Quantitative assessment of a field-based course on integrative geology, ecology and cultural history

Paul R. Sheppard\textsuperscript{a}\textsuperscript{*}, Brad A. Donaldson\textsuperscript{b} and Gary Huckleberry\textsuperscript{c}

\textsuperscript{a}Laboratory of Tree-Ring Research, University of Arizona, Tucson, Arizona, USA; \textsuperscript{b}General Biology MS Program for Teachers, University of Arizona, Tucson, Arizona, USA; \textsuperscript{c}Department of Geosciences, University of Arizona, Tucson, Arizona, USA

A field-based course at the University of Arizona called Sense of Place (SOP) covers the geology, ecology and cultural history of the Tucson area. SOP was quantitatively assessed for pedagogical effectiveness. Students of the Spring 2008 course were given pre- and post-course word association surveys in order to assess awareness and comprehension of the geology, ecology and cultural history of the Tucson area. Students who had previously taken SOP (2005–2007) and students who had never taken SOP also completed the survey. The survey consisted of 12 stimulus terms, all of which represent concepts integral to an understanding of environmental geography of the Tucson area. The students wrote words that they associate with each stimulus term. Differences between the pre- and post-course responses showed clear improvement in awareness and comprehension of the geology, ecology and cultural history of the Tucson area. Results from students who took SOP in past years indicate that long-term retention of course content is good. The word association technique proved to be effective for collecting data and evaluating the course. The field trips of SOP are described in the Appendix, which also contains the word association survey used in this research.

Keywords: field-based education; geology; ecology; cultural history; word association

Introduction

This paper describes a quantitative assessment of a field-based environmental geography course at the University of Arizona, Tucson, Arizona, USA. This course is entitled Sense of Place (SOP), borrowing the phrase from extensive literature on place-based theory as well as from a biography of the same title about Forrest Shreve, the internationally renown ecologist of the early twentieth century, who studied the deserts and mountains of southern Arizona and thereby had a profound understanding of the geography and environments of the region (Bowers, 1988). The phrase “sense of place” often implies subjective feelings of attachment to a place based on personal experience of being there (Holloway & Hubbard, 2001; Holloway, Rice, & Valentine, 2003; Johnston, Gregory, & Smith, 1994; Stokowski, 2002). Given such flexibility in definition, a sense of place can differ for different people, even for the same place, with no single sense of place being more or less valid than others (Gruenewald, 2003; Yung, Freimund, & Belsky, 2003).

However, sense of place can include other definitions and themes (Kaltenborn, 1998; Semken & Freeman, 2008; Williams & Stewart, 1998). For example, a foundational basis
of sense of place can include awareness and comprehension of natural environments of a place (Brandenburg & Carroll, 1995; Shamai, 1991; Stedman, 2003a), such as geology and ecology (Semken, 2005), as well as human interactions with environments (Stedman, 2003b), including those of the past (Stedman, Beckley, Wallace, & Ambard, 2004). The geology, ecology and cultural history of a place are less open to personal interpretation and therefore can constitute a concrete curriculum for the academic study of a place (Brown & de Lacerda, 1986).

Knowing the geology, ecology and cultural history of a place and thinking critically about human–environment interactions can lead to strong community leadership (Smith, 2002), an essential and desirable outcome as humanity grapples with complex ecosystem management (Williams & Stewart, 1998). Because of the cross-cutting nature of ecosystem management, interdisciplinary instruction should be made available to all students, not just to students of academic majors that fall within environmental science (Carter, 1993).

Learning any one of the disciplines of geology, ecology or human–environment interaction can be a daunting task, in and of itself. Integrating all three together into a comprehensive understanding can be even more formidable. Field trips can help in this regard (Paradis & Dexter, 2007). Field-based pedagogy has long been touted as being effective, to the point of being transformative (Whitmeyer & Mogk, 2009). Hands-on, active learning, which typifies field-based education (Orion, 1989; Tueth & Wikle, 2000), fosters comprehension and retention of course content (McKenzie, Utgard, & Lisowski, 1986). Additionally, other benefits accrue from field-based instruction, including self-confidence (McConnell, 1979), critical thinking (McNamara & Fowler, 1975), self motivation (Giardino & Fish, 1986) and socialization skills (Falk, Martin, & Balling, 1978), all of which are desired outcomes of education generally. Field-based education is even extolled in the literature, for example in the following declaration by the sixteenth-century Danish physician Peter Severinus (Geikie, 1962), which has been adopted as a guiding philosophy by SOP as well as by other field-based courses:

