Table 6. Citrus production in Cuba.

Variety	1990	1993	1994	1995	1996	1997
	1,000 boxes					
Oranges	14,793	9,286	6,101	6,738	6,934	11,809
Grapefruit	8,146	5,682	5,341	6,395	8,575	7,252
Lemons/limes	1,497	333	368	441	490	515
Tangerines	360	414	123	123	123	123
Others	118	142	98	74	74	74
Total	24,914	15,856	12,030	13,769	16,195	19,772

nies, downsizing the total citrus acreage and organizing the state farms into "grower" cooperatives (UBPCs). The UBPC cooperative members have been given more control of the decision making on what cultural inputs to use and are now allowed to retain the differences (profits) between the cost of inputs and guaranteed price paid by the Cuban government.

Both the downsizing of the citrus acreage into more efficient units of production and the "more privatizing" of the UBPC cooperatives have resulted in increased total citrus production. Initially, the market focus was to export early maturing fresh citrus primarily to Europe. However, due to the lack of essential production inputs such as chemicals, growing and exporting quality fresh was limited. Therefore, the recent focus in Cuba's citrus industry has been to develop the bulk concentrate citrus juice market. Citrus processing facilities have been expanded and/or refurbished and new joint ventures with foreign investors are intended to add new processing facilities in the citrus growing regions. Cuba's citrus industry appears to have substantially recovered from economic decline resulted from the 1990 dissolution of the Soviet Bloc.

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APPLICATION OF AERIAL PHOTOGRAPHY AND VIDEOGRAPHY TO CITRUS TREE INVENTORY

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Abstract. **Aerial photography from the Florida Agricultural Statistical Service was used as a base for a survey and inventory of citrus groves at Merritt Island National Wildlife Refuge. Blue (diazo) prints from FASS were used to identify groves and cross reference them with the Kennedy Space Center Facilities Master Plan. An aerial survey with color video was made of all the groves in 1996. The information extracted from resulting images was used to verify the health of trees in the respective groves. Digital enlargements were made from a previous overflight of the groves to record recent information and determine which groves were in good health and those that needed additional agricultural practices to bring them up to optimum production. Data from FASS was incorporated into the Master Plan for the first time which will make it easier in future inventories to rapidly access grove information for improved accounting and estimation of production.**

Introduction

In Florida one of the most important horticultural practices in citrus groves that has to be done on a yearly basis is to assemble information on the number of viable trees by location and variety and obtain a total tree count. This practice is not difficult in groves of all one variety or where replacements involve a single tree, but it becomes complicated in mixed-variety groves or where two trees are replanted in place of the original tree. In newer groves where tree spacing is reduced between trees (<16 ft), tree counts will be impossible by the 5th year after planting (Blazquez et al., 1989).

In Florida, aerial photography of citrus groves is used by a number of agencies on a sequential basis for tax purposes by county property appraisers (Blazquez et al., 1988), by the US Geological Survey (High Altitude Mapping, Holland, 1993), and by the Florida Agricultural Statistical Service for crop estimates (Blazquez and Horn, 1980), the USDA, and the University of Florida.

Interpretative experiments of aerial photographs from Florida citrus groves have been done by a number of individuals, by means of direct visual counting of each tree and recording on graph paper (Blazquez et al., 1978), by visual counts and entering the data into a computer program (Blazquez et al., 1986), or by digitizing a grove image and having a computer program count the trees (Glazer et al., 1998). Computer analysis allows for display of the results as an image, data entry in a spreadsheet for analyses, and the ability to archive the data for future use (Blazquez et al., 1986).

Color videography has been used to monitor citrus groves for cold damage and detection of damage in pasture lands, and the development of a Geographic Information System (GIS) for digital aerial videography (Yang et al., 1998). In this case oblique videography was used to observe the general health of trees from aerial surveillance flight over individual groves.

One of the principal objectives of this work was to evaluate the use of existing aerial photography to help improve grove management. This data is available at virtually no cost to growers and once it is properly extracted and analyzed with available computer software it should provide valuable information to the grower.

