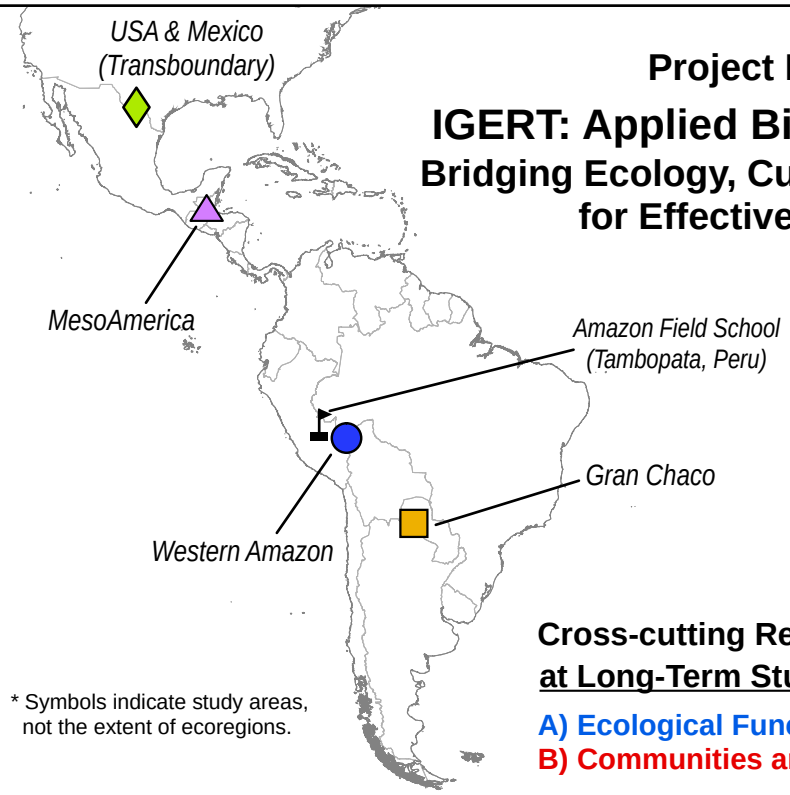


* Symbols indicate study areas, not the extent of ecoregions.

Project Description

IGERT: Applied Biodiversity Science:
Bridging Ecology, Culture, and Governance for Effective Conservation

Cross-cutting Research Themes at Long-Term Study Areas:

A) Ecological Functions and Biodiversity
B) Communities and Governance

Participants	Institution & Department	Research Focus	Geographic Expertise
Team Leaders	Texas A&M University		
Lee Fitzgerald (PI)	Wildlife & Fisheries Sciences	A & B	◆ ● ■
Amanda Stronza (Co-PI)	Recreation, Park, & Tourism Sciences	B	● ■
Kirk Winemiller (Co-PI)	Wildlife & Fisheries Sciences	A	◆ ▲ ●
Urs Kreuter (Co-PI)	Rangeland Ecology & Management	A & B	◆ ■
Thomas Lacher (Co-PI)	Conservation International Center for Applied Biodiversity Sciences	A & B	◆ ●
Faculty Participants	Texas A&M University		
Richard Woodward	Agricultural Economics	B	◆ ▲
Michael Alvard	Anthropology	A & B	●
Gil Rosenthal	Biology	A	◆
James Woolley	Entomology	A	◆ ▲
Christian Brannstrom	Geography	A & B	◆ ■
Wendy Jepson	Geography	B	◆
Andrew Millington	Geography	A & B	● ■
Will Heyman	Geography, Oceanography	A & B	▲
Don Albrecht	Recreation, Park, & Tourism Sciences	B	◆ ■
James Gramann	Recreation, Park, & Tourism Sciences; US National Park Service	B	◆
Donald Brightsmith	Veterinary Pathobiology	A	▲ ●
Thom DeWitt	Wildlife & Fisheries Sciences	A	◆
Frances Gelwick	Wildlife & Fisheries Sciences	A	◆
Leadership Training/Team-Building			
Michael McCormick	Agricultural Leadership, TAMU		
Manuel Piña	Agricultural Leadership, TAMU		

A. Project Summary: IGERT – Applied Biodiversity Science: Bridging Ecology, Culture, and Governance for Effective Conservation

***Intellectual Merit*:** Efforts to halt the loss of biodiversity must incorporate actions at multiple scales. All too often, however, disconnects between disciplines, conservation institutions, and practical implementation hinder effective biodiversity conservation. Most conservation research is based in universities with little interaction between scientists and practitioners, or between theory and practical conservation strategies.

The vision of **Applied Biodiversity Science (ABS)** is to achieve integration between biodiversity research and on-the-ground conservation practices. Three pillars support the program: 1) integrated research in social and biological sciences; 2) cross-disciplinary research and collaboration with conservation institutions and actors in the field; and 3) application of conservation theory to practice. Research teams of faculty mentors and students, in collaboration with international partners, will develop complementary dissertations related to two research themes: **A) Ecological Functions and Biodiversity**; and **B) Communities and Governance**. Research will be conducted in four areas: 1) USA and Mexico (transboundary); 2) Mesoamerica; 3) Western Amazon; and 4) Gran Chaco.

The proposed ABS establishes a new paradigm for graduate education in conservation, building upon research, field experience, and the expertise of faculty and collaborators in biological and social sciences at Texas A&M and throughout the Americas. The ABS IGERT team consists of 20 professors from ten departments in five colleges, with an extensive network of international collaborators and former students working in conservation in each of the four study regions. ABS students will also have access to Texas A&M's internationally recognized biodiversity collections.

***Response to panel comments*:** The revised research themes address biodiversity issues in landscapes and communities beyond as well as within the borders of parks. The broader impacts of potential conservation applications are socially acceptable and ecologically viable. Team-building is enhanced through complementary dissertations and ten points-of-integration in the learning path. The proposed IGERT is open to all qualified students at Texas A&M, and mechanisms are provided to support student participation beyond the number of NSF trainees and to sustain the program.

***Education and Training*:** The ABS IGERT will produce 35 cross-trained PhD scientists from diverse backgrounds with strong disciplinary knowledge and leadership skills for effective interdisciplinary collaborations in conservation. Points of integration include new courses in Applied Biodiversity Science, an Amazon Field School, Cross-cultural Leadership Training, and required internships at national and international institutions practicing biodiversity conservation. Complementary dissertation research is an innovative feature of ABS whereby students will have the opportunity to work together in more than one study region, integrating their research topics to align with the two cross-cutting research themes. Graduates will be prepared to face the multidimensional challenges of global biodiversity loss and will emerge qualified and trained to assume directorships and academic appointments. An agreement with the Peace Corps will help target diverse students with strong academic backgrounds, international experience, and language proficiency. Other successful recruitment models developed for educational initiatives funded by NSF and other federal/private agencies (e.g. REU, UMEB, LSAMP, Sloan, etc.) will be integral to ABS, and the curriculum will be open to all qualified graduate students. Faculty will also be directly involved in the recruitment process.

***Broader impacts*:** By producing scientists equipped to confront transboundary issues and the international biodiversity crisis, significant benefits will accrue to academic, NGO, and government agencies. The ABS-IGERT will lead to greater involvement of underrepresented groups in Applied Biodiversity Sciences; help build local capacity among scientists, communities and institutions in the U.S.A. and Latin America; and directly contribute long-term benefits for biodiversity conservation.

Key Words: Biology, Social Science, Environmental Science, Applied Biodiversity Science.

2. VISION, GOALS AND THEMATIC BASIS

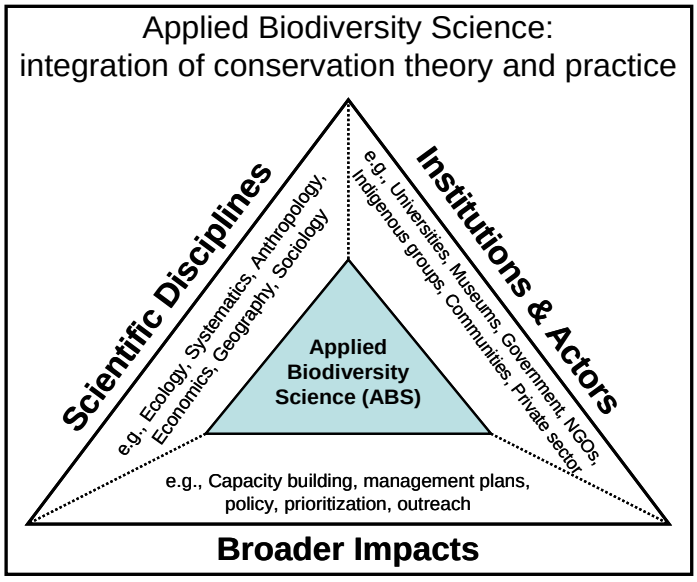
2.1. The Vision of Applied Biodiversity Science — Efforts to halt the loss of biodiversity must be based on integration between science and practice. Linking theory with real-world conservation requires the engagement of universities, museums, governments, nongovernmental organizations, communities, and the private sector, collating information accumulated over several decades. Such collaboration is used to prioritize areas for conservation (Myers et al. 2000), aid in reserve design (Terborgh et al. 2002), develop socially acceptable management plans (Harmon and Putney 2003), build local capacity for stewardship (O'Riordan and Stoll-Kleemann 2002), and guide policy for sustainable use, ecotourism, and other integrated strategies for conservation and development beyond the borders of protected areas (Sayer and Campbell 2004). Currently, a great deal of conservation research is based in universities with few linkages between scientists and practitioners, or between theory and practical strategies for conservation. Moreover, research on patterns and processes that underlie the loss of biodiversity are often conceptual and discipline-specific, with few lessons shared among researchers from diverse disciplines.

Applied Biodiversity Science (ABS) is aimed at integrating basic biodiversity research and conservation. ABS is supported by three main pillars: *1) Scientific Disciplines: disciplinary research in social and biological sciences, 2) Institutions and Actors: cross-disciplinary research and collaboration with conservation institutions and actors in the field, and 3) Broader Impacts: the application of conservation theory to practice* (Fig. 1).

We propose an IGERT in applied biodiversity science (ABS-IGERT) at Texas A&M University to produce 35 Ph.D. scientists over five years. The ABS-IGERT will produce scientists trained to consider not just ecological functions of local ecosystems, but also the activities, attitudes, and needs of surrounding communities, as well as wider social, economic, and political contexts. Texas A&M is poised to be a national leader in the biodiversity sciences, with excellent faculty, biodiversity collections, and a network of collaborators in the Americas.

2.2 The Need for Integrated Training in Applied Biodiversity Science — Because most biodiversity exists in developing countries in the tropics, a challenge for conservationists is balancing ecological goals with social, economic, and political imperatives. This makes achieving biodiversity conservation in the tropics an interdisciplinary endeavor that requires combined input from scientists and practitioners in the fields of ecology, systematics, economics, sociology, geography, anthropology, and others. The complexity of biodiversity conservation presents a daunting challenge to graduate students and their mentors, as well as to progress of the science itself.

Figure 1: Applied Biodiversity Science (ABS) is the integration of theory and practice among three pillars: multidisciplinary research, collaboration among institutions, and application to conservation.



Specialized (single-discipline) doctoral research programs, fragmented graduate curricula, and lack of formal frameworks for interdisciplinary collaboration and graduate training impede doctoral students in conservation science and hinder

development of the kinds of scientists recruited by the international conservation community (Reid et al. 2002). Not surprisingly, few conservationists have been trained to work across disciplines in biodiversity sciences (Jacobson and McDuff 1998). Robinson (2006:666) called for a transdisciplinary approach "where human systems and ecological systems are seen as one system with numerous feedbacks across scales in time and space."

Compounding the problem of biodiversity scholars working in isolation is the fact that scientific theory seldom translates to effective on-the-ground conservation. Training students exclusively at universities often fails to provide opportunities to realize the broader impacts of their intellectual endeavors. Classically trained biologists with field experience in the tropics have a surprising lack of understanding about how biodiversity information can be applied to conservation efforts, or how socioeconomic factors ultimately influence conservation policies. Conversely, many practitioners in sustainable development, ecotourism, and other strategies for conservation are uninformed on basic theories in biodiversity science such as island theory, diversity gradients, and speciation. These gaps highlight the need to integrate theories and methods from a diverse set of disciplines and improve methods for channeling scholarly research into conservation.

