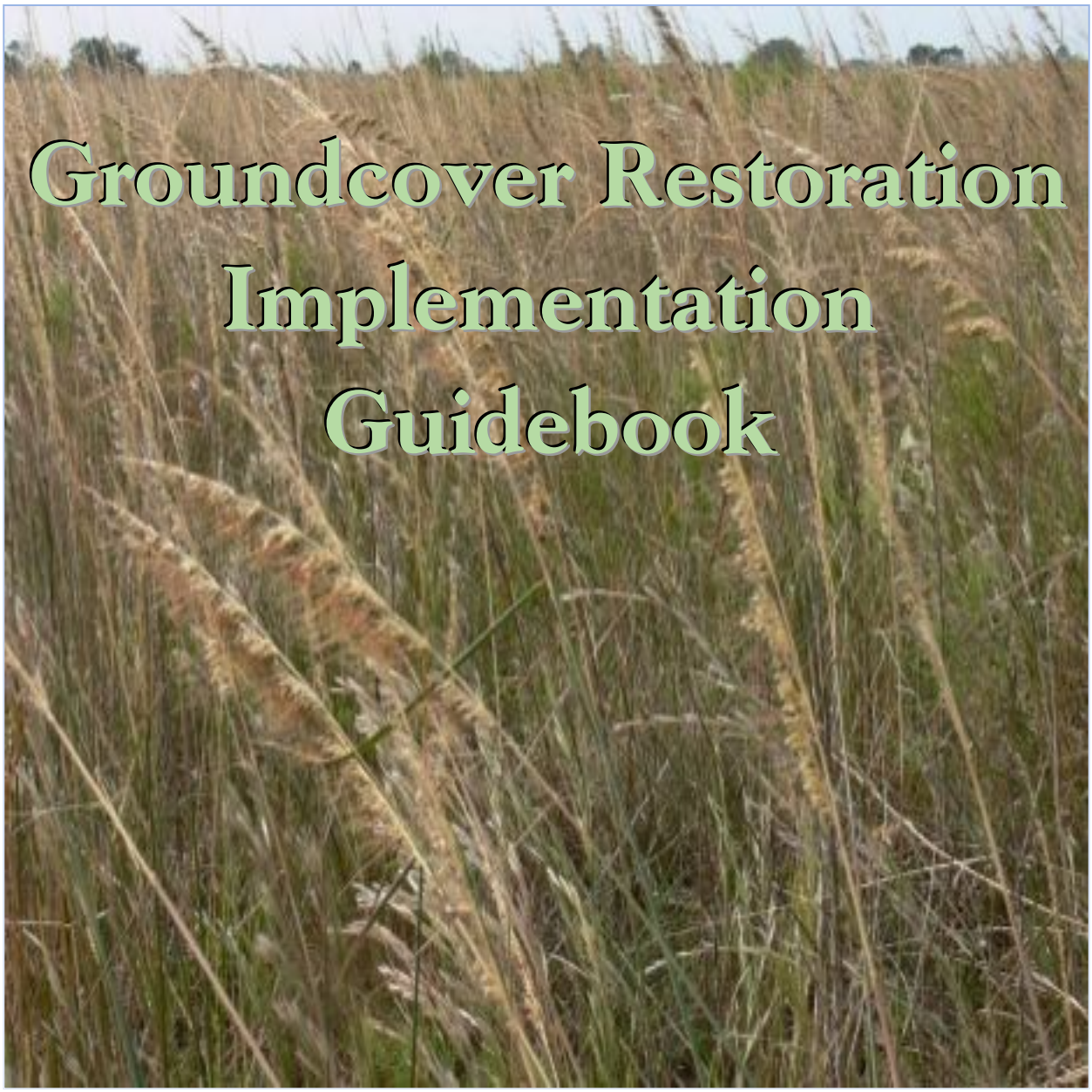
Groundcover Restoration Implementation Guidebook



Florida Fish and Wildlife Conservation Commission

Division of Habitat and Species Conservation
Terrestrial Habitat Conservation and Restoration Section

Groundcover Restoration Implementation Strategy Team

Groundcover Restoration Implementation Guidebook

Restoring Native Groundcover for FWC Restoration Practitioners

Prepared October, 2010

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FOREWORD

The Florida Fish and Wildlife Conservation Commission's (FWC) Terrestrial Habitat Conservation and Restoration (THCR) section created a *Ground Cover Restoration (GCR) Implementation Strategy Action Team* to "develop an effective strategy, and better internal knowledge of the process, costs, and expected outcomes of Ground Cover Restoration (GCR)." The GCR Team continues to function and maintains an FWC intranet SharePoint site containing documents, website links, photos, contacts, and other GCR related information. The GCR SharePoint site is located at: http://portal.fwc.state.fl.us/DOI/Divisions/HSC/THCR/GCR/default.aspx

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Kathleen Swanson; *FWC, THCR, Habitat and Restoration Program subsection leader*

Kent Williges; *FWC, FWRI, Ecosystem Assessment and Restoration Section, Upland Habitat Research and Monitoring program leader*

We are very grateful to all the FWC staff whose tireless work and devotion to groundcover restoration has led to its successful implementation in our agency.

"The mission of every ecological restoration project is to reestablish a functional community type, on the landscape scale, that contains sufficient biodiversity to continue its maturation by natural processes, to the extent possible, and to evolve over longer time spans in response to changing environmental conditions" (Clewell et al. 2000).

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(Top 3 photos by Jean McCollom; bottom photo by Nancy Bissett)

Groundcover Restoration Implementation Guidebook

INTRODUCTION

Restoring native habitat fulfills crucial environmental functions and services such as providing nesting and foraging habitat for native wildlife, promoting healthy natural communities, and restricting the expansion of non-native plants. The term "restoration" used in this document refers to the definition of "ecological restoration" from the *Society for Ecological Restoration (SER)*, which states that "Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed". Ecological restoration and land management may form a continuum and often employ similar types of intervention. Ecological restoration aims at assisting or initiating recovery of a degraded, damaged, or destroyed community type; whereas land management is intended to ensure the continued health of an existing community (SER Primer 2004).

The Florida Fish and Wildlife Conservation Commission (FWC) is the lead agency charged with protecting and managing approximately 1.5 million acres of public conservation lands (Wildlife Management Areas (WMA), and Wildlife and Environmental Areas (WEA)). Through the efforts of its Habitat and Species Conservation (HSC) Division, Terrestrial Habitat Conservation and Restoration (THCR) Section, FWC is involved in native habitat restoration on its managed lands. Since 2005, FWC has assumed a proactive role in the practice of restoring native groundcover.

Groundcover restoration (GCR) is the process of re-establishing native grasses, herbs, forbs, and other plants which occur at the ground-level of a community's vegetation. Native plant community vegetation is generally divided into three vertical layers. The ground-level, bottom-most layer of mostly low-growing, soft-stemmed plants is known collectively as *groundcover,* or *understory*; the middle layer composed mostly of woody,

Figure 1. Mesic flatwoods is an example of a type of pineland community FWC's THCR Section is restoring. *(Photo by Gary Knight, Florida Natural Areas Inventory, 2008.)*

shrubby plants is the *mid-story*; and the top-most layer composed mostly of dominant tall trees is the *canopy* or *overstory*. While restoring groundcover in other parts of the country has been underway for quite some time, groundcover restoration is a relatively new practice in the Southeast. FWC's restoration efforts to date have been limited to historic pinelands on which the native groundcover has been severely disturbed or eliminated. Restoration of the native groundcover on these altered lands is considered the first critical step in returning them back to functioning native pineland communities.

PURPOSE AND SCOPE OF MANUAL

The **purpose of this manual** is to provide restoration practitioners with a guidebook of options when restoring native groundcover. This is not an all-inclusive manual on what has been done throughout Florida, but it is built upon the successes and experiences of FWC staff while implementing restoration on FWC lands. By presenting concise and useful information gained from the knowledge and experience of FWC land managers and other staff, this manual is intended to guide groundcover restoration practitioners of all expertise levels in their efforts. The chapters are organized according to the key steps necessary for a successful groundcover restoration project. Many of the practices and methods being used by FWC for groundcover restoration have not been tried or tested enough to make definitive recommendations, but where practical and satisfactory, viable options are offered. Hyperlinks to pertinent documents and information are included throughout the text and an electronic version of the entire guidebook is available on the GCR SharePoint site: http://portal.fwc.state.fl.us/DOI/Divisions/HSC/THCR/GCR/default.aspx

In 2005-2006, FWC began four pilot restoration projects to develop procedures for restoring pasture areas in central and south Florida to native groundcover. Three Lakes WMA, Half Moon WMA, and Okloacoochee Slough WMA, each had one restoration site while Hilochee WMA had two sites. The size of the restoration areas ranged from 23-42 acres. Since that time, FWC is restoring or planning to restore additional degraded agricultural lands, pastures, or pine plantations on many of our other managed areas where we are the lead agency. To date, 17 FWC lead areas have been seeded with native groundcover (recipient sites) and four FWC lead areas have been used as native seed donor sites (Table 1). All the natural community types being restored are fire-dependent communities that require prescribed burning. These communities include wet, mesic, and scrubby flatwoods; sandhill, and scrub. The main restoration goal on these lands is to increase overall species biodiversity and re-establish key pyrogenic native grass species such as wiregrass (*Aristida stricta*) and lopsided Indiangrass (*Sorghastrum secundum*).

The primary **scope of this manual** deals with restoring agricultural lands and pastures back to natural pineland communities by re-establishing key native groundcover species, as described above. The methods, procedures, and experiences of FWC groundcover

restoration practitioners gained from the four pilot projects are the basis of most of the information presented; however relevant information from credible state, regional, and local outside and in-house sources, is also included where appropriate. Additionally, some general groundcover restoration knowledge, as well as more specific resources and references, are also offered (Appendix A). As more experience and expertise are acquired from current and future FWC restoration projects, an effort will be made to broaden the scope of this guidebook to include restoration of other types of altered lands to their former natural communities.

SUMMARY OF FWC GROUNDCOVER RESTORATION

The Fish and Wildlife Research Institute's (FWRI), Upland Habitat Research and Monitoring program, conducts monitoring of FWC groundcover restoration projects and summarizes the results. Monitoring of the four pilot restoration sites, Three Lakes WMA, Half Moon WMA, Hilochee WMA (North and South Fields), and Okloacoochee Slough WMA; and the primary donor site Three Lakes WMA (Babcock-Webb WMA was a secondary donor site), began in 2005-2006. The goal of the monitoring was to determine species composition and vegetation community characteristics of the "donor" site (the area from which the native seed for restoration use was harvested) and the "recipient" sites (the areas to be restored where the donor seed was planted) for the pilot projects. Species composition, frequency, and cover were sampled at each recipient site and at the donor sites.

In 2006-2007, FWC initiated more groundcover restoration projects, and additional donor and recipient restoration site monitoring, using the same protocol as in the previous years. Summary data and results for the years 2005-2007 are in three separate reports, all titled *Vegetation Monitoring at FFWCC Native Ground Cover Restoration Sites* but each with different dates corresponding to the monitoring period covered. All reports can be found at the link: *GCR Team SharePoint > Shared Documents > Reports > FWRI GCR Monitoring Reports*

In March 2009, FWRI produced a summary report for three years (FY05-06, FY06-07, and FY07-08) of monitoring results from FWC restoration projects. The Executive Summary of the report focused mainly on the initial five recipient sites (Three Lakes WMA, Half Moon WMA, Hilochee WMA (North and South Fields), and Okloacoochee Slough WMA) but monitoring results were also reported for additional restoration sites on Apalachee WMA, Apalachicola River WEA, Caravelle Ranch WMA, Big Bend WMA (Tide Swamp Unit), Ft. White WEA, and Moody Branch WEA. The full report containing detailed monitoring data and summary results for all these sites can be found at the same link immediately above.

The most recent GCR Monitoring Report from FWRI was prepared in March 2010. The "Executive Summary" of this report focused on monitoring results from the original five

restoration sites for four consecutive fall seasons (2006-2009) and the Spring 2006 season. Some of the important conclusions discussed in this summary were:

- The original five recipient sites have established a native grass assemblage capable of sustaining itself at least over the short term.
- The goal of establishing a native grass dominated understory is complete enough on four of the five original sites that the tree planting phase can proceed. The Half Moon WMA restoration site is the exception; it is recommended that tree planting be delayed there until the problem species, blackberry and hairy indigo, are under control.
- The keystone species, wiregrass and lopsided Indiangrass, seem to be holding their own, and while these sites do not resemble their respective donor sites with respect to species composition, they have attained a remarkable similarity in regards to their native graminoids structure (i.e., those species that contribute to the fire-carrying fine fuel structure of the understory).
- One of the most obvious differences in structure between the donor sites and all the recipient sites is the lack of a shrub layer. Additional restoration efforts will be needed, perhaps at the beginning of the 5-year mark, to establish and promote the growth of native shrubs, as well as desirable late-successional stage native forbs.
- To date, there has not been a restoration site that has been successful in achieving 100% eradication of exotic pasture grasses. Spot-treatment with herbicide should continue, and a few more rounds should be enough to eradicate these species completely.

Additional restoration sites that were monitored in Fall 2009, (and reported on in the March 2010 FWRI report), include Big Bend WMA (Tide Swamp Unit), Caravelle Ranch WMA, and Joe Budd WMA. Some newly planted sites including Apalachicola River WEA, Aucilla WMA, and Triple N Ranch WMA were monitored in Spring 2009 but due to poor or no wiregrass germination, Fall 2009 monitoring of these sites was delayed and they were not included in this report. Updated GCR monitoring data from FWRI for current and past restoration and donor sites can found on the GCR Team SharePoint site under Shared Documents > Research_Monitoring > GCR Monitoring Data.

Figure 2. A donor site located on Three Lakes WMA. ***(Photo by Steve Glass)***

Table 1: Summary of FWC groundcover restoration projects and sites as of Spring 2010.

GCR Site/ FWC Lead WMA or WEA	Date (FY) Project Began	Donor &/or Recipient Site	Number of Seasons Monitored	Number of Acres Being Restored	Habitat Type Being Restored	Current Status (as of Spring 2010)
Apalachee	2007/08	Both	2	16	Upland Pine	Re-planted wiregrass in Dec'09, utilizing different site prep and planting strategies
Apalachicola River	2006/07	Recipient	3	54	Mesic/Wet Flatwoods	Continuing site prep until next planting cycle (2010-2011)
Aucilla	2008/09	Recipient	2	32	Mesic/Wet Flatwoods	Wiregrass mix planted in March '09; very little found in July '09 monitoring; shifting to burning maintenance (no plans to replant)
Babcock-Webb	2006/07	Donor	1	n/a	n/a	
Big Bend (Tide Swamp Unit)	2007/08	Recipient	2	205	Sandhill	Planting of purchased wiregrass seed mix and plugs has been mostly unsuccessful to date
Caravelle Ranch	2007/08	Recipient	2	197	Mesic/Wet Flatwoods	39 acre restoration in maintenance and burning stage; 158 site being site prepped
Dinner Island	2008/09	Recipient	0	122	Wet/Dry Prairie	100 acres in contracted site prep; 22 acres site planted in '09/10
Ft. White	2007/08	Both	1	6	Sandhill	FWRI project was planted in strips; '09-10 monitored spread to non-planted strips
Half Moon	2005/06	Recipient	4	83	Mesic/Scrubby Flatwoods	23 acres in maintenance & burn stage; 15 (of 60) acres prepped & planted
Hilochee	2005/06	Recipient	4	156	Mesic Flatwoods	In maintenance & burn stage; ready for tree planting
Joe Budd	2008/09	Recipient	2	39.8	Upland Pine	Wiregrass planting completed in Dec'08; monitoring in '09/10 found scattered wiregrass, lots of weeds
Lake Wales Ridge	2008/09	Recipient	0	60	Mesic Flatwoods	Contracted site prep for +3 yrs; ready for seeding in Winter 2010
Moody Branch	2005/06	Recipient	1	159	Mesic/ Scrubby Flatwoods	In maintenance stage (contracted)
OK Slough	2005/06	Recipient	4	300	Mesic/Wet Flatwoods	Approx. 250 acres in maintenance & burn stage; some areas re-seeded in '09-10
Spirit of the Wild	2008/09	Recipient	0	100	Mesic/Wet Flatwoods	Prepped ('08-09) and planted ('09-10) (under contract)
Three Lakes	2005/06	Both	4	151	Mesic Flatwoods	In maintenance & burn stage; longleaf pines planted in Jan'09 but no survival
Triple N Ranch	2008/09	Recipient	1	88	Mesic Flatwoods	Wiregrass planted on 48 acres in '09 but failed; 40 acres to north planted in Jan'10
Watermelon Pond	2009/10	Recipient	0	84	Sandhill	Site-prep with herbicide treatments underway

Figure 3. Restoring pasturelands to native mesic flatwoods starting from the ground up by focusing on groundcover restoration.

