# THE BASIS FOR RAINFOREST DIVERSITY AND BIOSPHERE 2

By

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THE BASIS FOR RAINFOREST DIVERSITY AND BIOSPHERE 2

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A miniature rainforest created in the glass-enclosed Biosphere 2 mesocosm in Arizona was compared with montane rainforest in Puerto Rico to study the basis for biodiversity and succession. Initial seeding of high plant diversity was a technique for determining by extrapolation the carrying capacity in Biosphere 2 and in disturbed areas in Puerto Rico. In Biosphere 2 the rainforest area was started in 1991 with 1890 plants of 316 species in 0.19 hectares. Three hundred and thirty-nine plants in 92 species were added in 1993. A diversity index, species per 1000 individuals counted, decreased from 250 in 1991 to 96 in 1998 compared to 60 in the comparison forest while the Shannon-Wiener index decreased from an initial 5.39 to 4.64 in 1996 compared to 4.62 in the comparison forest. Although normal populations of insects and pollinators were absent, vegetative reproduction established productivity, diversity,

hierarchy and developed soil profiles approaching those in the comparison forest.

Graphs of cumulative species versus individuals counted were analyzed to identify mechanisms affecting diversity including seeding, competition for excess nutrients and carbon dioxide, extinction rate, seasonal change in insolation, and pruning and management by humans.

The productive basis for diversity was simulated with a model of production, consumption, and recycle that included management alternatives. Simulation runs showed total biomass production highest when the weedy vine biomass was regularly trimmed and removed.

Another model of main factors affecting diversity was simulated with a minimum species limit to help explain the observed patterns and anticipate species carrying capacity. With an addition of 50 new species after 2 years, the simulation showed an increase in diversity and decrease in biomass after 10 years when compared to the simulation without further additions. Emergy and emdollar evaluation showed resources required for developing the rainforest in Biosphere 2 were 2300 times larger than those for the natural succession.

# CHAPTER 1
# INTRODUCTION

The basis for biodiversity is a principal question in ecology and other fields. Whereas most studies of succession and development of ecosystems have concerned periods of increase and diversification, less studied are the limits to diversity. Are there general systems principles controlling the self-organization of diversity in all systems? What happens when there is initial seeding of high diversity and limited area? In this dissertation the self-organization of the rainforest in Biosphere 2, the glass-enclosed mesocosm in Arizona, is compared with the tabonuco rainforest in Puerto Rico. Floristic studies, measurements, and models are used to account for patterns of growth and diversity.

Suppose a system is defined to include a newly added set of individual organisms and species. Immediately, relationships develop between these and the flows of energy and matter and some between each other. Parts and relationships can be represented with systems diagrams that give an overview of the whole and the parts. Diversity and structure are the information of the system that, like other storages, requires energy for its maintenance. The amount and quality of energy available to a system in part determines which of the energy requirements for diversity, structure, and their connections can be supported, thus shaping its biodiversity. Science of the parts of ecosystems, such as physiology, and science of the whole, such as systems ecology, are converging with respect to understanding biodiversity.

To improve the synthesis when science of the parts is applied, ecosystems and energy are included in systems models.

This dissertation considers the self-organization of the diversity of systems with limited resources. Do systems have a carrying capacity for diversity? How do resources and mechanisms of system interaction account for observed patterns? The next section is a literature review of the theories and processes that have been offered to account for decreases in diversity and structure. In order to clearly relate diversity to its resource basis, Table 1-1 provides definitions of the measures used.

## Review of Diversity-Influencing Processes in Other Studies

Observations of diversity patterns over scales of time, space, or energy inputs suggest causal mechanisms affecting the processes that contribute to diversity. A comparative approach is often used in studying diversity in ecological systems.

### Species and Area

Diversity is the number of kinds of units in an area. In an ecosystem it may be the number of species found. Patterns of diversity have been observed and compared for decades over spatial scales ranging from the entire biosphere (latitudinally) to continents, regions and localities (Rosensweig 1995).

A general pattern in the relationship of species and area show that within a taxonomic group, large areas support more species than small areas. A clear description of the pattern was first published by Jaccard (1912), and in 1921 Arrhenius published a mathematical description of the curve, which

Table 1-1. Definitions and concepts used in this dissertation (after Odum 1996).

| TERM | DEFINITION |
|---|---|
| Emergy | The amount of available energy of one particular type that was used up, directly and indirectly, to make something (product or service). The unit with the prefix "em" is used with the units summed to indicate that it is an emergy rather than an energy scale. This study uses solar joules as energy units and solar emjoules as emergy units. |
| Power | Flow of useful energy per unit time. |
| Empower | Flow of emergy per unit time. |
| Transformity | A measure of energy quality defined as the emergy per unit available energy of a product or service. Units are emjoules per joule. |
| Species richness | The number of species found in an area. This is often used interchangeably with diversity, though richness only accounts for the number of species and not their distribution in an area. |
| Diversity | The accounting of different types within a system using taxonomic, functional, size, trophic levels, information content, etc., as the categories. The number of species and their relative abundances within an area are often used to calculate an index of diversity using various formulas. |
| Diversity indices: Shannon index | $H' = -\Sigma p_i \ln p_i$<br>$p_i$ is the proportion of individuals found in the *i*th species. |
| Margalef index | $(S-1)/\ln N$<br>S = number of species, N = number of individuals |
| Species/1000 individuals | A form of the Margalef index |

Table 1-1 – continued.

| TERM | DEFINITION |
|---|---|
| Logarithmic index | log S/log N |
| Information | The units, connections, and configurations of a system requiring some form of energy as their carrier. Information is useful if it can make its system operate. Genetic codes are an example of useful information. |
| Maximum empower theory | Self-organizing systems prevail by developing designs that maximize emergy inputs and effective use (Odum 1996). |
| System | A part of nature with components defined by artificial or real boundaries, where 'windows' of time and space delimit the system of study. Single organisms or single populations are systems since they have relationships to their external factors and among their parts. A set of organisms is a system even if the units are new and not interacting much with each other. They are interacting with the light, material and heat flows. A system can be any size. |
| Energy hierarchy | The natural arrangement of energy transformation processes in a chain in which each process uses energy of one kind to generate less energy of a different kind. Available energy decreases along the chain, but transformity increases. |

was quickly refuted by Gleason (1922). Extensive dialogue regarding the significance of the mathematical relationship has followed.

A plot of the increase of species as the sample size increases within an ecosystem is called the species/area curve. The first species/area curve is attributed to H. C. Watson in 1835 (Connor and McCoy 1979). The curve is used to indicate the number of species within an area of study larger than the sampled area; to determine the rate at which species accumulate within an area for comparison with other areas; and to determine the minimum sampling size needed to adequately characterize diversity of an area. Vestal (1949) attempted to calculate equivalent reference areas for vegetation types in about 240 areas worldwide. The reference areas were used to compare plant diversity within the area as well as to calculate sampling size required to characterize the vegetation type. The following site differences were cited as reasons for the necessity of varying the area sampled to determine diversity: size of plants or clumps of plants; degree of species dominance; low density of plants overall; productivity of the site; size and shape of the site; degree of heterogeneity of the environment; complexity of the community; floristic richness; abundance among species; successional stage; stand condition. Studies of diversity have to be carefully related to area. Though these reasons are plausible explanations for the need of varying sample sizes, his results have been considered "dubious", "purely hypothetical and probably wrong" due to methods he used in data conversions (Goodall 1952).

Though the pattern of diversity increasing with area may seem obvious or trivial, Huston (1994, p. 35) claims that, "...the underlying mechanisms include most of those that are potentially important in regulating diversity." Three hypotheses were suggested by Connor and McCoy (1979) in examining the causal mechanisms behind the pattern. The first is considered the null hypothesis, and states that the pattern is a statistical sampling phenomenon (Gotelli and Graves 1996). The alternate hypotheses are the result of biological processes. The first suggests that diversification of species is greater in heterogeneous habitats, which occur with greater frequency as total area increases. The second suggests that the extinction rate is higher in smaller areas where populations are smaller, and that immigration rates don't change between areas.

As the area over which species occur increases, the available resources for species support increase proportionally. Species-area curves comparing local and regional scales show the species increasing as the total energy available to support diversity increases. In a study of 82 different variably sized terrestrial ecosystems, Orrell (1997) found correlation between species richness and the energy flow of each ecosystem.

Due to difficulties in comparing species/area curves where different areas have been sampled, other researchers have recommended using a plot of the number of species that accumulate for the number of individuals counted. Research by Condit et al. (1996b) in tropical forests demonstrate that diversity estimates can be compared over sites where an identical number of stems have been counted.

## Species and Individuals

A common pattern measured in nature is the relationship between the cumulative number of species found and the individuals counted within a system. The typical pattern is a curve of decreasing slope (example Figure 3-11), and is the same type of pattern as the species/area curve (Huston 1994). The pattern holds for total enumeration of individuals within a site as well as for subsets, such as trees within a particular stem diameter range (Condit et al. 1996b). Documentation of this pattern has been repeated with various taxa such as aufwuchs in natural springs and a laboratory microcosm (Odum and Hoskin 1957; Yount 1956), fishes (Angermeier and Schlosser 1989), and insects (Fisher et al. 1943).

Succession

Succession is the process of self-organization of an ecosystem after a disturbance. It is linked to diversity in that species composition and dominance change in an area over time due to processes within the system or processes at a larger scale. Clements (1936) initially suggested succession as a phenomenon whereby early successional species facilitate later successional species. According to his conceptual model, each stage of succession paves the way for the next stage by altering soils, humidity, nutrients and water availability. Connell and Slatyer (1977) suggest 3 categories of causal mechanisms for successional changes, adding to Clements' facilitation category: facilitation, inhibition, and tolerance. With their model, the net effect of an earlier successional species on the establishment of a later species can be either positive (facilitation), negative (inhibition), or neutral (tolerance). A neutral effect allows equal probability of all organisms to become established in an area, and "leads to a community composed of those species most efficient in exploiting resources, presumably each specialized on different kinds or proportions of resources." (Connell and Slatyer 1977). All three of these mechanisms along with life history characteristics of organisms are important in any given ecosystem (Ricklefs 1990).

Gutierrez and Fey (975) developed a model simulating the general dynamic patterns of succession, relating ecosystem structure to successional patterns. Simulations of their model suggest that the internal feedback structure of an ecosystem drive secondary succession. Ulanowicz (1980) uses community flow networks through ecosystems to describe the development and information content of the systems, suggesting that flows by themselves adequately describe ecosystem succession.

Four stages of succession are suggested by Holling (1986): exploitation, conservation, creative destruction, and renewal (recycle). During the exploitation and conservation phases, an ecosystem develops structure, functions, and diversity from available energy and matter. Disturbances – the creative destruction phase - occur as pulses on widely varying spatial and time scales which are generally characteristic of a given ecosystem. Disturbances may be caused by abiotic elements or by biotic factors. The pulse of nutrients made available allows their recycle into a newly developing ecosystem, which may have very different configurations than the previous ecosystem (Holling 1986).

When a disturbance is widespread, the successional process may be in the same phase over the entire area of disturbance. In the case of treefalls, the successional process starts over in small local areas, creating a discontinuous, mosaic landscape. Remmert (1991) calls this a 'mosaic-cycle', where various-aged patches of different sizes occur throughout an ecosystem. The importance of spatial and temporal landscape patterns to vertebrate species diversity has been documented for avian species in Panama by Karr and Freemark (1983).

Diversity of an ecosystem is generally reduced after the creative destruction phase. During the establishment and conservation phases, diversity generally increases, though there are cases where diversity declines during these 2 phases. Diversity decline has been observed just after the point where all species (both opportunist and mature life-histories) occur at the same time. Eventually, the opportunist species are out-competed for resources, and a species decline is seen (Remmert 1991) where later successional species dominate.

## Theories of Diversity

Since species diversity reflects the sum of additions and removals of species from an area, local and regional processes that add or subtract species are important to its understanding. Species are added to an area by evolution or by immigration. They are subtracted from an area by total extinction or by one of following processes: change in physical conditions that no longer meet the needs of the species, such as catastrophes or climate change; random events that affect rates of propagation and mortality; or exclusion by local processes due to interactions between individuals, such as competition, predation, and pollination (Hawksworth and Kalin-Arroyo 1990).

Many theories have been offered to explain differences in diversity. They include both equilibrium and non-equilibrium processes. Theories invoking equilibrium dynamics suggest that the rate of addition and removal of species from a region is equivalent, and that areas have their own equilibrium value of species diversity. If species are lost, the processes of adding or subtracting species will adjust the value so that it remains constant. On the local scale, equilibrium theory suggests that species interactions account for the level of diversity saturation, and that local diversity is fed by the regional species pool (Ricklefs 1990). Non-equilibrium or dynamic equilibrium theory suggests that communities have fluctuating species diversity resulting from an approximate balance between local and regional processes (Ricklefs 1990). Competitive exclusion and its prevention are the basis of this theory, according to Huston (1994).

The following broad theories suggest underlying processes of observed patterns of diversity: 1) Diversity through fluctuations; 2) Time theory; 3) Diversity proportional to resources; 4) Energy or empower diverted for physiological adaptation; 5) Population mechanisms affecting diversity; and 6) Habitat heterogeneity theory.

Diversity through fluctuations

More diversity is predicted when fluctuations of conditions affecting species is large enough so that no one species can gain competitive dominance, but not so large as to cause extinctions. This is the basis of the "intermediate disturbance hypothesis" proposed by Connell (1978), who applied it to rainforests. Rainforests have numerous gaps, evidence that there is almost perpetual disturbance of small areas. Gaps are thought to occur before competitive exclusion within the forest can reduce its diversity. Hence, a high diversity is maintained in rainforests.

Previously, Hutchinson (1961) questioned the mechanism of co-existence of many species of phytoplankton in relatively large lakes as well as the co-existence of large numbers of species in other ecosystems. He framed his argument using the competitive exclusion theory, and maintained that if disturbance in the ecosystem recurred more frequently than the time over which species would have been excluded due to interspecific competition, species richness should remain high.

Fluctuations may cause extinction of rare species, leaving a lower diversity at least temporarily. Pimm (1991) discusses 2 ways in which species extinction rates increase for small populations: one due to random demographic causes, such as all individuals growing in one year are the same sex, and the second due to fluctuations that add to the risk of random extinction. Supporting this, Tilman and El Haddi (1992) reported a 40% extinction rate of species in grassland ecosystems due to drought. Most of the species lost were rare before the drought. Hall et al. (1992) suggest that the geographic distribution of individuals of a species reflects the net energy balance of the species, occurring in a gradient that can be divided over 3 parts of the distribution: the range over which the stored energy is sufficient for reproduction and long term existence of the species; the range over which stored energy is adequate for survival but not reproduction; and the range wherein energy reserves must be consumed for survival. The extremes of the gradient may be the areas over which a species becomes rare, and has a higher probability of extinction with fluctuations that will take energy for adaptation.

Seasonal fluctuations can increase diversity of an ecosystem. For example, in arid lands a large annual flora may flourish during seasonal rainfall events. Since the perennial plants of arid lands are widely spaced, probably due to competition for water, seasonal invasion by annual plants is possible when water is available (Colinvaux 1986).

Time theory

The amount of time over which a region has been undisturbed by major climatic changes, such as glaciations, may influence the number of species that are in the area. Tropical areas may have had more time for evolution to occur than temperate regions. Periods of drying may also have created refugia for tropical moist species, providing the isolation believed important to speciation. Temperate and arctic regions also have ancient floral elements, however, so the time that floras have had to evolve may not be as different as originally proposed (Ricklefs 1990), though temperate and arctic regions have been periodically nearly eliminated by expansion of glaciers.

Sanders (1968) proposed the stability-time hypothesis, which addressed the high diversity of the deep sea benthos compared to continental shelf benthos. He suggested that the difference was due to stability of the environment of the deep sea, allowing evolutionary specialization and low extinction rates due to environmental fluctuations. In addition, respiratory costs of living in the environment would be very low.

Diversity proportional to resources

More diversity is predicted when there is more energy to support the greater complexity of the system of more species. Odum (1960, 1970 and 1971) related diversity to the energy requirements using permutations and square functions to relate number of species to energy requirement. Where the levels of energy supporting an ecosystem decrease, species diversity has been observed to decrease. For example: Energy theory was suggested by Connell and Orias (1964) but they later retracted their view. Odum (1970a, 1970b) offered energy theory of diversity for a rainforest in Puerto Rico.

Wright (1983) proposes a species-energy theory, predicting diversity of species from either actual evapotranspiration (for plants) or total net primary production (for breeding land or freshwater bird species) of island biota. Wright showed that on islands of varying sizes and locations, as the basic energy resources decrease, as with increased latitude or seasonal changes, species diversity decreases. Since lower populations of species are supported with less energy, there is a higher probability of species extinctions. More recently Rosenzweig and Abramsky (1993) suggested a decrease of diversity with a decrease of primary productivity, as well as a diversity decrease with an increase of primary productivity above a certain level. In other words, the proposed pattern on a regional scale is hump-shaped.

The relationship between energy and species richness is scale-dependent. Wright et al. (1993) show the relationship on regional and local scales. He emphasizes the importance of using extensive measures of incoming energy to a system (total amount per area) for the correlation rather than intensive (amount per $m^2$).

The maximum empower theory predicts this. Empower (definition Table 1-1) is a measure of the rate of resource use by an ecosystem which combines different resources in one energy-evaluated unit. Emergy is used to combine inputs and processes on a common basis (insolation, precipitation, transpiration, evaporation, and primary production). Energy concentration has been proposed as a third measure of scale (with time and space) for relation to diversity.

Population mechanisms affect diversity

Population approaches to diversity describe processes occurring at the scale of individual organisms and their interactions with and effects on each other. These include predation, competition, and mutualism. The implication is that population densities change by each individual responding to its local conditions rather than in response to average conditions across an area (Tilman et al. 1997).

Three approaches to understanding population dynamics are discussed by Tilman et al. (1997): metapopulation-like models, cellular-automaton-like models, and reaction-diffusion models. Huston (1994) concludes that competition has a direct effect on species diversity only under a very restricted set of condition.

Spatial heterogeneity theory

Large-scale equilibrium dynamics are implied with the spatial heterogeneity theory (Huston 1994). Higher diversity is maintained by having enough different, local patches within a region so that there is a balance of losses and additions. Patches that are caused by disturbance will support species of different successional stages. Patches that are caused by environmental heterogeneity will support different species than the surrounding environment due to availability of different resources or the rate at which the resources can be exploited.

Diversity Decline

Insight into the way diversity may be limited comes from the study of situations with declining diversity. In studies of contained microcosms started with high diversity, an initial decline in diversity is generally observed (Beyers and Odum 1993). For any system, diversity decline may result from processes within the system or from those outside of the system.

A survey of common knowledge and published examples suggested the following circumstances where species diversity has been observed to decrease in natural and experimental systems.

Catastrophic destruction

Whether by human hands or by large scale planetary events, destruction of part of an ecosystem reduces the number of species.

Externally driven diurnal and seasonal changes

Declines in species are observed as part of the ups and downs of abiotic influences such as climatic cycles. For example: The Sonoran Desert in Arizona has a rich winter ephemeral flora appearing only in the years when the rainfall regime meets certain criteria. When the dry season begins, ephemeral species die and the local diversity decreases. Animal migrations also follow seasonal patterns of resource abundance, with a decline in local diversity occurring on a yearly cycle.

Oscillations

Declines in species are observed during parts of the oscillatory cycles due to internal rhythms. Diversity has been observed to rise and fall. For example: Ecosystems pulse with recurring cycles of production and consumption (Odum 1994), often due to recurring natural perturbations such as forest fires or floods. In general, systems grow and exhibit successional stages towards a climax stage which is followed by a descent; this oscillation is repeated through time.

Concentrated seeding

Wherever species are assembled in higher concentrations than can be supported, declines follow. For example: Experiments using microcosms showed that an initial high seeding of species in a microcosm were followed by a decrease of species to a lower level (Dickerson and Robinson 1986). This may be the result of competitive exclusion due to limited resources in a small volume, as well as due to the increased maintenance costs of species as they aged (Beyers and Odum 1993).

Competitive overgrowth by enriched populations

Where conditions for growth become enriched, rapid growth by some species can displace others. The result is generally an increase in the density or biomass of one or a few species, reducing the available resources (such as light) to remaining species which may then become locally extinct.

Cultural eutrophy is an example of available resources increasing abruptly. In a five month field plot experiment, Kent (1996) documented species declines due to the surge of competition with the abundant growth of cattails, water hyacinths, and other species that could most effectively use the excess resource.

In a study of old field succession in Michigan, Tilman (1993) recorded a decline of species in plots that were fertilized with nitrogen compared to those that were not fertilized. An increase in productivity of the plots was correlated both with an increased loss of species and a decreased rate of establishment of species, both contributing to a reduction in the number of species. Increased loss of species was attributed to competitive interactions, and decreased establishment of new species.

Changed conditions

Where environmental conditions change so that existing species are not adapted, species decreases are observed at least temporarily. For example: In a Barro Colorado Island study, a long term drying trend showed a decline and predicted extinction of 16 species, while colonizer species were increasing (Condit et al. 1996a). A similar decline in species was documented in a prairie ecosystem, where it was attributed to drought (Tilman and El Haddi 1992).

Decreased resources

Also, diversity decreases with decreasing production. Production is strongly correlated with precipitation. Though diversity in general decreases with less rain, correlations made of diversity and precipitation is not as compelling as diversity and evaporation. Increased competition due to a change in resources may cause the diversity decline.

Decreasing diversity along gradients

The number of woody plant species in 0.1 ha plots within 69 neotropical forests was compared, and richness was correlated with soils and climatic data (Clinebell et al. 1995). The most important variables correlated with number of species were annual rainfall and rainfall seasonality.

Gentry and Dodson (1987) showed richness of epiphytes in western Ecuador and southern Central America to decrease with decreasing absolute precipitation, using data from local floras.

Wright (1992) reports a consistent decrease in number of species with decreased rainfall in tropical forests, emphasizing the inverse relationship of rainfall and seasonality throughout the wet tropics. The standard forest plots that he examined showed a fivefold decrease in plant species densities in the Neotropics in rainfall gradient from 4000 to 1000 mm; and sixfold decrease over a Ghanan rainfall gradient of 1750 to 750 mm.

The number of species declines polewards from the equator and coincides with decreasing rainfall, temperature, evapotranspiration, insolation, and primary production. Whether these relationships are merely correlative or causal has been addressed widely, but the patterns have been observed for many life forms. For example: Based on 74 samples of 0.1 ha lowland sites, Gentry (1988) reports an order of magnitude downsizing in number vascular plant species between rich tropical forests and temperate forest.

Gentry (1982) used total plant species numbers in 0.1 ha samples across the upland Neotropics, and showed a strong correlation between diversity and precipitation in the Neotropics. He later discussed that this relationship may be a special case relevant to the Neotropics where there is a strong correlation of total annual rainfall and strength of dry season (Gentry 1988). Such a relationship was not apparent in the samples from tropics of Africa. In addition, he found that the relationship at the high end of actual precipitation was nonlinear, becoming asymptotic above 4,000 mm. This may show saturation level for species diversity. He also warns that the asymptote may be an artifact of sampling methods - species-area curves do not level off for the highest diversity sites; thus the area sampled at the lower sites may not reflect diversity at the highest-diversity sites. He further strengthens the relationship between rain and number of species with data from 1 ha plots measuring trees and lianas ≥ 10 cm diameter. In upper Amazonia, adjacent forest types were shown to have different species and were growing on different substrates, with little change in species diversity.

Overlaying the latitudinal pattern of diversity are regional or local declines in diversity with reduced rainfall. This often is associated with effects of local or regional topography influencing temperature and rainfall patterns. In arid northern Chilean Andes above the Atacama Desert, Arroyo et al. (1988) report a steep gradient of plant species diversity corresponding with the rainfall gradient. Surveys in 1620 minimum area quadrats were made on 6 transects 1/4 degree latitude wide and between 18-28 S, running from the edge of the Atacama Desert (1500-3000m) to the elevational limit for vascular plants (4500-5000 m depending on latitude). Data showed species diversity decline with increasing aridity on a latitudinal gradient along the western side of the Andes as well as from east to west across the Andes along the rainfall gradient.

Based on surveys in 48 sites in the Neotropics (lowland tropics of Middle and South America, montane cloud forests, and supra-treeline of Andes), Duellman (1988) found a decline in diversity from wet to dry regions and from low to high elevations for the entire anuran fauna.

Both a decrease in structure and diversity occurs with the decreased input of rainfall and temperature. Evapotranspiration is a function of both rainfall and temperature directly related to plant production.

Decreased information exchange due to fragmentation

Diversity has been observed to decrease where ecosystem areas are fragmented by insertion of other uses of space, and are isolated from exchanges of species and seeding with adjacent areas. Bierregard et al. (1992) documented loss of species in lowland tropical rainforest where habitat islands were created by the removal of forest around various size fragments. Diversity decline due to fragmentation of habitat is also reported on the islands that were created by the formation of Gatun Lake for the opening of the Panama Canal (Leigh et al. 1993).

Onset of stable conditions

Some researchers have related species decline to the onset of stable conditions after times of greater fluctuation. Whereas competitive exclusion may be pre-empted due to disturbance, the lack of disturbance will allow interspecies competition to cause a higher rate of extinction.

Growth in size

Where space is limited during a time of growth, increasing size of dominant species by occupying more space, may exclude species. This is demonstrated in a successional sequence of a very limited area of forest where a dominance hierarchy develops, shading out species in the understory.

Loss of controllers

Where species are dependent on control actions by other species, loss of the control species may cause loss of species. For example, plants dependent on insects for pollination were lost when insects were not available.

Physiological demand

Where special conditions require energy to be diverted to sustain life, diversity has been observed to decrease. For example: Increased levels of toxic stress may result in reduced diversity accompanied by an increase in biomass. Pratt et al. (1987) report a decrease of microorganism species present in microcosms with increasing zinc concentration.

## A Conceptual Model of Ecosystem and Diversity

In order to overview the principal parts and processes of an ecosystem and the role of diversity, a conceptual model was developed in Figure 1 -1. By using the energy systems language, Table 1-2, the main components and processes that appear to be involved in determining the diversity are shown not separately but as part of a connected whole. Enough parts and pathways of interaction are included to consider the observations and alternative theories discussed in the previous sections. The model diagram is a way to combine and synthesize the factors affecting diversity such as energy, competitors, nutrient materials, outside pulses, and internal oscillations. The conceptual model may be used for all scales over which diversity is studied.

A systems model is a complex hypothesis. To account for diversity declines, a systems model must have the main parts and processes that affect

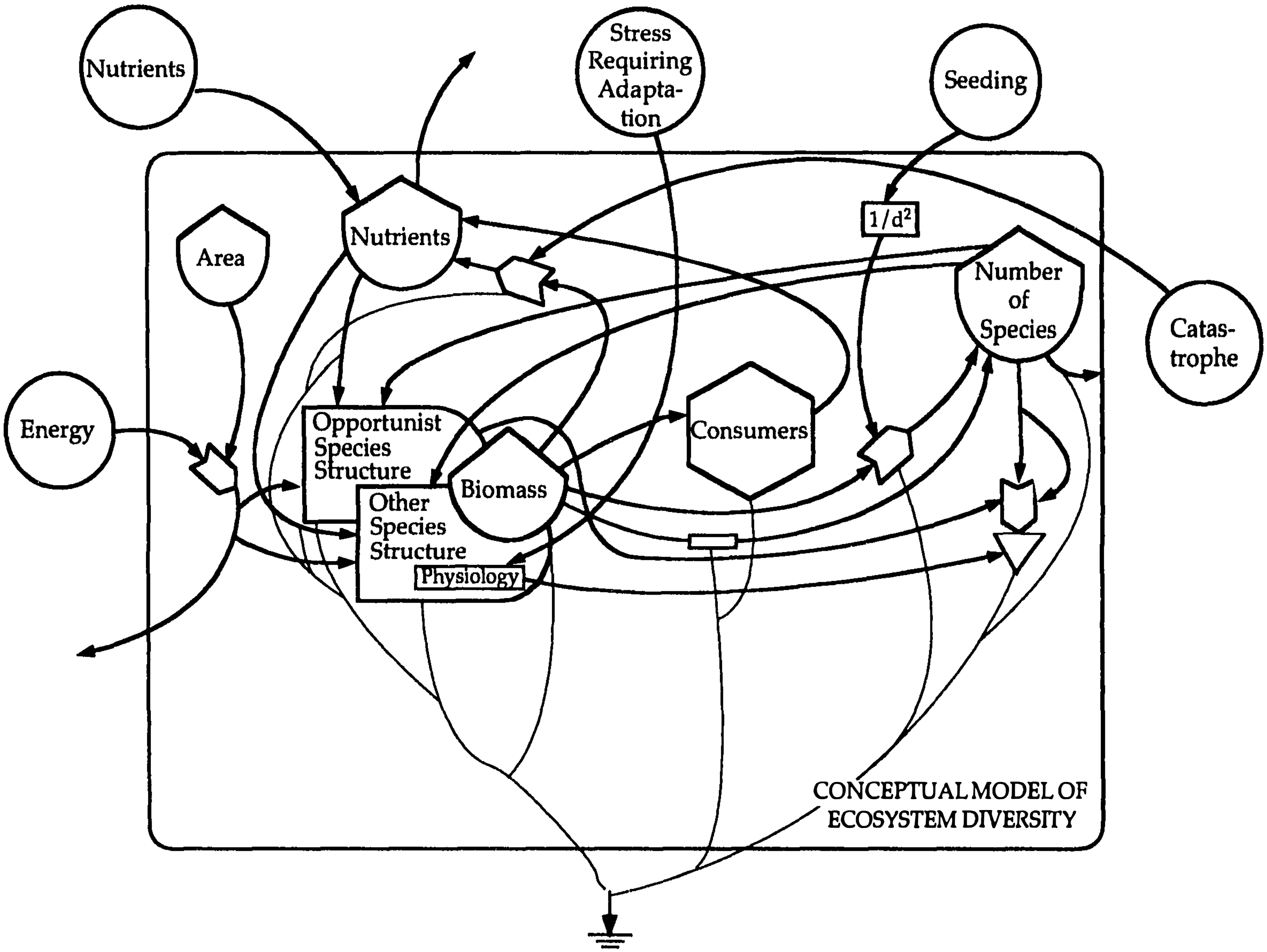
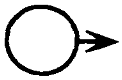
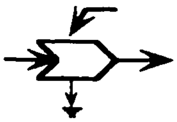
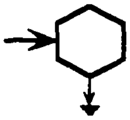
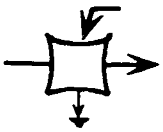
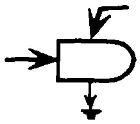
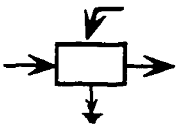
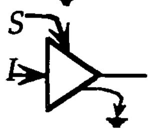
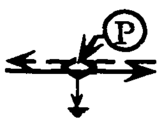



Figure 1-1. Systems diagram representing theories of ecosystem diversity.

Table 1-2. Symbols for the energy systems language used in this dissertation. From Odum (1983).

| Symbol | Explanation |
|---|---|
|  | *Energy circuit:* A pathway whose flow is proportional to the quantity in the storage or source upstream. |
|  | *Source:* Outside source of energy delivering forces according to a program controlled from outside; a forcing function. |
|  | *Tank:* A compartment of energy storage within the system storing a quantity as the balance of inflows and outflows; a state variable. |
|  | *Heat sink:* Dispersion of potential energy into heat that accompanies all real transformation processes and storages; loss of potential energy from further use by the system. |
|  | *Interaction:* Interactive intersection of two pathways coupled to produce an outflow in proportion to a function of both;control action of one flow on another; limiting factor action;work gate. |
|  | *Consumer:* Unit that transforms energy quality, stores it, and feeds it back autocatalytically to improve inflow. |
|  | *Switching action:* A symbol that indicates one or more switching actions. |
|  | *Producer:* Unit that collects and transforms low-quality energy under control interactions of high-quality flows. |
|  | *Box:* Miscellaneous symbol to use for whatever unit or function is labeled. |
|  | *Constant-gain amplifier:* A unit that delivers an output in proportion to the input *I* but is changed by a constant factor as long as the energy source *S* is sufficient. |
|  | *Transaction:* A unit that indicates a sale of goods or services (solid line) in exchange for payment of money (dashed line). Price (P) is shown as an external source. |

the species numbers and are capable of accounting for observed declines. Figure 1-1 is used here to suggest what parts and processes are important and how they may account for diversity decline in an ecosystem. Of course, whether the model and its inherent hypotheses are appropriate can only be verified by study of the behavior of the real systems. In Table 1-3, explanations for ways that diversity may decrease are suggested as consequences of the way the model was formulated.

External sources entering the system

The box drawn in Figure 1-1 defines the boundary of a system. Everything outside of the box is not considered part of the system. Inflows from sources outside the system are represented by circles outside of the box, with pathways crossing the boundary into the system. The external sources operate on larger spatial scales than the system.

The circle on the left labeled "energy" represents the energy sources sun, wind and rain that enter the system. The inflow may vary over time scales, such as diurnal, seasonal, and geological depending upon the scale of the system being studied. The total amount of energy entering is in proportion to the area of the system being studied, as represented by the interaction between the storage tank labeled "area" and the energy source. Thus, the total energy entering a larger area will be greater than that entering a smaller area in the same region. Some of the energy entering the system is used by the producers, represented with bullet-shaped characters. Some of the energy entering the system flows through the system without being used, and is shown as a pathway with an arrow exiting the system. An example is sun that is reflected from surfaces in the system.

Table 1-3. Parts and processes of ecosystem model that affect species numbers and account for observed declines.

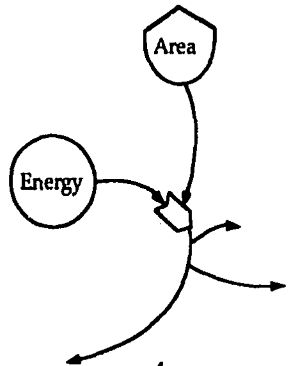
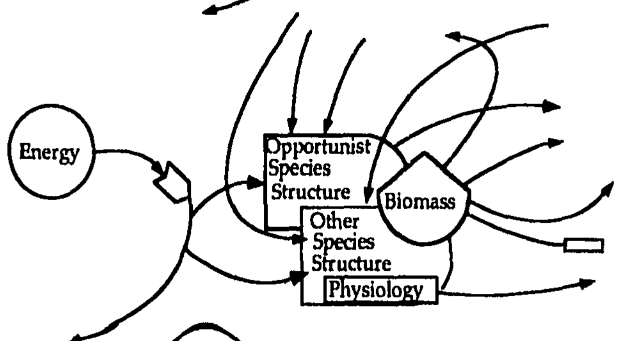
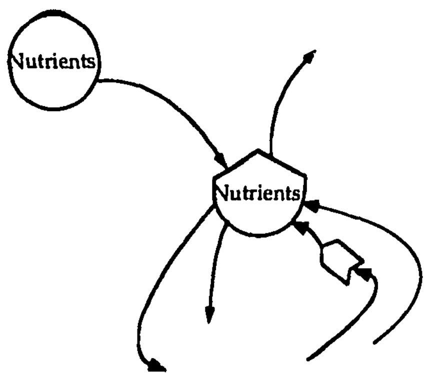
| Symbol | Explanation |
|---|---|
|  | **External Energy Sources**<br><br>The main energy inputs from the left (sun, rain, wind) support all the processes in the system. The inflow may vary diurnally, seasonally, and over geologic time depending upon the scale of the system being studied.<br><br>Reduction of the inflow of energy sources causes a decrease in all the storages and flows in the system, including the number of species. If the area over which energy is flowing into the system is reduced, primary production decreases proportionally, resulting in a similar decrease in number of species. |
|  | **Biomass**<br><br>As the energy from outside sources increases primary productivity will increase. |
|  | **Nutrients**<br><br>An increase of nutrient inflow, whether from rainfall, run-in, wandering wildlife, or additions such as fertilizer or sewage, can increase productivity of plants resulting in increased biomass of the species that can respond most quickly to those additions.<br><br>In such cases where only several species can make use of the additional nutrient loads, the number of species in the system may decrease due to competition with the species that could not respond. |

Table 1-3--continued.

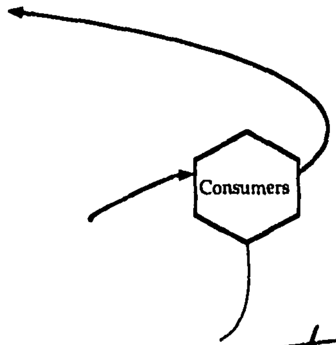
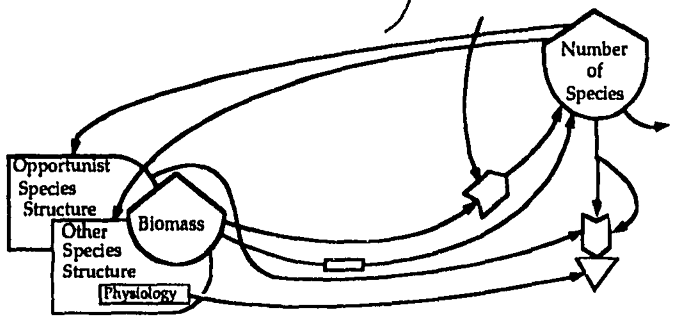
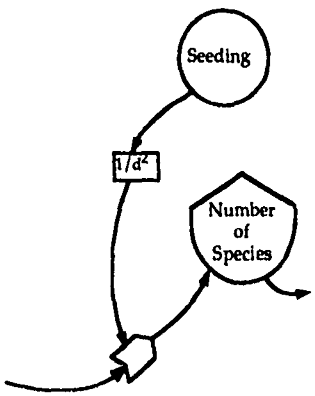
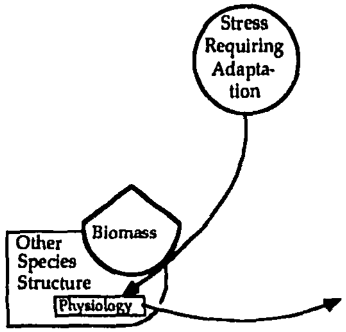
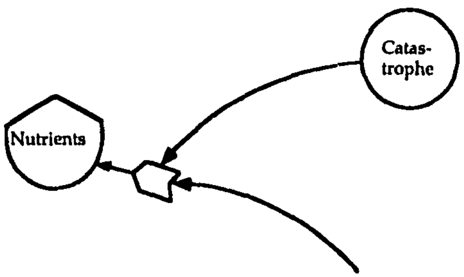
| Symbol | Explanation |
|---|---|
|  | **Consumers**<br><br>The consumer tank includes decomposers as well as herbivores and carnivores. An increase in plant biomass will result in more consumer biomass. The waste products from the consumers feeds back into the nutrient tank. |
|  | **Number of Species**<br><br>The number of species in a system is a result of, extinctions, emigration, immigration, and evolution.<br><br>A decrease in the number of species occurs with increased extinction or emigration or decreased immigration or evolution. |
|  | **Seeding (immigration)**<br><br>New species are shown inflowing from the upper right of the diagram, balancing the extinction pathways. The rate of immigration can be affected by a change in the distance to seed source, change in pollen carriers, and loss of an organism that disperses another.<br><br>Reducing the seeding rate decreases the number of species. |

Table 1-3--continued.

| Symbol | Explanation |
| --- | --- |
|   | **Stress from outside system**<br><br>Additional stresses from outside the system, as shown in the top center of the diagram, can necessitate physiological adjustment of species that are present in the system. Such changes increase the maintenance costs of the biomass supported in the systesm, resulting in an increase in the extinction rate. |
|   | **Catastrophe**<br><br>Pulse on a scale much larger scale than the system being studied, considered a 'reset' of systems. |

Over a latitudinal gradient from the equator to the poles, the energy from outside sources decreases. The reduction of energy to the system causes a decrease in all the storages and flows in the system, including the number of species per unit or area. If the area over which energy is flowing into the system is reduced, such as the fragmentation of a forest surrounded by clear-cutting for agriculture, primary production and number of species decrease proportionally.

