062978

FOREST RESOURCE INFORMATION SYSTEM

Quarterly Report

for the period

1 April 1978 to 30 June 1978

Prepared for

NATIONAL AERONAUTICS and SPACE ADMINISTRATION

Johnson Space Center
Earth Observations Division
Houston, Texas 77058

Contract: NAS9-15325
Technical Monitor: R. E. Joosten/SF5

Submitted by:

The Laboratory for Applications of Remote Sensing
Purdue University
West Lafayette, Indiana 47906

Principal Investigator: R.P. Mroczynski

E7.9-10010.
CR151832

(E79-10010) FOREST RESOURCE INFORMATION SYSTEM Quarterly Report, 1 Apr. - 30 Jun. 1978 (Purdue Univ.) 43 p HC A03/MF A01
CSCL 02F
G3/43
N79-12526
Unclas
00010

FOREST RESOURCE INFORMATION SYSTEM

Quarterly Report

for the period

1 April 1978 to 30 June 1978

Prepared for

NATIONAL AERONAUTICS and SPACE ADMINISTRATION

Johnson Space Center
Earth Observations Division
Houston, Texas 77058

Contract NAS9-15325
Technical Monitor: R. E. Joosten/SF5

Submitted by:

The Laboratory for Applications of Remote Sensing
Purdue University
West Lafayette, Indiana 47906

Principal Investigator: R.P. Mroczynski

MAP INFORMATION FORM

1 Report No

2 Government Accession No

3 Recipient's Catalog No

4 Title and Subtitle
Forest Resource Information Quarterly Report
Third Quarter

5 Report Date
30 June 1978

6 Performing Organization Code

7 Author(s)
R. P. Mroczynski, and FRIS Project Staff

8 Performing Organization Report No

9 Performing Organization Name and Address
Laboratory for Application of Remote Sensing
Purdue University
West Lafayette, Indiana 47906

10 Work Unit No

11 Contract or Grant No
NAS9-15325

12 Sponsoring Agency Name and Address
R. E. Joosten/SF5
NASA/Johnson Space Center
Houston, TX

13 Type of Report and Period Covered
Quarterly
1 April 1978 to 30 June 1978

14 Sponsoring Agency Code

15 Supplementary Notes

16 Abstract

This report documents activities of the Forest Resource Information System (FRIS) ASVT project staff for the period 1 April 1978 to 30 June 1978. Results of a preliminary classification study for winter, spring, and bi-temporal Landsat data are reported. Map digitizing of ancillary information necessary to make an operational FRIS was nearly completed during this quarter. A small test map was sent to a vendor who will digitize it with a laser following device. These results will be compared to LARS digitizing results for both accuracy and efficiency. The resources necessary to complete the prime site digitizing are defined and a study of classifier efficiency is also presented.

The initial plans for a remote terminal installation at Jacksonville, connected to LARS are also outlined.

Original photography may be purchased from·
EROS Data Center

Sioux Falls, SD 57198

17 Key Words (Suggested by Author(s))

Forest Inventory
Data Base
Information Needs
Computer Hardware
Remote Terminal Design
Cost Studies
Classification Procedures
Digitizing
Command Menu

18 Distribution Statement

19 Security Classif (of this report)

20 Security Classif (of this page)

21 No of Pages

22 Price*

*For sale by the National Technical Information Service Springfield Virginia 22161

Index

FRIS PROJECT SUMMARY

The Forest Resource Information System Project (FRIS) is a cooperative effort between the National Aeronautics and Space Administration (NASA) and St. Regis Paper Co.(STR). Purdue University's Laboratory for Applications of Remote Sensing (LARS), under contract to NASA, will supply technical support to the project.

FRIS is an Application System Verification and Transfer (ASVT) Project funded by NASA. The project is interdisciplinary in nature involving experties from both the public and private sectors. FRIS also represents the first ASVT to involve a large broad base forest industry (STR) in a cooperative with the government and the academic communities.

Purpose

The goal of FRIS is to demonstrate the feasibility of using computer-aided analysis of Landsat Multispectral Scanner Data to broaden and improve the existing STR Forest data base. The successful demonstration of this technology during the first half of the project will lead to the establishment by STR of an independently controled operational forest resource information system in which Landsat data is expected to make a significant contribution. FRIS can be viewed by the user community as a model of NASA's involvement in practical application and effective use of space technology.

Additionally, FRIS will serve to demonstrate the capability of Landsat MSS data and machine-assisted analysis technology to private industry by:

- Determining economic potentials,
- Providing visibility and documentation, and
- The ability to provide timely information and thus serve management needs,

The ultimate long term successfullness of FRIS be measured through future development of remote sensing technology within the forest products industry.

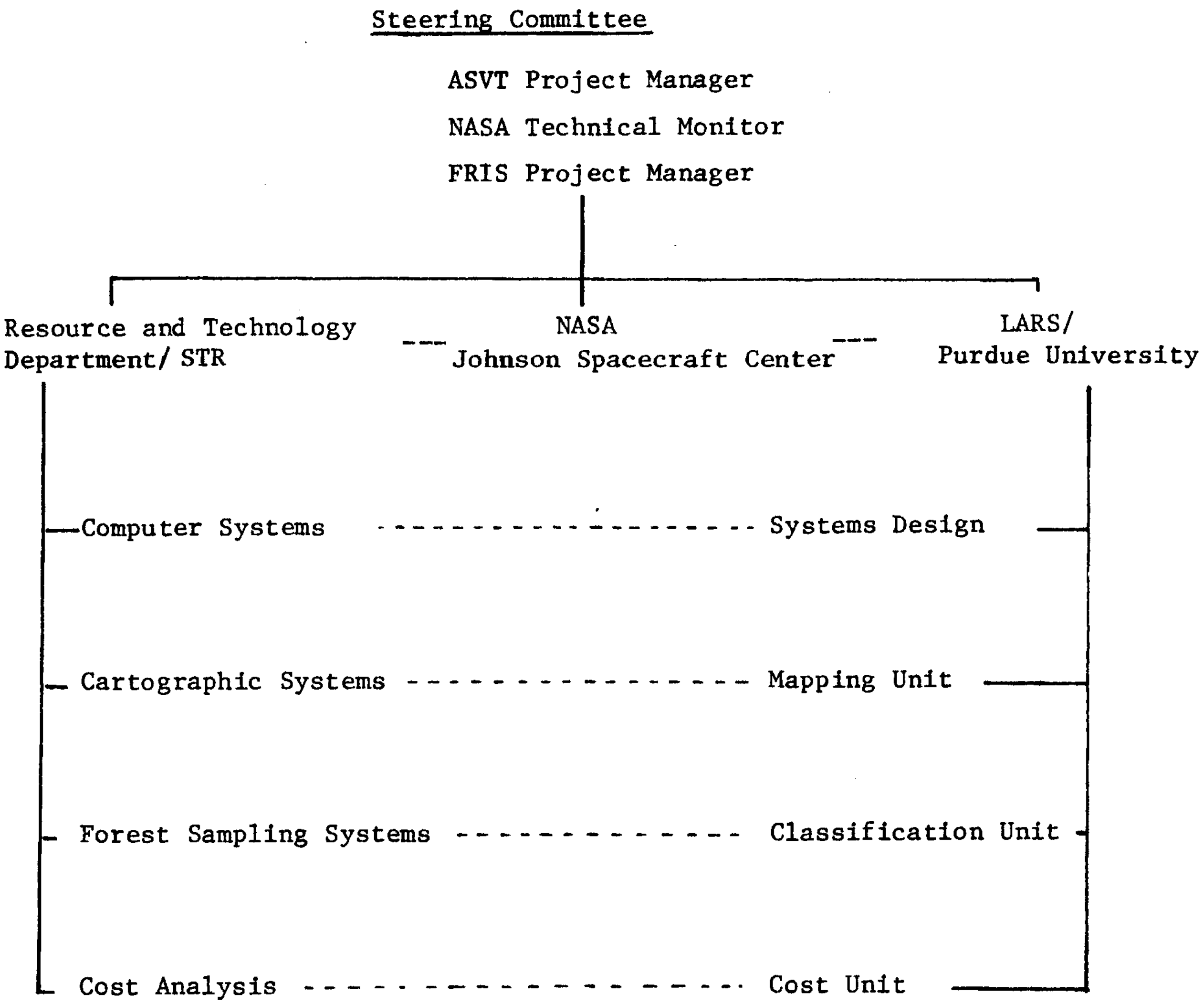
Scope

FRIS is funded as a modular or phasedproject with an anticipated duration of three years. The original project concepts were developed in 1973, and a formal project plan was submitted to NASA by STR in 1976. The project offically began in October 1977 after the signing of a cooperative agreement between NASA and STR; and after the completion of contractual arrangements with Purdue University.

Organization

The organization of FRIS is depicted in the chart that follows. Since FRIS is a cooperative involving three independent agencies, a steering committee consisting of a project manager from each institution was formed to provide for overall guidance and coordination. Operationally, both STR and LARS have project managers and project staff to insure for the timely completion of activities within the project. The NASA technical coordinator monitors project activities and provides a liasion between the STR and LARS staffs. The solid lines on the chart indicate the flow of management responsibility. The dash lines reflect the technical and scientific interchanges between operating units.

