TRANSFORMING ETHNOBOTANY FOR THE NEW MILLENNIUM[1]

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ABSTRACT

In the past several decades, the science of ethnobotany has evolved from a discipline primarily concerned with making lists of useful plants in a particular geographic region or among an individual tribe, to a multidisciplinary endeavor focused on understanding the relationship between plants and people. Ethnobotanists are involved in projects ranging from community level germplasm conservation to multinational biodiversity prospecting. One result of the renewed interest and activity in ethnobotany has been the increased public awareness of this branch of biological science. Several projects utilizing the contemporary ethnobotanical paradigm are discussed, including *in-situ* germplasm conservation in the western United States, ethnobotanical market surveys in Mexico, the management and use of *Sabal* palm resources in Mexico, quantitative studies in the Neotropics, and ethnopharmacological studies linked to drug development in Samoa. The Belize Ethnobotany Project's multidisciplinary approach to the study and conservation of traditional medicines and the development of an ethno-biomedical forest reserve in Belize are also reviewed. Contemporary ethnobotanical studies have value not only for the research questions they address, but as a way of catalyzing awareness of the value of biological diversity and support for its conservation among a broad range of people.

The term ethnobotany was first proposed in a lecture by John Harshberger to apply to the study of "plants used by primitive and aboriginal people . . ." (Anonymous, 1895). This initial concept of ethnobotanical investigation was typified in a paper by J. Walter Fewkes (1896), "A Contribution to Ethnobotany," in which he wrote of the work of his student J. G. Owens, who initiated a study on the foods and food resources of the Hopi Indians. In this paper, which was published after Owens's death, Fewkes wrote about their collaborative endeavors, presenting a list of the common names and uses of several dozen food species, and stating, "I simply wish to call attention to the interesting field of ethnobotany which the Hopi Indians furnish the ethnologist." This work reflects the style in which early ethnobotanical studies were undertaken—compiling lists of common and Latin names of plants used by an indigenous group.

Efforts previous to that time were carried out under the heading of "aboriginal botany," a term coined by Steven Powers (1873–1875) to include "all forms of the vegetable world which the aborigines used for medicine, food, textile fabrics, ornaments, etc." Edward L. Palmer, a botanist who made comprehensive descriptions of the flora of the western United States, was also one of the first botanists to investigate the cultural significance of plants to indigenous people through his fieldwork (Palmer, 1871, 1878). Prior to the above-mentioned endeavors, other investigators studied the use of plants by North American indigenous peoples, often focusing on the medicinal values that these conferred. Ford (1978) calculated that a total of 904 studies had been published on native North American ethnobotany before 1977.

In the past several decades, the nature of ethnobotanical investigation began to change, becoming more focused on studies of the relationship between plants and people in the broadest sense, and employing multidisciplinary perspectives. Examples include the study of Berlin et al. (1974), which combined botanical, linguistic, and utilization information, and that of Schultes and Hoffman (1973), which united ethnomedicine and phytochemistry. The emergence of ethnobotany as a multidisciplinary science, springing forth from its foundation in systematic botany, has resulted in interesting and important research questions that are being addressed. This "new" ethnobotany links diverse disciplines, such as anthropology, botany, nutrition, ecology, conservation, economics, and

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pharmacology, in a way that generates new ways of thinking and a new style of scholarship. Workers in this field also recognize the need to take a much more active role in addressing important issues of human society such as biodiversity conservation, food shortage, and the development of new medicines. Contemporary ethnobotanists are also raising concerns about the ethical implications of their research endeavors—for example, who should share in the benefits of new discoveries such as medicines or foods from plants (Boom, 1990; Cunningham, 1993; Axt et al., 1993). They are also forging closer ties with government and private sector research groups working to develop new food, drug, and energy resources. One important aspect of this renaissance in the field of ethnobotany has been the increased level of public interest in this subject. Through television documentaries, movies, magazine articles, and radio interviews, the research of ethnobotanists is being used to illustrate the importance of biodiversity and its conservation. In promoting the objectives proposed by Systematics Agenda 2000, it seems obvious that current research topics in ethnobotany can attract the attention of important constituencies whose thinking we wish to influence.

This paper will highlight examples of the research activities undertaken by contemporary ethnobotanists. It will summarize several papers presented at a recent meeting of the Society for Economic Botany that provide examples of active field- and laboratory-oriented ethnobotany projects, as well as the author's efforts in Belize.

