

Spatial Analysis of NWI & LLWW Data to Locate Restorable Ciénegas for Enhancement and Protection on the White Mountain Apache Indian Reservation Utilizing ArcGIS Model Builder

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Abstract

The White Mountain Apache Indian Tribe Reservation in east-central Arizona contains wetlands which were inventoried in a GIS through the National Wetlands Inventory. The reservation lands contain unique wetlands referred to as ciénegas, which are in jeopardy due to over grazing by cattle and wild ungulates (Elk). The need exists to locate these ciénega's and a model was built in ArcMap to begin the process of addressing the protection and restoration of these unique wetlands. Upon completion and analysis, this model was shown useful in locating potential ciénegas as well as highlighting potential improvements to the model and additional data needs.

Introduction

The reservation spans three counties and covers around 2,600 square miles. The land starts at about 2,600ft above sea level on the southwest side and ranges all the way up to 11,400ft on the peak of Mt. Baldy on the eastern border (WMAT Wetland Conservation Plan, 1997). The White Mountain area is made up of mostly Ponderosa pine forests to the east and Oak Chaparral and Pinon-juniper to the West. This habitat is home to a variety of forest wildlife. It is located directly south of the Mogollon Rim. The White Mountain Apache Tribe (WMAT) reservation spans 4 different watersheds.

Within the forests of the White Mountain reservation are a wide variety of wetlands ranging from high mountain streams, springs, lakes, impoundments, marshes, riparian areas and more. Among the most important types of wetlands

located in this area are what are known as ciénegas (see-en-uh-guh). Ciénega is a Spanish term for marsh or wet meadow and can be broken into "Cien" "aguas" meaning "one hundred fountains or springs (Davis, 1993).

Ciénegas are unique to the American Southwest and are both culturally and ecologically significant to the White Mountain Tribe. This type of wetland is often associated with seeps and springs and found in stream margins and headwater areas. Water is forced to the surface across large areas rather than single sources or channels. Large soft, anaerobic black soils and hydrophytic plants will exist in the high-quality ciénegas.

Today, undamaged ciénegas are practically non-existent. Historically, ciénegas were beautiful wet meadows that occupied many valley bottoms. Today, they are generally incised and damaged by

overgrazing cattle. They are typically classified as palustrine emergent wetlands, although some would prefer to list them in the palustrine forested or palustrine shrub-scrub category (Davis, 1993). Much of the scrub-shrub and forest is degraded or gone due to abuse and overgrazing. Although similar to other wet meadows across the country, they are a rare and unique type of wetland in (the arid west) and have been drastically reduced in number (Davis).

To the White Mountain Indians, the ciénegas are a rich resource, both in terms of the health of their water systems and as cultural sites for many reasons. Additionally, these wetlands high in the watersheds are sources of water to many other communities in the West (WMAT Conservation Plan, 1997).

The land is vast and sparsely populated. Ciénegas can range in size and can be located in difficult locations to identify and travel to. Providing land managers with potential sites and rankings could ease the burden of identification and expedite any process of evaluation and observations, as it has been shown that habitat modeling can increase the efficiency of agency resources for project support and in determining whether field surveys and/or mitigation are needed (Nock, 2002).

Study Area

The WMAT Reservation is in East Central Arizona near the Arizona-New Mexico border and covers approximately 1,684,279.6 acres (2,631.7 sq. mi) (Figure 1). There are four watersheds (Figure 2) within and across the reservation, with the easternmost two watersheds having the most elevation change and containing the majority of Palustrine wetlands. National Wetlands Inventory (NWI) data includes

polygon and linear data with codes describing their characteristics.

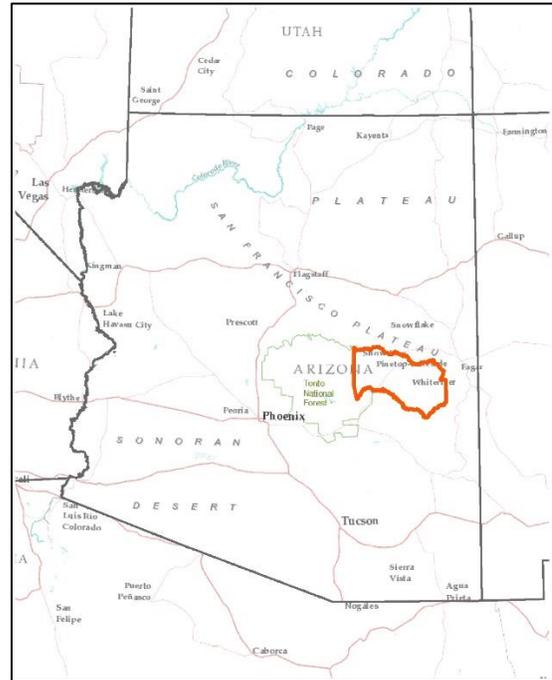


Figure 1. The White Mountain Apache Tribe (WMAT) Reservation lands location shown in red within the state of Arizona. The area within this boundary are the lands in jeopardy of ciénega loss.