> Go my children, . . . burn your books, . . . buy yourselves stout shoes, get away to the mountains, . . . the deserts, . . . and the deepest recesses of the earth; mark well the distinction between animals, the differences among plants, the various kinds of minerals . . . . In this way, and no other, will you arrive at a knowledge of things, and of their properties. *Idea Medecinae Philosophicae*, 1571

SOP aims for integrated comprehension of the geology, ecology and cultural history of the Tucson area, the hometown of the University of Arizona (Butler, Hall-Wallace, & Burgess, 2000). To achieve this goal, SOP takes four all-day field trips during a regular semester, with field trips thereby comprising 82% of the student–instructor contact time. SOP visits sites in and around Tucson that feature educational examples of geology, ecology and cultural history (narratives and maps of trips are in the Appendix). Geology covers volcanic origins, recent tectonic events and natural hazards, and students actively learn and practice identification of rocks and structural aspects of modern topography as well as assessment of flood hazards. Ecology covers the Sonoran Desert, one of the world’s most interesting deserts, and Sky Islands, also world renowned, and students actively learn and practice identification of plants and biotic communities, measurement of ecosystem health and productivity, and assessment of wildfire hazards. Cultural history covers human habitation of southern Arizona spanning thousands of years, and students actively describe and interpret material aspects of archaeological sites (e.g., room blocks, bedrock mortars, pottery and rock art). During trips, students keep field journals of notes, drawings, calculations and comprehensive, integrative summaries (Stanesco, 1991).
Unfortunately, field-based instruction is generally at risk of being cut from university course offerings (Berliner & Piñero, 1985), largely because of funding and striving for efficiency in academia, i.e. moving toward large lecture classes and/or distance learning (Salter, 2001). Evidence of effectiveness of field-based instruction can serve as a defense for maintaining field trips (Keown, 1984). The assessment of field-based instruction is largely qualitative (Jenkins, 1994; Kastens et al., 2009; Orion & Hofstein, 1991). For example, quantitative assessment of the effectiveness of SOP has yet to be done, even though SOP has run for 20 years now. Accordingly, the objective of this project was to quantitatively assess the effectiveness of SOP, in particular for awareness and comprehension of the geology, ecology and cultural history of the Tucson area.

Methods

**Techniques for assessing course effectiveness**

Multiple techniques exist for assessing the effectiveness of educational courses, including examination, interviewing (Dawson & Caulley, 1981) and questionnaires (Suskie, 1996). Unfortunately, assessment techniques have various drawbacks, including taking a long time to administer and complete (Gaddis, 1998), imparting bias (McKeachie, 1978) and inaccurately assessing comprehension of content matter (Aikenhead, Fleming, & Ryan, 1987).

The assessment technique called word association avoids these drawbacks. Word association allows free, unconstrained responses by test subjects, thereby minimizing experimenter bias (Kjeldal, 2003; Wagner, Valencia, & Elejabarrieta, 1996). Stimulus terms are chosen to reflect content of key importance, thereby accurately assessing comprehension of the course material (Bahar, Johnstone, & Sutcliffe, 1999). Word association surveys are usually quick and easy to administer and complete, thereby avoiding survey fatigue and allowing large numbers of samples to be collected (Schmitt, 1998). Because of these attractive features, word association has been used in assessing academic courses (Hovardas & Korfiatis, 2006). Accordingly, word association was chosen here for assessing the effectiveness of SOP.

**SOP word association survey**

Stimulus terms for the SOP word association survey were chosen to reflect key content of the course (Bahar et al., 1999), i.e. the geology, ecology and cultural history of the Tucson area. In all, 12 stimulus terms were tested (Table 1). These terms were listed in the survey in a random order (Szalay, Windle, & Lynse, 1970). The word association survey used in this research is given in the Appendix.