FRIS Organization



1.0 Introduction

The materials presented in this report document FRIS project staff activities for the third project quarter. The third quarter encompasses the calendar period beginning 1 April 1978 and ending 30 June 1978, and marks the end of the second three months of the demonstration Phase of the Forest Resource Information System (FRIS) ASVT. The working objective for this Phase of the Project remains:

> To provide St. Regis Paper Company (STR), through a demonstration of computer-aided Landsat analysis, information concerning the economic feasibility and practical applicability of remote sensing technology for forest inventory.

Activities during this Phase occured under one of five Working Units. They are:

1. Classification and Evaluation
2. Mapping and Digitizing
3. System Design
4. Cost Evaluations
5. Management

all Working Units expended significant levels of effort toward achieving their predefined timeline goals and thereby accomplishing the Phase objective. Noteworthy among the activities during this quarter were the following:

- The first FRIS project review was held at Purdue/LARS on April 14.

- Winter, Spring and a multi-temporal combination of Landsat data were classified and evaluated for a pilot study block of one test area. These results provide a dramatic demonstration of a level I classification capability.
- A benchmark classification ev aluation draft was completed and prepared for internal project review.
- A study of outside digitizing was completed.
- Modification that are expected to improved the operational digitizing capability of FRIS were undertaken.
- Work to define the FRIS system software requirements began, as did work toward defining an operational remote terminal facility at Jacksonville.
- The technology transfer task continued and included formalized training for three STR staff in the LARS advanced topics in remote sensing workshop in April. Also hands-on training for three STR staff occured at various times during the quarter.

A detailed discussion of these activities will appear in the sections that follow.

2.0 Working Unit Activities

The following sections contain discussions of activities conducted by each FRIS Working Unit during this quarter.

2.1 Classification Unit

The prime objective for this activity is to provide the demonstration of computer-aided Landsat analysis techniques. To accomplish this goal four Test Areas of the 1.7 million acres of St. Regis controlled lands in the southeast have been identified. Each area will be classified using predefined FRIS classification procedures. Replication of classification performance will allow the project staff to assess the feasibility of applying computer-aided Landsat analysis to meet St. Regis requirements.

Therefore, it is imperative that identical classification procedures be followed for each Test Area. The first task of the classification Unit was to outline these procedures. The documented procedures will help to insure repeatible classification results and also form the foundation for an operational FRIS classification manual.

As an aid to developing classification procedures a small test site, consisting of four Administrative Units (AU's) within Test Area 1, figure 1, was used for classification work.

Since St Regis normally works with 1:15840 scale maps and air photos, the decision was made to enlarge the Landsat data accordingly. In addition, the four AU boundaries had been digitized so that data runs consisting of the Winter 1976 and Spring 1977 Landsat data plus the boundary channels were created. Both the Cubic Convolution and Nearest Neighbor Data Expansion techniques were used to create these data runs. With this data run we were able to:

1. begin documenting a classification approach,
2. determine if there was any difference between the data expansion techniques, and
3. assess classification performance for single data versus bitemporal classifications.

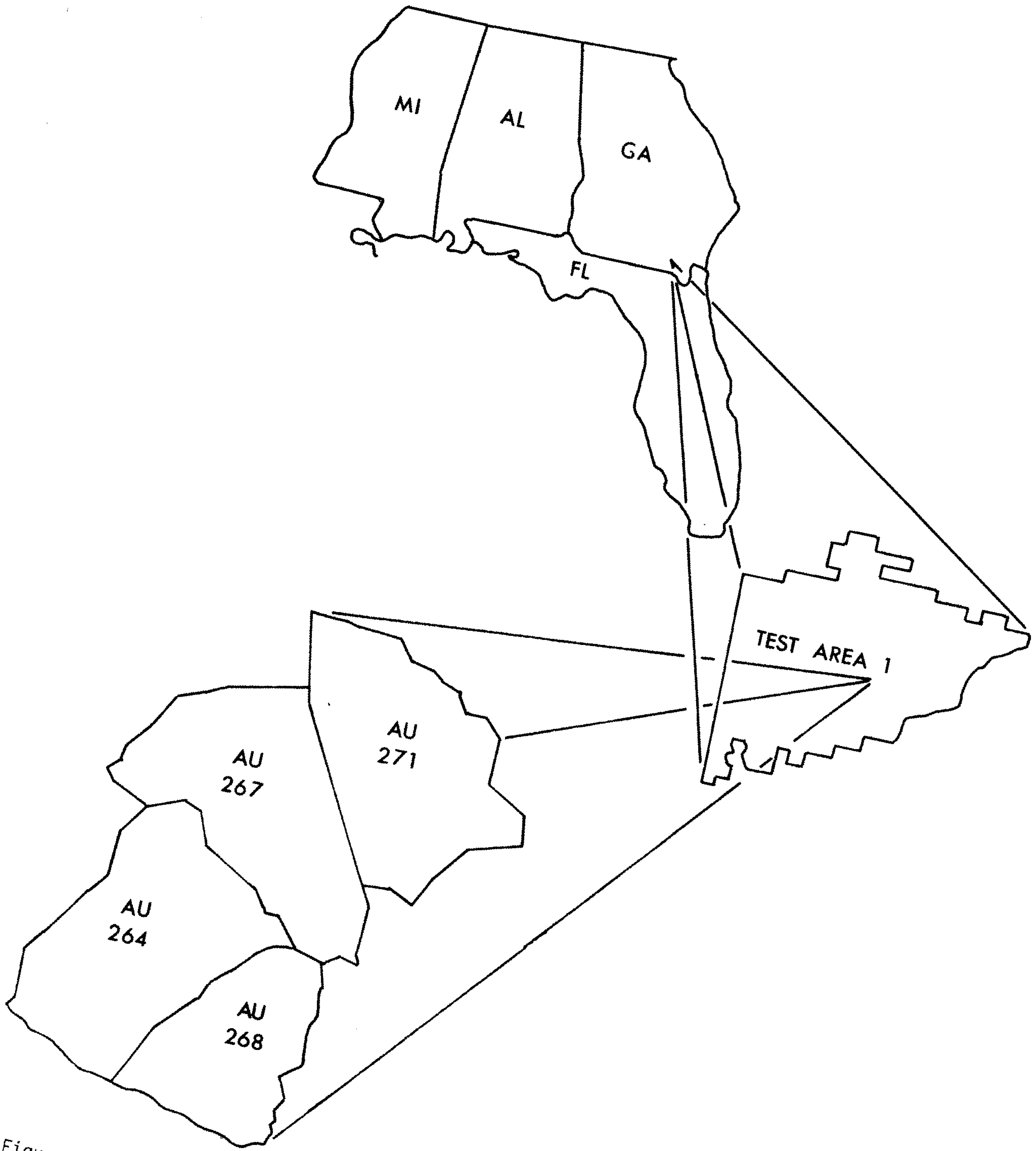


Figure 1. Four AU test sites located within Test Area 1 in Southeast Georgia.

The first task was to outline the classification procedure. The first iteration of the procedure appears as a flow diagram in figure 2. This procedure was defined jointly by LARS and STR staffs. Modification and improvement of this approach is expected throughout this Demonstration Phase. Ultimately, an operational form of this outline will become the FRIS classification document.

Having defined the approach, we set out to determine if there was any difference in classification performance between the Cubic Convolution and Nearest Neighbor Data Expansion techniques. Table I shows a level I[*] comparison between the two techniques compared to STR inventory information for the four AU test sites. From these results, especially for the pine class, it is apparent that the two methods are not substantially different, nor do they vary measurably from the STR inventory. However, there is a considerable cost difference (approximately three fold) between the Cubic Convolution and Nearest Neighbor

Table I. Comparison of Cubic Convolution and Nearest Neighbor Data Expansion for a 4-channel Bitemporal classification.

	Percent of Area by Class ( )		
Cover Type	Cubic Convolution	Nearest Neighbor	St. Regis Inventory
Pine	(55.4)	(56.8)	(56.8)
Mixed P/H	(39.0)	(37.3)	(40.1)
Non-stock	(5.6)	(5.9)	(3.1)

---

[*] The term Level I will be used throughout to indicate a separation of Pine, Mixed wood (including slash/cypress and hardwood classes) and non-stocked classes.

