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JUL 7 2004

Mr. Eli Kangas
U.S. Army Corps of Engineers
Fort Worth District
819 Taylor Street
Fort Worth, Texas 76102

Dear Mr. Kangas:

This letter transmits the Planning Aid Letter and Fish and Wildlife Coordination Act Report for the ecological restoration opportunities described in the February 2004 San Antonio River Channel Improvement Project's General Reevaluation Report (GPR) and April 2004 Alternative Formulation Briefing. This project was developed using expertise from San Antonio River Authority, regional, State of Texas, and Federal team members.

The riparian habitat assessment was made possible by the extensive involvement of Charissa Kelly of the Corps of Engineers and Kathy Boydston and Tom Heger of Texas Parks and Wildlife Department. The aquatic habitat assessment, developed by Jan Hoover and Jack Kilgore of the Waterways Experiment Station, provides an excellent means of quantifying the fish and wildlife benefits that would result from the GRR measures.

The elements of a Planning Aid Letter typically include descriptions of: environmental setting, fish and wildlife resources present, fish and wildlife concerns, and fish and wildlife recommendations. These are provided in the enclosed document, including our support for restoration efforts consistent with Design Condition 3 B.

A Fish and Wildlife Coordination Act Report includes descriptions of: the project area, fish and wildlife resources, aquatic and terrestrial resources, threatened and endangered species, the project and all alternatives considered, a habitat evaluation of fish and wildlife resources with and without the project, and our recommendations. These overlap and build on the Planning Aid Letter.

We appreciate the opportunity to participate in this project. If you have any questions, please contact Patrick Connor at (512) 490-0057, extension 227.

Sincerely,

Robert T. Pine
Supervisor

Enclosure

Fish and Wildlife Coordination Act Report and Planning Aid Letter

San Antonio River Aquatic Ecosystem Restoration Project

In

San Antonio, Texas

By

The U.S. Fish and Wildlife Service
Ecological Services Field Office
Austin, Texas

For

The Fort Worth District
U.S. Army Corps of Engineers
Fort Worth, Texas

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DESCRIPTION OF THE STUDY AREA

Location

The study area for the San Antonio River Improvement Project (SARIP) is located in San Antonio, Bexar County, Texas and is entirely within the San Antonio River watershed (Figure 1). The purpose of the U.S. Army Corps of Engineers' (USACE) reevaluation study is to identify ecosystem restoration, flood damage reduction, and recreational opportunities within the study area.

The study area extends from South Alamo Street downstream to a point below IH-410 and just above the confluence with San Juan Ditch near Espada Mission (Figures 2 through 8). The study area includes the San Antonio River flood control right-of-way and areas under consideration for acquisition by the San Antonio River Authority and others.

Ecoregion Setting

Bailey's classification of ecoregions in the United States places Bexar County in Province 315, Southwest Plateau, Plains Dry Steppe Shrub, (Bailey 1995). The study area straddles two sections of that province, Edwards Plateau and Rio Grande Plains (Figure 9). Kuchler (1964), focusing on potential vegetation, placed the study area in Mesquite-Acacia Savanna. The U.S. Fish and Wildlife Service (Service) (1993) following Bailey (1976) includes the study area in the Prairie Brushland (Mesquite-Acacia) province. The study area (and most of Bexar County) is located in the South Texas Brushlands physiographic region as determined for the Breeding Bird Survey (Butcher 1990). McMahan et al. (1984) following Gould et al. (1960) included the study area in the South Texas Plains Ecological Area.

The northern - northwestern third of Bexar County falls in the Edwards Plateau region. The Texas Parks and Wildlife Department (TPWD) has developed a natural regions classification system for Texas (http://www.tpwd.state.tx.us/gis/downloads/). The study area is in the blackland prairie class (Taylor et al. 1991) (Figure 10). In this classification, the southern edge of Bexar County is part of the extensive South Texas brush country class. The southern two-thirds of Bexar County is characterized as nearly level or undulating plain sloping downward from the northwest to the southeast and descending from 152.4 to 30.5 meters (500 to 100 feet) in elevation.

Taylor et al. (1991) placed the study area and most of the Salado Creek floodplains in the Venus-Frio-Trinity soil association, which are deep, calcareous soils found on bottomlands and river - creek terraces underlain by old and recent alluvium.

Figures 11 and 12 show Blair's biotic province classification for Texas and Bexar County, respectively. Blair (1950) placed the study area in the Tamaulipan Biotic Province. The flora and fauna of the southern half of Bexar County clearly have affinities with south Texas as reflected in the list of plants seen at study sites (Appendix 1) and animal species reported from the San Antonio area (Appendix 2).

Several river systems in Bexar County (San Antonio River, Salado Creek, and Medina River) dissect the surface, creating a rough and well-drained landscape. Average precipitation in Texas varies along an east – west axis with a general trend of increasing rainfall in the east. However, in Bexar County, the cline trends north and south with the highest mean annual rainfall in the north (Figure 13). The average annual rainfall for the study area falls in the 28- to 30- inch (71 to 76 cm) range (NRCS online http://www.ftw.nrcs.usda.gov/prism/prismdata_state.html 2004).

FISH AND WILDLIFE RESOURCES

The bottomland hardwood ecosystem in Texas prior to European settlement once extended over 6.5 million hectares; it is estimated that less than 40 percent of this original extent still remains (Frye 1986), with only a few small and isolated patches of old growth scattered among the floodplains of the eastern third of the state. Intact bottomland hardwood forests are listed among the endangered ecosystems in the United States. In the past 50 years, losses of these forests have at times been greater than 120,000 ha (296,640 acres) per year (MacDonald et al. 1979). According to Day et al. (1980), floodplain forests rank among the most productive ecosystems in the entire United States.

Channelization of major rivers has resulted in reduced plant and animal species richness and diversity (Barclay 1980, Frederickson 1980). Fish and wildlife in urban areas are under pressure from habitat fragmentation and other changes brought on by development of areas formerly in floodplains. The San Antonio River floodplain historically contained significant bottomland woodland habitats. Its riparian habitat, if restored, would also represent the northern most segment of the South Texas brush community. This unique Texas and south central United States habitat supports a diverse assemblage of amphibians, reptiles, birds, and small mammals.

Habitat Cover Types

Woodlands - This cover type is predominately composed of mature box elder (*Acer negundo*), Texas sugarberry (*Celtis laevigata*), pecan (*Carya illinoinensis*), live oak (*Quercus virginiana*), and cedar elm (*Ulmus crassifolia*) within the riparian corridors (areas that are periodically flooded). A variety of shrubs are found interspersed in these woodlands. Other woody native species expected are huisache (*Acacia farnesiana*), gum bumelia (*Bumelia lanuginosa* var. *albicans*), retama (*Parkinsonia aculeata*), and honey mesquite (*Prosopis glandulosa*). These bottomland ecosystems have been created by the interaction of streams, floodplains, and the adjacent terrestrial habitat. The hardwood tree woodlands, particularly old growth hardwoods (greater than 100 years old), contribute to the biodiversity and provide important feeding, nesting and cover/shelter habitats for wildlife. Periodic flooding enhances the diversity of habitat types within these areas. The disturbance of the bottomland forest by flooding is a natural and important part of the proper functioning of these areas. Bottomlands help to contain floodwaters and lessen the impact of flooding when rivers overflow. In addition, these bottomland forests help maintain water quality by trapping sediments, wastes, and pollutants from stormwater runoff.

Van Auken and Bush (1985) described the secondary succession along the terraces of the San Antonio River. They found the number of woody species, total density, and total basal area increased with stand age. They placed retama, mesquite, hackberry, huisache, and sugarberry as early successional species. Sugarberry, cedar elm, box elder, pecan, American elm (*Ulmus americana*), and gum bumelia were associated with more mature stands. Other trees found in the riparian areas include sycamore (*Platanus occidentalis*), cottonwood (*Populus deltoides*), and bald cypress (*Taxodium distichum*).

Van Auken (1981), in surveys at the San Antonio Missions National Park, found huisache to be the dominant tree species in the early and mid-successional stages. He found Texas sugarberry as the dominant late-successional stage species, whereas, box elder was the most common tree in the riparian areas surveyed at Mission San Juan.

Fentress (1986) reported that at least 189 species of trees and shrubs, 42 woody vines, 75 grasses and 802 herbaceous plants are known to occur in the bottomland hardwoods ecosystems in Texas. Even though central Texas bottomland hardwood ecosystems are not quite as diverse as the east Texas woodlands described by Fentress (1986), they are complex and dynamic habitats with their own large diverse communities. These plant communities provide habitat for a diversity of animal species. A field list of woody and herbaceous plants seen at our study sites was prepared by Kathy Boydston of TPWD (Appendix 1).

Most of the riparian habitat along the study area is highly fragmented and impacted by the flood control project and other land uses along the San Antonio River and its tributaries. At the lowest site sampled, woodlands in late successional stages still exist within the San Antonio River floodplain.

USACE subdivided the study area into several cover types for habitat accounting and incremental analysis purposes. Industrial land, roads and bridges were descriptions applied to areas generally dominated by impervious cover. Parkland was used to designate areas with a modicum of mature trees among mowed grasses. Legume woodland was used to classify areas dominated by huisache, acacia, mesquite, cedar elm, and hackberry. Legume woodlands generally fell into early successional stages. Woodland and park woodland were used for areas where tree densities were higher than parkland. Mid-successional woodland and late-successional woodlands were classes assigned to more natural wooded areas and the particular stage assigned was based on: canopy cover, species composition, and average tree diameter at 4.6 feet (1.4 meters) above grade. These late successional woodlands are considered optimal riparian fish and wildlife habitat by the U.S. Fish and Wildlife Service (Service).

Streams, creeks, rivers, and other bodies of water of bottomland hardwoods in Texas also support at least 116 species of fish, 31 species of amphibians, 54 species of reptiles, 273 species of birds and 45 species of mammals (Fentress, 1986). Over 50 percent of all the neotropical songbirds are associated with bottomland hardwood forests (Fentress, 1986). The San Antonio River bottomlands support a large diversity of insects, fish, amphibians, reptiles, birds, and mammals. Signs (tracks and road kill) of nine-banded armadillos (*Dasypus novemcinctus*), raccoons (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and opossums (*Didelphis virginiana*) were found in the study area. Leopard frogs (*Rana pipiens*) and cricket frogs (*Acris crepitans*) were abundant. Spiders, snakes, butterflies, bees, and other flying insects were also seen. These areas provide some habitat for white-tail deer (*Odocoileus virginianus*). Bird species seen during site visits are representative at that time of the year for south Texas brush country and Edwards plateau.

Grasslands

In recent decades, non-native grasslands have been established in the study area, replacing the riparian woodlands that historically dominated the San Antonio River. With the intent of maintaining conveyance of water, the floodway of the study area is regularly mowed during the growing season, promoting these non-native grasslands. As described in the ecological assessment prepared by the Lady Bird Johnson Wildflower Center (2002), a handful of non-native grasses dominate this community: Bermuda grass (*Cynodon dactylon*), Johnsongrass (*Sorghum halepense*), King ranch bluestem (*Bothriochloa ischaemum*), and giant reed (*Arundo donax*).

A variety of arachnids and insects were seen in grasslands along the San Antonio floodway during field visits to the project site. Small mammals, frogs, toads, and snakes are likely residents of old fields near the San Antonio River. Some of these fields are being invaded by shrubs and woody legumes, yet still appear to function as grasslands (for example, Study Site 5). Grassland birds including the eastern meadowlark (*Sturnella magna*), a year-round resident, can be detected in these flatter old fields. Raptors, including crested caracara (*Caracara cheriway*) and hawks (*Buteo* sp.), were noted in mature trees along the margins of meadows visited.

Wildlife Resources

The project area is used by both resident and migratory bird species that are somewhat tolerant of human activity. Migratory waterfowl, shorebirds, and resident wood ducks (*Aix sponsa)*, can be seen along the stream. A variety of migratory and resident passerine, owl, and hawk species use the woodlands as well. Some common resident birds that may be observed in the study area are white-crowned sparrows (*Zonotrichia leucophrys*), northern cardinals (*Cardinalis cardinalis*), blue jays (*Cyanocitta cristata*), common grackles (*Quiscalus quiscula*), common crows (*Corvus brachyrhynchos*), belted kingfishers (*Ceryle alcyon*), and red-tailed hawks (*Buteo jamaicensis)*.

Neo-tropical migrant songbirds will utilize the woodland habitats along the San Antonio River as stopover points and corridors during migration. These woodland areas provide valuable cover and food during the long migration from South and Central America to breeding grounds. A list of potential birds found along the San Antonio River corridor throughout a given year is shown in Appendix 6.

Mammal species that may use the riparian woodland in the study area include raccoons, nine-banded armadillos, striped skunks, opossums, eastern cottontail (*Sylvilagus floridanus*), fox squirrels (*Sciurus niger*), and hispid cotton rat (*Sigmodon hispidus*). Feral cats and dogs (and possibly hogs) are known from the San Antonio River bottomlands. Nutria (*Myocastor coypus*) have been introduced and are associated with creeks and small to large water bodies. Nutria are known from the study area.

<u>Aquatic Resources</u>

In the San Antonio River upstream of the study area, variable discharges of treated effluent are made by the San Antonio Water System (SAWS) to the San Antonio River at the northern edge of Brackenridge Park and at other locations. The San Antonio River at the upper boundary of the study area (Lone Star Boulevard and Roosevelt Park) has a consistent base flow (minimum of 10 cubic feet per second; 0.28 cubic meters per second), provided by the SAWS.

Common fish species that can be found in the San Antonio River and tributaries are listed in Table 1. Extensive fish surveys were conducted in 2003 by Jan Hoover and Jack Kilgore of the USACE Waterways Experiment Station (WES). Species collected and reported have been assembled into a guilds (2003 - Habitat Suitability Models for the San Antonio River, Texas) (Hoover and Kilgore 2003). During a site visit, a dense population of water snakes (*Nerodia* spp.) were observed on broken concrete boulders along the upper sections of the study area, indicating a suitable prey base of small fish.

Several species of frogs and turtles may also be found in the project area. Species sighted included cricket frogs, leopard frogs, snapping turtles (*Chelydra serpentina)*, soft-shelled turtles (*Apalone* spp.*)*, and red-eared sliders (*Trachemys scripta*). In addition, many bird species were observed using the aquatic habitat, including green herons (*Butorides virescens*), yellow-crowned night herons (*Nyctanassa violacea*), cattle egrets (*Bubulcus ibis*), great egrets (*Ardea alba*), little blue herons (*Egretta caerulea*), and great blue herons (*Ardea herodias*).

<u>Problematic Invasive Non-native Plants</u>

Non-native Woody Species

Privet (*Ligustrum* spp.) and Chinaberry (*Melia azedarach*) are found throughout the study area in stands of various ages. Privet forms a dense canopy in a number of riparian woodlands to the point of excluding virtually all other plants in their shade. As older trees in these privet mottes die, very little recruitment of native woody species will occur. While privet and chinaberry provide some food for birds and small mammals, their tendency to dominate and crowd out native species necessitates active treatments to limit and reverse their spread. Other non-native woody species known from the upper San Antonio River include: tree of heaven (*Ailanthus altissima*), mimosa (*Albizia julibrissin*), Chinese tallowtree (*Triadica sebifera*), and Chinese wisteria (*Wisteria sinensis*) (Van Auken 1981).

Non-native Herbaceous Species

The Lady Bird Johnson Wildflower Center (LBJWC) survey of the Mission Reach (LBJWC 2002) noted the dominance of Bermuda grass and Johnsongrass throughout the floodway. Other problematic species seen were: King ranch bluestem, rescue grass (*Bromus unioloides*), giant reed, and elephant's ear (*Colocasia esculenta*).

Habitat Evaluation Procedures (HEP) For Riparian Ecosystem

Wildlife values were analyzed using HEP (Service 1980) to describe and measure key habitats in the project area. The HEP requires the use of Habitat Suitability Index (HSI) models developed for indicator species (or communities) that best represent groups of species that use the habitats in the project area. Our evaluation is based on the arithmetic mean of output from four HEP models.

The models chosen include three wildlife species models for individual species associated with woodlands (barred owl (*Strix varia*), raccoon, and fox squirrel). These species are found within the San Antonio River study area. The fourth model chosen is a community model that provides an index of wildlife species richness in shelterbelts. The shelterbelt HEP model, though developed for the northern Great Plains, was considered representative of the San Antonio River riparian community that was not adequately addressed by the three species models. The shelterbelt HEP model, as modified, helped evaluate the wildlife benefits provided by shrubs in and along the margins of existing and potential future woodlands. References to the shelterbelt model in this document referred to a modified model as described below.

The HEP models chosen represent a diverse guild of riparian birds and small mammals that would be expected to respond similarly to increases in niche space resulting from the restoration measures planned.

Barred Owl

The barred owl is a resident of Bexar County and most of eastern Texas as well as eastern United States. It is a general predator found in riparian forests/woodlands and upland forests. Barred owls use elm (*Ulmus* spp.), beech (*Fagus* spp.), oaks (*Quercus* spp.), hickories (*Carya* spp.), and sycamore for nest trees (Allen 1987). The south central part of Texas (ca. Bexar County) represents the southernmost edge of the barred owl's range in the United States (Mazur and James 2000). In the eastern part of Texas, barred owls occupy forests, however, in the western part of its range in Texas, barred owls are typically found only in riparian corridors where mature deciduous trees provide for nesting and foraging (Lockwood and Freeman 2004). Figure 14 shows the known range of the barred owl.

Raccoon

The raccoon is thought to occur throughout Texas (Davis 1974). Raccoons use brush piles, hollow logs, rock dens, buildings, and ground dens typical of skunks and opossums. The HEP model focuses primarily on the availability of water, the maturity of the tree stand, and presence of refuge/den sites (Service 1980), all of which are assumed to improve with the duration of the project.

Fox Squirrel

The fox squirrel is known from the eastern two thirds of Texas and is strongly associated with forest/woodland habitats (Davis 1974). Figure 15 shows the fox squirrel's range in Texas. Fox squirrels use leaf nests and tree cavities for shelter and reproduction. Unlike the gray squirrel (*Sciurus carolinensis*), fox squirrels prefer open woodland habitats. Higher shrub density in the understory may decrease fox squirrel habitat suitability (Allen 1982), but large trees providing shelter and food are more crucial to success.

Wildlife Species Richness in Shelterbelts

This model was developed for the northern Great Plains and is based on measures of vegetative structure, plant diversity, and the size of the shelterbelt. The model was shown to have a positive correlation with year-round bird species richness. To simplify application of this model, we modified this model and used three of the six original variables: V1 (average height of the two tallest shelterbelt rows), V4 (number of woody plant species), and V5 (shelterbelt configuration of shrubs and trees).

Application of HEP models

Using these models, baseline habitat conditions are expressed as a numeric function (HSI value) ranging from 0.0 to 1.0, where 0.0 represents no suitable habitat for an indicator species and 1.0 represents optimum conditions for the species. For each cover type and evaluation year, a composite habitat suitability index was calculated by taking the arithmetic mean of the barred owl, fox squirrel, raccoon, and modified shelterbelt model suitability index. Habitat units (HU) are calculated by multiplying the HSI by the amount of acres of the habitat type available within each restoration area. Acreages were provided in GIS and spreadsheet formats from the USACE. The study area was classified into subareas based on the habitat type and land use. These subareas were rated for habitat values of existing conditions and future conditions without the project (at evaluation years 1, 5, 15, 25, and 50) based on the HEP/HSI results. Plant species found and animal species inferred to be present are listed in Appendices 1 and 2, respectively. Raw data for each HEP site are included in Appendix 3. A list of variables used for each HEP model applied is provided in Table 3.

Riparian HEP Results

Existing Conditions and Future Without Project

Riparian woodland habitat was assessed at 15 sites sampled along the San Antonio River using the barred owl, raccoon, and fox squirrel HEP models. Additional data for other HEP models (e.g., green heron, belted kingfisher, scissor-tailed flycatcher) were collected at a total of 27 sites but are not reported here. The barred owl, raccoon, and fox squirrel models were considered by the habitat assessment team as the best combination to evaluate riparian bottomland habitats, particularly when supplemented by the wildlife species richness in shelterbelt model. Photos of the sites are in Appendix 4. At each study site, habitat suitability indices variables were scored for each species model. The shelterbelt (modified) model was applied during a meeting of the Service, TPWD, and USACE in March 2004. Each land use (cover type) in the study area was evaluated for each of the shelterbelt model variables. Similar to results developed for each HEP species model, a table of character states for each model variable was estimated for the evaluation years.

Staff from USACE, TPWD, and the Service discussed the potential variables that could affect the habitat and its value within the study area. Among these were: (1) the continued mowing of floodway grasslands, (2) the gradual maturation of trees in the woodland patches, and (3) continued expansion of dense privet mottes in the riparian corridor. Land use was assumed to continue unchanged in part due to local flood ordinances. In general, habitat values for particular parcels are expected to slightly decrease, stay the same, and slightly increase depending on the local circumstances over the next 50 years.

Barred owl habitat suitability (SI 0.13) was low due to the lack of large diameter trees. Fox squirrel habitat (SI 0.11) rated low for winter food production, while cover/reproduction values appeared to be fairly high. Mast producing trees greater than or equal to 6 inches (15 cm) diameter at breast height (1.4 meters) (DBH) were rare throughout many of the riparian areas and thus the food value for fox squirrels rated poorly.

Similarly, raccoon habitat models emphasize the importance of large diameter trees. Large trees were rarely seen in the study area. All areas sampled lacked large diameter trees in the wooded areas near the floodway. This influenced the SI value for raccoons (SI 0.62). Study site 27 was technically downstream of project boundary, but had the most mature stand of trees seen in our study and appeared to provide optimal raccoon habitat.

The woodland site that had the highest composite SI score was the farthest downstream and was apparently not disturbed during or after the channelization of the San Antonio River (Site 27).

Upstream from Site 27, the remaining woodlands near the San Antonio River are likely sites that have been disturbed to some degree by logging and/or fires. In general, these woodlands lack medium and large diameter trees. The lack of mature trees lowered the habitat values for the barred owl, raccoon, and fox squirrel. Some sites did have waterways (acequias) increasing their value for fauna in general (Sites 22 and 23).

Future with Design Conditions: 0, 1, 2, 3 A, and 3B

Design conditions (DC) were developed by the Corps of Engineers in partnership with the San Antonio River Authority (SARA) and City of San Antonio. The first planning goal was to restore a diverse and sustainable ecosystem through improving the quality and quantity of aquatic and riparian habitat. The Alternative Formulation Briefing for the San Antonio River Channel Improvement Project – General Reevaluation Report (SARCIP – GRR) dated April 2004 provides descriptions of each design condition reviewed (see excerpt below). Each design condition is associated with an incremental purpose that would allow review of the benefits each measure would provide.

> **Design Condition 0 (DC0).** Under this condition, the existing channel would remain in its present condition, and no excavation would take place within the floodway channel. The purpose of this DC was to determine what, if any, vegetation could be placed within the existing floodway without violating the planning constraints. *The incremental purpose of DC0 is to improve aquatic and riparian habitat without any excavation.*
>
> **Design Condition 1 (DC1).** The formulation strategy for DC1 is to implement habitat restoration measures that would result in habitat unit (HU) gains and other ecosystem benefits without a deliberate adherence to geomorphic and sediment transport design guidelines. DC1 seeks to improve wildlife habitat and provide as much total ecosystem benefits as reasonably attainable without requiring additional lands or easements beyond the current floodway ROW. Excavation under DC1 would be necessary to construct riffle structures, increase the depth of pools and/or increase conveyance within the floodway channel, create wetlands, modify the channel longitudinal slopes for improvement in the long term dominant substrates, and that required to remove undesirable materials, such as concrete rubble, from the channel. *The increment isolated by DC1 is excavation for channel improvements and riparian vegetation.*
>
> **Design Condition 2 (DC2).** The formulation strategy for DC2 is to implement restoration measures that would result in habitat unit (HU) gains and other ecosystem benefits in conjunction with the creation of a new pilot channel designed to convey the "effective discharge" or "effective flow" as defined in the San Antonio River Geomorphic & Sediment Transport Technical Memorandum (GSTTM). The "effective flow" is the flow for which the frequency and sediment transport capacity are maximized. The goal of the pilot channel design for DC2 is to provide equilibrium of sediment transport and minimize the damaging effects of sediment accumulation and erosion within the system while providing for improved habitat and ecosystem values.

The sediment transport pilot channel designed for DC2 would be excavated within the current floodway channel and excavation would be primarily limited to the bottom width of the floodway channel and the existing project ROW. The existing floodway channel would not be modified in overall width in order to gain hydraulic conveyance and no additional lands, easements or rights-of-way would be required.

A base flow channel would be constructed within the pilot channel to convey the average low flow of 20 cubic feet per second (cfs) and located primarily within the river runs. Base flow channels are not applicable within pools or areas backwatered by riffle structures. Base flow channels would not be used within riffle structures in order to maximize the habitat potential of the riffle. Riffle structures would be constructed at various points along the river and at various heights to control grade and attain the reach average sediment transport equilibrium slope as recommended in the GSTTM. The findings and conclusions of the GSTTM have been used as a guide for the design of the pilot channel and base flow channels. *The increment isolated in DC2 is the inclusion of the pilot- and base flow channel for sediment transport*

Design Condition 3. The formulation strategy for DC3 is to implement habitat restoration measures that would result in HU gains and other ecosystem benefits while utilizing geomorphic and sediment transport design guidelines. Additionally, modification to the floodway channel would be permissible beyond the existing right-of-way limit. This would result in greater flood conveyance gains, and implementation of more extensive habitat improvement measures without compromising the flood carrying capacity. *The increment isolated in DC3 is the cost for the acquisition of real estate and the additional excavation costs.*

Two plans were formulated upon the DC3 pallet, termed DC3A and DC3B. The first plan, DC3A was developed by the Sponsor as their vision for the restoration of the San Antonio River. Upon review of the plan, the Fort Worth District felt changes could be made that would increase the habitat outputs provided by this design condition. Therefore, the DC3B plan was developed as a modification to the DC3A plan, and both were carried throughout the remainder of formulation. The differences in habitat measures between DC3A and DC3B are:

- Riffle structures have an inset base flow channel in DC3A but are removed in DC3B,
- Some larger pool areas in DC3A have been reduced in size to allow more riparian vegetation in DC3B, and
- The riparian vegetation measures for DC3B were developed using the same criteria used to develop vegetational designs for DC1 and DC2

Figure 16 shows the habitat units over a fifty year period for each design condition and the no action scenario. In general, DC 3 showed the greatest gain in habitat units with DC 3A slightly outperforming DC 3 B. DC 0, which involves no excavation, was similar to no action. DC 1 and DC 2 were similar in outputs and provided moderate increase in riparian habitat values midway between no action and DC 3 at year 50. Increases in habitat values for DC 1, DC 2 and DC 3 were notable after year 15 when tree maturation led to higher suitability in our HEP models.

