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WILDLIFE MANAGEMENT BY HABITAT UNITS -- A PRELIMINARY PLAN OF ACTION [1/]

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ABSTRACT

The Texas Parks and Wildlife Department recognizes the need for managing populations of wildlife species by defined area units. A data stratification scheme is required to investigate species populations for the purpose of identifying unit boundaries. Vegetation type maps are commonly used to stratify data collection points, and subsequently delineate boundaries of homogeneous populations.

Procedures for yielding vegetation type maps were developed using LANDSAT data and a computer assisted classification analysis (LARSYS) developed by Purdue University. Ground cover in Travis County, Texas was classified on two occasions using a modified version of the unsupervised approach to classification.

The first classification produced a total of 17 classes. Examination revealed that further grouping was justified. A second analysis produced 10 classes which were displayed on printouts which were later color-coded. The final classification was 82 percent accurate. While the classification map appeared to satisfactorily depict the existing vegetation, two classes were determined to contain significant error.

In the eastern portion of the county eastern red cedar (Juniperus virginiana) intermixed with post oak (Quercus stellata) was classified as an ashe juniper (Juniperus ashei)-live oak (Quercus virginiana) association. Also the class representing a composite of ashe juniper, live oak, mesquite (Prosopis glandulosa), and bluestem (Schizachyrium spp. and Bothriochloa spp.) of various physiognomic patterns as depicted on the classification map did not in some cases match species composition on the ground. A review of the procedures indicated that the major sources of error could have been eliminated by stratifying cluster sites more closely among previously mapped soil associations that are identified with particular plant associations. This could have served as a safeguard to prevent overlooking a vegetational class. Also, error could have been reduced by precisely defining class nomenclature using established criteria early in the analysis. A procedural plan has been developed which reflects modifications of the initial procedures developed in the Travis County study.

INTRODUCTION

Texas is experiencing rapid changes in land use. Domestic pasture grasses have been planted on many former croplands and woodlots. Ranch lands are being sold to developers and parceled out as "ranchettes", resorts, or suburban developments. Even-age silviculture with its attendant monotypic character is now practiced over much of the Pineywoods ecological region, and brush-clearing has greatly increased in the South Texas Plains. All of these changes have serious detrimental effects on wildlife. Natural habitats are shrinking drastically while the consumptive and nonconsumptive demand for wildlife increases. Thus, a vital need exists to inventory the remaining wildlife habitat.

The objective of this pilot study was to develop techniques for producing ground cover type maps compatible with current needs in wildlife management in Texas. Such an inventory is necessary for two different but related reasons. The first relates to game management. During 1974 the Wildlife Division of the Texas Parks and Wildlife Department implemented a series of programs based on species management concepts. These programs require an evaluation of wildlife species populations and their portrayal by management units.

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By stratifying measurements of animal population dynamics within plant associations, biologists can obtain a measure of the character and extent of homogeneous populations. Biologists may then begin to delineate species management units. Delineation of management units is essential for the determination of carrying capacity, range condition, harvest recommendations, and population trends .

The second reason for this inventory pertains to long-range planning. By knowing the identity, location and quality of the natural habitats and the impinging factors, managers may begin to propose rational alternatives to minimize losses of habitat brought on by industrialization, urbanization, water development projects, and other land uses.

The inadequacy of previous techniques for large-area mapping of ground features is reflected in the existing vegetation mapping literature for Texas. Winkler (1) presented an account of the activities of early botanists working in Texas. Most of the subsequent works were descriptive only in floristic terms, or were regional in application (2, 3, 4, 5, 6, 7 and 8). Tharp (9), Gould (10), and Kuchler (11) have published statewide presentations of vegetational areas of Texas; however, the contents are too gross for proposed wildlife management objectives.

The advent of remote sensing technology has opened new means of evaluating the environment for natural resource managers (12, 13). Initial applications of remote sensing products in the United States involved interpretation of high-altitude aerial photography or orbital imagery as exemplified by MacConnell and Garvin (14), Hay (15), and Cowardin and Myers (16). However, the versatility and objectivity of computer assisted analysis of digital data from spacecraft equipped with multispectral scanners is now being tapped for large-area land inventories (17, 18, 19). Computer technologists have developed operational or near-operational hardware and software to serve land resources analysts in this capacity (20, 21, 22). Current trends indicate a rapidly expanding field of remote sensing technology which has application to wildlife management, particularly in the area of habitat mapping.

