Cutthroat Grass Communities

FNAI Global Rank:	**G2**
FNAI State Rank:	**S2**
Federally Listed Species in S. FL:	**1**
State Listed Species in S. FL:	**13**

Cutthroat grass community.
Original photograph by Betty Wargo.

Cutthroat grass (*Panicum abscissum*) is a central peninsular Florida endemic species, found in scattered locations from Orange County south to Palm Beach County. However, it seems to dominate natural communities almost exclusively within Polk and Highlands counties, in association with the sideslopes of the central Florida Ridges. Cutthroat grass communities are mostly associated with areas of slight to strong groundwater seepage; however, not all cutthroat grass communities are well-developed seepage slopes.

Cutthroat grass communities fall into several community types-a cutthroat grass seepage slope complex with 11 microhabitat zones, cutthroat grass mesic flatwoods and dry prairies, cutthroat grass wet flatwoods, cutthroat grass depression marsh margins, cutthroat grass ecotones between flatwoods and drainageways, cutthroat grass wet prairies, and slash pine/cutthroat grass "basin swamp." Each of these can be characterized by differences in landform, topographic position, hydrology, soils, and dominant or characteristic plant species. The cutthroat grass seepage slope complex consists of distinct vegetation zones which vary in hydrology, soils, and species composition, ranging from dry cutthroat grass with only subsurface soil saturation, to mixed herbaceous seepage slopes with a constant year-round water table at the surface of the deep muck soil.

Cutthroat grass communities require frequent fire for maintenance of the open, graminoid-dominated character of these areas. The greatest threats to the integrity of cutthroat grass communities are continued fire-suppression and drainage effects. Even on protected lands, many cutthroat grass communities are not fire-managed aggressively enough to preserve the biodiversity of these community types.

Cutthroat grass communities cover more than 5,800 ha (14,326 acres) at Avon Park AFR, the largest areal extent remaining for these communities. Diverse, fire-maintained cutthroat grass vegetation continuums with intact species-rich ecotones are now found only in association with the Bombing Range Ridge in Polk and Highlands counties, although they likely historically also occurred in association with the Lake Wales Ridge. These communities support large populations of the endemic *Hartwrightia floridana*, and disjunct populations of species which are more common in seepage slopes of the Florida Panhandle, such as *Myrica heterophylla* and *Rhynchospora oligantha*.

Synonymy

Seepage slope (in part), cut-throat seeps, cutthroat seeps, cutthroat grass seasonal ponds, cutthroat grass flatwoods, swale (Abrahamson *et al*. 1984). The FLUCCS code for the cutthroat grass community includes: 310 (herbaceous), 320 (shrub/brushland), and 411 (pine flatwoods).

Distribution

Cutthroat grass is a central peninsular Florida endemic species, found in scattered locations from Orange County south to Palm Beach County. However, it seems to dominate natural communities almost exclusively in Polk and Highlands counties, in association with the sideslopes of the central Florida Ridges. Most of the available information on cutthroat grass concerns the distribution and ecology of the species, rather than of the communities it dominates. To begin, it is important to contrast the distribution of this narrow endemic species with the distribution of cutthroat grass communities.

History and Distribution of Cutthroat Grass

Cutthroat grass was first described as a new species in 1940, from a 1925 collection made near Sebring, Florida. Most references give the distribution of the species as Polk and Highlands counties *(i.e*., Wunderlin 1982, Soil Conservation Service 1989). There are references to the occurrence of cutthroat grass in Hendry County (Yarlett 1965, 1981), however, Yarlett (1984, 1996) later dropped Hendry County from its range, and research for the *Atlas of Florida Vascular Plants* (Wunderlin *et al.* 1996) did not locate any herbarium specimen to document this report. In 1988, cutthroat grass was first located in Palm Beach County, near the western base of the Atlantic Coastal Ridge. The three known localities for this community in Palm Beach County are still extant, although two locations have suffered partial losses due to development. The third location is the Yamato Scrub Natural Area, a former CARL project managed by the county. Two acres of cutthroat grass are being relocated from one of the development sites to the Yamato Scrub site. In 1992, cutthroat grass was collected on Walt Disney World property in Orange County by David Bickner during a wetland jurisdictional determination, however, only a few small clumps were seen. In 1993, cutthroat grass was first located on the Disney Wilderness Preserve in Osceola County, where there are a few populations. In 1995, cutthroat grass was located at Tosohatchee State Preserve in eastern Orange County, and this occurrence was reported by Taylor (1996).

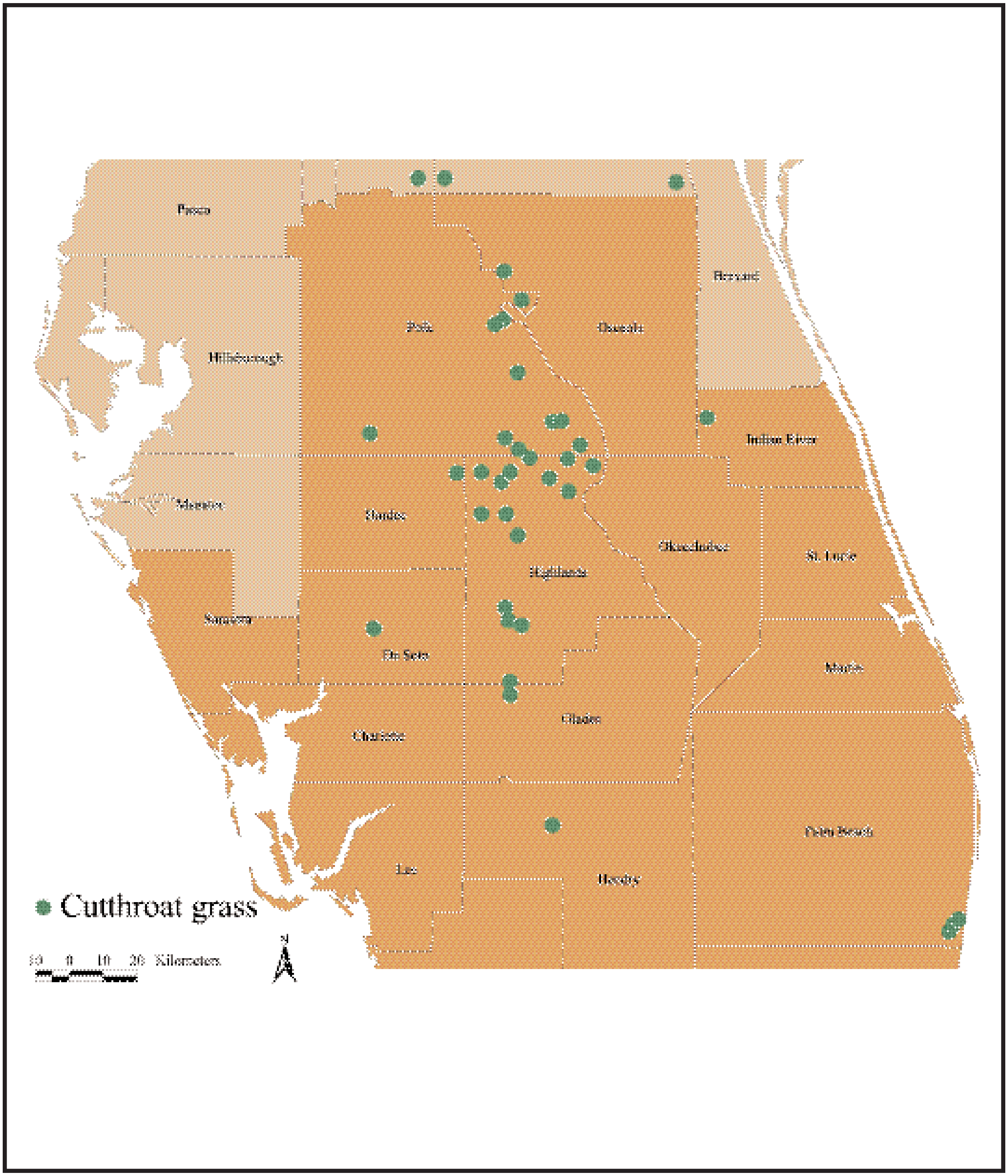

Figure 1. County distribution of cutthroat grass communities in South Florida.

Recent additional focused searches for cutthroat grass locations have been made. One of the methods for locating new sites for this species has been to make contacts with local ranchers and land managers in central Florida familiar with cutthroat grass, and inquire where they had seen cutthroat grass. As a result, new sites for cutthroat grass have been located and documented in Hardee, Lake, Glades, and Indian River counties, in addition to several new sites in counties where the species was previously known. A report from Desoto County has not yet been verified, but the report seems very reliable. This will bring the total range of cutthroat grass to 11 central and south Florida counties (Figure 1).

Physiographically, most historical occurrences of cutthroat grass are in association with the Lake Wales Ridge and the sideslopes and base of this ridge. The largest area of cutthroat grass communities still extant are in association with the Bombing Range Ridge. Cutthroat grass has been found once in association with the southeastern slope of the Lake Henry Ridge, and at three sites on the slope of the Atlantic Coastal Ridge. The remaining sites are in association with slope breaks within the Osceola Plain, and the slope break between the Osceola Plain and the St. Johns River Valley.

Cutthroat grass is listed as an endangered species in Florida (Coile 1998), is ranked as G2/S2 by FNAI (Marois 1997). In reality, cutthroat grass as a species is rather secure, since it is very likely to persist at several protected sites. However, cutthroat grass-dominated communities are less secure, and will be the focus of this account.

Distribution of Cutthroat Grass Communities

One of the first references to the existence of cutthroat grass communities is by Harper (1921), who reports on the occurrence of “cutthroats” in the eastern part of Polk County, about on the line between the lake region (central Florida ridges) and the flatwoods. Harper (1921) notes that the cutthroats are kept perpetually moist by seepage from nearby higher ground, and indicates that they seem to be the only thing in central Florida comparable to the boggy slopes of the West Florida (panhandle) pine hills.

Little information is available on the distribution of cutthroat grass communities, beyond the general statements that they occur in association with the Lake Wales Ridge and its sideslopes in Polk and Highlands counties (Soil Conservation Service 1989). Bacchus (1991) reports that as of 1991 only six locations for cutthroat seeps had been entered in the FNAI database, three in Polk County and three in Highlands County. She attempted to relocate all of these sites and found two to be destroyed, two locations too general to relocate, and two to be extant. However, she also found that many additional locations mapped as species locations for cutthroat grass, and previously undocumented locations, also supported cutthroat grass communities.

The best guide to the specific locations of cutthroat grass communities is the Highlands County soil survey (Carter *et al.* 1989). This is the only county soil survey that specifically recognizes cutthroat grass communities, and it defines a distinct soil association (one of nine soil associations in the county) for cutthroat seeps. There is also a specific soil mapping unit (Basinger-St. Johns-Placid complex) designated to correspond to cutthroat seeps in

Highlands County. By examining the areas mapped as this soil mapping unit in the Highlands County soil survey, it is possible to get an estimation of the original extent of cutthroat grass seeps in the county. This may not include other cutthroat grass communities, such as flatwoods and pond margins, which do not necessarily have this soil combination. No corresponding level of specificity in mapping cutthroat grass community soils is found in the Polk County soil survey, or any other county soil survey in Florida.

More intensive surveys in recent years have located a fairly large number of cutthroat grass communities, mostly in association with the Lake Wales Ridge in east-central and southeastern Polk County and in a north-south band through the west-central part of Highlands County, just overlapping into Glades County at the southern limit. It seems that the greatest extent of cutthroat grass communities associated with the Lake Wales Ridge is on the eastern slope of the ridge, but there are also cutthroat grass communities in flats and depressions on the ridgetop, in the intra-ridge valley, and on the western slope of the ridge. Extensive cutthroat grass communities also occur on the flat ridgetop, sideslopes, and slope base of the Bombing Range Ridge in southeastern Polk and northeastern Highlands counties. Scattered cutthroat grass communities are found along the slope break from the Osceola Plain to Arbuckle Creek in Highlands County, and a few isolated communities are found elsewhere on the Osceola Plain portion of Avon Park AFR.

Cutthroat grass communities are found in relatively few preserved or managed areas. Only three locations for significant areas of cutthroat grass communities seem to be preserved without a “multiple use” focus, these are in Highlands Hammock SP, Archbold Biological Station, and the Nature Conservancy’s Tiger Creek Preserve (Bacchus 1991). The cutthroat grass occurrences at Disney Wilderness Preserve (Osceola County), and Tosohatchee State Preserve (Orange County) are fairly limited in extent. However, there are more significant areas of cutthroat grass communities on three areas managed as “multiple-use” natural areas-Lake Wales Ridge SF, Avon Park AFR and the Platt Branch Mitigation Park (GFC-managed) in southern Highlands County.

The extent of cutthroat grass communities at Lake Wales Ridge SF has not been quantified, but certainly totals over several hundred hectares. The GIS plant community classification scheme developed and produced by the natural resources staff of Avon Park AFR recognizes 23 cover types, of which four are cutthroat grass cover types. These total greater than 5,800 ha (14,326 acres) of cutthroat grass communities, divided as follows: “cutthroat” (3,337 ha or 8,242 acres), “cutthroat-forested” (431 ha or 1,065 acres), “cutthroat flatwoods” (1,504 ha or 3,715 acres), and “cutthroat flatwoods-forested” (532 ha or 1,314 acres). Cutthroat grass-dominated communities at Avon Park AFR represent the largest areal extent remaining for these natural communities.

Description

Cutthroat grass dominated communities fall within four distinct natural community classes. Since the landscape position, hydrology, soil types, and community composition differ significantly between each of these types, they are best discussed as distinct sets of natural communities. Plant nomenclature essentially follows Wunderlin *et al.* (1996).

The most distinct set of cutthroat grass communities can be described as falling within the category of "seepage slopes." These will be the primary focus of this account. However, cutthroat grass communities also occur within the community classes of flatwoods, wet prairies, and depression marshes. It is important to recognize and discuss these communities to make it clear that not every occurrence of cutthroat grass, or even of cutthroat grass dominance of a plant community, is by definition a "cutthroat seep slope."

The structure of most fire-maintained cutthroat grass seepage slopes is a densely vegetated, single-layer grassland community. Only rarely are trees and shrubs present, and these tend to be correlated with particular zones, mostly at the ecotones of cutthroat seep slopes with other communities. Cutthroat grass is a stiff, strongly rhizomatous, turf-forming grass, which results in a large amount of both above-and below-ground biomass production of this species in a relatively short time period after fire. This tends to result in overwhelming dominance of cutthroat grass in the ground cover of almost all cutthroat grass communities. This is in distinct contrast to the ground cover dominance relationships of most central Florida flatwoods, wet prairies, and sandhills, in which several grass, forb, and low shrub species share dominance in the most natural, fire-maintained, stands. The cutthroat flatwoods community types differ in structure primarily in having an open canopy of widely spaced pines, mostly slash pine (*Pinus elliottii* var. *densa)*, but with some longleaf pine (*Pinus palustris*) on the mesic flatwoods sites.