For no action and all design conditions, a variety of cover types were determined not to provide any suitable habitat across all evaluation years based on the composite SI score: industrial land, grass, roads, bridges, and Bermuda grass dominated riparian zones 1 and 2 (Table 4). These cover types provide essentially no value as riparian habitats. Woodlands in early seral stages (cover types - woodland, park woodland, and legume woodland) provided marginal riparian habitat value. Late successional woodlands and to a lesser degree mid-successional woodlands provided high suitability for riparian habitat, although these cover types were not as common in the study area.

The HEP species specific models, which we used, are not directly sensitive to the proportion of native vs. non-native biota in a subject community. Under consideration is a major effort to replace a variety of established non-native grasses and trees with native flora. An index similar to the Index of Biological Integrity (Karr and Dudley 1981) could be constructed to consider species composition and species diversity relative to the natural (native) history of the area.

Aquatic Habitat

The aquatic habitat in the San Antonio River downstream of downtown has low quality compared to the historical conditions of predevelopment. This part of the river lacks: riparian shading, diversity of mesohabitats, and structure - cover features in the river. The watershed consists primarily of a highly developed urban land use. Base flows are no longer provided by springs. The lack of shading results in higher than normal summer water temperatures. Field data have been collected by the USACE WES, and new HEP models have been built based on those data and expert review. Results of their assessment of existing and potential fish habitat based on proposed habitat improvements are provided in Appendix 7.

The Alternative Formulation Briefing details the variety of aquatic habitat features that are generally lacking in the San Antonio River. Figure 17 shows the aquatic habitat outputs from the different design conditions with DC 3 B producing the most aquatic habitat, especially after year 5.

Federally Listed Threatened and Endangered Species

There are eleven endangered, and one candidate species that are federally listed and known to occur within Bexar County (Table 8). There is no habitat for any of the endangered species or the candidate species within the project area. There is critical habitat designated for several listed karst invertebrates in Bexar County, but no critical habitat is located within the proposed project area. Therefore, the proposed project should have no effect on these species.

Project Recommendations for Fish and Wildlife Enhancement

The channel improvement project as described in the April 2004 General Reevaluation Report, describes a diverse and well-considered approach to increasing fish and wildlife resources while maintaining the flood conveyance. The application of tree planting measures to restore riparian areas and connect restored habitat to adjacent woodland patches has been done in a manner that minimizes fragmentation and would lead to larger habitat values.

Based on the existing condition of the fish and wildlife habitat within the project area, the Service offers the following recommendations for each area.

The section of the San Antonio River that we studied presents conditions with significant opportunities to improve the biotic integrity and fish and wildlife habitat values. The ecological simplification that resulted from the channelization of the San Antonio River can be addressed in a manner that does not compromise the flood conveyance (protection) provided. In general, we expect that converting Bermuda grass and Johnsongrass stands in the floodway to native grasses will increase the diversity and standing crop of the arthropod community. This revitalized community in turn would support more amphibians, reptiles, and birds. The need for and frequency of mowing these grasses should be considered in light of potential impacts to species closely associated with ground cover. Tree and shrub plantings along the top of the floodway may enlarge the effective size of adjacent woodlands. Where hydraulic constraints allow, plantings of deciduous woody species along the river would provide shade, perch sites, and leaf litter-organic matter benefiting aquatic fauna (Marzolf 1978, Hynes 1970).

Management of invasive non-native trees is recommended throughout the upper San Antonio River, including local elimination of privet, Chinaberry, and Chinese tallow. Non-native herbaceous plants such as giant reed may require herbicide treatments (LBJWC 2002). As a native plant community is fostered, vigilant monitoring is needed. The frequency and timing of mowing (where SARA or the City of San Antonio intend to continue mowing) should be adjusted to accommodate nesting.

The LBJWC was tasked with preparing recommendations for terrestrial plants for plantings in the study area. PBS&J has also prepared a plant list for restoring riparian corridors on the San Antonio River. In general, we are supportive of efforts to restore the natural historic diversity of woody and herbaceous plants. In this manner, habitats of native songbirds and small mammals will increase in value and progress will be made in restoring biotic integrity. Tree and shrub plantings may include bare root saplings especially if the plantings will have greater success when drought returns. Tree plantings along the river corridor should include a variety of hard mast trees (oaks, pecan, black walnut (*Juglans nigra*)) and other long-lived trees like bald cypress. Where opportunities exist, tree plantings along the river's edge will provide shade - temperature benefits and leaf litter will support a broader aquatic invertebrate community. To the extent that hydraulic considerations allow, dead tree-snags in and near the river should not be removed.

The San Antonio River inside Loop IH-410 lacks a wide variety of aquatic and riparian habitat features that leaves the fish and wildlife community less diverse than 50 years ago. By restoring riverine functions, wetlands, oxbows, and connectivity among the aquatic and riparian habitats, the channel improvement project can make a significant and essential step towards establishing a sustainable ecosystem with habitats that attract diverse wildlife species.

Literature Cited

Allen, Arthur W. 1982. Habitat suitability index models: fox squirrel. U.S. Fish and Wildlife Service FWS/OBS-82/10.18. Washington, D.C.

Allen, Arthur W. 1987. Habitat suitability index models: barred owl. U.S. Fish and Wildlife Service Biological Report 82(10.143). Washington, D.C.

Bailey, Robert G. 1995. Description of the ecoregions of the United States (2nd ed.). Misc. Pub. No. 1391, Map scale 1:7,500,000. USDA Forest Service.

Barclay, J.S. 1980. Impact of stream alterations on riparian communities in south central Oklahoma. U.S. Fish and Wildlife Service OBS-80/17.

Blair, W.F. 1950. The Biotic Provinces of Texas. Texas Journal of Science, 2: 93-117.

Butcher, G.S. 1990. Audubon Christmas Bird Counts. Pp. 5-13 in J. R. Sauer and S. Droege, eds. Survey designs and statistical methods for the estimation of avian population trends. U.S. Fish and Wildlife Service Biological Report 90(1).

Davis, W.B. 1974. The mammals of Texas. Bulletin No. 41. Texas Parks and Wildlife Department, Austin, Texas.

Day, J.W., Jr., W.H. Conner, and G.P. Kemp. 1980. Contribution of wooded swamps and bottomland forests to estuarine productivity. In: Proceedings of the Gulf of Mexico Coastal Ecosystems Workshop. U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

Gould, F.W., G.O. Hoffman and C.A. Rechenthin. 1960. Vegetational areas of Texas. Texas A&M University, Tex. Agr. Extension Service L-492, College Station, Texas.

Hynes, H.B.N. 1970. The Ecology of Running Waters. University of Toronto Press, Toronto, Ontario, Canada.

Fentress, C.D. 1986. Wildlife of Bottomlands: Species and Status, Bottomland Hardwoods in Texas: Proceedings of an Interagency Workshop on Status and Ecology, Craig A. McMahan and Roy G. Frye, editors. May 6-7, 1986. Texas Parks and Wildlife Department, Wildlife Division, March 1987, Austin, Texas.

Frederickson, L.H. 1980. Management of lowland hardwood wetlands for wildlife: problems and potential. Transaction of the North American Wildlife and Natural Resources Conference 45:376-386.

Karr, J.R., and Dudley, D.R. 1981. Ecological perspective on water quality goals: Environmental Management. 5: 44-68.

Kuchler, A. W. 1964. Manual to accompany the map of potential vegetation of the conterminous United States. Special Publication No. 36. New York: American Geographical Society.

Lady Bird Johnson Wildflower Center. 2002. San Antonio River, Mission Reach: Ecological Assessment – Draft May 15, 2002. Austin, Texas.

Lockwood, M.W. and B. Freeman. 2004. The Texas Ornithological Society Handbook of Texas birds. Texas A&M Press, College Station, Texas.

Marzolf, G.R. 1978. The potential effects of clearing and snagging in stream ecosystems. U.S. Fish and Wildlife Service Biological Services Program. FWS/OBS-78/14.

Mazur, K.M. and P.C. James. 2000. Barred Owl (*Strix varia*). *In* The Birds of North America, No. 508 (A. Poole and F. Gill, eds. The Birds of North America, Inc., Philadelphia, PA.

MacDonald, P. O., W. E. Frayer, and J. K. Clauser. 1979. Documentation, chronology, and future projections of bottomland hardwood habitat loss in the Lower Mississippi Alluvial Plain. U.S. Fish and Wildlife Service, Vicksburg, Miss.

McMahan, C. A., R. G. Frye and K. L. Brown. 1984. The vegetation types of Texas including cropland: an illustrated synopsis to accompany the map. Pittman-Robertson Project W-107-R, Texas Parks and Wildlife Department, Wildlife Division, Austin, Texas.

Miller J.H. 2003. Nonnative invasive plants of southern forests – a field guide for identification and control. U.S. Forest Service. Southern Research Station, Asheville, North Carolina.

Natural Resource Conservation Service. 2004. Online data at http://www.ftw.nrcs.usda.gov/prism/prismdata_state.html

San Antonio River Authority. 1996. Evaluation of Aquatic Ecosystems in the San Antonio River Watershed Based on Rapid Bioassessment Protocols. San Antonio River Authority. San Antonio, Texas.

Schmidly, D.J. 1983. Texas mammals east of the Balcones Fault Zone. Texas A&M Press. College Station, Texas.

Schroeder, Richard L. 1986. Habitat suitability index models: wildlife species richness in shelterbelts. U.S. Fish and Wildlife Service Biological Report 82(10.128). Washington D.C.

Schroeder, Richard L. 1987. Community models for wildlife impact assessment: a review of concepts and approaches. U.S. Fish and Wildlife Service Biological Report 87(2). Washington D.C.

Shear, T. H., T. J. Lent, & S. Fraver. 1996. Comparison of restored and mature bottomland hardwood forests of southwestern Kentucky. Restoration Ecology 4(2):111-123.

Taylor, F.B., R.B. Hailey, and D.L. Richmond. 1991. Soil survey of Bexar County, Texas. Revision of 1966 edition. United States Agriculture Department. Soil Conservation Service; Texas Agricultural Experiment Station.

U.S. Fish and Wildlife Service. 1980. The habitat evaluation procedures. Department of the Interior, U.S. Fish and Wildlife Service, Ecological Services Manual 102.

Van Auken, O.W. 1981. Determination of the presence of threatened and endangered plant species on the grounds of the San Antonio Mission National Historical Park.

Van Auken, O.W. and J.K. Bush. 1985. Secondary succession on terraces of the San Antonio River. Bull. Torrey Botanical Club 112:158-166.

Table 1 Fish species commonly found in the upper San Antonio River.

Family	Common names
cyprinids	red shiner
	central stoneroller
	blacktail shiner
centrarchids	redbreast sunfish
	largemouth bass
	bluegill
	green sunfish
poeciliids	sailfin molly
	western mosquitofish
	amazon molly
cichlids	tilapia species
	Rio Grande cichlid

Table 2.
Models Used for HEP within the San Antonio River Study Area.

Habitat Evaluation Procedure Model
Raccoon (*Procyon lotor*)
Barred Owl (*Strix varia*)
Fox Squirrel (*Sciurus niger*)
Wildlife Species Richness in Shelterbelts (Modified)

Table 3		Variables for each HEP Model
fox squirrel	V 1	percent canopy closure of trees that produce hard mast greater than or equal to 10 inches dbh (25.4 cm)
fox squirrel	V 2	distance to available grain
fox squirrel	V 3	average dbh overstory (inches)
fox squirrel	V 4	percent tree canopy closure
fox squirrel	V 5	percent shrub crown cover
barred owl	V 1	no of trees > 51 cm per 0.4 hectare
barred owl	V 2	Mean DBH of overstory trees
barred owl	V 3	percent canopy cover overstory trees
raccoon	V 1	miles to water
raccoon	V 2	water regime
raccoon	V 3	overstory size class
raccoon	V 4	number of refuge sites per acre
shelterbelt (modified)*	V 1	average height of two tallest shelterbelt rows
shelterbelt (modified)*	V 2	percent tree and/or shrub canopy closure
shelterbelt (modified)*	V 3	number of shelterbelt rows
shelterbelt (modified)*	V 4	number of woody plant species
shelterbelt (modified)*	V 5	shelterbelt configuration
shelterbelt (modified)*	V 6	shelterbelt size
		* Only V 1, V 4, and V 5 were used; Shelterbelt Modified HSI = [V1 + (V4 * 2) + (V5 *4)] / 7 Modified HSI was a weighted arithmetic mean emphasizing importance of shrub/tree diversity (V4) and having shrubs in and along margins of woodlands (V5)

Table 4 Scenario for Riparian Habitats	ACRES	HSI YR 1	HSI YR 5	HSI YR 15	HSI YR 25	HSI YR 50
FUTURE WITHOUT PROJECT						
Industrial land	5.9	0.00	0.00	0.00	0.00	0.00
Grass	39.0	0.00	0.00	0.00	0.00	0.00
Late successional woodland	0.0	0.96	0.96	0.96	0.96	0.96
Legume woodland	47.0	0.37	0.36	0.35	0.33	0.30
Mid-successional woodland	0.9	0.48	0.48	0.50	0.53	0.58
Park woodland	10.7	0.34	0.34	0.34	0.34	0.34
Woodland	26.8	0.37	0.36	0.35	0.33	0.30
Roads, Bridges, etc.	11.3	0.00	0.00	0.00	0.00	0.00
Riparian Zone 1 (Bermuda)	162.8	0.00	0.00	0.00	0.00	0.00
Riparian Zone 2 (Bermuda)	115.5	0.00	0.00	0.00	0.00	0.00

Table 5 **Scenario for Riparian Habitats**	**ACRES**	**HSI YR 1**	**HSI YR 5**	**HSI YR 15**	**HSI YR 25**	**HSI YR 50**
DC Zero						
Industrial land	5.9	0.00	0.00	0.00	0.00	0.00
Grass	44.4	0.00	0.00	0.00	0.00	0.00
Late successional woodland	0.0	0.96	0.96	0.96	0.96	0.96
Legume woodland	47.0	0.37	0.36	0.35	0.33	0.30
Mid-successional woodland	0.9	0.48	0.48	0.50	0.53	0.58
Park woodland	10.7	0.34	0.34	0.34	0.34	0.34
Woodland	26.8	0.37	0.36	0.35	0.33	0.30
Roads, Bridges, etc.	18.5	0.00	0.00	0.00	0.00	0.00
Riparian Zone 1 (Bermuda)	167.9	0.00	0.00	0.00	0.00	0.00
Riparian Zone 2 (Bermuda)	96.5	0.00	0.00	0.00	0.00	0.00

Table 6 Scenario for Riparian Habitats	ACRES	HSI YR 1	HSI YR 5	HSI YR 15	HSI YR 25	HSI YR 50
DC 1						
Industrial land	5.9	0.00	0.00	0.00	0.00	0.00
Grass	44.4	0.00	0.00	0.00	0.00	0.00
Late successional woodland	0.0	0.96	0.96	0.96	0.96	0.96
Legume woodland	47.0	0.37	0.36	0.35	0.33	0.30
Mid-successional woodland	0.9	0.48	0.48	0.50	0.53	0.58
Park woodland	10.7	0.34	0.34	0.34	0.34	0.34
woodland	26.8	0.37	0.36	0.35	0.33	0.30
Riparian Zone 1						
Type A	10.8	0.18	0.30	0.33	0.50	0.91
Type C	22.6	0.17	0.17	0.18	0.35	0.72
Type D	36.8	0.17	0.17	0.19	0.35	0.70
Type E	56.7	0.00	0.00	0.00	0.00	0.00
Existing condition (Bermuda)	1.9	0.00	0.00	0.00	0.00	0.00
Riparian Zone 2						
Zone A	6.5	0.18	0.30	0.33	0.50	0.91
Zone C	12.8	0.17	0.17	0.18	0.35	0.72
Zone D	24.3	0.17	0.17	0.19	0.35	0.70
Zone E	60.5	0.00	0.00	0.00	0.00	0.00
Existing condition (Bermuda)	0.1	0.00	0.00	0.00	0.00	0.00

Table 7 Scenario for Riparian Habitats	ACRES	HSI YR 1	HSI YR 5	HSI YR 15	HSI YR 25	HSI YR 50
DC 2						
Industrial land	5.9	0.00	0.00	0.00	0.00	0.00
Grass	44.4	0.00	0.00	0.00	0.00	0.00
Late successional woodland	0.0	0.96	0.96	0.96	0.96	0.96
Legume woodland	47.0	0.37	0.36	0.35	0.33	0.30
Mid-successional woodland	0.9	0.48	0.48	0.50	0.53	0.58
Park woodland	10.7	0.34	0.34	0.34	0.34	0.34
woodland	26.8	0.37	0.36	0.35	0.33	0.30
Riparian Zone 1						
Zone A	10.6	0.18	0.30	0.33	0.50	0.91
Zone C	19.1	0.17	0.17	0.18	0.35	0.72
Zone D	29.3	0.17	0.17	0.19	0.35	0.70
Zone E	35.5	0.00	0.00	0.00	0.00	0.00
Riparian Zone 2						
Zone A	9.8	0.18	0.30	0.33	0.50	0.91
Zone C	21.3	0.17	0.17	0.18	0.35	0.72
Zone D	35.6	0.17	0.17	0.19	0.35	0.70
Zone E	37.8	0.00	0.00	0.00	0.00	0.00

Table 8 Scenario for Riparian Habitats	ACRES	HSI YR 1	HSI YR 5	HSI YR 15	HSI YR 25	HSI YR 50
DC 3 A						
Industrial land	0.0	0.00	0.00	0.00	0.00	0.00
Grass	0.0	0.00	0.00	0.00	0.00	0.00
Late successional woodland	0.0	0.96	0.96	0.96	0.96	0.96
Legume woodland	0.0	0.37	0.36	0.35	0.33	0.30
Mid successional woodland	0.0	0.48	0.48	0.50	0.53	0.58
Park woodland	0.0	0.34	0.34	0.34	0.34	0.34
Woodland	0.0	0.37	0.36	0.35	0.33	0.30
Riparian Zone 1						
Zone A	7.5	0.18	0.30	0.33	0.50	0.91
Zone C	20.7	0.17	0.17	0.18	0.35	0.72
Zone D	114.7	0.17	0.17	0.19	0.35	0.70
Zone E	6.8	0.00	0.00	0.00	0.00	0.00
Existing Condition (Bermuda)	4.1	0.00	0.00	0.00	0.00	0.00
Riparian Zone 2						
Zone A	27.1	0.18	0.30	0.33	0.50	0.91
Zone C	52.5	0.17	0.17	0.18	0.35	0.72
Zone D	72.7	0.17	0.17	0.19	0.35	0.70
Zone E	3.0	0.00	0.00	0.00	0.00	0.00
Existing Condition (Bermuda)	3.5	0.00	0.00	0.00	0.00	0.00

Table 9 Scenario for Riparian Habitats	ACRES	HSI YR 1	HSI YR 5	HSI YR 15	HSI YR 25	HSI YR 50
DC 3 B						
Industrial land	0.0	0.00	0.00	0.00	0.00	0.00
Grass	0.0	0.00	0.00	0.00	0.00	0.00
Late successional woodland	0.0	0.96	0.96	0.96	0.96	0.96
Legume woodland	0.0	0.37	0.36	0.35	0.33	0.30
Mid-successional woodland	0.0	0.48	0.48	0.50	0.53	0.58
Park woodland	0.0	0.34	0.34	0.34	0.34	0.34
Woodland	0.0	0.37	0.36	0.35	0.33	0.30
Riparian Zone 1						
Zone A	19.1	0.18	0.30	0.33	0.50	0.91
Zone C	32.4	0.17	0.17	0.18	0.35	0.72
Zone D	64.4	0.17	0.17	0.19	0.35	0.70
Zone E	44.6	0.00	0.00	0.00	0.00	0.00
Existing Condition (Bermuda)	0.4	0.00	0.00	0.00	0.00	0.00
Riparian Zone 2						
Zone A	34.4	0.18	0.30	0.33	0.50	0.91
Zone C	58.2	0.17	0.17	0.18	0.35	0.72
Zone D	55.7	0.17	0.17	0.19	0.35	0.70
Zone E	10.9	0.00	0.00	0.00	0.00	0.00
Existing Condition (Bermuda)	0.0	0.00	0.00	0.00	0.00	0.00

Table 10

	Riparian Habitat Units				
DESIGN CRITERIA	**Year 1**	**Year 5**	**Year 15**	**Year 25**	**Year 50**
Future w/out Project	31.4	30.6	29.9	28.5	26.3
DC0	31.4	30.6	29.9	28.5	26.3
DC1	50.9	52.2	53.6	71.7	110.3
DC2	53.0	54.7	56.3	75.5	119.4
DC3A	50.5	54.7	60.2	108.6	215.4
DC3B	45.5	51.9	56.8	100.5	198.0

Table 11

		Aquatic Habitat Units			
DESIGN CRITERIA	**Year 1**	**Year 5**	**Year 15**	**Year 25**	**Year 50**
Future w/out Project	26.7	26.7	26.7	26.7	26.7
DC0	26.7	34.4	34.4	34.4	34.4
DC1	46.8	65.7	73.8	75.8	77.8
DC2	44.6	62.1	71.1	72.9	73.1
DC3A	40.5	55.5	67.9	70.2	71.3
DC3B	47.1	66.2	78.6	81.8	83.4

Table 12. Federally Listed Threatened and Endangered Species and Candidates for Bexar County, Texas.

Common name	**Status**	**Scientific Name**
Black-capped vireo	E	*Vireo atricapilla*
Golden-cheeked warbler	E	*Dendroica chrysoparia*
Madla cave meshweaver	E w/CH	*Cicurina madla*
Robber Baron Cave meshweaver	E w/CH	*Cicurina baronia*
Braken Bat Cave meshweaver	E w/CH	*Cicurina venii*
Government Canyon Bat Cave meshweaver	E	*Cicurina vespera*
Government Canyon Bat Cave spider	E	*Neoleptoneta microps*
Cokendolpher cave harvestmen	E w/CH	*Texella cokendolpheri*
Ground beetle (no common name)	E w/CH	*Rhadine exilis*
Ground beetle (no common name)	E w/CH	*Rhadine infernalis*
Helotes mold beetle	E w/CH	*Batrisodes venyivi*
Black-tailed prairie dog	C	*Cynomys ludovicianus*

E denotes Endangered

w/CH denotes with Federally Designated Critical Habitat

C denotes Candidate species for addition to Threatened/Endangered List

Table 13.

