To the Graduate Council:

I am submitting herewith a thesis written by John Glenn Palmer entitled "Development and Evaluation of Self-Paced Instructional Units for Two Dendrology-Silvics Courses in Forestry." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Forestry.

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C

DEVELOPMENT AND EVALUATION OF SELF-PACED INSTRUCTIONAL UNITS FOR TWO DENDROLOGY-SILVICS COURSES IN FORESTRY

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

John Glenn Palmer

December 1976

ACKNOWLEDGMENTS

Much appreciation is expressed to Dr. Edward R. Buckner, Committee Chairman, Department of Forestry, for so willingly and patiently giving of his time and for his guidance, understanding and encouragement throughout the study; to Dr. Ron Hay, Associate Professor of Forestry, for helping to initiate the study and serving on the committee; and to Professor Horace Smith, Plant and Soil Sciences Department, for his expertise in the area of self-instructional laboratories and his willingness to serve on the committee.

Special acknowledgments are extended to all friends and family, especially to my parents, Senator and Mrs. Joe H. Palmer, for their encouragement and never ending confidence.

A note of special thanks to Mrs. Mary Harrison and Mrs. Mary Jones who willingly assisted with the typing throughout the study.

ABSTRACT

Self-paced instructional units were developed, used, and evaluated in two dendrology-silvics courses. This new teaching scheme: (1) completely replaced the group-paced, lectured laboratory sessions with self-paced, indoor, slide-tape programs in Dendrology and Silvics of the Gymnosperms (Forestry 3050), and (2) supplemented the group-paced, lectured fieldtrips with a self-paced, taped, fieldtrip program in Dendrology and Silvics of the Woody Angiosperms (Forestry 3040).

The study was divided into two major phases: (1) development of the instructional units, and (2) evaluation of the instructional units. The development phase was concerned with: (1) selection of appropriate instructional materials; (2) preparation of the instructional units; and (3) operational procedures of this teaching system. The evaluation phase was concerned with: (1) the learning effectiveness of the self-paced instructional units; (2) the students' attitudes toward the self-paced instructional units, and (3) the costs of implementing the self-paced instructional units.

Several evaluation procedures were used in the evaluation phase of this study. Student performance or achievement was evaluated in the Gymnosperms course by: (1) comparing the learning effectiveness of one of the eight self-paced instructional units developed with the same material taught in a traditional group-paced setting, and (2) observing the final grade distributions of the two classes that used the self-instructional system. Student performance or achievement was evaluated in the Angiosperms course by examing the students' grade distributions

from a written post-test. In both courses subjective measures of student satisfaction were evaluated from quiestionnaires made available to all the students. Subjective measures of student preferences toward different recording styles were evaluated from written critiques and discussion sessions with eight students in the Angiosperms course. The costs of the teaching materials used with the self-paced instructional systems were evaluated by examining the various expenditures.

Several conclusions were made from the findings. In the Gymnosperms course it was concluded that: (1) the self-paced instructional setting was as effective in teaching the one weekly experimental unit as was the traditional group-paced instructional setting, (2) the self-paced instructional setting was effective in stimulating high overall class grades, (3) the self-paced teaching format enabled the presentation of more material in less time, (4) the overall majority of the students preferred the self-paced instructional units, and (5) the self-paced instructional materials were more expensive than those formerly needed with the group-paced instructional method. In the Angiosperms course it was concluded that: (1) the self-paced, taped, fieldtrip instructional unit was effective toward providing high student grades, (2) the overall majority of the students were favorable to the self-paced, outdoor instructional unit, (3) the self-paced instructional materials were more expensive than those used for group-paced instruction, and (4) students were: more at ease with a tape recorded by the instructor, that continuous music used throughout the tape was distracting, that opening and closing music on the tape was appropriate, that beeps and musical interludes were unnecessary on the tape to signal a move to the next station, that an

enthusiastic, varying, conversational tone of voice was the best presentation format, and that a moderately rapid speaking rate was preferred.

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CHAPTER I

INTRODUCTION

Professional education in Forestry began at the University of Tennessee, Knoxville in 1964. Since that time, the principle instructional objective has been "to provide each student with the broad education needed to deal effectively with the complex of forest resources" (Departmental pamphlet, 1974). Through a program which offers a broad education in biological and physical sciences, as well as a sound cultural background, knowledge and skills are integrated to enable students to attain entry-level competencies as professional foresters.

One approach toward improving the integration of knowledge and skills in the learning process has been to replace some of the conventional group-paced instructional settings with self-paced instructional settings. In recent years several forestry programs have implemented various teaching formats using self instructional materials combined with independent study. The "audio-tutorial" teaching method was first introduced in forestry education in dendrology classes at Colorado State University (Fechner, 1972). The School of Forestry at Oregon State University developed for their dendrology classes a "self-paced, unstructured, mastery" teaching format (Bever, 1975). Since these schools claimed many advantages using self-pacing teaching techniques and since the goals of these forestry programs were similar to the goals of the Undergraduate Forestry Program at the University of Tennessee, a similar dendrology teaching strategy was initiated in 1974.

Simultaneously, this research study compared the effectiveness of self-paced instruction units to the same units in the conventional group-paced format.

Statement of Problem

In recent years a significant amount of knowledge has been gathered by educational specialists, psychologists, and others from their observations of how students act and react in certain learning settings. Dr. Lee Harrisberger (1971), Chairman of Oklahoma State University Committee on Educational Innovations, and Head of the Mechanical and Aerospace Engineering Department, summarizes some of these observations.

1. Investigations show that information communicated verbally without involvement has a short retention span; lecture classes fail because students are in a passive, nonparticipating role; and lectures in courses requiring higher cogitative skills are notable less effective.
2. Instructor-dominated student discussions are less effective than student-dominated discussions.
3. Students have different learning styles. This refutes the age-old premise that all students in a given classroom are identically equal in background and ability to learn and therefore should be able to learn at the same rate. A student learns best when given an opportunity to explore the topic in more than one way and at his own speed, starting at his own point of preparation.
4. All learners must have frequent reinforcement and rewards. Learning efficiency increases with frequent and repeated opportunities to evaluate progress.
5. A student's peers are more effective tutors than his professors.
6. Retention increases with involvement. Hence, student team-project activity involving problem solving of real situations is a powerful means for enhancing the relevance of acquired information and developing lasting synthesis technique.
7. Audio-tutorial tapes as a self-study aid are more effective than interviews with the instructor. There is no social pressure or embarrassment in admitting stupidity to a tape deck; it is also more accessible and repeatable than a live professor.

To respond to these findings, the Forestry Department redesigned two introductory professional level dendrology-silvics courses taught to all students enrolled in the Forestry curriculum. Self-paced instructional units were developed to replace the group-paced instructional settings formerly used.

These courses were also redesigned in response to steadily increasing student enrollments. The overcrowded classes made it impossible for the instructor to meet the students individual learning needs based on their individual differences. For example, Forestry 3050, Dendrology and Silvics of the Gymnosperms, had a student enrollment growth of 230 percent (33 students to 109 students) over the last ten years (1966-1975). In one year, from 1974 to 1975, the student enrollment in this course increased 49 percent (73 students to 109 students). Forestry 3040, Dendrology and Silvics of the Woody Angiosperms, also had a large enrollment growth. Over the last ten years (1966 to 1975), student enrollment in this course grew 179 percent (56 students to 156 students), and from 1974 to 1975, the student enrollment increased 17 percent (133 students to 156 students).

Basic Objectives

The following were the basic objectives for this study:

1. To develop self-paced instructional units for:
    a. Forestry 3040 (Dendrology and Silvics of the Woody Angiosperms) to supplement the group-paced lectured fieldtrips with self-paced taped fieldtrip programs, and

b. Forestry 3050 (Dendrology and Silvics of the Gymnosperms) to completely replace the group-paced lectured laboratory sessions with self-paced slide-tape programs.

2. To use the self-paced instructional units in the two classes under experimental conditions.

3. To evaluate:

   a. the learning effectiveness of the self-paced instructional units;

   b. the students' attitudes toward the self-paced instructional units; and

   c. the costs of implementing the self-paced instructional units.

Figure 1 shows the organization of the basic objectives used with the two dendrology-silvics courses.

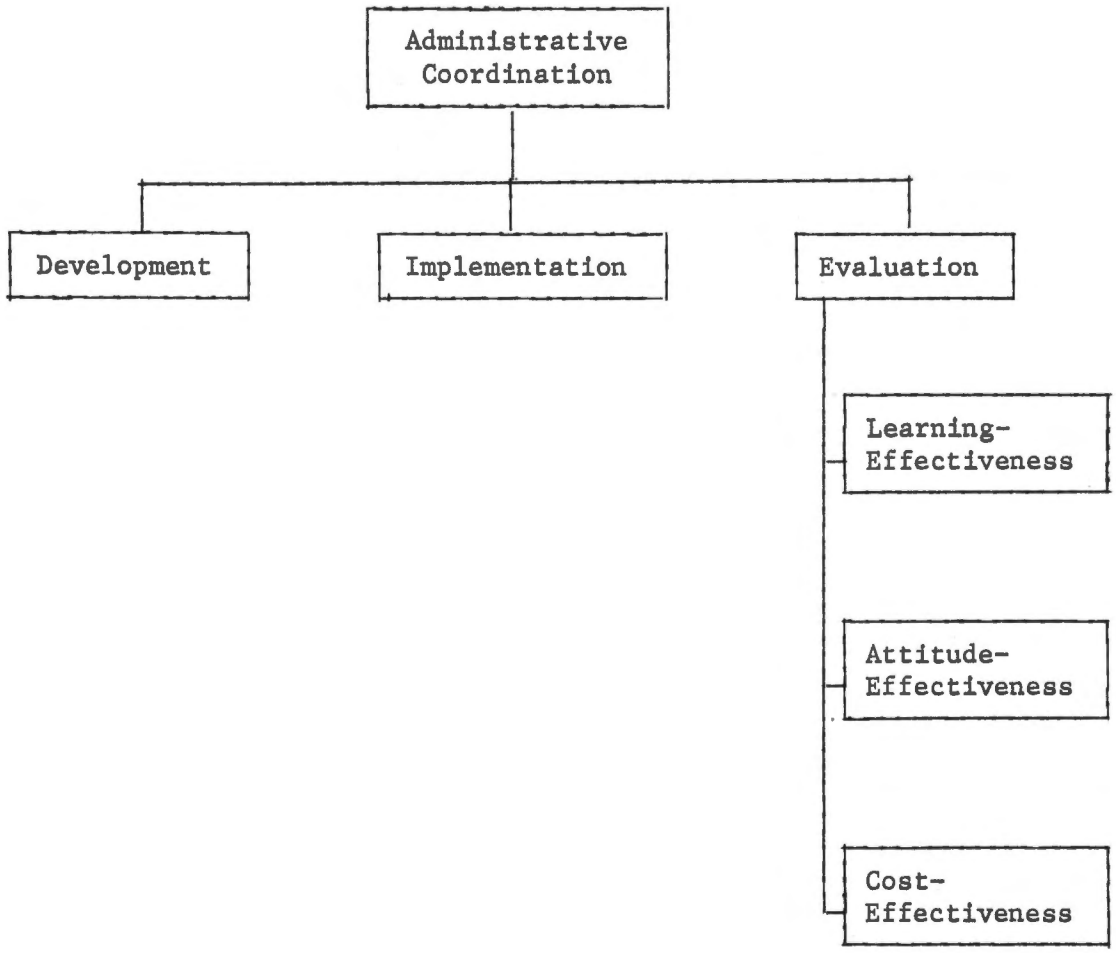

Figure 1. Organization of study which was used with two dendrology-silvics courses.

CHAPTER II

REVIEW OF LITERATURE

I. INDIVIDUALIZED LEARNING

One of the basic themes permeating the educational reform movement today is individualization of instruction and self-pacing in the learning process. Hopkins (1972) refers to this as a "student on one end of a log and a teacher on the other."

This is not a new theme in education. Looking back, Confucius, Aristotle, Socrates, Plato, Charlemagne, and additional early thinkers recognized the existance of human varibility in the educational process (Blake and McPherson, 1969). In more recent times, the one-room schoolhouse allowed students of different ages to meet with one teacher and progress at their own rate (McLaughlin, 1972). However, as enrollments grew and the inabilities to deal effectively with individual differences became apparent, the group-paced teaching strategy was developed to deal with these problems.

Only recently, due to the technological revolution, has the intensity of interest in instructional development for individualized learning become accelerated. Postlethwait (1972), the leader in higher education with the self-paced audio-tutorial teaching technique, stated:

> The purpose of technological devices in this context is to "capture" to the greatest degree possible the events or activity between the "good teacher" and student in a one-one relationship, so that the product can be duplicated to accommodate many students in a close approximation of the original situation. With today's audio and visual devices it is possible to involve the student with nearly every exposure to

> the subject conceivable. The programme can obtain tangible, printed, audio and visual materials in any combination in which the "good" teacher wishes to use them.

Educators knowingly believe that "everyone is essentially self-taught" (Bever, 1974). Any good educational system must be based on the fact that learning must be done by the learner, or as Duerr (1972) wrote, "Education is not something which one receives from others, but rather something which one gives to oneself."

Likewise, Postlethwait (1972) wrote:

> Education is more than an information dispensing and absorbing process. It requires a comradeship of sharing and exchanging of experiences and an excitement that grows from common interests and hopes between teacher and student. Most of us can trace our interest in a specific topic to the inspiration derived either directly or vicariously from some other human being. . . . Todays technology provides new dimensions to accomplish this and, when these new tools are used properly, they provide more intimate access to the teacher.

II. DEVELOPMENTAL CONSIDERATIONS*

There is no single "best method" for implementing instructional change. Of utmost importance is that the procedure work. The implementation of an exciting, rewarding, efficient, and quality education for all students must be the one overriding goal. It is only in this manner that the frustrations of the development process becomes worthwhile (Diamond, et al., 1975).

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*(Author's Note: Many of these procedures [i.e., generating objectives, selecting and designing media] are too complex to be more than touched on in this section. An attempt will be made only to place them in perspective while presenting some insights into considerations that various people have shown effective in dealing with them.)

Production and Implementation

Once a decision has been made to initiate a program the production and implementation phases can begin. "Actual production should begin only after the objectives of each unit have been specified, the instructional sequence has been outlined, and the instructional mode (live, independent study, etc.) has been chosen" (Diamond, et al., 1975).

Objectives

Statements of objectives, in measurable terms, should be developed for each unit. Student behavioral objectives should always be exact (Mager, 1962). From clearly defined objectives, the student will understand what, how, and how much is to be achieved (Wilford, 1972). Dalis (1970) tested the use of both precise and vague objectives in a health education program. The test scores indicated that the use of precise objectives enhanced achievement, whereas, vague objectives deterred learning achievement.

Objectives have been classified by Diamond (1975) as serving the following functions:

1. They change the instructional orientation from "what we must cover" to what a student should be able to do as a consequence of instruction, and, in the process, they facilitate evaluation and, in effect, long-term accountability.
2. They permit the design of a logical and effective instructional sequence by identifying a hierarchy of objectives.
3. In original and modified form, they can be given to the student to facilitate efficient study.
4. They provide a basis for instructional rapport and communication between faculty (both in and out of the project) and between faculty in the project and support staff.
5. They encourage self-evaluation by the student who knows what he is expected to do.

6. They facilitate student learning efficiency by providing direction and identifying instructional priorities.

Mode of Instruction

Many questions should be considered before the mode of instruction is selected. The available resources largely determine the range of options open to the course developer. Basis questions are: "Is a large group session warranted or, for this unit, should instruction be a combination of independent study and seminar discussions? . . . Does the need for self-pacing limit the use of large group meetings or does the availability of an outstanding lecturer, demonstration, or presentation make it worthwhile to build in a large group session while limiting somewhat the time flexibility for independent study?" (Diamond, et al., 1975).

The use of audio-visual materials is an important consideration in the selection of an instructional approach or combination of approaches. Dale (1969) credits audio-visual materials with many advantages. He explains that audio-visual media extends the horizon of experience by serving as a substitute for actual experience and, thereby, tends to widen the range of student experiences. A student's capacity can be increased only as he deals with a wide range of new experiences. Dale stresses that the media does not make learning easier, instead, it helps students develop workable useful generalizations for later use.

Media Selection

After objectives have been established and the mode of instruction has been chosen, the instructional components must be selected. One of the major problems in compiling an audio-tutorial lesson is the selection of an appropriate style for visual materials. At the present time, there is very little research evidence available that relates specific types of illustrative materials to specific kinds of learning (Dwyer, 1970). Without this information, the present basis for such choices, of necessity, is the judgment and experience of the designer of the lesson.

The various types of audio-visual media include "audio recordings (tape and record), video tape (reel or cassette), film (8mm and 16mm), slides, filmstrips, programmed texts, workbooks, charts, graphs, illustrations etc., and computers and calculators" (Diamond, 1975).

Each media alternative has obvious advantages and, in some instances, major disadvantages. Duane (1973) has reported the advantages of audio-visual materials in terms of their effectiveness toward individualized instruction environments. For example, he states slides:

1. are compact, individual visual reproductions.
2. can be classified as having both flexible sequencing and flexible pacing.
3. may be projected in small, light weight viewers or in simple-to-operate projectors designed for group presentation.
4. may be projected in a lighted room when utilized with rear screen [or sunmaster] screen projection devices.
5. are useful for group or individualized study and can be sequenced and projected at a rate controlled by the user.
6. are an efficient format for developing materials since slide programs can be easily revised and updated.
7. [both live shots and copy work] can be produced using inexpensive cameras.
8. cost approximately 35 cents per slide.

Also, according to Duane (1973), the advantages of audio recordings are:

1. Tape recording equipment is readily available, inexpensive, portable, light weight, and simple to operate.
2. Tape recordings can be classified as having fixed sequence and fixed pacing.
3. Tape recorders provide playback of commercially available prerecorded tapes or locally produced tapes.
4. Tape recordings are readily adaptable to either individualized instruction or large group instruction.
5. Cassette recorders are becoming the most widely used format since they are standardized in terms of tape size and speed.
6. Tape recorders are easily adapted to individualized listening by using headphones.
7. Tape recordings provide high quality reproduction even after being played a large number of times.
8. Tape recordings can be easily made from records, other tapes, film sound tracts, or television program sound tracts.
9. Tapes can be erased and reused several times.
10. Multiple tape copies are easily made by connecting two or more tape recorders together.
11. Tape cost - approximately $1.00 - $3.00 for blank cassette tape. Tape recorder cost - cassette recorders - approximately $20.00 - $120.00.

Evaluation

The final step in instructional development is evaluation. "Evaluation is a process designed to gather information that will yield descriptions and judgments of both effectiveness and worth in order that decisions may be made" (Diamond, et al., 1975).

The success or effectiveness of any instructional program should be determined by many factors, such as cost analysis, space utilization, and community reactions, but the final criterion must be the performance of the student. Has he learned? What were his attitudes when he finished? Is the "failure" rate high? (Diamond, et al., 1975).

Increasingly, instructional evaluations ask: "Is the investment worth it?" Cost-effectiveness accountabilities are difficult to evaluate, as Diamond (1975) so precisely wrote:

> The question is, how? How do we translate increased excitement in learning into dollars? . . . At what point should the operation be considered successful? The answers are extremely complex because there is no way to work out a one-to-one equation. Consequently, it is unrealistic to expect to find an answer in a simple or even in a complex formula, since the state of the art is such that we still do not know, for a specific project, what all the important variables may be or how to state them in measurable terms. What we do know is that there is increasing pressure on all educators to equate expenditures with results.

III. RELATED STUDIES WITH CURRICULUM INNOVATIONS

For about the past fifteen years there has been a concerted effort to do something about individualizing instruction. During this time schools throughout the nation have tested numerous individualized instructional programs of one kind or another (Peck and Brown, 1975; Travers, 1973; and Armsey, 1973). Two of the most notable instructional management systems were begun as single classroom teaching innovations by college professors. At Purdue University in 1961 Samuel Postlethwait (1972) first tried the audio-tutorial teaching approach in his freshman Botany course. The Personalized System of Instruction, or Keller Plan (1968) was first developed in depth in 1964 for a general psychology course at Arizona State University. Both systems have now been adopted by other faculty and instructional institutions all over the world.

The audio-tutorial technique has mainly been adopted within laboratory-oriented courses (science, nutrition, geography, etc.) and, more recently, in a number of elementary and secondary school courses as

well. Postlethwait (1972) explains the system:

> The basic philosophy of this system is very simple. A "good" teacher is asked to assemble the items he would use to teach one student and, while sitting among these items, to record on audio tape the conversation he would have with one student as he tutored that student through a sequence of learning activities. The product - the tape, tangible items, visuals and printed materials can be duplicated as many times as necessary to accommodate any number of students. . . . The student now has access to the clever instructor in more ways than through the written word. Subtle communications through connotations by inflections in the voice are provided by the audio tape and the tangible, visual and printed materials assembled can exhibit the full skill of a great teacher to involve a student in a sequence of learning activities or a "symphony of learning."

Professor Postlethwait's method thereby places great emphasis upon "independent study sessions" in which students carry out each individual work assignment in the course at their own pace, by means of the extensive use of tapes and films. Teaching assistants provide for oral quizzing on major concepts and help the students with difficult assignments. Weekly "small assembly sessions" are used primarily for recitation and the discussion of problems or small research projects; and "general assembly sessions" deal mainly with motivational materials (Postlethwait, 1972).

He reports high student interest and greatly improved performance with the use of this technique. "Grades have risen from 6 percent A's under the conventional system to as high as 25 percent A's in some semesters. Failures have decreased from 20 percent in the conventional system to as few as 4 percent."

The "Keller Plan" is an instructional approach which features mastery learning, self-pacing, and extensive student-proctor-faculty interaction on an individualized basis (Keller, 1968). This instructional strategy differs from the more conventional audio-tutorial system

chiefly with regards to the "mastery" learning philosophy. Here the student moves from unit to unit as soon as he is able to meet a specific achievement criterion, usually 80 to 100 percent, on individual unit tests.

Several comparative studies between traditional teaching and the "Keller Plan" have shown the Keller Plan produces greater mastery of academic material (Keller, 1968; McMichael and Corey, 1963; Shephard and MacDermot, 1970; and Born, et al., 1971), better retention (Corey, et al., 1970), and more favorable student attitudes toward a course (Gallup, 1969).

In forestry education, both of these teaching strategies have been modified to replace conventional group-paced instructional settings in Dendrology courses. The "audio-tutorial system" was first introduced and reported by Fechner in 1972 at Colorado State University. The "Keller Plan" was first introduced and reported by Bever in 1975 at Oregon State University.

Professor Fechner (1972) explains his audio-tutorial approach:

> We find that an automatic-focusing 35mm slide projector, a cassette recorder with head phones and a 9 x 9 inch viewer make suitable equipment for each carrel station. . . . The slides and tapes are made available during the second half of each of three weekly two-hour laboratory periods and at evening and Saturday study sessions. Most of our problems have been administrative rather than technical, such as providing adequate supervision and maintaining sufficient slides and tapes with a small budget. But these are minor compared to the opportunities provided.

Professor Bever (1974) replaced the traditional semester lecture and laboratory-fieldtrip sequence with a modified version of the "Keller Instructional Plan." The teaching system was broken into three basic

steps. First, the student was told exactly what he was expected to learn; second, the best possible study aids were placed at his disposal; and third, he had to master the material. Students were largely self-taught and had an unstructured time-line for completion of the course. Each "study unit" had to be mastered before the student could proceed to an advanced unit. An incomplete grade was recorded if the student did not complete the course the first semester he registered. The student had a full year thereafter to complete the course. The course was programmed with the aid of a loose-leaf notebook of instructions detailing exactly what the student had to learn. The notebook was supplemented with many slide-tape presentations. Instead of having an instructor take students on fieldtrips, cassette tapes were produced for students to use on their own fieldtrips by providing trails with labeled trees. Students could take examinations twice weekly under the guidance of a proctor. Since students were taking different unit examinations at different times it was important to avoid compromising questions on the examinations. This was solved with a large number of questions from which a computor randomly selected questions for each individual.