External nutrient sources can enter the system with rainfall, run-in, wandering wildlife, air pollution or additions such as fertilizer or sewage. A sudden increase of nutrients may result in a rapid rise in productivity of the system, in which case one or several plant species may respond with rapid growth. Some species may become locally extinct from competitive interactions such as shading, resulting in a system with fewer species.

Examples of stress from external sources are changes in water relations such as drought, temperature extremes, or input of substances resulting in toxic buildup in the soil. Plant response to adapt to stress may require use of energy, taking energy away from other uses. This may result in the diversion of energy from biomass production and diversity support in order to support adaptations for survival of the stressful condition.

Seeding from sources external to the system depends on dispersal methods and distance from the seed source. As distance (d) from the source increases, dispersal of propagules into the system decreases ($1/d^2$). Where ecosystems are separated in space from similar ecosystems that supply propagules, species with seeds that do not have a vector for farther dispersal may be eliminated from seeding an area.

Catastrophes cause a pulse of nutrients to a system and a resetting of successional pathways to an earlier stage. Systems are often adapted to certain frequencies, amplitudes and sizes of catastrophes such as hurricanes or fires. If one of these 3 changes, the results may be systems with lower diversity than the initial system.

Internal processes

Competition for light is shown between the opportunistic plant species and other species. Opportunistic species are those that establish as early successional species, or species that are 'weedy'. The opportunistic species draw light from the energy pathway first, before those species that are later successional species indicative of a more mature system (labeled "other species structure"). As the later successional species grow, they are able to pull more light for production and overshade the early successional species. Local diversity may show an increase when species from both early and later successional stages are present, and a decrease when the earlier species become locally extinct from overshading. As external energy sources increase, primary production increases. The symbol showing the mature species also shows physiology, which reflects the respiratory costs of physiological adjustment to changing conditions within the system. As stress from the outside increases, the energetic cost of plant adaptation increases. This is shown on the diagram as an increase in the constant-gain amplifier (triangle), which in turn increases the extinction rate from the species diversity tank.

Plant biomass is shown with 4 outflowing pathways. The first pathway flows into the nutrient storage. This occurs through decomposition of plant material from litterfall, plant mortalities including those due to catastrophe, and exudates. Another pathway shows biomass feeding consumers, where all consumers in the system are aggregated into one consumer storage. The other 2 pathways from biomass lead to the species diversity tank. Biomass (representing suitable habitat) interacts with seeding on one pathway, allowing colonization of new species when the energy base can support it. As the rate of seeding decreases, the rate of colonization also decreases. The second flow to diversity represents the habitat base supporting extant species.

Pathways from the diversity tank are either extinction pathways or pathways that feed back to the primary production of the system. The quadratic extinction pathway represents extinction due to competition with other species. The rate of extinction increases when opportunist species increase, such as with increase due to a pulse of nutrients. It also increases when the stress from outside the system increases, requiring more energy for plant adaptation to new conditions. The second extinction pathway is a linear pathway, representing extinction due to causes other than competition. Feedback pathways show an increased efficiency of the system due to new species or additional species added to the system.

Nutrients are added to the system either from outside sources or from cycling of biomass or through consumers. Available nutrients decrease when they are immobilized by plant uptake, or when they flow out of the system in processes such as runoff or soil erosion.

In any real ecosystem more than one of these mechanisms affecting diversity may be operating. Simulation is used to relate the complex hypothesis to the observations.

Because of its feedback amplifier loops (autocatalytic input designs and material cycles), the diversity model is consistent with the maximum empower concept. This principle may be stated as follows: Self-organizing systems prevail by developing designs that maximize emergy inputs and effective use.

The model in Figure 1-1 includes the general premise that some species variety is necessary to maximize a system's processes. To fit the principle, increasing or decreasing diversity needs to be consistent with increasing and/or sustaining resource inputs or increasing functional efficiencies.

## Carrying Capacity of Systems for Diversity

A general question asked by those responsible for maintaining diversity in public lands and parks is whether there is a carrying capacity of an ecosystem for diversity. If the maximum empower principle applies, ecosystems sustain that diversity that promotes total system function. Priority in self-organization may go for physiological adaptation of fewer species where this is necessary to maximize system productivity and efficiency.

## Spatial Organization

There are extensive published observations on the spatial patterns developed by ecosystems, including the patterns of horizontal plant organization on the forest floor and patterns of vertical structure. Explanations for observed distributions have to include the role of light energy and the apparently general tendency for self-organization to form hierarchies. Obviously changes of diversity are affected by the seeding, which determines the locations and survival of plants. In situations where humans do the planting, how does self-organization develop afterwards?

Hierarchical Organization

Like other ecosystems, the rainforest develops components and processes in an energy hierarchy, which is represented in model diagrams by position from left to right. Items on the left have more energy (low quality energy), turnover faster, and have smaller territory. Position of a component or pathway flow in an energy hierarchy is measured by its transformity. Transformity is the emergy per unit energy (Table 1-1). Emergy is the energy of one kind previously used directly and indirectly to make a product or service. Calculating emergy and transformities of ecosystem components and flows is a way of determining the pattern of energy hierarchy. Maps of transformity and changes of transformity over time may be estimated.

## Rainforest in Biosphere 2

Biosphere 2 is a 1.25 hectare mesocosm in Arizona designed to be closed to material exchanges with the environment outside of its glass boundary, but open to exchanges of energy and some types of information. Areas within Biosphere 2 were established to represent different biomes of earth, and included aquatic (ocean and estuary) and terrestrial (savannah, desert, and rainforest) wilderness areas and a habitat for human residents and their agricultural systems (Figure 1-2). Whereas the atmospheric chemistry and water systems were global phenomena among all of the areas of Biosphere 2, temperatures, rainfall regimes, and humidities were maintained locally within each area. Figure 1-3 shows the photosynthetically active radiation, $CO_2$ concentration and temperature for terrestrial wilderness areas in the Biosphere.

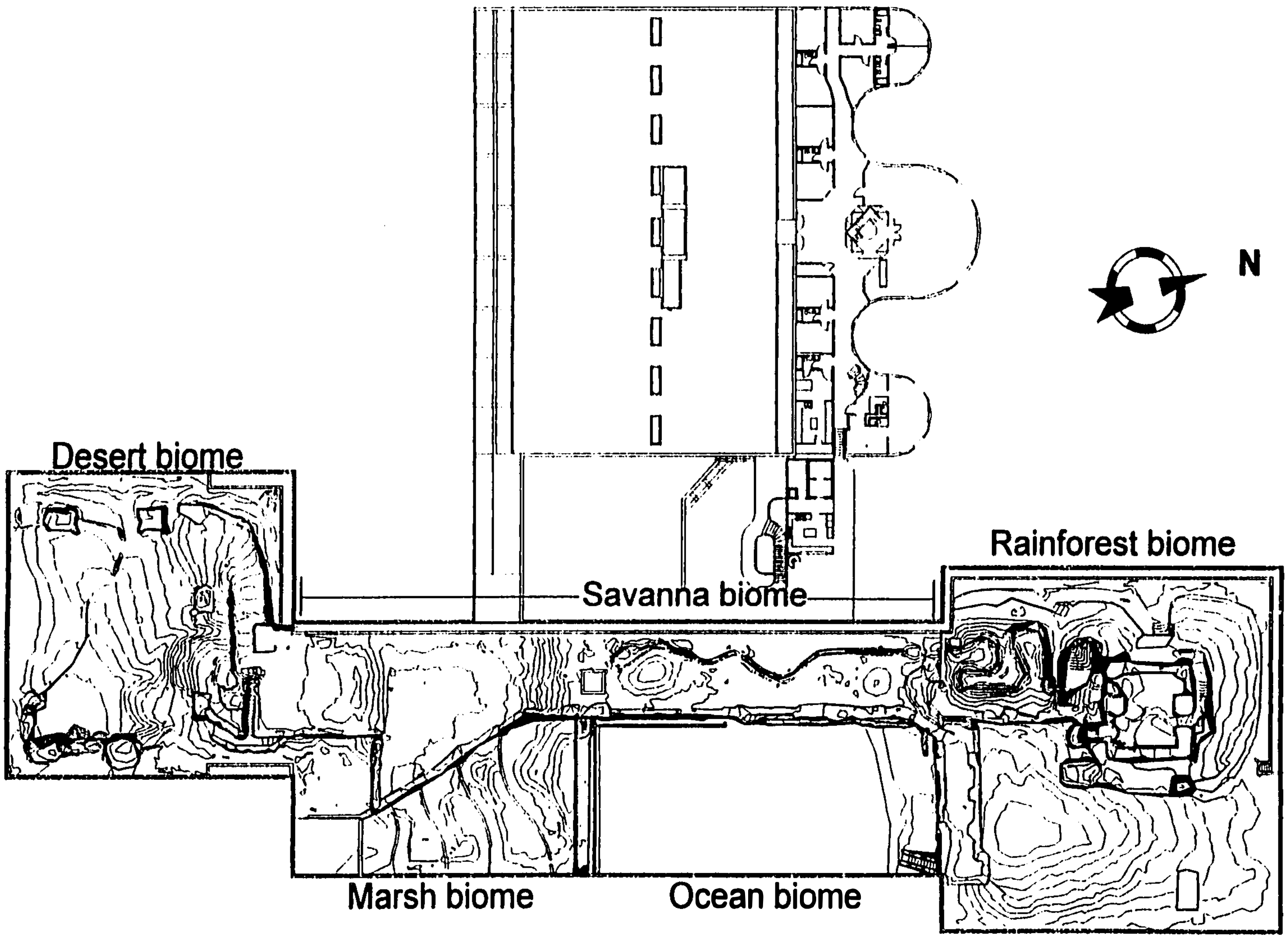



Figure 1-2. Areas within Biosphere 2.

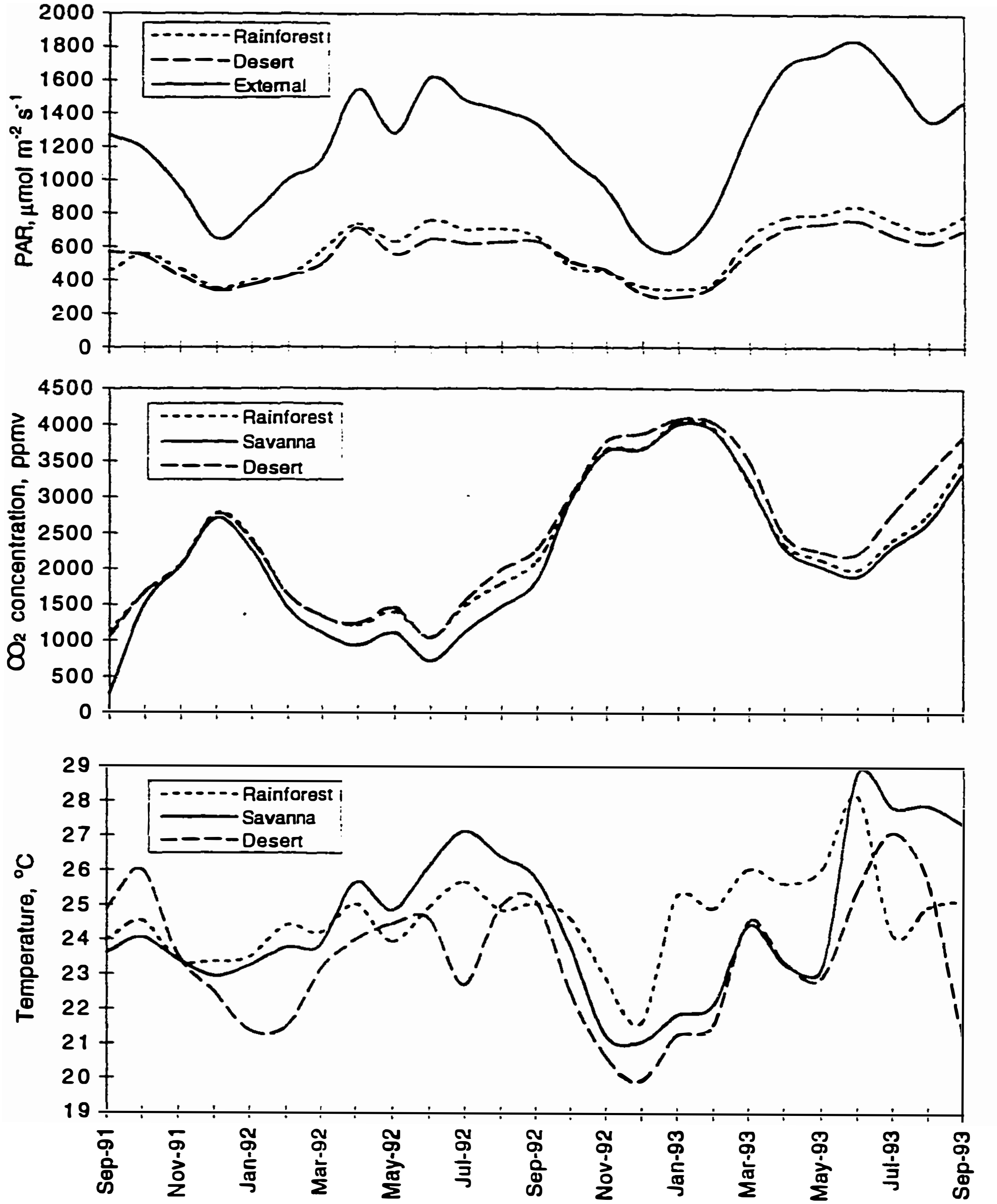



Figure 1-3. Continuous photosynthetically active radiation, $CO_2$, and temperature in terrestrial wilderness biomes of Biosphere 2 during the first material closure.

The footprint of the tropical rainforest biome within Biosphere 2 is 1900 $m^2$. The highest point of the pyramidal glass structure enclosing it is 22 m, measured from the soil surface in the lowland rainforest (Figure 1-4). The total volume of the rainforest is about 35,000 $m^3$ (Dempster 1993), nearly 17% of the total Biosphere 2 volume. The contribution of the rainforest to the atmospheric chemistry of the larger scale mesocosm has been modeled by Engel and Odum (1999). Their simulations suggest that the rainforest may be responsible for up to 50% of the whole Biosphere 2 metabolic rate.

The rainforest biome was designed to be functionally analogous to the planetary rainforest biome. It was built and its climate managed to emulate the general structure and function of a New World tropical rainforest. It is a geographical island, disjunct from the larger system from which its components were obtained.

Design Elements and Description

The climate of the Biosphere 2 rainforest was created by control of rain, temperature, humidity and air flow so as to support plant species from various humid tropical regions. The annual changes in day length were greater in Biosphere 2 than in a planetary rainforest, and temperature and atmospheric $CO_2$ ranges were greater on both a daily and annual basis.

The rainforest soils were created from a local desert grassland soil combined with other organic materials. The design objectives were to produce a functional equivalent of tropical rainforest soils, to allow soils to develop in place, and to provide a horticulturally adequate substrate. Over time, the formation of humic and fulvic acids was expected to reduce the soil pH, similar to a planetary rainforest (Scarborough 1994). The soils were designed to be deep enough to allow expansion of roots needed to stabilize

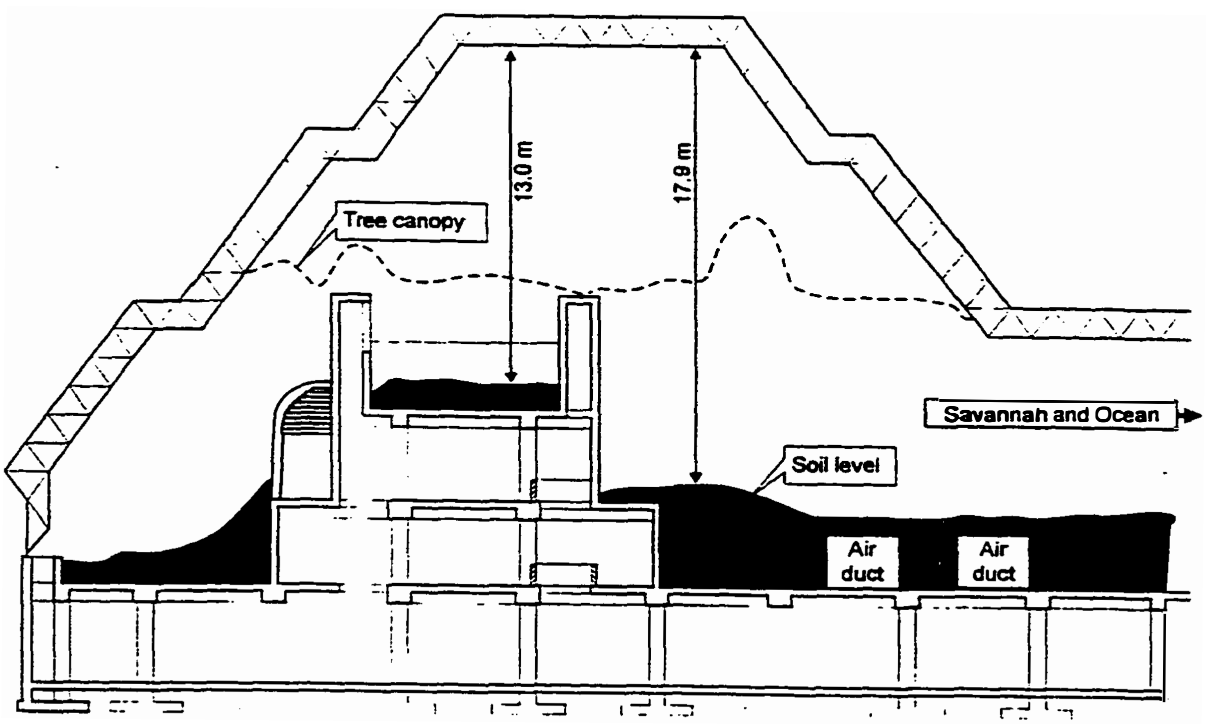



Figure 1-4. Side view of rainforest biome.

aboveground canopy expansion and to contain a storage of elements necessary plant growth.

The design challenge of the Biosphere 2 rainforest was to consider diversity over a hundred year time scale, as well as across the scales of population, community, and ecosystem, including functional diversity. The rainforest was excessively species-packed for self-organization over time under minimal influence of human management. Since no biotic introductions were to be made during the study period after the initial closure in 1991, initial planting had to include all of the species for succession and mature development. In contrast, an unconfined rainforest experiences continuing immigration during successional changes. Therefore, a much larger number of species was planted than could survive, letting extinction occur as a natural process in the system. Though effort was made through pruning to reduce competition for light during the first years of operation to ensure the survival of certain key species, decline in the number of plant species was expected. It was hypothesized that the rainforest structure would change over time from that of a recently cleared ecosystem to a complex primary forest (Prance 1991). The final mix of plant species was eclectic with a bias toward Neotropical taxa.

Eight separate habitats were initially delineated in the rainforest (Prance 1991). The habitats were named lowland rainforest, ginger belt, várzea, cloud bowl, surface aquatic systems, bamboo belt, mountain terraces, and cliff faces (Figure 1-5).

The conceptual design for the rainforest began in 1985; plant collections were made from 1986 to 1991; planting began in 1990; animal introductions began in 1991; and a total survey and mapping of every plant was completed prior to the first material closure, which lasted from September 1991 through

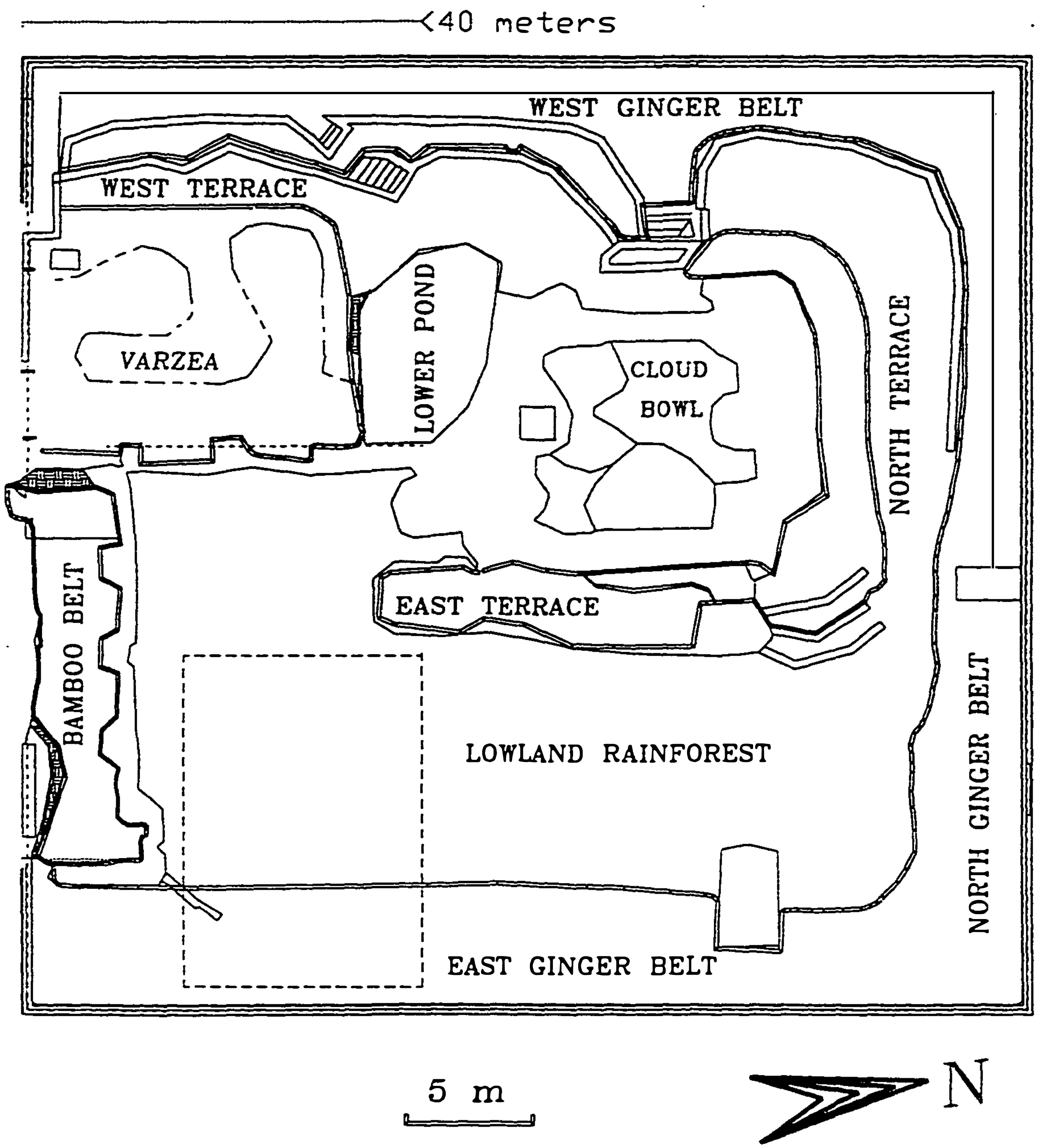



Figure 1-5. Habitats delineated within the Biosphere 2 rainforest.

September 1993. A total re-survey of plants in the rainforest was made after the 2-year closure and again in 1996.

Measurements of energy flows and storages made during and after the period of closure included temperature, relative humidity, rainfall duration, plant sizes, light level, atmospheric $CO_2$ and $O_2$, and trace gas concentrations.

An artificial ecosystem such as the Biosphere 2 rainforest or a botanic garden might be expected to behave according to models of a natural ecosystem with equivalent energy inputs and available information. What are the different options for ecosystems to maximize power, and what aspects of human management of 'artificial' systems will alter this?

## A Conceptual Model of Diversity in Rainforest of Biosphere 2

Whereas Figure 1-1 has the main features of any system believed to affect the diversity of stored information, Figure 1-6 represents these concepts for the rainforest biome area of Biosphere 2. The diagram is a complex hypothesis for understanding diversity changes in Biosphere 2. The differences between parts and processes of the earlier conceptual model of diversity in ecosystems (Figure 1-1) and the model of the Biosphere 2 rainforest are as follows.

### External sources entering the system

The striped border in Figure 1-6 defines the glass boundary of the Biosphere 2 structure that physically separates it from the outside. The inner, solid box in the diagram represents the rainforest biome, one of 7 biomes inside. There was no physical barrier separating the rainforest biome from the other biomes. Though many of the parts and processes within the

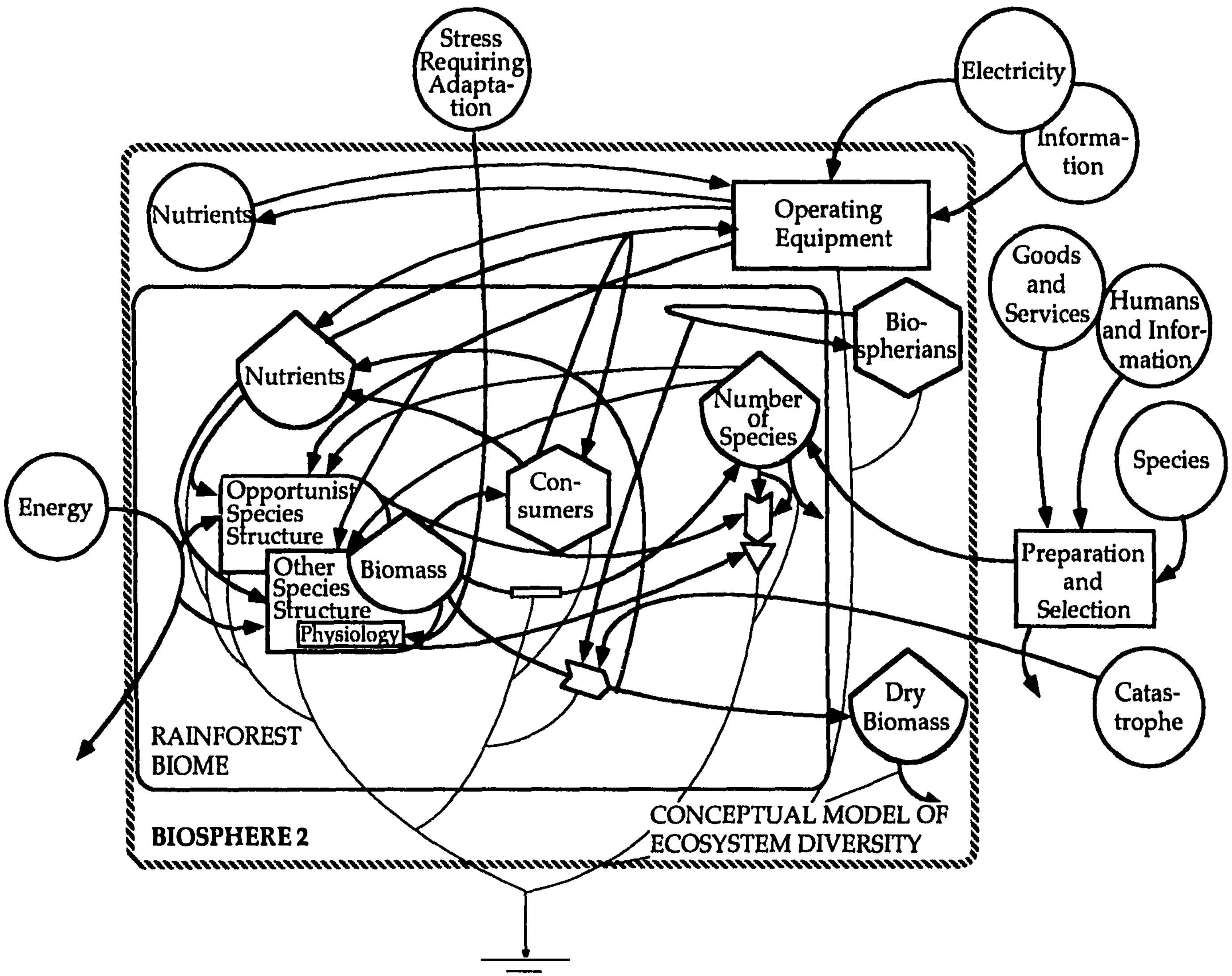



Figure 1-6. Systems diagram representing ecosystem diversity within Biosphere 2 rainforest.

rainforest model are the same as the earlier, general model, the external sources are quite different.

The primary energy source entering the rainforest was sunlight; rain and wind do not enter from an external source. Since the Biosphere 2 rainforest was contained, its area was constant and the tank for land area interacting with energy has been deleted. During periods of material closure, no nutrients entered the Biosphere from outside. Certain stress-causing external conditions could have affected the producers, such as a long period of reduced sunlight. Electricity and information were external sources used to operate and design the mechanical systems providing the subsidies normally produced by nature, such as waves in the ocean, airflow throughout the Biosphere, and rainfall operated by a sprinkler system.

The species that were planted in the rainforest were selected from the earth's species pool, with human decisions rather than habitat and dispersal characteristics determining which plant species would colonize the area. Catastrophes from outside sources would be those that would have affected the operating systems or caused massive collapse of the external structure. A total shutdown of the power systems, for example, may have caused overheating during the day, resulting in plant mortalities. This would have resulted in a pulse of dead biomass that would have been placed in the dry biomass storage, shown with the interaction of catastrophe and biomass pathways, flowing into the dry biomass storage tank.

Internal processes

The cycling of nutrients between the rainforest and other areas inside the Biosphere included flows driven by the operating equipment. Airborne nutrients such as $CO_2$ were exchanged by airflow through the air handlers.

Soil borne nutrients exited the rainforest in water that percolated through the soil profile and was pumped to a central storage reservoir, where it was mixed with water from the other areas. Some of these nutrients were then pumped back to the rainforest in rain water.

Biospherians lived in their habitat area outside of the rainforest, but visited the rainforest regularly. The model shows an interaction of the Biospherian pathway with biomass, representing pruning of the weedy biomass. Much of the weedy biomass was dried and stored, shown with the pathway to the dry biomass tank.

Some of the rainforest consumers traveled between areas in the Biosphere. This is shown with a flow pathway crossing over and then returning to the rainforest system. Examples were the galagos that concentrated their activities in the rainforest but traveled throughout the wilderness biomes.

Though the process of colonization of the rainforest by plant species differed from wild systems, the extinction process occurred similarly. This is shown in both conceptual models with a quadratic function representing competition with other plant species and a linear function representing other reasons for extinction.

## Rainforest in Puerto Rico

The rainforest compared with that in Biosphere 2 is in the Luquillo Experimental Forest (USDA) of northeastern Puerto Rico. The area has 4 different vegetation zones - tabonuco forest, colorado forest, sierra palm brake, and elfin forest. The tabonuco rainforest, named after its dominant tree species, has been the most extensively studied (Reagan and Waide 1996) and is the type used for comparison in this study.

Long-term data are available for the El Verde study site and the Bisley watersheds and MAB biodiversity plots. An extensive study of the tabonuco forest type funded by the Atomic Energy Commission was undertaken from 1963-1968, before and after irradiation (Odum and Pigeon 1970). Subsequently, a volume was published (Reagan and Waide 1996) describing the food web of El Verde.

Among the many papers that deal with plant diversity and successional patterns in the tabonuco forest are the following: Lugo (1992) compared the plant species in pairs of tree plantations and secondary forests; Taylor et al. (1996) analyzed numbers and densities of species by life form in an irradiated area of the tabonuco forest over 23 years after irradiation with data from 8 surveys; landslide succession has been documented by Myster and Walker (1997), Walker et al. (1996), and Guariguata (1990); Crow (1980) studied species changes in a 0.72 ha plot over 30 years, and Johnston (1990) followed Crow's work with a dissertation documenting successional change in the same plots.

Recent papers describing the effects of Hurricane Hugo on the tabonuco forest system and the re-development of the system to pre-hurricane conditions are published in a special issue of the journal Biotropica, Volume 28(4a), 1996.

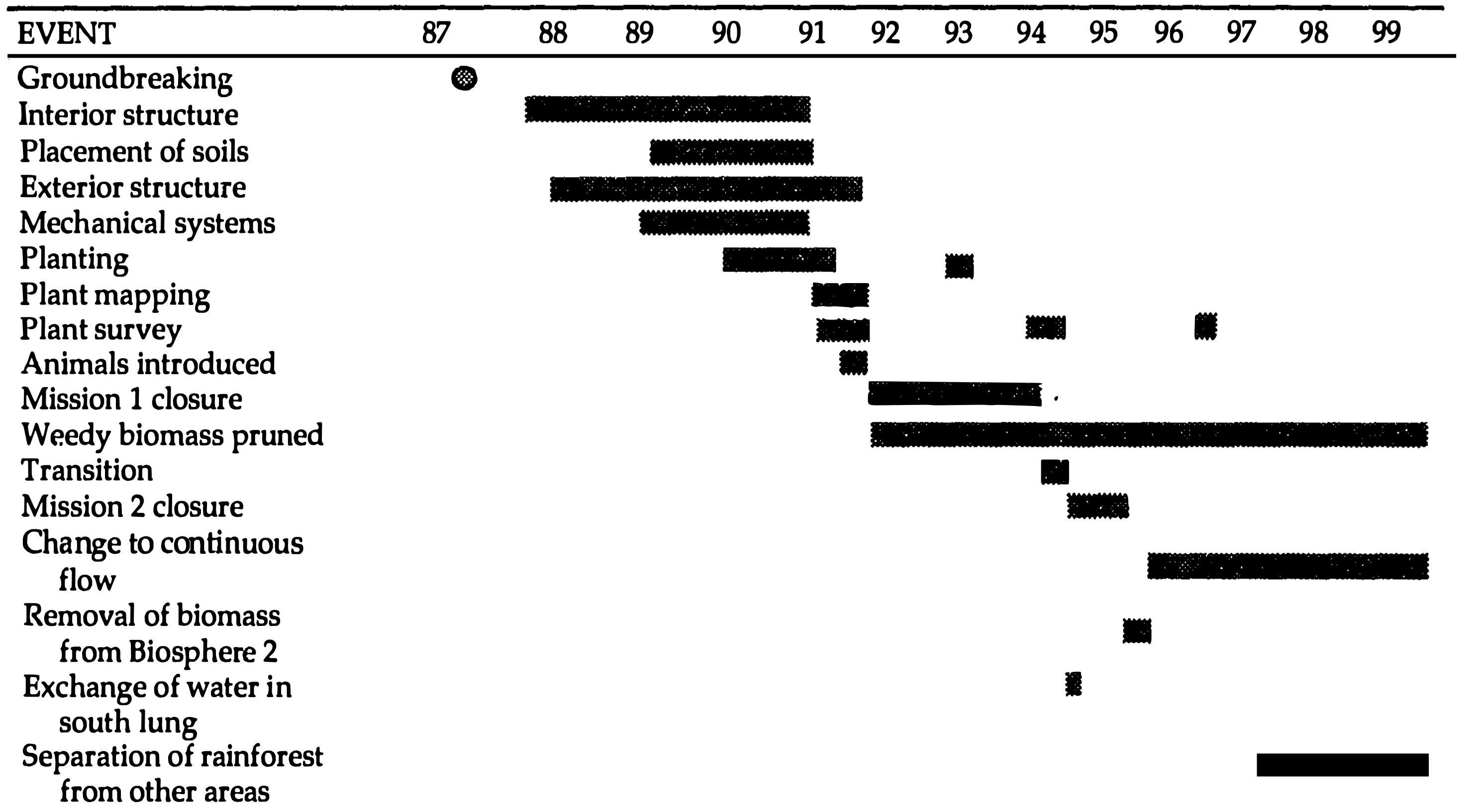
# CHAPTER 2
# METHODS

In this study, measurements of diversity were related to measures of the resources and productivity in Biosphere 2, in the rainforest in Puerto Rico and other situations where limited resources may have restricted diversity.

## Construction and Operation of the Rainforest in Biosphere 2

A chronology of the construction and operation of the mechanical, structural and life systems of the Biosphere 2 rainforest from 1987 through 1999 is shown in Table 2-1. Three different modes of operation of Biosphere 2 are distinguished by degree of material closure from the outside or the separation between biomes on the inside of the structure, and degree of control over composition of the atmosphere, as follows: (1) Complete material closure, with the entire atmosphere inside Biosphere 2 interacting as a unit separate from the outside atmosphere. (2) Forced airflow through the entire Biosphere from the outside. (3) Physical separation of the wilderness systems from the habitat and agriculture systems; separation of the wilderness biomes from each other with curtains; and forced airflow from outside. Construction and engineering details of Biosphere 2 are given in Zabel et al. (1999).

Table 2-1. Chronology of Biosphere 2 rainforest construction and operation.



## Procedures Used in Starting the Ecosystem

### Soil Components and Placement

The soil profile was assembled with subsoil and topsoil layers. The subsoil was a mix of a coarse sandy loam (highly weathered granitic grus) extracted from a local quarry and 5-15 cm granite rocks. It had uniform composition throughout the rainforest, and its thickness varied from 0 to about 5 m depending upon specifications made for root growth and the architectural structure over which it was placed. Criteria for subsoil selection were good downward percolation of water after repeated wettings; radon emissions not greater than background crustal emissions; low heavy metal content; price-competitiveness; and proximity to the Biosphere 2 site (Scarborough 1994). The subsoil volume was estimated to be 3340 cubic meters, based on measured volumes of the structure into which it was placed. Table 2-2 lists the quarry locations of the materials extracted for the rainforest soils. The subsoil was placed over a shallow gravel layer which covered and surrounded drainage pipes that carried water percolated through the soils to a collection trough, from which it was pumped to a global storage system inside the Biosphere.

Topsoils were placed on top of the subsoil. Their thickness varied from 0.3 – 3.2 m, averaging 0.9 m. Four mixtures formed the major volume (1750 cubic meters) of topsoil in the rainforest, with small amounts of 3 additional mixes (16 cubic meters) used for more specialized habitats (Scarborough 1994). Each mixture consisted of a different combination of the following materials: a local desert grassland soil ('Wilson Pond soil'), organic matter, gravelly

Table 2-2. Rainforest soil components and their origins. From Scarborough (1994).

| Material | Origin |
|---|---|
| Coarse sandy loam (subsoil) | Kalamazoo sand and gravel quarry, just southwest of San Manuel Copper Mine, Mammoth, AZ |
| Wilson Pond soil | Along boundary between Secs 2 & 3, T10S, R14E, 1200 feet south of highway 82 and 1.3 miles west of the Biosphere Road |
| Gravelly sand | Quarried on location |
| Compost, Coarse organic material | AAA Fertilizer, Tucson, AZ; various other local suppliers of organic materials |
| Fine peat | Purchased commercially |
| Coarse peat | Purchased commercially |
| Canadian sphagnum moss | Purchased commercially |
| Pumice chunks | Purchased commercially |

sand, sandy loam, and pumice chunks. Table 2-3 shows the different combinations and volumes of materials that were used and their placement within the ecosystem. The 'Wilson Pond soil' was an organic-rich (4-5% OM) silt loam to clay loam which was quarried from a large earthen cattle tank. The organic amendments were compost (made from forest mulch, cotton gin trash, rotted cattle silage, alfalfa hay, and cattle manure); coarse peat; coarse organic material; and Canadian sphagnum moss. The gravelly sand was quarried on location. Additional materials used in much smaller amounts were the coarse sandy loam subsoil, pumice chunks, and fine peat.

The soil materials were either mixed with heavy equipment outside or directly on conveyor belts feeding from the outside to the inside of the Biosphere. Various types of heavy equipment (both track and wheel vehicles), conveyor belts and/or shovels were used for soil placement inside the rainforest. Leaf litter and humus from local natural ecosystems were added to the soil surface after placement, and thousands of purchased earthworms and a much smaller number of earthworm species that were field-collected in southeastern Texas (Scott 1994) were placed in the soil.