Participants were instructed to write up to four words and/or phrases that came to mind for each stimulus term in the survey. Allowing for multiple responses, instead of just one response, improves the likelihood of accurately assessing comprehension of stimulus terms (Schmitt, 1998). Drawing from their knowledge and experience, participants responded in spaces provided next to each stimulus term. The survey was anonymous and therefore had no connection to grading in the course. At most, the survey needed only 10 minutes to complete, and participants knew that they could decline taking it at any time.

The principal survey group was of students enrolled in the 2008 edition of SOP. Twenty students enrolled that year and took the word association survey before the beginning of the course. Sixteen of these students completed the course and took the same survey again.
Table 1. Stimulus words or expressions used in this word association survey, plus representative answers for each grade of good, intermediate and poor.

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Grade 3 (good)</th>
<th>Grade 2 (intermediate)</th>
<th>Grade 1 (poor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desert</td>
<td>High evaporation-to-rainfall ratio</td>
<td>Sand and rocks</td>
<td>Hostile environment</td>
</tr>
<tr>
<td>Arizona</td>
<td>Diverse landscapes</td>
<td>Desert</td>
<td>A state of the US</td>
</tr>
<tr>
<td>Hohokam</td>
<td>Prehistoric desert dwellers</td>
<td>Native Americans</td>
<td>Hard life</td>
</tr>
<tr>
<td>Sonoran Desert</td>
<td>Plate tectonics</td>
<td>Mining</td>
<td>Rocks</td>
</tr>
<tr>
<td>Tucson</td>
<td>High biodiversity</td>
<td>Cactus</td>
<td>Dry, like all deserts</td>
</tr>
<tr>
<td>Desert</td>
<td>In desert, but near mountains</td>
<td>Little water</td>
<td>Dusty</td>
</tr>
<tr>
<td>Ecology</td>
<td>Interrelated life</td>
<td>Urban encroachment</td>
<td>A science</td>
</tr>
<tr>
<td>Wild fire</td>
<td>Cycle of landscape disturbance and renewal</td>
<td>More common now than before</td>
<td>Ugly, charred woods remain</td>
</tr>
<tr>
<td>American Southwest</td>
<td>Long history of human habitation</td>
<td>Drought</td>
<td>Western movies</td>
</tr>
<tr>
<td>Flooding</td>
<td>Sediment for farming</td>
<td>Lots of murky water</td>
<td>Destroys houses, roads</td>
</tr>
<tr>
<td>O'Odham</td>
<td>Modern native Southwesterners</td>
<td>San Xavier mission</td>
<td>Near Tucson</td>
</tr>
<tr>
<td>Archaeology</td>
<td>Past human cultures, related to present</td>
<td>Study of old things</td>
<td>Egypt</td>
</tr>
</tbody>
</table>

at the end of it, thereby establishing a pre- versus post-course comparison to assess the effectiveness of SOP (Bahar et al., 1999).

To serve as a control or comparison group (Libarkin & Kurdziel, 2002), other students of the University of Arizona who had not taken SOP were recruited to take this survey. These participants were acquaintances of students of the course, but they were not so close to SOP students that they knew about the course or its content. In total, 14 control students took this survey.

To assess long-term retention of the SOP content, students who had taken SOP during the years 2005 to 2007 and who were still in or around Tucson also completed this survey. In total, 10 alumni of SOP completed this survey.

Quantification of SOP word association responses

Word association surveys yield qualitative data, which have a strong place in assessment research (Hoepfl, 1997) but can be difficult to analyze statistically because of their non-numeric nature (Chi, 1997). To facilitate statistical analysis of this survey, responses were converted to numeric values (Vázquez-Alonso, Manassero-Mas, & Acevedo-Díaz, 2006) by a panel of three people (each of us authors) knowledgeable in the geology, ecology and cultural history of the Tucson area. Independent from each other, we graded responses for knowledge and comprehension of the geology, ecology and cultural history of the Tucson area based on extensive literature on environmental geography of the area (background references on the trips and their academic content are cited in the Appendix). A coarse grading scheme was chosen for this conversion (Rubba, Bradford, & Harkness, 1996): a grade of 3 represented good to excellent comprehension; a grade of 2, average comprehension; and 1, little comprehension (Table 1).
grade of 0 was given for no response and for answers that had no relevance to the stimulus term.

