GIS FOR PLANNING AND MANAGEMENT AT MERRITT ISLAND NATIONAL WILDLIFE REFUGE COMPLEX
OR
GIS FOR THE FUNDING IMPAIRED

Frederic W. Adrian, CF
Cheri M. Ehrhardt, AICP
U.S. Fish and Wildlife Service
Merritt Island National Wildlife Refuge,
Post Office Box 6504, Titusville, FL 32782

ABSTRACT

The history of GIS use at the Merritt Island National Wildlife Refuge Complex (MINWRC) is short. The first real application was to map a wildfire on one of the outlying properties in 2001. This fire burned for several days before the State Division of Forestry even knew that it was on federal lands. This wildfire helped highlight the fact that the MINWRC did not have the GIS databases and GIS skills needed to effectively manage these federal lands. Over the next few years, several members of the staff, only one of whom had any real knowledge of GIS, took it upon themselves to acquire imagery, obtain data and create databases. While some of this work was contracted, the majority was conducted in house. Where possible, existing data was begged, borrowed or stolen, which led to some confusion in ascertaining the proper coordinate systems and accuracies. Minimal funding was spent on hardware and networking was, and still is, archaic.

In spite of these challenges, progress was made. Several databases now exist, depicting land and fire management units on all of the refuges in the Refuge Complex. Also available is information on roads, water control structures and facilities. The mapping of wildfires and prescribed burns has progressed, as has the mapping of the restoration of habitat for the federally threatened Florida scrub-jay (*Aphelocoma coerulescens*). The acquisition of these data helped greatly when the MINWRC began to develop comprehensive conservation plans. Our experience shows that useful GIS support and products can be generated without extensive expenditures.

KEYWORDS. GIS, land management, planning, low-budget GIS, partnerships.

INTRODUCTION

Merritt Island National Wildlife Refuge (MINWR or Refuge) is located on the east-central coast of Florida in Brevard and Volusia counties. MINWR also has the responsibility for the management of two other refuges: Lake Wales National Wildlife Refuge (LWRNWR) in Highlands and Polk counties, Florida and St. Johns National Wildlife Refuge (SJNWR) in

In Prisley, S., P. Bettinger, I-K. Hung, and J. Kushla, eds. 2006. Proceedings of the 5th Southern Forestry and Natural Resources GIS Conference, June 12-14, 2006, Asheville, NC. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA.

Brevard County, Florida. Both of these satellite refuges have multiple parcels (Figure 1).

The majority of the Refuge is an overlay of the National Aeronautics and Space Administration's (NASA's) John F. Kennedy Space Center (KSC). The U.S. Fish and Wildlife Service (Service) administers these lands and waters under an interagency agreement. This agreement gives the responsibility for land management activities for KSC's non-operational lands to the Service. Included in these management responsibilities are wildland fire suppression and prescribed burning. The Refuge also has agreements with Canaveral National Seashore (CNS), a unit of the National Park Service, to assist with both prescribed burning and wildland fire suppression and with the Cape Canaveral Air Force Station (CCAFS) to assist in prescribed burning. Together, these four federal agencies manage over 180,000 acres of relatively undeveloped coastal barrier islands and lagoons in and around MINWR.

