

## **Chapter 1: Introduction**

The primary goals of this thesis are to provide a list of general types of natural vegetation that occur in the state of Texas and to estimate the acreage of each type that is preserved in national and state parks, wildlife refuges, and other conservation areas. Information necessary to accomplish these goals has been compiled from an array of published sources and from private interviews. It is hoped that this information will prove useful in planning future efforts to acquire and manage lands to preserve native animals, plants, and habitats in Texas.

Historically, most conservation programs in Texas (and elsewhere) have aimed to preserve areas of unique scenery or recreational value or to allow management of game animals or endangered species. Fewer efforts have been directed at identifying and protecting representative examples of landscapes or plant communities (Carls and Ludeke 1984). While many criteria may be used in identifying and prioritizing areas to set aside for wildlife and nature conservation, analysis of plant communities is a relatively easy and potentially useful approach because definition of plant communities often involves identification of sets of climatic, physiographic, and edaphic conditions that are necessary to support numerous animal and plant species (Gehlbach 1975). Preserving representative examples of ecological communities in a region typically assures the protection of most species occurring in the region (Hunter 1991). Thus, analysis of existing conservation areas with regard to representation of types of vegetation may provide a partial basis for assessment of the adequacy of conservation programs intended to protect flora and fauna.

Unfortunately, no comprehensive study of the protected status of plant communities in Texas has been published. To accomplish this task requires compiling and synthesizing data from many sources pertaining to vegetation on lands in conservation ownership in Texas, which comprise more than 2.9 million acres and are managed by two dozen entities (see Table 1).

Table 1. Areas managed for conservation in Texas.

Type of area	Acreage
National Park Service areas	1,085,000
U.S. Fish and Wildlife Service areas	530,000
U.S. Forest Service wilderness areas	36,000
U.S. Forest Service scenic areas and research natural areas	5,000
Texas Parks and Wildlife Dept. state parks, state natural areas, wildlife management areas (excluding national forest lands)	998,000
Conservation areas owned by Texas General Land Office	17,000
Nature preserves owned by municipal and county governments	45,000
Fee lands owned by Nature Conservancy of Texas or other nonprofit organizations (land trusts)	111,000
Conservation easements held by Nature Conservancy of Texas or other land trusts	166,000
Total conservation area acreage	2,980,000
Total land base of state	172,193,000
Percentage of land base in conservation management	1.7 <sup>1</sup>

Prepared by the author for the Nature Conservancy, 1999.

In 1996, the Texas Parks and Wildlife Department (TPWD) estimated the amount of acreage of each plant community protected within parks and wildlife management areas managed by the Department (TPWD 1996). However, the TPWD study did not estimate the acreage of each community occurring at preserves managed by other public and private entities. This study, therefore, is the first attempt to undertake a complete assessment of the representation of native plant communities in conservation areas in Texas.

Several factors make such a task difficult. While some areas, such as Big Bend National Park, have been extensively studied by ecologists (Plumb 1992), no quantitative studies of vegetation have been conducted at many other areas in public ownership. Adding to the difficulty of evaluating the status of native vegetation types or plant communities in Texas is the problem of defining vegetation types. No adequate classification system for vegetation has been completed in Texas. In their comprehensive treatment of the flora of Texas, Correll and Johnston (1970) identified habitat requirements associated with every plant taxon in the state, but did not discuss the roles of taxa in forming communities or assemblages. Numerous authors have described plant communities or types of existing or potential vegetation in Texas, but no single work has been universally adopted. Tharp (1939), Allred and Mitchell (1954), Küchler (1964), and others mapped general types of vegetation in Texas, but did not delineate finer differences in plant species composition or vegetative structure influenced by local variations in hydrology, substrate, climate, or other factors. McMahan et al. (1984) recognized 58 vegetation types based on analysis of Landsat satellite imagery and produced the most comprehensive statewide map of plant communities in Texas to date, but included non-natural disturbance types and omitted many native communities that are too limited in spatial extent to be depicted on small-scale maps. Diamond et al. (1987) defined 78 potential vegetation types in Texas based on descriptions of abundant species at certain relict sites, and assigned status rankings to each of these communities based on the estimated number of remaining examples and known potential threats. As

revised and amended (Diamond 1993), this classification system has been used extensively in ecological site assessments in Texas and allows analysis at an appropriate level of detail for conservation planning; however, the system omits some vegetation types that have been recognized by other authors. No classification system has been published that compiles or reconciles all descriptions of plant communities by previous authors working in Texas.