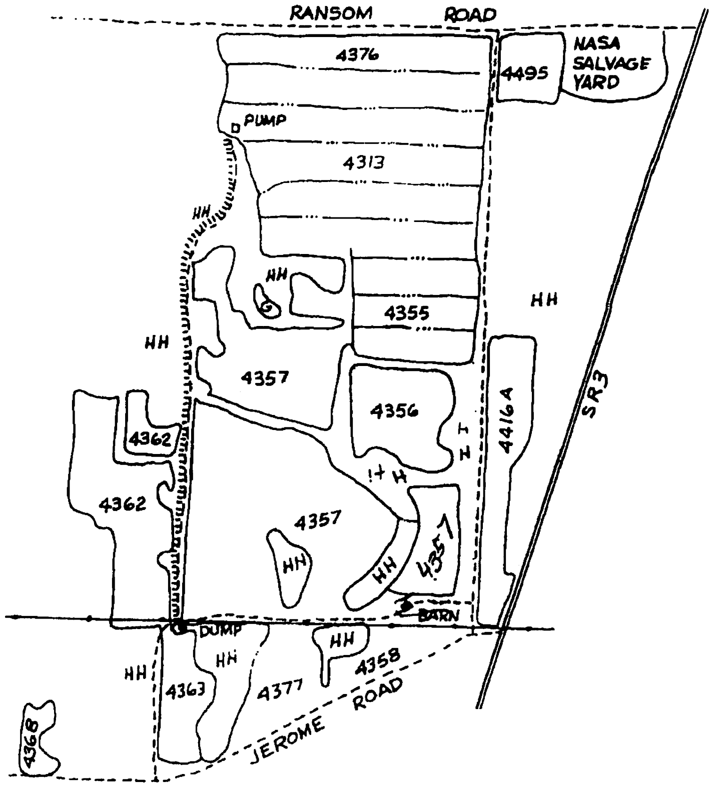

Figure 1. Map of Group 2 citrus groves of the Merritt Island National Wildlife Refuge showing tract numbers and reference roads.

Materials and Methods

Location of the citrus groves within the Merritt Island National Wildlife Refuge (MINWR) at the Kennedy Space Center (KSC), Cape Canaveral, Florida was obtained from grove maps (Fig. 1) provided by the U.S. Fish and Wildlife Service who manage the grove areas for KSC. Groves are identified by a tract number and were geographically located on KSC Facilities Master Plan (FMP) maps (Blazquez et al., 1988) (Fig. 2). Groves were not identified by tract number on KSC Master Plan maps, thus in some cases difficult to locate. Once referenced by tract number, this information was transferred to KSC to facilitate future identification.

Black and White (B&W) aerial photographs were taken by the Florida Agricultural Statistical Service (FASS) in January and March 1994 from 15,000 ft with a 6-inch focal length lens, resulting in a scale of 1:30,000, and enlarged on mylars to a scale of 1:640. Data from these enlargements were used to cross reference the photographic frames covering the MINWR groves with the KSC FMP maps. Enlargements of the frames were obtained as blue (diazo) copies with the registered grove location by Section, Township, and Range (Fig. 3).

FASS followed up the 1994 flight with a ground survey. Data from this survey were provided as Tree Census Section Printouts (TCSP) with information on date of the photograph, date of the field survey, county, section, township, range, and block number of the grove inspected, variety, age of trees, tree counts, acreage per variety, total acreage, and changes since last ground survey (Table 1).

The information recorded on the TCSP follows a sequential numbering system for each section and is referenced by block number. With reference to the blue (diazo) copy it is quite easy to identify the grove by block number then obtain information about number of trees, variety, and year planted from the TCSP. However, FASS does not record groves according to MINWR group or tract system, so it was necessary to develop a cross reference list.