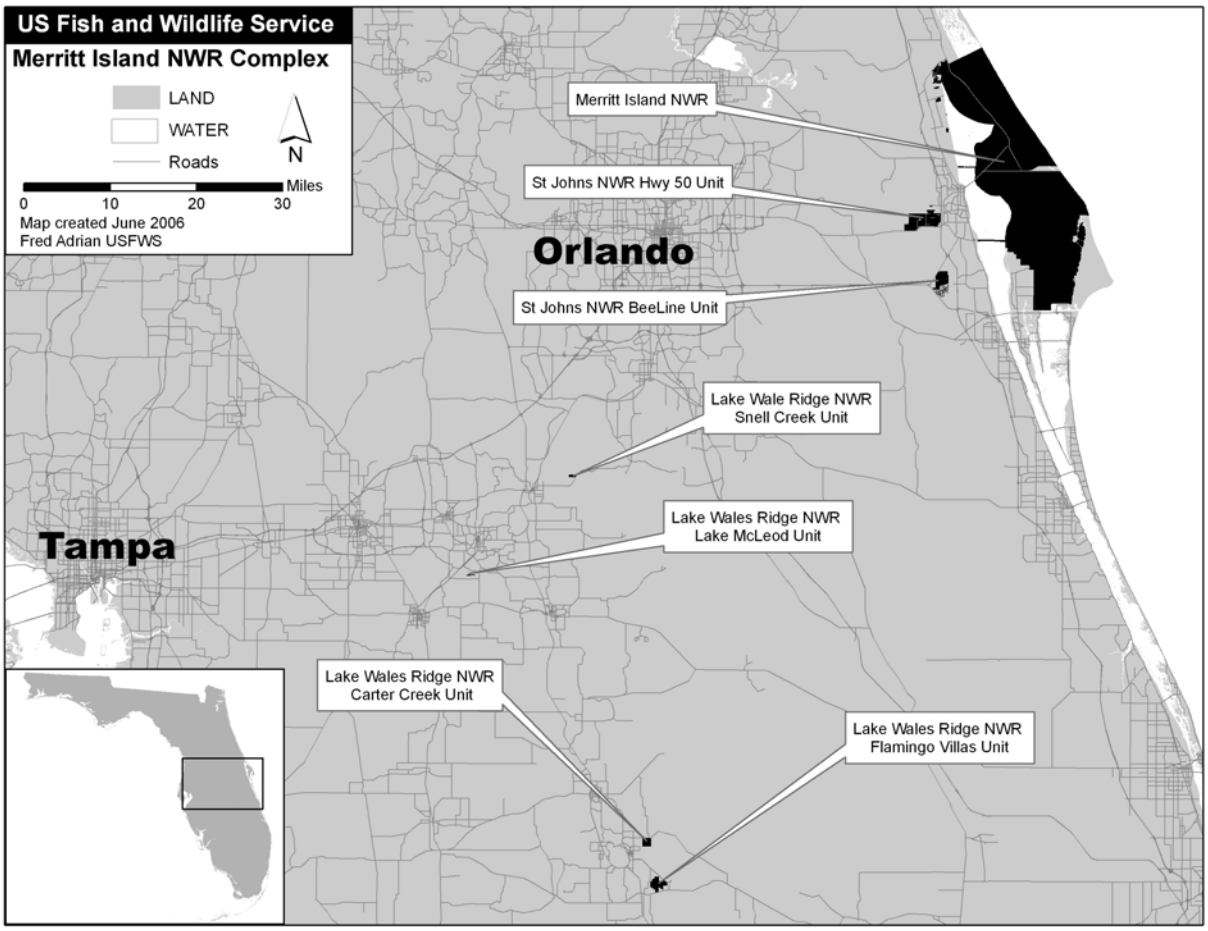

Figure 1. Location of lands administered by Merritt Island National Wildlife Refuge.

This coastal ecosystem is quite diverse. Schmalzer and others (2002) list 803 native plants on the Refuge and adjoining federal lands, where 38 taxa are listed as endangered, threatened or of special concern by the State of Florida. This wide array of plant species has been grouped into 20 native wetland and upland vegetative communities (U.S. Fish and Wildlife Service, 2006). The Refuge's habitats provide protection and management opportunities for 10 regularly-occurring

federally listed threatened and endangered wildlife species, as well as for 36 species of federal management concern and 47 wildlife and plant species listed by the State of Florida (Epstein and Blihovde, 2006). In addition, over 300 species of migratory and resident birds, 30 species of mammals, and 71 species of reptile and amphibians have been recorded on the Refuge (Adrian et al., 2006).

Lake Wales Ridge National Wildlife Refuge was created to protect endangered plants. There are nine distinct vegetative communities supporting fourteen federally listed plant species. In addition, there are five federally listed animal species. The St. Johns National Wildlife Refuge, originally purchased for the dusky seaside sparrow (*Ammodramus maritimus nigrescens*), provides habitat for five threatened and endangered animals. It also provides habitat for a number of species of secretive marsh birds including the black rail (*Laterallus jamaaicensis*).

