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Legacy Data Evaluation Report for Big Bend National Park and Rio Grande National Wild and Scenic River

Natural Resource Report NPS/CHDN/NRR—2011/301

ON THE COVER
Photograph within Big Bend National Park/Rio Grande Wild and Scenic River
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Legacy Data Evaluation Report for Big Bend National Park and Rio Grande National Wild and Scenic River

Natural Resource Report NPS/CHDN/NRR—2011/301

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Executive Summary

The National Park Service-Chihuahuan Desert Network (NPS-CHDN), Big Bend National Park (BIBE), and Rio Grande National Wild and Scenic River (RIGR), with the assistance of the National Vegetation Inventory Program (NVIP) staff, are preparing to conduct vegetation classification plot sampling in support of creating a vegetation map, geodatabase, and final report beginning in September 2010. As part of Study Plan (NPS-BIBE/RIGR 2010) preparation, historic or legacy data were identified for evaluation to determine if existing useful data can be used and save costs by reducing the amount of new data collection.

Discussions with the CHDN data manager, BIBE/RIGR natural resources staff, and employing Internet searches, resulted in identification of 26 potentially useful studies or databases (NPS-BIBE/RIGR 2010). During study plan preparation these studies were divided by potential use into project background and local vegetation type description utility (14 studies), geo-referenced information with a variety of project utility applications, particularly bio-physical unit (BPU) development under a gradient-oriented transect (gradsect) application (7 studies), and studies that would be useful for vegetation classification and to reduce sampling efforts providing project economy (5 studies). Following initial review, some studies were dropped from consideration and other studies were added as they were located; 16 studies and databases were evaluated in detail.

The purpose of Task 1.0: Legacy Data Evaluation for BIBE/RIGR is primarily to evaluate existing (legacy) data for usefulness in the vegetation classification at BIBE/RIGR and secondarily to provide usable legacy data in the project gradsect to reduce time and costs for the labor-intensive field sampling task. Legacy studies and databases generally form two groups, eg., vegetation classification information and plant species lists or digital vegetation map products and geodatabases. In general, the group of legacy studies for BIBE/RIGR and vicinity provide observations of vegetation distribution and condition for more than a century and black-and-white and color images (photographs, slides, and digital images) of the Big Bend region dating from the late 1890s to the present. Extremely useful data were received and analyzed in this study, the most useful information occurred in 10 studies and are summarized in **Table 1**.

Two legacy datasets (Ecological Survey of the Big Bend Area established by Dr. Barton Warnock beginning in 1955 and the invasive plant species location database constructed by Young and others between 2001 to 2007) could be recently enough sampled to contain existing vegetation data and adequately geo-referenced to allow researchers to revisit the sites if necessary for validation. Should the evaluation by NVIP ecologist Chris Lea determine these datasets to be usable for classification plot data then approximately 20 days of field crew time and nearly $20,000 could be saved in terms of overall project cost.

Table 1. Summary Analysis of the Most Significant Vegetation Legacy Datasets to Inform the BIBE/RIGR Vegetation Inventory Project.

Research Date - Author	Utility Cat.	Description	No. of Plots	Discussion	Recommendations	Sample Status
1901 - Bray	III	Five major vegetation formations were observed and described in the early 1900s: (1) Grass [Close, Open Bunch, Salt]; (2) Woody [Xerophytic Forest Formation of the Mountain Slopes of Trans-Pecos Texas and Mesophytic Forest Formations of the Streamways]; (3) Succulent [Agave, Sotol, Yucca, Lechuguilla, Cacti]; (4) Rock [Creosotebush, Mesquite]; and (5) Halophytic [Salt Grass].	0	The information does not describe existing conditions within BIBE/RIGR; the late 19th century / early 20th century landscape photographs are informative.	Use this early ecological paper to describe the historic condition of BIBE/RIGR.	N/A
1985 – Cochran and Rives	III	26 soils mapping units were described and prepared into a coverage map for BIBE/RIGR during the 1970s and 1980s.	0	The information describes existing conditions within BIBE/RIGR in terms of an important vegetation driver. The mid-to-late 20th century landscape photographs are informative.	This valuable account of geology, soils, and existing vegetation would be useful to inform the local vegetation alliance and plant association descriptions and appropriate historical and edaphic summary sections of the final report. The soils map will also provide a relevant coverage in the project geodatabase.	N/A
2008 – Fenstermacher, Powell, Sirotnak, Terry	III	Of the 1,701 plant species known for BIBE/RIGR, 662 species (39%) occur in six vegetation types described for the Dead Horse Mountains. Described in this paper are habitats and vegetation types that support a majority of the plant species, they are: (1) Mixed Desert Scrub; (2) Sotol-Yucca Grassland; (3) Chaparral; (4) Desert Canyon; (5) Rio Grande Riparian Corridor; (6) and Sandy Desert Arroyo.	0	The information allowed partial development of a provisional classification to inform the upcoming vegetation classification and mapping project within BIBE/RIGR.	This valuable botanical account of the Dead Horse Mountains will be useful to inform the historical and existing context of BIBE/RIGR vegetation and will aid in writing local vegetation alliance and plant association descriptions. The entire plant species list will be useful to botanists sampling field data for this project by informing taxonomic decisions during field work.	N/A

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Research Date - Author	Utility Cat.	Description	No. of Plots	Discussion	Recommendations	Sample Status
2002 - Muldavin, Wondzell, Ludwig	I	51 desert grassland transects were established by Dr. Barton Warnock under the Ecological Site Survey of the Big Bend Area (ESSBA) in 1955 and have 55 years of monitoring data.	51 – in-park	This summary report discusses 51 of 77 vegetation transects established in 17 sites in the north-central portion of BIBE by Dr. Barton Warnock to monitor vegetation change in desert grassland types; they were originally sampled between 1955-1957, then re-sampled in 1960-1961, 1967, 1981, and 1996. The data are within BIBE/RIGR boundaries, the transects are geo-located, the data represent existing vegetation and are adequate for classification and mapping, and the data contain sufficient structural, compositional, and site information and photographs to be placed within the standard classification framework.	These data and the record of photographs would be useful to inform the classification, descriptions of vegetation alliances/plant associations, examine the quality of 2007 NAIP imagery, develop photo-signatures, guide interpretation following formal vegetation classification, and will contribute to the historical context of the final report. Avoid re-sampling these areas in 2010 until the classification is known and the number of transects per plant association is known.	Current – data under review by NVIP, Lea.
2007 – Von Loh, Jannsen	II	60 mostly riparian plots describing 28 vegetation types/map units were collected along the Rio Grande up- and down-stream of BIBE/RIGR.	60 – off-park	Off-park surveys of riparian and limited upland plant communities along approximately 14 miles of the Rio Grande near Presidio and Del Rio were conducted to classify, map, and evaluate impacts related to tactical infrastructure installation on the U.S.-Mexico border. Nearly 60 observation points (dominant species structure and cover data, habitat data, site notes, species lists, location information, and	The plot data were not collected within BIBE/RIGR boundaries, however elements of the classification do occur within BIBE/RIGR on the Rio Grande floodplain as verified by a December 2009 site visit by one of the authors. The data would be useful to inform descriptions of vegetation alliances/plant associations, examine the quality of 2007 NAIP imagery, develop photo-signatures, and guide interpretation	N/A

Table 1. Summary Analysis of the Most Significant Vegetation Legacy Datasets to Inform the BIBE/RIGR Vegetation Inventory Project.

Research Date - Author	Utility Cat.	Description	No. of Plots	Discussion	Recommendations	Sample Status
				digital photographs) were sampled to prepare descriptions to the vegetation alliance and plant association level of the NVC and prepare a vegetation map. Twenty-eight riparian and upland vegetation types were described and delineated using 2007 NAIP imagery for the digital base map product.	following formal vegetation classification.	
2002 - Worthington	III	The base plant species list of 1,013 vascular plants was developed by Worthington and updated with the Dead Horse Mountains species survey of 2008.	0	Dr. Worthington submitted a working draft of plant species known to occur in BIBE/RIGR. The tabular data were divided into families and each taxa was described by scientific name and author, common name, and known location within the parks. Listed were 73 species of lichens, liverworts, and bryophytes and 1,013 species of vascular plants.	The information allowed partial development of a provisional classification to inform the upcoming vegetation classification and mapping project within BIBE/RIGR. With updates by the focused inventory of the Dead Horse Mountain area described above, it performed the basis of the plant species list for the Study Plan, the field data collection manual, the provisional list of vegetation alliances and plant associations and will be included in the the project final geodatabase.	N/A
2007 - Wondzell, Claeton, Bachelet	III	11 desert woodland transects established in the Chisos Mountains by Dr. Barton Warnock under the ESSBA in 1955 have 55 years of monitoring data	11 poss. more up to 26	This 2007 summary report discusses 11 vegetation transects established in the Chisos Mountains (Boot Canyon – 3 transects, Chisos Mountains Rim – 6 transects, Laguna Meadow – 2 transects) by Dr, Barton Warnock to monitor vegetation change in desert	Current data are not yet available, however the transects are geo-located and when sampled and classified the resultant dataset would fit Category I of utility for classification and mapping (the data contain sufficient structural, compositional, and site information and	Current – data under review by NVIP, Lea.

Table 1. Summary Analysis of the Most Significant Vegetation Legacy Datasets to Inform the BIBE/RIGR Vegetation Inventory Project.

Research Date - Author	Utility Cat.	Description	No. of Plots	Discussion	Recommendations	Sample Status
				woodland types and originally sampled in 1955, then re-sampled by him in 1961 and 1968. The Chisos Mountains transects described herein are known both as the Warnock sites and as the ESSBA sites. Warnock acquired data the first three readings, Wondzell, Ludwig, and Muldavin relocated all transects and collected coordinates using a GPS receiver, acquired new photographs, and recorded general observation notes in 2007. This study did not result in vegetation classification data, per se. Chris Lea, NVIP ecologist, will evaluate in detail a dataset collected from these transects in 2009 by Wondzell and others.	photographs to be placed within the standard classification framework). New sampling of some vegetation types could be reduced based on these data. As presented, the information would be useful to prepare the historical context, current vegetation impact types, and contribute to local vegetation alliance/plant association descriptions.	
2007 - Young, Schrader, Roemer, Caldwell, Boykin, Reiser, and Ernst	III	Eight invasive plant species have been mapped from 2001-2006 based on ground surveys and remote sensing techniques, resulting in 1,464 geo-referenced data points. The species documented include: salt cedar, giant reed, Johnson grass, Lehmann's lovegrass, Bermuda grass, buffelgrass, horehound, and Russian-thistle. These species rapidly colonize disturbed areas, out-compete native species, and alter natural processes that further promote invasive species invasions and establishment.	Unk.	Spatial locations on existing known occurrences in BIBE/RIGR were provided by park staff, including present and historic plant locations from opportunistic sightings and planned roadside surveys from 2001 to present. Additional ground surveys were conducted in 2006 throughout BIBE/RIGR to ascertain undocumented locations of target species populations. A systematic (opportunistic) sampling	The information allowed development of photo-signatures where the polygons were sufficiently large and updates to the provisional vegetation alliance/plant association list occurred to inform the upcoming field work within BIBE/RIGR. These nonnative plant species locations will provide a layer in the project geodatabase and aid in writing local vegetation alliance and plant association	Field crews will be asked to further document invasive plant population locations as practicable within this project.

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Research Date - Author	Utility Cat.	Description	No. of Plots	Discussion	Recommendations	Sample Status
				approach was used to optimize chances of detecting previously unknown invasive plant populations. Roads and trails were systematically surveyed throughout BIBE/RIGR; arroyos, springs, and cross-country surveys were also conducted as appropriate. UTM coordinates were acquired for each point.	descriptions and appropriate sections of the final report.	
2006 - Young, Kamienski, Schrader, Boykin, Lopez	III	Five wildlife species populations and their distribution were mapped including feral hogs that use water sources of all types (rivers, creeks, ponds, springs, seeps, tinajas, etc.) and bullfrogs which use a subset of these water sources, the database contributing to the hydrologic layer and inferring sites potentially with mesic vegetation.	Unk.	This spatial habitat model and dataset for selected bighorn sheep and nonnative wildlife species provides locations of water sources in BIBE/RIGR including bullfrog and feral hog habitats of rivers, creeks, streams, pools, seeps, springs, and tinajas. For each potential feral hog use loci, the water provides the centroid of a larger use area.	The information allowed partial development of the hydrology and mesic vegetation layer of the gradsect to inform the upcoming vegetation classification and mapping project within BIBE/RIGR. These mesic locations will aid in writing local vegetation alliance and plant association descriptions and appropriate sections of the final report and would inform the hydrology layer in the project geodatabase.	N/A
1988-1993 – Plumb and 1990 - Whitefield	III and III	Plumb: Vegetation maps that range in cover from 10 state-wide regions, to 13 landforms and vegetation types, and 29 map units based on analysis of 131 data transects resulting in 20 vegetation cover types were analyzed and two were used to develop the project gradsect. The first was Plumb's vegetation map classification that included one map unit for no data, two land use units (bare and water), and 26 vegetation map units prepared at the physiognomic level to some vegetation alliance levels of the NVC: (1) cottonwood grove; (2) creosote flats; (3) creosote-grass; (4) creosote-lechuguilla-prickly-	131 and 0	Dr. Plumb used Landsat imagery, elevation, aspect, and slope derived from DEMs, soils, panchromatic ortho-photography, and color-infrared photography to produce a digital elevation map of BIBE/RIGR in 1993; the original map he developed was created in MOSS GIS software in 1987. Data within the Plumb (1993)	The data in both maps were used to develop the gradsect, BPUs, and sampling plan and may be useful to provide information for descriptions of vegetation alliances/plant associations. For the Plumb map it was determined also that sample sites are not adequately geo-referenced and the data are not current. However, the data were used	N/A

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		pear; (5) creosote-lechuguilla; (6) creosote-tarbush; (7) creosote-yucca-grass; (8) desert willow; (9) forest meadow; (10) lechuguilla-grass; (11) lechuguilla-grass-candelilla; (12) lechuguilla-grass-hechtia; (13) lechuguilla-grass-viguiera; (14) mesquite thicket; (15) mixed oak; (16) mixed riparian; (17) mixed scrub; (18) oak scrub: (19) oak-ponderosa pine-cypress; (20) pinyon-juniper-grass; (21) pinyon-oak-juniper; (22) pinyon-talus; (23) reed grass; (24) sotol-lechuguilla-grass; (25) sotol-nolina-grass; and (26) yucca-sotol. The 1993 digital elevation map and classification / map units were condensed into vegetation types during preparation of the BIBE Fire Management Plan (2005). Six vegetation types and one unvegetated type were prepared from the Plumb (1993) dataset: (1) forest; (2) grassy woodland; (3) shrub woodland; (4) high desert grassland; (5) floodplain/upland riparian; (6) desert scrub; and (7) bare. Whitefield: The second was within the text of an uncompleted thesis (*Vegetation of the North Rosillos Mountains Area of BIBE*); Doug Bradley of NPS subsequently prepared a vegetation coverage for BIBE/RIGR using the Whitefield classification and GRASS software. Thirteen landforms and vegetation types identified and mapped during these studies are: (1) alkaline grassland; (2) arroyo scrub; (3) canyon scrub; (4) creosote scrub; (5) grama grassland; (6) mariola scrub; (7) mesquite scrub; (8) mixed scrub and succulent scrub; (9) mosaic of semidesert grassland, mariola, and lechugilla scrub; (10) mountain scrub; (11) oak woodland; (12) riparian; and (13) semidesert grassland – igneous substrate.		vegetation map are believed to be accurate within the original 30-meter pixel resolution of the Landsat and other data used to produce the original map; it ranges from 65%-75%. The majority of map errors occurred between vegetation cover types that were similar in structure and composition. The map is best used for graphic purposes (i.e., research, etc.); the supporting data are considered adequate for landscape level analysis. The original database is now about 20 years old and fires, floods, drought, and natural vegetation changes may have substantially affected small or specific areas of BIBE/RIGR.	to develop the vegetation classification, provide information for local vegetation alliance and plant association descriptions, and to the extent practicable to prepare the BIBE/RIGR gradsect consisting of biophysical unit polygons.	

