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Public Lands and Cultural Resource Protection: A Case Study of Unauthorized Damage to Archaeological Sites on the Tonto National Forest, Arizona

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Corresponding Author:	Saul L. Hedquist University of Arizona Tucson, Arizona UNITED STATES
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	University of Arizona
First Author:	Saul L. Hedquist
Order of Authors:	Saul L. Hedquist
	Leigh Anne Ellison
	Andy Laurenzi
Abstract:	Archaeological resource protection remains an important management concern on public lands in the U.S. Southwest and beyond. While legislation and educational programs have contributed to a general improvement in public attitudes toward cultural heritage, archaeological resources on public lands remain vulnerable to a variety of human impacts. We present results of a condition and damage assessment of 96 prominent precontact sites on the Tonto National Forest (TNF) in central Arizona. We summarize field methods and observations and discuss their implications for the management and protection of archaeological resources on the TNF and other public lands. Sites at varying distances from roads were assessed in an effort to identify potential relationships between damage frequency and road proximity. Field results indicate that 1) unauthorized damage occurs more frequently at sites near TNF roads; and 2) economical measures like advisory signage provide potentially effective means of deterring unauthorized damage to sites in higher risk locations. Our findings add to a knowledge base important for understanding patterns of damage and site vulnerability and for developing practical protection strategies in line with public land missions and administrative capabilities.
Suggested Reviewers:	John Welch Simon Fraser University welch@sfu.ca Familiarity with land management and cultural resource conservation issues in the U.S. Southwest
	Jon Czaplicki Archaeologist, Bureau of Reclamation, Lower Colorado Region jczaplicki@usbr.gov Familiarity with land management and cultural resource conservation issues in the U.S. Southwest
Opposed Reviewers:	

Data Availability Statement

Physical copies of completed condition assessment forms for the 96 assessed sites are maintained at the Tonto National Forest and Archaeology Southwest. Contact the Tonto National Forest Archaeologist* for access to completed forms. Digital copies of sample forms, including the Tonto National Forest Heritage Assets Priority Property Condition Survey Form (tDAR ID# 392715) and Site Inspection/Maintenance Assessment Form (tDAR ID # 392714), and an excel spreadsheet containing primary data (tDAR ID # 392716) are archived in the Digital Archaeological Record (tDAR), an online repository for archaeological information maintained by the Center for Digital Antiquity. The sample forms are publically available for download to registered users of tDAR. Registration is free, and only requires users to agree to tDAR's terms and conditions. Downloading the spreadsheet of primary data requires permission from the Tonto National Forest Archaeologist.

* 2324 E. McDowell Rd., Phoenix, Arizona 85006. Phone: (602) 225-5200

Cover Letter

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Archaeology Southwest Exploring and protecting the places of our past

August 24, 2014

RE: Advances in Archaeological Practice Resubmission

The attached manuscript, *Public Lands and Cultural Resource Protection*, has been edited for resubmission. Minor changes include style and copy edits suggested by journal co-editors.

Please contact me at any time with questions regarding this submission.

Thank you,
Saul Hedquist
hedquist@email.arizona.edu

300 N. Ash Alley Tucson, AZ 85701
phone 520-882-6946 fax 520-882-6948
email info@archaeologysouthwest.org
www.archaeologysouthwest.org
William H. Doelle, Ph.D.
President and CEO

La protección de los recursos arqueológicos sigue siendo un gran problema de la administración de tierras públicas en el suroeste de los EE.UU., al igual que en otras partes del país. Aunque los programas de la legislación y la educación han contribuido en mejorar las actitudes públicas hacia el patrimonio cultural, los recursos arqueológicos en tierras públicas siguen siendo vulnerables a una variedad de impactos humanos. En esta ponencia (o artículo) se presentan los resultados de una evaluación de la condición de daños en 96 prominentes sitios pre-hispánicos ubicados en el parque nacional *Tonto National Forest* (TNF) del centro de Arizona. Resumimos los métodos de campo y discutiremos las implicaciones para la administración y protección de los recursos arqueológicos en el TNF y en otras tierras públicas. Los sitios arqueológicos ubicados en diferentes distancias de las carreteras fueron evaluadas en un esfuerzo por identificar las posibles relaciones entre la frecuencia de daño y la proximidad de carreteras. Los resultados de los estudios indican 1) los daños no autorizada ocurren con más frecuencia en los sitios cercanos a las carreteras del TNF; y 2) medidas económicas como la señalización de asesoramiento proporcionan medio potencialmente eficaz para disuadir los daños no autorizada en sitios ubicados en áreas de alto riesgo. Nuestros resultados contribuyen a una base de conocimientos importantes para entender los patrones de daño y la vulnerabilidad de los sitios, así como para el desarrollo de estrategias de protección prácticas para las misiones de tierras públicas y las capacidades administrativas.

PUBLIC LANDS AND CULTURAL RESOURCE PROTECTION: A CASE STUDY OF UNAUTHORIZED DAMAGE TO ARCHAEOLOGICAL SITES ON THE TONTO NATIONAL FOREST, ARIZONA

Introduction

The protection of archaeological resources presents challenges for public land managers in the United States (U.S.) bound by missions to provide public access to land, resources, and recreational opportunities (e.g., Forest Service, Bureau of Land Management). Within these contexts, land managers are charged with the task of balancing the needs and requirements of multiple land uses while seeking to avoid, minimize, and mitigate damage to archaeological resources. Limited funds and a shrinking professional workforce further complicate the management situation (Department of Interior, National Park Service 2010). On public lands in the U.S. Southwest, the relative abundance, visibility (e.g., above-ground masonry architecture), and accessibility (e.g., vehicular access) of archaeological resources intensify the need for effective and economical management strategies (see Tainter and Hamre 1988). Communication and cooperation among land managers is critical in developing a broad awareness of successful strategies in different environments.

In 2010, Archaeology Southwest (formerly the Center for Desert Archaeology) conducted a condition and damage assessment of 96 prominent, late precontact archaeological sites on the Tonto National Forest (TNF) in central Arizona (Hedquist and Ellison 2010). The goal was to create a knowledge base useful in decision-making regarding resource management on the TNF.[1] Field inspections were performed to examine the current condition of sites, record the degree, type, and relative age of observed damage (if any), identify potential factors affecting site condition and damage and, in light of this information, develop recommendations regarding

site stewardship. In this article we summarize field methods and observations and discuss their implications for the management and protection of archaeological resources on the TNF and other public lands.

In Arizona, recreational exploitation of archaeological resources dates back generations. In earlier times, pothunting and surface collecting at ancient sites were considered socially acceptable, even admirable practices (Spangler et al. 2006:5). During the early to mid twentieth century, numerous families made regular visits to archaeological sites throughout the state. Certain families built extensive collections, some of which were awarded ribbons at county fairs (Ahlstrom et al. 1992:21).

In recent decades, archaeological resource protection on public lands has been strengthened by the passage and enforcement of state and federal legislation (e.g., National Historic Preservation Act [1966], Archaeological Resources Protection Act [ARPA, 1979], Native American Graves Protection and Repatriation Act [1990], Arizona Antiquities Act [1960]). ARPA is the primary legal tool for the protection of archaeological resources on the TNF and other public lands (see Cheek 1991). The act (as amended) specifically prohibits the unauthorized excavation, removal, damage, alteration, or defacement of archaeological resources on public or Indian lands[2] (Archaeological Resources Protection Act of 1979, Section 6a). Prohibited acts are potentially subject to criminal penalties such as fines or imprisonment.