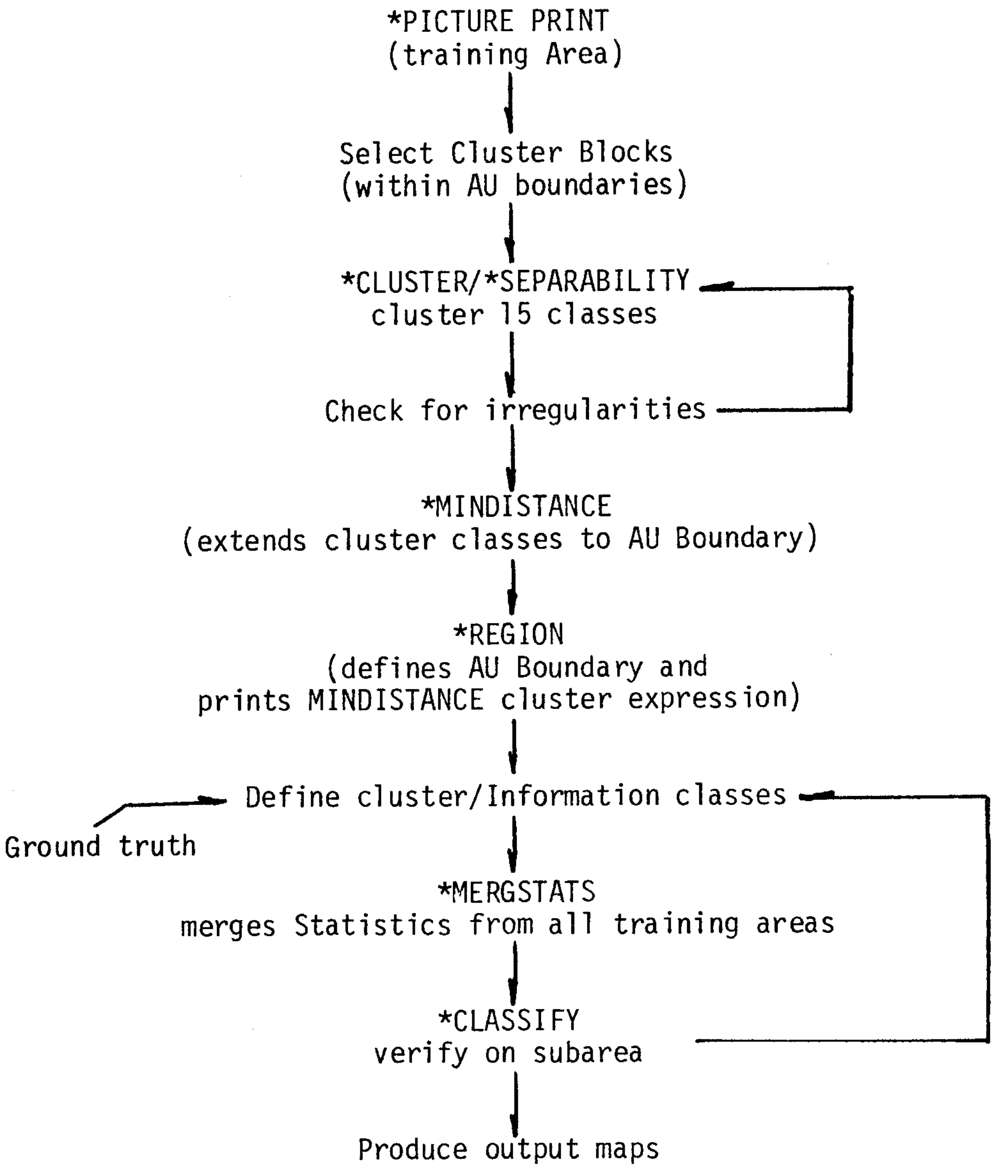


Figure 2. Flow diagram for FRIS classification procedures.

data expansions. For this reason the Nearest Neighbor data expansion method was selected for all FRIS Test Areas.

Having made this determination, our next task was to assess the relative merit of single versus bi-temporal classifications.

Winter and Spring data (1976 and 1977 respectively) were available for Test Area 1, figure 3. Using these data and the previously discussed approach, the three data date combinations were classified. Two analysts conducted the classifications. One used the Winter and bi-temporal data sets, the other the Spring data set. No fewer than four channels of data were used for the single date data sets. The best four channels (defined by the separability processor of LARSYS) were used for the bi-temporal classification.

Level I results for these classifications are presented as percentages of area classified in Tables 2, 3, and 4. These results indicate that no substantial differences exist in the pine classes between the classification results based on an areal comparison of STR inventory information for the four AU's.

Table 2. Percent of area by class for Winter Data Classification Results for AU's 264, 267, 268, and 271. (STR Inventory comparison shown in parentheses)

Cover Type	Administrative Unit				
	264	267	268	271	Total
Pine	56.3 (59.5)	52.2 (53.3)	52.4 (46.1)	60.2 (65.1)	55.5 (56.9)
Mixed P/H	39.7 (38.0)	46.9 (43.2)	45.6 (49.4)	36.5 (32.6)	41.9 (40.1)
Non-stock	4.0 (2.5)	1.0 (3.5)	2.1 (4.5)	3.4 (22.4)	2.6 (3.1)

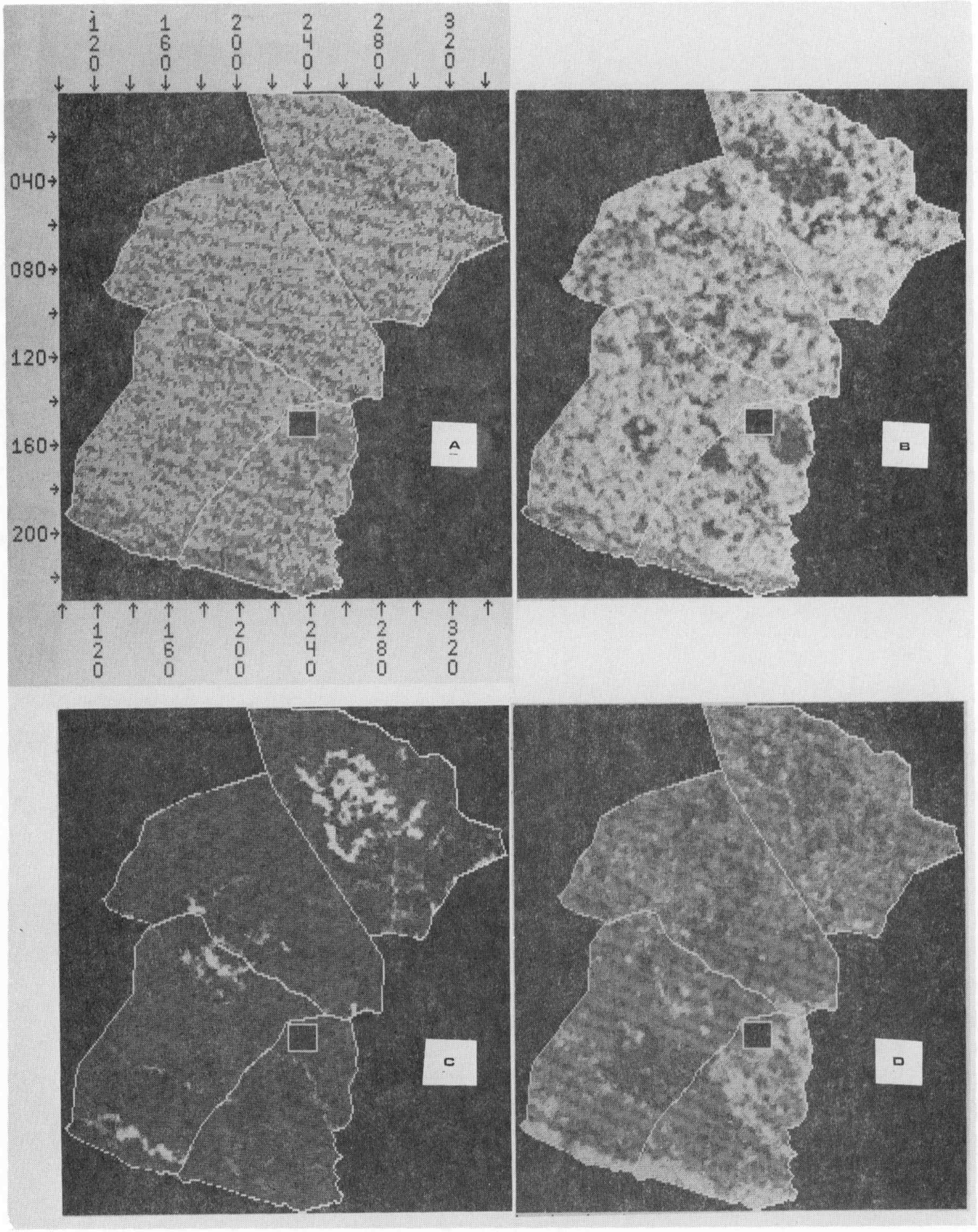


Figure 3. Bi-temporal Landsat data for a four-AU Site in Test Area 1. Winter 1976 data from band 5 (a) and 7 (b) and Spring 1977 data from band 5 (c) and 7 (d) are shown here with the boundary channel overlaid.

Table 3. Percent of area by class for Spring Data Classification Results from AU 264, 267, 268, and 271. (STR inventory comparison shown in parentheses)

Cover Type	Administrative Unit				
	264	267	268	271	Total
Pine	55.6 (59.5)	54.3 (53.3)	43.7 (46.1)	65.5 (65.1)	55.8 (56.9)
Mixed P/H	42.5 (38.0)	45.3 (43.2)	56.3 (49.4)	26.9 (32.6)	41.5 (40.1)
Non-stock	1.9 (2.5)	.4 (3.5)	0 (4.5)	7.6 (2.4)	2.7 (3.1)

Table 4. Percent of area by class for a 4 Channel *Bitemporal Classification of AU 264, 267, 268, 271. (STR inventory comparison shown in parentheses)

Cover Type	Administrative Unit				
	264	267	268	271	Total
Pine	57.8 (59.5)	51.3 (53.3)	49.2 (46.1)	61.5 (65.1)	55.4 (56.9)
Mixed P/H	36.2 (38.0)	46.1 (43.2)	49.5 (49.4)	27.3 (32.6)	39.0 (40.1)
Non-stock	6.0 (2.5)	2.6 (3.5)	1.2 (4.5)	11.2 (2.0)	5.6 (3.1)

*Channels Used:		
	December 30, 1976	0.70 - 0.80 micrometers
		0.80 - 1.10 micrometers
	April 17, 1977	0.60 - 0.70 micrometers
		0.70 - 0.80 micrometers

The variations that occur in the other Level I classes, mixed and non-stocked, are primarily a function of class diversity. Both these classes contain a proportionally large number of heterogenous cover types dispersed throughout the AU's as a number of small stands. This fact makes training class definition difficult, and could therefore cause the areal estimates to vary from the inventory information. Another cause of the difference in these classes could be directly related to the quality of the AU map and inventory information. That is, often heterogenous stand types are combined for operational purposes to form single Operating Areas (OA). This becomes quite obvious when one visually compares classification output with aerial photos rather than the ownership maps.