Introduction

CHDN and BIBE/RIGR, with the assistance of the NVIP staff, are preparing to conduct vegetation classification plot sampling in support of creating a vegetation map, geodatabase, and final report beginning in September 2010. Funding has been awarded to the Rio Grande Institute to provide qualified botanists/ecologist for initial field data collection in the form of classification plots as described in the project Study Plan (NPS-BIBE/RIGR 2010). Field crews benefit from having a field sampling plan containing a preliminary list of vegetation alliances and plant associations, developed from appropriate legacy datasets and the park plant species list from which to inform landscape observations of vegetation stands, classification plot site selection, plot density, and provisional plant community type decisions when sampling vegetation types for classification under the National Vegetation Classification (NVC).

The legacy data evaluated herein were collected by or submitted to CHDN and BIBE/RIGR staffs historically and along with interviews with responsible researchers directly involved in legacy data gathering comprise the results of this report. Results generated from this study were also used to prepare the gradsect (Task 2.0: Gradsect and Field Sampling Plan for BIBE/RIGR and to supplement the list of potential vegetation alliances and plant associations (Task 3.0: Vegetation Classification List Update for BIBE/RIGR). Please refer to the Study Plan (NPS-BIBE/RIGR 2010) for additional information explaining project tasks, examples, timing, and budget estimates.

The NVC, as developed by The Nature Conservancy (TNC) and currently maintained by NatureServe (2010), represents a national system containing seven levels: (1) Formation Class, (2) Formation Subclass, (3) Formation, (4) Division, (5) Macrogroup, (6) Group, (7) Alliance, and (8) Association with the finest level being the plant association. Alliances are usually aggregations of associations that are physiognomically uniform and share one or more characteristic or diagnostic species. An association is defined as a plant community or type with a consistent species composition, uniform physiognomy, and homogenous habitat conditions (Flahault and Schroter 1910). The plant association or community type is determined by environmental patterns and disturbance processes.

Associations are separated from alliances through the use of total floristic composition and are named by the most dominant and/or indicator species. For the name or title assigned to an association or alliance, a single dominant species may be used (*Prosopis glandulosa* Woodland). If two dominant species of the same stratum are used they are separated by a dash (*Larrea tridentata – Agave lechuguilla* Shrubland). If two dominant species occur in different strata, then a slash is used to separate them (*Larrea tridentata / Bouteloua eriopoda* Woodland). Parentheses are used when the diagnostic species are not consistently present in the association or alliance (*Distichlis spicata* – (*Hordeum jubatum*) Herbaceous Vegetation).

The purpose of the NVC is to provide a complete, standardized listing and description of all vegetation types that represent the variation in biological diversity at the community level and to identify those communities that require protection (Grossman et al. 1994). The NVC focuses on existing vegetation rather than potential natural vegetation, climax vegetation, or physical

habitats. Because it is not restricted to static vegetation types, classification units are useful both for inventory, site description, and as the basis for building dynamic ecological models. The NVC also includes vegetation along the natural-invasive-cultural (semi-natural and modified) continuum, but it emphasizes natural communities as the focus of biodiversity protection.

Typical vegetation stands sampled under the NVIP equal or exceed the project minimum mapping unit (MMU) of 0.5 hectares (1.24 acres). Unique vegetation patches less than the MMU may also be sampled using vegetation classification plots or less rigorous observation points. Small patches or stands are often termed "park specials" in the NVIP because of their value for overall management prescriptions. Resource management staff at BIBE/RIGR identified such stands of unique vegetation at the BIBE/RIGR Study Plan (NPS-BIBE/RIGR 2010) kick-off meeting. Typically, between three to five classification plots are required to adequately describe most vegetation alliances and plant associations.

Background

The ensuing discussion was excerpted in part from the BIBE/RIGR Study Plan (NPS-BIBE/RIGR 2010) and users are encouraged to review the Study Plan to place this legacy research study in context with the larger vegetation inventory project. BIBE is represented predominantly by desert shrubland and grassland plant communities, some woodland and forest stands including those of the Chisos and other mountains and the Rio Grande, and unvegetated geologic exposures and RIGR supports predominantly riparian woodlands, shrublands, and herbaceous vegetation in addition to Rio Grande flows.

The Big Bend region of Texas has been classified within the Chihuahuan Desert Province (Dry Domain [300], Tropical/Subtropical Desert Division [320]) (Bailey 1995). The Texas Parks and Wildlife Department (2009) describe this region and reach of the Rio Grande under the Chihuahuan Biotic Province; Trans-Pecos Natural Region; and the Level III Ecoregion of the Chihuahuan Desert. Six major vegetation types (derived from Plumb 1988) are described in the BIBE and RIGR fire management plans (2005 and 2004); which include: (1) Floodplain/Upland Riparian, (2) Scrub Desert, (3) High Desert Grasslands, (4) Shrub Woodland, (5) Grassy Woodlands, and (6) Forests (**Figure 2-1, Appendix 2**). Major vegetation types or landscape/ landform categories were further defined by Plumb (1988 and 1993) and Brown (1994 and 2000) and are summarized from the BIBE and RIGR fire management plans (2005 and 2004) as follows:

Floodplain/Upland Riparian: consists of two general cover-mapping categories - Mixed Riparian and Desert Willow from Plumb (1988, 1993) formed this vegetation category. The Rio Grande is controlled by upstream dams in the U.S. and maintains a relatively high water table and dependable year-round flow supporting dense stands of vegetation; although approximately 5% to 10% of the project area, it provides a vital habitat for wildlife. Upstream dams in New Mexico and Colorado now capture spring floodwaters; dense often nonnative vegetation stands have become established that along with geologic features, severely reduce meandering. The Rio Conchos, 100 miles upstream, draining Mexican highlands and smaller tributaries provides valuable surface flows and sediments. Upland Springs includes springs, seeps, and tinajas that provide water for wildlife and occur regularly in the mountains, canyons, and on the low-elevation desert floor. Salt-cedar (*Tamarix* spp.) and giant reed or carrizo (*Arundo donax*) are

being systematically removed from some reaches of the Rio Grande allowing native woodland species, including sugarberry (*Celtis laevigata*), netleaf hackberry (*Celtis laevigata* var. *reticulata*), mesquite (*Prosopis glandulosa*), and Fremont cottonwood (*Populus fremontii*) trees, to reestablish.

Scrub Desert: this physiognomic type was compiled from five cover-mapping categories from Plumb (1988, 1993); Creosotebush-Lechuguilla-Grass, Creosotebush-Lechuguilla-Prickly Pear, Creosotebush-Tarbush, Creosotebush-Yucca-Grass, and Lechuguilla-Candelilla-Hetchia. Desert scrub is characterized by shrubs (creosotebush [*Larrea tridentata*], mariola [*Parthenium incanum*], and ocotillo [*Fouquieria splendens*]) and succulents (prickly pear [*Opuntia* spp.], lechuguilla [*Agave lechuguilla*], and Texas false agave [*Hechtia texensis*]). Grasses are understory and usually provide insufficient fuels to carry fire. Scrub Desert occurs over 50% of the Parks between the low-lying floodplains (~1,700 ft) to mid-elevation desert grasslands (~3,000 ft).

High Desert Grasslands: represent the most diverse plant communities exhibiting the highest species per unit area. High desert grasslands cover about 40% of the parks ranging from ~3,000 ft to ~5,000 ft in elevation with scattered plants occurring at higher elevations of the Chisos Mountains. High Desert Grasslands support some shrubs, low-growing trees, and cacti that are largely confined to drainages (supporting little grass cover) and to areas of rocky and shallow soils where shrub herbaceous communities occur. Common grass species include tobosa grass (*Pleuraphis mutica*), black, blue, and hairy grama (*Bouteloua eriopoda*, *B. gracilis*, and *B. hirsuta*), bull muhly (*Muhlenbergia emersleyi*), and little bluestem (*Schizachyrium scoparium*).

Shrub Woodland: this vegetation structure includes three cover-mapping categories from Plumb (1988, 1993): they are Mixed Scrub, Oak Scrub, and Mixed Oak-Shrub Woodlands. Shrubby woodlands include stands that are scattered on the foothills and slopes of the Chisos and Dead Horse (Sierra del Caballo Muerto) mountains; the elevation range typically occupied by this type varies from ~4,500 ft at Green Gulch to ~5,500 ft near Chisos Basin. Common wooded shrubland species include gray, turbinella live, and dwarf oak (*Quercus grisea, Q. turbinella,* and *Q. pungens*), Mexican pinyon (*Pinus cembroides*), alligator and weeping juniper (*Juniperus depeanna* and *J. flaccida*), green sotol (*Dasylirion leiophyllum*), acacia (*Acacia* spp.), honey mesquite (*Prosopis glandulosa*), and mimosa (*Mimosa* spp.).

Grassy Woodlands: include three cover-mapping categories from Plumb (1988, 1993); they are Pinyon-Juniper-Grass, Pinyon-Oak-Juniper, and Forest-Meadow. Elevation ranges from ~5,500 ft to ~7,200 ft where most stands occur. Common wooded grassland species include Mexican pinyon; alligator, one-seed (*Juniperus monosperma*), and weeping juniper; gray, turbinella live, and dwarf oak; bull muhly; sideoats (*Bouteloua curtipendula*) and blue grama; mountain muhly (*Muhlenbergia montana*); and Arizona fescue (*Festuca arizonica*).

Forest: stands include two cover-mapping categories from Plumb (1988, 1993); they are Pinyon-Talus and Oak-Ponderosa Pine-Cypress. Forests occur above ~6,000 ft and form mosaics of conifer stands and wooded grasslands. Forest trees include Mexican pinyon, ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), Arizona cypress (*Cupressus arizonica*), and quaking aspen (*Populus tremuloides*).

Distinct Forest and Woodland Populations: Arizona cypress and Douglas-fir in Boot Canyon, red oak (*Quercus gravesii*) in West Chisos Mountains, quaking aspen on the northwest side of Emory Peak, one lateleaf oak (*Quercus tardifolia*), small stands of netleaf oak (*Quercus rugosa*) in the high Chisos Mountains, Texas madrone (*Arbutus xalapensis*) on north-facing slopes and in canyons, and Chisos hophornbeam (*Ostrya virginiana* var. *chisosensis*) on slopes north of Emory Peak and Crown Mountain (also in Boot Canyon, near Pinnacles Trail, and upper Cattail Canyon). Rare forest stands include ponderosa pine in Boot Canyon, Pine Canyon, and Crown Mountain; bigtooth maple (*Acer grandidentatum*) in canyons and on north-facing slopes; species of orchids scattered throughout the Chisos Mountains on appropriate habitat; and Guadalupe fescue (*Festuca ligulata*) on the moist slopes of Boot Canyon.

Runoff flows to the Rio Grande via desert washes, arroyos, and Terlingua, Smoky, Fresno, and Tornillo creeks within BIBE/RIGR. Flows from the Rio Conchos emanate from Mexico approximately 100 miles upstream from BIBE and contribute to surface and groundwater quantities in the BIBE/RIGR reach. The Rio Grande annual flows and sediment delivery/removal have been controlled by upstream dams and groundwater pumping for many decades resulting in diminished overbank flooding and establishment of nonnative, bank-armoring vegetation stands including salt-cedar, giant reed, Johnson grass (*Sorghum halapense*), buffelgrass (*Cenchrus [Pennisetum] ciliaris*), and Bermuda grass (*Cynodon dactylon*). These invasive species have become a management concern requiring Parks resources to map and monitor populations and attempt focused control and eradication. Water quality may also affect riparian and wetland plant communities along the Rio Grande due to the release of treated sewage from several cities upstream of BIBE/RIGR. Prior to human control of the Rio Grande flows, the Boquillas, Mariscal, and Santa Elena canyons had been dramatically eroded; while canyon erosion continues, it occurs at a much lower rate.

Project area vegetation distribution is influenced by several factors (ecologic drivers) that include hydrology, elevation, slope, aspect/slope exposure, precipitation patterns, temperature extremes, topographic position, geology, and soils. The environmental drivers are discussed in detail and used to prepare bio-physical unit maps in support of field crews in the companion study (Task 2.0: Gradsect and Field Sampling Plan for BIBE/RIGR).

Legacy Data and Existing Vegetation Maps

Legacy data are existing qualitative and quantitative vegetation information and vegetation maps collected/created prior to parks establishment and in support of a variety of BIBE/RIGR research projects over the decades since parks designation. Guidance has been prepared to aid the evaluation of existing vegetation datasets (TNC 1996) that is summarized in Appendix 1; the provided flow chart allows ecologists to place each dataset into a utility category (I-V) representing usefulness of the data for vegetation classification and mapping. The utility categories presented herein use this flow chart and these descriptions. All legacy studies are potentially useful to this project in various ways, typically to provide historical perspective during final report preparation; the most important studies are presented and discussed below and in Tables 1 and 2. The most important vegetation datasets to inform this project are relatively recent, accurately geo-referenced, have complete species lists, provide estimates of vegetation structure and cover, and describe edaphic elements.

Previous Vegetation Studies at BIBE//RIGR

As presented in the Study Plan (NPS-BIBE/RIGR 2010), 26 legacy vegetation studies were initially acquired from Internet searches, park staff, and/or provided by Missy Powell, CHDN data manager. They were divided into three preliminary groups based on perceived vegetation inventory project utility: (1) General Project Background Information; (2) Potential Category II; or (3) Potential Category I.

Studies and datasets originally placed within the General Project Background Information section (14 studies) are dated and were at best expected to be useful to support historical context in the final project report (background and history sections, land use discussion, local vegetation type descriptions, plant species list, etc.). This group of documents was further evaluated herein and the following were placed into utility category III (data can be used for vegetation classification and characterization of a vegetation type within the park, but not for mapping or analysis because the sample is not adequately geo-referenced, contains inadequate detail in the vegetation information, and/or may not represent existing vegetation at the sample location) or utility category IV (dataset was assessed and not found to be useful at any level): Bray (1901); Warnock et al. (1967, 1970); and Van Auken et al. (1979). Each evaluated dataset and study is described in detail within Table 2 in the results section.

Of the seven datasets and studies originally placed under Potential Category II in the Study Plan (NPS-BIBE/RIGR 2010), the research prepared by Plumb (1988, 1991, 1992, and 1993) was analyzed in detail in Table 2 in the results section. These datasets and reports were placed into utility category III due to their age (over 20 years old) and geo-location questions. The vegetation transect data Plumb collected (mid-1980s) from 131 sites to support the map unit classification are under evaluation by Chris Lea, NVIP ecologist, to determine their utility to possibly reduce/replace new data collection and reduce project costs. Plumb's 1988 vegetation map was consolidated into nine map classes for use as a gradsect layer by Dan Cogan, CTI GIS Coordinator, under Task 2.0: Gradsect and Field Sampling Plan for BIBE/RIGR of this contract.

The five datasets and studies originally listed under Potential Category I in the Study Plan (NPS-BIBE/RIGR 2010) were sought and analyzed in detail in Table 2 in the results section. These datasets and reports were placed in utility categories II (data are adequate to assist in photo-interpretation, photographic signature key development, or map accuracy assessment), III, and V (dataset was not available for assessment). The vegetation data collected from Warnock's ESSBA transects and newer sampling by Wondzell et al. (2009) and Muldavin et al. (2002) to determine vegetation trends are under evaluation by Chris Lea, NVIP ecologist, to assess their utility to possibly replace new data collection and reduce project costs.

An additional group of eight vegetation studies, maps, and plant species lists emerged under this contract task and are examined in further detail and summarized in Table 2 in the results section. These datasets, maps, and reports were placed in utility categories I (data are adequate for classification or mapping), III, IV, and V.

Preliminary Vegetation Alliance/Plant Association and Species Lists

Lists of vegetation alliances and plant associations that could occur within BIBE/RIGR were prepared to support Study Plan (NPS-BIBE/RIGR 2010) cost estimates and to inform field crews during the sampling phase. Please refer to the companion study (Task 3.0: Vegetation Classification List Update for BIBE/RIGR) and the BIBE/RIGR Study Plan (2010) for an in-depth summary of this project task. Several new alliances and associations, including semi-natural types were added to this list as a result of legacy data evaluation.

Affect on Field Data Collection Approach

Based on size, BIBE/RIGR is categorized as a very large park (TNC 1994b) for vegetation inventory and mapping. Very large parks are best sampled by first identifying each unique ecoregion and/or management zone and then creating separate modified gradsects (gradient-oriented transects) (Austin and Heyligers 1989) and biophysical unit (BPU) maps for each ecoregion/management zone in the park. The resulting BPUs can then be used to guide field crews, develop cost surfaces, and focus vegetation sampling. This BPU sampling design was based on the premise that if the field crews visit the full spectrum of physical environments at easy to moderately difficult-to-access representative sites, in a step-wise fashion, then most of the vegetation types would be economically sampled. Modifications of these methods have been statistically shown to capture more information than standard designs based on sampling systematic grids (Gillison and Brewer 1985, and Austin and Heyligers 1989).

