Descriptive and Exploratory Spatial Analysis of Archaeological Site Distributions at Locations in Northern Arizona

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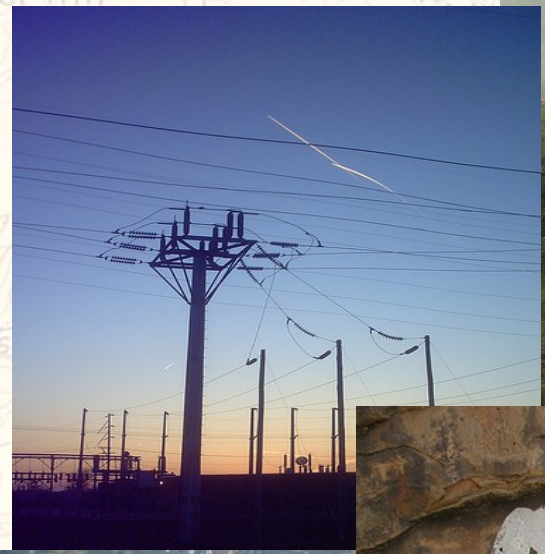
To better understand archaeological resources through GIS-based spatial analyses of existing site management data

Why analyze existing data?

Cultural resources are highly threatened and finite. Once they have been impacted they are no longer relevant, and there are no shortage of impacts:

- Urban sprawl
- Fire and fire abatement
- Resource extraction
- Infrastructure expansion
- Recreation and off-road travel
- Targeted looting and vandalism

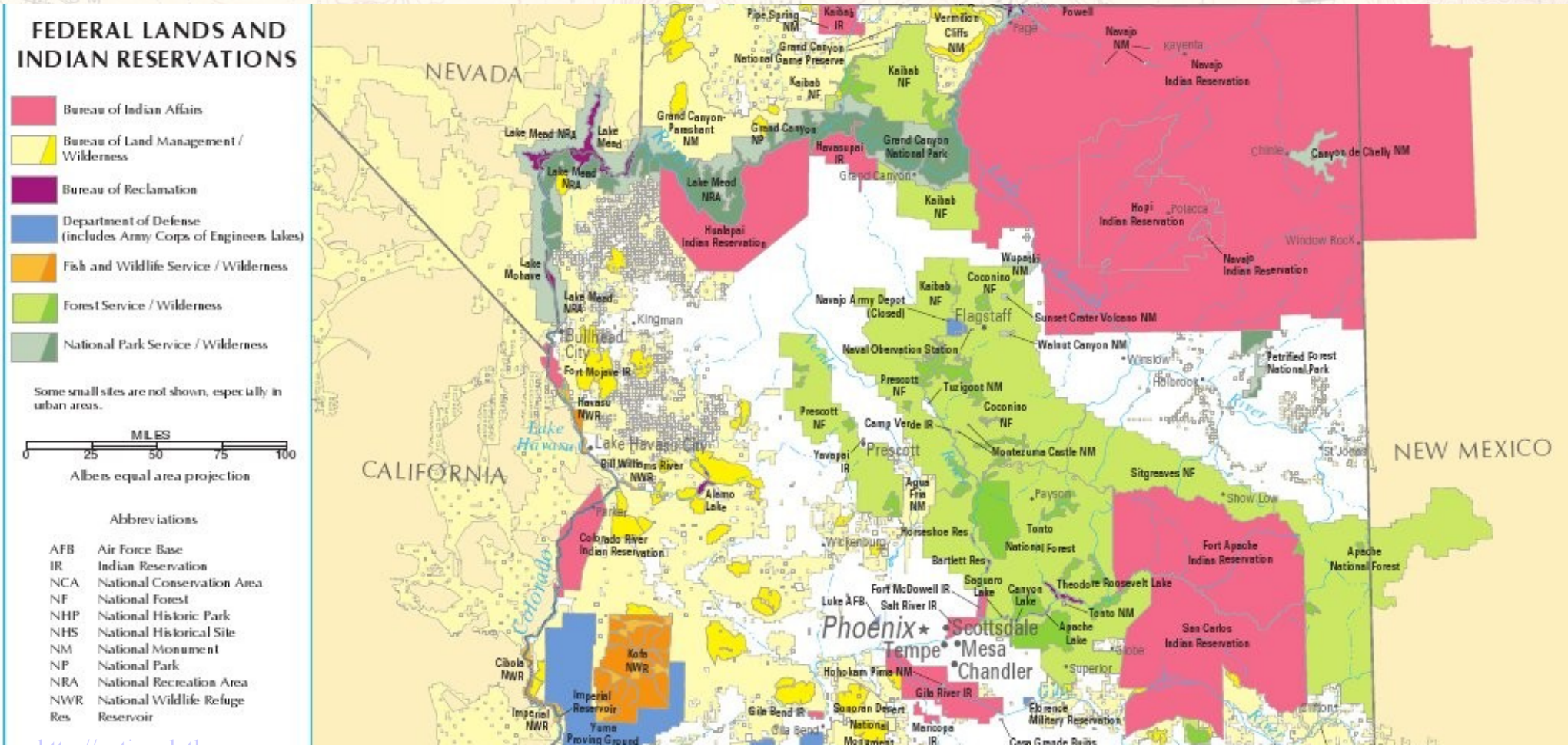


The archaeological site database is obligatory for public land management agencies as mandated by a number of state and federal regulations:

- **Archaeological and Historic Preservation Act (AHPA)** – preservation and maintenance of archaeological data (hence collection of data)
- **Archaeological Resource Protection Act (ARPA)** – curation of records and limitations on access to these archaeological site records (hence restricted access site records)
- **National Historic Preservation Act (NHPA)–** defines archaeological significance and mandates state and federal management programs (hence the databases used for the management and mitigation of sites on public properties)
- Various state codes also provide for the collection and protection of archaeological site data by the designated repository organization

Each agency maintains and operates their own separate and unique site database

A broad array of publicly owned lands are administered in Arizona, with a total of 88% of the entire state being managed by either state or federal agencies. As each agency is legally obligated to maintain an archaeological site database, they collectively represent a largely untapped resource of distributional data.



In the Northern Arizona counties of Coconino and Yavapai, most of the publicly owned lands are administrated by:

- **National Park Service**
  - **Grand Canyon National (1.2 Million acres)**
  - **Flagstaff Area Monuments (45,000 acres)**
- **United States Forest Service**
  - **Coconino National Forest (1.8 Million acres)**
  - **Kaibab NF (1.6 Million acres)**
- **State of Arizona – archaeological sites managed by Arizona State Museum by direction of Arizona revised statutes 41-844 & 865 (roughly 50,000 acres)**
- **Navajo, Hopi, Havasupai, and Hualapai Nations – access to data on these properties is limited to special use and tribal roles only (over 15 Million acres)**

The Colorado Plateau region of Northern Arizona has a deep history of human occupation. Sites found across this region bear evidence of the many diverse cultures who have occupied this region, including:

- **Paleoindian**
- **Archaic Traditions**
- **Kayenta (Puebloan)**
- **Cohonina (Puebloan)**
- **Sinagua (Puebloan)**
- **Pai, Apache, Navajo, and Hopi**
- **Anglo**








These cultures left behind a broad array of sites, leaving the management agencies with many different types of sites to locate, record, and manage on their properties

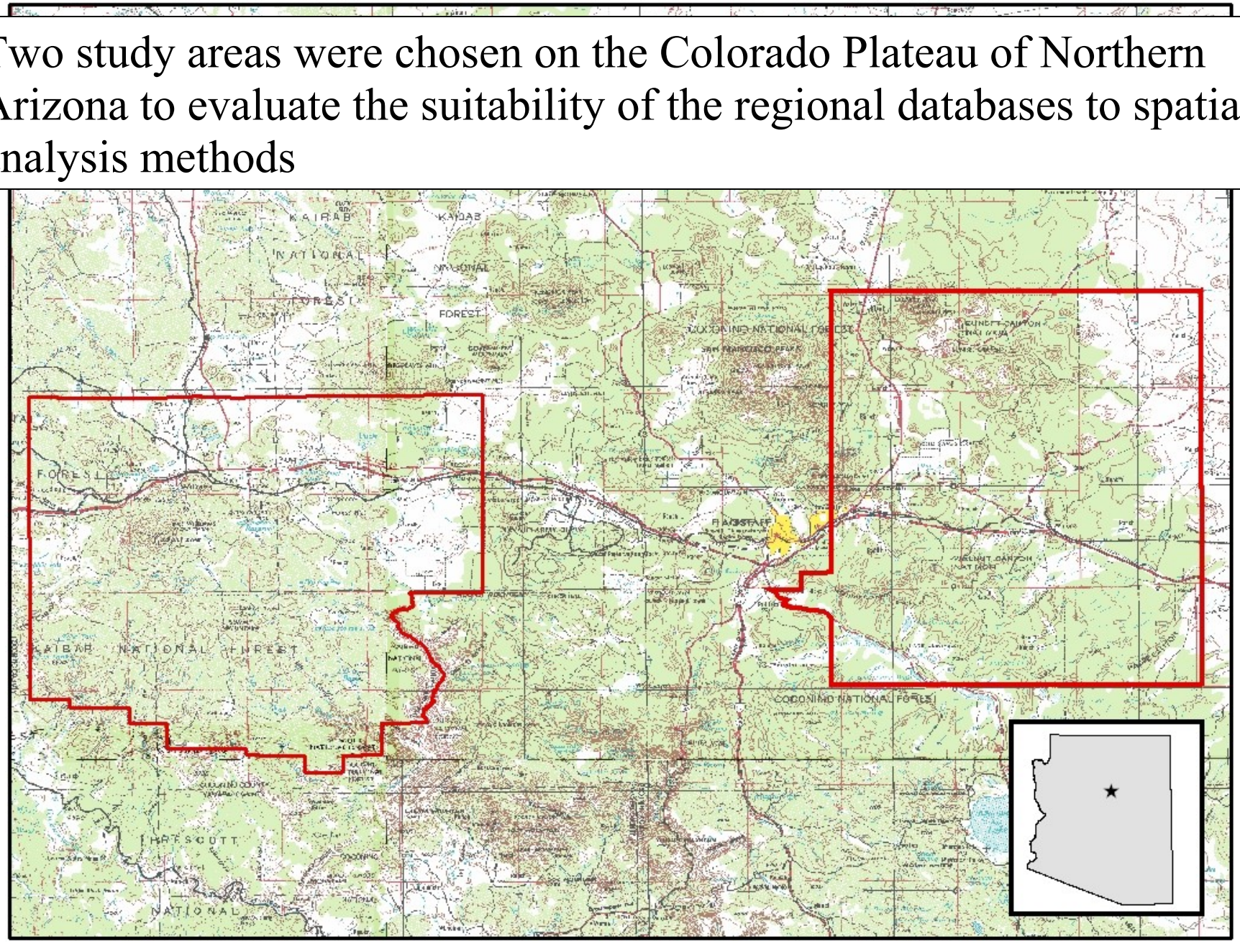
- **Architectural sites**
- **Agricultural sites**
- **Open camps and scatters**
- **Material procurement**
- **Rock art**

