categories applicable to the BMGR. Figure ES.1 depicts the spatial distribution of the land management units associated with the four land management categories. The emphasis on meeting conservation goals versus other desired human uses of the land differs between categories. The aggregate of all land management categories and their associated management standards represents a hypothesis: implementation of the applicable management standards across the full spatial expression of the land management categories, and in coordination with application of similar management standards on adjoining jurisdictions when necessary, will ensure the long-term persistence of the BMGR’s biodiversity.

Within the Special Natural Area category, four different land management units were identified. Special Natural Areas are the primary, but not sole, means through which biodiversity conservation and protection goals for the BMGR can be met when they are managed to appropriate standards. Areas outside of Special Natural Areas still require, however, appropriate management of military and
recreational activities to protect natural (and cultural) resource values. The level of attention may be less and the permitted activities more than what occurs within a Special Natural Area, but natural resource management (or human activity management) must still occur nonetheless. These latter areas may serve as ecological buffers within which, for example, monitoring and control of invasive plants may be needed to prevent incursions into Special Natural Areas. To achieve the intent of each land management category designation, all of the standards associated with a particular category must be implemented. As a result, a primary focus of the Air Force and Marines in the implementation of the INRMP for the BMGR must be to ensure that adequate resources are made available to implement management standards and accomplish management goals.

**Coda**

Single-species, compliance-driven natural resource management approaches characteristically are trying to make up for lost ground. Often by the time these approaches are implemented they are relatively costly and their chances for success uncertain. Natural resource management and land-use strategies that place a priority on maintaining resources that already have reasonable ecological integrity enable the federal land manager to preserve future options, in regard to both land-use (mission accomplishment) and natural resource conservation and protection. By waiting to react to compliance-induced natural resource management mandates, the federal land manager unwittingly invites their occurrence. By enacting proactive management strategies today that account for the full extent of biodiversity rather than just a focus on single species management, the federal land manager can reduce long-term management costs and improve the prospects for agency mission accomplishment that is compatible and sustainable in the face of resource conservation and protection responsibilities.

Based on the development of conservation elements applicable to the BMGR, The Nature Conservancy in this document makes recommendations on specific land management categories and management standards that are applicable to each category. Such recommendations are the critical endpoints of the biodiversity management framework that has been developed herein for the BMGR. The combination of land management categories and standards is proposed to be the linchpin of a proactive, ecosystem-based approach to natural resources management on the BMGR. We strongly suggest that the Air Force and Marines can improve their ability to protect and sustain their missions on the BMGR over the long-term by demonstrating today that they are taking a comprehensive approach to planning and implementing a reasonable set of natural resource management standards and supporting programs to accomplish biodiversity conservation and protection. We further suggest that if such a management framework, including its standards, is implemented appropriately and consistently across adjoining land management jurisdictions, it can be used to raise the standards of biodiversity management across the Greater Goldwater Complex (over 6 million acres of land involving multiple jurisdictions, including and surrounding the BMGR).
ACKNOWLEDGMENTS

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A number of individuals played a vital role in this project by participating in a workshop held on November 2, 2000 at which with their assistance we defined the ecological characteristics of a suite of natural community conservation elements applicable to the BMGR (and to Cabeza Prieta National Wildlife Refuge as well), assessed their current conservation status, and evaluated available data for accuracy in mapping these communities on the BMGR. The following individuals are recognized for their participation in the November 2000 workshop: Scott Bailey, Bob Barry, Russell Engel, Richard Felger, Annta Harlan, Thomas Harlan, Philip Jenkins, Jim Malusa, Karen Reichhardt, Sue Rutman, Linwood Smith, Dale Turner, Raymond Turner, and Peter Warren. Additionally, Michael Kunzmann of the University of Arizona provided valuable information on the accuracy and limitations of the U.S. Geological Survey’s North American Gap map project data to depict these natural communities within the Sonoran Desert Ecoregion. Finally, we thank Jim Malusa for letting us publish his personal photographs that demonstrate the appearance of a number of the natural community conservation elements.

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Cover photo and all photos contained in Chapter 6 are © Jim Malusa. The cover photo shows an aerial view of the Valley Bottom Floodplain Complex natural community as seen looking south through Growler Wash on Cabeza Prieta National Wildlife Refuge.
1.1 Scope

In September 2000 the 56th Fighter Wing, Luke Air Force Base and The Nature Conservancy entered into a cooperative agreement through which the entities mutually agreed to cooperate in the development and execution of an integrated natural resources management plan (INRMP) for the Barry M. Goldwater Range (BMGR). The cooperative agreement identified a number of general areas of technical expertise through which The Nature Conservancy could provide support to the plan’s development and execution.

In accordance with the cooperative agreement, Luke Air Force Base and The Nature Conservancy subsequently agreed to an initial collaborative project scope of work that focused on those tasks needed to support development of the BMGR’s INRMP. The specific tasks reflected The Nature Conservancy’s expertise in the area of site conservation planning, a planning methodology that uses a focused set of conservation “targets” (hereafter referred to as conservation elements) to capture within a planning and management context the overall native biodiversity of an area. Conservation elements can be either natural communities (ecological systems) or species.

This framework document provides the results from The Nature Conservancy’s site conservation planning process for the BMGR. The identification herein of conservation elements, and their subsequent use in the development of management goals and standards, serves as a biodiversity management framework that can be incorporated into the BMGR’s INRMP.

Project work initially was conducted in two phases, with the findings submitted each time to Luke Air Force Base in the form of a report. Phase 1 (Hall and others 2001) focused on the following tasks:

- identify a focused set of conservation elements that within a management planning context can be used to represent the overall native biodiversity of the BMGR
- through workshops and interviews, facilitate the use of regional scientific and agency experts to inform the collection of relevant ecological, conservation status, threat, and regional context information for each conservation element
- based on the occurrence and distribution of conservation elements on the BMGR, provide recommendations on appropriate management areas needed to conserve each element
- provide summary statistics on the relative occurrence and land management status of remotely sensed natural communities for the BMGR and the Sonoran Desert.

Phase 2 (Hall and Weinstein 2001) focused on the following tasks:

- identify management goals (desired future ecological conditions) for each conservation element identified during Phase 1

1 Although Marine Corps Air Station Yuma is not a party to the cooperative agreement, they have provided some funding in support of this project through Luke Air Force Base. Moreover, because a single INRMP will be prepared to cover the entirety of the BMGR’s natural resource management activities, this project is meant to support the planning needs of the entire range and both military entities.
• provide monitoring objectives for each conservation element
• provide information on the possible opportunities for coordinated management of conservation element on lands adjoining the BMGR.

Subsequent to the completion of Phases 1 and 2, additional materials were developed and submitted to Luke Air Force Base. These included geospatial data layers for recommended Special Natural Areas and land management categories, along with associated recommended management standards for each land management category.

The present document consolidates all materials submitted to date to Luke Air Force Base. Additionally, it incorporates reviewer comments to the previously submitted reports, adds Executive Summary and Acknowledgment sections, provides additional information on species conservation element occurrences on the BMGR, and expands on previous monitoring objective and information need recommendations.

1.2 DOCUMENT STRUCTURE

The first three chapters of the report constitute an introductory section in which the scope and structure (this subsection) of the document are described (Chapter 1), the legal, policy, and ecological context for management is outlined (Chapter 2), and the relationship between The Nature Conservancy’s site conservation planning methodology and the INRMP planning process is discussed (Chapter 3). Chapter 2 provides a basis for the BMGR INRMP’s focus on ecosystem management approach, including biodiversity management and protection, whereas Chapter 3 describes conceptually how the information provided here can be used within the INRMP planning process.

Chapter 4 provides an overview of the methods used to gather the data presented in the report and their subsequent analysis. The methods include a discussion on how conservation elements are selected. Chapter 5 is a summary chapter that provides an overview of the conservation elements, both natural community and species, that are recommended for incorporation into the BMGR INRMP planning process. The next two chapters provide more detailed ecological information on each of the natural community (Chapter 6) and species elements (Chapter 7). Chapter 6 includes a discussion of summary statistics on the relative occurrence and land management status of remotely sensed natural communities for the BMGR and the Sonoran Desert. These communities are not necessarily equivalent to the natural communities recommended as conservation elements for the BMGR.

Chapter 8 provides an overview of other species/taxonomic groups considered as conservation elements but which were not further evaluated either because data as to their occurrence or status on the BMGR was limited (or non-existent) or because they did not meet the criteria to be retained as a conservation element. This additional information on species or species groups (guilds) that were considered as conservation elements but not included at this time eventually may prove useful to BMGR natural resource managers.

Chapter 9 provides information on desired future ecological conditions for each natural community and species/guild conservation element. The chapter begins with a discussion of the main ecological processes that maintain ecosystem function in the Sonoran Desert. Chapter 10 provides information on

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2 Additional materials were submitted under cover of letters dated 8 February 2001, 23 March 2001, and 17 April 2001 from J.A. Hall (TNC) to R.X. Barry (Luke AFB) and R. Pearce (USMC Air Station Yuma) (except for the 17 April 2001 letter).
monitoring objectives for each natural community and species/guild conservation element. Additionally, Chapter 10 provides an overview of major information needs.

Chapter 11 summarizes recommendations for the designation of Special Natural Areas on the BMGR based on an analysis of the conservation elements and their status and distribution across the BMGR. Additionally, Chapter 11 provides a basis for designating four types of land management categories, including Special Natural Areas, and identifies a set of recommended management standards for each category. Chapter 12 describes some of the opportunities for coordinated management of conservation elements with landowners adjoining the BMGR.

Chapter 13 identifies the literature cited throughout the report. The report concludes with several appendices that provide definitions for some of the technical terms used in this report, identify the experts consulted, and provide additional information that supports conservation elements selection.
CHAPTER 2 CONTEXTS FOR NATURAL RESOURCES MANAGEMENT PLANNING AND BIODIVERSITY PROTECTION ON THE BARRY M. GOLDWATER RANGE

The following sections provide an overview of the legal, policy, and ecological contexts that affect natural resources management planning and biodiversity protection on the Barry M. Goldwater Range (BMGR).

2.1 LEGAL

Natural resources management planning for the BMGR draws its legal basis from two primary sources: the Sikes Act amendments of 1997 (Public Law 105–85) and Military Lands Withdrawal Act of 1999. The Sikes Act, as amended (Title 16, United States Code 670a et seq.), directs the Secretary of Defense to carry out a program that provides for the conservation and rehabilitation of natural resources on military installations. To facilitate such a program, the Act requires the secretary of each military department to prepare and implement an Integrated Natural Resources Management Plan at installations under their jurisdiction. Such plans ensure that natural resource conservation measures are integrated with military mission requirements and are consistent with federal stewardship requirements.

The Military Lands Withdrawal Act of 1999 (Public Law 106–65) also requires the development of an integrated natural resources management plan (INRMP) specifically for the BMGR (in accordance with Sikes Act requirements and other provisions specific to the BMGR stated in the Withdrawal Act itself). Moreover, different from previous withdrawal legislation the Act stipulates that the Secretary of the Navy (western portion of the range) and the Secretary of the Air Force (eastern portion of the range) are responsible for the natural and cultural resources management, as well as the enforcement of federal laws related thereto, of the lands that are withdrawn. Resource management is required to be in accordance with the INRMP once that plan is completed. Although the Act allows each military department to prepare its own INRMP for its portion of the range, the departments have agreed to prepare a single INRMP for the BMGR (in either case the Act specifies that the INRMP is prepared jointly with the Secretary of the Interior).

2.2 DEPARTMENT OF DEFENSE ECOSYSTEM MANAGEMENT AND BIODIVERSITY PROTECTION POLICIES

The Department of Defense has embraced the concept of ecosystem management. It is a signatory to a Memorandum of Understanding (MOU), along with 12 other federal agencies (and the Civil Works component of the Department of the Army), that fosters an ecosystem approach to natural resources management. The policy portion of the MOU states:

The federal government should provide leadership in and cooperate with activities that foster the ecosystem approach to natural resource management, protection, and assistance. Federal agencies should ensure that they utilize their authorities in a way that facilitates, and does not pose barriers to, the ecosystem approach. Consistent with their assigned missions, federal agencies should administer their programs in a manner that

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3Memorandum of Understanding to Foster the Ecosystem Approach between the Council of Environmental Quality, Department of Agriculture, Department of the Army, Department of Defense, Department of Energy, Department of Housing and Urban Development, Department of the Interior, Department of Justice, Department of Labor, Department of State, Department of Transportation, Environmental Protection Agency, and Office of Science and Technology Policy, dated 15 December 1995.
is sensitive to the needs and rights of landowners, local communities, and the public, and should work with them to achieve common goals.

Even before the MOU was signed, the Department of Defense already had made a strong policy commitment to the implementation of ecosystem management across the Defense complex. The Deputy Under Secretary of Defense (Environmental Security) articulated an overall ecosystem management goal, as well as principles and guidelines. According to the Secretary’s policy statement, an ecosystem management approach would include: a shift in focus from the protection of individual species to management of ecosystems, formation of partnerships to achieve shared goals, public participation, use of the best available science, and implementation of adaptive management techniques. An underlying theme of the policy is the maintenance and improvement of the native biodiversity of terrestrial and aquatic ecosystems on military lands to the extent compatible with sustaining the military mission needs on these lands.

Much of the Department of Defense’s specific policy on ecosystem management is codified in Department of Defense Instruction 4715.3 (Environmental Conservation Program; dated 3 May 1996). The instruction specifies that INRMPs shall incorporate the principles of ecosystem management. Additionally, the instruction highlights the promotion of biodiversity conservation on Department of Defense lands and waters (section F.2.b and c).

Of particular relevance to the findings and recommendations contained in this report is the instruction’s treatment of special management areas for natural resource conservation purposes. Two statements from the instruction provide the context:

F.1.j. Portions of installation real property that have significant ecological, cultural, scenic, recreational, or educational value may be set aside for conservation of those resources, where such conservation is consistent with the military mission.

F.2.e. Areas on DoD installations that contain natural resources that warrant special conservation efforts, after appropriate study and coordination, may be designated as special natural areas. The integrated natural resources management plan for the installation shall address special management provisions necessary for the protection of each area. Special natural areas include botanical areas, ecological reserve areas, geological areas, natural resources areas, riparian areas, scenic areas, zoological areas, “watchable wildlife” areas, and traditional cultural places having officially recognized special qualities or attributes.

Finally, as evidenced by the Notice of Intent to Prepare an Environmental Impact Statement (EIS) for the Barry M. Goldwater Range’s Integrated Natural Resources Management Plan, the Departments of the Air Force and Navy intend to provide, through the INRMP planning process, for “participation in local initiatives to advance regional biodiversity goals.” In combination the preceding policies and statement of intent provide an appropriate basis for incorporating an ecosystem management approach and for providing a focus on biodiversity management and protection in the BMGR’s INRMP. Specific guidance for conserving biodiversity on military lands can be found in Leslie and others (1996).

2.3 SONORAN DESERT ECOREGION

The Sonoran Desert Ecoregion (Figure 2.1) encompasses 55 million acres (22 million hectares) in southern Arizona, southeastern California, northern Baja California, and northwestern Sonora and is the

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4Memorandum from S.W. Goodman, Deputy Under Secretary of Defense (Environmental Security) to Assistant Secretaries of the Army, Navy, and Air Force, dated 8 August 1994, Implementation of Ecosystem Management in the DoD.

5Federal Register: 21 July 2000; Volume 65, Number 141, Page 45361.
The Sonoran Desert also is a fragile landscape and its biodiversity is under siege. Since the end of World War II, the Sunbelt of the American Southwest and Northwest Mexico has been the setting for the largest in-migration in human history (Nabhan and Holdsworth 1999). In 1990 the Sonoran Desert Ecoregion contained 6.9 million residents, nearly double the population size in 1970. The population is expected to reach 12 million by 2020. Under such human growth pressure, the threats to Sonoran Desert biodiversity reported by Nabhan and Holdsworth (1999) will only be exacerbated. Conversion of natural habitat to urban, suburban, and agricultural areas will continue and will result in widespread habitat loss. Overuse of natural surface water and groundwater resources and the loss of natural hydrological regimes even now...
threaten the viability of the ecoregion's most diverse areas—its riverine, riparian, and estuarine habitats. Little perennial surface flow of ecological significance remains across the ecoregion and groundwater pumping threatens the life-giving processes of water-dependent biotic communities. Increased recreational use of the desert is resulting in habitat loss and declines in some species. Finally, improper livestock management and the spread of invasive plants and animals threaten the viability of both terrestrial and riverine/riparian systems alike.

2.3.1 Ecoregional Planning in the Sonoran Desert

One of the principles of ecosystem management is to consider appropriate ecological units when formulating management strategies. Ecological regions (ecoregions), at any scale, can be defined as areas with relative homogeneity in ecosystems (Omernick and Bailey 1997). In the context of the preceding definition, ecosystems are themselves considered multi scale and inclusive of both biotic and abiotic components, aquatic as well as terrestrial. Ecoregions can provide a spatial framework for ecosystem assessment, research, inventory, monitoring, and management (Science Advisory Board 1991, Omernick and Bailey 1997). Because ecoregions delimit areas in which local ecosystems reoccur more or less throughout the area in a predictable pattern, similar ecological processes and biotic elements (and their aggregations) may occur within an ecoregion that in turn require similar management strategies. Ecoregions are useful when the ecological integrity of the aggregate of natural resources is of interest; as a result, ecoregions generally are less useful as an organizing principle for management when one particular resource is considered (Omernick and Bailey 1997).

The Nature Conservancy uses ecoregions to organize its on-the-ground conservation work (Groves and others 2000). The goals of ecoregional planning are to:

- identify the network of areas needed to protect the ecoregion’s biodiversity
- identify stresses (and their sources) that threaten the ecoregion’s biodiversity
- determine the methods and partnerships needed to manage and protect biodiversity and ecosystem functions (ecological processes) in landscapes that are often characterized by extremely diverse and growing human uses.

Funding from the Department of Defense Legacy Program was instrumental in enabling The Nature Conservancy and its conservation partners to develop the ecological basis for conservation throughout the Sonoran Desert Ecoregion. The ecological analysis was carried out by integrating regional Geographic Information System (GIS) databases, accessing published information, and conducting workshops that drew on the collective knowledge and experience of regional scientific experts. These facilitated workshops took advantage of taxonomic specialists, interdisciplinary expertise, and traditional knowledge to augment data on rare species, natural communities, and ecological processes. Expert involvement also served as a peer review and as a vehicle for identifying critical data gaps.

A representative sample of the Sonoran Desert’s natural communities and species served as conservation elements, the basic units of analysis used to identify a network of conservation areas. A total of 353 species from seven taxonomic groups (plants, invertebrates, fish, amphibians, reptiles, birds, and mammals) and 78 natural communities were selected (Marshall and others 2000) and assessed for their occurrence and conservation status (generally an occurrence of a species or natural community must be viable to be used to inform the selection of conservation areas) across the ecoregion. An emphasis was

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6The Nature Conservancy defines 80 such areas across the United States. A number of these ecoregions, such as the Sonoran Desert, extend across the U.S. boundaries into Canada or Mexico.
placed on selecting species endemic to the Sonoran Desert. The natural communities were intended to represent a broader level of biological organization across the ecoregion. The approach of using a combination of natural communities (coarse-scale data) and species (fine-scale data) was considered a robust way to represent the broadest array of biodiversity (see Marshall and others [2000] for a more complete description of how conservation areas were selected).

The products from the ecological analysis included a set of annotated maps that synthesized ecological information and, as a result, illustrated those areas of greatest importance for conserving the biological diversity of the Sonoran Desert (see maps in Marshall and others 2000). Over 100 landscape-scale areas and just under 80 small, localized areas were identified that constituted the conservation network for the Sonoran Desert Ecoregion. Figure 2.2 depicts the 100 landscape-scale conservation areas. The analysis can serve as a science-based foundation that agencies, communities, and local groups can use to identify specific conservation approaches and on-the-ground actions at each conservation area.

The aggregate of all conservation areas represents a hypothesis: the implementation of appropriate management at each of the conservation areas will ensure the long-term persistence of most the Sonoran Desert’s biodiversity (Marshall and others 2000). “Appropriate management” does not imply a one-size-fits-all approach to management. Nor does it imply the elimination of all non-resource management type activities. Appropriate management means that at each conservation area major stressors are identified and abated through management actions and degraded conservation elements are restored (passively or actively).

Within the U.S. portion of the Sonoran Desert Ecoregion (Arizona and California), 87% of the landscape-scale conservation areas is managed by federal or state agencies (Marshall and others 2000). The Department of Defense is second only to the Bureau of Land Management in regard to the amount of federal land ownership (or at least administrative control in the case of withdrawals of public land for military purposes) within the ecoregion. Although such an ownership pattern presents some opportunities to facilitate appropriate management over large areas, the current management status of many areas is less than favorable to biodiversity management and protection. Marshall and others (2000) conducted a Gap management analysis of the ecoregion’s conservation network. They found that less than 20% of the network of conservation areas is managed to promote the long-term persistence of conservation elements.

2.3.2 Conservation Planning at the Barry M. Goldwater Range

Several recommendations for improving the conservation status of conservation areas within the network derived from the ecological analysis (Marshall and others 2000). These can be summarized as:

- identify ecoregion-wide those conservation areas that are the most important for the management and protection of biodiversity
- provide a baseline characterization (for example, natural community types) from which to evaluate the status of conservation elements and trends in major stressors (for example, invasive species) across the ecoregion
- providing an ecoregional context for conservation-oriented projects, proposals, and budget needs.

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7Gap status criteria are taken from Crist and others (2000). A scale of 1 through 4 is used to classify the relative degree of management devoted to maintenance of biodiversity for land units. A status of “1” denotes the highest, most permanent level of management, whereas “4” represents the minimum level of management or an unknown status. Appendix A, Table A.1 contains a more expansive definition for each Gap Status category.
Many of these recommendations have a direct bearing on the approach to natural resources management at the BMGR. First, the BMGR was included in two priority conservation areas: Pinacate/Organ Pipe/Goldwater Complex and Sand Tank/Sauceda Mountains Complex. In the present report these two conservation areas combined constitute the Greater Goldwater Complex\(^8\) or “Heart of the Desert” (Figure 2.2: Areas 13 and 32; Figure 2.3). The first area alone contained 69 conservation elements (not necessarily all found on the BMGR) with broad taxonomic representation—the largest total of elements by far of any conservation area in the ecoregion.

Second, because of its size and shape the BMGR incorporates much of the diversity of landforms, rainfall, and elevation gradients that are present within the Sonoran Desert in Arizona and that contribute to this ecoregion’s biodiversity. Along with the adjacent public lands, the BMGR presents unique opportunities to standardize natural community conservation elements and to assess the need for and to implement multi-site threat abatement strategies across a relatively unfragmented landscape (relatively unfragmented both in regard to land-use and land ownership/administration when compared with other locations within the Sonoran Desert).

Third, because of the nexus of federal land involved and the trans-border nature of the Pinacate/Organ Pipe/Goldwater Complex, this area more than any other in the Sonoran Desert Ecoregion can benefit from a broad regional view of its management context. The Greater Goldwater Complex, as defined above, likely constitutes one of the largest landscape-scale conservation area identified in any of The Nature Conservancy’s ecoregional plans. Although there are multiple landowners involved, the number is manageable and numerous initiatives already are underway (including the Barry M. Goldwater Executive Committee) to coordinate natural resources management across the area.

The BMGR is not a nature preserve. As a result, the management of natural resources, with the intent of ensuring the continued persistence of the range’s biodiversity, must be accomplished in the context of sustaining the military mission. For lands on which conservation is only one of multiple management goals, the integration of ecoregional data and a goals-based management approach into natural resources and comprehensive land-use planning will help ensure that the Sonoran Desert’s biodiversity is adequately characterized, evaluated, accounted for, and conserved through development of appropriate management programs and strategies (Marshall and others 2000).

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\(^8\)The Greater Goldwater Complex is defined here as including the BMGR and the adjacent, ecologically linked areas of Organ Pipe Cactus National Monument, Cabeza Prieta National Wildlife Refuge, Pinacate Biosphere Reserve, Sonoran Desert National Monument and other Bureau of Land Management-administered lands, and the extreme northwest and western portions of the Tohono O’odham Reservation.
Figure 2.2
Landscape-Scale Conservation Areas in the Sonoran Desert Ecoregion
(adapted from Marshall and others 2006)

- Sonoran Desert Ecoregion Boundary
- 13 Pinacate/Organ Pipe/Goldwater Complex
- 32 San Pedro/Sanhua Mountain Complex

Scale: 1:400,000

Projection: UTM Zone 12, NAD 27
Printed: Tucson, AZ, June 2001
The Nature Conservancy has practiced land conservation for decades. Some approaches effectively achieved biodiversity conservation and some did not. Recently, the Conservancy evaluated what worked and what didn’t and codified its approach to site conservation planning (The Nature Conservancy 2000). The five-S framework—systems (conservation elements), stresses, sources, strategies, and success—for site conservation initially was developed to meet the planning needs of Conservancy bioreserves. Today, with the advent of the landscape-scale, community-based approach to conservation the Conservancy has adapted the framework to meet the conservation planning needs of conservation areas.

3.1 FUNDAMENTALS OF SITE CONSERVATION PLANNING

The site conservation planning process assesses contextual information about an area (that is, conservation elements, stresses, sources) and as outputs from this assessment provides conservation (management) strategies and metrics for measuring the success of those strategies. The steps in the process are briefly identified in the following sentences. First, a focused set of conservation elements (species or natural communities) is identified that can serve as a surrogate for the native biodiversity of an area. Second, these elements are evaluated for their current viability and then used to identify those critical stresses and sources of stress that threaten their continued persistence. Third, management strategies are developed that are focused on the abatement of the critical threats. Fourth, measures that track the success of threat abatement and the status of target viability are developed.

The processes of ecoregional planning and site conservation planning are linked. A subset of the conservation elements that are used to inform the design of the conservation network at the ecoregional scale are present at each conservation area. Depending on the conservation area under consideration, the number of conservation elements present can range from one or a few to a couple of orders of magnitude greater. Despite the linkage, the purpose of conservation elements differs between the two planning processes and may result in some differences in element selection. In ecoregional planning, the primary purpose of conservation elements is to guide the selection of conservation areas—to ensure all biodiversity in the ecoregion is adequately represented in the proposed conservation network (portfolio of conservation areas), whereas in site conservation planning the primary purpose of conservation elements is to guide conservation strategies at individual conservation areas—what threats must be abated to maintain or restore the viability of each of the conservation elements (The Nature Conservancy 2000). It is important, however, that the conservation elements selected for the conservation area of interest capture all ecoregional conservation elements that are present, as well as capture all relevant levels of biological organization and spatial scale. In this way, threat abatement strategies, which include the maintenance of ecological processes at large spatial scales, will be protective of the overall biodiversity of an area. The different purposes of ecoregional and site conservation planning often leads to the use of conservation elements in site conservation planning that may be idiosyncratic—they may be defined ad hoc by planning teams rather than take their basis from a formal taxonomic or community classification system (as tends to be the case with ecoregional conservation elements)—to the conservation area (The Nature Conservancy 2000).

From a practical standpoint the treatment of conservation elements also differs between site conservation and ecoregional planning in two ways: the amount of detailed information gathered about each
conservation element that can inform its management and whether one element can serve as a management surrogate for another conservation element or biodiversity in general. At the scale of the conservation area, it is desirable to have as much detailed information as is available for each conservation element on the ecological characteristics of the element, its distribution, relative abundance, and viability, and the threats to which it exposed. For conservation areas with large numbers of conservation elements, such as the Barry M. Goldwater Range (BMGR), this becomes problematic; however, by also assessing which elements can act as surrogates for other components of the biodiversity of an area, the number of elements can be reduced to a manageable amount.

A common goal of conservation element selection for both ecoregional and site conservation planning is to avoid concentrating on just those species that are currently federally listed or are otherwise regarded as globally rare⁹ (or are a focus for another reason, such as game management). Threatened and endangered species management is only one step towards achieving the long-term goal of biodiversity protection. Without a thorough assessment of the viability status and threats to a representative sample of the biodiversity of an area, it would be difficult to predict which species may be the next candidates for listing and may require exorbitant costs to recover. By also acknowledging the importance of including natural communities as conservation elements, both planning processes make the assumption that if the communities possess ecological integrity their component species populations also will be viable. As a result, management strategies are not needed for each individual species. Additionally, a focus on the integrity of communities forces natural resource managers to address the ecological processes that shape and maintain each natural community.

Although not explicitly stated, an implicit component of developing management strategies for each conservation element is the formulation of an ecological desired future condition for each element. Ideally, ecological desired future conditions should be defined on the basis of a natural (or attainable) range of variation in composition, structure, and function for a particular conservation element (Leslie and others 1996). For many conservation elements, especially for those natural communities that have been largely altered since human settlement, defining a natural or historical range of ecological variation based on empirical data is not always feasible. An understanding of current ecological conditions and how they may have come about may provide at least a baseline of information for defining acceptable variation in altered natural communities. Additionally, no matter what the state of knowledge is about a particular conservation element, not all desired conditions will have easily measured attributes (Leslie and others 1996). As a result, many ecological desired future conditions may need to be stated in non-quantitative terms. Information on ecological desired future conditions for each conservation element on the BMGR will be provided in the Phase 2 report.

Traditional monitoring of natural resource conditions tends to be compliance driven and focused on single resource concerns, such as a listed species or wetlands. Often these monitoring protocols are designed to track metrics that represent measures of the viability of the resource of concern. Often these protocols do not track the status of stresses and their sources that threaten resource viability. Because the site conservation planning process highlights the need to identify stresses and their sources, it provides the requisite information needed to develop threat-based monitoring strategies for the BMGR. Additionally, the selection basis for conservation elements ensures that any associated monitoring strategies that are developed will to some degree monitor the status of biodiversity on the BMGR. Moreover, if these strategies are developed in coordination with the adjacent property owners, then the assessment of

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⁹Natural Heritage Programs use a five-category ranking system to describe a species’ rarity. A ranking of Global 1 (G1) characterizes the rarest species, whereas G5 characterizes the most common. The rationale against using only G1 or G2 species as targets is that often rare species are rare because they require specialized habitat conditions and, as a result, if considered alone would preclude adequately capturing the full complement of biodiversity in an area. Appendix A, Table A.2 contains a more expansive definition of each global rank.
conservation element viability and the status of threats will be accomplished within a broader, and perhaps more appropriate, ecological context. Monitoring objectives will be provided for each conservation element in the Phase 2 report.

3.2 Integration with Natural Resources Management Planning

Natural resources management at the BMGR will have a continued need to address special status species and game species; however, the focus of management concern needs to be broader. Indeed, the Department of Defense is committed to a broader view of biodiversity management and protection. A broader approach to management forces natural resource managers to consider: (1) how individual organisms use the landscape, such as the natural movement of desert bighorn sheep (*Ovis canadensis mexicana*) between mountain ranges, (2) what the dominant ecological processes are that govern the composition, structure, and function of natural communities and how maintaining these processes contributes to functional landscapes, and (3) how a consideration of landscape features in general can contribute to the maintenance of biological diversity.

Notwithstanding the above, some special status and game species are included within the conservation elements identified in this report. The BMGR’s Integrated Natural Resources Management Plan (INRMP), insofar as the plan is intended to address biodiversity management and protection, can use the total suite of conservation elements as surrogates for the BMGR’s biodiversity. Appropriate management of these elements should provide a reasonable expectation that biodiversity can be conserved on the BMGR and within the Greater Goldwater Complex. To ensure that management is appropriate, however, single species management prescriptions, whether for special status species or for game species, should be compatible with the management of conservation elements.

Ultimately, the following products from the site conservation planning process for the BMGR will be available to incorporate into the INRMP:

- set of conservation elements that are a representative sample of the biodiversity present on the BMGR and that can be used to set management goals and objectives for biodiversity conservation
- information for each conservation element that describes, for example, its ecological characteristics, conservation status, stressors and sources of stress, desired future ecological conditions, and monitoring objectives
- geospatial data on the occurrence and distribution of natural community elements
- recommendations on appropriate management areas and associated management standards needed to conserve each conservation element
- regional context information on the occurrence and conservation status of conservation elements on land adjacent to the BMGR and an assessment of the opportunities for coordinated management, including a regional approach to ecological monitoring.

Although not an explicit requirement of the site conservation planning process, the approach used to collect the ecological data contained in this report is also of relevance to the INRMP development process. Data were collected from regional scientific and agency experts that typically would have been hard pressed to participate in the INRMP development process. As a result, through the site conservation planning process Luke Air Force Base and Marine Corps Air Station Yuma have gained access to scientific information that otherwise might not have been available to them. In summary, this report
provides a documented and science-based approach for making natural resources management decisions in the context of a military training environment that can be incorporated into the INRMP.
It has been only since the early 1990s that federal environmental policy has recognized native biodiversity protection and management as an end in itself. Up until then the focus of conservation tended to be on listed species (threatened or endangered) or otherwise rare species. As a result, whereas conservation within the private sector focused on relatively small nature preserves, on the more extensive public lands endangered species management and recovery planning dominated (Poiani and others 2000).

The Department of Defense’s policies in regard to biodiversity and management were outlined in Chapter 2. Other federal agencies also are placing a new focus on biodiversity management in the context of an ecosystem approach to natural resources management. Even in the context of environmental impact analysis, biodiversity considerations have taken on a new prominence (Council on Environmental Quality 1993).

Given that the long-term protection of native biodiversity is the desired outcome of management, then it becomes necessary to develop appropriate management frameworks and metrics to assess the status of biodiversity over time (Noss 1990). Moreover, because biodiversity viewed expansively includes many levels of biological organization (for example, species, communities, landscape types) that each reflect complex composition, structure, and function (that is, associated ecological processes) (Noss 1990), biodiversity management and protection must address the need to conserve dynamic, multi-scale ecological patterns and processes that sustain the full complement of species and natural communities (see Poiani and others 2000 and references cited therein).

The relevant question becomes: How do we represent and assess the status of biodiversity for the purposes of management and protection at a landscape-scale conservation area such as the Barry M. Goldwater Range (BMGR)? The following sections provide an overview of the general principles of conservation biology inherent in the selection of conservation elements that can serve as surrogates for biodiversity, the approach used to select conservation elements specifically for the BMGR, and the methods used to collect and analyze ecological data associated with each conservation element selected.

**4.1 SELECTION OF CONSERVATION ELEMENTS: GENERAL PRINCIPLES**

Although appealing in concept, the shift from biodiversity conservation based on rare or listed species to conservation based on other more inclusive levels of biological organization is itself problematic. Some attempts to broaden the management focus from a single-species approach used groups of species (guilds\(^{10}\)) or a surrogate species (indicator, umbrella, or flagship species [Caro and O’Doherty 1999]) to represent the conservation needs of other species of interest. These approaches have drawn sharp criticism for their lack of biological basis and rigor of application (Caro and O’Doherty 1999, Landres and others 1988, Poiani and others 2000).

In answer to these problems, a growing appreciation to use ecosystems—generally a spatially explicit, but scale-independent and dynamic, unit that includes all ecologically linked components of the biotic and abiotic environment within its boundaries—as the unit of biodiversity management has gained favor within the scientific community (Ecological Society of America 1995). The linkage of species- and

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\(^{10}\)A guild represents a group of species that exploit the same class of environmental resources in a similar way (Begon and others 1990).
ecosystem-level concepts in biodiversity conservation has lead to the coarse filter-fine filter strategy used herein. This approach stresses the importance of conserving viable examples of natural communities or ecosystems to protect the vast majority of species: the coarse filter.

Any rare or specialized species whose management needs would go unmet under a coarse-level approach are treated individually: the fine filter (Poiani and others 2000). Additionally, those species that may play a disproportionate role in maintaining the critical ecological processes that maintain natural communities—keystone species—also are considered. As discussed in section 3.1, some relatively abundant as well as rare species are considered as conservation elements to prevent overlooking those species, in addition to those whose specialized needs preclude them from capture by community targets, that are particularly vulnerable to a particular threat and, as a result, may be on the horizon for listing if not properly managed now. Additionally, an attempt is made to ensure species conservation elements are spread among higher-level taxonomic categories to ensure that property of biodiversity is addressed.

Biodiversity occurs at both different levels of biological organization and at different spatial or geographic scales (Noss 1990, Poiani and others 2000). To efficiently capture the biodiversity of an area both properties of biodiversity need to be considered. Figure 4.1 displays the relationship between four spatial scale representations and two organizational levels (species and communities) of biodiversity. Linear communities, such as riparian communities, do not fit easily into the spatial scale schema and may require a case-by-case assessment of their spatial properties. Table 4.1 provides a sample of ecological characteristics, applicable to each intersection of scale and organizational level. The intersections should be used as a guide and not be viewed as non-overlapping or rigid in their application. For example, some coarse-scale, area-dependent (sensitive) species may behave as habitat specialists for most of their life cycle but require the use of other habitats to meet dispersal requirements or other needs.

**Figure 4.1** Biodiversity Expressed at Different Spatial Scales and Levels of Organization (adapted from Poiani and others [2000])
TABLE 4.1 Characteristics of Species and Natural Communities at Different Spatial Scales

<table>
<thead>
<tr>
<th>Level of Biological Organization and Scale</th>
<th>Characteristic</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional-scale species</td>
<td>Wide-ranging</td>
<td>Caribou</td>
</tr>
<tr>
<td>Matrix community</td>
<td>Successional mosaic, large spatial extent, amorphous boundaries</td>
<td>Sagebrush steppe</td>
</tr>
<tr>
<td>Coarse-scale species</td>
<td>Area-dependent [sensitive], habitat generalists</td>
<td>Red-cockaded woodpecker</td>
</tr>
<tr>
<td>Large-patch community</td>
<td>Defined by physical factors/regimes, internal structure and composition either homogeneous or patchy</td>
<td>Pine barren</td>
</tr>
<tr>
<td>Intermediate-scale species</td>
<td>Use large patches or multiple habitats</td>
<td>Timber rattlesnake</td>
</tr>
<tr>
<td>Small-patch community</td>
<td>Geomorphically defined, spatially fixed discrete boundaries</td>
<td>Bog</td>
</tr>
<tr>
<td>Local-scale species</td>
<td>Habitat restricted or specific</td>
<td>Bay checkerspot butterfly</td>
</tr>
</tbody>
</table>

1 Adapted from Poiani and others (2000).

A more complete description of the spatial pattern associated with each of the natural community types listed in Table 4.1, as well as for linear communities, is provided in Appendix A, Table A.3. A particular conservation area will be composed of a mixture of natural communities that typify these different spatial patterns. Each species and natural community also can be characterized by its distributional characteristics. Distribution patterns are an additional piece of information that can be used to determine the appropriateness of a species or natural community to be used as a conservation element for a particular conservation area. Table A.4 in Appendix A provides definitions for each of the distribution categories considered in this report.

The various fine-filter criteria that have been discussed in the preceding paragraphs are summarized in Table 4.2. We consider specialized species in two contexts: area-dependent species that range across and require the use of more than one natural community at landscape scales (for example, they require mountain-valley-mountain complexes to meet their life cycle or demographic requirements) and those species that show a strong association with a particular natural community, but whose habitat needs may not be fully met by only managing for the persistence of that natural community (for example, species that rely on ephemeral water sources to reproduce and to support the habitat needs of their early life stages, but whose post-larval life stages use surrounding habitats when not breeding). Specialized habitats also are considered. Although in many cases these habitats may correspond to small-patch communities, they also can be large-patch communities that may be widely scattered and/or relatively rare throughout an ecoregion. In some contexts specialized habitats may constitute part of the coarse filter and the fine filter in others.

4.2 SELECTION OF CONSERVATION ELEMENTS FOR THE BARRY M. GOLDWATER RANGE

The approach used to select conservation elements for the BMGR followed the principles that are outlined in the previous section. This section describes the specific steps that were taken to select appropriate conservation elements for the BMGR.
Table 4.2 Fine-filter Criteria Used to Select Species and Specialized Habitat Conservation Elements

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialized habitats</td>
<td>A small-patch community that often is associated with local-scale, habitat-restricted species or large-patch communities that are widely scattered and/or rare throughout the Sonoran Desert Ecoregion.</td>
</tr>
<tr>
<td>Area-dependent species</td>
<td>Species that require the use of a large minimum area to meet all of their life cycle and demographic requirements and that may be especially vulnerable to habitat fragmentation that isolates various natural community types from each other.</td>
</tr>
<tr>
<td>Keystone species</td>
<td>Species that have a disproportionately large effect on other species in a community (Meffe and Carroll 1994) or on the maintenance of critical ecological processes (Poiani and others 2000).</td>
</tr>
<tr>
<td>Specialized species</td>
<td>Species that may demonstrate a strong association for a particular natural community or a specific biotic or abiotic component of that community, but whose management needs are not fully met within that community type. Not to be confused with an indicator species, which is a characteristic or surrogate species for a community or ecosystem (Meffe and Carroll 1994).</td>
</tr>
<tr>
<td>Regionally vulnerable species</td>
<td>Species that although they may be widely distributed throughout the ecoregion, they may be regionally vulnerable if the current or predicted future threats to their viability are considered. Such species may be subject to intense collection or overharvest pressures, may be especially vulnerable to the effects of fragmentation, or may be particularly sensitive to the impacts of a particular environmental threat (for example, acid rain) that is regional in its scope.</td>
</tr>
</tbody>
</table>

4.2.1 Steps Common to the Selection of All Conservation Elements

The first step in selecting conservation elements for the BMGR was to consult the information on ecoregional conservation elements acquired as part of the ecological analysis of conservation priorities for the Sonoran Desert Ecoregion (Marshall and others 2000). Two landscape-scale conservation areas identified in the preceding analysis overlapped with the boundaries of the BMGR: Pinacate/Organ Pipe/Goldwater Complex (with 69 conservation elements identified during the ecoregional analysis) and Sand Tanks Mountains (with 12 conservation elements, but only two of which were different than the elements in the other conservation area) (Marshall and others 2000).

The conservation elements to be selected as focal elements for incorporation into the integrated natural resources management plan (INRMP) development process generally must be known to occur on the BMGR. Because the boundaries of the Pinacate/Organ Pipe/Goldwater Complex and Sand Tanks Mountains conservation areas extend beyond the boundaries of the BMGR, some of the conservation elements identified for these areas may not occur on the BMGR. Additionally, natural resource managers for the BMGR may have additional species_communities for which they have a management concern or they may have information that indicates an ecoregional conservation element previously unknown to the BMGR actually occurs there. As a result, Step Two in the selection process consisted of providing BMGR natural resource managers and selected regional experts familiar with the BMGR with the Pinacate/Organ Pipe/Goldwater Complex and Sand Tanks Mountains conservation areas conservation element lists and the total list of conservation elements for the entire Sonoran Desert Ecoregion. These individuals were then asked to delete species/community elements not found on the BMGR, add those from the master ecoregional list that they thought did occur, and otherwise add those species/communities that occurred on the BMGR and for which they had some management concern. This first cut at developing a list of potential conservation elements for the BMGR identified a total of 91 potential
species/natural communities. The distribution by rarity (combined global rank) and taxonomic group of this initial list of conservation elements is provided in Table 4.3.

**Table 4.3** Distribution of Preliminary List of Conservation Elements for the Barry M. Goldwater Range by Combined Global Ranks and Taxonomic Group (91 Total Elements)

<table>
<thead>
<tr>
<th>Number</th>
<th>Combined Global Ranks</th>
<th>Taxon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G1 (rarest)</td>
<td>G2</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>26</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Community</th>
<th>Plant</th>
<th>Invertebrate</th>
<th>Fish</th>
<th>Amphibian</th>
<th>Reptile</th>
<th>Bird</th>
<th>Mammal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>24</td>
<td>39</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>8</td>
<td>11</td>
<td>8</td>
</tr>
</tbody>
</table>

1 Global ranks are defined in Appendix A, Table A.2. Criteria for converting global ranks to combined global ranks also are provided as part of Table A.2.

Although the distribution by rarity indicates that the initial screen of potential conservation elements is focused neither on the most rare nor the most common elements, the distribution by taxonomic group indicates some shortcomings. With no permanent flowing water on the BMGR, it is not surprising that fish species are absent; however, the presence of ephemeral water may lead to a local abundance of amphibians, though probably with low species richness because of poor niche differentiation. Still, because they tend to be associated with specialized habitats and also make use of the adjoining landscape, they may as a group serve as important conservation elements. The most obvious shortcoming is that no invertebrates were identified, which may be more a reflection of the lack of occurrence information for invertebrates species on the BMGR and their individual habitat requirements rather than an indication that no potential invertebrate conservation elements are present. Another finding that can be derived from the table is the large number of plant species that potentially could serve as conservation elements, but which in many cases perhaps can be adequately captured by a natural community element.

Step Three involved screening the initial list of potential conservation elements for their suitability as focal conservation elements. Each potential element was again evaluated as to the likelihood of its presence on the BMGR (especially the natural community targets) and whether it met of any of the screening criteria in Tables 4.1 and 4.2. A small-group workshop was held on September 20, 2000 with Luke Air Force Base and Marine Corps Air Station Yuma natural resource managers and staff from The Nature Conservancy to go over the initial list and to identify attributes of each potential conservation element in regard to the screening criteria and to make an initial determination as to whether geospatial data were available to document the occurrence and distribution of the element on the BMGR. Elements whose occurrence could not be documented or did not meet at least one of the screening criteria were eliminated from further consideration.

Step Four used interviews, questionnaires, and workshops involving regional scientific experts to further refine the selection process. Experts were used to address four areas of concern:

- potential conservation elements that were missing (As part of the interview process, experts were encouraged to identify species or guilds that they thought could serve as conservation elements for the BMGR. Additionally, experts also were queried for their knowledge about those species on the preliminary list that were poorly documented or for which their ability to meet the fine-filter screening criteria was uncertain.)

4.5
• specific invertebrate species known to occur on the BMGR that could serve as appropriate conservation elements

• additional information on the initial list of potential plant species elements to enable determining whether each plant would be captured by a natural community element or whether it should remain as a stand-alone conservation element

• additional information on the utility of and the capability to map the occurrences of the preliminary list of natural community conservation elements

Methods used to address the last three items above are contained in the following sections. This is followed by a section that describes how potential species conservation elements were further evaluated as to whether they could be adequately captured by a natural community element.

4.2.2 Selection of Invertebrate Conservation Elements

No invertebrate, ecoregional conservation elements were initially identified as occurring on the BMGR. To attempt to improve the taxonomic breadth of the conservation elements and, as a result, to better represent biodiversity, expert entomologists were contacted to ascertain the potential for invertebrates that were present on the BMGR to serve as conservation elements (See Appendix B for a list of experts that were contacted/gave feedback on invertebrates).

Two personal interviews were held with entomologists that have a wealth of experience with Sonoran Desert invertebrates. Dr. Carl Olson, the curator of the insect collection in the Entomology Department at the University of Arizona, was consulted for input on unique invertebrate fauna associated with tinajas or other specialized habitats on the BMGR. Dr. Steven Buchmann, a bee biologist, was interviewed to gather information about the importance of the BMGR to the bee and pollinator biodiversity of the Sonoran Desert. The Sonoran Desert contains the highest known diversity of bee species in the world (Phillips and Wentworth Comus 2000).

In addition to the interviews with Drs. Buchmann and Olson, other experts were consulted by telephone. A list of the invertebrate conservation elements for the entire Sonoran Desert Ecoregion was provided to experts as a starting point to confirm whether any of these species were known to occur on the BMGR. Invertebrate experts also were given a copy of the initial list of plant species conservation elements and were asked to consider the relationship between any invertebrates and the plants as potential host species for invertebrates.

We concluded that we do not have enough information at present to select an invertebrate as a focal conservation element on the BMGR. The recommendations provided by experts on this topic are presented in Chapter 8.

4.2.3 Selection of Plant Conservation Elements

Via letter, botanical experts familiar with the flora of the Sonoran Desert were requested to provide occurrence and ecological information on the 39 plants that were identified in the initial list of potential conservation elements. The information was used to confirm the documented occurrence of particular rare plant species on the BMGR and to assess the suitability of each species to meet the screening criteria (Tables 4.1 and 4.2) for retention as a focal conservation element. Botanists and other experts that provided information on plant conservation elements are listed in Appendix C, and their recommendations are discussed in Chapter 8.
4.2.4 Selection of Natural Community Conservation Elements

The choice of natural community elements for the BMGR presented special difficulties. Natural communities can be based on defined plant communities at different hierarchical levels of organization, on biophysical features, or strictly on abiotic features of the environment that account for hydrological and/or geomorphological characteristics of the community. For plant communities, the available mapped data for the area of the BMGR differs in the vegetation classification system used, the scale at which the mapping occurred, the method used to accomplish the mapping, and whether the information was available digitally. The following data sets were evaluated:

- Biotic Communities of the Southwest map (Brown and Lowe 1994) and classification system (Brown 1994, Brown and others 1979)
- Arizona Gap map (Arizona Gap Program 1998)
- Vegetation in the Sonoran Desert Ecoregion (Marshall and others 2000)
- Vegetation-type map of Luke Air Force Range (Tunnicliff and others 1986)
- Natural Vegetation Map of Arizona. Data collected by the Arizona Game and Fish Department in 1976 and digitized during 1992/1993 by the University of Arizona (University of Arizona 1993)
- Barry M. Goldwater Range aquatic data layers for playas, springs, and tinajas
- Barry M. Goldwater Range, Digital Orthophoto Quadrangle Quadrants (DOQQs)

Additionally, Michael Kunzmann (University of Arizona), an expert on the U.S. Geological Survey’s North American Gap map project, was interviewed to gain information about the accuracy and limitations of the Arizona Gap map, particularly in its ability to depict the natural communities that were under consideration as conservation elements. According to Kunzmann, the only plant communities that can be distinguished and accurately classified in the Sonoran Desert using remote sensing technology are the Arizona Upland Subdivision (Paloverde-Mixed Cacti Series) and the Lower Colorado River Valley Subdivision (Creosotebush-Bursage Series). When the Gap map vegetation classification was groundtruthed, the accuracy of these series was relatively high: 71.64% for Paloverde-Mixed Cacti and 77.01% for Creosote-Bursage (M. Kunzmann, personal communication). A more detailed Gap map is available, but Kunzmann recommended avoiding the use of this map because it was created for the purpose of habitat analysis and is inaccurate in its depiction of plant communities (for example, Saltbush Series accuracy on this map ranged from 0.08 to 50%).

For mapped plant communities, the most refined data layer available was contained in Tunnicliff and others (1986). The classification system used by these investigators was a modification of the hierarchical classification system developed by Brown and others (1979). The mapped communities can be divided into two subdivisions, three series, eight major associations, and 23 minor associations (Brown and others [1979] only provided examples of communities down to the major association level). An advantage of this map for use in this project was that it also included most of Cabeza Prieta National Wildlife Refuge within the mapping boundaries. Two disadvantages were that the data were collected via on-the-ground surveys for a large land area within only a week’s time and the map was no longer available in digital form. As a result, the classification accuracy and spatial accuracy of the mapped polygons more than likely were low.

To enable use of the data in a geospatial operating environment, the Tunnicliff and others (1986) map had to be digitized. This was accomplished in-house by The Nature Conservancy’s Geographic Information System (GIS) Manager. The administrative boundaries of the BMGR and Cabeza Prieta National Wildlife Refuge were used to geospatially orient the map. After digitizing and subsequent comparison to other georeferenced physical feature data layers, however, we found that the resultant mapped polygons generally had poor spatial correspondence with these other data layers.
The initial list of potential, natural community conservation elements was whittled down to those community elements that had a reasonable expectation of occurrence on the BMGR (some suggested natural community elements were outside their range of expected occurrence), were not easily subsumed within another natural community element for management purposes, and could be mapped. The capacity to map the natural community elements was based on a crosswalk with the mapped plant communities contained in Tunnicliff and others (1986). With some exceptions only the major association-level communities were considered in the crosswalk. Specialized habitats, such as playas and tinajas, could be mapped based on separately available data sets (see above) and didn’t rely on a crosswalk. A new digital map was prepared based on the crosswalk. Appendix D contains tabular information on this first cut at identifying the natural community conservation elements for the BMGR.

We then convened a facilitated workshop to which we invited regional scientific experts and natural resource managers that were knowledgeable of natural communities on the BMGR and/or plant community ecology in the Sonoran Desert. Nineteen individuals, including staff from The Nature Conservancy that facilitated the proceedings, attended the workshop (Appendix E). The goals of the workshop were to:

- evaluate the accuracy of the mapped distributions of the natural community elements on the BMGR (as depicted on the draft digital map described above)
- evaluate the relative significance of the BMGR to the persistence of these community elements within the Sonoran Desert Ecoregion.

Although the draft map of natural community elements and other data layers on hand provided a point of departure for framing the workshop discussion, it was clear early on that the assembled experts questioned the on-the-ground accuracy and descriptive utility for management purposes of many of the proposed community types. As a result, one of the most significant outcomes of the workshop was the discussion among attendees that resulted in a reasonable consensus to drop some communities from consideration, redefine others, and add new communities. Much of the information that the experts offered for defining natural community elements for the BMGR relied on biophysical descriptions. This information was used later to create a geospatial model for some of the community types as on-the-ground mapping data was not necessarily available. The specific modeling parameters used to map a particular community type are described in Chapter 6.

The redefined natural communities created community conservation elements that were practical and logical units for conservation and management. We used this set of meaningful natural community elements for the BMGR to further engage the experts in providing information on the ecological characteristics of each element, conservation status and relative importance of the BMGR to the element’s persistence in the Sonoran Desert, associated information needs, and known threats. The findings of the workshop are reported in Chapter 6. Community descriptions therein were supplemented using information from Reid and others (1999), which is a classification of vegetation alliances for the western United States. Summary information on the natural community conservation elements is provided in Chapter 5.

Results from and analysis of information obtained from the natural community workshop were sent to all participants. Workshop participants were asked to provide comments on the information presented in Chapter 6 and all comments received were considered and incorporated as appropriate into this report.
**4.3 DATA COLLECTION AND ANALYSIS**

The section that immediately follows describes the methods we used to gain conservation-related information for each of the species conservation elements. This is followed by a section that briefly describes how summary statistics were computed for demonstrating the existing land management protection status of coarse-scale natural communities for the Sonoran Desert Ecoregion and for the BMGR by itself. This analysis can be used to describe the relative importance of the BMGR to the conservation of these communities within the Sonoran Desert Ecoregion. A final section describes methods used to assess the efficacy of our selection of conservation elements.

**4.3.1 Species Conservation Elements**

A number of resources, including expert opinion, survey data, and published research, were consulted to obtain relevant conservation-related information on each of the conservation elements. In-person and/or telephone interviews were conducted with at least one expert for each taxonomic group that included a conservation element (Appendix F). Prior to each interview, background information was sent to the expert to explain the background and purpose of the meeting and to suggest how s/he could best prepare for the interview. This helped to clarify the interview’s purpose and to keep the discussion focused on relevant information needs. Additionally, a general interview script was prepared that acted as a guide during the interviews and further served to keep the discussion focused.

Similar to the information goals associated with the natural community conservation elements, the interviews with taxonomic experts focused on two key information areas:

- relative importance of the BMGR to the continued persistence of the conservation element in the Sonoran Desert Ecoregion
- occurrence information for the conservation element on the BMGR.

Although the preceding areas of inquiry seem broad, they were used as departure points to gain more detailed information on a species or guild to the extent that the expert was knowledgeable about specific areas of an element’s biology or conservation needs. Additional areas of inquiry included the occurrence of the conservation element within the lands surrounding the BMGR, the conservation status (viability) of the element throughout its distribution in the Sonoran Desert, and the main threats (past, present, and future) to the persistence of the element on the BMGR and throughout its range.

As a result of the expert interviews, some new species conservation elements were suggested and some were dropped from consideration. Additionally, some species were combined with other species to create guild conservation elements. Guilds were considered as conservation elements when the combination of species considered better captured the range of management issues that may be of management concern and potentially resulted in a more efficient management approach versus addressing each species individually. Summary information on the species/guild conservation elements is provided in Chapter 5 and a more complete description of these elements is included in Chapter 7.

**4.3.2 Summary Statistics for Land Management Status**

We calculated, using geospatial data layers for remotely sensed natural communities (as described in Marshall and others 2000) and Gap land management status, the intersection of community type with land
management status. We performed this calculation for the Sonoran Desert Ecoregion as a whole and for the BMGR. The results of our calculations are provided in Chapter 6.

4.3.3 Nesting of Conservation Elements

As a final check on the efficacy of our selection of conservation elements, we are conducted two post-hoc analyses. First, we identified whether those species from the original list of potential species conservation elements—67 species minus those later identified as not confirmed to occur on the BMGR, plus any additional species that may have been suggested by experts to add—had either an obligate (restricted to) association with a natural community element or at least relied on the community’s presence and viability to fulfill a significant portion of their life-cycle requirements. We created a matrix that crossed natural community with species and identified whether a relationship existed between each possible combination. Second, we identified the number of species associated with each natural community to assess how well a particular natural community functions as part of the coarse filter.

We used the first analysis in part to help us determine whether the natural community conservation elements do indeed function as a coarse filter for those species of management concern that we do not intend to recommend as species conservation elements. For these species we hypothesize that if the natural community element is properly managed, the long-term persistence of the species associated with this community should be reasonably ensured. As a result, we consider those species that are “captured” by the coarse filter to be nested conservation elements.

Generally, community-obligate species are by definition nested elements; however, one exception is possible. When the management of a species is compliance-driven (for example, federally listed species), then even obligate species may still require focused management attention (though part of their management may require a consideration of the viability of the natural community to which they are obligate). Those species that have multiple community associations must be evaluated on a case-by-case basis as to whether they qualify as fine-filter conservation elements in accordance with the criteria in Table 4.2. As a result, the assessment of community association is only one piece of information used to determine which species should be identified as part of the fine filter. Those species/guilds that have specialized management needs are not considered nested elements.

4.4 Development of Desired Future Ecological Conditions and Monitoring Objectives

The desired future ecological conditions and broad monitoring objectives for the conservation elements of the BMGR were developed through a one-day experts’ workshop held on January 4, 2001 and by subsequent interviews with selected experts. The workshop was attended by representatives from the BMGR’s INRMP Core Planning Team, land managers from properties adjoining the BMGR, and biologists with knowledge of the BMGR and expertise on the natural communities and species conservation elements previously identified for the BMGR. A list of workshop attendees is provided in Appendix G.

The main goals of the workshop were:

1. To define management goals—desired future ecological conditions—for the conservation elements (species and natural communities) identified for the BMGR
2. To develop broad monitoring objectives for each conservation element that can indicate whether desired conditions are achieved (that is, identify what management questions monitoring needs to address)

3. To consider the management goals and monitoring objectives (1 and 2, above) as they related to the conservation elements on the BMGR, as well as within a larger regional context, and to identify the potential for coordinated management strategies with properties adjoining the BMGR.

The general characteristics that were used to define the desired future ecological condition of a conservation element can be grouped into four categories: composition, structure, function, and landscape context. Examples of variables within each of these categories are provided in Table 4.4 for both natural communities and species/guilds. Examples for the first three categories are taken from Noss (1990).

**Table 4.4 Examples of Variables that May be Used to Define the Desired Future Ecological Conditions of a Conservation Element**

<table>
<thead>
<tr>
<th>Category</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natural Communities</strong></td>
<td></td>
</tr>
<tr>
<td>Composition</td>
<td>Native versus non-native species, species richness, evenness</td>
</tr>
<tr>
<td>Structure</td>
<td>Horizontal structure (patchiness, cover amounts, stem densities), vertical structure (vegetation strata), dead and downed woody debris component</td>
</tr>
<tr>
<td>Function</td>
<td>Hydrological regime, patch dynamics, human intrusion rates and intensities, resource productivity</td>
</tr>
<tr>
<td>Landscape context¹</td>
<td>May consider the above variables at three possible scales:</td>
</tr>
<tr>
<td></td>
<td>• within the boundaries of the natural community</td>
</tr>
<tr>
<td></td>
<td>• external to the boundaries of the natural community, but within the boundaries of the BMGR (an administrative context)</td>
</tr>
<tr>
<td></td>
<td>• external to the boundaries of both the natural community and the BMGR (that is within jurisdictions adjoining the BMGR; perhaps necessary to evaluate the correct ecological context)</td>
</tr>
<tr>
<td><strong>Species and Guilds</strong></td>
<td></td>
</tr>
<tr>
<td>Composition</td>
<td>Abundance</td>
</tr>
<tr>
<td>Structure</td>
<td>Population structure (age, sex), metapopulation characteristics, distribution pattern</td>
</tr>
<tr>
<td>Function</td>
<td>Recruitment, mortality, and fertility rates, metapopulation dynamics</td>
</tr>
<tr>
<td>Landscape context¹</td>
<td>May consider the above variables for the conservation element in a broader context; for example outside the boundaries of the BMGR.</td>
</tr>
</tbody>
</table>

¹Landscape context is the category within which issues of connectivity should be addressed.

Additionally, Dr. Sue Rutman, botanist at Organ Pipe Cactus National Monument, kindly took the time to elucidate her perspective on those key ecological processes that maintain the ecosystem function of natural communities in the Sonoran Desert. Discussions with Dr. Rutman formed the initial basis of the information provided in Chapter 9 as background to the desired future ecological conditions. Any introduced errors are our own.
4.5 OPPORTUNITIES FOR COORDINATED MANAGEMENT

As noted in section 4.4, justifications for coordinated management strategies for each conservation element (where applicable) across administrative boundaries were developed in part at the experts’ workshop, at which land managers from some of the properties adjoining the BMGR were present. Additionally, separate interviews were held with land managers from the Cabeza Prieta National Wildlife Refuge (John Morgart and Don Tiller) and Tohono O’odham Nation (Scott Bailey and Jefford Francisco) to discuss the opportunities for coordinated management of conservation elements across the BMGR boundaries. The results of these interviews are presented in Chapter 12.
CHAPTER 5 OVERVIEW OF CONSERVATION ELEMENTS FOR THE BARRY M. GOLDWATER RANGE

A total of 25 natural communities/guilds/species are proposed to serve as a focal set of conservation elements for the Barry M. Goldwater Range (BMGR). These elements represent the outcome of a coarse-filter/fine-filter approach meant to capture and represent the biodiversity of the BMGR for management planning purposes under the BMGR’s Integrated Natural Resources Management Plan (INRMP).

The proposed set of conservation elements is based on our knowledge to date of the natural resources occurring on the BMGR. Additional species were suggested by experts for consideration as conservation elements; however, in many cases we lacked the requisite information needed to determine either whether such species qualified as fine-filter conservation elements or whether their occurrence on the BMGR could be confirmed. As a result, some species can be considered as potential conservation elements. Although we do not discuss them in the context of our selected conservation elements, we do provide information on these species that may prove helpful when assessing at a later date the choice of conservation elements. As a result, we suggest that the selection of conservation elements should be viewed as a dynamic process in which, as new information becomes available, the selection is periodically assessed and updated.

The proposed conservation elements for the BMGR are identified in Table 5.1. They are arranged within a matrix that shows their alignment with geographic scale and level of biological organization. Linear communities do not necessarily align with a particular geographic scale, but they are included for completeness. The table also identifies the basis for including a fine-filter element.

5.1 NATURAL COMMUNITY CONSERVATION ELEMENTS

The natural community conservation elements represent the coarse filter for capturing the biodiversity of the BMGR. These communities were developed based on the results of an expert workshop on the natural communities of the BMGR. As a coarse filter, the combination of natural communities, when appropriately managed to ensure the long-term persistence of each community type on the BMGR, should provide a reasonable assurance that the majority of species associated with these communities will remain viable as well. A summary table of information for and detailed descriptions of the natural community conservation elements is provided in Chapter 6; however, the elements are identified in Table 5.1.

5.2 SPECIES CONSERVATION ELEMENTS

The species and guilds are included as part of the fine filter. They are identified for individual management attention based on the assumption that management of the natural communities alone may not be sufficient to ensure their long-term persistence. They may already be rare, and deserving of focused management attention (such as a federally listed species), or they may have specialized habitat needs that are overlooked at the community level. Keystone species also are included in the fine filter because of the unique role they play in structuring communities. Guilds are identified as conservation elements when they can represent a range of management considerations better than individual species within the guild can represent alone, especially when management needs may conflict.

