THE PROCESS OF HABITAT RESTORATION

With Specific Application to the

Upper Glen Rose Geologic Formation

Of Central Texas

By

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We acknowledge with warmth the inspiration of Carroll Abbott, who pioneered much of the interest in native plants in Texas and whose simple act of going out in the field and collecting seed of wild plants seemed somewhat novel and inspirational to many of us just a short decade ago.

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PREFACE

In 1985, David Mahler and Judy Walther began writing this procedural manual of restoration with native plants for the City of Austin's Department of Public Works. This was an extension of their already on-going involvement in the restoration of an old dump site, used partly by the City of Austin, located in and near Wild Basin Wilderness Preserve. In 1984 the Committee for Wild basin Wilderness, Inc. had contracted with the City of Austin to complete the physical restoration of the damaged dump area. The data from this and other restoration work was collected by the authors and then used as the basis for developing a methodological approach to native plant habitat restoration that can potentially be used as a process in other habitats.

It is hoped that this information will be useful to the City of Austin as they develop their guidelines for habitat restoration and for individuals and organizations which are attempting restoration both in Central Texas and elsewhere.

The authors consider this work to be very preliminary in nature and hope the information provided in this manual will be viewed that way. Suggestions, comments, and data, especially from people actively involved in restoration, are solicited. This information will be combined with the authors' continued research in any future revisions.

The July 1987 revision of the manual was based in part on the suggestions from the City of Austin staff.

INTRODUCTION: THE PURPOSE AND PROCESS OF RESTORATION

Interest in habitat restoration reflects a human attitude that perceives our species as an interdependent part of our habitat, rather than its owner. While this is fundamentally an aesthetic and philosophical approach, it is also eminently practical if one believes that we are capable, as a species, of degrading our habitat locally and globally to the extend of threatening our individual or collective well-being and, possible, our existence.

This perspective leads to a conservative approach to retain or restore as much of our global habitats as possible, while we decide to alter and utilize other parts for our more immediate health and convenience. The satisfactory ratio between utilization and protection is, of course, subjective. It is clear, however, that as more of our global resources are channeled toward current human consumptive needs, we must become more careful stewards of the remaining land and water.

Habitat restoration is the management process of assisting an altered or damaged habitat through various stages of succession toward its pre-altered state. At its best, this management process, whether dealing with an already disturbed site or with a site being planned for future alteration, generally involves:

1. Field analysis to record existing site conditions both prior to developing a management plan and during the restoration process.

2. Formulation of suitable habitat models upon which to base the design of the physical and biological restoration.

3. Preservation or re-establishment of the site's appropriate topographical, hydrological, soil, and chemical character.

4. An increase in diversity through the reintroduction of suitable species.

5. Utilization of management practices designed to assist habitat succession and reduce the presence of non-native species.

THE ECONOMIC BENEFITS OF RESTORATION

The more immediate and practical results of a conservation approach to our native habitats are illustrated by the economic benefits of native restoration to a local site and its nearby areas. These benefits tend to have longer-range economic benefits which outweigh the sometimes higher initial costs. Some potential economic benefits for habitat restoration in Central Texas are:

1. Reduction of imported topsoil costs.
2. A decrease in the cost of damage to waterways which usually is greatly increased by the use of unsuitable topsoil.
3. A decrease in or elimination of fertilizer-application costs with the additional benefit of reduced impact to receiving waterways.
4. Reduction or elimination of supplementary watering during species establishment, and elimination of watering once established.
5. Minimization or elimination of landscaping replacement costs caused by freeze damage or disease in non-native, un-adapted plants.
6. Reduction or elimination of maintenance costs for mowing and trimming.
7. Production of a market for the valuable indigenous species which are sometimes removed during development of a site.

SITE APPLICATIONS

There are many types of sites where the goals of native habitat restoration would be appropriate, which in Central Texas are now often managed as low-diversity colonies of primarily non-native, early successional plant species. Possible restoration sites include:

1. Utility Rights-of-Way: Utilities that traverse well-preserved habitats are an especially high priority.

2. Roadsides: These could function as ribbons of some of the original plant community, protected from grazing and browsing on the adjacent ranch lands. Public policy often has encouraged roadsides to function as the dispersal network for non-native species.

3. Cluster Housing and Commercial Development: Some development tracts contain greenbelt areas that have been damaged through previous alterations. These areas would better fulfill their buffering, filtering, and aesthetic functions if native species were reintroduced. Additionally, often there are extensive areas disturbed by roads, utilities, excavation, and evapo-transpiration beds, which are ideal locations for restoration.

4. Public Recreational Parks: While much parkland serves heavy-use purposes, it also includes areas such as creeksides, hike-and-bike trail borders, buffer zones, and back corners where native plant management is appropriate.

5. Preserve Land: These lands, where the protection or restoration of native habitats is a primary goal, frequently have areas where removal of non-native species and repair of damage from previous management are of prime concern.

6. Strip-Mining, Construction Spoil Disposal Sites, and Land-Fill Operations: The technical capability to restore habitat and effectively control erosion on these difficult areas is often a key component in the evaluation of the environmental impact of these projects.

7. Rangeland: Restoration of the native forbs and deep-rooted perennial grasses can be an option for over-grazed and under-productive rangeland.

8. Private Residential Land: The restoration of areas previously maintained as lawns or cultivated areas is currently a topic in which some homeowners are interested.

9. Flood Control and Water Quality Facilities: Various channel modifications, detention, retention, sedimentation and/or filtration structures may be appropriate sites in whole or in part for revegetation with native species.

THE IMPLICATIONS OF RESTORATION

The approach outlined in this manual implies certain fundamental differences from traditional development practices in Central Texas.

1. It stresses the asset value of the natural resources existing prior to site development: soil, plants, and ground and surface water.

2. It requires an integration of the biological aspects with the engineering plans from the beginning to the completion of development.

3. It requires more advance time for planning and preparing restoration activities such as seed harvesting.

4. It assumes a slower, more stable, and more continuous growth of plant cover, compared to the immediate but weak coverage of a non-native sod or cool season annual species.

5. It views the management of the permeable areas of a development site as a single responsibility by combining analysis, design, erosion control, topsoil management, construction-boundary maintenance, and restoration. These items are separate from, but coordinated with, construction. This integrated land management arrangement precedes construction, actively compensates for site instability during construction, and remains after the completion of construction during the process of restoring site stability and balance.

METHODS

This manual is organized as a step-by-step process of habitat restoration, encompassing the determination of scope and sequence of work, site analysis, physical and vegetative design, harvesting wild seed and site work.

Each chapter has topics that are organized into three sections: process, discussion, and example. The process section has been written for wide application and is applicable to many habitats. Most of the examples are taken from the authors' experiences in the Glen

Rose limestone habitat in the Texas hill country. A definitive mapping of the Glen Rose unit can be found in the University of Texas Bureau of Economic Geology map publication, Geologic Map of the Austin West Quadrangle, Travis County, Texas, 1979. Due to the preliminary and experimental nature of the authors' work, this organizational method will allow for easy inclusion of subsequent information as it develops.

The last chapter is an in-depth example of the step-by-step restoration process of a project at Wild Basin Wilderness Preserve. When species are mentioned in the text, the number which follows refers to its number on the Habitat Restoration Data Chart, p. 79-90. For species not on this list, the Latin name follows the common name.

CHAPTER 1: DETERMINING THE SCOPE AND SEQUENCE OF WORK

<u>Process</u>

In planning the scope and sequence of work for a habitat restoration project, it is important to establish a process in which the restoration goals are fully integrated at the earliest possible states with the structural and landscape architecture, engineering, economic, legal, and administrative aspects of the project.

<u>Discussion</u>

If the restoration and alterations of a site are planned concurrently, the potential for successful restoration will be increased, while the cost of restoration and the environmental damage will be decreased.

In less ideal situations, however, restoration may be required where alterations to the habitat have already occurred. Restoration will sometimes be requested where development activities are underway, where development designs have already boon completed and approved without an adequate restoration plan, or where the first attempts at soil placement, erosion control and revegetation have failed. These sites tend to have design problems or soil and non-native lant problems which make restoration more difficult and expensive. Many of the steps which should precede actual seeding and transplanting sometimes must be compressed into a time frame necessitated by unstable site conditions. Modifications and compromises in the restoration process must then be made. Projects of this type tend to have greater costs and slower success rates compared to the costs and time frame of a properly planned restoration.

On sites where habitat damage occurred further in the past, such as old farm fields, overgrazed and browsed ranch land, or old roadsides of non-native species, the restoration process may be administratively less complex if no further physical alterations are planned. Some of these sites may need only minor structural alterations for erosion control. But analysis may indicate the need for more specialized management techniques such as controlled burning or extensive removal of non-native species.

<u>Example</u>

Chart A on page 7 is an idealized example of the sequence and timing in Central Texas for a project where restoration is integrated with partial development of a site. Each project has its own uniqueness which will affect this outline both at the start of the project when the scope is being developed, and during the project when unforeseen factors require changes.

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CHAPTER 2: SITE ANALYSIS

In order to design restoration plans for a specific area, there first needs to be a site analysis covering the topics of existing geology, hydrology, physical structure, vegetation, and soil. Good restoration design is dependent on a description of the current site conditions, and, if the site has been altered from its natural state, a hypothesis of its previous habitat structure.

The site analysis should include:

2.1 Assemblage of existing information

2.2 Species list

2.3 Field mapping

2.4 Physical characteristics

2.5 Vegetative description

2.6 Detailed analysis of key areas

2.7 Recommendations

2.8 Analysis of material for salvage

2.9 Site documentation

2.1 ASSEMBLAGE OF EXISTING INFORMATION

Process

Acquire the best existing information about the site and nearby areas. The information assembled optimally should include:

1. Engineering / topographic maps
2. Drafted boundary and internal survey maps
3. Geology maps
4. Soil surveys and maps
5. Aerial photographs
6. Species lists and vegetation descriptions and maps

Discussion

It is important to include the analysis of off-site areas when there may be an impact on the site itself. Nearby development, especially uphill or upstream in the drainage basin should be anticipated when possible.

The potential quality of field mapping of sites larger than five acres is often determined by the aerial photo selected. Generally, the smallest scale aerial photo with good resolution and a minimum of scale distortion is the best selection. When a choice of scale for other maps is available, select those at the same scale as the aerial photo.

Example

For areas within the City of Austin, the 1 inch = 200 feet scale aerials and engineering maps available throughout the city are usually the best choice. Outside the city, 1 inch = 400 feet scale aerials are often the best available in Central Texas.

2.2 SPECIES LIST

Process

Develop a list of plant species found at the site which includes at a minimum:

1. Uncommon native species deserving special consideration in site planning or salvage.
2. The most abundant species which will help in defining existing vegetation units.
3. In areas of extensive negative impact, the remnant native species likely to have been significant in the former vegetation structure.
4. Species likely to be utilized in restoration or landscaping.

Annotation on abundance of each species at the site can be useful.

Discussion

The required degree of completeness of the species list should be carefully determined by the scope of an individual project. An essentially complete species list takes considerable time to compile, and its value may be primarily scientific and not significantly affect the planning and restoration process. Where possible, use an existing species list from a similar area to check off or add on species found at the site. Use caution in making assumptions about the similarity of two different sites.

Example

For Upper Glen Rose geologic units (Glen Rose members 4 & 5, see Geologic Map of the Austin West Quadrangle, Bureau of Economic Geology) and closely related habitats use the Annotated List of the Vascular Plants of Wild Basin Wilderness Preserve, Judy Walther, 1985, (available through Environmental Survey Consulting), as a guide to species likely to be found on the site.

Central Texas includes a large number of plant community types within close proximity. While some species may be indigenous to most of the Central Texas area, and others seem to belong primarily to either the eastern or western sides of the Balcones Fault zone, there are species which appear to be much more restricted. Based on field observations and mapping, the authors believe there are substantial differences in species composition based on geologic and soil substrate differences within the hill country limestones. Because the restoration and research models for this manual are based primarily on the Upper Glen Rose units in the Texas hill country, many of the examples cited are listed as specific to that area. It is clear from our research that these specific species and plant community descriptions cannot be loosely extrapolated to other Texas hill country areas. The most similar plant communities probably occur in the lower Glen Rose and the Walnut geologic formations.

In lieu of a more complete understanding of the correlation between various plant communities and the geological and soil types of Central Texas, the species list for a site is of fundamental importance as a basis for restoration design.

2.3 FIELD MAPPING

Process

The following features should be located in the field and drafted directly onto bluelines of the selected aerials:

1. Boundaries of existing vegetation units
2. Special biological features such as rare species or unusually large specimens
3. Physical features such as streams, drainage channels, springs, and cliffs
4. Cultural features such as fences, roads, dumps, and buildings
5. Existing survey pins

Discussion

The determination of what constitutes a distinct vegetation unit, or which individual trees should be mapped is a subjective decision based primarily on how this information will be utilized. For example, a park grassland with distinct islands of trees may be mapped and described as either a single vegetation mosaic unit or an many discrete tree clusters and open grass areas. Less detailed mapping is often acceptable when selected areas are expected to be mapped in greater detail during later stages of the design process as described later in this chapter.

When transcribing the drafted vegetation units from the aerials onto existing engineering maps and surveys, accuracy will be increased by matching the cultural features and existing survey pins found in the field with those drawn on existing maps and surveys. The best procedure is to draft the vegetation data from the field serial directly onto a transparent print of an engineering or survey map of the same scale. The aerial, which is never exactly at scale across a large area, can be shifted slightly so that features and survey pins on both the aerial and engineering map match in the vicinity surrounding the vegetation being transcribed.

2.4 PHYSICAL CHARACTERISTICS

<u>Process</u>
Describe these physical features of the site with emphasis on their relationship to existing and potential vegetation.

1. Geology
2. Topographic character
3. Soil
4. Drainage pattern
5. Available moisture

<u>Discussion</u>
Other than rainfall patterns, the geology of a habitat is the determining factor for all the physical and vegetational characteristics. Soil is directly related to the geology. The drainage pattern and topographic characteristics are also dependent upon the erosive nature of the rock and soil. All of these interdependent characteristics together determine what species of plants can survive.

<u>Example</u>
The typical physical form of the Upper Glen Rose geologic unit and the pattern of associated vegetation growth is shown in Figure 1, p.28. The bedrock geology is a series of thin (6 inches to 2 feet) limestone and dolomite layers which alternate between hard and soft. These weather to form a stairstep topography with wide benches formed by the soft layers. The hard layers form steeper slopes and sometimes outcrop at the top. There is generally a thin but rich topsoil up to one foot deep which accumulates with rock rubble near the base of the steep slopes. This soil thins, sometimes to nothing, at the downhill edge of the benches. During storms, these almost level terraces effectively maintain a sheet flow of water except at the water channels which, at wide intervals, cut into the terraces. Thin soil areas of the benches are very wet for short periods after rains but dry out quickly compared to the deeper solid of the steep areas. The species composition on these hillsides alternates between two main types with most of the woody plants and the taller grasses and flowers deeply rooted in the steeper areas. The more xeric shorter plants grow in the thin soil areas. This produces a distinct banding of vegetation across the hillsides which reinforces the patterns of soil accumulation and water retention.

2.5 VEGETATIVE DESCRIPTION

Process

Develop a generalized description of the vegetation, including the main variations, found on the site. Mapped vegetation units should be described as to:

1. Dominant and characteristic species
2. Height, form, and character of the vegetation
3. Successional level of the existing plant community
4. Relationship to nearby habitats
5. Soil and moisture characteristics

Describe located significant individual specimens and species of special interest. Provide an analysis of the extent of human alterations to the site, including the current role of non-native plant species. For areas which have been significantly altered by human activity, provide descriptions of the probably previous character of the native vegetation.

Discussion

To determine species dominance, tree heights, and canopy coverage, it is not always necessary to use precise field measurements and statistical analysis. Generalized field observation may be sufficient. Determine how the information compiled will be utilized, match the level of accuracy to the expected uses and clearly state the methodology and degree of accuracy.

Describing the successional level of a plant community is often a difficult, speculative, and incomplete venture. Even so, these descriptions and understandings must be central to the development of restoration models and management strategies.

The successional level of a plant community is a result primarily of:

1. Passage of time
2. Plant dispersal and growth rates
3. Synergistic effects of plants and animals
4. Interruptions by discrete natural events such as fires, windstorms, or floods
5. Impact of human activities such as clearing, burning, farming, and grazing

It is important to attempt to distinguish successional variation from variations caused by the physical characteristics of the site since restoration must approach the effects of these two factors differently. Generally, physical factors determine which species can and cannot grow on a site, whereas successional factors determine which of these species will prosper over time under different management conditions or approaches. A comparison of areas with similar physical characteristics but different histories (i.e., opposite sides of a fence, edges of burns, etc.) provide important clues for these inexact descriptions. For areas with significant human alterations, the models of the probable previous native vegetation are largely based on two sources: 1. Remnant species on the site, and 2. Other sites of very similar physical type where the native communities are still essentially intact. Remnant species can be searched for in areas such as cliff ledges inaccessible to goats.

<u>Example</u>

The authors consider Wild Basin Wilderness Preserve and some of the nearby private land to be an example of the plant communities of the Upper Glen Rose Formation which have escaped most human-related alterations. As such, it is a rare resource and invaluable as a restoration model. Based on extensive non-quantitative observation at Wild Basin and comparisons with other sites, a possible model for the plant community succession for this habitat is evolving. Although still under development, this theory offers both a context for analysis of other similar, but more heavily impacted areas and guidance in restoration design.

Periodic fires appear to be the primary natural factor interrupting the biotic community's slow succession. In the Glen Rose V unit (from approximately 800 feet to 920 feet elevation at wild Basin) these fires probably occurred naturally at irregular time intervals measured in decades. These fires seem to produce patchy burns. That is, within a large burn area there would be patches which escaped burning altogether and areas which burned at decidedly lower or higher intensities. The steep topography and sparse slow growth of understory vegetation, especially in certain patches, affected the nature of these fires. Juniper trees were also an important cause and result of patch fires.

If we could watch a hillside for a century after an extensive burn, we might see the following cycle. In the first decade there would be a strong showing of grasses and wildflowers. Many of these would be perennials both starting from seed and resprouting from burnt root stock. There would be significant quantities of a few annual grasses, primarily poverty dropseed (#425) and three awn grasses (#377-379), and a greater number of annual wildflowers, predominantly the hedeoma mints (#238-239), two crotons (#134-135), several euphorbs (#138&144), Texas geranium (#184), mountain pink (#194), ragweed (Ambrosia psilostachya) and the similar sumpweed (Iva angustifolia), two plantains (#250-251), and several other composites such as palafoxia (#332) and broomweed (#315).

Around the burnt stumps of large junipers would be a resprouting of the many woody species that had previously germinated almost entirely in the shaded needle mulch under older live juniper trees. After a fire these woody species would resprout, forming islands of diverse shrubs and trees surrounded by the grasses and wildflower community. Amongst the grasses, there would be almost no woody plant germination of the species which are resprouting around burned junipers. However, there would be three woody species slowly appearing from seed in small numbers among the grass: juniper (#10), lanceleaf sumac (#172), and false willow (#294).