The Nature Conservancy is currently developing a nationwide National Vegetation Classification System (NVCS) which has been adopted by the Federal Geographic Data Committee (FGDC) as the standard reference for plant community classification work conducted by federal agencies (FGDC 1997). A document containing NVCS descriptions of plant communities occurring in Texas has been released in draft (Weakley et al. 2000) and is extensively cited in this thesis. However, final review and publication are not expected for some years, and many descriptions of plant communities will likely be added or modified.

To avoid the necessity of amending or modifying a previously published classification system to define vegetation types, previously published descriptions of native plant communities in Texas have been incorporated in this thesis into a new classification system of 120 vegetation types. These types are listed in Table 2 and described consecutively in Chapters 3 through 12. Type descriptions are based on published studies and on interviews with botanists, ecologists, and land managers familiar with Texas flora. Citing these disparate sources of information has likely produced instances of redundancy and inconsistency, which are the author's responsibility. Further investigation involving comparison of species occurrence at more sites is needed to assess the amount of co-occurrence between these vegetation types, allowing more precise definition.

The vegetation types recognized in this thesis are now extant and are believed to be similar to vegetation that existed two centuries ago. Vegetation types known to be grossly altered by human activities, either by introduction of non-native species or by alteration of native species composition, are excluded.

Table 2. Vegetation types of Texas, as defined by the author, with equivalent classifications and status rankings assigned by Diamond (1993).

<b>Community Name</b>	<b>Equivalent in Diamond (1993)</b>	<b>Status (Diamond 1993)</b>
<b>East Texas Pineywoods</b>		
1. Xeric sand woodlands/barrens	Bluejack Oak-Pine Series	G4S2
2. Longleaf pine open forests	Longleaf Pine-Little Bluestem Series	G3S2
3. Upland hardwood-pine forests	Shortleaf Pine-Oak Series; Post Oak-Black Hickory Series	G4S4
4. Pine-hardwood dry-mesic forests	Loblolly Pine-Oak Series	G4S4
5. Sandstone barrens	Little Bluestem-Nuttall's Rayless-Goldenrod Series	G3S3
6. Glauconitic shale glades	none	
7. Herbaceous acid seeps (East Texas Pineywoods)	Sphagnum-Beakrush Series	G4S2
8. Wetland pine savannas	Longleaf Pine-Beakrush Series	G3S2
9. Forested acid seeps/wet creeksides	Sweetbay Magnolia Series	G4S4
10a. Mesic slope forests	none	
10b. American beech mesic slope forests	American Beech-White Oak Series	G3S2
11. Herbaceous depressional wetlands (East Texas Pineywoods)	none	
12. Forested depressional wetlands (baygalls)	none	
13. Magnolia-beech mesic forests	American Beech-Southern Magnolia Series	G3S2
14. Swamp chestnut oak-oak floodplain forests	Swamp Chestnut Oak-Willow Oak Series	G3S3
15a. Floodplain hardwood forests	Water Oak-Willow Oak Series	G4S3
15b. Frequently inundated floodplain forests	Overcup Oak Series	
16. Sloughs/seasonally flooded floodplain forests	Water Elm-Swamp Privet Series	G4S4
17. Baldcypress-tupelo inundated forests	Baldcypress-Tupelo Series	G4S3
18. Freshwater shrub swamps	Buttonbush Series	G4S4
19. River banks	none	
20. Freshwater wetlands (upland Texas)	none	
<b>Post Oak Savannas</b>		
21. Post oak-blackjack oak upland forests/woodlands	Post Oak-Blackjack Oak Series	G4S4