In the paragraphs that follow, a brief rationale is provided that identifies the basis for including a particular species/guild as a conservation element for the BMGR. These paragraphs are distillations of
**TABLE 5.1 Conservation Elements of the Barry M. Goldwater Range**

<table>
<thead>
<tr>
<th>Geographic Scale</th>
<th>Level of Biological Organization</th>
<th>Aquatic Natural Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional</td>
<td>Sonoran pronghorn (AD, federally listed)</td>
<td>N/A</td>
</tr>
<tr>
<td>Coarse</td>
<td>Bat guild (S, includes one federally listed species) Desert bighorn sheep (AD, RV) Kit fox (K, RV) Primary excavator (cavity) guild (K, S)</td>
<td>Creosotebush-Bursage Desert Scrub Paloverde-Mixed Cacti-Mixed Scrub on Bajadas</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Cowles fringe-toed lizard (S, RV) Crucifixion thorn (Castela emoryi) (RV) Desert tortoise (RV) Flat-tailed horned lizard (S, RV) Le Conte’s thrasher (S, RV) Valley bottom reptile guild (S)</td>
<td>Dune Complex and Dune Endemics Creosotebush-Big Galleta Scrub Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes Sand Tank Mountains Uplands Elephant Tree-Limberbush on Xeric Rocky Slopes Salt Desert Scrub</td>
</tr>
<tr>
<td>Local</td>
<td>Ephemeral water-breeding amphibian guild (S)</td>
<td>None identified to date</td>
</tr>
<tr>
<td>Linear</td>
<td>N/A</td>
<td>Valley Bottom Floodplain Complex Valley Xeroriparian Scrub Mountain Xeroriparian Scrub</td>
</tr>
</tbody>
</table>

1Legend: AD = area-dependent species; K = keystone species; RV = regionally vulnerable species; S = specialized species; SH = specialized habitat. Complete definitions for these fine-filter categories are provided in Table 4.2.

what appears in Chapter 7. Appropriate sources for cited information, when needed, are provided in Chapter 7. Elements are presented by taxonomic group.

**Plants**

**Crucifixion thorn (Castela emoryi).**—Castela emoryi (= Holacantha emoryi; Turner and others 1995) is an endemic species that may be in decline because of low levels of seedling establishment and poor growth/reproduction. Its habitat requirements are largely unknown, though it can be locally common on the silty soils of plains and alluvial bottomlands. Occasionally found on dunes. Stands of castela emoryi have been located on the BMGRP west of the Mohawk Dunes and along the margins of the Mohawk Playa, just east of the dunes (D. Turner, P. Warren). May be found in association with the Valley Bottom Floodplain Complex (Warren and others 1981 have found the species in habitats perhaps characteristic of
this community on Organ Pipe Cactus National Monument), though this relationship needs to be confirmed.

**Amphibians**

**Emphemeral water-breeding amphibian guild.**—This guild is composed of the Sonoran Desert toad (*Bufo alvarius*), red-spotted toad (*Bufo punctatus*), and Couch’s spadefoot (*Scaphiopus couchii*). The Sonoran Desert toad is currently the only amphibian endemic to the Sonoran Desert Ecoregion that is found on the BMGR. The Sonoran green toad (*Bufo retiformis*), another endemic, has yet to be documented on the BMGR, though it occurs in the Vekol Valley just to the east of the BMGR. Each of the three species included in this guild depends on the scarce surface water resources found on the BMGR to accomplish reproduction and to enable completion of the larval stage of development. They also make use of adjacent community types to fulfill the rest of their life-cycle needs (food, shelter, dispersal, and so on).

They are included within a guild for management purposes because of potential differences in the: types of surface water they may use (that is, playas, natural tinajas, and modified tinajas and artificial waters), competitive advantage each may have relative to the other (and other species associates) under different water regimes (that is, ephemeral versus permanent waters), and historic, current, and projected future spatial patterns of the distribution of surface water types across the BMGR. A focus on one species may not meet the management needs of the other species or could even be counterproductive. The Sonoran Desert toad can be found near permanent water associated with springs, streams, and reservoirs, but it more typically is seen at ephemeral, intermittent, or semi-permanent waters. It most likely has benefited from artificial water developments in the desert. On the BMGR the red-spotted toad is associated with temporary pools and natural tinajas in bedrock bajadas and mountains and would be unlikely to breed in modified water sources in which rocky walls are absent. Couch’s spadefoot is associated with natural, seasonal water sources on the BMGR, particularly playas, though it may breed in any desert water source including those modified by humans. Couch’s spadefoot is potentially at a competitive disadvantage in more permanent waters.

**Reptiles**

**Desert tortoise (*Gopherus agassizii*).**—The desert tortoise is a regionally vulnerable species that is federally listed as threatened in California. Although the Sonoran Desert population south and east of the Colorado River is not federally listed, regional trends in land use and other human activities potentially threaten the population’s viability. Continued urban expansion in the Phoenix and Tucson areas continues to lead to loss of habitat for the tortoise. In addition to habitat loss, other correlates of human development potentially affect the long-term persistence of the desert tortoise in the region: tortoise collection, release of pet non-native tortoises that potentially introduce diseases into desert tortoise populations, and increases in raven (*Corvus corax*) abundance (prey on juveniles). Desert tortoises typically have low recruitment; as a result, increases in mortality rates above natural rates may not be offset. On the BMGR desert tortoises occupy rocky slope and bajada habitats that are generally associated with the Paloverde-Mixed Cacti-Mixed Scrub communities. The Sand Tank and Sauceda Mountains may provide the most significant opportunity for conserving the desert tortoise on the BMGR. Because desert tortoises have been found on the middle bajadas in association with caliche caves along major arroyos, military use of such areas may adversely impact tortoise populations there. Baseline population and habitat use on the BMGR are important information needs.

**Flat-tailed horned lizard (*Phrynosoma mcallii*).**—Endemic species that is regionally vulnerable because of continued habitat loss. The flat-tailed horned lizard was proposed for federal listing in 1993. The proposed listing was withdrawn in 1996 in part because of inconclusive data on population declines and
because of a Conservation Agreement involving state and federal landowners in Arizona and California. The BMGR contains the best-protected portion (Yuma Desert portion of the Gran Desierto) of the species range in the U.S. Although the Gran Desierto in Mexico contains the majority of the species’ range, most of the area is not formally protected. Lizards inhabit the sand sheet of the Yuma Desert and not the active dunes. As mapped, the Dune Complex and Dune Endemics natural community does not encompass the entirety of what needs to be protected and managed to sustain the flat-tailed horned lizard population on the BMGR. Adult mortality currently is high and, as a result, a reduction in adult mortality rates may be critical for population viability. The U.S.populaiton likely is isolated from the Mexico population by such barriers as Highway 2. Adults are vulnerable to road kills; increases in vehicle use within the range of their habitat on the BMGR are a threat.

Cowles fringe-toed lizard (*Uma notata rufopunctata*).—The species (subspecies) is endemic to the Sonoran Desert Ecoregion. The BMGR and Cabeza Prieta National Wildlife Refuge contain the entire occurrence of the subspecies within the U.S. Individuals are found solely on loose sands, as are found on active dunes and wind-blown sand sheets. Although it is restricted to habitats encompassed by the Dune Complex and Dune Endemics natural community, the sand sheet portion of this community type may be underrepresented in how it’s mapped on the BMGR (see Figure 6.1). The species is singled out for management on the BMGR primarily because one of the main populations on the BMGR, the Mohawk Dunes (which has some connectivity with the smaller San Cristobal Dunes), is isolated from the main population in the Gran Desierto by habitat loss along the Gila River. The Mohawk Dunes population may be distinct enough genetically from the Gran Desierto population to warrant identification as a separate species. The Mohawk Dunes population is currently viable and should remain so for the foreseeable future provided potential sources of stress that threaten its viability are managed appropriately: recreational vehicles (currently not permitted on the dunes) and invasive plant species. The U.S. Yuma Desert population also is in danger of being isolated from the Mexico portion of the Gran Desierto by population growth and development activities on the Mexico side of the border.

Valley bottom reptile guild.—This guild is composed of the western leaf-nosed snake (*Phyllorhynchus decurtatus perkinsi*), Colorado Desert shovel-nosed snake (*Chionactis occipitalis annulata* [= *C. saxatilis*]), sidewinder (*Crotalus cerastes*) (two subspecies), desert iguana (*Dipsosaurus dorsalis*), southern desert horned lizard (*Phrynosoma platyrhinos calidiarum*), and long-tailed brush lizard (*Urosaurus graciosus*) (two subspecies). As a group, these species are found in the lowest, driest, and most sparsely vegetated areas of the Sonoran Desert. They are not limited, however, to a single natural community type within the Lower Colorado River subdivision. The BMGR may function as an important center of each species’s (subspecies’s) distribution in which the populations are more abundant and viable than at other locations. Because the BMGR contains large, unfragmented, relatively undisturbed expanses of Creosotebush-Bursage Desert Scrub, Dune Complex, Valley Bottom Floodplain, and Valley Xeroriparian Scrub natural communities, it may present the best opportunity to conserve the members of this guild and other associated reptile species. They may be threatened by altered vegetation composition and structure due to the introduction of invasive plants and ground disturbance activities, invasive ants, and loss of habitat (off BMGR) due to conversion by agriculture and urbanization.

Birds

Le Conte’s thrasher (*Toxostoma lecontei*).—Species has a limited distribution, occurring primarily within the Mojave and Sonoran Deserts, and is one of the few bird species associated with low, arid desert valley bottoms. Where its habitat is intact it seems to be viable; however, the species is intolerant of habitat disturbance associated with human activity. Le Conte’s thrasher shows a strong association with saltbush (*Atriplex*)-dominated areas (Salt Desert Scrub); however, much of this habitat has been converted to agriculture or urban development. The species is now characteristic of creosotebush flats (Creosotebush-Bursage Desert Scrub), though its distribution within this community is spotty. The
BMGR and Cabeza Prieta National Wildlife Refuge may represent important areas for the conservation of this species.

**Primary excavator (cavity) guild.**—This guild is composed of the gilded flicker (*Colaptes chrysoides*) (endemic to the Sonoran Desert Ecoregion), Gila woodpecker (*Melanerpes uropygialis*), and ladder-backed woodpecker (*Picoides scalaris*). As a group, these woodpeckers provide nest sites for many other cavity-nesting birds besides themselves (see Table 8.2). Saguars (*Carnegiea gigantea*) provide one of the main nesting site locations for cavity-nesting birds in the desert. On the BMGR, gilded flickers and gila woodpeckers will use predominantly saguaro for nest sites. Because each species may place nest sites differently within the saguaro, as well as excavate the hole differently, the characteristics of the cavity may affect which secondary cavity nesters use the nest site once the woodpecker vacates the cavity. Additionally, ladder-backed woodpeckers do not typically excavate their nest cavities within saguaro; instead, they use mesquite (*Prosopis* spp.), paloverde (*Cercidium* spp.), and ironwood trees (*Olneya tesota*), as well as agave stalks. They provide nest sites for secondary cavity nesters different than those dependent on the other woodpeckers for nest cavities. The distribution of each member of the guild will differ across the BMGR as each species’ response differs to components of the habitat; however, xeroriparian areas are important foraging areas for each species. The main distribution of cavity nesters on the BMGR is east of Highway 85 within the bajadas of the Sauceda and Sand Tank Mountains. West of Highway 85 their abundance lessens and they become reliant on xeroriparian habitats that can support saguaro and leguminous trees. The European starling (*Sturnus vulgaris*) is an invasive, secondary cavity-nesting species that has been documented on the BMGR. They can potentially outcompete other saguaro cavity nesters for nest sites. As human conversion of the landscape continues to encroach near the borders of the BMGR, the human habitat-associated starling can be expected to have increased opportunities to expand its range into the paloverde-mixed cacti-mixed scrub communities.

**Mammals**

**Sonoran pronghorn** (*Antilocapra americana sonoriensis*).—Endemic, area-dependent species that is federally endangered. We did not solicit expert input on this species as its management is well defined by a Recovery Team process. It is included here for completeness and because its presence does play a role in determining appropriate recommendations for designating Special Natural Areas and/or developing management standards for a particular area of the BMGR that is within the Sonoran pronghorn’s range.

**Desert bighorn sheep** (*Ovis canadensis mexicana*).—As an area-dependent species, desert bighorn sheep require large, unfragmented landscapes to maintain population viability. Although traditionally desert bighorn sheep have been managed as if they solely occurred within a mountain range, a landscape approach to management is needed, as the flats between mountain ranges may act as important corridors to gain access to other ranges for foraging and lambing. Sheep quickly and cautiously disperse between mountain ranges by crossing the shortest route. Bighorn sheep populations have dramatically declined throughout their range. In the desert Southwest populations potentially may become fragmented and isolated by roads and fences. As a result, the desert bighorn sheep can be considered a regionally vulnerable subspecies. Finally, habitat management activities associated with desert bighorn sheep are controversial and deserved focused attention. Management actions intended to “improve” habitat for desert bighorn sheep potentially could have unintended adverse impacts to non-target species and natural communities. As a result, management of this species should be viewed in a broader ecosystem context.

**Kit fox** (*Vulpes macrotis*).—In Table 5.1 the kit fox is identified as a keystone species. This may not be the most accurate descriptor of its ecological role, at least based on any specific data. Its inclusion as a species conservation element is to ensure that at least one top predator is included in those species to be included as a focal point for management. To the extent that predators shape trophic structure and prey population dynamics within a community, they do function as keystone species. Kit fox also may be
regionally vulnerable as their habitat, low desert Creosotebush-Bursage Desert Scrub and Salt Desert Scrub on fine, sandy soils, is particularly vulnerable to conversion to agriculture and urbanization. A historic stress was unintentional poisoning or trapping meant for coyote (Canis latrans) control. To the extent that coyote control may be practiced on the BMGR to assist with endangered species recovery, it is important to address the potential unintended impacts to kit fox populations.

Bat guild.—This guild is composed of the lesser long-nosed bat (Leptonycteris curasoeae yerbabuenae), California leaf-nosed bat (Macrotus californicus), and cave myotis (Myotis velifer). The lesser long-nosed bat is a federally endangered species. Each of these species relies on the availability of caves and/or mines to roost in. These landform features are not adequately captured by the natural community conservation elements. Additionally, each species uses other community types, such as xeroriparian areas, high-density saguaro stands, and tinajas, to meet their food and water requirements. Roosting colonies of bats are vulnerable to disturbance, particularly maternal colonies during the birthing season. Controlled light and temperature conditions are important for each species. Recreational use of caves/mines is a threat to roosting bats because of the effects of direct disturbance and the potential to affect cave/mine microclimate. The seasonal occurrence of each bat species in the BMGR area differs: the California leaf-nosed bats are resident species that do not migrate or hibernate, lesser long-nosed bats migrate to winter in the tropics, and cave myotis in southern Arizona migrate to locations above 6000 feet in the winter to hibernate.

The interplay of species ecology and management needs is of interest. Lesser long-nosed bats are not at present known to roost on the BMGR, though a few individuals have been observed foraging in the Sand Tank Mountains. These bats differ from most other bat species in that the traditional means of protecting roost sites by installing “bat-friendly” gates across cave/mine entrances may inhibit the movement of this species. To the extent that the BMGR provides potential roost sites for this species, the actions taken to protect bat roost sites in general need to account for the peculiarities of the lesser long-nosed bat. Additionally, increased availability of surface water near potential roost sites may provide favorable habitat for cave myotis that are often associated with proximity to water sources. To the extent that a particular bat species may preclude the use of roost sites by another species (this may not be the case), species interactions and how they change with changes in habitat conditions should be considered when managing for bats.

5.3 Species Conservation Elements: Distribution of Rarity Ranks and Taxonomic Breadth

Table 5.2 provides the distribution of species elements, including species within guilds, by combined global ranks and taxonomic groups as a check to see whether the selection of conservation elements is skewed to rare elements or a particular taxonomic group or groups.

Of the 40 total species included in Table 5.2, 17 plant species are included as part of a natural community conservation element description and 15 species are included within four different guilds. The remaining eight species are stand-alone conservation elements. With the exception of amphibians, which in regard to species richness is extremely limited on the BMGR, at least one of these stand-alone species is included within each taxonomic group. The four guilds, with the exception of the plants, are spread equally among the other taxa (one each).

Relatively few rare species (G1 and G2) are included. All federally listed species, whose status generally corresponds to the preceding global ranks, would by default be included as conservation elements. For a large landscape, the BMGR seems to contain a relatively low number of currently listed species. Global ranks G3 through G5, on the other hand, contain relatively high numbers of conservation elements that
### TABLE 5.2 Species Conservation Elements for the Barry M. Goldwater Range by Taxonomic Group and Combined Global Rank

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Total&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Combined Global Rank&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G1 (rarest)</td>
<td>G2</td>
</tr>
<tr>
<td>Plants&lt;sup&gt;3&lt;/sup&gt;</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>Amphibians</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Reptiles</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Birds</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Mammals</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>40</strong></td>
<td><strong>1</strong></td>
</tr>
</tbody>
</table>

<sup>1</sup>Total includes individual species within a guild.

<sup>2</sup>Global ranks are defined in Appendix A, Table A.2. Criteria for converting global ranks to combined global ranks also are provided as part of Table A.2.

<sup>3</sup>Plants species also include those that are considered integral to the natural community conservation element descriptions for: Dune Complex and Dune Endemics, Sand Tank Mountains Uplands, and Elephant Tree-Limberbush on Xeric Rocky Slopes.

are fairly evenly split between the three rank categories. With appropriate management of these latter conservation elements now, the BMGR can better position itself to anticipate future trends in resource viability and to make the necessary management adjustments that can hopefully avoid future listings.

### 5.4 Relationship Between Potential Species and Natural Community Conservation Elements

As described in section 4.3.3, we wanted to evaluate the robustness of the natural community elements to function as coarse filters by constructing a matrix that crossed natural community elements with all potential species elements considered in our selection of conservation element process and identified whether a relationship existed between each possible combination. Appendix H provides the results of this evaluation.
CHAPTER 6 NATURAL COMMUNITY CONSERVATION ELEMENTS

This section contains ecological and other descriptions for thirteen proposed, natural community conservation elements that occur on the Barry M. Goldwater Range (BMGR). Also included are summary statistics associated with Gap biodiversity management status based on Crist and others (2000).

6.1 SUMMARY OF NATURAL COMMUNITY CONSERVATION ELEMENTS

Proposed natural community conservation elements are identified in Table 6.1. The table also includes summary descriptive information on each community’s spatial pattern and range-wide distribution, as well as a comment field. Within the comment field, for those communities that include endemic plants and/or plants that are closely associated with the community as part of the description of the community type, the specific species considered are identified.

TABLE 6.1 Natural Community Elements of the Barry M. Goldwater Range

<table>
<thead>
<tr>
<th>Natural Community</th>
<th>Spatial Pattern and Distribution</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valley Bottom Floodplain</td>
<td>Linear/large patch system that is likely endemic to the Sonoran Desert Ecoregion</td>
<td>Linear xeroriparian areas may be embedded within the complex. As a community type that is characterized by a shifting mosaic of vegetation patches spread across a floodplain, it also can be considered a large patch system.</td>
</tr>
<tr>
<td>Floodplain Complex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valley Xeroriparian Scrub</td>
<td>Linear system that is likely to be distributed throughout the Sonoran Desert and Mojave Desert Ecoregions.</td>
<td>Mesquite bosques (<em>Prosopis</em> spp.) can be associated with this community. Significant examples of bosques on the BMGR need to be documented. See comment below in regard Mountain Xeroriparian Scrub.</td>
</tr>
<tr>
<td>Mountain Xeroriparian Scrub</td>
<td>Linear system that is likely to be distributed throughout the Sonoran Desert and Mojave Desert Ecoregions.</td>
<td>Although its spatial pattern is characterized as linear, it may create a mosaic pattern with associated matrix and large-patch communities that is repeated frequently across the landscape.</td>
</tr>
</tbody>
</table>
| Dune Complex and Dune Endemics | Large patch system that occurs throughout the Sonoran and Mojave Desert Ecoregions.               | Sonoran Desert endemic(E)/limited(L) plants that demonstrate a strong association with the dune complex are included within this element’s description. These plants include:  
  *Astragalus insularis* var. *harwoodii* (E)  
  *Astragalus madgalenae* var. *petersonii* (E)  
  *Croton wigginii* (L)  
  *Cryptantha ganderi* (E)  
  *Eriogonum deserticola* (E)  
  *Euphorbia (= Chamaesyce) platysperma* (E)  
  *Helianthus niveus* (L)  
  *Pholisma sonorae* (E)  
  *Stephanomeria schottii* (E)  
  *Triteleiopsis palmeri* (E).  


### TABLE 6.1 Natural Community Elements of the Barry M. Goldwater Range—continued

<table>
<thead>
<tr>
<th>Natural Community</th>
<th>Spatial Pattern and Distribution</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creosotebush-Bursage Desert Scrub</td>
<td>Matrix-forming system that occurs throughout the Sonoran and Mojave Desert Ecoregions.</td>
<td>None</td>
</tr>
<tr>
<td>Creosotebush-Big Galleta Scrub</td>
<td>Large patch system that occurs in the Sonoran Desert and also may occur in the Mojave Desert.</td>
<td>None</td>
</tr>
<tr>
<td>Paloverde-Mixed Cacti-Mixed Scrub on Bajadas</td>
<td>Matrix-forming system that occurs only within the Sonoran Desert.</td>
<td>None</td>
</tr>
<tr>
<td>Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes</td>
<td>Large patch system that occurs throughout the Sonoran Desert.</td>
<td>None</td>
</tr>
<tr>
<td>Sand Tank Mountains Uplands</td>
<td>Large patch system that occurs in the Sonoran Desert; in addition to the Sand Tank Mountains,</td>
<td>Unusual combination of plants that occur only at high elevations are included within this element’s description. These plants include:</td>
</tr>
<tr>
<td></td>
<td>limited in distribution to a relatively few high elevation mountain ranges throughout the Sonoran Desert; includes an unusual combination of plant species.</td>
<td>Canotia holocantha</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Juniperus coahuilensis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vaquelinia californica sonorensis.</td>
</tr>
<tr>
<td>Elephant Tree-Limberbush on Xeric Rocky Slopes</td>
<td>Large patch system that occurs in arid mountain ranges within the Lower Colorado Valley,</td>
<td>Some rocky soil associated plants are included within this element’s description. These plants include:</td>
</tr>
<tr>
<td></td>
<td>Central Gulf Coast, and Arizona Uplands subdivisions of the Sonoran Desert. On the BMGR it</td>
<td>Bursera microphylla</td>
</tr>
<tr>
<td></td>
<td>occurs on the western mountain ranges (Cabeza Prieta, Copper, Gila, and Tinajas Altas Mountains)</td>
<td>Jatropha cuneata</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nolina bigelovii</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rhus kearneyi.</td>
</tr>
<tr>
<td>Desert Playa</td>
<td>Large patch system that occurs throughout the Sonoran Desert and may occur in the Mojave Desert.</td>
<td>None</td>
</tr>
<tr>
<td>Desert Tinaja/Spring</td>
<td>Small patch system that occurs throughout the desert southwest.</td>
<td>None</td>
</tr>
<tr>
<td>Salt Desert Scrub</td>
<td>Large patch system that occurs throughout the desert southwest.</td>
<td>Specific occurrences still need to be mapped on the BMGR. Figure 6.1 identifies the locations (one location is indicated as a polygon and the other two as point locations) at which the community needs to be confirmed and delineated.</td>
</tr>
</tbody>
</table>
The occurrence of each of these species on the BMGR is documented as follows: *Astragalus insularis* var. *harwoodii*, Mohawk Dunes (Felger and others 1997) and Yuma Dunes (Center for Ecological Management of Military Lands [CEMML] unpublished data); *Astragalus magdalenae* var. *peirsonii*, Yuma Desert northwest of Yuma Dunes (unpublished data; collected by D. Turner and identified by R. Felger); *Croton wigginsii*, Yuma Dunes (Felger and others 1997, Warren and Laurenzi 1987); *Cryptantha ganderi*, Mohawk Dunes (Felger 2000, Felger and others 1998); *Eriogonum deserticola*, Yuma Dunes (CEMML, Felger and others 1997, Warren and Laurenzi 1987); *Euphorbia* (= *Chamaesyce*) *platysperma*, Yuma Dunes (CEMML, Warren and Laurenzi 1987); *Helianthus niveus*, Yuma Dunes (CEMML, Warren and Laurenzi 1987); *Pholisma sonorae*, Yuma Dunes (CEMML, Felger and others 1997, Warren and Laurenzi 1987); *Stephanomeria schottii*, Mohawk Dunes (Felger and others 1997, Warren and Laurenzi 1987) and Yuma Dunes (CEMML, Warren and Laurenzi 1987); *Triteleiopsis palmeri*, Yuma Dunes (CEMML, Felger and others 1997, Warren and Laurenzi 1987).

Natural communities represent an integration of ecosystem attributes, including biotic and abiotic composition, structure, and function, at scales that are practical and applicable to conservation planning. These communities in combination represent a coarse filter, which is intended to capture for management purposes the majority of the biodiversity occurring on the BMGR. The use of natural communities as a coarse filter when based predominately on vegetation has some limitations. A potentially serious one is that natural communities defined on the basis of floristic composition are not stable: “they change as species respond more or less independently to environmental gradients in space and time” (Ecological Society of America 1995, Noss and Cooperrider 1994). The effects of climate change can create such a gradient in which each species responds to environmental change in accordance with its own ecological amplitude.

The incorporation of abiotic features as part of the description for some community types, though not completely resolving the problem, does add a certain amount of robustness to the natural communities defined herein (Noss and Cooperrider 1994). Additionally, including specific species as part of the description for some communities provides an initial framework for establishing appropriate monitoring protocols that can detect changes in community composition, structure, and function. Because natural communities are dynamic, the appropriateness of each natural community as a coarse filter for biodiversity should be periodically assessed and revised as necessary.

Figure 6.1 shows the distribution of the natural community elements on the BMGR, as well as their distribution across most of the Cabeza Prieta National Wildlife Refuge. The map should not be construed as plant community map for the area of coverage. Many of the polygons are based at least in part on a biophysical model and not on an on-the-ground survey of the vegetation present. The following geospatial digital data layers were used to create the map of natural community conservation elements (Figure 6.1):

- Vegetation in the Sonoran Desert Ecoregion (Marshall and others 2000, which itself is based in part on the Arizona Gap map [Arizona Gap Program 1998]) (Figure 6.2)
- reclassified digitized hard copy of the vegetation-type map of Luke Air Force Range (Tunnicliff and others 1986) (Reclassed polygons are described in Appendix D) (Figure 6.3)
- Natural Vegetation Map of Arizona. Data collected by the Arizona Game and Fish Department in 1976 and digitized during 1992/1993 by the University of Arizona (University of Arizona 1993)
- Barry M. Goldwater Range, Digital Orthophoto Quadrangle Quadrants (DOQQs) (taken in June and/or October 1996)
• hydrography from Arizona State Land Department, Arizona Land Resources Information System (ALRIS) (converted in 1988 from U.S. Geological Survey 1:100,000 scale, digital line graph data).

• Luke Air Force Base’s Special Aquatic Sites (includes springs and natural tinajas)

• thirty-meter Digital Elevation Model (DEM) data

• U.S. Geological Survey 1:100,000 topographic Digital Raster Graphics (DRGs).

Acreage amounts for each natural community type are provided in section 6.3.

6.2 DESCRIBITIONS OF NATURAL COMMUNITY CONSERVATION ELEMENTS

In the sections that follow for each natural community conservation element, information is presented that describes the: ecological characteristics of the community; its status, threats to its persistence, and associated threat abatement strategies; and mapping and information needs. The comments made by expert participants on how each community could be mapped are noted in the sections titled “Mapping: workshop comments.” The actual assumptions and techniques used to map the communities as they appear in Figure 6.1 are described in sections titled “Mapping: application of assumptions.” Additionally, as appropriate, specific comments made by a workshop participant in regard to a particular natural community are attributed. Appendix E provides the complete list of workshop participants.

Descriptions and spatial delineations of the following natural communities can be refined through the collection of field survey data. A current vegetation mapping project, that is describing and delineating Sonoran pronghorn (Antilocapra americana sonoriensis) habitat on the BMGR and adjoining lands, provides one such opportunity (J. Malusa).

6.2.1 Valley Bottom Floodplain Complex

Ecological Characterisitcs

Composition.—Characteristic vegetation differs between the two patch types that contribute to the Valley Bottom Floodplain Complex. In the wetter depressions vegetation is relatively dense and composed of creosotebush (Larrea tridentata [= L. divaricata tridentata; Turner and others 1995]), triangle-leaf bursage (Ambosia deltaoida [= Franseria deltaoida; Turner and others 1995]), white bursage (Ambrosia dumosa [= Franseria dumosa; Turner and others 1995]), acacias (Acacia spp.), wolfberries (Lycium spp.), blue paloverde (Cercidium floridum floridum [= Parkinsonia torreyana; Turner and others 1995]), foothill paloverde (Cercidium microphyllum [= Parkinsonia microphylla; Turner and others 1995]), mesquites (Prosopis sp.), and annual and perennial grasses such as big galleta (Pleuraphis rigida [= Hilaria rigida; Turner and others 1995]). Species diversity in the depressions is directly related to patch size (S. Rutman). Typical co-dominants are creosotebush, triangle-leaf bursage, and big galleta (J. Malusa). Organic content of associated soils is high (P. Warren). Differences in floristic composition between different examples of this patch type may be related to different edaphic conditions (J. Malusa, S. Rutman). Vegetation variation also may be a response to the dynamic nature of this complex. The drier areas surrounding the depressions support floristic elements characteristic of the Creosotebush-Bursage Desert Scrub community.

Structure.—The community occurs as a shifting mosaic of patches of sparse vegetation (relatively dry areas) interspersed with patches of relatively dense vegetation that occur within shallow depressions (in which water accumulates). Figure 6.4 shows an example of the vegetation within a densely vegetated
Figure 6.2 Vegetation in the Sonoran Desert Ecoregion (adapted from Marshall and others 2000)

Barry M. Goldwater Range Biodiversity Management Framework
Dry patches are characterized by low density, cover, and diversity of plants and limited soil organic material. In some cases the dry patches are devoid of vegetation (J. Malusa). Depressions are characterized by plant cover that often approaches or exceeds 100% (ground cover can range from 70 to 100%), consists of greater plant diversity than the dry patches, and is associated with substantial surface litter (S. Rutman). Often the depressions have a sheet of plant litter on the surface. Dry patches consist of three layers of vegetation: seasonal annuals, subshrubs, and shrubs. Four layers characterize the depressions: seasonal annuals, subshrubs, shrubs, and trees. Some dry-patch areas that were formerly sites of dense vegetation may contain some dead/dying trees, but often these structural components have largely been lost to woodcutting (S. Rutman). Creosotebush within the depressions can reach up to 10 feet tall (S. Rutman). Patch type, size, and location changes over time as aggradation and degradation of soil resources within the floodplain responds to hydrological events. Relative proportion of each patch type is influenced by position on the landscape. Overall, however, the total areal coverage of depressions is less than the sparsely vegetated areas (J. Malusa). Within the boundaries of the Valley Bottom Floodplain Complex, linear occurrences of vegetation structure (and composition) characteristic of the Valley Xeroriparian Scrub community occasionally may be present (P. Rosen).

**Function (associated ecological processes).**—The ecological processes necessary for the formation and long-term maintenance of the Valley Bottom Floodplain Complex are poorly documented. The following is offered as a beginning sketch of the functional attributes of the complex. This community forms on nearly flat terrain (valley bottoms) with no apparent or weakly developed drainage channels (that is, little or no downcutting should occur). As a result, sheet flow may be an important hydrological phenomenon. Flow regime is not described in terms of intensity or frequency. It is assumed to follow seasonal pulses characteristic of the region. Xeroriparian areas may be embedded within this complex naturally and may contribute to sheet flow during flood events when the channels overflow. The relatively high productivity of the depressions may depend on the enhanced infiltration of water and nutrients. The vegetation within the depressions provides resources to wildlife, such as forage, cover, nest sites, and perches, that are scarce in the sparsely vegetated patches and communities bordering the Valley Bottom Floodplain Complex. The community is not fire adapted and any occurrence of fire generally would kill much of the native species present.

**Landscape context.**—Examples of this community (Figure 6.5) are located on level or nearly level terrain within valley bottoms. Examples are found on a variety of different soil types, though generally the soils are deep loams/sandy loams and are prone to accelerated erosion (P. Rosen, S. Rutman). Conditions throughout the entire upper watershed must be good to excellent to maintain natural flood-flow regimes (S. Rutman). The immediately

![Figure 6.4](image1)

**Figure 6.4** Local-scale view of a densely vegetated patch associated with the Valley Bottom Floodplain Complex. San Cristobal Wash, Cabeza Prieta National Wildlife Refuge.

![Figure 6.5](image2)

**Figure 6.5** Landscape view of Valley Bottom Floodplain Complex. Growler Wash looking south, Cabeza Prieta National Wildlife Refuge.
surrounding plant community is predominantly Creosotebush-Bursage Desert Scrub. Figure 6.5 shows both the landscape context of the Valley Bottom Floodplain Complex as well as an illustration of the spatial pattern of the two patch types.

**Status, Threats, and Management**

**Historic and current distribution.**—The natural communities typical of the valley bottoms of the Sonoran Desert mostly have been lost to urban development and farmlands. The Valley Bottom Floodplain Complex community is thought to have been common throughout the border area of Arizona-Mexico and extending a relatively short distance to the north, especially along the Gila River. Intact examples occur within the San Cristobal and Growler Valleys of the BMGR and Cabeza Prieta National Wildlife Refuge, as well as in the Valley of the Ajo Organ Pipe Cactus National Monument. Remnant examples also occur elsewhere throughout the Sonoran Desert, such as within the Santa Rosa Valley on the Tohono O’odham Nation, but generally landscape-scale examples are degraded by direct conversion to farmland and indirectly by watershed fragmentation resulting from development, construction of impoundments and drainage diversions, and livestock overuse.

**Conservation status.**—The BMGR contains some of the best remaining examples of this community and associated watersheds in Arizona and perhaps the entire Sonoran Desert. The Valley Bottom Floodplain Complex persists there on a landscape scale. The community is more fragile than most other natural community types because the associated soils tend to be erodable and human activities (for example, roads, camping, and so on) often are concentrated within the community’s extent, in part because vehicles can easily access the level terrain. As a result, few large areas remain outside the BMGR/Cabeza Prieta where this community type retains its functional characteristics (S. Rutman), except perhaps on the Tohono O’odham Nation (P. Rosen). On the Nation, Santa Rosa, Gu Oidak, and Aguirre Valleys should be further investigated for the occurrence and condition of this community (P. Rosen). In many areas where this community likely occurred historically (for example, the Gila River floodplain), it has been converted for agriculture. Various animal species are dependent on the floodplain areas year-round.

**Best examples on the BMGR.**—The best examples of this community are found in the Growler and San Cristobal Valleys.

**Stressors.**—Ecological stresses to this community include displacement of native vegetation by invasive plant species. Additionally, to the extent that sheet flow is a characteristic hydrological process, any activities or events that modify the flat terrain topography or otherwise alter the overland floodflows will negatively impact this community. Soil compaction that negatively impacts water infiltration rates also may be a stress (S. Rutman).

**Sources of stress.**—Stresses are caused principally by legal and illegal road establishment. This community type is particularly vulnerable to road establishment, because it is a primary corridor for illegal immigrant crossing and drug smuggling. Roads cause erosional downcutting, which, for those roads that cross more or less perpendicular to the flow gradient, may then capture and reduce/eliminate sheet flow. Roads also serve as pathways for invasive species such as Sahara mustard (Brassica tournefortii) and buffelgrass (Pennisetum ciliare [= Cenchrus ciliaris]). These two invasives can reach densities that are sufficient to carry fire, which can kill native species (S. Rutman, P. Warren). Additionally, bomb craters and otherwise poor watershed conditions, as well as entrenchment of drainage channels (downcutting) independent of roads, potentially can disrupt the natural ecological processes associated with this community. Past conversion of this system for farmland and livestock grazing is also a source of historic stress. See Information Needs for a discussion on other potential sources of stress.
Threat abatement strategies.—Military ground activities (associated with driving) should be kept to an absolute minimum where this community occurs, particularly in the Growler and San Cristobal Valleys where the best remaining examples in the Sonoran Desert are found. Additional road establishment should be avoided within this community; however, if they are needed, one expert (P. Rosen) suggested they should be paved as a means of avoiding the otherwise inevitable downcutting and consequent community degradation.

Mapping and Information Needs

Mapping: workshop comments.—This community can be readily identified in aerial photographs based on characteristic vegetation structure. The largest polygon designated as 154.1113 \([\text{Larea tridentata-Prosopis sp.-(Cercidium sp., Olneya tesota)}]\) from the reclassified map of Tunnicliff and others (1986) was identified in the November 2, 2000 workshop as a favorable starting point for mapping this community. Other areas where this community is found on the BMGR can be modeled using a 10- to 30-meter DEM with an analysis of soil texture. Detailed hydrography also could aid in mapping this community.

Mapping: application of assumptions.—The largest polygon designated 154.1113 from the reclassified map of Tunnicliff and others (1986) was shifted to align farther east with the Growler Valley wash complex and south on Cabeza Prieta with the San Cristobal Valley wash complex. Two polygons (one on the San Cristobal Valley wash between the Bryan Mountains and the Granite Mountains and one farther south just east of Dos Playas), identified as water on the Sonoran Desert Ecoregion vegetation map in Marshall and others (2000) and shown on U.S. Geological Survey topographic maps as dry lakes, were added to this element. The DOQQS clearly showed the similar braided-wash patterns implying the sheet flow described by the experts. A complete inspection of the DOQQS was not performed on the entire polygon for the Growler Valley and south San Cristobal Valley. Modelling this system using the DEM and soil texture was not performed because of time constraints; however, a coarse soil assessment contained in U.S. Department of the Air Force (1998) identifies the surface soil underlying the polygon as belonging to the Torrifluvents Association. This association is associated with nearly level to gently sloping floodplains, valley floors, and low alluvial fans and is characterized as loams, sandy loams, silt loams, and gravelly sandy loams (U.S. Department of the Air Force 1998). Further inspection of the DOQQS and additional modelling may help to refine the current polygons.

On review of the mapping application results, one of the experts (S. Rutman) cautioned against the use of DOQQS for identifying occurrences of the Valley Bottom Floodplain Complex. The infrared images may have been shot during a season of the year when most plants are dormant and therefore not visible on the DOQQ image. Rutman suggested a combination of soil type and slope be used as a coarse filter for determining the community’s presence or absence; however, allowances needed to be made for the coarse nature of the modeling approach that may result in missing small occurrences of the community otherwise mapped as Creosotebush-Bursage Desert Scrub. As indicated earlier in this chapter, the DOQQS for the BMGR may have been photographed entirely in either June or October or different quadrants may have been shot in either month. Information on the specific month each quadrant was photographed is lacking (B. Tunnicliff). The ability to recognize the Valley Bottom Floodplain Complex from DOQQS may differ between the two time periods. The use of the DOQQS herein was to assist in the alignment of the relevant polygon for this community from the vegetation map of Tunnicliff and others (1986) and to evaluate nearby features on U.S. Geological Survey topographic maps that may have represented this community type. In this regard the DOQQS were used to determine whether the expected pattern of vegetation (mosaic of sparse areas versus densely vegetated areas) could be ascertained. As described in the preceding paragraph, in some cases the expected pattern was observed.
Relationship to plant community classification systems.—It is difficult to establish the range of vegetation characteristic of this community. This community could be included in the Creosotebush- [White] Bursage Series (154.11; Brown and others 1979) and may correspond to the minor association Larrea tridentata-Prosopis sp.- (Cercidium sp., Olneya tesota) (polygon 154.1113) mapped in Tunnicliff and others (1986). Earlier plant community mapping associated with Organ Pipe Cactus National Monument by Warren and others (1981) may be of relevance here. These investigators extended the classification system of Brown and others (1979) to describe one or more plant community associations that may correspond in whole or in part to the Valley Bottom Floodplain Complex community description. Associations from Warren and others (1981) that may contribute to the Valley Bottom Floodplain Complex community description are: Larrea tridentata with Annuals Association (154.1114), Larrea tridentata-Prosopis glandulosa Floodplain Association (154.1115R) (generally contains the relevant species composition and structure described for the Valley Bottom Floodplain Complex [P. Rosen]), and Cercidium floridum-Prosopis glandulosa-Ambrosia ambrosioides Association (154.1215R).

Information needs.—Understanding of natural flow regime is needed to evaluate current patterns. It is unclear whether groundwater pumping surrounding the Gila River area could have any effect on this community within the BMGR, though this is unlikely; potentially downcutting within the Gila River Valley could affect portions of the Valley Bottom Floodplain Complex on the BMGR (P. Rosen). The potential for this latter phenomenon can be assessed using remote sensing and ground-truthing. The areas in which this community is located is relatively unknown on the BMGR, so once occurrences are modeled (see above) groundtruthing is needed to confirm presence and condition of this community.

6.2.2 Valley Xeroriparian Scrub

Ecological Characteristics

Composition.—Characteristic vegetation is highly variable due to the dynamic nature of this community. Regional descriptive information indicates that this community varies from sparse to dense and has cover dominated by xeromorphic, deciduous trees, including blue paloverde, ironwood (Olneya tesota), and mesquite. Other characteristic shrubs and trees may include: Acacia greggii, foothill paloverde, Chilopsis linearis, Hymenoclea sauloa, Lycium spp., honey mesquite (Prosopis glandulosa var. torreyana), Psorothamnus spinosa, and Ziziphus obtusifolia. Shrubby cacti, such as Opuntia acanthocarpa, O. leptocaulis, and O. phaeacantha, may be common. Sparse annual grasses may include: Aristida adscensionis, Bouteloua aristidoides, and Leptochloa filiformis. The rare shrub Castela emoryi is sometimes found in this community (R. Felger), though perhaps in areas associated with valley bottoms. Abundant herbaceous and woody perennial vines are a conspicuous component of this community. Forb cover is sparse but can be relatively diverse. Common forbs include: Ambrosia ambrosioides, Euphorbia spp., Heliomeris longifolia var. annua, Matelea parvifolia, and Pectis filipes. On the BMGR, composition likely changes from east to west along a precipitation gradient and in association with the differences in watershed area that pertain to each xeroriparian (wash) system (Warren and Anderson 1985).

Structure.—This community is found as narrow linear strips along clearly defined channels that may be downcut. Vegetation of this community has a moderate to dense layer of xeromorphic evergreen and deciduous trees and shrubs that are generally less than five meters tall (Figure 6.6). Tree height and vegetative density is likely lower in this community than in similar systems found on upper bajadas (see Mountain Xeroriparian Scrub); however, vegetative structure is still complex, with multiple layers that are often connected by vines. The herbaceous layer typically is sparse.

Function.—Channel-constricted flow is the dominant ecological process in this community. The frequency, volume, and duration of flow along wash channels of different size are a function of the
associated watershed area and the regional rainfall regime (Warren and Anderson 1985). As a result, flow also is assumed to follow seasonal pulses characteristic of the region. Several interacting environmental factors related to watershed area that control xeroriparian vegetation gradients are suggested by Warren and Anderson (1985): frequency and amount of runoff, shading, and channel scouring.

**Landscape context.**—This community is found on gradients less than 6% on mountain slopes and out onto wide valley bottoms. It is found at elevations ranging up to 500 meters above sea level. This community is generally found on coarse textured substrates, but it also may occur in places that include gravely silty loams. The soils associated with this community are not generally saline. This community is typically surrounded by a matrix of desert scrub dominated by creosotebush or Ambrosia spp. Figure 6.7 provides an indication of the landscape context of this community.

**Status, Threats, and Management**

**Historic and current distribution.**—This community typically occurred on mid to lower bajadas and along drainages in the Sonoran and Mojave Deserts in southern California, southern Arizona, and the Mexican states of Baja California and Sonora.

**Conservation status.**—This community is extremely important for wildlife, particularly migratory birds (Morrison and others 1997; see also Johnson and Haight 1985). Although this community occurs throughout the matrix communities of the Sonoran and Mojave Deserts, past and current road development has directly altered the flow regime, composition, and structure of many examples. Conservation goals should consider protecting an entire watershed and representing compositional differences that correspond to gradients of precipitation (from east to west) and watershed area (Warren and Anderson 1985). Even in disturbed areas, this community provides important wildlife habitat.

Mesquite bosques (Prosopis spp.), which obtain their maximum development on alluvium of old dissected floodplains (Brown 1994), can be associated with this community. Many of the large bosques associated with desert river systems are gone and the remaining bosques are all threatened by a variety of human-related causes (Brown 1994). Figure 6.8 shows an example of this type of ecological system along the BMGR-Cabeza Prieta border in which a bosque is associated with Valley Xeroriparian Scrub.

**Best examples on the BMGR.**—This community is most prominent in the more arid areas of the BMGR, west of Highway 85 (B. Barry). A good example of the community occurs within Daniels Arroyo where the arroyo crosses into the BMGR from the Cabeza Prieta National Wildlife Refuge (J. Malusa).
Stressors.—This community is adversely impacted by altered hydrological regimes. Another important stress is altered vegetation composition and reduction in tree density.

Sources of stress.—Hydrological regimes are affected by roads. Roads (permanent and otherwise) are established by recreationists, undocumented aliens, Border Patrol activities, and, on the BMGR, by the military conducting ground maneuvers including Explosive Ordnance Disposal (EOD) sweeps. Roads also serve as a conduit for invasive species; however, the relative impact of invasive plant species on this community is unclear. Woodcutting may have altered vegetation density (structure) and composition of many occurrences, both historically and currently. Exploitation of leguminous trees, especially ironwood, for firewood, charcoal, and wood-carving has been documented along the U.S.-Mexico border, even within the supposed protected area of Organ Pipe Cactus National Monument (Suzán and others 1997, 1999). Exploitation of these trees is detrimental to the tree itself, to the structure of the plant community in which they occur, and, especially for nurse trees such ironwood, to species that are dependent on nurse trees for their establishment (Suzán and others 1997, 1999).

Threat abatement strategies.—Additional road establishment should be avoided within this community. In areas that are considered important for use by wildlife, especially in the more arid areas of the BMGR, woodcutting should be discouraged to preserve vegetative structure and composition.

Mapping and Information Needs

Mapping: workshop comments.—This community can be located and modeled using a DEM and hydrography maps at slopes less than 6%. It may be easy to identify and map the largest occurrences from aerial photos. Digital orthophotos may be used to identify wash bottoms that have widths greater than five meters (J. Malusa). U.S. Geological Survey watershed maps also could be used to identify occurrences. Workshop participants emphasized that although it is possible to map the largest examples of this community, smaller xeririparian areas that are not feasible to map also have ecological significance and should be managed and protected.

Mapping: application of assumptions.—This community was mapped as described by the experts. A slope analysis on the 30-meter DEM was performed using ArcView Spatial Analyst 2.0. A grid was generated in which slopes were identified greater than 6% and less than 6%. A shapefile was generated from this grid and used to clip the ALRIS hydrography layer to determine hydrographic segments that fell in the less than 6% slope areas. This is a linear natural community; however, a buffer analysis was performed 10 meters on either side of the line segments to analyze “potential” areal extent and to enable occurrences to be visible for mapping purposes. This potential area was not subtracted from the other natural community elements this community dissects. As a comparison, for each mile-long transect across a typical Sonoran Desert bajada, Warren and Anderson (1985) reported crossing on average about 14 desert washes. Based on an average xeririparian width of 25 feet, they calculated that between 6 and 7% of the total bajada surface was covered by xeririparian vegetation. Further modeling using the DEM may help to find smaller units and inspection of DOQQs could assist determining the real extent of larger units. In the lower gradient portions of the hydrograph layer (that is, approaching the valley bottoms), channel-constricted flow generally transitions to sheet flow. The transition is accompanied by a tendency
to lose characteristic xeroriparian vegetation (J. Malusa). Some of the smaller polygons marked as 154.1113 in the reclassified Tunnicliff and others (1986) map should be ground-truthed to determine their community characteristics. One polygon in particular that occurs in association with a Valley Xeroriparian Scrub segment on the Sentinel Plain should be surveyed to determine whether a significant mesquite bosque occurs in that area.

**Relationship to plant community classification systems.**—It is difficult to establish the range of characteristic vegetation in this community. This community is included in the Creosotebush-[White] Bursage Series (154.11; Brown and others 1979). It also may share characteristics with the *Cercidium floridum-Prosopis glandulosa-Ambrosia ambrosioides* Association (154.1215R) of Warren and others (1981).

**Information needs.**—A greater understanding of the natural flow regime is needed to evaluate hydrology and vegetation composition. The relative impact of invasive plant species is not clear. Additional information on the effects of woodcutting, both on the vegetative community and the associated animal communities, is needed.

### 6.2.3 Mountain Xeroriparian Scrub

**Ecological Characteristics**

**Composition.**—Vegetation of this community typically consists of paloverdes, ironwood, mesquites, and succulents. Characteristic vegetation is highly variable due to the dynamic nature of this community. The sparse herbaceous layer is dominated by graminoids, with annual forbs present seasonally. On the BMGR, composition likely changes with aspect and from east to west along a precipitation gradient.

**Structure.**—This community is found as narrow linear strips in downcut channels. Vegetation has a moderate to dense layer of xeromorphic evergreen and deciduous trees and shrubs that are less than five meters tall (Figure 6.9). Tree height and vegetative density is likely higher in this community than in similar communities found in lower bajadas. The herbaceous layer is typically sparse.

**Function.**—Channel-constricted flow is the dominant ecological process in this community. The flow regime has not been described in terms of intensity or frequency, but it is assumed to follow seasonal pulses characteristic of the region.

**Landscape context.**—This community is found on upper bajadas and low- to moderate-elevation mountains on gradients greater than 6%. It is found at elevations ranging up to 1500 meters above sea level. This community may be found on exposed bedrock on upper mountain slopes and extend down-slope into the upper bajadas. Soils of this community generally are not saline. This community is typically surrounded by a matrix of desert scrub dominated by creosotebush, *Ambrosia* spp., foothill paloverde, and mixed cacti. Figure 6.10 shows the landscape context for an example of this community from the relatively drier portion of the BMGR.
Status, Threats, and Management

Historic and current distribution.—This community typically occurs on upper bajadas and low- to moderate-elevation mountain slopes in the Sonoran and Mojave Deserts.

Conservation status.—Because of the rugged nature of sites that support this community, most examples remain within their presumed historic range of variation for composition and structure. Conservation goals should consider representing compositional differences that are likely to correspond to gradients of aspect and precipitation (from east to west).

Best examples on the BMGR.—None were noted.

Stressors.—None were noted.

Sources of stress.—None were noted.

Threat abatement strategies.—None were noted.

Mapping and Information Needs

Mapping: workshop comments.—This community can be located and modeled using a digital elevation model and hydrography maps at slopes greater than 6%. It may not be easy to identify and map this community using aerial photos.

Mapping: application of assumptions.—See Valley Xeroriparian Scrub. Slopes greater than 6% were used to determine which hydrography segments applied to this community.

Relationship to plant community classification systems.—It is difficult to establish the range of characteristic vegetation in this community. This community could be included in the Creosotebush-White Bursage Series (154.11; Brown and others 1979). It also may share characteristics with the Ambrosia ambrosioides-Olneya tesota-Acacia spp. Association (154.1214R) of Warren and others (1981).

Information needs.—A greater understanding of the natural flow regime is needed to evaluate hydrology patterns and vegetation composition. The relative impact of invasive plant species is not clear.

6.2.4 Dune Complex and Dune Endemics

Ecological Characteristics

Composition.—This community includes active dune fields that are sparsely vegetated or lack vegetation altogether, as well as more densely vegetated stabilized dunes and wind-blown sand “sheets” found overlying other substrates. There is high compositional variation between some dune complexes, such as between the Mohawk Dunes and the Gran Desierto (R. Felger).
Sparsely vegetated portions of desert dune complexes are characterized by scattered forbs and grasses in the herbaceous layer. No one plant species is diagnostic, but typically three or more of the following can be found: big galleta, *Oenothera deltoides*, *Abronia villosa*, *Geraea canescens*, and/or *Dicoria canescens*. Other species present in this community include shrubs and dwarf-shrubs (subshrubs) such as white bursage, *Atriplex canescens*, *Croton wigginsii*, *Eriogonum deserticola*, creosotebush, and *Psorothamnus emoryi*. This community often has a high number of ephemeral forbs; in the Gran Desierto dunes, ephemerals comprise up to 63.5% of the flora (Felger 1980). Ephemeral forbs include *Dimorphocarpa pinnatifida*, *Dicoria canescens*, *Lupinus arizonicus*, and *Oenothera deltoides*. The perennial bunchgrass big galleta is common and may be co-dominant in some stands. Unlike most grasses, it has a woody structure and elevated renewal buds (Brown 1982).

Vegetative cover is typically sparse compared to adjacent vegetation; however, species diversity may be high (P. Warren). Warren and Laurenzi (1987) reported cover values of stands in the Yuma Desert of 9% total vegetation with 5.8% *E. deserticola*, 1.4% *Ephedra trifurca*, and 1% big galleta and the forbs *Brassica* sp., *Cryptantha* sp., *Dicoria canescens*, and *Palafoxia arida*. Stabilized dunes typically support creosotebush and mesquites. Endemic/limited plant species associated with dune complexes on the BMGR include: *Astragalus insularis* var. *harwoodii*, *A. magdalenae* var. *peirsonii*, *Croton wigginsii*, *Cryptantha ganderi*, *Eriogonum deserticola*, *Euphorbia platysperma Helianthus niveus*, *Pholisma sonorae*, *Stephanomeria schottii*, and *Triteleiopsis palmeri* (see footnote No. 1 to Table 6.1 for occurrence information).

**Structure.**—This community complex occurs as a large patch system that itself is composed of a shifting mosaic of smaller patches, all of which is typically nested within a matrix of Creosotebush-Bursage Desert Scrub. The typical mosaic includes active open dunes, stabilized dunes, and stabilized flat “sand sheets,” which typically surround the dune field. Figure 6.11 depicts the mosaic pattern of the Mohawk Dunes with Creosotebush-Bursage Desert Scrub mixed with Valley Xeroriparian Scrub in the background. Vertical vegetative structure varies from unvegetated to dense stands of graminoids, forbs, and low desert scrub. Vegetation included in this system has a sparse cover of xeromorphic shrubs and subshrubs less than two meters tall. The herbaceous layer is typically sparse and varies seasonally with precipitation. Figure 6.12 shows the local-scale vegetation pattern of an active dune within the Mohawk Dunes. Several years of above average annual precipitation can increase the cover of big galleta and other grasses to the point they resemble a desert grassland.

**Function.**—Active dune communities have a high number of endemic species with adaptations to moving sand (Bowers 1982). For example, the active dune endemic *Eriogonum deserticola* avoids being buried by moving sand by rapid growth of shoots. Water is held for long periods of time just under the surface by sand. As a result, where woody plants, such as mesquite, become established, they can persist through long droughts.

Active sand dunes of relatively small size may require outside sand sources to retain open, active areas. With increasing size, typical wind-caused sand dune dynamics, such as “blowouts” and vegetative succession, may be maintained without new sand sources. Sand sources and long-term dynamics are not well known for the Mohawk Dunes. It is thought that they are Pleistocene relics with little current additional sand inputs.
Landscape context.—Active, stabilized, and partially stabilized dune systems are found throughout the lower Sonoran and Mojave Desert Ecoregions between -10 and 1200 meters above sea level. The Yuma Dune complex on the BMGR is the northern most extension of the largest dune system in North America, the Gran Desierto of Mexico. Figure 6.13 shows the landscape context of the Mohawk Dunes.

Status, Threats, and Management

Historic and current distribution.—This community is scattered throughout the Sonoran and Mojave Desert Ecoregions.

Conservation status.—The BMGR includes two distinct large dune complexes: Mohawk Dunes and portions of the Gran Desierto at Yuma Dunes. Cabeza Prieta also includes another portion of the Gran Desierto dune complex at Pinta Sands. Conservation goals should include representing the compositional variation between these locations. Each of these dune complexes contains a number of narrow ecological endemics (see Table 6.1). Most dune systems elsewhere in the Sonoran Desert Ecoregion are threatened by recreational off-road vehicle use. The opportunity exists on the BMGR to protect this vulnerable community.

Best examples on the BMGR.—On BMGR dune complexes of various sizes are located: west of the Mohawk Mountains, in the Gran Desierto southeast of Yuma, in San Cristobal Valley, and in the northern Growler Valley. A dune complex also is present in the Pinta Sands area of Cabeza Prieta National Wildlife Refuge.

Stressors.—The major stresses to dune complexes are disturbances that result in the displacement of native vegetation and endemic wildlife, as well as disruption of natural dune dynamics that causes erosion and habitat loss.

Sources of stress.—The primary source of stress is off-road vehicle use in the dunes. Such use causes the elimination of perennial vegetation by damage to both above-ground stems and wide, shallow root systems. Elimination of vegetation can lead to increased sand mobility and loss of wildlife habitat. Off-road vehicles also can be vectors for introducing invasive species such as Sahara mustard and buffelgrass. Invasive species cause displacement of native vegetation including narrow endemics. Livestock and their pathways are also a source of stress by creating opportunities for spreading invasives, particularly buffelgrass. Sahara mustard can be tall and dense and, as a result, may limit animal movements through the dunes (S. Rutman). Reduced mobility can disrupt foraging behavior and make dune wildlife vulnerable to predators. Invasives can also carry fires that kill native shrubs. The Mohawk Dunes are particularly vulnerable to dune recreationists, and the Gran Desierto dune complexes along the Mexico
border are most threatened by illegal border crossings and Border Patrol activities, especially those associated with the use of vehicles.

**Threat abatement strategies.**—Driving should be forbidden on all dune areas in the BMGR, both by the Border Patrol agents and recreationists.

**Mapping and Information Needs**

**Mapping: workshop comments.**—Boundaries of dune fields are identified on U.S. Geological Survey topographic maps and the extent of the dune boundary and sand sheet can be confirmed from aerial photos and/or satellite imagery. The dune field of the American portion of the Gran Desierto (Yuma) dunes can be represented by extending the northwest boundary to encompass occurrences of the flat-tailed horned lizard (*Phrynosoma mcallii*) (P. Warren). The workshop participants recommended several other dune complexes that should be mapped besides the Mohawk and Yuma Dunes: for example, the San Cristobal Dunes.

**Mapping: application of assumptions.**—U.S. Geological Survey DRGs were used to map examples of this community. The DOQQs were inspected to refine the areal extent of the Mohawk and San Cristobal Dunes. The DOQQ quality was not sufficient to determine the extent of adjacent sand sheet habitat for the flat-tailed horned lizard in the Gran Desierto, Yuma Dunes. Ground-truthing may be necessary to determine the boundaries of inclusion of the sand sheet. The Pinta Sands also were added to the mapped coverage for this natural community using the areal extent mapped by the U.S. Geological Survey’s DRGs. Other potential dune complex areas mentioned by the experts could not be located using the DOQQs and also may require ground-truthing to confirm their presence.

**Relationship to plant community classification systems.**—This community is characterized by a land form, as well as by the occurrence of associated endemic plants, and has no described relationship to current vegetation classification systems.

**Information needs.**—Additional work is needed to characterize compositional, structural, and functional attributes of dune complexes. Most dunes are presumed to be of Pleistocene origin. Original sand sources remain unclear. Sand source-sink dynamics are not well understood in these communities.

**6.2.5 Creosotebush-Bursage Desert Scrub**

**Ecological Characteristics**

**Composition.**—Vegetation is composed of xeromorphic, microphyllous, and broad-leaved evergreen shrubs dominated by creosotebush. Many different shrubs, subshrubs, cacti, grasses, and forbs may co-dominate or form typically sparse understories. In the Sonoran typical co-dominants include: white bursage, triangle-leaf bursage, ocotillo (*Fouquieria splendens*), Krameri grayi, and *Opuntia fulgida*. Although their distributions in response to environmental gradients across the BMGR may be complex, white bursage tends to the more abundant species on the western portion of the BMGR and is replaced in dominance by triangle-leaf bursage on the eastern portion of the BMGR (S. Rutman). The understory is typically sparse but may be seasonally abundant with ephemerals. Species such as *Chamaesyce* spp., *Eriogonum inflatum*, *Erioneuron pulchellum*, *Aristida* spp., *Cryptantha* spp., *Lepidium* spp., *Lesquerella tenella*, *Muhlenbergia porteri*, *Nama* spp., *Phacelia* spp., and *Stipa speciosa* may be present. Woody and non-woody cacti and rosette succulents, such as *Agave* spp., are common on rocky slopes. The sparse herbaceous layer is dominated by perennial grasses with some perennial forbs, which are seasonally present. This system tends to have variable amounts of crytobiotic soil crusts. Ironwood, mesquites, and
paloverdes may occur in low abundances along watercourses too small to map as Valley Xeroriparian Scrub (J. Malusa).

**Structure.**—This community forms the dominant matrix of the Lower Colorado River Valley subdivision of the Sonoran Desert, as well as most of the Mojave Desert. The matrix typically includes extensive networks of Valley Xeroriparian Scrub communities and/or large patches of active and stabilized dune complexes (Figure 6.14). Within the Sonoran Desert, this community typically grades into Paloverde-Mixed Cacti-Mixed Scrub on Bajadas with increasing elevation and annual precipitation. Vegetation typically includes sparse to moderately dense layers of microphyllous and broad-leaved evergreen subshrubs and shrubs less than two meters tall, with less than a 20% overall cover (J. Malusa). Understory vegetation may be absent or seasonally present (ephemerals). Figure 6.15 shows the local-scale vegetation pattern of Creosotebush-Bursage Desert Scrub.

**Function.**—Most dynamic processes on landscapes dominated by this community involve linear xeroriparian systems and large patch dune fields that are often nested within the creosotebush-bursage “matrix.” Climate extreme, however, may be viewed as a periodic, dynamic process in which extremes in temperature and/or drought may cause die-back of many plant species. Cryptobiotic soil crusts provide a primary nitrogen input into this community. Tunneling by rodents aerates the soil and funnels rainwater deep into the soil.

**Landscape context.**—This community is found on lower bajadas and intermountain basins that are generally flat or on gentle to moderate slopes. The substrate characteristic of this community is usually sandy or gravelly alluvium derived from limestone and metamorphic rocks and the soils are typically of low salinity. In certain examples of this community’s occurrence, for example valley bottoms and flat uplands, the soils can range from sandy to clayey loams several meters thick to shallow soils where a caliche layer lies less than one meter below the surface, respectively. Cryptobiotic soils provide a major input of nitrogen and are particularly well developed on the western side of the BMGR (R. Felger), though the apparent difference in development from east to west may be an artifact of the difference in visibility of the component species (S. Rutman). Sheet flow originating in the vast expanses of this community type, accumulates the nitrogen and deposits it in the adjoining Valley Bottom Floodplain Complex and xeroriparian scrub communities (S. Rutman). Elevations for this system range from below sea level to 1600 meters above sea level. Climate is semi-arid to arid with hot summers. The potential for freezing winter temperatures depends on the latitude and elevation of this system. The
abundance and seasonality of annual precipitation varies with geography. Mean annual precipitation ranges from over 20 centimeters distributed bimodally, with half occurring during the late summer monsoons and half occurring in the winter near Tucson, Arizona to 5 centimeters or less of mostly winter precipitation in southeastern California (Brown and others 1994).

**Status, Threats, and Management**

**Historic and current distribution.**—This desert scrub community is widespread across the Mojave and Sonoran Desert Ecoregions on mesas, plains, valleys, bajadas, and low hills. Similar communities occur in the Chihuahuan Desert.

**Conservation status.**—It is recommended that large blocks of this community be protected from intensive land uses to protect soil crusts, especially in the most arid, western portions of the BMGR. Representative, well-protected examples are needed for long-term monitoring.

**Best Examples on the BMGR.**—The lower bajada and valley west of the Sauceda Mountains contains a good example of this community (S. Rutman).

**Stressors.**—The soils of this community are frequently subject to erosion, entrenchment, and compaction. Specifically, where it occurs on fine, deep soils the community is vulnerable to accelerated erosion and less so when it occurs on coarser, rockier soils (S. Rutman). Vegetation may be displaced by invasive plants, including Schizmus spp., red brome (Bromus rubens [= B. madritensis rubens]; Felger and others 1997), buffelgrass, and Sahara mustard. Fires can kill native vegetation, including creosotebush.

**Sources of stress.**—Roads and livestock grazing (historic) provide entry corridors for invasive species. Invasives may carry fire. The eastern part of the BMGR is most vulnerable to fire carried by red brome (R. Felger) and may in general have higher fuel loads generated by the presence of invasives due to its higher rainfall and greater proximity to vector sources for invasives compared to the western portion of the BMGR (S. Rutman). Roads also cause erosion and entrenchment of the soils of this community. On the BMGR military ground maneuvers in valley bottoms, including ground sweeps associated with explosive ordnance disposal activities, can be a source of stress on these systems. The resultant soil compaction can be long-lasting and disruptive to the high soil oxygen content required by the co-dominant species (S. Rutman). Vehicle traffic also can collapse rodent mounds, which are important to the structure and function of this community (S. Rutman).

**Threat abatement strategies.**—Unnecessary ground maneuvers and new road construction should be avoided. Standard practices for cleaning vehicles and equipment may assist in minimizing the inter-site movement of invasives.

**Mapping and Information Needs**

**Mapping: workshop comments.**—This community is accurately mapped in the current coverage provided by the Arizona Gap map. The experts also recommended combining the creosotebush and creosotebush-white bursage polygons from the reclassified map of Tunnicliff and others (1986).

**Mapping: application of assumptions.**—The Sonoran Desert Ecoregion vegetation map (Marshall and others 2000) polygons for Creosotebush-Bursage were used to map this community. Boundaries of the community were revised once other elements were mapped, such as Creosotebush-Big Galleta Scrub and Paloverde-Mixed Cacti-Mixed Scrub on Bajadas. As noted under Valley Xeroriparian Scrub, the areal extent of that community was not subtracted from the Creosotebush-Bursage Desert Scrub.
Relationship to plant community classification systems.—This community is included within the Creosotebush-[White] Bursage Series (154.11; Brown and others 1979).