Bever (1974) reported that after the first grades were recorded he believed the students had mastered the material.

> For the first class of 94 registered, 61 completed the course, 32 were incomplete, and one did not complete requirements for incomplete (F). By the end of the deadline for removing "I," one year later, 77 completed the course, 16 were incomplete, and one failed. Of the 16 who did not finish, only two were still registered in the School of Forestry. . . . The standard was 73-82, C; 83-93, B; and 93 and above, A. Finishers in the first class received 42 A's, 33 B's, 2 C's, and the one F.

Bever (1974) summarized his instructional innovation thusly:

> Essentially, Dendrology as now given is a body of knowledge available to students over a protracted interval, asking only that they master the subject matter, each in his own way and at his own pace. . . . This approach is not a panacea; it will not work for all courses. But for courses with a maximum of memory work and a minimum of problem solving, I believe it is a step in the right direction.

CHAPTER III

DEVELOPMENT OF TEACHING UNITS

The procedures used to develop the self-paced instructional units are presented in this chapter in two sections. The first section is concerned with the self-paced, indoor, slide-tape instructional units prepared for Forestry 3050 (Dendrology and Silvics of the Gymnosperms), and the second section is concerned with the self-paced outdoor instructional unit prepared for Forestry 3040 (Dendrology and Silvics of the Woody Angiosperms). The majority of trees studied in Dendrology and Silvics of the Gymnosperms were native to the Western United States. The majority of trees studied in Dendrology and Silvics of the Woody Angiosperms were native to the Eastern United States.

I. SECTION ONE - FORESTRY 3050: DENDROLOGY AND SILVICS OF THE GYMNOSPERMS

Initial development of the self-paced instructional units started during the Winter Quarter of 1974. Two units were prepared by Dr. Ronald Hay, Associate Professor of Forestry, and John Palmer. The units were for supplementary use and the students were not required to use them. Since the course was taught only once each year, it was the Winter Quarter of 1975 before the self-paced instructional units could be used again. By this time, six additional units had been prepared by Dr. Edward Buckner, Associate Professor of Forestry, and John Palmer. This was the first year the self-paced instructional format completely

replaced the group-paced, lectured instructional technique which had been traditionally used to teach the laboratory sessions. When the course was next taught, during the Winter Quarter of 1976, all eight of the units had been revised. The self-paced instructional units were then firmly established as the standard teaching system.

A. SELECTION OF INSTRUCTIONAL MATERIALS

Before the instructional materials and media resources could be selected, it was necessary to decide what instructional mode would be used for the "structured" independent learning sequences. This decision was especially important because the self-paced instructional units would require extensive production and there were several different approaches available. For example, it was possible to use the following in almost any combination: (1) audio recordings; (2) video tapes; (3) films (8mm and 16mm); (4) slides; (5) filmstrips; (6) microfishe; (7) programmed texts; and (8) workbooks, illustrations, etc.

The mode of instruction was selected after: (1) reviewing the literature on the different types of learning materials and media resources available; (2) visiting various classrooms and different campuses to examine different kinds of equipment and their operational procedures; and (3) contacting various media resource specialists to obtain their opinions. From this research, the instructors concluded that the best and easiest teaching approach for this particular course would be a combination of slides, cassette tapes, workbooks, and exhibits combined to form a structured, self-paced learning system of weekly units.

To implement this slide-tape instructional mode for the Winter Quarter course in 1975, money was approved for the limited purchase of several different types of equipment. Additional equipment had to be borrowed from the Plant and Soil Sciences Department to complete the equipping of the learning center with six operational self-learning modules. During the quarter, the different equipment combinations were observed and compared. The equipment included tape recorders and players, headphones, slide projectors, study carrels and screens, and photographic equipment.

Three different slide-tape equipment combinations were used in the course. They were (1) a commercially structured carrel equipped with a mirrow projection screen to observe slides from a slide projector (Howe Carrel); (2) a small rear screen slide-tape machine (Singer Caramate); and (3) a homemade peg board booth with a "mirra" front projection screen to observe slides from a slide projector.

At the conclusion of the course, the students were asked to rate equipment combination preferences. Most preferred the homemade peg board booths with the "mirra" projection screens. The "Singer Caramate" was not favored due to a depth-of-focus problem and because it was not equipped with a reverse control switch for the slides. The "Howe" carrel was downgraded because the 35mm slides could not be properly viewed in the vertical position since the mirrow screen was built to only show slides in the horizontal position.

After this study, the instructor was better able to understand the equipment needs for the course, and could more wisely purchase equipment combinations to match the instructional system and available room facilities.

By the time the course was taught again (Winter Quarter, 1975), a standard set of equipment combinations had been procured. The selection of each piece of equipment and furniture was based on the rationale that it was important to maintain the utmost flexibility, particularly in view of the rapidly changing technology of media resources. The learning materials and media resources were divided into two areas: (1) Presentation equipment; and, (2) Preparation equipment.

Presentation Equipment - Study Carrels

The booths or carrels were specially designed to reflect the findings of the equipment study (Figure 2). Commercially manufactured carrels could not be used in the room assigned to the course because it was equipped with stationary tables that were well suited to the other courses which used the room during other quarters. Furthermore, it was impractical to purchase expensive carrels that would be used only one quarter each year. The final design of the carrel was a three sided, "homemade," plywood structure designed to mount on top of the permanent tables.

Several features were considered in designing the carrel. It was built so that it could be folded and easily moved to serve different functions or to be placed in storage. The carrel sides came past the table edge far enough to "shield" the users from the adjoining carrels, thus, providing maximum privacy. Shelf space was provided for books and the slide projector which would have otherwise interfered with the students writing space. Holes were drilled in the back of each carrel through which the electrical cords for the slide and tape machines were

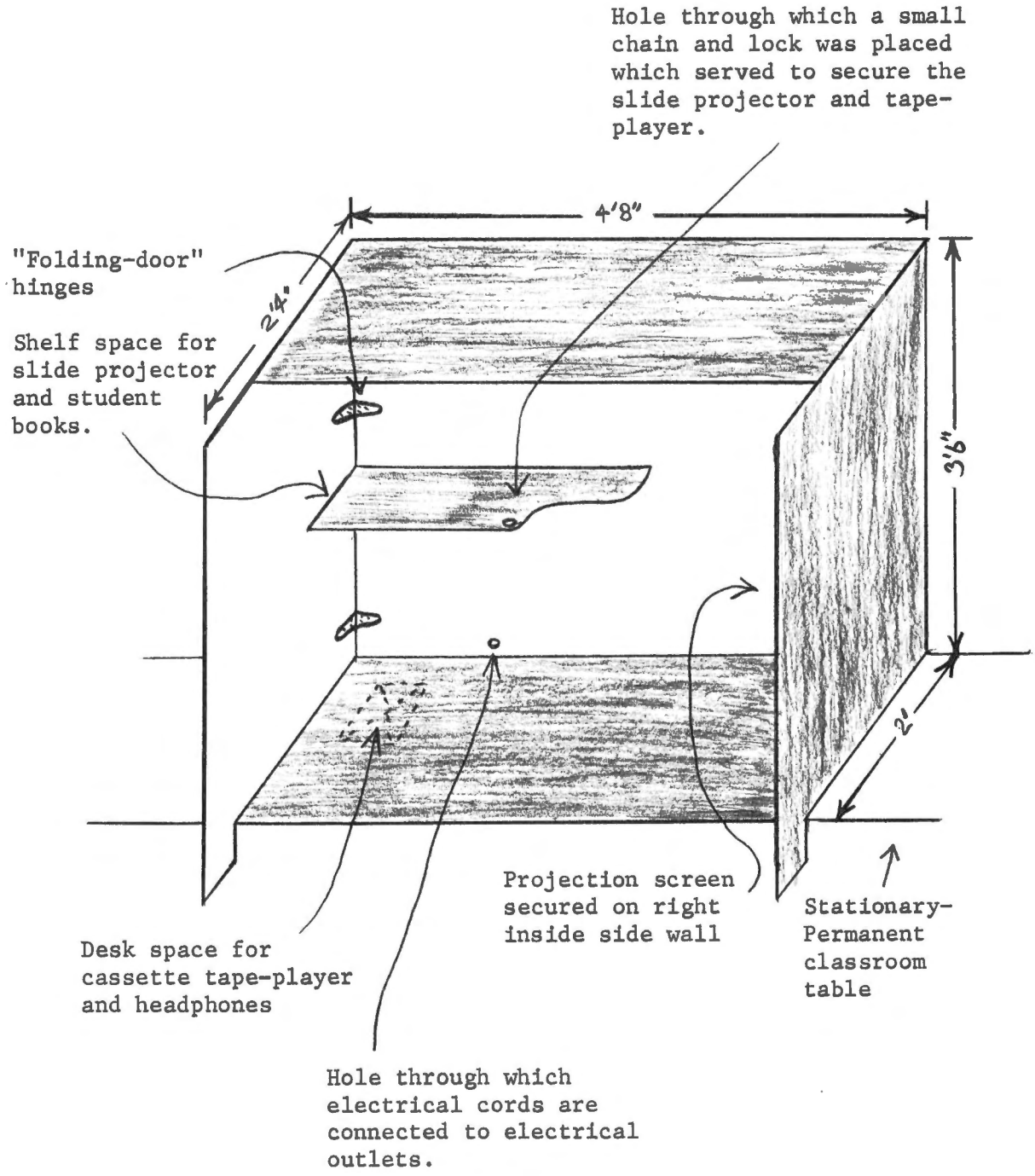

Figure 2. Sketch of carrel.

connected to electrical outlets. This eliminated the electrical cords from interfering with the students work space. Also, for security reasons, a small chain was placed through another hole drilled in the shelf through which the slide projector and tape player were secured with a lock. The six carrels were painted different colors on the outside while the interior of each carrel was painted light green, a color that minimizes glare and eye strain. The carrels were also designed for use with the "Sun-Master" projection screen which was taped to the side of the carrel.

Audio-Visual Equipment

Kodak Ektagraphic Carousel slide projectors with long life bulbs and various small cassette tape players were chosen for their rugged construction to withstand heavy use and their added flexibility for secondary use in group-paced presentations. The small tape-players could also be battery powered for use in outdoor instructional programs. The "Sun-Master" projection screen was chosen because slides could be clearly viewed on this material with the room lights remaining on. A carrel top was later constructed to improve defination by shielding the screen from the overhead lights. The screen material was easily installed and maintained, and was less expensive than rear view or mirrow projection techniques. Also this high-reflectance screen prevented possible loss of "defination" (unlike rear-projection screens) which is critical when slide detail is desired (i.e., armed umbo of pine cone). The slide image on this screen was very large (2' x 2'). This was accomplished over the short projection distance by using a three inch lense in the carousel slide projector. Audio tape cassettes and

35mm slides completed the list of audio-visual instructional materials used in the self-paced instructional system.

Preparation Equipment

The "Wollensak" cassette tape recorder was selected for cutting the master tapes. This high quality recorder had the ability of placing automatic pauses on the cassette tapes. A "Singer-Caramate" slide-tape machine was used in the instructor's office for monitoring and checking slide-tape presentations. A "Polaroid" photographic copying system was purchased to take indoor slides for the programs. This photographic system could make slides in minutes and was accompanied with a sturdy copying stand. The majority of the indoor and outdoor photographic work used a "Nikon" single lens reflex camera.

B. PREPARATION OF INSTRUCTIONAL UNITS

Eight minicourses or units were prepared for Forestry 3050: Dendrology and Silvics of the Gymnosperms. Each instructional unit evolved around slide-tape presentations to be observed in individualized study carrels. The course was divided into the following units: (1) Introduction of Gymnosperm Genera; (2) The Soft Pines; (3) The Eastern Hard Pines; (4) The Western Hard Pines and Nonnative Pines; (5) The Genera: Tsuga, Pseudotsuga, Larix, and Cedrus; (6) The Spruce and Firs; (7) Cupressaceae Family; and, (8) Taxodioceae Family.

Color slides were obtained on all the 87 species studied in the course. Each species had five to fifteen slides to show the general form of the tree, its native range, typical habitat, the bark, foliage,

cones, and other special features that might help with identification. The presentations varied from forty to eighty color slides per program. A total of 500 different slides were used in the eight instructional units. Six sets of each slide series were needed to serve the 100 students taking the course. This required more than 3,000 slides to establish the entire instructional system. Most slides were numbered with the aid of small "rub-on" numbers. This number was referred to in the audio portion of the tape. This enabled the student to synchronize the audio and visual portions of the program.

Two instructors wrote and taped the scripts used for the units. One instructor prepared units one and eight, and the other prepared units two through seven. After the first year of use, the tapes were revised and rerecorded. Each cassette tape was duplicated six times to provide a tape for each of the six study stations in the learning center. The nonstop listening time for each program was between 30 and 45 minutes. The instructors developed each unit or minicourse so that it would constitute one weeks material.

Another component of each unit was a printed workbook used by the students to facilitate note taking. The workbooks usually included the following sections: statement of objectives, introduction, classification and nomenclature, description of genera and species, questions, glossary, and dichotomous keys. The workbooks were organized in several different formats and varied in length from five to twenty-seven pages. Several included drawings and range maps while several others did not. All of the workbooks provided adequate space for note taking.

The last component was a series of exhibits for display with each instructional unit. The exhibits included cones, foliage mounts, potted trees, photographs, and charts. This material had been collected by several persons over a period of many years. During the period of this study, in the summer of 1974, a major collection effort was accomplished. Dr. Edward Buckner collected large quantities of gymnosperm cones and foliage material while working in the Pacific Northwest. John Palmer collected cones in the Central Rocky Mountains, and Dr. Ronald Hay added cones from the Southeastern United States. These collections helped make the exhibits an important part of the self-paced instructional system. Also, while on these travels, slides were taken to illustrate the trees of the region. These were a major contribution to the visual portion of each program. The absence of these slides would have created a major limitation in developing the teaching system.

C. OPERATIONAL PROCEDURES

Personnel

The senior instructor in charge of the course was the only instructor of professional rank. Other personnel needed to serve 100 students per quarter in Forestry 3050: Dendrology and Silvics of the Gymnosperms included one quarter-time forestry graduate teaching assistant, and ten forestry undergraduate student proctors.

The instructor had the overall responsibility for the course. His student contact time included lecturing one hour each week, meeting eight hours each week for discussion-quiz sessions, and scheduling two or three hours each week of contact time in the self-learning center.

He met one hour each week with the undergraduate proctors and one to two hours each week in briefing sessions with the graduate teaching assistant. He was responsible for writing four weekly written tests and he was responsible for grading these tests. He also conducted required class fieldtrips and optional weekend fieldtrips.

The forestry graduate teaching assistant was working on the Master of Science degree. He was required to formulate, administrate, and grade weekly practical quizzes. He met with the students, along with the instructor, eight hours each week in the discussion-quiz sessions. He was also responsible for preparing, setting up, and maintaining the weekly exhibits on display for each instructional unit, and he was responsible for setting up one booth each week as a guide for duplication by the undergraduate proctors. He was further responsible for disassembly and storage of the learning materials at the end of each weekly unit and at the end of the course.

The undergraduate student proctors were all required to have completed the course during a previous year. They were individually assigned to monitor the self learning center four hours each week. They were expected to listen to each slide-tape program so they would be prepared to answer questions from the students. Each proctor was also responsible for grading ten students "species description" notebooks.

The proctors were selected by the instructor on the basis of experience, potential capabilities, and the student's desire to work as a proctor. The undergraduate proctors received three hours credit and a grade as their remuneration.

The reaction of the proctors to the teaching approach was positive after the course was properly implemented. Most considered it an enlightening experience by: providing leadership responsibilities and experiences toward communicating and dealing with students, providing a "refresher" course in gymnosperm dendrology, providing experiences toward evaluating different students performance efforts, and providing a preview of the teaching profession.

Scheduling

The weekly schedule devised for Forestry 3050: Dendrology and Silvics of the Gymnosperms (three quarter hours credit) was: (1) a one hour lecture, (2) a two hour discussion-quiz session, and (3) an unscheduled session of one to two hours in the self-learning center, depending upon each students needs and desires.

The weekly lecture was the responsibility of the instructor. This group-paced session was used for introduction and orientation sessions, films, special guest speakers, slide presentations, and a series of lectures presented by the instructor.

Four weekly discussion-quiz sections (25 students each) were required to accommodate the class. The discussion-quiz sections were scheduled on Thursdays and Fridays. During this time the instructor and teaching assistant answered questions and administered both a written and a practical test. The written test was derived from lecture and slide-tape material and the practical test was derived from exhibit material. This time period was also used for one to two short field trip experiences each quarter to study native gymnosperms.

The unscheduled session in the self learning center was for the student to observe weekly slide-tape presentations. The students were allowed to reserve a station for one hour each week. After the learning center had been equipped with the weekly unit on Monday morning, the room was opened to the students and remained open for 40 hours which included two night sessions. Since there were six carrels in operation, the available time for student use totaled 240 carrel hours per week.

II. SECTION TWO - FORESTRY 3040: DENDROLOGY AND SILVICS OF THE WOODY ANGIOSPERMS

A. PREPARATION OF FIELD TRIP PROGRAM

One self-paced instructional unit was prepared for Forestry 3040: Dendrology and Silvics of the Woody Angiosperms. This fieldtrip program evolved around an instructor's tree identification commentary recorded on a portable tape player for use on a self-guiding nature trail. It was used by the students to supplement their weekly group-paced fieldtrips with the instructor.

The instructional system consisted of three components. The first was a nature trail. A section of university property located within easy walking distance of campus was chosen for the trail site. It was located along the "Cherokee Bluffs" overlooking Fort Loudon Lake and the Agricultural Campus of the University of Tennessee. The area was composed of a native hardwood forest and a planted Chinese Chestnut orchard. The trail was a loop approximately one-half mile in length. Yellow flagging on the trees and yellow posts in the ground were used

to identify the trails path. Two v-shaped gates were constructed through fences and the trail was improved over steep grades and rocky bluffs. Thirty-six different angiosperm tree species were found beside the trail. Seventy-two trees were marked along the trail. Each tree was taged with: (1) a number engraved in a plastic label (Phenolic Gravoply) which was nailed into the tree with one nonrusting aluminum nail; (2) yellow flagging around the trunk; and (3) small "dymo" tags by which half the trees were identified with their scientific name and half were classified as "quiz" trees.

The second component was the recorded commentary on two cassette tapes. The tapes were recorded by the instructor from a 40 page typewritten master script prepared as a part of this study. Seven lightweight, durable, and portable tape players with shoulder straps and earphones could be checked out by the students to listen to the program. (See page 63 for additional information on the tape script.)

The third component was a trail guide for student use along the trail. The guide included two maps and a few short written identification aids and illustrations about each of the 72 trees along the trail. Adequate space for note taking was also included. (See Appendix J.)

B. OPERATIONAL PROCEDURES

The tape players with the cassette tapes were distributed from three locations on campus: (1) the Forestry Department's Office, (2) the Agricultural Library, and (3) the Undergraduate Library. The Forestry Office provided recorders on a reserve system while the libraries provided recorders on a first-come-first-serve system.

During the first week of class, students visited the trail site for an orientation lecture from the instructor. Thereafter, they had five weeks in which to visit the trail and listen to the program. At the end of this period, a written quiz was administered to all students.

CHAPTER IV

EVALUATION OF TEACHING UNITS

An evaluation of this study is presented in this chapter in two sections. The first section evaluates the self-paced indoor instructional units prepared for Forestry 3050 (Dendrology and Silvics of the Gymnosperms), and the second section evaluates the self-paced outdoor instructional unit prepared for Forestry 3040 (Dendrology and Silvics of the Woody Angiosperms). Instructional units for each course are evaluated by: (1) student performance; (2) student satisfaction; and (3) implementation costs. Student performance and implementation costs are objective evaluation measures using performance test scores and cost comparison figures. Student satisfaction is subjective information tabulated from questionnaires completed by the students.

I. SECTION ONE - FORESTRY 3050: DENDROLOGY AND SILVICS OF THE GYMNOSPERMS

A. STUDENT PERFORMANCE

Student performance or achievement in the Dendrology and Silvics of the Gymnosperms course was evaluated by two studies. The first study compared the learning effectiveness of one of the eight self-paced instructional units used during the course with the same material taught in a group-paced setting. The second study evaluated the learning effectiveness of all eight of the self-paced instructional units used to

teach the laboratory portion of the course. This was accomplished by observing the final grade distributions of two classes that had completed the course using the self-paced instructional system.

Study One: Group-Pacing Versus Self-Pacing

The purpose of this study was to evaluate the level of learning (achievement) exhibited by students using a self-paced instructional unit in comparison to the same material taught using the traditional, group-paced method.

The population consisted of 94 students enrolled in Forestry 3050 (Dendrology and Silvics of the Gymnosperms) during the Winter Quarter of 1976.

The class was divided into two equivalent groups of 47 students forming an experimental group (self-paced) and a control group (group-paced). After the students were assigned to the groups, ten students (five from each setting) withdrew from the experiment leaving each group with $n = 42$. In order to assume equal abilities in the two groups, students were assigned to groups on the basis of their mid-term cumulative average test scores. Eight quizzes (four written and four practical) were averaged to rank students from highest to lowest. The students were paired to assure essentially equal performance levels and assigned to opposite groups. For example, the two students with the highest scores were randomly assigned, one in the experimental group and one in the control group, and so on down the rank. Next, by coin flip, one group was assigned to the group-paced, lecture setting and the other to the self-paced, slide-tape setting. By this stratification procedure, differences between the groups were minimized.

Selection of Unit for Evaluation

This study was restricted to evaluating the teaching effectiveness of only one of the eight self-paced instructional units used during the course. Time resources did not permit a study of the entire system. Furthermore it would have been unfair to the students to have two different instructional settings occurring during the same quarter for the entire course without knowing if there would be any significant differences between the two settings toward student achievement and satisfaction.

Unit six, "The Spruce and Fir Trees," was chosen as the weekly unit for experimentation inasmuch as it: (1) was considered to be a typical unit in the course which could facilitate possible comparisons with the other units; (2) was taught after midterm reports which would facilitate the statistical design of the study; and (3) was composed of the largest number of tree species taught in one weekly unit which would enable evaluation of one of the argued advantages of the audio-visual system; i.e., more material can be covered in a given time period.

Instructional Procedures Common to Both Groups

The purpose and design of the experiment was explained to the class one week before the study began. The students were told that if one group had a lower average score, their scores would be curved upward to match the group with the higher average score. Also, the students were aware from the first day of class that the lowest of their weekly quiz grades would be dropped. Thus, by these comparisons, the students were assured that the study would not adversely affect their final average grade.

The study was rigidly designed so that both groups received exactly the same instructional materials. The only variables between the two groups were the methods and times needed to present and use these materials. This required that the instructional materials be especially prepared such that they could be used with equal facility in both groups. Both groups were presented the following instructional materials: (1) a 27 page printed handout used to facilitate note taking (Appendix K); (2) a series of 2" x 2" slides used with a Kodak carousel slide projector; and (3) a collection of cones and leaf mounts.

The instructor's quantity of teaching material was greater than formerly taught on this subject matter. This was due to the more thorough preparation needed from the instructor to prepare the cassette-tape lecture.

The study was evaluated by means of a written post test and a practical post test which were administered simultaneously to both groups of students during the weekly lecture hour. The written and practical tests were given on the Tuesday following the week of teaching the two groups. The written test employed a variety of question types which were evaluated and approved by two forestry faculty members to ascertain that the test items were congruent with the instructional objectives and that the test was "fair" (Appendix F). The practical test had five cones for identification. Also, the effectiveness of learning in the two groups was further investigated by means of a retention test incorporated in the final practical exam during the last week of classes. This retention test followed two weeks after the weekly test on "The Spruce and Fir" unit.

