Ecological Footprints: Measuring and Reducing Students' Consumption of the Earth's Resources[1]

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Abstract

Ecological footprint calculators enable individuals to more easily assess the impact of their lifestyle on the earth's resources. These calculators can be accessed through the World Wide Web and provide information on the utilization of food, transportation, housing and other areas. Results are reported in an easily understood format. This study investigated the changes in student scores, expressed in number of acres, over the course of a semester and found that there were significant positive changes both in the overall scores as well as subscale scores.

Introduction

With the beginning of the new century, many are finding that the increased ecological awareness brought about by Rachel Carson and others in the 1960s is just as important, or perhaps even more so. As a result, Many institutions of higher education are looking for effective ways to integrate environmental sustainability into their curriculum (Perrin, 1992; Svejcara, 2002). Colleges and universities provide stimulating settings for producing and shaping beliefs, and can provide opportunities for envisioning change (Chafy, 1997). Changes in perceptions about affluence, consumerism, and environmental management are needed to avoid exceeding the carrying capacity of the Earth (Goodland et al., 1994; Chambers et al., 2000; Simmons and Lewis, 2003).

The Sustainable Universities Initiative (SUI) in South Carolina has established a network of faculty, staff, and students who share an interest in incorporating environmental considerations into their work. With funding support by grants from SUI and the United States Department of Agriculture (USDA), research and action on sustainability issues have been incorporated into landscape appreciation classes through pedagogical uses of ecological footprint calculators. Eco-footprinting is considered to be the "the most comprehensive measure of environmental impact to date" (York et al., 2003) and the "best method available for making a quantitative assessment of the extent to which consumption, by a specified human population, is exceeding biocapacity" (Ferguson, 2002, p.303).

Component footprinting methodology provides an exciting new way of measuring and communicating sustainability using an area-based indicator. Ecological footprint calculators enable students to quickly assess the demand or imprint their lifestyle or "ecological footprint" has on the earth's resources. First coined about ten years ago by Mathis Wackernagel and William Rees, the term "ecological footprint" is defined as "the area of land required to sustainably provide the required resources and absorb any wastes" (Simmons, 2003, p.4). Though a relatively new concept, ecological footprinting is widely used for public policy development, environmental awareness campaigns, and in education (Simmons, 2003; Chambers et al., 2000). Footprint calculators represent both human demand and the biological capacity of the planet to replenish and renew itself. This concept is expressed in the number of acres (or hectares) per person. By redefining consumption and capacity in easy to understand numbers, Footprint accounts help to present sustainability, not as an elusive concept but as easily comprehensible units (Redefining Progress, 2004).

Scores are calculated for the number of acres needed to support the student's lifestyle in four subareas: 1) food; 2) housing; 3) transportation; and 4) "other" areas (such as goods and services). Scores are also calculated for the total number of acres utilized per person. In presenting the results, the calculator also shows the average footprint for the participant's home country (for example, 24 acres in the U.S.) as well as the number of biologically productive acres per person (worldwide, that number is 4.5). Lastly, it graphically illustrates how many Earths would be necessary to support everyone on the planet at the student's standard of living. For example, a student may have the following scores: food = 4 acres, transportation = 0.7 acres, housing = 2.7 acres and other = 2.5 acres for a total footprint of 10 acres. If everyone enjoyed the same standard of living as this student, 2.5 Earths would be necessary to support the world's population at a similar level.

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The wide-spread availability of computer technology on college campuses makes the application of ecological footprint analysis very feasible as a homework assignment for college students. The continual development and refinement of user-friendly computer interfaces makes the assignment easy, informative, and powerful. In addition to encouraging discussion and reflection on sustainability issues, this methodology promotes personal engagement and action.

Most Americans, even those who consider themselves environmentalists, use more than their share of the planet (Todd, 2003). The average American has an ecological footprint of 24 acres while the average world citizen has a footprint of 5.6 acres. According to 1999 data, humanity is exceeding the biosphere's ecological capacity by over 20%. (Redefining Progress, 2004). By using the following methodology, which can be easily adapted in classrooms across the country, participating students at Clemson University successfully and significantly reduced their ecological footprint.