Germplasm Conservation

Recently, concern has been expressed that *ex situ* germplasm conservation may not be sufficient for preserving the genetic integrity of selected crop species or the plethora of landraces cultivated by traditional peoples. Crop plant relatives found in the wild are also at risk. Iltis (1974) suggested that *in situ* conservation was an important adjunct for *ex situ* conservation of crop plants. A combination of both strategies is now seen as desirable, in order to ensure preservation of the maximum amount of genetic diversity. *Ex situ* conservation activities have gone far beyond the intention of serving only crop breeders; such materials are seen as valuable for supporting low-input traditional agricultural systems and insuring their capacity to recover from natural disasters, as well as restoring the genetic diversity of crop varieties in traditional systems in areas where this diversity has been lost due to changes in the socioeconomic and/or biophysical environment.

Soleri and Smith (1995) investigated the results of conserving two Hopi folk varieties of *Zea mays* L. in a USDA germplasm program (*ex situ*) and by traditional farmers (*in situ*). They tested three hypotheses: "1) *Ex situ* conservation of populations of a maize folk variety results in significant changes to those populations; 2) There are no significant differences between populations of a maize folk variety maintained by Hopi farmers today; and 3) There are significant differences between a folk variety maintained *in situ* by farming households today and the same folk variety maintained *ex situ* by an institutional conservation program." Working with two traditional corn varieties, they measured significant changes in morphological characters such as anther color, glume color, glume bar, plant height, and central spike length. They concluded that, in terms of meeting the needs of traditional agriculture, the greatest concern for traditional varieties conserved using *ex situ* technology "may be the changes during conservation resulting from genetic shift as compared with genetic drift." The data collected to test the second hypothesis seemed to indicate that there were no differences between populations of a *Zea mays* folk variety maintained by contemporary Hopi farmers. Based on their data, however, they neither accepted nor rejected the hypothesis and, instead, concluded that further research would be required. The third hypothesis, suggesting significant differences between the same folk variety conserved in two different ways, was accepted. Despite the technical difficulties in testing these hypotheses it was clear that the invariable maintenance of material utilizing *ex situ* conservation methods is nearly impossible and that the two conservation strategies yield different results, demanding a reconsideration of crop genetic resources, conservation goals, and assumptions. Work such as that being done by Soleri and Smith, incorporating the ethnobotanical perspective into germplasm conservation, is clearly in the forefront of efforts to preserve crop germplasm and will, I am certain, help reshape a great deal of the future thinking on this topic.

Market Studies

Linares and Bye (1987) and their colleagues at the Jardín Botánico, Universidad Nacional Autónoma de México, have carried out exhaustive surveys of market plants in Mexico since the 1980s. Their studies, mostly focusing on medicinal and edible plants, have involved work with traditional healers, medical doctors, herb vendors, farmers, botanists, educators, and local health promoters. Linares and Bye (1987) compared medicinal herbs sold in the markets of central and northern Mexico to those sold in the southwestern United States and found that local people group plants into folk "complexes" of species that share common names, morphological and aromatic characteristics, as well as uses. For example, the complex known in this geographic region as "*hierba anís*" comprised several genera (*Tagetes* L., *Artemisia* L., *Pimpinella* L., and *Illicium* L.), all with the characteristic odor of anise. One observation from this study is that each of the four complexes of plants investigated was "labeled" by choosing an individual plant species considered the most valuable within the complex. Each particular "label" plant tended to be sold far outside of its natural range, and local plants were often substituted during times it was unavailable. The labeled plant for the "*hierba anís*" complex was *Tagetes lucida* Cav. In this study the authors suggested that plants categorized as such are considered most effective, whereas the other plants in the complex are given secondary status.

Using results of Linares and Bye and similar studies, the staff of the Jardín Botánico has been able to implement public education programs aimed at increasing the level of botanical literacy. Each year, special weeks are set aside to focus on traditional medicine, and individual healers set up stalls in the garden to advise the public on the uses of medicinal plants. There are also special workshops on medicinal plants of Mexico geared toward those interested in alternative medicine. In addition, the garden promotes the use of edible plants of Mexican origin. One project was a series of lectures on the botany, history, culinary preparation, nutrition, and other aspects of edible greens, both wild and cultivated. The public was invited to sample these species, and a publication with botanical information and recipes was issued. The staff of the Jardín Botánico used ethnobotany to communicate important messages about biological diversity, its utilization and conservation, to the public.

Quantitative Ethnobotany

The quantification of ethnobotanical data was first undertaken in a study of the Chácabo Indians of Amazonian Bolivia (Boom, 1987). This was a major step toward a much more rigorous methodology where a statistical approach could be utilized. Ethnobotanical studies of 360 species of vascular plants known by the Chácabo identified uses for 305 species. In a one-hectare plot, 78.7% of the tree species and 95% of the individual trees were utilized. Balée continued this work among the Ka'apor and Tembé Indians of Brazil, and Boom later studied the Panare of Venezuela; the results are summarized in Table 1 (Prance et al., 1987). Their conclusions indicate a particular need for conserving plant families, such as Palmae, Lecythidaceae, Chrysobalanaceae, and Malpighiaceae, that are utilized extensively by these four indigenous groups, as well as the terra firme forest, in which most of the useful species occur. These studies were the first attempt to quantify the value of the forest to indigenous people and thus argue for its conservation based on the percentage of species used locally.

