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INTEGRATED NATURAL RESOURCE PLANNING

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ABSTRACT: Deciding upon management strategies and use of natural resources becomes more challenging as urban areas expand and human population and consumption levels continue to increase. Given that a larger urban population, interestingly, seems to demand both more resources (products) and greater environmental protection, there will no doubt be a coincident heightening of conflicts over natural resource management in the next century. Making decisions on natural resource allocation and use under such circumstances will become even more complex and difficult than they are today. Skilled people will be needed who can develop an integrated approach to natural resource management that sheds light on the tradeoffs and implications of their decisions. The ability to identify and evaluate the potential consequences of particular management decisions will be critical. To help address this need, we developed a course in integrated natural resource management with funding received from the Cooperative State Research Service Higher Education Challenge Grants Program. This interdisciplinary course is team-taught and uses a combination of case studies and computerized models.

INTRODUCTION

Deciding upon management strategies and use of natural resources becomes more challenging as urban areas expand and human population and consumption levels continue to increase. Interestingly, urban populations seem to demand both more resources (products) and greater environmental protection than rural populations. As a result, heightened conflicts will occur over natural resource management in the next century. Moreover, making decisions about natural resource allocation and use will become even more complex and difficult than it is today.

NEED FOR INTEGRATED NATURAL RESOURCE PLANNING COURSE

Too many students with interests in environmental studies take advocacy positions on natural resource issues without fully considering the options and implications of various courses of action. For example, protecting large tracts of timber in the Pacific Northwest from harvesting to save the spotted owl might result in more widespread harvesting of tropical forests with the possibility of affecting many more endangered species. An efficient timber management option might have positive effects on wild ungulates, such as deer, but may adversely affect non-game bird species (Jaako Poyry 1992h). Skilled people are needed who can develop an integrated approach to natural resource management so that tradeoffs and implications of their decisions can be viewed in the context of both multiple use and ecosystem management. These people must be able to effectively use sound resource management decisions that meet societal needs. It will be critical that they have the ability to identify and evaluate the potential consequences of particular management decisions. Although most natural resource curricula have courses covering many of the components necessary for integrated resource planning, the opportunities for students to synthesize the information from these disparate courses are limited. Too many students finish their undergraduate education without the opportunity to demonstrate their understanding of multi-disciplinary relationships and of the constraints in selecting natural resource management options.

DEVELOPMENT OF A COURSE TO MEET THE NEED

The University of Minnesota College of Natural Resources includes three specialized curricula: forest resources, fisheries and wildlife and wood and paper science. Since 1989 a more general natural resources and environmental studies (NRES) curriculum has been offered and is home to the largest student group in the College. The NRES curriculum is designed for students with an interest in interdisciplinary studies focusing on the use and management of natural resources. The NRES curriculum includes a field experience and/or internship as well as a senior problem solving (capstone) course. The course we developed was to be an alternative to the existing problem solving course. Also, unlike the existing problem solving course, which is only open to NRES seniors, this course would be open to students in forest resources and graduate students.

In the fall of 1994 we developed a course in integrated natural resource management for senior level students in our forestry, recreation resource management and natural resources environmental studies curricula. This course is team taught and students learn through a combination of case studies and computer models. Funding to develop the course was received from the Cooperative State Research Service Higher Education Challenge Grants Program.

Five major activities were carried out to develop the new course:

Development of a specific course structure and assignment of instructional responsibilities,
Synthesis of existing information that reviews the role of the puiblic in previous planning efforts and techniques for acquiring that input,
Development of the computerized decision support system,
Development of computer-aided instruction modules for specific topical areas, and
Identification and development of a case study database with associated computer simulations.

Our course would complement more disciplinary offerings and, to some extent, bring a sense of closure to the multifaceted undergraduate program by concentrating on the reality of integrating multi-resource information in the decision-making process. This course also was designed to incorporate new instructional strategies based on active and collaborative learning experiences, and to make extensive use of computer-assisted learning tools.