In the next few decades this pattern would develop, with the perennial grasses and wildflowers crowding the annuals and restricting them to the thinnest soils. Patches of individual species of the grasses would become larger as whichever species most exactly suited to a small microniche asserts itself. The growing shrubs and trees would further conceal the still standing burned juniper stumps. The weak lanceleaf sumac and false willow would start to die of old age, but the cedar seedlings would very slowly take a larger share of the habitat and eventually start to provide the unique shaded, acidic microniche under their branches, where the seeds of certain other species would germinate. At this point another fire through this area would likely have mixed results. It would send the grasses, wildflower, and fire-resistant shrubs and trees back to resprouting from their roots. Some of the junipers would be burned, some individuals would escape burning because of the topography and nature of the fire and, perhaps, some clusters or whole hillsides would escape burning. Those junipers that escape this burn are headed during this century toward becoming the denser patches of older juniper referred to as “breaks” which almost entirely shade out many grass and flower species and develop a thinner, different understory community. They become more resistant to small fires because of the shortage of low flammable material, but almost explosive in a large fire which reaches into their crowns.

The Glen Rose V unit at Wild Basin serves as an excellent example of the above described variations, with the exception of the earliest stage after a fire (since the last fire occurred in the early 1960's). The Glen Rose IV unit (from approximately 640 feet to 800 feet elevation) at Wild Basin shows similarities to the Glen Rose V unit. However, several decades after a fire, it tends to become more of a shaded woodland with a large percentage of multiple trunk Spanish oaks resprouted from burned stumps.

The authors have not located and analyzed areas in the Edwards and related geologic units which have not had major human alterations to use for developing specific restoration models. Unaltered examples of the many habitats of eastern Central Texas are equally rare with a few small, isolated prairie remnants under consideration for protection. Some large areas at Lake Long Park have important value for at least their remnant species, if not their remnant communities.

2.6 DETAILED ANALYSIS OF KEY AREAS

Process

In selected areas of a site, develop a detailed map for use in final location and design of alterations and restoration. This map may include individual trees, shrub or tree clusters, of landscape value, and small topographic features such as dry washes and rock outcrops. The selection of these areas and the determination of which details are required should be based on preliminary site planning decisions.

Discussion

For many projects, certain areas will require more detailed analysis than other areas. The location of these areas and the degree of detail necessary is generally determined by a preliminary site plan based on information from the first stage of site analysis. For example, if a generalized location for a road is proposed, a detailed site analysis may be extremely useful in the location of: 1. Large trees, 2. Topographic and drainage features, and 3. Variations near critical areas such as creek crossings. This can aid both in making small shifts of a roadway and in the design of a realistic erosion control plan. Likewise, if a general area is designated as a future parking area, a detailed analysis can focus on trees and shrubs that could potentially be retained in the detailed design of a parking area.

A process where the analysis is done in several stages can minimize two potential problems. First, often a costly tree engineering survey is done of an entire site when a detailed precise analysis is only needed for a small area. The exact location of a tree may be crucial when it is near a proposed building line or parking island. Precise locations are not necessary in the middle of areas where all vegetation will be either removed or left undisturbed. Secondly, due to the large cost involved for detailing an entire site, sometime a decision is made to eliminate a detailed survey of the targeted small areas, even though such a survey would result in major economic and environmental improvements in the final design.

Example

Map D on page 70 is an example of a detailed vegetation analysis that was warranted for determining the location and design of a proposed building.

2.7 RECOMMENDATIONS

Process

Based on field observations and analysis, provide recommendations relevant to the design decisions which are anticipated for the site as outlined in the scope of the project. Discuss relative value or assign a value ranking to the different mapped vegetation units. Clearly state the criteria used for this evaluation.

Discussion

On large, complicated sites it can be important for the site analysis to include a ranking of the mapped vegetation units for use in site planning. Possible criteria for this ranking can include:

1. Rare and endangered plants
2. Important wildlife habitat
3. Especially old or large plant specimens
4. Important natural resources such as springs
5. High diversity
6. Degree of contamination by exotic species
7. Potential landscape value in its current location

Additionally, because of the familiarity of the site gained during the field work, many other useful observations may be made which would not be otherwise available to participants who spend much less time in the field during the planning process.

2.8 ANALYSIS OF MATERIAL FOR SALVAGE

Process

Once a site plant has been approved, inventory the area to be altered for materials that can be salvaged. This inventory should include:

1. Rare plants which should be moved to protected areas
2. Potentially harvestable seed sources
3. Transplant sources for restoration or nursery stock
4. Brush for erosion control or mulch
5. Construction timber
6. Usable rock
7. Salvageable topsoil
8. Firewood

Discussion

Many sites have the basic materials needed for actual restoration. On many sites this material is machined and destroyed and then later, at restoration stages, additional landscaping and restoration materials are brought to the site. Often these materials are much more costly and less suited to the restoration needs than the original material found on the site. For example, the topsoil existing on a site, if not heavily contaminated with non-native plant species, can be assumed to be the best kind of topsoil for restoration, whereas it is often almost impossible to purchase topsoil of the same type, especially the same type free of non-native species. However, when the construction contractor who is first on site is different from the contractor who will do the restoration at a later stage, it is difficult to coordinate the analysis and use of salvageable material. On a site where one restoration contractor manages the natural part of the site from the beginning to the end of a construction project, it is much more feasible to salvage the material before construction machinery arrives. The material should then be either stored until needed for restoration or utilized at another project already at the restoration stage.

Example

In much of the Upper Glen Rose and many other Central Texas sites there is an abundance of juniper (#10). This material can be effectively used in temporary or permanent erosion control and can also be shredded into a mulch. This mulch, which is very acidic, provides both organic material and a release of nutrients when applied to the very alkaline pulverized Upper Glen Rose rubble left after construction. The heartwood of this tree is one of the most rot resistant known. It is, therefore, excellent for outside uses such as steps, benches or check dams, whereas other woods would quickly rot.

2.9 SITE DOCUMENTATION

Process

Document the site photographically during the earliest stages of analysis. Continue how to documentation periodically to provide information on the effects of alterations and progress of the restoration areas. Keep accurate records of management activities such as the date, location, quantities, and results of seeding and transplanting projects.

Discussion

Photography can be an inexpensive and efficient way of documenting some aspects of a site. Color slides have the widest range of uses and are the least expensive, however black and white prints should be made where documentation is expected to last for decades. At the start of a project, before the site is disturbed, document areas that are most typical, as well as areas that are most likely to show the effects of management activities such as stream channels downstream from site impacts. As the site changes, return periodically to the same locations and attempt to duplicate the framing of the original pictures. It is often helpful to include in a corner of the picture distinctive objects expected to be relatively permanent, such as rock outcrops or telephone poles.

CHAPTER 3: DESIGN OF THE PHYSICAL SITE

A determination of the final physical structure of the site precedes the detailed design of the restoration of site vegetation. The data from the site analysis is incorporated with other planning considerations such as economic, engineering and governmental requirements, to develop the physical design of the site. This design includes:

3.1 Site planning: Determining the uses of the different areas of the site with a detailed site plan

3.2 Physical alterations: The detailed design of all physical alterations

3.3 Site protection: The design of site protection during the period of site work

3.1 SITE PLANNING

<u>Process</u>

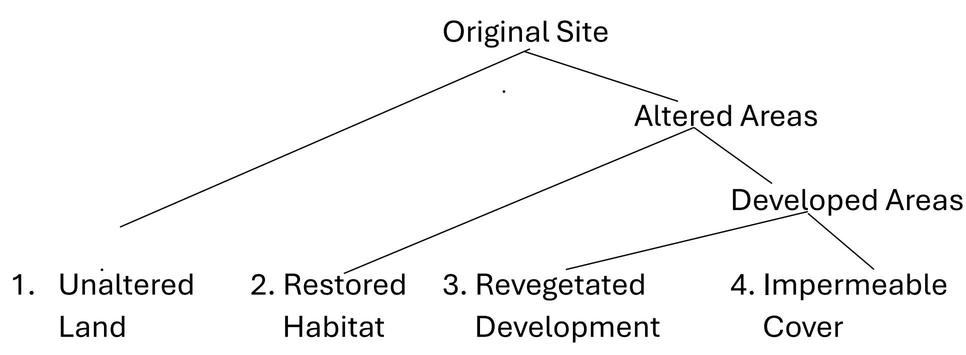
The site plan should include a division of the land into four land use categories.

1. Unaltered land
2. Restored habitat
3. Revegetated development
4. Impermeable cover

Initially, a general mapping of these divisions is sufficient. In the final site plan, however, these site divisions should be clearly delineated, based on detailed analysis of key areas.

<u>Discussion</u>

The eventual equality of a restoration project on land where part of the site is disturbed during development is greatly affected by the successful delineation between areas which will be fundamentally altered and areas which are unaltered and retain their existing vegetation. This division is often synonymous with areas where machinery will be allowed or prohibited on the site. Altered land is further divisible into two types, that which is scheduled for permanent development and that which will be restored approximately to native habitat after construction activities are completed. Land which is scheduled for permanent development is also of two basic types, either impervious cover such as buildings or parking, or permeable development such as lawns, traditional landscaping, and sports fields. The clarity of these divisions both in the design and in the field during construction has a major effect on the eventual quality and cost of restoration.



Four Land Use Categories

The most fundamental factor which affects the natural habitat value of a site is the ratio between altered and unaltered land. Next in importance is the ratio between the permanently developed area and the combined unaltered and restored habitat. These ratios are related to, but significantly different from, the density and impervious cover criteria of zoning regulations in Central Texas.

Additional factors related to land use designation which favor the natural quality of the site are:

1. The location of altered land areas furthest away from established water channels.

2. The selection of locations for altered land areas which require the fewest alterations to the existing landform and surface water patterns.

3. The preservation of large and preferably connected areas of unaltered land, rather than the preservation of many small and isolated areas.

4. The preference for preservation of the most diverse sampling of natural elements present on the site, especially the riparian community, uncommon species and, since age is not possible to restore, old specimens.

Subjective compromises between these various factors are often necessary.

3.2 PHYSICAL ALTERATIONS

Process

Design physical site alterations so the new forms as much as possible mimic the natural, undisturbed forms and niches found on the site in relationship to:

1. Subsurface geologic structure and chemistry
2. Surface topography
3. Drainage patterns
4. Available moisture
5. Topsoil

Discussion

The restoration of an indigenous plant community on a disturbed area is dependent upon the preservation or reconstruction of physical conditions which are similar to one or more of the physical conditions which are similar to one or more of the physical niches naturally occurring in the original or similar site. The natural plant associations and physical forms of a site have been evolving over millennia towards maximum stability and retention of resources such as available moisture, soil, and nutrients. This balance is based on both efficient utilization of typical annual conditions and an ability to survive the extreme variations in the climate on a site over decades and centuries, such as in frequent storms, extended droughts, or infrequent low temperatures.

Sites not reconstructed similarly to the original physical types tend to have a larger degree of instability. They tend to change towards the original physical characteristics which means that retaining the artificial forms is a continual and often increasingly difficult site management problem. Sites intelligently designed and constructed to resemble original configurations tend to progress in synchronization with the natural effects of climate toward a stability typical of an undisturbed site.

Example

In the Upper Glen Rose limestone the prime factors limiting plant growth are topsoil and water. Restructured slopes in the Upper Glen Rose should be designed to maximize the retention of topsoil and water since these are the most important factors to encourage plant growth on disturbed sites. Traditional design practices have often tended to concentrate surface run-off and direct it off a site as rapidly as possible. These types of designs tend to cause sever environmental problems both on and downhill from the site. They also tend to oppose the natural processes which are to develop a stable plant/soil/water relationship which maximizes the spreading and retention of available soil and surface water. Recently, retention/detention has been stressed in designs but often by concentrating the water in ponds. These ponds create a niche foreign to the Upper Glen Rose habitats and have a tendency to fill up with sediment, over either the short term or the long term, which decreases their retention/detention capacity.

Physically altered slopes in the Upper glen rose limestone fall primarily into two categories which require different approaches to their physical and vegetative design: cut slopes and fill slopes. Cut slopes typically expose the existing beds of alternative hard and soft limestones and dolomites. These slopes should be machined (Fig. 4, p. 29) or dynamited to restructure some of the original stairstep topography rather than machining a smooth slope. Wherever possible allow the hard layers to periodically be exposed or near the surface to prevent deep gullies from washing into the slope. Perch the rubble on these hard layers in imitation of the breakdown materials and soil that naturally accumulates on undisturbed slopes. Locally salvaged topsoil can be integrated into this material to assist plant growth. Brush berms can be placed at the front edge of these ledges to catch sediment and encourage plant growth. Plant growth across this slope will vary as on natural slopes *Fig. 1, p. 28), with more vigorous growth in the cracks of the deeper broken material and shorter growth near the edges of the hard exposed layers.

Traditionally in the Upper Glen Rose limestone (Fig.2, p. 28), cut slopes are engineered and carved into these layers as smooth two-to-one or three-to-one slopes. These new slopes, however, consist primarily of exposed bedrock with little loose material to provide a medium for plant growth and no unevenness of the original stairstep structure to retain any loose fill or topsoil during storms. Rubble or topsoil, especially the sandy loam which is sometimes brought into this habitat, tends to be unstable and highly erosive when placed on these sheer slopes. Plant growth then tends to be extremely sparse because of little penetration of water or roots into the exposed bedrock.

During their final shaping, fill slopes (Fig.3, p. 29) should have locally salvaged topsoil

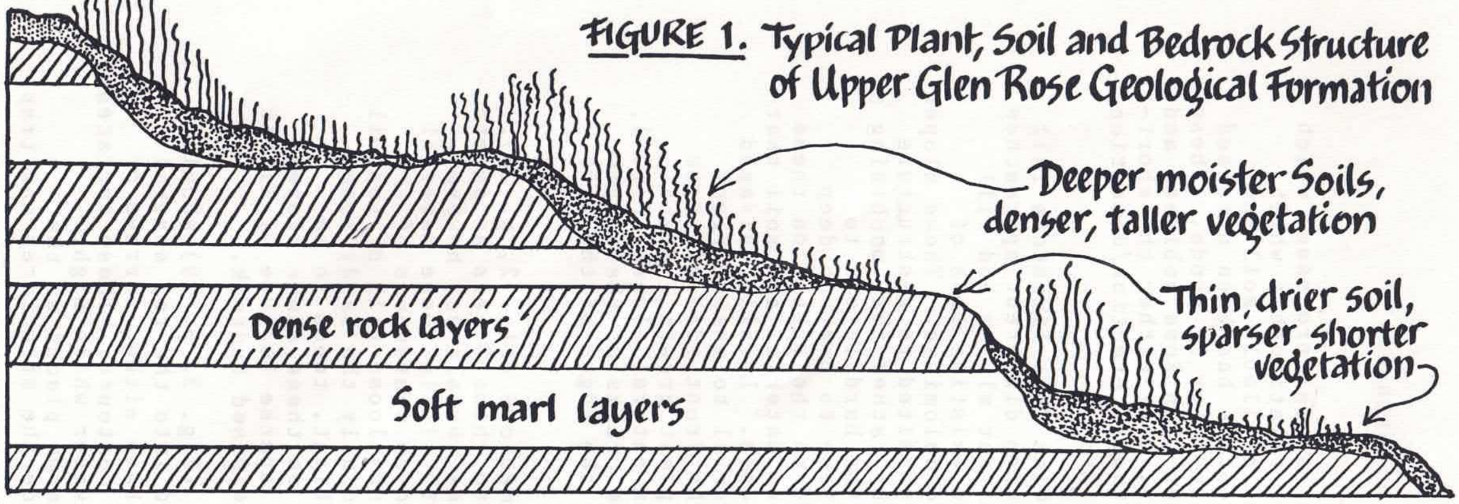


FIGURE 1. Typical Plant, Soil and Bedrock Structure of Upper Glen Rose Geological Formation