HISTORY OF GIS USE ON MINWR

[AUTHORS: Because this is not a paper reporting data analysis, I'd suggest flexibility in identifying main categories and subcategories. Consider the changes in this document as suggestions only].Although computer-driven GIS is a fairly recent phenomenon at MINWR, manual versions have been used at the Refuge for quite some time. In the early 1980s Refuge staff began efforts to develop a comprehensive vegetation map. The Refuge had been divided into nine management units, and the plan was to inventory and map one of these units each year. At the time, KSC was obtaining aerial photography on an annual basis. With some intensive lobbying, the Refuge obtained free stereo copies of one of the management units each year until all of the area of responsibility was mapped. The actual mapping was conducted in the time honored tradition of using plastic overlays and a grease pencil to delineate the various vegetation types. These were then transformed into presentable maps by a volunteer drafter. Although these maps were useful, updating them by hand was laborious.

Somewhat later, the Service's Southeast Regional Office decided that refuges should make the leap into the computer age so far as mapping was concerned. The platform chosen for this was AutoCAD. While funds were made available for software purchases, no money was available for training. Fortunately, the aforementioned volunteer drafter had, by that time, extensive training in Autodesk products. It was also fortunate that the drafter was the wife of the Refuge Forester and took it upon herself attempt to train said Forester in the finer points of the software. This effort was marginally successful at best. In the end, the Forester updated the old hand drawn maps and the volunteer drafter did the majority of the digitizing. The end result was electronic versions of maps that could be updated with minimal effort.

While the use of AutoCAD provided nice maps, it still did not give the Refuge real GIS capability. Attaching attributes to polygons was difficult and the ability to perform true spatial analysis was lacking. This situation lasted until the late 1990s when the first copy of ArcView 3.2 was obtained. Once again, it arrived with no provision for training. Also lacking was hardware capable of running the program efficiently. The Refuge did manage to acquire an HP Design Jet 1055 CM plotter, but few knew how to use it. Although there were some attempts to learn how to use ArcView, the software and what little hardware the Refuge possessed generally languished until February 2001.

In the latter days of that month, a wildfire broke out near the Lake Wales Ridge National Wildlife Refuge. The fire soon burned onto this un-staffed satellite of the MINWR Complex. Due to the lack of mapping information on the part of several agencies, the Florida Division of Forestry (FL-DOF) fought the fire for three days before it discovered that the land belonged to the U.S. Fish and Wildlife Service. During this time, the fire threatened the town of Desoto City, causing a partial evacuation. Upon learning of the fire and the continued threats to residences, Refuge staff decided that this would be a good time to apply its limited GIS abilities. With a trusty Garmin 12, purchased with personal funds, the fire was mapped.

After several attempts, a decent map of the fire, showing the probable point of ignition and the progression of the fire over several days was produced. What was surprising, considering the primitive nature of the GIS skills, was the tremendously positive reaction to the products. The other agencies involved with the suppression efforts were extremely pleased not only to have good maps for briefings and operational activities, but also to have available a database that provided fire statistics, such as the acreages burned each day.

The success of this limited application of GIS prompted the staff of the Refuge to expand the use of GIS to other areas of refuge management. Several problems were encountered. The first was lack of training. The only person on the Refuge who had a significant background in GIS was the Natural Resource Planner. While this position was located at MINWR, it was a regional resource with planning responsibilities at several different stations. The two permanent Refuge staff members (i.e., a Law Enforcement Officer and the aforementioned Forester) who began to utilize ESRI products were basically self-taught with tutoring from the Planner. Yet, none of the staff had any official responsibility to work with GIS.

The next problem was inadequate hardware. Funding was found to purchase individual computers for the three primary GIS users. However, networking capability was limited. This reduced the efficiency of the GIS program. Files common to all projects had to be transferred from computer to computer by CD. Modifications to these files then had to be distributed. This led to the problems of projects being scattered among the users who were sometimes using different versions of the same shapefile. To help alleviate this situation, a primitive network was built using discarded equipment from KSC. An excess router was given to the Refuge and several spools of cable were obtained through non-conventional supply sources. The router was installed by KSC technicians and the cabling was installed by Refuge employees. Finally a “GIS Computer”, a regular desktop computer, was purchased to act as a central repository for data files.