Information needs.—Much work is needed to clarify management and prevention of invasive plant species. Much more work is needed to better understand cryptobiotic soil crust communities and the potential strategies for management and/or restoration. An accurate mapping of the Valley Bottom Floodplain Complex may affect the mapped area of this community.

6.2.6 Creosotebush-Big Galleta Scrub

Ecological Characteristics

Composition.—Big galleta is the sole or dominant grass in the herbaceous layer. Creosotebush is the dominant shrub. On coarser soils white or triangle-leaf bursage can be a co-dominant or at least an associate. Under certain circumstances, such as along first order drainages or in bottomlands, *Prosopis velutina* (velvet mesquite) also can reach co-dominant status. *Dipodomys* spp. (kangaroo rats) may be a conspicuous faunal associate of this community (S. Rutman).

Structure.—Vertical structure typically is composed of two layers: scattered shrubs and dense grasses. When mesquite is present, a tree canopy provides a third layer. This community is best expressed on deep, sandy soils (J. Malusa). Figure 6.16 shows the local-scale vegetation pattern of Creosotebush-Big Galleta Scrub.

Function.—This community is located on highly erodable sands and can be found around downcutting desert washes. This community is found occasionally on hillsides, where sand has accumulated down-wind and vegetation is dispersed by birds that carry big galleta spikelets to these areas (R. Felger). If this community burned historically it is likely that the role of fire was minimal (S. Rutman); however, the presence of invasive plant species capable of sustaining fire may increase the frequency and extent of fires (see section on sources of stress).

Landscape context.—This community may be found in portions of the Mojave and Sonoran Deserts growing on flat ridges, low gradient slopes, and among stabilized sand dunes from -75 to 1400 meters above sea level. Yearly precipitation totals are between 0 to 25 cm. This community can occur as large patches, typically nested within a matrix of Creosotebush-Bursage Desert Scrub and/or Paloverde-Mixed Cacti-Mixed Scrub on Bajadas. It also may be found in proximity to the Dune Complex and Dune Endemics community. Finally, this community also may be associated with xeririparian scrub communities and may be found in association with high densities of mesquite. The community is best expressed on sand sheets surrounding dune systems. It also is present and more extensive on fairly level terrain where the soils are sandy loam and well-drained. It may occur on occasion on low gradient rocky slopes underlain by sandy loams (S. Rutman). Big galleta drops out on soils with high clay content (S. Rutman). Soil type and geomorphology may be significant in characterizing this community, though they are not well documented. Figure 6.17 shows the landscape context of patches of Creosotebush-Big Galleta Scrub nested within a matrix of Creosotebush-Bursage Desert Scrub.
**Status, Threats, and Management**

**Historic and current distribution.**—The distribution of this community is not well understood. This community may be found in portions of the Mojave and Sonoran Deserts and in a number of locations throughout the border area, but is not well documented. Creosotebush-Big Galleta Scrub is widely distributed throughout the Yuma Desert. The community may have been more prevalent before livestock grazing converted much of it to Creosotebush-Bursage Desert Scrub (S. Rutman). Additionally, farmland and urban development have likely contributed to its conversion.

**Conservation status.**—This community is important for soil stability and erosion prevention, particularly in xeroriparian areas (S. Rutman). Big galleta is extremely long-lived (over 200 years), but has a low recruitment rate, and is adversely impacted by livestock grazing (S. Rutman). Overstocking and poor grazing management practices throughout most of the areas occupied by this community have contributed to its decline. A number of locations exist where big galleta may have been lost completely because of roads, invasive species, or grazing. The BMGR is important for the conservation of this community because of its lack of grazing pressure.

**Best examples on the BMGR.**—Only one occurrence of this community, in the Sentinel Plain area, currently is mapped on the BMGR. Creosotebush-Big Galleta Scrub likely occurs on the sand sheet southeast of Yuma; however, its extent has yet to be mapped (D. Turner). This community also was noted to be found just south of San Cristobal Dunes on the BMGR (J. Malusa), in the Pinta Sands area of Cabeza Prieta National Wildlife Refuge (S. Rutman), and the Daniels Arroyo area of Cabeza Prieta at Chico Shunie Temporal (seasonal farming site; Broyles and others 1997) where it crosses the Charlie Bell Road (J. Malusa).

**Stressors.**—Excessive soil erosion is a severe ecosystem stress, as is the displacement of native flora/fauna. Loss of big galleta could lead to destabilization of the erodable soils (the rhizomatous nature of big galleta contributes to soil stabilization) (S. Rutman).

**Sources of stress.**—The primary sources of stress on this community are from legal and illegal roads, and associated vehicle traffic, that cause soil erosion and the spread of invasive plants, especially Sahara mustard and buffelgrass. Roads quickly entrench on the sandy soils, which can affect the local and community-wide drainage patterns. Livestock grazing (historic) and feral burros also have been an important source of stress on the community by removing native species or by acting as vectors for invasive plant species.

**Threat abatement strategies.**—Avoid locating roads on sandy soils. Remove/eradicate any remaining feral burros.

**Mapping and Information Needs**

**Mapping: workshop comments.**—This community can be mapped using existing big galleta polygons (154.113) from the reclassified Tunnicliff and others (1986) map and confirmed using aerial photographs.
Mapping: application of assumptions.—This community was mapped using the polygons for Big Galleta Grass Shrubland (154.113) from the reclassified Tunnicliff and others (1986) map. The southern polygons were shifted to align more properly with the Pinta Sands feature on the U.S. Geological Survey’s DRGs. Assumptions were made about how this community aligns with the adjacent Creosotebush-Bursage Desert Scrub in the Tule Desert and how it abuts the Paloverde Mixed Cacti-Mixed Scrub on Bajadas along the southeastern and southwestern slopes of the Sierra Pintas, Antelope Hills, and Agua Dulce Mountains. The extent of this community was not evaluated using aerial photographs or DOQQs.

Relationship to plant community classification systems.—This community is included within the Creosote-[
White] Bursage Series (154.11; Brown and others 1979) and includes polygons (minor associations) classified as 154.1130 (Hilaria [= Pleuraphis] rigida), 154.1131 (Larea tridentata-H. rigida), and 154.1132 (L. tridentata-H. rigida-Cercidium microphyllum-Carnegiea gigantea) by Tunnicliff and others (1986).

Information needs.—Much more work is needed to fully describe this community. Inventory efforts should focus on locating specific examples on the BMGR. This community is not well understood in terms of distribution and abundance. Whether the community is restricted to certain soil types requires investigation. Finally, to better understand the capacity to restore this community, it is important to learn how big galleta can be restored on disturbed sites.

6.2.7 Paloverde-Mixed Cacti-Mixed Scrub on Bajadas

Ecological Characteristics

Composition.—Vegetation of this community has a conspicuous, but relatively sparse, layer of saguaro cactus (Carnegia gigantea) (3 to 12 meters tall). The community also has a sparse to moderately dense short tree/tall shrub canopy co-dominated by the xeromorphic deciduous and evergreen foothill paloverde and creosotebush and with the less prominent Prosopis spp., ironwood, and ocotillo. Ambrosia spp. dominates the subcanopy layer and at the community level is at least a co-dominant and often a dominant in regard to overall abundance (J. Malusa). Other common shrubs and subshrubs are: Ayenia microphylla, Calliandra eriophylla, Janusia gracilis, Lycium berlandieri, and Menodora scabra. The sparse herbaceous layer is dominated by perennial grasses and forbs with annuals seasonally present and occasionally abundant. On slopes, plants are often distributed in patches around rock outcrops where suitable habitat is present. Grass species include: Bouteloua eriopoda, Erioneuron pulchellum, Hilaria mutica, Muhlenbergia porteri, and Setaria macrostachya. Forb species include: Allionia incarnata, Siphonoglossa longiflora, and Sphaeralcea ambigua. Cacti are present and may include besides saguaro: Echinocereus engelmannii, Opuntia engelmannii, O. leptocaulis, and O. spinosior.

Structure.—This community includes a conspicuous, but relatively sparse, layer of large columnar cacti that overtops any other layer (Figure 16.18). The dominant vegetation is contained in sparse to moderately dense woody layers of extremely xeromorphic, drought

![Figure 6.18](image)

**Figure 6.18** Local-scale view of Paloverde-Mixed Cacti-Mixed Scrub on Bajadas. Bryan Mountains, Cabeza Prieta National Wildlife Refuge.
 deciduous and evergreen, short shrubs, tall shrubs, and short trees, 0.5 to 5 meters tall. Ironwood and
foothill paloverde combined may represent 5 to 10% of the cover (J. Malusa). Many of the shrubs are
arborescent cacti. A sparse subshrub layer also may be present. The herbaceous layer generally is sparse
with scattered perennial grasses and forbs. Annual grasses and forbs are seasonally present and
occasionally abundant.

**Function.**—Most dynamic processes on landscapes dominated by this community involve linear
xeroriparian systems that are often nested within this matrix community. Climate extreme, however, may
be viewed as a periodic, dynamic process in which extremes in temperature and/or drought may cause
die-back of many plant species.

Ecological factors determining the occurrence of saguaro are complex. Major limiting factors are cold
winters and dry summers. According to Benson (1982), saguaros are killed by extended frosts and do not
occur above 1370 meters. Moisture and shade are vital to seed germination and seedling establishment.
In Arizona, north slopes are generally too cold for saguaros to germinate. Therefore, the best sites are
mesic microsites on warm exposures where there is shade and a slight depression to concentrate
precipitation. This shade may be in the form of rocks or shrubs called “nurse” plants that protects the
seedlings from drying out in the sun and possibly from frost and predation (Benson 1982, Brown 1982).
As it grows, a saguaro may interfere with the “nurse” and cause die-back in the stems of trees/shrubs such
as _Cercidium_ or possibly damage itself (Brown 1982).

**Landscape context.**—This community forms the “matrix” of the Arizona Uplands subdivision of the
Sonoran Desert Ecoregion. It typically surrounds rocky slopes of low mountain ranges. As with the
Creosote-Bursage Desert Scrub, this matrix forming system typically includes extensive networks of
Valley Xeroriparian Scrub communities. At lower elevations, this community grades into Creosote-
Bursage Desert Scrub. At higher elevations, it may grade into big galleta-dominated desert scrub and
semi-desert oak chaparral. Variants included in this community occur in the Sonoran Desert on gentle
rocky slopes of mountain, hills, and mesas at elevations below 1220 m. The parent material of this
system is usually gravelly alluvium, derived from basalt. Substrates are generally coarse-textured,
shallow, gravelly clay loams. Caliche is a common characteristic of these soils.

**Status, Threats, and Management**

**Historic and current distribution.**—This community is endemic to the Sonoran Desert in southern
Arizona, southeastern California, and adjacent Sonora and Baja Norte, Mexico. This community occurs
on hillsides and mesas in southern Arizona and southeastern California. Much of the historic range of
this system has been lost due to human activities in the accessible bajadas. Overgrazing may have lead to
loss of species in some areas, as well the loss of soil fines (silt and clay) (S. Rutman).

**Conservation status.**—The BMGR presents the only large, unfragmented example of this community in
the entire Sonoran Desert. This community is vulnerable throughout the ecoregion due to the
accessibility of the bajadas. There is a need to protect variation in this community across the full
ecological gradient of its distribution as a buffer against climate extremes, which may result in the death
of many plant species found in this community. Pronghorn may be seasonally dependent on the chain
fruit cholla (_Opuntia fulgida_) found within this community (P. Warren).

**Best examples on the BMGR.**—The lower slopes and bajada of the Sand Tank Mountains represent the
best example of this community on the BMGR and perhaps represent at least one of the best examples
remaining across the Sonoran Desert. The Sand Tank Mountains are uniquely situated geographically.
The range is located near the high end of the rainfall gradient in the Sonoran Desert. Additionally, unlike
many of the smaller ranges to the west, the moderate elevation of the range is sufficient to generate the
convection storms of the summer monsoon season while still precluding cold air drainage that can strongly influence species composition related to the occurrence of cold-sensitive subtropical species. Possibly as a result of the preceding factors, the Sand Tank Mountain, Paloverde-Mixed Cacti-Mixed Scrub on Bajadas community represents one of the most structurally complex examples found in the Sonoran Desert, both in terms of species composition and evenness (Turner and others 2000).

**Stressors.**—The main threats to this system are displacement of native vegetation, soil erosion, and alteration of the natural water regime.

**Sources of stress.**—Roads serve as corridors for invasive species and cause soil entrenchment and erosion. Historic livestock grazing, invasive species, illegal collection of cacti, and introduction of fire all can lead to adverse impacts to the native vegetation. This community can be subjected to on-the-ground military activities.

**Threat abatement strategies.**—Continue to prohibit livestock grazing and remove/eradicate feral burros. Avoid construction of new roads. Monitor recreational activities and take action to avoid/minimize impacts to the community.

**Mapping and Information Needs**

**Mapping: workshop comments.**—These communities are on pediments, with less than a 25 degree slope (distinguishing them from Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes). Current Arizona Gap mapping efforts may have underestimated the extent of this community. Some workshop participants felt that several locations could be extended out farther than currently depicted on the Gap map.

**Mapping: application of assumptions.**—This community was mapped as described by the experts. A slope analysis on the 30-meter DEM was performed using ArcView Spatial Analyst 2.0. A grid was generated in which slopes were identified that were greater than 25 degrees (about 50%) or less than 25 degrees. A shapefile was generated from this grid and used to clip from the existing polygons in the Sonoran Desert Ecoregion vegetation map (Marshall and others 2000) for the Palo Verde-Mixed Cacti to separate the bajada (slopes less than 25 degrees) from rocky slopes greater than 25 degrees. This model was applied to the central area of the BMGR, east of the Cabeza Prieta and Copper Mountains and west of the Sand Tank Mountains. As a result, this area included the Sierra Pinta as mentioned in the comments under Elephant Tree-Limberbush on Xeric Rocky Slopes (Sierra Pinta is classified differently in Marshall and others [2000]). Application of this model also identified areas of this community surrounding the Sand Tank Mountains that did not fall within the modeling parameters for the Sand Tank Mountains Uplands. Ground-truthing is necessary to determine the true boundaries suggested for extension by the experts on the northwestern side of the Sand Tank Mountains near Javelina Mountain and the Childs Valley in between Aguila Mountain and the Crater Range.

**Relationship to plant community classification systems.**—This community is included within the Paloverde-Mixed Cacti Series (154.12; Brown and others 1979).

**Information Needs.**—Much work is needed to clarify the compositional, structural, and functional attributes of this community throughout its limited range within the Sonoran Desert. Comparison of the long-term ungrazed bajadas of the Sand Tank Mountains with grazed areas may elucidate the effects of grazing on these communities and provide clues about restoration needs for degraded examples.
6.2.8 Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes

Ecological Characteristics

Composition.— Compositionally this community is similar to the Paloverde-Mixed Cacti-Mixed Scrub on Bajadas matrix system (see above), but additional associates, such as *Opuntia bigelovia*, likely distinguish it. A significant compositional variation likely is present due to aspect.

Structure.— This community forms large patches of a sparse to clumped vegetative canopy on highly irregular bedrock outcrops (Figure 6.19). Mountain Xeroriparian Scrub is found along narrow drainages throughout this large patch community.

Function.— Most dynamic processes on landscapes dominated by this community involve linear xeroriparian systems that are often nested within the matrix. Climate extreme, however, may be viewed as a periodic, dynamic process in which extremes in temperature and/or drought may cause die-back of many plant species.

Landscape context.— This community is found throughout low mountain ranges on the BMGR. Occurrences are primarily found above the major pediments. Winter rains are more characteristic of these ranges than those farther west that support *Jatropha-Bursera* dominated desert scrub. Surrounding communities that extend down onto lower elevation bajadas are the matrix-forming Paloverde-Mixed Cacti-Mixed Scrub and Creosote-Bursage Desert Scrub communities.

Status, Threats, and Management

Historic and current distribution.— This community is endemic to the Sonoran Desert Ecoregion. Distribution is limited to low mountain ranges throughout the Lower Colorado Valley and Arizona Uplands subdivisions. This community is widespread on the upper bajadas on the BMGR, extending east from and including the Mohawk Mountains to the Sand Tank Mountains. Some of the historic range of this community has been lost to urban expansion into the foothills of the mountains surrounding Tucson and Phoenix.

Conservation status.— These communities are important in watershed protection. In association with the Paloverde-Mixed Cacti-Mixed Scrub on Bajadas, the BMGR contains one of the few remaining unfragmented representations of the entire paloverde-mixed cacti ecological system, extending from the upper mountain slopes to lower bajadas, in the entire ecoregion. Although endemic to the Sonoran Desert ecoregion, this community is relatively isolated and inaccessible and is not considered to be significantly threatened. Although this community on the BMGR is not threatened currently by military training, some high concentrations of rare cacti are found in these areas and some areas are potentially threatened by recreation and cacti collectors.
Best examples on the BMGR.—The best described examples of this community are found in the Sauceda Mountains on the BMGR. The Growler Mountains on Cabeza Prieta also contain a good example of this community.

Stressors.—Altered vegetation composition.

Sources of stress.—Recreationists and professional cacti collectors.

Threat abatement strategies.—Limit and monitor recreation and its effects in the most vulnerable areas.

Mapping and Information Needs

Mapping: workshop comments.—This community could be mapped using slopes greater than 25 degrees.

Mapping: application of assumptions.—See Paloverde-Mixed Cacti-Mixed Scrub on Bajadas. This community was mapped at slopes greater than 25 degrees. This model also was applied to the area surrounding the Sand Tank Mountains that did not fall within the parameters for the Sand Tank Mountains Uplands.

Relationship to plant community classification systems.—This system is included within the Paloverde-Mixed Cacti Series (154.12; Brown and others 1979).

Information needs.—Much additional work is needed to characterize compositional, structural, and functional attributes of these systems. Long-term monitoring is needed to detect possible climate-induced changes in species composition.

6.2.9 Sand Tank Mountains Uplands

Ecological Characteristics

Composition.—Compositionally this system is similar to the Paloverde-Mixed Cacti-Mixed Scrub on Bajadas matrix community (see above), but additional associates distinguish it. Typical associates include crucifixion thorn (Canotia holocantha) (along lower margins), Vaquelinea californica sonorensis (in canyons), and Juniperus coahuilensis (on north slopes) along an elevation gradient up to 1400 meters above sea level (Felger and others 1997). The population of Canotia holocantha is disjunct from the main distribution of the species in central Arizona (Turner and others 2000). Berberis harrisonia is found (among 3 known populations) within this community. Composition is variable and influenced by aspect, edaphic characteristics, and sheltering cliffs and rocks.

Structure.—This community forms large patches of a sparse to clumped vegetative canopy frequently found on steep, highly irregular bedrock outcrops. Structure is variable and influenced by aspect, edaphic characteristics, and sheltering cliffs and rocks.

Function.—Most dynamic processes on landscapes dominated by this community involve linear xeroriparian systems that are often nested within this community. Climate extreme, however, may be viewed as a periodic, dynamic process in which extreme temperature and/or drought may cause die-back of many plant species.

Landscape context.—This variant on the matrix Paloverde-Mixed Cacti-Mixed Scrub on Bajadas community occurs at high elevations on steep, rocky slopes in and around the Sand Tank Mountains.
along an elevation gradient up to 1400 meters above sea level. Winter rains are characteristic of these eastern, high elevation desert areas that support species of Madrean affinity. Mountain Xeroriparian Scrub is found along narrow drainages throughout this large patch community. The matrix-forming Paloverde-Mixed Cacti-Mixed Scrub on Bajadas community extends down onto lower elevation bajadas and surrounds this system.

**Status, Threats, and Management**

**Historic and current distribution.**—This community is endemic to the Sonoran Desert Ecoregion. As the community is described in this report, distribution is limited to the Sand Tank Mountains above the pediments; however, similar expressions of this community may occur in the Ajo Mountains to the south (with the exception of the occurrence of *Canotia holacantha*).

**Conservation status.**—This community is known almost exclusively from the the Sand Tanks Mountains. A similar combination of plants may occur at the upper elevations of the Ajo Mountains (Turner and others 2000, Warren and others 1981). It is an extremely rare and vulnerable community that contains relict species more typical of woodland/chaparral communities from the Pleistocene (Turner and others 2000).

**Best examples on the BMGR.**—The only example is found in upper elevations of the Sand Tank Mountains.

**Stressors.**—Alteration of vegetation composition and structure.

**Sources of stress.**—The only examples are located close to Phoenix and could be increasingly vulnerable to recreationists and cactus collectors. Invasive species, especially red brome and Lehmann lovegrass (*Eragrostis lehmanniana*), that are spread by people and vehicles can impact vegetation composition and structure. Climate change also could be a threat that would alter composition.

**Threat abatement strategies.**—Control illegal access into the Sand Tank Mountains. Monitor recreational activities and take action to avoid/minimize impacts to the community.

**Mapping and Information Needs**

**Mapping: workshop comments.**—The distributional boundaries of this community type were drawn by experts during the November 2 workshop. These boundaries could be refined using an appropriate elevation cut-off that captures the relict high elevation plant species that are considered integral with this community type.

**Mapping: application of assumptions.**—The line drawn by experts at the workshop to delineate this community was vague and imprecise. The areal extent of the community was determined by taking the average lower elevation limit of *Canotia holacantha* and *Vaquelinea californica sonorenxis* to be 2600 feet or 792 meters (based in part on elevational occurrence and distributional data in Turner and others 1995). A grid analysis was performed on the 30-meter DEM to determine elevation less than 792 meters and greater than 792 meters. A shapefile was generated from the greater than 792 meters grid to produce the polygon for this community. The extent of the polygon was restricted to the Sand Tank Mountains range. Small outlying areas more than 300 meters from the range at the elevation limit were eliminated from this element polygon and coded to Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes.

**Relationship to plant community classification systems.**—This community is included within the Paloverde-Mixed Cacti Series (154.12; Brown and others 1979). The Sand Tank Mountains Uplands
demonstrates some affinity with the *Juniperus monosperma* [= *J. coahuilensis*; Felger and others 1997]-
*Vauquelinia californica* Mixed Shrub Association (122.4151) that Warren and others (1981) described
from the higher elevations of the Ajo Mountains, except that these authors did not report *Canotia holocantha* as part of the floristic composition of the association. Warren and others (1981) pointed out
that the association is a mixture of species of varied origin—“understory shrubs are mostly upper desert,
chaparral or desert-grassland species which often exceed the junipers in number”—and, as a result, the
association name may be misleading in regard to the floristic affinities of the association as a whole.

**Information needs.**—Much additional work is needed to characterize the compositional, structural, and
functional attributes of this community. Long-term monitoring is needed to detect possible climate-
induced changes in species composition.

### 6.2.10 Elephant Tree-Limberbush on Xeric Rocky Slopes

**Ecological Characteristics**

**Composition.**—Compositionally this community is similar to the Paloverde-Mixed Cacti-Mixed Scrub
on Bajadas matrix system (see above), but it is characterized by additional associates. Elephant tree
(*Bursera microphylla*), limberbush (*Jatropha cuneata*), *Nolina bigelovii*, and *Rhus kearnyi* are dominant
in a mixed canopy. Vegetation of this system may differ with substrate and may be best expressed on
granitic slopes (S. Rutman). Significant compositional variation likely exists based on changes in aspect.

**Structure.**—This community forms large patches with a sparse to clumped vegetative canopy on highly
irregular bedrock outcrops.

**Function.**—Most dynamic processes on landscapes dominated by this community involve linear
xeroriparian systems that are often nested within the matrix. Climate extreme, however, may be viewed
as a periodic, dynamic process in which extremes in temperature and/or drought may cause die-back of
many plant species.

**Landscape context.**—This community is found throughout low mountain ranges in the most arid
portions of the Lower Colorado Valley and Arizona uplands of the Sonoran Desert. It is commonly
associated with granite bedrock and granite-derived gravels at the base of the mountains. Winter rainfall
characterizes the primary precipitation pattern, and characteristic vegetation is limited to areas with
above-freezing temperatures (R. Felger). Mountain Xeroriparian Scrub is found along narrow drainages
throughout this large patch community. The surrounding community is the matrix-forming
Creosotebush-Bursage Desert Scrub community that extends down onto lower elevation bajadas.

**Status, Threats, and Management**

**Historic and current distribution.**—This community is endemic to the Sonoran Desert Ecoregion.
Distribution is limited to low mountain ranges in limited portions of the Lower Colorado Valley, Arizona
Uplands, and Central Gulf Coast subdivisions. In the United States, this community is found in the
western extreme of the BMGR in the Copper Mountains, southern Gila Mountains, and northern Tinajas
Altas Mountains. More than likely, however, this community represents a clearly distinct desert scrub
system that has its main distribution centered in northern Sonora, Mexico.

**Conservation Status.**—The BMGR and Cabeza Prieta contain the only representations of this
community in the United States. It is likely that this community is well represented in highly isolated
mountain ranges throughout northern Sonora; however, knowledge of this system and its conservation
status is considerably limited. On the BMGR this community is not impacted by any military training activities.

**Best examples on the BMGR.**—The Tinajas Altas and Gila Mountains.

**Stressors.**—Altered vegetation composition and soil erosion are the primary stresses on this system.

**Sources of stress.**—The Tinajas Altas and Gila Mountains are exposed to heavy recreational vehicle use.

**Threat abatement strategies.**—Restrict recreational vehicles to designated roads.

### Mapping and Information Needs

**Mapping: workshop comments.**—The areal extent of this community was drawn by experts at the workshop. Sheep Mountain (Fortuna Mines) polygons should be mapped as this type and Sierra Pinta should be coded as Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes.

**Mapping: application of assumptions.**—This community was mapped using polygons from the Sonoran Desert Ecoregion vegetation map (Marshall and others 2000) for Torchwood-Limberbush. The Sierra Pinta was removed from this community and the model for Paloverde-Mixed Cacti-Mixed Scrub was applied to that mountain range. The polygon from University of Arizona (1993) for *Bursera microphylla* Associations (363.127; nomenclature reflects an earlier application of the Brown and others [1979] classification published in Brown and Lowe [1974]) in the Gila and Sheep Mountains was added. It was noted during mapping that this polygon closely aligns with polygons generated from the greater than 6% slope analysis; however, it is shifted off some portions of the range. This shift was not corrected to be consistent with the original data. Ground-truthing may be necessary to confirm the actual areal extent of the community in this area.

**Relationship to plant community classification systems.**—This community may be included within the Copal-Torote Series (154.14; Brown and others 1979). Warren and others (1981) describe a plant community from the south-facing slopes of some of the mountains within Organ Pipe Cactus National Monument, *Cercidium microphyllum-Encelia farinosa-Lemaireocereus thurberi-Bursera microphylla* Association (154.1271), that shares some affinities with the Elephant Tree-Limberbush on Xeric Rocky Slopes described here. Both communities share elephant tree and *Jatropha cuneata* as characteristic species; however, *Nolina bigelowii* and *Rhus kearnyi* have not been documented on the monument (Warren and others 1981; J. Malusa).

**Information needs.**—Much additional work is needed to characterize compositional, structural, and functional attributes of this community.

### 6.2.11 Desert Playa

#### Ecological Characteristics

**Composition.**—Desert playas in the central Sonoran Desert are poorly studied. In general, they are sparsely vegetated, with periodic emergence of ephemeral species. A few perennial species, such as *Caesalpinia glauca* and *Malvella sagittifolia*, may be found on the Mohawk Playa. Unlike playa lake complexes in the Mojave Desert, few Sonoran Desert playas include narrow “rings” of salt desert scrub or inclusions of species such as *Suaeda moquinii* or *Prosopis* sp. Large playas in the Sonoran Desert, however, may have surrounding rings of vegetation (A. Harlan). Creosotebush-Bursage Desert Scrub tends to grade into playa lake margins. Characteristic vegetation differs between playas and may be
difficult to define because of unpredictable emergence of annuals. The Mohawk Playa on the BMGR and the eastern and western playas at Las Playas (Pinta Sands Playa) on Cabeza Prieta are distinct (T. Harlan and A. Harlan). The western playa includes occasional ferns and mercelias (R. Felger).

Structure.—This community typically forms large patches on flat plains and basins (Figure 6.20). Drainages into playas may form deep ravines that are subsequently filled in. Desert playas are often located within a matrix of Creosotebush-Bursage Desert Scrub and may be associated with active and stabilized sand dunes. Where associated with dunes, the playa water source may be extremely deep (S. Rutman).

Function.—Periodic flooding and subsequent evaporation are the dominant ecological processes of desert playas throughout the desert southwest. Large mud cracking at Las Playas may be related to volcanic activity. Little is known about the hydrology of the desert playas within and near the BMGR.

Landscape context.—Large open expanses that support playa lakes also may serve as sand sources for dunes that are located down-wind. Rainfall absorbed into dune fields may serve as a water source for seepage into the playa lakes. Many playas include dissected streambeds that are erased through time. Figure 6.21 shows a landscape view of a Desert Playa.

Status, Threats, and Management

Historic and current distribution.—Desert playas similar to those found at BMGR may occur in the Mojave and Sonoran Deserts, but little is known.

Conservation status.—Extremely few playas are found in the Sonoran Desert. They are important as seasonal, temporary water sources that many animal and plant species depend on. For example, playas may be important habitat for desert anurans such as Couch’s spadefoot (Scaphiopus couchii). Playas are critical resources that should be protected within a watershed context.

Best examples on the BMGR.—Mohawk Playa.

Stressors.—Hydrological disruption and alteration of vegetative composition can have disastrous effects on endemic biota that are dependent on this seasonal water source.

Sources of stress.—Rock dams on Mexico side may be causing changes within the Las Playas complex.
**Threat abatement strategies.**—Military and recreational activities (if any) should be excluded from all playa communities on the BMGR because of their rarity and critical importance to endemic flora and fauna.

**Mapping and Information Needs**

**Mapping: workshop comments.**—Playas should be mapped based on soil types and/or the location of its Pleistocene boundary.

**Mapping: application of assumptions.**—This community was mapped using the Sonoran Desert Ecoregion vegetation map (Marshall and others 2000) for the Sonora/Mojave Playa lake and the boundaries were refined using the ALRIS hydrography. Soil data were not used because of the coarseness of the available data (U.S. Department of the Air Force 1998).

**Relationship to plant community classification systems.**—This community is characterized by a land form and has no described relationship to current vegetation classification systems.

**Information needs.**—Playa locations are not well-known, so desert playas should be inventoried and mapped across the BMGR (and the Sonoran Desert Ecoregion). Hydrological studies are needed to evaluate the flow into and surrounding the playas on the BMGR. Research on invertebrate and vertebrate use of playa communities is needed.

**6.2.12 Desert Tinaja/Spring**

**Ecological Characteristics**

**Composition.**—Tinajas are typically small aquatic ecosystems formed through water accumulation in bedrock depressions (Figure 6.22). Both permanent and ephemeral tinajas may support a variety of temperate and tropical aquatic invertebrates (Larsen and Olson 1997). Some of the invertebrates are habitat generalists, though others are unique to tinajas and/or to a particular tinaja (Larsen and Olson 1997, Kingsley 1998). Vegetation is typically absent or present as a few individual plants.

**Structure.**—This community forms small patches among bedrock exposures.

**Function.**—Periodic inflow and slow evaporation are primary processes supporting tinajas. Aquatic community dynamics are not documented. Depending on their topographic position, tinajas may retain water permanently.

**Landscape context.**—This community may occur in bedrock depressions throughout the desert southwest.

*Figure 6.22* Talvez Tinaja in the Saucedo Mountains.
Status, Threats, and Management

Historic and current distribution.—Tinajas, or small aquatic ecosystems much like them, may occur throughout the desert southwest.

Conservation status.—Tinajas on the BMGR are important as a source of water for desert wildlife. This community is essential in the life cycles of many amphibians and invertebrates and as feeding and drinking areas for bats and other wildlife. Tinajas have not been adequately studied, and their importance to invertebrates, in particular, is not well understood. It is possible that there are invertebrates endemic to desert tinajas on the BMGR, but more sampling is needed for this to be determined.

Best examples on the BMGR.—None were noted.

Stressors.—Little is known about tinaja dynamics, but the potential exists for hydrology to be altered and aquatic faunal composition to be affected.

Sources of stress.—Tinaja “improvement” may be detrimental to other endemic wildlife that rely on these resources (M. Cochran, P. Rosen, S. Rutman, L. Smith, D. Suhre).

Threat abatement strategies.—Tinajas that are at present unmodified should be left in their natural state. Currently modified tinajas perhaps could be restored.

Mapping and Information Needs

Mapping: workshop comments.—None were noted.

Mapping: application of assumptions.—This community was mapped using point data obtained from Luke Air Force Base’s Special Aquatic Sites data layer and selecting from the data just natural tinajas and springs. The actual extent of natural tinajas is probably underrepresented by the available data.

Relationship to plant community classification systems.—This community is characterized by a land form and has no described relationship to current vegetation classification systems.

Information needs.—Much additional work is needed to characterize compositional, structural, and functional attributes of this community. Inventory and mapping of desert tinajas is needed. Invertebrate sampling and studies of aquatic community dynamics in natural versus unmodified tinajas also are needed.

6.2.13 Salt Desert Scrub

Ecological Characteristics

Composition.—This community is dominated by the facultatively deciduous, xeromorphic shrub, Atriplex polycarpa. Two main types of saltbush communities occur with different characteristic vegetation: those found along major riverine systems and that have been converted largely to agriculture and the drier upland type, which is associated with creosotebush and many cactus species (S. Rutman). Subshrubs such as Gutierrezia sarothrae or Eriogonum spp. may occur as part of the community. Atriplex polycarpa may occur with Atriplex linearis as a codominant, along with creosotebush and mixed cacti (S. Rutman). The sparse to moderately dense graminoid layer may be dominated by warm season medium-tall and short grasses. The species present depend on geographic range of the grasses,
alkalinity/salinity, and past land use. Forb cover is generally sparse, but annual forbs may be abundant in wet years. Cacti from the genus *Opuntia* are associated species in some stands.

**Structure.**—This community may form large patches on desert bajadas. Vegetation typically has a sparse to moderately dense layer of facultatively deciduous, extremely xeromorphic shrubs up to two meters in height. A sparse herbaceous understory may be present.

**Function.**—*Atriplex polycarpa* is tolerant of saline or alkaline soils, but it is not restricted to those soils. It marks the extent of deep, fine loamy soils of significant agricultural value (Nichol 1937). Finer soils relative to Creosotebush-Bursage Desert Scrub result in greater water retention capacity; lands occupied by *Atriplex* spp. are subject to periodic flooding, however infrequent (Brown 1994).

**Landscape context.**—This community may occur on lowland and upland sites throughout much of the arid and semi-arid western U.S. at elevations ranging from 75 meters below sea level to 2400 meters above sea level. Lowland sites include alluvial flats, drainage terraces, playas, washes, and interdunal basins. Upland sites include bluffs and gentle to moderately steep sandy or rocky slopes. The community may occur on all aspects. Soils are variable with depths ranging from shallow to moderately deep and textures ranging from sands to loams to clay. The lowland sites may be moderately saline or alkaline.

**Status, Threats, and Management**

**Historic and current distribution.**—A variety of salt desert scrub communities occur in arid and semi-arid areas throughout the southwestern U.S. from west-Texas to southern and eastern California and into Chihuahua, Mexico. They also are found in the western Great Plains to the Great Basin, from western Kansas, Colorado, and Wyoming to Utah, Nevada and eastern Oregon. *Atriplex* spp. are considered good forage for deer and many classes of livestock because they are highly nutritious and palatable and because much of the historic range of these communities have been lost or disturbed due to grazing pressures.

**Conservation Status.**—Most stands of this community have been lost in the Sonoran Desert due to conversion to agriculture, and where it remains it is largely disturbed by domestic livestock grazing (Brown 1994). The BMGR could be essential in the conservation of this community. The areas where this community may be found on the BMGR are not well known. These communities need to be found, assessed, and protected on the BMGR.

**Best examples on the BMGR.**—An example of Salt Desert Scrub occurs within the San Cristobal Valley (D. Turner), but its full extent remains to be mapped (Figure 6.1).

**Stressors.**—Altered vegetation composition and dynamics.

**Sources of stress.**—Past conversion to agriculture.

**Threat abatement strategies.**—None were noted.

**Mapping and Information Needs**

**Mapping: workshop comments.**—Ground-truthing is needed to confirm the occurrence and community composition of polygons drawn in the workshop and those minor association polygons mapped by Tunnicliff and others (1986): 154.1760 [*Larrea tridentata*-*Atriplex polycarpa*-(*Encelia farinosa, Ambrosia dumosa*)] and 154.1761 [*Atriplex polycarpa*-Ambrosia deltoidea-*L. tridentata*-(*Fouquieria splendens, Olneya tesota*)].
Mapping: application of assumptions.—This community was mapped by creating a point file using polygons from the reclassified Tunnicliff and others (1986) vegetation map and generating centroids of those polygons. One polygon location was added in the north San Cristobal Valley based on the field notes of D. Turner.

Relationship to plant community classification systems.—This community is included within the Saltbush Series (154.17; Brown and others 1979). Salt Desert Scrub communities on the BMGR may share affinities with one or more of the different Atriplex polycarpa associations (154.1761–1763) described by Warren and others (1981) that occur on Organ Pipe Cactus National Monument.

Information needs.—Inventory and mapping of Salt Desert Scrub is needed. Much additional work is needed to characterize compositional, structural, and functional attributes of this community.

6.3 SUMMARY STATISTICS: GAP BIODIVERSITY MANAGEMENT STATUS AND NATURAL COMMUNITY ACREAGE AMOUNTS

This section attempts to provide some context for setting appropriate conservation goals for natural communities on the BMGR. Two data sets contained within the Marshall and others (2000) ecological analysis of conservation priorities in the Sonoran Desert Ecoregion provide a starting point: natural vegetation in the Sonoran Desert Ecoregion and a Gap analysis of Sonoran Desert conservation sites (areas that contribute to the network of sites needed to conserve the biodiversity of the Sonoran Desert). The natural vegetation communities used by Marshall and others (2000) are based for the most part on remotely sensed satellite data and are fairly coarse both with respect to mapping accuracy and to community delineation (see Figure 6.2).

Gap analysis (Crist and others 2000) uses a scale of 1 through 4 to classify the relative degree of management devoted to the protection and management of a particular land management unit and its associated biodiversity. A status of “1” denotes the highest, most permanent and protective level of management, whereas a status of “4” represents the minimum level of management or unknown status. A complete definition of each status category is provided in Appendix A.1. All else being equal, land management units such as National Parks and National Monuments generally receive a status of 1, whereas, National Wildlife Refuges, because they often are subject to some consumptive uses, generally receive a status of 2. Other publicly held lands (generally those subject to multiple use), unless they have special included management units such as wilderness areas, are assigned a status of 3 when management plans are not designed to maintain a natural state.

Appropriate management for biodiversity conservation generally corresponds with Gap status categories 1 and 2. Although many federal land management agencies, such as the Department of Defense, will not administratively achieve the status of parks, monuments, or refuges, in some cases they may be able to establish management standards for substantial portions of their lands that achieve equivalence with Gap status 1 or 2.

The Gap analysis in Marshall and others (2000) evaluated Gap biodiversity management status across the entire Sonoran Desert Ecoregion without regard to natural vegetation community type. They found that only 11% of the Sonoran Desert Ecoregion is contained within status 1 and 2 lands. This percentage increases to 19% if only the network of conservation areas is considered. Table 6.2 provides Gap land biodiversity status across the Sonoran Desert Ecoregion broken down by natural vegetation community. Except for some specialized habitats, such as Sonora/Mojave Playa Lake—which are themselves rare across the ecoregion, even common matrix communities such as Creosotebush-Bursage do not exceed 20% in the amount of their acreage contained within status 1 and 2 lands. Some community types, such
### Table 6.2 Sonoran Desert Ecoregion Natural Vegetation Communities: Acreage by Gap Biodiversity Management Status Ecoregion-wide

<table>
<thead>
<tr>
<th>Natural Vegetation Community</th>
<th>Percent(^1)</th>
<th>Total Acres within Ecoregion</th>
<th>Acres by Gap Biodiversity Management Status Ecoregion-wide</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gap 1 (highest level of protection)</td>
</tr>
<tr>
<td>Creosotebush-Bursage</td>
<td>35.6%</td>
<td>19,546,180</td>
<td>422,790</td>
</tr>
<tr>
<td>Paloverde-Mixed Cacti</td>
<td>28.1%</td>
<td>15,440,560</td>
<td>309,840</td>
</tr>
<tr>
<td>Mesquite Woodland</td>
<td>8.2%</td>
<td>4,505,560</td>
<td>25,700</td>
</tr>
<tr>
<td>Coastal/Interior Dunes and Plains</td>
<td>7.7%</td>
<td>4,231,750</td>
<td>432,770</td>
</tr>
<tr>
<td>Agriculture/Urban(^2)</td>
<td>7.6%</td>
<td>4,189,580</td>
<td>50</td>
</tr>
<tr>
<td>Torchwood-Limberbush</td>
<td>5.5%</td>
<td>2,996,870</td>
<td>57,380</td>
</tr>
<tr>
<td>Industrial/Urban(^3)</td>
<td>2.1%</td>
<td>1,165,780</td>
<td>190</td>
</tr>
<tr>
<td>Sinaloan/Foothills Thornscrub</td>
<td>2.0%</td>
<td>1,119,620</td>
<td></td>
</tr>
<tr>
<td>Saltbush Desert Scrub/Coastal Marsh</td>
<td>1.0%</td>
<td>555,780</td>
<td>1260</td>
</tr>
<tr>
<td>Semi-desert Grassland/Chaparral</td>
<td>0.8%</td>
<td>421,550</td>
<td>7590</td>
</tr>
<tr>
<td>Water</td>
<td>0.3%</td>
<td>170,650</td>
<td>1360</td>
</tr>
<tr>
<td>Interior Chaparral/Encinal</td>
<td>0.4%</td>
<td>233,050</td>
<td>22,760</td>
</tr>
<tr>
<td>Interior Riparian Shrub/Woodland</td>
<td>0.3%</td>
<td>187,160</td>
<td>310</td>
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<tr>
<td>Desert Riparian Woodland</td>
<td>0.1%</td>
<td>71,430</td>
<td>500</td>
</tr>
<tr>
<td>Sonora/Mojave Playa Lake</td>
<td>0.1%</td>
<td>72,860</td>
<td>570</td>
</tr>
<tr>
<td>Agave-Bursage Scrub</td>
<td>&lt;0.1%</td>
<td>16,600</td>
<td></td>
</tr>
<tr>
<td>Interior Riparian Marsh</td>
<td>&lt;0.1%</td>
<td>3610</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Coastal Mangrove Marsh</td>
<td>&lt;0.1%</td>
<td>3140</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>&lt;0.1%</td>
<td>1180</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>54,932,910</strong></td>
<td><strong>1,260,310</strong></td>
</tr>
</tbody>
</table>

\(^1\) All acreage amounts are rounded to the nearest 10 acres.

\(^2\) As defined in Marshall and others (2000).

\(^3\) All percentages are rounded to the nearest 0.1%.

\(^4\) Gap status 1 and 2 show up in the Agriculture/Urban and Industrial/Urban categories because of scale differences, digitization errors, and derivation method differences (that is, remote sensing versus digital line graph) between the two geospatial files intersected to create this table: natural vegetation in the Sonoran Desert Ecoregion and Gap analysis of Sonoran Desert Ecoregion conservation sites (Marshall and others 2000). Often these are polygons on the borders of various wilderness areas, Areas of Critical Environmental Concern, or wildlife refuges.
as Torchwood-Limberbush (5.6%) and Saltbush Desert Scrub/Coastal Marsh (0.4%), have poor representation on status 1 and 2 lands.

The above numbers, as low as they are, do not tell the whole story. Marshall and others (2000) also set conservation criteria (goals) for each of the above natural vegetation communities. For matrix communities (that is, Creosotebush-Bursage and Paloverde-Mixed Cacti) the goal was to conserve 30% of their historic extent. For non-matrix communities, criteria related to the number of occurrences (examples) that should be conserved and differed depending on the communities distribution (endemic or otherwise) relative to the ecoregion. For endemic communities the goal was set at 60 examples, whereas the goals for limited (40 examples) and widespread communities (20 examples) were set lower. The distribution of these examples also was intended to be spread out across the ecoregion to ensure the full range of diversity within the communities was captured.

Table 6.3 next provides Gap biodiversity management status for the BMGR broken down by the same natural vegetation communities for those communities that could be mapped on the BMGR using remote data. Gap status was assigned to BMGR land management units in accordance with the “existing” land use depicted in U.S. Department of the Air Force (1998). Figure 6.23 shows the correspondence between Gap status and land management unit for the BMGR and surrounding areas. Although the management associated with any particular management unit, or newly identified units, will change with development of the BMGR’s Integrated Natural Resources Management Plan (INRMP) and with relinquishment of

| Natural Vegetation Community² | Total Acres within Ecoregion | Total Acres within BMGR | Acres by Gap Biodiversity Management Status for the Barry M. Goldwater Range
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gap 1 (highest level of protection)</td>
</tr>
<tr>
<td>Creosotebush-Bursage</td>
<td>19,546,180</td>
<td>1,379,640</td>
<td>455,500</td>
</tr>
<tr>
<td>Paloverde-Mixed Cacti</td>
<td>15,440,560</td>
<td>328,330</td>
<td>57,810</td>
</tr>
<tr>
<td>Coastal/Interior Dunes and Plains</td>
<td>4,231,750</td>
<td>106,010</td>
<td>19,560</td>
</tr>
<tr>
<td>Agriculture/Urban³</td>
<td>4,189,580</td>
<td>1350</td>
<td>430</td>
</tr>
<tr>
<td>Torchwood-Limberbush</td>
<td>2,996,870</td>
<td>52,750</td>
<td>47,690</td>
</tr>
<tr>
<td>Industrial/Urban³</td>
<td>1,165,780</td>
<td>720</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>170,650</td>
<td>180</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,868,980</strong></td>
<td><strong>533,300</strong></td>
<td><strong>762,450</strong></td>
</tr>
<tr>
<td>Total Acres within Ecoregion</td>
<td>54,932,910</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹All acreage amounts are rounded to the nearest 10 acres.
²As defined in Marshall and others (2000).
³Gap status 1 and 2 show up in the Agriculture/Urban and Industrial/Urban categories because of scale differences, digitization errors, and derivation method differences (that is, remote sensing versus digital line graph) between the two geospatial files intersected to create this table: natural vegetation in the Sonoran Desert Ecoregion and Gap analysis of Sonoran Desert Ecoregion conservation sites (Marshall and others 2000). Often these are polygons on the borders of various wilderness areas, Areas of Critical Environmental Concern, or wildlife refuges.

6.34
parcels no longer to be withdrawn after November 2001, Table 6.3 and Figure 6.23 provide a baseline, relative to the rest of the Sonoran Desert Ecoregion, for describing the BMGR’s management status and how it contributes to biodiversity management and protection.

A fairly high percentage (33%) of the Creosotebush-Bursage community on the BMGR is in Gap status 2 (no portion of the BMGR achieves Gap status 1). If this is a reasonable depiction of management status, this would indicate that proportionally the BMGR was achieving the ecoregional conservation goal for this community type (that is, conservation of at least 30% of the acreage that a makes up a matrix community). The number falls off for the other matrix community, Paloverde-Mixed Cacti, to 17.6%. Percentages do not apply to the two large patch community types: Coastal/Interior Dunes and Plains and Torchwood-Limberbush. A significant portion of the dune complexes on the BMGR; however, are included within Bureau of Land Management-designated Areas of Critical Environmental Concern (ACEC) (the active dune areas are either in Gap status 2 or 3). The Torchwood-Limberbush has no representation within Gap status 2. These percentages and their analysis do not take into account whether public lands will need to shoulder a disproportionate share of the biodiversity protection and management need (they probably will), whether the appropriate distribution of community representation is achieved across the ecoregion (and perhaps the BMGR itself), and pending land management changes (such as for Area A).

The preceding analysis was based on remotely sensed vegetation information synthesized in Marshall and others (2000). What about the natural community conservation elements described herein and their relationship to Gap biodiversity management status? Table 6.4 provides Gap biodiversity management status for the BMGR and Cabeza Prieta National Wildlife Refuge broken down by natural community conservation elements. Because the area within which these communities were described covers only the two preceding administrative areas, we can not extend our analysis to the entire Sonoran Desert Ecoregion. Of note is that the addition of Cabeza Prieta National Wildlife Refuge increases significantly the amount of land in Gap status 2.

The matrix communities, Creosotebush-Bursage Desert Scrub and Paloverde-Mixed Cacti-Mixed Scrub on Bajadas, are fairly well-represented in Gap status 2 (49.9% and 37.3%, respectively). The Valley Bottom Floodplain Complex is mostly in Gap 2 status; however, without additional data to confirm whether viable examples of this community type still exists elsewhere, it may be important to protect the full extent of this community on the BMGR and Cabeza Prieta. The more narrowly defined Dune Complex and Dune Endemics Community (compared to the Coastal/Interior Dunes and Plains community of Marshall and others [2000]) has 53.7% representation in Gap status 2; however, we did not map the full extent of associated sand sheets with this community. Of note is that none of the Sand Tank Mountains Uplands is represented in Gap status 2. The upcoming relinquishment of a large portion of this community type will undoubtedly affect its management status. By including Cabeza Prieta in the analysis, the land management protection status afforded the Elephant Tree-Limberbush on Xeric Rocky Slopes community type (similar to the Torchwood-Limberbush community of Marshal and others [2000]) significantly improved. As might be expected, rocky slope-associated communities are generally well-protected. Biodiversity management status for xeroriparian communities will correspond to the matrix/large patch communities that they dissect. Specialized habitats, such as Desert Playas and Desert Tinaja/Spring, should be protected (at least Gap status 2) no matter where they occur. The poor protective status of saltbush communities in the ecoregional analysis (Table 6.2) suggests that any representation of intact Salt Desert Scrub found to occur on the BMGR (as well as on Cabeza Prieta) should be protected.
### TABLE 6.4 Natural Community Conservation Elements: Acreage by Gap Biodiversity Management Status

<table>
<thead>
<tr>
<th>Natural Community Conservation Elements and Developed Areas</th>
<th>Total Acres within BMGR &amp; Cabeza Prieta NWR</th>
<th>Acres by Gap Biodiversity Management Status</th>
<th>Gap 1 (highest level of protection)</th>
<th>Gap 2</th>
<th>Gap 3</th>
<th>Gap 4 (lowest level of protection)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valley Bottom Floodplain Complex</td>
<td>64,840</td>
<td></td>
<td>58,150</td>
<td>1410</td>
<td>5280</td>
<td></td>
</tr>
<tr>
<td>Valley Xeroriparian Scrub</td>
<td>30,750</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mountain Xeroriparian Scrub</td>
<td>5760</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dune Complex and Dune Endemics</td>
<td>41,870</td>
<td></td>
<td>22,480</td>
<td>19,360</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Creosotebush-Bursage Desert Scrub</td>
<td>1,832,210</td>
<td></td>
<td>914,580</td>
<td>500,990</td>
<td>416,640</td>
<td></td>
</tr>
<tr>
<td>Creosotebush-Big Galleta Scrub</td>
<td>77,720</td>
<td></td>
<td>72,500</td>
<td>&lt;10</td>
<td>5220</td>
<td></td>
</tr>
<tr>
<td>Paloverde-Mixed Cacti-Mixed Scrub on Bajadas</td>
<td>365,460</td>
<td></td>
<td>136,240</td>
<td>137,670</td>
<td>91,550</td>
<td></td>
</tr>
<tr>
<td>Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes</td>
<td>91,300</td>
<td></td>
<td>56,490</td>
<td>23,610</td>
<td>11,200</td>
<td></td>
</tr>
<tr>
<td>Sand Tank Mountains Uplands</td>
<td>23,040</td>
<td></td>
<td>15,760</td>
<td>7280</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elephant Tree-Limberbush on Xeric Rocky Slopes</td>
<td>173,440</td>
<td></td>
<td>82,100</td>
<td>58,740</td>
<td>32,600</td>
<td></td>
</tr>
<tr>
<td>Desert Playa</td>
<td>1050</td>
<td></td>
<td>880</td>
<td>70</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Desert Tinaja/Spring</td>
<td>Point data</td>
<td></td>
<td>—</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Salt Desert Scrub</td>
<td>Point data</td>
<td></td>
<td>—</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Agriculture/Industrial/ Urban</td>
<td>1230</td>
<td></td>
<td></td>
<td>510</td>
<td>720</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2,672,160</td>
<td></td>
<td>1,343,420</td>
<td>758,120</td>
<td>570,620</td>
<td></td>
</tr>
</tbody>
</table>

1. All acreage amounts are rounded to the nearest 10 acres.
2. Derived using a 20 meter total buffer on the line file. The acreage amount was not subtracted from the acreage for community types such as Creosote-Bursage Desert Scrub, which this community dissects.
CHAPTER 7 SPECIES CONSERVATION ELEMENTS

This section contains ecological and other descriptions for twelve proposed, species conservation elements. Four of these species elements are guilds composed of at least three or more species. For each conservation element, information is presented that describes the: ecological characteristics of the species/guild; its status, threats to its persistence, and associated threat abatement strategies; and mapping and information needs. Information could not always be obtained for each category for each species/guild. Chapter 5 provides summary information for each species/guild conservation element, including the rationale for including each as an element in accordance with the fine-filter screening criteria outlined in Table 4.2. This information is not necessarily repeated in this chapter. Species/guild conservation elements are presented by taxonomic group.

7.1 PLANTS

The only plant species selected as a species conservation element was crucifixion thorn (*Castela emoryi*), which is an endemic species that may be in decline because of low levels of seedling establishment and poor growth/reproduction (Turner and others 1995). The species is not captured by a particular natural community, because it is uncommon and its habitat requirements are largely unknown/unpredictable (S. Rutman, P. Warren). Nevertheless, the Valley Bottom Floodplain Complex may be particularly important for this species (P. Warren), as it can be found in fine, loamy, floodplain-type soils (heavy, clayey, and not extremely sandy) in basins (S. Rutman) and may at times be locally common (Turner and others 1995). Warren and others (1981) report the species from habitats on the Organ Pipe Cactus National Monument that perhaps are similar to the Valley Bottom Floodplain Complex. Occasionally *castela emoryi* can be found on dunes (Turner and others 1995).

Stands of *Castela emoryi* have been located on the BMGRP west of the Mohawk Dunes and along the margins of the Mohawk Playa, just east of the dunes (D. Turner, P. Warren). Other potential places to look for *Castela emoryi* on the BMGR are in the center of valleys (S. Rutman): west of the Sand Tanks, west of the Saucedas (near the Well that Johnny Dug), and within the Valley Bottom Floodplain Complex communities (in the inter-depression areas) in the San Cristobal and Growler Valleys. *Castela emoryi* is not expected to be commonly associated with xeroriparian areas, nor the granite-derived soils on Cabeza Prieta National Wildlife Refuge.

7.2 AMPHIBIANS

Initially only one amphibian species, the Sonoran Desert toad (*Bufo alvarius*), was selected as a species conservation element. This species was chosen because of its association with tinajas and because it is the only amphibian endemic to the Sonoran Desert that is found on the BMGR. Two additional species were recommended to be added to the list of amphibian conservation elements by an expert on desert herpetofauna (Dr. Philip Rosen, University of Arizona): red-spotted toad (*B. punctatus*) and Couch’s spadefoot (*Scaphiopus couchii*) (A fourth species was later recommended, but not added; see section 8.3 for additional discussion on species selection.). Because these three anuran species may compete for the available natural and human-developed water sources on the BMGR, and because the competitive advantage between the species for a particular type of water resource for breeding and larval development may shift dependent on the type of water resource considered (playa versus tinaja, modified versus natural tinaja, ephemeral versus permanent water, and so on), we decided it was best to treat these three species together as a guild. Together they form the *ephemeral water-breeding amphibian guild*. 

7.1
These same species occur on Organ Pipe Cactus National Monument. At least within the valley habitats, much of the known or suspected primary anuran breeding sites on the monument are at present of human origin or modification (Rosen and Lowe 1996). Rosen and Lowe raised the question of whether egg-laying patterns and larval development periods for these species differed between natural and human-altered water sources. Without firm answers, a focus on the management needs of one species, or each in isolation from the others, could result in management decisions meant to favor one species that potentially could be adverse for one or both of the other species. As a result, although the species are described separately below, it is their potential competitive interactions that are of specific interest.

7.2.1 Sonoran Desert Toad (*Bufo alvarius*)

**Ecological Characteristics**

**Habitat associations.**—The Sonoran Desert toad is found in a wide variety of habitats from mesquite-creosotebush lowlands to bajadas, oak-sycamore-walnut association in mountain canyons, and tropical deciduous thornscrub in Mexico. On Organ Pipe Cactus National Monument it is the most wide-spread anuran and its occurrence has been documented in mountain canyons, on bajadas, and on valley bottom floodplains (Rosen and Lowe 1996). It is found near permanent water associated with springs, reservoirs, and streams, but more typically it is seen at ephemeral, intermittent, or semi-permanent waters (P. Rosen). It can venture several miles from water (Stebbins 1985, Phillips and Comus 2000). It breeds in most any water source, including stock ponds, tinajas, sewage overflows, and other human-influenced water sources (P. Rosen). For successful reproduction, however, this species requires water sources that persist for longer durations than some other desert anurans.

**Food and water requirements.**—The principal food source of the Sonoran Desert toad is beetles (Phillips and Comus 2000), but adults are relatively large and can eat mice, other amphibians, and a variety of invertebrates including tarantulas (P. Rosen). It is not known if they are predatory on spadefoot toads or red-spotted toads (P. Rosen).

**General life history.**—Sonoran Desert toads spend the winter underground in kangaroo rat burrows and may even be found in a hole still occupied by a kangaroo rat (D. Suhre; Cornejo, Schwalbe, and Suhre, unpublished data). They typically emerge from their shallow burrows earlier than other anurans (before the summer rains) (P. Rosen) and seek waters in which to breed. Individuals are active mostly during the summer rainy season, from May to September. Because of water development and human activity in the desert, the species’s breeding season is not necessarily tied directly to rainfall (P. Rosen), though it is, as for all other Sonoran Desert anurans, a summer rainy-season breeder. Adults are nocturnal during the hot summer months. They have greater reproductive success if they get a head-start on breeding before the Mexican spadefoot (*Scaphiopus multiplicatus*), whose larvae are predatory and cannibalistic (D. Suhre.) (This species of spadefoot and/or this interaction is most likely not present on the BMGR.). Adult Sonoran Desert toads travel between water sources at night using creosotebush areas, but inter-waterway routes are not well-known. Individuals can live between 10 to 20 years and development from the larval stage to the adult takes 6 to 10 weeks (Phillips and Comus 2000).

**Biotic interactions.**—Larval Sonoran Desert toads face competition (for food) with other larval anurans, including spadefoots, if they choose a breeding site in an ephemeral pool. In some areas with extreme resource competition and ephemeral waters, Sonoran Desert toad larvae and eggs fall victim to the predatory larvae of other species (D. Suhre) and are certainly preyed on by aquatic invertebrates as well.
Landscape context.—Sonoran Desert toads disperse between water sources at night and are capable of travelling long distances (over a mile) in a night (D. Suhre). The characteristics of their preferred inter-waterway dispersal corridors are not known.

Status, Threats, and Management

Distribution.—This toad is endemic to the Sonoran Desert Ecoregion. Its range extends from the Lower Colorado and Gila Rivers of Arizona and extreme southwestern New Mexico south to northwestern Sinaloa and extreme southeastern California. It occurs from sea level to above 4000 feet (Stebbins 1985).

Conservation status.—The Sonoran Desert toad is a generalist amphibian that has probably expanded its range in the desert because of human activity (P. Rosen). A common toad on the BMGR and in the Sonoran Desert where there is water, the Sonoran Desert toad has most likely benefited from human-induced water developments in the desert (P. Rosen).

Stressors.—An often localized, but significant, stress in some situations is altered population structure.

Sources of stress.—Vehicular traffic on highways can be a major source of adult mortality. Additionally, the population structure of the Sonoran Desert toad can be altered by competition and predation if it is breeding in the same habitat as other anurans that have a competitive advantage (such as spadefoots). Interactions between species adapted to breed and develop in ephemeral waters versus those adapted to permanent water are not fully understood. In one study (Woodward 1983) permanent-pool breeders (Rana spp.) were more successful than typical ephemeral-pool breeders (including Scaphiopus spp.) when they were both found in permanent waters. This was because of differences in predation rates: faster-moving, ephemeral-pool adapted larvae were smaller, but more visible to predators than permanent-pool adapted larvae that spent more time stationary and on the bottom. It is likely that the competitive advantages/disadvantages between the Sonoran Desert toad and other anurans differs with local conditions.

Threat abatement strategies.—None were noted.

Mapping and Information Needs

Mapping comments.—Can assume that it occurs near where water sources are mapped, springs and tinajas (modified and natural), out to perhaps 3 or more miles from the water source itself (P. Rosen).

Information needs.—Quantifying and analyzing the relative usage, as well as co-usage, of different water sources on the BMGR by members of the ephemeral water-breeding amphibian guild may elucidate their dynamic species interactions under different water regimes (that is, playa versus tinaja; ephemeral versus permanent water; modified tinaja versus natural tinaja; and so on). Such information could be used to ensure that management accounts for each species’s needs without unduly affecting conservation of the other species.

7.2.2 Red-spotted Toad (Bufo punctatus)

Ecological Characteristics

Habitat associations.—Red-spotted toads are generally associated with rocky slopes and arroyos in desertscape, thornscrub, and lower montane woodlands (P. Rosen). This species breeds in springs and temporary pools of seasonal streams and seeks shelter in rocky areas alongside these water sources (Stebbins 1985). On the BMGR it is associated with temporary pools and natural tinajas in bedrock
bajadas and mountains and would be unlikely to breed in modified water sources found away from the canyons and rock slopes (P. Rosen). Red-spotted toads are more restricted to natural (unimproved) desert water sources than is the Sonoran Desert toad.

**Food and water requirements.**—The principal food source of the red-spotted toad is insects (Phillips and Comus 2000)

**General life history.**—This species is nocturnal in the summer, but it may be active during the day in cooler weather. It breeds mainly after summer rains and its larvae metamorphose in 6 to 8 weeks (Phillips and Comus 2000).

**Landscape context.**—The red-spotted toad is a small animal, and little is known about its metapopulation dynamics and ability to travel between water sources.

**Biotic interactions.**—Larval red-spotted toads may face competition (for food) with other larval anurans if they choose a breeding site in which artificial water development results in a semi-permanent to permanent water source.

**Distribution.**—This species’s range extends from southeastern California to southern Nevada, southern Kansas, central Texas, and south through Mexico to Hidalgo and southern Baja California (Stebbins 1985). It is found at elevations below sea level up to 7000 feet (Phillips and Comus 2000).

**Conservation status.**—As is true for all anurans that occur on the BMGR, higher rainfall areas throughout the range of the red-spotted toad are perhaps more important to the conservation of this species; however, on the BMGR this species would be an important component of the herpetofauna of natural tinajas. Red-spotted toads are likely to be abundant on the BMGR in appropriate habitat (P. Rosen).

**Stressors.**—Largely unknown. Competitive displacement is a potential threat.

**Sources of stress.**—Artificial water development could provide the Sonoran Desert toad with a competitive advantage over the red-spotted toad. The Sonoran Desert toad is a larger, more mobile species that is not as closely tied to seasonal rainfall as the red-spotted toad. Unlike the Sonoran Desert toad, the red-spotted toad is too small for above-ground activity except during moist conditions; as a result, it may be at a serious disadvantage when water is maintained at breeding sites for long periods when the Sonoran Desert toad can make use of the site but it cannot (P. Rosen). Additionally, when the Sonoran Desert toad and red-spotted toad both breed in the same area, competitive interactions between the larvae may occur, particularly if resources are limited (P. Rosen).

**Threat abatement strategies.**—None were noted.

**Mapping and Information Needs**

**Mapping comments.**—Predicted to associate preferentially with natural tinajas and springs.

**Information needs.**—See information needs under the Sonoran Desert toad. Additionally, the competitive interactions between the Sonoran Desert toad and red-spotted toad deserve investigation. Although the red-spotted toad may have a slightly accelerated larval development period as compared with the Sonoran Desert toad (Phillips and Comus 2000), the competitive balance between the larvae of
these two species, especially under limited resource conditions and different water persistence regimes, is unknown.

7.2.3 Couch’s Spadefoot (*Scaphiopus couchii*)

**Ecological Characteristics**

**Habitat associations.**—Couch’s spadefoot is seasonally found in arid conditions in areas of sandy soils, creosotebush, mesquite, and desert grasslands and prairies. Its associated (more successful) breeding areas are in ephemeral waters such as playas, but individuals may be found breeding in any desert water source including those modified by humans ( tanks, charcos, sewage ponds) (P. Rosen; Rosen and Lowe 1996). The species breeding behavior is more closely tied to major rainfall events and ephemeral water sources than the Sonoran Desert toad.

**Food and water requirements.**—The main food sources of Couch’s spadefoot are insects, including beetles, grasshoppers, katydids, ants, spiders, and termites (Phillips and Comus 2000).