## Collection and Initial Placement of Plants

Starting in 1986, plants, seeds, and other propagules assembled for the rainforest were grown in greenhouses located near Biosphere 2. Plant accessions were acquired from botanic gardens, plant nurseries, and private collections, and from field collections in Puerto Rico, Belize, Venezuela, and Brazil. Permits were acquired for exportation from countries of origin and for importation to the United States and Arizona; state and federal quarantine

Table 2-3. Percent of components in topsoil mixture specifications and their corresponding habitats. From Scarborough (1994). Totals are approximations.

| Component | Mix 1[a] | Mix 2[b] | Mix 3[c] | Mix 4[d] | Mix 5[e] | Mix 6[f] | Mix 7[g] | Total ($m^3$) |
|---|---|---|---|---|---|---|---|---|
| Coarse sandy loam (subsoil) | | | | | 60 | 15 | | 1 |
| 'Wilson Pond' soil | 50 | 60 | 80 | 10 | | 35 | 50 | 996 |
| Gravelly sand | 25 | | | | | | | 239 |
| Compost | | | 20 | | | 35 | | 84 |
| Fine peat | | | | | | | 50 | 2 |
| Coarse peat | | 40 | | 50 | 30 | | | 167 |
| Coarse organic material | 25 | | | | | | | 239 |
| Canadian sphagnum moss | | | | 40 | | | | 37 |
| Pumice chunks | | | | | 10 | 15 | | 2 |

[a] Lowland rainforest – 688 $m^3$
Bamboo belt – 57 $m^3$
East terrace and west side of mountain – 203 $m^3$
TOTAL: 948 $m^3$

[b] Várzea – 298 $m^3$

[c] Ginger belt and papaya areas – 413 $m^3$

[d] Cloud forest – 92 $m^3$

[e] Behind cliff face – 8 $m^3$

[f] Tree ferns – 4 $m^3$

[g] Ledges and planting pockets – 4 $m^3$

and inspection protocols were followed. Following soils placement in the rainforest biome, plant accessions were transplanted from greenhouses into Biosphere 2. The largest plants were placed first due to the logistics of lowering them into the Biosphere with cranes before the glass was installed. Plants were fertilized and watered in place with drip irrigation, sprinklers, or by hand with hoses.

Each plant was mapped by standard survey methods (Thompson 1992) using different symbols to represent plant growth forms. Measurements such as basal diameter, crown width, and stem length were made. Each plant was assigned a unique number, and data on location, geographic origin, size, and phenology were recorded. Thus a history of every plant in the rainforest biome could be tracked through time.

Habitat Assembly

The initial design (Prance 1991) created 8 habitats within the rainforest biome, each planted with a different assemblage of plants including canopy trees, ground cover, shrubs and intermediate level life forms, and epiphytes and vines. Initial plantings of fast colonizers and secondary forest species (*Clitoria racemosa, Carica* spp., *Leucaena* spp., *Cecropia schreberiana*) provided shade and structure to the emerging and more characteristic primary rainforest species (Prance 1991).

Lowland rainforest

The concave topography of the lowland rainforest area centered in the southeast quadrant of the rainforest allowed trees to reach a height sufficient for a layered canopy. The topsoil mixed for the lowland rainforest was 50%

loam, 25% gravelly sand, and 25% coarse organic material. There were lianas, epiphytes, and many broad-leaved trees and shrubs.

Ginger belt

The ginger belt surrounded the rainforest on all sides bounded by glass, excluding only the south edge which abutted the top of the beach cliff and the upper savanna. Its purpose was to shield the forest understory from excessive light. Studies on isolated patches of planetary rainforests show that the typical understory vegetation is altered for some distance beyond the forest edge in part by light penetration (Bierregaard et al. 1992). Thus this peripheral dense belt of vegetation was planted to filter the light and allow the interior of the forest to develop the shaded conditions that would foster an understory more typical of extensive rainforests.

Ginger belt topsoils were a mix of 80% loam and 20% compost. Soil depth was about 60 - 90 cm on the northwest and west side where no subsoil underlies the topsoil, and 1 m on the northeast, east and southeast sides, where it was underlain by a subsoil of variable thickness. The ginger belt ranged from about 1 m to about 4 m wide. Plants in the Order Zingiberales dominated the ginger belt. Plants in these genera were most abundant: *Musa, Heliconia, Alpinia, Strelitzia,* and *Costus*.

Várzea

The várzea habitat was designed to resemble a forest that is seasonally flooded. It featured a tightly meandering stream that ran from the pond to the edge of the savanna biome. The stream course was made by first filling the regular topsoil layers to the specified level; then excavating the stream courses; and then lining them with concrete and thick PVC. The várzea topsoil was 60% loam and 40% coarse peat. The várzea was not flooded during the study period. It was planted with *Phytolacca dioica, Pachira aquatica, Pterocarpus indicus,* and palms.

Cloud bowl

Suggested by the tepui sandstone formation from eastern Venezuela, the central mountain 'cloud bowl' was planned as a cooler and more humid microclimate. The soil was less than 1 m deep. It was a mix of 40% Canadian sphagnum moss, 50% coarse peat moss, and 10% loam. Soil in the planter pockets extended all the way to the bottom of the mountain. Bryophytes, carnivorous plants, shrubs, gingers and aquatic plants were introduced to this habitat.

Surface aquatic habitats

Surface aquatic habitats in the rainforest biome were hydrologically connected. The moss seep and upper pond in the cloud bowl spilled over a cut in the edge of the cloud bowl, creating a waterfall. The waterfall poured into a splash pool, which overflowed into the larger, lower pond and then into the várzea stream. At the bottom of the stream water flowed over a weir into a sump, from which the water was pumped back to the lower pond. Another pump moved water back to the cloud bowl. The water systems were underlain with a thick vinyl liner beneath a concrete layer. Taxa inhabiting the aquatic habitats at the beginning of the first material closure were *Azolla, Eichhornia, Nymphaea,* and *Typha.*

Bamboo belt

A bamboo belt was constructed along the south edge of the rainforest to baffle any airborne salt particles from the forest interior. Soils of the bamboo belt were 50% loam, 25% gravelly sand, and 25% coarse organic material, varying between 30 - 90 cm deep and laying over air delivery plenums. There was no subsoil beneath the topsoil in the bamboo belt. *Bambusa multiplex, B. tuldoides* and other species of bamboo initially formed the major structure of this habitat.

Mountain terraces

The mountain terraces skirted the rainforest mountain on the east, north, and west sides, extending to the west side of the lower pond. Flagstone walls were in place around the periphery of the terraces, separating them from the ginger belt habitat on the west and north sides and from the lowland rainforest habitat on the east. The flagstone was placed during construction to prevent soil from eroding down the somewhat steep grade from the mountain to the ginger belt. The topsoil mix for the mountain terraces was 50% loam, 25% gravelly sand, and 25% coarse organic material. The soils to the west and north of the mountain were about 0.3 - 3 m deep, and those east of the mountain were about 0.3 - 6 m deep. The plants on the terraces initially included *Carica papaya, Clitoria racemosa, Coffea arabica, Carludovica palmata, Inga* sp., *Hibiscus rosa-sinensis,* and *Manihot esculenta.*

The cliff faces of the mountain had pockets of soil to support vines, bromeliads, and other plants that were to cloak its surface. Vines from the Araceae, Passifloraceae, and Vitaceae family and ferns planted in the cliff face planter pockets. Rhyolite pumice chunks were blended at 10 to 15% of the total soil volumes. The high porosity of the pumice provides water-holding capacity and releases trace nutrients as it weathers.

## Climate Maintenance Systems

### Water system

In contrast to the desert and savanna biomes, the rainforest plants were active continuously; dormancy was not part of the yearly cycle. In the tropical rainforest biome, water applied as rainfall flowed through and exited the soil profile throughout the year. Figure 2-1 shows the water flows and reservoirs of the rainforest biome and their connection with the global system.

Rain was distributed to much of the rainforest biome through overhead sprinklers mounted in the space frame; other areas were irrigated with ground sprinklers or a drip irrigation system. Water vapor evaporated from soil, rain, or surface waters, transpired from plants, or delivered through a misting system could subsequently have been condensed from the air using the air handlers located in the rainforest basement. Water condensate that collected on the inside surface of the windows during late autumn, winter and early spring was an additional, seasonal source of condensate. Water from both of these sources was re-used in the wilderness biomes, and was one of the sources of rainwater.

The major water reservoirs in the rainforest were atmosphere (humidity), soil, water storage tanks, the surface aquatic habitats, and plants and other biota. The major water flows among reservoirs in the rainforest were rainfall and irrigation, subsoil drainage, reverse osmosis system flow, condensation, mist, evaporation, root uptake, transpiration, and diffusion as water vapor to other areas.

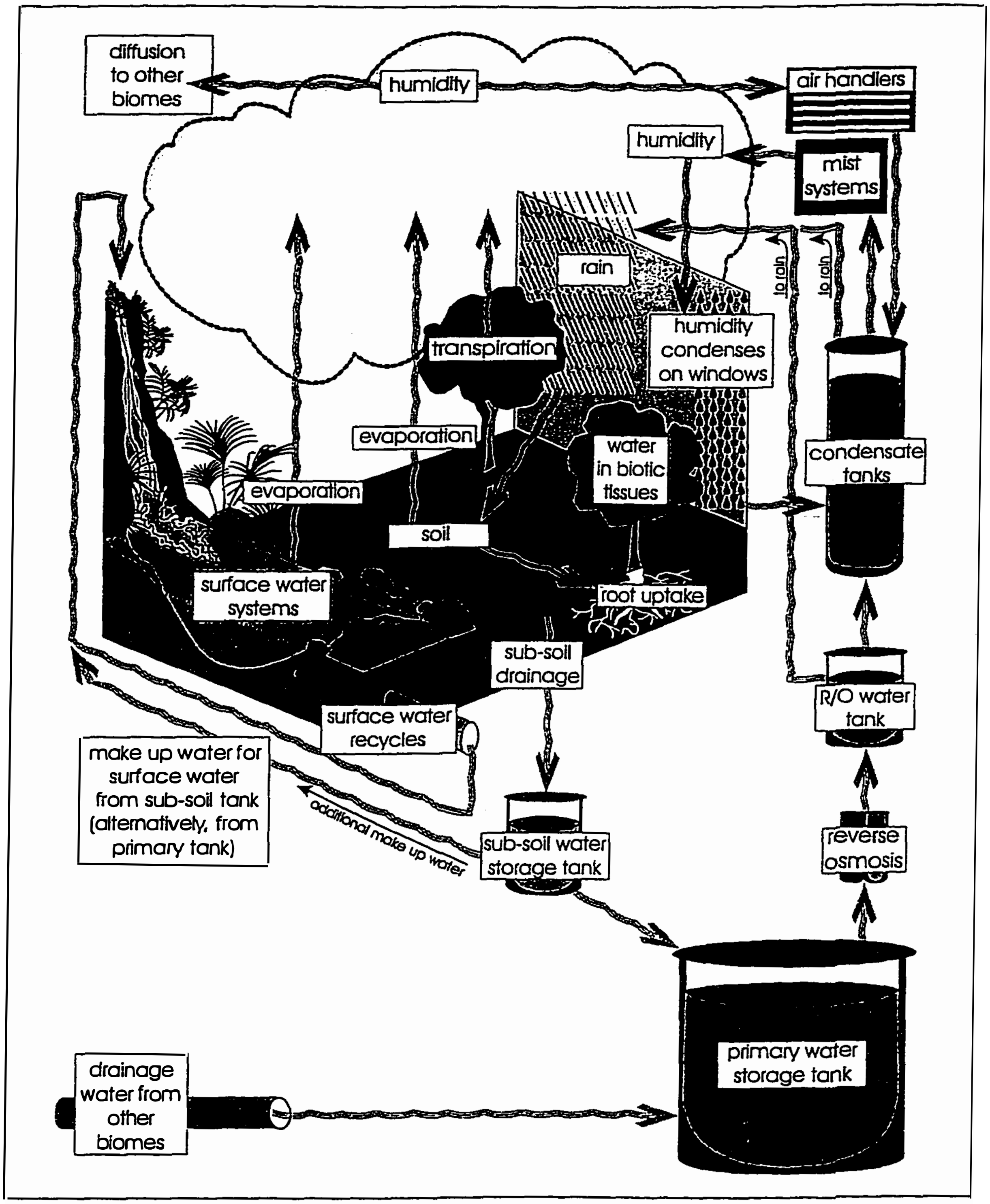



Figure 2-1. Hydrologic connection of Biosphere 2 rainforest to the rest of the Biosphere 2 system.

Some of the rain and irrigation water percolated through the entire soil profile. This sub-soil water, carrying substances leached from the soils, was collected and stored in a storage tank for future use. The subsoil water in the Biosphere was reused either as-is or after removal of dissolved solids by a reverse osmosis system. The remaining rain and irrigation water was either held in the soil pores by matric forces, taken up by plants and retained, or diffused back into the atmosphere via evaporation and transpiration. The average monthly relative humidity was over 65% year-round in the rainforest biome, with daily minima above 50%.

Air handling, temperature, and humidity control system

Seven air handlers in the rainforest basement were operated to regulate temperatures, extract condensate from the air, and to create air movement. Temperature was controlled by a heat exchange between a water coil and circulating air in the handler. Three temperature classes of water originating externally to the Biosphere were circulated in the coils of the system: heating water, cooling tower water, and chilled water which reached the lowest temperatures. The rate of the air flow through an air handler was controlled by opening or closing an 'econodisc' located inside each of the air handlers. Though normally controlled remotely, they were also controlled manually from inside the air handler. Air from the air handlers circulated through a system of plenums, ducts and openings from the basement into the rainforest. The air returned through gratings on the west and northwest periphery of the rainforest, where it entered the basement and was again pulled through the air handlers and over the heating coils.

Human Intervention

During the 2 year closure of the system (1991-1993) certain herbaceous plants in the rainforest biome were extensively pruned for two reasons. The first reason was to arrest primary succession. Early successional species were pruned so that the later successional species would survive. Pruning of vines occurred when they appeared to be heavily shading the trees and understory and when vines had grown into the tree canopies. Both vines and ginger belt herbs were pruned when they pressed against the glass causing algal growth on the glass surface. These selective harvests decreased the competitive advantage of high net-producers (e.g., *Ipomoea* and *Passiflora* vines) over species important for the long-term structure of the rainforest, particularly the larger trees. The second reason for harvest was an attempt to increase sequestration of $CO_2$ and to increase $O_2$ production. High levels of $CO_2$ were thought to be decreasing the ocean pH, and oxygen concentrations eventually decreased to the point of affecting the health of the human inhabitants. To meet these goals, plants were propagated in an attempt to cover vertical surfaces with photosynthetic biomass. Growth of high net-producing species (*Ipomoea* sp., *Passiflora edulis*) and herbaceous plant species in the circumferential ginger belt habitat was encouraged by judicious pruning in areas where they would not overwhelm other species, given the constraint of diversity maintenance.

The pruned biomass was removed from the rainforest, dried to retard respiration, and stacked in the basement. A small percentage of the material was used for fodder for domestic livestock. Of the three terrestrial wilderness biomes, the rainforest required the most time to manage for regulation of the atmosphere, while seeking to maintain species richness. Estimates of the amount of biomass removed through pruning were made from weekly records of time used for each task and from field journals.

## Plant Mapping and Identifications

### Initial Mapping and Identifications: 1990-1991

By September 1991, over 1800 individual plants had been planted in the rainforest mesocosm. Every plant was marked with a pink flag that had a unique number written on it which tracked it in the database, linking its location in the rainforest with size measurements and other information, including its origin, when available. Thus a history of every plant in the Biosphere 2 rainforest could be tracked through time. Specimens of many accessions are maintained in herbarium cabinets on location at the Biosphere 2 Center, and some were placed in the herbarium of the New York Botanical Gardens. Some plants have not been identified, and many identifications that were made have not been verified.

### Species Additions and Removals

During the first 2-year closure, Sept. 1991-Sept. 1993, additional papayas, bananas, malanga, and canna were planted in the rainforest for food production. These were mapped and logged into the database after the first closure. Additionally, some plants that had been planted before the first closure had been omitted from the original survey, and the corrections were made.

During the beginning of the period (Nov. 1993-Dec. 1993) between the first and second closures an additional 339 individuals were planted in the rainforest. The *Leucaena* trees that had been planted for initial shade of the key rainforest species were removed and weighed for subsequent estimates of biomass.

## Field Measurements

The first survey was the record made at the time of planting, shown in Figure A-1.

### Second Survey: Transition Period, 1993-1994

Base maps used for the second survey were made from the original CAD-generated survey maps completed in 1991. The complete map of the rainforest was divided into cells, each covering approximately 10.6 m x 7 m at a scale of 1:24. Thirty-five complete or partial cells provided total coverage of the rainforest.

Each plant found from the original survey was marked with a black plastic tag (approx. 5 by 8 cm) with its unique number etched in white. The tags were fixed around the base of plants with plastic cable ties. Data forms that were computer-generated for each plant specified the measurements that were to be taken for the plant. Data recorded on the forms were entered into a data base, and the paper forms stored at the Biosphere 2 Center. Plants that had not been mapped before the 1991 closure were tagged and added to the original maps. Additionally, plants that were introduced during the period of the survey were tagged and noted on the map.

Third Survey: June-August 1996

The third plant survey was made in 1996 using blueline base maps copied from the original maps that had been modified during the 1993-1994 resurvey. We searched for every plant indicated on the base maps and for all plants that were listed in the database provided by Biosphere 2 Center. Each of the 35 cells had a form listing all of the species within the cell. We assigned one of three status categories to each plant: alive, dead or not found. When a tag was located with no plant next to it at the mapped location, the plant was classified as 'dead' and the tag was removed. When neither tag nor plant was found at the mapped location, the plant was considered 'not found'. In most cases, the 'not found' category plants were dead, though since we had neither evidence of correct location by finding the tag nor a live plant we created this category to indicate uncertainty (plant tags are easily lost in or were previously removed from this site). When a living plant of the same species listed in the database was found in the location of the survey point, it was classified 'alives'.

When the identification listed on the forms was incorrect or suspect, it was corrected or questioned on the field forms. On less than 10 occasions, a plant classified as 'dead' or 'not found' in the previous survey was found alive in the 1996 survey. When we were unable to locate the tag on a plant, we tied survey flagging tape to it with the original survey number and Latin binomial written in waterproof ink so that replacement tags could be made and attached at a later time. Collections of plants in flower were made and pressed for later identification.

New numbers were assigned to plants that were in one of the following categories: plants (excluding tiny seedlings with only cotyledons or the first few leaves) recruited from seeds produced inside the Biosphere (e.g. *Pachira aquatica*); plants that had wandered to a new location but were clearly once located at a numbered survey point (e.g., *Dieffenbachia sp.*); plants that did not appear on the maps and did not have a tag, but clearly were intentionally planted at one point (e.g., *Eucharis grandiflora*).

Problems with the survey method

Clonal or creeping understory species and climbing plants and canopy vines were not mapped and total number of individuals for viney species that root at the nodes was not quantified during this period due to the uncertainty of delimiting an individual. This included *Scindapsus aureus, Syngonium podophyllum, Passiflora coriacea, Ipomoea sp., Cyperus alternifolius, Tradescantia sp., Calissia fragrans.* Likewise, the spread of clonal ginger belt species was not mapped. These plants were simply identified as alive, dead, or not found.

Not all of the planter pockets on the mountain could be accessed, and assumptions were made, in some cases with only limited visibility, that since there was no longer a functioning irrigation system to the pockets that the originally placed plants were dead. This included fewer than 20 individual plants.

Species lists and assembly of data

For the total species count, individuals within a genus that were unidentified to species were counted as a separate species only if there were no other species within the genus. If there were other species in the genus, the unidentified individuals were considered unknown, since they could have overlapped with species already counted. Unknown species were not included in species abundance figures or growth form spectra. Species that were classified as "not found" in a survey were considered dead for purposes of this study.

Surveys of Species Found per 1000 Individuals Counted

Biosphere 2 rainforest

A count of the cumulative number of species found per cumulative number of individuals was made in the Biosphere 2 lowland rainforest habitat in April, 1998. Plants were identified and recorded in 1.5 m belt transects covering the entire lowland rainforest and the east-facing ginger belt. As each individual was identified, it was recorded in a column with the proper species label until there were a certain number of individuals per column, starting with 1 in the first column, 10 in the next, and about 100 in the subsequent columns. All of the plants in the lowland rainforest area were counted. A diagram of the transects was drawn and transferred onto a map of the area so that similar counts could be made using maps from previous years.

The 1991 count of cumulative species per cumulative individuals was completed from the original map and species list from 1991. The 1.5 m wide belt transects drawn on the maps were sampled in the same order as they were sampled on the ground in 1998. The center of each plant was included only if the surveyed center of the plant (as recorded on the map) was encountered within the transect; overlaps were not counted. In addition, species/individual counts were made for the ginger belt, bamboo belt, cloud bowl, várzea, and mountain terraces on the 1991 map.

Puerto Rico rainforest

The same field method was used in Puerto Rico on a landslide near the El Verde Field Station, but the belt transect zig-zagged across the landslide area. All plants greater than 0.5 m tall within a 1 meter distance on either side of the observer were counted and identified. Where there was uncertainty as to whether or not 2 plants were the same, collections were made and checked later with local botanical technicians. Considerable care was taken to stay within the boundary of the 11-year-old landslide area. In addition, databases were sampled for number of species per 1000.

Leaf Area Index

Leaf area index in the Biosphere 2 rainforest lowland habitat was estimated from counts of vertical leaf overlap using a 50-foot extendable rod expanded upwards from a ground point. The interception of every leaf above the ground point was counted. A record of the number of leaf interceptions per ground point was made for 30 points in the lowland forest habitat of the Biosphere 2 rainforest biome over a ground area of approximately 300 $m^2$.

Number of Seedlings per 0.54 $m^2$

Thirty 0.54 $m^2$ circular plots were located 10 paces apart in the rainforest lowland habitat in April 1998. The plots were defined with a plastic hoop and were searched for seedlings. The counts were made over a ground area of approximately 370 $m^2$.

### Percent of Holes in Leaves

A visual estimate was made of the percent of holes in leaf blades. Holes were counted if they appeared to have been caused by consumers, and were not counted if they appeared to be the result of mechanical injury from wind or human activities. The leaves that were selected were within the range of view of the ground-based observer. Ten leaves on each of twenty trees were counted using the following percentage categories: 0, <1, 1-5, 5-10. There were no leaves that had more than 10% of the blade consumed.

### Number of Green or Yellow Fallen Leaves per 0.54 $m^2$

The 0.54 $m^2$ circular plots used for seedling counts were also used for counts of the number of green or yellow fallen leaves per 0.54 $m^2$. Each plot was searched for yellow or green leaves. A leaf that was 100% green was recorded as green. A leaf that had any amount of yellowing was recorded as yellow. If over 50% of the leaf was brown, it was considered brown and not recorded.

## Calculations

### Diversity Index

The Shannon-Wiener index of diversity, $H' = -\Sigma\, p_i \ln p_i$ where $p_i$ is the proportion of individuals found in the *i*th species, was calculated using the rainforest survey data for 1991, 1993, and 1996. Calculations were made to follow the plants from the first planting through all three sampling dates.

Biomass Estimates

Three estimates of biomass have been made: one for Nov. 1990, the second for July 1991 just prior to the first closure, and one in 1993 reflecting changes during the first 2 years of closure. The 1990 and 1991 estimates were made by personnel from Yale University School of Forestry and Environmental Studies (Haberstock 1991). Estimates were made from size attributes measured for individual plants inside the Biosphere such as height and diameter at breast height, using equations for trees from the literature (woody trees except for*Leucaena* from Scatena et al. 1993) and an equation for the 'Musa' type developed by Haberstock based on small destructive sampling at Biosphere 2.

For the 1990 estimate, every plant in the Biosphere 2 rainforest was measured. For the 1991 estimate, every large woody tree, about 1/2 of the 'Musa' category, and 10% of most other categories were measured. Measurements were made on randomly selected subsets of plant categories other than trees.

The July 1993 estimate (Bierner 1993) was extrapolated from a subset of tree measurements, using the equations cited above. The subset included 81 big trees, which were compared with their previous measurements to calculate a percent increase in biomass. That increase was assumed to be the same for all growth forms in the rainforest, and was applied to original biomass estimates to arrive at the 1993 estimate.

## Growth Form Spectra

The symbols used to represent the rainforest plants on the original maps were changed for this study. Nine growth forms are used to describe the plants, as follows: tree (T), arborescent palm and palmlike plant (P), shrub (S), giant-leaved herb (G), herb (H), graminoid (R), woody graminoid, such as bamboo (A), climber (C), and epiphyte (E). Discrimination between giant-leaved herbs (*Musa, Strelitzia*) and herbs (*Calathea, Maranta*) was somewhat arbitrary, but generally giant-leaved herbs have the form of herbaceous trees. All herbaceous and woody vines and lianas were lumped into the climber category. All bromeliads and orchids were considered epiphytes if a description of the species was not found to the contrary. Since these categories do not always agree with those of other studies, certain categories were lumped when comparisons were made with other published data. In particular, the following growth forms were lumped: Herb = Herb + Giant-leaved herb + Graminoid; Tree = Tree + Arborescent palm + Woody graminoid.

## Poisson Distribution

A grid of squares was printed onto transparencies, with each square representing a ground area of 2 m by 2 m. The transparency was placed over the map of plants in the rainforest biome, and the number of plants in each square was counted and recorded on the transparency. The entire rainforest biome was counted with the exception of squares containing concrete slabs, water bodies, or other features that would have prevented planting. A total of 389 squares were counted, or about 80% of the rainforest surface area.

The total number of squares containing the same number of plants was tabulated, and the mean number of plants per square was calculated. From this, a Poisson distribution was generated for comparison with the actual distribution. A chi-square test was used to make the determination.

The ratio of the variance to the mean was calculated to compare with the same ratio of the Poisson distribution, which is equal to one. A ratio greater than one would imply contagious distribution; less than one, regularity (Whittaker 1975).

## Simulation Method

The simulation method used in this dissertation is described in detail by Odum and Odum (in press). The first step of the method is to draw a diagram of the system being studied using symbols of the energy systems language (Table 1-2). The study system is delineated inside the border of a window to include material and information storages in their hierarchical order, energy flows, feedbacks, and energy drains. External energy sources are shown flowing in from outside across the system border. Next, rate equations are written from the diagrams. The method is explained with a simple example.

The diagram and equations in Figure 2-2 represent the species diversity on islands as described by MacArthur and Wilson (1967) and interpreted and drawn by Beyers and Odum (1993) using energy systems symbols. Here diversity (Q) is the result of the constant inflow of seeds, spores, and other propagules immigrating from outside the system and the outflow from the system due to linear extinction. The number of species already established on an island system as shown creates a backforce against colonization by new species. The backforce is represented diagrammatically by the pathway between P and S, which lacks an directional flow arrow; and mathematically in the equations which show the rate of flow as dependent on the difference between P and S.

Figure 2-3 shows a simple, one-tank model of biodiversity, where Q is the species diversity of the system; J is the constant flow of species from outside the system (seeds, spores, other propagules) immigrating into the system; K1 is the pathway coefficient for the rate of extinction, which is described with a quadratic drain representing extinctions in proportion to self interactions such as interspecies competition. K2 is the coefficient for linear extinction in proportion to species present. The inflow of species in this model is independent of the number of species already present, as shown by the constant flow of species P to the system storage Q.

For calibration, values of storages and flows are placed on the diagram to help visualize consistency. Then a calibration table is made to calculate the pathway coefficients. Table 2-4 calculates pathway coefficients for the model shown in Figure 2-4 when the biodiversity at steady state is 60 species.

An EXCEL spreadsheet was used to run the simple biodiversity simulation. Results of the simulation when started with different values of diversity are shown in Figure 2-5.

## Emergy Evaluation

Emergy evaluations of Biosphere 2 construction and rainforest development were made according to the method of Odum (1996), as summarized below:

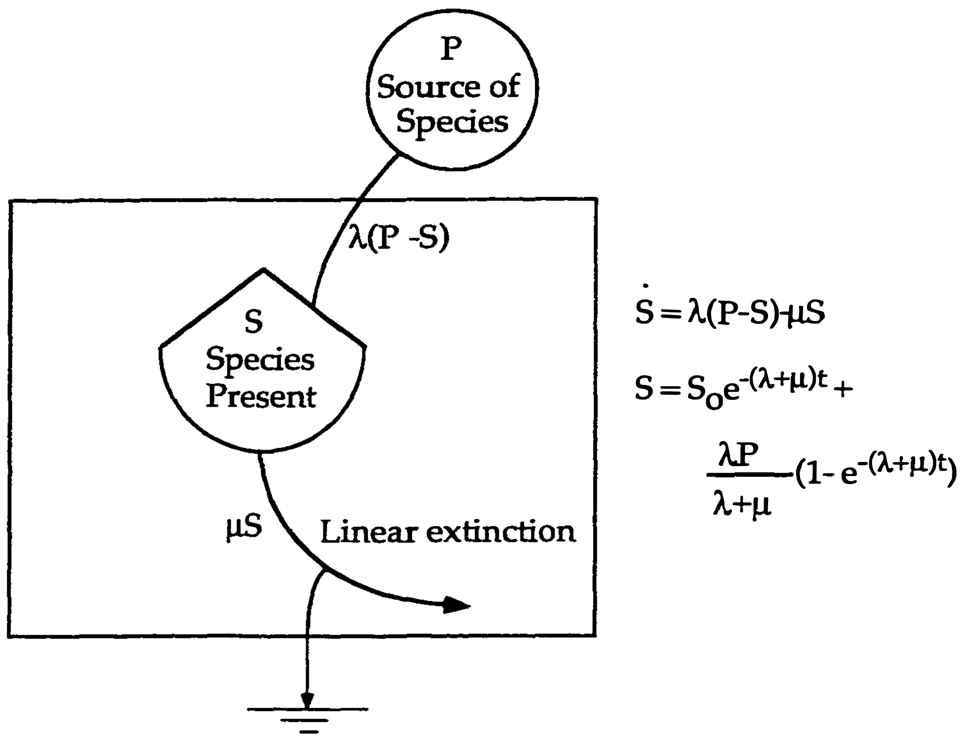



Figure 2-2. Diagram and equations for species diversity on an island as described by MacArthur and Wilson (1967) and drawn by Beyers and Odum (1993).

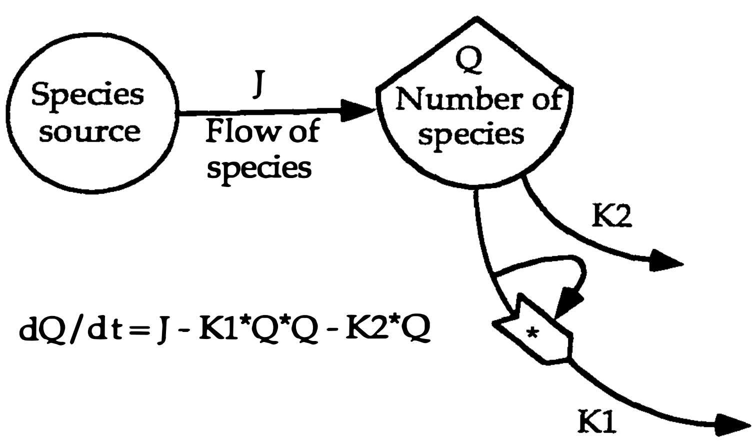



Figure 2-3. Single tank model of biodiversity as a balance of steady inflow and linear and quadratic extinction showing storages and pathway coefficients.

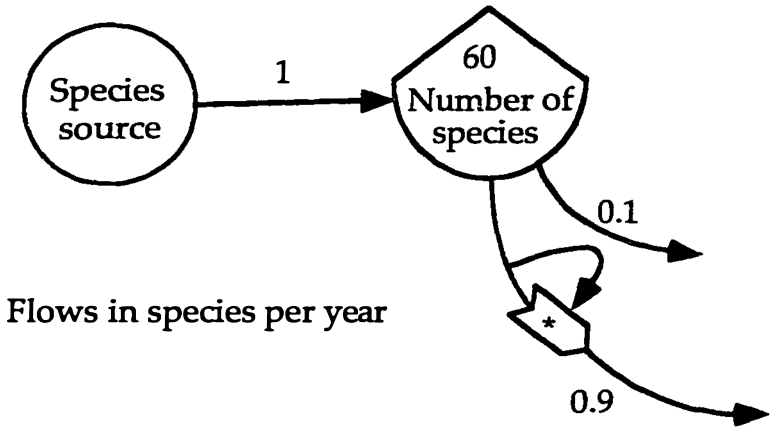



Figure 2-4. Single tank model of biodiversity with calibration values for flows and storages.

Table 2-4. Spreadsheet used to calculate coefficients for single tank biodiversity model in Figure 2-3, calibrated at steady state.

| Storage or flow | Steady state value | Coefficient calculation |
|---|---|---|
| Storage | | |
| Number of species | Q = 60 | |
| Flow | | |
| Yearly species additions | J = 1 | |
| Quadratic species extinction | K1*Q*Q = 0.9 | K1 = 0.00025 |
| Linear species extinction | K2*Q = 0.1 | K2 = 0.001667 |

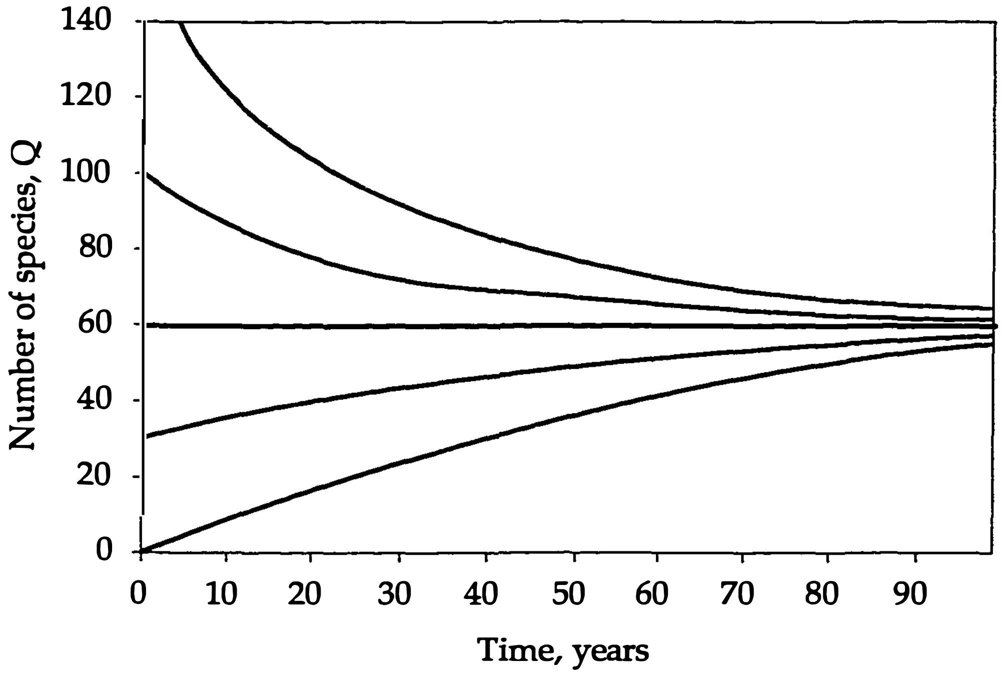



Figure 2-5. Simulation of number of species Q for different starting values using the single storage model in Figure 2-3.

First, a diagram of the system was drawn showing the elements that were to be included in the analysis. Second, the emergy evaluation table was constructed, including columns for the attribute of the system being measured and their energy values, transformity values, and emergy values. Others, such as emvalue, may be added if relevant to the analysis being made. The first column of each table is a note number, referring the reader to the notes following the table which explain the origin of the values and/or the calculations used to derive the values. The table was then filled in with available or calculated data.

The emergy analysis of the developing rainforest of Biosphere 2 included a summation of everything that went into creating the structure and ecosystems prior to the first material closure. A percentage of the total value in proportion to the relative size of the rainforest within the Biosphere was calculated, giving the total cost for the rainforest only. The final analysis was then used to compare to the tabonuco rainforest system of Puerto Rico.

# CHAPTER 3
# RESULTS

Data and analyses are presented for Biosphere 2 and the rainforest at El Verde in Puerto Rico.

## Characterization of the Rainforest in Biosphere 2

### Soil

The rainforest soils were relatively homogeneous in vertical profile after placement. Some textural discontinuities resulted from uneven mixing of the soil materials during their placement, creating sandier and rockier soils in parts of the lowland rainforest where the soil is a coarse sandy loam or coarse very sandy pebbly loam throughout the vertical profile (Scarborough 1994). Various soils used for potting mixes of individual plants became part of the rainforest topsoil after planting. Several of the larger trees had nearly a cubic meter of soil and root volume. In addition, clay aggregates in the soil mixture tended to maintain their structure as 'peds' from about 1–12 cm diameter (Scarborough 1994).

Measurements made by Scott (1999) for December 1993 and those reported by Lin et al. (1998) for later dates are shown in Table 3-1. Vertical development of the rainforest soils in the lowland and ginger belt habitats was apparent in December 1993, after 3 years of emplacement. Scott (1999) reports an accumulation of some elements (C, N, K, Ca, Mg) in the upper

Table 3-1. Characteristics of Biosphere 2 rainforest soils from samples taken on different dates. From Scott (1999) and Lin et al. (1998 and 1999).

| Characteristic | Depth (cm) | 1-Dec 1993[a] | 19-Dec 1995[b] | 25-Jan 1996[b] | No date[c] | 31-May 1996[d] | 16-Jun 1996[d] | 15-Jul 1996[d] |
|---|---|---|---|---|---|---|---|---|
| pH | 0-10 | 7.63 | - | - | - | - | - | - |
| | 10 20 | 7.53 | - | - | - | - | - | - |
| | 0-20 | - | 7.34± 0.10 | 7.38±0.21 | 7.68±0.07 | - | - | - |
| | 20-40 | 7.51 | 7.36±0.04 | 7.50±0.01 | - | - | - | - |
| | 40-60 | 7.52 | - | - | 7.98±0.10 | - | - | - |
| OM (% dw) | 0-20 | - | 3.62±0.49 | 4.08±0.47 | 4.16±0.42 | - | - | - |
| | 20-40 | - | 3.26±0.26 | 2.92±0.39 | - | - | - | - |
| | 40-60 | - | - | - | 3.88±0.39 | - | - | - |
| C (% dw) | 0-10 | 3.09 | - | - | - | - | - | - |
| | 10 20 | 2.35 | - | - | - | - | - | - |
| | 20-40 | 2.25 | - | - | - | - | - | - |
| | 40-60 | 2.35 | - | - | - | - | - | - |
| $N0_3$-N (mg $g^{-1}$) | 0-20 | - | 22.4±5.3 | 26.2±2.3 | - | 11.4±2.9 | 11.0±3.3 | 8.2±1.3 |
| | 20-40 | - | 21.4±6.0 | 19.6±3.3 | - | - | - | - |
| N (% dw) | 0-10 | 0.29 | - | - | - | - | - | - |
| | 10 20 | 0.22 | - | - | - | - | - | - |
| | 20-40 | 0.22 | - | - | - | - | - | - |
| | 40-60 | 0.24 | - | - | - | - | - | - |
| C/N | 0-10 | 10.6 | - | - | - | - | - | - |
| | 10 20 | 10.2 | - | - | - | - | - | - |
| | 0-20 | - | - | - | 7.68±0.07 | - | - | - |
| | 20-40 | 10.2 | - | - | - | - | - | - |
| | 40-60 | 10.2 | - | - | 12.3±1.4 | - | - | - |

Table 3-1--continued.

| Characteristic | Depth (cm) | 1-Dec 1994 [a] | 19-Dec 1995 [b] | 25-Jan 1996 [b] | No date [c] | 31-May 1996 [d] | 16-Jun 1996 [d] | 15-Jul 1996 [d] |
|---|---|---|---|---|---|---|---|---|
| K ($mg\ g^{-1}$) | 0-20 | - | 789±189 | 650±153 | - | 561±127 | 602±145 | 692±162 |
| | 0-10 | 1298 | | | | | | |
| | 10-20 | 1009 | | | | | | |
| | 20-40 | 856 | 533±132 | 523±89 | - | - | - | - |
| | 40-60 | 974 | | | | | | |
| Ca ($mg\ g^{-1}$) | 0-10 | 5497 | - | - | - | - | - | - |
| | 10 20 | 5210 | - | - | - | - | - | - |
| | 20-40 | 4967 | - | - | - | - | - | - |
| | 40-60 | 4841 | - | - | - | - | - | - |
| Mg ($mg\ g^{-1}$) | 0-10 | 509 | - | - | - | - | - | - |
| | 10 20 | 440 | - | - | - | - | - | - |
| | 20-40 | 425 | - | - | - | - | - | - |
| | 40-60 | 441 | - | - | - | - | - | - |
| $PO_4$-P ($mg\ g^{-1}$) | 0-20 | - | 117±25 | 111±24 | - | 64.5±11.5 | 67.4±10.8 | 60.9±9.8 |
| | 20-40 | - | 121±25 | 99±21 | - | - | - | - |
| Fe ($mg\ g^{-1}$) | 0-20 | - | 251±45 | 190±16 | - | 161±27 | 144±16 | 162±17 |
| | 20-40 | - | 207±44 | 215±31 | - | - | - | - |

[a] Scott (1999). n=6, avg. of ginger belt and lowland habitats. Data for K, Ca, Mg were converted from meq/100g to mg/g to make them easier to compare with other data presented.

