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RESEARCH

Evaluating course impact on student environmental values in undergraduate ecology with a novel survey instrument.

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ABSTRACT

Courses in environmental science or ecology can have formative impacts on student perspectives regarding environmental issues. We undertook this research to explore the effect our teaching has on the environmental attitudes and values of undergraduate students. Specifically, we wanted to know if student-active teaching approaches have an effect on attitude changes and whether or not those attitude changes are accompanied by a change in understanding of the underlying ecological principles. We used two survey instruments to assess student attitudes at the beginning and at the completion of a course. We coupled an established survey instrument (New Ecological Paradigm: NEP) with one we developed specifically for this study (Environmental Conflict Overview: ECO) to determine if attitude changes were consistent and to assess specific dimensions of attitude changes. The ECO survey asks students to respond to stakeholder perspectives in specific environmental issues. This study was done at two quite different institutions, which allowed us to examine responses of a wide range of students. Results showed consistent changes in attitude with both survey instruments at both schools. The ECO instrument also provided valuable insight into specific aspects of student attitudes that changed

most. Results showed a significant reduction in students' anthropocentrism and a reduced emphasis on economic valuation in resolving stakeholder conflicts. Students also demonstrated increased understanding of underlying ecological principles. Quantitative results on the impact of specific student-active teaching methods were equivocal, though free-responses did reveal preference for course topics captured in such activities. Although we do not have quantitative evidence at this point, it is our judgment that the active approaches that we used (think-pair-share, small group discussions and problem solving, debates) effectively helped students examine their environmental values and also learn course content. In addition, we suggest that that the combined surveys provide an effective method for assessing changes in student attitudes and therefore can be used as a powerful teaching tool.

KEYWORDS
environmental values, environmental attitudes, survey, student-active methods, guided discussion.

INTRODUCTION

It has long been recognized that environmental science education can play a central role in raising public awareness of anthropogenic impacts on natural systems (e.g. Diduck 1999). Many studies have assessed the impact of introductory environmental science courses on the values and attitudes of K-12 and undergraduate students about environmental issues (Leeming et al. 1993; Rickinson 2001). The general consensus is that such courses tend to have positive impacts on environmental attitudes, including heightened awareness of environmental issues and greater commitment to mitigating their own impacts as revealed through their actions (Carpenter 1981; Benton 1993; see Leeming et al. 1993, Zelezny 1999, or Rickinson 2001 for meta-analytic reviews).

Student-active approaches in teaching undergraduate science (as defined in McNeal & D'Avanzo 1997) have been demonstrated to have greater impact on student learning over classic, lecture-based approaches (National Research Council 1999, 2000). In this study our first goal was to examine whether active teaching approaches likewise effectively influence student attitudes concerning environmental issues. Although other studies have assessed changes in values, we are not aware of any that have attempted to assess the impact of student-active approaches on environmental values.

Our second goal in this study was to develop a survey that effectively assessed college students' environmental values and that linked specific information taught with changes in students' views between pre- and post-surveys. Many survey instruments exist for assessing environmental attitudes, particularly when applied in a pre- and post-intervention protocol (Leeming et al. 1993; Zelezny 1999; Rickinson 2001). However, few are specifically designed for undergraduate students in the sciences and most are not constructed to explicitly account for the connection between learning ecological principles and changing environmental attitudes. Few surveys attempt to query ecological learning and understanding directly or indirectly while simultaneously assessing environmental attitudes. A survey instrument that connects environmental issues with course content, and consequently the student-active teaching approaches used to deliver that content, would be most useful for assessing the impact of these teaching methods on student attitudes.

Therefore, we developed a survey designed to assess student perceptions of environmental issues as well as their knowledge of the ecological principles underlying those issues. In this paper, we discuss the validity of this survey and how using it has influenced our teaching of environmental science courses. For initial assessment, the novel instrument was coupled with an established instrument to determine if attitude changes were consistent between both surveys. We view this survey as a first step towards further investigation about relationships between changes in student attitudes and the course content and its manner of presentation. We applied these surveys in a pre- and post-course assessment of undergraduate students at two different institutes. We decided to pursue similar studies at two very different educational institutions in order to broaden the demographics and increase sample size. The two educational institutions involved in this study were Phoenix College (PC) and Virginia Military Institute (VMI). VMI is a four-year public military college, and its students are mostly white (87%), mostly male (92%), and young (applicants must be between 16 and 22 years old). PC is a public, two-year, Hispanic-serving institution (30% Hispanic). The median age of its students is 25, and 60% of students are female. The instructors of the participating courses used similar student-active teaching approaches, including many of the materials published in *Teaching Issues and Experiments in Ecology* (*TIEE*). In addition, one of us (EOB) is an author of a *TIEE* Experiment (Ortiz-Barney et al. 2005).

METHODS

We developed a survey for pre- and post-course distribution that coupled an established instrument for measuring environmental values with our own, novel survey querying student perspectives on specific environmental conflicts. The latter was developed for three reasons: 1) to assess specific dimensions of environmental values that are not explicitly measured in standard assessment instruments; 2) to provide a context for queries in which the complexity of environmental conflicts and underlying ecological dynamics are considered directly (rather than implicitly); and, 3) to assess student understanding of specific aspects of ecology underlying environmental issues. Therefore, our new survey addressed the two project goals described above.

The New Ecological Paradigm (NEP) survey

The New Ecological Paradigm (NEP) is an established survey instrument designed to gauge anthropocentrism (also termed *egocentrism*) or ecocentrism in environmental attitudes and values (Dunlap et al. 2000). With it we could address our first goal (assessing attitudinal change) but not our second goal (linking specific pedagogy with this change) in this study. The instrument includes a series of statements to which respondents state agreement or disagreement on a standard Likert scale. For example, the survey includes the statement:

> *"Humans have the right to modify the natural environment to suit their needs."*

Participants then indicate if they would characterize their response to this statement as "strongly agree," "agree," "neutral," "disagree," or "strongly disagree." A response of "strongly agree" indicates a high degree of anthropocentrism in an individual's perspectives on environmental concerns while a response of "strongly disagree" indicates a high degree of ecocentrism. Statements are either positive or negative with respect to environmental values. The example above would be considered negative with respect to ecocentrism, and disagreement with the statement indicates a high degree of ecocentrism. Other statements, such as:

> *"The balance of nature is very delicate and easily upset."*

are positive with respect to ecocentrism, and agreement indicates an ecocentric (or "pro-environment") perspective. Each ordinal response is scored on a scale of 1-5, with the highest value corresponding to the most ecocentric response. In

the first example (a negatively ecocentric statement) a response of “strongly disagree” would be scored a 5 and a response of “strongly agree” would be scored as 1. The scale is reversed for positively ecocentric statements. The minimum total score of 15 indicates extreme anthropocentrism, while the maximum score of 75 indicates extreme ecocentrism.

