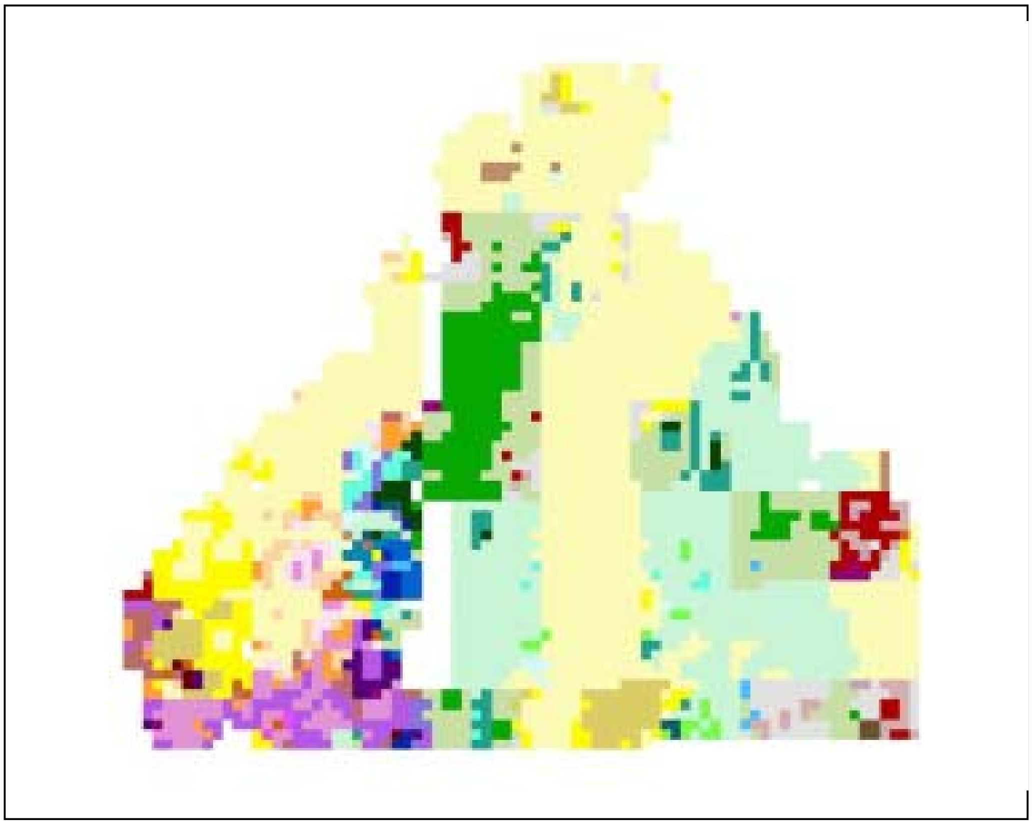
Historical Vegetation

of the

Borderlands Ecosystem Management Area



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Historical Vegetation of the Borderlands Ecosystem Management Area

Interim Report

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SUMMARY

We have developed historical vegetation maps for the Borderlands Ecosystem Management Area in southwestern New Mexico and southeastern Arizona. These maps are based on U.S. General Land Office surveyors' notes dated 1882-1936. We have created a general vegetation map, as well as maps showing the distributions of chaparral, mesquite, and desert scrub as recorded by the surveyors. These maps provide a potentially useful tool to assist management and restoration efforts in the region. They also provide a valuable source of information for future scientific research.

Acknowledgements

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TABLE OF CONTENTS

INTRODUCTION

To understand why vegetation exists where it does on a landscape, and how management may influence it, it is useful to understand how different forces have shaped that vegetation in the past. Here, we present historical vegetation maps that may help provide insights into past vegetation dynamics in the Borderlands Ecosystem Management Area, a region of approximately 800,000 acres (325,000 ha) in southwestern New Mexico and southeastern Arizona (Fig. 1). These maps provide baselines that can be used to determine how vegetation has changed in the region over the last century.

