Chapter 8: CONCLUSIONS

Can Sittee River become sustainable? In this section some challenges are outlined and speculations are made. The prospects for the future are both complicated and contradictory. Most tropical ecologists are pessimistic, like John Terborgh (1999) who wrote a "Requiem for Nature"; others are more optimistic, like Ariel Lugo (2004) who feels that humanity will sustain the tropics. Below some of the special features and problems that affect Sittee River village and its surrounding ecosystems are covered.

Modelling the Future of Ecotourism in Belize

Clearly ecotourism is an important industry in Belize and it is widely seen as an approach to sustainable development as discussed earlier. Ecotourism is particularly recognized by the people of Sittee River as a source of employment. Business is generated by the Possum Point Biological Station from education-based ecotourism and by other local operations from the more traditional leisure-based ecotourism. But how sustainable is ecotourism? For this industry to provide a stable basis for the economy, it must be able to generate business and income on a long term basis while conserving natural capital. In order to examine these long term prospects, a computer simulation of ecotourism in Belize was developed and studied (Blersch and Kangas, unpublished). Simulation modeling requires an explicit description (e. g., a quantitative model) of the causal basis of a system in the form of mathematical equations that can be programmed on a computer. Once developed, the model can be studied by changing parameters in the mathematical equations and simulating the consequences of the changes on behavior of the system over time. This is a form of theoretical experimentation which can be done quickly and graphically with the aid of a computer.

A model for the industry of ecotourism in Belize is shown in Figure 8-1, using the energy circuit language (Odum 1983). Tourists (To) enter the system on the right hand side of the diagram and interact in a series of three workgates, which represent the ecotourism experience. After the workgates, the tourists leave the system shown by the output flow on the lower right-hand side. The flow of tourists into and out of the system is functionally similar to a flood in Sittee River (see Figure ___). Both are energy subsidies for the systems: tourists pass through and leave dollars in the local economy while floods pass through and leave sediments and nutrients in the floodplain forest. The ecotourism workgates have multiplier inputs from natural ecosystems (N) and from tourist infrastructure (I) and a divisor input from the price of oil (Po) in the global economy, shown in the top right of the diagram. In a functional sense this means that tourists are attracted to the system in direct proportion to 1) the available pool of tourists (To), 2) the natural ecosystems that they would see during their visit (N), 3) the infrastructure in terms of lodging, etc. that they would use during their visit (I) and in inverse proportion to 4) the global price of oil (Po). Mathematically, this expression is:

$$\text{Flow of ecotourists} = k\,(\,To' * N * I\,)/Po$$

Where k is a proportionally constant that corrects for the dimensions of the units. Thus, this expression indicates that the flow of ecotourists into the Belize economy will

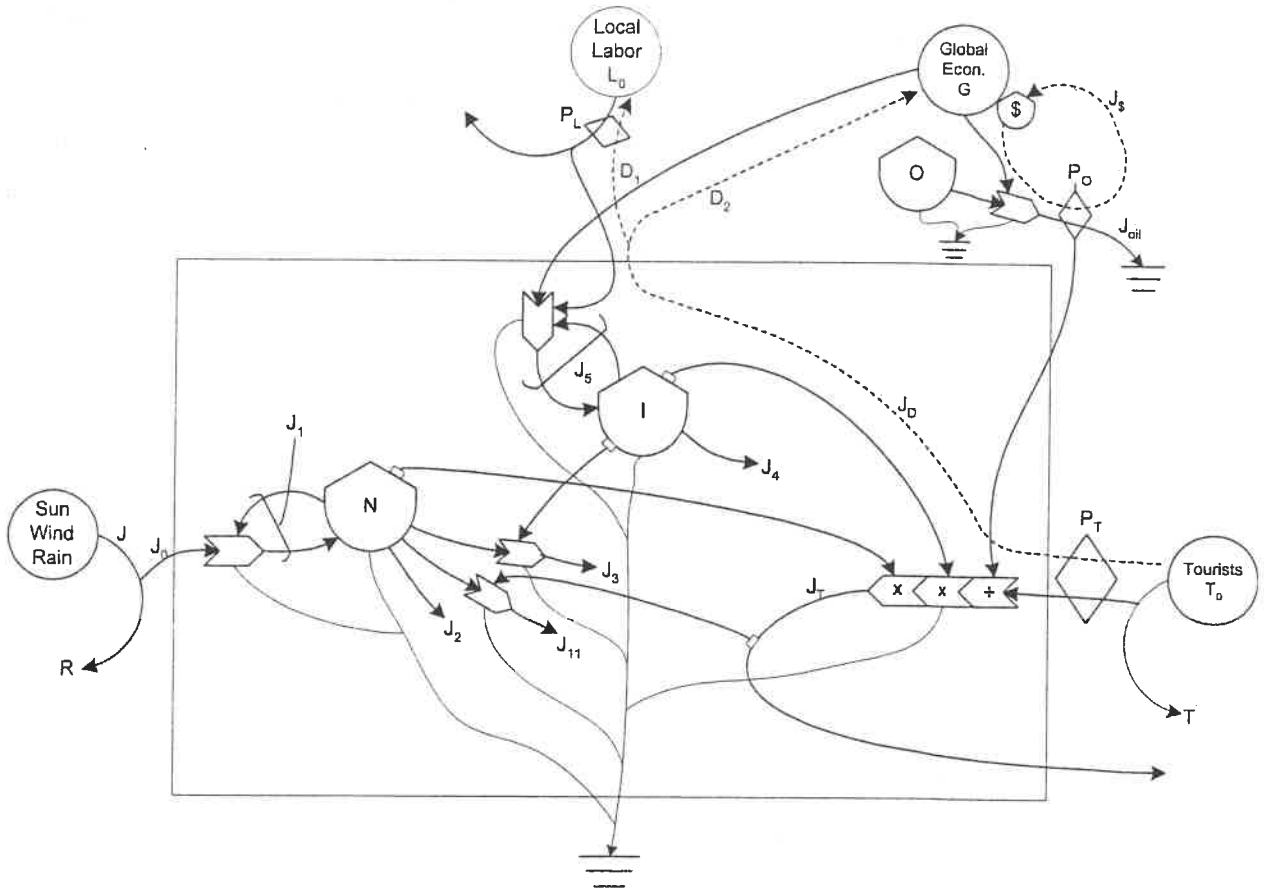


Figure 8-1. Energy circuit diagram of a simulation model of ecotourism in Belize as a whole.

increase if To, N or I increases but it will decrease if Po increases. This mathematical form of the ecotourist experience recognizes the critical relationship of the global price of oil in regulating the costs involved in the travel of tourists from their home countries to Belize. The math thus captures the idea that as the supply of oil declines, the price of oil increases, and in turn the costs of travel increase. A submodel that generates the price of oil is shown in the upper right-hand portion of the diagram with oil (O) declining as the global economy (G) consumes the supply. Price is determined as the ratio of the consumption of oil (Joil) to the flow of money in the global economy (J$). This submodel essentially describes the peak oil scenario of declining supplies of fossil fuels (Campbell 2005, Goodstein 2004, Deffeyes 2001).

Tourists bring money to the system in proportion to expenditures during their visit. This is shown as the dashed line from the tourist source (Jd). This money is in payment for services from the companies whose infrastructure help drive the ecotourism experience. Some of this money ultimately goes for local labor (D1) and the rest ultimately goes back out to the global economy to pay for investments, savings, etc.

Natural ecosystems (N) are obviously an important input to the ecotourism experience but no money goes back to nature in this model. Optimal ecotourism involves these kinds of feedbacks, as discussed earlier, but most operations do not conduct activities that directly support ecosystems. In fact, ecotourism actually stresses ecosystems through impacts from infrastructure (J3) and through impacts of the tourists themselves (J11). These impacts indirectly affect the total flow of ecotourists and the money they bring into the system by reducing N.