As should be apparent from the representative examples, the NEP statements are decidedly simplistic. This is a necessary symptom of one of the NEP’s strengths, that is, its applicability and repeatability across a broad spectrum of age groups and social backgrounds. However, for students even moderately versed in the fundamentals of ecology or environmental science, the implications of these simplistic statements are too easily apparent. This raises a concern for applying the NEP as a pre- and post-course assessment for courses in these areas. Students may perceive an agenda on the part of the instructor, and therefore may not respond honestly. This might be due to conditioning after a semester of study in the course – student performance in classes can hinge on their ability to detect what an instructor ‘wants to hear’ – or it may be an impulse to please the instructor, even under the condition of anonymity. It is also possible that students might respond more negatively if they perceive an agenda within the survey (particularly if they harbor negative feelings toward the instructor).

The Environmental Conflict Overview (ECO) survey

We developed the Environmental Conflict Overview (ECO) survey as a companion to the NEP in our pre- and post-course student assessments. The ECO survey is comprised of brief descriptions of specific environmental issues, generally highlighting stakeholder conflicts. Each case overview is followed by a series of statements to which students respond on a Likert scale, similar to the NEP. The statements are generally designed to assess a specific aspect of student perspective on the conflict, rather than simply anthro- or ecocentrism. The conflicts themselves are selected to resonate with undergraduate students with a general understanding of ecology or environmental biology. They are also intentionally divisive. Our hope was that this would elicit more personal (and therefore honest or candid) reactions from the students, and potentially reveal sociological biases in perspectives. For example, the survey distributed to cadets at the Virginia Military Institute included a review of the environmental threats posed by a chemical weapons incineration facility operated by the United States on Johnson Atoll. Following each set of Likert-scale responses, students had the opportunity to discuss their opinion of the issue further in a free-response format.

Scoring the ECO survey responses is less straightforward than the NEP. Each statement is first characterized according to the aspect of environmental perspective that it is designed to reveal. The survey statements were designated as querying:

a) Awareness of ecological principles fundamental to the conflict;
b) The degree to which economic aspects are given priority in resolving the conflict;
c) General anthropocentrism in student's assessment of the conflict;
d) If parity among stakeholders is favored as a resolution;
e) If a student is particularly 'protective' of the environment. These statements were intended to reveal "knee-jerk" environmental conservatism in student perspectives.

The Likert-scale response was scored from 1-5 for each statement, with a higher score indicating greater prevalence of a particular trait in the respondent's perspective. For example, one section of the survey reviewed issues in management of invasive species. The following statement is then offered:

> *"The cost of preventing species introductions – or removing invasive species – is too high to consider it."*

Agreeing with this statement clearly reveals that the respondent places an emphasis on economic aspects of the issue. Therefore, a response of "strongly agree" would score a value of 5 in the "economic priority" category (likewise, "strongly disagree" would score 1 in this category). The complete survey and annotated details of the scoring procedure are provided as supplementary materials for this article (see Resources).

Questions were scored in more than one category if they reflected more than one dimension of environmental perceptions. Strong disagreement with the example statement above could also be considered indicative of ecological conservatism; certainly, the cost of control or eradication must be considered in management of invasive species. Therefore, a response of "strongly disagree" to this statement scored 5 in the category of ecological conservatism. Here it must be noted that this survey was designed to assess differences in pre- and post-course perspectives. The categorical scores provided a relative measure of a certain aspect of environmental perspectives, which were primarily relevant in pre- and post-course comparison. Free-response statements were not scored, but they were used to gain qualitative insight into the perspectives of the students.

Connecting course and survey content

The case-review format of the ECO survey was inspired by the student-active teaching methods highlighted in *TIEE* and similar resources. It is an excellent way to get students thinking critically about the applied context of ecological fundamentals. There are, of course, many real-world contexts for any given aspect of ecological dynamics. For example, in ecology and environmental science classes top-down / bottom-up forcing in community dynamics is often discussed in the context of wolf-moose-vegetation populations on Isle Royale (e.g. McLaren and Peterson 1994; c.f. Fortier 2002). Some of the same ecological principles considered in that case study are relevant in the context of predator reintroductions, such as gray wolf reintroduction in the United States (one of the survey issues). By connecting survey content to course topics, the ECO survey can be used to assess student learning or changes in student perspectives in relation to those specific course topics. Consequently, the impact or effectiveness of the teaching methods used to introduce or develop those areas of the course can be evaluated as well. In the survey administered at VMI, half the conflicts reviewed in the ECO survey corresponded to student-active classroom exercises in the course (Table 1). The stakeholder perspectives and conflicts were not discussed explicitly in class, but some ecological aspects of the issue were discussed. For example, the VMI course employed the *TIEE* figure set by Shusler (2004) on forest community impacts from high deer densities to review indirect connections in communities (e.g., deer impacts on breeding bird populations; McShea and Rappole 2000). We did not discuss the economic aspects of deer hunting or crop damage; however, these stakeholder issues were raised in the ECO survey. In this way, students needed to consider their ecological understanding of the issue in the new context of these stakeholder concerns. Standardizing teaching methods between courses at the two institutions was not feasible; therefore, we only examine connections between specific teaching methods and ECO survey responses from students at VMI.

The post-course survey also contained three free-response questions asking students to briefly reflect on the course and what they learned. We were interested in querying students about topics they favored during the course, as well as any class activities that they felt contributed (or did not contribute) significantly to their learning the material. The questions were intentionally general, to avoid "leading" students toward identifying particular aspects of the course or types of activities:

"What topic(s) covered in class did you enjoy most?"

"Do you feel that any particular class topics or activities contributed to any change in your perspective on the preceding environmental issues?"

"What topic(s) or activities do you feel contributed the LEAST to your experience in this course?"

These questions were designed to determine if student-active course components were particularly formative in a student's course experience. We analyzed individual differences in scores on the NEP and ECO pre- and post-course surveys at VMI as a paired design, and differences in PC survey scores using group comparisons. The post-course survey also requested basic demographic data on each student. We do not present analyses of these data here, as sample sizes were too small for meaningful assessment of demographic biases.