These maps also offer important information on what types of vegetation different sites in the Borderlands region will support. This information may be very useful for management and restoration efforts in the region. It will aid managers in selecting areas with a given historical vegetation type (e.g., grassland) as targets for restoration. It will also provide a historical perspective in determining desired future conditions.

These maps are based on notes written by surveyors from the U.S. General Land Office (GLO), the precursor to the Bureau of Land Management (BLM). The surveys that produced these notes were carried out between 1882 and 1936, with about half the surveys in the region being completed by 1890, and about 90% by 1920 (Fig. 2). GLO surveyors' notes have been used previously in the Southwest to determine historical vegetation types for different areas, and to gain insight into patterns of vegetation change (Buffington and Herbel 1965, York and Dick-Peddie 1969, Bahre 1991). However, as far as we know, these are the first GIS maps created using surveyors' notes in this part of the country. This is also the first effort we know of to map an area this size using surveyors' notes, and to use that data to examine patterns of vegetation change as they relate to soil type and geomorphology.

This report accompanies the results of the first phase of our study: the historical vegetation maps themselves. We are now using these maps along with a current vegetation map, soils maps, and geomorphology maps to investigate patterns and underlying causes of vegetation change in the region. However, the historical maps are an important product that may be useful to others before other phases of our research are complete. We have included them both as paper maps and as digital maps on a CD-ROM, so that they may be used by managers and researchers with different needs and computer capacities. We hope they provide a useful tool for those developing management plans, carrying out restoration efforts, and conducting scientific research in the Borderlands region.

METHODS

Survey Data

Most of the Borderlands Ecosystem Management Area was surveyed by the General Land Office between 1882 and 1936 under the GLO's cadastral survey program.

As surveyors measured and marked township, range, and section boundaries, they recorded basic information on vegetation. For most townships, data were recorded for all internal boundary lines between sections, and a general description was written depicting overall vegetation in the township. For some townships, data were also recorded for boundaries lying along township edges.

We obtained GLO survey notes on microfiche for the study area from the BLM state offices in Santa Fe, NM, and Phoenix, AZ. All data on vegetation at the section-boundary level were transcribed and subsequently entered into a Microsoft Access database, which accompanies this report. These data form the foundation for our historical vegetation maps.

Interpreting Data by Quarter Section

Section-boundary data were available for 55 complete or partial townships in the study area. Data for some or all internal boundary lines were available for all townships. Data for perimeter boundary lines were available for 12 townships, although these data were incomplete in most cases. We entered 2385 records for internal section boundaries and 114 records for perimeter boundaries.

In most of the townships with perimeter data, perimeter data and internal boundary data were recorded during different years. Differences in dates ranged from one to 32 years, with the perimeter data nearly always being recorded prior to the internal boundary data. Presumably, some townships were laid out before the individual sections within them were delineated, and these differences in dates reflect delays in surveying the individual sections.

To produce a continuous map of the study area, we interpreted the historical data on a quarter-section-by-quarter-section basis (Fig. 3). To avoid merging data from different time periods for individual quarter sections, we considered only the internal boundary data in developing our maps. In the future, we plan to compare perimeter data with internal section boundary data recorded at different times for areas where both data sources exist. Such comparisons may yield insights into vegetation changes that occurred during the years in which the cadastral surveys were carried out.

We assigned one or more vegetation classes to each quarter section based on the corresponding section boundary data (Fig. 3). For most quarter sections, values were assigned using the data from the two section boundaries intersecting at the corner of the quarter section (Fig. 3a). However, quarter sections lining township edges were treated differently. Most quarter sections along township edges were assigned values based on the single adjacent internal section boundary (Fig. 3b). The quarter sections at the far corners of each township were assigned values based on the two nearest internal section boundaries (Fig. 3c).

Each quarter section was assigned one primary class, which represents our best attempt to characterize the overall vegetation for that quarter section. The primary classes form the basis for our general vegetation map. We took into consideration all data present on the section boundaries corresponding to the quarter section in assigning a primary class.

