Monitoring Long-Term Vegetation Dynamics in Big Bend National Park

Ecological Survey of the Big Bend Area

Monitoring Report

2007-2008

NATURAL HERITAGE NEW MEXICO

Museum of Southwestern Biology

The University of New Mexico

2010

NATIONAL PARK SERVICE

Monitoring Long-Term Vegetation Dynamics in Big Bend National Park
Ecological Survey of the Big Bend Area Monitoring Report
2007-2008 [1]

Esteban Muldavin[2], Steven Wondzell,[3] John A. Ludwig[4], and Yvonne Chauvin[2]

2010

Introduction

Long-term records of aridland ecosystems dynamics are rare, but they are critical to our understanding of the potential for recovery of these ecosystems from past desertification processes (as driven by climate, geomorphic processes, and human use), and how they might respond to various management practices in the future. One issue is that little is known about the interactions between biotic and abiotic factors that control dominance by either woody species or grasses over the long term.

In Big Bend National Park, 74 permanent vegetation transects were established between 1955 and 1956 in desert grasslands, shrublands, and woodlands as part of the Ecological Survey of the Big Bend Area (ESBBA)[5] conducted by Barton Warnock and others. These transects, referred to here as the ESBBA Transects, include charts of individual plants, cover estimates by species on a square-foot basis, and repeat photography at the transect stakes. The transects have since been re-read five time in various ways by only two crews: the original crew lead by Warnock (1955-56, 1961, 1967) and that of the authors in 1981 (by Wondzell & Ludwig), 1996 and most recently in 2007-08 (by Wondzell, Ludwig, and Muldavin). Hence, they offer a high-quality, consistent, long-term record of grass, shrub and tree dynamics that can be used to track individual plants to assess demographic changes in plant populations or to assess changes in community structure through time. These types of legacy data sets are of critical importance to the NPS's Chihuahuan Desert Network Inventory & Monitoring Program (CHDN I&M). Additionally, Landscape Dynamics and Soil/Vegetation are two monitoring protocols that are being developed by the CHDN with a focus on desert grassland/shrubland interface and the dynamics involved with these two vegetation types.

We report here the results of our 2007 and 2008 field campaigns to re-read the transects, and our compilation of the full record of the dataset from 1955 to the present in a digital form for long-term archiving.

---

[1] This report is submitted in fulfillment of National Park Service Cooperative Agreement No. H1200040002, Task Agreement No. J2124070041/UNM-05.a 1994 research grant from the Big Bend Natural History Association entitled "Forty years of vegetation change in desert grasslands of Big Bend National Park"
[2] Current address: Natural Heritage New Mexico Division, Museum of Southwestern Biology, Biology Department, University of New Mexico, Albuquerque, NM 87131
[3] Current address: USDA Forest Service Northwest Forest and Range Experiment Station, Olympia Washington.
[4] Current address: Commonwealth Scientific and Industrial Research Organization (CSIRO), Wildlife and Ecology, Mail Bag 44, Winnellie, Darwin, North Territory 0822 Australia
[5] Ecological Survey of Big Bend Area 1957, unpublished report, Big Bend National Park.

Acknowledgements

The National Park Service Chihuahuan Desert Network provided financial support for this project through the Colorado Plateau Cooperative Ecosystem Studies Unit. Additional support was provided by the USDA Forest Service's Pacific Northwest Research Station, and the Natural Heritage New Mexico Division of the Museum of Southwestern Biology, University of New Mexico. We also wish to thank the following staff and volunteers: Dominique Bachelet, Rosalind Blanche, Shannon Cleason, Charlie Jackson, Eric Lindahl, Elizabeth Milford, Teri Neville, Missy Powell, Pat Ward, and Mathew Wilder. Guidance and support were also provided by Joe Sirotnik and Raymond Skiles at Big Bend National Park.

Study Area

There are 74 ESBBA transects located within Big Bend National Park (BIBE) in west Texas (Figure 1). They are distributed from the top of the Chisos Mountains at about 7,200 ft (2,200 m) northward to Tornillo Flats some 20 miles (30 km) and down in elevation to about 2,800 ft (850 m). Of these, 51 were established in groups of three among 17 "Desert Grassland" (Figure 2). An additional set of six transects was established at Tornillo Flats itself (one has never been relocated). Most of the sites were in desert grasslands dominated by *Bouteloua breviseta* (chino grama), or *B. eriopoda* (black grama) with an assortment of xeromorphic shrubs such as *Agave lechuguilla* (lechuguilla), *Parthenium incanum* (mariola), *Larrea tridentata* (creosotebush), *Dasylirion* spp. (sotol) and *Jefea brevifolia* (shortleaf jefea). A few sites were clearly dominated by *Larrea* or *Flourensia cernua* (tarbush) and lack significant grass cover.

The remaining 17 transects were established among woodlands in the foothills up to higher elevations in the Chisos Mountains. There are two sites of three transects each in the open woodlands of the Green Gulch area in the foothills leading up to the Basin, and there are eleven single-transect sites in the woodlands and forests of the "High" Chisos. These sites are dominated by a wide variety of pygmy and tall conifers such as *Pinus cembroides* (Mexican piñon), *Juniperus deppeana* (alligator juniper), *Cupressus arizonica* (Arizona cypress), and *Pinus ponderosa* (ponderosa pine) with understories that are distinctly Madrean montane in character (e.g., grasses such as *Piptochaetium fimbriatum* (pinyon ricegrass), and *Muhlenbergia emersleyi* (bull muhly)).