Survey distribution

The surveys were distributed in the first and last week of semester-long courses at Virginia Military Institute (VMI) and Phoenix College (PC) in the spring semester of 2006. The VMI course is an upper division general survey of ecology offered as an elective for majors in Biology, while the PC course is a lower division survey of environmental biology for both science and non-science majors. Both courses introduce fundamental concepts of ecology including, but not limited to, population dynamics, trophic interactions and community dynamics. The institutions represent very different student demography and experience in biology. Comparisons between survey results from these schools provide a qualitative, first-order assessment of transferability of the survey between different student populations. Extensive steps were taken to ensure anonymity for the students At VMI a third party provided each survey with a numeric code replacing respondent identity so that pre- and post-course responses could be compared. Respondent identity was not coded at PC, therefore pre- and post-course comparisons were not possible with this sample. Completed surveys were withheld from the instructors until after the end of the semester, and the survey was not discussed in class except when instructing (and encouraging) students to respond honestly and candidly. It was emphasized to students that the survey was being used to evaluate the course and its content, not to scrutinize their particular perspectives on environmental issues. The survey and administration

protocol was approved by the Human Subjects and Animal Use Committee at Virginia Military Institute.

RESULTS

Scores on the NEP and ECO surveys at Virginia Military Institute (VMI)

The survey was completed by 10 students at VMI and 31 students at PC. At VMI, scores on the pre-course NEP survey ranged from 23 to 55, with a mean of 45.9 and standard deviation of 8.7. Post-course scores ranged from 21 to 61, with a mean of 50.1 and standard deviation of 11.1. The apparent high variation in these scores is attributable to a single outlier point at the lower end of the scale (Fig. 1). Changes between pre- and post-course scores ranged from -3 to +14, with an overall average increase of 4.2 points (SD = 5.9). Pre- and post-course NEP score differences were normally distributed (Shapiro-Wilk statistic = 0.923, df = 10, $p = 0.379$), and therefore we used a paired t-test to assess significance. The differences were significant at = 0.1 ($t = -2.243$, df = 9, $p = 0.051$), indicating a general shift toward decreasing anthropocentrism in environmental perspectives (Fig. 1).

Changes in scores on the ECO survey identified changes in specific aspects of student perspectives at VMI. We scored individual surveys according to the five 'dimensions' of environmental attitudes identified earlier, and analyzed changes between pre- and post-course scores using pairwise t-tests. Results indicated that students reduced emphasis on economic priorities in their perspectives on issues ($p < 0.001$), demonstrated an increase in awareness of ecological principles underlying issues ($p = 0.031$), and showed decreased anthropocentrism in their perspectives ($p = 0.027$; Fig 2). Students did not appear to change their emphasis on stakeholder parity in resolving issues, nor did they demonstrate a significant change in environmentally conservative attitudes. Changes in student attitudes were relatively consistent across all issues; therefore, the teaching methods used when reviewing the ecology underlying these issues did not specifically effect attitude changes (Fig. 3).

Scores on the NEP and ECO surveys at Phoenix College (PC)

Surveys at PC were not individually coded and therefore paired comparisons were not possible. Pre-course NEP scores ranged from 37 to 74, with a mean of 52.4 and standard deviation of 7.2. Post-course NEP scores ranged from 46 to 71, with a mean and standard deviation of 56.5 and 5.7

respectively (Fig 1). Distribution of pre-test NEP scores was not normal (Shapiro-Wilk statistic = 0.912, df = 31, p = 0.015) so we compared distributions of pre- and post-test scores using Mann-Whitney tests. Post-test NEP scores were distributed differently from pre-test scores (U = 268, N = 31, p = 0.003) with an apparent shift toward higher scores on average (Fig. 1), likewise suggesting a shift toward increased ecocentrism (decreased anthropocentrism) among student attitudes.

The ECO survey at PC was modified and included only three of the six case reviews from the original survey. These responses did not provide enough data to assess significance; however, the general pattern of pre- and post-course changes qualitatively mirrored survey results from VMI (Fig 2).

DISCUSSION

Our results indicate a general shift in environmental perspectives among students at both institutions with a corresponding increase in awareness of ecological principles. The change between pre- and post-course NEP scores suggests that students at both institutes demonstrated more ecocentric attitudes after completing their respective ecology and environmental biology courses. This is especially meaningful considering the differing demographics. This finding is consistent with previous studies that have demonstrated increased concern for environmental issues among undergraduate students following a course in environmental science (Carpenter 1981; Leeming et al. 1993; Mangas and Martinez 1997; Zelezny 1999). The results of the ECO survey are in general agreement with NEP results, and they further indicate that certain aspects of student perspectives changed more than others.

Quantifying the constituent dimensions and structure of environmental attitudes is a complex area that is in need of further study (Heberlein 1981; Schultz et al. 2005). It is important to note here that the ECO survey has not been validated in application nor evaluated by experts in educational psychology; therefore, its results must be considered qualitative (Leeming et al. 1993). Much work remains to be done before it can be considered an accurate measure of environmental attitudes. However, general agreement in results from the NEP and ECO surveys lends qualitative credibility to its application as an indicator of changes in student perspectives when applied in a pre- and post-test format.

The largest change in student values indicated by scores on the ECO survey is in the emphasis placed on economic value of resources. Students

appeared to reduce emphasis on economic gains from exploitation of natural resources in their perspectives on environmental conflicts. Certainly this reflects a decrease in anthropocentrism among students, and increased acknowledgement that those resources serve purposes other than exploitation; however, the structure of economic valuation is complex. Does this result reflect a shift in values (away from economic aspects), or a shift in the definition of a resource's economic value? In other words, do students recognize an economic component to the 'environmental service value' of these resources that equals their exploitation (e.g. harvest) value, and therefore offset it? Does decreased emphasis on exploitation reveal an increased awareness of service value, or a greater emphasis on general conservation? This particular result indicates that this might be an interesting area to consider explicitly during a course, perhaps as a class discussion topic.

A goal of the ECO survey was to connect the topics to the course material and the teaching methods associated with that material. This was very challenging, due to the connections between ecological dynamics at different levels of organization. This may have contributed to the apparent lack of correlation between teaching methods and changes in attitudes or awareness (Fig 3). Patterns in free-response answers are difficult to characterize or generalize, however these queries did generate interesting feedback from the students. When asked what course topics they enjoyed most, 70% of students at VMI identified topics that were featured in student-active course exercises such as those adapted from *TIEE* articles (D'Avanzo and Musante 2004; Shusler 2004). Recall of course topics is biased by the survey content and connections to class topics, so the implications of this result are equivocal. However, it is worth noting that environmental conflicts in the survey were connected equally with topics that were taught using student activities and those covered only in lectures. Changes in student perspectives and understanding among individual ECO survey issue did not suggest a correlation with the teaching method employed for each topic (Fig. 3). However, this sample is likely too small to quantitatively address this with adequate precision.

