The Arizona Native Plant Society

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& Our Regular Features

Above: Fremont Cottonwood (*Populus fremontii*), San Pedro River. *Photo courtesy Doug Ripley.*
Inset: Major General John Charles Frémont, USA.

Revealing Military Secrets:

The Little Known History of the U.S. Military in Discovering, Describing, and Conserving Native Plants in Arizona

by J. Douglas Ripley, Arizona Native Plant Society

When I entered the U.S. Air Force in 1969 as a recent biology graduate, I never imagined I would wind up having a 35-year career in the Air Force, initially as an Air Force officer and later as an Air Force civilian employee. Nor did I dare hope I might be able to work in the Air Force using my academic background in botany and plant ecology. But that is essentially what happened. After several initial assignments, I secured a position teaching biology at the U.S. Air Force Academy in Colorado. A youthful interest in natural history and growing up in San Francisco made me aware of the special environmental significance of both active and former military lands in coastal California. For example, the spectacular Marin Headlands north of the Golden Gate were protected from development because of their past use for coastal defense fortifications. Today they are protected and preserved by the National Park Service as part of the Golden Gate National Recreation Area. From 1846 to its deactivation in 1994 and subsequent transfer to the National Park Service, many important species (including three endemic plants) and natural habitats were protected by the U.S. Army at the Presidio of San Francisco.

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President's Note *by Douglas Ripley* jdougripley@gmail.com

Best wishes and happy botanizing to all Arizona Native Plant Society members as with hopeful anticipation we enter the monsoon season. Although long-term rainfall levels in Arizona and the West in general continue to be of great concern, the relatively good winter and early monsoon rains received in many parts of the state have been most welcome. I hope that you have been able to enjoy the positive effects of the increased rainfall on our native flora.

The first half of 2015 has been good for the Arizona Native Plant Society. We're continuing to pursue and sponsor a number of programs and activities that support our member's interest in native plant conservation and enjoyment. In April we held our annual Botany 2015 Conference at the beautiful Museum of Northern Arizona in Flagstaff. The theme of the conference was "Ethnobotany – Past, Present, and Future." In addition to a full day of compelling presentations and posters, three field trips were offered the second day. I thank the organizing committee (Tina Ayres, Susan Holiday, Andy Laurenzi, and Kirstin Olmon Phillips) for their hard work to make the conference a success, and the speakers for their informative and interesting presentations. We have not yet finalized plans for the Botany 2016 Conference, but anticipate that it will be held in the Feb–March timeframe in southern Arizona. We welcome ideas and suggestions from members on a theme for the conference and, of course, any offers to assist with the running of the conference itself.

Most of our ongoing activities are continuing in good form, including habitat restoration projects, Citizen Science programs in support of the Plant Atlas Project of Arizona (PAPAZ), plant taxonomy and plant-collecting workshops held in cooperation with the University of Arizona Herbarium, financial support for native plant research and publications through various chapter and state grant programs. The Tucson and Cochise Chapters will again sponsor a three-day field workshop in the Chiricahua Mountains on 5–7 September 2015 that is open to all members. Registration information will be announced on the website and in the *Happenings* newsletter.

As I have requested in the past, I again ask all members to let us know of new activities or initiatives that the Society might pursue on behalf of native plant conservation. Likewise any ideas or assistance with our ongoing activities would be most welcome. For example, *The Plant Press* would benefit from topic or theme suggestions for future issues or for the preparation of individual articles. Many of the Society's other activities and programs would also benefit from your suggestions and offers of assistance.

As will become quickly apparent in the introductory article, this issue of *The Plant Press* is devoted to a subject of considerable personal interest to me. Having spent my professional career helping to manage the natural and cultural resources conservation programs on Air Force lands, it occurred to me that an interesting journal topic would be the role the U.S. military played in discovering and describing Western plants and animals in the 19th century and its subsequent land stewardship mission on its current installations in Arizona. Consequently, this issue offers a history of past military involvement in Western plant and animal exploration and summaries of the natural resources conservation and research programs currently in place on the seven major Arizona military installations. I hope you will find this topic of interest and that it will provide you with a useful perspective on the conservation and environmental importance of our military lands.

All best wishes for a botanically rewarding summer!

Major Arizona Military Installations and Ranges

Revealing Military Secrets *continued*

It was at the Air Force Academy that I first became aware of the important role the U.S. military plays in protecting and managing the natural resources on its active installations and ranges. The 18,000-acre Air Force Academy reservation occupies and protects a significant and increasingly important section of the Colorado Front Range from the ever-increasing human development that encroaches upon it. Through an active natural resources management program, the Academy's lands are managed for a wide array of important environmental values such as biological diversity enhancement and conservation, sustainability, and natural aesthetics.

Following my Air Force Academy teaching assignment, I was transferred to the Environment Division at Air Force Headquarters in the Pentagon, Washington, DC, where I helped manage the Air Force's natural and cultural resources conservation programs for its approximately 130 major, world-wide installations. These facilities occupy nearly nine million acres of land. Through this work, I became directly involved with a wide array of environmental conservation programs the Department of Defense (DoD) has implemented on its lands. As I continued working in military conservation, I became aware of the truly remarkable role the U.S. military, and in particular, a number of 19th century military officer–scientists, played in discovering and describing the new plants and animals they encountered on many of their pioneering western expeditions and later during assignments to remote outposts.

The famous 1804–1806 expedition of the Corps of Discovery, led by U.S. Army officers Captain Meriwether Lewis and Lieutenant William Clark, was under a mandate from President Jefferson to explore, discover, and describe both the commercial as well as scientific characteristics of the Louisiana Purchase, the Pacific Northwest, and the Oregon Territory. Specifically, Jefferson directed the Corps to record everything possible about the land, including "the soils and face of the country, its growth and vegetation productions…the animals of the country…the remains or accounts of any which may be deemed rare or extinct" (Ambrose 1996).

Lewis and Clark encountered and described more than 40 American Indian tribes and 122 animals. Captain Lewis was especially interested in plants and more than 200 of his collections, many that were new to science, are now curated at the Academy of Natural Sciences at Drexel University in Philadelphia (Munger and Thomas 2003). The iconic wildflower genera *Clarkia* and *Lewisia* were named by Frederick Pursh in the expedition leaders' honor (Evans 1993).

As the exploration of the American West continued in the 19th century, the U.S. Army's role in the discovery and description of American plants and animals expanded. The establishment of the U.S. Army Corps of Topographical Engineers in 1838 contributed significantly to the Army's ability to accomplish those tasks. In addition to mapping duties and the design and construction of civil works such as lighthouses and coastal fortifications, the "Topos" were responsible for recording and documenting the natural phenomena on numerous Army expeditions in the West. Colonel John J. Abert, the commanding officer of the Corps for most of its existence, was largely responsible for recruiting and assigning qualified Corp officers (including his own son, James W. Abert) and contract civilians to participate in those expeditions (Brodhead 2000). He also established a very successful relationship with Spencer F. Baird, the first curator of the Smithsonian Institution. Baird encouraged Army officers, particularly from the Medical Corps, to collect scientific specimens during Western expeditions as well as at their permanent Western postings. Many of the significant, early contributions to the Smithsonian's natural history collections were made by such officers (Broadhead 1989).

John Charles Frémont is perhaps the best known of the military explorer-naturalists. Between 1842 and 1845 Frémont led three well-publicized Western exploring expeditions as a member of the Corps of Topographical Engineers. The first expedition explored and mapped the country from the Missouri River and the South Pass region of the Rocky Mountains. The second, more ambitious expedition mapped and described the second half of the Oregon Trail. His third expedition, in 1845, was intended to discover the source of the Arkansas River in the Rocky Mountains but, having accomplished that, Frémont continued on to California where he became involved with the early stages of Mexican–American hostilities. Frémont remained in California during the Mexican–American War and was engaged in a number of military operations while continuing to pursue his interest in California botany. Eventually Frémont resigned his Army commission and settled in California, but he led two more expeditions as a private citizen in 1848 and 1853 in an effort to determine the feasibility of building a transcontinental railroad along the 38th parallel. Entering politics, Frémont was elected as the first senator from California and an unsuccessful nominee for president in 1856. Returning to active duty at the outset of the Civil War, Frémont rose to the rank of major general. His final political activity was to serve as the Territorial Governor of Arizona from 1878 to 1881 (Harris 1990).

Frémont developed a particular interest in plants at an early age and brought that interest with him into the Corps of Topographical Engineers. As a result, he diligently collected and prepared plant specimens on many of his Western expeditions. In so doing, he discovered many plants new to science and helped to establish some of the earliest records for others. Frémont sent his plant collections to John Torrey, one of the country's preeminent botanists at the time. Torrey was himself a former Army medical officer and professor of natural sciences at the U.S. Military Academy. Torrey, often in collaboration with Asa Gray of Harvard University, eventually published botanical reports for most military exploring expeditions in the 1840s and 1850s (Brodhead 1989). A fitting

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Revealing Military Secrets *continued*

testament to Frémont's botanical diligence and dedication is the list of more than 20 plants Torrey and others named in his honor (Beidleman 2006).

William H. Emory was the most important Army Topographical Engineer to contribute to the understanding of Arizona plants. A distinguished graduate of the U.S. Military Academy, he received an excellent education in engineering and the natural sciences. After mapping assignments for the Canadian boundary survey and in Texas, he was assigned to the Army of the West during the Mexican–American War. Emory was an invaluable member of the Army of the West as it proceeded on its perilous route along the Santa Fe Trail — first to Santa Fe, then south along the Rio Grande River, then along the Gila River westward through the Sonoran Desert, and eventually into Alta California. Although his military duties were profound on this expedition, he nevertheless made numerous observations of the natural and cultural history along the way, and he is recognized as the first naturalist to traverse southwestern New Mexico and southern Arizona. His astute observations and notes about the Apaches were documented in his official reports and were the first of their kind. Emory was especially interested in the flora of the new lands he encountered, particularly the cacti. He and his assistants collected and preserved many plants on this expedition. He sent these to eminent botanists of his acquaintance — John Torrey at Columbia University, and the physician-botanist George Engelmann of St. Louis. Emory sent a large collection of cacti to Engelmann, which Engelmann thoroughly reviewed and analyzed. Engelmann's analyses resulted in the recognition and description of 15 new species, two of which he named in Emory's honor (*Echinocactus emoryi* and *Grusonia emoryi*) (Norris et al. 1998).

Emory was to play yet another major role in the American settlement of the Southwest while overseeing the work of the Mexican–United States Boundary Commission, which was established under the terms of the Treaty of Guadalupe Hidalgo following the Mexican–American War. The task of the commission was to set, survey, and mark the boundary between Mexico and the United States. Hampered by incredible political wrangling, logistical and funding shortages, and physical hardships, Emory nevertheless was able to successfully complete the work of the survey in October 1855 and a subsequent survey of the lands acquired from Mexico through the Gadsden Purchase (1854–57). During these border surveys, Emory continued to collect plant specimens and to make other natural and cultural records. These were meticulously recorded in his official reports. Emory went on to serve with distinction in the Civil War and retired from the Army in the grade of major general in 1876 (Norris et al. 1998).

The evolution of natural resources management on military lands in the 20th century is an interesting story of success. Following the transfer of millions of acres of public land for military training during preparations for World War II, the military services formally started the implementation of land-management programs. The earliest efforts involved developing measures to control erosion, dust, and general land degradation caused by heavy mechanized vehicles. During this period the military hired professional agronomists and foresters and entered into cooperative assistance agreements with the Soil Conservation Service. Following World War II, natural resources programs on military lands were expanded to include outdoor recreational programs (such as hunting and fishing), commercial forestry, and agricultural out-leasing. With the enactment of the many landmark environmental laws in the 1960s and 1970s (e.g. Endangered Species, Act, Clean Water Act, National Environmental Policy Act, Marine Mammal Protection Act, etc.) the military was required to expand its natural resources programs to ensure compliance with those laws. The Sikes Act (16 USC 670a-670o, 74 Stat. 1052), was enacted into United States law on September 15, 1960. This important law mandated that the DoD cooperate with the Department of the Interior and with state agencies in the planning, development, and maintenance of fish and wildlife resources on U. S. military reservations. Although initially addressing mainly wildlife programs, the Sikes Act has since been amended a number of times. Today it requires that

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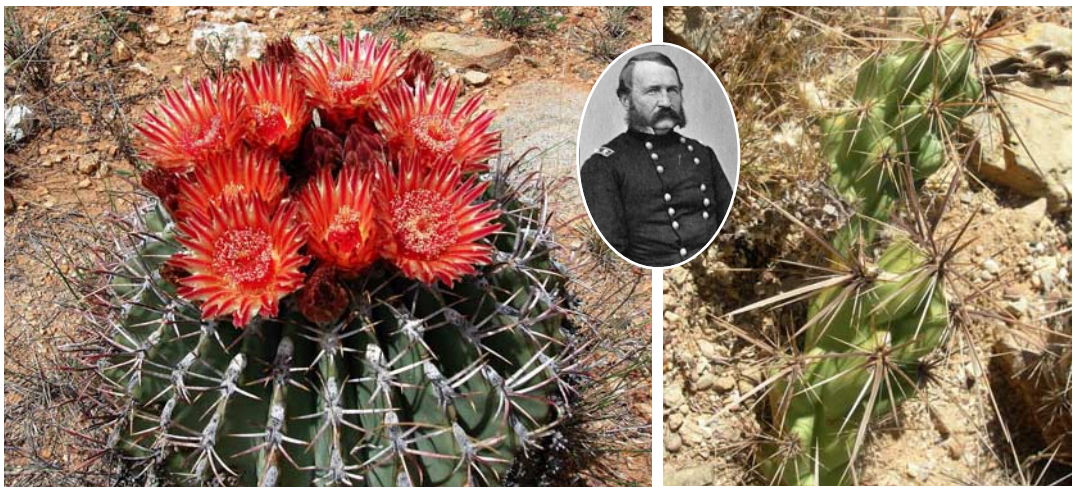


Left: Emory Barrel Cactus (*Ferocactus emoryi*). *Photo courtesy John Durham.*

Inset: Major General William H. Emory, USA .