CHAPTER 1: SITE SELECTION, ASSESSMENT, and PLANNING

SITE SELECTION and ASSESSMENT

All restoration is not identical. Some areas will respond more readily to restoration efforts than others, some areas will provide greater functional contributions, and other areas will be easier to manage. Restoration should provide the greatest opportunity for repairing native landscapes but these efforts do not come without a cost; therefore, thoughtful choices of where restoration will be implemented must be made. There are general guiding principles that should be followed when selecting a restoration site (The Nature Conservancy, 1998):

1. Prioritize sites based on their contribution to the surrounding natural landscape.
    a. Large systems will have a greater potential for sustaining regional biodiversity.
    b. Large systems are also more resilient and resistant to environmental disturbances.
    c. Linking adjacent similar ecosystems will support a greater biodiversity by offering sources of dispersing species.
2. Use the best available science to select sites, and to design and implement the restoration.
3. Integrate with any other regional planning processes in the area of the project site.
4. Build partnerships with agencies, organizations, and individuals to establish a broad coalition of cooperators and supporters.

Once the site has been selected, it needs to be assessed to determine if the proposed restoration will be feasible to implement. A site assessment is the process of collecting and organizing information about the physical and biotic characteristics, and land management issues of a site. A complete resource description including information about the current and historic site conditions, and status of surrounding land uses, provides a comprehensive foundation that feeds directly into the initial steps of developing a restoration plan. The *Site Assessment Checklist* (Appendix B) details the information needed to fully evaluate the existing site conditions; this includes boundary delineation, aerial photos, topography, soils types, hydrology, plant communities, wildlife presence, and cultural aspects.

PLANNING

Goals, Objectives, and Success Criteria

Accurately articulating overall restoration goals is paramount to the success of the restoration. The overall restoration goal is a general statement to ensure a common

understanding of why the restoration is required and to allow the setting of realistic, attainable, and measurable success criteria. Restoration objectives are a clear description of a measurable standard, desired state, threshold value, amount of change, or trend that you are striving to achieve for a particular aspect. As the foundation for all restoration and monitoring activity, developing good objectives is critical. Objectives must be realistic, specific, measurable, and clearly written.

Success criteria, or desired future conditions (DFCs), are specific parameters used to evaluate whether the restoration is successful. Success criteria determine the type of monitoring that will be conducted on the restoration site and document whether the restoration objectives have been reached. Some examples of success criteria include density measurements of mature trees for forested systems, satisfactory coverage of a specific plant/animal species, or functional parameters equivalent to a reference system.

Procedures for Initiating an FWC Groundcover Restoration Project

A number of procedures and standardized forms have been developed by the "Groundcover Restoration Implementation Strategy Action Team" (GCR Team) for use in the proper planning and initiation of groundcover restoration at FWC. These tools were created to aid and guide the practitioner through the necessary steps in proposing, planning, and obtaining approval for a restoration project. Currently these procedures (and associated forms) are under review but are still in place:

- New proposals require submission, by the initiating FWC biologist, of a ***Ground Cover Restoration Site Nomination Form*** and associated estimated budget, to the Regional GCR Coordinator.
- A GCR Regional Coordinator may conduct a site visit of the proposed new project.
- The GCR Team meets to rank and prioritize new proposals.
- After project proposal approval (including budget approval), the Area Biologists will submit a completed ***Restoration Plan*** to the GCR Regional Coordinator and State-wide GCR Coordinator (contacts list at: *Ground Cover Restoration Team Contacts*).
- Reviewed finalized plans will be uploaded to the GCR Team webpage.

A worksheet is available for estimating project budgets including options, time, and costs for specific restoration activities. This worksheet and all other forms, templates, and documents noted above are available from the GCR SharePoint site: *Ground Cover Restoration (GCR) Team > Shared Documents > MS WORD documents (file names self-explanatory)*

The Restoration Plan

A good restoration plan should include all the information necessary to fully understand and implement the restoration. There are three main aspects to a restoration plan: the

conceptual, strategic, and work-plan components. The conceptual component primarily details the overall restoration goals and specific objectives. The strategic component provides information gathered from the site assessment as well as any constraints related to site issues. The work-plan component details specific actions that will be implemented and the general time-line associated with those actions. The following outline details the format that FWC biologists use when creating a comprehensive restoration plan:

1. Conceptual Component
    a. Executive Summary
    b. Restoration Goal
    c. Desired Future Conditions
2. Strategic Component
    a. Project Description: information gathered from site assessment
    b. Constraints: site issues that would make restoration difficult
3. Work-Plan Component
    a. Large Scale Actions: strategies and actions for restoration
    b. Immediate Actions: activities to take place in the first year
    c. Near-term Actions: activities to take place in years 2-4
    d. Long-term Actions: activities to take place from year 5 and beyond
    e. Costs of Actions: costs of actions to take place in first 4 years
    f. Monitoring Plan (see Chapter 6)

A completed plan is required before initiation of any FWC GCR project and a *GCR Restoration Plan Template* is available for FWC use. The template includes metadata explaining the details for each section of the plan and can be found on the GCR SharePoint site at: *GCR Restoration Plan Template Instructions and Metadata* .
Examples of completed FWC project plans can also be found on the GCR SharePoint site at: *GCR Team SharePoint > Shared Documents > Restoration Plans* .

Cost Estimates for Restoration

FWC groundcover restoration costs have been found to vary considerably by site and by year based upon a number of factors including equipment purchases, types of restoration activities done, project scale, labor costs, and whether the work was done "in-house" or contracted out. A cost comparison of an in-house project on two 20 acres sites on Hilochee WMA versus a contracted project on one 150 acre site on Moody Branch WEA was done for FY 2005-2006 (Table 2) (Stefanie Nagid, 2007). Detailed total costs by site (WMA or WEA), by activity within a site, and by fiscal year (for FY's 2005-06 through 2009-10), can be compared from data reported on the GCR SharePoint at: *GCR Activities and Cost by Area for FY 2005-06 to 2009-10* . This tabbed spreadsheet reports the costs for the various restoration activities that have been done on each of the FWC restoration sites over a five year period. It can be useful for estimating the range of costs when planning budgets for

new groundcover restoration projects or for implementing specific activities on existing sites.

Table 2. Cost Estimates for Groundcover Restoration on In-House versus Contracted Sites.

Restoration Site (FY 2005-2006)	**Cost per Acre by Groundcover Restoration Activity**			**Total Cost per Acre**
	Site preparation	Seed collection and planting	Post-planting maintenance and monitoring	
In-House: Hilochee WMA	$250	$845	$200	$670*
Contracted: Moody Branch WEA	$500-$650	$800-$1200	$150	$1,450-$2,000

*As FWC has all equipment needed to collect and plant seed, this cost is not included in the Total Cost per Acre

Internal Resources Available for Groundcover Restoration

A number of internal resources are available to FWC groundcover restoration practitioners including specialized equipment, Society for Ecological Restoration (SER) membership benefits, and state-wide, as well as regional, technical assistance and coordination. Equipment available by region is as follows:

FWC Region	Flail-vacs	Grasslanders	Rollers
North Central	3	2	1
Northeast	4	3	2
Northwest	4	2	2
South	4	2	1
Southwest	4	3	2

The Society for Ecological Restoration benefits to FWC staff include an e-newsletter sent bi-monthly and on-line access to the journal "Ecological Restoration" (limited to 10 at one time). Instructions for online access are on the GCR SharePoint at: *Instructions for Accessing Ecological Restoration online journal* .

As part of the THCR section, the GCR Team is an indispensable resource available to all FWC staff. The Team consists of a state-wide coordinator, a state-wide technical restoration specialist, and regional coordinators with extensive experience and expertise. These team members can provide assistance in both planning and implementation of groundcover restoration. The list of state-wide and regional team contacts can be found on the GCR SharePoint site at: *Ground Cover Restoration Team Contacts* . Additional general and specific, internal and external restoration resources are listed in Appendix A.

CHAPTER 2: SITE PREPARATION

Site preparation is crucial to successful restoration because it creates a bed of bare mineral soil to plant native seeds, minimizes plant competition with those native seeds, and eliminates undesirable plants. Creating an appropriate seed bed is accomplished through prescribed burning, and mechanical and chemical treatments; all of which are usually necessary to achieve the best results. In general, the following steps are recommended for site preparation on former degraded pasture or agricultural sites:

1. Prior to initiating site preparation, conduct a plant survey to determine which rare, desirable, or pest plants exist on the site in different seasons (usually late spring and early fall)
2. Prescribe burn December to March to reduce midstory vegetation and dead grass (thatch).
3. Remove stumps and woody debris that will hamper use of disking and planting equipment.
4. Apply initial broadcast herbicide treatment in spring (if targeted, exotic grasses should be 4-6" high).
5. In summer, apply second herbicide treatment; spot treating unless another broadcast treatment is needed.
6. Continue spot treating in fall.
7. If needed, prescribe burn again after final herbicide treatment to remove dead biomass before disking.
8. If large amounts of dead rhizomes are still present; disk site thoroughly, using a root rake if necessary.
9. Roll and compact site to prepare seedbed for winter seeding.

The number of years needed to treat aggressive exotics is dependent upon their pervasiveness, extent, amount, and patchiness on a site. For example, a few isolated small patches of an aggressive exotic grass should not preclude proceeding with other site preparation and planting. Allow two years for site preparation if more than trace amounts of any of the following aggressive exotic grasses are present:

- Bermudagrass (*Cynodon dactylon*)
- Torpedograss (*Panicum repens*)
- Natalgrass (*Rhynchelytrum repens*)
- Cogongrass (*Imperata cylindrica*)

Success is likely only when these species have been eradicated before planting commences. Repeated herbicide treatments and spot spraying will be needed for these persistent grasses. Groundcover restoration can proceed while stands of these species continue to be treated, sometimes with more persistent (soil-active) herbicides. To expedite repeated

treatment, locations of pest plants should be marked and stored using geographical positioning system (GPS) technology.

Steps 2 and 3, prescribed burning and removing woody and other midstory vegetation, as well as dead plant matter and debris, are important as this material impedes contact between an herbicide and the exotic sod grasses targeted for spraying. Before disking the site, ensure that all weeds or pest grasses are gone. This requires regular inspection and spot spraying of the site throughout the year (steps 4-6). Disking and rolling (steps 8 and 9) create a smooth and level soil surface which increases contact between sown seeds and the moist soil needed for germination. Be aware that disking areas with species such as Bermudagrass, or other rhizomatous plants, can spread these weeds instead of reducing their viability.

As an alternative to Step 4 (spring treatment), herbicide treatments can begin in the fall (October and November). When plants are going dormant for the winter, increased uptake into roots and rhizomes may improve herbicide efficacy. The follow-up herbicide applications would occur the next spring, summer, and fall. Follow-up treatment should be continued until all undesirable grasses and exotics are dead.

If cattle are present, grazing should be maintained on a site targeted for restoration until just prior to site preparation. Grazing reduces bahiagrass (*Paspalum notatum*) flowering and seeding, thus diminishing the bahiagrass seed bank. Grazing also reduces thatch which as noted above, inhibits contact between herbicides and the growing grass targeted for elimination.

MECHANICAL SITE PREPARATION

Mechanical methods for site preparation include tree-cutting, root-raking, mowing, tilling (disking or plowing), and rolling or compacting. Three mechanical steps are usually required to:

- remove brush and dead biomass (mow, root rake, etc.)
- till the soil
- roll or compact the seed bed

Removal of Brush and Dead Biomass

Various mechanical means, such as mowing, can be used to remove hardwoods and encroaching brush from groundcover restoration sites. Mulching machines are not recommended because a mat of woody debris will impede groundcover restoration activities. Root raking of species such as wax myrtle (*Myrica cerifera*) may be needed. Before tilling, remove as much surface and partially-buried debris as possible to increase disking and

planting machinery efficiency, and protect it from damage. Also remove as much dead plant matter from the site as possible to improve the efficacy of herbicide applications on growing plants. Prescribed fire is another tool used to remove dead biomass.

Figure 4. Root raking is part of groundcover restoration site preparations at Three Lakes WMA. *(Photo by Steve Glass)*

Commercial sod removal is another option for removing unwanted biomass but FWC has not used this technique. Although some topsoil and native seeds will be lost, this method may assist with sod grass eradication. However, in the case of Bermudagrass removal, viable rhizomes may persist deeper than sod removal equipment penetrates and result in a more tenacious stand. Other possibly adverse affects include the required addition of soil amendments, and in low lying areas, the reduction in soil elevation from cutting.

Soil Tillage

Tilling or disking is generally used on groundcover restoration sites to produce a smoother, more uniform planting bed which promotes better germination of planted seed. To prepare the seed bed following chemical treatments, repeated passes with a plow, disk, or harrow are usually needed; thorough disking often requires passes in opposite or cross-wise directions. A finishing or grove disk can then be used to smooth and level the site. Other implements such as chain drags or cultipackers will further smooth and level the soil (Figure 5).

Figure 5. Finishing disk used at Hilochee WMA restoration areas (left), and finishing disk with cattle grate used at Okaloacoochee Slough WMA (right).

Most land managers advocate disking or disturbing the soil only after all aggressive weed species are eradicated. Avoid any disking if Bermudagrass, torpedo grass, or cogongrass are present. In addition to tilling for bed preparation, disking can be used between herbicide treatments to aid in bahiagrass eradication. Tilling stimulates re-sprouting, making pest grasses more vulnerable to herbicide. A deep disk can be used to break up the sod and turn over the bahiagrass rhizomes. Approximately 4-6 weeks after disking, a final herbicide application in the fall will reduce the remaining bahiagrass seedlings that have germinated from the seedbank or re-sprouted from rhizomes.

Soil Compacting

The best seed germination will occur on a site that has been rolled by a roller compactor or treated with a cultipacker (Figures 6 and 7). Using a roller compactor helps create a smooth, flat planting bed that maximizes soil moisture retention and seed-to-soil contact; any type of roller compactor that can be pulled behind a tractor is adequate (Figure 8). A cultipacker is a ridged packer that forms many small peaks and valleys in the soil; these peaks and valleys are believed to increase the flow and retention of moisture in the soil (Figure 9).

Figure 6. Drum roller from Okloacoochee Slough WMA.

Figure 7. Cultipacker used at Hilochee WMA.

Figure 8. Groundcover restoration site ready to be planted after being disked, leveled and "rolled."