For each response to each stimulus term, our three grades were compared. For the most part, our grading fell into reasonable agreement and the modal grade was taken as the final grade. If our grades diverged widely from one another, e.g. one of us grading a response to be a 3 while another of us grading it as a 1, we discussed the discrepancy and a consensus grade was agreed upon for that particular response (Rubba et al., 1996).

Response grades were summed for each stimulus term for each participant of the survey. The maximum sum possible for each stimulus term was 12, i.e. with each of four possible responses being graded a 3. The minimum sum possible for each stimulus term was 0, i.e. when no responses were given for a stimulus term.

Sums of stimulus terms were statistically analyzed. T-tests of means (Sokal & Rohlf, 1981) of participant sums were performed to determine the significance of differences between survey responses given before and after the course for students enrolled in SOP. T-tests were also performed to determine the significance of differences between students who took SOP and students who had not. Analysis of variance (ANOVA), which is related to the t-test but allows comparisons between more than two samples (Sokal & Rohlf, 1981), was used to determine the significance of differences between students who had completed SOP in the years 2005, 2006, 2007 or 2008. ANOVA was also used to determine if demographic variables were important predictors for how students responded to the stimulus terms.

Demographic variables

The survey collected demographic information about participants, including the following:

- Year in college: 25% were freshmen, 11% were sophomores, 11% were juniors, 44% were seniors and 9% percent were postgraduate students.
- Science or nonscience major: 40% were non-science majors and 60% were science majors.
- Gender: 58% were female and 42% were male.
- Race: 86% were white, 11% were Hispanic and 3% were Asian.
- Location of hometown: 25% were from Tucson, 11% were from Arizona outside of Tucson, 58% were from the US outside of Arizona and 6% were from outside the US.

Results

Pre-course and control-group comparison

No significant differences were found between pre-course survey results of students enrolled in SOP and the survey results of current University of Arizona students who never took the course (Figure 1). Serving as a control group, students not enrolled in SOP produced slightly higher mean sums in response to some stimulus terms and slightly lower mean sums to other stimulus terms. The lack of significant difference between these two groups shows that students enrolled in SOP were not particularly knowledgeable of the geology, ecology and cultural history of the Tucson area before taking the course. Accordingly, the students who took SOP were not especially predisposed to higher awareness of SOP curricula than the general population of students.
**Pre- and post-course comparison**

For all stimulus terms, the difference in sums before versus after taking SOP was positive, i.e. mean sums of associations to the stimulus terms increased in the post-course survey over the pre-course survey (Figure 2). Significant differences between pre- and post-course surveys were found with all but one stimulus term. The stimulus term “Arizona” was the lone exception, though even its $p$-value of .065 approaches significance. In general, upon taking and completing SOP, students responded to the stimulus terms with words and phrases that conveyed more knowledge of the geology, ecology and cultural history of the Tucson area than was evident before taking the course.
Additionally, student responses varied less in the post-course survey than in the pre-course survey (Figure 2). Confidence intervals narrowed for every stimulus term in the post-course survey relative to the respective terms of the pre-survey.

**Long-term retention**

Sample sizes for the alumni SOP classes of 2005–2007 were small, reflecting difficulty in tracking down and getting alumni of the course to come and take the survey. Nonetheless, responses to most of the stimulus terms showed no significant difference across students who took SOP in 2005, 2006, 2007 or 2008 (Figure 3). Only three stimulus terms – desert
Figure 3. Comparisons of survey sums of student responses by year of completion of SOP for each stimulus term. In 2005, 2006, 2007 and 2008, $n = 5, 2, 3$ and 16 students, respectively. Error bars are 95% confidence intervals. The confidence intervals for 2006 and 2007 were large, extending off the graphs, due to small sample sizes and, therefore, were deleted. $P$ values are the level of significance of difference by the year of completion of SOP.

($p = .034$), Hohokam ($p = .049$) and Tucson ($p = 0.036$) – revealed significant differences in responses. Responses to the other 10 stimulus terms showed no significant differences across the four years. At a minimum, for SOP students of the last four years, there has been little to no loss of awareness of the geology, ecology and cultural history of the Tucson area.
Demographic variables

Of the students who completed pre- and post-course surveys, the following demographic effects were found:

- The year of a student had no significant effect on pre- and post-course surveys.
- Majoring in science versus non-science had no significant effect on the pre- and post-course surveys.
- Gender did not account for variance in responses for any stimulus terms except for “archaeology”, for which females scored higher in both the pre- and post-course surveys ($p = .048$).
- Location of hometown had no significant effect on the pre- and post-course surveys.
- Race did not account for variance in responses for any stimulus terms except for the term “archaeology”, for which Hispanics scored higher than whites and Asians ($p = .011$).

