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PLANT COMMUNITY MONITORING IN THE UPPER ST. JOHNS RIVER BASIN

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by

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Palatka, Florida

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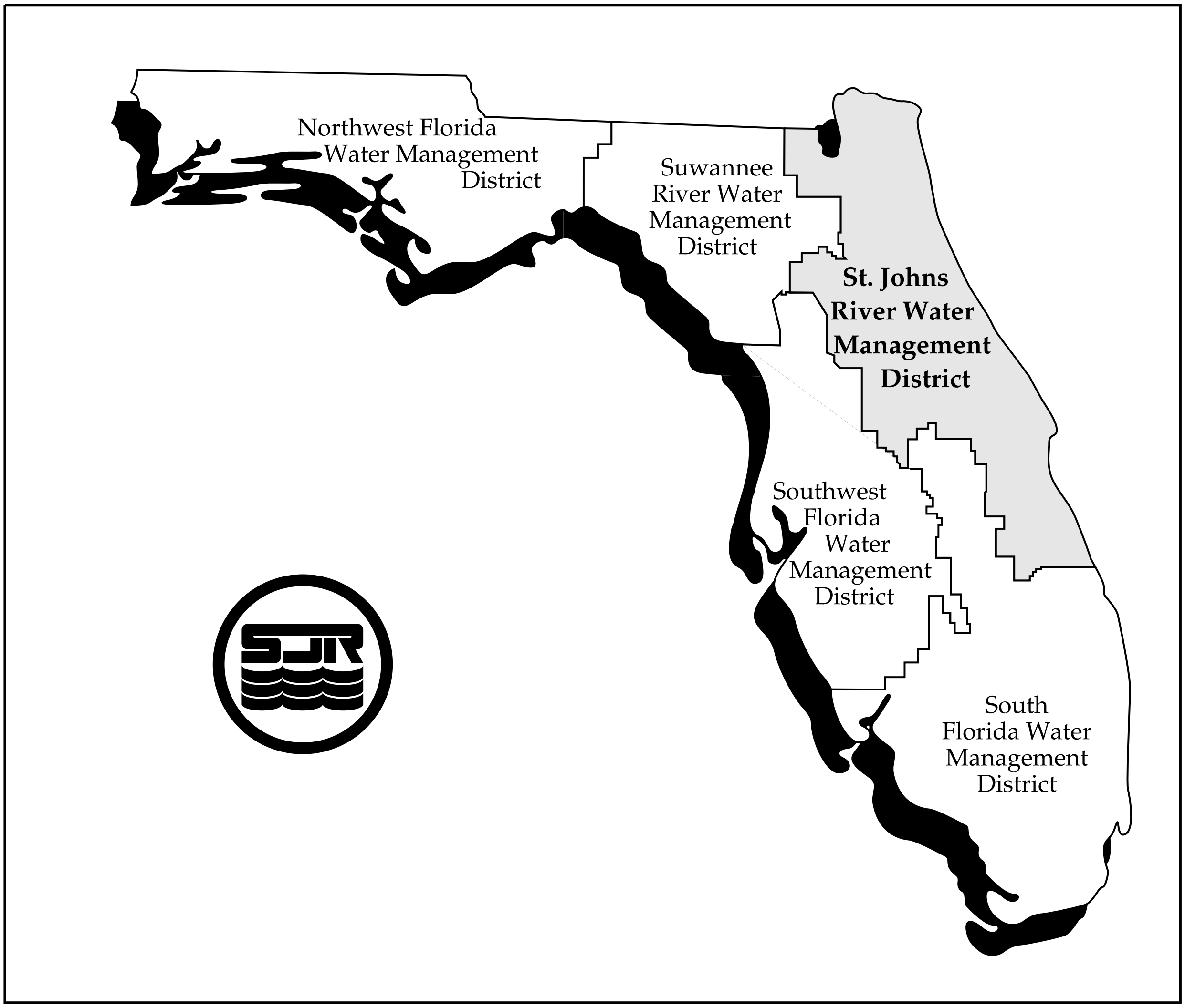

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EXECUTIVE SUMMARY

The purpose of this document is to outline a long-term plan for monitoring plant communities in the Upper St. Johns River Basin using remote sensing. Information collected from plant community monitoring will be useful for a number of purposes ranging from evaluating the quality of fish and wildlife habitat to documenting the success or failure of various restoration and management activities. To provide a long-term record of conditions within the basin, infrared aerial photographs at a scale of 1:24,000 were taken in 1995 and 1997 and will be taken of the entire basin every 2 years in the spring, beginning in spring 2001. These and future photographs will be examined systematically after they are received and compared to previous aerial photographs, in order to identify any widespread changes in vegetation patterns that may have occurred. These photographs will be useful for locating problem areas that may require immediate management attention. A detailed vegetation map of the entire basin will be created using the photographs taken in spring 2001. We plan to recreate this vegetation map every 6 years. In this plan, we provide a standard vegetation classification scheme using 32 defined categories and a standard technique for ground-truthing. Accuracy assessments will be reported on each map created. Plant species lists as well as a description of the dominant species present will be generated during the ground-truthing effort. Methods for assessing plant community change are also discussed.