We decided that an integrated, multiple-resource teaching framework would enhance students' ability to understand the complexity of natural resource management issues and to understand the tradeoffs among alternatives that are available to them before decisions are made. This integration is best accomplished by having the students work on actual case studies in which they can see how all of the various disciplines come together in developing a sound management plan. Through course assignments, students would also learn to better communicate and argue their specific concerns.

We also thought that dealing with the complexity of natural resource problems could be facilitated with the use of computer simulation models, designed to aid the analysis of specific questions. Use of computer models allows students to explore the consequences of various management decisions. Some of the more sophisticated models in particular allow planners and managers to perform long-term simulations under a number of development scenarios. These models might also lead to a better understanding of the constraints and tradeoffs of specific management actions. Models also have enormous potential as learning tools; they can help clearly define what we know, what we need to know, and what we do not know. A major component of the course would be teaching students the appropriate use and interpretation of models and their results.

Course Description

The course we developed, Integrated Natural Resource Planning, is 5 quarter-credits and has been taught for two years. It is offered to seniors in the forest resource's and NRES curricula. Graduate students may also enroll in it. The course has the following prerequisites: natural resource policy, forest management and planning, natural resource survey and measurements, silviculture, recreation resource management, ecology, and hydrology. The basic format for the class is two class lectures per week, a two-hour lab, and a one-hour recitation.

The course is team taught. Each instructor demonstrates how his/her particular expertise can be applied to the analysis of management and policy questions. In particular, students focus on two interrelated problems and the resolution of those problems. First, they look at and analyze a timber harvesting strategy for an area in northern Minnesota. Second, they look at the impacts of harvesting and other forest management practices on forest aesthetics, recreation opportunities, biodiversity and water resources. They then attempt to pull what they have learned about harvesting strategies and the impacts of harvesting on other forest resources together to arrive at a best solution. By using this approach, students are: a) provided with the opportunity to practice being professional resource analysts, b) encouraged to integrate previous educational experiences, c) provided with the necessary skills to integrate public input into decision making, d) motivated to develop a better understanding of the role of data and models in multiple resource management, e) provided with an appreciation of the uncertainty associated with data and models and how that affects the interpretation of model results, and f) Given an appreciation that all resource decisions reflect social values.

The course is organized into a number of study modules. Each module typically consists of two lectures, one lab, and a recitation. Each instructor is responsible for his/her module. But, all modules are closely integrated and use the same case study area. Students are assigned to study groups –usually four individuals—and each group is required to solve one problem for each study module. Most assignments include a group assignment and a set of questions that need to be answered by each individual. At times, students are asked to grade the contributions of individuals in their group.

Each of the modules are described below. The first four modules introduce students to natural resources planning, especially forest planning, and computer models that can aid in planning and decision making. In these modules, we introduce an example of a general framework for natural resource planning based on the experiences of the Minnesota Generic Environmental Impact Study (GEIS). The GEIS is probably the most encompassing study in the U.S. of timber harvesting impacts on the environment. In 1990 the Minnesota Environmental Quality Board (EQB 1990) ordered the state of Minnesota to conduct the GEIS (Jaako Poyry 1992a-h). All of the instructors involved in developing this course were also lead scientists on the GEIS. In the GEIS, we developed a framework for planning that has been successfully applied in several major studies since the GEIS. The framework's main components are: inventory and market information, management objectives, models for the development and evaluation of management alternatives that can contribute to specified objectives, a scheduling model that selects among all alternatives to meet objectives in an economically efficient manner, and procedures for tradeoff and impact analysis of developed plans. The GEIS is the reference point for all of the course modules. Individual instructors used this framework to identify where their specific module fits into integrated natural resource planning.