In addition to legislation, avocational initiatives and educational and interpretive programs have increased public interest in and awareness of the importance and non-renewable nature of archaeological resources (for discussions see Lipe 1974, 1984; McManamon 1991;

Society for American Archaeology 1990). These measures have contributed to a general improvement in public attitudes toward the preservation of cultural heritage (Propper 2012).

Despite these gains, however, archaeological resources on public lands in Arizona, as elsewhere in the U.S. Southwest, remain vulnerable to a variety of acts prohibited under ARPA. As described below, we observed evidence of unauthorized damage (both old and recent) at more than 90 percent of assessed sites on the TNF. Archaeological resource protection clearly has been and remains an important management challenge throughout the region (see McAllister 1988).

The importance of protecting and preserving archaeological resources on public lands cannot be overstated. As expressed in the opening lines of ARPA, "archaeological resources on public lands and Indian lands are an accessible and irreplaceable part of the Nation's heritage" (Archaeological Resources Protection Act of 1979, Section 2a). They provide direct, tangible connections to the past and illuminate cultural continuities (Lipe 1984:2).

Archaeological resources engender a range of values and interests (Anyon 1991; Lipe 1984). Archaeologists, land managers, and the public at large, for example, value the information yielding potential of archaeological sites, deposits, and other remains of material culture. The archaeological record, if cared for and properly studied, can yield new and exciting information about the past and its people (Lipe 2006). For Native Americans, these resources represent an integral part of their cultural identity. The archaeological record affirms a deep historical connection to the land, embodying both an ancestral past and cultural present (Anyon 1991:221). Sites provide important tangible evidence for situating oral traditions and other information within a greater physical and cultural landscape (see Ferguson and Colwell-Chanthaphonh 2006).

Importantly, archaeological resources are fragile and finite. Damage to sites is often irreparable, and may diminish the value of the resource in one facet or another (Lipe 2006; McAllister 1991; Nickens 1991). Understanding and addressing patterns of damage, i.e., different types, distributions, and frequencies of occurrence, is essential for preserving the archaeological record for future generations.

Study Area: Tonto National Forest

The Tonto National Forest was established in 1905 to protect watersheds and reservoirs supplying agricultural communities in the Salt River Valley of central Arizona. Stretching from Phoenix to the Mogollon Rim, the TNF encompasses over 12,000 km^2 (nearly 3 million acres) with elevations ranging from 400 to 2,400 m (1,300 to 7,900 feet) (Figure 1). Its boundary contains wide-ranging biodiversity, including woodland, grassland, desertscrub, and chaparral communities, along with abundant resources and recreational opportunities. Today, diverse recreational attractions such as hiking, hunting, target shooting, boating, fishing, swimming, and interpretative archaeological exhibits attract heavy, year-round visitation. A short drive from the greater Phoenix area, the TNF hosts nearly six million visitors annually (Tonto National Forest 2014). A dense network of roads provides public vehicular access to resources and recreational opportunities throughout much of the Forest (see Figure 1). Motorized vehicular use is prohibited within eight Wilderness Areas (approximately 2,400 km^2 in total) that constitute approximately 20 percent of the TNF's use area.

The TNF's size, proximity to an urban area, and popularity, in conjunction with the abundance and accessibility of significant and attractive archaeological resources, necessitate innovative and cost-effective approaches to archaeological resource protection. These conditions

make the TNF an ideal setting for examining human impacts to archaeological resources on public lands, as well as for evaluating the efficacy of management and protection strategies.

Site Selection and Field Methodology

A number of studies have examined unauthorized damage to archaeological resources in the U.S. in recent decades—nearly all have focused on areas of the greater Southwest (Ahlstrom et al. 1992; Christensen et al. 1988; Francis 1978; Hartley and Vawser 2004; Lightfoot 1978; Nickens et al. 1981; Sampson 2009; Simms 1986; Spangler 2006; Spangler et al. 2006; Sullivan et al. 2002; Uphus et al. 2006). While each provides an independent, context specific analysis, findings of factors contributing to site vulnerability are generally consistent throughout the region. These include: 1) site morphology—large sites with surface architecture (e.g., stone masonry) or large, visible artifact concentrations (e.g., middens) are generally more likely to sustain unauthorized damage; 2) distance to nearest road/vehicular access—sites closer to/more accessible by roads generally sustain more damage (Nickens et al. 1981; Plog 1978; Spangler et al. 2006), though those *not visible* from roads may also be vulnerable given their remoteness (Simms 1986); and 3) site setting (e.g., caves, open sites [Ahlstrom et al. 1992; Simms 1986; Spangler and Yentsch 2008]) and proximity to other recreational activities (e.g., hunting areas, camping areas [Schroeder 2010:14-15; Sullivan et al. 2002; Uphus et al. 2006]). Such findings provide valuable insights for informed management strategies and a useful baseline from which we developed our sampling strategy and recording methodology. Given limited time and funding, focus was placed on sites considered most vulnerable to unauthorized damage.

Ninety-six sites were evaluated for this study (see Figure 1), representing a 1.1 percent non-random sample of recorded archaeological sites located on and managed by the TNF. Sampled sites were identified using two primary sources of information: 1) the TNF Priority

Heritage Asset (PHA) list[3] (provided by TNF archaeologist J. Scott Wood, dated October 2009); and 2) the Coalescent Communities Database (CCD), which contains room count and spatial and temporal data from 3,000+ late precontact sites in the U.S. Southwest (Wilcox et al. 2003; see also Hill et al. 2012). As of 2009, the TNF's PHA list included 197 sites.[4] Over 400 sites in the CCD are located within the administrative boundaries of the TNF. Many sites are shared between the two sources.

From these overlapping databases, and in consultation with TNF archaeologists, sampled sites were selected using the following criteria:

1) Site chronology, type, and size: assessed properties are late precontact (A.D. 600–A.D. 1450) habitation sites containing 10+ rooms (e.g., large masonry roomblocks) or communal architecture (e.g. plazas, platform mounds, ballcourts)—TNF sites considered more susceptible to damage given their size, prominence, "richness", and visibility (Ahlstrom et al. 1992; see also Christensen et al. 1988; Nickens et al. 1981; Spangler et al. 2006:5).

2) Site significance: most assessed sites are listed in or considered eligible for inclusion in the National Register of Historic Places (National Register). Sixty-five are considered PHAs for the TNF. Many PHAs have a documented history of damage.

3) Site accessibility and proximity to TNF roads (i.e., nearest Forest route open to public travel via motorized vehicle): sites in varying distance from roads were assessed in an effort to identify relationships (or lack thereof) between damage frequency, site condition, road condition, and road proximity. Thirty-seven (38.5 percent of) assessed sites lie within 100 m of a TNF road. Many of these site locations are the terminuses of proximate

roads (i.e., roads lead directly to archaeological sites), which suggests the roads were constructed in part to provide vehicular access to archaeological resources. Table 1 separates the distribution of assessed sites by TNF road proximity.

4) Spatial distribution: Attempts were made to distribute our sample across the various environmental zones found throughout the TNF.