Discussion

This quantitative assessment of SOP confirms other quantitative analysis of field-based instruction. Field-based instruction significantly improves awareness and integrated comprehension of geographical/environmental content (Orion & Hofstein, 1994), and long-term retention of this content is good (Mackenzie & White, 1982). These effects cut across demographic characteristics of age, gender, major, race and personal background (Lisowski & Disinger, 1991), and they can be realized even with short, local field trips (Wheeler, 1985) in addition to epically long trips (e.g. GeoJourney, Elkins, Elkins, & Hemmings, 2008).

Theoretical advantages of word association as an assessment technique were realized in this research. Our survey was easy to administer and easy for participants to take. Participants were not biased by statements posed in either negative or positive tones, nor were they restricted by finite lists of multiple choices. Qualitative responses to stimulus terms were convertible to quantitative scores, thereby allowing statistical analysis. Consistent results were seen across multiple stimulus terms, not just for one or a few terms, making for confident interpretation of results (Libarkin & Kurdziel, 2002).

The next step in this research would be to assess a course that is similar to SOP in terms of content and instructors but differs in being principally classroom- and/or lecture-based (Kern & Carpenter, 1986; Lisowski & Disinger, 1991). This opportunity exists at the University of Arizona, where a course entitled Environmental History of the Southwest (EHSW) also covers geology, ecology and cultural history, though, of the entire American Southwest as opposed to just the Tucson area (Sheppard, Hallman, & Towner, 2008). EHSW is currently being assessed for pedagogical effectiveness, again with the word association technique, for the purpose of comparing it with SOP. This comparison will speak to the notion that field-based pedagogy leads to better comprehension of course content than traditional classroom teaching (Elkins et al., 2008; Kern & Carpenter, 1984).

Conclusions

Field-based education might be inefficient in terms of logistical expense and low student–instructor ratio (Salter, 2001), but field trips are worthwhile because of effecting integrated comprehension of challenging curriculum. As but one example of the field-based instruction, SOP is hereby shown to improve awareness and comprehension of the geology, ecology
and cultural history of the Tucson area. Given the increasingly complex environmental issues of today, field-based courses linking environmental studies with geography are ever more essential for training people to tackle difficult environmental challenges. Additionally, in this quantitative assessment, word association proved to be easy to administer and effective.

Acknowledgements

We thank the students who completed this word association survey. Drs Melanie Culver, Mark Borgstrom and Jeff Dean assisted in this project. This research was funded in part by the University of Arizona Foundation.

References


**Appendix: Assessment of a field-based course on integrative geology, ecology and cultural history**

**A1. UA Sense of Place Trip 1: Santa Cruz River Basin (Figure A1.1)**

Trip 1 traverses the Santa Cruz River Basin near Tucson. Geology starts on “A” Mountain, a suite of volcanic and sedimentary rocks that formed during explosive volcanism 20–25 million years ago (McGarvin, 2001). Physical properties of rocks and how they illuminate mountain formation are emphasized. Adjacent to “A” Mountain is Tumamoc Hill, where unobstructed views promote discussion of Basin and Range concepts (McPhee, 1981). South of Tucson, an entrenched tributary of the Santa Cruz River called Brickyard Arroyo shows Holocene wetlands (buried organic soils) and agricultural settlements (prehistoric artifacts).

Ecology starts with buffelgrass (*Pennisetum ciliare*) growing on rocky slopes of “A” Mountain. Buffelgrass is native to Africa, but it was introduced into the Southwest in the 1940s and has since expanded throughout the Sonoran Desert (Búrquez-Montijo, Miller, & Martinez-Yrízar, 2002). Buffelgrass “invasion” of the Sonoran Desert is a serious ecological concern (Yetman & Búrquez, 1994). Additionally, Tumamoc Hill is home to the Desert Laboratory, a premier center of desert ecology and paleoenvironmental science for more than 100 years (Bowers, 1990). Principal features
of the laboratory are its enclosed area of pristine desert and the permanent recording of saguaro cacti in 1908 in order to observe them throughout many decades (Pierson & Turner, 1998).