The overall model shown in Figure 8-1 is a set of hypotheses about the ecotourism industry in Belize. More detail could be added but it is hoped that the model abstractly describes the causal basis of the whole system. A system of equations (Table 8-1) was translated from the diagram according to the methodology described in Odum (1994). The equations and coefficients were programmed into an EXCEL spreadsheet for numerical solutions. Rate coefficients were calibrated using assumptions and economic data derived from the literature (Appendix Table 8-1). The model was calibrated to conditions as close to FY2000 as possible. It was then simulated over a time period of 100 years using a time step of 1 year.

The results for the baseline simulation, using initial values calibrated to FY2000, are shown in Figure 8-2 (A-D). These figures show that, as tourism infrastructure (I) increases over time, the remaining natural ecosystems decrease over time (Figure 8-2 A). The flow of tourists into the country peaks after a relative short time and then steadily declines for the remainder of the simulation run (Figure 8-2 B). The flow of ecotourism money into Belize follows the same trend as the flow of tourists (Figure 8-2 C), decreasing steadily after an initial increase. Continual payments to local labor causes the exported money (in the form of investors' profits) to eventually become negative as returns from tourism drops. Finally, the price of oil increases over time as production drops due to a continually reduced supply (Figure 8-2 D). These baseline results are consistent with expectations. Tourism is high so long as both the amount of natural ecosystems (N) and tourist infrastructure (I) are moderate or high. Infrastructure development and increased tourist flow have an effect on the natural ecosystems, which cannot regenerate fast enough to keep up with environmental impacts. As natural ecosystems decline over time, the flow of tourists decreases, even despite continually

TABLE 8-1

A. EOUATIONS

$$\frac{dN}{dt} = k_1 RN - k_2 N - k_3 IN - k_{11}\left(\frac{TIN}{P_o}\right)N$$

$$\frac{dI}{dt} = k_5 GL - k_4 I$$

$$\frac{dO}{dt} = -k_{oil} OG$$

$$J_T = k_9 \frac{TIN}{P_o}$$

$$R = \frac{J}{k_o N + 1}$$

$$T = \frac{T_0}{J_T + 1}$$

$$L = \frac{L_0}{1 + k_6 GI}$$

$$P_{oil} = \frac{k_{oil2}}{J_S J_{oil}}$$

$$J_D = P_T J_T$$

$$D_1 = P_L J_6$$

$$D_2 = J_D - D_1$$

B. CONSTANTS

$k_0, k_1, k_2, k_3, k_4, k_5$

$k_6, k_{10}, k_{11}, k_{oil}, k_{oil2}$

J

T_0

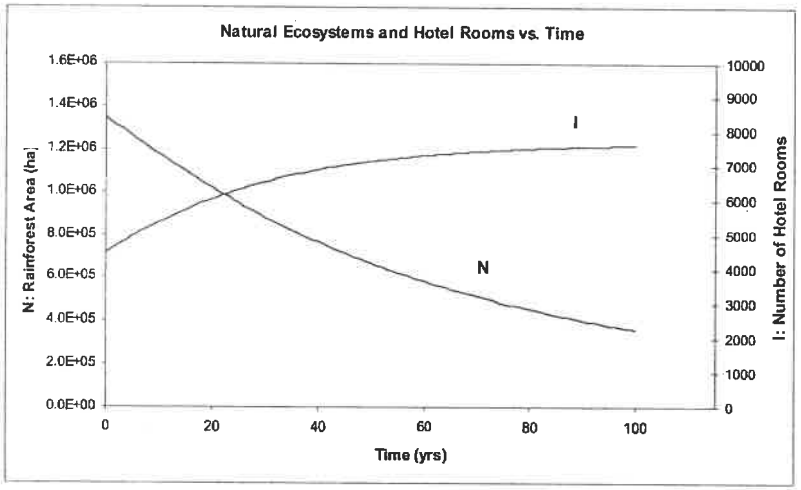
L_0

J_S

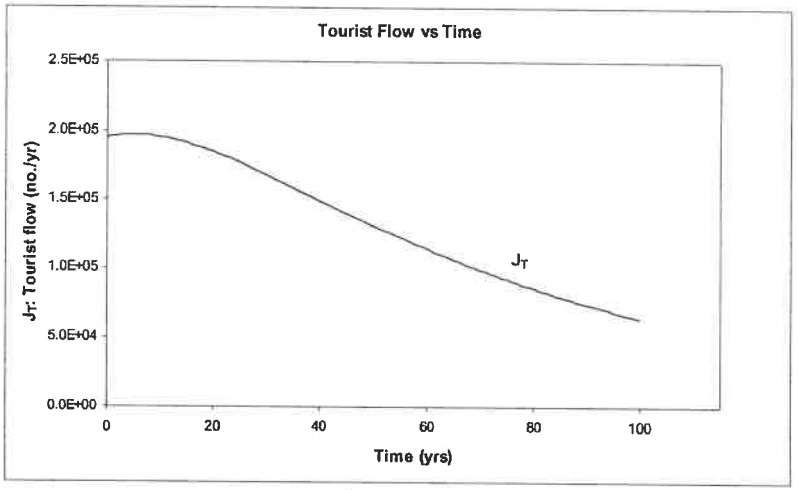
G

P_T

P_L



A.



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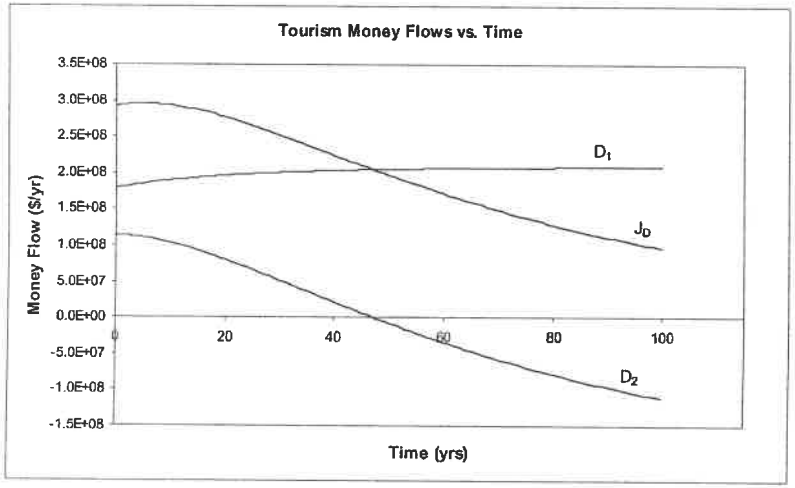

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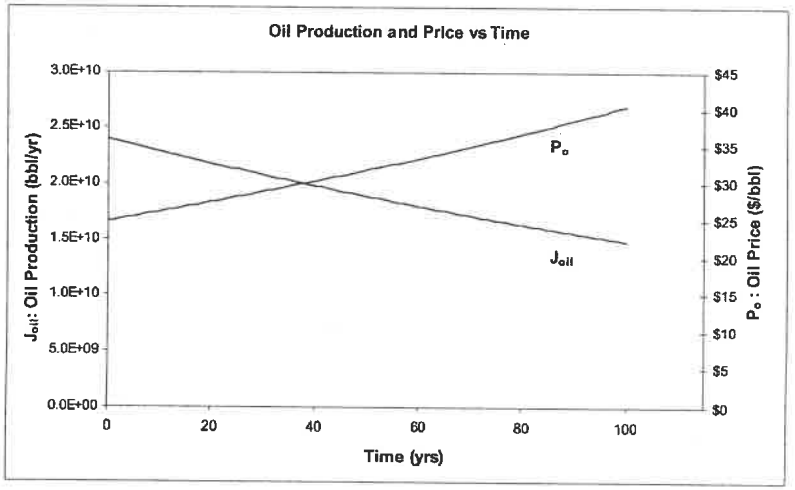


D.