Table 1. Percentage of useful species (in all categories specified) per hectare plot to the indigenous groups studied.

Indigenous group	Percentage of useful tree species from inventory sites
Ka'apor	76.8
Tembé	61.3
Chácabo	78.7
Panare	48.6

Source: Prance et al. (1987).

Working in Tambopata, Peru, with mestizo people, Phillips and Gentry (1993a) proposed a new quantitative method for ethnobotanical studies. They studied tree plots in seven different forest types in a total of 6.1 hectares. "Family use values" were calculated for plants employed for construction, in commerce, food, technology, and medicine. Using the same data set, Phillips and Gentry (1993b) questioned whether the age of the informant had any effect on his/her knowledge of plant use. They found that in some use categories, such as medicinal plant lore, the bulk of the information is held by older people, and suggested that areas such as this should be the main thrust of ethnobotanical studies and conservation efforts. Other students in this field, such as Miguel Alexiades and Ana Irene Batis, are currently undertaking fieldwork that uses the quantitative approach in ethnobotany. It seems apparent that a quantitative approach will allow ethnobotanists to question more precisely forest inventory, economics, forest management, market studies, or other topics.

Resource Management

Caballero (1994) studied the use and management of *Sabal* Adans. (Arecaceae) among the Yucatec Maya of Mexico, an example of a contemporary study of the relationship between plants and people. *Sabal* is a multi-use palm that has served as a source of construction material, firewood, food, medicine, and magic. Caballero discovered that some traditional uses of the trees had disappeared (magic, medicine), others were declining (broom making, poles, and fences), while others persisted (thatch, fuel) or increased (handicrafts). His studies showed the greatest pressure on the resource was for thatch, where some 3500–5000 *Sabal* leaves, requiring 250–1250 trees (ranging from juvenile to adult), are needed to thatch a house in the region. The importance of indigenous resource management as a way of maximizing future supplies of palm leaves is evident from this study, as are the dangers posed by overexploitation of the resource. Anderson (1988) studied *Euterpe oleracea* Mart., another palm commonly used in Amazonian Brazil, and found that a single family received U.S. $15,532.86 from sales of açai fruit (63.1% of its annual cash income), and U.S. $2,916.79, or 11.8% of its income from sales of palm heart. Because palms are so important to tropical forest dwelling people, this plant family is a primary candidate for additional resource management studies.

Pharmaceutical Prospecting

Cox (1994) estimated that at least 50 pharmaceutical drugs have been discovered from ethnobotanical leads. These include digoxin used to treat atrial fibrillation, isolated from *Digitalis purpurea* L., a plant employed in the eighteenth century to treat dropsy, an accumulation of fluid resulting from heart failure. A more recent discovery was of vincristine and vinblastine, both used to treat blood cancers, isolated from *Catharanthus roseus* (L.) G. Don, which has been used in the Caribbean to treat "sweet blood" (diabetes).

Cox's ethnobotanical research in Samoa has led to the discovery of a potent anti-viral compound, prostratin, derived from *Homalanthus nutans* Guill. Cox identified this plant in 1984, after learning about it from several healers who used it to treat yellow fever. When tested at the National Cancer Institute, an extract of this plant exhibited powerful *in vitro* activity against HIV (Gustafson et al., 1992). The National Cancer Institute is now planning to license prostratin to a drug company for additional study. Cox also identified a topical anti-inflammatory from *Erythrina variegata* L., utilized by healers in Samoa to treat skin inflammation. The active component, a flavanone, is now being developed by Shering-Plough Corporation. Cox has also worked to ensure that a significant portion of royalties earned from the sales of these compounds will be returned to the Samoan people. His foundation (Seacology Foundation) has helped raise funds to protect 64,000 acres of tropical forest by creating four village-owned and -managed reserves. Although most ethno-directed pharmacological prospecting in the past has not returned benefits to native people or helped to conserve the forest ecosystems where the source plants are found, it is clear that ethnobotanical studies such as those of Cox and his students have done much to create a new model for this type of research. A for-profit entity, Shaman Pharmaceuticals, Inc., was founded with a corporate philosophy that creates mechanisms to ensure both short- and long-term benefits to traditional people, and promotes conservation of forest ecosystems in the areas the company gathers plants through The Healing Forest Conservancy, a foundation it established and supports.

