

United States Department of the Interior
Bureau of Land Management

**East SPRNCA Complex Land Health
Evaluation**

Three Brothers Lease No. 5232
Lucky Hills Lease No. 5252

April 2022

U.S. Department of the Interior
Bureau of Land Management
Gila District
Tucson Field Office
3201 East Universal Way
Tucson, AZ 85756
Phone: (520) 258-7200
FAX: (520) 258-7238



This page left intentionally blank.

Table of Contents

LIST OF ACRONYMS AND ABBREVIATIONS	vi
1. Introduction.....	1
1.1 Definitions of Arizona Standards for Rangeland Health and Guidelines for Grazing Administration.....	1
2. Complex Profile and General Description.....	2
2.1 Location.....	2
2.2 Physical Description.....	2
2.2.1 Surface Land Ownership.....	2
2.2.2 Climate.....	2
2.2.3 Watersheds and Water Resources.....	3
2.2.4 Soils.....	4
2.2.5 Range Improvements.....	4
2.2.6 Management Category.....	4
2.3 Biological Resources.....	5
2.3.1 Major Land Resource Areas.....	5
2.3.2 Ecological Sites.....	5
2.3.3 Vegetation Communities.....	5
2.3.4 Wildlife Resources.....	7
2.4 Special Management Areas.....	8
2.4.1 San Pedro Riparian National Conservation Area.....	8
2.4.2 Wild and Scenic Rivers.....	8
2.5 Recreation Resources, Visual Resources, and Access.....	8
2.6 Cultural Resources.....	9
2.6.1 Three Brothers.....	9
2.6.2 Lucky Hills.....	10
2.7 Tribal Interests.....	11
3. Grazing Management.....	12
3.1 Allotment-specific Management.....	12
3.1.1 Three Brothers.....	12
3.1.2 Lucky Hills.....	12
3.2 Current Terms and Conditions for Authorized Use.....	12
4. Standards and Objectives.....	14
4.1 Land Health Standards.....	14
4.2 Resource Management Plan Objectives.....	15

4.2.1	SPRNCA RMP	15
4.2.2	Safford District RMP	16
4.3	Allotment-Specific Objectives	16
4.3.1	DPC Objective Methodology.....	17
4.3.2	Key Areas and AIM Study Plots	18
4.3.3	Three Brothers	18
4.3.4	Lucky Hills.....	22
5.	Rangeland Inventory and Monitoring Methodology	28
5.1	Rangeland Inventories.....	28
5.1.1	Indicators of Rangeland Health.....	28
5.2	Monitoring Protocols.....	28
5.2.1	Assessment Inventory and Monitoring (AIM).....	28
5.2.2	Actual Use.....	29
6.	Management Evaluation and Summary	30
6.1	Recent Rainfall Data	30
6.2	Rangeland Health Assessments	30
6.2.1	Standard 1: Upland Sites.....	32
6.2.2	Standard 2: Riparian-Wetland Sites	45
6.2.3	Standard 3 Desired Resource Conditions	45
7.	Recommendations	48
7.1	Recommended Management Actions	48
7.1.1	Cultural Resources.....	48
8.	Preparers and Reviewers.....	49
9.	References	50

This page left intentionally blank.

LIST OF ACRONYMS AND ABBREVIATIONS

AIM	Assessment Inventory and Monitoring
AUM	Animal Unit Month
BLM	Bureau of Land Management
C	“Custodial” Management Category
CFR	Code of Federal Regulations
DPC	Desired plant community
ESD	Ecological Site Description
GLO	General Land Office
GPS	Global positioning system
Guidelines	Guidelines for Grazing Administration
HCPC	Historical climax plant community
HDMS	Heritage Data Management System
I	“Improve” Management Category
ID	Interdisciplinary
IIRH	Interpreting Indicators of Rangeland Health
IPaC	Information for Planning and Conservation
LHE	Land Health Evaluation
M	“Maintain” Management Category
MLRA	Major Land Resource Area
NAD	North American Datum
NRCS	Natural Resources Conservation Service
OHV	Off-Highway Vehicle
P.L.	Public Law
p.z.	Precipitation zone
RMP	Resource Management Plan
RMZ	Recreation Management Zone
ROD	Record of Decision
SPRNCA	San Pedro Riparian National Conservation Area
SR	State Route
Standards	Arizona Standards for Rangeland Health
TEC	Topographic Engineering Center
TFO	Tucson Field Office
U.S.C.	United States Code
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior

East SPRNCA Complex Land Health Evaluation

USFWS U.S. Fish and Wildlife Service
VRM Visual Resource Management

1. INTRODUCTION

The purpose of this Land Health Evaluation (LHE) report for the Three Brothers and Lucky Hills Allotments (hereafter the “East San Pedro Riparian National Conservation Area [SPRNCA] Complex” or “Complex Allotments”) is to evaluate existing monitoring data against the Arizona Standards for Rangeland Health (Standards) and other site-specific objectives. An evaluation is not a decision document, but a standalone report that clearly records the analysis and interpretation of the available inventory and monitoring data. As part of the Land Health Evaluation process, allotment-specific objectives were established for the biological resources within the Complex Allotments.

The BLM made the draft LHE available for public comment May 18-June 24, 2021. This LHE has been updated and a stand-alone final land health determination document has been signed. The final determination document identifies the causal factors for the non-achievement of land health Standards and informs the development of alternatives to make progress towards achieving Standards on the East SPRNCA Complex Allotment.

The Secretary of the Interior approved the Arizona Bureau of Land Management (BLM) Standards for Rangeland Health and Guidelines for Grazing Administration (Standards and Guidelines) in April 1997. The Decision Record signed by the Arizona BLM State Director (BLM 1997) provides for full implementation of the Standards and Guidelines in Arizona land-use plans. Standards and Guidelines are implemented by the BLM through the terms and conditions of grazing permits, leases, and other authorizations, grazing-related portions of activity plans, and through range improvement-related activities. The Standards for Rangeland Health are measurable and attainable goals for the desired condition of the biological resources and physical components/characteristics of desert ecosystems found within the allotment.

1.1 Definitions of Arizona Standards for Rangeland Health and Guidelines for Grazing Administration

The Standards are expressions of levels of physical and biological condition or degree of function required for healthy, sustainable rangelands and define minimum resource conditions that must be achieved and maintained. Determination of rangeland health is based upon conformance with the Standards.

Guidelines consider the type and level of grazing use. Guidelines for grazing management are types of methods and practices determined to be appropriate to ensure the Standards can be met or that significant progress can be made toward meeting the Standards. Guidelines are tools that help managers and lessees achieve the Standards.

Although the process of developing Standards and Guidelines applies to grazing administration, present rangeland health is the result of the interaction of many factors in addition to grazing livestock. Other contributing factors may include, but are not limited to, past land uses, land-use restrictions, recreation, wildlife, rights-of-way, wild horses and burros, mining, fire, weather, and insects and disease (Arizona Standards and Guidelines, BLM 1997).

The Arizona Standards and Guidelines identify three standards regarding (1) upland sites, (2) riparian-wetland sites, and (3) desired resource conditions based on specific indicators.

2. COMPLEX PROFILE AND GENERAL DESCRIPTION

2.1 Location

The East SPRNCA Complex is located between the town of Tombstone and the SPRNCA in Cochise County, Arizona, with the Three Brothers and Lucky Hills Allotments situated adjacent to each other. Maps of the Complex Allotments are provided in Appendix A.

2.2 Physical Description

This section describes physical, or abiotic, characteristics of the East SPRNCA Complex, such as land ownership, soils, and infrastructure.

2.2.1 Surface Land Ownership

The Complex Allotments are predominately comprised of state lands, with lesser amounts of private and public lands (Table 1). These ownership boundaries are not separated by fence lines. Land ownership maps are provided in Appendix A.

Three Brothers Allotment

BLM-managed lands comprise about 30% of the Three Brothers Allotment, with most of these lands within the SPRNCA boundaries. The SPRNCA boundary is only partially fenced in the Three Brothers Allotment and thus the SPRNCA is not fully separated from the rest of the allotment. Private land acreages presented (about 12% of the allotment) are totals within the allotment boundary and are a combination of controlled and uncontrolled lands (Table 1). Private controlled lands are owned or leased by the livestock operator on the allotment and contribute to the total grazing operation within the Three Brothers Allotment. Private uncontrolled lands are not under control of the livestock operator (e.g., housing developments) and do not contribute to the forage base in the Three Brothers Allotment but are located within the allotment perimeter.

Lucky Hills Allotment

BLM-managed lands comprise about 37% of the Lucky Hills Allotment, with most of these lands outside the SPRNCA boundary. The SPRNCA boundary is only partially fenced in the Lucky Hills Allotment and thus the SPRNCA is not fully separated from the rest of the allotment. Private lands comprise about 10% of the allotment and are a combination of controlled and uncontrolled lands (see definitions above).

Table 1. Acreage of land ownership.

Land Ownership	Three Brothers	Lucky Hills
<i>Public Acres inside the SPRNCA</i>	2,279	1,739
<i>Public Acres outside the SPRNCA</i>	340	8,306
Total Public Acres (inside and outside the SPRNCA)	2,619	10,045
State Acres	5,064	11,750
Controlled Private Land Acres	160	800
Uncontrolled Private Land Acres	910	4,796
Total Acres	8,753	27,391

2.2.2 Climate

This section describes the long-term climate for the Tombstone area using the most recent published 30-year Climate Normal data (1981-2010) from the Tombstone Cooperative Observer Program (COOP) weather station (Arguez et al. 2012). The annual rainfall Climate Normal for the 30-year period at the

Tombstone site is 14.14 inches for precipitation (Table 2). The NRCS Ecological Site Descriptions used in this evaluation for reference conditions are based on a 12 to 16-inch annual precipitation zone.

Table 2. Precipitation and Temperature Averages.

Calendar Year Rainfall and Mean Temperatures per Month – NOAA 30-Year Climate Normal at Tombstone, AZ (1981-2010)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precipitation (Inches)													Total
<i>Average</i>	1.01	0.77	0.73	0.32	0.28	0.61	2.98	3.17	1.6	0.98	0.64	1.05	14.14
Temperature (°F)													Average
<i>High</i>	59.5	62.7	68.7	76.7	85.4	93.7	92.3	89.2	87.1	78.4	67.9	59.6	76.8
<i>Low</i>	35.7	37.9	41.4	47.5	55.3	63.1	66.3	65	61.3	52.2	42.9	36.1	50.4
<i>Average</i>	47.6	50.3	55.1	62.1	70.3	78.4	79.3	77.1	74.2	65.3	55.4	47.9	63.6
Source: Arguez et al. (2012)													

Using six rain gauges in the Walnut Gulch Experimental Watershed (WGEW), Goodrich et al. (2008) found the long-term (1956-2006) average annual rainfall to be approximately 12.2 inches. Thomas and Pool (2006) computed the long-term average from 1902 to 2002 at the Tombstone Weather Station to be 13.6 inches. The slightly higher average found with the Climate Normals is due to the inclusion of above average rainfall in the late 1980's and early 1990's in the shorter time period. The established Climate Normal serves as the baseline against which more recent site-specific allotment data (found in Section 6.1) is compared.

Rainfall in Southern Arizona is typically split into two seasons: summer and winter. Summer monsoon season rainfall accounts for approximately 60% of annual rainfall totals. Summer rains fall July through September, originate in the Gulf of Mexico, and are convective, usually brief, intense thunderstorms. This causes the rainfall to be unevenly distributed across the landscape. Even small areas separated by a relatively short distance can receive drastically different amounts of rain. Cool season moisture originates in the Pacific and Gulf of California, tends to be frontal, and falls in widespread storms with long duration and low intensity. Snow rarely lasts more than one day. May and June are the driest months of the year. Humidity is generally very low throughout the year.

The allotment is characterized by hot summers and mild winters. Data on average temperatures are shown in Table 2 above. The hottest days occur during June, July, and August; some days may exceed 100°F. Freezing temperatures are common at night from December through April; however, temperatures during the day are frequently above 50°F. Occasionally from December through February, temperatures may drop briefly to 0°F at night (c.f., Limy Upland Ecological Site Description [ESD] via the *Ecosystem Dynamics Interpretive Tool* [EDIT] 2020).

2.2.3 Watersheds and Water Resources

The Complex Allotments are located just east of the San Pedro River and lie within the Upper San Pedro HUC-8 Subbasin. Within this subbasin, both allotments are included in the smaller Walnut Gulch-San Pedro River and Clifford Wash-San Pedro River HUC-10 Watersheds.

The allotments cover the downstream (western) part of the USDA Agricultural Research Service's Walnut Gulch Experimental Watershed (WGEW). This watershed is representative of approximately 60 million hectares of brush- and grass-covered rangeland found throughout the semi-arid southwest and is a transition zone between the Chihuahuan and Sonoran Deserts. The primary drainage in the allotments

and WGEW is Walnut Gulch, which is an ephemeral tributary of the San Pedro River with a watershed size of 58 square miles.

The largest nearby perennial drainage to the Complex Allotments is the San Pedro River, which starts in its headwaters in Mexico and reaches its terminus at the confluence with the San Pedro River and the Gila River. The reach of the San Pedro River at the confluence with Walnut Gulch is intermittent, indicating it has continuous stream flow for only part of the year (NRST 2012). The San Pedro River has a drainage area of 1,234 square miles.

2.2.4 Soils

Soil data from the Natural Resource Conservation Service (NRCS) *Web Soil Survey* were used to identify ecological sites on the Complex. For example, based on the NRCS (2020a) *Web Soil Survey*, Luckyhills-McNeal complex is the most prevalent soil type (37% within the Three Brothers Allotment and 22% within the Lucky Hills Allotment). The common ecological site for this soil type is Limy Uplands. Other common soil types on the BLM portion of the Complex Allotments are Libby-Gulch complex, Luckyhills loamy sand, Brunkcow-Chiricahua-Andrada complex, Sutherland-Mule complex, and Brunkcow-Chiricahua-Lampshire complex (Appendix A: Figures A-3 and A-9). Complete descriptions of the soil types on the Complex Allotments are available through the online *Web Soil Survey*.

2.2.5 Range Improvements

The Three Brothers Allotment is fenced into three pastures with one well, storage tank, trough, and corral on BLM-managed land and two corrals and four watering locations on state and private land as shown in Appendix A: Figure A-5. The Lucky Hills Allotment boundary is entirely fenced on the BLM-managed lands in the SPRNCA. The Lucky Hills Allotment is further divided into nine pastures with 11 watering locations and three sets of corrals on BLM-managed land (one of the 11 watering locations is within the SPRNCA) and approximately 13 watering locations on state and private land (Appendix A: Figure A-10). Range improvements were identified on aerial imagery and verified by the lease holders. The SPRNCA boundary is partially fenced within the Complex Allotments. On the Three Brothers Allotment, the SPRNCA boundary is partially fenced on the eastern side, separating BLM lands from state lands for two miles (Appendix A: Figure A-6). On the Lucky Hills Allotment, the SPRNCA boundary is fenced on the southern side (separating SPRNCA BLM lands from non-SPRNCA BLM lands) but not on the eastern side (Appendix A: Figure A-7).

2.2.6 Management Category

The management category given to the Complex Allotments is Maintain (M).

The Selective Management Category process was initiated in 1982 and was used primarily to establish priorities for investing in range improvements. Those categories include: Improve (I), Maintain (M) and Custodial (C).

Category I: Allotments where current livestock grazing management or level of use on public land is, or is expected to be, a significant causal factor in the non-achievement of land health standards or where a change in mandatory terms and conditions in the grazing authorization is or may be necessary. When identifying Category I allotments, review condition of critical habitat, conflicts with sage-grouse, and whether projects have been proposed specifically for implementing the Healthy Lands Initiative.

Category M: Allotments where land health standards are met or where livestock grazing on public land is not a significant causal factor for not meeting the Standards and current livestock management is in conformance with guidelines developed by the State Directors in consultation with Resource Advisory

Councils. Allotments where an evaluation of land health standards has not been completed, but existing monitoring data indicates that resource conditions are satisfactory.

Category C: Allotments where public lands produce less than 10% of the forage in the allotment or are less than 10% of the land area. An allotment should generally not be designated Category C if the public land in the allotment contains: 1) critical habitat for a threatened or endangered species, 2) wetlands negatively affected by livestock grazing.

2.3 Biological Resources

2.3.1 Major Land Resource Areas

Major Land Resource Areas (MLRA) are geographically associated land resource units, usually encompassing several thousand acres. Soil scientists with NRCS in appropriate geographic states wrote the descriptions of MLRAs and are responsible for describing new MLRAs and/or adjusting the boundaries of existing MLRAs. A MLRA may be one continuous area or several separate nearby areas. MLRAs are characterized by patterns of soils, geology, climate, water resources, and land use. The Complex Allotments are in MLRA 41—Southeastern Arizona Basin and Range, which makes up about 15,730 square miles. Most of MLRA 41 is in the Mexican Highland Section of the Basin and Range Province of the Intermontane Plateaus, consisting of mountain ranges that trend southeast to northwest and relatively flat valleys between the mountains. The eastern one-fifth of the area is in the Sonoran Desert section of that same province and division. MLRAs are further broken down into ecological sites, which are associated units of soil and vegetation with quantifiable characteristics.

2.3.2 Ecological Sites

An ecological site is a distinctive kind of land that is unique in its ability to produce a distinctive kind and amount of vegetation. The soils, hydrology, and vegetation within an ecological site are the product of many environmental, biotic, and abiotic factors, which are described in the Ecological Site Description (ESD) as established by the NRCS. Ecological sites are named/classified based on soil parent material or soil texture and precipitation and provide a consistent framework for classifying and delineating land units that share similar capabilities to respond to management activities or disturbance. State and transition models in the ESD describe multiple plant community states and the natural range of variability within those states that may result from activities and disturbances, such as land use, vegetation management, climate change, and spread of invasive species. The NRCS also produces reference sheets for many ecological sites that detail the natural variability in rangeland health indicators. ESDs and reference sheets were accessed online through the *Ecosystem Dynamics Interpretive Tool* (EDIT 2020).