The greatest obstacle to the utilization of these agency databases is the broad diversity that underlies cultural resources and the almost complete lack of consistency between the databases themselves. These cultural and institutional differences are not only functional but also organizational. Strictly speaking, few if any of these databases were ever designed to facilitate spatial analysis despite the fact that each have inherently geospatial components. In order to analyze this data across multiple databases, it is necessary to first normalize the data, which initially requires the critical evaluation of the database designs to identify the traits that will facilitate analysis.

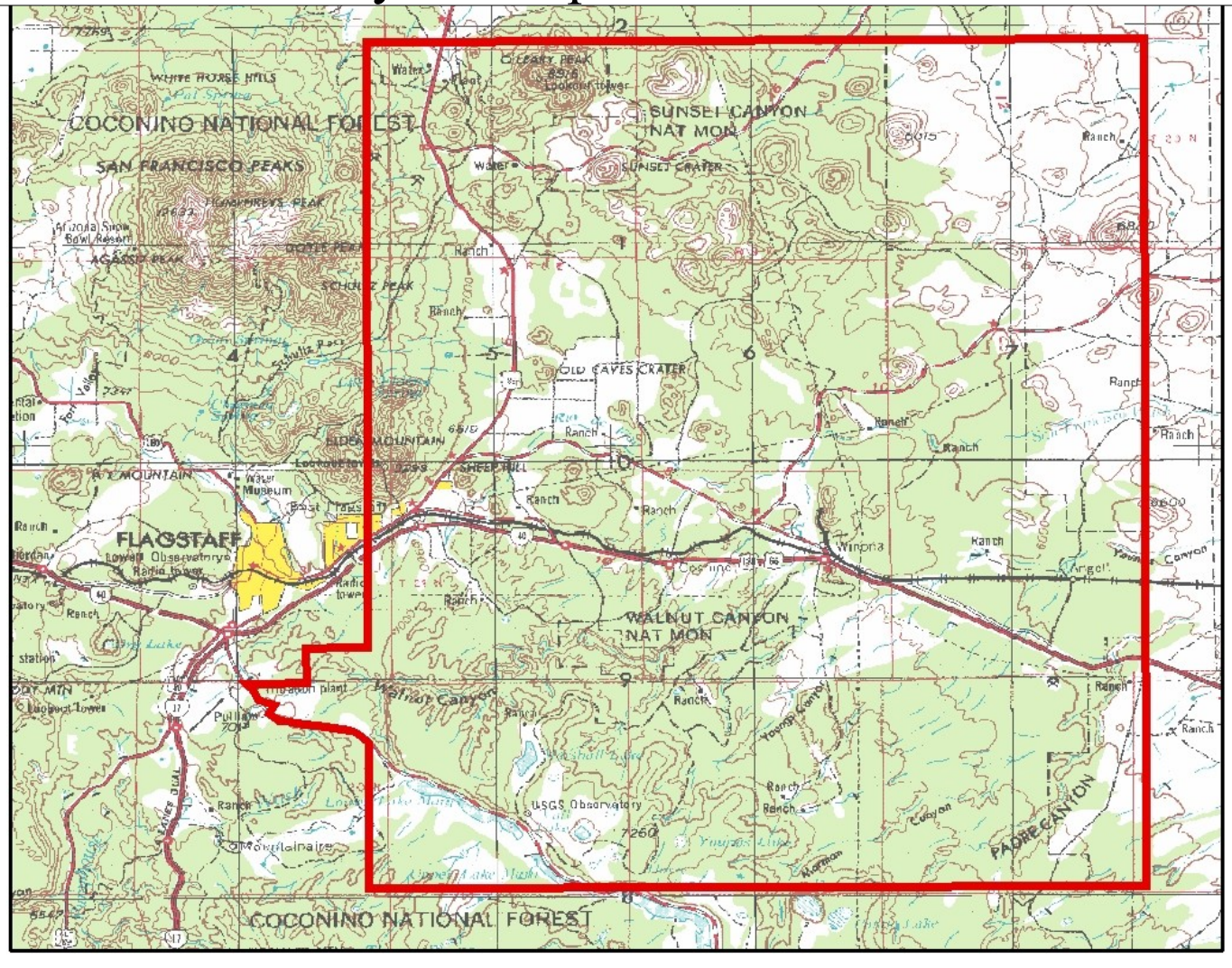
FS_Site_No	Temporal	NR_Status	Feature_Ty_A	Feature_Type_B	Cultural_A	Cultural_B
03040200056	UNK	Eligible			UNKNOWN	UNKNOWN
03040200070	PRE	Listed	PUEBLO: 20+ ROOMS		SINAGUA, NORT	UNKNOWN
03040200110	PRE	Unevaluated	ARTIFACT SCATTER		SINAGUA, NORT	NORTHERN SINAGUA -
03040200120	PRE	Eligible	PUEBLO: 20+ ROOMS		SINAGUA, NORT	UNKNOWN
03040200189	PRE	Unevaluated	PUEBLO: 1-2 ROOMS		SINAGUA, NORT	UNKNOWN
03040200217	PRE	Unevaluated	FIELD HOUSE		UNKNOWN	UNKNOWN
03040200218	PRE	Eligible	PIT HOUSE: 1-4 DEPRESSIONS	PUEBLO: 1-2 ROO	SINAGUA, NORT	UNSPECIFIED

