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Biodiversity research in the Neotropics: From conflict to collaboration

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ABSTRACT—Tropical biodiversity researchers are working in ecological, social, and economic contexts that are completely different from those of 150 years ago. In the 1800s, scientists from developed nations studied tropical biodiversity as part of expeditionary work. The social and economic benefits from these studies went to citizens of the developed nations that funded the research. Benefits accrued to foreigners rather than the native inhabitants of tropical nations explored by natural historians. Today, the governments and citizens of tropical nations view biodiversity components as natural resources that can contribute to national cultural, social, and economic development. Modern biodiversity researchers therefore find themselves working under socio-economic conditions that are radically different from those experienced by Darwin, Wallace, Humboldt, Bates and their contemporaries. In the last quarter of a century, biodiversity researchers from developed nations have struggled to meet the changing focus for their research and have substantially modified research processes to meet some of the needs and directions of developing nations. In this essay, we discuss how developed nation biodiversity researchers are changing their approach to working in tropical countries. We illustrate this change by examining how researchers from developed country work in developing countries. We examine potential reasons for conflict between developed nation biodiversity researchers and citizens of developing nations, and suggest potential solutions to these conflicts. In particular, we suggest that developed nation biodiversity researchers continue to place a strong emphasis on outputs that benefit the countries in which they work. We also suggest that biodiversity researchers should seek input from representatives of developing nations in planning projects so that research efforts can meet the needs of the host-country. We use experiences in Guyana, South America, to illustrate collaborative approaches to biodiversity research.

RESUMEN—Los investigadores de la biodiversidad de los países tropicales trabajan hoy en un contexto ecológico, social y económico completamente distinto de lo de 150 años atrás. En el siglo XIX, los científicos de los países más avanzados realizaban estudios sobre la biodiversidad tropical en el ámbito de exploraciones geográficas. Los beneficios sociales y económicos de estos estudios iban a los ciudadanos de los países que auspiciaban estas exploraciones. Los principales beneficios eran así proporcionados por naturalistas de los países coloniales más que por los mismos habitantes de los países tropicales. Hoy en día, los gobiernos y las poblaciones de los países tropicales perciben los componentes de la biodiversidad como recursos naturales que pueden contribuir al desarrollo cultural, social y económico nacional. Los investigadores modernos por lo tanto trabajan bajo condiciones socioeconómicas que son radicalmente diferentes de aquellas existentes durante las expediciones de Darwin, Wallace, Humboldt, Bates y sus contemporáneos. En el último cuarto del siglo, los investigadores de los países industrializados se han esforzado por cambiar el enfoque de sus trabajos, así como por adaptar los procesos de investigación a las exigencias y requisitos de las naciones en vía de desarrollo.

En este ensayo, discutimos como los investigadores de los países industrializados están cambiando su enfoque con respecto a sus trabajos en los países tropicales. Ilustramos este cambio examinando como estos investigadores trabajan en los países en vía de desarrollo. Examinamos causas potenciales de conflicto entre los investigadores de los países industrializados y la población de los países en vía dedesarrollo, y sugerimos posibles soluciones para estos conflictos. Enparticular, sugerimos que los investigadores de los países industrializados deberían seguir poniendo especial énfasis en investigaciones cuyos productos son de beneficio para los países en los cuales trabajan. También sugerimos que los científicos deberían solicitar el aviso de los representantes de los países en vía de desarrollo mientras planean sus proyectos, para que los esfuerzos de investigación puedan coincidir con las exigencias de los países huéspedes. Utilizamos nuestra experiencia en Guyana, Sudamérica, como ejemplo de colaboración en el ámbito de investigaciones sobre la biodiversidad.

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INTRODUCTION

There is a long history of scientists from developed nations working in biodiversity-rich tropical countries. Unfortunately, foreign scientists are sometimes perceived as being "neo-colonial" because they appear to ignore local needs and interests. This negative perception of foreign scientists is reflected in actual or potential conflicts (e.g., "biopiracy" and, in the past, the closure of countries like Brazil, Mexico, and Venezuela to foreign specimen collectors); these conflicts are changing the relationship between biodiversity owners and foreign scientists (see Grajal 1999). The conflicts between foreign scientists and biodiversity owners are surprising because both groups share common goals. In this paper, we analyze our perceptions of the views held by the two groups and suggest some approaches to conflict resolution.