STUDY AREA

Travis County, located in south central Texas, is considered to be one of the most topographically diverse counties in the state. The occurrence of the Balcones escarpment which runs through the center of the county creates two major geographical areas, each possessing significant topographical features. The western portion of the county is characterized by higher elevations, steeply sloping hills and ravines, abundant cliffs and limestone outcroppings, and generally shallow soils. This region represents part of the eastern edge of the Edwards Plateau. The eastern portion of the county exhibits generally flat or gently sloping terrain, with shallow to deep soils and is within the Blackland Prairie ecological region.

Such topographical differences permit the occurrence of numerous and diverse plant communities. The dominant woody plant species in the western portion include mesquite, ashe juniper, live oak and Texas oak (*Quercus texana*). Ranching is the predominant land use activity in the western portion of the county.

Eastern Travis County supports mesquite, eastern red cedar, live oak, post oak and bluestem grasses on the upland areas, with hackberry (*Celtis laevigata*), cedar elm (*Ulmus crassifolia*), and pecan (*Carya illinoensis*) occurring in lowland areas. Additionally, a large portion of the eastern half of the county is used extensively for agriculture. Cotton and grain sorghum serve as the main crops. The central portion of the county contains the city of Austin with its associated suburbs.

METHODS

A modified version of the unsupervised classification approach was employed to produce a classification map of Travis County. This was a test analysis to develop procedures for producing classification maps over the entire state. The unsupervised technique is an analysis approach developed by the Laboratory for Applications of Remote Sensing (LARS), Purdue University, West Lafayette, Indiana, for use with their computer-assisted analysis system (LARSYS-Laboratory for Applications of Remote Sensing System). Digital data obtained March 17, 1973, from LANDSAT were used for this classification.

The unsupervised approach consists of determining spectrally distinct classes within portions of a scene using a clustering algorithm (Appendix A) and later identifying these spectral classes as different types of ground cover. The efficiency of this procedure was increased by stratifying the location of the cluster sites according to the predetermined general distribution of ground cover classes.

Gray-scale printouts showing raw data for Travis County and vicinity were generated at every fifth pixel in each of the four channels of LANDSAT data. A pixel is the smallest resolvable element in multispectral scanner data. The printout for the near infrared channel was used as an orientation base since the bodies of water and major highways were best defined in this channel and could be outlined with map pencils.

These gray-scale printouts of every fifth pixel were similar in scale to the 1:126,000 scale general highway maps for counties in Texas. Consequently, more orientation features could be marked by overlaying the printout on a general highway map for Travis County.

Aerial photography of Travis County with an approximate scale of 1:63,000 was used to stratify the cluster sites. All portions of the photographs were visually examined to ascertain general topographical, and physiognomic characteristics. Stratification was accomplished by using these observations to determine the location of major plant associations, water bodies, and areas heavily influenced by man. A total of 13 sites was selected for use in the clustering process (fig. 1). A majority of these sites contained 2500 pixels. A maximum class notation (maximum but variable number of classes that the clustering function will depict) value of eight was designated on the control cards for each cluster site. Printed output included cluster maps for each site and separability information from the interclass divergences for each site. Punched output included training field description cards for each spectral class occurring within each site. A training field is a set of data that represents a class to be delineated. The separability information was used to group spectral classes and determine whether a larger maximum class value was needed. Classes having a quotient value of 0.75 or less were grouped together. If none of the quotient values were less than or equal to 0.75 for any given site, the clustering procedure was conducted again for that site with an increased maximum class value of 10.

Patterns of spectral classes appearing on each of the cluster maps were colored with map pencils to simplify recognition. These maps were taken into the field to each of their respective locations to identify the spectral patterns with actual ground cover. Names corresponding to the existing ground cover were given to each cluster site according to these observations.

The training field description cards of the 13 clustered sites were grouped under the categories of ground cover established from the field checks. Identical categories of ground cover occurring over all of the clustered sites were grouped together. Care was taken to establish definitive class categories by grouping all explicitly confirmed classes and not attempting to combine any classes appearing to overlap. For example, the category identified as live oak - bluestem savannah was grouped separately from the category ashe juniper - bluestem savannah.

The training field description cards, grouped according to classes of ground cover, were input into the statistics processor (Appendix A). The appearance of the histograms generated for each class in each of the four channels served as a measure of their statistical desirability in later training the classifier. Histograms exhibiting Gaussian distributions served as indicators of acceptable class groupings. Classes with unacceptable, multimodal histograms were manipulated through adjustment (combination or deletion) of the ordering of field description cards and additional statistical processing until acceptable histograms were obtained.

Final output from the statistics processor was used as input into the separability function (Appendix A) to determine whether further grouping or lumping of the classes was justified. Paired classes with transformed divergence values of 1,500 or less were grouped together. This was accomplished by combining the training field description cards for these paired classes into one group.