Right: Devil's Club Cholla (*Grusonia emoryi*). *Photo courtesy Ries Lindley.*

Revealing Military Secrets *continued*

comprehensive natural resources management programs are implemented on military lands. A key requirement is that all military installations with sufficient natural resources develop and implement an Integrated Natural Resources Management Plan (INRMP). The INRMP, which must be periodically reviewed and updated, is developed in cooperation with the U.S. Fish and Wildlife Service and the individual state game and fish agency and must include an Environmental Assessment with the opportunity for public comment. To support the preparation of INRMPs, the DoD began in the 1980s a program to inventory and document all lands for threatened, endangered, and sensitive (TES) species, as well as for environmentally sensitive habitats such as wetlands. Working with installation biologists, cooperating environmental organizations such as NatureServe and State Heritage offices, and environmental consulting firms, the DoD has completed natural resources inventories on approximately 420 large (greater than 500 acres) military installations. Those inventory data are important in the planning for future construction and training activities because they help the military to avoid impacts to TES species and sensitive habitats. The data also help direct future conservation programs. Interestingly, the approximately 25 million acres of DoD land contain the highest density of TES species of any other federal land management agency (Stein 2008 and NatureServe 2015). The DoD is responsible for managing and protecting approximately 400 federally listed threatened or endangered species on its lands (DoD Natural Resources Program 2015).

In the 1990s the DoD began to mandate a strategy of ecosystem management on its lands. The goal of this approach is to maintain and improve the sustainability and native biological diversity of terrestrial and aquatic (including marine) ecosystems while supporting the DoD mission. The policy states that military installations will use ecosystem management to: (1) restore and maintain ecological associations that are of local and regional importance and compatible with existing geophysical components (e.g., soil, water); (2) restore and maintain biological diversity; (3) restore and maintain ecological processes, structures, and functions; (4) adapt to changing conditions; (5) manage for viable populations; and (6) maintain ecologically appropriate perspectives of time and space (Benton, et. al 2008). These principles now are the foundation for natural resources management programs developed in INRMPs. On a larger scale, the DoD has engaged in ecoregional partnerships to enhance biodiversity conservation on its larger installations and ranges. In the late 1990s, the U.S. Air Force partnered with The Nature Conservancy of Arizona, the Sonoran Institute, and the Government of Mexico for the conservation of biological diversity in the Sonoran Ecoregion. That effort involved the development of comprehensive maps and databases of the region's biological diversity. The maps and databases, along with the facilitation of numerous planning and strategy meetings, resulted in a characterization of the Sonoran ecoregional biodiversity that was of particular value in helping to prioritize areas for conservation action. This work also helped in planning future military operations so as to minimize negative impacts on the environment (Ripley et. al 2000).

For more than two centuries, the U.S. military has been involved with the discovery, conservation, and management of biological resources in our country. I hope that the articles that follow, which describe the physical characteristics, important natural features, and current conservation programs of the seven major Arizona military installations, will effectively illustrate the environmental importance of military lands in Arizona.

References

Ambrose, S.E. 1996. Undaunted courage: Meriwether Lewis, Thomas Jefferson, and the opening of the American West. Simon and Schuster, New York. 521 pp.

Beidleman, R.G. 2006. California's frontier naturalists. University of California Press, Berkeley, CA. 484 pp.

Benton, N., J.D. Ripley, and F. Powledge (Eds.). 2008. Conserving biodiversity on military lands: A guide for natural resources managers. Available at: http://**dodbiodiversity.org**. NatureServe, Arlington, VA. 220 pp.

Brodhead, M.J. 1989. Contributions of medical officers of the regular Army to natural history in the pre-Civil War era. *In*: History and Humanities: Essays in Honor of Wilbur S. Shepperson. Francis X. Hartigan (Ed.), University of Nevada Press, Reno, NV.

Brodhead, M.J. 2000. James W. Abert: Soldier, explorer, and naturalist. The Journal of America's Military Past. XXVII(1) 65-75.

DoD Natural Resources Program. 2015. Available at: http://**www.dodnaturalresources.net**

Evans, H.E.. 1993. Pioneer naturalists: The discovery and naming of North American plants and animals. Henry Holt and Company, New York, NY. 294 pp.

Harris, E.D. 1990. John Charles Frémont and the great western reconnaissance. Chelsea House Publishers, New York. 112 pp.

Munger, S.H. and C.S. Thomas. 2003. Common to this country: Botanical discoveries of Lewis and Clark. Artisan, New York. 128 pp.

NatureServe. 2015. Species at risk on Department of Defense lands: Updated analysis, report, and maps. NatureServe, Arlington, VA.

Norris, L.D., J.C. Milligan, and O.B. Faulk. 1998. William H. Emory: Soldier-scientist. The University of Arizona Press, Tucson, AZ. 354 pp.

Ripley, J.D., T.H. Lillie, S.E. Cornelius, and R.M. Marshall. 2000. The U.S. Department of Defense embraces biodiversity conservation through ecoregional partnerships in the Sonoran Desert. Diversity 15(4) 3-5.

Stein, B.A. 2008. Federal lands and endangered species: The role of military and other federal lands in sustaining biodiversity. BioScience 58(4): 339-347.

Remembering Daniel Frank Austin, *Mr. Morning Glory*

(18 May 1943 — 20 January 2015)

by Richard Felger, Herbarium, University of Arizona, Tucson, Arizona

I was privileged to know Mr. Morning Glory even before he and Sandy permanently migrated from the wet tropics of Florida to Arizona. Like so many others, I came to admire Dan and we co-authored several botanical publications.

Sandra "Sandy" K. Roderick and Dan married in 1967 and shared 47 years of adventure, educating, and service to the environment and science. Dan obtained his Ph.D. from Washington University in 1970 working—you guessed it—on a large group of Convolvulaceae, the Morning Glory family. Dan and Sandy settled in Boca Raton, Florida, and had stellar academic careers inspiring and mentoring a cadre of students; Dan at Florida Atlantic University and Sandy at Broward Community College.

Dan and Sandy pioneered ecological education and environmental conservation in southern Florida long before it became a popular cause. In 2001, after 31 years on the faculty, Dan took an early retirement from Florida Atlantic University due in part to conflict with the administration's plans to build an athletic facility on an ecological reserve established by Dan and his associates. Sandy and Dan moved to Arizona, and of course, far from retiring, Dan ramped up his publishing. Mr. Morning Glory became deeply involved in Arizona and the Sonoran Desert, all the while keeping up an amazing international career and associating with the University of Arizona Herbarium and the Arizona-Sonora Desert Museum.

June 6, 2015: Sandy Austin wrote, "During the 1989–90 school year Dan had a sabbatical at ASU in Tempe. He was revising Convolvulaceae for the *Flora of Arizona* in the fall and team-teaching a course at ASU in the spring. That sabbatical was our trial year to see if we really wanted to move to the southwest when we retired." It was during that time I had the privilege to meet Dan and Sandy in Tucson.

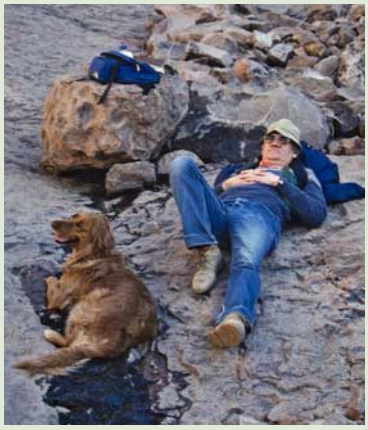
Sandy and Dan settled in the south end of the Avra Valley, looking westward towards the Baboquivari Mountains, which led to Dan's most recent book, *Baboquivari Mountain Plants* (2010), with a heavy dose of ethnobotany.

Among his 300 publications, more than 100 are on convolvs, a plant family of over 1,600 species. He covered the Morning Glory family in floras of places as diverse as Ceylon, French Guiana, Hawaii, New Mexico, Nicaragua, Sonora, and Venezuela. Even though his colleagues and other friends called him Mr. Morning Glory, his interests and publishing went far beyond that plant family. Look at his award-winning book, *Florida Ethnobotany* (2005), one of the classics in ethnobotany. This is one book that anyone interested in ethnobotany should have; the scholarship and information are deep and extend far beyond the state of Florida. I never tire of thumbing through the pages and re-reading about old friends.

For details about Dan's career, and especially pre-Arizona days, look at the tributes by George Staples (2015, *Taxon* 64 (2):403–404) and Bradley C. Bennett (2015, *Economic Botany* 69 (1):1–8).

Dan's scientific botanical publications are well known, but how many people are aware of the wide range of his "other" works? He was a great bibliophile and his decades as book review editor for *Economic Botany* helped fulfill his credo of doing what you most like (and getting paid for it, if you can).

But it was in the Morning Glory family where Dan found his glory—finding new species, deciphering hidden manuscripts, ethnobotany, evolution and systematic botany, and floras. A man of all seasons, a man of vast knowledge, a man of great generosity, loved and admired by all who knew him.



The hard-working professor and skilled field assistant, Amber, in the Superstition Mountains of Arizona, 1990. *Photo courtesy Sandy Austin.*

Here is a sampler of the breadth of his publications and subject matter:

Evolvulus alsinoides (Convolvulaceae): An American herb in the Old World. *Journal of Ethnopharmacology*, 2008.

Ipomoea aquatica, a new invasive weed from Viet Nam introductions. *Ethnobotany Research & Applications*, 2007.

Sacred connections with Cat-tail (*Typha*, Typhaceae)—Dragons, water-serpents and reed-maces. *Ethnobotany Research & Applications*, 2007. *[This publication links cat-tails to monsters, storms, diseases, and humans for over 3,000 years. Did you know Typha is linguistically related to typhoon and typhus?]*

Merremia dissecta (Convolvulaceae)—a condiment, medicine, ornamental, and weed. *Economic Botany,* 2007.

Christmas botany or how reindeer learned to fly. *The Palmetto*, 1997. *[One of my favorites.]*

Dan Austin & Don Pinkava, Uniqueness of the endangered Florida Semaphore Cactus (*Opuntia corallicola*). *Sida*, 1998.

M.C. Stewart, D.F. Austin, & G.R. Bourne, Habitat structure and the dispersion of Gopher Tortoises. *Florida Scientist*, 1993.

Garden Canyon. *Photo courtesy Doug Ripley.*

Fort Huachuca: A Treasure of Biological Diversity in Southeastern Arizona

by Sheridan Stone[1]

Fort Huachuca was established in 1877 as part of a series of fortifications to protect Southern Arizona from the Chiricahua Apaches. Occupying approximately 70,300 acres, the fort is located near the City of Sierra Vista and about 15 miles north of the U.S.–Mexican border.

Fort Huachuca has a rich and colorful history. Among the former distinguished units assigned to the Fort was the 10th Cavalry, the "Buffalo Soldiers," one of the Army's elite black cavalry corps. Over the years, the mission of Fort Huachuca has changed many times, even closing for a few years following World War II. The original "Old Post Area" was designated a National Historic Landmark in 1977 and contains many beautifully restored military buildings surrounding the original parade ground. A number of very significant archaeological sites exist on the Fort as well.

The Fort today is home to the U.S. Army Intelligence Center and the U.S. Army Network Enterprise Technology Command (NETCOM) / 9th Army Signal Command.

From a natural environmental perspective, Fort Huachuca is a national treasure. It occupies the eastern grasslands, slopes, and canyons of the Huachuca Mountains, one of Southern Arizona's most important Madrean Sky Islands. To the east, it is bordered by the BLM's San Pedro Riparian National Conservation Area; to the north, by the Whetstone Mountains; and to the south, the nearest Madrean Sky Island is Sierra San José, approximately 40 miles distant in Sonora, Mexico. Fort Huachuca is surrounded on the west by the Coronado National Forest and to the south by the National Park Service's Coronado National Memorial, along with some private land holdings, particularly on the southeastern slopes and canyons. Elevations on Fort Huachuca range from about 3,900 feet at the eastern grasslands to 8,410 feet at the highest peaks. Miller Peak is the highest peak in the Huachucas at an elevation of 9,466 ft.

Average annual precipitation at the Fort's cantonment area is approximately 17 inches but varies from less than ten inches to over 22 inches (Shaw 1999).

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[1]Installation Wildlife Biologist, U.S. Army, Environmental and Natural Resources Division, Fort Huachuca, Arizona 85613.

Fort Huachuca *continued*

Of particular biological, geological, and archeological interest on Fort Huachuca are Garden and Huachuca Canyons, which extend in an easterly direction from the higher western slopes. Garden Canyon in particular is an area of incredible biological diversity and beauty and is one of the premier wildlife viewing areas in Arizona, attracting visitors from throughout the country and abroad. At the mouth of Garden Canyon, the remains of an early village — occupied between A.D. 1,100 and 1,400 — have been systematically excavated and are listed on the National Register of Historic Places. In that general vicinity are also much older remains of pit houses and artifacts that may date to archaic times (> 10,000 B.P.) (Shaw 1999).

The Huachuca Mountains are considered the northernmost of the Madrean pine-oak woodlands, and are classified as part of the Sierra Madre Occidental pine-oak forests ecoregion, of the tropical and subtropical coniferous forests biome. Studies sponsored by the U.S. Army have identified ten distinct plant communities in Garden Canyon (Shaw 1999):

Chihuahuan Desert Scrub

Scrub Grassland

Madrean Montane Grassland/Madrean Evergreen Forest and Woodland (Encinal)

Madrean Evergreen Forest and Woodland (Encinal)

Madrean Evergreen Forest and Woodland (Pinyon-Juniper Woodland)

Interior Chaparral

Madrean Evergreen Forest and Woodland (Oak-Pine Forest)

Madrean Montane Conifer Forest

Interior Southwestern Riparian Deciduous Forest and Woodland (Mixed Broadleaf)

Madrean Riparian Deciduous Forest (Mixed Deciduous-Mixed Conifer)

Rare and sensitive species are an important component of the biota on Fort Huachuca, and they have been most extensively surveyed and monitored in Garden and Huachuca Canyons. Biological surveys at Fort Huachuca date to the late 19th century and were often conducted by U.S. Army officers such as Major Timothy E. Wilcox, a surgeon and the commanding officer of Fort Huachuca in the 1890s (Britton and Kearney 1895), or civilians employed by various government surveys such as the Mexican Boundary Survey (Mearns 1907). The famous botanical couple, John Lemmon and Sara Plummer Lemmon, collected many new plant species in Garden Canyon in the 1880s. Some of those species were named in their honor by Asa Gray at Harvard University, to whom they sent their specimens for identification. Through the years, the U.S. Army has increasingly funded detailed and specific biological surveys aimed at expanding the general knowledge of the installation and enhancing management strategies for sensitive species.