22. Loblolly pine-post oak upland forest	Loblolly Pine-Oak Series	G4S4
23. Eastern redcedar chalk glades	none	
24. Herbaceous seeps (Post Oak Savannas)	Sphagnum-Beakrush Series	G4S2
25. Water oak floodplain forest	none	
26. Sugarberry-elm floodplain forests	Sugarberry-Elm Series	G4S4
<b>Blackland Prairies</b>		
27. Upland Vertisol tall grasslands	Little Bluestem-Indiangrass Series	G2S2
28. Upland Alfisol tall grasslands	Little Bluestem-Indiangrass Series	G2S2
29. Switchgrass-gammagrass mesic tall grasslands	Gamagrass-Switchgrass Series	G2S1
30. Silveanus dropseed Alfisol tall grasslands	Silveanus Dropseed Series	G2S2
31. Deciduous dry-mesic slope forests	none	
32. Bur oak-Shumard oak floodplain forests	none	
<b>Gulf Coast Prairies and Marshes</b>		
33. Upland tall grasslands (Coastal Prairies)	Little Bluestem-Brownseed Paspalum Series	G2S2
34. Upland live oak woodlands (upper Gulf Coast)	Coastal Live Oak-Sugarberry Series	G3S3
35. Upland live oak savannas (Ingleside Barrier)	Coastal Live Oak-Redbay Series	G3S3
36. Coastal xeric brush	none	
37. Live oak-water oak floodplain woodlands	Coastal Live Oak-Pecan Series, Water Oak-Coastal Live Oak Series	G3S3
38. Ephemeral freshwater wetlands (Coastal Prairies)	Rush-Sedge Series	G4S3
39. Freshwater wetlands (Coastal Prairies)	none	
40. Coastal dune grasslands	Seacoast Bluestem-Gulfdune Paspalum Series	G4S3
41. Gulf cordgrass saline grasslands	Gulf Cordgrass Series	G4S4
42a. Intermediate marshes	Marshhay Cordgrass Series	G4S4
42b. Brackish marshes	Marshhay Cordgrass Series, Saltgrass-Cordgrass Series	G4S4
43. Sea ox-eye saline flats	none	
44. Glasswort-saltwort hypersaline estuarine flats	Glasswort-Saltwort Series	G4S4
45. Tidal salt marshes	Smooth Cordgrass Series	G4S4
46. Black mangrove tidal shrub marsh	Black Mangrove Series	G5S2
47. Beaches/active coastal dunes	Sea Oats-Bitter Panicum Series	G4S3

48. Wind-tidal algal flats	none	
49. Estuarine seagrass beds	none	
<b>South Texas Plains</b>		
50. Upland post oak-live oak woodlands	Coastal Live Oak-Post Oak Series	G4S4
51a. Upland grasslands (South Texas Sand Sheet)	Seacoast Bluestem-Gulfdune Paspalum Series	G4S3
51b. Live oak savannas (South Texas Sand Sheet)	none	
52. Upland mixed grasslands (South Texas Plains)	Cane Bluestem-False Rhodesgrass Series	G3S3
53a. Upland mesquite savannas	Mesquite-Granjeno Series	G5S5
53b. Mesquite-mixed shrub savanna (Lower Rio Grande Valley)	Mesquite-Granjeno Series	G5S5
54. Upland Texas paloverde-mesquite brush	none	
55. Blackbrush xeric brush	Blackbrush Series	G5S5
56. Cenizo-blackbrush xeric brush	Ceniza Series	G4S4
57. Guajillo xeric brush	Guajillo Series	G5S5
58. Saline flats	none	
59. Short brush on clay ridges (lomas)	Texas Ebony-Snake-eyes Series, Big Sacaton Series	G2S2, G4S3
60. Saline grasslands	none	
61a. Wetland brush	Mesquite-Huisache Series	G5S5
61b. Depressional wetlands (potholes)	Mesquite-Huisache Series	G5S5
62. Coastal saline grasslands	Gulf Cordgrass Series, Big Sacaton Series	G4S4
63a. Texas ebony floodplain forests	Texas Ebony-Anacua Series	G2S1
63b. Texas palmetto floodplain forest	Texas Palmetto Series	G2S1
64. Sugarberry-elm floodplain forests (South Texas Plains)	Sugarberry-Elm Series, Pecan-Sugarberry Series	G4S4
65. Sugarberry-elm floodplain forests (Lower Rio Grande Valley)	Sugarberry-Elm Series	G4S4
<b>Edwards Plateau</b>		
66. Ashe juniper low forests	Ashe Juniper Series	G4S4
67. Upland plateau live oak savannas	Plateau Live Oak-Midgrass Series	G3S3
68a. Upland post oak-blackjack oak woodlands (Llano Uplift)	Post Oak-Blackjack Oak Series	G4S4
69. Upland mixed grasslands (western Edwards Plateau)	Curlymesquite-Sideoats Grama Series	G3S3
70. Upland savannas (western Edwards Plateau)	Redberry Juniper-Midgrass Series	G4S4
71a. Oak-juniper dry-mesic forests (Edwards Plateau)	Texas Oak Series, Lacey Oak Series	G3S3
72. Deciduous mesic canyon forests	Bigtooth Maple-Oak Series	G4S2

