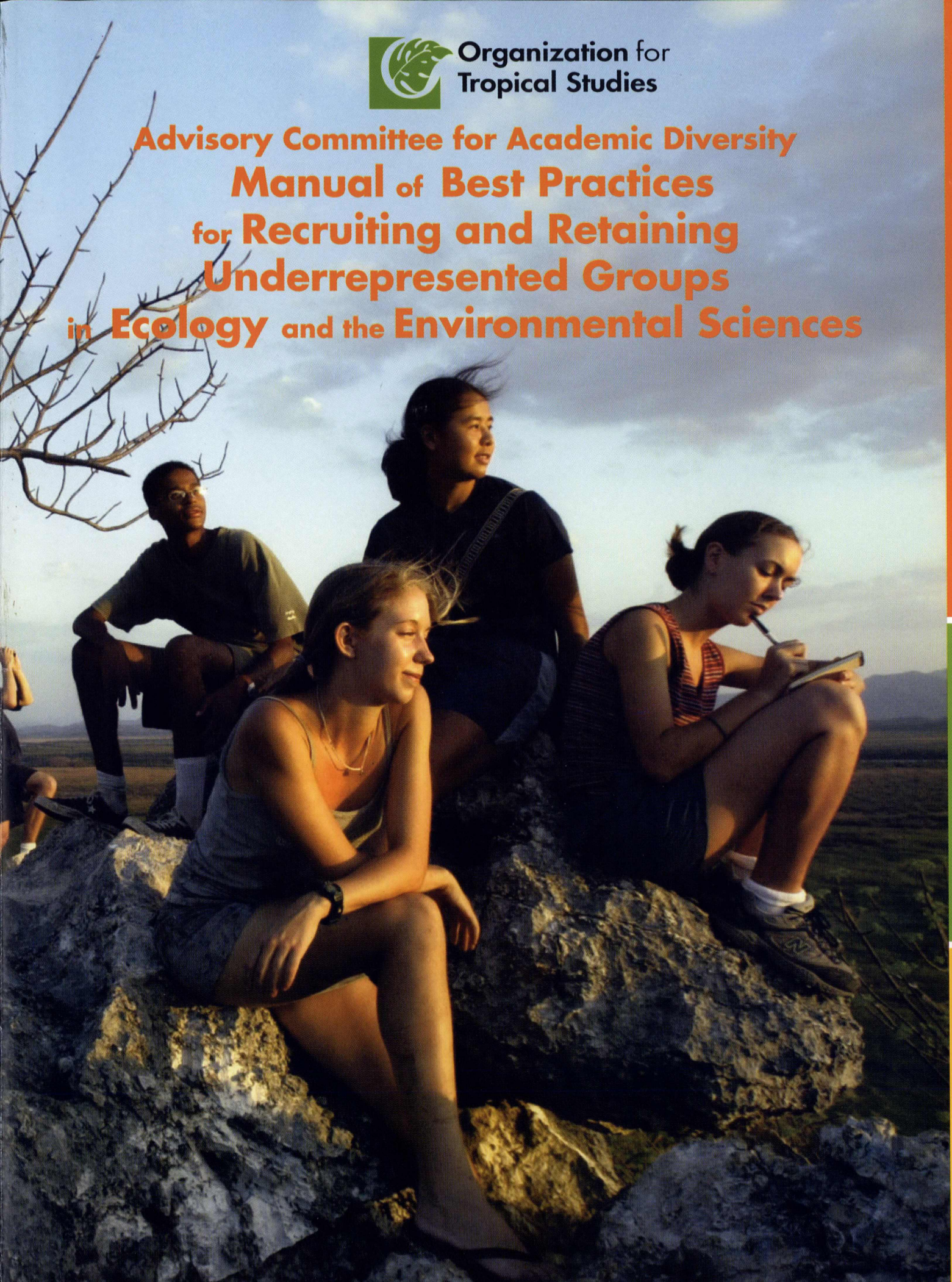
Organization for Tropical Studies

Advisory Committee for Academic Diversity

Manual of Best Practices for Recruiting and Retaining Underrepresented Groups in Ecology and the Environmental Sciences



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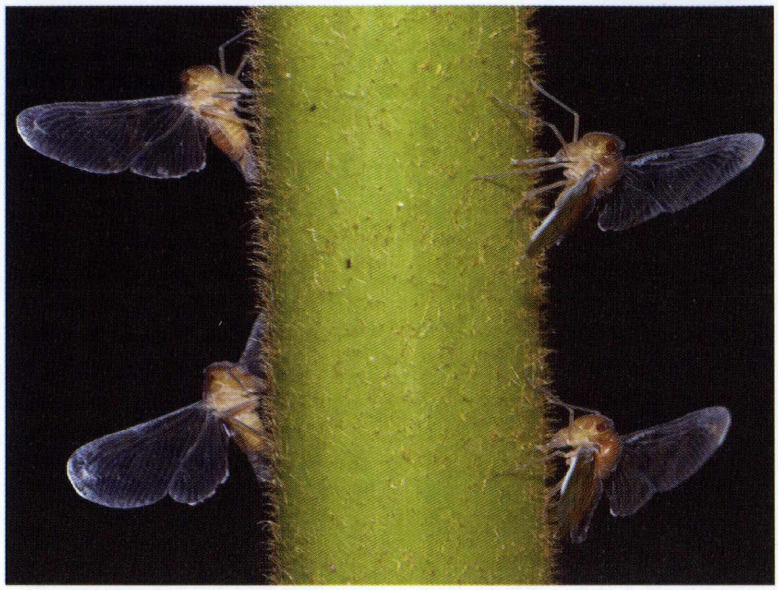

Dedication

This manual is inspired by the dedication and hard work of Mr. Carl Walker, a member of the Organization for Tropical Studies Advisory Committee for Academic Diversity since its inception in 2001. Carl was an integral part in the planning, development, and implementation of the OTS Minority Scholars program and was an important link between OTS and the 38 schools in the United Negro College Fund Mellon Program. Although Carl Walker recently retired from his official responsibilities on the committee, he remains actively involved with ACAD and passionately committed to its mission of broadening opportunities for underrepresented groups in ecology and the environmental sciences.

Acknowledgements

This manual would not be possible without the assistance and encouragement of those who worked tirelessly over the past year. In addition to members of ACAD, we want to thank the OTS Education staff for supplying critical data on the Minority Scholars Program. We also want to recognize the significant contributions of Gwen Wright and Dr. Ann Lewis who served as editors. A special thank you to Dr. Eloy Rodriguez of Cornell University for his contributions during the planning stages of this project. Finally, we want to acknowledge all the programs listed in this publication for their many contributions and unwavering support of fostering diversity in ecology and the environmental sciences.

"I would not simply say that my OTS experience just influenced my career choice, it changed my life. In my summer 2004 experience at La Selva I fell in love with tropical field biology and realized that this is the career for me. In my South Africa semester program I gained further experience in field biology and broadened my horizons due to the biological and cultural exposure. As a direct result of the international experience gained from the two OTS programs, I was hired as a research assistant by a botanist at NC State and am currently enjoying a summer in Brazil. Both my Costa Rica and Brazil research have yielded publishable results, and I plan to have two peer-reviewed publications by the end of the year. For both manuscripts I am lead author, and both will be published well before even beginning my graduate program. Furthermore, my mentor from the REU program, Craig Guyer, will be my main Ph.D. advisor at Auburn University. If I had not had the opportunity to work with him closely, I probably would not be as certain about my graduate school future and I probably would not be at the top of the list to enter his competitive lab." (2006)

Ryan A. Adasme
OTS Scholar in the REU and South Africa Programs

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Executive Summary

Novel ideas emerge from a diversity of backgrounds, so the lack of a diverse workforce in ecology and the environmental sciences may seriously reduce the range of solutions considered for environmental problems. A mixture of scientists from majority and underrepresented minority groups is likely to lead to more innovative solutions. Also, the United States must ensure that it trains a sufficiently large workforce to address domestic and international scientific problems, and underrepresented populations are potential sources of future scientists. Because of the local and global ramifications of ecology on humans and ecosystems and because of the changing population demographics in the United States, the recruitment and retention of students from diverse backgrounds is imperative.

The Organization for Tropical Studies (OTS), an international consortium of more than 60 colleges, universities, and research institutions, initiated the Minority Scholars Program in 1999 to introduce a diverse group of undergraduate students to hands-on, field-based research in tropical ecology. The program has proved successful in attracting underrepresented minorities. Minority scholars account for 25% of the OTS students in the undergraduate program over the past five years with Hispanic Americans comprising the largest ethnic constituency.

The OTS Advisory Committee for Academic Diversity (ACAD), established in 2001 to implement strategies to diversify OTS programs and to serve as a link between OTS and minority-serving colleges and universities, has contributed significantly to the success of the Minority Scholars Program. This past year, members of ACAD have examined OTS and other programs that focus on broadening participation in science, technology, engineering, and mathematics (STEM) in order to refine the approach used by OTS. Although few programs emphasize ecology and environmental sciences, the exploration emphasized strategies that would facilitate student entry into graduate school and professional careers in not only ecology and environmental sciences but in other STEM areas as well.

The result of ACAD's involvement is the *Manual of Best Practices for Recruiting and Retaining Underrepresented Minorities in Ecology and the Environmental Sciences.* The manual identifies and outlines important aspects of the OTS approach that encourage exploration by students into scientific fields previously unfamiliar to them. Introduction to new fields of study is central to broadening the career horizon of a student with an interest in science; he or she must be exposed to career paths beyond that of medicine. The OTS approach is also important in the delivery of hands-on research experiences in an environment where hands-on research is increasingly required for entry into and success in a scientific graduate program.

Analysis of other programs reveals several strategies that promote recruitment and retention of underrepresented minorities These strategies include: selection of students from a national pool; emphasis on faculty as key to student recruitment and retention; provision of financial support for tuition and related activities such as professional conferences; provision of opportunities for hands-on research experiences, particularly at the undergraduate level; creation and implementation of structured activities to prepare students for the completion of the Ph.D.; emphasis on mentoring throughout the academic career; collaboration and formation of partnerships to implement the goals of a program; and facilitation of outreach activities with K-12 teachers and students for expanding the pool of students who enroll in higher education. The most successful programs in science areas use a combination of these strategies. OTS and other organizations, institutions, agencies, and individuals who are interested in increasing the diversity of the ecological and environmental sciences workforce will find within this manual ideas and resources to help move their efforts forward.

The *Manual of Best Practices* makes recommendations for enhancing recruitment and retention activities to broaden the participation of underrepresented minorities in ecology and the environmental sciences. The major recommendations are:

1. Expand outreach to K-12.
2. Improve and extend partnerships and alliances with community colleges, minority-serving colleges and universities, industry, non-profit research organizations, government agencies, and families.
3. Increase the number of fully-funded programs that provide hands-on research experiences for students in ecology and environmental science.
4. Develop curricula that utilize multi- and interdisciplinary courses which show the relationship between ecology, environmental science and the human condition in order to attract and introduce students to these STEM fields.
5. Create faculty development programs to build a critical mass of underrepresented-minority mentors and role models in ecology and the environmental sciences and extend mentoring throughout the academic career.
6. Develop, promote, and support a comprehensive tracking and evaluation plan to measure progress and provide evidence of results.

Preface

The members of the Organization for Tropical Studies Advisory Committee for Academic Diversity are pleased to present this *Manual of Best Practices for Recruiting and Retaining Underrepresented Groups in Ecology and the Environmental Sciences.* A grant from the National Science Foundation's Louis Stokes Alliances for Minority Participation made publication possible. The shortage of underrepresented groups in ecology and environmental sciences has created a tremendous need to increase the number of African American, Hispanic Americans, and Native American students who pursue advanced degrees in these disciplines. The Organization for Tropical Studies, recognizing this urgent need within the science community created a scholars program in 1999 to increase the number of underrepresented groups participating in international research experiences in tropical ecology. The OTS experience has been shown to be beneficial in attracting and introducing underrepresented students to areas of science and disciplines to which they would otherwise not have exposure or that they would not be inclined to try during their normal course of studies. Working in collaboration with its 62-member consortium, The Andrew W. Mellon Foundation, the National Science Foundation, and other organizations and programs, OTS plays a major role in helping to foster a new generation of scientists and faculty committed to working on solutions for our most pressing environmental issues.