[b] Lin et al. (1998). (Table 1, n=5) (location of samples not given)

[c] Lin et al. (1999). (Table 1 - date of samples not given)

[d] Lin et al. (1999). (Table 2, n=5)

stratum (0 – 10 cm) of the rainforest soils during this period. Similar trends were reported by Lin et al. (1998) in Jan. 1996 for percent organic matter and $NO_3$-N, though in the same study the accumulation was not apparent just one month earlier. Over a short time (Dec. 95-July 96) the same study reports a clear decrease in concentrations of $NO_3$-N, $PO_4$-P, and Fe in the 0-20 cm stratum (the only layer for which data are available for both dates, n=5).

The pH values reported from Dec. 93 through Jan. 96 along a vertical profile are slightly alkaline, ranging from 7.34$\pm$0.10 to 7.98$\pm$0.10. Scarborough (1994) noted a "tendency towards precipitation of soil carbonate minerals in the rainforest soils, based upon several water chemistry signatures", and that the water routinely used for irrigation during the first 2 years was enriched with bicarbonate ions.

Soil bulk density in Dec. 1993 of the 0-10 cm stratum was 1.10 g $cm^{-3}$ for the lowland and 1.05 g $cm^{-3}$ for the gingerbelt (Scott 1999), Table 3-2. Bulk density was higher in all of the other strata (to 1.32 in lowland and 1.11 in ginger belt), but no further patterns were evident. Per cent volume of coarse fragments increased with depth.

Anoxic areas were reported by Scarborough (1994) after three years of soil development. He also reported "a great [deal] of soil homogenization of the upper 12–16 inches due to worm activity," and a gray surficial layer 0–7.5 cm deep forming in the NE quadrant of the lowland habitat that he attributed to worm activity. Soil fauna as described by Scott (1999) included worms to a depth of 40 cm, but not in the surface litter which he attributes to predation by and avoidance of ants. Other macrofauna counted by Scott were isopods, cockroaches, and millipedes.

Table 3-2. Soil bulk density and percentage coarse fragments in Biosphere 2 rainforest from samples made in November 1993. From Scott (1999).

| Location | Depth cm | Bulk density g $cm^{-3}$ | Coarse fragment vol., % |
|---|---|---|---|
| Biosphere 2[a] | | | |
| Lowland rainforest | 0-10 | 1.10 | 8.23 |
| | 10-20 | 1.26 | 12.88 |
| | 20-40 | 1.32 | 15.22 |
| | 40-80 | 1.18 | 15.54 |
| Ginger belt | 0-10 | 0.94 | 10.94 |
| | 10-20 | 1.11 | 14.60 |
| | 20-40 | 1.03 | 16.75 |
| | 40-80 | 1.10 | 21.13 |

[a] Data from Scott (1999), n=3.

## Plants

There were two periods of plant introductions to the Biosphere 2 rainforest. The first was from April 1990 to September 1991; the second from October 1993 to March 1994. The number of individual plants and species are summarized in Table 3-3.

At the start of the 1991 closure of the Biosphere, 1890 individual plants were recorded in the rainforest. Of the original plants recorded, 316 species (or monospecific genera) were recognized in 99 families, with 315 of the original 1890 plants not identified to species.

All of the plants growing in the rainforest by September, 1991 were mapped. Every plant was drawn on the map with a symbol representing its growth form and with a unique survey number. Canopy widths were mapped to scale. Figure 3-1 shows a section of the map. All of the map is shown in 20 sections in Figure A-1. Every survey point with its individual plant identification, growth form, and inventory status for 1991, 1993, and 1996 is listed in Table B-1.

During the second planting period at the end of 1993, 339 individuals were added in at least 92 species (or monospecific genera), 50 species of which were new to the rainforest.

In 1996 an additional 48 individual plants in 15 species were recorded. All of these plants appeared to have been self-propagated, some from seed (such as*Pachira aquatica* and *Coffea arabica*) and others clonally (such as*Colocasia*).

Table 3-3. Total number of species and individual plants seeded in the Biosphere 2 rainforest.

| Approximate dates of planting | Number of individuals | Number of species |
|---|---|---|
| 4/90-9/91 | 1890 | 316 |
| 11/93-2/94 | 339 | 92/50[a] |
| Total | 2229 | 366 |

[a]Of the 92 species, 50 were new to the Biosphere.

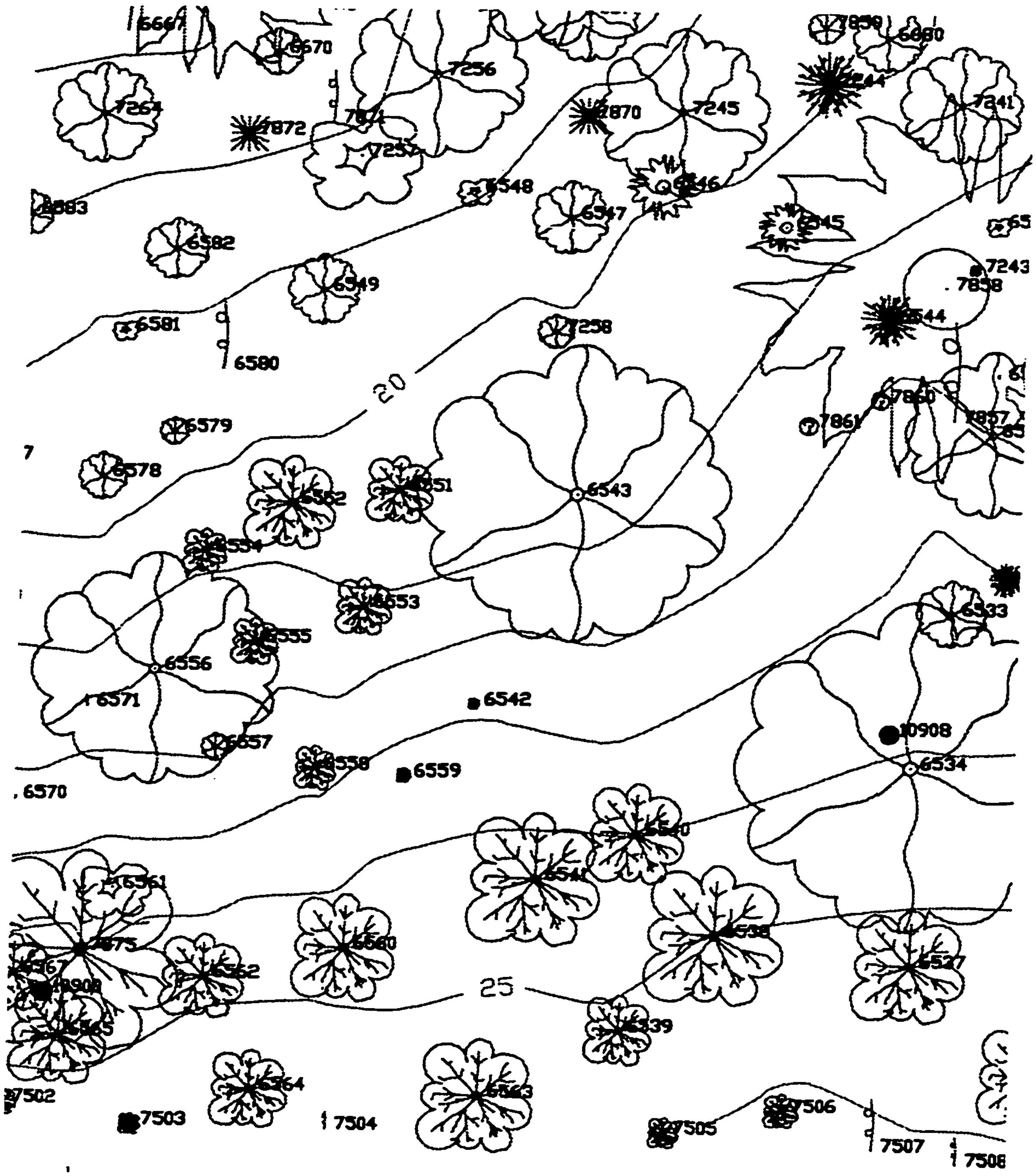



Figure 3-1. Map section #3 showing location, growth form, and canopy size of individual plants in the Biosphere 2 rainforest in September 1991. The twenty map sections are given in Figure A-1. Approximate scale: 1 cm = 0.6 m.

Plant survey results, first planting

At the end of 1993, a total of 872 (46%) of the original plants (first planting) were still alive. In 1996, 529 (28%) of the original plants were found. Table B-2 shows the number of individuals within each species at the time of closure in 1991, along with the subsequent inventories for 1993 and 1996.

In the 1993 inventory, 194 (61%) of the original species persisted and by 1996, 137 (43%) of the original species remained. The distribution of plants within species for both inventory years shows a decline in both numbers of species as well as number of individuals per species, as summarized in Table 3-4.

All or most of the plants in the following groups from the first planting died during the first 2 year study period: Adiantaceae (ferns), Aspleniaceae (ferns), Blechnaceae (ferns), Cyatheaceae (tree ferns), Orchidaceae, Polypodiaceae (ferns), Selaginellaceae (fern allies), and most Bromeliaceae (mostly epiphytes); *Sagittaria, Pontederia, Typha, Nymphaea,* and *Lycopodium*. This included almost all of the herbaceous and tree ferns, fern allies, epiphytes and aquatic plants. The large herbaceous species planted largely in the peripheral ginger belt thrived, spreading clonally. The most successful taxa in terms of maintaining large populations were all clonal species including the following taxa: Musaceae, Marantaceae, Zingiberaceae, and Strelitziaceae.

Table 3-4. Number of individual plants and species recorded in 1991, 1993, and 1996 surveys of Biosphere 2 rainforest. The first number in each entry includes plants from the 1991 planting, the second number from the 1993 planting, and third is plants that have self-propagated. Species reported are for species new to the rainforest.

| Survey date | Number of individuals | Number of species |
|---|---|---|
| 1991 | 1890 | 316 |
| 1993 | 872/339 | 194/50 |
| 1996 | 529/86/48 | 137/20/0 |

Plant survey results, second planting

In 1996, 41% of the second planting species and 25% of the individuals remained. Table A-3 lists the plants that were added to the rainforest after September 1993, and their subsequent inventory for 1996. In contrast to the first planting, many of the Bromeliaceae, largely epiphytes, survived. Most of the plants in the following families died: Orchidaceae, Arecaceae (palms), Aspleniaceae (ferns), and Polypodiaceae (ferns).

Abundance and distribution of plants within species

The change in the number of plants within species over 5 years is shown for the plants from the 1991 planting in Figure 3-2. For all years, there were relatively few common species and many rare species. In 1991, 90 species were represented by only one individual, whereas only about 15 species were each represented by more than 15 individuals. About 45% of the species in 1991 had only 1 or 2 individuals, which represented 11% of the plants. By 1993, both number of species and numbers of individuals within species had declined, and 56% of the species had only 1 or 2 individuals, representing only 15% of the individuals, a pattern repeated again in 1996.

Individual and species decline

The mortality rate of individuals and extinction of species was higher for the second planting than the first over the period 1993-1996 as shown in Figures 3-3 and 3-4. Seventy-five percent of the second planting individuals died, whereas only 39% of the first planting individuals died; and about 60% of the species from the second planting and 30% of the species from the first planting went extinct over the same period.

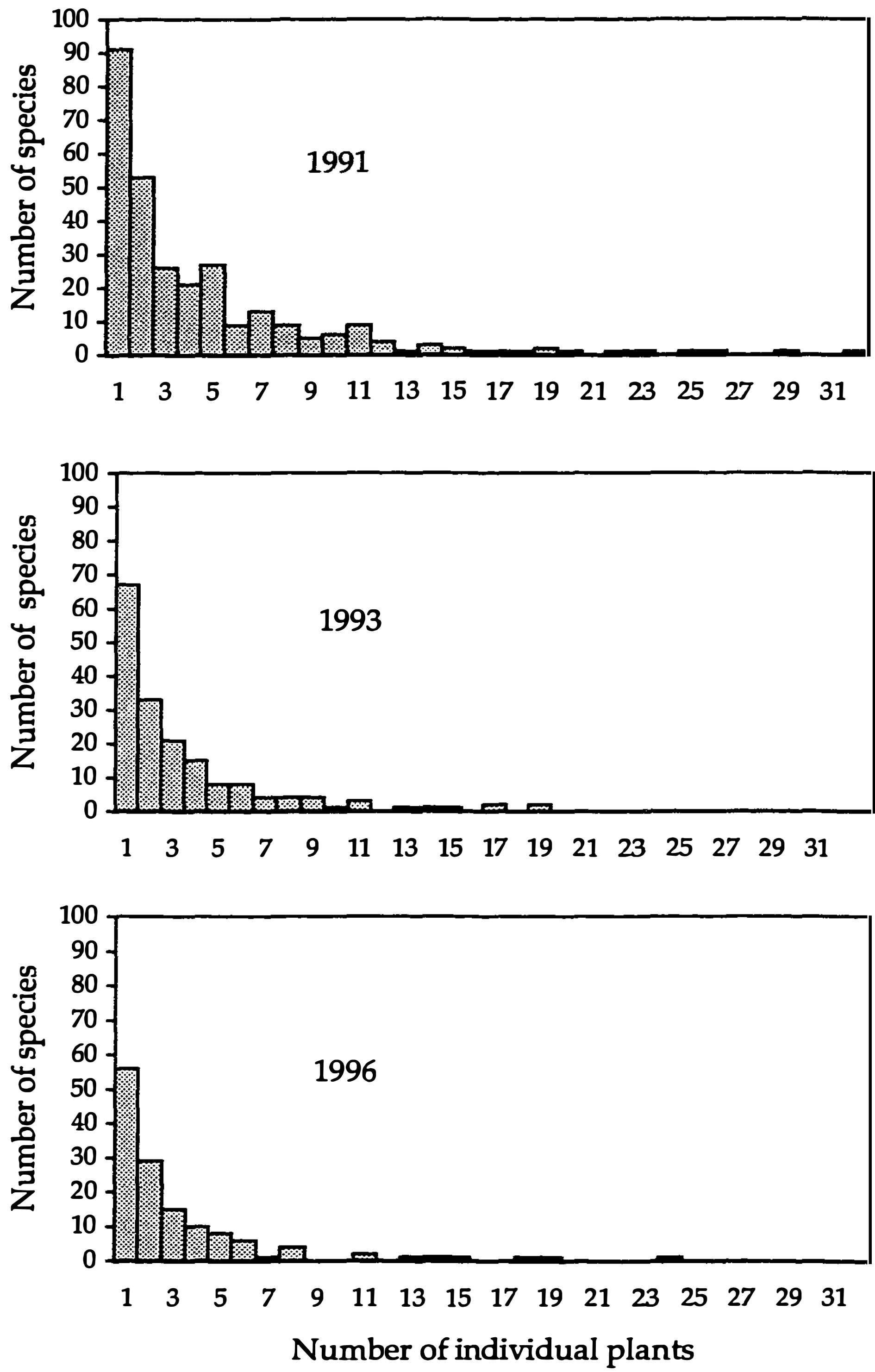



Figure 3-2. Change in plant species abundance and distribution in Biosphere 2 rainforest, 1991-1996, for plants from the first planting.

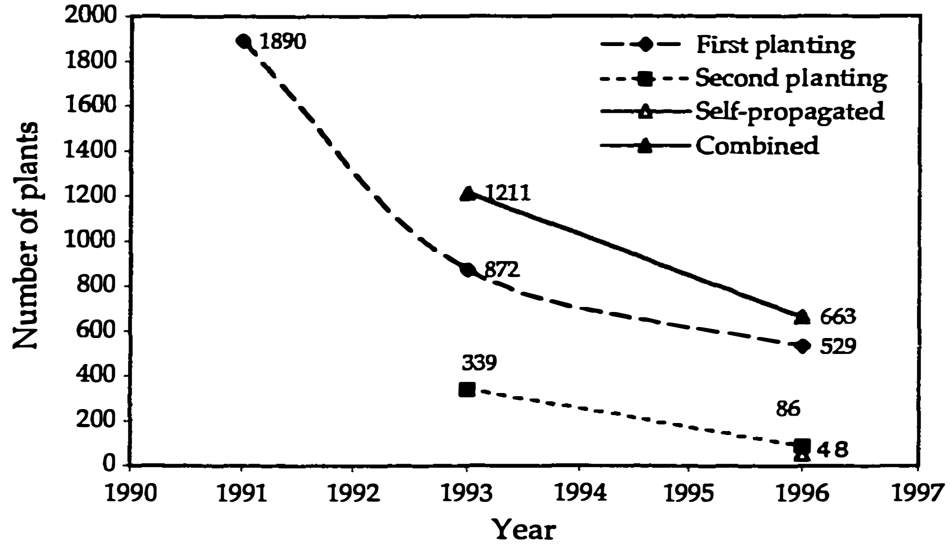



Figure 3-3. Number of individual plants in Biosphere 2 rainforest through time including 2 planting periods, 1991 and 1993.

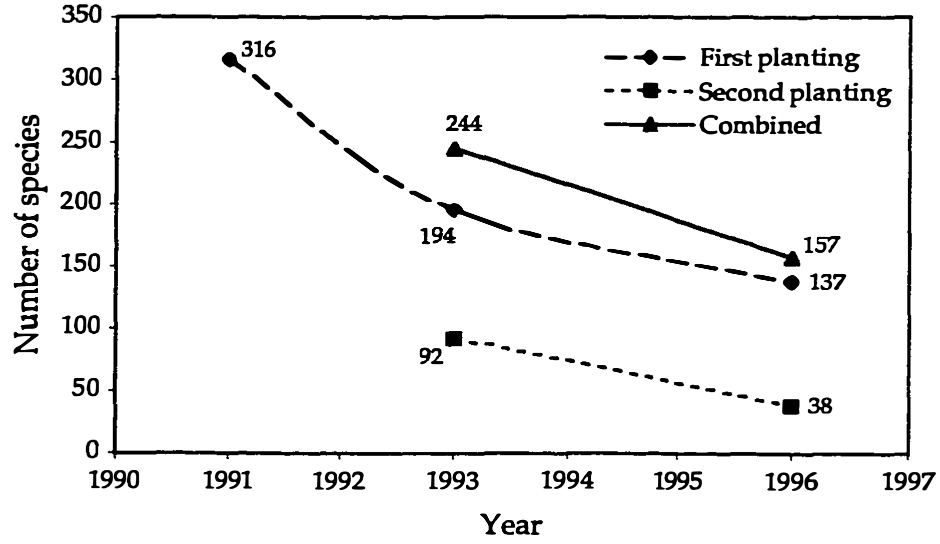



Figure 3-4. Number of species in Biosphere 2 rainforest through time including 2 planting periods, 1991 and 1993.

The decline of number of species was proportional to the decline of number of individuals, Figure 3-5.

Change in growth form spectrum

The decline of species and individuals within each of 9 growth forms is shown in Figure 3-6 and 3-7, respectively, for the plants from the initial 1991 planting. The largest percentage of survival in individual plants for both 1993 and 1996 was for bamboos, graminoids and giant herbs. The decline of absolute numbers of individuals was greatest for herbs, trees, and climbers, which also started out with the largest number of individuals.

Giant herbs, bamboos and palms showed the smallest percentage decline of species by both 1993 and 1996. Herbs and epiphytes had the largest percentage decline in species by 1993, and epiphytes, trees and climbers lost the largest percentage of species between 1993-1996. The epiphyte growth form was extinct by 1996.

For comparative purposes, plant growth forms in Figures 3-8 and 3-9 were lumped the into 5 types that are most commonly used in other studies: Herb = herb + giant herb + graminoid; tree = tree + arborescent palm + woody graminoid. Though the number of species with each growth form declined with time, the relative proportions of species within each growth form changed only slightly, with the greatest change seen in the increase in the relative proportion of tree species.

Plant reproduction

Most of the introduced pollinators died by the second year of closure. However, the following plant species set fruit at least once during the first 2 years: *Basella alba, Bixa orellana, Pachira aquatica, Carica papaya, Canna*

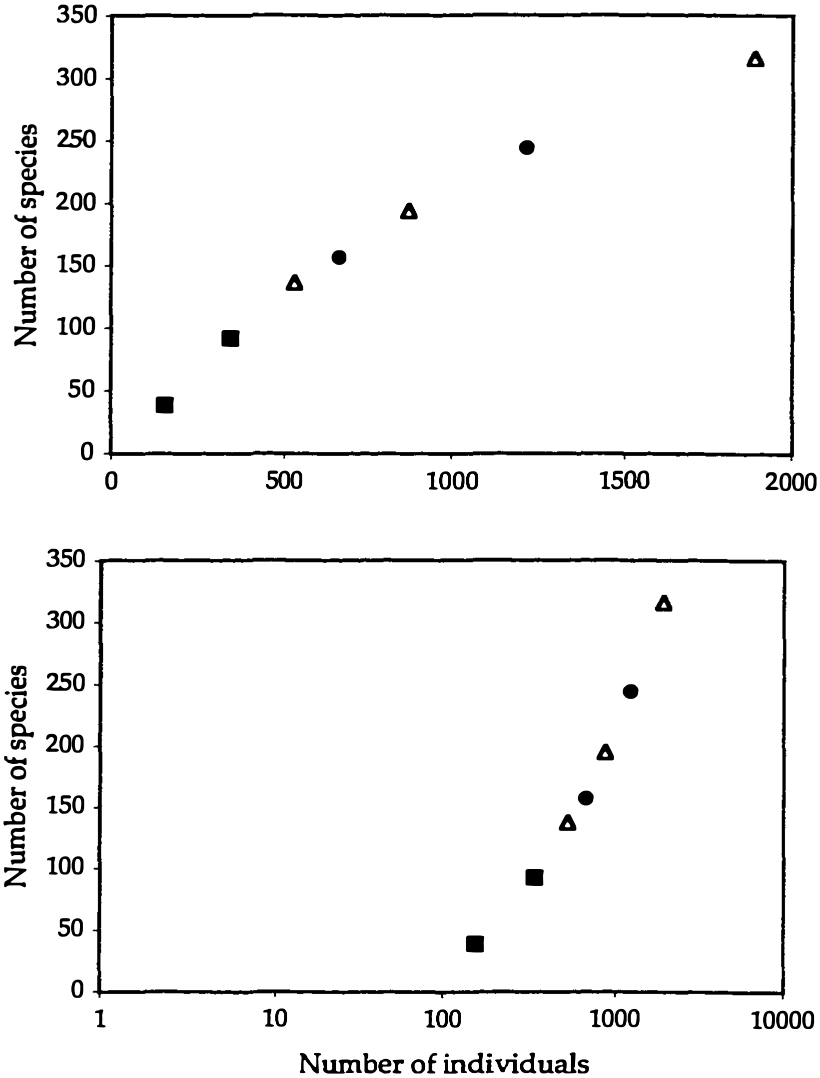



Figure 3-5. Relationship of number of species to number of individuals over time in Biosphere 2 rainforest on linear (upper figure) and semilog (lower figure) scale. Open triangles are plants from 1991 planting, squares from 1993 planting, and circles combine plants from both. Survey data are from 1991, 1993, and 1996.

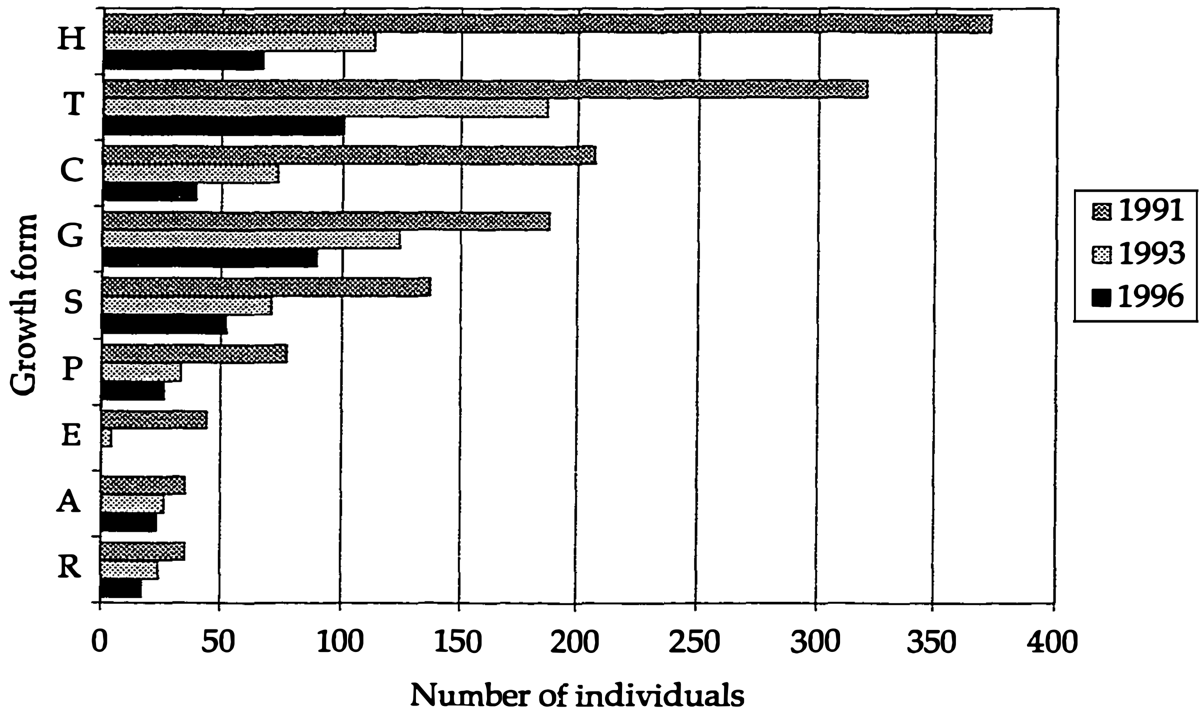



Figure 3-6. Number of individuals within growth forms in Biosphere 2 rainforest in 1991, 1993, and 1996. Data include only plants from first planting. H=Herb, T=Tree, S=Shrub, C=Climber, G=Giant herb, P=Arborescent palm, E=Epiphyte, R=Graminoid, A=Bamboo.

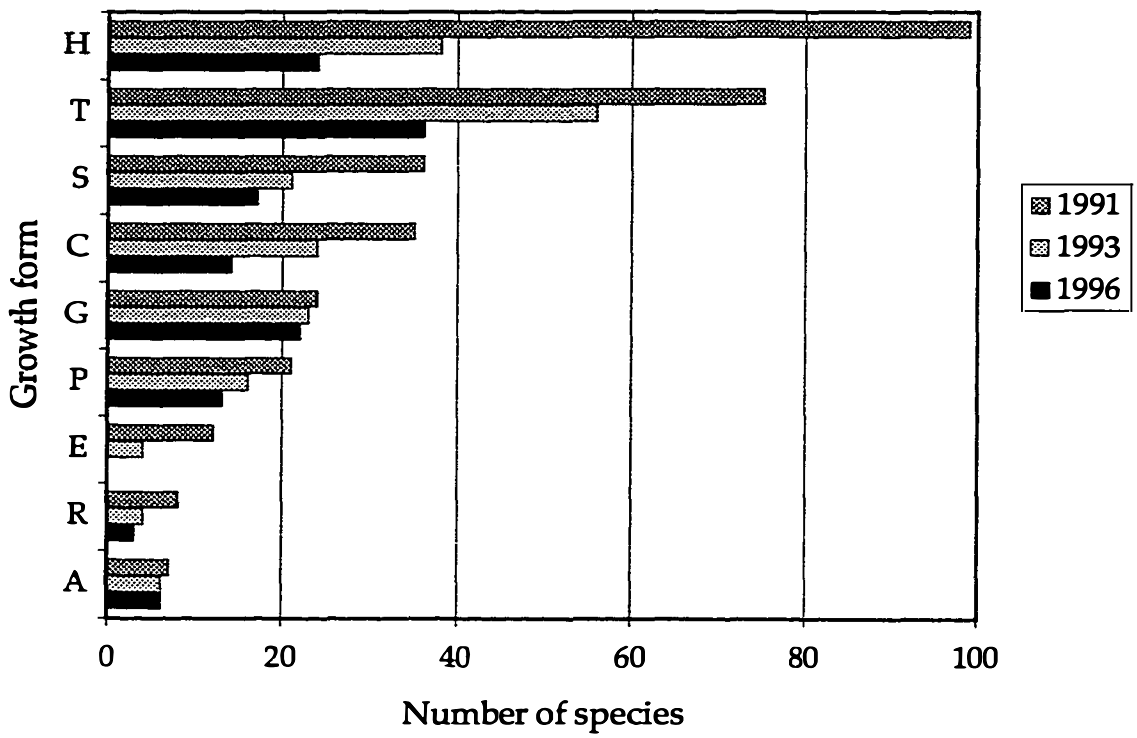



Figure 3-7. Number of species within growth forms in Biosphere 2 rainforest in 1991, 1993, and 1996. Data include plants from first planting. H=Herb, T=Tree, S=Shrub, C=Climber, G=Giant herb, P=Arborescent palm, E=Epiphyte, R=Graminoid, A=Bamboo.

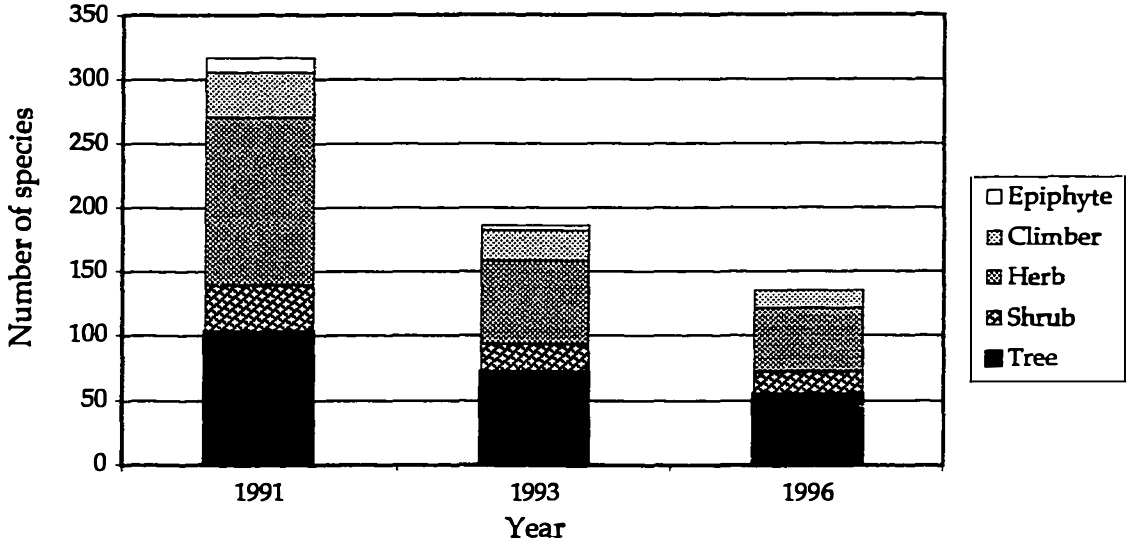



Figure 3-8. Change in number of species within growth forms from 1991 planting in Biosphere 2 rainforest through time.

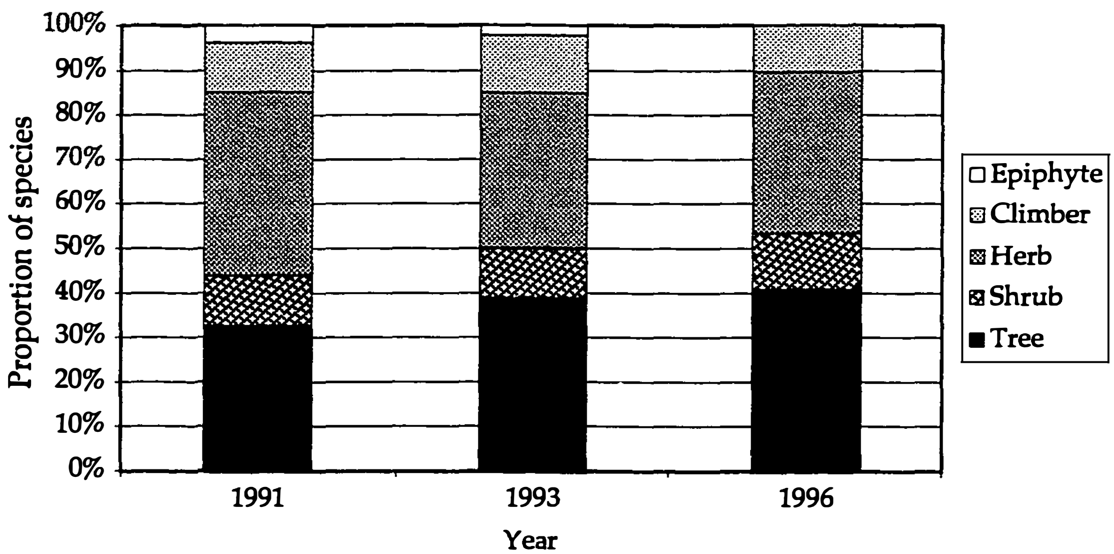



Figure 3-9. Change in distribution of species within growth forms from 1991 planting in Biosphere 2 rainforest through time.

*edulis, Coffea arabica, Ficus buxifolia, Moringa oleifera, Leucaena* spp., *Ricinus communis, Ipomoea* sp., *Passiflora* sp. and *Ceiba pentandra.* Viability of the seeds is not known. Seedlings of the following species were observed: *Coffea arabica, Pachira aquatica, Canna edulis,* and *Leucaena* spp. In subsequent years, additional species have set fruit. However, some plants that reproduced before the 1991 closure failed to reproduce between 1991-1993. Examples are *Clitoria racemosa, Averrhoa carambola,* and *Myrciaria cauliflora. Pachira aquatica* trees had not reproduced before their planting in the Biosphere.

Spatial Distribution of Plants

The Biosphere 2 rainforest plants were planted without a formal plan for their spatial distribution. A comparison of the distribution of the actual plants with the Poisson distribution is shown in Figure 3-10. The probability that the actual distribution of plants was only a change departure from the Poisson distribution was less that .001. Thus the actual distribution is not random. The variance to mean ration of the actual distribution was 0.355, suggesting regularity in the horizontal distribution of plants (Whittaker 1975).

Cumulative Species per Cumulative Individuals Counted

Plant species in the Biosphere 2 rainforest in 1991 accumulated as a function of the number of individuals counted, shown in Figure 3-11. Data are plotted on linear, semi-logarithmic and double logarithmic scales. Counts made in the lowland and east ginger belt habitats of the rainforest in 1998 are graphed In Figure 3-12. The graphs show species/individual counts both with

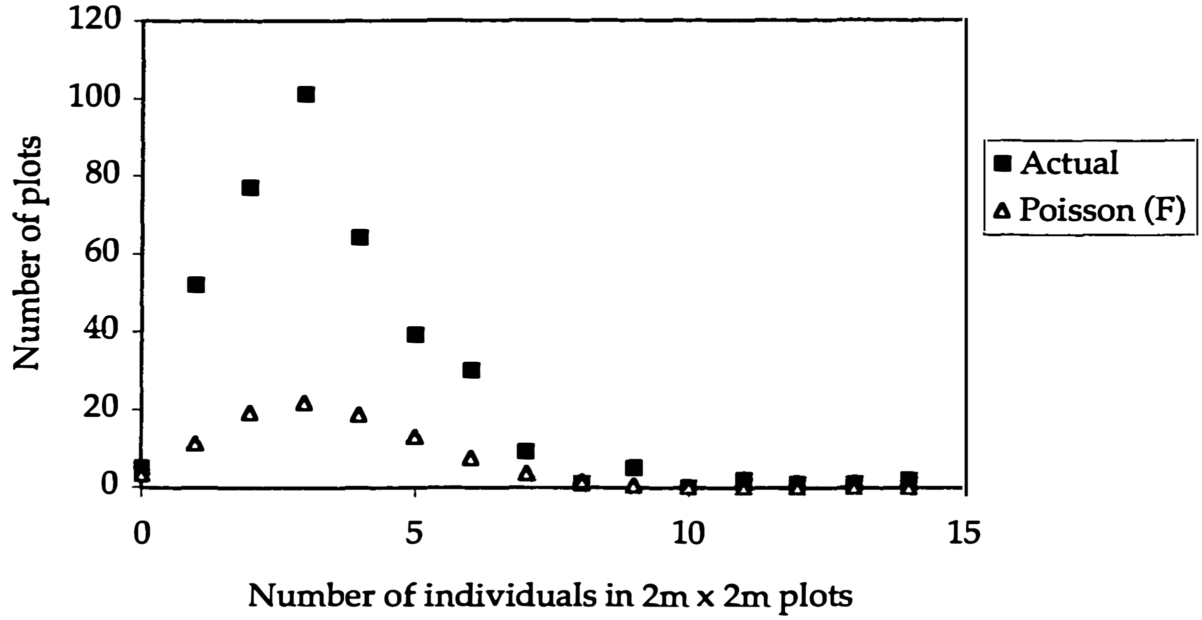



Figure 3-10. Spatial distribution of plants in Biosphere 2 rainforest in 1991 (solid squares) compared to Poisson distribution (open triangles).

