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Tumamoc Hill Cultural Resources Policy and Management Plan

September 2008

This project was financed in part by a grant from the Historic Preservation Heritage Fund which is funded by the Arizona Lottery and administered by the Arizona State Parks Board

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The University of Arizona thanks each of the many volunteers and university students who donated hundred of hours of time to successfully complete the archaeological field and laboratory work necessary to finalize this plan.

The University of Arizona appreciates the financial support provided by the Pima County Cultural Resources and Historic Preservation Office to print this plan and the support of SWCA Environmental Consultants in editing, formatting, and printing the plan.

End Use: To protect and preserve the prehistoric and historic resources of Tumamoc Hill so that continued ecological research and educational opportunities in this historic setting will be safeguarded for the benefit of future generations.

This document does not contain maps or provide the locations of prehistoric or historic features within the boundaries of the Desert Laboratory at Tumamoc Hill (see Arizona Revised Statutes §39-125 governing site locational data). University departments and Tumamoc Hill lessees who require these data for management purposes should contact Campus & Facilities Planning for procedures on how to obtain these data.

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Purpose

The Desert Botanical Laboratory (Desert Laboratory) of the University of Arizona (University) is a world-renowned center on Tumamoc Hill that attracts leading researchers on desert ecosystems and archaeology. The Carnegie Institution (Carnegie) established the Desert Laboratory on Tumamoc Hill in 1903 with enthusiastic assistance from the City of Tucson Chamber of Commerce, the Pima County Board of Supervisors, and the University. Starting with 40 acres, the Desert Laboratory grew in size through land purchases and leases and by 1940 controlled nearly 884 acres. In the mid-1930s, the Carnegie and the U.S. Forest Service (Forest Service) began cooperating in a number of research projects across the county, and in 1940, Carnegie transferred ownership of their deeded and leased lands to the Forest Service for $1. The land became the home of the Forest Service Southwestern and Rocky Mountain Forest and Range Experimental Station. Two decades later, the Arizona Board of Regents (ABOR) purchased the 349.41-acre laboratory for University research on the paleoecology of the greater Southwest. The University also acquired control of 520 acres of Arizona State Land Department (ASLD) State Trust lands through two original leases to maintain the traditional boundary of the laboratory (Figures 1 and 2). Today, the University leases 508.79 acres of ASLD State Trust lands and owns 345.27 acres (854.06 acres total).

To underscore its place in American scientific history, the Desert Laboratory was designated a National Historic Landmark (NHL) on 21 December 1965 and was placed on the National Register of Historic Places (NRHP) on 15 October 1966 (amended 1987). The Desert Laboratory and Tumamoc Hill were together designated a National Environmental Study Area in 1976 by the U.S. Department of the Interior and a State Scientific and Educational Natural Area in 1981.

Figure 1. The Desert Laboratory at Tumamoc Hill is bounded on the north by West Anklam Road, on the west by North Greasewood Road, and on the south by West Starr Pass Boulevard.

Other types of cultural resources at Tumamoc Hill have been overshadowed by the fame of the environmental research done at the Desert Laboratory, but these resources are equally important. The hilltop, enclosed by a massive wall, with remnant foundations of more than 160 prehistoric structures, is the earliest known *trincheras* village in the continental U.S., occupied more than 2,000 years B.P. (*trincheras* is a Spanish term applied to pre-Hispanic sites in the Southwest U.S. and northwest Mexico that have dry-laid- or stacked-rock walls, terraces, and other features built on hills). In addition to the trincheras site, Tumamoc Hill has hundreds of petroglyphs, Native American burial grounds, and numerous other cultural features, as well as 150 acres of prehistoric gardens on the adjacent western bajada. The ecosystem and cultural resources within the landmark make the Desert Laboratory a cultural landscape of unprecedented character and worthy of our full attention and care. The Arizona Preservation Foundation identified Tumamoc Hill as the "2006 Most Endangered Historic Place."

The Arizona State Museum (ASM) and Campus and Facilities Planning received a 2005 Arizona State Parks Board Heritage Fund Grant to update the Tumamoc Hill Policy Plan (Elkins et al. 1982). This updated plan, entitled the Tumamoc Hill Cultural Resources Policy and Management Plan, will guide the University in its mandate to protect, preserve, and manage the prehistoric and historic sites, historic buildings, and natural landscape within the Desert Laboratory NHL. The grant allowed for the completion of three interrelated tasks: 1) completing a detailed archaeological inventory of prehistoric and historic cultural features on the property; 2) preparing the nomination of the archaeological components of Desert Laboratory to the NRHP; and

3) updating the policy plan for the treatment and management of the landmark's prehistoric and historic cultural resources. Task 3 incorporates much of the original Tumamoc Hill Policy Plan because the goals and objectives of that plan remain pertinent today.

The Tumamoc Hill Cultural Resources Policy and Management Plan is a companion plan to be used in conjunction with the University of Arizona Historic Preservation Plan (UAHPP), approved by the ABOR in 2005. The UAHPP seeks a principled approach to historic preservation and enjoins us to follow that model. The National Trust for Historic Preservation and the American Planning Association recommend that a standard preservation plan include ten particular elements (see White and Roddewig 1994). White and Roddewig's outline is most relevant for municipalities undertaking a broad preservation planning effort. For the purposes of the University of Arizona Historic Preservation Plan, the overall outline has been modified and tailored to "meet the needs of the campus and to ensure that as many relevant issues as possible are discussed" (UUAHP:1).

The Tumamoc Hill Cultural Resources Policy and Management Plan has eight elements that are in keeping with philosophy of the UAHPP but that have been adapted to the unique character and uses of Tumamoc Hill.

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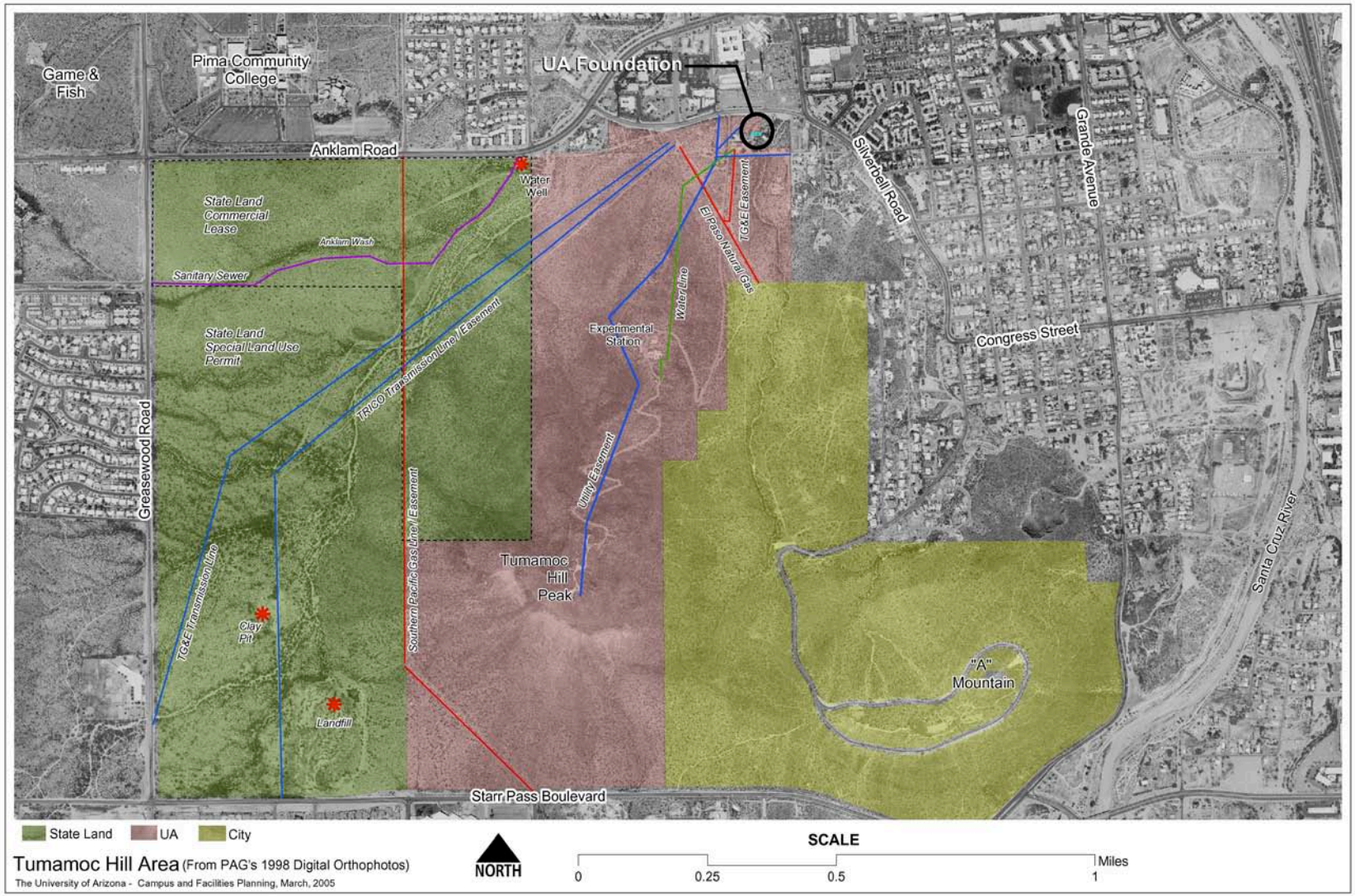

Figure 2. Aerial photograph showing land jurisdiction at the Desert Laboratory Tumamoc Hill.

Definition of the Cultural Landscape—the Natural, Prehistoric, and Historic Character of the Desert Laboratory

The ecological characteristics of Tumamoc Hill and the surrounding environs are as much a part of the cultural landscape of the Desert Laboratory as are the artifacts and features that have been left behind by various cultures over more than 30 centuries, up to the present. The flora, fauna, and hydrologic and geomorphologic resources on and adjacent to the hill provided optimal conditions for early settlement. Its unique geological character provided its earliest human tenants a comfortable hilltop home, an unparalleled view shed of the Santa Cruz River basin, and a profound sense of security because of the steep slope of the hillside. Around 1,300 years ago, settlement strategies changed and people moved away from the hill to join their neighbors living in other parts of the Tucson basin and elsewhere. The hill, however, continued to provide food and other economic resources to American Indian people well into historic times. The hill harbors great importance to the Tohono O'odham, Akimel O'odham, and the Hopi, who embrace it as an ancestral site.

The hill stood seemingly unaffected by European conquest and Spanish and Mexican settlement of the region. Through the early American period, Tumamoc Hill maintained most of its integrity, except for losses incurred from quarry operations and hillside forays to harvest the igneous stone used for architectural elements on homes and businesses built in the small town of Tucson. Then, in 1903, the hill attracted scientists who were interested in long-term multidisciplinary studies and who were drawn to the near-pristine nature of Tumamoc Hill. The earliest research focused on understanding desert ecosystems to better care for them. This one principle, applied to the better care of such environments, guides the research on the hill today.

Understanding Tumamoc Hill in the context of regional prehistory and history has also been the focus of research for the past five decades. This document provides a lengthy description of the resources to show that every facet of the ecological setting of Tumamoc Hill is intertwined with the cultures and people who used the hill over the millennia. This makes the hill a remarkable setting for anthropological and archaeological research. All that was and all that is the Desert Laboratory—the time, place, people, and natural world—represent a holistic cultural landscape in which none of the parts is separable.

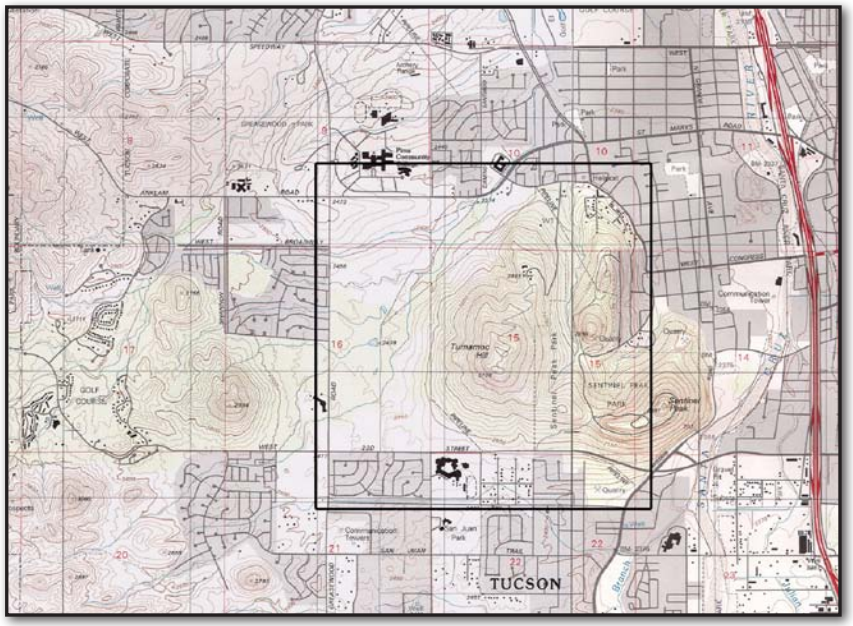

Figure 3. Topography of Tumamoc Hill displayed on the U.S. Geological Survey 1968 Cat Mountain and 1957 Tucson, Arizona, 7.5-minute topographic maps, which were photo-revised in 1975.

Natural Character

Elevation

Tumamoc Hill and neighboring Sentinel Peak form a small geologic unit called an inselberg or residual formation, which rises abruptly from the western edge of the Santa Cruz River floodplain. A series of ridges and washes extend westward from Tumamoc Hill conjoining it with the Tucson Mountain range. This inselberg rises from a low of 715 m (2,360 feet a.s.l.) at the northeastern base of Sentinel Peak to a high of 941 m (3,105 feet) at the crest of Tumamoc Hill (Figure 3).

Geology

As a geological unit, Tumamoc Hill, Sentinel Peak, and the adjoining ridge to the north are composed of alternating layers of lava and sediments in essentially horizontal layers. Fourteen rock types or units, covering a time span of approximately 40 million years, are recognized in a sequence of interbedded layers exposed in the 266 m (745 feet) from the base to the top of this residual formation. These layers constitute the most complete sections of Tertiary rocks in the Tucson Mountains for the period of 60 to 20 million years ago. A general cross section of the hill is shown in Figure 4.

Soils

Soil data for Tumamoc Hill, provided by Post et al. (1973) and by the USDA Natural Resources Conservation Service (NRCS 2008), were consulted. Variation exists between the earlier and later research but overall, both studies reach the same general conclusion about the character of soils on the Desert Laboratory grounds. One can review NRCS soil series technical reports for detailed soil classification, but for this document's purposes, soil descriptions provided by Baldwin et al. (ca. 1974), adapted from Post et al. (1973), are used.

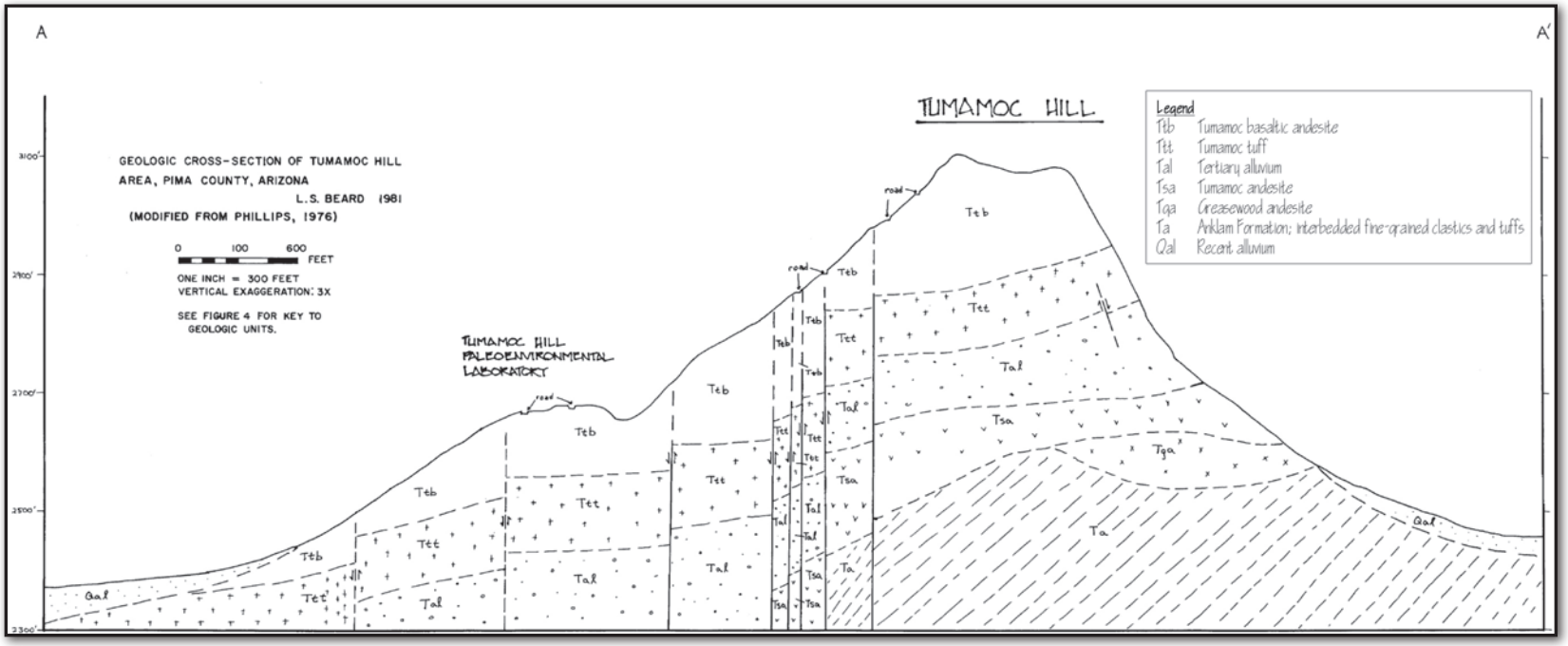

Figure 4. Geological cross section of Tumamoc Hill.

Four major soil associations characterize Tumamoc Hill (Figure 5) and are described in the following paragraphs.

The Nickel association is a very shallow, well-drained to excessively drained gravelly soil found in the sloping stream terraces that extend onto the laboratory grounds from the Tucson Mountains. The soils are formed in the old alluvium-colluvium deposits derived from rhyolite and andesite rock. The soil may contain anywhere from 35 to 75 percent gravel by volume throughout its profile and is found on nearly level, hilly upland fan pediments where slope ranges from 3 to 15 percent. High calcium carbonate causes the soil complex to be lighter in color than surrounding soils. Lime-tolerant plant species such as ocotillo dominate this soil association. A strong correlation between this soil and prehistoric agave plantations also exists at Tumamoc Hill (see NRCS Delnorte Series-Stagecoach Series Complex).

The Pinaleno-Palos Verdes association is the same material, on the same fan and stream terrace, that characterizes the Nickel association. The soil, however, is a deep, well-drained, very gravelly clay loam. Unlike the earlier series, this soil is reddish brown. Because of its clay loam texture, the soil has better water retention and supports a paloverde-saguaro community (see NRCS Pinaleno Series).

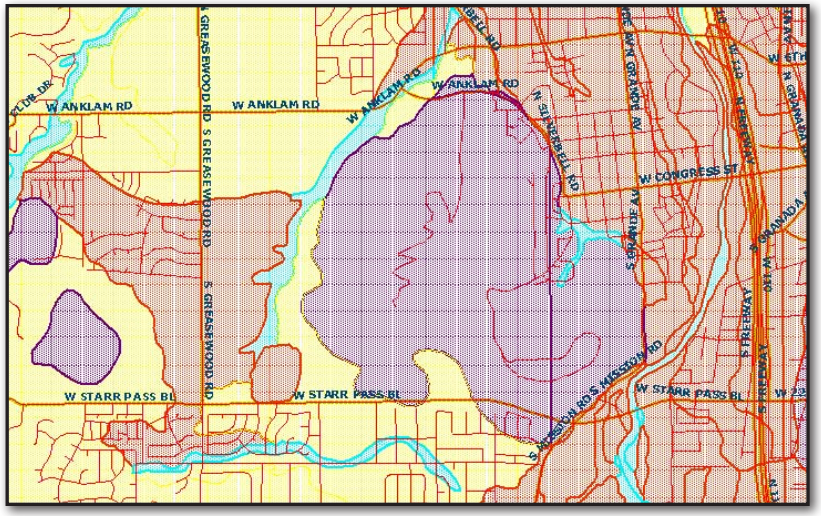

Figure 5. Tumamoc Hill soil types: yellow = Nickel association, red = Pinaleno-Palos Verdes association, blue = Anthony-Arizo association, and purple = Cherioni, thermic variant, Lehmans-Rock Outcrop association.

Recent alluvium deposited on the floodplain of Silvercroft Wash and five lesser drainages originated from the adjacent fans and terraces of the Tucson Mountains. This material is defined as the Anthony-Arizo association. The alluvium is a deep, excessively drained, fine gravelly sand (see NRCS Arizo Series and Riverwash Series Complex).

The largest soil association within the Desert Laboratory is the Cherioni, thermic variant Lehmans-Rock Outcrop association. This association applies to the summit, sides, and toe of Tumamoc Hill. The soil is characterized by many outcrops of andesite and tuff, talus slides, and rock fragments on gentle to steep slopes. The Cherioni, thermic variant, soil is the dominant soil type in the association and consists of a very shallow soil overlying a silica-cemented hardpan that extends to bedrock. The Lehmans soil is found on the gentle to moderate slopes of the hill and is a weathered soil formed in place. It is clayey soil that can reach a depth of 18 inches. This soil supports paloverde-saguaro community.

Hydrology

Journal entries and drawings from the 1850s and photographs from the late nineteenth and early twentieth centuries provide a glimpse of the Santa Cruz River valley near Tumamoc Hill when the river was a meandering stream, a time when the valley was filled with farms dependent on surface water and canal technology to water crops. From the earliest photograph, taken from Sentinel Peak, it is not difficult to extrapolate archaeological and geomorphological research to envision what the view of the valley looked like from Tumamoc Hill 2,000 years B.P. The Santa Cruz River made Tumamoc Hill a habitable place for humans because it provided a source of domestic water, farmable lands, and a riparian corridor filled with exploitable plants and animals.

By 1910, entrepreneurs created sizable ponds on the Santa Cruz River by impounding its water south of town. An unfortunate series of floods and pond breaches caused serious erosion of the meandering floodplain, resulting in a single deep channel by 1915. These natural events and the advent of mechanical well pumps forever submerged the river below its sandy bed. Today, the river carries surface water only during flood events.

Springs issued from the base of Sentinel Peak as late as 1878, but there is no mention of such water sources on Tumamoc Hill. Prolonged rain storms during winter rains and summer monsoons percolated down slope on Tumamoc Hill to create temporary seeps over exposed bedrock, but generated only enough water to serve animal populations temporarily. When the Carnegie moved to Tumamoc Hill in 1903, a permanent water source had to be secured from a well in what is now Menlo Park and piped to a reservoir on the hill by an electrically driven pump. By 1919, the Menlo Park well had become contaminated by a growing number of exposed cesspools, and a proposal was set forth to connect to the city main and to drill a new well west of St. Mary's hospital.

West of the hill, five drainages extend east and northeast across the Desert Laboratory property, where they join the larger Silvercroft Wash (Figure 6). Silvercroft Wash originates in the Tucson Mountains northeast of Cat Mountain and extends northeastward along the west base of Tumamoc Hill. During periodic heavy rains, Silvercroft Wash can carry sufficient water to pose flood threats in the urban area northeast of Tumamoc Hill. There is little arable land associated with the smaller washes west of the hill; however, they feed sediments into the Silvercroft Wash drainage, and this certainly provided opportunity for seasonal floodwater faming along its banks. Extraordinary, well-preserved prehistoric agave gardens cover the west end of the laboratory property and were completely dependent on direct seasonal rainfall and sheet flooding.