After the statistics processor was used to insure a Gaussian distribution of reflectance values within each class, the resulting statistics file was input into the classification and reporting processors (Appendix A). These processors produced a classification map on a computer-generated printout with cover types portrayed by alphanumeric symbols.

RESULTS

Two classification analyses were performed for Travis County. The first classification produced a total of 17 classes. Examination of these findings indicated that further modification in class groupings was justified to improve classification accuracy and facilitate interpretation of the final map. Modifications were made and a new statistics file was obtained. The second classification analysis produced 10 classes which were displayed on the printouts using revised alphanumeric symbols which were later color-coded. The statistical accuracy by class of the classification output was approximately 82 percent.

The final classification results of Travis County at the approximate scale of 1:24,000 were checked at actual field locations to determine credibility. While the classification map appeared to satisfactorily depict the existing vegetation, two classes were determined to contain an unacceptable degree of error.

In the eastern portion of the county eastern red cedar intermixed with post oak was classified as an ashe juniper - live oak association. This situation is exhibited in the classification map portrayed at every fifth pixel in Figure 2. Also, the class representing a composite of ashe juniper, live oak, mesquite and bluestem grasses did not, in some cases match species composition on the ground. These observations and a review of the test analysis procedures indicated that the major sources of error could have been eliminated by stratifying the cluster sites more closely among previously mapped soil associations that are identified with particular plant associations. This allows a safeguard to prevent overlooking a vegetational class. Error could also have been reduced by precisely defining class nomenclature using established criteria early in the analysis.

DISCUSSION

A procedural plan has been developed which reflects modifications of the initial procedures developed in the Travis County studies. This plan will guide the development of vegetation type maps required for biologists to proceed with delineation of species management units. The following is a narrative description detailing the procedures proposed for conducting a comprehensive vegetational type mapping inventory for the State of Texas. The inventory will be conducted utilizing remotely sensed data in digital form obtained from the LANDSAT-1 and processed through capabilities of computer-assisted analyses.

Our classification output will be multilevel in content. That is, natural areas will be classified more intensively than urban or agricultural districts. The final maps will portray detailed plant association patterns and generalized agricultural and urban patterns.

Based on wildlife management needs, we believe the plant association level (descriptive in floristic - physiognomic terms) will be most practical for application of the classification products. For the purposes of this vegetation mapping, the following proposed working definition is submitted:

> A plant association may be defined as two or more dominant plant species growing together, exhibiting a similar life form and generally characterizing the flora of the geographic area where they occur. Of course, at seral stages below climax the prevailing plant species which typify the association will not be the climax dominants. Nonetheless, these plants comprise the association type of the existing vegetation. A consociation is as above but only one plant species is dominant in the sere.

This definition was derived from Kuchler (23), Oosting (24), and Weaver and Clements (25).

Delineation and classification of ground cover will be accomplished by computer-assisted analysis. The analysis will involve stepwise processes that follow logically to a final classification of ground cover (fig. 3) .These results may be shown as alphanumeric symbols which are printed on paper or as colored patterns which can be visually displayed on an electronic screen (26).

The initial step in the computer-assisted analysis procedures will be to obtain basic information for the data to be investigated. Output from this function provides basic references on location of the frame, date and time of overflight, serious deviations in the scanner system, and other information of importance related to the bulk data.

Gray-scale printouts containing desired data will be obtained through display of every fifth pixel in each of the four channels of LANDSAT data. The gray-scale for band 6 seems most useful as an orientation tool and work map since roads and water are best defined in the raw data from this near infrared channel, however, other useful orientation information can be obtained by examination and comparison of the gray-scale printouts of data from the other three channels. The fifth pixel scale (approximately 1:125,000) closely approximates the county highway maps and facilitates transfer of orientation features from the highway map to the gray-scale printout.

Supportive information previously gathered from other vegetative studies, information provided by district biologists, examination of aerial photography, LANDSAT imagery, and topographic maps will be used to familiarize the analysts with the general floristic and physiognomic characteristics of the expected vegetation and determine locations of representative vegetational classes throughout the scene. This will be accomplished through district staff briefings and regional field tours. Previously documented maps containing information related to changes in land use, vegetation, soil types and range sites of Texas will be extensively examined to provide an overview about vegetational patterns that potentially exist in the area to be studied. Training received by the analysts in the staff briefings will be exercised in practical botanizing during the field trips. Also, during these tours land use and urban development will be observed. This will acquaint the analysts with the cultural features peculiar to the region.

With this supportive information assembled, the analyst should proceed with the next processing step, the clustering function. This step determines the number of classes represented within any area of the scene delineated. To amply represent all expected classes within a scene, a number of cluster areas should be chosen systematically. Careful scrutiny of aerial photographs at this point is necessary to more knowledgeably select areas containing classes of interest.