Wondzell and Ludwig (1983;1995) and Wondzell (1984) have provided detailed accounts of the history and landscape of the study area. Briefly, of the 17 desert study sites, 16 occurred on soils derived from Cenozoic igneous rhyolite formed in the surrounding mountains. Nine sites were placed on the Chilicotal gravelly loam soil series derived from Holocene alluvium parent material. These soils dominate the broad piedmont slopes at the base of the Chisos Mountains and elsewhere. Two sites were located on Canutillo gravelly/sandy loams associated with recent alluvial terraces imbedded in the piedmont. Only one site was established on Tornillo clay loam soils, which are restricted to valley bottom alluvial flats. Four sites occurred on Lajitas very cobbly loams that are derived from fractured rhyolite on colluvial hill slopes rather than alluvium. Lastly, only one site was established on Solis soils derived from

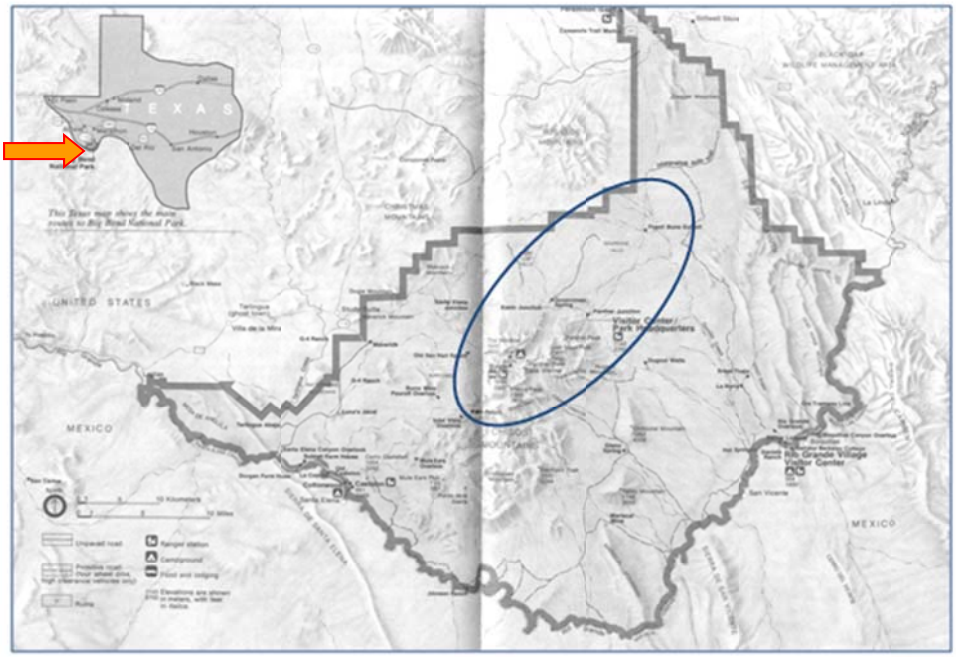


Figure 1. Study area within Big Bend National Park in the Trans-Pecos region of Texas. Ellipse represents the approximate area encompassing the ESBBA study transects considered here.

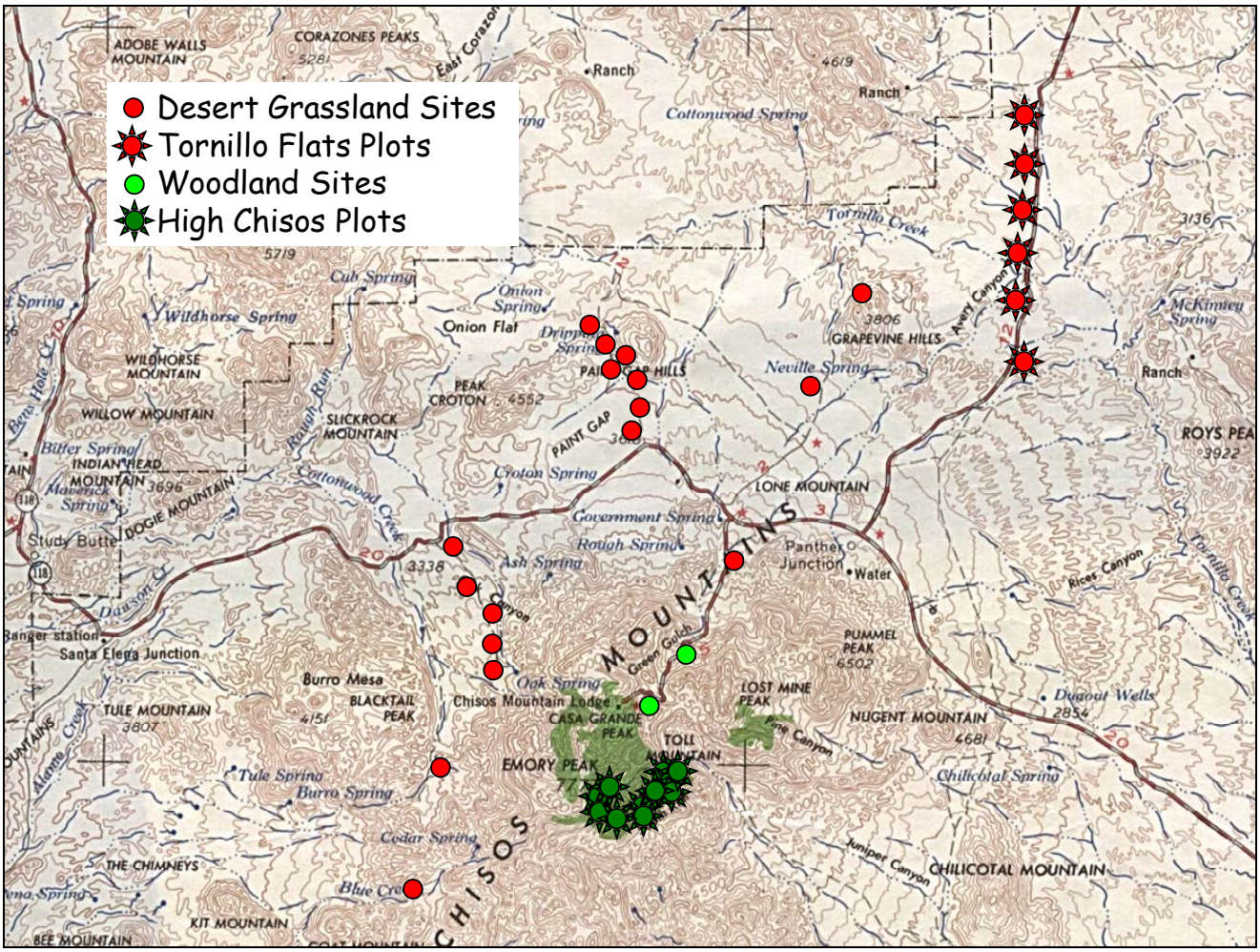


Figure 2. Location of the ESBBA sites in Big Bend National Park organized by sampling groups. See text for description of transects within each group.

sandstone, which, along with other sedimentary rocks, are uncommon in the immediate study area. The woodland sites occur on upland colluvial, often on steep slopes with soils derived from the underlying rhylolitic volcanic rocks.