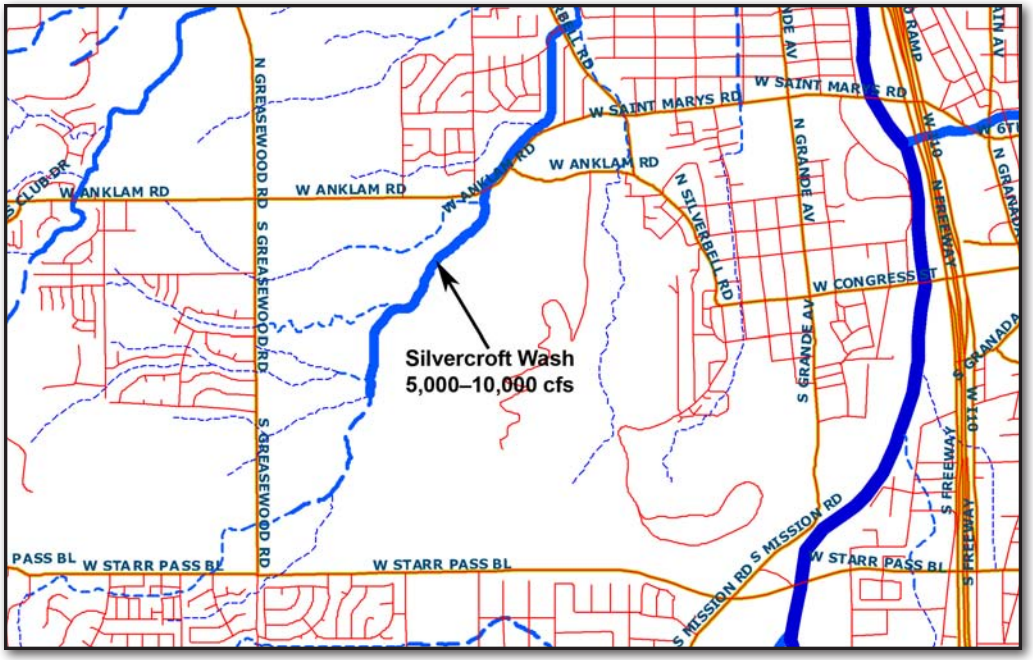

Figure 6. Hydrologic map showing washes on the Desert Laboratory property. Silvercroft Wash (center) is the recipient of stormwater moving northeast through the west side of the Desert Laboratory. The dark blue line on the far right is the Santa Cruz River.

Climate

Because the Tumamoc Hill summit rises only 266 m (745 feet) above the floor of the Tucson basin, rainfall patterns are not significantly different from the rest of the valley. Of note, however, are the daily weather records kept on the hill from 1907 to the present day. Representing the longest continuous weather record in the state, this information was first kept by the Desert Laboratory and is now maintained by the U.S. Geological Survey (USGS) office in Tucson. These data show that at this location at 2,685 feet in elevation, the average rainfall is about 12 inches, of which 53 percent occurs during the summer, from July to September, and 28 percent occurs during the winter, from December to March.

The warm climate of the Tucson basin provides a long growing season, averaging 265-frost-free days each

year (Masse 1979:146). With its dark, heat-retaining rocks and a site situation that is above the cold-air drainage, the Tumamoc Hill summit itself offers the advantage of a significantly longer growing season than the floodplain below, with as few as five or six weeks subject to freezing, and the potential for an early-season crop in conjunction with winter rains (Wallace et al. 2007).

Vegetation

Tumamoc Hill is an 854-acre preserve located within the city of Tucson. The land has been effectively preserved, with minimal perturbations to the native flora, from 1903 to present. Two biotic surveys have been carried out at Tumamoc Hill, the first in 1909 by J. J. Thornber, the second in 1968–1969 by R. M. Turner (Bowers and Turner 1985). The following discussion is based almost exclusively on the latter report, with minimal amendments based on more recent observations.

Bowers and Turner (1985) report that a total of 346 specific and intraspecific taxa were located on Tumamoc Hill during the 1968–1969 survey. This list differs substantially from the 238 recorded in 1909 by Thornber. Forty-nine of the 108 additions were invasive species, i.e., not native to the Sonoran Desert. The overall majority of the new species recorded in the 1960s, both native and non-native, were believed to have newly colonized the site as a result of incidental, artificial wetland creation. Non-systematic recent observations have added three new species to the list compiled by Turner: crown of thorns *(Koeberlinia spinosa)*, Santa Rita prickly pear *(Opuntia santa rita)* and Murphy's agave (*Agave murpheyi*); the last of these is known to have been introduced through scientific experiments.

The Tumamoc Hill preserve can be loosely divided into two subregions of rocky slopes/summit and lower bajada/wash. Both of these fall under Shreve's (1951) Arizona Upland subdivision of the Sonoran Desert. In their 1985 description Bowers and Turner (1985:22) listed the following species as predominating on the slopes and summit of Tumamoc Hill: foothills paloverde (*Cercidium microphyllum)*, saguaro (*Carnegiea gigantea)*, ocotillo *(Fouquieria splendens)*, desert lavender *(Hyptis emoryi)*, *Opuntia phaecantha* (no common name), brittlebush *(Encelia farinose)*, Berlandier wolfberry *(Lycium berlandieri)*, and whitethorn acacia (*Acacia constricta)*. Cursory observations of this region indicate this description remains accurate, with the possible note that the invasive species *Pennisetum ciliare* (buffelgrass) is now ubiquitous in this region despite numerous efforts to control its spread.

The lower bajada region has been subject to disturbance in the form of a now-retired landfill that measures approximately 18 acres, an abandoned brick clay quarry that now serves as a near-perennial artificial reservoir and that measures 1 acre, and a variety of disturbances resulting from sundry utility installations. These disturbance features, and the close proximity to residential zones with numerous non-native plants, have resulted in numerous invasive species colonizing portions of the bajada. Nonetheless, the dominant species list created in the 1960s remains largely accurate and is composed entirely of native species, including saguaro, creosote bush *(Larrea divaricata)*, triangleleaf bursage *(Ambrosia deltoidea)*, chainfruit cholla *(Opuntia fulgida)*, Mohave prickly pear *(Opuntia phaecantha)*, cholla *(Opuntia versicolor)*, ocotillo, and fairy duster *(Calliandra eriophylla)*. Recent observations warrant the addition of Christmas cholla (*Opuntia leptocaulis)* to this list. The now-predominant nature of this species in many areas of the bajada may result from reduced rainfall over the past several decades since Turner's survey was conducted. In wash regions, species such as foothills paloverde, blue paloverde *(Cercidium floridum)*, velvet mesquite *(Prosopis velutina)*, catclaw acacia *(Acacia greggii)*, whitethorn acacia, and gray thorn (*Zizyphus obtusifolia)* constitute the dominant species in what are generally the areas of highest primary biomass in the Tumamoc Hill preserve.

For a full list of species located on Tumamoc Hill, interested parties are directed to the frequently cited Bowers and Turner (1985) paper. Between the 1909 and 1968–1969 surveys, only two species appear to have been extirpated at Tumamoc Hill. It seems likely that this high level of continuity would hold for the period from 1969 to the present as well; however, it is possible that a similar increase in invasive species as occurred in the rocky slopes/summit subregion may have occurred in the lower bajada/wash region and not been fully noted by more recent survey efforts.

Wildlife

In spite of rapid adjacent urbanization, Tumamoc Hill is still home to many desert animals. Mammals such as mule deer (*Odocoileus hemionus*), javelina (*Tayassu tajacu*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), and bobcat (*Lynx rufus*) are permanent residents of the hill, and an occasional mountain lion (*Felis concolor*) will make a foray onto the property. The site also supports populations of many smaller species such as black-tailed jackrabbit (*Lepus californicus*) and kangaroo rat (*Dipodomys* sp.). The annual migration route of numerous western birds crosses the hill and the region. Many transient species such as warblers and orioles can be found on the site in spring and autumn. Species frequently observed year-round include red-tailed hawk (*Buteo jamaicensis*), mourning dove (*Zenaida macroura*), Gambel's quail (*Callipepla gambelii*), and cactus wren (*Campylorhynchus brunneicappillus*) (Steadman 1980).

Prehistoric Character[1]

Chronology of the Prehistoric Occupations

In Arizona, Archaic hunter and gatherer sites are assigned to one of three periods within the Southwest Archaic tradition: the Early Archaic (ca. 7500–5000 B.C.), Middle Archaic (ca. 5000–1700 B.C.), and Late Archaic (ca. 1700 B.C.–A.D. 150). Middle Archaic period projectile points found at the base of Tumamoc Hill (Masse 1979:150) provide the first tangible sign of human use of the property. With little difference in the ecological setting between then and now, the animal and plant resources and the proximity to the Santa Cruz provided optimal resources for the mobile lifestyle of these less-than-sedentary people.

The term Early Agricultural (previously labeled the Late Archaic) best reflects the cultural setting between 2100 B.C. and A.D. 50. During this time, farmers irrigated fields of maize on the floodplain of the Santa Cruz River, planted on the lower bajada, and farmed at the mouths of watered canyons. They supplemented their diet with deer and other small game and wild plant foods (Ezzo and Deaver 1998; Gregory 1999; Huckell and Huckell 1984; Mabry 1998). Most individual settlements were small (with a dozen or so round or bean-shaped structures for both occupation and storage use), and even the irrigation communities may have been semi permanent, as locations shifted in response to rainfall patterns or river conditions (Wallace et al. 2007:49). Two-thousand-year-old corn was discovered on Tumamoc Hill during excavation of an area behind one of the trincheras walls in 1985 (Fish et al. 1986). The intensity of this early occupation of Tumamoc Hill was not recognized until 1998, when it was found that the previous discovery of early corn came from a small pithouse cut into terrace fill supported by the massive wall. In fact, some, and perhaps most, of the trincheras walls encircling the top of the hill and the upper slopes for a cumulative 2.3 km were built during the Early Agricultural period (pre–A.D. 50), making them the earliest known public architecture in Arizona (Fish 2005; Wallace et al. 2007).

The reasons for which early farmers chose to live on the hill and invest an unprecedented amount of labor in massive public architecture are still unclear. The first explanations for the walls focused on their defensive qualities (e.g., Huntington 1904, 1914). During the 1970s survey and analysis of the site, Wilcox (1979; Wilcox et al. 1979) developed and tested several hypotheses to explain the walls and concluded that only the morphological and spatial evidence supported the defense hypothesis. Reexamining the 1970s data and considering the frequency and distribution of projectile points as well as the data provided by recent excavations, Wallace et al. (2007) find support for a primary defensive function. Paul Fish and Suzanne Fish, on the other hand, argue that the low (at most knee-high) wall height, the presence of houses and gardens behind the walls, and the trails that provide passage through the walls support a broader set of functions, including specialized agriculture, communication, and ritual (Wallace et al. 2007). The presence of a spouted stone-tray fragment, polished-stone cruciform, and a clay figurine further denotes Early Agricultural period ritual activities. The similar hilltop sites in

[1] All measurements in the following discussion of the Prehistoric period are metric.

northwest Mexico suggest that Tumamoc Hill shared in a regionally widespread style of construction on elevated landforms in the Early Agricultural period (Wallace et al. 2007).

No substantial use of Tumamoc Hill has been documented for the time immediately following the Early Agricultural period. This apparent hiatus likely spans the Early Ceramic period (ca. A.D. 50–500). The Early Ceramic period is marked by the introduction of undecorated plain ware ceramics for storage, but house design, social patterns, and exchange and production systems appear little changed from the preceding period until about A.D. 450, when rectangular structures were added to the round and bean-shaped forms and then became the dominant design (Wallace et al. 2007:50).

Hohokam is the English pronunciation of Hu Hu Kam, a Piman word that means "those who are gone." The geographical extent of the Hohokam tradition coincides closely with the basic and persistent patterns of settlement and subsistence seen in the Sonoran Desert before the sixth century. For the purposes of this discussion, the Hohokam sequence is divided into the Preclassic (A.D. 500–1150) and Classic (A.D. 1150–1450) periods. The Hohokam aggregated into cohesive agricultural communities that occupied every hospitable niche within the Sonoran Desert. The term "community" refers to clusters of related sites centered on a large village with public architecture, surrounded by multifaceted agricultural systems and smaller sites strategically situated for acquiring natural resources. Material culture is similar to that found during the Early Ceramic period, but the hallmark artifact that distinguishes the Hohokam from previous groups is brown and buff pottery painted with elaborate red decorations.

Although it occurred just prior to the advent of red-painted pottery, the Tortolita phase (ca. A.D. 500–650 to 700) is considered by some researchers to mark the beginning of Hohokam culture. Settlements shifted from the floodplain to adjacent river terraces and occurred in many other settings as well. Trough metates and perhaps a new floury strain of corn were adopted. Pottery became more abundant and was used for cooking for the first time; a variety of forms proliferated, although most communities made their own pottery. In contrast, specialization appears to have developed for the production of shell and stone jewelry. Some population aggregation occurred, perhaps correlated with the expansion of existing canal systems and fields and the development of land tenure (Wallace et al. 2007:50–54).

During the Tortolita phase, a village in the larger end of the size spectrum for this time period was built atop Tumamoc Hill. Excavations in 1998 revealed that some of the circular rock enclosures atop the hill were Tortolita pithouses and some were nonresidential terraces. Excavation also exposed pithouses not visible on the surface (Wallace et al. 2007:47). As with the earlier trincheras walls and terraces, the Tortolita phase pithouses and smaller residential terraces in the village required substantial investments of labor for their construction. Most notably, the pithouses were "excavated into rocky soils and compact substrates; in many cases, retaining walls were built and fill dirt and rock imported to create enough level space for house construction and activity areas" (Wallace et al. 2007:56). It is unknown whether these Tortolita phase occupants added to the existing massive encircling walls or reused existing house pits. The full range of artifacts present suggests a substantial occupation. Wallace et al. (2007) argue that the artifact frequency is lower than what might be expected at a year-round village site. A large, well-constructed trail connects the summit to the adjacent St. Mary's site, AZ AA:16:26(ASM). Although the St. Mary's site appears to be primarily a Rillito to Rincon phase Hohokam site (ca. A.D. 850–1150), it may have been first settled during the Tortolita phase (Wallace et al. 2007).

The setting of the Tumamoc Hill village is unique, at least within the limits of current knowledge. No other known Tortolita phase settlement is on a hilltop, and no other is surrounded by massive walls. Tortolita phase occupations have not yet been identified (although they have not been conclusively refuted, either) at other hilltop sites in the region. Although at least some of the walls were constructed during the Early Agricultural period, the Tortolita phase inhabitants may have chosen the location for its defensive qualities. Wallace et al. (2007) suggest that the Tumamoc Hill archaeological site could reflect strife associated with population aggregation and intensified use of prime agricultural land. For example, the intensified agriculture may have cut

off hunting and gathering groups from traditional riverine resources, resulting in conflict between the farmers and more-mobile neighbors like that of the post-contact period. Farmers could have sought refuge on the Tumamoc summit during raids, until their attackers retreated. On the other hand, Fish and Fish (2007) suggest that the hill was the location of a specialized village and the scene of ritual activities. The wide trail on the north side, for example, provides easy access to the summit and would seem compatible with ceremonial processions. The unique diversity of pottery sources in Tumamoc Hill's Tortolita phase assemblages may reflect the congregation of people for trade, rituals, or other social interaction. By A.D. 700, residents had left the hilltop in favor of settlements on the Santa Cruz floodplain.

From A.D. 700 through 1450, Hohokam culture matured, dominated the Sonoran Desert, and then faded. Tumamoc Hill was surrounded by Hohokam villages, but the hill itself was not occupied as a living space. The largest Hohokam village in the immediate vicinity of Tumamoc Hill continued to be the St. Mary's site (ca. A.D. 850–1150). Years of urban development have obliterated most surface signs of the village, but its relevance to Tumamoc Hill can still be seen in the presence of an extensive 300-acre agricultural field that covers the west side of the Desert Laboratory property. This plantation remains in excellent condition today, with hundreds of terraces, rock piles, and roasting pits. Small Hohokam artifact scatters and isolated fragments of decorated Hohokam pottery indicate that people continued to visit and use the natural resources of the hill and surrounding land throughout the Hohokam Preclassic and Classic periods.

Figure 7. Terrace wall on the top west side of Tumamoc Hill.

Petroglyphs appear to corroborate the long-term use of the hill. Different degrees of patina and the superposing of elements indicate time depth (Ferg 1979). Spatial distinctions in design elements, with some designs concentrated near the Tortolita phase village on top and some concentrated near a Rillito-Rincon village at the base (Ferg 1979), may reflect differences in chronology or function.

Although currently the Tumamoc Hill archaeological site presents more questions than answers, the surveys and excavations conducted to date confirm the site's data potential. Detailed mapping has refined knowledge of the nature and distribution of features and artifacts visible on the surface; excavations to date have revealed surprising new data, and future excavations will answer some of the current questions about Tumamoc Hill and, no doubt, raise new ones.

Physical Characteristics of the Prehistoric Components

The Tumamoc Hill prehistoric components include masonry rock walls, houses, trails, bedrock milling stations, petroglyphs, and agricultural fields below the slopes to the west, which include rock piles, roasting pits, check dams, and water control features. Each feature type is described below.

Rock Walls and Terraces

Tumamoc Hill has "one of the most extensive, massive, and complex arrays of trincheras features in southern Arizona" (Wallace et al. 2007). The largest walls and terraces are concentrated near the summit, enclosing an area that measures nearly 2 hectares (Figure 7). Rock retaining walls that form smaller terraces are located in the residential areas of the summit. In the 1970s, the Arizona Archaeological and Historical Society (AAHS) mapped 16 separate walls with an aggregate length of about 2 km (Wilcox 1979:24); individual wall lengths varied between approximately 20 to more than 300 m. Heights averaged less than 0.5 m, but Larson (1972:96) suggested that some walls may have been originally as high as 1 to 2 m. Being

"revetment" like, the walls are much wider than tall; widths varied from 0.75 m to over 10 m, with most averaging over 3 m.

Between 2005 and 2007, the University's Archaeological Field School provided additional measurements (Christopherson et al. 2005). They recorded 43 massive terrace walls that ranged from 5 to 252 m long, with a mean of 56 m. Thickness ranged from less than 1 to nearly 9 m, with an average of 2.4 m. The discrepancies between the 1970s and present measurements probably reflect differences in measuring techniques, instrument precision (use of global positioning system [GPS] units and total stations), and even feature definition.

Trails

A system of prehistoric trails was recorded during the AAHS survey (Hartmann and Hartmann 1979). The "main trail," a 1- to 3-m-wide area cleared of rocks and bordered by piled boulders and rocks, leads from the summit down the north side (Figure 8). Hartmann and Hartmann (1979) traced the main trail across the flat summit to a large break in the wall at the northwest "corner" of the summit; from there, the trail descends almost directly down the north side, in contrast with historic wagon roads and the modern road, which zigzag back and forth. The trail, which provides relatively easy access to the summit, was still being used in the early twentieth century, but parts were destroyed by construction of the current road (Hartmann and Hartmann 1979:41). Wallace et al. (2007:78) note that the breadth, formality, labor-intensive construction, and high visibility of the main trail are compatible with ceremonial processions. Another trail, on the east slope, is up to 2 m wide, and for the most part ascends straight up the slope. Where it crosses rock walls, however, the trail becomes narrower, with an S-shaped curve, restricting or camouflaging access (Hartmann and Hartmann 1979:46). Other possible prehistoric trails are present on the eastern and southern slopes of the hill and in the flats around the hill base (Figure 9).

Rock Enclosures or Outlines

More than 165 stone outlines, typically between 1.7 and 5.2 m on the longest axis, have been recorded on Tumamoc Hill (Fish and Fish 2007). In the original study and prior to excavation, Larson (1979:71) notes that "the dry masonry construction was accomplished by simply piling the abundant basaltic rocks around the periphery of a small area to be cleared" (Figures 10 and 11). The rocks, ranging in size from a few centimeters to several tens of centimeters, were loosely piled to heights of up to 0.5 m; the average wall height is 0.3 m. The floors of the structures have varying amounts of windblown fill and a few

Figure 8. Prehistoric trail terminus at the top of Tumamoc Hill.

Figure 9. One of many trails in the lowlands of Tumamoc Hill.

loose rocks, although bedrock sometimes protrudes through the floor. Most of the outlines enclose rounded cleared areas, but some are rectangular. Sixty-five percent of the rock outlines abut other outlines, and are nearly contiguous. There are 22 groups, with as many as 10 circles per group (Figure 12). Contiguous clusters are often adjacent to areas cleared of rocks, possibly work areas (Larson 1979:75).

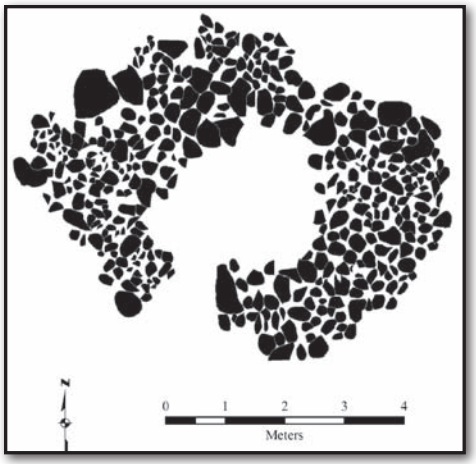

Figure 10. Drawings of each house were made by digitizing overhead photos taken from a camera mounted on a long pole.

Figure 11. General surface photograph of house in Figure 10.

Recent mapping projects have revealed a distinctive village layout. Unlike the later pre-Classic Hohokam courtyard groups, related sets of houses do not typically face a common open area; instead, many share walls in well-defined groupings, and the entrances face various directions (Fish and Fish 2007). In the original 1970s recording, the rock enclosures were inferred to be sleeping circles or brush shelter foundations. Recent excavations indicate that many of the enclosures are the remains of Tortolita phase structures, and other rock circles visible on the surface are small terraces considered to be contemporaneous. Diverse pollen and flotation remains indicate that use spanned spring through fall seasons (Wallace et al. 2007:76). Based on excavated pithouses, rock wall foundations of the Tortolita houses are estimated to have been knee high or so; burned daub found in burned structures indicates that the pole and brush superstructures of the pithouses were covered in mud.

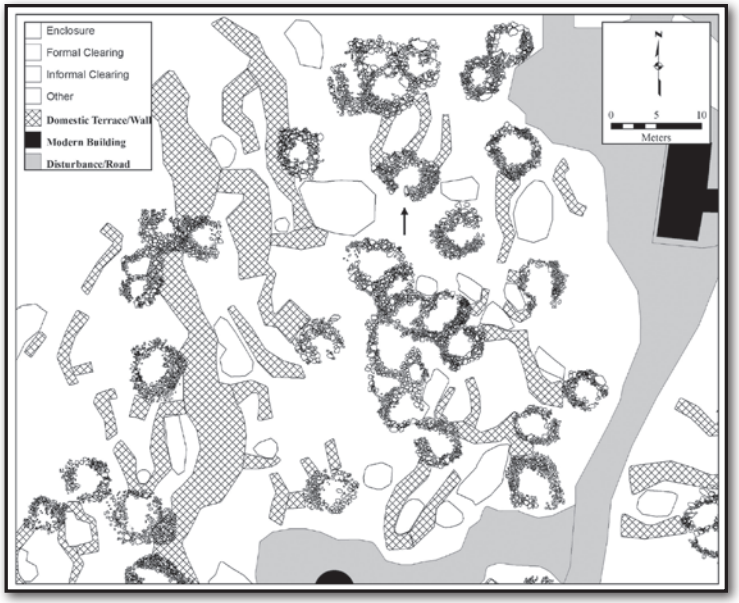

Figure 12. Instrument map of house clusters and cleared areas. The arrow in the center of the drawing identifies the house in Figure 10.

Bedrock Milling Features and Cupules

Thirteen bedrock metates (Figure 13) and 59 bedrock mortars (Figure 14) have been recorded within the Tumamoc Hill archaeological site, all on the summit and upper slopes. The mortars measure between 4.5 and 22 cm in diameter and between 1 and 15.4 cm deep. A ubiquitous distribution suggests

the mortars were utilitarian and were probably used to grind mesquite beans (Larson 1979:76–77) or palo verde beans (Wallace et al. 2007:Appendix 3.1).