Instructional Procedures of Control Group

The control group (group-paced) was taught the unit on the spruce and fir trees by the traditional, group-paced, lecture-demonstration method. This instructional method followed the traditional format used prior to attempts to implement the self-paced teaching technique. However, the format included updated and expanded teaching materials which had not been a part of the older group-paced teaching method. A description of this presentation format was as follows: (1) the instructor's presentation in the lecture setting was aided with over-head transparencies showing native ranges of each tree, and a series of eighty slides illustrating identification features and silvical characteristics of each tree; (2) the students were aided with a printed handout organized with appropriate topic headings to facilitate note taking as the instructor lectured; and (3) a collection of cones and foliage mounts were placed on exhibit for the students to study.

The group-paced students were taught during their regularly scheduled weekly quiz section. The normal quizzes given during this time were cancelled to allow for the experiment. The lecture took two hours to teach the material, whereas, in comparison, the same material was presented on the tape in 45 minutes. This teaching procedure involved presenting the same lecture four times during the week since there were four quiz sections per week. The members of the self-paced group did not attend these lectures.

Instructional Procedures of Experimental Group

The experimental group (self-paced) was taught the unit on the spruce and fir trees by the self-paced, slide-tape method. The experimental group used the same instructional materials that the control group used. The presentation format was changed by providing the experimental students with study carrels equipped with individual slide projectors, slides, and tape players with an audio-tape cassette directing them through a study sequence. Once again the students took notes on the same printed handout that those in the group-paced setting received, and studied the same foliage and cone exhibits.

The self-paced group used the instructional materials in six study carrels over a period of five days. Each student was guaranteed one hour of study time which he had reserved. The room was open 40 hours during the week which included two night sessions. The members of the group-paced setting were not allowed to use the carrels. Proctors enforced this rule by checking out the slide-tape program only to the self-paced students.

Statistical Analysis of Data

Paired t-test analysis was used to test for any significant differences between the self-paced setting (Experimental Group) and the group-paced setting (Control Group) as measured by written and practical post-tests and a practical retention-test.

For convenience, the group taught by the self-paced method hereafter is designated as the experimental group and the group taught by the group-paced method is the control group. The results are presented in Table I and Figure 3.

TABLE I

RESULTS OF CENTRAL TENDENCY, DEVIATION, AND PAIRED t-TEST ANALYSIS OF SIGNIFICANT DIFFERENCES BETWEEN SELF-PACED AND GROUP-PACED TEACHING SYSTEMS FOR THE "SPRUCE-FIR" UNIT

	Post-Test						
Test Group	Score Range	Mean	Standard Deviation	Mean Difference	Median	t-Values	Probability
Written (Total Possible = 100)							
Experimental-Self Paced (n = 42)	32-98	73.0	16.0		76.5		
				1.6		.2	N.S.*
Control-Group Paced (n = 42)	44-96	74.6	12.1		75.5		
Practical (Total Possible = 100)							
Experimental-Self Paced (n = 42)	0-100	85.5	27.3		100		
				1.9		.6	N.S.*
Control-Group Paced (n = 42)	0-100	87.4	27.1		100		
Retention-Practical (Total Possible = 6)							
Experimental-Self Paced (n = 43)	.5-6.0	5.0	1.4		5.5		
				.2		1.0	N.S.*
Control-Group Paced (n = 41)	0-6.0	4.8	1.4		5.0		

*N.S. indicates a nonsignificant difference at a level of .05 (95%).

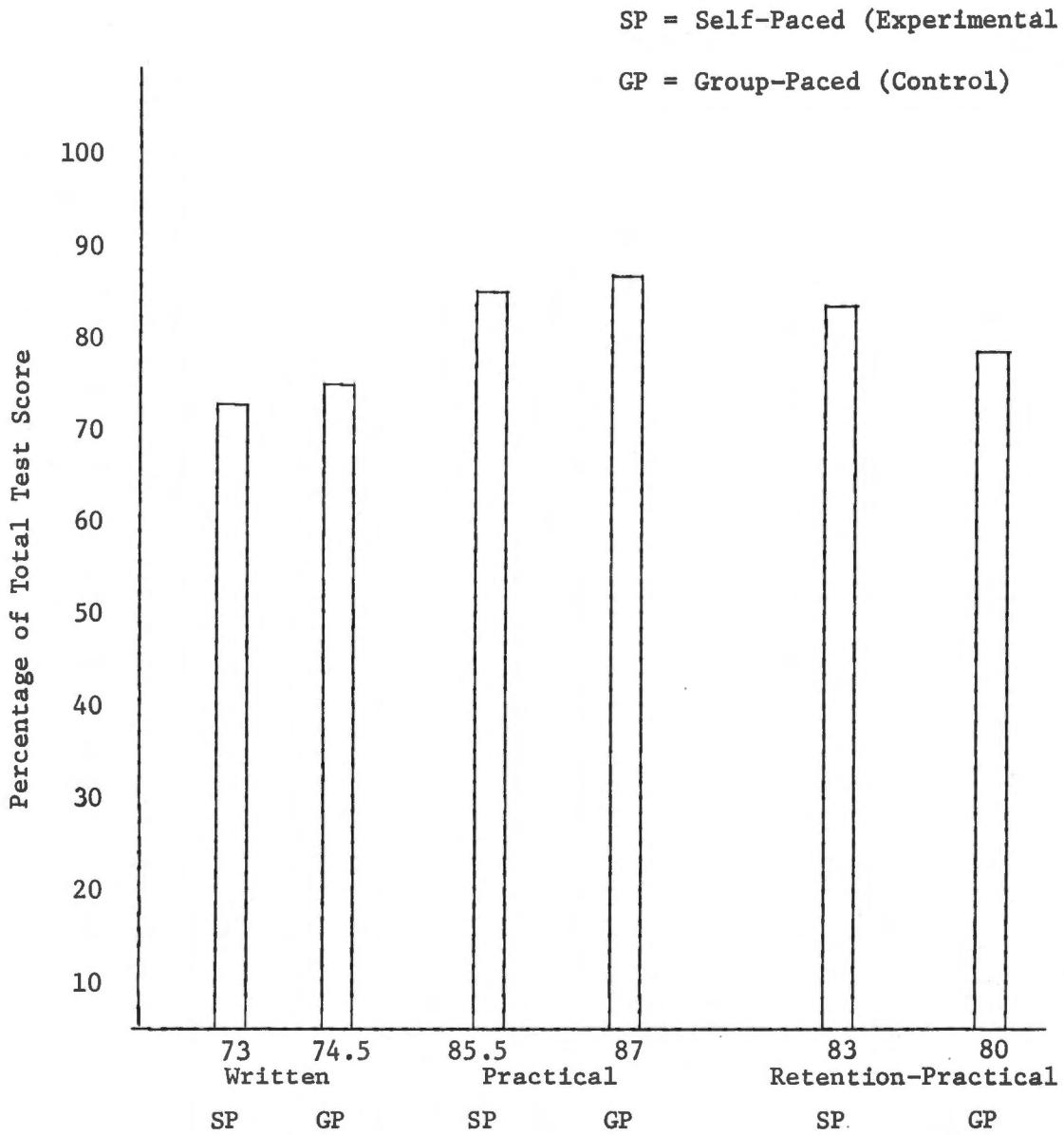

Figure 3. Mean scores of three test sets between the self-paced and group-paced instructional settings.

Written Post-Test Results

The written post-test scores for the control group ranged from 44 (one student) to 96 (one student) out of a possible 100. The mean score was 74.57 with a standard deviation of 12.07, and a median score of 75.5. The grade distribution was: 100 - 90, 7 percent; 89 - 80, 29 percent; 79 - 70, 38 percent; 69 - 60, 12 percent; and 59 - 0, 14 percent.

The experimental group ranged from 32 (one student) to 98 (one student) out of a possible 100. The mean score was 72.95 with a standard deviation of 16.04, and the median score was 76.5. The grade distribution was: 100 - 90, 14 percent; 89 - 80, 26 percent; 79 - 70, 26 percent, 69 - 60, 17 percent; and 59 - 0, 17 percent.

Comparing the differences between the groups, the mean score achieved by the control group (74.57) was slightly higher (1.62) than that of the experimental group (72.95). However, the median score for the experimental group (76.5) was slightly higher (1) than that of the control group (75.5). When the grade distributions were compared, the most prominent difference was 7 percent more students in the 100 - 90 category in the experimental group. When these results were analyzed by the "t-test for paired comparisons," none of the differences were significant.

Practical Post-Test Results

The practical post-test scores (identification quiz) for the control group ranged from 0 (2 students) to 100 (30 students) out of a possible 100. The mean score was 87.38 with a standard deviation of 27.06, and the median score was 100. The grade distribution was:

100 - 90, 74 percent; 89 - 80, 11 percent, 79 - 70, 5 percent; 69 - 60, 0 percent; and 59 - 0, 10 percent.

The experimental group ranged from 0 (2 students) to 100 (28 students) out of a possible 100. The mean score was 85.48 with a standard deviation of 27.34 and the median score was 100. The grade distribution was: 100 - 90, 74 percent; 89 - 80, 7 percent, 79 - 70, 2 percent; 69 - 69, 0 percent; and 59 - 0, 7 percent.

Comparing the differences between the groups, the mean score achieved by the control group (87.38) was higher (1.9) than that of the experimental group (85.48). The median score of both groups was 100 (58 students in total). When these results were analyzed by the "t-test for paired comparisons," none of the differences were significant.

Practical Retention-Test Results

The practical retention-test scores (identification quiz) for the control group ranged from 0 (1 student) to 6.0 (14 students) out of a possible 6.0 (100 percent). The mean score was 4.82 with a standard deviation of 1.4, and the median score was 5.0. The grade distribution was: 100 - 92, 37 percent; 91 - 83, 34 percent; 82 - 75, 5 percent; 74 - 67, 12 percent, and 66 - 0, 12 percent.

The experimental group ranged from 0.5 (2 students) to 6.0 (18 students) out of a possible of 6.0 (100 percent). The mean score was 5.0 with a standard deviation of 1.4, and the median score was 5.5. The grade distribution was: 100 - 92, 48 percent; 91 - 83, 34 percent; 82 - 75, 0 percent; 74 - 67, 7 percent; and 66 - 0, 11 percent.

Comparing the differences between the groups, the mean score achieved by the experimental group (5.0) was slightly higher (0.18) than

that of the control group (4.82). The median score for the experimental group (5.5) was higher (0.5) than that of the control group (5.0). When the grade distributions were compared, the most prominent difference was 11 percent more students in the 100 - 92 category in the experimental group. When these results were analyzed by the "t-test for paired comparisons," none of the differences were significant.

Study Two: Student Overall Grade Distributions

Student performance (achievement) was also evaluated by examining the students' final overall grade distributions. The grade distributions were taken from two classes which used the eight self-paced instructional units developed for Forestry 3050 (Dendrology and Silvics of the Gymnosperms). These courses were taught during the Winter Quarters of 1975 and 1976. In 1975, 109 students registered for the course, and in 1976, 108 students registered for the course.

The standard for grading was: 100 - 90, A; 89 - 80, B; 79 - 70, C;, 69 - 60, D; and 59 - 0, F. The grade distributions follow in Table II.

As stated, this study was limited to observing only the grade distributions for the self-paced instructional setting. An objective comparison of grade distribution with classes formerly taught by the group-paced instructional setting was impossible because of the various changes with instructors and their grading philosophies. However, a subjective comparison could be made from opinions from the instructors who had worked with the courses for many years. Their conclusions pointed to a dramatic improvement in grades with the new, self-paced instructional system.

TABLE II

GRADE DISTRIBUTIONS FROM TWO CLASSES WHICH USED THE SELF-PACED INSTRUCTIONAL UNITS DEVELOPED FOR THE DENDROLOGY AND SILVICS OF THE GYMNOSPERMS COURSE

1975			1976		
Grade	Number of Students	Percentage	Grade	Number of Students	Percentage
A	26	24%	A	32	30%
B	43	39%	B	34	31%
C	20	18%	C	10	9%
D	4	4%	D	5	5%
F	4	4%	F	8	7%
I	3	3%	I	4	4%
W	7	6%	W	13	12%
Audit	2	2%	Audit	2	2%
Total	109	100%	Total	108	100%

B. STUDENT SATISFACTION

Subjective measures of student satisfaction were tabulated from questionnaires given to students during the Winter Quarters of 1975 and 1976 in the Forestry 3050 course. The questionnaires were designed to determine the attitude of the students toward the self-paced instructional units.

The 1976 questionnaires were composed of different questions from those used in 1975 which reflected a change in the evaluation topics and an improvement in evaluation question types. The 1975 questionnaire was mainly concerned with evaluating the instructional materials and processes used to teach the self-paced units. Because this was the first year of developing and using the self-paced instructional units, it was important to receive feed-back from the students regarding the instructional materials and processes used to teach the course. The 1976 questionnaire was concerned with evaluating the students overall reaction toward the teaching and learning effectiveness of the self-paced instructional units.

Both evaluation questionnaires were given to the students during the last week of class. The students were told they did not have to put their names on the questionnaires. The 1975 questionnaire was completed by 75 students (75 percent participation). The 1976 questionnaire was completed by 72 students (76 percent participation).

The results from the two questionnaires are discussed separately and then compared. Following these sections, written student comments from the questionnaires are reviewed.

Each question in each category is considered in terms of over 70 percent favorable or unfavorable response, and between 50 and 69 percent favorable or unfavorable response. Items which did not receive above 50 percent student agreement are not discussed.

1976 Questionnaire Results

The 1976 questionnaire results are discussed in the following categories: (1) overall class evaluation, and (2) instructional materials and processes evaluation. All the 1976 student responses are shown in Appendix B.

Overall Class Evaluation

One item received over 70 percent favorable response. In this question 75 percent of the students rated the over-all value of the course from good to excellent.

To the items receiving between 50 percent and 69 percent favorable response, 59 percent of the students rated their attitude toward the self-paced teaching units from good to very good; 50 percent of the students thought that, in comparison with group instruction courses, generally, their enjoyment of this one was greater; 64 percent of the students thought, that in comparison with group instruction courses, generally, their tendency to memorize details was greater; 51 percent of the students agreed that their study habits improved as the term went on; and 68 percent of the students agreed that their confidence in their ability to master the weekly units increased as the term went on.

Students agreed, that in comparison with group instruction courses: the amount of work required by this course was about the

same (51 percent); the degree of pressure to do the work of this course was about the same (59 percent); the recognition of each peron as an individual in this course was about the same (51 percent); the likelihood of cheating was about the same (56 percent); the temptation to cheat was about the same (57 percent); and, the feeling of achievement generated by passing tests was about the same (49 percent).

Instructional Materials and Processes Evaluation

To the items receiving over 70 percent favorable response, 95 percent of the students thought that the audio-visual equipment and study carrels used in the course were effective; 77 percent of the students thought the size of the weekly units were about right; 82 percent of the students considered the student proctors helpful; and 78 percent of the students thought the lab room was open an adequate number of hours each week.

One item received between 50 percent and 69 percent unfavorable response. In this question 55 percent rated the "species description sheet" assignments from weak to poor (Appendix B).

1975 Questionnaire Results

The 1975 questionnaire results are discussed in the following categories: (1) general class questions, (2) audio-visual equipment, (3) lab hours, (4) workbooks, (5) audio cassette tapes, (6) slides, (7) exhibits), (8) proctors, (9) field trips, (10) lab (practical) testing, and (11) lecture (written) testing. The 1975 student responses are shown in Appendix C.

General Class Questions

To the items receiving over 70 percent favorable response, 88 percent of the students agreed that the teaching format was helpful in the learning experience and process; and 72 percent of the students agreed that the self-paced teaching units allowed each student to select a more flexible study pace to progress at his own rate.

To the items receiving between 50 and 69 percent favorable response, 50 percent of the students thought they were able to learn more under the slide-tape system in comparison to a conventional lecture-lab system; 52 percent of the students said they would like to see this system adopted for other forestry courses; and 69 percent of the students agreed with this quotation, "Education is not something one receives from others, but rather something one gives to ones-self--everyone is essentially self-taught," with 87 percent of these students agreeing that this teaching technique was used adequately in the course. Fifty-six percent of the students disagreed with the statement that the self-paced instructional system made it easier to procrastinate. Sixty-five percent of the students did not want more slide-tape units incoporated in the ongoing course.

Audio-Visual Equipment

The equipment used in 1975 was different from that used in 1976. To the items receiving between 50 and 69 percent response, 57 percent of the students favored the box screens in combination with the Kodak Carousel slide projectors; 61 percent of the students thought the small earphones were adequate; 61 percent of the students said they were

unable to use the equipment at sometime because it was broken; and 53 percent of the students said they were unable to use the equipment at sometime because it was in use.

Lab Hours

To the items receiving over 70 percent response, 83 percent of the students said they would prefer the room open additional time; and 80 percent of the students said that considering credit and course objectives, the amount of laboratory work required outside of the class room (i.e., completing the species description sheets) was too much.

To the items receiving between 50 and 69 percent response, 63 percent of the students wanted more than one night opening per week; 61 percent of the students did not use the one night opening; and 55 percent of the students agreed that the one hour per week they had a station reserved was an adequate amount of time to complete the slide-tape assignment; and 68 percent of the students said they would have preferred additional time reserved for review.

Workbooks

To the items receiving over 70 percent response, 77 percent of the students said they would prefer more visual aids (drawing, etc.) in the workbooks; and 90 percent of the students thought it was helpful to print a listing of the slides in the workbooks.

To the items receiving between 50 and 69 percent response, 57 percent of the students said the workbooks sufficiently explained the material; 52 percent of the students preferred the unit workbook that went into the greatest detail (Cupressaceae Family Unit) over the

shorter workbooks done for the other units; and 63 percent of the students preferred to have a complete description of each species in the workbook as was done with the Cupressaceae Family workbook.

Audio Tape Cassettes

To the items receiving over 70 percent response, 72 percent of the students said the tapes sufficiently explained the material; and 83 percent of the students thought the tape lengths were generally about right for the material covered.

To the items receiving between 50 and 69 percent response, 56 percent of the students said the silvical characteristics were adequately discussed; 69 percent of the students said the diagnostic identifying characteristics were covered adequately; 65 percent of the students thought the tape quality needed improvement; 68 percent of the students agreed the speed of the Cupressaceae Family tape (fastest tape prepared) was fast but acceptable due to the stop and replay ability of the tape players; and 69 percent of the students agreed that the speed of the other units was about right.

Slides

Ninety-one percent of the students agreed, in general, that the slide quality was satisfactory.

To the items receiving between 50 and 69 percent favorable response, 67 percent of the students agreed, in general, the slides were satisfactory for learning identifying characteristics; and 67 percent of the students also agreed, in general, the slides were satisfactory for learning the sites and silvical characteristics.

Exhibits

To the items receiving over 70 percent favorable response, 86 percent of the students agreed the exhibits (cones and foliage mounts) were easily located and adequately marked; and 100 percent of the students agreed the exhibits were pertinent to the materials being studied.

Proctors

Seventy-two percent of the students gave an unfavorable rating of the seniors helpfullness in learning the course material.

Fifty-six percent of the students were not satisfied with the way the proctors graded their species description sheets.

Field Trips

Ninety-three percent of the students agreed the field-trip to the Cherokee Woodlot was beneficial. Ninety percent of the students asked to have more field trips incorporated within the course.

Fifty-six percent of the students participated in the optional weekend trip to the Smokies and of those who participated in the optional weekend trip to the Smokies, 98 percent felt the trip was worthwhile.

Lab (Practical) Testing

To the items receiving over 70 percent favorable response, 73 percent of the students agreed the selection of the test materials for the lab practical quizzes were appropriate in terms of the course objectives; 93 percent of the students agreed the testing method was fair to all students; and 88 percent of the students agreed the tests reflected the objectives of the laboratory portion of the course.

Lecture (Written) Testing

To the items receiving over 70 percent favorable response, 70 percent of the students preferred weekly quizzes; 71 percent of the students thought the weekly quizzes gave a balanced treatment to the materials covered; and 83 percent of the students said they did not want comprehensive tests covering back materials.

Sixty percent of the students rated the clearness of the test questions from good to excellent.

Comparing the 1975 and 1976 Questionnaires

Because of the 1975 and 1976 questionnaire were composed of different questions, there could not be a direct comparison of questions, however, the questionnaires did overlap on several topics which could be compared.

Overall Class Evaluation

In 1975, 88 percent of the students agreed that the teaching format was helpful in the learning experience and process. A similar question in 1976 gave similar results, here 75 percent of the students rated the overall value of the course from good to excellent.

In 1975, 50 percent of the students thought they were unable to learn more under the slide-tape system in comparison to a conventional lecture-lab system. The 1976 class had 50 percent of the students agree that in comparison with group instruction courses, generally, their enjoyment of this one was greater.

Proctors

A major difference in student opinions occurred from 1975 to 1976 with regards to the use of undergraduate, upper classmen as "student proctors." In 1975, 72 percent of the students considered the student proctors unhelpful in aiding the learning of the course material. However, in 1976, 82 percent of the students considered the student proctors helpful. The difference in opinions possibly could be attributed to a change in the proctor's responsibilities, and because the 1975 proctors were unfamiliar with the new self-paced teaching system, whereas, the 1976 student proctors were familiar with the self-paced instructional system because this was the system their course had used the year before (1975). Also, the course instructors were able to devote more time working with the proctors in 1976.

Lab Hours

A difference in student opinions also occurred with regards to the amount of time the lab room was left open. In 1975, 83 percent of the students said they would prefer the room open longer hours, and 63 percent of the students wanted more night openings. In 1976, 78 percent of the students thought the lab room was open an adequate number of hours each week. This change possibly occurred by opening the lab room one additional night each week and opening during two supper hours each week (5 - 7 p.m.).

Species Description Sheet Assignment

The students gave an unfavorable response to the "species description sheet" assignments both years. In 1975, 80 percent of the students

said that considering credit and course objectives, the amount of laboratory work required outside of the classroom (i.e., completing the species description sheets) was too much, and 56 percent of the students were not satisfied with the way the proctors graded the assignments. In 1976, student opinions of the assignments had improved, though they were still unpopular. Fifty-five percent rated the assignments from weak to poor (Appendix H).

Student Comments

In general, students who did well gave the teaching method positive comments; those who did not gave the teaching method negative comments. Frequent negative comments included: "There is not enough exposure to the tree in its natural setting as would be the case in having more outdoor labs . . . the only way to learn trees is to see them where they grow; the species description sheet assignments were too much busy work and were poorly graded by the student proctors; there needs to be more opportunities (field trips, time in lab) for a "live" professor to impart his knowledge to the students; too much of the course is pure memorization." Positive comments included: "It is good to select your own lab time and repeat the slide-tape show as many times as you want to; the course was presented so that I was able to adapt and improve after a bad start; the species sheets will be good reference material in the future; the weekly examination was good motivation." One student summarized his feelings toward the course in this manner, "I recognize this particular course is very difficult to conduct in an adequate manner due to the inaccessability of the tree species

under study. With this handicap, I feel that the instructor is making a sincere effort to make the course as effective as possible. I feel the self-paced, slide-tape system is the best for this course . . . I'm not saying that there isn't room for improvement (tapes, slides, workbooks, etc.), but I feel the self-paced method is a good start in the right direction."

C. IMPLEMENTATION COSTS

The equipment expenditures needed for the Dendrology and Silvics of the Gymnosperms course (Forestry 3050) are presented in Table III. These expenditures are presented for both the self-paced instructional setting and the group-paced instructional setting formerly used to teach the course.

Equipment costs for the self-paced and group-paced settings were obviously different with regard to initial expenditures, since far more was required for the self-paced setting. A constant fixed cost in both settings was the salary of the instructor and teaching assistant. However, it did require a tremendous amount of labor to implement the self-paced instructional system since many of the instructional materials (slides, tapes, workbooks, carrels, etc.) had to be created and generated completely by the instructor and teaching assistant (on and off for three years).

Cost effectiveness accountabilities are very difficult to evaluate. Unfortunately, there is no formula which can accurately tell if the additional investment was worth it, since the state of the art is such that we do not know what all the important variables may be.