Potential birds found within the San Antonio River corridor
Sources:
San Antonio Audubon Society
Bexar County Birds, 1995 ed.
The Checklist of the Birds of Bexar County, Texas , 1997
The following list is of birds that are occasional sighted (2-10% sighting probability), uncommon (10-40% probability), common(40-70%), or abundant (70-100%) in habitats found within the project site
Podicipediformes
least grebe
pied-billed grebe
eared grebe
Pelicaniformes
American white pelican
double-crested cormorant
neotropic cormorant
Ciconiiformes
American bittern
great blue heron
great egret
snowy egret
little blue heron
tricolored heron
cattle egret
green heron
black-crowned night heron
yellow-crowned night heron
white-faced ibis
black-bellied whistling duck
Canada goose
American green-winged teal
wood duck
mallard
northern pintail
blue-winged teal
cinnamon teal
northern shoveler
gadwall
American widgeon
canvasback

Potential birds found within the San Antonio River corridor
redhead
ring-necked duck
lesser scaup
bufflehead
hooded merganser
ruddy duck
Falconiformes
black vulture
turkey vulture
osprey
Mississippi kite
northern harrier
sharp-shinned hawk
Cooper's hawk
Harris's hawk
red-shouldered hawk
broad-winged hawk
Swainson's hawk
red-tailed hawk
crested caracara
American kestrel
merlin
Galliformes
wild turkey
northern bobwhite
Gruiformes
purple gallinule
common moorhen
American coot
sandhill crane
Charadriformes
Plovers
semipalmated plover
killdeer
Revurvirostridae
black-necked stilt
American avocet
Sandpipers
greater yellowlegs
lesser yellowlegs
solitary sandpiper
spotted sandpiper
upland sandpiper
long-billed curlew
semipalmated sandpiper
western sandpiper
least sandpiper
white-rumped sandpiper

Potential birds found within the San Antonio River corridor
Baird's sandpiper
pectoral sandpiper
stilt sandpiper
long-billed dowitcher
common snipe
Phalaropidae
Wilson's phalarope
Jaegers, Gulls
Franklin's gull
Terns
Forster's tern
Columbiformes
rock dove
white-winged dove
mourning dove
Inca dove
common ground dove
Cuculiformes
yellow-billed cuckoo
greater roadrunner
Strigiformes
common barn owl
eastern screech owl
great horned owl
barred owl
Caprimulgiformes
common nighthawk
chuck-will's widow
Apodiformes
chimney swift
ruby-throated hummingbird
black-chinned hummingbird
Coraciformes
belted kingfisher
green kingfisher
Piciformes
golden-fronted woodpecker
yellow-bellied sapsucker
ladder-backed woodpecker
northern flicker
Passeriformes
Tyrranidae
olive-sided flycatcher
eastern wood pewee
yellow-bellied flycatcher
acadian flycatcher
alder flycatcher
willow flycatcher

Potential birds found within the San Antonio River corridor
least flycatcher
eastern phoebe
vermilion flycatcher
ash-throated flycatcher
great crested flycatcher
brown-crested flycatcher
western kingbird
eastern kingbird
scissor-tailed flycatcher
Hirundinidae
purple martin
tree swallow
bank swallow
cliff swallow
cave swallow
barn swallow
Corvidae
blue jay
western scrub jay
American crow
Paridae
Carolina chickadee
black-crested chickadee
Remizidae
verdin
Aegithalidae
bushtit
Sittidae
red-breasted nuthatch
Certhlidae
brown creeper
Troglodytidae
Carolina wren
Bewick's wren
house wren
marsh wren
Muscicapidae
Sylviinae
golden-crowned kinglet
ruby-crowned kinglet
blue-gray gnatcatcher
Turdinae
eastern bluebird
Swainson's thrush
hermit thrush
wood thrush
American robin
Mimidae
gray catbird

Potential birds found within the San Antonio River corridor
northern mockingbird
brown thrasher
long-billed thrasher
curve-billed thrasher
Motacillidae
American pipit
Bombycillidae
cedar waxwing
Laniidae
loggerhead shrike
Sturnidae
european starling
Vireonidae
white-eyed vireo
black-capped vireo
solitary vireo
yellow-throated vireo
red-eyed vireo
Emberizidae
Paulinae
blue-winged warbler
golden-winged warbler
Tennessee warbler
orange-crowned warbler
Nashville warbler
northern warbler
yellow warbler
chestnut-sided warbler
magnolia warbler
yellow-rumped warbler
black-throated green warbler
blackburnian warbler
yellow-throated warbler
black-and-white warbler
American redstart
prothonotary warbler
ovenbird
Louisiana waterthrush
Kentucky warbler
MacGilvray's warbler
common yellowthroat
hooded warbler
Wilson's warbler
yellow-breasted chat
Thraupinae
summer tanager
Cardinalnae
northern cardinal

Potential birds found within the San Antonio River corridor
pyrrhuloxia
blue grosbeak
indigo bunting
painted bunting
dickcissel
Emberizinae
spotted towee
Cassin's sparrow
chipping sparrow
field sparow
vesper sparrow
lark sparrow
lark bunting
savannah sparrow
grasshopper sparrow
Lincoln's sparrow
swamp sparrow
white-throated sparrow
white-crowned sparrow
dark-eyed junco
Icterinae
red-winged blackbird
eastern meadowlark
western meadowlark
great-tailed grackle
common grackle
bronzed cowbird
brown-headed cowbird
orchard oriole
Baltimore oriole
Bullock's oriole
Scott's oriole
Fringillidae
house finch
lesser goldfinch
American goldfinch
Passeridae
house sparrow

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Appendices

1. List of plant species found at San Antonio River HEP study sites
2. List of vertebrate species (other than fish) known from Bexar County
3. Raw data sheets from HEP study
4. Photographs of HEP study sites
5. HEP variable scores by study site for raccoon, barred owl, and fox squirrel.
6. Birds known from Bexar County
7. HEP models for: barred owl, wildlife species richness in shelterbelts, raccoons, and fox squirrels

Appendix 5

San Antonio HEP Study Sites Habitat Evaluation Procedure Scores

Study Site Number	Barred Owl SI	Raccoon SI	Fox Squirrel SI
3	0.00	0.50	0.00
4	0.00	0.50	0.00
5		0.02	
8	0.00	0.50	0.00
10	0.08	0.26	0.00
11	0.14	0.52	0.33
12	0.00	0.50	0.00
13	0.00	0.50	0.00
14	0.00	0.50	0.00
15	0.00	0.52	0.00
16	0.14	0.50	0.32
17	0.00	0.50	0.00
22	0.00	0.50	0.00
23	0.41	0.52	0.00
27	1.00	0.94	0.89
Mean	**0.13**	**0.49**	**0.11**

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Excerpt from AFB GRR

Establishment of Native Riparian Vegetation

Native riparian vegetation within the San Antonio River basin is characterized as a Sycamore/Eastern cottonwood/Box elder forest community. Other native woody species common within this association include cedar elm, pecan, black walnut, black willow, Texas persimmon, and hop tree. This riparian vegetation association is still in evidence within the city of San Antonio in numerous locations. Project biologists have investigated floodplain characteristics and structure of natural riparian zones in the vicinity of the project area as a tool for understanding riparian ecosystem restoration needs for this study.

In evaluating the restoration of riparian vegetation four scenarios comprised of differing vegetation types and densities were evaluated. Three of the vegetation types include trees and therefore approximate, to differing degrees, a forest condition. The fourth condition is comprised exclusively of native grasses and forbs. All three types of woody vegetation would provide varying degrees of habitat benefits associated with the riparian corridor and the aquatic environment. Some of the riparian benefits provided by increasing woody vegetation over the existing condition are: hard and soft mast production, tree and cavity nesting sites, perch sites, and horizontal and vertical cover. Benefits provided to the aquatic environment include: vegetative cover to regulate water temperatures, large woody debris inputs, detritus inputs, additional resources for fish species during periods of inundation, perch sites for aquatic avians, and perch sites for fishing birds (i.e. belted kingfisher). Additionally, woody vegetation would act to slow the velocity of floodwaters, thereby reducing the associated erosive energy. Each vegetative type was assigned a Manning's "n" value to characterize its hydraulic resistance.

Type A vegetation represents a historic "natural" condition for the San Antonio River's riparian corridor. This type is defined as having an average of 250 trees per acre, approximately 13 foot on center. Type A would be allowed to follow a natural successional pattern with a fully developed woody understory. Maintenance would be limited to removal of non-native species, and hazardous trees and brush. Type A contains the densest, highest resistance vegetation; therefore it has the highest resistance and impact to the water surface elevation. The Manning's "n" value assigned to Type A is 0.150.

While Type A represents the optimum vegetative regime from a restoration standpoint, it would not be practicable to utilize Type A vegetation throughout the project area due to the performance requirements of the floodway (reference Planning Constraints, p. 4). However, some level of lost aquatic and riparian habitat functions can be restored by using types of woody vegetation which have less hydraulic resistance than Type A. This reduction in hydraulic resistance can be accomplished by varying the density of the overstory and understory of the planted areas. Type C and D (described below) were developed to provide variety in the planting pallet and to allow for more restoration than would be practicable with only the use of Type A.

Type C vegetation is defined as having an average tree spacing of 25 foot on center, or an average of 70 trees per acre. Type C would have a native grass understory, and some areas of native woody understory and midstory would be allowed to develop. These "no mow" areas would typically run parallel with the river and have clear compensatory conveyance areas located on each side. The remaining understory would be native grasses maintained to a height of 12 to 24 inches.

No woody understory would be allowed to develop except in the designated "no mow" areas. The corresponding Manning's "n" value for Type C is a range of 0.075 to 0.085. [Note: Type B vegetation, intermediate between Type A and Type C was eliminated from inclusion during the planning process, and is not discussed herein.]

Type D vegetation is defined as having trees planted at a spacing of 40 foot on center, or approximately 30 trees per acre, on average. The understory component of Type D would be all native grasses mown to a height of 12 to 24 inches. No woody understory would be allowed to develop in Type D. "No mow" areas are not included as an option for this vegetation type. The Manning's "n" value assigned to Type D is 0.055.

Since the flood conveyance constraint precludes a completely wooded riparian corridor, some areas would necessarily have to remain as grassland communities.

Type E vegetation would be comprised on all native grasses and forbs. Type E vegetation, allowed to grow to heights of 12 to 24 inches would not increase the hydraulic resistance over the existing condition grasses. The increased height would provide slightly higher habitat gains over the existing condition. The conversion of the existing non-native grassland community to Type E vegetation would only occur where it is not hydraulically feasible to apply one of the three woodland types discussed above. However, with the inclusion of native grass/forb meadows, a synergy would be created between the grassland and adjacent woodlands such that the value of each increases. Synergy would also be increased over the existing condition where native grass/forb meadows occur adjacent to the water. Native forbs and grasses allowed to grow to natural heights would provide overhanging vegetative cover at the water's edge, increase insect production for aquatic species, and increase detritus inputs to the aquatic environment. Where Type E is in direct contact with the water's edge, some taller herbaceous species may be allowed.

The establishment of native riparian vegetation would require eradication of non-native, invasive species for both pre- and post construction. Limited chemical (herbicide) treatments and mechanical removal have been identified as effective methods to remove undesirable vegetation.

Appendix 1 List of Plant species found at San Antonio River HEP study sites

prepared by Kathy Boydston of TPWD

		Site Number																										
		1	1A	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Abutilon fruticosum	Texas Indian Mallow/Pelotazo			x	x																								
Acacia constricta	Huisache			x	x			x						x						x	x								
Acacia constricta	Mescat Acacia																				x	x							
Acer negundo	Box Elder	x													x										x				x
Agropyron smithii	Western Wheatgrass																								x				
Allium mobilense	Wild Onion																				x								
Alocasia macrorrhiza	Elephant Ears														x		x												
Alternanthera philoxeroides	Alligatorweed										x																		
Ambrosia cumanensis	Western Ragweed								x		x		x							x									
Ambrosia trifida	Giant Ragweed		x		x			x	x		x	x		x		x		x		x	x		x		x			x	x
Ampelopsis arborea	Peppervine				x												x	x											
Andropogon ternarius	Silver Bluestem																												
Bignonia radicans	Trumpet-Creeper/Cow-itch vine				x								x										x						
Bothriochloa ischaemum	King Ranch Bluestem																			x	x	x							
Bromus ciliatis	Brome Grass			x	x			x			x			x															
Bromus unioloides	Rescuegrass																									x		x	
Calliptocarpis vialis	Horse Herb			x	x				x	x		x		x		x	x										x		
Carex cherokeensis	Cherokee sedge																								x				
Carya illinoensis	Pecan	x										x					x							x					x
Celtis laevigata	Sugarberry/Hackberry			x	x	x				x		x	x	x	x	x		x	x					x					x
Centaurea americana	Basket Flower																												
Centaurea melitensis L.	Malta Star Thistle										x																		
Chasmanthium latifolium	Inland Seaoats																								x				
Cissus incisa	Ivy Treebine																												
Clematis spp.	Clematis											x													x				
Cocculus carolinus	Snailseed Vine			x	x	x			x							x									x				
Colubrina texensis	Hogplum/Texas Colubrina				x																								
Commelinantia anomala	False Dayflower									x													x						
Convolvulus equitans	Texas Bindweed																												

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prepared by Kathy Boydston of TPWD

		Site Number																											
		1	1A	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Coreopsis tinctoria	Coreopsis	x	x	x				x	x		x								x	x	x	x	x					x	
Coreopsis tinctoria	Plains Coreopsis	x	x	x				x	x		x																		
Cynodon dactylon	Bermudagrass		x	x	x		x	x	x		x		x							x	x	x	x			x	x	x	
Cyperus virens	Green Flatsedge										x			x									x						
Daucus carota	Queen Anne's Lace/Wild Carrot			x				x			x									x	x							x	
Diospyros texana	Texas Persimmon			x	x	x																							
Ehretia anacua	Anaqua			x	x										x														
Elymus canadensis	Canada Wildrye			x	x					x		x	x	x			x	x						x					
Equisetum hyemale L.	Horsetail/Scouring-Rush																x												
Fraxinus pennsylvanica	Green Ash																												
Gaillardia pulchella	Indian Blanket			x	x																								
Galium aparine	Bedstraw																												
Gaura spp.	Gaura										x																		
Helianthus annuus	Common Sunflower	x	x	x	x				x																			x	
Hydocotyle spp	Pennywort		x																										
Hydrocotyle umbellata	Dollarweed																												
Lantan horrida	Texas Lantana		x		x	x								x															
Lepidium virginicum	Peppergrass/Pepperweed	x		x				x	x																				
Ligustrum lucidum	Glossy Privet																												
Ligustrumjaponicum	Wax-leaf Ligustrum				x					x		x			x		x	x	x					x					
Lonicera japonica	Japanese Honeysuckle																												
Ludwigia peploides	Water Primrose																												
Malvaviscus drummondi	Turk's Cap											x			x		x	x	x					x					x
Matelea reticulata	Green Milkweed Vine				x	x								x															
Melia azedarach	Chinaberry				x					x			x				x	x											
Melilotus albus	White Sweet Clover			x				x	x		x									x	x		x						
Merremia dissecta	Alamo vine				x	x	x							x				x											
Monarda citriodara	Lemon Beebalm/Lemon Mint			x		x	x																						
Morus rubra	Red Mulberry														x	x		x											x

Appendix 1 List of Plant species found at San Antonio River HEP study sites

prepared by Kathy Boydston of TPWD

		Site Number																									
		1	1A	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Nandina domestica	Nandina				x																								
Neptunia lutea	Yellow Puff																				x								
Oenotera speciosa	Pink Evening Primrose			x																		x							
Opuntia engelmanni	Prickly Pear															x													
Oxalis dilleni	Woodsorrel/Sheep Sour	x														x													
Parkinsonia aculeata	Retama				x	x	x							x															
Parthenocissus quinquefolia	Virginia Creeper						x								x									x					
Paspalum dilatatum	Dallisgrass			x										x															
Paspalum setaceum	Thin Paspalum			x																									
Phyla sp.	Frogfruit																					x							
Plantago spp	Plantain																						x						
Polygonum spp	Smartweed sp.																												
Populus deltoides	Cottonwood																												x
Prionopsis ciliata	Saw-leaf Daisy													x															
Prosopis glandulosa	Mesquite			x	x	x								x		x		x											
Pteridium aquilinum	Eastern bracken																								x				
Pyrrhopappus carolinianus	Texas Dandelion/False Dandelion																			x		x							
Quercus macrocarpa	Bur Oak																												
Quercus virginiana	Live Oak																						x						
Ratibida columnaris	Mexican Hat/Prairie Coneflower		x								x																		
Rivina humilis	Pigeonberry																												
Rubus sp	Blackberry/Dewberry													x	x	x							x	x					
Ruellia sp.	Wild Petunia		x										x		x		x										x		
Rumex crispus	Curly Dock		x	x				x			x												x					x	
Sabal minor	Dwarf Palmetto		x												x														
Salix nigra	Black Willow														x														
Sambucus canadensis	American Elder	x																											
Sambucus canadensis	Elderberry/American Elder														x														

Appendix 1 List of Plant species found at San Antonio River HEP study sites

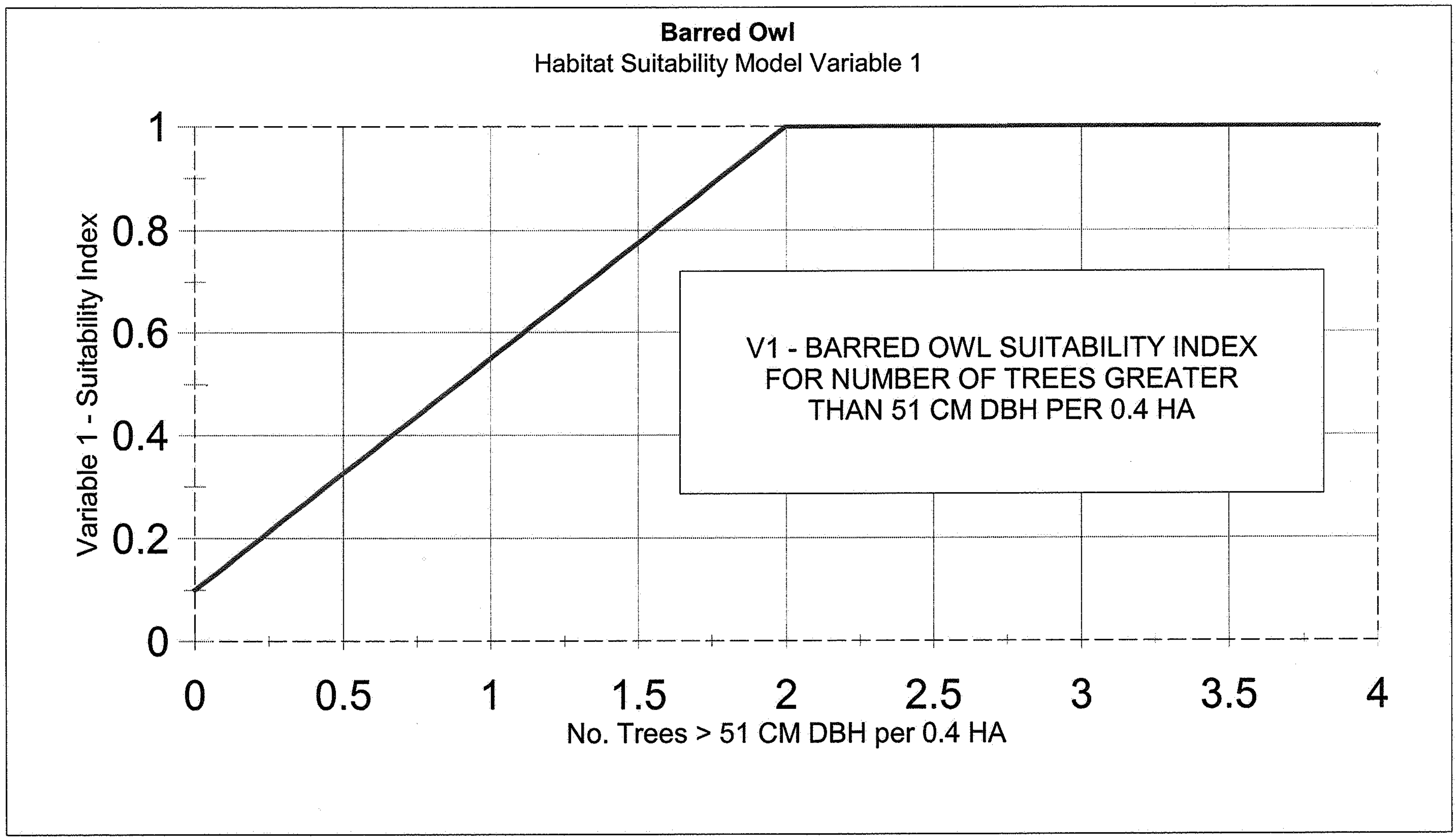
prepared by Kathy Boydston of TPWD

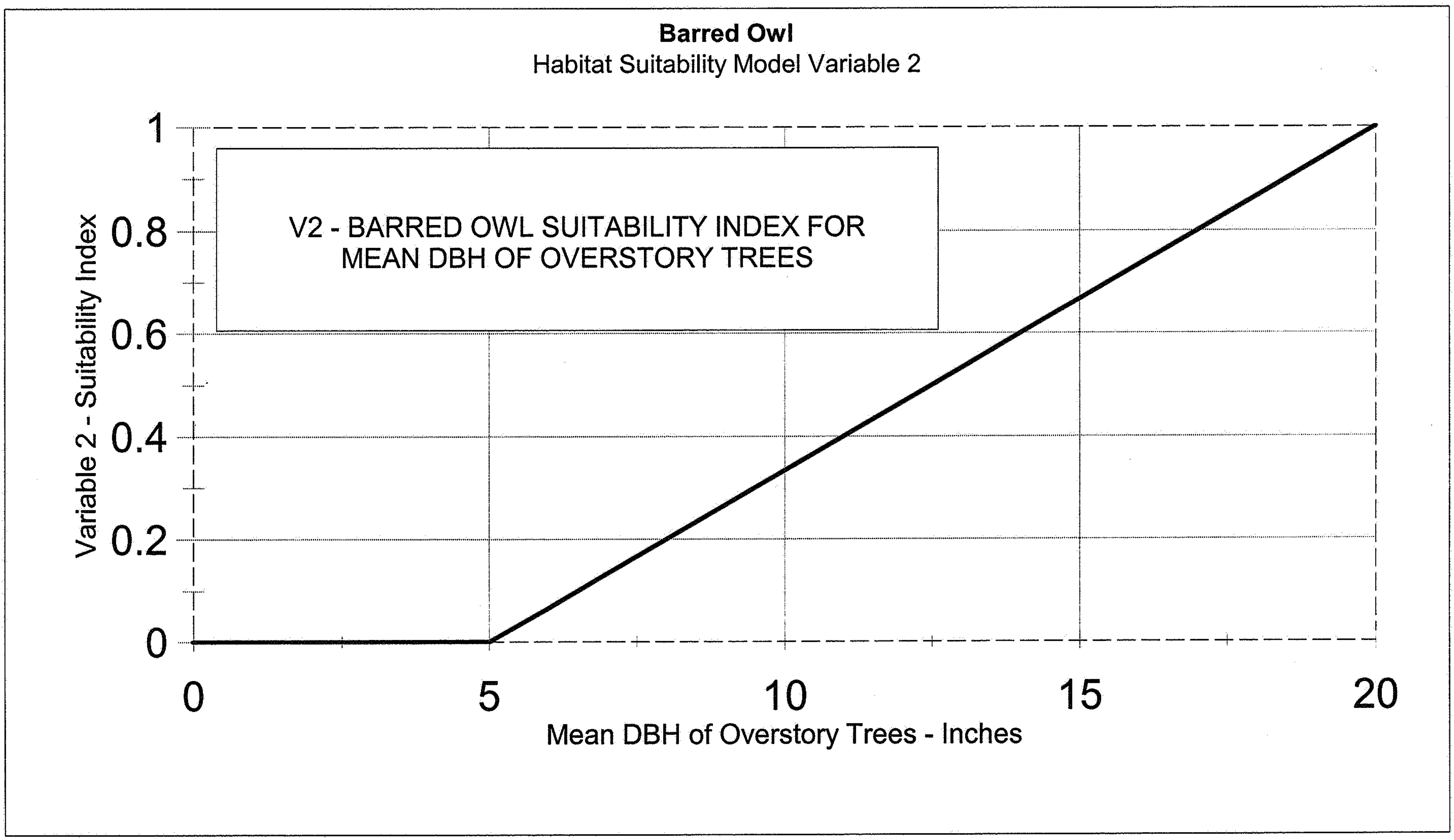
		Site Number																											
		1	1A	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Sapium sebiferum	Chinese Tallow												x																
Schrankia uncinata	Sensitive Brier		x	x		x	x							x						x	x	x	x				x		
Sesbania drummondii	Rattlebush/Sesbania																						x						
Smilax bona-nox	Greenbriar				x					x		x			x	x			x						x				
Solanum elaeagnifolium	Silverleaf nightshade	x					x																						
Sonchus asper	Sowthistle/Wild lettuce	x		x														x		x				x					
Sorghum halapense	Johnsongrass		x	x	x		x		x		x					x	x					x	x			x	x		
Taxodium distichum	Baldcypress																												
Tillandsia recurvata	Ball Moss																												
Torilis arvensis	Hedge Parsley/Beggars lice	x	x	x	x		x			x		x		x	x										x	x	x		
Toxicodendron radicans	Poison Ivy																							x					x
Tragia sp.	Noseburn																												
Triodanus perfoliata	Venus' Looking-glass																												
Ulmus crassifolia	Cedar Elm								x			x	x			x		x							x				
Verbena bipinnatifida	Prairie Verbena			x																									
Verbena brasiliensis	Brazilian Vervain		x	x	x				x		x																		
Verbesina microptera DC	Frostweed/Iceweed																x							x					
Viburnum nudum	Possumhaw																								x				
Viola missouriensis	Missouri Violet																												
Vitis sp.	Grape											x			x		x	x						x	x				
Ziziphus obutusifolia	Lotebush													x															
	unk vine 1 (yellow flower)	x		x	x																								
	unk vine 2 (purple flower)			x																									
	unknown Ground Cherry??					x																							
	unknown thorny w orange fruit															x		x											

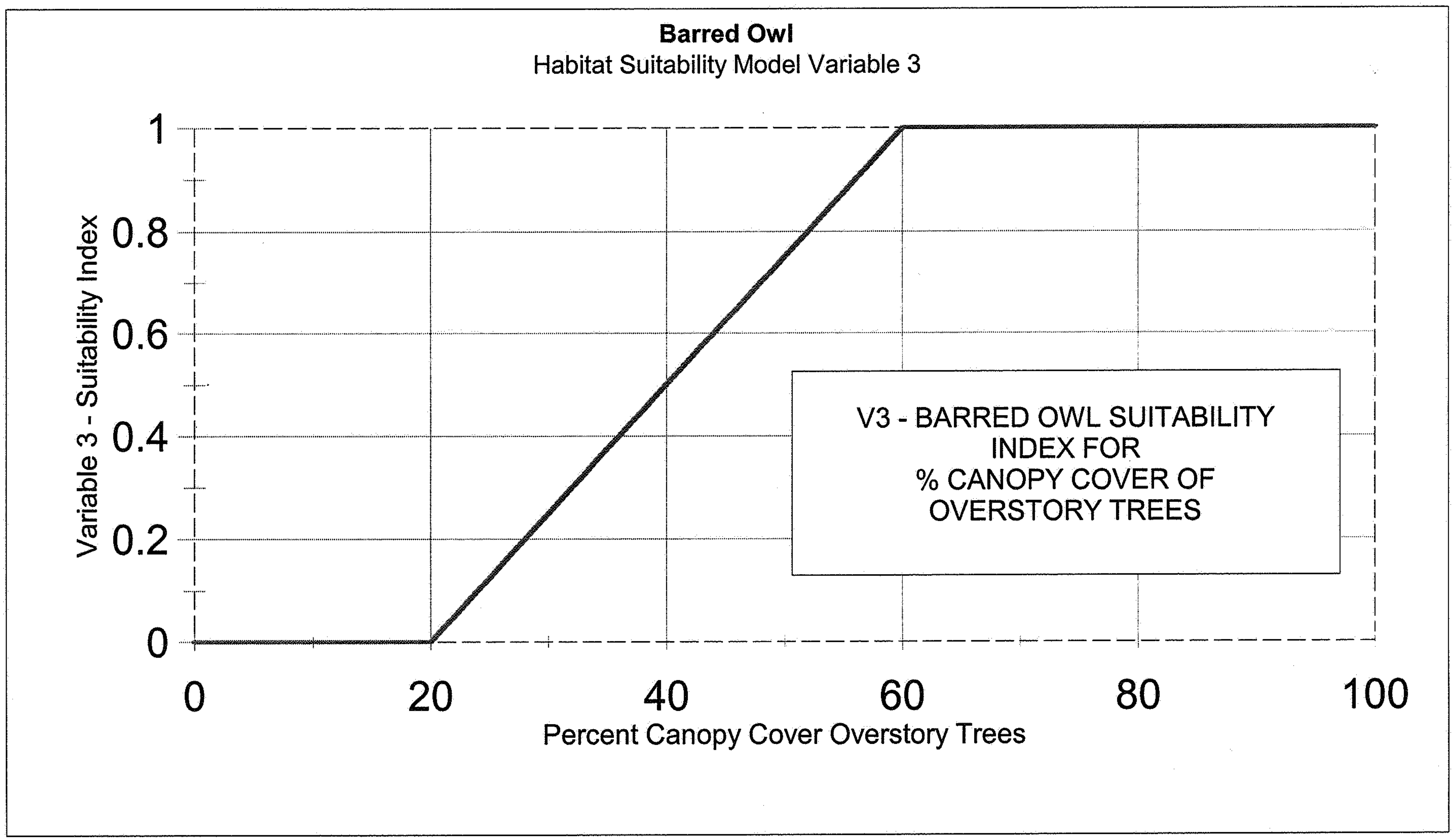
Habitat Evaluation Procedure Model
Barred Owl (*Strix varia*)
Allen (1987)