Once the Refuge had cobbled together the infrastructure, the next challenge was building databases. The exposure of most of the Refuge staff to GIS was limited. Some had attended meetings where end products were shown and discussed. Unfortunately, these presentations had given the false impression that one could make a few mouse clicks and a wonderful image would appear from the ether. The lack of understanding was pervasive among many of the non-GIS users as to the time required to acquire and process the data needed to produce meaningful products.

Much of the needed data did exist somewhere and only needed to be ferreted out by Refuge staff. KSC provided some information, as did local governments, the Florida Geographic Data Library (FGDL), the St Johns River Water Management District (SJRWMD) and the Service's Regional Office. Other needed databases had to be constructed. These included Refuge burn units, management units and public use facilities, as well as key wildlife data, including bald eagle nest sites. In most cases the work was done by non-refuge personnel. On rare occasions funding was found to contract GIS work. Such was the case for the vegetation mapping on two of the units of the Lake Wales Ridge NWR. In other instances, the Refuge was able to convince partners to provide GIS support at no cost to the Refuge. The Refuge's citrus groves are managed by the Florida Research Center, a non-profit research organization. As part of the Service's agreement with the Florida Research Center allowing it to use the groves, it provided the Refuge with the GIS information it developed. Another instance where partners were prevailed upon to help with GIS work was a vegetation map of the Refuge. The major work on this map was done in 2004-2005 by the Dynamac Corporation, the environmental contractor for KSC. A general vegetation map was obtained from the SJRWMD, which covered a large portion of north and east Florida. Dynamac employees cut out the areas owned by the Refuge and KSC and gave the draft database to the Refuge. Refuge employees then used old paper vegetation maps, the National Vegetation Classification System, personal knowledge and ground truthing to modify the shapefiles to better reflect reality. Dynamac personnel then cleaned up the files and developed the final vegetation database.

One of the more difficult database sets to develop were those related to management activities. The Refuge has conducted a number of management activities over the years including tree planting and timber harvesting, as well as scrub vegetation restoration. Many of the older records were hand drawn and incomplete, which increased the difficulty in achieving an accurate representation of past work. The development of this database is on going.

PRESENT USE OF GIS ON MINWR

At the present time, the Refuge is using GIS in a number of applications. However, the full capability of the system has yet to be realized. Most use is limited to planning and documentation.

Comprehensive Conservation Planning

The National Wildlife Refuge System Improvement Act of 1997 requires that all national wildlife refuges develop a Comprehensive Conservation Plan (CCP) by 2012. Merritt Island NWR has recently finished its draft CCP, which is now in the internal review process. The development of a CCP would be extremely difficulty without the assistance of GIS.

All stages of the planning process are supported by GIS. The preplanning stage involves evaluating and analyzing existing data and data needs to help determine the status and trends of refuge wildlife and habitat. GIS and mapping are highly important components of the public scoping phase where the Service coordinates with local, state, and federal agencies and where the Service interacts with interested members of the general public, businesses, organizations, and non-profit groups to determine the highest priority issues for the refuge to address during the 15-year life of the CCP. During public scoping, maps are provided for orientation and overview,

maps are used in charette style meetings to allow the opportunity for interested parties to draw ideas directly on the maps, and maps are used to illustrate various options in solving the priority issues. Following public scoping, a draft CCP is prepared. GIS and mapping document the existing conditions and the proposed changes in the draft CCP. For public review and comment on the draft CCP, GIS and maps graphically present the proposed changes to refuge management activities. A final CCP is then prepared with the final documentation and proposed changes.