Figure 4 shows a portion of the map for AU 264 and the corresponding area on an aerial photograph. The diversity of cover types are obvious when one views the aerial photograph. This same area on the map has been simplified considerably by on-the-ground operational considerations. Obviously, classification results will more closely reflect the aerial photos rather than the AU maps. This is only logical since the maps are drawn based on human, not spectral criteria.

Given that some basic differences exist between the maps and aerial photographs, one can develop an appreciation for the problems involved with evaluating Landsat classification results. Figure 5 shown the bitemporal classification map of slash pine for AU 264. The shaded portion of the overlay represents the hardwood and non-stocked areas of AU 264. (The OAs for this map have been combined to facilitate visual comparison.) The white areas on the map represent pine lands which visually correspond

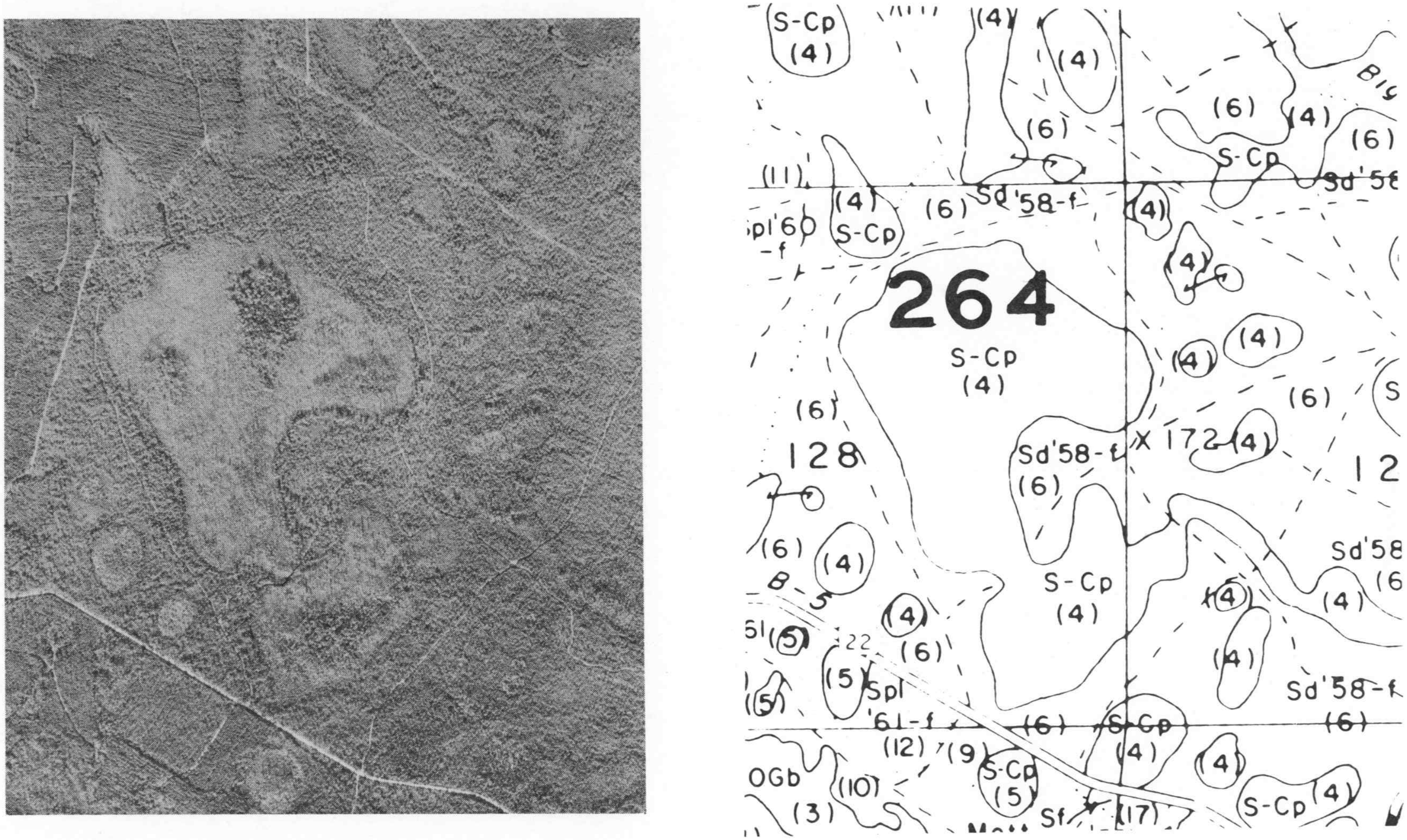


Figure 4. Comparison of a map and air photo rendition for a small portion of AU 264. The numbered map polygons define operating areas. Note the heterogenous appearance on the photo of areas numbered 4 on the map. This depicts the difficulty of using maps to evaluate classification accuracy.

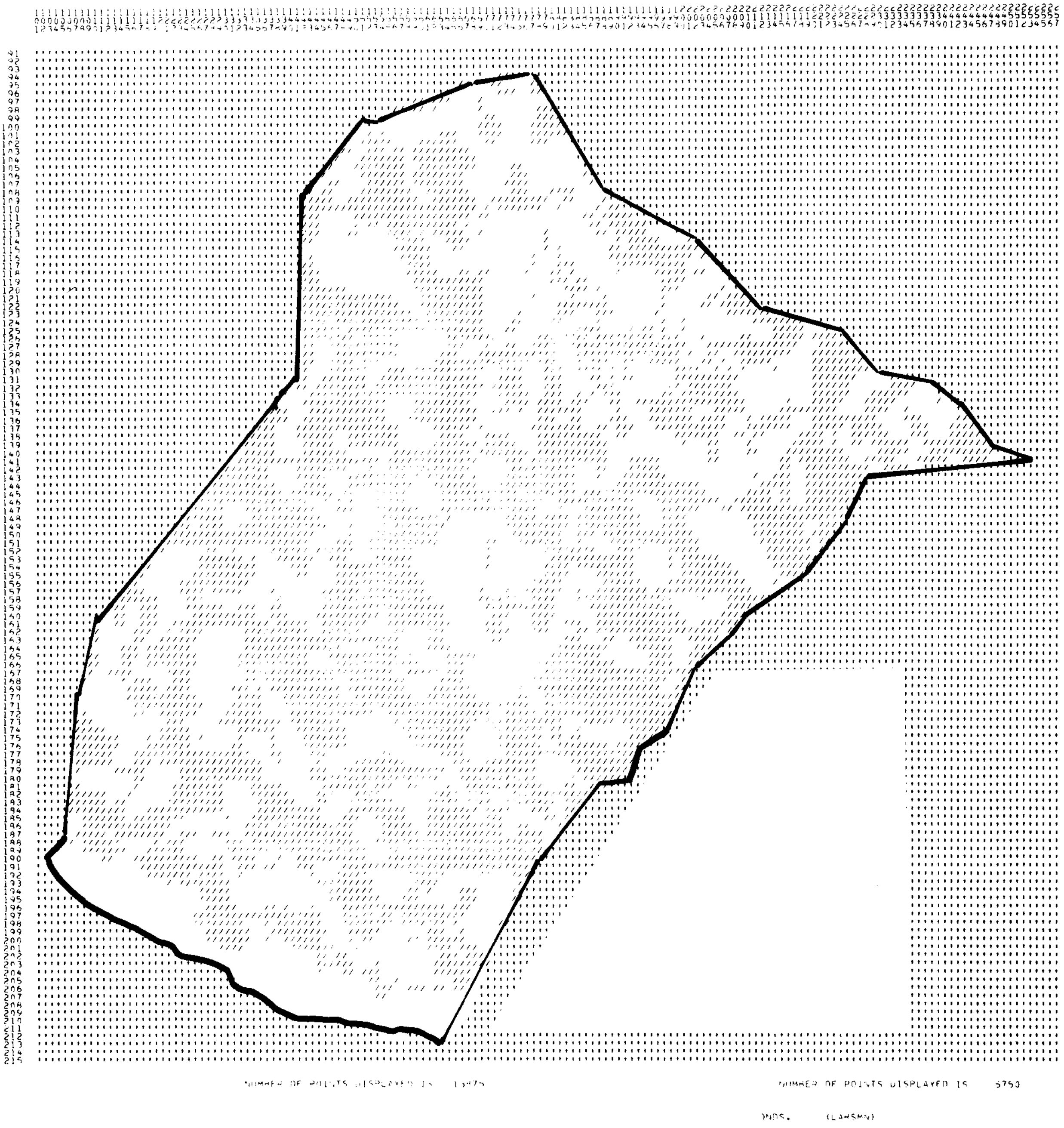
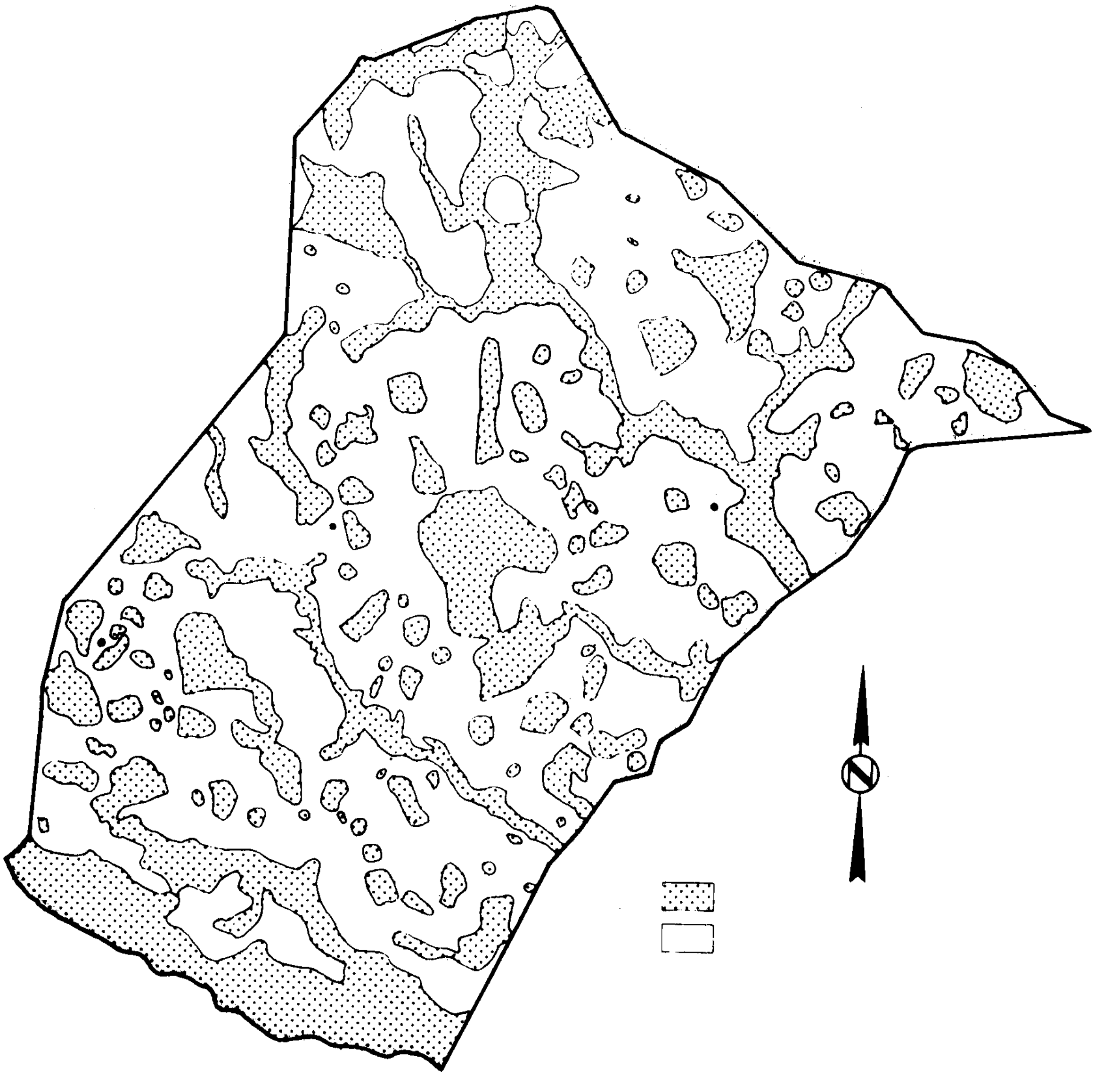