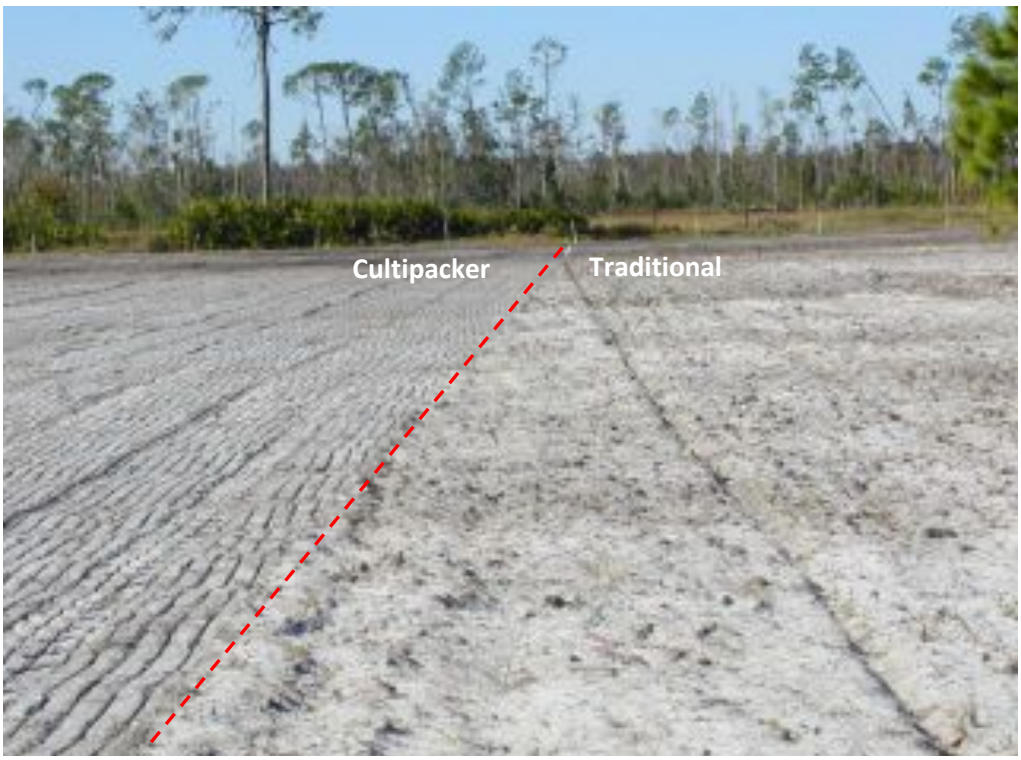

Figure 9. Hilochee WMA groundcover restoration site showing soil compacting using a cultipacker on half of the area (left side of photo), and a traditional roller compactor on the other half (right side of photo).

No-Till Site Preparation

As an alternative to the traditional till method of mechanical site preparation, land managers can consider using a no-till method. No-till is the best option if soil disturbance needs to be minimized. If the no-till method is being used, remove as many large sticks, roots, and other debris from the site as possible before planting.

Although seed drills or planting machines, such as the *Grasslander*, perform better if the soil has been tilled and roller-compacted, soil disturbance from tilling can promote proliferation of weedy species such as Bermudagrass or dog fennel (*Eupatorium capillifolium*). Tilling can also increase soil erosion while no-till methods reduce erosion, as well as loss of soil moisture and organic matter. Some desirable species in the seed bank may also be lost through tilling. No-till site preparation may be appropriate for groundcover restoration sites that have desirable overstory trees, or when gradually restoring groundcover in pine plantations. Machinery should be kept outside of the dripline of any overstory species that are to be retained.

Prescribed fire is usually needed for no-till site preparation. By removing dead biomass or litter, burning helps prepare the site for both herbicide application and planting. Fire also stimulates re-sprouting, making some pest plants more susceptible to herbicides.

CHEMICAL SITE PREPARATION

At least one year is needed for the two or three herbicide treatments recommended for site preparation. Herbicide applications over two or more years are recommended if Bermudagrass is present. Because past soil disturbance and farming practices can hide weed problems, proceed with herbicide application only after a growing season exposes existing, but possibly undetected, weeds. As noted previously, eradication of sod grasses should be ensured before proceeding with tilling or planting the groundcover restoration site.


Figure 10. Before and after herbicide spraying of groundcover restoration site on Moody Branch Mitigation Park WEA.

General Herbicide Guidelines

Some general guidelines and precautions for using herbicides in site preparation are given below:

- Always read and carefully follow the label instructions on all chemicals. Calibrate all equipment properly according to label instructions.
- Herbicides work best when plants are actively growing so avoid treatment when sod grasses are dormant due to low temperature or drought.
- Timing of application relative to weather conditions is crucial. Herbicide treatments should occur in low wind conditions to prevent effects on non-target areas. Allow ample time for herbicide to dry on leaf surfaces before any chance of rain. Be sure to read the chemical label concerning the best season for application as well as annual application limits.
- Translocation of chemicals can cause serious secondary damage to desirable species; check the label directions to determine if a chemical has the potential to spread and kill non-target plants.
- Chemical additives such as methylated seed oil (MSO) and ammonium sulfate (AMS) can increase the effectiveness of various herbicides.

Herbicide Application Methods

The choice of which herbicide application method to use, whether aerial, tractor, ATV, truck, or by back-pack sprayer, depends on the size and layout of the site and the existing vegetation. Aerial application is the most efficient and cost effective for large areas (>50 ac). For aerial applications, a foaming agent or thickener can be added to the herbicide to minimize drift to non-target vegetation communities such as wetlands. Tractor-mounted boom sprayers are most commonly used for herbicide application, especially on sites less than 50 acres.

Herbicide Formulations

An "herbicide formulation" refers to the herbicide's active ingredient (chemical actually controlling the weed) plus a carrier (such as oil, water, etc.) and any other chemical additives. Different brand name herbicides use different formulations or percent active ingredient. A table of herbicides commonly used for groundcover restoration in Florida, listed by chemical name and brand name can be found in Appendix D. Factors to consider in deciding which formulation to use include:

- Formulations vary in their effectiveness so choose the active ingredient that is most effective (labeled and registered for use) on the targeted pest species.
- Use the formulation that is most compatible with your application method and equipment.
- Formulation can affect the tolerance of a desirable species to an herbicide so use the formulation that has the least detrimental effect on unintended targets.
- Formulation affects the cost of an herbicide treatment depending upon the concentration, application rate, and additives.

Adjuvants are additives that, when mixed into the herbicide formulation, improve herbicide performance. Below are adjuvant classes and descriptions:

- Surfactants reduce surface tension and allow herbicides to better penetrate plant defenses such as hairs and waxy leaf surfaces. They include emulsifying agents, wetting agents or spreaders (e.g. *Sunwet*), crop oil concentrates (e.g. methylated seed oil or MSO) and 'stickers'.
- Drift control agents or thickeners are often used for aerial applications or if sensitive plants are in the vicinity of the target site.
- Antifoaming agents eliminate excess foam that results from agitation in the spray tank.
- Water conditioners and buffering agents (e.g. *AD100*, *Class Act*, and ammonium sulfate or AMS) help maintain pH of the herbicide solution and uptake by plants.
- Spray colorants are dyes that can help an applicator see the areas that have been treated.

Glyphosate (e.g., *RoundUp),* at 1.5-3% is currently recommended for groundcover restoration site preparation. Glyphosate is a non-selective, broad-spectrum herbicide that is used for total plant control. It persists 1-3 weeks in the soil with no apparent soil activity. Rates, timing, and other criteria for herbicide use on specific exotic grass species are shown in Table 3.

Table 3. Herbicide rates, timing, and other criteria for use in site preparation and maintenance.

Target Pest Species	Herbicide/ Chemical Name	Rates	Adjuvants	Timing	Comments
Bahiagrass	***Roundup; Roundup Ultra*** (glyphosate)	2 Q *Roundup Ultra* with10 G water/acre 2 Q *Roundup* with 20 G water /acre	17 lbs AMS per 100 G of water; 2.5 lb AMS + 1Q MSO with 20 G water /acre	Spray 2-4 wks after green-up; wait 2 wks to re-spray. Or apply in March/ April followed by up to 8 oz *Plateau* per acre in May	Re-spray with 1.5 Q *Roundup Ultra* per acre at time of seed head production
	Plateau (imazapyc) + ***Roundup*** (glyphosate)	12 oz *Plateau* + 1 Q *Roundup* with 15 G water / acre	1Q MSO with 15 G of water/acre; also add 17 lbs AMS per 100 G water	May not need to re-spray due to residual nature of *Plateau*, but need to treat problem areas as they develop	Check *Plateau's* residual time on label before reseeding
	Oust (sulfometuron methyl) + ***Escort*** (metsulfuron methyl)	2 oz *Oust* + 1 oz *Escort* with 15 G water /acre		Apply 2-4 wks after green-up & before hardened seed-head production; re-spray as needed	Prepare with mid-winter burning; has soil residual activity so area should not be seeded for up to a year after treatment
Bermuda-grass	***Arsenal*** (imazapyr) + ***Roundup*** (glyphosate)	20-24 oz *Arsenal* + 1 Q *Roundup* with 25 gallons of water /acre	1Q MSO with 25 G water/acre; also add 17 lbs AMS per 100 G water	Apply initial treatment, wait 10-12 wks then reapply as needed	Imazapyr has soil residual activity so area should not be seeded for up to a year after treatment
	Roundup (glyphosate)+ ***Arsenal*** (imazapyr)	2 Q *Roundup* + 1 pint of 2 lb *Arsenal* with 20 G water /acre	2.5 lb AMS + 1 Q MSO with 20 G water /acre	Apply in March/April	Imazapyr has soil residual activity so area should not be seeded for up to a year after treatment

CHAPTER 3: SEED COLLECTION

Groundcover restoration on FWC lands has initially focused on restoring pasture lands back to natural pinelands and prairies, or other fire-maintained natural communities. One of the difficulties with restoring pasture lands is that most of the original native groundcover species and their seedbanks have been eliminated. Therefore, the primary step in restoring groundcover is to directly seed the site with key native fire-adapted species, such as wiregrass and lopsided Indiangrass. Several options are available to obtain native grass seed but the desired species of seed is usually collected from nearby donor sites. In addition to donor sites on FWC lead management areas, our restoration projects have also used seed from donor sites located on private lands, as well as other public lands, such as the Apalachicola National Forest and St. Marks National Wildlife Refuge.

DONOR SITE SELECTION

The first consideration in selecting a donor site is to locate a nearby natural area which has an abundance and diversity of the native species that you want to re-establish on your restoration site. More specifically, the donor site should be within the natural distribution range of the species targeted for the restoration site. Additionally, the biotic and physical characteristics of the donor site such as topography, soil types, and plant communities, should be as similar as possible to the historic conditions of the restoration recipient site.

Prior to establishing a donor site, a formal assessment and plant inventory should be done to ensure the intended restoration site goals can be met, and exotic plant species are absent. The best collection sites for mechanical harvesting of seed should be devoid of, or have a low density of trees and stumps; however, seed can be collected in forested areas but will require more effort. Avoid collecting seed from areas with exotic plant species to prevent transferring these species to your restoration site. Collecting seed from areas grazed by cattle is difficult unless the cattle are excluded or grazing is low intensity.

Burning of Donor Sites for Wiregrass and Lopsided Indiangrass

In choosing a donor site for groundcover restoration, one of the most important requirements is the ability to prescribe burn enough acreage to meet the seed collection needs of the recipient site. For any given area, wiregrass seed production can vary from year to year depending upon a number of factors including burning. To ensure adequate donor seed, sufficient acreage must be burned to compensate for the unpredictable effects of weather and other factors on seed production. Season of burning within a year also affects wiregrass seed production. A reliable and consistent donor site for wiregrass needs an active growing season burn program, with ample burn units available to take advantage of

all possible weather and burn conditions. Burning should be conducted throughout the growing season (May through August) rather than focused in a particular month. Below average rainfall in the spring may have a negative effect on seed production in units that are burned in May or June (Steve Glass, personal communication). To optimize seed collection, the donor site should burn completely as patchy burns make seed collection inefficient.

For lopsided Indiangrass, the relationship between burning and seed production is not as well understood as for wiregrass; dormant and growing season burns both produce adequate amounts of lopsided Indiangrass seed. The best sites to collect lopsided Indiangrass are those that were burned 1.5 to 3 years prior to seed collection, although adequate lopsided Indiangrass may be produced in areas that haven't burned for at least 4 or 5 years.

EVALUATION OF SEED

Groundcover restoration success depends upon large amounts of viable donor seed but many environmental factors can influence seed production and viability on a donor site. It is imperative therefore that wiregrass and lopsided Indiangrass seed from donor sites be evaluated before harvesting. Technically "viability" means a seed's capacity to germinate under favorable conditions; this is usually determined by special lab testing. Alternatively, evaluating "germination potential" can be done by looking at seed maturity or ripeness. This type of seed evaluation is typically done in the field as it is easier, timelier, and less expensive than lab testing for viability.

Checking seeds before harvesting can prevent the collection of useless seed or seed that is not ripe enough to germinate. Lopsided Indiangrass and wiregrass should be examined to determine if the seed is alive or dead, and if it is ripe enough for harvest. Seed to be evaluated can be sent to FWRI's *Ecosystem Assessment and Restoration Section, Upland Habitat Research and Monitoring* office in Gainesville, or evaluated on site by FWC GCR practitioners using the field evaluation method described below.

If sending seed to FWRI, seed stems should be gathered a few days prior to the anticipated start date of donor site seed collection. Local personnel need to collect 10 bundles of wiregrass seed spikes; each bundle should contain a fist full of seed heads (1 to 2 inches in diameter). The bundles should be collected from locations which are representative of the entire collection area, as well as from areas that were burned at different times during the growing season. The bundles should be bagged separately and tagged by location, then mailed to FWRI as soon as possible. If seed evaluation is to be done on site over a period of days or weeks, fewer seed stems (smaller bundles) can be collected at each sampling time and location. The methodology for field evaluation is detailed in the following textbox.

FIELD EVALUATION OF WIREGRASS & LOPSIDED-INDIAN GRASS FOR RIPENESS

A dissecting microscope or other high magnification device (e.g. hand lens), as well as a dissecting kit with a probe, scalpel or knife, and a pin or needle, is needed. Collect seed stems as for FWRI testing; examine and evaluate seeds as follows:

1. Create a data or "tally' sheet for categorizing and counting the seeds. The categories that the seeds will be divided into are: ***Dead*** (or absent), ***Alive but Not Mature*** (not ready to collect), and ***Ready to Collect*** (ripe or mature). The categories and detailed criteria for determining them are listed in the table below.

2. Remove some intact seeds (seeds with sheaths) from about 20 stems per area and mix them together.

3. Pick approximately 30-50 seed "samples" randomly from the mix to be examined under the microscope.

4. For each sample, use the scalpel or knife (and pin or needle) to open the sheath around the seed. Using the microscope, check that a seed is present within the protective sheath. If there is a **not** a seed present (i.e. the sheath is empty), this sample is counted in the "**Dead**" category.

5. If a seed is present in the sheath, use the dissecting probe or needle to break open the seed. If under the microscope, the seed appears to be "brown, black or dry and crumbly"; this sample is also counted in the "**Dead**" category.

6. If the broken open seed sample appears as "a small green bud of a seed inside toward the base of the sheath" OR if the "seed is liquid or milky" (see Fig 11), then the seed is not mature and is counted in the "**Alive but Not Mature**" category

7. If the "opened" seed sample is not liquid but is white and crumbly, or breaks apart in chunks (i.e. has the consistency of feta cheese and can be flattened with flat side of scalpel), OR if the seed is hard and amber colored (readily pops out of sheath) (see Fig 11); these samples are counted in the "**Ready to Collect"** category.

8. From your sample tally sheet, determine the percent "Alive" seed and then within this category only, determine the percent of "Ready to Collect" seed.