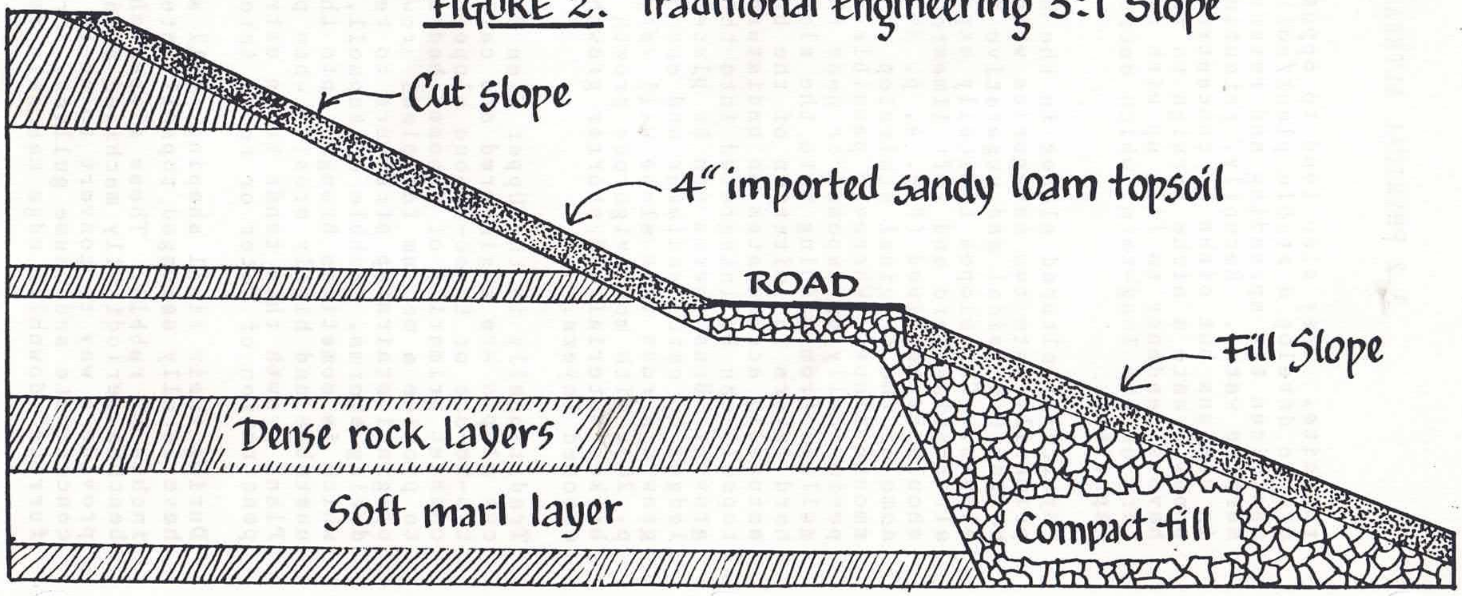


FIGURE 2. Traditional Engineering 3:1 Slope

FIGURE 3. Recommended Fill Slope

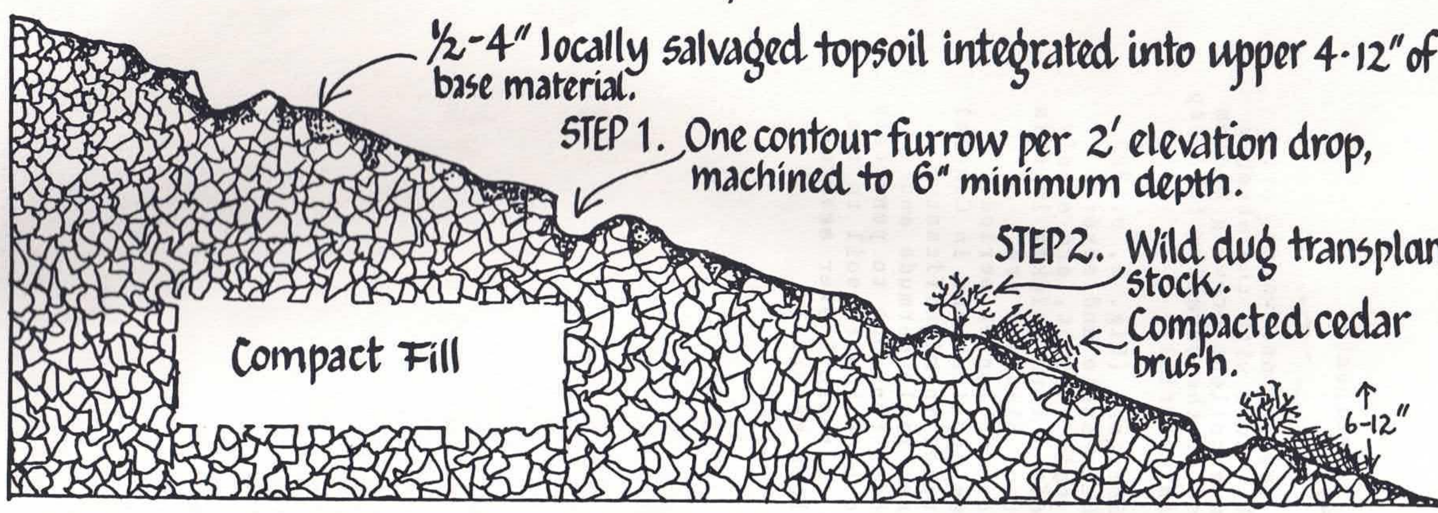
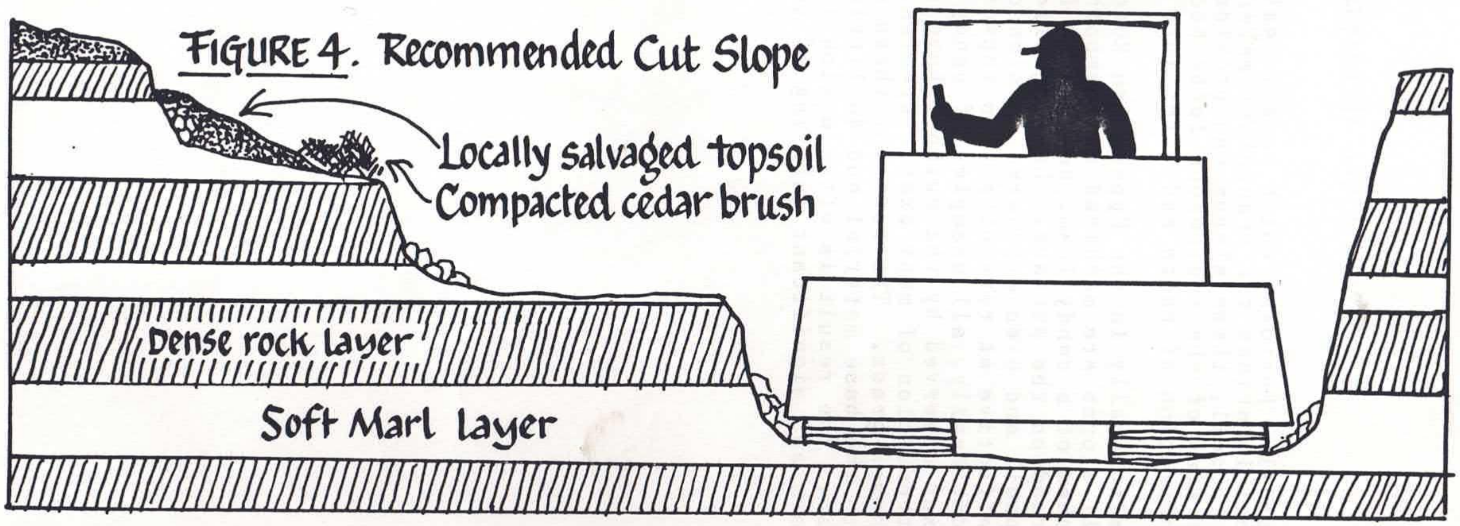


FIGURE 4. Recommended Cut Slope



integrated into the top several inches of rubble. These slopes should have either furrows or benches periodically machined along the contours. These terraces provide a way to convert to sheet flow water which might concentrate and cause gullies. Brush berms placed at the furrows' downhill edge can help reinforce the structures and trap topsoil. Furrows, which receive extra topsoil and water, are ideal locations for transplant material. Even with the absence of topsoil, these slopes can provide an excellent growing medium for many of the indigenous forbs because of the capacity for deep penetration of roots and water into this material.

Traditionally in the Upper Glen Rose limestone (Fig. 2, p. 28), fill slopes are machined at a smooth sheer angle and several inches of a sandy loam, unsuitable for this habitat, are evenly spread on the surface. Large gullies often form quickly in this topsoil and even expensive erosion control blankets are ineffective at retaining this topsoil over a longer period. Additionally, all examples of sandy loam applications in Central Texas observed by the authors have resulted in significant introduction of many exotic species, especially Bermuda and Johnson grass. The roots of these species tend not to penetrate into the base material and do little to bond the topsoil to the base. The result is often a slow loss of topsoil over several years and significant gullying of the base material.

3.3 SITE PROTECTION

Process
Include in the design careful sequencing and description of site protection measures.

1. Specify clear delineation of the limits of access for machinery in the field.

2. Design temporary and permanent erosion control.

3. Specify required salvage of resources in the work area.

4. Specify required arborist work.

Discussion
In planning site work, it is crucial to design a procedure for limiting machine access to the restoration areas.

Protection strategies should include:

1. An initial realistic assessment of the area required for safe and reasonable efficient construction practices.

2. A procedure for clearly marking the limits of access for construction equipment before its arrival on the site, and monitoring and maintaining these limits throughout construction.

3. A procedure for approval of requests from contractors for expansion of construction areas so that the supervising engineer can balance these requests against the concerns and costs of additional habitat removal and restoration.

4. A procedure for penalties of unauthorized ingress into protected areas.

The next concern is to design adequate erosion control devices. Temporary erosion control should be in place before any construction work begins. Often the temporary erosion control structures can be designed so that with minimal modification, they can be transformed into permanent erosion control devices after construction is completed.

Areas delineated for alteration and restoration can be utilized in different ways. The area to be cleared for development can be a valuable resource for the primary indigenous materials of restoration: rock, topsoil, seed, transplant stock, brush, and logs.

In the delineation of a site's restoration areas, a further distinction can sometimes be made for areas that may require only partial alteration and subsequent restoration, with significant quality and cost benefits. Certain areas may be needed for access of construction equipment, yet not require grade changes or topsoil removal. These areas are frequently machines bare, whereas hand cutting of brush and trees at ground level would sometimes be sufficient for access. By doing this, the remaining topsoil and the substantial re-growth following construction from the root structure and dormant seed following construction would greatly simplify restoration.

<u>Example</u>

Additional information on site protection is provided in Chapter 6.

CHAPTER 4 VEGETATION DESIGN\

The design of the vegetative component of a habitat restoration project should attempt to add the various missing elements which will combine, over time, to form some approximation of the selected habitat model. The habitat models developed during preliminary analysis of the site and nearby undisturbed habitat, plus the prediction of the physical condition of the site after machine work, form the basis for the design of the vegetation restoration. Many sites must be divided into discrete niches, requiring different treatments. Within this framework, there are often choices of emphases, such as trees and shaded forbs versus sunny grasslands. The vegetation design should include:

4.1 Species selection: Specifying the many species which will be added to or increased on the site as well as the sources for these species.

4.2 Schedule for restoration activities: Including a schedule for seeding, transplanting and other management activities.

4.1 SPECIES SELECTION

Process

From the species list compiled during analysis of the site and other examples of the same type of habitat, establish priorities for the use of each species in the restoration design.

The three primary factors which determine species selection are:

1. The utilization of suitable species for each habitat
2. The establishment of a high diversity of species on each site
3. The availability of each species

Discussion

Suitability: The best indicator of site suitability for a particular species is its original presence in that specific habitat before human impact. Obviously, disturbed areas require more skillful sleuthing and subjective interpretation than do pristine areas. Factors of development which alter the nature of pristine areas. Factors of development which alter the nature of the original physical habitat must also be considered. Within any given site, there can be important variations in moisture, shade, topsoil, subsoil, and bedrock chemistry. Therefore, there is variation in the species mixes suitable for different sites and different areas within a single site. Care must be taken that the source for each species matches the soil and climate of the restoration site.

Diversity: Native habitats have a high diversity. Any Central Texas habitat would originally have had over one hundred species. Restoration efforts may heavily utilize earlier-successional species because they tend to produce greater seed quantities and will often establish themselves more quickly than other plants in a disturbed site. However, it is very important for long-range success to establish some later successional species, at least in small amounts. This ensures a continuous seed supply on the site as the habitat develops. The use of non-native species is inconsistent with the goal of native habitat restoration.

Availability: There are four potential sources of native plant species: A. Cultivated Seed, B. Harvested Wild Seed, and C. Propagated Wild Transplant Stock. Each source has its advantages and disadvantages. These apply to woody plants, grasses, and forbs. However, at this time, there is greater availability of nursery stock woody plants and research on nursery propagation of seed with woody plants than there is for the grasses and forbs.

3.A. Cultivated Seed

Advantages:

1. Sometimes high purity.
2. Predictable availability, germination rates and quantification for design and bid-specification purposes.
3. Large quantity available at low cost.

Disadvantages:

1. Extremely few of the needed species are currently under cultivation.
2. It generally takes many years to develop a cultivar of a species not under cultivation, even if it is fully adaptable to cultivation and harvest.
3. Varieties of each species under cultivation are not always from a locally suitable strain and can have high failure rates.

3.B. Harvested Wild Seed

Advantages:

1. For almost all of the many species necessary for diverse restoration, this is the only seed source.
2. If local sources from habitats similar to the restoration site are used, site suitability of the variety is assured.
3. The seed-collector attachment to rotary weed trimmers, devised by Environmental Survey Consulting, now allows for large quantities of wild seed to be harvested at moderate cost.

Disadvantages:

1. It is difficult to certify pure live seed quantities for the large number of species (or species mixes) usually collected in a wild seed harvest. This has traditionally been expected in engineering design specifications.
2. Yearly seed quantities are significantly affected by weather variations.
3. Good wild seed sources are uncommon and should not be over utilized.

3.C. Wild Transplant Stock

Advantages:

1. There are species which are not readily established in a disturbed site by seed, or which produce little or no seed in a particular year. Wild stock will be the only way to establish these species in a diverse restoration when there is no available propagated transplant stock.

2. The salvage and recycling of a valuable resource of rare species which are traditionally destroyed by machine work during development is an important conservation measure.
3. Wild stock from diverse native habitats invariably brings along many volunteer plant species as “hitchhikers” in the sod, thus significantly increasing diversity.
4. If the transplant source is a similar local habitat, site suitability is assured.
5. The soil which comes with wild transplant stock contains a very complex association of bacteria, algae, mycorrhizal and other fungi, protozoans, worms, and arthropods which are essentially unknown for a given habitat, but which are important and, at times, necessary for the growth of certain plants and development of the soil. Man of these unidentified components will be brought to the site in the transplant sod. Their presence may play a key part in accelerating the restoration of native soil on the site, which is rarely given sufficient importance.

Disadvantages:

1. Where the source of wild transplant stock is a development site, there is often insufficient time allowed for salvage between final administrative approval and the arrival of machinery onto the site. Sometimes the salvage period occurs during a time difficult for transplanting, either because of dry weather or time of year.
2. Good sources of some species are sometimes difficult to find where digging is ethically justified.

3.D. Propagated Native Plant Stock

Advantages:

1. Successful propagation through wild harvested seed or cuttings is a high-efficiency use of these resources, which is especially important for uncommon species.
2. Usually, there is greater uniformity, predictability of success rates and ease of quantification for design and bid-specification purposes.
3. Results in no destruction of existing habitat.

Disadvantages:

1. Currently, there are many species not generally available from actual propagation, although it usually takes fewer years and a smaller scale operation.

to develop propagation of a species than it does to develop cultivated seed. A portion of nursery stock, especially larger, older specimens, consists of wild dug plants.

2. Propagated stock may have fewer, if any, of the complex soil organisms associated with wild stock, and sometimes contain considerable quantities of various biocides.
3. The origin of the propagated variety is not always compatible with the restoration site and is sometimes difficult to determine.

The relative advantages and disadvantages of each of these four sources will vary with species, location, year, weather, the current state-of-the-art of seed cultivation, propagation, as well as market factors affecting availability of commercially grown seeds and plant material. These factors, combined with a comparative-cost analysis, should be reflected in the design of each restoration project. Most diverse restoration attempts must utilize a combination of at least the first three of these sources.

The success of a restoration project in Central Texas will usually be very dependent on the availability and quantity of wild seed and transplant sources of the grass and flower components. It is a priority that, if possible, transplant sources be located in good habitats scheduled for destruction. Planning of seed availability must be tentative because weather conditions can greatly affect quantities of seed available each season. Variance in the quantities of seed for each species is less problematic on restoration projects where 50 to 100 species will be seeded than on traditional low diversity revegetation seed mixes. Reduction in the seed availability of certain species can be compensated for by adding transplants of these species and by increasing the seed quantities of other species with greater availability.

The Ethics of Harvesting Wild Seed and Transplanting Wild Stock

In brief, in order to restore and improve one area, do not significantly damage a source area. Here are some general rules to follow.

1. Utilizing a source which is scheduled for elimination by development is of the highest priority. In that circumstance, you are providing a plant rescue and recycling service. The digging of wild plants from any other area can only rarely be justified, perhaps where a source has a very high population of a certain species and only a small number of plants are taken for the purpose of supplementing diversity at the restoration site.
2. Harvest only the excess seed in source areas not scheduled for elimination. Do not remove all or even most of the seed of one species from a site. However, in most areas where a species is well established, there is usually a large excess of seed produced.

   With most species, it is extremely difficult to collect most of the seed produced in an area by any method, which is very obvious once you start collecting. There are important exceptions to this generality. For example, in Central Texas, mountain pink (#194) produces a single stem with a bouquet of pink flowers and the seeds stay in the seed pod for many months. Therefore, it would be quite easy to completely deplete the mountain pink population at some sites if care is not taken to leave enough seed.

   <u>Example</u>
   The Habitat Restoration Chart on page 79 lists 200 species important to Upper glen Rose habitat restoration and the priorities for their use as transplant stock or wild harvested seed.

4.2 SCHEDULE OF RESTORATION ACTIVITIES

Process

The scheduling of restoration should encompass at least a complete one-year cycle which includes one or more seasons of seed harvesting, seeding, transplanting and any necessary maintenance procedures. Thes cycle should mimic the seasonal processes which naturally occur in the model habitat.

Discussion

The vegetation design choices should remain consistent with an attempt to hasten succession of a native habitat that would otherwise re-establish itself more slowly over decades or centuries. One little recognized factor in the slowness of natural restoration is the relatively slow process of seed dispersal for almost all native plant species. The notable mobility of species which are exception to this general rule, such as dandelion seeds, cocklebursʼ, and brass burs, tends to obscure the fact that seeds of the vast majority of species fall and remain near their origin or are simply washed downhill. Old roadsides are a good place to observe this phenomenon. There is a slow but significant restoration process observable on a roadcut which has a remnant of native plant community directly up hill. However, the large areas of highway fill, with only roadbed above, have an extremely slow rate of accidental reseeding of native species. Once seed arrives at a site, other factors, such as competition, affect successful germination and growth.

Example

The yearly cycle of plant growth in Central Texas includes species with several different germination, growth, and seed production patterns. A number of annual species germinate in the fall. These species tend to bloom from early spring to early summer and form their seeds before the usual midsummer heat and drought arrive. Annuals of this type generally exist through the long dry summer only as dormant seed on the ground.

Some spring germinative annual species slow their growth during the extremes of summer heat and drought. They are then stimulated by late summer showers into vigorous growth, flowering, and seed production throughout the long Central Texas autumn. Biennials, perennials, and woody plants also generally produce their seed at the same two main harvest periods, late spring/early summer or fall.

The scheduling of the three following components of restoration in Central Texas depends on the time of year the restoration site becomes available for work.

1. Seeding: The seeds of spring-germinating species should be sown from January to May. It is greatly preferable to have seed out during the February and March rains. Seed put out as late as April and May may not germinate or survive summer dryness unless there is an unusual amount of late spring moisture, or supplementary water is available. Seed of fall-germinating species should preferably be on the ground at the onset of fall rains, which begin anywhere from mid-August through September. Later seedings will be less successful.

2. Harvesting: Seed for late summer sowing should be harvested the previous late spring and summer. Fall harvested seed is for spring planting. With good planning, seed will be harvested two to six months in advance of sowing, in anticipation of a date when the site will become available for restoration seeding. Save a small percentage of a harvest for addition to the sowing approximately nine months late.

3. Transplanting Wild Stock and Installing Container Stock: The best time for transplanting most species is late December to early March. Greater soil moisture corresponds directly with increases in both survival success and efficiency in transplanting. Sufficient natural or supplementary soil moisture can extend the potential transplanting period, perhaps even year-round for the hardiest species such as little bluestem (#419).

   This schedule contrasts greatly with the traditional erosion control seeding design in Central Texas and requires more patience on the part of all parties involved in a development project. Current engineering specifications most typically call for the spreading of sandy loam, followed by seeding of one of the several quick growing non-native species that will quickly green up with fertilization and watering. Within weeks or a few months, the site meets standards calling for 80 percent coverage and the revegetation contractor is paid in full, with no further site responsibilities. Often these applications on Upper Glen Rose sites later develop severe erosion and revegetation problems.

