Environmental History of the Southwest as a General Science Education Course

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ABSTRACT

Environmental History of the Southwest is a general science education course at the University of Arizona with an emphasis on human-environment interaction of the past and an objective of preparing non-science majors to understand and critically evaluate contemporary environmental issues. The American Southwest is well suited for such a course, as it is rich in many data sets of paleoenvironmental reconstruction techniques and has been inhabited by humans for thousands of years. Lectures are grouped into three parts. Part 1, Background, covers geology and climatology, paleoenvironmental techniques, and ecosystems. Part 2, Past Environments and Societies, covers environmental changes since the late Pleistocene and human response to and interaction with those changes. Part 3, Modern Environmental Issues, covers contemporary environmental issues as well as past analogs of these issues for comparison. Lecture topics are interconnected with one another, making for a comprehensive study of environmental history. Several elements of science are revealed and discussed, improving general science literacy among the students, who are mostly non-science majors. Other regions of North America have had long-term human habitation and are also rich in multiple data sets of paleoenvironmental indicators, so nearly all of the continental U.S. and Canada is suitable for a course on environmental history and human-environment interaction.

INTRODUCTION

General education is an important component of liberal arts higher education (Sterns, 2002). Critical thinking and the ability to synthesize and express wide-ranging information are desired results of a liberal college education (Clewett, 1998). At the University of Arizona (UA), the general education program “provides students with foundational facts, processes, theories, and habits of mind to meet the challenges of the 21st century across a variety of disciplines … using courses designed … to develop a critical and inquiring attitude and an appreciation of complexity and ambiguity, … an empathy with persons of different backgrounds or values, and a deepened sense of self” (University of Arizona General Catalog, 2008).

Basic science literacy across disciplines is an example of general education. Major science organizations and funding sources promote science literacy for all citizens (e.g., American Association for the Advancement of Science, 2000; American Geophysical Union, 2007), and public understanding of science is the sole topic of an academic journal entitled exactly that, Public Understanding of Science (Sage Journals Online, 2008). General science literacy does not require understanding exceedingly complex concepts or knowing highly technical science (Jemison, 2003), nor does it mean turning everyone into scientists (McDonald and Dominguez, 2005). Rather, science literacy means being familiar generally with scientific tenets (e.g., plate tectonics in the case of geology) as well as being able to follow media accounts of scientific findings well enough to evaluate them critically (Gregory, 1992). Science literacy also includes being able to apply quantitative skills and reasoning to real-world problems (Macdonald and Bailey, 2000). For example, literacy in geosciences allows citizens to understand and cope with natural hazards, which are often geological/climatological in nature (Grove, 2002). Ultimately, understanding science is a notable product of a liberal education (Hetherington et al., 1989), and quality of life is enhanced when citizens follow and understand science (Brunnhorst, 1991). In post-college life, liberal arts graduates value highly their science general education (Chinnici and Hiley, 1998; Klenow et al., 1998; Pryor and Dallam, 1999).

An increasingly important area of scientific literacy is human-environment interaction, for example, human/societal adaptation to variability in climate (e.g., long-term events such as drought and/or temperature trends as well as short-term and/or extreme events such as flooding) (Kane and Yohe, 2000) and to deterioration in natural ecosystem health (Daily, 1997). A key strategy for determining options for human response to variation in climate and natural ecosystems is knowing how human societies have interacted with environmental variability in the past (Stern, 1993; Redman 2004; Dearing, 2006). Although technological differences between past and present societies complicate direct comparisons, past human-environment interaction provides a baseline of information on how people have responded to environmental change (Dearing et al., 2006). In notable cases, past societies have collapsed entirely, perhaps due in part to environmental stress (Diamond, 2005), and it is especially instructive to understand those examples of human-environment interaction.

Thus, a general science education course for non-science majors on environmental history with emphasis on human-environment interaction is justified. In the United States, the Southwest is well suited for such a course. The American Southwest, which includes most of Arizona and New Mexico plus southeastern Utah, southwestern Colorado, and northern Sonora and Chihuahua (Byrkit, 1992), has experienced variability in climate (Sheppard et al., 2002) and changing ecosystem health (Bahre, 1991). This region has been inhabited by humans for thousands of years (Figure 1A), including prehistoric sedentary societies that existed for hundreds of years (Cordell, 1984). The American Southwest is also
rich with many data sets of multiple paleoenvironmental reconstruction techniques (Figure 1B-E). Accordingly, the American Southwest is an excellent region for studying environmental history with an emphasis on human-environment interaction.