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INTRODUCTION

The Upper St. Johns River Basin (USJRB) is a nationally significant biological resource that supports economically important species of fish and wildlife, imperiled habitats, and many threatened and endangered species. On-going St. Johns River Water Management District (SJRWMD) activities in the basin, such as the construction and operation of the USJRB Project, will affect virtually every biological aspect of the USJRB. For example, nearly 60,000 acres of land in the basin previously diked and drained for agriculture will be reflooded in an attempt to restore the floodplain wetlands. Water levels and flows will be altered on another 60,000 acres of existing marsh to attempt to reestablish a more natural hydrologic regime. Water quality in the basin will be impacted by segregating agricultural discharge from the marsh. All of these alterations will markedly affect vegetation patterns and biological productivity.

In addition to the direct effects of the USJRB Project, there will be indirect effects caused by SJRWMD management of the land and by public uses. For example, SJRWMD has a program of prescribed burning to manage vegetation. Prescribed fires have ecological as well as safety goals. Both ecological benefits and possible negative effects of the use of fire need to be documented. Management of invasive exotic weeds is also an on-going project that requires extensive SJRWMD effort.

It is critical that the effects of SJRWMD activities on the biological resources of the USJRB be closely monitored. Without such an effort, we will be unable to declare ecological success at the end of our restoration activities or, even more important, to detect problems with our management. Recognizing the need for biological monitoring, upper basin environmental sciences staff are developing programs to monitor ecological aspects of the project. Important in these monitoring efforts is a project to monitor plant communities.

Plant communities are perhaps the most easily monitored indicator of the condition and health of ecosystems found within the boundaries of the USJRB. Plant species composition, biomass, and community structure at a variety of spatial and temporal scales are important determinants of the value of the basin as fish and wildlife habitat. In turn, the structure of these plant communities and their value as habitat reflect factors such as hydrology and nutrient availability. Measuring changes in vegetation can be useful for a number of purposes ranging from documenting the success of restoration or management projects to identifying areas of anthropogenic stress (e.g., areas receiving excessive nutrient loading) to quantifying the creation (or loss) of endangered species habitat.

Vegetation monitoring can be done at a variety of scales, depending on the objectives of the study and the need for detail. Remote sensing analysis through the use of either satellite imagery or aerial photography is one technique that is often used to map vegetation communities over a large area through time; however, the level of detail that can be derived from these techniques is usually limited. On-ground surveys are useful for measuring plant species composition and relative frequency of occurrence, but the size of the area that can be sampled is small. To monitor plant communities in the USJRB, we propose using a combination of techniques. Vegetation maps created from aerial photographs collected through time will be the primary tool used for plant community monitoring. On-ground sampling will be used for ground-truthing the maps created from the aerial photographs and for developing comprehensive species lists for each of the community types mapped.

The purpose of this document is to outline the plan for long-term monitoring of plant communities in the USJRB. Issues addressed include identifying the communities or species that will be mapped, the scale at which data will be acquired, the frequency of data collection and analysis, and quality assurance.

MONITORING OBJECTIVES

Objectives of the USJRB plant community monitoring program are

- To create periodic vegetation community maps of the entire USJRB that contain species lists for the communities mapped as well as estimates of individual map accuracy
- To increase the potential for adaptive management by outlining a process whereby we should be able to identify ecological problems that may be occurring anywhere in the basin at an early stage
- To provide plant community assessments that will help further our understanding of the relationships between vegetation community structure and hydrology, nutrients, and fire
- To provide plant community assessments that will help to further develop our understanding of the wildlife habitat value of the various components (both singly and collectively) of the plant community mosaic

APPROACH

Our goal is to develop a plant community monitoring plan that provides the necessary level of detail to meet the above-stated objectives in the most cost-effective manner. Given the spatial extent of the USJRB, we have minimized on-ground sampling efforts and focused on using remote sensing techniques.

By the end of 2003, we propose to have completed the initial detailed vegetation map of all SJRWMD-owned lands within the USJRB, plus other areas within the upper St. Johns River floodplain south of Highway 46 (Figure 1). This initial map will be based on photographs made in the spring of 2001. The 2–3-year time frame is necessary to map an area of this size (about 270,000 acres) and to provide appropriate quality assurance of the plant communities mapped (e.g., ground-truthing). We propose that the upper St. Johns River floodplain map should be reproduced every 6 years to document changes that may have occurred. Maps of specific small areas may be produced more frequently on an as-needed basis.

