Chapter 1: INTRODUCTION

Since Alexander Von Humbolt and the Age of Enlightenment professional biologists and amateur naturalists (the original ecotourists) have been attracted to the tropics primarily because of the diversity of species and the complexity of ecosystems found there. These qualities are caused by high energy inputs, year-round growing seasons and, especially in the rain forests and coral reefs, a lack of dominant stressors, such as frost. These systems are literally filled with species. Some species are rather ordinary, as might be found anywhere in the biosphere, but others are quite extraordinary with intricate behaviors, brilliant colors and exotic morphological adaptations. These ecosystems represent the highest level of development of life and of ecology on the planet. However, these tropical ecosystems are also occupied by people who live there and support families and communities from the natural resources that they utilize. Only in parks and preserves can undisturbed ecosystems be found and even in these settings management occurs to some greater or lesser degree.

In the past it seemed possible to study tropical ecosystems independent of the humans associated with them. The biology of these systems is so engrossing that it was easy to focus on tropical nature. But as the threats of deforestation and other environmental impacts have become apparent and better understood, the old view of nature and humanity as separate concerns has been replaced by a new, unified view of nature and humanity as one system. Thus, to understand the tropics we must understand how human populations have used them from prehistoric times up to the present. Most ecosystems are not finely-tuned, fragile, evolutionary balanced sets of species but rather they are resilient collections of survivors clumped together in networks of strong and weak interactions. Since the Pliestocene Age humans have been a major component of ecosystems, transforming landscapes and altering the relative abundances of species to suit their needs and desires. All the while the humans have been developing cultures which include attitudes about nature. Biological evolution is too slow to keep up with the impacts of humans and some species have gone extinct. The results of these processes are very interesting systems of humanity and nature, where at least in some places the natural side is still made up of complex ecosystems. The great need now is to manage the whole systems of people and ecosystems so that both can survive. We must understand both the pressures on the ecosystems from the local population and the pressures on the local population from the larger systems of global economy, politics and society.

Several important concepts (Table 1-1) are used for relating humanity and nature, which are the basis for making plans and taking action. Basically these are strategies for using the land that apply across scales from small villages to whole countries. All offer paradigms for improving the systems in which they are applied and each has something to offer. However, conflicts can arise because the goals of the concepts are not necessarily compatible. The conflicts are made apparent by the effect of the different land use strategies on natural capital, which is an index of the values of an area's natural ecosystems from the new field of Ecological Economics (Costanza et al. 1997a), shown on the right-hand side of the table. Development usually refers to efforts to improve human quality of life by increasing the size of an economy or people's level of income. This activity is usually accomplished by the exploitation of natural (and human) resources of an area. This exploitation often causes environmental degradation which is

Table 1-1. Comparison of land use strategies.

Concept	goal	typical effect on natural capital
Development	Social progress and material growth through use of natural resources and employment of human resources	decrease
Conservation	Wise use of natural resources through stewardship and management	slight decrease or no change
Preservation	Protection of land from development based on its natural value	no change
Sustainable Development	Long term maintenance of a balance between human and natural values achieved by living within limits	no change
Restoration	Re-creation or rejuvenation of natural values on land degraded by development	increase

assessed by a decrease in the area's natural capital. Development activities have dominated human history but the associated impacts due to the loss of natural capital have lead to the generation of alternative land use strategies. Conservation, preservation, restoration and sustainable development limit development in various ways, thus tempering or even reversing the losses in natural capital. Sustainable development in particular is receiving a great deal of attention as an integrative, holistic, alternative concept that attempts to combine the positive aspects of all of the other land use concepts into a system that can be maintained in the long run. Some feel this is the great hope for humanity while others feel it is a mythical middle ground that can never be achieved. The concept of sustainable development was introduced in the early 1980s but no consensus has yet emerged on how to achieve it. One popular definition refers to sustainable development as systems which meet the needs of the present generation without reducing the abilities of future generations to meet their needs. Economic systems are necessary to meet the needs of people but there also is the need to maintain the natural resources base and the biodiversity on which local communities depend. The latter requirement ties sustainable development to conservation, and elevates concerns about ecology to an equal status with concerns about economy. Which land use concept from Table 1-1 gets emphasized at a particular place depends on the attitudes of the people who control the land. This usually means who owns the land and it can be either a government, a business corporation or an individual. Ultimately, because humans dominate the systems of humanity and nature, control of the land involves politics and economics.