TABLE III

EQUIPMENT COSTS FOR TWO TEACHING SYSTEMS IN THE DENDROLOGY AND SILVICS OF THE GYMNOSPERMS COURSE

Equipment	Self-Paced Setting	Group-Paced Setting
Audio	56 Audio cassette tapes @ 72¢ = $40.32	--
	Duplication costs $64.00	--
	Total $104.32	
	Salary of instructor and Teaching assistant ?	Salary of instructor and Teaching assistant ?
Visual	48 Sets of 2" x 2" slides = $700	8 Sets of 2" x 2" slides = $115
	8 Workbooks per student @ $2.00 - 100 students = $200	--
	Total = $900	
Presentation	6 Study carrels with audio-visual equipment (slide projectors, screens, tape players, and headphones)	1 Slide projector = $130 1 5' x 5' screen = 25 1 Overhead projector = 100
	Total = $1,321	Total = $255
Preparation	Tape recorder = $275	--
	Caramate slide-tape projector for instructor's office = 282	--
	Photography equipment (equal costs for both settings)	

Instructional materials costs, personnel costs, maintenance costs, utilities costs, and depreciation costs can be obtained. However, for example, it is more difficult to evaluate the worth of improved student learning, reduced failure rate, improvement in student and faculty attitudes, reduction in time requirements, increased retention of brighter students, increased faculty-student direct contact, etc.

II. SECTION TWO - FORESTRY 3040: DENDROLOGY AND SILVICS OF THE WOODY ANGIOSPERMS

A. STUDENT PERFORMANCE

One self-paced, outdoor-fieldtrip instructional unit was developed for Forestry 3040 (Dendrology and Silvics of the Angiosperms). This unit supplemented the traditional, group-paced lecture and laboratory-fieldtrip teaching format used in the course.

Student performance (achievement) on the self-paced instructional unit was evaluated by examining the students' grade distributions after a written post-test was given to all the students.

The post test was administered during the fifth week of the on-going course during the Fall Quarter of 1975. All 141 students who completed the course were required to take the post test inasmuch as it counted 10 percent of their final grade. Because there were four laboratory-fieldtrip meeting times per week, the testing procedure involved giving four different written post tests. All four tests had twenty multiple choise questions which were equivalent in their degree of "hardness." Care was taken to ascertain that the test items were

congruent with the instructional objectives and that the tests were "fair" (Appendix G).

The standard for grading was: 100 - 90, A; 89 - 80, B;, 79 - 70, C; 69 - 60, D; and 59 - 0, F.

The grade distribution was: 44 A's (31 percent); 35 B's (25 percent); 31 C's (22 percent); 13 D's (9 percent), and 18 F's (13 percent).

B. STUDENT SATISFACTION

Student satisfaction in Forestry 3040 (Dendrology and Silvics of the Woody Angiosperms) was evaluated by two studies. Both studies were subjective measures of student satisfaction designed to determine the attitude of the students toward the self-paced, outdoor-field trip instructional unit prepared for the Cherokee Bluff trail. The first study evaluated student satisfaction from questionnaires given to the students during the Fall Quarters of 1974 and 1975. The second study evaluated student satisfaction and preferences toward three different recording styles from written critiques and discussion sessions with eight volunteer students during the Fall Quarter of 1974.

Study One: Questionnaires

The 1974 questionnaire was composed of seven questions, whereas, the 1975 questionnaire was expanded to 26 questions. Both questionnaires were given to the students during the last week of class. The 1974 students were told they did not have to put their names on the questionnaire. The 1975 students were asked to put their social security number on the questionnaire. The 1974 questionnaire was completed by

84 students (70 percent participation). The 1975 questionnaire was completed by 134 students (95 percent participation).

The results of the two questionnaires are discussed separately and then compared. Following these sections, written student comments from the questionnaire are reviewed.

Each question in each category is considered in terms of over 70 percent favorable or unfavorable response, and between 50 and 69 percent favorable or unfavorable response. Most items which did not receive above 50 percent student agreement are not discussed.

1975 Questionnaire Results

The 1975 questionnaire results are discussed in the following categories: (1) general questions; (2) audio cassette tapes; (3) trail guide; (4) equipment distribution and operation; and (5) post test. All the 1975 student responses are shown in Appendix D.

General Questions

To the items receiving over 70 percent response, 99 percent of the students agreed the teaching format helped the learning experience and process; 80 percent of the students agreed they would like to have more tape programs at other locations; 91 percent of the students said the lectured, orientation fieldtrip to the Cherokee Bluff trail was good; 89 percent of the students tried to identify trees by the "quiz tree" idea on the trail, with 90 percent of these students agreeing it was an effective way to learn trees; 59 percent of the students said they would like to have a "late autumn" or "winter" tape program with

bud descriptions and without leaf descriptions (another 34 percent said they liked the idea but probably would not have time to use it during the ongoing course); and 81 percent of the students said they would recommend that students use the trail in groups of two or three people.

Several questions had the student responses divided such that none of the items received above 50 percent agreement. These included questions 1, 2, 4, 9, and 10 in Appendix D. Questions 1 and 2 asked the percentage of time each student spent on the trail and the percentage of time spent listening to the tape, while not on the trail. The results for time spent on the trail were: none (13 percent); one hour (8 percent); two hours (30 percent); three hours (25 percent); four hours (11 percent); and more than four hours (13 percent). The results for time spent listening to the tape while not on the trail were: none (27 percent); one hour (24 percent); two hours (30 percent); three hours (9 percent); four hours (7 percent); and more than four hours (3 percent).

Audio Cassette Tapes

To the items receiving over 70 percent response, 86 percent of the students agreed the silvical characteristics were adequately discussed; 87 percent of the students agreed the diagnostic identifying characteristics were covered adequately; 77 percent of the students thought that considering the "stop and replay" ability of the tape the speed was about right; 85 percent of the students rated the tape quality and speaker's voice (Dr. Buckner) good to adequate; and 91 percent thought the tape sufficiently explained the material.

One item received between 50 and 69 percent response. In this question 69 percent generally thought the tape length was about right for the material covered.

Trail Guide

Ninety-five percent of the students agreed the trail guide was sufficiently helpful with maps and tree identification aids, while 54 percent of the students said it would be all right to put more visual aids (drawings, etc.) in the trail guide though it was not necessary.

Equipment Distribution and Operation

At various times, students were unable to use the equipment because: batteries went dead (8 students); tape player was broken (1 student); cassette tape was broken (5 students); and equipment was unavailable (26 students).

When checking out the equipment, 37 percent of the students only needed the cassette tapes because they had access to a personal tape player. Sixty percent of the students needed a tape player and the cassette tapes.

The students used the equipment distribution places in the following amounts: Forestry Offices - 36 percent, Agriculture Library - 28 percent, and the Undergraduate Library - 39 percent.

Post Test

Sixty-eight percent of the students rated the fairness of grading from very good to good.

1974 Questionnaire Results

The 1974 questionnaire results are discussed in one category: general questions. All the 1974 student responses are shown in Appendix E.

General Questions

To the items receiving over 70 percent response, 98 percent of the students agreed the program aided the learning experience in some way; 87 percent of the students said they would like to see more nature trails with taped tree identification programs; 86 percent of the students recommended that the future teaching format of the course should include both lectured fieldtrips and tape programs; and 100 percent of the students thought the tape sufficiently explained the material.

To the items receiving between 50 and 69 percent response, 68 percent of the students said the speakers voice (John Palmer) was good; and 56 percent of the students said the tape length was too long.

The percentage of time each student spent on the Cherokee Bluff tape program was as follows: one hour (2 percent); two hours (36 percent); three hours (42 percent); four hours (17 percent); and more than four hours (3 percent).

Comparing the 1974 and 1975 Questionnaires

Six of the 1974 questions overlapped with similar 1975 questions and could be compared.

General Questions

In 1974, 98 percent of the students agreed the teaching format (trail tape) helped the learning experience. A similar question in 1975 gave similar results with 99 percent of the students agreeing the teaching format (trail tape) aided the learning experience.

In 1974, 87 percent of the students said they would like to see more nature trails with taped tree identification programs. In 1975,

students gave a similar response with 80 percent wanting more taped programs at other locations.

In 1974, 2 percent of the students recommended the course only use taped programs without lectured fieldtrips. In 1975, none of the students gave this recommendation. In 1974, 12 percent of the students recommended the course use only lectured fieldtrips without tape programs. Seven percent of the students agreed with this in 1975. In 1974, 86 percent of the students thought the course should use both lectured fieldtrips and tape programs. In 1975, the students were divided on this recommendation: 46 percent recommended more lectured fieldtrips than tapes; 10 percent recommended more tapes than lectured fieldtrips; and 37 percent recommended half and half.

Audio Cassette Tapes

One hundred percent said the tape sufficiently explained the material in 1974. In 1975, 91 percent of the students gave the same response.

A major difference in student opinions occurred from 1974 to 1975 with regards to the length of the taped lecture. In 1974, 56 percent of the students said the tape length was too long. However, in 1975, 69 percent of the students thought the tape length was about right for the material covered. This difference in opinions could be attributed to a revision in the tape program which shortened the program by thirty minutes.

Student Comments

All the student comments are presented in the following divisions. Positive comments included these:

> "I liked the idea because you could stop, replay, and digest the material; it allows the student to learn outside of class, on his own, at his own pace, without being rushed along; I enjoyed the taped program as a supplement to the lectured fieldtrips, especially since the fieldtrips were over-crowded; the audio-approach allows a second review of the trees after the lectured fieldtrip; in the field lectures you can miss a great deal because of the large lab sections; the taped program is a good idea for those who may miss the fieldtrip itself; the quiz trees were helpful; good idea to stop along the trail and try to identify the 'quiz trees;' need to develop more tapes for different trails because this teaching technique was helpful to me; you could get out and study the trees on your own time and not have to rush; the tape idea gives ample time to study the trees well; a second trip alone to study the trees was very helpful; tapes and field lectures are good ideas when used in combination and are easily accessible to the student; labeling the trees was a good idea for collecting leaves; good job - I'm sure a lot of hard work and time was put into every aspect of the trail-phase of the course."

Several students were complimentary and at the same time cautious with their favorable comments, such as:

> "tapes are beneficial in that they provide the basic information needed for identification and natural history, however, they can not take the place of a lecturer in helping to problem-shoot confusing species (especially for deviant trees that are not characteristic); the tapes were a good supplement but I think you do need an instructor on many fieldtrips in order that a student can ask questions that come immediately to mind - this generates more interest than impersonal tapes; the idea itself is excellent, however, lectured fieldtrips are necessary if nothing else, to maintain personal contacts with the instructor; the tapes were fine if you couldn't get it in class, but I prefer to have someone there to add in little things that the instructor wouldn't have time to put on tape; the identification tapes are very useful, however, a tape is physically limited by time (only a specific number of things can be said about each species) which allows only the major characteristics to be discussed."

Not providing enough equipment was a chief source of negative comments, such as:

> "Please more tapes - it was too difficult to get hold of the tapes; twice I went to check out a tape player but none were available; if a tape system is used, have more tapes and recorders made available for the students - I personally went five times to the libraries and forestry office and could not get a recorder; tapes are not readily available by the reserve system - either provide more tapes or have no reserve; if more trails are set up, much more equipment would be necessary."

Additional various comments included these:

> "Transportation to trail is difficult for people who have to walk; stress the importance of using the tapes more; work more on the trail to improve it - some tree markings were missing; too much comment on the tape was not related to visible characteristics, thus, it made the program too lengthy; make it clear what the test will be about before it is given; I would like another tape and handout covering trees on one of the trails in the Smokies (i.e., Noland Divide Trail); the location of the program was great because we could learn about the trees on their natural sites - the site factors on the tape were well demonstrated; I think the Cherokee Woodlot should also have a tape program because this is a perfect place to learn about tree sites in their natural settings; transcripts of the tapes should be provided in the reserve section of the library; you should realize that with this system some students may not follow the entire trail or may not go at all - instead they may just take the tapes back to their dorm rooms and listen to them in comfortable surroundings while cramming for the written test (I realize they are only hurting themselves by not getting out on the trail)."

Study Two: Evaluation of Recording Styles (1974)

When the tree identification tapes were first being prepared for the outdoor nature trail, it was not known what recording style would be received best by the students. To help answer this question a small study was designed to evaluate three different recording styles.

The study was composed of eight volunteer students during the ongoing Angiosperm course during the Fall Quarter of 1974. The students

were a representative sample of the different types of students who regularily take the course. The study included: one female, one graduate student, one military veteran, and one "repeat" student. There were six forestry majors and two nonforestry majors. All eight of the volunteer students were exempt from the usual course assignment of making a leaf collection.

The three recording styles can be characterized in the following manner: (1) Tape one was the instructors (Dr. Buckner). The tape included no music and had a formal presentation style. (2) Tape two was by the graduate teaching assistant (John Palmer). The tape included beginning and ending music and had an informal presentation style. (3) Tape three was done by the Agricultural Communications Department at the University of Tennessee with a professional radio announcer. The tape had continuous background music and a semi-formal presentation style.

All three tapes used a 40 page type-written master script prepared by this writer to cover the 71 labeled trees along the nature trail. The Communications Department had a professional script editor revise and shorten the original script to 30 type-written pages.

The students listened to the tapes in different sequences and were asked not to discuss the tapes among themselves. Each student turned in a written report on his opinions and then the entire group met for a group discussion session.

The edited results are presented under: (1) student written comments; and (2) group discussion conclusions.

Student Written Comments

Music. Continuous music used throughout the tape received negative comments from all the students. Opening and closing music was considered a good idea by all the students.

Music comments included these:

1. "The music proved to be distracting when used throughout the tape. This caused my mind at times to listen to the music rather than the voice. Without music, I could understand what was spoken better."

2. "The music in the Communication Department's tape is too loud in the context of the material. This becomes distracting at times. My own personal feelings are that anything which may hamper concentration on a subject where 100 percent concentration is required should be avoided. However, music at the beginning of the tape is alright."

3. "The Communication Department's tape reminded me of a soundtrack to a Walt Disney film. I did not agree with the idea of the forest being 'enchanted.' Snowwhite did not appear once! The music was simply not desirable."

4. "The music is not helpful when used as a background to the speaker's voice because it makes you sleepy. I do think music at the beginning and end of the program is appropriate."

5. "From fanfares to ring-ding Christmas music - none of this diversity of music types was appropriate when trying to learn the trees. When I go to the woods, I don't take a radio. I prefer quietness with perhaps idle talk or meaningful conversation. The purpose of this tape, as I see it, is to stimulate meaningful conservation with a guide covering local flora, geographical points of interests, and other useful information relevant to the trail. The student's concentration should not be forsaken for a transistor radio in the background. Music in the background is not my personal preference."

6. "The musical interludes are often simply annoying."

7. "The music was distracting and only added time to an already 'too long' program."

8. "The opening music was a good idea for all the tapes. However, the Communication Department's music throughout the tape reminded me of a 'C-movie' - the selection was poor."

Presentation Format

The students provided many comments concerning the quality of the tapes and the style in which they were done. Some of their more important comments were:

1. "I liked Dr. Buckner's tape the best because there was no music and because it sounded professionally done - like an actual lecture. I found myself on the other two tapes 'wishing they would hurry up' in places. They were just too long. I would rather get out there and get down to business as Dr. Buckner's tape did, especially when it is cold or rainy."

2. "I felt that Dr. Buckner's voice was the easiest to follow. I found that I could retain more of what he said than I could with the other speakers. Perhaps this is merely a matter of him being the 'teacher.' I think, that during the quarter one develops great listening power toward the familiar voice of your teacher."

3. "Dr. Buckner's tape had the best presentation format. John's script was better basically because he adds in a little humor."

4. "The radio announcer said everything clearly, smoothly, and without flaws - very professional. This is an unreal situation when you are walking through the forest with anyone - be he an authority or a local Joe. I feel more like listening to a person talking - as on John's tape. John's voice keeps me interested. His tape is more informal, yet authoritative. What I appreciated most, in the informal atmosphere, was the addition of side comments - the short jokes and the addition of small facts such as the information about acorn bread, leached buckeye meal, spring tonic concoctions, and hay fever stimulants. This broke the barrage of facts with a little local color which helps me remember the tree better. Also, the description of prominent woody vines and shrubs, as well as important local geologic factors answered questions that immediately came to mind.

I thought Dr. Buckner's tape was a great improvement over the Communication Department's tape. The information given didn't sound as 'off-the-cuff,' as John's, but it was interesting and authoritative. Dr. Buckner sounded like the authority he is. The speech was alittle formal, but that's the way Dr. Buckner speaks on a hike. I think, formality should be left to classrooms with 100 or more people. Local color in speech is one of the few unsynthetic things in our country. I believe in it strongly. I think most people in Forestry appreciate it."

5. "The person from the Communications Department was unfamiliar with the material and the results could be seen in the tape. Being unfamiliar with the scientific names, he 'chopped-up' the words and mispronounced them which is very distracting. His unfamiliarity with the material could also be felt by the way he hesitated over the material discussed. Also his voice was simply dull.

Dr. Buckner's tape was informative. It contained much useful information regarding the trees, and was 'pleasingly shorter' than the other tapes. However, I preferred John Palmer's tape the most because his voice was easiest to listen to. What he said on the tape had much useful information and some comic relief. However, its main fault was its length. It was too long for the number of species covered."

6. "Dr. Buckner's tape was the clearest and best presentation, but a little more enthusiasm would have been nice. The information he presented was generally good and was not in over-abundance as to make it difficult to digest.

John's voice indicated interest and personality throughout the entire program, but lacked professionalism and was sometimes too soft to be understood clearly.

The radio announcer's voice was too professional and lacked any personality. The monotone voice pattern definitely did not stimulate my interest."

7. "The pace set by John in explaining the different species was the best of the three tapes. He allowed time to digest the material. His drawl was a little slower and he paused between sentences. He does not have a monotonous tone to his voice. His attitude was lively and interesting throughout the tape."

Group Discussion Conclusions (1974)

After the eight students had listened to the three different tapes and had written their critiques about the tapes, they meet with the instructor and graduate teaching assistant for a group discussion session. The group established the following findings.

Regarding Recording Styles

1. The students observed that they were the most at east with a tape that had their instructor's boice. They agreed they had developed a "listening power" to the familiar voice of their particular teacher as the quarter progressed.

2. The students did not like continuous music used throughout the tape. They thought opening and closing music on the tape was a good idea.

3. The students agreed that "beeps" and "musical interludes" were unnecessary to direct one on to the next station.

4. The students agreed that an enthusiastic, varying, conversational tone of voice was best.

5. The students preferred a moderately rapid speaking rate, since one can listen faster than the average person talks. The slower student could always stop and restart the tape.

Regarding the Overall Program

1. The students agreed that additional tape players should be bought to ease their availability.

2. The students agreed that tape players and cassettes should be located in several locations across campus to ease their availability. They recommended the Agricultural Library and the Undergraduate Library in addition to the Forestry Department's office.

3. The students suggested that long-life batteries be used in the tape players and battery charge checkers be purchased to insure that the student's tape player does not go dead while on the trail.

4. The students were for "professionalism" with regards to script editing and revision to improve and shorten the tape program.

5. The students agreed that there should be an orientation field-trip conducted by the instructor through the area before the student proceeds to learn the trees by the tape program. They felt that the two learning experiences should not duplicate information.

6. The students felt they were inadequately prepared toward understanding terminology used on the tape to describe, differentiate between, and identify the different tree species. Thus, they recommended the need for an indoor laboratory session on descriptive terminology before starting the taped fieldtrip program.

7. The students sgreed they would like to have more taped, fieldtrip, tree identification programs developed. Recommendations were: (a) a "late autumn" or "winter" tape program with bud and bark descriptions and without leaf descriptions; (b) a Cherokee Woodlot program developed for the Cherokee Bluff trail; and (c) a Smokies program along one of the trails used for the weekend hikes.

C. IMPLEMENTATION COSTS

Initial equipment expenditures for the development of the self-paced, outdoor-fieldtrip teaching unit in the Dendrology and Silvics of the Woody Angiosperms course (Forestry 3040) are presented in Table IV.

The tape-players used for this teaching unit will also be used with additional self-paced, outdoor-fieldtrip programs which are being developed for future use. These same tape-players are also extensively used in the indoor, self-paced Gymnosperm course taught during a different Quarter.

TABLE IV

COSTS FOR SELF-PACED INSTRUCTIONAL UNITS
USED IN FORESTRY 3040

Item	Cost
7 Tape-players	$245.84
Tape cassettes and tape duplication	60.00
2 Battery checkers	13.90
5 Earphones	6.95
7 Neck straps for tape-players @ $4.76	33.50
Batteries (supply for 2 years)	50.00
Tree name tags, flagging, paint	50.00
Subtotal	$460.19
Labor to develop trail and tape program	
Salary of instructor and teaching assistant	

CHAPTER V

FINDINGS, CONCLUSIONS, RECOMMENDATIONS

Analysis of the data included in this study resulted in the following findings, conclusions and recommendations.

I. FINDINGS

From the results of the study, the following were the major findings.

Forestry 3050 - Dendrology and Silvics of the Gymnosperms

1. There was no significant difference in the level of learning in one weekly unit as measured by a written post-test between students in the self-paced setting (Experimental) and students in the group-paced setting (Control).

2. There was no significant difference in the level of learning in one weekly unit as measured by a practical post-test between students in the self-paced setting (Experimental) and students in the group-paced setting (Control).

3. There was no significant difference in the level of learning in one weekly unit as measured by a practical retention-test between students in the self-paced setting (Experimental) and students in the group-paced setting (Control).

4. The level of learning as measured by the students' final overall grade distributions in the self-paced course was:

a. 1975: A (24 percent); B (39 percent); C (18 percent); D (4 percent); F (4 percent); incomplete (3 percent); withdrawal (6 percent); and audit (2 percent).

b. 1976: A (30 percent); B (31 percent); C (9 percent); D (5 percent); F (7 percent); incomplete (4 percent); withdrawal 12 percent); and audit (2 percent).

5. The group-paced instructional setting required two hours to teach the one weekly experimental study-unit, whereas, the same material was presented on the tape in 45 minutes.

6. Student responses on the 1976 course evaluation questionnaire which received over 70 percent student agreement were as follows:

Students agreed that the overall value of the course was from good to excellent, that the audio-visual equipment and study carrels used in the course were effective, that the size of the weekly units were about right, that the student proctors were helpful, and that the lab room was open an adequate number of hours each week.

7. Student responses on the 1975 course evaluation questionnaire which received over 70 percent student agreement were as follows:

Students agreed that the teaching format was helpful, that the teaching format allowed a more flexible study pace, that the room should be open longer hours, that the work required outside of class was too much, that more visual aids in the workbooks were needed, that a listing of slides in the workbooks was helpful, that the tapes sufficiently explained the material, that the tape lengths were about right, that the slide quality

was satisfactory, that the exhibits were easily located and adequately marked, that the exhibits were pertinent to the study material, that the student proctors were unhelpful, that the fieldtrip to the Cherokee Woodlot was beneficial, that more fieldtrips should be incorporated within the course, that the selection of test materials for the lab practical quizzes were appropriate, that the testing method was fair to all students, that the tests reflected the objectives of the laboratory portion of the course, that weekly quizzes were preferred, that the weekly quizzes gave balanced treatment to the study material, and that they did not want comprehensive tests covering more than one weeks material.

8. Equipment costs for the group-paced and self-paced settings were different since far less was required for the group-paced setting.

Forestry 3040 - Dendrology and Silvics of the Woody Angiosperms

1. The level of learning on the self-paced outdoor instructional unit as measured by the students' grade distributions from a written post-test was: A (31 percent); B (25 percent); C (22 percent); D (9 percent); and F (13 percent).

Students agreed that the teaching format helped the learning experience and process, that they wanted more tape programs at other locations; that the lectured, orientation fieldtrip to the Cherokee Bluff trail was good, that the "quiz tree" idea was an effective way to learn trees, that they would recommend students use the trail in groups of two or three people, that the silvical characteristics were adequately discussed, that the diagnostic

identifying characteristics were covered adequately, that the tape speed was about right, that the tape sufficiently explained the material, that the tape quality and speakers voice was from good to adequate, and that the trail guide was sufficiently helpful with maps and tree identification aids.