Soil map units were used to help identify ecological sites in the Complex Allotments. Most soil map units are comprised of two or more ecological sites. For example, a soil map unit described as “Clayey Swale 90%, Loamy Swale 10%” refers to the approximate proportion of each ecological site found in a particular soil map unit. In other words, 90% of the unit is Clayey Swale ecological site and 10% of the unit is Loamy Swale ecological site. These are also referred to as blended sites. Ecological site maps for the Complex Allotments (Appendix A: Figures A-6 and A-11) are generalized to larger scales and on the ground ecological site identification and verification is necessary in determining the correct ESD and reference sheet. There are a total of 13 ecological sites within the Complex Allotments. Additional details on ecological sites within the Complex are provided in Section 4.3.

2.3.3 Vegetation Communities

Tables 3 and 4 (below) list the vegetation communities on all lands within the Complex Allotments, with the individual vegetation community acreages separated by whether they fall inside or outside of the

SPRNCA boundary. Specific vegetation community acreages are shown for the SPRNCA as these acreages tie to SPRNCA RMP vegetation objectives. They are also shown in Appendix A: Figures A-4 and A-8. Chihuahuan Desertscrub is the primary vegetation community for both allotments, comprising 78% of the total acreage of the Three Brothers Allotment and 84% of the total acreage of the Lucky Hills Allotment. The data source for lands outside the SPRNCA is Landfire. Data on BLM-managed land inside the SPRNCA is a combination of data from the U.S. Army Topographic Engineering Center (TEC) (2001), the Southwest Regional Gap Analysis Project, and ESDs. The data source on non-BLM lands within the allotment is U.S. Army TEC (2001).

Three Brothers

Table 3. Vegetation Communities found within the Three Brothers Allotment.

Vegetation Community	Inside SPRNCA		Outside SPRNCA		Allotment Total	
	Acres	Percent Area	Acres	Percent Area	Acres	Percent Area
Agriculture	0	<1	28	<1	28	<1
Chihuahuan Desertscrub	1,485	17	5,335	61	6,820	78
Cottonwood/Willow ¹	11	<1	56	1	67	1
Desert Washes (Xeric Riparian)	182	2	20	<1	202	2
Developed	0	0	66	1	66	1
Mesquite Bosque	78	1	0	0	78	1
Other	0	0	109	1	109	1
Semi-desert Grassland	523	6	862	10	1,385	16
TOTAL	2,279	26	6,475	74	8,754	100

¹ The Cottonwood/Willow Vegetation Community listed here was identified from remote sensing data and indicates either stray cottonwoods and willows along ephemeral washes or misclassified mesquites or other larger vegetation types.

Lucky Hills

Table 4. Vegetation Communities found within the Lucky Hills Allotment.

Vegetation Community	Inside SPRNCA		Outside SPRNCA		Total	
	Acres	Percent Area	Acres	Percent Area	Acres	Percent Area
Agriculture	0	0	44	0	44	<1
Chihuahuan Desertscrub	1,599	6	21,530	79	23,129	84
Cottonwood/Willow ¹	13	0	88	<1	101	<1
Desert Washes (Xeric Riparian)	0	0	15	<1	15	<1
Developed	<1	<1	806	3	806	3
Mesquite Bosque	28	<1	0	0	28	<1
Other	0	0	279	1	279	1
Semi-desert Grassland	99	<1	2,893	11	2,992	11
Total	1,739	6	25,656	94	27,395	100

¹ The Cottonwood/Willow Vegetation Community listed here was identified from remote sensing data and indicates either stray cottonwoods and willows along ephemeral washes or misclassified mesquites or other larger vegetation types.

Dominant Vegetation Community Descriptions

Chihuahuan Desertscrub and semidesert grasslands are the dominant vegetation communities on the Complex Allotments.

Chihuahuan Desertscrub

Dominant shrub species are whitethorn acacia, tarbush, and creosote bush. Other shrubs present are mariola, desert sumac, and mesquite. Bush muhly and threeawn grasses are common perennial grasses. Other important plant species are ocotillo, soap tree yucca, and Palmer's century plant. These species all provide nectar for migrating birds and certain bat species.

Semidesert Grassland

Semidesert grassland once covered vast areas of the San Pedro River Valley, where now only remnants remain (Latta et al. 1999). This habitat is now associated with drainages in the Chihuahuan Desertscrub. Native perennial grasses may include sideoats grama, blue grama, vine mesquite grass, tobosa grass, cane beardgrass, Arizona cottontop, and threeawn grasses. Lehmann lovegrass (*Eragrostis lehmanniana*), a non-native perennial grass, can also be common in this community, particularly in the Limy and Granitic Upland ecological sites (EDIT 2020).

2.3.4 Wildlife Resources

General Wildlife

The expected wildlife species composition on the Complex Allotments is characteristic of the Mexican Highland Section of the Basin and Range Province of the Intermontane Plateaus in southeastern Arizona. Possible common species include, but are not limited to: mule deer, Coues white-tailed deer, mountain lion, coyote, bobcat, raccoon, skunk, white-throated woodrat, white-footed mouse, a variety of bats, gopher snake, king snake, western diamondback rattlesnake, coachwhip, patch-nosed snake, western whiptail lizard, side-blotched lizard, and tree lizard.

Livestock may impact wildlife in a variety of ways, by their presence, through behavioral disturbance, and through competition for forage. Behavioral impacts resulting from interspecific encounters (including human and livestock) are difficult to quantify, as they vary by species and by type of interaction. Wildlife currently present on the Complex Allotments have, to varying degrees, acclimated to the presence of livestock and associated human disturbances.

Special Status Species

U.S. Fish and Wildlife Service (USFWS) *Information for Planning and Conservation (IPaC)* (USFWS 2020) and Arizona Game and Fish Department (AGFD) *Heritage Data Management System (HDMS)* (AGFD 2020) online databases show that 10 federally threatened or endangered species, 13 migratory birds protected under the Migratory Bird Treaty Act, and eight BLM sensitive species could occur within Complex Allotments boundary as well as within a five-mile buffer of the allotments (see Appendix B for species lists). In addition, yellow-billed cuckoo has proposed critical habitat that occurs within the Complex boundary. Some of the migratory birds that have the potential to occur within the Complex include: black throated sparrow, gilded flicker, common black hawk, lark bunting, and Virginia warbler. The BLM sensitive species that could occur on the Complex Allotments include: desert box turtle, Sonoran mud turtle, lowland leopard frog, cave myotis, longfin dace, desert sucker, golden eagle, and San Pedro River wild buckwheat.

2.4 Special Management Areas

2.4.1 San Pedro Riparian National Conservation Area

The SPRNCA is in Cochise County, Arizona, south of Benson and west of Tombstone and Bisbee, Arizona (see Appendix A: Figures A-1 and A-2). It starts at the US-Mexico border and runs north-south for approximately 47 miles, encompassing 55,990 acres of federal lands administered by the BLM's Tucson Field Office (TFO). Congress designated the SPRNCA as the nation's first riparian National Conservation Area on November 18, 1988, through Public Law (P.L.) 100-696. The SPRNCA contains four of the rarest habitats in the southwest, a rich diversity of plants and animals, and a number of nationally significant paleontological and cultural sites. The 2019 RMP established goals and objectives to achieve the purposes of the SPRNCA while providing for allowable uses.

The Three Brothers Allotment includes 2,279 acres of public land in the SPRNCA which is approximately 24% of the entire allotment acreage. The Lucky Hills Allotment includes 1,739 acres of public land in the SPRNCA which is approximately 6% of the entire allotment acreage.

2.4.2 Wild and Scenic Rivers

The Complex is located adjacent to the San Pedro Wild and Scenic River study corridor. The 2019 SPRNCA RMP found the San Pedro River suitable for addition to the National Rivers System with a recreational classification (BLM 2019: ama-WSR-1) and water quality is an important river value. Several major drainages on the allotments flow into the San Pedro River and are sources of surface runoff and sediment. Management of the allotments could affect the water quality in the study river and thus its suitability.

2.5 Recreation Resources, Visual Resources, and Access

The BLM-managed lands in the Complex Allotments provide opportunities for dispersed recreational use in undeveloped settings. The part of the Complex Allotments in the SPRNCA are under a Back Country Recreation Management Zone (RMZ) with planned motorized access and a Primitive RMZ. The RMZs identify recreation management objectives for recreational access, activities, and the recreational setting as described in the RMP. There are no specific recreation management objectives for the BLM lands outside of the SPRNCA. Typical activities in the area include sightseeing, off-highway vehicle (OHV) driving, hunting, target shooting, backcountry camping, hiking, mountain biking, and equestrian riding. There are no developed recreation sites or maintained trails on the allotments. The existing network of roads on BLM, state, and private land provide motorized and non-motorized recreational access to the BLM lands in the Complex Allotments. Some BLM lands in the Tombstone area are accessed via municipal streets and are used by locals for dispersed recreation.

The Complex Allotments are part of the scenery viewed in the foreground and other distances along State Route (SR) 82, SR 80, Charleston Road, local travel routes, and developed areas including Tombstone. The part of the allotments that is located in the SPRNCA is viewed from local travel routes, particularly the existing powerline road. Part of the allotment along the SR 82 corridor is under Visual Resource Management (VRM) Class II to preserve the character of the landscape and the rest of the allotments is under VRM Class III. Range improvements that involve construction of facilities (earthwork, structures, roads, tanks, etc.) are subject to visual design review to blend in with the surrounding landscape.

Public recreational access to BLM-managed lands in the Complex Allotments is mainly from SR 82, SR 80, and Charleston Road via existing unimproved roads that provide access to BLM and state lands. The historic railroad grade from Fairbank to Tombstone along Walnut Gulch and across the Three Brothers Allotment is identified by BLM (1995) as a connector trail route in the San Pedro Intermodal

Transportation System plan that established the San Pedro Trail system. Motor vehicle use is limited to designated roads and trails in the SPRNCA RMP (BLM 2019: ama-TTM-1).

2.6 Cultural Resources

The BLM’s evaluation of the Standards includes considerations for the protection and conservation of cultural resources—such as prehistoric and historic-age sites, buildings, and structures—in addition to plants and other resources with potential cultural significance to Native American tribes. Should the BLM identify impacts to cultural heritage sites or traditional-use resources, revised lease terms and conditions may be warranted, and rangeland management directives could be modified to achieve desired resource conditions.

The following sections describe the BLM’s assessment efforts regarding applicable cultural and traditional-use resources within the Complex Allotments. A BLM cultural resources specialist completed a comprehensive Class 1 (existing information) assessment of the subject allotments between February 20 and March 16, 2020. Data reviewed were obtained from BLM cultural program project files, site reports, and atlases, in addition to BLM-maintained General Land Office (GLO) plats and patent records. Electronic files also were reviewed using online cultural resource databases including *AZSite* (2020), Arizona’s statewide cultural resource inventory system, and the *National Register of Historic Places NPGallery Digital Asset Search* (2020). Archival information was compared with livestock grazing and range improvement data to determine the potential for resource conflicts, particularly in livestock concentration areas such as around water sources, at chutes/corrals, and near supplemental feeding locations. The results of archival research are summarized as follows; data provided are applicable to BLM-administered lands within the subject allotment (i.e., the jurisdictional Area of Potential Effect [APE]) and based on currently available information from the aforementioned sources.

2.6.1 Three Brothers

Background research identified 13 prior cultural resources investigations (Table 5) that, collectively, have inventoried approximately 160 acres of BLM-managed surface and documented four cultural resource sites within the Three Brothers Allotment. Known site types include prehistoric resource procurement and processing sites in addition to historic-age dumps/camps and a railroad alignment.

Table 5. Prior Cultural Resources Investigations within the Three Brothers Allotment.

No	Project No.	Project Name	Reference(s)
1	1980-31.ASM	ADOT Lease	Madsen 1980
2	1981-67.ASM	ADOT Materials Source #8278	Sullivan 1981
3	1983-124.ASM	Pit #8278 Haul Road	Dart 1983
4	1985-213.ASM	AEPCO San Rafael Project	Dosh et al. 1987
5	2003-910.ASM	360 Networks Fiber Optic Lines	Railey and Yost 2001
6	2012-73.ASM	Valley Telephone Fiber Optic	Knoblock 2001
7	2015-187.ASM	Three Brothers Tank	Whitney 2015
8	BLM-81-67	BLM Survey	BLM TFO Maps
9	BLM-85-24	BLM Survey	BLM TFO Maps
10	BLM-88-16	BLM Survey	BLM TFO Maps
11	BLM-89-04	BLM Survey	BLM TFO Maps
12	BLM-060-90-03	BLM Survey	AZSite 2020
13	BLM-422-2005-61	San Pedro Section 110 Inventory	Childress 2005

Historic-age GLO plat maps also were reviewed and depict a road, the “SPRR” alignment, fences, a house, a shed, a telephone line, and several mining claims (plat nos. 2389 and 2397, dated 1947 and

1905, respectively). One of these features corresponds with a livestock concentration area; however, it has likely been modified for continual livestock use. Such features—in particular, those associated with ranching and mining—may exist throughout the subject allotment. These serve as evidence of the long-term history of grazing and mining within the allotment and surrounding area, much of which predates the early 1900’s.

2.6.2 Lucky Hills

Background research identified 21 prior cultural resources investigations (Table 6) that, collectively, have inventoried roughly 765 acres of BLM-managed surface and documented 27 cultural resource sites within the Lucky Hills Allotment. Known site types include prehistoric resource procurement, processing, and rock art sites in addition to historic-age railroads, roads, dumps/camps, mining-related sites, and the Tombstone Townsite.

Table 6. Prior Cultural Resources Investigations within the Lucky Hills Allotment.

No	Project No.	Project Name	Reference(s)
1	1968-1.ASM	Charleston Dam Survey	Kayser n.d.
2	1985-213.ASM	AEPCO San Rafael Project	Dosh et al. 1987
3	1996-314.ASM	ADOT/US 80 Bridges	Kwiatkowski 1996
4	1997-392.ASM	SR 80 Tombstone	Stone and Palus 1997
5	2000-270.ASM	US 80: Clifford Wash-Tombstone	Punzmann and Jackman 2000
6	2000-817.ASM	Charleston Mine Survey	Hayes 2002
7	2003-910.ASM	360 Networks Fiber Optic Lines	Railey and Yost 2001
8	2009-54.ASM	Miner’s Dream Survey	Doak 2009
9	2011-182.ASM	Tombstone Jct to SWTC 230	Rawson 2011
10	2012-73.ASM	Valley Telephone Fiber Optic	Knoblock 2001
11	2014-187.ASM	Tombstone AML Survey	Lyon 2013
12	SHPO-2000-1718	Tombstone Quarry	Hammack 2000
13	BLM-060-84-22	BLM Survey	AZSite 2020
14	BLM-060-SP-99-16	BLM Survey-Henderson ROW	AZSite 2020
15	BLM-069-02-39	BLM Survey-Winters ROW	AZSite 2020
16	S#193	BLM Survey	BLM TFO Maps
17	S#228	BLM Survey	BLM TFO Maps
18	S#523	BLM Survey	BLM TFO Maps
19	S#602	BLM Survey	BLM TFO Maps
20	S#690H	BLM Survey	BLM TFO Maps
21	S#88-8	BLM Survey	BLM TFO Maps

Historic-age GLO plat maps also were reviewed that depict named and unnamed roads, railroad alignments, “J. L. McClellan” house, the “Watervale Millsite”, a pipeline from Sycamore Canyon to Tombstone, telegraph and telephone lines, fence lines, numerous buildings (e.g., sheds, cabins, and houses), abundant mining claims and related features (e.g., shafts, shaft houses, water tanks, windmills, and mine workings), and the Townsite of Tombstone (plat nos. 2335, 2389, and 2397; dated 1908, 1947, and 1905, respectively). Although none of these features correspond with range improvements or livestock concentration areas on BLM-managed surface, historic land-use features—in particular, ranching and mining features—may exist throughout the subject allotment. Such features serve as evidence of the long-term history of grazing and mining activities within the allotment and surrounding vicinity, much of which predates the early 1900’s.

Notably, the Tombstone Townsite, which is situated in the central portion of the subject allotment, is an NRHP-listed National Historic Landmark (aka the Tombstone Historic District) that is bordered in several

places by BLM-administered land; however, developed townsite buildings, structures, and properties that border BLM lands are fenced from livestock entry.

2.7 Tribal Interests

The BLM is consulting with nine Native American tribes who claim cultural affiliation to and/or traditional use of the area as determined through the online *Arizona Government-to-Government Consultation Toolkit* (2020). Identified tribes for consultation initiation include the Fort Sill Apache Tribe, Hopi Tribe, Mescalero Apache Tribe, Pascua Yaqui Tribe, Tohono O'odham Nation, San Carlos Apache Tribe, White Mountain Apache Tribe, Yavapai-Apache Nation, and Zuni Tribe. Plant species identified as having potential cultural significance include broom snakeweed (*Gutierrezia sarothrae*) and velvet mesquite (*Prosopis velutina*) (NRCS 2020b).

Currently, there are no known adverse impacts to any culturally significant plants, items, sites, or landscapes. If new information is provided by consulting tribes, additional or edited terms and conditions of land-use or mitigation may be required to protect or restore resource values.

3. GRAZING MANAGEMENT

The Complex Allotments have a long history of livestock grazing, predating the establishment of the SPRNCA or the BLM. Cochise County remains one of the top two livestock producing counties in Arizona, and Tombstone was a historic livestock market (Collins 1996). The following section discusses the allotment-specific management, permitted use, and terms and conditions on the current leases for the Complex Allotments.

3.1 Allotment-specific Management

3.1.1 Three Brothers

The Three Brothers Allotment consists of 8,753 acres of BLM, state, and private lands used in a three-pasture, year-long, rest-rotation livestock grazing system. The BLM portion of the allotment provides for 30% (identified as % public land in the terms and conditions) of the total forage on the allotment with 2,279 acres within the boundaries of the SPRNCA (see Table 1).

