

NORTH

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
|------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| --1 | G | Y | Y | V | V | F | F | G | Y | G | Y | F | G | Y | Y | Y | G | . | . | . | . |
| --2 | V | G | X | Y | Y | F | X | G | G | F | X | G | G | V | G | . | . | . | . | . | . |
| --3 | Y | G | F | G | F | G | F | G | G | G | G | Y | G | G | . | . | . | . | . | . | . |
| --4 | F | G | Y | Y | G | Y | T | G | G | G | G | G | G | G | . | . | . | . | . | . | . |
| --5 | G | V | G | F | V | G | G | F | G | G | F | G | G | Y | . | . | . | . | . | . | . |
| --6 | G | G | V | G | G | G | G | G | V | Y | F | G | Y | . | . | . | . | . | . | . | . |
| --7 | Y | G | X | V | G | G | Y | G | G | V | G | . | . | . | . | . | . | . | . | . | . |
| --8 | X | G | G | G | G | Y | G | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| --9 | G | G | G | G | Y | Y | V | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| --10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| --11 | . | . | . | . | . | . | . | . | . | . | . | . | . | G | G | G | G | G | G | G | G |
| --12 | . | . | . | . | . | . | . | . | . | . | . | . | . | G | G | G | G | G | G | G | Y |
| --13 | . | . | . | . | . | . | . | . | . | . | . | . | . | G | G | G | G | G | G | G | Y |
| --14 | . | . | . | . | . | . | . | . | . | . | . | . | G | G | G | Y | G | G | G | G | G |
| --15 | . | . | . | . | . | . | . | . | . | . | . | . | G | G | G | G | F | F | G | G | X |
| --16 | . | . | . | . | . | . | . | . | . | . | . | G | G | G | G | Y | G | F | V | G | G |
| --17 | . | . | . | . | . | . | . | . | . | . | . | G | G | G | Y | G | G | G | G | G | G |
| --18 | . | . | . | . | . | . | . | F | G | G | G | G | G | G | F | G | G | G | Y | G | G |
| --19 | . | . | . | . | . | . | . | F | F | G | G | G | G | G | G | G | G | G | G | G | G |
| --20 | . | . | . | . | . | . | . | Y | X | V | V | G | G | G | G | G | G | G | X | G | G |
| --21 | F | R | Y | F | X | X | Y | F | G | Y | G | G | G | G | V | G | G | G | Y | G | G |
| --22 | Y | Y | Y | Y | F | X | F | X | V | V | Y | G | Y | G | F | V | G | G | G | G | G |

Fig. 2. Printout of grove map showing grove orientation, tree location, row and column numbers.

tree was inserted in position #1 with the computer. If the row was recorded on the graph paper, the entire row would have to be erased and re-recorded. The deletion of trees was also simple and quick. Computer mapping also eliminated the need to transcribe the map from a field copy to a file copy. Overall, growers found that computer mapping reduced the mapping time by 25% or more, while other growers who balked at mapping groves have mapped their entire holdings.

In conclusion, the Citrus Survey Program provided growers with an accurate and easy method to collect data in the field using a portable computer that was inexpensive and durable. Also, the Citrus Mapping Program which formatted the data files allowed growers to utilize a wide range of Apple, IBM and IBM compatible computers to print their grove maps.

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GROVE MANAGEMENT WITH COMPUTER AIDED PHOTOINTERPRETATION

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Abstract. Color infrared aerial photography of groves is useful in grove management. When photointerpreted information is entered into a data base of a computer, the results can be used as a management tool. Photointerpreters looked at 5 different tree statuses of citrus trees: 1 = missing trees; 2 = trees 1 to 3-yr-old; 3 = trees 4 to 6-yr-old; 4 = trees 7-yr-old and older; 5 = stressed, dying, and dead trees. Other information entered was grove name, block no., variety and code,

rootstock and code, and tree spacing. This data was entered into an IBM computer using a custom data base program. Sums of tree statuses 1 and 5 were labeled potential acreage and sums of tree statuses 2, 3, and 4 were labeled planted acreage. A printout of the data base produced 4 reports: 1) sums for each class and totals by rootstock; 2) by variety; 3) by block, the tree statuses in the block are summed, along with total healthy trees, total potential trees, net total planted acres, net total potential acres, and total net planted to net potential acres; and 4) by grove, listing the sum of the tree statuses and total of all tree statuses.