The first four modules point out to students the importance of data in decision making. They also point out that it is rare that one would have all the data needed for decision making; therefore, the importance of being able to plan with uncertainty is stressed and modeled. Exercises students complete in these modules take them from forest stand-level decisions to forest-wide planning decisions. The next three modules (5, 6, and 7) introduce students to other forest resources and opportunities they must consider when making harvesting decisions. The purpose of these modules is to show students that forests have value beyond timber, that forests are managed to provide benefits to people and society, and that all stakeholders have a legal right to be (and must be) involved in forest management decision making. The next two modules (8 and 9) show students how to mitigate unwanted harvesting impacts and the importance of understanding the 'big picture' when developing resource plans. The last module involves the instructors and students in a panel discussion of the issues raised in the course and of the instructional methods used in the course. Student critiques are used to improve the next iteration of the course.

Module 1: Development of a modeling framework. The purpose of this module is for students to understand that, in the development of natural resource plans, a number of processes need to be followed. Furthermore, certain logically linked key components are present in any planning model. Students are first assigned the task of developing a generic framework for natural resource planning, which describes the key components, processes, and linkages. Students are then introduced to a general framework for natural resource planning based on the GEIS.

By developing a modeling framework, students learn the need to: a) clearly identify the objectives of a plan as well as the stakeholders in the plan, b) develop a wide range of alternatives, which will help meet these objectives, c) identify models and procedures that can evaluate and compare these alternatives in terms of meeting the objectives, d) gather data and information and recognize uncertainty surrounding data, and e) continuously monitor any implemented management plan.

Module 2: Data, models, and uncertainty. In module two students look specifically at the sources of information used in the GEIS, studying their scope, shortcomings and reliability. The impact of data reliability on decision making is also considered. The direct linkage between information bases and economic analyses and forest management planning activities is made explicit.

The lab portion of this module consists of three parts. In part one, each student group is assigned a supply area center (a city) with a specific annual aspen pulpwood demand. The group must use the USDA Forest Service Inventory and Analysis (FIA) database to estimate the size of the area needed to sustainably meet demand. The FIA database is accessed via a map-based, World Wide Web (WWW) interface. Using the WWW simplifies access to data and gives students experience using advanced WWW tools. The second part of the lab exercise requires students to use a growth model in conjunction with a harvest scheduling rule. Although both the growth model and harvest scheduling method are oversimplified, the link between models and decision making is made clear. Uncertainty is the focus of the third part of the lab (Hoganson and Smith 1989). Students are given a spreadsheet with 30 aspen cover type plots. The spreadsheet allows easy specification of standard deviations associated with initial conditions and individual equations of the growth model. Normal errors with the specified standard deviations are used to generate 30 alternative projections and a spreadsheet chart is used to illustrate the magnitude, pattern, and accumulation of model prediction errors over time. Groups use the spreadsheet to identify the relative importance of error components and the degree of error they would tolerate in predicting a future volume value.

Although the specific lab exercise is oversimplified, which students recognize and appreciate, they gain a taste for the complexity of working with large data sets, as well as an appreciation for error identification and computation. They must bring their professional training to bear on the problem of converting raw data to useful information, which is something most students have never done but which will dominate their future work lives.

Module 3: Economic analysis of stand-level decisions. This module emphasizes that management alternatives need to be developed no matter what the specific objectives are of natural resource planning. Whether the objectives are improved recreational opportunities, watershed protection, timber production, or a combination of several of these objectives, alternatives, including a 'do nothing' alternative, need to be developed. Students understand that the basic management unit for which alternatives are developed can be individual forest stands or stand aggregates depending on available data and the plan's scope. Moreover, these alternatives should be technically feasible and cover a wide range of options. A scheduling model can only select from among the alternatives formulated and will generate sub-optimal solutions if good alternatives are ignored (Hoganson and Rose 1984). Management recommendations are made for each individual stand based on what is considered the 'best' alternative. Taking into account forest-wide constraints, the sum of these individual stand level recommendations makes up the forest-wide plan.