The objective of this essay is to help foment discussion in the scientific community that will support foreign scientists who work in close collaborative partnerships with biodiversity owners (e.g., Janzen 1992*b*; Foster 1993). The focal message of this paper is that collaboration between developed and developing nations can contribute to management and conservation of tropical biodiversity. The antithesis of this view is that poor communication among the involved parties will lead to conflicts (Grajal 1999) and minimal contributions of developed nation individuals and institutions to the goal of tropical biodiversity conservation. Our essay is an attempt to assimilate lessons we have learned that we hope will assist future research efforts. We emphasize that effective collaboration depends on the capacity of scientists to listen to the people of the countries in which they work.

QUESTIONS OF BIODIVERSITY

How Do Biodiversity Owners View Biodiversity?

Biodiversity owners see the components of biodiversity as natural resources that can be used to generate national social, cultural, economic and ecological benefits. The Convention on Biological Diversity (UNEP 1992) urges integration of conservation and use of biodiversity to generate the aforementioned benefits (Glowka et al. 1994). The CBD represents a fundamental shift in the philosophy of biodiversity management by explicitly pointing out that biodiversity is under national jurisdiction. Because of the CBD, biodiversity is no longer considered the common heritage of humanity (Glowka et al. 1994) or a "free good" that can be exploited by foreigners (Janzen et al. 1993). The CBD also recognizes that while the majority of biodiversity is in developing countries, substantial human and financial resources for the effective management and use of biodiversity are in developed countries (see also Toledo & Sosa 1993; Wilson 1997). The CBD also recommends partnerships to ensure that benefits derived from the use of biodiversity are shared equitably among the managers, owners and users of biodiversity.

The links between the conservation and uses of biodiversity have been popularized by several international organizations including Conservation International, the World Wide Fund for Nature, the World Bank, the United Nations Development Programme and the International Union for the Conservation of Nature. Several development initiatives (e.g., conservation niche marketing, biodiversity prospecting, carbon trading; McNeely 1988; Kusler 1991; Reid et al. 1993; Broekhoven 1996; Sizer 1996; Freese 1997) emphasize effective management of natural resources as a market component. In the future, products that lack social, economic, and ecological sustainability may have lower market values than those that are demonstrably sustainable. It is therefore likely that access to the future global market place will increasingly depend on the effective and appropriate management of biodiversity. For example, markets for some traditional natural resources (e.g., timber, gold, diamonds, and agricultural products) may incorporate environmental costs into the cost of extraction (e.g., see the Forestry Stewardship Council www.fscoax.org). At the same time, industries are being regulated to reduce global and local environmental damage, and biodiversity-friendly activities like ecotourism, bioprospecting, and carbon trading, continue to develop rapidly in tropical countries. Many developing nations recognize the need for fostering the human resources, institutional capacities, and information systems necessary to effectively manage biodiversity and take advantage of future opportunities. The role of developed nations is seen as helping transfer skills and technologies to speed this process in developing nations.

How Do Researchers View Biodiversity?

Biodiversity researchers strive to understand the diversity of life on earth (Wheeler & Cracraft 1997). This endeavor requires understanding of relationships among and between organisms, the distribution and abundance of organisms, interactions between people and organisms, and organismal biology (including behavior, physiology and genetics). Systematists study relationships among organisms,

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and systematists, and the institutions in which they work, acquire specimens, study specimens, and develop nomenclatures and phylogenies. Through this work, systematists produce valuable information for user groups including the health sciences, agriculture, resource management, and biotechnology, and they educate others about the roles of systematics and systematists in understanding the diversity of life on earth. We choose systematists for our focus in this essay because they are key players in biodiversity research, and because specimen collecting has sometimes led to conflicts between biodiversity researchers and owners.