Although detailed plant community maps of the entire basin will only be produced every 6 years, we propose that aerial photographs of the entire basin be taken every 2 years. These photographs will provide an historical record of conditions within the basin. In addition, we propose that these photographs be examined systematically shortly after they are obtained to potentially locate problems that may require immediate management attention.

In this plan, we provide a standard technique for ground-truthing to quantify map accuracy, as well as a standard vegetation classification scheme to be used on all maps. As a part of the map ground-truthing effort, we propose that detailed plant species lists, along with descriptions of the most abundant species for each community type, be documented. While this technique will not provide quantitative data useful for statistical comparisons of individual species abundance, it will be valuable for qualitative long-term monitoring purposes.

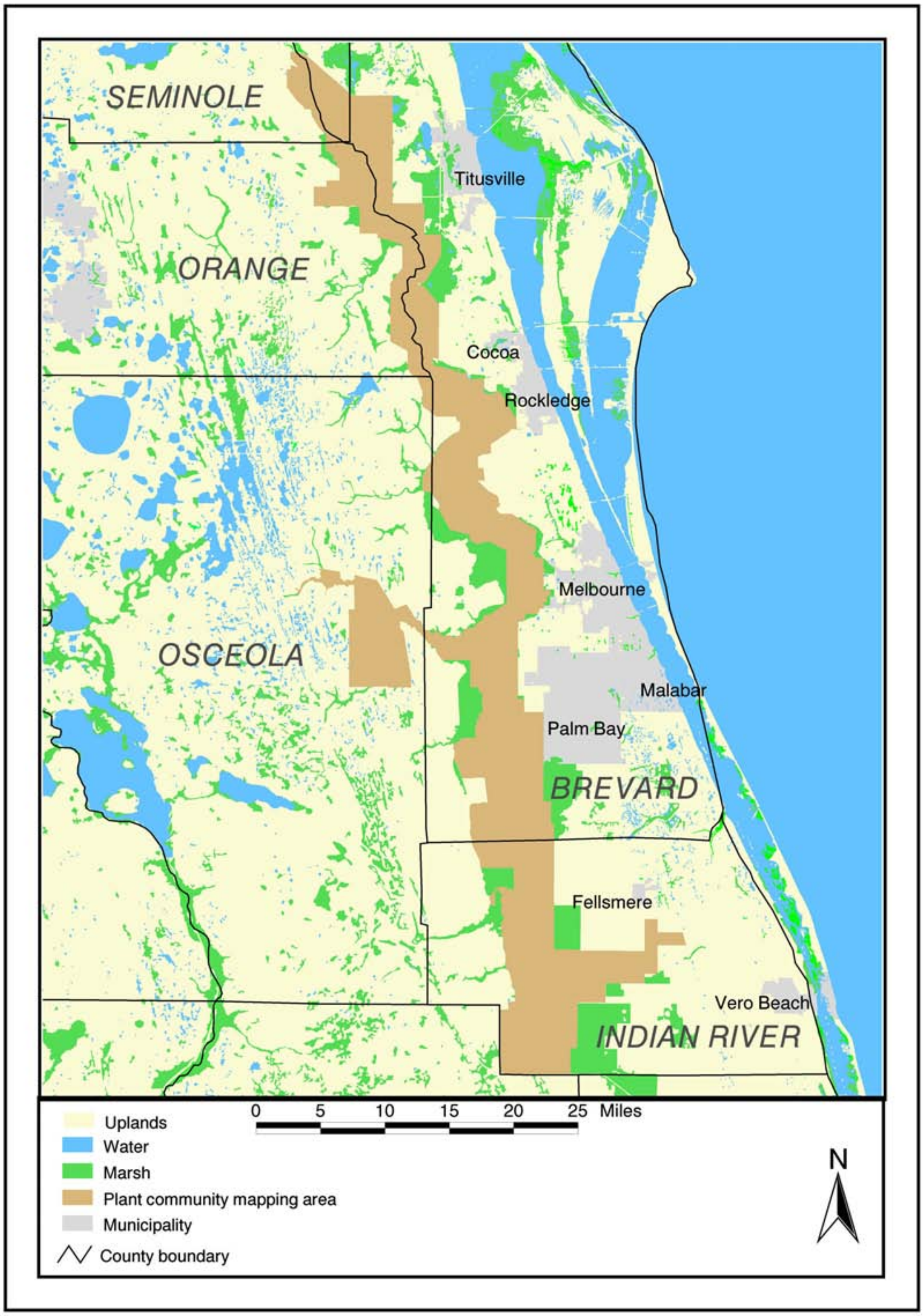

Figure 1. The St. Johns River floodplain and the Upper St. Johns River Basin Project area

Development of a plant monitoring program using remote sensing techniques required consideration of a number of issues such as scale, photo-interpretation versus computer-classified satellite imagery, film type, timing of image collection, etc. The advantages and disadvantages of a number of techniques used for collecting remotely sensed data were listed and considered in the development of this plan. Advantages and disadvantages of each technique and the rationale for choosing the one that we feel best met the needs of the USJRB monitoring program are outlined in the next section.