The *Manual of Best of Practices* was developed as a reference guide for exploring the factors influencing underrepresented minority students entry and persistence in these disciplines, and highlighting efforts, such as the Organization for Tropical Studies and other programs that promote identification, recruitment and retention of underrepresented groups in ecology and the environmental sciences, specifically and in science, technology, engineering and mathematics (STEM) areas, generally. Consistent with the organization's mission, this manual emphasizes efforts in higher education, while also recognizing that efforts at the K-12 and career level are also important.

The information contained in this document reflects the views and opinions of the Advisory Committer for Academic Diversity, a volunteer advisory group of the Organization for Tropical Studies charged to examine issues affecting diversity at OTS. Any comments or suggestions regarding the contents of this manual should be sent to:

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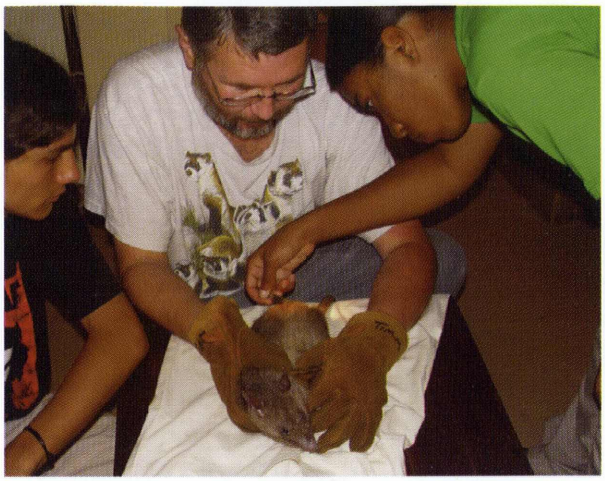
I. Introduction



As new issues in ecology emerge, the demand for more trained ecologists who are diverse in their thinking has increased. Cutting-edge issues in ecology such as global warming, tropical deforestation, and increasing rates of species extinctions are complex in scope and, by their nature, must be addressed with interdisciplinary approaches. Recent funding initiatives, such as the USDA's Managed Ecosystems Program (2005) and the National Science Foundation's (NSF) topical area of Biocomplexity in the Environment and Dynamics of Coupled Natural and Human Systems Programs, give evidence to the national and international need to address these issues through interdisciplinary research.

Because of the global ramifications of ecology for humans and the environment, individuals of all cultural and ethnic backgrounds need to contribute to our understanding of ecological issues. While there are no good statistics specifically for the general ecology and environmental sciences workforce, statistics from related areas and anecdotal observations indicate that diversification of the scientific workforce with US minorities is sorely needed. The number of minorities earning degrees in the biological sciences is increasing, but the numbers from fields related to ecology and environmental sciences have not shown any significant increase (NCES 2003). In the *Women and Minorities in Ecology (WAMIE) I and II Reports* (1993; 2006), statistics reveal that the membership of the Ecological Society of America is less diverse in comparison with STEM careers as a whole. Only 3.0% of the STEM workforce is Hispanic, 3.2% African American, and less than one percent Native American (NSF 2000 [Alaskan Natives, Pacific Islanders, African Americans, Native Americans, and Hispanic Americans are considered underrepresented in the sciences]). In addition, the diversity of STEM workers with respect to minorities is less than that of the overall United States population (Table 2).

The WAMIE I and II reports also revealed that while the numbers of ethnic minorities in the Ecological Society of America (ESA) have increased by a little more than 3%, this increase may have resulted from an 11% increase in the percentage of minorities in the general population (2006). By the year 2050, it is anticipated that about half of the U.S. population will be ethnic minorities, and Hispanics will constitute approximately 25% of the population. On the march to the "majority minority," non-Hispanic whites are projected to decrease to about 62% of the U.S. population by 2025 (U.S. Census Bureau 2005). The most immediate ecological issues of the 21st century are globalized and impact urban and partially developed areas in addition to wild habitats. For equity in environmental issues and to ensure a sufficiently large workforce with diverse ideas and experiences to address world problems in health and the environment, diversity of the ecology and environmental sciences workforce must more closely represent the diversity of the US population. The complexity and globalization of environmental problems demands a workforce that is highly proficient, skilled, mobile, tolerant, and able to adapt to work effectively in many cultural settings (Karsten 2003). It is imperative that the nation and the academy develop strategies to increase the number of underrepresented minorities in ecology and environmental sciences.

By bringing multiple perspectives, a diverse scientific workforce will utilize multidisciplinary and integrative approaches more effectively to address world problems. Equally necessary is an expanded and diverse workforce that can communicate science issues to the general public and increase science literacy, particularly in the areas of environmental science and ecology. This is especially important as the general public is more involved in environmental and health-related regulatory issues.

Despite limited information on the recruitment, retention, and advancement of underrepresented minorities in ecology and environmental science, this *OTS-ACAD Manual of Best of Practices* explores the literature that best relates to the issues and challenges of recruitment and retention of minorities in these fields. It highlights strategies that can be developed and implemented to increase the numbers of well-trained, minority Ph.D. ecologists and environmental scientists and to move them into the professoriate. It also highlights the most successful and promising of the large-scale projects that currently use some of these strategies to recruit, retain, and advance minorities in ecology and environmentally-related fields.

II. Significant Issues Affecting the Recruitment and Retention of Underrepresented Students

As described in this section, attracting students to the sciences occurs primarily in the lower grades. As students advance, the issue becomes one of retention. Many of the specific issues change by level but some critical issues remain no matter the level of the student or professional.

K-12 Education

Lack of Exposure to Science in the Early Years

The numbers of students in underrepresented groups available for recruitment into STEM fields may be limited by the challenges faced by students in kindergarten through high school. Historically, most students, but particularly students from African American, Hispanic, and Native American backgrounds, are introduced to and engaged in science towards the end of high school and in college (Baker 2000). Students need to be exposed to such fields as environmental science and ecology in the lower level grades (Starzomski et al. 2004). By the time students reach high school, many have already decided whether or not to pursue higher education and may have focused on broad areas of interest, such as medicine or the bio-medical fields.

Limited Interest in Science as a Career Choice

While early exposure to science and teaching methodology have been shown to have profound effects on a student's ability to continue in science, there is evidence to indicate that student expectation of a scientific profession may play a role in successful completion of that career choice. A recent report by Tai and collaborators (2006), postulates that young adolescents who expect to have careers in science are more likely to graduate with a degree in science than their counterparts with no expectation of scientific careers. The longitudinal study did not provide proof of a cause-and-effect relationship between expectations of careers in science and becoming career scientists; however, the data did suggest that an early interest in science, developing in middle school or earlier, should be considered in the recruitment of minorities into the sciences.

This study supports an earlier report by Berryman (1983), where he observed that the decision to earn a quantitative degree, such as one in a STEM field, is made early, usually before high school. Although some students join the "pool" during high school, essentially none change to a quantitative major after high school. Before high school, the pool is defined by interest. By the 12th grade, the pool is defined by both interest and mathematics achievement. This combination of interest and skill continues to define students in quantitative disciplines through graduate school (Berryman 1983). Additionally, Xie and Shauman (2003) were able to correlate mathematics achievement with choice of science and engineering majors, regardless of gender.

Increased High School Drop-Out Rates and Decreased Graduation Rates

Another major challenge to the recruitment and retention of minorities into ecology and environmental science is the small pool of students available to pursue higher education due to high school dropout rates and low graduation rates. Dropout rates in high school are greater for ethnic minorities than for any other group. The National Center for Education Statistics (NCES 1997) reported that the high school dropout rate for white students was fewer than 8% while it was just over 12% for African Americans and was approximately 30% for Hispanics. In an earlier report by Swisher and Hoisch (1992), they estimated the rate for Native Americans at 30%, although data for the Native American population were oftentimes difficult to collect and ascertain. In a more recent report (NCES 2005), the 2004 rates decreased slightly from the earlier rates reported showing 6.8% for white students compared with 11.8% for African Americans and 23.8% for Hispanics.

Concomitantly, the examination of high school completion rates, while increasing for underrepresented minority groups, reveals that the rates are still significantly lower for these groups when compared to the white students. The high school completion rate for African Americans age 18 to 24 increased from 75.6 percent in 1992-94 to 77.8 percent in 2002-04, while the rate for Hispanics showed the largest increase up from 56.6 percent in 1992-94 to 64.4 percent in 2002-04. However, Hispanics still lag behind whites and African

Americans in high school completion even though they show the greatest increase. The high school completion for whites was 87.6 percent in 2002-04, up from 85.6 percent in 1992-94 (American Council on Education, *Minorities in Higher Education Twenty-second Annual Status Report* 2006).

With high attrition rates and low graduation rates for minorities, the pool of minority students entering college is much lower than that observed for whites. Increased exposure to the sciences beginning as early as third grade and perhaps even as early as kindergarten, may encourage more students to stay in school and continue in science (NCES 2005).

Higher Education

Limited Funding Opportunities for Scholarships, Fellowships, And Training

The lack of financial aid in the form of grants and scholarships is a major deterrent to minority students attending college at the undergraduate level (Barlow and Villarejo 2004). Underrepresented minority students entering college usually must supplement their financial resources with large loans and heavy work schedules. For example, the number of students borrowing funds to complete undergraduate studies was considerably higher in 1997 and 1998 for minorities (66% of Hispanics, 76% of African Americans, and 81% of Native Americans) in comparison with 59% of Whites and 56% of Asians (NSF 2002). Minority students are less likely to complete college—they are reluctant to incur large debts by borrowing money for their education.

In addition, the heavy work schedules that minority students assume to support themselves makes it difficult for them to sufficiently prepare for their courses, especially in science and engineering. Furthermore, first generation college students—many minority students are in this category—and their families believe that the students should contribute to the family income and not embark on years without wages or a salary. As students consider the future beyond undergraduate school, they are unaware or do not believe that they can receive the necessary funds to earn a Ph.D. in the sciences. In STEM fields, approximately 20% of Ph.D. students relied primarily on their own personal resources for finances in comparison with 53% of non-STEM Ph.D. students (NSF 2006).

Lack of Role Models and Mentors

Funding is and will continue to be a central issue affecting the recruitment and retention of well-qualified, underrepresented minorities. However, students shy away from STEM disciplines even when funding is not the major issue. Effective mentoring and the presence of role models are often said to be key for establishing and maintaining a diverse academic environment (George et al. 2001). Many academic departments in STEM disciplines lack diversity, and students entering such institutions or departments often feel alienated by the absence of role models or individuals with whom they can identify. This feeling of alienation is sometimes abated in students who have had prior exposure to a given discipline.

For underrepresented minorities, the development of a

pool of role models and mentors is a circular problem. Often, academic departments and professional societies suggest that they cannot find qualified individuals of underrepresented groups to hire or participate. Yet, students of underrepresented minorities need to see successful individuals whom they can emulate. They want to talk one-on-one with these individuals about personal challenges and roads to success. Speaking to one of similar cultural background is essential for many students. Without mentoring and role models, students will shy away from ecology and other science disciplines, and migrate towards those fields that are perceived as better compensated, more prestigious, or where they feel more culturally accepted. Many professional societies and organizations advocate academic and personal mentoring for their members and students, such as the American Association for the Advancement of Science (AAAS), American Chemical Society (ACS), American Indian Science and Engineering Society (AISES), Ecological Society of America (ESA), Society for Advancement of Chicanos and Native Americans in Science (SACNAS), and Society for American Foresters (SAF).

Lack of Hands-On Research Experiences

Students who have hands-on research experiences are distinctly advantaged over their peers. For U.S. students, hands-on research experiences in ecology typically consists of voluntary, paid, or independent-study work in laboratories or field research or, increasingly, participation in summer research programs. Research experiences may also consist of international education or research, such as the OTS programs. Such real-world experiences bring to life theoretical concepts as students apply skills acquired in the classroom. Students begin to appreciate the need for developing skills in mathematics, the sciences and technology, and the scientific method. Students who have conducted hands-on research from conception and data collection through data analysis and presentation of results are more likely to be accepted at "top-quality" graduate schools and Ph.D. programs (NSF 2006).

