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DEVELOPING COMPUTER COURSEWARE
FOR FOREST MANAGEMENT

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ABSTRACT: Computers are an important tool for managing forests, and they can be used to help teach forestry students about forest management. This paper describes a project to develop computer-based learning models that will be integrated in a comprehensive courseware package suitable for teaching an entire undergraduate forest management course. The forest management courseware will supplement a traditional textbook and take advantage of the things that can be done better with a computer-based approach. While the computer is not likely to rival the textbook in the areas of depth and portability, it can provide an interactive medium to relieve some of the more tedious aspects of traditional course materials. Some of the more promising features of computer-based instruction are the non-linear, multi-level possibilities of hypermedia, interactive tutorials, animated graphics, computer-administered problem sets, and simulation programs. These features can relieve the student and the instructor of some of the more tedious traditional teaching activities to allow more focus on concepts and more general issues.

INTRODUCTION

Forest management is a senior level course in most forestry curricula. Students learn to use a variety of techniques and concepts related to making decisions regarding the management of forested properties. Subjects covered typically include: 1) principles of financial analysis; 2) stand-level management planning, including using growth and yield models and decision criteria for managing future and current even- and uneven-aged forest stands; 3) forest-level strategic planning, including traditional forest regulation concepts, harvest scheduling, sustained yield, and multiple-use management.

It has been my experience in teaching this course for five years that most of the students find the course to be one of the more difficult courses they have to take. I believe that the students are right – that it is a difficult course, primarily for two reasons: 1) there is a lot of material that is covered in the course, and 2) the material involves a lot of math, which forestry students are not used to doing. In addition, as I currently teach it, the course is hard for me to teach. Because of the mathematical content of the course, I believe problem sets are an important element of the course. However, problem sets take a lot of time to develop and to grade. My grading style could be streamlined, but I believe that the feedback I provide on the homework is an important part of its educational value. I considered two ways to make the work-load of the course more reasonable. The obvious and simplest solution is to reduce the content of the course. I have done this to some extent, and I continually consider what subjects could or should be dropped. However, I feel reluctant to exclude any additional course content – I simply think the subjects that are covered now are essential to a complete forestry education.[1]

The second way to reduce the difficulty of the course is to teach the same material more effectively so that the students catch on to the material more easily. This is certainly not the easy solution. I have spent a considerable amount of time developing teaching materials designed to make it easier for the students to meet the learning objectives of the course. Over five years of teaching the course, I have developed a fairly comprehensive set of handouts, each of which is comparable to a chapter in a textbook. In addition, I have developed Visual Basic programs to take some of the drudgery out of the course exercises. This year, I developed a course web site, which, for now, is used primarily for outside-class communication with the students and for making documents available to the students. I have plans to use the web for much more in the future. I believe that this solution is working. This year there were fewer complaints that the course is too hard and I am hearing more feedback about how interesting and valuable the course is.

I have now developed enough course material that, collectively, it can be considered the rough draft of a new forest management textbook. However, the materials constitute more than a traditional textbook. There are several programs that I use and several multimedia elements that have been developed. This year, I hope to organize all these materials into a draft CD-ROM textbook for forest management. Since many of the products are computer-based, I prefer to call the collected materials "courseware." This paper describes the key elements of the courseware that has been developed and plans for future development. A key to the further

development of the courseware will be to get others who teach forest management to adopt the courseware and try it in their classes. This will provide an important source of feedback so that the courseware can become useful to others.

COURSE OUTLINE

Management is fundamentally decision making. The approach to decision making espoused in the courseware described in this paper follows six fundamental steps: 1) clearly identify problem the decision maker needs to solve, 2) identify the objectives of the decision maker and the criteria by which alternative solutions should be judged, 3) formulate alternative solutions to the decision maker's problem, 4) analyze and rank the alternatives using the criteria identified in step two, 5) implement the preferred alternative, and 6) obtain feedback on the results of the management action. Much the material in my forest management courseware focuses on the fourth step in this process. Steps 1 and 2 are largely policy questions, but students are frequently reminded of the need to carry out these steps before any analysis can be done. Step 3 is generally a silvicultural question. As mentioned, the techniques taught in my forest management class focus mostly on step 4 in this process. Steps 5 and 6 are discussed, but are difficult to apply in an academic setting. In most cases, the courseware assumes that the objective of the landowner is to manage the forest for maximum financial return – generally from timber production. This may be a drawback of the courseware, given the importance of non-timber values for many forest landowners. However, as discussed earlier, there is limited time in the course, and it is necessary to focus on the most essential aspects of forest management.