The numerous cupules recorded on Tumamoc Hill are markedly smaller in diameter and depth and are occasionally spatially associated with petroglyphs, which suggest a non-utilitarian function (Figure 15). The cupules occur on slanted and vertical as well as horizontal surfaces, which would limit their usefulness for grinding. Two were incorporated into the design of a petroglyph, as though they were big round feet for a human figure. In one case, 13 cupules form an arc and may have been used in a game (Larson 1979:77).

Rock Art

One of the first systematic studies of rock art in the Tucson basin was Alan Ferg's documentation of petroglyphs on Tumamoc Hill (Ferg 1979:95–118). Ferg recorded 460 petroglyphs occurring in over 250 panels. Between 2006 and 2008, the area was re-examined by Gayle Hartmann and Peter Boyle and a team of recorders, Suzanne Fish, Paul Fish, and Gary Christopherson (2008). The team recorded 395 outcrops and boulders with 958 petroglyph elements. The larger number of elements, more than twice the number recorded by Ferg (1979), resulted from two factors: rock art that was missed during the 1974–1975 survey and, more importantly, graffiti that was not recorded during the 1974–1975 survey. Of the elements recorded by Hartmann and Boyle, 642 are prehistoric and 316 are modern graffiti.

Prehistoric petroglyphs are associated spatially with other features, such as trails, walls, and dry-laid enclosures, which suggests they served a decorative function or enhanced the secular features of their surroundings. Pecked motifs include anthropomorphs, footprints, insects, lizards, quadrupeds, and many geometric shapes, such as spirals, concentric circles, ladders, and squares (Figures 16 and 17). The pecked designs appear to be consistent with petroglyphs that have been defined as Hohokam elsewhere (Burton 1988; Hedges and McDaniel 1986; Martynec 1986; Thiel 1995; Wallace 1983; Wallace and Holmlund 1986). Spatial variations noted by Ferg in the clustering of element motifs may indicate functional or temporal differences.

The hill has a "scratched" style of Hohokam rock art (Figure 18), as well as the better known pecked style (Wilcox et al. 1979:189). Many of the scratched style designs consist of grids and diamond hachures; single or parallel and straight, wavy, or zigzag lines; chevron and nested chevron elements; triangles and hatched triangles pendant from lines; hatched bands; and concentric squares (Ferg 1979:97–99). The design elements appear to be reminiscent of motifs on Classic period Tucson basin red-on-brown pottery types (Ferg 1979:99).

Figure 13. An example of a boulder metate. Notice the desert vanish worn away by grinding.

Figure 14. A bedrock mortar.

Figure 15. An example of a boulder with cupules on Tumamoc Hill. Notice the patterning on lower right side of boulder.

Figure 16. Example of quadrupeds.

Figure 17. Example of geometric elements, particularly rectilinear designs.

Figure 18. Example of scratched designs.

Agriculture-Related Features

The western one-third of the property includes extensive dry-farming fields on the arroyo-dissected bajada of the Tucson Mountains. The fields are marked by rock piles, rock alignments, and check dams that were created to make use either of direct precipitation or runoff for agricultural purposes (Masse 1979:172; Fish et al. 2008). Within the fields are roasting pits and artifact scatters, differentiated by the number and variety of artifacts. Using arroyos as boundaries, Masse (1979) divided the bajada into six areas, numbered I to VI from north to south. Two soil horizons are visible on the surface: the light-colored Nickel Association, with numerous cobbles of rhyolitic tuff, and a darker Pinaleno-Palos Verdes Association, with little surface rock. Masse, who conducted the first systematic surveys of the Tumamoc Hill archaeological features on the bajada, found the largest and most complex dry-farming features in the rockier Nickel Association soils in the northern field areas (Masse 1979:143). Subsequent work, including that of the Tumamoc Hill Survey from 2005–2008, has corroborated the results of Masse's field mapping and identified additional dry-farming features outside the original six field areas (Allan et al. 2004; Estes et al. 2005; Fahrni and Twilling 2004; Fish et al. 2008; Hesse and Chenault 2003). The following paragraphs describe the various agriculture-related features identified primarily during Masse's survey and the 2005–2008 systematic investigations. Masse, of course, was limited by the current body of knowledge and the resulting range of interpretations that were available to him and his contemporaries. Parallels between Masse's 1970s descriptions of prehistoric behavior associated with certain features can sometimes, but not always, be drawn with those proposed in the investigations conducted between 2005 and 2008.

Figure 19. A typical prehistoric rock pile within the Tumamoc Hill agricultural fields.

Rock piles. Thousands of rock piles have been recorded throughout the bajada, at the foot of Tumamoc Hill and in the Silvercroft Wash floodplain. Rock piles exhibit a great range of morphology, from small clusters of a few cobbles to mounds several meters across and up to half a meter high, with hundreds of stones. On average, the piles are 1 to 2 m across and composed of a jumble of cobbles from 3 to 60 cm in diameter; the average cobble size is between 10 and 15 cm. Masse hypothesized that the crops were planted in the cobble-free areas between rock piles, but research in the northern Tucson basin (e.g., Fish et al. 1985; Fish et al. 1992) has

shown that agaves and possibly other plants were planted within rock piles. The rock piles act to conserve moisture and to protect the young roots from rodents. The different shapes and sizes of the rock piles within the site, however, may reflect a variety of functions.

Figure 20. This rock alignment, which extends across the slope, retains soil and moisture. Check dams are similar in appearance to this, but block small drainages.

Rock alignments. This category includes contour terraces, channeling borders, and miscellaneous alignments. Contour terraces are long stone alignments built across hillsides to retain soil and capture slope wash; they are distinguished from check dams by being sited away from intermittent drainages. More than 30 contour terraces were recorded on the southern slope of Masse's Bajada Field I; they usually occur in parallel rows on slopes of 6 to 12 degrees. While contour terraces are up to 150 m long and up to 4 m wide, most are less than 75 m long and not more than 3 or 4 stones (about 0.75 m) wide. In this class are "bordered gardens," defined as rectangular garden plots bordered by rock alignments on three or four sides; one is present on the northern slope of Bajada Field II, and others are on the southern slope of Bajada Field I (Masse 1979:169). The two garden plots enclosed in Bajada Field II are about 25 m long; one is 14 m wide, the other, 8 m wide. The rock alignments bordering the gardens are about 0.75 m wide.

Check dams. Check dams were built to capture sediments and moisture moving through channels and swales down the slopes. Check dams can be found as single isolated features, but they usually occur in a series, i.e., in parallel rows of stone placed across a channel. Masse recorded two series of check dams (1979:168–169). One series is composed of seven check dams, each 10 to 15 m long, 0.75 m wide, and 2 to 3 stones high, spaced about 6 to 8 m apart in a small drainage. The other series consists of nine dams in two separate small drainages a few meters apart; eight of the dams are 5 to 6 m long, 0.75 m wide, and spaced an average of 4 to 5 m apart, but one long check dam bridges both drainages. Masse noted the presence of another series of dams in Bajada Field I and considered additional dams likely. Field inspections by Allan et al. (2004), Estes et al. (2005), Fish et al. (2008), and Hesse and Chenault (2003) have confirmed the presence of other check dams.

Thermal features. Within the agricultural fields are a number of large features identified by a mounded appearance, ashy soil, and fire-cracked rocks. These areas are identifiable by the often highly dispersed and darkened soil resulting from ash produced during repeated thermal events. Other diagnostic characteristics are ubiquitous fire- and heat-altered rocks and the presence of both ceramic and lithic artifacts. Excavations of nearly identical features in other areas of the Tucson basin have demonstrated that their primary function was to roast agave hearts. Roasting pits at Tumamoc range in size from 10 to 20 m in diameter and up to 50 cm high. No roasting pits on Tumamoc Hill have been excavated, but pits elsewhere can range from 1 to 2 m deep and contain stone tools and pottery, charred fuel woods, and often charred agave leaves. Masse identified only one roasting pit during his survey and classified it as one of his "limited activity areas," i.e., as a light artifact scatter thought to be the remains of short-term plant procurement and processing (Masse 1979:154). It may also be that some features he identified as hearths are, in fact, roasting pits.

Artifact Scatters

Small concentrations of artifacts are found throughout the Tumamoc Hill Archaeological District. As stated above, Masse (1979:151–154) separated such scatters into "processing sites" and "limited activity areas." As delimited by Masse, a limited-activity area could include possible hearths, a petroglyph, and a masonry structure. His processing sites on Tumamoc Hill, on the other hand, in brief, are identified as containing fragments from at least three ceramic vessels (with bowls and jars equally represented), flaked stone debitage, a few formal flaked stone tools, and no ground stone or shell.

Today's refinements in feature typology identify these same features primarily as flaked stone procurement and reduction areas. Masse recorded seven of them. Decorated pottery at all seven loci was "stylistically transitional between Rillito Red-on-brown and Rincon Red-on-brown (ca. A.D. 850–1000)" (Masse 1979:151). Masse (1979:154) additionally recorded 15 light artifact scatters and interpreted them as being the remains of short-term or "limited" plant procurement and processing sites. Twelve of the limited-activity areas consist of a few sherds from one or two vessels and a few pieces of debitage. Two consist of debitage and tools with no ceramics, while one consists of ceramics with no lithics.

Characterizations of these features today describe some of them as being several meters in diameter. Within some of them, large andesite cobbles were reduced to produce expedient tabular knives, presumably to process the agaves growing nearby. Several sherd scatters are associated with activities such as pot irrigation or carrying water. All the isolated features and artifacts are associated with agricultural pursuits.

Eleven additional loci are considered to be limited-activity areas, although five occur outside of Masse's dry-farming areas and two are chipped-stone quarries apparently unrelated to farming. Two were recorded by Harris Environmental Consultants (HEG); one had a red-on-brown sherd, 10 plain sherds, two flakes, and a basalt chopper, the other had 10 plain sherds and a flake (Fahrni and Twilling 2004). Six limited activity areas were recorded by William Self Associates (WSA) during investigations for the Kinder Morgan pipeline replacement project (Allan et al. 2004; Estes et al. 2005). Three of the six are composed of flaked stone; of the three, one has more than 100 flakes; one has roughly 100 flakes and a core; and one has about 20 flakes, a core, and a hammer stone. The fourth limited-activity area WSA recorded has 12 sherds, four flakes, a tabular-knife fragment, and a circular scatter of rocks. The fifth is a roasting pit, 20 m in diameter, with four sherds, and the sixth consists of two sherds, five flakes, and two minimally used roasting pits that were revealed in the side walls of a modern gasoline pipeline trench. In the same way that the petroglyph and the masonry structure are problematic to include in the limited-activity category, so is the roasting pit.

General Artifact Scatter. All the prehistoric components of the Tumamoc Hill Archaeological District (from the massive trincheras to the smaller flaked stone procurement and reduction areas) are linked by a general artifact scatter. It is impossible to walk anywhere in the area without seeing isolated artifacts. Nine lithic tools found in the bajada field areas were attributed to the Archaic period: three Middle Archaic projectile points, one Late Archaic or Early Agricultural projectile point, four unifacially retouched flakes, and one biface (Masse 1979:149). In their 200-foot-wide survey transect across the property, WSA counted isolated artifacts and reported two tabular knife fragments, 10 plain sherds, and 65 flaked stone artifacts (Estes et al. 2005). In a 5.7-acre survey in the northern portion of the site, mostly within the floodplain of Silvercroft Wash, HEG recorded a basalt chopper and five flakes (Fahrni and Twilling 2004). Fish et al. (2008) noted a fairly even and continuous light blanket of flaked stone tools, with occasional pottery fragments, over the entire property.

Historic Components of Tumamoc Hill

The hill's evidently long and varied use was certainly not suspended during the Spanish-Colonial or Mexican periods, although there is no direct evidence of use. The first recorded use was in 1862 or 1863, when a soldier in Company C, 32nd Infantry, inscribed his name and company on a rocky outcrop on a west-side bench. Later inscriptions include names, dates, and musings of more recent Tucson residents. Continued sporadic American Indian use of Tumamoc is suggested by an 1883 *Arizona Weekly Citizen* report that the "south side of the mountain [Tumamoc Hill] is said to contain many graves of Apaches and Papagoes" (*Arizona Weekly Citizen* 1883). As a local landmark that attracted people, the hill continued to serve economic and symbolic functions into the nineteenth and early twentieth centuries. The continued multiple functions of Tumamoc Hill are reflected in the stone quarries and clay pits that provided symbolic, physical, and economic contributions to the creation of the modern city of Tucson.

Several newspapers of the 1880s and 1890s mention various uses for the quarried stone from the hill. The majority of these statements consist of one or two sentences that declare that there is a superior-quality stone being taken from the Tucson quarry west of the city. A few mention that the stone is being used for the façades or foundations of houses. Most of these accounts unfortunately do not mention any specifics of the stones' origins. One account, however, does state, "In 1883, the towers [of St. Augustine] were built of stones from the quarry on the southwest side of Sentinel Peak and the new cathedral was built also of stones from this quarry" (Rosettie 1964). The account does not mention from whom the stone was purchased, but the geographic and temporal description suggests the Valencia/Tully quarries on Tumamoc Hill rather than Sentinel Peak.

Besides newspaper articles, only one report, from 1916, makes any mention of quarrying in Tucson. This report states that light volcanic rocks of tuff, andesite, and rhyolite were quarried from a place near Tucson and that another quarry was 6 miles southwest of Tucson (Culin 1916). As an aside here, the Culin report also states that the value of rough, uncut volcanic rocks was 20 cents for each cubic foot in 1916. Because of the lack of historical documentation, definitive estimates for how long these quarries were operated and by whom are not possible; at any rate, in 1903 the purchase of Tumamoc Hill by Carnegie effectively ended the quarry operations on the hill.

The presence of stone foundations, artifacts, and distinctive features at the historic quarries suggests that these loci could provide important information about the extractive activities taking place on the hill in the late nineteenth and early twentieth centuries. Historical archaeology provides a perspective that is not available in the documentary record. When combined with archival information, the study of the features and artifacts left behind at Tumamoc Hill can provide information about working conditions and the workers' daily lives and social status.

In the late nineteenth century, fired bricks were considered a more modern material than the adobe of traditional Tucson and were thought more suitable for large commercial and public buildings. Diehl et al. (1996) note that the popularity of bricks coincided with a turn-of-the-century trend to "easternize" Tucson, i.e., to copy the styles and materials of the established cities of the East Coast. Two clay pits were dug at the western base of Tumamoc Hill to serve as a source of clay for fired bricks (Elkins et al. 1982:55–56). The pits and haul road within the site may have served brick yards between the river and the east side of Tumamoc Hill. The ages of these pits are in question but it seems unlikely that Carnegie would have allowed such uses on their leased state lands. During Forest Service tenure of the land (1940–1960), the agency maintained a liberal multiple-use policy that resulted in numerous leases. It seems more likely the pits were in use during this period. There are no kilns on the property, but misfired and damaged bricks were brought back to the property and dumped and used to shore up wash crossings. The bricks in the dumps are mainly a type used in the 1950s and 1960s. More research is required to determine the significance of this specific resource.

The Carnegie Era

In 1901, Dr. F. V. Coville, chairman of the Advisory Committee on Botany to the newly formed Carnegie Institution in Washington, D.C., proposed a desert laboratory. The purpose of the laboratory was to provide facilities for the investigation of all facets of desert plant life and to determine the differences between desert vegetation and more tropical plants. Coville argued that the development and success of arid-land agriculture and pure scientific research hinged on this first desert laboratory. As a result of Coville's proposal, a grant was established for a desert laboratory, and Coville and Dr. D. T. MacDougal were directed to search for the most advantageous site for the new laboratory. They chose Tumamoc Hill after an extensive survey of New Mexico, California, and Arizona. The natural and artificial advantages that led to the choice of the Tucson property were that the area had unique desert vegetation, the town was of a sufficient size and had a train stop, and the University had a growing agricultural program.

In 1903, with the site designated, Carnegie appointed the first resident investigator, W. A. Cannon, and hired a small staff. The Tucson Chamber of Commerce donated the Tumamoc Hill site, water supply, road, and electrical hookup. Construction was started on the first building, about halfway up

the 700-foot hill. The L-shaped building of volcanic rock was built from stones removed from the hillside and carted to the building site by mule-drawn wagons. The building's designer was S. F. Forbes of Douglas, Arizona, who had been recommended by his brother, R. H. Forbes, a professor of desert botany at the University. David H. Holmes, who taught at the University and was the architect of many buildings on the University campus and in Tucson, supervised the construction. The laboratory was considered noteworthy for its ventilation system of intake vents on the soffit of the roof eaves and exit vents in the form of dormers and a hip ridge.

The first years of the Desert Laboratory were very busy, and at least five major research papers were written at the laboratory between 1903 and 1904. In 1905, Carnegie organized a Department of Botanical Research, designating MacDougal, then the director of New York Botanical Laboratory, as the director of the Desert Laboratory, the headquarters selected for the newly instituted department. The new program, coupled with the lab's successful first years, led to a recommendation for the expansion of facilities and staff in September 1905. Among the new hires was Godfrey Sykes, an Arizona resident and personal friend of MacDougal's; Sykes was hired as the facilities and maintenance director.

In 1906, the laboratory acquired land through leases and purchases, increasing its land holdings to more than 800 acres. A building extension, started that same year on the east end of the existing laboratory, doubled the size of the facility and created a south-facing U-shaped building. Holmes, who had managed the construction of the original section, designed the addition. The contractor for the addition was F. M. Welsh of Tucson. The building, which then measured about 126 feet long and had 85-foot wings, was consistent in style and materials, giving the building a unified character. The discerning eye will identify the juncture between the 1903 building and its 1906 extension. The roof of both the old and new sections was covered with slate shingles at the time of this construction. The laboratory now contained a library and reading room, a drafting room, a photographic darkroom, and general laboratory and office space. The building also contained a chemical room with hoods, a subterranean constant-temperature chamber, and a structural roof platform for meteorological instruments. A greenhouse was started on the southeast end of the addition but was not completed until 1907.

By 1906, improvements to the laboratory included the addition of two reservoirs and a 5-mile-long wood post fence around the entire 800-acre site to keep out grazing animals that were disturbing the experimental plots. A reservoir to retain rainwater runoff from the roof of the main laboratory was built just to the south. Gutters and leaders were installed on both sections of the building and were connected to the reservoir. The collected water was used for a variety of purposes. The second reservoir was built on the hill above the laboratory. This reservoir was supplied with water pumped up from the Santa Cruz Valley from a well dug for the Desert Laboratory. It took 7,000 feet of pipe to connect the well to the reservoir.

In 1908, Dr. Forest Shreve and his wife joined the staff. That same year, a second building, a workshop designed by Sykes, was constructed at the base of the hill; again, F. M. Welsh was the construction contractor. Methods similar to those used in the construction and in the ventilation system of the main laboratory were employed on this 20 × 40–foot workshop. The walls were of double brick with a volcanic stone exterior surface; some reported that the wooden floors were built with "extra rigidity." The roof was covered with slate shingles and had a ventilating-ridge roll. A full complement of tools was installed, and the lighting was designed especially for the equipment used. A second reservoir was added to the main water system between 1908 and 1911 to provide water to the shop and the "adobe laboratory" and experimental fields near St. Mary's Hospital.

For the stone and concrete work for the construction of the laboratory's third stone building, F. M. Welsh was again hired in June 1914. A second contractor, J. Chapman of Tucson, was also hired to work on the building. The original designer is not known; what is known is that Sykes made alterations to the plan. The building, southeast of the main laboratory, was 46 × 28 feet, with exterior walls of volcanic rubble stone, lined with structural brick. The building was designed as a chemistry laboratory and was equipped with water, gas, air, AC and DC current, vacuum, and large fume hoods. The roof was used for solar experiments and had a flat insulation deck, measuring 30 × 25 feet, made of lead. The remainder of the roof was covered with tar paper.

Dr. A. Spoehr moved to Carmel, California, in 1921, and the equipment from the chemistry laboratory was removed and sent to California to aid Spoehr in his research (there is no record of how the chemistry building was used after 1921). On 6 November 1938 at 1:30 AM, a fire broke out in the chemistry building. Before the fire was extinguished, most of the building was destroyed, except the rock and brick walls. The building remained in disrepair until the Forest Service bought the property in 1940.

Other changes to the building that were completed in 1921 include painting and woodwork maintenance and replacing the wooden sidewalks with tile at the main building. In the 1930s, a natural gas pipeline was installed.

In the years between 1903 and 1937, the Desert Laboratory was extremely active. During this time, one of the main researchers was MacDougal, who was affiliated with the laboratory until its close. Spoehr worked at the laboratory from 1910 to 1920 and researched the biochemistry of plants. Dr. McGinnies worked for Carnegie from 1910 to 1932 and later was affiliated with the laboratory through the University. Dr. Cannon worked from 1903 to 1938. Carnegie supported Shreve, even after the close of the Desert Laboratory, until his death in the 1950s. Sykes, who was instrumental in the success of the laboratory, retired in 1929. Besides the work done by these men, about 40 men and women worked between 2 and 12 months, and several hundred scientists from all parts of the world visited. In 1938, due to economic problems, however, the Carnegie funding was drastically cut and only a small staff, under the direction of Shreve, remained. In 1940, Carnegie donated the Desert Laboratory to the Forest Service.

U.S. Forest Service Management

In June 1941, the Southwestern and Rocky Mountain Forest and Range Experimental Station moved to the Desert Laboratory. The property had been known locally as Tumamoc Hill, a Piman word for horned toad (To-ma-mock), a desert reptile of Arizona that was common to the hill. That name had seldom been used while the property was the Carnegie Desert Laboratory, but the Forest Service quickly adopted the name.

After taking possession of the land, the Forest Service began making improvements to the property, including widening the road up the hill, replacing boundary fences, and adding evaporative coolers to the buildings. Major improvements included rebuilding the interior and roof of the chemistry building, which had been gutted by the 1938 fire, and adding several new buildings, including a Santa Fe–style 37 × 45–foot rectangular building of volcanic rock, with concrete floors and a flat parapet roof. The Forest Service used the building for office space. The Research Foundation of New York, in collaboration with the Forest Service, erected two metal buildings near the chemistry building in 1940–1941. They also improved the water system and added power lines. The metal buildings are in use today. A small fire lookout was erected on the southeast side of the summit sometime between 1940 and 1961. The Forest Service also entered into lease agreements with at least 21 companies that represented communication, power, and petroleum interests and allowed clay mining on State Trust lands inside the boundary of the Desert Laboratory.

The Southwestern and Rocky Mountain Forest and Range Experimental Station used the hill as its headquarters until September 1953, when the organization was consolidated under the name Rocky Mountain Forest and Range Experimental Station and moved its headquarters to Fort Collins, Colorado. The Rocky Mountain Forest and Range Experimental Station continued to use only one of the Desert Laboratory buildings after this consolidation; the other buildings remained empty until 1956. In 1956, the University leased the buildings on the hill for use by the Geosciences Department, College of Earth Sciences.

University of Arizona Management

In 1960, the University purchased the Desert Laboratory for $140,500, with the provision that one building was to remain as offices for the Rocky Mountain Forest and Range Experimental Station. The University's Department of Geosciences has used the buildings for offices and research space and conducted in-depth biological research from the hill since that time. Observatories were constructed in 1962 and 1967. In the early 1960s, the U.S. Marine Corps constructed a small amphitheater and improved roads within the site. The large clay pit in the southern part of the archaeological site was used as a trash dump from 1962 to 1964.

The Desert Laboratory is important because it is the first center for the study of desert plant ecology and because of the outstanding scientists who paved the way for further development in the study of plants and ecology. The Desert Laboratory was designated an NHL in 1965, was registered in 1975, and is now listed in the NRHP. In 1981, the complex was designated a State Natural Area by the Arizona State Parks Board.