Figure 5. Bi-temporal classification of AU 264, Test Area 1. The slash (/) represents pine lands. The dot (·) on the overlay represents the mixed wood and non-stocked classes.



N

well with the slashes on the classification map. Statistically, the areal estimates from the Landsat classification correspond well with inventory updating, indicating about a 60/40 percent break between pine and the other classes at level I.

Most map accuracy problems noted between the AU map and classification can be related to the previous discussion of map compilation. A stated objective for preparing the FRIS Landsat data base is to attain a ½-pixel RMS error for each data set in the data base overlay. The RMS error refers to the average positional accuracy for all pixels in a corrected scene. Therefore, this does not mean that each pixel is positioned to within ½-pixel accuracy, but that the average of all pixels in the scene is no greater than ½-pixel accuracy. Actually, for this data set the RMS error achieved was .2 of a pixel accuracy.

Additional work to define Landsat mapping accuracy will be addressed during the next reporting period.

2.2 Mapping Unit

2.2.1 Vendor Selection

A key to the successful implementation of Landsat technology by STR will rest with their ability to utilize Landsat results in combination with the myriad of other information available over STR controlled lands. The marriage of these varied bits of information is feasible only through a large data base. To be workable the data base must be able to merge inventory information with Landsat classification results and these items to a specific location on the ground. The data base must, therefore, be geographically referenced.

To accomplish this geographic referencing STR maps must be digitized in order to convert line reference data to a grid coordinate system and overlaid on the Landsat data channels.

Digitizing complex map boundaries, especially OA boundaries can involve a heavy commitment of human resources. With this in mind a task was defined during the early part of the demonstration that would allow us to assess the availability of service organizations that could digitize the STR maps. Six organizations were identified, sample maps and requirement were prepared and bids were requested. Table 5 identifies six vendors, their capabilities and indicates their response to the bid.

From the six only two serious bids were received. One bid was from a firm that offered manual digitizing services similar to those provided by LARS. The other vendor offered semi-automatic digitizing done with a laser-line following device. Since we had no experience with the latter technology, we opted to accept vendor F's bid.

A mylar positive of the four AU's was prepared and edited to remove any ambiguous map lines. The map, a blank data tape and material describing the LARSYS tape format was forwarded to the vendor for digitizing.

The digitized map will be replotted and compared to the original. The replot will also be compared with a replot of the AU's done at LARS. Accuracy of the two products will be assessed and costs compared. Based on these comparisons a recommendation will be made to STR on the direction of future digitizing activity.

Table 5. Vendor capability and response status for digitizing a four AU pilot study site.

Vendor	Digitizing Capability		Bid Status
	Manual	Semi-Automatic	
A	X		Oral[1]
B	X	X	No
C	X		No[2]
D	NR		
E	NR		
F		X	Written[3]

NR - no response

1. Approximately $200/AU, no indication in LARSYS grid format could be provided.
2. Unable to respond in time frame - no price.
3. Approximately $175/AU, cannot provide data in LARSYS grid format.

2.2.2 Map Digitizing

For the Demonstration AU and OA boundaries are being manually digitized at LARS for a 46,000 hectare (115,000 acre) portion of Test Area 1. Modifications have been made to existing digitizing capabilities to meet the FRIS data base requirement.

The software available at LARS to construct a data set containing Landsat data and ancillary data from digitized map information was originally designed to overlay political boundaries with the Landsat data. To represent these political boundaries digitally only required a minimal amount of digitized data since in general they tended to be large and blocky. Since that time the registration of other types of ancillary data to Landsat data have become of interest. Natural boundaries such as soil types and watershed boundaries have also been overlaid using the present software. The types of ancillary data becoming of interest have occasionally been more digitally complex than the system was designed for. Since this has only rarely occurred in the past, the method used to overcome this limitation was to simply employ the additional man-time necessary to construct the data set.

The data sets needed for the FRIS project require the registration of very complex ancillary data with the Landsat data. Since the aim of the project is to do this operationally the brute force method used in the past is no longer adequate. In order to digitize the complex maps in an operational mode required the implementation of new digitizing software which could reduce the amount of man-time spent digitizing and enable some errors to be corrected during the digitizing.

In the process of digitizing the information on a map, the lines on the map are converted to x and y coordinate pairs which are grouped into arcs. Associated with each arc is an area left and an area right. In the past these area numbers were manually keypunched. Also associated with each arc is an arc number. Besides the arcs, during the digitizing, check points and tick marks are also digitized. Check points represent control points used to tie the Landsat data to the map. Tick marks are used to tie the maps together to form a single data set.

With the aim of reducing the amount of man-time spent digitizing, software was produced which makes use of a command menu, figure 6, and an area number menu, figure 7. Using this technique one may enter all necessary information directly at the table, figure 8, in lieu of entering a portion of the information at a terminal. Using the menus, one may enter the area numbers; digitize arcs, checkpoints, and tick marks; produce summaries of digitizing thus far; digitize in a point by point mode or in a stream mode; switch digitizing cursors while digitizing; switch boundary types that are being digitized; and also delete errors while digitizing. This software was not an added convenience, but required for the digitizing to be done in a timely fashion.