**General life history.**—These toads have extremely rapid metamorphosis, with eggs hatching within a day and larvae maturing into terrestrial juveniles in less than two weeks on average (Phillips and Comus 2000). Juveniles and adults bury themselves using their “spade foot” into sandy soil to avoid heat and dessication, and they spend the dry season underground in deep burrows made by gophers, kangaroo rats, or themselves (Stebbins 1985). They are mostly active at night during summer rains in the Sonoran Desert. If insufficient rain occurs, adults apparently can remain underground for over a year (P. Rosen). Their emergence is triggered by low frequency vibration from thunder and heavy rains (Phillips and Comus 2000). Upon emergence, they undertake a frenzied breeding and feeding cycle that is adapted to the infrequent desert rains. The extremely rapid development of spadefoot larvae is presumably an adaptation to ephemeral waters in which aquatic predators generally are lacking.

**Biotic interactions.**—Couch’s spadefoot larvae feed voraciously and can outcompete species adapted to more permanent water (Woodward 1982), though this species is at a disadvantage in more permanent waters in which predators are more abundant and other species (such as the Sonoran Desert toad) likely have a competitive advantage (P. Rosen, Woodward 1982).

**Status, Threats, and Management**

**Distribution.**—This species is distributed from southeastern California through southern Arizona and southern New Mexico into central Texas and southwestern Oklahoma. In Mexico it is found along eastern Baja California and on western and eastern mainland Mexico south to southern San Luis Potosi (Stebbins 1985, Phillips and Comus 2000).

**Conservation status.**—Couch’s spadefoot is a true desert amphibian that is adapted to the extreme and seasonal water conditions of the desert. Although this species benefits from human-made/ altered water sources in the desert, it is a particularly important component of the fauna associated with natural, seasonal water sources on the BMGR, particularly playas.

**Stressors.**—Largely unknown. Competitive displacement is a potential minor and localized threat. On the BMGR, Couch’s spadefoot, as is the case for all anurans, may be at or near the limits imposed by the reproductive cycle or water and energy balance (P. Rosen).

**Sources of stress.**—It is possible that water development in the desert puts this species at a competitive disadvantage with more generalist breeders, such as the Sonoran Desert toad (P. Rosen).
Threat abatement strategies.—None were noted.

Mapping and Information Needs

Mapping comments.—Predicted to associate preferentially with ephemeral waters such as playas, but they may be found breeding in any desert valley water source including those modified by humans (tanks, charcos, sewage ponds).

Information needs.—See information needs under the Sonoran Desert toad.

7.3 REPTILES

Three individual reptile species and one guild (composed of six species) were selected as conservation elements.

7.3.1 Desert Tortoise (*Gopherus agassizii*)

Ecological Characteristics

Habitat associations.—Desert tortoises occur in mountain ranges on rocky slopes and bajadas within paloverde-mixed cacti communities throughout the Sonoran Desert. The largest populations are found at the base of mountains within boulder-strewn areas. Some populations occur (off of the BMGR) in semi-desert grassland habitat in the Catalina and Rincon Mountains below 5000 feet. Boulders provide important habitat by blocking the sun and heat, providing a cooler, wetter environment, displacing water, and providing growing areas for more mesic vegetation. Desert tortoises also have been found as much as 3 miles away from the mountains on the middle bajadas in association with caliche caves along major arroyos (B. Wirt).

Burrows and caliche caves are important for tortoise viability and for maintaining constant temperature and relative humidity. Aspect is important, particularly in the western parts of the BMGR. Eastern and northern slopes are used during the summer months. Because these slope aspects are exposed during summer to the direct sun for shorter periods compared with other aspects, they provide relatively cool and mesic conditions. Tortoises hibernate, however, on southern and western slopes because these exposures provide relatively warm conditions during the winter (B. Wirt).

Food and water requirements.—Desert tortoises are generalist herbivores that eat a mixture of dried and fresh vegetation consisting of forbs, grasses, and perennial plant leaf litter, depending on what is available. The mixture of fresh and dried vegetation is important for maintaining blood hydration, salt, and mineral levels (B. Wirt). Tortoises can go for many months without drinking, but they must drink sufficient water at least once a year to maintain blood hydration (B. Wirt). They have been reported to dig catchment basins in the soil to use for rainwater collection and drinking (Burge 1996). Extended summer drought and high temperatures can be particularly stressful to tortoises in the Sonoran Desert (B. Wirt).

General life history.—Females become active in the spring, generally in March, and eat if vegetation is available to get ready for egg-laying in June. Males become active after the summer rains in July and usually both forage and “visit” all the females that occur within their home range. About 4 to 8 eggs are laid in nests that have been dug into the soil during May through July. One clutch of eggs is produced per year in the Sonoran Desert. Only a small percentage of the eggs laid hatch individuals that survive to adulthood. Females can store sperm for up to 3 years. Summer rains determine the timing of
reproductive activity, because they affect the availability of food and water resources. Tortoises are inactive in the winter. Winter rains determine the availability of winter annuals and, as a result, dictate when tortoises emerge from hibernation (B. Wirt). Desert tortoises characteristically have low hatchling survival and juvenile recruitment. Adults are long-lived, but may take 10 to 15 years to reach sexual maturity (B. Wirt). As a result, populations can be threatened by large adult mortality events. Because female tortoises store sperm, populations can remain viable even when population densities are relatively low.

**Biotic interactions.**—Available food and water is dependent on winter and summer rains. Predation of juveniles may be severe in places, particularly by ravens (*Corvus corax*) (Burge 1996).

**Landscape context.**—Some mixing of populations occurs because of dispersal by young males in the valleys where suitable habitat exists. Large populations in good habitat are the population source for the poorer habitat (sink) areas (B. Wirt).

**Status, Threats, and Management**

**Distribution.**—Desert tortoises occur in the Mojave and Sonoran Deserts of southeastern California, southern Nevada, extreme southwestern Utah, Arizona, and northern Sonora, Mexico, generally at elevations below 4000 feet. Desert tortoises also occur in tropical deciduous forests in southern Sonora and the northern edge of Sinaloa, Mexico.

**Conservation status.**—The eastern portions of the BMGR, the Sand Tank and Sauceda Mountains, provide significant areas for desert tortoises that are currently free of threats found elsewhere in parts of its distribution. Desert tortoise populations are more abundant in areas of higher rainfall, east of the BMGR (for example, Saguaro National Park), but in many of these areas human encroachment into tortoise habitat is a threat. Tortoises are found throughout the BMGR on all the mountain ranges, but the eastern portion of the range presents the most suitable habitat (B. Wirt). Dames and Moore (1996) did not find any sign of tortoises on the Aguila Mountains, but tortoises were found on all mountain areas on the BMGR in studies by Geo-Marine in 1992. The population density of desert tortoises decreases west of Highway 85 because of increasing aridity. The Sand Tank and Sauceda Mountains are the most important areas for tortoise on the BMGR, but the population density of tortoises is considered to be moderate in comparison to other areas in Arizona (B. Wirt).

**Stressors.**—Adult mortality due to severe climate conditions; habitat loss; low recruitment rates; disease; road-related mortality; illegal collection and release.

**Sources of stress.**—Urban expansion has led to the loss of large areas of important tortoise habitat in the foothills around Tucson and Phoenix. Habitat loss will continue into the future with development of White Tanks in Phoenix and expansion of Phoenix southwest into the Sierra Estrellas and, if not protected, the Maricopas. Important tortoise habitat also is lost due to commercial-scale boulder collection for landscaping—particularly in the Maricopas; other areas are not known (B. Wirt).

Tortoises may be sensitive to the effects of climate change, as they are subject to severe population die-offs due to extreme drought (for example, during a recent die-off in the Maricopas, presumed to have been caused by drought, the remains of nearly 200 tortoises were found; B. Wirt). Additionally, sex ratios could be affected by climate change (temperatures between 79 to 87 produce all males; 88 to 91 all females; Burge 1996).

In the eastern Mojave Desert, ravens are the primary predators on juveniles in some areas. Predation rates have increased because of the increased raven abundances associated with urban expansion (Burge 1996).
Illegal collecting and vandalism/killing of individuals is a threat. Recreation has led to tortoise collection and killing in some areas, and the rerelease of pet tortoises into the wild can spread disease to wild populations. Tortoise health may be compromised when they feed on invasive grasses (Phillips and Comus 2000).

There have been no documented effects of military activity on the BMGR affecting tortoise viability; however, fires and habitat destruction due to accidental bombings from the military is a potential threat (B. Wirt), as well as accidental road-related mortality from vehicular traffic on military roads. Populations in caliche caves on the bajadas are potentially impacted by to military activity and recreation.

**Threat abatement strategies.**—Avoid/minimize the impact of military activities on tortoise populations using caliche caves on middle (and possibly lower) bajadas.

**Mapping and Information Needs**

**Mapping comments.**—Some baseline data on desert tortoises in the Sand Tanks and Sauceda Mountains are available. They occur in most rocky slope areas (possibly can use vegetation and slope data to map). It is difficult to predict tortoise presence within caliche caves in xeroriparian areas as these are not mapped physical features.

**Information needs.**—More studies are needed to understand tortoise viability throughout the BMGR and patterns of population change. More tortoise surveys are needed in the western areas of the BMGR to assess population status throughout the BMGR. Baseline population information, even in the eastern BMGR, is not well known (B. Wirt). The relative importance and use of caliche caves should be investigated. The military may pose a threat to populations using caliche caves in middle bajadas and this should be investigated by looking for populations in vulnerable areas.

**7.3.2 Flat-tailed Horned Lizard (Phrynosoma mcallii)**

**Ecological Characteristics**

**Habitat associations.**—Flat-tailed horned lizards are found on light colored, sandy soils. Their preferred habitat is on sandy flats dominated by Creosotebush-Bursage Desert Scrub, particularly on the sand sheet of the Yuma Desert on the BMGR and in the Gran Desierto in Mexico.

**Food and water requirements.**—The diet of this species consists almost entirely of ants. The most important species are harvester ants in the genera *Veromessor* and *Pogonomyrmex*. Individuals derive all of their water from the ants they eat.

**General life history.**—Flat-tailed horned lizards are slow-moving and rely on cryptic coloration for their defense. They are extremely difficult to find. They burrow into the ground at night and for overwintering. During the day, they seek shade in vegetation.

**Biotic interactions.**—This lizard is an ant specialist, so any factor that reduces ant populations is a potential threat. Important predators are sidewinders, shrikes, coyotes, foxes, and ravens.

**Landscape context.**—The population of this lizard is divided by the international boundary between the United States and Mexico. The bulk of the population is found in the Gran Desierto in Mexico and extends into the United States on the fingers of this dune that extend across the border. Barriers between the two countries (such as Highway 2 in Mexico) can severely hinder dispersal and will affect the American portion of the population.
Species

Status, Threats, and Management

Distribution.—The entire distribution of this species is restricted to a small area of southern California, southwest Arizona, northeast Baja California, and northwest Sonora.

Conservation status.—The BMGR is extremely important to the long-term persistence of this species and contains the most important part of the species’ range in the U.S. The viability of this species is tenuous based on an analysis in Foreman (1997). The BMGR is the most protected portion of the range of the flat-tailed horned lizards (D. Turner). The Gran Desierto in Mexico forms the bulk of this species’ range. Currently, the lizard populations are relatively secure in the Mexican portion of their range, but most of this area is not formally protected. Much of the area formerly occupied by flat-tailed horned lizards has been lost (see Hodges [1997] for current and historical distributions). Outside the BMGR, the viability of flat-tailed horned lizards is not secure. In California, management areas exist, but they are not secure nor adequately enforced (D. Turner). The bulk of the population is found in the Gran Desierto in Mexico. A potential problem exists with sustaining population levels, because adult mortality is high and population size is limited by the number of breeding adults (D. Turner).

Stressors.—Adult mortality; habitat loss; decline of ant populations.

Sources of stress.—Foreman (1997) summarizes threats to the flat-tailed horned lizard and its habitat. Flat-tailed horned lizard habitat has largely been lost and continues to be lost because of agriculture and urban expansion (Hodges 1997). Outside the habitat management areas set aside in the Conservation Agreement, D. Turner expects that all suitable habitat in the U.S. eventually will be lost. Agricultural development south of Yuma is significant, as is industrial development around San Luis, Mexico (D. Turner). Habitat is vulnerable to disturbance from off-road vehicle use. The effects of off-road vehicles include crushing vegetation, soil compaction and erosion, decreased water retention, and crushing lizards on the sand or in shallow burrows.

Pesticide application in agricultural areas and in the desert (on agricultural pests that also live on native desert plants) is especially severe in California and can decrease ant abundance (D. Turner).

Adults are vulnerable to road kills, which is particularly severe in Mexico along Highway 2 (D. Turner). On the BMGR one road in particular may present a limited threat to the population (Auxillary 2 Road). Traffic here varies in intensity with military operations and is closed to public access. Any increase in recreation within the habitat of this species is a substantial threat. The Border Patrol in this region is also a threat to lizards.

Increased raven populations, associated with human activity/garbage dumps, also are a source of adult and/or juvenile mortality.

Threat abatement strategies.—Flat-tailed horned lizards are being monitored and managed as part of the Conservation Agreement between agency partners.

Mapping and Information Needs

Mapping comments.—This lizard is expected to be found in Pinta Sands area of Cabeza Prieta, but this has not yet been confirmed. They are known to occur west of the Gila and Tinajas Altas Mountains, south of Interstate 8. Additionally, they occur on the sand sheet of the Gran Desierto Dunes (not the active dunes).
Information needs.—Determine population status and trends.

7.3.3 Cowles Fringe-toed Lizard (*Uma notata rufopunctata*)

Ecological Characteristics

Habitat associations.—These lizards are solely found on loose sands, as is found on active sand dunes and wind-blown sand sheets. The preferred habitat on the Yuma dunes is swales (low points on dunes), which have more vegetation, rather than the unvegetated ridgelines. On the Mohawk dunes the swales are much more stable than those of the Yuma dunes and are covered with cryptobiotic soil crust. It resembles creosotebush flats, though it is surrounded by loose sand. On the Mohawk dunes the lizards are found on the dune ridgelines and not the swales (D. Turner).

Food and water requirements.—Cowles fringe-toed lizards are omnivorous lizards that eat leaves, flowers, seeds, insects, and occasionally other lizards. The main components of their diet are ants and the flowers and leaves of *Psorothamnus emoryi* (Turner 1998)

Biotic interactions.—Population densities might vary due to food availability, which may be affected by the amplitude of the interdunal areas (larger in Yuma dunes) (D. Turner, speculation). On the Mohawk dunes, rodent burrows provide important habitat for escaping the heat. It is not known where the lizards go to avoid high temperatures in the Yuma dunes, and studies have shown that at the burrowing depth of the lizards above-lethal temperatures are found (Turner 1998). Fringe-toed lizard predators include coyote, fox, loggerhead shrike, sidewinder rattlesnake, and possibly sand dune beetles (D. Turner).

Landscape context.—Currently there is genetic exchange between Mohawk and San Cristobal populations, which are connected by some sandy areas. The San Cristobal population is likely a genetic sink. The Gran Desierto population in Mexico and the portions that enter the U.S. at Pinta Sands and Yuma are also an interbreeding population. The Mohawk dune population of lizards and the Gran Desierto lizards are isolated from each other and are possibly distinct species based on genetic analysis (D. Turner).

Status, Threats, and Management

Distribution.—The Cowles fringe-toed lizard is only found in the Gran Desierto in Mexico and adjoining portions in the United States (the Yuma Desert and Pinta Sands) and in the Mohawk Dunes on the BMGR.

Conservation status.—The BMGR and Cabeza Prieta National Wildlife Refuge contain the entire occurrence of the subspecies in the United States. The most important areas to the long-term persistence of this subspecies are in the Gran Desierto, Mexico and in the Mohawk Dunes on the BMGR. The Mohawk Dunes is the largest dune system that is free of recreational vehicles in the U.S. The population in the Yuma Desert (BMGR) and Pinta Sands (Cabeza Prieta) are significant for the U.S. population of the lizards and may become even more crucial in the future if adjoining habitat in the Gran Desierto in Mexico becomes threatened (much of this area is not legally protected). Currently, however, the Gran Desierto in Mexico is more important for this population of fringe-toed lizards (D. Turner).

The largest population of the Cowles fringe-toed lizard is in the Gran Desierto in Mexico. The Gran Desierto in Mexico is connected to its portion within the BMGR south of Yuma. A small population of fringe-toed lizards is found near Dateland in coppice dunes, but this is a small patch of sand that is not well-protected, is poor quality habitat, and is not likely a viable population (D. Turner).
The Mohawk dunes population is isolated from the Gran Desierto population and is estimated to contain about 70,000 to 80,000 individuals (D. Turner). This is a larger population than that in the American portions of the Gran Desierto; however, the population density of fringe-toed lizards in the Yuma Desert is greater than in the Mohawk Dunes. The abundance of fringe-toed lizards in the Mexican Gran Desierto is unknown. Both locations of fringe-toed lizards in the Gran Desierto (Mexico and USA portions) and in the Mohawk Dunes have healthy populations and active recruitment.

**Stressors.**—Habitat alteration/fragmentation; genetic isolation.

**Sources of stress.**—Genetic isolation due to habitat fragmentation: specimens were found at the turn of the century from the Gila River (near Antelope Hill) suggesting that the Mohawk population was colonized via the Gran Desierto by travelling along the windblown sand along the Gila River margins. This habitat has been lost to agriculture causing isolation between the Gran Desierto and Mohawk populations. Habitat loss is a current threat and has the potential to get worse in the future. Genetic isolation between the American and Mexican populations of the Gran Desierto could be a threat in the future because of roads, ejidos in Mexico, and industrial expansion along the highway near San Luis/Rio Colorado (which is expected to experience more than doubling of its human population in the future). Currently, Highway 2 along the border is a barrier between the U.S./Mexico populations of fringe-toed lizards, which limits dispersal and causes frequent road kills (D. Turner).

Habitat disturbance: habitat is disturbed because of human activities on the dunes, which alter dune processes and cause erosion, alter dune vegetation, and impact dune destabilization. The primary source of habitat disturbance in the U.S. is off-road driving. In the Mohawk Dunes off-road vehicles are associated with recreation. Hikers could present a future threat to the Mohawk Dunes if they increase in volume in the future. In the Gran Desierto the border patrol is the main source of habitat disturbance because of off-road vehicle use. A potential source of habitat loss in the future in Mexico could be PEMEX (Petroleos Mexicanos) exploration in the Desierto de Altar (if oil is found and drilling occurs; D. Turner). Another threat to lizard populations is invasive plant species on the dunes, such as *Schismus arabicus* and *Brassica tournefortii*. These plants grow densely on sandy soils, displacing native vegetation and attracting fewer insect herbivores. The dense growth of these plants hinders the ability of the lizards to forage and escape predators, and their presence may alter food abundance (P. Rosen).

The military is not currently a threat, as it generally does not train on the dunes (D. Turner).

**Threat abatement strategies.**—Minimize/prohibit driving on the dunes, including military, recreationists, and border patrol. Control illicit recreation on the Mohawk Dunes.

**Mapping and Information Needs**

**Mapping comments.**—U.S. Geological Survey 1:250,000 maps can be used to map the area of active dunes (seen as stippled areas in Mohawk Dunes and towards San Cristobal). In the Yuma Desert, the blue dashed line on U.S. Geological Survey maps represents active dunes, but this area should be extended to incorporate the sand sheet.

**Information needs.**—Determine taxonomic status of the Mohawk Dune/San Cristobal Dune population.

### 7.3.4 Valley Bottom Reptile Guild

This guild is composed of the western leaf-nosed snake (*Phyllorhynchus decurtatus perkinsi*), Colorado Desert shovel-nosed snake (*Chionacis occipitalis annulata [= C. saxatilis]*) sidedninder (*Crotalus cerastes*) (two subspecies), desert iguana (*Dipsosaurus dorsalis*), southern desert horned lizard...
(Phrynosoma platyrhinos calidiarum), and long-tailed brush lizard (Urosaurus graciosus) (two subspecies). As a group, these species are found in the lowest, driest, and most sparsely vegetated areas of the Sonoran Desert. They are not limited, however, to a single natural community type within the Lower Colorado River subdivision. The BMGR may function as an important center of each species’s (subspecies’s) distribution in which the populations are more abundant and viable than at other locations.

The selection of this guild and its members is based in part on the findings of Rosen and Lowe (1996) in regard to the structure of reptile communities on Organ Pipe Cactus National Monument. Compared with other North American deserts, lizard assemblages in the Sonoran Desert are species rich, with as many as 14 species per site. Additionally, Sonoran Desert snake assemblages are species rich when compared with other subtropical-desert snake assemblages. At least at Organ Pipe, species richness for lizards and snakes is higher in the valleys than in the rocky and montane areas. Moreover, most of the obligate desert species are characteristic of fine-textured soils in valley bottom and dune complex habitats found in the Lower Colorado River Valley subdivision. Sonoran Desert lizard and snake communities differ in the degree to which they demonstrate macrohabitat partitioning between xeroriparian scrub and upland (outside the xeroriparian zone from valley bottom to mountain slope) desert scrub communities. Lizard communities do not show significant partitioning, whereas snake communities are structured by contrasting patterns of xeroriparian versus upland habitat usage.

Despite the above difference between lizards and snakes in typical usage patterns, Rosen and Lowe (1996) found that under conditions of extreme drought in the late 1980s snake community macrohabitat partitioning collapsed as almost all species congregated in the higher vegetation density and moister xeroriparian scrub habitats. The valley bottoms thus supported drought-refugium populations of several species, as well as supporting the typical complement of species associated with valley bottom xeroriparian scrub habitats. As a result, changes in species composition and abundance within valley bottom habitats may track the effects of extremes in climatic patterns. Although widespread and abundant species may have sufficient resiliency to survive drought cycles, rare species of limited distribution and local abundance, and whose viability may be threatened by other stresses such as collection, may be subject to local extirpation during extremes of climate. Additionally, Rosen and Lowe (1996) predicted that in areas with livestock grazing, drought-induced increases in grazing intensity within xeroriparian scrub habitats would destroy the principal drought refugium for virtually every species of snake. The result would be severely reduced snake populations brought about by a synergistic relationship between grazing and drought.

The six species chosen to be included in the valley bottom reptile guild generally are associated with valley bottoms and the lower portions of bajadas (Rosen and Lowe 1996: Tables 2 and 3). The sidewinder and western spotted leaf-nosed snake occur in middle bajada habitats but at lower abundances when compared to their typical habitat (Rosen and Lowe 1996: Table 3). As indicated above the lizard species show no partition between xeroriparian scrub and upland desert scrub habitats; however, the snake species guild members do demonstrate some partitioning. The sidewinder and western spotted leaf-nose snake associate with upland habitats, whereas the Colorado Desert shovel-nosed snake demonstrates an intermediate segregation between xeroriparian scrub and upland desert scrub habitats (Rosen and Lowe 1996: Table 4). As a result, this selection of species should be robust with respect to the ability to monitor reptile community compositional changes and to relate those changes to changing environmental/anthropocentric-related conditions.

Additional species are often associated with the valley bottom reptile guild. These species are described in Chapter 8. Little is known about the local geographic and habitat distribution of desert reptiles; as a result, the BMGR may be found to be important for the conservation of these other species as well. A similar suite of easily accomplished methods may be used to monitor all of the reptiles that are associated with valley bottoms.
Ecological Characteristics

Habitat associations and food requirements.—The habitat associations and food requirements of each species, taken in most cases from Stebbins (1985) unless otherwise attributed, are as follows:

- Western spotted leaf-nosed snake: most of its range in the United States corresponds with the distribution of creosotebush. As a soft-soil, excavating specialist, it is found on open desert plains in sandy or gravelly soils. Its localized distribution may prove to be as centered on the valley floors, including especially within the Valley Bottom Floodplain Complex, as any other member of the herpetofauna (P. Rosen). Eats small lizards and their eggs.

- Colorado Desert shovel-nosed snake: found in the driest parts of the desert, where vegetation is sparse and may include creosotebush, some grasses, and mesquites. Frequentes dunes, washes, sandy flats, and occasionally rocky hillsides with sandy areas between the rocks. Eats invertebrates.

- Sidewinder: usually found in open valleys with sand, loam, and silt soils, especially in creosotebush flats, dunes, and creosotebush-bursage habitats (P. Rosen). Eats mammals and lizards.

- Desert iguana: usually found in sandy creosotebush flats and hummocks. Also found along xeroriparian areas, silty floodplains, and clay soils. In Mexico it is found in arid subtropical scrub and deciduous forest associations (Phillips and Comus 2000). Creosotebush apparently is important to this species. It provides a food source—fresh leaves, buds, and flowers—and a favorable habitat for burrowing around its roots, which provides protection from heat extremes and predation (Phillips and Comus 2000). Primarily herbivorous, it also eats insects, carrion, and its own fecal pellets.

- Southern desert horned lizard: most commonly found around dunes, along washes, and on sandy soils, generally associated with creosotebush, saltbush, and mixed cacti. Eats ants, other insects, spiders, and some plant materials (such as berries).

- Long-tailed brush lizard: found on dunes, desert flats, and bajadas, living on ephedra, mesquite, creosotebush, paloverde, and other medium-sized to large shrubs (P. Rosen). Can live amidst extremely sparse growth. Prefers creosotebushes with exposed roots for shelter. Xeroriparian areas may represent important habitat for this species (P. Rosen). The Arizona brush lizard (U. g. shannoni) primarily is found on the larger desert trees of mesquite and catclaw acacia and some paloverde. Eats insects, spiders, and occasionally parts of plants.

Status, Threats, and Management

Distribution.—Range information is taken from Stebbins (1985).

- Western spotted leaf-nosed snake: range extends in the Mojave and Sonoran Deserts from California and southern Nevada to western Arizona and into northeastern Baja California and northwestern Sonora; occurs up to 3000 feet.

- Colorado Desert shovel-nosed snake: more restricted range than the sidewinder in the Mojave and Sonoran Deserts. Four subspecies of the western shovel-nosed snake are recognized: the Colorado Desert subspecies is found in southwestern Arizona and southeastern California to the most northern reaches of Baja California and Sonora arching around the Gulf of California.
Biodiversity Management Framework

- Sidewinder: distributed throughout the Mojave and western Sonoran Deserts from southeast California to southern Nevada, southwestern Utah, southwestern Baja, southwestern Arizona, and northwestern Sonora.

- Desert iguana: range extends from the Mojave Desert in east-central California and southern Nevada to the Sonoran Desert in western Arizona and through the desert regions of Baja California, Sonora, and Sinaloa. A separate subspecies may occur in Mexico.

- Southern desert horned lizard: occurs in the Mojave and Sonoran Deserts within California, southern Nevada, southwestern Utah, western Arizona, and slightly into northeast Baja California.

- Long-tailed brush lizard: restricted distribution within the Mojave and Sonoran Deserts from southeastern California, southern tip of Nevada, and western Arizona into Mexico in northeast Baja California and northwest Sonora.

Conservation status.—The valley bottom reptiles are a group of species that are found in the lowest, driest, and most sparsely vegetated areas of the Sonoran Desert. The BMGR represents a large, relatively undisturbed expanse of low desert communities in the most arid portion of the Sonoran Desert in the United States and is likely an extremely important area for the conservation of this guild. The species/subspecies in this guild are restricted to habitats specific to the Sonoran and/or Mojave Deserts. The conservation status of individual species in regard to the importance of the BMGR for their conservation is as follows:

- Western spotted leaf-nosed snake: spotted leaf-nosed snake is uncommon to moderately common east of Organ Pipe Cactus National Monument and, as the western spotted leaf-nosed snake subspecies, increases in abundance to the west to mostly common, including the low desert valleys of the Sonoran and Mojave Deserts; highest known abundances are in sparse desert scrub (P. Rosen). The BMGR can be expected to represent an important center of abundance for the conservation of this species, especially the western spotted leaf-nosed snake subspecies, across its range (P. Rosen).

- Colorado Desert shovel-nosed snake: BMGR is the heart of the species’ distribution and abundance. Probably represented better on the BMGR than anywhere else in Arizona. (P. Rosen). It is expected that the species will show significant differentiation and genetic diversity across the BMGR (P. Rosen). A species of questionable validity, Chionactis saxatilis, is described from the Gila Mountains and remains to be evaluated. Without additional evidence, it is assumed for now that the species is in synonymy with Chionactis occipitalis annulata.

- Sidewinder: BMGR contains populations that represent some of the genetic diversity of the species. Two subspecies occur on the BMGR: C. c. cercobombus (Sonoran Sidewinder) and C. c. laterorepens (Colorado Desert Sidewinder) (distributions overlap/come together toward the western end of the BMGR). The BMGR’s location is a major part of the heart of this species’s distribution and abundance (P. Rosen).

- Desert iguana: BMGR’s location is a major part of the heart of this species’s distribution and abundance (P. Rosen). Probably represented better on the BMGR than anywhere else in Arizona.

- Southern desert horned lizard: widespread and abundant lizard of the desert (Stebbins 1985). The species is a background matcher that likely has genetic differentiation across its distribution on the BMGR (P. Rosen). The BMGR is important in protecting the genetic diversity of the species. The BMGR’s location is a major part of the heart of this species’s distribution and abundance (P. Rosen). Probably represented better on the BMGR than anywhere else in Arizona.
• Long-tailed brush lizard: BMGR’s location is a major part of the heart of this species’ distribution and abundance (P. Rosen). Probably represented better on the BMGR than anywhere else in Arizona. The BMGR is also the place where the distributions of the two subspecies overlap/come together and is therefore important in protecting some of the genetic diversity found in this species.

**Stressors.**—Habitat loss and altered vegetation communities that decrease the abundance of some species’ preferred food and increase predation rates of some reptiles.

**Sources of stress.**—Off the BMGR, the main source of habitat loss is conversion to agriculture (mostly historic) and urbanization (historic and current). Off-road vehicles and the spread of invasive plant species contribute to habitat disturbance.

Vegetation is altered due to the spread of invasive species, particularly *Schismus* sp., *Bromus rubens*, and *Brassica tournefortii*. Invasive species affect reptiles in two main ways. First, they are not favored host plants for many insects; as a result, the food base and productivity of the habitat may decrease for insectivorous species. Second, some invasives grow densely on sandy soils and impede the locomotion of open-ground running lizards and their ability to escape predators, especially raptors and diurnal snakes. Among the members of the guild, the desert iguana is particularly affected by dense *B. tournefortii* and *B. rubens* (P. Rosen). The ability of invasive plants to carry fire also can cause habitat disturbance and negatively affect guild members. Because of their dependence on perennial plants, such as creosotebush and other shrubs, long-tailed brush lizard populations especially would be affected by *B. tournefortii* fires that caused a reduction in the vegetation structure of desert perennials (P. Rosen). As they have in Texas, invasive ants may prove to have adverse impacts on horned lizards (P. Rosen).

Large roads and vehicle traffic are a problem in many areas and cause the death of individuals that move across or stop to bask on roads. On the BMGR excessive military activity on creosotebush flats and valley bottoms is a source of habitat disturbance. Although most of the species in the guild have relatively small home ranges (less than 1 to about 20 hectares [P. Rosen]) and are fairly robust and tolerant of some activity, the attitude that the arid, sparsely vegetated flats are “lifeless” or “worthless” is a significant threat to these species and frequently leads to habitat disturbance and loss (P. Rosen). Pesticide use is not considered to be a big threat (P. Rosen).

**Threat abatement strategies.**—None were noted.

**Mapping and Information Needs**

One area that may be of particular importance to some valley bottom reptiles and should be targeted for inventory efforts is the Valley Bottom Floodplain Complex community. Many of the species in the guild may have their greatest abundance in this community, including especially the Colorado Desert shovel-nosed snake and long-tailed brush lizard (P. Rosen).

**7.4 Birds**

One bird species and one guild (composed of three species) were selected as conservation elements.
7.4.1 Le Conte’s thrasher (*Toxostoma lecontei*)

**Ecological Characteristics**

**Abundance.**—Le Conte’s thrashers are an uncommon resident of the desert Southwest (Sheppard 1996). They have a spotty distribution within creosotebush-dominated habitats, and it may be that the valley floors are not uniformly occupied by this species (L. Smith). The factors that affect the abundance and distribution of this bird within its range are poorly understood. Population density can approach 4 to 5 breeding pairs per kilometer squared (with floaters, densities can approach 10+ birds/km$^2$); however, overall density within the species’ U.S. range averages <0.2 pairs/km$^2$ (Sheppard 1996). Population estimates may represent underestimates if species phenology is not taken into account. Counts of birds in the United States are accurate from late December through early February; however, some survey protocols, such as Breeding Bird Survey data, tend to rely on data collected in the late spring (long after most Le Conte’s thrasher pairs have fledged broods and singing is reduced; Sheppard 1996).

**Habitat associations.**—Typical habitat throughout range consists of sparsely vegetated desert flats, sand dunes (vegetated margins), alluvial fans, or gently rolling hills containing one or more species of saltbush or shadscale (*Atriplex* spp.) and/or cylindrical cholla cactus (*Opuntia* spp.) 0.9 to 1.9 meters high (Sheppard 1996). Other desert habitats lacking the above species composition but with similar structural profiles—shrubs are well scattered, most rarely exceeding 2.5 meters in height, and ground cover is sparse—may be used; however, the Le Conte’s thrasher is rarely found in habitats consisting entirely of creosotebush (*Larrea tridentata*) (Sheppard 1996). Even in the preceding habitats, and especially in Arizona (T. Corman), isolated trees or tall, thin shrubs that can serve as nest site locations, may be a necessary habitat component. Saltbush-dominated areas are particularly favored by Le Conte’s thrashers (L. Smith). Substrates are typically sandy and typical territories generally lack surface water anywhere nearby and possess little topographical relief (Sheppard 1996).

**Food and water requirements.**—This bird feeds on the ground using its bill to dig in the soil for food. It is mostly insectivorous, feeding on soil larvae, but it may also eat spiders, centipedes, small lizards, berries, and seeds (Phillips and Comus 2000). Feeding usually takes place in the early morning and at dusk, when insects are most active (Phillips and Comus 2000). Almost all food is found under the litter of desert vegetation or on the substrate; as a result, the species requires accumulated leaf litter under most plants within its territory to provide diurnal cover for its arthropod prey (Sheppard 1996). Le Conte’s thrashers are not dependent on free-standing water, as they derive their water from their food.

**General life history.**—These birds are non-migratory. Pairs mate for life and remain together year-round (Phillips and Comus 2000). One study of nest site locations (n = 289) across the range of the species identified 85% of the nests as occurring in cholla cactus or saltbush (Sheppard 1996); however, in Arizona the species most frequently nests in shrubby trees and shrubs, such as mesquite (*Prosopis* spp.), paloverde (*Cercidium* sp.), ironwood (*Olneya tesota*), ocotillo (*Fouquieria splendens*), and wolfberry (*Lycium* spp.) (T. Corman). Individual territories are about 5 to 6 acres in size and are likely centered about the nest site (L. Smith); at least in saltbush/shadsale habitat typical pair generally uses less than 50 acres at any given time (Sheppard 1996). Mean clutch size is about 3.3 eggs, pairs produce 2 to 3 clutches per breeding season average, and about 2/3 of all nesting attempts produce at least one fledged young (Sheppard 1996).

**Biotic interactions.**—Predation rates in the San Joaquin Valley of Kern County, California documented at about 10% for both eggs and nestlings (Sheppard 1996). Potential predators of eggs and young include: desert spiny lizards (*Sceloporus magister*), round-tailed ground squirrels (*Spermophilus tereticaudus*), gopher snakes (*Pituophis catenifer [= P. melanoleucus*]), king snakes (*Lampropeltis* spp.), whipsnakes (*Masticophis* spp.), and coyotes (*Canis latrans*). After nest depredation, a pair may renest.
**Species**

**Status, Threats, and Management**

**Distribution.**—Distribution of Le Conte’s thrasher is limited mostly to low desert areas in the Sonoran and Mojave Deserts in western, southcentral, and southwestern Arizona, southern Nevada, southeastern California, extreme southwestern Utah, northwestern Sonora and northeastern Baja California, Mexico, and disjunct populations in the San Joaquin Valley, California and central and coastal Baja California (Sheppard 1996). The extent of its known distribution has not changed appreciably since the 1890s other than a contraction of its range because of habitat loss (Sheppard 1996).

**Conservation status.**—This species is one of the few birds that is associated with the low, arid desert valley bottoms. Le Conte’s thrashers seem to be persisting where their habitat is intact, but they are intolerant of habitat disturbance associated with human activity (Ehrlich and others 1988). Sheppard (1996) provides the following information and insights on the current status of the species. Agriculture and urbanization have eliminated considerable former habitat resulting in large reductions in population numbers in areas affected (for example, south and west of Phoenix and the lower Gila and Salt River Valleys). As of 1993 and based on satellite imagery, at least 26% of 243 historic sites in the United States no longer had suitable habitat within 3 kilometers of the site. Availability of suitable habitat seems to be the major factor limiting population density and distribution. Le Conte’s thrasher is designated a Species of Special Concern by the California Department of Fish and Game.

The BMGR represents an important center of Le Conte’s thrasher distribution in the United States (L. Smith). Moreover, the BMGR is an important area for conservation of this bird, because it includes relatively large, intact expanses of low desert and, along with Cabeza Prieta National Wildlife Refuge, and it contains the largest population of this species across its entire range (T. Corman). A population of Le Conte’s thrashers is present in the Mojave Desert, near Kingman, and also north of Interstate 8 on the Yuma Proving Grounds (T. Corman). Some areas in Mexico are also important to Le Conte’s thrashers, such as the Gran Desierto, Pinacate Biosphere Reserve, and some local patches; however, much of the species’ territory in Mexico is not formally protected.

Figure 7.1 shows the distribution and breeding status within the Arizona portion of the Sonoran Desert Ecoregion and breeding pair abundance on the BMGR and Cabeza Prieta National Wildlife Refuge of Le Conte’s thrasher. The relative importance of the BMGR and Cabeza Prieta to the Arizona distribution of the species is striking. The breeding bird abundance category of 11 to 100 breeding pairs per survey sector (a sector is one sixth of a block, which itself equals a 1:24,000 topographic quadrangle) translates to roughly 0.4 to 3.7 breeding pairs per square kilometer. This range compares favorably with the abundance estimates reported above. Four sectors on the BMGR and six on Cabeza Prieta contained 11 to 100 breeding pairs (Arizona Breeding Bird Atlas 2001). The BMGR contains 38% of the survey sectors within the ecoregion within which Le Conte’s thrasher was at least detected and 25% of the survey sectors in which breeding was confirmed. Breeding status was at least possible on all BMGR survey sectors (see Figure 7.1A and interpretation of breeding codes in Appendix I). Figure 7.1B shows how the survey sectors in which species presence was detected align with the natural community conservation elements. Not unexpectedly, the species seems to associate with those natural communities that are characteristic of the Lower Colorado River Valley subdivision.

\[12\]Atlas data discussed in this document were collected over a six-year time frame. Sectors were not all surveyed in the same year. As a result, we cannot account for the effects of year-to-year variation. Differences in breeding pair abundance between sectors could be due to differences in habitat conditions or simply reflect year-to-year variation in breeding densities. We assume that the effects of year-to-year variation are random with respect to survey sectors and that, as a result, the apparent trends in distribution, breeding status, and breeding pair abundance are robust.
Stressors.—Habitat loss and degradation.

Sources of stress.—Past conversion of its habitat (particularly saltbush) to agriculture. Urban development is a current threat in creosotebush and saltbush flats (T. Corman). Some habitat may be lost if large areas of creosotebush are cleared for artificial pronghorn feeding areas (L. Smith). High impact, widespread use of valley bottoms by the military is a threat, particularly in the western BMGR (L. Smith). Currently, the military does not have a large impact on Le Conte’s thrasher habitat, but an expansion of their activity in this area could be a potential threat. Roads probably don’t have much direct impact on this species (L. Smith). The potential for pesticides or invasive species to significantly impact the prey abundance of the Le Conte’s thrasher has not been evaluated. Sources of stress outside of the BMGR can include off-road vehicles, grass and brush fires, and livestock grazing (Sheppard 1996).

Threat abatement strategies.—Avoid/minimize habitat loss or activities that may lead to habitat degradation. Protect valley bottom areas and occurrences of Salt Desert Scrub.

Mapping and Information Needs

Mapping comments.—Distribution/breeding status/breeding pair abundance data (Figure 7.1) were obtained from the Arizona Breeding Bird Atlas (2001) surveys. Potential habitat can be mapped using Creosotebush-Bursage Desert Scrub and Salt Desert Scrub polygons. Areas on the BMGR that are used preferentially by this species are not yet known.

Information needs.—What areas do Le Conte’s thrashers use preferentially within creosotebush flats and why? Is occupancy due to differences in soils or prey abundance/types? Do invasive plant species or pesticide usage affect the prey base of the Le Conte’s thrasher? Other information needs include: specific food and water requirements, structural analysis of occupied/unoccupied habitats, territory/home-range size determinations, barriers to dispersal, habitat restoration requirements, and effects of drought on prey base and thrasher population (Sheppard 1996).

7.4.2 Primary Excavator (Cavity) Guild

This guild is composed of the gilded flicker (Colaptes chrysoides) (endemic to the Sonoran Desert Ecoregion), Gila woodpecker (Melanerpes uropygialis), and ladder-backed woodpecker (Picoides scalaris). As a group, these woodpeckers provide nest sites for many other cavity-nesting birds besides themselves. Desert trees are often small, with gnarled branches unsuitable for cavity construction and nesting, and have few naturally occurring holes suitable for a nest (T. Tibbitts). As a result, saguaros (Carnegiea gigantea) provide one of the main nesting site locations for cavity-nesting birds in the desert. On the BMGR, gilded flickers and gila woodpeckers will use predominantly saguaros for nest sites (these two species are the only common excavators of cavities in saguaros (Kerpez and Smith 1990a,b). Because each species may place nest sites differently within the saguaro, as well as excavate the hole differently (Kerpez and Smith 1990a, McAuliffe and Hendricks 1988), the characteristics of the cavity may affect which secondary cavity nesters use the nest site once the woodpecker vacates the cavity. Additionally, ladder-backed woodpeckers do not typically excavate their nest cavities within saguaro; instead, they use mesquite (Prosopis spp.), paloverde (Cercidium spp.), ironwood trees (Olneya tesota), and agave stalks, as well as cottonwood (Populus spp.) and willow (Salix spp.) in riparian habitats (Russell and Monson 1998, T. Corman). As a result, they provide nest sites for secondary cavity nesters different than those dependent on the other woodpeckers for nest cavities. Secondary cavity nesters (owls and other cavity-nesting birds) are briefly described in Chapter 8.
A
Distribution and Breeding Status within the Arizona Portion of the Sonoran Desert Ecoregion

B
Breeding Pair Abundance on the Barry M. Goldwater Range and Cabeza Prieta National Wildlife Refuge

Figure 7.1 Le Conte’s Thrasher
Ecological Characteristics

Abundance.—The abundance of Gila woodpeckers and gilded flickers closely correlates with the abundance of saguaros. Abundance decreases in the drier parts of the desert to the west (L. Smith). Additionally, Gila woodpeckers are fairly dependent on saguaros for food, so where saguaros exist in lower densities (for example, west of the Mohawk Mountains; L. Smith) or in smaller size/age classes (Kerpez and Smith 1990b) fewer birds are present. The relative abundance of each member of the guild also will differ across the BMGR as each species’ response differs to other components of the habitat beyond the presence of saguaro. For example, the number of Gila woodpecker nests is negatively related to slope, whereas the number of gilded flicker nests is positively related to the volume of ironwood trees (Kerpez 1986, Kerpez and Smith 1990b). In the western parts of the BMGR, saguaros are found associated only with xeroriparian areas. Under these conditions, the Gila woodpecker would be expected to be found in lower densities than the gilded flicker because of its greater dependency on saguaro densities for foraging opportunities (L. Smith). Ladder-backed woodpeckers, as they are not dependent on the presence of saguaro for nest sites, potentially can occur wherever large mesquite, paloverde, or ironwood trees are present (T. Corman).

Habitat associations and food and water requirements.—Xeroriparian areas are important foraging areas for all of the primary excavators (T. Tibbitts). Both Gila woodpeckers and gilded flickers don’t require standing water. They get their water from food, especially cactus fruits and nectar.

Gilded flickers are common residents wherever large cacti grow and within drainages up to about 1200 meters (Russell and Monson 1998). These flickers use large saguaro, generally at least 5 meters in height, for nest sites (Kerpez and Smith 1990a,b). Gilded flickers are almost completely dependent upon saguaros for nest sites in the Sonoran Desert (L. Smith). In riparian areas large deciduous trees, usually cottonwoods, are used (Russell and Monson 1998). Besides the association with saguaro, Kerpez and Smith (1990b) also observed a positive relationship between the abundance of nesting flickers and the volume of ironwood trees present in the habitat. These authors speculated that the amount of ironwood, and its correlation with the occurrence of other floristic components, may be indicative of plant communities with superior insect foraging opportunities (also see Kerpez 1986). Gilded flickers rarely use saguaros for foraging; instead, they forage primarily for insects, especially ants, on the ground and in annual foliage <10 centimeters high (Ehrlich and others 1988, Kerpez and Smith 1990b). Consequently, they are less dependent on an arborescent desert for foraging opportunities (T. Tibbitts). They also will eat cactus fruit (Phillips and Comus 2000).

Gila woodpeckers are associated with deserts containing large cacti or trees suitable for nesting, dry subtropical forests, and riparian woodlands (Edwards and Schnell 2000). In non-riparian areas of the Sonoran Desert, Gila woodpeckers rely almost exclusively on saguaro for nest sites (T. Corman). Moreover, Gila woodpeckers generally nest in areas with and preferentially use saguaros 7 meters or larger in height or with 6 or more arms; however, nesting density also shows a negative relationship with habitats of increased slope (Kerpez 1986, Kerpez and Smith 1990b). Slope as a habitat attribute may correlate with changes in the components of the vegetation that woodpeckers respond to, availability of insects that serve as prey, or woodpecker energetic requirements; the actual relationships are unknown (Kerpez and Smith 1990b). Gila woodpeckers will excavate nest cavities in a paloverde or mesquite tree in the desert infrequently and will use cottonwoods or willows within riparian areas (Edwards and Schnell 2000, L. Smith). Gila woodpeckers will nest in non-native shade trees and palm trees and, in contrast to the other members of the guild, will use urbanized landscapes (Edwards and Schnell 2000).

\footnote{Data for the gilded flicker (Colaptes chrysoides) assigned by these authors to the northern flicker (Colaptes auratus); however, C. chrysoides subsequently was separated from C. auratus (American Ornithologists’ Union 1995) and based on the respective ranges of the two species the data are likely attributable to C. chrysoides.}
Gila woodpeckers are omnivorous. They eat and capture insects by probing within or gleaning from the bark of trees and cacti; they also will go to the ground to capture visible food items (Edwards and Schnell 2000). They also eat cactus fruit, mistletoe berries, and bird eggs (Ehrlich and others 1988). Martindale (1983) examined foraging patterns of Gila woodpeckers within the Tucson Mountain Unit of Saguaro National Park. Ninety three percent of the visits to a foraging substrate by woodpeckers involved paloverde, ironwood, or saguaro. Both sexes spent over half of their total foraging time on saguaros, though paloverde and ironwood trees yielded higher prey capture rates. Apparently, two other behavioral/physiological needs besides foraging, nest defense (males use saguaro tops as perches) and avoidance of heat stress (both sexes spent time on the shady side of a saguaro that was correlated with temperature), determine Gila woodpecker usage of saguaro.

Ladder-backed woodpeckers are characteristic of desertscrub, thornscrub, and tropical deciduous forest. Their range extends to higher elevations in riparian corridors where cottonwoods dominate (Russell and Monson 1998). Within the broader vegetation categories just mentioned, the species is typically found amidst dense wash and riparian vegetation (T. Corman). These woodpeckers excavate nest cavities in mesquite, paloverde, ironwood, willow, and cottonwood trees, as well as in agave stalks (Ehrlich and others 1988, Russell and Monson 1998, T. Corman). Because they do not use saguaro in the same way that gila woodpeckers and gilded flickers do, in desert areas they may be more dependent on the density of leguminous trees as a needed habitat component than the other woodpeckers. Ladder-backed woodpeckers are primarily insectivorous bark probers and gleaners (Russell and Monson 1998). They also will eat cactus fruit (Ehrlich and others 1988).

Cavity characteristics and biotic interactions.—The type of substrates used and manner in which each member of the guild constructs its nest cavities will determine the nature of competitive interactions within and outside the guild and which species (secondary cavity nesters) will be affected by changes in the abundance of a particular guild member. Within the non-riparian portions of the Sonoran Desert, Gila woodpeckers and gilded flickers almost exclusively use saguaros for nest sites, whereas ladder-backed woodpeckers use leguminous trees (T. Corman, L. Smith). As a result, a competitive interaction may be expected to occur between the Gila woodpecker and gilded flicker.

The selection criteria for use of individual saguaros may differ between the Gila woodpecker and gilded flicker, though they both tend to use large saguaro at least 5 meters tall (Kerpez and Smith 1990a); however, both species will often locate nest cavities within the same saguaro (McAuliffe and Hendricks 1988). Each species may select a different location to excavate its nest site within a saguaro. Although Kerpez and Smith (1990a) did not detect any difference in mean height of the nest cavity between the two species, McAuliffe and Hendricks (1988) found differences in the vertical distributions of the nest cavities excavated by the two species. These latter authors concluded that competitive preemption of potential excavation sites could not fully explain the differential usage of vertical space and that cactus anatomy, and the differences in the capabilities of each species to excavate cavities within a saguaro, also may play a role. Still, some nest-hole competition may occur (Edwards and Schnell 2000, Kerpez and Smith 1990a,b) and each species may use cavities originally excavated the other species (Kerpez and Smith 1990a). Because the two species do differ in their usage of saguaros as a foraging substrate and in the manner in which they forage, their niche overlap in regard to saguaros, if any, is probably limited to nest-site competition.

Besides the difference in substrate usage, most notably demonstrated by the substrate preferences of the ladder-backed woodpecker as contrasted with the other members of the guild, characteristics of the cavity itself can affect, in some cases, which species of secondary cavity-nesting bird may use the nest site once the woodpecker vacates the cavity (Kerpez 1986, Kerpez and Smith 1990a). Gilded flicker cavities as compared with Gila woodpecker cavities are larger in the entrance dimensions and in the vertical extent
of the nest cavity chamber (Kerpez 1986, Kerpez and Smith 1990a and McAuliffe and Hendricks 1988); however, the studies upon which the preceding information is based also obtained contrasting results for the horizontal depth of the cavity. Overall, however, the larger size of the gilded flicker tends to result in the excavation of larger cavities as compared with the Gila woodpecker. Gila woodpecker cavities may be too small for use by larger species such as the American kestrel (*Falco sparverius*), whereas gilded flicker cavities may be too large for smaller species such as the elf owl (*Micrathene whitneyi*) (Kerpez and Smith 1990a).

Holes excavated in saguaros by Gila woodpeckers usually are not used in the year in which they are excavated, because the sap surrounding the excavation must harden first (Ehrlich and others 1988). Additionally, because Gila woodpeckers nest in the same cavity for several years (Kerpez 1986, Kerpez and Smith 1990b), the number of cavities they make available to secondary nesters may accrue at a relatively slow rate. Despite this limitation, cavities excavated by Gila woodpeckers in saguaro do not kill the cactus and are preserved over time; in contrast, an excavation by a gilded flicker (as it occurs near the stem apex) often results in the relatively quick demise (less than 10 to 20 years) of the saguaro (McAuliffe and Hendricks 1988). Finally, Gila woodpeckers may be important as pollinators of saguaro and disseminators of their seed (Edwards and Schnell 2000, Kerpez and Smith 1990b). As such they may play an important role in the maintenance of saguaros as a component of the paloverde-mixed cacti-mixed scrub plant communities.

The last biotic interaction may be the most important. In Arizona, European starlings (*Sturnus vulgaris*) commonly nest in cavities in saguaro that they do not excavate (Kerpez and Smith 1990b). European starlings compete with Gila woodpeckers, but not with gilded flickers, for nest cavities and may compete with secondary cavity nesters for available nest sites (Kerpez 1986, Kerpez and Smith 1990b). The number of Gila woodpeckers nesting in an area is negatively correlated with the number of European starling nests and the number of European starling nests is negatively correlated with the distance to agriculture and bare lawns (Kerpez and Smith 1990b).

**Status, Threats, and Management**

**Distribution.**—Gilded flickers are residents in southeastern California, northeastern Baja California, and central Arizona south to southern Baja California and through Sonora, Mexico to northern Sinaloa (American Ornithologists’ Union 1983). Gila woodpeckers are mostly permanent residents in southeastern California (Imperial Valley and lower Colorado River valley), extreme southern Nevada, extreme southwestern New Mexico, southern half of Arizona, most of Baja California except for the northwest corner, and south into central Mexico in a band along the eastern shore of the Gulf of California (Edwards and Schnell 2000). Ladder-backed woodpeckers are residents from the southwestern United States to northeastern Nicaragua (American Ornithologists’ Union 1983). On the BMGR the main distribution of the guild is east of Highway 85 in the Sand Tank and Sauceda Mountains (L. Smith). Distribution within the western portion of the BMGR tends to be along washes that can support saguaros and/or leguminous trees.

**Conservation status.**—Edwards and Schnell (2000) summarize status information for the Gila woodpecker. The species seems to be on the decline in southeastern California, possibly attributable to the clearing of woodlots and nest-site competition with European starlings. Population counts associated with riparian habitats in Arizona have declined from an estimated 650 birds in 1976 to 561 birds in 1986. Breeding Bird Survey data for 1982 to 1991 suggests a drop in Gila woodpecker numbers, with 12 of 15 routes showing declines. Gila woodpeckers are on the California list of endangered species and do not do well in the areas farther west in the desert (L. Smith). Decline in Gila woodpecker numbers could have negative impact on entire bird community that relies on saguaro nest sites (Edwards and Schnell 2000, Kerpez and Smith 1990b).
The BMGR represents a relatively undisturbed habitat for the primary excavator (cavity) guild and secondary cavity nesters. The eastern areas of the BMGR are most important to these species. The rest of the BMGR is lower quality habitat for cavity nesters, because the saguaros and leguminous trees are less abundant and subsequently there are fewer woodpeckers and cavities available for secondary cavity nesters. The highest population densities for these birds are found east of the BMGR in relatively mesic areas with high saguaro and tree densities (for example, Saguaro National Park, Organ Pipe Cactus National Monument, and Tohono O’odham Reservation) (L. Smith).

Figures 7.2 through 7.4 show the distribution and breeding status within the Arizona portion of the Sonoran Desert Ecoregion and breeding pair abundance on the BMGR and Cabeza Prieta National Wildlife Refuge of the members of the primary excavator (cavity) guild: gilded flicker, Gila woodpecker, and ladder-backed woodpecker, respectively. The data tend to support many of the assumptions identified above in regard to predicted changes in abundance from east to west of each guild member. All members of the guild tend to reach their highest breeding pair densities on the BMGR east of Highway 85, both the gilded flicker and Gila woodpecker decrease in abundance from east to west, and the Gila woodpecker seems to be less abundant than the gilded flicker in the western portion of the BMGR (Figures 7.2B, 7.3B, and 7.4B; Arizona Breeding Bird Atlas 2001). Ladder-backed woodpeckers do not necessarily show a decline in breeding pair abundance from east to west across the BMGR (Figure 7.4B). Cabeza Prieta seems to have relatively high breeding pair abundances for all three members of the guild (Figures 7.2B, 7.3B, and 7.4B). Based on these same figures, the overlay of survey sectors on which birds were detected over the natural community conservation elements seems to support a rough generalization that the members of each species are tracking the availability of xeroriparian scrub habitat, especially west of Highway 85, even they may differ in which component of that habitat they are tracking.

**Stressors.**—Potential stressors are habitat (saguaro) loss, competition for nest sites, and possible degradation of food sources.

**Sources of stress.**—Sources include urban development, livestock grazing on saguaro that potentially affects recruitment (T. Tibbitts), and pesticide drift from agriculture (although none of the cavity nesters are specialist feeders; T. Tibbits). Expansion of military activities into the upland bajadas or eastern mountains potentially could adversely impact members of the guild. These species are not negatively affected by military overflights (L. Smith). Saguaros are vulnerable to fire carried by invasive species such as Bromus rubens. Saguaros are usually over 70 years old when cavities are excavated in them, so providing replacement saguaros following loss by fire would take awhile (T. Corman).

European starlings can out compete other saguaro cavity nesters for cavities (Kerpez 1986, Kerpez and Smith 1990b). They already are found in some areas of the BMGR. Their range may expand into the desert, as they accompany the spread of agricultural activities and urban expansion. The lush saguaro-rich areas in the eastern BMGR (Sand Tank Mountains) are vulnerable to starling invasion as Phoenix expands towards the BMGR (T. Tibbitts).

**Threat abatement strategies.**—Maintain habitat integrity: for example, maintain adequate reproduction of saguaro cacti and leguminous trees. Additionally, maintain adequate buffer distances between agriculture and paloverde-mixed cacti-mixed scrub communities to avoid/minimize the impact of European starlings.

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14See footnote No. 12.
**Figure 7.2 Gilded Flicker**

A

Distribution and Breeding Status within the Arizona Portion of the Sonoran Desert Ecoregion

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B

Breeding Pair Abundance on the Barry M. Goldwater Range and Cabeza Prieta National Wildlife Refuge

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**CODING BREEDING BEHAVIORS**

- **Presence Detected**
  - A: Observed (O)
  - B: Possible (P)
  - C: Probable (P)
  - D: Confirmed (C)

- **Density Sectors**
  - 1/6 of 7.5 min Quad

Source Data:
Arizona Breeding Bird Atlas 2001
A
Distribution and Breeding Status within the Arizona Portion of the Sonoran Desert Ecoregion

B
Breeding Pair Abundance on the Barry M. Goldwater Range and Cabeza Prieta National Wildlife Refuge

Figure 7.3 Gila Woodpecker
Figure 7.4 Ladder-backed Woodpecker
Mapping and Information Needs

Mapping comments.— Distribution/breeding status/breeding pair abundance data (Figures 7.2, 7.3, and 7.4) were obtained from the Arizona Breeding Bird Atlas (2001) surveys. Potential habitat can be mapped using xeroriparian scrub and paloverde-mixed cacti-mixed scub natural community polygons.

Information needs.— The occurrence, abundance, and spread of European starlings need to be investigated and the potential adverse impact on the nesting dynamics of both the primary and native secondary cavity nesters should be monitored. Nature of the relationship (dependency) of secondary cavity nesters to a particular guild member or suite of guild members and their associated cavities should be investigated. The relationship of agriculture and urbanization to guild member persistence—insofar as these land uses affect the direct loss of suitable habitat or increase the amount of nest-site competition, requires additional study.

7.5 Mammals

Three species and one guild (composed of three species) were selected as conservation elements; however, Sonoran pronghorn (*Antilocapra americana sonoriensis*) were not evaluated. Sonoran pronghorn is a federally endangered and area-dependent (regional scale) species and an obvious choice as a conservation element; however, species management will be dictated strictly by an associated endangered species recovery team and the political arena. We did account for this species, however, when considering desired future ecological conditions (Chapter 9), monitoring objectives and information needs (Chapter 10), and the effect of the species’s distribution on recommendations for a network of Special Natural Areas for the BMGR (Chapter 11). Figure 7.5 includes geospatial data for Sonoran pronghorn survey locations across the BMGR, Cabeza Prieta National Wildlife Refuge, and Organ Pipe Cactus National Monument.

7.5.1 Desert Bighorn Sheep (*Ovis canadensis mexicana*)

Ecological Characteristics

Abundance.— The amount of vegetation available for foraging has a strong effect on sheep abundance and population densities. Population density within a mountain range also may be determined in part by differences in geomorphology. Sheep prefer mountainous areas that have a more complex and variable slope, with aspect changes and dips that provide vegetation and microhabitat diversity, than areas where the mountains rise more abruptly (L. Smith).

Habitat associations.— Found in dry, generally inaccessible mountainous areas, in foothills near rocky cliffs, and near seasonally available water sources. Association of browse plants (especially jojoba (*Simmondsia chinensis*)) with big galleta (*Pleuraphis rigida*) forms important habitat (Monson and Sumner 1980). Water sources that are used most often tend to be free of dense vegetation or other visual obstructions. Desert bighorn sheep habitat is farther from bajadas and has fewer large boulders and less sheet-rock than areas not used by sheep. Moreover, areas that are used by sheep are rugged and steep, with average slopes >55%, and areas abandoned by sheep tend to be fire-suppressed and have tall vegetation (Krausman and others 1999).

Food and water requirements.— Desert bighorn forage on grasses and sedges and forbs (in green and dried conditions), as well as on prickly pear and cholla cactus (*Opuntia* spp.) shoots and flowers of succulents (for example, agaves). Grasses (including big galleta) are important in the northern and eastern part of their range and are favored when available. Browse becomes more important in the fall and winter (between growing seasons) and in the southern and western parts of bighorn’s range. In the
northeastern part of bighorn range, jojoba is the most important year-round foraging plant (Monson and Sumner 1980). Other important browse include acacias, paloverde, ironwood, mesquite, fairy duster (*Calliandra eriophylla*) (leaves, twigs and flowers), Mormon tea (*Ephedra* spp.) stems, and desert mistletoe (*Phoradendron californicum*). The importance of surface water to desert bighorn has been investigated by many with inconsistent results (Krausman and others 1999). Differences in results may show a climate dependency or may even be based on differences in the preformed water content of available forage (Krausman and others 1999).

**General life history.**—Desert bighorn sheep form small groups of 2 to 3 individuals, but group size can range from 1 to 16. Larger group sizes may reflect better habitat and population health (Monson and Sumner 1980). Typically mature males form bachelor herds for much of the year and they separate from females and young shortly before the lambing season. In southwestern Arizona, however, desert bighorn sheep have an extended mating period with the result that the birth of lambs has been documented in all months except October (Krausman and others 1999). Only about one-third of the lambs survive their first year. Lamb recruitment depends on plant availability (and water within the plants). Harsh climate and inadequate winter rains can cause lamb abortions or death in the summer.

**Biotic interactions.**—A positive correlation is present between brittlebush (*Encelia farinosa*) and plantain (*Plantago* spp.) spring flowering and lamb survival. Brittlebush is not a food source, but it is a good surrogate for ascertaining climate conditions and general plant flowering and forage availability (L. Smith).

Predators include mountain lions (*Felis concolor*). A study on Pusch Ridge (Santa Catalina Mountains) suggested that fire suppression caused brush encroachment that may have led to better mountain lion habitat and contributed to the demise of the desert bighorn populations there (L. Smith). Some desert bighorn populations suffer from competition for water sources with mule deer (*Odocoileus hemionus*) and competition for food from livestock (Monson and Sumner 1980). On Cabeza Prieta National Wildlife Refuge, Simmons (1969) reported predation on bighorn sheep seemed insignificant.

**Landscape context.**—Desert bighorn require large, unfragmented landscapes to maintain population viability. Males have larger home ranges than females (based on a study in Utah, mean home range was 61 km$^2$ for males and 24 km$^2$ for females) and, as a result, travel more widely than females (Krausman and others 1999). Desert bighorn sheep migrate altitudinally, using upland areas in the summer and concentrating in sheltered valleys in the winter. Although traditionally desert bighorn sheep have been managed as if they solely occurred within a mountain range, a landscape approach to management is needed, as the flats between mountain ranges may act as important corridors to gain access to other ranges for foraging and lambing (Krausman and others 1999) and for gene flow between established populations and colonization of currently unexploited habitat (Simmons 1969). Bighorn sheep quickly and cautiously disperse between mountain ranges by crossing the shortest route, and they are most often observed crossing during cooler weather (Monson and Sumner 1980). Bighorn sheep males tend to make between-mountain moves more frequently than females. Bighorn sheep have been observed crossing between the Aguila and Granite Mountains and the Sierra Pinta and Sierra Cabeza Prieta (Monson and Sumner 1980, Simmons 1969).

Populations may become fragmented and isolated by roads and fences. Interstate 8 and its surrounding canals potentially isolate desert bighorn populations north and south of the highway (L. Smith, M. Cochran). Although Highway 85 has a fence, sheep are able to get under the fence along drainages and will cross this road. Interstate 10 is also a barrier; however, Arizona Game and Fish Department is providing opportunities for sheep to cross via culverts (M. Cochran). Monson and Sumner (1980) speculated that in a number of places where desert bighorn sheep exist [as isolated populations] they may not survive. These areas include: Big Hatchet Mountains in southwestern New Mexico, many of the
small desert ranges in northwestern Sonora, and in isolated peaks in southern Arizona (Figure 3.1 in Monson and Sumner [1980] implies these peaks occur east of the Ajo, Sand Tank and Maricopa Mountains) and California.