The ability to connect the format and content of the ECO survey to activities and topics in an undergraduate ecology course makes it a useful tool for evaluating courses; however, it could also be applied as a course activity to provide context for ecological principles and generate discussion. In this study, we explicitly avoided discussion of the specific environmental issues summarized in the ECO survey to prevent bias in student responses. Our initial objective in this study was to develop a tool strictly for evaluating student attitudes; however, it is readily apparent that this survey could also function as a backdrop for in-

class activities. If applied as a pre-course survey, the results could be raised in the context of course topics. Responses could be summarized and revealed to the class, which would stimulate discussion about the ecological aspects of environmental conflicts. Changes in student opinion could then be polled on the spot, or in follow-up writing assignments, which would give students the opportunity to reflect on how their new ecological knowledge may influence their perspective on the issues. The ECO survey does not require students to reflect on their own experiences, though the opportunity is there in the free-response questions. However, it is very difficult to characterize general patterns in these answers, and these questions likely function better as learning activities than as course evaluation tools. Utilizing the ECO survey as both a teaching tool and course evaluation instrument in the same course would constitute tautology, and therefore it should strictly be applied as one or the other. However, it offers a relatively straightforward application for generating student discussions in class and connecting ecological fundamentals to complex environmental issues.

Our results mirror previous studies that demonstrate the influence of undergraduate education in shaping environmental perspectives and values in students. Our results also suggest that the novel ECO survey has potential for use in evaluating student perceptions and course outcomes in undergraduate environmental biology or ecology classes. The survey requires further evaluation and validation before it can be considered a reliable measure of environmental attitudes (*cf*. Schindler 1995; 1999). Subsequent analyses will focus on evaluating the study in different student groups to determine its reliability and consistency. The New Ecological Paradigm (Dunlap et al. 2000) and other established surveys provide a more reliable scale of anthropocentrism in perspectives (Leeming et al. 1993). The ECO survey will benefit greatly from application and critical evaluation in a variety of courses and institution settings. We welcome and encourage faculty who wish to collaborate on further application of the ECO survey to contact us.

PRACTITIONER REFLECTIONS

The ECO survey has potential as a means of assessing student perspectives and ecological understanding in a pre- and post-intervention context. It is presently imperfect as a tool for identifying the impact or role of student-active teaching methods in effecting such changes, but we believe its conceptual structure holds potential – particularly if properly validated. However, it seems a logical conclusion that any methods that improve student learning in ecology will have greater impact on students' environmental attitudes. It may be

that such impacts can not be separated out within a single course, particularly if the benefits of student activities extend beyond the specific course topic for which they are employed. It may be that using these approaches increases overall student 'investment' in the course, with impacts for learning across all course activities.

As discussed above, focusing class discussions toward the intended learning outcomes can be challenging. It is easier when students have already been given the necessary background to focus on the ecological fundamentals of the issue rather than the sociological implications. Using guided discussion as a means of introducing new material or concepts can be very effective, as it provides an early context for ecological principles and familiar foundation from which to develop more complex ideas. However, it can be more challenging to keep the discussion on track in these cases and teachers must be prepared to take a more active role in guiding students toward the desired endpoint. At VMI, using paper discussions or case studies to introduce new topics has been abandoned altogether as a result of critically evaluating learning outcomes in this study. These methods are employed only after a sufficient knowledge base at the associated level of organization (individual, population, community, etc.) has been established and students can more easily make connections between discussion issues and topics and ecological principles. This may not be necessary in advanced courses as opposed to general survey courses.

Several students also commented that in-class discussions were sometimes allowed to drift off topic, and therefore were not as well connected to the lecture material as they could have been. This was an important revelation that highlights the challenges of managing student activities. Allowing student interests to dynamically direct the focus of discussions is often an effective way to engage more students in active debate. However, it can be difficult to redirect discussions that have become tangential to the ecological focus – particularly when the topic is emotionally evocative and class time is limited. As instructors, these comments spurred us to examine our own approaches to facilitating and moderating student discussions and activities. We realized that student engagement alone is not necessarily an indicator of productive discussion. Instructors need to be prepared to redirect discussion foci toward the teaching goals quickly, especially in a typical lecture period (50 minutes). Information to assist instructors on applying student active methods can be found in the Teaching section of *TIEE* (see Resources).

Even though our initial objective in this study was to develop a tool strictly for evaluating student attitudes, it became readily apparent that the ECO survey

could also be used for in-class activities. This was tested at VMI recently with encouraging results; however, the caveat regarding the instructor's role in focusing discussion was very applicable here. The divisive nature of the ECO conflicts can lead to contentious debate that is often more political than environmental. This has some benefits, in that the political aspects of policy-making provide real-world context for challenges facing conservation. A discussion that is too emotionally charged can lead to negative returns, therefore establishing "ground rules" for productive and considerate discussion was helpful. However, passionate involvement in environmental causes has produced important progress in the past. Perhaps it is not unhealthy to allow emotion to enter the room when students debate such things, but it is best for instructors to take a neutral stance. Independence of student thought underlies the strength of student-active teaching methods, and compromising that independence would likely compromise the learning benefits.

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Table 1. Connections between environmental issues discussed in the ECO survey and course content at VMI. Level of ecological organization and ecological principles involved are indicated, as well as direct connections between issue topic and teaching methods employed for those topics. Note that ecological principles are often related between issues, so there are often tangential connections between awareness of ecological aspects and teaching methods employed in other issues.

Issue	Level of Organization	Ecological Principles	Teaching Methods
Marine Protected Areas	Populations, communities	Population dynamics and harvest management; food webs and trophic dynamics.	Lecture
Wolf Reintroduction	Predator-prey, community.	Role of top predators in community structure / stability; ecological uncertainty	Case study (Fortier 2002) and guided discussion.
Johnston Atoll Chemical Agent Disposal System (JACADS)	Ecosystem	Connections in open systems; long-term impacts of human activity.	Lecture
Deer Population Management	Populations, communities	Community dynamics and succession, particularly as related to overabundance; population management.	Pairs share and guided discussion following TIEE article (Shusler 2004); guided discussion and citizen's argument following case study (Ribbens 2001)
Invasive Species	Populations, communities	Population dynamics and community impacts of invasive species; control of invasive species.	Informal group work and guided discussion following TIEE article (D'Avanzo and Musante 2004) and review article (Simberloff 2005)
Deforestation	Population, community	Forest succession; community / food web dynamics.	Lecture.