Oblique color videography of the groves was obtained on the morning of 18 July 1996 from a helicopter overflight at 1000 to 1200 feet with clear skies and full sunlight. A Beta Cam professional video camera with recorder was used to acquire the images. Images were then copied to VHS format for ease of viewing and interpretation.

A general survey overflight with B&W film was also completed in July 1995 by NASA, with a Wild 30 camera using a 6-inch lens, producing images at the scale of 1:800. The film was digitized and Intergraph GIS software was used to extract images. Images were enlarged to provide sufficient detail of the trees for ground truthing and then printed in large B&W format. In addition to the enlargements, the KSC Mapping Division provided CD-ROM data to the Kerr Center, so that additional digitized printouts as needed with correctly identified grove tract numbers could be made and included in the GIS.

The B&W printed images were duplicated, catalogued, and stored for reference. Specific enlarged photographs were trimmed and mounted on a light weight plastic boards for ease of handling in the field surveys. Six tracts in Group 2 were selected for ground-truth surveys to determine the accuracy of the FASS tree counts. Though a time period of 4.5

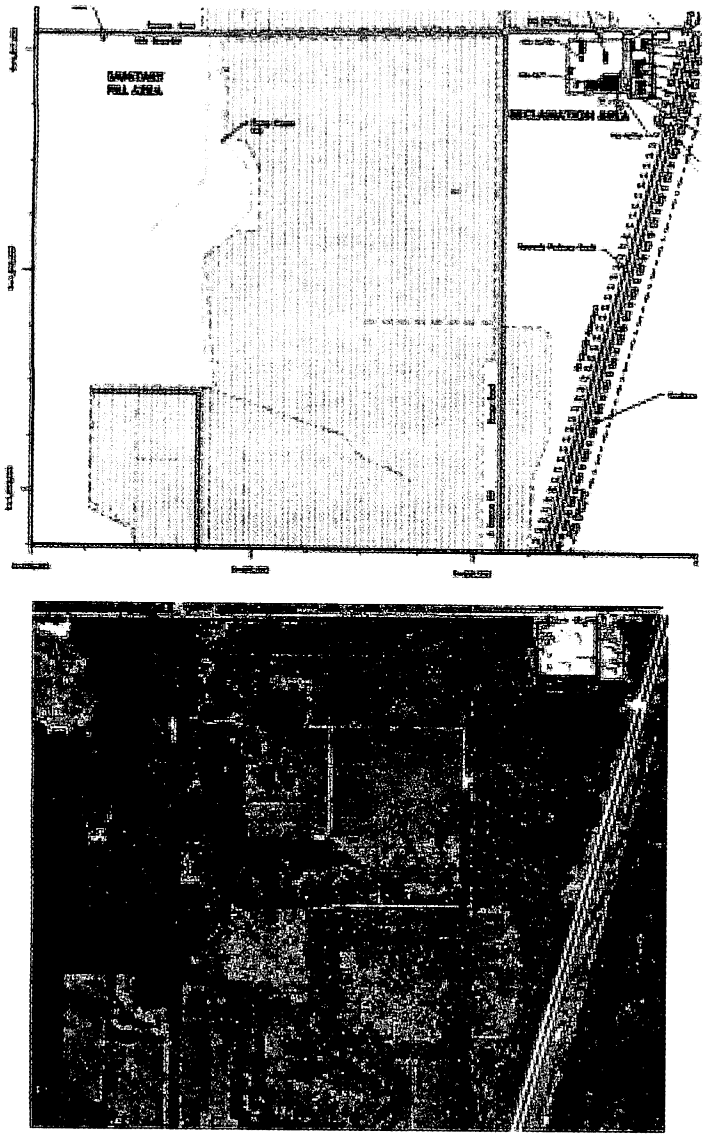

Figure. 2. Portion of Kennedy Space Center Facilities Master Plan map and aerial photograph showing the location of Group 2.

years had passed, ground observations could easily be matched with photographic image features.