Among the most significant animal species of special interest occurring on Fort Huachuca are the Mexican spotted owl (*Strix occidentalis* ssp. *lucida*), American Peregrine falcon (*Falco peregrinus* ssp. *anatum*), Buff-breasted flycatcher (*Empidonax fulvifrons*), Elegant trogon (*Trogon elegans*), and the lesser long-nosed bat (*Leptonycteris yerbabuenae*). Numerous plant species of concern have been documented on the installation over the years. Notable species in this category include the Huachuca water umbel (*Lilaeopsis schaffneriana* ssp. *recurve*), a Federally listed threatened species; Lemmon's fleabane (*Erigeron lemmonii*), an endemic to Fort Huachuca; Lemmon's aster (*Symphyotrichum potosinum*); lemon lily (*Lilium parryi*); Plummer's spurge (*Euphorbia macropus*); Lemmon's morning glory (*Ipomoea tenuiloba* ssp. *lemmonii*); Chiricahua dock (*Rumex orthoneurus*); and Huachuca groundsel (*Senecio multidentatus* var. *huachucanus*). Today the Fort's biologists place a special emphasis on monitoring populations of listed and sensitive species and their habitats. The Fort started monitoring sensitive plants about 1990 (Warren and Reichenbacher 1991) and expanded the monitoring program as the numbers of listed species grew. Now, scientific research on plants is being conducted by collaborating biologists and geneticists from Army laboratories and universities.

Described below are three recent research projects undertaken on Fort Huachuca involving rare and sensitive plants and animals. These projects represent ongoing efforts by the U.S. Army to fulfill its responsibilities to manage the land entrusted to its care in a way that increases overall biological diversity and sustainability.

Many portions of Fort Huachuca are open to the public, including Garden and Huachuca Canyons.

References

Britton, N.L. and T.H. Kearney, Jr. 1895. An enumeration of the plants collected by T.E. Wilcox, U.S.A., and others in Southeastern Arizona (1892-1894). Transactions of the Kansas Academy of Sciences, Vol 15.

Mearns, E.A. 1907. Mammals of the Mexican boundary of the United States. U.S. Government Printing Office. U.S. National Museum Smithsonian Bulletin 56. 529 pp.

Shaw, H.G. 1999. Garden Canyon Watershed: A vision and a mission. General Wildlife Services, Chino Valley, AZ.

Warren, P.L. and F.W. Reichenbacher. 1991. Sensitive plant survey of Fort Huachuca. The Arizona Nature Conservancy, Tucson, AZ.

Lilaeopsis schaffneriana (Huachuca water umbel) in Mexico. *Photo courtesy Oswaldo Tellez.*

Recent and Ongoing Genetic Studies of the Plants of Fort Huachuca, with a Focus on Rare, Threatened, and Endangered Species

by Christine Edwards[1], Denise L. Lindsay[2], and Richard F. Lance[2]

Fort Huachuca is home to a wealth of natural resources, including several rare, threatened and endangered (RTE) plant and animal species. One important task of natural resources managers at Fort Huachuca is to protect and manage these RTE species while at the same time maintaining military readiness. Because of that, there are many ongoing research projects that aim to understand more about the biology of sensitive species so they can be managed more effectively and cost-efficiently. We are conducting research that employs genetic approaches to understand the biology of plant species, many of which are of conservation concern on Fort Huachuca. Here, we provide a brief summary of three of these projects.

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Species Boundaries in Huachuca Water Umbel

One species we are currently researching is the federally endangered Huachuca water umbel (*Lilaeopsis schaffneriana* ssp. *recurva*). *L. schaffneriana* is a submerged aquatic plant in the carrot family (Apiaceae) that comprises two subspecies: *recurva* and *schaffneriana*. Affolter (1985) described these two subspecies based on the length:width ratios of dried fruits, which demonstrate overlapping patterns of variation in the two subspecies, and an observed geographic separation of the two groups. When originally described, it was believed that ssp. *recurva* was endemic to southern Arizona, whereas subsp. *schaffneriana* was distributed in Ecuador and from Chihuahua, Mexico to central Mexico. Since then, populations of ssp. *recurva* were discovered in Sonora, Mexico. Since the two subspecies are now known to occupy neighboring Mexican

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Left: Lemon Lily (*Lilium parryi*) in Garden Canyon. *Photo courtesy Sheridan Stone.*

Center: Lemmon Fleabane (*Erigeron lemmonii*) in Garden Canyon. *Photo courtesy Sheridan Stone.*

Above: Lesser long-nosed bat with pollen on its muzzle. *Photo courtesy Denise Lindsay.*

Genetic Studies *continued*

states, they have an essentially continuous distribution. Because little separation exists either geographically or morphologically between the two subspecies, the current subspecies classification may not accurately reflect patterns of natural variation. This is supported by a recent phylogeny of the genus (Bone et al. 2011), which found that ssp. *recurva* from Arizona and ssp. *schaffneriana* from Mexico have identical DNA sequences for two DNA regions.

The goal of the current project is to gather additional DNA evidence to clarify whether *L. schaffneriana* ssp. *recurva*, which has critical habitat on Fort Huachuca, is indeed a unique subspecies. We sampled populations of *L. schaffneriana* throughout its range in Arizona, Mexico, and Ecuador; extracted DNA; and are currently genotyping individuals using next-generation DNA sequencing technology. The data will be analyzed to determine the extent to which patterns of genetic differentiation agree with the current circumscription of the subspecies as described by Affolter (1985). The results of this study will clarify whether this endangered subspecies is accurately considered to be unique and endangered, thereby ensuring that conservation efforts are dedicated to a species that truly merits protection. The protocols developed in this project can also be used to quickly clarify the status of other taxonomically questionable species.

Levels of Genetic Diversity in the Rare Species, *Erigeron lemmonii*

Another study focused on the population genetics of *Erigeron lemmonii* (Edwards et al. 2014), which is a perennial plant that occurs in a single population located in Scheelite Canyon on Fort Huachuca (Nesom 2006). *E. lemmonii* is extremely rare; the size of the single population size is estimated to be fewer than 1,000 individuals (Malusa 2006). Although not federally listed, *E. lemmonii* is the target of ongoing conservation and management efforts by multiple partners, including the U.S. Army, which is the responsible land management agency. In this study, we compared genetic diversity and population genetic structure in *E. lemmonii* to those of a widespread congener, *E. arisolius.* The goals of this study were to assess whether rarity and small population size have negatively affected genetic diversity in *E. lemmonii* and to identify genetic threats to the persistence of the species. Genetic results indicate that both species are highly outcrossing and may be self-incompatible. Patterns of genetic structure in both species indicated widespread gene flow. Genetic diversity in *E. lemmonii* was approximately 60% of that found in *E. arisolius*. Because we found no evidence for inbreeding or a genetic bottleneck in *E. lemmonii*, it is likely that the species' lower genetic diversity is the result of genetic drift arising from small effective population size. Because *E. lemmonii* exists in a single population, no other populations exist to bolster the population in the event of declines. Thus, we suggest conservation efforts should focus on seed collection from as many individuals as possible, to protect against possible future losses of genetic diversity. We also recommend continued monitoring of both population size and genetic diversity in *E. lemmonii*.

Understanding Plants Utilized by Nectar-feeding Bats using DNA Metabarcoding

Another ongoing project employs a relatively new approach (DNA metabarcoding) to understand the diversity of plants utilized by nectivorous bats on Fort Huachuca. DNA metabarcoding, which has been employed rarely in plants, combines the use of barcode genes (i.e., DNA regions that are unique to different taxonomic groups) and next-generation DNA sequencing to identify the species occurring in a sample.

continued next page

Genetic Studies

continued

Palmer's agave at Fort Huachuca. *Photo courtesy Denise Lindsay.*

We collected samples of bat guano and swabbed pollen from muzzles and shoulders of Mexican long-tongued bats (*Choeronycteris mexicana*) and endangered lesser long-nosed bats (*Leptonycteris curasoae*) in southeastern Arizona. Each muzzle and guano sample was divided in half; plant diversity was quantified in one half, using standard visual identification of pollen (microscopy), and diversity in the other half, using DNA metabarcoding. DNA metabarcoding for each sample was conducted using PCR (polymerase chain reaction) amplification of three plant chloroplast DNA barcodes (*rbcL*, *psbA-trnH*, and *trnL-F*), followed by next-generation DNA sequencing. To identify the diversity of plant species, DNA barcode sequences from our samples were compared to sequences of potential food plants and to sequences archived in the National Center for Biotechnology Information GenBank database. Visual identification found that 99.6% of pollen from bats was *Agave*, which is the main food source utilized by nectivorous bats in this region. DNA metabarcoding likewise found that *Agave* is the most predominant genus in the samples, but also found a broader diversity of plant species, indicating that it has increased sensitivity to detect plants that may be utilized less frequently by these bats. The ecological significance of these additional plant species is unknown.

Also, results from muzzle and guano samples differed. Plant species identified from muzzle samples, which were composed almost solely of pollen, were similar to those found in visual analysis (i.e., predominantly *Agave*, with some *Yucca*). In contrast, guano samples had very different estimates of diversity; this discrepancy likely arose from using chloroplast genes for metabarcoding, in combination with bats eating some foods, such as fruit, that have higher densities of chloroplasts than pollen/nectar, such that these non-nectar foods were represented by a greater number of DNA sequences in guano samples. These results demonstrate that metabarcoding may be a powerful tool for understanding species interactions, but that care in the selection of DNA markers and in data interpretation are recommended to ensure the accuracy of results.

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References

Affolter, J.M.D. 1985. A monograph of the Genus *Lilaeopsis* (Umbelliferae). Systematic Botany Monographs 6: 1-140.

Bone, T.S., S.R. Downie, J.M. Affolter and K. Spalik. 2011. A phylogenetic and biogeographic study of the Genus *Lilaeopsis* (Apiaceae tribe Oenantheae). Systematic Botany 36: 789-805.

Edwards, C.E., D.L. Lindsay, P. Bailey, and R.F. Lance. 2014. Patterns of genetic diversity in the rare *Erigeron lemmonii* and comparison with its more widespread congener, *Erigeron arisolius* (Asteraceae). Conservation Genetics 15: 419-428.

Malusa, J. 2006. Surveys and monitoring plots of the Lemmon's fleabane, *Erigeron lemmonii,* in the Huachuca Mts, Arizona. A report to the United States Fish and Wildlife Service, the University of Arizona and the Arizona Department of Agriculture.

Nesom, G. 2006. *Erigeron lemmonii*. In: Flora of North America Editorial Committee (eds.), Flora of North America North of Mexico. 16+ vols., 342, New York and Oxford.

Surveys of Saguaro (*Carnegia gigantea*) on the Florence Military Reservation, Arizona

by Shelley Danzer[1] and Janet Johnson[2]

The mission of the U.S. military is to sustain military readiness and national security. Protecting and enhancing the lands upon which the military trains are critically dependent parts of this mission. In Arizona, the Natural Resources Program at the Arizona Army National Guard (AZARNG), is an integral part of managing training land and providing for the conservation and rehabilitation of natural resources in support of the military mission.

Located just north of the town of Florence, the Florence Military Reservation (FMR) was established in 1912 by Executive Order 1633 for the development of a military rifle range. By 1944, a portion of FMR was set aside as a prisoner-of-war (POW) camp and housed 13,000 prisoners between 1944 and 1945. Today FMR is the primary desert training installation for the Arizona National Guard. FMR encompasses approximately 19,000 acres that include both federal and state owned properties as well as lease lands held by the Bureau of Land Management and the Arizona State Land Department. Vegetative characteristics of FMR are predominately Sonoran Desert Scrub with both Arizona Upland and Lower Colorado River Valley subdivisions.

An iconic keystone species of the Sonoran Desert (Fleming 2002), the saguaro (*Carnegiea gigantea*), is a dominant species within the primary federal training areas and small arms complex of FMR. As part of a general biological survey of the FMR, the AZARNG Natural Resources Manager identified an area containing an especially high concentration of saguaros. Recognizing the significance of these saguaro populations, the AZARNG contracted with the Arizona Game and Fish Department (AZGFD) between 2006 and 2010 to inventory and map the saguaros at the FMR to determine the distribution and health of the populations and to identify potential affects to saguaros as a result of military training (Stingelin et al. 2011). This inventory provided an exceptional database that allowed many additional variables to be analyzed, including saguaro age; structure based on height (Danzer and Drezner 2010); condition of individuals based on percent epidermal browning, damage due to fire, lightning, and trunk girdling (Danzer and Drezner 2014 and Stingelin et al. 2011); and utilization by cavity-nesting birds during breeding season (Abbate and Grandmaison 2012). Physical location (UTM coordinates) and multiple variables were collected on each of 20,919 individual saguaro plants by systematically walking 50m-wide belt transects in each of nine training areas. Specific methodology for data collection can be found in Stingelin et al. (2011).

Even though the saguaro is an important species, basic information about plant demographics, including number of individuals and population fluctuations, has been lacking outside of well-documented areas with historical data. Saguaros do not produce annual growth rings but height can be used to estimate their age. Several studies that determined saguaro age have been conducted, but the results were site-specific (e.g., Hastings and Alcorn 1961, Niering et al. 1963, Steenbergh and Lowe 1983, Goldberg and Turner 1986) and rely on long-term data.