History of Land Ownership

1902–1903

Carnegie archives and local title records give a complete record of Tumamoc Hill land ownership. On 18 March 1903, the Carnegie Executive Committee authorized the Desert Laboratory Advisory Board (Coville and MacDougal) to secure the NE ¼ of the NW ¼ of Section 15, Township 14 South, Range 13 East (a total of 40 acres) for a desert laboratory. The deed was transferred from the Aztec Land and Cattle Company directly to Coville and MacDougal. As Agents of the Carnegie, they transferred the land to Carnegie through a Bargain and Sales Deed. The purchase was made possible through a cooperative arrangement with the City of Tucson Chamber of Commerce.

1905–1940

The sale of the SW ¼ of Section 15, Township 14 South, Range 13 East (a total of 160 acres) to Carnegie has a bit more history. On 17 March 1880, Pinckney R. Tully purchased the quarter section from Antonio Valencia for $500. Valencia was possibly the owner/operator of the original quarries in this section before 1880. A Tucson city directory for 1900 lists Valencia as a miner who resided at 254 North Meyer Street. He lived with Alcario Valencia, who is listed as a teamster. Stone structures and trash deposits on Tumamoc indicate that these workers may have lived on the hill at least part-time (Wilcox and Larson 1979:7). A reporter for the Tucson Citizen wrote that in the 1880s, "volcanic rock was quarried from the south and northwest slopes [of Tumamoc Hill] by Mexican teamsters for houses and apparently is the source of walls surrounding the older part of the University of Arizona campus" (Lee 2003). The land stayed under the ownership of Tully until 23 May 1905, when John W. Bogan, treasurer and ex-officio tax collector for Pima County, sued Tully (presumably for back taxes owed), and the land was handed over to the sheriff on 19 June 1905, to be sold at public auction. Nabor Pacheco, sheriff of Pima County, sold the quarter section to N. E. Plumer, Trustee, for $120.83. On 22 September 1905, Plumer sold the land to Carnegie for $1.

In a letter dated 26 September 1905, W. A. Cannon, Resident Investigator, Desert Laboratory, informed MacDougal at the New York Botanical Garden that he had secured control of laboratory lands. Cannon indicates he secured the E ½ of Section 16, Township 14 South, Range 13 East. (A map of the grounds prepared in November 1905 by W. B. Alexander, Pima County Surveyor, indicates the 320 acres in Section 16 was land controlled by the County Board of Supervisors.) Cannon goes on to mention that the "lease to the lands secured through the University of Arizona will be made at the next regular meeting of the Board of Regents, Oct. 10th [1905]." The University lands included the S ½ of the SE ¼ of Section 9; the S ½ of the SW ¼ and the SW ¼ of the SE ¼ of Section 10; the W ½ of the NW ¼ and the SE ¼ of the NW ¼ of Section 15, all in Township 14 South, Range 13 East. Cannon also notes

he was securing a lease on the west 20 acres of the NW ¼ of the NE ¼ of Section 15, Township 14 South, Range 13 East. Sometime before 20 October 1906, these University lands were secured by Carnegie through a lease.

Other important lands secured by Cannon by November 1905 include the lease of the W ½ of the NW ¼ of the NE ¼ of Section 15, Township 14 South, Range 13 East, from Thomas Kurtz. This quickly turned into a Quit Claim Deed from Kurtz and wife to Carnegie as suggested by a list of deeds dated 20 October 1906.

Three additional properties outside the core area were controlled by Carnegie by 1906: a 50 × 150–foot lot for a well site in Menlo Park; a 22.37-acre lot located south of St. Mary's Hospital with a well and pump shed that was first leased and then purchased from Fred J. Steward in 1921; and a 2.342-acre lot on Silverbell Road that contained the Office (Adobe Laboratory), automobile shed, and plant shelter. This last lot was identified as Lot 8 in Block One in the McKee Addition and was deeded to Carnegie by Frank G. McKee in 1906.

By 1906, Carnegie had secured ownership of 220 acres on Tumamoc Hill and controlled three smaller satellite properties. Carnegie also secured control of 640 acres of Territorial lands through two leases. The territorial lands included 320 acres of "school lands" from the Pima County Board of Supervisors and 320 acres of "university lands" from the ABOR. With statehood on the horizon, Carnegie feared 1912 might bring an end to their control of leased territorial lands, which contained a decade of "experimental scientific settings" and a shop building. Carnegie pushed hard with friends in Congress, the Arizona state legislature, and Tucson Chamber of Commerce to ensure that the 640 acres of territorial lands remained in their possession. An attempt to purchase the leased land waned as the fledgling state sorted through their responsibility to lands now subject to enabling legislation. Maintaining the 640 acres through state leases appeared to be the only option, and on 8 January 1914 the Carnegie Institution entered into a new lease with the State Land Commission entitled *Lease on School Lands or University Lands L 01 (University).* This lease covered the 320 acres originally secured from ABOR. On 18 May 1914, a second lease entitled *Permit to Occupy School Lands or University Lands—Held under Lease at the Date of Arizona's Admission to Statehood RP-a174* was initiated for the lands secured in 1905 from the Pima County Board of Supervisors.

1940–1960

In June 1940, Carnegie sold the Desert Laboratory to the Forest Service for $1 after the University declined the transaction. The transfer included 245 acres of land owned by Carnegie and 640 acres of leased State Trust land. Between 1940 and 1958, the Forest Service sold about 16 acres of oddly shaped parcels surrounding St. Mary's Hospital. These were formally Carnegie Institution–deeded land. A land exchange with the state land commission resulted in the Forest Service acquiring 120 acres in the SE ¼ of the NW ¼ of Section 15; the SE ¼ of the SW ¼ and the SW ¼ of the SE ¼ of Section 10. The two Carnegie State Trust land leases were integral parts of the land donation.

1960–present

On 6 July 1960, A. W. Greenly, Acting Chief of the Forest Service, sold the Desert Laboratory to the ABOR for $104,500.00. The total area of sale included 349.41 acres of federal land, together with improvements. The conveyance also required the continuation of 21 existing leases with outside parties These included seven electrical transmission rights-of-way, four gas pipelines, four radio towers, four radio towers with electric or communication easements, one road, and one exposure test site.

The sale of the Desert Laboratory to the ABOR came with deed restrictions regarding the sale and use of the land. In 1976, the board wanted to exchange lands with St. Mary's Hospital and the City of Tucson. Arizona Congressman Morris K. Udall sponsored H.R. 14227 during the 2nd session of the 94th

Congress which released 9.41 acres for sale or exchange. In 1977, the Secretary of Agriculture, under the provisions of Public Law 94-139, authorized an additional 3.341 acres to be sold or exchanged. During these negotiations, the University acquired 6.536 acres of land from St. Mary's Hospital south of Anklam Road (on file, Carnegie files, ASM archives). By 2008, the ABOR controlled 12 parcels of land totaling 854.06 acres. Eight of these parcels (totaling 345.27 acres) are owned by the ABOR on behalf of the University. The remaining four parcels are owned by the ASLD. The ABOR, on behalf of the University, leases three of these parcels from ASLD under Commercial Lease 89-98103 and Institutional Taking No. 92-98103 (196.63 acres) and maintains a Special Land Use Permit with ASLD on an additional 312.16 acres under Permit No. 23-98104 (on file, ASM archives).

Physical Characteristics of the Historic Components

Historic Features of O'odham Origin

Talus Pits

A talus pit is defined as "an open pit caused by the removal of loose rock from hillside talus slopes" (Wallace 1983:198). All but two of the 150 talus pits recorded on Tumamoc Hill occur in two concentrations, located on the northern and western slopes of the hill, within rocky basaltic andesite talus slopes. One cluster contains 53 pits, the other, 95 pits. The talus pits are typically 0.5 to 1 m deep and 1 to 2 m across; evidence of pit wall collapse suggests that some of the pits may have been originally slightly deeper and steeper sided (Figure 21).

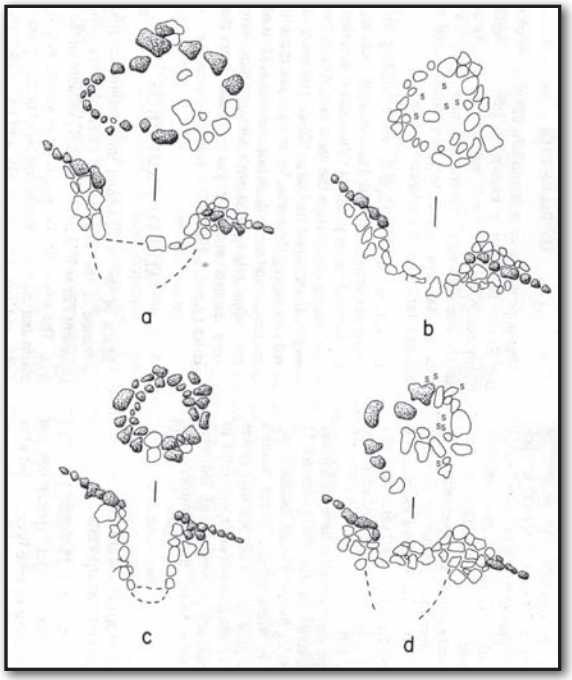

Figure 21. Aerial and side view drawings of talus pits.

Twenty-eight plain ware sherds were found in the north slope concentration, most wedged in the inner walls of the pits. One Cañada del Oro or Rillito Red-on-brown sherd was found inside one pit, suggesting a Pioneer or Colonial period age, ca. A.D. 500–900. Plain ware sherds were also found in and around the pits on the west slope, and sherds from a shouldered Rincon Red-on-brown vessel were found nearby, suggesting a Sedentary period date, ca. A.D. 900–1150 (Hartmann and Hartmann 1979:59–60). Fourteen percent of the talus pits recorded by the University Archaeological Field School had plain ware sherds of possible O'odham origin (Howell 2007). A number of talus pit sites have been documented on other inselbergs throughout southern Arizona (Madsen 1993). Pits are typically clustered together on talus slopes, and in a majority of instances, they contain broken Piman plain ware pottery that clearly postdates the Prehistoric period.

Because the talus pits on Tumamoc Hill are in close proximity to early trincheras features and contain Hohokam pottery, a prehistoric component cannot be ruled out. However, they likely postdate the prehistoric components because of their strong resemblance to the many similar-looking late talus pit sites elsewhere.

In the original archaeological evaluation of Tumamoc Hill, Hartmann and Hartmann (1979) suggest the pits were possibly created for storage or used as hunting blinds. Howell (2007) suggests the Tumamoc talus pits might be the locations of O'odham graves, based on research by Madsen (1993) near Cerro Prieto. Madsen thought talus pit clusters near Cerro Prieto might be cemeteries, based on the early work of Underhill (1939). Underhill documented an O'odham practice of burying the dead in crypt-like graves in hills near their villages. To make a grave, rocks were removed from a talus slope first; the body was then placed in the pit, along with plain vessels and

perhaps some of the deceased's personal property. The grave was then covered with wooden planks, ocotillo stems, or saguaro ribs, and rocks were piled on top to discourage scavengers. Careful mapping and excavation of some pits at Cerro Prieto produced broken bowl and jar fragments, but there was a complete absence of human remains, leading to uncertain conclusions.

No burials have been discovered at Tumamoc Hill, but in 1883, the *Arizona Weekly Citizen* reported that the "south side of the mountain [Tumamoc Hill] is said to contain many graves of Apaches and Papagoes. In the vicinity is a cave where Papagoes once laid away their dead" (*Arizona Weekly Citizen* 1883). The last reported attempt to bury someone on Tumamoc Hill was in the 1930s, when the Sheriff responded to a report of an O'odham family burying a child on the hill (personal communication, Peter Steere, August 15, 2007). The connection between the two talus pit clusters on Tumamoc Hill and the 1883 and 1930s reports merits further study because nineteenth- and early-twentieth-century hillside graves of O'odham origin are significantly larger than any of the talus pits on Tumamoc Hill. The full nature and extent of talus pit clusters on Tumamoc Hill will never be known because stone quarry operators removed significant portions of the talus slopes for building materials during the late nineteenth century. These historic stone extraction areas extend into the talus pit clusters.

Historic Resources of Euro-American Origin

Structures

Five historic structures have been identified within the Tumamoc Hill archaeological site. Structures 1 and 2 were recorded by Masse (1979:148) as small rectangular structures, located between 1 and 2 m above the floodplain of Silvercroft Wash against the slope of Tumamoc Hill. Structure 1 measured 2 × 3 m, and Structure 2 measured 2.5 × 3.5 m. Both were constructed from local unmodified chunks of basaltic andesite. At the time Masse recorded these two structures, the walls were standing to a height of nearly 1 m. No artifacts were noted around either structure. Both Structures 1 and 2 were modified by homeless individuals before 2008. Because no drawings or photographs exist from the original recording, the extent of modification is unknown.

Structure 3 (Figure 22) is located on a ridge that extends north below the Desert Laboratory. The structure was identified as part of Hartmann and Hartmann's Historic Component 1 in their trail survey (1979:42, 45). Its proximity to a historic road that leads to a rock quarry suggests it is related to that activity. The structure consists of a loose-laid rectangular foundation of local rock, with an opening on the north side. The foundation measures an estimated 6 × 9 m; a partial central wall divides the structure into two rooms. White glazed earthenware, sun-colored amethyst glass, and lead-seamed cans indicate an early-twentieth or late-nineteenth-century date. Other artifacts include wire nails, glass canning jar fragments, historic O'odham sherds, metal strapping, and a metal oil or gas can.

Figure 22. The square outline of the stacked field stone of Structure 3 is visible in the center of this plate.

Structure 4 is a small rectangular house, measuring 3 × 4 m, with single-course rock walls standing to over 1 m (Howell 2007:3). There is an opening on the west wall. Artifacts at the structure include a white glazed metal wash basin, cooking pot, tin cans, glazed ceramic dish fragments, and glass jars.

Structure 5, located on a small bench on the western slope, is an alignment of small to large boulders outlining a 3-m square within a larger cleared area. A pile of rocks at one end may have

Figure 23. An early wagon road on the western slope made by removing rock down to white hardpan.

Figure 24. The continuation of the haul road shown in Figure 23 but simpler in construction.

Figure 25. Horse and mule shoes are associated with most haul roads.

served as a fire ring or chimney. There is a rock cairn about 15 m to the south. This structure is located at the end of an old road or trail, not far from quarry areas. Artifacts noted in the vicinity included a sardine can and a can lid. There is a 1860s military inscription and scratched glyphs 20 m to the west. The structure may have been a sentry post related to military use or may have sheltered miners excavating at the nearby quarries.

Roads

There are numerous historic roads within the Desert Laboratory. Masse (1979:147) recorded six wagon/automobile roads west of Tumamoc Hill and Hartmann and Hartmann (1979:42, 45–49) noted traces of historical roads on the slopes of Tumamoc Hill as they mapped prehistoric trails. Between 2005 and 2008, the University Archaeological Field School confirmed the locations of these roads, found many more, and documented their locations.

Based on associated trash, Masse (1979:147) inferred that three roads west of Silvercroft Wash date from at least as early as 1890 to 1910; one is visible in a photograph of the area taken before 1909. Some of the wagon roads to the quarries required significant construction. One wagon road on the northern slope was constructed with a dry-laid rock retaining wall several hundred feet long and between 2 and 8 feet high (Howell 2007:4). On the western slope of Tumamoc Hill, surface rock was removed to expose hardpan. It appears the purpose was to make a smoother surface for the haul road to the quarries upslope (Figure 23). Not far to the south, the same road is a simple cleared path for wagons to travel (Figure 24). Whole and broken horseshoes are found along most of the haul roads (Figure 25).

Quarries

Many architectural elements of late-nineteenth-century Tucson were built with rock removed from the southern and western slopes of Tumamoc Hill (Wilcox and Larson 1979:7). The quarry activities within the Desert Laboratory ended in 1906 when the preserve was fenced. Several quarries from the late nineteenth and turn of the twentieth centuries dot the landscape of Tumamoc Hill. Basaltic andesite boulders were harvested from the surface of the hill or blasted from basaltic andesite and tuff outcrops (Figures 26 and 27).

Figure 26. Tumamoc Hill, ca. 1920. The white feature on the right site of the hill near the top is a tuff mine. Two basaltic andesite quarries are visible midway up the hill above the two saguaros in the center of the photograph.

Figure 27. This small historic basaltic quarry is visible in the center of Figure 26.

Figure 28. Rock chute (center).

Rock Chutes

Rock chutes facilitated movement of rocks down the hill to loading areas during quarry activities (Howell 2007). One chute, 110 yards long, was apparently used to move rocks from the higher slopes of Tumamoc Hill down the 35-degree western slope to a loading area at the end of a wagon road (Figure 28). The chute is composed of two parallel rock walls about 3 to 4 feet apart, each averaging 3 feet high × 4 feet wide. The space between the rock walls has been cleared to bedrock. The loading area at the foot of the slope is a massive, human-constructed terrace up to 40 yards wide (Howell 2007:4). Howell noted the beginnings of two other rock chutes connecting to the same loading area, but these were apparently not completed before the quarry was abandoned. Approximately 500 feet to the south, there is another rock chute and loading area of similar construction (Howell 2007).

Clay Pit and Brick Dump

Two clay pits were dug near the western base of Tumamoc Hill and served as a source of material for fired bricks (Elkins et al. 1982:55–56). One of the pits, with its morphology relatively intact, measures about 140 × 180 feet (within a 2-acre activity area). Because of the clay soil, the pit is often filled with water from precipitation and storm runoff, serving as a water source for wildlife (Figure 29). The largest clay pit was used by the City of Tucson and the University as a landfill in the early 1960s.

A haul road leads northeast from the pits toward former brickyards, located between the Santa Cruz River and Grande Avenue south of St. Mary's Road. Although much of the road has become revegetated with large cactus, the road tracks and wash crossings are still distinct. Along the road are many brick dumps, where various-sized bricks were discarded because of breakage or other manufacturing failures (Figure 30). Some of the brick dumps reinforced the haul road at wash crossings. The most common type of brick present is perforated, with ridged edges. The bricks found near the pits are of a 1950s or 1960s vintage, suggesting pit use during the Forest Service tenure (1940–1960).

Figure 29. Clay pit riparian habitat.

Figure 30. Example of a misfired brick and smaller brick debris.

Inscriptions

In addition to the hundreds of petroglyphs created by the pre-contact inhabitants, rock inscriptions were also

Figure 31. The person's name may be J. Scott. Only "Co C U.S." can be clearly read.

Figure 32. This inscription reads "R.A. Powers Feb 15 1896," and the bottom inscription might read "T. Mouniek 1896."

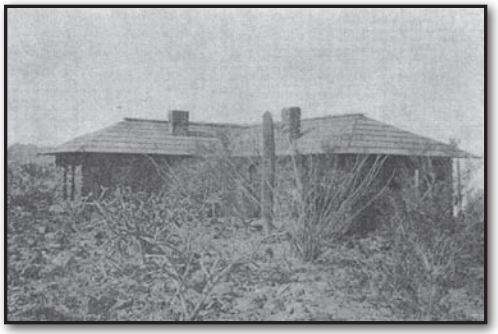

Figure 33. The laboratory ca. 1903.

created by later visitors to Tumamoc Hill. A member of Company C, 32nd U.S. Infantry, visited Tumamoc Hill (Figure 31). This military unit was stationed at Camp Lowell (which was then in downtown Tucson) from June 1867 through May 1868 (personal communication, Larry Ludwig 2007). On the summit, there are additional inscriptions (Figure 32), most of which date between 1885 and 1905 (Lindsay and Metcalf 1973).

The Original Laboratory, 1903–1940

The original structure, built in 1903, was an L-shaped building constructed of volcanic rock with a slate roof imported from the eastern U.S. (Figure 33). The slate was chosen as a good collection surface for rainwater that drained into catchment and was used to wash glassware. This roof was replaced with tin and then again with slate in 1999. The laboratory had two fireplaces, later replaced by stoves. Its cooling system used projecting eaves to keep the windows shaded and relied on air circulated through the large attic. The laboratory included a private study, a library, a dark room, a store room, and a main laboratory room. In 1906, additions to the laboratory were made that extended it to the U shape it has today (Figure 34). Although the focus of research has changed somewhat over the years, this building is still being used much as it was in the early 1900s. The grandeur of the laboratory's past is still evident in the interior and on the exterior of the building today (Figures 35 and 36).

Figure 34. This picture, ca. 1911, shows the 1906 addition that made the building U shaped with a greenhouse (right side front).

Greenhouse

Another early structure on the hill (construction date 1906) was a greenhouse attached to the southeast end of the main laboratory (Figure 37). After some years of non-use, the greenhouse was renovated in 1978 and again served its original purpose. The structure is an integral part of the historic fabric of the Desert Laboratory, and in 2008 it was in need of serious repair. A white wooden lath, pitched roof–style canopy once covered the greenhouse.

Figure 35. The south porch of the laboratory in 2007.

Figure 36. Desert Laboratory library in 2007.

Figure 37. A portion of the original greenhouse built in 1906.

Figure 38. The chemistry laboratory.

Figure 39. Today, the Carnegie shop is used to store equipment for ecological studies being conducted on the laboratory grounds.

Figure 40. Constructed of local field stone and concrete, this storage tank held water pumped through several thousand feet of pipe from a well on the floodplain of the Santa Cruz River.

Figure 41. No longer in use, this abandoned cistern (center) held an important water source, rainwater captured from the roof of the laboratory.

Chemistry Laboratory

This building was constructed in 1914 of local volcanic rock, just south and east of the main laboratory (Figure 38). It was gutted by fire in 1938 and was not replaced by Carnegie, but it was rebuilt in 1940 by the Forest Service. The building continues to house Desert Laboratory project staff.

Carnegie Shop (Boat House)

This building was built in 1908 from local volcanic rock and mirrors the style of other Carnegie buildings, with a slate roof, fireplace, and wood floors (Figure 39). The building was used to repair equipment and functioned as a storage space for boats used on expeditions. Over the years, the shop had fallen into disrepair, and it was renovated in 1982.

Water Storage Tanks and Cisterns

By 1906, water was pumped from a Carnegie-owned well located in the Menlo Park neighborhood to a circular, concrete-lined storage tank south and upslope of the laboratory (Figure 40). After 1908, a second reservoir on the same water system was built off the property to the east and distributed water to the shop. Also in 1906, a similar-style reservoir was built that stored rainwater captured from the slate roof of the laboratory (Figure 41). By 1919, a small pump pushed excess rainwater from the roof-fed reservoir to a larger square holding tank upslope. By the 1920s, water was being pumped from a new well in the vicinity of St. Mary's Hospital and eventually from a city pipeline connection.

Trash Dumps, ca. 1900–1915

Two trash dumps represent the early-twentieth-century trash of the Carnegie Desert Laboratory. One is located

Figure 42. General character of the trash dump on Silvercroft Wash.

Figure 43. The Carnegie administrative office, located in the McKee Addition.

Figure 44. Plant acclimation shelters.

in the floodplain along Silvercroft Wash, the other is on the western slope of Tumamoc Hill, just below the Desert Laboratory. The lower dump, noted by Masse (1979), is a concentrated deposit that measures 10 m in diameter and contains artifacts dating between 1900 and 1915. Trash includes firebrick, tin cans, window glass, milk bottles, patent medicine bottles, O'odham ceramics, porcelain, sun-colored amethyst glass, earthenware, battery parts, light bulbs, acid bottles, test tubes, and other laboratory glassware (Figure 42). The upper dump (measuring about 10 × 15 m, eroding downslope) includes similar kinds of artifacts, albeit apparently more recent.

Carnegie Office (Adobe Laboratory)

In 1906, Carnegie purchased a lot from Frank G. McKee on the east side of Silverbell Road, just east of St. Mary's Hospital. An adobe house served as the administrative headquarters and was referred to as the "adobe laboratory." Plant acclimation and temperature studies were conducted on the lands around the administrative office (Figures 43 and 44).

U.S. Forest Service (1940–1960)

The newest permanent building on the hill is a square, flat-roofed, stone structure immediately to the south of the main laboratory. It was constructed by the Forest Service in 1940 and served for many years as office for the Southwestern and Rocky Mountain Forest and Range Experimental Station, later the Rocky Mountain Forest and Range Experimental Station (Figure 45). During University ownership, the building housed ecologists working for the USGS (USGS vacated the building in 2008).