In the 20th anniversary issue of *Conservation Biology*, researchers from numerous disciplines ranging from anthropology to zoology called for greater collaboration to address the loss of biodiversity, "the most vexing and serious problem ever to face humanity" (Meffe et al 2006:596). Noted Mexican biologist, Jose Sarukhan (2006:675) wrote, "Conservation cannot be achieved without the soundest information from the natural and social sciences." A persistent issue with regard to the social effects of protected areas is the lack of discourse between social and natural scientists about why social effects matter and how methodologies can be designed to take social beliefs and practices into account prior to management interventions (West and Brockington 2006). This dialogue allows analyses of the complexity of human-environment interactions and movement away from "perspectives that pretend people can be separated from nature" (Folke 2006:686). From our point of view, these disconnects will persist until a critical mass of interdisciplinarians are working in the vision of Applied Biodiversity Sciences.

Biodiversity scientists with skills in interdisciplinary research and collaboration are in demand in academia, NGOs, and federal agencies. "Over one-half of the Senior Executive Service (SES) members at the Department of the Interior (DOI), USDA Forest Service, and Environmental Protection Agency (EPA) will retire by 2007. . . . DOI will lose 61 percent of its program managers, the Forest Service will lose 81 percent of its entomologists and 49 percent of its foresters, and EPA will lose 45 percent of its toxicologists and 30 percent of its environmental specialists" (Renewable Resources Foundation 2003). Meanwhile, scientific understanding is limited among decision makers. The U.S. Congress contains 218 lawyers, 12 doctors, and three biologists (N.D. Kristof *New York Times* 6 Dec 2005). Discovery-based research in biodiversity and biological complexity are priorities at agencies, including NSF. The Society for Conservation Biology website lists 108 academic programs with 815 professorships in environmental conservation (www.conbio.org). Although integrated approaches to conservation in the tropics do occur (Fitzgerald 1994; Lacher and Alho 2001; Stronza 2005) and there are some good models for building integrated graduate education in tropical conservation and development (Inouye and Brewer 2003; Zarin et al. 2003), there remains a great need for doctoral students to obtain more integrated training in order to become cutting-edge biodiversity scientists and conservationists. Graduates of the ABS program will be prepared to face the multidimensional challenges of global biodiversity loss and will emerge qualified to assume directorships and academic appointments to help mitigate this loss.

The stage is set to initiate an ABS-IGERT program at Texas A&M University (TAMU). The ABS-IGERT faculty offers years of experience in biodiversity science, with training and expertise in allied disciplines including conservation biology, ecological economics, cultural anthropology,

human ecology, human geography, evolution, and ecology. We maintain an extensive network of international collaborators and former students working in conservation throughout the Americas. These regions encompass a broad range of ecosystems, social and economic conditions, and conservation strategies. Further, TAMU houses internationally recognized biodiversity collections including the Texas Cooperative Wildlife Collection, Entomology Collection, S.M. Tracy Herbarium, and Biosystematics Center, and is involved in NSF-funded biodiversity research initiatives such as HerpNet, FishNet, Ornis, PEET grants, UMEB, and BRC grants.

TAMU is committed not only to building an integrated graduate program in ABS, but also to *sustaining* it beyond the funding period. The university will provide a substantial institutional support package that includes funding for three additional ABS students (see Sec. 5.2). The ABS team will actively recruit minority students to achieve broad and diverse participation in the program, partly through an innovative collaboration co-developed with the Peace Corps. We will also leverage our past successes in recruiting minority students for educational initiatives funded by NSF and other federal/private agencies (e.g. REU, UMEB, LSAMP, Sloan, etc.). These novel strategies will target diverse students with excellent academic backgrounds, international experience, and language proficiency (see Sec. 7).

***Response to previous panel comments*:** A reviewer of our preproposal pointed out that "Biodiversity and conservation efforts… successful elsewhere in the world (e.g., Africa) have benefited from this type of approach, more through trial and error than purposeful training." This ABS-IGERT is purposeful in this regard; it will prepare researchers of different disciplines to understand and coordinate with each other, linking interdisciplinary teams with institutions and actors in conservation. Revised research themes proposed here address biodiversity issues in landscapes and communities beyond the borders of parks as well as within them. The broader impacts of potential conservation applications are socially acceptable and ecologically viable. Team-building is enhanced through complementary dissertations and ten points-of-integration in the learning path. This IGERT is open to all qualified graduate students, and mechanisms are provided to support student participation beyond the number of NSF trainees and to sustain the program.

2.3 Products, Outcomes, and Broader Impacts — The ABS-IGERT curriculum and recruitment plan contains twelve mechanisms to produce interdisciplinarians with strong academic backgrounds (detailed in Sec. 4.2). The recruitment and retention plan builds on prior minority recruitment successes at TAMU to help ensure broad participation by a diverse pool of students. Students will take a core set of interdisciplinary courses, including a two-semester, team-taught course in Applied Biodiversity Science, and will attend an Amazon Field Course, develop complementary research within and across study areas, and collaborate with local partners to achieve broader impacts of their research. Trainees will complete internships at Conservation International's Center for Applied Biodiversity Science (CABS), or at any of 17 other government and non-government institutions in Latin America (as indicated by letters of commitment).

<u>Products</u>

1. A total of 35 Ph.D. graduates from diverse backgrounds who have strong interdisciplinary knowledge in Applied Biodiversity Science (ABS), with leadership and cross-cultural skills for effective scientific collaboration in applied interdisciplinary conservation programs;
2. A curriculum in ABS, open to all graduate students at TAMU, with *institutional support for more than the number of NSF-funded trainees*;
3. An ABS learning community, open to all faculty and students across disciplines at TAMU;
4. Student/advisor teams conducting complementary dissertation research linked to two overarching themes: a) Ecological Functions and Biodiversity; and b) Communities and Governance;
5. Internships at Conservation International's Center for Applied Biodiversity Sciences (CABS), with additional options at more than 17 partner institutions in Latin America;

6. Annual ABS research symposium, widely advertised with open participation;
7. Student involvement in the Ecological Integration Research Symposium at TAMU;
8. ABS-IGERT website with recruitment information, research activities, and course materials;
9. Integrated social and ecological data on biodiversity conservation available to other researchers, conservation managers, and collaborators;
10. Peer-reviewed publications on biodiversity science and conservation;
11. Results of ABS-IGERT presented in national and international conferences and workshops;
12. Findings of ABS-IGERT research applied to conservation policies and programs.

Outcomes

1. Placement of ABS-trained scientists in academia, government, and NGOs;
2. A sustained program in Applied Biodiversity Science at TAMU;
3. Enhanced collaboration among academic and NGO scientists and conservation stakeholders in the U.S. and abroad;
4. Strengthened interdisciplinary programs, departments, and colleges at TAMU;
5. Internationalization across departments and colleges at TAMU;
6. A diverse and broad network of biodiversity scientists and strategists dedicated to cross-disciplinary and cross-national collaboration for biodiversity conservation;
7. ABS-IGERT students and faculty trained to use their research findings to influence and implement biodiversity conservation.

Broader Impacts

1. Greater involvement of underrepresented groups in Applied Biodiversity Sciences;
2. Capacity-building of local counterpart scientists and institutions in host countries;
3. More effective communication between biodiversity scientists and conservation practitioners;
4. Long-term benefits for biodiversity conservation in the U.S.A. and Latin America.

3. MAJOR RESEARCH THEMES

ABS-IGERT research will focus on two cross-cutting themes: A) Ecological Functions and Biodiversity; and B) Communities and Governance. Interdisciplinary teams in four geographic locations will use the three-pillar ABS approach (multidisciplinary research, collaboration among institutions, and application to conservation) to integrate scientific findings with practical conservation efforts by local institutions and actors.

A. Ecological Functions and Biodiversity: Ecosystem services upon which human welfare and survival depend rely on properly functioning ecosystems (Daily et al. 1997; NRC 2004). Resilience is a critical characteristic of healthy ecosystems, and biodiversity is a key determinant of ecosystem resilience (Holling 1973; Walker et al. 2002). By identifying underlying interactions among ecosystem components, scientists will better understand the mechanisms that produce important ecological services, and thus more accurately calculate the intended outcomes and feasibility of management actions (Jeppesen et al. 1998). ABS faculty research programs draw from fields of population and community ecology, ecological morphology, phylogenetic systematics, behavior, landscape ecology, and biodiversity assessment to address various conservation issues, such as habitat requirements of single species, determinants of local and regional diversity, and mechanisms determining the fate of invasive and native species. Better understanding of the linkages between biodiversity and ecosystem function is critical to facilitate ecologically meaningful policy decisions (Arrington & Winemiller 2006).

Research in *Ecological Functions and Biodiversity* is aimed at the following types of questions:

- What local and historical processes determine presence and distribution of biodiversity?

- How is biodiversity tied to ecological function? and How are both altered by what people do?
- What are mechanisms influencing the fit between organism and environment?

B. Communities and Governance: This theme focuses upon the study of conservation as a social process, the success of which depends on participation and cooperation of local communities, government agencies, NGOs, indigenous federations, scientists, and the private sector (Brosius et al. 1998). Each interest group has its own set of priorities, visions, and perspectives for addressing conservation. These inherent differences, magnified by power disparities, can be major obstacles to collaboration. Thus, greater understanding of politics, institutions, and incentives of multiple actors at different scales is critical for effective conservation (Painter and Durham 1995). Agrawal and Ostrom (2006:682) have argued that understanding and strengthening governance systems at relevant scales is perhaps "the most important challenge of the next century for biodiversity conservation."

Research in *Communities and Governance* addresses the following types of questions:

- How do political, economic, and historical relations of power and inequality at different scales explain uses and values of biodiversity?
- How do institutional and organizational arrangements affect access, use, and protection of biodiversity?
- Under what conditions can adding economic value to biodiversity create incentives for conservation (e.g., ecotourism or sustainable use of wildlife and fisheries)?

3.1 Study Area Selection — Questions like those posed above will be addressed by faculty-student-collaborator teams in four geographic areas: 1) U.S. and Mexico (transboundary); 2) Mesoamerica; 3) Western Amazon; and 4) Gran Chaco (see map). These areas were selected based on long-term research and established partnerships with communities, governments, and NGOs. Each field site represents a microcosm of larger conservation and development challenges. All have networks of protected areas surrounded by communities (ranging from subsistence to urban) that are engaged in conservation and resource use through varying forms of governance.

Despite commonalities, there are striking differences between the four areas with respect to biological, cultural, socio-economic, and institutional characteristics. In addition, resource management challenges and international perceptions of conservation priorities vary. For example, the Western Amazon is considered a biodiversity "hotspot," while the Gran Chaco receives less attention because of its relatively low species richness and endemism. Although ultimate causes of biodiversity loss (e.g., land change, invasive species, poverty) play a role in each region, the proximal causes and interactions play out differently in each area. In Mesoamerican freshwater systems, for example, environmental degradation and invasive species are top conservation priorities, while in the Western Amazon and the Chaco, outright deforestation is of greater concern.

Conservation strategies may not be transferable among regions, but the differing perspectives of the interacting students and faculty in this ABS-IGERT program will help test the assumption. For example, community-based ecotourism seems to be working in the Western Amazon, but is unlikely to be an economically viable conservation strategy in the harsh thornforests of the Gran Chaco. Sustainable use of wildlife and indigenous co-management of protected areas are elements of conservation success in the Chaco (Arambiza and Painter 2006), yet these approaches may not be applicable in other areas, especially where land tenure regimes are unstable. The geographic foci will provide research teams with opportunities to compare their findings both within and among areas.