ENVIRONMENTAL HISTORY OF THE SOUTHWEST: COURSE STRUCTURE

The UA offers a lower division, general education course for non-science majors called “Environmental History of the Southwest” (EHSW). This course is targeted at the sophomore level, which examines topics more in-depth than at the freshman level (University of Arizona General Catalog, 2008). EHSW is offered through the UA Geosciences Department, which grants undergraduate degrees in Environmental Geology (University of Arizona Geosciences Department, 2008).

EHSW is primarily a lecture course, with lectures grouped into three parts (Figure 2). Part 1, Background, begins with geological provinces of the Southwest (e.g., Colorado Plateau, Basin and Range, southern Rocky Mountains) and climate of the region (e.g., wide ranging temperature and low precipitation that falls in two...
distinct seasons of the year). Background continues with techniques of dating environmental materials, especially radiometry (Dickin, 1997) and dendrochronology (Stokes and Smiley, 1968), as well as techniques of reconstructing past environments, especially packrat midden analysis (Betancourt et al., 1990) and dendrochronology (Fritts, 1976). Background concludes with descriptions of dominant environments of the Southwest (e.g., desert, plateau, and mountain ecosystems).

Part 2, Past Environments and Societies, is the crux of the course. Part 2 begins with Southwest environments and their changes from the late Pleistocene to present, as well as with first people of the Southwest. A key feature of early human-environment interaction is the extinction of many Pleistocene megafauna, a topic that includes the possible role of humans in the extinction event (Koch and Barnosky, 2006) as well as how early people coped with such a profound environmental change (Champagne, 1994). Next, human-environment interaction ofprehistoric sedentary societies is covered, including prominent Southwest examples such as the Anasazi (Gumerman, 1988), Hohokam (Noble, 1991), Mogollon (Whittlesey, 1999), and Sinagua (Colton, 1946). In covering past societies, common emphases are dates of establishment and abandonment of major population centers, various lifeways that were followed to make a living (e.g., hunting/gathering, agriculture, trading), and human manipulation of environments such as water diversion and storage and forest utilization. Past Environments and Societies concludes with subsequent societies of the Southwest, including Pueblos of the 14th and 15th Centuries (Spielmann, 1998), Navajo-Apache (Towner, 1996), and Spanish-Mexican (Fontana, 1994). Throughout Part 2, the different human societies and their interaction with the environment are compared and contrasted. It is also emphasized that most of these past cultures faced similar environmental challenges to those of today and yet existed for longer than modern US society has so far. Thus, Part 2 provides past analogs for

Figure 2. Lecture topics of Environmental History of the Southwest, arranged in order beginning at the top and going clockwise and grouped into three parts. Lines connect lectures that are related to one another to at least some degree, and numbers in parentheses indicate the number of other lectures that each topic ties in with.
comparison with modern human-environment interaction.

Part 3, Modern Environmental Issues, covers contemporary environmental topics of the Southwest, and in so doing the relevancy of environmental sciences to all students, regardless of their major field of study, is emphasized (Hobson, 2000). With the onset of the Anglo-American period and intensive livestock grazing in the Southwest, the vexing issue of arroyo formation is considered (Cooke and Reeves, 1976). Forest health is covered, especially the current polemic of wildland fire management and the fact that wildfires now burn more intensely and kill more trees than in the past (Swetnam and Baisan, 1996). Flooding and drought are covered, and it surprises students to learn that drought AND flooding occur simultaneously in the same area (Collier and Webb, 2002). Indeed, the Southwest is currently experiencing a multi-year drought (Breshears et al., 2005; Jacobs et al., 2005) while also seeing relatively frequent flooding recently (Webb and Betancourt, 1992). Also covered in Part 3 is water, a critical issue that regulates agriculture, economics, population growth, and regional development. Water supply and demand are key factors linking all human inhabitants of the Southwest (Reisner, 1993), and as such this topic ties modern society with those of the past. Additionally, water math, with its large absolute values and wide error bars, offers excellent opportunities for students to apply quantitative reasoning with "back of the envelope" calculations to estimate supply, capacity, and use.

