Understanding why underrepresented students pursue ecology careers: a preliminary case study

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While the literature can tell us something about the number of people from underrepresented populations in science, there is scant evidence to explain why ecology in particular has among the lowest proportions of underrepresented students and professionals of any science. We conducted a case study of 39 African-American students from ESA's Strategies for Ecology Education, Development, and Sustainability program, focusing on the factors that influenced their choice of an ecology career pathway. Although the case study includes only African-American students, we review the literature pertaining to all minority groups in science. Our results indicate that family support in particular, along with research experience and a positive view of an ecology career, are important factors in a student's decision to pursue this career path.

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Ecologists help us to both understand and respond to some of the most serious problems threatening the planet, and the questions asked and hypotheses formulated by ecologists are, in part, a reflection of their upbringing, interests, and worldview. The vitality of ecological investigations, therefore depends, to some extent, on the diversity of scientists posing such questions. Studies have shown that diversity in a workforce leads to greater creativity and innovation, higher levels of divergent thinking, and better decision making based on multiple perspectives (McLeod *et al.* 1996; Madjar 2005). For ecology to be truly relevant, the full breadth of society must be engaged in identifying which ecological questions are the most pressing, thereby bringing diverse perspectives to bear on solving these problems.

Diversity in the ecology profession?

Diversity is one of the most important features of the ecological communities examined by scientists, and there has been a concerted effort to assess the ecological causes and consequences of diversity patterns in ecosystems. Unfortunately, in the US, diversity is still very low within the community of ecologists themselves. Furthermore, until recently, there was little effort to understand or correct this problem. In 1992, the Ecological Society of America (ESA) surveyed its membership and produced the first reliable snapshot of its racial profile (Holland *et al.* 1992). Since 1999, ESA has tracked this metric annually. While not all ecologists are ESA members, these profiles provide our only rigorous assessment of the trends in participation of ethnic minority populations. Asian, Hispanic, African-American, and American Indian populations are underrepresented in science, even though they may be the geographic majority of particular communities. In this paper, we use the term "underrepresented minority" to refer to populations that occur in disproportionately low numbers within the science professions in general.

In 1992, fewer than 7% of ESA's members belonged to underrepresented minority groups (Holland *et al.* 1992). By 2006, this percentage had increased to 11% (Figure 1), reflecting a substantial growth in the absolute number of minority individuals, as ESA membership has increased rapidly in recent years, particularly since 2003.

While these trends are encouraging, the increases still do not result in a diversity profile that reflects that of American society as a whole (US Census Bureau 2005), but rather a three-fold underrepresentation of minorities in ecology. In addition, the ESA membership is about half as diverse as the PhD science workforce as a whole (NSF 2004; Table 1).

Minority populations in science

Undergraduate and graduate training are necessary gateways to science, engineering, and mathematics (hereafter, "the sciences"). While we recognize that for many or even most students, initial interest and preparation for a science career begin before college, an understanding of the influences acting on students during the undergraduate years is crucial in assessing the reasons for this lack of representation. For practicing scientists, most of whom are involved in undergraduate or graduate teaching, these insights can be useful in attracting, retaining, and prepar-

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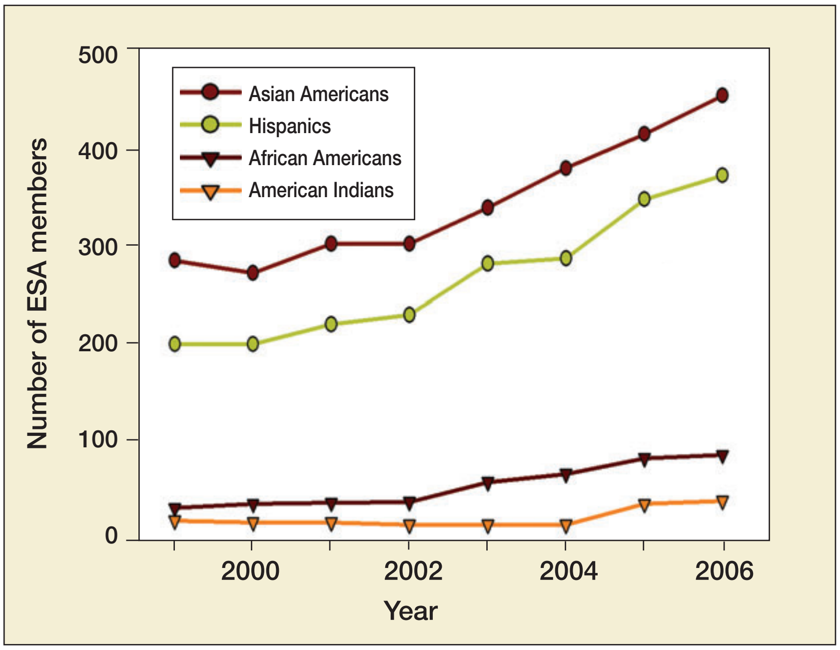

Figure 1. *Change in the number of ESA members of various ethnicities from 1999–2006.*

ing students from diverse backgrounds.