Course Outline for FOR 466W

1. Introduction: what is forest management?
2. Financial Analysis.
   A. Basic financial analysis.
   B. Financial analysis with inflation.
3. Managing individual forest stands.
   A. Basic growth and yield concepts.
   B. The Land Expectation Value.
   C. The Forest Value.
   D. Thinning.
   E. Uneven-aged management.
4. Managing large forested areas.
   A. Regulation.
   B. Linear programming.
   C. Basic harvest scheduling models.
   D. Incorporating non-timber values in harvest scheduling models.

Figure 1. Course Outline for FOR 466W – Forest Resources Management at the Penn State School of Forest Resources.

The outline of the course I teach is shown in Figure 1. The philosophy of the courseware is founded on the basic objectives of teaching forestry students to write management plans for forested properties. Because the tools and concepts are different for small and large properties, the bulk of the course is divided accordingly into two parts that address management problems at each scale. In order to give the students the basic financial tools necessary to evaluate forest management alternatives, two chapters are included in the beginning of the course on the basics of discounting – with and without inflation. The key concepts in the second part of the course are the Land Expectation Value (LEV) and the Forest Value for even-aged management, and Q-factors, cutting cycles, and financial maturity for uneven-aged management. These are the appropriate tools for assessing alternate management scenarios for individual stands when the landowner is primarily interested in maximizing the financial return of the property from timber production. In addition, the techniques can be generalized to accommodate a wider range of objectives. The second part of the course concludes with an assignment where the students write a management plan for a hypothetical 50-acre property. On the list of future improvements for the courseware is the addition of growth and yield simulators and tract-mapping software to increase the realism of this exercise and give the students more experience with important computer-based forest management tools.

The third part of the course addresses the management of larger properties and introduces many of the basic concepts of forest planning, including regulated forests, long-term sustained yield, even-flow, and harvest scheduling. Forest regulation is taught in the course because it gives a relatively simple framework within which to introduce the students to many forest-level concerns. In addition, regulation is still applied on many forests, so it is useful for the student to know what it is. In the regulation section, the students learn the basic concept of the cycling of forest acres through age classes, they learn to calculate the inventory and growth of a forest from the age-class distribution, and they develop an intuitive understanding of allowable cuts. The students then learn to formulate relatively simple harvest scheduling linear programming models, and they learn to incorporate some basic non-timber concerns into the models. For their final project for the course, students develop a management plan for a large (approximately 30,000 acre) forest using linear programming. I have written a user-friendly interface to facilitate this project that is discussed in more detail below. In addition to developing the management plan, the students give oral presentations to the class on their management plans.

COURSEWARE FEATURES

A basic question with computer-aided instruction is what can be done better with the computer than with traditional media such as a textbook. I do not believe that computer-based courseware should replace the textbook. I have observed that students tend to print copies of most of the material that I put on the web site. It is hard to beat the portability of a paper copy. I make the chapters of my textbook available to the students in Adobe Acrobat© format so they can print it up and take it with them. However, some things can be done better on a computer. In this section, I will discuss the computer-based elements of my courseware.

Hypertext

Hypertext can be an extremely useful medium because it offers many alternative paths through a set of material. With a textbook, the material tends to follow a predefined path; but with hypertext, the possibilities are much more varied. The advantages of this are significant. Some readers may want to follow the shortest path through the material, not needing any additional explanation and not wanting to delve any deeper. Other students will welcome some additional explanation, including links to earlier material that may need to be reviewed. Still others will be interested enough to follow some "advanced topics" links. In addition to more detailedexplanations and advanced topics, links allow students to jump to related sections, example problems, animated graphics, photographs, videos, a glossary, and a catalog of formulas. Figure 2 shows the Contents page of the Financial Analysis chapter.