To further enhance the speed of the digitizing, when operating in stream mode, requires the addition of floating point hardware. With this hardware the accuracy needed may be maintained and the number of points digitized per second, while in stream mode, may be increased from 5 points per second to a maximum of 200 points per second. Presently, running the digitizing software in the PDP 11/34 mini computer requires the sole use of the PDP. With additional memory the overall process of generating the data set may be enhanced by enabling another job to run

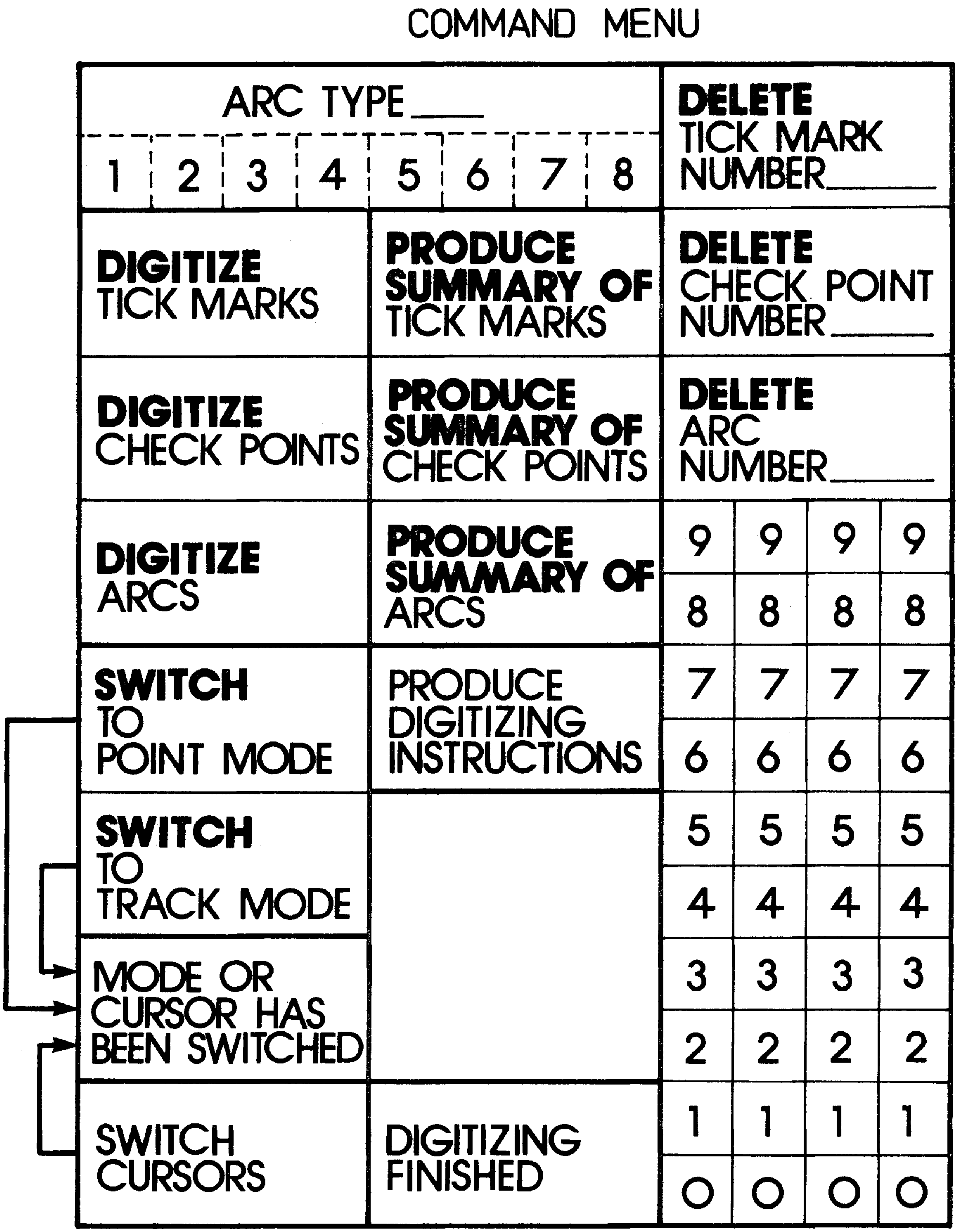


Figure 6. Command menu used for digitizing.

AREAS LEFT AND RIGHT MENU

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
32	33	34													
												253	254	255

Figure 7. Area number menu used for digitizing.

SEMI-AUTOMATED DIGITIZING WITH COMMAND AND AREA MENUS

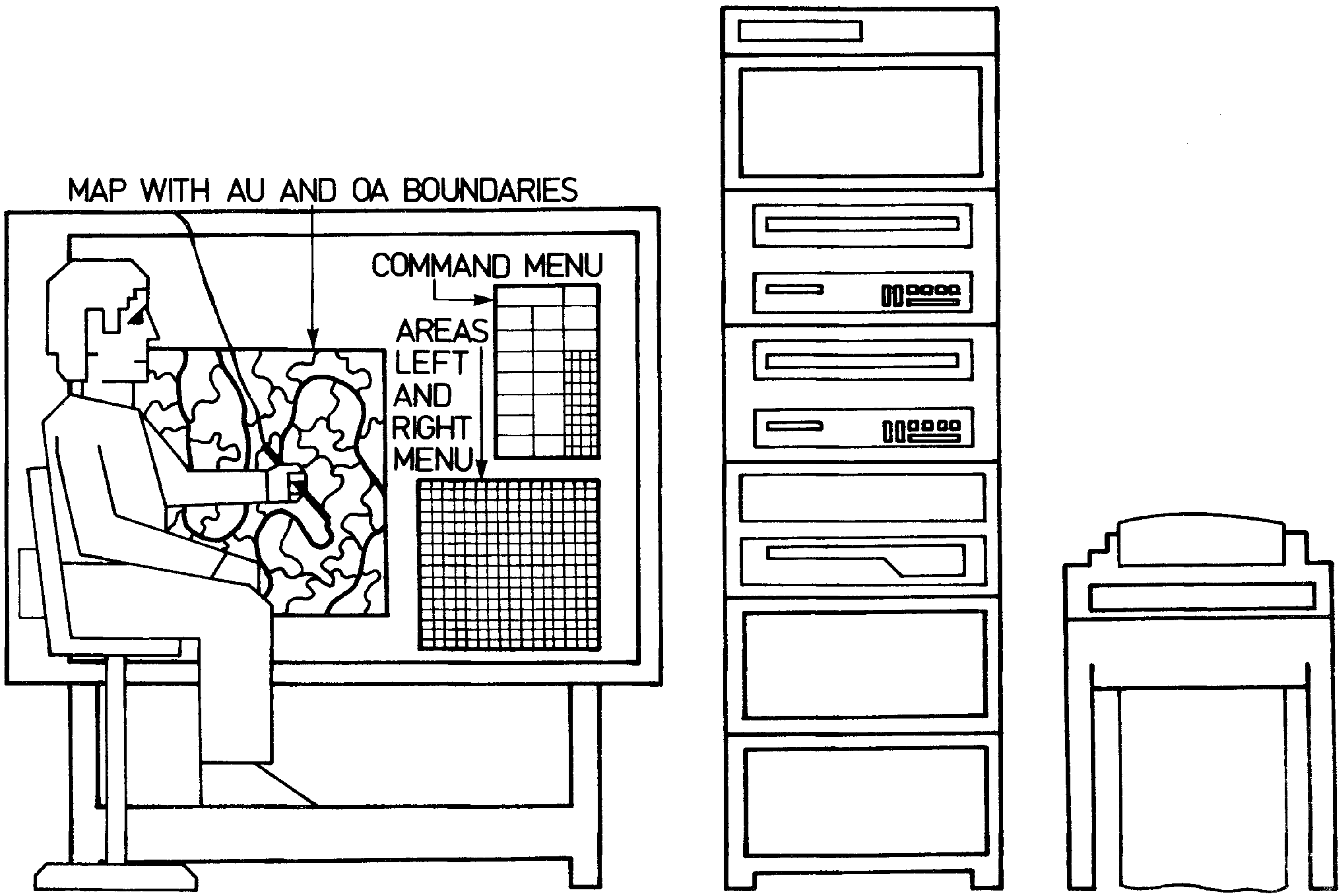


Figure 8. Hardware configuration used for digitizing.

simultaneously, such as assembling previously digitized data.

2.3 System Design

The Systems Design Unit is currently involved in two major activities:

1) Definition of FRIS information needs and their relationship to Landsat deliverable products, and
2) Design of a remote terminal installation at STR's Jacksonville, Florida Divisional office.

2.3.1 Information Needs Definition

As an initial step in developing the remote sensing components of a FRIS we have undertaken a task to define broad areas of St. Regis information needs. This activity is being pursued in conjunction with St. Regis staff who have identified areas and generic types of information necessary for the system to be functional. Obviously, the components of a total Forest Resource Information System would address a broad arena of management needs. Therefore, our task has been focused to just those components which can be somewhat addressable with Landsat data.

Information systems came into vogue because of their ability to manipulate vast quantities of data and provide management with various alternatives that can be used to make decisions. The quality, more so than quantity, of data being manipulated becomes important. Professional managers of forest resources must rely on inventory data, for the purpose of making decisions. These data are constantly being revised so that they reflect the current state of the resource. In order to account for the many and varied requirements of management it becomes necessary to utilize computer based information systems minimally just to track and sort the glut of data from the field. With this increased capacity for data manipulation more pressure is being placed on inventory systems to meet these data demands.

Given this thesis we set out to evaluate three survey methods that can provide inventory data to an information system. Traditionally, forest inventory is a never ending cycle, because forest resources occupy vast areas of land and their management and growth are dynamic in nature.

Table 6 presents an overview for FRIS information needs for ground, photo and Landsat survey types. At this stage each survey type is considered as a stand alone system. The information requirements are segmented into three categories:

A. Physically measureable phenomena

B. The managements constraints that may be imposed on survey type, and

C. The fact that any inventory information derived by a survey type should be accessible through a data base.

Table 6 represents a first iteration of the information needs definition task. However, it should be obvious from the Table that none of the survey types are optimum as a stand alone system. Traditional ground inventory methods fall short of providing the overview capable when aerial methods are utilized. Likewise, aerial photography cannot address many of physical measureables so necessary to meet forest quality and volume needs.