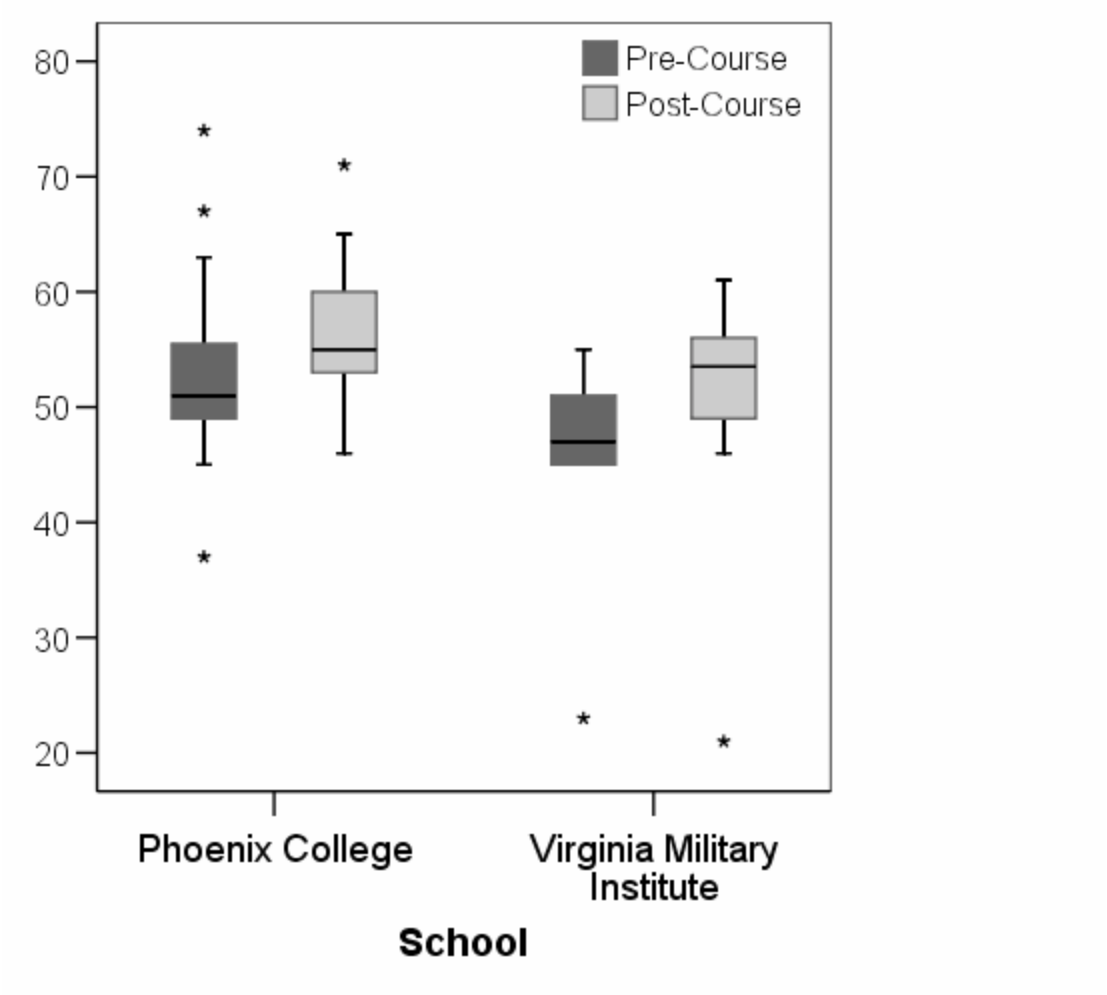

Figure 1. Comparison of pre- and post-course scores on the NEP survey at Phoenix College (N = 31) and Virginia Military Institute (N = 10). Modified boxplots indicate median, quartiles, total range, and potential outlier points (*). Increases in scores represent decreased anthropocentrism in student perspectives within institutions.

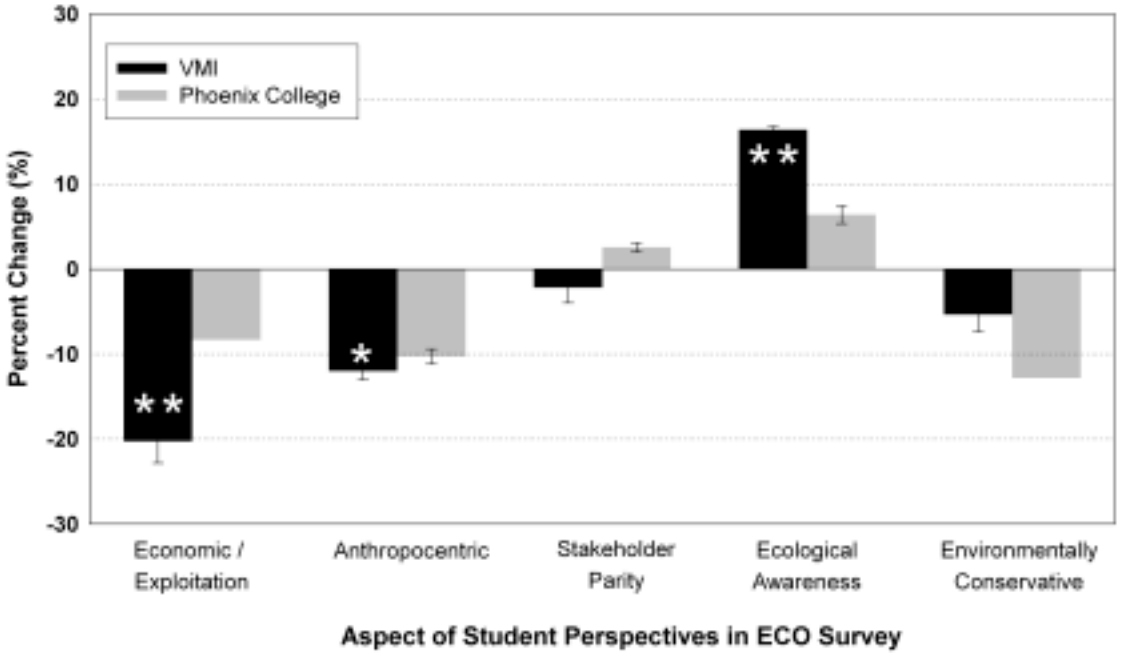

Figure 2. Average percent change in scores within individual categories of student perspectives as suggested in ECO survey scores. Error bars show standard errors of mean change in a category across all ECO issues; in some cases these were not calculable for scores at Phoenix College. Symbols indicate significance of changes assessed in paired t-tests (* $P<0.05$; ** $P<0.01$).