Field methods and documentation followed the TNF's *Site Inspection/Maintenance Assessment* form (see Data Availability Statement) to maintain consistent recording standards and assist in future condition assessments and resource management. Information collected during each site visit included: 1) general site condition; 2) damage if present, including type, extent, and estimated age if discernable; 3) proximity to nearest TNF road; 4) nearest road condition (when applicable); and 5) preventative/mitigation efforts (e.g., signing)—both observed actions and future recommendations. All previously undocumented damage was mapped and photographed.

Damage Types

Observed damage resulted from a variety of incidental and intentional actions including: unauthorized excavation or defacement of archaeological features (e.g., looting and graffiti); recreational removal and reuse of archaeological features (e.g., dismantling of masonry walls for use in constructing modern features such as campfire rings); and vehicle use (driving on or around architecture or artifacts) (Figure 2; see also Nickens et al. 1981:11-26; Nickens 1991:76-79; Spangler et al. 2006:6-8; Sullivan et al. 2002).

To assess temporal variation, damage was separated into two age categories—old or recent. Impacts were categorized as *recent* if they occurred within the last five years, as indicated by previous documentation, a lack of previous documentation (e.g., damage not noted on site records, plan maps, or inspection/maintenance forms), or lack of weathered sediment. In contrast, damage was categorized as *old* if it occurred more than five years ago. For most assessed sites, age was assigned using dated TNF site records, plan maps, or inspection/maintenance assessment forms noting the presence (or absence) and type of observed damage. In the rare absence of previously recorded information, age was subjectively categorized using physical evidence observed during fieldwork (e.g., degree of weathering [looter pits, backdirt] and extent of vegetative overgrowth, see Ahlstrom et al. 1992:52-54). Observations of damage type variety were largely limited to more recent occurrences—damage type was often not reliably discernable for older impacts, save for more severe acts of unauthorized excavation or defacement (e.g., looter pits).

Site Condition

Site condition is an approximate and qualitative measure of cumulative damage, alteration, or destruction resulting from a variety of agents, both natural and human (see Nickens et al. 1981:11-26 and Nickens 1991:76-79 for detailed descriptions and discussions of destructive processes). For our study, we followed general condition designations developed by TNF archaeologists and outlined in the TNF's *Heritage Assets Priority Property Condition Survey* form (see Data Availability Statement). Condition was categorized as *good* (site is generally intact, stable, and in need of no repair), *fair* (site shows some signs of deterioration needing attention, though the property is generally in sound condition), or *poor* (deterioration or damage affects at least 25 percent of the site).

Road Proximity and Condition

For each assessed site, a straight-line distance[5] to the nearest TNF road was calculated along with the road's current condition. Varying road conditions provide differential vehicular access to areas where motorized vehicle use is allowed (e.g., excluding Wilderness Areas, see Figure 1). Roads were categorized as *good* (regularly maintained for use by low-clearance passenger vehicles), *fair* (infrequently maintained; may not be passable by low-clearance passenger vehicles), *poor* (road in disrepair; high-clearance or four-wheel drive necessary for passage), or *impassible* (impassible by most vehicles with the possible exception of certain off-highway vehicles [OHVs]). These categories are also assumed to provide indirect measures for relative intensities of use.

Observations

Unauthorized damage was observed at 87 (90.6 percent) of the 96 assessed sites, most of which occurred decades ago—evidence of *old* damage was generally ubiquitous regardless of the site's proximity to a road. Old looter pits (greater than 5 years old) dominate among observed disturbances (Figure 3). To reiterate, the sites in our sample were selected in part given their perceived susceptibility based on site type and location.

Recent Damage

Recent unauthorized damage was observed at 15 of the 96 assessed sites, 13 (86.7 percent) of which are located at or within 300 m of a TNF road (Table 2 provides recent damage frequencies by TNF road proximity). No recent damage was observed at sites located beyond 800 m of a TNF road. Nine of the 15 recently damaged sites showed impacts from unauthorized excavation (e.g., looter pits), three by recreational activity, two by OHV use, and one by both

recreation and OHV use. Given the relative concentration of recent damage among sites near TNF roads, we used Fisher's exact test to evaluate whether a statistical relationship exists between the occurrence of recent damage and Forest road proximity. Statistical tests were performed using three distance thresholds at 100 m increments: 100 m, 200 m, and 300 m. These analyses indicate statistically significant associations when contrasting the presence/absence of recent damage and TNF road proximity (significance level of .05; see Table 3 for contingency tables). In all likelihood, the observed concentration of recent damage among prominent sites near TNF roads results from more than mere chance.

Site Condition

Ten of the 96 examined sites remain in good condition. The majority of assessed sites (53 of 96) are in poor condition. In general, the proportion of sites in poor condition decreases as distance to the nearest TNF road increases. Given the aforementioned statistical association, we made a similar comparison for general site condition, again using distance thresholds of 100 m, 200 m, and 300 m. For these analyses, Fisher's exact test yields probability values ranging from .034 to .065 (Table 4), An examination of chi-squared standardized residual values (see Table 4), reveals sites in poor condition were found in greater than expected frequency closer to TNF roads and less frequently than expected at greater distances from TNF roads. The association is reversed for sites in both fair and good condition. We recognize that singular measures of site condition, while providing insights into general patterns of damage, represent in essence a snapshot in time, and may conflate a complicated history of land use, archaeological site visitation, and natural site degradation. Factors affecting site condition through time may be exceptionally complex.

Higher probability values (i.e., probability of random distributions) are observed when comparing site condition and road condition (Table 5), which suggests that the *condition* of proximate roads has less of an effect on whether or not a site will be impacted by prohibitive acts under ARPA. A cursory examination of frequency observations across multiple distance thresholds reveals that sites in poor condition are found in greater numbers when the nearest road is in fair to good condition. The inverse, however, was not observed—instead, sites in good condition are found in nearly equal numbers despite the condition of nearby roads.

Regular Monitoring and Advisory Signage

In conjunction with federal laws, the TNF employs a number of preventative measures to avoid and mitigate unauthorized damage to archaeological resources. Observations regarding two such measures, volunteer site monitoring and signing, were recorded during fieldwork.

Volunteers with the Arizona Site Steward Program, a statewide organization designed to curb site destruction through public involvement (Hoffman 1991), regularly monitor a number of archaeological sites on the TNF. Monitoring efforts are generally focused towards sites deemed most at risk, including 35 of the 96 sites reported herein. Recent damage was observed at seven (20 percent) of the 35 monitored sites, a proportion likely explained by site type and prominence as well as various constraints that limit more frequent visitation. While their presence alone may not prevent damage to archaeological resources, monitors' efforts are critical in maintaining updated records regarding site condition and reporting evidence of unauthorized damage to appropriate public managers (Hoffman 1991).

Encouragingly, the frequency of recent damage at monitored sites in our sample dropped considerably among those with posted advisory signage stating: 1) the "fragile and irreplaceable"

nature of archaeological resources; 2) penalties for removing artifacts, disturbing or defacing sites on public and Indian lands (up to 5 years in prison and/or $250,000 in fines); and 3) contact information for law enforcement should suspicious behavior be observed (Figure 4). Such signs, primarily placed by volunteers, were observed at 14 sites during fieldwork, 11 of which are located within 300 m of a TNF road (Table 6). Only one of these sites had sustained recent damage (unauthorized excavation). No recent damage was observed at signed sites located beyond 100 m of a Forest road.