Other Structures

Two metal structures stand on the hill (Figure 46). These are used for a variety of research purposes and storage. The buildings were brought to Tumamoc Hill for the Forest Service. Their historic significance may lie in the history of their move. They are said to be from the Manhattan Project. A wooden garage is located on the west side of the laboratory complex, and two residential structures built in 1940–1941 are located near Anklam

Figure 45. The Forest Service followed the Santa Fe–style architectural theme.

Road at the entrance. Both are on University lands, but their relationship to the Forest Service is not known.

Figure 46. One of several metal structures moved to the hill after 1940.

The Spalding-Shreve Plots

The Spalding-Shreve permanent vegetation plots on Tumamoc Hill are among the oldest continually monitored vegetation plots in the world and provide a unique perspective on change and stability in desert vegetation (Figure 47).

Volney M. Spalding, a research botanist at the Desert Laboratory from 1903 to 1907, established 19 vegetation plots in several different habitats on the Desert Laboratory grounds in 1906. Most of these plots were approximately 10 × 10 m. Since then, 10 plots have been lost or inadvertently destroyed. After he retired, Spalding turned over the plot maps to Forrest Shreve, a plant ecologist at the Desert Laboratory from 1908 to 1940. In addition to mapping several of the existing plots in 1910, 1928–1929, and 1936, Shreve established additional plots in 1910 (Area A, about 557 m^2) and 1928 (Area B, eight contiguous plots, each approximately 10 × 10 m).

After Shreve's death in 1950, plot maps and data sheets were kept for a time by the Forest Service, which in 1940 had purchased the Desert Laboratory buildings and grounds from Carnegie for use as the Southwestern and Rocky Mountain Forest and Range Experimental Station. Eventually, S. Clark Martin of the Forest Service turned the plot materials over to Walter S. Phillips, head of the Department of Botany at the University. In 1957, Phillips in turn gave them to Raymond M. Turner, then a professor in the department. When Turner went to work for the USGS in 1962, he kept the maps and data sheets. In 1968 and 1969, he relocated Plots 4, 7, 9, and 10, which had been essentially lost after 1906, as well as Area A, which had not been examined since 1936. The Desert Laboratory keeps working copies of the plot maps. The originals are archived in Special Collections at the University of Arizona Library.

Figure 47. One of four iron posts that identify Spalding-Shreve's vegetation plot 15.

Extant plots are as follows: Plots 4, 7, 9–12, and 14–16 and Areas A, B-1, B-2, B-3, B-4, B-5, B-6, B-7, and B-8. Some or all of these plots were mapped in 1906, 1910, 1928, 1929, 1936, 1948, 1957, 1959, 1960, 1967, 1968, 1969, 1974, 1975, 1978, 1984, 1985, 1993, and 2001.

Scientific Plots and Apparatus

The Desert Laboratory grounds are covered with evidence of active scientific projects. Aluminum tags and rebar, galvanized sample trays, and other modern scientific apparatus dot the landscape. Remnants of earlier scientific projects are also present. The record of who built these scientific features and why and when they were built is not clear. Isolated rusted iron posts, wire mesh grids, concrete-lined pits, and a rusted barrel that contains what appears to be electric circuitry are among the intriguing features that appear to be more than 50 years old (Figures 48–50).

Figure 48. An elaborate concrete-lined pit that appears to be a water catchment and measuring device.

Research and Inventory

Cultural Resources

Tumamoc Hill was well known as an archaeological site at least since the beginning of the twentieth century. Geographer Ellsworth Huntington (1904, 1914) considered the hill a fortress because of its encircling terraces and walls. In 1919, the *Tucson Star* reported that Robert F. Gilder, a journalist, artist, and archaeologist affiliated with the University of Nebraska Museum, and Byron Cummings from the University visited the summit and found the remains of a large reservoir and 250 "room" outlines, erected around a central plaza, with "streets radiating from the central point like the spokes of a wheel" (*Tucson Star* 1919). Gilder's attention had been drawn to the site because he had seen, from a few miles away, a prehistoric trail on the north side of the hill that looked like a paved road leading toward the mountain top. The article also suggests that Gilder believed the builders of the Carnegie Desert Laboratory had unknowingly dismantled prehistoric ruins and reused the stone for the laboratory structures.

In the intervening years, many archaeological projects have been undertaken at the Tumamoc Hill archaeological site. The first detailed archaeological work at the site was conducted in anticipation of the proposed construction of a University observatory on the summit (Larson 1972). This work, while cursory, documented 1,200 linear meters of rock walls and 60 rock enclosures. Also noted were numerous mortars, cupules, petroglyphs, and artifacts. One enclosure was partially excavated, resulting in the recovery of two metate fragments, a shell bracelet fragment, and numerous plain ceramic sherds. Tumamoc Hill was inferred to be a Classic period Hohokam site, and the observatory site was moved to a previously disturbed area.

Figure 49. A 50-gallon metal drum placed on a concrete pad within a few feet of Spalding-Shreve's vegetation plot 15.

The Museum of Northern Arizona conducted work to determine the effects of proposed modifications to an existing Mountain State Telephone building (Lindsay and Metcalf 1973). Noted within the 1,000 × 100–foot lease area were portions of a massive wall, disturbed remnants of one or two structures, several bedrock mortars, and scattered sherds and flakes of stone from the manufacture of stone tools. Recommendations were made to adjust the project locations to protect the archaeological remains.

Figure 50. A poured-cement box filled with soil on the side of Tumamoc Hill near the laboratory.

Comprehensive archaeological studies of the Tumamoc Hill archaeological site were undertaken by the AAHS from 1974 to 1976, with results published in *The Kiva* in 1979 (Ferg; Hartmann and Hartmann; Larson; Masse;

McLean and Larson; Wilcox; Wilcox and Larson). This work resulted in the recording of walls and terraces, 125 structural remnants, a system of trails, 460 petroglyphs, and numerous other features and artifacts on the summit and slopes. On the west bajada, hundreds of dry-farming features were recorded.

Limited test excavations were undertaken by Paul Fish and Suzanne Fish in 1985 to provide comparative data for work at the Los Morteros trincheras site (Fish et al. 1986). A trench excavated perpendicular to one rock wall yielded projectile points and corn that dated to the Early Agricultural period (800 B.C.–A.D. 150). Additional excavation in 1998 adjacent to the trench and at six rock enclosures provided intriguing information about the chronology of the site (Wallace et al. 2007:Table 1). The ceramic occupation was firmly dated to the Tortolita phase (A.D. 450–700), but projectile points and a structure without ceramics and predating the Tortolita phase were also identified as having been intersected by the 1985 trench.

Over the past 25 years, several investigations within the Tumamoc Hill archaeological site have been undertaken as part of compliance activities for existing and proposed utilities. A 1983 survey of an existing power line through the site by Complete Archaeology Service Associates recorded four isolated features: two were rock piles associated with dry farming, one was a historical rock ring, and one was an old wagon road (Hammack 1983). Old Pueblo Archaeology Center completed a survey of 145 acres of State Trust land in advance of the proposed sale of the land for development. Preliminary results (Jones 2000) confirmed the presence of dry-farming features, historical roads, a military training area, and historical features associated with the Desert Laboratory, as recorded during the AAHS survey (Masse 1979). The project was cancelled before the entire 312-acre State Trust land parcel was surveyed and before the site records were updated.

In 2002, WSA surveyed 5.7 acres and monitored gasoline pipeline repairs (Allan et al. 2004). The archaeologists recorded three rock alignments, two check dams, six other rock features, and four lithic (chipped stone) scatters, apparently related to dry farming. Also in 2002, SWCA Environmental Consultants (SWCA) conducted a damage assessment of the effects to the cultural resources by KUAT's construction of a new digital transmitter building, antenna, and parking area on the hill summit (Twilling 2002). Construction sand and debris had been deposited on prehistoric features, and a new utility pole apparently had been placed within a rock structure. New rip-rap rock was dumped adjacent to a trincheras wall, and a mortar was removed, which is now stored at the Desert Laboratory. During an inspection conducted in 2007 as part of the NRHP nomination of the archaeological site, pottery sherds were found eroding out of the cutbank behind the building, which indicates that the leveling done for the construction had disturbed a buried cultural deposit.

Archaeologists with SWCA also surveyed a 20-m-wide corridor along an existing natural gas line in the northeast portion of the site (Hesse and Chenault 2003). They recorded two sparse prehistoric artifact scatters and noted the presence of rock piles in the area outside their survey. Desert Archaeology completed survey and monitoring of eight sites for groundwater-monitoring wells around the Tumamoc landfill (Brack and Diehl 2002; Diehl 2002a, 2002b). The survey encompassed a 20-m-diameter area around each location. No resources, other than landfill-associated trash, were noted.

HEG (Fahrni and Twilling 2004) surveyed 5 acres within the archaeological site for improvements to the Silvercroft Wash flood-control berm. Their survey area fell mostly within one of Masse's dry-farming areas, and they recorded 20 rock piles, one soil stain, six prehistoric artifacts, and two historic artifacts. No additional resources were discovered during the subsequent monitoring of the geotechnical studies (Twilling 2005). Tierra Right of Way Services (Klimas 2005) monitored the replacement of a power pole and the installation of a guy-wire anchor near the site's northern boundary. No resources were identified.

Desert Archaeology surveyed a 6-m-wide corridor along an existing power line to the top of Tumamoc Hill (Whitney 2005). Thirteen features were recorded: a trail, a cairn, a rock alignment, a rock concentration, four petroglyph boulders, two rock enclosures, two rock-wall alignments, and an

abandoned building at the Desert Laboratory. The prehistoric features were concentrated in two areas, one on the lower slope, and one on the upper slope and adjacent summit.

The rupture in July 2003 of a buried gasoline pipeline crossing the site necessitated additional archaeological work, which was undertaken by WSA to determine the effects of its repair and replacement. During the monitoring of the repair work (Estes et al. 2004), only disturbed fill that did not contain any prehistoric or historic resources was identified. During the WSA survey of a 200-foot-wide corridor along an existing gas line and the monitoring of replacement pipeline, 88 rock alignments, 64 rock features, four artifact scatters, 30 plain ware sherds, 88 flaked stone artifacts, two milling stone fragments, two tabular knives, 28 historic artifacts, and a petroglyph were recorded along the lower slope of the hill and the west bajada (Allan et al. 2004; Estes et al. 2005). A few military features and artifacts were also noted. No temporally diagnostic prehistoric artifacts were identified, but some of the features, including a possible field house, were considered part of the archaeological site and related to the prehistoric farming. Sixty-one of the rock alignments and 23 of the rock features were apparently created by the original pipeline construction. Other WSA work included total-station mapping of six areas encompassing 20 rock features, manually and mechanically excavating one feature, collecting pollen samples from six features, and collecting all prehistoric artifacts identified. During subsequent monitoring, two minimally used roasting pits were discovered.

In 2005, the University Archaeological Field School, under the direction of Paul Fish, Suzanne Fish, and Gary Christopherson, conducted two mapping and survey projects. With handheld GPS units, more than 1,000 modern and prehistoric features on the summit and slopes of the hill were recorded, including walls, houses, rock art, talus pits, trails, quarries, and wagon roads (Christopherson et al. 2005). Using a total station, the second field school project mapped the summit in detail. Survey, mapping, and excavation by the University Archaeological Field School provided additional data to formulate and address research questions; the information is incorporated into a database for site management purposes. In addition, the AAHS, under the supervision of Gayle Hartmann and Peter Boyle, re-recorded previously known rock art on the hill and identified and recorded new prehistoric rock art, historical inscriptions, and historical and modern graffiti. Their work will provide a valuable photographic archive as well as a current condition assessment and precise location data.

The following narrative description of the archaeological site is summarized from the reports of the above studies, especially the articles in the 1979 *The Kiva* volume and the related maps and field notes on file at the ASM. The 1986 *American Antiquity* article provides key temporal data. Preliminary reports and maps from the recent University Archaeological Field School classes were examined for up-to-date descriptions and spatial information, and Wallace et al. (2007) provide additional discussion and interpretations derived from this work. For some archaeological features and activity areas (loci), the existing reported information was supplemented with field inspections.

Research into Prehistoric Chronology

Preliminary studies of Tumamoc Hill suggested a Classic period origin for the rock walls, based in part on other trincheras sites that date to the Classic period. A Tanque Verde Red-on-brown sherd, considered to date between A.D. 1150 and 1450, was found on the surface during the first intensive mapping study, which corroborates the use of the site during the Classic period (Larson 1972:100). Some evidence, however, argues for a Rillito-Rincon hill occupation: decorated sherds from several vessels dating to the Rillito-Rincon period (A.D. 700–1100) were found during the survey (Hartmann and Hartmann 1979:62–63). The main occupation of the St. Mary's Site (AZ AA:16:26[ASM]) at the base of the hill dates to the Rillito-Rincon period (Jacobs 1979:128), and a well-defined trail leads from that site to the summit of Tumamoc Hill (Hartmann and Hartmann 1979). Scattered Archaic period projectile points indicate an earlier use. Overall, the temporally diagnostic artifacts found on the summit and slopes of the hill potentially span more than 4,000 years. Surface evidence alone, therefore, indicated the long use of Tumamoc Hill, but it was imprecise regarding when the stone walls and circular features were constructed.

Test excavations at the hill in 1985, directed by the Paul and Suzanne Fish of the ASM, provided surprising chronometric information (Fish et al. 1986:Table 2). A trench excavated in a terrace near the summit yielded Ceramic period remains in the top strata, as expected. Below those strata was an apparently intact Archaic period stratum with Late Archaic projectile points, other flaked stone tools, and charred corncob fragments, kernels, and pollen. Accelerator radiocarbon dates yielded what, at that time, was the earliest corn in the Tucson basin, with a 95-percent-confidence-calibrated range of 1235 B.C.–A.D. 10. The Archaic period occupants were not just using the hill for occasional hunting, as had been inferred from the projectile points found on the surface, but were cultivating corn, apparently long before pottery was in use. Together the chronometric data suggested a brief occupation of the hill around A.D. 1 (Fish et al. 1986:569). Early dated corn had been found at other sites in southern Arizona (e.g., Doelle 1985:321–322; Martin 1963) at the time of the Tumamoc excavation, and, in fact, much of the time span formerly called "Late Archaic" now has been redefined as the "Early Agricultural" period.

In 1998, additional test excavations of eight features encountered evidence that significant residential occupation of Tumamoc Hill occurred much earlier than the Classic or Rillito-Rincon periods. The Early Agricultural occupation was much more substantial than previously thought. When the original excavation trench was expanded, the early corn was discovered to have come from a pithouse. That pithouse was sitting in fill behind the wall, so the terrace wall had to have been built before the pithouse (Wallace et al. 2007). Therefore, some, if not most, of the massive encircling walls and terraces were built during the Early Agricultural period, around 500 B.C.–A.D. 1 (Wallace et al. 2007). As such, the huge walls are the earliest known public architecture in Arizona (Fish 2005:220).

Rather than the Rillito, Rincon, or Classic period occupation suggested by the few painted sherds found on the surface, several of the excavated rock circles were determined to be shallow pithouses dating to the Tortolita phase, around A.D. 500. Plain and red ware, rather than the red-on-buff and red-on-brown painted pottery associated with later Hohokam sites, characterize this phase. Tortolita phase pottery undoubtedly accounts for almost all the abundant plain ware and occasional red ware on the surface of the site. The assemblage recovered included many shapes of pottery vessels, formal (shaped) manos, formal and informal (expedient) metates, and a bracelet fragment. The full range of artifacts and the weathering present on the floors suggested substantial occupation; the presence of some secondary refuse in a pithouse may imply a somewhat extended occupation. Other rock circles visible on the surface are considered to be contemporaneous Tortolita phase houses. Hearths and postholes were encountered in one of the two largest structures. A different bent-pole construction technique for smaller structures may have been necessitated by the shallow bedrock on much of the hill. Most excavated structures were smaller than the average rock enclosure on the summit and represent less investment in materials than the larger enclosures.

Resource Integrity

Several areas of modern and historic intrusions lie within the 854-acre Tumamoc Hill archaeological site. The buildings and related facilities of the Desert Laboratory cover about 2.5 acres on the flat north spur of the ridge, below the summit. Three buildings on two parcels totaling 1 acre are also at the entrance and along Anklam Road. On the summit itself are communication towers, two astronomical observatories, a fire-lookout frame, eight television and microwave towers and related buildings, miscellaneous smaller structures, and roads and utility lines that service these facilities. Utility lines cross the bajada slopes west of the hilltop, and a landfill used in the 1960s (which encompassed an early-twentieth-century clay pit) covers 46 acres at the southern edge of the property.

The archaeological site on the hill and surrounding land remains a relatively undeveloped island amidst the much more intensive external disturbance. Housing tracts and other developments surround the property that is a little more than 1 mile from downtown Tucson. Pima Community College and St. Mary's Hospital lie to the north. Although modern construction on the summit has apparently destroyed evidence of a possible central courtyard and reservoir, and the Desert Laboratory's construction may have destroyed other prehistoric features, more than 180 rock enclosures and outlines and

numerous walls, trails, and other features are still visible on the summit. Excavations have revealed intact cultural strata with buried features and artifacts. The bajada dry-farming fields constitute a large, contiguous, prehistoric agricultural area with thousands of intact features.

The Tumamoc Hill archaeological site retains its integrity of location and setting, essential to understanding its creation and use. The arrangement of features on the hilltop, slopes, and bajada continues to illustrate the original form, plan, and use of space that are critical to the NRHP meaning of integrity of design. The integrity of materials and workmanship is evident at site, feature, and artifact scales. For example, the choice and combination of structural materials display the preferences and social organization of the builders; the agricultural features reveal essential components of the economy; and the unique variety of locally made Tortolita phase pottery provides clues about early social interactions. Through its setting and the presence of more-than-2,000-year-old walls and 1,500-year-old house foundations, thousands of agricultural features, and hundreds of petroglyphs, the archaeological site has the integrity of feeling necessary to convey the property's historic character. Finally, as a distinctive trincheras site with intact archaeological deposits, the site demonstrates the integrity of association that is necessary for revealing and understanding this pivotal era of our past.

The Tumamoc Hill archaeological site is considered prehistorically significant at a national level under NRHP Criterion D. The site is associated with the Early Agricultural and Hohokam periods in the American Southwest, which are time spans that encompassed major changes in technology, subsistence, social organization, and settlement patterns. The Tumamoc Hill archaeological site's massive walls appear to be the first public architecture in Arizona. As past and current research shows, the site has already yielded important information about the past and engendered pivotal issues for additional research. Tumamoc Hill plays a central role in questions and hypotheses about the development of early agriculture, agricultural intensification, the organization and integration of society, community planning, and warfare and defense.

Ecological Resources

The Desert Laboratory's contributions were critical to the early development of American ecology. The Desert Laboratory continues to provide hard-won insights about Sonoran Desert ecosystems, how they function and how they might respond to climate variability, invasions by introduced species, and urbanization. Among other uses, these fundamental insights are integral to the encompassing and visionary Pima County Sonoran Desert Conservation Plan. The permanent vegetation plots on the hill, protected from grazing since 1907, are among the longest-studied parcels anywhere in the world. They represent the only systematic effort to monitor and analyze the long-term population dynamics of perennial plants in the Sonoran Desert.

As one of many examples, much of what is known about saguaro demography (germinations and deaths) comes from repeated, sustained measurement of thousands of saguaros on the hill beginning in 1908. From these measurements we have learned that, despite population decline during the last two centuries, saguaros have persisted on Tumamoc Hill because of a few, brief episodes of seedling recruitment. This natural ebb and flow of saguaro populations will have to be considered when anticipating and managing the impacts of climate change and urbanization.

Ongoing field research by Desert Laboratory scientists spans the fields of biology, hydrology, climatology, geology, and anthropology in deserts of several countries and continents. A key part of the research program, however, remains the wide array of field studies on the hill. Of utmost concern is the increasing encroachment from urbanization and the inadvertent damage to field plots associated with public access and occasional maintenance along utility easements.

In 1960, the University bought the Desert Laboratory to house the new Department of Geochronology under T. Smiley's direction. A young pollen analyst from Michigan, Paul Martin, was hired to broaden the scope of research to include the history of desert environments; he has since become well known for his work on Pleistocene extinction and pack rat midden studies. During the 1950s, Ray Turner, then a professor in the University's Department of Botany,

monitored long-established permanent-vegetation plots on the Desert Laboratory grounds. After he left the University to work for the USGS, he continued to track vegetation changes on the plots. In 1976, he became a full-time presence at the Desert Laboratory, moving from sterile quarters downtown to the fertile slopes of Tumamoc Hill. Martin and Turner both retired in 1989. Their legacies include a rich paleobotanical archive now being exploited for geochemical, anatomical, and genetic studies; a series of long-term vegetation plots in the Sonoran Desert; a digitized data base of plant distributions in the Sonoran Desert; and an archive of repeat photography comprising some 3,000 historical views of western landscapes and one or more recent matches of each.

Jay Quade inherited Martin's position as director and injected the Desert Laboratory with a strong dose of geology and stable- isotope geochemistry. Upon Turner's retirement, the USGS hired Bob Webb and Julio Betancourt as replacements. Both have broad interdisciplinary interests and skills and have made several key contributions to the understanding of climatic effects on biological and physical processes in deserts. Webb has expanded Turner's repeat photography collection. From Tumamoc Hill, Betancourt has played a key role in reconstructing the long-term vegetation and climate history of the North and South American deserts.

Larry Venable, a professor in the University's Department of Ecology and Evolutionary Biology, has conducted experimental studies on the population biology of desert annuals at Desert Laboratory since 1982. In 1993, Jack Wolfe, a retired USGS paleobotanist who continues his research as an adjunct professor in the Department of Geosciences, also conducts research on the hill. M. E. Morbeck (now retired), Paul Fish, Suzanne Fish, John Madsen, and Nancy Pearson keep the Desert Laboratory connected to the University's Department of Anthropology and the ASM.

In 2007, Michael Rosenzweig, a professor in the University's Department of Ecology and Evolutionary Biology, inherited Quade's position as director and formed the Tumamoc Hill Management Council to oversee the laboratories research and educational programs.

Long-Term Monitoring of Permanent Plots

Perennial plants on vegetation plots established in 1906 and 1928 (yellow squares and rectangles in Figure 51) have been mapped (or, in the case of Area A, tallied) about once a decade. More than a dozen researchers have cooperated in the effort, most recently by the USGS group. Mapping and monitoring of individual plants has made it possible to determine life spans of long-lived perennials, to follow fluctuations in establishment and mortality during wet and dry periods and to study recovery of vegetation after a century of protection from domestic livestock.

In 1903, Volney Spalding, a retired botany professor from the University of Michigan, joined the staff of the fledgling Desert Laboratory. One of his first acts was to establish 19 plots on the Desert Laboratory's grounds. Most measured 100 m^2. He mapped the locations of all the perennial plants within the plots and, when he retired from the Desert Laboratory several years later, turned the maps over to Shreve. Shreve established some new plots: Area A, a polygon measuring about 557 m^2 for the study of seedling survival, and Area B, a set of eight contiguous plots, each 10 × 10 m. The locations of some original plots were lost in other years, and one or two plots were inadvertently destroyed by road construction. Ten Spalding plots, as well as Areas A and B, are still monitored by Desert Laboratory's researchers (yellow squares in Figure 51).

Maps made at decadal intervals have made it possible to follow changes in numbers of perennial plants as climate has fluctuated. The maps have revealed other kinds of changes, too, some of them unexpected (USGS 2008). Between 1928 and 2001, in plot 16, two woody, long-lived plants—creosote bush and white ratany—showed disproportional success rates: creosote bush declined and white ratany increased, especially since 1948. The replacement of one by the other was probably promoted by a combination of severe drought in the mid-twentieth century and a type of soil that magnifies the effects of

drought. This series of maps emphasizes the value of long-term research and the deep perspective it affords. If maps had been made only in 1928 and 1936, no change would have been evident, and the conclusion would be that desert vegetation is inordinately stable.