CHAPTER 5: HARVESTING WILD SEED

Harvesting wild seed is an important component in the re-establishment of a diverse habitat. Wild seed harvesting is most simply the intercepting of the seed before it falls and its transport to the restoration site which may be several yards or miles away. Techniques for facilitating this transfer are:

5.1 Wild seed sources

5.2 Timing the harvest

5.3 Harvesting methods

5.4 Seed storage

5.5 Processing seeds

5.1 WILD SEED SOURCES

Process

For wild seed harvesting, locate and utilize large colonies of single important species, as well as diverse communities with smaller quantities of many species.

Discussion

Potential seed sources are most easily located while the desired species are in bloom. Land that has been disturbed within the past decade but is not heavily contaminated with undesired species, often provides large single species colonies of earlier-successional native. These colonies can sometime provide large amounts of seed. Native habitats with neither a history of overgrazing nor extensive non-native species contamination must also be located. These sources provide large quantities of the dominant species as well as small quantities of the less dominant species which, collectively, are important components of a mix.

5.2 TIMING THE HARVEST

Process

Maturing seeds should be examined regularly and harvested when significant amounts of ripe seed are on the plants. As obvious as this sounds, care must be taken to avoid picking immature or empty seed heads.

Discussion

Generally, each species has its special time period for ripe seed production. This is fairly consistent for some species, whereas other species are more opportunistic and produce seed at intervals over a longer period of time, depending on available moisture.

Because seed fertilization and development are also weather-dependent, it is necessary to frequently examine seed heads to determine if the seed is mature and has actually developed from the flowers. There are species which in some years form only small amounts of seed, even after producing obvious flowers and what appear to be seed heads.

If harvested before full development, the seed's viability is reduced or completely destroyed. On some species seed remains attached to seed heads long after maturity and can, therefore, be harvested over a long period of time. There are other species, however, where the seed falls quickly, and care must be taken to avoid harvesting empty seed heads.

Sometimes a flowerhead opens its blooms gradually, from top to bottom or vice-versa, and the seed ripens and falls similarly. With these species harvesting should take place after the first seeds have fallen. This allows for some initial seed release at the harvest site while still providing the greatest quantity of mature seed.

There are four indicators of harvest readiness.

1. When seeds are full-sized. This is only obvious through regular examination of the developing seed.

2. When seed coats are changing color, usually from green to a darker blue.

3. When stems are dry, with no further nourishment arriving from the roots and leaves.

4. When the earliest formed seed is dropping.

To examine seed, it is frequently sufficient to separate the seed from the chaff by rolling the seed heads in your palms. However, it is sometimes necessary, especially with some grasses, to carefully pull apart the tiny lemmas, glumes, bracts, or sheaths that might hide the actual seed. To confirm that there really is a developing seed, it should be squeezed between the fingernails and examined for the soft white cotyledons.

Example

In general, most Austin area native plant species flower after the start of either spring or fall rains, producing seed correspondingly from late spring to midsummer or October to December. Consult the Habitat-Restoration Data Chart, p. 79 for approximate harvest times of individual species.

5.3 HARVESTING METHODS

Process

There are three main methods of harvesting wild seed: 1. by hand, 2. with a modified weed eater, and 3. with farm equipment. Collect the seeds, seed heads, stalks, or, with annuals only, the whole plant, into paper or breathable cloth bags.

Discussion

Much wild seed stock is currently harvested by hand. Contrary to initial expectations, large amounts of some species, especially early successional grasses and composites, can be acquired this way in a reasonable amount of time. This work can be tedious and involves cut hands and much stooping, but for small-size projects it can be satisfying outdoor work that teaches a great amount of botany.

Environmental Survey Consulting has developed and is marketing an attachment to an ordinary rotary weed trimmer which collects and bags most of the cut material. This attachment provides a seed-harvesting efficiency many times greater than hand harvesting seed from individual plants while avoiding non-native species as well as enabling them to harvest seed wherever they can walk. This mobility allows the operator to travel through steep, rocky or brushy territory, harvesting an assortment of seed which mimics the ratios of dominant and less common species characteristic of a diverse habitat.

In wide, flat areas free of large rock, brush and non-native plants, farm equipment has been used for wild seed harvesting. Seed hay, where the plants are cut and dropped, then later baled, or picked up is a different process than collecting seeds and stalks with a combine or weed eater attachment. This method has been reported useful for restoration, especially for species where the seed tends to stay firmly attached to stalks. Another technique used in flat areas is a “bumper gather,” a modified bag attached to the front bumper of a pick-up truck.

Regardless of the harvest technique adopted, seed should be placed into paper or cloth bags as seeds will easily rot in plastic containers. Old pillowcases are much more durable than proceri sacks, especially in damp weather. Bags made of a very fine-weave polyester mesh are often best for fast drying. Carroll Abbott, the late pioneer of wild seed harvesting and propagation in Texas said, “The first rule of harvesting is put a rock in your bag. When, not if, you drop it, the bag will usually fall right side up.”

The amount of seed, seed heads and seed stalks collected will vary depending on the collection technique. Generally, use the method which gets the most seed into the bag in the least possible time.

Harvested material must be dried quickly to avoid mold growth. Depending on the moisture content of the material, it should be either spread to dry in the sun or dried in harvesting bags which have been opened for circulation.

<u>Example</u>
In Central Texas there are few areas where the species required for a diverse habitat restoration project can be harvested with farm machinery. Almost all of the flat areas of Travis County have been harmed, whether wide mesas, river bottoms of the Edwards Plateau, or the rolling clay and sands to the east of Austin. Abandoned farmland is usually dominated by the invasive Johnson, Bermuda and KR bluestem grasses and other pest species. Any remnants discovered in Central Texas, of high-quality native habitats large and flat enough for farm equipment harvesting, are probably significant enough for acquisition and protection.

There exist occasional older roadways constructed prior to the extensive seeding of roadsides with non-native species. A few of these roadside strips with an uphill, diverse native seed source have become reestablished over time as diverse native communities and might possibly be useful for harvest by farm equipment. As governmental policies change from revegetating roadsides with non-0native species to native habitat restoration, roadsides could be developed into future sources of wild seed, harvestable with traditional farm equipment.

5.4 SEED STORAGE

Process

For small-scale operations without controlled temperature and humidity storage rooms, it is adequate to dry the seed, store it at outside temperatures, and use within a half year at the longest.

Discussion

Seed should be stored under a roof where it will be subjected to the existing outside temperature extremes. Unharvested seed in the field is obviously adapted to, and in some instances, probably requires these temperature variations. The seed should not be allowed to become overheated in metal storage shed or vehicles. Commercial seed processors use storage rooms with controlled humidity and low temperature, a process which extends shelf life for many species. Growers also utilize different germination stimulating processes for different species such as cold stratification and scarification of seed, as well as fairly sophisticated storage facilities. In lieu of a detailed and sophisticated knowledge of the seed storage and processing requirements for each of perhaps 100 species used in a habitat restoration project, a process which mimics natural temperatures and quickly gets the seed onto the ground will yield good results for many of the species.

5.5 PROCESSING SEEDS

Process

Processing seeds so they are ready for planting basically involves breaking apart the plant tops to release as many individual seeds as possible. When planning a restoration project, it is important to know how much seed has been harvested in order to determine how much area can be covered.

Discussion

For maximum spreading of seed it is important to break apart plant tops to release the seed. This can be done by hand or by mechanical means with a small hammer mill or mulch machine. For example, Mexican hat (#337) contains 100 or so seeds per flower head. Efficiency is increased if the seeds are separated rather than sown as entire heads.

When commercial processing methods are used the seeds are often completely separated from the chaff, leaves, and stalks. Such methods would be too time consuming for native seed harvests of small quantities of many species, almost impossible where seed assortments are involved, and unnecessary when a hand-sowing process will be used.

The best method for estimating the amount of seed is to divide a bag of seed in half, then, take half of the half, then half of the quarter, and on down until there is only a handful of seeds to count. The count should then be multiplied by the fraction denominator to get a rough overall estimate. An even cruder method but one still useful for future reference, is to make annotation of the volume and condition of the stock. For example, it is helpful to know that a half of a grocery bag of fairly full seed heads of a particular composite produced a good scatter of plants on a two-acre site.

Example

In Central Texas, data on quantities of seed mixes for many species and the success rate of individual species is still preliminary. Continuous record keeping on future projects of seed quantities, field conditions and success rates will provide invaluable information for further quantification of seed-mix specifications. Restoration, which relies on sowing wild seed in very diverse mixes, is relatively new and for a number of years will proceed with a green thumb understanding of successful practices rather than strictly quantifiable methods. Keeping these limitations in mind, rough estimates for harvested seed should be made.

CHAPTER 6: SITE WORK

For projects where the restoration is planned previous to and carried out immediately after physical alterations to the site, there is a three-phase site work process.

A. Preparation of the construction area and protection of the non-construction area previous to access of construction machinery, including:
   - 6.1. Field marking of limits of construction
   - 6.2. Temporary erosion control
   - 6.3. Plant rescue and salvage
   - 6.4. Tree protection
   - 6.5. Topsoil salvage

B. Maintenance of site protection during construction and supervision of final shaping of the site, construction of permanent erosion control and topsoil placement, including:
   - 6.5 Topsoil replacement
   - 6.6 Reshaping the site and constructing permanent erosion control

C. Restoration of vegetation after physical alterations are completed, including:
   - 6.7 Transplanting
   - 6.8 Seeding
   - 6.9 Management of the site

Proper attention to the first two phases will greatly improve the success and reduce the cost of the restoration phase. On projects where the site alteration occurred previous to restoration design, modification of these three phases may be necessary. This would involve completing all the omitted steps at the time the decision is made to convert a site design to habitat restoration.

6.1 FIELD MARKING OF LIMITS OF CONSTRUCTION

Process

The limits of construction should be clearly marked on the site with materials of appropriate durability and visibility for the expected equipment and personnel.

Discussion

All vehicles must stay within the limits of construction boundary. Vegetation within this boundary can be expected to be eliminated. No storage of materials is permitted outside this area. No chemical, salt or petroleum products are allowed outside this area. Spillage or discharge of these materials inside the construction limits shall be contained and removed from the site. The only work allowed outside the construction boundaries is for tree protection and trimming, erosion control, and restoration.

If construction requirements necessitate the expansion of a specific part of the construction area once sit work is underway, this expansion should be properly approved and marked in the field. These new areas must also be shown on construction documents and arrangements must be made to fund the increased size of the restoration area.

Example

An example of what kind of barrier may be appropriate for some sites can be found in the City of Austin Parks and Recreation Department, Construction in Parks Guidelines, page 8.

6.2 TEMPORARY EROSION CONTROL

Process

Temporary erosion control should be placed just outside the limits of construction in order to: 1. Prevent an increase in water and silt from leaving the construction area, 2. Filter water leaving the site, and/or 3. Convert the concentrated water flow to sheet flow as it leaves the construction area into established vegetation.

Discussion

There is an increasing body of information on erosion control being published. The City of Austin is actively refining erosion control strategies and ordinance requirements. Successful application, however, is always site specific.

Example

In the Texas hill country, juniper (#10) and rocks are the most important resource available for construction of temporary erosion control devices on most sites. Small branches should be used instead of large trunks because they can be compacted against the soils for maximum efficiency. Erosion control structures using large trunks tend to not touch the ground evenly and existing gaps allow sediment to slip under the berm.

How an erosion control device is actually placed depends on its function. For instance, is its function to deflect water, to make a dam in a channel or convert concentrated runoff to sheet flow? Actual placement is crucial to successful erosion control and is best decided on the site. While placement estimations can be drawn on the engineering plans, it is necessary to observe first-hand in the field where the water flows and where it concentrates, so they may be adjusted to fit the site.

6.3 PLANT RESCUE AND SALVAGE

Process

All vegetation within the construction area should be reviewed for its potential salvage uses. Endangered or rare species should be transplanted elsewhere.

Discussion

The great bulk of plants in a fairly natural area will not be rare, yet they have an important salvage value, either as stock for habitat restoration of similar habitat areas which are ready for transplant, or as a source of native species to be utilized for transplant, or as a source of native species to be utilized in standard nursery or landscaping processes. Vegetation remaining within the construction area after transplanting can have salvage value as erosion-control brush berms, juniper posts or other timber, firewood or stockpiling for later shredding into mulch.

6.4 TREE PROTECTION

Process

Trees and shrubs which are adjacent to or retained within the construction area should be protected from nearby machinery. Use standard arborist techniques to trim tree branches and exposed roots affected by construction.

Discussion

Trunks of trees near the edge of the construction boundaries should be protected by collars of planks or logs. Tree limbs overhanging the construction area that will interfere with construction or with structures should be removed according to standard arborist practices. Trees which are scheduled to have up to 35% of their root area removed should have their crowns reduced correspondingly before root damage occurs.

Example

There are numerous publications describing tree protection, including those provided by the City of Austin Greenspace Oddice and Department of Environmental Protection.

6.5 TOPSOIL SALVAGE & REPLACEMENT

Process

Salvage topsoil from the construction area (if free of undesirable species) by machine. On the site, stockpile topsoil out of water channel areas and if possible, near the areas where it will eventually be spread. Salvage available rock if it can be later utilized for permanent erosion control or other structures. Replace topsoil in a manner which most closely mimics original site conditions. If topsoil is not salvaged from the site, bring in only soil which is similar to the original soil and from a site free of non-native plant species.

Discussion

Topsoil should be salvaged by machine stripping. Different topsoil associated with different geological formations should be kept separate, if possible. Topsoil containing significant amounts of non-native plants should not be stored with high-quality topsoil containing significant amounts of roots of native grasses and forbs. If the storage period is short, maintenance of adequate moisture in high-quality topsoil can result in significant regrowth from the rootstock of perennial species in the respread topsoil.

6.6 RESHAPING THE SITE AND CONTRUCTING PERMANENT EROSION CONTROLS

<u>Process</u>
After construction is completed, reshape the site to imitate the natural topography. Construct permanent erosion control to mimic as much as possible the natural surface water flow of the original site.

<u>Discussion</u>
Work with the constraints of the available materials and the irregularities of the site. An original site is never uniform, and as a result the final shape of the site will have curves and low spots. The original site and other nearby examples will provide a model for restructuring the altered area. The site design should be fine-tuned in the field to fit the actual contours of the site and water flow patterns obvious during construction.

6.7 TRANSPLANTING

<u>Process</u>

After material to be transplanted is located, specific densities and placement designs should be decided before actual transplanting occurs. Dug-up transplants should be kept moist at all times and preferably set in place the same day.

<u>Discussion</u>

The materials transplanted onto a site performs numerous functions:

1. It aids erosion control at critical locations.
2. It provides an on-site seed source for species which are difficult to harvest.
3. It establishes species, particularly woody species, which are difficult or slow to develop from seed in sunny disturbed areas.
4. With wild dug stock, a large diversity of other species and a complex of soil organisms are brought in the transplant sod.

Even if only a small amount of transplanting is included in a restoration site, it can provide important improvements, especially if placement locations are carefully chosen. Much of the stock should be concentrated at the upper edges of slopes and at the heads of drainages for maximum dispersal of seeds and soil constituents. Placement along the erosion control terrace structures (Fig. 3, p. 29) helps to reinforce the terraces and place the plant in a moist and deep soil microniche. Larger grasses and forbs with high moisture needs can be placed along erosion control structures in water channels. The roots of many woody species can stabilize the sides of channels.

The most efficient process for transplanting wild dug stock is to move plants directly from the salvage site to the restoration site on the dame day. High soil moisture is the main factor in Central Texas for both maximizing survival of transplants and minimizing labor and time required. The ideal time to transplant is after a soaking rain. However, very successful results have been obtained where the transplanting site was soaked with lawn sprinklers prior to transplanting, and when transplants were placed in plastic bussing pans (purchased from restaurant supply outlets containing several inches of water immediately after being dug out of dry ground. Bussing pans hold almost two square feet of sod or plugs, are a convenient size for carrying, allow digging of large-size clumps of sod, aid in preventing desiccation, and can be carried in a pickup truck thirty to fifty at a time.

It is preferable to plant the stock the same day it is dug, but it can be held longer if kept moist, especially in cool weather. Replanting usually takes from two to four times the amount of time required for digging. Many grasses and some forbs can be divided into very small plugs, although they are more likely to die from drying out when excessively divided. Plants should be set into the ground slightly deeper than they originally grew and tamped down to eliminate air pockets. Artificial watering can be helpful, but much successful transplanting has been done during naturally moist periods without supplemental watering. Some forbs and all woody stock should be pruned back to compensate for root loss. Native grasses and forbs which survive the first several weeks seem to do well on their own if they have been transplanted into their proper habitat and niche.

Example

The Habitat-Restoration Data Chart, starting on page 77, contains recommendations of species for transplanting in the Upper Glen Rose area.

6.8 SEEDING

Process

Calculate the amount of seed needed for the density and diversity required by the design specifications. For wild harvested seed, the chaff, stalks, and leaves are broadcast by hand along with the seeds. Ensure good soil seed contact by hand raking the area or mixing the surface with a harrow.

Discussion

Seeding of wild harvested seed and seed mixes is best done by hand. If the seed/soil contact is increased, the first season's seeding will result in higher seed retention and higher germination rates. Contact can be increased by hand raking after seeding or use of a harrow on large, flat areas. For the second season's seeing, growth from the previous seeding usually precludes the working of seed into the soil, except in any large, bare areas. If mulch is to be applied to a site, it can be top dressed over the second seeding to help hold seed on the site.

Example

See the Wild Basin Data Chart, starting on page 72 for examples of approximate quantities of seed used on that site.

6.9 MANAGEMENT OF THE SITE

Process

Management of the site should follow a one-year cycle, to ensure adequate restoration success and to monitor stability of erosion control structures.

Discussion

Because restoration is a slow process, there should be regular site checks throughout the development of stability. Minor adjustments to the site's permanent erosion control while vegetation is becoming established can be an important aid to ensure that surface storm water remains spread, rather than concentrated. Additional seed or transplants can be added after the main work is complete. Additional management techniques may be started, such as removal of undesirable species or occasional cutting of dead stalks.

CHAPTER 7: WILD BASIN RFESTORATION TEST AREA

SCOPE OF A DUMP RESTORATION

Location

Wild Basin Wilderness Preserve is a 200-acre county park in the Balcones Escarpment in Travis County, Texas. It is an excellent example of Central Texas hill country oak/juniper/grassland habitat within the Glen Rose limestone formations.

Problem

On the northern part of the Wild Basin Wilderness Preserve, there are five acres that the City of Austin used as a municipal dump, under contract beginning in 1947, with the property owner, Mr. Ed Clark (Map A, p.67). This site was used for dumping after the expiration of the lease and, perhaps, before. A steep gully at the eastern edge of the dump area connects with the North Hollow tributary of Bee Creek, which is the mainstream channel in this drainage basin. Over the years, erosion progressively opened this gully. Glass and metal were exposed; in some places, there were ten-foot-deep cuts. Debris was washing into North Hollow but had not yet reached Bee Creek.