9. When testing reveals that at least 25% of the live seed is in the "Ready to Collect" category, then seed collection should start immediately.

10. You can continue to evaluation seed samples from the donor site each day during the seed collection period. Recording dates, along with the percent of seed in the "Ready to Collect" category, will help you plan the timing of future collecting and get an estimate of amount of ripe seed collected for that period.

Seed Stage	Detailed Appearance of Seed	Category
Empty	No seed inside sheath	**Dead** (absent)
Brown crumbly or black rust	Seed shriveled, dark brown or black	**Dead**
Little Green	A small green "bud" of a seed inside, toward the base of the sheath *(*See *Figure 11:left photo)*	**Alive but Not Mature** *(not ready to collect)*
Milky	Liquid to creamy, clear or white like milk	**Alive but Not Mature** *(not ready to collect)*
Mealy or Feta Cheese Stage	No longer liquid but white and crumbly, or breaks apart in chunks; can be flattened *(Figure 11:middle photo)*	**Ready to Collect** (ripening)
Hard	Seed hard amber colored, mature, often pops out when trying to open *((Figure 11:right photo)*	**Ready to Collect** (mature)

Figure 11. Three of the four stages of seed development in lopsided Indiangrass, from left to right: the "little green" stage; (milky stage is not shown); the "feta cheese" stage; and the mature seed. Note: These stages appear the same for wiregrass seed *(Photos by Jean McCollom)*

If the seed evaluation shows that at least 25% of the seed is "alive" and ripe", then the site is suitable for seed collection; although rates of at least 30-50% are more desirable. If live seeds are absent or low in number, a new collection site needs to be found so it is important to have "back-up" areas. If additional collection sites are not available, seed may have to be purchased from a commercial vendor or seed collection will have to be delayed.

TIMING OF SEED COLLECTION AND QUANTITIES NEEDED

The timing of seed collection will vary throughout Florida. In Central and South Florida, seed collection for lopsided Indiangrass usually begins in early to mid-October. The collection site should be monitored closely because there is a short collection window (7-10 days), between ripeness and seed drop, for lopsided Indiangrass. Monitor the lopsided Indiangrass to detect when the seed descends or falls away from the stem giving it a "lopsided" look. When the small yellow flowers are detected on the stem, collection should start within a few days. Seed collection can also be initiated when shaking of stems causes the seeds to fall off easily.

Wiregrass seed has a wider window for collection but close monitoring is required so the peak collection time isn't missed. In Central and South Florida, seed collection usually begins mid-November to early December. To determine when wiregrass seed is ready for collection, the best method is to pull a loosely held stem between your fingers and see if seed comes off easily. As noted earlier, tests for ripeness or maturity should be in progress or already complete before collection begins.

The quantity of seed needed for restoration efforts will depend on your goals for the site; if the goal is a continuous graminoid layer that will easily carry fire, a minimum of 10 lbs. of wiregrass should be collected for every acre to be restored. In addition, a minimum of 2 lbs. of lopsided Indiangrass should be collected per acre of restoration site.

For wiregrass, seed should be collected from areas that were burned the previous April through August (Table 4). As noted above, it is very important that prescribed burns are conducted throughout the growing season because the timing of the optimal burn period for seed production varies from year to year. On good sites, it will take approximately 6 to 18 acres and 6 to 10 man-hours to collect 100 pounds of wiregrass seed.

The amount of donor site acreage that needs to be burned in any given year is highly variable but, at a minimum, 10 acres should be burned for every 1 acre of planned restoration. This guideline is a recommendation; much more acreage may be needed depending on environmental conditions and the seed production of the burned area.

Table 4. Date of collection, number of hours required, amount of wiregrass seed, and dates the collection sites were burned at Three Lakes Wildlife Management.

Dates Collected	# of Days	Approx. Hrs	Lbs Collected	Lbs/Hr	Donor Acreage	Lbs/Acre	Dates Donor Sites Burned
11/21/05-12/2/05	8	205	2,063	10.1	378	5.5	5/23/05, 5/24/05, 6/14/05, 8/4/05
11/17/06-12/4/06	9	43.5	498	11.4	86	5.8	7/5/06, 8/3/06
11/26/07-11/29/07	4	32	573	17.9	45	12.7	6/27/07, 7/17/07
12/1/08-12/5/08	5	50	670	13.4	43	15.6	7/21/08, 7/25/08, 7/29/08
11/30/09-12/7/09	5	NA	303	NA	54	5.6	6/16/09, 7/9/09
Mean	-	-	-	13.2	-	9.0	-

Optimum sites for lopsided Indiangrass seed collection will have dense stands spread consistently over an area of at least 10 acres (Figure 12). On good sites, it will take approximately 7 to 15 acres, and 9 to 16 man-hours to collect 100 lbs. of lopsided Indiangrass seed (Table 5).

Figure 12. Ideal area for collecting lopsided Indiangrass using a flail-vac. (Note the abundant and dense stems of lopsided Indiangrass) *(Photo by Steve Glass)*

Table 5. Date of collection, number of hours required, amount of lopsided Indiangrass seed, and dates the collection sites were burned at Three Lakes WMA.

Dates Collected	# of Days	Approx. Hrs	Lbs. Collected	Lbs. /Hr.	Donor Acreage	Lbs./ Acre	Dates Donor Sites Burned
10/11/05-10/19/05	6	32	309	9.6	30.4	10.2	6/13/2003
10/9/06-10/16/06	6	36.5	228	6.3	18.6	12.3	7/30/02, 1/29/03, 6/6/03, 6/9/04
10/9/08-10/17/08	6	27	302	11.2	21.4	14.1	7/5/06, 7/10/06, 7/16/07
10/12/09-10/16/09	5	15	134	8.9	19.9	6.7	2/21/07
Mean	-	-	-	8.8	-	10.8	-

SEED COLLECTION METHODS

Mechanical Method

On FWC restoration sites, native seed is usually collected using a flail-vac mounted on the front of a tractor (Figure 13). The flail-vac utilizes a series of rotating brushes that are driven by the PTO of the tractor and seed is collected much like a vacuum cleaner picks up dirt. The rotating brushes strip the seed from the stem and deposit the seed in a large hopper. Most any sized tractor that has a front arm assembly and bucket attachment to mount the flail-vac can be used. Medium sized tractors (e.g., 80-100 hp) offer the best maneuverability while causing less vegetation damage and soil compaction to the collection site.

Figure 13. Proper positioning of flail-vac while collecting wiregrass seed at Three Lakes WMA. *(Photo by Steve Glass)*

Flail-vacs come in two different sizes for tractors: 6 and 12 foot models. The 6 foot model, which works especially well in areas with standing trees or other obstacles (e.g., fallen trees, stumps, uneven topography), is probably the best model for most seed collection. While the 12 foot model collects more seed, its size severely limits visibility; and it is heavier and more easily damaged than the 6 foot model. The 12 foot flail-vac is also wider than most tractors so when lining up the tire marks on each pass, there is overlap with the previous pass. With the 6 foot flail-vac, there is no overlap and a small strip of vegetation is actually left un-harvested, which may be desirable for the collection area. The best application for the 12 foot model is an area with little to no trees (e.g. dry prairie) or other obstacles.

There is also a 4 foot flail-vac made for ATVs which allows collecting in densely treed areas or other places inaccessible by tractor. While collecting from these areas may increase the diversity of native seed, more time will be needed to collect enough seed for large planting sites.

PROS AND CONS OF DIFFERENT FLAIL-VAC MODELS (SIZES)		
Model/ Length	**Advantages**	**Disadvantages**
Tractor 6 Foot	• Considered the best model for most seed collection. • Works especially well in areas with trees or other obstacles (e.g. uneven terrain) • Has minimal overlap and a some vegetation is actually left un-harvested, which may be desirable	• Leaves areas unharvested thereby collecting less seed
Tractor 12-Foot	• Collects more seed	• Size severely limits visibility; equipment is heavier, and more easily damaged. • Wider than most tractors so when lining up the tire marks on each pass, there is overlap with the previous pass
ATV 4 Foot	• Especially good for collecting seed in densely treed areas or other places inaccessible by tractor	• Has low clearance level and can be difficult to maneuver in areas with fallen debris.

Seed collection should be done after the morning dew has dried; collecting while vegetation is wet is not effective and should be avoided. Collection should also be done in a systematic manner, and use of a GPS unit within the tractor is recommended for efficient tracking. The GPS tracking record can be used later for monitoring possible effects of seed harvesting on donor sites.

Typically, the tractor speed during collection should be between 2 and 2.5 mph, and the bypass valve on the flail-vac should be near the top of the green mark with some gold showing. The tractor operator will need to experiment with the positioning of the opening in the flail-vac but in general, the opening needs to be angled so seed heads are hitting the brushes inside. The operator should also position the flail-vac opening so as to minimize collecting excess stems, leaves and other debris. If multiple tractors are being used, it is more efficient if they work in tandem side-by-side.

Seed collected with a flail-vac, will need to be emptied from the bucket and dumped on a trailer for transport to a storage facility (Figure 14). A 6 ft x12 ft or larger trailer, spread with plastic sheeting, and located in a shaded area, works well. In productive areas with thick wiregrass and lopsided Indiangrass, the flail-vac will need to be emptied at least once per hour. When the trailer is full, the plastic sheeting can be collected, secured with duct

tape or bungee cords, and transported to a facility where the seed is to be dried. The date, time, and place of seed collection should be written on the plastic sheeting.

At a storage/drying facility, such as an open pole barn or other covered building, the seed should be spread out to dry in a thin layer so there won't be pockets of damp seed (Figure 15). It is very important that the seed not remain sealed inside the plastic any longer than necessary, as heat and moisture can cause it to ferment and spoil.

Figure 14. Trailer for native seed collection *(Photo by Steve Glass)*

Turn the seed over periodically, to optimize drying. Additionally during the drying process, remove twigs, stems, leaves, and other non-seed vegetation that can clog the seed chutes of planting equipment. Seed will usually dry within 3 days; occasionally, more time is needed if the seed was wet during collection. Less time may be needed to dry seed if it is to be planted within a week of collection. Seed should not be damp or clumped together as it will not properly go through the Grasslander and planting will be uneven.

Once the seed is dry, it can be bagged into heavy duty plastic burlap sacks (see Appendix A: *Seed Collection and Planting Equipment Contractors*). Do not pack the seed too tightly as remnant trapped moisture may cause it to mildew and rot. A good rule of thumb is to put no more than 12 lbs of wiregrass or lopsided Indiangrass seed into any one bag. Label the bags with their filled weight, and the collection date and location (e.g. burn or management unit #). It is recommended that this information be recorded for determining seeding rates, donor sites seed production, and other operational planning uses. Once bagged, store the seed in a dry, well-ventilated area (preferably an air-conditioned facility) until it is ready to be planted. Seed should be planted as soon as possible but no more than 3-4 months after collection.

Figure 15. Lopsided Indiangrass seed drying at Three Lakes WMA. *(Photo by Steve Glass)*

Hand Collection Method

Although it is not a necessary component of successful groundcover restoration, supplementing the fall-collected seed with seed collected throughout the year, will increase the plant diversity on your site. Many plants that seed earlier than lopsided Indiangrass and wiregrass will be missed unless hand collecting is utilized. This can be done opportunistically as different plants are observed in seed, or more systematically with planned collections. This method can be time intensive so utilizing volunteer groups to hand collect different seed throughout the year may be a good option. Collecting seed by hand is easy and can be done by simply cutting flowers or stems with ripe seeds and putting them into brown paper bags.

Contracted Seed Collection

An alternative source for procuring seed is to hire a contractor for its collection. Contractors can be hired to collect seed from your chosen site or from their own sites. Seed can also be purchased from various native seed companies but be cautious as the seed may come from a genetically divergent source (e.g., from another state). It is difficult to compare prices by weight since Florida native seed is not cleaned like agricultural seed, and varying amounts of leaves and stems may be present in the mix. It may be also unrealistic to require a specific germination rate or other quantitative measures of seed quality, since weather, site preparation and other factors will affect these results. You can request that certain species be included in the mix, but again, amounts are difficult to quantify. You should require that a growing season burn was conducted on the collection sites, and ask for a DOF burn authorization number to confirm. If possible, visit the site to determine which native species are present and to check that aggressive exotics are absent. A list of species in seed at collection time should also be requested from the vendor. Since much depends on the vendor's knowledge and experience, ask for references and get recommendations from other FWC staff (Appendix A).

Grasses in seed and hand-collecting of seed by FWC Management Area staff at Three Lakes WMA. *(Photos by Steve Glass)*

CHAPTER 4: SEED PLANTING

PLANTING CONDITIONS

Planting of your groundcover restoration site can occur anytime after donor seed has been collected or procured; for most areas this means after early December. Although planting seed as soon as possible is desirable, it is also important that recipient site preparation is complete (see Chapter 2), and appropriate environmental conditions are met. For example, if the site is too wet or marginally wet, care should be taken not to plant too soon, especially if a period of above average precipitation is forecast. Planting should not be done when there is standing water or when the recipient site is damp enough for a tractor to cause ruts. Conversely, if the restoration site is too dry, it is best to wait until significant rainfall (0.5-1.0 inches) occurs and there is sufficient soil moisture so the seed does not blow away. To help determine the most appropriate time to plant, the National Weather Service, Climate Prediction Center website (http://www.cpc.noaa.gov/products/forecasts/) provides 6-10 day and 8-14 day forecasts for precipitation and temperature. A rain gauge located at or near the site to provide accurate rainfall information is also useful.

MECHANICAL PLANTING WITH A *GRASSLANDER*

The main method for seed planting on FWC restoration sites employs the *Grasslander*™ *No-Till Seeder*. The *Grasslander* uses a series of notched disks to create a small furrow and then broadcast the seed into the furrows via chutes. It also rolls the seed into the ground which is very important in establishing good seed to soil contact for germination. Both 5 and 8 foot models of *Grasslander* mechanical planters have been used in restoration plots but the 8 foot model has proven more durable and efficient. The *Grasslander* works best with a small tractor (around 55 HP). The tractor's smaller size causes less impact and rutting on a site, is more maneuverable, and provides greater visibility of the machine and its seed chutes. Additionally, a smaller tractor allows the operator and an assistant riding on the *Grasslander* to better communicate, and is easier to get on and off.

Figure 16. Grasslander gear setup for planting native seed

Prior to planting, the *Grasslander* should be modified so that the largest gear is used to maximize the amount of seed going through the chutes (Figure 16). Chute extensions can be made out of old tire tubes so there is less seed drift. In windy conditions, installing flaps on the side of the *Grasslander* will protect the chutes from wind; (tire flaps from

semi trucks work well). Finally, a rack or platform can be built on the back of the *Grasslander* to hold seed and accommodate an assistant (Figure 17).

Figure 17. Custom seating and storage rack built for 8 ft *Grasslander*

There have been some problems reported with the performance of the different *Grasslander* models. The 5 foot models (and to a lesser extent the 8 foot models) seem to have problems with the tines getting bent and rubbing against the seed bins. Seed chutes are known to clog up with seed stems and periodically need to be cleared. Gear pins also break but this can be minimized by limiting the stems, leaves and other debris in the seed mix (see Chapter 3: Seed Collection). There also have been some issues with tires wearing out and the steel belts in the tires coming unraveled.