One lecture in Part 3 covers global warming, which has received high media exposure recently (International Panel on Climate Change, 2008). Informed adults have heard about global warming (Fortner et al., 2000), but without specific coursework on this topic, many adults are unaware of details of global warming and/or they know details or even fundamental principles incorrectly (Stamm et al., 2000; Jeffries et al., 2001). It is important for citizens, including non-scientists, to be able to follow and understand scientific concepts underlying global warming in order to critically evaluate the debate about it (Khandekar et al., 2005). In addition to covering basics of atmospheric greenhouse physics, the global warming lecture in EHSW covers possible environmental change in the Southwest in the event that warming continues into future decades or centuries (Sprigg and Hinkley, 2000; Merideth, 2001). For this lecture, environmental change reconstructed for the Pleistocene-Holocene boundary (Part 2 of the course) serves as a model for what might occur with contemporary ecosystems in the future.

### TEACHING METHODS USED IN EHSW

To spic up lectures in EHSW, clips from video presentations are included. These include productions from government agencies (e.g., NOAA on climate), public broadcasting (e.g., NOVA on many subjects), learning channels (e.g., Discovery on Pleistocene megafauna), and many private entities. Video clips help avoid monotony in lecturing, offering variety to the typical large class format (Hoover, 2006).

A notable feature of lecture topics in EHSW is their interconnectedness with one another. On average, each lecture topic connects with 13 other lectures, or about two-thirds of the course (Figure 2). As evidence of the suitability of this course as an offering in the Department of Geosciences, geology and climatology connect with 14 and 19 other lectures respectively, nearly the entire course. Lecture interconnectedness allows constant reinforcement of early-semester material in subsequent lectures, making for a truly comprehensive study of environmental history. For example, each of Part 3, Modern Environmental Issues, reviews past analogs of these issues (Part 2) as well as basic geological/climatological background for it. Answers must draw from lectures from all three parts of the course.

To achieve the benchmark of science literacy of understanding the nature of science (American Association for the Advancement of Science, 1993), several elements of science are discussed throughout EHSW:

1. Sample replication: Literally thousands of tree-ring, packrat midden, and alluvial stratigraphy samples have been analyzed to reconstruct past environments of the Southwest (Figure 1B-E).
2. Multiple lines of evidence: Tree rings, packrat middens, and alluvial sequences integrate environmental conditions and changes in different ways, and analyzing multiple data types yields stronger interpretations than relying on just one data type (Reid and Thompson, 1966).
3. Modern calibration studies: Interpretation of past environments from tree rings or packrat middens requires knowing relationships between these data types and modern environments (Bradley, 1985).
4. Uniformitarianism: Upon completing modern calibration studies, a central tenet of paleoenvironmental reconstruction is that the present is the key to the past. The veracity of uniformitarianism is discussed many times in EHSW.
5. Treatment vs. control: As an observational science, experimental treatments are not usually applied to subjects in the classic scientific sense in paleoenvironmental reconstruction. However, by selecting study samples that are affected or not by an environmental factor of interest, it is possible to approximate this scientific concept.
6. Site selection vs. randomization: Much of science is predicated on random allocation of subjects to study treatments of interest. In contrast to randomization, particular sites and samples are often purposely selected in paleoenvironmental reconstruction to maximize sensitivity to an environmental factor of

<table>
<thead>
<tr>
<th>Student Demographic</th>
<th>Relative Number of Students (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sophomore or Junior Year</td>
<td>81</td>
</tr>
<tr>
<td>Took EHSW to fulfill general education requirements</td>
<td>86</td>
</tr>
</tbody>
</table>

**Table 1. Student Demographics in Environmental History of the Southwest at the University of Arizona.** Data from student evaluation summaries from 2001 through 2006.
Table 2. Student Major Representation in Environmental History of the Southwest from Colleges of the University of Arizona. Data from student evaluation summaries from 2001 through 2006.