3.1.2 Lucky Hills

The Lucky Hills Allotment consists of 27,391 acres of BLM, state, and private lands used in a nine-pasture, year-long, rest-rotation livestock grazing system. The BLM portion of the allotment provides for 37% (identified as % public land in the terms and conditions) of the total forage on the allotment with 1,739 acres within the boundaries of the SPRNCA (see Table 1).

3.2 Current Terms and Conditions for Authorized Use

Grazing use on the Complex Allotments are in accordance with the terms and conditions of the current leases issued for 196 and 1080 AUMs on BLM-managed lands, respectively. The mandatory terms and conditions of the lease are listed in Table 7 below:

Table 7. Mandatory terms and conditions of the existing leases.

Allotment Name	Allotment Number	Total livestock on the BLM acres of the allotment	Livestock Type	Grazing Period of Use	% Public Land*	Type Use	AUMs
Three Brothers	5232	68	Cattle	3/1 to 2/28	24	Active	196
Lucky Hills	5252	90	Cattle	3/1 to 2/28	100	Active	1080

* Percent Public Land is used for calculating AUMs on the BLM-managed acreage. This is not stating the percent of public land within the total allotment.

Existing Other Terms and Conditions (applicable to both leases)

1. In order to improve livestock distribution on the public lands, all salt blocks and/or mineral supplements will not be placed within a ¼ mile of any riparian area, wetland meadow, or watering facility (either permanent or temporary) unless stipulated through a written agreement or decision in accordance with 43 CFR 4130.3-2(c).
2. If, in connection with operations under this authorization, any human remains, funerary objects, or sacred objects of cultural patrimony as defined in the Native American Graves Protection and Repatriation Act (P.L. 101-601; 104 Stat. 3048; 25 U.S.C. 3001) are discovered, the permittee/lessee shall stop operations in the immediate area of the discovery, protect the remains

and objects, and immediately notify the Authorized Officer of the discovery. The permittee/lessee shall continue to protect the immediate area of the discovery until notified by the Program Manager that operations may resume.

3. In accordance with 43 CFR 4130.8-1(F), failure to pay grazing bills within 15 days of the due date specified in the bill shall result in a late fee assessment of \$25.00 or 10 percent of the grazing bill, whichever is greater, but not to exceed \$250.00. Payment made later than 15 days after the due date shall include the appropriate late fee assessment. Failure to make payment within 30 days may be a violation of 43 CFR Secs. 4150.1 and 4160.1-2.

4. STANDARDS AND OBJECTIVES

Arizona Rangeland Health Standards 1, 2, and 3 are applicable to all BLM lands in Arizona. The BLM is required to evaluate the Standards on lands that contain livestock grazing on them as part of the LHE process. Standard 3 requires the development of Desired Plant Community (DPC) objectives that tier to the relevant RMPs. Because the Complex covers lands inside and outside of the SPRNCA, both the SPRNCA RMP (BLM 2019) and the Safford District RMP (BLM 1994) apply to the respective portions of these lands. Section 4.2 lists the relevant SPRNCA RMP (BLM 2019) and Safford District RMP (BLM 1994) objectives that the required DPC objectives must tier to and Section 4.3 goes on to describe the allotment-specific DPC objectives.

4.1 Land Health Standards

This section describes the Arizona Standards for Rangeland Health and the criteria for meeting each standard. The following descriptions are taken directly from the “Arizona Standards for Rangeland Health and Guidelines for Grazing Administration” (BLM 1997).

Standard 1: Upland Sites

“Upland soils exhibit infiltration, permeability, and erosion rates that are appropriate to soil type, climate and landform (ecological site).”

Criteria for meeting Standard 1:

- Soil conditions support proper functioning of hydrologic, energy, and nutrient cycles. Many factors interact to maintain stable soils and healthy soil conditions including appropriate amounts of vegetative cover, litter, soil porosity, and organic matter. Under proper functioning conditions, rates of soil loss and infiltration are consistent with the potential of the site.
- Ground cover in the form of plants, litter, or rock is present in pattern, kind, and amount sufficient to prevent accelerated erosion for the ecological site; or ground cover is increasing as determined by monitoring over an established period of time.
- Signs of accelerated erosion are minimal or diminishing for the ecological site as determined by monitoring over an established period of time.

Standard 2: Riparian-Wetland Sites

“Riparian-wetland areas are in proper functioning condition.”

Standard 2 is **not applicable** because there are no riparian-wetland within the Three Brothers and Lucky Hills Allotments.

Standard 3: Desired Resource Conditions

“Productive and diverse upland and riparian-wetland plant communities of native species exist and are maintained.”

Criteria for meeting Standard 3:

- Upland and riparian-wetland plant communities meet allotment-specific objectives. Plant community objectives are determined with consideration for all multiple uses. Objectives also address native species, and the requirements of the Taylor Grazing Act, Federal Land Policy and Management Act, Endangered Species Act, Clean Water Act, and appropriate laws, regulations, and policies.

- DPC objectives will be developed to assure that soil conditions and ecosystem functions described in Standards 1 and 2 are met. They detail a site-specific plant community, which when obtained, will assure rangeland health, State water quality standards, and habitat for endangered, threatened, and sensitive species. Thus, DPC objectives will be used as an indicator of ecosystem function and rangeland health.

Desired Plant Community Objectives

DPC objectives are established for important biological resources. The DPC objectives for the Complex Allotments have quantifiable indicators that 1) ensure the natural diversity and abundance of native vegetation occurs as expected for the ecological site and 2) density, vigor, cover, and species richness of native perennial grass, shrub, and forb species are maintained or enhanced based on the ecological site potential. The Complex Allotments DPC objectives tie directly back to the broader SPRNCA RMP (BLM 2019) objectives to ensure that the requirements of P.L. 100-696 are being met. The objectives address resource conditions based on vegetation attributes, such as composition, structure, and cover, that are desired within the allotments. The DPC objectives for each site are based on current resource reference conditions and overall site potential as defined in the NRCS ESDs (per EDIT 2020).

4.2 Resource Management Plan Objectives

4.2.1 SPRNCA RMP

This section outlines applicable SPRNCA RMP resource objectives that are directly applicable to the BLM-managed lands on the Complex Allotments inside the SPRNCA.

Standard 3 depends on meeting the DPC objectives in Section 4.3. Those DPC objectives must tier to the following SPRNCA RMP (BLM 2019) objectives.

All Vegetation Community Objectives (SPRNCA RMP ROD, p. 2-4):

- **ob-VEG-ALL-1:** Ensure that the natural diversity and abundance of native vegetation occurs as expected for landform and ecological sites.
- **ob-VEG-ALL-2:** Maintain or improve the ecological processes and function of habitats that support priority or special status plant species.

Upland Vegetation Resource Objectives (SPRNCA RMP ROD, p. 2-7):

- **ob-VEG-UP-1:** Manage, on Three Brothers 2,008 acres and on Lucky Hills 1,698 acres, of upland vegetation toward restoring the perennial native grass component to address shrub encroachment.
- **ob-VEG-UP-2:** In the grassland vegetation community, maintain or enhance density, vigor, cover, and species richness of native perennial grass, shrub, and forb species based on ecological site potential.
- **ob-VEG-UP-3:** In the Chihuahuan Desertscrub vegetation community, increase native annual and perennial herbaceous plants based on ecological site potential.

Fish, Wildlife, and Special Status Species (SPRNCA RMP ROD, p. 2-8):

- **ob-WILD-1:** Conserve, protect, and enhance wildlife and aquatic resources in accordance with the aquatic, wildlife, scientific, cultural, educational, and recreational values of the SPRNCA.
- **ob-WILD-2:** Restore and maintain habitat of suitable quality and quantity to support identified priority fish and wildlife species.
- **ob-WILD-3:** Conserve, protect, and enhance the areas on the SPRNCA that were historically used for agriculture, providing management that allows ecological sites to return to habitat for priority species, appropriate to the landform, soils, and precipitation at the site.
- **ob-WILD-6:** Conserve, protect, and enhance desert washes with adequate cover and width while considering habitat connectivity and adequate patch size.

Livestock Grazing Objectives (SPRNCA RMP ROD, p. 2-15):

- **ob-GRAZ-2:** Maintain productive, diverse upland, riparian, and wetland plant communities of native species.
- **ob-GRAZ-3:** Ensure utilization of current year's growth on upland native perennial grass does not exceed 40 percent at the allotment scale, except for targeted grazing treatments.

4.2.2 Safford District RMP

This section outlines applicable Safford District RMP (BLM 1994) resource objectives. The Safford District RMP objectives are applicable to lands in the Complex Allotments that are outside of the SPRNCA.

Wildlife Habitat Objectives (Safford District Proposed RMP, p. 33):

- Maintain and enhance priority species (see Safford District RMP for the list of priority species) and their habitats.
- Manage priority wildlife species habitat (vegetation communities) or special features of that habitat (water, riparian vegetation, cliffs, etc.) to maintain or enhance population levels.
- Focus management efforts on enhancing biological diversity.

Soil Erosion (Safford District Proposed RMP, p. 44):

- Reduce accelerated erosion.

Vegetation (Safford District Proposed RMP, p. 45):

- The objective for management of upland vegetation is to restore and maintain plant communities for wildlife, watershed condition, and livestock. The DPCs will be determined in the preparation of activity plans.

4.3 Allotment-Specific Objectives

The Complex allotment-specific objectives are the DPC objectives. This section describes the DPC objectives and provides detailed rationale on how they align with the relevant RMP objectives. The RMP vegetation objectives are directly related to ecological site potential, thus the DPC objectives tie to the historic climax plant community (HCPC). In general, objectives were developed based on site potential as

described in the ESDs, site-specific monitoring data, professional judgement, and wildlife habitat requirements.

The DPC objectives developed in this LHE are supportive of wildlife objectives and priority species enhancement as described in the SPRNCA RMP (BLM 2019). Specifically, grassland birds, mule deer, and lesser long-nosed bats would benefit. Upland sites adjacent to riparian areas also support riparian species as wildlife move throughout the landscape for necessary resources. Attainment of the DPC objectives helps meet the SPRNCA RMP objectives ob-WILD-1, 2, and 3 as described in Section 4.2.1 and directly benefit all priority species listed in the RMP for upland sites noted in RMP ama-WILD-1 (BLM 2019).

The DPC objectives will maintain perennial grass and shrub cover that is supportive of wildlife habitat. An appropriate amount of perennial grass cover is necessary for nesting and protection of ground nesting birds, such as Gambel's and scaled quail, lesser nighthawk, greater roadrunner, grasshopper sparrow, and Botteri's sparrow. Reptiles such as ornate box turtle and northern Mexican gartersnake benefit from adequate perennial grass cover because of thermal and predator protection. A wide variety of small mammals such as white-throated woodrat, cactus mouse, banner-tailed kangaroo rat, and pocket gopher also use perennial grasses for protection and forage.

4.3.1 DPC Objective Methodology

The ESDs describe expected amounts of cover for various plant functional/structural groups, such as shrubs and perennial grasses. However, there is a small, noteworthy discrepancy in how the Assessment, Inventory, and Monitoring (AIM) protocol collects vegetative cover and how the ESD reports vegetative cover. The AIM protocol collects foliar cover, which is the percentage of ground covered (if the sun were directly overhead) by the vertical projection of the aerial portion of plants. Small openings in the canopy and intraspecific overlap are excluded in foliar cover. However, ESDs and corresponding reference sheets report expected canopy cover, which is defined as the percentage of the ground covered by a vertical projection of the outermost perimeter of the natural spread of foliage of plants. Small openings within the canopy are included with canopy cover (NRCS 2003). Foliar cover is always less than canopy cover and the sum of all species cover for canopy or foliar cover may exceed 100% (NRCS 2003).

Given the discrepancy between canopy cover and foliar cover, the BLM relied heavily on the 2019 and 2020 AIM foliar cover data to establish DPC objectives. After two more years of AIM data collection at key areas and at the un-grazed reference sites (see description below), key area foliar cover objectives will be updated to reflect an average of three years of AIM data. The BLM will seek to utilize a working group¹ who would review AIM data and provide input on updated objectives. Updated objectives, along with the associated rationale, will be posted on the BLM's ePlanning website.

There are some minor differences in the methodology that the BLM used to develop DPC perennial grass foliar cover objectives. For Limy Uplands, the BLM used the perennial grass key species bush muhly (*Muhlenbergia porteri*) to establish DPC objectives because bush muhly is a deep-rooted perennial grass that prevents erosion more effectively than shallow-rooted perennial grasses such as fluff grass (*Dasyochloa pulchella*), which also occurs on Limy Uplands. The other dominant ecological sites on the

¹ A working group would be comprised of technical experts for the applicable resource areas such as wildlife, vegetation, and soils who review monitoring data and provide input. A working group would be composed of representatives from other federal, state, and local agencies and organizations who have specific technical expertise and qualifications.

Complex Allotments support a variety of deep-rooted perennial grass species and thus it was not necessary to base those DPC objectives on one key perennial grass species.

The more abundant Limy Upland and Shallow Upland ecological sites are present on un-grazed portions of BLM lands in the SPRNCA and were used as reference sites to determine perennial grass and shrub foliar cover potential specific to the area. In addition, using these un-grazed reference sites allowed for direct comparison of foliar cover which is not available using ESDs. The BLM collected foliar cover at four Limy Upland and two Shallow Upland reference sites in fall 2019 and fall 2020 to help establish realistic site-specific objectives. The BLM used the reference data in addition to the Limy Uplands and Shallow Uplands state and transition models to establish the associated DPC objectives.

4.3.2 Key Areas and AIM Study Plots

The DPC objectives are established at key areas. In grazing administration, a key area is defined as a relatively small portion of a range selected because of its location, use, or value as a monitoring location for grazing use. Key areas are indicator areas that can reflect the overall conditions at larger scales, such as a pasture, grazing allotment, wildlife habitat area, herd management area, watershed area, etc. Key areas are usually non-randomly selected but can be randomly generated locations. In contrast, an AIM study plots, are usually randomly generated monitoring location where AIM data is collected and rangeland health indicators are assessed. AIM study plots are sometimes not representative of a larger area because they might fall close to disturbances, such as a road or watering location. However, AIM study plots in combination with key areas help paint a clearer picture of land health. TB-02 was a targeted key area that is being transitioned into an AIM study plot due to its proximity to a watering location. The AIM data analyzed in this LHE were collected at key areas and AIM study plots in 2019 (details on data collection methods and information gathered at key areas and AIM study plots are in Chapter 5).

4.3.3 Three Brothers

There are about eight different ecological sites in the BLM-managed portion of the Three Brothers Allotment, with Limy Uplands being most common (Appendix A: Figure A-6). There are three key areas (TB-01, TB-081 and GRZ-04) and two AIM study plots (TB-02 and TB-083) that correspond to either Limy Upland or Clay Loam Upland ecological sites (Table 8). All five monitoring locations are within the SPRNCA. Key area TB-01 and study plot TB-02 were established by the BLM and University of Arizona Extension in 2007 and pace frequency, cover, dry weight rank, and fetch data were collected intermittently from 2007-2016 using protocols described in Appendix C.

Table 8. Ecological site, location, and protocols established on the Three Brothers Allotment key areas and AIM study plots.

Name	Type	Ecological Site	Ecological Site ID	GPS Coordinates (NAD83 CONUS)	Year data was collected	Protocol
TB-01	Key Area	Limy Upland	R041XC309AZ	580551 3510167	2007, 2012, 2013, 2014, 2015, 2016	Pace frequency, cover, dry weight rank, and fetch ²
					2019	AIM, IIRH*
TB-02	AIM Study Plot	Clay Loam Upland	R041XC305AZ	580517 3508523	2007, 2012, 2013, 2014, 2015, 2016	Pace frequency, cover, dry weight rank, and fetch

² For a complete description of each of these monitoring protocols, see Appendix C.

Name	Type	Ecological Site	Ecological Site ID	GPS Coordinates (NAD83 CONUS)	Year data was collected	Protocol
					2019	AIM, IIRH
TB-081	Key Area	Limy Upland	R041XC309AZ	578826 3508176	2019	AIM, IIRH
TB-083	AIM Study Plot	Clay Loam Upland	R041XC305AZ	579726 3509062	2019	AIM, IIRH
GRZ-04	Key Area	Limy Upland	R041XC309AZ	579531 3510334	2019	AIM, IIRH

*Interpreting Indicators of Rangeland Health (IIRH)

Site-specific objectives for the Three Brothers Allotment are defined below.

Key Area TB-01, TB-081, and GRZ-04 DPC Objectives for Limy Upland 12-16” Precipitation Zone Ecological Site

KA TB-01 DPC Objective

- Perennial grass foliar cover of $\geq 11\%$
- Shrub foliar cover $< 30\%$

KA TB-081 DPC Objective

- Perennial grass foliar cover of $\geq 8\%$
- Shrub foliar cover $< 30\%$

KA GRZ-04 DPC Objective

- Perennial grass foliar cover of $\geq 2\%$
- Shrub foliar cover $< 30\%$

Rationale for establishment of Three Brothers Limy Upland DPC objectives:

The ESD for Limy Uplands identifies a potential of $>5\%$ canopy cover of perennial grass (labelled as MUPO [bush muhly] and ARIST [threeawn]) and $<45\%$ canopy cover of shrubs (labelled as LATR [creosote] and ACCO [whitethorn acacia]) in its historical climax plant community (HCPC) state (Figure 1). All three Limy Upland key areas are currently in the desired HCPC state (“Native shrub, grass, and forb”) (Figure 1) with perennial grass foliar cover between 2-12.7% and shrub foliar cover between 32.6-49.3% in 2019. Reference data collected at four nearby un-grazed Limy Upland sites on the SPRNCA show foliar cover between 0-1% for perennial grasses and 22-62% for shrubs (Appendix D: Tables D-78 through D-81). The reference sites show the general potential for Limy Uplands in un-grazed areas. However, given that the perennial grass foliar cover at the Three Brothers Limy Upland key areas exceeds that of the reference sites, the objective is to maintain 2019 foliar cover levels of the key perennial grass species bush muhly (*Muhlenbergia porteri*). Bush muhly is the primary perennial grass found at all three key areas (89-100% of all perennial grass foliar cover) and is listed in the ESD as a key perennial grass species for Limy Uplands as it helps prevent erosion. Maintaining current bush muhly cover levels will keep Limy Uplands in the desired HCPC state (Figure 1) and maintain perennial grass foliar cover at more productive sites (TB-01 and TB-081). Although shrubs are the expected dominant

functional/structural group on Limy Uplands, maintaining the objective of <30% shrub foliar cover would maintain an open shrub canopy appropriate for site potential.