Cultural history starts on the summit of Tumamoc Hill, where bedrock mortars, rock art and rock roomblocks speak of people who lived there from AD 500 to AD 700 (Fish, Fish, & Christopherson, 2007). Why would people live on a hilltop, far removed from water and agricultural fields of the Santa Cruz River floodplain? Later on this trip, Mission San Xavier del Bac is a modern, active church as well as a glimpse of the Spanish and Mexican periods of the American Southwest. The building is a blend of Spanish, Mexican and Native American architecture and design (Frontain, 1968). The arrival of Padre Francisco Eusebio Kino in 1687 started a grand change of cultures and environments of the southern Arizona (Fontana, 1994).

A2. UA Sense of Place Trip 2: Tucson Mountains (Figure A2.1)
Trip 2 circumnavigates the Tucson Mountains, which were formed by explosive, caldera-style volcanism 70 million years ago, when Arizona was located on the western edge of the continent and

Figure A1.1. Map of SOP Trip 1.

Figure A2.1. Map of SOP Trip 2.
colliding with subducting oceanic crust (Bezy, 2005; Kring, 2002). Geology emphasizes describing rocks and deciphering what they tell about landscape history, all for the purpose of visualizing plate tectonics and geologic time.

At each stop of Trip 2, iconic plants of the Sonoran Desert are featured. In particular, Prospect Wash allows easy entry into a lush, diverse tract of the Sonoran Desert, where multiple leguminous tree species as well as many cactus species are common (Phillips & Comus, 2000). Shreve’s (1936) concepts of multiple layers and varied life forms in the Sonoran Desert become obvious, as does the fact that the Sonoran is a highly productive desert (McGinnies, Goldman, & Paylore, 1968). Various food and drink items derived from desert plants are sampled on this trip, including prickly pear pads and saguaro lemonade, thereby challenging conventional opinion that deserts are desolate places with limited food resources.

A rock art site known as Signal Hill emphatically connects geology and ecology with cultural history. At Signal Hill, prehistoric Hohokam and historic O’Odham left marks on basaltic rocks overlooking the desert. Both groups integrated floodwater farming with foraging as part of an annual cycle to adapt to desert areas far removed from perennial streamflow (Castetter & Bell, 1942; Crosswhite, 1980; Doolittle, 2000, pp. 309–346).

A3. UA Sense of Place Trip 3: Desert washes and urban flooding (Figure A3.1)

Trip 3 explores desert washes and how humans live next to them. Hydrological measurements are made along the Rillito Creek, a major tributary to the Santa Cruz River. The amount of water that the Rillito can carry, i.e. maximum instantaneous discharge, is calculated from channel gradient, flow width and depth, and hydraulic roughness using a simple open-channel hydraulic equation such as the Manning formula (Barnes, 1967; Chow, 1959). In addition to improving quantitative skills, “back-of-the-envelope” calculations reveal patterns and interactions between elements of the landscape (Manduca et al., 2008). Ultimately, flooding is viewed as neither bad nor good, but rather as a natural process that does the job of moving water and sediment.

The Rillito also offers a chance to practice dendrochronology, the study of tree rings (Fritts, 1976). Cottonwood (Populus sp.) grows in the dry wash bed itself, but only at the mercy of flooding. An increment borer is brought along for students to try nondestructive sampling (Grissino-Mayer, 2003). Ring growth of trees growing in washes can indicate past flooding, thereby establishing frequency and discharge values (McCord, 1996). Realizing how easy it can be to collect data in the field is empowering.

Prehistoric farming is addressed. Fort Lowell Park is the site of a Hohokam community located along the edge of the Rillito and its tributaries (Gregonis & Reinhard, 1979). The importance of flooding and deposition of nutrient-rich silt for sustainable agriculture is evident. This theme is repeated at Catalina State Park, where another Hohokam village was located near seasonally flooding.