Solution

Since the drainage from this gully enters Wild Basin Wilderness Preserve, the staff decided to stabilize the erosion problems and restore the dump site along the gully, using native vegetation natural to this site. Over a several-year period, a consensus on a solution to the problems caused by the dump was developed. Discussions were coordinated by the Wild Basin staff with the numerous entities involved, including the City of Austin, the Texas Department of Health, Travis County, the Texas Historical Commission, Eanes School District (which was negotiating to buy a portion of the dump site), the Texas Highway Department, and Davenport Ranch (the owners of the dump site). In 1984, Committee for Wild Basin Wilderness, Inc. contracted with the City of Austin to restore and revegetate approximately 1/2-acre of the dump, including the large gully. In addition, the contract included a report on the restored site, a demonstration site for the City of Austin, and a manual on native plant revegetation. In March 1985, the work of completing data collection and writing the report was subcontracted to David Mahler and Judy Walther through their research firm, Environmental Survey Consulting.

ANALYSIS OF THE SITE

Primary Analysis

In 1981, the location of the dump and the impacted drainage channels were indicated on a Wild Basin Wilderness Preserve map (Map A, p. 67). Later a more detailed map was drawn of the dump site within Wild Basin, which included the location of superficial deposits of glass, recent surface piles of debris, deep compacted deposits of burned and broken debris, and washout accumulation in drainage channels (Map B, p. 68).

A series of water tests were completed by the Texas Department of Health in September and October of 1981 within the dump site and upstream and downstream from the site along North Hollow. No acid or base/neutral priority pollutants were detected. The tests for pesticides were at acceptably low levels, and the tests for metal showed no significant levels except of higher level of iron coming from the dump, and somewhat elevated levels of arsenic coming from both the dump area and from upstream of the entire dump area.

Detailed Analysis of Potentially Altered Areas

The dump area and adjacent building site area for the future Wild Basin interpretive center were mapped to locate existing trails, machined areas, dump stabilization areas, building and road sites, and plant salvage areas (Map C, pl. 69). A map entitled "Detailed Vegetation Map of Work Area Vicinity" (Map d, p. 70) indicates the location, species, and height of the woody vegetation and ranks the diversity of the understory for possible transplant information. The nearby model was a relatively undisturbed steep grassland habitat of Upper glen rose limestone, dominated by a mosaic of grasses (little bluestem (#419), seep muhly (#409), hairy grama (#384), diverse forbs and evergreen shrubs and a Quercus-Juniperus woodland. The "General Map of Test Plots and Erosion control in Revegetation Area" (Map E. p. 71j) locates stabilizing rock terraces and walls and brush terraces built within the dump area. This map also shows the vegetation test plot divisions.

Material to be Salvaged

The future Wild Basin building site was assessed for priority species for transplant use. The dominant forbs were little bluestem, blackfoot daisy (#331), hairy zexmenia (#355), twisted-leaf yucca (#444) and slim tridens (#430), as well as a large variety of other species. Almost no non-natives were found. A finger cactus (#33) fround on the building site was recommended for rescue prior to construction.

Site Analysis
The dump site was documented before restoration. Using existing engineering maps and survey pins, a boundary map of the disturbed area to be restored was calculated and drawn. Next, all existing features were placed on the map, including notable trees and trails. Comparable undisturbed areas were studied to determine the choice of plants to be used in the dump restoration.

Continuing Analysis
The research area was divided into thirty test plots, and records were kept on seeding, transplants, and results. Photographic documentation was kept throughout the project.

DESIGN OF THE SITE

Based on six years of habitat studies at wild Basin, lists were developed for dry and wet areas. A design for thirty test plots was implemented, using native species from harvested wild seeds and local transplant stock. A small number of species were sowed in each of the test plots at the upper edge of the restoration area to better determine germination success of individual species. In an attempt to establish high diversity, the lower plots received different mixtures of many species.

DESCRIPTION OF SEED HARVEST

Seeds used in this project were hand-collected by volunteers under supervision. All seeds, except for a few noted exceptions, were collected from the immediate Wild Basin area. For the spring 1985 planting, seed was harvested in fall 1984. For the fall 1985 planting, seed was harvested in spring and summer 1985. The included wild Basin Data Chart, p. 74, has specific quantities and names of species harvested.

Seeds were stored in paper bags. Fall-harvested seed was kept in wild Basin's metal, un-air-conditioned shed over the winter. Most seed harvested in spring and summer was moved during midsummer to an air-conditioned room, but some heat damage may have already occurred.

SITE WORK

Pre-Machine Work

Prior to machine work, glass and metal material found near the area to be machined was raked into the gully, where it would be covered. Limits of construction were marked, with a string line, and temporary erosion control brush berms were placed below the limits of construction at the bottom of the gully.

Machine Work

Approximately 900 cubic yards of fill material, consisting of all sizes of rock from pulverized powder up to three-foot-diameter stones, were brought in from identical Glen Rose V limestone strata. Small amounts of native topsoil were included but not separated for use in top dressing. The source material, essentially free of non-native seed, was dumped at the head of the gully and worked downward by machine. Fill depths range from six inches to ten feet. The surface was a rough mixture of large to small particles of limestone and dolomitic limestone, with almost no topsoil.

Permanent Erosion Control

Several permanent erosion control structures were placed in the gully. Two large sedimentation check dams, approximately twenty feet long and two to four feet high, were constructed of large rock with a layer of cedar branches on the upstream side. Uphill from the check dams, a stream channel was formed and reinforced using large rocks. Low rock terraces were constructed across the steep section of the gully. Also, a low rock wall was placed along the western edge of the fill in order to catch slippage of glass and metal from a steep unrestored slope at the western edge of the restoration area. An access path of rock and anchored cedar logs was constructed. Along the upper section, permanent brush terraces were built to spread water, catch soil, and restructure the slope into terraces.

Transplanting

Transplanting took place in April 1985, using material from the nearby site of the planned wild Basin building. Transplants were placed along the upper side of brush terraces and scattered throughout the whole site. No topsoil, fertilizer or supplementary water was utilized. Little bluestem (#419) was used for half of the transplant stock. Additionally, blackfoot daisy (#331), agarita (#14), twisted-leaf yucca (#444), side-oats grama (#383), grapevine (#158-160), nolina (#439-440), hairy zexmenia (#355), Texas sage (#244), slim tridens (#430), switchgrass (#415), seep muhly (#409), elbow bush (#252), and Lindheimer muhly (#408) were transplanted.

Seeding

Harvested seed amounts were estimated, then each species was assigned to one or more test plot areas. All test plots were seeded with a diversity of species, consisting of various combinations and ratios. Spring seeds were broadcast and raked over their test plot area; there was no watering or fertilizing. The included Wild Basin Data Chart, p. 74, lists the amounts and locations of each species. Fall seeds were assigned to various test plots and were over-seeded without raking, except in one new bare area.

RESULTS

Success was determined after a spring and fall planting, with current updates continuing. The original planting was completed in April 1985, and, by august 1985, there was an almost complete coverage with a significant diversity (Wild Basin Data Chart, p. 74). The Habitat-Restoration Data Chart, p. 79, of over 200 species, derived from data collected, gives specific plant information, harvest and transplant times, ease of establishment, and priorities for inclusion in future restoration of Upper Glen Rose habitats.

Overall, stabilization and restoration efforts were highly successful. A nearly complete vegetative cover from both seeding and transplanting, combined with structural work, resulted in no dump material or sediment, other than suspended clays, being washed into the North Hollow tributary of Bee Creek. Even though initial seeding was completed later than the optimum time due to delays in machine work, sufficient subsequent rainfall resulted in a proliferation of diverse species. Small areas invaded by non-natives such as K-R bluestem (*Bothriochloa ischaemum var. songarica*) and Johnsongrass (*Sorghum halepense*) have been kept under control by hand removal.

Spring 1985 Seeding

Successes:

The most successful grasses were poverty dropseed (#425), tall dropseed (#424), little bluestem (#419), slim tridens (#430), plains lovegrass (#401), Indian grass (#422), and inland sea oats. Poverty dropseed (#425), an annual grass with a high rate of seed production, is an early-successional plant which quickly holds the soil while building up mulch for later species. Lovegrass (#401), slim tridens (#430) and tall dropseed (#424) are important intermediate-successional perennial grasses. Little bluestem (#419) is a climax perennial grass which is an important component in Texas hill country grasslands. The most successful wildflowers were cowpen daisy (#349), goldeneye (#354), prairie tea (#134) and ironweed (#253).

Failures:
Few seedlings of woody species have yet been observed. This may reflect a delay in germination or a low seed viability. However, it is suspected that many of these woody species do not appear in sunny, disturbed early-successional sites, but rather are later-successional species which germinate primarily beneath older junipers. Some wildflower species sown have not yet been observed, perhaps due in part to late planting, specific weather requirements, or other unknow factors.

Spring 1985 Transplants
Successes:
There was an almost 100-per cent success rate for little bluestem (#419) transplants. Other major successes were blackfoot daisy (#331), agarita (#14), twisted-leaf yucca (#444), side-oats grama (#383), nolina (#439-440), Texas sage (#259), slim tridens (#430), and switchgrass (#415).

Failures
A significant number of woody plant transplants were lost, probably due to late planting and lack of water while transplanting.

Fall 1985 Seeding
As of May 1986, there was a diversity of species from seeds sowed in early fall 1985, including Texas sage (#244), red-seeded plantain (#251), star thistle (#297), Indian blanket (#312), and Texas star (#328).

Erosion Control
No sediment is entering the North Hollow tributary of Bee Creek from this site, other than a minor film from suspended clays. Adequacy of the check dams and stability of the slopes and gully were proven by three intense storm events in May 1986 ranging from two to three-and-a-half inches of rain each. A small amount of sediment accumulated behind the check dams, but vegetation is beginning to spread to these areas. The successful change of the gully from highly erosive to almost stable can be attributed to the erosion control structures, lack of unsittable topsoil, restoration of the original terrace topography and restoration of diverse, deep-rooted, drought-resistant native plants.

POTENTIAL FUTURE STUDIES

Germination

Further data could be collected over several years of monitoring. Additional species will probably germinate, thus providing more complete information on germination needs and schedules.

Inhibition

Further tests could help determine whether some species actually inhibit the growth of other species. In particular, sumpweed (#324), ragweed (#288), and buffalo burr (#212), all weedy invader plants, seem to be inhibited in some plots, yet invasive in others.

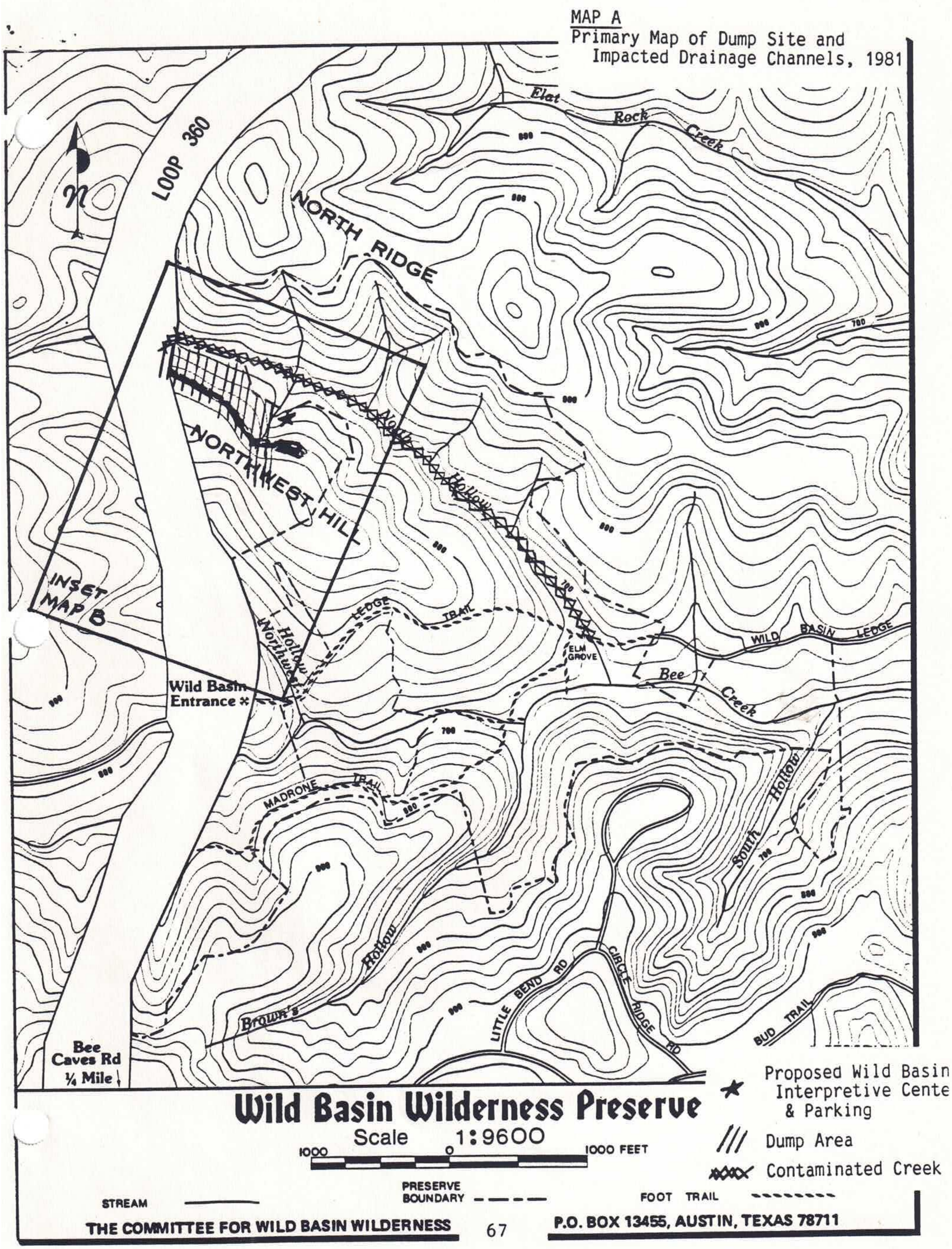
Dominance

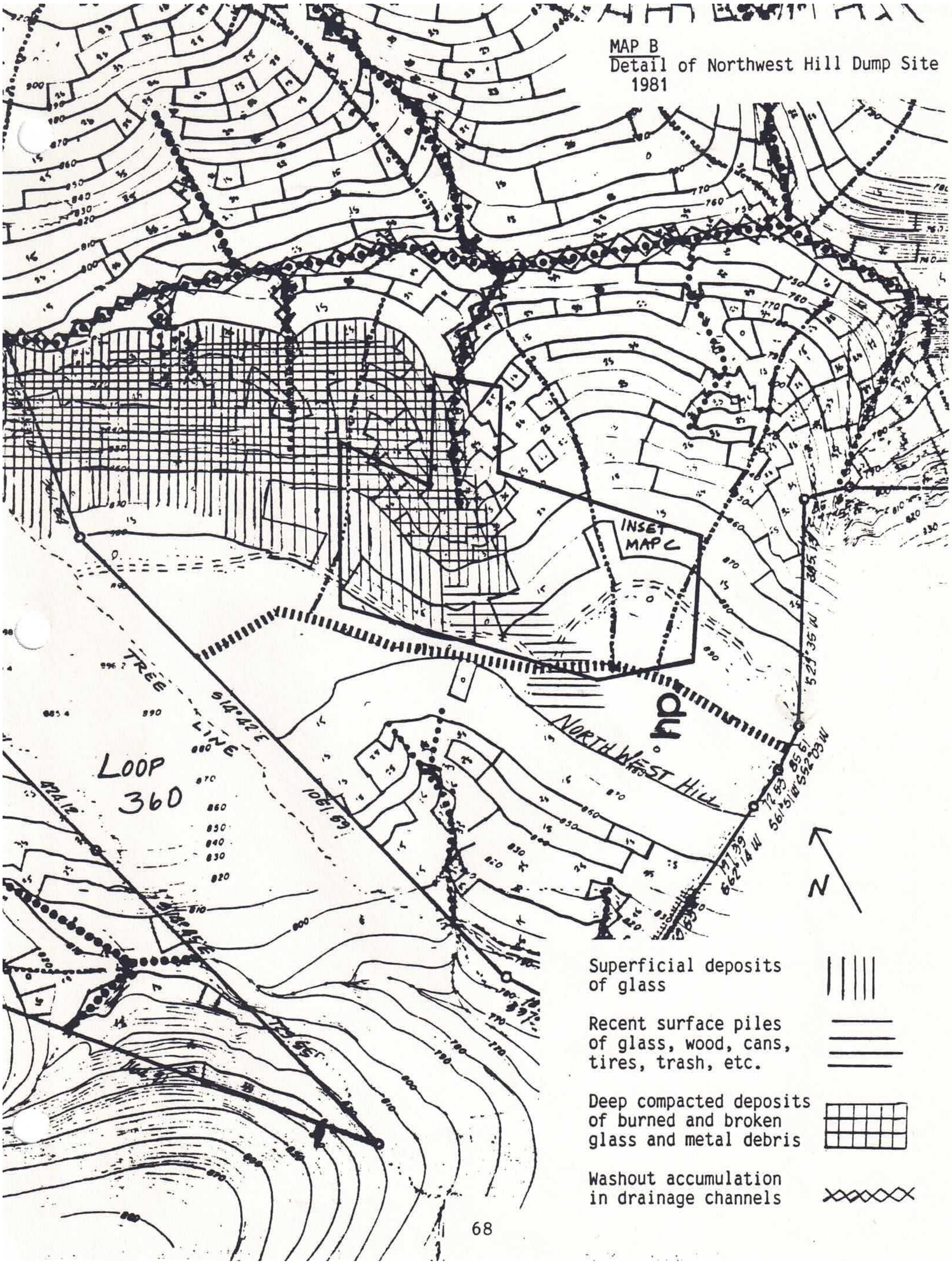
Continued monitoring could result in information on whether the native later-successional plants will be dominant over the non-native and early-successional plants.