CTI GIS staff cooperated with the CHDN and BIBE/RIGR GIS staffs to create the BPUs and the overall field sampling design under Task 2.0: Gradsect and Field Sampling Plan for BIBE/RIGR of this contract. Effective ecoregion/management zones identified by parks staff during the project planning meeting included: (1) Rio Grande Riparian, (2) High Chisos Mountains, (3) Chisos Mountains and Sierra Quemada, (4) Dead Horse Mountains (Sierra del Caballo Muerto) and Mesa de Anguilla, and (5) Desert Basin. Plumb's 1988 vegetation map was consolidated into nine map classes for use as a gradsect layer to prepare BPU polygons by Dan Cogan, CTI GIS coordinator, they are: (1) Bare, (2) Closed Canopy Woodland, (3) Creosote Scrub, (4) High Desert Grassland, (5) Lechuguilla Scrub, (6) Open Canopy Woodland, (7) Riverine Riparian, (8) Scrub Woodland, and (9) Upland Riparian. A map of BPU polygons for BIBE/RIGR, the UTM coordinates of each polygon centroid, and a field sampling scheme was prepared by CTI with assistance from legacy data analyzed herein.

Results

Several vegetation, soils, and hydrology classifications, datasets, species lists, and digital maps were evaluated during this project planning task. The datasets and studies were evaluated under the criteria of Appendix 1 and the results were summarized in Table 2; pertinent support information and data tables were copied into Appendix 2.

Bray (1901) determined five major vegetation formations within BIBE/RIGR that he further discussed as three forested sub-formations, three grassland formations, and seven shrubland formations. Also interesting within Bray's research are the representatvie black-and-white photograph reproductions that depict the landscape and distribution/cover of vegetation in an era of intense livestock grazing and browsing.

Cochran and Rives (1985) mapped 26 soil associations that have been summarized relative to dominant plant communities and diagnostic plant species in Table 2-1, Appendix 2. The soils layer contributed significantly to the gradsect development task of this project, which is described separately.

The floristic inventories of the Sierra del Caballo Muerto conducted by Fenstermacher et al. (2008) and of greater BIBE/RIGR by Worthington (2002) resulted in a majority of the plant species list, over 1,700 plant taxa, provided in the Study Plan (NPS-BIBE/RIGR 2010). A thorough plant species list in addition to the six habitats described in the reports allowed a comprehensive list of potential vegetation alliances and plant associations to be developed for the Study Plan and updated based on the legacy data accrued. The species list and updated vegetation type list will greatly enhance the proficiency of field crews, particularly when they are determining the plot floristic list and the provisional community name portions of field data forms. Enhanced proficiency will reduce the costs associated with field data collection, but it is not possible to estimate a value.

ESSBA vegetation trend transects established by Dr. Barton Warnock in 1955 and sampled by him (Warnock et al. 1967, 1970); Muldavin et al. (2002); and Wondzell et al. (1983, 1984, 1995, 2009) number 77 and because they were recently sampled could reduce the number of classification plots required for this project, accordingly. Table 2-2, Appendix 2 provides the electronic field coordinates for the relocated and resampled Chisos Mountains woodland ESSBA sites. Chris Lea, NVIP ecologist, is evaluating these data to determine if they/how many of them are useful for the current database. These ESSBA plot data could reduce the number of vegetation classification plots sampled by 77, which equals approximately 15 days of time and expenses for one field crew or approximately $12,000.

Plumb (1988) sampled 131 vegetation transects to determine map classes for BIBE/RIGR and plotted the locations by estimating them relative to topographic map contours and distance from roads and trails. These data are under review by Chris Lea, NVIP ecologist, but due to their age, it is unlikely they will be used to reduce the number of classification plots to sample during this project. The map unit classification prepared by Plumb (26 units) and another prepared by Whitefield (1990) in the Rosillos Mountains area (13 units) were used to create and update the

provisional list of vegetation alliances and plant associations under Task 3.0: Vegetation Classifiation List Update, of this project.

The vegetation classification data and map prepared by DHS-USBP (2008) was managed by contract ecologists Jim Von Loh and Gena Janssen, who used the approach of the NVIP to create the species list, prepare vegetation descriptions, and GIS products. However, these data were recorded off-park in the Rio Grande floodplain near Sierra Blanca and Presidio to the west of BIBE and on the edge of the city of Del Rio to the east of RIGR. Approximately 60 observation points were recorded that represented seven ecological systems and 28 vegetation alliances; these types contributed to the potential list of vegetation alliances/plant associations prepared in the Study Plan (NPS-BIBE/RIGR 2010) for field crew reference.

Young et al. (2007) prepared a digital database of locations of eight invasive plant species all of which could be individually dominant within stands, co-dominant with one another, or co-dominant to understory with native plant species. In total, nearly 1,500 relatively current locations (2001-to2006) have been recorded and the UTM coordinates are provided in Table 2-3, Appendix 2. Sufficient data are likely represented with this database to classify and map up to 10 invasive vegetation alliances and/or associations within BIBE/RIGR without further field work other than verification observations to insure accuracy in terms of existing vegetation. This database would result in reducing the number of classification plots sampled by approximately 50, which equals approximately 8 days of time and expenses for one field crew or approximately $5,500.

Young et al. (2006) prepared a digital database of important wildlife habitats including mesic locations of the introduced bullfrog (*Rana catesbeiana*) and feral hog (*Sus scrofa*). Over 300 mesic sites including rivers, creeks, seeps, springs, tinajas, etc. were geo-located within BIBE/RIGR, the UTM coordinates are presented in Table 2-4, Appendix 2. These data will aid field crews to search more efficiently for diverse plant communities; it is anticipated that a great deal of overlap will occur between the mesic habitat data and data for invasive plant species (Young et al. 2007). Enhanced proficiency will reduce the costs associated with field data collection, but it is not possible to estimate a value.

Table 2. **Summary of Databases Deemed to be Potentially Useful for the Vegetation Inventory Project of BIBE/RIGR.**

Research Title and Date	Utility Category	Discussion	Recommendations
Bray, W. L. 1901. The ecological relations of the vegetation of western Texas. Bot. Gaz. 32(2): 99-123.	III: because the information does not describe existing conditions within BIBE/RIGR.	This general discussion of the ecology of the Big Bend region (Trans-Pecos Physiographic Province) was prepared from observations in 1900 and 1901 and contains over 30 black-and-white photographs with lists of dominant species of five major vegetation formations encountered: (1) Grass Formations; (2) Woody Formations; (3) Succulent Formations; (4) Rock Formations; and (5) Halophytic Formations. Bray defined forest and woodland stands under the Xerophytic Forest Formation of the Mountain Slopes of Trans-Pecos Texas and described stands of pinyon pine, juniper, and oak as open and stunted on canyon slopes to closed on alluvial deposits. Forests of the Rio Grande were described under the Mesophytic Forest Formations of the Streamways and included stands of pecan (*Carya illinoensis*), hackberry, elm (*Ulmus pumila*), oak, Texas green ash (*Fraxinus berlandieriana*), and sycamore (*Platanus* spp.) trees. Plains cottonwood (*Populus deltoides*) groves occurred around springs. Shrubland formations described and illustrated with photographs were depicted as mostly open in terms of canopy cover. The most common formations noted were dominated by creosotebush, mesquite, yucca (*Yucca* spp.), sotol (*Dasylirion* spp.), agave (*Agave* spp.), lechuguilla, or species of cacti. Grasslands of alluvial fans, flats, basins, and playas were described under three formations: (1) Close Grass Formation (grama grasses and other bunchgrasses with dense cover); (2) Open Bunch Grass Formation (grama grasses and other bunchgrasses in open stands on drier sand and gravel deposits); and (3) Salt Grass Formation (saltgrass [*Distichlis spicata*] and other halophiles of alkaline basin bottoms). The annual flora which was well represented in 1900-1901 was considered part of the grassland formations but also described as “a vegetation phenomenon which peridically overshadows everything else”. Bray was impressed with the huge floristic display of bluebonnets (*Lupinus havardii*) and other annual forbs and described their forage value to livestock (cattle, sheep, and goats). One of Bray’s conclusions was that profound changes to native vegetation was occurring as a result of disturbed equlibrium (advancement of civilization) and that some species, particularly grasses were being exterminated; he alluded to establishment of woody or weedy plant species and denudation of hill slopes. One photograph described the Tornillo Desert as a dead bunchgrass desert on adobe soil.	This valuable historical account and photographs occurred during an intense period of livestock grazing and would be useful to inform the historical context of BIBE/RIGR vegetation in the final report and possibly to aid in writing local vegetation alliance and plant association descriptions.

Research Title and Date	Utility Category	Discussion	Recommendations
Cochran, R. A. and J. L. Rives. 1985. Soil Survey of Big Bend National Park Part of Brewster County, Texas. U. S. Department of Agriculture, Soil Conservation Service in cooperation with U. S. Department of the Interior, National Park Service and the Texas Agricultural Experiment Station. Austin, TX.	III: because the information describes existing conditions within BIBE/RIGR in terms of an important vegetation driver.	This 1985 soil survey is focused on BIBE/RIGR and is based on data developed through 1981. Each of 26 soil mapping units is supported by soils data and lists of the dominant plant species among other data (**Appendix 2; Table 2A**) and the map was used as a vegetation driver to divide physiognomic map units, e.g., woodland, shrubland, herbaceous vegetation, and sparse vegetation from one another during gradsect development under Task 2.0. The soils map was very useful as an element to prepare the gradsect layer and resultant BPUs to guide field research.	This valuable account of geology, soils, existing vegetation, and land use would be useful to inform the local vegetation alliance and plant association descriptions and appropriate historical and edaphic summary sections of the final report. The soils map will also provide a layer in the project geodatabase.
Fenstermacher, J., A. M. Powell, J. Sirotnak, and M. Terry. 2008. Annotated vascular flora of the Dead Horse Mountains, Big Bend National Park, Texas, with Notes on local vegetation communities and regional floristic relationship. Journal of the Botanical Research Institute of Texas. 2(1): 685-730.	III: because the information allowed partial development of a provisional classification to inform the upcoming vegetation classification and mapping project within BIBE/RIGR.	This study was conducted from 2003-2006 and published in 2008 over approximately 176,800 acres (71,548 ha) including the Dead Horse Mountains (Sierra del Caballo Muerto) in the northeastern and eastern portions of BIBE. The elevation range was approximately 4,100 feet (1,250 m); of the 3,796 plant specimens collected or examined as herbarium specimens, 662 species, 344 genera, and 91 families of vascular plants were identified. Twenty-four plant species are nonnative and of these three species are considered noxious and six species are considered invasive. Of significance floristically were the co-dominance of the Poaceae and Asteraceae in terms of number of plant species per the total flora. Previously unknown BIBE plant species determined from this study were added to the species list provided in the project Study Plan (NPS-BIBE/RIGR 2010). Described in this paper are habitats and vegetation types that support a majority of the plant species, they are: (1) Mixed Desert Scrub; (2) Sotol-Yucca Grassland; (3) Chaparral; (4) Desert Canyon; (5) Rio Grande Riparian Corridor; (6) and Sandy Desert Arroyo. The dominant species comprising these habitats and types were used in part to develop the potential list of BIBE/RIGR vegetation alliances and plant associations within the companion document prepared under Task 1.0.	This valuable botanical account of the Dead Horse Mountains will be useful to inform the historical and existing context of BIBE/RIGR vegetation and will aid in writing local vegetation alliance and plant association descriptions. The entire plant species list will be useful to botanists sampling field data for this project by informing taxonomic decisions during field work.

Research Title and Date	Utility Category	Discussion	Recommendations
Moir, W. H. 1980. Forest and woodland vegetation monitoring, Chisos Mountains, Big Bend National Park, Texas: baseline 1978, (Alpine [TX]): (Chihuahuan Desert Research Institute.) (CDRI contribution: 83) 51 p.	V: because the dataset was not available for assessment.	N/A: We conducted Internet searches and contacted the Chihuahuan Desert Research Institute (Hoyt 2010) but could not obtain a copy of the report or dataset from their library.	The data would likely be useful to inform the historical context of BIBE/RIGR vegetation and possibly to aid in writing local vegetation alliance and plant association descriptions.
Muldavin, E., S. Wondzell, and J. Ludwig. 2002. Forty years of vegetation change in desert grasslands of Big Bend National Park. The New Mexico Natural Heritage Program. Albuquerque, NM.	I: because the data are within BIBE/RIGR boundaries, the transects are geo-located, the data represent existing vegetation and are adequate for classification and mapping, and the data contain sufficient structural, compositional, and site information and photographs to be placed within the standard classification framework.	This summary report discusses 51 of 77 vegetation transects established in 17 sites in the north-central portion of BIBE (between the Paint Gap Hills, Grapevine Hills, and the Chisos Mountains) by Dr. Barton Warnock to monitor vegetation change in desert grassland types; they were originally sampled between 1955-1957, then re-sampled in 1960-1961, 1967, 1981, and 1996. Twenty-six transects were established in woodlands and are not included in this study; they are being analyzed and discussed separately below. The desert grassland transects described herein and the woodland transects described elsewhere together are known as the Warnock sites and also as the Ecological Site Survey of the Big Bend Area (ESSBA) sites. Warnock acquired data the first three readings (1955, 1960, 1967); Wondzell and Ludwig acquired transect data in 1981 and in 1996. The quality of this long-term dataset was maintained by providing a relational database incorporating the data from all sampling periods accompanied by a set of repeat photographs (digitally scanned) and charts for long-term archival at BIBE/RIGR. In addition to analyzing overall vegetation dynamics in the context of soils and climate, the dynamics of individual plants and species is discussed in a spatial context using the explicit and detailed charting of individual plants along each transect. Soil types supporting the sampled stands include: (1) Chilicotal gravelly loam soil series (derived from Holocene alluvium parent material); (2) Canutillo gravelly/sandy loams (derived from recent alluvial terraces imbedded in the piedmont); (3) Tornillo clay loam soils (rare, developed on valley bottom alluvial flats); (4) Lajitas very cobbly loams (derived from fractured rhyolite on colluvial hill slopes); and (5) Solis soils (derived from sandstone, uncommon in the immediate study area). The desert grassland transects were distributed in threes among 17 sites with uniform soils corresponding to one of the five above-identified soil series. Each transect is 6.10m (20 ft) long and 0.31m (1 ft) wide and gridded	The data would be useful to inform the classification, descriptions of vegetation alliances/plant associations, examine the quality of 2007 NAIP imagery, develop photo-signatures, and guide interpretation following formal vegetation classification. Chris Lea is currently preparing a summary analysis of these data and the entire ESSBA dataset relative to the NVC and the NVIP to inform this project.