Long-Term Saguaro Plots

The first saguaro studies on the hill were conducted by members of the Desert Laboratory from 1908 through 1910 in response to observations that saguaro recruitment was not occurring in much of the Tucson vicinity. Maps were produced with a plane table to record the location of all the saguaros present in a 700-hectare area on Tumamoc Hill and adjacent Sentinel Hill relative to slope, aspect, and topography. Careful observations of growth rates were made for a subset of the population to estimate establishment date and age structure.

In 1964, four plots (nearly 10 hectares each) were established within the 1908 mapping on the north, south, and west aspects of the hill (yellow dotted lines in Figure 51). All saguaros were individually identified and mapped to allow repeated measurements of height and assessment of flowering and health. The irregular polygons show the location of the 1964–1993 censuses on each slope where Elizabeth A. Pierson and Turner mapped and re-measured more than 4,000 saguaros to develop a robust age-growth model. The plots and individual saguaros were recorded on aerial photographs, and these were re-evaluated in 1970 and 1993. A model was developed for determining saguaro age, using observed growth rates of more than 3,000 uninjured plants from 1964 to 1970. Average height and annual growth during this period were calculated for each plant and combined into 0.5-m height classes. The studies showed that saguaro populations fluctuated substantially in size and age structure over the 85 years. During much of the past two centuries, populations were in decline due to low regeneration rates. Although some recruitment probably occurs most years, saguaro persistence is maintained by episodic surges in regeneration resulting in substantial population gains such as occurred in the mid-nineteenth and twentieth centuries.

Blue Palo Verde Riparian Study

Blue lines in Figure 51 correspond not only to major drainages on the Desert Laboratory grounds, they show the location of a long-term study of blue palo verde, a common riparian tree in the Sonoran Desert. Maps made in 1907 and again in 1966 showed large losses of blue palo verde, probably a response to drought and the entrenchment of a major drainage channel. A round of mapping in 1985 demonstrated a dramatic reversal of this decline. A series of wetter years promoted a substantial increase in blue palo verde trees, especially along reaches where sediment accumulated, making a favorable environment for seedling establishment.

Winter Annuals Permanent Plots

Permanent plots established for the study of winter annuals are located within the areas circumscribed by dotted white lines in Figure 51. These plots have been instrumental in testing theoretical predictions about the way plants behave in variable environments. In 1982, Venable, of the University's Department of Ecology and Evolutionary Biology, began long-term studies of winter annuals at the Desert Laboratory with particular emphasis on population ecology. Annual plant species constitute 50 percent of local flora in the Sonoran Desert; of these, about 60 to 80 percent are winter annuals. Seeds of winter annuals germinate during cool season rains, and, if the seedlings survive, the plants flower between February and April and die when hot weather arrives in May. When abundant, winter annuals help sustain populations of rabbits, tortoises, and other browsing animals. In good years, after abundant winter rains, spring-blooming annuals add millions of seeds to the soil seed bank, renewing the major food source for certain species of ants, rodents, and birds. Not all seeds germinate, even in good years. Rather, a fraction of seeds remains dormant, thus preventing extinction should no seedlings survive long enough to flower and disperse seeds.

Invasive exotic species constitute a large, growing threat to biodiversity and ecosystem stability in the Sonoran Desert region. Early in the twentieth century, when fields and open desert surrounded the Desert Laboratory, only three species of exotic plants grew on the grounds. One hundred years later, suburban sprawl has nearly isolated the laboratory grounds from the natural desert, and weeds and cultivated plants have invaded from nearby yards and gardens. Fifty-two of the 346 species now in the Desert Laboratory flora community are exotic. Of these, red brome, an annual grass from the Mediterranean region, and buffelgrass, a perennial grass from southern Africa, are a major fire hazard. Most native Sonoran Desert plants do not survive wildfire. By promoting frequent burning, these exotic grasses might greatly alter the species composition and structure of natural Sonoran Desert communities. Buffelgrass poses an additional threat by depriving native shrubs and trees of soil moisture.

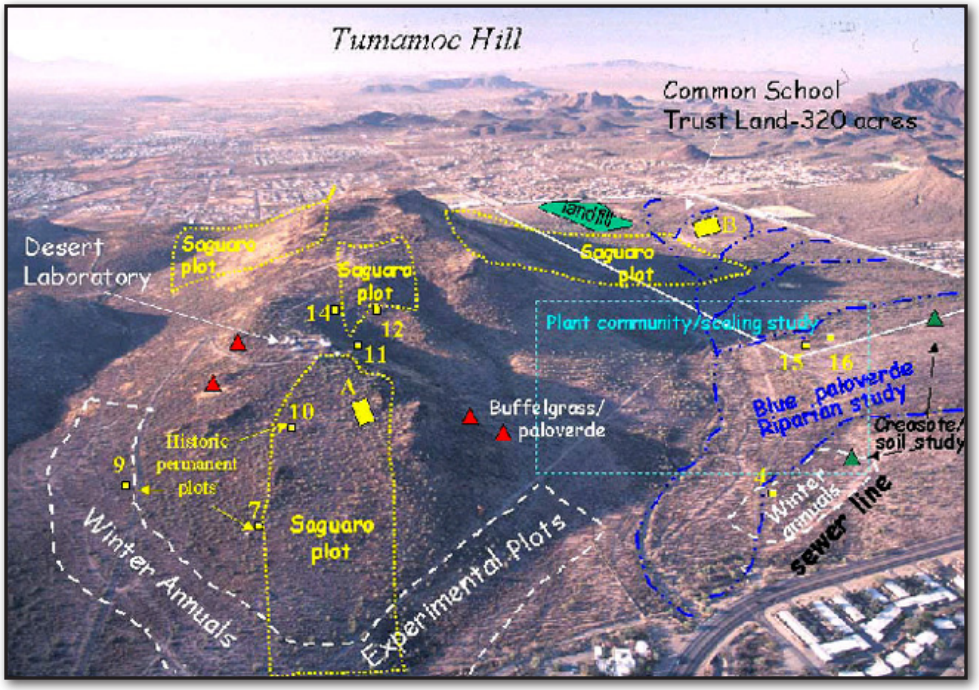

Figure 51. Ecological study plots.

In 1983, Tony Burgess, Turner, and Jan Bowers surveyed the grounds of the Desert Laboratory in a regular grid, recording all species of exotic plants encountered on the gridlines. Figure 4 illustrates the distribution of six exotics in 1983. The stippled area on the map for filaree shows where this species occurred in 1903. It has since naturalized throughout the grounds. Red brome, not even present in 1903, was first collected on the laboratory grounds in 1968, at which time it was not common. The species has since become one of the most abundant winter annuals on the grounds. The Desert Laboratory grounds were fenced in 1907 to exclude domestic livestock. Subsequent disturbances included clearing and digging for a natural gas pipeline and a city sewer line, installation of electric utility lines, excavation of shallow clay quarries, and construction of a landfill. Although localized, these disturbances apparently gave exotics a foothold for invasion, whence they spread into undisturbed patches, perhaps after drought when the deaths of native plants left spaces open.

Population Ecology of Desert Plants

Bowers studies the effects of climatic variability on the reproduction, establishment, and survival of woody desert plants such as foothill's palo verde, barrel cactus, Engelmann prickly pear, and triangle-leaf bur sage. Her work has demonstrated that populations of foothill's palo verde are less stable than previously supposed and that they can experience large fluctuations in establishment over the course of a century. She has discovered that Engelmann prickly pear and fishhook cactus are remarkably sensitive to climatic variability, producing more flowers and fruits during wetter years. She has challenged other preconceived ideas about desert plants as well, showing that seeds of barrel cactus, triangle-leaf bur sage, and other woody plants can and do live in the soil for more than a year; that episodic rather than constant mortality is typical of certain species; and that seedling survival is as likely to reflect intensity of predation as seasonal drought.

The plants that Bowers studies locally on Tumamoc Hill are intricately woven into the fabric of the Sonoran Desert. Some are vitally important to insects, birds, and mammals as seasonal sources of pollen, nectar, and seeds. Others function as nurse plants, hiding seeds and seedlings from hungry animals and protecting tender shoots from heat and frost. As global climatic change continues, knowing how these species respond to climatic variability will help us predict the future of Sonoran Desert plant and animal communities. Lastly, it bears mentioning that other research groups are also interested in pursuing work related to maintaining, and expanding, and monitoring the long-term vegetation plots found on the hill.

Desert Tortoise Disease Study

Desert tortoises are being studied on Tumamoc Hill by Bill Shaw and Cristina Jones of the University's School of Renewable Natural Resources, Cecil Schwalbe of the USGS Sonoran Desert Field Station, and Don Swann of Saguaro National Park. Urban development adversely affects the desert tortoise through habitat loss, illegal collection, uncontrolled domestic dogs, and road traffic. A less visible consequence, yet just as detrimental, is the spread of disease into free-ranging populations along urban boundaries, which can be transmitted by escaped or released captive desert tortoises. One such disease is Upper Respiratory Tract Disease (URTD). Though extensive studies have been conducted on the Mojave population of the desert tortoise following a catastrophic decline attributed to URTD, very little is known about the prevalence of URTD in the Sonoran population. Tumamoc Hill is one site being used to conduct searches for free-ranging tortoises; the site is a prime example of tortoise habitat along the urban-wildland interface.

Land and facility use and development at the University are inevitable, necessary, and mandated for the integrity of the infrastructure and the mission of the University. Unfortunately, land and facility use and development can have, and have had, unforeseen and deleterious effects on important prehistoric and historic resources on land owned or controlled by the University. Several laws have been promulgated at the national, state, and local levels to protect, conserve, and preserve cultural resources for the benefit of the public. These laws reflect a long-standing public appreciation of the inherent value of local, state, and national history and prehistory as well as the physical remains of the historic and prehistoric record. The University has recognized its custodial role as a state public institution in guarding the cultural resources under its purview and has developed its own policy regarding these resources that is reflective of society's interest and concern. Part II of the Tumamoc Hill Cultural Resources Policy and Management Plan will describe the pertinent federal, state, and local laws and plans and policies that interlock around the issues for managing the cultural resources on Tumamoc Hill.

Federal Statutes

Certain federal legislation promotes the use of historic properties to meet society's contemporary needs. These statutes direct the federal government to take a leadership role in historic preservation in cooperation with state, local, and tribal governments and the interested public. Two national acts initiated in the late 1960s have the authority to affect the management of the cultural and natural resources at the Desert Laboratory.

1. ***National Historic Preservation Act of 1966 (NHPA).*** When the university receives federal funds, grants, or monies for projects at the Desert Laboratory or if a federal agency must conduct ground-disturbing activities within the Desert Laboratory property, the University is required to follow the cultural resources compliance requirements of the NHPA, the most widely cited and widely applicable federal preservation law. The funding federal agency will lead the University in ensuring that the requirements of the NHPA are followed during the course of the project. Section 106 of the act specifies a process wherein federal agencies are required to consider the effects of their undertakings on historic properties in consultation with the Arizona State Historic Preservation Office (SHPO), and to allow the Advisory Council on Historic Preservation (ACHP) an opportunity to review and comment on the proposed project.

   Properties listed in or eligible for listing in the NRHP, the nation's master inventory of designated historic resources, are subject to Section 106 review during federal undertakings. The NRHP includes listings of buildings, structures, sites, objects, and districts that possess historic, architectural, engineering, archaeological, or cultural significance at the national, state, or local level. The NRHP also maintains a list of nationally significant properties that are cataloged into the NRHP as NHLs, designated thus by the Secretary of the Interior under the authority of the Historic Sites Act of 1935. The Desert Laboratory is currently listed in the register as an NHL and is in the process of being nominated for inclusion separately as a locally, regionally, and nationally significant prehistoric archaeological district.

   Because the Desert Laboratory is listed as an NHL, any federal undertaking that directly or indirectly involves the Desert Laboratory also triggers advance planning and other actions under the provisions of Section 110(f) of the NHPA. Implementation of this directive requires federal agencies to minimize harm to a landmark—whether it is on federally controlled land or not—from the effects of an undertaking and to consult with SHPO and afford the ACHP the occasion to comment on the undertaking. Federal agencies are obliged to exercise a higher level of care when they consider the deleterious effects on NHLs from their undertakings and they are obliged to consider prudent and reasonable alternatives to mitigate the negative effects. Section 106 is not superseded by Section 110(f); rather, Section 110(f) is intended to raise the standard of planning for NHLs beyond those afforded to cultural resources with solely state or regional significance. For instance, during planning meetings for project undertakings considered for the Desert Laboratory, property treatment such as data recovery, documentation before demolition, and some kinds of adaptive uses considered appropriate mitigative tools for less significant properties may be found to be inappropriate and insufficient with regard to the Desert Laboratory.

The Desert Laboratory's status as an NHL may also bring it additional protection under Section 111 of the NHPA. If a federal undertaking could result in a federal lease, exchange, or management contract, the agreement document should provide for the preservation of the property, and the ACHP should be consulted to ensure adequate protection. This consultation may be combined with Section 106 consultations to streamline the process.

2. ***National Environmental Policy Act (NEPA).*** While parallel in some ways to Section 106 review, NEPA is a broader program, enacted in 1969, that requires federal agencies to consider the environmental effects of their activities, including those that have the potential to adversely impact historic and natural resources. The potential for projects to involve federal agencies or federal funding on University-owned and leased State Trust lands is high due to federal oversight of power and gas leases and federal grants.

3. ***Endangered Species Act of 1973 (ESA).*** This landmark legislation is administered by the U.S. Fish and Wildlife Service. The intent of the legislation is to protect and conserve components of the nation's natural heritage. The act also provides that no project using federal funds will adversely affect species of plants or animals determined to be endangered or threatened with extinction. Certain authorities have been delegated to the Arizona Department of Agriculture (ADA) and the Arizona Game and Fish Department (AGFD) through cooperative agreements pursuant to Section 6(c) of this act.

State Statutes and Rules

The Arizona legislature has passed certain statutes to protect, preserve, and conserve the state's cultural and natural resource heritage and wildlife for the enjoyment, needs, and appreciation of the state's present and future citizens and communities. Three Arizona governmental bodies are the main administrators of these statutes in their statewide applications, including those applied to the cultural and natural resources at Tumamoc Hill.

Cultural Resources Statutes that apply to the management of the Desert Laboratory.

1. ***State Historic Preservation Act of 1982***, codified in Title 41 *State Government*, Chapter 4.2, Historic Preservation. Includes Arizona Revised Statutes (ARS) §41-862 through 864 and is administered by the Arizona SHPO on behalf of the Arizona State Parks Board (ASPB), whose authority is provided at Title 41 Chapter 3, Article 1.1, ARS §41-511 *et seq*. Pertinent ASPB administrative rules are found in Arizona Administrative Code Title 12, Natural Resources. These four statutes mandate that state land managing governmental bodies consider the effects their activities may have on cultural properties at all levels of planning and development. By the creation and maintenance of a register for significant properties—the Arizona Register of Historic Places (ARHP)—this act provides for the preservation and protection of historic or prehistoric properties that are significant at the local, regional, or state level. Because the Desert Laboratory is listed on the ARHP, any activities, changes, alterations, plans, or decisions that may have an effect on the prehistoric or historic resources lying within its boundaries must be reviewed by the SHPO. This legislation requires state agencies and institutions, including the University, to consult with the SHPO. Incidentally, cultural resources determined eligible for or listed in the NRHP, are automatically entered into the ARHP. Separate nominations to the ARHP are not necessary in those instances.

2. ***Arizona Antiquities Act of 1960 (AAA)*** (as amended), codified in Title 41 *State Government*, Chapter 4.1, Article 4, Archaeological Discoveries, includes ARS §41-841 through 845, and is administered by the ASM on behalf of the ABOR, whose authority is provided in Title 15, Chapter 13, Article 2, ARS §15-1621 *et seq.* The act contains regulations designed to protect archaeological and paleontological resources on property

owned or controlled by the state. By virtue of its authority, derived from the state statutes and Chapter 8 of the ABOR *Policy Manual*, the ASM is responsible for the issuance of AAA permits to qualified individuals or entities that would conduct archaeological or paleontological research on state-owned or controlled land, including the Desert Laboratory. The ASM evaluates the professional qualification of permit applicants, reviews the appropriateness of treatment plans and research proposals, reviews and approves survey and excavation results and reports and is the state repository for collections acquired under permit. Important amendments to ARS §41-844 (B) 1991 further protect human remains and associated funerary objects that are 50 years old or older, sacred objects, and objects of national or tribal patrimony.

3. ***Information relating to location of archaeological discoveries and places or objects included or eligible for inclusion on the ARHP; confidentiality***, codified in Title 39 *Public Records, Printing and Notices*, Chapter 1, Article 2 Searches and Copies, ARS §39-125. Nothing in this chapter requires the disclosure of public records or other matters in the office of any officer that relate to the location of archaeological discoveries as described in §41-841 or 844 or places or objects that are included on or may qualify for inclusion in the ARHP as described in §41-511.04, Subsection A, Paragraph 9. An officer may decline to release this information if the officer determines that the release of the information creates a reasonable risk of vandalism, theft, or other damage to the archaeological discoveries or the places or objects that are included in or may qualify for inclusion in the ARHP. In making a decision to disclose public records pursuant to this section, an officer may consult with the director of the ASM or the State Historic Preservation Officer.

4. ***Arizona Native Plant Law of 1991*** is codified in Title 3, *Agriculture*, Chapter 7, Articles 1 Administration and 2 Enforcement, and is administered by the ADA. This law contains several statutes that protect certain native vegetation and promote native plant conservation in a way that brings threatened and endangered plants to the point of recovery. Protected native plants are a component of the nation's natural heritage and cannot be disposed of from any lands without the owner's permission and an ADA permit. The ADA has additional enforcement authority to protect archaeological and paleontological sites and materials under Title 3, Chapter 7, Article 2, ARS §3-931 (E), Title 13, Chapter 37 ARS §13-3702 and 3702.01

Other State Statutes applicable to the management of natural resources on the Desert Laboratory

1. ***Wildlife Protection Statutes*** are found in Title 17, *Game and Fish*, Chapter's 1 through 6, and administered by the AGFD on behalf of the Game and Fish Commission, whose authority is provided in Title 17, Chapter 2, ARS §17-201. Pertinent Game and Fish Commission rules are found in Arizona Administrative Code Title 12, Natural Resources, Chapter 4. These statutes apply to all land within Arizona, including private land. A permit from the AGFD is required for the taking of any wildlife for food, sport, or research: part of the mission of the AGFD is "to conserve, enhance, and restore Arizona's diverse wildlife resources and habitats through aggressive protection and management programs, for the enjoyment, appreciation, and use by present and future generations."

2. ***Arizona State Trust Land Statutes*** are found in Title 37 *Public Lands*, Chapter 1 State Agencies and Offices, Article 1 State Land Department, ARS § 37-101 *et seq.* and Chapters 2 through 7. Pertinent ASLD rules are found in Arizona Administration Code Title 12 Natural Resources, Chapter 5. The ABOR on behalf of the University leases three parcels of land from ASLD under Commercial Lease 89-98103 and Institutional Taking 92-98103 (199.720 acres, now 196.63), and maintains a special land use permit with ASLD on an additional 320 acres (now 312.16 acres) under Permit 23-98104.

3. ***Selected Arizona statutes*** that may apply to the protection of the Desert Laboratory, including but are not limited to:

    a. Title 37 *Public Lands*, Chapter 2 Administration of State and Other Public Land, Article 12 Trespass on State Lands, ARS §37-501 Trespass on State Lands; Classification.

    b. Title 13, *Criminal Code*, Chapter 15 Criminal Trespass and Burglary, ARS §13-1501 (1) (a) "critical public service facilities" and ARS §13-1502 Criminal Trespass in the Third degree: Classification.

    c. Title 13, §13-1601 through 1603, *Criminal Damage and Littering and Polluting*.

    d. Title 28 *Transportation*, Chapter 3, Article 20 Off-Highway Vehicles ARS §28-1171, 1173, 1174.

    Note: these statutes were selected because they are pertinent to reoccurring trespass and motorcycle and quad vehicle encroachment on the Desert Laboratory.

Plans and Policies

The University, Pima County, and City of Tucson have adopted certain plans and policies, to protect, preserve, and conserve the cultural and natural resource heritage and wildlife on and adjacent to the Desert Laboratory.

1. ***The University of Arizona Functional Plans*** (University of Arizona 2007a) contains the 2006 UAHPP. The preservation plan and associated 2006 Preservation Plan Manuals provide guidance on the care and treatment of historic architecture and landscapes within the boundary of the University main campus. The UAHPP does not specifically address satellite properties like Tumamoc Hill, but the plan and appendices, particularly Appendix 3, entitled *Maintenance Manual for Historic Buildings*, will be the guiding document on maintenance and upkeep of the Desert Laboratory buildings and surrounding historic infrastructure. This manual recognized that all repair and alterations of historic properties must be in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties.

2. ***The University of Arizona General Administrative Policy Relating to Historic Preservation Activities*** (University of Arizona 2007b) was adopted on 1 May 2006 and articulates the custodial obligations and position of the University for the preservation of the resources under its control in all aspects of land or facility use and development. This administrative policy succinctly reiterates and reaffirms the University's stewardship role and responsibilities for the cultural resources under its ownership or control, whether they are located on campus or off. The policy states that cultural resources will be considered in all phases of planning for land and facility use and development.

    The policy reaffirms the University's accord with the state's historic preservation acts and its willingness to document professionally the cultural resources it owns or controls and to consult with the SHPO. It names the president of the University as the official who will nominate historically significant cultural resources under the University's ownership or control to the national or state registers; it proposes that the University adaptively use or reuse the cultural resources it owns or controls in project planning and implementation; it enjoins the University to encourage public appreciation of all Arizona's cultural resources through education, study, and interpretation; and it identifies the University's historic preservation coordinator as the appointed official who will ensure that policy compliance, SHPO consultation, and any reporting requirements issuing from the University's preservation activities will be met.

1. ***City of Tucson Tumamoc Area Plan (effective 2003)*** (City of Tucson 2007) provides land use policy direction and design guidelines for new development within the plan boundaries. The goal of the Tumamoc Area Plan is to establish a model for regional planning, recognizing the hills dynamic interactive place in the larger ecosystem. This plan takes a new approach to responsible development, in which property owners and developers can realize better economic and environmental gain through concern for the following: 1) property and income rights; 2) respect for existing residents and cultures, including communities of native wildlife and plants; and 3) a long-range view of sustainable habitation. This plan promotes environmentally responsible planning, design, building practices, and mechanisms which provide for long-term natural-space preservation.

   The plan partitions the areas north, west and southwest of Tumamoc Hill into 23 subareas, each with a specific policy direction. Tumamoc Hill and the Desert Laboratory are identified as Subarea 16. The policy direction for Subarea 16 proposes that the University Desert Laboratory should remain an open space and scientific preserve in perpetuity. To limit degradation of the preserve, no new buildings or roads should be constructed within the study area. The State Trust land located within the Desert Laboratory should be acquired and added to the preserve. If the State Trust land is developed, it should be at a rural density. Expansion of office/laboratory and other facilities for University Desert Laboratory can be accommodated in Subarea 15. Modification of utilities in the area should be sensitive to the concerns expressed and should provide mitigation. Existing communications towers should be removed. Any addition of new communications towers is discouraged. Public interpretation of the history of Tumamoc Hill and any ongoing studies should be provided.

   Subarea 15 also includes a narrow strip of University land along Anklam Road and includes the St. Mary's Hospital, Medical Office Complex; residentially scaled offices; and residential, at mid-urban densities. The policy's direction suggests that expanded office/laboratory and other facilities for Tumamoc Hill University Desert Laboratory are appropriate for this subarea. Office uses are acceptable south of Anklam Road and northwest of St. Mary's Road if residentially scaled, compatible in height with adjacent development, and designed sensitively to adjacent residential property. Should the area south of Anklam Road and northwest of St. Mary's Road be developed for residential use, mid-urban densities are appropriate. All future development in this subarea should be compatible with adjacent land_uses, sensitive to drainage and slope concerns, and befitting of the historic nature of the area.