The National Science Foundation's Research Experiences for Undergraduates (NSF-REU) programs are primarily domestic programs that emphasize the inclusion of underrepresented minorities [description of REU under model programs]. According to Dr. Sally O'Connor, director of the REU program at NSF, 45% of the participants are underrepresented minorities (pers. comm. 2006). This emphasis should help to alleviate some of the disadvantages that minorities have in applying to and gaining acceptance to graduate schools in STEM fields.

Lack of International Experiences

NSF has recognized the need to add an international dimension to educational and research experiences related to STEM areas (NSF 2002). NSF contends that in an increasingly global world, it is critically important that U.S. students in early career stages have international experiences and develop international capabilities (NSF 2002). The Institute for International Exchange (IIE 2005a), a consortium that includes 600 institutions of higher education in the US and abroad, administers the Fulbright Programs, and sponsors large numbers of international students at US universities, has been concerned about low levels of participation by minority groups in international research experiences. Commonly cited benefits of study-abroad programs include the development of self-esteem and self-confidence (Nash 1976; Carsello and Creaser 1976; Orndorff 2002), openness to diversity, and cultural awareness (Wortman 2002; Dwyer 2004; Ismail et al. 2006). There is a positive association between study-abroad experiences and both graduation rates and grade point averages (Posey 2003). Futhermore, international education may positively influence the decision to pursue post-graduate degrees (McMillan and Opem 2004). For underrepresented students, the additional hands-on international experiences give them an advantage in the academic and employment arenas.

III. Strategies for Effective Recruitment and Retention

K-12 Education

Several approaches are documented as effective in the recruitment and retention of underrepresented minorities into ecology and other STEM disciplines at various levels.

Provide Early Exposure to Science

Engaging students with science as early as possible is a critical factor for increasing student interest in the pursuit of careers in ecology and other science fields. Children in lower grades (elementary and middle school) have a natural curiosity about the world around them. For example, students in kindergarten use their own senses and simple tools to collect information from their environment. As students progress, the skills of asking questions (first grade), planning and executing simple investigations (second-grade), and collecting data and making inferences and decisions based on the data as well as communicating their conclusions (third grade) are naturally present.

The acquisition of this progressive skill set may require a variety of teaching methodologies. Engaging students early by using project-based or inquiry-based methodology to study science allows students to develop the skills necessary to pursue science as a career later in life. The utilization of project-based methodology enables students to gain an understanding of science concepts while seeing the application of science to real-world problems and issues.

As described by Tobin in 1989, the Biological Science Curriculum Study Group (BSCS) developed the 5-E method of studying science. In this method, the 5 Es of the model are: ***Engage, Explore, Explain, Elaborate, and Evaluate.***

- **Engage:** This stage engages the learner as the teacher asks questions or tells a story about an unusual event. In this stage, the student's curiosity is piqued.
- **Explore:** In this stage, the student has the opportunity to work through a problem with hands-on experiences, to discuss that problem with other students, and to receive minimal guidance from the instructor. This process helps the student become more familiar with a specific problem, and it generates additional interest in solving the problem.
- **Explain:** During this stage, students begin to learn terminology (definitions, explanations, and relationships) related to the problem.
- **Elaborate:** This is the stage where the students use what they have learned in order to solve the initial problem, and they use the concepts learned in the previous stage to solve additional problems. The instructor encourages their understanding of the concepts and terminology, but does not provide direct answers or introduce new material.
- **Evaluate:** During this stage, the instructor assesses student learning through a variety of techniques, including student self-assessments. The teacher avoids focusing on isolated facts, but instead focuses on ability to discuss concepts.

This curriculum model can be used for entire programs or individual lessons. The BSCS 5E Instructional Model plays an important role in the curriculum development process as well as the enactment of curricular materials in science classrooms throughout the United States and internationally (Bybee et al., 2006).

Expose Students to Career Opportunities in Science and Ecology

Early exposure to STEM fields, particularly ecology and environmental science, at the elementary school level would probably give students the opportunity to develop a career path early and may even promote more students considering these fields of study. Numerous studies, such as the report sponsored by AAAS (George et al. 2001) point out that repeated early exposure, particularly in K-12, is influential in molding and exposing students to career choices in ecology and other science fields. In addition, it is imperative that while exposing students to these fields early in their academic career, that they also are counseled about potential jobs that they may embark and that they see individuals engaged in careers with ecology and environmental sciences emphases.

In a world that is increasingly globalized socially, economically, and environmentally, it is important that members of underrepresented groups understand the relevancy of careers that are not as visible. For example, individuals who work in environmental justice may formulate policy that can impact a student or family at the local level. These positive impacts are not well known because they are not well advertised or discussed. If the aim of a student is to make a difference in the local community or region, then the student must make the connections among careers, policies, actions, and his or her life.

Further, exposing teachers and mentors to alternative biological careers may be an efficient means of reaching students as well. The Organization for Tropical Studies recognized the importance of early exposure at the K-12 level and began offering fellowships to middle and high school science teachers for participation in independent research experiences at an OTS field station in Costa Rica. Since 2002, the Research Experiences for Teachers (RET) program, sponsored by the National Science Foundation, has provided funds for teachers to conduct hands-on research for the enhancement of their scientific skills and knowledge in ecology. Upon return to their home institutions, the teachers then translate the knowledge from their field experiences into their classroom curricula and share it with students and fellow teachers. Overwhelmingly, follow-up with the participants showed that experience with the scientific method and data collection, which are integral to good scientific research, became a priority in their classroom curricula.

In addition to the RET, the National Science Foundation supports the Graduate Teaching Fellows in K-12 Education (GK-12) Program, designed to enrich science instruction in K-12 schools by funding graduate students to work with teachers and students in local school districts. For example, Tuskegee University graduate students in Master of Science programs in Biology and Chemistry in the NSF GK-12 joint program between Auburn and Tuskegee Universities are linked with teachers in the local middle and high school science classes to give students real world experiences while allowing them to see people who look like them engaged in cutting-edge scientific research. Students are given the opportunity to visit the laboratories where the graduate students are conducting research thereby giving them exposure to real science.

Intervene Early for At-Risk High School Students

Early intervention helps retain students who are at risk of dropping out of high school. Martin (1999, p. 1) states, "Early intervention partnerships with colleges provide a significant opportunity for 'at-risk' students to have the available resources, funding, curriculum, and guidance to enter postsecondary education. Beginning as early

as kindergarten and progressing through high school, encouragement for students to enter college and receive a baccalaureate degree gives 'at-risk' students the much needed support and extra attention they need. Many 'at-risk' students need this help to successfully apply, attend, and graduate from college."

The University System of Georgia's task force on enhancing access for African American males published a major report that identified seven state and eight national programs of excellence (2003). The Coastal Georgia Community College administers one such program, the Minority Outreach Program. This program focuses on rising seventh-grade African-American males and has twelve years of excellent success in their retention and academic accomplishment. The students are from single-parent homes without an African-American male role model. The program, which focused on proper mentoring and intensive academic instruction, boasted an 85% completion rate for the last two years of school.

Pre-college experiences for high school students can also be extremely valuable. For example, Upward Bound (www.ed.gov/programs/trioupbound), in which high school students attend programs on college campuses, provides excellent early exposure to high school students, especially when the students are the first generation in their families to attend college and are unprepared in the basic college skills. According to Martin (1999), early intervention strategies 1) eliminate boundaries between schools and colleges, 2) discourage students from dropping out, and 3) give students hope to enter college. Martin (1999, p.1) advises that "active participation by school counselors, teachers, school and college administrators, college student support staff, and faculty generates involvement between schools and colleges but also eases the transitions from one institution to another."

Another important component is that programs that have strong communication with families and develop the expectation that students will graduate high school and matriculate into college may be more able to encourage

students into higher education than programs that do not develop strong foundations with families. In writing about the Meyerhoff Scholarship Program at the University of Maryland, Baltimore County, Hrabowski and his colleagues (1998, 2002) stress the importance of strong family support and encouragement to the academic success of African American men and women. The Meyerhoff Scholarship Program (http://www.umbc.edu/meyerhoff/) also stresses the importance of the formation of a tight community with a critical mass of high-achieving, like-minded students in STEM fields who support and inspire each other.

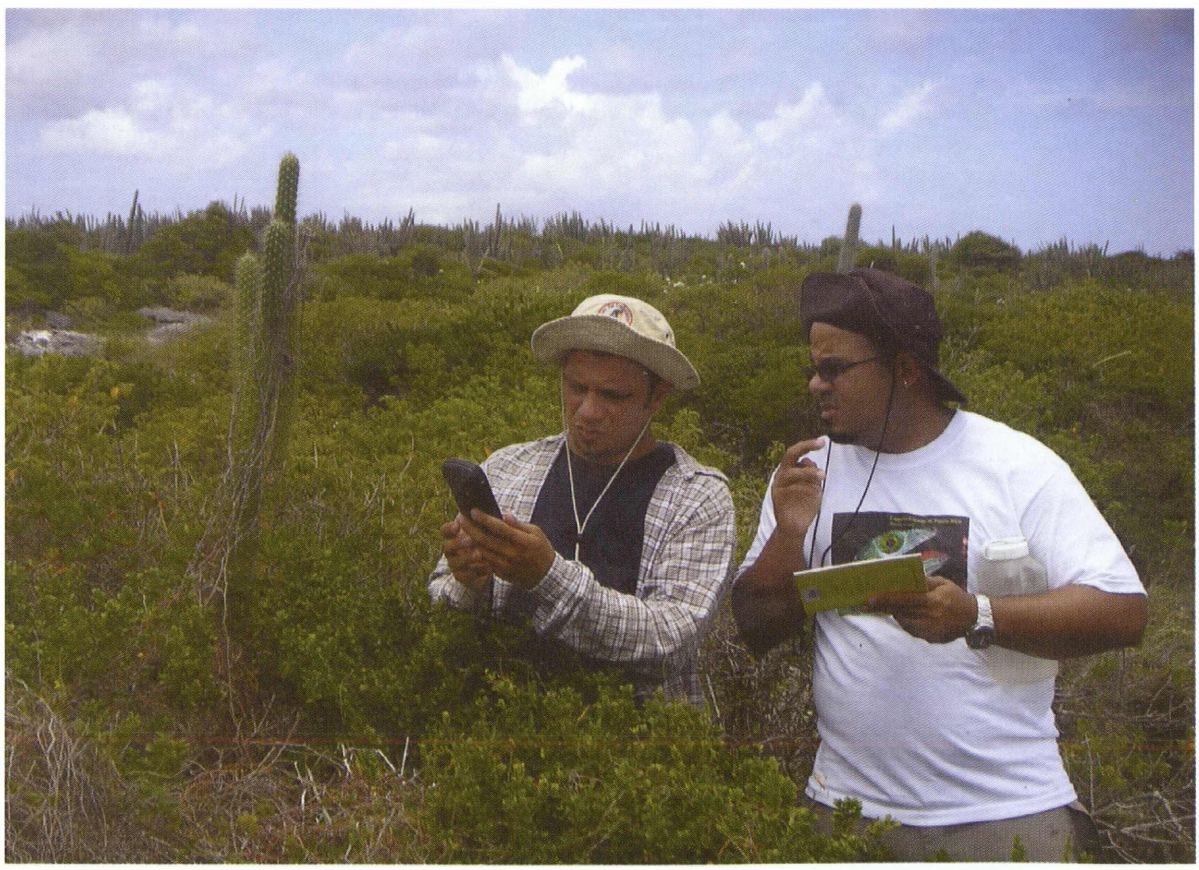
Form Partnerships

Many of the successful approaches described in this manual and used by various programs to improve recruitment and retention rates of all underrepresented minority groups involve the formation of partnerships at all levels. For example, to promote the satisfactory transition from high school to college for Native Americans, Pavel (1999, p.248) suggests that state governments and postsecondary institutions encourage K-16 partnerships with tribal communities. He believes that partnerships would elevate the overall level of pre-college academic preparation and postsecondary aspirations and orientation of American Indian students. Lack of expectations for college entry and degree completion, and lack of formal and informal integration of social systems and academics on college campuses, reduces the numbers of college graduates.