The lab portion of this module introduces students to techniques for developing and analyzing stand level alternatives. It uses a user-friendly cash flow program written by the instructor. The exercise is built around a small sample inventory. Each student group is asked to identify one or more specific management objectives and to develop specific management alternatives for the individual stands in the inventory. Students also are required to identify regeneration linkages for any stands that follow the first and any subsequent clear cuts. They must also develop management alternatives for these regeneration stands. By doing this lab exercise students gain an understanding and appreciation of the connection between management objectives and alternatives. They also learn to collect and use information necessary for describing inputs and outputs associated with alternatives including growth and yield, cost and value information, the role of discount rates, and the valuation of non-market goods and services.

Module 4: Forest-wide planning models: formulation of forest management scheduling models. In this module students have the opportunity to understand how a scheduling model, such as linear programming (LP), can be used to select among a large number of management alternatives to optimize some objective function subject to constraints on management (Hoganson and Rose 1987). The overall objective of this module is for students to understand and appreciate that the sum of optimal individual stand-level management decisions rarely produces an optimal forest-wide plan. Forest-wide constraints are usually not considered when individual stand-level decisions are made, hence the discrepancy between optimal stand-level decisions and the optimal forest-wide decision. For example, a stand might be harvested before optimal rotation because early harvesting of it will fill a gap in required harvest volume in a given time period better than other stands would.

In the lab portion of this module, students are provided with a sample, taken from the 1990 forest inventory, for which several LP formulations have been developed. Students examine the impact of changes in the objective function, discount rate, and types and levels of constraints on the ultimate optimal schedule. Students then write a critique of LP scheduling models focussing on the model's limitations as a decision making tool. At this point they are given a preview of an alternative scheduling model that can overcome some of the disadvantages of LP. They will use the alternative model in module 8.

Module 5: Biodiversity and wildlife. Natural resource managers (including foresters), as well as the public, agree that maintenance of biodiversity is important. Despite its importance, generally few specifics are included to address it in natural resource planning processes and documents. This lack of specifics can be largely attributed to the fact that biodiversity is more a philosophical rather than an operational concept (Probst and Crow 1991). This module explores strategies to integrate biodiversity issues into the natural resource planning process at both local and regional scales.

Just as all natural resource management practices affect biodiversity, they affect wildlife habitats. The evaluation of these impacts is complicated by the fact that many wildlife species have contradicting habitat needs. This module challenges students to work through an exercise and integrate the contradicting habitat needs for multiple species. Students gain an appreciation of issues regarding the integration of biodiversity and wildlife habitat quality into regional and local planning processes. They also learn that to move from philosophy to management, they must develop operational definitions for biodiversity issues. They also learn how to work with incomplete data to arrive at planning and management decisions.

The biodiversity exercise follows an outline similar to that presented by Lautenschlager (1996). Students develop a list of potential natural resource or asset concerns for a component of the biodiversity definition. These concerns can be biotic (species or species group), abiotic (aggregates, aesthetics) or biotic/abiotic processes. Components of the biodiversity definition include topics such as ecosystem functions or ecological structures on a local or regional scale and variety and abundance of communities and ecosystems. For each potential concern the students generate a list of data needs. The data needs are then compared with the data available through the Eastwide Forest Inventory Data Base (Hansen et. al. 1992). Finally, students discuss the discrepancies and look for approaches that bridge the gap between the data needs and availability.

The wildlife exercise starts with a general discussion about quantifying wildlife habitat quality on a regional level. Special attention is paid to the different scales at which habitat quality for various species is determined. Students develop a separate list of strategies to mitigate harvest impacts for two species. Species are chosen that have partially opposing habitat needs (e.g., young versus old forest) and cover both stand level and forest wide issues.

