

**VEGETATION MAPPING, ASSESSMENT AND
MONITORING OF THE MADERAS DEL CARMEN
PROTECTED AREA, MEXICO**

INTERIM REPORT

**Sub-Agreement 14
Cooperative Agreement No. CA7029-1-0012
Between
National Park Service,
Southwest Regional Office
and the
University of New Mexico**

by

**Esteban Muldavin
Sarah Wood
and
Glenn Harper**

**New Mexico Natural Heritage Program
University of New Mexico
Albuquerque, New Mexico 88131**

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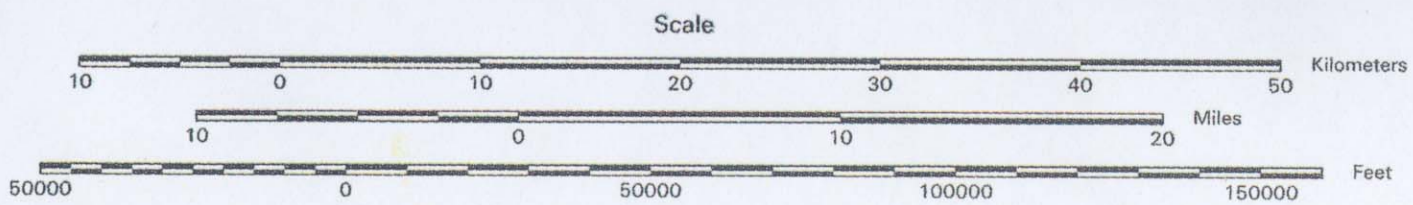
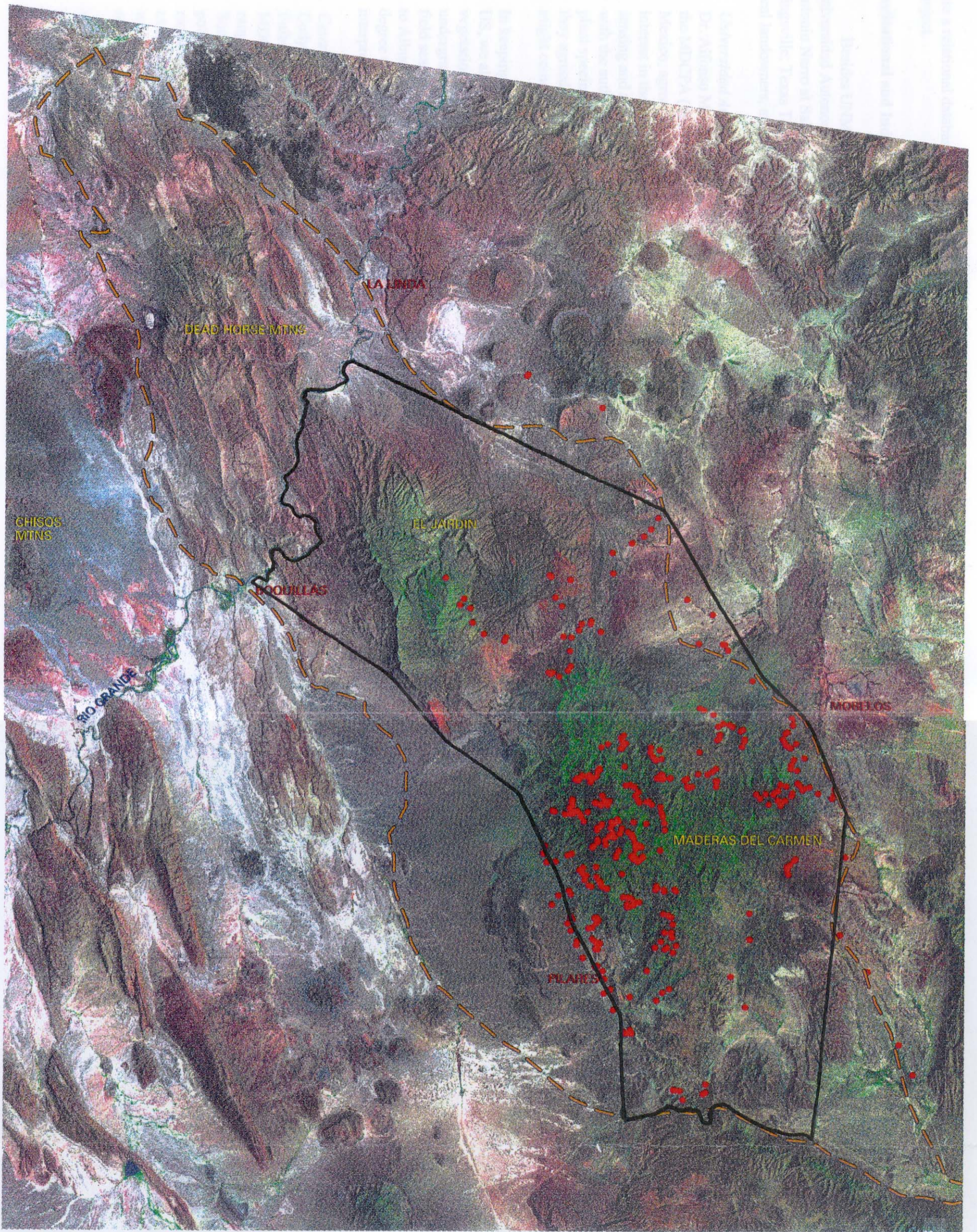
Introduction

The New Mexico Natural Heritage Program (NMNHP) at the University of New Mexico has been engaged in the development of a vegetation map and an ecological assessment for the Sierra del Carmen in Big Bend National Park and the Maderas del Carmen Protected Area (MDCPA) near Boquillas, Mexico¹ (Figure 1). This project was initiated in the fall of 1996 under cooperative agreement with the National Park Service and the Biological Resources Division (BRD) of USGS (CA70209-1-0012, Sub-agreement 14). This report reviews the progress made over the last year using as a guide the milestones and deliverables outlined in the Project Plan attached to the Cooperative Agreement. The emphasis here is on the accomplishments of the field expeditions during the summer and fall of 1997, along with our current status, details on the types of product we plan to deliver, and recommendations for future work.

The Sierra del Carmen is a very remote, geologically complex mountain range that straddles the US-Mexico border and includes the Dead Horse Mountains on the US side, and the El Jardin and Maderas del Carmen in Mexico. On its western side the range rises from the floor of the Chihuahuan Plateau at 700 m (2290 ft) to over 3,100 m (9,000 ft) at the summit (Maderas del Carmen). Consequently it harbors a wide variety of ecosystems, from desert shrublands to high montane forest, and a wide variety of endemic species and communities of high biological interest both to US and Mexican agencies, universities and individuals. The remoteness of the range suggests that impacts from grazing and timber/fuelwood harvest might be less intense than in other areas of Mexico and the US. Our goal is to produce the first detailed vegetation map of the range as a tool for trans-border biological resource management, and to provide an initial assessment of the ecological condition and biological importance of the Sierra del Carmen in a regional context.

The remoteness and political-social complexity of this area pose special challenges to project execution. There are nine agencies and universities involved on both sides of the border along with many collective and individual landowners with a wide variety of perspectives on the work to be accomplished. Much of the work from the initiation of project in September of 1996 through to July of 1997 was devoted to establishing contacts on both sides of the border, arranging permits, hiring personnel on both sides of the border, plus a preliminary reconnaissance followed by equipment and logistical preparations for the field expeditions (see June 30, 1997 Status Report). The period from August 17 to October 30, 1997 was dedicated to two extended field sessions to collect vegetation data for mapping purposes, establish monitoring plots and make local contacts. Since returning from the field we have been actively uploading the data

¹ The study area boundary shown in yellow in Figure 1 was the approximate project area initially designated by NPS to show the trans-boundary relationships. Our project focused on the Protected Area as designated by Instituto Nacional de Ecologia.