The University of Puerto Rico at Río Piedras Center for Applied Tropical Ecology and Conservation (CATEC), established through the NSF CREST Program, works in partnership at the K-12, undergraduate, graduate and professional levels (CATEC http://crest-catec.upr.edu). This interdisciplinary research center supports partnerships with academic, research, government and private organizations to conduct and disseminate research findings. CATEC serves as catalyst and an agent of change in the development of human resources in ecological science. It also provides a breadth of research and technical training opportunities in relevant ecological disciplines that are available to a wide diversity of students. In five years it has had a 41% rate of graduate school enrollment among 129 students that it has supported during that period (Cuevas, 2006). Its newest outreach effort includes the facilitation and sponsorship of activities by AKKA SEEDS, an ecology student chapter affiliated ti the Ecology Society of America's SEEDS Program with a mission to expose undergraduate students to ecological research and increase ecological literacy in pre-college students.

Higher Education

Strategies to increase recruitment and retention of underrepresented students at the postsecondary level incorporates a wide-range of strategies that include funding, mentoring, accessibility to hands-on research experiences in a domestic and global setting. These strategies are not exhaustive but central to the success of the model programs that reviewed for this document.



Increase Funding Opportunities

Lack of financial support is a major barrier to recruiting and retaining students in the ecological disciplines as well as in other STEM fields. For students, the thought of supporting themselves throughout undergraduate and graduate training can be intimidating; however, funds are available to pay for undergraduate and graduate studies in the sciences. For example, programs at the undergraduate level such as Minority Access to Research Careers (MARC) and Minority Biomedical Research Support (MBRS) programs were designed to attract undergraduate (MARC and MBRS) and graduate (MBRS) students into the biomedical sciences while providing the students with support for their education. These programs allowed students to advance in their education without the financial burden. Similar programs could be instituted for ecology and environmental science programs to provide a greater incentive for students to pursue these fields of study at the undergraduate level.

The Research Experiences for Undergraduates (REU) sponsored by the National Science Foundation is an example of how financial support is used to introduce students to disciplines in which they otherwise would have little interest. The REU program offers full fellowships to students for participation in programs designed to develop and enhance student knowledge and skills needed for the development of independent research. Importantly, REU programs fund participation and living expenses, in addition to a stipend that can be applied to school year expenses. For example, OTS has received funding from the NSF REU program for the past six years. Through the REU, OTS offers fellowships that include tuition and living expenses, roundtrip airfare, and a stipend for a 10-week program at the La Selva Biological Station in Costa Rica. The OTS REU fellowships are not restricted to minority students, but approximately 40% of the students are from underrepresented populations. NSF's REU program as a whole includes approximately 45% of students from underrepresented minorities (O'Connor 2006, pers.comm.).

Other programs, such as those administered by the United Negro College Fund/Andrew W. Mellon Foundation (UNCF/Mellon), provide undergraduate internships in ecology for students enrolled at Historically Black Colleges and Universities (HBCUs). UNCF/Mellon programs work in collaboration with Friday Harbor at the University of Washington, Harvard Forest at Harvard University, OTS, and other biological field sites.

In graduate Ph.D. STEM programs, the burden of debt is not an issue. According to a study conducted by Science Careers (Parks 2006), the majority of doctoral students support themselves without incurring large debts. This is done through a combination of research assistantships, teaching assistantships, and fellowships. Research and teaching assistantships usually have work requirements related to specific research projects or teaching undergraduate courses. Fellowships are the most flexible with respect to activities expected of graduate students and are usually acquired from outside the university. Research assistantships are the most common type of funding, accounting for 31% of graduate funding. Teaching assistantships account for 20% of graduate funding. Fellowships are the most treasured and competitive and account for 9.5% of graduate funding. Programs such as NSF's Louis Stokes Alliances for Minority Participation (LSAMP) Bridge to the Doctorate, Alliances for Graduate Education and the Professoriate (AGEP), Integrative Graduate Education and Research Traineeship (IGERT), Graduate Teaching Fellows in K-12 Education (GK-12), and the Graduate Research Fellowship Program are examples of government programs that may include fellowships. The Sloan, Ford, and Andrew W. Mellon Foundations are examples of private sources that support graduate work for students in ecology, as well as other disciplines in science and mathematics [details under model programs].

Complementing fellowships and scholarships, another important retention factor for students is funding to attend

professional conferences, such as the Ecological Society of America (ESA) Annual Meeting. Among other activities, the Strategies for Ecology Education, Development and Sustainability (SEEDS) provides travel awards to underrepresented-minority students and their advisors for attendance at the ESA Annual Meeting. SEEDS also provides conference mentors to assist students and advisors in navigating all aspects of this large meeting. For example, mentors guide students in getting the most from attending paper and poster presentations, coping with concurrent sessions, networking, and taking advantage of the social aspects of the conference.

The American Association for the Advancement of Science (AAAS) sponsors a web site, GrantsNet (http://sciencecareers.sciencemag.org/funding), to help students search for undergraduate and graduate fellowships, scholarships and internships through an extensive database of sources.

Provide Effective Mentoring

Underrepresented groups are discouraged from careers in ecology and environmental science by a scarcity of role models and a lack of knowledge about the culture and idiom of science and the academy. Mentoring can be one of the most effective tools in helping to attract, nurture, and encourage students to persist (American Society for Mechanical Engineers 2006).

The Council of Graduate Schools (Zelditch 1990) defines mentors as:

> *"Advisors, people with career experience willing to share their knowledge; supporters, people who give emotional and moral encouragement; tutors, people who give specific feedback on one's performance; masters, in the sense of employers to whom one is apprenticed; sponsors, sources of information about, and aid in obtaining opportunities; models of identity of the kind of person one should be to be an academic."*

This definition of mentoring goes beyond that of academic advising and includes giving support to the whole person.

Faculty and scientists of all races can accomplish effective mentoring of underrepresented groups. Dr. Patrick Limbach (2005) a white chemistry professor at the University of Cincinnati, articulates three general rules for success in working with students of color. First, do no harm: faculty must examine their behavior for actions that seem innocuous but that might be perceived differently by the student. Next, demand excellence but also provide

appreciation for a student's efforts. Finally, Dr. Limbach says it is crucial to take time to understand the culture and background of students.

The Andrew W. Mellon Foundation's Mellon Mays Undergraduate Fellowship program recognizes the mentoring relationships between faculty and students as key to the success and sustainability of its program. At the National Science Foundation, mentoring undergirds its efforts to broaden participation of underrepresented groups. The Undergraduate Research and Mentoring program advocates long-term mentoring opportunities with on-going research projects to give students a richer exposure to ecology and other biological disciplines. This process encourages more students to get PhDs (Baker, 2000).

The Alfred P. Sloan Foundation enlists faculty members as the primary means to facilitate the recruitment and retention of students into the Sloan Minority Ph.D. program. An extensive process is initiated on select campuses to find faculty members with a history of graduating students of color in math and science to serve as mentors.

At OTS, the formal process of mentoring occurs through OTS courses, research experiences, and other structured activities; students also informally interact and connect with senior researchers at the field stations, which provides another layer of learning important to the social, intellectual, and professional development of the scientists of tomorrow. The OTS Research Experiences for Undergraduates (REU) Program is designed for biology students who plan, conduct, and present an independent field research in collaboration with an experienced tropical ecologist. The program supports twelve undergraduates, selected through a competitive application process, for a ten-week research program at the world-renowned La Selva Biological Station in the Caribbean lowlands of Costa Rica.

Programs such as the Ford Foundation Campus Diversity Initiative and NSF's Louis Stokes Alliances for Minority Participation (LSAMP) and Alliances for Graduate Education and the Professoriate (AGEP) all advocate for strong mentoring components as crucial to the personal and professional success of students in

higher education and beyond. In a different approach, MentorNet is an example of an e-mentoring network geared toward increasing retention of women and underrepresented groups in engineering and science; it is available at http://www.mentornet.net/. The American Association for the Advancement of Science (AAAS) hosts another Internet site for mentoring underrepresented minorities in STEM disciplines, the Minority Scientists Network (MiSciNet). MiSciNet is available at http://sciencecareers.sciencemag.org/career_development/miscinet.

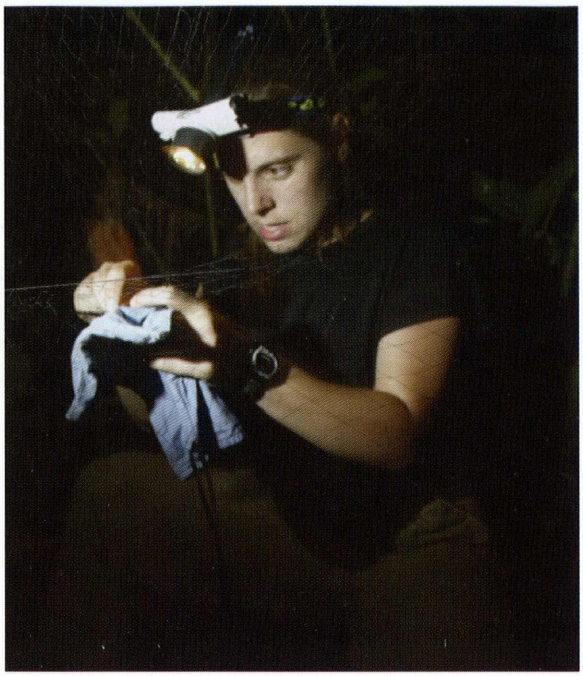
In more narrowly focused efforts, several colleges and universities are examining, improving, and formalizing the mentoring of students and faculty. Some examples of these are:

- University of Michigan (2005 & 2006) Rackham Graduate School has literature aimed at faculty who mentor and at students who want to be mentored: http://www.rackham.umich.edu/StudentInfo/Publications/FacultyMentoring/contents.html http://www.rackham.umich.edu/StudentInfo/Publications/StudentMentoring/contents.html.

- University of Miami School of Medicine (Braunschweiger and Goodman 2004) has a web page on mentoring aimed at their faculty, http://researchedu.med.miami.edu/x16.xml. It includes a section on boundaries (behavioral boundaries?) and a list of other resources.

- University of Massachusetts Amherst Task Force Report on Graduate Student Mentoring (2001) recommends that mentoring be horizontally integrated among all programs and vertically integrated at all educational levels (Lewis 2003).

Mentoring is also important at the professional level (George, et al. 2001) found that barriers to retention and promotion at the postdoctoral and faculty levels include less interaction with peers than their majority counterparts, belief that minorities are hired only because they are minorities, difficulty in attracting grant funding, and lack of an influential sponsor or mentor. If students are ushered by good mentoring through the quagmire of grant-writing, publication of research results, networking, and teaching, many of the barriers would not stand because colleagues would know the individual and his or her work for its real quality. Also, the minority postdoctoral student or faculty member would have a guided first-hand experience with these complex processes, as do many of their colleagues. Just as majority students frequently get postdoctoral positions through their and their advisors' networks, good mentoring for underrepresented minorities includes assisting students with networking for job placement. The University of Michigan Minority Environmental Leadership Development Initiative (MELDI) also fosters and supports mentoring at the career and professional levels.



Make "Hands-On" Research Experience More Accessible

Students should have hands-on research experience before applying to Ph.D. programs in STEM. Graduate admissions committees look for such experience as an indicator for future success in research. Undergraduate research experiences may help students gain acceptance to program, give the scientific experience needed to move directly from an undergraduate program to the Ph.D., and strengthen the quality of graduate-level research. Students obtain hands-on research experiences in a variety of ways, such as working on senior theses, in independent studies, as voluntary or paid laboratory or field assistants, and in formal research programs for undergraduates. Research Experiences for Undergraduates (REU) are discussed in a previous section as initiatives that can provide hands-on research experiences. In the private sector, the Amgen Foundation announced a $25 million initiative to support hands-on undergraduate research experiences to encourage students to pursue graduate degrees and careers in science (www.amgenscholars.com). Participants in the program are involved in research projects at universities across the United States, including MIT, University of California at Berkeley, and Howard University.

