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A Geographic Data Base for Texas Pecan

Computer software and graphics were utilized to determine and present the abundance and distribution of native pecan in Texas.

Abstract: *A geographically referenced data base of the native pecan in portions of Texas was compiled from color infrared aerial photographs at a scale of 1:10,000. The Universal Transverse Mercator grid system was employed to reference the photographs to U.S. Geological Survey quadrangle maps. Four categories of pecan were employed in the classification: orchard, native, wild, and urban. Data extracted from the photographs on a one hectare cell size included pecan classification category, percent crown cover of all species of trees, and percent crown cover of pecan. Computer software and graphics were utilized to determine and present the abundance and distribution of native pecan in Texas.*

Introduction

There are between 600,000 and 800,000 acres in Texas which support native, orchard, or wild pecan (*Carya illinoensis* [Wangenh.] K. Koch) stands. Native stands are naturally occurring, characterized by high concentrations of pecan from which other hardwood species have been removed. Orchards are genetically improved stands of grafted trees planted in rows, and wild stands refer to pecan intermixed with other hardwood species.

Wild and native pecan stands grow predominantly in the alluvial soils adjacent to rivers and streams. This flood plain terrain provides an excellent site for the growing of orchard pecans as well.

Native stands of pecan account for 80 percent of the nut production in Texas, with genetically improved orchards accounting for the remaining 20 percent (Harris, 1974). The native stands were the hardest hit in 1973 by an infestation of the walnut caterpillar (*Datana integerrima* Grote and Robinson, Lepodoptera:Notodontidae). The subsequent defoliation spread over approximately 30,000 square miles in Texas (Harris and Van Cleave, 1974).

Due to the geographical extent of the defoliation, color infrared aerial photographs were taken of portions of the defoliated area (Harris *et al.*, 1976). The immediate objective was to assess the damage done by the walnut caterpillar and to provide a permanent photographic record for the later analysis.

As the study progressed, long range objectives were realized. Identification of pecan on aerial photographs and subsequent classification into three consistently recognizeable categories would assist in long range resource identification. A second long range objective that has led to continuation of this study is the ability to determine distribution, abundance, and condition of the pecan resource through time. This has required development of methodology to establish and rapidly store, retrieve, and analyze large amounts of data on pecan.

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METHODOLOGY

The study area (Figure 1) was the flood plain area along a 22-mile segment of the Guadalupe River between Sequin and Gonzales in south-central Texas. The area is typified by gently rolling terrain and flood plains ranging from 1/2 to 1-1/2 miles wide. These flood plains support the pecan habitat.

A geographically referenced data base was created from aerial photographs to supply retrievable information on the abundance, distribution, and enumeration of pecan. Data interpreted from large scale photographs were entered into a data base and were displayed in a more versatile format using computer graphics. Statistical analysis was performed on selected portions of the data set as well as on the entire data set.

THE GRID SYSTEM

The following criteria were used to select the grid system: (1) grid cell size must be uniform; (2) cell coordinates must be unique throughout the study area; and (3) assignment and computer retrieval of coordinate number must be easily accomplished. Three grid systems were considered: subdivisions of longitude-latitude, state plane coordinates, and the Universal Transverse Mercator (UTM) grid.

Subdivision of longitude and latitude results in cells of varying size, eliminating this system from consideration. Both state plane coordinates and UTM coordinates have the advantages of being rectangular coordinate systems (Davis, 1976). These coordinate systems consist of two sets of equally spaced parallel lines which are mutually perpendicular, intersecting to form a grid pattern of squares. Unlike the quadrangles of longitude and latitude, these grid lines have constant linear dimensions, and the grid cells are equal in area. Both can be superimposed on U.S. Geological Survey quadrangle maps with known mathematical relationships between the map projection and the projection of the coordinate system. Data referenced by one system can be referenced to the other system through computer software transformations.

The state plane coordinates were designed specifically for each state by the U.S. Coast and Geodetic Survey in order to limit scale error in map projections and to simplify surveying (Davis, 1976). If error is to be limited, however, the projection must be recentered frequently. This need for recentering is the primary reason this system was rejected for the project.

The UTM system was selected for this project because it offers several practical advantages. UTM zones are much broader in extent; therefore, they change less frequently. The coordinates are expressed in metric units which have computational advantages over English units. The UTM grid can be global in extent and is a convenient means of referencing data from satellites. This system is also particularly suitable for computer applications.