The enlarged photographs were covered with a protective clear plastic sheet and marked according to condition in cells of 8 by 8 trees for ease of counting (Blazquez et al., 1978) (Fig. 4). Geographical important reference points were recorded on the photographs to eliminate problems of direction of ground travel among the rows of trees. Marking was done with felt tip pens.

Travel through the groves was done verifying conditions on two rows of trees on either side of the vehicle. Once the end of the grove was reached the return trip was done in a similar fashion, but four rows over to examine previously uninspected rows. Travel was done slowly enough to properly record individual tree condition on the photographic enlargement. Condition codes followed that used in Blazquez et al. (1978). Appropriate observations regarding ditches and other anomalies were also made on the enlargements, so that they could be included in the GIS.

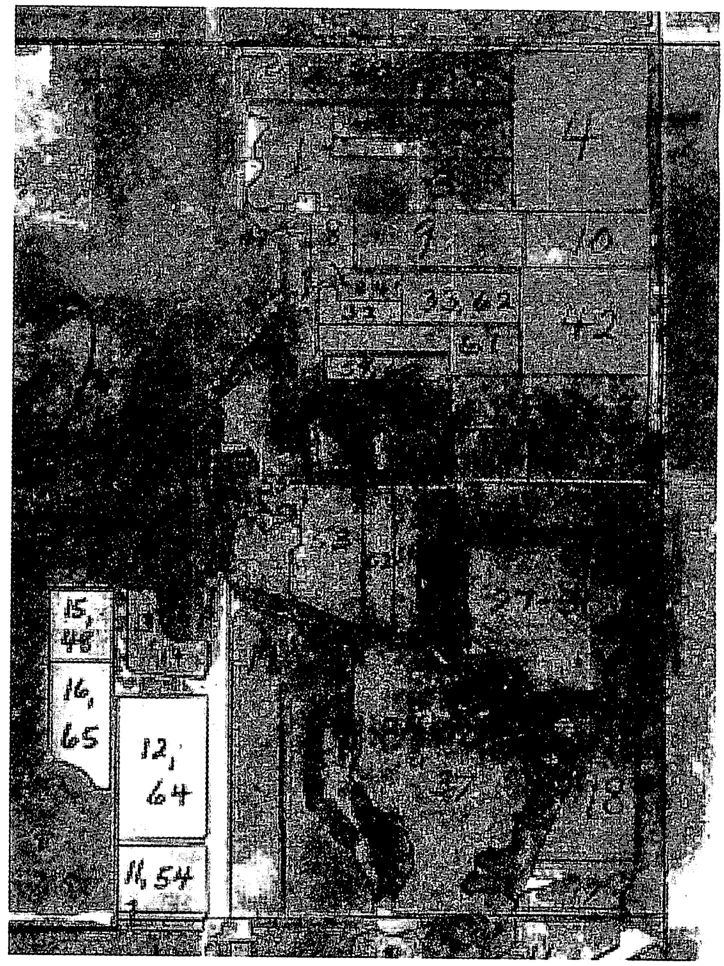

Figure. 3. Photograph of blue diazo image from FASS locating Group 2 citrus groves with block numbers.

Preliminary analysis and tree counts from the enlargements were recorded and compared with data from the FASS database (Table 2). Once the FASS data was compiled for the area it was entered into a spreadsheet format and summarized by total tree numbers (Table 3), area, variety, in order to better interpret the data and facilitate management decisions.

Results and Discussion

The information recorded on the FASS TCSP was difficult to correlate to the MINWR groves, because it was necessary to match up the FASS block number with the MINWR tract number before data could be analyzed.

Many areas within groves were marked by multiple block numbers making impossible identification of specific characteristics especially since the blue diazo copies are not contrast balanced, and it is possible to find underexposed images of groves as well as overexposed images (Fig. 3). Local tracts may include three or four distinct groves under the same number, further confusing the identification. In addition, many groves have multiple varieties not restricted to distinct areas but in some cases alternating with or randomly occurring within a dominant variety. The available map of the groves at the beginning of the project were not very accurate (Fig. 1), and sometimes tract numbers were omitted adding to the confusion.