Additional Habitats

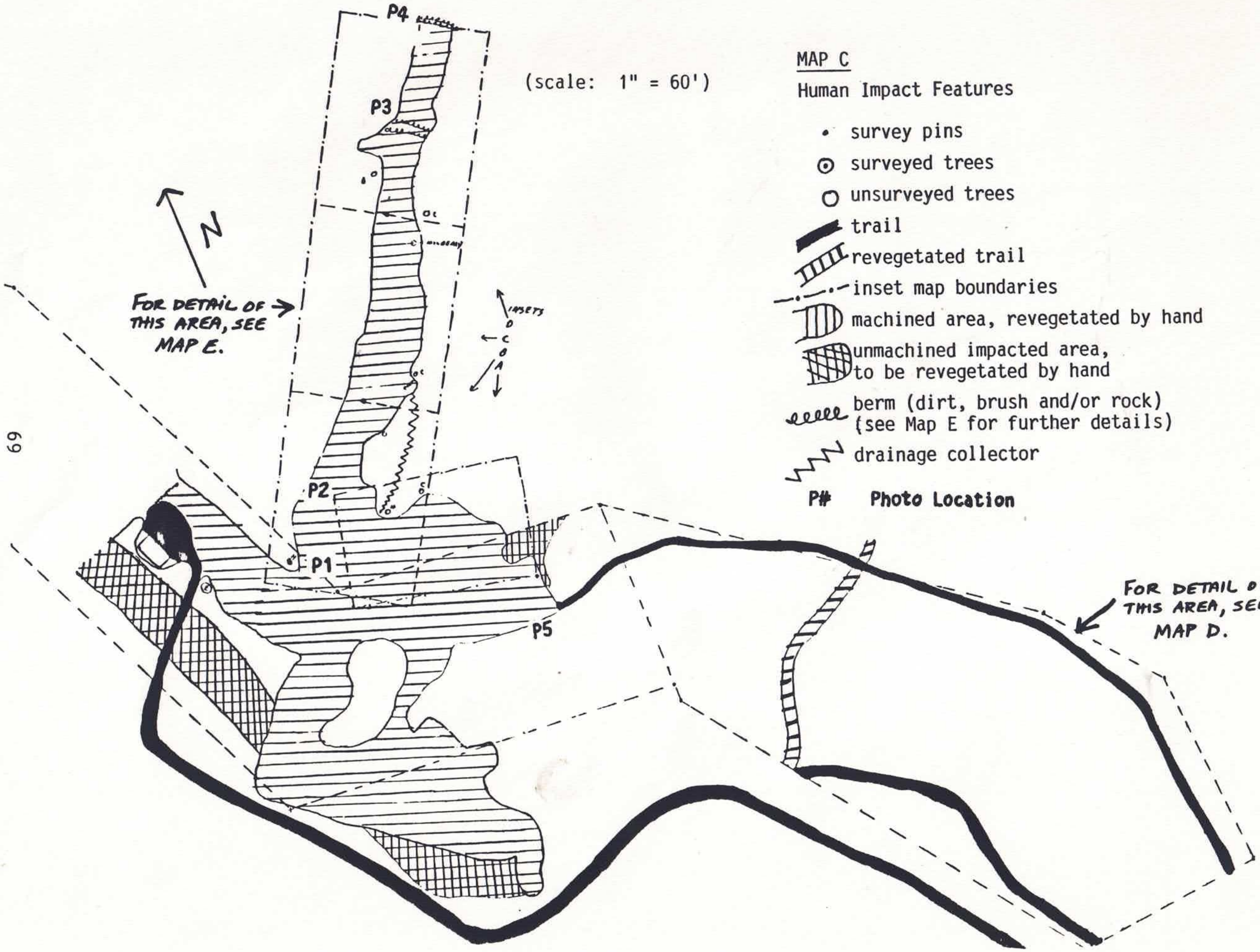
Detailed studies and test restoration projects on the many other different habitats in Central Texas would provide more of the kinds of details for these sites which are partially provided here for the Upper Glen Rose geologic unit.

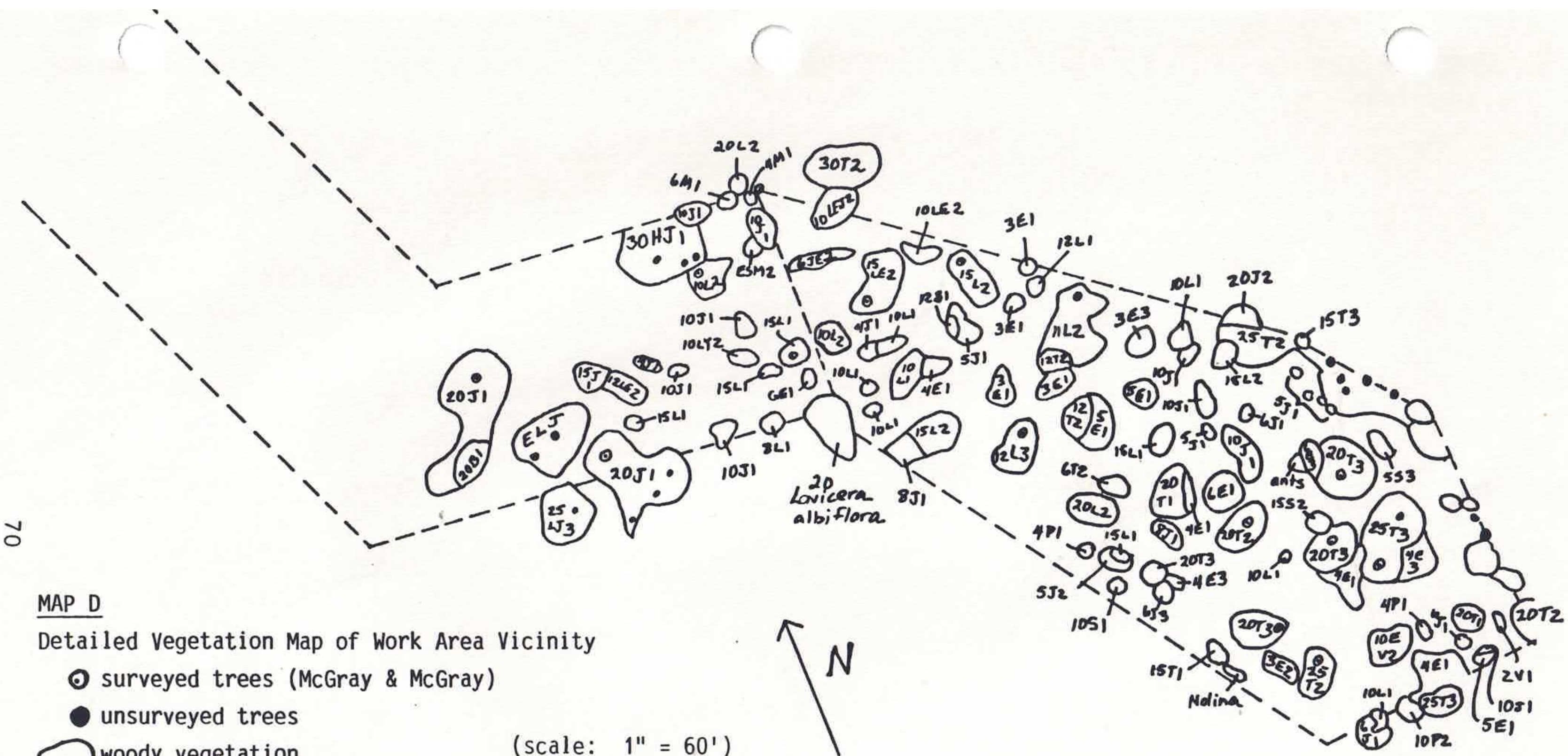
APPENDIX: MAPS AND CHARTS





MAP B
Detail of Northwest Hill Dump Site
1981


MAP C
Human Impact Features
survey pins
surveyed trees
unsurveyed trees
trail
revegetated trail
inset map boundaries
machined area, revegetated by hand
unmachined impacted area, to be revegetated by hand
berm (dirt, brush and/or rock) (see Map E for further details)
drainage collector
P# Photo Location
(scale: 1" = 60')
N
FOR DETAIL OF THIS AREA, SEE MAP E.
FOR DETAIL OF THIS AREA, SEE MAP D.
P1
P2
P3
P4
P5
INSETS
D
C
B
A



MAP D

Detailed Vegetation Map of Work Area Vicinity

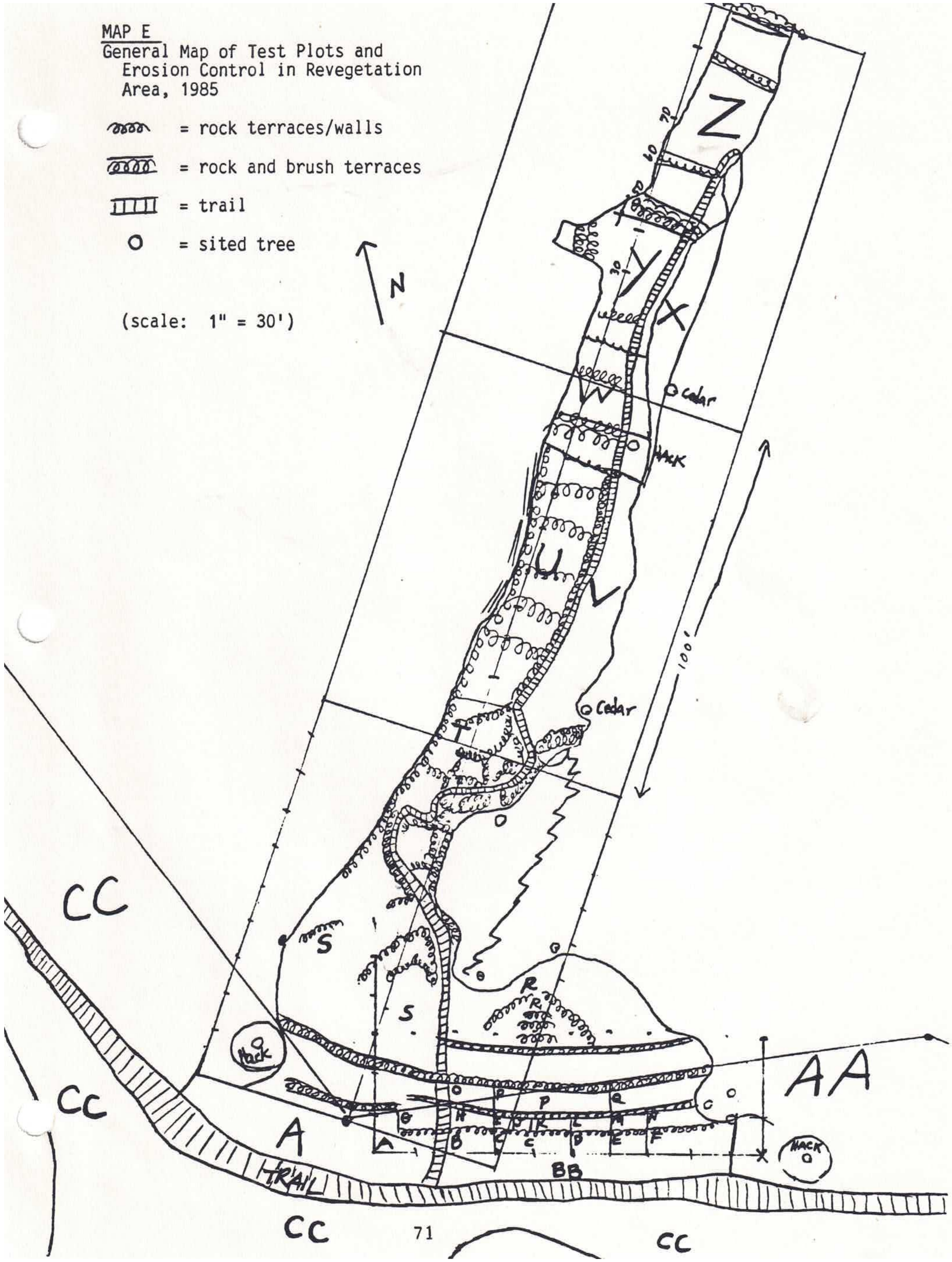
- surveyed trees (McGray & McGray)
- unsurveyed trees
- woody vegetation

(scale: 1" = 60')

Code: First number Height in feet	Letter Dominant species	Last number Diveristy of woody understory
	L - Live Oak	3 - abundant
	T - Texas Oak	2 - moderate
	J - Juniper	1 - infrequent
	E - Evergreen Sumac	
	Y - Evergreen Yaupon	
	G - Grape	
	S - Lanceleaf Sumac	
	P - Prickly Ash	
	H - Hackberry	
	V - Vitis berlanderi (Winter Grape)	
	M - Mimosa	
	B - Chinaberry	

MAP E

General Map of Test Plots and Erosion Control in Revegetation Area, 1985



KEY TO WILD BASIN DATA CHART

The following list is an explanation of the headings and entries for the Wild Basin Data Chart.

Species Number
These refer to the numbering system devised in the Annotated List of the Vascular Plants of Wild Basin Wilderness Preserve compiled by Judy Walther in October 1985. The species names and numbers used in the project are also found on the Habitat-Restoration Chart on p. 79 of this report.

*	=	Commercial
N	=	Not collected in Wild Basin

Found on Site: These are the species found on the dump site and surrounding study area during the preliminary vegetative survey.

Indigenous: These species are native to this area.

Site Priority: These priority listings were determined before the restoration was started. Later changes in priority are reflected in the Habitat-Restoration Chart, p. 79 and are based on data analyzed after one year of results.

1	=	High Priority
2	=	Medium Priority
3	=	Low Priority

Approximate Seed Quantities: A set fraction of the seeds were counted, from which seed quantity was approximated.

Seeding Location: The location letters refer to test plots indicated on Map E, p. 71.

Seeding Results:

3	=	prolific amount of species growth
2	=	moderate amount of species growth
1	=	trace amount of species growth
0	=	no identifiable growth to date

Transplanting Location:

Occasional	=	occasional transplanting
Throughout	=	transplanted throughout site
Trace	=	trace amounts transplanted

Transplanting Results:

3	=	high survival
2	=	moderate survival
1	=	low survival
0	=	no apparent survival
H	=	hitchhiker; species brought in with transplant sod

WILD BASIN DATA CHART

SPECIES NUMBER	FOUND ON SITE	INDIGENOUS	SITE PRIORITY	SEEDING — DATE: Spring 1985 — APPROX. SEED QUANTITY	LOCATION	DATE: Fall 1985 — APPROX. SEED QUANTITY	LOCATION	DATE: — RE-SULTS	TRANSPLANTING — DATE: — LOCATION	DATE: — RE-SULTS
10	√	√	3	750-1000	P S			0	Occasional	3
11	√	√	3						Occasional	0
12	√	√	2	1000-2000	S V	5-10,000	V X Y Z	1		
14	√	√	2						Trace	2
42	√	√	2			2000-3000	AA P S	2		
43	√	√	1	1000-2000	R-W	1000-2000	K S Y Z	1		
60	√	√	3			20,000	W	2		
66	√	√	2						Trace	0
80	√	√	2	150-200	O S			0	Trace	0
84	√	√	2			800-1000	AA	0		
84N	√	√	2			2000-4000	AA S	0		
104	√	√	1			98	P	0	Trace	3
113	√	√	2	400-500	Q S			1		
118	√	√	1			2000-3000	AA S	2	Occasional	2H
124	√	√	2	500-700	O S			0	Trace	0
127	√	√	1						Occasional	2
134	√	√	2	5-10,000	BHOR-TVW			2		
147	√	√	2			700-800	P	0		
158	√	√	2						Trace	3
162	√	√	2			2000-5000	S R	2	Occasional	H
172	√	√	1	21-28,000	ACFSTVW			0		
174	√	√	2	4000-6000	Q S			0	Occasional	0
177N	√	√	2			100-200	AA	0		
178	√	√	2	80	P S			0		
183	√	√	2			200	AA	0		
184	√	√	2			1500	AA C	2		
194N	√	√	1	50-100,000	C-E I-M	5000	AA K	2		
197	√	√	1			400-450	AA E	0		
198	√	√	2			500-1000	P	0	Trace	3
223	√	√	2			500-1000	Q	0	Occasional	H
231	√	√	2			20-30,000	AA C Y Z	2	Trace	3
232	√	√	1			2000-4000	AA	0	Occasional	H
233	√	√	1			75-150,000	AA R S	2	Occasional	H
234	√	√	2			100-300,000	AA V W Y	2	Occasional	H
238	√	√	1			350,000	A AA CC S	2	Occasional	H
239	√	√	1			5-10,000	AA BB R U	2	Occasional	3H
242	√	√	2			10-20,000	AA V Y Z	3		
243	√	√	1	50-100	N	1000-2000	X	1		

WILD BASIN DATA CHART

SPECIES NUMBER	FOUND ON SITE	INDIGENOUS	SITE PRIORITY	SEEDING					TRANSPLANTING	
				DATE: Spring 1985		DATE: Fall 1985		DATE:	DATE:	DATE:
				APPROX. SEED QUANTITY	LOCATION	APPROX. SEED QUANTITY	LOCATION	RE-SULTS	LOCATION	RE-SULTS
244	√	√	1			5-10,000	AA BB T U V	3	Occasional	3H
247	√	√	1						Occasional	3H
249	√	√	2			4000-5000	T Y Z	0		
250	√	√	1			10,000	A AA	2		
251	√	√	1			30-40,000	AABBCCRVW	3		
252	√	√	1						Occasional	3
275	√	√	2			500	V	1		
280	√	√	2						Occasional	H
286	√	√	2			300-500,000	AA T U V	2		
295	√	√	1	trace	M			0		
297	√	√	2			1000-1500	S V	3		
302a	√	√	2			90-150,000	AACCVWYZ	1		
308	√	√	1	10-30,000	Q-T V W			2		
309	√	√	2	15-40,000	R S V			2		
310	√	√	1			±1,000,000	AABBCCTUV	2		
312	√	√	1			50-100,000	AABBCCRUW	3		
316	√	√	2	2000-8000	P R S T V W			2	Occasional	3
317	√	√	2			1000-5000	V Y Z	2		
323	√	√	1						Occasional	3H
327	√	√	2	50-200	H			1		
328N	√	√	2			100-200	AA S	3		
331	√	√	1	trace	G	500-1000	F R	1	Throughout	2H
332	√	√	1	2000-4000	ABGHOR-TW			2	Occasional	H
337	√	√	2			250-375,000	AA CC R Y Z	2		
338	√	√	2			200-300,000	Y Z	2		
341	√	√	2	2000-5000	DELMOR-TW			0		
342	√	√	2	0-5000	CIJKPRSTV			0		
347	√	√	1	750-1250	AGORSTWN			1	Trace	H
348	√	√	2			5000-8000	AA S	2	Occasional	H
349	√	√	3	6-15,000	IJPRSTUW	7000-9000	IJPRSTUW	3		
350	√	√	2	50-100	L	2000-3000	A R	0	Occasional	3
351	√	√	2	25-40,000	S U V			2		
352	√	√	1	50-2000	Q R	100-200,000	AAACCSTUV	2		
354	√	√	1	25-50,000	FNQRSTVW			3	Occasional	3H
355	√	√	1	500-1000	Q R S T V W	10-20,000	AACCSTUW	2	Occasional	3H
363	√	√	2			4,000,000	Y Z	0	Trace	H
364-5	√	√	2			500,000	Y Z	0		
375	√	√	2	trace	J					

WILD BASIN DATA CHART										
				SEEDING					TRANSPLANTING	
				DATE: Spring 1985		DATE: Fall 1985		DATE:	DATE:	DATE:
SPECIES NUMBER	FOUND ON SITE	INDIGENOUS	SITE PRIORITY	APPROX. SEED QUANTITY	LOCATION	APPROX. SEED QUANTITY	LOCATION	RE-SULTS	LOCATION	RE-SULTS
377	√	√	2	trace	M	25,000	AA CC	2		
383	√	√	1	trace	N			0	Trace	2
383*	√	√	2	trace	T			0		
384	√	√	1	trace	G			0	Throughout	3
386	√	√	2			trace	C	0		
387	√	√	2	trace	H			0		
392	√	√	2	50-100,000	J R S U	30,000	Y Z	2		
401	√	√	1	200-400,000	FNQRSTVW	300-800,000	AA CC	2	Occasional	3
402a	√	√	2			1-50,000	AA K	0		
404	√	√	2	2000-4000	O R S T			0	Occasional	2
407	√	√	3	trace	K			0		
408	√	√	1	100-500,000	R S V			0	Occasional	1
409	√	√	1	trace	I S T			0	Occasional	2
411	√	√	2	2000-3000	P R			0	Occasional	2H
415	√	√	1	10-20,000	R S V			2	Occasional	3
419	√	√	1	trace	L			3	Throughout	3
422	√	√	1	trace	J R S V			2		
424	√	√	1	200-500,000	DLPRSTVW			2	Occasional	3
425	√	√	1	2-3,000,000	AGORSTV			3	Occasional	H
428	√	√	1	5-15,000	Q R			1		
429	√	√	2	40-80,000	E M Q R S T			1	Occasional	3
430	√	√	1	50-150,000	BHORSTVW			2	Occasional	3
431	√	√	1			trace	Y	0		
436	√	√	2						Occasional	H
440	√	√	1						Occasional	3
442	√	√	1			250-7500	AA	0		
443	√	√	3	300-350	S			0		
444	√	√	1						Occasional	3
445	√	√	1			200	U	0		
446	√	√	2			200	T	1	Occasional	H

(*Commercial)

KEY TO HABITAT-RESTORATION DATA CHART

Overview

Plants in this list are native to the Upper Glen Rose habitat. The chart is divided into two sections: 1. Plant description data and 2. Restoration data. The data in the restoration section is based on research described in Chapter 7 of this report and on eight years of other field observations and restoration attempts. This data should be considered preliminary and subject to further research. Categories marked with a "T" rather than with an "X" are especially tentative.