Drezner (2003) developed a technique to estimate individual saguaro age without long-term data. This technique was applied to 12,000 individuals in the FMR population. Results of this study were compared to other local populations and regional relationships were analyzed. Two clear periods of favorable regeneration were seen across the study site, with peaks of growth in the 1920s and the 1970s. These peaks were positively correlated to previously sampled sites in Arizona, Silverbell, and Harcuvar (Drezner 2006). Several other studies (Parker 1993, Pierson and Turner 1998) noted higher regeneration during the 1910s to 1920s and attributed it to wetter conditions. Drezner (2005) shows an increase in growth rate in conjunction to the east-west precipitation gradient across the Sonoran Desert, with the fastest-growing individuals in eastern populations and slower growth in western populations.

Of the 20,929 (total) saguaros surveyed, 92% were live and 8% were dead, with the highest percentage of dead saguaros in the in the Small Arms Range Complex, adjacent to the Impact Area, possibly due to military training activities or as a result of fire (Stingelin et al. 2011). Saguaro densities were highest in areas with more rugged terrain and coarser-textured soils. This has been noted in other studies (Niering et al. 1963), and may be attributed to higher available moisture and a higher density of trees and shrubs, which serve as nurse plants for saguaro seedlings (Warren et al. 1981).

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Inset: Large mature saguaro with an active Great Horned Owl nest. *Photo courtesy AZ Army National Guard.*

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Surveys of Saguaro *continued*

Saguaros provide nesting and roosting sites in an area where trees may be limited (Abbate and Grandmaison 2012). Of the saguaros inventoried on FMR, 19.5% contained cavities considered suitable for nesting. A majority of these (85%) contained multiple cavities. The Gilded Flicker (*Colaptes chrysoides*) and the Gila Woodpecker (*Melanerpes uropygialis*) are the primary cavity excavators in saguaro, but the cavities are used by a variety of other birds, including House Finch (*Haemorhous mexicanus*), Ash-throated Flycatcher (*Myiarchus cinerascens*), American Kestrel (*Falco sparverius*), Purple Martin (*Progne subis*), and Elf Owl (*Micrathene whitneyi*) (Corman and Wise-Gervais 2005). Cavities may also provide perches for hunting, singing and territorial calling; concealment from mobbing or predators, heat and rain, and serve as diurnal or nocturnal roosts. Analysis by Abbate and Grandmaison (2012) and by Danzer and Drezner (2014) suggest that occupancy by cavity-nesting birds decreased with increasing saguaro height and that probability of saguaro occupancy increased with the number of cavities per saguaro.

The majority of saguaros included in the 2014 analysis by Danzer and Drezner were estimated to be in good condition, with

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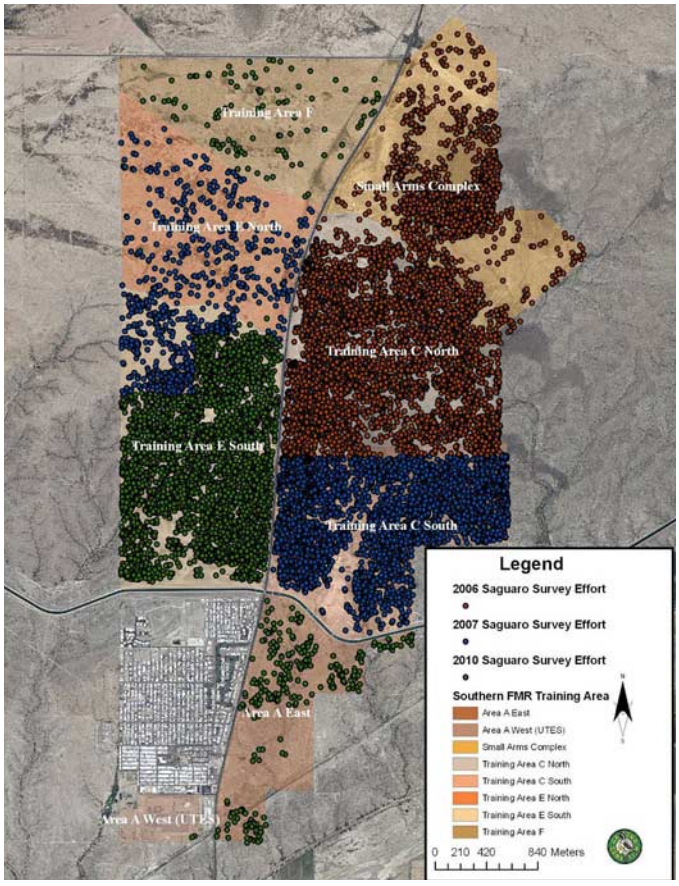

Saguaro inventory and mapping effort completed in 2006, 2007, and 2010 on the Florence Military Reservation, Pinal County, Arizona.

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Surveys of Saguaro *continued*

epidermal browning evenly represented across size classes above 0.9m (Danzer and Drezner 2014). While it is suggested that solar radiation is the primary cause of epidermal browning (Evans et al. 2001), other factors, such as girdling, lightning strikes, presence of bird cavities, and gunshot wounds may hasten the browning process. Damage tends to increase with plant height, but a taller plant is an older plant, which can sustain more damage.

This study provided valuable information on the resident saguaro populations at the FMR which will help inform and direct the long-term management of the installation.

References

Abbate, D. and D.D. Grandmaison. 2012. Evaluation of saguaro cactus (*Carnegiea gigantea*) occupancy, cavity characteristics, and suitability as nesting substrate on the Florence Military Reservation, Pinal county, Arizona. Arizona Game and Fish Department, Wildlife Contracts Branch, Phoenix, AZ.

Corman, T.E. and C. Wise-Gervais (eds.). 2005. The Arizona breeding bird atlas. University of New Mexico Press. Albuquerque.

Drezner, T.D. 2003. Saguaro (*Carnegiea gigantea*, Cactaceae) age-height relationships and growth: the development of a general growth curve. American Journal of Botany 90: 911-914.

Drezner, T.D. 2005. Saguaro (*Carnegiea gigantea*, Cactaceae) growth rate over its American range and the link to summer precipitation. Southwest Naturalist 50: 65-68.

Drezner, T.D. 2006. Regeneration of *Carnegiea gigantea* (Cactaceae) since 1850 in three populations in the northern Sonoran Desert. Acta Oecol. 29: 178-186.

Danzer, S. and T. D. Drezner. 2010. Demographics of more than 12,000 individuals of a keystone species in the northern Sonoran desert since the mid-1800s. International Journal of Plant Science. 171(5): 538-546.

Danzer, S. and T.D. Drezner. 2014. Relationships between epidermal browning, girdling, damage, and bird cavities in a military restricted database of 12,000+ plants of the keystone *Carnegiea gigantea* in the northern Sonoran desert. Madroño, Vol. 61, No. 1, pp. 115-125.

Evans, L.S., J.H. Sullivan, and M. Lim. 2001. Initial effects of UV-B radiation on stem surfaces of *Stenocereus thurberi* (organ pipe cacti). Environmental and Experimental Botany. 46: 181-187.

Fleming, T.H. 2002. Pollination biology of four species of Sonoran desert columnar cacti. Pages 207-224 in T.H. Fleming, A. Valiente-Banuet, eds. Columnar cacti and their mutualists. University of Arizona Press, Tucson.

Goldberg, D.E., and R.M. Turner. 1986. Vegetation change and plant demography in permanent plots in the Sonoran Desert. Ecology 67: 695-712.

Hastings, J.R., and S.M. Alcorn. 1961. Physical determinations of growth and age in the giant cactus. Journal Arizona Academy of Science 2: 32-29.

Niering, W.A., R.H. Whittaker, and C.H. Lowe. 1963. The saguaro: a population in relation to environment. Science 142: 15-23.

Parker, K.C. 1993. Climatic effects on regeneration trends for two columnar cacti in the northern Sonoran Desert. Ann Assoc. American Geographers. 83: 452-474.

Pierson, E.A., and R.M. Turner. 1998. An 85-year study of saguaro (*Carnegiea gigantea*) demography. Ecology 79: 2676-2693.

Steenbergh, W.F., and C.H. Lowe. 1983. Ecology of the saguaro. III. Growth and demography. National Park Service Science Monograph Ser. 17. National Park Service, Washington, D.C.

Stingelin, A.M., D.J., Abbate, S.F. Lowery, and M.F. Ingraldi. 2011. Saguaro cactus (*Carnegiea gigantea*) inventory and mapping on the Florence Military Reservation, Pinal County, Arizona: final report. Arizona Game and Fish Department, Research Branch, Phoenix, AZ.

Warren, P., K. Mortenson, B.D. Treadwell, J.E. Bowers, and K.L. Reichardt. 1981. Vegetation of Organ Pipe Cactus National Monument. Technical Report No. 8. Tucson, AZ: Cooperative National Park Resources Studies Unit, University of Arizona.

Inset: AZGFD biologist Dennis Abbate uses a fiber-optic camera to survey saguaro cavities for active nests on Florence Military Reservation in 2012. *Photo courtesy AZ Army National Guard.*

Emory oak in western foothills of the Dragoon Mountains, Cochise County. *Photos courtesy Doug Ripley.*

SPOTLIGHT ON A NATIVE PLANT *by Douglas Ripley, Arizona Native Plant Society, Cochise Chapter*

Emory Oak (*Quercus emoryi*)

In keeping with the theme of this issue of *The Plant Press*, we selected for the Spotlight on a Native Plant feature a species that was discovered by U.S. Army officer William H. Emory. Perhaps the most common of the 12 oaks occurring in Arizona, the Emory oak may occur as a shrub but more typically it forms a handsome tree with heights as much as 40 feet or more. It has the potential for long life and individual trees have been aged up to 350 years old. The species can be easily distinguished by its 1–3.5" oblong, pinnately veined, shiny leaves with spines at the margins. The acorns, often referred to by the Spanish name "bellotas," mature in one year and are an important food source for many species of wildlife, including migratory and non-migratory birds and small mammals. Raw Emory oak acorns are sweet, edible, and are sometimes gathered for commercial markets. They were used by Native Americans for flour and meal. The foliage of the Emory oak is also a larval food for a number of butterflies, including Poling's hairstreak, Ares metalmark, Dull firetip, and Arizona sister. The wood is close-grained, heavy, strong, and brittle but is of little commercial use beyond firewood. The tree flowers in the spring, often producing a dramatic display of golden catkins. Although the species is classified as "evergreen," it may display deciduous characteristics by dropping most or all of its leaves in periods of drought (usually in May–June) to reduce water demand. For that reason, the tree is better described as "drought deciduous."

The Emory oak's range extends from central Arizona eastward through southern New Mexico into western Texas, and in northern Mexico from Chihuahua west to Sonora and south to Durango. Its elevation range is from 3,000 to 8,000 feet and it occurs in many communities ranging from pine-oak, Madrean evergreen and open oak woodlands to interior chaparral, semidesert grasslands, and savannas. It is the most abundant oak in the border region.

The eminent botanist John Torrey of Columbia University described this species and named it in honor of William H. Emory who collected it in October 1846 near what is now the town of Truth or Consequences, Sierra County, New Mexico. Emory was a soldier-scientist attached to the Army of the West on its march to California.

Davis–Monthan Air Force Base, Arizona: Stewards of Natural Resources *by Kevin Wakefield*[1]

The Department of Defense (DoD) requires each U.S. military installation with sufficient natural resources to prepare and implement an Integrated Natural Resources Management Plan (INRMP). In the U.S. Air Force, the requirement for the INRMP is identified in Air Force Instruction 32-7064, dated 18 Nov 2014. The INRMP identifies the natural resources management goals and objectives that are consistent with the military mission, and it ensures there is no net loss in the capability of installation lands to support the military mission. At Davis-Monthan Air Force Base (DMAFB), the current INRMP was developed in 2011 and received final approval for implementation, in accordance with the Sikes Act, when the document was signed in 2012 by the Wing Commander, the Regional Director of the U.S. Fish and Wildlife Service, and the Director of Arizona Game and Fish Department.

DMAFB INRMP

The DMAFB INRMP identified the goals and objectives for the management of the lands controlled by the base. The base consists of approximately 10,587 acres, plus several outlying areas controlled by the base. The goals for the INRMP are reviewed yearly in a joint meeting between the base, USFWS, and AZGF department. If needed, the goals and objective can be changed to reflect changes to the environment.

Surveys

To help meet our goals and objectives, the base has contracted with AZGF to conduct surveys on the installation. In FY 2014, four surveys were conducted, each relating to the goals identified in the INRMP. One survey, titled "Planning Level Survey for Invasive and Noxious Plants," was conducted to identify and map the invasive/noxious plants found on the base. This occurred between 19 April and 10 September 2014. During the survey, six target species were discovered and mapped; they included buffelgrass (*Pennisetum ciliare*), fountain grass (*P. setaceum*), Johnson grass (*Sorghum halepense*), Sahara mustard (*Brassica tounefortii*), Malta starthistle (*Centaurea melitensis*), and Russian thistle (*Salsola tragus*). Data from this survey are being used to plan herbicide application and mechanical removal of these species. Included with the survey was the initiation of the first phase of a mechanical removal of buffelgrass from several locations on the base. This work was performed through a cooperative agreement with the Arizona Conservation Corps (AZCC).

Another survey, "Vegetation Classification and Mapping," was conducted to develop a baseline determination of the vegetation communities on the base. The results of the survey identified three biomes, one subdivision, five series, and 10 associations. Table 1 shows the DMAFB vegetation classification revealed in this survey.

Other surveys conducted on the base identified the baseline bird populations found during different seasons. This information provides useful avian occurrence data but is also vital to safeguard the military air operations and is used by the base Bird/Wildlife Aircraft Strike Hazards program to conduct daily briefings to aircrews on the status of bird hazards on the airfield and the immediate surrounding area.