The outputs of systematic research have demonstrative value when applied to biodiversity management problems. Systematists play an important role in the development of biodiversity use by producing unique identifiers for organisms, aiding communication about biodiversity, and providing inferential tools (Janzen 1996; Butler et al. 1998). Systematists also provide fundamental prerequisites for effective natural resource management in the form of keys and guides (e.g., de Schauensee and Phelps 1978; Ridgely & Tudor 1994; Emmons & Feer 1997). Much of the increased recent attention to systematics and naming organisms comes from interest in sustainable use and conservation of tropical biodiversity in developing nations (Wilson 1988; Alberch 1993; Reid et al. 1993; Savage 1995; Reaka-Kudla et al. 1997). There are now greater demands on developed nation systematists to demonstrate the social and economic relevance of their work in their home countries (Alberch 1993; Mehrhoff 1997) and in developing countries (Janzen 1992*a*, *b*; Foster 1993; Scoble 1997). Systematists are also spearheading attempts to raise awareness about tropical biodiversity conservation (Wilson 1988, 1992; Savage 1995; Reaka-Kudla et al. 1997).

Why Are There Conflicts Between Biodiversity Owners and Systematists?

Biodiversity owners and systematists are all working toward the broad goals of sustainable use and conservation of tropical biodiversity. Any conflicts that exist between researchers and biodiversity owners and managers must lie in the processes through which the two groups attempt to achieve their broader goals. We feel that some of the conflicts arise because biodiversity research and management mechanisms are evolving from being externally driven to being locally driven.

The present social, economic and ecological environment for biodiversity research is radically different from the environment in which 18th and 19th Century tropical systematists, plant geographers and natural historians worked (e.g., Schomburgk 1841, 1843; Schomburgk & Bentley 1841; Darwin 1846; Bates 1962; Wallace 1969). The outputs from research clearly benefited the people of the countries that sponsored the research 150 years ago (Fig. 1). The involvement of the host local and national communities was peripheral, and the benefits of the research to the people of the countries in which the research was carried out were assumed rather than demonstrated. Most importantly, 150 years ago biodiversity was considered either as a "free good" (Janzen et al. 1993) or as owned by colonial powers.

Biodiversity research has changed substantially in the last 150 years (Fig. 2). First, tropical nations see components of biodiversity (e.g., timber, wildlife, resins, and medicinal products) as natural resources that can contribute to sustainable development. Second, biodiversity research provides information to help develop sustainable uses of biodiversity. Third, human and institutional capacity- building will allow developing countries to take full advantage of biodiversity, and may help promote biodiversity conservation. Finally, national agencies are taking responsibility for administering biodiversity research processes and so ensuring that research benefits the country.

ISSUES FOR DISCUSSION IN DEVELOPING COLLABORATIONS

Helping to Build National Research and Management Capacity

Developing national and local capacity is essential for the effective conservation and sustainable use of biodiversity in tropical countries (Wemmer et al. 1993). We believe that effective conservation of biodiversity will not occur in developing countries unless there is a substantial grass-roots conservation effort. Involving people locally and nationally requires the opportunities for employment and participation in conservation activities. Biodiversity research can contribute to capacity building through on-the-job training, the dissemination of information through presentations, structured workshops and courses, and the production of education and training materials as outputs from research. In addition, collaborative research and management networks that span countries can play an important role in developing training and education opportunities (Medellin 1998). These networks offer opportunities for formal or informal training courses in developed countries' research institutes. Capacity building in the context of collaborative networks can extend to the collaborative funding of research institutes (e.g., www.sdnp.org/csbd).