73. Limestone bluffs and seeps	none	
74. Exposed granite outcrops	none	
75. Spring-fed streams (Edwards Plateau)	none	
76a. Pecan-elm floodplain woodlands (Edwards Plateau)	Pecan-Sugarberry Series	G4S4
77. Streambeds	Sycamore-Willow Series	G5S5
78. Baldcypress riparian woodlands	Baldcypress-Sycamore Series	G3S3
79. Netleaf hackberry-plateau live oak floodplain woodlands	Plateau Live Oak-Netleaf Hackberry Series	G4S4
<b>Prairies and Cross Timbers</b>		
68b. Upland post oak-blackjack oak woodlands (Cross Timbers)	Post Oak-Blackjack Oak Series	G4S4
71b. Oak-juniper dry-mesic forests (Cross Timbers)	Texas Oak Series	G3S3
76b. Pecan-elm floodplain woodlands (Cross Timbers)	Pecan-Sugarberry Series	G4S4
80. Upland Mollisol tall grasslands	Little Bluestem-Indiangrass Series	G2S2
<b>Rolling Plains</b>		
81. Upland mesquite-midgrass savannas	Mesquite-Midgrass Series	None given
82a. Upland mixed grasslands	Sideoats Grama Series	G3S3
82b. Deep sand grasslands	Sideoats Grama Series	G3S3
83. Switchgrass-gammagrass mesic tall grasslands	Gamagrass-Switchgrass Series	G2S1
84. Sand sage shrub grassland	Sandsage-Midgrass Series	G4S4
85. Havard shin oak brush	Havard Shin Oak-Tallgrass Series	G3S3
86a. Upland juniper-mesquite savannas	Redberry Juniper-Midgrass Series, Oneseed Juniper Series	G4S4
86b. Rocky Mountain juniper woodlands	Rocky Mountain Juniper Series	G4S2
87. Mesquite floodplain brush	none	
88. Cottonwood-willow riparian woodlands	Cottonwood-Tallgrass Series	G3S3
<b>High Plains</b>		
89. Blue grama-buffalograss short grasslands	Blue Grama-Buffalograss Series	G4S3
90. Intermittent wetlands (playa lakes)	none	
<b>West Texas</b>		
91. Saline or gypsic hardlands	none	
92. Mesquite-saltbush saline brush	Mesquite-Saltbush Series	G4S4
93. Hypersaline flats	Pickleweed-Seepweed Series	G4S4

94. Sacaton saline grasslands	Alkali Sacaton-Fourwing Saltbush Series	G4S3
95. Saline or alkaline wetlands	Saltgrass-Olney Bulrush Series	G3S2
96. Gypsum scrub/grasslands	Rough Tiquilia Series	G4S4
97. Quartz sand dunes	Mesquite-Sandsage Series	G4S4
98. Havard shin oak low shrublands	Havard Shin Oak-Tallgrass Series	G3S3
99. Viscid acacia thickets	Viscid Acacia Series	G4S4
100. Creosotebush open shrub deserts	Creosotebush Series	G5S5
101. Mesquite thickets	none	
102. Cottonwood-willow riparian woodlands	Cottonwood-Willow Series	G3S3
103. Arroyo scrub	Apache-plume Series	G4S4
104. Chihuahuan Desert scrub	Lechuguilla-Sotol Series	G4S4
105. Alluvial short grasslands (tobosa flats)	Tobosa Series	G4S4
106. Lower-elevation desert grasslands	Sideoats Grama-Black Grama Series	G4S3
107. Yucca shrub savannas	Spanish Bayonet Series	G4S3
108. Riparian shrublands	Netleaf Hackberry-Little Walnut Series	G4S4
109. Lower-elevation juniper woodlands	Redberry Juniper-Midgrass Series, Oneseed Juniper Series	G4S4
110. Spring-fed streams/cienegas	none	
111. Limestone cliffs and outcrops	none	
112. Igneous outcrops	none	
113. Mid-elevation mixed grasslands	Sideoats Grama-Black Grama Series	G4S3
114. Canyon riparian woodlands	Velvet Ash-Willow Series	G3S2
115. Montane shrub thickets	Scrub Oak-Mountain Mahogany Series	G4S4
116. Juniper-oak-pinyon savannas	Pinyon Pine-Oak Series	G4S4
117. Deciduous canyon forests	Bigtooth Maple-Oak Series, Emory Oak Series	G4S2
118. Montane oak-juniper-pinyon woodlands	Gray Oak-Oak Series, Emory Oak Series	G4S4
119. Montane grass openings	none	
120. Montane conifer forests	Ponderosa Pine Series, Douglas-Fir-Pine Series	G4S3, G4S1