In addition to attempting to represent particular sets of classes the analyst should also exercise care in adequately orienting the placement of these cluster areas. Specific landmarks or orientation points should be contained in these areas to facilitate total orientation of the field party when ground truth information is collected for the purpose of naming respective cluster classes. Roads and cultural features will be traced onto the cluster maps from 1:24,000 topographic maps when possible. In most instances positive ground identification of the cluster classes cannot be accomplished unless the field party is oriented perfectly with respect to the cluster map. Careful study of aerial photographs of the candidate site will be made to insure that the area can be recognized in the ground truth step. With background information on the potential number, kinds, and locations of classes, the analyst can make better decisions related to the required number and strategic placement of the cluster areas. These decisions will determine whether the analyst encompasses all the classes of interest in the data.

Once a cluster area is located and processing for cluster classes begins the analyst is confronted with the question of how many classes of interest may be obtained from the particular data to be clustered. This number must be determined for use in entering maximum class (maximum but variable number of classes that the function will select) notations on the control cards. The generally accepted rule of twice the number of classes expected (for the cluster site) will be applied. Indication of the adequacy of any given maximum class value can be noted by examining the quotient values in the separability information listed in clustering output. At least one quotient value of 0.75 or less should be noted. If no values are less than 0.75, the maximum class designation should be elevated at least by one (perhaps two) and the clustering function run again for that site.

Clustering functions should be run for each of the designated areas and appropriate output obtained. Punched output should be obtained as in the unsupervised approach which allows the computer to select classes and training fields. Immediate evaluation of the output from clustering is undertaken at this point. Decisions based on the separability information (quotient values) from interclass divergences are made and class groupings should follow which conform to these decisions. Dr. Edward Kan of Lockheed Electronics Corporation, Lyndon B. Johnson Space Center, Houston, Texas, advises that Laboratory for Application of Remote Sensing, Purdue University, favors grouping classes with values less than 0.9 (Personal Communication 1975). Utilizing these higher values to govern the grouping rule at this point could reduce grouping problems arising from the separability function later in the classification analysis. On the basis of these groupings the various classes should be delineated through colored patterns displayed on the respective cluster maps.

Accurate ground truth information must be gathered at this point by a field investigator. Ground truth will be recorded on the Training Field Record (fig. 4). The colored cluster maps serve as vital references in gathering this information. Also, aerial photographs, topographic quadrangle maps, and county highway maps assist on-site determination of ground truth.

The magnitude and scope of a complete statewide vegetation study of this nature prohibits the use of time consuming quantitative measurements to devise vegetation class nomenclature. A technique which will satisfy project objectives within a minimum time frame will be used. This technique will involve fitting ground truth information obtained by field checks to previously established criteria for name designation. Such criteria will include a floristic-physiognomic description of currently existing plant associations. Dominant plant species (floristic components) within areas under study will be visually determined. Measurements of two physiognomic parameters, average height and amount of canopy cover (crown coverage projected vertically over the ground surface), will be obtained at the specified locations using an ocular method similar to the technique described by DeVos and Mosby (27). These ocular skills will be developed by initially measuring height and canopy cover objectively. Height will be measured by field applications of hypsometer techniques described in Forbes (28) and/or with a clinometer. Crown cover will be measured from aerial photographs by application of the crown density scale described by Avery (29) or by on-site woody belt transects modified from Hahn (30). After an initial experience with these measurement techniques the analysts are expected to acquire skills adequate to allow acceptable subjective ocular estimates of height and crown cover.

The initial physiognomic descriptions (Appendix B) will be similar to those stated in Haas and McGuire (31). However, due to later class grouping dictated by analysis functions discussed previously, final designation of class nomenclature will vary accordingly. Consequently, nomenclature for all types or subtypes of vegetation found in Reference 31 or all similar classes found in Levels II and III of the land use classification system devised by Anderson et al. (32) may not be represented.

Due to the boundary limitations of the clustering function, duplications and similarities occur in the cumulative class list as the analyst proceeds with cluster processing across the scene. Through evaluation of histograms, statistics, and separability values the analyst strives to combine the duplications, detect the degrees of similarity and catalog the separations. By these processes a list of classes of interest is gradually developed. Only by applying thresholding values (Appendix A) can the analyst gain indication that a class or classes may have been overlooked. However, wise application of supportive materials such as aerial photographs and potential class hierarchies can reduce the chances of missing a class of interest.

Additionally, classification accuracy would be increased in ecotonal areas or those having a wide diversity of ground cover and potentially containing a large number of classes, if such areas were subdivided into portions with each subdivision analyzed separately. Although more than one classification analysis would be needed, each process would be simplified due to representation of fewer classes within each subdivision.