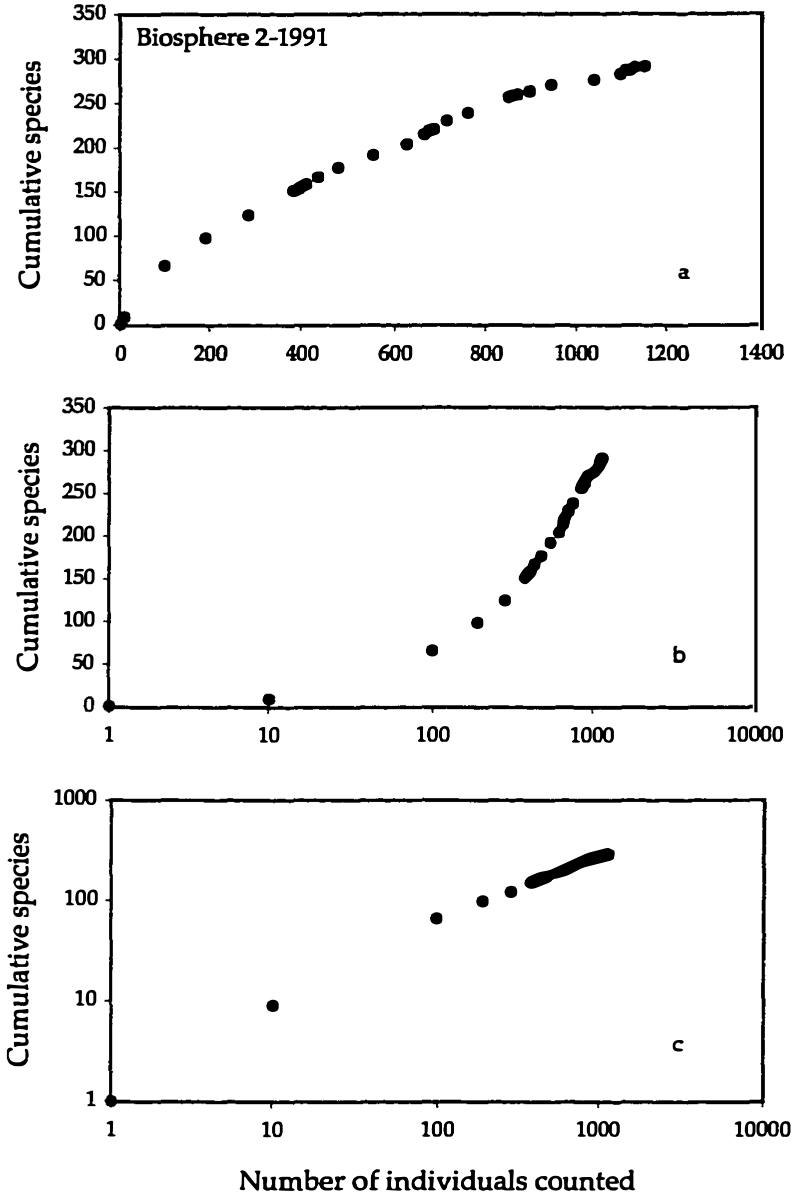



Figure 3-11. Cumulative plant species as a function of cumulative individuals in Biosphere 2 rainforest, 1991. Data for all habitats except cliff faces and surface aquatic systems are plotted on linear (a), semi-log (b) and log-log (c) scales.

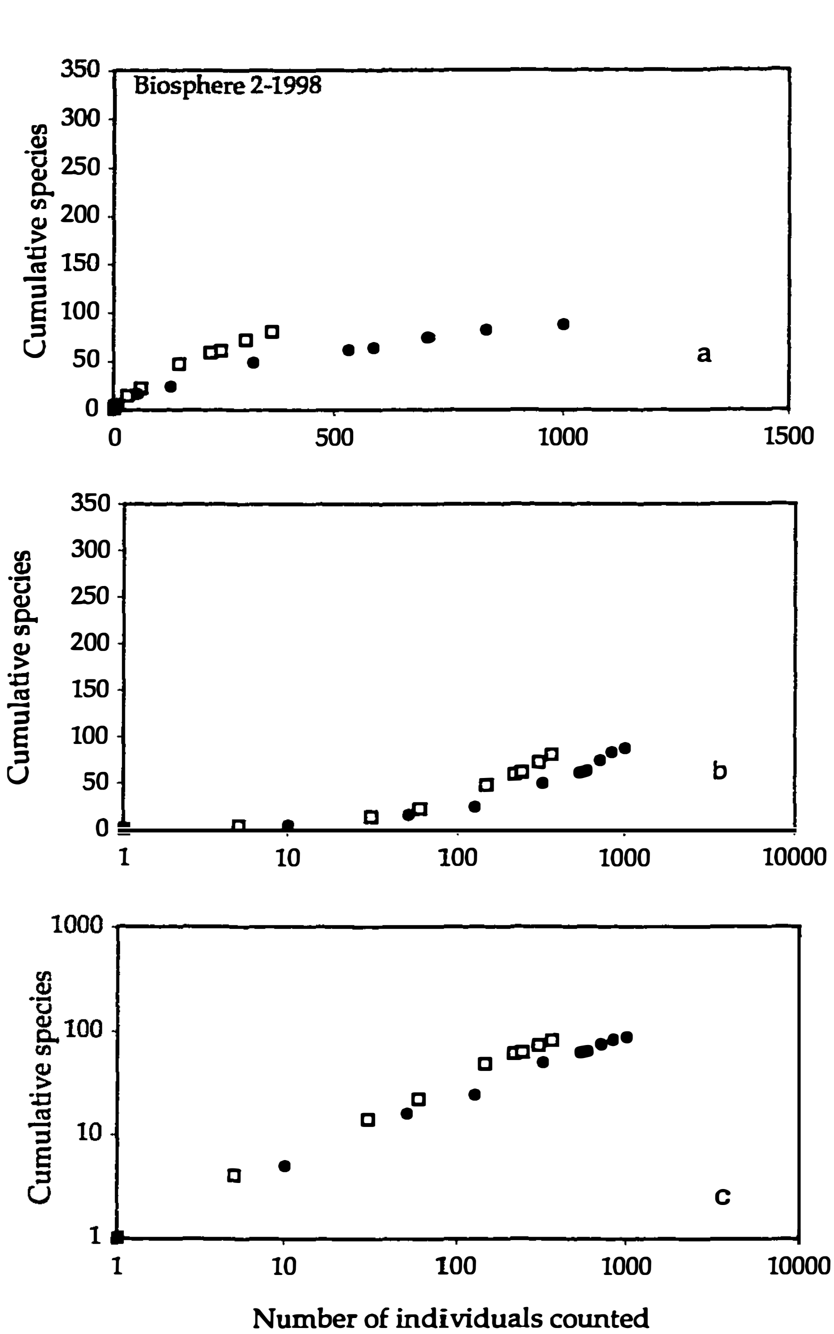



Figure 3-12. Cumulative plant species as a function of individuals in Biosphere 2 rainforest, April 1998. Open squares have *Scindapsus* and *Syngonium* subtracted.

and without the 2 most common species that formed a continuous ground cover in some areas, *Scindapsus aureus* and *Syngonium podophyllum*. Together they accounted for over half of the individual plants in 1998. Without the 2 species, the slope of the graph is steeper since more species accumulate with fewer individuals. Data for the 2 years are graphed together in Figure 3-13.

Leaf-Area Index

The leaf-area index averaged for 30 observations in April, 1998, was 6.07 $cm^2/cm^2$, Table 3-5. The range of leaf interceptions per point was 0 – 16. Notes from field observations made in November, 1993 (Odum et al.) show a leaf-area index of 4.9 averaged for 10 observations, with a range of leaf interceptions from 2-7. The mean number of interceptions of branches was 0.9.

Number of Seedlings and Green and Yellow Fallen Leaves per $m^2$

In 1996, a single *Leucaena* seedling was found in one of the 30, 0.54 $m^2$ circular plots, Table 3-6.

Green and yellow fallen leaves counted per circular plot were distributed as shown in Table 3-7. The average number of green leaves per plot was 1.8 with a range from 0 – 8 leaves, and the average number of yellow leaves per plot was 1.7, with a range of 0 - 6 leaves.

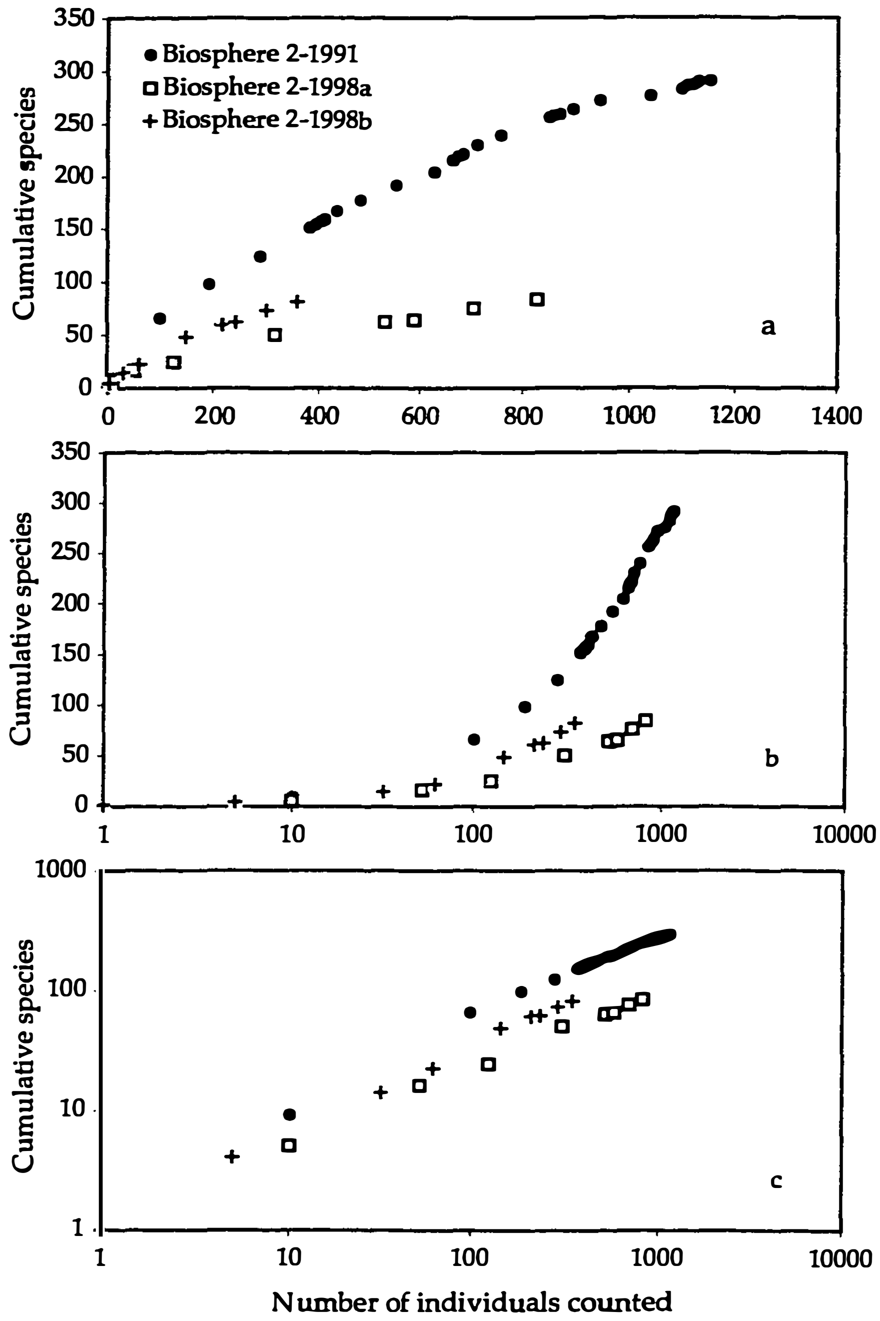



Figure 3-13. Cumulative species as a function of cumulative individuals in Biosphere 2 rainforest in 1991 (solid circles), 1998a (all plants, open squares), and 1998b (*Syngonium* and *Scindapsus* deleted, crosses).

Table 3-5. Leaf and branch interceptions per observation through vertical points in Biosphere 2 rainforest. Data for 1993 from Odum et al. (1993).

| Date | No. of observations | No. of interceptions per observation |
|---|---|---|
| | | Leaves |
| Nov. 93[a] | 10 | 2,5,7,4,5,6,6,5,5,4 |
| Apr. 98 | 30 | 7,8,3,4,4,7,3,4,10,7,4,16,1,7,5, 13,7,4,7,0,7,7,10,5,4,1,3,4,14,6 |
| | | Branches |
| Nov. 93[a] | 10 | 0,0,0,1,3,2,1,0,0,2 |

[a] Data from field notes by Odum et al. (1993), on file at Biosphere 2.

Table 3-6. Distribution of seedlings found in 30, 0.54 $m^2$ circular plots in Biosphere 2 rainforest understory in 1998.

| No. of seedlings | No. of plots |
|---|---|
| 0 | 29 |
| 1 | 1 |

Percent of Holes in Leaves

Table 3-8 shows the mean values for percent holes in tree leaves. Visual estimates were made for 20 trees throughout the rainforest in April 1998 and for 7 trees in Nov. 1993. The range of leaf holes per leaf in 1993 was 0 – 3.3%, and in 1998 the range was 0.1% - 1.7%.

Litterfall and Decomposition Rates

Litterfall and decomposition rates for the Biosphere 2 rainforest were reported by Nelson (1999) for measurements made from Oct. 1992 to Sept. 1993. Litter was collected monthly from 40, 0.25 $m^2$ baskets distributed among the habitats in the rainforest. Yearly dry weight of litterfall averaged over all habitats of the rainforest was 723 $\pm$ 158 g $m^{-2} yr^{-1}$. The total yearly litterfall for the rainforest biome weighted by the size of each habitat in which it was collected was 1078 kg $yr^{-1}$. Average monthly litterfall values ranged from about 40 g $m^{-2}$ in Dec. 1992 to about 95 g $m^{-2}$ in May 1993. The high value for May was attributed to tree fall and branch breakage, but could also include leaf and stem drop from rising temperatures in the higher levels of the rainforest, killing the new growth of the taller trees and resulting in increased litterfall.

Decomposition rates were measured for leaves of three species in the rainforest, and the average rate of disappearance was 95% per year. Leaf samples from two species, *Leucaena sp.* and *Cecropia schreberiana,* disappeared completely within one year.

Table 3-7. Distribution of green and yellow leaves in 0.54 $m^2$ circular plots on lowland rainforest ground, April 1998.

| | No. of plots | |
|---|---|---|
| No. of leaves | Green | Yellow |
| 0 | 9 | 12 |
| 1 | 7 | 3 |
| 2 | 5 | 7 |
| 3 | 5 | 3 |
| 4 | 2 | 1 |
| 5 | 1 | 2 |
| 6 | 0 | 2 |
| 7 | 0 | 0 |
| 8 | 1 | 0 |

Table 3-8. Percent of holes in leaves in Biosphere 2 rainforest trees. Data for 1993 from Odum et al. (1993).

| Date | No. of lvs. observed/tree | Percent holes in leaves per tree (mean of all leaves observed per tree) |
|---|---|---|
| Apr. 98 [a] | 10 | 1.6, 1.6, 0.1, 1.3, 0.4, 0.1, 1.7, 1.0, 0.9, 0.4, 0.4, 0.6, 1.2, 0.2, 1.6, 0.1, 1.4 |
| | 21 | 0.9 |
| | 11 | 0.3 |
| | 7 | 1.1 |
| Nov. 93 [b] | 12 | 1.3, 0.2 |
| | 10 | 0, 0.5 |
| | 9 | 3.3 |
| | 8 | 2.6 |
| | 6 | 1.8 |

[a] Data were recorded as ranges, <1, 1-5, etc. The midpoint of the ranges was used to calculate the mean value per tree, where <1 = 0.5, 1-5 = 2.5, etc.

[b] Data from field notes by Odum et al. (1993) on file at Biosphere 2.

Carbon Uptake and Respiration

Engel and Odum (1999) calculated community respiration and average daily $CO_2$ absorption rates for the entire Biosphere using diurnal curve analyses of oxygen and carbon dioxide measured in Jan. – Feb. 1995. They found an average community gross production rate of 23 g $O_2$ $m^{-2}$ $d^{-1}$, community respiration rate of 25 g $O_2$ $m^{-2}$ $d^{-1}$, and average $CO_2$ absorption rate of 0.2 g $CO_2$ $m^{-2}$ $h^{-1}$.

Net ecosystem exchange of $CO_2$, total soil respiration and canopy assimilation were reported by Lin et al. (1999) for the rainforest biome for June-July 1996. During this period the rainforest was separated with a secure curtain from the rest of the Biosphere. Estimates were made from measurements of diurnal variation of $CO_2$ in the atmosphere when atmospheric $CO_2$ levels were kept at about 450 ppm. Results are summarized in Table 3-9 in units given in the original publication. Average total canopy assimilation was 18.8 g $CO_2$ $m^{-2}$ $d^{-1}$ (day = 13.5 hours), or, stated as production,

$$(18.8 \text{ g } CO_2 \text{ m}^{-2} \text{ d}^{-1})(32 \text{ g } O_2 / 44 \text{ g } CO_2) = 13.7 \text{ g } O_2 \text{ m}^{-2} \text{ d}^{-1}.$$

Total respiration rates were 25.1 g $CO_2$ $m^{-2}$ $d^{-1}$, or 18.2 g $O_2$ $m^{-2}$ $d^{-1}$, and net ecosystem exchange per day was 6.3 g $CO_2$ $m^{-2}$ $d^{-1}$ , or –4.5 g $O_2$ $m^{-2}$ $d^{-1}$. These production and respiration rate estimates are somewhat lower than those made by Odum and Engel, even though measurements were made when more light would be entering the Biosphere and higher metabolic rates would be possible.

Table 3-9. System metabolism of Biosphere 2 rainforest for summer, 1996. NEE=Net ecosystem exchange, $R_s$=Soil respiration, $A_c$=Canopy assimilation, RUE= Radiation use efficiency, $R_p$=Plant respiration. From Lin et al. (1999).

| Location | Date & time | NEE | Total $R_s$ | Total $A_c$ | RUE |
|---|---|---|---|---|---|
| Rainforest[a] | June-July '96 | | | | |
| | Day, 13.5 hours | 113.2±19.1 mmol $CO_2$ $m^{-2}$ | -313.6±14.2 mmol $CO_2$ $m^{-2}$ | 426.8±12.3 mmol $CO_2$ $m^{-2}$ | 0.013±0.001 mol $CO_2$ $mol^{-1}$ |
| | | | | | (Total $R_p$) |
| | Night, 10.5 hours | 256.8±8.0 mmol $CO_2$ $m^{-2}$ | -233.8±9.2 mmol $CO_2$ $m^{-2}$ | - | -23.0±10.0 mol $CO_2$ $mol^{-1}$ |

[a] Data from Lin et al. (1999).

Cutting and Consumers

An estimated 22 hours per month was used for pruning in the Biosphere 2 rainforest, and an approximation of 10 kg per hour was cut. Rate of cutting for the first 2 year study period was 220 kg per month. A small fraction of this was used as fodder for the domestic animals, and the remainder was air-dried and stored in the basement area.

Diversity Index

Results of calculations of the Shannon-Wiener index is given in Table 3-10, showing decreasing plant diversity through time in the Biosphere 2 rainforest for the plants from the first planting.

Biomass Estimates

Aboveground plant biomass estimates for three dates are listed on Table 3-11. For the 1991 estimate, the standard error was estimated to be 25% of the biomass. The second estimate shows a 161% increase over the first, in 8 months. From July 1991 to July 1993 there was a 97% increase. Estimated increase in biomass from Nov. 1990 to July 1993 was 414%.

Comparisons Between Biosphere 2 and Tabonuco Forest in Puerto Rico

Data were assembled from secondary and plantation forests within the tabonuco forest type in Puerto Rico for comparison with trends in the developing structure, diversity and processes of the Biosphere 2 forest. The secondary forests are located in El Verde forest and Bisley watersheds, and are

Table 3-10. Shannon-Wiener index of diversity in Biosphere 2 rainforest for 1991, 1993, and 1996.

| Location | Date | Index* |
|---|---|---|
| Biosphere 2 | 1991 | 5.39 |
| | 1993 | 4.91 |
| | 1996 | 4.64 |

* Natural log (ln) used in calculations.

Table 3-11. Aboveground plant biomass estimates in Biosphere 2 rainforest for 1990, 1991, and 1993. From Haberstock (1991) and Bierner (1993).

| Date | Biomass (kg) | Increase |
|---|---|---|
| Nov. 1990[a] | 809 | |
| July 1991[a] | 2112 | 161% |
| July 1993[b] | 4161 | 97% |

[a]Data from Haberstock (1991).
[b]Data from Bierner (1993).

successional forests that are recovering from land uses and hurricanes, developing without human management. The plantation sites, often paired with the secondary forest sites with regard to age and soil type, are single-species tree plantations in which additional plants from nearby forests have become established.

In addition, a count of cumulative species per cumulative individuals was made for a landslide site near the El Verde Field Station in the tabonuco forest type in Puerto Rico in May 1999. The vegetation on the site has been developing over 11 years and is described by Myster and Walker (1997) as early successional, continuing to increase in plant diversity and biomass. In contrast, the Biosphere's rainforest system is 9 years old with declining diversity and increasing biomass.

## Physical Environment

Table 3-12 shows values for environmental variables that distinguish the Arizona and Puerto Rico rainforests. The Biosphere 2 rainforest is approximately 12° further north than the tabonuco forest in Puerto Rico, and has a greater range of daylength through the year. The light reaching the Biosphere 2 rainforest is 68% that of the tabonuco forest due to shading and reflection by the outside structure. Vapor pressure deficit for the Biosphere from Oct. '97 - May '98 was 6 - 9 millibars. Vapor pressure deficit for El Verde was less (1.8 - 6 millibars). There was a greater range of temperatures, both diurnally and seasonally in Biosphere 2. During the first 2 years of material closure, the $CO_2$ ranged between 500 and 4200 ppm. Thermal stratification of

Table 3-12. Environmental variables at El Verde and Biosphere 2 forests. From Odum (1970), Romer (1985), Ahrain et al. (1998), and Cuevas et al. (1991). Dashes mean no data are available.

| Variable and units | El Verde | Biosphere 2 |
|---|---|---|
| Insolation, kcal $m^{-2}$ $day^{-1}$ | | |
| Above canopy | | |
| Annual avg.[a] | 3830[b] | 2610[c] |
| Near forest floor | | |
| Avg. | 134[h] | -- |
| Daylength, hrs. | | |
| Avg. | | |
| Range | 12-13 | |
| Vapor pressure deficit millibars | | |
| Avg. | 5.5[d] | -- |
| Range | 1.8 - 6[e] | 6-9[f] |
| Temperature, C° | | |
| Above forest | | |
| April - Dec. avg. | 22.6[g] | -- |
| Jan. - Mar. avg | 20.6[g] | -- |
| Diurnal range | 21-25[g] | 23-42[f] |
| Near forest floor | | |
| Avg. | 22.9 | 27-29[f] |
| Diurnal range | 20.7 - 25.2[i] | 25-35[f] |

[a] Averaged over full year, 24 hours per day.

[b] Odum (1970), p. I-217.

[c] Romer (1985), p. 32, reports 253 W $m^{-2}$ for Tucson, AZ. approximately half of ambient light entered Biosphere 2 structure. 0.5(253 W $m^{-2}$)(2.30 E-4 kcal $sec^{-1}$)(3600 sec $hr^{-1}$)(24 hrs.)= 2612 kcal $m^{-2}$ $d^{-1}$

[d] Odum (1970), H-41.

[e] Odum (1970), B-415.

[f] Ahrain et al. (1998), monthly mean values, Oct. 97-May 98.

[g] Odum (1970), B-347.

[h] Odum (1970), I-218.

[i] Cuevas et al. (1991).

the air in the Biosphere due to low air flow created temperatures at the canopy top that were too high for plant growth, limiting the height of trees.

Soil

The Biosphere 2 soils were alkaline (pH range from 7.4 - 7.98); those in tabonuco forests acidic (pH range from 4.2 - 5.7), Table 3-13. Values for iron were lower in Biosphere 2, but other cations were much higher in all profile depths. Total percent nitrogen is similar in the two systems for the upper 10 cm of the soil profile, and higher in Biosphere 2 for in the deeper parts of the profile. The range of both total nitrogen and organic matter for Bisley samples is greater than that found in the Biosphere. Soil bulk density values for both systems are shown in Table 3-14. The highest value from all sites (1.32 g $cm^{-3}$ at 20-40 cm) are in the Biosphere 2 lowland rainforest habitat; the lowest values from Bisley watershed (0.63$\pm$0.04 g $cm^{-3}$ at 0-10 cm) and the North Cut Center (0.66 g $cm^{-3}$ at 0-15 cm).

Plants

Species and individuals

Thirty-nine species, or 12.3% of the flora planted in Biosphere 2 in 1991 were species that occur in El Verde, Table 3-15. Many of those plants were collected in Puerto Rico. By 1996, 21 species, or 54% of the original Puerto Rican species were still alive compared to 43% of the total species in the rainforest. About 13% (241) of the original individuals were El Verde species, and 34% of the individuals were still alive in 1996 compared to 28% of the total original individuals.

Table 3-13. Comparison of soil properties of Puerto Rico and Biosphere 2 forests. From Edmisten (1970), Silver et al. (1994), Scott (1999), and Lin et al. (1998 and 1999).

| Location | Depth | | P | OM | Total N | ppm | | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | cm | pH | ppm | % dry wt | % | Ca | Mg | K | Fe |
| | | | | Puerto Rico | | | | | |
| South Control Ctr.[a] | 0-13 | 4.3 | 21 | - | - | 202 | 300 | 104 | - |
| Sept. '64 | 13-25 | 4.3 | 17 | - | - | 270 | 87 | 24 | - |
| Radiation Ctr.[a] | 0-13 | 4.8 | 21 | - | - | 810 | 285 | 96 | - |
| Sept. '64 | 13-25 | 4.9 | 14 | - | - | 415 | 99 | 24 | - |
| North Cut Ctr.[a] | 0-13 | 5.7 | 13 | - | - | 3840 | 1515 | 186 | - |
| Sept. '64 | 13-25 | 5.4 | 6 | - | - | 1110 | 873 | 30 | - |
| Bisley[b], June 88 | | | | | | | | | |
| Ridge | 0-10 | 4.7±0.1 | 34±7 | 9.6±2.2 | 0.34±0.07 | 461±100 | 267±49 | 195±16 | 1340±149 |
| | 10-35 | 4.9±0.1 | 7±1 | 3.1±0.3 | 0.14±0.01 | 140±40 | 134±49 | 78±47 | 707±112 |
| | 35-60 | 4.2±0.1 | 3±1 | 1.4±0.2 | 0.08±0.01 | 120±60 | 134±61 | 39±12 | 74±93 |
| Slope | 0-10 | 4.8±0.1 | 23±2 | 7.1±0.6 | 0.31±0.02 | 601±100 | 389±49 | 235±19 | 968±93 |
| | 10-35 | 5.0±0.1 | 6±1 | 2.6±0.2 | 0.13±0.01 | 301±100 | 292±85 | 78±16 | 372±56 |
| | 35-60 | 5.0±0.1 | 3±0 | 1.7±0.2 | 0.07±0.01 | 220±80 | 255±121 | 39±4 | 168±19 |
| Upland Valley | 0-10 | 5.1±0.1 | 21±4 | 4.4+0.5 | 0.25±0.02 | 741±260 | 547±182 | 156±12 | 652±118 |
| | 10-35 | 5.1±0.1 | 9±1 | 2.4+0.4 | 0.13±0.02 | 601±301 | 340±97 | 78±7.8 | 391±130 |
| | 35-60 | 5.1±0.1 | 5±1 | 1.2±0.3 | 0.05±0.01 | 601±521 | 365±194 | 39±12 | 205±93 |
| Riparian Valley | 0-10 | 5.3±0.1 | 26±2 | 5.2±0.6 | 0.23±0.02 | 1242±200 | 523±73 | 235±27 | 577±93 |
| | 10-35 | 5.4±0.1 | 20±4 | 3.7±1.0 | 0.19±0.04 | 842±220 | 377±73 | 117±16 | 521±112 |
| | 35-60 | 5.3±0.2 | 9±1 | 1.3±0.0 | 0.06±0.01 | 481±0 | 474±170 | 78±12 | 205±56 |

Table 3-13 -- continued.

| Location Date | Depth cm | pH | P ppm | OM % dry wt | Total N % | Ca (ppm) | Mg (ppm) | K (ppm) | Fe (ppm) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Biosphere 2 | | | | | |
| Lowland & Gingerbelt Dec. '93[c] | 0-10 | 7.63 | - | 6.18 | 0.29 | 5497 | 509 | 1298 | - |
| | 10-20 | 7.53 | - | 4.70 | 0.22 | 5210 | 440 | 1009 | - |
| | 20-40 | 7.51 | - | 4.50 | 0.22 | 4967 | 425 | 856 | - |
| | 40-60 | 7.52 | - | 4.70 | 0.24 | 4841 | 441 | 974 | - |
| Rainforest | | | | | | | | | |
| Dec. '95[d] | 0-20 | 7.34±0.10 | 117±25 | 3.62±0.49 | - | - | - | 789±189 | 251±45 |
| | 20-40 | 7.36±0.04 | 121±25 | 3.26±0.26 | - | - | - | 533±132 | 207±44 |
| Jan. '96[d] | 0-20 | 7.38±0.21 | 111±24 | 4.08±0.47 | - | - | - | 650±153 | 190±16 |
| | 20-40 | 7.50±0.01 | 99±21 | 2.92±0.39 | - | - | - | 523±89 | 215±31 |
| No date[e] | 0-20 | 7.68±0.07 | - | 4.16±0.40 | - | - | - | - | - |
| | 20-40 | 7.98±0.01 | - | 3.88±0.39 | - | - | - | - | - |
| May '96[e] | 0-20 | - | 64.5±11.5 | - | - | - | - | 561±127 | 161±27 |
| June '96[e] | 0-20 | - | 67.4+10.8 | - | - | - | - | 602±145 | 144±16 |
| July '96[e] | 0-20 | - | 60.9±9.8 | - | - | - | - | 692±162 | 162±17 |

[a] Edmisten (1970), p H-82.

[b] Silver et al. (1994) Data are mean values with standard errors made in 2 watersheds at 4 different topographic positions. The number of samples per mean varies between depth and site from 2-41.

[c] Scott (1999). OM % dry weight is calculated as 2 times the reported value for carbon.

[d] Lin et al. (1998).

[e] Lin et al. (1999).

Table 3-14. Soil bulk density in Biosphere 2 rainforest and Puerto Rico tabonuco forest. From Scott (1999), Edmisten (1970), and Silver et al. (1994).

| Location | Depth cm | Bulk density $g\ cm^{-3}$ |
|---|---|---|
| Biosphere 2[a] | | |
| Lowland rainforest | 0-10 | 1.10 |
| | 10-20 | 1.26 |
| | 20-40 | 1.32 |
| | 40-80 | 1.18 |
| Ginger belt | 0-10 | 0.94 |
| | 10-20 | 1.11 |
| | 20-40 | 1.03 |
| | 40-80 | 1.10 |
| Puerto Rico | | |
| South Control Center[b] | 0-15 | 1.05 |
| | 15-30 | 1.02 |
| | 30-61 | 1.00 |
| Radiation Center[b] | 0-15 | 1.18 |
| | 15-30 | 1.14 |
| | 30-61 | 1.11 |
| North Cut Center[b] | 0-15 | 0.66 |
| | 15-30 | 0.92 |
| | 30-61 | 1.03 |
| Bisley Watershed[c] | 0-10 | 0.63+0.04 |
| | 10-35 | 0.98+0.03 |
| | 35-60 | 1.13+0.06 |

[a] Data from Scott (1999). n=3, samples from Dec. 1993.

[b] Data from Edmisten (1970). Composite sample from each site.

[c] Data from Silver et al. (1994). Mean value and standard error of 87 measurements.

Table 3-15. Plant species occurring in El Verde that were originally planted in Biosphere 2 forest, with an inventory of individuals counted per species in 1991 and 1996.

| Growth form | Species[a] | Number of plants 1991 | 1996 |
|---|---|---|---|
| Trees | *Cecropia schreberiana* Miq. | 11 | 5 |
| | *Ceiba pentandra* (L.) Gaertn. | 6 | 5 |
| | *Cordia alliodora* (Ruiz & Pav.) Oken | 2 | 0 |
| | *Mangifera indica* L. | 5 | 0 |
| | *Psidium guajava* L. | 8 | 2 |
| | *Spathodea campanulata* P. Beauv.. | 1 | 1 |
| | *Syzygium jambos* (L.) Alston | 7 | 2 |
| | *Tabebuia heterophylla* (DC.) Britton | 3 | 0 |
| Arboreal palms and palm-like plants | | | |
| | *Cnemidaria horrida* (L.) C. Presl | 1 | 0 |
| | *Cocos nucifera* L. | 2 | 2 |
| | *Cyathea arborea* (L.) Sm. | 3 | 0 |
| | *Prestoea montana* (Graham) G. Nicholson | 1 | 0 |
| Shrubs | *Coffea arabica* L. | 18 | 13 |
| | *Hibiscus rosa-sinensis* L. | 4 | 3 |
| | *Theobroma cacao* L. | 11 | 0 |
| Climbers | *Dioscorea alata* L. | 3 | 1 |
| | *Marcgravia rectiflora* Triana & Planch. | 5 | 1 |
| | *Philodendron angustatum* Schott | 7 | 1 |
| Giant herbs | *Alpinia purpurata* (Vieill.) ex K. Schum. | 4 | 4 |
| | *Hedychium coronarium* Koenig | 19 | 8 |
| | *Heliconia caribaea* Lam. | 8 | 2 |
| | *Musa sp.* | 31 | 24 |

Table 3-15 — continued.

| Growth form | Species[a] | Number of plants 1991 | 1996 |
|---|---|---|---|
| Herbs | *Asclepias curassavica* L. | 4 | 1 |
| | *Bacopa monnieri* (L.) Wettst. | 1 | 0 |
| | *Blechnum occidentale* L. | 1 | 0 |
| | *Colocasia esculenta* (L.) Schott | 1 | 1 |
| | *Eryngium foetidum* L. | 1 | 0 |
| | *Etlingera elatior* (Jack) R.M. Sm. | 4 | 1 |
| | *Ludwigia octovalvis* (Jacq.) P.H. Raven | 1 | 0 |
| | *Nephrolepis exaltata* (L.) Schott | 32 | 0 |
| | *Polypodium aureum* L. | 1 | 0 |
| | *Polytaenium feei* (W. Schaffn. ex Fée) Maxon | 5 | 0 |
| Graminoids | *Paspalum plicatulum* Michx. | 1 | 1 |
| Epiphytes | *Guzmania berteroniana* (Schult. & Schult.) Mez | 1 | 0 |
| | *Guzmania monostachia* (L.) Rusby ex Mez | 2 | 0 |
| | *Polypodium crassifolium* L. | 6 | 0 |
| | *Rhipsalis baccifera* (J.S. Muell.) Stearn | 5 | 0 |

[a] Plant list from Biosphere 2 cross-checked with El Verde checklist of Charlotte M. Taylor in Lawrence (1996).

Growth form spectra

Graphs of the spectra for the 2 systems are shown in Figure 3-14. The growth form spectra of the 2 rainforests show a much smaller proportion of herbs in the tabonuco forest than in Biosphere 2, and a large percentage of epiphyte species.

Cumulative species as function of cumulative individuals

The sites, size class of plants measured, dates of measurements, and results of number of species per number of individuals counted are summarized in Table 3-16.

Cumulative species encountered per 1000 individuals counted are shown in Figure 3-15 for the landslide site sampled at El Verde. The data are graphed alongside data for the Biosphere 2 rainforest in 1998, Figure 3-16. The graphs show that species are accumulated at about the same rate until about 500 individuals were counted; then the Biosphere 2 accumulated species more quickly than the landslide.

Data from the Bisley grid and the Radiation Center were graphed similarly, using databases provided by El Verde LTER staff. The 3 Puerto Rico sites are graphed together on Figure 3-17. The Bisley and landslide graphs are nearly identical, though the Bisley data only account for woody species greater than or equal to 2.5 cm at diameter breast height. The Radiation Center accumulated the least species for 1000 individuals counted. The Radiation Center data set included all plants, including sprouts and seedlings, and according to Taylor et al. (1996) the 1988 counts were made at a time when a lot of seeds were sprouting.

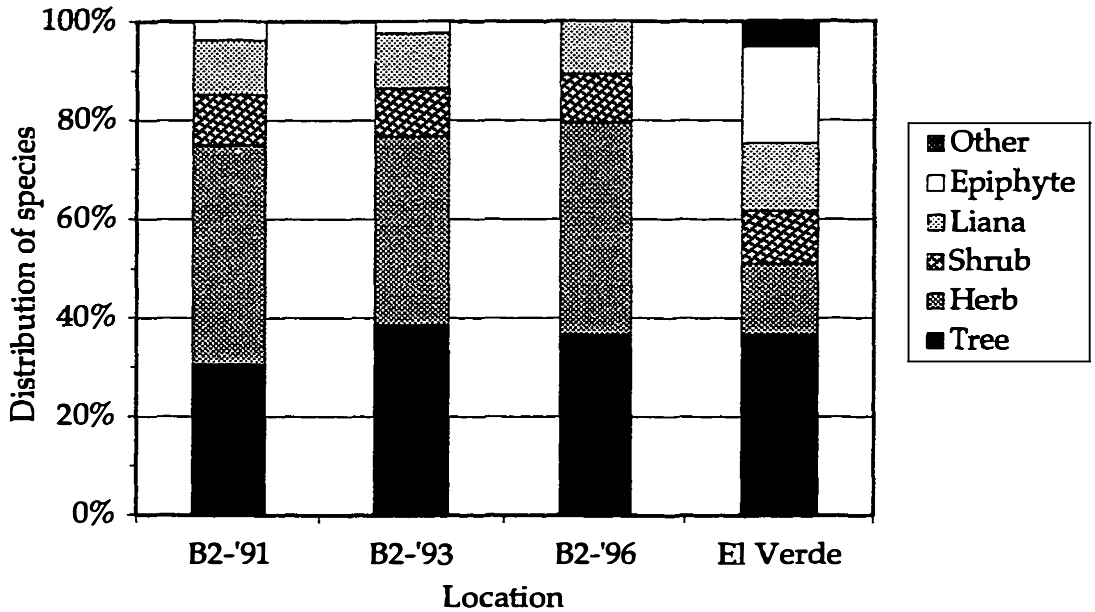



Figure 3-14. Growth form spectra of Biosphere 2 rainforest and El Verde tabonuco forest. B2 = Biosphere 2. Data for El Verde from Smith (1970).