3. Student responses on the 1974 evaluation questionnaire which received over 70 percent student agreement were as follows:

Students agreed that the program aided the learning experience in some way, that they would like to see more nature trails with taped tree identification programs, and the course should include both lectured fieldtrips and tape programs, and that the tape sufficiently explained the material.

4. The group discussion session established the following findings concerning:

Recording Styles

a. Students were more at ease with a tape which had been recorded by the instructor.
b. Continuous music used throughout the tape was distracting, though opening and closing music on the tape was appropriate.
c. Beeps and musical interludes were unnecessary on the tape to signal a move to the next station.
d. An enthusiastic, varying, conversational tone of voice was the best presentation format.

e. A moderately rapid speaking rate was preferred, since one can listen faster than the average person talks. The slower student could stop and replay the tape.

Overall Program

a. Additional tape players should be bought to ease their availability.

b. The tape players and cassettes should be located in several locations across campus to ease their availability.

c. Long-life batteries should be used in the tape players and batter charge checkers should be purchased to insure that the student's tape player does not go dead while on the trail.

d. An orientation fieldtrip should be conducted by the instructor through the program area before the student proceeds to learn the trees by the tape program, though the two learning experiences should not duplicate information.

e. An indoor laboratory session should be taught on descriptive terminology used to describe, differentiate between, and identify the different tree species before the student listens to the taped fieldtrip program.

f. Additional taped tree identification fieldtrip programs should be developed.

5. Equipment costs for the group-paced and self-paced settings were different since none was required for the group-paced setting.

II. CONCLUSIONS

From the findings of the study, the following conclusions were made.

Forestry 3050 - Dendrology and Silvics of the Gymnosperms

1. The self-paced instructional setting was as effective in teaching the weekly unit on the spruce and fir trees as the traditional group-paced instructional setting (Findings 1 through 3).

2. The self-paced instructional setting was effective in stimulating high overall class grades (Finding 4).

3. The self-paced teaching format enabled the presentation of more material in less time (Finding 5).

4. According to the responses given on the course evaluation questionnaire, the overall majority of the students preferred the self-paced instructional units (Findings 6 and 7).

5. The self-paced instructional materials were more expensive than those formerly needed with the group-paced instructional setting (Finding 8).

Forestry 3040 - Dendrology and Silvics of the Woody Angiosperms

1. The self-paced, outdoor instructional unit was effective toward providing high student grades (Finding 1).

2. According to the responses given on the evaluation questionnaire, the overall majority of the students were favorable to the self-paced, outdoor instructional unit (Findings 2 and 3).

3. According to the responses given in the group discussion session regarding recording styles, the students concluded that they

were more at ease with a tape recorded by the instructor, that continuous music used throughout the tape was distracting, that opening and closing music on the tape was appropriate, that beeps and musical interludes were unnecessary on the tape to signal a move to the next station, that an enthusiastic, varying, conversational tone of voice was the best presentation format, and that a moderately rapid speaking rate was preferred (Finding 4).

4. The self-paced instructional materials were more expensive than those used for group-paced instruction (Finding 5).

III. RECOMMENDATIONS

As a result of the study, the following recommendations were made.

Forestry 3050 - Dendrology and Silvics of the Gymnosperms

1. Additional work should be done to improve the quality of slides, tapes, and unit guides.

2. The unit guides should be developed according to a uniform style and combined in one workbook for students to purchase at the beginning of the course.

3. An additional "live" lectured fieldtrip should be scheduled.

4. A comprehensive final practical exam should be implemented to improve the students retention of the course material.

5. The grading standard should be set higher in response to the high final overall grade distribution observed for two years while the self-paced instructional system was used.

6. Student proctor selection, training, and roles in the course should be further analyzed. Student satisfaction with proctors should be monitored. Differences in proctor performances and effectiveness as a function of their varied backgrounds should be analyzed.

7. The "Keller Plan" or mastery teaching approach could be studied.

Forestry 3040 - Dendrology and Silvics of the Woody Angiosperms

1. Additional taped tree identification fieldtrip programs should be developed for supplemental student use.

2. Additional tape players should be bought to ease their availability.

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APPENDICES

APPENDIX A

TABLE V

PAIRED STUDENT TEST SCORES USED TO COMPUTE THE PAIRED t-TEST STATISTICAL ANALYSIS IN THE 1976 FORESTRY 3050 COURSE

Student Pair No.	Written		Practical		Retention-Practical	
	SP	GP	SP	GP	SP	GP
1	91	96	90	100	6	6
2	98	77	100	100	6	5
3	92	75	100	100	5.5	6
4	65	78	100	100	6	6
5	82	82	90	100	6	6
6	92	78	100	100	5	5
7	76	83	100	100	5	5
8	89	85	100	100	6	5.5
9	87	71	100	100	5.5	-
10	73	91	100	100	6	5
11	79	77	100	80	5.5	5
12	59	88	0	100	6	4
13	-	84	-	100	-	6
14	87	70	100	80	5	6
15	85	82	100	100	6	6
16	92	70	100	100	6	6
17	85	73	50	100	5	5
18	81	87	100	100	6	4
19	77	68	100	100	5	6
20	87	84	100	100	5	6
21	65	58	100	100	5	6
22	61	86	100	100	5	6
23	71	54	100	100	6	5
24	92	65	100	100	5	4.5

TABLE V (Continued)

Student Pair No.	Written		Practical		Retention-Practical	
	SP	GP	SP	GP	SP	GP
25	73	73	80	100	6	5
26	-	79	-	100	6	5
27	70	65	100	100	2	5
28	64	75	40	80	6	5
29	60	70	70	100	5	6
30	80	52	100	0	6	-
31	78	-	100	-	5	5
32	63	86	100	100	6	5
33	43	81	80	100	5	3.5
34	77	74	100	80	6	4
35	80	63	100	0	5	6
36	72	89	100	20	4	5
37	48	68	100	90	4	3.5
38	71	-	100	-	6	4.5
39	86	44	40	80	4	3.5
40	64	95	30	100	5	-
41	44	-	90	-	2	-
42	38	71	0	100	3.5	4
43	55	57	80	70	-	2
44	-	76	-	20	0.5	0.5
45	32	52	50	70	0.5	-
46	-	-	-	-	x	x

APPENDIX B

STUDENT ATTITUDE QUESTIONNAIRE USED DURING THE WINTER QUARTER OF 1976 IN THE FORESTRY 3050 COURSE

This questionnaire was divided into the following two sections: (1) overall class evaluation; and (2) instructional materials and processes evaluation.

Overall Class Evaluation

1. Rate your attitude toward the "self-paced, slide-tape teaching units."

Very Good,	Good,	Average,	Weak,	Poor,	No Response
14	29	17	6	4	2
19%	40%	24%	8%	6%	3%

2. Rate your attitude toward the overall value of the course to you.

Excellent,	Good,	Average,	Weak,	Poor,	No Response
20	34	10	5	2	1
28%	47%	14%	7%	3%	1%

3. In comparison with group instruction courses, generally, my enjoyment of this one was:

Much greater,	Greater,	About the same,	Less,	Much Less
9	27	16	16	4
12%	38%	22%	22%	6%

4. In comparison with other courses, generally, my understanding of basic concepts and principles in this course was:

Much greater,	Greater,	About the same,	Less,	Much Less
6	25	31	9	1
8%	35%	43%	13%	1%

5. In comparison with group instruction courses, generally, my tendency to memorize details in this course was:

Much greater,	Greater,	About the same,	Less,	Much less
14	32	16	10	0
20%	44%	22%	14%	0%

6. In comparison with group instruction courses, I think that the amount of work required by this course is:

Much greater,	Greater,	About the same,	Less,	Much less
1	30	37	4	0
1%	42%	51%	6%	0%

7. In comparison with group instruction courses, the degree of pressure on me to do the work of this course was:

Much greater,	Greater,	About the same,	Less,	Much less
1	18	42	10	1
1%	25%	59%	14%	1%

8. In comparison with group instruction courses, the percentage of my mastery of the assignments in this course was:

Much greater,	Greater,	About the same,	Less,	Much less
1	26	29	15	1
1%	37%	40%	21%	1%

9. In comparison with group instruction courses, the feeling of achievement generated by passing tests in this one was:

Much greater,	Greater,	About the same,	Less,	Much less,	No response
3	25	35	8	0	1
4%	35%	49%	11%	0%	1%

10. In comparison with group instruction courses, generally, the influence of the instructor on me in this course was:

Much greater,	Greater,	About the same,	Less,	Much less
5	17	21	28	1
7%	24%	29%	39%	1%

11. In comparison with group instruction courses, generally, the recognition of me as an individual in this course was:

Much greater,	Greater,	About the same,	Less,	Much less,	No response
2	8	37	22	2	1
3%	11%	51%	31%	3%	1%

12. In comparison with group instruction courses, generally, the likelihood of cheating was:

Much greater,	Greater,	About the same,	Less,	Much less,	No response
0	2	40	14	9	7
0%	3%	56%	19%	13%	10%

13. In comparison with group instruction courses, generally, the temptation to cheat was:

Much greater,	Greater,	About the same,	Less,	Much less,	No response
0	3	41	13	7	8
0%	4%	57%	18%	10%	11%

14. As the term went on, I found that my study habits in this course were:

Greatly improved,	Improved,	Unaffected,	Harmed,	Unsure
6	31	24	10	1
8%	43%	34%	14%	1%

15. As the term went on, confidence in my ability to master the weekly units:

Increased greatly,	Increased,	Was unchanged,	Decreased
7	42	18	5
10%	58%	25%	7%

Instructional Materials and Processes Evaluation

16. The size of the weekly units (average) in this course were:

Much too great,	Too great,	About right,	Too small,	No response
1	13	55	1	2
1%	18%	77%	1%	3%

17. Rate your attitude toward the audiovisual equipment and study carrels used in this course.

Greatly effective,	Effective,	Somewhat effective,	Not effective
10	41	17	4
14%	57%	24%	5%

18. Rate your attitude toward the student proctors.

Greatly helpful,	Helpful,	Slightly helpful,	Not helpful,	No response
8	21	30	11	2
11%	29%	42%	15%	3%

19. Was the lab room open an adequate number of hours per week? (in addition to your one hour of reserve time).

Yes,	No,	No response
56	13	3
78%	18%	4%

20. Several types of workbooks (unit guides) were used this quarter. Which format did you prefer?

The "pine" guides,	The "spruce-fir" guide,	All Effective,	No response
16	31	22	3
22%	43%	31%	4%

21. Rate your attitude toward the "species description sheet" assignments.

Very good,	Good,	Average,	Weak,	Poor,	No response
4	15	11	19	21	2
6%	21%	15%	26%	29%	3%

APPENDIX C

STUDENT ATTITUDE QUESTIONNAIRE USED DURING THE WINTER QUARTER OF 1975 IN THE FORESTRY 3050 COURSE

This questionnaire was divided into the following eleven sections: (1) general class questions; (2) audio-visual equipment; (3) lab hours; (4) workbooks; (5) audio cassette tapes; (6) slides; (7) exhibites; (8) proctors; (9) fieldtrips; (10) lab practical testing; and (11) lecture written testing.

General Class Questions

1. Does this teaching format help the learning experience and process?

A great deal,	Some,	None,	Hinders,	No response
41%	47%	6%	4%	3%

2. Do you think you were able to learn more under the slide-tape system than the conventional lecture-lab system?

Yes,	Generally about same,	Hinders,	Not sure,	Blank
50%	17%	8%	18%	7%

3. Did the system allow you to select a more flexible study pace?

   Yes - 72%, No - 25%, Blank - 3%

4. Did you find it easier to procrastinate using this system?

   Yes - 27%, No - 56%, Blank - 7%

5. Would you like to have more slide-tape units for this course?

   Yes - 30%, No - 65%, Blank - 5%

6. Would you like to see this system adopted for other forestry courses? Yes - 52%, No - 36%, Blank - 12%

7. a. Do you agree with this quotation: "Education is not something one receives from others, but rather something one gives to ones-self - everyone is essentially self-taught."

      Yes - 69%, No - 11%, Not sure - 16%, Blank - 4%

   b. If yes, do you feel this technique was used adequately in this course? Yes - 87%, No - 13%

Audio-visual Equipment

1. Which audio-visual equipment combinations did you like best? (a) Singer Caramate with headphone (15%); (b) Howe Carrell (assuming correcting projection screen to show entire slide) (23%); (c) Box screens with Kodak Carousel projectors (57%); and (d) No response (5%).

2. Were the small earphones adequate? Yes (61%), No (36%), Blank (4%)

3. At any time did you find yourself unable to use the slide-tape equipment because:
   (a) machines were broken. Yes (28%), No (61%), Blank (11%)
   (b) they were all in use. Yes (41%), No (53%), Blank (7%)

Lab Hours

1. Would you prefer the room open longer hours?

   Yes (83%), No (15%), No response (2%)

2. Would you prefer more night openings (i.e., more than one night per week)? Yes (63%), No necessary (37%).

3. a. Did you use the Wednesday night opening during this quarter?

      Yes (39%), No (61%)

   b. Number of times used: One - 6; two - 8; three - 2; four - 5; five - 2; six - 0; seven (weekly) - 6.

4. a. Was the one hour per week that you had a station reserved for you adequate to complete the assignment? Yes (55%), No (45%)

   b. Would you have preferred additional time reserved for you for review? Yes (68%), No (20%), Blank (12%)

5. Was the amount of laboratory work required outside of the classroom (i.e., completing the species description sheets), considering credit and course objectives:

Too much,	About right,	Too little,	No response
80%	]7%	0%	3%

Workbooks

1. Did the workbooks (unit guides) sufficiently explain the material?

Too high degree,	Adequately,	Needs improvement,	Blank
11%	57%	31%	1%

2. Would you prefer more visual aids (drawings, etc.) in the Unit guides? Yes (77%), No (20%), Blank (3%)

3. Was it helpful to print a listing of the slides in the unit guide?

   Yes (90%), No (9%), Blank (1%)

4. Did you prefer the unit guide for the Cupressaceae Family over those done for the other units?

Better than others,	About same,	Poorer than others,	Blank
52%	28%	13%	7%

5. Do you prefer a description of each species in the unit guide, as was done with Cupressaceae, or do you prefer the separate species description sheets?

Within the Unit Guide,	Species Description Sheets,	Blank
63%	29%	8%

Audio Tape Cassettes

1. Did the tapes sufficiently explain the material?

   Yes (72%), No (25%), No response (3%)

2. Were the silvical characteristics adequately discussed?

   Yes (56%), No (41%), No response (3%)

3. Were the diagnostic identifying characteristics covered adequately?

   Yes (69%), No (29%), No response (2%)

4. Tape length:

   3% (a) generally were too long
   83% (b) generally were about right for the material covered
   9% (c) generally were too short (didn't adequately cover material)
   5% (d) no response

5. Was the speed of the Cupressaceae Family tape?

Much too fast,	Fast but acceptable due to stop and replay ability
32%	68%

6. Was the speed of the other units?

Too slow,	About right,	Too fast,	No response
9%	69%	20%	2%

7. Tape quality:

Needs improvement,	Adequate,	No response
65%	32%	1%

Slides

1. In general, were slides satisfactory for learning diagnostic characteristics?

   Yes (67%), No (32%), No response (1%)

2. In general, were slides satisfactory for learning sites and silvical characteristics?

   Yes (67%), No (33%)

3. In general, was slide quality satisfactory?

   Yes (91%), No (8%), No response (1%)

Exhibits

1. Were exhibits (cones and foliage mounts) easily located and adequately marked?

   Yes (96%), No (4%)

2. Were exhibits pertinent to the materials being studied?

   Yes (100%), No (0%)

Proctors

1. Did the seniors help you in learning the material?

A lot,	Some,	Very little,	No response
7%	20%	72%	1%

2. Were you generally satisfied with the way proctors graded your species description sheets?

   Yes (39%), No (56%), No response (5%)

Field Trips

1. Was the field trip to the Cherokee Woodlot beneficial?

   Yes (93%), No (3%), No response (4%)

2. a. Did you participate in the weekend trip to the Smokies?

      Yes (56%), No (43%), No response (1%)

   b. If yes, was it worthwhile? Yes (98%), No (2%)

3. Would you prefer to have additional field trips?

   Yes (90%), No (6%), No response (4%)

Lab (Practical) Testing

1. Was the selection of test material for the lab-tests appropriate in terms of the objectives?

Too high degree,	Adequate,	Needs improvement,	No response
32%	41%	5%	2%

2. Was the testing method fair to all students?

   Yes (93%), No (4%), No response (3%)

3. Tests reflected the objectives of the laboratory portion of the course? Yes (88%), No (7%), No response (5%)

Lecture (Written) Testing

1. Do you prefer the weekly quizzes?

   Yes (70%), No (28%), No response (2%)

2. Do you feel your grades are:

   28% (a) higher,
   29% (b) about the same, or
   35% (c) lower where weekly quizzes are used rather than hour exams plus a final.
   8% (d) No response

3. Would you prefer more comprehensive tests covering back materials?

   Yes (12%), No (83%), No response (5%)

4. Did weekly quizzes give balanced coverage to the materials covered?

To high degree,	Adequate,	Poor,	No response
15%	56%	23%	7%

5. Clearness of test questions:

Exceptional,	Good,	Average,	Weak,	Poor,	No response
9%	51%	20%	15%	3%	3%

6. Fairness of grading:

Exceptional,	Good,	Average,	Weak,	Poor,	No response
3%	13%	43%	29%	8%	4%

7. Hardness of grading:

Exceptional,	Good,	Average,	Weak,	Poor,	No response
9%	31%	40%	9%	7%	4%

APPENDIX D

1975 STUDENT EVALUATION QUESTIONNAIRE FOR THE SELF-PACED, OUTDOOR-FIELDTRIP INSTRUCTIONAL UNIT PREPARED FOR THE CHEROKEE BLUFF TRAIL

This questionnaire was divided into the following five sections: (1) general questions; (2) audio cassette tapes; (3) trail guide; (4) equipment distribution and operation; and (5) post test.

General Questions

1. Time spent on trail with tape player was:

None,	1 hour,	2 hours,	3 hours,	4 hours,	More than 4
18	11	39	33	15	18
13%	8%	30%	25%	11%	13%

2. Time spent listening to tape while not on trail was:

None,	1 hour,	2 hours,	3 hours,	4 hours,	More than 4
36	32	40	12	9	5
27%	24%	30%	9%	7%	3%

3. Does this teaching format help the learning experience and process?

Not helpful,	Slightly helpful,	Somehwat helpful,	Helpful,	Greatly helpful
2	10	33	59	30
1%	7%	25%	44%	23%

4. Do you think you would learn more with taped programs than lectured fieldtrips?

Strongly disagree,	Disagree,	Uncertain,	Agree,	Strongly agree	No response
20	38	37	29	9	1
]5%	28%	28%	22%	7%	1%

5. Did the orientation fieldtrip to the Cherokee Bluff trail duplicate too much information that was on the tape?

Yes,	No-duplication of information was good,	No response
9	122	3
7%	91%	2%

6. a. Did you try to identify trees by the "quiz tree" idea or the trail?

Yes,	No,	No response
119	14	1
89%	10%	1%

b. If yes, did the "quiz tree" idea help you learn the trees?

Not effective,	Slightly effective,	Somewhat effective,
2	9	32
1%	7%	24%

Effective,	Greatly effective,	No response
53	25	13
40%	19%	9%

7. Would you like to have a "late autumn" or "winter" tape program with bud descriptions and without leaf descriptions?

Yes - 78 (59%), No - 10 (7%), Would like, but probably would not have time to use it - 45 (34%).

8. Would you like to have more tape programs at other locations? (i.e., campus, Woodlot, Ut arboretum)

Yes - 107 (80%), No - 27 (20%)

9. Your preference for recommendations in the future.

0	(0%)	Tape programs without lectured fieldtrips
9	(7%)	Lectured fieldtrips and no tape program
49	(37%)	Half and half
62	(46%)	More lectured fieldtrips than tapes
13	(10%)	More tapes than lectured fieldtrips

10. Did you visit the trail alone or with other class members?

Alone,	With other class member,	Other people
62	60	15
45%	44%	11%

11. Would you recommend that students in the future use the trail in groups of 2 or 3?

Yes,	No,	Depends on the other student,	No response
108	18	4	4
81%	13%	3%	3%

Audio Cassette Tapes

1. Were the silvical characteristics adequately discussed?

   Yes - 115 (86%), No - 14 (10%), No response - 5 (4%)

2. Were diagnostic identifying characteristics covered adequately?

   Yes - 116 (87%), No - 13 (9%), No response - 5 (4%

3. Tape length:

35	(26%)	Generally too long
92	(69%)	Generally about right for the material covered
2	(1%)	Generally too short (didn't adequately cover material)
5	(4%)	No response

4. Considering the "stop and replay" ability of the tape was the speed:

Too slow,	About right,	Too fast,	No response
17 (13%)	103 (77%)	8 (6%)	5 (4%)

5. Tape quality and speakers voice (Dr. Buckner):

Good,	Adequate,	Needs improving,	No response
71 (53%)	43 (32%)	15 (11%)	5 (4%)

6. Did the tape sufficiently explain the material?

   Yes - 122 (91%), No - 6 (4.5%), No response - 6 (4.5%)

Trail Guide

1. Was the trail guide sufficient with maps and tree identification aids?

5	(4%)	Not helpful
10	(7%)	Slightly helpful
27	(20%)	Somehwat helpful
60	(45%)	Helpful
31	(23%)	Greatly helpful
1	(1%)	No response

2. Would you prefer more visual aids (drawings, etc.) in the trail guide?

38	(28%)	Strongly needed
73	(54%)	Would like more though it is not necessary
19	(14%)	Acceptable as it presently is
4	(3%)	No response

Equipment Distribution and Operation

1. Did you find yourself unable to use the equipment because

8	Batteries went dead
1	Tape player broken
5	Cassette tape broken
26	Not enough equipment
97	No response

2. From what distribution source did you check out the supplies?

54	(36%)	Forestry Offices
42	(28%)	Agricultural Library
44	(29%)	Undergraduate Library
11	(7%)	No response

3. Since the Forestry Office was the only location reserving equipment, would you have preferred that all equipment been located there to make more equipment available for the reserve system?

29	(22%)	Strongly agree
58	(43%)	Generally agree, though a few should be located in libraries
41	(31%)	Disagree (library was more convenient for me)
6	(4%)	No response

4. When checking out equipment, what were your needs?

50	(37%)	Only the cassette tapes (had access to a personal tape player)
80	(60%)	Cassette tapes and tape-player
4	(3%)	No response

Post Test

1. Degree to which test gave balanced coverage to major topics.

Very good,	Good,	Average,	Weak,	Poor,	No response
12	54	48	13	3	4
9%	40%	36%	10%	2%	3%

2. Clearness of test questions.

Very good,	Good,	Average,	Weak,	Poor,	No response
15	43	43	13	6	4
11%	36%	36%	10%	4%	3%

3. Fairness in grading.

Very good,	Good,	Average,	Weak,	Poor,	No response
22	69	30	8	1	4
17%	51%	22%	6%	1%	3%

APPENDIX E

1974 STUDENT EVALUATION QUESTIONNAIRE FOR THE SELF-PACED, OUTDOOR-FIELDTRIP INSTRUCTIONAL UNIT PREPARED FOR THE CHEROKEE BLUFF TRAIL

General Questions

1. Time spent on Cherokee Bluff Tape Program

1 hour,	2 hours,	3 hours,	4 hours,	More than 4 hours
2	30	35	14	3
2%	36%	42%	17%	3%

2. Extent program aided learning experience

Great,	Some,	None,	Hindered
33	49	1	1
40%	58%	1%	1%

3. Would you like to see more nature trails with taped tree identification programs? (i.e., campus, Woodlot)

Yes - 73 (87%), No - 11 (13%)

4. Your preference for recommendations in future

2	(2%)	Tape programs without lectured fieldtrip
10	(12%)	Lectured fieldtrip without tape program
72	(86%)	Some of both - lectured fieldtrips and tape programs

5. Tape length:

Too long,	Just right,	Too short
47	37	0
56%	44%	0%

6. Speakers voice (John Palmer):

Good,	Fair,	Poor
68%	32%	0%

7. Did tape sufficiently explain material?

Yes - 84 (100%), No - 0 (0%)

APPENDIX F

POST TEST USED TO EVALUATE DIFFERENCE OF STUDENT LEARNING BETWEEN SELF-PACING AND GROUP-PACING TEACHING SYSTEMS

Forestry 3050
3/2/76
Quiz #6 Name_____ Lab (Circle) Ram, Ram

DENDROLOGY AND SILVICS OF THE GYMNOSPERMS

A. On the range maps provided, shade in the native range of:
   1. Sitka spruce
   2. Balsam fir
   3. White fir
   4. Brewer spruce
   In the space at the base of each map give the scientific name for the species.