A burrowing owl nesting survey was also conducted to determine the number of

continued next page

Inset: Burrowing owl at DMAFB. *Photo courtesy Kevin Wakefield.*

Table 1. DMAFB Vegetation Classification. (Singelin 2015)

VEGETATION: UPLAND
FORMATION: DESERTLAND
BIOME: SONORAN DESERTSCRUB
SUBDIVISION: Arizona Upland
SERIES: Creosotebush
Association: *L. tridentata*
Association: *L. tridentata–C.fulgida*
Association: *L. tridentata*–A.deltoidea
Association: *L. tridentata*–mixed cacti
Association: *L. tridentata*–mixed scrub–mixed cacti
SERIES: Prickly Pear–Cholla
Association: *O. engelmannii–C.fulgida*–mixed scrub (low density)
Association: *O. engelmannii–C.fulgida*–mixed scrub–mixed cacti
SERIES: Paloverde–Mixed Cacti
Association: *P. microphylla–L.tridentata*–mixed cacti
SERIES: Mixed Overstory–Mixed Scrub
Association: Mixed overstory–mixed scrub
SERIES: Mixed Scrub
Association: Mixed scrub (low density)
VEGETATION: WETLAND
FORMATION: SWAMP–SCRUB, RIPARIAN SCRUB
BIOME: SONORAN RIPARIAN SCRUBLAND
BIOME: SONORAN INTERIOR STRAND

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Left: Boyce Thompson hedgehog cactus (*Echincereus boyce-thompsonii*) at former Titan II missile site, Waterman Mountains.
Right: Former Titan II missile site, Waterman Mountains. *Photos courtesy Kevin Wakefield.*

Davis–Monthan AFB *continued*

owls and to map the location of active burrows found on the base. The information can be used to determine whether burrows need to be moved for safety reasons.

Other Lands Controlled by the Base

DMAFB also is responsible for several outlying areas, one being a decommissioned Titan II Missile Silo located to the Northwest of the base near the Waterman Mountains. The Air Force and the base are in the process of returning this 300-acre property to the Bureau of Land Management (BLM) from which it was obtained in the 1960s. As part of this process, the base conducted an Environmental Baseline Survey to determine the current status of the site. Of particular botanical interest from the survey were the identification of a number of cacti species, including Boyce Thompson Hedgehog cactus (*Echincereus boyce-thompsonii)*, the Nichol's hedgehog cactus or golden hedgehog cactus (*E. nicholii*), the Common fishhook (*Mammillaria tetrancistra*), Saguaro cactus (*Carnegia gigantia*), and the Federally listed endangered Nichol Turk's head cactus (*E. horizonthalonius* var. *nicholii*). These occurrences data were shared with the BLM.

Undeveloped airfield buffer zone at Davis–Monthan AFB. *Photo courtesy Douglas Ripley.*

Conclusion

Davis–Monthan Air Force Base takes its responsibilities to protect the natural resources under its control seriously and will continue to work with local stakeholders to continue its conservation program. The INRMP is a living document that was designed to be changed as situations in the environment and the military mission change. The base will continue to work closely with the Arizona Game and Fish Department and the U.S. Fish and Wildlife to implement their recommendations and changes to the goals and objectives found in the INRMP.

References

Abbate, D.J., C. Hofer, and S.F. Lowery. 2014. Planning level survey for invasive and noxious plants on Davis–Monthan Air Force Base Tucson, Arizona. Arizona Game and Fish Department Wildlife Contract Branch. Phoenix, Arizona.

Air Force Instruction 32-7064. 2014. Integrated natual resources management. United States Air Force, Washington, DC.

Singelin, A.M. 2015. Vegetation classification and mapping of the Davis–Monthan Air Force Base, Pima Country, Arizona. Airzona Game and Fish Department, Wildlife Contract Branch, Phoenix. Arizona.

The Barry M. Goldwater Range (West) *by Abigail S. Rosenberg*[1]

The Barry M. Goldwater Range (BMGR) is a major U.S. military installation in southwestern Arizona located in portions of Yuma, Maricopa, and Pima counties. It encompasses 1,733,921 acres and was first established through public land withdrawal in 1941 to provide gunnery training for pilots during World War II. The BMGR is recognized as a nationally significant landholding, as it is the largest continuous tract of relatively unfragmented Sonoran Desert in the United States. The ecological integrity of the BMGR has been maintained over the past 60 years because most land uses, such as development, grazing, and mineral extraction which are known to have negative ecological effects, are excluded from the range in order to effectively carry out military training operations. Given that the mission predominantly uses the airspace, its actual surface disturbance footprint is extremely small.

While Federal agency responsibility for natural and cultural resources management has varied over the years, primary surface management responsibility of the BMGR West has been assigned to the Commanding Officer of the Marine Corps Air Station (MCAS) Yuma. Land management responsibility for the BMGR East has been assigned to the Commander of the 56th Fighter Wing at Luke Air Force Base. Thus, these installations provide local command and control on a daily basis for military operations, public access and use, and resources management activities for their respective portions of the BMGR. MCAS Yuma also manages and operates Chocolate Mountain Aerial Gunnery Range (CMAGR) that is located in Imperial and Riverside counties in southeastern California. MCAS Yuma again has a unique role in that it operates under the differing regulatory constructs of two states, Arizona and California, and the three counties of Imperial, Riverside, and Yuma.

Military Mission & History of Marine Corps Air Station Yuma and its Gunnery Ranges

MCAS Yuma is headquartered at Yuma. It operates the airspace over the U.S. Army Yuma Proving Ground, numerous satellite sites, military operating areas, and military training routes. All told, MCAS Yuma offers 10,000 square miles of special-use airspace designated for military aviation training and occupies almost 2,000 square miles of underlying land.

MCAS Yuma traces its origins to 1928, when Fly Field was built near Yuma to accommodate growing demand for air travel. The facility was expanded as the Yuma Army Air Base during World War II, serving as one of the busiest flight schools in the nation. Following the war, it was briefly Vincent Air Force Base under the newly formed U.S. Air Force before transferring to the Department of the Navy (DoN) in 1959 as MCAS Yuma.

The CMAGR supports training by units within the Department of the Navy, U.S. Air Force, U.S. Army, U.S. Reserve Components, and U.S. National Guard; however, the USMC is the primary user of this Range. In total, roughly 100 squadrons from throughout the nation collectively fly more than 11,500 training flight annually at the CMAGR. In 2014, the BLM transferred to the DoN the administrative jurisdiction of approximately 228,465 acres of land (nearly 357 square miles) in support of the military operations at the CMAGR.

Because of safety hazards presented by the military mission, public access on these ranges is restricted. Limited portions of BMGR–West are regularly open to recreational users possessing an access permit obtainable from the MCAS Yuma Pass and ID office. For public safety, flight safety, and operational security reasons, there is no public recreational access onto the CMAGR; however, there is an off highway vehicle route, the Bradshaw Trail, adjacent to its northern boundary.

Ecological Description

The desert environment surrounding MCAS Yuma and its ranges is hyper-arid with an annual rainfall less than 4" and extreme temperatures averaging an annual high of 89°F and a record high of 124°F. As a result, the dominant terrain feature at first glance is barrenness, whether on desert pavements, rugged mountains, or the sand "seas" of the Gran Desierto. Yet according to SEINet (http://**swbiodiversity.org/seinet/checklists**), the operational area under MCAS Yuma oversight is likely habitat for approximately 800 plant species. The vegetation is classed as the Lower Colorado River Subdivision of the Sonoran Desert, dominated by creosotebush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*). Plants on BMGR West that are significant because of relative rarity or limited distribution include Kearney sumac (*Rhus kearneyi*),

continued next page

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Inset: Sand Food (*Pholisma sonorae*) at the BMGR–West. *Photo courtesy Jordan Zylstra.*

Goldwater Range West *continued*

elephant tree (*Bursera microphylla*), and Algodones sunflower (*Helianthus niveus* var. *tephrodes*).

The CMAGR is located within the Salton Sea Air Basin. The climate of the CMAGR is desert, with low humidity, average precipitation of less than 4 inches, average high summer temperatures of 124°F, and moderate winter temperatures averaging 64.4°F. The vegetation at CMAGR is further diversified, as it is near the transition zone to the Mojave Desert along its northern boundary. Higher elevations on the range support isolated populations of Joshua tree (*Yucca brevifolia*) and other representatives of the Mojave Mid-elevation Mixed Desert Scrub vegetation type. Rare plants recorded at CMAGR include the Orocopia sage (*Salvia greatae*) and the sand evening primrose (*Camissonia arenaria*), both considered to be special status species by the California Native Plant Society.

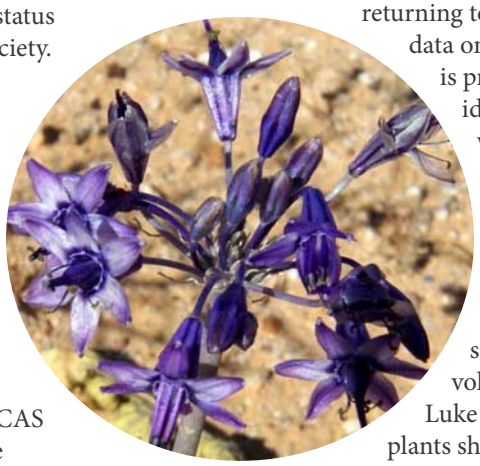
Conservation Programs

Ecosystem management is the basis for the conservation of natural resources on lands under Marine Corps jurisdiction. Several projects outlined below highlight MCAS Yuma's implementation of ecosystem management on the BMGR–West and the CMAGR.

Yuma Conservation Garden Among MCAS Yuma's important partnerships is the one established with the Yuma Conservation Garden (YCG) (http://**www.yumaconservation garden.org**). Through this partnership a 28-acre botanical garden and state-sanctioned Environmental Education Center was established under the MCAS airfield approach flight path. MCAS Yuma must ensure that uses of the land under the airfield approach do not interfere with the military mission and public safety. The long-standing relationship between MCAS Yuma and YCG has helped ensure the compatible use of the botanical garden. An MCAS Yuma representative serves on the YCG Board to ensure that flight hazards are minimized arising from new structures, vegetation, or potential nuisance attraction of birds and other wildlife. This coordination is also essential for safe access to the Garden for school groups and other visitors.

Chocolate Mountains Aerial Gunnery Range Research The first vegetation-related project for the CMAGR is the MCAS Yuma-funded development of a vegetation map. Jim Malusa (The University of Arizona) has partnered with Andy Sanders (Curator, University of California Riverside Herbarium) to complete a vegetation map following the protocol established for BMGR–West and described above. In addition to curating the collections at UC Riverside, specimens will be housed at the Arizona Western College Herbarium in Yuma. This should be a great resource for Yuma's students and biologists as the Herbarium strives to serve as a regional repository for this floristically under-represented region of southwest Arizona and southeast California.

Noxious Weed Control The University of Arizona (UA) has partnered with the National Park Service's (NPS) Lake Mead Exotic Plant Management Team to map for noxious weeds and to implement a program for their control throughout the BMGR–West. The project aims to give land managers a timely method for tracking the spread of invasive weeds, particularly Sahara mustard (*Brassica tournefortii*) and buffelgrass (*Pennisetum ciliare*), as well as access to information on effective control methods. The project uses a novel method — a cloud-based GIS application that allows data collection by smartphones, even out of cell range. After returning to cell coverage, the phone uploads the data onto a cloud-based map. This information is provided to the NPS which coordinates, identifies, and prioritizes treatment areas with UA and MCAS Yuma staff. In 2015, the NPS surveyed a total of 1,192 acres and treated 2.3 acres.



Rare Plant Survey In the spring 2014, volunteer botanist Charmaine Delmatier coordinated a rare plant survey with support from other volunteers and staff from MCAS Yuma and Luke AFB. Among the more interesting plants she recorded were sand food (*Pholisma sonorae*), Schott wire lettuce (*Stephenomeria pauciflora*), and the blue sand lily (*Triteleiopsis palmeri*).

Vegetation Mapping, Sahara Mustard Control, and Elephant Tree-Gray Vireo Interactions Through an MCAS Yuma-funded project, Jim Malusa and Pete Sundt from the UA School of Natural Resources and the Environment have completed a vegetation map for the BMGR–West. MCAS Yuma and Luke AFB sponsored a research project that investigated the differences in the seed and growth characteristics between Sahara mustard (*Brassica tournefortii*) and native winter annual species in the Mohawk Valley and Mountains of the BMGR–West. John Arnett, the wildlife biologist with the 56th Range Management Office undertook a study of the relationships between the Elephant Tree and the Grey Vireo on the BMGR–West. *Each of these studies is briefly described in the following articles.*

Inset: Blue Sand Lily (*Triteleiopsis palmeri)* at the BMGR–West. *Photo courtesy Michael Plagens.*



Left: The view south along the summit ridgeline of the Mohawk Mountains, festooned with teddy bear cholla (*Opuntia bigelovii*). *Photo courtesy Jim Malusa.* Center: The north slope of Sheep Mountain is home to desert beargrass (*Nolina bigelovii*) and Mormon tea (*Ephedra aspera*). *Photo courtesy Jim Malusa.* Right: An elephant tree (*Bursera microphylla*) contemplates the strangely shaped Jim Malusa, somewhere in the Tinajas Altas Mountains. *Photo courtesy Mara McKinnon.*

Mapping the Vegetation of the Barry M. Goldwater Range

by Jim Malusa[1]

We wish to preserve the beauty and diversity of a pre-industrial world, and our military bases offer some of our best opportunities. The Barry M. Goldwater Range (BMGR) covers over 1.1 million hectares (2.8 million acres) of southwestern Arizona, including the restricted airspace above the Cabeza Prieta National Wildlife Refuge (CPNWR).

For the past decade, the range management offices of the U.S. Air Force and U.S. Marine Corps have funded mapping of the vegetation. And not just a general map proclaiming the area to be desert, but detailed mapping that distinguishes, for example, places holding primarily creosote and white bursage from places with creosote and triangle-leaf bursage. The resulting map looks an awful lot like a soils map, because soils explain much of who lives where.