As with recent damage and site condition, Fisher's exact test was employed to assess the relationship between observed frequencies of recent damage and advisory signage at distance thresholds of 100 m, 200 m, and 300 m. As shown in Table 6, the 100 m distance category yields the lowest probability value, suggesting an 89 percent probability that observed distributions are not a factor of chance. Within this category, recent damage was observed at 10 of 37 sites (27.0 percent, see Table 2). By comparison, only 1 of 11 sites with advisory signage (9.1 percent) had sustained recent damage. These results allude to the potential impact of advisory signage, particularly when placed on prominent sites near roads. Our limited sample size, however, highlights the need for additional research.

While difficult to measure the impact of signing and monitoring efforts on the TNF and elsewhere, our observations provide hopeful support. When combined, signing and monitoring by trained volunteers provide seemingly cost-effective means of protection by deterring destructive behavior and ensuring timely reporting of new damage or suspicious behavior should they occur (Jameson and Kodack 1991).

Summary of Observations

Human impacts, most decades old, remain visible at over 90 percent of assessed sites. Evidence of *recent* damage—resulting from both incidental and intentional actions—was observed at 15 sites, 13 of which lie within 300 m of a TNF road. No recent impacts were observed at sites beyond 800 m of TNF roads. Likewise, site condition varies in relation to TNF road proximity, with the proportion of sites in poor condition decreasing as distance to the nearest Forest road increases. The influence of road proximity appears to be independent of road condition.

The statistical association found between recent damage and road proximity suggests a real relationship—at least among prominent, late precontact sites on the TNF. Signing and regular monitoring, particularly when combined, appear to be effective deterrents. In our sample, only one of 14 monitored sites with signage had sustained recent human-caused damage.

These findings add to an increasingly informative baseline important for understanding patterns of damage and site vulnerability, and for developing effective protection strategies (Christensen et al. 1988). While each land unit deals with different assortments and degrees of factors, this growing knowledge base has important implications for travel management and resource protection on public lands throughout the U.S. Southwest and beyond.

Management Implications

In the face of budgetary and personnel constraints, public land managers must choose where to focus their efforts—specifically, which sites to protect and by what effective means (Christensen et al. 1988; Laurenzi et al. 2013). Land managers need documented and supportable means by which to best assess the frequency and distribution of different damage types, identify and prioritize sites most vulnerable to damage given local and regional observations, and develop

effective protection strategies in line with public land missions and administrative capabilities. Moreover, recommendations for mitigation must be realistic, able to be implemented in spite of potential constraining factors, both general and locally specific.

Understanding the Problem

Every public land unit in the U.S. Southwest confronts a unique suite of factors that affect site vulnerability and the efficacy of associated mitigation strategies. Following Nickens and colleagues (1981:129-134), such factors include but are not limited to: 1) the density, distribution, and visibility of archaeological resources; 2) access to sites where unauthorized excavation or surface collection may occur; 3) local history of the problem and associated mitigation efforts; 4) local attitudes toward cultural resources and resource protection; 5) government actions towards resource protection; and 6) local demands for archaeological resources and the prevalence of commercial exploitation.

Reliable inventories are critical for land managers seeking to understand and address different damage types and associated spatial and temporal patterns of occurrence. As discussed above, the TNF maintains a series of forms that guide consistent Forest-wide recording of site condition and damage. Associated documentation greatly assisted our assessments by providing a baseline of information for determining the ages, distributions, and frequencies of damage observed during fieldwork. When available, GIS technologies provide powerful and cost-effective tools to augment the management and spatial analysis of data pertaining to site damage. For example, Uphus et al. (2006) describe employment of GIS to evaluate the probability of certain impacts to sites given their proximity to different activity areas (e.g., camping areas, woodcutting areas).

By whatever available means, recognizing the variety and frequency of behaviors that impact archaeological sites in a given setting provide insights essential for the development of effective, targeted responses. Our observations indicate that a variety of unauthorized damages continue to occur on the TNF, the result of both intentional (malicious, predatory) and incidental actions. Importantly, while the intent behind incidental damages may not be malicious, their widespread occurrence, often a byproduct of lawful uses of public lands, remains a significant management concern throughout the U.S. Southwest (Sullivan et al. 2002; Uphus et al. 2006). Further, single or cumulative episodes may be equally as harmful as unauthorized excavation or defacement, particularly if allowed to continue unchecked (Nickens 1991). Inadvertent damages range in intensity from the mixing and displacement of archaeological resources (e.g., vehicle tire damage, artifact caching, removal/reuse of architectural features) to partial or total destruction (e.g., harvesting/burning of architectural wood for modern campfires) (Nickens 1991; Nickens et al. 1981; Sullivan et al. 2002). At the same time, however, individuals behind incidental damages, being perhaps ignorant of laws or the nonrenewable nature of archaeological resources, may be more receptive to mitigation measures like signing. This is in contrast to malicious damages resulting from motives that are difficult to prevent or control (Nickens 1991:77).

Observed damage patterns, combined with the distribution and perceived effectiveness of extant preventative measures, shed light on the different kinds of damages that occur on the TNF, where they tend to occur, and what mitigation strategies might successfully deter them. Our observations are by no means definitive—additional work is undoubtedly needed to better understand and address a broader suite of potential damages. Nonetheless, our findings, coupled

with those of other damage assessments in the U.S. Southwest (see above), provide a knowledge base useful for site stewardship on the TNF and elsewhere.

Mitigation Recommendations

In conjunction with knowledge of local damage patterns, public land managers need an informed understanding of the practicality and potential efficacy of different mitigation strategies to best approach varying damage types in a given setting. We discuss a number of practical and economical measures that may ameliorate unauthorized damage to archaeological resources on public lands when appropriate—namely signing, volunteer site monitoring, and travel access restrictions. While we agree with many others that existing laws must be strengthened and that more money and staff are needed to improve state and federal protection efforts (e.g., Society for American Archaeology 1990), we make little discussion of law or policy change here, focusing instead on more readily available measures, i.e., more locally controlled actions not involving legislation.

Travel Access Restrictions

Our study suggests prominent, late precontact sites near roads will continue to sustain unauthorized damage absent adequate means of protection; findings consistent with prior investigations of damage to archaeological resources on public lands in the greater U.S. Southwest (Nickens et al. 1981; Plog 1978; Spangler et al. 2006). Our data lend support to the idea that travel access restrictions (i.e., complete or partial road closures) may be effective in reducing unauthorized damage to archaeological resources, and should be considered when evaluating travel management decisions. We note, however, that despite our observations regarding relative road proximity and frequencies of damage, our study was not designed to test whether or not closing a road would reduce future occurrences of unauthorized damage—an

issue in need of further research. There are many important factors to consider (some discussed here) when restricting or authorizing motorized use of roads on public lands.

Consideration of travel access restrictions for resource protection has grown in recent years. In 2005, the Department of Agriculture instituted a Travel Management Rule designed to provide a decision-making framework for designating a sustainable system of roads, trails, and areas for motor vehicle use (Department of Agriculture, Forest Service 2005). General criteria for designation include consideration of effects on cultural resource (36 CFR 212). By closing lands open to off-road travel and reducing the number of roads open to motorized vehicle use, the Travel Management Rule is intended to have both general and localized benefits to cultural resources.