For the most part, the 120 vegetation types described in this thesis can be distinguished on the basis of hydrologic characteristics (e.g. soil moisture, duration of seasonal inundation), the structure or physiognomy of vegetation (i.e. the growth habit of dominant species, defined by terms such as closed forest, woodland, savanna, and grassland), or the identity of dominant species. Defining an ecological community by reference to dominant species (e.g. "juniper-oak forest" or "blue grama-buffalograss grassland") is a potentially confusing practice because the abundance of any species may vary widely among sites that share many other attributes. However, in some instances using particular species to distinguish communities has been unavoidable, because the identity of dominant species often varies without corresponding variation in physical environment being detectable (for example, Ashe juniper is a dominant species on rocky, upland sites in the Edwards Plateau of western Texas, but similar sites on the nearby Stockton Plateau are dominated by redberry juniper, a different species).

Ideally, classification of vegetation should be based on statistical analysis of quantitative data collected at multiple sites, allowing assessment of the significance of variation in species occurrence and the identification of correlation between species occurrence and environmental factors. Unfortunately, published quantitative data for Texas are currently insufficient to support reliable statistical characterization of plant communities statewide. While more data will doubtless be compiled in the future, only a limited number of sites containing examples of late-seral native vegetation are accessible to researchers (Diamond et al. 1987). Virtually all landscapes in Texas have been profoundly altered by human activities in the two centuries of Anglo-European settlement, in addition to unknown but possibly extensive modification by pre-European cultures. Few sites in Texas, even in parks or refuges, have not been extensively modified by grazing, clearing, or planting. Interpretation of existing remnants of vegetation may be biased by incorrect assumptions about the hypothetical effects of natural processes, such as fire or herbivory by native animals, in the absence of human alteration. Even the

"natural" community types defined in this thesis contain many elements influenced by human disturbance.

Classification of plant communities presents a number of other problems. While the occurrence of plant species is often indicative of environmental factors such as rainfall levels, retention of soil moisture, topography, and soil chemistry (Barbour et al. 1987), relationships between vegetation and environmental conditions are often complex and many species utilize multiple habitats. Variation in species occurrence is often gradual, with the optimal ranges of different species scattered along environmental gradients; categorization of these continua into discrete "communities" is inherently arbitrary except perhaps where abrupt changes in the occurrence of dominant species are present (Whittaker 1962, Turner 1999). Further, all classification systems contain subjectivity regarding hierarchical distinctions. For example, an attribute of vegetation corresponding to a local change in terrain, hydrology, substrate, or soil chemistry may be regarded as the basis for defining a distinct community by one author, but as a subtype within a more broadly defined community by another author. Finally, vegetative structure and composition may be greatly influenced by disturbance, and the potential stability of a population or species in the absence of disturbance may be difficult to infer. The occurrence of a species at a given site emphatically does not mean that the species will persist after future succession or disturbance. Species may be supplanted temporarily or permanently by dramatically different vegetation following natural disturbances (e.g. Scifres and Mutz 1965) as well as grazing and other land uses (e.g. Chapman 1935, Dyksterhuis 1948, Grover and Musick 1990). This is perhaps especially true in Texas, an area encompassing dramatic environmental gradients and disparate types of vegetation. For all of these reasons, attempts to classify plant communities are seldom definitive, even where adequate supporting data are available.