The social–cognitive theory of career development (Lent *et al.* 1994) provides a useful framework for considering how people make decisions to explore and pursue a scientific career path, particularly in ecology. It includes three interlinked models: (1) interest development, (2) career choice, and (3) performance. These three models integrate the roles of self-efficacy (belief about one's ability or, "Can I do this?") and outcome expectations (belief about the effect of a particular action or, "What will happen if I do this?"). The models also integrate background, learning experiences, personal factors, and feedback loops that can modify self-efficacy and outcome expectations. For example, a student's gender, ethnicity, and family life (background) can directly impact their exposure to nature and their interest in the field of ecology. These influences can, in turn, impact a student's self-efficacy and outcome expectations, encouraging them to seek out research experience and other skills that either confirm or redirect decisions about pursing a career in ecology.

The literature indicates that a wide variety of factors are important in determining whether minority students consider or reject a career in the sciences. Role models and mentors have been shown to exert a strong positive influence on students' decisions to pursue science careers, including in ecology (Brown 2000; Maton *et al.* 2000). Such influences affect students' outcome expectation (awareness, through the role model, of pathways otherwise unrecognized or unappreciated), and/or their self-efficacy (inspiration by someone perceived as "like me"). Since minority faculty represent less than 3% of full- or part-time faculty employed in science and engineering (Brown 2000), undergraduate students rarely interact with science and mathematics faculty from underrepresented minorities (Hall and Post-Kammer 1987). Often, if minority students do go into the sciences, it is to pursue a career in medicine, dentistry, or nursing (Taylor 2005). In this way, they can follow in the footsteps of other members of their community.

Underrepresented minority students often experience discrimination and isolation when they first engage in the sciences (Seymour and Hewitt 1997). This can diminish their confidence in their own ability to succeed in the sciences, turning them away from a career in these fields (Griffin 1990; House 2000). Students with an initial interest in science and engineering tend not to go on to pursue a graduate degree, mainly because of financial concerns, weak academic advising, and/or a general lack of knowledge about science and engineering doctorate holders, their lifestyles, and other rewards (Brazziel and Brazziel 2001).

Family support has been identified as another factor that strongly encourages minority students to pursue a science career (Turner and Lapan 2003). Environmental, aquatic, and other ecological sciences offer enrichment programs that involve working with scientists in the field and conducting hands-on research (Cuker 2001; Taylor 2005). These have been shown to positively influence students' perceptions of science (Stake and Mares 2005), leading to a better understanding of career opportunities and, if students see the career as attainable and enjoyable, retention in the profession.

Table 1. Comparison of the demographic composition of ESA membership to whole of US population and academic science workforce*

	ESA 1992	*ESA 1999*	*ESA 2006*	*US pop 2004*	*Employed US PhD scientists*
Caucasian	93.1%	91.8%	89.0%	68.5%	78.1%
Hispanic-American	2.1%	3.1%	4.3%	14.1%	2.8%
African-American	0.3%	0.4%	0.9%	12.7%	2.3%
Asian-American	2.4%	4.4%	5.3%	4.9%	16.4%
American Indian	1.1%	0.2%	0.4%	1.2%	0.3%
All underrepresented minorities	6.9%	8.2%	11.0%	31.5%	21.8%

*ESA 1992 from Holland *et al.* (1992); ESA 1999 and 2006 from ESA Annual Reports (ESA 1999; ESA 2006); US population 2004 from US Census Bureau (2005); employed US PhD-holding scientists 2001 from NSF (2004).

Understanding career choices in ecology

To better understand why so few underrepresented students pursue ecology careers, we conducted telephone interviews with 39 African-American students who had participated in the first phase of ESA's Strategies for Ecology Education, Development, and Sustainability program (SEEDS; Panel 1), which promotes diversity within the ecology profession. The first phase of the SEEDS program (1996–2001) served African-American students at certain Historically Black Colleges and Universities (HBCUs), unlike the current SEEDS program, which serves all underrepresented minorities in ecology. In 2002, we sought to explore the decisions of African-American students regarding careers in ecology and to better understand the group of students the SEEDS program had initially served.