Making and updating maps helped the Refuge inform the public and to gather information from the public regarding future management of the Refuge. The vegetation map produced in partnership with Dynamac was a requirement of the planning process and aided the Refuge in decision making regarding future management activities. In fact, much of the development of an organized set of databases for the Refuge was the direct result of CCP needs. Data were gathered from various sources in order to support the development and analysis of alternatives for future management of the Refuge and to support the presentation of the proposed action to the public and intergovernmental partners. Without GIS data and mapping, the Refuge would have been hard pressed to propose and garner support for several actions in the CCP. These actions included the development of pole and troll zones where the public has voluntarily and enthusiastically supported imposing limitations on boating and fishing in over 2,500 acres of Mosquito Lagoon based upon a variety of information, not the least of which were key GIS databases, including aerials, seagrass scarring and historic loss of seagrasses over time.

Habitat Management

The greatest potential for GIS use on the Refuge is in various land management programs. Some limited uses of GIS capability have been employed in the arenas of exotic plant control, citrus management and timber management, but most of the work has occurred in conjunction with the Refuge's scrub restoration and fire management programs.

Exotic Plant Control: The refuge has at least 25 known species of exotic plants (Adrian et al., 2006). Infestations range from a few individuals of easily controlled plants, such as *Eucalyptus* sp., to widespread areas of Brazilian pepper (*Schinus terebinthifolius*). Mapping of both the location of the plants and control actions are documented. GIS products are also used to prepare proposals to apply for grant money to combat these pests. Once developed, an exotic plant database for the Refuge will be used to track the locations, spread, treatments and success of exotic plant control program at the Refuge.

Timber Management: The Refuge's timber management program is another area where GIS has been used to a limited extent. Large areas of fallow citrus groves were planted in timber in the mid 1980s. The old hand drawn planting maps are being incorporated into a GIS format. GIS is also used to plan and document timber sales.

Citrus Management: The citrus groves on the Refuge are an artifact of previous land use activities which were continued after NASA began operating Kennedy Space Center. For a long time the groves were managed under a commercial contract, but with declining economics and due to several freezes, they are now managed by the Florida Research Center under a Memorandum of Understanding. The Center is using the groves to develop a more environmentally sound citrus culture program. As part of this program, extensive records on

caretaking costs, soils, production and income are kept. Much of these data are in GIS databases and these are provided to the Refuge under the agreement. Some of these data will be used to support future habitat restoration activities.

Scrub Restoration: Maintaining quality habitat on MINWR for the federally threatened Florida scrub-jay is essential to support recovery of the species (U.S. Fish and Wildlife Service, 2006). The Florida scrub-jay has specific habitat requirements (Breininger et al., 1996). Optimal habitat for the jays as described by Breininger (1996) is a landscape composed primarily of shrubs three to ten feet in height with greater than 50% of the vegetation being scrub oaks (*Qurecus* sp.). This area should have between 20% and 50% open space or be within 300 feet of an open edge. The shrub layer can have a scattered overstory of pine, but the crown closure should be less than 15%. Finally, no forests should be within 300 feet. Among other things, this open landscape allows scrub-jays to spot predators while they are still some distance away from nests and from jays. If the landscape is more enclosed, the ability of jays to defend against predators is greatly reduced. The survivability of nests within 100 feet of a forest is greatly reduced from the survivability in areas beyond 100 feet.

Up to the 1940s, extensive areas of scrub-jay habitat persisted along the east central coastal region of Florida (Duncan et al., 2004) and on the Refuge itself. As the area became more populated, scrub-jay habitat was lost and fragmented. In addition, fire was excluded from many areas of the landscape. The lack of fire caused the remaining wildland areas to become overgrown. The once low and open scrub became enclosed and tall. Mesic hardwood hammocks expanded into the oak scrub and scrubby flatwoods. The stocking of pines, which are acceptable as a scattered overstory, became denser, greatly exceeding the needed 15% crown closure previously noted. Grassy swales, an integral part of the scrub landscape, became hydric forests. This put forests in the middle of otherwise suitable habitat, reducing the open nature of the landscape. Not only did these changes lower the habitat suitability of the scrublands (Breininger, et al., 1996), but they also decreased the ability of fire to maintain the landscape (Duncan and Schmalzer, 2004).

Over the past decade, the Refuge has put considerable effort into restoring the scrubland landscape. This ongoing effort has been a partnership between KSC, Dynamac Corporation and the Refuge. Part of the effort has been directed towards reducing the height of overgrown scrub oaks through mechanical treatment, followed by burning. Other work has reduced the extent and density of forests in scrub areas.