In addition, quarter sections with more than one vegetation type present were assigned one or more secondary classes. The secondary classes represent vegetation types noted by the surveyors that are not reflected in the primary class. While the primary class represents a generalized class for the entire quarter section, the secondary classes represent additional vegetation types recorded along the section boundary/ies. As an example, consider a quarter section in which dense chaparral was recorded on two section boundaries, and desert scrub and scattered mesquite were recorded along one of those boundaries. In this case, the quarter section would be assigned a primary class of dense chaparral, and desert scrub and scattered mesquite would be entered as secondary classes.

Vegetation Classification

We assigned primary and secondary classes using the classification shown in Table 1. Our classification is based on major vegetation types, as well as on modifying terms used in the surveyors' notes (e.g., "good," "scattered"). Table 2 shows the types of historical data represented by terms in our classification.

We divide grass into three categories: good, fair or undefined, and poor. The terms "good grass", "fair grass", and "poor grass" are ubiquitous in the surveyors' notes. Because of the surveyors' apparent economic emphasis, as suggested by frequent references to timber and grazing, we assume that the terms "good," "fair," and "poor" refer to the suitability of the grass for grazing.

In some cases, surveyors referred to grass by common names such as "grama grass" (*Bouteloua* spp.) or "tobosa grass" (*Pleuraphis mutica*). In these situations, we assigned records to either the good, fair, or poor grass classes following the forage value assignments of Allred (1993). Most of the perennial grama grasses (*B. gracilis, B. eriopoda, B. hirsuta, B. curtipendula* and *B. radicosa*) in the region are highly palatable to livestock ("good" to "excellent" forage value), and we therefore classified grama grass into the good grass category. Tobosa grass is also considered to have good forage value by Allred (1993), and we classified it into good grass, as well.

We use the term "fair or undefined" to represent grass identified as "fair" by the surveyors, and to represent other grass types that could not be readily classified as good or poor. An example of a type placed in this category is "bunch grass," a term that appears frequently in the surveyors' notes. Since many species with varying degrees of palatability occur in a bunch-like form in the study area, it would be very difficult to assign "bunch grass" to either a good or poor class. We also classified "salt grass"

(*Distichlis spicata*) into this category, since this species' palatability is considered to be fair (Allred 1993).

We classified woody species into the following four categories: woodland, chaparral, mesquite, and desert scrub. Our woodland classes include any woody plants occurring as trees. Chaparral includes low, shrubby oaks and other woody plants with a similar growth form. Mesquite classes include mesquite (*Prosopis glandulosa*) and catclaw mimosa (*Mimosa aculeaticarpa*), a brushy species often found in association with mesquite. Desert scrub includes creosotebush (*Larrea tridentata*) and tarbush (*Flourensia cernua*).

We distinguished woodland from chaparral primarily by growth form rather than by species present. The surveyors' notes are nearly always entered in a very standardized format, with information on timber, undergrowth, and grass in distinct positions. (The term "undergrowth" can be somewhat misleading in the surveyors' notes, since this term is often used when no trees are present. We assume that the term simply refers to woody plants of a low, shrubby stature.) From one township to another, the order of these three types of information varies, but within a given township, the order is typically highly consistent. The words "timber," "undergrowth," and "grass" are used frequently in the surveyors' notes, but even when these words are absent, it is normally clear which type of vegetation the surveyor is referring to.

Whenever timber was present, we classified the vegetation into one of the woodland classes. The most common terms describing timber in the surveyors' notes are "pine" (likely *Pinus leiophylla* or *P. engelmannii*), "pinon" (likely *P. cembroides*), "juniper" (likely *Juniperus deppeana* or *J. monosperma*), "cedar" (likely *J. monosperma*), "oak" (likely *Quercus arizonica*, *Q. grisea*, *Q. emoryi*, *Q. hypoleucoides*, or *Q. rugosa*), and "scrub oak" (possibly any of the species listed for "oak").