Plant Description Data

Species Number: This numbering system was devised in the Annotated List of the Vascular Plants of Wild Basin Wilderness Preserve compiled by Judy Walther in October 1985.

Type:	W = woody	H = herbaceous	V = vine
	E = evergreen	D = deciduous	
	P = perennial	B = biennial	A = annual

/ = or (i.e., HA/B = herbaceous annual or biennial)

Typical Height: The height of most plants under typical Upper Glen Rose conditions; for grasses, this is the height of the seed stalks.

Light Needs: These express typical habitat preferences in the wild. Some species may grow in more than one habitat.

L = light, full sun
P = partial sun
D = dark, shade

Soil/Moisture Needs: Plants have been ranked from 1 to 5, with 1 being the driest thin soil areas and 5 being the wettest deep soil areas for the Upper Glen Rose habitat only.

Restoration Data

Harvest Time: Each species is checked in the season or seasons when seed is usually available for harvest.

Harvest Potential: These results are a combination of two factors: 1. How much seed is produced by the plants and 2. How easy it is to harvest, considering the length of time seed remains on the plant and whether seed ripens all at the same time.

Sowing Time: This category indicated whether this species should be primarily sown in spring or fall.

Growth from Seed: This category indicates the likelihood of good growth from seeds distributed in disturbed areas. Some species seem to thrive from seeds sown in disturbed areas, while others, such as many woody species, seem to produce little or no plants when sown in disturbed areas, even though they may produce high germination rates in other propagation situations.

Priority: Seed Mix: This category gives an indication of the species' priority for inclusion in a seed mix for Upper Glen Rose geologic unit, based on such factors as harvest potential, ease of growth, erosion control potential and importance in the developing plant community.

Transplant Hardiness: This category indicates how well a plant survives transplanting.

Priority: Transplant: these priorities for the Upper Glen Rose geologic unit reflect a number of factors such as hardiness, importance in the developing plant community and the need to include transplants in the site as future seed sources for species that are more difficult to establish by seed.

HABITAT-RESTORATION DATA CHART

SPECIES NUMBER	NAME (COMMON AND SCIENTIFIC)	PLANT DESCRIPTION			
		TYPE	TYPICAL HEIGHT	LIGHT NEEDS	SOIL/ MOISTURE NEEDS
10	*Juniperus ashei* (mountain cedar)	WE	tree	LP	1-4
11	*Anemone heterophylla* (ten-petal anenome)	HP	ankle	LP	2-4
12	*Clematis drummondii* (old man's beard)	HV	head	L	3-4
14	*Berberis trifoliolata* (agarita)	WE	waist	LP	1-4
15	*Cocculus carolinus* (Carolina snailseed)	WV	head	PD	3-4
17	*Platanus occidentalis* (American sycamore)	WD	tree	LP	4-5
19	*Celtis reticulata* (net-leaf hackberry)	WD	tree	LP	3-5
21	*Ulmus crassifolia* (cedar elm)	WD	tree	LP	3-5
24	*Morus microphylla* (Texas mulberry)	WD	head	LP	2-4
25	*Parietaria floridana* (Florida pellitory)	HA	ankle	D	3-4
29	*Quercus buckleyi* (Texas oak)	WD	tree	LP	2-4
30	*Quercus fusiformis* (plateau live oak)	WD	tree	LP	2-5
31	*Quercus sinuata var. breviloba* (white shin oak)	WD	tree	LP	3-4
40	*Paronychia parksii* (Park's nailwort)	HP	ankle	L	1
42	*Abutilon incanum* (Indian mallow)	HP	knee	L	3-4
43	*Allowissadula holosericea* (velvet leaf)	HP	waist	L	3-4
48	*Sida abutifolia* (spreading sida)	HP	ankle	L	1-3
54	*Salix nigra* (black willow)	WD	tree	LP	5
60	*Lepidium austrinum* (southern pepperweed)	HA/B	ankle	L	2-4
66	*Bumelia lanuginosa* (gum elastic)	WD	tree	P	3-4
67	*Diospyros texana* (Texas persimmon)	WD	head	LP	2-3
72	*Geum canadense* (white avens)	HP	ankle	D	4
73	*Prunus mexicana* (Mexican plum)	WD	head	P	4
75	*Prunus serotina* (black cherry)	WD	tree	LP	3-4
76	*Rubus trivialis* (southern dewberry)	WV	knee	L	3-4
80	*Cercis canadensis* (redbud)	WD	head	LP	2-4
84	*Desmanthus sp.* (bundleflower)	HP	ankle	L	1-3
88	*Eysenhardtia texana* (Texas kidneywood)	WD	waist	LP	1-3
90	*Indigofera miniata* (scarlet pea)	HP	ankle	L	2-3
92	*Lespedeza texana* (Texas bush clover)	HPV	ankle	PD	3-4
100	*Mimosa biuncifera* (cat's claw)	WD	waist	LP	2-3
101	*Mimosa borealis* (pink mimosa)	WD	waist	LP	2-3
104	*Psoralea sp.* (scurfpea)	HP	ankle	L	2-3
105	*Psoralea hypogaea* (edible scurfpea)	HP	ankle	L	2-3
109	*Schrankia roemeriana* (Roemer's sensitive briar)	HV	ankle	L	3-4
110	*Senna lindheimeriana* (Lindheimer senna)	HP	waist	L	3-4
111	*Senna roemeriana* (two-leaf senna)	HP	knee	L	2-3
112	*Sophora affinis* (Eve's necklace)	WD	tree	LD	3-4
113	*Sophora secundiflora* (Texas mountain laurel)	WE	head	LP	2-3
117	*Vicia ludoviciana* (deer pea vetch)	HAV	knee	L	3-4

HABITAT-RESTORATION DATA CHART

SPECIES NUMBER	HARVEST TIME			HARVEST POTENTIAL			SOWING TIME		GROWTH FROM SEED			PRIORITY: SEED MIX			TRANSPLANT HARDINESS			PRIORITY: TRANSPLANT		
	SPRING	SUMMER	FALL	PROLIFIC	MODERATE	SMALL	SPRING	FALL	EASY	MODERATE	HARD	HIGH	MODERATE	LOW	HARDY	MODERATE	LOW	HIGH	MODERATE	LOW
10			X	X			T			T			T		T				T	
11	X				T		T	T					T		T				T	
12		X			X		T	T		T			T			T			T	
14	X				T			T		T				X		X		X		
15			X		T		T						X		T				X	
17			X	X			X		T					X	X				X	
19			X		X		X		T					X	X					T
21			X	X			X			T			X		X			X		
24	X					X		T						X		T		X		
25	X				T			T	T				X		X				X	
29			X	X			T				T			X		T		X		
30			X	X			T			T			T			X		X		
31			X		T		T				T			X		T		X		
40			X		X		X						X			T			T	
42		X	X		X		T	T		T			X		T				X	
43		T	X			X	T	T		T			T			T		X		
48		X	X		T		T	T	T				T		T				T	
54		T												X	X				X	
60	X	X		X				X	X				T							X
66		X				X					T			X	T					T
67		X	X		X		T	T			T			X	T			X		
72	T					T		T						X	X				X	
73		X			T			T			T			T		T		X		
75		X			T		T				X			T		T		X		
76	X				X									T	X				X	
80		X	T		X						X			T		X		X		
84		X	T		X		T	T	T			X			T				X	
88		X	X		X					T				T	T			X		
90		X	T			T		T					T			T			T	
92			X		T		T			T				T	T				T	
100		X				X					T			T	T				T	
101		X				X					T			T	T			X		
104		T				T								T	T				X	
105		T				T								T	T				X	
109		T			T		T	T		T			T			T			T	
110			X	X			T		X				T		T					X
111		X			T		T	T		T			T		T				X	
112			X			X	T				T			X		T		X		
113		X	X		X		X	X			X			X		T		X		
117	X				X		T	T	T				X		T					T

HABITAT-RESTORATION DATA CHART

SPECIES NUMBER	NAME (COMMON AND SCIENTIFIC)	PLANT DESCRIPTION: TYPE	TYPICAL HEIGHT	LIGHT NEEDS	SOIL/ MOISTURE NEEDS
118	*Calylophus drummondianus* (Drummond sundrops)	HP/A	knee	L	2-3
120	*Oenothera missouriensis* (flutter-mill)	HP	ankle	L	1-2
121	*Oenothera speciosa* (pink evening- primrose)	HP	ankle	L	3-4
123	*Cornus drummondii* (roughleaf dogwood)	WD	head	D	4-5
124	*Garrya lindheimeri* (Lindheimer silktassel)	WE	head	LP	2-4
126	*Ilex decidua* (deciduous yaupon/possum haw)	WD	head	PD	3-5
127	*Ilex vomitoria* (yaupon)	WE	head	LP	2-4
128	*Acalypha limdheimeri* (Lindheimer copperleaf)	HP	ankle	L	3-4
130	*Argythamnia simulans* (plateau wild mercury)	HP	ankle	PD	2-4
131	*Bernardia myricaefolia* (mouse ears)	WD	waist	P	2-3
133	*Croton fruticulosus* (bush croton)	WD	knee	P	3-4
134	*Croton monanthogynus* (prairie tea)	HA	knee	L	1-3
135	*Croton texensis* (Texas croton)	HA	knee	L	1-3
138	*Euphorbia dentata* (toothed spurge)	HA	ankle	L	2-3
144	*Euphorbia villiferra* (hairy euphorbia)	HP	ankle	L	1-2
145	*Phyllanthus polygonoides* (knotweed leaf-flower)	HP	ankle	L	2-3
147	*Stillingia texana* (Texas stillingia)	HP	knee	L	1-2
149	*Berchemia scandens* (rattanvine)	WV	head	PD	4-5
150	*Ceanothus herbaceus* (ceanothus)	WD	waist	LH	2-3
151	*Colubrina texensis* (Texas snakewood)	WD	waist	LH	3-4
152	*Condalia hookeri* (Brasilwood)	WD	head	L	2-3
153	*Rhamnus caroliniana* (Carolina buckthorn)	WD	tree	LP	3-4
154	*Ampelopsis arborea* (peppervine)	WV	head	PD	3-4
156	*Parthenocissus hyptaphylla* (seven-leaf creeper)	WV	head	P	3-4
157	*Parthenocissus quinquefolia* (Virginia creeper)	WV	head	P	4-5
158	*Vitis sp.* (grape)	WV	head	LP	2-3
159	*Vitis mustangensis* (mustang grape)	WV	head	LP	4
162	*Linum rupestre* (rock flax)	HP	ankle	L	1-2
165	*Polygala lindheimeri* (shrubby milkwort)	HA	ankle	L	1-2
166	*Krameria lanceolata* (trailing ratany)	HP	ankle	L	1-2
167	*Sapindus saponaria var. drummondii* (soapberry)	WD	tree	LP	3-4
168	*Ungnadia speciosa* (Mexican buckeye)	WD	head	L	3-4
169	*Aesculus pavia* (red buckeye)	WD	head	LD	4-5
171	*Rhus aromatica* (fragrant sumac)	WD	waist	P	2-4
172	*Rhus lanceolata* (lance-leaf sumac)	WD	head	L	1-3
174	*Rhus virens* (evergreen sumac)	WE	head	L	1-3
176	*Ptelea trifoliata* (hop tree)	WD	head	LP	2-4
177	*Thamnosma texana* (Dutchman's breeches)	HP	ankle	L	1-2
178	*Zanthoxylum hirsutum* (toothache tree)	WD	head	LP	2-3
179	*Oxalis dillenii* (yellow wood-sorrel)	HP	ankle	PD	3-4

SPECIES NUMBER	HARVEST TIME: SPRING	HARVEST TIME: SUMMER	HARVEST TIME: FALL	HARVEST POTENTIAL: PROLIFIC	HARVEST POTENTIAL: MODERATE	HARVEST POTENTIAL: SMALL	SOWING TIME: SPRING	SOWING TIME: FALL	GROWTH FROM SEED: EASY	GROWTH FROM SEED: MODERATE	GROWTH FROM SEED: HARD	PRIORITY: SEED MIX: HIGH	PRIORITY: SEED MIX: MODERATE	PRIORITY: SEED MIX: LOW	TRANSPLANT HARDINESS: HARDY	TRANSPLANT HARDINESS: MODERATE	TRANSPLANT HARDINESS: LOW	PRIORITY: TRANSPLANT: HIGH	PRIORITY: TRANSPLANT: MODERATE	PRIORITY: TRANSPLANT: LOW
118		X		X			T	T	X			X				X			X	
120		X	X			X	T	T					T			T		T		
121	X	X		X				X	X				X			T				X
123			X		X		X				X			X		T		X		
124			X	X			X				X			X		T		X		
126			X		X		X				X			X	X			X		
127			X		X		T				X			X	X			X		
128			T			X	T			T				T	T				X	
130			T		T		X			T			T			T			X	
131			X		X		T				X			T		T			X	
133		X	X			X	T				T			T		T			X	
134			X	X			X		X				X			T				X
135		X			X		X		X				X							X
138		X	X			X	X			T			X		X					X
144		X	X		T		X		T				X		X					X
145		X	X		T		X		T				X		T					X
147			X			X	X							T		T			X	
149			X		X		X							X	T			T		
150			X			T	T				T			T	T			X		
151			X			T	T				T			T	T				T	
152			X		T		T				T			T	T				T	
153			X		T		T				T			T		T		X		
154			X		T		T			T				T	T				X	
156			X			T	T				T		T		T				X	
157			X			T	T				T		T		T				X	
158			X		T		T			T			T			T		X		
159		X			T		T				T			T		T			X	
162		X				X	T	T		T			T			T				X
165		X	X		T		T			T			T		T				X	
166		X	X			X	T						X		T				X	
167			X	X			T				T			T	T				X	
168			X			X	T				X			X	T			X		
169			X			X	T				X			X	T			X		
171		X				T	T	T		T			X		T			X		
172			X	X			T	T		T			X		X			X		
174			X		X		T				X			X		X		X		
176		X	X		X		T			T				T	T			X		
177		X	X			X	T	T		T			X		T				X	
178		X			X		T	T			T			T	T			X		
179		X			X		T	T		X			T		T					X

HABITAT-RESTORATION DATA CHART

SPECIES NUMBER	NAME (COMMON AND SCIENTIFIC)	PLANT DESCRIPTION			
		TYPE	TYPICAL HEIGHT	LIGHT NEEDS	SOIL/ MOISTURE NEEDS
183	*Erodium texanum* (Texas filaree)	HA	ankle	L	1-2
184	*Geranium texanum* (Texas geranium)	HA	ankle	L	2-3
191	*Buddleja racemosa* (wand butterfly-bush)	WD	knee	LP	2-3
194	*Centaurium beyrichii* (mountain pink)	HA	ankle	L	1
195	*Centaurium texense* (Texas centaury)	HA	ankle	L	1
197	*Amsonia ciliata* (blue-star)	HP	knee	L	3
198	*Asclepias asperula* (spider antelope-horn)	HP	knee	L	2-3
199	*Asclepias oenotheroides* (green milkweed)	HP	knee	L	2-3
200	*Asclepias texana* (Texas milkweed)	HP	knee	L	2-3
201	*Cynanchum barbigerum* (bearded swallow-wort)	HV	waist	L	2-3
202	*Cynanchum unifarium* (talayote)	HV	head	P	2-3
203	*Matelea reticulata* (milkvine)	HV	head	L	2-3
204	*Sarcostemma crispum* (wavy-leaf twine vine)	HV	waist	L	2-3
206	*Chamaesaracha coronopus* (green false-nightshade)	HP	ankle	L	1-3
214	*Convolvulus equitans* (Texas bindweed)	HV	ankle	L	2-3
215	*Dichondra carolinensis* (ponyfoot)	HV	ankle	L	2-3
216	*Evolvulus sericeus* (silky evolvulus)	HP	ankle	F	1-3
219	*Gilia incisa* (split-leaf gilia)	HP	knee	L	1-3
220	*Gilia rigidula* (prick-leaf gilia)	HP	ankle	L	1-3
223	*Nemophila phacelioides* (baby blue eyes)	HA	ankle	LP	3-4
224	*Phacelia congesta* (blue curls)	HA/B	knee	LP	3-4
225	*Heliotropium tenellum* (pasture heliotrope)	HA	ankle	L	1-2
226	*Lithospermum incisum* (puccoon)	HP	ankle	L	1-2
228	*Callicarpa americana* (American beautyberry)	WD	head	D	3-4
229	*Lantana horrida* (common lantana)	WD	waist	LP	3-4
231	*Phyla incisa* (Texas frogfruit)	HP	ankle	L	3-4
232	*Verbena bipinnatifida* (Dakota vervain)	HP	ankle	LP	2-4
233	*Verbena canescens* (Grey vervain)	HP	ankle	L	1-2
234	*Verbena halei* (Texas vervain)	HP	knee	L	2-4
238	*Hedeoma acinoides* (slender hedeoma)	HA	ankle	L	1-2
239	*Hedeoma drummondii* (limoncillo)	HA/P	ankle	L	1-2
242	*Monarda citriodora* (horsemint)	HA/B	knee	L	3-4
243	*Salvia roemeriana* (cedar sage)	HP	ankle	DS	2-3
244	*Salvia texana* (Texas sage)	HP	ankle	L	1-2
245	*Scutellaria drummondii* (Drummond skullcap)	HA	ankle	L	1-2
246	*Scutellaria ovata* (egg-leaf skullcap)	HA/P	knee	LP	3-4
247	*Scutellaria wrightii* (skullcap)	HP	ankle	L	1-2
248	*Stachys crenata* (shade betony)	HA/B	ankle	PD	3-4
249	*Tevcrium canadense* (American germander)	HP	waist	L	4-5
250	*Plantago helleri* (cedar plantain)	HA	ankle	L	1-2