The use of GIS has been an important tool for this program in several ways. The Refuge made the decision to mimic the landscape features that were present prior to human development and fire exclusion. Comparisons of present day vegetation coverage with what was historically present have been conducted on several areas of the Refuge (Duncan et al., 1999) (Figure 2). These studies have been used to decide where forests should be removed and/or thinned. The comparison of past and present landscapes is also used to determine which modern day hydric forests within the scrubland matrix were historically grassy swales.

Another use of GIS in scrub landscape restoration is determining where the greatest return for efforts will be. Research has shown that the scrub-jays do not disperse over great distance (Stith

et al., 1996). It is therefore more advantageous to restore scrub close to sites that are presently occupied by jays. Using GIS data provided by the Dynamac Corporation, occupied jay territories can be plotted. These are now compared with areas in need of habitat restoration work so that more informed decisions can be made. This information is used to develop funding requests for future projects.

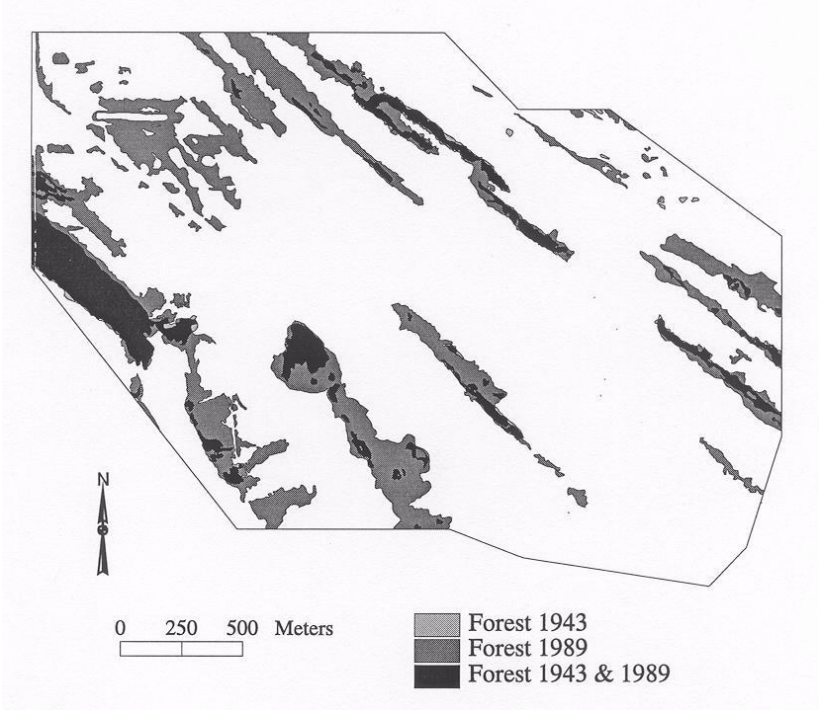

Figure 2. Difference in forest in the Happy Creek area of Merritt Island NWR between 1943 and 1989 (from Duncan et al., 1999).

Fire Management: Another program where GIS is being used more intensively is fire management. This is somehow appropriate, since the first on the ground application of GIS for the MINWRC was on the Red Beach Fire in 2001. Currently, the over 100 Refuge burn units have been entered into GIS databases. Although upkeep of the database file tends to be periodic, information on size, perimeter, date of last prescribed burn and projected date of the next prescribed fire are available. Under development is a database to plan the prescribed fires for each coming year. These data are used in the fire prescription development process. In the future it is planned to use the new vegetation map to determine the acreage of each fuel type within the burn units. Plans to incorporate fuels monitoring data in the fire GIS package are also underway.