**Status, Threats, and Management**

**Historic and current distributions.**—Valdez and Krausman (1999) depict the historic and current distribution of desert bighorn sheep. The current distribution encompasses seven [major/minor] deserts throughout which desert bighorn sheep occur sparsely scattered in isolated rugged mountain ranges: in Arizona these consist of highly dissected, north-south trending ranges (Krausman and others 1999). From 1960 to 1980 desert bighorn sheep disappeared from four mountain ranges in Arizona and were judged to be declining in 14 other ranges (Krausman and others 1999). In 1978 the population estimate for Arizona was between 2100 to 2600 individuals, with most found in the western third of the state. The majority of the population was found in Yuma County, in the mountain ranges extending to the Cabeza Prieta National Wildlife Refuge. Desert bighorn sheep were relatively abundant in the Kofa, Plomosa, and Chocolate Mountains (Monson and Sumner 1980). Suitable habitat exists on the Tohono O’odham Reservation, but populations declined there dramatically and were estimated to be less than 50 in 1972 (Monson and Sumner 1980). Sheep populations in Sonora are not well known, but the species disappeared from the uplands east and north of Highway 2. Population estimates as of 1991 estimated a total number of 23,055 desert bighorn sheep in North America, with 6500 sheep in Arizona (Valdez and Krausman 1999).

**Conservation status.**—Since 1990 desert bighorn sheep populations have declined significantly and species distribution reduced from its historic range (Krausman and others 1999). Contributing factors include: habitat loss, habitat fragmentation resulting from dam, canal, fence, and road construction, presence of invasive species such as feral burros, overgrazing, domestic sheep diseases, and recreational activities (Krausman and others 1999, Valdez and Krausman 1999). Overall desert bigorn sheep are an ecologically fragile species that is adapted to limited habitats that are increasingly fragmented (Valdez and Krausman 1999). To be successful future conservation actions must minimize land uses that result in additional fragmentation of habitats.

The BMGR and the adjoining lands in Cabeza Prieta National Wildlife Refuge, Sonoran Desert National Monument, and Organ Pipe Cactus National Monument are important for the long-term persistence of desert bighorn sheep. The BMGR-Cabeza Prieta-Organ Pipe area contains one interbreeding population of desert bighorn (L. Smith, M. Cochran). At least the Sand Tank Mountains portion of the Sonoran Desert National Monument also is part of this interbreeding population. This area provides desert bighorn with a large landscape that is free of most of the significant threats that this species encounters in many other parts of its desert range. The area is free of many large roads that cause genetic isolation—a common threat in small-patch populations found elsewhere throughout the desert bighorn’s range. The BMGR also is important because it is relatively inaccessible to recreationists, who present a large threat to the population in other regions, and because it lacks large populations of burros that outcompete sheep for water in the summer. Kofa National Wildlife Refuge is also important for ensuring desert bighorn sheep persistence throughout the region (L. Smith, M. Cochran).

Table 7.1 indicates recent population estimates provided by the Arizona Game and Fish Department for desert bighorn sheep on the Barry M. Goldwater Range and Cabeza Prieta National Wildlife Refuge. These estimates were derived from aerial surveys conducted by the Department. Surveys followed a set protocol and population estimates were calculated using an estimator that relies on frequencies of observed group sizes. All mountain ranges are not surveyed each year, so the listed population estimates are based on the most recent data available for each range. Desert bighorn sheep are known to occur in
**Table 7.1 Population Estimates of Desert Bighorn Sheep on the Barry M. Goldwater Range and Cabeza Prieta National Wildlife Refuge**

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<tr>
<td>Growler Mts</td>
<td>55</td>
<td>Gila Mts</td>
<td>76</td>
<td>Sauceda Mts</td>
<td>102</td>
</tr>
<tr>
<td>Agua Dulce Mts</td>
<td>31</td>
<td>Tinajas Altas Mts</td>
<td>49</td>
<td>Sand Tank Mts</td>
<td>41</td>
</tr>
<tr>
<td>Granite Mts</td>
<td>8</td>
<td>Mohawk/Copper Mts</td>
<td>125</td>
<td></td>
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<tr>
<td>Child’s Mt</td>
<td>18</td>
<td>Crater Mts</td>
<td>—</td>
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<tr>
<td>Cabeza Prieta Mts</td>
<td>97</td>
<td>Aguila Mts</td>
<td>—</td>
<td></td>
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<tr>
<td>Tule Mts</td>
<td>27</td>
<td></td>
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<tr>
<td>Sierra Arida</td>
<td>7</td>
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<tr>
<td>Sierra Pinta</td>
<td>102</td>
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<td>Bryan/Mohawk</td>
<td>43</td>
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Some movement of sheep likely occurs between all of the mountain ranges on BMGR and Cabeza Prieta. The Department has never identified specific movement corridors in the area, but they can be assumed to exist between any adjoining ranges (B. Henry). Simmons (1969) documents a number of inter-mountain dispersal movements (movements to a new home range) by desert bighorn sheep on the BMGR and Cabeza Prieta, for example: north end of Cabeza Prieta Mountains to south tip of Copper Mountains, north end of Sierra Pinta to northeast side of Cabeza Prieta Mountains, south end of Mohawk Mountains to north end of Bryan Mountains, and south end of Aguila Mountains to north end of Granite Mountains. Typically bighorn sheep made valley crossings quickly during mild weather and by the shortest routes possible across flat terrain. The longest inter-mountain dispersal route Simmons (1969) was about 8 miles; however, he also describes the movement of one dye-marked bighorn sheep that ended up 31 miles from where it was marked.

**Stressors.**—Reduced genetic diversity resulting from the isolating effects of habitat loss and fragmentation, increased competition for food and water resources, and population reduction from predation, environmental stress, and human disturbance.

**Sources of stress.**—Habitat loss is principally caused by agricultural conversion, mining, and urban expansion. Large, paved roads isolate bighorn sheep populations and can lead to genetic isolation and population declines. Desert bighorn populations are particularly vulnerable to isolation from north-south roads between mountain ranges (mountain ranges in southern Arizona trend north-south). Mining was a historic threat and it could be a future threat in some areas, including the BMGR (for example, copper is present in Javelina Mountain in the Sand Tanks; historic mine locations are located in the Mohawks, Tinajas Altas, and Copper Mountains). Urban expansion of Phoenix and housing developments from the Gila Mountains towards the BMGR boundary are future threats.
Associated with urban expansion toward the foothills and mountain ranges is increased human recreation, which can result in constant harassment of sheep. Recreationists (especially with dogs) in desert bighorn habitat cause sheep to flee, cause them to use valuable energy, and prevent them from resting in the shade and from ruminating. Harassment can prevent bighorn sheep from locating water or preferred foraging areas and can cause illness and death (L. Smith). Harassment was the primary cause of the extirpation of desert bighorn populations in the Pusch Ridge area of the Santa Catalina Mountains near Tucson (L. Smith). Recreation on the BMGR is not currently a threat to bighorn populations, but it could become one in the future with increased recreation, particularly in the Yuma region and in the Sand Tank Mountains. Despite access control procedures for the Sand Tank Mountains, many individuals illegally enter via the Vekol Valley (L. Smith).

A climate change to hotter, drier conditions could negatively affect sheep populations in the future. Water enhancements could inadvertently harm desert bighorn by providing water to their predators or to competitors who are more dependent on water than desert bighorn (for example, feral burros, coyotes [Canis latrans], and mountain lions).

Hunting does not seem to pose a threat, nor do current military activities on the BMGR, including overflights (L. Smith).

**Threat abatement strategies.**—Human access and intrusion into desert bighorn habitat should be minimized. Access control into the BMGR should be enforced (to prevent illegal entry). It is essential to keep people away from water sources during the summer. The ecological integrity of valley corridors between mountain ranges should be maintained to permit bighorn sheep movement between mountain ranges.

**Mapping and Information Needs**

**Mapping comments.**—Desert bighorn sheep are found in every mountain range on the BMGR (L. Smith, M. Cochran). Population data supplied by Bob Henry (Arizona Game and Fish Department) provided current population estimates and location data based on aerial surveys. The data provided included a geospatial data file that indicated bighorn sheep locations throughout the BMGR and Cabeza Prieta National Wildlife Refuge (see Figure 7.5). Population estimates are provided in the Conservation Status section.

**Information needs.**—The beneficial/adverse effects of water enhancement on desert bighorn populations and non-target species (such as desert bighorn predators, invertebrates, plants, and amphibians) need to be scientifically investigated. Work should not be done to increase the bighorn population size without knowing what the habitat can support (L. Smith, M. Cochran). In the opinion of some experts, water enhancements should be eliminated or minimized, except in those rare cases in which a lack of water may cause die-offs during extreme climate years (M. Cochran). The issue is obviously controversial. Dr. Paul Krausman (University of Arizona) will be leading a four-year study on the effects of permanent water on the productivity and recruitment of desert bighorn sheep on mountain ranges within Cabeza Prieta National Wildlife Refuge and the BMGR. Some of the existing human-created permanent water sources in the Growler, Granite, Mohawk, and Tinajas Altas Mountains will have their water supply eliminated. Bighorn sheep will be satellite-collared and monitored to track their responses to water removal.
7.5.2 Kit Fox (*Vulpes macrotis*)

**Ecological Characteristics**

**Habitat associations.**—Kit foxes are associated with open and level ground in low desert scrub and semi-desert grassland habitats that are characterized by sandy soils (for example, soft alluvial soils and sand dunes) that are easy to dig in (but not in desert pavement) (Burt and Grossenheider 1976, Hoffmeister 1986). Within the Sonoran Desert they are found in creosotebush-bursage and saltbush related community types.

**Food and water requirements.**—Preferred source of food is kangaroo rats; however, they also feed on a variety of other rodents, as well as insects, lizards, and birds (Hoffmeister 1986). Kit foxes get their water from their food. They feed opportunistically, changing prey base with seasonal abundance and with prey population fluctuations (Fisher 1981). Food found (seasonally) in scat, such as mesquite pods, birds, bird eggs, and arthropods, also suggests opportunistic feeding (Fisher 1981). Although kit foxes avoid heavily vegetated riparian zones, open stock pond areas were found to be important resource-rich patches where individuals feed on many rodents and lagomorphs (excluding kangaroo rats) (Fisher 1981).

**General life history.**—Kit foxes are nocturnal and carnivorous. They dig multiple den holes, which they use year-round for raising young and to escape daytime heat. They are solitary but form pairs in the early spring during the breeding season (Jaeger 1961). Young are born in February or March (Hoffmeister 1986). Based on the number of dens and apparent population density kit foxes seem to have relatively small home ranges: possibly less than 100 acres but more than 10 acres (L. Smith). Management considerations would benefit from quantifying home range information for kit foxes on the BMGR and its dependency on habitat quality, especially prey availability.

**Biotic interactions.**—Their main predators are bobcats (*Lynx rufus*) and coyotes. Kit fox diet can reveal fluctuations in prey abundance (Fisher 1981).

**Status, Threats, and Management**


**Conservation status.**—Not much has been reported on kit foxes; however, they seem to be persisting at present in locations where their habitat is intact. Kit fox habitat is particularly vulnerable to conversion to agriculture and urbanization, because it is easily accessible to humans. The BMGR could be an important area for kit foxes, because it includes relatively large, intact expanses of low desert. Kit foxes are expected to occur throughout the BMGR in the low desert. Many kit fox dens are present in the East Tactical Range between the Saucedas and Sand Tank Mountains, and foxes are often seen along the road coming into the Saucedas from the west (L. Smith). Little is specifically known about their populations, but they seem to be widely distributed and relatively abundant throughout their range. They may decrease in abundance in the western portion of the BMGR, but this is not known for sure (L. Smith). Although two subspecies of kit fox are present in Arizona, based on Hoffmeister (1986) only the subspecies *Vulpes macrotis macrotis* occurs within the Sonoran Desert.

**Stressors.**—Habitat loss.

**Sources of stress.**—Urban and/or agricultural development in low desert valleys. Some of the species former range was reduced because of conversion of Salt Desert Scrub to agriculture. Historic stress was unintentional poisoning or trapping meant for coyote elimination (L. Smith). Current military operations
do not seem to have a significant effect on kit foxes. No apparent effects of noise are indicated from military overflights over kit fox populations, and prey populations were not significantly different on and off military target areas; however, at the time these evaluations were made it was a drought and a low-density prey year, so differences may not have been perceived (L. Smith).

**Threat abatement strategies.**—Avoid/minimize habitat loss or activities that may lead to habitat degradation. Protect valley bottom areas and occurrences of Salt Desert Scrub.

**Mapping and Information Needs**

**Mapping comments.**—Can map potential kit fox habitat using vegetation: Creosotebush-Bursage Desert Scrub and Salt Desert Scrub polygons plus soil data (not rocky soils).

**Information needs.**—What areas on the BMGR are best for kit foxes? Are kit foxes and/or their prey relatively robust to vegetation change caused by invasive species? What are kit fox home ranges sizes on the BMGR and elsewhere and how do they change with habitat condition?

**7.5.3 Bat Guild**

This guild is composed of the California leaf-nosed bat (*Macrotus californicus*), cave myotis (*Myotis velifer*), and lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*). The lesser long-nosed bat is a federally endangered species. Each of these species relies on the availability of caves and/or mines to roost in. These landform features are not adequately captured by the natural community conservation elements. Additionally, each species uses other community types, such as xeroriparian areas, high-density saguaro stands, and tinajas, to meet their food and water requirements.

**7.5.3.1 California leaf-nosed bat (*Macrotus californicus*)**

**Ecological Characteristics**

**Habitat associations.**—California leaf-nosed bats are found in desertscrub. They roost and raise their young in mines or caves usually below 3500 feet (Bradshaw 1961). These bats will use the same day roosts as other bats, but they tend to segregate to the rear of the roosting site (Bradshaw 1961). Warm, geothermally active mines are particularly important for these cold-intolerant bats (L. Smith). Xeroriparian corridors and larger tinajas are important foraging areas (T. Tibbitts), as well as high-density saguaro areas because they attract many insects (L. Smith).

**Food and water requirements.**—This bat captures its insect prey (crickets, grasshoppers, beetles, moths) from foliage, from the ground, or in flight and it may occasionally feed on cacti fruit (Hoffmeister 1996). It may drink from tinajas (T. Tibbitts).

**General life history.**—California leaf-nosed bats are year-round residents in southern Arizona and, because of the year-round availability of food, they do not need to hibernate or migrate (Hoffmeister 1986). Breeding takes place in the fall, and the embryo develops slowly through the winter and then speeds up development in the spring. Young (born singly or as twins) are born in May or June (Phillips and Comus 2000). Populations in most caverns are about the same size in winter and summer; however, some nursery colony sites may be occupied all year, whereas others are not occupied in winter (Hoffmeister 1986).
Status, Threats, and Management

Distribution.—These bats range throughout the Sonoran and Mojave Deserts, from the Colorado River valley in southern California, Nevada, and Arizona and throughout western Mexico (Belwood and Waugh 1991).

Conservation status.—The BMGR is an important area for this bat, because it is a large area of hot desert. This species cannot go into torpor and cannot tolerate cold temperatures for any length of time (L. Smith). This is the most common bat on the BMGR (L. Smith). Roosting locations have been surveyed in the Sand Tank and Sauceda Mountains (Dalton and Dalton 1999, Dalton and others 2000). Active roosts have been documented at 11 sites throughout the BMGR in the Sand Tank and Sauceda Mountains (Noonan Group), Mohawk Mountains (Red Cross Mine), Copper Mountains (Old Soak, Betty Lee Mine, and Buck Peak), Wellton Hills (Wellton Hills Mine and Poorman), and Gila Mountains (Fortuna Mines) (Dalton and Dalton 1994, Dames and Moore 1996).

Stressors.—Disturbance of roosting colonies; reduction in populations due to insect population decline; insecticide poisoning of adults; and vandalism.

Sources of stress.—Roosting colonies of bats are vulnerable to disturbance, particularly during the birthing season. People entering caves have been known to purposely kill entire bat populations (L. Smith, Belwood and Waugh 1991). Increased recreation is a threat to bats because of the potential for increased human-caused disturbance of roosting colonies and/or causing a change in the cave microclimate, which makes the cave unsuitable for bats (T. Tibbitts). Mine closures, reclamation, or reinitiation of mining activities is also a threat that can kill large numbers of these bats (L. Smith, T. Tibbitts, Belwood and Waugh 1991). Pesticide spraying could affect local insect abundance or cause toxicity/death to adult bats (Reidinger 1972), particularly near agricultural areas close to Yuma and along the Gila River (T. Tibbitts).

Threat abatement strategies.—Limit human access to roosting colonies in areas where recreation is a potential threat (for example, near roads; Sand Tank Mountains). Access can be prevented by placing barbed wire fencing and warning signs around the perimeter of the roost area. Caution should be used if installing a bat-friendly gate (with appropriately sized slots through which the bats can easily enter/exit the mine), because lesser long-nosed bats may not be able to enter or exit these mines due to their rapid flight pattern (T. Tibbitts).

Mapping and Information Needs

Mapping comments.—Current documented roosting sites are mapped by Dalton and Dalton (1994, 1999). Figure 7.5 depicts documented roosting locations on the BMGR.

Information needs.—Effective means of protecting bat cave/mine roost sites from unauthorized access are needed that provide an adequate deterrent to human entry, but will not prevent colonization by lesser long-nosed bats.

7.5.3.2 Cave myotis (Myotis velifer)

Ecological Characteristics

Habitat associations.—Hoffmeister (1996) provides a general description of habitat associations for this species. Cave myotis use mine shafts, tunnels, caves, and the underside of bridges as roost sites within the desertscrub habitats of the Sonoran Desert. The species usually roosts near the entrances of mine...
shafts or tunnels and, as a result, can use tunnels as short as 100 feet. Of the nine species of *Myotis* that occur in Arizona, the cave myotis shows the greatest correspondence with Sonoran Desert habitats (Hoffmeister 1996: Figure 5.17). Xeroriparian corridors and large tinajas are important foraging areas (L. Smith, T. Tibbitts). Areas with saguaros are important, because they attract many insects (L. Smith). Roosts are situated within several miles from water sources (Dames and Moore 1996, Hoffmeister 1996).

**Food and water requirements.**—Insectivorous: catches prey in flight using echolocation. Drinks from free water at tanks, tinajas, and guzzlers (L. Smith).

**General life history.**—Some cave myotis individuals in southern Arizona migrate in the winter to locations in the southernmost part of the state above 6000 feet to hibernate; however, most individuals probably migrate outside of Arizona to the south (Hoffmeister 1986: Figure 5.10). According to Hoffmeister (1996) nursery colonies may support from 50 to 15,000 female bats. Females move north during early April and arrive at the nursery colony already inseminated. Young are born in mid-June. Females leave the nursery colonies in August and join the males. Individuals seem to show fidelity to roost locations. Home range estimates for a population (individuals occupying one or several mine tunnels that are in close proximity) range from 360 to 625 square miles.

**Status, Threats, and Management**

**Distribution.**—Distributed throughout the Sonoran Desert.

**Conservation status.**—The cave myotis seems to be uncommon on the BMGR. The Sand Tank Mountains are probably an important area for this species. The northern and eastern boundary areas of the BMGR are the most important areas for cave myotis (Dalton and Dalton 1994). The bat probably decreases in abundance heading west on the BMGR (T. Tibbitts). Only one roosting site has been found, near Sand Tank Well, at an elevation of 2360 feet (Dalton and Dalton 1994). Additionally, cave myotis were captured near Arizona Game and Fish Department guzzlers at three sites located in the Sand Tank Mountains, one in the Saucedas, and one site east of Javelina Mountain (Dames and Moore 1996).

**Stressors.**—See California leaf-nosed bat.

**Sources of stress.**—See California leaf-nosed bat.

**Threat abatement strategies.**—See California leaf-nosed bat.

**Mapping and Information Needs**

**Mapping comments.**—Roosting sites are mapped based on Dalton and Dalton (1994). Figure 7.5 depicts documented roosting locations on the BMGR.

**Information needs.**—Need better population estimates for this species on the BMGR. Also see the comment for this section under the California leaf-nosed bat.

7.5.3.3 Lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*)

**Ecological Characteristics**

**Habitat associations.**—Areas of dense columnar cacti in the spring and at higher elevations in areas of high agave density in oak-piñon forests in the summer and fall. Roosts during the day in caves or mines, where it needs total darkness and a specific temperature range (T. Tibbitts).
Food and water requirements.—This bat is primarily nectarivorous but will feed on the pollen and fruit, as well as nectar, of columnar cacti and agaves (Hoffmeister 1996). They can be found drinking at tinajas (T. Tibbitts).

General life history.—This bat migrates from the tropics and arrives in southern Arizona in mid-/late-April. It has acute vision and feeds on night-blooming columnar cacti flower nectar and fruits during its migration in the spring. It moves east and south to higher elevations to feed on agave nectar in the fall. Some populations in Baja California are non-migratory and feed on cactus and agave flowers year-round (Fleming 1991). Females arrive at nursery colonies already pregnant and young are born from early May until late June (Hoffmeister 1996).

Biotic interactions.—These bats are crucial pollinators of many plants. They play a key role in the reproductive success of organ pipe cactus (*Stenocereus thurberi*) and cardon (*Pachycereus pringlei*) and are important saguaro pollinators. Without lesser long-nosed bats, the pollination success of *Agave palmeri* dropped to 1/3000th of normal (Fleming 1991).

Landscape context.—These bats are migratory and depend on many habitats and roosting sites in southern Arizona and Mexico.

Status, Threats, and Management

Distribution.—Found from southern Arizona and southern Baja California to western Mexico and Central America (Phillips and Comus 2000).

Conservation Status.—The lesser long-nosed bat is an endangered species. Roosting colonies have not been found on the BMGR, and only six light-tagged individuals potentially were sighted foraging in the Sand Tank Mountains (Dalton and others 1994). If they are on the BMGR, they are currently not abundant. The eastern areas of the BMGR (particularly the Sand Tank Mountains); however, represent good habitat for *Leptonycteris* foraging or roosting, so the BMGR is potentially important for this species (T. Tibbitts). It is important to monitor for this species on the BMGR, because it is vulnerable at roost sites and it can best be protected if roost sites are known and appropriately managed (T. Tibbitts). A large colony (16,000 to 19,000 females) of lesser long-nosed bats is present in the Copper Mountains on Organ Pipe Cactus National Monument and an additional colony of 5000 females occurs at Bluebird mine on Cabeza Prieta National Wildlife Refuge. Two colonies are present on the Tohono O’odham Reservation in undisclosed locations.

Stressors.—Habitat loss and roost disturbance.

Sources of stress.—Over-harvesting of agave in Mexico eliminates important fall habitat. Lesser long-nosed bats roost in large colonies that are particularly vulnerable to roost disturbance. People entering caves have been known to purposely kill entire bat populations (L. Smith, Belwood and Waugh 1991). Increased recreation is a threat to bats because of the potential for increased human-caused disturbance of roosting colonies and/or causing a change in the cave microclimate, which makes the cave unsuitable for bats (T. Tibbitts). Mine closures, reclamation, or reinitiation of mining activities is also a threat that can kill large numbers of these bats (L. Smith, T. Tibbits, Belwood and Waugh 1991). These bats are fast fliers and it is not known if traditional “bat-friendly” gates inhibit the movement of this species (T. Tibbitts). Not much is known about the threats in their winter habitat (T. Tibbitts).
Threat abatement strategies.—None currently needed on the BMGR. Bat-gates should not be used to protect roosting colonies of other bat species because of its potential to inhibit lesser long-nosed bat colonization in the future (T. Tibbitts).

Mapping and Information Needs

Mapping comments.—Not currently found in colonies on the BMGR. Areas of high density saguaro on the Sand Tank Mountains are potentially important foraging areas (current or future) (T. Tibbitts).

Information needs.—See California leaf-nosed bat.
CHAPTER 8 OTHER SPECIES/TAXONOMIC GROUPS CONSIDERED BUT NOT FURTHER EVALUATED

The following sections briefly describe some of the other species/guilds considered as conservation elements. For some we purposely canvassed relevant taxonomic experts to gain specific input on taxa we either thought were underrepresented (invertebrates) or for which we had numerous candidates but needed more ecological information to judge their robustness to serve as a conservation element (for example, plants). The species/guilds below were not carried forward as conservation elements because we lacked adequate information to determine whether they met the fine-filter criteria (Table 4.2), further investigation determined that they did not occur on the Barry M. Goldwater Range (BMGR), or they were determined to be adequately captured or addressed by other conservation elements. Additional information may reveal that any one of these may serve as robust conservation elements. The other species/guilds considered are described by taxonomic group.

8.1 PLANTS

Appendix C identifies the plant experts contacted. Two plant species deserve comment.

**Amole (Stegnosperva halimifolium).**—Possibly a keystone species as a host plant for insects. “It is perhaps the most attractive plant I have ever seen for pollinators and it would be key to survival of many species of insects” (J. Schimdt, U.S. Department of Agriculture, Carl Hyden Bee Research Center). Unfortunately, this species has yet to be documented in Arizona, though it occurs within the Pinacate Biosphere Reserve in Mexico (Turner and others 1995).

**Burrobush (Hymenoclea monogyra).**—A potential keystone species for large wash beds (S. Rutman). It occurs as a component of certain xeroriparian communities in certain reaches along primary (main stem) or perhaps secondary wash beds, but not along the tributaries. The species is locally abundant on floodplains and along washes (Turner and others 1995). Its occurrence in the broad wash beds makes it susceptible to off-road driving. It is found in areas that are often used as travel corridors by military and recreationists. It is fairly tolerant of these types of activities, because it is adapted to scouring floods and resprouts after topkill. It is documented from the Organ Pipe Cactus National Monument along Kuakatch Wash near the eastern boundary and from Growler Wash. Possibly is adequately captured by the Valley Xeroriparian Scrub community.

8.2 INVERTEBRATES

The information is too sparse at present to enable us to recommend selection of an invertebrate species conservation element at present. The common theme throughout our inquiries with experts is that not enough is known about invertebrates in general and the best way to learn more about conservation needs of this group on the BMGR is to selectively sample unique habitats/host plants. Appendix B identifies the invertebrate experts contacted.

Specific recommendations and/or information avenues to pursue include:

- Certain taxonomic experts can be contacted to determine whether specific specific species of snails could be potential conservation elements. Such experts include: Jim Hoffman, Dwight Taylor (U.S. Geological Survey), and Robert Hershler (Smithsonian Institution).
• A survey of aquatic Coleoptera and Hemiptera on Organ Pipe Cactus National Monument showed that desert water sources (both natural and human-made) may have unique aquatic invertebrate fauna associated with a particular site or with a particular type of habitat; however, uniqueness may in some cases be an artifact of sampling effort (that is, more sampling is needed to clarify the results) (Larsen and Olson 1997).

• Eric Larsen felt that he had not sampled enough in various habitats to state what invertebrates might be unique to tinajas, but he suggested a particular true bug (*Buenoa* sp.) in the family Notonectidae (backswimmers) seems to specialize on middle elevation tinajas. This species is found in tinajas and stock tanks, but rarely in ponds. It has been collected from the Organ Pipe Cactus National Monument-Pinacate Biosphere Reserve area (a few specimens), Santa Catalina Mountains, Redington Pass, and Rincon Mountains.

• Marshall and others (2000) did identify “concentration of aquatic invertebrates” as an ecoregional conservation element. Lacking specific taxonomic information about aquatic invertebrates on the BMGR, species richness could be used as a surrogate; however, Carl Olson thinks that desert-adapted aquatic insects are good dispersers and that it is unlikely that there are unique or rare associates.

• Carl Olson expressed skepticism at the need in general to have an invertebrate conservation element and felt that habitat protection is the most important factor for conservation of invertebrates, especially when we may be unjustifiably concerned over insect population declines because little is known about natural population fluctuations and dynamics, life history, and appropriate sampling methods (seasonality/time of day best for sampling). Olson doesn’t think that a single invertebrate is a good indicator for these reasons; however, he thinks that invertebrates can be good indicators of environmental stress (for example, insect infestations on certain plants can be indicative that the plant is adversely affected by a particular stress).

• Olson recommended concentrating on sampling host plants to find specialist associates and to concentrate on specialized terrestrial habitats, especially dunes. As a result, one possible species to consider is a scarab beetle (*Pseudocotalpa sonorica*), which was collected (adult) from the Mohawk Dunes. Its life history is unknown, but it is possible that it specializes (as a larva) on the roots of certain dune-associated plants.

• The Sonoran Desert is the center of the world’s bee biodiversity; however, an interview with Steve Buchmann did not lead to the selection of a potential bee species or guild conservation element. Many bees specialize on host plants, particularly creosotebush; however, a large, unfragmented area of creosotebush does not seem to be crucial for these species (so possibly little advantage for these species on the BMGR). The areas for highest bee diversity in the Sonoran Desert are unknown, but some areas with high diversity are riparian corridors adjacent to low desert and lush areas of the Arizona Uplands. Another area that is especially rich and of potential interest is the Mexico/U.S. border area (corridor of 50 miles on each side). Buchmann will be inventorying native bee biodiversity on the Yuma Proving Grounds and Kofa National Wildlife Refuge starting in the spring of 2001. An inventory of the BMGR would supplement our knowledge of this area and also enable comparisons with known areas.

### 8.3 AMPHIBIANS

Dr. Philip Rosen (University of Arizona) assisted with the identification of members of the ephemeral water-breeding amphibian guild. This guild was selected as a conservation element and is characterized in section 7.2. The guild was defined as including three species: Sonoran Desert toad (*Bufo alvarius*),
red-spotted toad (*B. punctatus*), and Couch’s spadefoot (*Scaphiopus couchii*). Subsequent to the initial description of this guild, Dr. Rosen recommended that a fourth species, Great Plains toad (*B. cognatus*), be added as a member. The Great Plains toad is a wide-ranging species that also is primarily a grassland species (Stebbins 1985). The species does occur in creosotebush (*Larrea tridentata*) desertscrub, mesquite (*Prosopis* spp.) woodlands, and sagebrush (*Artemisia* spp.) plains, but within the desert part of its range its distribution is highly spotty (Stebbins 1985). On the BMGR the Great Plains toad likely makes use of similar breeding habitats as the Sonoran Desert toad and, again as for the Sonoran Desert toad, is less dependent on rainfall patterns to trigger breeding than the red-spotted toad and Couch’s spadefoot (P. Rosen). The species occurs in modest or low abundance at localities in the eastern half of Organ Pipe Cactus National Monument and is known from the Quitobaquito Springs area (Rosen and Lowe 1996). The Great Plains toad does occur on BMGR, as it has been observed on the Mohawk Dunes (D. Turner); however, until additional information can be gathered on its distribution, habitat relationships, and biotic interactions with other amphibian species on the BMGR, we have decided not to include it at present as a member of the ephemeral water-breeding amphibian guild.

### 8.4 Reptiles

An in-depth interview was conducted with herpetologist Dr. Philip Rosen, in regard to the herpetofauna of the BMGR, to discern whether any species or groups could be recommended to serve as conservation elements for the BMGR. Dr. Rosen divided the reptiles of the BMGR into two broad groups based on their habitat affinities. The boundary between these reptile faunas is approximately at the Sauceda Mountains. These groups are described briefly below.

**Western desert reptile group.**—The majority of the land within the boundaries of the BMGR is habitat for the western desert reptile group. The BMGR is significant habitat for this group, as it represents the core of the range and distribution for many of the species that are in the group. This group of reptiles can be subdivided into two guilds based on habitat associations: valley bottom reptile guild and rocky slope reptile guild. Dr. Rosen recommended both guilds to serve as conservation elements.

**Eastern scrub reptile group.**—The reptiles included within this group associate with the more mesic habitat of the Sand Tank and Sauceda Mountains and areas east of the BMGR, which are characterized by higher summer and annual rainfalls than the western portion of the BMGR. The BMGR may represent the western edge of the range for many of these species, but still may represent a significant area for their conservation because of habitat loss elsewhere, principally due to urban expansion in suitable habitat in the Phoenix and Tucson vicinities. Dr. Rosen recommended no conservation elements from this group; however, he did recommend some monitoring of certain species because of their potential susceptibility to changes in their environment caused by climate change.

The two reptile guilds included within Dr. Rosen’s western desert reptile group, valley bottom and rocky slope, were not originally identified as conservation elements for the BMGR. The interview with Dr. Rosen helped to define these guilds and to qualify the importance of the BMGR to their long-term viability in the Sonoran Desert. The valley bottom reptile guild was selected as a conservation element and is characterized in section 7.3.4; however, the guild’s composition only includes those species for which the BMGR forms a core area of their distribution and provides a vital area for their conservation. The other associated species, not formally included in the guild, are briefly described below.

The rocky slope guild was not selected at this time. More information is needed to determine the significance of the BMGR for this guild’s conservation. At present, threats to this guild seem minimal. The guild can be added at a later date if additional information on the BMGR’s significance to their conservation or additional threat information warrants their inclusion. The guild is briefly described below.
8.4.1 Valley Bottom Reptile Guild: Additional Associates

**Banded sand snake** (*Chilomeniscus cinctus*).—In the United States the species is distributed in central and southwestern Arizona; in Mexico its range extends to southern Sonora and throughout Baja California, except for the northeastern and extreme southern portions (Stebbins 1985). Found in sandy soils and areas of loose plant litter in xeroriparian areas from rocky canyons down to valley floors (P. Rosen). The species may be abundant in the Growler Wash (Valley Bottom Floodplain Complex) and inventory efforts should focus on this area on the BMGR (P. Rosen).

**Glossy snake** (*Arizona elegans*).—Range extends from central California to central Texas, north to southern Utah to southern Sinaloa, Zacatecas, and San Luis Potosi; from below sea level to 6000 feet. Found in open areas in a variety of habitats from chaparral, grassland, sagebrush, and woodland. Prefers sandy to loamy soils (Stebbins 1985). Two subspecies are potentially found on the BMGR. The distribution of this snake is poorly known on the BMGR.

**Mojave rattlesnake** (*Crotalus scutulatus*).—Most common at lower elevations in the United States in creosotebush flats-mesquite scrub; also in desert grasslands of southeastern Arizona. Uncommon where vegetation is dense or in rocky terrain. Its range extends from the western edge of the Mojave Desert in California through southern Arizona to extreme west Texas through Mexico south into high altitudes in the Sierra Madres. The distribution of this snake is poorly known on the BMGR.

**Zebra-tailed lizard** (*Callisaurus draconoides*).—A fairly widespread lizard ranging from Nevada and southeastern California south throughout much of Baja California, Sonora, and Sinaloa. Occurs at elevations ranging from sea level to 5000 feet (Phillips and Comus 2000). Most commonly found in areas that are sparsely vegetated with open expanses of sandy soils, such as canyon bottoms, desert pavement, hardpan, and xeroriparian washes. The importance of the BMGR to the occurrence of this species is not known.

**Western whiptail** (*Cnemidophorus tigris*).—Found throughout the desert southwest and Great Basin. Eight subspecies are recognized throughout its range (Stebbins 1985). Found over a large elevation gradient, from sea level up to 8000 feet, in arid/semiarid areas with sparse vegetation and open habitat for running. Habitat association ranges from deserts to pine forests. The species avoids densely vegetated areas. Found in open areas in grasslands, woodlands, low deserts scrub and pine forests, on a variety of soil types (Stebbins 1985, Phillips and Comus 2000). The BMGR may represent an important component of the species desert habitat distribution in Arizona. Two subspecies occur on the BMGR: Great Basin whiptail (*C. t. tigris*) and Arizona desert whiptail (*C. t. gracilis*).

**Long-nosed leopard lizard** (*Gambelia wislizenii*).—Range extends from the Great Basin south to southern Baja California, Mojave, and Sonoran Deserts. Found in arid/semiarid, open areas, with scattered low plants such as creosotebush or sagebrush. Avoids dense grass and brush, which interfere with running. Found on sandy to gravelly soils; rocks may be present. The relative importance of the BMGR to its conservation is not known.

8.4.2 Rocky Slope Reptile Guild

The rocky slope-associated reptiles are found throughout the extremely dry western Sonoran Desert, as well as in the eastern portions of the BMGR. The latter occurrences are at or near the eastern extent of their distributions. These species prefer rocky habitats on the bajadas and at higher elevations that are often moister than the xeric valley bottoms. The members of this guild are:
**Speckled rattlesnake** (*Crotalus mitchellii*).—Its distribution mirrors that of the Mojave and Sonoran Deserts. It is generally found in rocky mountain desert areas, occasionally ascending to 8000 feet above sea level (Stebbins 1985). The BMGR incorporates the eastern-most area of the distribution of this species (B. Wirt). Three subspecies are recognized (Melli 2000, Stebbins 1985). It is the most abundant rattlesnake and most conspicuous snake in rocky habitats on the BMGR (P. Rosen). The southwestern speckled rattlesnake (*C. m. pyrrhus*) occurs on the BMGR. This species is differentiated throughout its range. It frequently matches its background in color.

**Chuckwalla** (*Sauromalus ater* [= *S. obesus*]).—Found strictly in rocky habitats of the Mojave and Sonoran Deserts; in rocky outcrops, rocky hillsides, and lava flows (Stebbins 1985). The eastern-most population of this species is found east of the BMGR in the Silverbells (B. Wirt).

**Side-blotched lizard** (*Uta stansburiana*).—This species is one of the most abundant lizards in the arid southwest and is distributed across most of the western United States and northern Mexico. It is found in a variety of habitats from coastal cliffs to semi-arid chaparral and desert scrub to high mountains. It is frequently seen on rocks and branches of shrubs (Schwenkmeyer 2000) and also is abundant on flat rockless ground where it lives among shrub stems (P. Rosen). As many as five subspecies are recognized throughout this lizard’s range (Schwenkmeyer 2000). In southern Arizona and on the BMGR, the desert side-blotched lizard (*U. s. stejnegeri*) occurs. The importance of the BMGR to the conservation of this species is uncertain. It has been included as part of the guild because it is the most abundant and, along with the chuckwalla, most prominent lizard on rocky slopes and will be a convenient monitoring index species (P. Rosen). Side-blotched lizards are good indicators of large-scale vegetation changes and, because they are an important food source for many other species, their abundance is important to monitor (P. Rosen). Moreover, because it is an abundant species, informative data can be collected easily (B. Wirt).

**Conservation status.** —The BMGR includes a large area of relatively undisturbed mountain ranges and rocky areas, which potentially represent an important area for the conservation of this guild. These species are not highly threatened throughout their range, but the BMGR represents a landscape-scale area that is important for genetic diversity and gene flow between populations (B. Wirt).

**Stressors.** —Habitat loss; collection of adults.

**Sources of stress.** —Urban development on hillsides is a source of habitat loss for these species. In the Mojave Desert, these species are found on geologically younger bajadas than those in the Sonoran Desert. In the Mojave, these bajadas are threatened by agriculture, grazing, and recreation (B. Wirt). Few threats exist to these species on the BMGR; however, off of the BMGR the chuckwalla population is locally threatened by amateur and professional collectors who remove the animals from their native habitat by using a crow-bar to extract the wedged lizard from between rocks. Chuckwalla removal can disrupt the rocky slope habitat, which is used by many other reptiles in addition to chuckwallas (P. Rosen).

**8.4.3 Species Potentially Vulnerable to the Effects of Climate Change**

Many of the species found in the western desert are replaced by closely related species in the eastern scrub area. This natural herpetofauna ecological boundary is found within the BMGR in the vicinity of the Sauceda Mountains (P. Rosen). A potential effect of climate change on the region’s biota may manifest itself as a shift in the distribution and abundance of certain reptile species across this boundary. Climate change could potentially affect many species throughout the BMGR. Those species-pairs whose abundance and distribution might be affected by climate change are presented in Table 8.1.
### Table 8.1 Reptile Species-pairs on the Barry M. Goldwater Range Potentially Vulnerable to the Effects of Climate Change

<table>
<thead>
<tr>
<th>Western Desert</th>
<th>Eastern Scrub</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common Name</strong></td>
<td><strong>Scientific Name</strong></td>
</tr>
<tr>
<td>Speckled rattlesnake</td>
<td><em>Crotalus mitchelli</em></td>
</tr>
<tr>
<td>Coach whipsnake</td>
<td><em>Masticophis flagellum</em></td>
</tr>
<tr>
<td>Spotted leaf-nosed snake</td>
<td><em>Phyllorhynchus decurtatus</em></td>
</tr>
<tr>
<td>Desert horned lizard</td>
<td><em>Phrynosoma platyrhinos</em></td>
</tr>
<tr>
<td>Desert spiny lizard</td>
<td><em>Sceloporus magister</em></td>
</tr>
<tr>
<td>Long-tailed brush lizard</td>
<td><em>Urosaurus graciosus</em></td>
</tr>
<tr>
<td>Western whiptail</td>
<td><em>Cnemidophorus tigris</em></td>
</tr>
</tbody>
</table>

### 8.5 Birds

Several other bird species or guilds were considered as species conservation elements. The following sections describe these elements and the rationale for not including them at this time in the final list of species conservation elements for the BMGR.

**Northern flicker (Colaptes auratus).**—The fortieth supplement to the American Ornithologists’ Union Check-list of North American Birds (American Ornithologists’ Union 1995) removed the *chrysoides* subspecies-group from *Colaptes auratus* and recognized it as the separate species, *C. chrysoides* (gilded flicker). The gilded flicker is a member of the primary excavator (cavity) guild identified in this document as a species conservation element for the BMGR (see Chapters 5 and 7). The ranges of the gilded flicker and an additional subspecies-group, *C. auratus cafer* (red-shafted flicker) are sympatric (overlap) along the California and Arizona border areas with Mexico (American Ornithologists’ Union 1983). In Arizona *C. auratus cafer* and *C. chrysoides* hybridize at a few sites, but the hybrid zone has remained small and stable for decades (American Ornithologists’ Union 1995; Figure 8.1 shows the area of range overlap and potential hybrid zone). Additionally, most populations are pure parental types, occurrences of the two forms are mostly separated by barriers of unsuitable habitat, and, in contrast to the uniformity of life-history traits that characterizes the *auratus-cafer* subspecies-group complex (yellow-shafted flicker and red-shafted flicker), important differences in life-history traits and genetic isolation seem present (American Ornithologists’ Union 1995).

Tim Tibbitts (Ornithologist at Organ Pipe Cactus National Monument) recommended that the northern flicker be considered for inclusion within the primary excavator (cavity) guild, based on its presumed occurrence on the BMGR (the red-shafted flicker subspecies occurs on Organ Pipe Cactus National Monument; T. Tibbitts) and the potential for the BMGR, Cabeza Prieta National Wildlife Refuge, and Organ Pipe Cactus National Monument area to include a significant portion of the zone of hybridization between the northern flicker and gilded flicker. Figure 8.1 shows the distribution and breeding status of the northern flicker within the Arizona portion of the Sonoran Desert Ecoregion based on data from the Arizona Breeding Bird Atlas (2001). Interpretations of breeding codes are provided in Appendix I. Based on these data it is unlikely that the BMGR contains breeding individuals. Within the two survey
survey sectors (each sector equals one sixth of a 1:24,000 topographic quadrangle) that northern flickers were observed on the BMGR, the individuals were recorded as non-breeders or migrants (Arizona Breeding Bird Atlas 2001). Additionally, the zone of hybridization seems to be north and east of the Sonoran Desert Ecoregion.

Secondary cavity nesters.—Table 8.2 identifies the secondary cavity nesters (birds only) that occur or potentially occur on the BMGR and that rely, at least in part, on members of the primary excavator (cavity) guild for nest sites. The European starling (Sturnus vulgaris) also occurs on the BMGR (sighted in seven different Arizona Breeding Bird Atlas [2001] survey blocks on the BMGR). This non-native species may compete successfully for nest sites with the native cavity nesters, particularly the Gila woodpecker (Kerpez 1986, Kerpez and Smith 1990b).

We decided to focus on the primary excavator (cavity) guild members as the conservation element rather than include all secondary nesters in a combined cavity-nester guild based on the assumption that the primary excavators performed a keystone function in providing nest sites for all cavity nesters. Excavated cavities also may provide roost sites for solitary bats such as pallid bats (Antrozous pallidus) (T. Tibbitts).

Prairie falcon (Falco mexicanus).—The prairie falcon is important as a top predator and as a raptor, a group vulnerable to threats from environmental toxins (such as mercury poisoning; Ehrlich and others 1988). The species is found throughout southwestern Canada, western United States, and into southern Mexico. The importance of the BMGR to this species is unclear at this point. They were sighted in nine
### TABLE 8.2 Secondary Cavity Nesters of the Barry M. Goldwater Range

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Habitat Associations</th>
<th>Importance of the BMGR to the Species Conservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>American kestrel</td>
<td><em>Falco sparverius</em></td>
<td>Nests in saguaro</td>
<td>Neotropical migrant.</td>
</tr>
<tr>
<td>Ash-throated flycatcher</td>
<td><em>Myiarchus cinerascens</em></td>
<td>Nests in saguaro; however, frequently nests along xeroriparian washes in tree cavities constructed by ladder-backed woodpeckers (<em>Picoides scalaris</em>) (T. Corman).</td>
<td>Occurs throughout the BMGR; neotropical migrant.</td>
</tr>
<tr>
<td>Brown-crested flycatcher</td>
<td><em>Myiarchus tyrannulus</em></td>
<td>Probably uses saguaros more than ash-throated flycatchers (L. Smith); in the Sonoran Desert almost exclusively, except where riparian habitats containing cottonwood and willow occur (T. Corman).</td>
<td>Neotropical migrant.</td>
</tr>
<tr>
<td>Cactus ferruginous pygmy-owl</td>
<td><em>Glaucidium brassilianum cactorum</em></td>
<td>Nests in saguaro.</td>
<td>Federally endangered; has not been documented to date on BMGR, but is expected to occur in the eastern portion of the BMGR in xeroriparian habitat; has been documented on the nearby Organ Pipe Cactus National Monument and Tohono O’odham Reservation.</td>
</tr>
<tr>
<td>Cactus wren</td>
<td><em>Campylorhynchus brunneicapillus</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elf owl</td>
<td><em>Micrathene whitney</em></td>
<td>Nests in saguaro; hunts in xeroriparian areas and on hillsides where it eats insects.</td>
<td>Occurs in high densities in the eastern portion of the BMGR; neotropical migrant.</td>
</tr>
<tr>
<td>House finch</td>
<td><em>Carpodacus mexicanus</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lucy’s warbler</td>
<td><em>Vermivora luciae</em></td>
<td>May nest along xeroriparian washes in tree cavities constructed by ladder-backed woodpeckers (T. Corman).</td>
<td>Neotropical migrant.</td>
</tr>
<tr>
<td>Purple Martin</td>
<td><em>Progne subis</em></td>
<td>In the Sonoran Desert the species nests exclusively in saguaro (T. Corman); one individual may have displaced a cactus ferruginous pygmy-owl in a saguaro in Organ Pipe Cactus National Monument (T. Tibbitts).</td>
<td>Occurs throughout the United States; occurs in the eastern portion of the BMGR; an indicator of general diversity in the Sonoran Desert; neotropical migrant (T. Tibbitts).</td>
</tr>
<tr>
<td>Western screech-owl</td>
<td><em>Otus kennicottii</em></td>
<td>Nests in saguaro; hunts in xeroriparian areas and on hillsides where it eats small rodents.</td>
<td>Common in the eastern portion of the BMGR.</td>
</tr>
</tbody>
</table>
For the species to be listed, it must have been documented to have used a cavity excavated by one or more of the members of the primary excavator (cavity) guild as a nest cavity. Data based on literature summaries in Edwards and Schnell (2000) and Kerpez and Smith (1990a,b) and the observations of T. Corman, L. Smith, and T. Tibbitts.

different Arizona Breeding Bird Atlas (2001) survey sectors on the BMGR (five of the nine sightings possibly involved breeding pairs). Prairie falcons can be missed easily by atlas surveyors; as a result, a more concentrated survey effort likely would identify additional nesting pairs on the BMGR (T. Corman).

Prairie falcons nests on cliffs and hunts over plains. They are found in every mountain range where there is vertical relief (T. Tibbitts). Prairie falcons are generalist omnivorous, eating birds, reptiles, and small mammals. In urban areas they eat “city” birds (doves and so on) (T. Tibbitts). On Organ Pipe Cactus National Monument, prairie falcons are found at high densities: 8 to 10 breeding pairs are located within the park (T. Tibbitts). They have a spotty distribution because of their unique habitat association, but their populations are robust throughout the desert. Even in developed areas (for example, Camelback Mountain and Squaw Peak in Phoenix), they can be found nesting (T. Tibbitts). Current threats to prairie falcons on the BMGR have not been demonstrated; however, low overflights by the military along cliffs during the nesting season potentially could disturb nesting adults. In summary, the species probably is not appropriate as a conservation element because it is a generalist feeder, found throughout Arizona in any mountainous habitat, and are highly adaptable to human-induced disturbance and development (T. Tibbitts).

Greater roadrunner (*Geococcyx californianus*).—This species was recommended for consideration as a conservation element by Tim Tibbitts. Roadrunners are difficult to find on standard bird surveys, so there is little sense of their conservation status in the Sonoran Desert (T. Tibbitts). Roadrunners are widespread in the Sonoran Desert and are ecologically important predators. Further evaluation of the screening criteria in relation to this species is recommended.
CHAPTER 9 DESIRED FUTURE ECOLOGICAL CONDITIONS

9.1 INTRODUCTION TO DESIRED FUTURE ECOLOGICAL CONDITIONS

A desired future ecosystem condition “is an attempt to envision all aspects of an ecosystem in the future, including human organizations and needs, in measurable terms” (Leslie and others 1996). A clear picture of current ecosystem conditions, as well as desired future conditions, is fundamental to ecosystem management (Leslie and others 1996); however, such pictures must be tempered by an understanding of the inherent uncertainties and limitations associated with predicting the behaviors of natural and altered ecosystems and human social systems. Uncertainty is addressed by using an adaptive approach to management.

In this report we focus on the desired future ecological conditions of the conservation elements identified for the Barry M. Goldwater Range (BMGR) (Chapter 5 through 7) rather than the entire ecosystem per se. As a result, although the desired ecological conditions expressed herein for the Barry M. Goldwater Range (and its surrounding environs) are stated in the context of a military training environment, specific human uses of the land and their distribution across the landscape are not specified (for example, the amount of heavily disturbed training area and urbanized area is not specified). That is left for a separate process; however, the desired future ecological conditions identified in this chapter for each of the conservation elements provide a framework against which future human uses of the land can be planned and executed in a sustainable manner.

The specific desired future ecological conditions selected gain cohesiveness when they are organized around a central theme. The organizing theme used in this report is the promotion (protection and management) of native biodiversity across the BMGR landscape. As a result, all desired future ecological conditions should be consistent with the promotion of native biodiversity. Additionally, however, they should also reflect conditions that are indeed achievable.

Ideally, desired ecological conditions should be defined on the basis of a natural (or attainable) range of variation in composition, structure, and function for a particular conservation element (Leslie and others 1996). For many conservation elements, especially for those natural communities that have been largely altered since human settlement, defining a natural or historical range of ecological variation based on empirical data is not always feasible. An understanding of current ecological conditions and how they may have come about may provide at least a baseline of information for defining acceptable variation in altered natural communities. Additionally, no matter what the state of knowledge is about a particular conservation element, not all desired conditions will have easily measured attributes (Leslie and others 1996). As a result, many desired ecological conditions may need to be stated in non-quantitative terms.

A key challenge for the BMGR’s future ecosystem monitoring strategy is choosing a suite of measurable indicators of ecological condition for each conservation element, perhaps even in situations when condition itself can be described only qualitatively.

An understanding of the primary ecological processes that maintain the ecosystem function of natural communities within the Sonoran Desert can be an aid to the development of desired future ecological conditions for those communities. Additionally, such an understanding also may elucidate which stresses and sources of stress should be monitored that may alter these processes and adversely impact community composition, structure, and function. As a result, we begin our identification of desired future ecological conditions for the BMGR by providing an overview of those ecological processes that are considered to
be some of the most important ones for establishing and maintaining natural communities in the Sonoran Desert. The processes described do not represent an exhaustive list; surely other processes exist that are not identified here, but that also may be significant.

### 9.2 ECOLOGICAL PROCESSES THAT MAINTAIN ECOSYSTEM FUNCTION IN THE SONORAN DESERT

The natural range in variation of each of the processes described below may not be well understood at present. Additionally, the range in variation will be dependent on the particular natural community and on local conditions. A human-induced alteration in the natural ecological processes likely will have adverse consequences on the community under consideration, though the magnitude of the effect will be different for each community.

#### 9.2.1 Climate

Climate, especially as manifested by precipitation and temperature patterns, is the dominant ecological process in the Sonoran Desert Ecoregion that shapes its plant animal communities. Although its western extremities are characterized by scant winter-spring rainfall and its eastern extremities by summer convection storms (Brown 1994), much of the ecoregion has a bi-seasonal rainfall pattern (Phillips and Wentworth Comus 2000). Although the predominant weather patterns do result on average in a large annual variation in precipitation amounts east to west, the ecoregion’s unifying theme is that of an unreliable and uneven bi-seasonal rainfall pattern, characterized by periods of spring and fall drought (Brown 1994). The Sonoran Desert differs primarily from the other North American deserts in having mild winters in which freezing temperatures, if they occur at all, are of short duration (Brown 1994, Phillips and Wentworth Comus 2000). Freezing temperatures are more limiting to plant life than aridity and, as a result, the rarity of frost events in the Sonoran Desert accounts in part for the tropical affinity of much of the biota (Phillips and Wentworth Comus 2000).

As a result of the mostly east-west orientation of its boundaries, its extensive length along this orientation, and the amount and variety of its topographic relief, the BMGR’s landscape and associated biota experience a wide range of environmental variation in precipitation and temperature typical of the Sonoran Desert as a whole, but expressed at a smaller geographic scale. Because the BMGR captures a large range in the variation of a number of environmental variables, it potentially captures corresponding natural variation in composition, structure, and function of its plant and animal communities (Felger and others 1997). Average annual precipitation can range three to four-fold from about 50 millimeters of rain at the western end of the range to near 200 millimeters of rain in the Sand Tank Mountains (Brown 1994; Figure 113). The relatively cool, moist microsites afforded by the Sand Tank Mountains enables species more typical of northern climes, such as *Canotia holocantha* to persist, whereas the lack of freezing temperatures in the western portion of the range enables plant communities to establish whose composition includes species intolerant of freezing temperatures.

#### 9.2.2 Spatial Distribution of Water

The quantity of water and its temporal and spatial distribution are key factors that affect the characteristics of natural communities in the Sonoran Desert. Aside from rainfall, water distribution and abundance are affected by drainage system characteristics. When natural drainage systems are unregulated and lack impediments to flow and diversions, such as entrenched roads and washes, dams, and charcos, erosion rates are stable and water and nutrients are distributed from the upper to the lower watershed at rates to which community components are adapted.

The relationship, and perturbations thereof, between groundwater and surface water also can affect the spatial distribution of water that is available for use by natural communities. On the BMGR
aquatic/riparian communities that depend on perennial surface flow do not occur, so the role of groundwater in shaping natural communities is restricted to those portions of xeroriparian systems in which groundwater may be forced near the surface (such as may occur when washes travel within narrow gaps between mountain ranges).

9.2.3 Soil Health and Nutrient Distribution

Soils in the Sonoran Desert are nitrogen- and phosphorus-poor. The main source of phosphorous, as for many other mineral nutrients, is the chemical weathering of rocks (parent bedrock and soil), whereas atmospheric nitrogen and its subsequent fixing by nitrogen-fixing microbial organisms (free-living and those occurring in a symbiotic relationship with plants, such as legumes, in biological soil crusts), electrical discharges produced in thunderstorms, and decomposition are the main sources of nitrogen (Begon and others 1990).

Besides contributing to fixed nitrogen, an intact biological soil crust regulates the distribution of soil moisture (by reducing runoff) and nutrients in time and space, stabilizes soil erosion rates, enhances germination and seedling establishment of some vascular plants, and maintains natural levels of albedo (see Belnap [1994] and references therein for a discussion of these characteristics of biological soil crusts as determined primarily for cold desert-associated crusts). A significant decrease in the characteristic cover or abundance of biological soil crusts may result in an increase in albedo (which represents an increase in the amount of reflected light). Changes in albedo could lead to an increase in ground temperature variation. In the cold deserts of the Great Basin, the characteristic black crusts may stimulate vascular plant growth and nutrient uptake by producing warmer soil temperatures during cool seasons when free water is most likely to be available (Belnap 1994). A reduction in the ground cover contributed by an intact biological soil crust also may lead to accelerated rates of erosion.

9.2.4 Soil Stability

The natural range of soil stability in a system is maintained by the characteristic vegetation composition and structure for that community (including, but not limited to biological soil crusts). A change in the natural composition of vegetation in a system—such as may occur by the introduction of an invasive plant into a community—can result in an alteration of subsurface root biomass and structure that leads to soil destabilization.

9.2.5 Geomorphology, Soil Characteristics, and Landscape Complexity

Major floral compositional changes across the Sonoran Desert are due mostly to climatic and historical (for example, geographic isolation) factors; however, considerable local variation in composition can occur in response to changes in soil characteristics (McAuliffe 1999). Differences in soil characteristics that relate to differences in plant-available water have a profound effect on the type of vegetation that can occur in an area. Soil texture affects infiltration and moisture availability in desert soils. Differences in soil texture and variation in texture with depth because of soil horizonation leads to spatial and temporal complexity (that is, seasonal fluctuations in moisture availability) in the distribution of soil moisture (McAuliffe 1999). The distribution of soil coarseness along the elevational gradient of a bajada (gently sloping alluvial fan deposits that flank mountains in the desert Southwest) is not necessarily a simple relationship, but rather is a reflection of the landscape pattern of past, multiple alluvial deposition events, parent material of the alluvium, and the time since deposition for erosional and soil formation processes (which can include the formation of clay [agricillic] and caliche [cemented accumulation of calcium carbonate] soil horizons) to occur (McAuliffe 1999). As a result, bajada plant community composition may show complex patterns of distribution in response to alluvial surfaces of different ages—the more
complex the deposition pattern within a localized area, potentially the greater the changeover in plant community compositions within that area.

Additional phenomena associated with desert soils occur in areas generally receiving less than 200 millimeters of annual precipitation. Materials that contribute to soil horizon formation—clay minerals, calcium carbonate, and soluble salts—accumulate at shallower depths as less water is available to move them downward into the soil (McAuliffe 1999). Despite this, the clay horizons are more weakly developed than in areas of greater precipitation. The result seems to be a weaker manifestation of the soil-plant relationship under more arid conditions—species such as creosotebush (*Larrea tridentata*) that are inhibited from establishing in soils containing well-developed clay horizons in less arid areas near Tucson, can establish and grow in the more arid areas of the Lower Colorado River Valley subdivision (McAuliffe 1999).

Desert pavement also forms in areas generally receiving less than 200 millimeters of annual precipitation (McAuliffe 1999). It can gain prominence in the most arid areas. Desert pavement consists of a single layer of tightly packed pebbles and small stones whose upper, exposed surface usually is covered with a varnish that increases in thickness as the pavement ages (McAuliffe 1999). Desert pavements generally are devoid of perennial plants, instead supporting a sparse seasonal cover of ephemerals (Brown 1994). The pavement surface and the associated fine-grained soil horizons beneath inhibit water infiltration, reduce permeability, cause a shallow accumulation of soluble salts, and promote runoff (McAuliffe 1999). Vegetation on alluvial surfaces associated with strongly developed desert pavements is constrained mostly to the shallow runnels that receive the runoff (typically resulting in the accumulation of more water than falls directly) and in which harsh soil conditions (for example, salt accumulation) is ameliorated (Brown 1994, McAuliffe 1999).

**9.2.6 Organic Material**

Organic material is important as a source of nutrients for both plants and animals. Additionally, organic material in the form of litter may provide cover and nesting material resources for some animals. The amount and distribution of plant litter should be within the natural range of variation for a particular community. For example, creosotebush-bursage communities characteristically have little organic material, whereas quantities are relatively high within xeroriparian communities.

**9.2.7 Vegetation Composition and Structure**

Vegetation communities have a characteristic composition and structure under natural conditions. For example, Desert Playas and Creosotebush-Bursage Desert Scrub communities are characterized by a simple structure, whereas a more complex vertical structure is found in xeroriparian and Valley Bottom Floodplain Complex communities. Additionally, natural communities have levels of native species richness, as well as alpha (within-habitat species diversity) and beta diversity (degree of change in species diversity along a transect [for example, as taken along a xeroriparian community as one moves upslope] or between habitats; Magurran 1988), that are characteristic under natural conditions for each community.

McLaughlin and Bowers (1999) investigated correlation patterns between gamma diversity (landscape diversity; Magurran 1988) and several environmental variables in the Sonoran Floristic Province (includes the Mojave and Sonoran Deserts) using a sample of 25 local floras. They found that latitude and maximum elevation are the most important contributors to species diversity within the province. Maximum elevation (indicator of the potential for moist habitats) was itself highly correlated with relief (maximum to minimum elevation), which was used as a correlate of total habitat diversity.
About 50% of the species recorded in local Sonoran Desert floras are annuals and 60 to 80% of these are winter annuals (Venable and Pake 1999). Desert annuals must respond to extreme levels of environmental variation driven by rainfall; however, some of their adaptations to such variation—for example, spending much of their lives in the seed bank, may make them more susceptible to invasion and extirpation by non-native plants than perennials (see Venable and Pake [1999] for examples from local flora). Changes to a community’s composition and structure can alter a community’s response to disturbance regimes, natural or otherwise. Additionally, homogenization of a community’s composition and structure that occurs as the result of the introduction of invasive plants can create habitat conditions unfavorable to those species adapted to the natural composition and structure.

9.2.8 Natural Disturbance Regimes

Natural disturbance regimes affect communities within ranges of intensity and frequency that are characteristic of the community. Some of the natural disturbance regimes that are important in maintaining ecosystem processes in the Sonoran Desert are described below.

Burrowing rodents and ants.—Rodents and ants create localized soil disturbances and act as dispersal vectors for the progeny of other species. Both processes are crucial to the functioning of Sonoran Desert communities. Rodent and ant activities aerate soil, direct water into the subsurface, and serve to disperse the seeds of many species of plants.

Flood events.—Natural flooding events are highly variable in frequency and intensity and can have a strong effect on natural community composition, structure, and function. The natural periodicity and intensity of flood events may be strongly influenced by the condition of the watershed (that is, the amount of cover, the degree of anthropogenic alterations in drainage patterns, and so on).

Wet and dry cycles.—The periodicity of rain and drought is variable and results in a natural range in variation in plant cover and composition over space and time. Climate change potentially will affect the long-term pattern, and perhaps intensities, of wet and dry cycles. Changes in the cycles may be reflected in future changes in plant cover and composition that correspond to the individual responses of plant species to the new climate pattern.

Freezes.—The frequency and intensity of freezing temperatures affects the natural rate of die-offs of some plant species. Plants that use C4 and CAM (many succulents) metabolic pathways are particularly vulnerable to freezes. As a result, the relative proportion of C3, C4, and CAM plants will shift over time with climate change and periodic freezing events.

Fire.—Humphrey (1963) identified the generally limited role of fire in shaping the plant communities of the Sonoran Desert, limiting the occurrence of fire mostly to toboza (Hilaria mutica) swales. In the Sonoran Desert fires typically should be infrequent, weak in intensity, and small in the area that they affect. Schmid and Rogers (1988) calculated a fire recurrence interval of 294 years for the Sonoran Desert portion of the Tonto National Forest in Arizona during the 29-year period 1955 to 1983. Of note, however, they also reported an increase in fire occurrence when comparing the recurrence intervals from the second half of the study period (226 years) with the first half (340 years). They attributed the increase to wetter-than-normal winters toward the end of the study period, fuel provided by the presence of non-native annual plants, improved fire detection and reporting, and fire ignition by people.

Natural fire frequency and intensity within the Sonoran Desert also has been altered recently by the introduction of non-native, perennial grass species of African origin. These grasses, such as buffelgrass (Pennisetum ciliare), fountain grass (P. setaceum), Lehmann lovegrass (Eragrostis lehmanniana), and Johnson grass (Sorghum halepensis), have the potential to affect ecosystem function by: 1 increasing
the frequency and intensity of fire, (2) altering productivity or trophic structure, (3) altering microclimate and shifting the rates of consumption and supply of light, water, and mineral nutrients, (4) altering competitive interactions, and (5) compromising ecosystem stability (Williams and Baruch 2000). The above suite of processes affected make these grasses formidable threats to the viability of Sonoran Desert species and natural communities. They can each create conditions conducive to their own persistence and detrimental to the viability of native species and communities.

Of most concern is the positive feedback relationship of these grasses with fire that can lead to rapid conversion to African grass-dominated areas that are not a result of plantings. The preceding relationship results in an alteration of the natural fire regime that clearly represents an invasion-induced ecosystem-level change (D’Antonio and Vitousek 1992). As a result, these grasses do not simply compete with native species; “they change the rules of the game by altering environmental conditions or resource availability” (D’Antonio and Vitousek 1992). Fire under these circumstances potentially can be an extremely powerful and disruptive force that alters the natural composition, structure, and function of natural communities. Although some Sonoran Desert native plant species show adaptations to fire, either they are not strongly developed (Rogers and Steele 1980) or they are typically limited to species that are not restricted in their distribution to the Sonoran Desert (McAuliffe 1997). Many of the characteristic cacti, woody legumes, and shrubs of the Sonoran Desert are intolerant of fire (McAuliffe 1997, Nabhan and Holdsworth 1999).