Planting native seed is done much like you would plant any other type of agricultural seed. The tractor should make long, straight passes at a fairly slow speed (2-4 mph). At the end of each pass, top off the seed bin to ensure the target rates of wiregrass and lopsided Indiangrass are achieved. In some cases, multiple passes can be made to use any remaining seed and also to "double plant" the perimeter where adjacent exotic grasses may re-establish. The tractor operator should periodically check the seed chutes to make sure seed is falling out; an assistant riding on the back of the *Grasslander* should examine the chutes for blockage, and refill the seed bins. The disks at the front of the *Grasslander* should also be watched as pieces of roots or branches tend to get caught on them. A flap made from tape can be attached to the shaft of the *Grasslander* so the tractor operator can see if the shaft is actually turning and dispensing seed. A GPS unit should be on the tractor at all times and can be used to calculate the amount of seed being spread per acre, if seed bag usage is also properly tracked. This method of planting is a relatively slow process, taking approximately one hour to plant 1-1.5 acres.

Seeding Rates for Planting with a *Grasslander*

Usually a mixture of wiregrass, lopsided Indiangrass, and hand-collected seed are planted using the *Grasslander*. Fill the seed bin almost completely with wiregrass; add several large handfuls of well-separated lopsided Indiangrass, and a scattering of hand-collected seed. Seed collected on different days and from different areas should be mixed together to ensure a greater diversity of seed over a larger area.

The target amounts of seed to be planted are 10 lbs/acre of wiregrass and 2 lbs/acre of lopsided Indiangrass, plus varying amounts of hand-collected native seed, if desired. In general, if the seed mix has been collected with a flail-vac, plan to use between 10-15 lbs/acre. Seed mixes collected in Florida by flail-vac can be purchased from several companies (Appendix A). Actual seeding rates (lbs of seeds per acre) used by FWC vary by restoration site and year (Table 6).

Table 6. Amount of seed planted during planting seasons on selected WMAs.

Year	WMA/WEA	Acres Planted	Lbs of seed	Lbs per acre
2005	Three Lake WMA	42	464.5	11.1*
2005-06	Okloacoochee Slough WMA	33	645	19.5**
2006-07	Okloacoochee Slough WMA	44	1094	24.9**
20007-08	Okloacoochee Slough WMA	51	1112	21.8**
2009-10	Okloacoochee Slough WMA	20.2	249	12.3
2005-06	Half Moon WMA	23	250	10.9
2009-10	Half Moon WMA	15	170	11.3

*Wiregrass seed only; does not include approximately 1-2 lbs/acre of lopsided Indiangrass that was planted concurrently
**Portions of these plots were planted with 1, 2, or 3 passes of a Grasslander (approx. 12-13 lbs/acre/pass)

OTHER PLANTING METHODS

If seed collection and planting are contracted, harvesting with a "green silage cutter" is an option; however these machines are too expensive for FWC to consider as an in-house collection method. Green silage cutters cut stems and transfer the collected material directly to a semi-truck trailer pulled behind the cutter. Due to the large amount of plant material mixed in with the seed, special planters are also required. Fifty acres were planted using this method on Okloacoochee Slough WMA in 2003 (McCollom, Jean. 2005). Ten semi-trailer loads of cut plant material were spread on the 50 acres with good results. A custom-made modified tree sprigger was used for this planting, and a second tractor was necessary to load seed in the planter.

For small areas (i.e. less than an acre), planting can be done manually. This involves taking your seed mixture and spreading the seed by hand. Although this is an inefficient and less effective method of planting, it can be used for small areas that need to be re-seeded. Manual seeding is most successful when the seed is 'rolled' after planting.

From planting groundcover seed to planting pine seedlings, THCR staff work to make restoration successful at Three Lakes WMA. (*Photos by Steve Glass*)

CHAPTER 5: POST PLANTING MAINTENANCE

Post planting maintenance treatments should be an integral part of any groundcover restoration and are critical for success. Maintenance treatments can include weed control, animal damage control, prescribed burning, and other management techniques that are beneficial to restoration plantings. Post planting maintenance is expensive and labor-intensive so a commitment to funding and time should be in place before any site is planted.

WEED CONTROL

The goal of weed control is to reduce competition by eliminating aggressive exotic or native species so the planted seeds, especially the slower growing perennials, can become established. Any plant in excess can potentially be a problem. All exotics are not aggressive and some natives can be aggressive enough to cause damage. All Florida Exotic Plant Pest Council (FLEPPC) Category I and II exotics should be eliminated (Florida Exotic Plant Pest Council 2009). FWC's experience however has shown that some exotic pasture grasses, not on the FLEPPC list, can be the most aggressive weeds in a newly planted groundcover restoration area.

Major Problem Species Encountered

FWC restoration practitioners have found that certain frequently encountered weed species are especially problematic to control. Identifying these problem species, especially in early stages of growth, is a serious difficulty in post-planting maintenance. Since many of the invasive grasses are not on the FLEPPC list of exotic species, most contractors are unfamiliar with the plants' various growth stages and forms. Some major exotic and nuisance species encountered, and treatment options tried by FWC biologists on restoration sites are shown in Table 7. Also listed in the textbox below are some characteristics of young pest plants and general guidelines for their identification.

Treatment Methods for Weed Control

Spot Spraying of Herbicides

Spot spraying is the most effective way of treating exotic and nuisance plants in a newly planted groundcover restoration plot without affecting the planted seedlings. Spot spraying can begin as soon as species can be accurately identified. An early treatment to catch exotic plants while small and before seed maturation, is desirable. Treatment in late fall is optimum for mature grass species. Frequent follow-up treatments may be necessary in both cases.

Table 7. Treatment methods for groundcover restoration tried by FWC on major exotic problem species and native nuisance species.

Target Plant Pest	Treatment Methods	Treatment Timing or Extent	Treatment Success or Problems
BAHIAGRASS (*Paspalum notatum*)	Spot treat with glyphosate herbicide	As soon as possible, as often as possible	Successful, but may take several treatments
	Broadcast treat with imazapic herbicide	Late spring or early summer for seedlings; late fall for mature plants	Can suppress but not always kill bahiagrass; found to suppress or kill other desirable species
TROPICAL SODA APPLE (*Solanum viarum*)	Spot treatment with glyphosate herbicide or hand pulling; remove and dispose of all fruit	Can pull easily when <2" tall before large spines develop	Well controlled if caught early and no further ground disturbance occurs
SMUTGRASS (*Sporobolus indicus)*	Spot treat with glyphosate herbicide	Before seed develops (late May - June); repeat as often as possible	Persistent - may need repeated treatments
VASEYGRASS (*Paspalum urvillei)*	Spot treat with glyphosate herbicide	Treat early before seeds develop (by late May or June)	Does seem to decrease over time if native species are vigorous
BERMUDAGRASS *(Cynodon dactylon)*	Multiple treatments with glyphosate and/or imazapyr usually required to eliminate	Spray to farthest extent found, create a completely bare zone	Very difficult to treat post-planting; plants creep over large areas underneath native species; Plateau herbicide does not work
TORPEDO GRASS (*Panicum repens)*	Multiple treatments with glyphosate, imazapyr or both to eliminate	Apply liberally on all available leaves and stems	Very difficult to kill with spot treatments; Plateau herbicide does not work
NATALGRASS (*Rhynchelytrum repens)*	Spot treat with glyphosate	Very frequent spraying to avoid seed production.	Plateau herbicide does not kill it; may suppress seed production
HAIRY INDIGO (*Indigofera hirsuta)*	Spot treatment with glyphosate	Easily killed with glyphosate	Generally not treated but spot treatment if persists.
DOGFENNEL (Native) (*Eupatorium capillifolium)*	Mowing	Best in late summer; less successful in spring	Summer mowing eliminated regrowth but plants resprouted the next spring; on all sites cover diminished after the first year without any mowing
	Prescribed burning if natives are vigorous	Growing and dormant season	Doesn't burn well, need other fuels beneath it to carry fire
WAX MYRTLE (Native) *(Myrica cerifera)*	Spot treat with glyphosate if small; if older, treat with triclopyr	Early spot treatment is best	Triclopyr is for woody species; requires a separate coverage of the plot if used
	Prescribed Fire	Growing season only	In S. FL, fire 4 growing seasons after planting killed about 40% of wax myrtles
SALTBUSH (Native) *(Baccharis halimifolia)*	Spot treat with glyphosate if small; if older, treat with triclopyr	Early spot treatment is best	Triclopyr is just for woody species so requires a separate coverage
	Prescribed Fire	Growing season only	In S. FL, fire 4 growing seasons after planting killed about 80% of saltbush

IDENTIFYING CHARACTERISTICS FOR FREQUENT PROBLEM PLANTS

Good characters to look for when trying to distinguish between grasses or small forbs that can be seen while wearing a backpack sprayer:

- Color of the plant (is it a yellow-green, grayish-green, blue-green?)
- Texture (is it shiny, fuzzy, dull, and hairy?)
- Shape of leaf tips (are the leaves long pointed, blunt pointed, rounded?)
- How the leaves come out at the base (do the leaves come out all on one plane, i.e. flat and spread like a fan or in a round clump?)
- How the leaves are distributed on the stem (are they small and spread along the stem or do all the leaves come out of the base of the plant in one clump?)
- Differences in the edge of the leaf blade (some are hairy, some are wavy)

"If you look for these types of differences in the plants long enough, you'll get a "gestalt" image of what they look like standing up!" (Jean McCollom, 2009)

Some examples are:

Bahiagrass (*Paspalum notatum*) has many different looks depending on location, some are more of a grey-green, leaf tips pointed; usually the base of the plant near the ground is shiny and red/purplish colored and goes into the ground at a bit of an angle when it's older.

Smutgrass (*Sporobolus indicus)* has a yellow-green color, stems are round at the base near ground level, leaf tips are very long pointed, blades are fairly thin and narrow.

Torpedo grass (*Panicum repens)* is a bluish-green and has small leaves along a stem (not all coming out in a clump at ground level).

Vaseygrass (*Paspalum urvillei)* often has wavy leaf edges, even when small (but so does the desirable native, *Paspalum setaceum*); older plants have fairly broad leaf bases at ground level, these bases are not shiny and have rough hairs.

Bermudagrass *(Cynodon dactylon)* is often hidden under other plants; green to green-grey color, thin leaves in an alternate pattern on a single plane.

Natalgrass (*Rhynchelytrum repens)* is in bloom or seed most of the time so look for white or pink bloom to identify.

Hairy indigo (*Indigofera hirsuta)* has alternate compound leaves with 5-9 leaflets, the tip leaflet is the biggest; the plant is hairy and the pea type reddish flowers are in clusters.

FWC staff use backpack sprayers to spray individual plants at very close range and with very low pressure to avoid drift on neighboring plants. The wand is placed within an inch to less than one foot above the plant, and spray is directed at the center of the plant (Figure 18). If the plant is tall, the herbicide is dripped down the stem rather than sprayed. Spot spraying is slow going and is best done with several people forming a line. Temporary flags

Figure 18. Spot spraying: careful spraying with wand in center of plant at Okaloacoochee Slough WMA. *(Photo by Jean McCollom)*

can be placed along one side of the line to keep track of what has been sprayed. If only one person is spraying, setting up a grid helps track which plants have been treated. Herbicide treatments are most effective when plants are growing well; avoid spraying during droughts or extremely wet conditions that stress plants and limit chemical uptake.

A glyphosate herbicide is the first choice for spot treatments since it is taken up by the foliage and translocated systemically to act on treated plants. Also glyphosate is not active in the soil and therefore does not affect the roots of non-target plants. If only one coverage of the planted site is possible, glyphosate is the best herbicide for treatment of the most species. However, if time allows, other herbicides, that are more effective on specific species, can also be applied (Table 8).

Spot spraying can also be done with an imazapic herbicide. Drift from this herbicide has been found to be less damaging to neighboring desirable plants, but it is also not as effective on the toughest exotic species such as Bermudagrass, torpedo grass, and smutgrass. Specific chemical combinations are used by FWC for spot treatments (Table 8). If bahiagrass is a major problem, imazapic might be a better choice for spot spraying, especially on seedlings the first spring after planting.

Table 8. Herbicide types and combinations used by FWC for groundcover restoration herbicide treatments after planting.

Chemical Type	Rate	Species Controlled	Adjuvants
Glyphosate	2-5%	General	Various adjuvants including wetter/spreaders, stickers, ph regulators & dyes, such as Kinetic, Sunwet, ammonium sulfate.
Imazapic	1.50%	bahiagrass	
Imazapyr	2%	cogongrass, Bermudagrass, torpedo grass	
Imazapyr & glyphosate	1% Imazapyr; 3% glyphosate	cogongrass, Bermudagrass, torpedo grass	

Broadcast Spraying with Imazapic (Plateau) Herbicide

At this time, imazapic under the brand named *Plateau*, is the only commercially available formulation of this chemical that is not combined with other, more broad-spectrum herbicides. It is used to selectively target bahiagrass, and is only available to government agencies for restoration uses. The *Plateau* label gives rates for killing bahiagrass, hairy indigo, barnyardgrass (*Echinochloa crus-galli*), and vaseygrass, but claims only suppression of smutgrass, torpedograss, velvetleaf (*Abutilon theophrasti*), and Guineagrass (*Panicum maximum*). Few central and south Florida species are listed as tolerant of this herbicide, but bushy bluestem (*Andropogon glomeratus*), broomsedge bluestem (*Andropogon virginicus*), fingergrass (*Eustachys* spp.), and blackeyed susan (*Rudbeckia hirta*), as well as some Florida tree species, are listed as tolerant at rates of 2-12 oz/acre.

FWC has limited experience with broadcast spraying of imazapic but has collected information on its possible use from other sources. Plateau is not effective on some of the most undesirable exotics, such as Bermudagrass, smutgrass, and torpedo grass. However if bahiagrass is too common to effectively spot spray, broadcast spraying with imazapic may be a good option but could possibly kill some unintended species. Lopsided Indiangrass has been seriously affected on some restoration sites but only slightly affected on others. Slash pine has also been killed with aerial spraying on some sites.

OTHER REFERENCES ON IMAZAPIC USE

Imazapic evenly applied at 0.5% (9-12 oz/acre) did not kill wiregrass, encouraged legumes and composites, but did kill native lopsided Indiangrass, Paspalums, Hypericums, Cyperaceaes, and possibly pines. It was also noted imazapic did kill bahiagrass, Natalgrass, and vaseygrass. (Chris Matson (The Nature Conservancy, personal communication 2009))

Imazapic treatments (at 9-12 oz/acre) work best on bahiagrass seedlings in early June and on mature bahiagrass plants in the late Fall. Fall treatments stress but do not always kill the bahiagrass; treatments may adversely affect lopsided Indiangrass. (Nancy Bissett (The Natives, personal communication 2009))

Bahia seedlings are much more sensitive to imazapic (*Plateau* brand) than other seedlings; bahiagrass seedlings were severely affected at rates of 4-8 oz/acre. Injury to mature bahiagrass plants was found to vary with cultivar type. (University of Florida's North Florida Research and Education Center (2004))

Wicking or Wiping with Herbicides

This method is used for treating tall exotic or nuisance species like dogfennel. Herbicide is applied directly to the plants with a wick or spongy applicator on a bar which extends like a boom sprayer, from a vehicle. So far, FWC has not used mechanical wickers on groundcover restoration sites but several commercial models are available. Handheld wickers are also available and some models were tried by staff, but were too slow for use on large areas.

Hand Pulling

Pulling young exotics is very labor intensive and not practical in most cases. However, if a large volunteer workforce is available, this method could possibly be used for sites where individual species are easily identifiable. In south and central Florida, FWC used contracted herbicide crews to hand-pull tropical soda apple and hairy indigo.

Mowing

As a control method for problem species, mowing is most useful for tall-growing species. Advantages of mowing include opening up sites to additional sunlight and reducing competition for water and nutrients. Disadvantages of mowing include possible elimination of seed production by desirable natives, killing of desirable natives by tractor or bushhog tires, clippings covering and suppressing young seedlings, and release of additional exotics due to soil disturbance. Mowing should be done with the mowing deck as high as possible to avoid cutting as much of the non-target species as possible. It is best to avoid mowing when soils are very wet or very dry, since this can increase disturbance. Spring (April-

June) mowing can cause plants to spread horizontally so that they actually block more sunlight than plants not mowed.