The Belize Ethnobotany Project

The Belize Ethnobotany Project was initiated in 1988 as a collaborative endeavor between the Ix Chel Tropical Research Foundation, a Belizean non-governmental organization, and the Institute of Economic Botany of The New York Botanical Garden. The principal purpose of the project has been to inventory the ethnobotanical diversity of Belize, a country with significant tracts of intact forest as well as nine different cultural and ethnic groups. Dozens of expeditions since 1988 have resulted in some 3600 collections of plant specimens, over 50% with ethnobotanical descriptions. Duplicate specimens have been deposited in the herbaria of the Belize College of Agriculture, the Belize Forestry Department, The New York Botanical Garden, and the US National Herbarium. A database maintained at The New York Botanical Garden will be distributed to several computer facilities within Belize. The Project has gathered traditional knowledge graciously provided by over two dozen traditional healers of Mopan, Yucatec, Kekchi, Maya, Ladino, Garifuna, Creole, East Indian, and Mennonite descent.

The ethnobotanical inventory has been combined with the production of an annotated checklist of the flowering plants and ferns of Belize, based on collections of the ethnobotany project, previously available herbarium specimens, and relevant literature. With the input of dozens of taxonomic specialists, the checklist will help determine the comprehensiveness of the ethnobotanical survey.

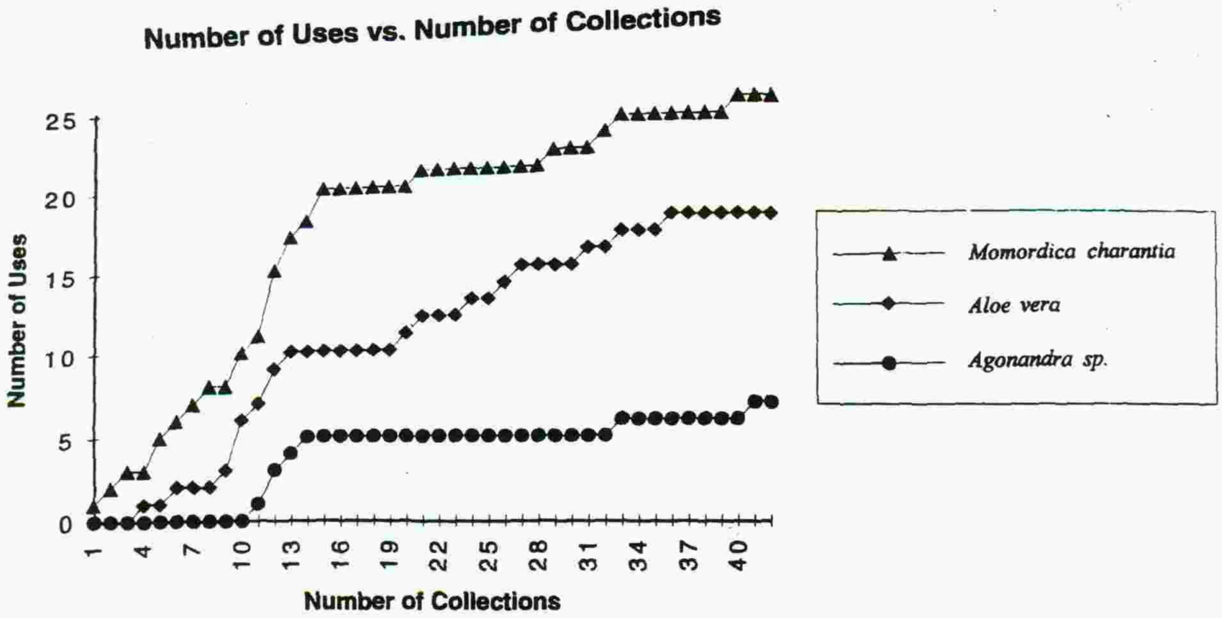

Figure 1. Graph demonstrating the importance of multiple interviews in investigating local uses of economically important plants. The Number of Collections represents the number of people interviewed and the Number of Uses, the different ways in which each species is used. With each of the species represented in this graph, new uses are still being described after interviews with as many as 40 people.

A. THE CONCEPT OF THE MULTIPLE USE CURVE

Rigorous ethnobotanical study demands accurate determination of appropriate sample size, the number of collections, and number of people interviewed, in order to ensure that the information on a specific plant is relatively complete. Many previous ethnobotanical studies have depended on one or a small number of collections as the basis for their information and conclusions. A mathematical relationship can be developed, based on the concept of the species area curve (Campbell et al., 1986), to assess the appropriate number of collections or interviews.

Figure 1 graphs the relationship between the number of different uses of three species versus the number of people interviewed, based on 42 interviews in August and September 1994. Interviewees were, for the most part, not traditional healers, but elderly people willing to discuss the uses of ten plant species. Three species have been selected to illustrate the type of knowledge obtained.