Domestic REUs are well established; however, international REUs are gaining popularity as recognition of their importance to training students as globalization increases. While there is a need to examine more rigorously the extent and types of benefits derived from international education programs (Wortman 2002), a number of themes clearly emerge in terms of the potential benefits of international programs for attracting minority students to the sciences. One such theme is the development of global perspectives and global responsibility (Willies and Enloe 1990; Rhodes and Hong 2005). The National Science Foundation recognizes

that scientific and technological research and education are increasingly global in nature (National Science Board 2004). NSF has pointed out the need to include international experiences in research training programs as a means of fostering the development of professional competencies of future US scientists and engineers in that global setting (NSF 2002).

Additionally, alliances that are part of NSF's Louis Stokes Alliances for Minority Participation frequently support their own programs to give underrepresented minorities research experiences at the undergraduate level (Clewell et al. 2006). One of the most successful examples of the LSAMP model is found at Puerto Rico-LSAMP (www.prlsamp.org, Gómez and Piñero, 2006). This is an alliance of the main higher education institutions in Puerto Rico including those of the University of Puerto Rico System that work jointly to strengthen undergraduate education. It is one of the longest running LSAMP programs in the nation and sponsors and co-sponsors a diversity of pre-college, undergraduate and graduate training opportunities. For the past 15 years it has organized the Puerto Rico Interdisciplinary Scientific Meeting (PRISM), the largest local scientific conference for undergraduate and graduate students. In 2006, 455 students (227 undergraduates, 128 graduates) presented their work at these meetings. Four of seven PR-LSAMP Institutions are among the top 25 baccalaureate institutions of Hispanic-American PhDs in the natural sciences for the period of 1999-2004 including the University of Puerto Rico at Rio Piedras, which ranked at the top of the list (NSF, 2001).

More and more employers seek individuals with international experience on their résumés, so such experiences may enhance job opportunities (Dwyer 2004; Lashbrooke 2002). The Institute for International Education (IIE 2005b) indicates that there has been a dramatic increase of participation by US undergraduate students in study abroad experiences. Data show that in the last decade, the number of US students participating in international education programs increased by 129%. With a participation pattern suggesting that study-abroad education has become more attractive to US students, student research-training activities that contain an international component may be an effective recruitment tool for students into ecology and the environmental sciences. Even with this prospect students of color remain underrepresented in study abroad experiences. This phenomenon has prompted more visible discussions within IIE on how to increase student diversity in international activities. Last year the consortium's magazine dedicated an entire issue to topics related to diversity in study-abroad programs (e.g., Dass-Pickard and Ganz 2005; Jackson 2005a).

In 2004, the National Association of Foreign Student Advisers (NAFSA), an association of international educators, began a newsletter dedicated solely to underrepresentation in study-abroad programs (e.g., Jackson 2005b; Slind 2004). A profile comparison of students who attended the Organization for Tropical Studies programs and the students who participated in study-abroad programs nationwide showed that OTS programs have a higher participation of African Americans, Hispanic Americans, and Native Americans relative to the average participation by these groups in study-abroad programs at the national level (Table 3). The data suggest that OTS programs are more successful at recruiting these underrepresented ethnic groups relative to the average study-abroad program nationwide.

IV. Model Programs

Increasingly, more organizations and agencies realize the importance of diversity in the STEM workforce and adopt programs to increase diversity. Ultimately, for a program to succeed, it must fit the needs of the population that it seeks to recruit and retain, and it must fit the special needs of the hosting organization. The approach adopted by a graduate program of a research university will undoubtedly differ from that of an organization that offers independent field courses; techniques used by a small minority-serving college that wishes to develop an ecology major will differ from those used by a federal agency that employs specialized hiring practices to diversify its workforce. However different these programs are, certain common strategies will be shared by all.

While the following list of programs is not all-inclusive, it does provide a wide-ranging sample of some of the high-quality programs and strategies that may be used to identify, recruit, and retain underrepresented groups in ecology and environmental sciences. Although most of these programs focus on STEM fields in general, they can be targeted to support disciplines in ecology and environmental science. The Organization for Tropical Studies program is described in detail as a case study to illustrate the connection between the employment of "best practices" and gains in diversity.

Importantly, model projects go far beyond providing financial aid to students in the form of scholarships and fellowships; these models are successful in constructing and fostering an infrastructure to sustain students at various steps on the academic ladder. Some of the most important features common to many of these projects include: 1) the selection of students from a national pool; 2) the creation and implementation of structured activities to prepare students for the completion of the Ph.D.; 3) financial support for tuition and for related activities, such as professional conferences; 4) opportunities for hands-on research experiences, particularly at the undergraduate level; 5) a strong emphasis on mentoring throughout the academic career; 6) a focus on collaboration and partnerships to implement goals of the program; 7) an emphasis on faculty as key to student recruitment and retention; 8) the fostering of outreach activities with K-12 teachers and students; and 9) tracking of students and evaluation of program goals.

Many successful programs are not listed here because they concentrate on a small pool of students that is limited by geography or institutional affiliation.

Organization for Tropical Studies
A Case Study

The Organization for Tropical Studies (http://www.ots.duke.edu/) is a nonprofit consortium of more than 62 universities, colleges and research institutions from the United States, Costa Rica, Perú, México, South Africa, and Australia. OTS was founded in 1963 with the mission to provide leadership in education, research, and the responsible use of natural resources in the tropics.

For most of its forty-four year history, the OTS education program provided graduate courses and training in tropical ecology. Starting in the fall of 1997, OTS offered its first undergraduate semester-abroad program in Costa Rica. With this initiative, OTS introduced U.S. undergraduate students to a diversity of tropical habitats, the application of the scientific method to ecological inquiry, hands-on inquiry-based study, a broad spectrum of international scientists and their research, the cultural and ethical context of tropical research, and the environmental challenges facing developing tropical nations. Accredited through Duke University, the OTS Undergraduate Program now includes Fall and Spring semester programs in Costa Rica and South Africa, summer courses in Costa Rica, and a Research Experiences for Undergraduates (REU) program in Costa Rica. Students in these programs conduct independent field projects designed to enhance their research skills.

Development of Minority Scholars Program

In 1999, with an initial pilot grant from NSF's Office of International Science and Engineering, OTS offered scholarships (the OTS Minority Scholars Program) to

fund course participation by undergraduates from groups underrepresented in the sciences. Establishment of the Andrew W. Mellon Undergraduate Fellowships Program and the creation of the OTS Advisory Committee for Academic Diversity (ACAD) consolidated the effort in 2001. ACAD is a standing committee of faculty and administrators from Historically Black Colleges and Universities, Tribal Colleges, and Hispanic-Serving Institutions that aids OTS in its diversity efforts in multiple ways.

As a result of these ongoing efforts, OTS welcomed Howard University into the consortium as its first historically black university in May 2004. In August 2004, OTS held a symposium at Howard University that focused on developing strategies for identifying, recruiting, and retaining minorities in environmental and biological sciences. This symposium, entitled "Fostering a Diverse Scientific Community," showcased the research of minority students who received OTS course scholarships and research fellowships, including those from the REU Program. The symposium also highlighted presentations from faculty at minority-serving institutions who worked at OTS research stations in Costa Rica.

An analysis of OTS programs from 2001 to 2006 after the establishment of ACAD showed an overall increase in the number of underrepresented, ethnic-minority participants. African Americans, Native Americans, and Hispanics represented nearly 25% of the undergraduate population during this period. In general, overall student participation in OTS undergraduate programs has tripled since 1999 (Figure 1a); most of the growth occurred after 2001. In 2006, total student participation regardless of ethnic background was still increasing. The percentage of students belonging to underrepresented groups also increased after 2001 but held at approximately 22% in the last four years, except in 2003. In 2003, the percentage fell lower than that in any other year over the last five (Figure 1b). This reduction correlated with the availability of funds to support minority scholars, which were reduced that year (Figure 1c). Overall, the number of student applications to the Minority Scholars Program showed an increase after 2001, and the number of applications always exceeded the funding capacity (Figure 1c). Homologous data are not available for the OTS graduate program.

Minority Participation

OTS data for ethnic groups shows considerable variation in participation rates within and among years (Figure 2). Most increases in minority participation in the OTS undergraduate programs reflect increased participation of African Americans and Hispanics (Hispanics represent a larger increase) between the period of 2002 and 2004 and increased participation of Native American and Pacific Islander students. The percentage of participation by Native American students, in particular, has been erratic and is characteristically lower relative to Hispanics and African Americans between 1999 and 2004 (Figure 2). However in 2005, Native American students were the bulk of participants from underrepresented groups (Figure 2). That year, OTS initiated its innovative Native American and Pacific Islander Research Experiences (NAPIRE), a specialized experience exclusively for Native American and Pacific Island students. The year 2005 was also notable in that the percent participation by Hispanics declined. This reduction was not the result of a reduction in the number of students recruited but an increase in overall student participation in the OTS undergraduate programs, which jumped again in 2005 (Figure 1). While 42.9% of students of color recruited into OTS programs were enrolled in OTS consortium schools, 22.2% were recruited from the Minority-Serving Institutions (MSIs) represented on the OTS Advisory Committee for Academic Diversity, most of which are not OTS consortium schools. Of the Minority Scholars Program alumni, OTS estimates that approximately 75 to 80% of these undergraduates attended graduate or professional schools or jobs in the biological sciences after graduation (Figure 3).

When analyzing the OTS model, the following emerge as crucial strategies for the successful recruitment of underrepresented groups to the OTS undergraduate study-abroad program: 1) implementation of a comprehensive plan for student recruitment; 2) a successful search for external funding in support of student scholarships and fellowships; and 3) implementation of a sound and innovative science curriculum.

Comprehensive plan for student recruitment at OTS

- *Cooperation and coordination* – Cooperation and coordination through an alliance- or consortium-type structure can be one of the most effective tools to increasing the recruitment, retention, and advancement of minorities in STEM disciplines. This approach enables organizations and institutions working in partnership to increase their capacity to disseminate information, deliver services, maximize resources, and provide opportunities for students to move seamlessly from one stage in the process to the next.

  The Organization for Tropical Studies makes use of its more than 62 member-institution consortium to recruit a diverse group of students, identify resource faculty to teach courses, and provide mentors to work with students. The OTS consortium consists of graduate universities, colleges, and research institutions from the United

States, Latin America, Australia, and South Africa, and was formed to promote research, education, and conservation activities in tropical ecology.

To improve OTS' outreach to students and faculty with interests in ecology and the environmental sciences, OTS collaborates with outside organizations, such as the Louis Stokes Alliances for Minority Participation through the Native American Pacific Islander (NAPIRE) REU program. LSAMP has been successful in creating partnerships among colleges, universities, national research laboratories, business and industry, and federal agencies to accomplish their diversity goals and build student interest in science-related fields. Further, the alliance model enables LSAMP to expand learning and teaching strategies through a multidisciplinary approach (Clewell et al. 2006).

OTS has utilized this alliance model by partnering with minority-serving institutions (MSIs) that graduate the highest percentage of undergraduate minority students who go on to earn Ph.D. degrees. Key faculty and administrators from these MSIs have been solicited to assist OTS in the identification and recruitment of students from underrepresented minority groups to participate in the OTS undergraduate programs. Subsequent involvement of the individuals from the MSIs has been at the level of advisement in which OTS enlisted those individuals to become members of a newly developed standing committee to OTS referred to as the Advisory Committee for Academic Diversity (ACAD).

The Alliances for Graduate Education and the Professoriate use a similar approach to build supportive and sustaining infrastructure at the institutional level for increasing the numbers of underrepresented graduate-students who earn Ph.D.s in STEM disciplines. As coordination between LSAMP and AGEP increases, OTS plans to extend its cooperation with AGEP programs to reach more minority graduate students.

- *ACAD*– OTS created the Advisory Committee for Academic Diversity to assist with the recruitment of underrepresented students. ACAD is comprised of faculty and administrators from minority-serving institutions that graduate the highest percentage of undergraduate minority students who go on to earn Ph.D. degrees.