3.2 Complementary Dissertation Research — The **ABS-IGERT** will implement the three-pillar model of applied biodiversity science (Fig. 1) through **Complementary Dissertation Research.** Student/advisor teams working within both Major Research Themes (A and B) will

address the multifaceted causes and consequences of biodiversity loss and potential conservation applications in the research areas. Each dissertation will represent a solid disciplinary contribution, but will be linked to other dissertations that share the broader impacts for biodiversity conservation.

Complementarity in research is not presumed to be automatic. Ten points of integration embedded in the learning path ensure that student/advisor groups communicate regularly, share research findings, and participate in symposia focusing on conservation efforts (see Sec. 4.1). Student/advisor teams will work on Complementary Dissertation Research during the ABS I and II courses (year 1), the Amazon Field school (year 1), Cross-cultural Leadership Workshops (year 2), required peer-review of dissertation proposals during Reading Group (on-going), and presentations during ABS Annual Research Conference. A key mechanism to achieve the vision of ABS revolves around students in each Major Research Theme (A and B) working together and with the same local institutions and actors throughout their graduate training to achieve broader impacts of their research.

Research Integration Process **— The IGERT proposal writing process has already catalyzed integration of the 20 ABS faculty. We met in plenary and in subgroups over the past 1.5 years to produce a synthesis of our expertise and research approaches in ABS.** We identified the causes and consequences of biodiversity loss that we address with our collective field experience and research programs. Next, we categorized the research approaches we use. Finally, we produced a research integration matrix to help us (and the panel) see three things: (1) The diversity and breadth of our research in biodiversity sciences; (2) Overlapping strengths in the two Major Research Themes; and (3) Emergent trends and opportunities for complementary ABS research (Fig. 2).

In many instances (shaded areas in Fig. 2), the ABS team has a strong track record of integration. For example, ABS faculty who specialize in biodiversity assessment, community ecology, and landscape ecology apply their research to understanding land use change and habitat loss. Similarly, the pervasive issue of overexploitation (with negative feedbacks to poverty, access, and equitability) is addressed by faculty who employ six distinct research approaches in both Major Research Themes. Nevertheless, achieving the vision of ABS requires the creation of stronger linkages and further integration among biodiversity scientists. Within our matrix, empty boxes represent some of the most persistent disconnects in the field of biodiversity science, and illustrate key opportunities for new integrative research by TAMU ABS-IGERT faculty and students.

Training ABS students who will “fill the boxes” entails mentoring in social science approaches for answering questions relevant to ABS themes of Ecological Functions and Biodiversity and conversely, mentoring in methods and insights from biological sciences to inform research in Communities and Governance. For example, the empty box in the matrix that represents the intersection between participatory/community-based studies and environmental degradation identifies a research opportunity for ABS-IGERT trainees. We can envision collaboration between one student working with Rosenthal (biology) and another student with Stronza (anthropology) to produce complementary dissertations related to community-based biomonitoring of indicators of health or disturbance of an ecosystem. Biology students would use data from biodiversity and behavioral assays to design monitoring methods, and then in collaboration with anthropology students could develop and implement community-based monitoring. In tandem, the anthropology students could evaluate the efficacy and level of acceptance or rejection by local residents. The application to conservation would be to build the capacity of local communities to measure and monitor environmental conditions and invasive species.

Another complementary set of studies might use approaches from landscape ecology to understand the causes and consequences of overexploitation of species. ABS faculty, including Alvard (anthropology), Fitzgerald (ecology), Woodward (economics), and Millington (geography) foresee working with students to explore the spatial and behavioral consequences for species that are

Figure 2. The research integration matrix shows the breadth and diversity of research approaches among the 20 ABS-IGERT faculty. Research approaches in the Major Research Themes (columns) are applied to causes and consequences of biodiversity loss (rows). The shaded boxes highlight our strengths in assembling complementary teams of scholars. Empty boxes highlight critical areas for more ABS research among student/advisor teams.

Participant Expertise Within and Across the Two Primary Research Themes										
			Research Approaches							
			A. Ecological Functions & Biodiversity				B. Communities & Governance			
			Biodiversity assessment	Population & community ecology	Evolutionary, phylogenetic, behavioral studies	Landscape ecology	Historic & ethnographic studies	Demographic studies	Participatory & community-based studies	Ecological & resource economics
Causes and Consequences of Biodiversity Loss Addressed	A. Ecological Functions & Biodiversity	Land-use change & habitat loss	***Fitzgerald Gelwick Lacher Winemiller Woolley***	***Brightsmith Fitzgerald Gelwick Heyman Lacher Rosenthal Winemiller***		***Brannstrom Lacher Millington***	***Jepson Stronza***	***Gramann Kreuter***	***Fitzgerald Kreuter Lacher***	***Kreuter***
		Invasive species	***Fitzgerald Winemiller Woolley***	***Fitzgerald***	***DeWitt Rosenthal Woolley***			***Kreuter***		
		Declining range size & diminishing populations	***Fitzgerald Gelwick Lacher Winemiller Woolley***	***Brightsmith DeWitt Fitzgerald Gelwick Heyman Lacher Winemiller***	***Brightsmith Gelwick***	***Fitzgerald Lacher***				***Woodward***
		Environmental degradation	***Kreuter***	***Gelwick Lacher Winemiller***	***DeWitt Gelwick Rosenthal Winemiller***	***Lacher Millington***		***Kreuter***		***Woodward***
	B. Communities & Governance	Inequalities in biodiversity access			***Alvard***	***Millington***	***Alvard Stronza***	***Albrecht Kreuter Gramann***	***Heyman Stronza Lacher***	
		Poverty & social conflict				***Brannstrom Jepson Millington***	***Stronza***	***Albrecht Heyman Kreuter***	***Heyman Rosenthal Stronza***	***Kreuter Woodward***
		Over-exploitation		***Brightsmith Fitzgerald Gelwick Winemiller***	***Alvard***		***Alvard Stronza***	***Heyman***	***Fitzgerald Heyman Kreuter Stronza***	***Kreuter Woodward***
		Deteriorating governance structures & policies	***Kreuter***			***Brannstrom Millington***	***Brannstrom Jepson Millington Stronza***	***Albrecht Gramann***	***Fitzgerald Heyman Kreuter***	

hunted for subsistence and commercial use. One student could study the conditions under which certain species are more or less suitable for sustainable use, while another could explore the impacts of markets upon hunting. A third could assess land-use to determine the size of indigenous reserves suitable for subsistence-based harvesting, and a fourth could evaluate how hunters select prey and the processes by which decisions change over time.

Below we describe ongoing research in the four study areas, using the matrix to graphically represent links between our diverse experience, expertise, and local contacts. Then we identify new pathways to cutting-edge research and describe novel approaches for effectively mentoring students

via complementary dissertations. We first review the conservation challenges and opportunities in each region, and then offer ideas that link theory in biodiversity science to conservation practices.

USA and Mexico (transboundary) (Albrecht, DeWitt, Fitzgerald, Gelwick, Jepson, Kreuter, Lacher, Rosenthal, Winemiller, Woolley, Woodward)

Overview: The U.S. borderland is an area of high cultural and biological diversity, coupled with great disparities in wealth, technology, and capital. Complex political, environmental, and social problems are impinging upon ecosystem functions that affect agriculture, wildlife, water quality, and human livelihoods. Along the extensive border between Texas and Mexico, the conservation challenges range from maintaining wilderness and endangered species in a biodiversity hotspot, to mediating conflict over logging and fire suppression, to dealing with water scarcity in the face of rapid land use change.

The California Floristic Province, the Baja, Sonoran, and Chihuahuan desert complex, and the high elevation pine-oak woodlands all have exceptional biotic diversity and conservation importance, making the borderlands between the United States and Mexico an area of increasing concern to conservationists (Dinerstein et al., 1995; Mittermeier et al., 2002). The largest conservation area in the region, the Big Bend-Carmen Conservation Corridor, includes over 1.5 million hectares spread among 12 protected areas, six on each side of the border. Other major parks and protected areas also occur outside of the corridor.

Changes in the annual fire regimes in the conservation corridor either by suppression or excessive burning, are also impacting natural habitats. Fire suppression in combination with widespread increase in livestock grazing pressure has led to the conversion of open grasslands and savannas to closed canopy woodlands across much of Texas (Archer and Smeins 1991; Archer 1994). For example, fire suppression has transformed native Ponderosa pine savanna forests into closed mixed conifer stands. In the high elevation forests the major threat is legal and illegal logging. Between 50 and 67% of these forest are gone and the remainder altered. Several species are extinct locally (Mexican wolf, Mexican grizzly bear), or globally (Imperial woodpecker).

On the border region of the Lower Rio Grande/Bravo Valley of South Texas and Northern Mexico the conservation issue of greatest concern is water scarcity. Beginning with Mexico's industrialization-led economic development of the 1960s, the region has become a magnet for rural labor, resulting in considerable urbanization. Since 1990, this transboundary area has moved from an agricultural economy toward an industrial-oriented economy that tends to concentrate demands for water. Acute water scarcity is giving rise to social conflicts. Legal and institutional frameworks for managing water, created in the first half of the 20th century, are outmoded. In sum, the combination of rapid demographic change, urbanization, and economic restructuring has altered the entire region's environment.

***Opportunities for Complementary Doctoral Research*:** TAMU has a long legacy of collaborative research and teaching with Mexican institutions. TAMU and the *Consejo Nacional de Ciencia y Tecnología* (CONACyT), for example, have an agreement in place to fund transborder cooperation in research and graduate student training. In research under the theme of Communities and Governance, Jepson and Brannstrom (geography) are co-PIs on a current TAMU/CONACyT grant to study water governance and land-use change in the transboundary region. ABS students will use high-resolution aerial photography to estimate rates and patterns of rural-urban transformation. Complementary dissertations will analyze local community responses to land use transformations, and concomitant shifts in formal and informal systems of water governance. Kreuter and other TAMU faculty are currently conducting an integrated assessment of the ecological, economic, and social implications of reintroducing fire as a management tool in Texas. Fire reduces woody brush encroachment, with positive feedbacks for water quality and water infiltration.

Collaboration by Gelwick (ecology) and colleagues from the Universidad Autónoma de Nuevo León focuses on watershed integrity, ecological functions, and conservation of threatened native fishes in the face of agricultural and urban development. Winemiller's (ecology) lab has researched the ecology of endangered fishes and their environments in Texas drainages of the Rio Grande Basin, focusing on effects of exotic species (e.g. Valdes Cantu and Winemiller 1997; López-Fernández and Winemiller 2005). Together, these complementary dissertations will inform environmental policy and water management activities in the Texas and Mexico border regions.

In the Big Bend-Carmen Corridor, ABS faculty and Mexican colleagues have a track record of research in biodiversity assessment and community ecology (e.g., Dayton and Fitzgerald 2001; 2006). Both the US and Mexican sides of the border contain a mix of public and private lands of varying conservation status. Complementary dissertations will involve definition of biological priorities for protected area status (Fitzgerald and Lacher) and studies of mechanisms for corridor-level conservation involving public-private collaboration under differing cultural and economic contexts (Kreuter, Woodward). Conservation corridors are the next great challenge to effective biodiversity conservation, and this region provides an excellent scenario for investigation of the most appropriate biological, social, and economic processes to facilitate conservation activities (Koleff et al. 2004).

Mesoamerica (Brightsmith, DeWitt, Heyman, Rosenthal, Winemiller, Woodward, Woolley)

***Overview:* –** The region stretching from central Mexico to Costa Rica spans a continuum from one of the world's largest mega-cities, through rural mestizo villages to remote indigenous communities, and from high-altitude deserts to lowland tropical rainforests and coral reefs. Diverse government and community responses to conservation challenges in Mesoamerica provide rich opportunities for integrative conservation research. ABS faculty are conducting research at three locations: Mexico's eastern Sierra Madre, the eastern Yucatan Peninsula of Mexico, and the ridge-to-reef system of coastal Belize (e.g. Heyman et al. 2005). Much of the current research is conducted by biologists on topics related to ecological functions and biodiversity. To achieve broader impacts for conservation in these areas, more social science research on communities and governance is needed.