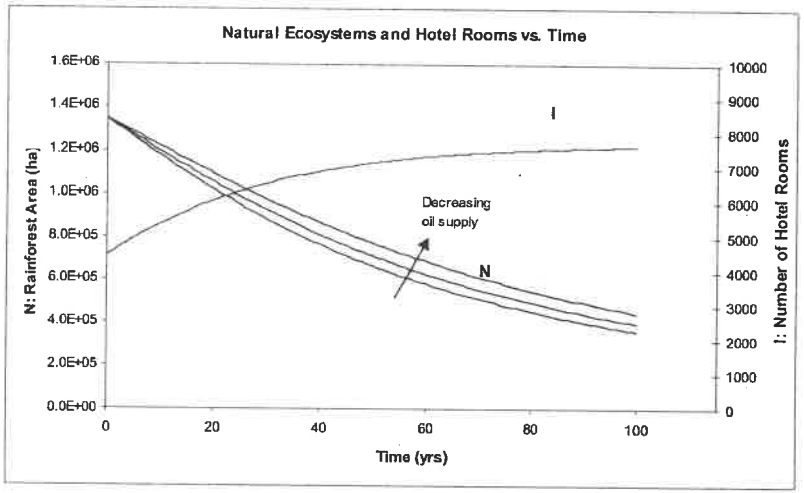
Figure 8-2. Results of the standard run of the ecotourism simulation model showing the changes in parameters over time as a result of the decline in fossil fuels.

increasing tourist infrastructure development. Because tourist income is directly proportional to the flow of tourists, total money and exported money (profit to foreign investors) follows this same declining trend over time. Money paid to local labor approaches a constant, as it is a function only of the number of rooms and the percent of total work force employed. Overall, this simulation indicates that there is a balance point between tourist development and ecosystem conservation that maximizes tourist flow, and thus tourist dollar flow, into Belize; too much sustained impact on the natural ecosystems will eventually erode the tourist economic base as tourism falls. The model predicts this point may be reached with a few decades.

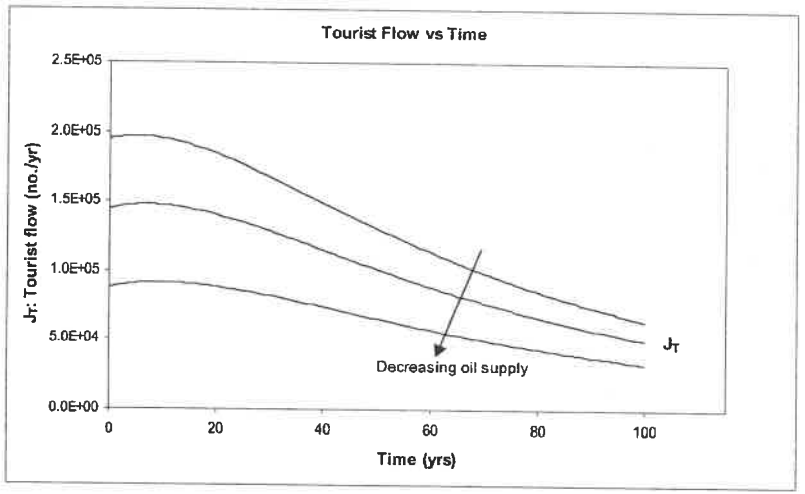
To examine hypotheses about the overall system, simulations were made by changing the model. One scenario tested was the impact of increasing oil prices, resulting from decreased estimates of remaining in-ground oil reserves, on the ecotourism industry. Results are shown in Figure 8-3 A-D. These results show that, as oil supply decreases, the impact upon natural ecosystems is lessened, although no change is seen in the hotel development, I (Figure 8-3 A). The flow of tourists is seen to decrease with decreasing oil supply (Figure 8-3 B), thus explaining the decreasing impacts of natural ecosystems. Declining tourism also explains declining receipts of money along with decreasing oil supply (Figure 8-3 C), shortening the time when profits to foreign investors as export dollars fall below zero. Declining production of oil, as a result of lessened reserves in ground storage, creates increasing prices for oil over time (Figure 8-3 D). These results are also consistent with expectations. As oil prices increase, tourism decreases, thereby decreasing total and exported revenues accordingly. The amount and rate of tourist infrastructure development, and thus the money paid to local laborers, remains constant as with the baseline simulation. In one sense, this is reasonable where hotels and resorts are built by foreign investors who speculate on the future demand for ecotourism. In reality, however, few developments might be undertaken unless perceived demand exists. This points to one possible improvement to the model: the growth of tourist infrastructure, I, should be moderated by a feedback from the perceived tourist flow, Jo. This change would produce a growth in infrastructure that is scaled to a demand by the tourists.

An additional simulation examined the effects of decreasing environmental impacts due to ecotourism on the dynamics of the system. This simulation was studied by a series of reductions in the drains on the natural ecosystems due to flows J3 and J11 in the baseline model. These kinds of changes can occur either due to more stringent regulation of the ecotourism industry or by improved natural resources management. The lessened environmental impacts cause reduced rates of decline of natural ecosystems over time even though tourist infrastructure increases gradually to a steady state (Figure 8-4 A) and oil prices rise (Figure 8-4 D) as in the baseline run of the model. The flow of tourists and their income is maintained over longer time periods with lessened environmental impacts (Figures 8-4 B and C), because of the improved conditions of the natural ecosystems.

The overall conclusions of these modeling experiments are that benefits of ecotourism are limited and temporary over the long run. The dominant factor controlling the simulations was the decline in oil production which drives up the cost of travel. The simulated experiments of decreasing environmental impacts of tourism were not capable of overcoming the effects of decline in oil production, though the economic benefits of ecotourism can be extended by policies that would result in these kinds of structural



A.



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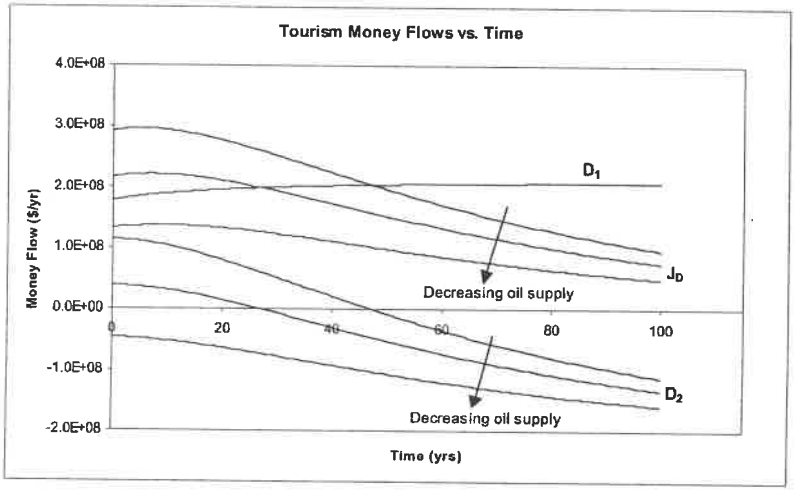