When "pine", "pinon", "juniper", "cedar", "oak," or "scrub oak" appeared only as undergrowth, we assigned the vegetation into one of the chaparral classes. Of these terms describing undergrowth, "oak" and "scrub oak" appear most often in the notes, and in this context, these terms likely refer to *Q. turbinella*, *Q. toumeyi*, or *Q. grisea*. It is worth noting that the terms "scrub oak timber" and "scrub oak brush" are both seen frequently in the surveyors' notes. These terms were assigned to woodland and chaparral, respectively. When the term "scrub oak" appears by itself, we classified it as woodland or chaparral, depending on whether it was in the timber or undergrowth position in the notes. We also classified "manzanita" (probably *Arctostaphylos pungens*) and "mahogany" (probably *Cercocarpus montanus*) into the chaparral classes.

The word "mesquite" appears frequently in the surveyors' notes, and we assume they used it to refer to the same species of mesquite we find in the region today, *Prosopis glandulosa*. Catclaw mimosa (*Mimosa aculeaticarpa*) now occurs frequently with mesquite, and apparently it did when the surveyors' notes were written, as well. We have included it in the same vegetation category. Unfortunately, the surveyors simply used the term "catclaw" in their notes, and since this term can refer to either *M. aculeaticarpa* or *Acacia greggii* (Kearney and Peebles 1951, Turner et al. 1995), there is some ambiguity in interpreting it. Because *M. aculeaticarpa* now occurs much more frequently in the study area than *A. greggii* (Muldavin et al. 1998), we think it is likely that the surveyors were referring to *M. aculeaticarpa*. R. Turner (personal communication) arrived at the same conclusion.

The term "greasewood" is seen throughout the surveyors' notes. This term has commonly been used to refer to *Larrea tridentata* (Kearney and Peebles 1951, Turner et al. 1995), and that is how we interpret it here. The term "black brush" also appears in the surveyors' notes. Following Kearney and Peebles (1951) and Turner (personal communication), we interpret this term as referring to *Flourensia cernua*, now known more commonly as tarbush. We include these two species in our desert scrub category.

We did not use information on the presence of yucca, agave, or cactus in classifying vegetation. Species in these groups tend to occur within many different vegetation types ranging from grassland to desert shrubland to woodland. Yucca, agave, and cactus do not normally occur in communities by themselves, and they are generally poor indicators of other vegetation types. Furthermore, data on the current distribution of these groups in the Borderlands region are lacking, making it difficult to compare historical data with present data in an analysis of vegetation change.

We have decided to create vegetation classes that combine different grass categories with different woody species categories partly because information on both grass and woody species is commonly recorded along individual section boundaries in the surveyors' notes. This reflects the reality that grass co-occurs with woody species throughout the Borderlands region, and that many areas are impossible to classify simply as grasslands, shrublands, or woodlands. By using classes that include information on both grass and woody species, we are able to retain information on both types of vegetation that would be lost if we attempted to classify areas into "pure" grassland or other vegetation types. Since many land managers and scientists in the region are interested both in grass condition and woody species density, we felt it was important to retain as much information on both aspects of the vegetation as possible.

Assigning a Primary Class

The most challenging aspect of our vegetation classification was assigning a primary class to a quarter section when several vegetation types were present and/or when the same vegetation type was recorded at different densities. It was common for multiple vegetation types to be noted along an individual section boundary. It was even more common for multiple vegetation types to be present at the quarter section level, since in most cases, two section boundaries were considered in assigning a primary class (Fig. 3). There were also cases in which the same vegetation type was recorded on different section boundaries, but it was recorded at different densities (e.g., scattered vs. dense).

To assist in combining data from different section boundaries, we developed a series of rules, shown in Table 3. To account for different vegetation types, we considered the species recorded and their densities, if indicated. To determine the appropriate quality or density for vegetation in a primary class, we took an "average" of the values from the two section boundaries.