INDEX MAP

Figure 1 - Provisional Sierra del Carmen Vegetation Map and Ecological Assessment study area (yellow dashed line). The actual Maderas del Carmen Protected Area boundary as defined by the Instituto Nacional de Ecología is indicated by the solid black line. Red dots indicate 1997 sample plot locations. Boundaries and dots are overlain on a Landsat Thematic Mapper (TM) image where red color represents TM band 7 (mid-infrared), green TM band 4 (near-infrared), and blue TM band 2 (visible).

into a relational database, writing reports and preparing for the analysis phase of the project.

Institutional and Individual Arrangements

Besides UNM, Big Bend NP and BRD, the project is directly involved with the Universidad Autonoma de Nuevo Leon at Linares; Universidad Autonoma Agraria Antonio Narro at Saltillo, Coahuila; Maderas del Carmen Protected Area; Texas A&M, Kingsville; Texas Tech, Lubbock (center for the Texas and Mexican GAP programs); local landowners, and other contributing scientists. Details on these arrangements follow.

- 1 *Universidad Autonoma de Nuevo Leon, Facultad de Ciencias Forestales at Linares.* Dr. Alfonso Martinez, a professor at Linares, who has ongoing research projects in the MDCPA (in cooperation with Kleberg Institute) and elsewhere in northern Mexico, agreed to be our Mexican sponsor and collaborator because of our mutual interest in the project area. Marisela Pando Moreno, M.Sc. a specialist in remote sensing and also on the faculty at Linares, is a co-sponsor. Dr. Martinez, working with the authorities in Mexico City, provided us with the necessary permits to collect plant specimens. Dr. Martinez and Dr. Muldavin met in Monterrey, Mexico where they agreed to a mutual data exchange and discussed projects of mutual interest that might come from our current collaboration.

In keeping with our goal to support students on the project, both in Mexico and in the US, we also offered to support a student from Linares who might have interest in vegetation analysis and mapping. Dr. Martinez nominated Juan Medel-Anorve, an undergraduate in his final year, and he was offered a fellowship during and after the field season. Juan assisted field crews during the summer and fall and has now come to Albuquerque to complete his senior project and requirements for his bachelor's degree using data he collected and our facilities (he will be producing a map from interpretation of aerial photos and analysis of physical characteristics).

2. *Cesar Kleberg Wildlife Research Institute at Texas A&M in Kingsville.* Diana and Cody Crider, respectively graduate students of Dr. David Hewitt and Dr. Tim Fulbright at the Institute, have initiated studies on Mexican black bears in the MDCPA in Mexico, following up on Ms. Crider's work in the neighboring mountain ranges in Mexico. The Criders were introduced to us at the behest of the NPS Southwest Regional Office in Albuquerque in the fall of 1996 because of the potential value of our vegetation map to their black bear project, and because of the experience the Criders have in doing work in Mexico that might help us effectively execute the project. At that time the Criders had established working relationships with large landowners in the MDCPA and were planning to establish a camp for their research in the more remote area of the protected area.

We enlisted their cooperation and had a meeting in Kingsville with Drs. Hewitt and Fulbright as well as the Kleberg Institute director, Dr. Fred Bryant. Cody Crider had

a particular interest in our vegetation mapping and analysis with respect to his own thesis work on black bear habitat utilization. Because of this we offered him a research assistantship (RA) on the project so that he could learn techniques to support his work. We also agreed to provide Geographic Positioning System (GPS) support to the Kingsville project. The Kingsville project provided invaluable logistical support in the form of liaisons between us, landowners and other authorities to obtain permission for our sampling activities. This was crucial to expedite our field season because well over half of the MDCPA is privately owned.

3. *Universidad Autonoma Agraria Antonio Narro (UAAAN)*. Dr. Jesus Valdes, a botanist and ecologist at UAAAN and an expert on the flora of Coahuila and Chihuahua, was contacted to see if he would like to participate in the project. At a meeting in Monterrey, Mexico, Dr. Valdes agreed to help us with the identification of specimens, but because of time constraints, extensive collaboration on the project was impractical at this time. We plan to bring the specimens to UAAAN in January, 1998 for identification and accession to his herbarium, and at the same time discuss further collaborative studies for the coming year.
4. *Maderas del Carmen Protected Area*. Dr. Julio Carrera, director of the Sierra Del Carmen Protected Area, was contacted by phone and writing by Dr. Muldavin in the Spring of 1997. A copy of the project proposal and study plan was sent to him for comment. By phone, Dr. Carrera authorized our work in the Protected Area on the assurance that we had the proper permits for collecting. At that time Dr. Carrera was not prepared to offer any direct collaboration or support, but he did express interest in receiving our results in a form that would be useful for the protected area management. Dr. Muldavin also met briefly with Dr. Carrera at the end of the field season in Boquillas, Mexico and described the project progress and reaffirmed our need to cooperate more closely with protected area personnel in the future.
5. *Alberto Garza Santos and Mauricio M. Brittingham, Maderas del Carmen Landowners*. Alberto Garza and Mauricio Brittingham are major landowners in the central Maderas del Carmen area and were introduced to us by Diana and Cody Crider. They graciously permitted us to maintain a cooperative base camp in the mountains with the Criders. Dr. Muldavin met informally with Mr. Brittingham in Monterrey, Mexico where it was agreed that in exchange for being able to work on their land, they would receive a copy of our reports, maps and data.
6. *Texas Cooperative Fish and Wildlife Research Unit at Texas Tech University (Texas and Mexico Gap Project)*. Dr. Nick Parker and Dr. Carlos Rebeles at the Coop Unit at Texas Tech are leading the Texas Gap project and helping to coordinate the Mexico Gap Project. NMNHP is a cooperator in the New Mexico Gap project as well and was responsible for the New Mexico Gap map legend classification. The Texas Gap project had already acquired the most recent Landsat TM scenes for their project that also covered our study area. An MOU for data exchange was agreed upon in which the Texas Gap project would provide us with imagery in exchange for our ground

data and a copy of our map. This would avoid duplication of effort over the same area. In addition, we also agreed to work closely to ensure that our map legends are compatible and crosswalkable for later analysis and integration.

7. *James Henrickson, California State University* Dr. Henrickson has worked extensively in the Sierra del Carmen and the Northern Chihuahuan desert region. He loaned us, for use and comment, a draft of his *Flora of the Chihuahuan Desert Region* which he co-wrote with Marshall Johnston of the University of Texas. This also covers the mountain ranges of the region, including the Sierra del Carmen. This is a useful tool as no other flora reference exists specifically for this region.
8. *Instituto Nacional de Estadística, Geografía e Informática (INEGI), Saltillo, Nuevo Leon, Mexico.* INEGI is the branch of the Mexican government dealing with geographical resources. We were able to purchase from them black and white aerial photos (1:75,000) taken in November of 1994 which covered 95% of the study area. These will aid us in mapping, especially in under-sampled areas. In addition we acquired 1:250,000 Digital Elevation Models (DEMs) of the area to supplement digital line graphs (DLGs) we had acquired earlier from the Texas Dept. of Transportation.

Field Sessions -- Summary of Activities

Three field sessions were conducted during the peak of the summer growing season beginning with a week-long reconnaissance trip from July 9-15, followed by two extended sampling expeditions from August 17 through October 30. A total of 58 days were spent in the field, not including travel to and from Albuquerque. The following is a breakdown of the major activities by number of days and the percentages of total field time these represent:

- *Travel to different field sites within the MDCPA; organization; establishing base camps* 8 days=13.7%
- *Establishing contact/gaining permission to sample* 5.5 days=9.4%
- *On-site breaks* 4 days=6.8%
- *Sampling* 41 days=70%

Specifics of these activities are outlined below along with a description of our GPS and bird listing work. Appendix 1 is a day-by-day log of our activities.