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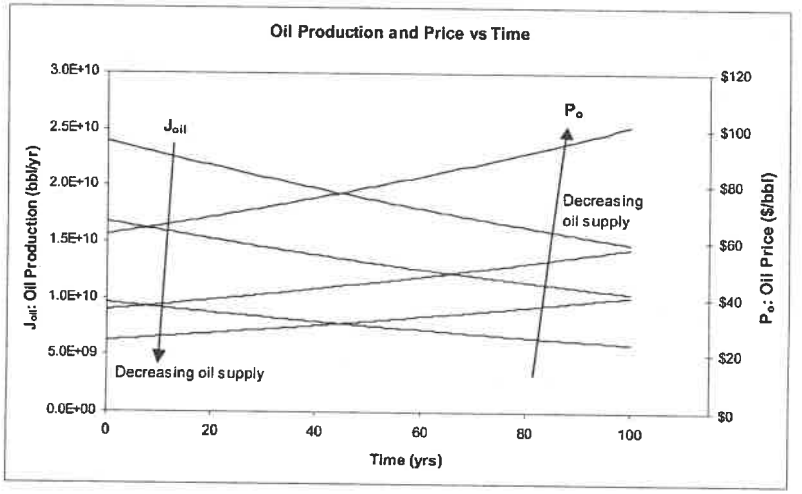
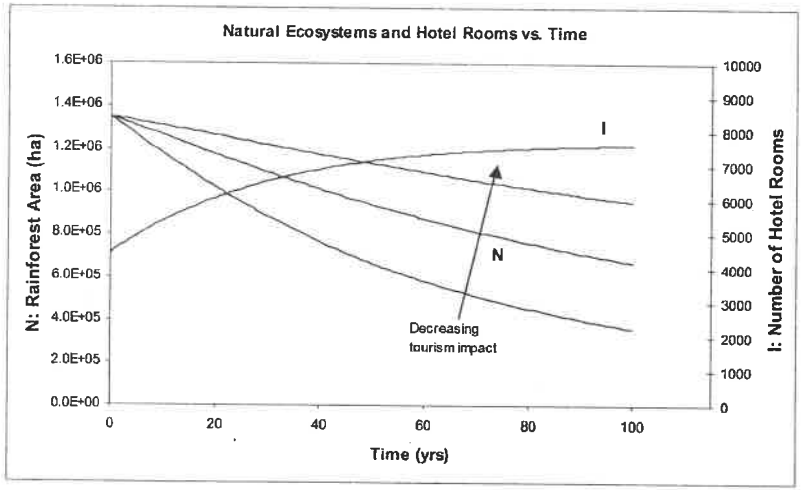
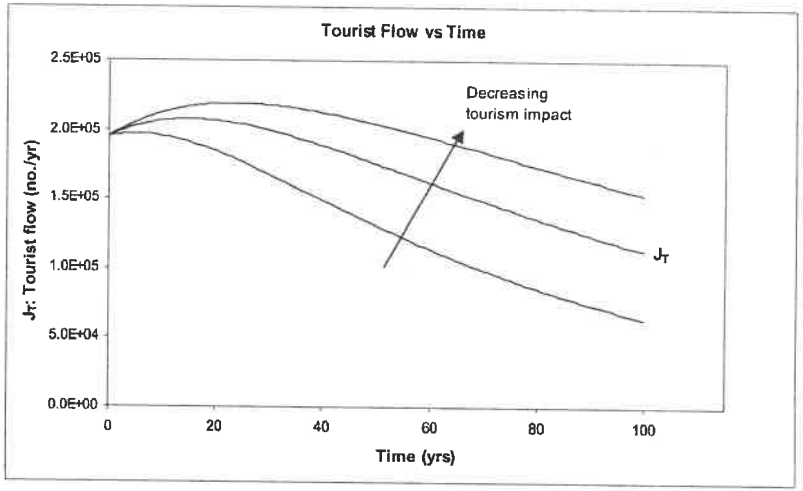


D.

Figure 8-3. Results of simulating the ecotourism model with increasing rates of fossil fuel depletion rates.



A.



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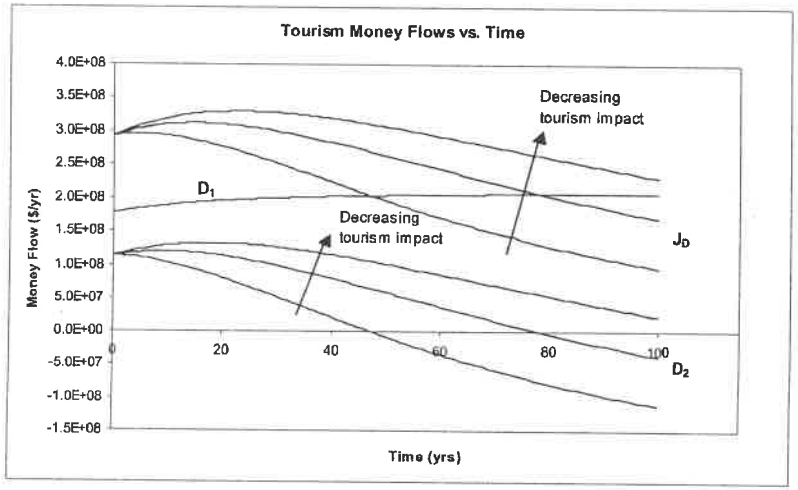
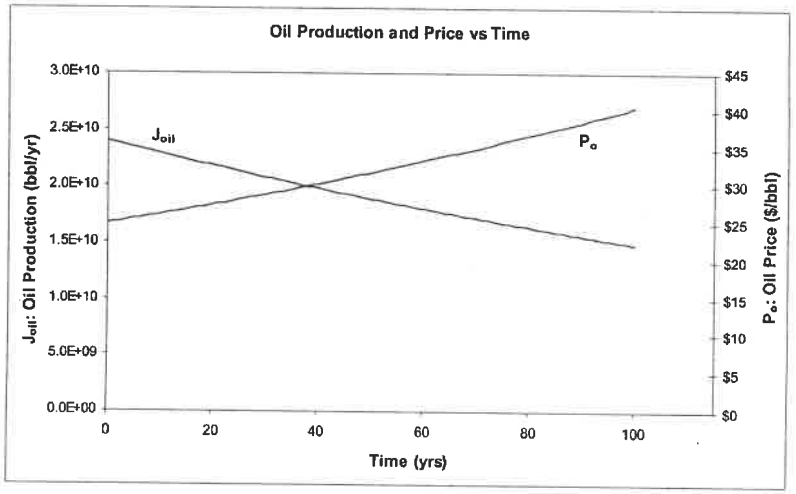


C.



D.

Figure 8-4. Results of simulating the ecotourism model with descreasing rates of environmental impacts from ecotourism, as would occur with improved management rules and regulations.

changes in the system. The model predicts that the decline in the ecotourism economy of Belize will begin within a few decades of the initial conditions, which were calibrated for the year 2000, and will take place gradually. However, timing of the decline will depend on the timing of peak oil production which is still not completely predictable. Because of the proximity of Belize to the ecotourism market in the United States, economic inflows to the country will continue but ultimately the industry will be limited. Thus, while important to Belize in the short run, ecotourism is not sustainable in the long run. Although not shown in the simulations, the tourist infrastructure will ultimately decline and natural ecosystems will be able to recover, assuming no other land use emerges. History may then repeat itself, as occurred after the fall of the Maya civilization, and the forest will again cover over the developments built by humans.

Foreignization and the Loss of Bioliteracy

Globalization first reached Belize in the 1600s when the Spanish tried to subdue the Maya people and it blossomed soon after with the colonization by the British. The impacts of this first wave of change were dramatic but more so in the social and economic realms than in the environment as the forests remained mostly intact. New tools and ideas were introduced by the Spanish and British and the old Maya social system was gradually replaced with a modified European based way of living and the local economies grew up entrained in global markets. Along the Sittee River Creoles took the place of the ancient Maya and they have remained there since the 1800s with support from wage labor and small scale agriculture. In the surrounding watershed a few wealth landlords have implemented a succession of land uses that produced commodities for the global markets: logwood, mahogany, sugar cane and citrus. The second wave of globalization began after World War II and it has been driven by world capitalism that has even more fully integrated national economies into the international economy. The current issues of globalization and its effects are complicated and the subject of much debate (Bhagwati 2004, Petras and Veltmeyer 2001, Isaak 2005), but here two apparent local effects of the global process are discussed.