Research Title and Date	Utility Category	Discussion	Recommendations
		into 20 contiguous 0.31m (1 ft) square quadrats. The three transects at each site were set parallel approximately 12m apart and monuments installed at each end using steel re-enforcement bars near ground level with identification tags at the zero ends (embossed with G. & F. Comm. of Texas Seine License numbers). In 1996, the location of each rebar was surveyed with a GPS receiver to record the Easting and Northing values to the nearest 5m. Within each quadrat, each plant was identified to species then charted at a scale of approximately 1:12. Only canopy cover within the quadrats was recorded in the first three transect readings from 1955 to 1967. In 1981, Wondzell and Ludwig added basal area of each individual plant and extended the chart drawings approximately 0.5m to each side to provide further context. They also estimated percent canopy cover for each species in each quadrat. For each sampling period, mean absolute cover and density per species were computed based on the 20 contiguous quadrats per transect. High-precision repeat black-and-white photography was acquired during each sampling period (color slides were added in 1996 as were wide-angle exposures) providing a semi-quantitative visual record of vegetation change. The dominant plant species included chino grama (*Bouteloua ramosa*), black grama, sideoats grama, species of threeawn (*Aristida* spp.), creosotebush, mariola (*Parthenium incanum*), lechuguilla, and tarbush (*Flourensia cernua*). For the analysis of species and community dynamics, the standard summary univariate statistics and a multivariate canonical discriminant analysis (CDA) were conducted to detect successional trends through the years on a community level. Each transect at a site represented a single data point defined by the most common species in the dataset as a whole. Also addressed was individual species trends and turnover in a spatial context using the transect charts. Although not a direct measure of the turnover of individuals, this method provided a computable index of species dynamics at a fine spatial scale. Besides the standard summary univariate statistics, a multivariate canonical discriminant analysis (CDA) was conducted to detect successional trends through the years on a community level. Only those species that were present on greater than 10% of the total pooled transects over all years were considered in the CDA. Each transect at a site represented a single data point defined by the most common species in the dataset as a whole. CDA is an ordination tool that derives a new set of coordinate axes (CDA functions) that serve to maximize the differences among years based on	

Research Title and Date	Utility Category	Discussion	Recommendations
		differences in abundance among the suite of species considered. The CDA was computed using the SAS CANDISC procedure that generates estimates of the multivariate variance (eigenvalues) and a correlation structure that correlates the original species cover variables with the new derived CDA functions. All data are maintained at BIBE/RIGR.	
Van Auken, O. W., A. L. Ford, and A. Stein. 1979. A comparison of some woody upland and riparian plant communities of the Southern Edwards Plateau. The Southwestern Naturalist, Vol. 24, No. 1. Pp. 165-180.	IV: because the data were not collected within BIBE/RIGR boundaries, they represent a different, although adjacent, ecoregion, and the riparian data represent small creeks which have limited useful data for BIBE but not the large Rio Grande floodplain as occurs in RIGR and BIBE.	This 1978-1979 study focused on the Buda Formation and alluvial deposits (small creeks) of the Edwards Plateau on the western edge of the Trans-Pecos Region. Fourteen sites with relatively mature and undisturbed woodland vegetation were selected to be sampled using the point-centered quarter method to determine major plant community relationships. Although present, shrublands, grasslands, other herbaceous communities, and large creeks or rivers were not sampled. In total, 35 woody species were encountered; 37% were common, 14% occurred only on uplands, and 49% occurred only in riparian habitats. Common trees of the Buda Formation were Mexican juniper (*Juniperus* sp.), live oak (*Quercus* spp.), and Texas persimmon (*Diospyros texanum*); common trees of creeks were Mexican juniper, cedar elm (*Ulmus crassifolia*), sycamore (*Platanus* spp.), and Texas persimmon.	These descriptions and dataset will unlikely be used to inform the historic or regional context within the final report preparation task.
Von Loh, J. and G. Jannsen. 2007. In USDHS; USCBP; USBP. 2008. Environmental Assessment for the proposed construction, operation, and maintenance of tactical infrastructure, USBP Del Rio and Marfa Sectors, Texas.	II: because the plot data were not collected within BIBE/RIGR boundaries, however elements of the classification do occur within BIBE/RIGR on the Rio Grande floodplain as verified by a December 2009 site visit by the Study Plan (NPS-BIBE/RIGR 2010) authors.	Off-park surveys of plant communities along approximately 14 miles of the Rio Grande near Presidio and Del Rio were conducted to classify, map, and evaluate impacts related to proposed tactical infrastructure installation on the U.S.-Mexico border. During November 2007, Mr. Von Loh and Ms. Janssen collected nearly 60 observation points (dominant species structure and cover data, habitat data, site notes, species lists, location information, and digital photographs) to prepare descriptions to the vegetation alliance and plant association level of the NVC and prepare a vegetation map (DHS-USBP 2008). Twenty-eight riparian and upland vegetation types were described and delineated using 2007 NAIP imagery for the digital base map product. Dominant plant species encountered in these largely disturbed riparian and floodplain sites included: sugarberry, black willow (*Salix nigra*), Athel tamarisk (*Tamarix aphylla*), salt cedar, honey mesquite (*Prosopis glandulosa*), granjeno (*Celtis pallida*), huisache (*Acacia farnesiana*), retama (*Parkinsonia aculeata*), creosotebush, seepwillow (*Baccharis* spp.), rabbitbrush (*Ericameria* spp.), seepweed (*Suaeda* spp.), arrowweed (*Pluchea [Tessaria] sericea*), Bermuda grass (*Cynodon dactylon*), giant reed (*Arundo donax*), common reed (*Phragmites australis*), narrowleaf cattail (*Typha angustifolia*), crowngrass (*Pappophorum* spp.), bristlegrass (*Setaria* spp.), alfalfa (*Medicago sativa*), cocklebur (*Xanthium strumarium*), and Russian-thistle (*Salsola kali*). They represented seven ecological systems and over 20 named or provisional vegetation alliances under the NVC.	The data would be useful to inform descriptions of vegetation alliances/plant associations, examine the quality of 2007 NAIP imagery, develop photo-signatures, and guide interpretation following formal vegetation classification.

Research Title and Date	Utility Category	Discussion	Recommendations
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. U.S. Forest Service, Pacific Northwest Research Station and The Nature Conservancy. Olympia, WA.	III: because current data are not available, however each transect is geo-located and when sampled and classified the resultant dataset would fit Category I of utility for classification and mapping (the data contain sufficient structural, compositional, and site information and photographs to be placed within the standard classification framework).	This 2007 summary report discusses 11 of 77 vegetation transects established in the Chisos Mountains (Boot Canyon – 3 transects, Chisos Mountains Rim – 6 transects, Laguna Meadow – 2 transects) by Dr. Barton Warnock to monitor vegetation change in desert woodland types and were originally sampled in 1955, then re-sampled by him in 1961 and 1968. Fifty-one transects were established in grasslands and are not included in this paper, but are described above. The Chisos Mountains transects described herein are known both as the Warnock sites and as the ESSBA sites. Warnock acquired data the first three readings, Wondzell, Ludwig, and Muldavin relocated each transect and collected coordinates using a GPS receiver (**Appendix 2; Table 2B**), acquired new photographs, and recorded general observation notes in 2007. This study did not result in vegetation classification data, per se. A valuable visual treatment of each transect appears in this document where the 2007 photograph is placed side-by-side with an earlier photograph, usually acquired in 1961. The observations recorded existing disturbance within plots that could be eliminated with management decisions to do so, including relocating hiking trails, informal camp sites, bear-proof storage cabinet, and a composting toilet. Some patches of weedy plant species were introduced by trail construction and use.	As presented, the information would be useful to prepare the historical context, current vegetation impact types, and contribute to local vegetation alliance/plant association descriptions. Chris Lea, NVIP Ecologist, will evaluate in detail a dataset collected from these transects in 2009 by Wondzell and others.
Worthington, Richard. 2002. Inventory of the flora of Big Bend National Park, Brewster County, Texas. First Working Draft. Floristic Inventories of the Southwest Program. El Paso, TX.	III: because the information allowed partial development of a provisional classification to inform the upcoming vegetation inventory and mapping project within BIBE/RIGR.	Dr. Worthington submitted a working draft of plant species known to occur in BIBE/RIGR. The tabular data were divided into families and each taxa was described by scientific name and author, common name, and known location within the Parks. Listed were 73 species of lichens, liverworts, and bryophytes and 1,013 species of vascular plants (including club mosses and ferns and fern allies).	With updates by the focused inventory of the Dead Horse Mountain area described above, it performed the basis of the plant species list for the Study Plan (NPS-BIBE/RIGR 2010), the field data collection manual, the provisional list of vegetation alliances and plant associations, and will be included in the project final report and geodatabase.

Research Title and Date	Utility Category	Discussion	Recommendations
Young, K., S. Schrader, G. Roemer, C. Caldwell, K. Boykin, H. Reiser, and A. Ernst. 2007. Early detection of invasive species in Big Bend National Park: Remote Sensing and Geographic Information System Strategies. New Mexico Fish and Wildlife Research Unit, Department of Fishery and Wildlife Science, Center for Applied Spatial Ecology, and National Park Service, Chihuahuan Desert Network. Las Cruces, NM.	III: because the information allowed development of photo-signatures where the polygons were sufficiently large and updates to the provisional vegetation alliance/plant association list occurred to inform the upcoming vegetation classification and mapping project within BIBE/RIGR.	This recent GIS research study evaluated the efficacy of using remotely sensed and GIS data as tools to support early detection of invasive plant species occurring within BIBE/RIGR. Four objectives were explored: (1) identify a subset of invasive plant species that occur within BIBE/RIGR that may be useful for landscape scale modeling; (2) create spatially explicit models of predicted distributions of targeted species using remotely sensed and GIS data; (3) conduct a risk assessment of areas for invasive plant incursion; and (4) conduct computer simulations of common field sampling designs to evaluate efficient ground survey methods to detect invasive species in BIBE/RIGR. Eight invasive plant species were selected for predictive modeling: giant reed (*Arundo donax*), Bermuda grass (*Cynodon dactylon*), Lehmann's lovegrass (*Eragrostis lehmanniana*), horehound (*Marrubium vulgare*), buffelgrass (*Pennisteum ciliare*), Russian-thistle (*Salsola kali*), Johnson grass (*Sorghum halepense*), and salt-cedar (*Tamarix* sp.). These species are a concern because they rapidly colonize disturbed areas, out-compete native species, and alter natural processes that further promote invasive species invasions and establishment. Also developed was a predictive model of all eight species combined to investigate areas where management efforts could affect multiple invasive species. Spatial locations on existing known occurrences in BIBE/RIGR were provided by Park staff, including present and historic plant locations from opportunistic sightings and planned roadside surveys from 2001 to present. Additional ground surveys were conducted in 2006 throughout BIBE to ascertain undocumented locations of target species populations. A systematic (opportunistic) sampling approach was used to optimize chances of detecting previously unknown invasive plant populations. Roads and trails were systematically surveyed throughout BIBE; arroyos, springs, and cross-country surveys were also conducted as appropriate. A total of 1,464 invasive plant locations were documented for the eight species of interest and UTM coordinates were acquired (**Appendix 2; Table 2C**). The number of occurrence points used to generate individual species models ranged from 26-627, however small sample sizes (< 50 occurrences) occurred with giant reed, horehound, and Russian thistle. The influence of small sample sizes on model performance and variable selection was unknown.	These nonnative plant species locations will provide a layer in the project geodatabase, assist development of the potential list of vegetation alliances and plant associations, assist in developing the photo-signatures, and aid in writing local vegetation alliance and plant association descriptions and appropriate sections of the final report. Field crews will be trained to further document invasive plant population locations as practicable within this project.

Research Title and Date	Utility Category	Discussion	Recommendations
Young, K., T. Kamienski, S. Schrader, K. Boykin, and V. Lopez. 2006. Spatial habitat models for bighorn sheep, Barberry sheep, bullfrog, and feral hog in Big Bend National Park. Center for Applied Spatial Ecology, New Mexico Cooperative Fish and Wildlife Research Unit, Department of Fishery and Wildlife Sciences, New Mexico State University. Las Cruces, NM.	III: because the information allowed partial development of the hydrology layer of the gradsect to inform the upcoming vegetation classification and mapping project within BIBE/RIGR.	This spatial habitat model and dataset for selected bighorn sheep and nonnative wildlife species provides locations of water sources in BIBE/RIGR including bullfrog and feral hog habitats of rivers, creeks, streams, pools, seeps, springs, and tinajas. **Appendix 2; Table 2D** provides UTM coordinates for spring and tinaja sites and these data have been considered in developing the gradsect and biophysical units under Task 2.0 of this project. These flowing waters, seeps, springs, and other mesic sites with descriptive information and known UTM coordinates number 307.	These mesic locations will aid in writing local vegetation alliance and plant association descriptions and appropriate sections of the final report, will assist in selection of photo-signatures, and would inform the hydrology layer in the geodatabase.
Bowman, I., PhD. 1911. Vegetation of the Texas Region, 1911. Forest Physiography. John Wiley and Sons. New York, NY.	IV: because the data are general and are not current.	Dr. Bowman created a general vegetation map that provides ten regions statewide: (1) Atlantic Forest Belt; (2) Rocky Mountain Forest; (3) Chaparral; (4) Black Prairie; (5) Bolson Desert Flora; (6) Grand Prairie; (7) Great Plains; (8) Transitional, with Plains, Prairie, and Atlantic Flora; (9) Coast Prairies; and (10) Yucca Belts. BIBE/RIGR is located within the Bolson Desert Flora and Yucca Belts classifications. The projection is unknown.	The map may be used to place the project in context for a regional floristic discussion in the final project report.
Plumb, G. A., PhD. 1988. An algorithmic approach to automated mapping of Big Bend National Park, Texas. Ph.D. Dissertation, University of Kansas, Lawrence Kansas.	III: because sample sites are not adequately geo-referenced and the data are not current.	Gregory A. Plumb, PhD, prepared a classification, combined digital data, and prepared a vegetation map for BIBE during the late 1980s and early 1990s. He subjectively identified vegetation types occurring at 131 sites within BIBE, mostly located along existing roads and trails (TX 385, Brewster County 118, Maverick Road, Ross Maxwell Scenic Drive, Grapevine Hills Road, Dagger Flat Road, Mesa de Anguilla Trail, and Chisos Mountains Trail). A large-scale location map of the subjective identification sites is included in the published paper. Sample sites were located at least 50 meters from the influence of highways or trails and were determined using a systematic stratified sampling approach of different plant communities and varying environmental conditions. Potential vegetation types were determined from the existing literature, field reconnaissance was conducted to locate the named types, and sites selected for sampling. Some additional sites were selected to expand distribution over diverse environmental conditions, particularly 22 soil classes depicting topographic variation. At each site lifeform (trees, shrubs, succulents and semi-succulents, grasses, or forbs) and species components were estimated, however no field forms were available for evaluation. The	The database and descriptions were used to develop the vegetation classification, provide information for local vegetation alliance and plant association descriptions, to the extent practicable to prepare the BIBE/RIGR gradsect consisting of biophysical unit polygons, and to guide photo-signature selection. The vegetation transect data are currently being evaluated for usefulness in the classification task by Chris Lea, NVIP Ecologist.

Research Title and Date	Utility Category	Discussion	Recommendations
		shrub and succulent/semi-succulent life-forms were divided into two height classes (shrubs less than 50 cm or more than 50 cm, approximately 20 inches in height). Plant taxa were identified to genus for characterization of the relative importance to overall vegetative cover, except for *Agave lechuguilla* and *Agave havardiana*, which were treated at the species level. Data were recorded along a group of 25-m long transects oriented parallel to the site slope and covering approximately 600 meters in area (24 m X 25 m). Linear vegetation stands were sampled using transects of 50 meters long covering approximately 300 meters in area. A species list was developed and floristic richness analyzed in the field with a species-area curve. Data recorded for the sample sites included height and cover by taxa. The six-class cover scale used was that created by Daubenmire in 1959 (0-5%, 5%-25%, 25%-50%, 50%-75%, 75%-95%, 95%-100%). Cluster analysis was used to create dendrograms separating vegetation types. Twenty vegetation cover types were thus determined and descriptions provided: (1) Larrea Flats; (2) Larrea-Agave; (3) Larrea-Gramineae; (4) Agave-Bouteloua-Opuntia; (5) Agave-Flourensia; (6) Larrea-Yucca-Bouteloua; (7) Chilopsis; (8) Prospis Thicket; (9) Populus Grove; (10) Agave-Bouteloua; (11) Agave-Bouteloua-Viguiera; (12) Dasylirion-Agave-Bouteloua; (13) Dasylirion-Nolina; (14) Agave-Bouteloua-Euphorbia; (15) Mixed Scrub; (16) Quercus Scrub; (17) Mixed Quercus; (18) Pinus-Juniperus-Gramineae; (19) Pinus-Quercus-Juniperus; (20) Stipa Meadow.	
Plumb, G. A., PhD. 1993. Vegetation classification of Big Bend National Park, Texas. The Texas Journal of Science 44:375-386.	III: because the data are not current.	Dr. Plumb's vegetation map classification included one map unit for no data, two land use units (bare and water), and 26 vegetation map units prepared at the physiognomic level to some vegetation alliance levels of the NVC: (1) cottonwood grove; (2) creosote flats; (3) creosote-grass; (4) creosote-lechuguilla-prickly-pear; (5) creosote-lechuguilla; (6) creosote-tarbush; (7) creosote-yucca-grass; (8) desert willow; (9) forest meadow; (10) lechuguilla-grass; (11) lechuguilla-grass-candelilla; (12) lechuguilla-grass-hechtia; (13) lechuguilla-grass-viguiera; (14) mesquite thicket; (15) mixed oak; (16) mixed riparian; (17) mixed scrub; (18) oak scrub: (19) oak-ponderosa pine-cypress; (20) pinyon-juniper-grass; (21) pinyon-oak-juniper; (22) pinyon-talus; (23) reed grass; (24) sotol-lechuguilla-grass; (25) sotol-nolina-grass; and (26) yucca-sotol. The classification was developed following a literature review of vegetation studies encompassing BIBE/RIGR up to the early 1990s and refined using a quantitative assessment of field data obtained over 131 sites within the Park.	This map was used to prepare the BIBE/RIGR gradsect consisting of biophysical unit polygons and to prepare the project sampling plan to guide field crews.