- *Mentoring*– Mentoring activities are important elements for the recruitment and retention of students of color (Woodrow Wilson National Fellowship Foundation 2005; Barlow and Villarejo 2004). A mentor also facilitates the re-integration of students at their home institutions after participation in international experiences (National Science Foundation 2002). During the application process and selection of students, OTS tries to identify mentors at home institutions to give continuity to the OTS experience. If such a mentor for a particular student cannot be identified, an ACAD member is asked to assume that responsibility. During the regular and NAPIRE REU Programs, OTS takes care to pair students with mentors as closely related as possible to their research interest. The NAPIRE program goes a step beyond and offers a pre-course workshop for coordinators and mentors on best-practices for mentoring Native Americans (here broadly defined). Many of the faculty, mentors and teaching resources of OTS programs are from underrepresented groups, although mostly Latin Americans.

- *Multicultural context*– With respect to diversity and minority recruitment, factors that limit recruitment of underrepresented groups may not be uniform across ethnic groups because of differences in cultural context (Ibarra 2001). Before 2005, participation of Native Americans in OTS programs was limited primarily to summer courses, especially the Ethnobiology program. The development of the NAPIRE program increased recruitment from this ethnic group. This program is tailored specifically to Native Americans and Pacific Islanders and combines elements of an REU program (research training) and the Ethnobiology course, which emphasizes the relation between indigenous people and their surrounding resources.

Successful search for external funding in support of student scholarships and fellowships

- *Scholarships and Fellowships*– Beginning with the National Science Foundation's Division of International Programs and the Coca Cola Foundation, OTS engaged in an aggressive grant-writing campaign designed to increase funding opportunities for targeted underrepresented groups. The increased funding allowed OTS to support a larger number of minority students (Figure 1c). Funding for OTS programs has come from many sources including: NSF (HBCU Program, International Programs, and LSAMP), the Hispanic Scholarship Fund Institute, The Roger Perry Endowment, and foundations, such as the Andrew W. Mellon Foundation and the Duke Energy Foundation. The availability of funding has had a clear and strong positive impact on the

participation of underrepresented groups in OTS undergraduate programs.

Development of a sound and innovative science curriculum

- *Field-based, hands-on research experiences*– Most professionals would agree that "learning-by-doing" is the most essential component of research training. This approach engages students in all phases of the research project from inception and design, through data collection, analysis, and presentation of results. A recent study shows that undergraduate research experiences increase the likelihood of graduation from college and the pursuit of graduate studies (Barlow and Villarejo 2004). All OTS programs offer lectures and activities that are complemented with field research activities designed to address issues in ecology and environmental sciences. These activities differ from typical on-campus experiences in that they are tailored to the unique resources available at each field site to facilitate hands-on learning.

- *State-of-the-art biological stations*–OTS field study is done at stations with outstanding infrastructure. Many students from underrepresented groups attending four-year institutions are not typically exposed to state-of- the art facilities at their home institutions. Therefore, OTS provides students with research experiences that allow the students to gain proficiency on equipment currently used in the area of study.

  At many of the stations, funding from NSF is critical to the quality of the facilities. These stations include the world-renowned La Selva Biological Station, which is considered one of the most intensively studied tropical field sites in the world (McDade et al. 1994). It is well known for research productivity, particularly in forest dynamics and biodiversity. OTS makes a concerted effort to include students from non-R1 institutions and community colleges to expose them to state-of-the-art research facilities that typically are not available at these institutions.

- *Diversity of teaching faculty and OTS resources*– The lack of diversity among role models is a major impediment to the effective recruitment of minority students (National Science Board 2004). Fortunately, OTS courses have almost equal numbers of Hispanic [also Latin American] and Caucasian teaching personnel and mentors. The high preponderance of Hispanic resources (from faculty and staff to field sites and cultural issues) within the OTS organization may be one of the factors behind the extensive participation of Hispanic students in OTS study-abroad programs (Table 3).

- *Variety of Opportunities and Specialty courses*– U.S. students enrolled in study-abroad programs show a preference for semester-long and summer programs over year-long programs (IIE 2006b). OTS provides short-term (summer) and medium-term (semester) undergraduate experiences which may be more attractive that to students than year-long opportunities. Since the creation of the OTS-Duke Undergraduate Program, OTS has expanded its semester and summer offerings. Current OTS courses and activities for undergraduates are summarized below:

Summer offerings

The Tropical Ecology Field Course explores tropical habitats and the ecological and evolutionary principles that govern them in a four-week study.

- **Ethnobiology** focuses on the use of plant and animals for medicinal, ceremonial, esthetic, or subsistence purposes in Costa Rica.

- **Research Experiences for Undergraduates (REU)** in Tropical Biology in Costa Rica supports independent research during a ten-week research program at OTS's La Selva Biological Station. Each student has his or her own faculty mentor.

- **NAPIRE** introduces Native American and Pacific Island students to the study of biodiversity and ecological research during a seven-week program at the Las Cruces Biological Station in southern Costa Rica.

Semester offerings

- **Semester Program in Costa Rica** explores tropical field ecology in a 15-week program that includes courses in Spanish and the social sciences, as well as courses in tropical biology and research.
- **Semester Program in South Africa** introduces students to the biological and cultural diversity of South Africa in a 15-week program based in Kruger National Park.

- *Opportunities for effective faculty-student interactions*– The OTS teaching scheme of using multiple faculty resources results in small student-to-faculty ratios and encourages outstanding opportunities for the development of mentoring relationships between students and participating faculty.

Brief Descriptions and Contact Information for Other Model Programs

The Alfred P. Sloan Minority Ph.D. Program

The Sloan Foundation Minority Ph.D. provides scholarships to underrepresented minority students pursuing doctoral work in the natural sciences, engineering, and mathematics. The Foundation selects faculty with a successful record of graduating minority students on their campuses to recruit, mentor, and guide students to the completion of the Ph.D. Scholarship awards vary depending on the completion rate of past students working with particular faculty. Since the program began in 1995, 830 students have participated in the program, 477 are enrolled in graduate school, and 159 have received the Ph.D.

In addition to graduate funding, the Sloan Foundation also makes awards to undergraduate and masters programs that have proven successful as feeder components in sending their students to doctoral programs. The Sloan Minority Ph.D. Program is administered through the National Action Council for Minorities in Engineering (NACME).

Contact: Aileen Walter, Vice President for Scholarship Management, NACME 914-539-4010; awalter@nacme.org
Website: http://www.sloanphds.org/

NSF Alliances for Graduate Education

The Alliances for Graduate Education and the Professoriate began in 1998 as the Minority Graduate Education program of the National Science Foundation, designed to significantly increase earned doctoral degrees in STEM fields by underrepresented populations, and to place these Ph.D. recipients in postdoctoral, faculty, and industry positions. Based on a model similar to LSAMP, the AGEP program fosters recruitment and retention of students through 22 alliances of graduate universities and undergraduate partner institutions.

Although AGEP does provide some fellowship support, the primary emphasis is on building an efficient and effective infrastructure within member institutions that will yield long-term success, such as:

- support for students to attend conferences
- coordinated recruitment among partner institutions
- proactive use of faculty in student recruitment
- development of systemic mentoring and mentor training
- faculty and student exchange programs
- specific preparation for the professoriate
- effective career counseling and career placement

From 2000 to 2005, AGEP institutions enrolled more than 6,036 students and 635 have already earned PhDs.

Contact: Roosevelt Y. Johnson, Program Director, National Science Foundation 703-292-4669; ryjohnso@nsf.gov
Website: http://www.nsf.gov/

The Andrew W. Mellon Foundation Mellon Mays Undergraduate Fellowship Program (MMUF)

Started in 1988, the Mellon Mays Undergraduate Fellows (MMUF) program serves as the centerpiece of The Andrew W. Mellon Foundation effort to increase minority faculty in higher education. Typically, students are selected in their sophomore years and guided through the completion of the Ph.D. Currently 34 colleges and universities, as well as the 38-member institutions from the United Negro College Fund, participate in the MMUF Program.

Central to the success of MMUF is the selection of dedicated campus coordinators and faculty who identify, recruit, and mentor the undergraduate fellows. MMUF offers complementary activities to ensure retention of the participants, such as regional conferences and meetings that allow the fellows to stay connected and on track with the program. By March 2006, MMUF can count over 2,500 alumni and over 170 students who have earned PhDs.

The MMUF Program also addresses the tremendous disparity in ecological fields by placing special emphasis on increasing the number of underrepresented minorities that participate in ecology and the environmental sciences. The UNCF component of the Mellon Mays Program initiated a program with several biological field stations to offer summer research experiences in ecology.

Contact: Lydia English, Program Officer and Director of MMUF 212-838-8400
Website: http://www.mellon.org/
Cynthia Spence, Programs Director for the United Negro College Fund/Andrew W. Mellon Programs
404-270-5686; cspence@spelman.edu

NSF Centers for Research Excellence in Science and Technology (CREST)

Minority-serving institutions account for a significant number of students of color who graduate each year. The Centers of Research Excellence in Science and Technology (CREST) program makes substantial resources available to improve the research infrastructure of minority-serving institutions. CREST promotes the development of new knowledge, enhancements of the research productivity of individual faculty, and expanded diversity of the student population in STEM disciplines.
Historically Black Colleges and Universities-Research Infrastructure for Science and Engineering (HBCU-RISE) is now part of the CREST solicitation. It supports increasing the research infrastructure and fostering the production of terminal degrees at historically black colleges that offer doctoral degrees in STEM fields.

Contact: Victor A. Santiago, HRD Division Director, National Science Foundation 703-292-4673; vsantiag@nsf.gov
Website: http://www.nsf.gov/

Ford Foundation Diversity Fellowships

The Ford Foundation Diversity Fellowships provide support to increase the diversity of higher education faculty and for faculty to use diversity as a tool for enriching the educational experiences of all students. Fellowships are awarded to students at the predoctoral, dissertation, and postdoctoral levels who wish to enter the professoriate. The Ford Foundation Diversity Fellowships program is administered through the Office of the National Research Council.

Contact: Fellowships Office, National Research Council 202-334-2872; infofell@nas.edu
Website: http://www7.nationalacademies.org/fellowships/

NSF Graduate Research Fellowship Program

Sponsored by the National Science Foundation, the Graduate Research Fellowship Program (GRFP) provides fellowships to support the initial three years of graduate school leading to a research-based masters or doctoral degree. Institutional awards on behalf of selected students include a $30,000 stipend, a cost of education allowance of $10,500, and a one-time $1,000 international research travel award. The GRFP is highly competitive. Approximately 1,000 awards are made from about 10,000 applications received each year. This program is open to all students but encourages participation of students underrepresented in STEM fields.

Contact: Grad Research Fellowship Operations Center 866-673-4737; help@nsfgradfellows.org
Website: http://www.nsf.gov/

NSF Graduate Teaching Fellows in K-12 Education (GK-12)

The NSF Graduate Teaching Fellows in K-12 Education brings together the talents and expertise of graduate students and K-12 teachers to enrich the science curriculum and instruction in K-12 education. Concurrently, higher education institutions are offered the opportunity to make lasting changes in their graduate programs by integrating GK-12 activities in the training of STEM graduate students.

Graduate students selected as fellows work directly with K-12 teachers. Both the fellow and the K-12 teacher receive financial support for participation. Fellows are awarded a $30,500 stipend yearly plus $10,500 tuition allowance; teachers receive a stipend of $4,500 yearly for summer educational institutes, travel, or professional development workshops.

Contact: Sonia Ortega, Program Director, National Science Foundation 703-292-8697; sortega@nsf.gov
Website: http://www.nsf.gov/

NSF Integrative Graduate Education and Research Traineeship (IGERT)

The Integrative Graduate Education and Research Traineeship (IGERT) program of the National Science Foundation was developed in 1997 to catalyze a cultural change in graduate education for students, faculty, and institutions. A key feature of this new and innovative model is the emphasis on multi- and inter-disciplinary collaborations that contribute to fostering a diverse and globally-engaged research and education community. IGERT grantees are encouraged to work closely with programs such as AGEP, LSAMP [again, it would be good to have LSAMP before this, since it is referred to here], and others to ensure significant representation of underrepresented groups in the project.