Module 6: Water resources and planning. This module begins with an overview of the hydrologic consequences of timber harvesting with a focus on Minnesota conditions (Verry 1986). The hydrologic model used in the GEIS to estimate harvesting impacts is described (Jaako Poyry 1992f), and the problems of interfacing the timber stand model with the hydrologic model are discussed. The benefits of using a model that is specifically designed to interface with other resource components are discussed with reference to a Lake State model developed by Ffolliott et al. (1984). Students are given a problem that requires them to: a) examine the impacts associated with current and potential future elevated levels of statewide timber management and harvesting activity on water and related resources, b) develop strategies to mitigate such impacts where existing or potential significant impacts are identified, and c) gain an understanding of the methods used, the data and informational requirements, and the constraints that exist in trying to quantify impacts of forest management options on water resources.

The lab portion of this exercise requires students to develop a matrix in which important water related characteristics of concern (parameters) are identifies that would be impacted by timber harvesting. Certain parameters may be more important for one system (e.g. a lake) than for another system (e.g. a stream). Groups are asked to be specific in defining each parameter. For example, water quality is a very broad parameter that must be further defined into key components of interest to be meaningful. In each matrix cell the group indicates four things: the relative response to harvesting of the parameter as either increasing (+) or decreasing (-); and ranks from 1 to 5: the relative magnitude of change, the response variability, and the relative uncertainty of the response. In all cases '1' represents the smallest change, least variability or least uncertainty. For example, the annual water yield of streams is expected to increase in response to harvesting with a potential large magnitude of change, moderate variability of response, and low uncertainty. The matrix cell for that parameter would be (+,5,3,1).

Once students complete the matrix they indicate five issues/ impacts that should receive the highest priorities and provide a justification for their assessment. They also quantify the effects of harvesting on their top five priority areas of concern and suggest mitigation strategies for unwanted impacts. They learn and appreciate the need for site specific analyses and the use of stream channels and watersheds as units for assessment, the need to consider cumulative effects, the influence that issues of scale have on their assessments, and the need for well-defined linkages among the various resources and changes that are expected.

Module 7: Harvesting impacts on recreational opportunities. The purpose of this module is to give students an appreciation and understanding of the impacts of timber harvesting and forest management on recreation opportunities provided on public lands within an ecoregion and statewide. Students are presented with data gathered for and analyzed in the GEIS (Jaako Poyry 1992i). These data show the distribution of recreation opportunities, recreation activities, and hours of engagement per recreation activity for each ecoregion in the state. Data are also given to the students that show the magnitude and level of significance of harvesting activities on recreation experience opportunities and activities.

In the lab exercise, students are given a forest area in which they must remove a specified amount of timber from one or more of five specified areas containing one or more stands. For each of the five areas they are given information on soils, slope, wildlife, water resources, current levels of recreational use and recreation experience opportunities provided. Three harvest alternatives are suggested: 1) harvest equal amounts of timber from each of the five areas over the given time period, 2) harvest all of the timber from the two most accessible areas and conduct no harvesting during the summer months, and 3) harvest two-thirds of the timber from the two most accessible areas and the remainder from any combination of the other 3 areas and allow no harvesting during the summer months.

Students are assigned to one of six groups. Using the constructive controversies technique, two groups are assigned a harvest alternative. One group develops an argument in support of the alternative and the other group develops an argument against the alternative. In their arguments students must address the following questions: a) what recreational experience opportunities and activity opportunities are improved through harvesting activities and in what ways are they improved, b) what recreational experience opportunities and activity opportunities are diminished through harvesting activities and in what ways are they diminished, c) what new recreational experience and activity opportunities are created in the areas where harvesting occurs, d) what changes occur in the relative availability and accessibility of recreation opportunity settings within the forest where harvesting occurs, and e) what changes occur in the supply of recreation opportunity settings within the ecoregion and statewide? Groups assigned to the same harvest alternative present their arguments to each other. They then reverse roles and develop arguments for the opposing side and present those arguments to each other. At this point, both groups are asked to work as one large group and, based on the arguments they have presented both pro and con for the harvest alternative given to them, to develop what they believe is a harvesting alternative that will not significantly impact recreational opportunities and the resources they depend on (visual scenery, wildlife, water, and so on) within the area. If significant impacts cannot be avoided, they develop a mitigation plan to address them. Once the large groups have developed their harvest alternative, the class comes back together and each of the three large groups presents their proposed alternative. The class then works together to arrive at an alternative they can all agree upon.