Population growth and development have dramatically impacted Mesoamerica. For example, in the Riviera Maya, Quintana Roo, Mexico, human impacts include groundwater drawdown and contamination, and changes in river flow regimes. Recreational demands are inducing habitat modifications, species introductions, and growth of infrastructure leading to habitat decline and severed connections among habitat remnants. At the other end of the spectrum is the rural municipality of Calnali (population about 20,000) in the foothills of the eastern Sierra Madre, Mexico, populated by several primarily Nahua-speaking indigenous communities. The surrounding Huasteca region is biologically unique, with distinctive limestone topography and dozens of endemic species. The region is a prime candidate for ecotourism, but discharge of raw sewage into natural bodies of water has devastated many areas and created a health hazard for local people (Fisher et al., 2006). Firewood harvest, which destroys habitat and accelerates erosion, also threatens biodiversity in this region. Federal and local regulations prohibit both sewage discharge and unmanaged logging, but infrastructure and enforcement are lacking.

Turning to marine ecosystems, the Mesoamerican Reef (MAR) is the second largest reef in the world, stretching 720 km along the western edge of the Caribbean. A World Heritage Site, the area provides critical habitat for rare and endangered species, such the whale shark, West Indian Manatee, American crocodile, hawksbill turtle, and green turtle. This reef contributes significantly to the economies of Guatemala, Belize, Mexico and Honduras, primarily through tourism and fishing. Unfortunately, it is threatened by over fishing, unregulated tourism development, sedimentation, and widespread coral bleaching. Recognizing the values of the reef, the four countries launched the

Mesoamerican Barrier Reef Initiative in 1997 to promote conservation and sustainable use of the reef. The centerpiece of this program is a network of marine protected areas. The MAR provides an excellent opportunity to practice ABS through study of bleaching resistance, spawning aggregations, connectivity, and sustainability in a network of marine protected areas (Gibson et al. 2004).

Opportunities for Complementary Doctoral Research: Several ABS faculty have field sites in Mesoamerica. Rosenthal and DeWitt (ecology) investigate how human impacts on water bodies affect communication systems, and evolutionary diversification of fish populations. Rosenthal's group showed that two endemic swordtail fish (Xiphophorus spp.) in the Huasteca region of Mexico were hybridizing because pollution disrupted chemical communication channels (Fisher et al. 2006). Collaborative research in these labs is currently dissecting the functional genetic responses to gradients of disturbance in the hybrid zone. Complementary dissertation topics abound. Students under Albrecht (sociology) or Stronza (anthropology) can study how the degradation of these same aquatic systems affects local livelihoods and water policy in and around the community of Calnali. This cadre of student and faculty researchers will then be equipped to inform local institutions and actors who are working to solve these conservation problems.

ABS faculty have ongoing research on fisheries and coral reef conservation in the Mesoamerican Reef. Students under Heyman (oceanography) can study marine resources, especially the breeding aggregations of commercially important reef fish species. Social science students may evaluate needs and concerns of fisher and coastal communities and how local institutions, such as fishing cooperatives, can benefit co-management efforts of marine reserves. Winemiller's lab is analyzing food web structure along the ridge-to-reef elevation gradient in southern Belize using stable isotope methods. This study compares adjacent watersheds, one pristine and the other intensively cultivated. Undergraduate students from underrepresented groups have been heavily involved in this project under the NSF UMEB training grant. His lab also is collaborating with local scientists to research comparative ecology of fishes in southeastern Mexico and Belize.

One of most socially and ecologically relevant subjects for complementary dissertation research in this region is the social, economic, and ecological effects of ecotourism. For example, spawning aggregations on reefs are vulnerable to overfishing. Ecotourism has been proposed as an economic alternative, but to be viable, the benefits of ecotourism must be greater than the costs. Complementary studies could include: ecological studies of the effects of dive tourism on fish behavior and spawning (Heyman's students); economic cost/benefit analysis of tourism versus fishing (Woodward's students); resource allocation studies of stakeholders (winners vs losers) (Kreuter's students); social effects of changing from fishing to tourism (Stronza's students).

Western Amazon (Alvard, Brightsmith, Fitzgerald, Lacher, Millington, Stronza, Winemiller)

Overview – The Western Amazon basin is one the most biologically diverse regions on earth (Foster et al. 1994; Terborgh et al. 1990) and is marked by great human diversity, including uncontacted indigenous peoples, legally-titled indigenous communities, second-generation colonists and mestizos, Aymara and Quechua-speaking colonists from the highlands, and international ecotourists (Chicchon 2001). It is one of the most pristine regions in the Americas, largely due to lack of transportation and access. There are over five million hectares of government protected areas, a size greater than the total land area of Costa Rica (INRENA 2005). This includes the Bahuaja-Sonene National Park and Manu National Park in southeastern Peru. However, threats from logging; gold mining; over-harvesting of game, fish and forest products; expansion of ranching; coca cultivation; and wildlife trafficking are continually increasing (Alvarez and Naughton-Treves 2003).

People are also being impacted. Indigenous and long-established communities face challenges of new settlers claiming their territories. There is little support from regional and national governments, poor access to credit and extension services, low prices and unstable markets for produce, poor

infrastructures for education, health and transportation, and loss of cultural identity in the rapidly modernizing area (Coomes and Barham 1997; Takasaki et al 2001). Recent plans for the Trans-Oceanic Highway connecting the heart of the Peruvian Amazon to markets in Lima and Brazil threaten to end the isolation that has protected this area (Naughton-Treves 2004). Similar plans exist to connect cities to the western Amazon in Bolivia, a change that will have significant ecological and social ramifications in the coming decades. In some areas this process is just beginning, and there is still time to mitigate some of the effects of road building.

Opportunities for Complementary Doctoral Research — Ecotourism has exploded in parts of the region, bringing the promise of diversified economic alternatives and livelihoods, along with the possibility of unregulated growth negatively impacting local cultures, communities, and wildlife (Kirkby et al 2000; Stronza 2001). Stronza and Brightsmith have conducted research on ecotourism, providing ABS students with opportunities to integrate social, economic, and ecological analyses of ecotourism. Stronza has been working with farmers, indigenous federations, tourism operators, and local communities since 1993, studying impacts of ecotourism on local livelihoods, natural resource use, and cultural identity (Stronza 1999, 2005). A major focus is changes in governance and community-based institutions for conservation that result from ecotourism. Working at the same sites, Brightsmith (ecology) investigates effects of ecotourism on population and community ecology of macaws, parrots, and other avifauna (Brightsmith 2005). Related ecological research on reptiles, amphibians, and mammals can be initiated by ABS students working with Lacher and Fitzgerald.

Complementary studies in the Western Amazon can draw on ABS faculty expertise in tropical food-web ecology and fisheries management (Winemiller), resource economics (Woodward), human ecology (Alvard), and population ecology (Fitzgerald, Lacher, Brightsmith) to compare direct uses of wildlife (hunting, fishing) with indirect uses (ecotourism). For example, Alvard (anthropology) has conducted long-term research among subsistence hunters to test the hypothesis that native peoples are “natural conservationists” (Alvard 1993, Redford 1990). His students can examine the conditions under which local resource users choose to voluntarily conserve more imperiled resources (like slowly reproducing primates, Hodson et al.1995) and focus their efforts on more sustainable and easily managed resources (like fast breeding peccaries, Alvard et al. 1997). This information would then be fed directly back to collaborators and other stakeholders in the region.

An integrative study on the impacts of mercury-based gold mining on aquatic ecosystems would address a major conservation and human health problem in the region. Winemiller uses food-web approaches to examine ecological dynamics in tropical rivers and to address ecological hypotheses with direct applications to fisheries management and, ultimately, to the livelihoods of local fishers (e.g, Winemiller 2005, Layman et al. 2005). Aquatic biodiversity is critically important for human welfare throughout Latin America because inland fisheries in tropical regions provide a cheap source of animal protein for low-income people in rural and urban areas (Arthington et al. 2005, Allan et al. 2006). ABS students studying ecological economics with Kreuter and Woodward will complement the studies of Winemiller’s students by evaluating cost-benefit trade-offs in different fisheries management scenarios. These dissertations will also lead to emergent collaborations among ABS students: comparison of the impacts of ecotourism on local people and its impacts on wildlife, relative importance of different economic activities in local communities and their potential, and economic evaluations of fish management versus gold mining for local people.

Large-scale development projects like the Trans-Oceanic Highway threaten to open wilderness areas of the Amazon for colonization and exploration. Millington (geography) and Lacher (ecology, Conservation International) study the relationships between road construction, colonization dynamics and the spatial patterns of forest fragmentation using remote sensing combined with social and economic survey techniques (Savitzky et al. 1994; Millington et al. 2003). Advisor/student teams will work together to synthesize, through complementary dissertations, the impacts of land

fragmentation on biodiversity at multiple spatial scales. Emergent collaborations among these students and those working on ecotourism in the region will then be able to explore alternatives to road-related unsustainable resource exploitation. In turn these findings will link to the formulation of conservation priorities and policies through the broad array of established regional collaborators.

Gran Chaco (Albrecht, Brannstrom, Fitzgerald, Kreuter, Millington, Stronza)

Overview: The Gran Chaco, in Paraguay, Bolivia, and Argentina, is a tropical dry forest and the third largest biome in South America. Rates of deforestation of the Gran Chaco equal or exceed global trends — 85% of original lowland and montane Chaco forests were cleared over the last 30 years (Zak et al. 2004). The abundant biodiversity of the Gran Chaco has been under-appreciated by the conservation community, perhaps because species numbers are higher in Amazonia, and media focus is on rainforests. In fact, Neotropical drylands support more endemic mammals than does Amazonia (Mares 1986) and species richness of mammals >1kg in the Chaco is almost as high as in the most speciose Amazonian sites (Redford et al. 1990).

Land use varies among the three countries, creating a panorama for studying and understanding impacts on the Chaco in relation to different economies, development histories, and national policies. Deforestation for ranching, agriculture, and fuel led to conversion of much the Argentine Chaco by the mid-20th century, primarily because of demand for beef for European markets, and demand for railroad ties and fuel for the Argentine railroad system (Schofield and Bucher 1986; Grau and Brown 2000). What remains of the Argentine Chaco is largely a fragmented mosaic of land uses.

Ranching and unsustainable agriculture are also problematic for the Chaco forests in Paraguay. The Paraguayan Chaco remained largely unsettled until the 1980s, with the exception of the Menonite colony of Filadelfia established in the 1920s. The rapid expansion of Filadelfia and neighboring Menonite colonies in the 1980s led to deforestation, rapid salinization and desertification. Menonite leaders are now implementing sustainable land use practices. Forest clearing in Paraguay is also associated with the Trans-Chaco Highway. A critical conservation locus for the Paraguayan Chaco is the Parque Nacional Defensores del Chaco near the Bolivian border. Efforts have been initiated to link this park with adjacent conservation areas in the Bolivian Chaco.

Parts of the Bolivian Chaco remain relatively isolated and undeveloped, but extensive areas have been deforested for export-led soybean cultivation, and by Menonite colonies and Bolivian and expatriate ranchers. The result is environmentally unsustainable modern agriculture alongside economically unsustainable traditional resource-use systems. Rapid changes are resulting from the Bolivia-Brazil gas pipeline (Pató 2000) and associated rail and road links. The Chaco in Bolivia is especially notable among conservationists for having one of the world's largest protected areas co-managed by indigenous people. The 3.4 million hectare Kaa-Iya del Gran Chaco National Park, on the Bolivia-Paraguay border, is administered by the Capitanía de Alto y Bajo Izozog representing some 9,500 Guarani Izoceños in 25 communities. The Izoceños own >300,000 ha of adjacent territorial lands, which they use for hunting and resource extraction (Arambiza and Painter 2006).