Travel to different field sites within the MDCPA; organization; establishing base camps

We made five major moves during the sampling sessions in the MDCPA. These entailed packing up and moving all equipment and belongings, and establishing new base camps at sites closer to the sampling targets. We initially set up a base camp at Canon

Moreno in the high country of the Maderas del Carmen. From there we were able to directly sample most of the forested and woodland country at the higher elevations. We then moved the camp to Pilares, a private ranch at the base of the mountains on the west side. To do work on the east side, we moved first to the Guadalupe ranch and then to the Morelos ejido. A final camp was established at El Jardin, a ranch at the northern end of the MDCPA. We also did a backpacking trip to El Club, a remote drainage centrally located on the east side. Accommodations varied from tents to ranch houses to cinderblock outbuildings on ranches.

Establishing contact/gaining on-the ground permission to sample

It was necessary to establish contact with authorities on ejidos (collective ranch holdings) and owners of private ranches for permission to sample. This was a complex problem as the protected area is composed of 26 properties: 6 ejidos, and 17 private ranches (Figure 2). The problem is made more complex by the sensitive political climate involving the interactions between private landowners, ejidos and the Mexican government. For the most part, however, landowners and ejido authorities were gracious and welcoming, especially if they felt they would benefit from our research. Much of this goodwill stems from the Crider's previous presence in the area and the relationships they had established with landowners of adjacent properties (e.g. on Rancho El Rincon within the Sierranias del Burro to the east).

The Crider's initially put us in touch with Alberto Garza and Mauricio Brittingham, owners of the Maderas del Carmen ranch, where we did our first month's sampling. Our primary local contact on the west side was Ricardo Ramirez, the ranch manager at Maderas del Carmen and owner of the Pilares Ranch. Ramirez contacted the owners of San Ysidro, Guadalupe and El Jardin ranches for us. However, this was a lengthy process, since there are no telephones in the MDCPA area. For example, Ramirez initiated contact with the owner of El Jardin ranch at the beginning of October, but permission was not acquired until four weeks later, near the end of our field season.

On the east side, ranchhands at Rancho Guadalupe introduced us to "Yolanda", an authority at Ejido Morelos. She was not only able to authorize us to sample in Morelos, but also mediated contact with the owners of Ranchos Piedra Blanca and El Potrero and authorities of Ejido Venustiano Carranza. Otherwise, we made our own contacts by knocking on doors and introducing ourselves. This was done at Rancho Santo Domingo, Rancho la Florida and Ejidos Alamo and Torrecillas.

As our presence became better known in the area, we were more confident about asking permission as we went along, thus minimizing time on this activity by combining it with sampling days towards the end. We would also divide effort between teams - one team would go get permission in a particular area while the other would sample.

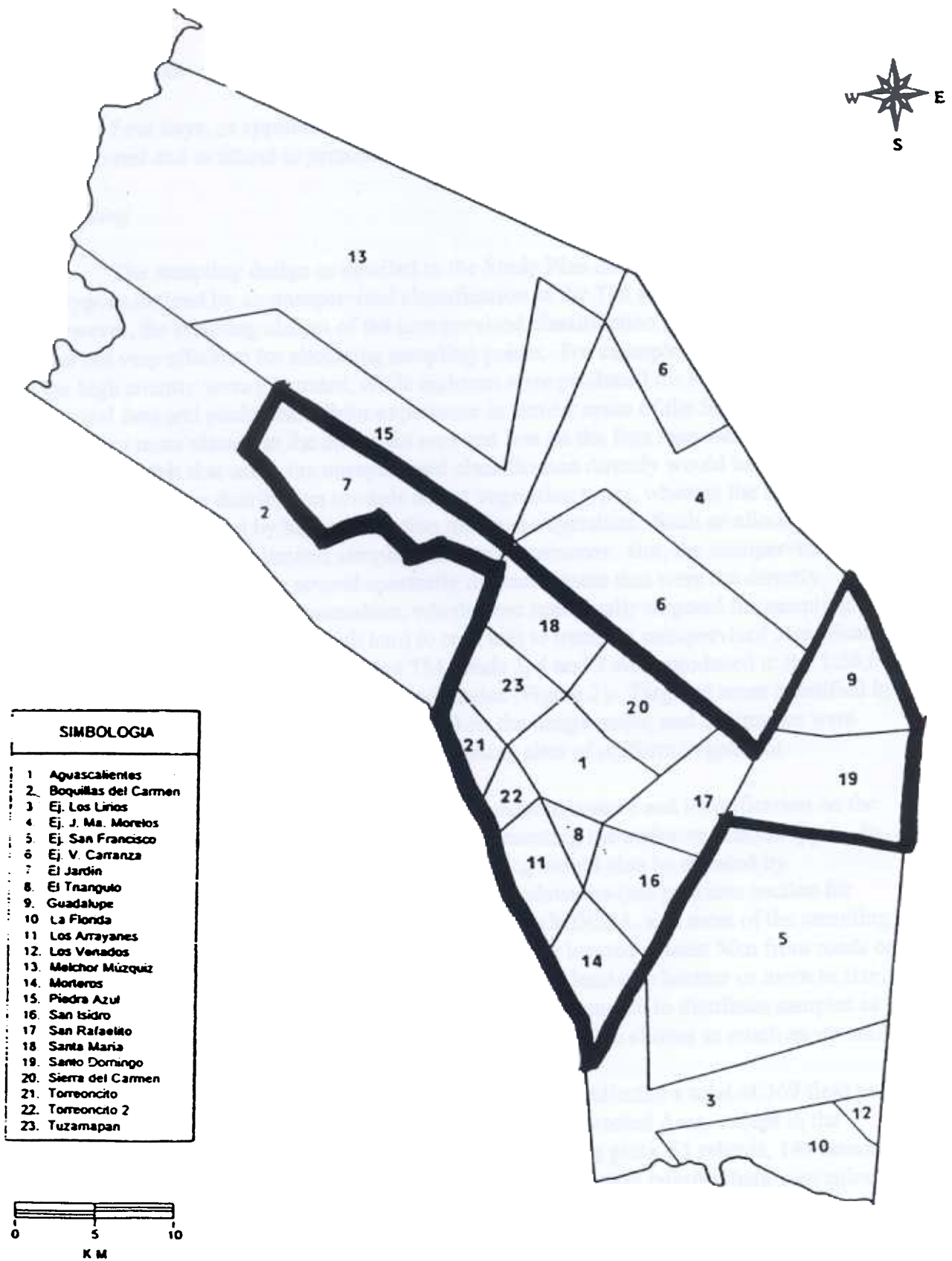


Figure 2: Land ownership in the Maderas del Carmen Protected Area

On-Site Breaks

Four days, or approximately one day for each 14 days of work, were taken in the field to rest and to attend to personal matters.

Sampling

The sampling design as detailed in the Study Plan called for sampling within the polygons defined by an unsupervised classification of the TM satellite imagery. However, the resulting classes of the unsupervised classification proved to be complex and not very effective for allocating sampling points. For example, only three classes in the high country were generated, while eighteen were produced for lower elevation alluvial fans and piedmonts. Prior experience in similar areas of the Southwest has led us to expect more classes in the mountain area and less on the fans than were produced. Hence, we felt that using the unsupervised classification directly would have led to a skewed sampling distribution towards desert vegetation types, whereas the majority of the area is dominated by higher-elevation montane vegetation. Such an allocation would be unacceptable given limited sampling time and resources. But, the unsupervised classification did identify several spectrally distinct classes that were not directly interpretable and possibly anomalous, which were specifically targeted for sampling. Rather than go into the field with hard to read and to interpret unsupervised classification maps, raw satellite image maps using TM bands 2, 4 and 7 were produced at the 1:50,000 scale corresponding to the Mexican quadrangles (Figure 2). Targeted areas identified by unsupervised classification were delineated on the image maps, and the images were directly interpreted to identify potential sampling sites of uniform vegetation.