While our observations on the TNF indicate recent damages to prominent archaeological sites have occurred more frequently near roads, exceptions indicate the relationship is not so clear-cut. For example, in one assessed area of the Forest, the only (two) sites from our sample with recent damages are those located farthest from the main roads. Both sites lie within Perry Mesa, a relatively flat, open grassland with high visibility (northwest portion of TNF). Here, suspicious behavior could easily be observed from nearby roads, whereas distance would afford greater concealment (see similar observations by Ahlstrom et al. 1992). In addition, the location is easily accessed from a major interstate (Interstate 17, see Figure 1), and therefore experiences heavier visitation than more remote areas of the TNF. Here, the increased presence of an interested public may deter rather than increase incidences of unauthorized damage. Elsewhere there is more terrain or vegetation to protect thieves or vandals, even close to roads, and less traffic generally. As this example demonstrates, limiting access is not a perfect solution to deterring damage in all cases, and could even help more dedicated looters (see Ahlstrom et al.

1992:62). Careful evaluation of local damage types, site types, environmental factors, and land use patterns is clearly needed to develop travel management plans that adequately consider the protection of cultural resources while providing appropriate levels of motorized access.

Advisory Signage

Observations from the TNF allude to the potential of advisory signage for reducing unauthorized damage to archaeological resources on public lands. In clearly communicating the presence, importance, and fragility of archaeological resources and outlining the laws and regulations designed to protect them, signage like that employed by the TNF (see Figure 4) provides a cost-effective tool that encourages lawful site visitation and enjoyment while also discouraging damage (see Jameson and Kodack 1991; Nickens et al. 1981:140-141). We advocate the widespread placement of advisory signage at sites on public lands, particularly in situations where visitation is heavy or site visibility high. This action is strongly recommended when other means of protection (e.g., travel restrictions) are impractical or inappropriate given other land management considerations.

For the most part, the posting of advisory signage is focused towards visitors with lawful intent, this following the assumption that most do not intentionally damage archaeological sites. While advisory signs alone may deter incidental types of damages by making the presence of archaeological resources known to lawful visitors, they are less likely to prevent determined thieves or vandals. We observed one incident of looting (unauthorized excavation) when signage was in place, indicating the measure is by no means a panacea. Overall, however, signing may help to reduce the occurrence of nefarious damages by increasing awareness (even if only implied) that archaeological resources are known to, and monitored by, agency personnel. Further, and important for law enforcement and the successful criminal prosecution of looters

under ARPA, signing precludes a defensive plea of ignorance regarding the presence of archaeological resources and the criminality of prohibitive acts, e.g., unauthorized excavation or defacement (Jameson and Kodack 1991:243).

On the TNF, carsonite advisory signs are placed on site (free-standing), often in multiple locations to ensure greater visibility. Importantly, however, while posted signs remain readily apparent on site, their conspicuousness quickly fades with distance, a product of size and appearance (thin, brown), which blends with the local desert landscape (see Figure 4). As such, the signs themselves draw minimal additional attention to sites when present (compare to the fencing of sites, for example). Nonetheless, in certain circumstances, signage could attract attention to sites not otherwise readily visible (e.g., artifact scatters)—its use should therefore be guided by the nature of sites and the contexts in which they reside (see Jameson and Kodack 1991:238).

All told, however, signing has much to recommend it. Though the signs themselves carry a production cost, their placement can be accomplished relatively quickly and inexpensively, especially if piggybacked on existing projects that place personnel (or volunteers) at or near site locations. Signing thus provides among the most immediate means of effective protection.

Volunteer Site Monitoring, Public Education, and ARPA

Public involvement in the protection of archaeological resources has had an important, positive impact in Arizona. The Arizona Site Stewards Program in particular provides a tried and true model worthy of imitation (see the most recent Site Stewards Handbook for more information [Arizona State Parks 2008]). The program consists of a statewide organization of volunteers trained by the Arizona State Historic Preservation Office to actively monitor the

condition of specially selected resources. Objectives of the program include reducing site destruction, data collection, and providing opportunities for public involvement. For the most part, Stewards are not professional archaeologists, but rather "interested and concerned citizens" seeking opportunities to contribute to the preservation of Arizona's rich cultural heritage (Hoffman 1991:253). The program is managed with the cooperation of public land managers of Arizona. The basic responsibilities of Stewards include visiting archaeological resources to monitor site condition and reporting evidence of damage to the responsible land manager. Additionally, Stewards may also become involved in public education and outreach activities (Hoffman 1991:257).

Given the limited number of available personnel and potential challenges of organizing regular site visitation, monitoring efforts should be focused where the likelihood of unauthorized damage is highest (e.g., prominent sites near roads or activity areas). The work of monitors is critical in maintaining an updated database of damage patterns (e.g., types, frequency, and dispersal) within a given land unit—information necessary for the development of targeted mitigation responses by the public land manager (Hoffman 1991). Following our observations, we recommend monitoring efforts be augmented by additional measures such as signing.

In addition to volunteer involvement in archaeological resource protection, the TNF actively promotes public interpretation and education through publications, brochures, and exhibits available at developed recreation sites throughout the Forest. Interpretative trails are currently available at two prehistoric sites (Tonto National Forest 2014). Educational programs promoted by the TNF aim to increase public interest in the value of the past. TNF initiatives are augmented by a number of statewide public and avocational programs that provide additional

opportunities for public learning and involvement (e.g., through site tours and expositions) (Davis 1991; Lerner 1991). An interested and educated public are thought more likely to understand proper treatment of archaeological resources and recognize and report damage when it does occur (Lerner 1991). On the TNF, visitors enhance protection efforts by reporting violations on a regular basis—site monitoring is not done solely by Stewards and Forest personnel (J. Scott Wood, personal communication, 2013).

In conjunction with volunteer involvement and public education, the passage and enforcement of resource protection legislation has also been critical in improving public attitudes regarding cultural heritage and reducing overall vandalism to archaeological sites (Propper 2012). What was once considered a harmless pastime or legitimate hobby is now widely recognized as an illegal activity that robs the public of an important and non-renewable resource. On the TNF, severe damage to archaeological resources has decreased dramatically since the passage of ARPA in 1979. This reduction is particularly evident in damage assessment reports for PHAs from the last 40 years (totaling approximately 200 sites). Prior to 1979, estimates of damage to sites in the sample document a total volume of disturbance equivalent to approximately 24,880 cubic meters. In contrast, since 1979, inspections and damage assessments for all sites in the sample document a total of only 1,884 cubic meters of disturbance. This constitutes a 92.5 percent reduction in measurable disturbance to sites resulting from various forms of unauthorized damage since the passage of ARPA and the development of monitoring practices that include regular Forest Service inspections, Site Steward monitoring, and reporting by TNF visitors (J. Scott Wood, personal communication, 2013).

Conclusion

Incidental and intentional human actions will likely remain a perpetual threat to archaeological resources on public lands in the U.S. Southwest and beyond. However, careful evaluation of cultural resource types, local damage patterns, and environmental contexts can lead to practical strategies for deterring adverse human impacts while still accommodating the many needs of public land users.