In phase two of the project, students began analyzing their results, reflecting on the outcome, and brainstorming on what they needed to do to act in an environmentally sustainable manner. To facilitate this process, students were asked to make detailed, specific notes in the margin beside each category indicating how they could decrease their footprint over the semester. Also, they were expected to read "Ecological Footprint Accounts: Moving Sustainability from Concept to Measurable Goal" (Redefining Progress, 2004) and to compare their footprint to that of the average world citizen's footprint and to the footprints of various nations. One lecture included excerpts from 50 Simple things you can do to save the earth (The Earthworks Group, 1989) to illustrate specific actions that students could pursue to reduce their impact on the earth. Students devoted approximately two hours to completing phase two of the process.

After reflecting and writing as individuals, students were asked to compare notes and to brainstorm in groups of three to five. Each group was given twenty minutes of class time to develop a list of suggested actions, which were noted on an acrylic overhead. A representative chosen by the students in each group then shared their list with the rest of the class using an overhead projector to visually reinforce the oral presentation. Remembering the slogan, "If you're not part of the solution, then you're part of the problem," students were asked to continue to expand this list and to begin taking action to reduce their footprints. Reading material was put on reserve in the library for students interested in obtaining additional ideas, motivation, or information. Students were notified that they would be asked to recalculate their footprint at the end of the semester and turn their new footprint in with notes and observations. At the end of the semester, footprint calculator scores served as the post-test (Table 2), and the pre-test and post-test footprint scores were analyzed using paired samples t-tests (Table 3).

Table 1. Ecological Footprint Scores (in acres) at the Beginning of the Semester

Category	Mean Score	Std. Deviation	Minimum Score	Maximum Score
Total Acres	19.86	7.44	7.00	38.50
Food	5.87	1.80	1.70	10.60
Transportation	4.02	3.11	0.20	13.00
Housing	4.33	2.57	1.10	10.90
Other	5.24	2.05	1.20	10.40

Methods

Subjects for this study were 62 students from a large, land grant, research university in upstate South Carolina. They were enrolled in one of two sophomore-level, landscape appreciation classes involved in the analysis. One student was found to have participated in both groups and was removed from the calculations and two students' scores were removed from the study because they were believed to be invalid. Of the remaining students (n = 59), 35 were males (59%) and 24 were females (41%).

In phase one of the project, early in the semester, students were instructed to use the "Redefining Progress Ecological Footprint Calculator" (Redefining Progress, www.myfootprint.org, accessed 11/22/2004) at the Sustainable Universities web page (http://www.sc.edu/sustainableu/) to calculate their personal footprint scores. To calculate their scores, students took a quiz consisting of thirteen questions designed to assess their lifestyle choices. This quiz required approximately ten minutes to take. Based on answers to the questions, the program calculated how much biologically productive space students used per year. Students were asked to print and submit the results of their quiz. These were used as pre-test scores (Table 1).

Results and Discussion

This study found that there were significant positive changes both in the overall footprint scores as well as in subscale scores. Paired sample t-tests found statistically significant ($\alpha = .05$, $n = 46$) decreases in the total acre measures ($t = 5.32$, $df = 45$, $P = .001$) as well as in each of the sub-scales; food ($t = 5.571$, $df = 45$, $P = .001$), transportation ($t = 4.269$, $df = 45$, $P = .001$), housing ($t = 2.076$, $df = 45$, $P = .044$) and other goods and services ($t = 5.274$, $df = 45$, $P = .001$).