B. In the blank preceding each statement on the left, place the letter corresponding to the single best answer as listed on the right. Answers may be used more than once. Before beginning, scan the answer column to become aware of the range of possible answers.

1.	_____a variety of Calif. Red fir having exerted bracts on conc.	a.	Red spruce
2.	_____coastal species having very sharp needles.	b.	Abies balsemea
3.	_____originally and best classified as a variety of Balsam fir.	c.	Abies
4.	_____generally having 4-sided needles.	d.	Stika spruce
5.	_____cones erect, disintegrate at maturity.	e.	White fir
6.	_____a variety of Subalpine fir.	f.	Picea mariana
7.	_____transcontinental thru Canada, generally found in bogs.	g.	fraser fir
8.	_____a timberline tree having 4-sided foliage.	h.	Abies procera
9.	_____western species with bracts strongly exserred but not reflexed.	i.	Coniferales
10.	_____thick bark helps prevent sun scald in this fir.	j.	Spruces and firs
11.	_____cones pendant.	k.	Abies magnifica
12.	_____commonly found on cool, moist sites.	l.	Shasta red fir
13.	_____wood has high strength-to-weight ratio.	m.	Pacific silver fir
14.	_____order to which spruces and firs belong.	n.	Picea
		o.	White spruce
		p.	Abies lasiocarna
		q.	Corkbark fir
		r.	Pinaceae
		s.	Bristlecone fir
		t.	Brewer spruce
		u.	Engelmann spruce
		v.	Picea puagens

15. _____native tree having a "weeping" habit.
16. _____a common tree at 4000 feet along State-line divide in Tennessee.
17. _____Colorado blue spruce.
18. _____commonly called "cat" spruce due to the odor of crushed foliage.
19. _____resin blisters on bark.
20. _____foliage 4-sided, cones disintegrate at maturity, bracts shorter than cone scales.

C. Various spruce-fir associations characterize cool, moist habitate over a vast area. Name a species (common name O.K.) that will complete the following associations and give the physiographic region in which it is commonly found.

	Spruce		Fir	Physiographic Region
1.	Engelmann spruce	-	_____	_____
2.	Sitka spruce	-	_____	_____
3.	_____	-	Balsam fir	_____

D. List the spruces and firs (common names O.K.) native to Colorado.

APPENDIX G

POST TESTS USED TO EVALUATE STUDENT LEARNING ON THE CHEROKEE BLUFF TRAIL AUDIO PROGRAM

Forestry 3040
10/23/75
Quiz #1

Cherokee Bluff Dendrology Trail Quiz

Multiple choice: Circle the letter preceding the best answer.

Carpinus caroliniana (Am. Hornbeam): (a) Ironwood, (b) Blue Beech, (c) Musclewood, (d) a, b, and c.

Ailanthus altissima (Tree of Heaven): (a) Exotic, (b) weak wooded, (c) leaflets with small pointed margin at base, (d) a, b, and c.

Morus rubra (Red Mulberry): (a) Exotic, (b) Native

Fraxiaus pennsylvanica (Green Ash): (a) glabrous twigs always, (b) opposite arranged leaves, (c) Pubescent twigs always, (d) compound leaves alternately arranged.

Cercis canadensis (Eastern Red Bud): (a) toothed leaf margin, (b) prefers basic sites, (c) corky bark, (d) purply-pink flowers in fall.

Ulmus americana (American Elm): (a) Calciphyte, (b) slippery inner bark, (c) corky ridges on bark, (d) susceptible to Dutch Elm disease.

Morus alba (White Mulberry): (a) Native, (b) Non-native.

Prunus serotina (Black Cherry): (a) shade tolerant, (b) best growth on intermediate site conditions, (c) poisonous cherries to cattle, (d) commercially valuable wood when grown from rich site conditions.

Fagus grandifolia (American Beech): (a) calloused corky bark, (b) blunt flat buds, (c) leaf margin entire, (d) incurved marginal teeth on leaf margin.

Celtis occidentalis (Hackberry): (a) warty bark, (b) zigzagged twigs, (c) 3 prominant veins per leaf, (d) a, b, and c.

Fraxinas quadrangulata (Blue Ash): (a) Blue leaves, (b) triangular stem in cross section, (c) alternate leaf arrangement, (d) square stem in cross section.

Castanea mollissima (Chinese chestnut): (a) smooth leaf margin, (b) felty leaf underside, (c) fine pubescence on leaf underside, (d) 5-6 nuts per prickly husk.

Paulownia tomentosa (Empress Tree): (a) named for Dutch queen, (b) woody capsuled fruit, (c) exotic, (d) a, b, and c.

Diospyros virginiana (Permisson): Leaf stem in cross section.

(a)  (b) 

Staphylea trifolia (American Bladdernut): (a) calciphyte, (b) opposite leaves, (c) usually 3 leaflets per leaf, (d) a, b, and c.

Cornus florida (Dogwood): (a) "alligator-like" leaves, (b) alternate arranged leaves, (c) shade intolerant, (d) leaf veins curving upward along the smooth wavy margin.

Asimina triloba (Paw Paw): (a) velvety buds, (b) fruit citrus-like, (c) fruit extremely sour, (d) b and c.

Quercus falcata (Southern Red Oak): (a) variable leaves, (b) "Turkey foot" leaves, (c) leaf lobes prickle tipped, (d) a, b, and c.

Quercus machlenbergii (Chinkapin Oak): (a) cal ciphyte, (b) bitter acorns, (c) wavy leaf margins, (d) relatively common tree along rivers.

Ostrya virginiana (Eastern Hophornbeam): (a) "Musclelike" bark, (b) shreddy bark, (c) intolerant, (d) softwood.

Cherokee Bluff Dendrology Trail Quiz

Quiz No. 2

Multiple choice: Circle the letter preceding the best answer.

Diospyrus virginiana (Persimmon): (a) compound leaf, (b) opposite leaf arrangement, (c) thick, blochy bark, (d) worthless.

Paulownia tomentosa (Empress Tree): (a) tomentose leaf underside, (b) named for Dutch queen, (c) exotic, (d) a, b, and c.

Ulmus americana (American Elm): (a) lopsided leaf base, (b) doubly serrate leaf margin, (c) roughed or smooth leaf surface, (d) a, b, and c.

Fraxinus americana (White Ash): Leaf stem in cross section.

(a)  (b) 

Ostrya virginiana (Eastern Hophornbeam): (a) "muscelelike" bark, (b) shreddy bark, (c) Betulaceae Family, (d) b and c.

Rhmnus caroliniana (Carolina Buckthorne): (a) large thorne, (b) compound leaves, (c) shrublike, (d) ash-gray smooth bark.

Robinia pseudacacia (Black Locust): (a) bud submerged beneath leaf scap, (b) wood easily decays, (c) black thorns, (d) opposite arranged leaves.

Carya cordiformis (Bitternut Hickory): (a) terminal leaflet smallest, (b) all leaflets same size, (c) yellowish bark, (d) yellowish bud.

Prunus serotina (Black Cherry): (a) "cornflakes" bark on young trees, (b) "corn flakes" bark on older trees, (c) entire leaf margin, (d) twigs free from odor and taste.

Ailanthus altissima (Tree of Heaven): (a) alternate, simple leaves, (b) leaf 1 to 3 feet long, (c) leaf odor disagreeable, (d) b and c.

Morus rubra (Red Mulberry): (a) Exotic, (b) native.

Carya orata (Shagbark Hickory): (a) thick nut husks 1/4" to 1/2", (b) smooth bark after fruiting age, (c) odd-palmately compound leaves, (d) smooth twigs always.

Fraxinus pennsylvanica (Green Ash): (a) glabrous twigs always, (b) opposite arranged leaves, (c) pubescent twigs always, (d) terminal leaflet largest.

Fagus grandifolia (American Beech): (a) sharp lance-shaped buds, (b) calloused, corky bark, (c) member of Oak Family, (d) a and c.

Cercis canadensis (Red Bud): (a) toothed leaf margin, (b) prefers acid sites, (c) corky bark, (d) purply-pink flowers in spring.

Quercus muehlenbergii (Chinkapin Oak): (a) found only on moist sites beside rivers, (b) calciphyte, (c) wavy leaf margins, (d) b and c.

Castanea mollissima (Chinese Chestnut): (a) smooth leaf margin, (b) felty leaf undersurface, (c) fine pubesence on leaf underside, (d) 5-6 nuts per prickly husk.

Sink holes: (a) unsoluble limestone, (b) soluble limestone, (c) old, metamorphic bedrock, (d) granite outcrop.

Carpinus caroliniana (American Hornbeam): (a) Ironwood, (b) Blue Beech, (c) Musclewood, (d) a, b, and c.

Acer saccharum (Sugar Maple): (a) v-shaped seed pair, (b) seed mature in spring, (c) 3 lobed, (d) rounded sinus between leaf lobes.

Cherokee Bluff Dendrology Trail Quiz

Quiz 3

Multiple choice: Circle the letter preceding the best answer.

Sassafras albidum (Sassafras): (a) pioneer species of secondary succession, (b) olive green bark on new growth stems, (c) twigs free from odor and taste, (d) a and b.

Diospyros virginiana (Persimmon): Leaf stem in cross section.

(a)  (b) 

Morus alba (White Mulberry): (a) milky sap, (b) variable leaf shape, (c) silk worms, (d) a, b, and c.

Carya illinoensis (Pecan): (a) tall trees grown in south for nuts, (b) short trees grown in Mississippi Valley region for timber, (c) a and b, (d) sickle-shaped leaflets.

Liriodendron tulipifera (Yellow-Poplar): (a) most utilized hardwood for general purposes, (b) insect pollinated, (c) one of the largest eastern hardwoods, (d) a and c, (e), a, b and c.

Morus rubra (Red Mulberry): (a) Exotic, (b) Native.

Quercus rubra (Northern Red Oak): (a) rounded leaf lobes without bristles, (b) nonporous wood, (c) entire leaf margin, (d) wind pollinated.

Fraxinus quadrangulata (Blue Ash): (a) prefers acid sites, (b) opposite leaf arrangement, (c) square leaf stem in cross section, (d) b and c.

Ailanthus altissima (Tree of Heaven): (a) Exotic, (b) weak wooded, (c) leaflets with small pointed margin at base, (d) a, b and c.

Quercus prinus (Chestnut Oak): (a) calciphyte, (b) wavy leaf margin, (c) bark high in tannic acid, (d) b and c.

Cercis canadensis (Red Bud): (a) bloom in fall, (b) cordate leaf base, (c) dioecious, (d) b and c.

Carya ovata (Shagbark Hickory): (a) usually 7, rarely 9 leaflets per leaf, (b) twigs always hairy, (c) tight fitting smooth bud scales, (d) pubescene, loosely fitting bud scales.

Fagus grandifolia (American Beech): (a) calloused corky bark, (b) blunt flat buds, (c) leaf margin entire, (d) incurved marginal teeth on leaf margin.

Staphylea trifolia (American Bladdernut): (a) calcipayte, (b) opposite leaves, (c) usually 3 leaflets per leaf, (d) a, b and c.

Quercus falcata (Southern Red Oak): (a) variable leaves, (b) "Turkey-foot" leaves, (c) leaf lobes prickle tipped, (d) a, b and c.

Castanea mollissima (Chinese Chestnut): (a) poor wildlife food, (b) native to Japan, (c) nuts poisonous, (d) generally resistant to chestnut blight.

Prunus serotina (Black Cherry): (a) "cornflakes) bark on young trees, (b) "cornflakes" bark on older trees, (c) entire leaf margin, (d) twigs free from odor and taste.

Carya cordiformis (Bitternut Hickory): (a) terminal leaflet smallest, (b) all leaflets same size, (c) yellowish bark, (d) yellowish bud.

Asimina triloba (Paw Paw): (a) velvety buds, (b) fruit citrus-like, (c) fruit extremely sour, (d) b and c.

Ostrya virginiana (Eastern Hophornbeam): (a) "musclelike" bark, (b) shade intolerant, (c) Betulaceae Family, (d) "Blue Beech."

Cherokee Bluff Dendrology Trail Quiz

Quiz 4

Multiple Choice: Circle the letter preceding the best answer.

Acer negundo (Boxelder): (a) 3 v-shaped leaf scars encircle twig, (b) "Hard" maple, (c) new growth olive green color, (d) slow growth.

Aesculus octandra (Yellow Buckeye): (a) 3 leaflets per leaf, (b) poisonous nuts, (c) nuts surrounded by prickly bur-like husks, (d) b and c.

Prunus serotina (Black Cherry): (a) shade intolerant, (b) poisonous cherries to cattle, (c) 2 glands a base of leaf on petiole, (d) commercially valuable when grown from rich site conditions, (e) a, c and d, (f) a, b, c and d.

Diospyros virginiana (Persimmon): (a) golf clubs, (b) 1 vascular bundle scar, (c) dioecious, (d) a, b and c.

Quercus alba: (a) leaf margin with bristles, (b) acorns mature in 1 year, (c) porous wood, (d) easy to transplant.

Morus rubra (Red Mulberry): (a) variable leaf shapes, (b) milky sap, (c) inner bark orange, (d) a, b and c.

Fraxinus americana (White Ash): leaf scar on twig

(a)  (b) 

Carya cordiformis (Bitternut Hickory): (a) yellowish bud, (b) compound leaves alternately arranged, (c) "pecan" hickory group, (d) a, b and c.

Cornus florida (Flowering Dogwood): (a) "weed" tree, (b) excellent ornamental, (c) poor soil improved, (d) a and b.

Morus alba (White Mulberry): (a) white berries, (b) exotic, (c) rough, hairy leaf, (d) a and b.

Ailanthus altissima (Tree of Heaven): (a) exotic, (b) weak wooded, (c) leaflets with small pointed margin at base, (d) a, b and c.

Paulownia tomentosa (Empress Tree): (a) compound, large leaves, (b) exotic, (c) named for Chinese Empress, (d) b and c.

Carya illinoensis (Pecan): (a) short trees grown in south for nuts, (b) tall trees grown in Mississippi Valley region for timber, (c) a and b, (d) yellowish bud.

Liriodendron tulipifera (Yellow-Poplar): (a) pioneer species or secondary succession on good sites, (b) most utilized hardwood for general purposes, (c) insect pollinated, (d) a and b, (e) a, b and c.

Robinia pseudoacacia (Black Locust): (a) bud submerged beneath leaf, (b) wood easily decays, (c) black thorns, (d) opposite arranged compound leaves.

Carpinus caroliniana (American Hornbeam): (a) Iron wood, (b) Blue Beech, (c) Musclewood, (d) a, b and c.

Ostrya virginiana (Eastern Hophornbeam): (a) "musclelike" bark, (b) shade intolerant, (c) Betulaceae Family, (d) "Blue Beech."

Fraxinus quadrangulata (Blue Ash): (a) calciphyte, (b) blue dye obtained from inner bark, (c) square stem in cross section, (d) a, b and c.

Fagus grandifolia (American Beech): (a) sharp lance-shaped buds, (b) calloused corky bark, (c) member of Oak Family, (d) a and c.

Acer saccharum (Sugar Maple): (a) v-shaped seed pair, (b) seed mature in spring, (c) 3 lobed, (d) rounded sinus between leaf lobes.

APPENDIX H

EXAMPLE OF THE "SPECIES DESCRIPTION" SHEETS

Forestry 3010, Winter Quarter, 1975
DENDROLOGY AND SILVICS OF THE GYMNOSPERMS

Numerical Grade (Instructor's use only)	
100 Excellent	DEPARTMENTAL STAMP
90 Superior	
80 Average	
70 Acceptable	
XX Do over	

SPECIES DESCRIPTION

NOMENCLATURE

Specimen #_____ Page #_____

A. Family_____

B. Genus_____ Species_____ Author_____

C. Common Name(s) (SPN)_____

IDENTIFICATION (if helpful, make sketches)

A. Leaves:

B. Fruit:

C. Twigs (buds):

D. Bark:

SILVICAL CHARACTERISTICS

A. Habitat:
   1. Geographic region:
   2. Physiographic region:
   3. Topographic position(s) and aspect:
   4. Edaphic factors:

B. Regeneration Requirements:
   1. Tolerance:
   2. Competitive level:
   3. Artificial regeneration adaptability:

C. Intermediate Growth:

D. Geological Maturity:
   1. Age:
   2. Size:
   3. Patterns of natural regeneration:

E. Management Problems:

VALUE AND USES

A. Important Uses:

B. Unique Properties:

APPENDIX I

CLASS SCHEDULE AND ASSIGNMENT SHEET

DENDROLOGY AND SILVICS OF THE GYMNOSPERMS
Winter Quarter, 1976

Time: 10:00-10:50 T = Lecture

Quiz Sections: 40911 = 10:00 R
40924 = 2:20 R
40937 = 7:50 F
40940 = 12:10 F

Texts: (1) Textbook of Dendrology (TD) by Harlow & Harrar (McGraw-Hill)
(2) Silvics of Forest Trees of the U.S. (SFT), Ag. Hendbook #271

Instructors: Ed Buckner and John Palmer

Assignments: Read appropriate sections of the texts listed above as the family, genus and/or species is assigned below. Material covered by texts will not be a part of the lecture material; ask questions on any part that is not clear.

Note: All laboratory work is by self-study using audio-visual programs. Each student should sign the carrel roster to reserve a carrel for one hour each week. Additional carrel time is on a first-come first-serve basis.

Week of	LECTURE (Tuesdays)	AUDIO-VISUAL	RECITATION
1/5	Registration	None	Orientation
1/12	Gymnosperms of Tennessee species-site relationships, distribution.	None	Field trip to Cherokee Woodlot Orientation Film (Gymnosperms) Botonical Descriptive Terminology Lecture
1/10	Classification of gymnosperms; their distribution relative to angiosperms.	UNIT # 1: Genera	Review and Quiz 1
1/26	Flowering and fruiting contrasts with angiosperms.	UNIT # 2: The Soft Pine Group	Review and Quiz

Week of	LECTURE (Tuesdays)	AUDIO-VISUAL	RECITATION
2/2	Physiographic and climatic features controlling distribution of gymnosperms	UNIT #3: The Eastern Yellow Pines	Review and Quiz
2/9	The fossil record; primative gymnosperms and their descendants.	UNIT #4: The Western Yellow and nonnative Pines	Review and Quiz (Mid-term)
2/16	SAF Forest Cover Types in which gymnosperms are dominants.	UNIT #5: Larix, Pseudotsuga, Tsuga and Cedrus.	Review and Quiz
2/22	Regional account of the gymnosperms in the Pacific Northwest.	UNIT #6: Picea and Abies.	Review and Quiz
3/1	Regional account of gymnosperms in the Pacific Southwest	UNIT #7: Taxodiaceae Family	Review and Quiz
3/8	Regional account of gymnosperms in the Rockies and the East.	UNIT #8: Cupressaceae and Taxaceae Families	Review and Quiz
3/15	3/16 is last day of classes; all papers returned and final grades		

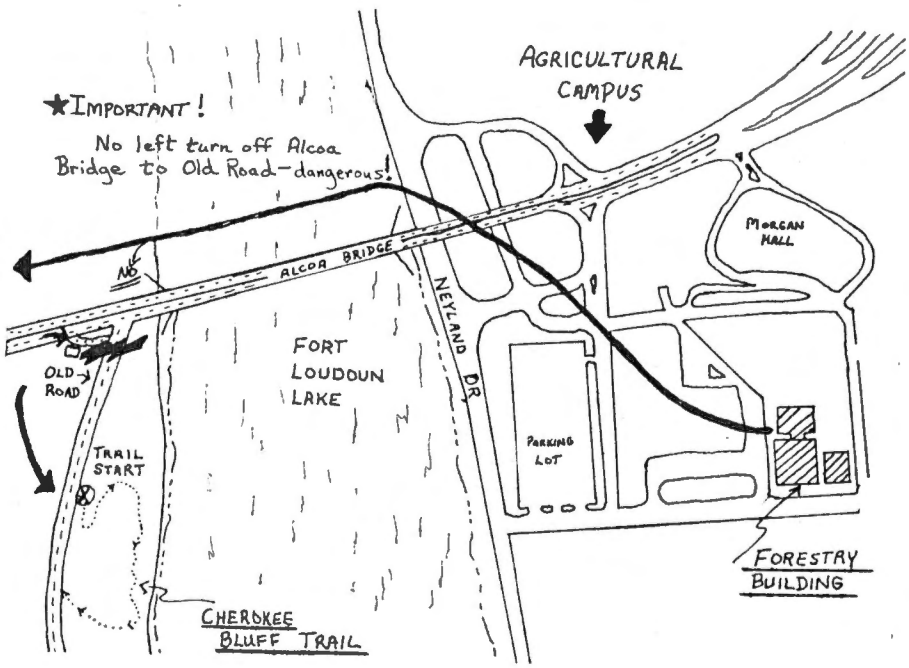
APPENDIX J

TREE GUIDE FOR CHEROKEE BLUFF AUDIO-TUTORIAL TRAIL

Forestry 3040
Dendrology & Silvics of
Woody Angiosperms
Forestry Department
University of Tennessee
Edward Buckner
Associate Professor
John Palmer
Graduate Assistant

TRAIL LOCATION

(On Southwest side of Fort Loudon Lake
across Lake from student parking lot.)