It is hoped that the vegetation types described in this thesis are meaningful and stable entities and that distortion and oversimplification of the dynamic, statistical nature of landscapes have been minimized. Ideally, a comprehensive

taxonomy of existing habitat types could be produced so that if one example of each type were preserved, every native species would have a refuge or potential reintroduction site. However, such an effort is far beyond the scope of a master's thesis, as it would require extensive collection of new quantitative data and much more detailed definition of communities than has yet been attempted in Texas.

Public and private programs to acquire and manage "natural" habitat areas for wildlife, nature study, recreation and other purposes are proceeding rapidly in Texas. Decisions regarding the protection of habitat are often made without consideration of botanical resources, partly because no complete survey of what has been protected is available. Thus, it is hoped that conservation efforts in Texas may benefit from this inventory despite its limitations.

### **Organization of Work**

This thesis begins with a brief introduction to geological, climatic, and cultural factors that influence vegetation in Texas. Descriptions of vegetation types and assessments of their status are then presented in Chapters 3 through 12. These ten chapters correspond to ten natural and cultural regions that have been recognized by numerous Texas geographers (e.g. Cory and Parks 1937, Gould et al. 1960, LBJ School of Public Affairs 1978). The purpose of organizing this thesis in this way is to allow the reader to quickly navigate to a region of the state that may be of particular interest. The ten regions are shown in Figure 1, with county boundaries also shown for reference. Ordered from east to west, the ten regions are the East Texas Pineywoods, the Post Oak Savannas, the Blackland Prairies, the Gulf Coastal Prairies and Marshes, the South Texas Plains, the Edwards Plateau (including the Llano Uplift), the Prairies and Cross Timbers, the Rolling Plains, the High Plains, and West Texas (including the Trans-Pecos and adjacent counties). These regions are familiar to the public and are botanically, geologically, and culturally distinct. The approximate boundaries of the ten



Fig. 1. Natural regions of Texas as defined by Gould et al. (1960), with modifications by the author based on other works.

regions shown in Fig. 1 are derived from Gould et al. (1960), with modifications by the author based on the boundaries of vegetation or land cover types delineated in McMahan et al. (1984) or mapped by other authors, including Dyksterhuis (1948), McLeod (1971), LBJ School of Public Affairs (1978), and Wilson (1990).

A brief description of the physical and ecological character of each region precedes each chapter. This is followed by descriptions of the vegetation types that occur within the region. Vegetation types that occur in more than one region are described in the region where the type is most abundant.

For each vegetation type, a list of synonymous terms used by previous authors is provided, allowing "cross-walking" between some of the many published plant community classification systems. This is followed by a description of the vegetation type which includes a partial list of dominant species and citations of published descriptions. Available information about the status of each vegetation type is then given, including the general spatial extent of the vegetation type, the severity of existing threats to it, the approximate amount of acreage in conservation land holdings, and selected conservation areas containing examples of the vegetation type.

Finally, a recommended priority value for future preservation is given for each community. Possible values are High, Fairly High, Medium, Fairly Low, and Low. These subjective values are based on available information about the rarity of the community, the amount of protected acreage, and the severity of perceived threats to the community. Communities receiving a "High" ranking are scarce or threatened in Texas (and perhaps globally) and have received little permanent protection in parks, wildlife refuges, nature preserves, or similar areas. Communities receiving a "Low" ranking are widespread, little threatened by development or economic activities, or are already extensively protected within conservation areas.

As mentioned above, Diamond (1993) described roughly 90 vegetation types and assigned status values to each type, following the system used by

state natural heritage programs. These status values were based on experts' assessment of the rarity of, and severity of threats to, remaining examples of the vegetation type. Each of the 90 types was given two values, a "G" (global) ranking based on the community's rarity worldwide and an "S" (state) ranking based on its rarity in the state of Texas. Possible values for each ranking are: 1=Endangered; 2=Threatened; 3=Possibly Threatened; 4=Apparently Secure; 5=Secure. For example, bigtooth maple-oak forests (which occur in the Edwards Plateau and Trans-Pecos mountains) were assigned a status value of G4S2, meaning that such forests are apparently not threatened worldwide but are rare and vulnerable to extirpation within the state of Texas. Table 2 lists equivalent nomenclature and global and state rarity rankings for the types recognized by Diamond (1993). The recommended priority values assigned in this thesis for those vegetation types were derived from Diamond's status values: S1 was equated to High, S2 was equated to Fairly High, and so on to S5, which was equated to Low. These values were then adjusted based on the amount of protected acreage in Texas. If more than 20,000 acres of a community was found to be preserved in Texas, the community's priority value (if not already "Low") was decreased by one ranking (e.g. a "Fairly Low" was re-assigned as "Low"). If 1,000 acres or less of the community is protected in the state, the community's priority value (if not already "High") was increased by one ranking. In a few cases, other factors were taken into account, which are summarized in the footnotes to Table 13 and in the Discussion.