To calculate the average quality/density value for a primary class, we first assigned vegetation on the section boundaries to categories based on the surveyors' descriptions. Using Table 2 as a guide, we assigned grass to one of the following categories in decreasing order of quality: good, fair/undefined, or poor. We used adjectives from the surveyors' notes (e.g., "dense", "scattered", "sparse") to assign woody species to one of the following categories in decreasing order of density: dense, undefined, or scattered. We use the term "undefined" as before—to indicate that the presence of a particular vegetation type was recorded, but that no further information was present in the surveyors' notes. For example, surveyors sometimes refer to "dense mesquite" and "scattered mesquite," but they frequently just refer to "mesquite." In the latter case, we consider mesquite to be undefined.

Since there were at most two values for each quarter section, averaging these ranked values was straightforward. We considered "good" and "dense" to be positive attributes (these can be thought of as having a value of 1). We considered "fair" and "undefined" to be neutral attributes (these receive a value of 0). We considered "poor" and "scattered" to be negative (these receive a value of -1). For grass, if the average of the two values fell above the fair/undefined level (i.e., the average was positive), the grass was considered to be "good" in the primary class. If it fell below the undefined level, it was considered to be "poor." Likewise, for woody vegetation types, if the result fell above the undefined level, the primary class became "dense", and if it fell below the undefined level, it became "scattered." When the presence of a particular vegetation type was noted on one boundary but not the other, we considered it to have a negative quality/density value on the latter boundary.

These rules have important implications for the appearance of the final maps. For example, since the primary class is assigned to one of the woodland types if any trees are present, large areas are classified as woodland and scattered woodland (with or without grass present) in our general vegetation map. We have developed additional maps to present information on undergrowth not available in the general map.

Producing the Final Maps

To create our final maps, we first converted the township/range/section data into latitude/longitude coordinates using the program TRS2LLX.EXE (for information on this program, visit the Web site http://www.crl.com/~wefald). Although this program does not return latitude/longitude coordinates by quarter section, we were able to obtain coordinates at the quarter-section level by adding or subtracting standard values from the section centrum values returned. For latitude, we added or subtracted 0.0035 decimal degrees; for longitude, we added or subtracted 0.004 decimal degrees.

We then used these latitude/longitude coordinates to generate a point coverage in ARC/INFO v. 7.1.2 (ESRI 1997). To correct for inaccuracies in the township/range/section conversion process, we edited this point coverage using digitized section boundaries (RGIS 1993, ALRIS 1994) as a reference. We then created grids from these points using ArcView GIS v. 3.1.1 (ESRI 1999) to produce continuous vegetation maps.

Quarter sections are approximately 805 m on a side. In theory, if the study area were covered with complete, perfectly square quarter sections arranged in perfect lines, we would be able to create a grid with a cell size of approximately 805 m, where each cell corresponded to one quarter section. Because of irregularities in the arrangement of sections in the study area, though, we found that a cell size of 1015 m was the smallest we could use to produce a continuous grid. Given our methods for interpreting vegetation at the quarter-section level based on section boundaries (Fig. 3), this cell size reflects the accuracy of our original data reasonably well.

Our general vegetation map is based on primary class values associated with quarter sections. As can be seen in Table 1, there were 65 potential classes available for use in the primary class field. Of these, 46 were actually used during the classification process. Since 46 classes still proved to be somewhat unwieldy and difficult to interpret in a single map, we reduced this number further by combining classes with small numbers of records.

First, we combined all dense vegetation types with their corresponding undefined versions. For example, one "Good Grass/Dense Woodland" cell was lumped with 26 "Good Grass/Woodland" cells, and the results were all named "Good Grass/Woodland." We did not lump most cells with scattered vegetation types because there were frequently a large number of cells in these categories. However, we did combine two "Poor Grass/Scattered Chaparral" cells with 12 "Poor Grass/Chaparral" cells, two "Poor Grass/Scattered Mesquite" cells with two "Poor Grass/Mesquite" cells, and three "Poor Grass/Scattered Desert Scrub" cells with 18 "Poor Grass/Desert Scrub" cells. We also lumped two "Poor Grass/Woodland" cells with 20 "Poor Grass/Scattered Woodland" cells, and named the results "Poor Grass/Scattered Woodland." The value "No Grass", which appeared in one cell, was changed to "No Data." The result of this process was to reduce the final classification from 46 to 34 vegetation classes for the general vegetation map.