The Limy Upland DPC objectives support wildlife and priority species enhancement objectives described in the SPRNCA RMP (BLM 2019) by maintaining perennial grass and reducing shrub cover as described in Section 4.3.1.

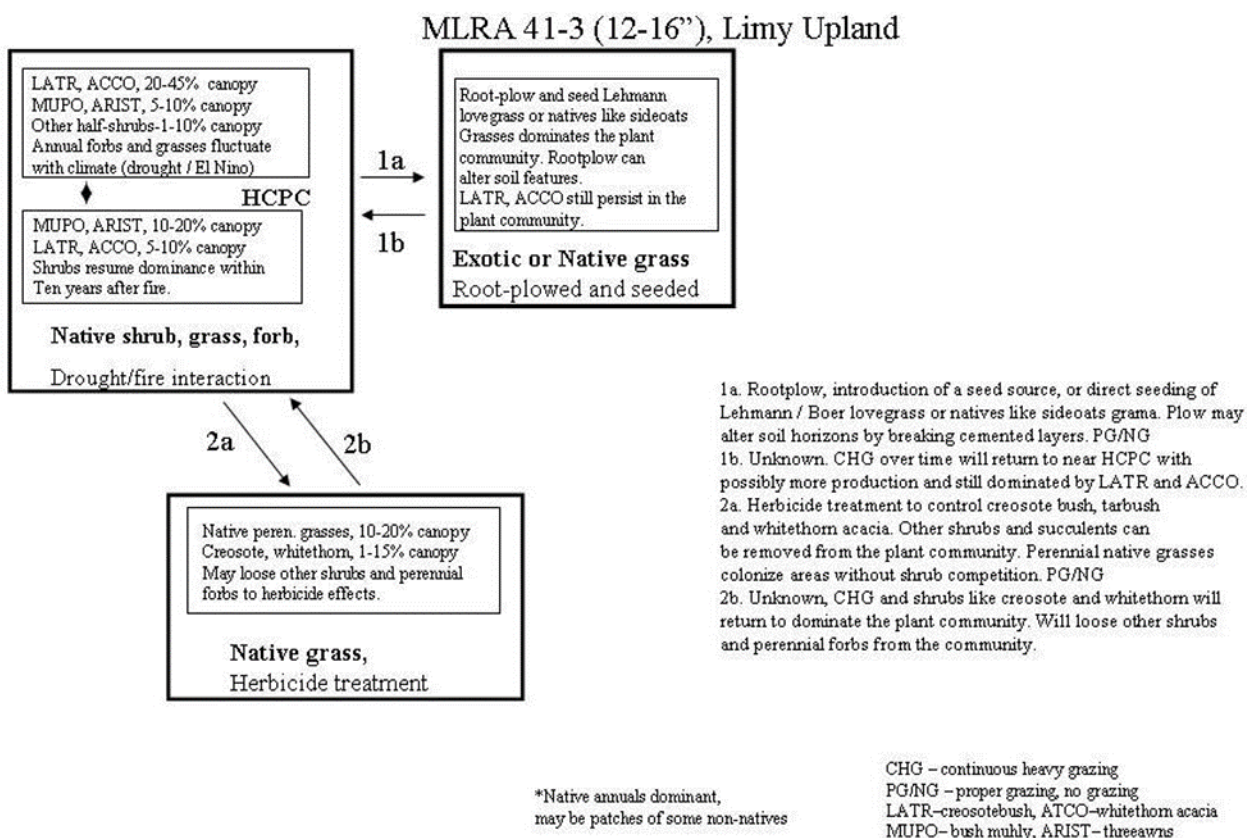


Figure 1. State and transition model from Limy Upland ESD.

**AIM Study Plots TB-02 and TB-083 DPC Objective for Clay Loam Upland 12-16''
Precipitation Zone Ecological Site**

- Perennial Grass foliar cover >5%

Rationale for establishment of Clay Loam Upland DPC objective:

The ESD for Clay Loam Upland identifies a potential of 10-55% canopy cover of perennial grass (labelled as short grammas and mid-grass) and 2-5% canopy cover of shrubs in its HCPC state (Figure 2). TB-02 and TB-083 are currently out of desired HCPC state and are in the “Mesquite, Annuals” state of the state and transition model (Figure 2) with 3.3% and 0% perennial grass foliar cover and 22.6% and 20% shrub foliar cover in 2019, respectively. Achieving the >5% perennial grass foliar cover objective will help move the site towards the “Native Mid-Grassland, Fire/Drought Interaction” HCPC state for perennial grass

foliar cover. There is not a shrub cover objective for Clay Loam Upland because shrubs provide soil stability on this site and altering shrub cover may result in additional erosion.

In addition, the Clay Loam Upland DPC objectives support wildlife objectives in the SPRNCA RMP by increasing perennial grass cover as described in Section 4.3.

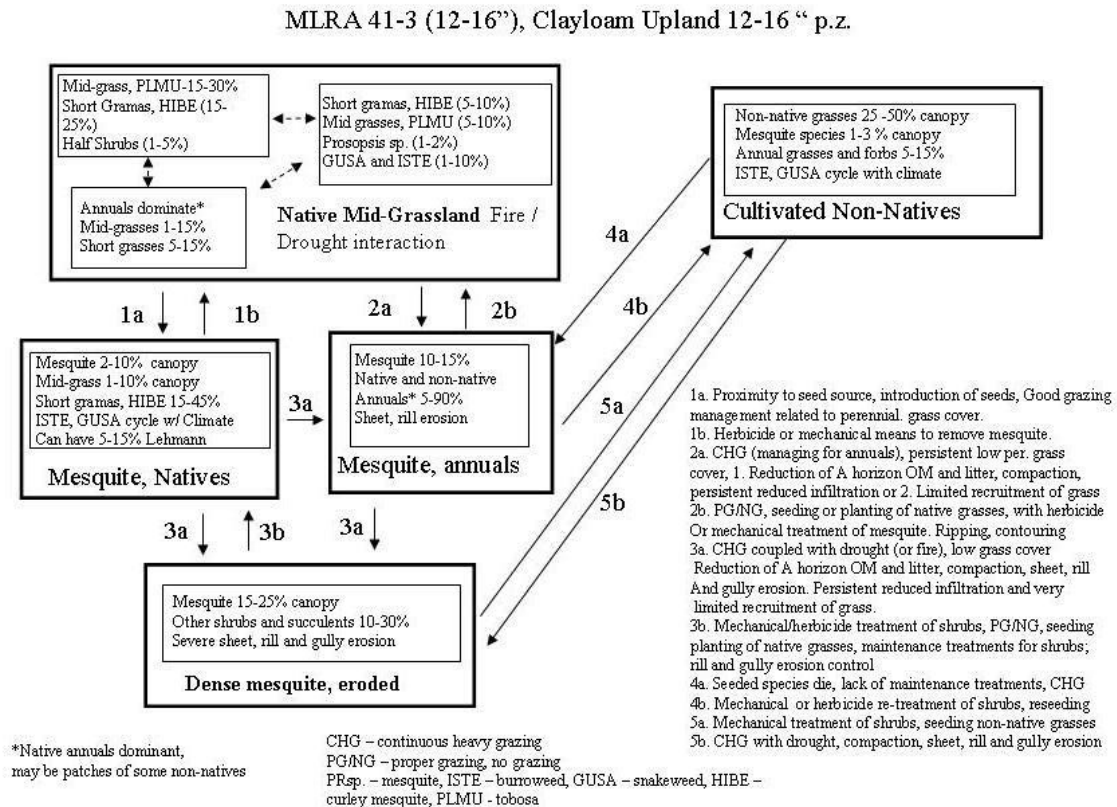


Figure 2. State and transition model for Clay Loam Upland ESD.

4.3.4 Lucky Hills

There are about nine different ecological sites in the BLM-managed portion of the Lucky Hills Allotment, with Shallow Hills, Shallow Upland (also called Granitic Upland), Limestone Hills, and Limy Upland being most common (Appendix A: Figure A-11). There are five key areas (LH-04, LH-06, LH-041, LH-042, and LH-043) and one AIM study plot (SP-245) that correspond to the four most common ecological sites (Table 9). Key area LH-042 is located inside the SPRNCA boundary. Key areas LH-04 and LH-06 were established by the BLM and University of Arizona Extension in 2009 and pace frequency data were collected intermittently from 2009-2017.

Table 9. Ecological site, location, and protocols established on the Lucky Hills Allotment key areas and AIM study plot.

Name	Type	Ecological Site	Ecological Site ID	GPS Coordinates (NAD83 CONUS)	Year data was collected	Protocol
LH-04	Key Area	Shallow Hills	R041XC306AZ	585205 3505983	2009, 2012, 2013, 2014, 2015, 2016, 2017	Pace frequency, cover, dry weight rank, and fetch
					2019	AIM, IIRH
LH-06	Key Area	Shallow Hills	R041XC306AZ	585211 3505207	2009, 2012, 2013, 2014, 2015, 2016, 2017	Pace frequency, cover, dry weight rank, and fetch
					2019	AIM, IIRH
LH-041	Key Area	Shallow Upland	R041XC322AZ	581482 3503408	2019	AIM, IIRH
LH-042	Key Area	Limy Upland	R041XC309AZ	579344 3506595	2019	AIM, IIRH
LH-043	Key Area	Limestone Hills	R041XC307AZ	586777 3504423	2019	AIM, IIRH
SP-245	AIM Study Plot	Shallow Upland	R041XC322AZ	583684 3504490	2019	AIM, IIRH

Site-specific objectives for the Lucky Hills Allotment are identified below.

Key Area LH-042 DPC Objectives for Limy Upland 12-16” Precipitation Zone Ecological Site

- Perennial grass foliar cover of ≥24%
- Shrub foliar cover <30%

Rationale for establishment of Limy Upland DPC objective:

The ESD for Limy Uplands identifies a potential of >5% canopy cover of perennial grass (labelled as MUPO [bush muhly] and ARIST [threeawn]) and <45% canopy cover of shrubs (labelled as LATR [creosote] and ACCO [whitethorn acacia]) in its HCPC state (Figure 1). The Lucky Hills Limy Upland key area (LH-042) is currently in the desired HCPC state (“Native shrub, grass, and forb”) (Figure 1) with

perennial grass foliar cover of 24% and shrub foliar cover of 44.7% in 2019. Reference data collected at four nearby un-grazed Limy Upland sites on the SPRNCA show foliar cover between 0-1% for perennial grasses and 22-62% for shrubs (Appendix D: Tables D-78 through D-81). The reference sites show the general potential for Limy Uplands in un-grazed areas. However, given that the perennial grass foliar cover at the Lucky Hills Limy Upland key area exceeds that of the reference site, the objective is to maintain 2019 foliar cover levels of the key perennial grass species bush muhly (*Muhlenbergia porteri*). Bush muhly is the primary perennial grass found at LH-042 (100% of perennial grass foliar cover) and is listed in the ESD (EDIT 2020) as a key perennial grass species for Limy Uplands as it helps prevent erosion. Maintaining current bush muhly cover levels will keep Limy Uplands in the HCPC state (Figure 1) and maintain higher productivity at LH-042. Although shrubs are the expected dominant functional/structural group on Limy Uplands, maintaining the objective of <30% shrub foliar cover would maintain an open shrub canopy appropriate for site potential.

The Limy Upland site LH-042 DPC objectives support wildlife and priority species enhancement objectives described in the SPRNCA RMP (BLM 2019) by maintaining perennial grass and reducing shrub cover as described in Section 4.3.

Key Area LH-041 DPC Objectives for Shallow Upland 12-16" Precipitation Zone Ecological Site

- Perennial grass foliar cover of $\geq 20\%$
- Shrub foliar cover $< 10\%$

Rationale for establishment of Shallow Upland DPC objective:

The ESD for Shallow Uplands identifies a potential of 20-35% canopy cover of perennial grass and $< 15\%$ canopy cover of shrubs in its HCPC state (Figure 3). The Lucky Hills Shallow Upland key area LH-041 is currently in the "Native grass, forb, half shrub" HCPC state, moving toward a more shrub dominated state with 24% perennial grass foliar cover and 22.7% shrub foliar cover in 2019. Reference data collected at two nearby un-grazed Shallow Upland reference sites on the SPRNCA show perennial grass foliar cover between 25-39% and shrub foliar cover between 24-25% (Appendix D: Tables D-82 and D-83). These reference site data show a similar natural range of variability, expressed in foliar cover, to the expected range of variability in canopy cover as described in the ESD (Figure 3). Therefore, 20% perennial grass foliar cover is within the range expected for the Shallow Uplands HCPC. The shrub foliar cover objective of $< 10\%$ would prevent the site from moving into the "Shrub Increase" state and would create an open shrub canopy appropriate for site potential.

The Shallow Upland DPC objectives support wildlife and priority species enhancement objectives described in the SPRNCA RMP (BLM 2019) by maintaining perennial grass cover and reducing shrub cover. In addition to the benefits to species described in Section 4.3, species of economic importance, such as mule deer, white-tail deer, javelina, and a variety of predatory fur-bearing mammals, are more likely to rely on Shallow Upland habitat due to the relatively greater forage production and cover.

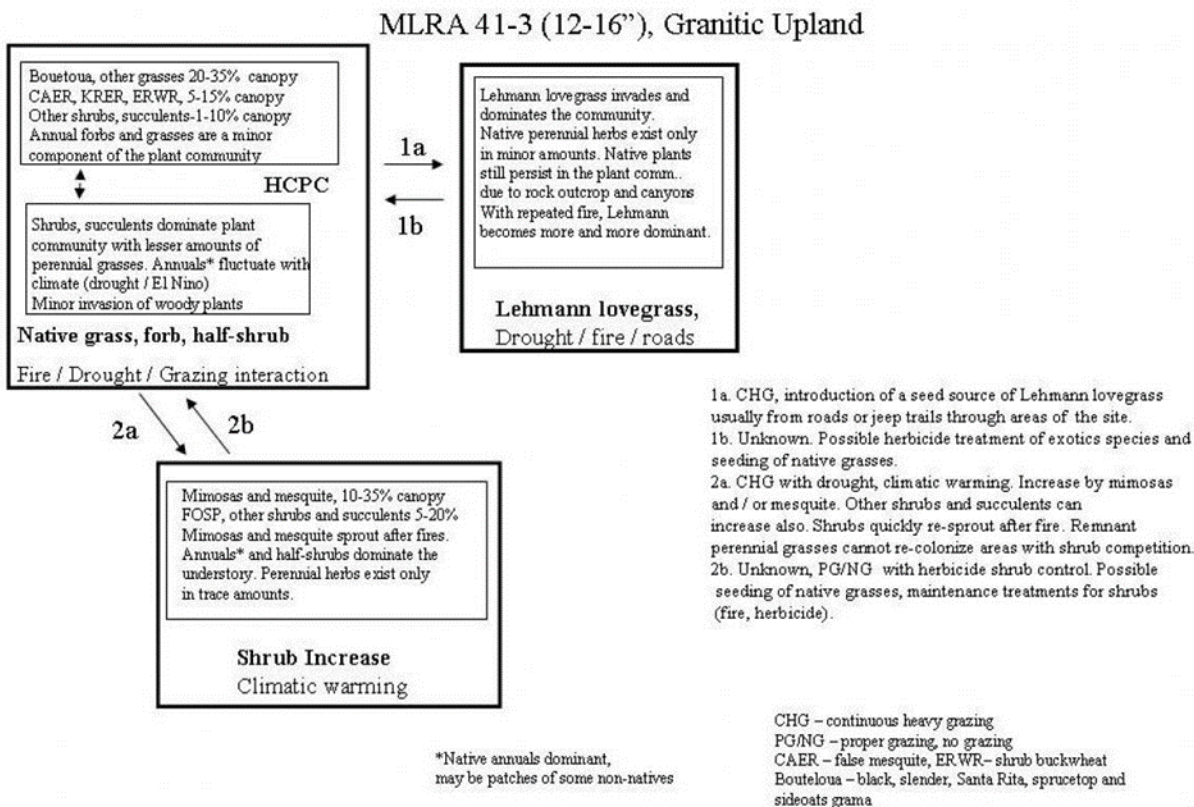


Figure 3. State and transition model for Shallow Upland ESD (also called Granitic Upland).

Key Areas LH-04 and LH-06 DPC Objectives for Shallow Hills 12-16'' Precipitation Zone Ecological Site

- Perennial grass foliar cover ≥15%
- Shrub foliar cover <10%

Rationale for establishment of Shallow Hills DPC objective:

The ESD for Shallow Hills identifies a potential of 20-35% canopy cover of perennial grass and <15% canopy cover of shrubs in its HCPC state (Figure 4). Both Lucky Hills Shallow Hills key areas (LH-04 and LH-06) are currently in the “Shrub Increase” state (Figure 4) with perennial grass foliar cover between 12-14.7% and shrub foliar cover between 32-40% in 2019. The objective of ≥15% perennial grass foliar cover is appropriate grass cover for site stability and overall ecological health and to move the site to the “Native grass, forb, half shrub” HCPC state. The shrub foliar cover objective of <10% would move the site to the HCPC state with an open shrub canopy appropriate for site potential.

The DPC objectives for Shallow Hills sites support wildlife and priority species enhancement objectives described in the SPRNCA RMP (BLM 2019) by maintaining perennial grass and reducing shrub cover as described in Section 4.3. Like Shallow Upland, Shallow Hills provide important habitat to larger mammals, such as deer and javelina.