One of the most significant changes in Sittee River in the last decade has been the foreignization of the village. This process refers to the increasing frequency with which foreigners, mostly Americans and a few Europeans, have bought land in the village. Most of the foreigners who have bought land in the village have been attracted by the beauty and relatively undisturbed character of the surrounding landscape. Although there have probably always been a few foreigners in the village, the trend of foreign ownership increased dramatically since 2002 when the Southern Highway was paved. This event allowed easy mobility for the new residents, most of whom own new sport utility vehicles or pick-up trucks. Also, to some extent the Possum Point Biological Station has contributed to the process because some of the foreigners who have bought land first came to Sittee River in a travel-study course, either as an instructor or as a student. Most of these purchases are regular sized lots suitable for residential occupation of 1-5 acres (___ ha). Development of the property falls into three categories: 1) land purchased but not built upon, 2) land purchased and a house is built but people live there only part-time and 3) land purchased and a house is built in which people live full-time. The spatial distribution of foreign ownership is not random, but rather foreigners have primarily

purchased river front property. For example, a survey in 2004 found that, out of a total of 94 properties along the river, 59% were owned by foreigners. However away from the river, foreigners only owned ____% of the properties (S. Robinson, personal communication). This is a dramatic change from just a decade ago when most of the land was owned by local people. There are several important consequences of the process of foreignization. First, land tenure has shifted away from the local Creole people, especially in terms of the high value properties along the river. The original Belizean owners often still live in the village but away from the river on lower value properties. In the past when Belizeans owned most of the land, ownership of property was passed down from parents to children. The change due to foreignization means that local Belizeans probably will never be able to live along the river in the future, because of the high price of the property. The sale of the high value properties brings a one-time windfall income to the local people but in the long run there is a major shift in the social distribution of land. The second consequence of foreignization is simply that there is a greater physical presence of foreigners in the village, from those people who have moved here either full- or part-time. This presence causes changes in the culture of the village. The most obvious change is a stratification of the population in terms of material wealth. In general, the foreigners have a great deal more money than the local people and it shows dramatically in the type of houses they build, in the type of automobiles they drive and probably in other ways. The foreigners consist primarily of people who live in the village on a part-time basis, essentially during vacations, and a few retirees who live in the village full-time. Only a few of the foreigners operate businesses, and those businesses almost exclusively serve foreign tourists. All of the American and European property owners are either of middle age or older and none are raising children in the village.

In conclusion, foreigners have taken up land and stratified the population in Sittee River but they also brought in new ideas and money to the village. Income has been generated for local people who provided services for the foreigners, for example in the construction of their houses. The question of whether the foreigners are having a positive or negative effect must be left to cultural anthropologists but it is clear that the foreignization is a major change taking place in the village.

Another important change taking place in the village that is at least related to globalization is the loss of indigenous ecological knowledge or bioliteracy by the local people. This phenomenon is occurring throughout the region (Atran 2001) as interactions between people and wild ecosystems have been reduced. In the past people developed a detailed knowledge of the local biodiversity because they were supported by it. This knowledge came from activities such as hunting, fishing and harvesting of building materials, medicines and other useful products from the environment. In the 1800s and most of the 1900s Sittee River village was largely isolated and the quality of life of the local people depended on their ability to exploit the free goods and services that the surrounding natural ecosystems provided. To exploit Nature they developed both a folk taxonomy and detailed knowledge of the natural history of the species that had value. The Creole people in particular exploited Nature in a variety of ways (Horwich and Lyon 1990, Arvigo and Balick 1993) and their indigenous ecological knowledge was passed down from one generation to the next. Even though the Creoles have only occupied

Sittee River for about five to seven generations, they learned from cultural contacts with the Maya people and refined their indigenous knowledge through practical use over time.

This knowledge is now being lost over perhaps as little as a single generation with people switching to use of purchased goods and services and with the loss of the natural ecosystems due to environmental impacts of development. The problem is outlined in Figure 8-5. Indigenous ecological knowledge or bioliteracy was important in sustaining people when they were isolated from development (Figure 8-5a). In this situation knowledge is reinforced by continual use of resources from the environment. Development changes this role when people become attached to an external economy (Figure 8-5b). The source of goods and services for people switches from Nature to the external economy and, moreover, Nature is stressed by the actions of the external economy through deforestation, pollution and other impacts. As a consequence of these changes, indigenous knowledge is no longer reinforced because it isn't being used and it is lost as the older generation dies and the younger generation forgets.

The indigenous ecological knowledge of the Belizean staff at the Possum Point Biological Station has been invaluable to the project reported in this book. The local people who have worked at the biological station grew up in Sittee River Village when Nature was still being exploited for subsistence life support and their level of bioliteracy is high. We have relied on their folk taxonomy as a critical introduction to certain groups, especially trees and fishes, and their knowledge of local natural history has guided all forms of field work. These key staff members are all either middle aged or approaching middle age however, and the next generation does not seem to have their level of bioliteracy to any significant degree. This is because the younger generation is not interacting with Nature very much and they are drawn to other interests such as commercial-based entertainment and social activities in nearby towns. Thus, there is a strong trend away from the reinforcement of bioliteracy in Sittee River. To some extent this trend is being reversed by the growth of ecotourism, which relies on local people to act as guides for nature tours. Ecotour guides do reinforce indigenous ecological knowledge because they use it in their work. While this activity is a viable source of employment for local people who are bioliterate, unfortunately the demand for this kind of job is not high relative to the number of people seeking work in the village.

An interesting aside concerning local bioliteracy relates to recreational bird watching, which is an important activity for most foreign ecotourists. Folk taxonomy of songbirds was not strong among the local people in Sittee River village because this group of species was not especially useful to them, in terms of providing direct goods or services for life support. The second and third authors of this book, as owners of the Possum Point Biological Station, have helped teach some bird identification to the Belizean staff at the biological station, either directly or indirectly, so that they can cover this important group of species in nature tours. In general, the staff has quickly learned bird identification because it is now useful, just as the trees and fishes had always been useful for other reasons. This situation illustrates how foreigners can help develop local bioliteracy and, ultimately, indigenous ecologically knowledge through a new pathway of learning.