DATA ACQUISITION

We considered plant community mapping from photo-interpretation of infrared aerial photographs at the 1:12,000 and 1:24,000 scale and computer analysis of digital satellite imagery. For aerial photography, we also considered the use of true color film versus color infrared film. Our goal was to develop the most cost- and time-effective plan for meeting our objectives. Advantages and disadvantages of each technique considered are listed below.

DIGITAL SATELLITE IMAGERY WITH COMPUTER-ASSISTED IMAGE ANALYSIS

Advantages

- Easily obtainable; four scenes cover entire basin at 20-meter (m) resolution
- Entire basin can be mapped at variable return frequency
- Computer-generated delineation based on infrared wavelength signatures speeds up delineation time and takes out human subjectivity. Once appropriate signatures have been determined, there is no loss of accuracy or precision between different interpreters
- Relatively low cost

Disadvantages

- Lower resolution and limited spectral bands
- Vegetation signatures influenced by season and other factors, such as water depth
- Low classification accuracy (reported to be 60%–70%), based on spectral signatures rather than the multiple factors used by photo-interpreters
- Applicability of the technique needs further refinement and documentation
- To achieve desired accuracy, the number of plant communities that can be identified and delineated may be small

A recent study conducted by staff at the South Florida Water Management District (SFWMD) (Rutchey and Vilchek 1999) concluded that photo-interpretation of 1:24,000 color infrared images was preferable to using computer-assisted image analysis techniques on 20x20-m pixel SPOT imagery for mapping Everglades plant communities. Accuracy of community delineations from SPOT images was only around 70% and was not noticeably increased by reducing the number of vegetation classes. SFWMD staff concluded that the interactions of four confounding factors (water depth and color, impacts from fire, periphyton species composition, and growth morphology of the individual species) complicated satellite imagery interpretations. Compared to aerial photography, computer classifications from SPOT images overestimated the cattail distributions in Water Conservation Area 2A. As a result, SFWMD no longer uses classified SPOT images to delineate wetland vegetation communities in their ecological studies. All ecological analysis is done using aerial photography. Given that the mosaic of plant communities in the St. Johns River floodplain is much more complex than in the Everglades, we anticipate that computerized plant community classification using multispectral images would be even less accurate than the 70% obtained in Everglades marshes.

This technology is continuously improving, both in resolution and in techniques for computer analysis of images, and may be reconsidered in the future. At the present time, however, computer analysis techniques cannot match human photo-interpreters in feature recognition at the level of detail required for our monitoring effort.

1:24,000-Scale Infrared Aerial Photography

Advantages

- Improved resolution compared with currently available satellite imagery
- Experienced human photo-interpreters can generally delineate more communities with greater accuracy at a given scale
- Four times fewer images needed to cover the entire basin than with 1:12,000 photography
- Intermediate in cost to other two methods

Disadvantages

- Delineation of community boundaries and digitizing are labor-intensive
- Vegetation signatures influenced by season, water depth, and fire
- Requires extensive signature development and ground-truthing
- Assignment of community type and boundaries subjective; increased variability between interpreters
- Amount of time required to map the entire basin (based on our experience, it would take approximately 1 year for an individual to map the entire basin)

- To achieve desired accuracy, the number of communities that can be delineated may be limited (better than SPOT imagery, but not as good as 1:12,000)

1:12,000-Scale Infrared Aerial Photography

Advantages

- Highest resolution of all the techniques considered
- Highest initial community designation accuracy of all the techniques

Disadvantages

- Delineation of community boundaries and digitizing more labor-intensive than for 1:24,000 photographs
- Vegetation signatures influenced by season, water depth, and fire
- Requires extensive signature development and ground-truthing
- Assignment of community type and boundaries subjective; increased variability between interpreters
- Large number of photographs needed to cover the entire basin means considerably greater cost for photography and rectification

Aerial photo-interpretation currently offers a tool for vegetation mapping that is preferable to satellite images, mainly because of the higher accuracy that can be obtained from the photography. To document trends, the 60%–70% accuracy rate reported for computer classification from digital satellite images is not acceptable. With proper signature development, we believe that the accuracy rates for aerial photo-interpretation can exceed 90%. Photographs taken at the 1:24,000 scale have enough resolution for individual trees and large shrubs to be seen clearly, and we believe that the increased resolution of 1:12,000 photography does not add sufficient information to outweigh the much greater cost. Given the size of the area to be mapped, it is not feasible to create vegetation maps annually or even biannually. We propose to produce a baseline plant community map for the upper St. Johns River floodplain and SJRWMD lands in the USJRB at a scale of 1:24,000 and use 1:12,000 or higher resolution aerial photography on an as-needed basis. We further propose that the plant community map of the entire floodplain be reproduced every 6 years to document trends that may be occurring in the basin.