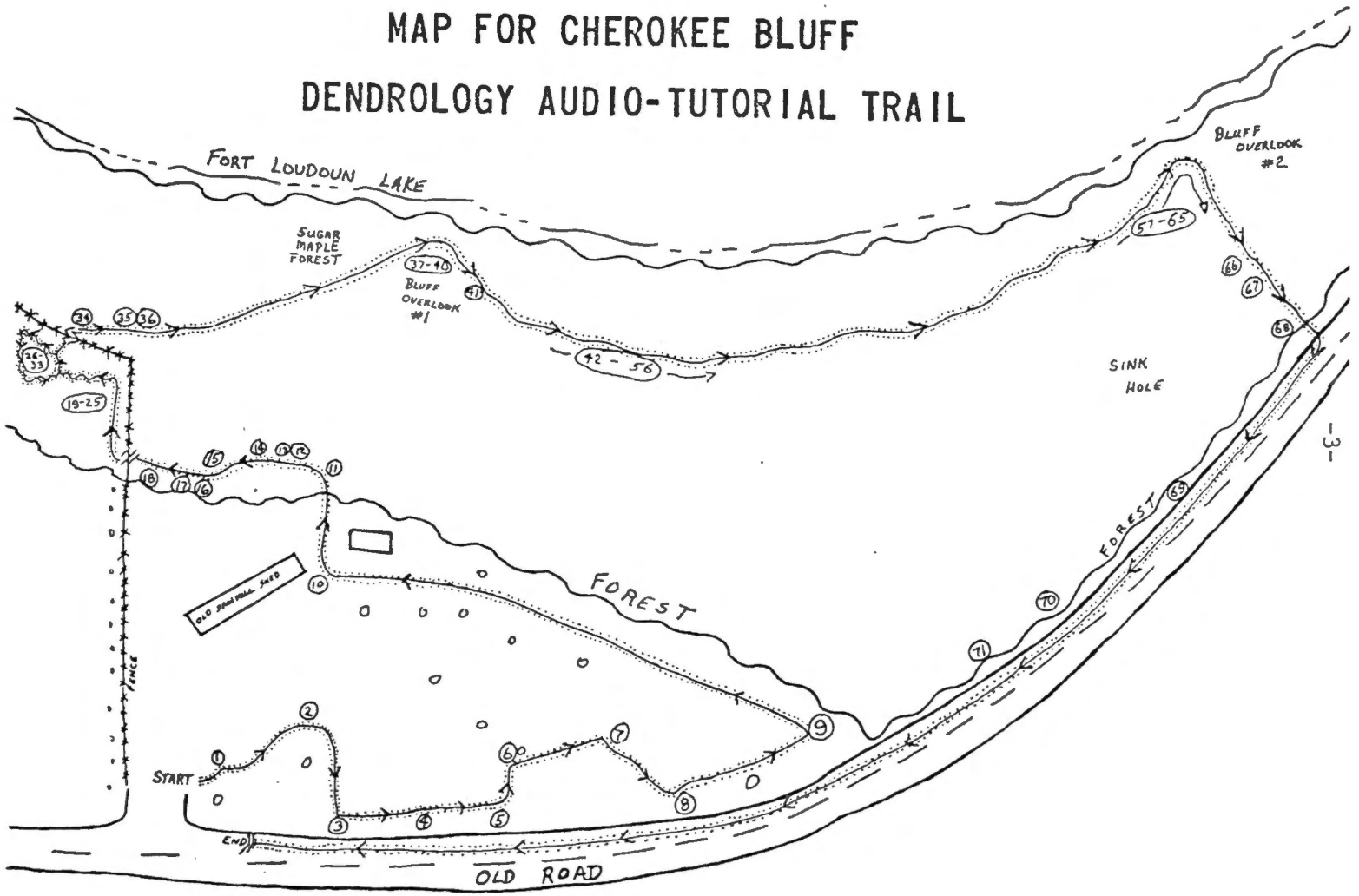


Instructions:

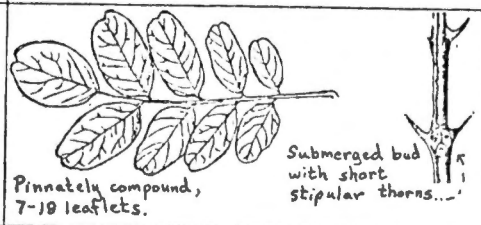
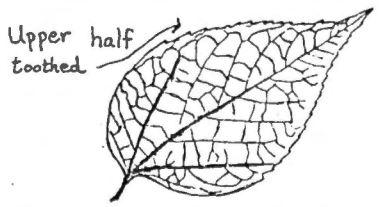
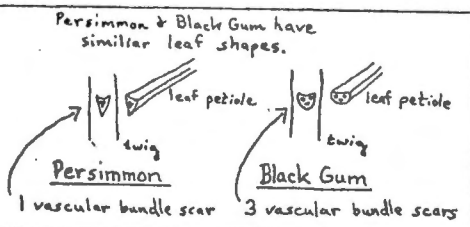
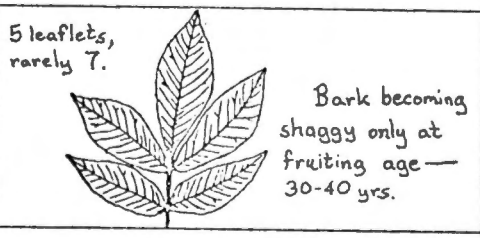
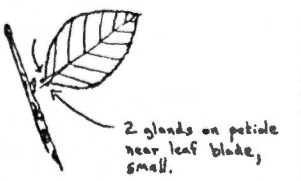
1. Proceed to starting point indicated on above map.
2. Refer to map on next page for the location of trees described on the tape; study trees that are tagged.
3. Become familiar with your recorder so you can effectively control the tape. Set a comfortable pace moving in the direction indicated by arrows along the trail. Trail is marked with yellow flagging and yellow paint on posts.
4. Refer to comments and sketches under the LOOK FOR THESE CHARACTERISTICS column as an aid for identification.
5. Use the blank column for sketches and comments that you find helpful in identification, or for other pertinent information.

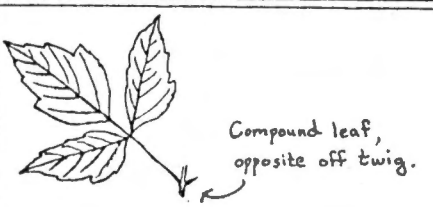
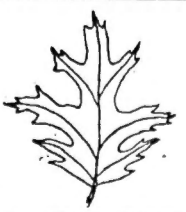
MAP FOR CHEROKEE BLUFF

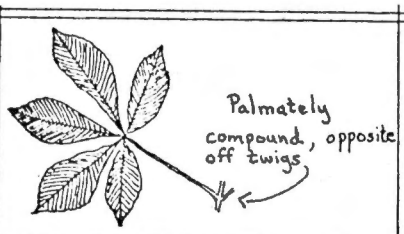
DENDROLOGY AUDIO-TUTORIAL TRAIL

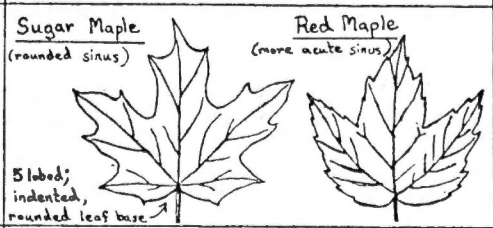


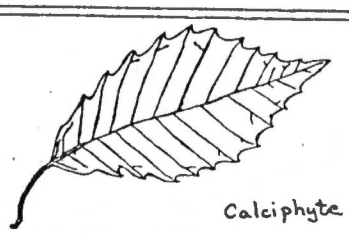
TREES ALONG THE CHEROKEE BLUFF TRAIL

NAME	LOOK FOR THESE CHARACTERISTICS	SKETCH OR TAKE NOTES ON OTHER DISTINCTIVE CHARACTERISTICS
#1-Castanea mollissima (Chinese Chestnut)	Broader and thicker leaf than American Chestnut; fine pubescent leaf undersurface.	
#2-Robinia pseudoacacia (Black Locust)		
#3-Celtis occidentalis (Hackberry)		
#4-Diospyros virginiana (Persimmon)		
#5-Carya ovata (Shagback Hickory)		
#6-Prunus serotina (Black Cherry) and Ligustrum spp. (Privet shrub)		

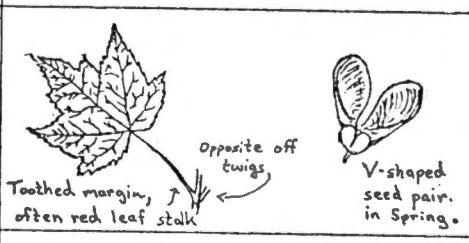
NAME	LOOK FOR THESE CHARACTERISTICS	SKETCH OR TAKE NOTES ON OTHER DISTINCTIVE CHARACTERISTICS
#7-Acer negundo (Boxelder)	 Compound leaf, opposite off twig.	
#8-Carya illinoensis (Pecan)	Sickle shaped leaflet, 11 to 17 leaflets.	
#9-Morus alba (White Mulberry)	Leathery leaf - underside smooth ; milky sap ; exotic.	
#10-Morus rubra (Red Mulberry)	Leaf underside hairy and rough above ; milky sap.	
#11-Quercus rubra (Northern Red Oak)		
#12-Diospyros virginiana (Persimmon)	Thick blocky bark. Sexes on different trees.	

NAME	LOOK FOR THESE CHARACTERISTICS	SKETCH OR TAKE NOTES ON OTHER DISTINCTIVE CHARACTERISTICS
#13-Aesculus octandra (Yellow Buckeye)		
#14-Carya ovata (Shagbark Hickory)	Mature tree - shaggy bark. Nut husks ¼ to ½ inch thick.	
#15-Sassafras albidum (Sassafras) and vines: Toxicodendron radicans (Poison Ivy) Parthenocissus quinquefolia (Virginia Creeper) Vitis rotundifolia (Muscadine Grape)	3 leaf shapes.	
#16-Fraxinus pennsylvanica (Green Ash)		
#17-Fraxinus americana (White Ash)		

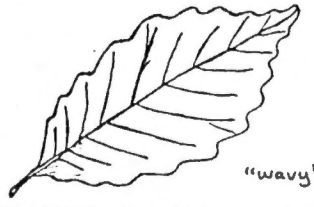
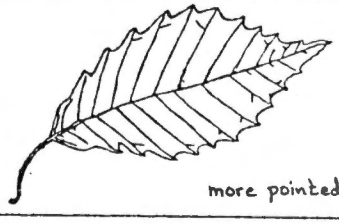
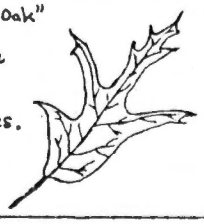
NAME	LOOK FOR THESE CHARACTERISTICS	SKETCH OR TAKE NOTES ON OTHER DISTINCTIVE CHARACTERISTICS
#18-Ulmus americana (American Elm)	 Oblique or inequilateral.	
#19-Carpinus caroliniana (American Hornbeam)	Musclelike appearance of trunk.	
#20-Carya cordiformis (Bitternut Hickory)	Sulphur-yellow bud.	
#21-Prunus serotina (Black Cherry)	"Cornflakes" bark.	
#22-Acer saccharum (Sugar Maple)		
#23-Lonicera tatarica (Tartarian Bush Honeysuckle)	Exotic shrub.	

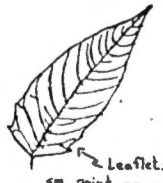
NAME	LOOK FOR THESE CHARACTERISTICS	SKETCH OR TAKE NOTES ON OTHER DISTINCTIVE CHARACTERISTICS
#24-Quercus muehlenbergii (Chinkapin Oak)		
#25-Liriodendran tulipitera (Yellow Poplar)		
#26 - QUIZ TREE:		
#27 - QUIZ TREE:		
#28 - QUIZ TREE:		
#29 - QUIZ TREE:		
#30 - QUIZ TREE:		
#31 - QUIZ TREE:		
#32 - QUIZ TREE:		

NAME	LOOK FOR THESE CHARACTERISTICS	SKETCH OR TAKE NOTES ON OTHER DISTINCTIVE CHARACTERISTICS
#33-Asimina triloba (Pawpaw)	Naked buds covered with velvety hairs. Large drooping leaves.	
#34-Tilia americana (American Basswood)	Sprouts around trees and stumps. Leaf undersurface glabrous.	
#35-Fraxinus pennsylvanica		
#36-Quercus rubra		
#37-Aesculus octandra		
#38-Aesculus octandra		
#39-Fraxinus quadrangulata (Blue Ash)	Square stem. Calciphyte.	
#40-Staphylea trifolia (American Bladdernut)	Opposite 3 leaflet leaves. Calciphyte.	

NAME	LOOK FOR THESE CHARACTERISTICS	SKETCH OR TAKE NOTES ON OTHER DISTINCTIVE CHARACTERISTICS
#41-Quercus alba (White Oak)	Whitish Bark.	
#42-Ostrya virginiana (Eastern Hophornbeam)	Shreddy Bark.	
Above trail- Platanus occidentalis (American Sycamore)	Large trees with distinctive exfoliating, flaky bark, exposing the greenish-white underbark.	
#43-Acer rubrum (Red Maple)		
#44-Cornus florida (Flowering Dogwood)	Alligator-like bark. Opposite arranged leaves.	
#45 - QUIZ TREE:		
#46 - QUIZ TREE:		

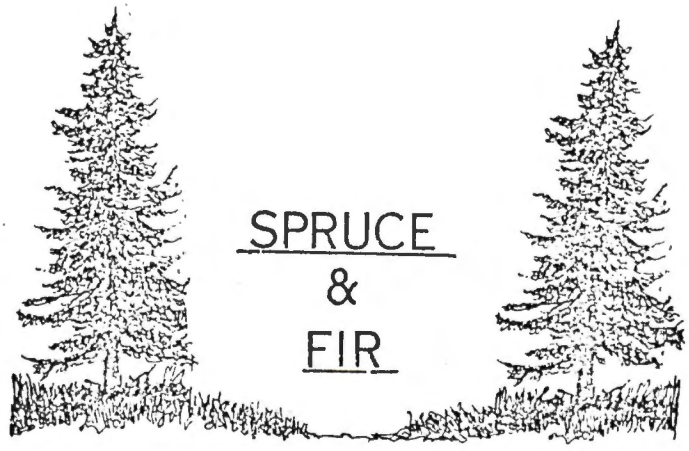
NAME	LOOK FOR THESE CHARACTERISTICS	SKETCH OR TAKE NOTES ON OTHER DISTINCTIVE CHARACTERISTICS
#47 - QUIZ TREE:		
#48 - QUIZ TREE:		
#49 - QUIZ TREE:		
#50-Fagus grandifolia (American Beech)	Thin, firm, smooth, gray bark.	
#51-Rhamnus caroliniana (Carolina Buckthorn)	Smooth, ash-gray bark. Yellow inner bark.	
#52 - QUIZ TREE:		
#53 - QUIZ TREE:		
#54 - QUIZ TREE:		
#55 - QUIZ TREE:		
#56 - QUIZ TREE:		

NAME	LOOK FOR THESE CHARACTERISTICS	SKETCH OR TAKE NOTES ON OTHER DISTINCTIVE CHARACTERISTICS
#57-Quercus prinus (Chestnut Oak)		
#58-Quercus muehlenbergii (Chinkapin Oak)		
#59 - QUIZ TREE:		
#60 - QUIZ TREE:		
#61 - QUIZ TREE:		
#62 - QUIZ TREE:		
#63 - QUIZ TREE:		
#64 - QUIZ TREE:		
#65 - QUIZ TREE:		
#66-Quercus falcata (Southern Red Oak)	"Turkeyfoot Oak" - long middle finger. Variable leaves. 	

NAME	LOOK FOR THESE CHARACTERISTICS	SKETCH OR TAKE NOTES ON OTHER DISTINCTIVE CHARACTERISTICS
#67-Cercis canadensis (Red Bud)	 Heart shaped with "cordate" leaf base.	
#68-Liriodendron tulipitera	Large tree beside road.	
#69-Ailanthus altissima (Tree-of-Heaven)	 Compound leaf, 1 to 3 feet long; many leaflets.  2 Leaflets with sm. point on margin at base.	
#70-Paulownia tomentosa (Empress Tree; Royal Paulownia)	Exotic; leaves with wooly underside; woody capsuled fruit hanging in tree.	
#71-Quercus alba (White Oak) White Oak with deep sinus, as is the case here, is locally referred to as "Forked Leaf Oak."		

The End

APPENDIX K



UNIT 6

FORESTRY 3050
DENDROLOGY AND SILVICS OF THE GYMNOSPERMS

FORESTRY DEPARTMENT
UNIVERSITY OF TENNESSEE
KNOXVILLE

TABLE OF CONTENTS

I. STATEMENT OF OBJECTIVES

Upon completion of this unit, the student should be able to:

1. Recall the scientific names of the spruce and fir species presented in this unit.
2. Recall the taxonomic classification system used for the spruce and fir species.
3. Use the distinguishing botanical features (leaves, twigs, growth forms, bark, and cones) to describe, differentiate between, and identify the spruce and fir species presented in this unit.
4. Use the important silvical characteristics (light tolerances, tree associates, reproductive characteristics, and especially site or habitat requirements) to describe, compare, and contrast the spruce and fir species presented in this unit.
5. Describe the native ranges and altitudinal distributions of the spruce and fir species presented in this unit.
6. Describe important properties and commercial uses of the spruce and fir species presented in this unit.
7. Successfully use a botanical dichotomous key to identify spruce and fir species.

THE GENERA PICEA AND ABIES
(Pinaceae Family)

II. INTRODUCTION

The two remaining genera belonging to the Pinaceae family are second only to the genus Pinus in importance and the extent of their distributions, both in this country and abroad. It is appropriate to consider these two genera together as their various members are common associates and spruce-fir forests dominate the boreal forests of the world. This name combination generally signifies the severest of site conditions as regards cold and high winds. Spruce stands comprise the northern-most stands of arborescent trees which are subject to freezing temperatures every month-of-the-year. Permafrost, or permanently frozen ground limits their northernly migration.

In general, members of the genus Abies, the firs, are more tolerant and tend to form the more stable climax associations. Wood properties of the spruces are superior to those of the firs, spruce wood having a high strength-weight ratio while the wood of most firs is brittle and splinters easily. Although generally found on the more exposed sites, the spruces are generally more shallow-rooted than are the firs and are commonly subject to windthrow.

Since members of these groups are generally restricted to cool, moist climates, they extend into the southern latitudes only along the high mountains. (several exceptions to this generalization will be found along the Pacific Coast)

To help comprehend the complicated distribution patterns that characterize the members of these groups we will, for both genera, begin our study with species native to the southern highlands of Eastern North America, move northward to the lower elevations where members tend to become transcontinental through the lowlands of Northern Canada, then move southward, first along the Rocky Mountains and then southward along the Cascade and Sierra Nevada ranges and including Pacific Coastal species last.

III. CLASSIFICATION AND NOMENCLATURE OF PICEA & ABIES**

KINGDOM: Plants

DIVISION: Spermatophyta

SUBDIVISION: Gymnospermae

ORDER: Coniferales

FAMILY: Pinaceae

GENERA, SPECIES, & VARIETIES:

Picea (The Spruces)

(native)

*1. rubens . . . . . Red spruce
*2. glauca . . . . . White spruce
*3. mariana . . . . . Black spruce
*4. engelmannii . . . . . Engelmann spruce
*5. pungens . . . . . Colorado blue spruce
*6. sitchensis . . . . . Sitka spruce
*7. breweriana . . . . . Brewer spruce

(non-native)

*8. abies . . . . . Norway spruce

Abies (The Firs)

(native)

*1. fraseri . . . . . Fraser fir
2. balsamea . . . . . Balsam fir
3. lasiocarpa . . . . . Subalpine fir
4. lasiocarpa var. arizonica . . . . . Corkbark fir
5. grandis . . . . . Grand fir
6. concolor . . . . . White fir
7. amabilis . . . . . Pacific silver fir
8. procera . . . . . Noble fir
9. magnifica . . . . . California red fir
10. magnifica var. shastensis . . . . Shasta red fir
11. bracteata . . . . . Bristlecone fir

*Responsible for cone identification.

**Harlow & Harrar, Textbook of Dendrology (according to the German botanical taxonomic classification system of Engler and Prantl)

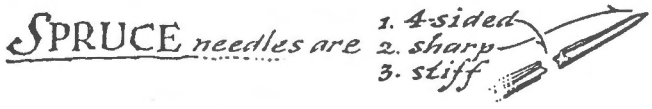
IV. DESCRIPTIONS OF GENERA, SPECIES, AND VARIETIES

A. PICEA.....The Spruces

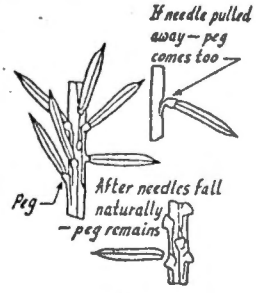
Of the 35-40 species that belong to this genus approximately half are native to China, where the exact number of intergrading species in unknown. Although generally confined to cool regions, they extend as far south as Mexico along the high mountains. Seven species are native to the United States, 5 of which are of major importance.

Characteristics Of The Genus Picea

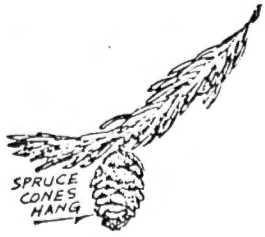
1. thin, scaley bark,
2. non-resinous buds,
3. needle-like, usually 4-sided needles,



4. peg-like stalks to which needles are attached, and



5. pendant, woody cones.



SPRUCE SPECIES

1. Red Spruce: Picea rubens Sarg. (also referred to as "He Balsam")

**Native Range

**Botanical Features

Foliage: 4-sided, sharp-pointed; 1/2" - 5/8".

Cones: 1 1/4" - 2", pendant, often staying on tree first winter; margin of scale sometimes erose.

Growth form: large, long lived trees, esp. on so. end of range.

**Silvical Characteristics

HABITAT. Varied, ranging from swamps and bogs where growth is slow to mountain tops; best growth on well-drained uplands and mountain slopes; in pure stands or mixed with yellow birch, beech, maple, white pine and hemlock on better sites and with black spruce, balsam fir, tamarack, and red maple on swampy sites. The common spruce in the mountains of New York and New England and with white pine the most important timber species in this region.

ADDITIONAL SILVICAL FEATURES. Very tolerant, though growing slowly under heavy shade; long-lived, attaining age of 400 years; good reproduction; spreading root system; susceptible to damage by fire and wind throw.

**Additional Notes, Drawings, Etc.

In the southern Appalachian Mts., Red Spruce is usually found at elevations between 4,000 and 6,000 feet.

2. White Spruce: Picea glauca (Moench) Voss

**Native Range

**Botanical Features

Foliage: 1/3"-3/4", 4-sided, pungent odor when crushed = cat spruce.

Cones: 1 1/2"-2 1/2", scale margin rounded or emarginate but not erose.

Habit: 60'-70' high, 1 1/2'-2' diam. crown narrowly to broadly pyramidal with long, thick branches.

**Silvical Characteristics

HABITAT. Hudsonian and Canadian zones; typical of low, damp woods, and banks of streams and lakes; altitudinal range from sea level to 5,000 ft; frequently gives way to black spruce or tamarack on wet sites, and to lodgepole pine on dry sites; often forms pure, dense forests, but also in mixture with black spruce, fir birch, poplars, and willows.

ADDITIONAL SILVICAL FEATURES. Tolerant of considerable shade, recovers from suppression well; growth slow, but faster than black spruce; tree attains age of 250-300 years; reproduction abundant on moist sites; shallow spreading root system.

**Additional Notes, Drawings, Etc.

3. Black Spruce: Picea mariana (Mill.) B. S. P.

**Native Range

**Botanical Features

Foliage: 1/4"-1/2", 4-sided, glaucous.

Cones: 3/4"-1 1/2", erose on margin, semi-serotinous.

Habit: sometimes 40'-80' high, 2/3-3' in diam., but commonly much smaller.

**Silvical Characteristics

HABITAT. Hudsonian and Canadian zones; typical of cold sphagnum bogs and swamps, but also found on dry slopes in Northwest; altitudinal range from 100-3,500 ft.; with white spruce and tamarack, reaches northern limit of tree growth; in dense, pure stands, or in mixture with tamarack, balsam fir, white spruce, white birch, aspen, etc.

ADDITIONAL SILVICAL FEATURES. Very tolerant, recovering from suppression at an advanced age; growth slow; tree rather short-lived, attaining an age of 200 years; shallow, spreading root system; reproduction good on moist sites; lower branches often take root, forming clusters of small trees.

**Additional Notes, Drawings, Etc.

4. Engelmann Spruce: Picea engelmannii Parry

**Native Range

**Botanical Features

Foliage: 1"-1 1/8"; 4-sided; rank odor when crushed.

Cones: 1"-2 1/2"; scales erose; thin & papery.

Habit: 60'-120' high, 1 1/2'-3' diam. Bole limby. A prostrate shrub at high elevations.

**Silvical Characteristics

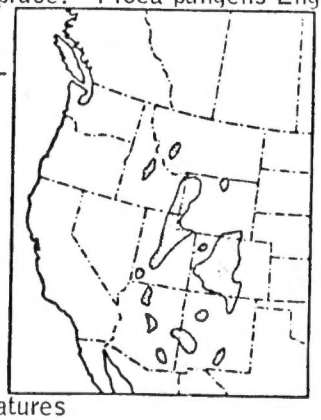
HABITAT. Hudsonian and Canadian zones; varying from 1,500 - 5,000 ft. in the northern Rockies to 10,000-12,000 feet in the southern Rockies; rich, loamy soils with abundance of moisture; in pure stands or in mixture with alpine fir, lodge-pole pine, and other conifers growing at high elevations.

ADDITIONAL SILVICAL FEATURES. Tolerant and recovering well from prolonged suppression; growth generally rather slow because of short summer season; a long-lived tree, reaching ages of 350-500 or more years; reproduction abundant and vigorous; shallow, spreading root system.