The purpose of this book is to describe one little place in the tropics and some attempts at applying the concepts of Table 1-1 there. Sittee River is a small village in central Belize, located on a river of the same name. The village and the river are intertwined so it seems proper that they have the same name. It is also appropriate to see them as one system in order to conserve both the culture and biodiversity of this tropical place. For the most part, Sittee River is like many other rural places in the tropics. Approximately 90% of the land in the watershed is owned by less than 1% of the people living there. The forests have been and are being converted to agriculture and the main type of agriculture (citrus) is entrained in a dependency relation with the world economy. Finally, the local culture is being changed by globalization in various ways. But Sittee River is also unique, as is every other village in the tropics, because of the particular people who live there and because of the particular natural ecosystems nearby.

Another special feature of this village is a biological station established there in the mid-1980s by the second two authors of this book. The Possum Point Biological Station serves educational groups, primarily from the U. S., who visit to learn about tropical ecology. It is an ecotourist operation (Kangas et al. 1995) but it differs from most other examples of ecotourism because it caters only to organized student groups. This book covers what has been learned about Sittee River, both the river and the village, by the students who have visited Possum Point, especially those led by the first author. Recognizing that the local system is an interaction between humanity and Nature as discussed earlier, coverage includes aspects of the ecology of the river and the economy of the village. The approach taken is not that of a dispassionate, external observer but rather as a passionate, active participant. In a philosophical sense this is not a choice but it is dictated by the physical law (actually part of Heisenburg's Uncertainty Principle

from physics) which states that no system can be observed in isolation; the actions of observing cause change and make the observer a part of the system. This effect could have been minimized, as is attempted in most scientific studies, but instead the consequences of the physical law have been embraced and incorporated into the study. It is a fact that the biological station is part of Sittee River and the overall system is richer, more complex and more interesting because of it. This book is really about the larger system of river + village + biological station and the prospects of this larger system's sustainability.

In part, inspiration for the study has come from the work of Dan Janzen in the dry forest region of northwestern Costa Rica (Allen 2001, Janzen 1988). Since the 1960s Janzen has been one of the leading academic ecologists who study the tropics. In the mid-1980s though, he realized that he needed to shift attention to conservation if the systems he had been studying were to survive humanity's environmental impacts. He therefore launched into a program to help establish a large-scale national park which is designed to be sustainable. Along the way Janzen has defined an approach to conservation that can be applied anywhere. His basic message is "use it or lose it". In other words, in order to save nature, it must be demonstrated to be useful to humanity. Thus, the concepts of preservation and development from Table 1 must be combined and integrated.

Most relevant to the study of Sittee River is a paper by Janzen entitled, Sustainable Society Through Applied Ecology: The Reinvention of the Village (Janzen 1990). In this short paper, actually a forward to a book on tropical conservation, he describes the problems facing the tropics and his view of what is needed for sustainability. For the "use it or lose it" approach to be successful, nature must be an integral part of society. Janzen discusses his conservation approach in terms of traditions which are created and maintained through cultural evolution:

"The single largest specific task facing tropical humanity today is reinventing the traditions that adjust population size and demands to the size and nature of the resource base. What makes this reinvention so excruciatingly difficult is that, today, the consequence of trashing the natural resource base is either ameliorated or surfaces much later (and thus is not experienced by the trasher). Humanity is living on a credit card. Every time the going gets rough, we just change address. Those that have the ability to invent new traditions can leave the scene and those that cannot, die. Not the best of circumstances for evolution.

What are the basic ingredients of evolution? Selective process that favor one tradition over another, a variety of traditions among which the selective process chooses, and a mechanism by which the favored traditions are transmitted. We have had nearly two decades of global public exposition of the burgeoning and every day more indiscriminate selective processes. As this book emphasizes, it is time to move on past advertising the presence of selection. Let's move on to increasing the variety of traditions among which the selective process can select, and get to thinking about the transmission and institutionalization of this information into traditions once again. . . .