On the TNF, observed frequencies of recent damage—including both incidental and intentional types—are highest among sites near roads, suggesting that in general, vehicular accessibility increases the likelihood that sites will continue to sustain unauthorized damages (at least among prominent, precontact sites included in our study). These observations warrant consideration of travel access restrictions as a protective strategy when evaluating travel management decisions. Given limitations faced by public land managers, protection efforts should be focused towards areas and resources where the likelihood of damage is highest.

In addition to frequencies of damage, our study notes management successes worthy of expansion and imitation. For advisory signing in particular, benefits appear to greatly outweigh the costs, and investment risk is minimal. As such, the immediate implementation or expansion of signing efforts is strongly recommended where possible, particularly for archaeological sites with inherently high visibility. At a minimum, signing should be viewed as an initial line of defense until other complementary measures can be implemented.

For our study, attention was focused on large, generally more conspicuous archaeological resources. Other site types (e.g., artifact scatters, smaller structures), which comprise the bulk of the nearly 10,000 recorded sites on the TNF, are also at risk, though perhaps more vulnerable to inadvertent impacts (e.g., recreational use of features, vehicular damage) than unauthorized

excavation or defacement. Additional research is needed to evaluate human impacts to these sites and the potential for effective mitigation (see Uphus et al. 2006 for discussion).

We believe that site protection measures found to be effective on a large, heavily visited public land unit such as the TNF may also be successfully implemented elsewhere. We encourage managers of public lands to share strategic approaches to archaeological resource protection. Where successes have been recognized, those measures should be publicized and expanded.

Acknowledgements

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Notes

1. The Department of Agriculture is revising regulations regarding travel management on National Forest System lands to clarify policy related to motor vehicle use, including the use of off-highway vehicles. The Travel Management Rule announced in 2005 requires each National Forest and Grassland to identify and designate those roads, trails, and areas that are open to motor vehicle use. The final rule is intended to provide a consistent framework under which travel management decisions are made at the local level (Department of Agriculture, Forest Service 2005).

2. It should be noted that unauthorized damage to archaeological sites on the TNF was a primary impetus for the passage of ARPA in 1979 (see Ahlstrom et al. 1992:16; McAllister 1980; Propper 2012).

3. The PHA list comprises properties of distinct public value that are or should be actively maintained and that meet one or more of the following criteria:

a. The significance and management priority of the property is recognized through an official designation; such as listing on the National Register, State Register of Historic Places, etc.
b. The significance and management priority of the property is recognized through prior investment in preservation, interpretation, and use.
c. The significance and management priority of the property is recognized in an agency-approved management plan.

4. The number of sites on the TNF's PHA list has fluctuated slightly since the list's inception. Sites are periodically added or removed (J. Scott Wood, personal communication, 2013).

5. These "as the crow flies" distances represent the most direct route between roads and sites, but not necessarily actual walking distances, which may be greater due to topography, vegetation, etc.

References Cited

Ahlstrom, Richard V. N., Malcom Adair, R. Thomas Euler, and Robert C. Euler

1992 *Pothunting in Central Arizona: The Perry Mesa Archaeological Site Vandalism Study*. Cultural Resources Management Report No. 13, USDA Forest Service, Southwestern Region and USDI Bureau of Land Management, AZ.

Anyon, Roger

1991 Protecting the Past, Protecting the Present: Cultural Resources and American Indians. In *Protecting the Past*, edited by G. S. Smith and J. E. Ehrenhard, pp. 215-222. CRC Press, Boca Raton.

Arizona State Parks

2008 Arizona Site Steward Handbook. Electronic document, http://azstateparks.com/volunteer/v_sitestewards.html, accessed April 1, 2014.

Cheek, Annetta L.

1991 Protection of Archaeological Resources on Public Lands: History of the Archaeological Resources Protection Act. In *Protecting the Past*, edited by G. S. Smith and J. E. Ehrenhard, pp. 33-39. CRC Press, Boca Raton.

Christensen, Harriet H., Ken Mabery, Martin E. McAllister, and Dale P. McCormick

1988 Cultural Resource Protection: A Predictive Framework for Identifying Site Vulnerability, Protection Priorities, and Effective Protection Strategies. In *Tools to Manage the Past:*

Research Priorities for Cultural Resources Management in the Southwest, edited by J. A. Tainter and R. H. Hamre, pp. 62-67. USDA Forest Service, General Technical Report RM-164, Rocky Mountain Forest and Range Experiment Station, Fort Collins.

Davis, Hester A.

1991 Avocational Archaeology Groups: A Secret Weapon for Site Protection. In *Protecting the Past*, edited by G. S. Smith and J. E. Ehrenhard, pp. 175-180. CRC Press, Boca Raton.

Department of Agriculture, Forest Service

2005 Travel Management; Designated Routes and Areas for Motor Vehicle Use. *Federal Register* 70(216).

Department of Interior, National Park Service

2010 The Secretary of the Interior's Report to Congress on the Federal Archeology Program, FY2004-2007. Departmental Consulting Archeologist, Washington, DC.

Ferguson, T. J. and Chip Colwell-Chanthaphonh

2006 *History Is in the Land: Multivocal Tribal Traditions in Arizona's San Pedro Valley*. University of Arizona Press, Tucson.

Francis, Julie E.

1978 The Effects of Casual Surface Collection on Variation in Chipped Stone Artifacts. In *An Analytical Approach to Cultural Resource Management: The Little Colorado Planning*

Unit, edited by F. Plog, pp. 114-132. Anthropological Research Papers No. 13, Arizona State University, Tempe.

Hartley, Ralph J. and Anne M. Wolley Vawser

2004 *Assessing Contemporary Human Activity at Sites in the Anasazi Archaeological District, San Juan National Forest: A Quantitative Approach*. Midwest Archaeological Center, National Park Service.

Hedquist, Saul L. and Leigh Anne Ellison

2010 *Condition and Damage Assessment of 96 Previously Recorded Archaeological Sites Located on the Tonto National Forest in Gila, Maricopa, Pinal, and Yavapai Counties, Arizona*. Center for Desert Archaeology, Tucson.

Hill, J. Brett, David Wilcox, William Doelle, and William Robinson

2012 Coalescent Communities Database Version 2.0. Archaeology Southwest, Tucson.

Hoffman, Teresa L.

1991 Stewards of the Past: Preserving Arizona's Archaeological Resources through Positive Public Involvement. In *Protecting the Past*, edited by G. S. Smith and J. E. Ehrenhard, pp. 253-259. CRC Press, Boca Raton.

Jameson, John H., Jr. and Marc Kodack

1991 Signing as a Means of Protecting Archaeological Sites. In *Protecting the Past*, edited by G. S. Smith and J. E. Ehrenhard, pp. 235-246. CRC Press, Boca Raton.

Laurenzi, Andy, Matthew A. Peeples, and William H. Doelle

2013 Cultural Resources Priority Area Planning in Sub-Mogollon Arizona and New Mexico. *Advances in Archaeological Practice* 1(2):61-76.

Lerner, Shereen

1991 Saving Sites: Preservation and Education. In *Protecting the Past*, edited by G. S. Smith and J. E. Ehrenhard, pp. 103-115. CRC Press, Boca Raton.

Lightfoot, Kent G.

1978 The Impact of Casual Collecting on Archeological Interpretation Through Regional Surface Surveys. In *An Analytical Approach to Cultural Resource Management: The Little Colorado Planning Unit*, edited by F. Plog, pp. 91-113. Anthropological Research Papers No. 13, Arizona State University, Tempe

Lipe, William D.