Final plot selection was based on field reconnaissance and identification on the ground of large, intact stands of vegetation representing the major vegetation types. In the field, it quickly became clear that our sampling would also be dictated by accessibility, both in terms of permission from landowners (see previous section for details) and topography. There are few roads in the MDCPA, and most of the sampling was achieved by hiking. Additionally, most plots are located at least 50m from roads or trails, and within homogenous plant associations of at least one hectare or more in size. In keeping with our proposed sampling strategy, we attempted to distribute samples as widely as possible and at the same time replicate vegetation classes as much as we could

Following this optimized sampling strategy we collected a total of 369 field points that are widely distributed over most of the MDCPA Protected Area, except in the northern quarter (Figure 1). These include 13 monitoring plots, 55 relevés, 144 standard plots and 157 fast plots plus additional photo and observation points where vegetation was directly mapped on topographic quadrangles and image maps.

Plot types differ primarily with respect to the amount of quantitative data collected as follows:

- 1) Monitoring plots involved the most intensive sampling. These are designed to be re-measured and include a complete plant species list along with high resolution plant cover estimates and detailed site characterization. Within each plot, two parallel 20m transects were established and monumented with rebar at each end and identified with aluminum tag. Vegetation was estimated along the transects using 50X20cm quadrat frames (Daubenmire frames) at one-meter intervals along the lines. These plots also served to calibrate visual estimates of species cover for relevé sampling described below. This type of sampling is extremely time-consuming and was limited to sites of high biological interest and with the highest likelihood of being revisited. Most were located on the Maderas del Carmen ranch where we had permission to install stakes and where there is the highest likelihood of returning to re-read the plots. We did two plots in each of the forest types mixed conifer, mesa pine forest, oak forest, pinon-juniper woodland and one plot each in oak woodland, montane shrubland, desert foothill shrubland and mesa grassland. Additionally, two plots were done in old-growth forest stands.
- 2) Relevés are similar to monitoring plots in that complete species lists are compiled for the stand and detailed site information is taken, but transects are not established and they are not monumented. Cover is visually estimated for all species on a 400-square-meter circular plot. Relevés were done throughout the field season in all vegetation types.
- 3) Standard plots are the same size and shape as relevés, but with reduced species lists. Cover estimates are made of the most abundant plant species only; low cover or occasional forbs are commonly ignored. Site characterization is fairly complete, but not as detailed as in the monitoring plots.
- 4) Fast plots are observations of the dominant flora and striking environmental characteristics along with a GPS point and usually a photo. Most of these were taken in areas where a standard plot in a similar area had already been done - in other words, they were a quick way to replicate a plant association.

Photo points were often taken in conjunction with a standard or fast plot. These were panoramic views taken of surrounding, but distant, and potentially inaccessible landscape (although some areas in photos were later visited). Observers would determine vegetation using binoculars, describe the photos taken and delineate the plant associations on the topographic or TM image map. These photo points will serve as an indispensable mapping tool in areas which we could not access.

Global Positioning (GPS) in the Field

A significant GPS problem was encountered in the first month of sampling where satellite signals were very difficult to pickup with our receivers. Normally, this takes only a few minutes, but within the rough topography of the Sierra del Carmen, average time was about 45 minutes, and occasionally it took as long as two hours. This problem

slowed our sampling speed during the first month, but was alleviated at lower elevations during the second month of sampling. At lower elevations, changes in topography may eliminate physical barriers, or there is some other anomaly on the mountain top that prevents satellites being readily located.

Bird Checklist

A bird checklist list was compiled opportunistically during the course of the field season. Glenn Harper and Juan Medel-Anorve have extensive experience in field identification of wildlife and observed sixty-two bird species and five bear sightings. Although not a requirement of the cooperative agreement, this checklist will be processed as part of the assessment work

Post-Field Work and Preliminary Results

Data Entry and Processing

We are entering field data into a PC-based Microsoft Access platform, and submitting the data to standard NMNHP quality control protocols (error checking computer routines and direct repetitive checks of the data). All GPS points have been differentially corrected using base station data from the Texas Department of Transportation. Photographs are being processed and annotated. We collected about 450 plant specimens (this number includes duplicates) and are pre-processing them for herbarium work. We plan to identify the more familiar plant specimens and then enlist the help Dr. Jesus Valdez at UAAN in Saltillo for more difficult specimens. Additionally, Dr. Richard Spellenberg, an oak expert at New Mexico State University in Las Cruces, has agreed to assist with oak identification in exchange for duplicate specimens.

Map Development

We have begun the mapping process by developing a preliminary legend of target vegetation map units. Based on our experience in the field with the image maps and our previous work in these types of landscapes, we have identified fifteen preliminary map units (Table 1). They are described below, along with approximate elevational limits and the number of points sampled within each (n). We are planning to assign each plot to a plant association and determine which associations belong within each map unit. The vegetation classification will necessarily be more detailed than the map units, but will help clarify ecological characteristics and relationships between the map units.

Table 1. Preliminary map units for the Maderas del Carmen Vegetation Map (Mexican Section)

Forests

Mixed Conifer Forest: 7200-8900' Densely forested high elevation or cool slopes, generally with a combination of white fir, Douglas fir, Arizona cypress, southwestern white pine and Arizona pine. n=32

Mesa Pine Forest: 5700-8900' Forested areas on gentle to flat slopes. Canopies are open to dense and are generally dominated by Arizona pine or southwestern white pine with scattered silverleaf and Grave's Oak. A dense grassy understory of Arizona fescue, poverty danthonia and Pringle's spear grass is common. n=29

Oak Forest: 5600-8200' Forests found within montane drainages or along mesic slopes. Generally, Graves's, silverleaf or chinkapin oaks form the dense canopy. Ground surfaces are dominated by scattered piñon ricegrass and deciduous accumulation. n=20

Woodlands

Pinyon Pine-Juniper Woodland: 4500-7500' Coniferous woodlands characterized by both alligator juniper savannahs-found locally on Mesa Guadalupe, and open or closed canopies of Mexican piñon, juniper and oaks with understories of bull muhly and little bluestem. n=31

Oak Woodland (Encinal): 4500-7900' Evergreen oak stands typically dominated by Arizona or grey oak. Canopies vary from open savannahs to closed-canopied woodlands. Bull muhly, sideoats grama and little bluestem are generally found in the well established grassy understory. n=42

Montane Shrubland

Oak-Mountain Mahogany-Manzanita: 4800-7800' Mixed, low-growing and typically dense shrublands of mostly oak, mountain mahogany, manzanita, evergreen sumac and Eve's needle. Stands of chaparral scrub are commonly found on exposed ridges or flats where fire frequency may help to maintain shrub diversity. Conifers may be present although they are generally very scattered. n=24

Grasslands

Mesa Grassland: 4300-6400' A dense prairie-like grassland found on expansive flats or within swales of mesa platforms. The grasslands may be highly heterogeneous but are generally dominated by blue or hairy grama, finestem needlegrass or tobosagrass. n=16

Sotol-Yucca Grassland: 3800-6500' Foothill or upper bajada grasslands that have a strong Chihuahuan shrub component which is generally dominated by sotol or yucca. The grass layer is typically dominated by sideoats grama, chino grass, tanglehead or black grama. These grasses are commonly scattered, although, luxuriant growth is common in undisturbed areas. n=42

Honey Mesquite Grassland: 3300-4900' Basin bottom or alluvial flat grassland with a honey mesquite component. Luxuriant understories of tobosagrass and black or blue grama occur in undisturbed or low impact areas. Disturbance alters the grassland structure and these grasses become very scattered or grow in clumps which intermix with large bare soil patches. These areas are generally dominated by invasive grasses such as sixweeks grama, sixweeks threeawn and feather fingergrass. n=13

Table 1. Continued.