I don't argue for a return to the tropical village. But what is crystal clear is that the site-specific traditions that were once held together by god, marriage, and pests must now

be replaced by a new species of social glue that once again renders the human occupant responsible for its actions, be they underfoot or at the end of a 5,000-kilometer fax line."

In this book we hope to help create some sustainable traditions that will be held together by the "social glue" of the people in Sittee River.

Janzen has termed this as biocultural restoration (Janzen 1988), implying the past traditions be reinvented. However, we adapt his approach, viewing the process as self organization rather than restoration. Because of globalization, deforestation and other impacts, the system of humanity and nature has changed too much to try to bring back the old traditions. Instead we feel it necessary to mix the old with the new in order to create traditions that will be sustained in the twenty-first century. Somehow we need to mix nike shoes with dirt foot paths, computer games with folk taxonomy and stories about jaguars in the back yard with dreams about travel to New York City.

Self organization is a term from the new field of complexity theory for the process that develops order in living and non-living systems. It is an internal selection process through which systems adapt to external conditions by a filtering of inputs or components. In ecosystems it is the familiar process by which species composition, relative abundance distributions, and network connections develop over time, known as succession. The mechanism of self organization within ecosystems is a form of natural selection of those species that reach a site through dispersal. The species that successfully colonize a site have survived this selection process by finding a set of resources and favorable environmental conditions that support a population of sufficient size for reproduction. Analogous to ecological succession, human cultures also self organize through mixing and selection of ideas contributed by people in a community (Fog 1999, Taylor 1996). This is what Janzen was describing, as noted earlier, in terms of cultural evolution of traditions. We utilize the concept of self organization and some others from complexity theory, such as emergence, throughout the book because of their generality for explaining system dynamics in an interdisciplinary way. Such concepts help transcend disciplinary boundaries that separate ecology, economics and sociology so that the system of nature and humanity can be studied and managed in a unified way. In particular, we hope the new concepts offer explanation of how Sittee River is changing and how this change may be directed towards sustainability.

Background on Belize

Belize is a good place for conservation because so much nature exists compared with many other locations in the Neotropics. The presence of relatively intact forests and watershed provides a head start and gives hope that sustainable systems of man and Nature can be achieved here. The main reason that so much Nature remains in Belize is its unique history of human use. This story of history began with the great pre-colombian Maya civilization, which rose and fell 500 years before Europeans arrived. The Maya world included southern Mexico, all of Belize, Guatemala and El Salvador along with northern Honduras. With seeding from the older Olmec culture, this civilization reached its demographic and cultural peak during the classical period from 300AD to about 900AD. During this period the Maya grew to high population densities and they had a

highly stratified society with a small but powerful elite class that managed the society and a larger peasant class that provided labor for various large scale projects. They created monumental architecture, intensive forms of agriculture, a sophisticated mathematics and calendar and, most importantly, a form of writing that allowed them to record their history. These achievements are especially noteworthy because they were reached with only a stone age technology within a tropical forest climate.

Belize was part of the southern lowlands of the Maya world and archeological sites of the civilization are found throughout the country (Awe 2006, Foster 1989, Ford no date). The Maya certainly occupied the study area covered in this book and, in fact, the Sittee River may have been of regional significance to the classic period Maya for several reasons. A number of unexcavated mounds exist in the watershed, especially around Kendal which has been listed as a major ceremonial center (Branche 1984). Graham (1987) suggests that the Sittee River was an important source of slate, shale and white clay which were probably exchanged widely by the Maya as resources for craft production. Finally, because the Maya used the waters of the Caribbean as fishing grounds and the Cayes of the coral reef as trading posts, the Sittee River most likely provided an easy transportation route connecting inland population with the coast. Pot shards and worn stone tools found both in the river and at Wee Wee Caye document the presence of the classic Maya in our study area and provide fuel for the imaginations of the students who visit in travel-study groups.