TRUE COLOR VERSUS COLOR INFRARED FILM FOR AERIAL PHOTOGRAPHY

Aerial photography is frequently made with either true color film or false color infrared film. Use of true color film can help differentiate some categories of marsh communities better than infrared, provided that adequate signature development is done and the photography is done in the growing season. Under those conditions, true color film, because it is sensitive to shorter (blue) wavelengths, can show color differences between different species of broadleaf herbaceous marsh plants. Infrared film is not sensitive to blue and thus does not "see" wavelengths that are scattered by water vapor in the atmosphere. For photographs made during the growing season in Florida, infrared usually produces sharper images. Also, infrared images are more useful for the detection of differences between senescent and rapidly growing plants, which can help the interpreter differentiate mature or dormant grasses from other herbaceous vegetation. Based on these considerations, it appears that color infrared is the best choice of film for most plant community monitoring in the USJRB.

Seasonal Considerations for Aerial Photography

Shrub swamp, primarily willow, is a community of major concern in the USJRB. Expansion of the willow community and how willow distribution is affected by fire is a concern in several project areas. Infrared photographs of the USJRB have historically been taken in the winter season when willows have lost their leaves. While dense willow may be identifiable from winter photographs, transitional willow communities may be difficult to detect. To obtain maximum differentiation between shrub and herbaceous communities, the recommended season for photography is early to mid-spring (C. O'Neill, USGS National Wetlands Research Center, pers. com.). This timing also produces good differentiation between cattail, sawgrass, and other herbaceous wetland communities.

Frequency of Aerial Photography and Map Production

We propose to acquire 1:24,000-scale color infrared aerial photographs of the entire USJRB every 2 years, in the spring. We feel that, at this frequency, adequate coverage of possible plant community shifts in the basin can be covered and that these photographs will provide an excellent long-term record of the basin. Photographing the basin annually seems an unnecessary expense because plant community shifts tend to be more gradual. Photographing the basin every 3 years however, may make determination of possible cause-effect relationships difficult for any observed plant community changes. We propose that plant community maps of the upper St. Johns River floodplain within the USJRB be completed every 6 years. More-frequent maps can be produced for individual project areas on an as-needed basis.

MAP ACCURACY ASSESSMENT

Our goal is to produce vegetation maps that have an accuracy level of 90%. When 90% accuracy cannot be achieved, the actual accuracy level will be reported. Map accuracy assessment includes two aspects: map positional accuracy and thematic feature accuracy.

Map Positional Accuracy Assessment

Positional accuracy refers to the correct map registration of ground features. For our purposes, the positional error for any randomly selected point on a map should not exceed 15 m (50 feet) for all maps compiled from aerial photography taken at 1:24,000 scale or greater. For each area mapped, our assessment will be based on at least three independent reference points/landmarks per 1,000 acres, which must not be part of the ground control points used for georeferencing the image or map. Coordinates of reference points will be obtained in the field by a differential global positioning system unit or from orthorectified images such as SJRWMD’s digital orthophotoquads (DOQQs). The latter method is greatly preferred for high positional accuracy of the resulting map because the average positional accuracy of SJRWMD’s DOQQs greatly exceeds our mapping standard of 15 m, and the use of SJRWMD’s images as reference will save the time and expense of collecting ground control points. Accuracy assessment methods will depend on which of two types of map production are employed: (1) an image will either be georeferenced to a standard orthorectified image and the map created by on-screen digitizing using the image as background or (2) digitizing will be done from unrectified photographs and individual frames will be joined and rectified using SJRWMD’s bundle adjustment program or the equivalent.

If on-screen digitizing methods are used for map production, the positional accuracy assessment will have two phases: (1) assessment of the accuracy of the match of the scanned and rectified aerial photographs to the reference DOQQs and (2) the accuracy and placement of the digitized lines delineating different plant communities. Selected landmarks on the rectified photographs should be no greater than 10 m from the corresponding landmark on the DOQQs, and the average for a set of 10 landmarks on a single image should be less than 5 m. Digitized lines should be no more than 5 m from recognizable community borders. If digitizing is done from unrectified photographs with rectification of the finished map, then test points will be selected from well-defined boundaries, such as levees or roads, and their coordinates compared with the same point on the reference image.