The photointerpreted results of sample blocks in an actual grove of large acreage, using color infrared aerial photography, computers, and a modified data base program, are reported.

Systematic mapping of citrus groves can provide an accurate account of tree conditions related to production, disease, and nutrition. Annual mapping can point to areas of change that may be trouble spots (1). Few industrial managers would attempt to manufacture a product without an accurate inventory. Yet, due to the difficulty in collecting citrus tree data, few citrus managers engage in resource mapping. Thus, citrus growers can only approximate grove condition by cursory inspection of the grove or by a change in production (6).

The Florida Agriculture Statistics Service has photographed the state's citrus production area every 2 yr since

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the 1965-66 season to maintain an inventory of commercial groves. Since the early 1970's, the gross loss of all citrus has averaged 2.8% annually. The desire for citrus tree information, compiled from aerial photography, has contributed to the most current and reliable statistics for any agricultural crop in the world (7).

It has been shown that photographs made in the spring season give the best separation between healthy and stressed citrus trees. Aerial photographs at a scale of 1:4000 have been found to be the most useful for photointerpretation with inexpensive equipment. At this scale, 1 inch on the film equals 330 ft on the ground (3).

Mapping a grove is very time consuming. For example mapping on foot and recording tree conditions on graph paper of a block of trees planted on 4 row beds took 90 man min for the 336 tree spaces or 3.7 tree spaces per min. While using a 4-wheel drive vehicle and driver, it took 75 man min or 4.5 tree spaces per min. Conversely, photointerpretation of aerial photographs of the same block took one person 5 man min or 67.2 tree spaces per min. Thus, the use of aerial photography is a savings in manpower and time, while providing a readily available permanent record (5).

Photographs show a synoptic overview of a large area of the grove making it possible to see various patterns in the soil, moisture, and tree conditions. The use of infrared film often pinpoints tree stress before the eye can see it (4).

Successful grove mapping was accomplished by directly inputting tree condition into a microcomputer as the operator was driven through the grove. The data was stored on a portable audio tape recorder. A printout of the data, when returning to the office, gave total tree count and totals of each tree condition (2).

Equipment and Methods

Aerial photographs were taken by a commercial aerial photographer using Kodak's 9 x 9 inch format aerial color infrared film, type 2443. The groves were flown over in Feb. and March 1987 and the aerial photographs taken at a scale of 1:4000.

Photointerpretation was made with a Mark II Type 3 Variscan film viewer, manufactured by Westwood Division of Houston Fearless Corp. (Los Angeles, CA 90064). The viewer was on loan to the Citrus Research and Education Center from NASA Kennedy Space Center. The Variscan has 4 magnifications: 3.0, 5.8, 12.06, and 28.4. Most of this work was performed at the 5.8 magnification. The light intensity control was set to 50% or 75%, depending on the film density. The roll of film can be moved forward or backwards, left and right, as well as rotated from the operating console.

Data was manually entered in an IBM 8086 computer equipped to run MS DOS version 3.1 and having 640K of Ram, a 360K floppy disk, and a 20 Meg. hard drive. The tree count system was developed by DLG Consulting. This system used Asthon Tates d Base III+ (tm) and compiled with Nantucket's Clipper (tm) software. This eliminated the need to purchase any other software. The compiled data was compatible with Coca Cola's main frame computer.

Before the film was ready for interpretation, someone knowledgeable about the holdings outlined the block on

Area 4

Unit 300

Frame 79

Grove (724-N) Cloud

Block 799

Variety Pa. (13)

Rootstock Cleo. (41)

Spacing 15 x 25

Fig. 1. 3 x 5 file card information.

the film. The holding was then given a frame number and block number on the film. A 3 x 5 file card was also filled out giving frame number, grove name and code, area number, variety and code, rootstock and code, and tree spacing (Fig. 1). See Table 1 for code numbers.

Data from the computer was compiled at the grove, block, variety, and rootstock levels. At the block level, total net planted acres were calculated for healthy trees. Also, net potential acres, total net acres, totals in each tree status with its acreage, totals of tree statuses 2, 3 and 4 (healthy trees), and totals of tree statuses 1 and 5 (potential trees) were compiled. Additional data entered into the computer was frame number, date, area code, grove name and code, block number, variety and code, rootstock and code, and tree spacing. Also, the photointerpreter's evaluation of each tree space (tree status) was entered as a code for each tree space: 1 = missing tree; 2 = trees 1 to 3-yr-old; 3 = trees 4 to 6-yr-old; 4 = trees over 7-yr-old; 5 = stressed, dying, or dead trees.