Figure 2. Screen Capture of the Contents Page of the Financial Analysis Chapter

The hypertext medium is different from traditional texts, and developers of hypertext courseware must follow some basic rules. First, the limit to the amount of material that people will read is much lower on a computer screen than in a textbook. It is necessary to keep hypermedia relatively short and shallow. This is one of the main reasons why hypermedia is not likely to completely replace textbooks. I use hypertext to cover material at about the same level as I cover it in a lecture. For more depth, the students must generally read the text. A second potential pitfall of using hypermedia is that it is easy to lose sight of where the start and finish points are. In some cases, this may be by design, but when there are specific course objectives that must be met, the students need to be able to tell what is the required material and when they have covered it. Each learning module I develop has a well-defined set of main pages. Links are clearly identified, for example, as a providing "more detail" or as an "advanced topic." Each module begins with an overview of the learning objectives of the module and ends with a summary of the key points and a set of study questions.

Animated Graphs

Graphics can be extremely useful for teaching mathematical concepts. For example, graphs dramatically illustrate the power of compound interest and can help students gain a more intuitive understanding of concepts such as optimal rotation ages, stocking-mortality relationships, and the development of age-class distributions over time. With the computer, animated charts can be developed that allow students to interactively change key parameters and see the impact of these changes on the shapes and positions of functional relationships. For example, in one graph, students can change a price assumption or the interest rate and observe how the cost of holding timber and land shift when those parameters are changed. Students can also observe the impact on the optimal rotation for an even-aged forest stand and on the predicted value of the property.

Tutorials

A computer can act as a student's personal tutor. Interactive practice problems have been developed that walk students through example problems step-by-step. Each problem has been broken down into sub-problems to help the student learn how to solve the problem systematically. At each step, the student can either select an answer, ask for a hint, or ask the computer to show them the correct answer and provide an explanation. For example, the solution process for a financial analysis problem can be broken down into the following steps: 1) select the correct type of discounting formula, 2) identify the relevant information from the problem and put the appropriate numbers in the formula, 3) enter the numbers in a calculator to obtain the correct answer. If the student selects the wrong answer, the computer gives an explanation of why that answer is incorrect and gives the student the opportunity to try again. Thus, the tutorials give students immediate feedback on whether they understand how to do the exercises correctly.

Web-Based Homework Assignments

Because much of the course material is mathematical, I believe the students must do problem sets in order to learn the material. Problem sets push the students to keep up with the material and give them early feedback on how they are doing in the course. In a course like forest management, where each subject builds on another, students cannot afford to wait until the first midterm to find out that they don't have an adequate grasp of the material. I also believe that the problem sets should be graded, or many students will not do them. Furthermore, graded homework assignments help students earn some points outside of a testing environment where some students simply do not perform well. One of the main drawbacks of giving problem sets, of course, is the amount of time it takes to grade them. There tends to be a direct relationship between the amount of time spent grading problem sets and the value of the feedback given to the students as a result of the exercise.

One of the key advantages of giving homework assignments is that it encourages students to work together. This is generally good, since students can often understand a peer's explanation better than the one given by the professor. Also, for those students doing the explaining, the exercise of trying to explain concepts from the course helps them to improve their own understanding of the material. However, a common problem with homework is that some students will simply copy another student's homework.

Computers provide an opportunity to eliminate many of the problems of giving problem sets and, at the same time, enhance many of their benefits. While we have not perfected this system yet, the intention is to develop the capacity to let the computer give and grade the problem sets. Ideally, the system will work as follows: 1) students will each be given a unique problem set which they will obtain by logging into the course web site, 2) after working the problem set, the student will log back onto the web site and enter his or her answers, 3) the computer will immediately respond by indicating which questions were missed, and the student's score will be logged in a file. The problem sets would all be unique – or at least there would be enough unique variations to discourage trying to find someone with the same set of problems. However, the questions would be similar on each problem set, perhaps with only a few numbers changed. The system could be set up to allow students to re-enter their answers as many times as they wish, or to only allow a limited number of re-takes. This system would improve on the traditional approach to problem sets in many ways:

   • It would give the students immediate feedback on what they understand and what they don't understand.
   • It would encourage the students to go back and study the material related to the questions they missed.