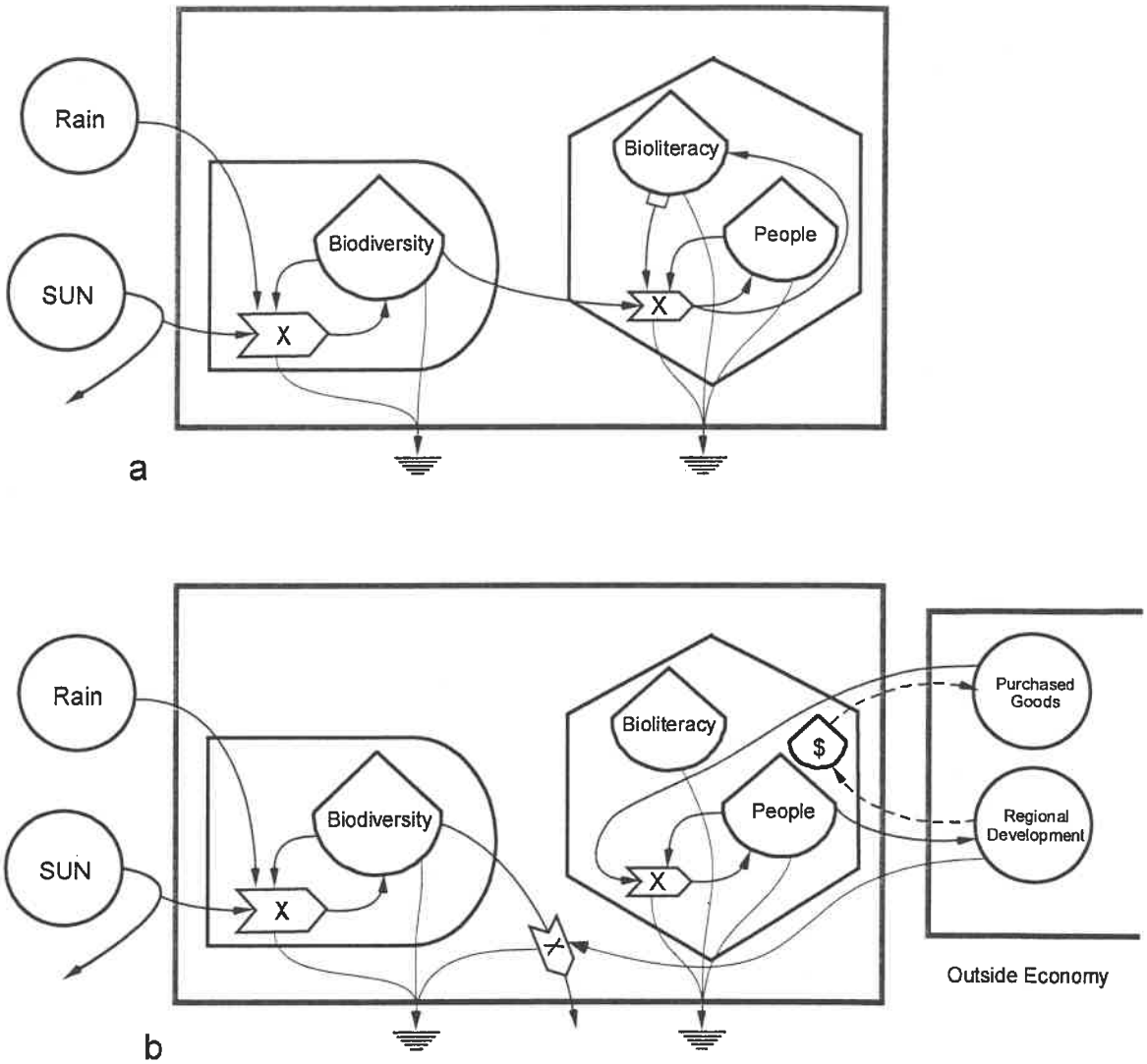


Figure 8-5. Energy circuit diagrams of interactions between people in the village and local biodiversity. A. The past system in which people were isolated from the economy with strong ties to biodiversity. B. The present system in which people no longer utilize biodiversity and, in fact, cause environmental impacts due to reliance on the outside economy.

Regional Development and Biodiversity

Throughout this book there has been an emphasis on the relatively high biodiversity of the environment around Sittee River. Biodiversity, as a form of natural capital, is an important basis for many approaches to sustainable development (Kangas 1997) and its presence around Sittee River is a fortunate situation for people in the village. At the landscape scale this biodiversity is expressed by the variety of habitats in the area which include salinity zones in the river from freshwater to full seawater, the two tributaries with different water chemistries, mangroves that range from dwarfs to some of the tallest in the Caribbean and several types of riparian forests. At the community scale these habitats contain a variety of species.

A goal of this study has been to document at least a cross-section of the biodiversity of the Sittee River Ecosystem. However, the taxonomic surveys included here were limited in a number of ways, especially in terms of sampling efforts. For example, more species of fish certainly occur in the river but they were not caught with the small sample sizes that were possible to be taken. In other cases, some species that were sampled could not be identified. This happened with some trees that lacked distinctive morphological features. Finally, some groups were not sampled at all. The highest diversity in tropical forests world wide is in terrestrial insects but this group was not studied around Sittee River. Thus, only a fraction of the total species diversity of the area has been touched upon in this work, but even so 356 taxa are listed in the book (Table 8-2).

The biodiversity of Sittee River is threatened by development when natural ecosystems are replaced by other land uses (deforestation and loss of habitat) or stressed by adjacent land use (habitat fragmentation and pollution). Fortunately, the rich diversity has survived past development in which the large land parcels were converted from forests to citrus plantations. This phase of deforestation took place more than twenty years ago and only a few large plots of forest have been cleared recently. In general, large areas of upland forest are intact in the upper watershed and the riparian forest and large areas of the pine savanna are intact in the lower watershed. These relatively undisturbed ecosystems are a refuge for terrestrial biodiversity and they provide a buffer for aquatic biodiversity by absorbing water quality impacts.

Sittee River village itself is growing only slowly, mostly through the construction of homes built for foreigners, as mentioned in the previous section. This growth could accelerate if a road was built along the south side of the river, but development would probably still be limited to low density residential housing. Regional development, however, is a more significant issue. Fast growth is occurring in nearby Hopkins directly on the coast. This growth includes both residential housing and hotels. Land is being cleared in a pattern that is parallel to the coastline, spreading out from the original village site. As discussed earlier, the most alarming development is road building and land clearing for housing that is moving into the northern side of Sittee Point at the rivermouth. On the southern side of the river, significant land clearing and road building is occurring from All Pines on the coast and extending up into the pine savanna. A hotel is planned to be built on the beach at All Pines and some shrimp ponds have already been

Table 8-2. Biodiversity surveys included in this book.

Taxonomic group	number of taxa	citation
Riparian forest trees	35	Tables 4-6, 4-7, 4-10 and 4-17
Fruit trees in home gardens	25	Tables 4-9 and 4-12
Mangroves	3	Table 4-3
Macroinvertebrates	49	Tables 4-13, 4-14, 4-15, Appendix Tables 4-7 and 4-8
Fishes	39	Tables 4-18, 4-19, 4-20, 4-22, Appendix Tables 4-9 and 4-10
Reptiles	5	pages ____
Aquatic birds and song birds	175	Table 4-26 and Appendix Table 6-3
Mammals	25	Appendix Table 2-1

constructed inland from the mangroves further south. All of the regional developments threaten to a greater or lesser extent the biodiversity described in this book, though compared to most other places in Central America, Sittee River and more broadly the entire country of Belize remain a refuge for tropical biodiversity.

Developments in Sittee River and the surrounding watershed reach outward into the Caribbean Sea through the discharge of the river. Pollution carried by the river discharge thus can impact biodiversity beyond the boundaries of the study area considered in this book. In particular, the offshore coral reef may be impacted (Perkins and Carr 1985). Studies in other regions, including south Florida (Brand 2006), the Gulf of Mexico (Deslarzes and Lugo-Fernandez 2007) and Australia (Wolanski and Duke 2002) have documented the impact of terrestrial runoff on coral reefs and this kind of impact is likely to be occurring in Belize as well. Figure 8-6 illustrates the connections of the Sittee River to the offshore coral reefs. Runoff from agriculture and other land uses generates pollution that eventually washes into the Caribbean coastal waters. Coral reefs are only found in clear, shallow, oligotrophic waters and the pollutants can seriously impair the water quality conditions of the reef. Nutrients, from fertilizers, cause eutrophication on the reef which favors macroalgae rather than corals. Sediments reduce light transmission to the corals and cause further stress as they settle out of the water column. Pesticides have direct toxic impacts and all of the pollutants combine to generate cumulative impacts that may increase the incidence of coral diseases. Maintaining the riparian forest buffer along the river (Figure 1-1) is an important mechanism for managing runoff from land use, but conservation of forests throughout the watershed may also need to be considered (Carr 1982).

Sea level rise needs to be addressed as a final note concerning regional development and biodiversity. Al Gore's "Inconvenient Truth" (Gore 2006), namely that climate change is inevitable and will cause serious environmental impacts, applies to Belize and to Sittee River as well as everywhere else on the planet. Sea level is rising at a rate of approximately 1-2 mm/year (Douglas 1991) and this rate is projected to increase as global warming continues. Much has been written about the impacts of sea level rise on mangroves (Woodroffe 1990, Bacon 1994, Parkinson et al. 1994, Schaeffer-Novelli et al. 2002) which relates to the Sittee River ecosystem. Coastal wetlands such as mangroves will be drowned if they are not able to match the rate of sea level rise by an increases rate of vertical growth due to sediment deposition and biomass accumulation. In this regard the mangroves at Sittee Point may be able to survive since they grow on a delta supported by sedimentation from the erosion of the Maya Mountains. Other local mangrove forest types, such as the dwarfs behind the beach ridge at All Pines and the overwash community on Wee Wee Caye, will probably not be able to match sea level rise through vertical growth and they will disappear due to flooding. These kinds of habitat changes will cause changes in the aquatic food webs supported by the production of the mangroves.