Table 3-16. Sampling sites for species/individual counts, and number of species/1000 individuals.

| Site name | Date | Subset of plants counted | Species/ 1000 plants | Notes |
|---|---|---|---|---|
| Biosphere 2 | 1991 | All plants | 273 | |
| Biosphere 2 | 1998 | All plants on east side of rainforest | 96 | Most common 2 species were *Syngonium podophyllum* and *Scindapsus aureus*, sprawling species on forest floor. |
| El Verde landslide | 1999 | All plants, ≥0.5 m tall | 60 | Landslide occurred in 1988. |
| Bisley grid | 1992 | Woody plants ≥2.5 cm dbh | 63 | |
| Radiation Center | 1988 | All plants, including seedlings and sprouts | 41 | Sampling occurred during fruitfall and seedling germination time (Taylor et al. 1996). |

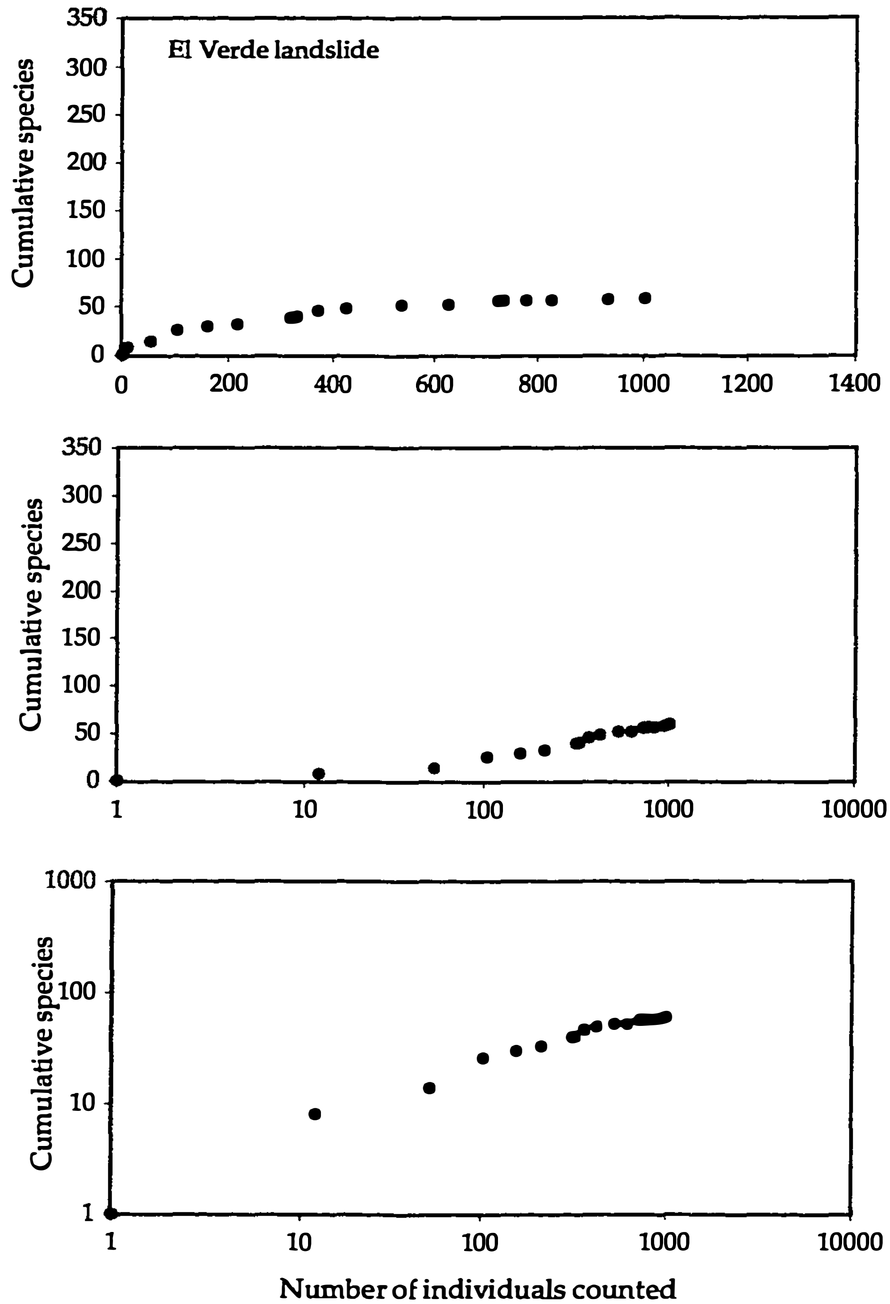



Figure 3-15. Cumulative plant species as a function of cumulative individuals >0.5 m tall counted on an 11-year-old landslide at El Verde site.

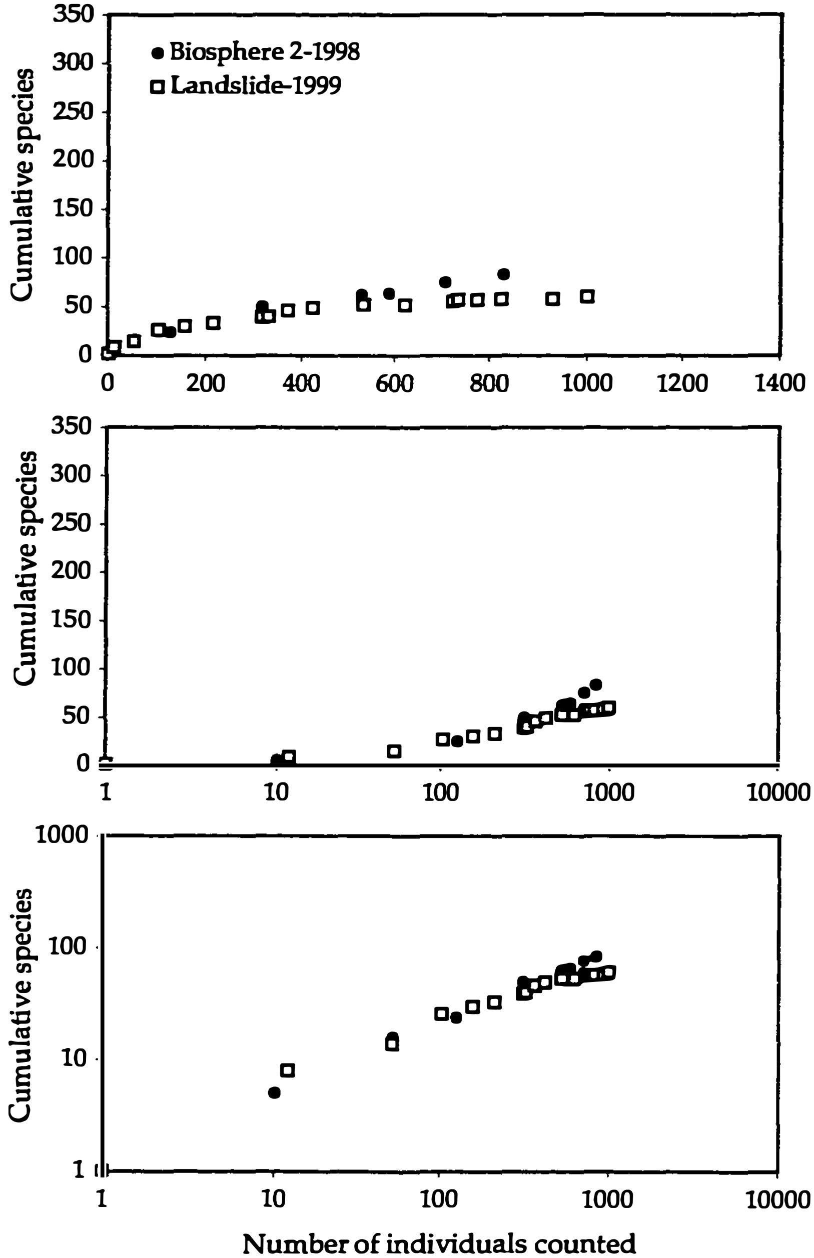



Figure 3-16. Cumulative plant species as a function of cumulative individuals counted in Biosphere 2 (solid circles) and on an 11-year-old landslide at El Verde (open squares).

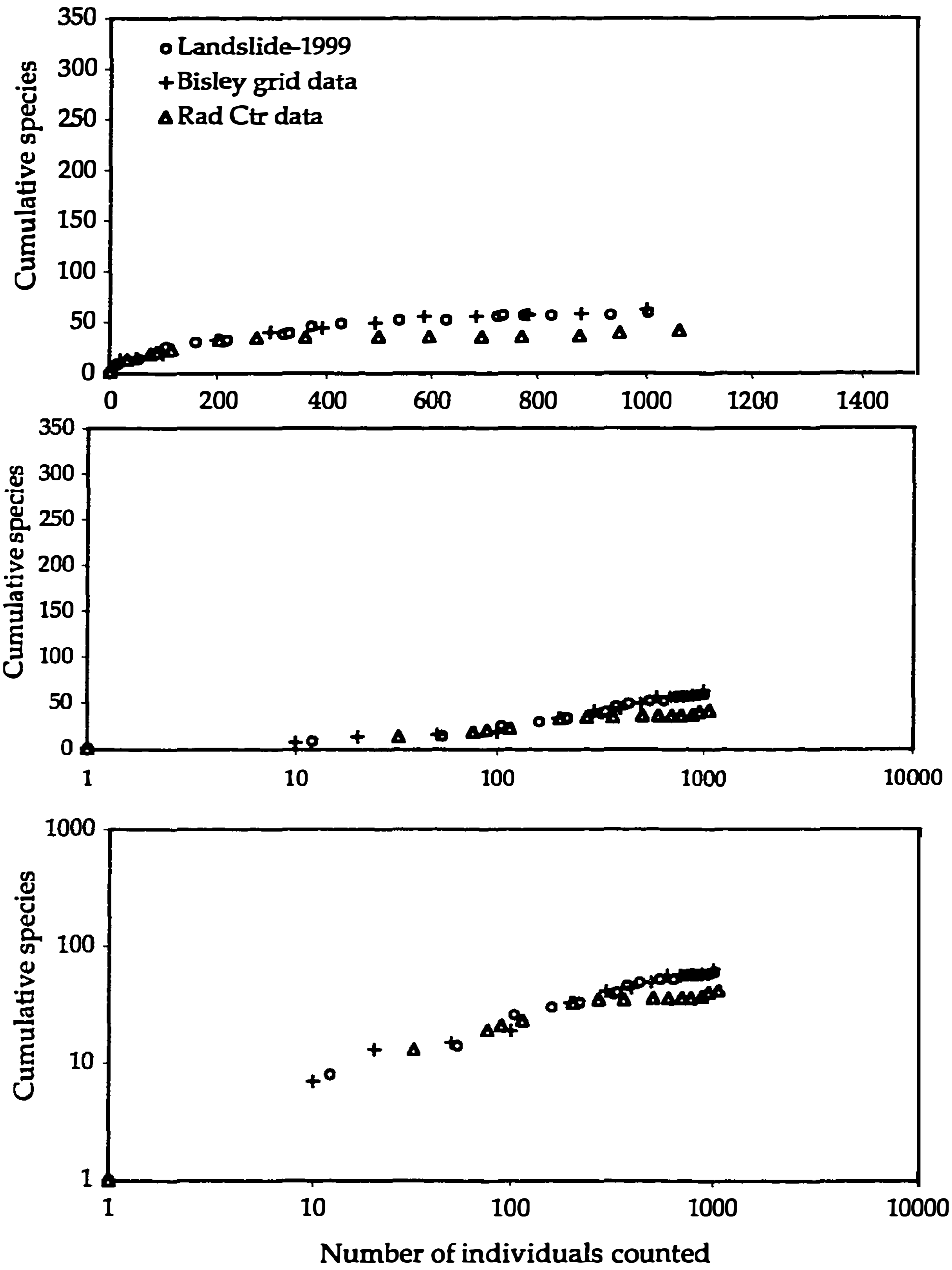



Figure 3-17. Cumulative plant species as a function of cumulative individuals counted on El Verde landslide (open circles), Radiation Center (open triangles), and Bisley grid (crosses).

In Figure 3-18 all sites are graphed. By 1998, the Biosphere 2 rainforest had approached the values of the landslide and Bisley rainforest.

Leaf area indices

Table 3-17 shows leaf area indices for a number of sites in the tabonuco forest, and for 2 dates in the Biosphere 2 rainforest. Though measurements for the Biosphere are sparse, they indicate an increase in leaf area through time, approaching or exceeding values for the tabonuco system. Data from the tabonuco forest also show an increase after disturbance for the Radiation Center and North Cut Center.

Seedling density

Seedling density was higher in the tabonuco than the Biosphere 2 rainforest, Table 3-18. The Biosphere data reflect the low rate of reproduction by seed for most of the species.

Percent of holes in leaves

Table 3-19 shows the extent of leaf surface herbivory, measured by the absence of leaf tissue. The percent of holes in leaves at El Verde ranged from over 30% to less than 5%, depending on the species of tree (Mercado 1970). The average number of leaf holes was 7% (Odum 1970b), compared to an average in Biosphere 2 of less than 1 in 1998 and less than 2 in 1993.

Litterfall and decomposition rates

The mean litterfall rate for the Biosphere 2 rainforest was slightly lower than the mean range of the tabonuco forest, shown on Table 3-20. However, the Biosphere lowland rainforest data include large woody branches from a treefall, which skews this value upward from the mean

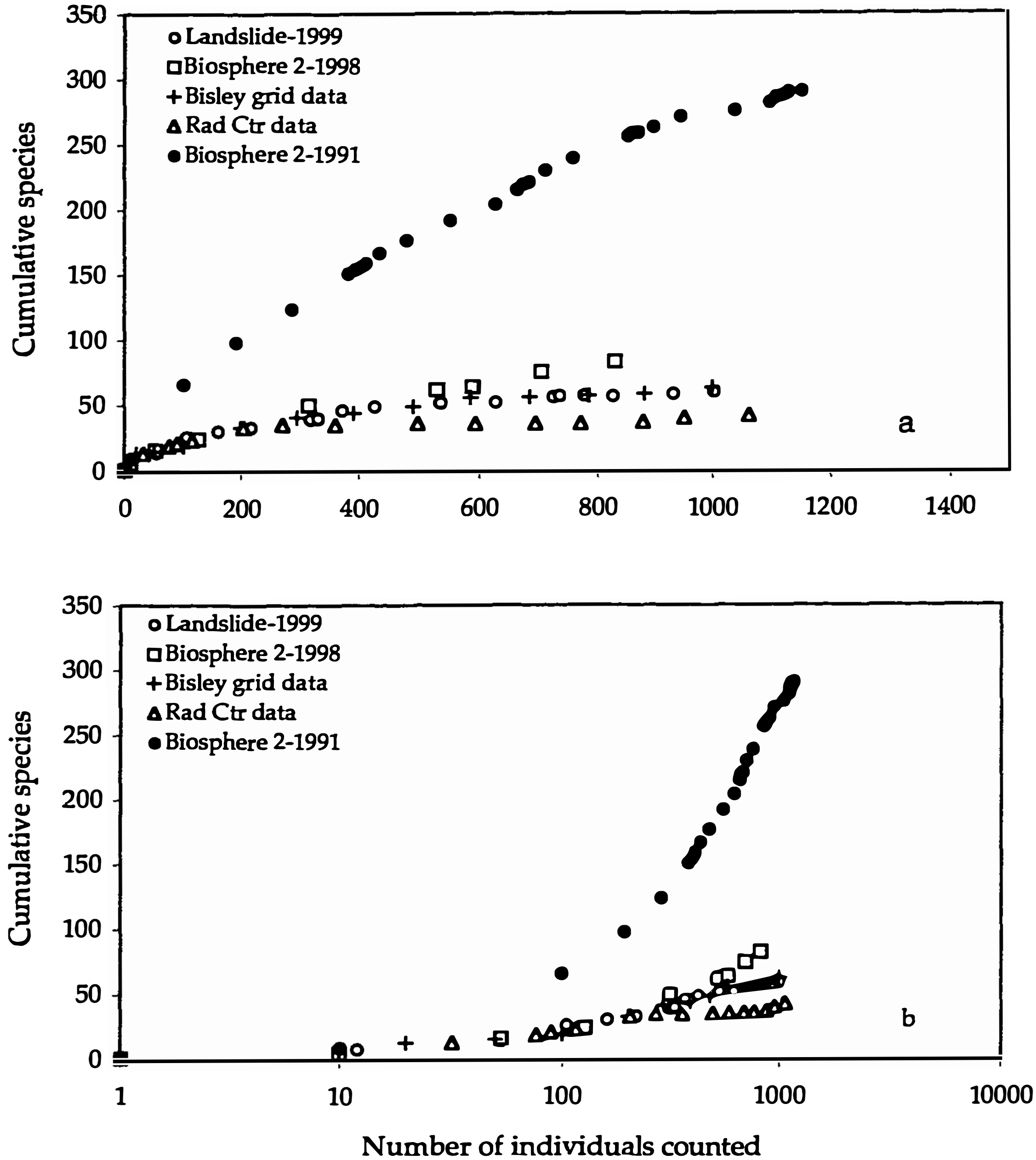



Figure 3-18. Cumulative plant species as a function of cumulative individuals counted on El Verde landslide, Radiation Center, Bisley grid, and Biosphere 2 rainforest for 1991 and 1998. a) linear scale; b) semi-log scale; c) log-log scale.

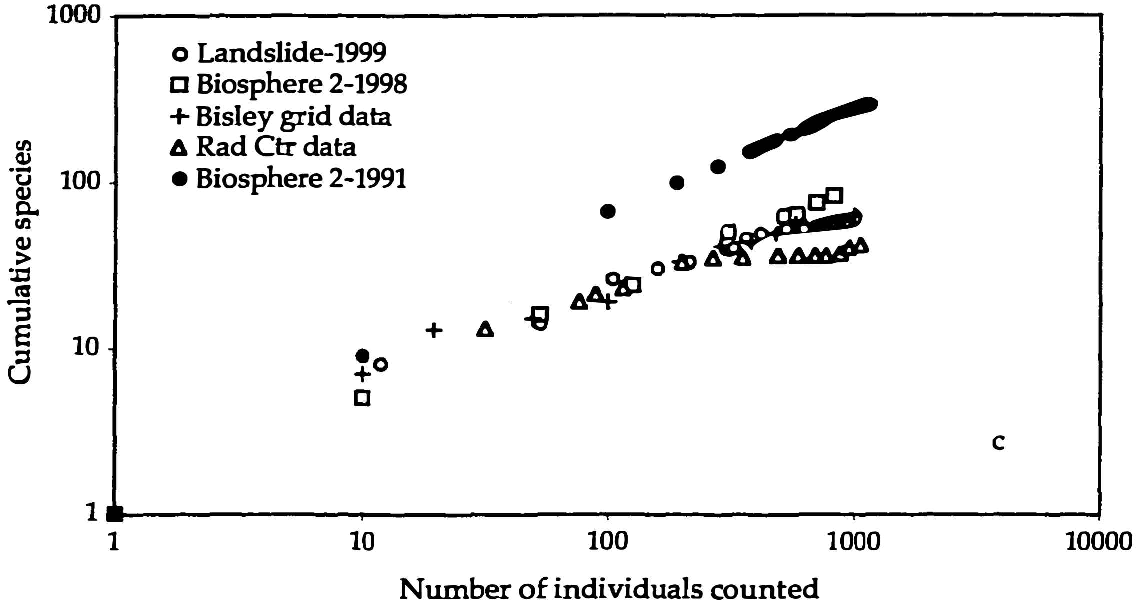



Figure 3-18 – continued.

Table 3-17. Leaf-area indices of Puerto Rico tabonuco forest and Biosphere 2 rainforest. From Odum (1970), Jordan (1969), Odum and Pigeon (1970), and Odum et al. (1993).

| Location | Method | Leaf area/ ground area |
|---|---|---|
| | Puerto Rico tabonuco forest | |
| El Verde[a] | Direct harvest | 6.4 |
| Ravine | Subset, n=2 | 2.1 |
| Slope | Subset, n=4 | 6.4 |
| Ridge | Subset, n=4 | 8.7 |
| El Verde[b] | Plumb line | 6.6 |
| Slope | Subset, n=16 | 6.68 |
| Slope | Subset, n=16 | 5.60 |
| Ridge | Subset, n=16 | 8.60 |
| El Verde[c] | Plumb line | 5.24 |
| Radiation Center | 1 yr. after irradiation | 3.16 |
| | 3 yrs. after irradiation | 5.51 |
| North Cut Center | 1 yr. after cutting | 4.03 |
| | 3 yrs. After cutting | 4.45 |
| | Biosphere 2 rainforest | |
| Entire rainforest[d] | Extended pole, 1993 | 4.9 |
| Lowland rainforest | Extended pole, 1998 | 6.1 |

[a] Odum (1970).

[b] Jordan (1969).

[c] Odum and Pigeon (1970). I-175.

[d] Odum et al. (1993).

Table 3-18. Seedling density in Biosphere 2 and tabonuco rainforest. Tabonuco forest data from Odum (1970).

| Location | Seedlings per $m^2$ |
|---|---|
| Biosphere 2, Apr. 98 | <0.1 |
| | |
| Puerto Rico[a] | |
| Control Center | 5.12 |
| Cut Center | 11.2 |
| Radiation Ctr, Oct. 64 | 2.25 |
| Radiation Ctr, Dec. 64 | 3.95 |

[a] Odum (1970), D-139, for 20-1 $m^2$ plots in each center.

Table 3-19. Percent of holes in leaves in Biosphere 2 rainforest and tabonuco forest trees. Tabonuco forest data from Odum (1970b).

| Date | No. of lvs. observed/tree | Percent holes in leaves per tree (mean of all leaves observed per tree) |
|---|---|---|
| | | Biosphere 2 |
| Apr. 98[a] | 10 | 1.6, 1.6, 0.1, 1.3, 0.4, 0.1, 1.7, 1.0, 0.9, 0.4, 0.4, 0.6, 1.2, 0.2, 1.6, 0.1, 1.4 |
| | 21 | 0.9 |
| | 11 | 0.3 |
| | 7 | 1.1 |
| Nov. 93[b] | 12 | 1.3, 0.2 |
| | 10 | 0, 0.5 |
| | 9 | 3.3 |
| | 8 | 2.6 |
| | 6 | 1.8 |
| | | El Verde |
| | (No. of baskets) | |
| 1964[c] | 49 | 6.34 ±0.42 |
| | 101 | 5.8 ±0.30 |
| | 97 | 5.61 ±0.28 |
| | 243 | 5.85 ±0.22 |

[a] Data were recorded as ranges, <1, 1-5, etc. The midpoint of the ranges was used to calculate the mean value per tree, where <1 = 0.5, 1-5 = 2.5, etc.

[b] Data from field notes by Odum et al. (1993) on file at Biosphere 2.

[c] Data from Odum (1970b).

yearly value. The average disappearance rate of leaf material for the Biosphere was higher than that measured for tabonuco forest, Table 3-21.

Nutrient content of leaves

Nutrient content of leaves for the two forests are given in Table 3-22. Values overlap for all elements except phosphorus, which was an order of magnitude higher in the Biosphere rainforest than the tabonuco. Both potassium and nitrogen in the leaves of the Biosphere were closer to the maximum value of the ranges given for tabonuco.

Carbon exchange

Soil respiration and canopy assimilation were both lower in the Biosphere 2 rainforest tabonuco forest, shown in Table 3-23. Carbon assimilation in the Biosphere (measured in summer) was 56 to 76 percent that of the tabonuco forest, and soil respiration was 40% that of the tabonuco forest.

Aboveground biomass density

The aboveground biomass density values for different sites in the tabonuco rainforest vary between 8 and 24.6 kg $m^{-2}$, Table 3-24. The Biosphere 2 rainforest was 4.2 kg $m^{-2}$ in July, 1993, and beyond that value later.

## Overview Simulation Models

Two different overview simulation models were used to consider processes affecting diversity and production in these ecological systems. The first model simulates production, consumption and biomass, the resource basis for diversity. The second model relates plant diversity to resources,

Table 3-20. Litterfall rates in Biosphere 2 rainforest habitats and tabonuco forests. From Nelson (1999), Wiegert (1970), Cuevas et al. (1991), Lugo (1992), and Lodge (1991).

| Location | Rate, g $m^{-2}$ $yr^{-1}$ |
|---|---|
| Biosphere 2[a] | |
| Bamboo belt | 578 ± 81 |
| Terraces | 466 ± 70 |
| Lowland | 1317 ± 283 |
| W. Ginger belt | 492 ± 46 |
| Varzea | 641 ± 89 |
| All habitats, mean | 723 ±158 |
| Puerto Rico[b] | |
| Radiation Center | 623 |
| So. Control Ctr. | 571 |
| Secondary forest[c] | 820 ± 100 |
| Mature secondary forest[d] | 970 |
| Bisley and El Verde, mean[e] | 856 |

[a] Nelson (1999). Data from collections made monthly Oct. '92 - Sept. 93, mean and standard error.
[b] Data from Wiegert (1970), H-92, for litter collections made 2/64 - 12/64 extrapolated for one year.
[c] Cuevas et al. (1991).
[d] Lugo (1992).
[e] Lodge (1991).

Table 3-21. Decomposition rates of litter in Biosphere 2 rainforest and El Verde forest in Puerto Rico. From Nelson (1999) and Wiegert (1970).

| | | Rate of disappearance | |
|---|---|---|---|
| Location | Material | g $g^{-1}$ $yr^{-1}$ | Annual, g $m^{-2}$ |
| Biosphere 2[a] | *Leucaena sp.* | 1.00 | |
| | *Cecropia schreberiana* | 1.00 | |
| | *Musa* | 0.90 | |
| | Average | | 1024 |
| Puerto Rico[b] | | | |
| Radiation Center | | 0.850 | 705 |
| So. Control Ctr. | | 0.519 | 265 |

[a] Data from Nelson (1999).
[b] Data from Wiegert (1970) p. H-95.

Table 3-22. Nutrient content of leaves in percent of dry weight in Biosphere 2 and El Verde forests. From Odum (1970a), Ovington (1970), Medina et al. (1981), and Lin et al. (1999).

| | Puerto Rico[a,b,c] | | | Biosphere 2[d] | | |
|---|---|---|---|---|---|---|
| Element | | min.-max. | | 31-May-96 | 16-Jun-96 | 15-Jul-96 |
| Nitrogen | 1.606 | 0.61-3.37 | 1.04-2.02 | 3.47±0.33 | 3.68±0.29 | 3.52±0.29 |
| Calcium | 0.999 | 0.23-2.92 | | 1.08±0.23 | 1.26±0.21 | 1.46±0.29 |
| Magnesium | 0.366 | 0.01-1.04 | | 0.39±0.08 | 0.36±0.06 | 0.41±0.07 |
| Potassium | 1.035 | 0.24-2.96 | | 2.62±0.22 | 2.90±0.71 | 2.93±0.70 |
| Phosphorus | 0.03 | 0.003-0.045 | 0.042-0.068 | 0.26±0.02 | 0.32±0.05 | 0.26±0.12 |

[a] Data from Odum (1970a), I-236. Attributed to Ovington 1970.

[b] Nutrient ranges - Ovington (1970), H-59.

[c] Medina et al. (1981). Range of nutrient contents for individual leaves of selected tabonuco species.

[d] Data from Lin et al. (1999). Samples made taken at different atmospheric $CO_2$ levels; values between dates are not significantly different at $P<0.05$. Leaves sampled from 5 most common species.

Table 3-23. Carbon exchange in Biosphere 2 (summer) and tabonuco rainforests. $R_S$= Soil respiration, $A_C$= Canopy assimilation. From Lin et al. (1999) and Odum (1970b).

| Location | Date & time | Total $R_s$ g C $m^{-2}$ $hr^{-1}$ | Total $A_c$ g C $m^{-2}$ $hr^{-1}$ |
|---|---|---|---|
| Biosphere 2 | June-July 1996 | | |
| rainforest[a] | Day (13.5 hours) | -0.28 | 0.38 |
| | Night (10.5 hours) | -0.267 | |
| El Verde[b] | | | |
| Giant cylinder | 1963 | -0.68 | 0.68 |
| Ten prisms | | - | 0.53 |

[a] Lin et al. (1999).
[b] Odum (1970b).

Table 3-24. Estimates of aboveground biomass density in Biosphere 2 and tabonuco forests. From Haberstock (1991), Bierner (1993), Ovington and Odum (1970), Scatena et al. (1993), and Lugo (1992).

| Location | Biomass density, kg $m^{-2}$ |
|---|---|
| Biosphere 2 | |
| 1991[a] | 1.0 |
| 1993[b] | 4.2 |
| Puerto Rico | |
| Primary forests: | |
| Radiation center[c] | 24.6 |
| South Control Center[c] | 14.5 |
| North Cut[c] | 19.8 |
| Bisley[d] | 22.6 |
| Secondary forests: | |
| Mature[e] | 8.0 |
| Mahogany plantation[e] | 12.5 |

[a] Haberstock (1991).
[b] Bierner (1993).
[c] Ovington and Odum (1970).
[d] Scatena et al. (1993).
[e] Lugo (1992).

mechanisms of interaction and management, where diversity is measured as the total number of species (species richness).

Production and Biomass Minimodel Description

Figure 3-19 is a model of relationships believed important to metabolism, a systems hypothesis. Included are the parts and processes of the Biosphere 2 rainforest that affected production and biomass. The outer window of the systems diagram shows the material isolation of Biosphere 2 from the earth as it was operated during 1991-1993. The inner window defines the rainforest biome as a separate system of the Biosphere 2 mesocosm, with air, humans, consumers and biomass moving across the biome boundaries. Labels on the flow pathways (K1, etc.) are the coefficients used to calculate the rates of flow between storages.

Main pathways in the model are described as follows: Approximately half of the energy from the sun reaching Biosphere 2 is reflected from the external glass or absorbed by the stainless steel spaceframe structure, represented by an arrow from the sunlight pathway deflected from the outer window. Most of the sunlight entering the glass is used by the production process, which has been split between two producer groups of different physiological types, weedy plants (generally eutrophic vines and herbaceous perennials) and plants of a more mature forest. The flow pathway to the weedy plants is labeled K1 and the flow K2 to mature plants. The sunlight which is not used by the production process (R) is re-radiated out of the rainforest.

Figure 3-19. Systems diagram for simulating production and biomass in Biosphere 2 rainforest showing storages, pathway coefficients and equations.

$$I = Im+Ir*SIN(.017*T)$$

$$R = I/(1+K1*N*W+K2*N*M)$$

$$DW = K4*N*R*W-K3*N*R*W-K7*W*H-K10*W*H-K12*W-K8*W$$

$$DM = K6*N*R*M-K5*N*R*M-K14*M-K16*M$$

$$DN = K9*W+K17*M+K23*S+K28*C+Ja+K29*B-K25*N*R*M-K24*N*R*W-K21*N$$

$$DS = K11*H*W+K13*W+K15*M-K27*S*C-K22*S$$

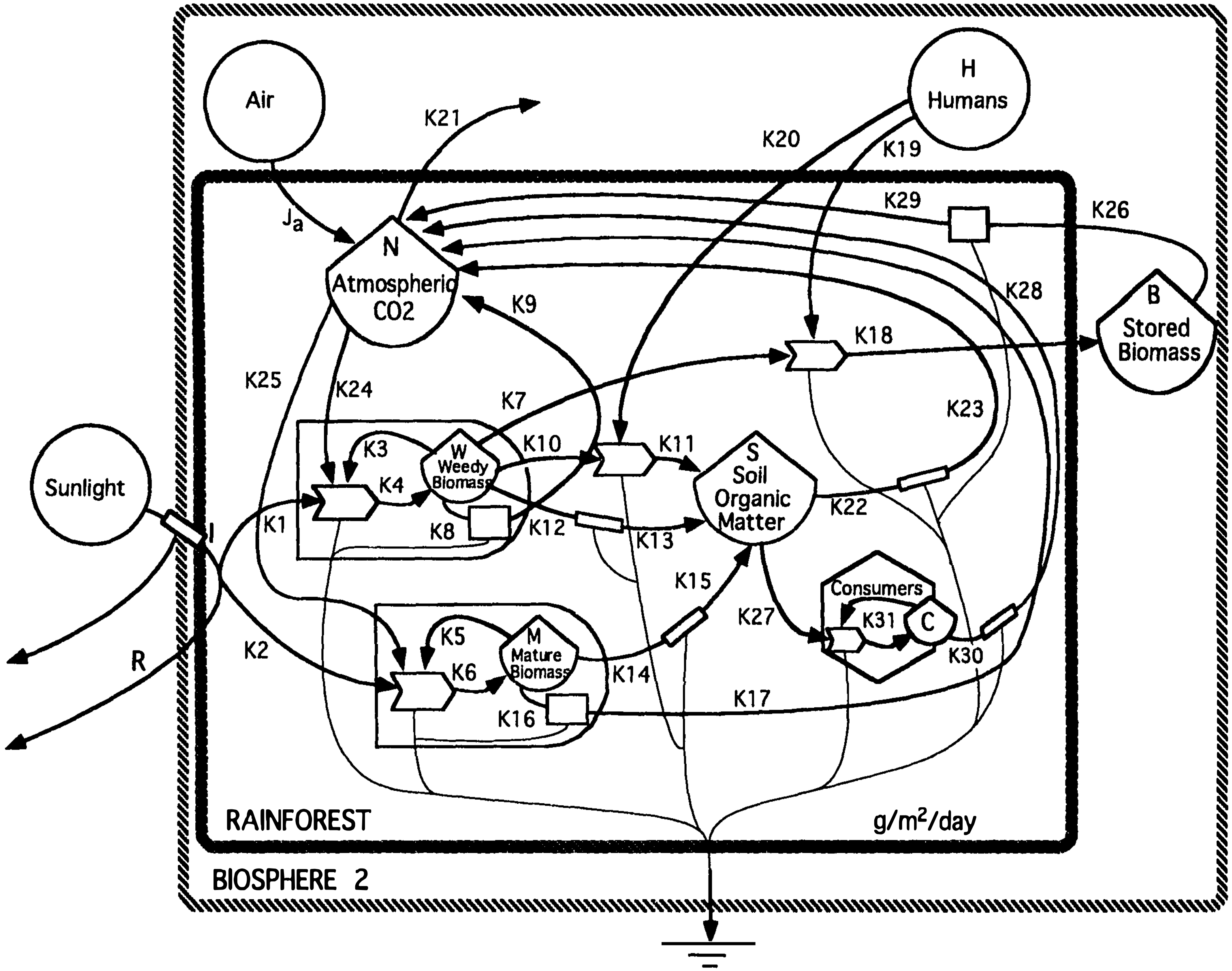
$$DB = K18*H*W-K26*B$$

$$DC = K31*S*C-K30*C$$

$$Pg = K4*R*N*W+K6*R*N*M$$

$$Rp = K3*R*N*W+K5*R*N*M+K8*W+K16*M+K22*S+K27*S*C$$

$$PR = Pg/Rp$$


Air
H
Humans
Sunlight
K21
K20
K19
K29
K26
$J_a$
N
Atmospheric
CO2
K28
B
Stored
Biomass
K9
K18
K25
K24
K7
K23
K3
W
Weedy
Biomass
K10
K11
S
Soil
Organic
Matter
K4
I
K1
K8
K12
K13
K22
K15
Consumers
K27
K31
C
K5
M
Mature
Biomass
K30
R
K2
K6
K14
K16
K17
RAINFOREST
g/m²/day
BIOSPHERE 2

The 2 producer units (bullet-shaped symbols) receive flows of sunlight, atmospheric $CO_2$ (K24 and K25), and feedback from the living biomass (K3 and K5). The 3 flows interact with producers in the process of photosynthesis. The pathway K4 is the gross productivity of weedy biomass; K6 the gross productivity of mature biomass.

The respiratory functions from plant biomass (K8 and K16) show biomass conversion to carbon dioxide by microconsumers (boxes along the pathway), which flows (K9 and K17) into the atmospheric $CO_2$ storage, N. Pathways K12 and K14 leading from the plant biomass storage tanks represent natural litterfall feeding into the soil organic matter storage, and K10 and K7 from the weedy biomass storage are for the litterfall created by humans through pruning, passing into either the soil organic matter storage or stored as dried biomass in the basement of the rainforest biome. Though dried, the stored organic matter still had a slow respiration rate, hence the pathway K26 from stored biomass (B) to the atmospheric $CO_2$ storage (N).

The soil organic matter is consumed by detritivores such as earthworms and arthropods on one pathway (K27) where a storage of macroconsumer biomass (C) accumulates. The feedback from macroconsumer storage to the production process (K31) works to increase macroconsumer production. Some of the organic biomass consumed is returned to the atmosphere along the respiration pathway (K30 to K28). On another pathway (K22) soil organic matter is decomposed by microconsumers (represented by a rectangle along the pathway) and returned to atmospheric $CO_2$ along another respiration pathway (K23).

The calibration values shown in Figure 3-20 were estimated by extrapolating storages for the steady state condition that could be expected in the Biosphere 2 rainforest, projected to occur after 20 years of similar operation (year 2011). Many of the pathway coefficients were calculated using rates measured inside the Biosphere 2 rainforest. An EXCEL spreadsheet, Table C-1, shows the initial calibration values for storages and rates and details the values used in the calibration.

A minimodel (B2METAB) was written using QUICKBASIC, Appendix C-2, for simulation of the production and biomass model described above. Baseline simulation runs are presented in the text, and other runs where conditions are varied are in Appendix C.

## Results of Simulating the Production and Biomass Minimodel

Baseline simulations of the minimodel for 10 and 100 years were set with initial storage values that were close to the Biosphere 2 rainforest values at the start of the first closure in September 1991. The 10-year simulation (Figure 3-21) shows atmospheric $CO_2$, soil organic matter and consumer storages declining at first with a rapid increase in plant biomass. Initially, the net ecosystem production (Pr = Pg/Rs) was greater than 1, which reflects the initial fast growth of primary producers. Over 100 years, shown in Figure 3-22, the soil organic matter increases, and as it reaches its maximum storage value the system is able to support more macroconsumers, which increase in a pulse. This pattern is repeated, showing the switch to a heterotrophic system (Pr<1) when consumers pulse, CO2 increases, and the soil organic matter decreases. The amplitude of the pulses decreases over

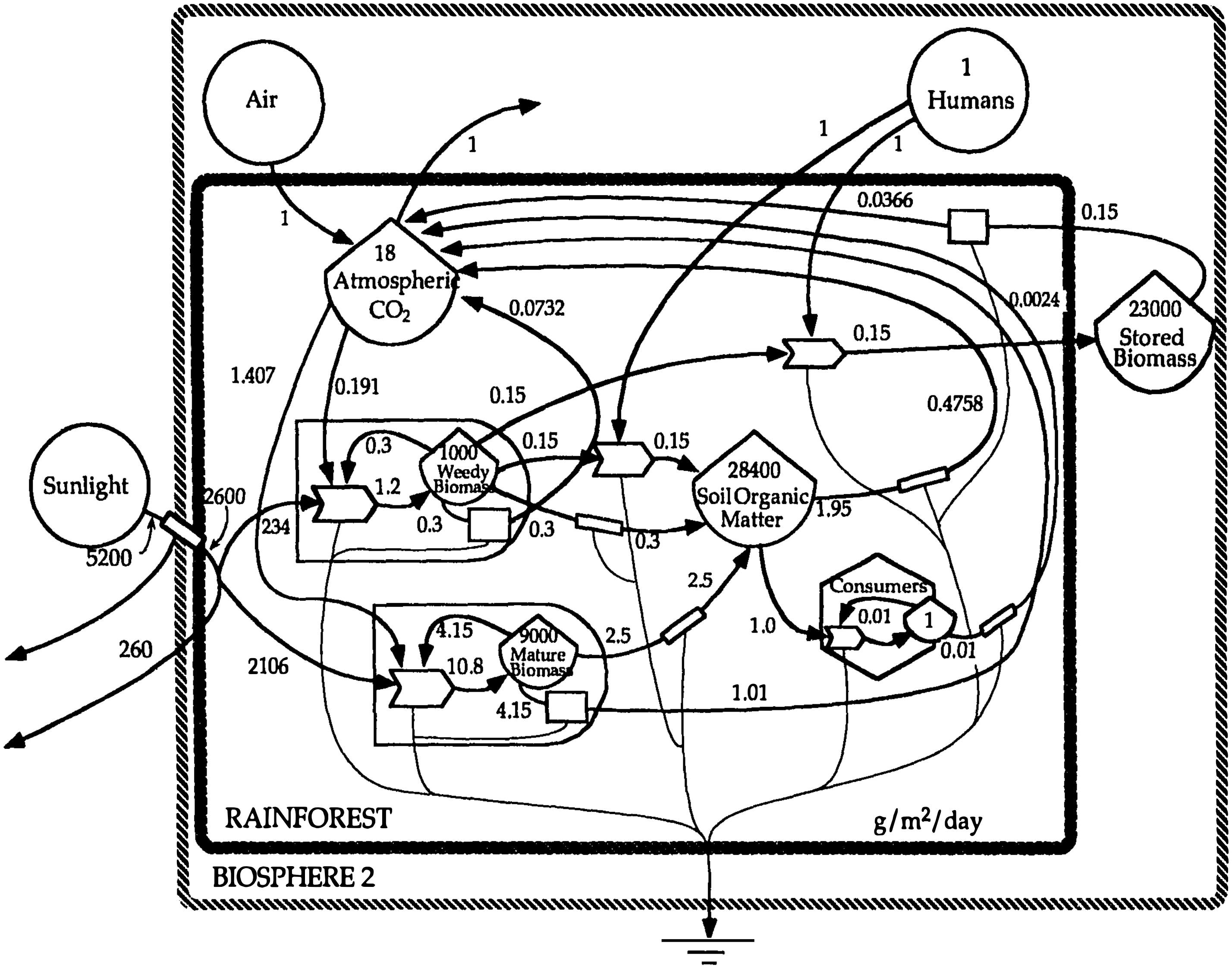



Figure 3-20. Systems diagram for simulating production and biomass in Biosphere 2 rainforest showing calibration values projected for steady state after 20 years of operation.