In addition to the general vegetation map, we also created specific maps showing the historical extent of chaparral, mesquite, and desert scrub in the Borderlands region. To produce these maps, we considered not only the content of the primary class field, but also any values for the targeted vegetation occurring in the secondary class fields. By taking into account both primary and secondary class fields, we were able to create maps illustrating the full range of these vegetation types as recorded by the surveyors.

RESULTS

Our general historical vegetation map for the Borderlands region is shown in Fig. 4. This map emphasizes grass and woodland classes. Whenever the presence of grass was recorded by the surveyors, the corresponding cell falls into a category containing grass. Likewise, whenever the presence of woodland was recorded, the corresponding cell falls into a woodland category.

The converse of these patterns is also true. The absence of grass from a cell on the map indicates that no grass was recorded in the surveyors' notes (i.e., grass does not "hide" in secondary classes). The absence of woodland indicates that no woodland species were recorded. Cells that fall into chaparral categories, for example, correspond to what we normally think of as chaparral: low brush without trees. It is also important to note that for cells in the grass-only categories ("Good Grass", "Fair or Undefined Grass", and "Poor Grass"), no species falling in any of our other categories were recorded.

The same patterns do not hold for chaparral, mesquite, and desert scrub. Unlike the situation with grass and woodland, cells that do not fall into chaparral, mesquite, and desert scrub categories may still contain species in these groups. Since woodland species were given priority in classification (Table 2), quarter sections that contain both woodland species and species in one of these categories were put into woodland classes. Cells classified as woodland in the general map may also have chaparral, mesquite, and/or desert scrub present as undergrowth.

The historical extent of chaparral, mesquite, and desert scrub in the Borderlands region is shown in Figs. 5, 6, and 7. In these maps, the presence or absence of the given vegetation type is shown regardless of whether woodland, or any other vegetation type, is present. The occurrence of chaparral across the entire Animas range may seem odd, but this may be explained by the fact that dense oak brush was recorded along with various species of timber for most of the Animas Mountains.

The general vegetation map shows the complete distributions of grass and woodland species in the Borderlands as recorded in the surveyors' notes. The following three maps complement this map by showing the complete distributions of chaparral, mesquite, and desert scrub. Taken together, these maps provide a thorough view of the historical data recorded by the GLO surveyors.

DISCUSSION

These maps provide a potentially valuable tool for management, restoration, and scientific research in the Borderlands region. They may offer insights into whether specific management and restoration strategies make sense from a historical perspective.

For example, grassland restoration efforts may be more likely to succeed in areas that supported grassland historically than in other areas.

It is important to recognize, though, that these maps provide only a limited view of the historical vegetation in the region, and that there are many other factors to consider in determining appropriate management and restoration plans. Many authors suggest that the vegetation in the region underwent significant changes around the turn of the century with the influx of large numbers of livestock into the area (Hastings and Turner 1965, Bahre 1991, Humphrey 1987). Thus, the vegetation may have already been altered from its pre-settlement condition when many of the surveyors' notes were written. Fig. 2 shows the dates that different areas within the Borderlands region were surveyed. In general, the later an area was surveyed, the more likely significant vegetation changes resulting directly or indirectly from human settlement may have occurred. The extent to which these maps show pre-settlement vegetation may vary considerably across the study area, and any efforts aimed at restoring vegetation to pre-settlement conditions should not use these maps as a sole guide.

Another consideration in planning and interpreting restoration efforts is that soil properties may have changed since historical times. When grasslands convert to shrubland, for example, topsoil may be lost from inter-shrub spaces (Schlesinger et al. 1990). Soil nutrients often become concentrated beneath shrubs in so-called "islands of fertility" (Schlesinger et al. 1996). These changes in soil properties may make it difficult to restore grasslands in areas that now support shrublands, even if grasslands were present in historical times.