Cutthroat Grass Seepage Slopes

Cutthroat grass seepage slopes can best be thought of as a seepage slope complex, within which subtle variations in slope, relative elevation, and hydrology result in high turnover in community composition over short distances. These plant communities or microhabitat zones of cutthroat seepage slopes are often clearly defined and highly predictable. The general occurrence of cutthroat seep slopes is correlated with slope breaks from deep sand ridges, at the point where groundwater reaches the surface of the slope and begins to diffusely flow at or near the surface downslope. This often occurs at an upper or mid-slope position, particularly where the area and sand depth of the upslope ridge is relatively large, but can occur at lower slope or even on flats at the base of the adjacent sand ridges. The upslope limit of cutthroat grass is highly correlated with the rise of the wet season water table to levels near the surface, however, at this upslope extreme there is rarely evident surface seepage. At the peak of seepage influence in the center of the cutthroat seepage slope complex, water may be present at the surface year-round. Gradually, at the downslope edge of cutthroat seep slopes the seepage influence becomes more diffuse, and there is a gradual transition from seep slope to a more typical flatwoods community. With variation in local microtopography, this transition can be to a mesic flatwoods, wet flatwoods, or wet prairie.

There has been very little scientific study of cutthroat seep slopes. The only quantitative vegetation sampling of cutthroat seep slopes has been a study by Bridges and Orzell (1995a), and there have been only a few detailed floristic studies of cutthroat seep slopes (Bridges and Orzell 1995a, 1995b; Orzell and

Bridges 1995). The results of these studies provided most of the information concerning vegetative composition and environmental factors included in the cutthroat seepage slopes of this account.

For these studies, the locations of herbaceous-dominated seepage slopes within Avon Park AFR were determined by close examination of true color aerial photographs flown in 1992 and printed at a scale of 1:400 (1 in = 400 ft). Floristic surveys of these sites were conducted at several dates from 1993 to 1995, with attempts to visit each site at various seasons. The floristic surveys emphasized sites which had been prescribed-burned within the previous 12 months, although some sites had not been burned recently. At each site, floristic lists were compiled by zones. These zones were easily delineated by a combination of vegetative physiognomy and dominance, slope position, surface soil characteristics, and hydrology. In October of 1993, quantitative sampling of several seepage slopes was conducted. The sampling design consisted of 268-0.25 m^2 (2.7 ft^2) plots, located along five transects within four seepage slopes, and for comparison, one transect in a mesic flatwoods to wet prairie transition. The transects began at the upslope end of the continuous herbaceous-dominated zones and extended perpendicular to the slope, following the hydrological/slope gradient, terminating at the end of the herbaceous-dominated zone or within a community not influenced by seepage. Within each plot, all species were enumerated and an estimate of percentage cover by each species was determined.

All floristic lists were computerized by date and zone, and summarized to produce 230 lists of species presence by site and zone. These were used to produce total floristic lists for each zone and for the entire seepage slope complex, and relative frequency of each species within each zone. Relative frequencies for each zone were compiled to determine preliminary lists of characteristic and differential species of each zone based on floristic data. The quantitative plot data was plotted along transects and utilized for cluster analysis. Results of the cluster analysis were used to determine the average cover of each species in each of 11 clusters, and this was compiled to produce tables of characteristic and differential species of each cluster.

In these studies a total flora of 234 taxa was compiled from the 230 seepage slope zone floristic lists collected at Avon Park AFR from June 1993 through July 1995. Although a few more species of low frequency are likely, this flora is quite complete for the more frequent vascular plants. A total of 53 families are represented 5 fern and fern ally, 1 gymnosperm, 15 monocot, and 32 dicot families. The largest plant families are Poaceae (43 taxa), Cyperaceae (34), Asteraceae (28), Xyridaceae (10), Orchidaceae (8), Ericaceae (7), Clusiaceae (incl. Hypericaceae) (7), Eriocaulaceae (6), Lentibulariaceae (6), Melastomataceae (5), and Polygalaceae (5). Monocots account for 116 total taxa, dicots for 106 taxa, ferns and fern allies for 9 taxa, and gymnosperms for 2 taxa. The largest genera in the flora are *Rhynchospora* (17 taxa), *Xyris* (10), *Andropogon* (9), *Panicum* (7), *Dichanthelium* (6), and *Hypericum* (6).

Analysis of the compiled floristic data supported the *a prioiri* assumptions of the distinction of floristic zones within the seepage slopes. This was expected since there is rather high species turnover in a short distance along the sharp edaphic gradients within these communities. Between each pair of adjacent zones along the gradient, differential species could be determined based on the constancy of occurrence in each of the two zones. Between communities farther apart on the topoedaphic gradient, the number of differential species is obviously even higher. An exception is the comparison of the dry *Panicum abscissum* communities (Zone 1) to the mesic flatwoods downslope from the seepage slopes. Analysis of quantitative plot data revealed very similar patterns to the floristic list data. Cluster analysis of plot data produced clusters with an almost perfect correlation to the zones within which each plot was located.

Table 1 lists the microhabitat zones defined for Cutthroat Grass. (See page Slope Complex at Avon Park AFR). This is based on the quantitative analysis of floristic data, and comparison with environmental features of each zone. It should be noted that not all microhabitat zones are known to occur at each cutthroat grass seepage slope complex. Table 2 gives the percentage frequency of occurrence of each species in each zone, based on compilation of floristic lists.

The driest, most upslope, zone of the cutthroat seep slope complex is here termed the “dry cutthroat grass” zone (Zone 1). This zone represents the transition from the scrubby flatwoods which are usually found immediately upslope of the cutthroat grass seepage slope complex, to communities dominated by cutthroat grass. The dominant species of this zone include cutthroat grass, gallberry holly (*Ilex glabra*), wiregrass (*Aristida beyrichiana*), and saw palmetto *(Serenoa repens*). Additional differential species of this zone from other cutthroat grass seepage slope zones include *Asimina reticulata, Hypericum reductum, Pterocaulon pycnostachyum, Befaria racemosa, Vaccinium myrsinites, Schrankia microphylla* var. *floridana, Polygala setacea, Xyris caroliniana, Euthamia tenuifolia, Galactia elliottii,* and *Gratiola hispida.* In this zone, there is not a mucky textured soil surface, and the water table stays below the surface throughout the year. The presence of cutthroat grass in this relatively dry habitat indicates the presence of subsurface seepage, which emerges downslope in the wetter zones.

The second seepage slope zone is termed the “cutthroat grass lawn,” due to its even, low appearance in the natural, fire-maintained condition, much like a well-maintained turfgrass lawn. These tend to occur on midslope flats, and are roughly linear features oriented perpendicular to the overall slope of the ridge. Similar communities are also found in shallow linear depressions within the sand ridges, and the “swale” community described for Archbold Biological Station (Abrahamson *et al.* 1984) may represent a variant of this zone which occurs in the absence of wetter, stronger seepage zones. The average relative cover of cutthroat grass in this zone is 74 percent, and in some plots it has almost 100 percent relative cover. The only other species with more than 2 percent average relative cover in this zone are *Eleocharis baldwinii, Lyonia lucida,* and *Rhexia nuttallii*. These species, along with *Xyris platylepis, Rhynchospora ciliaris,* and *Polygala rugelii*, differentiate this zone from the “dry cutthroat grass” zone. This zone can be distinguished from wetter zones by the low frequency of *Xyris ambigua, Marshallia tenuifolia, Sabatia* *difformis,* and *Eriocaulon decangulare*, among others. This zone is saturated to the surface for most of the growing season, but rarely has surface water except for a few hours after rainfall events. The soils tend to have a surface of a few centimeters of pure muck and/or several centimeters of mucky fine sand.

Often present at a landscape position slightly downslope from the cutthroat grass lawns is a shrubby zone, sometimes forming linear shrub bands separating cutthroat grass-dominated communities. Cutthroat grass is still quite frequent in this zone, but does not form the continuous cover of the previous zone due to shading. Frequent shrubs in this zone include *Serenoa repens, Lyonia lucida, Ilex glabra, Lyonia fruticosa,* and *Vaccinium myrsinites.* The most differential herbaceous species in this zone is *Osmunda cinnamomea*, with other frequent herbs including *Aster reticulatus, Hypericum cistifolium,* and *Hartwrightia floridana*. It is unclear why these shrubby bands occur regularly in a fire-maintained seepage slope, but it is perhaps due to slightly better local soil drainage because of subtle increases in microtopographic relief. Although these areas tend to have deeper surface soil muck layers, partially due to the increased organic matter from the denser vegetation and reduction of oxidation by shading, they rarely have standing water at the soil surface.

Wet cutthroat grass lawns are found in the areas transitional between cutthroat grass lawns and seepage slopes proper. In this microhabitat zone, there is less dominance by cutthroat grass (mean relative cover of 48 percent), and associated species have greater cover, including *Ilex glabra, Dichanthelium ensifolium* var. *ensifolium*, *Scleria reticularis, Xyris ambigua, Hartwrightia floridana, Myrica heterophylla,* and *Sarracenia minor*. This microhabitat zone has the most seepage of the cutthroat communities observed at most sites on the Lake Wales Ridge; however, on the Bombing Range Ridge it is transitional to zones with greater seepage. The soils of this zone have a muck surface layer of usually 10 to 20 cm (3.9 to 7.9 in.), and are saturated to near the surface year-round, with standing water at the soil surface for much of the growing season.

Cutthroat grass seepage slopes, *sensu stricto*, are at most sites the most strongly seepage-influenced communities found within the cutthroat grass seepage slope complex. The dominant species of this zone are cutthroat grass with a distinct ground cover layer of *Sphagnum* spp. Other species with significantly higher cover values in this zone include *Myrica heterophylla, Xyris elliottii, Eriocaulon decangulare, Rhynchospora cephalantha*, and *Andropogon glomeratus* var. *hirsutior.* Cutthroat grass seepage slopes are saturated to the surface year-round, and with standing water at or above the soil surface for most of the year. These communities are relatively common along the sideslopes of the Bombing Range Ridge, but have only rarely been seen in recent surveys of the Lake Wales Ridge, at a few locations in Lake Wales Ridge SF. Vascular plant diversity is very high in this seepage slope zone, with as many as 23 species per 0.25 square meter (2.7 sq. ft.).

At some sites, there is a seepage slope microhabitat zone which is transitional between cutthroat grass seepage slopes, *sensu stricto*, and mixed herbaceous seepage slopes. In this zone, there is a decline in the relative cover of cutthroat grass, and an increase in the cover of wiregrass. Associated species are indicative of the very wet nature of this transition zone, and include *Myrica heterophylla, Hartwrightia floridana, Lycopodiella alopecuroides, Sarracenia minor,* and *Dichanthelium ensifolium* var. *ensifolium*. At some seepage slope sites, a community reflecting this transitional zone is present as the most seepy zone, without an adjacent mixed herbaceous seepage slope zone. The characteristic indication of this zone is the presence of both cutthroat grass and wiregrass on deep mucky soils.

The best developed seepage community in the cutthroat grass seepage slope complex, the mixed herbaceous seepage slope, often lacks cutthroat grass entirely. The dominant species in this zone are *Hartwrightia floridana, Dichanthelium ensifolium* var. *ensifolium*, *Scleria reticularis,* and *Rhynchospora oligantha*. The locations of this community represent the only locations of *Rhynchospora oligantha*, a common species of seepage slopes in the Florida Panhandle, in peninsular Florida. Other species which tend to differentiate mixed herbaceous seepage slopes from all other seepage slope zones include *Rhynchospora rariflora, Polygala cruciata, Hypericum fasciculatum, Calopogon tuberosus, Xyris smalliana, Xyris fimbriata*, and *Andropogon glomeratus* var. *glomeratus*. The species of this zone tend to be a mixture of species of very mucky seepage slopes and species more characteristic of wet prairies. However, the water source of this community is totally from copious groundwater seepage. The soil has a muck surface often 60 cm (23.6 in.) or more deep, and there is standing water on the soil surface throughout the year. These seepage-influenced communities differ strongly from other deep-muck herbaceous wetlands in not being subject to flooding, therefore having an almost constant water table. Many of the species of this community are very rare in peninsular Florida.

On the lower slope below either the cutthroat grass seepage slope, *sensu stricto*, or the mixed herbaceous seepage slope, there is often a zone resembling the cutthroat grass lawn (Zone 2), but more irregular in shape and mixed in composition. This is referred to as the cutthroat grass lawn below seepage slope (Zone 8). This zone seems to occur when the slope flattens slightly below Zone 5, 6, or 7, and seepage influence distinctly lessens. The vegetation is a mixture of seepage slope and lawn species, in an irregular pattern. This zone is present mostly on the larger, best developed examples of the seepage slope complex.

Gradually, at the lower slope end of the seepage slope complex, there is a transitional zone to the natural communities of the surrounding flatwoods landscape. This is referred to as transitions from seepage slope to flatwoods (Zone 9). With variation in the microtopography and hydrology of the surrounding landscape, this transition can be to either mesic or wet flatwoods. In this zone, cutthroat grass loses dominance to wiregrass, and there is a mixture of seepage slope complex and flatwoods species. This transition zone is often rather broad, with some seepage influence extending locally to the base of the slope or beyond.

A distinct variant of the transitions of the seepage slope complex to other communities is the boggy sphagnous meadow (Zone 10). This seems to occur where the seepage slope complex extends to the broad, flat base of a slope or into a broad, shallow drainageway. This zone combines the characteristics of cutthroat grass seepage slopes, *sensu stricto*, and wet prairies. There is often standing water in this community, and a thick mat of *Sphagnum* mosses, much as in a fringing peaty wet prairie. However, seepage slope species are also quite common, even very abundant. This zone seems to support more *Hartwrightia floridana* and *Platanthera blephariglottis* var. *conspicua* than any other community in Florida. Wet prairie species such as *Hypericum myrtifolium, Ctenium aromaticum, Paspalum praecox,* and *Chaptalia tomentosa* are more common in this zone than in other zones.

The last zone of the seepage slope complex consists of the natural drainageways through seepage slopes (Zone 11). These small natural drainageways form where seepage water becomes channeled through microtopographic lows in the slope, and are narrow, shallow intermittent stream channels, generally less than one meter deep and wide. Seepage slope species are often present within the channel, along with *Hypericum fasciculatum* and *Osmunda cinnamomea.* The composition of these channels is quite variable, due to differences in depth and permanence of surface water and diffuse seepage within the channels.