Precipitation measured at Panther Junction (approximately 5 km from the desert study sites) over the duration of the 50-year sampling period averaged 330 mm/year, with 80% coming in the summer rainy season (May through September). Departures from seasonal mean precipitation over the course of the sampling period are shown in Figure 3 (pre-1956 data was calculated by Wondzell and Ludwig (1983) from the Chisos Mountain station). The mean annual temperature is 19°C (66.2°F), but seasonal temperature flux can be extreme, reflecting an essentially continental climate. July is the hottest month with the monthly maximum averaging 35°C (95°F). In contrast, the January monthly maximum averages 15°C (59°F) dipping to a mean monthly minimum of 1°C (34°F).

Livestock grazing was the primary land use prior to park establishment in 1944. By the 1880s there were between 10,000 and 15,000 head of cattle and horses that were using the open range. This increased to 30,000 head by the mid 1930s, half of which were sheep and goats. At the time of park establishment, 40,000 head were removed from within the park boundaries. The rangeland at that time was considered severely overgrazed and damaged. Yet immediately after the removal of livestock there was anecdotal evidence of the beginnings of recovery of desert grasslands (see Wondzell and Ludwig 1983).

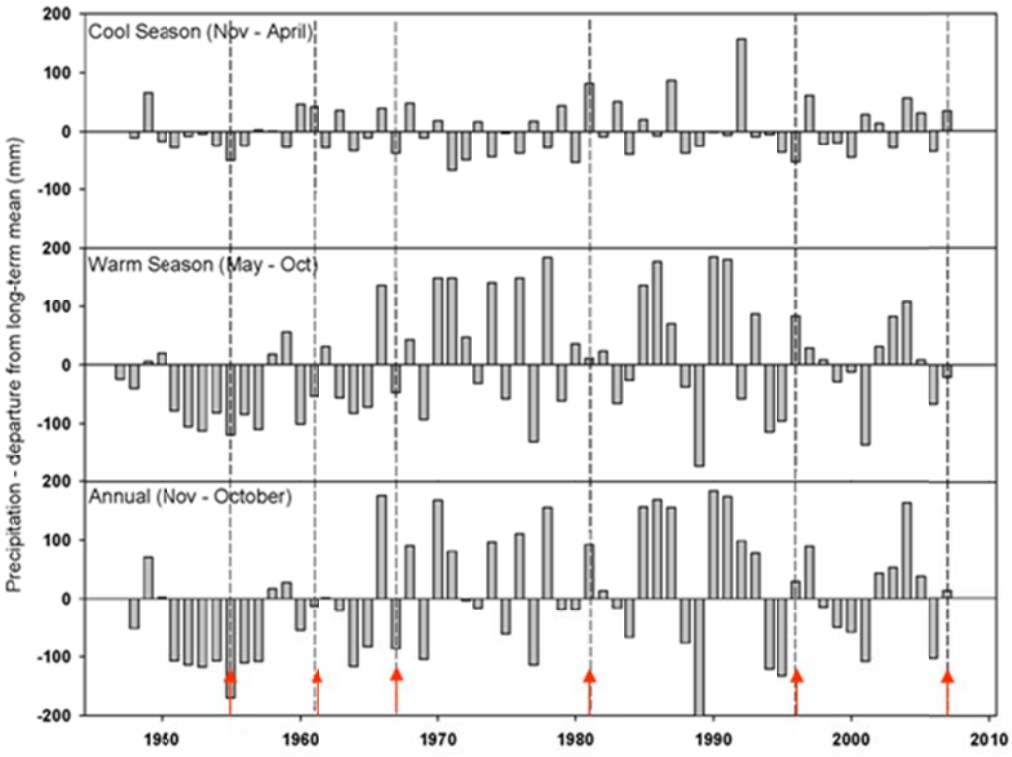


Figure 3. Annual and seasonal pattern of precipitation at at Panther Junnction, Big Bend National Park over the course of the various ESBBA samplings (red arrows).

Methods

Desert grassland Measurements

The desert grassland transects come in two groups. The first is set from 51 belt transects and shrub plots grouped in trios among 17 sites representing the Desert Grasslands (Figure 2). These are further partitioned among five soil series (Table 1). The belt transects were read in 1955-56, 1961, 1967 (only one transect of the three in 1967), 1996, and 2007. Each transect is 6.10 m (20 ft) long and 0.31 m (1 ft) wide and gridded into 20 contiguous 0.31 m- (1 ft) square quadrats (Figure 4). The three transects at each site were set parallel to one another ca. 12 m apart and monumented at each end with steel rebar near ground level, along with identification tags at the zero ends (embossed with G. & F. Comm. of Texas Seine License numbers). In 1996 and 2007, the location of each rebar was surveyed with a global positioning system (GPS) to the nearest 5 m (16 ft).

The two stakes mark the centerline of the belt transects with 0.15 m (6 in) to each side. To measure the belt transects, a cloth tape, preferably marked in tenths of feet, is tightly stretched between the two stakes as close to ground level as possible (Figure 5). The tape must be carefully passed through any obstructing vegetation so as to neither damage the vegetation nor let the vegetation displace the tape. Then a 0.31 m by 0.31 m (1 ft by 1 ft) sampling frame is placed at each 0.31 m (1 ft) mark and centered on the tape and each plant identified and charted at a scale of 1:12 (Figure 6). Only canopy cover within the quadrats was charted in the first three readings from 1955 to 1967. In 1981, Wondzell and Ludwig (1983) added basal area of each individual and extended the drawings approximately 0.5 m to each side to provide better spatial context, especially for shrubs. In addition, they made on-site estimations of percent canopy cover for each species in each quadrat. Wondzell (1984) provided detailed instructions and guidelines for drawing and canopy estimations. Wondzell (1984) recharted the transects from each sampling period side by side, which has allowed effective quantitative comparison of spatial pattern changes through time. In 1996, we followed the protocols established in 1983 by taking the copies of the 1983 charts into the field and charting the 1996 quadrats side by side with the 1983 data (Figure 7). In 2007-08, the 1981-1996 charts were available, but the actual charting was done on extended, single sheets of graph paper (8.5 by 22 in). Voucher specimens for unknown or questionable species were collected from the transects for later identification (these have been archived at the University of New Mexico Herbarium).