Research Title and Date	Utility Category	Discussion	Recommendations
		Dr. Plumb used LANDSAT imagery, elevation, aspect, and slope derived from DEMs, soils, panchromatic ortho-photography, and color infrared photography to produce a digital elevation map of BIBE/RIGR in 1993; the original map he developed was created in MOSS GIS software in 1987. The 1993 digital elevation map and classification/map units were condensed into vegetation types during preparation of the BIBE Fire Management Plan (2005). Six vegetation types and one unvegetated type were prepared from the Plumb (1993) dataset (**Appendix 2; Figure 2E**): (1) forest; (2) grassy woodland; (3) shrub woodland; (4) high desert grassland; (5) floodplain/upland riparian; (6) desert scrub; and (7) bare (unvegetated from a fire management viewpoint). Each of these vegetation types is described in the BIBE Fire Management Plan (2005). Data within the Plumb (1993) vegetation map are believed to be accurate within the original 30-meter pixel resolution of the LANDSAT and other data used to produce the original map. Actual accuracy of each analysis component and detailed information on the horizontal accuracy is discussed extensively in his PhD dissertation; it ranges from 65%-75%. The majority of map errors occurred between vegetation cover types that were similar in terms of structure and species dominance. Actual accuracy of each vegetation cover type is discussed extensively in the dissertation that produced the map. The map is best used for graphic purposes (i.e., research, etc.); the supporting data are considered adequate for landscape level analysis. The original database is now about 20 years old and fires, floods, drought, and natural vegetation changes may have substantially affected small or specific areas of BIBE/RIGR.	
Whitefield, M. P. 1990. The vegetation of the north Rosillos Mountains area, Big Bend National Park, Texas. 26 p.	III: because the data are not current.	Mr. Whitefield prepared a vegetation classification for BIBE/RIGR in 1990, within the text of an uncompleted thesis (*Vegetation of the North Rosillos Mountains Area of BIBE*) for the Master's degree at an unknown college. Doug Bradley of NPS subsequently prepared the vegetation coverage for BIBE using the Whitefield classification and GRASS software. Thirteen landforms and vegetation types identified and mapped during these studies are: (1) alkaline grassland; (2) arroyo scrub; (3) canyon scrub; (4) creosote scrub; (5) grama grassland; (6) mariola scrub; (7) mesquite scrub; (8) mixed scrub and succulent scrub; (9) mosaic of semidesert grassland, mariola, and lechuguilla scrub; (10) mountain scrub; (11) oak woodland; (12) riparian; and (13) semidesert grassland – igneous substrate.	These data were used to develop the gradsect, BPUs, and sampling plan and may be useful to provide information for descriptions of vegetation alliances/plant associations.

Research Title and Date	Utility Category	Discussion	Recommendations
Wood, S., G. Harper, E. Muldavin, and P. Neville. 1999. Final report: vegetation map of the Sierra del Carmen, U.S.A. and Mexico. Unpublished report to the National Park Service, Big Bend National Park, Texas.	V: because the data are not available for assessment.	The authors prepared a vegetation map and report for the Sierra del Carmen (Dead Horse Mountains or Sierra del Caballo Muerto) area of BIBE/RIGR.	The data would potentially be useful to inform gradsect preparation and development of BPUs, aid in developing the field sampling plan, and provide information for descriptions of vegetation alliances/plant associations.

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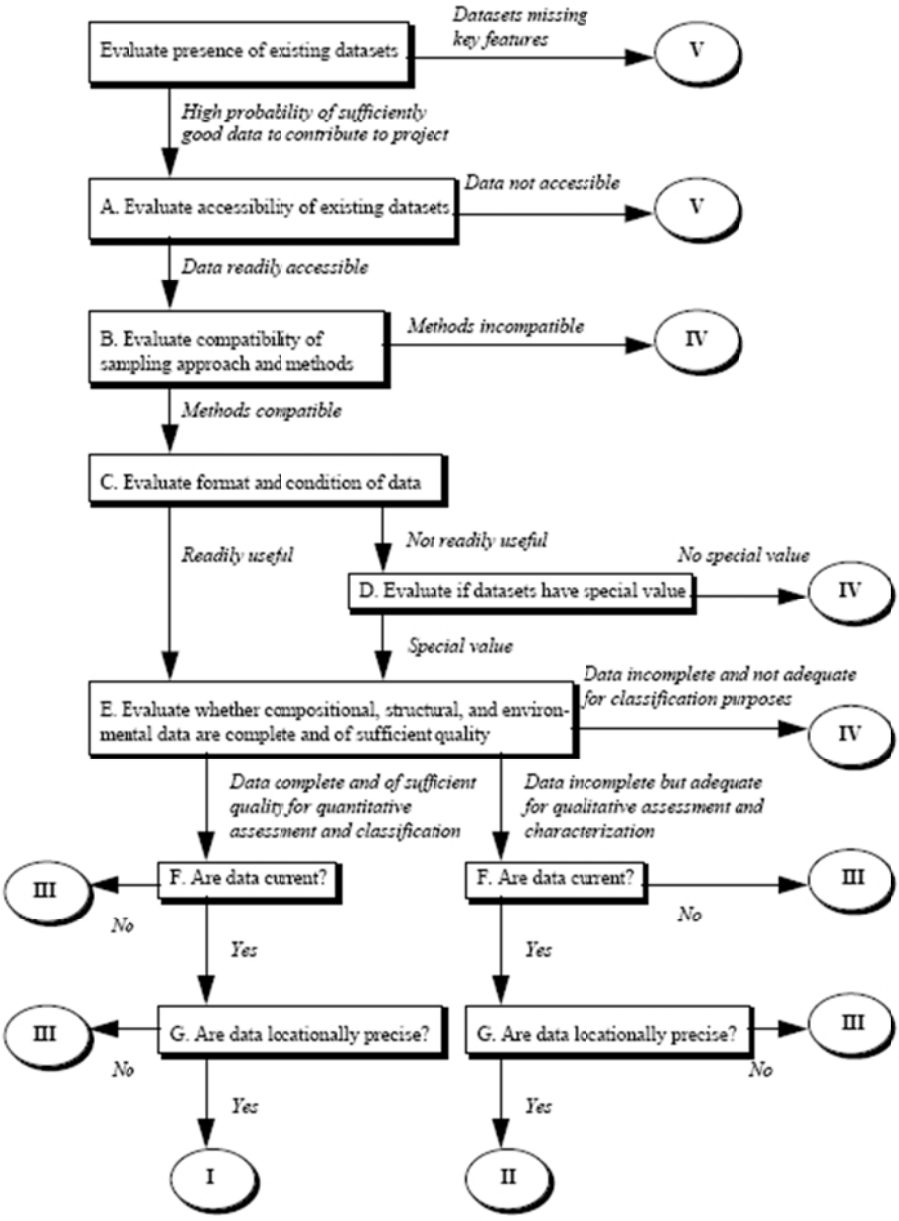
Appendix 1: Evaluating Existing Datasets

Figure 1-1 presents a step-by-step process to evaluate existing datasets according to seven components for their utility in vegetation mapping. Starting from the top of the figure, datasets are assessed and placed into appropriate categories of utility, which are characterized in table 1.

Each step of the process, as it is linked to the seven factors, is further described below.

Figure 1-1. Flow Chart for Evaluating Existing Datasets



Categories of Utility for Existing Data Sets.

Category Description

I. Samples are adequate for classification and mapping (i.e., the data are geo-referenced, represent existing vegetation, and contain sufficient structural, compositional and site information to place the sample within the standard classification framework).

II. Data are adequate to assist in photo interpretation, photographic signature key development, or map accuracy assessment (i.e., the vegetation and site information are of lower quality, but the samples represent existing vegetation and are geo-referenced with reasonable confidence).

III. Data can be used for vegetation classification and characterization of a vegetation type within the park, but not for mapping or analysis because the sample is not adequately geo-referenced, contains inadequate detail in the vegetation information, and/or may not represent existing vegetation at the sample location.

IV. Data set was assessed and not found to be useful at any level.

V. Data set was not available for assessment.

Appendix 2: Support Datasets and Maps Providing Vegetation Classification and Location Information within Big Bend National Park and Rio Grande National Wild and Scenic River

Table 2-1. Soils Map Units and Representative Plant Species in Big Bend National Park (Source: Cochran and Rives [USDA-SCS] 1985).

BIBE Soil Map Units	Diagnostic Plant Species
Brewster-Rock Outcrop Complex, Very Steep (BRG)	Mexican pinyon pine, oak species, juniper species, Texas madrone, mountain mahogany, sotol, evergreen sumac, littleleaf sumac, skeletonleaf goldeneye, sideoats grama, cane bluestem, threeawn species
Chamberino Very Gravelly Loam, Undulating (CHC)	Creostebush, dog cacti, lechuguilla, ocotillo, fluffgrass, threeawn species, slim tridens, chino grama
Chamberino Very Gravelly Loam, Rolling (CHD)	Creosotebush, dog cacti, lechuguilla, leatherstem, prickly pear, range ratany, chino grama, threeawn species, fluffgrass, slim tridens
Chilicotal Very Gravelly Fine Sandy Loam, Undulating (CLC)	Chino grama, lechuguilla, sotol, creosotebush, tarbush, ocotillo, prickly pear, skeletonleaf goldeneye, mariola, threeawn species, bush muhly, plains bristlegrass, Arizona cottontop, plains blackfoot, paperflower, black grama
Chilicotal-Monterosa Association, Rolling (CMD)	Sotol, ceniza, chino grama, ocotillo, lechuguilla, whitethorn acacia, mariola, prickly pear, ephedra, skeletonleaf goldeneye, guayacan, red grama, sideoats grama
Ector-Rock outcrop Complex, Steep (ERF)	Sideoats grama, black grama, slim tridens, green sprangletop, muhly species, sotol, juniper species, giant yucca species, Mexican pinyon pine
Glendale-Harkey Association, Occasionally Flooded (GHA)	Salt cedar, mesquite, cottonwood, willow, tree tobacco, whitebrush spiny aster, Bermuda grass, common reed, giant reed
Hurds very gravelly sandy loam, rolling (HRD)	Mexican buckeye, foothills basketgrass, littleleaf leadtree, Apache plume, juniper species, sotol, catclaw acacia, century plant, little bluestem, hairy grama, cane bluestem, Mexican pinyon pine, Texas madrone
Hurds Very Cobbly Loam, Steep (HRF)	Mexican pinyon pine, redberry juniper, Gambel oak, catclaw acacia, footthill basketgrass, Mexican sagewort, wolftail, deer muhly, bracken fern, little bluestem, hairy grama, cane bluestem, Texas madrone
Lajitas-Rock Outcrop Complex, Hilly (LAE)	Lechuguilla, leatherstem, skeletonleaf goldeneye, prickly pear, ocotillo, ceniza, ephedra, feather dalea, sotol, guayacan, yucca species, chino grama, tanglehead, sideoats grama, black grama, fluffgrass, cane bluestem, threeawn species
Lajitas-Rock Outcrop Complex, Steep (LAF)	Lechuguilla, skeletonleaf goldeneye, ratany species, leatherstem, prickly pear, ceniza, feather dalea, chino grama, tanglehead, threeawn species, black grama, sideoats grama
Liv-Mainstay-Rock Outcrop Complex, Steep (LMF)	Mexican pinyn pine, gray oak, Graves oak, Emory oak, Chisos red oak, drooping juniper, oneseed juniper, alligator juniper, Texas madrone, green ash, bigtooth maple, evergreen sumac, littleleaf sumac, agave, sotol, lechuguilla, prickly pear, skeletonleaf goldeneye, whitethorn acacia, sideoats grama, cane bluestem, buffalograss, green sprangletop, dropseed species, fluffgrass
Lozier-Rock Outcrop Complex, Steep (LRF)	Sideoats grama, slim tridens, chino grama, tanglehead, threeawn species, lechuguilla, sotol, false agave, leatherstem, candelilla, skeletonleaf goldeneye, resurrection plant
Lozier-Rock Outcrop Complex, Very Steep (LRG)	Black grama, chino grama, sotol, lechuguilla, yucca species, mariola, candelilla, resurrection plant, flase agave
Mariscal-Rock Outcrop Complex, Hilly (MRE)	Lechuguilla, candelilla, leatherstem, creosotebush, resurrection plant, skeletonleaf goldeneye, ephedra, cacti, chino grama
Pajarito-Augustin Association, Gently Sloping (PAA)	Creosotebush, lechuguilla, tasajillo, prickly pear, dog cacti, mariola, chino grama, threeawn species
Pantera Very Gravelly Sandy Loam, Frequently Flooded (PNA)	Desert willow, Texas persimmon, whitethorn acacia, creosotebush, threeawn species, dropseed species, fluffgrass, ocotillo, dog cacti, catclaw acacia, lechuguilla

BIBE Soil Map Units	Diagnostic Plant Species
Puerta-Madrone Complex, Steep (PRF)	Mexican pinyon pine, Arizona cypress, juniper species, oak species, quaking aspen, fir, Junegrass, pine dropseed, finestem needlegrass, pinyon ricegrass, muhly species
Riverwash (RVW)	Unvegetated channel or annual grasses and forbs
Solis-Chamberino Association, Gently Undulating (SCB)	Creosotebush, tasajillo, mesquite, fourwing saltbush, lechuguilla, whitethorn acacia, sand dropseed species, twoflower trichloris, Arizona cottontop, cane bluestem, sixweeks grama
Solis-Rock Outcrop Complex, Rolling (SRD)	Creosotebush, dog cacti, whitethorn acacia, tasajillo, annual grasses and forbs, false grama, fluffgrass, threeawn species
Terlingua-Mariscal Association, Hilly (TAE)	Lechuguilla, ephedra, yucca species, skeletonleaf goldeneye, mariola, chino grama, fluffgrass, black grama, threeawn species
Terlingua-Rock Outcrop Complex, Hilly (TLE)	Lechuguilla, ocotillo, skeletonleaf goldeneye, leatherstem, range ratany, feather dalea, whitethorn acacia, fluffgrass, chino grama, tanglehead, false grama, threeawn species, bush muhly, slim tridens
Tornillo Loam, Occasionally Flooded (TOA)	Creosotebush, mesquite, lechuguilla, mariola, fourwing saltbush, tasajillo, tobosa, burrograss, fluffgrass, threeawn species, six-weeks grama
Upton-Nickel Association, Undulating (UNC)	Creosotebush, lechuguilla, mariola, ceniza, candelilla, dog cacti, prickly pear, ephedra, chino grama, threeawn species, fluffgrass, slim tridens, six-weeks grama
Vieja-Badland Complex, Rolling	Creosotebush, fluffgrass, dog cacti, six-weeks grama, annual forbs

Table 2-2. ESSBA Chisos Mountains Woodland Plot Location Information. Datum is NAD27 CONUS (Source: Wondzell et al. 2007).

Plot ID	Location Type	Location (hddd°mm'ss.s")	Elevation (ft)
11001-0	zero-end rebar	N29 14 39.0 W103 17 38.1	6818
11001-0 2	zero-end rebar - second reading	N29 14 38.7 W103 17 37.8	6748
11001-20	20’ end-rebar	N29 14 38.8 W103 17 37.9	6780
11002-0	zero-end rebar	N29 14 42.2 W103 17 39.6	6719
11002-0 2	zero-end rebar - second reading	N29 14 42.1 W103 17 39.6	6706
11002-20	20’ end-rebar	N29 14 42.0 W103 17 39.2	6710
11003-0	zero-end rebar	N29 14 42.7 W103 17 41.0	6736
11003-20	20’ end-rebar	N29 14 42.6 W103 17 40.7	6678
11004-0	approx zero-end	N29 14 07.7 W103 17 33.5	7410
11004-20	20’ end-rebar	N29 14 08.0 W103 17 33.6	7414
11005-0	approx zero-end	N29 14 12.1 W103 17 18.9	7474
11006-0	approx zero-end	N29 13 42.8 W103 17 48.9	7294
11006-OAK	approx direction to end	N29 13 43.1 W103 17 48.9	7300
11007-0	approx zero-end	N29 13 45.6 W103 17 50.0	7268
11007-END	approx 20’ end	N29 13 45.8 W103 17 49.9	7208
11008-0	approx zero-end	N29 13 32.2 W103 17 55.4	7321
11008-20	20’ end-rebar	N29 13 31.9 W103 17 55.4	7316
11009-0	approx zero-end	N29 13 34.2 W103 18 07.8	7288
11009-END	approx 20’ end	N29 13 33.9 W103 18 07.7	7232
11010-0	zero-end rebar	N29 14 43.8 W103 18 48.9	6697
11010-20	20’ end-rebar	N29 14 43.9 W103 18 48.7	6695
11011-0	zero-end rebar	N29 14 39.0 W103 18 44.1	6619
11011-END	approx direction to end	N29 14 38.9 W103 18 46.7	6660

Table 2-3. Coordinates (Datum is UTM, NAD 83, Zone 13) of Invasive Plant Occurrences in Big Bend National Park Used to Model Potential Distribution within the Park (Source: Young et al. 2007).