Desert Shrublands

Creosotebush-Whitethorn Acacia Shrubland: 2900-4600' Foothill or bajada shrubland dominated by creosotebush or whitethorn. Creosotebush is generally limited to gravelly bajadas or alluvial flats where it occurs with mariola or whitethorn. In contrast, whitethorn may occur on both bajadas and along foothill slopes where it commonly grows alongside lechuguilla and grama grasses. n=36

Mimosa-Honey Mesquite-Beebrush Shrubland: 3800-6400' Foothill or bajada shrubland dominated by mimosa, honey mesquite and beebrush. The bajadas and alluvial flats are predominated by honey mesquite but the other species such as tarbush and wolfberry are generally present. Mimosa and beebrush typically intermix on foothill slopes but also grade in with honey mesquite on the bajadas. n=23

Desert Foothill Shrubland: 2900-5200' Low-growing and diverse desert succulent and mesic foothill shrublands predominantly found on limestone footslopes and upper bajadas. The succulent shrublands are dominated by lechuguilla, candelilla, and leatherstem. The mesic shrublands are characterized by an open distribution of slimleaf vauquelinia and desert ash but may contain a high diversity of succulents. Grasses include sideoats grama, which is distributed between shrubs and is in contrast to chino grama, which is found growing within shrub canopies. n=14

Miscellaneous

Semi-riparian Thicket: Mixed-shrub thickets found around bodies of water or along arroyos of lowland areas. It is characterized by dense stands of honey mesquite, netleaf hackberry, littleleaf sumac, beebrush and Texas persimmon. n=1

Rock Outcrops or Talus: Non-vegetated rock outcrops and unstable talus occurring on the steep slopes of the Maderas del Carmen. n=1

Barren or Disturbance: This represents bare soil and development including roadside disturbance, homesteads and other extensive development.

We will develop the final map using a supervised image classification based on the ground data we have collected and the provisional legend as the target. The use of a supervised classification strategy over an unsupervised goes beyond we had originally proposed in the study plan. But based our preliminary image analysis, we think that a supervised classification, although more intensive, will be more effective.

How effective the classification will be is spatially contingent on the distribution of sampling points. The more widely and evenly spread the points the better. There is a decidedly unequal distribution of points in the study area, primarily as a result of the logistic complexity of access described above. The majority of points fall within the Torrecillas and Venustiano Carranza quadrangles: 194 and 110 points respectively (Figures 1 & 3). In contrast, Sierra Encantada and Boquillas del Carmen have six points each, Cuatro Palmas has only two points, and the La Linda and Jaboncillos have none.

This spatial sampling disparity has differing effects on the mapping process. A relatively small amount of the MDC Protected Area actually occurs within the Sierra la Encantada and Jaboncillos quads, and the majority of vegetation in these areas is relatively homogeneous desert grassland and shrubland. As a result, the low sampling density may be adequate. The area covered by the Torrecillas and Venustiano Carranza quads, in contrast, contains the majority of the Protected Area, with the widest range of vegetation types and the most spectral diversity, stretching from the highest elevation coniferous forests to low elevation desert shrublands. We believe our sampling will be adequate for most vegetation types in these quads.

The Boquillas del Carmen, Cuatro Palmas, and La Linda quads are definitely under-sampled. We were only able to gain access to upland areas in Boquillas quad (El Jardin) during the last week of sampling before the frost, and we did not reach the lowlands nor the other quads. The region covered by these quads is of moderate spectral and vegetation diversity, and as a result will require further sampling to map adequately. These quads can be mapped by extrapolation from the limited samples we have, and points from adjacent areas and derived from aerial photo interpretation, but the maps should be considered provisional at this time, and subject to potentially extensive revision when new data becomes available.

Discussion

Project Context

Our current project is the result of an evolution of an idea that had its beginning over a decade ago as a vision to do comparative surveys between Big Bend and neighboring areas in Mexico that would aid coordinated trans-boundary management. The “General Plan of Study for Vegetational and Geological Survey of Big Bend National Park and Coahuila” developed cooperatively with BRD (Lafayette), Big Bend NP, Texas Bureau of Economic Geology and the Cooperative Fish and Wildlife Unit at

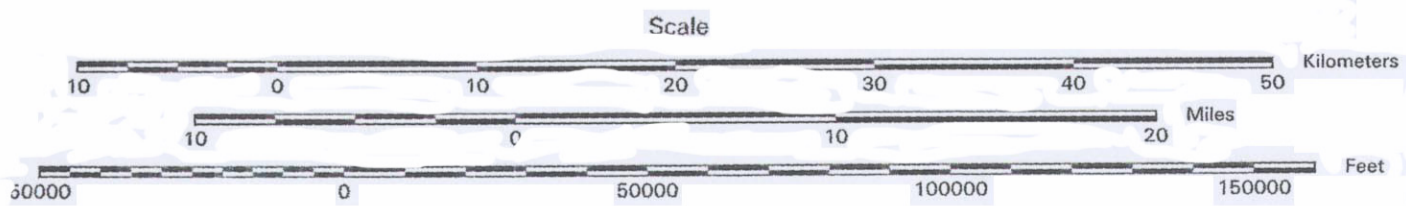
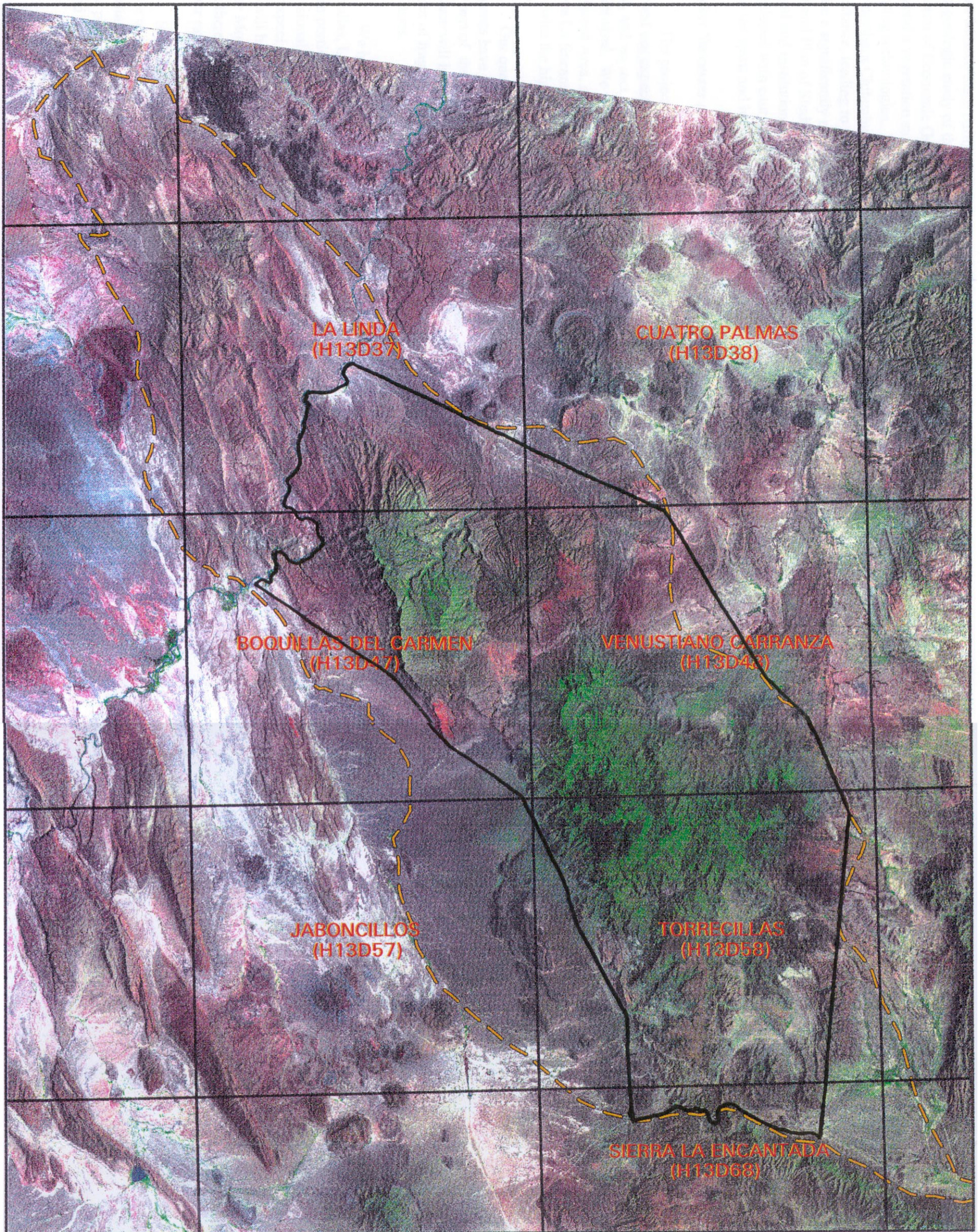


Figure 3 - 1:50,000 scale Mexican quadrangles overlain on the Sierra del Carmen Vegetation Map study area (yellow dashed lines) and Protected Area boundary (solid black line).