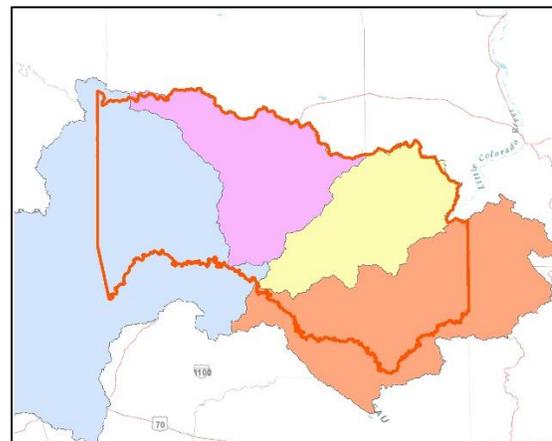


Figure 2. The four major HUC8 Watersheds (Named left to right Upper Salt-blue, Carrizo-pink, White-yellow, and Black-orange) within the WMAT lands.

Additionally, other codes are often added for more understanding of the wetland its relation to the landscape.

Graphically, topographic drainage features are illustrated in Figure 3.

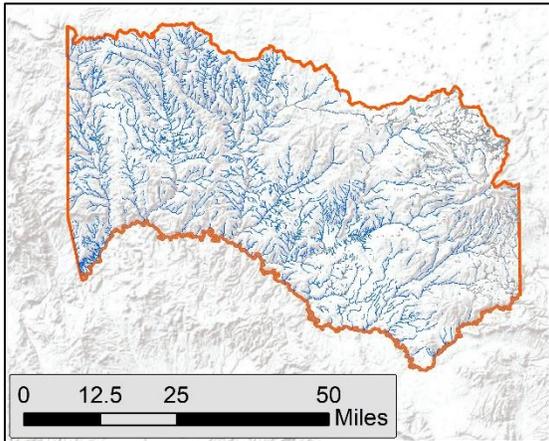


Figure 3. The White Mountain Apache Reservation Lands shown with major drainage patterns of riverine features and relative size to scalebar.

Data Sources

Data sources were collected from various sources including the National Wetlands Inventory, WMAT, State and Federal agencies and more. Completed wetland mapping through the National Wetlands Inventory (NWI) was obtained and clipped to the boundaries of the tribal land. The wetlands data consists of polygons and linear features in a file geodatabase, feature dataset, and individual feature classes.

Wetlands are identified through Heads-up Photo Interpretation and delineation in ArcMap from ESRI and adhere to FGDC standards for mapping. Each feature is given a code based on the NWI system. These codes describe the characteristics of the wetlands in terms of Class, Subclass, Water Regime and more. Further information on the NWI coding can be found on the NWI website and within the Cowardin Classifications of Deepwater Habitats of the United States (Cowardin, Carter, Golet, and LaRoe, 1979). See Figure 4 for an example portion of the mapping.

Each polygon was also given a code known as LLWW, Landscape



Figure 4. The WMAT National Wetland Inventory (NWI) data zoomed to show line and polygon features and examples of NWI coding.

Position, Landform, Waterbody and Water flow Path (Tiner, 2011). The National Wetlands Inventory developed a hydrogeomorphic type coding system to complement the national wetlands classification system. This coding system adds to the habitat classification and the system by providing descriptors for landscape position, landform, water flow path, and waterbody type. Figure 5 shows examples of this coding system.

An additional set of data was utilized which are line features also coded with the NWI system. These lines are used to delineate features that are too narrow to be added by polygon but are visible in both imagery and topographical maps. These features are typically riverine in nature but can have palustrine characteristics. The NWI data on the WMAT mapped lands contained 6,411 wetland Polygons, 3,827 Riverine Linear features with 84, and 36 unique attributes, respectively.