Training and education efforts and the associated

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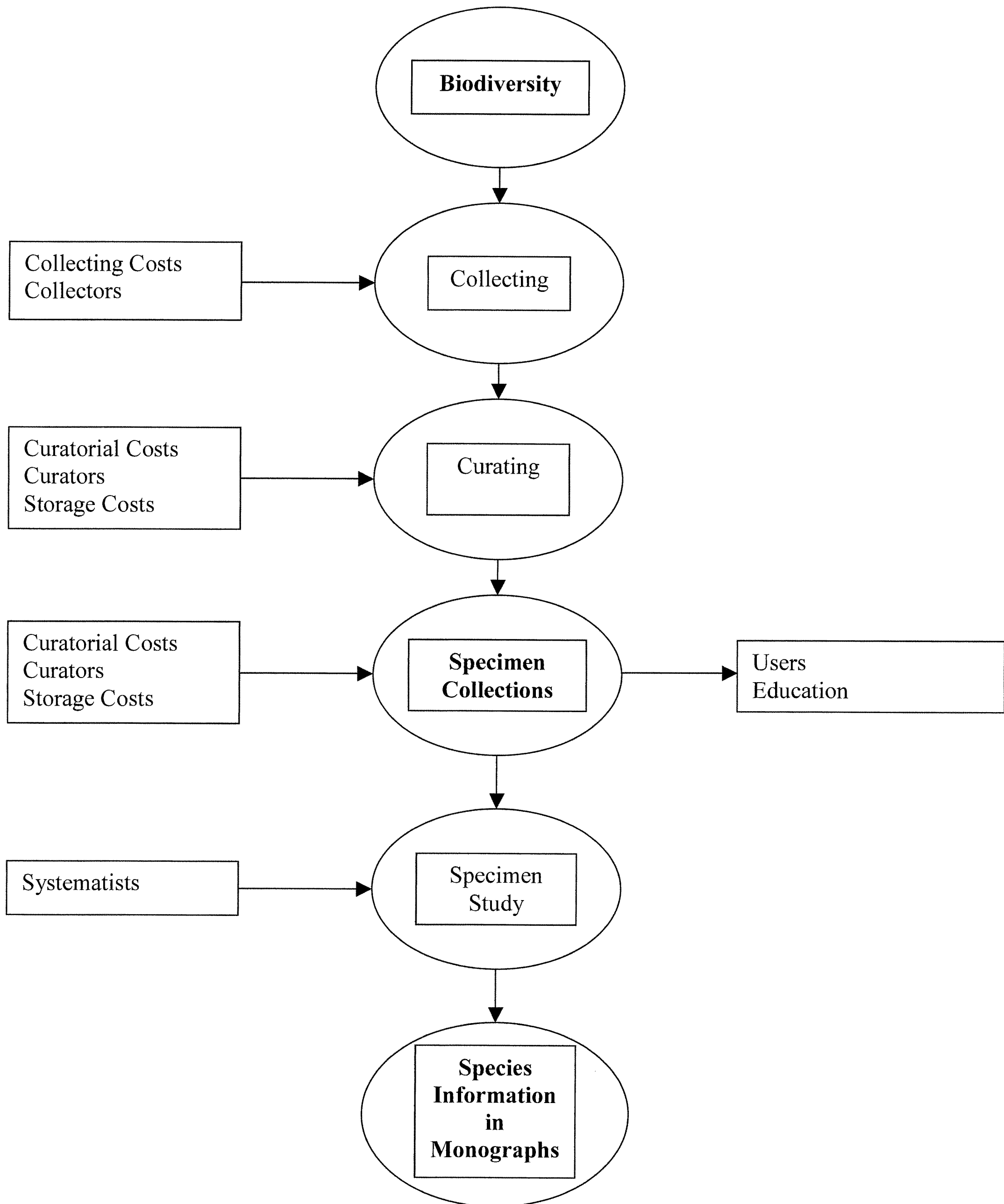

Fig. 1. Inputs and outputs from scientific specimen collection in tropical countries during the 19th Century.

collaborative links are also being extended beyond national research and education institutes to local communities. The potential for these kinds of linkages for biodiversity management in complex ecosystems is great (e.g., see Berkes et al. 2000). Examples of functional collaborations between researchers and local owners and managers include "*parataxonomy*" programs (e.g., www.inbio.ac.cr/en/invn/Invent.html) and collaborative systematic research projects (e.g., www.iwokrama.org/Wildlife/ROM/index.html) that boost support for systematics research.