**Additional Notes, Drawings, Etc.

5. Colorado Blue Spruce: Picea pungens Engelm.

**Native Range



**Botanical Features

Distinguished from other spruces by: 1) sharp-pointed needles extending at right angles from twig, 2) glabrous twigs, 3) reflexed bud scales, 4) cones 3" long, and 5) "layered" appearance of crown.

**Silvical Features

HABITAT. Transition and Canadian zones, but mostly below the Engelmann spruce belt; varying from 6,000-9,000 feet in the north to 8,000-11,000 feet in the south; rich, moist soils, typically on stream banks; never abundant; in scattered pure groves or singly in mixture with ponderosa pine, Douglas-fir, alpine fir, Engelmann spruce, and hardwoods.

ADDITIONAL SILVICAL FEATURES. Moderately tolerant, but least so of spruces; slow-growing; long-lived; reproduction generally scanty because of dense ground cover; widespread, moderately deep root system and decidedly windfirm.

**Additional Notes, Drawings, Etc.

6. Sitka Spruce: Picea sitchensis (Bong.) Carr.

**Native Range

**Botanical Features

Foliage: very sharp needles; 1/2"-1 1/8", flattened, extending at right-angeles from twig.

Cones: 2"-4"; papery, erose at edge.

Habit: Large tree 180'-200', 3'-4 1/2' diam. (max. 300 by 16 ft.) Crown pyramidal, open.

**Silvical Characteristics

HABITAT: A tidewater species; best development in deep, moist loams; in pure stands or mixed with hemlock, Douglas-fir, western redcedar, alder and maple.

ADDITIONAL SILVICAL FEATURES. Tolerant; growth fairly rapid; long-lived, ages of 700-800 years; reproduction vigorous; shallow roots.

**Additional Notes, Drawings, Etc.

7. Brewer Spruce: Picea breweriana S. Wats.

**Native Range

**Botanical Features

Readily distinguished from other American spruces by: 1) weeping habit, 2) dark green, flattened or remotely 3-angled needles, and 3) entire-margined cone scales.

**Silvical Characteristics

HABITAT. An uncommon timber-line species restricted to the Siskiyou mountains of southern Oregon and northern California.

**Additional Notes, Drawings, Etc.

8. Norway Spruce: Picea abies (L.) Karst.

The only important exotic spruce planted in North America; widely used for ornamental purposes, commonly outgrows native species. The best mark of Norway spruce in this region is its drooping habit. Cones of Norway spruce are larger than those of native spruce species.

**Additional Notes, Drawings, Etc.

B. ABIES.....The Firs

Nine species of the 40 that belong to this genus are native to the U.S., of which 7 are of major importance. Though not as important to the timber industry, Canada balsam, Strasburg turpentine and other oleoresins are obtained from these trees.

Characteristics Of The Genus Abies

1. erect cones that disintegrate at maturity,

2. leaves sessile, usually flattened (rarely 4-angled); leaving round leaf scars on twigs, and

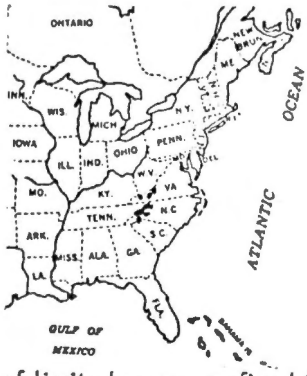
FIR needles are flat

3. resin blisters on bark.

FIR SPECIES

1. Fraser Fir: Abies fraseri (Pursh.) Poir. (also referred to as "She Balsam" or "Balsam")

**Native Range



Fraser fir is a tree of limited range confined to the high mountains of the Southern Appalachians in North Carolina, Tennessee, and southwestern Virginia. Between 5,000 and 6,000 ft., it is usually associated with Red spruce (Picea rubens), in general there being a greater percentage of fir with increase in elevation. Above the 6,000 ft. altitude it forms almost pure stands. On north-facing slopes and in sheltered ravines some firs may occur down to approximately 4,000 ft., but usually the lower limit of this species lies between 4,500 and 5,000 feet.

**Botanical Features

Fraser fir is very similiar to Balsam fir, Abies balsamea, except for the long exserted bracts from the cones which extend beyond the scales and are strongly reflexed.

**Additional Notes

The 60,000 acres of Fraser fir in the southern Appalachians are presently seriously threatened by a sapsucking insect, the Balsam Woolly Aphid, which was introduced from Europe in 1908. As the aphid has spread southward, many acres of mature Fraser fir have been lost. Presently little can be done to save the trees. Chemical control is effective but extremely costly and thus limited to very high-value areas along scenic road-ways.

**Additional Notes, Drawings, Etc.

2. Balsam Fir: Abies balsamea (L.) Mill.

**Native Range

**Botanical Features

Foliage: 3/4"-1 1/2", blunt or slightly notched at apex.

Cones: 2"-3 1/2", bracts shorter than scales, erose shoulders.

Habit: Medium-sized tree 40-60' high and 1-1 1/2' diam.; dense, dark green, narrowly pyramidal crown.

**Silvical Characteristics

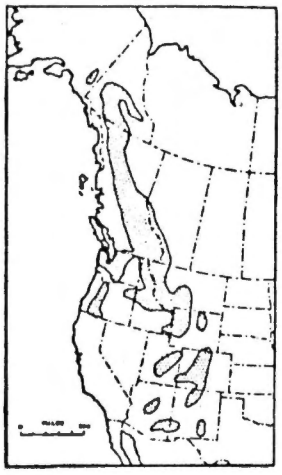
HABITAT. Canadian and Hudsonian zones; demands abundant soil moistrue and humid atmosphere; forms pure stands in swamps; on higher sites in mixture with spruce, hemlock, and broad-leafed species. The variety phanerolephis Fern., Intermediale fir, ranging north from northern Virginia has slightly exposed fruit bracts.

ADDITIONAL SILVICAL FEATURES. Tolerant (less so than spruce), recovering well from suppression; a short-lived tree reaching an age of 150 years, but generally defective before 90 years; reproduction plentiful and aggressive; shallow root system; lower branches sometimes take root, producing new trees.

**Additional Notes, Drawings, Etc.

3. Subalpine Fir: Abies lasiocarpa (Hook.) Nutt.

**Native Range



**Botanical Features

Foliage: 1"-1 3/4", blunt, or notched.

Cones: 2"-4", scales 3 times longer than bracts, dark purple.

Habit: 60'-100' high, narrowly pyramidal; a prostrate shrub at timberline.

**Silvical Characteristics

Timberline tree of the Northern Rocky Mts. with outliers extending all the way down to Arizona & New Mexico; a small tree or little commercial importance.

HABITAT. Canadian and Hudsonian zones; growing form 3,500 feet to timber line in the north and from 10,500 feet to timber line in the south; in cool, moist sites; commonly with Engelmann spruce, lodgepole, whitebark, limber, or bristlecone pines, alpine larch, cork fir, and aspen.

ADDITIONAL SILVICAL FEATURES. Tolerant (of its associates; only Engelmann spruce and mountain hemlock are more so); growth not rapid; reproduction abundant and vigorous; shallow root system; lower branches sometimes taking root.

**Additional Notes, Drawings, Etc.

4. Corkbark Fir: Abies lasiocarpa var. arizonica (Merriam) Lemm.

A variety of subalpine fir which grows in New Mexico, Arizona, and southern Colorado. Distinguished by thick, soft, corky bark that does not have resin blisters.

5. Grand Fir: Abies grandis (Dougl.) Lindl.

**Native Range:

**Botanical Features

Foliage: 1/2"-2", flattened often 2-ranked.

Cones: 2 1/2"-4 1/2", bracts shorter than scales.

Habit: 140'-160' in height and 2-4' in diameter.

**Silvical Characteristics

HABITAT. Transition and Canadian zones; altitudinal range form sea level to 5,000 feet; on deep, moist, alluvial soils along streams or on mountain slopes; in limited pure stands, or more frequently in mixed hardwood and coniferous forests with ponderosa, western white, and lodgepole pines, Douglas-fir, western larch, alpine fir, Engelmann spruce, etc.

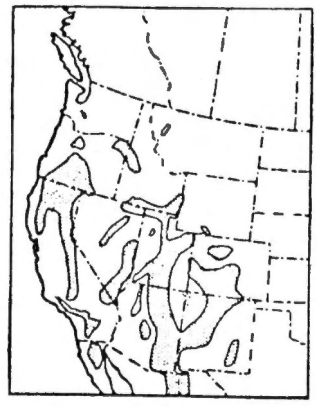
ADDITIONAL SILVICAL FEATURES. Moderately tolerant, but less so than associated firs; growth moderate, maturity being reached in about 200 years; reproduction abundant if sufficient moisture and protection against frost is present; windfirm with deep, spreading root system; subject to attach by spruce budworm and stringy brown-rot fungus.

**Wood: Has a fetid (disagreeable) odor, and so known as "stinking fir."

**Additional Notes, Drawings, Etc.

6. White Fir: Abies concolor (Gord. and Glend.) Lindl.

**Native Range



**Botanical Features

Foliage: 2"-3", longest leaves of western firs, generally 2-ranked.

Cones: 3"-5", bracts shorter than scales.

Habit: 120-150' high; a dense cone like crown with heavily foliaged, short branches.

**Silvical Features

HABITAT. Transition and Canadian zones; altitudinal range from 6,000-11,000 feet; requires less moisture than other western firs, existing surprisingly well on poor, dry sites; seldom in pure stands, usually with ponderosa and limber pine, Douglas-fir, alpine fir, Engelmann spruce, and aspen.

ADDITIONAL SILVICAL FEATURES. Tolerant, although less so than alpine fir; growth moderately rapid, maturity being reached in about 300 years; reproduction generally abundant and aggressive; root system normally shallow.

**Additional Notes, Drawings, Etc.

7. Pacific Silver Fir: Abies amabilis (Dougl.) Forbes

**Native Range

**Botanical Features

Foliage: silvery-white to blue-green; 3/4"-1 1/2", grooved above.

Cones: 3 1/2"-6", bracts shorter than scales.

Growth form: One of most beautiful trees in NW; crown spire-like.

**Silvical Characteristics

HABITAT. Transition and Canadian zones; altitudinal range from sea level to 6,000 feet; best on deep, moist soils with southern or western exposure; in pure stands or mixed with Sitka spruce, Douglas-fir, grand fir, western hemlock, and western redcedar.

ADDITIONAL SILVICAL FEATURES. Moderately tolerant; growth moderate, maturity being reached in about 250 years; reproduction abundant; often planted as ornamental because of handsome crown shape and dense foliage; the most abundant fir of the northwest.

**Additional Notes, Drawings, Etc.

8. Noble Fir: Abies procera Rhed.

**Native Range

**Botanical Features

Foliage: 1"-1 1/2", 4-angled, grooved above,

Cones: 4"-6", bracts exserted and imbricate due to strong reflexing.

Growth form: Largest of firs but with smallest range; heavily logged.

**Silvical Characteristics

HABITAT. Transition zone; in stands of mixed conifers; altitudinal range from 2,000-5,000 feet; on cool, deep, moist sites.

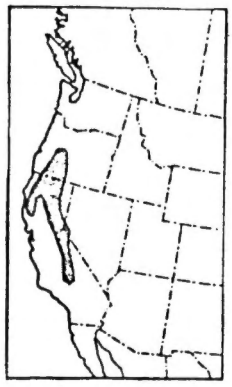
ADDITIONAL SILVICAL FEATURES. Seedlings and trees both intolerant; growth rather rapid; maturity reached in about 350 years; reproduction sparse; deep, spreading roots.

**Wood: Best quality of native true firs, used in aircraft; light, straigh-grained, not durable.

**Additional Notes, Drawings, Etc.

9. California Red Fir: Abies magnifica A. Murr.

**Native Range



**Botanical Features

Foliage: 3/4"-1 1/4", 4-angled, crowded on upper side of branch.

Cones: 6-9", bracts shorter than scales.

Growth form: Large tree, similar to Noble but with reddish bark.

**Silvical Features

HABITAT. Transition zone to timber line in some places; altitudinal range form 5,000-10,000 feet; in pure stands or mixed with Douglas-fir, sugar and ponderosa pine, and numerous other species.

ADDITIONAL SILVICAL FEATURES. Moderately intolerant at maturity; growth rather slow, with maturity being reached in about 300 years; reproduction abundant on moist mineral soil; deep, spreading roots.

**Additional Notes, Drawings, Etc.

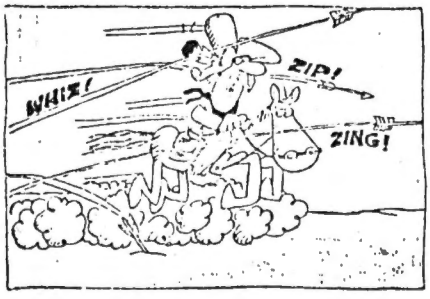
10. Shasta Red Fir: Abies magnifica var. shastensis Lemm.

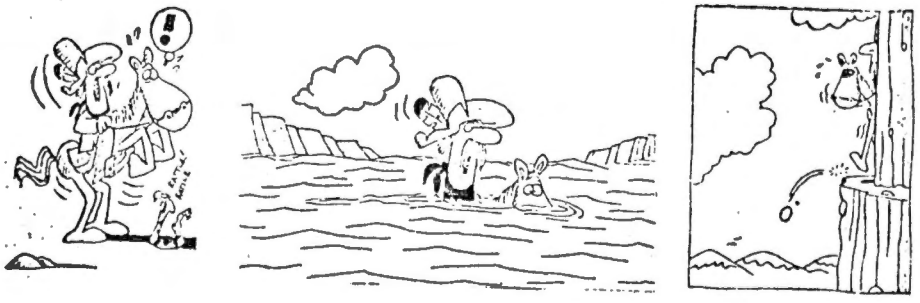
Occasionally found throughout the range of California Red Fir. Very similar to both Red fir and Noble fir, probably a hybrid. Distinguished by exserted bracts on cone, deep red bark, and winter buds almost free of resin.

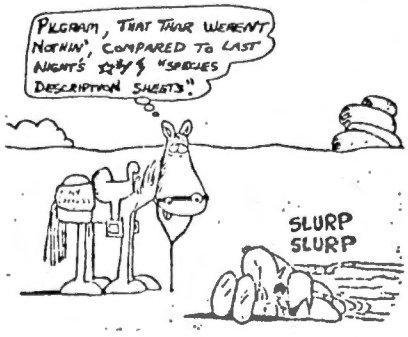
11. Bristlecone Fir: Abies bracteata D. Don.

**Native Range

This curious species is native only to Monterey County, central California in the Santa Lucia Mts. Distinguishing features are sharp-pointed needles and long, exserted bracts on cones.







V. QUESTIONS

1. What are the differences between Balsam and Fraser fir?

2. Given needles only, how would you distinguish between Fraser fir and Red spruce?

3. Why are spruce and fir absent from the beech gaps in the Smokies?

4. What are the differences between sun and shade needles on Fraser fir?

5. Briefly describe the growth-form and commercial importance of Nobel fir and the extent of its native distribution.

6. Contrast the sites on which you would expect to find Sitka and Engelmann spruce.

7. Name the spruces as you would encounter them, moving from the high mountains of East Tennessee and North Carolina northward along the Appalachians into Canada, westward in Canada to British Columbia, then southward to the Oregon coast.

8. Name all the firs that have exserted bracts that are longer than the cone scales.

9. Contrast the site and growth differences that characterize white and black spruce.

10. Red fir, white fir, and gaint sequoia are all found on the western slopes of the Sierra Nevada Mountains of California. List them as they are encountered going from West (low elevation) to East (higher elevation).

11. You are a Forester working in:
    a) Maine
    b) Wisconsin
    c) Colorado
    d) California

    For each state, list the spruce and fir species native there and then discuss each species site or habitat requirements being sure to include the altitudinal distribution.

12. What is the botanical taxonomic classification system we are using for the Gymnosperms?

13. Using the "Key to the Species of Firs" found on page 26 of this guide, describe the characteristics used to key Nobel Fir, A. procera.

VI. GLOSSARY OF TERMS

Abies .....Old Latin name for European fir. From "abire", to rise, alluding to the great height of some species.

Axis.....The central line of a cone.

Bract .....A modified leaf subtending a flower or belonging to an inflorescence.

Decurrent . . Said of a leaf or leaf scar, part of which extends in a ridge down the twig below the point of insertion.

Erose.....Irregularly toothed or eroded.

Exserted . . .Prolonged beyond the surrounding organs, as bracts from cone scales.

Krummholz . .Timberline, prostrate, grotesque tree shrubs = "Flag" trees

Notched. . . .Indented (i.e. apex of fir needle )

Picea .....The Latin name for pine, spruce, or fir; from Greek "pissa", pitch, or "peuke", the Greek name for fir.

Prostrate. . .Lying flat on or near the ground surface.

Reflexed . . .Abruptly bent downward.

Resin pocket, blisters, or cysts . . . Cell or cavity occluded with resin.

Stomatiferous. . Furnished with stomata (covered with minute white dots forming distinct white bands; some fir needles).

Subglobose. Generally spherical.

Transcontinental. . . Said of trees whose distributions cross a continent.

Woolly. . . . .Covered with long and matted or tangled hair.

VII. DICHOTOMOUS SPRUCE AND FIR KEYS

Key To The Species Of Spruces

1. Cone scales rounded at tip, smooth or wavy (erose) on margin.
   2. Cones under 2 inches long; needles 4-sided; eastern or northwestern.
      3. Cones 1/2 - 1 1/2 inches long, ovoid, purple, persistent many years; scales stiff, rigid, brittle, with wavy margins; twigs hairy; needles blunt-pointed; transcontinental and northern.....
      .....P. mariana, Black Spruce.
      3. Cones 1 1/4 - 2 inches long, oblong, brown, falling in 1 year; scales smooth on margin or nearly so; needles pointed.
         4. Cones scales stiff and rigid at maturity; twigs more or less hairy; eastern United States and Canada.....
         .....P. rubens, Red Spruce.
         4. Cone scales soft and flexible at maturity; twigs not hairy; transcontinental and northern.....
         .....P. glauca, White Spruce.
   2. Cones 2-4 inches long; scales with entire margins; needles flattened; alpine in California and Oregon.....
   .....P. breweriana, Brewer Spruce.
1. Cone scales wedge-shaped at tip, margin wavy (erose).
   5. Cones 4-7 inches long; drooping foliage; needles 4-sided, not prickly; common European ornamental.....
   .....P. abies, Norway Spruce.
   5. Cones rarely 4 inches long; native and western.
      6. Needles flattened, not prickly, yellow-green; cone 2 1/2-4 inches long; Pacific Coast area.....
      .....P. sitchensis, Sitka Spruce.
      6. Needles 4-sided, blue-green; western mountain region.
         7. Cone 1-2 1/2 inches long, persistent 1 year; needles flexible, acute but not prickly to touch; twigs minutely hairy; buds 1/8-1/4 inch long with scales usually appressed; bark on mature trees thin and scally.....
         .....P. engelmanii, Engelmann Spruce.
         7. Cone 2 1/4-4 1/2 inches (mostly about 3 1/2 inches) long, persistent 2 years; needles stiff, bristle-pointed; twigs glabrous; buds 1/4-1/2 inch long with scales usually reflexed, bark on mature trees thick and furrowed; central Rocky Mts.
         .....P. pungens, Blue Spruce.

Key To The Species Of Firs

1. Winter buds subglobose, 1/8 - 1/3 inch long; needles not bristle-tipped; cones without spiny-tipped bracts.
   2. Needles crowded toward the upper side of the twigs; cones large and broad (3 1/2 - 9 inches long); Pacific Coast region.
      3. Needles 4-sided, stomatiferous (covered with minute white dots) on all sides and usually glaucous; bark furrowed or scaly on mature trunks.
         4. Cones 4-6 inches long; bracts much longer than, and covering cone scales; needles with sharply defined groove on upper surface; Washington, Oregon, and northern California..... .....A. procera, Noble Fir.
         4. Cones 6-9 inches long; bracts never covering scales; needles ribbed above and below.
            5. Cones with bracts inserted..... .....A. magnifica, California Red Fir.
            5. Cones with bracts exserted..... .....A. magnifica shastensis, Shasta Red Fir.
      3. Needles flattened, dark green and lustrous above, with 2 distinct white bands (stomata) on lower surface; bark smooth and ashy gray on mature trunks; cones 3 1/2 - 6 inches long with inserted bracts; British Columbia and Alaska to Washington and Oregon..... .....A. amabilis, Pacific Silver Fir.
   2. Needles flattened, on sterile branches spreading and not crowded, often 2-ranked; cones narrow, 2-5 inches long.
      5. Cones with bracts inserted.
         6. Needles on lower branches 3/4 - 1 3/4 inches long; cones dark purple, scales slightly longer than broad.
            7. Needles dark green and lustrous above with 2 distinct white bands (stomata) below, 2-ranked on lower branches; northeastern United States to northwestern Canada..... .....A. balsamea, Balsam Fir.
            7. Needles stomatiferous on both surfaces, nearly erect on lower branches; western.
               8. Mature bark hard, smooth, gray; high western mountains .....A. lasiocarpa, Subalpine Fir.
               8. Mature bark distinctly soft and corky, yellow-white; Colorado, Arizona, and New Mexico..... .....A. lasiocarpa arizonica, Corkbark Fir.
         6. Needles 1 1/2 - 3 inches long; cones yellow to green - purple, scales slightly broader than long; western.
            9. Needles distinctly 2-ranked, 1 1/2 - 2 inches long, dark green above with 2 white bands of stomata below; Montana to British Columbia and California..... .....A. grandis, Grand Fir.

9. Needles spreading or obscurely 2-ranked, 2-3 inches long, stomatiferous and pale green on both surfaces; western United States.....A. concolor, White Fir.

5. Cones with bracts exserted; needles 1/2 - 1 inch long; Appalachian Mountains.....A. fraseri, Fraser Fir.

1. Winter buds ovoid, pointed, 3/4-1 inch long; needles 1 1/2 - 2 1/4 inches long, flat, rigid, bristle-tipped; cones 3 -4 inches long with spiny bracts exserted 3/4 - 1 3/4 inches; California (Monterey County) .....A. bracteata, Bristlecone Fir.

****The "keys", "range maps" and "silvical characteristics" used in this workbook were taken from R. J. Preston's North American Trees, pp. 49 - 61 and pp. 73 - 87.

****Five drawings used in this workbook were taken from Eric Sloane's A Reverence for Wood, p. 109

VITA

John Glenn Palmer was born in Haywood County, North Carolina, on April 23, 1951, the son of Senator and Mrs. Joe H. Palmer. He attended Crabtree-Iron Duff Elementary School, North Carolina, and was graduated from Tuscola Senior High School in 1969. After completing two sessions of summer school in the summer of 1969 at Western Carolina University, Cullowhee, he entered North Carolina State University, Raleigh in September, 1969. Here, after four years, he received two Bachelor of Science degrees in Forestry and Conservation in May 1973. After graduation, he became a forestry exchange student, working three months for the Forestry Commission in Wales and Scotland.

In September 1973 he entered Graduate School in the Forestry Department at the University of Tennessee. For two years, from January 1974 to December 1975, he was employed as a Graduate Teaching Assistant in the Forestry Department. He received a Master of Science degree in Forestry with a minor in Ecology in 1976.

Each summer during the three years of graduate school, time was spent working away from school. During the summer of 1974 he attended the Rocky Mountain Biological Laboratory, Gothic, Colorado for research and course work. During the summer of 1975 he worked for the Division of Forestry (TVA) where he coauthored a "High School Forest Resources Teacher's Guide" and a slide-tape presentation on "The Forestry Profession and Its Career Opportunities." During the summer and fall of 1976 he worked as a naturalist and ranger for the Great Smoky Mountains National Park.

He is a member of: Xi Sigma Pi, Alpha Zeta, Society of American Foresters, American Forestry Association, Audubon Society, Wildlife Society, and Farmhouse Fraternity. After graduation, in December 1976, he was hired as an Instructor in the Forestry Department at the University of Tennessee.