Other Cutthroat Grass Communities

In addition to the 11 microhabitat zones of the cutthroat seep slope complex, the following cutthroat grass-dominated natural communities are known to occur at Avon Park AFR:

Cutthroat grass dry prairie
Cutthroat grass mesic flatwoods
Cutthroat grass wet flatwoods
Cutthroat grass wet prairie
Cutthroat grass deep wet prairie/slough
Cutthroat grass outer rim of depression marsh
Cutthroat grass ecotone between mesic flatwoods and drainageways
Slash pine/Cutthroat grass "basin swamp"

For convenience in description, these will be combined into six categories-mesic flatwoods, wet flatwoods, depression marsh margins, ecotones to drainageways, wet prairies, and seepage-fed basin swamps. Each of these is markedly different from communities of the cutthroat grass seepage slope complex in vegetation, soils, hydrology, landform, and relationship to the surrounding landscape. The presence of cutthroat grass as a dominant or subdominant species in so many different community classes attests to the ecological breadth of cutthroat grass in the center of its range.

Although almost all of the data used to describe these communities is from examples at Avon Park AFR, some of these communities are similar to those described by Abrahamson *et al.* (1984) for Archbold Biological Station. At Archbold Biological Station, cutthroat grass occurs in three community types. The first is a "cutthroat grass flatwoods" type, which differs from typical wiregrass flatwoods in the greater robustness of saw palmetto, lower frequency of *Quercus minima, Hypericum reductum*, and *Myrica cerifera* var. *pusilla,* and greater frequency of *Lyonia lucida* and *Pinus elliottii*, in addition to the dominance of the ground cover by cutthroat grass. This would correspond to the "cutthroat grass wet flatwoods" type described for Avon Park AFR. The second cutthroat type is termed as "Swale" by Abrahmson *et al.* (1984). In this community, cutthroat grass cover is nearly 100 percent, associated with such species as *Andropogon brachystachyus, A. virginicus* var. *glaucus*, *Polygala rugelii, Drosera capillaris, Burmannia biflora, B. capitata, Carphephorus paniculatus*, and *Syngonanthus flavidulus*. This community is said to occupy "low-lying stretches of land," and seems to correspond to the "cutthroat lawn" zone of cutthroat seepage slopes, but without the corresponding areas of stronger seepage-influenced community types. It is possible that the "Swale" community at Archbold Biological Station has just enough seepage influence from the surrounding sand ridges to support the formation of a "cutthroat lawn (Zone 2)" seepage slope, but without enough topographic relief downslope of this zone to support other seepage slope zones.

The third cutthroat grass type at Archbold Biological Station is the cutthroat grass seasonal pond, or pond margin. Depending on the depth of the depression pond, cutthroat grass can either be restricted to the outer margin of the pond, or for shallower ponds can dominate the entire pond. Species with more than 1 percent average cover in cutthroat grass-dominated pond zones at Archbold Biological Station include *Hypericum edisonianum, Schizachyrium stoloniferum, Woodwardia virginica, Syngonanthus flavidulus, Rhynchospora cephalantha,* and *Spartina bakeri* (Abrahamson *et al.* 1984).

At Avon Park AFR, a total of 217 plant species are associated with cutthroat grass communities other than cutthroat grass seepage slopes (Table 3). Some of these community types are very limited in occurrence, whereas others are quite extensive. The driest of these cutthroat grass communities are cutthroat grass dry prairies and cutthroat grass mesic flatwoods. These occur in close proximity to the base of the slope of the Bombing Range Ridge, and represent an extension of cutthroat grass dominance into the flatwoods landscape off of the ridge. They occur on poorly drained flats, mostly on Myakka soils, and can be distinguished from other cutthroat grass communities by the higher frequency of *Pterocaulon pycnostachyum,Vaccinium myrsinites, Serenoa repens, Pinus palustris, Xyris caroliniana, Hypericum reductum,* and *Asimina reticulata*. The composition of this community is much like the dry cutthroat grass zone (Zone 1) of the seepage slope complex, but it differs in landscape position.

Cutthroat grass wet flatwoods are much more common, and are fairly extensive at Avon Park AFR and Highlands Hammock SP. Only 7.63 ha (18.8 acres) of cutthroat grass flatwoods are mapped for Archbold Biological Station. These are found at Avon Park AFR on extensive poorly drained flats at the base of the Bombing Range Ridge. Similar communities are located at the western base of the Lake Wales Ridge in the southern addition to Highlands Hammock SP. Cutthroat grass wet flatwoods combine characteristics and species of seepage slopes and flatwoods landscapes. They can be distinguished from cutthroat grass mesic flatwoods by dominance of slash pine (*Pinus elliottii* var. *densa*) rather than *Pinus palustris,* and by an increased frequency of *Sarracenia minor, Xyris platylepis, Eriocaulon decangulare, Scleria reticularis, Centella asiatica, Rhynchospora cephalantha,* and *Paspalum praecox.* Cutthroat grass wet flatwoods can be distinguished from typical wet flatwoods by increased frequency of *Hartwrightia floridana, Eleocharis baldwinii*, and *Sphagnum* spp., in addition to the increase in cutthroat grass and slash pine.

Cutthroat grass depression marsh margins are fairly common even a few miles away from the base of the Bombing Range Ridge at Avon Park AFR, and seem to be fairly common on the southern Lake Wales Ridge. In this community, cutthroat grass forms a concentric ring around deeper depression marsh zones. In most cases, the cutthroat grass zone is immediately waterward of the saw palmetto margin at the boundary between the depression marsh and the surrounding flatwoods. Waterward of the cutthroat grass zone is typically a zone of intermediate hydroperiod which is dominated by *Hypericum*. At Avon Park AFR, this zone is dominated by St. Johns wort (*Hypericum fasciculatum)*, but at Archbold Biological Station and other areas on the southern Lake Wales Ridge, Edison's hypericum *(Hypericum edisonianum*) is dominant in this intermediate hydroperiod depression marsh zone. Cutthroat grass depression marsh margins have many species in common with cutthroat grass wet flatwoods. Species with higher frequency in depression marsh margins include *Eupatorium recurvans, Rhexia cubensis, Hypericum fasciculatum, Sabatia grandiflora, Pluchea rosea,* and *Hypericum cistifolium*. In general, the cutthroat grass depression margin is much like the wiregrass-dominated margin of many other depression ponds in Florida, except for the dominance of cutthroat grass and a higher percentage of species adapted to mucky soil surface conditions.

Cutthroat grass ecotones between mesic flatwoods and drainageways are found in scattered locations on the Osceola Plain at Avon Park AFR. These differ from the cutthroat grass seepage slope complex in not being associated with sand ridges. Rather, they occur where there is a drop in elevation of a few feet between broad expanses of mesic flatwoods and deep, flowing-water herbaceous marsh-dominated drainageways. These are occurring in response to an increase in groundwater seepage, but without sufficient seepage flow to produce a seepage slope with surface water. Similar slight seepage ecotones occur in other areas of central Florida, in association with slope breaks to drainageways or to dome swamps, but outside of the range of cutthroat grass are most often dominated by wiregrass or by big chalky bluestem (*Andropogon glomeratus* var. *glaucopsis*). Common indicator species of these seepage ecotones, with or without cutthroat grass dominance, include *Rhynchospora ciliaris, Pinguicula caerulea, Sarracenia minor,* and *Ilex glabra* (particularly in absence of fire). These zones are usually less than 3 to 6 m (9.8 to 19.7 ft) in width, but can extend for a hundred meters or more along such an ecotone. In aspect, they are similar to the wet cutthroat grass lawn (Zone 4) of the cutthroat grass seepage slope complex, but differ in topographic position and the surrounding landscape.

Cutthroat grass wet prairies have been found only on Avon Park AFR, where they tend to be associated with the margins of bay-dominated depression swamps at the slope base of the Bombing Range Ridge. In this cutthroat grass community, trees and shrubs are essentially absent from frequently burned examples. The water table is at or above the surface for most of the year, and most of the area of this community is inundated for up to 30 cm (11.8 in.) above the surface for most of the growing season. In aspect, these are analogous to wet wiregrass prairies, but perhaps with more of a mixture of mucky soil indicators (such as *Xyris fimbriata* and *Andropogon glomeratus* var. *glaucopsis*). The composition of this community is a mixture of seepage slope and wet prairie species, but it differs from wiregrass-dominated wet prairies in the abundance of cutthroat grass and of *Hartwrightia floridana.*

To our knowledge, there is only one example known of a Slash pine/ cutthroat grass "basin swamp." This area is known as "The Deadens," and is found at the base of the western slope of the northern part of the Bombing Range Ridge on Avon Park AFR. This community has a canopy of slash pine, mixed with sweet bay (*Magnolia virginiana*) and loblolly bay (*Gordonia lasianthus*), a shrub layer with moderate to dense cover, including *Lyonia lucida, L. ligustrina, Ilex cassine, I. glabra, Myrica cerifera, M. heterophylla,* and *Hypericum fasciculatum*, and a ground cover dominated by cutthroat grass, with mucky wet prairie and seepage slope indicator species present in the ground cover. At first impression, one would suspect that this area is a fire suppressed example of a cutthroat grass wet flatwoods or wet prairie, or even perhaps a fire-AFR "boggy sphagnous meadow" (Zone 10), of the seepage slope complex. However, this area is indicated, in essentially its current configuration, as a "Bay & Pine Swamp" on the 1859 public land survey plat map and notes. We surmise that because of the close proximity of sand pine scrub to the east and a deep stream channel to the west, that this area was naturally protected from almost all landscape-level fires. In the absence of frequent fire, this area passed the threshold needed to become a naturally "fire-retardant" community, reaching the point where fires would naturally extinguish at the border of the swamp. It is possible that other such situations existed at the base of the Lake Wales Ridge, but each example must be examined critically to determine whether woody dominance of these areas is a natural state or the result of post-settlement fire suppression.

Species Diversity and Species of Concern

Several species of conservation concern are associated with cutthroat grass communities. Although little information is available at this time on faunal species associated with this cutthroat communities, it is likely that the eastern indigo snake (*Drymarchon corais couperi*) occurs here.

Endangered State-listed plant species that occur in the cutthroat grass community include: cutthroat grass, many flowered grass-pink (*Calopogon multiflorus),* and Edison's ascyrum (*Hypericum edisonianum).* A large number of plant species that are State-listed as threatened occur in the cutthroat grass community (Coile 1998). Among these are *Hartwrightia floridana, Lilium catesbaei, Pinguicula caerulea, Pinguicula lutea, Platanthera blephariglottis* var. *conspicua, Platanthera integra, Platanthera ciliaris, Platanthera cristata, Pogonia ophioglossoides,* and *Sarracenia minor*. Most of these species were relatively common in the fire-maintained, undrained natural landscape of peninsular Florida, and most are still quite common in the cutthroat grass communities of Avon Park AFR.

The flora of these cutthroat grass communities consists of at least 279 plant taxa, including many Florida endemics and near-endemics, as well as many other species that are widespread in the southeastern coastal plain, but reach their southern limit in these communities in Highlands County. The nearest known locations to the cutthroat grass community region for other herbaceous-dominated seepage slopes are in Clay County, just southwest of the Jacksonville area in northeastern Florida. Therefore, many species of seepage habitats are dependent on cutthroat grass communities for maintenance of viable populations in peninsular Florida.

Panicum abscissum (Poaceae) is an endemic perennial grass that grows on mositure-receiving seepy slopes on the sandy eastern and western slopes of the Lake Wales Ridge. It may also occur on small isolated slopes which receive moisture from a scrub site at higher elevation, around small seasonal ponds in scrubby flatwoods, and around depression marshes and ponds in wet pinelands. It can be frequently found in pure stands with an open slash pine overstory. The species occurs in Highlands, Orange, Osceola, Palm Beach, and Polk counties.

Calopogon multiflorus (Orchidaceae) is a diminutive and poorly known species which is more common in dry prairie and dry-mesic sandy longleaf pine savanna than in cutthroat communities. It has recently been found in frequently burned examples of the dry cutthroat grass zone of the cutthroat grass seepage slope complex. This orchid is State-listed as endangered and dependent on frequent winter or early growing season fire for flowering, which tends to occur only three to four weeks after fire.

Hypericum edisonianum (Hypericaceae): is a distinctive semi-woody shrub that has the most restricted geographic range of any member in the genus *Hypericum*. This species is State-listed as endangered and is known from four contiguous counties in south-central Florida (Highlands, Glades, Desoto, and Polk). The type specimen was originally cited in error from Desoto County, since it is actually from Highlands County (before it was split from Desoto County). In 1995, Bridges and Orzell reinstated Desoto County into the overall range of this species, having collected specimens from eastern Desoto County. The only Polk County record is that discovered by Orzell in 1994 from Avon Park AFR, and it represents the first record from the Osceola Plain (Orzell 1997). *Hypericum edisonianum* can be locally abundant, forming thick stands an acre or more in extent in sandy depressional ponds, open prairies, and pine flatwoods. It seems to be most commonly associated with cutthroat grass depression marsh margins on the southern portion of the Lake Wales Ridge.

Hartwrightia floridana (Asteraceae) is a distinctive monotypic genus which is strongly associated with seepage slopes throughout its range, extending from extreme southeastern Georgia south to Highlands County, Florida. It was probably historically widespread within this region, occurring both in well-developed seepage slopes and in the fire-maintained herbaceous slight seepage ecotones between flatwoods and wetlands. Although historically it has been found in 11 Florida counties and 3 Georgia counties, it is currently known to be extant only in two small regions within this range. One of these comprises the seepage slopes and roadside seepage ecotones of northeast Florida and Charlton County, Georgia, in a total of four counties (Clay, Putnam, Nassau, Charlton). The only other extant locations for this species are in the cutthroat grass communities of Polk and Highlands counties. All of the intervening localities seem to have been extirpated due to fire-suppression and/or drainage. Field surveys have revealed that Avon Park AFR contains the largest known number of reproducing, viable populations occurring within intact habitat (based on FNAI database records and field visits to all known populations as of 1994). It is found at Avon Park AFR in most zones of the cutthroat grass seepage slope complex, cutthroat grass wet flatwoods, cutthroat grass wet prairie, cutthroat grass depression marsh margins, and cutthroat grass ecotones to drainageways. There are also a very few locations of *Hartwrightia floridana* at Avon Park AFR which are not in association with cutthroat grass. These are found in a few ecotonal seepage slopes which lack cutthroat grass. There are well over 100 populations with over 1,000 plants each on Avon Park AFR, easily over 90 percent of the entire worldwide abundance of this species.

Hartwrightia floridana is one of the few rare species of cutthroat grass communities that has been recently confirmed in cutthroat grass areas other than Avon Park AFR. It occurs in cutthroat grass seepage slopes at Lake Wales Ridge SF, and in association with a degraded cutthroat grass seepage slope at the southeast end of the Lake Henry Ridge. *Hartwrightia floridana* seems to have persisted in other former seepage slopes on the Lake Wales Ridge, particularly where roadsides provide the open seepy habitat necessary for this species. This species is dependent on prescribed growing-season burns, to maintain groundcover diversity in communities and prevent or inhibit woody encroachment, and lack of alteration of natural hydrology. Long-term monitoring studies should be conducted to determine the life history and aid in developing management strategies for this plant. The State of Florida has listed *Hartwrightia floridana* as a threatened species.