9.3 Desired Future Ecological Conditions

Desired future ecological conditions are presented first for natural community conservation elements and then for species conservation elements. As discussed in the introductory section of this chapter, although it is desirable to be able to define desired future ecological conditions in quantitative terms, often our limited understanding of the natural (or attainable) range of variation of a natural community or species’s composition, structure, function, and landscape context initially restricts us to qualitative descriptions of desired conditions. As our understanding grows, these descriptions may take on a more quantitative nature. The desired future ecological conditions provided below represent hypotheses that should be refined over time as requisite ecological data on each of the conservation elements are collected.

9.3.1 Valley Bottom Floodplain Complex

Composition.—Vegetation occurs in patches of relatively high native species diversity and density, generally consisting of creosotebush (Larrea tridentata), bursage (Ambrosia spp.), mesquite (Prosopis spp.), paloverde (Cercidium spp.), perennial grasses, and winter and summer annuals, interspersed with sparsely vegetated areas of low diversity consisting of mainly creosotebush-bursage. Non-native species, such as Schismus barbatus (Mediterranean grass), are present but do not contribute appreciably to overall species diversity and abundance. Variation in the composition of high-density patches is in response to the effects of patch size and different edaphic conditions rather than anthropogenic disturbance.

Structure.—Mosaic of high-density vegetation patches in low areas (shallow depressions in which water accumulates), usually less than one acre in size, interspersed with low-density vegetation patches. Low areas are generally only a few centimeters less in height than areas of soil aggradation. Vegetation structure of high-density patches is complex, consisting of: substantial surface litter, a layer each of seasonal annuals, subshrubs, shrubs, and trees, and dead and downed woody debris. Structure is simpler in low-density patches, consisting of: a layer each of seasonal annuals, subshrubs, and shrubs. Low-density patches also contain standing dead trees (these trees occur as remants that reflect the shifts in location of high-density patches over time). Relative height of the vegetation in high-density patches is greater than in low-density patches. Ground cover in high-density patches exceeds 70%. Differences in relative cover between the patch types vary by location. Obvious incised channels are few or absent.
Soils within the boundaries of the complex are characteristically fine and mobile. Community structure is not altered appreciably by the presence of non-native plant species.

**Function.**—Size and location of vegetation patches shift in time and space concordant with the natural patch dynamics characteristic of the community. Sheet flow is the dominant hydrological regime and is unimpeded by roads or other anthropogenic ground disturbance. At the landscape scale, the community complex functions overall as a low gradient system. Resource productivity is higher in depressions (densely vegetated patches) than in the surrounding areas. Densely vegetated patches are used disproportionately by wildlife in comparison with other parts of this community complex, as well as in comparison with other surrounding community types. Fires do not occur within this community. Erosion rates are characteristic of natural variation and are not accelerated by anthropogenic influences. Community function is not altered appreciably by the presence of non-native plant species.

**Landscape context.**—Connectivity of the system is maintained across ownerships (Barry M. Goldwater Range [BMGR], Organ Pipe Cactus National Monument, and Cabeza Prieta National Wildlife Refuge). Activities that lead to downstream downcutting have minimal impact on upstream ecological processes. Watershed condition is such that the spatial and temporal distribution of water, soil, and nutrients to the Valley Bottom Floodplain Complex are within their natural ranges of variation.

**Justification for coordinated management across ownerships.**—Unfragmented examples of this community are rare in the Sonoran Desert and those that occur are vulnerable to disturbance because of their highly erodible soils. Changes in watershed condition at any particular location can have significant effects on downstream and/or upstream conditions, as disturbances downstream may influence upstream ecological processes. This community type is disproportionately important to wildlife, as it provides resources such as forage, nest sites, perches, and cover that are scarce in adjoining communities.

### 9.3.2 Valley Xeroriparian Scrub

**Composition.**—Vegetation is composed of mixed leguminous trees, whose relative density at any particular locale ranges from low to high in response to differences in available soil moisture (as related to differences in geomorphology, soil coarseness, and precipitation). Shrubs are abundant. Abundant herbaceous and woody perennial vines are a conspicuous component of this community. Well-developed biological soil crusts are present on banks outside the scour zone (distribution of such crusts is within the range of variability that is natural for the community and is not significantly reduced by anthropogenic activities). Organic material and dead and downed woody debris are common components of the community. Beta diversity responds to changes in watershed area and east-west precipitation regimes.

**Structure.**—Vegetative structure is complex, with multiple layers that are connected by vines. Vegetation is present in nearly continuous bands along both sides of the channels. Channels broaden as slope decreases and the valley bottom is approached.

**Function.**—Delivery of water, soil, and nutrients from upstream occurs at rates that are within the natural ranges of variability in regard to volume, periodicity, and content. Channel banks are stable and widespread or accelerated entrenchment in the valley bottoms is lacking; in general, aggradation equals degradation. Biomass, productivity, and vegetative cover, density, and complexity always exceed that of adjoining communities. Fires occur infrequently (as a result of lightning strikes or military activity), if at all, within this community. Wildlife, especially birds, large mammals, and invertebrates, make disproportionate use of the resources within this community compared with surrounding communities.

**Landscape context.**—Watershed condition is such that the functional attributes of the community are maintained across the landscape. The hydrological regime and drainage patterns are not significantly
altered by human land use, such as by a road that cuts across a wash. The connectivity of the community is maintained for those major lower bajada xeroriparian corridors that cross administrative boundaries.

**Justification for coordinated management across ownerships.** — Unfragmented examples of this community, in which the entire xeroriparian corridor, as well as the associated watershed, is not bisected by roads and/or development at any point, are rare in the Sonoran Desert. This community is disproportionately important to wildlife, including migratory birds, and provides resources that are scarce in adjoining communities. To maintain its natural function and to deliver water and nutrients within the ranges of natural variability, the community must be managed in a watershed context.

**9.3.3 Mountain Xeroriparian Scrub**

**Composition.** — Vegetation is composed of mixed leguminous trees, whose relative density at any particular locale ranges from low to high in response to differences in available soil moisture (as related to differences in geomorphology, soil coarseness, and precipitation), slope, and aspect. Shrubs are abundant. Herbaceous and woody perennial vines are present, but are a less conspicuous component of this community compared with the Valley Xeroriparian Scrub community. Well-developed biological soil crusts are present on banks outside the scour zone; however, because of the rockier substrate compared with the Valley Xeroriparian Scrub community the abundance and distribution of crusts is less (still, the distribution of such crusts is within the range of variability that is natural for the community and is not significantly reduced by anthropogenic activities). Organic material and dead and downed woody debris are common components of the community. Beta diversity responds to changes in east-west precipitation regimes, aspect, slope, geomorphology, and soil coarseness.

**Structure.** — Vegetative structure is complex, with multiple layers. Unlike Valley Xeroriparian Scrub; however, these layers are not connected by vines. Vegetation is present along both sides of the channels in linear strips that are less continuous when compared with Valley Xeroriparian Scrub. Gaps in the vegetation are natural and are associated with areas of bedrock outcrops that contain limited soil.

**Function.** — Delivery of water, soil, and nutrients from upstream occurs at rates that are within the natural ranges of variability in regard to volume, periodicity, and content. Biomass, productivity, and vegetative cover, density, and complexity always exceed that of adjoining communities; however, the magnitude of any differences is less than the differences between the Valley Xeroriparian Scrub community and its surrounding communities. Fires do not occur within this community. Wildlife, especially birds, large mammals, and invertebrates, make disproportionate use (perhaps less so than for the Valley Xeroriparian Scrub community) of the resources within this community compared with surrounding communities, particularly in major mountain canyons.

**Landscape context.** — Watershed condition is such that the functional attributes of the community are maintained across the landscape. The hydrological regime and drainage patterns are not significantly altered by human land use, such as by mining or water development/damming.

**9.3.4 Dune Complex and Dune Endemics**

**Composition.** — Dune endemics are present in appropriate abundance and distribution. Native species composition is stable, especially in regard to herbaceous perennials and annuals. No new non-native species are introduced, purposely or otherwise, from what occurs today. No major declines in native species abundance occurs.

**Structure.** — Densities of deeply rooted native species (such as big galleta [Pleuraphis rigida]), mesquite, and creosotebush) are stable. Both mobile and stable dunes are present within the natural range of
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variation for size, number, and distribution. Mammal burrow abundance and density is maintained within a natural range of variation typical for this community.

**Function.**—Fires do not occur. The natural pattern of shifting dune mobility and stability in space and time is maintained. Vehicle-caused soil disturbance does not occur, unless it is necessary to address an agency emergency situation when no other viable alternative exists.

**Landscape context.**—Connectivity is maintained between the San Cristobal and Mohawk dunes via the wash system that runs between the two dune systems and between the Yuma Dunes and Gran Desierto in Mexico.

### 9.3.5 Creosotebush-Bursage Desert Scrub

**Composition.**—Species composition differs with soil type and slope, as well as along a climate/precipitation gradient. Shrubs are abundant, but they relatively low in diversity and dominated by creosotebush and bursage (*Ambrosia deltoidea* and/or *A. dumosa*). Subshrubs, cacti, grasses, and forbs are present, but their abundance is variable in response to local soil, climate, and topographic conditions. Annual grasses and forbs (ephemerals) are present and seasonally abundant. Biological soil crusts are present and well developed. Non-native plant populations are declining or at least are not increasing.

**Structure.**—Three vertical layers are typically present: ephemerals, subshrubs, and shrubs. Cover ranges from sparse to moderately dense in response to precipitation gradients and local edaphic conditions. Community structure is not altered appreciably by non-native plant species. Rodent borrows are present at abundance levels that correspond to soil texture differences and the natural fluctuations in rodent populations. Human activities that result in soil compaction have minimal impact on the structure of this system.

**Function.**—Hydrological regimes within this matrix community are maintained such that water and nutrients are distributed in space and time within the natural range of variability for this community. Vegetation patches shift in response to climate extremes. Community function is not altered appreciably by non-native plant species. Erosion rates are characteristic of natural variation and are not accelerated by anthropogenic influences. Human activities that result in soil compaction have minimal impact on the function of this community. Fires do not occur in this community.

**Landscape context.**—Nitrogen is accumulated in this community as a result of sheet flow across the biological soil crusts and is deposited in xeroriparian scrub communities at rates that are within the range of natural variability for this complex of communities. The expression of community composition and structure is highly variable throughout the BMGR in response to a variety of soil types, landforms, and climates and is represented by extensive unfragmented areas. These unfragmented areas are juxtaposed with other natural communities to form functional complexes that can support area-dependent species and the full expression of ecological processes.

**Justification for coordinated management across ownerships.**—This community is extremely vulnerable to development and disturbance because it occurs on valley bottoms. Where it has not already been lost, it is threatened by invasive plant species, erosion, and soil compaction, which in combination significantly alter the natural composition, structure, and function of this community. The BMGR and surrounding areas contain some of the few remaining, large unfragmented areas of this community, where it is expressed under the full variety of environmental conditions in which it occurs.
9.3.6 Creosotebush-Big Galleta Scrub

Composition.—Big galleta grass and creosotebush are abundant and dominate this community. The composition of subdominant species corresponds with soil type and landform and may include white bursage and/or mesquite. Non-native plants are rarely present, but where they are, their populations are declining or at least are not increasing. Big galleta abundance and density is stable (not decreasing). Dipodomys is a conspicuous component of this community.

Structure.—Two to three vertical layers are present: grass, shrub, and tree (where mesquite occurs). Ground cover is high. Subsurface root structure is maintained within the natural range of variation for this community. Soil movement is minimal and occurs within its natural range of variability. Rodent burrows are present at abundance levels that correspond to soil texture differences and the natural fluctuations in rodent populations. Community structure is not altered appreciably by non-native plant species. The structure of this community is minimally altered by human-activities that lead to soil erosion and entrenchment.

Function.—The natural drainage pattern and soil movement within this community are not significantly altered by human activities, such as roads or grazing. Fires are infrequent to nonexistent and when they occur, they burn small areas at low intensities (less than one acre). Erosion rates are characteristic of natural variation and are not accelerated by anthropogenic influences. Community function is not altered appreciably by non-native plant species.

Landscape context.—Connectivity is maintained within this community in all locations where it extends across ownership boundaries.

9.3.7 Paloverde-Mixed Cacti-Mixed Scrub on Bajadas

Composition.—Species composition, abundance, and diversity differs with soil type and slope, as well as along a temperature/precipitation gradient. Saguaros (Carnegiea gigantea) are present at levels of abundance and in age cohorts that fall within a range of natural variation. Trees include foothill paloverde (Cercidium microphyllum) and ironwood. Cacti and shrubs, such as Ambrosia spp. and ocotillo (Fouquieria splendens), are common. Native grasses are present and herbaceous annuals are seasonally abundant. Non-native plant populations are declining, or at least are not increasing, and do not alter appreciably community composition.

Structure.—Vertical structure is complex, with layers of seasonally abundant annuals, perennial grasses and forbs, subshrubs, shrubs, trees, and large columnar saguaro cacti. Ground cover is naturally variable along both soil and climate gradients. Trees and shrubs are sparse to moderately dense, and grasses and forbs are sparse. Community structure is not altered appreciably by non-native plant species.

Function.—Hydrological regimes within this matrix community are maintained such that water and nutrients are distributed in space and time within the natural range of variability for this community. Vegetation composition and structure shift in response to natural, long-term patterns in the occurrence of freezing temperatures and variation in precipitation. Fires do not occur within this community. Erosion rates are characteristic of natural variation and are not accelerated by anthropogenic influences. Human activities that result in soil compaction and entrenchment have minimal impact on the function of this community. Community function is not altered appreciably by non-native plant species.

Landscape context.—The expression of the composition and structure of this community is highly variable throughout the BMGR in response to different soil types, landforms, slope angles, aspects, and microclimates and is represented in extensive unfragmented areas. These unfragmented areas are
juxtaposed with other natural communities to form functional complexes that can support area-dependent species and the full expression of ecological processes.

9.3.8 Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes

**Composition.**—Species composition is variable and changes in accordance with aspect, as well as soil type, slope, and climate. Saguaro are present at levels of abundance and in age cohorts that fall within a range of natural variation. Trees include foothill paloverde and ironwood. Cacti and shrubs, such as ocotillo, are common. Native grasses are present and herbaceous annuals are seasonally abundant. Non-native plant populations are declining, or at least are not increasing, and do not alter appreciably community composition. Human activities, such as cactus collection, do not alter appreciably community composition.

**Structure.**—Vertical structure is complex and clumped on rocky outcrops, with layers of seasonally present annuals, perennial grasses and forbs, subshrubs, shrubs, trees, and large columnar saguaro cacti. Ground cover is naturally variable along a soil and climate gradient. Trees and shrubs are sparse to moderately dense, and grasses and forbs are sparse. Community structure is not altered appreciably by non-native plant species.

**Function.**—Hydrological regimes within this community are maintained such that water and nutrients are distributed from the upper to the lower watershed in space and time within the natural range of variability for this community. Vegetation composition and structure shift in response to natural, long-term patterns in the occurrence of freezing temperatures and variation in precipitation. Fires do not occur within this community. Community function is not altered appreciably by non-native plant species.

**Landscape context.**—The expression of the composition and structure of this community is highly variable throughout the BMGR in response to a variety of soil types, landforms, and climates and is represented on all rocky mountain slopes on the BMGR and surrounding areas.

9.3.9 Sand Tank Mountains Uplands

**Composition.**—This community contains components of the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes community at its lower elevations and south-facing slopes, but in comparison, this community has greater overall species richness, as well as alpha and beta diversity, when its full elevation range is considered. Composition is naturally variable and corresponds to changes in aspect and landform, as well as in elevation. *Vaquelinia californica, Berberis harrisoniana, Canotia holocantha* and *Juniperus coahuilensis* are present. Non-native plant populations, including red brome (*Bromus rubens*) and Lehmann lovegrass, are declining or at least are not increasing in abundance. Human activities, such as plant collection and recreation, do not alter appreciably community composition.

**Structure.**—Characteristic structure is variable and changes in accordance with changes in aspect, edaphic traits, and landform. Vertical structure is complex and clumped on rocky outcrops, with layers of seasonally present annuals, perennial grasses and forbs, subshrubs, shrubs, trees, and large columnar saguaro cacti. Ground cover is naturally variable along a soil and climate gradient. Trees and shrubs are sparse to moderately dense, and grasses and forbs are sparse. Community structure is not altered appreciably by non-native plant species.

**Function.**—Optimal site productivity exists when plant community composition and structure is maintained within its natural range of variability. Hydrological regimes within this community are maintained such that water and nutrients are distributed from the upper to the lower watershed in space and time within the natural range of variability for this community. Vegetation composition and structure
shift in response to natural, long-term patterns in the occurrence of freezing temperatures and variation in precipitation. Fires do not occur within this community. Community function is not altered appreciably by non-native plant species.

Landscape context.—This community is rare within the Sonoran Desert. The adjoining Paloverde-Mixed Cacti-Mixed Scrub on Bajada/Rocky Slope communities are intact and viable.

**9.3.10 Elephant Tree-Limberbush on Xeric Rocky Slopes**

**Composition.**—Species composition is variable and changes in accordance with aspect, as well as soil type, slope, and climate. *Bursera microphylla*, *Jatropha cuneata*, *Nolina bigelovii* and *Rhus kearnyi* are dominant. This community also contains components of the Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes community. Non-native plant populations are declining, or at least are not increasing, and do not alter community composition. Human activities, such as plant collection and recreation, do not alter appreciably community composition.

**Structure.**—Vertical structure is complex and clumped on rocky outcrops, with layers of seasonally present annuals, perennial grasses and forbs, subshrubs, shrubs, trees, and emergent saguaro. Ground cover is naturally variable along a soil and climate gradient. Trees and shrubs are sparse to moderately dense, and grasses and forbs are sparse. Community structure is not altered appreciably by non-native plant species.

**Function.**—Hydrological regimes within this community are maintained such that water and nutrients are distributed from the upper to the lower watershed in space and time within the natural range of variability for this community. Vegetation composition and structure shift in response to extreme variation in temperature and precipitation. Fires do not occur within this community. Community function is not altered appreciably by non-native plant species. Soils are stable. Erosion rates are characteristic of natural variation and are not accelerated by anthropogenic influences.

Landscape context.—The expression of the composition and structure of this community is best seen on granitic soils in the low mountains in the western portion of the BMGR where temperatures seldom drop below freezing. Occurrences of this community are juxtaposed with other natural communities to form functional complexes that can support area-dependent species and the full expression of ecological processes.

**9.3.11 Desert Playa**

**Composition.**—Species composition differs between playas and temporally with precipitation patterns. Creosotebush and white bursage are present as dominants within the adjacent plant community. Non-native plant populations are declining, or at least are not increasing, and do not alter appreciably community composition. Human activities, such as plant collection and recreation, do not alter appreciably community composition.

**Structure.**—The vertical and horizontal structure of this community is simple, but shows some natural variation associated with precipitation patterns. Community structure is not altered appreciably by non-native plant species nor human activities. Soil stability is within the natural range of variation for this community.

**Function.**—Human activities do not alter the dominant hydrological regime of periodic flooding and evaporation. A disproportionate use of playas (seasonally/unpredictably when water is present) by native
amphibians and invertebrates occurs in relation to adjoining communities. Community function is not altered by non-native plant species.

**Landscape context.**—Connectivity between playas and nearby associated dune complexes are maintained.

### 9.3.12 Desert Tinaja/Spring

**Composition.**—Non-native flora and fauna are absent or rare in tinajas. Aquatic invertebrates are common and amphibians are seasonally present.

**Structure.**—The bedrock depressions that seasonally fill to form the tinajas are free from anthropogenic modification. Springs are free from anthropogenic modification.

**Function.**—Natural hydrological regime that supports tinajas is maintained. Tinajas continue to provide seasonally important water resources to wildlife and aquatic organisms. Springs have natural flow characteristics.

**Landscape context.**—Springs and tinajas are embedded within large-patch and matrix communities that are intact and viable.

### 9.3.13 Salt Desert Scrub

**Composition.**—Saltbush (*Atriplex* spp.) is common and creosotebush, cacti, and grasses are present.

**Structure.**—Cover varies with seasonality and precipitation. A sparse, seasonally present understory and a sparse to moderately dense shrub layer are typical. Community structure is not altered appreciably by non-native plant species nor human activities. Soil stability is within the natural range of variation for this community.

**Function.**—Soil properties, such as the degree of salinity and/or alkalinity, are maintained within the natural range of variation for this community.

**Landscape context.**—All intact and viable Salt Desert Scrub communities on the BMGR and in the surrounding areas are protected from any activity that could alter system composition, structure, and/or function.

### 9.3.14 Crucifixion thorn (*Castela emoryi*)

**Composition.**—This species is rare, but at times common in some locales. The BMGR-wide population is stable.

**Structure.**—Unknown at present.

**Function.**—Recruitment rates exceed rates of mortality.

**Landscape context.**—Unknown at present.
9.3.15 Ephemeral Water-breeding Amphibian Guild

This guild is composed of the Sonoran Desert toad (*Bufo alvarius*), red-spotted toad (*B. punctatus*), and Couch’s spadefoot (*Scaphiopus couchii*).

**Composition.**—Viable populations of all three species are present on the BMGR. Sonoran Desert toads are present in and near semi-permanent to permanent water sources, Couch’s spadefoot is moderately abundant in and near playas, as well as in and near other water sources, and red-spotted toads are present in the rocky areas around tinajas and in tinajas. Couch’s spadefoot and red-spotted toad abundance and distribution are not significantly decreasing. Sonoran Desert toad abundance and distribution is stable.

**Structure.**—Each species is distributed across the BMGR in appropriate habitat.

**Function.**—Recruitment rates equal rates of mortality over time periods that account for natural population fluctuations.

**Landscape context.**—Connectivity between seasonally used water sources and adjacent habitat and hibernacula is maintained. Water developments do not result in an increase in Sonoran Desert toad populations throughout the BMGR and adjoining areas that result in an associated substantial decline in abundance and distribution of red-spotted toad and Couch’s spadefoot populations.

9.3.16 Desert Tortoise (*Gopherus agassizii*)

**Composition.**—Desert tortoise group size tracks habitat quality. Population density is about 30 individuals per square kilometer in good quality habitat and about 15 individuals per square kilometer in fair habitat.

**Structure.**—Tortoise populations are genetically diverse. Populations are clustered spatially (that is, not homogeneously distributed) in appropriate habitat. Sex ratios are 50:50, and adults constitute 75% of the population. Sink populations occur in marginal habitat close to source populations in years with high rainfall.

**Function.**—Recruitment rates exceed mortality rates within a deme and average 2 to 20% over a five-year period. Adult mortality is less than 5% on average; however, natural periodic population die-offs occur occasionally due to climate extremes. Tortoise population structure functions as a metapopulation (dispersal distances can be up to five miles in the valleys and longer along wash corridors during periodic flooding events).

**Landscape context.**—Desert tortoises are locally common in all mountain ranges in the BMGR and adjoining areas.

**Justification for coordinated management across ownerships.**—Desert tortoise is a regionally vulnerable species found throughout the Sonoran Desert in appropriate habitat.

9.3.17 Flat-tailed Horned Lizard (*Phrynosoma mcallii*)

Desired future ecological conditions identified below for the flat-tailed horned lizard are consistent with and complementary to the management objectives for this species contained in Foreman (1997).

**Composition.**—Viable population levels of flat-tailed horned lizards are maintained on the BMGR and elsewhere.
**Desired Conditions**

**Structure.**—Stable or increasing population densities occur throughout the identified range of the species, including on the BMGR.

**Function.**—No degradation or net loss of habitat occurs. A stable or reduced level of mortality among reproductive adults is maintained.

**Landscape context.**—Connectivity is maintained between the population segments on the BMGR and adjoining lands. Sand sheet habitat maintains its connectivity and ecological relationship with the Dune Complex and Dune Endemics natural community.

**Justification for coordinated management across ownerships.**—This species is extremely vulnerable to continued reductions in viability because of its restricted distribution and because it already has lost substantial portions of its habitat. The center of the species’s range lies in the Gran Desierto of Sonora, which is separated from the BMGR population by Mexico Highway 2 and urban/industrial development around San Luis Rio Colorado, Sonora. The majority of the species’s entire distribution in Arizona is found on the BMGR, though the BMGR habitat represents only about 12.5% of the suitable habitat remaining in the United States. Flat-tailed horned lizards found in the Gran Desierto in Mexico are part of this interbreeding population.

9.3.18 Cowles Fringe-toed Lizard (*Uma notata rufopunctata*)

**Composition.**—Maintain population densities within or above historic ranges (estimated for Mohawk Dunes at 14 to 21 lizards/hectare and at higher than 20 lizards/hectare for Yuma Dunes).

**Structure.**—Maintain an adult sex ratio of approximately 1:1. Maintain species presence throughout suitable habitat.

**Function.**—Maintain recruitment at or above replacement levels.

**Landscape context.**—Connectivity is maintained between the Yuma Dunes population and the center of the species’s range in the Gran Desierto of Sonora (Mexico Highway 2 does not form a barrier to genetic exchange). The Mohawk Dunes population probably will remain completely isolated from the Yuma Dunes population; however, connectivity is retained with the San Cristobal Dunes subpopulation.

**Justification for coordinated management across ownerships.**—This is the only described subspecies of *Uma notata* present in Arizona. It occurs only in the Pinta Sands and Yuma and Mohawk Dunes. Current research is underway on the potential genetic and morphological distinctiveness of the Mohawk Dunes population. The fringe-toed lizards that are distributed in the Pinta Sands and Yuma Dunes are small portions of the larger population that occurs within Mexico’s Gran Desierto.

9.3.19 Valley Bottom Reptile Guild

This guild is composed of the western leaf-nosed snake (*Phyllorhynchus decurtatus perkinsi*), Colorado Desert shovel-nosed snake (*Chionactis occipitalis annulata*), sidewinder (*Crotalus cerastes*) (two subspecies), desert iguana (*Dipsosaurus dorsalis*), southern desert horned lizard (*Phrynosoma platyrhinos calidiarum*), and long-tailed brush lizard (*Urosaurus graciosus*) (two subspecies).

**Composition.**—Western leaf-nosed snake, Colorado Desert shovel-nosed snake, sidewinder, desert iguana, and southern desert horned lizard are abundant within the valley floor. Long-tailed brush lizards are common to uncommon but are regularly seen.
Structure.—Abundance changes across natural community types are typical of individual species habitat associations. The distribution of the long-tailed brush lizard in comparison with its cogenitor, the tree lizard (*Urosaurus ornatus*), is fixed.

Function.—Recruitment rates equal rates of mortality over time periods that account for natural population fluctuations.

Landscape context.—Unfragmented expanses of low desert natural communities (that is, Creosotebush-Bursage Desert Scrub, Creosotebush-Big Galleta Scrub, Valley Bottom Floodplain Complex, and Valley Xeroriparian Scrub) are maintained to support population viability.

9.3.20 Le Conte’s thrasher (*Toxostoma lecontei*)

Composition.—Uncommon to rare in valley bottom Creosotebush-Bursage Desert Scrub and Salt Desert Scrub communities. Breeding pair density approaches 4 to 5 pairs/km$^2$ in multiple valley bottoms on the BMGR.

Structure.—Patchily distributed throughout its habitat (though the relationship of this distribution pattern to changes in the species’s habitat is poorly understood).

Function.—Recruitment rates exceed or at least equal rates of mortality over time periods that account for natural population fluctuations.

Landscape context.—Unknown at present, though the demise of Salt Desert Scrub communities across the Sonoran Desert is of concern. The presence of sufficient shrubby trees, in regard to providing a suitable nesting substrate, seems to be a prerequisite habitat component and should be present in all areas managed for Le Conte’s thrasher.

Justification for coordinated management across ownerships.—Le Conte’s thrasher is a regionally vulnerable species that may have been pushed into marginal habitat because of the wholesale conversion of Salt Desert Scrub to agriculture and urban development throughout the Sonoran Desert.

9.3.21 Primary Excavator (Cavity) Guild

This guild is composed of the Gila woodpecker (*Melanerpes uropygialis*), gilded flicker (*Colaptes chrysoides*), and ladder-backed woodpecker (*Picoides scalaris*).

Composition.—Viable population levels of all three species are present on the BMGR. Relative abundance of each species reflects natural responses to differences in density of saguaros (for Gila woodpeckers and gilded flickers) in particular (and to the occurrence of composition variations in Paloverde-Mixed Cacti-Mixed Scrub communities in general) that are a result of differences in topography and precipitation. Ladder-backed woodpeckers are less numerous than the other woodpeckers, but are present in areas of mesquites and dense paloverde-mixed cacti.

Structure.—Population densities of the three species attenuate naturally going from east to west across the BMGR. Distribution of each species reflects natural responses to differences in density of saguaros and leguminous trees in particular and foraging sites.
**Function.**—No degradation or net loss of habitat occurs. Recruitment rates equal rates of mortality over time periods that account for natural population fluctuations. European starlings (*Sturnus vulgaris*) are not present to compete for nest sites.

**Landscape context.**—Natural community diversity is maintained, especially in the eastern BMGR.

### 9.3.22 Sonoran Pronghorn (*Antilocapra americana sonoriensis*)

Desired future ecological conditions identified below for the Sonoran pronghorn are consistent with and complementary to the recovery objectives and criteria for this species contained in U.S. Fish and Wildlife Service (1998).

**Composition.**—A viable, self-sustaining U.S. population (BMGR/Cabeza Prieta National Wildlife Refuge/Organ Pipe Cactus National Monument) of at least 300 adults (averaged over a five-year period).

**Structure.**—At least three self-sustaining populations: two in the U.S and one in Mexico.

**Function.**—Pronghorn population ranges freely across Highway 85 within appropriate habitat. Recruitment exceeds mortality over time or is equal when population is at carrying capacity. Occasional gene flow occurs naturally or artificially between the Mexico and U.S. populations.

**Landscape context.**—Connectivity is maintained and there are no barriers (fences, roads, railroads, and canals) that limit pronghorn movement within the entire BMGR, Cabeza Prieta National Wildlife Refuge, Organ Pipe Cactus National Monument, and Bureau of Land Management lands (including either side of Highway 85) south of Interstate 8 (Southern Pacific railroad line and/or Wellton-Mohawk Canal, rather than strictly Interstate 8, may function as a northern barrier to pronghorn movement).

**Justification for coordinated management across ownerships.**—Sonoran pronghorn is a federally endangered species. The species is sensitive to human encroachment and is dependent on large, unfragmented landscapes to be able to roam widely in search of forage and water that are seasonally available and geographically variable in quality and quantity.

### 9.3.23 Desert Bighorn Sheep (*Ovis canadensis mexicana*)

**Composition.**—Viable, self-sustaining populations occur within each suitable mountain range.

**Structure.**—Bighorn populations function as a metapopulation, with populations of sheep existing within each suitable range.

**Function.**—Recruitment exceeds mortality or, when a population has reached the carrying capacity of the habitat, is at least equal over time.

**Landscape context.**—The metapopulation is maintained by connectivity among self-sustaining populations. Connectivity is achieved by having intact bajada and valley bottom habitat that can serve as a movement corridor for sheep, viable populations within each major range, and smaller ranges available as “stepping stones” between the major ranges. Connectivity includes maintaining north-south corridors along mountain ranges and passes that cross between the BMGR and Cabeza Prieta National Wildlife Refuge, Tohono O’Odham Nation, and Bureau of Land Management lands, as well as east-west corridors between mountain ranges.
Justification for coordinated management across ownerships.—Bighorn sheep are dependent on large, unfragmented landscapes (that is mountain-valley-mountain complexes) to maintain dispersal corridors and the ultimate viability of the metapopulation.

9.3.24 Kit fox (*Vulpes macrotis*)

**Composition.**—Abundant in valley bottoms on habitats with friable soil (Creosotebush-Bursage Desert Scrub and Salt Desert Scrub communities).

**Structure.**—Kit fox are patchily distributed but widespread in valley bottom habitats. Kit fox range freely throughout all inter-montane valleys on the BMGR.

**Function.**—Recruitment rates equal rates of mortality over time periods that account for natural population fluctuations. Unknown at present.

**Landscape context.**—Extensive areas of connected valley bottoms are maintained to ensure connectivity between subpopulations.

9.3.25 Bat Guild

This guild is composed of the California leaf nosed bat (*Macrotus californicus*), cave myotis (*Myotis velifer*), and lesser long-nosed bat (*Leptonycteris curasoae yerbahuenae*).

**Composition.**—California leaf nosed bat and cave myotis colony populations are stable on the BMGR. California leaf nosed bats are common and cave myotis are uncommon. The lesser long-nosed bat is a possible rare forager on the BMGR; however, habitat is maintained such that a roosting colony could potentially be established. The relative abundance of each species reflects a natural response to gradients in temperature and water availability near roost sites throughout the BMGR.

**Structure.**—The distribution of each species reflects a natural response to gradients in temperature and water availability near roost sites throughout the BMGR.

**Function.**—Mortality rates do not exceed recruitment rates for these species.

**Landscape context.**—Unknown at present.
CHAPTER 10 MONITORING OBJECTIVES AND INFORMATION NEEDS

The first part of this chapter provides baseline information that can be used in the development of a comprehensive monitoring strategy for the Barry M. Goldwater Range (BMGR) to support biodiversity conservation and protection. This chapter will not provide, however, an exhaustive description and analysis of a monitoring strategy that can be incorporated directly into the BMGR’s Integrated Natural Resources Management Plan (INRMP). Such a strategy will require an extensive effort that should be accomplished as part of the INRMP’s implementation requirements.

After a brief introductory section on the development of monitoring objectives, the next section identifies the specific monitoring objectives (in the form of management questions that need to be addressed) that are applicable to each of the 25 conservation elements. This is followed by a section that highlights information needs associated with each conservation. Many of these information needs represent baseline inventory information. The chapter concludes with two sections that attempt to provide some synthesis. The second to last section consolidates the element-specific monitoring objectives and information needs with an emphasis on a threat-based approach to monitoring. The last section briefly outlines some considerations in regard to designing a biodiversity monitoring strategy for the BMGR.

10.1 DEVELOPMENT OF MONITORING OBJECTIVES FOR THE BARRY M. GOLDWATER RANGE

Even [in situations in which] it is not legally required, monitoring is an important component of good environmental management. Monitoring provides the singular mechanism for evaluating whether conservation objectives are being met and for determining the effectiveness of management strategies (Leslie and others 1996).

Monitoring can be resource intensive (that is, funding- and staff-wise), unfocused, and inefficient unless it focuses on clear management questions, the answers to which are needed to meet management goals and objectives. Not everything can be, nor should be, monitored. The conservation elements developed for the BMGR provide a focus for monitoring in which the primary overarching management goal is the conservation and protection of biodiversity. The desired future ecological conditions that are identified for each conservation element in Chapter 9 specify the long-term management goal for each element. Monitoring objectives that are developed to address these goals should enable the assessment of success or failure in restoring and/or maintaining desired future ecological conditions.

We provide here the first step towards developing a comprehensive monitoring strategy for the BMGR. For each conservation element, and based on the desired future ecological conditions for the element, we identify the relevant management questions monitoring needs to provide answers for to assess whether desired conditions are achieved (or maintained) and, when necessary, whether those threats that could prevent achievement of a desired condition are abated. The management questions are meant to address the key factors that will determine management success for each element. To the extent that the conservation elements either include directly, or indirectly through a natural community conservation element, those special status species currently known to occur on the BMGR, a monitoring strategy based on conservation elements can meet all compliance requirements. For species not presently documented on the BMGR, such as the cactus ferruginous pygmy-owl (Glaucidium brassilianum cactorum), military natural resource managers may feel compelled to continue monitoring efforts associated with these species.
Managers will need to consider monitoring techniques that are efficient and standardized. This increases the opportunities for data sharing and cross-boundary analysis of similar data. An ecosystem based approach to monitoring, in which those ecological boundaries that are necessary for maintaining conservation element persistence are considered rather than administrative boundaries, provides the appropriate conceptual context and also necessitates the need for cross-boundary/cross-agency coordination of monitoring activities. As noted by Cornelius and others (2000), the time is right, for at least a portion of the Sonoran Desert, for a comprehensive monitoring program that crosses agency boundaries. As a result, some of the management questions are best viewed in a broader regional context and will require answers at that scale. It would be in the BMGR’s best interest, as well as in the interest of the surrounding landowners and natural resource agencies, to forge a monitoring strategy that whenever possible can be applied seamlessly. The conservation elements proposed for the BMGR, and the accompanying desired future ecological conditions and monitoring objectives for each element, provide a starting point for determining what shared monitoring strategies can be pursued.

10.2 Monitoring Objectives

Monitoring objectives are presented first for natural community conservation elements and then for species conservation elements.

10.2.1 Valley Bottom Floodplain Complex

- What are the characteristic patch dynamics of this community, and how do human-induced alterations in the hydrological regime (for example, roads) affect patch creation and extinction dynamics, as well as the distribution, relative sizes, and ratio of relatively dense vegetated patches (occurring within shallow depressions in which water accumulates) to sparsely vegetated patches (surrounding relatively dry areas)?

- What are the natural ranges in variability of soil movement amounts and patterns, and what types of human activities within the community or the surrounding watershed can cause increased soil mobility and erosion in this community beyond natural rates?

- What are the characteristics of the natural hydrological regime that maintain this community?

- What is the effect of downstream downcutting on upstream hydrology?

- What are the natural disturbance regimes associated with this community, at what different scales and intensities do they operate, and how do they affect community composition, structure, and function?

- What is the natural range of variation in composition, structure, and function of the sparsely and relatively dense vegetated patches?

- Under what conditions is this community vulnerable to invasion by non-native plant species such as Sahara mustard (Brassica tournefortii) and buffelgrass (Pennisetum ciliare)?

10.2.2 Valley Xeroriparian Scrub

- What are the natural patterns of entrenchment within this community and how do anthropogenic activities adversely alter such patterns?

- Is human use of this community excessively depleting resources or adversely impacting resource availability to the degree that community composition, structure, and/or function (including usage by
wildlife) are measurably degraded? Human uses may include fuel wood collection, road and vehicle usage, undocumented alien traffic, and hunting.

- What are the seasonal usage patterns of this community by both humans and wildlife and when is human use potentially detrimental to wildlife (for example, are human use impacts potentially greater from June to September when wildlife may use this community for thermal cover)?

- Have invasive plant species significantly altered the composition, structure, and/or function of this community?

**10.2.3 Mountain Xeroriparian Scrub**

- What is the effect of artificial water development projects, such as putting in dams to create catchments, on community function and the hydrological regime?

- Are human uses of this community excessively depleting resources or adversely impacting resource availability to the degree that community composition, structure, and/or function (including usage by wildlife) are degraded? Human uses may include existing mines, water development, fuel wood collection, road and vehicle usage, undocumented alien traffic, and hunting.

- What are the seasonal usage patterns of this community by both humans and wildlife and when is human use potentially detrimental to wildlife (for example, are human use impacts potentially greater from June to September when wildlife may use this community for thermal cover)?

- Have invasive plant species significantly altered the composition, structure, and/or function of this community?

- Are mountain passes of disproportionate significance in regard to the amount of native diversity that may be present over a short distance (perhaps in part due to aspect changes) and in their role as dispersal corridors for wildlife? What implications for management does this significance have, especially if human activities tend to concentrate on passes?

**10.2.4 Dune Complex and Dune Endemics**

- What is the effect of *Brassica tournefortii* on floral and faunal composition, structure, and/or function?

- What types of human uses of the dunes adversely impact dune composition, structure, and/or function?

**10.2.5 Creosotebush-Bursage Desert Scrub**

- What human land uses, including military ground activities, result in soil compaction, erosion, and the spread of non-native plant species?

- To what degree can this community sustain human-caused disturbance (soil compaction, erosion, spread of invasive species) without significant adverse effects to community composition, structure, and/or function?

- What is the natural range in variability in species composition across this community on the BMGR?
10.2.6 Creosotebush-Big Galleta Scrub

- What is the distribution and abundance of this community on the BMGR?
- What human land uses, including military ground activities, result in soil compaction, erosion, and the spread of non-native plant species?
- To what degree can this community sustain human-caused disturbance (soil compaction, erosion, spread of non-native species) without significant adverse effects to community composition, structure, and/or function?
- Can big galleta be used to stabilize soils in disturbed sites?

10.2.7 Paloverde-Mixed Cacti-Mixed Scrub on Bajadas

- What human land uses, including military ground activities, result in soil compaction, erosion, and the spread of non-native plant species?
- To what degree can this community sustain human-caused disturbance (soil compaction, erosion, spread of non-native species) without significant adverse effects to community composition, structure, and/or function?
- What is the natural range in variability in species composition across this community on the BMGR?

10.2.8 Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes

- What are the effects of human activities, including recreation, on community composition, structure, and/or function?

10.2.9 Sand Tank Mountains Uplands

- What are the effects of human activities, including recreation, on community composition, structure, and/or function?
- What is the natural range in variation in species composition in this community?
- What is the difference in community composition, structure, and function between this community and adjoining Paloverde-Mixed Cacti-Mixed Scrub on Bajada/Rocky Slope communities that have not been grazed for over 60 years and other Paloverde-Mixed Cacti-Mixed Scrub on Bajada/Rocky Slope communities that are currently or have been historically affected by grazing?

10.2.10 Elephant Tree-Limberbush on Xeric Rocky Slopes

- What are the effects of human activities, including recreation, on community composition, structure, and/or function?
10.2.11 Desert Playa

- What is the natural range in variation of playa composition, structure, and function on the BMGR and Cabeza Prieta?
- What species (flora and fauna) use playas during flooding events?
- What is the natural hydrological regime of playas and how do changes in watershed condition affect this regime?
- What is the effect of non-native species on playa composition, structure, and/or function?

10.2.12 Desert Tinaja/Spring

- What is the effect of tinaja modification for water development purposes on the natural composition, structure, and function of tinajas?
- What is the ecological importance of tinajas to invertebrate taxa?

10.2.13 Salt Desert Scrub

- What is the distribution and abundance of this community on the BMGR and throughout the Sonoran Desert Ecoregion?
- What is the natural range in variation in composition, structure, and function of this community on the BMGR?
- What is the relative importance of Salt Desert Scrub to native wildlife (for example, Le Conte’s thrasher \(\text{Toxostoma lecontei}\) and kit fox \(\text{Vulpes macrotis}\))?
- What can an understanding of the existing Salt Desert Scrub communities on the BMGR teach us about saltbush restoration in other degraded areas?

10.2.14 Crucifixion thorn (\textit{Castela emoryi})

- Where on the BMGR does this species occur and with what biophysical characteristics, such as natural community, soil, precipitation, climate, slope, and so on, is it associated?
- Does this species exhibit adequate growth, reproduction, and seedling establishment on the BMGR?
- Is this species distribution significantly associated with archeological sites/areas of prior human habitation?

10.2.15 Ephemeral Water-breeding Amphibian Guild

This guild is composed of the Sonoran Desert toad \(\text{Bufo alvarius}\), red-spotted toad \(\text{B. punctatus}\), and Couch’s spadefoot \(\text{Scaphiopus couchii}\).

- What is the effect of water development on the relative species composition and distribution of these species?
• What are the metapopulation dynamics of each species?

• What are the characteristics of terrestrial corridors that are important for dispersal of each species and what habitat components are necessary for each species to meet its hibernation requirements?

• What significant competitive interactions exist between the species in this guild and what environmental conditions result in a competitive advantage of one species over another?

• What is the distribution and relative abundance of the Great Plains toad (*B. cognatus*) on the BMGR and what are its biotic interactions with members of the ephemeral water-breeding amphibian guild?

10.2.16 Desert Tortoise (*Gopherus agassizii*)

• What might be the effect of climate change on the rates of tortoise mortality and recruitment?

• What might be the effect of climate change on tortoise hatchling sex ratios?

• What is the relative importance of the lower bajadas (caliche caves) for tortoise habitat and dispersal?

• How do military and recreational activities in the lower bajadas affect tortoise population composition, structure, and/or function?

• Does the Geographic Information System (GIS) tortoise habitat model (currently being developed by B. Wirt) accurately reflect tortoise distribution on the BMGR and adjoining areas?

10.2.17 Flat-tailed Horned Lizard (*Phrynosoma mcallii*)

• What effects do invasive plants have on the population composition, structure, and/or function of this species?

• What effects do undocumented alien and Border Patrol traffic have on the composition, structure, and/or function of this species?

• What is the current population density and trend in abundance of this species?

10.2.18 Cowles Fringe-toed Lizard (*Uma notata rufopunctata*)

• Is the Yuma Dunes population sufficiently large to maintain genetic viability if isolated from lizards in Mexico’s Gran Desierto?

• Is the Mohawk Dunes population sufficiently large to maintain genetic viability if it remains permanently isolated from lizard populations elsewhere (other than the San Cristobal Dunes population)?

• What adverse effects do invasive plant species have on the long-term viability of this species?

• What are the adverse effects of vehicular use of the dunes on habitat quality and lizard viability?
10.2.19 Valley Bottom Reptile Guild

This guild is composed of the western leaf-nosed snake (*Phyllorhynchus decurtatus perkinsi*), Colorado Desert shovel-nosed snake (*Chionactis occipitalis annulata*), sidewinder (*Crotalus cerastes*) (two subspecies), desert iguana (*Dipsosaurus dorsalis*), southern desert horned lizard (*Phrynosoma platyrhinos calidiarum*), and long-tailed brush lizard (*Urosaurus graciosus*) (two subspecies).

- Does the abundance of these species change in response to habitat degradation in the valley bottoms?
- Are any of the species in this guild subject to collection pressure?
- Does the distribution of the long-tailed brush lizard, associated with changes in climate, shift over time?
- Does the assemblage change in response to non-native plant and/or ant invasions?

10.2.20 Le Conte’s thrasher (*Toxostoma lecontei*)

- Given that Salt Desert Scrub is present, what is the relative use of Salt Desert Scrub in comparison to Creosotebush-Bursage Desert Scrub for this species?
- What do existing survey data reveal about the present and historical abundance and distribution of Le Conte’s thrasher?
- How do livestock grazing and/or the presence of burros affect habitat quality for Le Conte’s thrasher?

10.2.21 Primary Excavator (Cavity) Guild

This guild is composed of the Gila woodpecker (*Melanerpes uropygialis*), gilded flicker (*Colaptes chrysoides*), and ladder-backed woodpecker (*Picoides scalaris*).

- How specific is the ecological relationship between each primary excavator and a particular secondary cavity nester and are non-native species, such as the European starling (*Sturnus vulgaris*), disrupting this relationship?
- What is the baseline abundance and distribution of the cavity excavators?
- Do significant competitive interactions exist between the species in this guild and, if so, what environmental conditions result in a competitive advantage of one species over another?
- How does the distribution of saguaro age cohorts and saguaro recruitment patterns affect Gila woodpecker and gilded flicker populations?
- What are the occurrence, abundance, and potential for spread of European starlings in relation to the distribution of paloverde-mixed cacti-mixed scrub and xeroriparian natural communities?

10.2.22 Sonoran Pronghorn (*Antilocapra americana sonoriensis*)

- What are the benefits and/or adverse effects of water development on the distribution and abundance of this species?
What are the benefits and/or adverse effects of forage supplementation on the distribution and abundance of this species?

Are there human activities or modifications to the landscape (for example, fences and roads, illegal border crossing, or military activities) that pose barriers to connectivity south of Interstate 8 and/or north of Highway 2 in Mexico?

Is connectivity between the Mexico and U.S. populations across Highway 2 possible over the long term and, if not, will periodic exchanges in animals be necessary to maintain genetic diversity?

What is the effect of military activity on the BMGR (ground and air) on pronghorn population composition, structure, and/or function?

What is the effect of livestock grazing on pronghorn habitat and population composition and structure?

What is the effect of predation on pronghorn abundance and recruitment?

What is the taxonomic status of the Sonoran pronghorn subspecies and how does the status affect recovery options?

Can Sonoran pronghorn be restored to the Vekol Valley of the Sonoran Desert National Monument and can such a restored subpopulation achieve connectivity with the remainder of the U.S. population?

10.2.23 Desert Bighorn Sheep (*Ovis canadensis mexicana*)

Are there human activities (for example, illegal border crossing or military activities) that pose barriers to connectivity south of Interstate 8 and/or north of Highway 2 in Mexico?

Are domestic livestock (sheep)-borne diseases affecting desert bighorn sheep population viability?

What are the benefits and/or adverse effects of water developments on desert bighorn sheep (and non-target wildlife and plants)?

What are the current inter-mountain movement patterns of desert bighorn sheep on the BMGR, Cabeza Prieta National Wildlife Refuge, Sonoran Desert National Monument, and Organ Pipe Cactus National Monument?

10.2.24 Kit fox (*Vulpes macrotis*)

What is the natural range of variability in kit fox abundance and home range size across soil, vegetation, and climate gradients in appropriate habitat?

Given that Salt Desert Scrub is present, what is the relative use by kit fox of Salt Desert Scrub in comparison with Creosotebush-Bursage Desert Scrub?

How do livestock grazing and/or the presence of burros affect habitat quality for kit fox?

What is the effect of invasive plants on habitat quality for kit fox?
• What is the relative importance of kit fox as prey for other predators such as bobcat and coyote?

10.2.25 Bat Guild

This guild is composed of the California leaf nosed bat (Macrotus californicus), cave myotis (Myotis velifer), and lesser long-nosed bat (Leptonycteris curasoeae yerbabuenae).

• How can roosting sites of California leaf nosed bats and cave myotis be protected from human disturbance while not precluding establishment of a lesser long-nosed bat colony on the BMGR?

• What is the natural range in variability in abundance and distribution of the cave myotis on the BMGR?

• Is water availability a limiting factor in bat abundance and distribution? What is the effect of artificial water development projects on the population composition, structure, and/or function of each of these bat species?

• How do the abundance and distribution of the cave myotis and California leaf nosed bats respond to the precipitation gradient that is present from west to east within the BMGR? Is this natural response altered by the presence of artificial water developments?

10.3 INFORMATION NEEDS

Information needs are grouped according to conservation element group or management category.

10.3.1 Natural Community Conservation Elements

For each natural community listed below, the associated ecological characteristic information need(s) is stated in a brief phrase:

• Valley Bottom Floodplain Complex: natural flow regime; effect of roads (both within the delineated community boundary and immediate watershed) on function; effect of invasive plants and control measures on composition

• Valley Xeroriparian Scrub: natural flow regime; effect of invasive plants and control measures on composition; effect of roads on function; effect of recreational and undocumented alien activities on composition and structure

• Mountain Xeroriparian Scrub: natural flow regime; effect of invasive plants and control measures on composition; effect of recreational and undocumented alien activities on composition and structure

• Dune Complex and Dune Endemics: sand source-sink dynamics; effect of invasive plants and control measures on composition, structure, and function

• Creosotebush-Bursage Desert Scrub: cryptobiotic soil crust community structure and function; effect of invasive plants and control measures on composition, structure, and function; restoration strategies

• Creosotebush-Big Galleta Scrub: effect of invasive plants and control measures on composition, structure, and function; restoration strategies
• Paloverde-Mixed Cacti-Mixed Scrub on Bajadas: effect of invasive plants and control measures on composition, structure, and function

• Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes: potential effect of climate change on species composition

• Sand Tank Mountains Uplands: potential effect of climate change on species composition

• Elephant Tree-Limberbush on Xeric Rocky Slopes: potential effect of climate change on species composition

• Desert Playa: hydrological dynamics (local and watershed); importance of playas to fauna; effect of invasive plants and control measures on composition, structure, and function; effect of roads on function

• Desert Tinaja/Spring: hydrological dynamics; importance of tinajas to fauna, particularly invertebrates.

In addition to the above ecological characteristic information needs, the following inventory information is needed. Using the mapped polygons/point data as a starting point (Figure 6.1), occurrence and/or descriptive (composition/structure) information is needed for:

• Valley Bottom Floodplain Complex: confirmed occurrences and description

• Creosotebush-Big Galleta Scrub: confirmed occurrences and description

• Sand Tank Mountains Uplands: description

• Elephant Tree-Limberbush on Xeric Rocky Slopes: confirmed polygon delineation and description

• Desert Tinaja/Spring: occurrences

• Salt Desert Scrub: confirmed occurrences and description.

The preceding occurrence information needs apply to specific needs for a particular community. In general, management of natural community conservation elements on the BMGR would be assisted by an overall ground-truthing of the distribution of natural community occurrences and by descriptions of major associations of plant communities contained within each natural community.

10.3.2 Species/Guild Conservation Elements

Aside from some focused inventory efforts that have been accomplished principally in the Sand Tank and Saucedas Mountains, little is known about the distribution and abundance of all the conservation elements throughout the BMGR. Directed inventory efforts are needed to establish baseline population information and to determine the location of important habitat and potential management areas. The specific locations and habitat associations of those species (kit fox, Le Conte’s thrasher, and members of the valley bottom reptile guild) occurring in the low desert communities may be of particular interest. These species may not be evenly distributed throughout the BMGR and the preceding information would assist in identifying those areas most important to their conservation. Information obtained from the Arizona Breeding Bird Atlas (2001) that is presented in Chapter 7 provides useful occurrence, breeding status, and breeding pair abundance estimates for Le Conte’s thrasher and members of the primary excavator (cavity) guild.
Information, however, is still needed that indicates the primary habitat associations of these species. Surveys for federally endangered species that have the potential to occur on the BMGR, cactus ferruginous pygmy-owl and the lesser long-nosed bat, would be expected to continue. Specific information needs by taxon are described in the paragraphs below.

**Plants**

Occurrences of *Castela emoryi* on the BMGR need to be evaluated for the factors that affect its occurrence and abundance (for example, associated geology, soils, and plant species associates).

Presence of *Atimisqua emarginata* and *Stegnosperma halimifolium* on the BMGR needs to be assessed. If populations of these species occur on the BMGR, they are likely important host plants for invertebrates. *Atimisqua emarginata* is the only host plant for Howard’s white (*Ascia howarthis*; Lepidoptera) and *S. halimifolium* might function as a host plant keystone species for a variety of pollinator species (J. Schmidt). The only known population of *A. emarginata* occurs on Organ Pipe Cactus National Monument.

**Invertebrates**

Little information is available on the occurrence of specific invertebrate species on the BMGR. Even a cursory sampling of each natural community would be informative as to the relative species richness, evenness, and ecological importance of invertebrate species on the BMGR. Invertebrate species that could serve as focal conservation elements might be found by focusing sampling efforts on those invertebrate species that are specialized on certain plants, which themselves are rare or specific to a natural community (for example, *Castela emoryi* or plants that are endemic to a natural community element), or by focusing sampling at specialized habitats such as dunes and tinajas.

**Amphibians**

Quantifying and analyzing the relative usage, as well as co-usage, of different water sources on the BMGR by members of the ephemeral water-breeding amphibian guild may elucidate their dynamic species interactions under different water regimes (that is, playa versus tinaja; ephemeral versus permanent water; modified tinaja versus natural tinaja; and so on). Such information could be used to ensure that management accounts for each species’s needs without unduly affecting conservation of the other species.

**Reptiles**

Reptiles are an extremely important group that is highly diverse and successful in the desert Southwest. Little is known about the distribution and abundance of reptile species on the BMGR. General inventory and monitoring of reptiles is needed throughout the BMGR to know what species occur, where they occur, and their population viability, especially members of the valley bottom reptile guild. More information on inventory needs for reptiles is found in Chapter 8.

Studies are needed to understand the viability and population fluctuations of desert tortoise throughout the BMGR. Tortoises need to be inventoried in the western mountains of the BMGR. The relative importance of caliche caves to desert tortoise needs to be assessed, because it may be an important and vulnerable habitat in the bajadas. Appropriate tortoise habitat can be modeled using Geographic Information System computer software and would be helpful to predict occurrence and direct inventory efforts (B. Wirt).
Biodiversity Management Framework

Birds

The European starling (*Sturnus vulgaris*) is a recent invader to the Sonoran Desert that may compete with other cavity nesters for saguaro cavity nest sites. The occurrence, abundance, and spread of European starlings need to be investigated and the potential adverse impact on the nesting dynamics of the native secondary cavity nesters should be monitored.

The nature of the relationship (dependency) of secondary cavity nesters to a particular primary excavator (cavity) guild member or suite of guild members and their associated cavities should be investigated.

Mammals

Effective means of protecting bat cave/mine roost sites from unauthorized access are needed that provide an adequate deterrent to human entry, but will not prevent colonization by lesser long-nosed bats.

10.3.3 Water Development Projects

Water development and the associated adverse/beneficial effects on targeted and non-targeted species and natural communities are controversial. Well-conceived and peer-reviewed study designs and analyses are needed to instill confidence in management decisions made relative to the installation of water development projects. Within Special Natural Areas (see Chapter 11), the appropriate experimental/management context should account for whether artificial modifications or management manipulations of surface water features are necessary to mimic a missing ecological component or process.

10.4 CONSOLIDATION OF ELEMENT-SPECIFIC THREAT-BASED MONITORING OBJECTIVES AND INFORMATION NEEDS

The list of management questions (monitoring objectives) and information needs above, though reasonably extensive, may not be necessarily exhaustive. Still, even this list will need to be prioritized. A priority may have to be placed on monitoring associated with those conservation elements that are expected to be potentially susceptible to rapid change—either because they are actively managed or they are subject to stresses that may affect their condition in the near term—versus those for which management is passive and immediate stresses are minimal. Moreover, when following a threat-based approach to monitoring, those stresses and sources of stress that have a major impact on the viability of a particular conservation element or that affect multiple elements should receive a priority for monitoring.

To better ascertain what the focus should be of a threat-based monitoring strategy for the BMGR, Table 10.1 provides a matrix of the primary sources of stress and the types of stresses they cause on the BMGR crossed against the 25 conservation elements. Matrix entries relate to threat-based monitoring objectives identified in section 10.2, supplemented by information on stresses and sources of stress in Chapters 6 and 7. Entries are made whenever a particular source of stress applies to a conservation element. The sources of stress identified in Table 10.1 are not an exhaustive list of all possible sources of stress occurring on the BMGR; however, the list consolidates the primary sources. The stresses associated with the sources represent generalized categories of ecological stress. Each matrix entry is an example of a potential threat-based monitoring variable (generally non-specific). Each matrix entry can relate to the source of the stress or to a characteristic of the conservation element (or its habitat) that the source affects. As a result, threat-based monitoring can assess metrics directly associated with the source of the stress (for example, measuring the occurrence of invasive plants within a natural community) or with the conservation element’s response to the presence of the source (for example, changes in the native species composition, structure, and function of a natural community as a result of an invasion by a non-native
Monitoring

plant species). The appropriate choice of monitoring metric depends on which approach optimizes the trade-off between the metric’s sensitivity to change and degree to which it is an indication of the viability of the conservation element of interest and the ease, reliability, and cost of measurement.

The last row in Table 10.1 provides a summary of the number of conservation elements that are potentially impacted by a particular source of stress. Invasive species, and invasive plants in particular, are a pervasive threat to the long-term persistence of much of the BMGR’s biodiversity, as over 60% of the elements are potentially adversely impacted by invasive species. For some natural communities, such as the Dune Complex and Dune Endemics community, invasive plants may be the primary threat to the community’s viability, whereas an invasive animal species, European starling, is a major concern for one or members of the primary excavator (cavity) guild. Clearly, any monitoring strategy that purports to monitor the status of biodiversity on the BMGR must address invasive species.

Altered hydrological regimes potentially threaten five of the natural community conservation elements; however, the source of the stress differs between elements. This is an indication that though a particular type of stress may be pervasive, its sources may be multiple. For some of the natural communities potentially affected by altered hydrological regimes, the list of information needs also points towards a lack of knowledge on the natural hydrological regime for these communities. Monitoring in these instances may need to establish baseline information on natural hydrological regimes, in addition to tracking the altered regimes and their associated impacts that are potentially induced by anthropogenic activities such as roads and water developments. With the possible exception of Desert Playas, the natural communities potentially affected by altered hydrological regimes all have disproportionate value for wildlife on the BMGR. Conservation of Desert Playas is important because of their rarity within the Sonoran Desert Ecoregion.

Recreational activities, undocumented alien traffic, and agency responses to undocumented alien traffic potentially threaten xeroriparian scrub communities, including their wildlife inhabitants, in a number of ways (Table 10.1). Additionally, a number of species elements are threatened directly by the preceding sources of stress. These sources also act as potential vectors for the spread of invasive plants. This relationship illustrates an additional monitoring concern: some sources and the stresses they cause act synergistically. In the case of invasive plants, human activities enable or at least exacerbate their spread. Monitoring would need to address not only the changes in the spatial distribution of invasive species, but also the human activities that facilitate their spread.

Many of the information needs identified in section 10.3 overlap with the consolidated threat-based monitoring objectives discussed above. For example, an understanding of the natural hydrological regime associated with the Valley Bottom Floodplain Complex also will lead to an understanding of how improperly constructed roads may adversely impact this community.

10.5 Designing a Biodiversity Monitoring Strategy for the Barry M. Goldwater Range

This document has provided only an initial step toward the design of a biodiversity monitoring strategy for the BMGR. The suite of 25 conservation elements represents the initial ingredients. The associated monitoring objectives (section 10.2) and information needs (section 10.3) provide a fairly robust starting point for deciding which metrics of element and threat status are important to monitor. Because not everything can or should be monitored, some prioritization, streamlining, and consolidation among monitoring options will be necessary. The following brief paragraphs outline some considerations that should be addressed when making decisions about what to monitor.

Gather baseline information.—The amount of available baseline information on ecological characteristics and status differs between the conservation elements. Elements should be prioritized in
regard to their information needs according to rarity, regional vulnerability, and degree to which they serve as a coarse filter or keystone species/guild. Understanding within-guild interactions is especially reliant on having good information on distribution and habitat associations for each guild member.

**Account for degree of rarity or projected vulnerability.**—The window of opportunity to conserve and protect rare, but viable, or projected vulnerable conservation elements may necessitate that monitoring occur sooner rather than later.

**Focus on pervasive threats.**—As discussed in section 10.4, those stresses and sources of stress that have a major impact on the viability of a particular conservation element or that affect multiple elements should receive a priority for monitoring.

**Monitor to scale.**—By monitoring at the appropriate spatial scale, efficiencies can be gained. For example, remote sensing (for example, aerial photography or satellite imagery) of land cover changes may be an efficient method of tracking changes in the status of natural community conservation elements. Monitoring to scale also implies that ecological processes and species movement patterns that operate at landscape scales need to be monitored and assessed at that scale.

**Pay attention to ecological processes.**—Simply enumerating individuals in a population or mapping the extent of a natural community may overlook the key factors that affect the long-term persistence of a conservation element. Monitoring should address the key ecological processes associated with a particular conservation element.