Students learn that several harvesting alternatives may be feasible within a given area. They also learn and appreciate that differences, both real and perceived, among the alternatives are related to their impacts on other resources and resource uses, in this case recreational opportunities. Finally, they understand that the alternative selected is based on social choice driven by technical, as well as nontechnical concerns.

Module 8: Impact mitigation and tradeoff analysis. This module demonstrates directly how a forest management scheduling model can be used as a learning tool for a range of forest management issues (Hoganson and Rose 1984). It is linked to the other modules in that they all contributed to the modeling framework and data used for the GEIS analysis. This module applies the GEIS modeling framework to examine a variety of potential concerns. In this module students use what they learned from modules 3 and 4 in terms of linear programming, cash flow analysis, shadow pricing and basic financial measures to compare stand level management alternatives.

The lab portion of this module introduces students to the DTRAN model used to develop various harvesting scenarios for the GEIS. Several model runs are used to illustrate the statewide effect that potential harvesting policies on national forest lands could have on statewide timber markets in the region.

Module 9: The importance of spatial concerns in resource planning. Spatial aspects of forest management are one of the most challenging aspects to address in forest planning. In this module students demonstrate their understanding and appreciation of the complications involved when spatial arrangement factors are addressed (Kapple and Hoganson 1991). They learn how to coordinate management decisions for adjacent forest management units, and they learn how a detailed spatial management plan for a subregion might be linked directly with a broader regional planning model. Students are also introduced to a new spatial modeling approach for forest management scheduling. This new model is under development by some of the course instructors.

The lab portion of this module focuses on the timing of harvesting on adjacent lands. All of the examples students work with in this exercise use simple checkerboard forests where stand conditions mimic the aspen forest type in Minnesota. In the first part of the exercise student groups are given data for a 50 stand forest and are asked to develop an approach for scheduling stands for harvest to maximize net present value under the constraint that no two adjacent stands are harvested in the same period. Next each group is introduced to a dynamic programming (DP) approach to the same problem. Each group is asked to consider two larger 1,000-stand forests to examine the performance of the DP approach. By using successively larger model formulations, students explore how large formulations may need to be if good solutions are to be developed. Finally, each group uses this modeling framework in a forest-wide module that also includes constraints on the acres harvested each decade.

Module 10: Class summary and critique. The final week is used to review and pull together the previous nine modules. Students also formally critique the class.

BENEFITS OF THE COURSE TO STUDENTS AND INSTRUCTORS

Student Benefits

The individual modules were arranged as much as possible in a logical sequence such that each module built upon one or more previous modules. Through module 1 students gained an insight into key elements of natural resource planning models. Module 2 exposed students to the importance of data and information as well as an understanding of the role of uncertainty. Module 3 introduced them to the importance of developing a wide range of alternatives that can help meet specified management objectives. It also gave them procedures to evaluate and compare alternatives. In module 4, students were introduced to linear programming formulations of management schedules. These formulations helped students understand the role of LP models in finding optimal solutions and the impact of changing constraints as well as other assumptions on model outputs.