Contact: Carol Van Hartesveldt, Program Director, National Science Foundation 703-292-8696; cvanhart@nsf.gov
Website: http://www.nsf.gov/

NSF Louis Stokes Alliances for Minority Participation (LSAMP)

The Louis Stokes Alliances for Minority Participation (LSAMP) program has 36 alliances located throughout the United States. The alliances focus on encouraging and facilitating access to careers in STEM fields for underrepresented groups. Participants in the LSAMP program benefit from a variety of services geared to the recruitment of minority students and retention of these students through to the successful completion of the baccalaureate degree. For the 2004-2005 academic year, the LSAMP alliances reported more than 24,642 students enrolled. The Urban Institute (Chu Clewell et al. 2006) recently conducted an evaluation of the LSAMP program and concluded LSAMP provided an effective model for increasing the quality and quantity of underrepresented students in STEM baccalaureate programs.

Recently, LSAMP initiated a new component that helps students transition successfully to graduate school. The Bridge to Doctorate (BD) program includes effective strategies that formally connect newly-minted LSAMP graduates to doctoral degree programs at participating universities. The BD program provides financial support in the form of stipends and tuition for the first two years of graduate studies.

Contact: A. James Hicks, Senior Program Director, National Science Foundation. 703-292-8640; ahicks@nsf.gov
Website: http://www.nsf.gov/

NSF Research Experiences for Undergraduates (REU)

The National Science Foundation's Research Experiences for Undergraduates (REU) Program provides undergraduates with the opportunity to participate in research activities in STEM areas. Recognizing the importance of finding meaningful ways to incorporate research activities in the training of undergraduate students, the REU program supports projects that expose students to scientific research to enhance the undergraduate experience and prepare students for graduate school. REU projects can be constructed as site awards, independent projects in which a number of students conduct research, or as supplements to on-going research grants for one or a few students per project. The success of the REU program lies in its focus on mentoring and role modeling as key aspects of the program. NSF strongly encourages the participation of underrepresented groups in this program.

Contact: Sally O'Connor, Program Director, National Science Foundation 703-292-8470; soconnor@nsf.gov
Website: http://www.nsf.gov/

NSF Research Experiences for Teachers Program (RET)

The National Science Foundation's Research Experiences for Teachers (RET) enhances the professional development of K-12 science teachers by providing research opportunities in STEM areas. The RET program serves as an important tool to bring new knowledge and skills to teaching and curricula in K-12.

Contact: Sally O'Connor, Program Director, National Science Foundation 703-292-8470; soconnor@nsf.gov
Website: http://www.nsf.gov/

The Ronald McNair Post Baccalaureate Achievement Program

The Ronald McNair Post Baccalaureate program aims to increase the number of students from underrepresented groups acquiring Ph.D. degrees. McNair is administered through the US Department of Education as part of the Federal TRIO programs. Institutional awards help transition students from the undergraduate and graduate levels to successful completion of the doctorate. Funds can be used for academic counseling, financial aid, mentoring, research opportunities, summer internships, and tutoring. Awards average $236,000 per institution yearly.

Contact: Eileen Bland, Office of Postsecondary Education
202-502-7857; trio@ed.gov
Website: http://www.ed.gov/programs/triomcnair

Strategies for Ecology Education, Development and Sustainability (SEEDS)

Established in 1996, the Strategies for Ecology Education, Development and Sustainability (SEEDS) is coordinated by the Ecological Society of America, a professional society for ecologists. The primary goal of SEEDS is to reduce the disparity of underrepresented groups within ecological fields. SEEDS provides opportunities for students to conduct research through its fellowship program and sponsors underrepresented students and their faculty on SEEDS field trips and to the Ecological Society of America Annual Meeting. SEEDS encourages the development of ecology chapters at participating colleges and universities.

Contact: Ecological Society of America
301-588-3873; seeds@esa.org
Website: http://www.esa.org/seeds

NSF Undergraduate Research and Mentoring in the Biological Sciences (URM)

The Undergraduate Research and Mentoring in the Biological Sciences (URM) Program , formerly Undergraduate Mentoring in Environmental Biology (UMEB), was created to foster greater numbers of diverse students pursuing graduate studies in the biological sciences. Particular emphasis is placed on mentoring and research activities as a way to engage and retain students in biological disciplines.

Contact: Sally O'Connor, Program Director, National Science Foundation 703-292-8470; soconnor@nsf.gov
Website: http://www.nsf.gov/

V. Recommendations for Improvement of Recruitment and Retention of Underrepresented Minorities in Higher Education Ecological and Environmental Sciences

The Advisory Committee for Academic Diversity of OTS recommends several approaches or strategies for improving recruitment and retention of underrepresented minorities in ecology and environmental science for institutions and organizations concerned with higher education. Details of how to implement recommendations are not included here because every organization has its particular circumstances a nd develops an implementation plan to best suit its needs. References throughout the text give contacts that can provide specifics on approaches and strategies; learning successes and failures of other programs helps an organization determine which approaches are best suited for its own implementation.

Each technique is best implemented at certain organizational levels or combinations of levels at an institution. Regardless of whether a strategy is implemented within an academic program, field station, individual course, or by individual faculty, or some combination, all of the concerned parties must maintain close coordination and cooperation for maximum effectiveness.

Recommendations

1. **Expand Outreach to K-12**

   - Improve science curricula through training and professional development of K-12 teachers through RET, GK-12, and other programs designed to integrate learning and ecological research for teachers
   - Expose students to hands-on and experiential learning as early as possible
   - Partner and collaborate with local school districts to coordinate and maximize resources
   - Disseminate information to parents and the general public about the importance of ecology and environmental science
   - Develop special programs and strategies that target students from underrepresented populations

2. **Develop, promote, and support a comprehensive tracking and evaluation plan to measure progress and provide evidence of results at all levels**

   - Identify and provide simple, functional tools for tracking all students, but especially underrepresented minorities, in targeted programs
   - Identify and provide simple, functional tools for tracking students after programs and as they advance in their careers
   - Provide the required resources (e.g., funding, customer support, software) to effectively initiate and continue the tracking and evaluation

3. **Increase funding to provide more hands-on research experiences for students in ecology and environmental science, especially at the undergraduate level**

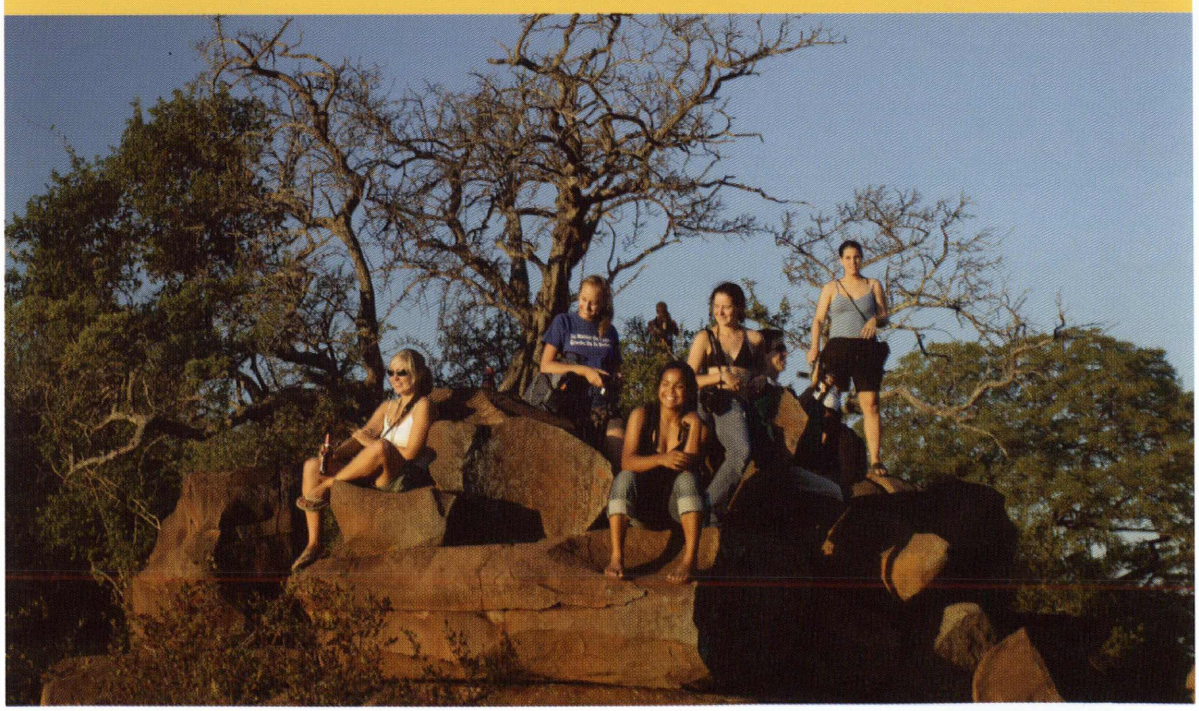
   - Include student funding for participation fees, travel awards, and stipends to participate in international research experiences.
   - Include funding for travel to conferences and meetings
   - Provide research support to allow students to complete projects after the initial field research experience and to support analysis and publication of results

4. **Develop more multi- and inter-disciplinary courses in curricula in order to introduce students in other disciplines to ecology and the environmental sciences and to show the relationship between ecology and environmental sciences to other scientific disciplines.**

5. **Create a mentorship development program for faculty in ecology and environmental science, particularly those faculty members from underrepresented groups, to provide more role models.**

6. **Improve and extend funding for research, education, mentorship, training experiences by creating multi-organizational partnerships and alliances with community colleges, minority-serving colleges and universities, industry, non-profit research organizations, government agencies, and families. These alliances should act synergistically in the diversification of educational and research programs. Specifically, these alliances will:**

   - Cooperate and share in the efficient use of diversity resources.
   - Coordinate activities to ensure that topic areas and approaches remain relevant to a diverse population
   - Coordinate activities to ensure the smooth transition of students and faculty along the career ladder
   - Cooperate to facilitate the movement of students into areas of interest that may be outside the traditional realms of ecology and environmental sciences, but that may be more in line with a particular student's interests
   - Communicate the importance of ecology and the environmental sciences to partners and the general public
   - Track students more efficiently for recruitment and retention purposes



VI. Conclusions

As policy makers and scientists strive to ensure a workforce that can address the diversity of both local and global science issues, the best practices for recruiting and retaining underrepresented minorities into STEM disciplines are being developed and refined. Environmental problems are increasingly global, so ecologists and environmental scientists adapt these methods to improve the strength in numbers and diversity of those who work on ecological and environmental science problems. Experiences of students and professionals in the Organization of Tropical Studies and other ecology programs that have tried these methods give credence to the use of the practices cited in this manual.

The most successful programs show that there are essential items for success in the recruitment and retention of underrepresented minorities in higher education:

- active, whole-person mentoring and encouragement along with visible role models
- partnerships and alliances to make efficient use of all resources, including formal and informal educational and career placement services
- hands-on domestic or international research experiences
- evaluation and tracking programs to measure the long-term success of students in the pipeline
- communication of the relevance of ecology and environmental sciences to society's health and well-being
- funding to cover these programs and for student stipends

Every practice with proven success is closely allied with at least one of these items. Although, implementation may vary by institution or organization, almost every successful program has some component of each of these. Every part of a program supports every other part of the program to make a successful whole.

The critical need to solve environment problems makes it absolutely imperative that ecologists and environmental scientists and policy makers come from a diversity of backgrounds and have a diversity of outlooks in order to bring new approaches and ideas to solutions for environmental challenges. OTS and ACAD believe that implementation of these best practices will help move forward the diversification of the ecological and environmental science workforce and make it possible to resolve pressing environmental problems on a global scale. The authors urge ecologists and environmental scientists and those who support them to work quickly to institute such programs more broadly.