One of the amazing features of the history of the Maya is that their civilization to some degree collapsed at the end of the classic period between about 800-1000AD. Although the collapse did not occur to the same degree in all parts of the Maya world, the change was especially extreme in the southern lowlands where the cities were abandoned and the population level declined dramatically over a relatively short period of about 100 years. The cause or causes of the collapse are still only poorly understood by archeologists but the favored theories involve failure of the agricultural system, due to soil exhaustion and perhaps triggered by a long series of droughts, and social disruption, in which the elite class lost its power to organize and control the peasant population. The environmental consequences of the collapse were as dramatic as the cultural consequences because the forests came back and covered over the abandoned cities after the civilization disappeared. During the classical period of the Maya, deforestation was extensive, driven by the need for agricultural production to support the high population to support the high population densities. But after the collapse the populations declined and the forests were able to restore themselves through ecological succession. Thus, by the time the Spanish arrived in the mid-1500s, there was only fragmentary evidence of the once great civilization and the forest cover was extensive. The Maya people remained but at much lower population densities. For example, as noted by Robinson (1983), "the population of Belize fell from perhaps as many as half a million in the 10th century to below 50,000 at the time of the Spanish conquest in the 16th century. . .".

At the time of Spanish contact, the Maya populations in the northern portions of the Yucatan peninsula and in the highlands of Guatemala were still at a fairly high density and with some social stratification. In these areas the collapse was not as extreme as in the southern lowlands, such as Belize, where only a loosely organized, dispersed Maya population remained. However, once contact occurred the Spanish proceeded to conquer all of the Maya, as they had done 20 years earlier in the valley of Mexico with the Aztec

peoples. The conquest took place along social, economic and religious dimensions and the Maya submitted partly due to the superior military force of the Spanish and partly because the diseases the Spanish brought with them weakened their populations. Although the conquest took place quickly in a political sense, it was actually a complex process that occurred at different rates and to different degrees of completion along different cultural dimensions. Where the land was favorable to Spanish colonization, conquest took place more quickly and more completely, as in the northern Yucatan and the Guatemala highlands. In fact, these areas may have reminded the conquerors of their homeland back in Spain in terms of climate and geography. Here the climate was drier (northern Yucatan) or cooler (Guatemalan highlands) and the soils were more fertile and the Spanish developed the hacienda form of land use with various kinds of export agriculture tended by enforced Maya labor. However, in the rain forest-type climate of the southern lowlands, in Belize and the Peten region of Guatemala, the land was not desirable to the Spanish and here the conquest took place much slower and to a lesser degree. These areas lacked the resources that the Spanish wanted in terms of quality land for agriculture and a dense peasant population to serve as a source of labor and therefore they remained "on the fringes of conquest" (Graham et al. 1989). An important consequence of this aspect of Spanish conquest is that the forests of the southern Maya lowlands remained intact. In most of the areas of Latin America that were conquered and colonized by the Spanish (and the Portugese in South America), the forests were cut and replaced with agriculture. But, of special note to the present study, the Spanish did not want Belize and because of this historical judgment the conservation value or, in other words, the natural capital, of the country remains high to the present day.

A final note on the Maya is that even where the conquest did take place quickly and completely, some aspects of Maya culture survived. The Spanish came to dominate the land and they imposed their way of life on the indigenous people but the process of cultural assimilation resulted in a mix of traits. Thus the culture that emerged had some new traits from the Spanish and some old traits from the Maya. This has been documented by anthropological studies that find, for example, that the religion practiced by modern Maya contains some qualities of the traditional Catholicism from the Spanish along with some qualities that can be traced back to the ancient Maya (Farriss 1984, Redfield 1941). Moreover, the Spanish took on some of the traits of the Maya in terms of foods, domestic architecture and agricultural practices. Because of this complexity of the cultural assimilation process, Clendinnen (1987) titled her book on the contact between Maya and Spanish in the Yucatan as "Ambivalent Conquests". The lessons are that, when cultures come in contact, assimilation need not be one way or complete, some middle ground or mixtures of traits are possible and perhaps sustainable. We will return to these lessons later in thinking about the contact between foreigners and the indigenous Creole people that is currently taking place along the Sittee River.