THE CELL SIZE

The hectare was selected as the grid cell size for this project for several reasons: (1) a one-hectare

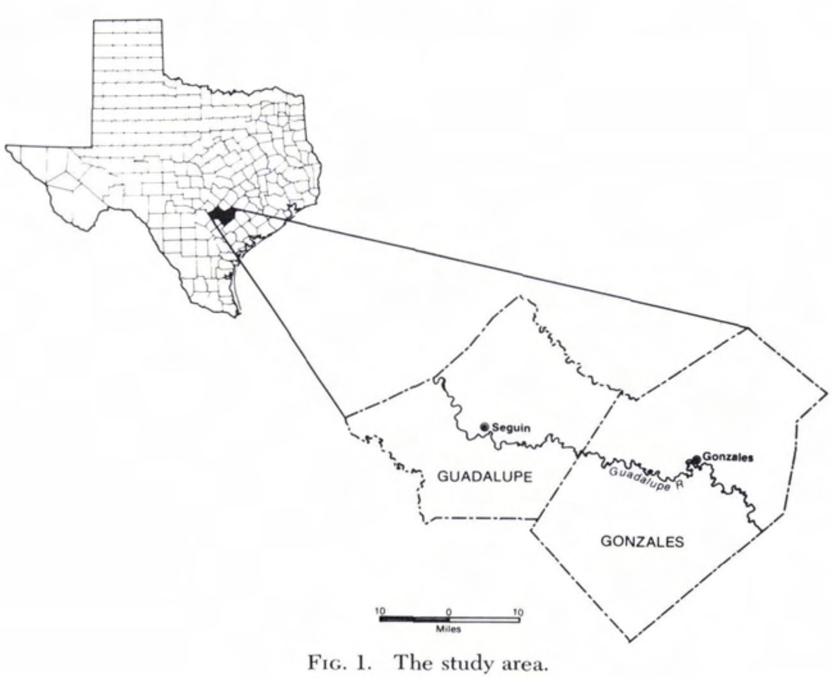

FIG. 1. The study area.

cell was large enough to permit identification, evaluation, and classification of individual tree species on aerial photographs of 1:10,000 scale and larger; (2) an adequate number of trees was found within a one-hectare cell without too many crowns being borderline between cells; (3) this cell size fit easily into the UTM system; and (4) this cell size could easily be aggregated into larger units. When the UTM grid lines on a 7-1/2 minute U.S. Geological Survey quadrangle sheet are connected, a network of one-kilometre square quadrangles is produced. This quadrangle can conveniently be subdivided into 100 square cells, each of which is one hectare (2.471 acres).

Subdivision of the kilometre quadrangle to produce hectare cells was accomplished using a 10 by 10 cell grid (Figure 2). The four-digit eastings are distances in thousands of metres east of UTM zone lines. Truncation of the three zeros and addition of one digit for the northing and one for the easting from the 10 by 10 cell grid will give each hectare a coordinate that is unique within the UTM zone in which it occurs. With the addition of the two digit zone number, it becomes unique throughout the world.

REGISTERING PHOTOGRAPHS TO THE GRID SYSTEM

A flow chart (Figure 3) shows the steps in the construction of the data base. The construction of the data base is logically divided into two basic parts: (1) that performed by the photointerpreter (steps 1 through 7) and (2) that portion done by machine processing (steps 8 through 14).

In order to locate each hectare according to its UTM northing (*Y* coordinate) and easting (*X* coordinate), the UTM grid was registered to the 1:10,000 scale photographs (Figure 4). On the 7-1/2 minute U.S. Geological Survey quadrangle sheet, the UTM tic marks appear in the margins of the maps. These numbered tics represent, in thousands, the distances measured in metres north from the equator and east from a zone line. The UTM lines are marked at intervals of 1 kilometre (1,000 metres). For this project, matching tic marks were connected from one side of the map to the other, thus forming a grid on the quadrangle maps.

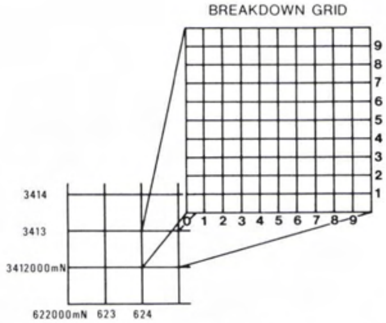

Fig. 2. Grid used to break down one-kilometre square quadrangles into 100 one-hectare cells.