HABITAT-RESTORATION DATA CHART

SPECIES NUMBER	HARVEST TIME			HARVEST POTENTIAL			SOWING TIME		GROWTH FROM SEED			PRIORITY: SEED MIX			TRANSPLANT HARDINESS			PRIORITY: TRANSPLANT		
	SPRING	SUMMER	FALL	PROLIFIC	MODERATE	SMALL	SPRING	FALL	EASY	MODERATE	HARD	HIGH	MODERATE	LOW	HARDY	MODERATE	LOW	HIGH	MODERATE	LOW
183	X	X			X			X		T			X			T				X
184	X	X			X			X		T			X			T				X
191			X		T		T				T			X		T			X	
194			X	X			T	T		T		T				T			X	
195		X			X		T	T		T		T				T				X
197			X			X	T						T			T			X	
198		X				X	T						X			T			X	
199		X				X	T						X			T			X	
200			X			X	T						X			T			X	
201			X			X	T						X			T			X	
202			X			X	T						X			T			X	
203			X			X	T						X			T			X	
204		X				X	T						X			T			X	
206		X			X			X	T			T			T					X
214			X			X	T			T			X			T			X	
215		X				X	T			T			X			T			X	
216			X			X	T			T			X			T			X	
219		X	X		T		T	T		T			X			T				X
220		X	X		T		T	T		T			X			T				X
223		X			T			T	T				X		T				T	
224		X		X				T	T				X		T					T
225		X	X		X		T	T	T				X		T					X
226		X				X		T						X		T			X	
228			X		X		T				T			X	X			X		
229			X		X		T			T				T	X					X
231		X	X		X		T			T			X		X				X	
232	X	X	X	X			T	T	X			X			X				X	
233		X	X		X		T	T		T			X		X					X
234		X	X		X		T	T	T				X		X					X
238	X	X		X				X	X			X				T				X
239		X	X		X			T	T			T			X				X	
242		X		X			T	X	T				T							T
243	X	X				X		T		T			T		X			X		
244	X	X			T			T	X			T			X				X	
245		X			T			T	T				X		X				X	
246			X			X	T			T				T	T					T
247		X			T			T	T				X		X				X	
248		X				X		T		T			T			T			T	
249			X		T		T			T			T							X
250	X	X			X			X	X			X					T			X

HABITAT-RESTORATION DATA CHART

SPECIES NUMBER	NAME (COMMON AND SCIENTIFIC)	PLANT DESCRIPTION: TYPE	TYPICAL HEIGHT	LIGHT NEEDS	SOIL/ MOISTURE NEEDS
251	*Plantago rhodosperma* (red-seeded plantain)	HA	ankle	L	1-3
252	*Forestiera pubescens* (elbow-bush)	WD	waist	LD	3-4
254	*Fraxinus texensis* (Texas ash)	WD	tree	LP	3-4
256	*Agalinis edwardsiana* (plateau gerardia)	HA	knee	L	2
258	*Castilleja purpurea* (paintbrush)	HP	ankle	L	1-2
259	*Leucophyllum frutescens* (cenizo)	WD	waist	L	2-3
261	*Maurandya antirrhiniflora* (snapdragon vine)	HV	waist	LP	3-4
268	*Dyschoriste linearis* (snake herb)	HP	ankle	L	3-4
270-3	*Ruellia sp.* (false petunia)	HP	knee	P	3-4
275	*Triodanis coloradoensis* (Colorado Venus' looking glass)	HA	ankle	LP	3-4
276	*Triodanis perfoloata* (clasping Venus' looking glass)	HA	ankle	L	3-4
279	*Galium virnatum* (southwest bedstraw)	HA	ankle	L	1-2
280	*Hedyotis nigricans* (bluets)	HP	ankle	L	1-2
281	*Lonicera albiflora* (white honeysuckle)	WV	head	LP	2-3
283	*Lonicera sempervirens* (coral honeysuckle)	WV	head	LP	3-4
284	*Viburnum rufidulum* (viburnum)	WD	head	P	4-5
286	*Schillea millefolium* (common yarrow)	HP	knee	P	3-4
290	*Aster drummondii var. texansus* (Texas aster)	HP	waist	L	3-4
294	*Baccharis neglecta* (false willow)	WD	head	L	1-2
295	*Brickellia cylindracea* (gravelbar brickle-bush)	HP	waist	P	2-3
296	*Calyptocarpus vialis* (prostrate lawnflower)	HP	ankle	L	3-4
297	*Centaurea americana* (star thistle)	HA	waist	L	3-4
299	*Chrysactinia mexicana* (damianita)	WD	knee	L	1-2
302A	*Coreopsis sp.* (coreopsis)	HA/P	knee	L	3-4
303	*Dyssodia pentachaeta* (common dyssodia)	HP	ankle	L	1-2
304	*Dyssodia tagetoides* (marigold dyssodia)	HA/P	ankle	L	2
305	*Erigeron modestus* (plains fleabane)	HP	ankle	L	3
307	*Eupatorium havanense* (shrubby boneset)	WD	waist	LP	2-3
308	*Eupatorium rugosum* (white snakeroot)	HP	knee	PD	2-3
309	*Eupatorium serotinum* (late eupatorium)	HP	waist	L	3-4
310	*Evax prolifera* (bighead rabbit tobacco)	HA	ankle	L	1
312	*Gaillardia pulchella* (Indian blanket)	HA	knee	L	2-3
313	*Gnaphalium sp.* (cudweed)	HA	knee	L	2-3
315	*Gutierrezia texana* (Texas broomweed)	HA	knee	L	1-2
316	*Gymnosperma glutinosum* (tatalencho)	WD	knee	L	1-2
317	*Helenium elegans* (pretty sneezeweed)	HP	knee	L	3-4
319	*Helenium maximiliani* (Maximilian sunflower)	HP	head	L	4-5
320	*Heterotheca latifolia* (camphorweed)	HA	knee	L	2-3
321	*Hymenopappus scabiosaeus* (old plainsman)	HB	knee	L	2-3
322	*Hymenoxys linearifolia* (fine-leaf bitterweed)	HP	ankle	L	1-2

HABITAT-RESTORATION DATA CHART

SPECIES NUMBER	HARVEST TIME			HARVEST POTENTIAL			SOWING TIME		GROWTH FROM SEED			PRIORITY: SEED MIX			TRANSPLANT HARDINESS			PRIORITY: TRANSPLANT		
	SPRING	SUMMER	FALL	PROLIFIC	MODERATE	SMALL	SPRING	FALL	EASY	MODERATE	HARD	HIGH	MODERATE	LOW	HARDY	MODERATE	LOW	HIGH	MODERATE	LOW
251		X		X				X	X			X				T				X
252		X				X		X			T			X	X			X		
254		X			T			T		T				X	X				X	
256			X		X		X			T			T							X
258	X					X		X	X			X				T				X
259			X		T		T				T			X	X				X	
261			X		X		T			T			T		T				T	
268		X	X			X	T			T				X		T				X
270-3		X	X			X	T			T			T		X				X	
275		X				X	T			T			T			T				X
276		X				X	T			T			T			T				X
279	X	X			X			X	T				X		X					X
280			X		T		X		T				X		X				X	
281			X			X	T				T			X		T		X		
283			X			X	T				T			X	T			X		
284			X			X	T				T			X	T			X		
286		X		X				T	X			X			X				X	
290			X		X		X			T			X		X				X	
294			X	X			X			X			T		X				T	
295			X	X			X		T			T			X				X	
296		X	X			X	T	T		T			X		X					X
297		X			X			T	T				T		T				X	
299		X			X			T		T			T		T			X		
302A		X		X			T	X	X			X					T			X
303		X			T			T		T			T			T			T	
304		X				T		T		T			T			T			X	
305		X			X			T		T			T		T				X	
307			X		X		T				T			T	T			T		
308			X		X		X		T				X		T				X	
309			X	X			X		T			X			T					X
310		X			X			X	X				X				T			X
312		X	X	X			T	X	X			X				T			T	
313			X		X		T			T			T			T			T	
315			X	X			X		X				X				T			X
316			X	X			X			T			X		T				X	
317		X	X		X		X	T	T			X			T					X
319			X		X		X		T				X		T				X	
320		X		X			X	T	X				X			T				X
321		X		X				X	X			X				T				X
322		X	X	X			X	X	X			X				T				X

HABITAT-RESTORATION DATA CHART

SPECIES NUMBER	NAME (COMMON AND SCIENTIFIC)	PLANT DESCRIPTION			
		TYPE	TYPICAL HEIGHT	LIGHT NEEDS	SOIL/ MOISTURE NEEDS
323	*Hymenoxys scaposa* (plains bitterweed)	HP	ankle	L	1-2
327	*Liatris mucronata* (gayfeather)	HP	knee	L	1-2
328	*Lindheimera texana* (Texas star)	HA	knee	L	2-3
329	*Lynodesmia texana* (Texas skeleton plant)	HP	knee	L	1-2
330	*Marshallia caespitosa* (Barbara's buttons)	HP	knee	L	1-2
331	*Melampodium leucanthum* (Plains blackfoot)	HP	ankle	L	1-3
332	*Palafoxia callosa* (small palafoxia)	HA	knee	L	1-2
335	*Pluchea purpurascens* (marsh fleabane)	HA	knee	LP	3-4
337	*Ratabida columnaris* (Mexican hat)	HP	waist	L	3-4
338	*Redbeckia hirta* (brown-eyed Susan)	HA	knee	L	3-4
341	*Solidago canescens* (tall goldenrod)	HP	waist	L	3-4
342	*Solidago nemoralis* (dyersweed goldenrod)	HP	knee	L	2-3
343	*Solidago radula* (rough goldenrod)	HP	knee	L	2-3
347	*Tetragonotheca texana* (plateau nerve ray)	HP	waist	L	2-3
348	*Thelesperma simplicifolium* (slender greenthread)	HP	knee	L	1-3
349	*Verbesina enceliodes* (cowpen daisy)	HA	waist	L	3-4
350	*Verbesina lindheimeri* (Lindheimer crownbeard)	HP	knee	L	1-3
351	*Verbesina virginica* (frostweed)	HP	waist	LD	3-4
352	*Vernonia lindheimeri* (woolly ironweed)	HP	ankle	L	1-3
353	*Vernonia sp.* (ironweed)	HP	waist	L	3-4
354	*Viguiera dentata* (plateau goldeneye)	HP	waist	L	1-3
355	*Wedelia hispida* (hairy zexmenia)	WD	knee	LP	1-3
363-5	*Juncus sp.* (rush)	HP	knee	L	4-5
363-5	*Juncus sp.* (woolly bear rush)	HP	knee	L	4-5
367A	*Carex planostachys* (cedar sedge)	HP	ankle	LD	2-3
377-9	*Aristida sp.* (threeawn)	HP	knee	L	1-3
383	*Bouteloua curtipendula* (side-oats grama)	HP	knee	L	2-3
384	*Bouteloua hirsuta* (hairy grama)	HP	knee	L	1-3
386	*Bouteloua rigidiseta* (Texas grama)	HP	ankle	L	2-3
387	*Bouteloua trifida* (red grama)	HP	ankle	L	1-2
390	*Buchloe dactyloides* (buffalo grass)	HP	ankle	L	3-4
392	*Chasmanthium latifolium* (inland sea oats)	HP	knee	LP	4-5
401	*Eragrostis curtipedicellata* (gummy lovegrass)	HP	knee	L	1-3
402A	*Erioneuron pilosum* (hairy tridens)	HP	ankle	L	1-2
403	*Leptochloa dubia* (green sprangletop)	HP	waist	L	2-3
404	*Leptoloma cognatum* (fall witchgrass)	HP	knee	L	1-2
405	*Limnodea arkansana* (Ozarkgrass)	HA	knee	L	1-3
407	*Muhlenbergia involuta* (muhly)	HP	knee	L	2-3
408	*Muhlenbergia lindheimeri* (Lindheimer muhly)	HP	waist	L	3-4
409	*Muhlenbergia reverchonii* (seep muhly)	HP	ankle	L	2-3

HABITAT-RESTORATION DATA CHART

SPECIES NUMBER	HARVEST TIME			HARVEST POTENTIAL			SOWING TIME		GROWTH FROM SEED			PRIORITY: SEED MIX			TRANSPLANT HARDINESS			PRIORITY: TRANSPLANT		
	SPRING	SUMMER	FALL	PROLIFIC	MODERATE	SMALL	SPRING	FALL	EASY	MODERATE	HARD	HIGH	MODERATE	LOW	HARDY	MODERATE	LOW	HIGH	MODERATE	LOW
323		X	X		X		X	T	T			X			X				X	
327			X		X		X			T		X				T		X		
328		X			X			X	X			X				T				X
329		X				X		T		T			T			T			X	
330		X			X			T	T			T			T				X	
331	X	X	X		X		T	X	T			X			X				X	
332		X	X		X		T	X	T			X				T				X
335			X		X		T			T			T		T				T	
337		X	X	X			T	X	X				X			X				X
338		X	X		X		T	T	T			T			T					X
341			X		X		T			T			T			T			X	
342			X	X			T			T			T		T				T	
343			X	X			T			T			T		T				T	
347		X	X	X			T	X	T			T			T					X
348		X	X		X		T	T	T				X			X				X
349		X	X	X			X	T	X				X			X				X
350			X		X		X			T			X			X			X	
351			X	X			X			T			T			T				X
352			X		X		X		T			T			T				X	
353			X		X		T						T			T			X	
354			X	X			X		X			X			X				X	
355		X	X		X		X	T	T			X			X				X	
363-5			X	X			T				T		T		T					X
363-5			X	X			T				T		T		T					X
367A		X			T			T		T				X		X			X	
377-9	X	X	X	X			X	T	T				T		T					X
383		X	X		X		X	X	X			X			T					X
384			X		T		X		T			X			X			X		
386	X	X	X		X		X	T	T			X			T					X
387		X	X			X	T	T	T				X		T				X	
390	X	X				X	X	T			T			T	X				X	
392			X	X			X		T				X		T					X
401		X	X	X			X	T	X				X		T					X
402A	X	X	X		X		T	T	T			X			T					X
403		X	X	X			X	T	X				X		T				X	
404			X		X		X			T		X			T					X
405	X				X			X	T			T				T				X
407			X			T	T				T			X		T			X	
408			X		T		X				T		T			T		X		
409			X		T		X			T		X				T		X		

HABITAT-RESTORATION DATA CHART

SPECIES NUMBER	NAME (COMMON AND SCIENTIFIC)	PLANT DESCRIPTION			
		TYPE	TYPICAL HEIGHT	LIGHT NEEDS	SOIL/ MOISTURE NEEDS
411	*Panicum hallii* (hallii panicum)	HP	ankle	L	1-2
412-4	*Panicum sp.* (short panicum)	HP	ankle	PD	2-3
415	*Panicum virgatum* (switchgrass)	HP	waist	L	4-5
419	*Schizachyrium scoparium* (little bluestem)	HP	waist	L	1-4
421	*Setaria scheelei* (southwestern bristlegrass)	HP	knee	L	3-4
422	*Sorghastrum avenaceum* (yellow Indian grass)	HP	waist	L	3-4
424	*Sporobolus asper* (tall dropseed)	HP	knee	LP	2-4
425	*Sporobolus vaginaeflorus* (poverty dropseed)	HA	ankle	L	1-2
426	*Stipa leucotricha* (Texas speargrass)	HP	knee	PD	3-4
427	*Tridens albescens* (white tridens)	HP	knee	L	2-3
428	*Tridens buckleyanus* (endemic tridens)	HP	knee	P	2-3
429	*Tridens flavus* (purpletop)	HP	waist	P	3-4
430	*Tridens muticus* (slim tridens)	HP	knee	L	1-2
431	*Tripsacum dactyloides* (eastern gamagrass)	HP	waist	LP	4-5
436	*Allium drummondii* (Drummond onion)	HP/B	ankle	L	2-3
439	*Nolina lindheimeriana* (devil's shoestring)	HP	knee	LP	2-3
440	*Nolina texana* (sacahuista)	HP	knee	LP	2-3
442	*Schoenocaulon texanum* (Texas schoenocaulon)	HP	knee	LP	2-3
443	*Smilax bona-nox* (saw greenbriar)	WV	head	LD	3-4
444	*Yucca rupicola* (twisted-leaf yucca)	HP	knee	LD	1-2
445	*Nemastylis geminiflora* (celestial lilly)	HP	knee	L	3-4
446	*Sisyrinchium sp.* (blue-eyed grass)	HP	ankle	L	2-3
451	*Spiranthes cernua var. odorata* (ladies' tresses)	HP	ankle	L	2-3

HABITAT-RESTORATION DATA CHART																				
SPECIES NUMBER	HARVEST TIME			HARVEST POTENTIAL			SOWING TIME		GROWTH FROM SEED			PRIORITY: SEED MIX			TRANSPLANT HARDINESS			PRIORITY: TRANSPLANT		
	SPRING	SUMMER	FALL	PROLIFIC	MODERATE	SMALL	SPRING	FALL	EASY	MODERATE	HARD	HIGH	MODERATE	LOW	HARDY	MODERATE	LOW	HIGH	MODERATE	LOW
411		X	X		X		X	T	T				X		T				X	
412-4		X	X		X		X	T	T				X		X				X	
415			X	X			X		X			X			X			X		
419			X		T		X		X			X			X			X		
421			X		T		X		T				X		T					X
422			X		X		X			T		X			T				X	
424			X	X			X	T	X			X			X				X	
425			X	X			X		X			X					T			X
426		X		X				X	T					T	T					T
427			X			X	X		T				X		T				X	
428			X		X		X		T			X			T			X		
429			X	X			X		T				T		T				X	
430			X	X			X	T	X			X			X				X	
431			X			X	X				X			X	X			X		
436	X	X			X			X		T			T		X					X
439			X		X		X			T			X		X			X		
440			X		X		X			T			X		X			X		
442			X		T		X			T				T		T			T	
443			X			X	X				X			X	X					T
444			X			X	T			T				X	X			X		
445		X				X					T		T			T		X		
446		X				X				T			X		X				X	
451			X			X	T				X	X				T		X		