The English, unlike the Spanish, did find value in Belize and the country took on their heritage starting in the 1600s (Dobson 1973, Bolland 1977). Early records suggest that British pirates created the first settlement at the mouth of the Belize River. From here they raided the Spanish treasure fleets that moved along the coast, usually traveling from Panama to Cuba, before undertaking the transatlantic passage to Spain. Belize provided a refuge because the offshore coral reef shielded the pirates from the Spanish. This barrier reef is a complex limestone platform of islands and shoals, 200 miles (___ km) long, and

only the British pilots knew the safe passages for large ships. To some extent this activity was encouraged by the English government, one of the principal enemies of Spain, but this occupation was relatively short-lived, as the Spanish fleets became less frequent and as a treaty between England and Spain in the mid-1600s outlawed this form of piracy.

The English remained in Belize however, and switched to cutting logwood (Haemtoxylon campechianum) whose heartwood contained organic molecules that could be used as a dye. There was a demand for sources of natural dyes in the English textile factories and the high price of logwood made the trade profitable. Logwood is a small tree (25 feet or 8 m in height) that grows in dense stands along the coast of the Yucatan Peninsula south to the Bay of Honduras. Because the tree was relatively small in stature and concentrated in river swamps, small teams of loggers could cut the trees into short pieces and float them to the coast where the wood was loaded onto ships for transport to England. The loggers worked in temporary camps which moved to a new location once a stand of trees had been competely felled. The logwood trade continued into the mid-1700s when the prices declined as other, less expensive sources of dyes became available.

But even as the demand for logwood was falling, a new market opened for mahogany (Swietenia macrophylla), whose wood was highly valued in shipbuilding and in the furniture manufacturing industry. Unlike logwood, mahogany is a very large tree, often 45m (ft) in height with a thick, buttressed trunk. Also, it occurs as widely scattered individuals dispersed throughout the forest. These aspects of the tree's natural history led to a more complex logging operation with larger crews of up to 50 persons. Trees were cut in the dry season and rolled or dragged by teams of oxen to the nearest river where they were floated to the coast in the wet season to be loaded onto transport ships. Much of this work was done by slaves of African descent. The mahogany trade peaked in the mid-1800s and then declined as most of the easily accessible trees had been harvested. The trade has continued at reduced levels up to the present as newer forestry technologies became available which allowed large trees to be removed from more remote locations.

The main point of this survey is that, throughout much of its history, Belize has been a kind of forestry colony of England. The main type of forestry has been selective logging of highly valued tree species while leaving the forest intact. Commercial agriculture began late in Belizian history and grew slowly, which meant that deforestation for agriculture has only recently become a matter of concern in terms of conservation.

The people of Belize have capitalized on their unique history by supporting conservation and preservation through various mechanisms. As a demonstration of this national spirit, one of the first orders of business for the new country, upon being granted independence from Great Britian in 1981, was to establish a National Park Systems Act. Table 1-2 lists some of the different kinds of designated nature reserves that can be found in Belize. These range from traditional government-sanctioned parks such as in the Cockscomb Mountains, from which the Sittee River drains, to a diverse array of privately supported conservation operations. One of the most innovative examples of conservation is the Community Baboon Sanctuary along a portion of the Belize River. The focus of this conservation effort is protection of a population of black howler monkeys (Alouatta palliata) which are referred to locally as baboons. The sanctuary covers about 18 square miles (km2) of privately-owned land within which the majority of land owners

Table 1-2. Selected examples of conservation or preservation land use in Belize.

Name	special features	reference
Community Baboon Sanctuary	preserve for howler monkeys on private land	Horwich and Lyon 1990
Cockscomb Basin Wildlife Sanctuary	government forest reserve originally set up to preserve jaguars	Emmons et al.
Hol Chan Marine Reserve	government marine park on the barrier reef in which no fishing is permitted	Anonymous 1994
Terra Nova Rain Forest Reserve	extractive reserve and educational center for ethnobiomedical aspects of the forest flora on private land	Balick et al. 1994
El Pilar	archeological reserve with nature trails and a cultural center	Ford and Wernecke no date
Belize Zoo	private zoo with educational center and nature trails	Anonymous 1996, Coc et al. 1998

have pledged to follow individualized management plans that support the baboon population but still allow most of the land to be farmed. These management plans include strategies that 1) protect riparian forests, 2) leave food trees for the monkeys when land is cleared, and 3) maintain corridors of standing trees among the farmed lands that allow movements of this arboreal species. The amazing feature of the sanctuary is that it is based completely on voluntary cooperation of land owners, who still can farm most of their land. The sanctuary has been operated sustainably since the 1980s and it generates income from ecotourists who are attracted to the site. In total, the sanctuary includes eight villages and over 100 land owners, who may be thought to be held together in common purpose by the "social glue" that Dan Janzen imagined. To some extent we hope that a conservation effort of a similar or related kind emerges from the biocultural self organization taking place along the Sittee River in our study area.