The next major step in analysis involves evaluation of statistical information primarily in the form of class histograms and transformed interclass divergences. In any classes formed through grouping of two or more subclasses, the analysts should examine immediately the characteristics of the class histograms. Histograms should exhibit normalized distributions. The Gaussian distribution is a basic assumption built into the maximum likelihood classifier employed in the classification process (33). Training data must meet this qualification. Classes exhibiting strong bimodal or multimodal histograms should be re-evaluated and an effort made to correct this undesirable situation. At this point the transformed divergence values from separability function become the key indicators to further class groupings.

When final class groupings have been accomplished to the satisfaction of the analyst, a final statistics and separability run should be made. The statistics file that is developed will be utilized for the classification process. The separability run may not be particularly necessary at this step provided the analyst has been most perceptive and made no mistakes. Perhaps this run serves best as an "insurance" check on all decisions to this point and as an analysis landmark to lend credence to the performance ratings. The analyst should be able to proceed to the classification (Appendix A) function as the next step.

In the classification function a maximum likelihood classification scheme assigns all data points under consideration to one of the classes represented by the refined training class statistics (33). Thus, this processor will evaluate and classify all data points into the specified classes whether or not all classes in the scene are represented in the training statistics. Consequently, an overlooked or unrepresented class would be obscured through classification of its data points into the represented class that statistically most closely resembled the unrepresented class. However, detection of an overlooked class can be remedied through statistical thresholding options that may follow immediately after the classification function in the computer job string.

By classifying every pixel in the scene the analyst provides for later options related to varied scale. That is, if every pixel is classified then the scene can be portrayed on the basis of every pixel (approximately 1:24,000 scale), every second pixel (approximately 1:62,000 scale), etc. according to the desires of the analyst or user. This is in contrast to conducting the classification function on the basis of other than every pixel. Such action would result in forfeiture of the capability to portray the scene in more detail than the degree employed in the classification process. We have elected to classify on the basis of every pixel since expected as well as yet unrecognized uses for the classification results will require the versatility of this type output. Thus, the classification processor is essentially a straightforward function designed solely to produce sets of classified data points obtained through methodical comparison with refined training class statistics. No lengthy results, evaluations and decision-making steps are associated with this processor. The resulting classification will be stored on magnetic tape rendering these results available for practically unlimited temporal usage.

The reporting function, a follow-up processing stage to the classification function, provides various options for manipulation of classification results for the purposes of evaluation and application. The analyst may obtain printed maps, request performance tables, omit class symbols, detect overlooked classes, vary the scale (pixel designation) and/or select a portion of the classified scene. Additionally, this function yields insights into classification accuracies and provides total acreage figures for the various classes in any area of any size. A reporting job including performance options (accuracy evaluations) always follows the classification job.

The final results of the classification process will be checked for accuracy prior to the cartographic conversion. This will be accomplished by examining training field and training class performance values provided by the reporting function and verifying the final vegetational patterns indicated by the computer analysis. Suspected classification errors will be compared to the ground truth information derived from aerial photographs or on-site field inspections and corrected prior to final cartographic processing. Extensive classification errors may require reanalysis of the data.

Furthermore, we wish to mention the indirect capabilities this system will allow. We suspect that discrete spectral signatures cannot be developed for plant associations in all cases. However, we do believe the system is highly reliable in delineating broad classes such as forest, grass, etc. While detection of these broad classes is a limitation to the direct approach described above, this capability becomes an asset when linked to the descriptive material for soil associations. These soil associations already are described in published soil maps and legends. Thus, if only the physiognomic classes (e.g. woodlands) can be delineated through computer-assisted pattern recognition, refinements to provide the floristic components can be made by utilizing the information from soil mapping materials. In this manner, the desired plant association patterns can be determined.

The analysis for pattern recognition will be completed and subsequent tasks will deal with cartographic aspects. The computer printout "maps" alone are limited in application. Therefore, the results displayed on the printouts must be rendered into more practical map form. Techniques for producing desirable map products are being explored and tested for operational utility.

Generally, these cartographic approaches involve sophisticated electronically oriented procedures involving computer-controlled display screens that yield colored photographic prints of classified scenes. These methods are under experimentation by the Remote Sensing Center, Texas A&M University and Johnson Space Center, Houston, Texas. Output in the form of colored photographic mosaics from image display screens are expected.

The final products will be base maps in 1:126,000 scale with the ground cover classes in color codes. Illustrated narratives of legends will provide descriptive information for each of the classes portrayed. Also, the base maps will contain most of the information present in county highway maps presented in the same scale. This information would include such features as roads, urban areas, stream courses, etc. Inclusion of this information from the highway maps is essential to lending orientation attributes to the base maps.