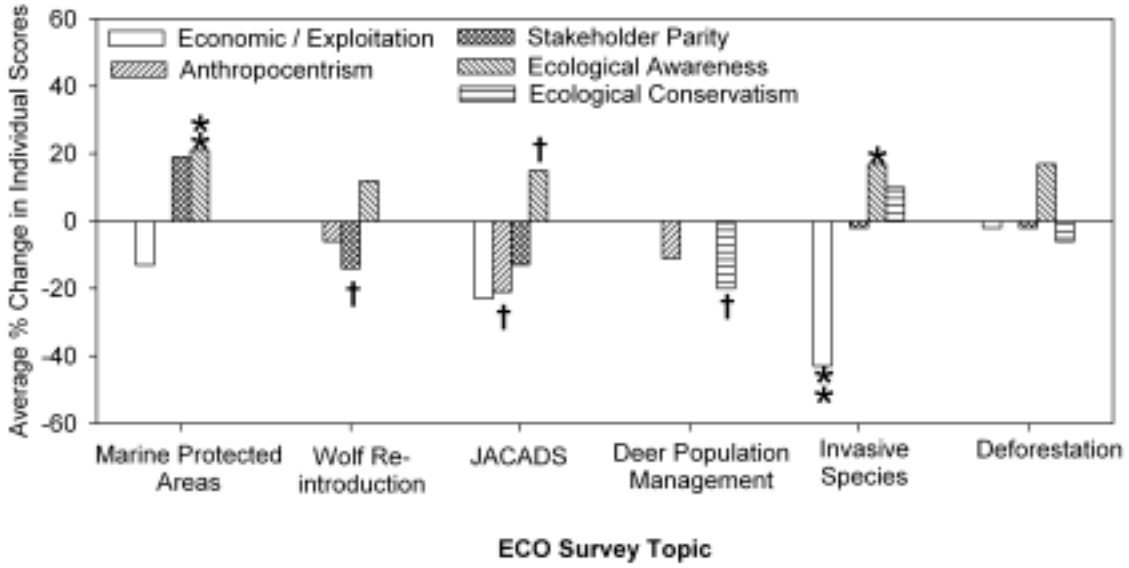

Figure 3. Mean percent changes in scores within individual categories of student perspectives, separated by specific ECO survey topics (Virginia Military Institute only). JACADS refers to the chemical agent disposal facility at Johnson Atoll. Note that some categories were not assessed in all topics (e.g., Ecological Awareness was not assessed in the Deer Population Management issue). See Table 1 or supplemental material for more details on the specific aspects of student perspectives queried in each ECO section. Symbols indicate significance of changes indicated by pairwise t-tests († $P < 0.1$; * $P < 0.05$; ** $P < 0.01$).

TIEE

Teaching Issues and Experiments in Ecology - Volume 5, July 2007

RESOURCES

The Annotated Environmental Conflict Overview (ECO) Survey

Author Notes to TIEE Readers:

Below are the conflict reviews and statements from the ECO survey, as distributed to biology majors enrolled in the general ecology course at Virginia Military Institute (Spring 2007). A reduced version (including only issues 1, 2, and 4) was distributed to students of various majors enrolled in an environmental biology course at Phoenix College. We have included scoring procedure for each issue / statement. We have highlighted potentially problematic statements in italics, and offer comments about these statements at the end of each section.

Issue 1: Marine Protected Areas

Scientists have documented that many marine fish populations have reached critically low levels. In the case of reef fishes – those fish that are commonly found living in or near coral or rocky reefs – one way to protect part of the population is to completely prohibit fishing on certain reefs. There is a great deal of controversy surrounding this idea. Stakeholders generally argue that there is not enough evidence of fish population declines to support such drastic measures, that there isn't enough evidence that these Marine Protected Areas (MPAs) will actually work, and that there are already effective protection measures in place (closed seasons, minimum size restrictions, etc). More importantly, nobody wants to lose the right to fish their favorite local hotspot. Then there are disagreements between different groups of stakeholders as well. These conflicts and stakeholder positions are summarized below:

a. *Commercial Fishermen.* Commercial anglers catch fish and sell them for a living. They feel that closing reefs will hurt them economically, either by limiting the areas they can legally fish or by forcing them to travel farther to reach legal areas. They also feel that the current harvest restrictions are strong enough to keep stocks from collapsing.

b. *Recreational Fishermen.* Recreational anglers catch fish for fun, not profit; though some earn livings as charter captains. They fear that closing reefs would keep them from fishing productive areas, and in some cases might force them to travel further (i.e., spend more on gas) to fish legal reefs. Regulations only allow them to keep a few fish per day, and they insist that they do not kill nearly as many fish per year as commercial anglers. They would support closing areas to commercial fishing, but do not support prohibiting recreational fishing on any reefs.

c. *SCUBA Divers and Charter Dive-Boat Operators:* SCUBA diving and snorkeling are a popular activities in areas with good reef fish populations. Closing reefs to fishing would lead to good conditions for operators of charter dive boat businesses. Closing reefs to fishing means dive boats would not have to compete with fishing boats for anchor space in closed reefs, and eventually divers would start seeing more large fish in these areas. However, commercial and recreational anglers argue that divers damage coral reefs and scare fish out of the area. Anglers say that if reefs are closed to fishing, they should be closed to snorkeling and SCUBA diving as well.

1.1	Since commercial anglers rely on these reefs for their livelihood, they should be allowed to fish everywhere.	Economic / Exploitation (+)
1.2	*Recreational anglers do not kill many fish, and therefore they shouldn't be barred from any reefs.*	Economic / Exploitation (+)
1.3	Protecting these fish populations from extinction is important. If evidence suggests that MPAs will protect the future of these stocks, then we should start closing some reefs to fishing.	Ecological Awareness (+)
1.4	If fishing is not allowed on a reef, then SCUBA diving and snorkeling should not be allowed there either.	Stakeholder Parity (+)
1.5	The loss of a few fish species is not likely to have a major impact on the entire coral reef ecosystem.	Ecological Awareness (-)
1.6	There is probably a solution that can satisfy the concerns of all stakeholders.	Stakeholder Parity (+)

Author Notes on Issue 1:

Statement 1.2 was designed to reveal a common misconception associated with the impacts of recreational fishing. However, this does not fit well into any scoring category. We scored it as favoring the economic value of recreational fisheries, however it could also be considered a negative indicator for stakeholder parity or ecological awareness. This statement should likely be replaced unless it is connected to a specific course objective.