Information Accessibility and Relevance

There has already been a shift in the way systematists present research information. Accurate pictorial guides to tropical organisms (e.g., de Schauensee and Phelps 1978; Ridgely & Tudor 1994; Emmons & Feer 1997) now complement systematic mono-

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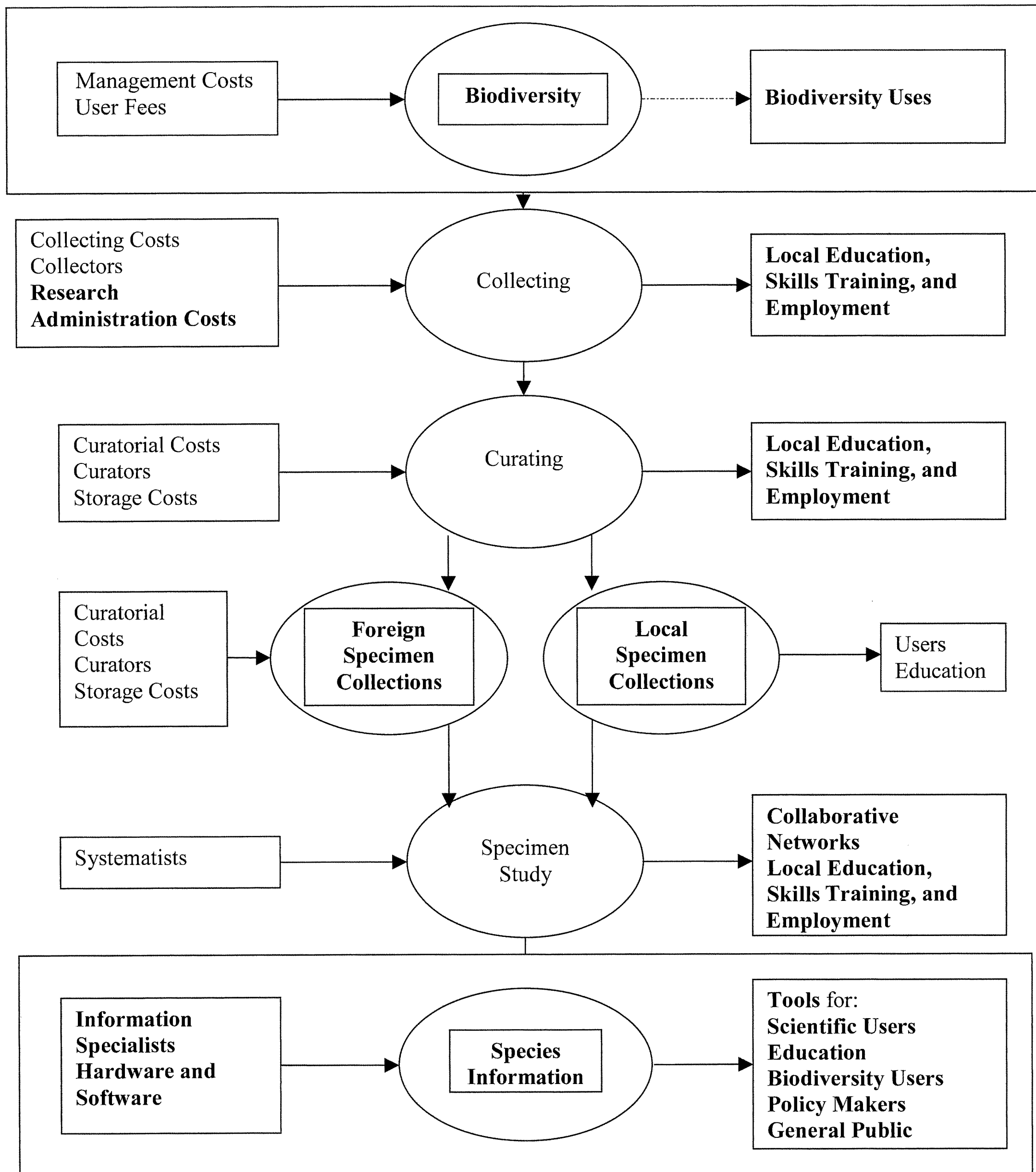

Fig. 2. Inputs and outputs from scientific specimen collection in tropical countries during the 21st Century.

graphs. Several information dissemination services are also available through the Internet (e.g., "NEODAT" at www.neodat.org and "The Species Analyst" at chipotle.nhm.ukans.edu/nabin/). However, the effectiveness of web-based mechanisms as an information dissemination tool is low until Internet access improves in developing nations.