20-foot radius circular shrub plots were also established over the zero-end stake (Figure 4). On these plots, all shrubs canopies were charted in the field in 1955 & 1968. The original sampling methods proved overly laborious as vegetation density and cover increased leading to significant modifications in the sampling methods over time. Starting in 1981, the plot size was reduced to 10-foot radius circular plot but shrubs were still charted by hand. Then in 2007, rather than chart the shrubs, the center locations of the shrubs to the nearest decimeter were measured from the zero-post along with an azimuth (from the center-post to the shrub). A 10-ft PVC pole marked in decimeters and with a right angle 3-ft leg that fit over the rebar post was used to measure the distances (Figure 5). The pole was swung in an arc around the plot with care taken to minimize entrance into the plot when measuring individual shrubs. The maximum diameter of the each shrub was measured along with diameter at right angles to the first.

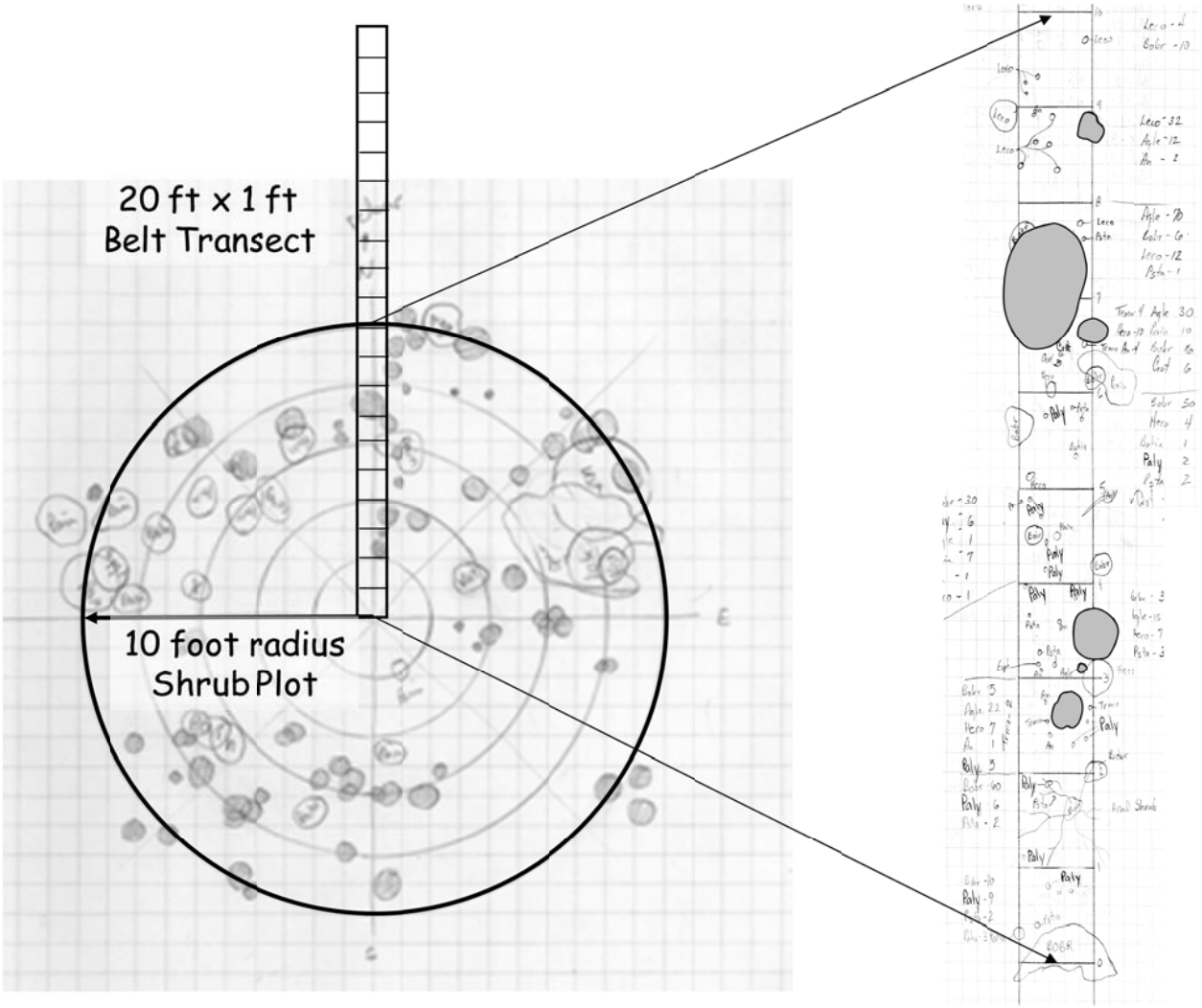


Figure 4. Layout of ESSBA belt transects and shrub plots as measured in 2007 and 2008. There is a tagged rebar at the zero-end of the belt transect that also serves as the center point for the shrub plot (the original shrub plot radius was 20 feet). The first 10 feet of the belt transect chart is shown along with an example of a 1981 charting of shrubs in a circular plot.

Table 1. ESBBA transects organized by sampling group, soil series, and site with locations in UTM northing and easting (NAD83, Zone 13). DG = Desert Grassland group; TF = Tornillo Flats; HC = High Chisos, and FH = Foothill woodlands.