Issue 2: The Yellowstone Gray Wolf Restoration Project

When Yellowstone National Park was created in the 1870's, gray wolves were native to the area. An aggressive predator control program effectively extirpated (i.e., exterminated) wolves from most of the lower 48 states in the early 1900's. Recent evidence indicates that wolf populations are slowly being reestablished naturally in some states (Montana, Idaho). In the mid 1990's the National Park Service (NPS) began a cautious wolf reintroduction program, releasing wolves captured from Canada into select areas of Yellowstone National Park. The public response has been mixed and emotionally charged.

a. *The National Park Service:* NPS policy calls for restoring native species if extirpation was caused by human activities, and if the present habitat can support the species. Therefore, the NPS views wolf reintroduction as an integral part of its government-mandated mission for preserving the heritage of public lands.

b. *Tourism-Based Businesses:* People are generally fascinated with large, predatory animals, and wolf reintroduction will likely spur more people to visit Yellowstone every year. Business operations around Yellowstone that cater to tourists support the wolf reintroduction program. An increase in tourism would benefit local economies as a whole.

c. *Livestock Ranchers and Landowners:* Ranchers are allowed to graze their cattle and other livestock on public lands as well as on their private land. Ranchers contend that reintroducing wolves will lead to attacks on livestock in the areas surrounding Yellowstone National Park. They argue that visitors to Yellowstone will rarely see a free-roaming wolf, and meanwhile ranchers and landowners will have to deal with livestock losses and harassment by wolves. Landowners are also concerned about the safety of their families if wolf populations are reestablished.

2.1	*The wolves were once an important part of the ecosystem; their population should be restored so that the ecosystem can return to its original state.*	Ecological Awareness (+)
2.2	It is not realistic to expect humans and predators to live so closely together.	Anthropocentric (+)
2.3	The economic threat to livestock ranching is much more substantial than the environmental benefits of wolf reintroduction.	Anthropocentric (+)
2.4	*We should be certain of the ecological outcome before we reintroduce wild predators into our public*	Ecological Awareness (-)

	lands.	
2.5	The tourism benefits to the local communities outweigh the potential losses to the smaller community of ranchers.	Stakeholder Parity (-)
2.6	There is probably a solution that can satisfy the concerns of all stakeholders.	Stakeholder Parity (+)

Author Notes on Issue 2:

Statement **2.1** does not fit any particular scoring category well and should likely be altered. The first part of the statement reveals an understanding of the importance of predators in community ecology; while the second part reflects a somewhat conservative environmental perspective (restoring "original" states is contentious).

The scoring of statement **2.4** is non-intuitive, but disagreement reflects an understanding of uncertainty in community dynamics and ecological states. To suggest that we can be "certain" of the outcome of a community / ecosystem perturbation of this significance, or predict the subsequent equilibrium conditions, ignores any uncertainty in the strength of direct and indirect community interactions.

Issue 3: Johnston Atoll Chemical Agent Disposal System (JACADS)

Chemical weapons were commonly used in warfare early in the 20th century. Though their use was banned by the Geneva Protocol in 1925, many nations continued to develop, produce, and stockpile chemical weaponry. In 1990, the Soviet Union and the United States reached an agreement to destroy their ageing arsenals of chemical agents. The U.S. built an incineration facility (known as JACADS) on Johnston Atoll, a small island in the south Pacific. If JACADS is successful, it will be the model for other incineration facilities around the world. However, success has been slow to come and there have been several accidents at the facility.

a. *Environmental Protection Groups:* Many environmental advocacy groups (such as Greenpeace International) have protested the JACADS facility, suggesting that it poses many environmental risks. Dangerous emissions from the plant will enter the surrounding oceans and possibly contaminate fish populations. Ocean transport of ageing chemical weapons is risky, and the risk of environmental damage and/or loss of human life from an accidental spill is very high. They contend that the U.S. government has not considered cleaner, safer, and potentially portable alternatives to incineration, and provide evidence that such alternatives exist.

b. *South Pacific Island Nations:* Residents of the surrounding island nations (such as American Samoa, Micronesia, etc.) are very unhappy about the JACADS facility.

Any toxic emissions from incineration – or chemicals lost in accidental spillage – will enter the surrounding ocean environment, and may contaminate the fish these local populations rely on for food. This could result in people being poisoned by toxins accumulating in fish, or large-scale fish kills and subsequent food shortages.

c. *The U.S. Army and Government:* The Army claims it has evaluated all possible options, and incineration is the safest and most efficient way to dispose of these weapons. All accidents at JACADS have been minor, and the local environment has not been compromised by spillage. Finally, nobody disputes that there will be harmful emissions produced by incineration. However, they will be easily diluted by the vast oceans around Johnson Atoll before they pose any threat to marine life or local human populations.

3.1	If there is potential risk to the ocean ecosystem, the JACADS facility should shut down until such risk is properly evaluated.	Ecological Awareness (+)
3.2	There is a certain amount of risk in the destruction process, but there is greater risk in keeping these deteriorating weapons around and in reach of potential terrorists.	Anthropocentrism (+)
3.3	Johnson Atoll is sufficiently isolated so that no human populations should be directly harmed by emissions or accidents. Potential risk to the ocean ecosystem is an acceptable tradeoff for minimizing threat to human life.	Anthropocentrism (+) Ecological Awareness (-)
3.4	Science can easily find a way to fix any environmental damage caused by activities at JACADS.	Anthropocentrism (+) Ecological Awareness (-)
3.5	The cost of shutting down JACADS and evaluating new disposal methods is too high to consider at this point.	Economic / Exploitation (+)
3.6	There is probably a solution that can satisfy the concerns of all stakeholders.	Stakeholder Parity (+)

Issue 4: Managing Deer Herds for Hunters, Farmers, and Forests

Around the end of the 19th century, whitetail deer populations reached an all-time low due to the combined pressure of habitat destruction and unregulated hunting. With deer populations apparently on the verge of collapse, most states prohibited deer hunting and the whitetail deer became a protected species. By the mid 1900's, populations were rebounding to the point that limited hunting was allowed again. Following decades of restrictive harvest regulations (e.g., males only, one deer per year, etc.) the whitetail deer populations are now at an all-time high. There is now a great deal of concern that deer populations are too large, and that they pose a threat to the forest ecosystem. Evidence indicates that browsing by deer has severely affected forest vegetation in areas of high deer density, and damage to farm crops has increased as well.

a. *Deer Hunters:* Deer hunters are enjoying the high deer densities, and most do not want deer populations reduced. They maintain that the goal of game population management has always been to provide quality hunting opportunities for the public. Harvest by deer hunters is presently the only form of deer population control; therefore, any successful control effort will require the support of the deer hunting community.

b. *Farmers and Landowners:* Land and crop damage by deer has increased as the deer populations have grown in number, causing economic losses to farmers. Landowners are often granted permission to harvest large numbers of deer on their property, but the high density of deer on nearby public lands simply means that more deer move on to their property every year to replace the ones removed the year before. These people would like to see a more aggressive population control strategy on public lands.

c. *Game and Forest Management Departments:* The effect of deer on forest habitats has been profound. The composition of forest vegetation has changed, which in turn has affected the populations of other animals that inhabit the forests. Game and forest management offices would like to see the numbers of deer reduced so that the forests may return to their 'natural' composition, thereby improving habitat for other animals.