FWC has tried mowing to reduce the amount of dogfennel cover. Three years after planting, whether mowed or not, all four initial restoration sites showed decreasing amounts of dogfennel (Williges et al., 2009). Monitoring data showed virtually no differences in mowed versus not mowed halves of one south Florida FWC plot (Jean McCollom, personal communication, 2009). Our land managers have mixed feelings about the success of this method and would recommend against mowing to control or reduce dogfennel, except in extreme cases.

ANIMAL CONTROL

Installed fencing had mixed success in protecting plantings from cattle and hogs. The types of fencing used included barbed wire, hogwire, and electric. In north central Florida, a barbed wire fence was used to keep cattle out of a planted area. Hogs were successfully controlled with electric fencing in central Florida. In south Florida, where hogs are dense, electric fence success varied. Electric fencing was less successful when soil moisture was insufficient to ground the hogs, and when high water came in contact with the wire. Hogwire fencing worked best; however, it is the most expensive.

Figure 19. Electric fence around groundcover restoration plot on Hilochee WMA.

All installed electric fences use solar chargers, are 3-wire with the central wire as a ground, and have the top wire 18-20 inches high (Figure 19.) Metal t-posts were found to be sturdier than plastic and fiberglass posts. Plastic and fiberglass posts are easily pulled out of the ground when hogs hit the wires. To keep electric fencing from shorting out, vegetation growing under the fence must be controlled. In south Florida, fences needed spraying with imazapyr at least once a year, or glyphosate several times a year. Trimming of vegetation is also required. Additionally, electric fences will also short out and not work if standing water touches the low wire.

In summary, electric fencing is cheaper but maintenance is very labor intensive, and may not work in some cases. If less maintenance time is available, hogwire fencing, though costing about twice as much, is another option which has proved maintenance-free.

FIRE

Fire is an important tool in maintaining groundcover in any system. The ability to burn an area regularly with growing season fires should be considered when choosing any groundcover restoration location. Generally a plot of perennial grasses can be burned when they have reached full size, have well established roots, and are large enough to easily carry a fire. This may vary from two to four years in most plots so burning after three growing seasons is a good rule of thumb; however plant maturity should be the deciding factor for when to burn. Fire has also been applied with mixed results to control undesirable species (herbaceous and woody) once native grasses have matured (Figure 20). Timing of burning is important because many exotics set seed if burned during the dormant season.

Figure 20. Wax myrtle and saltbush killed by a late July burning on Okaloacoochee Slough WMA (photo taken 1 day after the burn). *(Photo by Jean McCollom)*

DIFFERENT POST PLANTING MAINTENANCE METHODS TRIED ON FWC GCR SITES.

Spot Spraying of Herbicide - implemented on OK Slough, Hilochee, Half Moon, and Three Lakes WMAs *Seasons method was applied*: Year round, but spring and fall after planting is critical	Used to control any aggressive weedy species Okloacoochee Slough - Data from 16 spot treatments averaged 3.1 (1-6.6) gallons of herbicide mix per acre and took 2.7 (1.3-4.6) person-hours per acre.
Broadcast Herbicide – implemented on Half Moon And Three Lakes WMAs *Seasons method was applied*: best in spring or fall after planting	Used to control large amounts of bahiagrass Mixed results with imazapic in Central FL – killed once, only stressed another time.
Handpulling - implemented on 50 and 100 acres at Okloacoochee Slough and Hilochee WMAs using hand-held dibble sticks or pulling weeds wearing gloves; *Seasons method was applied* - early Feb and May.	Handpulling method was used to control small tropical soda apple seedlings, Vaseygrass, and hairy indigo with mixed success; early February timing when all seedlings had not sprouted may have caused less desirable results Average amount of time was approx. 1 acre/hr; (either using dibble sticks on 50 acres or hand-pulling using gloves on 100 acres).
Fire – implemented at OK Slough, Three Lakes and Half Moon WMAs. *Seasons method was applied:* Okloacoochee Slough – Late July (of the 4th growing season); Three Lakes – July but burn incomplete so redid in December; Half Moon – winter.	Prescribe Fire was used to control saltbush, wax myrtle Okloacoochee Slough - fire killed roughly 80% of the saltbush but only about 40% of the wax myrtles. Burning sooner after planting might be more effective, possibly the second or third year when the slower growing native perennial grasses are well developed and sufficient fuel is present. Three Lakes - the wiregrass returned vigorously but did not bloom Half Moon – winter burn improved native grass frequency and diversity
Fencing – installed on OK Slough, Hilochee, and Half Moon WMAs Types of fencing: barbed wire, electric and hog wire with wooden posts. Okloacoochee Slough - 4 miles electric fence surrounding 5-50 ac plots, and hogwire with wooden posts surrounding 50 acre plot (hog exclusion). Hilochee – electric fencing surrounding plot (hog exclusion). Half Moon – barbed wire fencing surrounding plot (cattle and hog exclusion).	Fencing was used to exclude cattle and hogs with mixed results. Electric fencing is cheaper but very labor intensive, and may not work in some cases. If less maintenance time is available, hogwire fencing, though costing about twice as much, proved to be maintenance-free. Okloacoochee Slough - Installation: 3- wire electric fencing w/ solar charger; posts were spaced every 12 feet, with 4-inch wooden fence posts at all corners and at all bends of 35 degrees or more, and a wood or metal t-post at least every 4th post within the fence. Remaining posts or t-posts were fiberglass with built in or attached insulators. Gates were made with 3 coiled electric wire pulls and 4 inch wood fence posts at each side. Top wire was 12-18” above ground; top and bottom wires were charged, with the middle wire as a ground; 14-gauge wire was used. Wire gates were charged the same. Hilochee – electric fence successfully excluded hogs; Half Moon - Cattle breached barbed wire fencing.

CHAPTER 6: MONITORING

Monitoring is used to determine the success of restoration and can provide information on what did or did not work, and why. As discussed in Chapter 1, a properly planned restoration project should attempt to meet clearly stated goals which are attainable through specific measurable objectives. Specific restoration objectives need to be set by FWC land managers for each site. The basic components of a complete and well-thought out objective include:

- what will be monitored (e.g. specific species, groups of species)
- attribute(s) to monitor (e.g. percent cover, density)
- action(s) to do (e.g. increase, decrease, or maintain)
- quantity of change (e.g. 20% cover, 500 individuals, etc.)
- time frame (most restoration plans are on a 5 year plan even if actions will be completed prior to 5 years).

The initial steps in designing a monitoring plan therefore, are to determine what needs to be measured in order to know if your restoration objectives have been met. FWC's THCR section, in cooperation with FWRI's Upland Habitat Research and Monitoring team, established a monitoring protocol which is discussed briefly below. Regardless of the type of groundcover restoration project, all sites will be monitored by FWRI according to this protocol. The primary question trying to be answered by FWRI's monitoring is: "has there been a change in species composition on the restoration sites over time?" In general, careful monitoring of first year plantings, followed by continued monitoring of major vegetation shifts until stable, will help clarify actions needed to achieve successful restoration.

VEGETATION MONITORING

Quantitative Vegetation Monitoring

FWC Methodology and Protocol for Vegetation Monitoring

For FWC groundcover restoration, the primary type of quantitative monitoring has been the sampling of vegetation parameters on the restoration area. Specific restoration objectives for the first five years after planting are established and a monitoring program is designed to determine the extent to which these objectives are being met. The current methodology used by FWC for quantitative vegetation monitoring is located at:
GCR Team SharePoint > Shared Documents > GCR Project Monitoring Plan_2008
A brief general description of the methodology is given in the box below.

FWC Groundcover Restoration Vegetation Monitoring Protocol Overview

The location of sample sites is determined by generating random points within the monitoring site boundary using ArcGIS and the Hawthorne's Analysis Tools extension. WMA managers supply FWRI with boundary shapefiles of both donor and recipient sites. Site mapping is conducted by FWRI in some instances. Coordinates of random points are downloaded onto dataloggers for navigation in the field using ArcPad software. At each random point, a 2 x 10 ft quadrat (see description below) is placed on the ground and oriented by random compass bearing.

The sample size (# of random point quadrats) is determined by calculating species-sample curves for each site. This is done by plotting the cumulative number of species against the cumulative number of physical samples. The number of samples is considered sufficient after the curve levels off. Currently, approximately 30 quadrats are sufficient to capture the majority of species present on the recipient sites, since very few new species are observed in subsequent quadrat samples. It is anticipated that species richness at the restoration sites will increase over time, and the number of quadrats sampled will be adjusted accordingly.

The sampling design was adapted from the method developed by the Ecosystem Research Corporation (©ERC, 1992, Gainesville, Florida) (Garren 1998). Monitoring of herbaceous vegetation is done within a 2 x 10 ft. quadrat. Each quadrat is divided into ten 2 x 1 ft. subsections.

- All plant species within the quadrat are identified.
- Frequency for each plant species is determined by counting the number of subsections in which that species is present.
- Percent cover is estimated for each species over the entire 2 x 10 ft quadrat using a 7 category classification system: <1%, 1-10%,10-30%, 30-50%, 50-70%, 70-90%, and >90%.
- Bare ground frequency and cover are also recorded.

Cover ranges are calculated for both the total sampled area and for occurrence area. Occurrence area includes only those quadrats where the particular taxa are observed.

This method provides a large number of individual frequency measurements for each recorded species while use of cover classes or ranges enables more consistent percent cover estimates to be made among sampling events and field personnel. Unlike traditional square plot techniques, use of an elongated quadrat provides a larger, spatially contiguous area of measurement. This allows small changes in vegetative patterns to be elucidated and is particularly useful on newly established sites where succession is rapid. This analysis yields a thorough assessment of the developing community and allows for detailed tracking of the migration of herbaceous species. Bare ground is tracked along with the vegetation so that an accurate measure of community establishment can be recorded over time.

Based on site specific objectives, FWRI staff has conducted vegetation monitoring and produced four summary reports for the years 2005-2008, titled *Vegetation Monitoring at FFWCC Native Ground Cover Restoration Sites* (Prenger et al. 2006b, 2007b) and (Williges et al., 2007, 2009, 2010). These reports can be found on the THCR/GCR Team SharePoint site at: *GCR Team SharePoint > Shared Documents > Reports > FWRI GCR Monitoring Reports*

Donor Site Vegetation Monitoring

Collecting vegetation data from a donor site provides information on species composition and density that can be compared with the planted recipient sites. FWC assesses donor sites before seed collection to determine which plants could contribute to the seed mix collected, and to track future changes to the site (Figure 21). Over time, as donor sites are re-used, monitoring data from consecutive samplings can be compared to determine the impacts of seed collection on the plant community. Soil disturbance, seed removal, or other

Figure 21. Babcock-Webb donor site monitored by FWRI.

factors may affect the donor site. As more donor sites are used, monitoring data can also help determine which donor sites contain the desired seed mix for individual recipient areas. Monitoring by FWC is currently only done on wiregrass donor sites but mixtures obtained from these sites may contain seeds of many other species.

Data collection and tabulation use the same methods as planted (recipient) sites. FWC donor site monitoring protocol and results are available in two reports (Prenger et al. 2006a and 2007a). A cursory list of species with seed at time of collection can also be recorded by field staff while harvesting a donor site. Additionally while harvesting, estimates of seed quantity by species can be made using categories such as abundant, common, frequent, occasional, and rare.

Seedbank Monitoring

Seedbank monitoring is an option for accessing baseline species presence and density in the seedbank. FWC conducted seedbank studies prior to site preparation on eight pastures slated for groundcover restoration (Prenger et al. 2006a, 2007a). The goal of these seedbank studies was to determine species presence and density in the seedbank and provide information on their desirability, invasiveness, and exotic status. Soil cores were collected and seed from the cores was grown in a greenhouse; making this method time and labor intensive. An alternative to seedbank studies is a comparison of plant species found on the restoration site, pre- and post-planting (McCollom 2005).

Figure 22. FWRI scientists collect soil cores for a seedbank study on Half Moon WMA.

Analyses for Quantitative Monitoring Data

For analyses of quantative monitoring data, some of the commonly used methods are *dominance curves, relative frequency, percent cover, floristic quality assessment*, and *similarity indices*. Additional information on and application of these analyses can be found in five summary reports titled *Vegetation Monitoring at FFWCC Native Ground Cover Restoration Sites* for the years 2005-2008 (Prenger et al. 2006b, 2007b), (Williges et al. 2007, 2009, 2010) and (McCollom 2005). General information on these analyses is given

below; see Appendix G for an example of the specific application of these analyses to a FWC restoration.

- *Dominance-diversity curves* plot total cover versus ranked abundance for each species and provide information on the level of diversity, and dominance by species.
- *Relative frequency* is recorded for each species. It can be used to determine seedling establishment in early stage monitoring and emphasizes plants where individuals may be small in size but large in number.
- *Percent cover* is a measure of the density of vegetation. It is recorded in cover classes (<1%, 1-10%, etc) for each species. It is used to show which species, or groups of species (native vs. exotic, early successional species vs. long-lived perennials, etc.) dominate the restoration site and how these interactions change over time. Cover values can also be compared with donor sites, and can indicate if fuels are dense enough to carry fire.
- *Floristic Quality Assessments* rank each native species along a numeric scale from low quality or "ubiquitous and very weedy", to high quality or "very microhabitat-specific and very rare plants". It uses metrics to indicate the quality of the sites based on the species present and is a fairly good indicator of whether the plant population of the restoration site is comprised of desirable or undesirable species.
- *Similarity Indices* can be used to determine how closely recipient sites resemble their donor sites; floristic composition of high quality donor site can be used as a goal or target for a restoration site.

All these analyses can be used to track changes in species composition over time on a site. The results can also be compared with other factors such as previous land use, site preparation and planting methods, and weather and hydrologic conditions during planting and young plant development.

Qualitative Vegetation Monitoring and Evaluation

Observation

Common qualitative criteria for evaluation of groundcover restoration success vary, based mainly on the observer's knowledge of native groundcover and their past experience. FWC biologists listed the following most frequently used observational evaluation criteria:

- Key species are often used as an indicator of success, especially wiregrass and lopsided Indiangrass, since mechanical seed collection times target these two species. Other long term perennials, like native lovegrasses (*Eragrostis* spp.), shortspike and splitbeard bluestems (*Andropogon brachystachyus* and *A. ternarius*), and gayfeathers (*Liatris* spp.) are also good indicators because these species are least likely to remain in a pasture seedbank.
- A visual assessment of high species diversity can be an indication of success, especially if many are desirable species.
- Amount of cover can indicate success. Too much bare ground can provide space for exotics, while moderate cover can give slower growing perennials room to get

established. Dense cover of just a few species such as flatsedges (*Cyperus* spp.) or dogfennel (*Eupatorium capillifolium*) might out-compete other species, but a dense cover of many desirable species would be a positive indicator.

- Presence and amount of aggressive exotics is another visual factor that may determine ultimate success. If exotics are too dense, it is difficult for native species to become established; it is also difficult to avoid affecting natives when applying herbicides to kill the exotics.
- Nuisance native species such as dogfennel, are often more of an eyesore than an indication of lack of success.