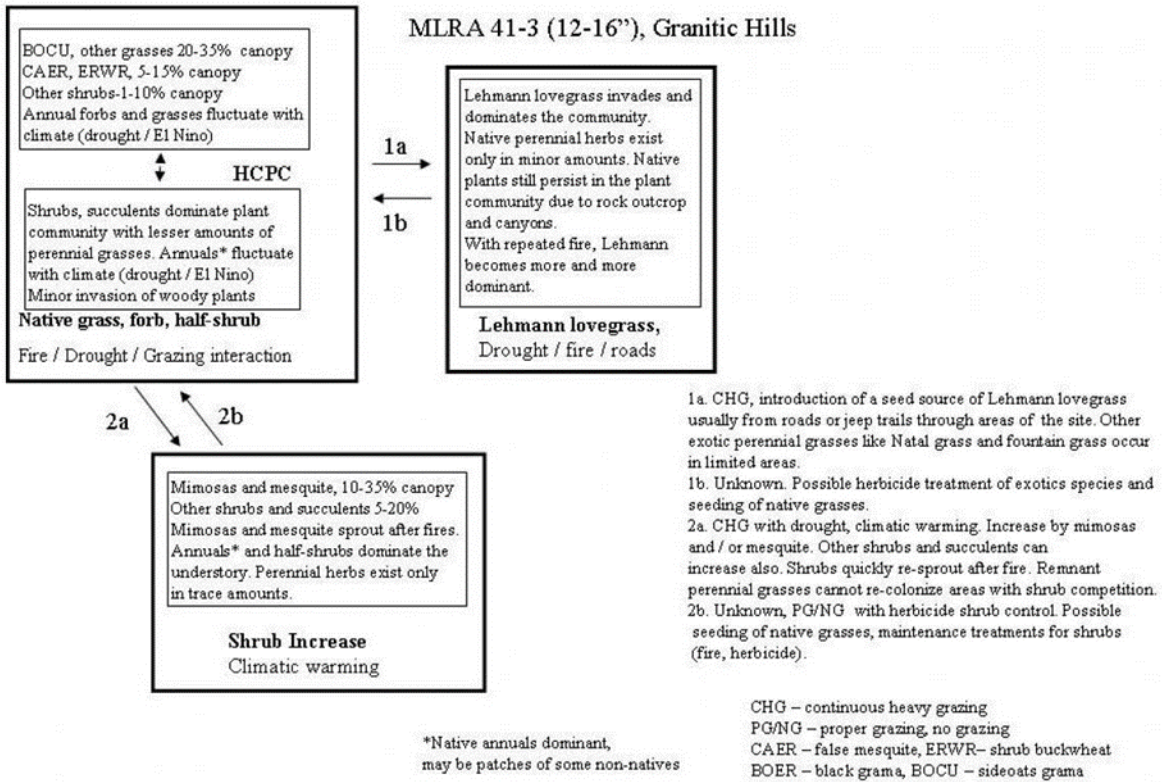


Figure 4. State and transition model for Shallow Hills ESD (also called Granitic Hills).

Key Area LH-043 DPC Objectives for Limestone Hills 12-16” Precipitation Zone Ecological Site

- Perennial grass foliar cover $\geq 15\%$
- Shrub foliar cover $< 10\%$

Rationale for establishment of the Limestone Hills DPC objective:

The ESD for Limestone Hills identifies a potential of 10-30% canopy cover of perennial grass and $< 15\%$ canopy cover of shrubs in its HCPC state (Figure 5). Limestone Hills key area LH-043 is currently in the “Native shrub, succulent, grass, forb” HCPC state moving toward the “shrub, succulent increase” state with 10% perennial grass foliar cover and 20.6% shrub foliar cover. The objective of $\geq 15\%$ perennial grass foliar cover is appropriate grass cover for site stability and overall ecological health and will help keep the site in the “Native shrub, succulent, grass, forb” HCPC state. The shrub foliar cover objective of $< 10\%$ would prevent the site from moving into the “shrub, succulent increase” state and would create an open shrub canopy appropriate for site potential.

The DPC objectives for Shallow Hills sites support wildlife and priority species enhancement objectives described in the SPRNCA RMP (BLM 2019) by maintaining perennial grass and reducing shrub cover as described in Section 4.3.

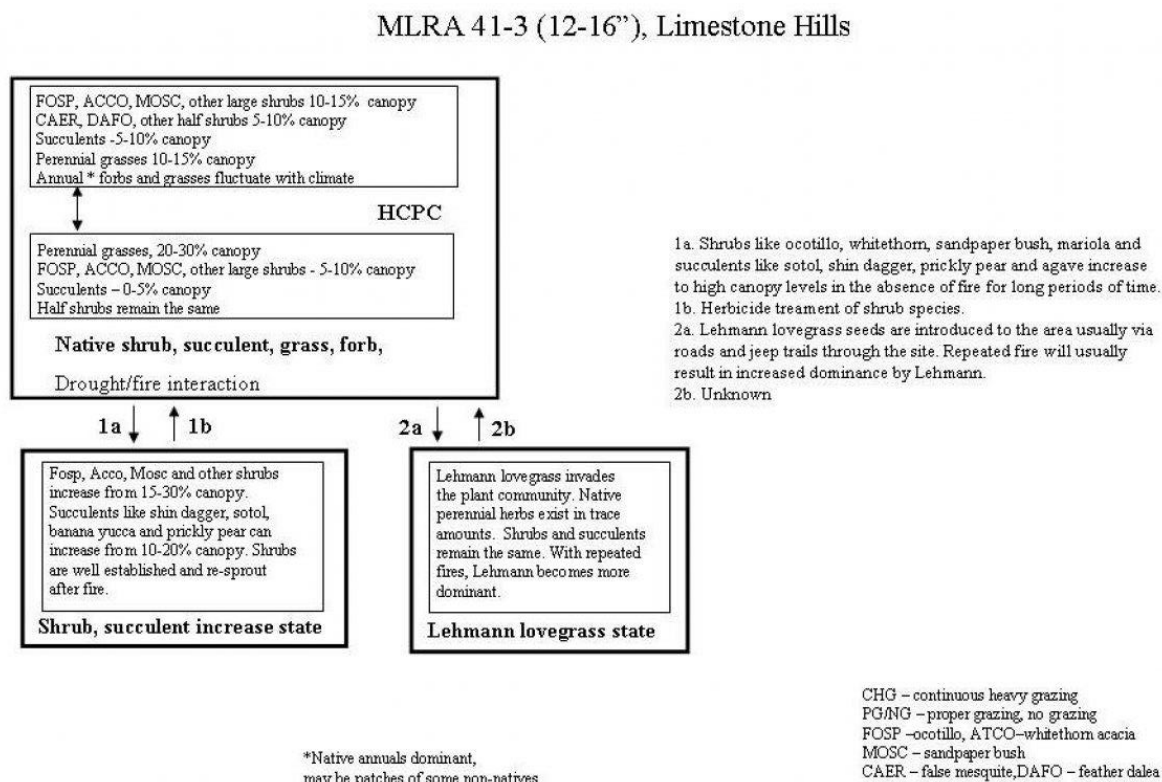


Figure 5. State and transition model for Limestone Hills ESD.

5. RANGELAND INVENTORY AND MONITORING METHODOLOGY

This section describes the protocols used by BLM to conduct current inventory and monitoring. Historic monitoring protocols are provided in Appendix C for additional information.

5.1 Rangeland Inventories

5.1.1 *Indicators of Rangeland Health*

The protocol Interpreting Indicators of Rangeland Health (IIRH) (Pellant et al. 2020) was used to help evaluate Standards 1 and 3. During the IIRH process, 17 indicators of three rangeland health attributes are assessed: soil and site stability, hydrologic function, and biotic integrity. The BLM uses this protocol to assess the presence or absence, quantity, and distribution of multiple components of a system. By using this qualitative, observational procedure, the functional status of rangeland indicators can be assessed and used to guide future management.

This LHE evaluates the three rangeland health attributes and provides information on the functioning of ecological processes (water cycle, energy flow, and nutrient cycle) relative to the reference state for the ecological site. The IIRH assessments are a snapshot of the status of the rangeland attributes at key areas and AIM study plots at the time of the site evaluation.

Attribute ratings reflect the degree of departure from expected levels for each indicator per the applicable ESD reference sheet (EDIT 2020). The degree of departure may be categorized (rated) as:

- None to Slight
- Slight to Moderate
- Moderate
- Moderate to Extreme
- Extreme to Total

5.2 Monitoring Protocols

Quantitative data is also used to assess Standards 1, 2, and 3. The following monitoring protocols describe the type of monitoring data collected at key areas and AIM study plots and used in this LHE.

5.2.1 *Assessment Inventory and Monitoring (AIM)*

The AIM strategy provides a framework for the BLM to inventory, monitor, and quantitatively assess the condition and trend of natural resources on public lands and is used to evaluate Standards 1 and 3 in this LHE. The standardized terrestrial data measurements (or indicators) collected with the AIM protocol include bare ground (soil not covered by plant foliar cover or any of the ground cover categories), species-specific foliar cover, species-specific basal cover, ground cover (rock fragment, biological soil crust, and litter), species diversity, vegetation height, plant canopy gaps, soil texture, and soil stability. In addition, plot characterization information is collected, such as slope, aspect, landscape position, ecological site identification, and noted at the time of data collection. AIM indicator data are used in the IIRH assessments for each monitoring location. Key area repeat monitoring data will be collected using the AIM protocol. Additional information regarding the BLM's AIM strategy can be accessed online through the *AIM Landscape Toolbox* (BLM 2020).

5.2.2 Actual Use

Actual use was determined from billed use. Lease holders are billed for their maximum use available on public lands unless non-use or partial use is requested and approved. The Three Brothers Allotment lessee paid for full use from 2009-2020. The Lucky Hills Allotment lessee paid for full use from 2009-2020, except for in 2009 when half use was taken.

6. MANAGEMENT EVALUATION AND SUMMARY

6.1 Recent Rainfall Data

Rainfall data from 2010 to 2020 was gathered from 12 gauges located inside the Complex boundary. This data is collected by the Agricultural Research Service Southwest Watershed Research Center and made available through Data Access Project (Goodrich et al. 2008). The graph below (Figure 6) displays the average of the 12 gauges for each year as well as the maximum and minimum values for annual rainfall. It also includes the 30-year Climate Normal from the Tombstone gauge (see Section 2.3.2). The rain gauges were chosen for spatial distribution in or near Complex Allotments. Since the Walnut Gulch watershed only encompasses the northeastern half of the Complex, the western portion—primarily BLM-managed—does not have the same amount of rain gauges. Only two of the last 10 years are close to (within one inch) or greater than the previous 30-year Normal for annual rainfall totals.

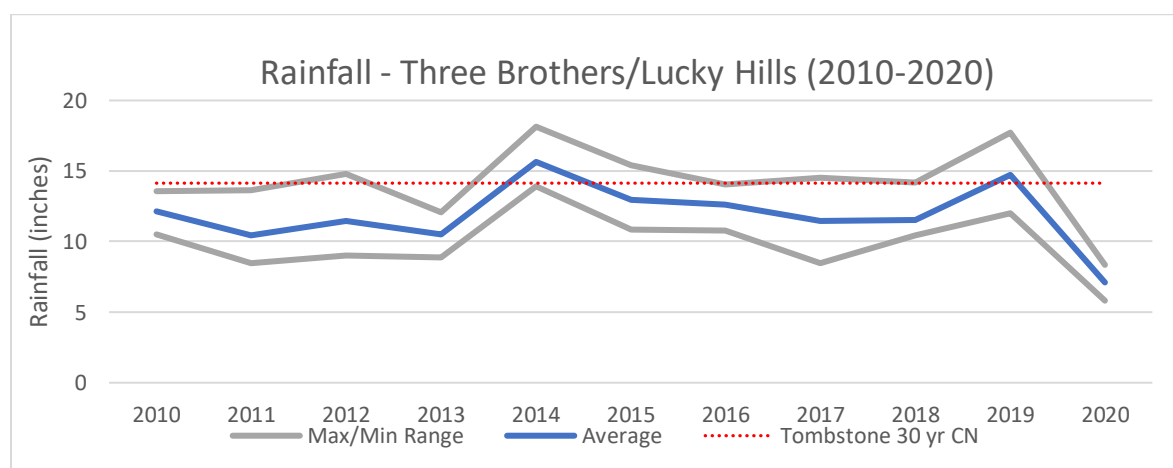


Figure 6. Average rainfall on the Complex Allotments compared to the 30-year Climate Normal from the Tombstone gauge.

6.2 Rangeland Health Assessments

The following section analyzes and evaluates Indicators for Rangeland Health, AIM data, and pace frequency data as they apply to Standards 1 and 3. Standard 2 relates to riparian and wetland sites and is not applicable to the Complex Allotments because there are no riparian areas or wetlands on the allotments.

The IIRH assessments were completed by an interdisciplinary (ID) team consisting of a rangeland management specialist, hydrologist, natural resource specialist, hydrologic technician, range technician, and vegetation biological technician. Three Brothers field assessments were on November 25, 2019, January 29, 2020, and February 5, 2020. Lucky Hills field assessments were on February 10, 2020 and February 12, 2020. In addition to AIM data, documents and publications used in the assessment process include the *Web Soil Survey* (NRCS 2020a), ESDs for MLRA 41 (NRCS 2006), *Interpreting Indicators of Rangeland Health Technical Reference 1734-6* (Pellant et al. 2020), *The Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems* (Herrick et al. 2005), *Sampling Vegetation Attributes Technical Reference 1734-4* (Coulloudon et al. 1999), and the *National Range and Pasture Handbook* (NRCS 2003). All reference materials are available online or at the BLM TFO for public review.

Comprehensive AIM data tables, IIRH assessment data sheets, and photographs of key areas and AIM study plots used in this analysis are in Appendix D. Table 10 is a summary of the degree of departure of soil and site stability, hydrologic function, and biotic integrity at all monitoring locations on the Complex Allotments. Monitoring locations are listed in Tables 7 and 8, with maps provided in Appendix A: Figures A-3, A-6, A-9, and A-11. All five monitoring locations on Three Brothers (TB-01, TB-081, GRZ-04, TB-02, TB-081) and one key area on Lucky Hills (LH-042) are within the SPRNCA.

Table 10. Summary of Interpreting Indicators of Rangeland Health attribute ratings.

Allotment	Key Area	Ecological Site	Range Health Attributes – Degree of Departure		
			Soil and Site Stability	Hydrologic Function	Biotic Integrity
Three Brothers*	TB-01	Limy Uplands 12-16"	Slight to moderate	Slight to moderate	None to Slight
Three Brothers*	TB-081	Limy Uplands 12-16"	None to slight	None to slight	None to slight
Three Brothers*	GRZ-04	Limy Uplands 12-16"	None to slight	None to slight	Slight to moderate
Lucky Hills*	LH-042	Limy Uplands 12-16"	None to slight	None to slight	None to slight
Three Brothers*	TB-02 AIM Study Plot	Clay Loam Upland 12-16"	Moderate	Moderate	Moderate
Three Brothers*	TB-083 AIM Study Plot	Clay Loam Upland 12-16"	Moderate to extreme	Moderate to extreme	Moderate
Lucky Hills	LH-04	Shallow Hills 12-16"	Moderate	Moderate	Moderate
Lucky Hills	LH-06	Shallow Hills 12-16"	None to slight	Slight to moderate	Moderate
Lucky Hills	LH-043	Limestone Hills 12-16"	Slight to moderate	Slight to moderate	None to slight
Lucky Hills	LH-041	Shallow Uplands 12-16"	None to slight	None to slight	Slight to moderate
Lucky Hills	SP-245 AIM Study Plot	Shallow Uplands 12-16"	Moderate	Moderate	Slight to moderate

* Indicates monitoring area within the SPRNCA.

6.2.1 Standard 1: Upland Sites

This section describes the results of the IIRH assessments and AIM data used as they apply to Standard 1 at each key area and AIM study plot.

Standard 1 for the Arizona Standards for Rangeland Health is:

- *Upland soils exhibit infiltration, permeability, and erosion rates that are appropriate to soil type, climate, and landform (ecological site).*

Limy Upland Sites (Three Brothers TB-01, TB-081, GRZ-04 and Lucky Hills LH-042)

Key areas at Three Brothers TB-1 (Tables 11 and 12), TB-081 (Tables 13 and 14), GRZ-04 (Tables 15 and 16), and Lucky Hills LH-042 (Tables 17 and 18) are in the Limy Upland 12-16” precipitation zone (p.z.) ecological site. Limy Uplands occur in the middle elevations of the Madrean Basin and Range province in southeastern Arizona on pediments, fan terraces, and hillslopes. The expected reference condition and potential plant community for Limy Uplands is a diverse mixture of desert shrubs (e.g., creosote bush and whitethorn acacia), half shrubs (e.g., desert zinnia), perennial grasses, and forbs (listed in order of dominance). Most of the major perennial grasses, such as bush muhly and Aristida, are expected to be well dispersed throughout the plant community. Cryptogam cover (moss, lichen) can be considerable in the plant community but diminishes as the surface cover of gravel increases (c.f., Limy Upland ESD via EDIT 2020).

Three Brothers Limy Uplands

Three Brothers TB-01 Key Area

Table 11. Key area TB-01 AIM data compared to Limy Upland ESD.

	Basal Cover				Biological Crust	Litter	Surface Fragments ¼" - 3"	Surface Fragments > 3"	Bedrock	Bare Ground
	Grass	Forb	Shrub	Tree						
ESD R041XC309AZ	1-3%	0-1%	2-3%	0%	1-25%	10-20%	5-45%	0-8%	0-1%	15-55%
TB-01	1.4%	0%	0%	0%	0.7%	25.3%	14.7%	0%	0%	41.3%

Three Brothers TB-01 Rangeland Health Attribute 1: Soil and Site Stability

The overall rating for the soil and site stability attribute at TB-01 was Slight to Moderate departure from ecological site reference condition. Nine out of ten indicators for soil site stability were rated as None to Slight because they were within the natural range of variability expected under reference conditions. Indicator 2 (presence of water flow patterns) was rated at Moderate to Extreme departure. The observed water flow patterns were 100 feet long, connected, and widespread. Discontinuous and short water flow patterns are expected for the ecological site. Other than water flow patterns, the site did not exhibit any erosional features (e.g., gullies, rills, wind scoured areas) and had soil stability values within the range expected for the ecological site.