Table 1. Excerpt from printout of FASS Tree Census Section database showing data classification system.

Sec	Twp	Rng	Block No.	Var	Year	Spacing	Acres	Trees
12	23	36	36	22	31	2525	0.4	25
12	23	36	66	31	90	2525	1.3	88
12	23	36	38	13	46	2425	1.4	98
12	23	36	39	52	21	2425	2.6	180
12	23	36	40	52	30	2224	3.5	287
12	23	36	63	13	46	2224	0.3	28

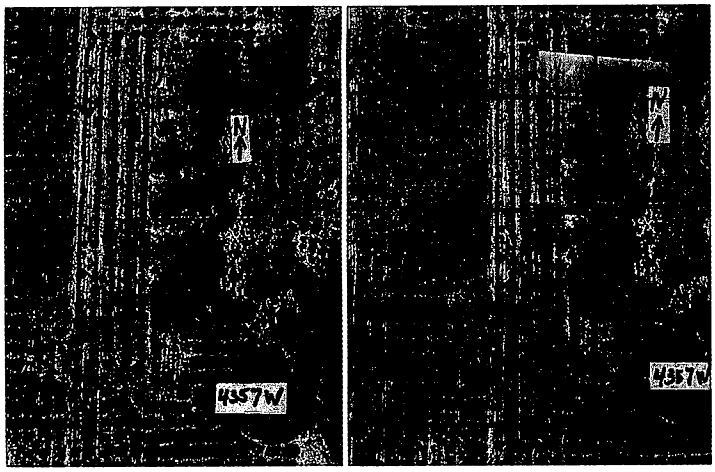

Figure. 4. Enlargement of NASA B&W image of Group 2 Tract 4357W without cell overlay and with right overlay showing wet areas of the grove where tree mortality was severe.

The use of the FASS blue (diazo) images was extremely helpful in locating groves and verifying information obtained from KSC FMP maps. However, the KSC FMP maps only located the areas where citrus had been planted and provided no information on the tract numbers, or other pertinent grove data (Fig. 2).

The digital data made it possible to reproduce images of aerial photographs as needed, with properly recorded tract numbers, making grove identification a very easy proposition while providing for a time-referenced GIS layer.

As ground surveys of the groves progressed using the photographic enlargements from the KSC Mapping Division the impressive details of the aerial photographs was noted. The majority of changes to the grove have occurred in areas that were poorly drained, and in some cases flooded. The lack of maintenance and fertilization during a period of two years in this group severely affected trees growing in poorly drained soil, while those planted in dry areas with good soil did not appear to be as affected. There were groves that have almost reverted to native and exotic vegetation, so that it may be necessary to abandon them. Wet areas could be easily identified in groves (Fig. 4). Observations from the oblique video imagery was most helpful in locating potential problem areas due to poor drainage, as it was taken before Kerr Center involvement and subsequent caretaking efforts.

Analysis of the ground survey data indicates that there is a good correlation between the tree counts obtained by FASS and six representative tracts surveyed in 1998 (Table 2). In all of the groves surveyed more trees were reported by FASS than actually counted, ranging from a high of 13% in a small grove to 5.2% in a large grove. The percentage of producing trees ranged from 94.4% of the plantable spaces to 47.0% in some wet areas.

Tree condition observed in the ground surveys indicated that many trees had died and the rootstock sprouted and developed into good size trees confounding tree stands. This made it hard to accurately count trees in ground surveys or B&W photography. In addition there were many different varieties not recorded in the FASS data.

Combining FASS data and aerial photographs made it possible to rapidly obtain a preliminary survey of existing citrus groves at MINWR and establish a management strategy. Without the photography and data from FASS developing a tree inventory of the MINWR groves would have been a much more expensive proposition. The use of B&W photography did not make it possible to determine the health, disease, or stress of the trees, although a first look of tree conditions was

Table 2. Comparisons between tree counts of six selected tracts of MINWR citrus groves taken in November 1994 by the FASS and ground surveys conducted in September 1998.