Habitat Suitability Index (Allen 1987)

HSI = [(v1 * v2) ** 0.5] * v3


Barred Owl
Habitat Suitability Model Variable 1
1
0.8
0.6
0.4
0.2
0
Variable 1 - Suitability Index
0
0.5
1
1.5
2
2.5
3
3.5
4
No. Trees > 51 CM DBH per 0.4 HA
V1 - BARRED OWL SUITABILITY INDEX
FOR NUMBER OF TREES GREATER
THAN 51 CM DBH PER 0.4 HA


Barred Owl
Habitat Suitability Model Variable 2
V2 - BARRED OWL SUITABILITY INDEX FOR
MEAN DBH OF OVERSTORY TREES
Variable 2 - Suitability Index
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20
Mean DBH of Overstory Trees - Inches



Barred Owl
Habitat Suitability Model Variable 3
1
0.8
0.6
0.4
0.2
0
Variable 3 - Suitability Index
0
20
40
60
80
100
Percent Canopy Cover Overstory Trees
V3 - BARRED OWL SUITABILITY INDEX FOR % CANOPY COVER OF OVERSTORY TREES

Habitat Evaluation Procedure Model
Wildlife Species Richness in Shelterbelts
Schroeder (1986)

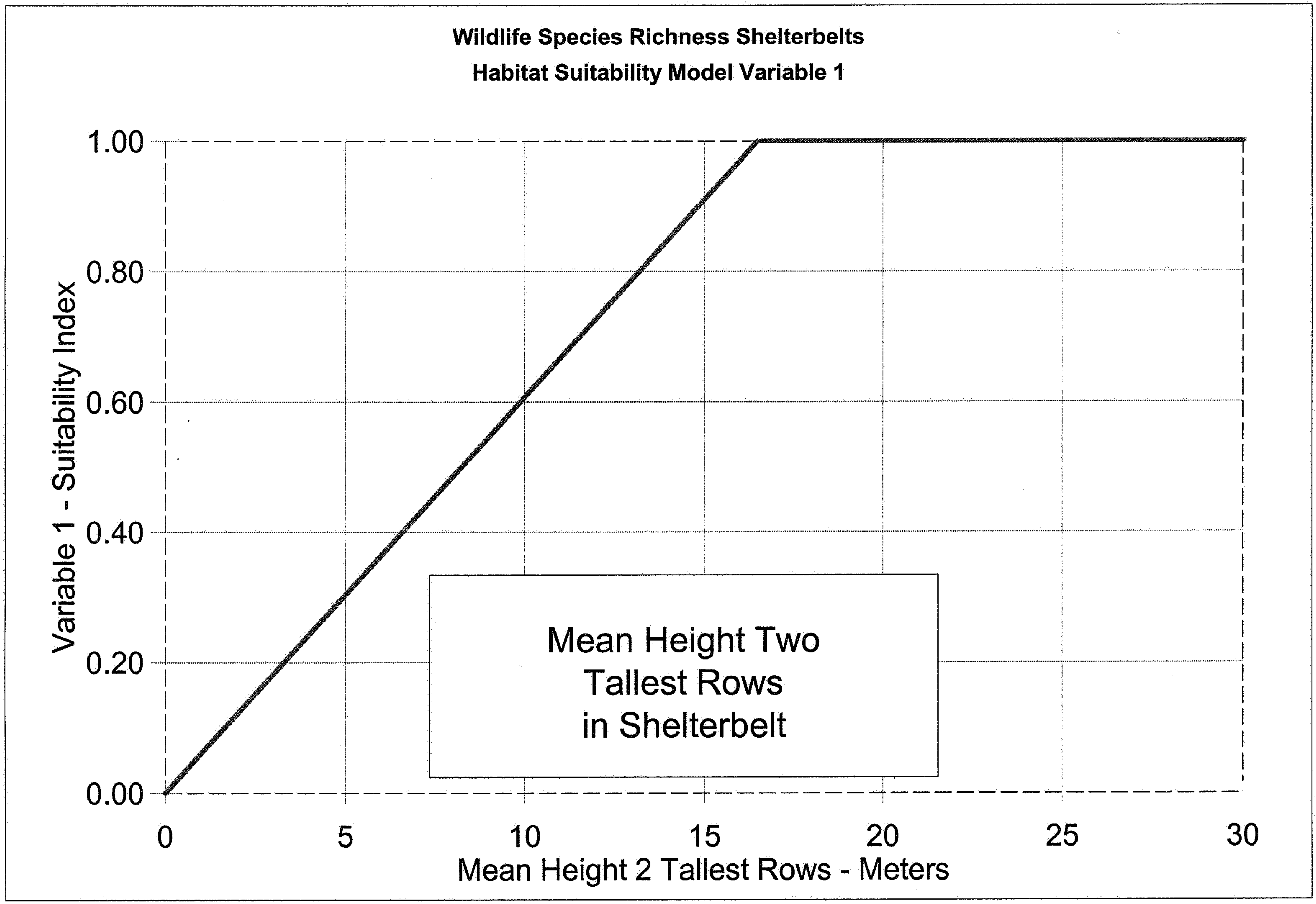
$HSI_{original}$

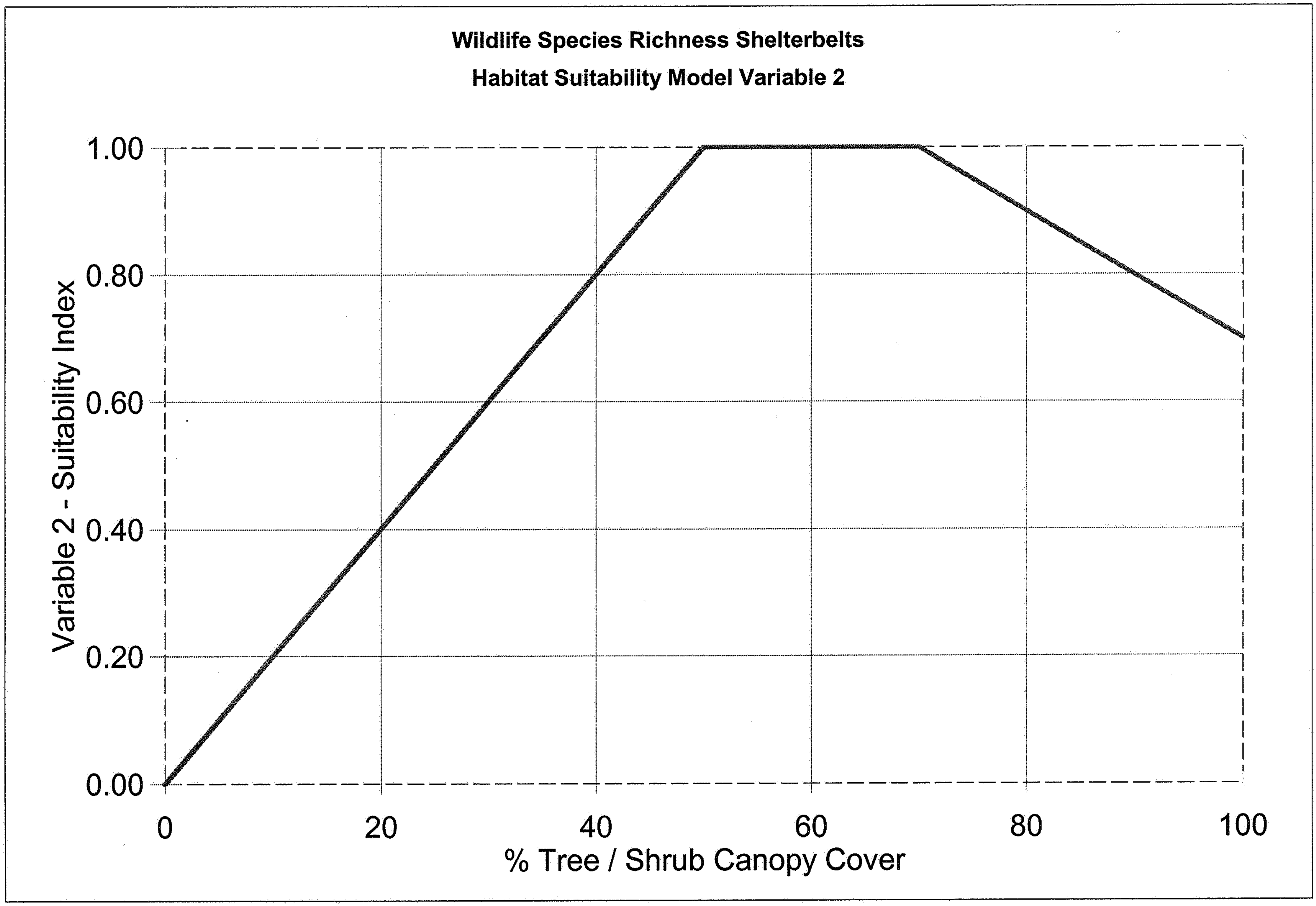
$$((v1 + v2) / 2) * ((v3 + v4 + v5) / 3) * v6$$

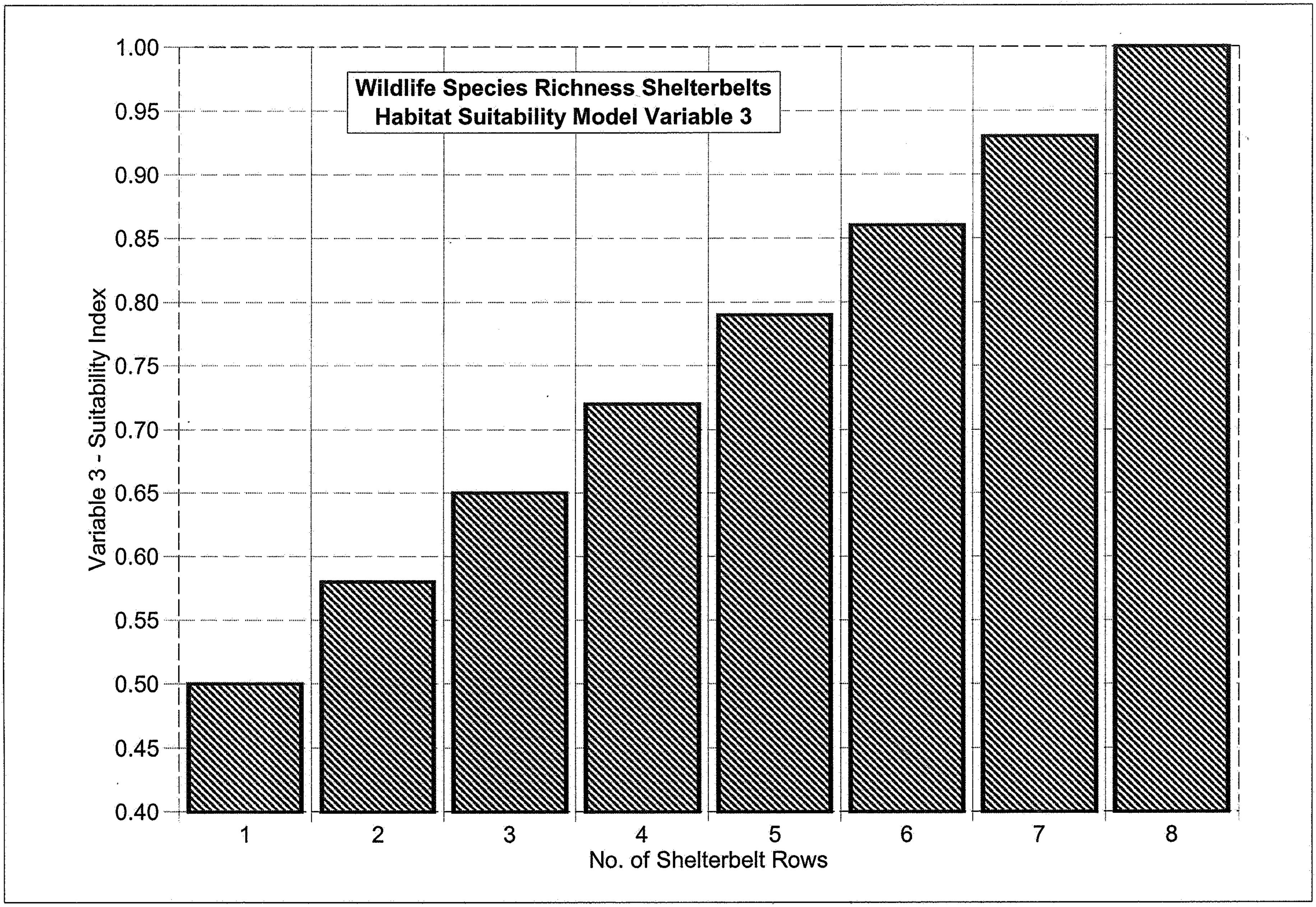
$HSI_{modified}$

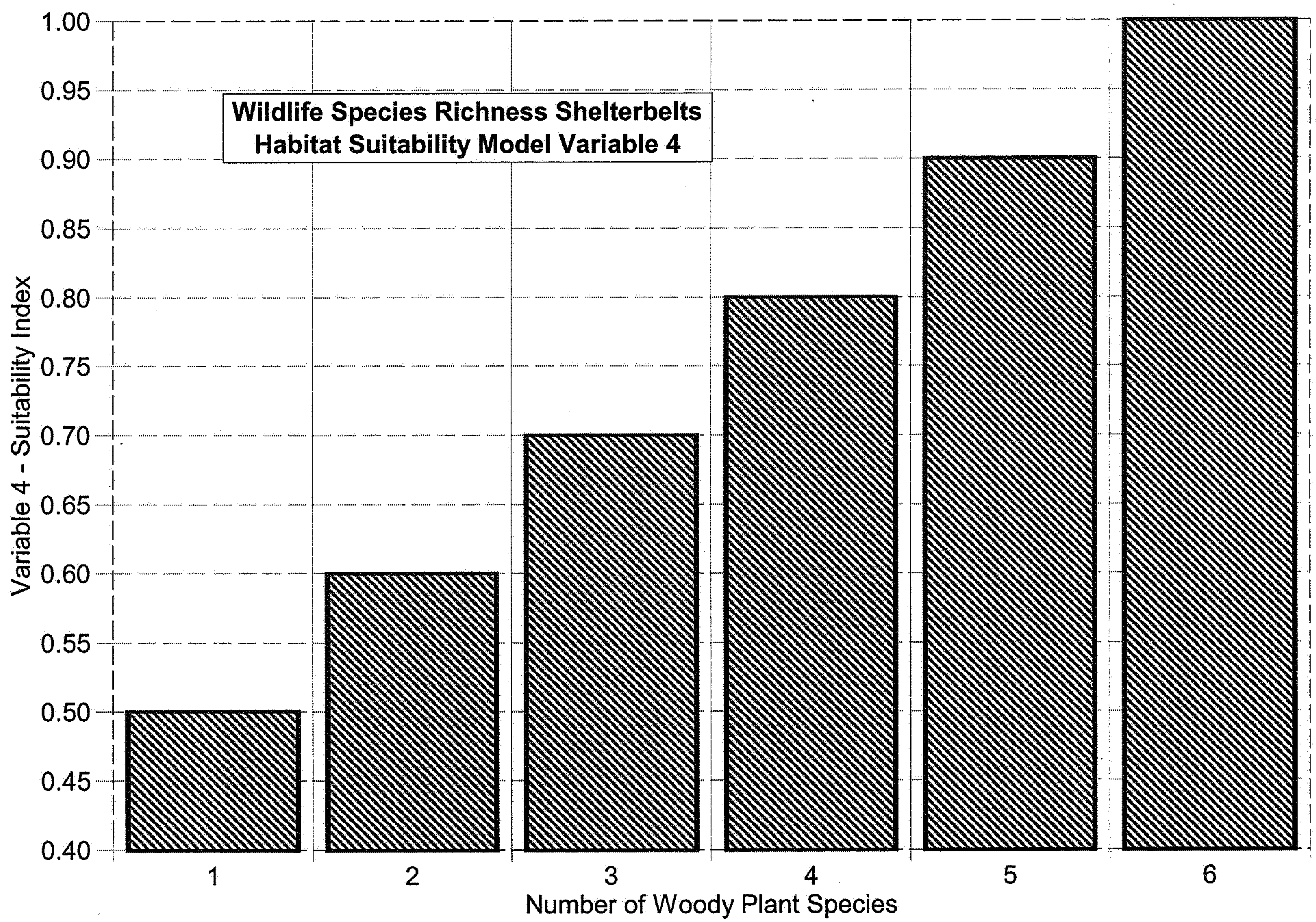
variables 1, 4, and 5 only:

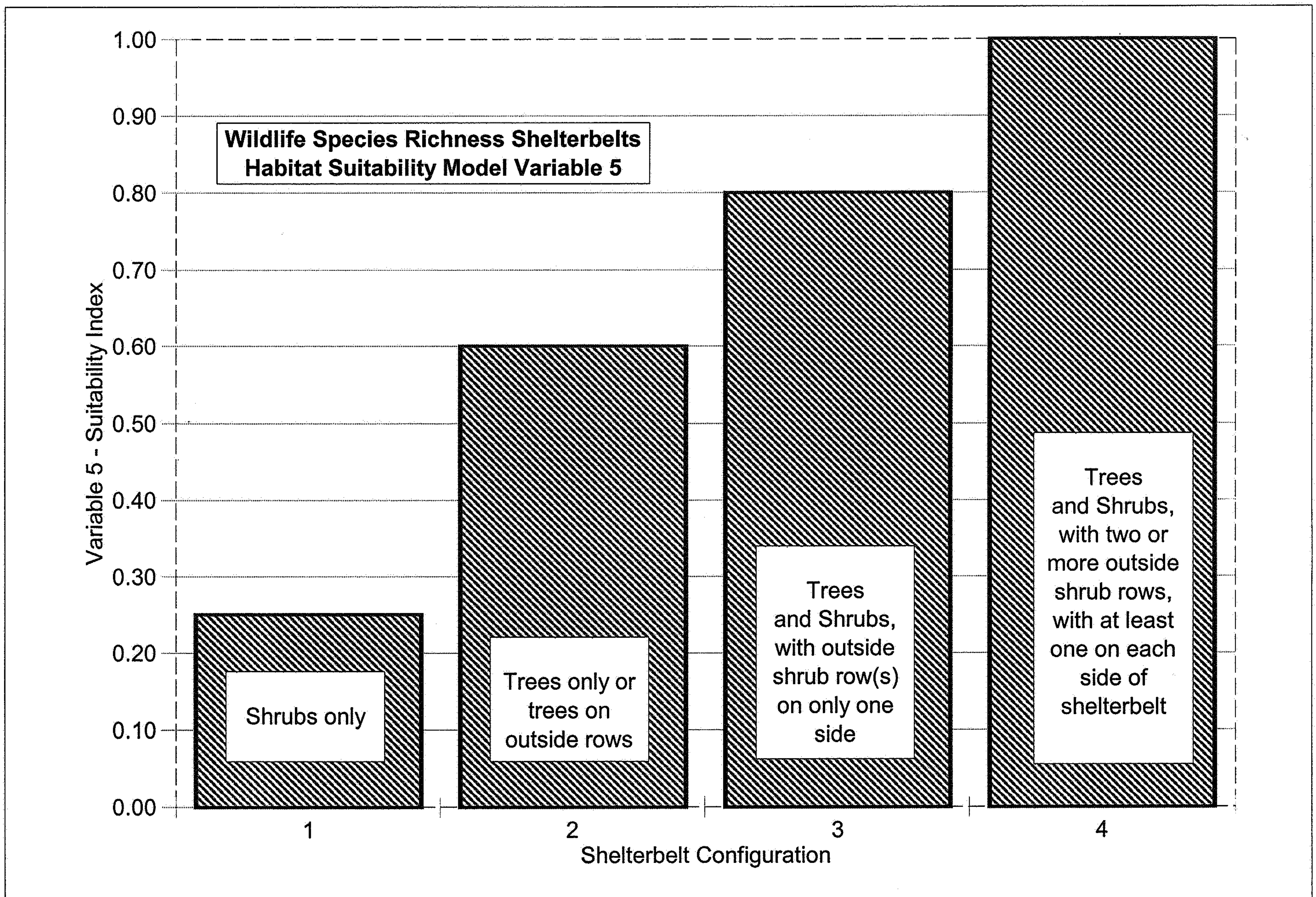
$$((v1 + (v4 * 2) + (v5 * 4)) / 7$$

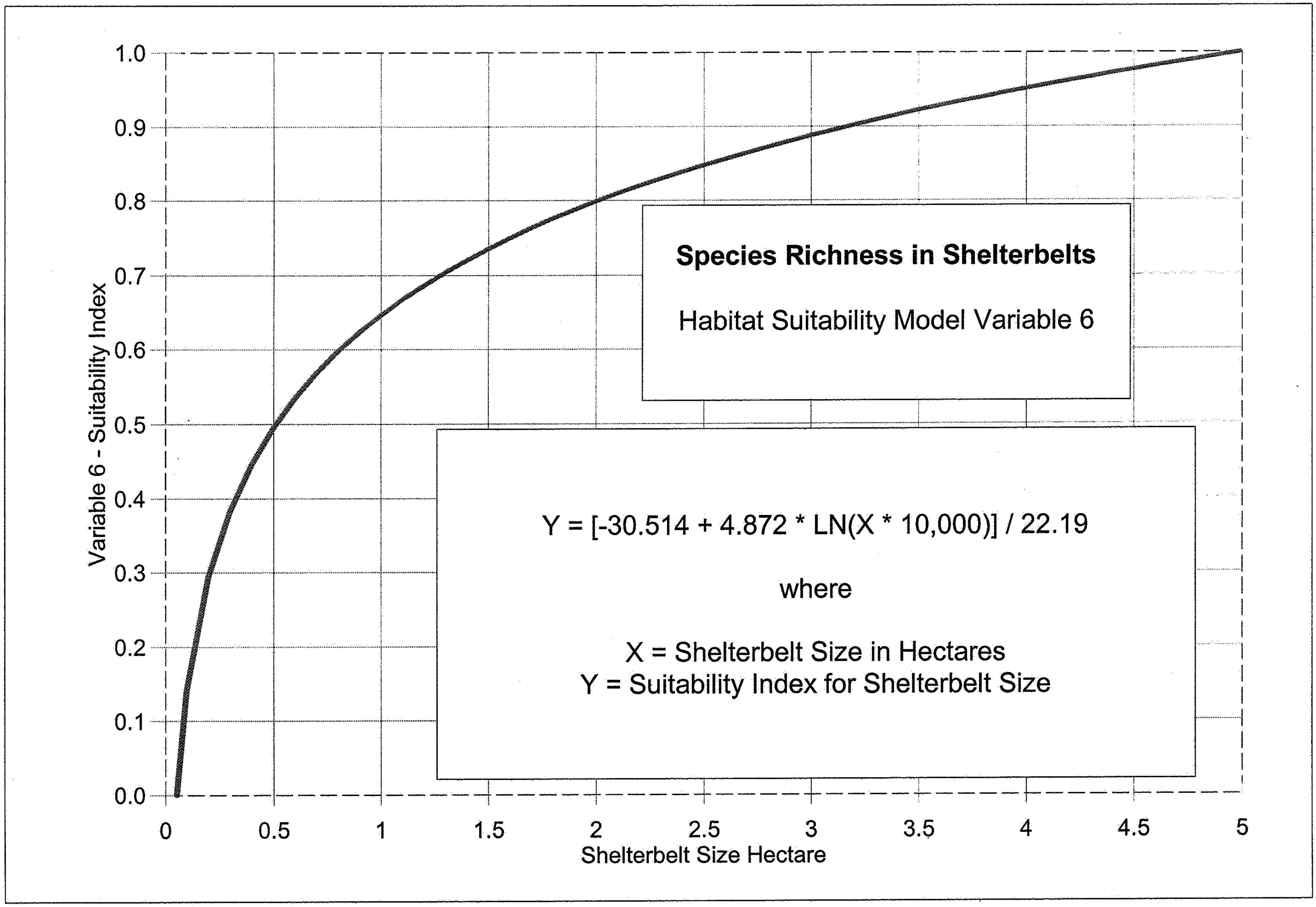

Wildlife Species Richness Shelterbelts
Habitat Suitability Model Variable 1
Variable 1 - Suitability Index
1.00
0.80
0.60
0.40
0.20
0.00
0
5
10
15
20
25
30
Mean Height 2 Tallest Rows - Meters
Mean Height Two
Tallest Rows
in Shelterbelt