The upper curve in Figure 1 illustrates the uses of *Momordica charantia* L., a vining herb common to much of the Caribbean and elsewhere. The initial 13 interviews record 20 uses, but 5 additional uses were documented by the 39th interview. This curve illustrates a pattern for a "powerful plant" (Balick, 1990), one that is widely known with multiple uses. The middle curve is for *Aloe vera* (L.) Burm. F., a commonly known plant with a more focused series of uses, especially in the area of dermatology. The final species, *Agonandra* Miers ex Benth. sp., is an example of a plant that is not commonly known throughout the community and appears to have fewer uses, focused on "male" problems. It also has a more limited distribution in Belize than the other two taxa, primarily in forests. One point illustrated by the multiple use curve for these three plants is the large number of interviews/collections necessary to obtain the maximum amount of data. Many ethnobotanical studies, including contemporary ones that utilize statistical methods, are based on a small number of interviews/collections per species. For some plants, such as those with specialist uses, a few collections from traditional healers may be sufficient, while more widely used plants may require several dozen interviews/collections before the total extant information can be obtained.

B. VALUATION STUDIES

One method of ascertaining the value of non-timber forest products in the tropical forest is to inventory a clearly defined area and estimate the economic value of the species found there. Peters et al. (1989) were the first to document the commercial value of non-timber forest products found within a hectare of forest in the Peruvian Amazon, but they did not include medicinal plants in their inventory. This aspect was evaluated later in Belize (Balick & Mendelsohn, 1992). From two separate

Table 2. Medicinal plants harvested from a 30-year-old valley forest plot (no. 1) in Cayo, Belize.

Common name	Scientific name	Use[a]
Bejuco verde	*Agonandra racemosa* (DC.) Standl.	Sedative, laxative, "gastritis," analgesic
Calawalla	*Phlebodium decumanum* (Willd.) J. Smith	Ulcers, pain, "gastritis," chronic indigestion, high blood pressure, "cancer"
China root	*Smilax lanceolata* L.	Blood tonic, fatigue, "anemia," acid stomach, rheumatism, skin conditions
Cocomecca	*Dioscorea* sp.	Urinary tract ailments, bladder infection, stoppage of urine, kidney sluggishness and malfunction, to loosen mucus in coughs and colds, febrifuge, blood tonic
Contribo	*Aristolochia trilobata* L.	Flu, colds, constipation, fevers, stomach ache, indigestion, "gastritis," parasites

[a] Uses listed are based on disease concepts recognized in Belize, primarily of Mayan origin, that may or may not have equivalent states in Western medicine. For example, kidney sluggishness is not a condition commonly recognized by Western-trained physicians, but is a common complaint among people in this region.

plots of 30- and 50-year-old forest a total of 308.6 and 1433.6 kg per hectare (dry weight) of medicines, respectively, whose value could be judged by local market forces, was collected. Local herbal pharmacists and healers purchase and process medicinal plants from herb gatherers and small farmers for an average price of U.S. $2.80 per kg, suggesting that harvesting the medicinal plants from a hectare would yield the collector between $864 and $4014 of gross revenue. Subtracting the costs required to harvest, process, and ship the plants, the net revenue from clearing a hectare was calculated to be $564 and $3054 on each of the two plots (Balick & Mendelsohn, 1992). The lists of plants and their uses are presented in Tables 2 and 3.

Not enough information is available to understand the life cycle and regeneration time needed for each species, thus we cannot comment on the frequency and extent of collection involved in sustainable harvest. However, assuming the current age of the forest in each plot as a rotation length, we calculated an estimate of the present value of harvesting plants sustainably into the future using the standard Faustman formula: $V=R/(1-e^{-rt})$, where R is the net revenue from a single harvest and r is the real interest rate; t is the length of the rotation in years. Given a 30-year rotation in plot 1, the present value of medicine is $726 per hectare. A similar calculation for plot 2, with a 50-year rotation, yielded a present value of $3327 per hectare. These calculations assume a 5% interest rate.

These estimates for the harvest of medicinal plants compare favorably with alternative land uses in the region, such as milpa (corn, bean, and squash cultivation) in Guatemalan rainforest, which yielded $288 per hectare. Other commercial products, such as allspice, copal, chicle, and construction materials, in the plots could be harvested and

Table 3. Medicinal plants harvested from a 50-year-old ridge, forest plot (no. 2) in Cayo, Belize.