			Number of Trees				
Tract Number\ Variety	Acres	Planting Distance (ft)	Available Tree Sites	1994 FASS Count	% Difference	1998 Ground Survey	% Producing
4478 Red GF	31.1	30 × 30	1578	1500	5.2	1412	89.5
4355SW Minneola	2.6	27 × 27	168	148	13.5	136	80.5
4355SE Navel	3.9	22 × 24	312	305	2.2	210	67.2
4362C Navel	9.2	25 × 15	1070	1026	4.0	813	75.9
4357E Navel	14.8	25 × 25	586	550	6.5	553	94.4
4357W Minneola	10.4	25 × 30	1265	583	46.1	595	47.0
Total	72.0		4979	4112	82.6	3719	74.7

Table 3. Summary table of total tree counts of citrus groves at MINWR Group 2 from the FASS database for 1994.

Variety	No. Trees
Hamlin Oranges	872
Early Seedy Oranges	324
Navel Oranges	5775
Pineapple Oranges	2411
Valencia Oranges	3761
White Grapefruit	216
White Grapefruit	723
Pink Grapefruit	1228
Ruby Red Grapefruit	1383
Dancy Tangerine	113
Unid. Mandarins	20
Sunburst Tangerine	153
Temple	2252
Minneola Tangelos	1638
TOTAL	20869

obtained with the oblique color video. Incorporation of video data into the GIS system could improve future assessment of grove health and provide archival data on previous grove conditions.

The work was done with minimal expense using Kerr Center resources. The information obtained is being incorporated into a GIS system for the management of MINWR groves using the Kerr Center's Sustainable Citrus Program (SCP). Because of the mixed nature of varieties and native growth in the groves, it will be necessary to continue to conduct ground surveys of each grove until accurate tree counts are obtained and mapped. Additional aerial photographic surveys will be performed with color infrared film to detect tree health and water damage. Once an accurate inventory of all groves is made, the sequential use of color and/or infrared aerial photography will make it possible to rapidly determine if any major changes have occurred and pinpoint where. This will refine yield estimates and greatly assist with management plans and decision making. In addition the imagery will be entered into a GIS system to study other trends that may not be observed in annual inventories such as disease and insect movements. The relatively low cost of the entire tree inventory using existing and available photography has made it a very cost effective and useful project.

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PERFORMANCE OF 'FALLGLO' CITRUS HYBRID ON TEN ROOTSTOCKS IN LAKE COUNTY[1]

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Additional index words. Tree growth, fruit production, fruit quality, Citrus reticulata.

Abstract. **A replicated rootstock field trial for 'Fallglo' (hybrid of *Citrus reticulata* Blanco) was established in 1992 at the Whitmore Foundation Farm in Lake County to compare performance on ten rootstocks, including Carrizo citrange, Swingle citrumelo, Cleopatra, Sun Chu Sha, and six new USDA hybrids. Yield, fruit quality, tree size, and tree health information were collected for 1995-98 from the trial and differences between performance on the different rootstocks were documented. Three new USDA hybrid rootstocks appeared to be equal or superior to the standard rootstock cultivars in productivity and fruit quality when used with 'Fallglo' scion in this location. One hybrid of 'Sunki' (*C. reticulata*) × Flying Dragon trifoliate (*Poncirus trifoliata* [L.] Raf.), identified as HRS 942, and a hybrid of 'Sunki' (Benecke trifoliate (HRS 812) appeared to be especially good candidates for additional field testing.**

Fallglo', a hybrid of 'Bower' × 'Temple' released by USDA in 1987, has been a successful early fresh fruit variety for some Florida growers (Hearn, 1987; Tucker et al., 1993). This cultivar generally reaches best quality in November, but is more

[1]Mention of a trademark, warranty, proprietary product, or vendor does not imply an approval to the exclusion of other products or vendors that also may be suitable.