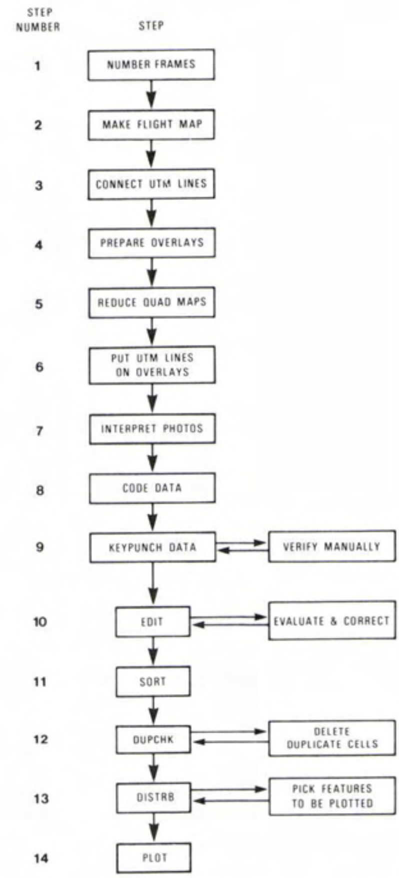

Fig. 3. Flow chart for data base development.

Transparent overlays were placed on each aerial photograph to transfer this grid from the quadrangle sheet to the photographs. The Guadalupe River was the central feature of each frame and therefore was of primary importance in locating the frames on the quadrangle maps. Other outstanding cultural features such as roads, gravel pits, and railroads were also marked on the overlays.

The scale of the quadrangle sheets was 1:24,000 and that of the photographs was 1:10,000. These scale differences were reconciled by using a Kail Reflecting Projector. The maps were optically reduced and superimposed under the transparent overlay. The UTM grid lines from the map were then drawn on the overlay, thus registering the UTM grid system to the aerial photographs.

The altitude of the airplane varied by several hundred feet during the photo mission, resulting in a variation of scale between successive photographs. This variation in scale from frame to frame resulted in varying image size of the square kilometre quadrangle. The dimensions for a

TABLE 1. CLASSIFICATION CODES FOR PECAN INVENTORY

Code	Class	Description
10	ORCHARD	Improved pecan trees planted in rows. Approximately 40 trees per acre.
11	ORCHARD/RIVER	An orchard that has the river running through the cell.
16	ORCHARD/BORDER	An orchard that is also the border cell of the frame on which it is found.
20	NATIVE	Pecan which have obvious canopy outlines and appear to have been cleared and thinned of competing trees and brush.
21	NATIVE/RIVER	Native pecan that has the river running through the cell.
26	NATIVE/BORDER	Native pecan that is also the border cell of the frame on which it is found.
30	WILD	Pecan intermixed with other trees—usually a rather continuous foliage canopy.
31	WILD/RIVER	Wild pecan that has the river running through the cell.
36	WILD/BORDER	Wild pecan that is also the border cell of the frame on which it is found.
01	RIVER	Cells that consist of the river only.
06	BORDER	Cells that have no data; they merely denote the corner of the photo, only where edge material is of no importance. These cells were used to plot the flight path of the photographic mission.

kilometre varied from 96.5 mm to 104.1 mm (3.8 inches to 4.1 inches) on the photographs. In order to subdivide each kilometre into 100 hectare cells that would be uniform in area from frame to frame, seven overlay grids of varying sizes (96.5 mm to 104.1 mm) were developed. The photointerpreter measured the scale on each photograph and then selected the proper kilometre grid to use.

INTERPRETING AND CLASSIFYING PECAN ON AERIAL PHOTOGRAPHS

Color infrared positive transparencies taken at midday in April 1974 at a photographic scale of 1:10,000 on a 9 by 9 inch format were utilized for this project. At this time of year in Texas, virtually all hardwoods except pecan had leafed out, thus making identification and crown cover estimates possible.

Recognition and classification of pecan was performed using crown size and shape, tonal characteristics, and height. The leafless pecan (see cover photo) tree crowns on the April photographs took on a three- to five-point, star-shaped appearance due to the prominence of large bare branches. Tonal hues varied from grey for bare branches to light pink for trees showing early bud break. Pecan in the study area generally ranged in height from 60 to 100 feet.