Common name	Scientific name	Use
Negrito	*Simaruba glauca* DC.	Dysentery & diarrhea, dysmenorrhea, skin conditions, stomach and bowel tonic
Gumbolimbo	*Bursera simaruba* (L.) Sarg.	Antipruritic, stomach cramps, kidney infections, diuretic
China root	*Smilax lanceolata* L.	Blood tonic, fatigue, "anemia," acid stomach, rheumatism, skin conditions
Cocomecca	*Dioscorea* sp.	Urinary tract ailments, bladder infection, stoppage of urine, kidney sluggishness and malfunction, to loosen mucus in coughs and colds, febrifuge, blood tonic

added to the total value of the medicinal plants. Thus, this study suggested that protection of some areas of rainforest as extractive reserves for medicinal plants appears to be economically justified. It seems that a periodic harvest strategy is a realistic and sustainable method of utilizing the forest. Based on our evaluation of forest similar to the second, 50-hectare plot analyzed, it would appear that one could harvest and clear one hectare per year indefinitely, assuming that all of the species found in each plot would regenerate at similar rates. More than likely, however, some species, such as *Bursera simaruba* (L.) Sarg., would become more dominant in the forest ecosystem, while others, such as *Dioscorea* L., could become rare.

This analysis is based on current market data, and estimates of the worth of the forest could change with local market forces. For example, if knowledge about tropical herbal medicines becomes more widespread and their collection increases, prices for source plants would fall. Similarly, if more consumers became aware of the potential of some of these medicines, or if the cost of commercially produced pharmaceuticals became too great, demand for herbal medicines could increase, substantially driving up prices. Finally, destruction of the tropical forest habitats of many of these important plants could increase their scarcity, driving up local prices. This scenario has already been observed in Belize with some species, indicating that the value of tropical forest for the harvest of non-timber forest products will increase relative to other land uses over time, as these forests become more scarce.

C. DEVELOPMENT OF A FOREST-BASED TRADITIONAL MEDICINE INDUSTRY

One of the primary dilemmas in the development of an extraction program for non-timber forest products has been the long history of overcollecting and resultant decline of resources, and export and processing of raw materials at centers and countries far from their origin. Rattan is a classic example of people in producing countries, who are closest to the resource, receiving the smallest percentage of the profits derived from its manufacture into high-quality furniture (Dransfield & Manokaran, 1993). In Central America, as elsewhere in the developing world, locally developed brands of plant-derived medicine are now being marketed with a value-added component (production and packaging) remaining in the country of origin of the raw material. As more of these products appear, based on the success of the original endeavors, greater demand for ingredients from rainforest species will result. This could contribute to preservation of tropical forest ecosystems, but only *if* people carefully manage the production or extraction of the plant species that are primary ingredients in these products. In addition to using methods of sustainable extraction from natural ecosystems, small farmers will cultivate some species for sale to both local herbalists and commercial companies. To address the latter possibility, our work in the Belize Ethnobotany Project has included a program with the Belize College of Agriculture (BCA), Central Farms, to learn how to propagate and grow over 24 different plants currently utilized in traditional medicine. Hugh O'Brien, Professor of Horticulture at BCA, has coordinated this effort, which has included the genera *Achras* L., *Aristolochia* L., *Brosimum* Sw., *Bursera* Jacq. ex L., *Cedrela* P. Browne, *Croton* L., *Jatropha* L., *Myroxylon* L.f., *Neurolaena* R. Br., *Piscidia* L., *Psidium* L., *Senna* Miller, *Simarouba* Aublet, *Smilax* L., *Stachytarpheta* Vahl., and *Swietenia* Jacq.

D. ESTABLISHMENT OF AN ETHNO-BIOMEDICAL FOREST RESERVE

The concept of the extractive reserve as a tool for conservation has received a great deal of attention over the last few years. Many of these reserves are tracts of forest where non-timber products can be harvested by local individuals or groups who theoretically have a stake in the preservation of the forest's biological integrity (Allegretti, 1990). Products such as rubber, Brazil nuts, copal resin, plant oils, fruits, fiber, construction materials, foliage and house plants for the florist trade, and other items have been selected for harvest and marketing from extractive reserves in the Amazon, Central America, Asia, and Africa. Numerous perspectives on these resources, both positive and negative, have been highlighted recently (Browder, 1992; Ryan, 1991).

In June 1993, a 6000-acre, lowland tropical forest, government-owned reserve was established for the extraction of medicinal plants, teaching, and apprenticeship, with financial support from The Healing Forest Conservancy and The Rex Foundation. This particular forest, in the Yalbak region of Belize, contains a broad diversity of medicinal plant species. Also within its borders are many species of animals, including jaguar, tapir, peccary, howler monkeys, and numerous other mammals, birds, and reptiles.

A unique feature of this reserve is that it has been designated for the extraction of medicinal plants used locally as part of the primary health

Table 4. Credibility rating for use information collected.