Still another factor to consider in restoring vegetation in the Borderlands region is climate change. Brown et al. (1997) report that there has been an increase in winter precipitation in the region over the past 20 years, and that this may account for increases in the density of woody species in some areas. Vegetation patterns are strongly influenced by local climatic conditions (Neilson 1986), and climatic changes in the region may alter the ability of certain areas to support specific types of vegetation. Restoration efforts based solely on historical conditions may fail if the climate in an area has changed such that the area no longer supports the type of vegetation it once did.

Because of the complexities involved in restoring vegetation from one state to another, it is often impossible to predict the results of different restoration strategies. The only way to determine for certain whether a given restoration strategy will work is to try it. One of the most important uses of these maps may be in helping land managers and scientists select promising sites for restoration experiments.

The maps can also play a useful role in other research efforts, including research focusing on grazing effects. By analyzing areas that had similar vegetation at the turn of the century but that have had different grazing histories since then, it may be possible to gain insights into grazing effects in the region. Furthermore, the maps suggest that some areas currently dominated by mesquite and desert scrub have been that way for many decades, while in other areas these vegetation types have increased over the past century. One might hypothesize that mesquite and desert scrub species are present in some areas because of large-scale topoedaphic factors, while in other areas they are present because grazing pressure has reduced competition from grasses. These maps can be used to identify appropriate sites for carrying out research (including both GIS analyses and field experiments) to test such hypotheses.

Over the next year, these maps will be used as the basis for research funded by the U.S. Forest Service and carried out at the New Mexico Natural Heritage Program (NMNHP). These historical maps will be compared to a current vegetation map of the region recently produced by the NMNHP (Muldavin et al. 1998). GIS analyses will be carried out to quantify vegetation change in the region, and to identify spatial patterns of vegetation change.

In addition, NMNHP staff will work with Cathy McGuire of the Natural Resources Conservation Service and Tom Biggs of the Arizona Geological Survey to determine how patterns of vegetation change relate to soil type and geomorphology. Soils and geomorphology maps have recently been completed for the San Bernardino Valley (McGuire 1998, Biggs et al. 1999), and a geomorphology map has been completed for the Animas Valley (Vincent and Krider 1998). By overlaying historical and current vegetation maps with soils and geomorphology maps, we will be able to assess the potential dynamic range of vegetation that can be supported on different soil types and geological substrates. This will help us better understand the variable patterns of vegetation change that have occurred across the Borderlands region. It will also provide insights into the potential productivity and restoration capacity for different soils and geological substrates in the region.

The maps presented here provide a view into the history of the Borderlands. They provide insight into the types of vegetation that specific areas are capable of supporting, insight that may be of direct interest to land managers trying to meet conservation and/or economic objectives. They also provide a readily accessible source of data for researchers working in the region. We hope that land managers and researchers trying to understand vegetation dynamics in the present and future benefit from this glimpse into the past.

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Table 1. Classification used to produce historical vegetation maps for the Borderlands Ecosystem Management Area using General Land Office surveyors' notes.

"Good Grass" Classes

Good Grass

Good Grass/Scattered Woodland
Good Grass/Scattered Chaparral
Good Grass/Scattered Mesquite
Good Grass/Scattered Desert Scrub
Good Grass/Scattered Unknown Shrubs

Good Grass/Dense Woodland
Good Grass/Dense Chaparral
Good Grass/Dense Mesquite
Good Grass/Dense Desert Scrub
Good Grass/Dense Unknown Shrubs

Good Grass/Woodland
Good Grass/Chaparral
Good Grass/Mesquite
Good Grass/Desert Scrub
Good Grass/Unknown Shrubs

"Fair or Undefined Grass" Classes

Fair or Undefined Grass

Fair or Undefined Grass/Scattered Woodland
Fair or Undefined Grass/Scattered Chaparral
Fair or Undefined Grass/Scattered Mesquite
Fair or Undefined Grass/Scattered Desert Scrub
Fair or Undefined Grass/Scattered Unknown Shrubs

Fair or Undefined Grass/Dense Woodland
Fair or Undefined Grass/Dense Chaparral
Fair or Undefined Grass/Dense Mesquite
Fair or Undefined Grass/Dense Desert Scrub
Fair or Undefined Grass/Dense Unknown Shrubs

Fair or Undefined Grass/Woodland
Fair or Undefined Grass/Chaparral
Fair or Undefined Grass/Mesquite
Fair or Undefined Grass/Desert Scrub
Fair or Undefined Grass/Unknown Shrubs

“Poor Grass” Classes

Poor Grass

Table 1. Continued.