At the completion of the data entry for a block, a copy of the screen was printed on paper. In case there was a malfunction of the computer, a copy of the work would be on file (Fig. 2). A backup of the hard disk was made to insure against the loss of the data. The tree status numbers on the paper print were also used in a separate Apple computer program, written by Edwards, to keep track of

Table 1. Scion and rootstock variety codes.

| Variety | Citrus species |
|---------------------------------|--|
| Scions | |
| Hamlin (Ham.) (11) | <i>Citrus sinensis</i> (L.) Osb. |
| Page (Pa.) (13) | <i>C. reticulata</i> Blanco hyb. |
| Valencia (Val.) (22) | <i>C. sinensis</i> |
| White grapefruit (W. gft.) (33) | <i>C. paradisi</i> Macf. |
| Red grapefruit (R. gft.) (44) | <i>C. paradisi</i> |
| Rootstocks | |
| Rough lemon (R.L.) (11) | <i>C. jambhiri</i> Lush |
| Volkamer lemon (Volk.) (12) | <i>C. volkameriana</i> Pasq. |
| Macrophylla (Macro.) (14) | <i>C. macrophylla</i> Wester |
| Sour orange (S.O.) (21) | <i>C. aurantium</i> L. |
| Swingle citrumelo (Cit.) (31) | <i>Poncirus trifoliata</i> (L.) Raf. x <i>C. paradisi</i> |
| Carrizo citrange (Carr.) (32) | <i>P. trifoliata</i> x <i>C. sinensis</i> |
| Cleopatra mandarin (Cleo.) (41) | <i>C. reticulata</i> |

| | | | | | |
|-------------------------|-----|-----------------|-------------|-------------|----------|
| Frame | 114 | | | | |
| Area | 4 | | | Date | 07/01/87 |
| Unit | 300 | | | | |
| Grove | 735 | Grove Name | Cloud | | |
| Block | 114 | | | | |
| Variety | 22 | Variety Name | Valencia | Avg-spacing | |
| Root Stock | 21 | Root Stock Name | Sour Orange | 15.0 x 25.0 | |
| S T A T U S C O D E S | | | | | |
| 1 - [429] | | 2- [62] | | 3- [189] | |
| 4 - [3217] | | 5- [215] | | 6- [0] | |

Fig. 2. Printout of screen at completion of data entry.

the weekly progress. The program computes the total tree spaces read, total tree space acres, and the average number of tree spaces read per min for the week.

The numbers of each status were used to calculate the total tree space acres, the percentage of each tree status, and the percentage of productive tree spaces of the block (Table 2). Total tree space acreage was calculated by summing tree statuses 1 through 5, multiplying the results by the tree spacing and dividing the results by 43,560 square ft per acre. Tree space acres are used in this paper as there was no way to note interplanting of trees in the computer program. The program was written in this manner as the acreage of trees was not as important as the tree status. The computer program has been updated to include a change in tree spacing and/or variety in the row since this work was done. Tree space acres that are greater than the known acreage reflects interplanting. This is true only for solid block plantings.

Table 2. Results of selected blocks.