Wildlife Species Richness Shelterbelts
Habitat Suitability Model Variable 2
Variable 2 - Suitability Index
1.00
0.80
0.60
0.40
0.20
0.00
0
20
40
60
80
100
% Tree / Shrub Canopy Cover


Wildlife Species Richness Shelterbelts
Habitat Suitability Model Variable 3
Variable 3 - Suitability Index
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
1
2
3
4
5
6
7
8
No. of Shelterbelt Rows


Wildlife Species Richness Shelterbelts
Habitat Suitability Model Variable 4
Variable 4 - Suitability Index
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
1
2
3
4
5
6
Number of Woody Plant Species


Wildlife Species Richness Shelterbelts
Habitat Suitability Model Variable 5
Variable 5 - Suitability Index
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Shrubs only
Trees only or trees on outside rows
Trees and Shrubs, with outside shrub row(s) on only one side
Trees and Shrubs, with two or more outside shrub rows, with at least one on each side of shelterbelt
1
2
3
4
Shelterbelt Configuration


Species Richness in Shelterbelts
Habitat Suitability Model Variable 6
Y = [-30.514 + 4.872 * LN(X * 10,000)] / 22.19
where
X = Shelterbelt Size in Hectares
Y = Suitability Index for Shelterbelt Size
Variable 6 - Suitability Index
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Shelterbelt Size Hectare

Habitat Evaluation Procedure Model

Raccoon (*Procyon lotor*)

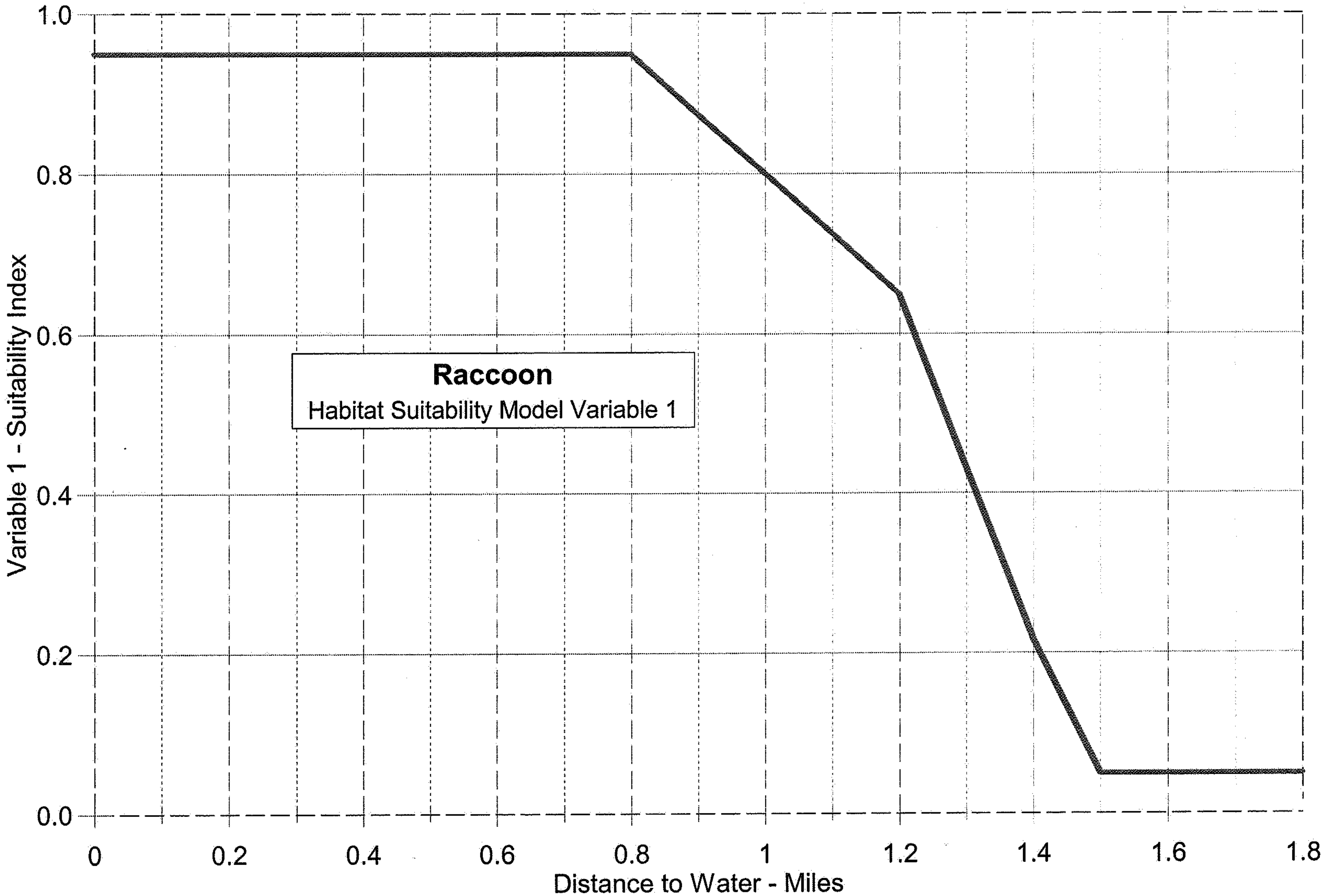
USFWS (1980)

(a) Water Value = (v1 * v2) ** 0.5

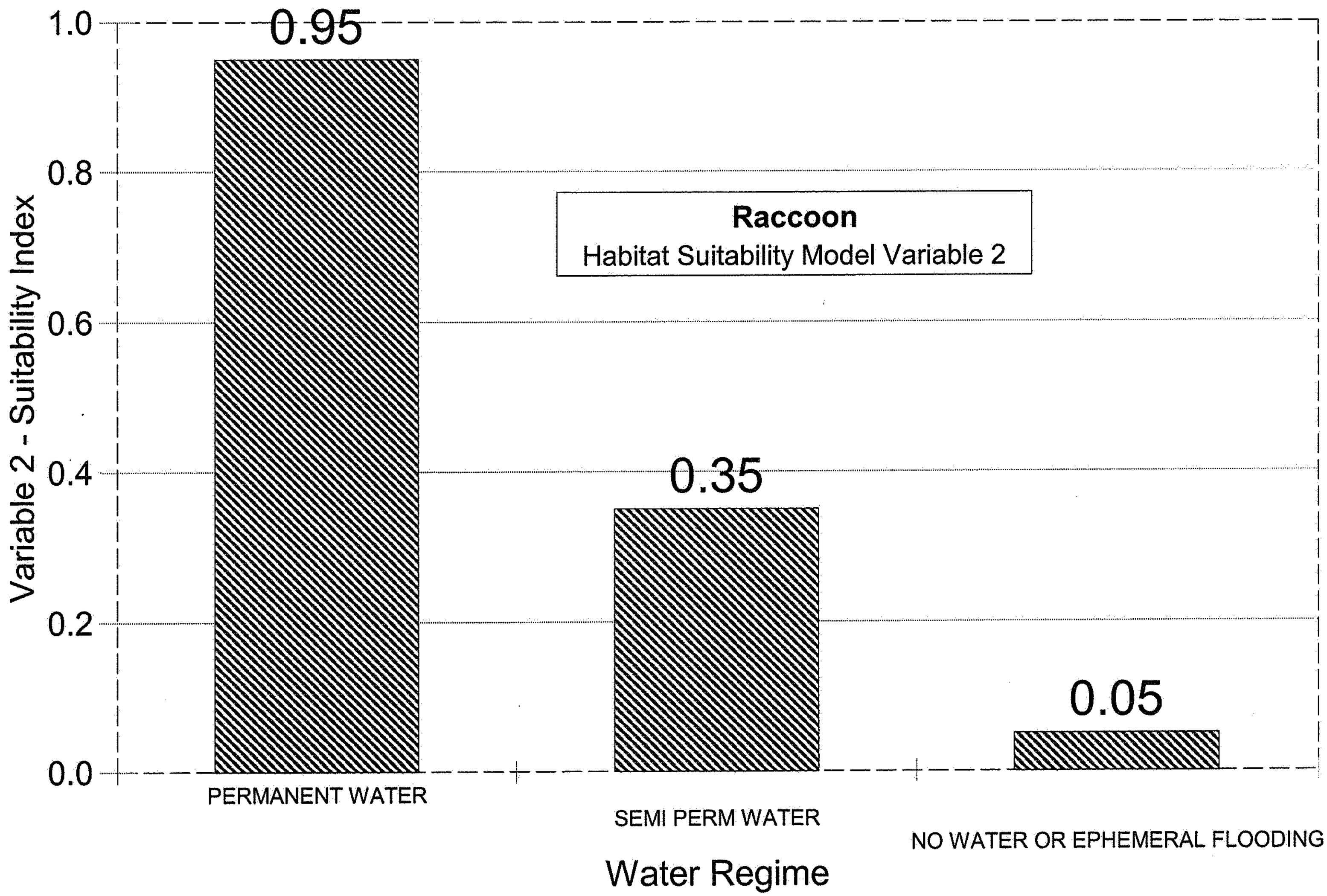
(b) Cover & Reproduction Value

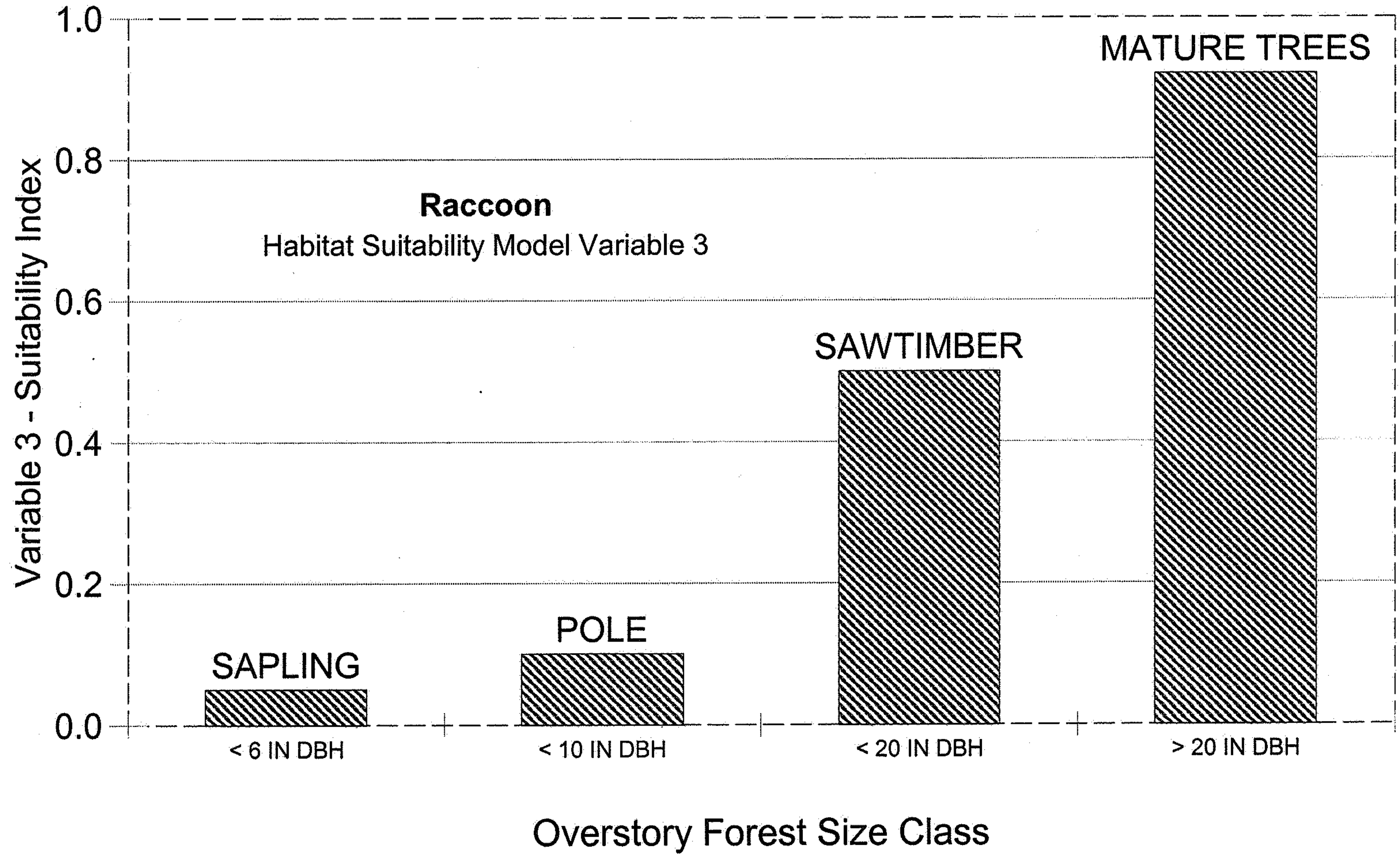
(v3 + v4) / 2

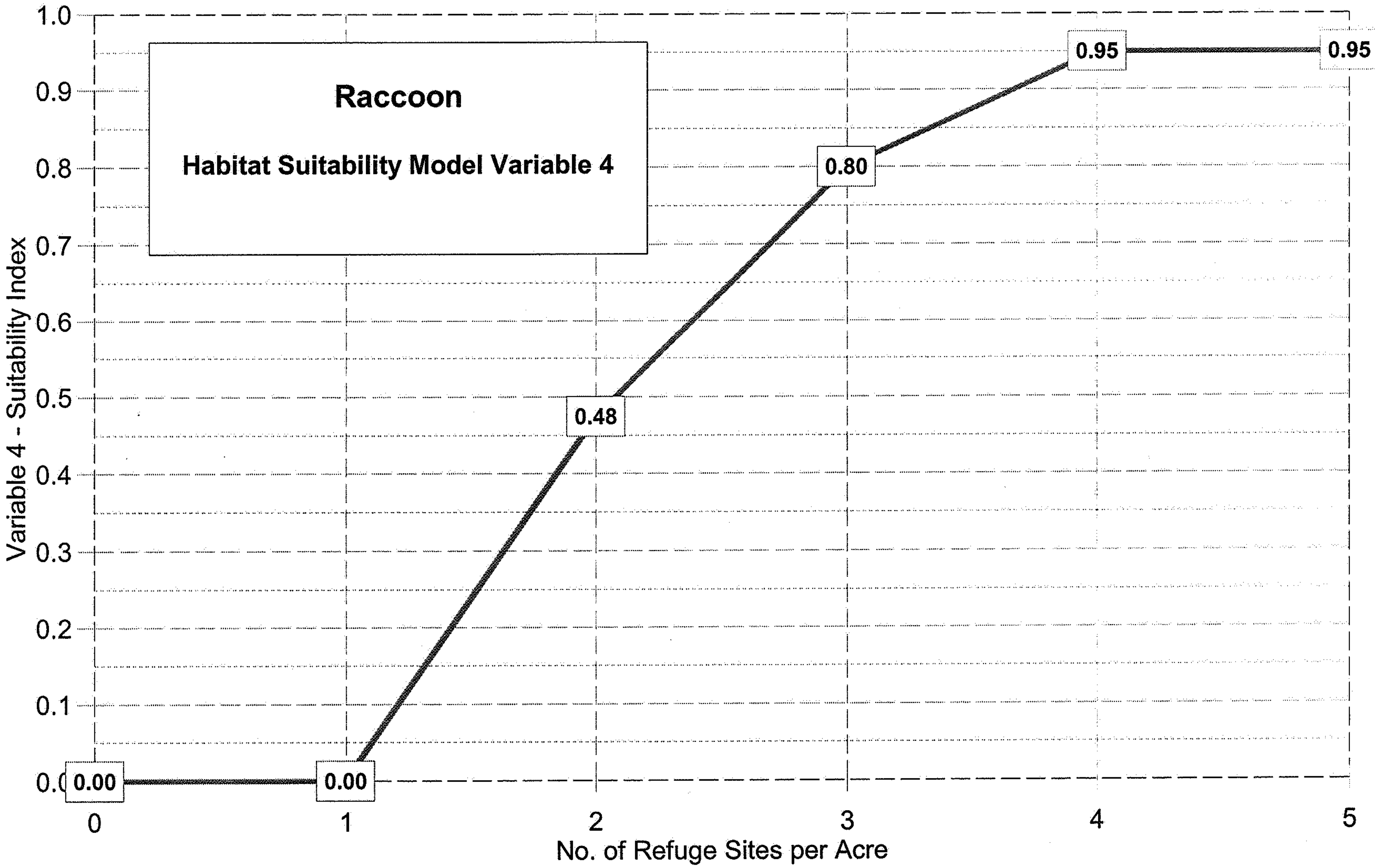
HSI = minimum (a), (b)



Raccoon
Habitat Suitability Model Variable 1
Variable 1 - Suitability Index
1.0
0.8
0.6
0.4
0.2
0.0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Distance to Water - Miles


Raccoon
Habitat Suitability Model Variable 2
Variable 2 - Suitability Index
1.0
0.8
0.6
0.4
0.2
0.0
0.95
0.35
0.05
PERMANENT WATER
SEMI PERM WATER
NO WATER OR EPHEMERAL FLOODING
Water Regime


Raccoon
Habitat Suitability Model Variable 3
Variable 3 - Suitability Index
1.0
0.8
0.6
0.4
0.2
0.0
SAPLING
POLE
SAWTIMBER
MATURE TREES
< 6 IN DBH
< 10 IN DBH
< 20 IN DBH
> 20 IN DBH
Overstory Forest Size Class

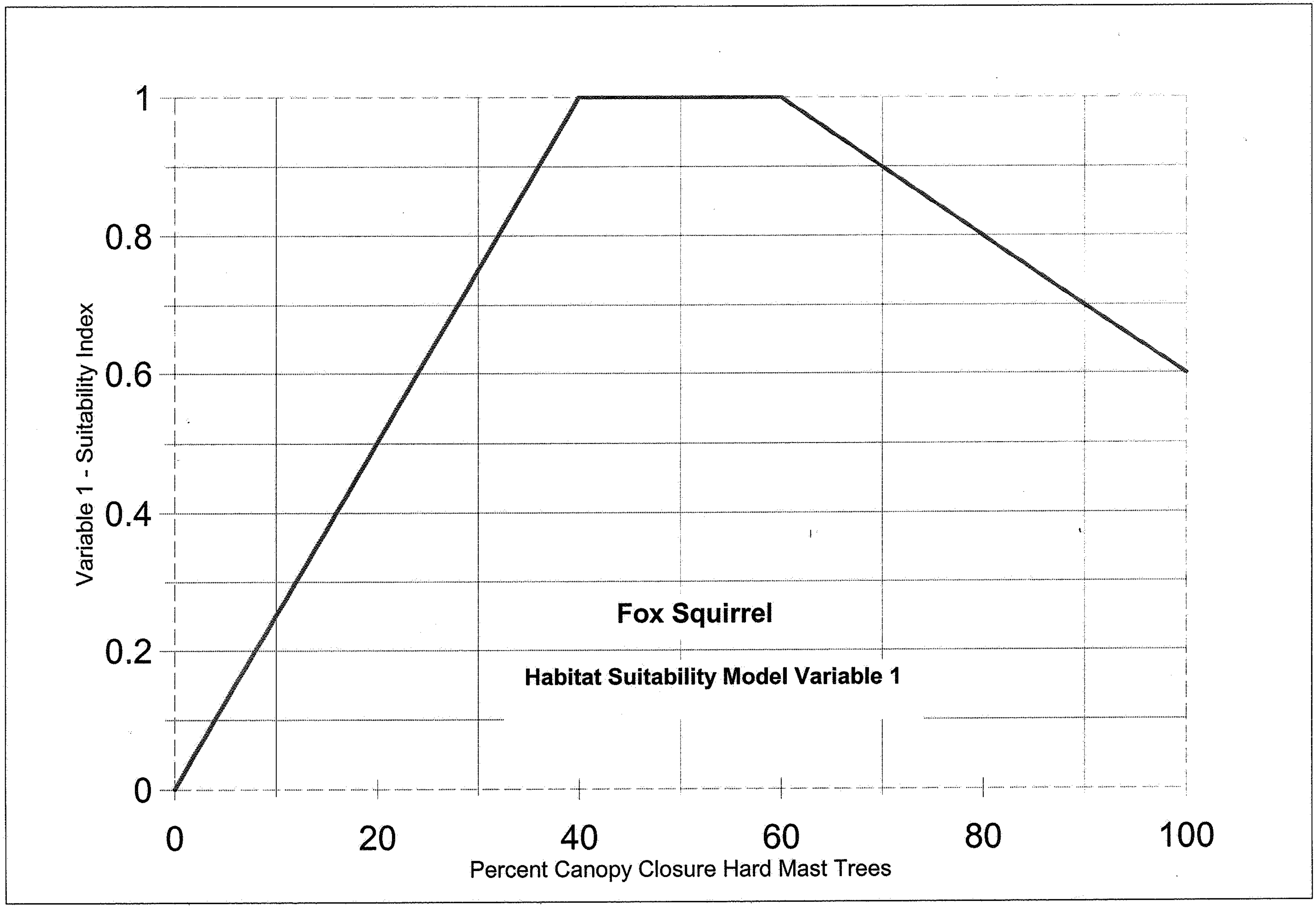

Raccoon
Habitat Suitability Model Variable 4
Variable 4 - Suitability Index
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.00
0.00
0.48
0.80
0.95
0.95
0
1
2
3
4
5
No. of Refuge Sites per Acre

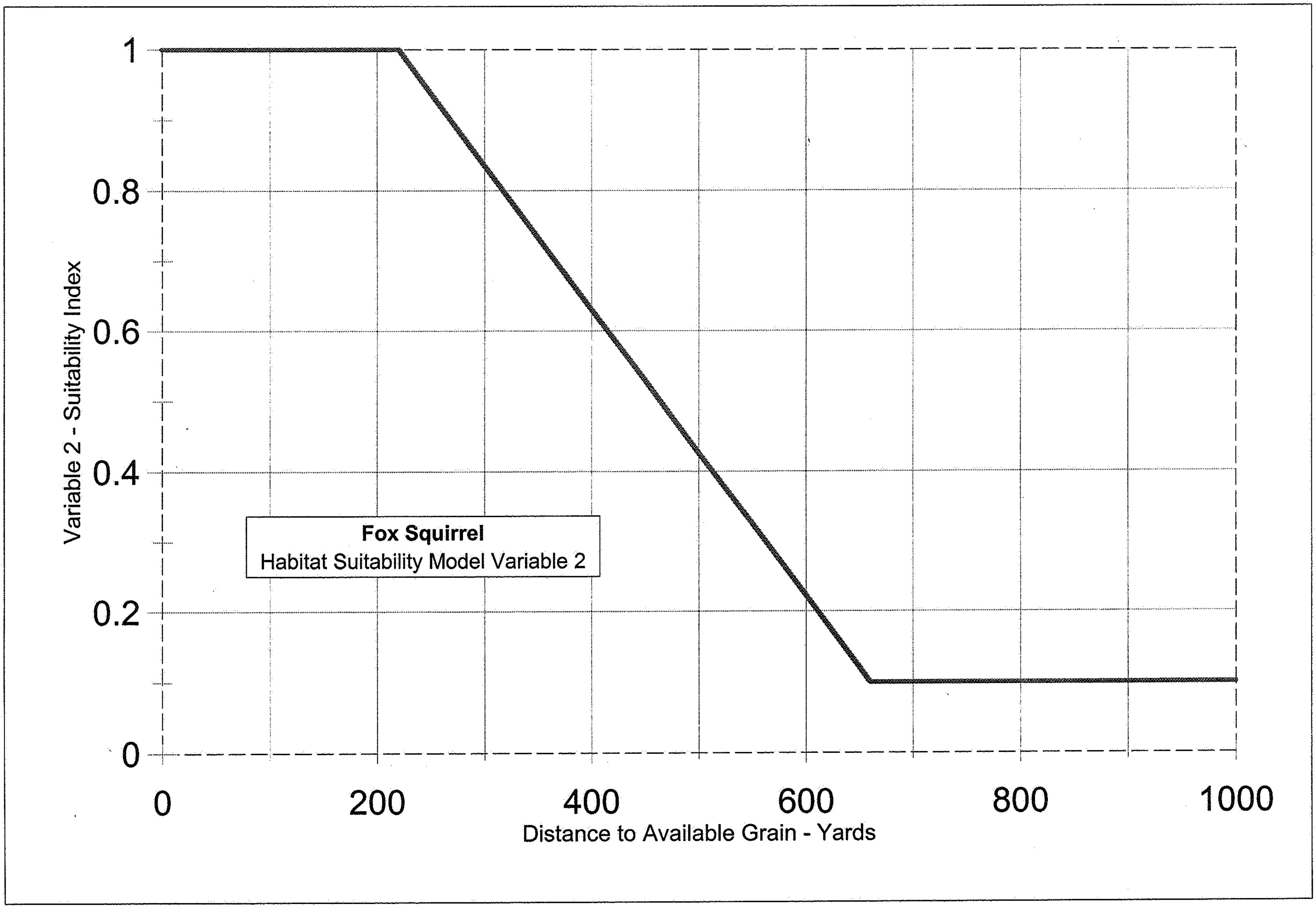
Habitat Evaluation Procedure Model
Fox Squirrel (*Sciurus niger*)
Allen (1982)