Opportunities for complementary doctoral dissertations: One set of complementary dissertations in the Gran Chaco will examine the effectiveness of community institutions for monitoring and managing biodiversity. Fitzgerald has led research teams at long-term study sites in Paraguay, Argentina, and Bolivia since 1980, focused on community-based biodiversity monitoring and sustainable use of wildlife as a conservation strategy (e.g., Fitzgerald et al. 1991, 1994). In the Bolivian Chaco, our collaborator, Dr. Andrew Noss, Wildlife Conservation Society, implemented a program to train local Izoceño, Ayoreo, and Chiquitano hunters to work as para-biologists, who self-monitor wildlife use in their communities and carry out field research on target species (Painter et al. 2003). Fitzgerald (ecology) is working with these communities to implement sustainable use of *Tupinambis* lizards, red-footed tortoises, and peccaries. Variation in how the 25 Izoceño communities

are engaged in the conservation process creates a model system for integrative study. For example, how do wildlife populations respond to varying types of community-based management? Several ABS dissertations in ecology may be developed comparing population dynamics of target species, and makeup of ecological communities across a spectrum from unregulated use to full protection. These ecological studies will be closely tied to social science research on the ways in which communities govern wildlife use in the Chaco by students of Albrecht (sociology), Kreuter (ecological economics), and Stronza (anthropology). Students in Millington's lab (geography) will take a landscape ecology approach by incorporating remote sensing tools and GIS-based modeling to add spatial context to understanding variance in the effectiveness of community-based approaches.

ABS students working under Millington, Kreuter, Stronza, Albrecht, and Brannstrom will also conduct complementary research on the history, drivers, and patterns of land cover change in the three countries to research the role of different development histories and governance regimes on biodiversity in the Gran Chaco. For example, in contrast to the indigenous co-management of conservation areas in Bolivia, the Paraguayan Chaco is characterized by predominantly private landholdings and isolated national parks that are off-limits to locals. Understanding the effects of such differences in governance on land use is critical because, to be successful, biodiversity conservation requires not only locally effective conservation programs but also broad geographic linkages among such programs. Construction of the Trans-Chaco Highway may preclude the integration of regional biodiversity conservation initiatives. Therefore, the transboundary region that encompasses the Kaa-Iya del Gran Chaco and Defensores del Chaco national parks in Bolivia and Paraguay, respectively, provide an ideal opportunity to examine variations and potential complementarities or conflicts among land uses, communities and governance structures.

4. EDUCATION AND TRAINING

We project 35 doctoral students will enter the program over five years; funding is requested from NSF for 18 trainees. TAMU is committed to helping us build this program, and is enhancing the IGERT with three additional traineeships fully funded at the NSF level that we can use to recruit premier ABS students from Latin America (letter). **Additional participants will be funded by Graduate Diversity fellowships, Sloan Foundation Minority Doctoral Fellowships, Regents Scholarships, Graduate Merit Scholarships, TAMU teaching and research assistantships, NSF-predoctoral and graduate minority fellowships, and foundation funding**. Our partnerships with NGOs and other institutions will also provide potential recruits to the ABS-IGERT. The ABS curricula and activities, including the Amazon Field Course, ABS core courses, ABS Seminar, the Reading Group, and all integrative mechanisms, ***are open to every graduate student who meets the program requirements***. **Students will be taught how to seek funding for participation in the Amazon Field School from the L.T. Jordan Institute for International Awareness at TAMU (http://ltjordan.tamu.edu/), from Graduate Program Enhancement Funds, and from other in-house and external sources.**

4.1 Team-building and Learning Path — The goal of the ABS-IGERT training program is to produce interdisciplinarians with strong disciplinary backgrounds, whose research addresses the banner questions in the ABS themes. The program differs from traditional programs in environmental studies, conservation, and ecology because we facilitate teamwork between students and faculty from the moment their research is formulated through data collection and application of results to on-the-ground conservation efforts. Building international collaboration is also critical because the biodiversity crisis requires an international response. Therefore, we have designed several strategies to build international collaborations, explained in greater detail in Section 9.

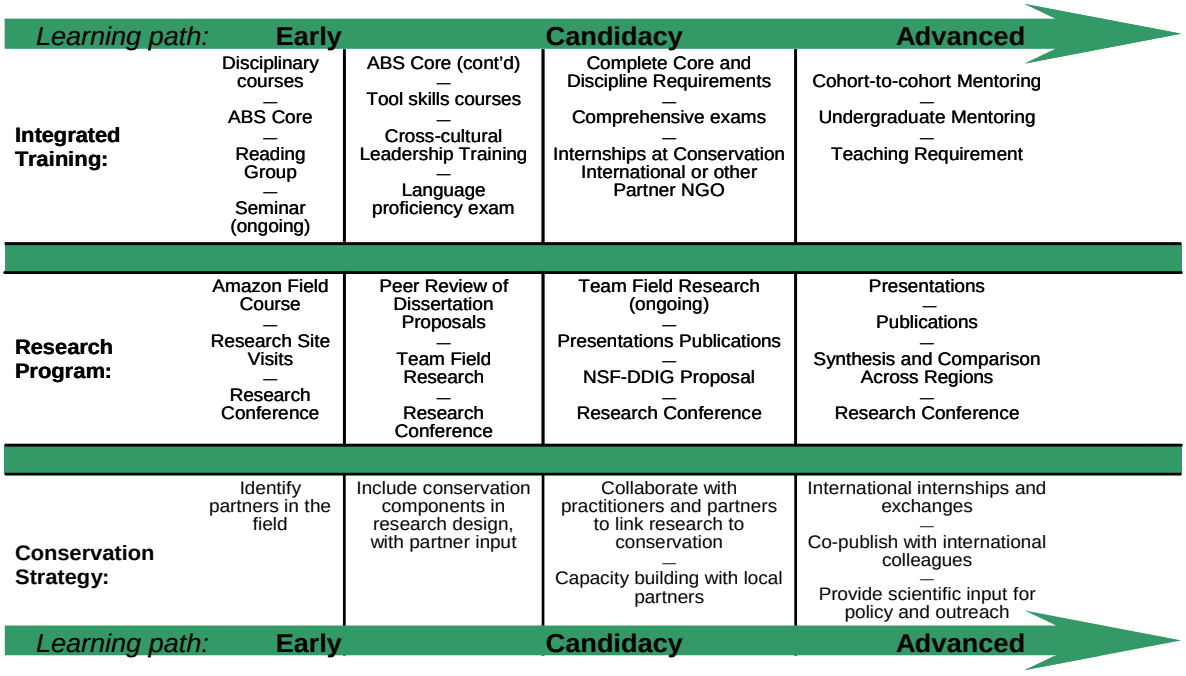
The ABS learning path (Fig. 3) creates positive feedback between cross-disciplinary coursework, complementary dissertation research, and the application of scientific findings to conservation in Latin America, effectively integrating the three pillars of the ABS model.

Ten points of integration are embedded in the learning path:

- New two-semester core courses: Applied Biodiversity Science I and II
- New three-week Amazon Field School
- Cross-cultural Leadership Training and student-to-student mentoring
- Required peer review of dissertation proposals during Reading Group meetings (ongoing)
- Application of research with partners at study areas
- Required internships at institutions practicing biodiversity conservation (e.g. CABS)
- Annual research symposium for ABS students, faculty, and international collaborators
- Participation in existing research symposia (i.e., TAMU Ecological Integration Symposium)
- ABS invited Research Seminar (through participating departments)
- Weekly ABS Reading Group

A focus on Complementary Dissertation Research throughout the students' learning path will encourage collaborative exchanges among teams working in each of the four geographic regions. Students will experience the Western Amazon during the field school and then conduct their research in one of the four regions. This means that in the course of their graduate careers, ABS students will have the opportunity to work together in more than one region. The collaboration *across regions* will facilitate synthesis and comparison of results in Major Research Themes.

Figure 3. The ABS-IGERT students follow an integrated learning path that addresses the three pillars of Applied Biodiversity Science. Each stage includes key integrative features designed to link the training, research, and conservation pillars. Broader impacts such as international capacity building, minority involvement, and incorporation of undergraduate researchers are natural outcomes. Columns correspond to years in a 4-year program, recognizing that because of international field work, individual students may alter their semester schedules.



Progression of the Learning Path: Early Stage (Year 1) — Students will concentrate on disciplinary requirements and the ABS Core Curriculum. The ABS Core ensures that students receive rigorous theoretical training in both social and natural sciences. Students will participate in the ABS Research Seminar and weekly Reading Group, which are open to all graduate students and faculty. A key integrative activity during the early stage is the ABS Amazon Field Course (Year 1, Summer). This intensive three-week course in Tambopata, Peru, will immerse students in the theory and practice of ABS, including methodologies for biodiversity assessment and monitoring, and analysis of integrated conservation and development projects (see Field Course description in Section 9). Following the field course, students will visit research sites to initiate international collaborations. The ABS Coordinator will work with students and their advisors to facilitate site visits and identify research partners at NGOs, in communities, local universities, and other institutions.

Progression of the Learning Path: Candidacy Stage (Years 2-3) — Integrative features at this stage include initiation of fieldwork and building research partnerships with conservation actors and institutions in the field. Also during the candidacy stage, students will be required to participate in three Cross-Cultural Leadership Workshops and attend monthly Leadership Seminars. These activities will lay the foundation for future ABS professionals to serve as leaders in conservation while also working effectively in teams. Leadership and cross-cultural training will be in the second year, following the Amazon Field Course and site visits. By then, students will have gained an appreciation for improving their communication skills, especially to work in other cultural settings. This will enable them to bring their own perspectives and experiences from the field to leadership training. Additionally, leadership skills will be developed through mentoring of undergraduates and fellow graduate students. By the time Cohort I students are reaching candidacy, they will be able to mentor those in Cohorts II and III. Faculty participants will rely on past experience in NSF-REU and UMEB grants to get undergraduates involved in the ABS training program. ABS graduate students will also have opportunities to mentor undergraduates through research, the Reading Group, and teaching. By the end of year two, students will finish the core curriculum, the disciplinary requirements, a research prospectus, and the language proficiency requirement. Upon reaching candidacy, students will prepare funding proposals and be encouraged to submit NSF-DDIG proposals with their advisors. **The weekly Reading Group provides on ongoing forum for peer review and discussion of students' proposals and manuscripts.**

Progression of the Learning Path: Advanced Stage (Years 3-4) — At the advanced stage, students will fulfill an internship at an institution engaged in the practice of biodiversity conservation. Students will be able to choose among internship opportunities at Conservation International headquarters in Washington, D.C., and at collaborating institutions in each of the geographic regions (see Training Mechanism 7 below; Table 1).

Advanced students should be fully immersed in their fieldwork, presenting at meetings, fulfilling a teaching requirement, and starting to publish. Advanced ABS students will be well prepared for productive internships and exchanges with collaborators and institutions. Before graduation, ABS students will have formed their own independent international collaborations and will be making their research findings available to the conservation practitioners, land managers, communities, and NGOs with whom they have partnered.

4.2 Training mechanisms to link the three pillars of ABS — We have designed 12 integrative training mechanisms to link the three pillars of ABS and build a community of ABS scholars that will reach far into the academic and conservation community (Fig. 1). All students will emerge from this program with theoretical and practical training necessary to make new contributions to ABS research themes.

1. **Disciplinary Training** — We expect ABS students to enter the program with a well-developed set of skills. We predict most of the students will have master's degrees, although an M.S. degree is not a strict requirement. Students will need to meet departmental requirements.