Lilium catesbaei (Liliaceae) is a perennial lily that ranges from southeastern Virginia to Florida and west to Louisiana on the coastal plain. Southern red lily is a rather common species in wet prairies, wet flatwoods, and seepage slopes throughout nearly all of Florida. It is most frequently encountered at Avon Park AFR in undisturbed frequently burned flatwoods and sometimes in seepage slopes. Florida has designated this species as threatened.

Pinguicula caerulea and ***Pinguicula lutea*** (Lentibulariaceae) are rather common in a wide variety of seepage slope, mesic to wet flatwoods and pine savannas, and wet prairies throughout most of Florida. The State of Florida has listed these plants as threatened species.

Platanthera blephariglottis* var. *conspicua (Orchidaceae) reaches its southern limit in Highlands County. In the Florida panhandle, this orchid is uncommon but not particularly rare. However, in peninsular Florida it is currently quite rare, despite having been historically recorded from numerous central Florida counties. This State-listed species may have suffered a similar fate as described for *Hartwrightia floridana*. Within central peninsular Florida, it seems to be currently extant only from cutthroat grass seepage slopes at Avon Park AFR in Polk and Highlands counties. A Polk County population north of Smith Road near the old Bravo target area, growing in a seepage slope and downslope wet

Lilium catesbaei **(southern red lily).** *Original photograph by Betty Wargo.*

prairie, had an estimated population exceeding 500 flowering plants (and countless vegetative plants) in September 1994, making this the largest extant population currently known in central Florida. For management of this orchid, it is important to conduct prescribed burning during the growing season and prevent alteration of the hydrology. Plants should also be protected from feral hogs. The fact that the largest population of this orchid occurs in the Bravo Range at Avon Park AFR, which has been subject to very little or no grazing pressure, indicates that the sensitivity of this species to livestock grazing needs to be investigated (Orzell 1997). This plant is listed by the State of Florida as a threatened species.

Platanthera integra (Orchidaceae) is a rather widespread species, occurring sporadically in the southeastern United States. However, it is not common except in frequently burned wet pine savannas and pitcher plant bogs on the southeastern United States coastal plain. In Florida, it is listed as an endangered species and very rarely occurs outside of the panhandle region, where it occurs in fire-maintained pine savannas, wet prairies, seepage slopes and hillside seepage bogs. It is exceedingly rare in peninsular Florida (historical from Orange and Osceola counties and extant in Highlands County) and northeast Florida (Nassau and Duval counties) and highly habitat-restricted. The only known extant population in central Florida is the population at Avon Park AFR in Highlands County, which represents the southernmost record. In September 1994, a total of some 171 plants (most in peak flowering condition) were observed in a wet wiregrass prairie and adjacent seepage-influenced roadside ditches through the wet prairie habitat. This population is just downslope and adjacent to a cutthroat grass seepage slope community, and may be influenced by seepage from that area. This is undoubtedly one of the largest extant populations of this orchid in Florida and certainly the largest population currently documented in all of north and peninsular Florida (Orzell 1997).

Prescribed growing season burns should be conducted to maintain groundcover diversity and prevent woody invasion. Care should be taken to protect the only known population on Avon Park AFR, particularly following prescribed burning, from feral hog damage. There has been some recent feral hog damage to the groundcover adjacent to the known population; however it is not known whether this damage caused localized extirpation of the population. The absence of orchids from the feral hog-rutted portion of the site makes it highly suspect that the hogs have already impacted the population. This population should be monitored to determine population dynamics and aid in developing management strategies.

Platanthera ciliaris and ***Platanthera cristata*** (Orchidaceae) are rather common and widespread orchids in the southeastern United States, but become increasingly rare and restricted in peninsular Florida. *Platanthera ciliaris* is the slightly more common of the two, being known historically from most central peninsular Florida counties south to Highlands County. *Platanthera cristata* was only known to occur south to Orange and Hillsborough counties until its discovery in 1981, from Polk County at Avon Park AFR (Wunderlin *et al.* 1982). *Platanthera ciliaris* is known from one cutthroat grass seepage slope complex at Avon Park AFR, and could possibly occur in other cutthroat grass seepage slopes. These orchids are subject to declining populations for the same reasons as *Hartwrightia floridana*. Both species are State-listed as threatened.

Pogonia ophioglossoides (Orchidaceae) is a threatened species listed by the State. It is a spring-flowering orchid that is rather common in cutthroat grass seepage slopes, and occasionally occurs in other cutthroat grass communities. It ranges south to Highlands and Martin counties in Florida. The habitat conditions and requirements of this species are rather similar to the *Pinguicula* species.

Sarracenia minor (Sarraceniaceae) is the only pitcher plant species in central peninsular Florida, ranging south to Highlands and (rarely) to Okeechobee counties. It is present in almost every example of the cutthroat grass seepage slope complex, being quite common in Zones 4 through 10 of the complex. This species is also quite common in fire-maintained wet flatwoods, wet prairies, and seepage ecotones throughout the Osceola Plain. There are at least several hundred populations of *Sarracenia minor* at Avon Park AFR with hundreds or more clumps each. *Sarracenia minor* is also found in most other cutthroat grass communities, and is particularly rather common in cutthroat grass wet flatwoods and wet prairies. It is known from cutthroat grass wet flatwoods as far south as near Highlands Hammock SP.

Several additional species of cutthroat grass seepage slopes are regionally rare, in most cases much rarer and more endangered in peninsular Florida than the State listed species of these communities. These are not listed as rare plants for Florida due to their relative abundance and secure populations in the Florida Panhandle. Disjunct populations of plant species are very important to regional biodiversity. They are usually very habitat-specific where they occur in peninsular Florida and indicative of the unique seepage slope conditions of cutthroat grass communities. These include *Rhynchospora oligantha, Myrica heterophylla,* and *Eleocharis tuberculosa*. *Sarracenia minor* is listed as a threatened species by the State of Florida.

Ecology

Hydrologic Regimes and Soil Conditions

Cutthroat grass seems to occupy a fairly wide hydrologic range, from subsurface seasonal soil saturation to nearly year-round shallow inundation. The hydrologic key to the occurrence and dominance of cutthroat grass seems to be at least some diffuse groundwater seepage. However, out of the relatively narrow range of cutthroat grass, other grasses (particularly *Aristida beyrichiana)* seem to flourish under these same hydrologic conditions. It has been speculated that cutthroat grass displaces wiregrass in certain natural communities within a narrow geographical range, but is less favored with only slight changes in geography and edaphic conditions.

Cutthroat grass communities, at least the cutthroat grass seepage slopes, are habitats in which groundwater flows downslope at or near the soil surface for at least part of the year. These habitats are hydric (although the hydroperiod may be variable) and nutrient levels are related to soil organic matter and chemistry, and the chemistry of the geologic materials in the upslope, unconsolidated aquifer.

No specific hydrologic or soil research has been conducted on cutthroat grass communities. The Highlands County soil survey maps cutthroat seeps as having Basinger, St. Johns, and Placid soils (Spodic Psammaquents, Typic Haplaquods, and Typic Humaquepts). These soils are poorly drained to very poorly drained, with a water table within 30.5 cm (12 inches) of the surface for most of the year (Carter *et al.* 1989). All of these soils have a thick dark gray to black sand upper horizon, sometimes with a thin layer of pure muck at the soil surface. There is a moderately developed subsurface spodic layer in St. Johns soils, a weak indication of a developing spodic layer in Basinger soils, and no diagnostic subsurface horizon in Placid soils. Included within this soil mapping unit are smaller areas of Myakka, Samsula (Terric Medisaprists), Sanibel (Histic Humaquepts), and Smyrna soils. The Myakka and Smyrna soils (both Aeric Haplaquods) have a well-developed spodic layer, and indicate conditions transitional to mesic or wet flatwoods. The Sanibel and Smyrna soils have a deep organic surface horizon, and correspond to the muckier areas within the seepage slope complex. Deeper histisol soils, perhaps representing undescribed soil series, are present in seepage slopes at Avon Park AFR, but are too limited in extent to merit description on a county soil survey level (L. Carter, retired from Soil Conservation Service, personal communication 1997).

In the Polk County soil survey (Ford *et al.* 1990), no specific soil mapping unit is used for cutthroat grass communities. However, the soil types mapped for cutthroat communities can be determined from examination of the mapped soil types for known cutthroat grass communities. The most common soil mapped for cutthroat communities in Polk County seems to be Basinger fine sand. Not all areas mapped as Basinger soils are cutthroat communities; however, since this mapping unit is also used for wet flatwoods and wet prairie communities. Some areas of cutthroat grass in Polk County are mapped as St. Johns sand. This seems to be utilized as the soil mapping unit for some of the wetter zones of the cutthroat grass seepage slope complex. St. Johns sand is mapped for only 818 ha (2,022 acres) in Polk County, and an examination of the Polk County soil survey indicated that all of this area may be current or former cutthroat grass communities. Some areas mapped as Placid and Myakka sand, depressional in the Polk County soil survey, support cutthroat grass communities, and limited areas mapped as Immokalee (Arenic Haplaquods), Myakka, or Sanibel series also have some cutthroat grass communities.

Hydrologic and soil parameters of cutthroat grass seepage slopes can be estimated from research conducted on seepage slopes in other areas of the Coastal Plain. The hydrologic and soil conditions of seepage slopes have best been summarized by Platt *et al.* (1990), which forms the basis for this section.

The soil and water chemistry of seepage slopes is relatively complex. They are typically poor in certain nutrients, such as calcium and magnesium, since some ions are leached from the soil by water. In east Texas and western Louisiana, potassium and sodium levels in seepage slope soils may be comparable to other forest soils in the region, and seepage slope soils may contain 5 to 10 parts per million (ppm) nitrate and ammonium nitrogen (Platt *et al.* 1990). Organic matter content of seepage slope soils is regularly 3 percent or more by weight, and is often greater than 5 percent at depths less than 15 cm (5.9 in.).

Seepage areas are integrated hydrologically with surrounding habitats. Water seeping out at the surface originates from rainfall in the upslope watershed that percolates through the soil and moves along a sloping gradient. The emergence of the seepage water on the sideslope can be the result either of reaching a shallow, less permeable layer (such as a subsurface spodic horizon), or the saturation of the surficial aquifer such that hydrostatic pressure alone results in emergence of seepage flow. The flow of water is directed by hydraulic conductivity and soil porosity until it reaches the surface.

It is characteristic of seepage slope complexes throughout the Coastal Plain to have different kinds of seeps, ranging from seasonally moist areas along slopes with relatively few seep-associated species, to bogs that have standing water (due to a "terraced slope" effect) throughout the year and support a large array of bog-associated herbaceous species. The degree of seepage is primarily dependent on five major characteristics that influence water flow: (1) surface and subsurface soil characteristics which govern soil infiltration and saturated flow rates,(2) size of the recharge area, (3) vegetation present in both recharge and seepage areas, (4) local topography, and (5) depth, gradient, and extent of the underlying impermeable layer (Bridges and Orzell 1989, Platt *et al.* 1990).

Surface soil characteristics determine the degree to which water percolates through the soil. Water infiltration into a soil generally increases as the percentage of sand and soil depth increases. Under saturated conditions, water flow in coarse-textured soil will be faster than in fine-textured soils; however, total storage capacity will be greater in fine-textured soils. The mineral soil surface texture of all cutthroat grass communities is fine sand, and it is likely that few, if any, cutthroat grass communities have soil textures other than sand or fine sand throughout the soil profile.

The size of the recharge area or watershed is also important. Most of the geologic strata of these watersheds are of relatively recent marine origin. Since there may have been subtle variations in the deposition of sediments over time, drainages and divides may be present but covered by more recent deposits. The general slope and drainage pattern of subsurface layers may or may not correspond to the present topography. One of the few generalizations that can be stated with certainty is that water feeding a seepage slope must come from positions topographically higher than the seep itself.

The degree to which a seepage slope remains wet throughout the year will depend on the size of the watershed, the soil infiltration rate, the rate of saturated flow in the soil, the topographic position of the seepage slope, its water storage ability, and the rate of water leaving the seepage slope from evapotranspiration and surface and subsurface flow. In general, the greater the infiltration rate of the watershed soils and the water-holding capacity of the seepage slope soils, the smaller the recharge area needed to maintain seepage throughout dry periods of the year.

Vegetation will have a different effect on the hydrologic regime of the watershed recharge area than on the seepage area. Vegetation on the recharge area intercepts a portion of the rainfall and in large rainfall events may redistribute rainfall. The infiltration of rainfall reaching the ground surface on some deep sandy soils is nearly 100 percent, even with a sparse vegetative cover. Again, infiltration is dependent upon rainfall intensity and duration. Vegetation in the seepage area has a much greater impact on water relations. Woody vegetation in seeps removes water in excess of actual needs and acts as a phreatophyte but woody vegetation also has the effect of “stabilizing” the soil immediately around it.

Seepage slope hydrology can, within the limits set by the physical properties of the soil, underlying impermeable layer, and by the size of the recharge area, be influenced via management of the vegetation in the recharge area and in the seepage slope itself. Normally, the volume of water entering subsurface soils will decrease as the biomass of woody vegetation increases; so, a reduction in the amount of vegetation should increase water flow and facilitate the seepage character. Likewise, shifting the dominant vegetation from hardwoods to pines and herbaceous ground cover should increase the water entering subsurface soils. It is important to accomplish such changes in the vegetation with a minimum of soil disruption to avoid erosion and a possible alteration of sheet flow across the ground surface (Platt *et al.* 1990).

Fire Regimes

Cutthroat grass communities are strongly dependent on frequent fire. Without fire, cutthroat grass seepage slopes become invaded by shrubs such as *Lyonia lucida, Myrica heterophylla*, and *Ilex glabra.* Within a short period, perhaps only a decade without fire, trees begin to become established within cutthroat grass seepage slopes. The most characteristic tree which invades, and eventually dominates, unburned seepage slopes is loblolly bay (*Gordonia lasianthus*). These can be mixed with swamp red bay (*Persea palustris*), sweet bay (*Magnolia virginiana*), and swamp black gum (*Nyssa sylvatica* var. *biflora*) in some areas.

Cutthroat grass is very flammable, even during the growing season. This is likely due to its high productivity, with biomass production of as much as 10,105 kg/ha (9,000 pounds/acre).

Although the character of cutthroat grass communities is dependent on the hydrology of the landscape in which they occur, fire regimes are critical in determining the type of vegetation present. Fire regimes that involve frequent, early growing-season fires (generally April to mid-June in south central Florida) favor cutthroat grass and other herbaceous species. These fires are critical for flowering and seed production by most species of grasses and many forbs, especially fall-flowering composites. Early growing-season fires can also depress woody shrubs and trees since they introduce a second stress at the time of year that these species are already under stress and have low carbohydrate reserves after green-up (Platt *et al.* 1990). Consistent application of annual or biennial growing-season fires, in other southeastern United States seepage communities can lead to a decline of shrub recruitment and also a decrease in shrub abundance (Drewa and Platt 1997, Olson and Platt 1995).