Available data beyond the NWI and other attributions added to the NWI is sparse. This is due in part to the remoteness of the study area as well as the private nature of the Tribal lands. The

tribe has seen the need to improve mapping on many levels of their natural

OBJECTID *	Shape *	ATTRIBUTE	LLWW_2_0
1	Polygon	PUBKx	PD3fVR
2	Polygon	PUBKx	PD3fVR
3	Polygon	PUBKx	PD3fVR
4	Polygon	PUBKx	PD3fVR
5	Polygon	PUBKx	PD3fVR
6	Polygon	PUBKx	PD3fVR
7	Polygon	PUBKx	PD3fVR
8	Polygon	PEM1Cx	TEBAVRhi
9	Polygon	PUBFx	PD3a2VR
10	Polygon	PEM1Ch	TEBAippdIN

OBJECTID *	Shape *	ATTRIBUTE	LLWW_2_0
1	Polyline	R4SBJ	ST3TI
2	Polyline	R4SBJ	ST3TI
3	Polyline	R4SBA	ST3TH
4	Polyline	R4SBA	ST3TH
5	Polyline	R4SBA	ST3TH
6	Polyline	R4SBA	ST3TH
7	Polyline	R4SBA	ST3TH
8	Polyline	R4SBA	ST3TH
9	Polyline	R4SBA	ST3TH
10	Polyline	R4SBA	ST3TH
11	Polyline	R4SBA	ST3TH

Figure 5. A screenshot showing attribute tables for NWI polygons and NWI linear features. The right two columns show portions of the NWI and LLWW coding applied to the mapped features.

resources and this will be addressed in the discussion at the conclusion. A 10m Digital Elevation Model (DEM) (Figure 6) for the study area was available for the WMAT lands and proved invaluable to this endeavor as discussed in the methods. A higher resolution set of elevation data could greatly enhance any outcomes of such an undertaking.

Criteria Development

The criteria for locating ciénegas was established using topographical map data,

inferred characteristics of known ciénegas and descriptions of historic lands.

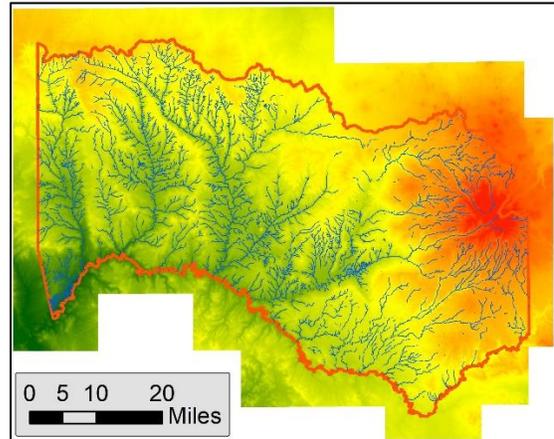


Figure 6. The WMAT 10m DEM symbolized as reds being higher elevation to greens in the lower elevations and including riverine data overlay.

Ciénegas tend to be in low slope areas of treeless wetlands in intermountain valleys with some adjacencies to springs, seeps or stream features. In the WMAT reservation, Palustrine Emergent wetlands (PEM1B, PEM1D, and PEM1E in NWI mapping), as well as riverine features (R4% NWI code), were selected as primary characteristics. PEM1 in the NWI code indicates a Palustrine (Pond like) area with persistent Emergent wetlands plants, and the E, B, and D portion of the code refers to the water regime of the NWI code and indicates different types of saturated wetlands.

The LLWW code which best matches ciénegas was the Terrene Sloped code (TESL%) as long as the wetland was shown to not be human-altered such as impoundments (NOT ‘code%h’). The known ciénegas were shown to be located in the areas of lowest slope within the White Mountains (i.e. < 4 degrees).

Once all these criteria were met, the final characteristic to be met was adjacency to riverine features. It was decided based on known cinenegas that a proximity of less than or equal to 150 meters would be used. This decision was

arrived at based on known and site visited ciénegas on the WMAT reservation.

Methods

ArcGIS Model Builder was used to build a tool which would create a shape file showing potential ciénegas as opportunities for protection and/or enhancement. Figure 7 immediately below illustrates a summative representation of the model. This model is explained below and is illustrated in larger detail on the following page and is represented as Figure 8 for greater readability and interpretation of processes.