4. ***Pima County Sonoran Desert Conservation Plan*** (Pima County 2008a) was initiated in 1998 by the Pima County Board of Supervisors to undertake science-based planning. Work on the Sonoran Desert Conservation Plan fulfills three areas of need: it provides a science-based conservation plan; it updates the comprehensive land use plan; and it complies with federal regulations that protect endangered species. The following elements were included in the plan: 1) Critical Habitat and Biological Corridors, 2) Riparian Restoration, 3) Mountain Parks, and 4) Historical and Cultural Preservation, and Ranch Conservation. The plan's conservation principles guide land use decisions of the county. It guides where public money is spent to conserve open space, how cultural and historic resources are protected, and how to protect the western lifestyle.

   In 1997 voters endorsed several Pima County historic preservation bond projects. Among these were $400,000.00 to purchase Arizona State Trust lands within the Desert Laboratory NHL for preservation purposes (Project. No. TU3101, Bond No. CA-31). On 10 October 2007, the County Administrator submitted bond ordinance amendments related to Tumamoc Hill. At the request of the Conservation Acquisition Commission, the County Bond Advisory Committee recommended several modifications be applied to the bond implementation ordinance to aggregate bond funds for the possible purchase of State Trust lands within the NHL. In 2007 the Pima County Board of Supervisors submitted an application to purchase

state lands (sale pending). This sale of State Trust lands within the NHL, if successful, will remove the threat of residential and commercial development. The Pima County 2008 bond election includes funding for the proposed Sentinel Peak–"A" Mountain Park Improvement Project. This project, if funded, includes funds to protect Tumamoc Hill research by prompting use of "A" Mountain as an alternative recreational hiking area.

Zones, Corridors and Areas

1. ***City of Tucson Land Use Code, Article 2 Zones, Division 8 Overlay Zones 2.8.6 Environmental Resource Zone*** (City of Tucson 2008a) provides regulations intended to recognize the value of Tucson's natural open space resources, particularly the critical and sensitive wildlife habitat of eastern Pima County that is associated with public monuments, forests, and preserves. These regulations relate to areas associated with Tucson's public lands and preserves, including Saguaro National Park, Coronado National Forest, and Tucson Mountain Park. It is the intent of these regulations to protect valuable habitat resources to the greatest extent possible. Development, compatible with these public resources, is allowed.

   This overlay zone specifically serves Saguaro National Park and Tucson Mountain Park and provides a buffer from the impacts of new development by allowing development that is compatible with preservation of critical wildlife habitat and the park environs. These regulations conserve certain designated washes that extend from the parks as areas of natural and scenic resources and provide valuable wildlife habitat and assist in implementing the General Plan policies, which call for the preservation of Tucson's significant natural areas along designated watercourses where identified in adopted area and neighborhood plans. (Ord. No. 9517, §2, 2/12/01).

   City of Tucson, Development Standard No. 9-06.0: Floodplain, Wash, and Environmental Resource Zone Standards should be consulted for additional guidance (City of Tucson 2008b). These regulations and standards apply to portions of Silvercroft Wash located in the west half of the Desert Laboratory NHL. Specifically, that portion of Silvercroft Wash that extends from south to north through Sections 9 and 16, Township 14 South, Range 13 East is identified as a resource corridor containing critical riparian habitat.

2. ***Pima County, Sonoran Desert Conservation Plan, Critical Habitat and Biological Corridors*** (Pima County 2008b) is focused on preventing the fragmentation of diverse plant and animal populations and strives to link public land reserved as either national forests, parks, or monuments as well as mountain parks and riparian areas. The Tucson Mountain Biological Corridor links to the Santa Cruz River Corridor and other nearby natural areas such as Tumamoc Hill. The Starr Pass Resort Hotel project provided 150 acres to link Tucson Mountain Park and Tumamoc Hill. By protecting the surrounding land, natural corridors will be created, allowing area wildlife to sustain their migration patterns undisturbed. Expansion of the desert park will also ensure that researchers at the University will be able to continue their studies at the nearby Desert Laboratory.

3. ***The Santa Cruz Valley National Heritage Area*** (Santa Cruz Valley 2007) was approved by U.S. House of Representatives October 2007. A "National Heritage Area" is a place designated by the U.S. Congress where natural, cultural, historic, and recreational resources combine to form a cohesive, nationally distinctive landscape arising from patterns of human activity shaped by geography. These areas tell nationally important stories and are representative of the national experience through both the physical features that remain and the traditions that have evolved within them.

   A National Heritage Area is not a unit of the National Park Service (NPS), nor is any land owned or managed by the NPS. Instead, a National Heritage Area is a locally managed designation that focuses heritage-centered interpretation, conservation, and development projects over a complex matrix of public and private land. National Heritage Area initiatives are coordinated by a local entity in partnership with varied

stakeholders that work collaboratively on projects that meet the area's stated management plan goals. In addition, while a National Heritage Area designation is permanent, the NPS relationship with and commitments to a National Heritage Area vary over time.

The designation comes with limited technical and financial assistance from the NPS. NPS primarily provides planning and interpretation assistance and expertise, but also connects regions with other Federal agencies. Federal financial assistance provides valuable "seed" money that covers basic expenses such as staffing, and leverages other money from state, local and private sources. The region also benefits from national recognition due to its association with the NPS through the use of the NPS arrowhead symbol as a branding strategy.

The Desert Laboratory NHL is in the heart of the Santa Cruz Valley National Heritage Area and will seek opportunities through this regional recognition.

Management

Statement: On 6 July 1960, the acting chief of the USDA, on behalf of the U.S., sold the Desert Laboratory to the ABOR. This conveyance was made on the condition that the property would be used for "research or educational purposes" and that if the land ceased to be used for that purpose, the title would revert back to the U.S. In 1961, the ABOR obtained grazing leases from the State of Arizona to maintain control of the western slope and flats that made up the original boundary of the outdoor laboratory. After 1980, the grazing leases were converted to one commercial lease and one special land use permit solely and exclusively for desert plant life and wildlife ecological research. It is the goal of the ABOR and the University to maintain the Desert Laboratory as a premiere ecological research and education center and to promote research and education in a manner that protects the historical integrity of Tumamoc Hill.

Property Management: The assistant vice president of Real Estate Administration oversees the buildings, property, and leases at the Desert Laboratory through the Office of the Senior Vice President of Business Affairs.

Research Management: The Desert Laboratory is managed by a director appointed by the dean of the College of Science. The director oversees an activities and operations manager and a research director. The director shall chair the Tumamoc Hill Management Council. The director may manage his or her program under a recognized University department or program.

The director oversees research and educational programs on 12 parcels of land totaling 854 acres. Eight of these parcels (344.86 acres) are owned by the ABOR on behalf of the University. The remaining four parcels are owned by the ASLD. The ABOR, on behalf of the University, leases three of these parcels from ASLD under Commercial Lease 89-98103 and Institutional Taking 92-98103 (196.63 acres) and maintains a special land use permit with ASLD on an additional 312.16 acres under Permit 23-98104. The director shall oversee research and educational programs in accordance with ABOR rules, applicable state statutes, and the provisions of leases and special land use permits.

Other Tumamoc Hill Management Functions:

1. The Tumamoc Hill Management Council (established in 2007) will include but is not limited to the director, activities and operational manager, research director, historic preservation advisor, and planning coordinator. The intent of the council is to promote communication between all Tumamoc Hill users, develop and oversee a strategic plan, and keep the university apprised of Desert Laboratory activities.

2. The activities and operations manager will oversee the day-to-day operations of the Desert Laboratory and will be the point of contact for all internal University and external inquires (this is an existing 0.5 Full Time Equivalent (FTE) position at this time).

3. The research director shall be the point of contact for all proposed research at the Desert Laboratory. The research director shall accept applications to conduct research and shall coordinate the application review process. The research director will maintain a list of approved research projects and maps of approved project locations.

4. The historic preservation advisor will be selected by the University of Arizona Historic Preservation Coordinator (UAHPC) to provide the Tumamoc Hill Management Council with advice on historic preservation policy. The advisor will report monthly, or as necessary, to the UAHPC on Desert Laboratory activities that are relevant to historic preservation.

5. The planning coordinator collaborates with diverse communities to promote Desert Laboratory ecological research and education.

6. The UAHPC is appointed by the University President. The UAHPC is responsible for overseeing University compliance with preservation policies and state and federal preservation law.

Research and Educational Program Policy

Statement: Ecological research and education programs are an integral part of the cultural landscape at the Desert Laboratory. The types of traditional ecological research and education programs conducted have had no appreciable negative effects on prehistoric or historic features on the laboratory grounds. The purpose of this section is to express the University's stewardship role and responsibilities regarding the preservation of historic resources owned or under the control of the University at the Desert Laboratory by providing historic preservation guidance to laboratory users.

University of Arizona, Desert Laboratory, Ecological Use Application

Ecological Research

1. Federal agencies providing funding for research projects are required to consider the effects of their funding on cultural resources. Faculty, students, and visiting scholars are advised not to apply for federal or state grants to conduct ecological research on the Desert Laboratory until the researcher has successfully negotiated the application process and has approval of the project scope regarding its effect on cultural resources.
2. Faculty, students, and visiting scholars will not conduct ecological research on the Desert Laboratory without written approval from the research director. To obtain permission to conduct research, candidates shall
    a. obtain a Desert Laboratory, ecological use application from the research director; and
    b. submit the completed application and five copies to the research director. A detailed research proposal and a USGS topographic map showing the research location will be attached to the original and copies of the application.
3. Responsibility of the research director to the applicant includes the following:
    a. The research director will determine whether a proposed project will directly or indirectly affect approved research on the Desert Laboratory and will consult with researchers whose projects might be directly or indirectly affected by the proposed research.
    b. Within 20 days of receipt of an ecological use application, the research director will provide two copies of that application to the historic preservation advisor.
4. Responsibility of historic preservation advisor to the applicant includes the following:
    a. Within 20 days of receipt of an application from the research director, the historic preservation advisor will consult with the applicant to ensure that the proposed ecological project will not directly or indirectly affect cultural resources.
    b. If the historic preservation advisor is satisfied that the applicant will not directly or indirectly affect cultural resources, the advisor shall recommend approval of the project in writing to the research director.

c. In the event that there is a disagreement between the historic preservation advisor and the applicant about cultural resource avoidance, the advisor and applicant shall consult with the research director and UAHPC.

Arizona Antiquity Act Permit Application (Implemented)

Cultural Resources Studies

Only the ASM can authorize cultural resources studies on lands owned or controlled by the State. No one may conduct cultural resources studies on the Desert Laboratory without first submitting an AAA project-specific permit application to the ASM.

1. Responsibility of ASM to the Desert Laboratory

    a. Within 20 days of receiving a qualifying project-specific permit application, the ASM shall schedule a consultation meeting between the research director, UAHPC, and applicant.

        1) Surface Survey

            a) Non-disturbing surface evaluation and documentation of cultural resources on ABOR-owned lands may be approved by ASM in consultation with the research director and the UAHPC without external review.

            b) Non-disturbing surface evaluation and documentation of cultural resources on lands other than ABOR lands may be approved by ASM in consultation with the research director and the UAHPC but will require the applicant to obtain written final approval by the land managing agency before ASM will issue a permit (this applies to the leased State Trust lands or its subsequent property owner, if governmental).

        2) Excavation and artifact collecting (henceforth data recovery)

        Data recovery is generally discouraged on the Desert Laboratory but will be considered by ASM in consultation with the research director and UAHPC.

            a) If the ASM, in consultation with the research director and UAHPC, agrees that a proposed data recovery project on lands owned by ABOR will contribute new knowledge or understanding about the past, the ASM will advise the applicant in writing to submit the research proposal to the SHPO and interested tribes for review and comment. The comments provided by SHPO and the tribes shall weigh heavily on approval of a project-specific permit.

            b) If the ASM, in consultation with the research director and UAHPC, agrees that a proposed data recovery project on lands other than ABOR lands will contribute new knowledge or understanding about the past, the ASM will advise the applicant in writing to submit a research proposal to the land managing agency, SHPO, and interested tribes concurrently for review and comment. Approval of a project-specific permit is dependent on written final approval from the land managing agency. Comments received by SHPO and tribes will weigh heavily on approval of a project-specific permit.

Access

Statement: The Desert Laboratory is protected under a number of state statutes. First, the lands owned or controlled by the ABOR at the Desert Laboratory are public lands subject to state egress and ingress rules, policies, and statutes (ARS §37-501 Public Lands). To protect the ecological and cultural integrity, criminal trespass statute ARS §13-1502 shall be applied when appropriate. Communication facilities, public utilities and liquid-transfer pipelines are protected under "critical public service facilities" statute ARS §13-1501 (1) (a). The entire Desert Laboratory is also protected under the AAA (ARS §41-841 *et seq*.). The Desert Laboratory shall be controlled in a manner that prevents damage to cultural and ecological resources.

1. Unsupervised public access to the Desert Laboratory.
    a. Unsupervised walking on the paved road from the Anklam Road entrance to the end of pavement at the top of Tumamoc Hill may be opened or closed to public use at the discretion of the University.
2. Signs (8.5 × 11 inches) will be posted on the perimeter fence at intervals prescribed by state statute and with language approved by the University's General Council and shall clearly reflect the access policies of the State.
3. Larger signs will be erected along the paved road and elsewhere as needed to provide the public with clear information on public access policies. Signs will not exceed 2 feet high × 3 feet wide, mounted on heavy-duty metal u-channel posts or greater, and will not exceed 6 feet high.
4. Protocol for reporting unauthorized activities and trespass.
    a. All employees and lessees are encouraged to wear visible identification badges when working on Tumamoc Hill. Employees and lessee should not approach strangers. Call 911 to report unauthorized activities, including simple trespass.

University of Arizona Educational Programs Access Policy

1. Requests by individuals or groups to tour the historically significant Carnegie buildings or Manhattan Project buildings will be conducted at the discretion and availability of Desert Laboratory staff. Employees or designees providing tours will be trained in cultural resources sensitivity. Policies shall be written that specify where and when tours may be given.
2. Requests by individuals or groups to tour the Desert Laboratory ecological or botanical grounds will be conducted at the discretion and availability of Desert Laboratory staff. At a minimum, employees or designees shall be trained in cultural resources sensitivity and study plot sensitivity. Policies will be written that specify where and when tours may be given.
3. Requests by individuals or groups to tour Desert Laboratory cultural resources will be deferred to the Desert Laboratory historic preservation advisor.
4. The Tumamoc Hill Management Council, in consultation with the ASM, UAHPC, and tribes, will identify a representative sample of prehistoric and historic features that may serve as places to be made available for public viewing and interpretation under the supervision of the historic preservation advisor or designee.
5. All University employees with approved ecological or archaeological research projects are responsible for scheduling cultural resources sensitivity training for each student or class working on the laboratory property.

Lessee Stipulations

Statement: These stipulations were incorporated into all lease renewals beginning in April 2007, and the wording has not been changed.

Stipulations

Section I. Procedures for the protection and preservation of cultural resources on the Desert Laboratory

1. To the extent feasible, the University will avoid adverse effects to historic properties on Tumamoc Hill through a permanent moratorium on new private, commercial, university, municipal, state or federal agency construction.
2. As part of the permanent moratorium, the University of Arizona and LESSEES shall not expand outward beyond existing foot prints of foundations, or widen or expand the rights-of-way of overhead or underground utilities lines in any way.
3. LESSEES, their contractors and subcontractors, shall be notified of the moratorium.
4. In the course of maintaining existing facilities and infrastructure on Tumamoc Hill, LESSEES, will avoid adverse effects to historic properties.
    a. Once a year LESSEES, their contractors, and subcontractors that work on Tumamoc Hill shall attend a one hour cultural resources sensitivity session provided by the University of Arizona Preservation Coordinator (UAHPC) and tribes claiming affinity to the hill.
    b. All new contractors and subcontractors shall attend a one hour cultural resources sensitivity session provided by the UAHPC and tribes prior to working on Tumamoc Hill.
    c. All vehicles shall remain on existing roads and shall only park in designated lots.
    d. During normal work hours from 7 a.m. to 5 p.m. Monday-Friday, general maintenance activities on equipment attached to the exterior of buildings, communication towers, and utility poles may proceed after registering at the designated Desert Laboratory building.
    e. Any access before 7 a.m. or after 5 p.m. will be considered to be an emergency situation and a completed log of events, including times entered and exited, nature of the emergency, names of the company or agency, names of participants, and the license plate of the vehicles shall be turned in to the designated laboratory building within 24 hours after the event.
    f. When maintenance requires the use of vehicles greater than ¾ ton in size, truck or trailer mounted cable pullers, mechanical lifts, or cranes of any kind, the project proponent shall:
        1) Submit a work plan to the UAHPC 30 days prior to the project.
        2) UAHPC shall review the work plan within 15 days of receipt of the plan and notify the LESSEE of any special cultural resources condition.
        3) The UAHPC may request that a permitted archaeologist be hired by the LESSEE to monitor the work.
    g. The University of Arizona and LESSEES shall comply with A.R.S. §41-864 [Review of Agency Plans] when any vehicle, truck or trailer mounted cable puller, mechanical lift or crane, or any other similar mechanical device must be placed somewhere other than on approved

roads or in designated parking lots on Tumamoc Hill. The LESSEE shall:

1) Submit a work plan to the Arizona State Historic Preservation Office and UAHPC for concurrent review and comment 30 days or more in advance of the proposed maintenance project. The UAHPC shall have 30 days from receipt of the work to comment.
2) The UAHPC shall submit a copy of the work plan to Tribes claiming affinity to Tumamoc hill within 3 working days of UAHPC receiving the work plan from the LESSEE.
3) The Tribes claiming affinity to Tumamoc Hill shall have 30 days to comment on the work plan from the date of receipt.
4) If after review by SHPO and UAHPC and the Tribes, no suitable alternative is found and a maintenance activity requires equipment to be placed somewhere other than on approved roads or in designated parking lots the LESSEE shall hire a permitted archaeologist to monitor the work.
5) Tribe's claiming affinity to the hill shall be given an opportunity to be present during the work, if this is feasible without delaying the work.

h. Should an unforeseen event cause facility and/or infrastructure damage, the University of Arizona and its LESSEE shall secure the area and notify UAHPC immediately.

1) The UAHPC, in consultation with SHPO and Tribes claiming affinity to Tumamoc Hill shall provide prompt guidance to the University of Arizona, LESSEE, their contractors, and subcontractors on how to avoid adverse affects to historic properties if repairs have a potential to cause ground disturbance.
2) The University of Arizona and its LESSEE shall comply with A.R.S. §41- 864 [Review of Agency Plans].

Section II. Procedures for Implementing Project Review Pursuant to Section 106 of the National Historic Preservation Act (16 USC 470f)

1. These cultural resource lease stipulations do not substitute for a federal agency's consultation efforts as required by Section 106 of the National Historic Preservation Act (16 U.S.C. 470f).

   a. The University of Arizona and its Lessee shall notify the UAHPC of all projects that require, or might require, federal funding and/or federal oversight. This contact should be made as early as possible in the planning process.

2. The University of Arizona and LESSEE, assisted by the UAHPC shall initiate consultation with SHPO, and the affected federal agency, tribes claiming affinity to Tumamoc Hill, other tribes as appropriate, and state agencies as appropriate pursuant to 36 CFR 800 of the regulations implementing Section 106 of the National Historic Preservation Act (16 U.S.C. 470f).

Section III. Preparation of a Treatment Plan

1. Every effort will be made to avoid adverse effects to historic properties on Tumamoc Hill. Where avoidance is not feasible, as described in Section I (D) (6) (7), and (8), the University of Arizona, UAHPC and LESSEE shall in consultation with SHPO and tribes ensure that a treatment plan is developed for the mitigation of anticipated effects on historic properties that will result from the project.

2. LESSEE shall hire a consultant specializing in cultural resources management and meeting all state and federal standards, for such firms to develop a treatment plan according to the outcome of consultation.

3. The treatment plan shall be consistent with the Secretary of Interior's Standards and Guidelines (48 FR 44716-44742) and the Arizona SHPO Reporting Standards, Parts I and II.

    a. Lessee shall provide the UAHPC with 10 copies of the treatment plan. The UAHPC will send copies of the draft Treatment Plan to the signatories and concurring parties that have not received the document and any report modification for review and comments.

    b. If UAHPA, Tribes and SHPO do not provide comment within 30 calendar days of receipt of the treatment plan, they shall be assumed to concur with the plan. No work shall begin until ASM reviews the plan and issues a project specific permit pursuant to A.R.S. §41-842.

    c. All historic preservation work carried out by designated archaeological consultants must be conducted by or under the supervision of a person, or persons, meeting at a minimum the Secretary of Interior's Professional Qualifications Standards (45 FR 44738-44739).

    d. A designated consultant shall work under the authority of a project specific permit (A.R.S. §41-842) issued by ASM. The designated consultant is subject to all permitting conditions as provided in A.R.S. §41-841 *et seq.* implementing 8-204, Arizona Board of Regents, Chapter VII ASM Rules and any pertinent regulation for federal projects under standards set forth in 36 C.F.R. Part 79.

4. LESSEE shall be the only party responsible for financial reimbursement to the designated consultant specializing in cultural resources management and the Project Proponent is responsible for disputes and/or disagreements between the Project Proponent and the designated consultant.

5. A burial agreement developed by ASM Coordinator pursuant to A.R.S. §41-844 will be implemented for each project. This agreement identifies methods and procedures for the recovery, analysis, and disposition of the human remains; associated funerary objects; and objects of cultural patrimony that reflect concerns or conditions identified as the result of consultation among ASM and those groups claiming affiliation with the remains or objects.

6. If an objection is raised by a member of the public at any time during implementation of the measures stipulated here, the LESSEE shall take the objections into account and consult as needed with the objecting party, the University, and SHPO to resolve the objection.

7. These stipulations shall be deemed amended by any state or federal law affecting the subject matter hereof to the extent necessary to make the stipulations comply with such law provided that said law shall be enacted or become affected after the effective date of this agreement.

Section IV. Tumamoc Hill Restoration

1. The Tohono O'odham Nation, the Ak Chin, the Salt River Pima-Maricopa, and the Gila River Indian Communities and the Hopi and Pascua Yaqui Tribes have strong cultural ties to the landscape of Tumamoc Hill itself and to the prehistoric and historic cultural resources on it. It is the desire of these tribes to see Tumamoc Hill restored to its former natural condition. Should technological advancements make Tumamoc Hill nonessential to the operation of A LESSEE, the LESSEE shall remove equipment, buildings, and infrastructure from the property in consultation with the Arizona State Historic Preservation Office, UAHPC and Tribes claiming affinity to Tumamoc Hill so as to avoid adverse affects to the cultural resources.

Section V. Ad Hoc Committees

1. The University of Arizona Historic Preservation Coordinator may delegate responsibilities for the management of special Tumamoc projects to ad hoc committees as needed. The ad hoc committee members will be selected from UA faculty, staff, interested parties, other agencies, and tribal members to serve consensually as needed for the duration of specific projects. Committee members will also be selected for their expertise and interest appropriate to the project at hand; a balance of backgrounds will be sought as well among the ad hoc committee members. The ad hoc committees will report to the Coordinator on the status of subject projects at previously agreed-upon intervals and the ad hoc committee members will be bound to no minimum time of service.

The Desert Laboratory as a Cultural Landscape

As mentioned previously, the cultural resources found on Tumamoc Hill constitute a cultural landscape. The National Park Service has defined a cultural landscape as "a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values" (Birnbaum 2007). The four general types of cultural landscapes are historic sites and historic-designed, historic-vernacular, and ethnographic landscapes. A property may be composed of aspects of each type. Furthermore, all the landscapes, buildings, archeological sites, and collections found within a historic property are part of the cultural landscape. The terms historic-vernacular landscape describe a landscape that has evolved out of the long-term activities and residence of the land's occupants: "through social or cultural attitudes of an individual, family or a community, the landscape reflects the physical, biological, and cultural character of those everyday lives. Function plays a significant role in vernacular landscapes. They can be a single property such as a farm or a collection of properties such as a district of historic farms along a river valley" (Birnbaum 2007). Historic-vernacular landscape may be the term that will most appropriately characterize the resources at Tumamoc Hill. A future goal for the management and preservation of the cultural resources on Tumamoc Hill would be to complete the nomination requisites for listing the Desert Laboratory in the NRHP as a national historic vernacular landscape.