(a) HSI winter food = [(v1 * 3) + v2] / 3

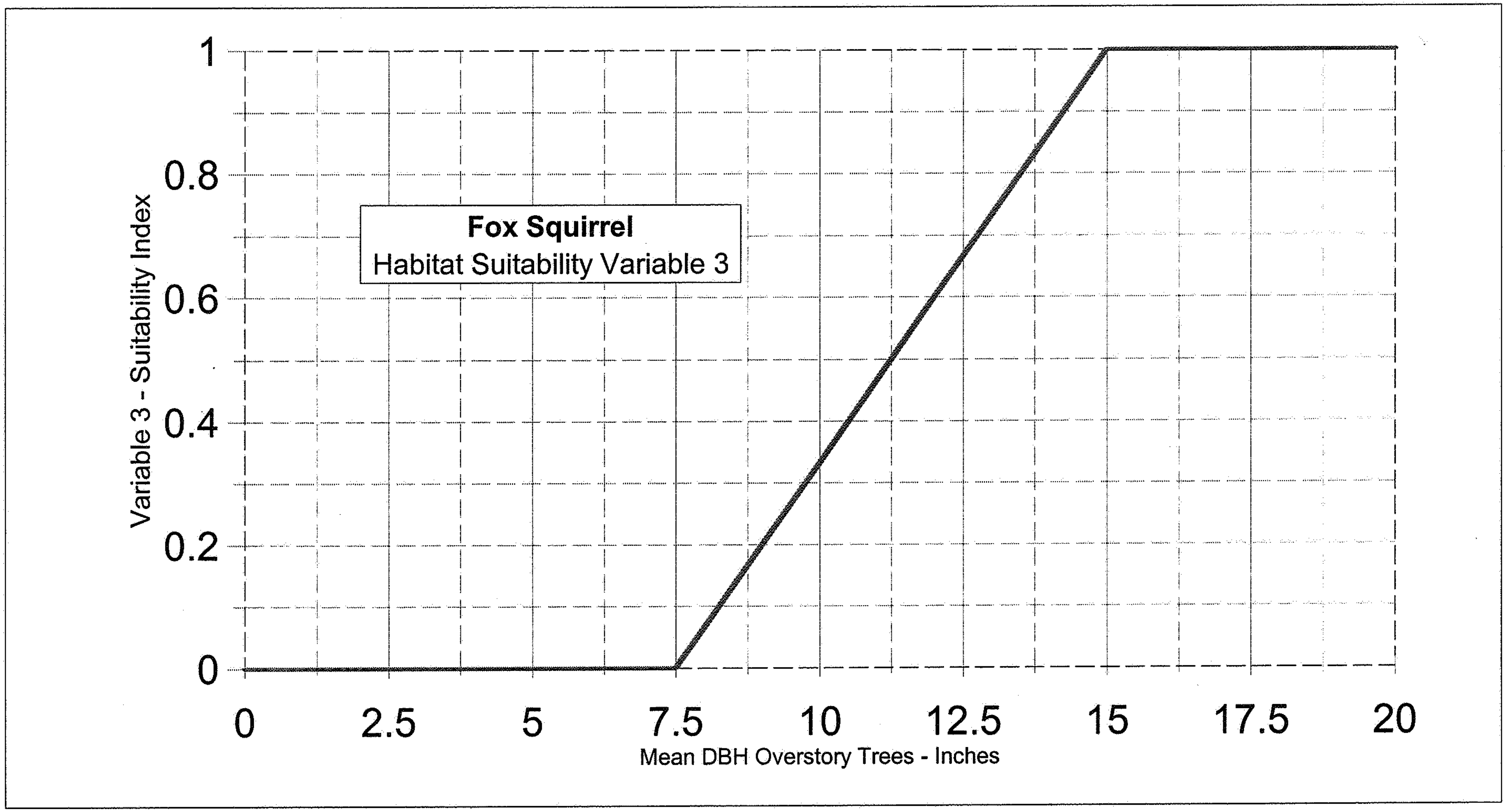
(b) HSI cover / reproduction = (v3 * v4 * v5) ** 0.33

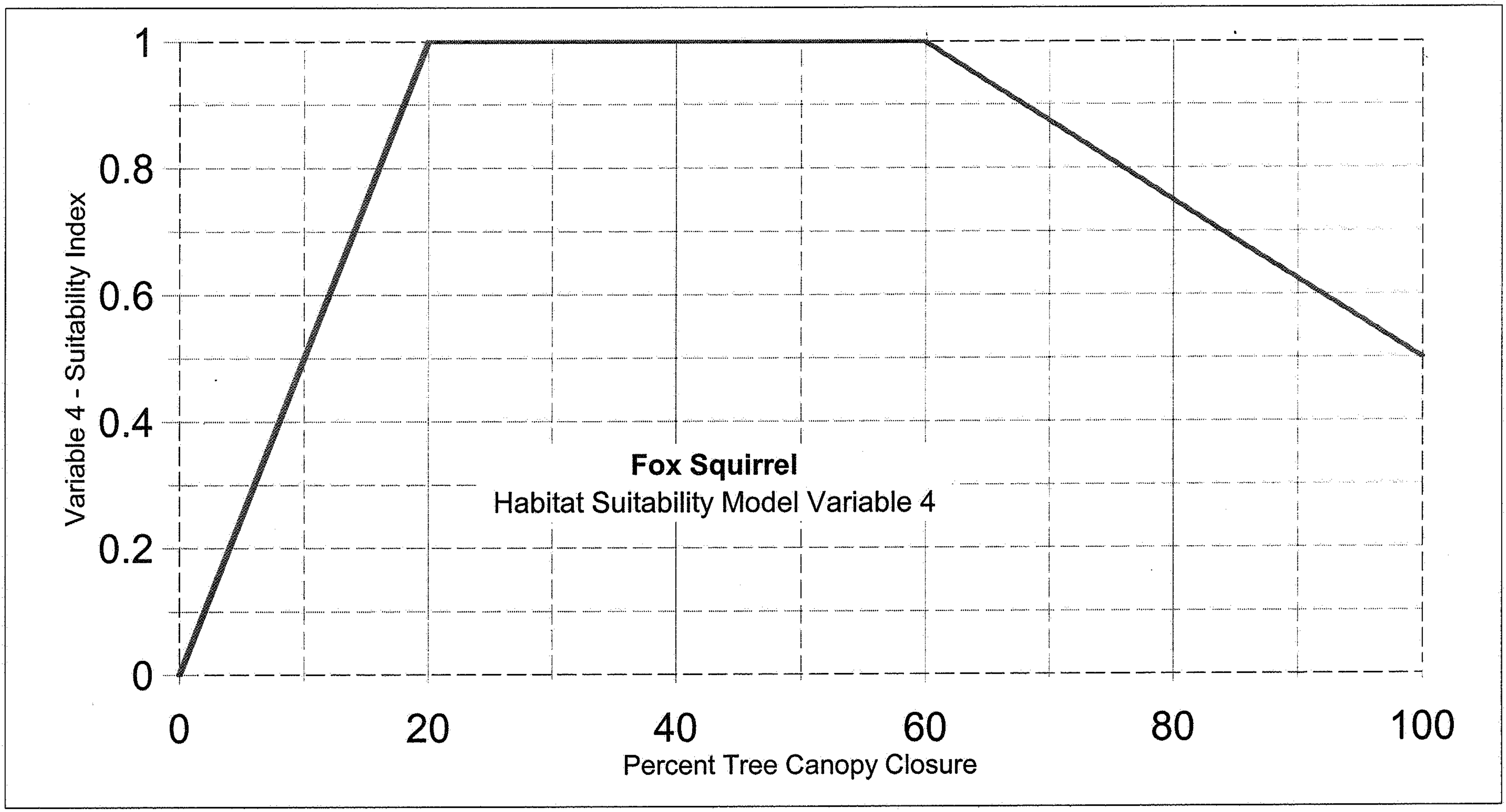
HSI = minimum (a),(b)

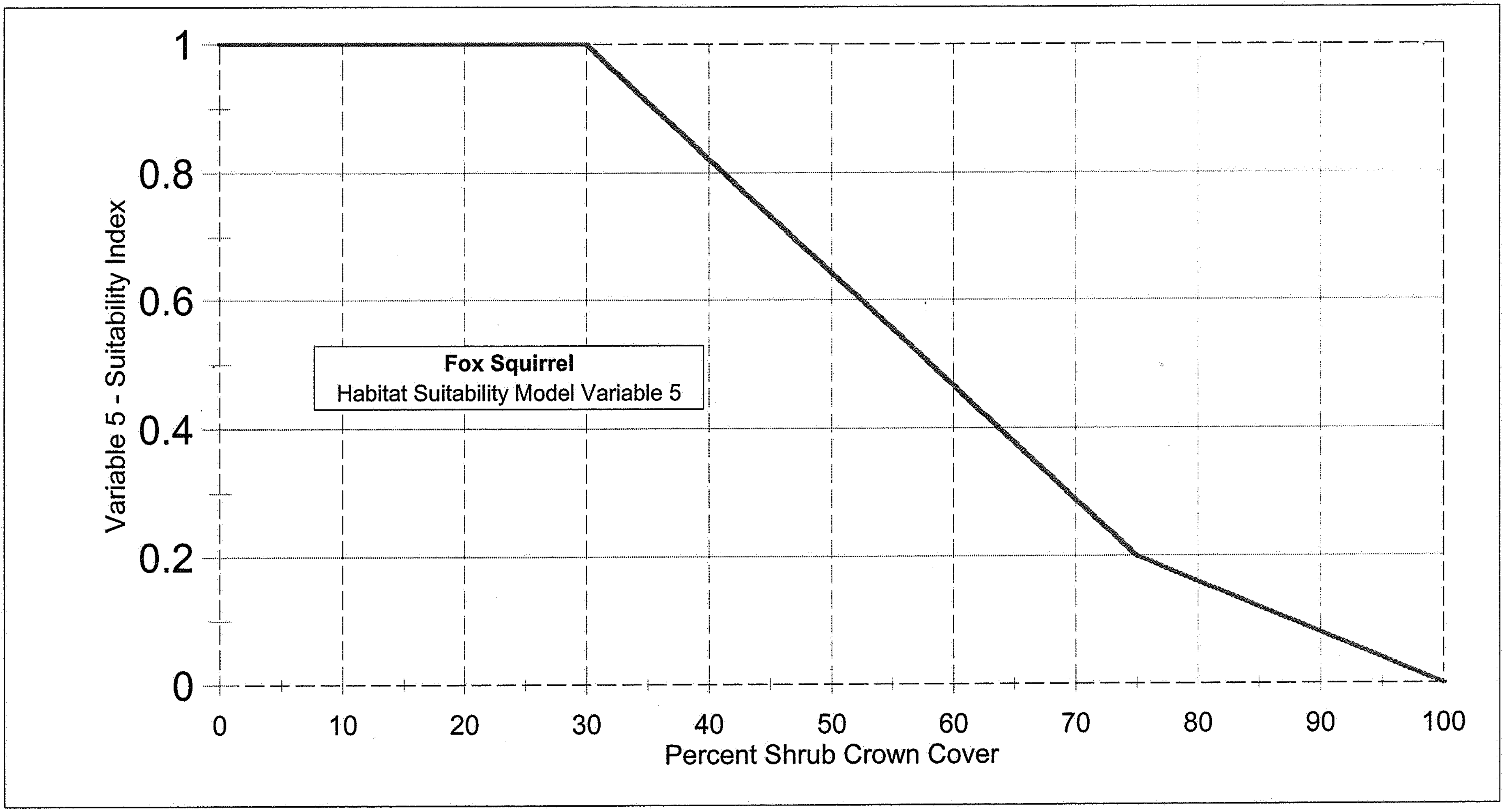

Fox Squirrel
Habitat Suitability Model Variable 1
Variable 1 - Suitability Index
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
Percent Canopy Closure Hard Mast Trees



Fox Squirrel
Habitat Suitability Model Variable 2
Variable 2 - Suitability Index
1
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1000
Distance to Available Grain - Yards


Fox Squirrel
Habitat Suitability Variable 3
Variable 3 - Suitability Index
0
0.2
0.4
0.6
0.8
1
0
2.5
5
7.5
10
12.5
15
17.5
20
Mean DBH Overstory Trees - Inches


Fox Squirrel
Habitat Suitability Model Variable 4
Variable 4 - Suitability Index
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
Percent Tree Canopy Closure


Fox Squirrel
Habitat Suitability Model Variable 5
Variable 5 - Suitability Index
1
0.8
0.6
0.4
0.2
0
0
10
20
30
40
50
60
70
80
90
100
Percent Shrub Crown Cover

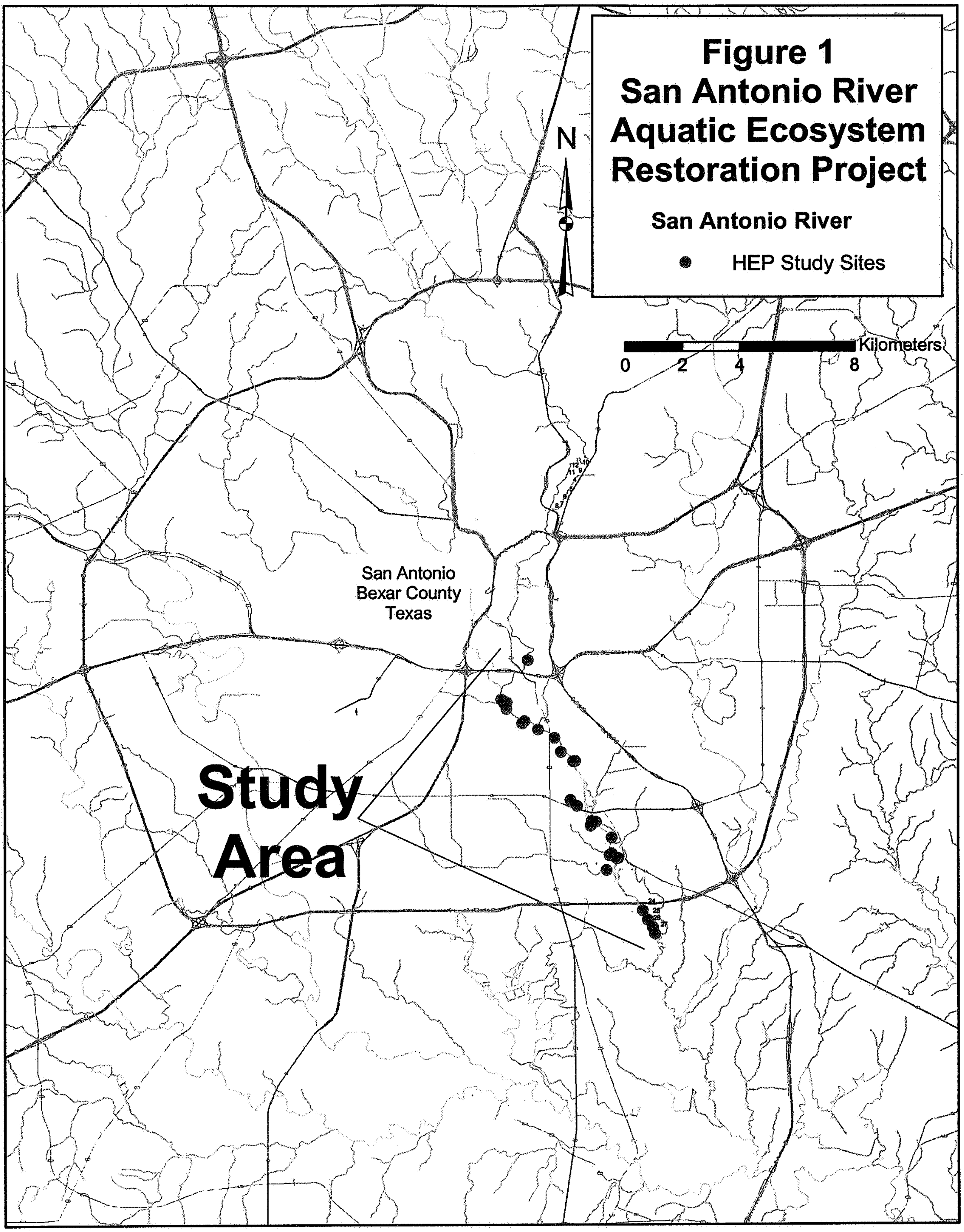
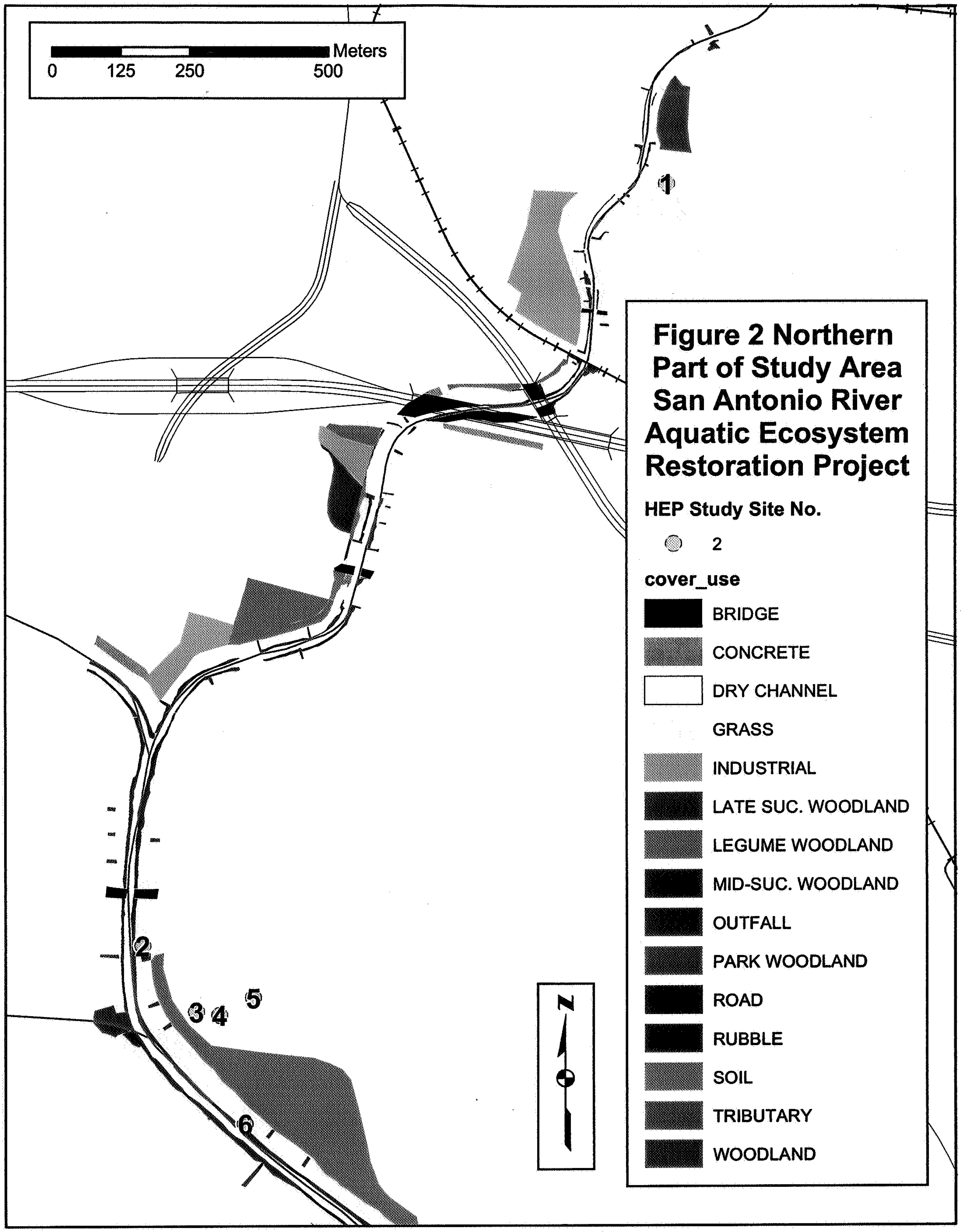


Figure 1
San Antonio River
Aquatic Ecosystem
Restoration Project
San Antonio River
HEP Study Sites
N
Kilometers
0 2 4 8
San Antonio
Bexar County
Texas
Study
Area


Meters
0
125
250
500
Figure 2 Northern Part of Study Area San Antonio River Aquatic Ecosystem Restoration Project
HEP Study Site No.
2
cover_use
BRIDGE
CONCRETE
DRY CHANNEL
GRASS
INDUSTRIAL
LATE SUC. WOODLAND
LEGUME WOODLAND
MID-SUC. WOODLAND
OUTFALL
PARK WOODLAND
ROAD
RUBBLE
SOIL
TRIBUTARY
WOODLAND
N
1
2
3
4
5
6

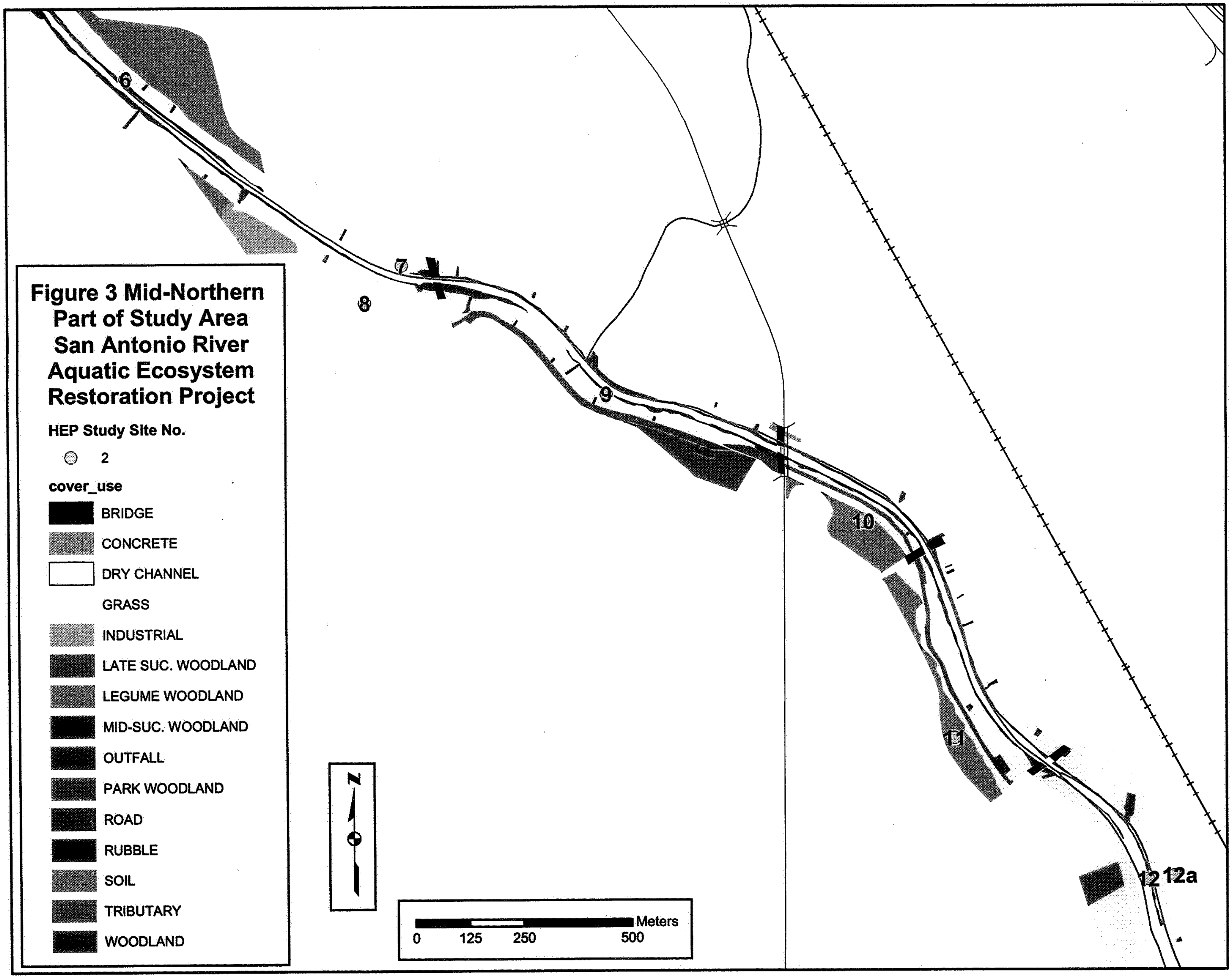


Figure 3 Mid-Northern Part of Study Area San Antonio River Aquatic Ecosystem Restoration Project