Giant Reed (*Arundo donax*)

UTM E	UTM N	UTM E	UTM N	UTM E	UTM N	UTM E	UTM N
693719	3226042	694916	3229543	656800	3212934	642217	3224830
692370	3223860	643789	3223034	658755	3211669	666118	3209855
687917	3219932	643690	3222621	666035	3209892	664820	3211292
697200	3230351	643689	3224073	667098	3209018	664668	3211015
701058	3231395	677030	3207484	664675	3210973	664578	3210764
702421	3231880	684458	3214381	662573	3212344	662727	3212458
702828	3232316	652502	3215071	636500	3225746	667094	3209013
694761	3229307	654566	3213321	634296	3226972		

Bermuda Grass (*Cynodon dactylon*)

UTM E	UTM N	UTM E	UTM N	UTM E	UTM N	UTM E	UTM N
693719	3226042	636500	3225746	664216	3239914	653350	3229776
688562	3222636	634296	3226972	664672	3239540	653233	3231751
697200	3230351	642217	3224830	666035	3209892	657666	3233079
694244	3229226	647075	3225591	667098	3209018	658102	3232942
694916	3229543	647296	3225679	662573	3212344	658473	3237823
692810	3237831	644158	3231762	662491	3214058	658430	3239592
690842	3240497	668912	3275463	636500	3225746	656863	3244080
691435	3244017	668798	3275186	634296	3226972	635930	3227055
685479	3254672	670701	3275768	642217	3224830	635960	3226681
685684	3254887	672374	3274544	647075	3225591	636113	3226663
679184	3228840	668415	3273209	647296	3225679	636117	3226511
698202	3229814	664519	3271428	644158	3231762	636108	3226441
681097	3239612	677475	3280634	668912	3275463	636169	3226410
665090	3239100	680757	3277082	668798	3275186	636657	3225979
664855	3239499	680058	3276007	670701	3275768	636997	3225678
664548	3240018	679182	3275198	672374	3274544	638030	3225857
662241	3240362	676697	3277818	668415	3273209	638265	3225914
663107	3239713	674205	3275632	664519	3271428	639054	3226611
664216	3239914	669803	3273897	677475	3280634	665228	3239203
658438	3239587	666118	3209855	680757	3277082	664904	3238913
649164	3226355	664820	3211292	680058	3276007	664715	3239601
644526	3223702	664668	3211015	679182	3275198	698259	3230836
642936	3235438	664578	3210764	676697	3277818	656000	3244218
641931	3232807	662727	3212458	674205	3275632	678219	3234907
635648	3230555	658438	3239587	669803	3273897	643811	3224086
643789	3223034	649164	3226355	666118	3209855	674197	3275623
643690	3222621	644526	3223702	664820	3211292	697986	3229919
643661	3222346	642936	3235438	664668	3211015	697898	3230056
643689	3224073	641931	3232807	664578	3210764	697216	3230267
669669	3247393	635648	3230555	662727	3212458	697170	3230369
669383	3247032	643789	3223034	667094	3209013	673957	3245793
664188	3254031	643690	3222621	679183	3228766	674049	3245748
677030	3207484	643661	3222346	702211	3232074	669159	3246161
652502	3215071	669669	3247393	680549	3255632	673675	3244582
656800	3212934	669383	3247032	668183	3273203	673603	3244808
684458	3214381	643689	3224073	679986	3253125	673908	3245286
658755	3211669	664188	3254031	677214	3280789	673730	3245363
660936	3214774	677030	3207484	645650	3225500	662491	3214058
664672	3239540	684458	3214381	668529	3247099	660936	3214774
666035	3209892	652502	3215071	668361	3247272	674264	3275647

667098 3209018 656800 3212934 662198 3246450 662573 3212344
658755 3211669 661806 3246334

Russian Thistle (*Salsola kali*)

UTM E	UTM N	UTM E	UTM N	UTM E	UTM N	UTM E	UTM N
644150	3223548	672372	3274928	680073	3276533	676530	3276189
647256	3220171	672374	3274544	675738	3276992	679866	3278215
647733	3220102	668415	3273209	677557	3276601	660161	3246165
652502	3215071	662311	3269577	676512	3276185	664633	3271463
654566	3213321	663765	3271321	676697	3277818	665356	3239440
664672	3239540	663728	3271492	674205	3275632	665167	3239217
642887	3234776	664519	3271428	674307	3274274	655559	3244254
668912	3275463	664588	3271791	670059	3273791	668198	3273235
668934	3275280	678558	3279736	669803	3273897	669367	3275439
679600	3277834	668130	3273340				

Horehound (*Marrubium vulgare*)

UTM E	UTM N	UTM E	UTM N	UTM E	UTM N	UTM E	UTM N
664855	3239499	673787	3244623	674027	3245062	665044	3239114
664548	3240018	673694	3244595	664688	3239670	665065	3239142
672147	3249787	673843	3244304	664939	3239769	665037	3239133
669383	3247032	673538	3244681	664986	3239763	665070	3239051
664672	3239540	673599	3244895	664920	3239860	665135	3239077
663756	3271593	673690	3244954	664883	3239860	664688	3239510
674137	3245016	664848	3239913				

Lehmann's Lovegrass (*Eragrostis lehmanniana*)

UTM E	UTM N	UTM E	UTM N	UTM E	UTM N	UTM E	UTM N
664548	3240018	669562	3246102	657815	3241820	645159	3242063
664216	3239914	676910	3281565	658380	3240629	644865	3242312
666618	3248847	679852	3277951	658438	3240619	646016	3241460
663028	3246510	681808	3264836	658484	3240182	646145	3241517
659497	3246146	681139	3263079	674260	3245711	646139	3241466
658589	3245978	682023	3265730	674338	3245669	646367	3241553
662027	3240388	679798	3277271	674565	3245519	646811	3241928
660282	3240538	651418	3227581	675044	3245136	647534	3242368
659679	3240140	668952	3246734	675265	3244885	648100	3243391
658530	3233068	665848	3248940	675337	3244795	652142	3245028
655178	3235063	665755	3248864	675559	3244478	655398	3244260
644526	3223702	662602	3246445	676169	3243089	674169	3245790
654990	3244534	662367	3246463	667043	3240691	669276	3246350
647826	3243030	662318	3246467	666938	3240502	669225	3246331
680702	3259541	662242	3246454	666513	3239578	645446	3241430
673006	3253716	661144	3246107	666507	3239628	676950	3241353
672682	3252897	657342	3245107	666318	3239726	677067	3241244
671925	3249385	657515	3245222	666183	3239787	677496	3240837
671510	3248693	675425	3275904	666071	3239743	677628	3240715
669669	3247393	652690	3229115	665211	3239122	677734	3240615
664521	3254874	652737	3229089	665059	3239011	677849	3250396
664417	3254473	652995	3229206	665140	3239217	678160	3280118
664188	3254031	653340	3229722	664921	3239969	674099	3245688
666025	3251328	653360	3229950	664746	3239527	674012	3245771
670607	3245401	653327	3230299	680692	3262665	669140	3246124
670179	3244957	653229	3230457	680665	3262579	668916	3243970
669581	3244884	653387	3231228	680685	3261799	669037	3244355

670222	3245276	653293	3231687	680596	3260362	668738	3243474
670272	3245518	653300	3231865	680526	3257390	668348	3242073
670646	3245952	653343	3231972	680423	3256739	668305	3241977
655897	3244849	653806	3232985	680370	3256089	667761	3241625
656363	3243360	654018	3233240	680317	3255950	668420	3242131
661484	3246207	656003	3233606	680310	3255764	668459	3242627
660116	3245915	656590	3233569	680357	3255780	668512	3242742
663599	3247146	656854	3233555	680357	3255478	668550	3242848
665212	3248391	656925	3233505	680360	3254403	668671	3243084
667217	3248157	657170	3233374	680038	3253717	668719	3243238
674663	3251500	657793	3233082	680018	3253601	668825	3243503
680571	3258222	657663	3234652	679992	3253129	668887	3243590
668038	3266517	657787	3234994	679955	3252897	669051	3244148
666111	3266863	657824	3234980	679988	3252837	669118	3244384
680644	3261430	657840	3235011	679603	3251961	669147	3244456
676512	3276185	657864	3235078	679600	3251882	669252	3246208
680347	3255636	657827	3235162	678771	3250853	669814	3247475
673573	3246020	657988	3235950	678021	3250468	674225	3245585
673134	3246143	658028	3236090	677460	3250180	673831	3244744
672989	3246164	658125	3236432	675536	3248856	673706	3244641
672927	3246171	658206	3236647	675443	3248793	673670	3244589
672257	3246240	658166	3232928	675247	3248600	673778	3244606
672098	3246243	658110	3237069	675187	3248361	673791	3244639
671949	3246233	658427	3237763	675187	3248222	673814	3244733
671279	3246160	658470	3237783	674736	3246381	673836	3244266
670913	3246109	658404	3238080	674208	3245727	673608	3244749
670744	3246088	658434	3238087	674238	3245770	673637	3244808
670415	3246064	658483	3239549	684300	3237588	673580	3244806
669908	3246071	658444	3239473	681995	3238820	673796	3244893
670101	3246005	657006	3244676	690153	3233414	673701	3244914
670664	3246043	657023	3244590	689458	3233814	673999	3245375
670903	3246064	656987	3244465	688273	3234650	673711	3245287
673428	3246008	657042	3244468	687496	3235191	673711	3245219
674136	3245725	657528	3243255	686316	3236025	673747	3245162
669424	3246230	657662	3242619	645417	3241613	674113	3245039
669307	3246326	657659	3242550	645378	3241886	674082	3245081
673965	3245060						

J**ohnson Grass (*Sorghum halepense*)**

UTM E	UTM N	UTM E	UTM N	UTM E	UTM N	UTM E	UTM N
678257	3234919	670570	3273395	658072	3236261	680386	3256544
698202	3229814	672768	3274299	658112	3236372	680320	3255926
658589	3245978	672692	3274360	658075	3236463	680313	3255737
635648	3230555	679684	3278674	658146	3233626	680307	3255641
643689	3224073	679698	3278538	656876	3244054	680337	3255177
680702	3259541	679839	3277829	656944	3243689	680675	3255887
677030	3207484	679784	3278320	657773	3241986	680413	3254977
684458	3214381	679602	3279015	658168	3241105	680446	3254871
636500	3225746	676766	3281952	636527	3226018	693975	3231236
634296	3226972	681487	3264278	637921	3225831	653662	3245555
693924	3231447	681376	3263984	638291	3225927	678115	3234816
680571	3258222	681839	3265172	638383	3225914	678193	3234889
671379	3275218	681760	3267929	666567	3239534	664284	3271889
672374	3274544	680456	3272842	665970	3239703	668226	3273301
668415	3273209	679798	3276635	665110	3239200	667767	3273267

667826	3273195	650109	3226120	665282	3239645	681163	3258496
662494	3268680	649164	3226364	665120	3239774	680259	3255398
662311	3269577	650667	3226716	665053	3239763	698216	3231579
663180	3269124	668552	3247077	665053	3239655	680592	3258892
663765	3271321	663656	3247157	664874	3239581	670549	3273435
663800	3271685	663563	3247054	664688	3239723	696871	3230401
663239	3271324	675530	3275852	664833	3239473	696973	3230393
664519	3271428	674736	3275713	664897	3239733	643737	3224137
680056	3278063	674264	3275611	665059	3239922	644142	3223921
679600	3277834	674238	3275615	665329	3239507	644175	3223805
680757	3277082	672728	3274261	665302	3239372	669288	3246377
680058	3276007	672692	3274223	665336	3239338	652899	3245512
680073	3276533	670047	3273770	680605	3260542	680485	3261178
679182	3275198	670410	3273391	680718	3259855	682183	3265932
677557	3276601	670028	3273470	680632	3258647	698648	3229704
674205	3275632	668398	3273101	680559	3258206	674303	3245599
674307	3274274	667794	3273034	680559	3258375	673705	3244937
670059	3273791	697782	3231319	680509	3258571	665021	3239150
692262	3233744	698016	3231456	680529	3257751	676167	3250977
653830	3233015	680556	3257154	680345	3255602	657800	3235037
680529	3256985	680329	3255642	657830	3235208	680493	3257134
667674	3273170	657934	3235752	680433	3256849		

Buffelgrass (*Pennisteum ciliare*)

UTM E	UTM N	UTM E	UTM N	UTM E	UTM N	UTM E	UTM N
696940	3231888	656737	3233585	673768	3244666	690423	3233119
692901	3237006	657093	3233367	673771	3244667	690424	3233118
692810	3237831	657083	3233324	673770	3244666	690426	3233119
679184	3228840	656948	3233190	673770	3244666	690425	3233118
692141	3225509	657344	3233072	673771	3244666	690425	3233115
698313	3231548	657549	3233082	673772	3244667	690445	3233124
695905	3232036	657669	3234685	673771	3244668	690447	3233121
659497	3246146	658028	3236315	673770	3244667	690450	3233121
649164	3226355	658427	3237813	673771	3244670	690448	3233119
644526	3223702	658427	3237899	673770	3244669	690451	3233086
644480	3240027	658467	3237743	673770	3244669	690474	3233066
642840	3238053	658460	3240035	673771	3244671	690472	3233067
642936	3235438	656886	3244077	673770	3244667	690491	3233033
642871	3233815	656899	3243953	673768	3244669	690493	3233034
643081	3233103	656860	3243959	673764	3244672	690491	3233031
641436	3232265	657258	3243428	673767	3244673	690490	3233032
641931	3232807	657545	3243314	673768	3244674	690510	3233035
635708	3230803	657678	3242978	673764	3244671	690518	3233031
635648	3230555	657662	3242684	673764	3244669	690512	3233029
677487	3226669	657642	3242374	673763	3244674	690526	3233016
679770	3218514	657642	3242270	673774	3244658	690529	3233011
681750	3217867	658477	3240097	673775	3244660	690526	3233010
684139	3217158	635938	3227661	673773	3244662	690565	3232989
644803	3225007	635847	3227530	673736	3244656	690567	3232985
647390	3223929	635851	3227474	673749	3244643	690564	3232985
647256	3220171	635912	3227278	673744	3244639	690544	3233005
660156	3213096	635956	3227282	673746	3244639	690541	3233006
660936	3214774	635943	3227129	673747	3244643	690538	3233007
664672	3239540	636087	3226637	679578	3237928	690538	3233008
686112	3220784	636108	3226550	679578	3237928	677282	3226455