| Grove no. | Block no. | Frame no. | Variety | Rootstock | Spacing | No. trees in status | | | | | Total ^z acres | % trees in status | | | | | % ^y prod. | Ratio ^x |
|-----------|-----------|-----------|---------|------------|---------|---------------------|------|------|------|-----|--------------------------|-------------------|------|------|------|------|----------------------|--------------------|
| | | | | | | 1 | 2 | 3 | 4 | 5 | | 1 | 2 | 3 | 4 | 5 | | |
| 710 | 4 | 1 | W. gft. | S.O. Mix | 20 x 25 | 58 | 113 | 977 | 205 | 40 | 16.0 | 4.2 | 8.1 | 70.1 | 14.7 | 2.9 | 93.0 | 13.2 |
| 714S | 9 | 9 | Ham. | Carr. | 10 x 25 | 64 | 40 | 761 | 503 | 4 | 7.9 | 4.7 | 2.9 | 55.5 | 36.7 | 0.3 | 95.0 | 19.2 |
| 714S | 9 | 9 | Ham. | Cit. | 10 x 25 | 127 | 75 | 524 | 30 | 6 | 4.4 | 16.7 | 9.8 | 68.8 | 3.9 | 0.8 | 82.5 | 4.2 |
| 714S | 9 | 9 | Ham. | S.O. | 10 x 25 | 49 | 129 | 865 | 382 | 0 | 8.2 | 3.4 | 9.1 | 60.7 | 26.8 | 0 | 96.6 | 28.1 |
| 714S | 9 | 9 | Ham. | Macro. | 10 x 25 | 33 | 14 | 157 | 814 | 0 | 6.0 | 3.2 | 1.3 | 15.0 | 80.5 | 0 | 96.8 | 30.7 |
| 714N | 10 | 10 | Ham. | Carr. | 10 x 25 | 45 | 64 | 811 | 314 | 5 | 7.1 | 3.6 | 5.2 | 65.5 | 25.3 | 0.4 | 96.0 | 23.8 |
| 715 | 21 | 34 | Val. | S.O. | 15 x 25 | 196 | 134 | 370 | 675 | 174 | 13.3 | 12.7 | 8.7 | 23.9 | 43.6 | 11.2 | 76.1 | 3.2 |
| 716 | 37 | 37 | Ham. | S.O. | 15 x 25 | 39 | 1783 | 7 | 0 | 6 | 15.8 | 2.1 | 97.2 | 0.4 | 0 | 0.3 | 97.5 | 39.8 |
| 717S | 11 | 11 | Ham. | S.O. | 15 x 25 | 254 | 4064 | 2 | 0 | 1 | 37.2 | 5.9 | 94.1 | 0.05 | 0 | 0.02 | 94.1 | 15.9 |
| 717N | 12 | 12 | R. gft. | S.O. | 20 x 25 | 98 | 13 | 907 | 2765 | 18 | 43.6 | 2.6 | 0.3 | 23.9 | 72.7 | 0.5 | 96.9 | 31.5 |
| 718S | 13 | 13 | Val. | R.L.Mix. | 15 x 25 | 246 | 178 | 541 | 223 | 4 | 10.3 | 20.6 | 14.9 | 45.4 | 18.7 | 0.3 | 79.0 | 3.8 |
| 719 | 41 | 41 | Val. | R.L. Mix. | 15 x 25 | 1146 | 15 | 950 | 1058 | 41 | 27.6 | 35.7 | 0.5 | 29.6 | 33.0 | 1.3 | 63.0 | 1.7 |
| 720 | 17 | 17 | W. gft. | S.O. | 20 x 25 | 77 | 6 | 672 | 1836 | 8 | 29.8 | 3.0 | 0.2 | 25.9 | 70.6 | 0.3 | 96.7 | 29.6 |
| 720 | 17 | 17 | Val. | Carr. | 15 x 25 | 30 | 11 | 217 | 478 | 66 | 6.9 | 3.7 | 1.4 | 27.1 | 59.6 | 8.2 | 88.0 | 7.4 |
| 721 | 191 | 19 | Val. | Volk. | 10 x 25 | 1263 | 1023 | 3089 | 1753 | 185 | 42.0 | 17.3 | 14.0 | 42.2 | 24.0 | 2.5 | 80.2 | 4.1 |
| 721 | 32 | 32 | Val. | R.L. Volk. | 10 x 25 | 363 | 114 | 3252 | 1773 | 198 | 32.7 | 6.4 | 2.0 | 57.1 | 31.1 | 3.5 | 90.2 | 9.2 |
| 724 | 41 | 41 | Pa. | Cleo. | 15 x 25 | 1095 | 24 | 321 | 811 | 76 | 20.0 | 47.1 | 1.0 | 13.8 | 34.9 | 3.3 | 49.7 | 1.0 |
| 727 | 47 | 47 | Pa. | Cit. Mix. | 15 x 25 | 372 | 574 | 1633 | 133 | 193 | 25.0 | 12.8 | 19.8 | 56.2 | 4.6 | 6.6 | 80.6 | 4.1 |
| 729N | 711 | 71 | Pa. | Cleo. Mix. | 15 x 25 | 1474 | 1424 | 1108 | 600 | 220 | 41.5 | 30.5 | 29.5 | 23.0 | 12.4 | 4.6 | 64.9 | 1.8 |
| 730 | 722 | 72 | Val. | S.O. Mix. | 15 x 25 | 1364 | 1691 | 2592 | 500 | 132 | 54.1 | 21.7 | 26.9 | 41.3 | 8.0 | 2.1 | 76.2 | 3.2 |
| 733 | 111 | 111 | Val. | S.O. | 15 x 25 | 192 | 78 | 150 | 3330 | 508 | 36.7 | 4.5 | 1.8 | 3.5 | 78.2 | 11.9 | 83.6 | 5.1 |

^zTotal acres = No. trees in statuses 1, 2, 3, 4, 5 x spacing/43,560.