CONCLUSIONS

With the rendition of the classification results into base maps biologists will use the vegetation type maps to begin the job of delineating species management units. The first task apparent to the wildlife manager is to determine the habitat of the animal species under investigation. The user of vegetation type maps must integrate existing information on animal habitat with contents of the base maps to obtain a generalized idea of the extent of the range of a particular wildlife species. Following this initial overview to discern the generalized extent of the range of the species, the manager is concerned with detecting characteristics of the population(s) of animals within the range.

At this point the manager begins to concentrate his attention on the detail within the boundaries of the general range of animals he initially outlined. By studying the computer-generated type maps he will be able to draw bounds around areas having similar characteristics. The landscape and composition of the vegetation of the area within each unit delineated by the manager can be regarded as unique. When the manager has reconstituted the base maps on the basis of the ground cover classification, he has devised preliminary "habitat maps" similar to the specifications of Alexander (34). These maps then will become the guides for stratification in the ensuing population analyses.

Stratified data collection will allow the application of statistical tests to the parameters from the respective strata. These tests will enable biologists to identify differences or similarities in various wildlife populations. According to evaluations of the statistical test results biologists will be able to delineate geographic areas inhabited by similar populations of a given wildlife species. These areas will be termed management units. The wildlife resources within each unit will be administered according to appropriate management treatments deemed necessary to produce sustained yields of wildlife resources.

Furthermore, these units, in themselves, will become stratification guides for intensive studies designed to provide data input for population modeling. Wildlife managers then will be able to examine management alternatives with respect to any given set of circumstances influencing any given population of animals.

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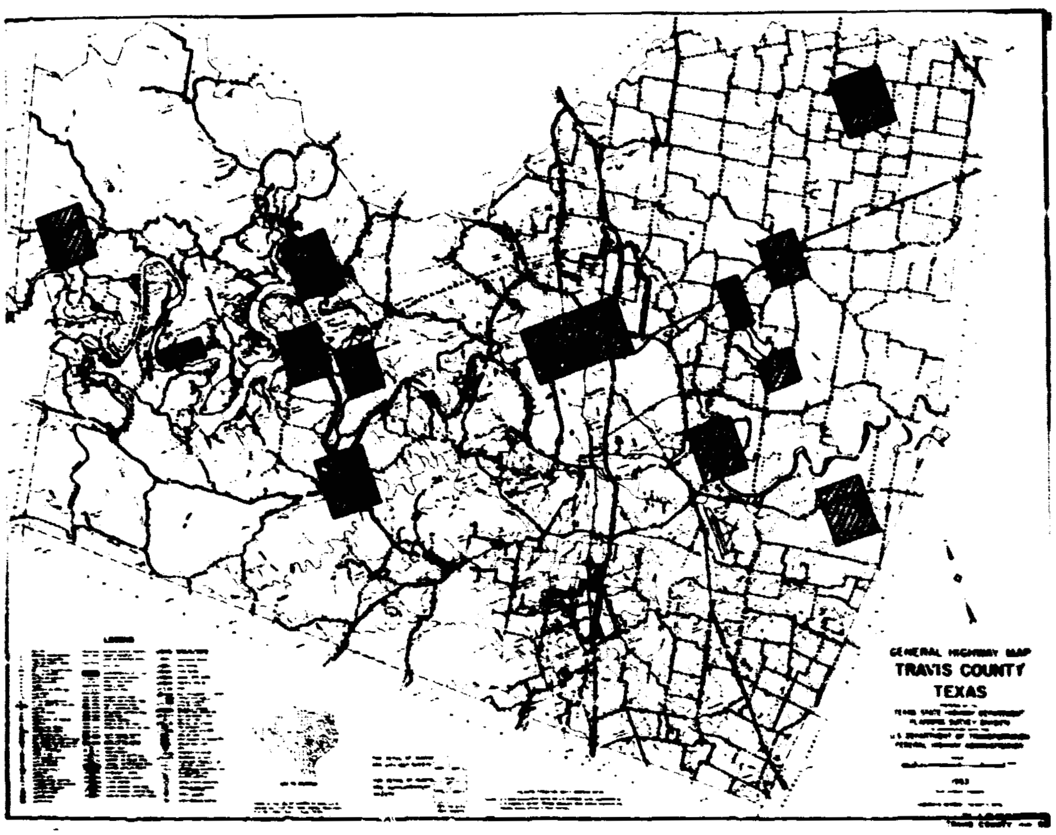