Category	Rating	Hypothetical example
Collector uses or directly observed use	1	Dr. Smith saw these *Orbignya cohune* leaves being used as thatch in Belize.
Informant uses or directly observed use	2	Maya healer, Don Elijio, told Dr. Smith he uses these *Piper amalago* roots for snakebite.
Informant heard/knew from a further source	3	Ethnographer on the Sioux reservation heard that the Sioux used the *Aster* for menstruation problems.
Use reported from the literature	4	As for the IEB teaching collection, where uses will be gathered from the literature and summarized on the use label.
Common knowledge	5	As, for example, a collection of a cultivar of coffee from a coffee plantation with a reported use as a stimulant beverage.
Credibility of use information unknown	6	New field botanist neglected to write down any information about his informant.

care network. Accordingly, this type of extractive reserve was classified as an "ethno-biomedical forest reserve" (Balick et al., 1994), a term intended to convey a sense of the interaction between people, plants, and animals, and the health care system in the region.

One objective of the reserve is ethnobotanical and ecological research, designed to identify the plant resources it contains and develop appropriate technologies for their sustainable extraction. David Campbell and his students from Grinnell College (Iowa, U.S.A.) have constructed ecological transects in selected parts of the reserve to serve as long-term study sites. Some of these transects will monitor extraction, while others monitor changes in the native vegetation. Ethnobotanical inventories have begun to catalog economically important plants in the reserve, as well as in the surrounding Cayo District. Other scientists will be invited to participate in these studies.

It will be many years before this first ethno-biomedical forest reserve can be judged a success or failure. A great deal of work must go into developing the management plan and finding the financial and human resources to implement it. Land use pressures surrounding the reserve, specifically logging and agriculture, as well as sociological and political factors, could endanger the long-term existence of the reserve. However, in Belize there is a great deal of optimism and support, much of it at the grass roots level. Reserves for protecting medicinal plants recently have been established across India, in a nationwide effort to ensure the supply of these important species.

Conclusion

The discipline of ethnobotany is currently evolving both in its philosophical underpinnings and methodology. Contemporary studies are incorporating the most powerful techniques of molecular pharmacology and computerization in the analysis of ethnobotanical data. One recent development being implemented at The New York Botanical Garden's (NYBG) Institute of Economic Botany (IEB) is the establishment of a "credibility rating" for information that is collected on plant utilization. In the past there was little opportunity to evaluate the quality of data based on the way it was collected during ethnobotanical studies. When extracting information from the ethnobotanical literature, it is rarely clear whether the investigator actually observed or participated in the uses discussed, or whether the data were collected during a casual walk through the forest with a younger person who remembers specific uses of the plants by one of his forebears. To address this, the credibility rating presented in Table 4 will be incorporated into the database at NYBG. Data with a rating of 1 have a reasonable certainty of being accurate, while those with a rating of 5 or 6 may be less authoritative. Although this rating is an experiment, and will certainly be revised over time, it is an attempt to begin to standardize the quality of data collected and evaluate its relative credibility.

There is a deep, often spiritual relationship between plants and people, in both traditional settings and among more acculturated societies. These relationships can be elucidated through ethnobotanical studies and used to increase biological literacy among the non-scientific community, as evidenced by work in Mexico, Samoa, and Belize. If the most crucial issues of biodiversity conservation are to be addressed successfully, we need to improve the educational system's ability to communicate the importance of science, not only to people in the United States but around the world. It is essential to build on the value of systematic knowledge and link it with the world in a way that inspires the largest possible constituency to appreciate the importance of biodiversity and the need for its conservation. Ethnobotany has been an important tool for meeting this goal, and will continue to be in the future. In the context of Systematics Agenda 2000, it is worth recalling the words of Ralph Waldo Emerson who wrote, "Nature tells every secret once." It is imperative that we heed these words and become better prepared to understand those secrets.

Literature Cited

Allegretti, M. H. 1990. Extractive reserves: An alternative for reconciling development and environmental conservation in Amazonia. Pp. 252–264 *in* A. B. Anderson (editor), Alternatives to Deforestation: Steps Towards Sustainable Use of the Amazon Rain Forest. Columbia Univ. Press, New York.

Anderson, A. 1988. Use and management of native forests dominated by Açai palm (*Euterpe oleracea* Mart.) in the Amazon estuary. Advances Econ. Bot. 6: 144–154.

Anonymous. 1895. Some new ideas. Philadelphia Evening Telegraph. December 5.

Axt, J. R., M. L. Corn, M. Lee & D. M. Ackerman. 1993. Biotechnology, Indigenous Peoples, and Intellectual Property Rights. CRS Report for Congress (93–478A), Congressional Research Service, The Library of Congress, Washington, D.C.

Balick, M. J. 1990. Ethnobotany and the identification of therapeutic agents from the rainforest. Pp. 47–55 *in* D. J. Chadwick & J. Marsh (editors), Bioactive Compounds from Plants. John Wiley & Sons, Chichester.