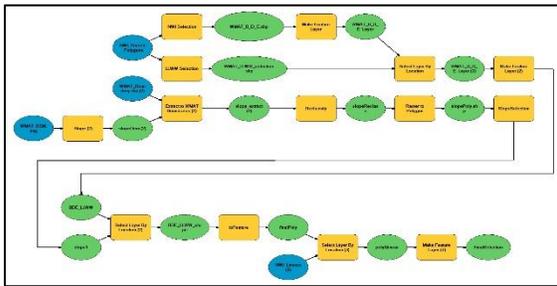


Figure 7. An overview display of the finished model.

The model begins with NWI selection Palustrine wetlands with the B, D, or E water regime, which was then used to make a feature layer for continued use. A selection of LLWW coded polygons was also conducted, selecting only Terene/Sloped (interpreted) (TESL%) that were not human-altered (i.e. not coded with ‘hi’ as a modifier). Simultaneously, the Model would build a slope raster and clip the 10m DEM to the study area boundary. Upon finishing the ‘clip’, the Slope Raster would be reclassified to separate lands less than 4 degrees of slope from those greater. The Raster to Polygon tool was then used to make a selectable later for additional queries. The first portion of the tool is shown in Figure 9.

The model continues at this point (Figure 10) with a select by location tool

selecting only those wetland polygons which were found to be within the less

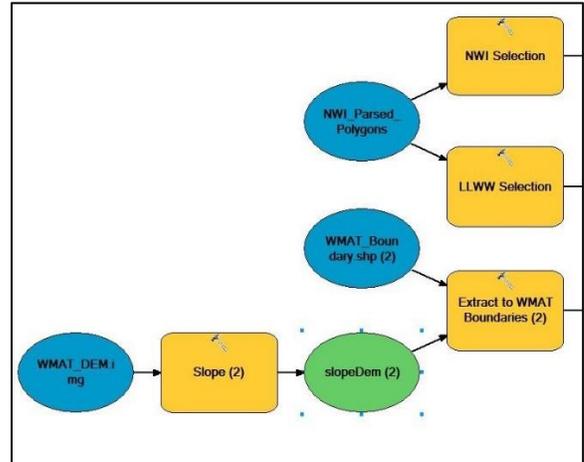


Figure 9. The first portion of the Cienega Model with NWI B, D, & E selection, LLWW selection, and slope creation and reclassification.

than 4 degrees of slope and then sent to a Create Feature tool for the next step.

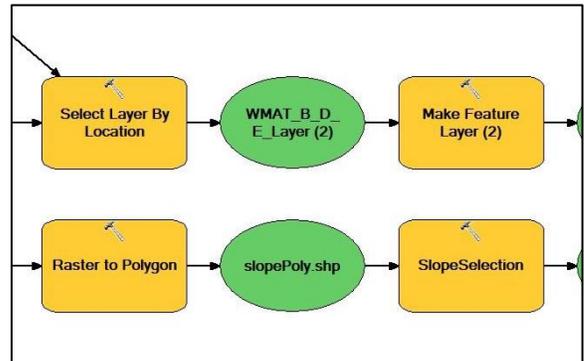


Figure 10. Select by location of B, D, E. wetlands and required slope.

As stated in the criteria development the final piece of the study was to locate the wetlands that landed within 150 meters of the linear features which are known to be riverine in nature. When the selection was made it was sent again to a create feature layer with a final output of a polygon shapefile.

A final shapefile (Figure 11) was the resulting output of the model. This shapefile can serve as a dataset to field verify the locations of the potentially restorable ciénegas.

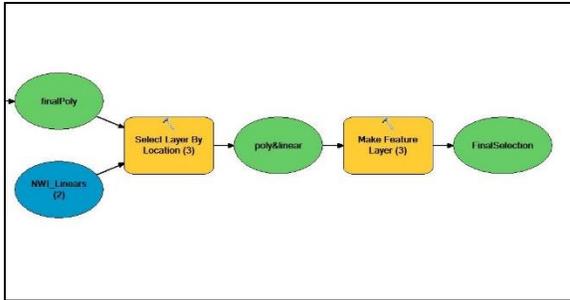


Figure 81. The final portion of the model with a shapefile output.

An attribute table of all data accompanies the polygons with all relevant data (i.e. NWI, LLWW, etc.) and the resultant polygons on the landscape were shown to have the correct output data as intended with the model. Meaning the model worked in its selection of B, D, & E polygons and only selecting those with the TESL% LLWW codes. Figure 12 illustrates sample data extraction. Labels applied to the polygons show the characteristics of the data (Figure 13).