Field inspections of selected areas were made to confirm observations made from the photographs. Three tree species were occasionally misclassified as pecan. Other hickory (Carya Spp.), in the same genus as pecan, has similar leaf patterns, but smaller branch size and increased number of branches in the hickory aided in its distinction from pecan. Hackberry (Celtis occidentalis, L) has a translucent leaf and shows up on color infrared photographs as a lighter red or pink. For this reason it was occasionally confused with pecan and, once again, the increased number and reduced size of branches on the hackberry aided in the separation between pecan and hackberry. Mesquite (Prosopis juliflora, Schwartz) was the species most often mistaken for pecan. Due to the low density of its foliage, mesquite branches took on photographic tonal characteristics similar to those of pecan in early bud break. The mesquite was distinguished from pecan because it attains a maximum height of approximately 30 to 40 feet in this area compared to 60 to 100 feet for pecan, the crown sizes are generally smaller (20 to 25 feet) than pecan, and branch size is smaller.

INTERPRETING PECAN BY GRID CELL

The overlay with the UTM kilometre grid lines was placed over the photograph and the proper 10 by 10 cell grid was selected and placed over each kilometre quadrangle in turn. Interpretation of each cell was conducted in two phases.

In phase one, each hectare containing pecan crowns was interpreted and assigned an inventory code (Table 1). Assignment of the code was determined by (1) the species of the trees within the cell and (2) the position of the cell within the stand. Cells that contained both pecan and other species, but were found in an area which had been cleared of most of the competing species, were classified as "native." Conversely, cells of pure pecan that fell in an area of mixed species were recorded as "wild," due to the classification of adjacent cells. Those pecan trees arrayed in rows and columns were classed as "orchard."

Phase two consisted of analysis of crown cover. Using a dot grid (256 dots per square inch), percent crown was estimated for all trees and for pecan trees only.

DATA INPUT

Each quadrangle has a four digit X and a three digit Y coordinate taken from the quadrangle maps; the 10 by 10 cell grid was numbered from

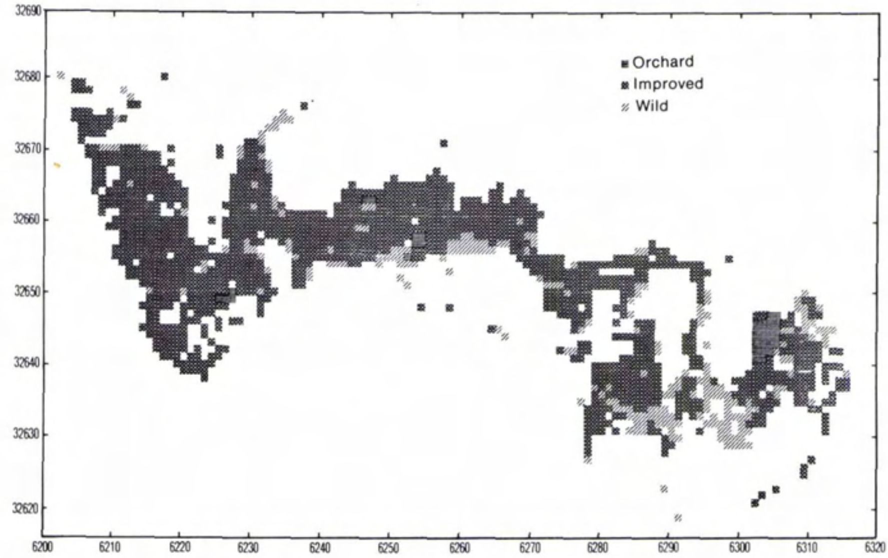

FIG. 4. Computer graphics presentation of the data base.

zero to nine on each axis to give an additional digit to each coordinate. Using this procedure, a unique nine digit coordinate was assigned to each hectare cell. In addition to the *X* and *Y* coordinates, other data for each cell included UTM zone number, pecan classification code, percent total tree crown cover, percent pecan crown cover, and film roll and frame number.

Each numbered square kilometre consisted of 100 hectare cells, each of which had a unique nine digit number. To expedite data recording, a tally sheet was prepared so that each of the 100 cells had a pre-numbered slot corresponding to its nine digit coordinate.

The photointerpreter completed a tally sheet on each square kilometre in which pecan was present, recording crown cover data for those hectare cells containing pecan trees. For each cell, the percent tree crown cover was recorded for all species and for pecan only. In addition to the cells containing pecan, one other type of cell was recorded. Cells that had the river flowing through them were classified and recorded to allow graphical presentation of distribution of pecan in reference to the river.

All data were keypunched into an Amdahl 470/V8 computer by means of a remote terminal. The software was written in FORTRAN Level H computer language and Statistical Analysis System (SAS).