Detailed mapping of the BMGR began with the North and South Tactical Ranges (McLaughlin et al. 2007); the East Tactical Range and Area B (Osmer et al. 2009); the western San Cristobal Valley (Shepherd 2011); and the eastern San Cristobal Valley, Aguila Mountains, and Sentinel Plain (Whitbeck 2013). Mapping continues in the Crater Range and Black Gap (Jaron Weston and Jeff Fehmi, University of Arizona, in progress), and the western portion of the Cabeza (Malusa, in progress). When the Cabeza mapping is completed in 2019, all of southwestern Arizona will be mapped using a common methodology and mapping units.

The most recently completed map covers about 283,000 hectares (700,000 acres) of the BMGR–West (Malusa and Sundt 2015). Perhaps you've seen a bit of the range: south of Interstate 8, between Yuma and Dateland. Of course, the highway is the dull way, through creosote flats. What lies beyond was mapped using a combination of aerial imagery, topo maps, GPS/camera, and about 200 days in the field. The process was simple — we became experts at interpreting imagery. To make this happen we aimed to visit every corner of the study area.

Or at least we tried. We documented our travels with 656 relevés, a kind of plotless sample unique to vegetation mapping, at elevations ranging from 56 meters (185 feet) at the southwest corner of the range near San Luis, to 962 meters (3156 feet) at Sheep Mountain, summit of the Gila Mountains. The resulting vegetation map was documented at the alliance, association, and the subassociation levels (alliance is the broadest level of vegetation mapping, while subassociation is the finest),

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Inset: A 1-meter tall dune buckwheat (*Eriogonum deserticola*), all alone in the Yuma Dunes in a restricted area just north of the international frontier. *Photo courtesy Jim Malusa.*

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Mapping Vegetation *continued*

reflecting the hierarchical structure of the National Vegetation Classification (FGDC 2008).

The map itself would be a pretty, but nonsensical, splash of colors if it were reduced to fit this journal. Photos best reveal this lovely landscape, and for these photos we can thank the BMGR range managers, who made this research happen.

References

FGDC. 2008. National Vegetation Classification Standard, Version 2. Vegetation Subcommittee, Federal Geographic Data Committee. FGDC Document number FGDC-STD-005-2008. Available as a pdf from many sources, including the National Vegetation Classification website, accessed in December 2014 at http://**usnvc.org/resources**. Direct downloads at: http://**usnvc.org/wp-content/uploads/2011/02/NVCS_V2_FINAL_2008-02.pdf**.

Malusa, J. and P. Sundt. 2015. Vegetation of the Barry M. Goldwater Range West, Marine Corps Air Station–Yuma, Arizona. Report delivered to MCAS Yuma under Cooperative Agreement DACA87-05-H-0018. Available at https://**www.researchgate.net/publication/277013268_Vegetation_of_the_Barry_M._ Goldwater_Range_West**

McLaughlin, S., S. Marsh, and S. Drake. 2007. Vegetation mapping of Sonoran Pronghorn habitat on the Air Force ortion of the Barry M. Goldwater Range, Arizona. A Project of the Desert Southwest Cooperative Ecosystem Studies Unit. Office of Arid Lands Studies, University of Arizona.

Osmer, E., J. Fehmi, and P. Guertin. 2009. Vegetation mapping of Sonoran desert communities on the Barry M. Goldwater Range – East (BMGR–East), Arizona. Report submitted to the 56 RMO/ESM, United States Air Force. Cooperative Agreement DACA 87-05-H-0018, Task Agreement No. 1.

Shepherd, A. 2011. Mapping of Sonoran Desert vegetation communities and spatial distribution differences of *Larrea tridentata* seed density in relation to *Ambrosia dumosa* and *Ambrosia deltoidea*, San Cristobal Valley, Arizona. MS thesis submitted to School of Natural Resources and the Environment, University of Arizona. http://**arizona.openrepository.com/arizona/handle/ 10150/217053**

Whitbeck, D.C. 2013. Mapping of Sonoran Desert vegetation communities of San Cristobal Valley and Southern Sentinel Plains, Barry M. Goldwater Range and variables influencing route proliferation in the Barry M. Goldwater Range's San Cristobal Valley. MS thesis, University of Arizona. Electronic version at: http://**arizona.openrepository.com/arizona/handle/10150/129649**.

Summary of Work on Annual Plant Coexistence in the Mohawk Valley, Barry M. Goldwater Range, Arizona

by Yue Max Li[1]

In an ongoing effort to understand the nature of biological diversity and strategies for invasive species control on the Barry M. Goldwater Range, the Marine Corps Air Station Yuma and Luke Air Force Base sponsored my doctoral dissertation research in which I endeavor to reveal how the constant change of environment in time and space affects plant diversity. Using various types of habitats in the Mohawk Valley as a natural experimental ground, I have spent the past few years addressing two main questions.

The first question is: Will the fluctuating environment provide niches for native winter annual plants to coexist with the noxiously invasive Sahara mustard (*Brassica tourenfortii*)? My research to date suggests that the answer to this question is yes. I found that in years of dry winter-springs, native annual plants can compete successfully with Sahara mustard because it does not grow as well as native annuals under dry conditions and fares surprisingly poorly in terms of its seed bank. Native annuals are well-known for maintaining long-lasting seed banks, allowing their populations to persist through unfavorable years. In contrast, most Sahara mustard seeds do not survive over a year, leading to a plunge in its population when a devastating growing season hits. After four years of meager winter rains between 2009 and 2013, the population of Sahara mustard in the Mohawk Valley plummeted, whereas those of the natives stayed strong. The evidence suggests that Sahara mustard is an opportunistic invader, and there is hope for its effective control. Cost-effective management of this species should focus on limiting seed production both in years of favorable cold-season rainfall and, during unfavorable years, in spatial strongholds where populations can persist due to local water accumulation (e.g. dunes, washes, roadsides).

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Left: A diverse group of winter annual plants thrive in study sites situated on the sandy substrate in the Mohawk Valley (visible in this picture, *Oenothera deltoides, Mentselia multiflora, Baileya pauciradiata, Palafoxia arida, Cryptantha micrantha,* and *C. angustifolia*). Right: Overlook of the Mohawk Valley from the Mohawk Mountains. Habitat heterogeneity over the Valley (dunes, sand flats, flood plains, gravelly washes, hill slopes) provide opportunities for spatial niche differentiation among plant species. *Photos courtesy Max Li.*

Annual Plant Coexistence *continued*

The second question I am addressing is: What factors contribute to the maintenance of the high diversity of plants in the Sonoran Desert? As was shown in my studies of Sahara mustard and its native competitors, plants are known to take advantage of variable environments and differentiate their spatial and temporal niches in order to coexist under competition. What challenges ecologists is the need to quantify exactly the degree to which variable environments can promote competitive coexistence and thus maintain biodiversity. For my study, I chose to evaluate three native winter annual species (*Cryptantha angustifolia, Chaenactis stevidoides* and *Plantago ovata*) that are found to coexist across almost all habitat types in the Mohawk Valley. I tried to determine how much the variable conditions in space allow for niche differentiation and thus contributed to their coexistence. It may seem foolish to look for spatial niche differentiation between species that share almost the same types of habitat. But a diligent botanist should carefully look for subtle differences in growth between plants in the same location and subsequently quantify those differences to determine if those subtle differences are significant. Though not definitive, the results of my study suggest that those three common species can barely differentiate any spatial niche. In some rare cases, the spatial heterogeneity, instead of creating spatial niches, makes the coexistence between those species even less likely.

An example of one of the thousands of digital photos taken for recording density and size of winter annual plants within the study area. *Photo courtesy Max Li.*

With these observations, the question arises of how these species can appear so commonly. First, it should be noted that the conclusions I am developing are restricted to these three species and also to a fairly limited distributional range. Many plant species show strong habitat differentiation, but were not included in this study. Also, the three focal species are distributed over a much larger region than this single study could encompass. The increasing habitat heterogeneity over their regional distribution can eventually bring in positive influences for their coexistence. Second, temporal-environmental fluctuation can strongly promote coexistence. These three species coexist in high abundance over the Mohawk Valley despite the lack of spatial niche differentiation. This fact hints that temporal niche differentiation may be the main force behind their coexistence. Whether or not that is true requires a long-term study that adopts a similar approach to that used in this study.

I am in my final year of completing my dissertation research. I am still collecting plant demographic data from the tens of

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Annual Plant Coexistence *continued*

thousands of digital photos I took. I hope to use the more detailed demographic data to find out why exactly the three native species do not strongly differentiate their spatial niche.

Impermanence occurs in a complex manner that never ceases to bring surprise and inspiration. For the moment, we may simply observe the never-ending change in nature and contemplate the fact that such impermanence may be behind the splendid biodiversity that we cherish.

The *Bursera–Vireo* Relationship at the Barry M. Goldwater Range *by John Arnett*[1]

A flowering Elephant Tree (*Bursera microphylla*) on the western slope of the Mohawk Mountains, Barry M. Goldwater Range–West. *Photo courtesy John Arnett.*

I'm a wildlife biologist for the U.S. Air Force, and I'm a BUMI-holic.

A few years ago I was shown my first Elephant Tree, *Bursera microphylla*, at a remote corner of the Barry M. Goldwater Range (BMGR) in southwestern Arizona. I was hooked. The tan bark flaking away from a stout, contorted trunk, the tiny verdant leaflets sprouting from purplish branches, and of course that wonderful aroma…what's not to love?

Later I learned that *Bursera microphylla*, which I now call BUMI, is relatively common at BMGR, particularly in the Tinajas Altas and Gila Mountains. Then I learned something else — Gray Vireo, a species of conservation concern and a migratory songbird that normally eats arthropods, also eats BUMI fruit during the winter. This relationship was well-documented in the 1980s by John Bates, then with the University of Arizona. He studied wintering Gray Vireos and their *Bursera* frugivory in Sonora, Mexico (Bates 1992).

Historically, Gray Vireos had been found during the winter in Arizona, but only sporadically. In late 1999, wintering vireos were found at *Bursera* patches in Anza-Borrego Desert State Park in southern California (Unit 2000). However, never had there been a concerted effort to study the winter distribution and ecology of Gray Vireos and their relationship with *Bursera* in Arizona.

Because of the close connection between BUMI and the vireo, and because BUMI are relatively common at BMGR and surrounding lands, it seemed that vireos should be there during the winter. Moreover, because Gray Vireo is a species at risk of declining, and because the Department of Defense (DoD) is a leader in promoting the conservation of at-risk wildlife, it seemed important that I try to determine if the birds over-winter on DoD and surrounding lands and, if so, what were the environmental factors contributing to their winter presence.

Happily, I determined that they do.

I compiled known BUMI locations in Arizona and supplemented the list with sites I found during my own exploration. In late 2009, some intrepid colleagues and I began visiting and searching for vireos at BUMI sites in La Paz, Maricopa, Pima, and Yuma Counties. This initial survey was supported by my office, the Arizona Game and Fish Department, and the U.S. Fish and Wildlife Service.

Over the next few years, I intensified and broadened the search and more people became involved with the study. The Arizona Field Ornithologists sponsored two volunteer surveys, most recently in December 2011, and gave me a grant to search for vireos at Kofa NWR where, incidentally, BUMI is absent.

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BOOK REVIEW *by Ries Lindley, Arizona Native Plant Society, Tucson Chapter*

Field Guide to Cacti and Other Succulents of Arizona

by P. Breslin, R. Romero, G. Starr, and V. Watkins

Tucson Cactus & Succulent Society. 302 pp. ISBN 978-0-692-26554-3.
$30.95 USD, shipping included.

This book caused an almost audible sigh in the Southwest when it hit the market. Desert plant lovers everywhere knew it was coming, and the wait was intense. No one was disappointed. Here's a few reasons why.

Every plant treatment should have some explanation of special terms. *Cacti & Other Succulents* has both a glossary and an illustrated section on plant morphology, which cover the basics needed for understanding these special genera. There is nothing stingy about this book. The illustrations are large, well drafted, and well labeled. You get what you need to know for field identification in the best way.

Genus accounts are grouped into a single section of the book. Genus accounts aren't the first thing an end-user thinks of in the field. It's the species account pages that get most of their thumbing in the field, so it makes sense to group the genus accounts together where they can become part of the larger introductory overview. With over 25 genera covered, it's good to have them in one place for that leisurely night-time reading and picture ogling.

The meat of the book is the species accounts. Each account has a consistent list of topics. For cacti the list is etymology, size, shape, stem, spines, flower, fruit, distribution, and notes. Descriptions are succinct and hit the right points for a field guide. There is enough information to give a plant a name without turning the guide into a tome. The etymology is a nice touch too. For people struggling to leap the chasm between common names and scientific names, these little blurbs help bridge the gap with some easy-to-remember English translations of the Latin names. Knowing that the *versicolor* in *Cylindropuntia versicolor* refers to the many colors of flowers on different individuals makes it more memorable.

Cacti & Other Succulents makes generous use of color, bold text, and indented paragraphs to make the species accounts useful at a glance. Each of the species accounts

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The Gray Vireo eating fruits of the Elephant Tree (*Bursera microphylla*) on the Barry M. Goldwater Range–West. *Photo courtesy Pierre Deviche.*

Bursera–Vireo Relationship *continued*

I found that Gray Vireos reliably occur during the winter at mountain ranges in southwestern and central Arizona where BUMI are plentiful and, as Dr. Deviche's iconic photo illustrates, the vireos do indeed eat BUMI fruit. Because the seed is scarified in the vireo's crop, and because the bird later regurgitates the seed at another location, vireos may be important seed dispersers. This also may be true of other birds we've observed eating BUMI fruit, especially Ash-throated Flycatchers.