Photos

Photopoints can be best used to show gross changes in vegetation structure, density, or diversity over time. They are not a good method for detecting changes in groundcover composition as individual species are difficult to see and identify in photographs. Opportunistic photos with many plants in bloom, and therefore more distinguishable, are an excellent way of demonstrating changes that have occurred. Methodology for traditional photopoint monitoring has been developed by the USDA (Hall 2001). The Brevard County Environmentally Endangered Lands program has also developed a photopoint monitoring program with detailed documentation describing how to construct and set up permanent photopoints (Mojica et al. 2005). Any consistent photopoint method should provide good results; a link to more photopoint documentation can be found on the GCR SharePoint site: *GCR Team SharePoint > Shared Documents > Photo Point Monitoring*

EXOTICS MONITORING and ASSESSMENT

The most common cause of groundcover restoration failure is not eliminating aggressive exotics. Monitoring of site preparation herbicide treatments by FWC has been observational only. A systematic visual assessment of the whole field should be made for exotic species when plants emerge after each herbicide treatment (including spot treatments). If necessary, a botanist or person familiar with pasture grasses and exotics should aid in the appraisal. Continued retreatment, waiting for plants to emerge again, and rechecking for exotics should be repeated until all aggressive exotics are eliminated. To estimate the effectiveness of exotic control and to identify areas in need of follow-up spot-treatment, FWRI Upland Habitat scientists have conducted spring sampling on some restoration sites that were planted the previous fall. In addition to the general vegetation monitoring of a planted area, exotic species monitoring can also be done by the herbicide crew when spot treating. This monitoring method has been used at Okaloacoochee Slough WMA; details can be found in Appendix E.

OBSERVATION OF FACTORS THAT CAN INFLUENCE SUCCESS

Vegetation monitoring can determine the degree of restoration success but to understand what factors positively or negatively influence success, additional data needs to be collected. The number of factors that might be correlated with success is considerable. Since time and funding is limited, careful consideration of which parameters will provide the best measure of your objectives is critical, and should be done prior to the start of your project. FWRI's restoration monitoring plans have not been designed to compare data from all sites, by year or by region, as multiple variables must be taken into account. FWRI's Upland Habitat group stated "Monitoring efforts were never intended to be an experiment in which the variability of these parameters could be controlled but there may be some benefit into investigating possible correlations between population means and certain environmental factors such as soil type and rainfall" (Kent Williges, personal communication, 2009). Some practitioners note that further information is needed on early restoration site characteristics, site characteristics first year after planting, and site successional changes over time towards mature groundcover. Other types of observations, as described below, may be useful for determining when to initiate a particular groundcover restoration practice, for evaluating a specific restoration site objective, or as part of a separate study (e.g., seed bank studies).

Weather, Climate and Hydrologic Observations

Weather plays an important role in the success of a restoration effort. High temperatures, strong winds, and periods without rain, can dry out and kill seeds and young seedlings. On the other extreme, extended periods of standing water can drown young plants, and freezing temperatures can kill exposed seedlings. On-site weather monitoring is most accurate but data can also be collected from neighboring weather stations. Combining several stations in your surrounding area is more accurate than picking just the closest station since rainfall and cloud cover can be patchy, especially during the rainy season. In Florida, Water Management Districts have weather data available for downloading from the internet; for example, South Florida Water Management District's DBHydro website has hydrologic, meteorologic, hydrogeologic, and water quality data that can be downloaded from individual stations: SFWMD > DBHYDRO (Environmental Data) . Downloads of current and archived temperature, solar radiation, dewpoint, rainfall, wind speed and direction, relative humidity, evaporative transpiration, and wet bulb temperature collected at IFAS stations throughout Florida are available from the University of Florida's FAWN website.

Rainfall

Rainfall amount and pattern has a major influence on groundcover restoration during the first year. Because rainfall on site is so critical from planting through the first growing season, a simple rain gauge or even a bucket checked regularly, will give some indication of how moisture conditions may be influencing germination and growth.

Climatic Data Source Links and Contacts

Current and archived temperature, solar radiation, dewpoint, rainfall, wind speed and direction, relative humidity, ET, and wet bulb temperature:

University of Florida FAWN (Florida Automated Weather Network) website: http://fawn.ifas.ufl.edu/data/

Rainfall Data Sources

Florida Water Management Districts provide summarizations of rainfall data for a particular area and/or a particular time period. Data requests back to 2001, can be obtained for a basin, county, shapefile, or some other existing known location (i.e. lat/long). To request data for your area, contact the following person/WMD:

North West Florida WMD	Kris Barios (850-539-5999)
Suwannee River WMD	Megan Wetherington (386-362-1001)
St. Johns River WMD	Michael Daly (386-329-4494)
South West Florida WMD	Granville Kinsman(352-796-7211)
South Florida WMD	Chandra Pathak (561-682-2567)

Drought index sources

Keetch-Byram Drought Index (KDBI) – Florida Division of Forestry
http://flame.fl-dof.com/fire_weather/KBDI/index.html

Palmer Drought Severity Index – National Oceanic and Atmospheric Administration (NOAA)
http://www/drought.noaa.gov/palmer.html

GIS data - National Integrated Drought Information System
http://www.drought.gov/portal/server.pt.

Drought Index

Drought indices are a good climatic value to correlate with donor site burns and viable seed production, as well as recipient site success. The Keetch-Byram Drought Index, (KBDI) which indicates the dryness of the soil and surface fuels, is a tool used in prescribed burning and wildfire danger prediction. KDBI is available daily by district and county on the Florida Division of Forestry website. Other drought indices, such as the Palmer Drought Severity Index, are more oriented to agriculture and groundcover restoration plantings.

Water Level Monitoring

Wet and mesic flatwoods, and wet and dry prairies, where groundwater is often fairly close to the surface, may be naturally inundated for portions of the year. How close groundwater is to the surface could influence soil moisture and the outcome of plantings. Since groundcover plantings are influenced only by water levels close to the surface, a shallow well (<10 ft) can be used for groundwater monitoring. Data can also be correlated to nearby wells based on elevations above sea level.

Fire Monitoring

FWC has done no additional burn monitoring on restoration sites beyond the data collected for all our burns. Comparison of burn characteristics and weather data with production of viable seed might explain what conditions are most likely to initiate good seed production. Observations so far indicate soil moisture and drought may play a role in seed development, and burns conducted later in the growing season (when it is also wetter) may be more likely to produce seed (Steve Glass, personal communication 2009).

Wildlife Monitoring

Monitoring the response of wildlife to groundcover restoration areas may be used to demonstrate increased wildlife use of a site. This can be difficult however, since most restoration plots are relatively small compared to the home ranges of many animals. Before designing any type of wildlife monitoring of restoration sites, consult with FWC Taxa Coordinators and Regional Conservation Biologists to determine appropriate FWC approved protocols to use.

Big Bend WMA groundcover restoration site showing gopher tortoise and burrow on area.

Literature Cited

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Clewell, A., J. Rieger, and J. Munro. 2000**. Guidelines for Developing and Managing Ecological Restoration Projects.** A Society for Ecological Restoration Publication.

Florida Exotic Pest Plant Council. **2009 Invasive Plant List**. **http://www.fleppc.org/list/list.htm**

Garren, R.A. 1998. **Quantitative herbaceous monitoring methodology and associated summary statistics, a brief description of the procedures used to collect and analyze the CF Industries Plant City herbicide plot dataset**. Prepared for CF Industries, Inc. Plant City, FL by Robert A. Garren, Ecologist, Gainesville, FL, 10 pp.

Glass, Steve. 2009. Personal communication. Biological Administrator, Florida Fish and Wildlife Conservation Commission, Prairie Lakes Wildlife Field Office, Kenansville, FL

Hall, Frederick C. 2001. **Ground-based photographic monitoring**. Gen. Tech. Rep. PNW-GTR-503. Portland, or: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 340 p. http://www.fs.fed.us/pnw/pubs/gtr503/

Matson, Chris. 2009. Personal Communication. Restoration Biologist. The Nature Conservancy. Disney Wilderness Preserve. Kissimmee, FL.

McCollom, Jean. 2005. **Restoration of Native Groundcover Vegetation on Abandoned Improved Pasture at Okaloacoochee Slough Wildlife Management Area**, Contract Number OT040604 submitted to the South Florida Water Management District Big Cypress Basin Watershed Initiative. Florida Fish and Wildlife Conservation Commission, Okaloacoochee Slough Wildlife Management Area, P.O. Box 716, Felda, FL 33930. 95pp.

McCollom, Jean. 2006. **Restoration of Native Groundcover Vegetation on Abandoned Improved Pasture at Okaloacoochee Slough Wildlife Management Area**, Contract Number OT051030 submitted to the South Florida Water Management District Big Cypress Basin Watershed Initiative. Florida Fish

and Wildlife Conservation Commission, Okaloacoochee Slough Wildlife Management Area, P.O. Box 716, Felda, FL 33930. 11 pp.

McCollom, Jean. 2009. Personal Communication. Wildlife Biologist, Florida Fish and Wildlife Conservation Commission, Okaloacoochee Slough WMA, Felda, FL.

Mojica, Raymond, Mike Knight, and India Dawn Clark, and Briana Donahue. 2005. **Reproducible Panoramic Photo-point Guidelines**. PDF file available from Brevard County Environmentally Endangered Lands Program at http://www.eelbrevard.com/index.php ,4673 KB, 26pp.

Nagid, Stefanie M. 2007. **In the Beginning, There was Planning**. Presented at the *Applied Management on Conservation Lands in Florida* meeting. June 20-22, 2007. Orlando, FL

North Florida Research and Education Center Newsletter. 2004. **Plateau Herbicide Update**. Volume 6 Issue 6 March 2004. Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL. page 2.

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Prenger, Joseph, Alex Caffrey, Kent Williges, John Baker, and George Otto. 2007a. **Determination of Seed Bank Constituents at FFWCC native Ground Cover Restoration Sites, September 2006-March 2007 (FY 06-07 Final Report).** Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Ecosystem Assessment and Restoration Section, Upland Habitat Research and Monitoring, 4005 S. Main Street, Gainesville, FL 32601. 9 pp.

Prenger, Joseph, George Otto, Kent Williges, and John Baker. 2006b. **Vegetation Monitoring at FFWCC Native Ground Cover Restoration Sites, November 2005-February 2006 (FY05-06 Year 1 Report).** Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Ecosystem Assessment and Restoration Section, Upland Habitat Research and Monitoring, 4005 S. Main Street, Gainesville, FL 32601. 41 pp.

Prenger, Joseph, Alexis Caffrey, George Otto, Kent Williges, and John Baker. 2007b. **Vegetation Monitoring at FFWCC Native Ground Cover Restoration Sites,**

November 2005 – February 2007 (FY06-07 Year 2 Report). Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Ecosystem Assessment and Restoration Section, Upland Habitat Research and Monitoring, 4005 S. Main Street, Gainesville, FL 32601. 47 pp.

The Nature Conservancy. 1998. **Restoration Procedures Manual for Public Lands in Florida.** Prepared for FL Dept. of Environmental Regulation by TNC, 6075 Scrub Jay Trail, Kissimmee, FL 34759. 130pp.

Williges, Kent, Kori Jacobs, John Baker, Joe Prenger, and George Otto. 2007. **Vegetation Monitoring at FFWCC Native Ground Cover Restoration Sites, October 2006 – June 2007 (Spring 07 Monitoring Report).** Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Ecosystem Assessment and Restoration Section, Upland Habitat Research and Monitoring, 4005 S. Main Street, Gainesville, FL 32601. 67 pp.

Williges, Kent, Johanna Freeman, Amber Pouncey, and Shawn Clemons. 2009. **Vegetation Monitoring at FFWCC Native Ground Cover Restoration Sites June 2007-December 2008 (2008 NGCR Monitoring Report)**, Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Ecosystem Assessment and Restoration Section, Upland Habitat Research and Monitoring, 4005 S. Main Street, Gainesville, FL 32601. 89 pp.

Williges, Kent, Johanna Freeman, Amber Pouncey, and Michael Stevens. 2010. **Vegetation Monitoring at FFWCC Native Ground Cover Restoration Sites April 2009-December 2009 (2009 NGCR Monitoring Report)**, Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Ecosystem Assessment and Restoration Section, Upland Habitat Research and Monitoring, 4005 S. Main Street, Gainesville, FL 32601. 81 pp.

Williges, Kent. 2009. Personal communication. Research Associate, Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Gainesville, FL.

Appendix A: Useful Resources for Groundcover Restoration*

General Groundcover Restoration Information

Websites

FWC's Groundcover Restoration Team SharePoint site:
http://portal.fwc.state.fl.us/DOI/Divisions/HSC/THCR/GCR/default.aspx

Society for Ecological Restoration (and *Ecological Restoration* journal online (limited access)): *http://www.ser.org/ (http://ecologicalrestoration.info/)*

Selected Groundcover Restoration Literature References (from GCR SharePoint site, Shared Documents, Excel spreadsheet titled "GCR Bibliography"):
http://portal.fwc.state.fl.us/DOI/Divisions/HSC/THCR/GCR/Shared%20Documents/Forms/AllItems.aspx

Publications, Journals, and Selected Print References

Ecological Restoration (Journal published by University of Wisconsin Press): (see online link above)

Restoration Ecology (The Journal of the Society for Ecological Restoration International, published by Wiley-Blackwell)
http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1526-100X

Cramer, V.A. and R. J. Hobbs. 2007. **Old Fields: Dynamics and Restoration of Abandoned Farmland**. Island Press, Washington, DC

Pfaff, S., M.A. Gonter, and C. Maura. 2002. **Florida Native Seed Production Manual.** USDA-NRCS Brooksville Plant Materials Center and Florida Institute of Phosphate Research, Brooksville, FL. Jun. 2002.

The Nature Conservancy. 1998. **Restoration Procedures Manual for Public Lands in Florida.** Prepared for FL DEP by The Nature Conservancy, Kissimmee, FL. 130pp.

Trusty, J.L., and H.K. Ober. 2009. **Groundcover Restoration in Forests of the Southeastern United States.** CFEOR Research Report 2009-01. University of Florida, Gainesville, FL. 115 pp.

Plants – Native, Exotics, and Weeds

Websites

Atlas of Florida Vascular Plants (UCF), (searchable by common or scientific name with info and photos): http://florida.plantatlas.usf.edu/Default.aspx

USDA Natural Resources Conservation Service Plants Database, (searchable by common or scientific name with photos, drawings & regional maps): http://plants.usda.gov/

FNAI Field Guide to the Rare Plants and Animals of Florida Online. (searchable by common or scientific name and county): http://www.fnai.org/fieldguide/search_001.cfm

Identification of Grass Weeds in Florida Citrus (Univ. of Florida, IFAS Extension publication #HS955): http://edis.ifas.ufl.edu/scripts/hs175

Identification of Sedge and Sedge-Like Weeds in Florida Citrus (Univ. of Florida, IFAS Extension publication #HS962): http://edis.ifas.ufl.edu/hs205

Grasses and Sedges and Rushes of Palm Beach and Martin Counties, Florida. (Grass biology, a grass key and photos): http://floridagrasses.org/index.htm

Florida Exotic Pest Plant Council (includes FLEPPC lists, publications, and management plans): http://www.fleppc.org/

Invasive Weeds, EDIS, Univ. of Florida, IFAS Extension (includes identification, biology, and treatment for selected group of invasives): http://edis.ifas.ufl.edu/topic_invasive_weeds

Center for Aquatic and Invasive Plants, University of Florida, IFAS: http://plants.ifas.ufl.edu/

Nonnative Invasive Plants of Southern Forests, A Field guide to Identification and Control, (online version of USDA Forest Service publication): http://www.srs.fs.usda.gov/fia/data_acquisition/field_guide/Nonnative_Invasive_Plants_of_Southern_Forests.pdf

Publications, Journals, and Selected Print References

Wunderlin, R. P., and B. F. Hansen. 2003. **Guide to the vascular plants of Florida**, 2nd edition. University Press of Florida. Gainesville, FL.