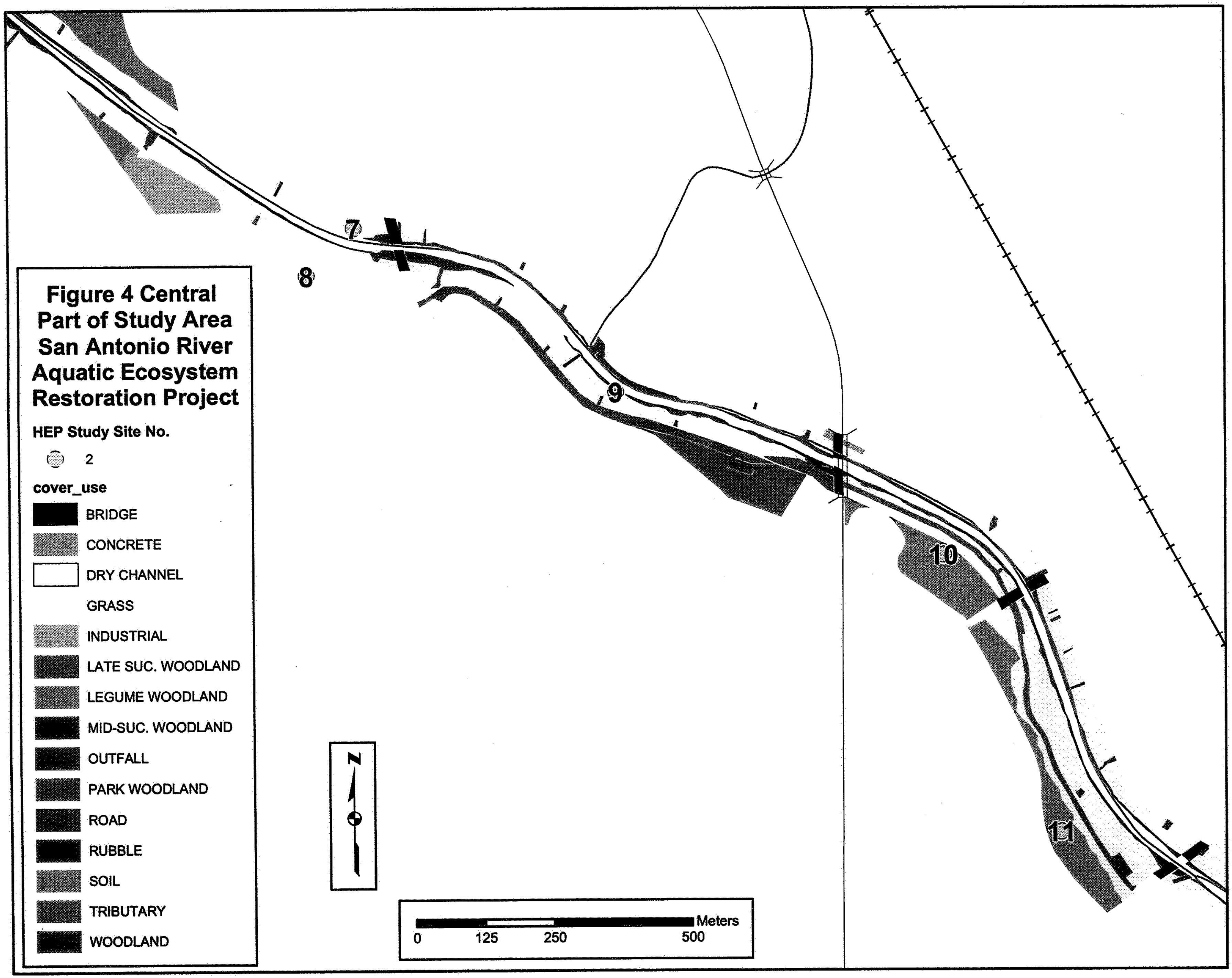


Figure 4 Central
Part of Study Area
San Antonio River
Aquatic Ecosystem
Restoration Project
HEP Study Site No.
2
cover_use
BRIDGE
CONCRETE
DRY CHANNEL
GRASS
INDUSTRIAL
LATE SUC. WOODLAND
LEGUME WOODLAND
MID-SUC. WOODLAND
OUTFALL
PARK WOODLAND
ROAD
RUBBLE
SOIL
TRIBUTARY
WOODLAND
7
8
9
10
11
N
0
125
250
500
Meters

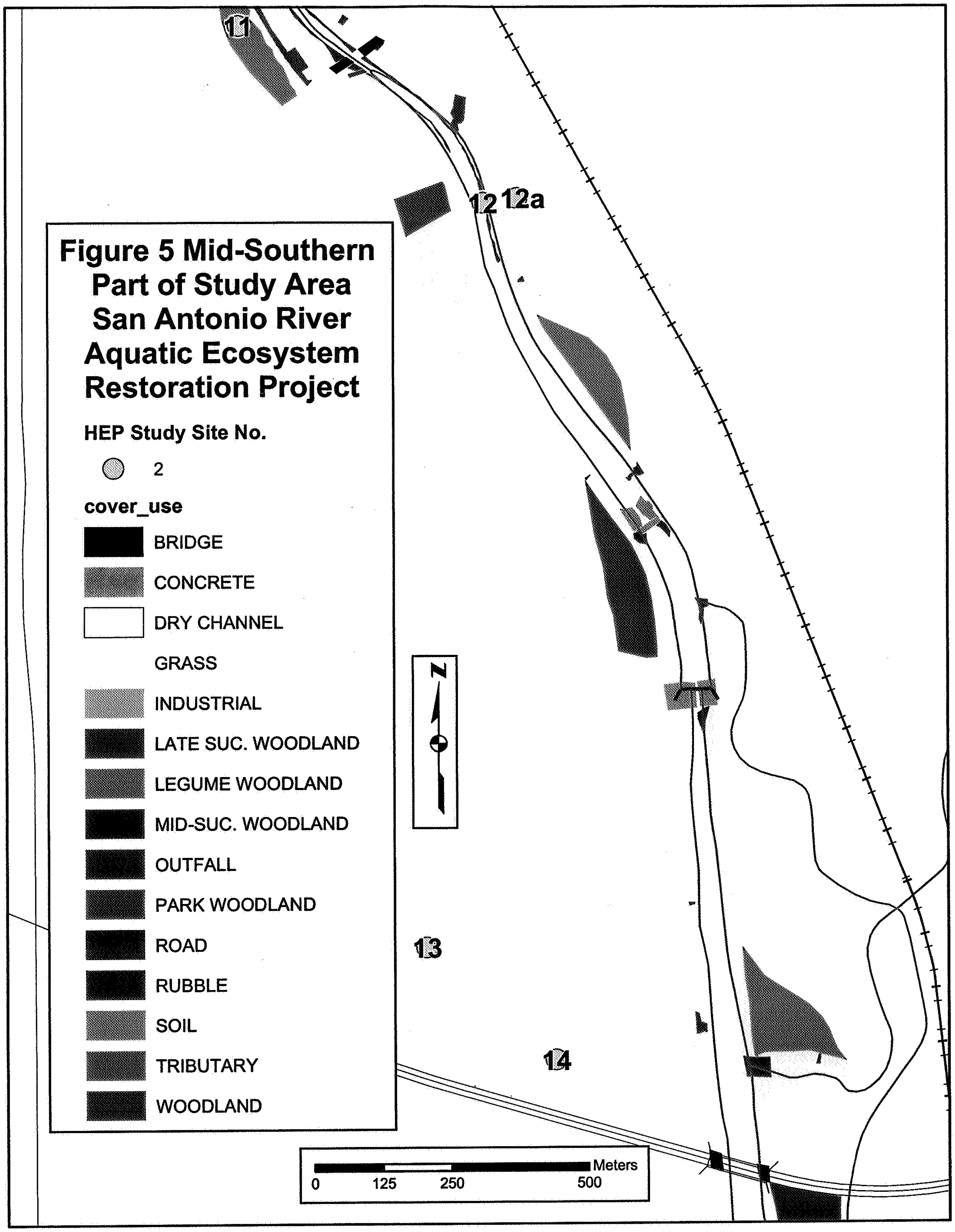


Figure 5 Mid-Southern Part of Study Area San Antonio River Aquatic Ecosystem Restoration Project
HEP Study Site No.
2
cover_use
BRIDGE
CONCRETE
DRY CHANNEL
GRASS
INDUSTRIAL
LATE SUC. WOODLAND
LEGUME WOODLAND
MID-SUC. WOODLAND
OUTFALL
PARK WOODLAND
ROAD
RUBBLE
SOIL
TRIBUTARY
WOODLAND
11
12
12a
13
14
N
0
125
250
500
Meters

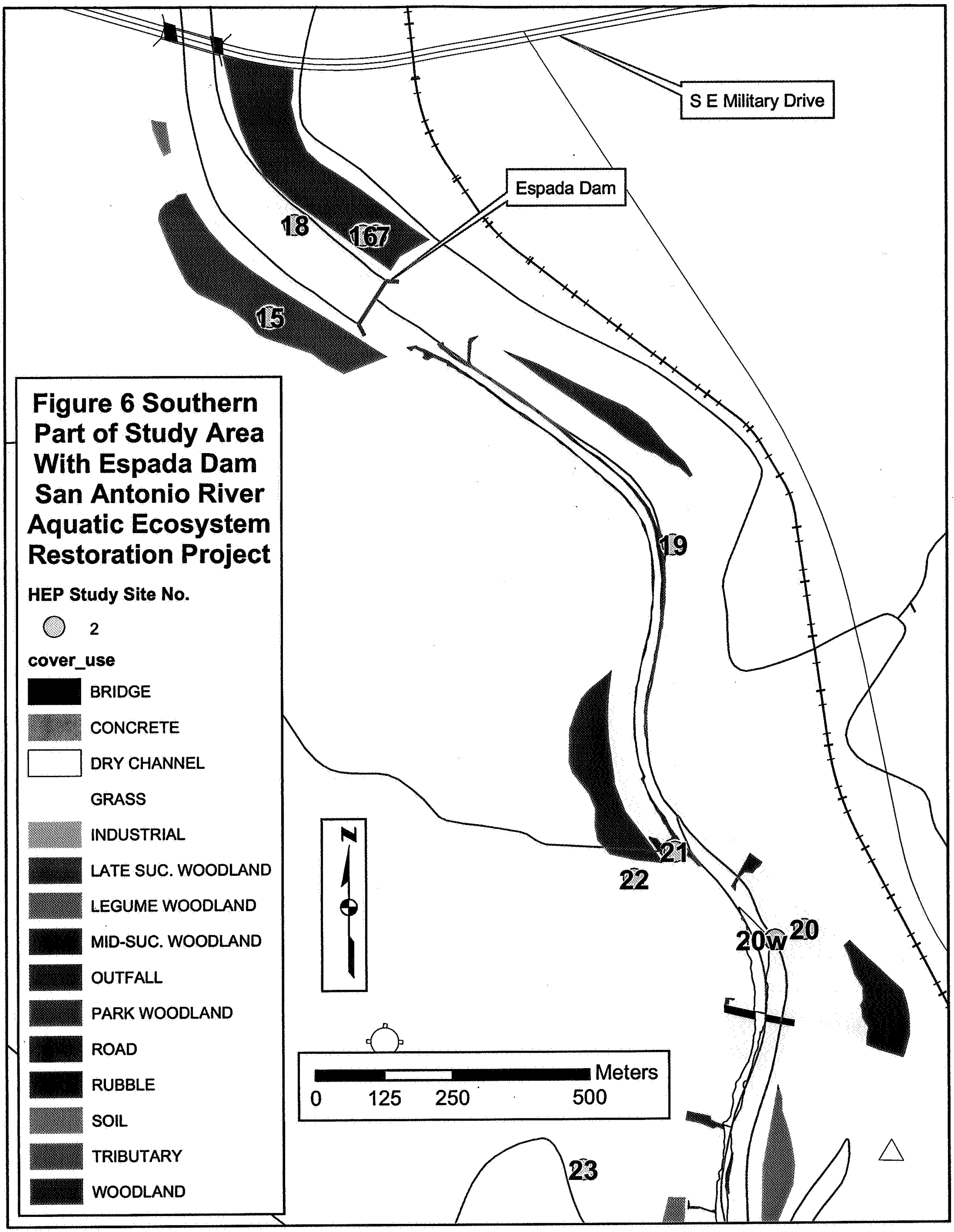


Figure 6 Southern Part of Study Area With Espada Dam San Antonio River Aquatic Ecosystem Restoration Project
HEP Study Site No.
2
cover_use
BRIDGE
CONCRETE
DRY CHANNEL
GRASS
INDUSTRIAL
LATE SUC. WOODLAND
LEGUME WOODLAND
MID-SUC. WOODLAND
OUTFALL
PARK WOODLAND
ROAD
RUBBLE
SOIL
TRIBUTARY
WOODLAND
S E Military Drive
Espada Dam
18
167
15
19
21
22
20w
20
23
N
Meters
0
125
250
500

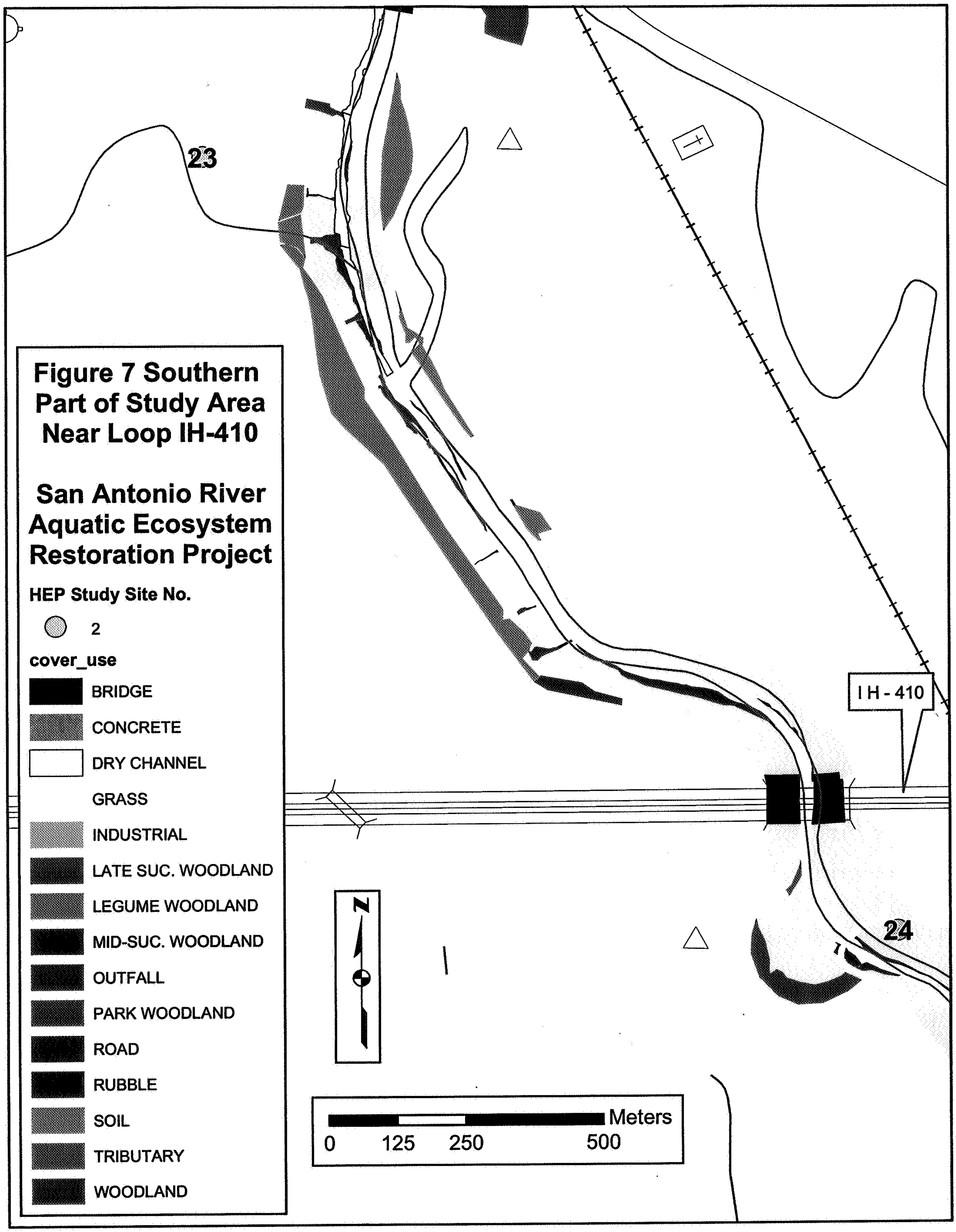


Figure 7 Southern Part of Study Area Near Loop IH-410
San Antonio River Aquatic Ecosystem Restoration Project
HEP Study Site No.
2
cover_use
BRIDGE
CONCRETE
DRY CHANNEL
GRASS
INDUSTRIAL
LATE SUC. WOODLAND
LEGUME WOODLAND
MID-SUC. WOODLAND
OUTFALL
PARK WOODLAND
ROAD
RUBBLE
SOIL
TRIBUTARY
WOODLAND
23
24
I H - 410
N
Meters
0
125
250
500

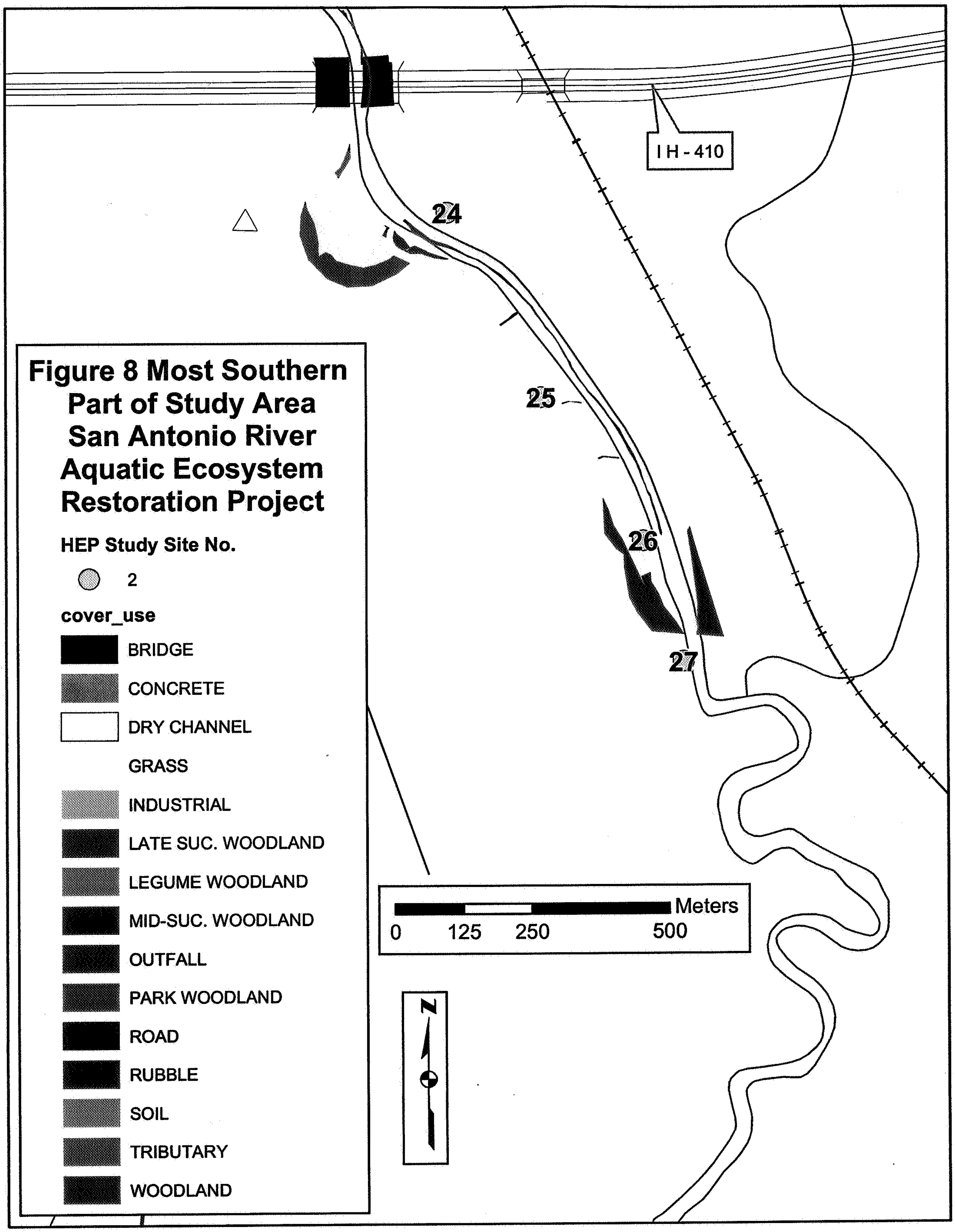
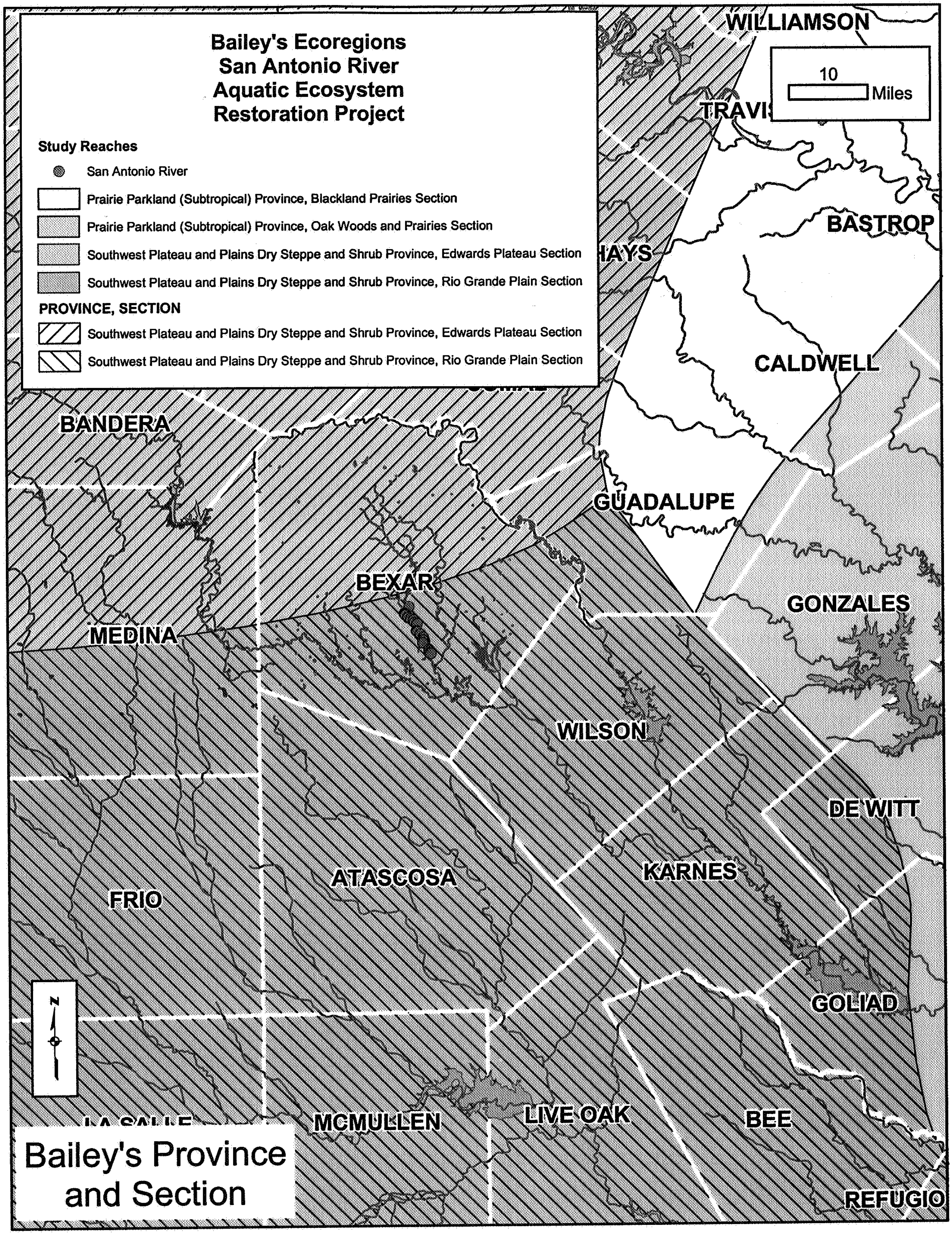
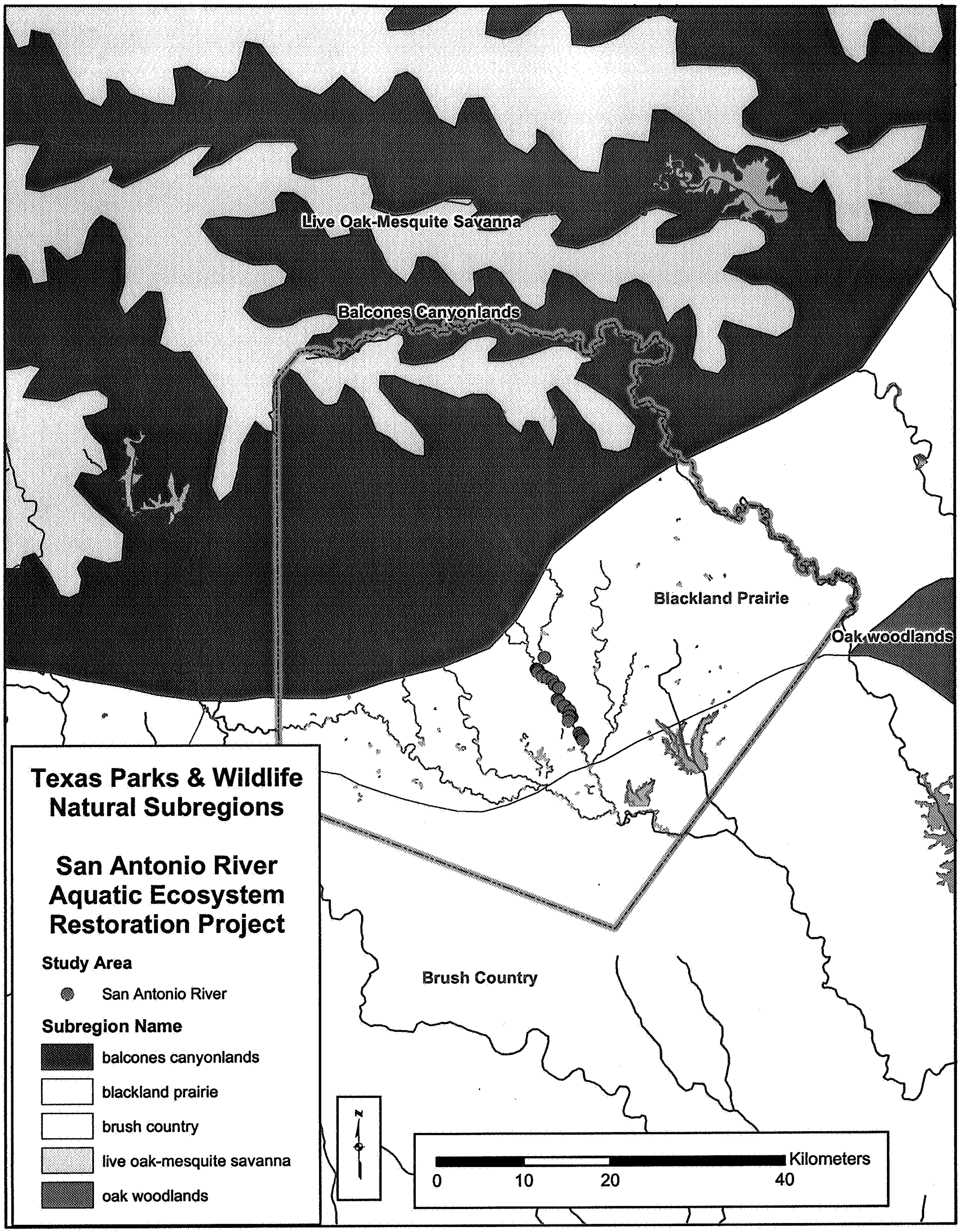