FS_SITE_NUM	REGION	FOREST	DISTRICT	SITE_NUMBER	SITE_USE_DESC	SITE_TYPE	SITE_TYPE_DESC	YEARS_FROM
03070100001	3	7	1	1	Limited Activity	3	Refuse Scatter	1000
03070100002	3	7	1	2	Habitation	606	Multiple Units (	1000
03070100003	3	7	1	3	Limited Activity	31	Rock Pile	4000
03070100004	3	7	1	4	Habitation	606	Multiple Units (	1050
03070100005	3	7	1	5	Habitation	606	Multiple Units (	1050
03070100006	3	7	1	6	Habitation	606	Multiple Units (	1050
03070100007	3	7	1	7	Habitation	606	Multiple Units (	1050

Two study areas were chosen on the Colorado Plateau of Northern Arizona to evaluate the suitability of the regional databases to spatial analysis methods



The first study area lies East of the city of Flagstaff, Arizona on forest managed by the Coconino National Forest, the National Park Service, and a myriad of private owners

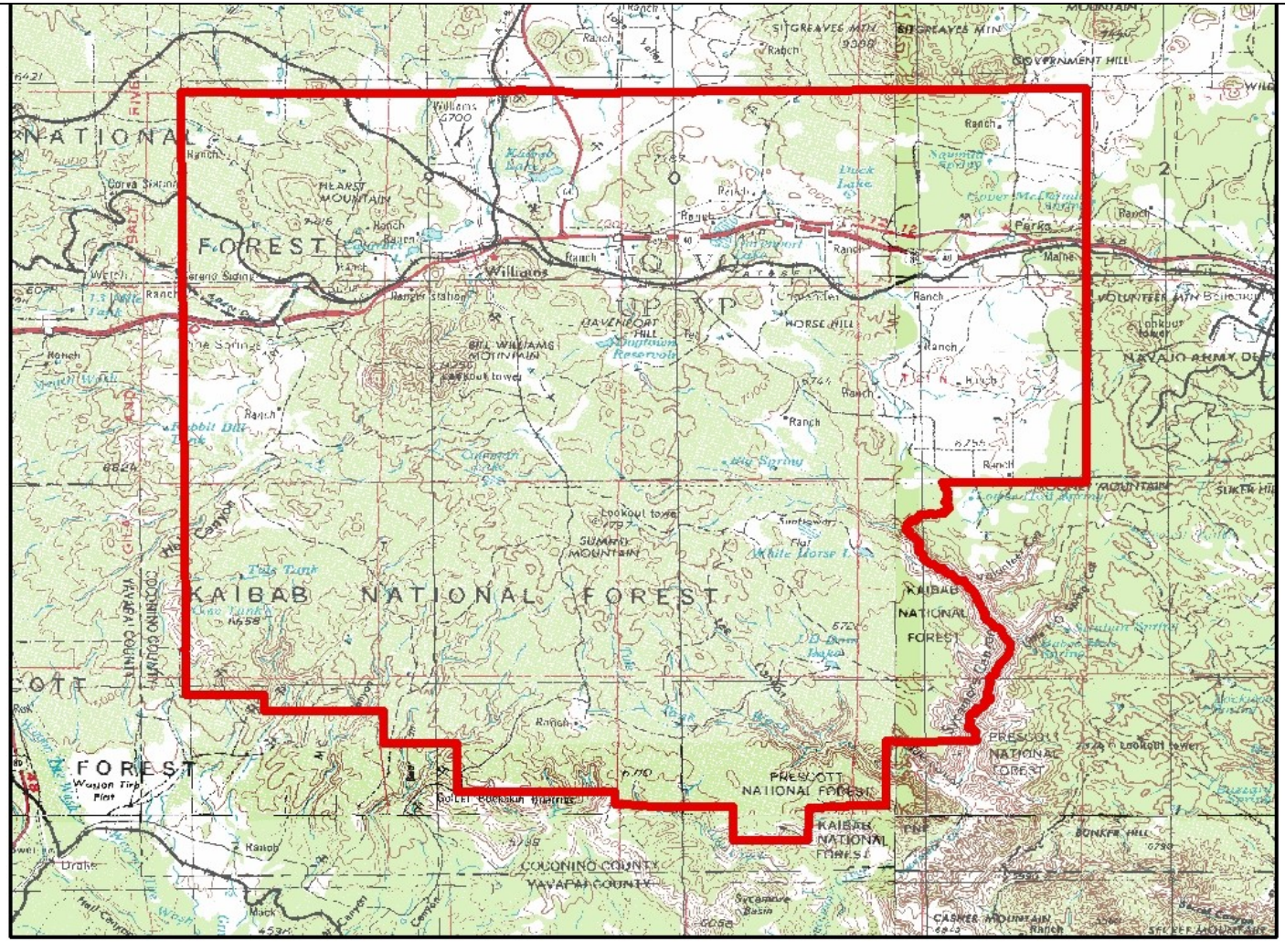


This pilot study area was chosen based on its proximity to Walnut Canyon National Monument. From Summer 2010 to Spring 2011, this area was evaluated by Museum of Northern Arizona archaeologists for a so-called Special Resource Study. This study was conducted to evaluate the possibility of expanding the monument to include additional resources outside of current boundaries. As part of this study, a descriptive analysis was performed on site distributions within this area to identify possible site concentrations contemporaneous with those protected in Walnut Canyon National Monument.

Study area metrics:

- Comprised of NPS, USFS, and privately owned properties
- Roughly 295,000 acres
- Archaeological data procured from NPS and USFS sources
- Roughly 750 archaeological surveys representing about 26% of the total study area
- 4,031 recorded sites

The second study area lies West of the city of Flagstaff, Arizona on forest managed entirely by the Kaibab National Forest



This secondary study area encompasses the modern town of Williams, Arizona and lies roughly twenty miles from the Walnut Canyon study area. It was selected according to its comparable size and geographic composition. Taken as a whole, each study area is ecologically diverse, ranging from Piñon-juniper scrub to Ponderosa forest and from 500 foot deep canyons to mountain peaks over 7000 feet in height. Most importantly, each area hosts high densities of culturally diverse archaeological sites.

Study area metrics:

- Comprised exclusively of USFS property
- Roughly 290,000 acres
- Archaeological data procured from single USFS source
- Roughly 420 archaeological surveys representing about 43% of the total study area
- 1,170 recorded sites