Lands Leased to the University of Arizona

Should Pima County acquire the E ½ EXC RDS in Section 16, Township 14 South, Range 13 East (312.16 acres) from the ASLD an intergovernmental agreement for the planning and management of the land by Pima County should be executed with the University to ensure continued access to existing and future research projects.

Educational Opportunities that Enhance Resources Protection

Public Outreach

The goal of public outreach is to raise community awareness of the ecological and cultural importance of Tumamoc Hill and to provide visitors with educational opportunities that enhance resource preservation and protection. Recommendations:

1. A visitor center should be established in Building 811 at the base of Tumamoc Hill to serve as an environmental education center. Acquire Arizona heritage funds and other sources of funding to make repairs to Building 811, including electrical, water, and fire-safety improvements. Ensure the building, entrance, and other access points serve individuals with disabilities. Partner with St. Mary's Hospital to establish three or more handicapped parking bays and two school bus bays within their south hospital parking lot. Work with the City of Tucson to establish a pedestrian crossing on Anklam Road from the Hospital to the laboratory entrance. All other public parking should continue to be located in designated street locations on Anklam Road.
2. Develop a Desert Laboratory docents and friends program to disseminate information about the hill and be a presence on the land.
3. Educational outreach should include a quarterly newsletter, audio-visual and web-based programs, and small exhibits with an emphasis on Desert Laboratory projects that can be set up on campus or within the community. Offer public lectures and University-led public tours focused on current and past ecological and anthropological/archaeological research.

4. Educational outreach should be linked to the University Science Center and ASM at Rio Nuevo and to tribal museums.
5. Develop interpretive signage at key locations along the road for hill walkers to read and produce a brochure that can be obtained on-site that contains pertinent information about the hill's ecological and cultural history.
6. Encourage local media to run short segments on the ecological and anthropological/archaeological research activities of the Desert Laboratory.
7. Develop on site surveys and assess what visitors know about Tumamoc Hill. Survey responses will help managers make the public outreach program more affective.
8. Coordinate with the Campus Community Relations Committee and make the Desert Laboratory a special category for discussion at meetings.
9. Understand that the members of the surrounding neighborhoods consider the Desert Laboratory and Tumamoc Hill an integral part of their immediate community and they have much to offer the University with regard to preservation efforts both on and off the Desert Laboratory grounds.
10. Understand that many neighborhood members hold a great deal of institutional memory related to Desert Laboratory activities along the boundary. Use this information to inform current and future decisions.
11. Create opportunities for the campus community to appreciate and participate in exploration of the Desert Laboratory at Tumamoc Hill.
12. Expand Desert Laboratory educational opportunities to included tours with alumni, faculty, staff, and students. Engage all scholars with past and present research interests in Desert Laboratory in developing promotional materials and signage to enhance the tour experience. Coordinate scripts for Desert Laboratory tours to integrate information about Desert Laboratory history and development, ecological research, and archaeological research.

Short-term goal: To foster public appreciation for past and current ecological and anthropological and archaeological research conducted on the hill.

Long-term outcomes: To foster community collaboration and a sense of public investment in the protection and preservation of Tumamoc Hill.

Enhancing Cultural Resources Protection

1. The weakest link in the protection and preservation of cultural and ecological resources at the Desert Laboratory is the absence of a full-time activities and operational manager. It is recommended that the position and responsibilities be similar to those of the Santa Rita Experimental Range position, in that a full-time manager would reside on the property in the existing residential structure at the base of the hill. This manager would report to the Desert Laboratory director and, in the absence of a director, may act in a supervisory capacity to carry out University policy regarding the laboratory.
2. Cultural resource protection activities will include a programmatic agreement between the Arizona State Parks Site Steward Program, the ASM, and the University. The site stewards would monitor the condition of cultural resources and report damage to the UAHPC.
3. A modest iron post barrier will be constructed in the designated parking area immediately west of the KUAT transmitting facility to protect archaeological features on the lot's edge.

4. The pithouse and cupule boulder exposed in the roadway on the summit of the hill shall be protected through appropriate measures determined in consultation with SHPO, UAHPC, and the Tribes.

5. The locations of all historic plant plots have been mapped (such as the Shreve study plots). All future vegetation study plots shall be mapped with a GPS unit. A set of photographs and maps of each study plots will be prepared and kept on file in the Desert Laboratory library. GPS coordinates shall be kept on all metal posts, pipes, and rebar that identify past study plots.

6. Law enforcement intervention, fencing, and signs are deterrents but not an effective solution when addressing trespass issues. Outreach programs focused on creating a positive community atmosphere that promotes a sense of land stewardship and opportunities shall be examined.

7. Homeless encampments and activities associated with these camps have direct and indirect impacts on cultural resources. Documented problems include the dismantling of historic and prehistoric structures to build shelters, creation of foot trails and bike paths, human waste deposits, garbage dumps, and cooking pits. A permanent maintenance fund to immediately dismantle and remove camps upon their discovery is recommended.

8. It is recommended that the University request an emergency funding package from the Arizona legislature to make full repairs and educational upgrades to the Desert Laboratory.
    a. Historic Buildings
        1) All of the historic buildings require repair and maintenance. These include the Main Laboratory (Building 801, built 1903), the Shop Building (Building 118, built 1906), the Chemistry Building (Building 802, built 1914), two reservoirs (1906) and forest service buildings (804, 805, and 807 Manhattan Project buildings). Building 806, a wooden shed, should be dismantled because of its dilapidated condition.
    b. Road Repair
        1) The road from the top of Tumamoc Hill to the bottom should be repaved, with emphasis on building up the edges where erosion has removed the base material; drainage devices should be installed to control rainwater in a manner that prevents pavement degradation.
    c. Perimeter Fence
        1) The four-strand wire fence around the Desert Laboratory should be fully repaired with new steel U-channel posts. The original historic concrete posts will be protected and stabilized where bases have cracked. AGFD regulations for wildlife egress and ingress shall be followed when reinstalling wire. Alternatives to traditional barbed-wire fencing should be explored.
    d. Utility upgrades
        1) An assessment should be made of the historic buildings in consultation with risk management and the state fire marshal to determine the feasibility of sprinkler systems and fire hydrants.
        2) The buildings provide ample research space and room for educational programs, but the information technological connectivity to the University requires upgrades.

9. Fire suppression strategies should be developed by risk management in cooperation with the state fire marshal and local fire departments to address rangeland and structure-specific fire scenarios on the Desert Laboratory property. The plan should consider protection of the prehistoric and historic components of the hill, where fire suppression might require ground-disturbing activities.

10. Paper, Photographic, and Digital Records Management

    Administrative records, including correspondence, property maps, photographs, receipts, ledgers, and other materials related to Desert Laboratory, are archived in several locations, including the Carnegie, University Special Collections, Arizona Historical Society, ASM, and Desert Laboratory, to name a few. Research directly related to observations made on the Desert Laboratory grounds is diverse. Documentation, such as field notes and resulting papers and publications, is maintained by researchers. The Desert Laboratory is not equipped to house original documentation or to compile and store copies of every document related to research at the laboratory. It is recommended that a finding aid be prepared that identifies archival repositories holding Desert Laboratory records and a bibliography of all literature pertaining to the Desert Laboratory. Individuals who maintain their own original research documentation, conducted on the Desert Laboratory grounds, should be encouraged to donate their records to a public repository and notify the Desert Laboratory of the selected archival location.

11. Day-to-day cultural resources management is guided by this document, but there will always be some damage caused by the accumulative effects of natural processes and, unfortunately, damage and loss caused by unauthorized human activity. At this time (2008), full documentation of most prehistoric and historic resources on Tumamoc Hill provides the baseline to evaluate the condition and health of these resources into the future. It is proposed here that the UAHPC plan and oversee a cultural resources condition assessment every five years.
    a. The UAHPC will seek grant funds to accomplish a condition assessment of at least 10 percent of each surface feature type identified in this policy plan.
    b. The condition assessment will be overseen by a professional archaeologist permitted in the Arizona to conduct such work. The UAHPC may draw this support from the ASM, Department of Anthropology, or from an outside archaeological contractor. Volunteer organizations such as the AAHS may assist in this effort under professional supervision.
    c. All feature locations are mapped and will be made available through the ASM, AZSITE Office. All original paper records, digital records, and photographs shall be stored in perpetuity at the ASM Archives. Copies of these data will be on file in the Tumamoc Hill Library.

12. The Tumamoc Hill Cultural Resources Policy and Management Plan will be reviewed at least every three years, unless it is necessary to do so sooner, in which case it will be revised at that time.

Allan, James, Kyle Brown, Allen Estes, Kyle Kearney, and William Self
2004 *Preliminary Report on Data Recovery: Tucson Pipeline Project, Phases III and IV, Pima County, Arizona*. William Self Associates, Orinda, California.

Arizona Weekly Citizen
1883 No title, author, or date of publication are known.

Baldwin, Kerry L., Stanley K. Brickler, Paul B. Dumond, John H. Skibinski
1974 *An Environmental Study Area Plan for Tumamoc Hill, Tucson, Arizona.* A project of the Tumamoc Hill Committee, Natural Resource Recreation, College of Agriculture, University of Arizona, Tucson.

Birnbaum, Charles A.
2007 Protecting Cultural Landscapes. National Park Service Preservation Briefs No. 36. Available at: http://www.nps.gov/history/hps/tps/briefs/brief36.htm. Accessed 14 August 2007.

Bowers, Jan E., and Ray M. Turner
1985 A Revised Vascular Flora of Tumamoc Hill, Tucson, Arizona. *Madroño* 32:225–252.

Brack, M. L., and Allison C. Diehl
2002 *A Cultural Resources Survey of 12 Ground Water Monitoring Wells and Access Routes around 5 Existing Landfills in Tucson, Pima County, Arizona*. Project Report No. 02-105. Desert Archaeology, Tucson.

Burton, Jeffery F.
1988 Prehistoric Rock Art of the Southeast Arizona Uplands: A Formal Record of 53 Rock Art Sites on the Coronado National Forest. Manuscript on file, U.S. Forest Service, Coronado National Forest, Tucson.

Christopherson, Gary, Paul Fish, Suzanne Fish, John Chamblee, and Phillip Leckman
2005 Integrating ArcGIS and ArcPAD in an Archaeological Field School. Paper presented at the 25th Annual ESRI Conference, San Diego, California. Available at: <http://gis.esri.com/ library/userconf/proc05/ abstracts/a1429.html>. Accessed 10 October 2005.

City of Tucson
2007 Tumamoc Area Plan. Available at: http://www.tucsonaz.gov/planning/plans/all/tumtext.pdf. Accessed 20 August 2007.

2008a Land Use Code. Available at: http://www.tucsonaz.gov/planning/codes/luc/lucweb/Art2div8.html#P1424_85473. Accessed 28 January 2008.

2008b Development Standard. Available at: http://www.tucsonaz.gov/dsd/Codes___Ordinances/DS_Renumbered/DS_9-06__Floodplain_Wash_ERZ.pdf. Accessed 28 January 2008.

References Cited

Culin, Frank L., Jr.
1916 Building Stones. *University of Arizona Bulletin.* Economic Series No. 10. University of Arizona, Bureau of Mines.

Diehl, Allison C.
2002a *Archaeological Monitoring of the Drilling of Groundwater Monitoring Wells at AZ AA:16:6 (ASM) and AZ BB:13:17 (ASM) in Tucson, Pima County, Arizona*. Project Report No. 02-116. Desert Archaeology, Tucson.

2002b *Cultural Resources Assessment of Five Proposed Monitoring Well Locations at Tumamoc Landfill, Tucson, Pima County, Arizona*. Project Report No. 02-152. Desert Archaeology, Tucson.

Diehl, Michael W., Allison Cohen Diehl, James M. Heidke, Elizabeth Miksa, Mark A. Neupert, and Michael K. Wiley
1996 *Archaeological Investigations of the Tucson Pressed Brick Company, Tucson, Arizona.* Technical Report No. 96-13. Center for Desert Archaeology, Tucson.

Doelle, William
1985 *Excavations at the Valencia Site: A Preclassic Hohokam Village in the Southern Tucson Basin.* Report No. 3. Institute for American Research, Tucson.

Elkins, Rosemary, Gayle H. Hartmann, Robert C. Johnson, Thomas Saarinen, Terah L. Smiley, Brock Tunnicliff and Stanley K. Brickler
1982 *Tumamoc Hill Policy Plan*. Prepared for the Tumamoc Hill Advisory Committee, University of Arizona, Tucson.

Estes, Allen, Aimee Arrigoni, Jenni Price, Kyle Kearney, James Allan, and William Self
2004 *Cultural Resources Survey and Monitoring Report: KMEP 12 Anomaly Digs, Line Section 53/54, Maricopa, Pinal, and Pima Counties, Arizona*. William Self Associates, Orinda, California.

Estes, Allen, Morgan Reider, Kyle Brown, Kyle Kearney, Aimee Arrigoni, Tom Young, Adam Marlow, James Allan, and William Self
2005 *Final Data Recovery and Monitoring Report: KMEP Tucson Pipeline Replacement Project, Phases III and IV, Pima County, Arizona*. William Self Associates, Orinda, California.

Ezzo, Joseph A., and William L. Deaver
1998 *Watering the Desert: Late Archaic Farming at the Costello-King Site*. Technical Series No. 68. Statistical Research, Tucson.

Fahrni, Grant, and Shannon Twilling
2004 *A Class III Cultural Resource Survey of Approximately Five Acres near the Intersection of West Anklam Road and North Camino Santiago, Tucson, Pima County, Arizona*. Harris Environmental Group, Tucson.

Ferg, Alan
1979 The Petroglyphs of Tumamoc Hill. *The Kiva* 45:95–118.

Fish, Paul
2005 Tumamoc Hill and University Indian Ruin. In *Cross-Cultural Vernacular Landscapes of Southern Arizona: A Field Guide for the Vernacular Architecture Forum, 25th Anniversary Conference, Tucson, Arizona*, edited by L. Hollengreen and R. Jeffery, pp. 219–226. Vernacular Architecture Forum, Harrisonburg, Virginia.

Fish, Paul, and Suzanne Fish
2007 Tumamoc Hill Revisited: New Data and Alternative Perspectives on Early Trincheras Sites. *Glyphs* 57:8. Arizona Archaeological and Historical Society, Tucson.

Fish, Paul, Suzanne Fish, Austin Long, and Charles Miksicek
1986 Early Corn Remains from Tumamoc Hill, Southern Arizona. *American Antiquity* 51:563–572.

Fish, Suzanne K., Paul R. Fish, and Gary Christopherson
2007 Early occupations on Tumamoc Hill. *Archaeology Southwest* 21:4–5.

2008 Tumamoc Hill Archaeological Data Base. Consists of maps, locational data, drawings, photos, field notes, and forms. Data base to be added to AZSITE Data Base at the Arizona State Museum, University of Arizona.

Fish, Suzanne, Paul Fish, and John Madsen
1992 *The Marana Community in the Hohokam World*. Anthropological Papers No. 56. University of Arizona Press, Tucson.

Fish, Suzanne, Paul Fish, Charles Miksicek, and John Madsen
1985 Prehistoric Agave Cultivation in Southern Arizona. *Desert Plants* 7:107–112.

Gregory, David A.
1999 *Excavations in the Santa Cruz River Floodplain: the Middle Archaic Component at Los Pozos*, edited by D. A. Gregory. Anthropological Papers No. 20. Center for Desert Archaeology, Tucson.

Hammack, Nancy S.
1983 *Cultural Resource Assessment, Tucson-Apache 115kV Transmission Line*. Complete Archaeological Service Associates, Cortez, Colorado.

Hartmann, Gayle H., and William K. Hartmann
1979 Prehistoric Trail Systems and Related Features on the Slopes of Tumamoc Hill. *The Kiva* 45:39–70.

Hedges, Ken, and Anita McDaniel
1986 A Sampler of Hohokam Rock Art. In *Rock Art Papers*, Vol. 3, edited by K. Hedges, pp. 117–128. Museum Papers No. 20. San Diego Museum of Man, San Diego.

References Cited

Hesse, S. Jerome, and Mark L. Chenault
2003 *A Cultural Resource Survey of Eighteen Construction Sites along EPNG Line 1007 in Tucson, Pima County, Arizona*. SWCA Environmental Consultants, Tucson.

Howell, R. Emerson
2007 A Preliminary Report on the Historic Archaeological Resources at Tumamoc Hill. Manuscript on file, Arizona State Museum, University of Arizona, Tucson.

Huckell, Bruce B., and Lisa W. Huckell
1984 *Excavations at Milagro, a Late Archaic Site in the Eastern Tucson Basin*. Arizona State Museum, University of Arizona, Tucson.

Huntington, Ellsworth
1904 Field Notes. Yale University Library Archives, New Haven, Connecticut.

1914 *The Climatic Factor in Arid North America*. Publication No. 192. Carnegie Institution, Washington, D.C.

Jacobs, Mike
1979 The St. Mary's Hospital Site. *The Kiva* 45:119–130.

Jones, Jeffrey T.
2000 Cultural Resources Survey of 145 Acres of State Trust Land West of Tumamoc Hill in Tucson, Arizona. Letter Report No. 2000.049. Old Pueblo Archaeology Center, Tucson.

Klimas, Thomas
2005 *Monitoring of AZ AA:16:6 (ASM) and AZ AA:16:51 (ASM): Replacement of One Utility Pole and Placement of One Guy Wire on Tumamoc Hill, Pima County, Arizona*. Tierra Right of Way Services, Tucson.

Larson, Stephen M.
1972 The Tumamoc Hill Site near Tucson. *The Kiva* 38:95–102.

1979 The Material Culture Distribution on the Tumamoc Hill Summit. *The Kiva* 45:71–82.

Lee, Bryan
2003 Joggers and Walkers Get a Rise out of the Scenery and Serenity of Tumamoc Hill. *Tucson Citizen.* 30 October. Tucson.

Lindsay, Alexander J., Jr., and Michael N. Metcalf
1973 Archaeological Clearance Investigations, Mountain States Telephone and Telegraph Company, 1973 Kitt Peak Tucson Radio Project, Arizona State Land–University of Arizona, Pima County, Arizona. Manuscript on file, Museum of Northern Arizona, Flagstaff.

Mabry, Jonathan B.
1998 Architectural Variability and Site Structures. In *Archaeological Investigations of Early Village Sites in the Middle Santa Cruz Valley: Analyses and Synthesis*, edited by J. Mabry, pp. 209–244. Anthropological Papers No. 19. Center for Desert Archaeology, Tucson.

Madsen, John H.
1993 Rock Cairn and Talus Pit Features in the Los Robles Community. In *Between Desert and River: Hohokam Settlement and Land Use in the Los Robles Community,* edited by C. Downum, pp. 96–105. Anthropological Papers No. 57. University of Arizona Press, Tucson.

Martin, Paul
1963 *The Last 10,000 Years, a Fossil Pollen Record of the American Southwest*. University of Arizona Press, Tucson.

Martynec, Richard J.
1986 A Comparative Analysis of Rock Art at Trincheras Sites in the Tucson Basin. In *Rock Art Papers*, Vol. 3, edited by K. Hedges, pp. 103–116. Museum Papers No. 20. San Diego Museum of Man, San Diego.

Masse, W. Bruce
1979 An Intensive Survey of Prehistoric Dry Farming Systems near Tumamoc Hill in Tucson, Arizona. *The Kiva* 45:141–186.

McLean, David R., and Stephen M. Larson
1979 Inferences from the Distribution of Plainware Sherd Attributes on Tumamoc Hill. *The Kiva* 45:83–94.

Natural Resources Conservation Service (NRCS)
2008 Web Soil Survey. Available at: http//websoilsurvey.nrcs,usda.gov/aap/. Accessed 10 January 2008.

Pima County
2008a Intro: Sonoran Desert Conservation Plan. Available at: http://www.pima.gov/cmo/sdcp/intro.html. Accessed 21 July 2008.

2008b Critical Habitat and Corridors: Sonoran Desert Conservation Plan. Available at: http://www.co.pima.az.us/cmo/sdcp/Archives/SDCP.htm. Accessed 28 January 2008.

Post, Donald, David Hendricks, and M. L. Richardson
1973 *The Soils of Tumamoc Hill*. Unpublished report on file, Water, Soil and Environmental Science Department, University of Arizona, Tucson.

Rosettie, F. D.
1964 *St. Augustine's*. St. Augustine's Cathedral, Tucson.

Santa Cruz Valley
2007 National Heritage Area. Available at: http://www.santacruzheritage.org/. Accessed 15 November 2007.

References Cited

Shreve, Forest
1951 *Vegetation of the Sonoran Desert*. Carnegie Institution, Washington, D.C.

Steadman, David W.
1980 Birds of Tumamoc Hill. Manuscript on file, Department of Geosciences, University of Arizona, Tucson.

Thiel, J. Homer
1995 *Rock Art in Arizona: A Component of the Arizona Historic Preservation Plan*. Arizona State Historic Preservation Office, Phoenix.

Tucson Star
1919 Evidence of Ancient Civilization Are Found West of Tucson. 23 February. Tucson. Paul Fish of the ASM provided a copy of this article; the precise date of the article has not been confirmed.

Twilling, Shannon D.
2002 *Post-Construction Site Damage Assessment of the KUAT-TV Digital Conversion Project on Tumamoc Hill, Tucson, Arizona*. Cultural Resources Report No. 02-30. SWCA Environmental Consultants, Tucson.

2005 *Archaeological Monitoring of Geotechnical Investigations within the Limits of AZ:16:6 (ASM) and AZ:16:51 (ASM), Tucson, Pima County, Arizona*. Revised. Harris Environmental Group, Tucson.

Underhill, Ruth M.
1939 *Social Organization of the Papago Indians*. Columbia University Press, New York.

University of Arizona
2007a University of Arizona Historical Preservation Plan. Available at: http://web.arizona.edu/~cfp/planning_studies/. Accessed 17 December 2007.

2007b University of Arizona General Administrative Policy Relating to Historic Preservation Activities. Available at: http://web.arizona.edu/~cfp/planning_studies/historic_preservation_policy.shtml. Accessed 17 December 2007.

U.S. Geological Survey (USGS)
2008 Maps of Tumamoc Vegetation. Available at: http://www. paztcn.wr.usgs.gov/Tumamoc_research pdf. Accessed 21 July 2008.

Wallace, Henry D.
1983 The Mortars, Petroglyphs, and Trincheras on Rillito Peak. *The Kiva* 48(3):137–246.

Wallace, Henry D., Paul R. Fish, and Suzanne K. Fish
2007 Tumamoc Hill in the Context of Early Ceramic Occupations of the Tucson Basin. In *Enduring Traditions: Trincheras Sites in Time, Space and Society*, edited by S. Fish, P. Fish, and M. Villalpando. University of Arizona, Tucson.

Wallace, Henry D., and James P. Holmlund
1986 *Petroglyphs of the Picacho Mountains, South Central Arizona*. Anthropological Papers No. 6. Institute for American Research, Tucson.

White, Bradford J., and Richard J. Roddewig
1994 *Preparing a Historic Preservation Plan*. American Planning Association, Washington, D.C.

Whitney, Gregory J.
2005 *Cultural Resources Survey of a Proposed Overhead Fiber Optic Line along the Northern Slope and Summit of Tumamoc Hill, Tucson, Arizona*. Project Report 05-144. Desert Archaeology, Tucson.

Wilcox, David R.
1979 Warfare Implications of Dry-Laid Masonry Walls on Tumamoc Hill. *The Kiva* 45:15–38.

Wilcox, David R., and Stephen M. Larson
1979 Introduction to the Tumamoc Hill Survey. *The Kiva* 45:1–14.

Wilcox, David, Stephen Larson, Bruce Masse, Gayle Hartmann, and Alan Ferg
1979 A Summary of Conclusions and Recommendations of the Tumamoc Hill Survey. *The Kiva* 45:187–195.