Sea level rise will also impact the human developments at nearby Hopkins and along the coast. All of the new hotels and houses of foreigners along with the historic Garifuna village will be flooded, probably within 50 to 100 years. The village of Sittee River is

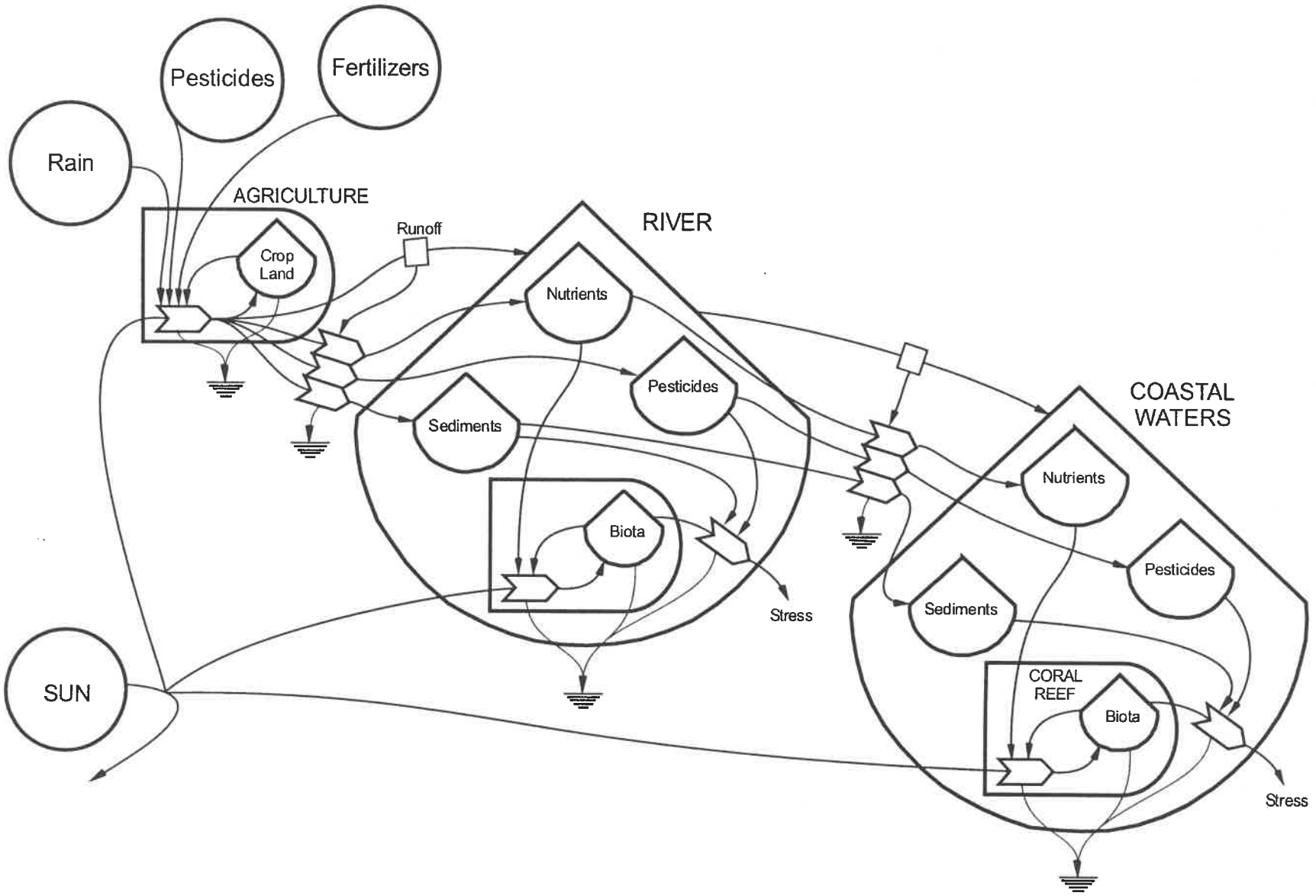


Figure 8-6. Energy circuit diagram of the connections between the Sittee River watershed and the offshore coral reef.

high enough in terms of elevation not to be directly impacted for many years but indirect effects will certainly occur, such as an influx of new residents that have been displaced from the coast. Eventually, perhaps within 100-200 years, Sittee River village itself may be located on the beach due to the rising sea level!

Sustainable Already?

In the travel-study course taught by the first author, students tour several of the major Maya ruin sites in Belize before coming to Possum Point. The remarkable story of the rise and fall of the pre-hispanic Maya civilization is covered in this first part of the course. The ancient Maya provide many lessons relevant to consideration of the present, but especially one on how not to develop a tropical landscape. Belize was once part of what Schele and Freidel (1990) called the "Forest of Kings", referring to the ruling class which organized and directed the May social system. The rulers were historically important people who were responsible to a large extent for the great achievements of the Maya, such as the development of a unique writing system, monumental architecture and intensive forms of agriculture. At the peak of the Classic Period, between 600 and 700 AD, these Maya rulers wielded great power and must have felt tremendous pride in their social system which produced so many accomplishments with only a simple "stone age" technology. But then the civilization collapsed, precipitously in the southern lowlands of which Belize was a part, and the rulers were also responsible to a large extent for this tragedy. The Maya elite seemed to have pushed their system of man and land too far beyond its carrying capacity and the system was destroyed. Whatever the direct cause of the collapse, either agricultural failure, social upheaval or some other trigger, it was ultimately caused by the inability of the rulers to direct the civilization to some form of sustainability. Watt (1974) referred to events such as the collapse of the Maya civilization as an example of the "Titanic Effect", in reference to the great ship that was thought to be unsinkable but, in fact, that sank on its maiden voyage when it collided with an ice burg in the North Atlantic Ocean. The builders and those in charge were so confident that the Titanic could not sink that they didn't provide enough life boats for all of the passengers and crew! In similar fashion, the Maya rulers were so confident in their great civilization that they didn't prepare for the catastrophes that ultimately brought them down. In the travel-study course we challenge the students to compare the Classic Maya to the present social system and to ask whether or not our system could collapse, as did the Maya.

Certainly at the large scale the question of whether or not our system is capable of achieving sustainability is very relevant. Many people are calling for changes in our present system so that sustainability is possible in the long run. Plans are being proposed and experiments are being undertaken from the top down and from the bottom up. The story of Sittee River is just one of many studies in the broader search for sustainability. The previous sections of this conclusion described some limitations to sustainable development in Sittee River but there are also positive local features and potentials that are encouraging. Sustainability doesn't necessarily mean that a biocultural system is sustained without change but rather that certain key biological and cultural characteristics of a local system are retained amid changes to other less critical characteristics.

Sustainability requires adaptability and Sittee River has proven to have this quality. For many years Sittee River seems already to have been sustainable to a degree with a mix of remnant natural ecosystems, patches of intensive and extensive agriculture and low density residential development. Several major changes have occurred but the system has adapted and maintained itself. For example, in terms of the overall landscape, a large scale sugar plantation was operated in the area in the mid- to late-1800s that caused local deforestation and development. This was a major commercial business as described earlier with several mills, many hectares of sugar cane fields and even a narrow gauge railroad network to move the cane in and the molasses and other products out. Some descendants of people living in Sittee River today worked in the old sugar plantation and raised families with income from this employment. But then the plantation was closed down as the business move elsewhere. Employment income was lost and probably many people left the village. The mills turned into ruins and the forests came back covering them over, like the Maya pyramids of a thousand years before. The Serpon Mill Historic Site is evidence of this once major land use, now largely forgotten. The village survived the closure of the sugar plantation, though most likely with a lower population. More recently, the economic system of Sittee River was stressed by the fungal disease of coconuts in the late 1990s. This disease effectively wiped out the local coconut population that had supported the business of coconut oil production, as mentioned earlier. The sale of coconut oil had been a significant, long-term source of income for a number of families in the village that was completely lost over a short period of about two years as coconuts died or at least stopped producing fruit. However, there were no outward effects within the village to this economic impact. None of the families that had operated coconut oil operations left the village as a consequence of the fungal disease and, apparently, they compensated for the lost income in some way or perhaps got along with less.