2. **ABS Core Curriculum** — ABS students will be required to take the first two courses and choose two others. All courses are interdisciplinary and will be based in different departments. Thus, ABS students are required to take four interdisciplinary courses from four departments.

a. **NEW:** Applied Biodiversity Science I. Required (Fitzgerald-Stronza-Winemiller team-taught) — Ecological Functions and Biodiversity; Conservation Genetics; Metapopulations; Landscape Ecology; Ecosystem Management. The course is organized around modules: 1) Biodiversity Module–Classic patterns of Biodiversity; Speciation and Extinction; 2) Population Module–Conservation Genetics, Forms of Rarity, Metapopulations, Minimum Viable Populations; 3) Landscape Conservation Module–Landscape ecology, Reserve design, Ecosystem management; and 4) Sustainability Module–Sustainable use approaches to conservation, Community-based approaches.

b. **NEW:** Applied Biodiversity Science II. Required (Stronza-Fitzgerald-Kreuter team-taught) —In this course students will: 1) examine linkages between varying forms of governance and biodiversity; 2) analyze interactions between social systems and ecosystems at local, regional, and international scales; 3) identify the interests and needs of diverse stakeholders in conservation programs; and 4) critically evaluate social, economic, and environmental trade-offs of various conservation strategies.

c. Ecological Economics (Kreuter) — Critical evaluation of policies in natural resource development and use; identification of problems in resource development, the political-economic decision-making processes, and analytical tools which can contribute to economic decisions.

d. Human Evolutionary Ecology (Alvard) — Evolutionary ecology of human behavior and culture, including habitat choice and use of space, time allocation, resource acquisition and allocation, sex and reproduction, altruism and cooperation, and the coevolution of genes and culture.

e. Geography of Latin America (Brannstrom) — Examination of geopolitics, both past and present. Through the lens of environmental geography, students learn about neoliberalism, trade relations, globalization, immigration, and local livelihoods in Latin America.

3. ***NEW*: Applied Biodiversity Sciences Amazon Field Course** — IGERT faculty will lead a three-week Amazon Field Course in the Tambopata National Reserve and Bahuaja Sonene National Park in Madre de Dios, Peru, during the first summer for each cohort. Objectives of the course are to: 1) provide direct, experiential learning in ABS concepts and principles; 2) engage ABS students in projects representing ABS research themes; 3) teach field research methods; and 4) connect ABS students with local organizations and practitioners. The Field Course will serve as the experiential phase of the students' learning path before they embark on their own doctoral research projects (see Section 9, International Collaboration for more details on the Field School).

4. **Research Site Visits** — ABS students will visit future dissertation field sites following the ABS Amazon Field Course. Site visits are justified by the need for students to initiate collaborations, obtain research permits, establish rapport with locals, understand logistical constraints of their field sites, and begin data collection. In most cases, study sites will be areas where mentors are currently working so that students can build upon mentors' programs. Our network of Latin American colleagues ensures that students will be taking advantage of contacts already in place, enabling them to choose appropriate study sites and address locally relevant and critical research topics. Faculty will work with local collaborators to secure in-kind support for students.

5. **Language Proficiency** — Language skills are a must for field-based and community-based interdisciplinary research in Latin America. We expect ABS-IGERT applicants for the program to possess good foreign language skills in Spanish or Portuguese. The Department of Hispanic Studies offers a range of courses in Spanish and Portuguese that are available to students in

need of additional training. ABS students will be required to pass a language proficiency exam administered by a collaborating language instructor.

6. Cross-cultural Leadership Training Workshops and Seminars — Leadership is necessary to link the three pillars of ABS: multidisciplinary science, collaboration with multilevel institutions and actors, and the achievement of broader impacts for conservation. That is, biodiversity scientists must learn the skills of leadership to make theory and strategies work effectively among a variety of institutions, actors, and ideas (Cannon et al. 1996). The objective of the Cross-cultural Leadership Training is to develop leadership skills of ABS students to enable them to fulfill leading roles in national and international conservation organizations and institutions of higher learning. ABS students will be trained to open channels of communication, find commonalities, bridge divisions, and broker solutions for more effective biodiversity conservation. Leadership Training is composed of workshops and conferences, as described below:

Self-Leadership and Direct-Leadership Workshops: The *goals* of this three-day workshop, conducted early in the first semester of Year 2, are to: *1) increase the self-awareness of the ABS students*, and *2) to train the ABS students to work in teams and to provide leadership*. A group effectiveness model will help students accurately observe different factors that contribute to successful team performance. Students will receive feedback on their group dynamics and will explore how cultural differences influence interpersonal and group performance. Following the workshops, students will have a personal development plan, and will conduct a group project involving a real-world problem based on one of the ABS Research Themes. The personal development plans and group problem-solving project will be shared with the project directors, assessment team, and ABS students. Executive Leadership Workshop: The *goal* of this three-day workshop, conducted during mid-semester of Year 2, is to *enable students to lead other leaders*. The importance of networking and systems-thinking as processes for leading leaders will be stressed, planned, and practiced. By the end of the workshops, students will have completed an action plan detailing how leadership skills may be used in their own ABS research program.

Partners Research Conferences: The *goal* of these one-day conferences is to *permit all ABS students to convene and reflect on the original intent of the IGERT*, and the *important role that relevant research, teamwork, and leadership play in society's effort to achieve biodiversity conservation*. Each Cohort of ABS students will participate in three, one-day conferences of the course in Years 1 and 2. By design, there will be some overlap among students in these conferences, allowing Cohort I to interact in this setting with Cohort II, etc. The *product* from these workshops will be a summary of discussions held during the conference, highlighting the central themes discussed and agreements reached about those themes. The summary will be shared among the project directors, assessment panel, students, and other ABS faculty.

Multicultural Leaders and Scholars Academy: These monthly meetings at TAMU are sponsored by three colleges, with the *goal* of *enabling graduate students to compete effectively for careers in academia, government, and private industry*. Example topics are: a) excelling in graduate school, b) developing leadership skills, and c) preparing adequately for employment. The format is a mix of lectures, workshops, field trips, policy-setting seminars, and faculty mentoring.

7. Internships at Institutions Practicing Biodiversity Conservation — Our extensive network in the study areas ensures multiple opportunities for internships and professional development experiences (Table 1; letters). In addition to their dissertation research projects, ABS students will obtain professional development experience at an institution in the country where they are doing research. Internships will last at least four weeks. Project collaborators will pledge in-kind support and opportunities for internships, and students will build on their mentors' collaborations (Section 9). Fitzgerald, for example, will introduce students to partners working on sustainable use of

wildlife and community-based conservation in the Chaco Ecoregion in Paraguay and Bolivia where he has worked for 25 years. Lacher and Winemiller will facilitate partnering for students working on research questions related to conservation prioritization through the CABS network of biodiversity monitoring field stations in Mexico, Amazonia, and Mesoamerica. Stronza's long-term study sites and network of colleagues in the Western Amazon will be available for students testing hypotheses about outcomes of community-based approaches to biodiversity conservation. The Center for Applied Biodiversity Sciences (CABS) and other units at Conservation International will provide professional development experiences to ABS students through internships and participation in ongoing projects, giving them real-world experience in a conservation NGO based in the USA. The attached letter of support lists the names of mentors and 10 research topics for CABS interns. Internships strengthen both the students' doctoral research and the ABS-IGERT by broadening the pool of students who may apply to ABS-IGERT and by potentially employing graduates of the program.

Table 1. Institutions that may receive interns in the four study areas and the USA. Our collaborators at government, non-government, academic institutions ensures multiple internship opportunities for ABS students.

Conservation Institution	Conservation Institution
U.S.A.	**Western Amazon**
Conservation International, CABS, Washington D.C.	Rainforest Expeditions, Inc., PE
U.S. National Park Service, Washington, D.C.	Conservation International-Ecuador, Quito, EC
MesoAmerica	Conservation International-Bolivia, La Paz, BO
Friends of Nature & Nat. Park Service, BE	San Jose de Uchupiamonas Community Leaders, BO
Toledo Inst. for Development and Environment, BE	**Gran Chaco**
Ecocolors, Ecotourism company, Sian Ka'an preserve, Yucatan, MX	Wildlife Conservation Society-Bolivia, Santa Cruz, BO
Amigos de Sian Ka'an, Yucatan, MX	World Wildlife Fund-Paraguay, Asuncion, PY
Mexico (transboundary)	CABI, Indigenous governing body, Santa Cruz, BO
Conservation International -MX/Mesoamerica	Guyra Paraguay (NGO), PY
Francisco García de León, CIBNOR La Paz, MX	Noell Kempff Museum, Santa Cruz, BO

8. Ecological Integration Symposium — Now in its eighth year, graduate students, with support from the interdisciplinary research program in Ecology and Evolutionary Biology, invite prestigious speakers for a one-day lecture series organized around a cutting-edge theme in evolutionary ecology and conservation. Graduate students raise >$20,000 annually from departments and colleges for this event. The symposium has raised the bar for ecologically-based science at TAMU, and has resulted in tangible benefits for students who get a chance to interact with the speakers. ABS students will be involved in the organizing committee of this nationally recognized event. Previous speakers are listed at http://wfsc.tamu.edu/symposium/index.html.

9. Applied Biodiversity Science Annual Research Conference — An annual ABS Research Conference will take place the day after the Ecological Integration Symposium (described immediately above). **ABS students at all stages will be expected to present their ongoing research.** The conference will be designed, advertised, and run by ABS students and open to all researchers. Selected speakers from collaborating institutions in the four study areas will be invited. By combining this event with the Ecological Integration Symposium, it will be easier to attract student and faculty participation from outside of TAMU. The annual ABS Conferences will lead to inter-institutional collaborative projects; co-authored papers and conference presentations; work in professors' labs at collaborating institutions; and sharing laboratory and biodiversity collections resources among institutions. These outcomes will be part of the Assessment Plan (section 6 below).

We have already initiated collaboration with the Tropical Conservation and Development (TCD) Program at the University of Florida, which supports this ABS-IGERT (letter). Their current Working Forests in the Tropics IGERT provides an ideal connection to our program. We will develop proposals for joint conferences that would lead to a book publication on biodiversity conservation in Latin America. Such interactions add value to the IGERT network.

10. ABS Seminars — Engagement in invited seminar programs is an integrative group activity that will help build a community of ABS scholars. We do not request funding for this activity; rather, we will link to existing seminar programs in the 10 departments. **The ABS Seminar Committee,** made up of ABS students and one faculty advisor, will coordinate invitations and advertise to the ABS community. Benefits of this activity will be to get students immersed in groups of faculty and students outside their home departments, and exposed to different conceptual frameworks, methods, types of data, and presentation styles among disciplines.

11. Reading Group — **The Reading Group is the forum for required peer-review of dissertation proposals.** In addition to peer review of each other's proposals and manuscripts, students will choose articles and lead discussions. Reading Group discussions will educate and keep students informed on the history and current state of biological and social science disciplines relevant to biodiversity science and conservation.

12. Teaching Requirement — Teaching experience is an important part of graduate training. ABS students will give four consecutive lectures in a formal class during their degree program.

5. ORGANIZATION, MANAGEMENT, AND INSTITUTIONAL COMMITMENT

5.1 Organization and Management — The IGERT will be managed by four committees: an Executive Committee; Selection Committee; Internship Committee; and a Development Committee (Table 2). The committees will select their own Chairs.

Table 2. ABS-IGERT program management and committee responsibilities.

	Responsibilities	Members
Director	Lead program management; Supervise coordinator; Select and chair Executive Committee; Fiscal reporting	Fitzgerald (PI)
Coordinator	Daily administrative tasks; International logistics; website; Point-person for faculty and students	To be named
	COMMITTEES	
Executive	Establish and oversee program policies and procedures; review student progress	Fitzgerald, Stronza, Lacher, Winemiller, Kreuter, Coordinator, Student
Selection	Implement recruitment strategies; review and rank applications	Piña, Woodward, Rosenthal, Alvard, DeWitt, Gelwick, Brannstrom, Albrecht
Internship and Collaboration	Match students with internships; Coordinate South-to-North visits	Lacher, Gramann, Gelwick, Brightsmith, Heyman, McCormick
Development	Fund-raising; Promote ABS at TAMU	Stronza, Fitzgerald, Lacher, Woolley, Millington
Seminar	Coordinate invitations of ABS speakers to existing departmental research seminars	Students (4), Stronza (faculty advisor)

Executive — The Executive Committee will consist of the Project Director (Fitzgerald, PI), the four co-PIs, the Coordinator, and a student. The Executive Committee will address policy issues as they arise, and ensure IGERT resource allocations follow procedures set forth in this proposal. The Executive Committee may accept new faculty participants and collaborators via an open process that includes nominations from participating faculty and students. The Executive Committee will have the power to remove non-participating faculty if necessary. The Project Director will name replacement members to the Executive Committee from the standing group of participating faculty when necessary, after consulting with other Executive committee members. The Project Director will also be responsible for reporting all budgetary matters annually. During spring and fall semesters, the **Executive Committee will meet monthly at the TAMU biodiversity collections. We will hold ABS-IGERT-wide meetings with students and faculty once each semester.**

The Coordinator position is a hub for the ABS-IGERT. S/he will become a central communicator and facilitator for faculty, students, and the international network. The Coordinator will be a Ph.D.-level or 10-year experienced social or biological scientist, bilingual, with a background in

international conservation. The Coordinator's duties include: managing day-to-day activities; answering information requests; supervising the website; arranging interviews for applicants; coordinating logistics for site visits; Field Course arrangements; internships; verifying curriculum requirements; compiling assessment data; and coordinating assessment activities (also see budget justification). Additionally, a half-time staff person is needed to manage the large amounts of financial documentation for this project, including travel justifications and vouchering.