In contrast, fires that occur late in the growing season, or between growing seasons, stimulate clonal growth of woody shrubs and many trees, such as scrub oaks. In addition, fires at this time depress flowering of most species in the ground cover. While this does not result in immediate changes in the ground cover, continued use of such fires over long time intervals would result in a reduction in the number of herbaceous species present in the ground layer and an overall displacement of herbaceous plants by clonal woody species in the ground cover. Such changes are magnified by soil disruption and/or removal of the ground cover during clear-cutting and site preparation activities.

Cutthroat grass very rarely flowers in the absence of prescribed burning (Myers and Boettcher 1987) or some type of mechanical soil disturbance in the near vicinity of the clumps. The seasonality of prescribed burning was found to have a dramatic effect on the flowering phenology of cutthroat grass (Myers and Boettcher 1987, Robbins and Myers 1992). Fall and winter burns resulted in the production of very few inflorescences in cutthroat grass, whereas it flowered abundantly when burned between mid-April and mid-August. This is consistent with the general trend for increased flowering of native forbs with growing-season burning (Robbins and Myers 1992).

Status and Trends

Long-term fire suppression has resulted in a decline in the extent and natural integrity of cutthroat grass communities more than any other factor. Over much of the original extent of cutthroat grass communities along the Lake Wales Ridge, the open grassland nature of these areas has been replaced by shrub thicket and baygall communities. At this date, it is impossible to even determine the pre-settlement extent of cutthroat grass communities. Our best estimate is from the Highlands County soil survey, which maps 11,850 ha

(29,281 acres) of the Basinger-St. Johns-Placid soil complex in the county, amounting to 4.4 percent of the county. Examination of the areas mapped as this soil complex in Highlands County indicates that the vast majority of the area mapped as this soil association once supported cutthroat grass communities. There are also areas of cutthroat grass communities on other soil mapping units in Highlands County; however, these seem to be much more limited in extent, and we can assume that the 11,850 ha figure is a reasonable approximation of the pre-settlement extent of cutthroat grass communities in Highlands County. Unfortunately, since a specific soil mapping unit was not used for cutthroat grass community soils in the Polk County soil survey, it is not possible to arrive at a similar estimate for Polk County.

Currently, the extent of cutthroat grass communities is much more limited than the soil survey would indicate. There is a very good correlation between the extent of cutthroat grass soil types and extant cutthroat grass communities at Avon Park AFR. However, in most of the remainder of Highlands County, most of the area mapped as cutthroat grass soils is now dominated by woody vegetation, particularly broadleaf evergreen wetland shrubs and trees. This is likely due to the effects of long-term fire suppression. Typical trees which have invaded cutthroat grass communities include loblolly bay, sweet bay, swamp red bay, and slash pine. Many former cutthroat grass communities have also developed a dense shrub layer, typically including fetterbush (*Lyonia lucida*), gallberry holly, and wax myrtle *(Myrica cerifera*), all tied together with puncture vine (*Smilax laurifolia*). This is also true of most of the cutthroat grass communities in Polk County.

The only study which attempts to determine a percentage loss of cutthroat grass communities is Yahr *et al.* (1995) which looks at changes in cutthroat-dominated communities at Archbold Biological Station in relation to fire suppression and drainage history. They found in comparing the extent of cutthroat grass communities at Archbold between 1940 and 1994, that 39 percent of the sites which were cutthroat-dominated in 1940 were no longer cutthroat grass dominated. Over half of these were in areas which were fire-suppressed or both fire-suppressed and drained. Given that Archbold Biological Station has been more subject to good ecosystem management practices than almost anywhere else in the range of cutthroat grass communities, we can anticipate that the percentage loss would overall be much higher in the surrounding landscape.

Intact cutthroat grass community landscapes with the full range of cutthroat community types are now found only within Avon Park AFR. Even at Avon Park AFR, there has been a decrease in cutthroat grass communities since the 1940s (based on examination of aerial photography from 1941, 1943, 1958, 1973, and 1993). These losses have been due to past limited ditching, conversion to pine plantations, and less frequent and intense fire in most areas. Despite these losses, the over 5,800 ha (14,326 acres) of cutthroat grass communities remaining at Avon Park AFR represent the largest areal extent remaining for these natural communities. Avon Park AFR is the only area remaining where it is possible to see cutthroat grass communities with intact, fire-maintained ecotones extending from near the top of a central Florida sand ridge to the base of the ridge and grading into fire-maintained open pine savannas.

Cutthroat grass communities are secure at Avon Park AFB. However, there are some cutthroat community types which may not be represented at Avon Park AFR, and there are important biodiversity linkages which cutthroat communities on the Lake Wales Ridge could have which would not be duplicated on the Bombing Range Ridge. Archbold Biological Station provides protection for some of these other communities. It will be necessary to begin intensive fire management, and probably remove many mature pine trees, to begin restoration of cutthroat grass communities at Highlands Hammock SP, Lake Wales Ridge SF, and other protected areas.

Management

Most cutthroat grass communities have been subjected to alterations in hydrology and fire regimes that have resulted in deterioration of these sensitive habitats. The goal of proposed restoration and management efforts thus is to delineate the general nature of the changes that have occurred in these natural communities and to suggest restoration and management actions that will reverse these changes. The goal of this management should be to reinstitute environmental conditions present in the original habitats.

Management of cutthroat grass seepage slopes must also consider the environmental conditions present within the recharge areas of the upslope watershed. A low density of arboreal vegetation and moderate density of herbaceous ground cover will best approximate pre-settlement conditions that characterized the recharge areas. Changing these characteristics of recharge areas should increase the seepage character, both in terms of the amount of water flow and the length of hydroperiod. Such alterations of the hydrological regimes can be accomplished via prescribed burning in recharge areas, preferably via frequent, randomly timed, early growing-season fires. Such management direction should enhance the dominance of the hillside seeps by herbaceous species of plants, and should suppress trees and shrubs. Study of the extent to which such alterations in the vegetation of recharge areas will affect the seepage slopes needs to be conducted.

Removal of overgrown shrubs and promotion of herbaceous vegetation will favor species indigenous to cutthroat grass communities. Growing-season fires provide an essential environmental cue for flowering by herbaceous species. Early growing-season fires provide an effective management tool to remove woody species and prevent their re-invasion.

There are likely to be a number of changes that will result from changes in management. The environment of cutthroat grass communities will be modified following the institution of forces similar to those that historically controlled these habitats. Populations of endemic or disjunct seepage slope herbaceous species likely will be enhanced, including populations of rare or sensitive plant species. The increased water flow, coupled with the removal of shrub cover and herbaceous litter by fire, will cause a natural sheet flow across the soil surface in certain areas of the seepage slopes. This is a natural characteristic of these habitats, and is, in fact, part of the reason that some plant species are found only in these seepage slopes. Care must be taken to protect the seepage slope environment from accentuation of erosion via regulation of vehicular and foot traffic in the seepage slopes to the extent practicable, especially during wet periods.

Buffer zones for cutthroat grass seepage slopes should be designated to contain the recharge areas upslope from the seepage slope, if readily identifiable, and extend to the drainageways below the seepage slope. In areas with an obvious slope gradient, the recharge zone may be considered to extend to the top of the slope above the seepage slope. However, in areas with little topographic relief, it may not be possible to accurately delimit the total recharge zone for cutthroat grass communities. This is due primarily to an almost complete lack of information on the details of groundwater hydrology in this region. On broad, shallow slopes, the recharge zone is more difficult to delineate, and is probably quite extensive. Therefore, in these cases the outer buffer boundary should be established at least a minimum of 61 m (200 ft.) beyond the edge of cutthroat grass communities.

In some situations, some very selective timber removal activities should be conducted in the zone upslope from the seepage slope. Methods of timber management in this critical zone should incorporate sensitive, non-invasive practices, such as those used in streamside management zones (*e.g.*, directional tree falling near seepage slopes). Further, timber removal should be conducted in a manner that favors maintenance of indigenous ground cover vegetation and minimizes soil disruption: use only skidders with large, soft tires, log only in driest weather to prevent rutting and compaction, do not drag log butts or ends on the ground, do not damage trees to remain on site, designate log-haul routes if this will minimize overall soil/vegetation disruption, leave no logging slash piles, locate log landing areas outside of sensitive habitats. Mechanical site preparation activities, such as drum-chopping or discing, should never be conducted in these areas. In no case should machinery enter the seepage slope itself.

Other mechanical disturbances of soil and vegetation should be prevented to the greatest extent practicable, including off-the-road vehicle use and plowed firelines. If new firelines are plowed in improper positions, they must be repaired immediately. Existing plowed firelines through or immediately upslope of seepage slopes should be restored, where possible, to eliminate ditching effects and alteration of local hydrology. Attempts should be made to determine desirable methods of restoring these old firelines. New firelines or roadways should never be created upslope from seepage slopes, as these can serve to alter or divert seepage flow.

Initial removal of trees in cutthroat grass communities, both pine and hardwood, may be necessary to restore areas where these trees have shaded out herbaceous vegetation. Removal may be accomplished by hand cutting or careful use of stem-selective herbicides. Note that scattered longleaf and/or slash pines are characteristic of some cutthroat grass communities, especially cutthroat grass flatwoods, and so a few should be left, particularly older trees.

Continuation of timber management in the buffer zone is contingent upon the activity not causing significant soil disturbance and damage to the herbaceous layer. The effects of logging on ground cover must be assessed after each logging event. If it is determined that there has been significant disruption of the soil and herb layer, as judged by the presence of key indicator weed species, and by the critical reduction or elimination of certain disturbance-intolerant perennial grass species, timber management in the buffer zone must be appropriately modified.

Most cutthroat grass communities should be prescribed-burned in the growing season, during the period generally from April through mid June. If a site has been fire-suppressed for several years, an initial fuel reduction burn may be necessary in the dormant season prior to implementation of growing-season burns. These sites may require yearly growing-season burns thereafter for the first few years to bring woody encroachment under control. After woody encroachment is controlled, burn every 1 to 3 years on a random cycle, not burning at the same time of year each time. Vary the prescribed burning to the extent possible within the April through mid-June period. If manpower or legal restrictions (such as fire danger and smoke management issues) result in limited spring burning opportunities, then it is better to burn some cutthroat grass communities in the dormant season, rather than risk not being able to burn the site at all that year. To facilitate longleaf pine recruitment into the stands surrounding the cutthroat grass communities, burn late in the spring of a mast year (before fall seed-drop), and do not burn the spring after a mast year (Platt *et al.* 1990).

Broadscale application of herbicides in or near seepage slopes, and in areas that drain into seepage slopes, should not be allowed. However, some stem-selective herbicide treatment may prove a safe and efficient method of controlling undesirable woody vegetation within seepage slopes or buffer zones in some instances. This possibility should be investigated.

Historically, there has been an emphasis on grazing of much of the intact area of cutthroat grass communities. With grazing, creeping bluestem (*Schizachyrium stoloniferum)* and chalky bluestem (*Andropogon virginicus* var. *glaucus*) have been considered as decreasers, but cutthroat grass is considered an increaser (Sievers 1985). Various estimates have been given for the biomass production of cutthroat grass, up to 10,105 kg/ha (9,000 lb/acre), where slash pine overstory remains open (Sievers 1985). This productivity is higher than the maximum estimated for flatwoods, 8,420, kg/ha (7,500 lbs/acre), and only slightly less than that for freshwater marshes, 11,227 kg/ha (10,000 lbs/acre) (Sievers 1985).

An important factor making cutthroat grass communities highly suitable for grazing is the sod-forming nature of cutthroat grass (Penfield 1985). With careful management of the grazing timing and intensity, Avon Park AFB has successfully grazed cutthroat grass communities through leases for over 20 years with no seeming detrimental effect on biodiversity.

Where cattle grazing or trampling is shown to be an intolerable problem in a seepage slope, steps should be taken to attract cattle away from the seepage slope. Fencing may be necessary if livestock trampling becomes problematic.

In summary, cutthroat grass communities are highly diverse natural communities which are primarily found in Polk and Highlands counties in south-central Florida. They are threatened by fire-suppression and drainage, and have been lost from most of the landscape in which they once existed. An active fire management program with high fire-return intervals is needed in order to protect the biodiversity of these communities.

Abrahamson, W. G., Ann F. Johnson, James N. Layne, and Patricia A. Peroni. 1984.

Table 1: Microhabitat zones of the cutthroat grass seepage slope complex:

ZONE	DESCRIPTION
1	Dry cutthroat grass
2	Cutthroat grass lawn
3	Shrubby cutthroat grass lawn
4	Wet cutthroat grass lawn, transitional to seepage slope
5	Cutthroat grass seepage slope
6	Transition from cutthroat grass to mixed herbaceous seepage slope
7	Mixed herbaceous seepage slope
8	Cutthroat grass lawn below seepage slope
9	Transition from seepage slope to flatwoods
10	Boggy sphagnous meadow
11	Natural drainageway through seepage slope

Table 2. Frequency of plant species in cutthroat grass seepage slope complex microhabitat zones at Avon Park Air Force Range.