Group	Soil	Site	Transect	Datum	Zone	Northing	Easting
DG	CHILICOTAL	1	11012	NAD83	13	660661	3240616
DG	CHILICOTAL	1	11013	NAD83	13	660639	3240624
DG	CHILICOTAL	1	11014	NAD83	13	660615	3240614
DG	CHILICOTAL	2	11015	NAD83	13	660552	3241157
DG	CHILICOTAL	2	11016	NAD83	13	660544	3241187
DG	CHILICOTAL	2	11017	NAD83	13	660549	3241203
DG	CHILICOTAL	3	11018	NAD83	13	660214	3242295
DG	CHILICOTAL	3	11019	NAD83	13	660223	3242252
DG	CHILICOTAL	3	11020	NAD83	13	660222	3242332
DG	CHILICOTAL	4	11021	NAD83	13	659531	3243896
DG	CHILICOTAL	4	11022	NAD83	13	659498	3243960
DG	CHILICOTAL	4	11023	NAD83	13	659469	3243990
DG	SOLIS	5	11024	NAD83	13	658500	3244960
DG	SOLIS	5	11025	NAD83	13	658513	3244977
DG	SOLIS	5	11026	NAD83	13	658520	3244999
DG	CHILICOTAL	6	11027	NAD83	13	665905	3249330
DG	CHILICOTAL	6	11028	NAD83	13	665918	3249351
DG	CHILICOTAL	6	11029	NAD83	13	665906	3249383
DG	LAJITAS	7	11030	NAD83	13	664655	3252436
DG	LAJITAS	7	11031	NAD83	13	664652	3252459
DG	LAJITAS	7	11032	NAD83	13	664656	3252476
DG	TORNILLO	8	11033	NAD83	13	664551	3252362
DG	TORNILLO	8	11034	NAD83	13	664538	3252380
DG	TORNILLO	8	11035	NAD83	13	664546	3252392
DG	CHILICOTAL	9	11036	NAD83	13	664904	3251934
DG	CHILICOTAL	9	11037	NAD83	13	664906	3251952
DG	CHILICOTAL	9	11038	NAD83	13	664914	3251975
DG	CHILICOTAL	10	11039	NAD83	13	665763	3250109
DG	CHILICOTAL	10	11040	NAD83	13	665764	3250137
DG	CHILICOTAL	10	11041	NAD83	13	665761	3250165
DG	LAJITAS	11	11042	NAD83	13	664183	3253446
DG	LAJITAS	11	11043	NAD83	13	664177	3253469
DG	LAJITAS	11	11044	NAD83	13	664163	3253500
DG	LAJITAS	12	11045	NAD83	13	664544	3252793
DG	LAJITAS	12	11046	NAD83	13	664561	3252806
DG	LAJITAS	12	11047	NAD83	13	664573	3252820
DG	CANUTILLO	13	11048	NAD83	13	658786	3232906
DG	CANUTILLO	13	11049	NAD83	13	658805	3232913
DG	CANUTILLO	13	11050	NAD83	13	658836	3232925
DG	CANUTILLO	14	11051	NAD83	13	657734	3234367
DG	CANUTILLO	14	11052	NAD83	13	657733	3234395

Group	Soil	Site	Transect	Datum	Zone	Northing	Easting
DG	CANUTILLO	14	11053	NAD83	13	657714	3234448
DG	CHILICOTAL	15	11063	NAD83	13	669092	3245352
DG	CHILICOTAL	15	11064	NAD83	13	669099	3245366
DG	CHILICOTAL	15	11065	NAD83	13	669122	3245358
DG	CHILICOTAL	16	11066	NAD83	13	672552	3250760
DG	CHILICOTAL	16	11067	NAD83	13	672540	3250760
DG	CHILICOTAL	16	11068	NAD83	13	672512	3250778
DG	LAJITAS	17	11069	NAD83	13	673738	3254685
DG	LAJITAS	17	11070	NAD83	13	673775	3254646
DG	LAJITAS	17	11071	NAD83	13	673799	3254627
TF	TORNILLO	18	11101				
TF	TORNILLO	18	11102				
TF	TORNILLO	18	11104				
TF	TORNILLO	18	11105				
TF	TORNILLO	18	11106				
HC	Upland	21	11001	NAD83	13	665759	3236263
HC	Upland	22	11002	NAD83	13	665692	3236370
HC	Upland	23	11003	NAD83	13	665671	3236393
HC	Upland	24	11004	NAD83	13	665885	3235310
HC	Upland	25	11005	NAD83	13	666278	3235452
HC	Upland	26	11006	NAD83	13	665484	3234535
HC	Upland	27	11007	NAD83	13	665446	3234623
HC	Upland	28	11008	NAD83	13	665316	3234205
HC	Upland	29	11009	NAD83	13	664977	3234263
HC	Upland	30	11010	NAD83	13	663834	3236386
HC	Upland	31	11011	NAD83	13	663925	3236240
FH	Upland	19	11057	NAD83	13	666845	3239508
FH	Upland	19	11058	NAD83	13	666836	3239498
FH	Upland	19	11059	NAD83	13	666821	3239497
FH	Upland	20	11060	NAD83	13	667356	3241131
FH	Upland	20	11061	NAD83	13	667386	3241107
FH	Upland	20	11062	NAD83	13	667401	3241107

Figure 5. Measurement setup for ESBBA belt transects and shrub plots.

Figure 6. For vegetation charting, a one-foot frame is centered over the transect at each one-foot interval along the tape. Individual plant canopy and stem basal areas are charted on gridded graph paper where a square inch represents a square foot. In addition, the total percent cover of each species by quadrat is estimated visually.