Figure A3.1. Map of SOP Trip 3.
watercourses (Swartz & Doelle, 1996). These Hohokam sites were located above floodplains, so flooding was restricted to agricultural fields and away from residences, showing how flood hazard is influenced by where people place themselves on the landscape.

Fort Lowell Park also has a grove of pecan trees. Southern Arizona is home to large tracts of pecans, making the region important for pecan production. However, growing pecans in the desert poses a dilemma: How to reconcile water use of thirsty, broadleaf trees in this arid eco-region? Catalina State Park also has trees, native mesquite (*Prosopis* sp.) in this case. Mesquite is one of many legume species of the Sonoran Desert (Daniels & Meixner, 1999) and is truly a magnificent species (Rogers, 2000).

**A4. UA Sense of Place Trip 4: Santa Catalina Mountains (Figure A4.1)**

Trip 4 treks up the Santa Catalina Mountains, all the way to the top of Mt. Lemmon. Geologically, the Catalinas are a mountain range quite unlike others visited during previous field trips. Metamorphic core complexes are formed by regional crustal extension, thermal intrusion and uplift, all resulting in mountain ranges with granite cores surrounded by deformed and metamorphosed igneous and sedimentary rocks (Crittenden, Coney, & Davis, 1980; Davis & Coney, 1979). These rocks were once deep within the crust and consequently pulled and stretched under conditions of high temperature and pressure, but horizontal movement along low-angle detachment faulting brought these deep rocks to the surface, where they are now visible at road cuts along the lower part of the Catalina Highway (Bezy, 2004).

Ecologically, southern Arizona is internationally known for its sky islands, i.e. high mountains (the “islands”) sticking up from low deserts (the “ocean”) (Crowley & Link, 1989). Floral and faunal influences from the Sierra Madre to the south and the Rocky Mountains to the north as well as from the Sonoran and Chihuahuan Deserts combine to make southern Arizona sky islands highly diverse. The Catalinas peak out almost 2000 m (6500 ft) higher than Tucson, and the Catalina Highway makes for easy passage across this large elevational gradient. Along the way, multiple ecosystems are traversed (Lowe, 1967).

The Catalina Mountains are also a textbook of wild land fire. Most of the mountain burned recently in two large fires, much to the grief of Tucson (Barnes, 2005). Fire used to burn on the Catalinas frequently but with low intensity such that mature trees typically were not killed (Swetnam & Baisan, 1996). The question for Tucson, as well as for similar settings worldwide, is how to manage forests to accommodate the inevitability of fire without suffering devastating, big, intense wildfires.

![Figure A4.1. Map of SOP Trip 4.](image-url)
Driving the Catalina Highway is not just educational. It is an honor to experience so conveniently such diversity and richness in geology, ecology and cultural history.

**A5. Word Association Survey for Geos. 195D, Sense of Place**

This word association survey is part of the research evaluating general knowledge of the surrounding Tucson area and the interactions between the environment and society. If you agree to participate you will be asked to complete a survey now and one at the end of the semester. This survey is anonymous. Individual answers will be kept confidential. You were selected because you are 18 years of age or older. Completing this survey implies consent to participate in this research. However, this survey is voluntary. You may choose to stop participating at any time. There is no risk and no benefit to your participation. The survey will have no impact on grades and has no relation to your work in the classroom. This survey should take no more than 10–15 minutes. There is no compensation for participating in this survey.

Please write up to four words or phrases that come to mind in relation to the following words. If you have no word associations with a particular word, please write “NONE” in its box.

<table>
<thead>
<tr>
<th>Word</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
</tr>
</thead>
<tbody>
<tr>
<td>desert</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arizona</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hohokam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>geology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sonoran Desert</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tucson</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ecology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
This section will help describe demographics of the survey group.

1. Circle your year in college.
   a. Freshman
   b. Sophomore
   c. Junior
   d. Senior
   e. Post-graduate

2. Would you describe your major as science or non-science?
   a. science
   b. non-science

3. Circle your gender.
   a. male
   b. female

4. Circle the most specific location indicating where you’re from.
   a. Tucson
   b. Arizona
   c. New Mexico
   d. USA
   e. International
5. Circle your race.
   a. Hispanic
   b. White
   c. Native American
   d. Black
   e. Asian

6. Have you completed Geos. 195D?
   No  Yes If yes, in what year? ________