The Travel-Study Course Approach to Long Term Research and Involvement

The approach utilized in our work in Sittee River has evolved around the college students from the U. S. who visit the Possum Point Biological Station. The students come in travel-study courses to learn about tropical ecology and resource management. A number of different universities utilize the Possum Point Biological Station but this book is primarily about the tropical ecology course from the University of Maryland. This is a research course so, in addition to lectures and field trips, students contribute to group research projects and conduct their own independent projects. Although all aspects of tropical ecology are covered in the course, from the start in 1990, the focus has been on river ecology, using the Sittee River as a case study. Unlike other tropical ecosystem types, tropical rivers have not been studied extensively and are not well understood. For example, even something as seemingly straight-forward as the effect of deforestation on flooding is not clear (Gentry and Lopez-Parodi 1980, 1982, Nordin and Meade 1982, Sternberg 1987). Additionally, tropical rivers are endangered by human development impacts and their biodiversity is threatened with extinction. Because of these problems many calls for further research on tropical river ecology have been made (Farnworth and Golley 1974, Obeng 1981, NRC 1982, Lowe McConnell 1988, Pringle and Scatena 1999).

The first priority of the travel-study course has been to develop a baseline description of the Sittee River ecosystem. Two broad hypotheses have guided the data gathering for this objective over time. The first hypothesis is that the river is an expression of its watershed (Sioli 1975). Changes in the land use of the watershed result in changes in the river ecosystem and, thus, the river can be used as an index of "landscape health". Forests in the watershed are being converted to citrus plantations and other uses and we expect that changes in the river ecosystem have occurred or will occur in the future. The second hypothesis is the continuum theory (Cummins 1977, Vannote et al. 1980) which states that stream ecosystem structure and function change with position in the drainage system. Thus, for example, the types of macroinvertebrates found in a headwater stream are distinctly different from those in the river mouth. For practical purposes the study has been confined to the lower Sittee River which is an estuary, so the gradient of salinity causes major changes in the ecosystem along the study area.

The second priority of the travel-study course has been to make conservation recommendations based on the field work. From the beginning a goal has been to study the riparian forest and to find ways to communicate its importance as a buffer between land use and the river ecosystem. The riparian forest buffer concept is well developed as a conservation practice in the temperate zone (Lowrance 1998, Lowrance et al. 1984, 2002) and so it is a logical best management practice to advocate along a tropical river. A model of the concept is shown in Figure 1-1 in the energy circuit language (Odum 1983). The forest acts as a buffer by absorbing pollutants in agricultural runoff, therefore acting to protect the water quality in the river. This conservation practice ought to be effective along the Sittee River since much of the riparian forest is intact, though this condition is changing. Early in the program that has developed around the travel-study course, we imagined helping to create a corridor park that would stretch from the Maya Mountains to the Caribbean Sea along the Sittee River (Kangas 1994) but we rather quickly adjusted the expectations of the program towards smaller scale, more achievable conservation goals. The students themselves have altered the direction of the program by voicing their interests and feelings over the years that the travel-study course has been taught. Many of the students who participate have never left the U. S. before signing up for the course and the experience of traveling and living in the rural landscapes of a tropical country, even for a short period of time, has a strong effect upon them. In many cases the individuals come to care about the land and the people and they genuinely wish to make a contribution towards local conservation and sustainable development. In general therefore, the course has moved from emphasizing descriptive ecology towards greater involvement in the human side of conservation. Because of this involvement, the students have become a part of the system in a sense and the work of the course has become a kind of participatory natural resources management. As a consequence, a number of trials of conservation and sustainable development options have been attempted over the years. These actions sometimes failed and sometimes succeeded modestly but lessons have always been learned. One of the main purposes of this book is to describe the lessons we've learned from working on these conservation projects.