Poor Grass/Scattered Woodland
Poor Grass/Scattered Chaparral
Poor Grass/Scattered Mesquite
Poor Grass/Scattered Desert Scrub
Poor Grass/Scattered Unknown Shrubs

Poor Grass/Dense Woodland
Poor Grass/Dense Chaparral
Poor Grass/Dense Mesquite
Poor Grass/Dense Desert Scrub
Poor Grass/Dense Unknown Shrubs

Poor Grass/Woodland
Poor Grass/Chaparral
Poor Grass/Mesquite
Poor Grass/Desert Scrub
Poor Grass/Unknown Shrubs

Classes With No Grass

Scattered Woodland
Scattered Chaparral
Scattered Mesquite
Scattered Desert Scrub
Scattered Unknown Shrubs

Dense Woodland
Dense Chaparral
Dense Mesquite
Dense Desert Scrub
Dense Unknown Shrubs

Woodland
Chaparral
Mesquite
Desert Scrub
Unknown Shrubs

No Timber
No Grass

Table 2. Relationships between our vegetation classification and historical terms used in the General Land Office surveyors' notes.

Term in Our Classification	Historical Terms Represented
Good Grass	good grass fine grass good grazing fine grazing grama grass tobosa grass good bunch grass good salt grass
Fair or Undefined Grass	fair grass bunch grass salt grass
Poor Grass	poor grass scattering grass scant grass sparse grass
Woodland	spruce pine pinon juniper cedar oak (as timber) scrub oak (as timber) mountain oak live oak
Chaparral	oak (as undergrowth) scrub oak (as undergrowth) manzanita mahogany
Mesquite	mesquite catclaw
Desert Scrub	greasewood creosote black brush

Table 3. Rules used in assigning a primary vegetation class to quarter sections using General Land Office surveyors' notes.

Rules to account for different vegetation types present

1. If woodland species are present, primary class will include woodland.
2. If multiple vegetation types are present but no woodland species appear, primary class will include densest type if densities are indicated.
3. If chaparral and mesquite are present at same densities, primary class will include mesquite.
4. If chaparral and desert scrub are present at same densities, primary class will include desert scrub.
5. If mesquite and desert scrub are present at same densities, primary class will include desert scrub.

Rules to account for quality/density differences on different section boundaries

Grass

1. If good and fair/undefined grass are present, primary class will include good grass.
2. If good and poor grass are present, primary class will include fair/undefined grass.
3. If good grass is present on one boundary and no grass is present on the other, primary class will include fair/undefined grass.
4. If fair/undefined and poor grass are present, primary class will include poor grass.
5. If fair/undefined is present on one boundary and no grass is present on the other, primary class will include poor grass.
6. If poor grass is present on one boundary and no grass is present on the other, primary class will include poor grass.

Woody vegetation types

1. If vegetation type is dense on one boundary and undefined on the other, it becomes dense in the primary class.
2. If vegetation type is dense on one boundary and scattered on the other, it becomes undefined in the primary class.
3. If vegetation type is dense on one boundary and not present on the other, it becomes undefined in the primary class.
4. If vegetation type is undefined on one boundary and scattered on the other, it becomes scattered in the primary class.

5. If vegetation type is undefined on one boundary and not present on the other, it becomes scattered in the primary class.
6. If vegetation type is scattered on one boundary and not present on the other, it becomes scattered in the primary class.

Additional rules

1. Primary class is only assigned “no timber” when no other data is present.