**Be on the lookout for signs of encroachment.**—Changes in land use probably will continue along or near to some portions of the BMGR boundary. Adjacent incompatible land uses can affect the viability of BMGR’s natural resources. Increases in raven (Corvus corax) abundance associated with urbanization and the occurrence of European starlings associated with agriculture were identified in Table 10.1 as threats to particular species conservation elements on the BMGR. Monitoring can help to identify the impacts of encroachment.
<table>
<thead>
<tr>
<th>CONSERVATION ELEMENT</th>
<th>SOURCES OF STRESS: STRESSES CAUSED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land cover conversion or disturbance from military or other projects:</td>
<td>Incompatible development of roads, utilities, and fences:</td>
</tr>
<tr>
<td>• habitat loss</td>
<td>• altered composition/structure</td>
</tr>
<tr>
<td>• habitat fragmentation</td>
<td>• alteration of natural hydrological regimes</td>
</tr>
<tr>
<td>• habitat disturbance</td>
<td>• loss of genetic diversity.</td>
</tr>
<tr>
<td>• loss of genetic diversity</td>
<td>Incompatible recreational, including vehicular, use:</td>
</tr>
<tr>
<td>• alteration of natural flow regimes.</td>
<td>• altered composition/structure</td>
</tr>
<tr>
<td></td>
<td>• habitat disturbance</td>
</tr>
<tr>
<td></td>
<td>• resource depletion</td>
</tr>
<tr>
<td></td>
<td>• physiological stress.</td>
</tr>
</tbody>
</table>

**NATURAL COMMUNITIES**

| Valley Bottom Floodplain Complex | Land cover conversion or disturbance from military or other projects: |
| • watershed condition | Incompatible development of roads, utilities, and fences: |
| • invasive plants | • altered composition/structure |
| • hydrological regime | • alteration of natural hydrological regimes |
| | • loss of genetic diversity. |

| Valley Xeroriparian Scrub | Incompatible recreational, including vehicular, use: |
| • invasive plants | • altered composition/structure |
| • hydrological regime | • habitat disturbance |
| | • resource depletion |
| | • physiological stress. |

| Mountain Xeroriparian Scrub | Undocumented alien traffic and agency responses: |
| • invasive plants | • altered composition/structure |
| • hydrological regime | • habitat disturbance |
| | • resource depletion |
| | • physiological stress. |

| Dune Complex and Dune Endemics | Incompatible construction/ modification of water retention and diversion structures: |
| • invasive plants | • altered composition/structure |
| • vehicle usage | • habitat disturbance |
| | • alteration of natural hydrological regimes |

| Creosotebush-Bursage Desert Scrub | Incompatible management of/ for certain species: |
| • soil compaction and erosion | • altered composition/structure |
| • invasive plants | • alteration of natural hydrological regimes |

| Creosotebush-Big Galleta Scrub | **NATURAL COMMUNITIES** |
| • soil compaction and erosion | Valley Bottom Floodplain Complex |
| • invasive plants | • watershed condition |
| | • invasive plants |
| | • hydrological regime |

| Paloverde-Mixed Cacti-Scrub on Bajadas | **NATURAL COMMUNITIES** |
| • soil compaction and erosion | Valley Xeroriparian Scrub |
| • invasive plants | • invasive plants |
| | • hydrological regime |

| Paloverde-Mixed Cacti-Mixed Scrub on Rocky Slopes | **NATURAL COMMUNITIES** |
| • soil compaction and erosion | Mountain Xeroriparian Scrub |
| • invasive plants | • invasive plants |
| | • hydrological regime |

| Sand Tank Mountains Uplands | **NATURAL COMMUNITIES** |
| • habitat disturbance | Dune Complex and Dune Endemics |
| | • invasive plants |
| | • hydrological regime |

| Elephant Tree-Limberbush on Xeric Rocky Slopes | **NATURAL COMMUNITIES** |
| • habitat disturbance | Creosotebush-Bursage Desert Scrub |
| | • invasive plants |
| | • hydrological regime |

| Desert Playa | **NATURAL COMMUNITIES** |
| • watershed condition | Paloverde-Mixed Cacti-Scrub on Bajadas |
| • invasive plants | • invasive plants |
| | • hydrological regime |

| Desert Tinaja/Spring | **NATURAL COMMUNITIES** |
| • direct and indirect effects on wildlife usage | Sand Tank Mountains Uplands |
| | • hydrological regime |

| Salt Desert Scrub | **NATURAL COMMUNITIES** |
| • habitat condition and extent | Elephant Tree-Limberbush on Xeric Rocky Slopes |
| | • invasive plants |
### TABLE 10.1 Matrix of Primary Sources of Stress and the Types of Stresses They Cause on the Barry M. Goldwater Range in Relation to Threat-based Monitoring Objectives Identified for Individual Conservation Elements

<table>
<thead>
<tr>
<th>CONSERVATION ELEMENT</th>
<th>SOURCES OF STRESS: STRESSES CAUSED</th>
</tr>
</thead>
</table>
| Land cover conversion or disturbance from military or other projects: | • habitat loss
   • habitat fragmentation
   • habitat disturbance
   • loss of genetic diversity
   • alteration of natural flow regimes.
| Invasive species or anthropogenic-induced increases in native species abundance: | • altered composition/structure
   • alteration of natural fire regimes
   • extraordinary competition for resources.
| Incompatible development of roads, utilities, and fences: | • habitat fragmentation
   • alteration of natural hydrological regimes
   • loss of genetic diversity.
| Incompatible recreational, including vehicular, use: | • altered composition/structure
   • habitat disturbance
   • resource depletion
   • physiological stress.
| Undocumented alien traffic and agency responses: | • altered composition/structure
   • habitat disturbance
   • resource depletion
   • physiological stress.
| Incompatible construction/modification of water retention and diversion structures: | • altered composition/structure
   • habitat disturbance
   • alteration of natural hydrological regimes
   • thermal alteration.
| Incompatible management of/for certain species: | • altered composition/structure
   • alteration of natural hydrological regimes.

#### SPECIES (GUILDS)

<table>
<thead>
<tr>
<th>Species (Guild)</th>
<th>Stressors</th>
</tr>
</thead>
</table>
| Crucifixion thorn | • competitive interactions
   • thermal and nutrient environments |
| Desert tortoise | • condition of lower bajada caliche caves
   • increased raven abundance |
| Flat-tailed horned lizard | • habitat extent and condition (limited habitat available off site)
   • invasive plants
   • increased raven abundance |
| Cowles fringe-toed lizard | • invasive plants
   • population (deme) isolation
   • vehicle use |
| Valley bottom reptile guild | • invasive plants and animals (ants)
   • collection pressure |
| Le Conte’s thrasher | • invasive animals (habitat condition) |
| Primary excavator (cavity) guild | • invasive animals (European starling) |
| Sonoran pronghorn | • habitat condition
   • excessive predation
   • population (deme) isolation
   • human disturbance |
| Desert bighorn sheep | • population (deme) isolation
   • human disturbance
   • predator-prey interactions |
| Kit fox | • invasive plants and animals (habitat condition) |
| Bat guild | • human disturbance
   • competitive interactions
   • bat gate responses |

**Total No. of Entries Per Source of Stress**

<table>
<thead>
<tr>
<th></th>
<th>9</th>
<th>16</th>
<th>6</th>
<th>11</th>
<th>6</th>
<th>5</th>
<th>2</th>
</tr>
</thead>
</table>

1 See text for details on how matrix entries were made.
CHAPTER 11 RECOMMENDATIONS FOR LAND MANAGEMENT CATEGORIES AND ASSOCIATED MANAGEMENT STANDARDS

Single-species, compliance-driven natural resource management approaches characteristically are trying to make up for lost ground. Often by the time these approaches are implemented they are relatively costly and their chances for success uncertain. Natural resource management and land-use strategies that place a priority on maintaining resources—here considering species as resources embedded within natural communities and functional landscapes—that already have reasonable ecological integrity enable the federal land manager to preserve future options, in regard to both land-use (mission accomplishment) and natural resource conservation and protection. By waiting to react to compliance-induced natural resource management mandates, the federal land manager unwittingly invites their occurrence. By enacting proactive management strategies today that account for the full extent of biodiversity rather than just a focus on single species management, the federal land manager can reduce long-term management costs and improve the prospects for agency mission accomplishment that is compatible and sustainable in the face of resource conservation and protection responsibilities.

In this chapter we provide recommendations on specific land management categories and management standards that are applicable to each category. Such recommendations are the critical endpoints of the biodiversity management framework that has been developed herein for the Barry M. Goldwater Range (BMGR). The combination of land management categories and standards is proposed to be the linchpin of a proactive, ecosystem-based approach to natural resources management on the BMGR. We strongly suggest that the Air Force and Marines can improve their ability to protect and sustain their missions on the BMGR over the long-term by demonstrating today that they are taking a comprehensive approach to planning and implementing a reasonable set of natural resource management standards and supporting programs to accomplish biodiversity conservation and protection. We further suggest that if such a management framework, including its standards, is implemented appropriately and consistently across adjoining land management jurisdictions, it can be used to raise the standards of biodiversity management across the Greater Goldwater Complex (see section 2.3.2 for a definition of this complex). Consistent implementation will ensure an equitable distribution of management responsibility among jurisdictions and will facilitate an ecosystem approach to management. The immediate benefit of implementation to the Air Force and Marines will be a demonstration to regulators and the public of their ability to manage biodiversity through an informed decision-making process that leads to visible management standards, which itself can lead to a stream-lining of environmental review and listed species consultation processes.

11.1 DERIVING LAND MANAGEMENT CATEGORIES AND MANAGEMENT STANDARDS: OVERVIEW

Information presented in earlier chapters pertaining to ecological attributes and desired future conditions of individual species and natural community conservation elements is now considered in this chapter in the broader contexts of agency and land management unit missions, land-use constraints and opportunities, landscape features, and cross-jurisdictional coordinated management opportunities. This “roll-up” of mission, biological—now considering the occurrence and condition of conservation elements in combination and not just individually, and land-use data at relatively large spatial scales is used to derive recommendations for: (1) geographically defined land management units and (2) management standards applicable to each unit.

Land management units (corresponding to spatially delineated, generally contiguous areas) that share similarities in ecological condition and land use and that can be addressed by a similar set of management
standards are assigned to a common land management category (land management category designations also can be spatially delineated). The emphasis on meeting conservation goals versus other desired human uses of the land differs between categories. Present ecological condition and land use constrains the assignment of a particular land management category to any specified geographic area. Sharing similarities in ecological condition does not necessarily mean sharing the same conservation elements. The goal is to ensure adequate management of the full range and natural variation of conservation elements that occur on the BMGR. Often a single land management unit will be insufficient in this regard. The aggregate of all land management categories (inclusive of one or more land management units each) and their associated management standards represents a hypothesis: implementation of the applicable management standards across the full spatial expression of the land management categories, and in coordination with application of similar management standards on adjoining jurisdictions when necessary, will ensure the long-term persistence of the BMGR’s biodiversity.

Individual land areas are assessed, delineated, and assigned to an appropriate land management unit and category based on that particular land area’s attributes with respect to the following:

- representation and stratification of natural community elements, species elements, and ecological gradients
- ecological integrity (based on size, condition, and landscape context)
- coarse filter function for rare species and endemics
- anthropogenic disturbance levels
- opportunities for coordinated management across jurisdictions.

A primary consideration of the above assessment is to identify areas that qualify to be managed as Special Natural Areas (see section 2.2 and below). These are areas that represent one type of land management category that share characteristics of high biodiversity value (based on the first three assessment criteria above), low anthropogenic disturbance levels, and opportunities for coordinated management with one or more adjoining jurisdiction. Special Natural Areas are the primary, but not sole, means through which biodiversity conservation and protection goals for the BMGR can be met when they are managed to appropriate standards.

In the remainder of this chapter, we will describe our process for identifying Special Natural Areas and other land management categories on the BMGR. We begin by first providing an overview of existing resource conservation and protected areas on the BMGR to provide some initial context for our recommendations. We then provide an overview of the principles of conservation biology we applied to inform the designation of Special Natural Areas. This is followed by our specific recommendations and justifications for the designation of each proposed Special Natural Area. We conclude with a section that describes each of the land management categories and our recommendations for appropriate management standards applicable to each category.

11.2 EXISTING RESOURCE CONSERVATION AND PROTECTED AREAS ON THE BARRY M. GOLDWATER RANGE

The existing resource conservation and protected areas on the BMGR that are of primary relevance to this report are the Bureau of Land Management (BLM) Areas of Critical Environmental Concern (ACEC) and the Yuma Desert Flat-tailed Horned Lizard Habitat Management Area. The amendment to the Lower Gila South Resource Management Plan (Goldwater Amendment; Bureau of Land Management 1989)
provided the basis for the designation of the three existing ACECs on the BMGR: Gran Desierto Dunes, Mohawk Mountains and Sand Dunes, and Tinajas Altas Mountains. The BLM designates ACECs on the basis of relevance and importance criteria, as required by its planning regulations [Title 43 Code of Federal Regulations 1610.7–2(a)]. The Record of Decision to the Resource Management Plan identified the final amount of acreage designated as ACECs on the BMGR (U.S. Department of the Air Force 1998). Although the Goldwater Amendment (Bureau of Land Management 1989) proposed boundaries for a Yuma Desert and Sand Dunes Habitat Management Area, whose management goal in part was to maintain habitat for the flat-tailed horned lizard (Phrynosoma mcallii), the boundaries of the proposed management area (now referred to as the Yuma Desert Flat-tailed Horned Lizard Habitat Management Area) were changed and the area covered increased by the Flat-tailed Horned Lizard Rangewide Management Strategy (Foreman 1997).

Through the Integrated Natural Resources Management Plan (INRMP) development process and the associated Environmental Impact Statement public review process, the Department of Defense can propose alternatives to the public that: (1) accept the existing resource conservation and protection areas, (2) eliminate them, (3) modify them, or (4) add new areas (an alternative also could consist of a combination of the preceding). The Department of Defense does not use the ACEC designation; instead it refers to areas that contain important natural and cultural resource values as Special Natural Areas (see section 2.2). Each existing resource conservation and protected area is briefly described in the paragraphs below based on descriptions in the Goldwater Amendment (Bureau of Land Management 1989) and/or Foreman (1997).

11.2.1 Gran Desierto Dunes Area of Critical Environmental Concern

A rare dune system that provides habitat for the Cowles fringe-toed lizard (Uma notata rufopunctata) and several dune endemic plant species. Only one of four major Sonoran Desert dune fields in Arizona. Provides habitat for several other reptiles with limited distributions associated with dune and dune-fringe environments, including the flat-tailed horned lizard. The dominant dune plant community is an unusual assemblage found nowhere else in Arizona. Potential threats to the resource values of the ACEC included off-road vehicle use and expanded military ground use. An area under consideration as part of the ACEC (about 3000 acres) was removed because of the presence of active live-fire target areas, strafing targets, a mobile land target, observation facilities and towers, and access roads. As a result, the BLM determined that the area needed special management attention because: (1) resources present had limited occurrence, (2) unique and rare biological resources of special significance were present, and (3) current or future changes in land use potentially threatened significant and undisturbed resource values. Relevant management prescriptions recommended by the BLM can be summarized as follows:

- limit vehicle use to designated roads; post all other areas (including dunes and dune fields) closed to public use
- prohibit woodcutting and the taking of dead and down trees within the ACEC
- prohibit new rights-of-way and other land use authorizations
- encourage military ground activities to stay within current training areas inside the Gran Desierto ACEC sand dune complex
- reclaim military use areas with surface damage within the ACEC, if identified as non-essential to current and future military training missions and where restorative efforts have a potential for success
- establish long-term study plots to inventory and monitor natural resources.
11.2.2 Mohawk Mountains and Sand Dunes Area of Critical Environmental Concern

The area contains the largest and least disturbed dune system in Arizona. The dunes contain a population of Cowles fringe-toed lizards and various assemblages of rare or unusual Sonoran Desert sand dune plant communities, and the area potentially is used by the Sonoran pronghorn antelope (*Antilocapra americana sonoriensis*) (later confirmed). The Mohawk Mountains, a unique minimally eroded mountain range, provide habitat for desert bighorn sheep (*Ovis canadensis mexicana*) and add to an undisturbed semi-stabilized dune and mountain ecosystem. The area was threatened by increased recreational use, including off-road vehicle use, because of local population growth. The potential for increased military use of the area also was considered a threat. The BLM concluded that the dune and mountain ecosystem was of more-than-local significance because of its rarity, large size, and undisturbed condition, but that at the time it was threatened by increased levels of off-road vehicle recreation and military use. The BLM’s recommended management prescriptions were similar to those recommended for the Gran Desierto Dunes ACEC.

11.2.3 Tinajas Altas Mountains Area of Critical Environmental Concern

The area contains: habitat and migration routes for the desert bighorn sheep; a unique assemblage of deep-water tinajas, or slickrock water tanks; the Davis Plain ironwood tree (*Olneya tesota*) population; and, amidst the weathered granitic mountain rockfaces of the Tinajas Altas Mountains, a unique assemblage of plant species adapted to extremely hot and arid conditions. The area was threatened by ironwood poaching, off-road vehicle activity, and military training use. The BLM concluded that the area was of more-than-local significance because of its unique habitat features and associated flora and fauna, but that without special management attention public recreation, military training, and wood poaching threatened the resource values of the area with irreplaceable loss. The BLM’s recommended management prescriptions were similar to the other ACECs in regard to vehicle use, woodcutting, and rights-of-way. Other area-specific recommendations included:

- limit military ground operations to designated or established roads and remove or reclaim military ground operation sites
- close roads and vehicle trails to the main Tinajas Atlas rock pool (tinajas) complex
- restore the natural appearance and setting of the Tinajas Altas High Tanks
- prohibit camping within one-quarter mile of the Tinajas Altas High Tanks area
- establish regular ranger supervision and patrol of the Tinajas Altas and Davis Plain areas to curtail unauthorized cross-country motorized vehicle use and illegal ironwood harvest
- initiate reclamation procedures on all areas of the ACEC with significant evidence of natural resources damage or impairment from off-road vehicle use and other surface-disturbing activities.

11.2.4 Yuma Desert Flat-tailed Horned Lizard Habitat Management Area

The original BLM-recommended boundaries, outside of the Gran Desierto Dunes ACEC, were meant to include additional dune-fringe areas that represented habitat for the flat-tailed horned lizard, as well as for other flora and fauna of the Yuma Desert. The Flat-tailed Horned Lizard Rangewide Management Strategy (Foreman 1997) proposed changes to the habitat management area that changed the configuration of the management boundaries within the BMGR (still inclusive of the Gran Desierto
Dunes ACEC). The proposed management area avoided extensive, existing, and predicted management conflicts, but it did include land management conflicts that may be localized in nature (for example, military bombing targets). Management prescriptions were similar to, but at times more permissive than, those recommended by the Bureau of Land Management (1989) for the Gran Desierto Dunes ACEC. The proposed habitat management area and management prescriptions were adopted by the Marine Corps Air Station Yuma as a signatory to the Conservation Agreement for the flat-tailed horned lizard (effective 26 June 1997) that adopted implementation of the rangewide management strategy.

11.2.5 Coda

The BLM’s criteria for designating ACECs are unique to that agency. The criteria focus on protecting unique resource values that are threatened unless specific management actions are taken. The criteria do not necessarily focus on maintaining the landscape ecological integrity of communities, species, and ecological processes that require geographic scales beyond the local or intermediate scales, though some small or large patch community representations or entire local populations of individual populations may be captured within the boundaries of an individual ACEC (for example, the Mohawk Mountains and Sand Dunes ACEC possibly captures the full extent of the local population of Cowles fringe-toed lizard that occurs within the dunes).

The Department of Defense lacks, via promulgated regulation or guidance, specific criteria that guide how to choose and establish the boundaries for Special Natural Areas (section 2.2 identifies the available guidance). We propose herein that the development of such criteria, insofar as designation of an area is meant to protect biodiversity, should be based on sound principles of conservation biology. As a result, in the next section we provide a brief overview of relevant conservation biology principles that can be used to help inform the process of selecting and delineating Special Natural Areas.

11.3 USE OF CONSERVATION BIOLOGY PRINCIPLES TO INFORM THE DESIGNATION OF SPECIAL NATURAL AREAS

Given the large geographic scale of the BMGR, multiple areas may need to be considered as Special Natural Areas to capture the full extent of biodiversity across its natural range of variability. Three issues, developed initially to guide the selection of natural community occurrences in ecoregional planning (Anderson and others 1999) and adapted here to apply to conservation elements in general, are important to consider in this regard:

- spatial representation and stratification of conservation elements across the planning unit within Special Natural Areas (the planning unit considered here is the BMGR, but the unit could be considered at the scale of the Sonoran Desert Ecoregion as a whole or something in between)

- ecological integrity of individual occurrences

- value of each Special Natural Area to function as a coarse filter.

\[15\] A Conservation Agreement is a formal written document agreed to by the U.S. Fish and Wildlife Service and other cooperators that identifies specific actions and responsibilities for which each party agrees to be accountable. The objective of a conservation agreement is to reduce threats to a candidate species or its habitat, thereby possibly lowering the listing priority or eliminating the need to list the species (Foreman 1997).
11.3.1 Spatial Representation and Stratification

To manage and protect biodiversity to the greatest extent possible, each conservation element within the planning unit should be represented within the network of Special Natural Areas. Additionally, some elements, such as a natural community, may have a large range of natural variability that needs to be considered. The objective of stratification is to represent each natural community across its range of variation within a planning unit. Stratification then is mostly a function of how restricted a natural community is to a planning unit (Anderson and others 1999). The more restricted a community is, the more each occurrence within a planning unit needs to be represented. Some natural communities, such as playas and natural tinajas, are relatively rare across the entire Sonoran Desert. Generally, each viable representation of these communities should be protected no matter the planning unit scale. Other natural communities, such as the Valley Bottom Floodplain, Sand Tank Mountains Uplands, and Dune Complex and Dune Endemics natural communities on the BMGR, may qualify as unique representations of more broadly defined communities. In a sense their occurrences are relatively restricted to the BMGR. Finally, natural communities that may be widespread in their occurrence across the ecoregion, such as Creosotebush-Bursage Desert Scrub and Valley Xeroriparian Scrub, may have their best representation within a landscape context (that is, generally unfragmented, of a sufficient size and connectivity, and ecologically intact) within a particular planning unit.

11.3.2 Ecological Integrity

Although the criteria for assessing the ecological integrity of natural communities have been expressed in a number of different ways and with some degree of overlap in the criteria (for example, see Anderson and others 1999, Noss 1990, and Poiani and others 2000), we will consider three criteria—size, condition, and landscape context—that also have been used to assess the viability of species (The Nature Conservancy 2000). Size relates to the concept of minimum dynamic area: the area necessary to enable natural disturbance regimes to occur (sometimes of broad geographic scale) without risking a catastrophic loss of organisms but also enabling, for those matrix and large-patch communities to which the process applies, a shifting mosaic of habitat patches (Poiani and others 2000). For species that function with a metapopulation spatial structure (and small-patch communities that function similarly), replication and connectedness may be more important than size per se (for example, see Fahig and Merriam 1985).

Condition is an integrated measure of composition, structure, and function (Noss 1990, The Nature Conservancy 2000). For natural communities, composition is related to the presence of native versus non-native species or the presence of appropriate patch types for broadly defined communities, structure refers to the vertical and horizontal structure of the vegetation or the spatial distribution and juxtaposition of patch types or seral stages, and function relates to those ecological processes, including biotic interactions, that establish and maintain the community. For species, composition relates to some measure of abundance, structure includes how individuals are distributed across the landscape and population structure (age and sex), and function relates to demographic processes (fertility, recruitment, and mortality), growth rates, phenology, and so on. A conservation element’s condition will contribute to ecological integrity when the factors that contribute to condition (above and others) are within their natural range of variability.

Landscape context addresses issues of connectivity and, by some definitions (for example, see The Nature Conservancy 2000), the dominant enviromental regimes (or ecological processes; function of Noss 1990). The distinction may be warranted if one wants to distinguish ecological processes that occur within a defined natural community from those that occur outside the community (for example, processes that provide sand sources to dune complexes), but are necessary for the community’s establishment and maintenance. Connectivity addresses whether: natural communities are fragmented (perhaps cut-off from the ecological processes that shape them), species have access to the habitats and resources needed
to complete their life cycles, and both can respond to environmental change by dispersal, migration, or recolonization, as appropriate. To enable such movements, conservation areas (Special Natural Areas or otherwise) should encompass and connect elevational, substrate, and other ecological gradients. The scale at which connectivity is necessary differs for each species and natural community. This understanding emphasizes the importance of selecting conservation elements that function at multiple geographic scales (Poiani and others 2000; also see Figure 4.1 and Tables 4.1 and 5.1).

Opportunities to link Special Natural Areas with adjacent properties that contain contiguous resources and for which similar management can be achieved (and whose inclusion ecologically perhaps is necessary to achieve the appropriate landscape context) can improve the ecological integrity of a Special Natural Area and further enhance its ability to meet biodiversity management and protection goals. Additionally, such linkages may create opportunities that facilitate each landowner’s ability to meet biodiversity conservation goals and mandates, while permitting other uses of their respective land ownerships.

11.3.3 Coarse Filter

The value of each Special Natural Area increases the more it can function as a coarse filter for representing the management and protection needs of the biodiversity contained within a planning unit. Some specific criteria to consider when assessing the degree to which a Special Natural Area functions as a coarse filter are whether: many natural communities are included, occurrences of rare species are captured within the boundaries, and a number of endemic species are present (the area represents a center of narrow ecological or distributional endemics). To fully function as a coarse filter, the Special Natural Area must have ecological integrity appropriate to the conservation elements it is designed to include.

11.4 RECOMMENDATIONS AND JUSTIFICATIONS FOR SPECIAL NATURAL AREAS ON THE BARRY M. GOLDWATER RANGE

The Special Natural Areas proposed below attempt to address the issues described above in regard to the selection of appropriate areas for designation and their efficacy for managing and protecting biodiversity on the BMGR. We attempted to honor compromises that must be made as far as boundary selection is concerned because of existing land-disturbance history and military training needs. Additionally, when appropriate and available we used roads as boundaries, because they provide a convenient way of delineating the boundaries of a Special Natural Area that is recognizable on-the-ground. Figure 11.1 shows the relationship of each recommended Special Natural Area to military ground disturbance areas and the natural community conservation targets. Table 11.1 provides summary information on the ecological attributes of each Special Natural Area that can serve as the justification for each proposed designation. The attributes provide information in the context of the conservation biology principles outlined in section 11.3. Each recommended area is described in narrative form below. This section concludes with a discussion of how each Special Natural Area contributes when considered as part of a network of Special Natural Areas. Recommended management standards for the proposed Special Natural Areas are addressed in section 11.5.

11.4.1 Yuma-Lechuguilla Deserts-Tinajas Altas Mountains Special Natural Area

The proposed Yuma-Lechuguilla Deserts-Tinajas Altas Mountains Special Natural Area encompasses two previously designated BLM ACECs, Gran Desierto Dunes and Tinajas Altas Mountains, portions of the BLM designated El Camino del Diablo Backcountry Byway, and the Yuma Desert Flat-tailed Horned Lizard Habitat Management Area. Based on geography, this area includes that portion of the Yuma Desert that occurs within the United States, including the Yuma Dunes and adjoining dune-fringe habitat, Tinajas Altas Mountains, and that portion of the Lechuguilla Desert south of the Border Patrol east-west drag line (Figure 11.1).
### TABLE 11.1 Ecological Attributes of Proposed Special Natural Areas on the Barry M. Goldwater Range

<table>
<thead>
<tr>
<th>Attribute Category</th>
<th>Special Natural Area</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geographic description</strong></td>
<td><strong>Yuma-Lechuguilla Deserts-Tinajas Altas Mountains</strong></td>
</tr>
<tr>
<td>Located within the western portion of the BMGR, west and south of the Gila Mountains, and adjoining the Cabeza Prieta National Wildlife Refuge to the east.</td>
<td>Encompasses that portion of the Yuma Desert that occurs within the U.S, including the Yuma Dunes and adjoining dune-fringe habitat, Tinajas Altas Mountains, and the Lechuguilla Desert south of the Border Patrol east-west drag line. Total area equals 270,670 acres.</td>
</tr>
<tr>
<td>Encompasses land cover representative of the Lower Colorado River Valley subdivision (dunes and creosotebush flats). Additionally, the Elephant Tree-Limberbush on Xeric Rocky Slopes community (Tinajas Altas Mountains) shares affinities with plant communities characteristic of both the Arizona Upland and Central Gulf Coast subdivisions.</td>
<td>Includes land cover representative of the Lower Colorado River Valley subdivision (dunes and creosotebush flats). Additionally, the Elephant Tree-Limberbush on Xeric Rocky Slopes community (Tinajas Altas Mountains) shares affinities with plant communities characteristic of both the Arizona Upland and Central Gulf Coast subdivisions.</td>
</tr>
<tr>
<td><strong>Contribution to representation and stratification of:</strong></td>
<td>Unique assemblages of deep-water tinajas.</td>
</tr>
<tr>
<td>Natural community elements</td>
<td>One of the three significant occurrences of the Dune Complex community on the BMGR; contains the best expression of dune endemic plant species and one of two populations of Cowles fringe-toed lizard on the BMGR.</td>
</tr>
<tr>
<td>Species elements</td>
<td>Dune-fringe habitat to the west of the Yuma Dunes potentially contains an occurrence of Creosotebush-Big Galleta Scrub.</td>
</tr>
<tr>
<td>Ecological gradients</td>
<td>Northern expression of the Elephant Tree-Limberbush on Xeric Rocky Slopes community (most of the community’s distribution is in Sonora, Mexico).</td>
</tr>
<tr>
<td></td>
<td>Concentrated areas of Valley and Mountain Xeroriparian Scrub communities.</td>
</tr>
<tr>
<td></td>
<td>One of the largest unfragmented blocks of Creosotebush-Bursage Desert Scrub on the BMGR.</td>
</tr>
<tr>
<td></td>
<td>Only occurrence of the flat-tailed horned lizard on the BMGR; occupied habitat (which is encompassed by the Special Natural Area boundary) represents the majority of the range for the species in Arizona (Foreman 1997).</td>
</tr>
<tr>
<td></td>
<td>Other species elements that are captured within this special natural area include: desert bighorn sheep, valley bottom reptile guild, kit fox, and Le Conte’s thrasher.</td>
</tr>
<tr>
<td></td>
<td>Ecological gradients captured include: valley bottom to mountain top, xeroriparian strips within matrix communities, and dune complex to dune fringe habitats.</td>
</tr>
<tr>
<td><strong>Ecological integrity:</strong></td>
<td>Encompasses all of the Yuma Dunes and most of its associated dune-fringe habitat occurring in the Yuma Desert.</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>Encompasses most of the range of occurrence of the flat-tailed horned lizard in the Yuma Desert.</td>
</tr>
<tr>
<td><strong>Condition (composition, structure, and function)</strong></td>
<td>Contains a large, mostly intact (unfragmented) portion of the lower Lechuguilla Desert.</td>
</tr>
<tr>
<td><strong>Landscape context (connectivity)</strong></td>
<td>Except for localized disturbances resulting from military, Border Patrol, and public recreational activities, natural communities generally retain their composition, structure, and function. Some artificial water development has occurred within the Tinajas Altas Mountains.</td>
</tr>
<tr>
<td></td>
<td>Enables connectivity between the Tinajas Altas Mountains, and its associated desert bighorn sheep population, and the Cabeza Prieta Mountains on the Cabeza Prieta NWR.</td>
</tr>
<tr>
<td></td>
<td>Enables connectivity through the pass connecting the Lechuguilla Desert and Mohawk Valley and the Copper and Cabeza Prieta Mountains.</td>
</tr>
</tbody>
</table>
### Table 11.1 Ecological Attributes of Proposed Special Natural Areas on the Barry M. Goldwater Range—continued

<table>
<thead>
<tr>
<th>Attribute Category</th>
<th>Special Natural Area</th>
</tr>
</thead>
</table>
| **Coarse filter function for:**  
  • Rare species  
  • Endemics | • Occurrences of at least six different natural community elements are captured.  
  • Yuma Dunes contains a number of rare, dune endemic species  
  • Only documented occurrence of Peirson’s milk-vetch (*Astragalus magdalenae var. peirsonii*) in Arizona (species is federal-listed as threatened).  
  • Appendix H identifies the relationship between potential species conservation elements, many of which are rare and/or Sonoran Desert Ecoregion endemics and only some of which finally qualified as species conservation elements for the BMGR, and the natural community conservation elements. The information in the table can be used to assist in determining which species may be nested (captured by the coarse filter for management purposes) under a particular natural community. |
| **Anthropogenic disturbance levels** | • The boundary of the special natural area skirts several ground support areas.  
  • Auxiliary Field No. 2, 2 inert bomb target areas, 2 ground support areas, an Explosive Ordnance Disposal operating area, a rifle range, and 2 inactive target areas are included as inclusions. Combined area of the inclusions represents about 0.5% of the total area.  
  • The area includes a few artificial/modified water developments.  
  • Public access is not authorized in the western portion of the special natural area (west of the Davis Plain), but is authorized by permit within the eastern portion.  
  • Areas of the previously designated Tinajas Altas Mountains Area of Critical Environmental Concern have received in the past intense public recreational use leading to ground disturbance.  
  • Road density is 0.0007 miles/acre. |
| **Additional boundary considerations** | • Encompasses two previously designated Bureau of Land Management (BLM) Areas of Critical Environmental Concern, Gran Desierto Dunes and Tinajas Altas Mountains, portions of the BLM designated El Camino del Diablo Backcountry Byway, and the Yuma Desert Flat-tailed Horned Lizard Habitat Management Area. |
| **Opportunities for coordinated management across jurisdictions** | • Contiguous across its eastern boundary with the Cabeza Prieta National Wildlife Refuge. |

**Mohawk-San Cristobal Complex**

| Geographic description | • Located within the west-central portion of the BMGR, extending from the northern to the southern boundary, east of the Copper Mountains and west of the Aguila Mountains, west of the South and North Tactical Ranges, and adjoining the Cabeza Prieta National to the south.  
  • Encompasses the Mohawk-Sand Cristobal Dunes and those portions of the Mohawk Valley, Mohawk Mountains, San Cristobal Valley, Granite Mountains, and eastern Growler Valley that occur on the BMGR. Total area equals 408,368 acres.  
  • Includes land cover representative of both the Arizona Upland and Lower Colorado River Valley subdivisions. |
## TABLE 11.1 Ecological Attributes of Proposed Special Natural Areas on the Barry M. Goldwater Range—continued

<table>
<thead>
<tr>
<th>Attribute Category</th>
<th>Special Natural Area</th>
</tr>
</thead>
</table>
| Contribution to representation and stratification of: | • One of two occurrences of a Desert Playa community on the BMGR, which includes a large population of Castela emoryi (P. Warren, pers. comm.).  
• Two of the three significant occurrences of the Dune Complex community on the BMGR, which include a potentially unique population of Cowles fringe-toed lizard (the Mokawk Dunes were identified by the BLM [1989] as the largest and least disturbed dune system in Arizona).  
• Only occurrences of the Valley Bottom Floodplain community on the BMGR.  
• Concentrated areas of Valley and Mountain Xeroriparian Scrub communities.  
• Western-most expressions (low end of the precipitation gradient) on the BMGR of Paloverde-Mixed Cacti-Mixed Scrub on Bajadas and on Rocky Slopes.  
• One of the largest unfragmented blocks of Creosotebush-Bursage Desert Scrub on the BMGR.  
• One of two potential occurrences of Salt Desert Scrub on the BMGR.  
• Large portion of the northern range of the U.S. population of the Sonoran pronghorn.  
• Large population of desert bighorn sheep in the Mohawk Mountains.  
• Bat guild roost locations.  
• Other species elements that are captured within this special natural area include: valley bottom reptile guild, desert tortoise, kit fox, Le Conte’s thrasher, and primary excavator (cavity) guild.  
• Ecological gradients captured include: valley bottom to mountain top, mountain to mountain (across relatively narrow passes), xeroriparian strips within matrix communities, and dune complex to dune fringe habitats. |
| Category | Size  
Condition (composition, structure, and function)  
Landscape context (connectivity) | • Encompasses all of the Mohawk and San Cristobal Dunes and the associated dune-fringe habitat occurring on the BMGR.  
• The preceding dune complex area encompasses the entire range of the local population of Cowles fringe-toed lizard; however, historic connectivity with the Gran Desierto (Yuma Desert) population along the Gila River corridor has been lost because of conversion to agriculture.  
• Contains a large, mostly intact (unfragmented) portion of the upper Mohawk Valley.  
• Includes most of the Valley Bottom Floodplain Complex community and, at least to the west, its associated watershed.  
• Except for localized disturbances resulting from military, Border Patrol, and public recreational activities, natural communities generally retain their composition, structure, and function. East Tactical Range, Explosive Ordnance Disposal five-year sweep zones are outside the margins of the Valley Bottom Floodplain Complex in the Growler Valley (B. Tunnicliff, pers. comm.). Some artificial water development has occurred within the Mohawk Mountains.  
• Enables connectivity between the Mohawk, San Cristobal, and Growler Valleys and the Granite and Mohawk Mountains east to west and north to south into the Cabeza Prieta NWR, which provide movement corridors for Sonoran pronghorn and desert bighorn sheep.  
• Enables connectivity through the pass connecting the north and south portions of the Mohawk Mountains. |
**TABLE 11.1** Ecological Attributes of Proposed Special Natural Areas on the Barry M. Goldwater Range—continued

<table>
<thead>
<tr>
<th>Attribute Category</th>
<th>Special Natural Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse filter function for: Rare species Endemics</td>
<td>• Occurrences of at least eight different natural community elements are captured. • Appendix H identifies the relationship between potential species conservation elements, many of which are rare and/or Sonoran Desert Ecoregion endemics and only some of which finally qualified as species conservation elements for the BMGR, and the natural community conservation elements. The information in the table can be used to assist in determining which species may be nested (captured by the coarse filter for management purposes) under a particular natural community.</td>
</tr>
<tr>
<td>Anthropogenic disturbance levels</td>
<td>• The boundary of the special natural area skirts the Explosive Ordnance Disposal five-year sweep area (sweep area recently reduced; see text) for the South Tactical Range (potential areas of overlap are likely due to errors in mapping accuracy of the Valley Bottom Floodplain Complex in the Growler Valley in relation to the five-year sweep area), Stoval Auxiliary Field, and several ground support areas. • Six ground support areas are included as inclusions. Combined area of the inclusions represents about 0.4% of the total area. • The area includes a few artificial/modified water developments. • Public access is either not authorized or prohibited without special permission within the eastern portion of the special natural area, but is authorized by permit within the western portion. • Road density is 0.0006 miles/acre.</td>
</tr>
<tr>
<td>Additional boundary considerations</td>
<td>• Encompasses the previously designated Bureau of Land Management’s Mohawk Mountains and Sand Dunes Area of Critical Environmental Concern.</td>
</tr>
<tr>
<td>Opportunities for coordinated management across jurisdictions</td>
<td>• Contiguous across its southern boundary with the Cabeza Prieta National Wildlife Refuge.</td>
</tr>
<tr>
<td>Geographic description</td>
<td>• Located in the east-central portion of the BMGR along the northern boundary, west of Manned Range No. 4, north of the Crater Range, and adjoining to the north a formally withdrawn parcel to be relinquished back to Bureau of Land Management in November 2001. • Encompasses the Sentinel Plain lava flow area. Total area equals 55,996 acres. • Includes land cover representative of the Lower Colorado River Valley subdivision.</td>
</tr>
</tbody>
</table>

*Sentinel Plain Lava Flow*
### TABLE 11.1 Ecological Attributes of Proposed Special Natural Areas on the Barry M. Goldwater Range—continued

<table>
<thead>
<tr>
<th>Attribute Category</th>
<th>Special Natural Area</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contribution to representation and stratification of:</strong></td>
<td></td>
</tr>
<tr>
<td>• Natural community elements</td>
<td></td>
</tr>
<tr>
<td>• Species elements</td>
<td></td>
</tr>
<tr>
<td>• Ecological gradients</td>
<td></td>
</tr>
<tr>
<td>Only documented occurrence of Creosotebush-Big Galleta Scrub on the BMGR.</td>
<td></td>
</tr>
<tr>
<td>Part of the largest lava flow in southern Arizona; local substrate may contribute to locally adapted (melanistic) faunal populations (Turner and others 2000).</td>
<td></td>
</tr>
<tr>
<td>Inclusion of the lava flow captures a unique substrate within the BMGR.</td>
<td></td>
</tr>
</tbody>
</table>

| Ecological integrity: |
| Size |
| Condition (composition, structure, and function) |
| Landscape context (connectivity) |
| Except for localized disturbances resulting from military activities, natural communities generally retain their composition, structure, and function. |
| Enables connectivity with the BLM portion of the Sentinel Plain to the north. |

| Coarse filter function for: |
| Rare species |
| Endemics |
| Occurrences of at least three different natural community elements are captured. |
| Appendix H identifies the relationship between potential species conservation elements, many of which are rare and/or Sonoran Desert Ecoregion endemics and only some of which finally qualified as species conservation elements for the BMGR, and the natural community conservation elements. The information in the table can be used to assist in determining which species may be nested (captured by the coarse filter for management purposes) under a particular natural community. |

| Anthropogenic disturbance levels |
| The boundary of the special natural area skirts the Explosive Ordnance Disposal five-year sweep area (sweep area recently reduced; see text) associated with Manned Range No. 4. |
| A retired target area is included as an inclusion. The area of the inclusion represents about 0.5% of the total area. |
| Public access is either not authorized or prohibited without special permission. |
| Road density is 0.00011 miles/acre. |

| Additional boundary considerations |
| Encompasses most of the BMGR portion of the previously designated Bureau of Land Management’s Sentinel Plain Lava Flow Special Recreation Management Area. |
### TABLE 11.1 Ecological Attributes of Proposed Special Natural Areas on the Barry M. Goldwater Range—continued

<table>
<thead>
<tr>
<th>Attribute Category</th>
<th>Special Natural Area</th>
</tr>
</thead>
</table>
| Opportunities for coordinated management across jurisdictions | • Contiguous with one of the parcels that will be relinquished by the Air Force as of November 2001.  
• The responsible land manager of the above parcel once relinquished, the Director, Bureau of Land Management, received direction from the Secretary of the Interior (via a letter dated 19 January 2001) to manage the area in a manner that will maintain and enhance its scientific and historic resources. |

**Sand Tank-Sauceda Mountains**

| Geographic description | Sand Tank Mountains Upland community has its only occurrence on the BMGR here (it extends into the adjoining Area A); more importantly, the unusual combination of plant species that occur within the higher elevations of this community (some representing relict populations of chaparral vegetation stranded after the last ice age) is found rarely within the ecoregion (only reported similar combination of plants occurs at the upper elevations of the Ajo Mountains [Turner and others 2000]).  
• Paloverde-Mixed Cacti-Mixed Scrub community in the Sand Tank Mountains is one of the most structurally complex examples found in the Sonoran Desert, both in terms of species composition and evenness of plant distribution (Turner and others 2000) and the community’s occurrence across the whole special natural area is the largest and most intact expression of the bajada and rocky slope types on the BMGR.  
• Numerous tinajas.  
• Bat guild roost locations and potential foraging areas for the lesser long-nosed bat.  
• Largest combined population of desert bighorn sheep on the BMGR.  
• Possibly the largest population of desert tortoise on the BMGR.  
• Other species elements that are captured within this special natural area include: kit fox, primary excavator (cavity) guild, and ephemeral water-breeding amphibian guild.  
• Ecological gradients captured include: valley bottom to mountain top and xeroriparian strips within matrix communities. |

<table>
<thead>
<tr>
<th>Contribution to representation and stratification of:</th>
<th>Sand Tank-Sauceda Mountains</th>
</tr>
</thead>
</table>
| • Natural community elements                         | • Located within the eastern portion of the BMGR, east of Highway 85, surrounding the East Tactical Range and Manned Range No. 3, and adjoining the Sonoran Desert National Monument to the northeast.  
• Encompasses the Sand Tank and Sauceda Mountains and bajadas/low desert valleys northeast and southwest of the Sauceda Mountains. Total area equals 224,135 acres.  
• Mostly includes land cover representative of the Arizona Upland subdivision, though the Lower Colorado River Valley subdivision is represented in the low desert areas. |
| • Species elements                                  | • Sand Tank Mountains Upland community has its only occurrence on the BMGR here (it extends into the adjoining Area A); more importantly, the unusual combination of plant species that occur within the higher elevations of this community (some representing relict populations of chaparral vegetation stranded after the last ice age) is found rarely within the ecoregion (only reported similar combination of plants occurs at the upper elevations of the Ajo Mountains [Turner and others 2000]).  
• Paloverde-Mixed Cacti-Mixed Scrub community in the Sand Tank Mountains is one of the most structurally complex examples found in the Sonoran Desert, both in terms of species composition and evenness of plant distribution (Turner and others 2000) and the community’s occurrence across the whole special natural area is the largest and most intact expression of the bajada and rocky slope types on the BMGR.  
• Numerous tinajas.  
• Bat guild roost locations and potential foraging areas for the lesser long-nosed bat.  
• Largest combined population of desert bighorn sheep on the BMGR.  
• Possibly the largest population of desert tortoise on the BMGR.  
• Other species elements that are captured within this special natural area include: kit fox, primary excavator (cavity) guild, and ephemeral water-breeding amphibian guild.  
• Ecological gradients captured include: valley bottom to mountain top and xeroriparian strips within matrix communities. |
| • Ecological gradients                              | • Sand Tank Mountains Upland community has its only occurrence on the BMGR here (it extends into the adjoining Area A); more importantly, the unusual combination of plant species that occur within the higher elevations of this community (some representing relict populations of chaparral vegetation stranded after the last ice age) is found rarely within the ecoregion (only reported similar combination of plants occurs at the upper elevations of the Ajo Mountains [Turner and others 2000]).  
• Paloverde-Mixed Cacti-Mixed Scrub community in the Sand Tank Mountains is one of the most structurally complex examples found in the Sonoran Desert, both in terms of species composition and evenness of plant distribution (Turner and others 2000) and the community’s occurrence across the whole special natural area is the largest and most intact expression of the bajada and rocky slope types on the BMGR.  
• Numerous tinajas.  
• Bat guild roost locations and potential foraging areas for the lesser long-nosed bat.  
• Largest combined population of desert bighorn sheep on the BMGR.  
• Possibly the largest population of desert tortoise on the BMGR.  
• Other species elements that are captured within this special natural area include: kit fox, primary excavator (cavity) guild, and ephemeral water-breeding amphibian guild.  
• Ecological gradients captured include: valley bottom to mountain top and xeroriparian strips within matrix communities. |
### Table 11.1 Ecological Attributes of Proposed Special Natural Areas on the Barry M. Goldwater Range—continued

<table>
<thead>
<tr>
<th>Attribute Category</th>
<th>Special Natural Area</th>
</tr>
</thead>
</table>
| **Ecological integrity:**  
  • Size  
  • Condition (composition, structure, and function)  
  • Landscape context (connectivity) |  
  • Contains largest and most intact expression of the Paloverde-Mixed Cacti-Mixed Scrub bajada and rocky slope community types on the BMGR.  
  • Except for localized disturbances resulting from military and public recreational activities, natural communities generally retain their composition, structure, and function. Substantial artificial water development has occurred within the Sand Tank and Sauceda Mountains.  
  • Captures portions of the lower bajadas and valley bottoms adjoining the Sauceda Mountains both to the southwest and northeast.  
  • Enables connectivity between the Sauceda and Sand Tank Mountains, which provides movement corridors for desert bighorn sheep.  
  • Enables connectivity to that portion of the Sand Tank Mountains contained within the Sonoran Desert National Monument and to the mountain ranges that extend to the south of the special natural area. |
| **Coarse filter function for:**  
  • Rare species  
  • Endemics |  
  • Occurrences of at least seven different natural community elements are captured.  
  • Appendix H identifies the relationship between potential species conservation elements, many of which are rare and/or Sonoran Desert Ecoregion endemics and only some of which finally qualified as species conservation elements for the BMGR, and the natural community conservation elements. The information in the table can be used to assist in determining which species may be nested (captured by the coarse filter for management purposes) under a particular natural community. |
| **Anthropogenic disturbance levels** |  
  • The boundary of the special natural area skirts the Explosive Ordnance Disposal five-year sweep areas (sweep areas recently reduced; see text) for Manned Range No. 3 and the East Tactical Range.  
  • The area includes numerous artificial/modified water developments.  
  • A railroad grade separates the eastern portion of the previously designated Crater Range Special Recreation Management Area from the rest of the special natural area; otherwise this grade is used as the western boundary of the special natural area.  
  • Public access within a large portion of the special natural area (Area B) is authorized by permit; otherwise areas associated with Manned Range No. 3 and the East Tactical Range airspace are either not authorized for public access or prohibited without special permission.  
  • Road density is 0.0010 miles/acre. |
| **Additional boundary considerations** |  
  • Encompasses the eastern portion (east of Highway 85) of the previously designated Bureau of Land Management’s Crater Range Special Recreation Management Area and the Air Force’s Area B Recreation Management Area. |
| **Opportunities for coordinated management across jurisdictions** |  
  • Contiguous to the northeast with the newly proclaimed Sonoran Desert National Monument, a portion of which is a parcel that will be relinquished by the Air Force as of November 2001 and to the south with the Tohono O’odham Nation and the Bureau of Land Management’s Coffee Pot Mountain Botanical Area of Critical Environmental Concern.  
  • The Department of Defense already has expressed a desire, within the Final Legislative Environmental Impact Statement for continued military withdrawal of the Barry M. Goldwater Range, to coordinate management of the Sand Tank Mountains area with the Bureau of Land Management. |
Because the proposed area encompasses the existing BLM Gran Desierto Dunes ACEC, the boundaries include the occurrences of dune endemic plant species associated with the Yuma Dunes and encompass the local Yuma Dune population of Cowles fringe-toed lizard (though the management concern for this population also includes maintaining connectivity with the Mexico population within the Gran Desierto). The boundaries also encompass the sand sheet habitat that is necessary to ensure the long-term persistence of the flat-tailed horned lizard. The Tinajas Altas Mountains area includes tinajas (natural and modified), a population of desert bighorn sheep, an example of the Elephant Tree-Limberbush on Xeric Rocky Slopes natural community. Mountain Xeroriparian Scrub communities, and Creosotebush-Bursage Desert Scrub mixed with Valley Xeroriparian Scrub communities on the adjacent Davis Plain to the west of the mountains. The southern portion of the Lechuguilla Desert is a relatively unroaded expanse of Creosotebush-Bursage Desert Scrub mixed with Valley Xeroriparian Scrub communities. Its inclusion within the Special Natural Area creates mountain-valley-mountain protected areas through linkage with protected areas on the Cabeza Prieta National Wildlife Refuge. This would benefit area-dependent species such as the desert bighorn sheep (that is, it would provide a safe movement corridor between mountain ranges: Tinajas Altas and Cabeza Prieta Mountains and Copper and Cabeza Prieta Mountains), as well as the valley bottom reptile guild members, kit fox (*Vulpes macrotis*), and Le Conte’s thrasher (*Toxostoma lecontei*).

### 11.4.2 Mohawk-San Cristobal Complex Special Natural Area

We recommend a significant expansion of the existing Mohawk Mountains and Sand Dunes ACEC to form the proposed Mohawk-San Cristobal Complex Special Natural Area (Figure 11.1). In addition to the resource values identified by the Bureau of Land Management (1989), the existing ACEC boundary encompasses: an example of a Desert Playa community (one of two occurrences on the BMGR); roost sites for two members of the bat guild; documented habitat usage by Sonoran pronghorn; and examples of Paloverde-Mixed Cacti-Mixed Scrub on Bajadas and on Rocky Slopes (western-most expression of these communities on the BMGR), Valley and Mountain Xeroriparian Scrub, and Creosotebush-Bursage Desert Scrub.

The recommended eastern expansion of the existing ACEC would encompass: the full extent of the Valley Xeroriparian Scrub communities to the east of Mohawk Mountain, the majority of the Valley Bottom Floodplain Complex community within the San Cristobal Valley and that portion that courses to the south and west of the South Tactical Range in the Growler Valley (only expressions of this community on the BMGR), and the BMGR portion of the Granite Mountains and the surrounding valleys. The proposed eastern boundary is the road that runs to the west of the pre-August 2001, five-year Explosive Ordnance Disposal (EOD) sweep areas for the South Tactical Range. Inclusion of the Granite Mountains and surrounding valleys would protect the entirety of the southern extent of the Sand Cristobal Valley. The expanded area would protect habitat for the Sonoran pronghorn, valley bottom reptile guild, desert tortoise (*Gopherus agassizii*), kit fox, Le Conte’s thrasher, desert bighorn sheep, primary excavator (cavity) guild, and potentially crucifixion thorn (*Castella emoryi*). An example of a Salt Desert Scrub community is located in the San Cristobal Valley near the eastern edge of the proposed expansion. The eastern boundary for the proposed expansion would be formed by the road that trends from the northwest to the southeast in the northern San Cristobal Valley, passes north of the Granite Mountains, then runs along the western boundary of the South Tactical Range, and finally terminates at the boundary with Cabeza Prieta National Wildlife Refuge. Boundary adjustments may be necessary to ensure appropriate resources values are protected (for example, the actual location and condition of the Salt Desert Scrub communities).
community may necessitate a boundary adjustment to protect the occurrence). The proposed expansion would create a broad linkage with potentially similarly managed areas on Cabeza Prieta.

The recommended western expansion of the existing ACEC would encompass the Mohawk Valley to the west of the Mohawk Dunes and southern portion of the Mohawk Mountains. This valley is a largely unroaded expanse of low desert. Marine ground support areas are generally located to the west of the unroaded area (U.S. Department of the Air Force 1998). As a result, the western boundary is proposed to use roads just east of the Copper Mountains, exclusive of ground support areas. Inclusion of this area within the Special Natural Area would protect a large expanse of Creosotebush-Bursage Desert Scrub that contains a fair representation of Valley Xeroriparian Scrub. Despite their limited areal extent, xeroriparian habitats are disproportionately the most important habitats for wildlife, especially in the more arid parts of the Sonoran Desert. It also would protect the habitat of those species that are associated with dune-fringe habitat rather than the dunes themselves, such as members of the valley bottom reptile guild. Finally, inclusion of the area would also protect habitat for the Sonoran pronghorn, kit fox, and Le Conte’s thrasher.

Military training within the proposed Special Natural Area includes limited ground activities, so the proposed expansions should not impact the training mission. Some degree of public access is permitted within a significant portion of the proposed Special Natural Area. The Mohawk and San Cristobal Dunes are the most susceptible resources in the area, as far as the impacts of recreational activities are concerned. We recommend that the impact of invasive species on the natural communities contained within the Special Natural Area should be evaluated and appropriate abatement strategies, if necessary, implemented. Additionally, the impact of existing roads on the functioning of the Valley Bottom Floodplain Complex community should be evaluated and if deemed to be detrimental to the long-term persistence of this community, then appropriate mitigation measures should be implemented (for example, roads that adversely impact the sheet flow hydrology characteristic of the community should be removed from service and restored).

One other consideration potentially affects either the appropriate ecological boundary of the Special Natural Area or the ability to maintain the natural communities that are contained within. Part of the Valley Bottom Floodplain Complex community is either potentially located within the pre-August 2001, five-year EOD sweep area for the South Tactical Range or may be affected by South Tactical Range activities farther up in the watershed. The Air Force recently reduced the potential areal extent of the five-year EOD sweep area.¹⁷ As a result, the reduction in the five-year sweep area for the South Tactical Range may enable: (1) further expansion of the Special Natural Area boundary to better capture natural resources of interest and/or (2) reduce potential impacts to the Valley Bottom Floodplain Complex community by facilitating improved watershed condition. To the extent achievable and compatible with military mission requirements, the Air Force should try to conduct its activities within the Growler Valley in a manner that avoids or at least minimizes ground-disturbing activities. Such actions would not only

¹⁷The Air Force recently implemented Air Force-wide in August 2001 new requirements (criteria) for controlling the surface buildup of both inert and live munitions (Air Force Instruction 13–212 Volume I, Training and Test Range Policy, Section 8.4, dated 19 April 1999). Previous surface clearance criteria specified annual and five-year clearance distances away from targets for both manned ranges and tactical ranges of 305 meters (1000 feet; 4000 feet for manned range target areas used for simulated nuclear weapons drops) and one nautical mile (6076 feet) or to the distance at which the density of munitions on the surface is reduced to five or less complete ordnance items per acre (whichever distance is farther from the target), respectively. Additionally, manned ranges were cleared every 50 use-days to a distance of 100 meters away from the target. Current criteria extends the manned range use-days requirements for clearance from 50 to 75 days, standardizes the annual clearance distance requirement at 305 meters, and reduces the five-year clearance requirement to a radius of 1000 meters surrounding each target, or until a density factor of less than or equal to five complete ordnance items per acre is reached, whichever distance is farther from the target.
help to maintain the ecological integrity of the Valley Bottom Floodplain Complex community, but it also would provide another intact mountain-valley-mountain complex from the Growler Mountains to the Granite Mountains.

11.4.3 Sentinel Plain Lava Flow Special Natural Area

We recommend establishing a Special Natural Area north of the North Tactical Range. The recommended boundaries roughly correspond to the BMGR portion of the Sentinel Plain Lava Flow Special Recreation Area (Bureau of Land Management 1989), except that we have excluded the pre-August 2001 five-year EOD sweep areas associated with Manned Range No. 4 (Figure 11.1). The proposed area encompasses the BMGR portion of the Sentinel Plain lava flow, a 225 square mile volcanic field consisting of basalt flows up to 100 feet thick and the largest lava flow in southern Arizona (Bureau of Land Management 1989, 2000).

The proposed Sentinel Plain Lava Flow Special Natural Area contains the only currently documented occurrence of Creosotebush-Big Galleta Scrub on the BMGR, though other occurrences likely occur on the sand plains surrounding the Yuma Dunes. As the lava flow captures a unique substrate, the associated fauna may show local adaptations not found elsewhere on the BMGR. The natural communities that occur within the area generally retain their composition, structure, and function because most of the area has been subjected to minimal ground-disturbing activities for the past 60 years or more. Because of how BLM intends to manage the adjoining 24,756 acre parcel to the north of this area (Bureau of Land Management 2000), designation as a Special Natural Area is a compatible designation and presents opportunities for coordinated management at a larger landscape-scale than is otherwise achievable.

11.4.4 Sand Tank-Sauceda Mountains Special Natural Area

We recommend establishing a Special Natural Area in the eastern part of the BMGR. The proposed area would include most of Area B (except for small portions along the eastern margin of Highway 85) and the portions of the Sand Tank and Sauceda Mountains, and their associated upper bajadas, that surround the East Tactical Range and that occur within the boundary of the BMGR (Figure 11.1). The proposed outer boundaries would include: (1) the BMGR’s southern boundary east of Highway 85 (part of this boundary actually runs north-south due south of the center of the East Tactical Range), (2) its boundary with Area A to the northeast (in accordance with the Military Lands Withdrawal Act of 1999, Area A, currently a part of the BMGR, will be relinquished by the Air Force as of November 7, 2001), and (3) its relatively small eastern boundary. The railroad line immediately east of Highway 85 would form the western boundary of the Special Natural Area, except for where the highway forms the boundary for the eastern portion of the current Crater Range Special Recreation Management Area (Bureau of Land Management 1989), from the BMGR’s southern boundary north to a mostly east-west trending road that runs through the southeastern portion of Manned Range No. 3’s four nautical mile radius airspace perimeter. The inside boundaries (that is, around Manned Range No. 3 and the East Tactical Range) are proposed to take advantage of the roads that are closest to the pre-August 2001, five-year EOD sweep areas, without crossing inside the sweep area, or otherwise use the sweep zone boundary as the boundary for the Special Natural Area to protect as much of the upper bajadas as possible.

Seven different natural community conservation elements would be protected within the proposed natural area: Creosotebush-Bursage Desert Scrub, Paloverde-Mixed Cacti-Mixed Scrub on Bajadas and on Rocky Slopes, Sand Tank Mountains Uplands, Mountain and Valley Xeroriparian Scrub, and Desert Tinaja/Spring. The Sand Tank Mountains Uplands community contained within the area is the only occurrence on the BMGR; it extends into the adjoining Area A, but it may have only limited occurrences elsewhere within the Sonoran Desert Ecoregion (Turner and others 2000). The Creosotebush-Bursage Desert Scrub community between the Sauceda Mountains and Highway 85 would protect a mountain-
valley complex in the eastern portion of the range (given that the South Tactical Range occupies this community type between the Sand Tank and Sauceda Mountains). The Paloverde-Mixed Cacti-Mixed Scrub communities within the proposed Special Natural Area are the largest and most intact expressions of the bajada and rocky slope community types. Species conservation elements that occur within the area include: two members of the bat guild that have roost sites here (individuals of the lesser long-nosed bat \[Leptonycteris curasoae yerbabuenae\] also have been observed foraging in the area), desert bighorn sheep (largest combined population on the BMGR), kit fox, primary excavator (cavity) guild, desert tortoise (possibly the largest population of this species on the BMGR), and the ephemeral water-breeding amphibian guild. Finally, the area contains potential habitat for the federally endangered cactus ferruginous pygmy-owl (\[Glaucidium brasilianum cactorum\]).

The Crater Range Special Recreation Management Area portion of the Special Natural Area functions as movement corridor for desert bighorn sheep and contains a significant tinaja (not shown on Figure 6.1). Although not the subject of this document, this area also contains significant cultural resources. The area currently is subject to habitat disturbance from motor vehicles, though there are few roads, and collectors of herpetofauna and would benefit from more rigorous management standards (B. Barry).

As proposed, this Special Natural Area potentially will have a robust landscape context. The recently designated Sonoran Desert Monument abuts the northeast boundary of the Special Natural Area (Figure 11.2). The monument, at just over 486,000 federal acres, includes Area A (temporarily under Air Force administration until November 7, 2001 when it would be relinquished to the Bureau of Land Management), Vekol Valley and Table Top Mountain to the east of Area A, and the South and North Maricopa Mountains and associated valleys to the north of Area A. In the Final Legislative Enviromental Impact Statement for renewal of the BMGR land withdrawal, the Air Force indicated its desire to coordinate management of the Sand Tank Mountains region with the Bureau of Land Management to support both military requirements (for example, access control) and management and protection of the natural (and cultural) resources of the area. Designation of the Sand Tank-Sauceda Mountains Special Natural Area would assist the Air Force in this undertaking. Additionally, establishing the southern boundary of the Special Natural Area coincident with the BMGR’s southern boundary will enable coordinated management with such areas as the Coffee Pot Mountain Botanical ACEC and lands administered by the Tohono O’odham Nation.

11.4.5 Assessment of the Proposed Network of Special Natural Areas

The proposed network of Special Natural Areas described above generally includes, both in terms of representation of individual conservation elements and their stratification, examples of much of the biodiversity of the BMGR. In regard to specialized habitats, all major Dune Complex and Dune Endemics examples were included, one of two Desert Playas that are present on the BMGR was included, and many examples of Desert Tinaja/Spring were included. Although one Desert Playa and potentially many Desert Tinaja/Spring communities were left outside the protection boundaries of the proposed Special Natural Areas, these rare communities should be protected wherever they occur; however, outside of a Special Natural Area they are less likely to have their landscape context protected as well.

The one existing example of Sand Tank Mountains Uplands community was included within the proposed Sand Tank-Sauceda Mountains Special Natural Area. Only one example of the Elephant Tree-Limberbush on Xeric Rocky Slopes community was included within the network. Given the rarity of this community within the U.S. (though it is perhaps extensively represented in Mexico and another example is present on Cabeza Prieta), this may be a shortcoming of the proposed network of Special Natural Areas. Additionally, the one documented occurrence of the Creosotebush-Big Galleta Scrub community on the BMGR occurs within the Sentinel Plain Lava Flow Special Natural Area west of Manned Range No. 4; however, it is likely that other currently undocumented occurrences of this community type are
present on the BMGR. The Salt Desert Scrub community occurrences still require additional evaluation as to extent and condition; however, at least one of the two known possible occurrences of this community on the BMGR is potentially included within the proposed expansion of the Mohawk-San Cristobal Complex Special Natural Area. The preceding Special Natural Area also would include a significant portion of the Valley Bottom Floodplain Complex community. Full management and protection of the Growler Valley occurrence of this community would require careful management of ground-disturbing activities associated with the operation of the South Tactical Range.

Good representation of the Paloverde-Mixed Cacti-Mixed Scrub communities was achieved across the east-west ecological gradient. Xeroriparian communities are important habitat for wildlife wherever they occur, but especially in the more arid regions of the BMGR. We attempted to include as much representation of these communities as we could, especially in areas that seemed to be heavily dissected. The Valley Xeroriparian Scrub community most often was found in association with the matrix-forming Creosotebush-Bursage Desert Scrub community. As a result, we took a landscape approach to find both the best examples (that is, relatively unroaded and unused by the military) of the combination of these two communities and the most favorable landscape context of their occurrences in regard to juxtaposition to other communities, such as dune complexes and upper bajadas/mountain ranges. To the extent achievable, we tried to create protected mountain-valley-mountain complexes, either within the BMGR or by using opportunities afforded by the proximity of non-BMGR management areas that could achieve management similar to a Special Natural Area.

Inclusion of both the northern portion of Mohawk Valley and the southern portion of Lechuguilla Desert within the network of Special Natural Areas is important because they both represent relatively undisturbed examples of low desert communities and because of their landscape context. They add to the overall ecological functioning of the adjoining dunes, upper bajadas, and mountain ranges and they themselves provide important habitat for species conservation elements, including in the case of the Mohawk Valley, the Sonoran pronghorn.

Representation and stratification was achieved for each species/guild conservation element. A significant portion of the Sonoran pronghorn’s habitat on the BMGR was included within the proposed the Mohawk -San Cristobal Complex Special Natural Area. Bat roosts were included in several areas; however, the cluster of roosts present in the northern portion of the Lechuguilla Desert were not included within a Special Natural Area. Several populations of desert bighorn sheep were included. Perhaps just as important, the Special Natural Areas would provide better protection of movement corridors for bighorn sheep between mountain ranges. Several locations important to kit fox, Le Conte’s thrasher, and the valley bottom reptile guild were included. Desert tortoises were included in their main population center on the BMGR, the Sand Tank and Sauceda Mountains, as well as on a few other mountain ranges within the BMGR. Similarly, a significant portion of the habitat of the primary excavator (cavity) guild was included. All populations of Cowles fringe-toed lizards were included. The entire manageable habitat of the flat-tailed horned lizard on the BMGR is included within the Yuma-Lechuguilla Deserts-Tinajas Altas Mountains Special Natural Area. Many breeding locations and associated habitat were included for the ephemeral water-breeding amphibian guild, though the distribution is biased toward the eastern end of the BMGR. By inclusion of the majority of the Valley Bottom Floodplain Complex, as well as the Mohawk Dunes and Playa, the most likely occurrences of Castela emoryi were included.

One caution is in order. The natural community conservation elements are fairly broadly defined, though our approach in using biophysical models to characterize them should capture some of their most biologically and management-relevant variation. Still, some of the matrix and large patch communities may include a number of plant associations that express themselves on a local scale in response to differences in microclimate, soils, and so on. Such expressions may be of ecological importance, but they are difficult to capture within the approach taken herein. One such example is the chain-fruit cholla

11.19
(Opuntia fulgida) “woodland” located near the western boundary of the East Tactical Range. Such occurrences need to be managed on a case-by-case basis as they are identified and their ecological role and importance assessed.