Like many countries in the Tropics (Gourou 1961, Kamarck 1976), Belize is considered to be underdeveloped, relative to Temperate countries in Europe and North America. This is a traditional sense of development that is based on economic wealth and, even though it is limited, for example in ignoring natural capital, it provides a critical context for understanding tropical ecology and resource management. Examples of indicators of this form of development are shown in Table 1-3. The most obvious indicator is income as expressed as GNP per capita, but there are many other less obvious indicators which measure the degree of underdevelopment of a country such as Belize. The significance of the patterns of development indices, such as those shown in Table 1-3, are important to appreciate, especially for most of the students in the travel study courses that have never traveled to underdeveloped countries. Basically, Belize is a poor country in terms of traditional measures of development. This is further illustrated for students in the travel study course by noting that in 2004 for example, the University of Maryland at College Park actually had a larger annual budget (1.16 x 10E9 US$) than the country of Belize (0.6 x 10E9 US$)! This kind of comparison and the patterns shown in Table 1-3 demonstrate the seriousness of issues of tropical development and conservation. There are no easy solutions to problems of land use but it is important to

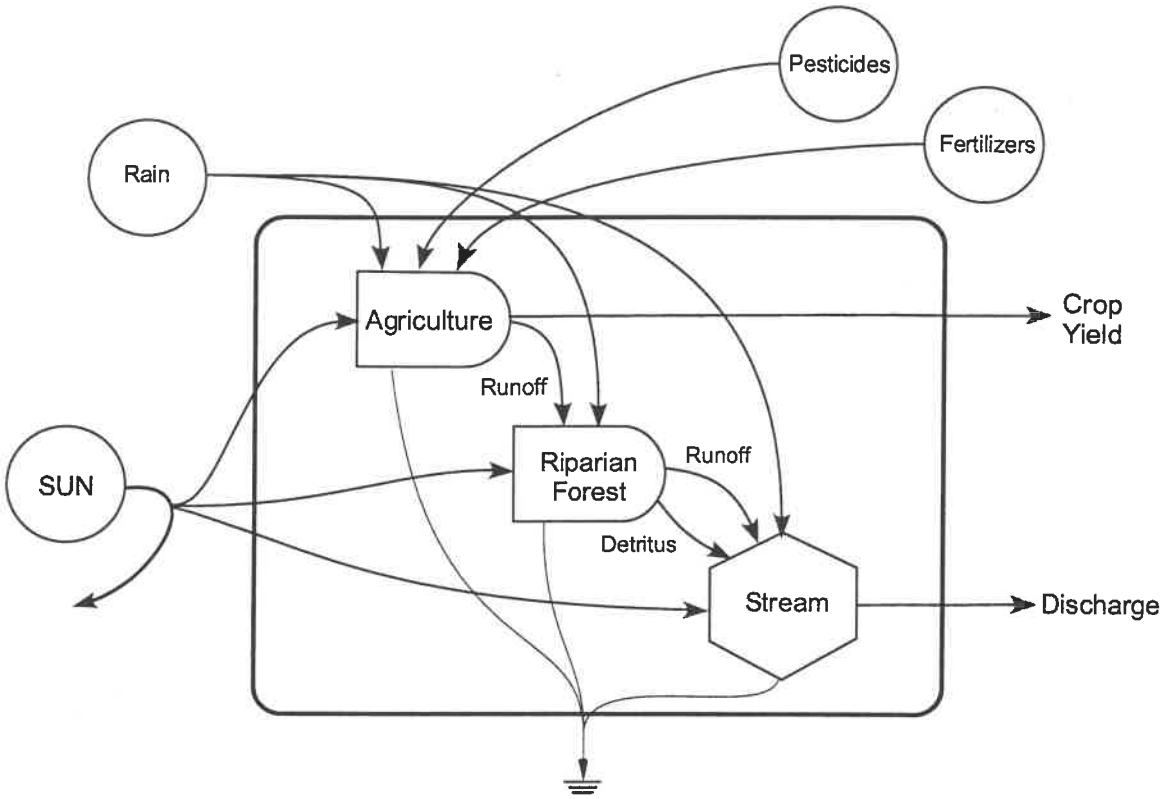

Figure 1-1. Energy circuit diagram showing the role of the riparian forest as a buffer between agriculture and the river.