684423	3216999	636161	3226254	679578	3237927	677200	3226340
673106	3215062	636261	3226227	679571	3237930	674533	3224197
670725	3213643	636422	3226049	679569	3237927	674536	3224185
667876	3211500	637076	3225700	679570	3237927	674557	3224081
668967	3212369	637651	3225905	679571	3237928	674555	3224080
669177	3213212	638108	3225892	679572	3237928	674554	3224081
666481	3213208	638540	3226027	679572	3237929	674554	3224078
666088	3215215	639272	3226968	679570	3237927	674552	3224081
663911	3214728	639921	3226899	679572	3237928	674552	3224083
636500	3225746	640034	3226794	679573	3237927	674550	3224080
634296	3226972	640239	3226737	679579	3237932	674563	3224077
635888	3227643	640431	3226742	679573	3237929	674563	3224080
638118	3225923	640792	3226406	679573	3237929	674563	3224079
643326	3225139	640849	3226302	679572	3237928	674565	3224078
641723	3227427	640954	3226275	664546	3239641	674567	3224075
641723	3227427	640954	3226275	664546	3239641	674567	3224080
638552	3226200	641045	3226145	664547	3239638	674567	3224079
647075	3225591	641564	3226005	664549	3239633	674568	3224080
647296	3225679	641629	3225835	664550	3239632	674443	3223379
642832	3233335	641764	3225413	664553	3239631	675510	3224930
642887	3234776	641947	3225291	664552	3239630	677259	3226416
642659	3237292	642013	3225217	664551	3239630	677798	3230645
697246	3231242	642509	3224912	664549	3239629	677503	3227393
693924	3231447	642544	3224912	664552	3239628	677215	3226400
691567	3231455	642614	3224864	664556	3239623	677240	3226412
691384	3232396	642653	3224920	664557	3239626	677250	3226404
688339	3235127	642792	3224898	664557	3239630	677240	3226422
680056	3278063	643019	3224842	664556	3239630	677228	3226425
679600	3277834	643089	3224724	664555	3239630	677239	3226430
675738	3276992	644087	3224010	664556	3239632	677233	3226378
677557	3276601	644217	3223879	664554	3239633	677239	3226379
693202	3231105	680665	3262552	664555	3239633	677216	3226372
692930	3231926	680596	3260409	664554	3239634	689551	3233757
692433	3232489	680692	3258551	664553	3239634	688815	3234304
692262	3233744	680615	3257512	664556	3239641	688815	3234305
691810	3234470	680562	3257260	664555	3239641	688813	3234305
677255	3226430	680360	3256464	664557	3239642	688813	3234304
667742	3211344	680360	3254513	664557	3239643	688811	3234306
670732	3213621	680068	3253979	664557	3239641	688810	3234308
669109	3213202	697538	3231331	664560	3239641	688809	3234309
698309	3231550	697492	3231418	664560	3239642	688808	3234308
698406	3231539	697251	3231800	664559	3239643	688811	3234305
701135	3231735	697141	3231875	664570	3239620	688818	3234304
701703	3231668	696782	3232062	664572	3239619	688819	3234303
701791	3231637	696782	3232095	664576	3239616	688820	3234301
701818	3231280	696487	3232093	664578	3239623	688820	3234303
701944	3231625	694881	3231390	664574	3239639	658512	3245899
702120	3232089	694583	3231364	664581	3239639	673862	3244361
702211	3232074	694534	3231323	664580	3239638	657921	3245180
676167	3250977	692159	3230856	664580	3239642	657882	3245196
680346	3255529	692139	3230972	664584	3239643	657847	3245210
680345	3255716	691841	3231264	664584	3239642	657531	3245254
644595	3224083	691685	3231546	664585	3239640	657454	3245212
644579	3224142	691490	3231787	664585	3239641	657373	3245132
644675	3224676	691474	3231905	664587	3239640	657357	3245106
644919	3224811	691382	3232044	664599	3239613	657343	3245082

645048 3224852 691133 3232459 664601 3239613 657327 3245066
645092 3224815 690692 3233003 664619 3239580 657306 3245020
645314 3224984 689753 3233660 664617 3239577 657296 3245007
645623 3225417 689561 3233796 664607 3239592 657071 3244812
646200 3225664 645411 3241673 664607 3239592 657022 3244779
645836 3225707 689271 3233939 664606 3239593 657043 3244792
646342 3225627 645366 3241919 664603 3239593 656899 3244672
646370 3225454 646355 3241604 664603 3239591 656879 3244657
646777 3225204 647033 3242081 664597 3239593 656832 3244632
646888 3225241 652558 3245286 673764 3244668 656718 3244567
647083 3225478 653122 3245406 673764 3244666 656707 3244561
648806 3226797 653764 3245552 673760 3244669 656680 3244555
648784 3226747 653943 3245510 673761 3244667 656555 3244532
649108 3226401 654156 3245430 673763 3244667 656528 3244526
649164 3226315 656810 3244563 673766 3244669 656504 3244522
649216 3226340 656780 3244629 673765 3244669 659522 3246139
649315 3226191 656651 3244575 673768 3244667 673862 3244361
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650053 3226087 654540 3244710 673763 3244668 659558 3246128
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651313 3227383 693468 3230638 673767 3244667 673829 3244356
661451 3246254 693089 3230748 673767 3244667 673792 3244596
659792 3245987 702167 3232060 673766 3244666 673787 3244882
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659627 3246058 702599 3232017 673766 3244664 673692 3244926
659352 3246129 698116 3229986 673766 3244663 673705 3244935
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658569 3245871 697138 3230334 673761 3244665 673749 3244935
658258 3245236 697565 3231326 673760 3244664 673765 3244925
657947 3245138 658444 3245860 673760 3244661 679031 3229109
657618 3245240 691315 3232043 673754 3244661 677669 3227458
657320 3244964 698801 3229576 673751 3244657 677241 3226416
657071 3244751 699291 3229807 673748 3244659 673771 3244923
657004 3244782 673658 3244842 673747 3244657 673773 3244922
676420 3276188 673635 3244988 673746 3244653 673680 3244923
697600 3231322 673601 3245024 673748 3244655 673763 3244918
697770 3231358 673606 3245013 690091 3233465 673785 3244913
698097 3231540 673605 3245015 689845 3233579 673606 3245010
698223 3231522 673649 3244995 689189 3234001 673611 3245019
698932 3231196 673864 3244386 689202 3234091 652567 3228982
699064 3231214 676954 3237590 689226 3233975 652887 3229189
699402 3231217 676962 3237594 689553 3233734 653259 3230373
699869 3231136 676970 3237595 689562 3233730 653816 3232770
699947 3231145 673771 3244651 689572 3233709 654935 3233642
700016 3231214 673753 3244654 689571 3233711 655888 3233602
700292 3231184 673754 3244655 689576 3233706 657015 3233510
700588 3231355 673755 3244655 689592 3233761 657740 3233073
700974 3231543 673756 3244657 689574 3233756 658429 3238041
700693 3231397 673755 3244656 687579 3235202 658436 3237718
701016 3231564 673762 3244660 689164 3234061 657676 3242215
701750 3231657 673763 3244657 689925 3233554 657677 3242570
701819 3231648 673765 3244659 689927 3233552 657694 3242763
701950 3231780 673764 3244658 689973 3233456 657447 3243351
652230 3228582 673763 3244661 690087 3233479 656897 3244048

652824	3229199	673765	3244661	690089	3233466	688811	3234308
653018	3229216	673766	3244660	690100	3233475	689652	3233703
653347	3229739	673766	3244660	690092	3233478	689755	3233642
653290	3231590	673767	3244659	690092	3233477	690426	3233319
653233	3231785	673767	3244660	690091	3233478	690274	3233493
653283	3231781	673769	3244660	690115	3233478	673645	3244836
653776	3232781	673767	3244660	690355	3233182	673767	3244922
653843	3232972	673770	3244661	690358	3233182	673782	3244888
653967	3233173	673770	3244664	690379	3233170	673753	3244896
654933	3233673	673767	3244663	690380	3233168	673768	3244892
655188	3233673	673766	3244663	690422	3233124	654900	3233628
655637	3233572	673765	3244656	690420	3233123	673674	3244823
655855	3233612	673764	3244664	690421	3233121	654760	3227002
656127	3233622	673766	3244666	690425	3233121	673674	3244830
656603	3233619	673769	3244666	690423	3233118		

Saltcedar (*Tamarix* spp.)

UTM E	UTM N	UTM E	UTM N	UTM E	UTM N	UTM E	UTM N
693719	3226042	650105	3226056	657126	3245532	653015	3247429
692370	3223860	650068	3226136	657120	3245600	652969	3247371
687917	3219932	650670	3226642	657086	3245714	652958	3247324
702421	3231880	661655	3246227	657053	3245734	652921	3247252
702828	3232316	657910	3241774	657033	3245763	652887	3247221
694244	3229226	635982	3227086	657032	3245762	652773	3247199
693924	3229376	636082	3226689	656937	3245779	652697	3247255
694761	3229307	636967	3225744	656877	3245775	652603	3247342
694761	3229307	636967	3225744	656733	3245832	652525	3247412
642871	3233815	638331	3225975	656456	3245978	652405	3247433
641436	3232265	638527	3225953	656454	3245928	652354	3247375
641931	3232807	643233	3224633	656397	3245950	652261	3247305
635648	3230555	643280	3224554	656381	3245959	652091	3247344
635829	3228371	679142	3228900	656264	3246000	651907	3247488
643789	3223034	679933	3238920	656228	3246039	651947	3247665
643690	3222621	679028	3276726	656194	3246060	651151	3247716
643661	3222346	698719	3229595	656074	3246262	652034	3247690
644150	3223548	698818	3229577	656050	3246299	652111	3247798
643689	3224073	666640	3230061	656028	3246322	652285	3247904
677921	3250347	667130	3230422	655972	3246320	652410	3248145
679008	3250728	667164	3230438	655883	3246307	652797	3248091
677030	3207484	667703	3230100	655849	3246284	653275	3248788
674145	3218381	667918	3230024	655530	3246415	653294	3248844
684458	3214381	667851	3230133	655474	3246394	653430	3248927
647256	3220171	667739	3230146	655441	3246382	653482	3248954
647733	3220102	660517	3247226	655452	3246380	653550	3249181
652247	3215582	660518	3247288	655393	3246370	653634	3249239
652502	3215071	660527	3247312	655361	3246418	653706	3249391
654566	3213321	660526	3247310	655309	3246465	653757	3249444
656800	3212934	660520	3247300	655271	3246484	653872	3249462
658755	3211669	660536	3247322	655224	3246402	653992	3249306
666035	3209892	660456	3247286	654825	3246445	653997	3249204
667098	3209018	649583	3232116	654807	3246524	654031	3249177
664675	3210973	653401	3227094	654793	3246588	654242	3249178
662573	3212344	664311	3225351	654765	3246641	654305	3249145
662491	3214058	664304	3225373	654680	3246633	654461	3249219
636500	3225746	664329	3225709	654585	3246578	654562	3249294

634296 3226972 664346 3225816 654485 3246514 654710 3249370
642217 3224830 664448 3225991 654410 3246547 654931 3249329
647296 3225679 664426 3225920 654365 3246572 655027 3249249
681637 3236485 664423 3225851 654309 3246605 655074 3249208
692930 3231926 664294 3225488 654200 3246687 655165 3249129
692433 3232489 650670 3226693 654170 3246786 655200 3249097
692262 3233744 649752 3226074 654092 3246827 655811 3246215
691810 3234470 649756 3226064 654038 3246853 655773 3246099
662562 3214090 649159 3226370 653948 3246919 656167 3245259
666118 3209855 649767 3226031 653979 3246895 655806 3245909
664820 3211292 646121 3225760 653899 3246959 656233 3245076
664668 3211015 646017 3225765 653828 3247081 656579 3244589
664578 3210764 646557 3225387 653771 3247156 656551 3244544
668546 3212298 649162 3226358 653737 3247189 656524 3244527
662842 3212497 649188 3226368 653683 3247215 662727 3212458
664301 3225571 653670 3247211 667094 3209013 657434 3245302
653563 3247210 664567 3215593 657399 3245371 653444 3247296
680347 3255669 657282 3245409 653387 3247276 680530 3255674
657256 3245431 653271 3247212 649253 3226358 657191 3245490
653182 3247293

Table 2-4. Name and location (UTM Coordinates, NAD83, Zone 13) of Potential Spring Water Sources Identified with National Hydrography Dataset, National Park Service, and Feral Hog Distribution Data in Big Bend National Park (Source: Young et al. 2006).

Date	Name	Utm_E	Utm_N	Date	Name	Utm_E	Utm_N
4/4/1995	Abbey Spring (new 1995)	648352	3222978	4/18/1995	Claro Spring 3	665345	3230299
5/20/1995	Adler Spring	667095	3231408	4/13/1995	Cloud Spring	654336	3240459
5/8/1995	Alba Spring - Harte Ranch	666723	3266569	4/18/1995	Cooper Spring	664672	3231079
1/7/1991	Alto Tank	692183	3245159	4/24/1995	Corral Spring	661322	3231219
4/12/1995	Apache Canyon Spring	653532	3240499	4/7/1995	Cottonwood Spring	657740	3241299
4/13/1995	Araneid Spring	653502	3238829	6/15/1999	Cottonwood Spring	671143	3261504
5/22/1995	Ash Spring	662152	3243799	2/18/1991	Coyote Heaven Tank (1990)	665973	3282219
4/19/1995	Banta Shut-In	686423	3246019	11/10/1990	Crazy Windmill (new 1990)	662303	3269579
5/22/1995	(Vernon) Bailey Spring	662542	3242719	4/10/1995	Cricket Spring	664652	3225879
4/18/1995	Bee Spring	647972	3231179	6/15/1999	Croton Spring	660597	3247400
5/23/1995	Bell Spring	659912	3235759	4/25/1995	Cuatro Spring	661572	3228679
5/11/1995	Bois d'Arc Spring	671402	3244019	8/5/1995	Dagger Mountain Seep	682173	3268059
4/18/1995	Bonito Spring	665844	3231719	5/1/1995	Dam Tinaja	627782	3235769
12/31/2003	Borracho Spring	674249	3269495	4/26/1995	Derek Spring	655832	3225819
4/26/1995	Borrego Windmill	675973	3269409	3/26/2004	Desert Spring	688614	3240857
4/27/1995	Boundary Tank	675633	3269409	5/17/1995	Devil's Den Tinajas	682923	3276679
5/15/1995	Bruja Tinaja	631442	3231089	3/26/1995	Dickey Well	685743	3263999
5/18/1995	Burnham Spring (new 1995)	666922	3244149	5/18/1995	Dodson Spring (1995)	666732	3232179
3/13/1995	Burns Spring A	681033	3237719	4/9/1995	Dog Spring	664310	3225369
3/13/1995	Burns Spring B	681107	3237983	4/9/1995	Dominguez Spring	664312	3223680
3/13/1995	Burns Spring C	681213	3237739	4/19/1995	Dos Spring (new 1995)	646232	3231527
4/19/1995	Burr Spring	667082	3230834	4/11/1995	Double Spring	666702	3227299
6/15/1999	Burro Spring	653045	3235422	4/24/1995	Double Windmills	667863	3274199
3/27/2004	Burro Spring	652985	3235333	4/11/1995	Dove Spring	666507	3227361
4/20/1995	Burro Spring	652936	3235628	1/12/2004	Dripping Spring	664181	3254031
4/11/1995	Burro Tank	646732	3239929	4/24/1995	Duck Tank	674193	3275619
4/30/2004	Buttrill Spring A	667289	3269643	3/13/1995	Dugout Wells	681223	3239549
4/29/2004	Buttrill Spring C	666936	3269909	3/14/1995	Dunham Spring	674462	3235379
4/29/2004	Buttrill Spring D	666786	3269672	4/10/1995	Dutch Boy Seep (new 1995)	665843	3226403
4/29/2004	Buttrill Spring E	666789	3269706	5/10/1995	Eleanor Spring	659612	3222139
4/29/2004	Buttrill Spring F	666667	3269870	3/13/1995	Electric Line Spring A and B	681053	3240389
4/10/1995	Calcite Spring	641552	3231019	3/13/1995	Electric Line Spring C (1995)	681023	3240569
4/10/1995	Cansado Spring (new 1995)	664481	3226658	4/12/1995	Elegant Spring	668982	3227649
4/25/1995	Canyon Spring	658472	3226797	4/12/1995	Elephant Spring	668075	3228629
4/26/1995	Capsite Seep	674013	3270752	4/12/1995	Elf Spring	668252	3228198
3/29/1995	Carlota Tinaja	690843	3240519	4/25/1995	Encinál Spring	670283	3269769
4/10/1995	Carney Spring	664428	3226194	12/16/2003	Equipaje Spring	672470	3271183
4/25/1995	Carolyn's Tinaja	659072	3227379	3/30/1995	Ernst Tinaja	693494	3237999
5/9/1995	Casita Spring Complex	658202	3222979	3/26/2004	Ernst Tinaja	693186	3238002
5/9/1995	Cattail Falls	661742	3239469	4/13/1995	Estrecho Spring	669092	3229469
5/15/1995	(Upper) Cattail Spring	662232	3236489	4/24/1995	Fenceline Tank	671533	3275619
3/14/1995	Chilicotal Spring Complex	681403	3236469	4/24/1995	Fenceline Windmill	671493	3278469
4/18/1995	Chimneys Spring	649466	3232565	3/27/1995	Fertile Sands (new 1995)	676057	3252206