Our approach was guided by the social cognitive theory of career development (Lent *et al.* 1994). We interviewed students to gain an understanding of the relationships among factors that influenced their interest in ecology, their acquisition of necessary skills, and the cognitive processes that prompted them to pursue a career in ecology. Ethical considerations of the study as a whole, the interview questions, and of the interviewer were approved by an Internal Review Board. The interview included open-ended questions that dealt with nine main areas: (1) status of the student's ecology career pathway, (2) involvement in the SEEDS program, (3) understanding of ecology, (4) first awareness of the environment, (5) first awareness of academic ecology, (6) decision about an ecology path, (7) preparation and training to pursue an ecological career, (8) confidence in the ability to excel in the field, and (9) perceived satisfaction with the thought of a future career in ecology (outcome expectation). Open-ended questions were used because of the exploratory nature of the study, to capture all possibilities that interview participants might include. The interviewer was an African-American woman, familiar with the SEEDS program but not directly involved in it. All students who had participated in the first phase of SEEDS (1996–2001) were invited to participate in the study; 39 responded, and interviews were scheduled with each one. Interviewees were given a small stipend for their participation. Of the 39 participants, 30 were women and nine were men, and 21 were undergraduates at the time of the interview, while 18 were alumni.

The interviews were transcribed and coded, and then searched for information pertaining to participants' decisions about an ecology career pathway using NVivo software. This information was compiled as nine categorical-predictor variables (see above for description of each) and the response variable, chosen career pathway. We used chi-squared and strength-of-association analyses (Cramer's V) to test hypothesized relationships between predictor variables and career path. Results from these analyses were used to construct a heuristic path model (Figure 2) that is a subset of the social cognitive theory model (Lent *et al.* 1994).

We identified three different pathways planned by students:

(1) **not pursuing ecology** – those who gained some experience of ecology, but had decided to pursue another, unrelated career path ("not pursuing");
(2) **applying ecology to another field** – those who applied their interest in, and knowledge of, ecology to their main area of interest ("applying"); and
(3) **pursuing ecology** – those who were on a pathway leading to a career in ecological research ("pursuing").

We found that the greatest number of participants (15 or 38%) were planning to apply ecology to another field, particularly to the health professions. Twelve participants (31%) expressed some interest in ecology and said that they had gained some experience, but that they had decided not to pursue a career in ecology. The remaining participants (12 or 31%) were pursuing a pathway that would lead to a career in ecology.

Participants mentioned a wide variety of influences that encouraged their interest in ecology, including exposure to the natural environment at a young age, exposure to the field of ecology, and family support. Family support (χ^2 [2] = 12.7, P = 0.0017, Cramer's V = 0.57), research experience (χ^2 [2] = 12.3, P = 0.0021, Cramer's V = 0.56), and positive outcome expectation (χ^2 [2] = 9.7, P = 0.0079, Cramer's V = 0.50) were positively associated with a student's decision to become an ecologist. The strength of association, as measured by Cramer's V, was high for these three predictor variables.

Panel 1. SEEDS program

The Strategies for Ecology Education, Development, and Sustainability (SEEDS) program was created in 1996 by the United Negro College Fund (UNCF), the Ecological Society of America (ESA), and the Institute of Ecosystem Studies (IES) to address the serious absence of underrepresented minorities among the ranks of professional ecologists. In its first 7 years (Phase I), the SEEDS partners worked with 14 Historically Black Colleges and Universities (HBCUs) to strengthen ecology learning opportunities at each school, thereby making an ecology career pathway available to students early in the undergraduate phase of their studies. The research described here was conducted during this initial phase of the SEEDS program, with students who participated between 1996 and 2001. The Phase I SEEDS program focused on building institutional capacity at participating schools to support students and faculty in ecology. In addition, the program provided a variety of opportunities for students and faculty to be exposed to ecologists and ecology research, including faculty-development workshops, travel to ESA Annual Meetings for faculty and students, and field trips to facilitate learning about the work of professional ecologists. In 2002, the SEEDS program expanded to its current format, focusing on multiple, positive experiences in ecology for ethnic-minority students across the nation. More information about SEEDS can be found at www.esa.org/seeds.