Figure 8 Most Southern Part of Study Area San Antonio River Aquatic Ecosystem Restoration Project
HEP Study Site No.
2
cover_use
BRIDGE
CONCRETE
DRY CHANNEL
GRASS
INDUSTRIAL
LATE SUC. WOODLAND
LEGUME WOODLAND
MID-SUC. WOODLAND
OUTFALL
PARK WOODLAND
ROAD
RUBBLE
SOIL
TRIBUTARY
WOODLAND
I H - 410
24
25
26
27
Meters
0
125
250
500
N



Bailey's Province and Section

FIG 10


Live Oak-Mesquite Savanna
Balcones Canyonlands
Blackland Prairie
Oak woodlands
Brush Country
Texas Parks & Wildlife
Natural Subregions
San Antonio River
Aquatic Ecosystem
Restoration Project
Study Area
San Antonio River
Subregion Name
balcones canyonlands
blackland prairie
brush country
live oak-mesquite savanna
oak woodlands
N
Kilometers
0
10
20
40

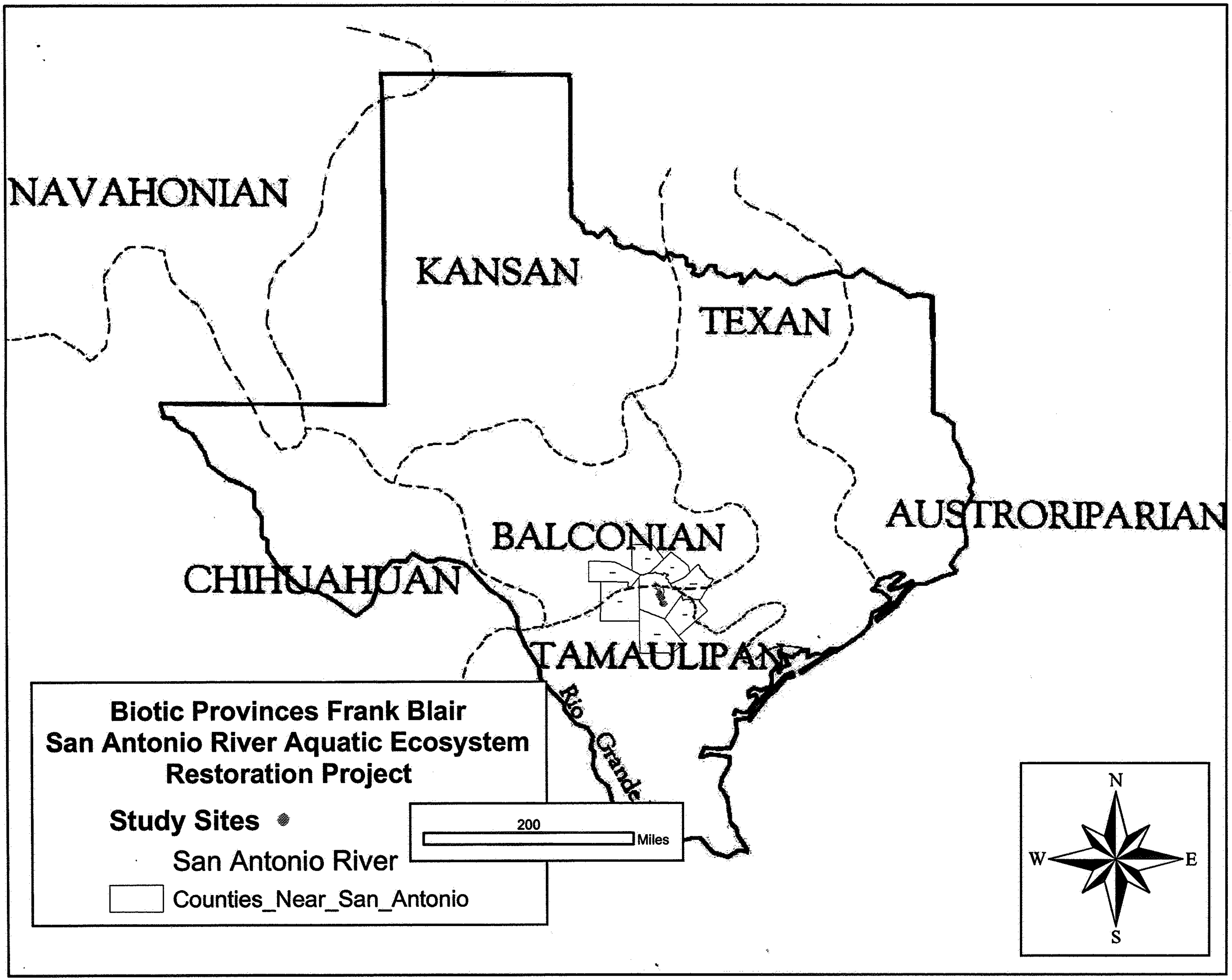

NAVAHONIAN
KANSAN
TEXAN
AUSTRORIPARIAN
BALCONIAN
CHIHUAHUAN
TAMAULIPAN
Rio Grande
Biotic Provinces Frank Blair
San Antonio River Aquatic Ecosystem
Restoration Project
Study Sites
San Antonio River
Counties_Near_San_Antonio
200
Miles
N
W
E
S

FIG 11

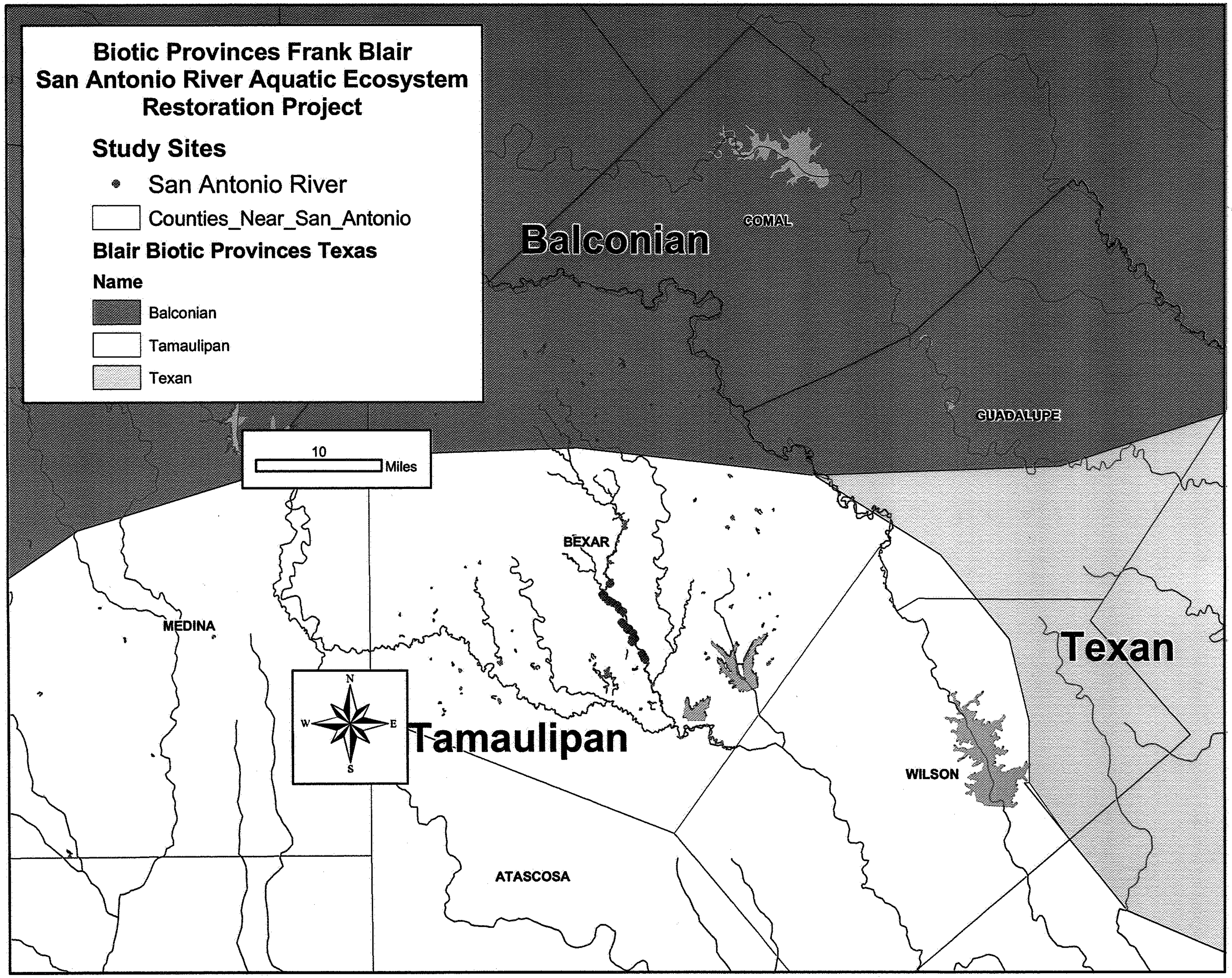
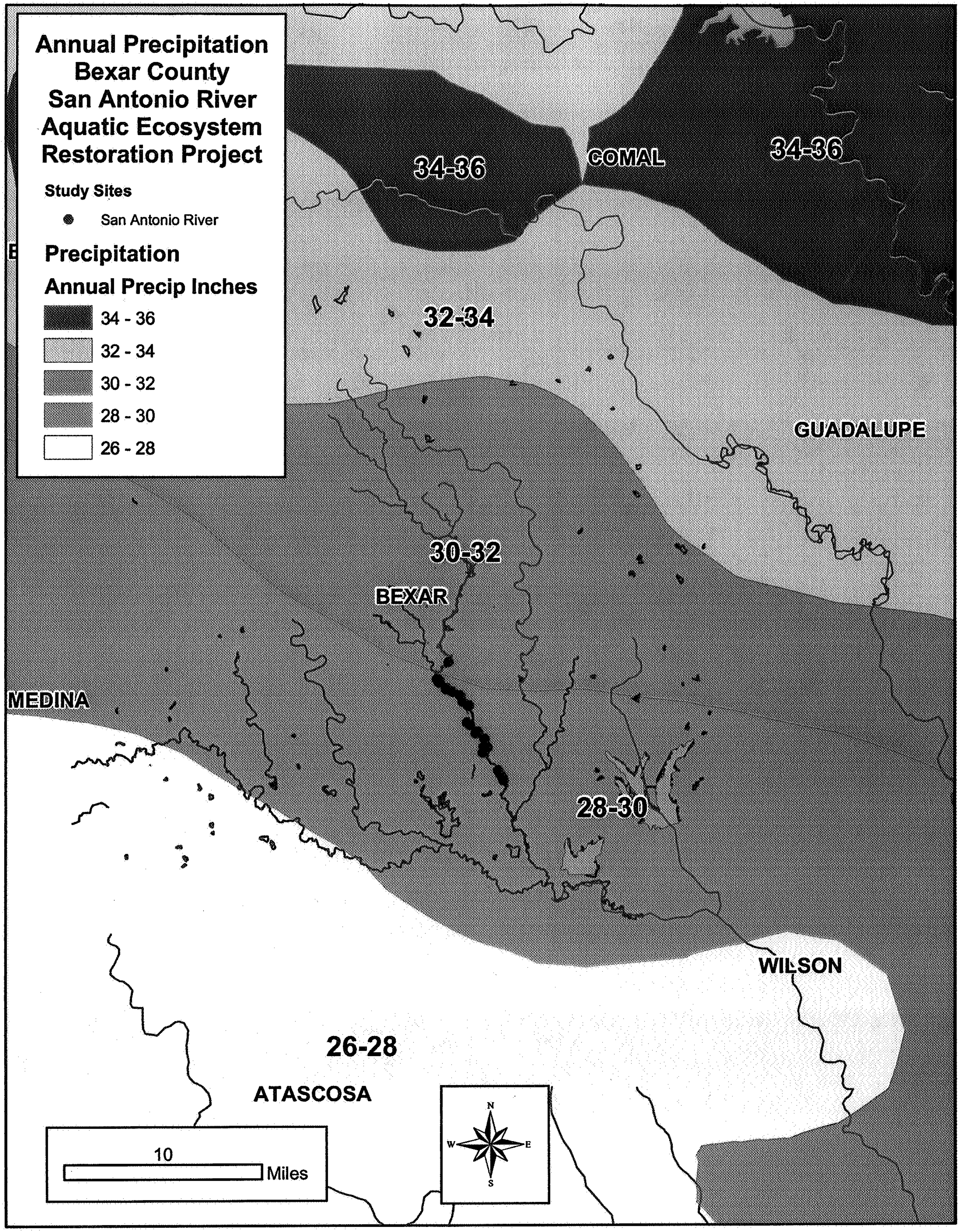

Biotic Provinces Frank Blair
San Antonio River Aquatic Ecosystem
Restoration Project
Study Sites
San Antonio River
Counties_Near_San_Antonio
Blair Biotic Provinces Texas
Name
Balconian
Tamaulipan
Texan
10
Miles
N
S
E
W
Balconian
COMAL
GUADALUPE
BEXAR
MEDINA
Tamaulipan
WILSON
ATASCOSA
Texan

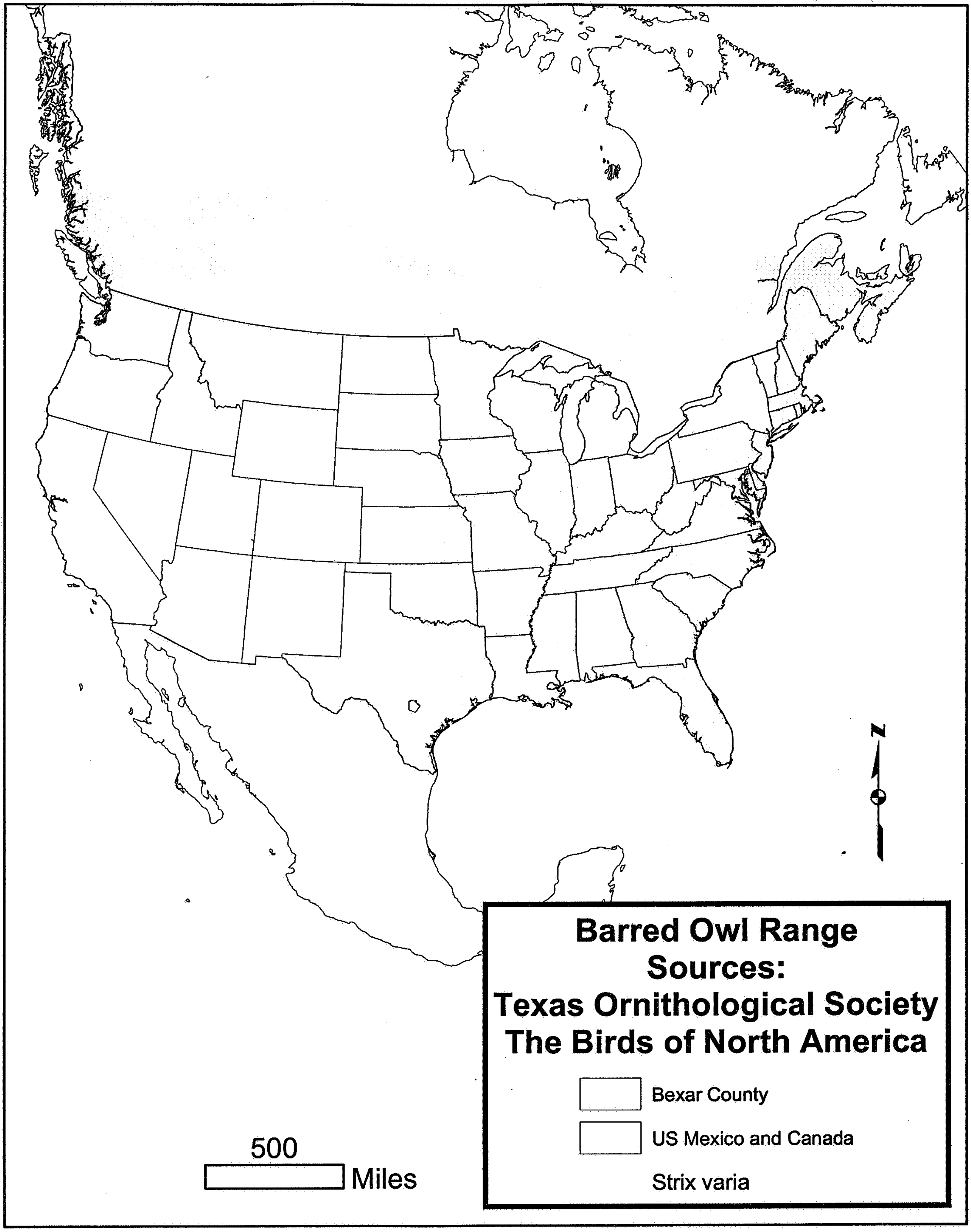
FIG 12

FIG 13



Annual Precipitation
Bexar County
San Antonio River
Aquatic Ecosystem
Restoration Project
Study Sites
San Antonio River
Precipitation
Annual Precip Inches
34 - 36
32 - 34
30 - 32
28 - 30
26 - 28
34-36
COMAL
34-36
32-34
GUADALUPE
30-32
BEXAR
MEDINA
28-30
WILSON
26-28
ATASCOSA
10
Miles
N
W
E
S

FIG 14



Barred Owl Range
Sources:
Texas Ornithological Society
The Birds of North America
Bexar County
US Mexico and Canada
Strix varia
500
Miles
N

Range in Texas of Fox Squirrel
From Davis 1974
San Antonio River
Aquatic Ecosystem Restoration

- Bexar County
- Texas_range_Fox_Squirrel

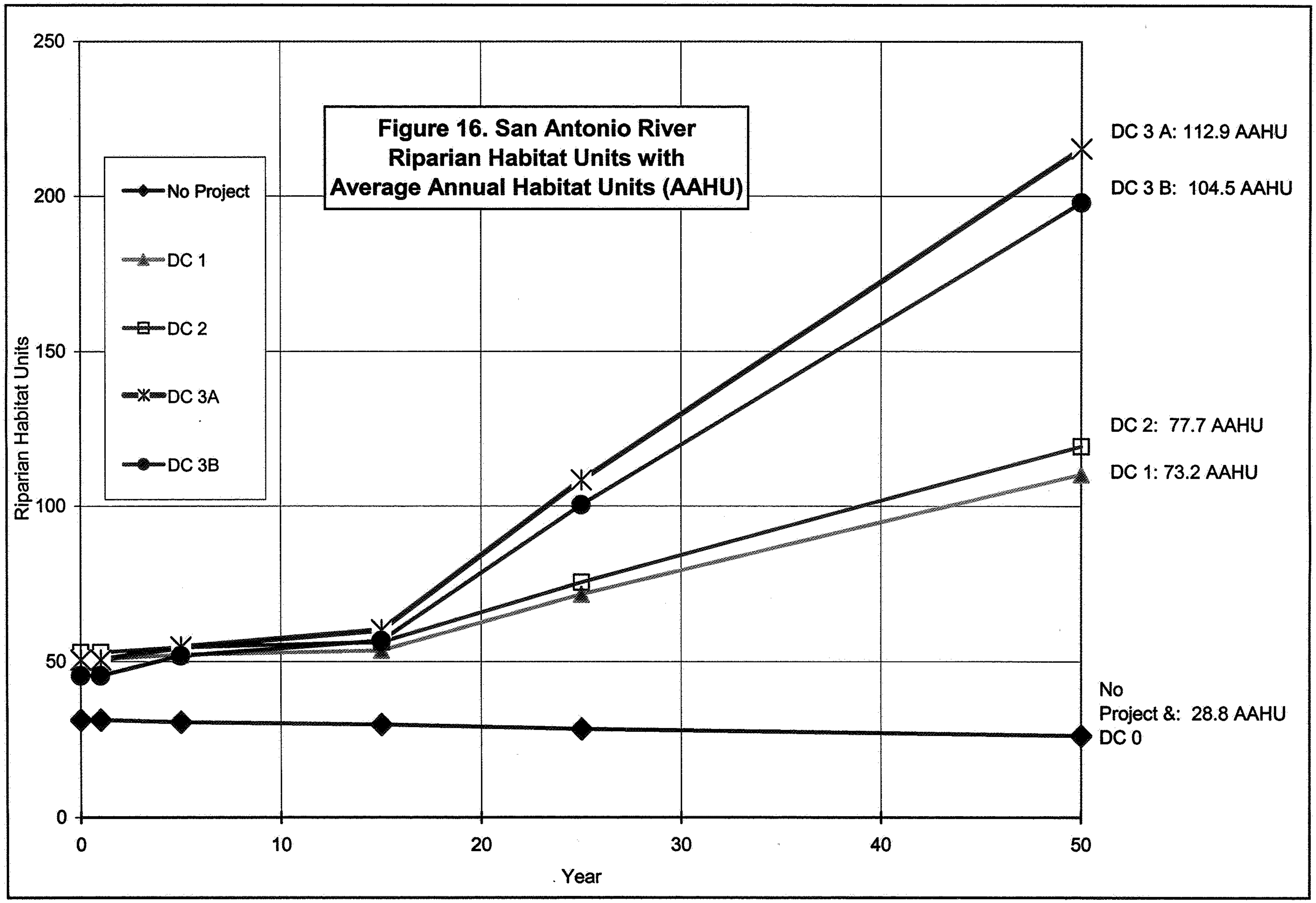


Figure 16. San Antonio River Riparian Habitat Units with Average Annual Habitat Units (AAHU)

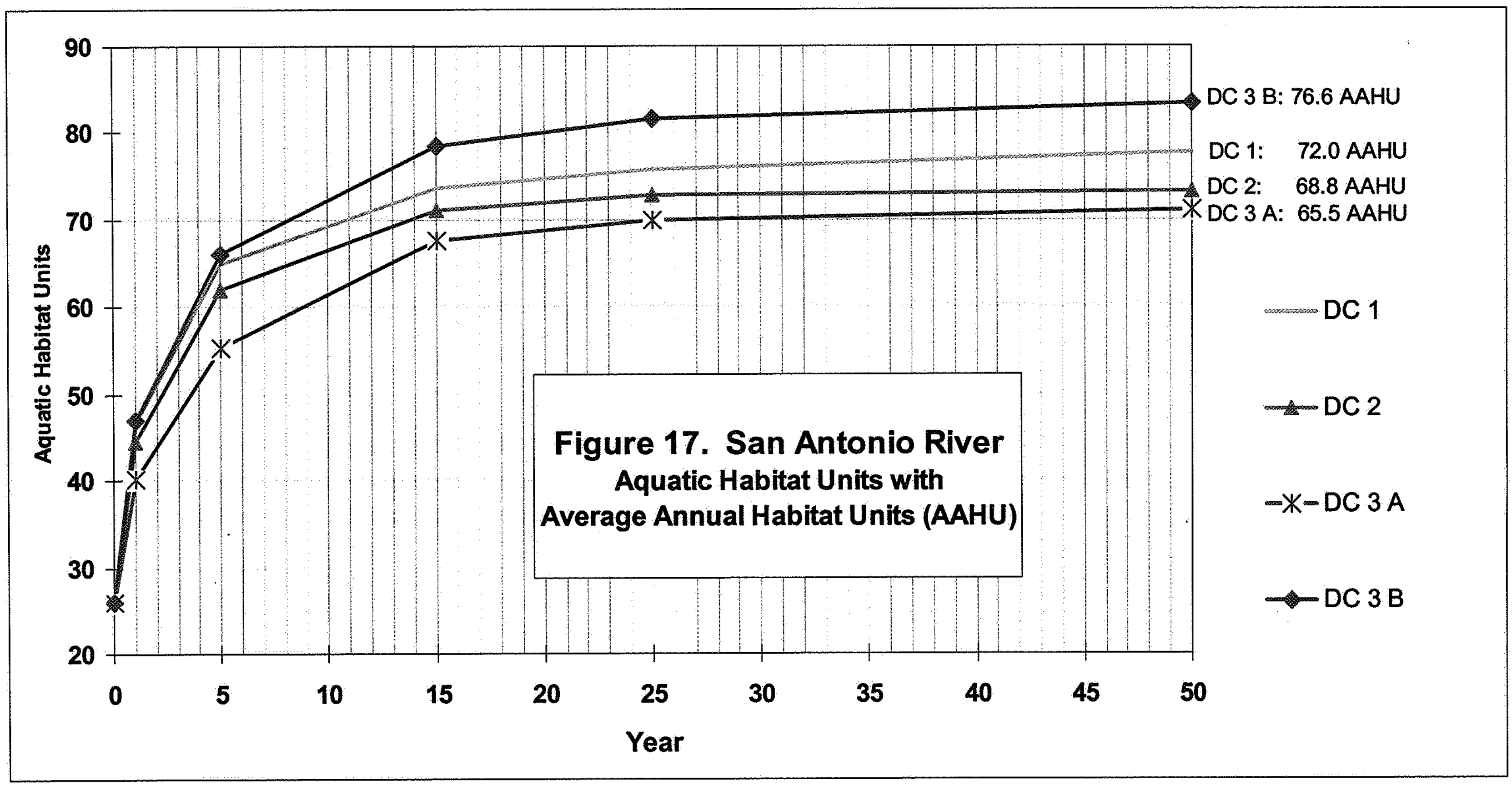


Figure 17. San Antonio River
Aquatic Habitat Units with
Average Annual Habitat Units (AAHU)
Aquatic Habitat Units
Year
90
80
70
60
50
40
30
20
0
5
10
15
20
25
30
35
40
45
50
DC 3 B: 76.6 AAHU
DC 1: 72.0 AAHU
DC 2: 68.8 AAHU
DC 3 A: 65.5 AAHU
DC 1
DC 2
DC 3 A
DC 3 B