Selection — The Selection Committee will implement the recruitment plan outlined in Section 7.1 below, emphasizing faculty involvement in minority recruitment (Mervis 2006. *Science* 312:1454). Students applying to the ABS-IGERT also apply to departments, who send application materials to the Selection Committee Chair. Applications will be ranked based upon "whole applicant" criteria, taking into account academics, background, experience, letters of recommendation, personal statements, and skills. Applicants will be ranked by the committee, and rankings will be discussed during ABS-IGERT Faculty meeting in February. A selection of candidates will be invited to interview as a group at TAMU. During interviews, applicants will be hosted by their prospective advisor, visit labs and classes, meet with graduate students and faculty, and attend a recruiting social with overview presentations about ABS-IGERT.

Internships and Collaboration — This committee will match students with mentors at CABS, and help advisors and students arrange professional development experiences at institutions in Latin America that are actively engaged in the practice of conservation. The committee will facilitate south-to-north visits from collaborators by leveraging departmental funds, PIs' research grants, and in-house international programs at TAMU. An important charge of the committee is to monitor the efficacy and benefit of the internship program, and compile indicator data for assessment.

Development — This team will develop and implement a plan to carry ABS at Texas A&M University beyond the years of NSF funding. Fundraising efforts will be aimed at environment- and development-oriented foundations. The committee will also work with the TAMU Development Foundation to access donors interested in international awareness and environment/natural resources.

5.2 Institutional Commitment —Texas A&M University is committed to institutionalizing ABS, as evidenced by the strong support for this proposal. The College of Agriculture and Life Sciences, Texas Agricultural Experiment Station, Office of the Vice President for Research (VPR), and Office of Graduate Studies are enhancing the program with ***three additional trainees funded with the same support package stipulated for NSF trainees*.** Moreover, the departments and colleges have committed to supporting all trainees in Years 3-4, including support for tuition and fees. This level of support entails significant financial commitment to the program. The State of Texas does not allow tuition waivers, meaning that university funds for tuition must be programmed.

With support from faculty, departments, colleges, and the VPR's office, TAMU is demonstrating strong institutional commitment to our IGERT proposal and more broadly to the development of ABS scholarship. Participating departments filed their support of the proposal, voicing the need for institutional commitment to the Deans of the five colleges. The recently established Interdisciplinary Research Program in Ecology and Evolutionary Biology (EEB) was the result of grassroots interest by faculty across a dozen departments to increase the university's prominence in the fields of ecology, evolution, and environmental sciences. Texas A&M is poised to be a national leader in biodiversity sciences, with excellent faculty and cutting-edge technology equal to the best programs in the world, including our genomics labs, cutting-edge GIS/remote sensing capabilities, and biodiversity informatics infrastructure. Also, the biodiversity collections (Texas Cooperative Wildlife Collection, Entomology Collection, and S.M. Tracy Herbarium) are institutional focal points for biodiversity science at TAMU. This IGERT will jump-start graduate training in ABS at our university, and will create support feedbacks needed to justify faculty hires in ABS, further

institutionalizing the EEB and perpetuating support for ABS facilities such as the biodiversity collections.

6. PERFORMANCE ASSESSMENT

The Assessment process will answer three questions: 1) How well are we meeting the IGERT objectives in research, management, and minority recruitment? 2) How are the students developing as integrative scientists? 3) How do ABS students compare to other graduate students at TAMU (Haag. 2006. *Nature* 443:265)? The ABS-IGERT Assessment Plan includes yearly, program-wide self-assessment and full external review by an external Advisory and Assessment Panel at critical points. The management structure of the ABS-IGERT allows for adjustments in curriculum, recruiting, and timing.

6.1 External review — We have recruited a blue-ribbon Advisory and Assessment Panel from leading programs in biodiversity science for the ABS-IGERT (named in Table 3). They will design evaluation protocols, taking advantage of assessment tools used at Conservation International, their own research, and the information we provide. They will select their own Chair. Panel members have established records in research grant administration, biodiversity science and conservation, and extensive international research experience. The supporting documentation indicates the panelists' willingness to serve and includes their biographical sketches.

Table 3. Assessment panel membership and components of the assessment plan: Yearly self-assessment, External review, and Program adjustment. Biosketches of panel members are in the supporting letter agreeing to serve.

PANEL MEMBERS: Professor Robert Ditton, TAMU; Professor William H. Durham, Stanford; Dr. Arun Agrawal, University of Michigan; Dr. Karen Kainer, University of Florida; Dr. Puja Batra, Conservation International; Professor Terry Yates, University of New Mexico
a. Yearly self-assessment
i. External Panel member, Dr. Robert Ditton, participates and informs rest of Advisory and Assessment Panel
ii. Executive Committee completes a Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis
iii. Interviews with a sub-sample of ABS-IGERT participants
iv. Written survey to all ABS-IGERT stakeholders
v. Exit interviews with students
vi. Compilation of descriptive statistics on program and participant indicators
vii. Provide self-assessment findings to external Advisory and Assessment Panel
b. External review by Advisory and Assessment Panel at critical points
i. End of Years 1, 3, 4: Panel receives written summary and statistics from self-assessment, provides feedback for improvement
ii. End of Year 2: Panel visits A&M to complete mid-term review of ABS-IGERT
iii. End of Year 5: Panel visits A&M for five-year review of ABS-IGERT
c. Program adjustments based on assessment findings
i. The timing of yearly assessments is strategic. Assessments will be complete before summer break, thus giving the Executive Committee time to act before fall semester.

6.2 Yearly self-assessment — We will conduct written surveys and interviews, and collect statistical data on the IGERT program and participants. Self-administered written surveys will be given to all ABS students, faculty participants, administrators, internship mentors, and host-country partners during each spring semester. Participants will take part in face-to-face interviews. Similar data will be collected for a sample of graduate students in Life Sciences and Social Sciences departments who are not participants in the ABS-IGERT. We will use SWOT analysis to ask questions regarding strengths and weaknesses and suggestions for improvement. We will also create a protocol for receiving confidential evaluations. After each set of interviews, the Executive Committee will meet with the local external panel member, Dr. Robert Ditton, and discuss how to

incorporate necessary changes. Results from the interviews and descriptive statistics will be compiled yearly and presented to the Advisory and Assessment Panel. Members of the panel will also have the opportunity to conduct interviews and focus groups. The Coordinator and half-time Staff Assistant will be responsible for arranging surveys and interviews, and taking notes for the Panel.

6.3 Indicators and measurement tools — We show a few products/outcomes with indicators for measurement (Table 4). Stronza (co-PI) has used Logical Framework (log-frame) evaluation tools on a previous grant, and will work with the ABS-IGERT Coordinator and Fitzgerald (Director) to provide a log-frame for evaluating the ABS-IGERT. **Rather than presume that we know best how to assess ourselves, we will consult with experts on the external Advisory and Assessment Panel to help us determine the best indicators and measurements for charting our progress**. Space limitations preclude inclusion of a complete log-frame.

Table 4. A sample of the kinds of products and indicators to be used in assessment. The Assessment Panel will design protocols, in consultation with Executive Committee, participants, and students.

Example products and outcomes	Timing	Example Indicators
ABS students as integrated scientists	Yearly	Descriptive statistics (students, grades, presentations, participation in activities, etc.); interdisciplinary skills; leadership skills
Cohort and program diversity	Each cohort	Recruitment successes and failures; interviews with participants; effective group interactions
Sustained ABS program at TAMU	Years 3 & 5	Faculty hires in ABS; fund-raising for ABS program; continued student recruiting; stronger departmental linkages

7. RECRUITMENT, MENTORING, AND RETENTION

We have designed novel strategies to recruit diverse applicants (Fig. 4). Established links with Conservation International, Wildlife Conservation Society, World Wildlife Fund, other NGOs, and government agencies result in a large and diverse pool of professional biologists and social scientists available for recruitment. In the last three years, over 1,184 students applied to Ph.D. programs in the ten participating departments at TAMU. Of these, 564 were women and 179 were minority applicants. Master's-level biologists and social scientists at these organizations are well suited to apply for our IGERT and will arrive with research experience, networks of collaborators, cross-cultural skills, and language proficiency.

7.1 Minority recruitment — We have a solid plan for recruiting excellent minority doctoral candidates, despite the challenges of finding students with international experience, foreign language competency, and background in relevant fields of study. We will take advantage of what has worked for us in recruiting for NSF-funded UMEB, UMB, REU grants, the highly successful TAMU diversity initiatives, and our strong connection to Peace Corps (Fig. 4). The TAMU Department of Wildlife & Fisheries Sciences has a joint Doctoral Degree program with Texas A&M University-Kingsville, and together produce significant numbers of Hispanic doctorates. The Pathways to the Doctorate program and Hispanic Leadership Program are extremely successful in recruiting minority graduate students. Importantly, the PIs have excellent records of attracting and mentoring minority graduate students. The Departments of Wildlife and Fisheries Sciences (four participating faculty) and Recreation, Parks, and Tourism Sciences (three participating faculty) have the most outstanding minority recruitment records in the College of Agriculture and Life Sciences, if not the entire university. In Fall 2005, there were 21 minority graduate students in WFSC, including Hispanics, African Americans, and Native Americans. Piña, Fitzgerald, DeWitt, Gelwick, and Winemiller and other faculty participants on the IGERT team are recognized mentors for Sloan Foundation Minority Doctoral Fellowships. Faculty will *personally visit* TAMU System campuses and other universities to

recruit diversity candidates (Mervis 2006. *Science* 312:1454). We will link our efforts to two existing NSF-LSAMPs, the existing IGERT, and the NSF-Diversity in Geosciences grant at TAMU. Part of the ABS-IGERT Coordinator's responsibilities will be to help the Director implement these recruitment strategies and collect data on their effectiveness for the Assessment Plan. Another effective minority recruitment strategy is **students-recruiting-students**. Minority students in our departments are our most effective recruiting tools, and they will participate in the recruiting process.

Figure 4. We will actively recruit minority students to achieve broad and diverse participation in the ABS-IGERT. Novel strategies will target diverse students with excellent academic backgrounds, international experience, and language proficiency. We will take advantage of our past success recruiting minority students for NSF-REU, UMEB, and UMB programs, link to existing IGERT, LSAMP, Sloan, and other diversity initiatives at TAMU.