If a map exceeds the positional accuracy limits, the problem will be corrected by adding more control points for the georeferencing process or by redigitizing inaccurate lines. While we are attempting to obtain a high level of accuracy using the methods described, the plant community maps produced are not intended to meet any legal requirements for accuracy.

Thematic Feature Accuracy and Ground-Truthing

Thematic feature accuracy refers to the correct thematic representation of the real-world points, according to the chosen classification scheme, that is, how accurately the plant communities on the ground are represented in the map. Since thematic accuracy is dependent on both the correct classification and the correct location of a plant community, positional accuracy must be corrected before the thematic accuracy assessment can be completed. Thematic accuracy assessment compares a compiled map with ground-truthing information to determine map accuracy. It is not feasible to conduct field visits to every delineated polygon of a map to determine the actuality on the ground. Therefore, a predetermined set of ground-truthing points is used, and ground-truthing information will be based only on field visits to these sites. There are three methods which could be used to select ground-truthing points:

1. Randomized selection. With this method, ground-truthing points are randomly selected. This technique greatly lessens or eliminates the possibility of bias in sample site selection. One drawback of this approach is that some community types may not have any ground-truthing points, while other communities are over-represented in the sample.

2. Community-weighted random. Selection of ground-truthing points for a given community type is based on the weighted presence of that community in the mapped area. This presence can be either by frequency (number of polygons of that community type in the map) or by total area covered by that community. Area covered is generally preferred because community types usually differ greatly in the average size of the polygons (e.g., herbaceous wetland tends to have larger and thus fewer polygons, while tree islands tend to have smaller and more numerous polygons for the same total area).

3. Equalized random. This approach selects an equal number of reference points in each community type. This method may create bias by over-representing rare communities.

We propose using a modified randomized selection method for ground-truthing. Randomized selection may overlook some important community types, whereas the community-weighted random and equalized random techniques may misrepresent overall map accuracy if the largest communities are also the easiest to delineate accurately (such as open water). In addition, there is currently no available geographic information system (GIS) software that will easily assign random points by community. A solution to these problems would be to use randomized selection with the constraint that each plant community must be represented by at least 2% of the points.

All ground-truthing will be based on project areas so that map accuracy can be assessed for each project area map independently. Ground-truthing points will be selected by an appropriate GIS program (currently an ArcView script) that randomly chooses a number of cells from a computer-generated grid and then places a point in the center of each selected cell. To avoid confounding positional and thematic accuracy, random points selected for thematic accuracy will not be located within 30 m of a map polygon boundary. Community assessment on the ground will be done within a 10-m radius circle, with the selected point at the center. If any plant community with greater than 2% of the area fails to be represented by at least 2% of the points within a project area, a sufficient number of points located closest to polygons representing that community will be moved so that they fall inside the polygon. Alternatively, a computer program that allows specifying the number of points generated per community will be used to meet the minimum points requirement when such a program becomes available.

We also recognize that all points selected for ground-truthing may not be accessible due to the type and density of the vegetation. For example, it may not be practicable to visit a randomly selected ground-truthing point that lies in the middle of a dense willow or hardwood swamp. In such cases, a more accessible point within the same polygon will be used when possible, or otherwise within the same community type as close as possible to the original point. While we recognize that this procedure violates the assumption of randomness, it may result in a significant reduction in ground-truthing cost and staff time. Our objective is to balance the desirability of random points with practical considerations; however, substitution of points should be done only when necessary. When selected points are substituted for randomly selected points, it will be noted in the community description for that project area.

To provide a qualitative description of plant species composition within different communities and project areas, a species list will be compiled for each ground-truthing site visited. The plant community description will include a list of the most common species and a description of those that are dominant. Data from all the ground-truthed points will be combined to provide an overall community description for each project area.

METHODS FOR ASSESSING PLANT COMMUNITY CHANGE

There are two methods for collecting quantitative data that can be used for direct comparison with other data collected using remote sensing. First, standard mapping techniques with extensive ground-truthing could be used to generate a complete and accurate map of the desired area, and these data could be analyzed using ArcView Spatial Analyst or a similar computer program. This technique will be used to compare detailed vegetation maps between two or more time periods.

Second, a “virtual sampling” technique could be used in which, after an initial detailed vegetation map is created as above, in subsequent years, a randomly chosen number of 30-square-meter plots are mapped in detail and quantitative data for change or other analyses are based on this representative sample. The initial detailed vegetation map is necessary to determine how many samples (squares) are needed to obtain the desired confidence level. The number of samples needed would depend on the number of communities mapped and the heterogeneity of the area. Since this process would not actually create a map, it should be used when accurate quantitative data, but not necessarily an actual map, are appropriate. This technique has a number of advantages in that it produces detailed plant community data with less effort than complete mapping and produces data which are more amenable to statistical analysis. This is the technique that will be used to describe changes that are documented from the systematic examination of photographs taken every other year if a more detailed quantification of the changes is needed.