Figure 1. Distribution of cluster sites in Travis County, Texas

LEGEND

- Cedar (ashe juniper) Woodland
- Cedar-Liveoak Woodland
- Cedar-Liveoak-Mesquite/Bluestem composite (indicates a mosaic pattern of highly interspersed, but individually distinct plant associations composed of these dominants)
- Native Grassland
- Tame Grassland (agriculturally induced; bermuda, etc.)
- Agriculture (plowed or disced cropland and fields, grazed cover crops)
- Elm-Hackberry-Mesquite Mixed Woodland
- Urban, residentially built up areas, roads
- Urban, commercially built up areas
- Water

Figure 2. Classification map of eastern Travis County, portrayed at every fifth pixel

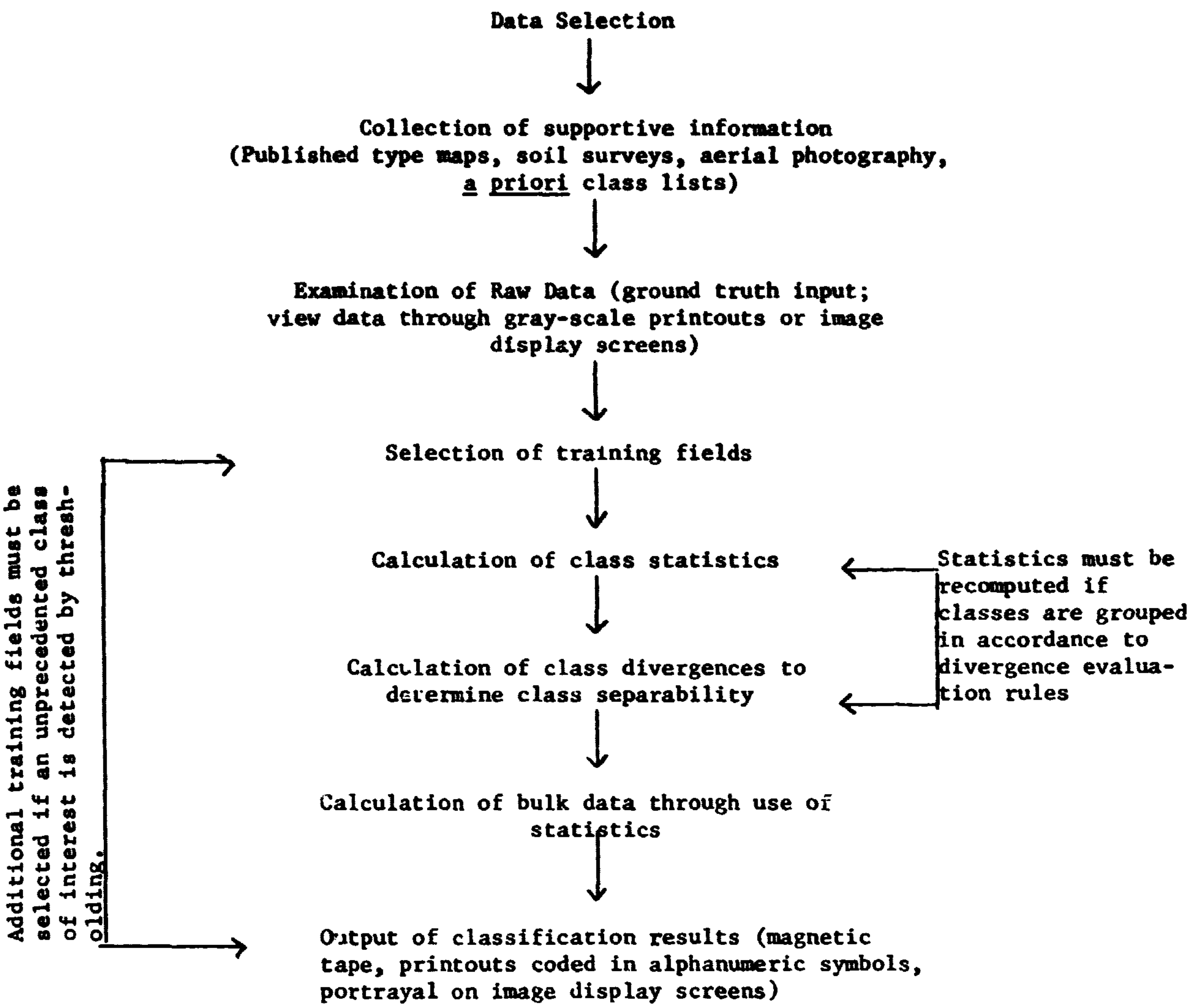

Figure 3. Flow Diagram of Procedures for Computer-assisted Analyses

Frame No.: ____________________

Cluster No.: ____________________

Date: ____________________

County: ____________________

General Topography of Cluster Site ____________________

____

Supplemental Information: ____________________

____

Designation of Classes on Cluster Map

Cluster Symbols:	1	2	3	4	5	6	7	8
Physiognomic ID.:								
Floristic Dominants:								