^yPercent production = No. trees in statuses 2, 3, 4 x 100/No. trees in statuses 1, 2, 3, 4, 5.

^xRatio = No. trees in statuses 2, 3, 4/No. trees in statuses 1, 5.

Two persons from the Kelly Girl People Service were hired to do the photointerpretation and input the data. The work requires a lot of concentration and causes eye strain, so the operators only worked 4 hr at a time. The operator should be familiar with inputting data into a computer. They were shown what a missing tree looks like, the difference in tree size, and the color change in trees, representing stressed, dying, and dead trees on the viewer. No field checking of the data was performed.

Selected blocks for the example in this paper were from a grove where the photointerpretation had been completed. The grove consisted of 148 blocks of various combinations of 15 varieties and rootstocks for a total of 545,739 tree spaces and 5,108 tree space acres. It took 7 weeks to photointerpret this grove. The example taken from this grove had 60,153 tree spaces, 486 tree space acres in 21 blocks. These blocks were selected to represent the various varieties and rootstocks in the grove. Five varieties with various rootstocks were selected for the example (Table 1).

A ruler was used to measure 9 blocks on the film to have a check on the tree space acres and grove acres. A difference in these two acreage estimates would indicate interplanting. The width of 4 rows in a bed were 75 ft. The 75 ft scaled to 0.6 cm. This was used to calculate the scaled bed length in ft. The rows width in ft x the length in ft x number of rows in the block/43,560 square ft per acre is the computed acres of the block (Table 3).

Results and Discussion

All the results were calculated from the data in the computer printout (Table 2 and 3). Of the 4 rootstocks that the 'Hamlin' oranges were on, Swingle citrumelo had the largest number of status 1, missing trees, 16.7%. This may reflect that the trees have been pushed, for only 0.8% were of status 5, stressed, dying, and dead trees. 'Hamlin'

Table 3. Acres computed from tree spacing and block size.

| Grove no. | Block no. | Frame no. | Variety | Rootstock | Spacing | No. trees in statuses | | | | | Total ² acres | Acres ³ computed |
|-----------|-----------|-----------|---------|-----------|---------|-----------------------|------|------|------|-----|--------------------------|-----------------------------|
| | | | | | | 1 | 2 | 3 | 4 | 5 | | |
| 710 | 4 | 1 | W. gft. | S.O. Mix | 20 x 25 | 58 | 113 | 977 | 205 | 40 | 16.0 | 15.9 |
| 716 | 37 | 37 | Ham. | S.O. | 15 x 25 | 39 | 1783 | 7 | 0 | 6 | 15.8 | 10.1 |
| 717S | 11 | 11 | Ham. | S.O. | 15 x 25 | 254 | 4067 | 2 | 0 | 1 | 37.2 | 36.9 |
| 717N | 12 | 12 | R. gft. | S.O. | 20 x 25 | 98 | 13 | 907 | 2765 | 18 | 43.6 | 30.0 |
| 718S | 13 | 13 | Val. | R.L. Mix | 15 x 25 | 246 | 178 | 541 | 223 | 4 | 10.3 | 6.0 |
| 720 | 17 | 17 | W. gft. | S.O. | 20 x 25 | 77 | 6 | 672 | 1836 | 8 | 29.8 | 27.5 |
| 727 | 47 | 47 | Pa. | Cit. Mix | 15 x 25 | 372 | 574 | 1633 | 133 | 193 | 25.0 | 25.0 |
| 730 | 722 | 72 | Val. | S.O. Mix | 15 x 25 | 1364 | 1691 | 2592 | 500 | 132 | 54.1 | 38.8 |
| 733 | 111 | 111 | Val. | S.O. | 15 x 25 | 192 | 78 | 150 | 3330 | 508 | 36.7 | 15.5 |

²Total acres = (sum of No. trees in each status) x spacing/43,560.