——— & R. Mendelsohn. 1992. Assessing the economic value of traditional medicines from tropical rain forests. Conservation Biol. 6: 128–130.

———, R. Arvigo & L. Romero. 1994. The development of an ethnobiomedical forest reserve in Belize: Its role in the preservation of biological and cultural diversity. Conservation Biol. 8: 316–317.

Berlin, B., D. E. Breedlove & P. H. Raven. 1974. Principles of Tzeltal Plant Classification. Academic Press, New York.

Boom, B. M. 1987. Ethnobotany of the Chácabo Indians, Beni, Bolivia. Advances Econ. Bot. 4: 1–68.

———. 1990. Giving native people a share of the profits. Garden 14: 28–41.

Browder, J. O. 1992. Social and economic constraints on the development of market-oriented extractive reserves in Amazon rain forests. Advances Econ. Bot. 9: 33–41.

Caballero, J. 1994. Use and Management of *Sabal* Palms Among the Maya of Yucatan. Ph.D. Dissertation, University of California at Berkeley, Department of Anthropology.

Campbell, D. G., D. C. Daly, G. T. Prance & U. N. Maciel. 1986. Quantitative ecological inventory on terra firme and várzea tropical forest on the Rio Xingu, Brazilian Amazon. Brittonia 38: 369–393.

Cox, P. A. 1994. The ethnobotanical approach to drug discovery: Strengths and limitations. Pp. 25–41 *in* D. J. Chadwick & J. Marsh (editors), Ethnobotany and the Search for New Drugs. John Wiley & Sons, West Sussex.

Cunningham, A. B. 1993. Ethics, Ethnobiological Research, and Biodiversity. WWF-World Wide Fund for Nature, Meyrin, Switzerland.

Dransfield, J. & N. Manokaran (Editors). 1993. Plant Resources of Southeast Asia, No. 6. Rattans. Pudoc Scientific Publishers, Wageningen.

Fewkes, J. W. 1896. A contribution to ethnobotany. Amer. Anthropol. 9: 14–21.

Ford, R. I. 1978. Ethnobotany: Historical diversity and synthesis. Pp. 33–49 *in* R. I. Ford (editor), The Nature and Status of Ethnobotany. Museum of Anthropology, University of Michigan, No. 67, Ann Arbor.

Gustafson, K. R., J. H. Cardellina, II, J. B. McMahon, R. J. Gulakowski, J. Ishitoya, Z. Szallasi, N. E. Lewin, P. M. Blumberg, O. S. Weislow, J. A. Beutler, R. W. Buckheit, Jr., G. M. Cragg, P. A. Cox, J. P. Bader & M. R. Boyd. 1992. A non-promoting phorbol from the Samoan medicinal plant *Homalanthus nutans* inhibits cell killing by HIV-1. J. Med. Chem. 35: 1978–1986.

Iltis, H. H. 1974. Freezing the genetic landscape—The preservation of diversity in cultivated plants as an urgent social responsibility of the plant geneticist and plant taxonomist. Maize Genet. Coop. Newslett. 48: 199–200.

Linares, E. & R. E. Bye, Jr. 1987. A study of four medicinal plant complexes of Mexico adjacent United States. J. Ethno-Pharmacol. 19: 153–183.

Palmer, E. 1871. Food products of the North American Indians. U.S. Commissioner of Agriculture Report 1870: 404–428.

———. 1878. Plants used by the Indians of the United States. Amer. Naturalist 12: 593–606, 646–655.

Peters, C. M., A. H. Gentry & R. O. Mendelsohn. 1989. Valuation of an Amazonian rainforest. Nature 339: 655–656.

Phillips, O. & A. H. Gentry. 1993a. The useful plants of Tambopata, Peru: I. Statistical hypotheses tests with a new quantitative technique. Econ. Bot. 47: 15–32.

——— & ———. 1993b. The useful plants of Tambopata, Peru: II. Additional hypotheses testing in quantitative ethnobotany. Econ. Bot. 47: 33–43.

Powers, S. 1873–1875. Aboriginal botany. Calif. Acad. Sci. Proc. 5: 373–379.

Prance, G. T., W. Balée, B. M. Boom & R. L. Carneiro. 1987. Quantitative ethnobotany and the case for conservation in Amazonia. Conservation Biol. 1: 296–310.

Ryan, J. C. 1991. Goods from the woods. Forest Trees and People 14: 23–40.

Schultes, R. E. & A. Hoffman. 1973. The Botany and Chemistry of Hallucinogens. Charles C. Thomas Publishers, Springfield.

Soleri, D. & S. E. Smith. 1995. Morphological and phenological comparisons of two Hopi maize varieties conserved *in situ* and *ex situ*. Econ. Bot. 49: 56–77.