<table>
<thead>
<tr>
<th>Representative Departments</th>
<th>Relative Number of Students (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social and Behavioral Sciences (Anthropology, Geography, History, Journalism, Political Science, Sociology)</td>
<td>34</td>
</tr>
<tr>
<td>Business and Public Administration (Accounting, Economics, Management Information Systems, Marketing)</td>
<td>20</td>
</tr>
<tr>
<td>Education (Educational Psychology, Higher Education, Teaching &amp; Teacher Education)</td>
<td>13</td>
</tr>
<tr>
<td>Fine Arts (Art, Dance, Music, Theater)</td>
<td>8</td>
</tr>
<tr>
<td>Science (Mathematics, Chemistry, Physics, Atmospheric Science) and Agriculture and Life Sciences (Agriculture, Entomology, Nutrition, Natural Resources, Soil and Water)</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 3. Summary of Student Evaluation of Environmental History of the Southwest at the University of Arizona. Data from student evaluation summaries from 2001 through 2006.

<table>
<thead>
<tr>
<th>Evaluation Level of Amount Learned</th>
<th>Relative Number of Students (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than usual or an exceptional amount</td>
<td>60</td>
</tr>
<tr>
<td>About as much as usual, more than usual, or an exceptional amount</td>
<td>89</td>
</tr>
</tbody>
</table>

STUDENT EVALUATION OF EHSW

Since its first offering in 1998, well over 1000 students have taken EHSW. Based on summary data from student evaluations for the years 2001 through 2006, the great majority of students of this course have been sophomores and juniors (Table 1), as expected. Some seniors have taken this course, apparently still needing to fulfill lower division requirements, and even a few freshmen have taken it, though prerequisites usually preclude freshmen eligibility. Most students have taken EHSW to satisfy general education requirements (Table 1), namely, the second-year natural science requirement for non-science majors. Students not using EHSW to satisfy general education requirements have taken it instead for a variety of other reasons, including out of personal interest in the subject matter, i.e., with no other reason related to graduation (personal communication with students).

The great majority of students in EHSW have not been majors in the natural, physical, chemical, biological, or agricultural sciences. Predominant majors in this course have included social and behavioral sciences, business, education, and others including humanities (Table 2). A few majors in fine arts have also taken this course. To date, students majoring in engineering have not taken EHSW, largely because they are not required to take a second-year natural sciences general education course.

Student evaluation of EHSW has generally been favorable. Considering the variable "amount learned," a strong majority of students have claimed either "more than usual" or "an exceptional amount" (Table 3). A great majority of students have claimed to have learned at least "about as much as usual." This positive consensus is...
gratifying given that most students of this course have not been natural science majors and therefore might have begun the course with low expectation of finding it useful given their particular majors.

ENVIRONMENTAL HISTORY BEYOND THE SOUTHWEST

The American Southwest is a perfect region for a course on environmental history, especially at the UA, where a large fraction, if not a majority, of the student body is from Arizona. However, the American Southwest is by no means the only appropriate region for such a course. For example, in North America other regions are rich in data sets of the multiple paleoenvironmental indicators of tree rings, pollen, and packrat middens (Figure 1B-D). Holocene alluvial stratigraphy studies (Figure 1E) also exist for other regions (e.g., Ashley and Hamilton, 1993; Knox, 1996; Daniels and Knox, 2005). Northern regions even have significant long-term accumulations of ice as well as ice core research for paleoenvironmental reconstruction (e.g., Cecil, 2005), which would be appropriate in a course on environmental history. Additionally, other regions with long-term human habitation include the Northwest Coast and Southern Woodland, (Figure 1A). If relatively more recent sedentary human societies are considered, then this list can include Subarctic, Prairie, California, Great Basin, Plateau, and Northern Woodland. Even the Plains, with its relatively recent sedentary human habitation, could be a geographic region of human-environment study covering the last several centuries. Consequently, nearly all of the continental U.S. and Canada is suitable for a course on environmental history and human-environment interaction.

CONCLUSION

General education is as valuable now as ever before in higher education because of the great cultural heterogeneity of students and the wide array of issues facing human society (Scott, P., 2002). General education courses on environmental history contribute to this lofty goal of education, i.e., to develop integrative human beings who can create a better world (Scott, D.K., 2002). At the UA, EHSW meets this goal.

ACKNOWLEDGEMENTS

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