In just a few years we answered several questions and, of course, developed new ones. My current view is that vireos consume BUMI fruit when arthropod availability is low, particularly after cold weather. After breeding, some

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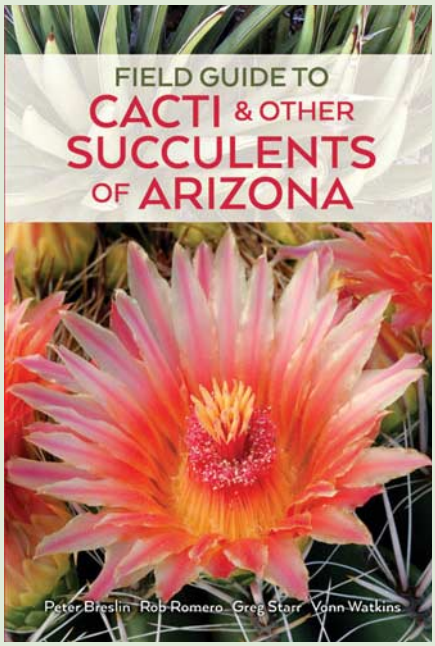
follows the same format. Headings are predictable, bolded, and set against the left margin to create a hanging indent that makes the heading stand out. A large (and beautiful) color map is provided for each species, and a number of large, well-chosen, mouth-watering photographs illustrate each plant.

From an author and publisher point of view, field guides are tough. Decisions have to be made about the dimensions, weight, and cost of the book. How many illustrations will be used and how few can be used to get the salient points across? There were a lot of cooks involved in this feast and the results are still a taste treat. *Cacti & Other Succulents* measures 5.75 inches by 8.75 inches and weighs about the same as a brick. That's because some very high-quality paper was used. The good paper means that photographs look like they should and not like overblown thumbnails from an online picture browser. Oh, yes, and when the wind blows in the field, the paper won't get whipped to shreds.



If there were to be any substantive criticism of this book, it might not lie with the book but with the plants. Cacti, agaves, yuccas, as well as some of the others written about here can be difficult plants to sort out. Where does *Echinocereus engelmannii* stop and where does *E. fasciculatus* begin? Separating one agave from another is not always a matter of reading a book, any book. This issue seems to detract very little from *Cacti & Other Succulents*. To be sure, the most endearing quality of this field guide is the peek it gives us into the world of these wonderful desert plants.

Bursera–Vireo Relationship *continued*

southbound vireos settle in southern Arizona at large xeroriparian washes where arthropod prey and cover are available. In response to the first freeze of the winter, these birds move south to northwest Mexico or move into sheltered canyons where BUMI fruit sustains them until arthropod availability increases.

One of my favorite discoveries is that vireos can be found at BUMI patches at South Mountain, Sierra Estrella, and the White Tank Mountains. Though these sites are within view of downtown Phoenix, the reliable occurrence of wintering vireos there was not known until I and others started looking.

My greatest concern is how *Bursera*, and the species that depend on it, will respond if Arizona's future climate is hotter and drier. For example, many trees, including *Bursera*, on the western and southern aspects of the Tinajas Altas and Gila Mountains are dead, and we attributed this die-off to the drought of 2002. If similarly harsh conditions become more frequent, the *Bursera* distribution could shift, or their abundance could diminish.

The persistence of *Bursera microphylla* in Arizona will be crucial for Gray Vireos and other species that consume its fruit. It will be important too for the many devoted fans, like myself, of this remarkable plant.

References

Bates, J.M. 1992. Frugivory on *Bursera microphylla* (Burseraceae) by wintering Gray Vireos (*Vireo vicinior*, Vireonidae) in the coastal deserts of Sonora, Mexico.

Unitt, P. 2000. Gray Vireos wintering in California Elephant Trees. Western Birds 31: 258-262.

Left: View of Hat Mountain at the Barry M. Goldwater Range–East. *Photo courtesy John Arnett.* Above: The endangered Sonoran pronghorn at the Barry M. Goldwater Range–East. *Photo courtesy U.S. Air Force.*

The Barry M. Goldwater Range–East

by Susan K. Gladstein, Second Lieutenant, USAF[1]

The Barry M. Goldwater Range complex is a vast training range for U.S. and allied pilots. The range consists of 1.7 million acres of relatively undisturbed Sonoran Desert southwest of Luke Air Force Base and south of Interstate 8 between Yuma and Tucson. Overhead are 57,000 cubic miles of airspace where pilots practice air-to-air maneuvers and engage simulated battlefield targets on the ground. Roughly the size of Connecticut, the immense size of the complex allows for simultaneous training activities on nine air-to-ground and two air-to-air ranges.

The Luke Air Force Base 56th Range Management Office manages the eastern 1.05 million acres of the Range, known as BMGR–East. Marine Corps Air Station Yuma oversees operations on the western portion of the range.

The range has played an integral role in the flying mission at Luke AFB since both the Gila Bend Auxiliary Air Field and the range were constructed in 1941. In the early years, it provided training for air crews from both Luke AFB and Williams AFB (now deactivated). During World War II, the range complex consisted of a ground gunnery layout of five aerial ranges, measuring about five miles by 35 miles. Today, the range is within the unrefueled flight radius of 12 military installations and the U.S. Pacific fleet carriers. Combat pilots from the Army, Navy, Marine Corps, and Air Force — active duty, Guard and Reserve — use the range to hone their skills.

The land that makes up the gunnery range was withdrawn from public use by Executive Order 8892, which was issued by President Franklin D. Roosevelt on Sept. 5, 1941. More than 70 years of military training has insulated the range from intensive human intrusion. Only about six percent of the land is intensively used for roads, targets, and support areas. The remaining 94 percent is relatively undisturbed Sonoran Desert, which thrives under natural conditions. Flora and fauna flourish and the archaeological record of 10,000 years of human activities lie mostly undisturbed. Together, the Goldwater Range complex, the Pinacate Biosphere Reserve in Sonora, and the Organ Pipe Cactus National Monument make up the largest unfragmented protected area in Mexico or the U.S. outside of Alaska.

Military users drop live ordnance on five pinpoint targets; however, 98 percent of the weapons dropped in the complex are inert practice bombs. Most of the land consists of a safety buffer for low-flying fighter aircraft. The safety zones provide refuge-like conditions for the animals, including a number of protected and endangered species, such as the Sonoran pronghorn, cactus ferruginous pygmy owl, flat-tailed horned lizard, and lesser long-nosed bat.

Natural and cultural resources protection is an important part of the military use of the range. As responsible stewards of the lands entrusted to the Air Force, the Range Management Office employs an environmental team to protect the habitat included within the boundaries of the complex. Staff biologists and archaeologists, specifically trained in the ecology and culture of southwestern Arizona, have developed comprehensive programs to monitor protected species like the Sonoran pronghorn and to inventory Native American cultural sites inside the range's boundaries.

Before live, high-explosive bombs are dropped on designated impact areas, biologists are sent to ensure there are no pronghorn within five kilometers of a target. If there are animals present, missions are either redirected or canceled.

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[1]Public Affairs Specialist, Barry M. Goldwater Range–East, 56th Range Management Office, Luke AFB, Arizona 85309.

Goldwater Range–East *continued*

To protect the range's remnants of the past, care has been taken to avoid disturbing or destroying significant cultural resources during ground activities by the military or the public. Special protection is provided for archaeologically significant sites and surrounding areas that could be impacted by both the military and the public.

The range is filled with reminders of more than 10,000 years of civilization, including pottery sherds, prehistoric settlements, ancient roads and trails, abandoned mining operations, and historic and prehistoric gravesites. The range also contains a historically significant road, the Camino Del Diablo, which was listed in 1978 on the National Register of Historic Places. This rough, unpaved road crosses the southern portion of the range and dips into Mexico.

Human settlements have been on the range since 9,500 B.C. Prehistoric pottery is not uncommon on the range — fragments are scattered along prehistoric trails, near watering places, along playa edges, and in mountain passes. Pictographs adorn flat rocks in many places.

Because of the high potential for encountering culturally significant objects on the range, surveys are performed by qualified archaeologists at areas where ground activities are planned. If the survey results in significant findings, an alternative location is selected for the planned activity. Additional inventories are being conducted or planned for the BMGR–East, with the resulting data to be entered into a geographic information system. This system is a management tool that allows mapping of these sites and other significant features of interest.

In addition to cultural preservation, the Air Force collaborates with local partners in a major natural resources conservation program that is specified and implemented through the BMGR–East Integrated Natural Resources Management Plan (INRMP). As a Federally listed endangered species, the Sonoran pronghorn has been a major conservation concern for the Air Force for over three decades. Working with the Marine Corps, Army National Guard, U.S. Fish and Wildlife Service, and the Arizona Game and Fish Department, the Air Force has worked to conserve the remaining subpopulation of the Sonoran pronghorn found on the range.

In 2002, the Sonoran pronghorn population on the range dropped nearly 80 percent, primarily due to drought conditions. Lack of rainfall from mid-August 2001 to the winter of 2002 contributed to the lowest count ever — 21 individuals. At that point the Air Force and its partners began a vigorous program of planning, funding, and implementing emergency recovery measures to reverse the low population trend.

The recovery team hauled in water directly to the animals and constructed a one-square mile semi-captive breeding enclosure. Personnel continue to monitor the animals and patrol the perimeter fence for predator intrusion or other tampering.

Equally important native plant conservation measures have been taken on the BMGR–East. Of particular interest is the work undertaken to survey for and protect the extremely rare and federally listed endangered Acuña cactus (*Echinomastus erectocentrus* var. *acunensis*). The Range Management Office contracted for an Acuña cactus survey in 2012 that identified two populations on BMGR East, one with nearly 200 individuals. The Range Management Office now conducts annual monitoring surveys for the species. In 2013, Range biologists discovered that the larger of the two Acuña cactus populations was threatened by infestations of the invasive red fountain grass (*Pennisetum setaceum*) located less than a mile distant. Fountain grass is similar to buffelgrass (*P. ciliare*) in its ability to carry wild fires. The fountain grass populations were eradicated and the Acuña cactus habitats are carefully monitored.

The range is also in the final stages of a multi-year cooperative agreement with the University of Arizona to create a single, seamless, Vegetation Classification Map for all of the BMGR East. Several of the adjoining federal properties, including BMGR–West, have undertaken similar projects, and our goal is to ensure that BMGR–East ultimately contributes to the preparation of a seamless vegetation map for most of Southwestern Arizona.

Although tight Air Force controls have limited public access and kept the proliferation of off-road vehicles from damaging the fragile desert landscape, most of the range complex can be visited by obtaining a permit. There are several visitor regulations associated with obtaining a permit. These are designed to help protect personal safety of visitors while protecting natural and cultural resources on the range. For instance, all vehicles must remain on existing roads at all times. While on the range, each adult, 18 years or older, must have in his or her possession a permit. Each visitor must also call before entering or departing the range. Permits can be obtained from the Range Offices at Gila Bend Air Force Auxiliary Field and Marine Corps Air Station Yuma, Cabeza Prieta National Wildlife Refuge, and the Bureau of Land Management offices in Yuma and Phoenix.

Inset: The endangered Acuña cactus (*Echinomastus erectocentrus* var. *acunensis*) at the Barry M. Goldwater Range–East. *Photo courtesy Richard Whittle.*

Left: Camp Navajo viewed looking north from the Volunteer Mountain Lookout Tower, with the San Francisco Peaks in the distance. *Photo courtesy Hannah Telle.* Right: Arizona Potentilla (*Potentilla arizonica*). *Photo courtesy Mark Daniels.*

Natural Resources Conservation on Arizona Army National Guard Training Installation Camp Navajo, Coconino County, Arizona *by Hannah Telle*[1]

The Department of Defense (DoD) is host to the highest density of species listed as threatened or endangered of any federal land management agency. As stated by Peter Boice, the Deputy Director of Natural Resources for the Secretary of Defense, "The DoD manages approximately 28 million acres of land across approximately 420 large military installations (greater than 500 acres); 340 of those installations have natural resources significant enough to require active management plans. Access limitations due to security and safety concerns shelter many military lands from development pressures and large-scale habitat loss. As a result, some of the finest remaining examples of rare wildlife habitats are found on military installations" (Boice 2013). The DoD is responsible for managing and protecting over 425 Federally listed threatened and endangered species found on its installations; of those listed species, 219 are plants. As the Natural Resources Manager for Camp Navajo, an Arizona Army National Guard installation in Northern Arizona, I am a part of this conservation effort on a daily basis.

Camp Navajo was established in 1942 as an ordnance depot to support WWII. It became a National Guard Training Installation in 1981. It is the only Southwest installation to provide soldiers from all four military services with a unique high-altitude training environment. Located just west of Flagstaff, Camp Navajo is surrounded by a mixture of U.S. Forest Service, State Trust, and private lands. The elevation within Camp Navajo ranges from 6,770 feet in Volunteer Canyon to 8,047 feet on Volunteer Mountain. The installation encompasses 28,473 acres that support a wide variety of plant and animal species. It is representative of the Northern Mesic Evergreen Forest cover type. The installation is dominated by Ponderosa pine and pine-oak forest; additional vegetation types include: grasslands, mixed conifer forests, wetlands, and springs. A small mixed conifer community of Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*) can be found on Volunteer Mountain, and in Volunteer Canyon resides a relic stand of a once larger mature blue spruce (*Picea pungens*) forest.

Due to Camp Navajo's dual training and munitions storage mission, it is not open to the general public for recreational activities, with the exception of hunting. Livestock grazing was previously permitted on Camp Navajo but was discontinued in 2002.

Healthy ecosystems and a diversity of vegetation types provide our soldiers with tactical concealment and realism in battle simulations; so habitat conservation and management are key aspects to sustaining the military mission at Camp Navajo. The environmental policy for the Arizona Army National Guard (AZ ARNG) states:

> "The AZ ARNG is committed to sound environmental stewardship, continuous improvement, compliance to regulatory and other requirements, conserving our natural resources, preventing pollution or contamination, gaining the support of the communities in which we work and live, and incorporating professionalism and environmental planning in all that we do" (Arizona Department of Emergency and Military Affairs 2010).

continued next page

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Camp Navajo *continued*

Left: Rough-fruited fairy bells (*Prosartes trachycarpa*). Right: Dwarf hesperochiron (*Hesperochiron pumilus*). *Photos courtesy Mark Daniels.*

Outreach and education are important activities we stress regarding the conservation of our native plants. These efforts apply to the open spaces of the installation as well as to the cantonment areas. For example, a past outreach project in support of National Public Lands day replaced current landscaping at the Officers' Club with native plants. Other past projects include reseeding disturbed areas with native plant species, participating in Earth Day events, and participating in Seeds of Success — a project that collected native seed from Camp Navajo and throughout Arizona. While education and outreach are important, we have recently conducted native and rare plant surveys to increase our knowledge of what occurs within Camp Navajo. These surveys have helped us determine sensitive areas within Camp Navajo that need extra protection and restoration from past overuse and disturbance.