Landsat, can be timely and offers repetitive coverage over broad areas and may be economically advantageous for addressing certain

Table 6. FRIS Information Needs Matrix

Requirements:	Survey Type		
	Ground	Photo	Landsat
A. Physical Measurements:			
Objective: to provide information relative to the physical characteristics of forest resources in terms of their composition, location, areal extent and quality. Such measurements should relate to -			
1. Stand Type	++	+	+++
2. Stand Area	+++	++	+
3. Stand Volume	+	++	+++
4. Stand Quality	+	++	+++
5. Stand location	+	++	++
B. Constraints			
Objective: to quantitively evaluate the effect of limitations in the form of monitary, political, technical or operational in developing an operational FRIS. The following factors will be considered -			
1. Physical related to the natural composition of the forest ecosystem.	++	++	++
2. Monitary relating to the cost of acquiring and implementing a new technology.	++	++	+++
3. Technical related to the capability to utilize the data to provide information.	+	++	++
4. Operation relating to the suitability of implementing a technology.	++	++	++
5. Political related to the continued ability to independently acquire information to manage a resource.	+	++	+++
C. Data Base			
Objective: to evaluate the suitability of a remote sensing data base to be responsive to management needs. Items to be considered:			
1. Repeatibility of physical measurements.	+++	++	+
2. Suitability to manipulate boundary information by type -			
a. AU	+++	++	+
b. OA	+++	++	+
c. Ownership	+++	++	+
d. Political	+++	++	+
3. Value of automated map deviation.	+++	++	+

Key

A. Physical Measurements
1. Most Useful source to determine: +
2. Moderate Usefulness for determining: ++
3. Least Useful source to determine: +++

B. Constraints
1. Fewest constraints: +
2. Moderate constraints: ++
3. Most constraints: +++

C. Data Base
1. Least difficult to update: +
2. Moderate difficulty in updating: ++

information needs. However, Landsat cannot provide the specific information required by management. Therefore, some combination of systems is required. Additional work is being done to define the expected benefit of the interaction between survey types. This aspect of the task will be reported in the future.

2.3.2 System Design Considerations

An important part of the FRIS Technology Transfer activity centers on providing St. Regis staff hands-on analysis experience. In order to privide this experience the Jacksonville Divisional office will become a LARS remote terminal site. In the last quarterly report a potential remote terminal site was described. What follows is description of an remote installation that utilizes existing St. Regis hardware.

One option currently being investigated for establishing a remote terminal to the LARS computer in Jacksonville, Florida is to make use of existing equipment. St. Regis has an IBM 3776 remote job entry terminal which could be configured to communicate with the LARS computer. This terminal has a card reader, dual-drive diskette storage and a printer. This hardware would provide access to any of the programs on the IBM 370/148 at LARS. Job Control cards could be enetered into a file on the diskette storage or keypunched on cards. These control cards could then be submitted to the computer from the IBM 3776 terminal by directing the job to one of the LARS batch machines. Printer output would later be received on the IBM 3776 printer.

In order for the IBM 3776 terminal to communicate with the LARS computer, a telephone line with a modem at each end is required. This terminal is currently connected to the St. Regis's National Computer Center in Dallas, Texas, so its connect time to LARS' computer would be limited. A dial-up arrangement to LARS would be most economical in this situation. Since St. Regis already has an ICC 9600 bps (bits per second) modem, of which half (4800 bps) is used to support the IBM 3776 terminal, we are investigating leasing a 4800 bps modem from ICC which would be compatible with the modem at St. Regis and could operate in a dial-up environment. A new telephone line into the LARS computer room and a port on the 3705 communications controller would also be required. The telephone line and data access arrangement (DAA) would cost $36.70 per month.

Since the demand on the IBM 3776 batch terminal is reported to be heavy during the day, some of the additional load on the terminal from proposed LARSYS usage could be relieved by obtaining an acoustic coupler and a CRT terminal. An Infoton GTX terminal can currently be purchased for $990. Such a CRT would serve adequately for remote terminal use. Then personnel could dial-up one of the five existing low-speed lines at LARS and initiate execution of their jobs. The IBM 3776 would only be needed to receive printer output. An IBM 3275 CRT terminal may become available at St. Regis in the near future. However, this operates at a higher speed than the previously mentioned GTX terminal. The cost of the modem and phone line into the LARS computer may exceed the price of the GTX. This will be investigated further.

Based on the above information, the remote terminal at St. Regis would consist of a CRT keyboard terminal and an IBM 3776 batch terminal, both operating in a dial-up environment. The LARSYS user at Jacksonville would use the CRT terminal to set up control card files and initiate job execution. He could then disconnect or log-off the computer and hang up the phone while the jobs are running. At a later time the IBM 3776 terminal could be connected to the LARS computer to receive all printer output in the queue. The terminal hardware configuration is illustrated in figure 9; the analysts use of the system is shown in figure 10. To analyze a set of four Administrative Units of approximately 87500 points would require an estimated 6-8 hours on the CRT terminal and 6-10 hours on the batch terminal (depending on the number of map outputs generated), ususally in half to one hour sessions.

2.4 Cost Evaluations

The prime emphasis for the Cost Unit during the Demonstration Phase of FRIS is on collecting the costs associated with the technology. Two studies relating to the costs of the operational aspects of FRIS will be reported here. One deals with the resources of preparing the Test Area 1 data base, the other relates to the computer time required by various processors for classifying Landsat data.

As indicated in the previous section, map digitizing for the purpose of creating a data base containing Landsat data and AU map boundaries is heavily man-power dependent. Table 7 lists the resources, both human and computer, necessary to digitize one Test Area 1 composite map containing an average of 10·AUs. Even at this level of resource expenditure, we estimate that the Test ARea 1 data base, including the necessary manipulation of Landsat data can be accomplished with a fairly low expenditure of resources.

Since the resource in Table 7 reflect a "first-time" activity we feel

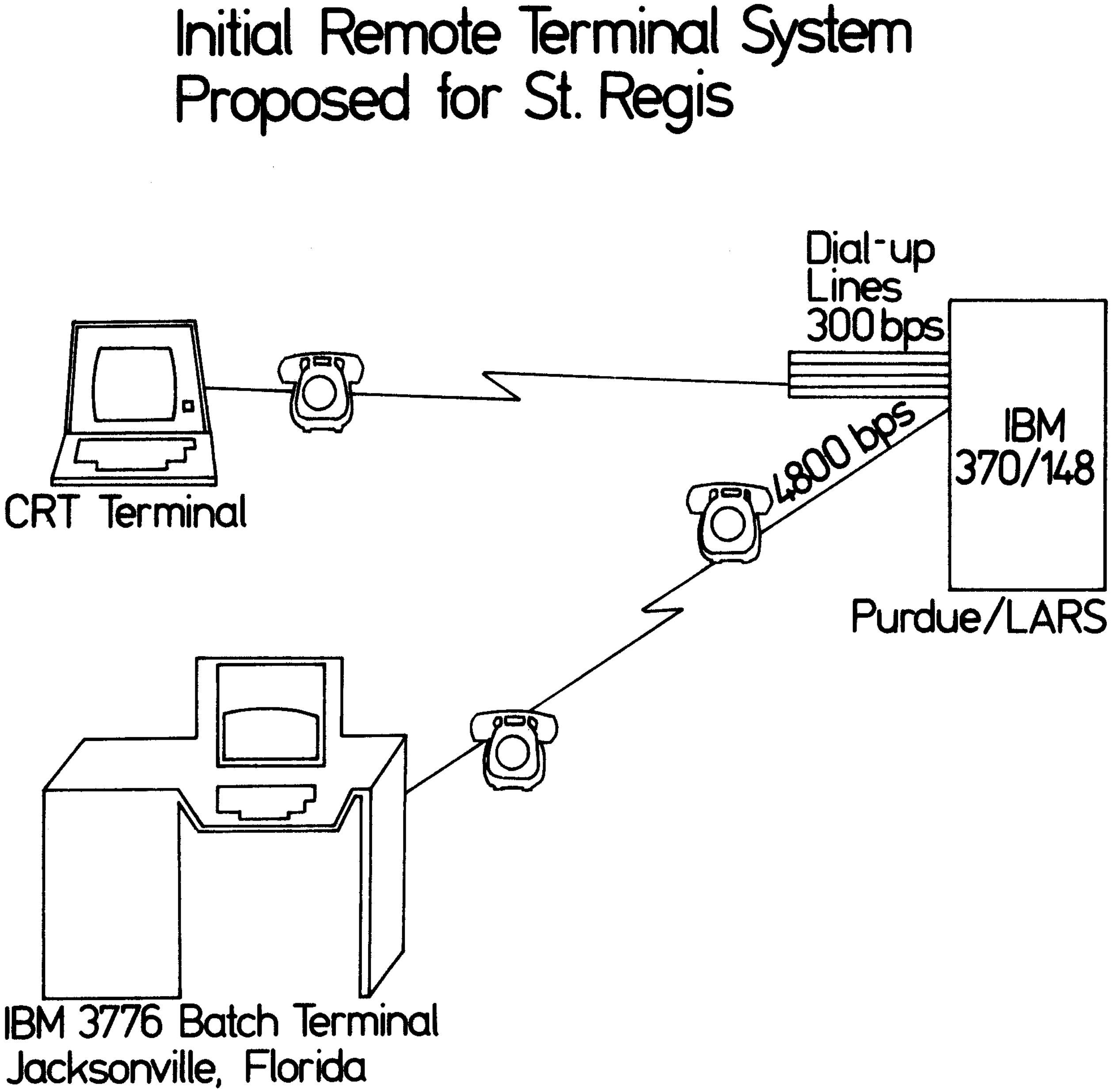


Figure 9. Terminal hardware configuration.