Figure 4. Training Field Record

APPENDIX A

LARSYS ANALYSIS PROCESSORS

From Phillips, T. L., ed. 1973. LARSYS Version 3 User's Manual, Volume 2. Purdue Research Foundation, West Lafayette, Indiana

IDPRINT	Prints listing of the identification record for multispectral image storage tape runs; gives information on date data acquired, observation identification number, orbit number, cloud cover, and time of day of overflight.
PICTUREPRINT	Produces alphanumeric pictorial printouts of the data for each channel that is specified; used to check data quality and select subsets of data to be used; alphanumeric symbols are shown in gray scale tones.
CLUSTER	Classifies individual data points into a predefined number of clusters: user must estimate the number of clusters (or classes) to be produced; guides analyst to features to be identified for use in developing training statistics.
STATISTICS	Calculates statistics of subsets of data values (mean, standard deviation, a covariance matrix, and a correlation matrix) for the channels specified; resulting statistics file contains statistical descriptions of the specified training classes.
SEPARABILITY	Uses class statistics to calculate measurements of how well the individual classes may be distinguished from one another, or the degree of "separability" between the classes.
CLASSIFYPOINTS	Classifies multispectral data on a point-by-point basis; uses class means and covariance matrices (computed in STATISTICS) and the data from each point to be classified to calculate the probability that the point belongs to each of the training classes; stores output on disc file or magnetic tape.
PRINTRESULTS	Provides variety of printed outputs describing the classification results produced by CLASSIFYPOINTS; provides researcher with a flexible capacity to display the results of a classification in the form of a map image and/or tabular outputs.

APPENDIX B

PHYSIOGNOMIC CLASSES

<u>Cropland</u> — Includes cultivated, fallow or human altered locations used for the purpose of producing food and/or fiber for either man or domestic animals.

<u>Grasses</u> — Herbs (grasses, forbs, and grasslike plants) <u>dominant</u>; woody vegetation lacking or nearly so ($\leq$5 percent woody canopy coverage).

<u>Savannah</u> — Individual woody plants $>$9 ft. tall widely scattered throughout grass (6-10 percent woody plant canopy coverage).

<u>Groves</u> — Clusters, or groves of woody plants widely scattered throughout grass (6-10 percent woody canopy cover).

<u>Parks</u> — Woody plants $\geq$9 ft. tall generally dominant (11-30 percent canopy cover) with continuous grass or forbs.

<u>Brush</u> — Woody plants $<$ 9 ft. tall dominant, occurring in generally evenly spaced stands ($>$10 percent canopy cover).

<u>Woods</u> — Woody plants 9-30 ft. tall growing evenly spaced or nearly so ($>$30 percent canopy cover); midstory usually lacking.

<u>Forest</u>

- Mature — Deciduous or evergreen trees dominant; mostly $>$30 ft. tall, ($>$30 percent canopy cover); midstory apparent except in managed monoculture.
- Young — Deciduous or evergreen trees $\leq$30 feet tall ($>$ 30 percent canopy cover); midstory usually absent; potential to form mature forests.

<u>Marsh</u> — Emergent herbaceous plants dominant in inundated areas; woody vegetation lacking or nearly so ($\leq$ 15 percent woody canopy coverage).

<u>Brush Swamp</u> — Woody plants $<$ 9 ft. tall ($>$15 percent canopy coverage occurring on inundated or almost constantly inundated sites).

<u>Parkland Swamp</u> — Woody plants $>$30 ft. tall generally dominant (15-30 percent total woody canopy cover) occurring on inundated or almost constantly inundated sites.

<u>Wooded Swamp</u> — Woody plants mostly 9-30 ft. tall occurring on inundated or almost constantly inundated sites ($>$15 percent canopy coverage).

<u>Forested Swamp</u>

- Mature — Trees mostly $>$ 30 ft. tall occurring on inundated or almost constantly inundated sites ($>$30 percent canopy coverage).
- Young — Trees mostly $\leq$30 ft. tall occurring on inundated or almost constantly inundated sites ($>$ 30 percent canopy coverage); potential to form "mature forested swamp."

<u>Water</u> — Streams, lakes, ponds, estuaries, lagoons, flooded oxbows and water treatment facilities.

Inert Materials

Spoil	Bare soil deposited from dredging operations in marsh, swamp, estuaries, lagoons, or streams.
Dunes	Unvegetated sand mounds or hills.
Urban	Includes roads, industrial and suburban developments.

Other Vegetated areas which portray physiognomy difficult to define or categorize and which could produce significant classification error if labeled separately; includes those groups that do not appear to fit above criteria.