³Acres computed = width of rows in a bed in cm converted to ft x bed length in cm converted to ft x No. rows in the block/43,560.

oranges on either sour orange or *C. macrophylla* rootstocks did not have any status 5, dead or stressed trees. The percentage of producing trees was 96.6 and 96.8%, respectively. Two blocks of 'Hamlin' oranges on sour orange did not have any status 4, full size trees. These two blocks had 84.1 and 97.5% of status 2 trees 1 to 3-yr-old. One block of 'Valencia' on sour orange had 21.7% of status 1, missing trees, and 2.1% of status 5, stressed, dying, or dead with 76.1% productive trees.

The largest percent of status 1, missing trees was 47.1%, for Page tangerine on Cleopatra mandarin and 49.7% were productive trees. Percent productive trees can be misleading if other tree statuses are not examined. In the case of 'Hamlin' orange on sour orange, 97.5% of the trees were noted as productive, but status 2, trees 1 to 3-yr-old, represented 97.2% of the tree spaces and statuses 3 and 4 accounted for 0.05%.

Large numbers of statuses 3 and 4 along with about 10% of the tree spaces in statuses 2 and 5 gave a ratio of 9.2 (net planted acres to net potential acres). While percent productive trees gave 90%. About equal numbers of statuses 2, 3, and 4 to statuses 1 and 5 gave a ratio of 1, with a percent productive of 49.7%. A ratio of 13.2 had the greatest number of status 3 with a percent production of 93% (Table 2).

From the sum of status 1 trees, the number of nursery trees to be ordered can be determined. If a large percentage of status 5 trees is noted, these numbers could also be added to the nursery order for they will be on the list to be pushed. Also, status 5 can be used to estimate the cost of tree removal. In Table 3, there is a total of 916 status 5 trees to be pushed. In status 1, there is 2,700 tree spaces. To figure a nursery order for the same variety for the block, you would sum statuses 1 and 5. The block of white grapefruit on sour orange mix would call for a nursery order of 98 trees. The 2 blocks, 37 and 11, of 'Hamlin' orange on sour orange would call for an order of 300 trees. See Table 3 for other examples. A large percentage of status 2 trees indicates that the grove has been reset (see grove 717S, block 11 in Table 2). Yield may be estimated by the percentage of productive trees, statuses 2, 3, and 4. Scion rootstock performance could be studied from the percentage trees of each status. A large number of status 5 tree spaces on a given scion rootstock combination may indicate the wrong selection for that bed. If budwood source is included in the data base, tree loss may be corre-

lated to the source. Data on net planted acres may be useful for reassessment of taxes. These calculations do not include the roads, ditches, and non-planted areas.

Tree space acres may not be equal to the actual grove acreage in these results. Interplanting will give larger acreage values for the block as there was no way to include interplanted tree spaces in the data base at the time this work was done. This is seen in grove 733, block 111 in Table 3; total acres are 36.7 and computed acres are 15.5.

For those interested in this type of study, a new instrument by Kerns Instruments of Switzerland may be a more reliable way to count trees, tree health, and acreage than the method used here. This instrument can be programmed to measure the distance between trees in the row, thus allowing for the interplanting. With some research, the tree stress could be automatically determined. A ratio of the red and blue signal of the color video camera can be correlated with tree stress. The tree size could also be given relative values of small, medium, and large.

This project began in April 1987 and ended in the middle of Sept. 1987. Five decisions were made and entered for each of 1,632,029 tree spaces for a tree space acreage of 15,351.0 acres. Average tree spaces read per min was 44. The advantages of the information gained from the output of the data base are that managers can make judgments such as trees to be pushed, nursery orders, and percent production to estimate yield. Also, this is faster than mapping with a 4-wheel drive vehicle and you have a permanent photographic record of the grove as of the date of the flight.

The greatest drawback in this work was the turnover of photointerpreters, six. Also, the variability in the tree status count as shown by the same person photointerpreting the same block twice. There was the same total number of tree spaces but the total tree status numbers changed. For example, Status 1 changed from 1231 to 1183; 2 from 255 to 257; 3 from 2500 to 2245; 4 from 2132 to 2496; and 5 from 152 to 136. Tree status is a judgment call, your first call is usually the best. An expensive optical color comparator may reduce this problem or photointerpreters with a lot of grove experience.