In 2010 and 2011, a rare plant survey was conducted in conjunction with the Ecological Restoration Institute (ERI) at Northern Arizona University. In this survey, ERI compiled a list of rare species that could potentially occur within Camp Navajo. From previous surveys and mapping, ERI decided to focus the first year of study on Volunteer Canyon, the only stream channel on Camp Navajo. These surveys located a number of plants that are listed as salvage restricted and species of concern. With the knowledge of where these plants occur, we have developed guidance for any future construction or training activities that may occur in the vicinity. Our recommendations will include suggesting alternative areas for training, construction, or mitigation strategies when a direct impact cannot be avoided.

A few of the more interesting native plants that were located in Volunteer Canyon in our most recent survey were rough-fruited fairy bells (*Prosartes trachycarpa*), Mogollon columbine (*Aquilegia desertorum*), and a *Potentilla* hybrid. This *Potentilla* hybrid is a cross between *Potentilla arizonica* and another *Potentilla*. It has been found in other locations outside of Camp Navajo such as Pumphouse Wash, but there is some taxonomic uncertainty associated with this species. The *Potentilla* expert was contacted during the study regarding its identity and her opinion was that it was most likely a hybrid. Of the known population, the majority of plants are found in open meadow or washes in ponderosa pine forests.

During the second year of surveys, specific areas were targeted such as limestone cliffs and outcrops along the northeastern slope of Volunteer Mountain. ERI researchers found Rusby's milkvetch (*Astragalus rusbyi*) and creeping milkvetch (*A. troglodytus*) at this location. Other plants that were found during the second year of surveys were Garland Prairie cinquefoil (*Potentilla arizonica*) and dwarf hesperochiron (*Hesperochiron pumilus*). The Garland Prairie cinquefoil was described many years ago as a unique species; later it was lumped with other *Potentillas*. It has recently been recognized once again as a separate species and will be so indicated in a future treatment in the *Flora of North America*.

Fortunately, the majority of our rare native plants reside in areas that are hard to access and/or are located in areas that were previously protected because of the existence of the Mexican spotted owl. While we have no known threatened or endangered plant species on Camp Navajo, we do have the threatened Mexican spotted owl (*Strix occidentalis*). As the natural resources manager/wildlife biologist on Camp Navajo, I currently monitor the protected activity centers for this species and assist in protecting the habitats that support them. Besides the spotted owl surveys and monitoring, we also conduct research projects in conjunction with the Arizona Game and Fish Department. We are currently studying the effects of forest treatments on bats and songbird populations. The forest treatments that are planned and ongoing for Camp Navajo will protect it from a catastrophic fire and provide a variety of forest conditions for training. The Natural Resources Department at Camp Navajo works hard to make recommendations to the Arizona Army National Guard that will support training and protect our natural resources within Camp Navajo.

I never would have thought, when I began my career as a natural resources manager/wildlife biologist, that I would be working for the Arizona Army National Guard. It has proven to be a rewarding and challenging position.

References

AZ Department of Emergency and Military Affairs. 2010. AZDEMA Policy Letter No 50.06, dated 1 Feb 2010, signed by Hugo E. Salazar, Major General, AZARNG, The Adjutant General.

Boice, Peter. 2013. Threatened and Endangered Species on DoD Lands. http://**www.dodnaturalresources.net/files/TE__s_fact_sheet_5-24-13.pdf. May 2013**.

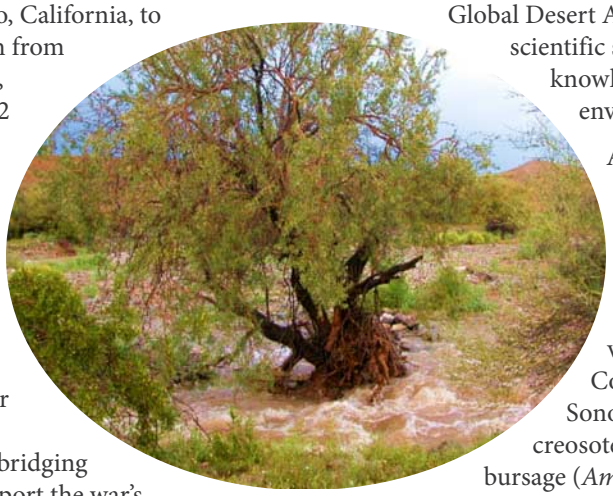
Springer, J.D., M.L. Daniels, J.E. Crouse, and D. W. Huffman. 2011. Integrated natural resources management plan (INRMP) required species monitoring: Targeted floristic survey of portions of Camp Navajo, Bellemont, AZ (Volunteer Canyon, wetlands throughout the base, road to Volunteer Mountain, and proposed firing range). Ecological Restoration Institute. Northern Arizona University. 30pp.

U.S. Army Yuma Proving Ground

Military Mission & History

The U.S. Army Yuma Proving Ground (YPG) is a 'U'-shaped installation occupying 1,100 square miles of far southwestern Arizona between Yuma and Quartzsite. YPG's military mission is Research, Development, Testing and Evaluation (RDTE) of military equipment and doctrine. Its major test programs are munitions and weapons, air systems and armament, combat and automotive systems, and surveillance systems, including unmanned vehicles. YPG differs from many military installations in that the majority of its personnel aren't active military. Instead, federal employees and contractors, serving as engineers, scientists, and technicians, make up the bulk of its workforce.

YPG traces its origins to 1942, when in response to World War II, the War Department created the California–Arizona Maneuver Area (CAMA), an 18,000 square mile training area stretching east from Indio, California, to Gila Bend, Arizona, and north from the U.S. Border to Searchlight, Nevada. Portions of 3 of the 12 former CAMA camps — Camps Laguna, Bouse, and Horn — fit within YPG's current borders. In 1943, soon after CAMA, the Yuma Test Branch (YTB) was activated adjacent to Camp Laguna to conduct an RDTE mission on the Colorado River below Imperial Dam. YTB's principal mission was testing bridging and fording equipment to support the war's European and Pacific campaigns. Both CAMA and YTB closed following the end of the war, but the test mission returned in 1951 as Yuma Test Station and then later in 1959, as a broad spectrum RDTE facility designated as YPG. Entertaining and informative articles about the region's military history are available at http://**www.yuma.army.mil/History.aspx**.



Interestingly, YPG serves a truly unique mission for the Department of Defense, as it is the center of natural environmental testing for all of the military services: one in which the military tests its equipment and procedures against the harshest realistic environmental extremes. These extremes are the principal reason that YPG was reactivated as a military RDTE.

Because of safety hazards and the national security concerns of the military mission, YPG is considered to be a closed post. Limited portions of YPG are open seasonally to hunters possessing YPG permits, obtainable from the YPG Visitor Center.

Ecological Description

As the desert environmental test center, YPG has operated its own meteorological service for more than 60 years. Interestingly, more upper atmospheric "met" data are collected at YPG than anywhere else in the world. Using data standardized since 1958, YPG's annual rainfall is about 3.5" and temperatures average 88°F, the annual mean high. The record high is 128°F.

Terrain characterization also originated in the 1950s with the first mapping of YPG's surface materials and vegetation, undertaken from a military operational perspective. For example, landform features were mapped for dust potential, an operational detection and surveillance concern. Vegetation mapping was limited to trees with canopies > 10' diameter, as a line-of-sight and tactical concealment concern. Since then, numerous Test Operating Procedures, Global Desert Analogs, information systems, and scientific studies have contributed to the knowledge base of YPG and desert environments.

Additionally, studies performed by YPG's Conservation and Sustainable Range programs are furthering the understanding of YPG's natural environment and its condition. Like all low deserts in Arizona, the region's vegetation is classed as the Lower Colorado River Subdivision of the Sonoran Desert, dominated by creosotebush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*). Extensive plant documentation and monitoring have been undertaken over the decades, and current efforts are underway to fulfill the proposed inventory work outlined in the 2012–2016 Integrated Natural Resources Management Plan. Thus far, well over 400 species have been recorded. Voucher specimens are predominately housed at Rocky Mountain Herbarium in Laramie, Wyoming, the Desert Botanical Garden, the University of Arizona, and Yuma's Arizona Western College. These collections are currently being added to the SEINet database. No federally listed plants are confirmed to occur at YPG, though the endangered Nichol's Turk's head cactus (*Echinocactus horizonthalonius* var. *nicholii*) has been previously reported.

Examples of Projects Relevant to Arizona Native Plants

Over the years, YPG's RDTE role in natural environments testing, its commitment to ecosystem-based management, and its investment in sustainable range management have contributed immensely to the conservation of native plants

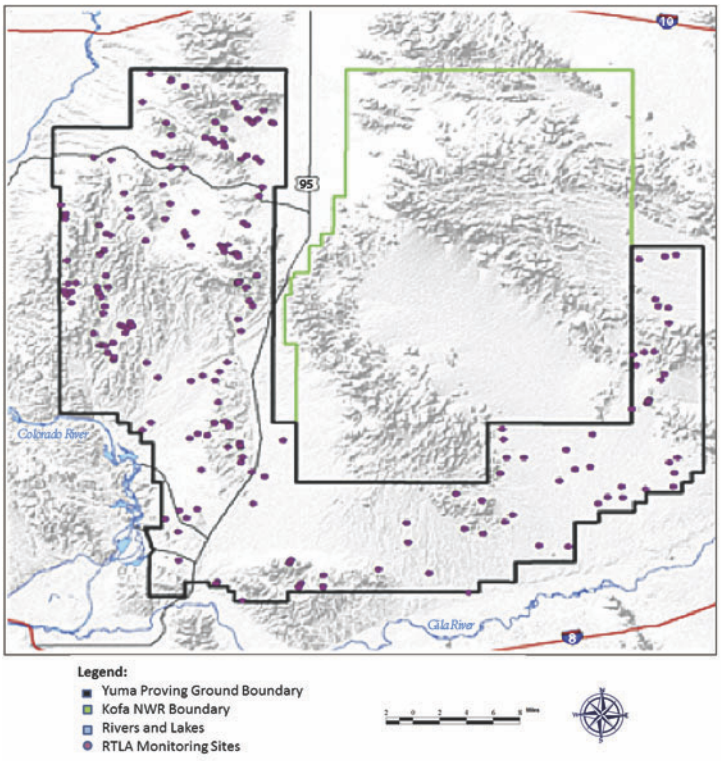
continued next page

Inset: Short-lived flooding in a desert wash.

Yuma Proving Ground *continued*

in its multiple operating environments. The several projects below highlight examples of YPG's implementation within the desert southwest:

Range and Training Land Assessment YPG participates in the Army-wide Sustainable Range Program (SRP), an overall approach for managing and operating U.S. Army ranges to ensure long-term mission sustainability. SRP provides uniformity in its land management capability across the entire Army. It establishes a systematic framework for decision-making by integrating operational, environmental, and facility planning that support sound conservation and sustain military training and testing. A principal component of SRP is the Range and Training Land Assessment (RTLA), where soil and vegetation parameters are monitored for their resiliency in supporting the mission. YPG periodically assesses the condition of the 200+ permanent RTLA survey plots established in the early 1990s. Over the years, resurveying the plots has demonstrated that YPG range condition is stable, though some surprises have materialized. For example, the population of brittlebush (*Encelia farinosa*) has shown a six-fold increase between 1991 and 2003 — likely a short-lived response to El Niño and Pacific hurricane events.



Distribution of permanent RTLA monitoring plots on YPG.

Remote Detection of Desert Vegetation Using Hyperspectral Image Processing YPG staff worked with J. David Lashlee at the Topographic Engineering Center and Joseph Boardman of Analytical Imaging and Geophysics, LLC, in the development and application of a top-down approach to create quantitative and accurate maps of desert vegetation using only calibrated remotely sensed data. The project demonstrated the ability to process hyperspectral imaging to detect, characterize and map critical vegetation parameters such as leaf water content, abundance of non-photosynthetic (woody) vegetation as well as to discriminate among a suite of species-level and community-level remotely sensed, green vegetation classes. The results include an unambiguous separation of the locally abundant paloverde (*Parkinsonia* species) and ironwood (*Olneya tesota*) trees. The positive results of this study, using operationally available instruments, methods, and software, illustrate the usefulness of airborne-imaging spectrometry for quantitative vegetation studies in arid lands.

Recent Multi-disciplinary Studies Many projects at YPG continue the tradition of integration across scientific disciplines in studying the desert's hyper-aridity and the significance of the metabolic availability of water. Among much of the research performed by the Desert Research Institute is a project that teamed a plant ecologist (Joseph McAuliffe), an archeologist, and geomorphologists who definitively clarified the biological origin and climate implications of plant scars (also known as 'sleeping circles') in desert pavements. Another project monitored the metabolic 'heartbeats' of species in response to plant available moisture: creosote bush response was erratic — feast or famine —whereas phreatophytes such as ironwood never skipped a beat.

The Arizona Game and Fish Department has worked with YPG for many years on water and habitat response. They recently spearheaded an effort to map and characterize small bosques dominated by mesquite (*Prosopis* species) and perennial grasses. These landscape features result where gradient change — of either natural or manmade causes — slows flow. Bosques are high in biomass and biodiversity relative to the surrounding terrain, but can often harbor invasive species such as salt cedar (*Tamarix* species).

Colorado State University also continues an ongoing research relationship with YPG. An early project, examining the role of the cryptogamic flora (biological soil crusts) in the structure and function of desert ecosystems, discovered two new species in the process. Current work addresses the Department of Defense's increasing concern about the impacts of climate change on its assets, operations, and on global security. The project teams — geomorphologists, wetlands ecologists, and hydrologists — are determining the baseline hydrologic characteristics and resiliency of ephemeral streams and xero-riparian vegetation in light of future climate change.

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