New Mexico State outlined the general goals which included, among others, a plant study and geologic study of the Sierra del Carmen. The geologic study was completed by the Bureau of Economic Geology in 1995. The concept of the plant study was expanded beyond a vegetation survey to include a vegetation map developed by using remote sensing technologies. Because of our extensive remote sensing and biological work in the northern Chihuahuan Desert, the original cooperators looked to NMNHP for assistance, leading to this Cooperative Agreement. But along with the expanded scope came a significantly reduced budget than had been originally projected (66% of the General Plan of Study estimated cost)! Regardless of the funding constraints and the social and institutional unknowns in doing an international project of this scale, we developed with cautious optimism the current Study Plan, one that we feel is in keeping with the spirit and intent of the original vision and general study plan.

Project Successes and Limitations to Date

The project as a whole, and the field season in particular, has been successful beyond our expectations. Overall, few problems were encountered in gaining access to land, and we met or exceeded our goals with regard to the number and type of plots established. We were able to sample extensively in the heart of the Maderas del Carmen Protected Area, and we feel that we can map the Torrecillas, Venustiano Carranza and Sierra La Encantada quadrangles with a high degree of confidence. This represents the area with the highest diversity and direct biological interests in the study area.

Our quantitative data, reconnaissance and conversations with experts and local residents have provided us with ample material for a preliminary ecological assessment of this part of the Maderas del Carmen Protected Area. Besides this data, the map we produce will be used to analyze landscape structure and ecological questions such as what degree of fragmentation has occurred in the study area, and what are the effects of various land uses.

We have very limited sampling in the northernmost end of the MDCPA on the Boquillas, La Linda and Cuatro Palmas Quads, the majority of which constitutes the El Jardin portion of the Sierra del Carmen. Any mapping of these quads would be provisional, based primarily on extrapolation from the other more heavily sampled areas. We expect that because of the lower elevation and lower landscape heterogeneity, this area will have lower overall biological diversity. But the area is very similar to the Dead Horse Mountains, the northern extension of the Sierra del Carmen on the adjacent US side, therefore, it may be very important for trans-boundary comparisons, and require further exploration.

Similarly, given the logistical and financial constraints of the project, we were unable to sample in the Big Bend National Park this season. To map the Dead Horse Mountains had been one of the original goals of the project. But it became clear early on in the planning stages that this might not be possible, and the NPS, BRD and NMNHP agreed that the sampling in Mexico should take precedence over that in the US. But,

knowing what we now know about the Sierra del Carmen in Mexico should make any future sampling in Big Bend easier to plan and execute. In particular it has become clear that not only the sedimentary Dead Horse Mountains need to be mapped, but also the volcanic Chisos Mountains should be considered because of their similarity to the volcanic Maderas del Carmen in the heart of the Protected Area.

Another outcome of the project is the establishment of the first network of monitoring sites for vegetation at higher elevations in the heart of the protected area. More sites need to be established, particularly at lower elevations. The MDCPA staff is also establishing monitoring sites and future work should be coordinated with them. It would also be ideal to expand the scope of the monitoring to include faunal elements, particularly birds. Birds, along with large mammals in this area, are of keen interest because of their regional differential abundance and migratory patterns that speak directly to issues of trans-boundary biological management.

One of the less tangible, but important outgrowths of the project is the establishment of relationships with Sierra del Carmen stakeholders such as landowners, on ejidos and private ranches, and with government and university interests (particularly student projects). We plan to continue building on these relationships with visits to Saltillo to meet with MDCPA managers and UAAN faculty to expand our collaboration there. We also plan to make the data from this project available to any who have a scientific/management interest in the area, particularly participating landowners. We are continuing our relationship with UANL at Linares by sponsoring a Mexican student at UNM to participate in the analysis phase of the project and to develop his own senior thesis project. We cannot emphasize enough the amount of energy that went into developing these relationships, and a momentum has been established that should facilitate future work and cooperation.

Projections for Project Completion and Future Work: the Optimal Strategy

Our current course action is to follow the study plan and produce a vegetation map and ecological assessment of the MDCPA as specified. Based on the results of the field season, the emphasis will be put on Venustiano Carranza, Torrecillas and Jaboncillos Mexican quadrangles that cover the majority of the Protected Area, with provisional mapping of Boquillas, La Linda and Cuatro Palmas quadrangles to the north. Products will include the map in digital and paper form, a detailed report with complete data addenda and associated databases, and the delivery of voucher specimens to Mexican and US universities. We believe this will satisfy the most important immediate goals of the project, namely providing the first detailed vegetation map of the Protected Area and a preliminary ecological assessment that will serve as first step in our understanding the Protected Area in a regional context.

Appendix 1: Daily Log of Activities

This appendix is a table detailing field activities day by day. The table is organized into columns. 'Date', 'Activity', 'Where?' and 'Persons Contacted' fields are self-explanatory. The 'Plots Completed/Type' column shows the number of plots done by plot number and the initials following the slash refer to the plot type. An 'M' stands for a monitoring plot; an 'S' stands for a standard or relevé plot; and an 'FP' indicates a fast plot or observation point. The 'Notes' contains remarks on interesting and unusual occurrences or expands and clarifies information contained in the other three columns.

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Date	Activity	Where/When?	Persons Contacted	Plots Completed/Type	Notes
9-Jul-97	Travel	Esteban Muldavin, Sarah Wood and Glenn Harper go from Albuquerque to Del Rio (approx 11 hrs)	Diana & Cody Crider, Dave Hewitt, Tim Fulbright in Del Rio		
10-Jul-97	Travel	Del Rio to main camp in Sierra del Carmens via Musquiz	Hugo, Jonas (students picked up in Musquiz)		Main camp, set up by Criders, is on Garza's land in Canon Moreno. Six hours from Musquiz to camp; bear demolished Diana and Cody's tent
11-Jul-97	Sampling/Plant Collecting	Canon Moreno		97SW001/S	Lots of rain, Carmen whitetail deer around camp.
12-Jul-97	Sampling/Plant Collecting	Mesa Bonita	Maurice Brittingham, Alberto Garza, landowners of Maderas del Carmen, arrive at main camp.		Mesa Bonita north of main camp. Lots of rain
13-Jul-97	Travel/Plant Collecting	From main camp to Los Cojos (abandoned mine) about halfway down escarpment			Camp at Los Cojos; very windy. Discussion of plant communities along road; lots of plant collecting
14-Jul-97	Travel	From Los Cojos to Alpine via Musquiz			
15-Jul-97	Travel/Contact	Visit Sol Ross herbarium; travel from Alpine to Albuquerque	Michael Powell curator of herbarium at Sol Ross, Billy Turner		Powell agrees to help ID in exchange for specimens; Turner IDs a few composites
17-Aug-97	Travel/Prep	Sarah Wood and Glenn Harper depart Albuquerque. 2pm, arrive Del Rio 3am			Two 4WD vehicles taken; SW and GH each drive one