1974 A Conservation Model for American Archaeology. *The Kiva* 39:213-245.

1984 Value and Meaning In Cultural Resources. In *Approaches to the Archaeological Heritage: A Comparative Study of World Cultural Resource Management Systems*, edited by H. Cleere, pp. 1-11. Cambridge University Press, Cambridge.

2006 Archaeological Ethics and Law. Crow Canyon Archaeological Center, Cortez, CO. Electronic document, http://www.crowcanyon.org/education/ethics_law.asp, accessed June 15, 2014.

McAllister, Martin E.

1980 Smokey and the Looters: The Jones-Gevara Pothunting Case, December 1977-June 1980. In *Cultural Resources Law Enforcement: An Emerging Science*, 2nd edition, compiled by D. F. Green and P. Davis, pp. 44–49. USDA Forest Service, Southwestern Region, Albuquerque.

1988 Areas and Issues in Future Research on Archaeological Resource Protection. In *Tools to Manage the Past: Research Priorities for Cultural Resources Management in the Southwest*, edited by J. A. Tainter and R. H. Hamre, pp. 52-61. USDA Forest Service, General Technical Report RM-164, Rocky Mountain Forest and Range Experiment Station, Fort Collins.

1991 Looting and Vandalism of Archaeological Resources on Federal and Indian Lands in the United States. In *Protecting the Past*, edited by G. S. Smith and J. E. Ehrenhard, pp. 93-99. CRC Press, Boca Raton.

McManamon, Francis P.

1991 The Federal Government's Recent Response to Archaeological Looting. In *Protecting the Past*, edited by G. S. Smith and J. E. Ehrenhard, pp. 261-269. CRC Press, Boca Raton.

Nickens, Paul R.

1991 The Destruction of Archaeological Sites and Data. In *Protecting the Past*, edited by G. S. Smith and J. E. Ehrenhard, pp. 73-81. CRC Press, Boca Raton.

Nickens, Paul R., Signa L. Larralde, and Gordon C. Tucker, Jr.

1981 *A Survey of Vandalism to Archaeological Resources in Southwestern Colorado*. Bureau of Land Management, Cultural Resources Series No. 11. Denver.

Plog, Fred.

1978 *An Analytical Approach to Cultural Resource Management: The Little Colorado Planning Unit*, Arizona State University, Anthropological Research Papers No. 13, Tempe.

Propper, Judith G.

2012 Perspectives on the Protection of Archaeological Sites on National Forests in Arizona and New Mexico. In *An Archaeological Legacy: Essays in Honor of Ray T. Matheny*, edited by D. G. Matheny, J. C. Janetski, and G. Nielson, pp. 309-333. Occasional Paper No. 18, Museum of Peoples and Cultures, Brigham Young University, Provo.

Sampson, Michael P.

2009 The Effects of Off-Highway Vehicles on the Cultural Resources of Red Rock Canyon State Park, California. *Proceedings of the Society for California Archaeology* 21:190-201

Schroeder, Melissa R.

2010 Cultural Resources Specialist Report For the Travel Management Environmental Impact Statement. USDA Forest Service Southwestern Region, Apache-Sitgreaves National Forests.

Simms, Steven R.

1986 Cultural Resource Investigations in Southeastern Utah to Aid in the Assessment of Archaeological Vandalism. Archaeological Technician Program, Weber State College. Submitted to USDA Forest Service, Salt Lake City and Monticello.

Society for American Archaeology

1990 *Save the Past for the Future: Actions for the '90s*. Society for American Archaeology, Office of Government Relations, Washington, DC.

Spangler, Jerry D.

2006 *Site Condition and Vandalism Assessment of Archaeological Sites, Lower and Middle Arch Canyon*. Colorado Plateau Archaeological Alliance, Ogden, UT.

Spangler, Jerry D., Shannon Arnold, and Joel Boomgarden

2006 *Chasing Ghosts: A GIS Analysis and Photographic Comparison of Vandalism and Site Degradation in Range Creek Canyon, Utah*. Utah Museum of Natural History Occasional Papers 2006:1, Salt Lake City.

Spangler, Jerry D. and Andrew Yentsch

2008 *Final Report: Baseline Site Condition and Vandalism Assessments of Archaeological Sites in Tenmile Canyon, Grand Canyon, Utah*. Colorado Plateau Archaeological Alliance, Ogden, UT.

Sullivan, Alan P. III, Patrick M. Uphus, Christopher I. Roos, and Philip B. Mink II

2002 Inadvertent Vandalism: The Hidden Challenge for Heritage Resource Management. *Cultural Resources Management* 25:42-46.

Tainter, Joseph A. and R. H. Hamre (editors)

1988 *Tools to Manage the Past: Research Priorities for Cultural Resources Management in the Southwest*. Symposium Proceedings, May 2-6, Grand Canyon, Arizona. General Technical Report RM-164, USDA Forest Service.

Tonto National Forest

2014 Tonto National Forest – History and Development. Electronic document, www.fs.usda.gov/detail/tonto/home, accessed April 1, 2014.

Uphus, Patrick M., Alan P. Sullivan III and Philip B. Mink II

2006 Identifying At-Risk Heritage Resources with GIS: Modeling the Impact of Recreational Activities on the Archaeological Record. *International Journal of Risk Assessment and Management* 6(4-6):330-3.

Wilcox, David R., William H. Doelle, J. Brett Hill, and James P. Holmlund

2003 Coalescent Communities GIS Database: Museum of Northern Arizona, Center for Desert Archaeology, GeoMap Inc. Manuscript on file, Archaeology Southwest, Tucson.

Figure Captions

Figure 1. Tonto National Forest and location of assessed archaeological resources.

Figure 2. Representative examples of observed damage types: recent looter pit (top left), bench and windbreak constructed of archaeological masonry (top right), graffiti (defacement of petroglyph panel, bottom left), and OHV tracks (bottom right).

Figure 3. Representative examples of old looter pits.

Figure 4. Advisory sign posted at an archaeological site on the TNF.