Three Brothers TB-01 Rangeland Health Attribute 2: Hydrologic Function

The overall rating for the hydrologic function attribute at TB-01 was Slight to Moderate departure from ecological site reference condition. Nine out of ten indicators were rated None to Slight departure

because they were within the natural range of variability expected for the site. Indicator 2 (presence of water flow patterns) was rated at Moderate to Extreme departure because water flow patterns were longer, connected, and more widespread than expected for the ecological site. This may be because the site is proximal to a sandy wash ecological site (observed by the ID team in the field) and water flow patterns were widespread in sandy portions of the key area. The site had an appropriate cover of perennial grass that enhances water infiltration on the site.

Three Brothers TB-01 Rangeland Health Attribute 3: Biotic Integrity

Table 12. Functional group AIM foliar cover data at TB-01.

Functional group	Foliar cover %
Shrub	32.6
Perennial Grass	12.7
Forb	0.0
Sub-shrub	1.3

The overall rating for the biotic integrity attribute at TB-01 was None to Slight departure from ecological site reference condition. Eight out of nine indicators for biotic function were rated None to Slight departure because they were within the natural range of variability for the site. Indicator 15 (expected annual production) was rated as Slight to Moderate because there was less estimated above ground production (about 78%) than expected during periods of unfavorable precipitation.

Three Brothers TB-081 Key Area

Table 13. Key area TB-081 AIM data compared to Limy Upland ESD.

	Basal Cover				Biological Crust	Litter	Surface Fragments ¼" - 3"	Surface Fragments > 3"	Bedrock	Bare Ground
	Grass	Forb	Shrub	Tree						
ESD R041XC309AZ	1-3%	0-1%	2-3%	0%	1-25%	10-20%	5-45%	0-8%	0-1%	15-55%
TB-081	0%	0%	0.7%	0%	0%	38.7%	26%	0%	0%	34%

Three Brothers TB-081 Rangeland Health Attribute 1: Soil and Site Stability

The overall rating for the soil and site stability attribute at TB-081 was None to Slight departure from ecological site reference condition. Eight of the ten indicators for soil site stability were rated as None to Slight because they were within the natural range of variability expected for the site. Indicator 1 (rills) and Indicator 9 (soil surface loss and degradation) were rated Slight to Moderate departure. Rills were on the site but were minimal and only in exposed areas with steeper slopes. Slight to Moderate soil surface loss was observed, but high rock cover helps stabilize the site.

Three Brothers TB-081 Rangeland Health Attribute 2: Hydrologic Function

The overall rating for the hydrologic function attribute at TB-081 was None to Slight departure from ecological site reference condition. Seven indicators for hydrologic function were rated as None to Slight because they were within the natural range of variability for the ecological site. Indicator 1 (rills), Indicator 9 (soil surface loss and degradation), and Indicator 10 (effects of plant community composition on infiltration) were rated Slight to Moderate. Rills were on the site but minimal and only in exposed areas

with steeper slopes. Infiltration is reduced at the site due to a higher-than-expected proportion of shrub cover.

Three Brothers TB-081 Rangeland Health Attribute 3: Biotic Integrity

Table 14. Functional group AIM foliar cover data at TB-081.

Functional group	Foliar cover %
Shrub	36.0
Perennial Grass	8.7
Forb	2.7
Sub-shrub	2.0

The overall rating for the biotic integrity attribute at TB-081 was None to Slight departure from ecological reference condition. Six indicators for biotic function were rated None to Slight departure because they were within the natural range of variability expected for the ecological site. Indicator 9 (soil surface loss and degradation), Indicator 13 (plant mortality and decadence), and Indicator 17 (perennial plant reproductive vigor) were rated Slight to Moderate departure. Some perennial grass mortality and reduced seed head production were observed at the site. The relative dominance of plant functional/structural groups was as expected for the site.

Three Brothers GRZ-04 Key Area

Table 15. GRZ-04 key area AIM data compared to Limy Upland ESD.

	Basal Cover				Biological Crust	Litter	Surface Fragments ¼" - 3"	Surface Fragments > 3"	Bedrock	Bare Ground
	Grass	Forb	Shrub	Tree						
ESD R041XC309AZ	1-3%	0-1%	2-3%	0%	1-25%	10-20%	5-45%	0-8%	0-1%	15-55%
GRZ-04	0%	0%	2.7%	0%	0%	16.7%	38%	0%	0%	25.3%

Three Brothers GRZ-04 Rangeland Health Attribute 1: Soil and Site Stability

The overall rating for the soil and site stability attribute at GRZ-04 was None to Slight departure from ecological site reference condition. Nine indicators for soil site stability were rated None to Slight departure because they were within the natural range of variability for the ecological site. Indicator 8 (soil surface resistance to erosion) was rated Slight to Moderate departure. The reference condition of the Limy Upland ecological site expects soil stability values of 1-3 in plant interspaces and 4-6 under plant canopies, with 6 being the most stable. The data collected at the site showed an average value of 2.25 in interspaces and 3.4 under plant canopies, marginally lower than expected.

Three Brothers GRZ-04 Rangeland Health Attribute 2: Hydrologic Function

The overall rating for the hydrologic function attribute at GRZ-04 was None to Slight departure from ecological site reference condition. Eight indicators of hydrologic function were rated None to Slight departure because they were within the natural range of variability of reference conditions. Indicator 8 (soil surface resistance to erosion) was rated Slight to Moderate departure because of the lower-than-expected soil stability test average value for under plant canopies (described in the previous section). Indicator 10 (effect of plant community composition on infiltration) was rated Slight to Moderate departure

because the proportion of perennial grass cover of total vegetation cover was lower than expected. The site had high rock and total foliar cover, which helps slow overland water flow and promotes infiltration.

Three Brothers GRZ-04 Rangeland Health Attribute 3: Biotic Integrity

Table 16. Functional group AIM foliar cover data at GRZ-04.

Functional Group	Foliar Cover %
Shrub	49.3
Perennial Grass	2.0
Forb	0.0

The overall rating for the biotic integrity attribute at GRZ-04 was Slight to Moderate departure from ecological reference condition. Five indicators of biotic integrity were rated None to Slight because they were within the natural range of variability of reference conditions. Indicator 9 (soil surface loss and degradation), Indicator 12 (plant functional/structural groups), and Indicator 17 (perennial plant reproductive vigor) were rated Slight to Moderate and Indicator 15 (annual production) was rated Moderate departure. The relative proportion of perennial grass cover and production, as well as total production, was lower than expected for the ecological site. In addition, perennial grasses had reduced seed head production and generally reduced reproductive capabilities from drought stress.

Lucky Hills Limy Uplands

Lucky Hills LH-042 Key Area

Table 17. LH-042 key area AIM data compared to Limy Upland ESD.

	Basal Cover				Biological Crust	Litter	Surface Fragments ¼" - 3"	Surface Fragments > 3"	Bedrock	Bare Ground
	Grass	Forb	Shrub	Tree						
ESD R041XC309AZ	1-3%	0-1%	2-3%	0%	1-25%	10-20%	5-45%	0-8%	0-1%	15-55%
LH-042	0%	0%	0%	0%	0%	37.3%	43.3%	0%	0%	12.7%

Lucky Hills LH-042 Rangeland Health Attribute 1: Soil and Site Stability

The overall rating for the soil and site stability attribute at LH-042 was None to Slight departure from ecological site reference condition. Nine indicators for soil and site stability were rated None to Slight because they were within the natural range of variability of reference conditions. Indicator 1 (rills) was rated Slight to Moderate departure because rills were observed at the site where none are expected, however they were scarce, in exposed areas, and of minimal width and depth.

Lucky Hills LH-042 Rangeland Health Attribute 2: Hydrologic Function

The overall rating for the hydrologic function attribute was None to Slight departure from ecological site reference condition. Eight indicators for hydrologic function were rated None to Slight because they were within the natural range of variability of reference condition. Indicator 1 (rills) and Indicator 14 (litter) were rated Slight to Moderate departure from reference state. Though scarce, rills were observed on the site and none are expected. Litter cover was 37.3% and 10-20% is expected for the site. Although more than

expected, high amounts of litter increase soil moisture and roughness which reduce runoff and provide soil surface protection from rain splash displacement.

Lucky Hills LH-042 Rangeland Health Attribute 3: Biotic Integrity

Table 18. Functional group AIM foliar cover data at LH-042.

Functional Group	Foliar Cover %
Shrub	44.7
Perennial Grass	24.0
Forb	0.0
Cactus/Succulent	0.7

The overall rating for the biotic integrity attribute at LH-042 was None to Slight departure from ecological site reference condition. Eight indicators of biotic function were rated None to Slight because they were within the natural range of variability of reference condition. Indicator 14 (litter) was rated Slight to Moderate because data collected at the site showed higher-than-expected litter cover. The site had high foliar cover and the relative dominance of plant functional/structural groups matched what was expected for the ecological site. It was also noted that low utilization was observed in the area due to its distance from existing permanent watering locations.

Clay Loam Upland Sites (Three Brothers TB-083 and TB-02)

AIM study plots TB-083 (Tables 19 and 20) and TB-02 (Tables 21 and 22) are in the Clay Loam Upland 12-16" p.z ecological site. The potential plant community is warm season perennial grass dominant. Most major perennial grass species are expected to be well dispersed throughout, with tobosa, vine mesquite, and curly mesquite typically occurring in patches. Perennial forbs are expected to be well represented on the site, as well as a few species of low shrubs. Due to heavy soil surface textures, this site can be an inefficient user of intense summer rainfall if perennial grass cover has been removed or greatly reduced. Mesquite, when present on the site, tends to be shrubby due to the presence of clay horizons at shallow depths (c.f., Clay Loam Upland ESD via EDIT 2020).

Three Brothers Clay Loam Uplands

Three Brothers TB-083 AIM Study Plot

Table 19. TB-083 AIM study plot data compared to Clay Loam Upland ESD.

	Basal Cover				Biological Crust	Litter	Surface Fragments ¼" - 3"	Surface Fragments > 3"	Bedrock	Bare Ground
	Grass	Forb	Shrub	Tree						
ESD R041XC305AZ	3-10%	0-1%	3-5%	0-1%	0-1%	15-50%	25-65%	0-10%	1-10%	5-50%*
TB-083	0%	0%	0.7%	0%	0%	16%	13.3%	0%	0%	61.3%

Three Brothers TB-083 Rangeland Health Attribute 1: Soil and Site Stability

The overall rating for the soil and site stability attribute at TB-083 was Moderate to Extreme departure from ecological site reference condition. The AIM study plot was within ¼-mile of a watering facility.

Indicator 11 (compaction layer) was rated as None to Slight because there was no evidence of soil compaction at the site. Indicator 3 (pedestals and terracettes), Indicator 4 (bare ground), and Indicator 6 (wind-scoured, blowouts, and/or depositional areas) were rated as Slight to Moderate. Indicator 1 (rills), Indicator 7 (litter movement), Indicator 8 (soil surface resistance to erosion), and Indicator 9 (soil surface loss or degradation) were rated Moderate. Indicator 2 (water flow patterns) and Indicator 5 (gullies) were rated as Moderate to Extreme. Rills were present on the site and had moderate width and depth (no rills are expected). Water flow patterns were longer, wider, and deeper than expected for the site and were occasionally connected. Plant pedestals were 2-6 inches and common with signs of active erosion visible in shrub interspaces. The AIM data collected at the site shows bare ground at 61% while 55% is the maximum expected bare ground for the ecological site. Gullies were about 6-8 feet deep and 5-15 feet wide with head cutting and some vegetation along the sides and bottom of the channel (none are expected for the site). There was evidence of wind deposition but scouring was not present. Small and medium litter size classes appeared to move in water flow patterns with small litter accumulations in obstructions and depressions. Soil surface resistance to erosion was rated Moderate departure because soil stability test values were lower than expected for the ecological site. Soil surface loss and degradation was Moderate due to evidence of topsoil loss and degradation in interspaces and beneath plant canopies.

Three Brothers TB-083 Rangeland Health Attribute 2: Hydrologic Function

The overall rating for the hydrologic function attribute at TB-083 was Moderate to Extreme departure from ecological site reference condition. Indicator 14 (litter) and Indicator 11 (compaction layer) were rated None to Slight departure because they were within the natural range of variability for the ecological site. Indicator 3 (pedestals and terracettes) and Indicator 4 (bare ground) were rated Slight to Moderate. Indicator 1 (rills), Indicator 8 (soil surface resistance to erosion), and Indicator 9 (soil surface loss or degradation) were rated Moderate. Indicator 2 (water flow patterns), Indicator 5 (gullies), and Indicator 10 (plant community composition relative to infiltration) were rated as Moderate to Extreme. The observed water flow patterns, rills, and gullies are all erosional features that promote runoff and do not keep water on the site. The soil surface was degraded and unstable, contributing to the erosional problems at the site. The plant community was dominated by shrubs, which do not infiltrate water as well as perennial grasses. In addition, the site did not have perennial grasses in swales, which normally serves to reduce erosion and increase infiltration.

Three Brothers TB-083 Rangeland Health Attribute 3: Biotic Integrity

Table 20. Functional group AIM foliar cover data at TB-083.

Functional Group	Foliar Cover %
Shrub	20.0
Perennial Grass	0.0
Forb	0.0
Sub-shrub	1.4

The overall rating for the biotic integrity attribute at TB-083 was Moderate departure from ecological site reference condition. Indicator 11 (compaction layer), Indicator 13 (dead or dying plant parts), Indicator 14 (litter), Indicator 17 (plant reproductive vigor) were rated None to Slight because they were within the natural range of variability for the ecological site. Indicator 16 (invasive plants) was rated Slight to Moderate because burroweed (*Isocoma tenuisecta*)—an invasive native plant—was present throughout the site. Indicator 8 (soil surface resistance to erosion) and Indicator 9 (soil surface loss or degradation) were rated Moderate and Indicator 12 (plant functional/structural groups) and Indicator 15 (annual production) were rated Moderate to Extreme. Soil stability test values measured at the site were lower than expected for the ecological site and there were signs of soil surface loss and degradation in plant

interspaces and under shrub canopies. Reduced organic matter at the soil surface limits seed germination and seedling establishment. Perennial grasses, the expected dominant plant functional/structural group for Clay Loam Uplands, was only found in trace amounts. Annual production at the site was low, at about 33% of the expected annual production under low rainfall conditions.

Three Brothers TB-02 AIM Study Plot

Table 21. TB-02 key area AIM data compared to Clay Loam Upland ESD.

	Basal Cover				Biological Crust	Litter	Surface Fragments ¼" - 3"	Surface Fragments > 3"	Bedrock	Bare Ground
	Grass	Forb	Shrub	Tree						
ESD R041XC305AZ	3-10%	0-1%	3-5%	0-1%	0-1%	15-50%	25-65%	0-10%	1-10%	5-50%*
TB-02	0%	0%	0%	0%	0%	30%	2%	0%	0%	56%

Three Brothers TB-02 Rangeland Health Attribute 1: Soil and Site Stability

The overall rating for the soil and site stability attribute at TB-02 was a Moderate departure from Clay Loam ecological site reference conditions. Four indicators of soil and site stability were rated None to Slight because they were within the natural range of variability expected for the ecological site. Indicator 1 (rills), Indicator 3 (pedestals or terracettes), Indicator 5 (gullies), and Indicator 7 (litter movement) were rated Moderate departure and Indicator 2 (water flow patterns) and Indicator 4 (bare ground) were rated Moderate to Extreme departure. Rills and gullies are not expected under reference conditions and were found throughout the site, mostly in exposed soils. Gullies were common, 2-3 feet wide and 100+ feet long. Water flow patterns were longer, wider, and deeper than expected for the site and were occasionally connected. Plant pedestals were observed in water flow patterns in the evaluation area, but there were no exposed roots. Bare ground was measured at 56%, which is slightly higher than the estimated maximum range expected (55%). At the time of the evaluation, the team ranked the bare ground departure as Moderate to Extreme. Smaller sized litter were concentrated around obstructions, indicating litter movement where no litter movement is expected under reference conditions.

Three Brothers TB-02 Rangeland Health Attribute 2: Hydrologic Function

The overall rating for the hydrologic function attribute at TB-02 was Moderate departure from ecological site reference conditions. Four indicators for hydrologic function were rated as none to slight because they were within the natural range of variability expected for Clay Loam Uplands. Indicator 1 (rills), Indicator 3 (pedestals or terracettes), and Indicator 5 (gullies) were rated Moderate departure and Indicator 2 (water flow patterns), Indicator 4 (bare ground), and Indicator 10 (plant community effect on infiltration) were rated Moderate to Extreme departure. The site has erosional features (rills, gullies, water flow patterns) that encourage runoff. In addition, the plant community at the site had a greatly reduced perennial grass component, limiting infiltration. Under reference conditions, perennial grasses are expected to be 85% of total plant cover and data collected at the site shows perennial grasses at less than 5% of total cover. The evaluation team determined that the site is in the “Mesquite, Annuals” state of the state and transition model for Clay Loam Uplands due to persistent low perennial grass cover. Legacy data shows that the site is heavily dependent on annual plants with 2012-2015 data showing over 90% frequency of annuals.

Three Brothers TB-02 Rangeland Health Attribute 3: Biotic Integrity

Table 22. Functional group AIM foliar cover data at TB-02.