Overall Scores

Students (n=58) had a wide range of overall or "total acres" scores. At the beginning of the semester, the minimum total score was utilized for sustainability 7 acres and the maximum, a total of 38.5 (mean score, 19.38) acres. At the end of the semester, students' scores (n=50) ranged from a low of 7.9 acres (7.9) to a high of 27.6 acres with an average score of 15.63.T for students Changes in total acres utilized ranged from a decrease of 23 acres to an actual increase of 3 acres. 5 at the beginning of the semester 20

Over 15% of the students reduced their overall footprint by at least 10 acres over the course of the semester. Students decreased their total acre scores by a mean of over 4.21 acres. On average, each student decreased his or her footprint nearly the equivalent of the number of acres available, on a global basis, to sustain one additional individual. (Currently, there are 4.5 acres of biologically productive area for each person on the planet.)

Component Scores

Pre-test component scores (food, transportation, housing and other) ranged from a low of 0.20 acres to a high of 13 acres, both for transportation. This component showed the greatest range in pretest scores (12.8). Pre-test food scores averaged 5.87 acres; transportation scores, 4.02 acres; housing, 4.33 acres and "other," 5.24 acres. Post-test scores also showed the widest range for transportation; the lowest transportation score was 0.20 and the highest, 10. At the end of the semester, the average food score was 4.56; the average transportation score, 2.92; housing, 3.89 and other, 4.25. From the beginning of the semester until the end, scores for the food component were lowered by an average of 1.41 acres; transportation, 1.06 acres; housing, .66 acres and "other" areas, 1.15 acres

In both pre-test and post-test scores, food accounted for the majority of the biologically productive area utilized by study participants. The "other" category (goods and services) accounted for the second highest consumption pattern; housing, the third greatest and transportation the least.

Most students are surprised at the magnitude of their impact on the earth's resources. Because the quiz measures their personal footprint, they are immediately aware of the importance of personal action as a means to correct their overshoot. As indicated above, students were often surprised at the magnitude of the effects of their lifestyles on the Earth. Consequently, this study indicates that students were able to make some real progress toward change. This result is, in some ways, somewhat surprising. Because college students have limited choices with regard to many of their lifestyle components, there was a possibility that change, if any, would be minimal. However, this was not the case. Students managed to reduce the number of acres symbolizing their impact on the ecosystem in each of the component areas as well as for the total acres measure.

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Table 2. Ecological Footprint Scores (in acres) at the End of the Semester

Category	Mean Score	Std. Deviation	Minimum Score	Maximum Score
Total Acres	15.63	4.94	7.90	27.60
Food	4.56	1.30	2.40	7.50
Transportation	2.92	2.64	0.20	10.00
Housing	3.89	1.62	1.20	8.00
Other	4.25	1.37	1.70	7.50

Table 3. Average Change (in acres) in Footprint Scores Over the Course of the Semester.

Category	n	Change in Mean Score
Total Acres	46	-4.21***[1]
Food	46	-1.41***
Transportation	46	-1.06***
Housing	46	-.66*
Other	46	-1.15***

[1] ***, * *Significant at p=.001 or p=.05 level respectively using Student's t-test.*

The adage that every journey starts with a single step comes to mind when reviewing student actions. Each of these small steps is multiplied when they ask their roommates, friends, or family to participate as well. One of the advantages of making this a class assignment is that students can see the results their individual actions and can experience the exhilaration of multiplying the effect through a collective effort.

The largest change, as might be expected, was in an area where they had considerable control over their consumption habits food. According to comments by the students, they were able to make a difference by reducing food waste. Solutions ranged from using up leftovers to limiting the amount of food taken in the dining hall.

Student participants were creative with identifying and taking action in other areas in an effort to live more sustainably. For example, they show evidence of heightened environmental awareness and activity in areas not directly addressed by the footprints quiz. Students planted deciduous trees around buildings for energy efficiency, planted wildlife habitats, designed xeriscapes to conserve water in the landscape, planted ground covers to control erosion and sedimentation, helped with reforestation efforts in their community, used native plants in landscaping, and participated in educational programs at K-12 schools, the South Carolina Botanical Garden, and on campus. These efforts indicate considerable influence from classroom lectures and other activities associated with horticulture and related fields.