Figure 1 a

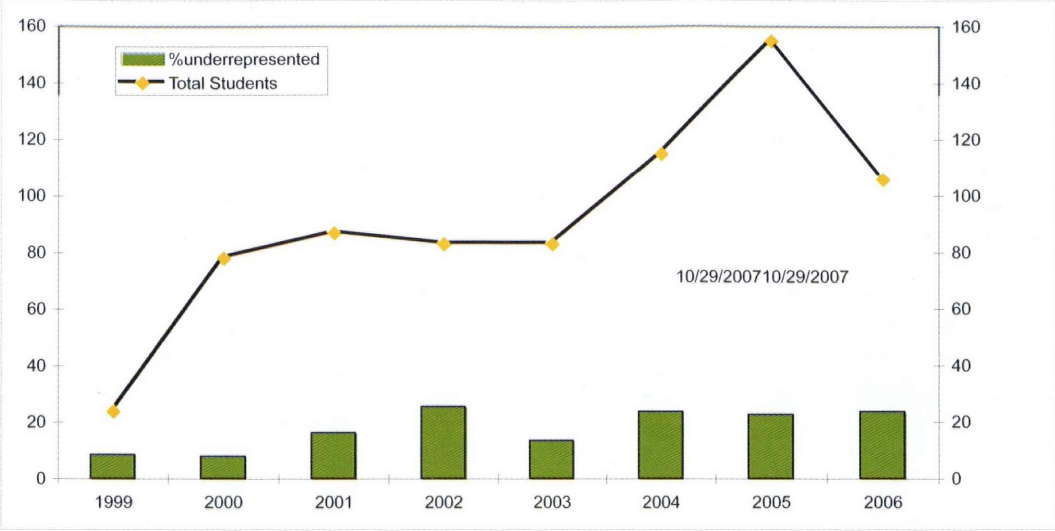


Figure 1 b

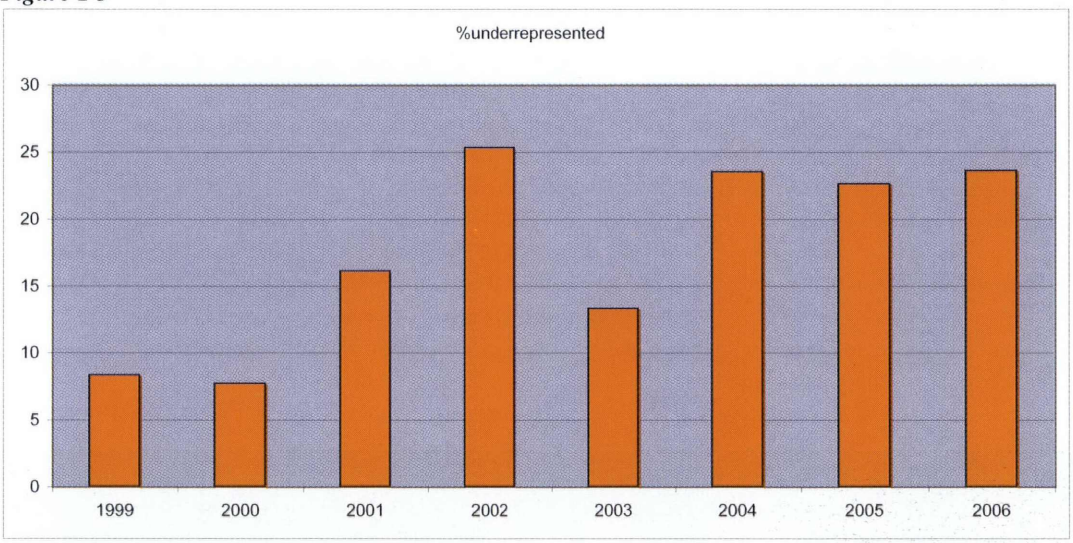


Figure 1 c

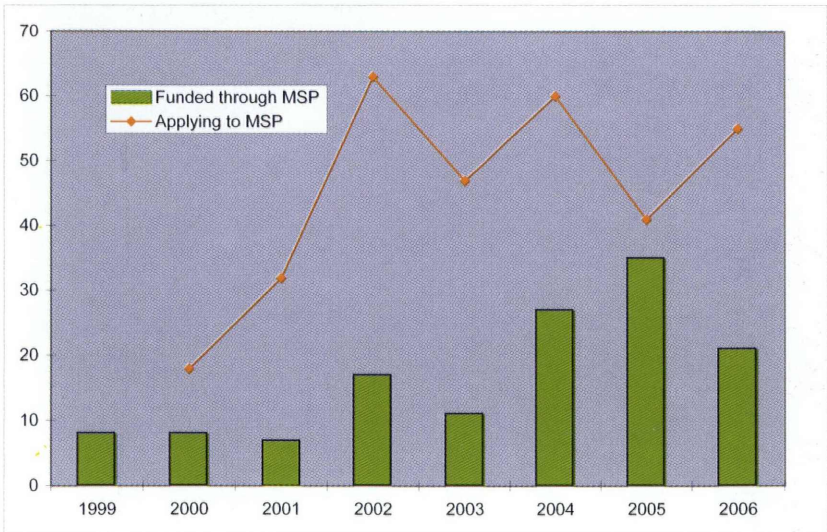


Figure 1. Student participation in OTS undergraduate programs between 1999 and 2005. a) Total number of participants in OTS programs and number of students from underrepresented groups; includes international students; b) Percent participation by underrepresented ethnic minorities in OTS programs since 1999; c) Number of applications and Minority Scholarship Program (MSP) awards between 1999 and 2005.

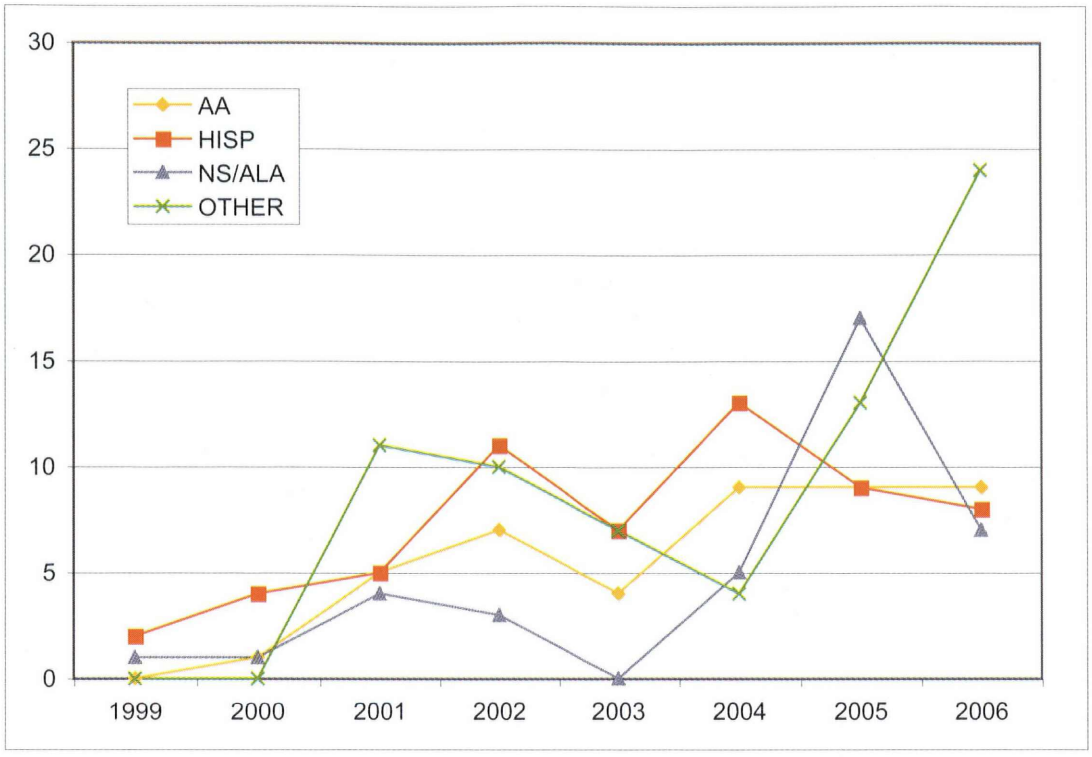


Figure 2. Overall participation of students from underrepresented groups in OTS undergraduate programs. Totals include international students; "Other" includes students of other races, students who declared as multiracial, and students who did not declare their ethnic backgrounds

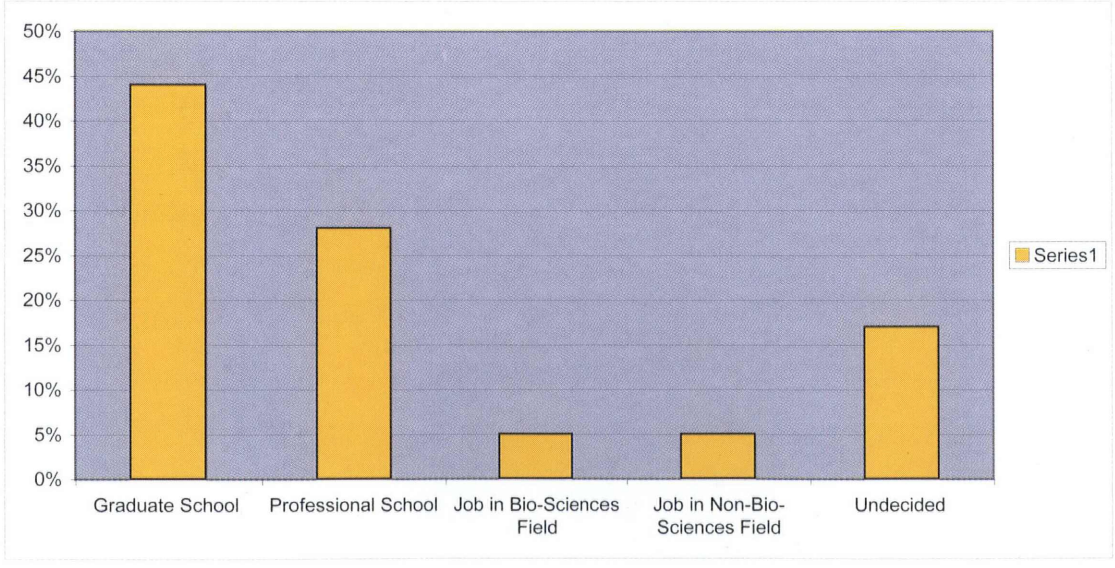


Figure 3. Distribution of post-baccalaureate activities of the 23 OTS Minority Scholars Program alumni (1999 to 2005) who responded to a survey

Table 1. Ethnic profiles of individuals with degrees conferred in Biological and Agricultural Sciences in comparison with those in the general United States population

	US Population[1]	College-Age population (20-24yrs)[2]	Bachelor's degrees Conferred in Agricultural/Biological Sciences [3]	PhDs conferred in Agricultural/ Biological Sciences [3]
	Year 2000	Year 2005	Year 2002-2003	Year 2002-2003
Caucasian	**75.1%**	**64.6%**	**75.4%**	**57.6%**
African American	**12.5%**	**14.0%**	**6.7%**	**2.3%**
Hispanic American	**12.3%**	**16.0%**	**5.2%**	**2.8%**
Native Alaskan and American Indian	**1.0%**	**1.0%**	**0.7%**	**0.2%**
Other	**3.6%**	**4.4%**	**11.9%**	**37.0%**
Total	281,421,906	20,159,000[2]	83,366[3]	6,232[3]

[1] US Census Bureau 2000

[2] National Science Board Science and Engineering Indicators 2006

[3] National Center for Education Statistics (NCES) 2003

Table 2. Ethnic profiles of individuals in STEM-related careers vs. those of the general United States population

	US Population	STEM Workforce	STEM Ph.D.'s Awarded
	Year 2000[1]	Year 1997[1]	Year 2001[2]
White	**75.1%**	**83.3%**	**78.1%**
African American	**12.5%**	**3.2%**	**4.3%**
Hispanic American	**12.3%**	**3.0%**	**4.3%**
Native Alaskan/American Indian	**1.0%**	-	**0.5%**
Other	**3.6%**	**10.2%**	**13.0%**

[1] Wamie II [2] NSF 2001

Table 3. Ethnic profiles of undergraduate students who are U.S. citizens or permanent residents attending OTS and of students attending Study-Abroad Programs Nationwide. "Other" includes Asian Americans, biracial or muliracial, and students not responding

Totals	Study Abroad Nationwide (2001 to 2004)[1]	OTS (2001 to 2004)	OTS (2001 to 2005)
# Students	772,763	495	748
African American	3.5%	6.9%	7.5%
Native American	0.45%	5.9%	8.3%
Hispanic American	5.3%	9.1%	6.0%
Caucasian	83.2%	62.0%	60.2%
Other	7.3%	18.2%	18.0%

[1] IIE 2006a

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