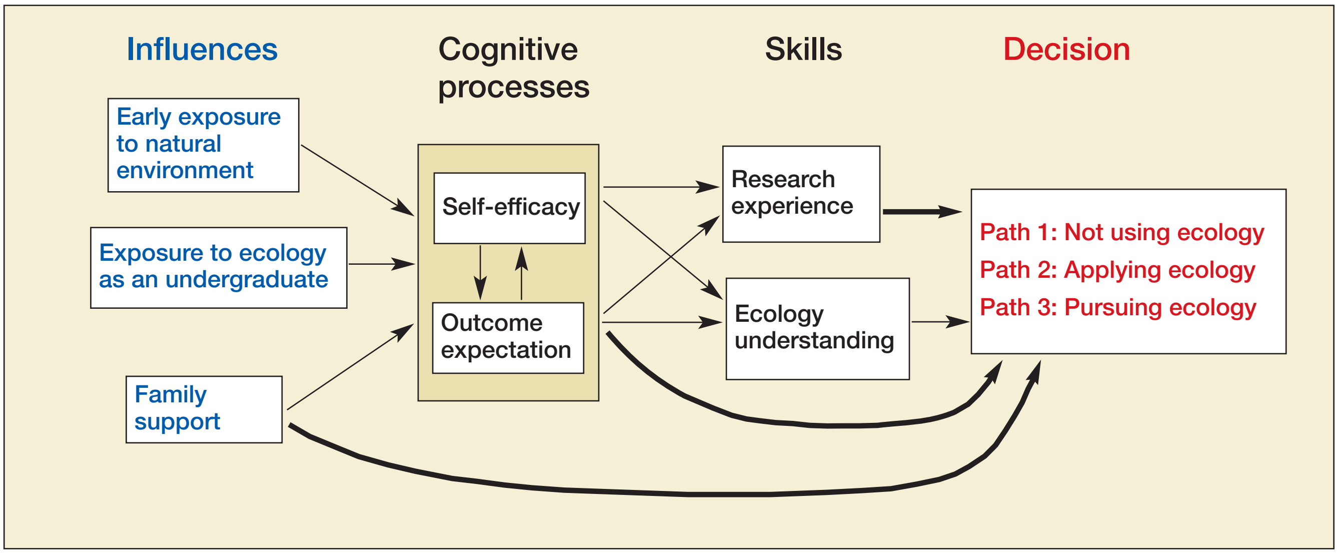

Figure 2. *An heuristic path model based on the social-cognitive model of career choice, supported by data from interviews with 39 African-American ecology students. The model summarizes a pathway by which students develop an interest in an ecology career and take steps to pursue that career. Bold arrows indicate pathways that were statistically supported (P < 0.05) by contingency tables utilizing data from a survey of SEEDS students and alumni. Other associations were not supported by these data.*

Family support

It is well documented that family support often drives the choice to pursue a science career, and we confirmed this for the SEEDS students interviewed. Eight of the 12 (67%) students in the study who were "pursuing" ecology mentioned that they had the support of their families, whereas only two (13%) "applying" and one (8%) "not pursuing" had had their family's support to choose a career in ecology (Figure 3; Quote 1 in WebPanel 1). On the contrary, one student (7%) "applying" and two students (17%) "not pursuing" actually experienced negative family pressure about this career choice (Quote 2 in WebPanel 1). No participants pursuing ecology experienced family pressure to avoid ecology.

Research experience

Several elements are essential to becoming an ecologist, including an accurate understanding of the science and potential careers available (ie what ecologists do), the ability to succeed academically, and experience of doing research. Eleven of the 12 students (92%) pursuing ecology had gained some ecology research experience. Eight of the 15 students (53%) applying, and only four of the 12 students (33%) not pursuing ecology, had gained direct experience in ecological research (Figure 3; Quotes 3 and 4 in WebPanel 1).

Outcome expectations

In the interviews, we explored with the students the fit between ecology and their long-term personal ambitions. Some of the goals expressed were to be wealthy, happy, active in their community, or to live near family. Eight students "pursuing" (67%), four students "applying" (27%), and one student "not pursuing" (8%) ecology believed they would, in fact, be happy in an ecology career (Figure 3; Quote 5 in WebPanel 1).

On the other hand, many students "not pursuing" or "applying" ecology could not envision that they would be satisfied in an ecology-related career. Interestingly, even some of the "pursuing" students had doubts about their level of satisfaction. These concerns appeared to arise from the suspicion that, upon gaining more experience in the field, they would learn more about what an ecology career might involve and be disappointed (Quote 6 in WebPanel 1).