SCIENTIFIC NAME	1	2	3	4	5	6	7	8	9	10	11
	n=24	n=31	n=16	n=18	n=26	n=6	n=10	n=9	n=6	n=6	n=11
Agalinis linifolia	0	0	0	0	0	0	0	11	0	0	0
Aletris lutea	0	10	0	28	15	17	30	33	67	50	9
Amphicarpum muhlenbergianum	4	0	0	22	27	33	30	22	83	50	45
Andropogon brachystachyus	17	0	0	6	19	17	10	11	17	33	0
Andropogon glomeratus var. glaucopsis	4	55	6	33	50	33	20	56	50	33	18
Andropogon glomeratus var. glomeratus	0	3	0	0	19	0	10	11	33	17	9
Andropogon glomeratus var. hirsutior	0	13	13	11	31	33	20	0	33	17	0
Andropogon glomeratus var. pumilus	4	0	0	6	0	0	40	0	17	17	0
Andropogon gyrans var. stenophyllus	0	0	0	0	12	17	10	0	50	17	0
Andropogon ternarius var. cabanisii	4	0	0	0	0	0	0	0	0	0	0
Andropogon virginicus var. glaucus	8	13	0	0	8	0	0	0	17	0	0
Andropogon virginicus var. virginicus	8	3	0	6	31	0	10	0	0	0	0
Aristida beyrichiana	79	13	13	28	12	17	30	33	83	67	0
Aristida palustris	0	0	0	6	8	0	10	0	33	17	0
Aristida spiciformis	46	23	0	11	8	0	0	33	17	0	0
Asclepias connivens	0	3	0	0	12	0	0	11	0	33	0
Asclepias pedicellata	21	16	6	0	12	0	0	0	33	17	0
Asimina reticulata	71	16	13	11	8	0	0	33	50	17	0
Aster dumosus	0	3	0	0	8	0	0	0	0	0	0
Aster reticulatus	25	42	63	61	58	67	40	78	67	0	18
Axonopus compressus	0	0	0	6	0	0	0	0	0	0	0
Axonopus fissifolius	0	0	0	0	4	0	0	0	17	0	0
Axonopus furcatus	0	10	0	28	12	0	0	22	33	17	18
Bacopa caroliniana	0	0	0	0	0	0	0	0	0	0	9
Bartonia verna	0	0	0	0	0	0	20	0	33	0	9
Bartonia virginica	0	0	0	11	15	33	40	33	33	17	18
Befaria racemosa	54	0	19	0	0	0	0	0	17	0	0
Bigelowia nudata subsp. australis	0	3	0	22	19	0	40	11	67	17	9
Boltonia diffusa	0	0	0	0	0	0	0	11	0	0	0
Buchnera americana	4	0	0	0	0	0	0	0	0	0	0
Bulbostylis ciliatifolia	4	0	0	0	0	0	0	0	0	0	0
Burmannia biflora	0	0	0	11	0	0	20	0	17	0	9
Burmannia capitata	0	3	0	0	12	17	10	0	17	0	27
Calopogon barbatus	4	10	6	22	27	0	50	22	17	17	18

Table 2. ***Cont.***

SCIENTIFIC NAME	1	2	3	4	5	6	7	8	9	10	11
	n=24	n=31	n=16	n=18	n=26	n=6	n=10	n=9	n=6	n=6	n=11
Calopogon pallidus	0	10	0	17	23	17	20	22	0	33	0
Calopogon tuberosus	0	6	6	11	35	33	70	0	33	0	36
Carphephorus carnosus	0	6	0	11	4	0	0	22	50	33	0
Carphephorus corymbosus	4	0	0	0	0	0	0	0	0	0	0
Carphephorus paniculatus	29	52	0	28	27	0	0	44	33	17	0
Carphephorus odoratissimus	4	0	0	0	0	0	0	0	17	0	0
Centella asiatica	4	29	13	39	42	33	50	33	50	67	45
Chaptalia tomentosa	0	3	0	17	12	17	30	11	33	50	0
Cirsium nuttallii	0	0	0	0	4	0	0	0	0	0	0
Cnidoscolus stimulosus	4	0	0	0	0	0	0	0	0	0	0
Coreopsis floridana	0	6	0	0	15	17	20	0	33	17	18
Ctenium aromaticum	0	3	0	17	31	33	50	11	67	83	0
Cuphea carthagenensis	0	0	0	0	4	0	0	0	0	0	0
Cyperus haspan	0	0	0	6	4	17	0	0	0	33	27
Cyperus lanceolatus	0	0	0	0	4	0	0	0	0	0	0
Cyperus polystachyos	0	10	0	6	4	0	0	0	0	0	9
Cyperus retrorsus	8	6	0	0	0	0	0	0	0	0	0
Dichanthelium dichotomum	0	0	0	0	8	0	0	11	0	0	9
Dichanthelium ensifolium var. ensifolium	0	10	19	28	62	83	70	33	83	33	18
Dichanthelium ensifolium var. unciphyllum	21	3	0	0	0	0	0	11	17	0	0
Dichanthelium leucothrix	0	0	0	0	0	0	0	0	0	17	0
Dichanthelium portoricense	25	39	0	17	4	0	0	33	17	17	0
Dichanthelium scabriusculum	0	0	6	0	8	0	0	0	0	17	9
Dichanthelium strigosum var. glabrescens	0	0	0	0	0	0	0	0	17	0	0
Dichanthelium strigosum var. strigosum	0	0	0	6	8	0	0	11	17	17	0
Drosera capillaris	0	26	0	22	35	50	50	11	67	17	55
Eleocharis baldwinii	29	94	25	44	35	0	0	78	33	17	9
Eleocharis vivipara	0	0	0	0	0	17	0	0	0	0	18
Elephantopus elatus	17	0	19	0	0	0	0	0	17	0	0
Eragrostis elliottii	0	3	0	0	8	17	0	0	33	0	0
Eragrostis virginica	4	0	0	0	0	0	0	0	0	0	0
Erigeron vernus	8	13	6	28	38	17	20	33	67	33	27
Eriocaulon compressum	0	0	0	0	0	0	0	0	0	0	9

Table 2. *Cont.*

SCIENTIFIC NAME	1	2	3	4	5	6	7	8	9	10	11
	n=24	n=31	n=16	n=18	n=26	n=6	n=10	n=9	n=6	n=6	n=11
Eriocaulon decangulare	0	16	13	61	77	83	70	33	83	83	64
Eryngium yuccifolium	0	0	0	6	0	17	0	0	0	17	0
Eupatorium leptophyllum	0	0	0	0	0	17	0	0	0	0	0
Eupatorium pilosum	0	6	0	6	8	0	0	0	17	17	0
Eupatorium recurvans	25	45	0	56	31	0	10	67	33	50	9
Eupatorium rotundifolium	8	10	13	0	4	0	0	33	0	17	18
Euphorbia inundata	0	0	0	6	0	0	0	11	33	33	0
Euthamia tenuifolia	38	16	6	44	19	0	10	44	33	33	9
Fimbristylis autumnalis	0	0	0	0	4	0	0	0	0	0	9
Fimbristylis dichotoma	0	0	0	0	4	0	0	0	0	0	0
Fimbristylis puberula	13	3	6	0	0	0	0	11	17	0	0
Fimbristylis schoenoides	0	0	0	0	4	0	0	0	0	0	0
Fuirena breviseta	0	0	0	0	0	33	0	0	0	17	9
Fuirena scirpoidea	8	13	6	28	42	17	60	22	50	67	55
Galactia elliottii	38	0	44	0	8	0	0	0	17	0	0
Galactia regularis	4	0	0	0	0	0	0	0	0	0	0
Gaylussacia dumosa	50	32	6	33	8	17	20	0	0	0	9
Gaylussacia nana	13	13	13	6	12	0	0	22	0	0	0
Gordonia lasianthus	0	3	31	0	15	0	0	0	0	0	9
Gratiola hispida	25	0	0	0	0	0	0	0	17	0	0
Gratiola pilosa	0	0	0	17	15	0	0	0	0	67	18
Gymnopogon chapmanianus	17	0	0	0	0	0	0	0	0	0	0
Habenaria repens	0	0	0	0	0	0	0	0	0	0	9
Hartwrightia floridana	4	48	50	72	88	100	80	67	83	100	55
Hedyotis uniflora	4	0	0	17	4	0	0	11	0	17	9
Helianthus angustifolius	0	0	0	0	4	0	0	0	0	0	0
Hydrocotyle umbellata	0	0	0	0	0	0	0	0	0	17	9
Hypericum cistifolium	0	32	50	50	54	33	20	56	67	33	73
Hypericum fasciculatum	0	3	13	28	27	17	50	0	50	50	64
Hypericum mutilum	0	0	0	0	0	0	0	0	0	0	9
Hypericum myrtifolium	0	0	0	28	15	0	20	22	50	67	9
Hypericum reductum	83	10	0	0	0	0	0	33	17	0	0
Hypericum tetrapetalum	42	23	6	17	8	0	0	33	17	17	0

Table 2. ***Cont.***

SCIENTIFIC NAME	1	2	3	4	5	6	7	8	9	10	11
	n=24	n=31	n=16	n=18	n=26	n=6	n=10	n=9	n=6	n=6	n=11
Hypoxis juncea	54	32	19	6	23	0	10	44	33	17	0
Ilex cassine	0	3	6	0	0	17	0	0	0	0	0
Ilex glabra	58	61	75	72	77	83	60	89	100	67	55
Juncus marginatus var. biflorus	4	0	0	11	4	17	0	0	0	17	0
Juncus scirpoides	8	6	0	28	8	0	0	0	17	0	36
Lachnanthes caroliniana	0	10	0	0	23	50	40	0	0	33	9
Lachnocaulon anceps	13	16	0	22	19	0	0	22	50	50	9
Lachnocaulon beyrichianum	4	0	0	0	0	0	0	0	0	0	0
Lachnocaulon engleri	0	0	0	0	8	0	0	0	0	0	9
Lachnocaulon minus	0	0	0	0	0	0	0	0	0	0	18
Lechea torreyi	4	3	6	0	0	0	0	11	0	0	0
Liatris spicata	0	6	0	6	19	17	40	22	50	33	18
Liatris tenuifolia var. quadriflora	21	0	0	0	0	0	0	0	0	0	0
Lilium catesbaei	0	0	0	6	27	17	20	22	33	33	9
Linum medium var. texanum	0	0	0	6	0	0	0	11	17	0	0
Lobelia glandulosa	0	6	0	6	12	17	0	0	50	17	9
Lobelia paludosa	4	6	0	11	15	17	0	11	0	33	0
Ludwigia alata	0	0	0	6	8	0	0	0	0	17	0
Ludwigia maritima	21	6	0	22	4	0	0	0	0	17	0
Lycopodiella alopecuroides	0	29	13	44	65	83	80	33	83	67	27
Lycopodiella appressa	0	0	0	0	8	0	0	0	17	0	18
Lycopodiella caroliniana	4	3	0	11	19	17	30	0	33	0	36
Lycopodiella prostrata	0	0	0	0	0	0	10	0	0	0	0
Lygodesmia aphylla	17	0	6	0	0	0	0	0	33	0	0
Lyonia fruticosa	67	61	44	33	8	0	0	78	33	0	9
Lyonia ligustrina var. foliosiflora	0	13	44	6	31	17	10	22	17	0	9
Lyonia lucida	79	77	50	67	54	0	20	67	33	0	18
Magnolia virginiana	0	0	0	0	0	0	0	0	17	0	0
Marshallia tenuifolia	0	10	0	56	38	67	50	33	67	67	27
Myrica cerifera	75	61	63	50	50	0	20	56	83	50	27
Myrica heterophylla	0	0	25	28	54	100	60	0	50	0	27
Osmunda cinnamomea	4	10	69	17	23	50	20	22	17	0	45
Osmunda regalis var. spectabilis	0	0	6	6	4	17	0	0	0	0	18

Table 2. ***Cont.***

SCIENTIFIC NAME	1	2	3	4	5	6	7	8	9	10	11
	n=24	n=31	n=16	n=18	n=26	n=6	n=10	n=9	n=6	n=6	n=11
Oxypolis filiformis	4	6	0	0	27	17	20	33	50	33	27
Panicum abscissum	96	94	63	83	96	67	30	100	83	67	55
Panicum hemitomon	0	0	0	0	4	0	0	0	0	17	0
Panicum hians	0	0	0	0	0	17	0	0	0	0	0
Panicum longifolium	0	0	0	0	0	0	0	0	33	0	0
Panicum repens	0	0	0	0	0	0	0	0	0	0	18
Panicum rigidulum	0	0	0	6	0	0	0	0	0	17	0
Panicum tenerum	0	0	0	0	0	0	0	0	33	0	9
Panicum verrucosum	0	3	0	0	4	17	10	11	17	0	0
Paspalum laeve	0	0	0	11	12	17	0	0	33	17	9
Paspalum notatum var. saurae	0	0	0	6	4	0	0	0	0	0	0
Paspalum praecox	0	10	0	17	23	0	30	11	33	50	18
Paspalum setaceum	42	19	0	6	4	0	0	0	0	0	0
Paspalum urvillei	0	0	0	0	4	0	0	0	0	0	0
Persea palustris	0	6	44	0	8	17	10	0	17	0	18
Physostegia purpurea	0	0	0	6	4	0	0	0	17	33	0
Piloblephis rigida	8	0	0	0	0	0	0	0	0	0	0
Pinguicula caerulea	0	16	6	11	19	0	30	33	17	17	0
Pinguicula lutea	25	71	19	33	23	33	0	56	33	0	0
Pinguicula pumila	4	3	0	6	0	17	0	11	0	0	0
Pinus elliottii var. densa	13	19	31	6	19	17	50	22	33	0	9
Pinus palustris	25	32	25	22	31	50	40	44	83	0	27
Pityopsis graminifolia	12	0	0	0	0	0	0	0	17	0	0
Platanthera blephariglottis var. conspicua	0	6	6	6	8	17	20	11	33	17	18
Platanthera ciliaris	0	0	0	6	4	0	0	11	0	0	9
Platanthera integra	0	0	0	0	4	0	0	0	0	0	9
Pluchea foetida	0	0	0	6	0	17	0	0	0	33	9
Pluchea rosea	0	3	0	0	0	0	0	0	0	0	0
Pogonia ophioglossoides	0	0	6	11	31	67	60	11	0	17	27
Polygala cruciata	0	0	0	11	19	17	60	11	33	17	18
Polygala incarnata	0	3	0	0	0	0	0	11	0	0	0
Polygala lutea	0	3	0	6	8	0	0	11	33	33	9
Polygala ramosa	0	0	0	0	0	0	10	11	0	17	9

Table 2. *Cont.*

SCIENTIFIC NAME	1	2	3	4	5	6	7	8	9	10	11
	n=24	n=31	n=16	n=18	n=26	n=6	n=10	n=9	n=6	n=6	n=11
Polygala rugelii	38	81	13	67	73	83	50	100	100	50	27
Polygala setacea	58	13	0	0	4	0	0	33	33	17	0
Polypremum procumbens	4	0	0	0	0	0	0	0	0	0	9
Pontederia cordata	4	0	0	0	0	0	0	0	0	0	0
Proserpinaca pectinata	0	0	0	6	0	0	0	0	0	33	18
Pteridium aquilinum var. latiusculum	17	3	38	0	4	0	0	11	17	0	9
Pterocaulon pycnostachyum	71	23	19	17	8	0	10	44	33	17	0
Pyrus arbutifolia	0	0	13	0	0	0	0	0	0	0	0
Quercus geminata	13	3	0	0	0	0	0	0	0	0	0
Quercus laurifolia	0	3	0	0	0	0	0	0	0	0	0
Quercus minima	25	3	6	0	0	0	0	22	17	17	0
Rhexia cubensis	0	6	19	17	46	17	20	11	33	17	27
Rhexia mariana	8	29	0	50	50	33	60	44	67	67	45
Rhexia nashii	0	0	0	0	15	0	0	0	17	17	9
Rhexia nuttallii	54	68	13	67	73	83	50	78	67	33	36
Rhexia petiolata	0	3	6	11	12	33	30	0	0	0	36
Rhynchospora baldwinii	0	6	0	6	0	0	10	11	0	0	0
Rhynchospora breviseta	0	3	0	6	35	67	40	22	83	33	18
Rhynchospora cephalantha	0	3	6	39	62	67	80	11	67	50	36
Rhynchospora chapmanii	0	0	0	11	19	17	10	11	17	17	9
Rhynchospora ciliaris	8	84	25	67	77	83	70	89	83	50	36
Rhynchospora colorata	0	0	0	0	4	0	0	0	0	0	0
Rhynchospora decurrens	0	0	0	6	4	0	0	11	0	17	0
Rhynchospora fascicularis	42	55	13	33	46	50	50	78	67	50	9
Rhynchospora fascicularis var. distans	0	0	0	0	0	0	0	0	17	0	0
Rhynchospora fernaldii	13	3	0	0	0	0	0	0	0	0	0
Rhynchospora inundata	0	0	0	0	0	0	0	0	33	17	0
Rhynchospora latifolia	0	0	0	0	0	17	20	0	17	17	0
Rhynchospora microcarpa	0	0	0	0	8	0	0	0	0	0	9
Rhynchospora microcephala	0	0	0	0	0	0	0	0	0	0	9
Rhynchospora oligantha	0	0	0	0	15	50	50	0	0	0	0
Rhynchospora plumosa	4	3	0	0	8	0	0	0	0	0	0
Rhynchospora rariflora	0	3	0	17	31	83	70	33	0	67	18