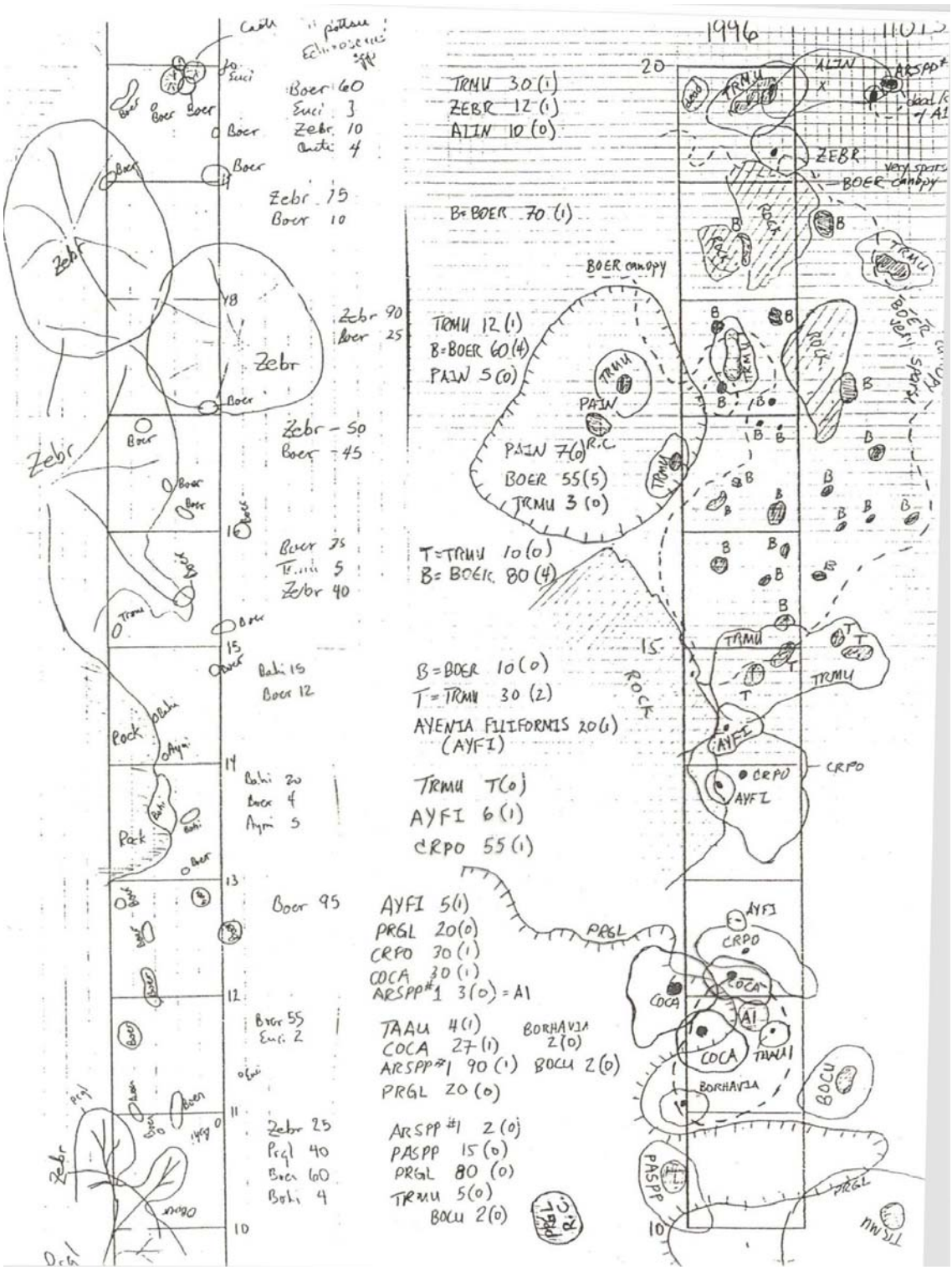


Figure 7. An example of a transect chart from 1996. The 1981 chart was placed on the left for comparison during the 1996 charting process on the right.

These measurements were later converted to circular canopy areas. Because of its abundance, the succulent subshrub, *Agave lechuguilla*, was not measured in the shrub plots, but rather we relied on the more precise measurement from the transect charts for this species.

A second group of six transects was established at Tornillo Flats, and because of the sparseness of vegetation, these were measured differently. Only five of the six transects were relocated in 2007 (Transect 11103 remains to be found and may have been destroyed by road changes). The belt transects were expanded to 10 feet wide by 200 feet long. All shrubs, grass, and forbs cover was charted on 10 ft by 10 ft-scale gridsquares. These had not been re-read since 1967. In 2007, we modified the procedure in a similar way to that of the shrub plots on the Desert Grassland transects. That is, we used the graduated 10-ft PVC pole and held it at right angles to a measurement tape stretched between the zero and 200-ft end point. As we walked up the line, when a shrub intersected the PVC pole, the distance out to the center of the shrub was measured from the line, and the maximum and right-angle diameters of the shrub measured to be later converted to circular-canopy areas. Forbs and grasses were vary sparse, and rather than measuring individual locations, counts of individuals were madei on each 10 x 10-ft grid cell. In 2007, we added standard 1 ft by 20 ft belt transects for comparison to the other sites.

Woodland measurements

Among the woodlands and forests, there two groups of sites. There are two sites in lower foothills of the Chisos Mountains in Green Gulch that are arranged like the Desert Grassland sites with three transects per site (Woodlands sites 19 and 20 in Table 2). These have been read on the same rotation as the latter (1955, 1961, 1967, 1996, and 2008) and using the same methods. Circular stem maps were also located around the zero-end rebar and read in 1955 and in 1968. These circular plots were treated identically to the desert grassland plots, with all tree and shrubs canopies charted in the field. The documentation of the methods for the circular plots is confusing, however. The 1957 report states that the circular plots are 10-feet in radius, not 20 feet as stated in the 1968 report (Unpublished Final Report, Ecological Survey of the Big Bend Area, Part III, Appendix B, pages 2-3, 1957). Comparison of plant locations on the 20-foot belt transects and on the circular plot charts should allow correct determine the sizes of the circular plots.

In addition, there are 11 sites in the High Chisos (sites 21 through 31). A reconnaissance report by Wondzell et al. (2007) is provided in the supplementary materials that provides details on how the sites were relocated and an assessment of their significance. They consist belt transects that were established and read in the same way as those of the Desert Grasslands (but only in 1955 and 2007). Additionally, tree-stem maps were also established at these plots in 1955. The original intent was to use a plane-table to map all trees in a 40-foot semi-circle centered on the zero-end rebar of the belt transect. After completing the first plot (11001) in Boot Canyon, the original investigators realized that the proposed methods would be too time consuming and reduced the plot size to a 30-foot radius semi-circle for plots 11002 through 11011. The location of all woody and succulent species was located in the semi-circular plot using a plane table and measuring tape. Dots were used to mark stem locations and estimates were made of height (and apparently stem diameter) (B. H. Warnock, unpublished report, 1968).

This still proved too tedious so that the methods were again modified for the 1968 re-reading (B. H. Warnock, unpublished report, 1968). Instead of using a plane table, the investigators used a line from an automatic fishing-reel, marked in 5 foot intervals, to determine the size and location of each species after which the approximate canopy outlines of each plant was drawn to scale. Comparison of the 1955 and 1968 stem maps shows a substantial loss in data quality in 1968. Consequently, we decided not to use the 1968 data.

In 2008, tree plots were expanded to provide a better sample of forest composition and structure than is possible from the small plots established in 1955. Thus, we established fully circular a 40 foot radius stem plots over the zero-end stakes. These plots completely overlap the earlier plot outlines so that earlier data can also be analyzed. To sample the plots, the bearing and distance to each tree was measured, using a staff compass and cloth tape, respectively. For tall tree plots, the diameter at breast height (DBH) was measured with a D-tape calibrated in inches. For small-statured trees, the measurement was made at diameter root crown (DRC) and indicated as such. Stems of multi-stemmed trees were measured separately and later summed to compute basal area. The height of each tree was estimated with survey rod or measured with a clinometer and tape. Seedlings and saplings were counted in the first two quadrants of the plot (usually the NW and NE) in three height classes: 2-9 inches, 4-12 inches, and 12-54 inches.