The spatial analysis of the archaeological site distributions within these two study areas will rely on a three step inductive process:

I. Data evaluation and comparison

II. Descriptive analysis

III. Exploratory analysis

Step One: Data evaluation and comparison – each database is evaluated for its analytical fitness based on its contents and organization. The principal goal of this step is to define critical aspects of each database that either promote or hinder the analysis process. Key record attributes will be identified that will in turn have a pivotal role in the analytical steps to follow. The ultimate purpose here is the aggregation of site data across multiple data tables to a single location for analysis.

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Data evaluation

A total of three separate regional databases are employed in this project:

- ASMIS – National Park Service/ Flagstaff Area Monuments

- INFRA – Coconino National Forest
- INFRA – Kaibab National Forest

ASMIS – National Park Service/ Flagstaff Area Monuments

- Represents site data from Walnut Canyon and Sunset Crater National Monuments
- Accounts for 508 sites, of which 487 contained sufficient attribution for inclusion
- Complex relational database allows for site query operations
- Old version (used herein) lacked consistent data dictionary
- Uses a simple code-number primary key site number (e.g. WACA0234) that also requires disaggregation and re-concatenation; database also includes alternate site number fields that facilitate QA of duplicate sites

INFRA – Coconino National Forest

- Represents the bulk of site data from the area surrounding Walnut Canyon and Sunset Crater National Monuments in the Eastern study area.
- Accounts for 3,523 sites, of which 2,901 contained sufficient attribution for inclusion
- Complex relational database has recent origins (2004) and is based on legacy paper records dating to the Early 20th Century
- Data dictionary inconsistently applied and many key data fields remain null

Uses a simple number-based site ID primary key (e.g. 02-4587) that also requires disaggregation and re-concatenation; database also includes alternate site number fields that facilitate QA of duplicate sites

INFRA – Kaibab National Forest

- Represents the entirety of site data from the Western study area.
- Accounts for 1,170 sites, of which 1,139 contained sufficient attribution for inclusion
- Complex relational database dates to early 1990's and, while based on legacy paper records dating to the Early 20th Century, has received extensive QA since adoption
- Data dictionary consistant with very few missing data fields