Table 2. ***Cont.***

SCIENTIFIC NAME	1	2	3	4	5	6	7	8	9	10	11
	n=24	n=31	n=16	n=18	n=26	n=6	n=10	n=9	n=6	n=6	n=11
Rhynchospora wrightiana	0	19	0	17	19	17	20	0	17	17	0
Sabatia difformis	0	26	19	39	58	83	60	22	67	17	36
Sabatia grandiflora	4	16	6	33	46	50	60	56	67	50	18
Saccharum giganteum	0	0	0	0	0	17	10	0	0	0	0
Sacciolepis indica	0	0	0	0	0	0	0	0	0	17	27
Sagittaria graminea var. chapmanii	0	0	0	0	0	0	0	0	0	17	36
Sagittaria isoetiformis	0	0	0	6	0	0	0	0	0	0	0
Sagittaria lancifolia	0	0	0	0	0	0	10	0	0	0	0
Sarracenia minor	4	45	31	50	73	83	70	67	50	100	64
Schizachyrium stoloniferum	29	16	6	17	27	17	20	33	33	17	0
Schrankia microphylla var. floridana	67	19	13	6	8	0	0	11	33	17	0
Scleria georgiana	0	0	0	0	4	0	10	0	0	0	0
Scleria pauciflora	8	6	6	0	0	0	0	0	0	0	9
Scleria reticularis	13	26	6	56	62	50	20	44	50	67	36
Scleria triglomerata	13	6	19	11	15	17	20	22	0	0	0
Serenoa repens	83	48	81	28	15	33	0	33	67	33	9
Setaria geniculata	0	6	0	0	4	0	0	0	0	0	0
Sisyrinchium angustifolium	0	0	0	0	0	0	10	0	0	17	9
Smilax auriculata	4	3	0	0	0	0	0	0	0	0	0
Smilax laurifolia	0	0	19	0	4	0	0	0	0	0	9
Solidago fistulosa	4	6	13	11	15	0	0	0	0	33	18
Solidago odora var. chapmanii	4	0	0	0	0	0	0	0	0	0	0
Sorghastrum secundum	8	6	0	0	4	0	0	11	17	0	0
Sphagnum spp.	0	13	31	33	65	100	70	11	33	50	91
Spiranthes vernalis	0	3	0	0	8	0	10	11	0	17	0
Stillingia sylvatica var. sylvatica	8	3	6	0	0	0	0	0	17	0	0
Stillingia sylvatica var. tenuis	0	0	0	0	0	0	0	0	0	17	0
Syngonanthus flavidulus	92	81	25	56	38	0	40	78	100	50	36
Triadenum virginicum	0	0	0	0	4	0	0	0	0	0	0
Utricularia fibrosa	0	0	0	0	0	0	0	0	0	0	9
Utricularia juncea	0	0	0	6	8	0	10	11	17	0	27
Utricularia purpurea	0	0	0	0	0	0	0	0	0	0	9
Utricularia subulata	13	19	6	17	23	17	30	22	50	33	36

Table 2. ***Cont.***

SCIENTIFIC NAME	1	2	3	4	5	6	7	8	9	10	11
	n=24	n=31	n=16	n=18	n=26	n=6	n=10	n=9	n=6	n=6	n=11
Vaccinium myrsinites	92	48	44	17	12	0	0	44	33	0	0
Viola lanceolata	0	3	6	6	4	0	10	0	0	17	9
Viola primulifolia	0	0	0	0	0	0	0	11	0	0	0
Vitis rotundifolia var. rotundifolia	0	0	19	0	0	0	0	0	0	0	0
Woodwardia areolata	0	0	0	0	0	0	0	0	0	0	18
Woodwardia virginica	0	0	31	22	35	50	30	0	33	33	27
Xyris ambigua	0	23	0	50	65	50	60	67	83	67	18
Xyris brevifolia	38	39	6	6	0	0	10	33	33	0	9
Xyris caroliniana	50	10	6	0	0	0	0	11	17	0	0
Xyris difformis var. floridana	4	3	0	11	4	33	0	11	33	0	0
Xyris elliottii	17	42	19	50	54	67	60	67	100	67	36
Xyris fimbriata	0	3	13	11	35	33	60	0	17	17	36
Xyris jupicai	0	6	0	6	4	17	0	0	0	0	27
Xyris platylepis	4	77	19	61	85	33	30	100	50	33	27
Xyris serotina	0	0	0	0	0	0	0	0	0	0	9
Xyris smalliana	0	0	0	6	0	0	30	0	0	17	0
Zigadenus densus	0	3	6	0	12	0	20	0	0	0	0

Table 3. Percent frequency of species in other cutthroat grass community types at Avon Park Air Force Range.

SCIENTIFIC NAME	Mesic flatwoods	Wet flatwoods	Depression marsh margin	Drainage ecotone	Wet prairie
	n=4	n=10	n=14	n=5	n=11
Pterocaulon pycnostachyum	100	10	7	20	0
Vaccinium myrsinites	100	20	14	60	9
Serenoa repens	100	40	14	80	18
Pinus palustris	75	20	7	20	0
Xyris caroliniana	75	20	0	20	0
Hypericum reductum	75	30	0	20	0
Asimina reticulata	75	30	0	20	9
Gratiola hispida	50	0	0	0	0
Befaria racemosa	50	10	0	0	0
Aristida spiciformis	50	30	7	20	0
Galactia elliottii	50	10	0	0	0
Quercus minima	50	20	0	20	0
Schrankia microphylla var. floridana	50	10	0	20	0
Eleocharis baldwinii	50	60	36	40	9
Dichanthelium ensifolium var. unciphyllum	50	10	0	0	9
Lyonia fruticosa	50	20	14	0	9
Carphephorus paniculatus	50	60	7	40	9
Lyonia lucida	75	60	57	80	36
Euthamia tenuifolia	50	40	7	20	18
Aristida beyrichiana	50	50	7	40	18
Tephrosia hispidula	25	0	0	0	0
Carphephorus odoratissimus	25	0	0	0	0
Carphephorus corymbosus	25	0	0	0	0
Pityopsis graminifolia	25	0	0	0	0
Lechea torreyi	25	0	0	0	0
Eragrostis virginica	25	0	0	0	0
Bulbostylis ciliatifolia	25	0	0	0	0
Liatris tenuifolia var. quadriflora	25	10	0	0	0
Aster dumosus	25	0	0	0	0
Gymnopogon brevifolius	25	0	0	20	0
Rhynchospora plumosa	25	10	7	0	0
Seymeria pectinata	25	0	0	0	0

Table 3. ***cont.***

SCIENTIFIC NAME	Mesic flatwoods	Wet flatwoods	Depression marsh margin	Drainage ecotone	Wet prairie
	n=4	n=10	n=14	n=5	n=11
Agalinis obtusifolia	25	0	0	0	0
Elephantopus elatus	25	0	0	0	0
Pinguicula pumila	25	0	0	0	0
Hypericum tetrapetalum	25	10	0	0	0
Lygodesmia aphylla	25	10	0	0	0
Rhynchospora fernaldii	25	10	0	0	0
Gaylussacia dumosa	25	10	0	20	0
Scleria pauciflora	25	10	0	0	0
Blechnum serrulatum	25	0	0	0	0
Gaylussacia nana	25	0	0	0	0
Andropogon virginicus var. decipiens	25	10	0	0	0
Gaylussacia tomentosa	25	0	0	0	0
Pinguicula lutea	25	40	14	0	0
Pityopsis graminifolia var. tracyi	25	10	0	0	0
Schizachyrium stoloniferum	50	20	0	40	27
Rhexia nuttallii	50	50	64	40	27
Andropogon brachystachyus	50	20	7	20	27
Andropogon ternarius var. cabanisii	25	0	0	0	9
Solidago fistulosa	25	10	14	20	9
Paspalum setaceum	25	20	0	60	9
Sorghastrum secundum	25	10	0	0	9
Xyris brevifolia	25	10	7	0	9
Hypoxis juncea	25	20	7	20	9
Polygala setacea	25	30	0	20	9
Dichanthelium dichotomum	25	0	0	20	9
Aster reticulatus	25	20	21	0	9
Pinus elliottii var. densa	25	70	0	0	9
Stillingia sylvatica var. sylvatica	25	0	0	0	9
Dichanthelium portoricense	25	30	0	20	9
Lachnocaulon anceps	50	40	7	80	36
Rhynchospora fascicularis	50	70	14	40	36
Myrica cerifera	75	90	36	80	64

Table 3. ***cont.***

SCIENTIFIC NAME	Mesic flatwoods	Wet flatwoods	Depression marsh margin	Drainage ecotone	Wet prairie
	n=4	n=10	n=14	n=5	n=11
Utricularia subulata	25	0	7	40	18
Ludwigia maritima	25	40	0	20	18
Xyris difformis var. floridana	25	10	7	40	18
Syngonanthus flavidulus	50	70	21	60	45
Eupatorium recurvans	50	20	50	40	45
Polygala lutea	0	20	7	40	0
Vaccinium corymbosum	0	0	0	20	0
Pteridium aquilinum var. latiusculum	0	10	0	0	0
Hydrocotyle umbellata	0	10	0	0	0
Polygonum hydropiperoides	0	0	7	0	0
Eriocaulon compressum	0	0	7	0	0
Juncus repens	0	0	7	0	0
Bartonia virginica	0	0	7	0	0
Scleria baldwinii	0	0	7	0	0
Gratiola pilosa	0	20	7	20	0
Diodia virginiana	0	10	0	0	0
Burmannia capitata	0	0	7	0	0
Nyssa sylvatica var. biflora	0	0	7	0	0
Sagittaria lancifolia	0	0	7	0	0
Juncus scirpoides	0	20	0	20	0
Ludwigia suffruticosa	0	0	7	0	0
Scleria triglomerata	0	10	7	20	0
Myrica heterophylla	0	30	7	0	0
Ludwigia lanceolata	0	0	7	0	0
Gratiola ramosa	0	0	7	0	0
Rhynchospora chapmanii	0	0	14	20	0
Sacciolepis striata	0	0	7	0	0
Polygala ramosa	0	0	0	20	0
Sagittaria isoetiformis	0	0	7	0	0
Sisyrinchium angustifolium	0	10	0	0	0
Ilex cassine	0	10	0	0	0
Chaptalia tomentosa	0	30	0	0	0

Table 3. ***cont.***

SCIENTIFIC NAME	Mesic flatwoods	Wet flatwoods	Depression marsh margin	Drainage ecotone	Wet prairie
	n=4	n=10	n=14	n=5	n=11
Viola lanceolata	0	10	0	20	0
Persea palustris	0	30	0	0	0
Panicum tenerum	0	10	0	20	0
Xyris jupicai	0	10	0	20	0
Pluchea rosea	0	0	29	0	0
Rhexia petiolata	0	20	0	0	0
Ludwigia linifolia	0	0	7	20	0
Rhynchospora filifolia	0	0	7	20	0
Calopogon tuberosus	0	0	7	20	0
Polygala cruciata	0	20	7	0	0
Dichanthelium scabriusculum	0	10	0	0	0
Asclepias connivens	0	10	0	0	0
Dichanthelium strigosum var. glabrescens	0	10	0	0	0
Spiranthes longilabris	0	0	0	20	0
Lyonia ligustrina var. foliosiflora	0	10	7	0	0
Rhynchospora baldwinii	0	0	0	20	0
Sacciolepis indica	0	20	0	0	0
Bartonia verna	0	0	0	20	0
Gordonia lasianthus	0	20	0	0	0
Lycopodiella caroliniana	0	0	14	0	0
Setaria geniculata	0	20	0	0	0
Panicum verrucosum	0	10	0	0	0
Juncus marginatus var. biflorus	0	10	0	0	0
Osmunda cinnamomea	0	10	7	0	0
Cyperus polystachyos	0	10	0	0	0
Smilax walteri	0	10	7	0	0
Paspalum notatum var. saurae	0	10	0	0	0
Polygala cymosa	0	0	14	0	0
Hedyotis uniflora	0	0	14	0	0
Vitis rotundifolia var. rotundifolia	0	10	0	0	0
Viola primulifolia	0	10	0	0	0
Cyperus retrorsus	0	10	0	0	0

Table 3. *cont.*

SCIENTIFIC NAME	Mesic flatwoods	Wet flatwoods	Depression marsh margin	Drainage ecotone	Wet prairie
	n=4	n=10	n=14	n=5	n=11
Calopogon pallidus	0	10	0	0	0
Andropogon virginicus var. virginicus	25	10	7	20	27
Andropogon virginicus var. glaucus	25	10	0	40	27
Axonopus furcatus	25	30	0	40	27
Rhynchospora ciliaris	25	40	43	100	27
Ilex glabra	50	70	7	100	55
Cyperus haspan	0	0	7	0	9
Ludwigia alata	0	0	7	0	9
Helianthus angustifolius	0	0	0	0	9
Asclepias pedicellata	0	10	7	20	9
Andropogon glomeratus var. hirsutior	0	0	0	0	9
Utricularia purpurea	0	0	0	0	9
Spartina bakeri	0	0	0	0	9
Lycopodiella appressa	0	0	0	0	9
Rhynchospora rariflora	0	30	0	0	9
Saccharum giganteum	0	0	0	0	9
Dichanthelium erectifolium	0	0	7	20	9
Rhynchospora fascicularis var. distans	0	0	7	20	9
Rhynchospora wrightiana	0	10	0	20	9
Woodwardia virginica	0	40	14	0	9
Panicum repens	0	0	0	0	9
Dichanthelium ensifolium var. ensifolium	0	10	21	20	9
Fimbristylis puberula	0	10	7	0	9
Eupatorium rotundifolium	0	20	0	0	9
Rhynchospora microcarpa	0	0	0	0	9
Drosera capillaris	0	10	29	20	9
Dichanthelium strigosum var. strigosum	0	0	0	20	9
Physostegia purpurea	0	0	0	20	9
Scleria georgiana	0	10	14	0	9
Utricularia juncea	0	0	7	0	9
Pogonia ophioglossoides	0	10	7	0	9
Sarracenia minor	25	90	43	80	36