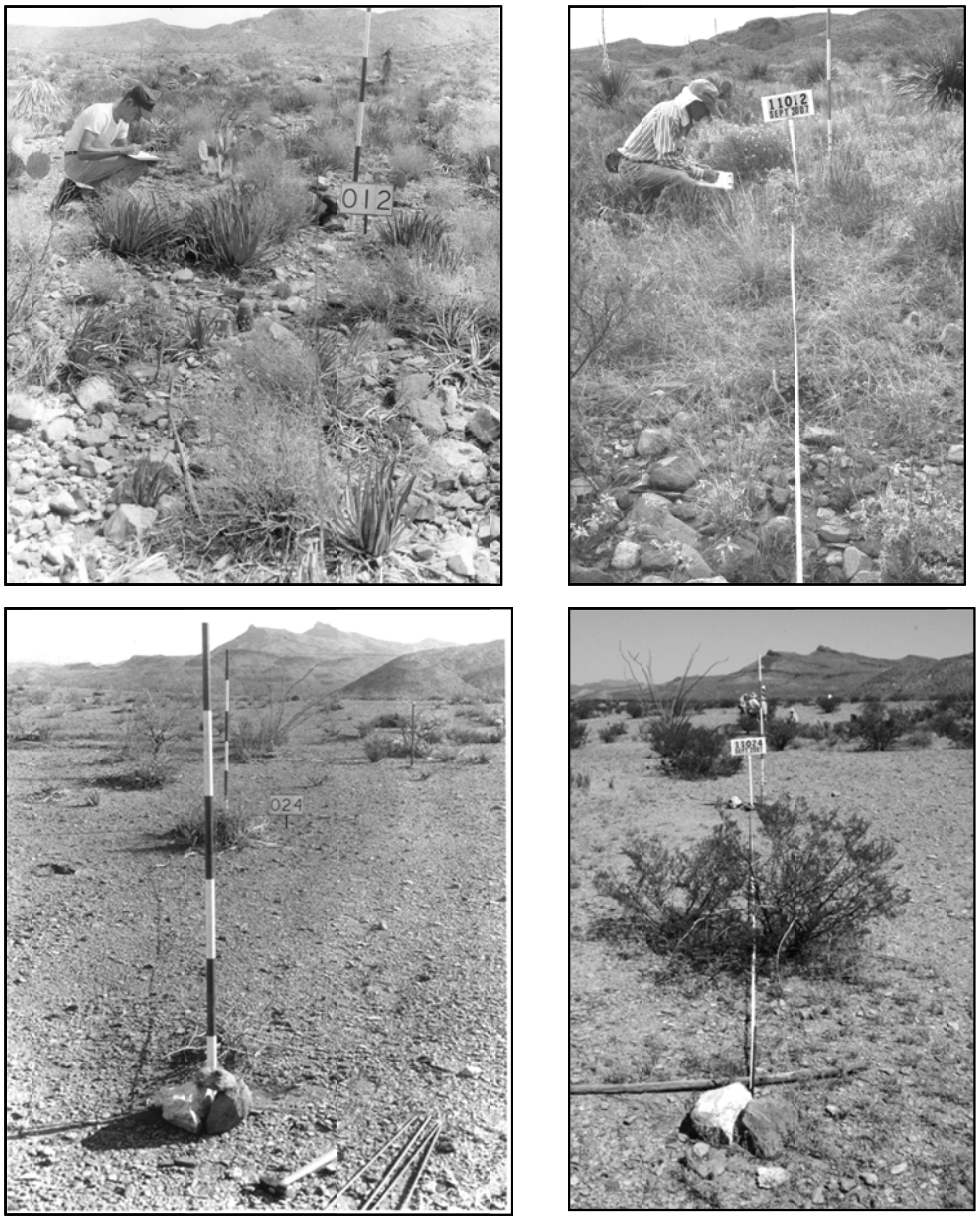
Repeat Photography

Repeat photography was conducted during each sampling period, providing a semi-quantitative visual record of change. At each measurement date, the plots were photographed from the zero-end rebar. The methods state that the camera was held at chest level and the field of view was chosen so that the end-rebar would be centered, both horizontally and vertically, in the photograph (Unpublished Final Report, Ecological Survey of the Big Bend Area, 1957). However, there appears to be great variation in the actual field of view photographed. Further, a variety of large-format cameras were used along with tripods, resulting in substantial differences in both focal length and field of view on each measurement date.

While tripod positions sometimes varied, in general photographs were taken over the zero-end stake with the measurement tape in place and a placard on a pole placed on or near the 20-foot location, and often a range pole was place in the shot (Figure 8). Although formats changed over time, the attempt was made to match the focal length and view as closely as possible from sampling period to sampling period. For the 1981, 1996, and 2008 readings, the photos from all the previous sampling periods were taken into the field to guide the setup of cameras. Starting in 1967, color slides were taken along with black and white prints, and starting 2007-08 digital images were taken (using a Nikon D300 with its slightly reduced format). In addition, wide-angle shots added to expand the view of the transects in 1996 and 2007. In 2007, an additional photopoint was added to each transect by moving the tripod backwards five to ten feet from the zero-end stake so as to capture the zero-end stake in the photo (this was done in a few earlier sequences). Photos from all sampling periods were digitally scanned and archived with files names that identify the transect, year, and format.

There were some differences between sampling periods that need to be taken into consideration. The 1961 sampling was conducted in the dormant season of winter 1960-61. The

transect photography indicates that the canopies of the grasses and shrubs were still intact and that the major impact of the winter season sampling was most likely on the detection of small perennial and annual forbs. In 1967 all transects were re-photographed, but only one transect at a site was recharted Full sampling and photography was conducted during the growing seasons of 1981, 1996, 2007, and 2008.



l955

Figure 8. Examples of repeat photography. Generally the tripod was placed over the zero-end stake, but occasionally the shot was taken from behind the stake. In 2007 and 2008, additional photo points were established behind the stake to explicity include it and the entire transect in the scene.

Results

Outcomes focus on (1) field resampling of permanent vegetation transects and plots, (2) data entry and QA/QC in the development of a long-term archival datasets, and (3) preliminary analysis of data collected to date.