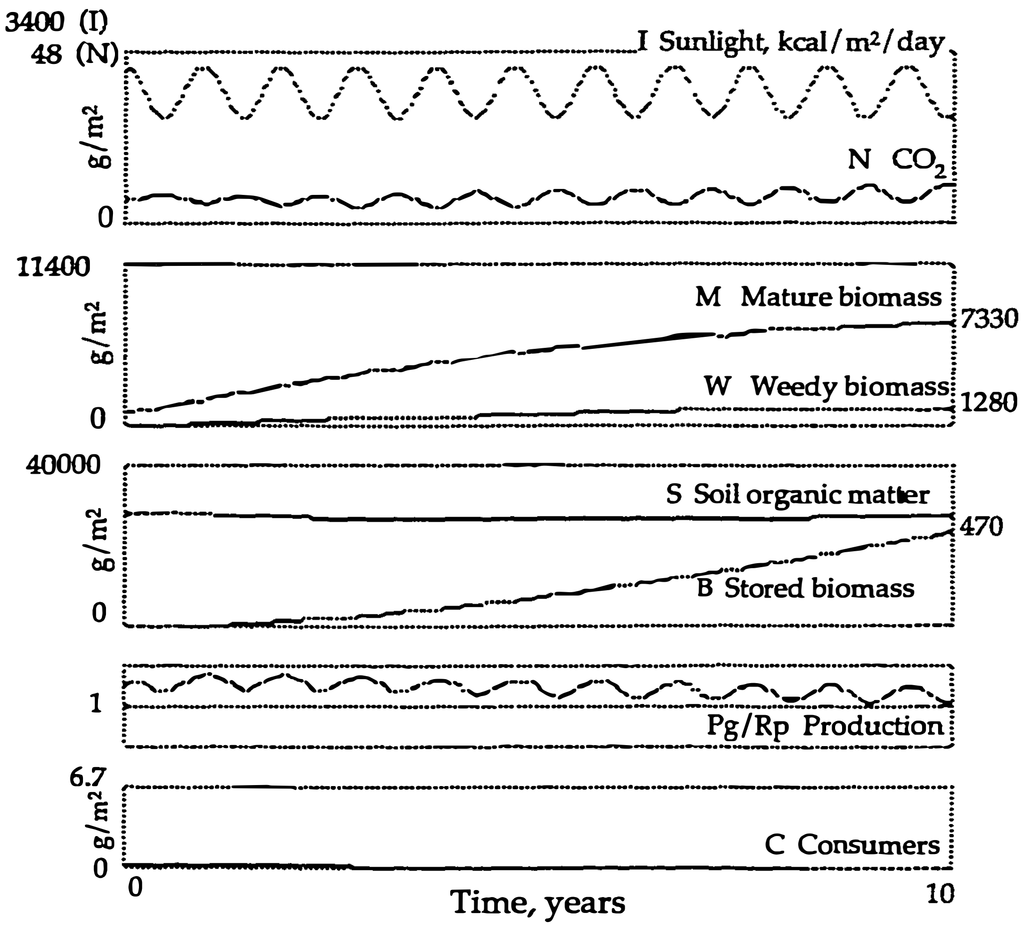



Figure 3-21. Ten-year simulation of production and biomass minimodel, B2METAB in Figure 3-19. Final values for plant biomass are on the right side of their graphs. $g/m^2$ = grams per square meter, dry weight for biomass.

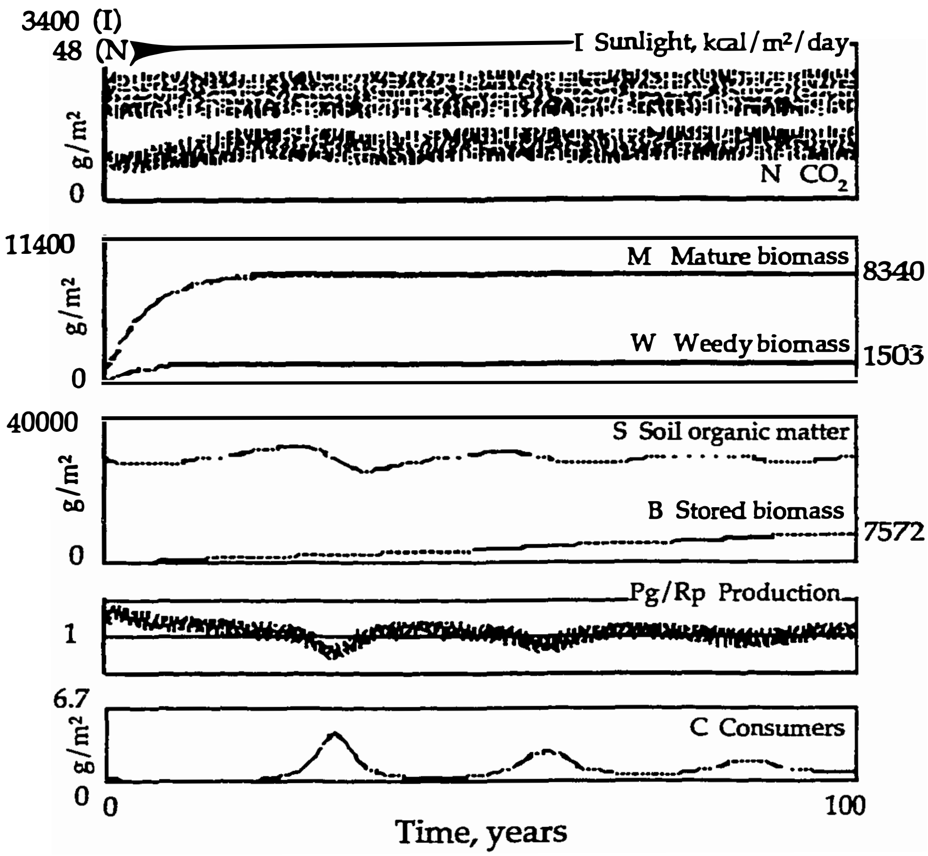



Figure 3-22. One-hundred-year baseline simulation of production and biomass in the minimodel B2METAB in Figure 3-19. Final values for plant biomassare on the right side of their graphs. g/m2 = grams per square meter, dry weight for biomass.

time as macroconsumers assimilate plant biomass and build a storage. The system sustains a stable population of macroconsumers over time (centuries) where the mean value of Pr is 1. All storages move towards a stable value with the exception of stored biomass, which continues to increase due to a continuous harvest.

The following alterations to the baseline simulation, such as increased light or reduced pruning, demonstrate the effects of changes on the developing ecosystem. Figures 3-23 and 3-24 compare the effects of each alteration of the system on biomass or production.

Increased sunlight (I = 3120)

When sunlight entering the Biosphere was increased by 20% biomass storages (B, M, W, C, S) built more quickly than at the lower light levels (Figure 3-23), amplitudes of the consumer pulses were higher, and stable values of net production, soil organic matter, and macroconsumer storage were approached more quickly than with less light (Figure 3-24). The mean value of carbon dioxide in the air was lower, and the sum of plant biomass storages after 100 years was greater than with lower light.

No weedy biomass (W=0)

When the minimodel is started and run without weedy biomass, the mature plant species biomass increases faster and has a higher steady-state value than the baseline simulation value. Total plant biomass accumulation is less since there are neither weedy plants nor stored weedy biomass. Consumer and soil organic matter storages grow more slowly, and consumer pulses are smaller. Though the effect of no weedy species is to increase

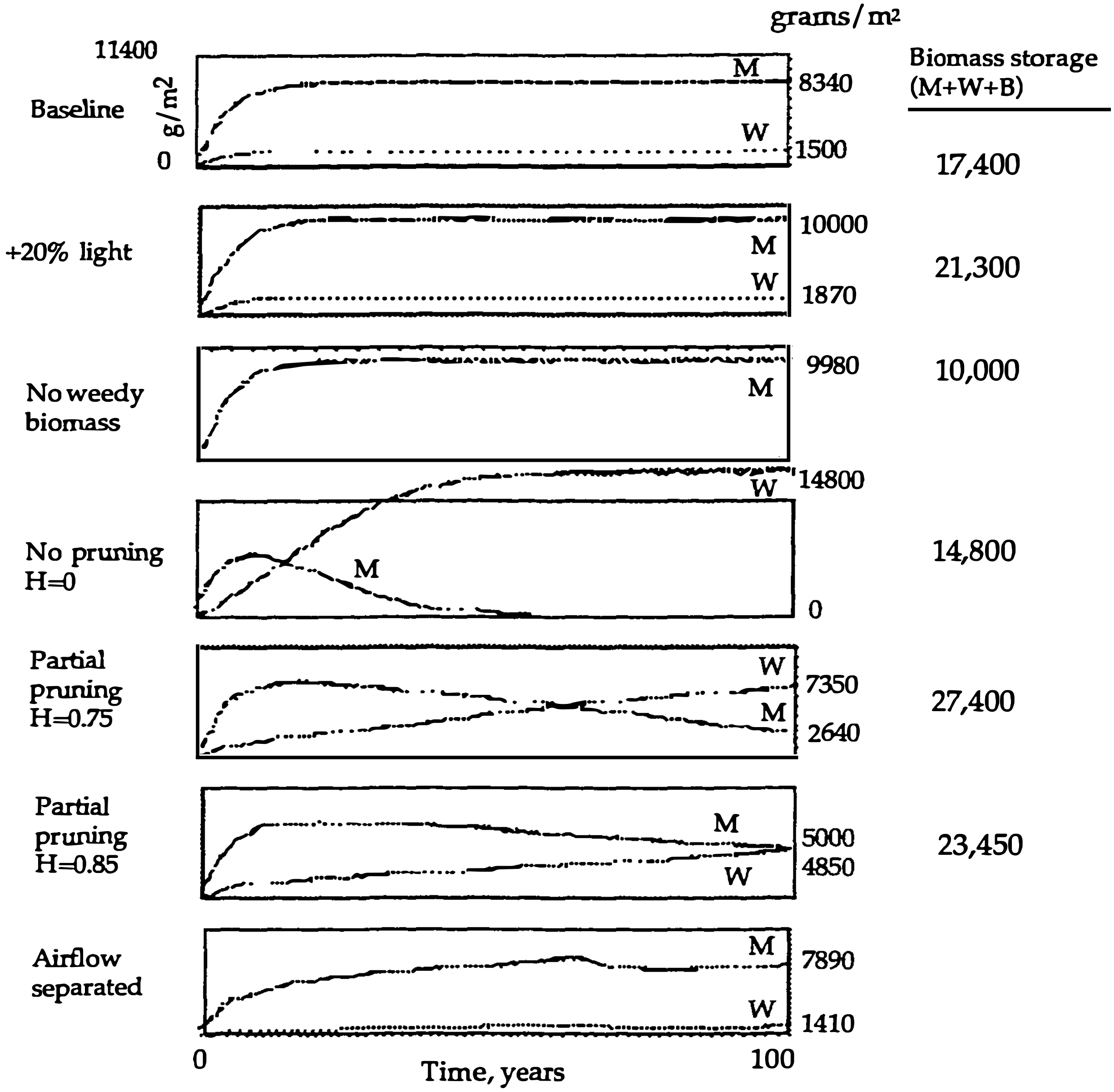



Figure 3-23. Comparison of simulations of biomass by the model in Figure 3-19 showing effects of light, elimination of weedy biomass, limited pruning, and altered airflow on mature and weedy plant biomass. Values for biomass at 100 years are given on the right side of the graphs in grams of dry biomass per square meter. Scales are the same for each box. M=Mature plants, W=Weedy plants.

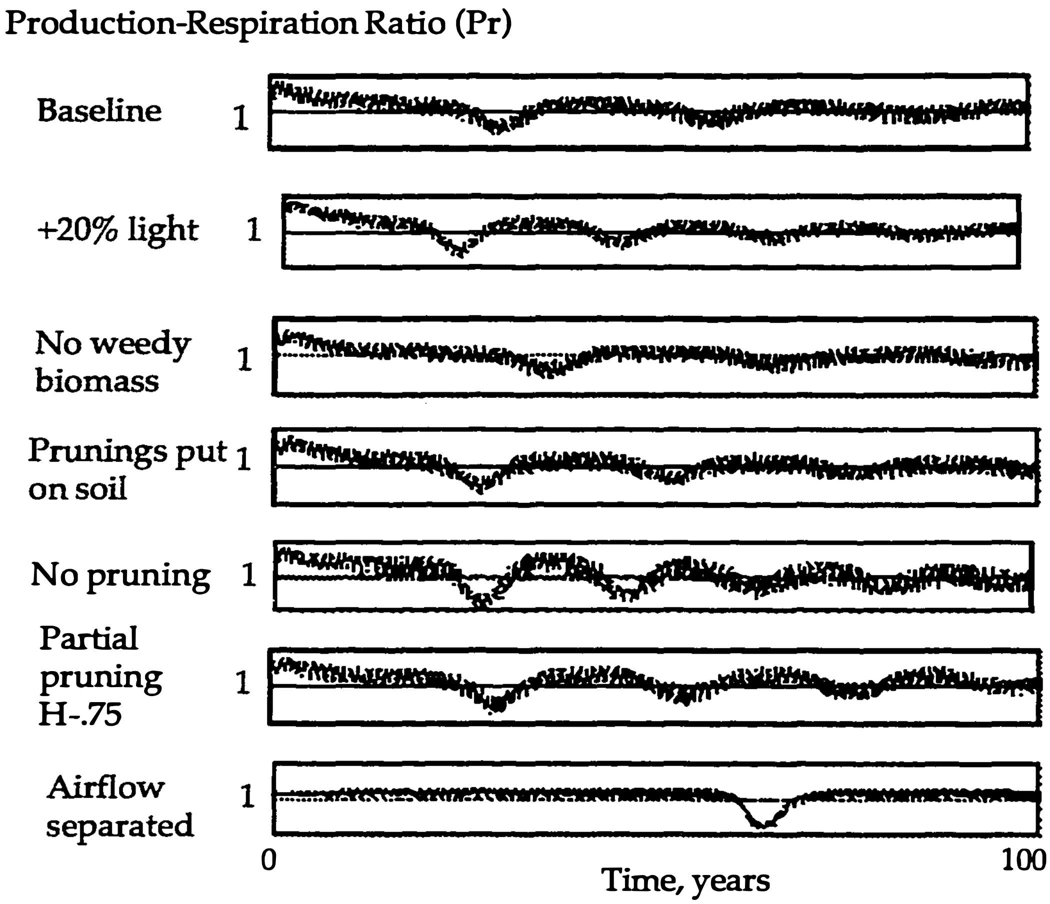



Figure 3-24. Comparison of effects of light, elimination of weedy biomass, limited pruning, and altered airflow on production-respiration ratio, Pg/Rp, from simulations of the model B2METAB in Figure 3-19. Scales are the same for each box, with the center line = 1.

mature species biomass, total ecosystem development is slowed and total storages are less after 100 years.

All pruned biomass added to soil (K18*H*W added to DS, B removed)

With diversion of the pruned biomass from dry storage to the soil (additional litterfall), consumer storages build more rapidly and are larger. Biomass storages and $CO_2$ are virtually unchanged.

No removal of weedy biomass (H = 0)

Pruning of weedy biomass during the start-up of Biosphere 2 was thought to be important for the survival of some of the key mature species by releasing them from light competition with the weedy species. The simulation of the system with no pruning shows the increased growth of weedy species and eventual total decline of mature species. A larger plant biomass storage occurs with only weedy species than with only mature species (Figure 3-23), since the weedy plant type has the higher ratio of Pg/Rp. However, the runs with both weedy and mature plants with weedy plant pruning show the largest combined plant biomass storage over time. The rapid increase of plant biomass when no pruning occurs promotes much more rapid storage and cycling of soil organic matter and consumer pulsing than the baseline run.

Whether weedy plant biomass could reach this amount with climbers or herbaceous perennial growth forms depends on the ability of vines to use the superstructure of Biosphere 2 to overgrow other species. To achieve the biomass storage without well-developed vertical structure is unlikely. Inside Biosphere 2 the spaceframe structure was used by climbers for support, and to increase the volume in which they were able to produce biomass.

Reduction of human effort in removing weedy biomass (H = .75)

A reduction of human effort in removing weedy species was simulated to see whether the amount of pruning would change total plant biomass production – the sum of live plant biomass and dried, stored biomass – and lower the atmospheric $CO_2$ concentration. Figure 3-23 shows that combined plant biomass storages would be increased over the baseline values and $CO_2$ reduced when H is reduced. Weedy biomass increases and stored biomass increases, though mature biomass decreases, with lower $CO_2$ compared with the baseline simulations where H=1. However, below a certain level of human intervention, mature species will be out-competed by the weeds.

No airflow between biomes (Ja = 0 and K21 = 0)

The atmosphere of the Biosphere 2 rainforest connected to the atmosphere of the other biomes within the structure. Without airflow between the different areas, atmospheric $CO_2$ level increased, plant growth increased, soil organic matter increased, and consumers increased. The Pr ratio of the system was greater than one until the pulse of consumers occurred, when it switched to a heterotrophic system (Figure 3-24). After consumers used up the organic matter resource, they crashed and the Pr ratio of the system returned to the pre-pulse condition.

Production and Diversity Minimodel Description

That diversity and structure of an ecosystem compete for energy is especially evident during the early stages of ecosystem development. In a system with limited resources, amount and quality of energy may determine the extent to which diversity, structure and their connections can be supported.

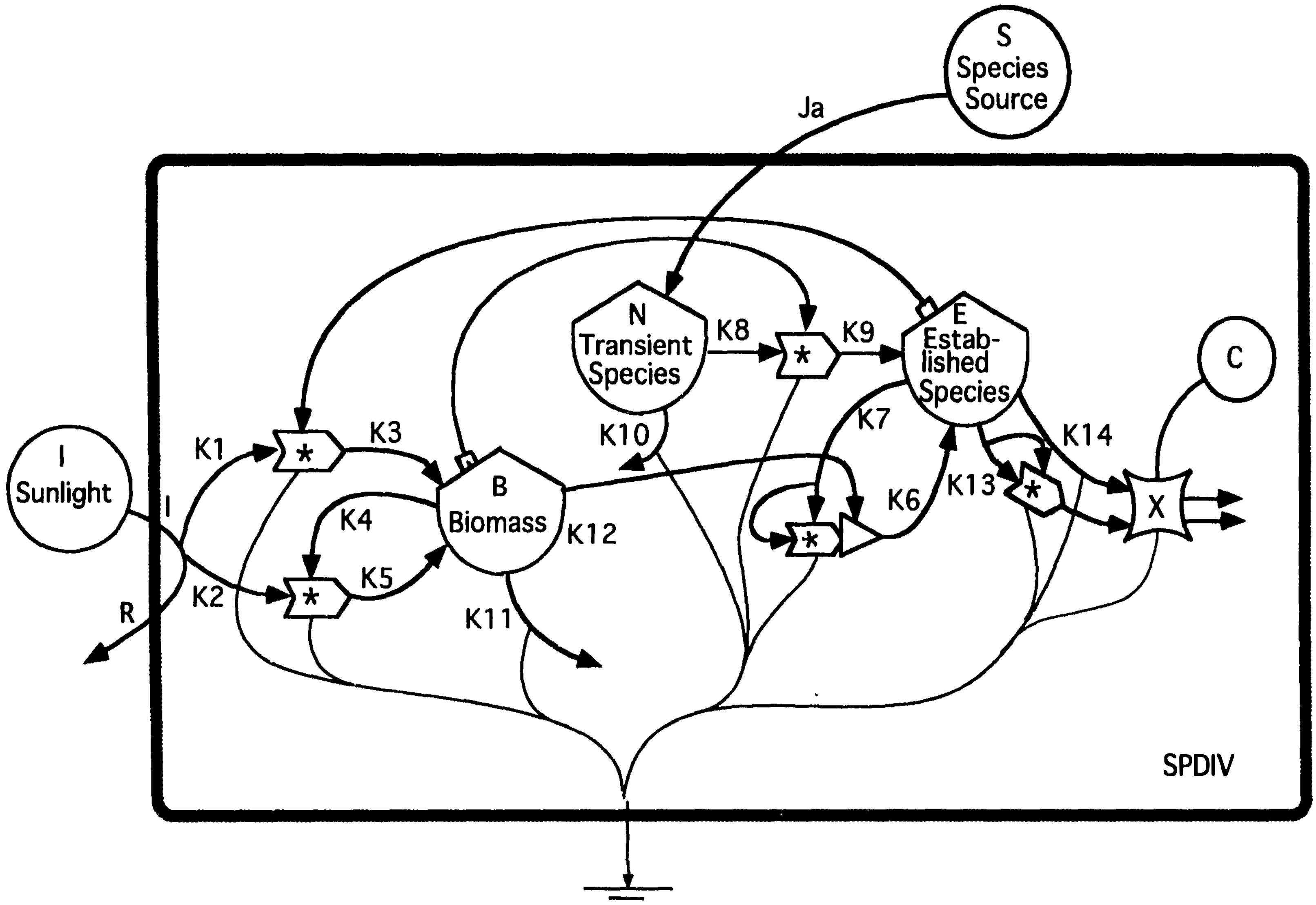
A model SPDIV was developed to represent the main factors supporting biodiversity in the rainforest study areas (Figure 3-25). The number of species at any time is the balance between species introduced and those becoming extinct. Species are in two categories, those just planted (N) but not yet interacting with the surrounding ecosystem and those which have become established (E). The latter species cause additional productivity in proportion to their number by drawing energy from the main plant biomass in proportion to the interactions of species ($E^2$).

The main pathways in the model are as follows: Sunlight and species are the two outside sources that pass from the outside to inside the boundary of the Biosphere structure. About half of the ambient sunlight (I) enters the rainforest, most of it used for the production process with a small re-radiated portion labeled R. The production process is shown with 2 pathways. The flow of sunlight labeled K1 interacts with the diversity of established species (an interaction of flow K1 and force from E), and the flow labeled K2 interacts with a flow which is fed back from biomass, K4, in the process of photosynthesis. The result of those interactions is the gross productivity of the system, pathways K3 and K5. The 2 gross productivity pathways flow into a common biomass tank, with the respiratory costs and consumer losses associated with maintaining the system shown as a drain from biomass labeled K11.

Major plantings of new species to the Biosphere 2 rainforest occurred twice, one with the initial planting of about 300 species during 1990-1991, and

Figure 3-25. Systems diagram for simulating diversity and production in Biosphere 2 rainforest showing storages, pathway coefficients and equations.

```
R = I/(1+K1*E+K2*B)
DB = K3*E*R+K5*B*R-K4*B*R-K11*B-K12*E*E*B
DE = K9*N*B-K6*E-K13*E*E*X-K14*E*X
DN = Ja-K10*N-K8*N*B
IF E>C THEN X = 1
IF E<C THEN X = 0
```


S
Species
Source
Ja
I
Sunlight
I
R
K1
K2
K3
K4
K5
B
Biomass
K11
K12
N
Transient
Species
K10
K8
K9
E
Estab-
lished
Species
K7
K6
K13
K14
C
X
SPDIV

another with about 92 species (50 of them were new to the system) after the first closure period, 1993-1994. The pathway of species introductions is labeled Ja. The value of Ja was 0 in the first two years after the initial planting. After planting, species were considered transient since they lacked connections and interactions which normally develop with surrounding organisms and environment as an ecosystem matures. In proportion to organic habitat (B) some of the planted species developed those connections and interactions and became established. The transfer of species is shown as pathway K8 which interacts with a force from biomass storage and enters the established species tank as flow K9. The number of species becoming established depends on the biomass (representing suitable habitat and soils). Some species became extinct, as shown with the pathway K10 draining the transient species storage.

When a transient species (N) becomes established (E), it has additional opportunities for extinction and maintenance. As part of the species assemblage, it consumes energy through competitive interactions with other species, through the work of strategies that prevent competition, or through other interactions with the environment. Some established species become extinct, shown as linear pathway K13 and quadratic K14 that represents effect of competition from the established species tank. The energy used to maintain the species information flows from biomass, K12, which interacts with established species. Given the time and opportunity for evolution, K6 is the pathway along which new species would be added (K6 > K7).

In microcosms that have been sealed for long periods without species being added, life appears to persist. Examples were not found where last species or several species went extinct. Apparently some species are capable of operating an ecosystem with low diversity. The model has a provision so that extinctions do not continue once the species number is less than the threshold C. This is diagrammed as a switch X. The switch is set to 1 when the number of established species is greater than C, and to zero when the number of established species is less than C, preventing further extinctions while still using energy from biomass storage for maintenance of extant species.

The calibration values shown in Figure 3-26 were made from estimations of biomass from measurements made in Biosphere 2, productivity rates measured for the El Verde rainforest (adjusted at one-third of that value for the system inside Biosphere 2), and extinction rates experienced in the Biosphere 2 rainforest after the first 5 years of operation. Details of the calculations are presented as notes to the EXCEL spreadsheet used to make the calculations, Table D-1.

A minimodel was written using QUICKBASIC, Table D-2, for simulation of the production and diversity model described above.

Results of Simulating the Production and Diversity Minimodel

A baseline simulation of the minimodel was run for both 10 and 100 years, starting with values close the 1991 values of Biosphere 2 (biomass = 1000 grams dry weight per square meter, transient species = 300, established species = 60 ). Figure 3-27 shows that within the first 5 years, the transient species have all either become extinct or become established species using energy from the system to support the additional information. As the total

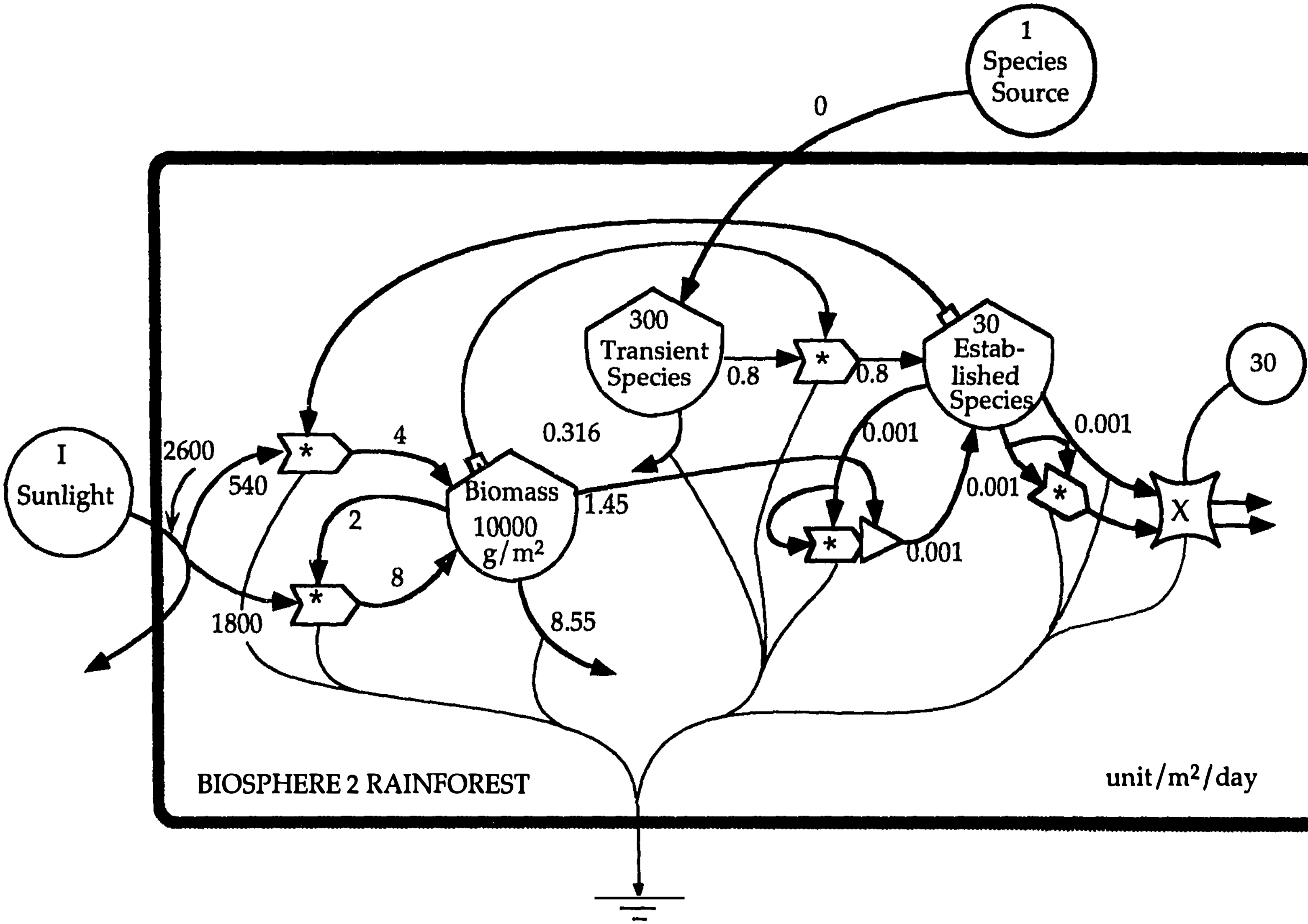



Figure 3-26. Systems diagram for simulating production and diversity in Biosphere 2 rainforest showing calibration values for storages and flows.

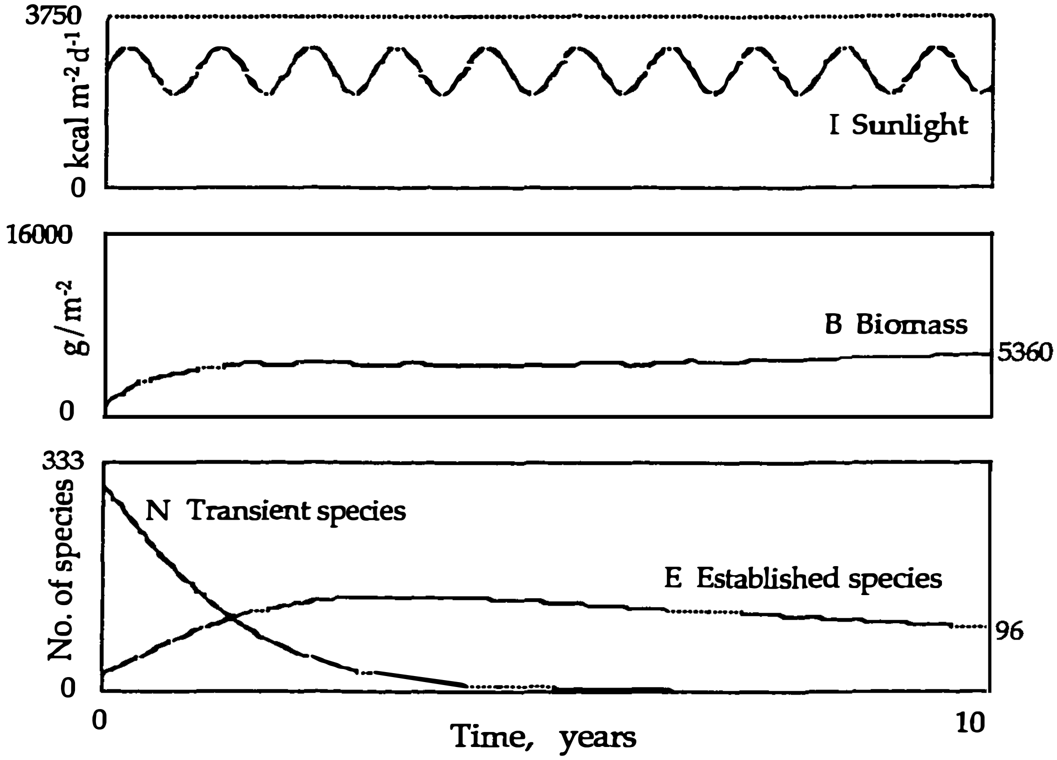



Figure 3-27. Baseline simulation of diversity and production minimodel, SPDIV, in Figure 3-25 for Biosphere 2 rainforest for 10 years. Final values for plant biomass and species are on the right side of their graphs. $g/m^2$ = grams of dry biomass per square meter.

number of species in the system (transient plus established) declines during the first year, the biomass increases. As the number of species in the system reaches a relatively stable level after about 3 years, the biomass also approaches a stable value. When the established species begin to decline around year 5 due to interactions with other species and factors other than the amount of energy available, biomass increases, using the energy once used for species support for biomass production. The 100 year simulation, Figure 3-28, shows the continual increase of biomass as diversity declines. When there are only 10 species remaining, the switch in the model prevents further decline and biomass also remains stable, dividing energy between information support and biomass production.

Continuous addition of species (5 or 20 per year)

The simulation results show the effects of continuous additions of species to the system over 10 and 100 years. The 10 year simulation shows 5 and 20 species per year added to the system (Ja=5/365 and Ja=20/365), resulting in higher diversity after 10 years of both transient and established species and lower biomass as the diversity increases. The 100 year simulation with additions of 20 species per year shows higher final diversity than the baseline – 25 transient species rather than none, 150 established species rather than 10; and lower biomass, 4290 $g/m^2$ rather than 26000.

One-time addition of many species

A simulation was run with the addition of 50 new species after the first 2 years of operating Biosphere 2. After 10 years, the effect is to increase the number of established species to 112 above the baseline value of 96, with accompanying decrease of biomass from 5364 in the baseline run to 4920 with

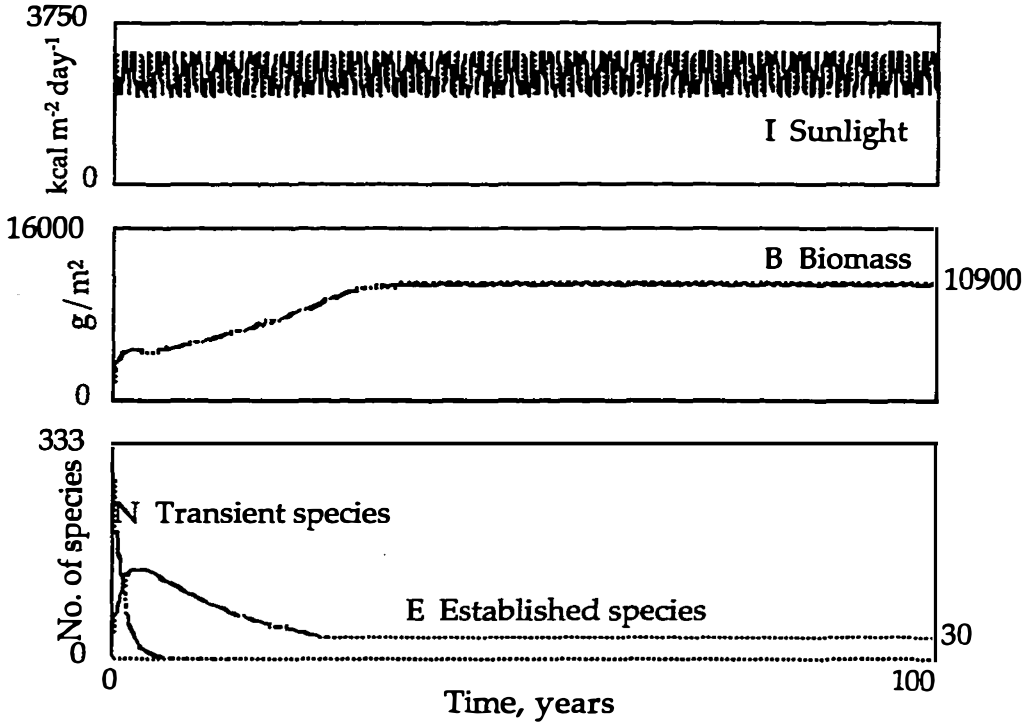



Figure 3-28. Baseline simulation of diversity and production minimodel SPDIV in Figure 3-25 for Biosphere 2 rainforest for 100 years. Final values for plant biomass and number of species are on the right side of their graphs. $g/m^2$ = grams of dry biomass per square meter.

species additions. Over 100 years, the addition of 50 species in the second year had no apparent effect on biomass or number of species in the system.

## Emergy Evaluation of Rainforest in Biosphere 2

The design and construction phase of Biosphere 2 lasted from 1985 until the first closure in September 1991. The costs accumulated during that phase were assembled so that the total could be annualized over the planned lifespan of the Biosphere. Figure 3-29 shows a summary diagram of inputs to the Biosphere 2 rainforest used in evaluating the emergy of system start-up. The start-up costs include costs of construction, intellectual capital invested in the design of structures and ecosystems, the stored emergy of soil and biotic collections made from both captive and wild sources, and the direct input of sun to plants and of wind for the evaporative cooling tower process used after the mechanical systems were in operation. Table 3-25 shows the values for each item, with notes explaining the origin of the values. The emergy value of design and construction, which included all goods and services of building and designing the structure, dwarfs that of the collection of ecosystem components during the start-up phase.

The emergy output of the Biosphere 2 system is information and tourism. Information is in the form of published scientific results, media coverage, web page usage, and the undergraduate program through Columbia University that has been in place since 1997. Tourism includes the visitation by a certain number of people yearly to see the Biosphere and learn about how the earth works.