Table 1-3. Comparison of development indices for four countries (Anonymous 2005).

Parameter	Belize	US	Italy	Taiwan
GNP per capita (US$)	3,190	37,610	21,560	12,570
Doctors (no. per persons)	1/1558	1/346	1/164	1/731
Fertility Rate (births per woman)	3.9	2.1	1.3	1.2
Internet users (% of population)	11	54	32	39
Personal computers (no. per persons)	1/8	1/2	1/4	1/3

consider both the economy and the ecosystems when trying to establish sustainable systems of humanity and nature.

In conclusion, the research approach utilized in this book – long term involvement of students in a travel-study course – is unique relative to traditional tropical ecology and conservation studies. Usually tropical studies are undertaken over short time periods by an individual researcher or a team of researchers with external funding from a government agency or non-profit organization. However, in this case the project has essentially been self-funded by the students and faculty in a long standing college course on tropical ecology. The critical component has been the Possum Point Biological Station which has served as the home base for the project. Thus, although the approach utilized in this book may be unique, the work can be a model for others to follow. The ingredients exist all over the Tropics: good field stations and university based travel-study courses. It is proposed here that with a long term commitment, the mixing of these ingredients can produce an important result: a local-scale description of the system of man and nature that can examine the potential for tropical sustainable development.

A Note on the Use of Energy Circuit Models

The energy circuit language of H. T. Odum (1971, 1983) is used throughout the book to create diagrammatic models. This is a symbolic modeling language for portraying the causal basis and internal detail of systems. A list of the common symbols used in the language is given in Figure 1-2. Some of the most often used symbols are as follows: the circle represents an energy source, the tank-shaped symbol represents a storage or state variable, the line represents a pathway of flow and the arrow-headed symbol (the workgate) and the collapsed box-shaped symbol (the switch) represent processes in which different energy flows interact. Models are always simplifications of reality so not everything is included in the energy circuit models. However, these diagrams provide holistic descriptions in which the relevant forcing functions and components of a system under consideration are connected according to the rules of the language. Mathematics translate from the symbols and the model configurations so that equations can be written and simulated on a computer. This is done in Chapter 8 with a model of the future of ecotourism in Belize.

On of the strengths of the energy circuit language is that both natural and human systems can be portrayed in the same format. Thus, in the book there are many diagrams of natural ecosystems, human economic systems and systems that combine Nature and human components. For economic systems dashed lines represent money flows. Money usually flows counter-current or in the opposite direction, to energy or materials, illustrating the economic exchange process.

It is hoped that the energy circuit diagrams help show the unity between natural and human systems. In this way they can facility a new visual form of bioliteracy, or in other words, they can help communicate about whole ecological systems. Words can do this but diagrams can be more effective at communication. Fostering bioliteracy, actually biocultural literacy, is one of the goals of this book.

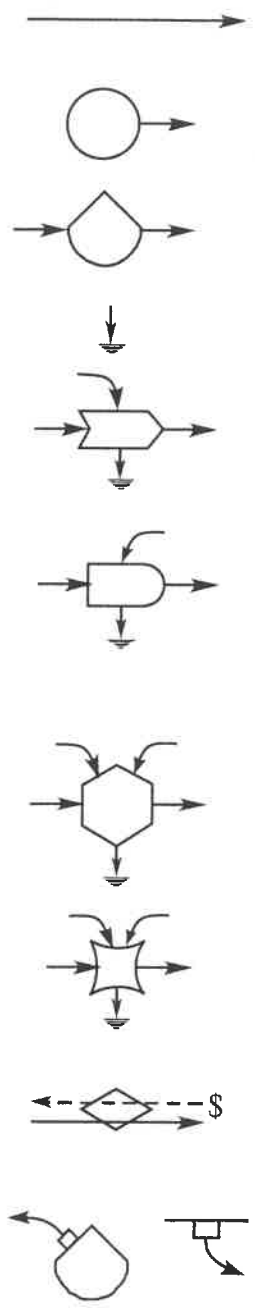

Figure 1-2. Listing of the basic symbols used in constructing energy circuit diagrams (Odum 1983).