As was noted several times, the mapping of a wildfire was what jump-started the Refuge's interest in GIS. It is appropriate that the latest real time use of GIS also involves a fire. Starting on the 21st of April, 2006 the Areca Palm Fire started near the BeeLine Unit of the St. Johns National Wildlife Refuge, one of MINWR's areas of responsibility. The initial fire burned onto the SJNWR, burning for two days. It lay dormant for about a week, then, on April 27th it broke out and ran toward a large residential area. The fire grew several times over the next two weeks, and several smaller fires ignited in the same general area. Firefighters and support staff from the

Service, the Florida Division of Forestry, Brevard County Fire Rescue, Orange County Fire Rescue and the St. Johns River Water Management District eventually were involved in what became the Orlando Fire Complex. By May 16th the total area consumed was over 6,500 acres. During the various runs that this fire made over 2000 homes were threatened and no primary residential structures were lost.

The Refuge provided GIS support for the fire in the form of the Refuge's Natural Resource Planner who served as a Geographical Information System Specialist (GISS). Through the use of a laptop, a portable printer (purchased for this) fire and a vehicle equipped with 110 volt outlets, maps could be produced on the fireline at crucial times. Frequent GPS mapping of the fire perimeter from the ground and air allowed planning and operational maps to be provided in a timely manner. One of the more important functions of the GISS was to help develop maps which showed trigger points for the evacuation of threatened residences. Some of the situation maps were picked up by both the print and electronic media for publication. The amazing thing was that as limited as the Refuge staff was and still is in the use of GIS, none of the other cooperators on this fire had the capability to provide this service.

CONCLUSIONS

The experience of Merritt Island National Wildlife Refuge with its GIS program points out several important items. First, you do not need a lot of money to get a GIS operation going, although this would certainly make things easier. Second, although it would be more efficient for an organization to provide formal training commensurate with the needs of the program, self-taught GIS personnel can produce useable products. Third, it pays to form partnerships. In many cases, data that are needed already exist. With the proper partners, these data can then be begged, borrowed or otherwise appropriated. Finally, no matter how bad off you think you are, there is always someone who has it worse than you.

REFERENCES

Adrian, F.W., M. Epstein, R. Lloyd, J. Lyons. 2006. Draft habitat management plan for Merritt Island National Wildlife Refuge. Titusville, FL: U.S. Fish and Wildlife Service.

Breininger, D.R., V.L. Larson, R. Schaub, B.W. Duncan, P.A. Schmalzer, D.M Oddy, R.B. Smith, F. Adrian, and H. Hill Jr. 1996. A conservation strategy for the Florida scrub-jay on John F. Kennedy Space Center/Merritt Island National Wildlife Refuge: an initial scientific basis for recovery. NASA Technical Memorandum NASA-TM-111676. John F. Kennedy Space Center, FL: National Aeronautics and Space Administration.

Duncan, B.W., S. Boyle, D.R. Breininger, and P.A. Schmalzer. 1999. Coupling past management practice and historic landscape change on John F. Kennedy Space Center, Florida. *Landscape Ecology*. 14: 291-309.

Duncan, B.W., and P.A. Schmalzer. 2004. Anthropological influences on potential fire spread in a pyrogenic ecosystem of Florida, USA. *Landscape Ecology.* 19: 153-165.

Duncan, B.W., V.L. Larson and P.A. Schmalzer. 2004. Historic landcover and recent landscape changes in the North Indian River Lagoon watershed, Florida USA. *Natural Areas Journal*. 24(3): 198-215.

Epstein, M., and B. Blihovde. 2006. Listed species of the Merritt Island National Wildlife Refuge. Titusville, FL: U.S. Fish and Wildlife Service.

Schmalzer, P.A., T.E. Foster, and D.W. Duncan. 2002. Revised flora and list of threatened and endangered plants of the John F. Kennedy Space Center area, Florida. NASA Technical Memorandum NASA/TM-2002-211175. John F. Kennedy Space Center, FL: National Aeronautics and Space Administration.

Stith, B.M., J.W. Fitzpatrick, G.E. Woofenden, and B. Pranty. 1996. Classification and conservation of metapopulations: a case study of the Florida scrub-jay. In *Metapopulations and wildlife conservation*, 187-215, D.R. McCullough, ed. Washington D.C.: Island Press.

U.S. Fish and Wildlife Service. 2006. Draft comprehensive conservation plan for Merritt Island National Wildlife Refuge. Titusville, FL: U.S. Fish and Wildlife Service.