The second largest change was in the “other” area. Since this component measures waste generated, students were able to decrease their scores significantly by increasing their recycling efforts. For example, in addition to commonly recycled materials such as cans, newspapers and plastics, some reported reusing canvas grocery bags, reusing containers and saving scrap paper for projects.

Transportation, another area where students have some measure of control, had the third largest change. Activities contributing to this decrease were carpooling, vehicle maintenance for better performance, taking public transportation, walking and buying a more efficient form of transport.

Not surprisingly, housing showed the least change. Many students have little or no choice with regard to their housing circumstances. They may live with their parents, in dorms or in other areas where individual choice is limited. However, they did decrease their impact somewhat. They did this by taking in an additional roommate to share apartment space.

Probably perceived control over a situation may have some influence on which area students approach in their attempts to make changes. Other factors that might influence change include living arrangements (single or group quarters), financial considerations, knowledge of effective activities and resources and previous commitment to the environment.

Other Influences

We would like to point out that there are several potential factors that may account for at least part of the changes observed in this study. While it is hoped that students would react to their footprint scores by making significant lifestyle changes, there are other possibilities that must be acknowledged.

First and foremost, in spite of being told that their participation and effort would determine their grade rather than their progress on the footprint, students in any classroom environment are subject to experimenter or investigator bias or in this case “professor” bias. Some students may have provided answers that they believed would be “good” answers as opposed to actual changes or events.

Similar to this would simply be the desire for approval. Media coverage, emphasis on sustainability by Clemson University’s administration and other pro-environmental influences send a strong message. Students may not wish to be seen by their professor or by other students as being insensitive to these issues. Decreased scores may reflect this desire for approval more than actual changes in the student's behavior.

Variability in reported measures may influence the outcome. Students may over or underestimate their activities. Increased scores may have resulted not from actual increased environmental impact but from increased awareness of their activities by the student. For example, students may not have an accurate idea of how much processed food they consume at the beginning of the semester. After being exposed to the footprint calculator and class activities, they become much better at assessing their activities. A more accurate appraisal of their usage patterns may be reflected in very different scores.

Peer pressure is another possible influence. Also, there exists the possibility that those students who take these landscape appreciation classes may be predisposed toward environmental stewardship simply by their interests. In fact, the pretest average of 19.86 acres is less than the average American footprint of 24 acres (Redefining Progress, www.myfootprint.org, accessed 11/22/2004). However, it is the element of change that is of paramount importance for this study, not the final amount of ecological impact.

Another likely source of the variation in the outcomes could be linked to the use of slightly different footprint calculators. For this study, students were asked to use a footprint calculator at the Sustainable Universities website. However, a number of students used slightly different calculators. While technically, all footprint calculators should be the same, different web sites use different graphics, different terminology and different layouts. How much variation this accounts for in the outcomes for this study has not been calculated. Mandatory use of a single calculator would help to eliminate some of this variation.

Summary

The results of this study indicate that quantifying human use of nature through ecological footprints is an effective way to encourage change and help to guide individual choice regarding environmentally responsible behavior. This outcome, however, is limited to a relatively small sample of students who are taking horticulture and landscape architecture classes and may be pre-disposed toward ecological awareness and action.

Further research in this area would include using different types of student groups and classes such as social and behavioral sciences, agriculture, biological sciences, humanities etc., in a study. This would help to indicate the effectiveness of this type of intervention across a broad range of university students. In order to more accurately assess the long term effects of this procedure, students would be asked to complete the footprint calculator over a multiple semester time period. This would also help students become more familiar with the instrument and increase the validity of their responses.

In addition, the implications of this study strongly suggest that the efficacy of this methodology be tested on those who are not university students. The ecological footprint is something that can be done with comparative ease wherever individuals have access to internet facilities. Programs using this process outside the classroom environment may provide a simple and effective way to increase environmental awareness for a variety of audiences.

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