   • Students would have to do their own work, but they would still be able to collaborate on understanding the concepts common to all the homework sets.
   • The effort of grading the assignments would be eliminated, allowing professors and teaching assistants to spend their teaching time explaining concepts, rather than in grading.
   • Instructors can get timely feedback on which questions the students are having to re-take so they can review the material in class and/or consider re-wording the question for future assignments.

This approach to managing problem sets is not new. It has been implemented at Michigan State with a Unix-based system called CAPA (Computer-Assisted Personalized Approach, **http://www.pa.msu.edu:80/educ/CAPA/,** Kashy, et al. 1993). The CAPA system is very promising, but I decided not to use it because it requires that students work on a local, Unix-based network. I believe that I can implement this type of approach over the Internet, which would make it more available to students and easier for other instructors to implement.

WRITELIN: A Harvest Scheduling Model Formulation Interface

As mentioned earlier, for their final project for the class, students develop management plans for a large forested area. The students are organized into teams of three to four students. By mixing and matching different parameter sets a large number of unique management plan problems can be generated, and each team is given a unique problem. This assignment is difficult and time-consuming. In an effort to reduce busy-work for the students and to make it easier for me to check their work, I have written a stand-alone Visual Basic program called WRITELIN that allows users to interactively enter information about their forest and their management goals and constraints. The program then creates a linear programming formulation that can be solved by a separate program. WRITELIN includes extensive help, which is coordinated with the harvest scheduling chapters of the text. Virtually every window available in WRITELIN has a context-sensitive help button. The program is easy to use, allowing the student to enter their current forest inventory data, yield tables, economic data, and formulation parameters interactively and easily. The program works well and has been well-received by students, but there is still work to do to integrate it into the textbook's format. Figure 3 below shows the main screen in WRITELIN. Figure 4 shows WRITELIN's model formulation screen where students specify the formulation parameters of their model.

The next step is to develop a back-end system to facilitate the organization and interpretation of the information provided in the linear programming solution. Ultimately, I would like to integrate a GIS component in the system to help students visualize the results of the planning model. Linking the output

of the system to a GIS would also provide a setting for addressing the many spatial issues that arise in forest planning.

CONCLUSIONS

Forest management is an ideal class to teach using computers. Computers are becoming essential forest management tools. Computer models are widely used to manage forest inventories and to simulate stand development. Geographic Information Systems (GIS) are used by forest industries and agencies to store and update inventory information, to map management areas, and for performing analyses of management policies. Today, spreadsheets and word processors are essential basic tools in virtually all fields. Familiarizing students with computers and forestry-related and general-use software has become a key element of a professional forestry education.

The forest management courseware described in this paper will supplement a traditional textbook and take advantage of the things that can be done better with a computer-based approach. While the computer is not likely to rival the textbook in the areas of depth and portability, it can provide an interactive medium to relieve some of the more tedious aspects of traditional course materials. Some of the more promising features of computer-based instruction are the non-linear, multi-level possibilities of hypermedia, interactive tutorials, animated graphics, computer-administered problem sets, and simulation programs that can relieve the student and the instructor of some of the more tedious activities to allow more focus on concepts and more general issues.

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[1] The subjects covered in the course are listed later in this paper, and comments or suggestions regarding the course content are welcome.
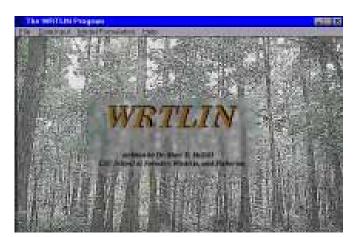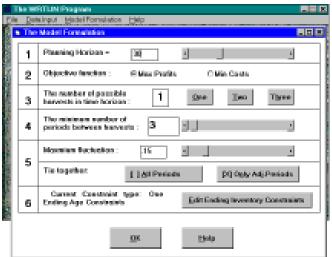

Figure 3. The Min Screen in WRITELIN.

Figure 4. The Model Formulation Screen in WRITELIN.