Once the data were entered into the computer, they were edited for mistakes. This editing software checked for possible errors in keypunching. Errors in photointerpretation were not detectable. A list of cells that contained errors was produced and these errors were resolved by the operator, who then corrected the entry in the data base. The edited data were then sorted by the *Y* coordinate and were checked for duplicate cells. Cells which were duplicated due to overlap of photographic coverage were deleted by the operator.

The distribution and abundance of pecan was determined by a computer program which calculated the distribution of the data cells according to the variables in the data base.

PRODUCTS

The distribution and abundance of pecan was geographically presented for portions of the data base by supplying the northeast and southwest coordinates of the desired area. Computer graphics was used to present a portion of the pecan data base (Figure 4). This plot shows the geographic distribution of the three types of pecan: (1) orchard, (2) native, and (3) wild. Each square symbol represents one hectare in which pecan was present. The coordinates that form the border of the plot are the UTM coordinates of those hectares represented in the plot.

The plotting program is sufficiently versatile to allow output of a wide range of graphical presentations of the data. Plots of pecan crown cover classes, all tree species crown cover classes, and geographical distribution in relation to the river can be obtained with minor changes in the software.

Tabular presentations of the data include frequency bar charts arrayed by class (Figure 5) and percent crown closure arrayed by percentage group midpoints (Figure 6).

Utilizing the methodology described in this

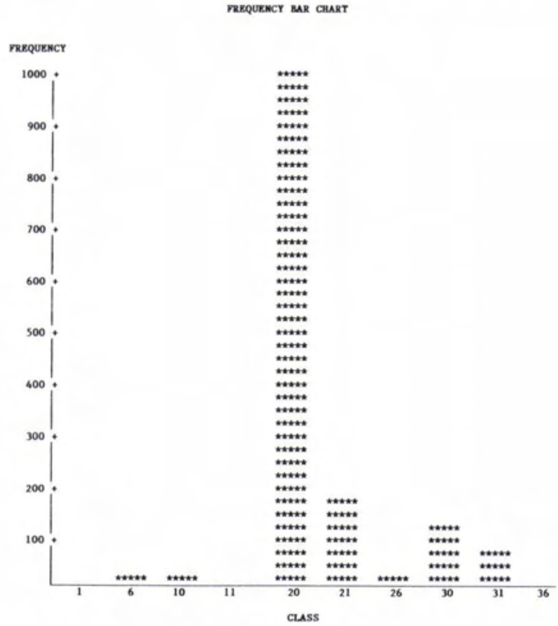

FIG. 5. Frequency bar chart of data arrayed by class.

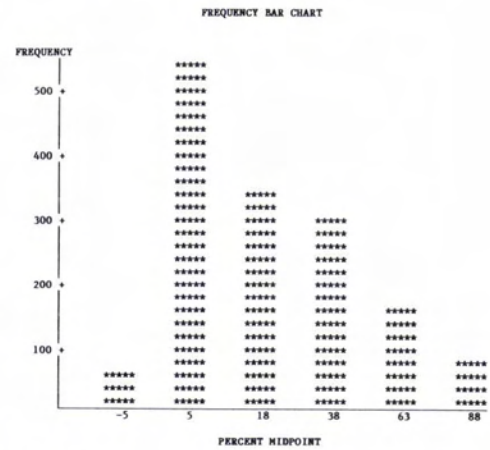

FIG. 6. Frequency bar chart of data arrayed by crown cover classes.

paper, 327 miles of the Brazos River system were entered into a geographically referenced data base which consisted of over 40,000 hectare cells. This information was photointerpreted and entered into the data base at a cost of 7.39 cents per hectare.

CONCLUSIONS

Native pecan is concentrated in the flood plains of water courses throughout Texas. Unlike more intensively managed natural resources, its natural distribution is closely related to these water courses. This flood plain distribution poses special management problems; without complete enumeration, only estimates of abundance and distribution of native pecan in Texas have been made. Creation of a geographically referenced data base allows enumeration of the distribution, abundance, and location of native pecan.

A data base generated utilizing this methodology would provide not only current location of this resource but also supply a land-related base from which sampling for detailed measurement of various attributes could be performed. Areas of wild pecan, as yet unmanaged, could be located and evaluated for their potential for nut production. The cost to remove competing species from the site, and the management effort needed to bring the new areas into nut production, could be calculated. A data base such as this would be invaluable should an infestation by a pest or pathogen occur. Monitoring the infestation level, spread, and geographic position would be made easier if the resource distribution and location were accurately known.

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