Systematists and managers of wilderness areas and the wildlife they support are often at odds because of a lack of mutual understanding (Prendergast et al. 1999). Biodiversity managers administer natural areas to conserve species richness, maintain endemic and rare species, and develop sustainable uses of natural resources. To help accomplish this, managers use spatial and temporal data on species richness to zone reserves and monitor impacts (Noss 1990; Dallmeier 1993; Oliver & Beattie 1993; Burley & Gauld 1994; Colwell & Coddington 1994; Gaston 1994; Savage 1995; Oliver & Beattie 1996; Fagan & Kareiva 1997; Longino & Colwell 1997; Reaka-Kudla et al. 1997; Kress et al. 1998; Funk et al. 1999; Maddock & DuPlessis 1999).

While it is easy to talk about the potential benefits for management from systematic research, prag-

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matic demonstrations of this value are rare. Traditional systematic approaches have distinct goals and objectives that differ from those of biodiversity managers who require an ecological approach to understanding biodiversity. The requirements of managers include a more complete understanding of the distribution and abundance of organisms in management areas. To help managers, systematists could easily provide estimates of relative abundance for species found in wildlife management areas in addition to species lists.

Our knowledge of tropical biodiversity is incomplete. Complete enumeration of species richness is prohibitively expensive for most management areas (roughly estimated as US $100 million for a 100,000 ha All Taxa Biodiversity Inventory; Janzen & Hallwachs 1994). Because of these high costs, there have been several attempts to estimate biodiversity parameters that can be used for decision-making (Noss 1990; Colwell & Coddington 1994; Balmford 1998; Kremen et al. 1998). Unfortunately, the effectiveness of parameter estimates depends on identifying appropriate "indicator" species (Landres et al. 1988; Lawton et al. 1998). Selection of appropriate indicator species may take a longer time than that allotted for most collecting expeditions. The standardized random or random-stratified sampling strategies required to accurately to estimate species richness (Gillison & Brewer 1985; Wessels et al. 1998; Maddock & Du Plessis 1999) might conflict with systematists' sampling strategies, which are designed to collect as many species as possible. Substantial work is still needed to resolve these issues. This work needs to build on the work of systematists and ecologists to standardize sampling strategies (e.g., Heyer et al. 1994; Wilson et al. 1996) and develop cost effective methods to provide data useful to managers. It is, however, still important to recognize that systematists are the first and fundamental link in a chain of ecological research efforts required for effective conservation and management of biodiversity.

Repatriation: The Return of Scientific Specimens to the Country of Origin

The work unit of systematists is the scientific specimen and the concerns of systematists are therefore not surprisingly tightly linked to the acquisition, curation, and study of specimens (see Figs 1 and 2; Parkes 1963; Vuilleumier 1998; Winker 1996). The specimens are vouchers and records for future work, and are important education and training tools (Foster & Cannell 1990; Earl of Cranbrook 1996). In addition, specimens are repositories of information on spatial and temporal variation in species (Winker 1996; Shaffer et al. 1998). Repatriating scientific specimens to national collections is an area in particular need of negotiation. From the systematists' perspective, the need to return specimens to the country of origin might be seen as reducing the benefits of working in a country. Specimens need to be accessible and available for direct study and the most efficient mechanism for this (from the systematists' point of view) is to house the specimens at the institutions where the systematists work. The return of specimens to frequently underfunded national collections often means that for international systematists the specimens are being consigned to effective inaccessibility and possible loss to the scientific community.

For the country of origin, identified specimens are both a tangible output of the systematic process and an export product sent out of the country. Alternatively, housing specimens in the host country means that the specimens are available for study by national scientists and students while housing them abroad would mean they are inaccessible to nationals. Scientific specimens are regarded as national patrimony but funding for explorations often comes from developed countries so the details of collection distribution need to be negotiated to benefit all participants.

Systematists currently often use DNA for their studies, and molecular resources are currently an area of conflict. If an organism is collected to serve as a specimen, tissue collection and preservation should be part of the process to maximize the value of the collected specimen. Host countries perceive that the use of DNA is an area of conflict because they are concerned that profit-generating compounds may be lost. In most cases, the systematic relationships of organisms are not likely to result in profit generation or a loss to the host nation, but foreign scientists need to be sensitive about this issue and agree to conditions that protect against piracy.