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Date	Activity	Where/When?	Persons Contacted	Plots Completed/Type	Notes
18-Aug-97	Travel	Depart Del Rio 8am, arrive Main Camp 9pm	Juan Medel picked up in Musquiz		JM working on finishing his bachelors' at Linares; will use data gathered on this trip to do a separate, related study that will complete his requirements
19-Aug-97	Organization	Main camp	Cody Crider, field tech at El Cinco Base Camp		CC working on habitat of Mexican black bears for his masters' project. Vegetation mapping and plant community identification is part of this project
20-Aug-97	Sampling	Mesa Bonita	Pepe, Ramon, Ambrosia and Mario - ranchhands familiar w/ area	97GC001-004/S	Teams were SW and CC, GH and JM. CC and JM trained by SW and GH. (GH's plots labelled GC to avoid confusion with an earlier project this year)
21-Aug-97	Sampling and Travel	Main camp to El Uno		97GC005/S, 1FP 97SW003/S	El Uno is an old homestead east down Canon Moreno; GH and JM drive, going above Canon Moreno, taking supplies; SW and CC do substantial plant collecting, Ramon accompanies us as a guide.
22-Aug-97	Sampling	El Uno		97GC006-009/S, 4 FP 97SW004-007/S, 1 FP	Sampling on peaks and ridges N and E of El Uno. Very rugged country; difficult hiking.
23-Aug-97	Attempted sampling	El Secadero Peak, La Laguna		1 FP	Secadero Peak and La Laguna NE of El Uno. Rained out at peak before it is possible to do any sampling.
24-Aug-97	Sampling	El Secadero Peak, La Laguna		97GC010-012/S; 5 FP 97SW008-010/S; 3 FP	
25-Aug-97	Sampling and Travel	El Uno to main camp		97GC013/S; 1 FP 97SW011/M, SW012/S	Delineation of vegetation occurrences on map and taking photos between El Cinco and El Uno; lots of roadside plant collection.

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	Activity	Where/When?	Persons Contacted	Plots Completed/Type	
26-Aug-97	Sampling	Top of northwest escarpment; area near base camp		97GC014-016/S; 3FP 97SW013-14/S; 2FP	GH and JM discover old growth Arizona pine stand in canyon near camp
27-Aug-97	Sampling	Diablo Canyon area	Diana Crider returns to camp with Rachel Ratcliff, a graduate student who is studying the patrilineal genetics of the Mexican black bear.	97GC017-021/S 2 FP 97SW015/M 4 FP	Diablo Canyon is north of main camp off Mesa Bonita. Dropoffs and cliff faces obstruct passage along ridgeline to El Centinel; masses of ladybugs going into diapause on ridges.
28-Aug-97	Organization; logistics; half day off		Ricardo Ramirez, ranch manager		Some plant ID and map transcription. We ask Ricardo to get permission from Guadalupe and El Jardin ranch owners to sample on their land. RR also tells us which areas we can go to with no or minimal advance contact with owners.
29-Aug-97	Sampling	West escarpment; El Cinco		97GC022-025/S; 2 FP 97SW016-17/S; 1FP	El Cinco is an old logging camp SE of main camp.
30-Aug-97	Sampling	El Cinco; Gobbler Canyon		97GC026-029/S; 3 FP 97SW018-020/S; 2 FP	Gobbler Canyon is SE of El Cinco
31-Aug-97	Day off				
-Sep-97	Sampling	Mesa Bonita, El Cinco, Main Camp		97GC030-31; 1 FP 97SW021-022/M	
2-Sep-97	Sampling	El Cinco; El Cuatro		97GC032-34/S; 6FP 97SW023/M; 1FP	El Cuatro is on mesa east of main camp.

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Date	Activity	Where/When?	Persons Contacted	Plots Completed/Type	Notes
3-Sep-97	Sampling	El Cinco; Mesa NE of El Cinco (Manzanita Mesa)		97GC035-036/S; 6FP 97SW024/M; 1FP	
4-Sep-97	Day off, SW sick				
5-Sep-97	Sampling	El Cinco; Gobbler Canyon		97GC037-039/S; 2FP 97SW025/M	
6-Sep-97	Sampling	Main Camp; Gobbler Canyon; El Cinco		97GC040-043/S; 4FP 97SW026-027/M	
7-Sep-97	Day off/some sampling	El Cinco		97SW027/M	SW finished this plot
8-Sep-97	Sampling	El Cinco; Mesa Bonita		97GC045/S; 4FP 97SW028/M	Also set up 97SW029 which CC read later
9-Sep-97	Prep; Travel (backpacking)	From Main Camp down canyon in Diablo Canyon area			Hiked down extremely dangerous, rugged, bouldery, brushy canyon ephemeral riparian area; bear sign galore; camped on a flat in above drainage; bear in camp at night; .
0-Sep-97	Sampling/Travel (backpacking)	From first campsite down canyon to just west of El Club		97GC046/S; 4FP 97SW030-32; 3FP	El Club is NE of Diablo Canyon. CC talks to son of Don Juan who is the goat farmer at El Club and has a reputation for shooting folks. However, his son is welcoming.

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Date	Activity	Where/When?	Persons Contacted	Plots Completed/Type	Notes
11-Sep-97	Travel (backpacking)	Depart from El Club 10pm, arrive after dark at Mesa Bonita 9 pm.		GC-1FP	Arduous struggle to get to top - arrive around 9pm after about 11 hours of hiking; 6 in rain. Torrential rains at main camp previous day.
12-Sep-97	Pack/Travel	Depart main camp at 4 pm, arrive at Pilares at 9 pm.	Chavita and son - cowboys at Pilares; feed us dinner		Pilares is a ranch managed (and owned) by Ricardo Ramirez, who has agreed to let us use the ranch as a base camp for the next month's sampling.
13-Sep-97	Travel	Depart Pilares 6am; arrive Albuquerque 12am.			
14 Sep to 22 Sep	Break				
23-Sep-97	Prep	Albuquerque			Buy food and supplies for a month's worth of work.
24-Sep-97	Travel	Depart Albuquerque 9am; arrive at Del Rio 8pm.			
25-Sep-97	Travel	Del Rio to Acuna and back to motel.	Carlos Garcia Arellano, customs administrator; Mexican consulate worker		Stayed in Del Rio another night because we couldn't get through Federal Police check station south of Acuna with GPS unit. They wanted to be sure we were not taking it to sell in Mexico. Demanded we return to get permission from customs administrator. Problem at border resolved with a letter faxed from Dr. Alfonso Martinez stating he was collaborating with us on the project (this letter at the suggestion of the consulate); customs officials concur with many official-looking stamps.
26-Sep-97	Travel	Del Rio to Pilares (A. 6pm)			

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Date	Activity	Where/When?	Persons Contacted	Plots Completed/Type	Notes
27-Sep-97	Organization	Pilares			CC in Truth or Consequences until October 5. We are given a small room to set up camp in. Ricardo Ramirez has procured permission for us to sample on two ranches east of Pilares (Vista Hermosa and San Ysidro) owned by Don Isiderio.
28-Sep-97	Sampling	Rancho San Ysidro; east of Pilares	Two cowboys: Juan and another, employees of Don Isiderio	97GC047-0049/S; 1FP 97SW033/M, SW034/S	In CC absence, GH works alone, SW works with JM. Cowboys tell us that Don Isiderio is fickle and that although we may have permission, this may change.
29-Sep-97	Sampling	Vista Hermosa		97GC050-054/S; 2FP 97SW0035-038/S; 4FP	
30-Sep-97	Sampling	Fresno Mesa	Gerardo Gonzales, goatherder at San Ysidro Ranch up the canyon, who gives us permission to camp overnight	97GC055-056/S; 1FP 97SW039-040/S	Big prairie-like grassland on mesa but with disturbance increases. Northern part of mesa not grazed because of lack of water.
1-Oct-97	Sampling	Rancho San Ysidro; abandoned mine up canyon	Gerardo Gonzales	97GC057-058/S; 2FP 97SW041-043/S; 1FP	Saw smooth green snake (?) on ridge near abandoned mine; camped overnight in San Ysidro Canyon
2-Oct-97	Sampling	Fresnos Mesa	Gerardo Gonzales	97GC059-061/S; 5FP; 97SW044-045/M	Cannot get onto southern portion of mesa without securing permission from Ejido Los Lirios, but GH maps from a distance.
3-Oct-97	Day off				Watched the ranchhands break horses.
4-Oct-97	Sampling	Vista Hermosa Ranch		97GC062-063/S, 1FP	SW, GH and JM work together but rained out by early afternoon. Witness lightning strike ignite a sotol and burn for some time.