Figure 1
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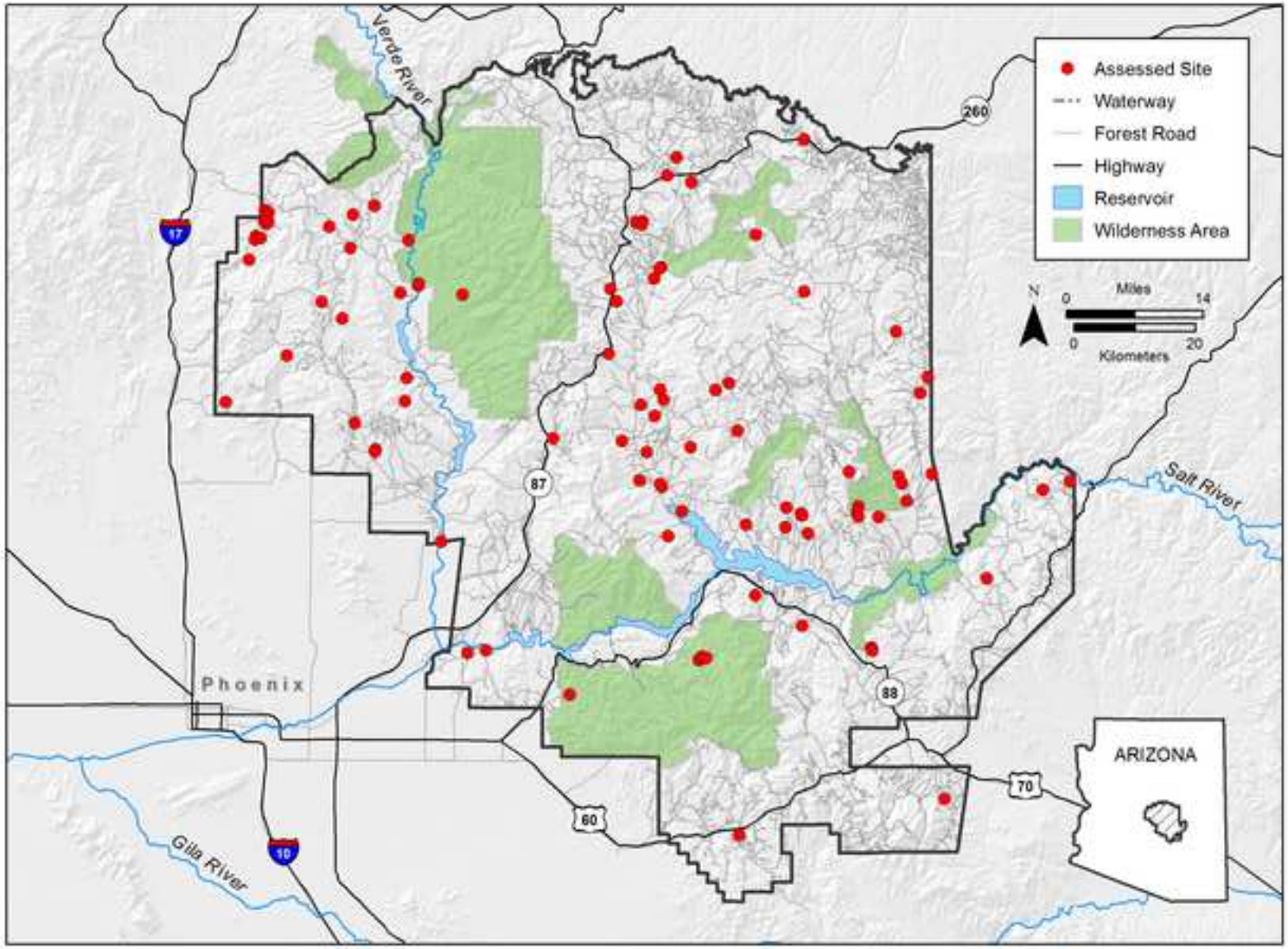

Figure 2
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Figure 3
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Figure 4
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Table 1. Site Distribution by TNF Road Proximity.

Road Proximity										
≤100 m	101-200 m	201-300 m	301-400 m	401-500 m	501-600 m	601-700 m	701-800 m	801-900 m	901-1 km	>1 km
37 (38.5%)	11 (11.5%)	9 (9.4%)	8 (8.3%)	5 (5.2%)	6 (6.3%)	2 (2.1%)	3 (3.1%)	2 (2.1%)	3 (3.1%)	10 (10.4%)

Table 2. Recently Damaged Sites by TNF Road Proximity (percentages shown are column percentages).

		Road Proximity									
		≤100 m (n=37)	101-200 m (n=11)	201-300 m (n=9)	301-400 m (n=8)	401-500 m (n=5)	501-600 m (n=6)	601-700 m (n=2)	701-800 m (n=3)	>800 m (n=15)	Total (n=96)
Recent Damage	Present	10 (27.0%)	2 (18.2%)	1 (11.1%)	0 (0.0%)	1 (20.0%)	0 (0.0%)	0 (0.0%)	1 (33.3%)	0 (0.0%)	15 (15.6%)
	Absent	27 (73.0%)	9 (81.8%)	8 (88.9%)	8 (100.0%)	4 (80.0%)	6 (100.0%)	2 (100.0%)	2 (66.7%)	15 (100.0%)	81 (84.4%)

Table 3. Recently Damaged Sites by TNF Road Proximity: 100 m, 200 m, 300 m, 400 m, and 500 m Proximity Thresholds (percentages shown are column percentages; probabilities [p] indicate the likelihood that the observed distributions are random).

		Road Proximity					
		≤ 100 m (n=37)	> 100 m (n=59)	≤ 200 m (n=48)	> 200 m (n=48)	≤ 300 m (n=57)	> 300 m (n=39)
Recent Damage	Present	10 (27.0%)	5 (8.5%)	12 (25.0%)	3 (6.3%)	13 (22.8%)	2 (5.1%)
	Absent	27 (73.0%)	54 (91.5%)	36 (75.0%)	45 (93.7%)	44 (77.2%)	37 (94.9%)
		p=0.017		p=0.011		p=0.016	

Table 4. Comparison of General Site Condition and TNF Road Proximity: 100 m, 200 m, and 300 m Proximity Thresholds (percentages shown are column percentages; corresponding residual values are shown below frequency values).

		Road Proximity					
		≤ 100 m (n=37)	> 100 m (n=59)	≤ 200 m (n=48)	> 200 m (n=48)	≤ 300 m (n=57)	> 300 m (n=39)
Site Condition	Good (n=10)	2 (5.4%) (-0.944)	8 (13.6%) (0.747)	2 (4.2%) (-1.341)	8 (16.7%) (1.341)	3 (5.3%) (-1.205)	7 (18.0%) (1.457)
	Fair (n=33)	9 (24.3%) (-1.042)	24 (40.7%) (0.825)	15 (31.2%) (-0.369)	18 (37.5%) (0.369)	17 (29.8%) (-0.585)	16 (41.0%) (0.708)
	Poor (n=53)	26 (70.3%) (1.233)	27 (45.8%) (-0.976)	31 (64.6%) (0.874)	22 (45.8%) (-0.874)	37 (64.9%) (0.986)	16 (41.0%) (-1.192)
		p=0.062		p=0.065		p=0.034	

Table 5. Comparison of General Site Condition and nearest Road Condition: 100 m, 200 m, and 300 m Proximity Thresholds (percentages shown are column percentages).

		Site Condition/Road Proximity					
		≤ 100 m		≤ 200 m		≤ 300 m	
		Good to Fair (n=11)	Poor (n=26)	Good to Fair (n=17)	Poor (n=31)	Good to Fair (n=20)	Poor (n=37)
Road Condition	Good to Fair	5 (45.5%)	16 (61.5%)	9 (52.9%)	21 (67.7%)	10 (50.0%)	26 (70.3%)
	Poor to Impassible	6 (54.5%)	10 (38.5%)	8 (47.1%)	10 (32.3%)	10 (50.0%)	11 (29.7%)
		p=0.294		p=0.241		p=0.110	

Table 6. Comparison of Recent Damage and Advisory Signage: 100 m, 200 m, and 300 m Proximity Thresholds.

		Advisory Signage/Road Proximity					
		≤ 100 m		≤ 200 m		≤ 300 m	
		Present	Absent	Present	Absent	Present	Absent
Recent Damage	Present	1	9	1	11	1	12
	Absent	10	17	10	26	10	34
		p=0.114		p=0.162		p=0.216	