ABS-IGERT Recruitment Strategies

1. **Texas A&M Office of the Vice President and Associate Provost for Diversity** (see letter of support)
   - a) **Leverage TAMU Fellowships and combine with NSF support**
     - **Pathways to the Doctorate Program**
     - **Hispanic Leadership Program**
     - **Diversity Fellowships**
     - **Sloan Foundation Minority Doctoral Fellowships (several faculty are designated mentors for this program)**
   - b) **Disseminate information to recruiting offices**

2. **Students-Recruiting-Students**
   - a) **Involve current minority students in the recruitment process**

3. **Link to Peace Corps** (see letter of support)
   - a) **Target minority volunteers**
   - b) **Target Masters International Program for returning PCVs with masters degrees**
   - c) **Include ABS-IGERT information in volunteers' close-of-service folders**
   - d) **Email Country Directors to identify minority candidates, disseminate information**
   - e) **Visit Country Directors in Latin America**

4. **Recruit from pool of NSF-UMEB, REU, UMB students at Texas A&M;**
   Link recruiting to existing IGERT, NSF-LSAMP, NSF-Diversity in Geosciences grants at TAMU

5. **Recruiting visits by ABS-IGERT mentors to TAMU System campuses and other minority-serving institutions in Texas**
   - a) **TAMU-Kingsville; TAMU Prairie View; Other**

6. **Institutionalize a career track for international research:**
   Undergraduate research & international experience → Peace Corps Service → Masters International Program with Peace Corps → Doctoral program in ABS-IGERT

7. **Traditional recruiting tools**
   - a) **Websites, brochures, email ListServ announcements**

Recruitment links with US Peace Corps — Our arrangement with US Peace Corps will enable us to target Returning Peace Corps Volunteers, including minorities (see letter from K. Raftery, Director of InterAmerica and Pacific Operations, Peace Corps). Peace Corps maintains programs in forestry, environmental education, fisheries, ecotourism, sustainable agriculture, and other fields related to biodiversity conservation. Peace Corps has an excellent track record of minority recruitment; about 15% of Volunteers have diverse ethnic backgrounds (www.peacecorps.gov, *"Recruiting a diverse group of Volunteers is a high priority for the Peace Corps"*). Linking our recruiting efforts to Peace Corps will facilitate access to minority applicants with language skills and international experience. We will advertise in the Minority Retired Peace Corps Volunteer Associations of New York and Chicago newsletters. Peace Corps agrees to include ABS-IGERT brochures in Close-of-Service Folders received by retiring Volunteers, and will post brochures in Peace Corps offices. We will target volunteers in the Masters International Program that Peace Corps maintains with 40 universities. We will also send recruiting information to Country Directors, and visit Peace Corps offices while on research trips.

TAMU Diversity Initiatives — We will leverage off of TAMU's successes at diversification. The Office of Vice President and Associate Provost for Diversity supports the ABS-IGERT. The university is putting ~$30M/year into Diversity Fellowships. Texas A&M is nationally recognized for its efforts to diversify (http://www.tamu.edu/oisp/factbook/student.htm and http://resi.tamu.edu). Minority recruitment efforts are showing success for both graduate students as well as undergraduates. "**Since new admissions strategies were adopted in 2003, "African-American freshman enrollment will have increased in three years by 77 percent, Hispanic freshman enrollment by 59 percent, and Asian-American freshman enrollment by more than 71 percent. We also have made great strides in diversity among our graduate students. Since 2002, graduate African-American enrollment is up 86 percent and Hispanic enrollment is up 48 percent. We expect further increases this fall."** (TAMU President Robert Gates, Convocation Address, 8 September 2006). We will nominate IGERT applicants for the three-year Diversity Graduate Fellowships, Merit Fellowships, and Regents Fellowships; these can be combined to bolster the support packages and broaden the pool of trainees beyond the NSF-funded participants. The Office of Undergraduate Research supports recruitment of talented students and also leads in providing institutional policies and services for promoting student retention and success. We will identify potential IGERT participants from these programs. Our ABS-IGERT website will provide detailed information on program goals, faculty, international opportunities, descriptions of field sites, descriptions of research, and how to apply. An advertisement will be posted to social science and ecology/evolutionary biology ListServs, in *Science* magazine on-line, and the TAMU jobs board. We will access databases in our departments, colleges, and other campuses in order to contact minority undergraduates with excellent academic records in social and biological sciences.

7.2 Mentoring and Retention — ABS-IGERT trainees will enter the program with four-year support packages. TAMU is committed to supporting IGERT trainees during Years 3 and 4 with Research and Teaching assistantships (see letter). Students will receive degrees from one of the ten ABS-IGERT departments, depending on their research focus and mentor's home department. The combination of departmental requirements, along with the ABS Integrated Core, the Cross-Cultural Leadership Training, and the Amazon Field Course, may require more than the minimum 64 credit-hours needed for the doctorate in some departments. **However**, **all ABS degree requirements can be completed in four years, and the learning path contains incentives for doctoral students to progress in a timely manner. In most departments, the ABS Core can be filled with elective slots.** The ABS-IGERT Executive Committee will monitor students' progress. Formal letters of offer to ABS students will explain requirements in detail. Home departments are prepared to take ABS requirements into account when approving degree plans for students.

Community of ABS Scholars —Integrated training activities at TAMU and internationally will build cohesion among ABS students and other biodiversity graduate students and faculty at TAMU and beyond. Our planning of shared experiences early in the learning path will forge collegial relations among the cohorts. Leadership Training, ABS Research Seminar, Reading Group, and other open activities ensure we are building a community of scholars, not an elitist group of fellows.

8. RECENT TRAINEESHIP EXPERIENCE AND RESULTS FROM PRIOR NSF SUPPORT:

Our recent undergraduate training grants have created potential to recruit minority participants for the IGERT, and given us experience in project management. Winemiller, Gelwick, and Fitzgerald are co-PIs on a NSF-UMEB; Fitzgerald led the team, Visualizing Biodiversity for the NSF-Information Technology in Teaching and Learning Science Center at TAMU and is a faculty mentor on a UMB. Winemiller led three trips of UMEB students to Latin America. Several ABS faculty have mentored REU students. Together these programs have trained > 70 undergraduate students in the last five years, including many minority students. Lacher designed and implemented CI-CABS's TEAM project to establish biodiversity monitoring at field stations world-wide.

9. INTERNATIONAL COLLABORATION

Biodiversity conservation is an international, multidisciplinary endeavor. As such, ABS students will require mentoring and support to build collaborative partnerships with international colleagues. The ABS-IGERT provides multiple opportunities for students to gain research and practical experience in conservation while also building partnerships (Fig. 5). We will establish a pathway for students to meet our collaborators and their students, build long-lasting professional relationships with them, and work together in conservation theory and practice. The advantage for ABS students is access to an extensive network of contacts and colleagues that ABS faculty has already established in Latin America (Table 5). The training program and learning pathway includes mechanisms to help students become successful international biodiversity scholars. The pathway begins with the Amazon Field Course, continues with student visits to research sites, and culminates with South-to-North visits by Latin American colleagues.

Figure 5. The ABS-IGERT incorporates a process to build international collaborations. Students initiate partnerships during the Amazon Field Course and at study sites. Collaborations are strengthened during field research, and when faculty mentors visit study sites. Reciprocal research visits by Latin American colleagues to TAMU round out Mentor-Student-Collaborator relationships.

9.1 Justification for the Amazon Field Course — ABS students will participate in an Amazon Field Course during their first year (Section 4.2.3). For three weeks, students will be immersed in a biodiversity hotspot region where they will learn about concepts central to ABS, ranging from natural history to community-based conservation. The field course will include local scientists and stakeholders, and will set the stage for international collaborations in ABS.

Site Description — The location for the course is the Tambopata National Reserve and Bahuaja Sonene National Park in the Department of Madre de Dios, Peru. This site lies within the Western Amazon study region. Although Tambopata has the some of the highest recorded levels of biodiversity in the world, it is also vulnerable to a number of threats, including extensive agriculture and land conversion; gold mining; illegal logging; over-harvesting of game, fish, fruit, palm fronds, and other resources; road construction; and increased migration to the region. Various conservation institutions and actors have sought to mitigate threats to biodiversity loss by declaring it a hotspot for biodiversity conservation, demarcating and managing over five million hectares of protected areas, encouraging ecotourism and sustainable use, and establishing research stations and programs for ongoing monitoring and assessment.

Pedagogical advantages — Tambopata is a microcosm containing many of the research opportunities and conservation problems the ABS students will encounter during their training. Students in the field course will be assigned to interdisciplinary teams to conduct mini field research projects. Each project will require students to gather ecological, social, and economic data relevant to a particular cause or consequence of biodiversity loss in the region. For example, students in the first year may be asked to work in teams to evaluate the short and long-term effects of the TransOceanic highway on local economies, social relations, ecological functions, and biodiversity.

By the end of the course, they will conduct preliminary analyses and work with local collaborators to draft plans to mitigate the problems, incorporating ideas about effective governance and coordination among diverse stakeholders.

The Field School will take place over four years during this IGERT, and we aim to keep it going. Datasets generated by the Amazon Field School will be databased and placed on the ABS website. The cross-disciplinary data will build on itself and be available to successive cohorts (and anyone), enhancing the course and increasing potential for publications.

Practical advantages —Stronza and Brightsmith have lived and conducted research in the Tambopata area for a combined total of 21 years. The institutional relations between Texas A&M, ABS-IGERT Faculty, Conservation International, and the Peruvian ecotourism operator, Rainforest Expeditions, are especially strong (letter). The faculty experience and institutional support will allow students to visit research projects, hold discussions with NGO directors, national park managers, ecotourism operators, indigenous leaders and subsistence farmers, hunters and fishers, government leaders, and biodiversity specialists from various academic fields. The area also boasts good facilities and excellent logistics that will allow the class to move efficiently along a gradient from a typical frontier city, through local communities, to uninhabited protected areas.

Table 5. Partial list of collaborators by study region. Space precludes listing all collaborators and complete titles. Types: academics, NGOs, communities, government, museums, private sector.

Collaborator	Type	Collaborator	Type
MesoAmerica		**Western Amazon**	
Beverly Wade, Fisheries, Belize	GOV	Luis Suarez, M.Sc., CI-Ecuador	NGO
Wil Maheia, Toledo Inst., Belize	NGO	San Jose de Uchupiamonas, Leaders, Bolivia	COM
Rudolf Williams, Hydrology, Belize	GOV	Federico Murrugarra, U. Agraria La Molina, PE	ACAD
Alfredo Arellano, Sian Ka'an Res., Yucatan, MX	NGO	Elena del Castillo, Inst. Nac. Rec. Natur., PE	GOV
Arnulfo Lara Oviedo, MIUSH, Hidalgo, MX	NGO	Kurt Holle, Rainforest Expeditions Ecotourism, PE	PRIV
Friends of Nature and Nat. Park Service, BE	GOV	Robert Bensted Smith, Director, CI Andes	NGO
Toledo Inst. Dev. & Env (TIDE), GOV&NGO partners	NGO	Susana Arrazola,U Mayor San Simon, Cochabamba, BO	ACAD
Carlos Rodriguez, Director, CI-MX/Mesoamerica	NGO	Mario Baudoin, Inst. Ecologia, U San Andres, BO	ACAD
Ecocolors, Ecotourism company, Yucatan, MX	PRIV	Tim Killeen, Museo Noel Kempff, Santa Cruz, BO	MUS
Amigos de Sian Ka'an, Yucatan, MX	NGO	Mariella Leo, APECO, Lima, Peru	NGO
Mexico (transboundary)		**Gran Chaco**	
Francisco García de León, CIBNOR La Paz, MX	ACAD	Andrew Noss, WCS-Bolivia	NGO
Scott Monks UAEH, Hidalgo, MX	ACAD	Lucy Aquino, M.Sc., WWF-Paraguay	NGO
Hector Espinosa Perez, UNAM, MX	ACAD	Alberto Yanosky, Guyra Paraguay	NGO
Salvador Contreras Balderas, UNAL, Nuevo Leon	ACAD	Felix Cruz & Gabriela Perotti, CONICET Argentina	ACAD
Carmen Mar Tovar, Inst. Nac. Agr. Pec. Durango,MX	ACAD	CABI, Isosog, Community Leaders, BO	COM
Alfredo Arellano, Sian Ka'an Res.	NGO	Rosa Leny Cuellar &Erika Cuellar, WCS-Bolivia	NGO
Gerardo Ceballos, UNAM	ACAD	Ricardo Grau, LEIY, U Nac Tucuman, Argentina	ACAD
Arnulfo Lara Oviedo, MIUSH, Hidalgo	NGO	Lucindo Gonzales, Mus. Noell Kempff , Santa Cruz, BO	MUS
Ella Vazques-Dominguez, Inst. Ecologia, UNAM	ACAD	Alejandro Arambiza, Indigenous Parabiologist coord.	COM

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