Functional Group	Foliar Cover %
Shrub	22.6
Perennial Grass	3.3
Forb	0.7
Sub-shrub	10.0

The overall rating for the biotic function attribute at TB-02 was a Moderate departure from ecological site reference conditions. Five indicators of biotic function were rated None to Slight because they were within the natural range of variability of the Clay Loam ecological site. Indicator 12 (plant functional/structural groups) and Indicator 15 (annual production) were rated Moderate and Indicator 16 (invasive plants) and Indicator 17 (plant reproductive vigor) were rated Moderate to Extreme departure. Burweed, which is considered invasive, was very common throughout the site. Utilization of perennial grasses was high and most grasses under canopies of shrubs had been grazed. Production was lower than expected for periods of unfavorable precipitation. Only trace amounts of perennial grasses were present at the site, a significant departure from their expected dominance on Clay Loam Uplands. Reproductive capability of perennial plants was rated Moderate to Extreme departure due to heavy grazing on perennial grasses. Mesquite and whitethorn acacia showed some signs of stress at the site.

Shallow Upland Sites (Lucky Hills LH-041 and SP-245)

Key area LH-041 (Tables 29 and 30) and AIM study plot SP-245 (Tables 31 and 32) are in the Shallow Uplands 12-16" p.z. ecological site. The Shallow Uplands ecological site potential plant community is warm season perennial grass dominant and shrub sub-dominant. Perennial forbs and annual grasses and forbs are a minor component on this site. All major perennial grasses and shrubs are expected to be well dispersed throughout the plant community. Common plant species include grama grasses (*Bouteloua spp.*), curly mesquite grass (*Hilaria belangeri*), and fairy duster (*Calliandra eriophylla*). Most common plant species can re-sprout and recover quickly after disturbances such as drought and fire. This site occurs in the middle elevations of the Madrean Basin and Range province in southeastern Arizona, southwestern New Mexico, as well as Chihuahua and Sonora, Mexico on gently sloping to moderately steep pediments which flank mountain areas. Small rock outcroppings can be common on Shallow Uplands (per the ESD via EDIT 2020).

Lucky Hills Shallow Uplands

Lucky Hills LH-041 Key Area

Table 23. LH-041 key area AIM data compared to Shallow Upland ESD.

	Basal Cover				Biological Crust	Litter	Surface Fragments ¼" - 3"	Surface Fragments > 3"	Bedrock	Bare Ground
	Grass	Forb	Shrub	Tree						
ESD R041XC322AZ	3-10%	0-1%	3-5%	0-1%	0-1%	15-50%	25-65%	0-10%	1-10%	5-50%
LH-041	0.7%	0%	0.7%	0%	0%	46.7%	94%	0%	0%	1.3%

Lucky Hills LH-041 Rangeland Health Attribute 1: Soil and Site Stability

The overall rating for the soil and site stability attribute at LH-041 was None to Slight departure from ecological site reference conditions. Nine indicators of soil and site stability were rated None to Slight because they were within the natural range of variability expected for the ecological site. Indicator 2 (water flow patterns) was rated Slight to Moderate departure because water flow patterns on the site were continuous and extended less than 40 feet in length and were in open areas (none are expected under reference conditions). There was one small area devoid of vegetative and rock cover on the site that appeared to be a historic disturbance. Very high rock cover throughout the site helps prevent erosional features from developing.

Lucky Hills LH-041 Rangeland Health Attribute 2: Hydrologic Function

The overall rating for the hydrologic function attribute at LH-041 was None to Slight departure from reference conditions. Eight indicators of hydrologic function were rated None to Slight because they were within the natural range of variability expected for the ecological site. Indicator 2 (water flow patterns) and Indicator 10 (plant community effect of infiltration) were rated Slight to Moderate departure. Water flow patterns on the site were continuous, at most 40 feet long, and found in open areas. The site had higher-than-expected shrub cover and lower-than-expected grass cover. The rock fragment ground cover at the site aides in resisting erosion and adds roughness to the surface to slow the flow.

Lucky Hills LH-041 Rangeland Health Attribute 3: Biotic Integrity

Table 24. Functional group AIM foliar cover data at LH-041.

Functional Group	Foliar Cover %
Shrub	22.7
Perennial Grass	24.0
Forb	17.3
Sub-shrub	0.7

The overall rating for the biotic integrity attribute at LH-041 was a Slight to Moderate departure from ecological site reference conditions. Seven indicators of Biotic Function were rated None to Slight because they were within the natural range of variability expected for Shallow Uplands. Indicator 12 (plant functional/structural groups) was rated Slight to Moderate and Indicator 16 (invasive species) was rated Moderate. Plant functional/structural groups indicator was rated Slight to Moderate due to shrub encroachment on the site. Invasive plants were rated Moderate due to mesquite and Lehmann lovegrass being present and scattered throughout.

Lucky Hills SP-245 AIM Study Plot

Table 25. SP-245 AIM study plot compared to Shallow Upland ESD.

	Basal Cover				Biological Crust	Litter	Surface Fragments ¼" - 3"	Surface Fragments > 3"	Bedrock	Bare Ground
	Grass	Forb	Shrub	Tree						
ESD R041XC322AZ	3-10%	0-1%	3-5%	0-1%	0-1%	15-50%	25-65%	0-10%	1-10%	5-50%
SP-245	0%	0%	0%	0%	0%	10%	36%	0%	0%	36.7%

Lucky Hills SP-245 Rangeland Health Attribute 1: Soil and Site Stability

The overall rating for the soil and site stability attribute at SP-245 was a Moderate departure from ecological site reference conditions. Three indicators of soil and site stability were rated None to Slight departure because they were within the natural range of variability expected for Shallow Uplands. Indicator 4 (bare ground) and Indicator 9 (soil surface structure and organic matter) were rated Slight to Moderate. Indicator 1 (rills), Indicator 3 (plant pedestals), Indicator 5 (gullies), and Indicator 7 (litter movement) were rated Moderate and Indicator 2 (water flow patterns) was rated Moderate to Extreme. Rills were present on steeper slopes and bare areas. Water flow patterns were continuous, over 100 feet in length, 3-4 feet wide, and 1 foot deep. Plant pedestals were on 60-70% of shrubs, but no roots were exposed. Bare ground was measured at 37% at SP-245 and 15-25% is expected under reference conditions. Gullies were present with vegetation growing on the bottom and partially on the sides. Some gullies were about 10 feet wide and 2 feet deep. There was evidence of litter movement with accumulation in waterflow patterns and under shrubs. Shrub interspaces had inadequate ground cover and there was evidence of soil surface loss and degradation. The site was a randomly generated AIM point that fell very close to Charleston Road, which is a main contributor of runoff at the site.

Lucky Hills SP-245 Rangeland Health Attribute 2: Hydrologic Function

The overall rating for the hydrologic function attribute at SP-245 was Moderate departure from reference conditions. Three indicators of hydrologic function were rated as None to Slight because they were within the natural range of variability expected for the ecological site. Indicator 4 (bare ground) and Indicator 9 (soil surface structure and organic matter) were rated Slight to Moderate. Indicator 1 (rills), Indicator 3 (plant pedestals), Indicator 5 (gullies), and Indicator 10 (effect of plant community on infiltration) were rated Moderate and Indicator 2 (water flow patterns) was rated Moderate to Extreme. Erosional features on the site (rills, gullies, water flow patterns) encourage runoff and soil surface degradation. Shrub encroachment and low perennial grass cover limit infiltration and water holding capacity on the site. Rock fragment cover is protecting exposed areas.

Lucky Hills SP-245 Rangeland Health Attribute 3: Biotic Integrity

Table 26. Functional group AIM foliar cover data at SP-245.

Functional Group	Foliar Cover %
Shrub	21.4
Perennial Grass	7.3
Forb	5.3
Cactus/Succulent	0.7

The overall rating for the biotic integrity attribute at SP-245 was Slight to Moderate departure from reference conditions. Six indicators of biotic integrity were rated None to Slight. Indicator 9 (soil surface structure and organic matter) was rated Slight to Moderate, Indicator 16 (invasive plants) was rated Moderate, and Indicator 12 (plant functional/structural groups) was rated Moderate to Extreme. At the site, there was evidence of soil surface loss and degradation in shrub interspaces. Reduced cover of perennial grasses was the biggest departure for this site. Perennial grasses, the expected dominant plant functional group under reference conditions, had become sub-dominant in the plant community. Potentially invasive plants for Shallow Uplands (Lehmann lovegrass, prickly pear, mesquite, and ocotillo) were scattered throughout the site.

Shallow Hills Sites (Lucky Hills LH-04 and LH-06)

Key areas LH-04 (Tables 23 and 24) and LH-06 (Tables 25 and 26) are on the Shallow Hills 12-16" p.z. ecological site. The potential plant community on Shallow Hills is warm season perennial grass dominant with several species of low shrubs and cacti sub-dominant. Larger species of shrubs are concentrated at

the edges of rock outcroppings and in canyon bottoms. Most of the grass and low shrub species are well dispersed throughout the plant community. In the absence of wildfire and/or with continuous heavy grazing, shrubs increase to dominate the plant community. Well-developed gravel and cobble protect the soil from erosion and protect forage species from heavy use. The HCPC described in the Shallow Hills ESD (EDIT 2020) occurs at a midpoint in the fire free interval (5 to 7 years after fire).

Lucky Hills Shallow Hills

Lucky Hills LH-04 Key Area

Table 27. LH-04 key area AIM data compared to Shallow Hills ESD.

	Basal Cover				Biological Crust	Litter	Surface Fragments ¼" - 3"	Surface Fragments > 3"	Bedrock	Bare Ground
	Grass	Forb	Shrub	Tree						
ESD R041XC306AZ	3-7%	0-1%	2-4%	0-1%	0-1%	25-45%	25-50%	0-10%	0-10%	5-40%
LH-04	0%	0%	0%	0%	0%	36%	52%	0%	0%	8%

Lucky Hills LH-04 Rangeland Health Attribute 1: Soil and Site Stability

The overall rating for the soil and site stability attribute at LH-04 was a Moderate departure from ecological site reference conditions. Three indicators for soil and site stability were rated None to Slight departure because they were within the natural range of variability for Shallow Hills. Indicator 1 (rills), Indicator 4 (bare ground), and Indicator 9 (soil surface structure and organic matter) were rated Slight to Moderate departure. Indicator 3 (plant pedestals) and Indicator 5 (gullies) were rated Moderate departure. Indicator 2 (water flow patterns) was rated Moderate to Extreme. Rills and gullies were present with evidence of active erosion (none are expected in the Shallow Hills ecological site). Gullies on the site had bank sluff, however they were re-vegetating on the bottoms and rocks were protecting head cuts from forming. Water flow patterns on the site were greatly departed from reference conditions because they were continuous, in regular intervals, and approximately 50-100 feet long with a 6-inch depth. More than half of shrubs had pedestals 2-3 inches tall when plant pedestals are expected to be uncommon. Bare ground was measured at 8%, which is within the normal range of bare ground for Shallow Hills of 5-40%. There was evidence of litter movement with accumulations in gullies and depressions. Overall, the amount of litter was appropriate for the site, but the litter distribution was uneven with higher concentrations under shrub canopies and inadequate cover in the plant interspaces to protect the soil.

Lucky Hills LH-04 Rangeland Health Attribute 2: Hydrologic Function

The overall rating for the hydrologic function attribute at LH-04 was a Moderate departure from reference conditions. Two of the indicators of hydrologic function were rated None to Slight because they were within the natural range of variability for Shallow Hills. Indicator 1 (rills), Indicator 4 (bare ground), Indicator 9 (soil surface structure and organic matter), and Indicator 14 (litter) were rated Slight to Moderate. Indicator 3 (plant pedestals), Indicator 5 (gullies), and Indicator 10 (plant community effect of infiltration) were rated Moderate departure and Indicator 2 (water flow patterns) was rated Moderate to Extreme. The site had rills, gullies, and water flow patterns which increase runoff and transport sediment off the site. In addition, the site was shrub dominated with higher-than-expected shrub cover and lower-than-expected perennial grass cover, which reduces water infiltration on the site.

Lucky Hills LH-04 Rangeland Health Attribute 3: Biotic Integrity

Table 28. Functional group AIM foliar cover data at LH-04.

Functional Group	Foliar Cover %
Shrub	32.1
Perennial Grass	14.7
Forb	15.3
Sub-shrub	0.7

The overall rating for the biotic integrity attribute at LH-04 was a Moderate departure from reference conditions. Two indicators for biotic function were rated None to Slight because they were within the natural range of variability expected for the ecological site. Indicator 9 (soil surface structure and organic matter), Indicator 13 (plant mortality/decadence), Indicator 14 (litter), Indicator 15 (annual production), and Indicator 17 (plant reproductive vigor) were rated Slight to Moderate. Indicator 16 (invasive plants) was rated Moderate and Indicator 12 (functional/structural groups) was rated Moderate to Extreme. Reduced organic matter at the soil surface and perennial grass seed head production limit perennial grass reproduction and recruitment. The ecological site HCPC expects shrubs to be a trace functional/structural group and shrubs have become dominant at LH-04. Whitethorn acacia and Lehmann lovegrass have invaded the site and are scattered throughout the area. Annual production at the site was estimated to be slightly lower than expected under drought conditions.

Lucky Hills LH-06 Key Area

Table 29. LH-06 key area AIM data compared to Shallow Hills ESD.

	Basal Cover				Biological Crust	Litter	Surface Fragments ¼" - 3"	Surface Fragments > 3"	Bedrock	Bare Ground
	Grass	Forb	Shrub	Tree						
ESD R041XC306AZ	3-7%	0-1%	2-4%	0%	0-1%	25-45%	25-50%	0-10%	0-10%	5-40%
LH-06	2%	0%	2%	0%	0%	46%	60%	0%	0%	6%

Lucky Hills LH-06 Rangeland Health Attribute 1: Soil and Site Stability

The overall rating for the soil and site stability attribute at LH-06 was None to Slight departure from reference conditions. All ten indicators for soil and site stability were rated None to Slight because they were within the natural range of variability expected for the ecological site. The site had high rock cover and no erosional features.

Lucky Hills LH-06 Rangeland Health Attribute 2: Hydrologic Function

The overall rating for the hydrologic function attribute at LH-06 was None to Slight departure from reference conditions. Nine indicators of hydrologic function were rated as None to Slight because they were within the natural range of variability expected for the ecological site. Indicator 10 (plant community effect on infiltration) was rated Slight to Moderate due to the higher-than-expected shrub cover, which has the potential to increase runoff. The site's high rock and litter cover aids in slowing runoff and keeping water on the site.

Lucky Hills LH-06 Rangeland Health Attribute 3: Biotic Integrity

Table 30. Functional group AIM foliar cover data at LH-06.

Functional Group	Foliar Cover %
Shrub	40.0
Perennial Grass	12.0
Forb	0.0
Cactus/Succulent	6.0

The overall rating for the biotic integrity attribute was a Moderate departure from reference conditions. Seven indicators of biotic function were rated as None to Slight because they were within the natural range of variability expected for the site. Indicator 16 (invasive plants) was rated Moderate departure and Indicator 12 (plant functional/structural groups) was rated Moderate to Extreme. Shrub encroachment at the site leading to altered plant functional/structural groups is the main factor driving the site's departure from optimal biotic integrity.

Limestone Hills Sites (LH-043)

Monitoring location LH-043 (Tables 27 and 28) is in the Limestone Hills 12-16" p.z. ecological site. The potential plant community on Limestone Hills is dominated by warm season perennial grasses. Several species of shrubs are well represented on the site. Shrubs can be concentrated at the edges of rock outcrops and in canyon bottoms. Most of the grass and shrub species are well dispersed throughout the plant community. A few species (black grama, New Mexico feathergrass, amole, sandpaper bush, and mariola) grow in patches which vary in size and are not well dispersed over larger areas of the site.

Lucky Hills LH-043 Key Area

Table 31. LH-043 key area AIM data compared to Limestone Hills Ecological Site

	Basal Cover				Biological Crust	Litter	Surface Fragments ¼" - 3"	Surface Fragments > 3"	Bedrock	Bare Ground
	Grass	Forb	Shrub	Tree						
ESD R041XC307AZ	2-5%	0-1%	2-5%	0%	0-1%	10-25%	25-50%	0-8%	0-15%	5-60%
LH-043	0.7%	0%	0%	0%	0%	27.3%	58%	0%	0%	15.3%

Lucky Hills LH-043 Rangeland Health Attribute 1: Soil and Site Stability

The overall rating for the soil and site stability attribute at LH-043 was Slight to Moderate. Six indicators of soil site stability were rated None to Slight because they were within the natural range of variability expected for the ecological site. Indicator 4 (bare ground), Indicator 5 (gullies), and Indicator 9 (soil surface structure and organic matter) were rated Slight to Moderate and Indicator 7 (litter movement) was rated Moderate. Bare ground was measured at 15% at the site, which is in the normal range of bare ground for the Limestone Hills ecological site of 5 to 60%. Gullies on the site had vegetation in bottoms and sides and were more evident on slight drops in grade. There was some litter accumulation at plant bases and evidence of soil loss where rock cover was lower than the rest of the site. Overall, the site had extensive rock cover, which reduces erosion.

Lucky Hills LH-043 Rangeland Health Attribute 2: Hydrologic Function

The overall rating for the hydrologic function attribute at LH-043 was Slight to Moderate departure from reference condition. Six indicators of hydrologic function were rated None to Slight because they were within the natural range of variability expected for the ecological site. Indicator 4 (bare ground), Indicator 5 (gullies), Indicator 9 (soil surface structure and organic matter), and Indicator 10 (plant community effect of infiltration) were rated Slight to Moderate. Shrub encroachment at the site is likely limiting water infiltration. Rocks and perennial grasses help reduce runoff at the site. Gullies at LH-043 had no evidence of active erosion with vegetation on the sides and bottom. Visual evidence of historic mining in the area indicates that this historic land use could have contributed to the depth of the gullies.

Lucky Hills LH-043 Rangeland Health Attribute 3: Biotic Integrity

Table 32. Functional group AIM foliar cover data at LH-043.