4.1	Deer hunting provides major economic benefits to surrounding communities, outweighing any losses from crop and land damage.	Stakeholder Parity (-)
4.2	Deer populations should be managed to minimize crop damage on farms.	Anthropocentrism (+)
4.3	The goal of management should be to provide excellent opportunities for deer hunting.	Anthropocentrism (+)

4.4	Deer populations should be reduced until the forest ecosystem is restored to its original state.	Environmental Conservatism (+)
4.5	We should allow people to kill as many deer as they want on their own land.	Anthropocentrism (+)
4.6	There is probably a solution that can satisfy the concerns of all stakeholders.	Stakeholder Parity (+)

Issue 5: Impacts of Introduced Species

When a new species is introduced into a system, the results are unpredictable. In some cases, introduced species have had devastating effects on native species. In other cases, introduced species simply don't last in their new environment. When an introduced (or *exotic*) species can out-compete and aggressively "push out" native species, the introduced species is described as invasive. Some ecologists have said that invasive species are the greatest threat to the future of our ecosystems.

Others have argued that introduced species are not a pressing environmental issue. They argue that ecosystems will adapt to introduced species, and that the introduced species will eventually just become an integral part of the ecosystem. Moreover, it would be an economic and logistic nightmare to try to stop new introductions, or remove all the existing invasive species from their present habitats. Humans have introduced many species around the world, on purpose and by accident. Fish have been stocked into lakes and rivers where they previously never existed, exotic tree and shrub species are commonly planted as landscape 'ornamentals,' and species occasionally "hitch a ride" between countries and continents in shipping crates, etc. While there are many examples of invasive species upsetting ecosystems, there are also many examples of "successful" species introductions as well.

5.1	Introduced species only need to be removed if they threaten native species.	Stakeholder Parity (-) Ecological Awareness (-) Environmental Conservatism (-)
5.2	Ecosystems will eventually adapt to introduced species.	Environmental Conservatism (-) Ecological Awareness (-)

5.3	The cost of preventing species introductions – or removing invasive species – is too high to consider.	Economic / Exploitation (+) Environmental Conservatism (-)
5.4	New species introductions should never be allowed.	Environmental Conservatism (+)
5.5	I rarely encounter any introduced species.	Ecological Awareness (-)
5.6	Invasive species are here to stay, so we may as well find a way to live with them.	Stakeholder Parity (-)

Author Notes on Issue 5:

In this issue, native species and invasive species emerge as "stakeholders" in the conflict. The human aspects of this issue are largely represented in either a protective tendency toward native species or in the cost of control.

Issue 6: Logging and Deforestation in Belize

In the Toledo district of Belize, several communities exist that are direct descendents of the Maya Indian civilization. The Maya have lived in the rainforests of Belize for the past four centuries, though their distribution is now limited to this southern area due to extensive logging activity in the rest of the Belizean rainforest. Logging has been an integral part of the Belizean economy since early British settlement, but in the last 20 years it has increased dramatically. In 1993 the Belizean government began granting access for foreign logging companies on to traditionally Mayan forest lands. Though these companies are required to follow strict sustainable land management guidelines, violations have been reported. Violations include: logging in restricted areas, harvesting protected species, and logging during the normally closed rainy season. Many environmental groups indicate that the rainforests will never recover from this level of logging activity, leading to massive loss and even extinction of local plant and animal populations. They also claim that deforestation is affecting Belize's river and coastal ecosystems.

a. *The Maya:* The Maya claim that the unrestricted logging is exceeding the limits of what the forest can sustain. Animals that they hunt are being scared away by logging activity, and logging during the rainy season increases soil erosion which muddies the rivers they rely on for drinking water. Their traditional way of life –

and the very existence of these extremely poor communities – is being threatened in order to support a foreign market.

b. *The Logging Industry:* The logging industry provides many jobs for the Belizean people and makes up a substantial proportion of the nation's economy. They insist that while some violations have occurred, the lack of adequate maps makes it difficult to distinguish areas that are closed or open to logging. They claim that the amount of timber they harvest is monitored by the Belizean government, and insist they are harvesting a renewable resource in a sustainable manner.

c. *Environmental Groups:* The rainforests of Belize are home to a tremendous variety of plant and animal species, many of which are not found anywhere else in the world. Deforestation threatens to destroy the habitats these species rely on, and increased soil erosion is affecting the river habitats and drinking water sources. The loss of Belizean rainforests would have far-reaching, devastating impacts on the global environment.

6.1	The primary goal should be to preserve the economic benefits of the logging industry while meeting the needs of the Maya communities.	Economic / Exploitation (+) Stakeholder Parity (+) Environmental Conservatism (-)
6.2	New trees will eventually replace the trees removed by logging, and then the forest animals will return as well.	Ecological Awareness (-)
6.3	The economic benefits of logging to the nation of Belize far outweigh the concerns of a small community of people.	Economic / Exploitation (+)
6.4	Lack of compliance on the part of logging industries is the source of the problem; better enforcement is the solution.	Economic / Exploitation (+)
6.5	*If rainforests are maintained in pristine condition, the potential for a strong "eco-tourism" industry in Belize would make up for the loss of logging revenues.*	Environmental Conservatism (+)
6.6	There is probably a solution that can satisfy the	Stakeholder Parity (+)

	concerns of all stakeholders.	

Author Notes on Issue 6:

Statement **6.5** does not fit neatly into a scoring category, as it reflects economic valuation of the resource as well as a conservative environmental perspective. It should likely be replaced or modified unless it corresponds with a particular course topic / objective.

Links

TIEE resources on using student-active methods in teaching:
(http://tiee.ecoed.net/teach/teach_essays.html)

Guided class discussions:
http://tiee.ecoed.net/teach/essays/guided_discussion.html

Other resources on lecture methods:
http://tiee.ecoed.net/teach/teach_links.html#lectures

National Center for Case Study Teaching in Science:
http://ublib.buffalo.edu/libraries/projects/cases/case.html