Date	Name	Utm_E	Utm_N	Date	Name	Utm_E	Utm_N
4/19/1995	Chimneys Vista Spring	644857	3231066	4/13/1995	Fresno Spring	670092	3229077
11/7/1990	Chino Spring	682133	3236869	3/20/1995	Frivol Spring	671632	3227542
5/23/1995	Christmas Spring	652682	3252029	4/19/2004	Frog Spring	672048	3225716
3/14/1995	Chuckwagon Spring	681553	3237039	3/21/1995	Frosty Spring	671702	3226699
2/20/2004	Cicada Spring	681542	3236140	5/17/1995	Gano Spring	653432	3243249
4/18/1995	Claro Spring 1	665132	3231199	1/27/2004	Gano Spring	658080	3243307
4/18/1995	Claro Spring 2	665113	3230964	1/27/2004	Gap Spring	658431	3243252
4/18/1995	Claro Spring 2.5 (new 1995)	665258	3230555	2/5/2004	Glenn Spring	679171	3228890
4/26/1995	Goat Mountain Spring	656422	3229659	5/9/1995	Oak Spring	661562	3240399
4/10/1995	Gomez Spring	641522	3229449	9/21/1990	Old Ranch Spring	658272	3240059
3/22/2004	Grapevine Hills Spring	675255	3254785	3/22/1995	Ombligo del Elefante Spring	672057	3221927
3/23/1995	Grapevine Hills Spring B	675373	3254749	3/29/1995	Paint Gap Seep	662852	3252619
3/23/1995	Grapevine Hills Spring C	675473	3254609	4/11/1995	Paintbrush Spring (new 1995)	665372	3227159
3/23/1995	Grapevine Hills Spring D	675843	3254379	1/12/2004	Painted Hills Spring	663055	3253812
3/23/1995	Grapevine Spring	675763	3254289	4/19/1995	Paloma Spring	665472	3229889
4/12/1995	Hambly Spring	655012	3241389	6/15/1999	Panther Spring	672076	3242916
3/27/1995	Hannold Spring 1	675353	3251059	5/2/1995	Parousia Tinaja	693773	3258399
3/27/1995	Hannold Spring 2	676203	3251359	4/12/1995	Paseo Spring	667526	3225618
4/20/1995	Heading Out Spring (1995)	652382	3234979	5/23/1995	Patch Nose Seep	659692	3235589
4/25/1995	Hermoso Spring A	660422	3228204	5/23/1995	Patty Spring	660582	3235409
4/25/1995	Hermoso Spring B	660072	3227979	6/15/1999	Pea Spring	645415	3231371
2/2/1991	Hobran Spring	669752	3238039	4/18/1995	Pena Spring 2	645462	3231569
3/16/1995	Holly Spring	677189	3228329	4/19/1995	Picasso Spring (new 1995)	665680	3230081
4/13/1995	Hop Spring	668022	3229889	4/19/1995	Poco Agua Spring	666122	3230655
4/11/1995	Indian Head Spring	645832	3246139	4/10/1995	Poor Man's Loco Tinaja	664205	3226980
3/22/1995	Jest Spring	674572	3228559	3/16/1995	Pouroff Spring A	677869	3228139
3/22/1995	Jewell Spring	674422	3229349	3/16/1995	Pouroff Spring B	677759	3228129
3/21/1995	Jobeck Spring	680053	3235409	4/19/1995	Premonition Spring (1995)	666212	3229869
4/11/1995	Joe Black Spring	644932	3245929	4/11/1995	Pretty Good Seep (new 1995)	665472	3226209
5/15/1995	Kibbe Spring	666312	3229519	8/2/1996	Punta de la Sierra Middle	664082	3219539
6/15/1999	Kibbe Spring	666301	3239489	4/4/1995	Punta de la Sierra East	664646	3219779
3/22/1995	Kirtley Tinaja (new 1995)	677194	3225179	4/5/1995	Punta de la Sierra Middle	664072	3219559
10/31/1990	La Loma Windmill/Well site	664663	3272199	4/6/1995	Punta de la Sierra West	662892	3219279
3/30/1995	La Noria Spring	691303	3237199	4/27/1995	Raven Spring	672283	3271999
3/27/1995	Leopold Tinaja	686863	3265669	4/27/1995	Raven Windmill	671577	3271779
4/18/1995	Linda Spring	645142	3232679	4/19/1995	Red Ass Spring	648282	3233989
4/1/1995	Little Cotton Spring	656762	3243359	4/19/1995	Red Bird Spring (new 1995)	665902	3229919
4/24/1995	Lizard Spring	659832	3228877	4/24/1995	Red Peak Spring	660802	3229774
5/16/1995	Loco Spring	664592	3228169	3/10/1995	Reed's Spring (new 1995)	665482	3226139
1/22/2004	Lorn Spring	673272	3255882	5/2/1995	Restoration Tinaja	693353	3256629
2/3/2004	Lower Glenn Spring	679122	3228477	4/25/1995	Rhyolite Spring	657712	3228879
4/17/1995	Lower Juniper Spring	668902	3234549	4/17/1995	Rim Spring	666852	3233159
4/19/1995	Madiera Springs 1	666312	3230215	3/21/1995	Robber's Roost Well	675723	3229959

Date	Name	Utm_E	Utm_N	Date	Name	Utm_E	Utm_N
4/19/1995	Madiera Springs 2	666412	3230259	3/16/1995	Rock Spring	675954	3239319
4/10/1995	Mano Abaja (new 1995)	664440	3225831	4/12/1995	Rocky East Spring	655352	3248899
4/10/1995	Mano Spring	665095	3225889	4/12/1995	Rocky West Spring	654452	3249199
5/17/1995	Maple Canyon Springs A,B	666232	3241899	4/11/1995	Rough Run Spring	646992	3245359
2/12/2004	McKinney Spring	685578	3254795	5/17/1995	Rough Spring B	667322	3245419
3/27/1995	Melba Spring	685613	3251669	1/23/2004	Rough Spring B	667309	3245187
2/11/2004	Menagerie Spring	683744	3253294	7/24/1996	Sam Nail Ranch Spring	658272	3230059
8/11/1990	Mercy Spring	685603	3255599	5/1/1995	Sammy Spring	651952	3239299
4/26/1995	Mesa Bonita Spring	656177	3229519	5/10/1995	San Jacinto Spring A	658782	3223619
1/26/1991	Mirage Spring	659402	3215898	5/10/1995	San Jacinto Spring B	658712	3223399
12/18/2003	Moonshee Spring	673042	3270819	5/25/1995	San Juan (Lower) Spring	673543	3266159
5/18/1995	Moss Well	667772	3242679	5/25/1995	San Juan (Upper) Spring	673013	3265859
3/27/2004	Mule Ears Spring	654845	3227053	6/15/1999	San Juan Spring	673372	3265818
3/27/1995	Muskhog Spring	685013	3260179	3/22/1995	Sand Spring	674732	3229179
3/27/1995	Neville Spring	672658	3251459	5/9/1995	Santa Spring	654912	3222739
6/15/1999	Neville Spring	674619	3251477	3/22/1995	Screwbean Spring	677153	3227399
6/2/1995	Newman Spring (new 1995)	669351	3256374	6/2/1995	Seco Spring	669535	3257813
4/19/1995	North Spring	649032	3235019	3/28/2004	Seep Du Jour	672025	3244237
2/18/1991	North Windmill (new 1990)	665493	3284199	1/27/1996	Serendipity Spring A (1995)	655375	3251099
4/24/1995	Nunca Spring	660412	3229259	1/27/1996	Serendipity Spring B (1995)	655311	3251019
3/22/1995	Shelf Spring	673882	3228349	4/25/1995	Willow Spring	657212	3228419
3/21/1995	Shrub Spring	673152	3228369	5/29/1995	Wilson Spring	663942	3235499
5/9/1995	Sidhe Seep	658842	3239489	5/10/2004	Window Spring (above)	662427	3240085
4/20/1995	Silky Spring	668945	3230282	5/9/1995	Window Spring (below)	662147	3240279
4/10/1995	Silver Spring	663652	3227779	7/2/1993	Winterrowd Spring	622872	3232699
4/13/1995	Skip and Jump Tinajas 1995	668202	3229739	4/25/1995	Witch Spring	661162	3228709
5/22/1995	Skree Tinaja	661992	3244049	4/14/1995	Wulfkuhle Tinajas	652552	3239049
4/24/1995	Slickrock Spring	661987	3231309	4/6/1995	Y Spring	670560	3214243
4/12/1995	Slickrock Wellsite	657662	3250079	3/21/1995	Yum Spring (new 1995)	672573	3228588
5/9/1995	Smoky Spring	658492	3225099	4/13/1995	Zapato Tuerto Spring (1995)	667502	3230052
5/1/1995	Smuggler's Tinaja	628792	3233539	6/15/1999	Unknown	659208	3216353
5/11/2004	Snippur Spring	675793	3229340	6/15/1999	Unknown	658162	3222824
4/19/1995	South Spring	648682	3234499	6/15/1999	Unknown	648701	3222717
4/12/1995	Steps Spring	667172	3225899	6/15/1999	Unknown	664652	3223376
4/4/1995	Steven's Waterhole	683833	3219949	6/15/1999	Unknown	664742	3225706
4/24/1995	Surprise Tank A	676766	3275009	6/15/1999	Unknown	658733	3226934
4/11/1995	Swirl Tinaja	649952	3243169	6/15/1999	Unknown	661426	3229075
4/24/1995	Taza Spring	661902	3230399	6/15/1999	Unknown	657579	3228768
3/29/2004	Terlingua Abaja Gaging	635542	3230952	6/15/1999	Unknown	660734	3229500
4/19/1995	The Wright Pool (1995)	646121	3233736	6/15/1999	Unknown	656275	3229418
4/12/1995	Thomas Spring	657592	3249939	6/15/1999	Unknown	649595	3232138
5/1/1995	Tinaja Blanca	626082	3232049	6/15/1999	Unknown	667850	3228965
5/2/1995	Tinaja Grande A	629622	3231689	6/15/1999	Unknown	665974	3230687
10/17/1990	Tinaja Grande B (new 1990)	629802	3231849	6/15/1999	Unknown	665980	3230100
5/3/1995	Tinaja Grande C	629952	3231889	6/15/1999	Unknown	677797	3228022

Date	Name	Utm_E	Utm_N	Date	Name	Utm_E	Utm_N
5/1/1995	Tinaja Lujan	627352	3233459	6/15/1999	Unknown	660152	3235626
5/1/1995	Tinaja Rana	625032	3232599	6/15/1999	Unknown	668689	3234766
2/2/2004	Tinaja Spring	650241	3245612	6/15/1999	Unknown	661932	3239452
5/3/1995	Tinaja Susan	630627	3231574	6/15/1999	Unknown	661821	3239384
5/3/1995	Tinaja Swan	631112	3231329	6/15/1999	Unknown	665308	3235700
3/29/1995	Tinaja Verde	694913	3242739	6/15/1999	Unknown	662167	3236368
5/3/1995	Tinajas de Kongaleena	631252	3231199	6/15/1999	Unknown	690878	3235490
5/2/1995	Tinajas de la Verga	630682	3228569	6/15/1999	Unknown	691089	3237433
3/27/2004	Trap Spring	653712	3227159	6/15/1999	Unknown	647246	3245187
4/19/1995	Tres Spring	646782	3231199	6/15/1999	Unknown	672256	3243234
4/20/1995	Tule Spring	651292	3235889	6/15/1999	Unknown	657822	3241074
4/12/1995	Tusk Spring	667252	3226399	6/15/1999	Unknown	660459	3247309
7/28/1996	Unnamed - Glenn Spring	675513	3229329	6/15/1999	Unknown	660698	3247683
3/29/1995	Upper Ernst Tinaja Complex	693328	3238199	6/15/1999	Unknown	685469	3254651
1/26/2004	Upper Oak Spring	664241	3238892	6/15/1999	Unknown	670961	3262241
4/25/1995	Walled Spring	661552	3229064	6/15/1999	Unknown	669569	3257538
5/22/1995	Ward Spring	660212	3236219	6/15/1999	Unknown	683785	3252881
5/11/1995	Wasp Spring	653634	3230399	6/15/1999	Unknown	683718	3253116
5/11/1995	Water Boy Tinaja (new 1995)	672052	3244119	6/15/1999	Unknown	683615	3253320
2/2/1991	Wauer Spring	669462	3238299	6/15/1999	Unknown	675555	3254403
4/18/1995	Wax Spring	685813	3229929	6/15/1999	Unknown	675592	3254338
3/29/2004	Wild Duck Tinaja	645995	3238214	6/15/1999	Unknown	676764	3262034
4/19/1995	Wild Spring	667092	3230409				

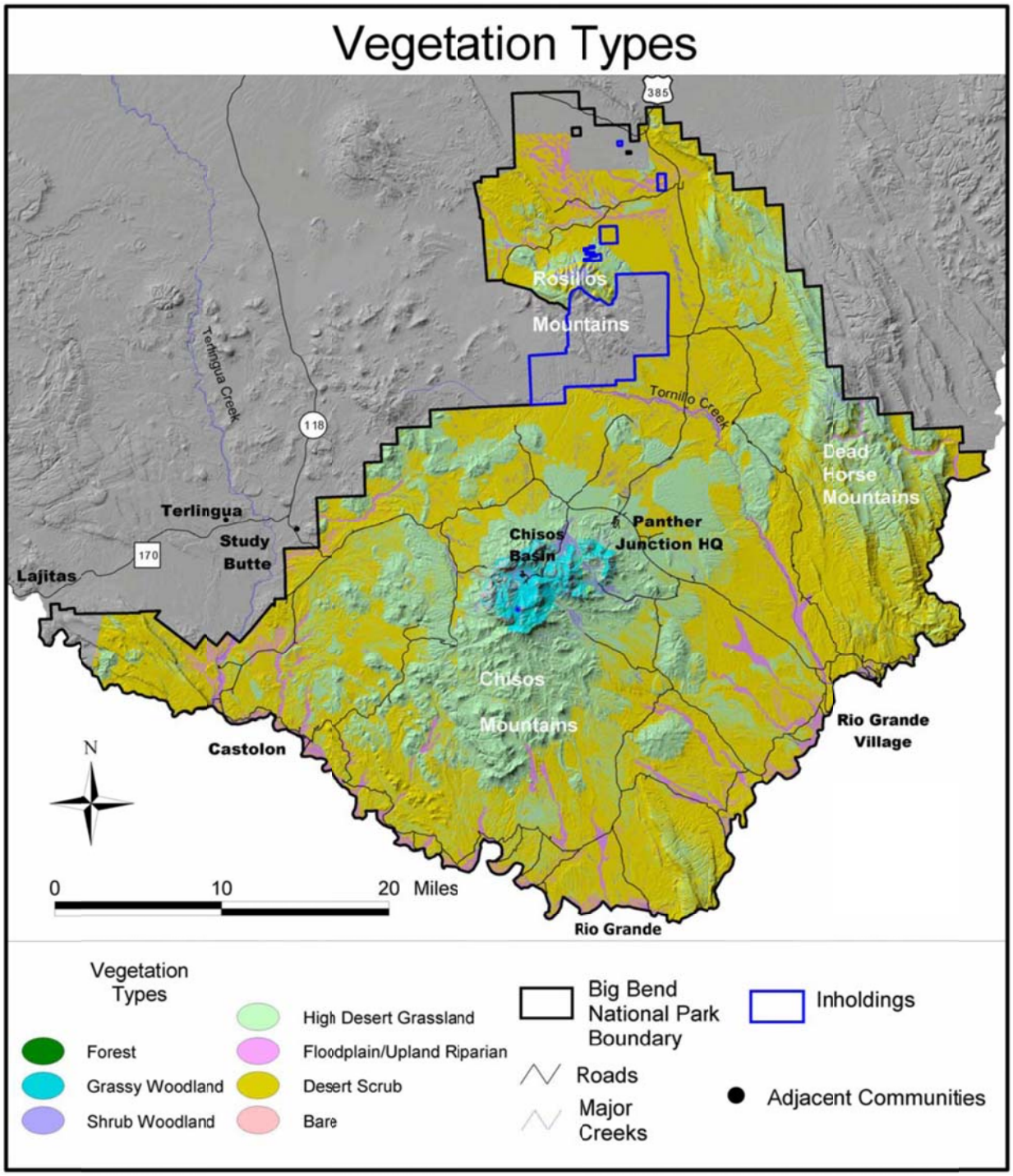

Figure 2-1. BIBE Fire Management Plan (2005) Vegetation Type Map Derived from Plumb (1988, 1993).

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