Functional Group	Foliar Cover %
Shrub	20.6
Perennial Grass	10.0
Forb	6.1

The overall rating for the Biotic Integrity attribute at LH-043 was None to Slight departure from reference conditions. Six indicators of biotic integrity were rated as None to Slight because they were within the natural range of variability expected for the ecological site. Indicator 9 (soil surface structure and organic matter), Indicator 12 (plant functional/structural groups), and Indicator 17 (plant reproductive vigor) were rated Slight to Moderate. Shrubs are the dominant functional group at LH-043 but are expected to be sub-dominant in the plant community. Reproductive capability of perennial plants was reduced due to utilization of seed heads.

6.2.2 Standard 2: Riparian-Wetland Sites

There are no riparian-wetland sites in the Lucky Hills Allotment, thus this standard is Not Applicable.

6.2.3 Standard 3 Desired Resource Conditions

Standard 3 for the Arizona Standards for Rangeland Health is:

- *Productive and diverse upland and riparian-wetland plant communities of native species exist and are maintained.*

In addition, Standard 3 requires the development of quantitative allotment-specific objectives that tier from the RMP objectives. The Complex’s allotment-specific objectives are the DPC objectives described in Section 4.3., which also describes how the DPC objectives support the SPRNCA RMP (BLM 2019) objectives. The following tables show the DPC objectives for the Lucky Hills and Three Brothers Allotments compared to the AIM monitoring data collected in 2019 and whether the objective is being met. Additional description and rationale for Standard 3 is provided in Section 7.3.

Limy Upland Sites (Three Brothers TB-1, TB-081, GRZ-04, and Lucky Hills LH-042)

Three Brothers Limy Uplands

Three Brothers Key Area TB-01

Objective	KA TB-01 monitoring result	Conclusion
Perennial grass foliar cover of ≥11%	12.7% perennial grass foliar cover	Achieved

Objective	KA TB-01 monitoring result	Conclusion
Shrub foliar cover <30%	32.6% shrub foliar cover	Not Achieved

Three Brothers Key Area TB-081

Objective	KA TB-081 monitoring result	Conclusion
Perennial grass foliar cover of ≥8%	8.7% perennial grass foliar cover	Achieved
Shrub foliar cover <30%	36% shrub foliar cover	Not Achieved

Three Brothers Key Area GRZ-04

Objective	KA GRZ-04 monitoring result	Conclusion
Perennial grass foliar cover of ≥2%	2% perennial grass foliar cover	Achieved
Shrub foliar cover <30%	49% shrub foliar cover	Not Achieved

Lucky Hills Limy Uplands

Lucky Hills Key Area LH-042

Objective	KA LH-042 monitoring result	Conclusion
Perennial grass foliar cover of ≥24%	24% perennial grass foliar cover	Achieved
Shrub foliar cover <30%	44.7% shrub foliar cover	Not Achieved

Clay Loam Upland Sites (Three Brothers TB-083 and TB-02)

Three Brothers Clay Loam Uplands

Three Brothers AIM Study Plot TB-083

Objective	TB-083 monitoring result	Conclusion
Perennial Grass foliar cover >5%	0% perennial grass foliar cover	Not Achieved

Three Brothers AIM Study Plot TB-02

Objective	KA TB-02 monitoring result	Conclusion
Perennial Grass foliar cover >5%	3.3% perennial grass foliar cover	Not Achieved

Shallow Upland Sites (Lucky Hills LH-041 and SP-245)

Lucky Hills Shallow Uplands

Lucky Hills Key Area LH-041

Objective	KA LH-041 monitoring result	Conclusion
Perennial grass foliar cover of ≥20%	24% perennial grass foliar cover	Achieved
Shrub foliar cover <10%	22.7% shrub foliar cover	Not Achieved

Lucky Hills AIM Study Plot SP-245

Objective	SP-245 monitoring result	Conclusion
Perennial grass foliar cover of ≥20%	7.3% perennial grass foliar cover	Not Achieved
Shrub foliar cover <10%	21.4% shrub foliar cover	Not Achieved

Shallow Hills Sites (Lucky Hills LH-04, LH-06, and LH-043)

Lucky Hills Shallow Hills

Lucky Hills Key Area LH-04

Objective	KA LH-04 monitoring result	Conclusion
Perennial grass foliar cover of ≥15%	14.7% perennial grass foliar cover	Achieved
Shrub foliar cover <10%	32.1% shrub foliar cover	Not Achieved

Lucky Hills Key Area LH-06

Objective	KA LH-06 monitoring result	Conclusion
Perennial grass foliar cover of ≥15%	12% perennial grass foliar cover	Not Achieved
Shrub foliar cover <10%	40% shrub foliar cover	Not Achieved

Limestone Hills Site (Lucky Hills LH-043)

Lucky Hills Key Area LH-043

Objective	KA LH-043 monitoring result	Conclusion
Perennial grass foliar cover of ≥15%	10% perennial grass foliar cover	Not Achieved
Shrub foliar cover <10%	20.6% shrub foliar cover	Not Achieved

7. RECOMMENDATIONS

The following section represents recommendations identified through the LHE process.

7.1 Recommended Management Actions

Based on the results of the above evaluation, the BLM recommends the following actions to ensure the Standards are achieved:

- Develop an adaptive management framework to make progress towards achieving Land Health Standards.
- Prioritize construction of erosion control structures in sites that are not meeting Standard 1.
- Implement shrub reduction treatments that target creosote and whitethorn acacia in Limy Uplands.
- Construct more reliable fencing over waterways that experience flashfloods on allotment boundaries.
- Construct the SPRNCA boundary fence.
- Consider implementing season of use restriction on the portion of the Three Brothers Allotment that is located inside the SPRNCA.
- Initiate waterflow/erosion control measures on the Powerline roadway.
- Maintain existing watering locations and add covered storage to reduce evaporation.
- Inventory and treat roadways for weeds.
- Change allotment management category from M (Maintain) to I (Improve).

7.1.1 Cultural Resources

Future cultural resources inventory and assessment should focus on BLM-administered areas where livestock may concentrate, such as along waterways and the location(s) of any existing or proposed range improvements. If, as a result of assessment or monitoring, historic properties are identified and found to exhibit potential for or actively occurring grazing impacts, mitigation measures would be developed in coordination with the State Historic Preservation Office and other interested or affected parties, including Native American tribes.

8. PREPARERS AND REVIEWERS

List of Preparers

Name	Title
Eric Baker	Rangeland Management Specialist
Theresa Condo	Biological Science Technician
Phil Cooley	Arizona State Office Rangeland Management Specialist Lead
Dave Murray	Hydrologist
Amy McGowan	Planning & Environmental Specialist
Kim Ryan	Cultural Resources Specialist
Mark McCabe	Natural Resource Specialist
Francisco Mendoza	Outdoor Recreation Planner

List of Reviewers

Name	Title
Margarita Guzman	Tucson Field Office Assistant Field Manager
Jayne Lopez	Tucson Field Office Manager
Scott Feldhausen	Gila District Manager
Clara Gauna	Technical Writer/Editor
Zach Driscoll	GIS Specialist
Emilio Corella	Range Technician
Margaret (Peggy) Monkemeier	Hydrologic Technician
Lea Schram von Haupt	Planning & Environmental Specialist Intern

9. REFERENCES

- Al-Hamdan, O.Z., F.B. Pierson, M.A. Nearing, C.J. Williams, J.J. Stone, P.R. Kormos, J. Boll, and M.A. Weltz. 2013. Risk assessment of erosion from concentrated flow on rangelands using overland flow distribution and shear stress partitioning. *Transactions of the ASABE* 56(2):539-548.
- Arguez, A., Imke Durre, Scott Applequist, Mike Squires, Russell Vose, Xungang Yin, and Rocky Bilotta. 2012. NOAA's U.S. Climate Normals (1981-2010). Station: Tombstone, AZ, GHCND:USC00028619. NOAA National Centers for Environmental Information. DOI:10.7289/V5PN93JP (accessed September 16, 2020).
- Arizona Game and Fish Department (AGFD). 2020. Heritage Data Management System (HDMS), Project Evaluation Program. Arizona Game and Fish Department, Phoenix, Arizona.
- Arizona Government-to-Government Consultation Toolkit. 2020. Available online at <https://sites.google.com/view/az-consultation-toolkit/home> (accessed February 27, 2020).
- AZSite. 2020. Arizona's Cultural Resource Inventory, maintained by the Arizona State Museum. Available online at <http://azsite3.asurite.ad.asu.edu/azsite/> (accessed February 20, 2020).
- Bureau of Land Management (BLM). 1987. Eastern Arizona Grazing Environmental Impact Statement and Record of Decision. BLM Phoenix and Safford Districts, Arizona.
- __. 1994. Safford District Resource Management Plan and Record of Decision (Amended). BLM Safford Field Office, Arizona.
- __. 1995. San Pedro Intermodal Transportation System. BLM, Sierra Vista, Arizona.
- __. 1997. Arizona Standards for Rangeland Health and Guidelines for Grazing Administration (Arizona Standards and Guidelines). BLM, Arizona State Office, Phoenix.
- __. 2019. San Pedro Riparian National Conservation Area Approved Resource Management Plan and Record of Decision. BLM Tucson Field Office, Arizona.
- __. 2020. Assessment, Inventory, and Monitoring (AIM) Landscape Toolbox. Available online at: <https://aim.landscapetoolbox.org/>
- Childress, Jane P. 2005. San Pedro Section 110 Inventory. Project Records on File at the Bureau of Land Management, Tucson Field Office.
- Collins, William S. 1996. *Cattle Ranching in Arizona: A Context for Historic Preservation Planning*. Arizona State Historic Preservation Office, Phoenix.
- Coulloudon, B., Eshelman, K., Gianola, J., Habich, N., Hughes, L., Johnson, C., Pellant, M., Podborny, P., Rasmussen, A., Robles, B., Shaver, P., Spehar, J., and J. Willoughby. 1999. Sampling Vegetation Attributes. Tech. Ref. 1734-4. U.S. Department of the Interior, Bureau of Land Management, National Operations Center, Denver, CO.
- Dart, Allen. 1983. *An Archaeological Clearance Survey for Materials Source 8278 Haul Road Near Fairbank, Cochise County, Arizona*. ASM Accession No. 1983-124. Arizona State Museum, University of Arizona, Tucson.

- Doak, David P. 2009. *A Class III Cultural Resources Survey of Eight Segments of Power Line Corridor South of Tombstone, Cochise County, Arizona: The Miner's Dream Survey*. ASM Accession No. 2009-54. Tierra Right of Way Services, Ltd., Tucson.
- Dosh, Steven G., David H. Greenwald, and Sara T. Stebbins. 1987. *Archaeological Survey of the San Rafael Transmission Line Alternate Route Corridors, Cochise County, Arizona*. Museum of Northern Arizona, Flagstaff.
- Ecosystem Dynamics Interpretive Tool (EDIT). 2020. Online Ecological Site Description database cooperative managed by NRCS, the USDA Agricultural Research Service Jornada Experimental Range, and New Mexico State University. Available online at: <https://edit.jomada.nmsu.edu/> (accessed December 19, 2020).
- Gifford, G.F. 1985. Cover allocation in rangeland watershed management (a review). In *Watershed management in the Eighties* (pp. 23-31). ASCE.
- Goodrich, D. C., T. O. Keefer, C. L. Unkrich, M. H. Nichols, H. B. Osborn, J. J. Stone, and J. R. Smith. 2008. Long-term precipitation database, Walnut Gulch Experimental Watershed, Arizona, United States, *Water Resour. Res.*, 44, W05S04, doi:10.1029/2006WR005782
- Hammack, Laurens. 2000. *Cultural Resource Inventory, Tombstone Quarry*. CASA Project Report No. 00-65. Complete Archaeological Service Associates, Cortez, Colorado.
- Hayes, John. 2002. *A Cultural Resources Assessment Survey of Approximately Seven Acres at the Charleston Lead Mine Near Tombstone, Cochise County, Arizona*. ASM Accession No. 2000-817. Tierra Archaeological and Environmental Consultants, Tucson.
- Herrick, Jeffrey E., Justin W. Van Zee, Kris M. Havstad, Laura M. Burkett, and Walter G. Whitford. 2005. *Monitoring manual for grassland, shrubland and savanna ecosystems. Volume I: quick start. Volume II: design, supplementary methods and interpretation*. USDA-Agricultural Research Service Jornada Experimental Range.
- Kayser, David W. n.d. *Archaeological Survey of the Proposed Charleston Dam and Reservoir, Southwest Arizona*. ASM Accession No. 1968-1. Arizona State Museum, University of Arizona, Tucson.
- King, D. M., Skirvin, S. M., Collins, C. H., Moran, M. S., Biedenbender, S. H., Kidwell, M. R., ... & Diaz-Gutierrez, A. 2008. Assessing vegetation change temporally and spatially in southeastern Arizona. *Water Resources Research*, 44(5).
- Knoblock, Keith. 2001. *A Cultural Resource Survey for a Proposed Fiber Optic Corridor Spanning Southeastern Arizona in Pima, Santa Cruz, and Cochise Counties*. ASM Accession No. 2012-73. Lone Mountain Archaeological Services, Inc., Tucson.
- Kwiatkowski, Scott. 1996. *Cultural Resources Survey in the Vicinity of Arizona Department of Transportation Bridges 0103, 0107, and 0236, U.S. Highway 80, Cochise County, Arizona*. ASM Accession No. 1996-314. Archaeological Research Services, Inc., Tempe.
- Latta, M. J., C. J. Beardmore, and T. E. Corman. 1999. Arizona Partners in Flight Bird Conservation Plan. Version 1.0. Nongame and Endangered Wildlife Program Technical Report 142. Arizona Game and Fish Department, Phoenix, Arizona.
- Lyon, Jerry D. 2013. *A Class III Cultural Resources Survey of Abandoned Mine Lands (AML) on Bureau of Land Management Lands near Tombstone, Cochise County, Arizona*. ASM Accession No. 2014-187. Harris Environmental Group, Tucson.

- Madsen, John H. 1980. Letter Report Regarding Cultural Survey for ASLD Application 04-77728-08. ASM Accession No. 1980-31. Arizona State Museum, University of Arizona, Tucson.
- National Register of Historic Places NPGallery Digital Asset Search. 2020. Maintained by the National Park Service. Available online at <https://www.nps.gov/subjects/nationalregister/database-research.htm> (accessed February 27, 2020).
- Natural Resources Conservation Service (NRCS). 2003. National Range and Pasture Handbook. U.S. Department of Agriculture, Grazing Lands Technology Institute. Washington D.C.
- _____. 2006. *Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin*. U.S. Department of Agriculture Handbook No. 296. Washington D.C.
- _____. 2020a. Web Soil Survey database, available online at websoilsurvey.nrcs.usda.gov (accessed February 20, 2020).
- _____. 2020b. Culturally Sensitive Plants Database. Available online at <https://plants.usda.gov/java/factSheet?cultural=yes> (accessed February 4, 2020).
- National Riparian Service Team (NRST). 2012. Proper Functioning Condition (PFC) Riparian Assessment Report, San Pedro River, San Pedro Riparian National Conservation Area, Arizona. Prineville, Oregon. November 16, 2012
- Pellant, M., P.L. Shaver, D.A. Pyke, J.E. Herrick, N. Lepak, G. Riegel, E. Kachergis, B.A. Newingham, D. Toledo, and F.E. Busby. 2020. Interpreting Indicators of Rangeland Health, Version 5. Tech Ref 1734-6. U.S. Department of the Interior, Bureau of Land Management, National Operations Center, Denver, CO.
- Punzmann, Walter R. and Carolyn Jackman. 2000. *Cultural Resource Assessment of State Route 80 Between Mileposts 309.00 and 316.53, Tombstone, Cochise County, Arizona*. ASM Accession No. 2000-270. Archaeological Consulting Services, Ltd., Tempe.
- Railey, Jim A. and Stephen W. Yost (eds). 2001. *Cultural Resources Survey of the 360 Networks Fiber Optics Line from Mesa, Arizona to El Paso, Texas*. ASM Accession No. 2003-910. TRC Mariah Associates, Inc., Albuquerque.
- Rawson, Paul M. 2011. *Archaeological Survey for the Tombstone Junction to SWTC 230 Transmission Line Maintenance Project, Cochise County, Arizona*. ASM Accession No. 2011-182. SWCA Environmental Consultants, Inc., Tucson.
- Stone, Bradford W. and Matthew M. Palus. 1997. *Cultural Resources Survey of a 14.11 Mile Long Segment of State Route 80 Between Tombstone and the Intersection of State Routes 80 and 90 (Mileposts 318-332.9), Southwestern Cochise County, Arizona*. ASM Accession No. 1997-392. Archaeological Research Services, Inc., Tempe.
- Sullivan, Alan P. 1981. Project Registration Form for ADOT Materials Source #8278. ASM Accession No. 1981-67. Arizona State Museum, University of Arizona, Tucson.
- Thomas, B.E., Pool, D.R. 2006. Trends in Streamflow of the San Pedro River, Southeastern Arizona, and Regional Trends in Precipitation and Streamflow in Southeastern Arizona and Southwestern New Mexico: U.S. Geological Survey Professional Paper 1712, 79 p.
- U.S. Army Topographic Engineering Center (TEC). 2001. Vegetation Map of the San Pedro Riparian National Conservation Area and Babocomari River, *Final Report*, submitted to U.S. Army Garrison at Fort Huachuca, Arizona.

U.S. Fish and Wildlife Service (USFWS). 2020. Information for Planning and Conservation (IPaC) Environmental Online Conservation System. Available online at: <https://ecos.fws.gov/ipac/>

Weltz, Mark A., Mary R. Kidwell, & H. Dale Fox. 1998. Influence of Abiotic and Biotic Factors in Measuring and Modeling Soil Erosion on Rangelands: State of Knowledge. *Journal of Range Management*, 51(5), 482-495. doi:10.2307/4003363

Whitney, Gregory J. 2015. *Cultural Resources Survey for the Three Brothers Ranch Dirt Tank Renovation Project, West of Tombstone, Cochise County, Arizona*. ASM Accession No. 2015-187. Desert Archaeology, Inc., Tucson.