Modules 5, 6, and 7 introduced students to the impacts of harvesting and other forest management activities on other forest resources. In module 5 students learned to separate philosophical from operational concepts. Students learned that measurable criteria need to be developed to evaluate philosophical concepts if these concepts are to be integrated into planning processes. They also learned that the current inventory system was not set up to address biodiversity issues directly, but provides data that can be used to develop biodiversity criteria. In addition, students gained an understanding and appreciation of conflicting habitat needs. The latter can also be seen as a surrogate for conflicting demands of society. In module 6 students quickly realize that harvesting impacts on water depend on many factors that do not necessarily coincide with ecoregions—watersheds and stream channel level assessments are necessary to deal with water issues such as stream temperature, flooding, and instream flow during specific periods of time. The incompatibility of timber inventory models and methods with water models becomes evident. In module 7 students addressed the impact of timber harvesting activities on recreational opportunities forests provide. They quickly realize that recreational data exist at a variety of scales, are seldom available statewide, and are infrequently updated. They also learn that much can be gleaned about forest recreation use from the literature and from selected FIA variables. They also come to understand that the primary use of many of Minnesota's forests is recreational use and that the benefits accruing to people and society from their recreational experiences sometimes outweigh the benefits of harvesting a particular stand. Balancing the needs of society for forest recreation opportunities and forest products is complex. Students come to understand that a variety of alternatives are possible to meet those needs and that a number of alternatives must be examined to arrive at an optimal forest plan that balances harvesting and other forest management activities with other forest uses. Finally, they learn that regardless of the alternative chosen, it is a reflection of social choice at a particular point in time.

Modules 8 and 9 bring students back to forest planning for timber harvesting but, in these modules, students were introduced to models that may help them to arrive at optimal forest plans taking into consideration other forest uses. They realized first hand how complicated the management situation is in Minnesota—many interacting aspects and few simple answers. In module 8 even though all data and model input files were developed for them, students gained a better appreciation for all the work involved in comparing model runs and attempting to draw insights to explain results. They found that some background in forestry was extremely helpful for interpreting results. To many students, the complicating aspects of mixed-species, multi-product stands managed over a multi-period time frame with multiple market locations made the exercise seem overwhelming at times. Yet, despite not always understanding the nuances and intricacies of the model, students learned that their insights on the type of interactions that might occur were likely correct. The modeling tools were helpful to them in estimating the extent of those impacts and pointing to the interactions of most concern. In module 9 students gained a better understanding of the complexity of spatial problems and associated difficulties in planning. Students recognized that the computer and computer models were excellent tools for examining potential solutions. But, they had difficulty in understanding why some forest issues and uses were more easily modeled than others. Some students seemed somewhat surprised with the difficulties of addressing spatial interactions with current models.

Instructor Benefits

In developing and teaching this course, instructors developed new skills through collaboration with other faculty and in the development of computer assisted instructional materials. Although computer assignments have been a common part of many College of Natural Resources courses over the years, the use of computer programs specifically for instruction and information delivery has not been extensively developed. Students better appreciate the need for using advanced technologies to store and analyze the massive amount of information required for making good decisions. The experience instructors gained with the new course will help them transfer the new ideas and tools developed to educational programs of other natural resources colleges. Furthermore, instructors involved in developing and teaching this course jointly have gained insights into the research of their colleagues and have enhanced cooperative efforts. Several instructors have developed innovative instructional software to aid in delivering their research to undergraduate and graduate students.

Student Critique

Each group of students provided written feedback on the course. The two most common critiques students gave were that they had learned quite a bit from the course and that they appreciated the hands-on experience with data and models. Although they thought they had learned a lot, they also expressed concern that they felt ill prepared to take the course. In some cases they were not properly prepared for a course such as this. Many of them lacked one or more of the course prerequisites. They suggested that in the future we *"… better advertise the course along with its prerequisites."* They also thought that courses, which are prerequisites for this course, should be advertised as such. On the other hand they may have felt ill prepared because planning and managing natural resources is a complex task. As one group noted: *"As seniors in NRES we all went into the class knowing that natural resources are very difficult to manage due to the many different components involved."* Yet another group offered, *"After working through each module, we understood how hard it really is to integrate all the different aspects of natural resources."* And, another group said, *"We learned that the planning process is very complicated and that decisions that seem simple at first can quickly become very complicated as the scope of the problem expands."*