11.5 LAND MANAGEMENT CATEGORIES AND ASSOCIATED MANAGEMENT STANDARDS

As described in section 11.1, land management units that share similarities in ecological condition and land use and that can be addressed by a similar set of management standards can be assigned to a common land management category. Moreover, the emphasis on meeting conservation goals versus other desired human uses of the land differs between categories. Present ecological condition and land use, as well as opportunities for restoration, constrain the assignment of a particular land management category to any specified geographic area. In previous sections we provided recommendations and justifications for one particular type of land management category, Special Natural Areas. In this section we complete our recommendations for different types of land management categories on the BMGR. Most importantly, we also outline recommended sets of management standards for each category that when implemented in aggregate across our recommended land management units will promote an appropriate level of biodiversity conservation and protection on the BMGR.

11.5.1 Land Management Categories

In addition to Special Natural Areas, we developed three other land management categories applicable to land management on the BMGR. In developing the suite of four categories, we accounted for the interaction between current ecological condition (that is, the status of the natural communities and their associated ecological processes within an area) and current and reasonably projected land uses (for example, some Marine ground support areas identified in U.S. Department of the Air Force [1998] have not yet been put into service). Land use included both military land use and recreation-based use. The intensity of land-use, insofar as intensity relates to the degree of ground-disturbance and conversion of natural land cover associated with any particular use, was used to differentiate different types of land use.

Table 11.2 provides general descriptions/examples of each proposed land management category and the range of ecological conditions that can be considered within a particular category. Figure 11.3 depicts the spatial delineation of each of the land management categories on the BMGR. It also provides some summary information on size and other quantitative information. Only the Special Natural Areas are separately identified as individual land management units for purposes of quantifying the preceding information.

Areas categorized as belonging to Urban/Intensive Use Areas tend to be relatively small in size. As a result, they were treated as inclusions within the other three land management categories. To qualify as a Special Natural Area, inclusions of Urban/Intensive Use Areas or areas not otherwise qualifying as Ecological Condition I (Table 11.2), must not exceed 5% of the total area. To distinguish between areas of the BMGR that qualified as either Moderate Use Areas or Urban/Intensive Use Areas, we relied in part on surface disturbance information resulting from various military activities as indicated in Table 3–6 in U.S. Department of the Air Force (1998; compare Figures 11.1 and 11.3 herein). Delineation of EOD sweep areas are based on the pre-2001 clearance criteria.\(^{18}\) As a result, the estimate of ground-disturbed areas should decline over time as recovery takes place. Calculations of road densities and inclusion percentages were accomplished post-hoc as a way of testing the veracity of our assignments of land management units to a particular land management category (Figure 11.3).

\(^{18}\)See footnote No. 17.
11.5.2 Management Standards Associated with Land Management Categories on the Barry M. Goldwater Range

Table 11.2 also provides recommended sets of management standards appropriate to each land management category. For the Moderate Use Areas category one of two possible sets of standards is meant to be applied depending on which ecological condition category is appropriate for the land management unit in question. For those Special Natural Areas that were based in part on previously delineated ACECs, our standards generally incorporate the Bureau of Land Management’s (1989) recommended management prescriptions. We added standards if we thought the BLM did not adequately address a particular natural resource management concern, such as in regard to invasive species, or to account for the landscape-scale nature of our recommended management areas.

Once planning is complete, the true test of management is implementation. To achieve the intent of each land management category designation, all of the standards associated with a particular category must be implemented. We do not know to what extent any of the BLM’s management prescriptions were implemented. A lack of previous implementation or new threat conditions would require modified or new management prescriptions for the existing ACECs, even if these areas are the only land management units that transition to Special Natural Areas under the Department of Defense’s oversight. As a result, a primary focus of the Air Force and Marines in the implementation of the Integrated Natural Resources Management Plan for the BMGR must be to ensure that adequate resources are made available to implement management standards and accomplish management goals.

Obviously, not all of the BMGR could be recommended for inclusion within a Special Natural Area. Areas outside of Special Natural Areas still require, however, appropriate management of military and recreational activities to protect natural (and cultural) resource values. The level of attention may be less and the permitted activities more than what occurs within a Special Natural Area, but natural resource management (or human activity management) must still occur nonetheless. Perhaps the simplest analogy is that in regard to natural resources the Special Natural Areas function as core areas and the remainder of the BMGR, except the urbanized and heavily disturbed areas, function as buffer areas. In this analogy, even the buffer areas have a role to play in the management and protection of biodiversity. As a result, ultimately the Department of Defense must implement appropriate management standards for both core and buffer areas.

In section 6.3 we described the Gap biodiversity management status of the BMGR at a coarse scale of analysis in relation to both remotely sensed communities and the natural community conservation elements described in this document. Gap status was assigned for the BMGR in a manner that tried to take into account both military use and public access considerations. Because the original gap status assignments were made on an ecoregional basis, the finer points of land management on the BMGR probably were missed. At ecoregional scales, such errors are acceptable if the goal is to have a coarse understanding of biodiversity management status over a broad region.

Are Gap status ranks (criteria) appropriate, useful, and assignable to land management units on the BMGR? The Gap criteria are quite general (and implicitly relate to differences in federal agency mandates toward natural resources management rather than actual management conditions); however, they can be used to develop corresponding management standards that generally meet the criteria. When applied spatially, they are useful as a short-hand way of demonstrating on an areal basis the land management status of a particular land management unit that is assumed to be managed uniformly. In Table 11.2 we have identified the correspondence between our recommended sets of management standards and the Gap biodiversity management status achieved if the standards are implemented. We have attempted to phrase the management standards, especially when they imply quantitative limits, such that they are consistent with the intent of Gap for the Gap status to which they correspond.
Because of the correspondence that can be made to Gap biodiversity management status achieved, faithful implementation of the management standards proposed herein, especially when applied to those land management units for which Gap status 1 or 2 can be achieved, provides the Department of the Defense with a powerful tool to demonstrate the comprehensiveness and rigor of their biodiversity management efforts as compared with their sister agencies. Such a demonstration can lead to: (1) public and tribal trust in the Air Force and Marine’s ability to be an effective steward of the BMGR’s natural (and cultural) resources, (2) credibility with the adjoining jurisdictions that the Air Force and Marines can be an effective and engaged cooperator in natural resource management issues within the Greater Goldwater Complex, and (3) credibility with regulating agencies that the Air Force and Marines are taking pro-active measures to not only meet natural resource-related compliance mandates today but to minimize the chances that additional measures may be needed in the future.
### Special Natural Areas

**Description/Examples**
- Areas that largely retain their natural land cover and ecological function at a landscape scale (generally 50,000 acres or more); human activities on the ground generally occur at a localized scale and do not result in altered natural community composition, structure, and function.
- **Examples:**
  - Previously defined Bureau of Land Management, Areas of Critical Environmental Concern
  - Newly designated areas for which the management goal is to protect the area from conversion of its natural land cover and to enable ecological processes to operate unimpeded

**Condition I:**
- Plant/natural communities and ecological processes closely approximate a "natural" state
- Low anthropogenic disturbance levels
- Little or no restoration needed (though continued maintenance activities may be necessary)

**Condition II:**
- Document management intent for the area through an agency management plan
- Demonstrate an institutional long-term intent to conserve the natural ecological function of the total ecosystem within the area, with no more than 5% of the area in anthropogenic use
- Avoid all new ground-disturbing activities or activities that would otherwise lead to the conversion of natural land cover in preference to siting such activities in areas other than Special Natural Areas
- Prohibit new rights-of-way and other land use authorizations
- Prohibit mineral, gas, oil, and borrow material extraction
- Prohibit artificial modifications or management manipulations of natural features (for example, water development projects) or processes (for example, prescribed fire) unless the modification/manipulation is necessary to mimic a missing ecological component or process, including natural disturbance regimes
- Prohibit livestock grazing; control entry by and remove trespass livestock and wild burros and horses
- Inventory, establish priorities for management by invasive species, geographic area, and, as appropriate, the natural community conservation element potentially impacted, and control invasive species to avoid/minimize adverse impacts to natural community composition, structure, and function
- Prohibit all off-road motorized and mechanized vehicle activity, including military, except when necessary for emergency purposes (for example, life-saving); limit vehicle use to designated roads; avoid/minimize vehicle-associated (including towed/dragged apparatus) transport of invasive species; maintain, close, and/or restore all roads, as appropriate, to minimize or eliminate adverse impacts to the ecological functioning of natural communities; prohibit new road construction unless necessary to replace an existing and necessary administrative road whose continued use is ecologically damaging and replacement results in a net ecological benefit
- Use and enforce a permit system, when a Special Natural Area is open to the public for recreational purposes, that can limit, if appropriate, the amount and intensity of recreational activities to preclude resource damage; establish ecological thresholds that would lead to management action to limit the adverse impacts of recreational activities before natural community composition, structure, and function is altered adversely; establish regular patrol and enforcement within the area to ensure resource values are protected
- Prohibit woodcutting and the taking of dead and down trees
- Confer protection to federally listed endangered and threatened species throughout the area
- Monitor the viability status of conservation elements and the status of threats to these elements and their abatement
- Restore to the extent feasible, when an area is no longer needed to support the military mission, the natural community composition, structure, and function of areas with evidence of significant natural resources damage or impairment; similarly, restore areas historically damaged by concentrated public recreational activities; restore previously modified tinajas pending an evaluation that considers both the potential beneficial and adverse effects of such actions
- Seek opportunities to coordinate management of Special Natural Areas, whose biotic elements of management concern ecologically extend across jurisdictional boundaries, with adjacent property owners/administrators, especially when such coordinated management may be necessary to maintain the functionality of and appropriate landscape context for the biotic elements contained within the Special Natural Area
- Confer protection to federally listed endangered and threatened species throughout the area
- Conserve, restore, and manage other species (for example, life-saving); limit vehicle use to designated roads; avoid/minimize vehicle-associated (including towed/dragged apparatus) transport of invasive species; maintain, close, and/or restore all roads, as appropriate, to minimize or eliminate adverse impacts to the ecological functioning of natural communities; prohibit new road construction unless necessary to replace an existing and necessary administrative road whose continued use is ecologically damaging and replacement results in a net ecological benefit
- Monitor the viability status of conservation elements and the status of threats to these elements and their abatement

**Management Standards Appropriate to Each Land Management Category**
- Confer protection to federally listed endangered and threatened species throughout the area
- Conserve, restore, and manage other species (for example, life-saving); limit vehicle use to designated roads; avoid/minimize vehicle-associated (including towed/dragged apparatus) transport of invasive species; maintain, close, and/or restore all roads, as appropriate, to minimize or eliminate adverse impacts to the ecological functioning of natural communities; prohibit new road construction unless necessary to replace an existing and necessary administrative road whose continued use is ecologically damaging and replacement results in a net ecological benefit
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- Confer protection to federally listed endangered and threatened species throughout the area
- Conserve, restore, and manage other species (for example, life-saving); limit vehicle use to designated roads; avoid/minimize vehicle-associated (including towed/dragged apparatus) transport of invasive species; maintain, close, and/or restore all roads, as appropriate, to minimize or eliminate adverse impacts to the ecological functioning of natural communities; prohibit new road construction unless necessary to replace an existing and necessary administrative road whose continued use is ecologically damaging and replacement results in a net ecological benefit

**Gap Biodiversity Management Status Achieved if Standards Implemented**
- Can achieve Gap Status 1: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management.

### Limited Access Areas

**Description/Examples**
- Limited ground-disturbing activities, now or in the past, and with present- or process, including natural disturbance regimes.
- Areas in which public access is unimpeded.
- Air-to-air firing ranges
- Areas in which public access is generally restricted and that don’t experience any significant on-the-ground military training activities.

**Condition I or II**
- Plant/natural communities still retain a good representation of species typical of the “natural” state; ecological processes generally intact
- Moderate anthropogenic disturbance levels
- Restoration needed and is feasible and relatively easy (continued maintenance may be necessary)

**Management Standards Appropriate to Each Land Management Category**
- Prohibit mineral, gas, oil, and borrow material extraction
- Prohibit livestock grazing; control entry by and remove trespass livestock and wild burros and horses
- Inventory, establish priorities for management by invasive species, geographic area, and, as appropriate, the natural community conservation element potentially impacted, and control invasive species to avoid/minimize adverse impacts to natural community composition, structure, and function
- Prohibit all off-road motorized and mechanized vehicle activity, including military, except when necessary for emergency purposes (for example, life-saving); limit vehicle use to designated roads; avoid/minimize vehicle-associated (including towed/dragged apparatus) transport of invasive species; maintain, close, and/or restore all roads, as appropriate, to minimize or eliminate adverse impacts to the ecological functioning of natural communities; prohibit new road construction unless necessary to replace an existing and necessary administrative road whose continued use is ecologically damaging and replacement results in a net ecological benefit
- Confer protection to federally listed endangered and threatened species throughout the area
- Can achieve Gap Status 2: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance.
<table>
<thead>
<tr>
<th>Land Management Category</th>
<th>Description/Examples</th>
<th>Range of Ecological Condition Categories</th>
<th>Management Standards Appropriate to Each Land Management Category</th>
<th>Gap Biodiversity Management Status Achieved if Standards Implemented&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate Use Areas</td>
<td>Description: Areas experiencing moderate ground-disturbing activities, now or in the past. Human access possible for either military training or recreational opportunities. Examples: • Five-year Explosive Ordnance Disposal sweep areas • Areas with dispersed public recreation that may have resulted in some alteration of natural community composition, structure, and function</td>
<td>Condition I or Condition II</td>
<td>If the land management unit is predominately in Ecological Condition I, manage to these standards: • Document management intent for the area through an agency management plan • Demonstrate an institutional long-term intent to conserve the natural ecological function of most of the ecosystem within the area, in which anthropogenic activities that may occur on more than 5% of the area is limited to low levels of anthropogenic disturbance, renewable resource use, and compatible levels of human visitation • Avoid all new ground-disturbing activities or activities that would otherwise lead to the conversion of natural land cover to the extent feasible; however, do not exceed 5% of the area that is subjected to human land uses that result in type conversion • Prohibit mineral, gas, oil, and borrow material extraction • Prohibit livestock grazing; control entry by and remove trespass livestock and wild burros and burros and horses • Inventory, establish priorities for management by invasive species, geographic area, and, as appropriate, the natural community conservation element potentially impacted, and control invasive species to avoid/minimize adverse impacts to natural community composition, structure, and function • Prohibit all off-road motorized and mechanized vehicle activity, including military, except when necessary for emergency purposes (for example, life-saving); limit vehicle use to designated roads; avoid/minimize vehicle-associated (including towed/dragged apparatus) transport of invasive species; maintain, close, and/or restore all roads, as appropriate, to minimize or eliminate adverse impacts to the ecological functioning of natural communities; prohibit new road construction unless necessary to replace an existing and necessary administrative road whose continued use is ecologically damaging and replacement results in a net ecological benefit • Use and enforce a permit system, when an area is open to the public for recreational purposes, that can limit, if appropriate, the amount and intensity of recreational activities to preclude resource damage; establish ecological thresholds that would lead to management action to limit the adverse impacts of recreational activities before natural community composition, structure, and function is altered adversely; establish regular patrol and enforcement within the area to ensure resource values are protected • Confer protection to federally listed endangered and threatened species throughout the area • Monitor the viability status of conservation elements and the status of threats to these elements and their abatement</td>
<td>Can achieve Gap Status 2: An area having permanent protection from conversion of natural land cover for the foreseeable future, subject to extractive uses of either a broad, low-intensity type (for example, livestock grazing) or localized intense type (for example, mining). It also confers protection to federally listed endangered and threatened species throughout the area.</td>
</tr>
<tr>
<td>Urban/Intensive Use Areas&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Description: Urbanized areas or areas experiencing severe ground disturbance and/or natural land cover conversion, now or in the past. Examples: • Cantonment areas • Air strips • Target areas and one-year Explosive Ordnance Disposal sweep areas • Military training ground support areas • Areas of concentrated public recreation that severely alter natural community composition, structure, and function</td>
<td>Condition III: • Plant/natural communities generally lack a good representation of species typical of the “natural” state; ecological processes may be disrupted • Severe anthropogenic disturbance levels • Restoration needed but may not be feasible, will be relatively difficult, and will be long-term in its accomplishment (continued maintenance may be necessary)</td>
<td>• Maintain management intent for the area through an agency management plan • Confer protection to federally listed endangered and threatened species throughout the area • Avoid/minimize or otherwise mitigate adverse impacts to adjoining Special Natural Areas, Limited Access Area, and Moderate Use Areas that would result in ecologically significant alterations of natural community composition, structure, and function within these areas by projects/activities conducted within Urban/Intensive Use Areas</td>
<td>Limited to Gap Status 4: There are no known public or private institutional mandates or legally recognized easements or deed restrictions held by the managing entity to prevent conversion of natural habitat types to anthropogenic habitat types. The area generally allows conversion to unnatural land throughout. Despite this limitation, adoption of the recommended standards will ensure compliance is achieved with environmental laws and adverse environmental impacts will be avoided/minimized to the extent attainable.</td>
</tr>
</tbody>
</table>


<sup>2</sup>Based on criteria that consider the differences between biotic communities in the presence and absence of humans and their culture.

<sup>3</sup>Urban/Intensive Use Areas that are relatively small in size may be treated as inclusions—that have different management requirements—within the other three Land Management Categories rather than as separate land management units.
CHAPTER 12 OPPORTUNITIES FOR COORDINATED MANAGEMENT

In Chapter 9 opportunities for coordinated management of natural communities and species across property boundaries were presented in relation to the desired future ecological condition of the conservation elements in a landscape context. In this chapter specific opportunities for coordination, as well as current obstacles to such coordination, are presented for two landowners adjoining the Barry M. Goldwater Range (BMGR): Cabeza Prieta National Wildlife Refuge and Tohono O’odham Nation. Staff representatives from both entities expressed an interest and a desire to coordinate management of conservation elements across boundaries. Coordination, however, may need to be phased in over time, and starting with mutual critical needs, as currently both have pressing management priorities within their boundaries that may force their attention away from extensive coordination strategies with the BMGR in the near term.

12.1 CABEZA PRIETA NATIONAL WILDLIFE REFUGE

Opportunities for Coordinated Management

• Cabeza Prieta is currently working with Organ Pipe Cactus National Monument to develop a monitoring program for herpetofauna. This methodology, when focused on the conservation elements identified for the BMGR, could be extended to the BMGR and to the northern portion of the refuge’s boundary adjoining the BMGR.

• As mentioned in Chapter 3, the Valley Bottom Floodplain Complex in the Growler and San Cristobal Valleys should be managed as a connected ecological system across political boundaries. Maintaining a functioning connected system may necessitate coordinated management strategies between Cabeza Prieta and the BMGR, including jointly studying and monitoring the ecological processes that maintain the system and avoiding those activities that may degrade system function.

• A large maternal roosting colony of lesser long-nosed bats (Leptonycteris curasoae yerbaeuenae) is present in Bluebird mine on Cabeza Prieta. It is possible that this population currently forages or will in the future forage on the BMGR or may establish a colony there.

• Desert bighorn sheep (Ovis canadensis mexicana) and Sonoran pronghorn (Antilocapra americana sonoriensis) will continue to be needed to be managed in a landscape context across political boundaries.

Current Obstacles to Coordinated Management

• Ninety three percent of the Cabeza Prieta is managed as a Wilderness Area. As a result, it is difficult for staff and biologists to go to a majority of the areas on the refuge and to apply intrusive management strategies.

• Current management strategies are focused on the southern boundary of Cabeza Prieta and not on the boundary adjoining the BMGR. The main threats to conservation elements on the refuge are the increase in frequency and intensity of undocumented alien passage across the property and the spread of non-native plant species (particularly buffelgrass [Cenchrus ciliaris] and Sahara mustard [Brassica tournefortii]). One of the main routes for illegal border crossing cuts across the Valley Bottom
Floodplain Complex in the Growler Valley. Cabeza Prieta currently is working with Border Patrol to try to control undocumented alien access from Mexico.

12.2 TOHONO O’ODHAM NATION

Opportunities for Coordinated Management

- Interest currently exists in working with other agencies to establish management strategies and monitoring objectives of conservation elements as they occur on the Nation. Projects that are under consideration include: modeling desert tortoise (*Gopherus agassizii*) habitat and coordinated burro (*Equus asinus*) management across political boundaries.

- The northwestern boundary of the Nation adjoins the BMGR near the Sand Tank Mountains. Included within this portion of the Nation are examples of Paloverde-Mixed Cacti-Mixed Scrub and Creosotebush-Tubosa Grass (*Hilaria mutica*) Scrub communities. A potential exists to coordinate management of these communities across political boundaries.

- At least one large maternal roosting colony of lesser long-nosed bats is present on the Nation. It is possible that this population currently forages or will in the future forage on the BMGR or may establish a colony there.

- Natural resource managers on the Tohono O’odham Nation have expressed interested in working with The Nature Conservancy to manage and protect areas on the Nation that were identified as landscape-scale conservation areas in the Sonoran Desert ecoregional plan (Marshall and others 2000).

- Desert bighorn sheep populations occur in scattered mountain ranges on the Tohono O’odham Nation. As a result, the potential exists to manage this species in a landscape context across political boundaries.

Current Obstacles to Coordinated Management

- The Wildlife and Vegetation Management Program is less than two years old. Little baseline information exists for natural communities or species found on the reservation, so the main priority is currently basic inventory work. To assure that game species populations can continue to support subsistence hunting for tribal members—and possibly to support permitted hunts for non-tribal members that can serve as a revenue generating source for an expanded Wildlife and Vegetation Management Program, initial inventory efforts will focus on game species. Additionally, to facilitate compliance with applicable regulations for development projects on the Nation (for example, utility infrastructure, transportation projects, building construction, and so on), species that are listed by the federal government also will be a focus of initial inventory efforts.
CHAPTER 13 LITERATURE CITED


APPENDIX A TECHNICAL DEFINITIONS

TABLE A.1 Gap Analysis Program Land Management Status Criteria\(^1\)

| Status 1: | An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management. |
| Status 2: | An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance. |
| Status 3: | An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense type (e.g., mining). It also confers protection to federally listed endangered and threatened species throughout the area. |
| Status 4: | There are no known public or private institutional mandates or legally recognized easements or deed restrictions held by the managing entity to prevent conversion of natural habitat types to anthropogenic habitat types. The area generally allows conversion to unnatural land cover throughout. |

\(^1\)From Crist and others (2000). www.gap.uidaho.edu/handbook/stewardship/

TABLE A.2 Natural Heritage Program Global Ranking Definitions\(^1,2\)

<table>
<thead>
<tr>
<th>Global Rank</th>
<th>State Rank</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>S1</td>
<td>Very Rare: 1 to 5 occurrences or very few individuals or acres</td>
</tr>
<tr>
<td>G2</td>
<td>S2</td>
<td>Rare: 6 to 20 occurrences or few individuals or acres</td>
</tr>
<tr>
<td>G3</td>
<td>S3</td>
<td>Uncommon or Restricted: 21 to 100 occurrences, rather rare throughout a fairly wide range, or fairly common in a rather restricted range.</td>
</tr>
<tr>
<td>—</td>
<td>S3S4</td>
<td>Fairly Common: 51 to 100 occurrences and found over a rather wide range within the State.</td>
</tr>
<tr>
<td>G4</td>
<td>S4</td>
<td>Apparently Secure: more than 100 occurrences, though it could be quite rare in some parts of its range.</td>
</tr>
<tr>
<td>G5</td>
<td>S5</td>
<td>Demonstrably Secure: more than 100 occurrences.</td>
</tr>
<tr>
<td>GU</td>
<td>—</td>
<td>Unranked.</td>
</tr>
</tbody>
</table>

\(^1\)Priority ranking (1 to 5) based on the number of occurrences throughout the entire range of the element (from Arizona Game and Fish Department, Heritage Data Management System, 1/12/94).
Combined global ranks were determined from the following global rank designations:

- **G1** = G1, G1T1, G4T1, G5T1Q, G4G5T1, G5T1 (G_T1Qs need case by case review), G1G2
- **G2** = G2, G2?, G3T2, G1G3, G2G3, G3T2, G3G4T2, G2G4T1T2Q, G4T1T2, G4T2, G4?T2?, G5T2, G5T1T2, G5T1T2Q (again, G_T2Qs need case by case review)
- **G5** = G5, G5?, G5T, G5T?

**TABLE A.3** Global Distribution Characteristics for Conservation Elements in the Sonoran Desert Ecoregion¹

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restricted/Endemic</td>
<td>Species or natural community occurs primarily in one ecoregion: it is either entirely endemic to the ecoregion or has more than 80% of its range within ecoregion.</td>
</tr>
<tr>
<td>Limited</td>
<td>Species or natural community occurs in the ecoregion, but also within a few other adjacent ecoregions (that is, its core range is in one or two ecoregions, yet it may be found in several other ecoregions).</td>
</tr>
<tr>
<td>Widespread</td>
<td>Species or natural community is distributed widely in several to many ecoregions and is distributed relatively equally among ecoregions. Widespread does not necessarily mean &quot;common.&quot; For example, some wetland types are distributed widely, though total acreage is small and the occurrences are widely separated.</td>
</tr>
<tr>
<td>Disjunct</td>
<td>Species or natural community occurs in the ecoregion as a disjunct from the core of its distribution (less than 10% of its total distribution is in the ecoregion) and is more commonly found in other ecoregions. Disjunct occurrences of communities reflect similarly disjunct occurrences of key environmental factors or ecological processes, and these occurrences may represent variation in composition, structure, and potential for evolutionary divergence.</td>
</tr>
<tr>
<td>Peripheral</td>
<td>Species or natural community is more commonly found in other adjacent ecoregions (less than 10% of its total distribution is in the ecoregion of interest). Peripheral occurrences may or may not represent significant variation relative to occurrences in adjacent ecoregions. Goals for peripheral communities should account for the fact that most of their conservation will take place in other ecoregions. Opportunistic capture of these types often may be sufficient. Selection of examples for conservation should be informed by consideration of how they compare in size, quality, and variation with those in the adjacent or other ecoregions.</td>
</tr>
</tbody>
</table>

¹Distribution characteristics adapted from Anderson and others (1999).
### TABLE A.4 Typical Spatial Patterns for Natural Communities in the Sonoran Desert Ecoregion

<table>
<thead>
<tr>
<th>Spatial Pattern</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Matrix</strong></td>
<td>Natural communities form extensive and contiguous cover 2,000 to 500,000 ha in size. Occur on ecoregion's most extensive landforms and typically have wide ecological tolerances; aggregate of all matrix communities covers 70 to 80% of ecoregion; often influenced by large-scale processes (for example, climate patterns).</td>
</tr>
<tr>
<td><strong>Large patch</strong></td>
<td>Natural communities with interrupted cover ranging in size from 50 to 2,000 ha. Aggregate of all large-patch communities may cover as much as 20% of the ecoregion.</td>
</tr>
<tr>
<td><strong>Small patch</strong></td>
<td>Natural communities that form small, discrete areas of cover one to 50 ha in size. Occur in very specific ecological settings, such as on specialized landform types or in unusual microhabitats. May contain disproportionately large percentage of ecoregion's total flora and also support a specific and restricted set of specialized fauna.</td>
</tr>
<tr>
<td><strong>Linear</strong></td>
<td>Natural communities occur as linear strips. Often represent ecotone between terrestrial and aquatic ecosystems. Aggregate of all linear communities covers only a small percentage of the natural vegetation of the ecoregion. Local-scale processes, such as river flow regimes, strongly influence community structure and function, leaving communities highly vulnerable to alterations in the surrounding land and water-scape.</td>
</tr>
</tbody>
</table>

1Spatial pattern characteristics adapted from Anderson and others (1999).
APPENDIX B INDIVIDUALS WHO PROVIDED INFORMATION ON POTENTIAL INVERTEBRATE CONSERVATION ELEMENTS

Richard Bailowitz, private researcher
Steve Buchmann, The Bee Works
Ken Kingsley, SWCA
Eric Larsen, Ph.D. candidate, University of Chicago
Carl Olson, Entomology Department, University of Arizona
Justin Schmidt, U.S. Department of Agriculture, Carl Hayden Bee Research Center

Four additional experts were contacted, but did not respond to questionnaires.
APPENDIX C INDIVIDUALS WHO PROVIDED INFORMATION ON POTENTIAL PLANT CONSERVATION ELEMENTS

Mark Baker, Southwest Botanical Research
Philip Jenkins, University of Arizona Herbarium
Ken Kingsley, SWCA
Sue Rutman, U.S. Department of the Interior, National Park Service, Organ Pipe Cactus National Monument
Justin Schmidt, U.S. Department of Agriculture, Carl Hayden Bee Research Center
Peter Warren, The Nature Conservancy

Ten additional experts were contacted, but did not respond to questionnaires.
# Appendix D Draft Working List of Natural Community Conservation Elements for the Barry M. Goldwater Range

<table>
<thead>
<tr>
<th>Community Name</th>
<th>Brown, Lowe, and Pase (1979) Nomenclature</th>
<th>Description</th>
<th>Global Rank</th>
<th>Nested Elements or Associated Species Elements/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dune complex and dune endemics</td>
<td>250 154.11</td>
<td>Global distribution is limited and spatial occurrence pattern is large patch; includes both active and stabilized sand dunes and associated endemic plant species</td>
<td>G1</td>
<td>Interior dunes and planes ecological group</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Active and stabilized dunes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Desert sand-verbena interior dune</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Endemic plants that are dune complex</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>associates: <em>Chamaesyce platsperma,</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>Croton wigginsii,</em> <em>Cryptantha ganderi,</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>Drymaria viscosa,</em> <em>Eriogonum deserticola,</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>Helianthus niveus,</em> <em>Palafoxia arida var. gigantea,</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>Pholisma sonorae,</em> <em>Stephanomeria schottii,</em> and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>Triteleiopsis palmeri</em></td>
</tr>
<tr>
<td>Creosotebush shrubland</td>
<td>154.111</td>
<td>Global distribution is limited and spatial occurrence pattern is matrix</td>
<td>G5</td>
<td>Creosote-bursage ecological group in part</td>
</tr>
<tr>
<td>Creosotebush-white bursage shrubland</td>
<td>154.112</td>
<td>Global distribution is limited and spatial occurrence pattern is matrix</td>
<td>G5</td>
<td>Creosote-bursage ecological group in part</td>
</tr>
<tr>
<td>Big galleta grass shrubland</td>
<td>154.113</td>
<td>Global distribution is limited and spatial occurrence pattern is matrix</td>
<td>G2</td>
<td>Creosote-bursage ecological group in part</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Associated shrub dominant could be</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>creosote or white bursage; needs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>confirmation for BMGR</td>
</tr>
<tr>
<td>Honey mesquite shrubland</td>
<td>154.114</td>
<td>Global distribution is limited and spatial occurrence pattern is large patch; occurs as shrub hummocks on stabilized dunes</td>
<td>G3?</td>
<td>Creosote-bursage ecological group in part</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Shrub hummocks on stabilized dunes</td>
</tr>
<tr>
<td>Microphyll riparian woodlands (desert</td>
<td>154.115 154.1113</td>
<td>Global distribution is endemic and spatial occurrence pattern is linear; generally associated with dendritic drainage patterns in areas of greater topographic relief compared to areas with reticulated drainages; the vegetation consists of relatively tall trees and shrubs along the edges of washes</td>
<td>G3</td>
<td>Creosote-bursage ecological group in part</td>
</tr>
<tr>
<td>wash, xeroriparian)</td>
<td>(Tunnicliff and others 1986)</td>
<td></td>
<td></td>
<td>Desert wash, xeroriparian habitat</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>154.1113 = <em>Larrea tridentata-Prospis sp.-</em> (Cercidium sp., Olneya tesota)</td>
</tr>
<tr>
<td>Brittlebush-mixed desert scrub</td>
<td>154.126</td>
<td>Global distribution is limited and spatial occurrence pattern is matrix</td>
<td>G5</td>
<td>Paloverde-mixed cacti ecological group in part</td>
</tr>
</tbody>
</table>
### APPENDIX D DRAFT WORKING LIST OF NATURAL COMMUNITY CONSERVATION ELEMENTS FOR THE BARRY M. GOLDWATER RANGE—continued

<table>
<thead>
<tr>
<th>Community Name</th>
<th>Brown, Lowe, and Pase (1979) Nomenclature</th>
<th>Description</th>
<th>Global Rank</th>
<th>Nested Elements or Associated Species Elements/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brittlebush rocky hillside-mixed desert scrub and associated endemics</td>
<td>154.1262</td>
<td>Associated with rocky soils; distribution and spatial occurrence pattern open to discussion</td>
<td>GU</td>
<td>Paloverde-mixed cacti ecological group in part&lt;br&gt;154.1262 = &lt;i&gt;Larrea tridentata&lt;/i&gt;-&lt;i&gt;Encelia farinosa&lt;/i&gt;-&lt;i&gt;Jatropha&lt;/i&gt; sp.&lt;br&gt;Endemic plants that are potentially rocky soil associates in this community: &lt;i&gt;Acalypha californica&lt;/i&gt;, &lt;i&gt;Agave deserti&lt;/i&gt;, &lt;i&gt;Bursera microphylla&lt;/i&gt;, &lt;i&gt;Ferocactus emoryi&lt;/i&gt;, &lt;i&gt;Stenocereus thurberi&lt;/i&gt;, &lt;i&gt;Rhus kearnyi&lt;/i&gt;</td>
</tr>
<tr>
<td>Paloverde-mixed cacti-mixed scrub</td>
<td>154.127</td>
<td>Global distribution is endemic and spatial occurrence pattern is large patch</td>
<td>G3</td>
<td>Paloverde-mixed cacti ecological group in part</td>
</tr>
<tr>
<td>Saltbush desert scrub</td>
<td>154.17</td>
<td>Global distribution is limited and spatial occurrence pattern is large patch; associated with fine-textured, alkaline soils</td>
<td>GU</td>
<td>Saltbush series of Brown, Lowe, and Pase (1979) captured at the ecological group level</td>
</tr>
<tr>
<td>Natural tinaja Modified natural tinaja Spring</td>
<td>200</td>
<td>Global distribution is limited and spatial occurrence pattern is small patch; mostly tinajas with a few springs on the BMGR</td>
<td>GU</td>
<td></td>
</tr>
<tr>
<td>Intermittently flooded playa lake</td>
<td>240</td>
<td>Global distribution is widespread and spatial occurrence pattern is large patch</td>
<td>GU</td>
<td></td>
</tr>
</tbody>
</table>


2. Global ranks (see Table A.2 in Appendix A) are assigned for illustrative purposes only. Ranks typically are assigned to narrowly defined plant communities that though similar to the communities identified in the table may not be exactly the same or may represent a subdivision of the communities described in the table.

3. All polygons identified in Tunnicliff and others (1986) that contribute to the mapping of the natural community are nested by definition. Some communities that may occur on the BMGR, such as ocotillo shrublands (154.116), teddy-bear cholla shrublands (154.117), triangle-leaf bursage-foothill paloverde-mixed scrub (154.121), triangle-leaf bursage-saguaro-mixed scrub (154.122), and desert pavement, are perhaps nested, but they cannot be unambiguously assigned to the natural community targets identified in the table. Tunnicliff and others (1986) did not map these preceding communities. Only plant species targets that are obligate associates with the natural community being considered are identified. Various faunal conservation target species also may be associated with particular natural communities, but these are not identified here.

APPENDIX E INDIVIDUALS WHO ATTENDED THE NOVEMBER 2, 2000 BARRY M. GOLDFWATER RANGE, NATURAL COMMUNITY CONSERVATION ELEMENT WORKSHOP

Scott Bailey, Tohono O’odham Nation
Pat Comer, The Nature Conservancy
Russell Engel, Arizona Game and Fish Department
Richard Felger, Drylands Institute
Anne Gondor, The Nature Conservancy
John Hall, The Nature Conservancy
Annita Harlan, consultant
Thomas Harlan, consultant
Philip Jenkins, University of Arizona Herbarium
Jim Malusa, School of Renewable Natural Resources, University of Arizona
Rob Marshall, The Nature Conservancy
Karen Reichhardt, U.S. Department of the Interior, Bureau of Land Management, Yuma District
Sue Rutman, U.S. Department of the Interior, National Park Service, Organ Pipe Cactus National Monument
Linwood Smith, Environmental Planning Group
Dale Turner, School of Renewable Natural Resources, University of Arizona (now with The Nature Conservancy)
Peter Warren, The Nature Conservancy
Stephanie Weinstein, consultant to The Nature Conservancy

Six additional individuals were invited but could not attend.
### APPENDIX F INDIVIDUALS WHO PROVIDED INPUT ON SPECIES CONSERVATION ELEMENTS

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Conservation Element</th>
<th>Individual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphibians</td>
<td>Sonoran Desert toad</td>
<td>Phil Rosen (Department of Ecology and Evolutionary Biology, University of Arizona), Dennis Suhre (Department of Ecology and Evolutionary Biology, University of Arizona)</td>
</tr>
<tr>
<td></td>
<td>Couch’s spadefoot toad</td>
<td>Phil Rosen, Dennis Suhre</td>
</tr>
<tr>
<td></td>
<td>Red-spotted toad</td>
<td>Phil Rosen</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Cowle’s fringe-toed lizard</td>
<td>Dale Turner (School of Renewable Natural Resources, University of Arizona; now with The Nature Conservancy)</td>
</tr>
<tr>
<td></td>
<td>Flat-tailed horned lizard</td>
<td>Dale Turner</td>
</tr>
<tr>
<td></td>
<td>Desert tortoise</td>
<td>Betsy Wirt (Luke Air Force Base)</td>
</tr>
<tr>
<td></td>
<td>Valley Bottom Reptile Guild</td>
<td>Phil Rosen</td>
</tr>
<tr>
<td></td>
<td>Rocky Slope Reptile Guild</td>
<td>Phil Rosen</td>
</tr>
<tr>
<td>Birds</td>
<td>Le Conte’s thrasher</td>
<td>Linwood Smith (Environmental Planning Group), Tim Tibbitts (Organ Pipe Cactus National Monument), Troy Corman (Arizona Game and Fish Department)</td>
</tr>
<tr>
<td></td>
<td>Cavity-nesting Guild</td>
<td>Linwood Smith, Tim Tibbitts, Troy Corman</td>
</tr>
<tr>
<td></td>
<td>Prairie Falcon</td>
<td>Tim Tibbitts</td>
</tr>
<tr>
<td>Mammals</td>
<td>Sonoran Pronghorn</td>
<td>No interviews conducted; assessment deferred to Recovery Team</td>
</tr>
<tr>
<td></td>
<td>Bat guild</td>
<td>Linwood Smith, Tim Tibbitts</td>
</tr>
<tr>
<td></td>
<td>Desert Bighorn sheep</td>
<td>Mark Cochran (CH2M Hill), Paul Krausman (School of Renewable Natural Resources, University of Arizona), Linwood Smith</td>
</tr>
<tr>
<td></td>
<td>Kit fox</td>
<td>Linwood Smith, Tim Tibbitts</td>
</tr>
</tbody>
</table>

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1Excluding invertebrates and plants; see Appendices B and C, respectively, for experts contacted in regard to these taxa.
2Not originally included as a proposed species conservation elements, but suggested by experts during interviews as ones that should be considered.
APPENDIX G INDIVIDUALS WHO ATTENDED THE JANUARY 4, 2001 WORKSHOP ON DEVELOPING DESIRED FUTURE ECOLOGICAL CONDITIONS AND MONITORING OBJECTIVES

Scott Bailey, Tohono O’odham Nation
Gene Dahlem, U.S. Department of the Interior, Bureau of Land Management, Phoenix District
Russ Engel, Arizona Game and Fish Department
John Hall, The Nature Conservancy
Ron Pearce, U.S. Department of Defense, Marine Corps Air Station Yuma
Philip Rosen, Department of Ecology and Evolutionary Biology, University of Arizona
Sue Rutman, U.S. Department of the Interior, National Park Service, Organ Pipe Cactus National Monument
Linwood Smith, Environmental Planning Group
Timothy Tibbetts, U.S. Department of the Interior, National Park Service, Organ Pipe Cactus National Monument
Don Tiller, Cabeza Prieta National Wildlife Refuge
Brock Tunnicliff, consultant to Dames and Moore Consultants (which is now URS Corporation)
Dale Turner, School of Renewable Natural Resources, University of Arizona (now with The Nature Conservancy)
Stephanie Weinstein, consultant to The Nature Conservancy
### Appendix H Relationship Between Potential Species and Natural Community Conservation Elements on the Barry M. Goldwater Range

<table>
<thead>
<tr>
<th>Taxon: Common Name</th>
<th>Scientific Name</th>
<th>Combined Global Rank (Endemism): Comment</th>
<th>Valley Bottom Floodplain Complex</th>
<th>Valley Xeroriparian Scrub</th>
<th>Mountain Xeroriparian Scrub</th>
<th>Dune Complex and Dune Endemics</th>
<th>Creosotebush -Bur sage Desert Scrub</th>
<th>Creosotebush -Big Galleta Scrub</th>
<th>Paloverde- Mixed Cacti-Mixed Scrub on Bajadas</th>
<th>Paloverde- Mixed Cacti-Mixed Scrub on Rocky Slopes</th>
<th>Sand Tank Mountains Uplands</th>
<th>Elephant Tree-Limberbush on Xeric Rocky Slopes</th>
<th>Desert Playa</th>
<th>Desert Tina/ja/ spring</th>
<th>Salt Desert Scrub</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphibian: Sonoran Desert toad</td>
<td><em>Bufo alvarius</em></td>
<td>G5 (Endemic): Included in ephemeral water-breeding amphibian guild</td>
<td>Potential associate</td>
<td>Potential associate</td>
<td>Potential associate</td>
<td>Associate</td>
<td>Potential associate</td>
<td>Associate</td>
<td>Associate</td>
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<tr>
<td>Amphibian: Great Plains toad</td>
<td><em>Bufo cognatus</em></td>
<td>G5: Possibly found in similar breeding habitats as the Sonoran Desert toad (P. Rosen)</td>
<td>Potential associate</td>
<td>Potential associate</td>
<td>Potential associate</td>
<td>Associate</td>
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<tr>
<td>Amphibian: Red-spotted toad</td>
<td><em>Bufo punctatus</em></td>
<td>G5: Included in ephemeral water-breeding amphibian guild</td>
<td>Potential associate</td>
<td>Potential associate</td>
<td>Potential associate</td>
<td>Associate</td>
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<tr>
<td>Amphibian: Couch's spadefoot</td>
<td><em>Scaphiopus couchii</em></td>
<td>G5: Included in ephemeral water-breeding amphibian guild</td>
<td>Potential associate</td>
<td>Potential associate</td>
<td>Potential associate</td>
<td>Associate</td>
<td>Associate</td>
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<tr>
<td>Bird: Rufous-crowned sparrow</td>
<td><em>Ammodramus phaeocephalus</em></td>
<td>G5?: Subspecies requires verification</td>
<td>Potential associate</td>
<td>Potential associate</td>
<td>Potential associate</td>
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<tr>
<td>Bird: Burrowing owl</td>
<td><em>Athene cunicularia</em></td>
<td>G4: Habitat associations on the BMGR undocumented</td>
<td>Potential associate</td>
<td>Potential associate</td>
<td>Potential associate</td>
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<tr>
<td>Bird: Northern flicker</td>
<td><em>Colaptes auratus</em></td>
<td>G5: Hybrid zone with gilded flicker occurs just north of the BMGR</td>
<td>Potential associate</td>
<td>Potential associate</td>
<td>Potential associate</td>
<td>Associate</td>
<td>Associate</td>
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<tr>
<td>Bird: Gilded flicker</td>
<td><em>Colaptes chrysoides</em></td>
<td>G5 (Endemic): Included in primary excavator (cavity) guild</td>
<td>Associate</td>
<td>Associate</td>
<td>Associate</td>
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<td>Associate</td>
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<tr>
<td>Bird: Prairie falcon</td>
<td><em>Falco mexicanus</em></td>
<td>G5</td>
<td>Potential associate</td>
<td>Associate</td>
<td>Associate</td>
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<tr>
<td>Bird: Greater roadrunner</td>
<td><em>Geococcyx californianus</em></td>
<td>G5: Habitat associations on BMGR not documented</td>
<td>Associate</td>
<td>Potential associate</td>
<td>Potential associate</td>
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<tr>
<td>Bird: Cactus ferruginous pygmy-owl</td>
<td><em>Glaucidium brasilianum cactorum</em></td>
<td>G3 (Endemic): Not documented on BMGR, but suitable habitat present</td>
<td>Associate</td>
<td>Associate</td>
<td>Associate</td>
<td>Associate</td>
<td>Associate</td>
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<tr>
<td>Bird: Oila woodpecker</td>
<td><em>Melanerpes uropygialis</em></td>
<td>G5: Included in primary excavator (cavity) guild</td>
<td>Associate</td>
<td>Associate</td>
<td>Associate</td>
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<tr>
<td>Bird: Elf owl</td>
<td><em>Micrathene whitneyi</em></td>
<td>G5</td>
<td>Associate</td>
<td>Associate</td>
<td>Associate</td>
<td>Associate</td>
<td>Associate</td>
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<tr>
<td>Bird: Ladder-backed woodpecker</td>
<td><em>Picoides scalaris</em></td>
<td>G5: Included in primary excavator (cavity) guild</td>
<td>Associate</td>
<td>Associate</td>
<td>Associate</td>
<td>Associate</td>
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<tr>
<td>Bird: Abert's towhee</td>
<td><em>Pipilo aberti</em></td>
<td>G3: Widespread in the Sauceda and Sand Tank Mountains (B. Barry)</td>
<td>Potential associate</td>
<td>Potential associate</td>
<td>Potential associate</td>
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</table>
## APPENDIX H RELATIONSHIP BETWEEN POTENTIAL SPECIES AND NATURAL COMMUNITY CONSERVATION ELEMENTS ON THE BARRY M. GOLDWATER RANGE

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>Bird: Bendire's thrasher</td>
<td><em>Toxostoma bendirei</em></td>
<td>G4: Occurs in the Sauceda Mountains (B. Barry)</td>
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<tr>
<td>Bird: Le Conte's thrasher</td>
<td><em>Toxostoma lecontei</em></td>
<td>G3: Species conservation element</td>
<td>Associate</td>
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<tr>
<td>Bird: Lucy's warbler</td>
<td><em>Vermivora lucia</em></td>
<td>G5 (Endemic)</td>
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<tr>
<td>Mammal: Sonoran pronghorn</td>
<td><em>Antilocapra americana sonoriensis</em></td>
<td>G1 (Endemic): Species conservation element; seasonal associations are based on Thompson-Olais (1998)</td>
<td>Potential associate</td>
<td>Associate (summer)</td>
<td>Associate (spring)</td>
<td>Associate</td>
<td>Associate (spring fawning areas, summer)</td>
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<tr>
<td>Mammal: Lesser long-nosed bat</td>
<td><em>Eptesicus curasoeae verbabuenuae</em></td>
<td>G4: Included in bat guild; roosting areas not documented on BMGR but potentially forages there</td>
<td>Associate</td>
<td>Associate</td>
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<tr>
<td>Mammal: California leaf-nosed bat</td>
<td><em>Macrotus californicus</em></td>
<td>G4: Included in bat guild</td>
<td>Associate</td>
<td>Associate</td>
<td>Potential associate</td>
<td>Associate</td>
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<tr>
<td>Mammal: Cave myotis</td>
<td><em>Myotis velifer</em></td>
<td>G5: Included in bat guild</td>
<td>Associate</td>
<td>Associate</td>
<td>Potential associate</td>
<td>Associate</td>
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<tr>
<td>Mammal: Desert bighorn sheep</td>
<td><em>Ovis canadensis mexicana</em></td>
<td>G4: Species conservation element; must use valley bottoms to cross between mountain ranges</td>
<td>Associate</td>
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<tr>
<td>Mammal: Kit fox</td>
<td><em>Vulpes macrotis</em></td>
<td>G4: Species conservation element; may require areas with friable soils good for dens/digging (L. Smith)</td>
<td>Potential associate</td>
<td>Associate</td>
<td>Potential associate</td>
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<tr>
<td>Plant: Copperleaf</td>
<td><em>Acalypha californica</em></td>
<td>G3 (Endemic)</td>
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<tr>
<td>Plant: Desert agave</td>
<td><em>Agave deserti simplex</em></td>
<td>G4 (Endemic): Occurs vicinity of Tinajas Altas Mountains; occurs on sandy flats &amp; occasionally on rocky slopes (Turner and others 1995)</td>
<td>Potential associate</td>
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<tr>
<td>Plant: Harwood milk-vetch</td>
<td><em>Astragalus insularis var. harwoodii</em></td>
<td>G3 (Endemic): Mohawk and Yuma Dunes (see Table 6.1); shifting dunes, sand plains, playa edges (Felger 2000)</td>
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<tr>
<td>Plant: Poison's milk-vetch</td>
<td><em>Astragalus magdalenae var. poirsonii</em></td>
<td>G2 (Endemic): Known on the BMGR from a single specimen from the Yuma Desert NW of the Yuma Dunes (see Table 6.1); dunes (Felger 2000)</td>
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<tr>
<td>Plant: Kofa Mountain barberry</td>
<td><em>Berberis harrisoniana</em></td>
<td>G2 (Endemic): Found only in the Ajo, Kofa, and Sand Tank Mountains in rocky canyons at about 2500 ft. (Benson and Darrow 1981, Felger and others 1997)</td>
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<tr>
<td>Plant: Elephant tree</td>
<td><em>Bursera microphylla</em></td>
<td>G4 (Endemic)</td>
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<td>Plant: Crucifixion thorn</td>
<td><em>Canavalia holocantha</em></td>
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## APPENDIX H RELATIONSHIP BETWEEN POTENTIAL SPECIES AND NATURAL COMMUNITY CONSERVATION ELEMENTS ON THE BARRY M. GOLDWATER RANGE

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<tr>
<td>Plant: Saguaro cactus</td>
<td>Carnegiea gigantea</td>
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<tr>
<td>Plant: Crucifixion thorn</td>
<td>Castela emoryi</td>
<td>G4 (Endemic): Species conservation element; habitat associations are poorly understood</td>
<td>Potential associate</td>
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<tr>
<td>Plant: California catalogna</td>
<td>Colubrina californica</td>
<td>G4</td>
<td>Occurs scattered in desert canyons and washes (P. Warren); rocky or gravelly slopes (Turner and others 1995)</td>
<td>Associate</td>
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<tr>
<td>Plant: Wegg's cryptantha</td>
<td>Croton wigginsii</td>
<td>G2</td>
<td>Yuma Dunes (see Table 6.1); low stabilized to high shifting dunes, sometimes on sand flats (Felger 2000)</td>
<td>Associate</td>
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<td>Potential associate</td>
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<tr>
<td>Plant: Guider's cryptantha</td>
<td>Cryptantha gunderi</td>
<td>G2 (Endemic): Mohawk Dunes (see Table 6.1); sand flats and dunes, especially their interface (Felger 2000)</td>
<td>Associate</td>
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<td>Plant: Acuna cactus</td>
<td>Echinomastus exsertocentrus var. acumenisi</td>
<td>G1 (Endemic): On the BMGR, documented only just NNE of Coffee Pot Mountain (M. Baker)</td>
<td>Associate</td>
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<td>Plant: Desert wild-buckwheat</td>
<td>Erigonum deuterocolus</td>
<td>G3 (Endemic): Yuma Dunes (see Table 6.1); low to high shifting dunes and sand flats (Felger 2000)</td>
<td>Associate</td>
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<td>Plant: Flatseed spurge</td>
<td>Euphorbia platysperma var. Chamaesyce platysperma</td>
<td>G3 (Endemic): Yuma Dunes (see Table 6.1); shifting dunes of all heights (Felger 2000)</td>
<td>Associate</td>
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<td>Plant: Coville barrel cactus</td>
<td>Ferocactus emoryi</td>
<td>G4 (Endemic)</td>
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<tr>
<td>Plant: Dune sunflower</td>
<td>Helianthus niveus</td>
<td>G4</td>
<td>Yuma Dunes (see Table 6.1); dunes and sand plains (Felger 2000)</td>
<td>Associate</td>
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<td>Plant: Pink velvet-mallow</td>
<td>Horsfordia alata</td>
<td>G4 (Endemic): Occurs west of Gila Mountains on BMGR but habitat associations not certain; washes and bedrock outcrops (Turner and others 1995)</td>
<td>Potential associate</td>
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<td>Plant: Burro bush</td>
<td>Hymenoclea monogyna</td>
<td>G3</td>
<td>Locally abundant on floodplains and along washes (Turner and others 1995)</td>
<td>Associate</td>
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<td>Plant: Limber bush</td>
<td>Justicia cuneata</td>
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<td>Plant: Juniper</td>
<td>Juniperus coahuilensis</td>
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<tr>
<td>Plant: Hierba azul</td>
<td>Justicia canescens</td>
<td>G4 (Endemic): Canyon bottoms and washes (P. Warren)</td>
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<td>Plant: Slender woolly-heads</td>
<td>Nemacladus demidchilt var. gracilis</td>
<td>G3 (Endemic): Occurs east of the Mohawk Dunes 7 &amp; in Yuma Desert (Felger and others 1997); BMGR habitat associations need verification</td>
<td>Potential associate</td>
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<td>Plant: Bigelow nolina</td>
<td>NOLINA BIGELOVII</td>
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<tr>
<td>Plant: Silver cholla</td>
<td>Opuntia echinocarpa</td>
<td>G3: Occurs east of Mohawk Dunes; BMGR habitat associations not known</td>
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<td>Plant: Giant Spanish needle</td>
<td>Palafoxia urida var. gigantea</td>
<td>G3 (Endemic): not documented on the BMGR but potentially occurs just south of the Yuma Dunes within the Gran Desierto; dunes (Felger 2000)</td>
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<td>Plant: Longleaf sandpaper plant</td>
<td>Petalexis linearis</td>
<td>G4 (endemic): Occurs in Tinajas Altas Mountains area (Felger and others 1997); grows on sandy soils (Turner and others 1995); habitat associations on the BMGR require verification</td>
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<td>Plant: Sandfood</td>
<td>Pholessma sonorae</td>
<td>G3 (Endemic): Yuma Dunes (see Table 6.1); sand flats, stabilized lower dunes, moving dunes (Felger 2000)</td>
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<td>Plant: Arizona pholistoma</td>
<td>Pholessma auritum var. arizonicum</td>
<td>G3: Occurs in Sauceda Mountains²; BMGR habitat associations not known</td>
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<td>Plant: Kearney sumac</td>
<td>Rhus kearneyi</td>
<td>G4 (Endemic)</td>
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<td>Plant: Organ pipe cactus</td>
<td>Stenocereus thurberi</td>
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<td>Plant: Schott's wire lettuce</td>
<td>Stephanomeria schottii</td>
<td>G2 (Endemic): Mohawk and Yuma Dunes (see Table 6.1); sand flats, (low) dunes, washes (Felger 2000)</td>
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<td>Plant: Blue sand lily</td>
<td>Triteleopsis palmeri</td>
<td>G4 (Endemic): Yuma Dunes (Table 6.1); sand flats, dunes (Felger 2000)</td>
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<tr>
<td>Plant: Rosewood</td>
<td>Vaquelinia californica isorenensis</td>
<td>GU (Endemic subspecies)</td>
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<tr>
<td>Reptile: Glossy snake</td>
<td>Arizona elegans</td>
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<tr>
<td>Reptile: Zebra-tailed lizard</td>
<td>Callossaurus draconoides</td>
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<tr>
<td>Reptile: Banded sand snake</td>
<td>Chilomeniscus cinctus</td>
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<tr>
<td>Reptile: Colorado Desert shovel-nosed snake</td>
<td>Chonosaurus occipitalis annulata (= C. assimilis)</td>
<td>G5 (Endemic subspecies): Included within the valley bottom reptile guild</td>
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<tr>
<td>Reptile: Red-backed whiptail</td>
<td>Cnemidophorus burti xanthomineus</td>
<td>G2 (Endemic): Eastern slopes Sand Tank Mtns. (Dames and Moore 1996); BMGR habitat associations unknown</td>
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### APPENDIX H RELATIONSHIP BETWEEN POTENTIAL SPECIES AND NATURAL COMMUNITY CONSERVATION ELEMENTS ON THE BARRY M. GOLDFRANGE

**Potential Species Conservation Elements**

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<tbody>
<tr>
<td><strong>Reptile:</strong> Western whiptail</td>
<td>Chasmophorus tigris</td>
<td>G5</td>
<td>Associate</td>
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<tr>
<td><strong>Reptile:</strong> Sidewinder</td>
<td>Crotalus cerastes</td>
<td>G5: Included within the valley bottom reptile guild</td>
<td>Associate</td>
<td>Potential associate</td>
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<tr>
<td><strong>Reptile:</strong> Speckled rattlesnake</td>
<td>Crotalus mitchellii</td>
<td>G5</td>
<td>Potential associate</td>
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<tr>
<td><strong>Reptile:</strong> Mojave rattlesnake</td>
<td>Crotalus scutulatus</td>
<td>G5</td>
<td>Associate</td>
<td>Potential associate</td>
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<tr>
<td><strong>Reptile:</strong> Desert iguana</td>
<td>Dipsosaurus dorsalis</td>
<td>G5: Included within the valley bottom reptile guild</td>
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<tr>
<td><strong>Reptile:</strong> Long-nosed leopard lizard</td>
<td>Gambelia wislizeni</td>
<td>G5</td>
<td>Associate</td>
<td>Potential associate</td>
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<td><strong>Reptile:</strong> Desert tortoise</td>
<td>Gopherus agassizi</td>
<td>G4: Species conservation element; mostly occurs on rocky slopes and bajadas and also associated with xeroriparian caliche caves (B. Wirt)</td>
<td>Associate</td>
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<tr>
<td><strong>Reptile:</strong> Desert rosy boa</td>
<td>Lichanura rexgrigia</td>
<td>G3 (Endemic): occurs in the eastern portion of the BMGR (B. Barry); occurs on bajadas (Phillips)</td>
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<tr>
<td><strong>Reptile:</strong> Flat-tailed horned lizard</td>
<td>Phrynosoma callifragum</td>
<td>G3 (Endemic): Species conservation element; occurs on the sand sheet of the Yuma Dunes</td>
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<td><strong>Reptile:</strong> Southern desert horned lizard</td>
<td>Phrynosoma platyrhinos callidus</td>
<td>G5: Included within the valley bottom reptile guild</td>
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<tr>
<td><strong>Reptile:</strong> Western leaf-nosed snake</td>
<td>Phyllorhynchus decurtatus perkinsi</td>
<td>G5: Included within the valley bottom reptile guild</td>
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<td><strong>Reptile:</strong> Chuckwalla</td>
<td>Sauromalus ater (=S. obesus)</td>
<td>G5: Present in all BMGR mountain ranges surveyed, Aguila Mountains and eastward (Dames &amp; Moore 1996)</td>
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<td><strong>Reptile:</strong> Cowles fringe-toed lizard</td>
<td>Uma notata rufoptata</td>
<td>G2 (Endemic subspecies): Species conservation element</td>
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<td></td>
</tr>
<tr>
<td><strong>Reptile:</strong> Long-tailed brush lizard</td>
<td>Urosaurus gracilis</td>
<td>G5: Included within the valley bottom reptile guild</td>
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</tr>
</tbody>
</table>

1 Assigned relationships are preliminary and require field data to confirm. Xeroriparian relationships are based in part on data contained in Arizona-Sonora Desert Museum (2000: Appendix II) and Rosen and Lowe (1996: Table 4). These references were not always in agreement.

2 Unpublished data set from the Center for Ecological Management of Military Lands (CEMML).
## Appendix I Arizona Breeding Bird Atlas Breeding Codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed (OB)</td>
<td>Non-breeder or migrant observed in block during breeding season, but not believed to be breeding. Used to address species in unlikely breeding habitat, flying over the block or out of their normal breeding range and with no indication of breeding; for example, could apply to ducks summering on a pond with no breeding habitat or a great blue heron foraging when no heronry exists on the block.</td>
</tr>
<tr>
<td>Possible (PO)</td>
<td>Based on one of the following:</td>
</tr>
<tr>
<td></td>
<td>Species observed in suitable nesting habitat during its breeding season. Used to address birds seen in likely breeding habitat, such as a western tanager in a ponderosa pine forest; however, caution is necessary during the migration period of birds that may be passing through or for birds that may linger on wintering areas before concluding possible breeding. Additionally, some wintering species may be present in late winter and early spring in the desert, while some resident species have commenced breeding.</td>
</tr>
<tr>
<td></td>
<td>Singing male present in suitable nesting habitat during its breeding season.</td>
</tr>
<tr>
<td>Probable (PR)</td>
<td>Based on one of the following:</td>
</tr>
<tr>
<td></td>
<td>Pair observed in suitable habitat during its breeding season. Applies to situations when a male and female of the same species are seen in the right habitat, though some birds (for example, ducks) are often paired during migration.</td>
</tr>
<tr>
<td></td>
<td>Permanent territory presumed through song at same location on at least 2 occasions 7 days or more apart.</td>
</tr>
<tr>
<td></td>
<td>Permanent territory presumed through defense of territory (chasing individuals of the same species).</td>
</tr>
<tr>
<td></td>
<td>Courtship behavior or copulation between a male and female. Includes courtship displays or food exchange.</td>
</tr>
<tr>
<td></td>
<td>Visiting probable nest-site, but no further evidence obtained. Applies to a bird that consistently flies into the same likely nest site, but which provides insufficient behavior for upgrading to confirmed. Applies especially to hole-nesters.</td>
</tr>
<tr>
<td></td>
<td>Agitated behavior or anxiety calls of adult, indicating nest site or young in the vicinity. Two birds circling above or a goshawk distress call falls into this category. Does not include agitation that is induced by &quot;pishing&quot; or using taped calls.</td>
</tr>
<tr>
<td></td>
<td>Nest building by wrens or excavation of cavities by woodpeckers, chickadees and nuthatches. Woodpeckers and other cavity excavators usually make only one nest hole, but use other holes for roosting; wrens will build several nests before a female selects one, and unmated males do this too.</td>
</tr>
</tbody>
</table>

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1. L1
## APPENDIX I ARIZONA BREEDING BIRD ATLAS BREEDING CODES

<table>
<thead>
<tr>
<th>Code</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confirmed (CO)</td>
<td>Based on one of the following:</td>
</tr>
<tr>
<td></td>
<td>Bird seen <strong>carrying nesting</strong> material (that is, sticks, grass, mud, and cobwebs). Applies for all species except wrens.</td>
</tr>
<tr>
<td></td>
<td><strong>or</strong></td>
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<tr>
<td></td>
<td><strong>Nest building</strong> seen at the actual nest site, excluding wrens, woodpeckers, chickadees and nuthatches.</td>
</tr>
<tr>
<td></td>
<td><strong>or</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Distraction displays</strong>, defense of unknown nest or young or injury feigning. Used if adult bird is seen trying to lead people away from nest or young. Commonly seen in most ground nesters, this is the typical killdeer broken-wing act. This also includes active defense such as a Cooper's hawk diving at an intruder. Does not include agitated behavior.</td>
</tr>
<tr>
<td></td>
<td><strong>or</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Used nest</strong> or eggshells found. Unless carefully identified, used only for unmistakable egg shells and nests that were used during the atlas period. Magpie nests, for example, are characteristic.</td>
</tr>
<tr>
<td></td>
<td><strong>or</strong></td>
</tr>
<tr>
<td></td>
<td>Recently <strong>fledged</strong> young of altricial species incapable of sustained flight or downy young of precocial species restricted to the natal area by dependence of adults or limited mobility. A duck brood on an isolated pond merits this code, but barely fledged blackbirds and swallows may fly considerable distances. The presence of young cowbirds confirms both the cowbird and the host.</td>
</tr>
<tr>
<td></td>
<td><strong>or</strong></td>
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<tr>
<td></td>
<td><strong>Occupied nest</strong> indicated by adult entering or leaving nest site in circumstances indicating an occupied nest, including those in high trees, cliffs, cavities, and burrows in which the contents of the nest and incubating or brooding adult cannot be seen.</td>
</tr>
<tr>
<td></td>
<td><strong>or</strong></td>
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<tr>
<td></td>
<td>Adults seen <strong>carrying food</strong> for the young. Some birds, especially corvids and raptors, may carry food some distance before eating it themselves.</td>
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<tr>
<td></td>
<td><strong>or</strong></td>
</tr>
<tr>
<td></td>
<td>Adults feeding recently <strong>fledged young</strong>. Young cowbirds begging food confirm both the cowbird and the host.</td>
</tr>
<tr>
<td></td>
<td><strong>or</strong></td>
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<tr>
<td></td>
<td>Adult carrying <strong>fecal sac</strong>. Many passerines keep their nests clean by carrying fecal sacs away from the nest.</td>
</tr>
<tr>
<td></td>
<td><strong>or</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Nest with eggs</strong> found. Same cautions as under <strong>used nest</strong> apply here. Cowbird eggs confirm both the cowbird and the host.</td>
</tr>
<tr>
<td></td>
<td><strong>or</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Nest with young</strong> seen or heard. Used when young actually seen or, as with most cavity nesters, when young only are heard. A cowbird chick in the nest confirms both the cowbird and the host.</td>
</tr>
</tbody>
</table>

1Modified from Corman (1994).