Early exposure to the natural environment and the ecology profession

Most participants (36 or 92%), regardless of their chosen path, were exposed to the natural environment at an early age. This included outdoor recreation, K–12 school activities, the location of the childhood home, youth-group activities such as scouting and 4-H programs, and/or exposure through the media. Similar research on the significant life experiences that contribute to involvement in an environmental profession or group found exposure to natural environments as a youth to be an important factor in later decisions (Tanner 1980; Chawla 1998). In this study, although 92% of students were exposed to the natural environment at a young age, it did not seem to influence their career choice. This may be because most (36 or 92%) students did not equate their early experiences in nature with ecology; they felt they were simply having fun outside, as kids do. Most students did not become aware of ecology as a profession until they were undergraduates. They may have learned about ecology in a high school biology or earth science class, but this brief exposure does not usually mention career options, leaving students unaware of such possibilities (Quotes 7 and 8 in WebPanel 1).

Conclusions

The results of this case study support the basic premise that families play a significant role in a student's career choice. Family support was the most important initial influence included in the heuristic model (Figure 2) and had the greatest effect on whether a student chose to pursue ecology versus another career. While family support is often beyond our control when we attempt to stimulate student interest in ecology, our results suggest that we should seek ways to inform, engage, and encourage families to support their child's interest in ecology. SEEDS participants noted a lack of awareness of ecology careers as one of the reasons for the lack of family support, but a general awareness of ecology can be built over time.

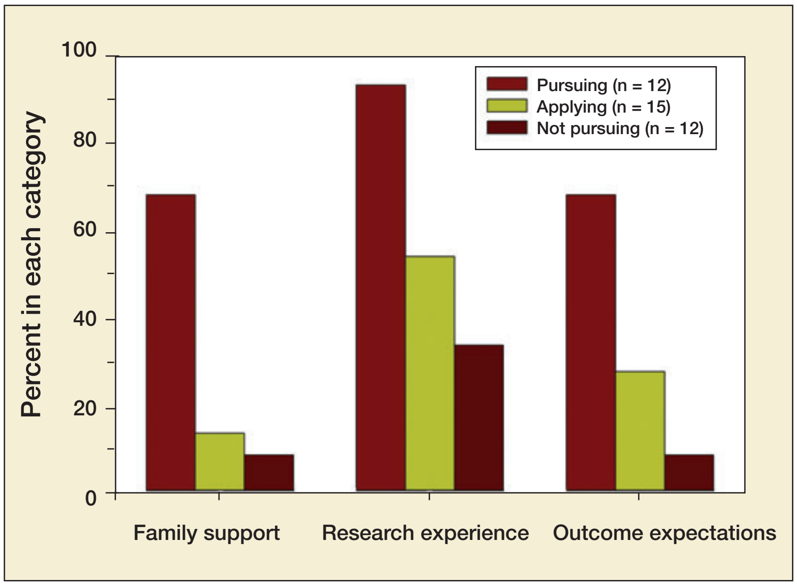

Figure 3. *Percentage of students in each of three ecology pathways (pursuing ecology, applying ecology to another field, not pursuing ecology) reporting the importance of the predictor variables family support, research experience, and positive outcome expectations.*

Our results also indicate that a lack of family support or early exposure to the environment does not exclude the possibility of a later decision to pursue a career in ecology. For instance, participants who had authentic research experiences in ecology were able to make more informed decisions, since these experiences gave them a meaningful glimpse into what life as an ecologist is like.

Finally, students need to feel that being an ecologist will be a positive and rewarding career. This is the factor over which other professional ecologists have the most control. If there is an ethnic-minority student working in the lab, efforts should be made to ensure that the student's experience is positive, especially since they may be the only representative of that group in the lab, or even the building. If such students are to be able to envision themselves continuing further along the ecology career path, it is essential that they feel comfortable and validated.

We also learned that, with respect to encouraging minority student participation in ecological research, it is not too late for students to first learn about ecology at the college level. It is rare for students to have an ecology course or research experience or to know about a career in the field prior to attending college. However, the finding that students other than those in these three categories who had pre-college exposure to the ecology profession ended up "pursuing" or "applying" ecology supports the conclusion that exposure, whether before or during college, is important to the development of interest in the field.

Biological diversity will continue to be a driving theme in ecology. However, for the ecological community to thrive, we must continue to work toward increasing our own diversity. This critical point cannot be stressed enough. The power of the ecology profession will be greatly augmented when it can reach communities from the most remote areas on the planet to the densest parts of mega-cities, and when the communities themselves have a voice in the ecological research agenda. Further studies are needed to better explain why underrepresented minorities of all backgrounds choose or decide against a career in ecology. In the meantime, we learned from this preliminary study that reaching out to the families of students from underrepresented minorities, to help them understand the relevance of an ecology career, working diligently to recruit such students and offering opportunities for ecology research experience, and then being thoughtful of the overall experience for students, are three ways we can work to diversify the ecology profession now.

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