Specific accomplishments were:

1. Remeasurement of 51 belt transects (20 ft x1 ft) located in the Desert Grassland biotype of BIBE including species-level charting and repeat photography.
2. Voucher specimen analysis of vouchers collected in 1981, 1996, and 2007-08, and subsequent correction of species identifications for rare or uncommon species on the belt transects.
3. QA/QC of all belt-transect data with special attention to species identifications and nomenclature to ensure compatibility across sampling dates.
4. Preliminary analyses of desert grassland belt-transect data for trend analysis for a poster presentation.
5. Recopying original charts of 51 matching, circular shrub plots (10-ft radius) measured in 1955 and 1981 into a uniform format.
6. QA/QC of all circular shrub-plot data with special attention to species identifications and nomenclature to ensure compatibility across sampling dates.
7. Resampling the 51 circular shrub plots in BIBE in 2007.
8. Digitizing charts of the circular shrub plots in ArcGIS for the 1955, 1981, and 2007 measurement dates.
9. Relocation of five out of six transects located on Tornillo Flats in 2005 that were last measured 1967.
10. Remeasurement of the five out of six transects located on Tornillo Flats in 2007 that were last measured 1967 including shrub measurements and repeat photography.
11. Relocating historical woodland plots (20-ft belt transects and 30-ft radius half-circular tree-stem maps) in 2007.
12. Resampling historical woodland plots in 2008 including transect charts, repeat photography, and repeat tree measurements.
13. Recopying original tree-stem maps of the 11 woodland plots measured in 1955 into a uniform format.
14. Preliminary analyses of a subset of woodland plots (the four most similar plots) to examine trends in tree recruitment for a poster presentation.
15. Cataloging and creating digital files of all repeat photographs on all transects.
16. Compilation of all transect data into a relational database and associated digital data files.
17. Presentations at Ecological Society of America annual meetings (2008, 2009, and 2010); George Wright Society (2009); National Center for Ecological Analysis and Synthesis (NCEAS) working group on long-term ecological data sets (2007).

The Datasets

We have complied the full ESSBA record into a series of digital files that are in turn organized into a set of hierarchical folders corresponding to major aspects of the project (Table 1). Each file or folder has metadata associated with it to explain the specific content of the files. There are three basic directory folders:

1. Data. Folder containing both the quantitative and qualitative data for the transects organized by grassland and woodland groups. Includes species-level quadrat and plot data, and scans of original and derived charts, along with files on transect locations and classification.

2. Documents. Folder containing reports and presentations by the authors

3. TransectPhotos. Folders of labeled, repeat photography scans and ordinal digital photo files.

All folders were delivered electronically to the NPS Chihuahuan Desert Network office.

Table 2. ESBBA digital archive list of folders and their content.

Directory Folder Level						Description
1	2	3	4	5	6	
Data						
	Grasslands					Desert Grassland and Tornillo Flats data groups
		Belt_Transects				Data associated with 1 x 20 foot belt transects
			Transect_Data			Spreadsheets of belt transect quantitative data for all years
			TransectCharts_1955_81_recharted			Redrawn transect charts from originals by Wondzell (1984) and later photographed and scanned
			TransectCharts_1981_96_YCcorrected			Scans of 1981/1996 charts with corrected species identifications by Y. Chauvin
			TransectCharts_1996			Scans of 1996 charts uncorrected
			TransectCharts_2007			Scans of 2007 charts
				Full _Charts_BW		Black and white scans
				Full_Charts_color		Color scans
				Half_Charts_BW		Black and white 1/2 chart scans
			TransectCharts_Tornillo_1955_2007			Original 1955 transect chart scans
		ShrubPlots				Data associated with circular shrub plots
			ShrubCharts			Charts scans
				GIS_ShrubCharts_1955-2007		Charts generated from GIS esbbaShrubs.gdb
				Shrub chart originals 1955		Scans of original 1955 shrub charts
				Shrub chart originals 1981		Scans of original 1981 shrub charts
			ShrubGIS			Geographic Information System containing geo-referenced shrub plot data from all years

Directory Folder Level						Description
1	2	3	4	5	6	
				geodb		Shrub geodatabase containing spatial layers specified in the metadata file
					esbbaShrubs.gdb	
				metadata		Geodatabase metadata
			ShrubPlotData			
	TransectLocations					Files containing information of transect locations
	Woodlands					Woodland data group
		Belt_Transects				Data associated with 1 x 20 foot belt transects
			Transect_Data			Spreadsheets of belt transect quantitative data for 2008
			TransectChartsWoodland 1955			Scans of original 1955 transect charts
			TransectChartsWoodland_2008			Scans of original 2008 transect charts
Documents						
	Presentations					
	Reports					
TransectPhotos						Repeat photography digital files for all years
	Grassland					Desert Grassland and Tornillo Flats photos
		ESBBA photo scans_1955_96				1955 through 1996 scans of transect photos
		ESBBA_color prints from CD 2007				2007 color prints commercially scanned
			JPGs			
			Tiffs			
		ESBBA_Grassland_2007_dig				2007 direct digital photo files shot with a Nikon D300 with an 18-200 anti-vibration DX lens
			ESBBA_2007_JPGs			
			ESBBA_2007_Tiffs			
	Woodland					Woodland transect repeat photos
		ESBBA_Woodland 2008_Chisos				2008 direct digital photo files shot with a Nikon D300 with an 18-200 anti-vibration DX lens
			JPGs			
			Tiffs			
		ESBBA_woodland_photos_1955_61_67_96				1955 through 1996 scans of transect photos

References

The Ecological Survey of the Big Bend Area. 1957. Report on Work Accomplished in the Initial Survey from January 1, 1955 to August 31, 1957. A Cooperative Research Project for the Texas Game and Fish Commission conducted by the Department of Wildlife Management, Texas Agricultural Experiment Station, a part of the Texas A and M College System. Unpublished report submitted to Big Bend National Park on 28 October, 1957.

Warnock, B. H. undated. Charts, Measurement Data and Examination on Selected A. & M. Circular Plots. 1955 and 1968. Unpublished report submitted to Big Bend National Park.

Wondzell, S.M. 1984. Recovery of desert grasslands in Big Bend National Park following 36 years of protection from grazing by domestic livestock. M.Sc. Thesis. New Mexico State University, Las Cruces, NM.

Wondzell, S.M. and J.A. Ludwig. 1983. Plant succession as influenced by soil-geomorphic process in desert grasslands of semi-arid piedmonts of the U.S.A.-Mexico border. Final report to U.S. Man and the Biosphere Program (MAB) Cooperative Research Grant No. RM-81-189-CR.

Wondzell, S.M. and J.A. Ludwig. 1995. Community dynamics of desert grasslands: influences of climate, landform and soils. Journal of Vegetation Science 6:377-390.

Wondzell, S. S. Claeson, and D. Bachelet. 2007. Report on the 2007 Reconnaissance Expedition to Relocate the Ecological Survey of the Big Bend Area Woodland Plots in the Chisos Mountains, Big Bend National Park, Texas, USA. Report to the National Park Service, Chihuahuan Desert Network. 42p.