The hands-on experience was especially well-received by students. Many believed that they were now better prepared for their future jobs –*"We had hands-on experience trying to prepare management plans ourselves and know first hand the extent of work that is involved—on a much smaller scale of course."* Another group said that, *"Models are useful to look at trends or generalizations and to help choose the best alternative to use."* However, they were quick to point out that models, while useful, could not be counted on to answer all their questions. They would still need to rely on their technical knowledge and expertise to arrive at many natural resource solutions--*"The problem with models is that they are just models and do not take into consideration natural disasters, fire, disease, etc."*

Most students also noted that they had a better understanding and appreciation of the values people have about natural resources. They realized that it is not only important to know who the stakeholders are, but that they must also know how stakeholders perceive the resource, the benefits they attain from the resource, and what type and level of management they will support. Groups offered that,*"It is hard to manage* *natural resources because there are so many different view points involved,"* and *"Some people place a higher value on non-market goods such as recreation, biodiversity, and aesthetics than others. We now realize that these are important issues and that economics is not the only issue."*

Many groups thought that they had gained more than just academic knowledge and skills from the course. Many thought that the active and collaborative learning format was invaluable to them in terms of what can be learned from and accomplished with a group of colleagues in a short amount of time. They said, *"Beyond all the scholastic knowledge we gained in Integrated Natural Resource Planning, we obtained many group oriented skills as well as problem solving skills. We learned how to coordinate our schedules to fit with other group members; to meet deadlines; to work well in groups with people we did not know before; and to express concerns and ideas in an effective and efficient manner."* Another group mentioned that it was exciting to work together to get the labs done because the labs allowed them to collectively tie *"…a lot of information from other classes together and we liked the fact that we each had to contribute our individual knowledge on the subjects that we are specializing in to complete the assignments."*

Several groups commented positively on the instructors. Although each student previously had taken courses from one or more of the instructors, very few, if any, had taken courses from each of the instructors. They liked being exposed to a variety of instructors and would have liked to have had the opportunity to have taken other classes with these instructors.

Instructor Critique

A primary concern of all the instructors was the lack of preparation of many students for this course. Very few had the prerequisites. The first two years the course was taught, we allowed students to remain in the course even though they were lacking the prerequisites. We allowed them to stay because, for many of them, this course was taken during the last quarter of their degree program. We enforced the prerequisites the third time the course was offered. The result was that we did not have enough students signed up to offer the course. Some students readily admit that they do not pay much attention to a course's prerequisites. If the course looks interesting, they sign up for it. Apparently, there are no checks in place to stop registration if a student is lacking course prerequisites. The level of performance of groups who had several members lacking some of the prerequisites was below average. As this is a 'capstone' type course, the instructors were not inclined to 'water down' the course to meet the needs of the least prepared students.

The second major concern of the instructors was the amount of time each of us had to devote to his/her module(s). Perhaps we were over ambitious in developing the course, or perhaps is was the lack of preparation we noted in the students, but none of us thought we had enough time to adequately teach each module. We especially felt that we had far too little time to integrate the modules. To many of us, we felt the modules appeared to 'stand alone' rather than appear to be well integrated with the other modules. It might also be that devoting 80% of the class time to collaborative or active learning methods was uncomfortable for us. Many of us were not sure if students were learning what we thought they should be learning from the course. Students tended to agree with us when we expressed concern about whether they understood the linkages among each module. In particular, students and we thought that there needed to be a time, after a module was completed, to talk about how that module built upon or was linked to other modules. The format of the course did not allow us to address these linkages in any detail until the last week of the course. In fall of 1999 we will move to semesters. The added time we will have once we begin teaching this course in semesters will largely be used to discuss and more fully explore those linkages.

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