Uses a simple number-based site ID primary key (e.g. 02-4587) that also requires disaggregation and re-concatenation; database also includes alternate site number fields that facilitate QA of duplicate sites

Data comparison

Organization:

- INFRA contains many tables containing detailed feature and artifact data that allow for specialized queries, circumventing MAUP by allowing for multiple means of grouping; ASMIS relies almost entirely on predefined data groupings
- ASMIS relies very heavily on nominal data where INFRA uses many ordinal fields and binary (presence v absence) fields that also facilitate organization and analysis

Completeness:

- Overall, the Kaibab N.F. INFRA database is the most complete (97%), followed by the NPS ASMIS database (96%), and the Coconino INFRA database comes in last (75%)
- No matter how well designed a database is, a lack of completion demands the elimination of null record fields before any analysis can be performed

Key analysis fields

Eastern survey area:

- Site type (nominal) – 86% complete
- Temporal class (nominal e.g. prehistoric v historic) – 79% complete
- Cultural affinity (nominal) – 65% complete

Western survey area:

- Site type (nominal) – 97% complete
- Temporal class (nominal e.g. prehistoric v historic) – 97% complete
- Temporal range (ordinal) – 96% complete
- Vegetative zone (nominal) – 96% complete
- Cultural affinity (nominal) – 96% complete
- Cultural phase (nominal) – 72% complete

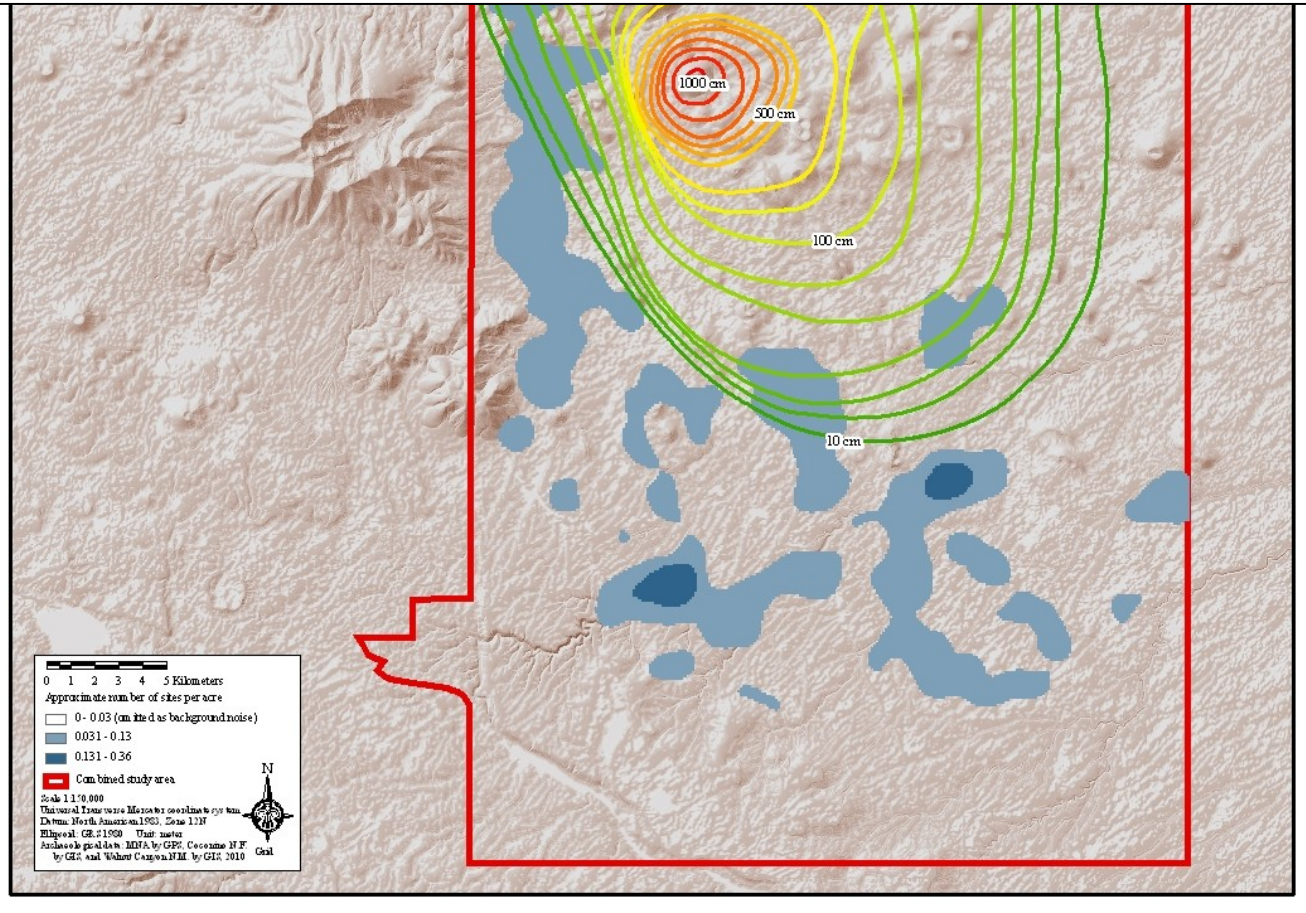
Assumptions must be made prior to the analysis to provide a point of conjecture:

- Null Hypothesis: observed site distribution is primarily the result of the

  Independent Random Process (IRP)

- Archaeological sites cluster relative to:
  - access to water
  - available material resources
  - arable ground and ecological zones that promote agriculture
- Certain types of archaeological sites cluster relative to their environment
- Site distributions change through time

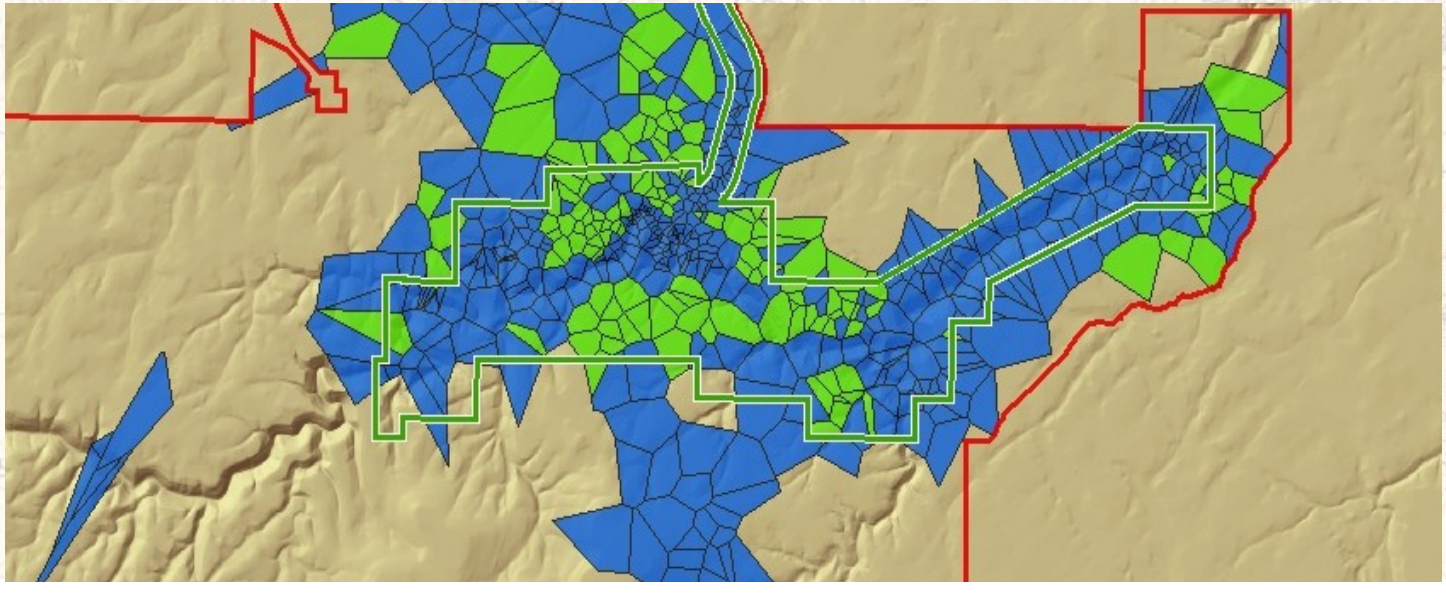
Step Two: Descriptive analysis – once the aggregated dataset is joined to the combined site distribution point layer it can thus be tested for the presence of statistical clustering against the null hypothesis. The site data is then filtered by attributes such as site type and temporal affiliation (at minimum) as a point of comparison with the unfiltered distributions as a whole. The goal of this stage is to identify statistically relevant site cluster events within the study areas.