Both of these changes illustrate the adaptability of the local people. The mechanism of this adaptability is through self organization of people, ideas and resources by the people in the village. Information is passed through filters based on beliefs and aspirations in a process to continually adjust the local culture. A good example is the present day mixing of foreigners and Creoles in Sittee River village, which has some similarities with the mixing of Maya and Spanish nearly 500 years ago. Like the Maya upon contact with the Spanish conquistadors, the Creoles are sometimes resistant and sometimes resilient in the face of changes. Some of the ancestors of the Creole people were escaped slaves that by necessity developed and maintained a strong but flexible culture in the face of adversity. Though globalization is clearly changing aspects of the Creole culture, the assimilation is not completely one-way within the village. The Creoles are clearly taking on material aspects of western culture but the foreigners in the village also adapt to the Creole way of life in subtle ways. There are, in effect, different species of foreigners in the village that interact with the local people in different ways and to different degrees. Some of these foreigners have been interested in learning about the local biodiversity and local horticultural knowledge developed from home gardens. Others have interest in local crafts and other aspects of culture. These are positive interactions in which the flow of information is from the Creoles to the foreigners.

Among the flows of information from the foreigners to the Creoles, knowledge about computers may be most significant. Many of the foreigners own and use computers and some of them help the local people to learn to use this important technology. As noted earlier in this book, electronic sustainability offers a very real opportunity for local people to increase their standard of living without much increase in income. Access to the internet and its vast informational resources has great potential to enrich the lives of the local people and to stimulate the self organization of the culture. Travel-study classes that come to the Possum Point Biological Station have a special role to play in electronic sustainability by making the information they cover, broadly available on the internet to both the Creoles and the foreigners in the village. A veritable Wexpedia, or free electronic encyclopedia, of local biodiversity can be made available from the course notes of the travel-study classes in tropical ecology that use the Possum Point Biological Station. The material in this book provides a first step towards this goal in the print media, but some of the material is also on the first author's University of Maryland web site. In discussing future scenarios for humanity, H. T. Odum and E. C. Odum have stated the need to develop a "Prosperous Way Down", in reference to declining fossil fuels (Odum and Odum 2006). They suggests, as do many others, that cultures will need to adjust to having less material wealth in the future since the basis of this kind of wealth is in the fossil fuels needed to support the global economy. While this is certainly true for most modern western cultures, people in the underdeveloped world may actually be able to improve their standard of living even while the standard of living declines in the developed world. Electronic sustainability provides a source of informational wealth in the underdeveloped world that can become available with access to the internet. In this regard, people in Sittee River might actually follow a "Prosperous Way Up" to a new and higher standard of living in the future.

The kind of cultural evolution described by Janzen (1990) in the introduction of this book is taking place in Sittee River with the generation of new traditions on which socio-economic selection operates. In Sittee River village these new traditions are a form of creativity that results from mixing Creoles, foreign residents and the temporary visits of students in travel-study courses. To use the origin-of-life analogy that was introduced earlier concerning the hoped-for origin-of-sustainability, Sittee River is like one little pool in the primordial soup of society that is adjusting to environmental, social and economic changes it faces, in an effort to maintain itself. The area is still a remarkable place with jaguars roaming the forests and crocodiles reproducing in the river along with a vibrant culture of several ethnic groups and social strata. Will the mix of biodiversity and culture at Sittee River be selected for and survive into the future? Will the village and surrounding ecosystems spin into a hypercycle of sustainable development or get caught up in a vortex of unsustainable growth that leads to environmental degradation and social instability. The collapse of the pre-hispanic Maya civilization is one example of the vortex of unsustainability but modern versions are nearby. One possible future is the dreary company towns of citrus workers who live along North Stann Creek west of Dangriga. Here the water is polluted and the villages are crowded rows of clap-board houses set within the citrus groves. Another possible future is Belize City with its urban over-development located on the coast with limited water treatment capacity and the

absence of forests needed to buffer the environmental impacts of the high population density.

The people of Sittee River live with problems and limits but they enjoy a valuable natural capital in the river and nearby forests. The landscape provides ecosystem services that people in other villages lack and must substitute for with costly technology. Hopefully the present and future generations in Sittee River will appreciate, value and protect their rich natural capital before it is used up. This requires the development of social capital to match with the natural capital of the area (Schwartz 2006, Pretty and Smith 2003). Development of educational programs, especially through the local school, is one approach towards this objective (Figure 8-7). These kinds of programs can reconnect the people to biodiversity, as shown in Figure 8-5a, while still enjoying the benefits of regional development, as shown in Figure 8-5b. As one example of this effort, a recent student group developed an educational game entitled "The Mahogany Tree House" (Mcguirk et al. 2007). A set of questions from various school classes (math, science, history) is integrated into the game. Since these questions are part of existing lesson plans in the school, the game can be a teaching tool rather than a distraction for the instructors. By answering questions correctly, the players progress along pathways on the game board toward the final end point at the top of mahogany tree. Aspects of the tree's life history are included in the game through special event cards that move the player ahead (such as dispersal) or back (such as herbivory) by chance. We hope the game will be used as a part of environmental lesson plans in the school in Sittee River village. This kind of activity along with tree plantings and field trips can expand environmental awareness.

The original goal of the project that has resulted in this book was to somehow save the riparian forest so that it could serve as a buffer for the water quality in the Sittee River. Towards this goal one losing battle has been fought to preserve the mangroves at Sittee Point. In this effort we hoped the tall mangroves at the point might act like the howler monkeys of the Baboon Sanctuary, as a catalyst for conservation and a stimulus to ecotourism. While this goal has not been successful, other goals about conservation and sustainable development have emerged in the overall project. One of the more interesting new objectives deals with understanding and fostering notions of environmental ethics. We hope the presence of the biological station and the actions of the travel-study student groups have had a positive effect in this regard. Ultimately, the people of Sittee River will decide the future of the village and the ecosystem and, in the long run, the development of a holistic environmental ethic may be more important than changes in the riparian forest in the short run.

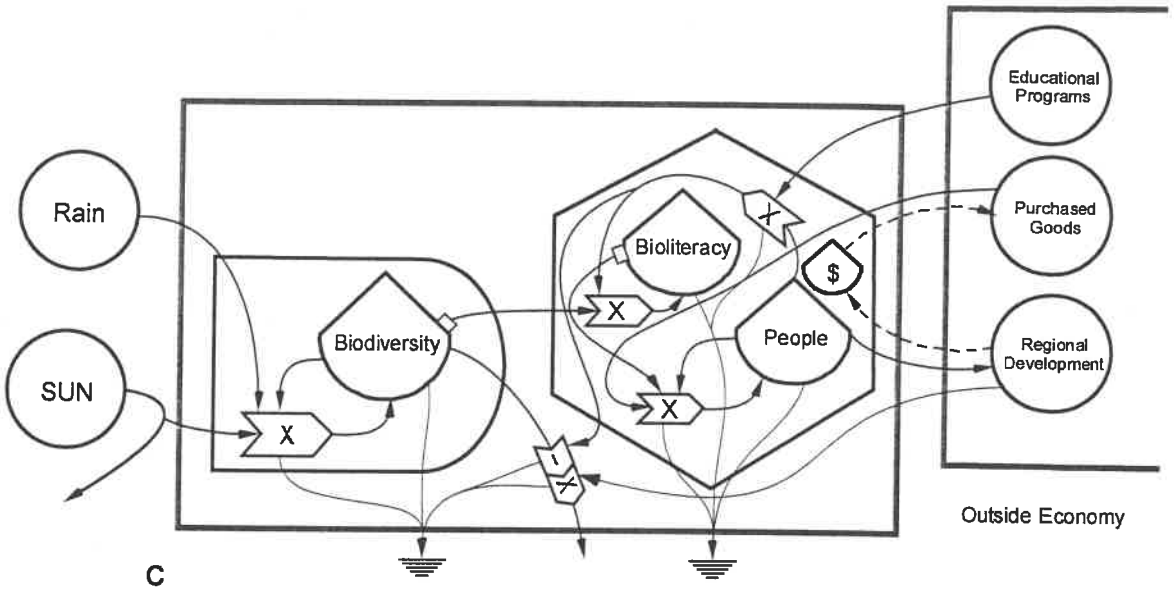


Figure 8-7. Energy circuit diagram, similar to Figure 8-5, showing how people can be reconnected to local biodiversity through educational programs.