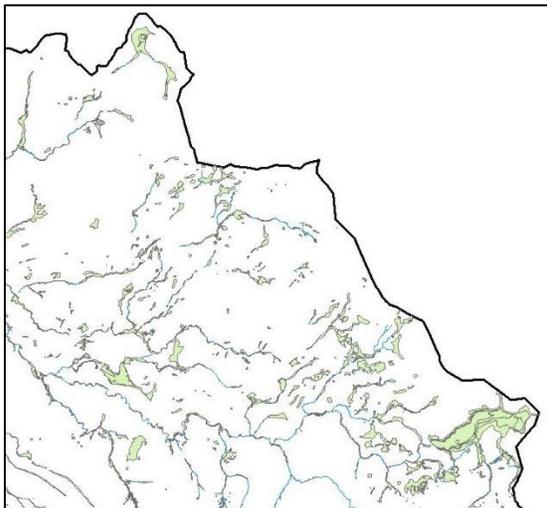


Figure 12. A graphical only example of potential Ciénegas polygons created from the model.

Discussion

The White Mountain Apache Tribe in east-central Arizona is home to many important wetlands. As mentioned earlier, one type of wetland unique and important

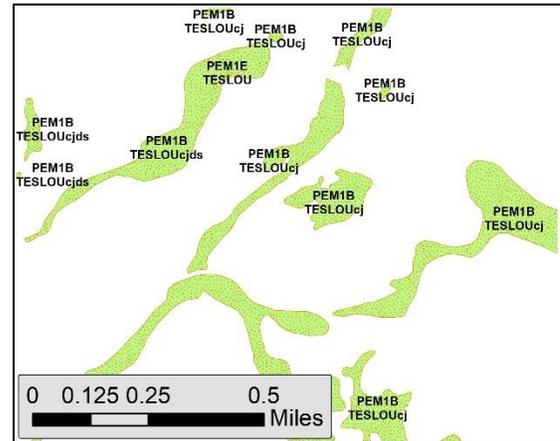


Figure 93. A 'zoomed' example of selected polygons with NWI & LLWW attributes, showing the correct selections were made by the model.

to the area is known as the ciénega. The need to have known locations of these features is critical to their preservation, protection and/or their restoration.

The tool created in this study was run on the available collateral data and 1,648 polygons were identified by the Ciénega model. These wetlands represented 6,445.66 acres of land within the WMAT study area, or approximately .38% of the Reservation land and approximately 25.7% of the originally mapped NWI polygons. The vast majority of the polygons appeared to land in the eastern mountainous portion of the WMAT lands, which holds true to early suggestions that the ciénegas are high in the watersheds and in low slopes of inter-mountain areas.

A very subjective high level (landscape level) check of USGS DRG Topographic maps showed the larger more significant polygons matched well with known/named Ciénegas with historic meanings to the White Mountain Tribe. In other words, the model output ciénegas 'landed on' known ciénegas, indicating that on some level the model output was generating accurate data. Figures 14 – 17 illustrate topographic maps with the

known and named cienega along with the mapped wetland polygon (coral color) which was identified by the tool and shown to be in the correct location. Beyond this, little can be confirmed with the large number of polygons and remoteness of the landscape.

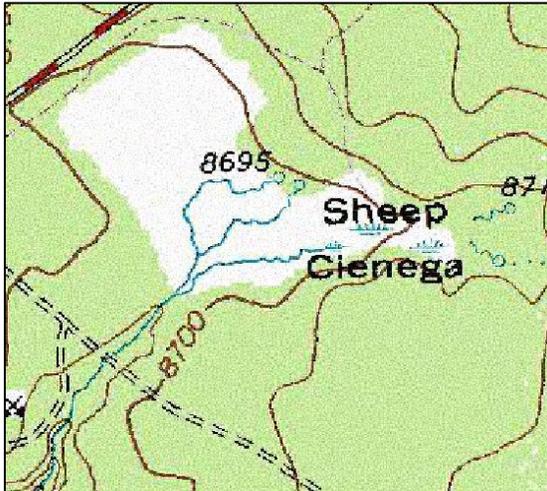


Figure 104. Sheep Ciénega shown in DRG map.