Tobe, J. D. *et al*. 1998. **Florida Wetland Plants, an Identification Manual.** Dept. of Environmental Protection and Univ. of Florida Press. Tallahassee, FL. 598 pp. (*Oriented toward wetter species, descriptive text, photos and drawings*)

Godfrey, R. K. and J. W. Wooten. 1981. **Aquatic and Wetland Plants of Southeastern United States. 2 Volumes. Monocotyledons and Dicotyledons**. Univ. of Georgia Press, Athens, Ga. 712pp and 933pp. (*Very good detailed descriptions, keys, and good drawings*)

Langeland, Kenneth. A. **Natural Area Weed Management, A Training Manual for Restricted Use Pesticide Applicators.** Available from IFAS-Extension Bookstore 1-800-226-1764 or http://ifasbooks.ufl.edu (*Good introduction to the types of herbicides and adjuvants, application methods, and where to use which chemicals*)

Natural Communities and Ecosystems

Websites

Guide to the Natural Communities of Florida, 2009 Update, Florida Natural Areas Inventory: http://www.fnai.org/natcomguide_update.cfm

Publications, Journals, and Selected Print References

Myers, R. L., and J. J. Ewel. 1990. **Ecosystems of Florida**. University of Central Florida Press. Orlando, FL.

Whitney, E., D.B Means, and A. Rudloe. 2004. **Priceless Florida: Natural Ecosystems and Native Species**. Pineapple Press. Sarasota, FL.

SOIL SURVEYS

Websites

USDA, NCRS Soils, Published Soil Surveys for Florida (by county): http://soils.usda.gov/survey/printed_surveys/state.asp?state=Florida&abbr=FL

LIST OF GCR CONTRACTORS

Native Seed Collection and Planting Contractors

Ernst Conservation Seeds and Ernst Southern Native Seeds, 9006 Mercer Pike, Meadville, PA 16335; (800)-873-3321; ernstsales@ernstseed.com (catalogue available)

The Natives, Inc. 2929 J. B. Carter Road, Davenport, FL 33837; (863)422-6664; *http://thenatives.net/* ; Nancy Bissett, Botanist, Restoration Ecologist; nbissett@natives.net

Seed Collection and Planting Equipment Contractors

Grasslander, (Native seed planting equipment) Rt #1 Box 56, Hennessey OK 73742; (405)853-2607; *www.grasslander.com*; Chuck Grimes, owner; email available on website.

Native Seedsters, Inc. (Native seed harvesting equipment), 100 Poly Dr., Suite 150, Billings, MT 59101; (406)-294-2995; *www.nativeseedster.com*; Marty Malone, Sales Engineer, marty@nativeseedsters.com

Woodward Flail-vac seed strippers, Ag-renewal, Inc; (Native seed harvesting equipment); (800)658-1446; *http://ag-renewal.com/FLAIL-VAC.htm* ; email: ag-renewal@itlnet.net

Gulf Coast Bag & Bagging Co., Inc., (Plastic burlap bags, 30" x 46"); 3914 Westhollow Pkwy, Houston, TX 77082; (281)556-8500; *http://www.gulfcoastbag.com/*

LIST OF GCR CONTACTS

Nancy Bissett: Botanist, Restoration Ecologist. The Natives, Inc., Davenport, FL. nbissett@natives.net

Chris Matson: Restoration Biologist. (formerly with The Nature Conservancy, Disney Wilderness Preserve); currently at Florida Fish and Wildlife Conservation Commission, Lake Wales Ridge WEA Field Office, Lake Placid, FL 33852 Christopher.Matson@MyFWC.com

Stefanie Nagid: Natural Resources Management Program Coordinator, Nature Operations Division, City of Gainesville, Gainesville, Florida 32641 nagidsm@cityofgainesville.org

David Prentiss: Restoration Biologist. The Nature Conservancy. Apalachicola Bluff and Ravines Reserve, Bristol, FL. 32321

Debi Tharpe: Restoration Biologist. The Nature Conservancy. Disney Wilderness Preserve, 2700 Scrub Jay Trail, Kissimmee, FL 34759

*Note: This list is by no means complete and your input for more Useful GCR Resources is needed; please email any useful resources to: Katherine.Marois@myfwc.com

Appendix B: Site Assessment Checklist

SITE ASSESSMENT CHECKLIST

Project Name _____

EXISTING SITE CONDITIONS: Status Source Location

Location/Boundary map _____

Aerial photos _____

Topography map _____

Soils map _____

Hydrology map _____

Plant communities map_____

Wetlands issues on-site _____

Wildlife issues on-site _____

Special elements on-site _____

Cultural sites on-site _____

SITE ISSUES:

1. Land use and conditions/physical structures: (exotics, trash piles, dip vats, poaching, access, pastures, borrow pits, buildings, roads, fences, ditches)

2. Policy Issues: (existing or future policies to which the site must conform, management policies)

3. Legal Issues: (easements, title restrictions, MOU's)

4. Surrounding Conditions: (ownership surrounding the project site, current status of adjacent tracts, future development)

HISTORICAL CONDITIONS: Year Source Area Covered Location

Aerial photos _____

Other info _____

Appendix C: Common and Scientific Names of Plants

Table of Scientific and Common Names for Plant Species referred to in Guidebook

COMMON NAME	SCIENTIFIC NAME	SYNONYMS or ALTERNATE COMMON NAMES	COMMENT
Bahiagrass	*Paspalum notatum*		
Barnyardgrass	*Echinochloa crus-galli*		
Bermudagrass	*Cynodon dactylon*		
Blackberry	*Rubus cuneifolius* and *Rubus pensilvanicus*	Alternate common names are “sand blackberry” & “sawtooth or Pennsylvania blackberry”	These 2 species listed in *Atlas of Florida Vascular Plants* are commonly called “blackberry”
Blackeyed susan	*Rudbeckia hirta*		
Broomsedge bluestem	*Andropogon virginicus*	*Andropogon virginicus* var. *decipiens*	Synonym is for common name “broomsedge bluestem”
Bushy bluestem	*Andropogon glomeratus*		
Cogongrass	*Imperata cylindrica*		
Dogfennel	*Eupatorium capillifolium*		
Fingergrasses	*Eustachys* spp.	*Chloris* spp.	Both genera have multiple species commonly named “fingergrass(es)”
Flatsedges	*Cyperus* spp.		Multiple species in this genus commonly named “flatsedge”
Gayfeather	*Liatris* spp.	Alternate common name is “blazing-star”	Multiple species in this genus commonly named “gayfeather”
Hairy indigo	*Indigofera hirsuta*		
Lovegrasses	*Eragrostis spp.*		Multiple species in this genus named “lovegrass
Lopsided Indiangrass	*Sorghastrum secundum*		
Natalgrass	*Melinis repens*	*Rhynchelytrum repens*	
Saltbush	*Baccharis halimifolia*		
Shortspike bluestem	*Andropogon brachystachyus*		
Splitbeard bluestem	*Andropogon ternarius*		
Smutgrass	*Sporobolus indicus*		
Torpedo grass	*Panicum repens*		
Tropical soda apple	*Solanum viarum*		
Vaseygrass	*Paspalum urvillei*		
Velvetleaf	*Abutilon theophrasti*	Alternate common name is “butterprint”	
Wax myrtle	*Myrica cerifera*	Alternate common name is “southern bayberry”	
Wiregrass	*Aristida stricta*	*Aristida stricta* var. *beyrichiana*	

Appendix D: Common Herbicide Chemical and Brand Names

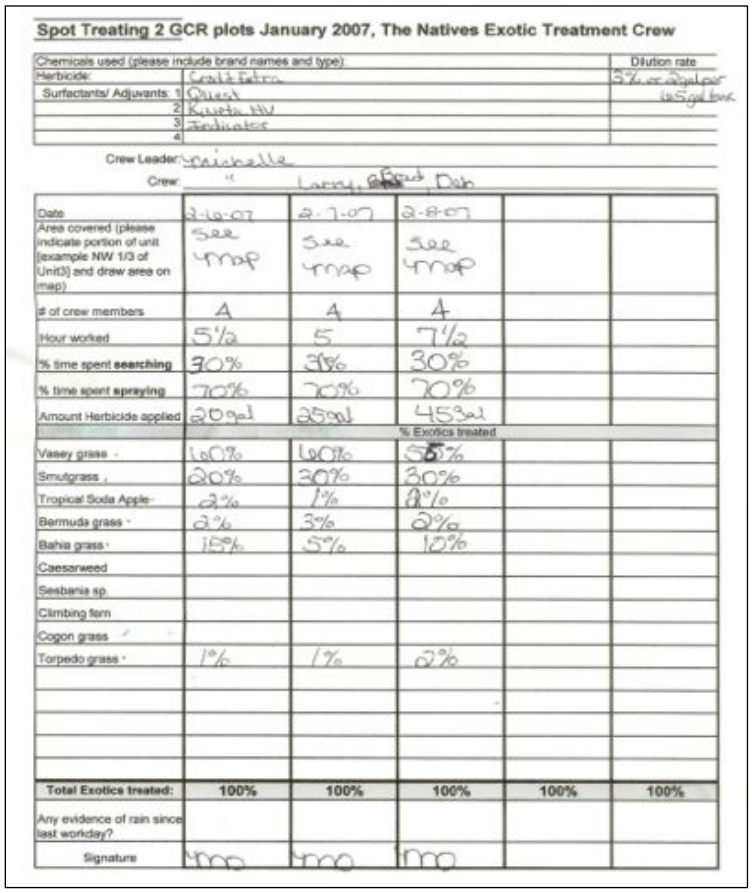
Table of Herbicides Commonly Used for Groundcover Restoration in Florida.
(Note that different brand names use different formulations or percent active ingredient.)

Chemical Name	Brand Names	Comments
aminopyralid	***Milestone, Forefront***	Very potent, affects broadleaf plants; persistent & mobile in soil, absorbed by foliage & roots; half-life = 34-100 days but up to 17 mo.
glyphosate	***Accord, Alecto, Aquastar, Buccaneer, Cinco, Cornerstone, Credit, Durango, Honcho, Mirage, Ranger, Rattler, Razor, Rodeo, Roundup, Roundup Pro, Shackle, Touchdown***	Non-selective, broad spectrum, absorbed by foliage; binds to soil molecules, i.e., inactive in soil; half-life =47 days
hexazinone	***Velpar L***, ***Velpar ULW***, ***Pronone Power Pellets***	Non-selective, broad spectrum; controls some grasses, many annual & perennial broadleaves, & some woody species; mobile in soil; half-life = 90 days
imazapic	***Plateau***	Controls selected annual & perennial grasses & broadleaf plants; half-life = 120 days
imazapyr	***Arsenal***, ***Assault***, ***Chopper, Habitat, Polaris, Stalker***	Non-selective, broad spectrum, persistent & mobile in soil, absorbed by foliage & roots; half-life = 25-142 days but up to17 mo.
metsulfuron methyl	***Escort***	Many grasses tolerant at low levels; half-life=30 days
sulfometuron methyl	***Oust***	Very potent, broad spectrum, half-life= 5-33 days but persists in soil for up to one year
tryclopyr amine	***Garlon 3A, Brush-B-Gone****, ***Brush Killer**** , ***Confront, Crossbow*** *(with 2,4-D ester)*, ***Remedy***	Grasses more tolerant than broadleaves; readily absorbed by leaves & roots; half-life = 30 days
tryclopyr ester	***Access, Garlon 4***, ***Pathfinder II, Turflon***	Ester form absorbed more rapidly; half-life = 30 days
2, 4 – Dichloro-phenoxyacetic acid	2,4-D ester, ***Gladeamine, Riverdale LV4, Opiamine, Solution, Weedar 64, Weedone***	Grasses more tolerant than broadleaves; half-life = 10 days

* lower concentration for homeowners

Appendix E: Monitoring Method for Exotic Species Control Used at Okaloacoochee Slough WMA

The herbicide spraying crew estimates how much of their time was spent actively searching for plants to spray versus actually spraying plants after they are located (Figure E1). The crew also estimates how much of each problem species they treated that day. Area sprayed each day is also recorded on a map (Figure E2) or GPS track. Data are used to monitor progress in reducing each exotic species within the plot (Figures E3 and E4).



Spot Treating 2 GCR plots January 2007, The Natives Exotic Treatment Crew

Chemicals used (please include brand names and type):					Dilution rate
Herbicide:	Garlon Ultra				3% or 3qt per 100gal tank
Surfactants/ Adjuvants: 1	Quest				
2	Kinetic NV				
3	Indicator				
4					

Crew Leader: Danielle
Crew: " Larry, [redacted], Deb

Date	2-6-07	2-7-07	2-8-07		
Area covered (please indicate portion of unit [example NW 1/3 of Unit3] and draw area on map)	See map	See map	See map		
# of crew members	4	4	4		
Hour worked	5½	5	7½		
% time spent **searching**	30%	30%	30%		
% time spent **spraying**	70%	70%	70%		
Amount Herbicide applied	20gal	25gal	45gal		
			% Exotics treated		
Vasey grass	60%	60%	55%		
Smutgrass	20%	30%	30%		
Tropical Soda Apple	2%	1%	0%		
Bermuda grass	2%	3%	2%		
Bahia grass	15%	5%	10%		
Caesarweed					
Sesbania sp.					
Climbing fern					
Cogon grass					
Torpedo grass	1%	1%	2%		
Total Exotics treated:	**100%**	**100%**	**100%**	**100%**	**100%**
Any evidence of rain since last workday?					
Signature	[redacted]	[redacted]	[redacted]		

Figure E1. Datasheet filled in daily by the herbicide crew when spot treating exotic species in groundcover restoration areas.

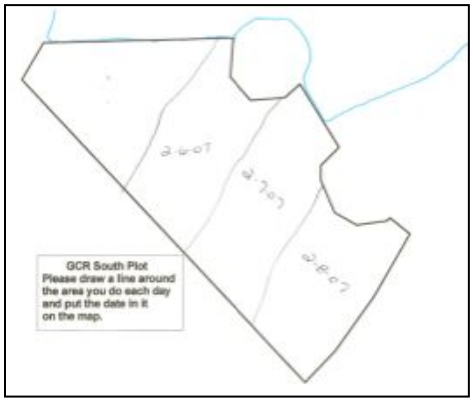


Figure E2. Example of outline map given to herbicide crews to mark the area they treat each day.

Figure E3. Data recorded by the herbicide crew during three post-planting spot treatments to kill aggressive problem species in the 50-acre North Plot GCR area planted Winter 2005-6 at Okloacoochee Slough WMA.

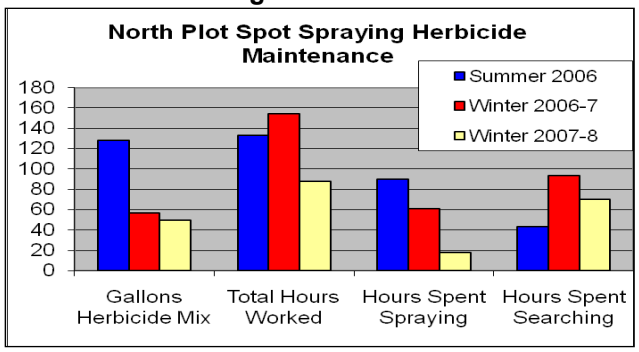


Figure E3 graphs the amount of herbicide used and total work time, as well as time spent spraying, and searching for exotics. This calculation is used to determine if amount of effort or quantity of herbicide are decreasing over time; which can be a useful measure of control. Another calculation is used to determine the amount of time spent spot-spraying herbicides on individual problem species (Figure E4). Each day crews record what percent of each species is treated that day. The percent for each species is then multiplied by time (in hours) spent actually spraying (not searching) that day. Days are totaled to determine hours spent on each species during that round of treatment.

Figure E4: Data recorded by the herbicide crew during three post-planting spot treatments to kill aggressive problem species in the 50-acre North Plot GCR area which was planted Winter 2005-6 at Okloacoochee Slough WMA.