Resolution of conflicts over the final destinations for scientific specimens and tissue samples will require negotiation that includes careful consideration of the value of scientific specimens and the costs of their curation. Systematists, natural history artists, education groups, and ecologists use scientific specimens. Ecologists can also use specimens to analyze diet, functional morphology and other aspects of animal life that otherwise are difficult to work on. Systematic collections are essential elements of biodiversity knowledge. The value of any particular specimen therefore depends on how accessible the specimens are to user groups. Developing countries will need to make long-term strategic decisions about the future of collections in their countries. Developing, curating, storing and maintaining access to a specimen collection is costly and may not be cost effective for small countries. Balancing in-country

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needs for curated specimens with the increasing costs of effectively maintaining structures to keep the specimens useful will require negotiation between systematists and biodiversity owners, and is likely to be active area of discussion in coming years.

Administration of Research

Research carried out by foreign systematists requires in-country administration to ensure that benefits to the host country are maximized and liabilities minimized. The benefits of biodiversity research to a tropical developing country are potentially large. However, biodiversity research is not economically or socially neutral. There are several potential negative impacts from research all of which are recognized and incorporated into national, provincial and protected area regulations in many countries. Foremost among the concerns about biodiversity research is the question of controlling access to genetic resources to ensure that if biodiversity uses are developed then there is equitable sharing of the benefits (Reid, et al. 1993). These concerns are reflected in the CBD and documents associated with the implementation of the CBD (Glowka et al. 1994; Glowka 1997).

Regulators of biodiversity research are also concerned about the negative ecological impacts of collecting and the ethics of collecting specimens. Systematists require a series of specimens to document variation accurately. Managers and regulators frequently want to minimize the size of the series collected. A large series of specimens (e.g., 25 specimens per site) is better than a small series (5 specimens per site) for systematic studies. Appropriate research guidelines need to be based on biological, cultural, social and economic realities. The onus is on researchers to demonstrate that the benefits of their research outweigh the ecological impacts, and resultant costs, of their work. The concerns about collecting impacts are not restricted to developing nations, and conflicts have long existed over the same issue between protected area managers and researchers in the developed world (Concannon 1990; Winker 1996; Vuilleumier 1998). Resolution of these conflicts requires effective communication between managers and researchers.

Administrative structures need to be transparent and simple (Grajal 1999). Biodiversity-rich countries find themselves in an open market to attract researchers for direct economic benefits and the indirect social and economic benefits that researchers can bring. Complex regulations and permitting processes are likely to result in high transaction costs and may deter research by foreign scientists. Transparency and accountability of the permitting and regulatory process is also necessary to ensure that individual agendas do not overcome the agendas defined by biodiversity owners and managers (Janzen et al. 1993). Transparency in the permitting process will increase the likelihood that effective long-term partnerships can be built between biodiversity owners and biodiversity researchers.

Effective administrative processes are expensive and these costs need to be absorbed, in part, by the research process. Collecting and research permit fees are a simple means of partial cost recovery. Additional innovative mechanisms for cost recovery need to be investigated. However, if one accepts the need for administration and monitoring of the research process, then there is clearly a need for funds to support these activities and these funds must come from the process itself.

An Example of Collaboration

Our interests in this topic emerged because of our experiences in an extensive vertebrate faunal survey of the Iwokrama Forest in Central Guyana conducted by the Academy of Natural Sciences of Philadelphia. The Iwokrama International Centre (www.iwokrama.org), which commissioned the faunal surveys, is a collaborative effort between the Government of Guyana and the International Community designed to promote the conservation and the sustainable and equitable use of tropical rain forest ecosystems in a manner that will lead to lasting ecological, economic, and social benefits for the people of Guyana and the world in general.

On 1 June 1996, the Ministry of Foreign Affairs of the Government of Guyana contracted the Academy of Natural Sciences of Philadelphia to carry out systematic surveys of the vertebrate fauna of the Iwokrama Forest in central Guyana. The ANSP surveys began in July 1996 and the field work ended in January 1998. The surveys involved a consortium of research institutes including the ANSP, the Royal Ontario Museum (ROM), Florida International University (FIU), the University of Kansas Museum of Natural History (UKMNH), and the University of Guyana (UG).