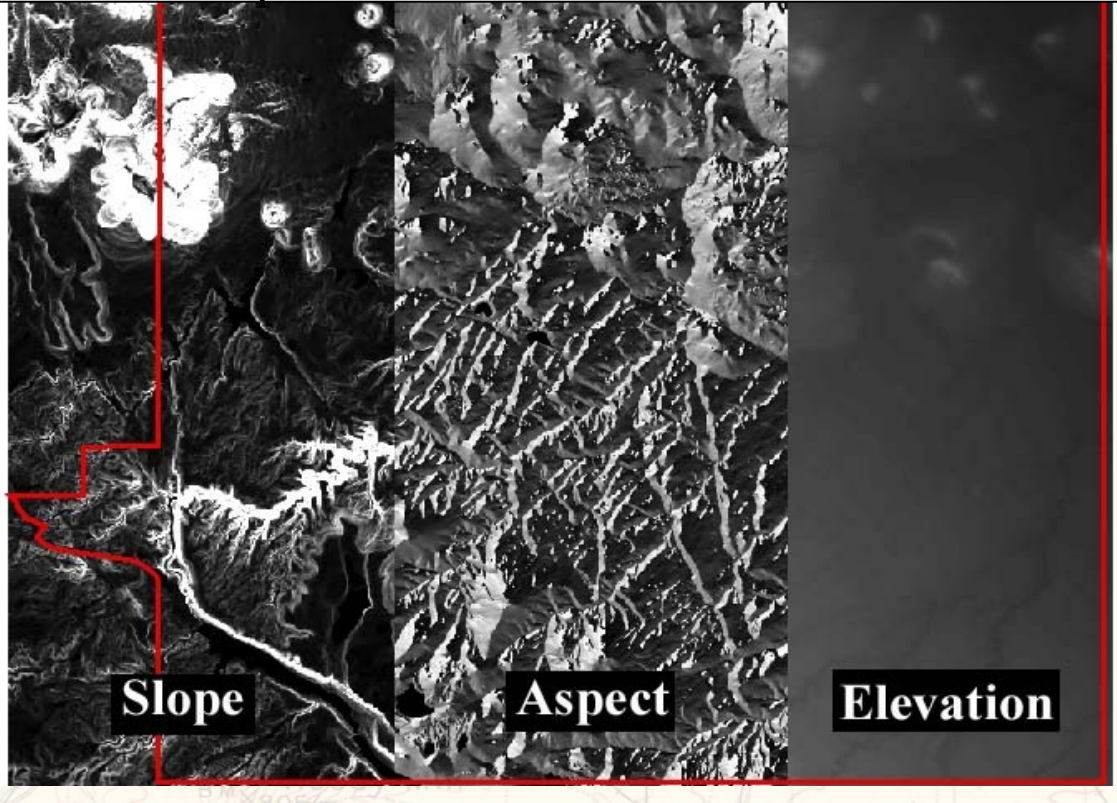
Descriptive Analysis

Relevant site cluster patterns will be identified through:

- Definition of central tendencies for point distributions
- Nearest Neighbor analysis of unfiltered distributions to evaluate null hypothesis
- Nearest Neighbor analysis of attribute filtered distributions
- Cluster detection analysis of attribute filtered distributions using:
  - Kernel Density Estimation (KDE)
  - Theissen Polygon cluster visualization



Step Three: Exploratory analysis – Once a series of archaeological site clusters have been identified each will be evaluated in terms their relationship with their surrounding landscape. This exploratory step will begin with correlative variables such as slope, aspect, elevation, and distance to water and hopefully progress to include such variables as watershed, soil type, bedrock geology, ecological zone, and presence of other resources. This step is by far the most "open-ended" and its precise procedure is largely contingent on previous results and the detail of environmental data that is acquired.



Exploratory Analysis

This final step, at the minimum, will involve:

• Exploration of the environmental tendencies of filtered and unfiltered site distributions (e.g. by slope, aspect, elevation, etc)

• Use of LISA (Local Indicators of Spatial Autocorrelation) tests on observed distribution clusters against environmental variables using the Getis-Ord General G function

• Development of an incipient Archaeological Predictive Model (APM) using filtered site data and an array of relevancy-tested environmental layers to produce a series of weighted indices.

Project Goals

- Identify clustered site distribution patterns within the study area
- Provide statistical support for anecdotal/ tacit distribution observations
- Identify key elements of these databases that facilitate their aggregation and fitness for use in spatial analysis
- Justify the expense incurred in the population and maintenance of robust regional archaeological site management databases
- Develop early-stage APM for use in evaluating un-surveyed areas and the facilitation of agency management decisions by identifying potentially vulnerable localities

Project timeline

- ✓ *Pilot Project: January 2011* - site data acquired from Walnut Canyon National Monument
- ✓ *Pilot Project: March 2011* - site data acquired from Coconino National Forest
- ✓ *Pilot Project: July 2011*- Analysis of Archaeological Sites in the Walnut Canyon Special Resource Study Area Draft report delivered to NPS
- ✓ *Pilot Project: October 2011* - Analysis of Archaeological Sites in the Walnut Canyon Special Resource Study Area - Final report delivered to NPS
- ✓ *November 2011* – site data acquired from Williams Ranger District, Kaibab National Forest, Arizona
- *December 21, 2011* – GEOG 596A project presentation
- *March, 2012* – Walnut Canyon Special Resource Study public presentation – Museum of Northern Arizona, Flagstaff, Arizona
- *March 2012* – Kaibab Site Analysis draft report due to Williams Ranger District, Kaibab National Forest, Arizona
- *April 18, 2012* – Presentation of analysis findings to Society for American Archaeology national conference, Memphis, Tennessee
- *May 2012* – Kaibab Site Analysis final report due to Williams Ranger District, Kaibab National Forest, Arizona

Thank you!

Special thanks go out to:

- Archaeologists of the Flagstaff Area Monuments
- Archaeologists of the the Coconino National Forest
- Dr. Ted Neff and the archaeologists of the of the Museum of Northern Arizona
- Dr. Larry J. Gorenflo and the MGIS dept. at PSU World Campus
- Neil Weintraub of the Kaibab National Forest