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Date	Activity	Where/When?	Persons Contacted	Plots Completed/Type	Notes
5-Oct-97	Sampling	San Ysidro Canyon, Vista Hermosa Ranch		97GC064-069/S, 2FP 97SW046-050/S, 3FP	Road up east leg of San Ysidro Canyon impassable - SW and JM hike it. CC returns in evening; goes up to mountain (Moreno Canyon) to get things
6-Oct-97	Sampling/Logistics	GH/JM sample @ Las Vacas and Los Frijoles; SW to Musquiz	Ranchers at Las Vacas and Los Frijoles ; Dona Ana in Musquiz (has phone)	97GC070-073/S, 2FP	SW to Musquiz for supplies and contact with Este about end of field season; stays overnight.
7-Oct-97	Logistics	Packed to head out to Rancho Guadalupe			SW back from Musquiz; CC returns to Pilares, half day off
8-Oct-97	Sampling	Canons Morteros and Morrano	Hernando Flores, caretaker of small ranchette up Cyn. Murrano; another caretaker near end of canyon.	97GC074-078/S, 2FP 97SW051-054/S, 1FP	CC back, works with SW. Trip to Rancho Guadalupe postponed because permission not yet granted.
9-Oct-97	Sampling	Los Cojos, Sierra Encantada, Florida Ranch	Chango (nickname) at Florida Ranch and ranchhands.	97GC079-0082/S 3FP 97SW055-058/S, 4FP	Permission to go to Guadalupe tomorrow granted (via Ricardo Ramirez)
10-Oct-97	Travel	To Guadalupe Ranch in one truck (accommodations, situation unknown)	Don Juan, owner of Guadalupe Ranch	Photo point, map vegetation occurrences along road using imagery.	Don Juan agrees to let us stay at his ranchhouse and ranchhands (Gustavo and wife) find a place for us to stay at Ejido Morelos later. Relative security of area lead to decision to get other vehicle to improve sampling efficiency.
11-Oct-97	Organization/Travel/Sampling	Sarah back to Pilares w/ Diana to pick up Bronco	Yolanda, Benjamin (Ejido Morelos), Gustavo and wife Rosa (Rancho Guadalupe)	97GC083-84/S, 1FP	Gustavo is ranchhand at Guadalupe; Yolanda knows many ranchers and ejiditarios in area and asks for permission for us to sample on their land; Benjamin is owner of house in E. Morelos and ranchhand at Piedra Blanca.
12-Oct-97	Sampling	Rancho Guadalupe (El Conejo, along eastern foothills of Mesa Guadalupe)		97GC085-87, 4FP 97SW060-065, 4FP	Unseasonably hot.

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	Activity	Where/When?	Persons Contacted	Plots Completed/Type	
13-Oct-97	Sampling	Mesa Guadalupe		97GC088-0091/S, 4FP 97SW066-069/S, 3FP	2 hour hike to summit of mesa; lack of water precludes grazing here.
14-Oct-97	Sampling/Logistics	GH and CC to Rancho Santo Domingo for permission to sample; SW and JM sample on Guad. Ranch	Sam and Jackie, caretakers of Rancho Santo Domingo	97SW070-074/S	
15-Oct-97	Reconnaissance trip	Ejidos Morelos and Venustiano Carranza	Jimmy Scuddy, Ralph Powell, Thomas Barksdale		No one at V. Carranza to give us permission to sample. The three men are Texas ranchers familiar with area (TB grew up on El Jardin)
16-Oct-97	Sampling	Mesa Candelaria, Piedra Blanca	Benjamin, ranchowner of Piedra Blanca	97GC092-095/S, 1FP 97SW075-078/S, 3FP	Piedra Blanca is a ranch NW of Guadalupe Ranch; Benjamin gives us permission to stay at his house in Morelos
17-Oct-97	Sampling	Cuatro Palmas, El Portrero	Alejandro Falcones, owner El Portrero	97GC096-098/S, 2FP 97SW079-082, 1FP	El Portrero is in a broad valley SW of Piedra Blanca; Alejandro invites us on to the main site of his ranch
18-Oct-97	Sampling	El Portrero	Alejandro and ranchhands	97GC099-100/S, 7FP 97SW083-085/S, 5FP	Alejandro shows us around El Portrero which he bought 18 months ago; feeds us dinner
19-Oct-97	Recon trip/Logistics	To La Linda	Military at La Linda	mapped along road	Walked across border at La Linda; phoned Este on U.S. side of La Linda to arrange for trip at end of week; Mexican military south of La Linda thoroughly searched us coming and going. Packed to move to Morelos.
20-Oct-97	Sampling/Travel/Organization	Moved to Morelos; sampled on lower bajadas near there.	Yolanda	97SW086-088/S	GH and JM half day off

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21-Oct-97	Sampling/ Logistics	Rancho Santo Domingo	Sam and Jackie	GH maps a canyon (Pasta de las Yuegas) 9SW089-090, 5FP	Sam guides GH and CC around ranch where they demonstrate the type of sampling that will be taking place.
22-Oct-97	Travel/ Logistics	To Musquiz/Pilares	Alejandro Falcones and his father.		Sarah to Pilares to collect rest of belongings; Glenn and Juan to Musquiz to get food and gasoline (100 gallons)
23-Oct-97	Reconnaissance trip	El Jardin Ranch	Ranchhands at "Ann's House of Nuts" ranch, who open a gate for us; Marcoantonio and ranchhands at El Jardin	2FP	Traveled out to barrancas at north end of El Jardin - little time for sampling, but permission granted to return, sample and camp overnight
24-Oct-97	Sampling	Ejidos & roads S. of Santo Domingo - El Alamo, Torrecillas		97GC101-103/S, 2FP 97SW091-093/S, 2FP	CC retires from field work; spent night at Santo Domingo
25-Oct-97	Sampling/ Logistics	SW & JM to La Linda ; GH to El Jardin		97GC104-106/S, 3FP	Picked up Este (EM) in La Linda; travel to El Jardin; GH samples alone in El Jardin
26-Oct-97	Sampling	El Jardin	Marcoantonio and ranchhand Alberto	97GC107-109/S, 4 FP 97SW094-097/S, 1FP	SW works with EM, GH w/ JM. El Jardin has been through many owners; present owner Italian consul who has owned it for only 6 months.
27-Oct-97	Sampling	El Jardin		97GC110-114/S, 1FP 97SW098-101/S, 2FP	SW works w/ JM, GH w/ EM.
28-Oct-97	Travel	Albuquerque via La Linda, Alpine via Musquiz	EM meets w/ protected area and Big Bend park personnel on US side and in Boquillas		GH and EM cross at La Linda; GH to Albuquerque; SW to Musquiz, drops off JM at bus station, arrives Alpine 5pm

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Date	Activity	Where/When	Persons Contacted	Lots Completed/Type	Notes
9-Oct-97		SW and EM arrive Albuquerque (driving separately)			