Helping to Build National Research and Management Capacity

During the surveys, researchers collaborated with UG and the Iwokrama Centre to help build biodiversity research and management capacity in Guyana. Fourteen local Amerindian people from the North Rupununi and seven UG graduates were trained in biodiversity survey techniques through "learning by doing" during the surveys. In total, Guyanese counterparts spent the equivalent of seven

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person-years working in the field with developed country researchers.

In addition, visiting researchers taught three half-semester classroom courses and a week-long field course in wildlife management and herpetology at UG. This teaching has continued beyond the scope of the original project with staff members from FIU and the ROM training Iwokrama Forest Rangers in herpetology and mammalogy.

Information Accessibility and Relevance

Outputs from the Iwokrama faunal surveys will include scientific papers that are of interest to scientists and guides and keys that will be used by ecotourists, resource managers, and local parabiologists. Because we have provided web-based guides as well as scientific papers, we are making the information accessible and relevant. In addition, during the surveys, researchers associated with the project gave three presentations to local schools, eight presentations to local communities, and 15 presentations to academic audiences in Guyana.

The Return of Scientific Specimens to the Country of Origin

One thousand, three hundred and seventy one bird specimens, 1,931 mammal specimens, 2,029 amphibian and reptile specimens, and 15,129 fish specimens were collected within the Iwokrama Forest during the faunal surveys. Most of these specimens were exported for determination at ANSP, American Museum of Natural History (AMNH), United States National Museum of Natural History (USNM), UKMNH, and ROM. 35% of the reptiles and amphibian specimens, 25% of the fish, 15% of the birds, and 4.5% of the mammals collected have been returned to Guyana. These specimen returns represent 72%, 53%, 75%, and 46% of the total number of species collected for each of the taxonomic groups, respectively. A developing cadre of Guyanese biologists is now using these specimens to teach and crosscheck identifications of specimens collected in subsequent survey projects.

Administration of Research

The Iwokrama Centre offers the opportunity for biodiversity researchers and managers to work in circumstances similar to those of national governments. Iwokrama faces constraints including responsibilities to the owners of biodiversity that include local communities around the Iwokrama Forest and the national community in Guyana. As a result, Iwokrama is able to experience some of the issues that national agencies and governments face; this paper contains some of those lessons and suggestions for change to deal with those problems. The experience for both authors has been illuminating and the need for research administration is, we hope, integral to the whole of this essay. The social and economic circumstances in any country will determine the most effective approaches to capacity building, technology transfer, information dissemination and specimen deposition. We feel that effective communication between foreign researchers and biodiversity owners is the key to the development of research programs o f international, national, and local communities.

CONCLUSIONS

"Participation," "partnership" and "collaboration" are the buzzwords in new global paradigms for natural resource management. Local, national, and international initiatives for the conservation and sustainable use of natural resources are developing in a context of building relationships and links among partners. In this essay, we have identified several areas for improvement of the relations between two major stakeholder groups in the management of biodiversity research.

Several mechanisms for effecting change in biodiversity research management are evident and already being implemented in biodiversity research partnerships between developing and developed countries. The formalization of partnerships and the assurance of the integrity of these partnerships are fundamental to effective biodiversity research. The CBD and other international agreements provide frameworks for relationships among biodiversity researchers, owners, and managers.

We recommend that biodiversity researchers who wish to work in developing countries consider, in more depth, the perspectives and needs of developing nations. In this context, researchers should be prepared to collaborate with biodiversity owners and managers in the countries in which they work. In particular, discussions with local and national communities should address the value of their work including producing data for the country that can be used for management, contributing to ongoing capacity- building programs, discussing specimen repatriation, and working closely with administrators to develop clear agreements defining the roles and responsibilities of foreign researchers in developing nations.

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K. Nicholson, D. Bickford, K. Hines, C. Ugarte, J. Watling, J. H. Waddle, M. Robbins, N. Rice, T. Peterson, M. Hoosein, D. Hammond, S. Conyne, J. Forte, D. Cassells, M. Foster and D. Arjoon. The paper, however, reflects the views of the authors.

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