Flowchart of LARS Data Analysis System for St. Regis

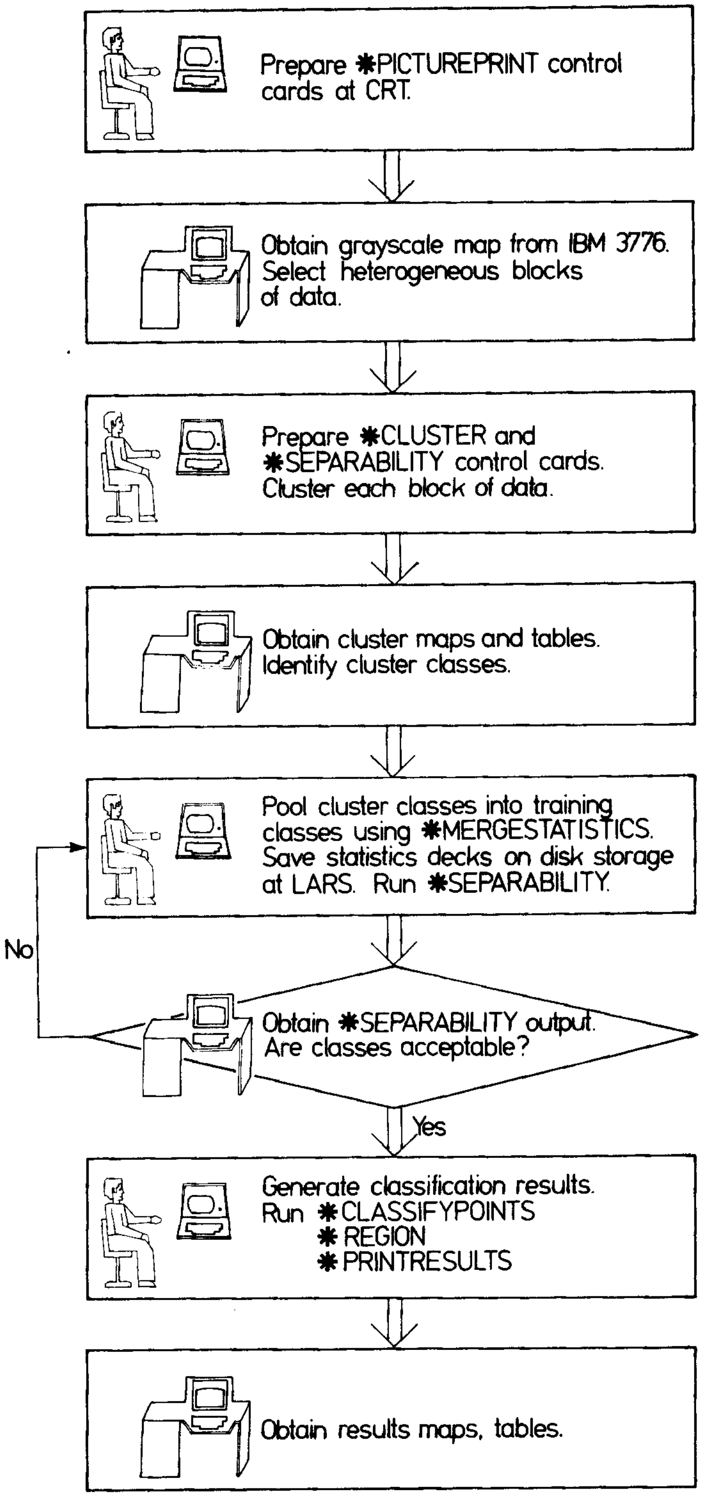


Figure 10. Conceptual utilization of St. Regis hardware in a LARS remote terminal mode.

Table 7. Relative resource expenditure necessary to digitize and prepare AU and OA maps for Test Area 1.

Operation	Resource	
	Human time[1]	CPU time[2]
Map Preparation & Digitizing	9 man-days/map[3]	61.6 hours/map[4]
Data Assembly	16.1 man-days/map	307 minutes/map
Boundary Processing	5.3 man-days/map	344 minutes/map
Total	30.4 man-days	651 minutes/map

Note:
1) Human resources are based on the average time in days necessary to digitize a composite Test Area 1 map containing an average of 10 AU's.
2) CPU time relates to the LARS IBM 370/148 except for table digitizer and varian replot times.
3) This time includes 1.3 man-days necessary to edit ownership maps on a per-map basis.
4) This time relates to the clock time that the table digitizes, and to a lesser extent the varian plotter is in use.

that they could be reduced in an operational system. Obviously, manpower costs can be reduced if the digitizing were done by an individual familiar with the St. Regis maps. Also the costs of digitizing AU and OA boundaries could be allocated against the costs of creating a larger geo-referenced data bank which would include planimetric as well as political and ownership information. Such a data bank could form the foundation for a semi-automated, division-wide mapping system.

Computer time would be expected to decrease if a computer more powerful than an IBM 370/148 were used to process the data. Or conversely, if some of the assembly and boundary processing could be accomplished on a mini rather than a main frame, the costs would be expected to decrease.

These figures are estimates based on the current activity and do not reflect a "bottom-line" estimate of operational resources necessary for FRIS. Cost tracking will continue before any final operational figures can be stated with certainty.

Various classification approaches are available for processing Landsat data. Previous diccussions of classification performance were based on results from a per-point maximum likelihood classifier. A per-field classifier, which accounts for spatial scene variability and a minimum distance algorthm, which only uses the minimum distance to the means to define classes are availabe to the analyst.

Table 8 shows a comparison of the various classifiers and CPU time for the four AU's in Test Area 1. Generally, the per-point and per-field (ECHO, for Extraction and Classification of Homogenous Objects) classifiers perform well compared to the inventory update. Certainly the areal estimates for pine are satisfactory. Also the estimates of the area in

Table 8. Comparison of Classifier Performance and CPU Time By Cover Type and Percent

Cover Type	Classifier (CPU Time, Seconds)						
	St. Regis Inventory	Per-Point (731)	ECHO[1] 2 x 2 (457)	ECHO[2] 2 x 2 (383)	ECHO[1] 3 x 3 (460)	ECHO[2] 3 x 3 (280)	Minimum Dis.[3] (265)
Slash	(56.9)	(55.5)	(55.7)	(56.4)	(55.4)	(56.4)	(49.8)
Mixed P/H	(40.0)	(41.9)	(40.6)	(38.5)	(40.9)	(36.0)	(48.3)
Non-stock	(3.1)	(2.6)	(3.7)	(5.2)	(3.7)	(7.5)	(1.9)

1. Medium Homogeneity value - Moderate cell splitting
2. High Homogeneity value - very little cell splitting

NOTE - All ECHO classification done with ANNEXATION = 0.5 which will allow very little annexation.

The notations '2 x 2' and '3 x 3' indicate cell sizes of 4 and 9 data points respectively. At the expanded scale of the data used (1:15,840) these cells represent approximately 2 and 4.5 acres respectively.

3. The Minimum Distance classifier uses only distance to class means and does not consider class variance.

the other classes are well within the limits of our expectations. The most significant difference occurs in classifier time (in CPU seconds) with a difference of over 450 seconds separating the per-point from a 3 x 3 ECHO classification in which each homogenous block equals approximately 1.7 hectares (4.3 acres).

The least expensive, in terms of CPU time was the minimum distance classifier. But since this is not as powerful a classifier as either the per-point or per-field approach, the classifier performance is not as good.

The figures reported here are based on IBM 370/148 CPU time required to classify a fairly small test site. The necessary man-time and additional CPU required for training are not included in this analysis. These figures are intended to provide an indication of various classifier capabilities and their relative efficiencies in terms of CPU resources.

3.0 Summary

Significant strides toward the FRIS goals were made during this quarterly period. A summary of accomplishments follow:

- An evaluation of areal estimates from Landsat and St. Regis Inventory Updating indicates:
  - a. Satisfactory results are obtainable from either winter or spring Landsat data.
  - b. Bi-temporal results obtained by comgining winter and spring data improve class discrimination.
  - c. Per-point and per-field classifiers perform comparably except regarding time, where the per-field classifiers are more efficient.

- The greatest bulk of map digitizing was completed during this quarter.
- A vendor was selected to digitize a portion of Test Area 1. Evaluation of these results will help us determining the suitability of semi-automated digitizing methods for use in FRIS.
- Work toward making Jacksonville a LARS remote terminal site is progressing. St. Regis could be operating as a remote site as early as the end of the next quarter.
- The technology transfer activity is continuing and appears to be very successful. The measure of this success is reflected by the advanced Jacksonville remote site installation which has been moved up from April 1979.

References

Barker, G. R., 1976.

"Project Plan - Applications System Verification and Transfer." Forest Resource Information System. 71 pp.

____

FRIS information needs. Internal project memoranda.

Davis, B. 1978.

Benchmark Evaluation Criteria. Project review draft. 14 pp.