Table 3. ***cont.***

SCIENTIFIC NAME	Mesic flatwoods	Wet flatwoods	Depression marsh margin	Drainage ecotone	Wet prairie
	n=4	n=10	n=14	n=5	n=11
Polygala rugelii	50	60	79	80	64
Proserpinaca pectinata	0	30	14	0	18
Pinguicula caerulea	0	0	7	0	18
Sabatia difformis	0	30	14	0	18
Sagittaria graminea var. chapmanii	0	0	7	0	18
Coreopsis floridana	0	0	0	0	18
Aletris lutea	0	30	14	20	18
Aristida palustris	0	0	14	20	18
Hypericum cistifolium	0	0	21	40	18
Pluchea foetida	0	10	21	0	18
Liatris spicata	0	10	0	0	18
Taxodium ascendens	0	0	0	0	18
Eragrostis elliottii	0	0	0	0	18
Coelorachis rugosa	0	0	0	0	18
Paspalum laeve	0	0	0	20	18
Agalinis linifolia	0	0	0	0	18
Xyris elliottii	25	50	36	60	45
Panicum abscissum	75	100	93	100	100
Andropogon glomeratus var. glomeratus	0	0	0	0	27
Xyris smalliana	0	0	7	0	27
Fuirena scirpoidea	0	20	14	60	27
Panicum longifolium	0	0	7	0	27
Lobelia glandulosa	0	10	0	40	27
Bidens mitis	0	0	0	0	27
Sphagnum spp.	0	50	36	0	27
Rhynchospora inundata	0	0	0	0	27
Rhynchospora decurrens	0	0	14	0	27
Oxypolis filiformis	0	20	7	20	27
Andropogon gyrans var. stenophyllus	0	0	0	0	27
Rhexia nashii	0	0	0	20	27
Xyris ambigua	25	50	57	40	55
Rhexia mariana	25	60	50	40	55

Table 3. *cont.*

SCIENTIFIC NAME	Mesic flatwoods	Wet flatwoods	Depression marsh margin	Drainage ecotone	Wet prairie
	n=4	n=10	n=14	n=5	n=11
Rhynchospora breviseta	0	20	7	20	36
Bigelowia nudata subsp. australis	0	20	7	40	36
Erigeron vernus	0	40	14	60	36
Lobelia paludosa	0	10	0	40	36
Carphephorus carnosus	0	40	7	60	36
Panicum hemitomon	0	0	7	0	36
Marshallia tenuifolia	25	40	36	20	64
Paspalum praecox	0	50	7	0	54
Lachnanthes caroliniana	0	40	29	0	45
Xyris fimbriata	0	10	29	0	45
Rhexia cubensis	0	20	43	20	55
Ctenium aromaticum	0	20	0	60	55
Hypericum fasciculatum	0	20	43	0	55
Xyris platylepis	0	80	43	60	55
Lycopodiella alopecuroides	0	40	43	20	55
Scleria reticularis	25	80	29	60	82
Sabatia grandiflora	0	10	36	40	64
Andropogon glomeratus var. glaucopsis	0	30	36	60	64
Hypericum myrtifolium	0	30	21	40	73
Amphicarpum muhlenbergianum	0	30	21	40	73
Centella asiatica	0	60	50	60	73
Hartwrightia floridana	0	60	43	20	82
Rhynchospora cephalantha	0	50	50	0	82
Eriocaulon decangulare	0	80	71	40	91

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Restoration of Cutthroat Grass Communities

Restoration Objective: Maintain and enhance the structure, function, and composition of cutthroat grass communities, protect cutthroat grass biodiversity to encompass the range of geographic variation, and increase the spatial extent of cutthroat grass habitat in South Florida.

Restoration Criteria

The restoration objective will be achieved when: (1) cutthroat grass communities are adequately protected from further habitat loss, degradation, exotic plant invasion, and fire suppression; (2) degraded areas are identified, acquired, and restored to suitable habitat; (3) appropriate ecosystem management plans (including monitoring and research) have been prepared, funded, and implemented for long-term perpetuation of the cutthroat grass landscape; (4) cutthroat grass is appropriately protected and managed to benefit community-dependent species; (5) ecological linkages to adjacent communities are restored; and (6) landscape-level habitat diversity is restored.

Community-level Restoration Actions

1. **Determine the historical and current distribution and status of cutthroat grass communities in peninsular Florida.** There is very little specific published or unpublished data on the rangewide distribution and status of cutthroat grass and cutthroat grass communities. Estimates of the current extent of cutthroat grass communities are known only for Archbold Biological Station and Avon Park AFB.

    1.1. **Estimate the historical extent and location of cutthroat grass communities for all counties within the range of cutthroat grass.** This would require interpretation of soil surveys, geomorphologic features, and historical aerial photography, in conjunction with mapping of known occurrences, to derive an estimate of potential range and extent of cutthroat grass and cutthroat grass communities.

    1.2. **Determine the current distribution and status of cutthroat grass communities on both private and public lands in Florida.** Some cutthroat grass communities could be located by interpretation of recent aerial photography. However, fire-suppressed examples and cutthroat grass flatwoods communities would be difficult to accurately locate on aerial photographs, and would require intensive ground-truthing to eliminate errors in interpretation.

1.3. **Identify, map and conduct ecological (plant and animal) inventories of remaining cutthroat grass communities to determine locations for the highest quality cutthroat grass community sites.** Data from a systematic and comprehensive inventory would be used to develop, rank and prioritize a listing of the most ecologically significant cutthroat grass communities and to determine the degree of vulnerability of sites. Plant and animal inventories and *de novo* searches for rare taxa would uncover previously unknown sites and thereby provide updated documentation on the status and distribution of rare taxa. To date, these surveys have been conducted at few sites other than within Avon Park AFB.

2. **Prevent further destruction or degradation of existing cutthroat grass communities.**

2.1. **Secure protection for all of the remaining intact, high-quality cutthroat grass community sites.** Develop a protection plan for all tracts identified in **1.2** and **1.3**. Continue through land acquisition, landowner agreements, and conservation easements, land trades, or other conservation measures protection of cutthroat grass sites. Priority should be placed on preventing the loss of any remaining high-quality cutthroat grass community sites, with emphasis on protection of sites with intact landscapes and an intact, diverse native ground cover. Devise and negotiate interagency agreements (with Water Management Districts, Department of Environmental Protection, U. S. Fish & Wildlife Service, *etc*.) to improve mitigation procedures for loss of wetlands in cutthroat grass community landscapes. Sites identified as most threatened with destruction should be targeted and protected to prevent destruction. Once cutthroat grass communities have been converted to agricultural, commercial, or residential uses, there is no known way to restore cutthroat grass or associated species. The highest priority should be placed on preventing development of remaining cutthroat grass communities.

2.2. **Prevent further degradation of disturbed, but recoverable examples of** cutthroat grass communities by securing protection of such sites. This could be accomplished by conservation methods that prevent development, other than land acquisition, such as conservation easements, particularly on large cattle ranches where land acquisition is prohibitively expensive.

2.3. **Ensure proper protection of existing protected areas.** Fire-suppression and lack of sufficiently frequent or intense prescribed burning continues to be a problem in management of cutthroat grass communities even in protected areas. Drainage and other hydrologic alterations on private land adjacent to existing protected areas, and alterations in the source of seepage hydrology within the uplands adjacent to cutthroat grass communities could be a major long-term problem in maintaining protected sites. Federal and State agencies need to work more efficiently and closely together to solve problems that cross the jurisdictional boundaries of an agency.

2.4. **Ensure proper management of existing protected areas.** Staffing and budgetary constraints continue to present the greatest threat to proper management of existing protected areas. Other problems faced by land managers that hinder implementation of proper management strategies include lack of technical guidance information, insufficient equipment and manpower, and restrictions on the timing, size, and intensity of prescribed burning.

2.5. **Develop private landowner protection incentives for cutthroat grass communities.** Provide an economic or tax incentive to private landowners to prevent drainage and alteration of the watersheds supporting cutthroat grass communities.

Federal, State and county governments should explore new and innovative ways to provide tax breaks or other economic incentives to private landowners that choose ecological stewardship of their lands. Economic opportunities for private landowners to retain native vegetation should be encouraged, including hunting, eco-tourism, low-intensity grazing of native rangeland, and harvesting of native grass seed for reclamation and restoration purposes. All of these help provide economic incentives to landowners to retain areas in natural cutthroat grass vegetation. Eliminate any tax incentives for silvicultural operations on cutthroat grass communities.

2.6. **Connect existing cutthroat grass community preserves by acquiring lands for conservation between them**. Land acquisition, landowner agreements or conservation easements should be used to prevent development of lands between existing conservation areas. Lands acquired as connectors between cutthroat grass community preserves need not be cutthroat grass communities. Much of this interconnection can be provided by designing preserves and connectors which encompass scrub and other xeric upland communities in association with the adjacent cutthroat grass communities.

2.7. **Conduct vegetation monitoring of cutthroat grass communities to determine responses to various management strategies.** Several potential results could come from vegetation monitoring of cutthroat grass communities which have implications for long-term management strategies. First, by considering the effects of management on a broader set of ecosystem components (*e.g.* all the plant species present) the possibility of misleading results (in the context of ecosystem management) based on a single species subject to possibly non-management related events is minimized. Secondly, because much more replication is possible in a vegetation study, the chances of uncovering statistically significant differences between treatments is increased. Thirdly, long-term trends in the abundance of conservative versus weedy or opportunistic species can be monitored within the plots, and can be used as input for management decisions.

2.8. **Encourage and support the efforts of the central and South Florida interagency prescribed fire councils.** Without the ability and flexibility to use prescribed burning, management of cutthroat grass communities would be virtually impossible. The role of the prescribed fire councils in safeguarding, promoting and educating the public about the use of prescribed fire is essential to the future of prescribed burning.

3. **Restore existing degraded cutthroat grass communities.** Develop techniques for restoring modified or disturbed cutthroat grass communities.

3.1. **Reintroduce natural fires and/or prescribe controlled burns.** Cutthroat grass communities that have been degraded because of fire exclusion may be restorable with prescribed fires. Each protected cutthroat grass community site should have a fire management plan. Management plans should specifically include allowing natural, lightning-ignited fires to burn through the cutthroat grass community landscape whenever possible, especially on the larger preserves. Burn plans for sites should specify fire type, intensity and frequency in order to mimic natural fires to meet management objectives.

3.2. **Encourage maintenance and recovery of landscape-level ecological processes.** Where possible, management efforts should strive to maintain and enhance ecological processes (natural fire regimes, natural hydrologic perturbations, biological interactions, ecosystem function, *etc.)* characteristic of the natural landscape. In particular, allowing natural lightning fires and other natural disturbances should receive special attention in management plans for areas with intact landscapes. Firebreaks and roads should be placed well away from ecotones. Firebreaks at ecotones can greatly disrupt the hydrology of cutthroat grass communities. Ecotones that have been degraded by existing roads and fire breaks should be restored.

3.3. **Eliminate or control exotic and off-site species.** The native ground cover of some cutthroat grass communities has been altered by past attempts to improve the livestock grazing potential and /or commercial forestry potential. Effort to eliminate or control exotic plants should be implemented. In addition, eradication of feral hogs should be a priority on cutthroat grass community preserves.

3.4. **Continue to allow appropriate public uses.** Cutthroat grass communities acquired for conservation of biotic resources must be protected from inappropriate public use. However, public access is very important for educational purposes and to build public support for conservation efforts. Off-road vehicle use and commercial rare plant collecting are not compatible with conservation.

3.5. **Monitor for negative population trends among important cutthroat grass community plant and animal taxa.** Each cutthroat grass community preserve should have a specific monitoring plan that will alert land managers to extirpations or downward trends in populations of selected cutthroat grass community species, including endemic species, listed species, and imperilled species.

3.6. **Monitor and eliminate hydrologic alterations.** Artificial drainage from cutthroat grass communities should be minimized by plugging of ditches, and filling ruts associated with old firebreaks, fire plow furrows, and woods roads, particularly those which run downslope and serve to drain the community. Vegetation sampling and monitoring of permanent vegetation plots is needed to determine the effects of hydrologic alteration on cutthroat grass communities.

4. **Encourage ecosystem/landscape-level research projects in cutthroat grass communities.** Identify ecosystem processes (vegetation composition and structure, successional patterns, hydrologic regimes, burn regimes, herbivory, *etc*.) in cutthroat grass communities and use research findings to aid in development of management guidelines and strategies.

4.1. **Determine the rangewide geographic and local edaphic variation in the cutthroat grass community ecosystem.** Conduct rangewide studies incorporating floristic surveys (considering species composition, phytogeographic patterns, relative frequency data and vegetation physiognomy), faunal surveys and correlated environmental parameters (climate, hydrology, edaphic factors and regional landscape context) to recognize and differentiate regional variation and local edaphic variation. This is of particular importance to determine if the cutthroat grass communities described for Avon Park AFR (mostly on the Bombing Range Ridge) are similar or dissimilar to communities on the Lake Wales Ridge, and if additional, as yet undescribed, cutthroat grass community types are present on the Lake Wales Ridge. Understanding local and regional variation is necessary in order to protect the biodiversity of cutthroat grass communities.

4.2. **Fund and conduct research on the effect of livestock grazing on cutthroat grass communities.** Since much of the economic benefit to private landowners of cutthroat grass communities is derived from revenues generated from livestock grazing, it is important to fund studies evaluating the effects of livestock grazing on not only the cutthroat grass community, but also on its flora and fauna. Funding to evaluate the effects of livestock grazing on cutthroat grass vegetation through establishment of permanent plots and exclosures to monitor the long-term effects of livestock grazing should be encouraged.

4.3. **Encourage research on prescribed burning in cutthroat grass communities.** As more land with cutthroat grass communities is purchased and/or protected, management knowledge about the effects of fire frequency, intensity and seasonality will become increasingly important if we are to maintain the biodiversity of the cutthroat grass community and landscape. In addition, the long-term effect of differing fire frequency needs study, since recent trends indicate that many land managers of public properties are burning cutthroat grass communities typically on a 3-year rotation, rather than the potentially more natural annual or biennial burn cycle. Knowledge about the natural fire season and research on fire intervals would lead to initiation of improved fire management programs.

4.4. **Conduct research to determine the applicability and effectiveness of various mechanical treatments for restoration of severely degraded cutthroat grass communities.** Former cutthroat grass communities that have been degraded because of fire suppression or other disturbances should benefit from controlled burns.

5. **Increase awareness and knowledge of the cutthroat grass ecosystem.**

5.1. **Provide technical advisory support to private landowners of cutthroat grass communities.** Provide technical information on ecosystem management strategies and practices to private landowners willing and interested in protecting biodiversity of cutthroat grass communities.

5.2. **Increase public awareness and understanding of the cutthroat grass ecosystem.** Public understanding and approval are required for any conservation effort to be successful. Public announcements should highlight land acquisition projects such as Florida’s Conservation and Recreational Lands (CARL) program and Preservation-2000. Environmental education programs in South Florida should be encouraged to distribute materials or develop lesson plans on cutthroat grass community habitats, cutthroat grass community species and the importance of maintaining natural biodiversity. Develop a Wildlife Series, like others at GFC, and an education campaign on cutthroat grass communities.