An improvement to the utility of the data base computer program would be the printout of a grove map. The map could represent the tree status location on the map in different colors. A computer generated map would give the manager a map of the grove showing where the replants

are needed, trees to be pushed, and a base for comparison of future photointerpreted data. The colors, when in an area, may give a clue as to the type of problem in the block or grove.

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THE POST-FREEZE U.S. GRAPEFRUIT INDUSTRY FROM A FLORIDA AND TEXAS PERSPECTIVE

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Abstract. This paper examines significant trends and changes in the pre-freeze and post-freeze situations in both Florida and Texas. Factors considered include acreage, tree spacing, varieties planted and projected grapefruit production. Also included is a discussion of the Florida and Texas positions in the U.S. and world grapefruit markets as well as the current and anticipated competition facing Florida and Texas.

The 1983 freeze had varying degrees of impact on the Florida and Texas grapefruit industries. While Florida sustained significant grapefruit tree losses, Texas grapefruit was virtually wiped out. As Florida replants and expands production and as Texas rebuilds its industry, implications emerge for the structure of the Florida and Texas industries as well as the U.S. grapefruit market.

Market Trends

U.S. retail sales of grapefruit juice have been generally declining since the late 1970's (Table 1). Sales of grapefruit juice in retail grocery stores have fallen from a high of 105.7 million single strength equivalent (SSE) gallons in the 1977-78 season (Dec. to Nov. basis) to the 80 million SSE gallon level as projected for the 1986-87 and 1987-88 seasons. Much of this volume decline can be attributed to freeze-reduced crops in Florida and Texas and associated price increases. However, an examination of both the sales of grapefruit juice by product form and the components of consumer demand suggests a general lack of strength in the retail demand for grapefruit juice.

Retail grapefruit juice sales consist of three product forms: frozen concentrate (FCGJ), chilled (CGJ), and canned single strength (CSSGJ). Historically, CSSGJ has dominated the retail grapefruit juice market (Table 1). However, sales of CSSGJ have declined steadily from 68.3 million SSE gallons in 1977-78 to 36 million SSE gallons in 1985-86. Canned sales are projected to further decline to 29.8 million SSE gallons in the 1987-88 season.

FCGJ sales have moderated from 14.1 million SSE gallons in 1978-79 to a projected 11.1 million SSE gallons in 1987-88. The only bright spot in the retail grapefruit juice market is chilled grapefruit juice. CGJ sales have increased steadily from 21.4 million SSE gallons in 1976-77 to a projected 38.2 million SSE gallons in 1987-88.

In determining the underlying strength of the retail grapefruit juice market, several dimensions of demand need to be considered. The percent of U.S. households buying grapefruit juice in a given year indicates the consumer base which purchases the product. Comparing the percentage of U.S. households purchasing each of the three leading fruit juices indicates that fewer families buy

Table 1. U.S. retail grapefruit juice sales and prices.^z

| Season (Dec.-Nov.) | Retail sales | | | | Retail Price |
|-----------------------|--|---------|--------|-------|-----------------|
| | Frozen | Chilled | Canned | Total | |
| | ----- million SSE ^y gallons ----- | | | | \$/SSE gallon |
| 1976-77 | 10.9 | 21.4 | 64.1 | 96.4 | 2.04 |
| 1977-78 | 12.2 | 25.2 | 68.3 | 105.7 | 2.22 |
| 1978-79 | 14.1 | 29.0 | 61.2 | 104.3 | 2.50 |
| 1979-80 | 13.7 | 29.9 | 53.0 | 96.6 | 2.95 |
| 1980-81 | 14.0 | 29.8 | 47.7 | 91.5 | 3.27 |
| 1981-82 | 13.5 | 27.8 | 49.4 | 90.8 | 3.20 |
| 1982-83 | 13.9 | 28.3 | 47.4 | 89.6 | 3.06 |
| 1983-84 | 13.2 | 28.5 | 39.8 | 81.5 | 3.42 |
| 1984-85 | 14.0 | 34.2 | 42.4 | 90.6 | 3.75 |
| 1985-86 | 12.3 | 36.6 | 36.0 | 84.9 | 3.92 |
| 1986-87 ^x | 11.3 | 37.8 | 31.5 | 80.6 | 4.19 |
| 1987-88 ^x | 11.1 | 38.2 | 29.8 | 79.1 | 4.26 |

^zSource: A. C. Nielsen.

^ySSE represents single strength equivalent gallons.

^xEstimated by Economic and Market Research Department.