CONCLUSIONS

This document establishes the objectives and methodology for the long-term monitoring of plant communities within the USJRB. We believe that this monitoring plan should be viewed as a flexible program that can change with improvements in remote sensing technology. In addition, we expect that there could be changes in the plant community classification if our understanding of what information is important for adaptive management of the marsh improves. However, the classification categories were designed to minimize the necessity for changes because of the complications that changes in category definitions would produce in comparisons between new maps and older ones. The use of this plan over time will likely require compromises between the desire to refine the plan and the value of the plan for tracking changes in plant communities.

VEGETATION CLASSIFICATION CATEGORIES

To monitor plant community dynamics in the upper St. Johns River floodplain, including the USJRB Project, we developed a vegetation classification scheme that is detailed enough to meet monitoring needs but not so detailed that map creation takes excessive effort. Obviously, the more communities we attempt to delineate, the greater the amount of time it will take, with regard to both map creation and ground-truthing. Therefore, we propose a general classification scheme in which all plant community coverages will have a two-tiered heirarchical classification scheme. A general community type based on structure will be recorded in a field labeled “Type” in the polygon attribute table. This field will have six categories based on vegetation structure and one category for open water.

Open water	(OW)
Herbaceous wetland	(HW)
Shrub wetland	(SW)
Forested wetland	(FW)
Herbaceous upland	(HU)
Shrub upland	(SU)
Forested upland	(FU)

The second classification field will be labeled “Community” and will be based on both structure and species associations. Each “Community” classification will fall under one of the “Type” classifications as indicated below. This will allow maps to be easily produced at either level of classification for any area that has been mapped.

Plant species classifications into Obligate (OBL), Facultative Wet (FACW), Facultative (FAC), or Upland (UPL) are based on designations published in *Florida wetland plants: An identification manual* (Tobe et al. 1998).

A description of each of the community types follows; a photograph of each of the types is found in the appendix.

PLANT COMMUNITY CLASSIFICATION

Open Water

1. Open water (OW)
   Natural or large impounded water bodies with no floating or emergent vegetation; submersed vegetation may be present, however.

2. Canals, ditches, and borrow pits (CA)
   Small, man-made water bodies. Category may be omitted on some community level maps. Category may be useful for spatial analysis of relationship of canals to vegetation changes.

3. Free-floating plants (FF)
   Waterhyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratiotes*), *Salvinia* spp., and other species that are not connected to the bottom of the water body.

4. Hydrilla (HY)
   Areas with hydrilla covering more than 70% of the water surface.

Herbaceous Wetland

5. Sawgrass (*Cladium jamaicense*) (SG)
   Contains 70% or greater coverage of sawgrass. Cattail, ferns, other herbaceous species, and small shrubs may also be present.

6. Cattail (*Typha* spp.) (CT)
   Contains 70% or greater coverage of cattail. Sawgrass, ferns, other herbaceous species, and small shrubs may also be present.

7. Cattail / sawgrass (CTSG)
   Contains 30%–70% cattail, less than 70% sawgrass, and less than 10% other species.

8. Grass / sedge marsh (GS)
   Contains 70% or greater coverage of OBL wetland grass or sedge species such as maidencane (*Panicum hemitomon*), cupscale (*Sacciolepis striata*), and spikerush (*Eleocharis* spp., *Rhynchospora* spp.). Other herbaceous species, such as sawgrass and cattail, and small shrubs may be present.

9. Broadleaf emergent marsh (BE)
   Contains 70% or greater coverage of emergent OBL wetland plants with wide leaf structure, such as *Pontedaria, Sagittaria, Peltandra,* and *Thalia.*

10. Mixed herbaceous marsh (HM)
    Consists of a combination of broadleaf emergents, semi-floating species such as *Hydrocotyle* spp., and *Polygonum* spp. with grasses, sedges, cattail, and / or sawgrass such that components classified in other categories are each less than 70%.

11. *Spartina* prairie (SP)
    Contains 70% or greater coverage of sand cordgrass, *Spartina bakeri,* with soft rush, *Juncus effusus,* and other shallow-water, short-hydroperiod plants as minor components.

12. Wet prairie / wet pasture (WP)
    A mix of herbaceous species that are typical of short hydroperiod wetlands, with most plants classified as FACW or FAC. Similar to mixed herbaceous marsh except that long hydroperiod species such as most of the broadleaf emergents should not be present, while *Spartina bakeri* and *Juncus effusus* may be present as minor components. Category should be used for former pastures that have been reflooded or for wet, unimproved pastures.