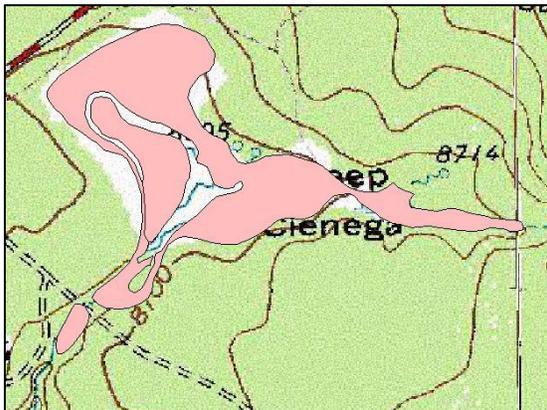


Figure 115. Sheep Ciénega with NWI mapped polygon overlay.

Further study of the area, both in acquiring improved data as well as fieldwork could show accuracies or discrepancies with the model selections.

Conclusions

A few conclusions can be drawn from this model build exercise. The first among them is that potential Ciénegas locations can be located from Landscape Level

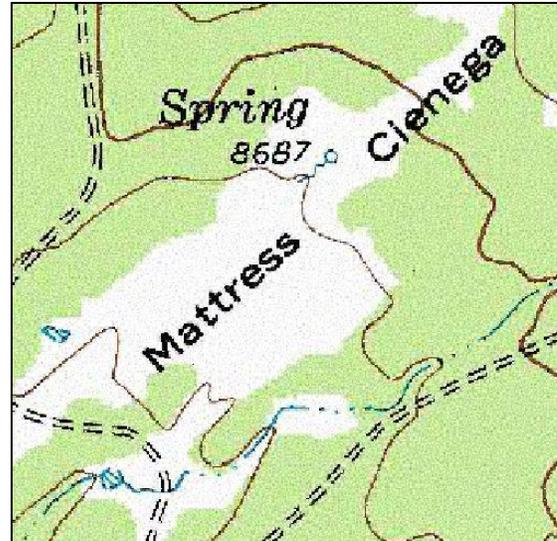


Figure 126. Mattress Ciénega shown in DRG map.

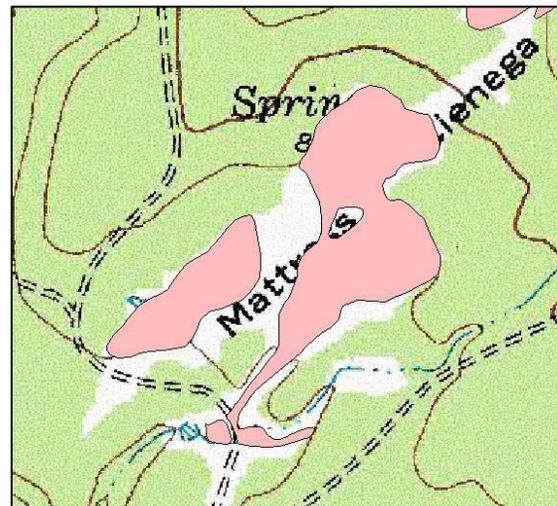


Figure 137. Mattress Ciénega with NWI mapped polygon overlay.

mapping, queries of the wetland data and other collateral data, which, when analyzed will provide adequate results.

This mapping data can be put to use on the ground to then perform closer evaluation of the wetlands. Only when they are visited can stakeholders make decisions on preservation or restoration and utilize resources wisely. In order to visit them, they need to be located.

Another conclusion that can be stated, is that only from extensive fieldwork and site verification (i.e. plant identification, soil sampling, and other

site-level indicators) will more information be obtained on the quality and accuracy of the data output.

Future Considerations

Future iterations of this study or those like it could be enhanced and refined to create more reliable maps by doing a number of things. Refining the definition of *ciénegas* to give more criteria to the model would be an important first step. A deeper study of what makes a *ciénega* and what characteristics define it may allow analysis to seek other collateral data for the model.

A second step in improving the model would be to gather higher quality data for the study area. As an example, a more refined DEM would improve the quality and output of the model by providing more detail to slope and location to these small wetlands. The 10m DEM was critical to the process and any enhanced elevation data would only further the cause of this work. As additional data is acquired, more information is obtained and refinements in the model are made and the output will be enhanced.

Along with fieldwork, additional work on model criteria refinement and improved data, one other change that could be made is to include additional data layers. These could include Hydric Soils layers, springs data, deeper investigations of geology layers, as well as local knowledge of environmental conditions. If these, and possibly other information can be added it would create a greater understanding of the results.

Ciénegas are both culturally and biologically important to the White Mountain Tribe. However, wetlands like these should be thought of as important to everyone. These small wetlands perform functions that are important on small

scales for wildlife and local stakeholders, but collectively they can enhance and maintain vital resources to much larger communities and society as a whole.

Acknowledgments

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