This thesis recognizes 120 community types occurring in Texas, 40 more than were recognized by Diamond (1993). For communities not described by Diamond (1993), recommended priority values have been assigned based on the advice of ecologists familiar with the vegetation type in question. Recommended priority values are subject to further revision based on additional investigation.

Each vegetation type discussed in this thesis has been given a corresponding unique number from 1 to 120. A few types have been split into two subtypes (e.g. 10a and 10b); these are communities that share one or more

dominant plant species but differ in geographic location or subdominant species. These unique numbers are used to denote communities in Tables 3 through 12, in which selected conservation areas in Texas are listed (by region) and the approximate amount of each vegetation type occurring in each conservation area is given as a percentage of the area's acreage, where this information was available. The acreage of vegetation types is based on a few published references such as TPWD (1996), interviews with area managers, and in a few cases, geospatial (geographic information system) datasets, including National Park Service (1997a, 1998) and U.S. Fish and Wildlife Service (1996, 1997, 1999). These data were converted to an Albers Equal-Area projection and acreage of polygonal areas was calculated using Arc/Info software. In addition, data for the Lower Rio Grande National Wildlife Refuge were calculated in ArcView software by tracing polygonal areas on digital orthophotos. Estimates of the extent of a plant community within a park or refuge are necessarily approximate, as detailed maps or remotely sensed data are often not available and gradients between plant communities are frequently indistinct. Percentage values of the "natural" communities within a given area often do not add up to 100 percent because most parks and refuges contain areas of non-natural, "managed" vegetation such as timber plantations, regressed native pastures, or revegetated areas as well as artificial impoundments and disturbed areas dominated by exotic plant species. (It should be noted that exotic plants --- both invaders and planted commercial species --- are often common at many sites regarded as "natural," even in conservation areas.)

For the purposes of this thesis, a "conservation area" is considered to be any public or private tract under formal management compatible with the protection of the native condition and composition of vegetation. These areas include national parks, national wildlife refuges, "special management areas" managed by the U. S. Forest Service (i.e. wilderness areas, scenic areas, and research natural areas), state parks and wildlife management areas, conservation lands held by the Texas General Land Office and Lower Colorado River Authority,

and nature preserves and nature centers owned by municipal and county governments. Some properties owned by private land trusts, arboretums, and other nonprofit organizations are also mentioned. A few Texas Parks and Wildlife Department units are omitted, including historic areas and recreation sites that contain little natural vegetation (TPWD 1996). U.S. Forest Service lands managed primarily for timber or range production are excluded.

Only lands managed by entities with permanent management mandates (assuming current legal and governmental realities) that incorporate preservation of natural habitat have been studied. Private lands under conservation easement are omitted, both to protect landowners' privacy and because of the differing provisions of conservation easements. In excluding voluntary private conservation efforts, this thesis must unfortunately omit many examples of excellent land stewardship of great importance in Texas.

The conclusion briefly summarizes the findings reported in the ten chapters and reiterates the need for further preservation of some types of vegetation by private landowners or public entities. In identifying plant communities that are less extensively protected in conservation areas, the goal of this thesis is to enhance conservation planning by public agencies that manage land and wildlife. Better information about the status of native plants and wildlife can also enhance their protection by private landowners, which is crucial as 97 percent of Texas is in private ownership (Governors' Task Force on Conservation 2000).

This thesis is intended primarily for an audience of planners and policymakers, rather than botanists or ecologists. Accordingly, English colloquial names are used for plant species, with the corresponding botanical names given in the Appendix. Acronyms have been kept to a minimum, but a few abbreviations for public agencies are used throughout (including "TPWD") and "WMA" is used in place of "Wildlife Management Area."