13. Water lilies (slough) (WL)
    A mixed area which contains 70% or greater coverage of bottom-rooted species with floating leaves, including water lily *(Nymphaea* spp.*)* and *Nuphar luteum.* Also may contain bladderworts *(Utricularia* spp.*).*

Shrub Wetland

To meet the following classifications, the shrub or woody layer must be twice as tall as the herbaceous layer but less than half the height of the tree layer. Use of relative layer height rather than species composition will facilitate identification using a stereoscope without resorting to stereoscopic height measurements.

14. Willow (WS)
    Contains 70% or greater canopy coverage of willow, *Salix caroliniana,* that is at least twice as tall as the herbaceous layer.

15. *Ludwigia* (LU)
Contains 70% or greater canopy coverage by *Ludwigia* spp. that is at least twice as tall as the herbaceous layer.

16. Mixed shrub wetland (MS)
Contains a mixture of shrub species and / or trees that are at least twice as tall as the herbaceous layer. Tree species such as red maple should be either less than twice as tall as the shrubs or cover less than 30% of the area.

17. Transitional shrub wetland (TS)
Contains 70% or greater cover by species found in areas with shorter hydroperiods than shrub wetlands described above; characterized by the presence of wax myrtle (*Myrica cerifera*) and saltbush (*Baccharis halimifolia*) or other FAC shrub species.

Forested Wetland

18. Cypress (CY)
Contains 70% or greater cover by *Taxodium* spp. May be an extensive swamp or a small cypress head.

19. Hardwood swamp (HS)
Contains 70% or greater coverage of mixed wetland tree species such as maple *(Acer rubrum)*, black gum (*Nyssa sylvatica*), and ash (*Fraxinus*), which are tolerant of fairly long hydroperiods and deeper water than other tree species. Associated with streams or rivers.

20. Hydric hammock (HH)
Contains 70% or greater coverage of mixed wetland tree species associated with depressions having moderately long hydroperiods.

21. Cabbage palm hammock (CP)
Hammocks consisting of more than 70% cabbage palm, which may occur in hydric to mesic conditions.

22. Tree island (TI)
Relatively small patches of trees within the marsh (tree islands), consisting of mixed wetland tree species including maple, cabbage palm (*Sabal palmetto*), and dahoon (*Ilex cassine*). Island may be surrounded by a narrow border of shrubs.

Herbaceous Upland

23. Dry prairie (DP)
Contains greater than 70% coverage of mixed upland grasses, herbs, etc., with few or no trees.

24. Pasture (PA)
Similar to dry prairie but with evidence of maintenance by humans (drainage ditches, fence lines, structures, water troughs, etc.); on the ground, diagnosed by the presence of introduced and cultivated grass species. This category should also be used for abandoned pastures until they are essentially replaced by another type.

25. Row crop / orchard (RC)
Contains 70% or greater coverage by cultivated species with evidence of arrangement in rows, with or without drainage ditches. Includes orchards and groves.

26. Levees with road (LR)
Levees, either mowed or paved, with surface maintained for vehicles.

Shrub Upland

27. Palmetto prairie (PP)
Contains greater than 70% coverage by saw palmetto (*Serenoa repens*) and / or scrub palmetto (*Sabal etonia*).

28. Scrub (SC)
Contains 70% or greater coverage by scrub oak and other scrub species, with or without an overstory of sand pine (*Pinus clausa*).

Forested Upland

29. Oak hammock (OH)
Contains greater than 70% coverage by upland oak species, except scrub oaks.

30. Pine flatwoods (PF)
Contains greater than 50% coverage by pine species.

31. Mixed hardwood (MH)
Contains mixed hardwood species, with pines or palms less than 70%.

32. Wooded levees or spoil banks (LV)
Levees with surface not maintained or cleared, or spoil banks formed when canals were made. Usually covered with *Sabal palmetto* and *Shinus terebinthifolius*.

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APPENDIX—CATALOGUE OF PLANT COMMUNITIES

1. Open water

2. Canals, ditches, and borrow pits

3. Free-floating plants

4. Hydrilla

5. Sawgrass

6. Cattail

7. Cattail/sawgrass

8. Grass/sedge marsh

9. Broadleaf emergent marsh

10. Mixed herbaceous marsh

11. *Spartina* prairie

12. Wet prairie/wet pasture

13. Water lilies (slough)

14. Willow

15. *Ludwigia*

16. Mixed shrub wetland

17. Transitional shrub wetland

18. Cypress

19. Hardwood swamp

20. Hydric hammock

21. Cabbage palm hammock

22. Tree island

23. Dry prairie

24. Pasture

25. Row crop/orchard

26. Levees with road

27. Palmetto prairie

28. Scrub

29. Oak hammock

30. Pine flatwoods

31. Mixed hardwood

32. Wooded levees or spoil banks