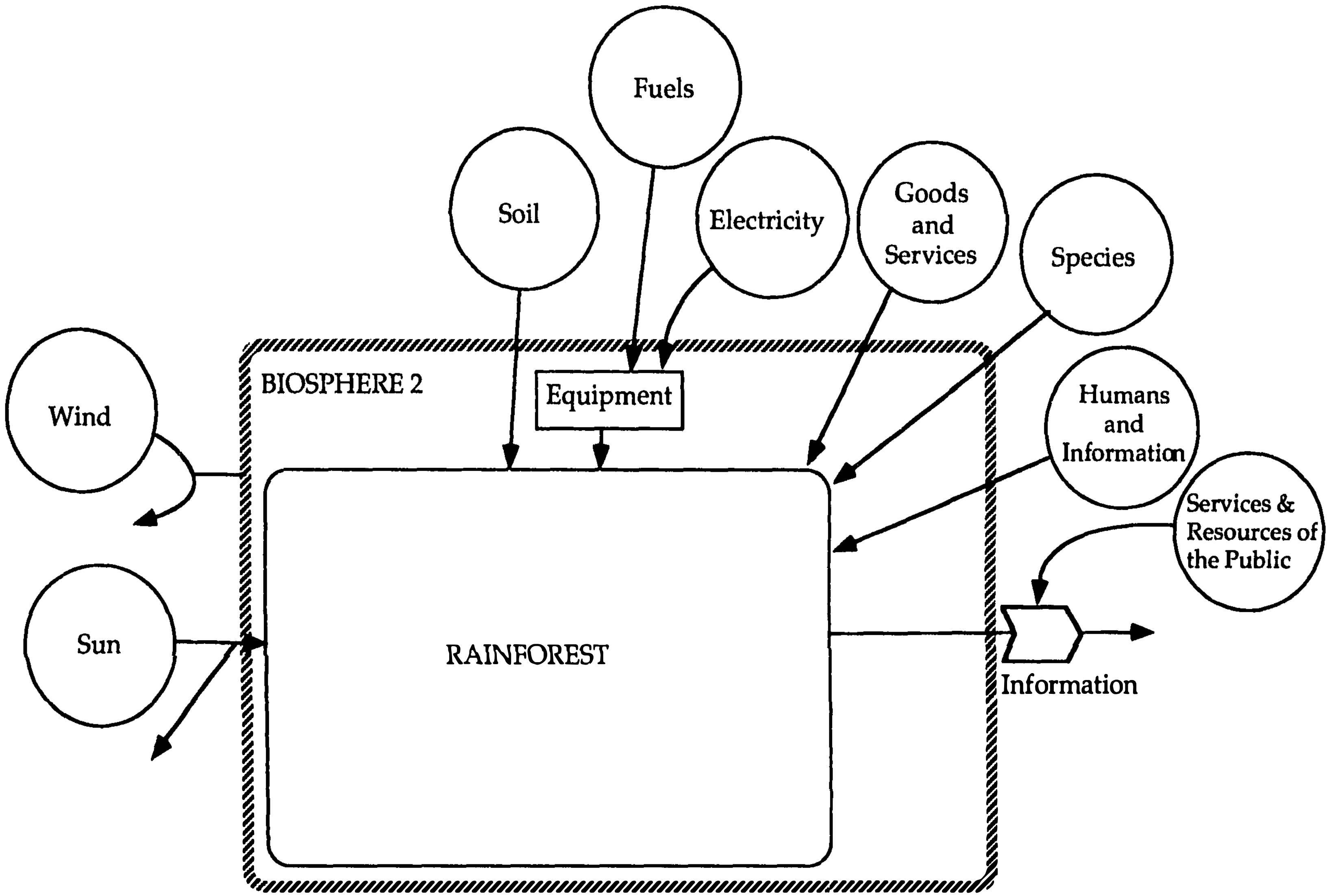



Figure 3-29. Emergy analysis summary diagram of Biosphere 2 rainforest.

Table 3-25. Accumulated emergy inputs to Biosphere 2 rainforest for start-up of the system prior to material closure in 1991.

| Note | Item | Data & Units | Solar Transformity | Solar EMergy E13 sej | EM$value |
|---|---|---|---|---|---|
| Environmental Sources | | | | | |
| 1 | Sun | 5.66 E12 J | 1 sej/J | 0.566 | 3.45 |
| 2 | Wind | 1.75 E14 J | 1.5 E3 sej/J | 26,300 | 160,365 |
| Ecosystem Components | | | | | |
| 3 | Plants at closure | 4.18 E10 J | 1.63 E7 sej/J | 68,134 | 415,451 |
| 4 | Plant collection | 6.0 E5 $ | 1.64 E12 sej/$ | 98,400 | 600,000 |
| 5 | Soil, mineral fraction | 4.78 E9 g | 1.0 E9 sej/g | 47,762 | 291,231 |
| 6 | Soil, organic fraction | 1.32 E12 J | 7.4 E4 sej/J | 9,768 | 59,561 |
| Design, construction and operations | | | | | |
| 7 | Design and construction | 22.5 E6 $ | 1.64 E12 sej/$ | 3,690,000 | 22,500,000 |
| 8 | Electricity | 5.4 E13J | 2.0 E5 | 1,080,000 | 6,585,366 |

Notes.

Rainforest is approx. 15% (1900 $m^2$/12,766 $m^2$) of the total surface area and 17% (34,690 $m^3$/204,000 $m^3$) of the total volume of Biosphere 2. Transformity values from Odum (1996).

Environmental Sources

1 Sun

Average outside insolation for Tucson is 5200 kcal/$m^2$/day (Romer 1985). Approximately 50% of the outside light enters the Biosphere and approximately 50% of the sun was intercepted by plant biomass. The rainforest biome is 1900 $m^2$. Planting began about 1.5 years before the 1991 closure.

(5200 kcal/$m^2$/day)(.5)(.5))(1900 $m^2$)(1.5 years)(365 days/yr)(4184 J/kcal) = **5.66 E12 J**

2 Wind

Wind contributed 3.37 E14 J/yr of kinetic energy for evaporative water cooling external to the Biosphere (SBV data cited in Engel 1994). Cooling began in Sept. 1989. Wind energy assumed to have been contributed in proportion to volume. Solar transformity for wind from Odum (1996).

(3.37 E14 J/yr)(2 yrs)(.26) = **1.75 E14 J**

Table 3-25--continued.

| Notes |
| --- |

Ecosystem Components

3 Rainforest plants

Biomass at closure was approximately 2500 kg dry weight (Bierner (1994) estimate for July, 1991).

(2500 kg*1000 g/kg)(4 kcal/gm)(4184 J/kcal) = **4.18 E10 J**

4 Plant collection

Emergy/money ratio for 1986-1991. The cost of collections, including labor, transportation, and permits, was approximately $600,000. Average $/sej ratio for the years 1987-1991 is 1.64 E12 sej/$ (Odum 1996).

($6.0 E5)(1.64 E12 sej/$) = **9.84 E17 sej**

5 Soil, organic fraction.

Transformity of topsoil organic matter = 7.4 E4 sej/J (Odum 1996). Average organic matter content of topsoil is 3% (Scott 1999). Total amount of topsoil in rainforest is 1766 cubic meters. Avg. bulk density of topsoil = 1.1 $g/cm^3$.

(.03)(1766 E6 $cm^3$)(1.1 $g/cm^3$)(5.4 kcal/g)(4184 J/kcal) = **1.32 E12 J**

6 Soil, mineral fraction

Solar transformity for world sedimentary cycle is 1.0 E9 sej/g (Odum 1996). Bulk density for subsoil is 1.43 $g/cm^3$ and for topsoil = 1.1 $g/cm^3$ (Scott 1999). Volume of subsoil is 3340 cubic meters and for topsoil is 1766 cubic meters (Scarborough 1994). Mineral fraction of topsoil is 97%.

(3340 E6 $cm^3$)(1.43 $g/cm^3$) + (0.97)(1.1 $g/cm^3$)(1766 E6 $cm^3$) = **4.78 E9 g**

Design, construction and operations

8 Overall design, construction and operation prior to 1991 closure

Total cost for Biosphere 2 of design, construction and operation prior to 1991 closure was $150,000,000 (SBV, personal communication). The rainforest surface area is approx. 15% of the total Biosphere 2 area. Average $/sej ratio for the years 1987-1991 is 1.64 E12 sej/$ (Odum 1996).

($150 E6)(.15)(1.64 E12 sej/$) = **3.69 E19 sej**

10 Electricity

Electrical consumption for Biosphere 2 is approximately 5 E6 kWh/yr. The energy center was supporting the Biosphere for 3 years prior to closure in 1991.

(5 E6 kWh/yr)(3.6E6 J/kWh)(3 yrs) = **5.4 E13 J**

A comparison of emergy in the developing rainforest in Biosphere 2, including only start-up costs incurred before September 1991, and a 25 year old natural tabonuco forest are shown in Table 3-26.

Table 3-26. Comparison of emergy in developing rainforest in Biosphere 2 in 1991 and 25 year old natural tabonuco forest.

| Note | Location | Emergy/ha | Em$[a]/ha | $ cost/ha |
|---|---|---|---|---|
| 1 | Biosphere 2 | 2.64 E20 | 230,000,000 | (147,400,000) |
| 2 | Tabonuco forest | 1.15 E17 | 100,152 | 4050 |

[a]Emergy/(1.15 E12 1995 sej/$)

Notes

1 See Table 3-27.
2 Odum et al. (1999).

# CHAPTER 4
# DISCUSSION

Understanding the unusual process of ecological succession with declining species in Biosphere 2 was studied considering the species becoming established, species-individual relationships, models of mechanisms, and comparisons with early succession in the rainforest at El Verde, Puerto Rico.

## Succession with Declining Diversity

The self-organization of a rainforest ecosystem in Biosphere 2 was the combination of human efforts to plant a rainforest and patterns of self-organization by the developing ecosystem. The process resembled previous efforts to establish small aquatic ecosystems in microcosms by seeding with many more species than could be supported, letting the system develop a compatible set by processes of reinforcement, selection, and extinction.

Multiple seeding of more species than could be supported provided a way to find the carrying capacity for diversity and its limits. The biota of the Biosphere 2 rainforest was assembled at the start in functional groups. In the case of the plants, species were chosen for the following attributes: early shade producers, food web species support, potential foods or medicines, evolutionary interest, shade-tolerant canopy trees, and others. In the case of animals, functional groups included the following: food web complexity, detritivores, pollinators, and prey items. Opportunities for a unique ecosystem existed as a result of the assembly of plants and animals from different regions of the world, and the packing of species into an area that in nature would not normally support such high diversity. In the Biosphere 2 rainforest, the rate of species decline was expected to decrease as food webs became organized and vertical forest structure matured. For example, species that could not survive the open canopy of the first year of plant succession may have survived during later succession, when a more continuous canopy and more consistent humidity were established. The vascular epiphytes were an example.

Effect of First Arrivals

First arrivals, or colonizing species, in natural system may have either positive, negative, or neutral net effect on later species colonization (Connell et al. 1987). Walker et al. (1996) noted that first arrival on landslides may slow the rate of plant succession, largely due to effects of shading. This was noted especially for a landslide-colonizing fern that formed dense thickets in high-light areas.

Comparison of survival data over the two planting dates in the Biosphere 2 rainforest suggests that individuals planted earlier (1990-1991) had a survival advantage over those planted later (1993-1994). Between 1993 and 1996, 75% of the individuals from the second group (total=339) died, whereas only 39% of the first group individuals (total=872) died; and about 60% of the species from the second group (total=92) and 30% of the species from the first group (total=192) went extinct over the same period. An exception was epiphytes, where the second group had the higher survival rate. Mueller-Dombois and Ellenberg (1974) have noted that vascular epiphytes are usually the last plant growth form to establish in a tropical rainforest, presumably due to their need for structure providing moist microsites (Kohyama 1997).

Limited Access to Genes

Most systems do lose species, but they are constantly replaced by other species. Though the number of species may appear constant, the composition of species may change.

With succession in a closed system, the species will not be replaced by species from outside the present system. Unless there are species with unusual plasticity of genetic change, the organization of the species that are in place will not be improved by addition of genetic information above the microorganism scale. Selection by competition will eliminate species but there will be no new species unless planned and implemented by managers. Without seeding, plant diversity in the Biosphere 2 rainforest can either decrease or stay the same.

Figure 3-5 showed the decline in species. The 3 survey results over a 5 year period showed plant species decreasing through time as a log function of cumulative individual plant loss. A straight line in a semi-log graph means that the rate of loss was proportional to the number remaining, a linear rate of extinction. This suggests that the species losses at first did not involve many interactions or organization.

Declining Diversity and a Species Plateau

As expected and as shown in Figures 3- 5 and Tables A-1 and A-2, the diversity in the Biosphere 2 rainforest declined from the initial condition in which an excess of plant species was introduced. Many of the species were not adapted to the unique conditions of soil (amended desert grassland soil), atmosphere (elevated $CO_2$ and lowered $O_2$) , and rainwater composition (varying salinity and nutrients). Also, after time, the Biosphere supported few animals to aid pollination and seeding. Although no example of an isolated terrestrial mesocosm was found to suggest the species diversity that could prevail, studies of sealed aquatic microcosms showed that a few species were supported for years in small volumes (Folsome and Hanson 1986). Some models of species would predict no species surviving without some introductions, but the microcosm studies suggest that there are species adapted to survive indefinitely in low diversity situations. Figure 3-5 shows the rate of extinction is slowing down. The central question is when would the species decline stop and how many species would be sustained.

Imagine if, as in recent management of the Biosphere 2 rainforest, no species were added. Where would extinction stop? Hubbell (1979) described single species dominance when there is no addition of species. Experience with sealed microcosms over long periods of time does not reveal cases where life disappeared.

After initial organization to maximize energy intake from its limited gene pool, the Biosphere 2 system can go no further in addition of plant species without additional seeding. Evolution among the vascular plants may not occur at all over the 100-year life of the Biosphere. However, evolution could take place in microorganisms, affecting the organization and feedbacks of the overall ecosystem. For example, two previously undescribed species were described from the Biosphere, an amoeba in the ocean and a nematode in the agriculture area. It is possible that these species existed elsewhere before their discovery in Biosphere 2, but were able to achieve noticeable densities inside the Biosphere in the unusual conditions there that had not been seen before.

For the plants, however, further self-organization required building forest structure with fewer species and limited reproduction. Growth in the Biosphere 2 rainforest may build similar age structure to El Verde, thus the number of individuals within similar areas may be similar. Trees in the Biosphere 2 rainforest will continue to close the canopy, shading the plants beneath. The decline in species may be the result of both senescence and failure to reproduce.

Figure 4-1 compares the patterns for species and individuals at the start in 1991 with the condition in 1998 (Figures 3-3 and 3-4). By 1998 the number of individuals from the original plantings of 1890 and 339 species had decreased, but new individuals had developed mostly from vegetative propagation rather than seeds. Defining an individual as a new stem or stem cluster, there were about 90 species per 1000 individuals based on the 1998 counts. As Figure 4-1 shows, the self-organizational process had a typical species-individual curve made up of original plants and the asexually developed plants.

An analysis follows of the species remaining to estimate the possible long term species diversity that could be sustained under the 1998 conditions where the animals needed for normal propagation were absent.

## Extrapolation of Species Composition According to Reproduction

An examination of species growing in the rainforest in 1998 showed some species reproducing, some not reproducing, and many spreading clonally. Based on the survey in Table B-2, the list of plant species was

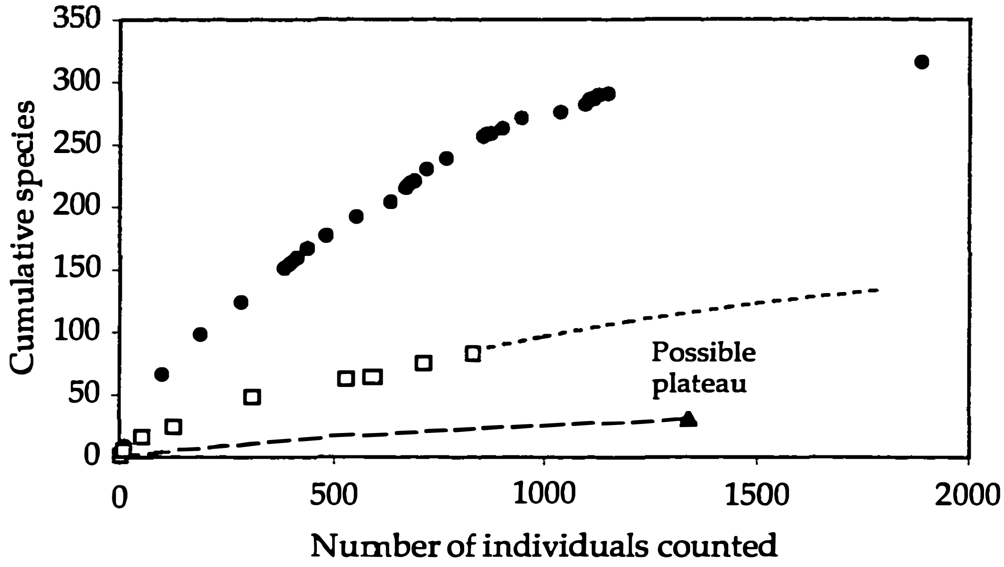



Figure 4-1. Extrapolation of number of plants in El Verde rainforest to a possible diversity plateau (solid triangle) for the Biosphere 2 rainforest. Measured data from Biosphere 2 are shown with solid circles (1991) and open squares (1998).

modified to predict species that might be part of the eventual composition if there is little further seeding from outside and all the non-reproducers and short-lived species have lived and died.

Some of the species expected to live for 100 years are the trees that form the canopy layer. Those that do not senesce earlier will be part of the later flora. *Cecropia,* for example, is part of the current canopy but will eventually either be overshaded by other species or, since it is a short-lived species, it will die. Additionally, several *Cecropia* treefalls have occurred during the first 3 years of forest development, but the fallen trees sprouted. If sprouting occurs, *Cecropia* will persist as part of the flora. Other species, such as *Heliconia* and *Strelitzia,* may flower yet not set seed, propagating by extending underground organs which sprout culms a distance from the original plant. The extrapolated composition, Table 4-1, shows a potential species pool of 30 species for the 0.19 ha area. See the species-individual curve (Figure 4-1) for an extrapolation of the number of individual plants.

## Simulation of Species Decline

A simulation of the diversity decline was made with the model in Figure 3-25 with a one-time addition of 50 species after 2 years of development. The model was run for 10 years (Figure D-3). After 10 years, diversity was increased over the baseline simulation with no additions. The addition had no effect on diversity at 100 years. A simulation with yearly additions of 20 species, Figure C-2, resulted in 175 species at 100 years compared to the minimum species number of 30 established when no additions were made. Extrapolations made from the actual measurements

Table 4-1. Extrapolation of species composition of Biosphere 2 rainforest to 100 years with 30 species. H=Herb, T=Tree, P=Palm, G=Giant herb, A=Bamboo, C=Climber, S=Shrub.

| Family | Species | Growth form | Reproductive mode in Biosphere 2 |
|---|---|---|---|
| Amaryllidaceae | *Eucharis grandiflora* | H | Clonal |
| raceae | *Colocasia sp.* | H | Clonal |
| | *Dieffenbachia sp.* | H | Clonal |
| | *Monstera deliciosa* | C | Clonal |
| | *Scindapsus aureus* | C | Clonal |
| | *Zamioculcas zamiifolia* | H | Seed |
| Bignoniaceae | *Spathodea campanulata* | T | Long-lived |
| Bombacaceae | *Ceiba pentandra* | T | Will survive if long-lived |
| | *Pachira aquatica* | T | Seed, needs high light to reproduce |
| Cecropiaceae | *Cecropia schreberiana* | T | Sprouting |
| Cyclanthaceae | *Carludovica palmata* | G | Seed |
| Euphorbiaceae | *Hura crepitans* | T | Long-lived |
| Heliconiaceae | *Heliconia sp.* | G | Clonal |
| Malvaceae | *Hibiscus rosa-sinensis* | S | Clonal |
| Moraceae | *Ficus pumila* | C | Long-lived |
| Musaceae | *Musa textilis* | G | Clonal |
| | *Musa paradisiaca* | G | Clonal |
| Phytolaccaceae | *Phytolacca dioica* | T | Long-lived |
| Poaceae | *Bambusa multiplex* | A | Clonal |
| | *Bambusa tuldoides* | A | Clonal |
| Rubiaceae | *Coffea arabica* | S | Seed |
| Solanaceae | *Brugmansia suaveolens* | S | Clonal, sprouts |
| Strelitziaceae | *Phenakospermum guyanense* | G | Clonal |
| | *Strelitzia reginae* | G | Clonal |

Table 4-1—continued.

| Family | Species | Growth form | Reproductive mode in Biosphere 2 |
|---|---|---|---|
| Vitaceae | *Cissus sicyoides* | C | Clonal |
| Zamiaceae | *Zamia furfuracea* | S | Long-lived |
| Zingiberaceae | *Alpinia purpurata* | G | Clonal |
| | *Costus sp.* | H | Clonal |
| | *Hedychium coronarium* | G | Clonal |
| | *Zingiber spectabile* | G | Clonal |

also showed that the addition of 50 species after 2 years will have little effect on the diversity of the rainforest at 100 years.

The turn-over times of species within geographic areas varies with internal and external processes. The extinction rate declined over time (Figure 3-5), from about 60 species per year from 1991-1993 to about 30 species per year from 1993-1996. A total of 366 species were added during that period, averaging 73 per year. Species seeding on a continuous basis may be required to maintain the diversity of the system above the approximately 30 species that are expected to survive. Most of the additions may be considered the "transient species" in the model (Figure 3-25).

## Mechanisms Affecting Diversity in Biosphere 2

In the introduction many mechanisms affecting diversity were cited from published literature. The following seemed to be operating in Biosphere 2.

### Excess Resources and Diversity

When nutrients and/or light are in excess, diversity is often reduced by competitive overgrowth by a few species. This concept was applied to the ecosystem in Silver Springs by Yount (1956). For example, Kent (1996) found species diversity lower in fertilized pond plots in Puerto Rico over his clear water controls, and vegetation came in more quickly to the fertilized plots. Odum and Odum (in press) used a model NUTRSPEC, and Odum (1999) used a more complex version PIONINFO to show the mechanisms.

In 1991-1995 in Biosphere 2 one of the most obvious resource excesses was $CO_2$. Growth of 'weedy' species, and in particular vines was observed, helping sequester carbon dioxide rapidly. These species were aided by the large amount of structure for climbing provided by the stainless steel spaceframe. The result was a dense weedy canopy above the upper tree canopy of the rainforest. This diversity-reducing factor was at least partly counteracted by the frequent pruning of the weeds by the author and others.

Effect of Trimming Weedy Growth

A major effort was made to trim out rapidly growing vines and other successional weeds in Biosphere 2 during the first two years after seeding and thereafter. During the first two years, most of the pruned biomass was removed from the rainforest and stored and air dried in the underground stainless steel and concrete passageways. A fraction of the fresh biomass was fed to the domestic livestock. Thus, human effort was directed to truncate early successional processes and to accelerate the development of the climax state. Pruning was analagous to a large herbivore or a large pulse of herbivorous insects. The total number of person hours pruning was about 22 hours per month during the first 2-year closure.

Alternatively, a different climax state may have developed had early successional processes not been arrested. Removal of the early successional biomass may have altered the relative frequencies of species in the rainforest. Those species that were adapted to conditions of higher light may have been favored over shade-adapted species. The result may have been loss of species that were adapted to shading. An extreme possibility is that over a longer period, when the light-adapted species formed a continuous canopy, no species would remain to grow in the shaded conditions.

Additionally, removal of biomass that may have contributed to the litter accumulation could have an effect on nutrient cycles, nutrient availability and productivity of the rainforest as has been suggested for the rainforest of Puerto Rico (Lodge et al. 1991).

An effect of removing the two most abundant species from the data and replotting the graph, Figures 3-12, is a higher species diversity number of individuals counted. The species diversity graphs during this were steeper than they might have been without the pruning, partly reversing the effect of high nutrient overgrowths.

The production and biomass model in Figure 3-19 was run with and without pruning (Figure 3-23) to see whether possible effects of pruning were indicated. The simulation results of the minimodel suggest that without pruning, diversity would have been reduced through loss of mature species. Over 100 years, no mature species remained and the simulated system was composed of only weedy species.

Pulsing Disruption

Many ecologists offer the theory that disruption increases diversity by preventing competitive exclusion overgrowths between species. Where disruptions create open patches of successional vegetation in formerly closed canopy forest, diversity is augmented by the successional colonizers. Hurricanes and landslides at El Verde create patches in various seasons. Disturbances in Biosphere 2 include those by pruning, trampling by visitors, and the shift to lower CO2 regime with throughflow of air in 1995. Some shocks obviously reduce diversity such as transplant shock and excessive heat on the tops of trees in summer.

A more recent management strategy (starting in 1997) for the Biosphere 2 rainforest has been to trim trees that are touching the glass boundary and to deposit all of the biomass on the forest floor. Pruning is scheduled cyclically, and creates a pulse of organic matter added to certain areas. An interesting question would be what effect the pulsed pruning and pulsed biomass deposition has on forest productivity, and to what extent this would vary from normal leaf and branch fall and litter accumulation.

## Consumers

Several hundred insect species were either intentionally introduced, accidentally introduced, or became established in Biosphere 2 before the structure was completed. By 1997, the most conspicuous insects in Biosphere 2 were ants, homopterans, katydids, and cockroaches (Wetterer et al. in press) The ecologically dominant species is the ant *Paratrechina longicornis,* a species which has spread from the Old World throughout disturbed areas in the tropics and subtropics. It is the same tramp ant species that has taken over nests normally occupied by native species in the Dry Tortugas in the Florida Keys (Wetterer et al. in press).

The lack of herbivorous insects is shown by the low percentage of leaf holes in Biosphere 2 compared to the tabonuco forest (Table 3-21). Canopy arthropods may have a significant effect on primary productivity, nutrient cycling and hydrology.

## Graphical Representation of Cumulative Species-Individual Counts

To help understand patterns of diversity, species-individual counts were represented on several coordinates with linear scales, with semi-logarithmic plot, and double logarithmic plot. See the example of the study sites in Figures 3-18a-c. Consider the kind of graphs that some hypotheses might predict.

First, suppose there were many species available for seeding in a large area so that each individual added was a different species. In that case the species added would increase in a straight line on the linear plot, but curve sharply up on the semi-log plot.

Next, suppose there was a great excess of individuals of one or two species, a situation sometimes occurring where nutrients are in excess and there is competitive exclusion or the seeding from a low diversity source. In that case the graph will be shifted to the right, and will increase very slowly.

Third, suppose that there are interactions among species so that the species are being organized in systems relationships with resource use of the organization increasing as the square of the number of kinds. In that case the number of individuals required to support each additional species increases as the square of the species. Lines are added to the graphs to show the situation where S is proportional to $N^2$ or conversely that N is proportional to the square root of species S. Hierarchical relationships are suggested when there are many of a few species and few of many species.

Fourth, loss of pollinators in a system would show a loss of certain species that can no longer reproduce. The number of individuals of species that do not require pollinators or of clonal species would increase, reducing the number of species while not necessarily reducing the number of individuals where an individual was defined as a separate stem.

Another characteristic curve-shape reflects extremes of available energy such as in both shallow tropical seas (high energy inputs from currents, sunlight, etc.) and deep ocean bottoms (low energy inputs), both with many species and individuals per 1000 count, but in the former they are concentrated in less area compared to the latter, where there is a larger distance between individuals.

The shapes of curves of cumulative species versus cumulative individuals observed in Biosphere 2 and in the colonization in the rainforest were compared with the theoretical patterns. Initial patterns of seeding in Biosphere 2 and in natural seeding of landslide openings within the complex forest turned up on semi-log plot suggesting less organizational interactions. Slopes of species curves from the natural forest were not so steep or declining with increased individuals--suggesting more hierarchy or organization.

If when species are first added, there is one new species for each individual, the line is straight on the linear plot and sharply curving upward on semi-log. As more individuals are seeded, duplications occur either on purpose as in Biosphere 2 or out of probabilities of seeding access as in the landslides. The curve bends to the right on linear plot and develops as a straight zoned beyond the first few individuals on a semi-log plot.

The effect of many individuals of a few species was demonstrated by removing two abundant species and replotting (Figure 3-12). The effect is to shift the curve to the left. Adding an excess of species that dilute the others shifts the straight zone of the graph to the right. In the Radiation Center 23 years after radiation (before hurricanes) there was a predominance of a few species with many seedlings making the linear curve flat and the semilog irregular.

The graphs for Biosphere 2 were compared with the El Verde and Bisley graphs used as a reference of normal organization of diversity. In the semi-log graph, the Biosphere 2 curve turns up at the end whereas the natural forest line is straighter. This curvature can be interpreted as an indicator that the species are less organized. See Table 4-2 for comparison of the slopes on the double log plot.

Effect of Spatial Characteristics of Plants in Biosphere 2

With the exception of *Leucaena spp.* trees, the plants at the time of placement in the Biosphere 2 rainforest were between approximately 0.5 meters and 3 meters tall. A comparison of the horizontal distribution of plants in their initial configuration suggests a regular distribution of plants (Figure 3-10). This departure from successional pathways that are found in nature -- beginning with a seed pool rather than uneven size classes of plants and regular rather than clumped distributions -- could have an effect on survival of species as related to shading. In particular, species that were not shade-tolerant may have been planted in the shade of other species, without an opportunity to overgrow other species. Resulting composition of the rainforest may have been shaped by such differences.

Comparisons with El Verde

With the passage of time, the rainforest in Biosphere 2 developed properties similar to those at El Verde. There were similarities between early self-organization and the successional stages at El Verde.

## Comparisons Between Rainforest Structure in Biosphere 2 and El Verde

A visual survey of the Biosphere 2 and El Verde rainforests showed differences and similarities. In the tabonuco forest, a deep organic mat of fine roots forms above the heavy clay soil. In Biosphere 2 the roots were deeper in the ground with no mat at the surface. Previous authors accounted the mat of small roots at El Verde as an adaptation to low transpiration rates and low soil nutrients (Odum 1970). Saturation deficit aiding transpiration was 6 to 9 millibars in Biosphere 2 compared to 1.8 to 6 mb at El Verde. Nutrients were higher in Biosphere 2, especially phosphorus. Root adaptations were consistent with the theory. Wind velocity was lower in the Biosphere 2 rainforest breeze. Another striking difference was the greater density of certain growth forms, and in particular of epiphytes, both vascular and non-vascular, in the tabonuco forest (Figure 3-14). Most of the vascular epiphytes had perished from the Biosphere 2 rainforest by Sept., 1993. There were no mosses, liverworts, and filamentous algae species covering leaves, trunks and rocks.

## Soil Structure

The soils in the Biosphere 2 rainforest had a coarser texture than the clays and organics at El Verde. Scott (1999) found some differentiation of soil profiles in his 1993 measurements. Earthworms were processing clays and organic matter. However the pH was still above 7 below the litter, compared to the normally acid conditions in El Verde. Whereas soil was generating carbon dioxide from high levels of organic matter, some was being absorbed by the basic substances.

In a study by Gonzalez et al. (1999), the tabonuco forest was compared with wet areas dominated by palms and *Heliconia*. Litterfall in the two areas studied was similar. The tabonuco had lower pH, with a mean value of 4.8 (4.5 – 6.5), and twice as many earthworms. The palm area had more soil water and higher pH (5.1-5.9). The earthworm *Pontoscolex corethrurus* was dominant in both, with 20 to 160 grams/$m^2$ and 30 to 400 individuals/$m^2$.

Absence of Most Animals and Simplification of Food Web

Most of the animals of typical rainforests either died or were never seeded in Biosphere 2. The hundreds of insect species at El Verde were absent from Biosphere 2, yet decomposition was slightly faster in Biosphere 2 (Nelson 1999). Litter fall developed values like those at El Verde and organic differentiation of the soil was accelerated (Scott 1999). Earthworm populations were present and the numerous tiny ants, *Paratrechina longicornis* (Latreille), became the dominant ant species.

The effect of the lack of animals in the Biosphere 2 rainforest can be related to the possible effects of the loss of animal diversity in increasingly fragmented ecosystems.

Plant Reproduction

Minimal plant reproduction by seed has occurred in the Biosphere 2 rainforest since the 1991 closure. Since most potential pollinators perished during the first 2-year closure, a lack of pollen dispersal vectors along with low light and other environmental factors would prevent both pollination of flowers or flowering of plants. Most of the species that reproduce sexually were located in sunnier locations, such as the ginger belt. Species that fruited at first stopped producing after they were shaded later. The most conspicuous characteristic of the forest floor in Biosphere 2 was the many stems of plants emerging from asexual growth from runners of several species.

In contrast, most of the species in the El Verde rainforest reproduce by seed. In disturbed areas, clonal taxa such as *Heliconia* may be part of the early successional flora, but they are not a dominant species of the forest. The energy involved in normal reproduction (formation of fruits) in the El Verde forest was 0.075 kcal $m^{-2}$ $d^{-1}$ (Odum 1970). By favoring vegetative reproduction in Biosphere 2, this energy was saved for growth, but genetic diversity was lost increasing risk of epidemic mortalities later. The species that flowered without setting seed, either due to lack of pollinators or light quantity or quality, were using energy for reproduction that will not be manifest, taking the energy from growth.

Species and Individuals

At El Verde, in mature forest there were 7063 plants per hectare (average of pre-radiation center, south control center (Rushing 1970), and counts by R. F. Smith (1970)). For the equivalent area of Biosphere 2 (0.19 ha) there were 1342 plants.

The species-individual count in the successional development of bare areas of landslides after 11 years (Figure 3-16) was 60 species per 1000 individuals compared to about 80 species in Biosphere 2 in 1998 after 8 years. Extrapolating the extinction rate, diversity in Biosphere 2 will be similar to that in succession at El Verde in 1999. At El Verde, diversity may plateau at a lower level, while developing more vegetative structure among those species

Table 4-2. Comparison of diversity indices: species/1000 individuals and slope of log-log graphs (K).

| Site name | Species/ 1000 | K |
|---|---|---|
| Biosphere 2 | | |
| 1991 | 273 | 0.621 |
| 1998-subset | 115 | 0.486 |
| 1998-all | 96 | 0.413 |
| Bisley grid | 63 | 0.364 |
| Landslide | 60 | 0.339 |
| Radiation Center | 41 | 0.276 |

K=slope of the graph of log of number of species as a function of log of number of individuals.

that prevail. Figure 4-1 shows a possible future with 1342 plants and 30 species.

Table 4-2 compares Biosphere 2 with tabonuco forests and introduces another diversity index, where the slope of the log-log curve of species/1000 individuals is measured. The index may indicate the amount of organization that exists in the ecosystems measured. Margalef (1997) used this double logarithmic index to contrast low diversity plankton blooms with mature high diversity populations.

## General Implications

### Comparison of Biosphere 2 with Role and Trends of Global Diversity

Biosphere 2 is useful to help understand the global biosphere. Earth is also a closed system whereby seeding of species does not occur from outside the system. On a much larger scale, much like the Biosphere, the process of diversity on earth includes only extinction and evolution. Because evolution occurs over a relatively long time scale, it probably will not occur in Biosphere 2 for macroorganisms, but could feasibly occur for microorganisms. There is controversy now in determining if diversity on earth is downsizing as in Biosphere 2. Species extinction may be occurring faster than species evolution. Adding 1 species per hectare per year in rainforest systems at El Verde, Puerto Rico (Scatena, personal communication) may be enough to replace species and maintain the current diversity. The diversity minimodels can indicate the number needed if the extinction rate is known.

## Declining Diversity and Downsizing

The decrease of diversity in Biosphere 2 may have parallels with a civilization which is downsizing. Many specialized jobs (analogues to species) only have few or no species who can do them, as a more generalist way of making a living prevails. In a civilization which is downsizing - the many specialized jobs now only have one person who can do them, as others have had to find another more generalist way of making a living. The ethnic diversity in colonizing systems and the costs of organization may be like a forest.

## Comparing Succession of Diversity in Biosphere 2 with Global Cultural Change

On a different scale there may be analogy between diversity in ecosystems and in human cultural change. Diversity includes the number of species and patterns of their distribution. Higher levels of organization might be expected to increase ethnic diversity of occupations, cultures and social differences.

The Balkan war of 1999 started with separation of cultures with destructive competition (ethnic cleansing). At first this was a loss of diversity. The patterns that developed through interactions with the larger, developed system appeared to be diminishing competition and increasing diversity in 1999.

Carrying Capacity of Systems for Diversity

There is growing evidence that there is a carrying capacity for diversity for a given system at a given time. For instance, Ashton (1977) states: "We now have growing evidence . . . that there is a maximum number of species that a forest can accommodate, that this varies with site conditions and that it has already been approached in west Malesian forests." Diversity indices on an area basis measure the carrying capacity.

Carrying capacity is the diversity that is eventually stabilized in Biosphere 2. According to some models such as the one in Figure 3-28, the diversity achieved coming down should be similar to that achieved by gradually adding species – typical of natural succession, such as the landslide at El Verde. Even now the diversities are similar.

APPENDIX A

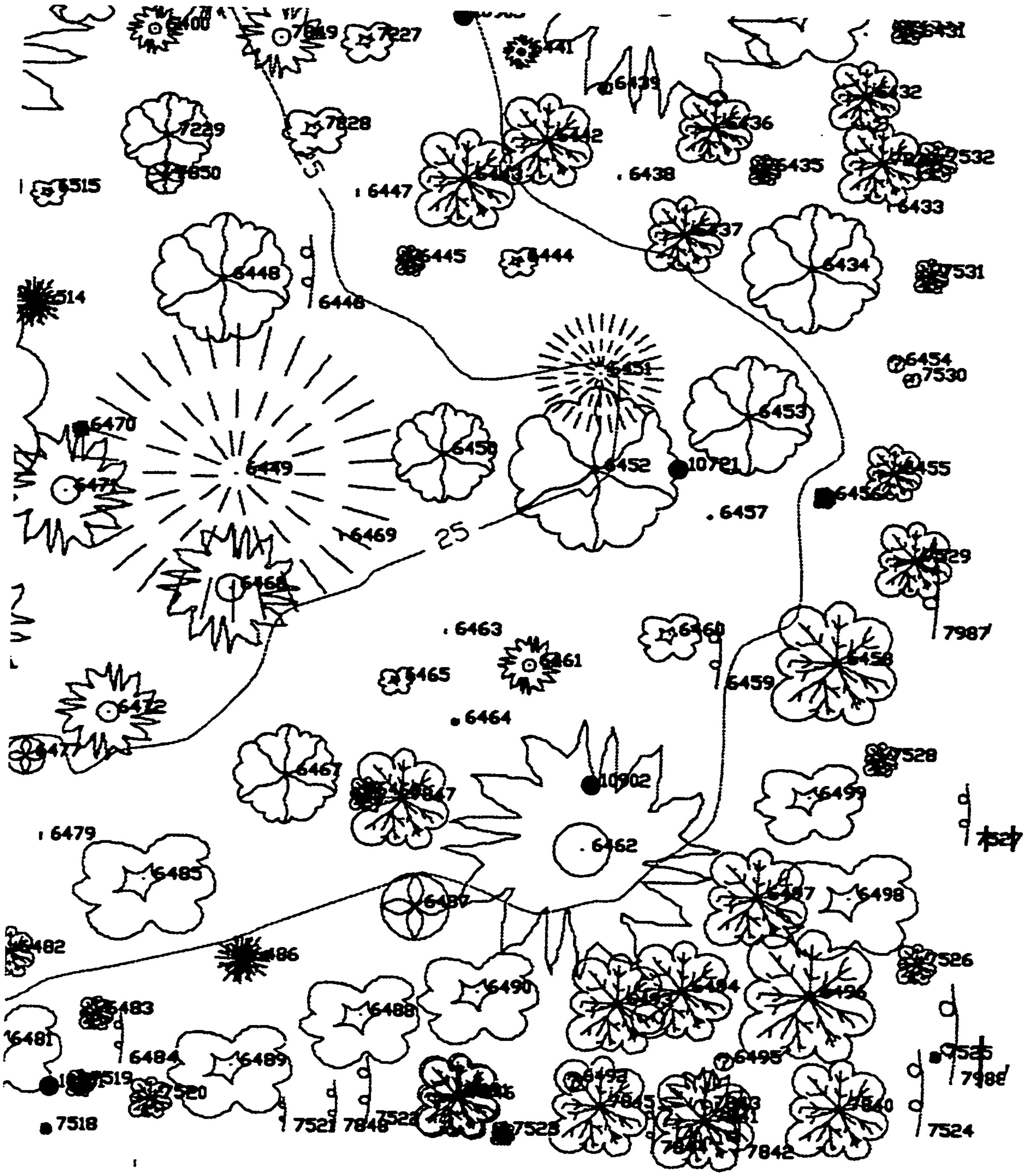
BIOSPHERE 2 RAINFOREST MAPS

Figure A-1. Map cells showing the location of individual plants in the Biosphere 2 rainforest. See Table A-1 for corresponding list of species and survey of individuals. a) Key to the location of individual map cells within the rainforest; b) Cell 1; c) Cell 2; d) Cell 3; e) Cell 4; f) Cell 5; g) Cell 6; h) Cell 7; i) Cell 8; j) Cell 9; k) Cell 10; l) Cell 11; m) Cell 12; n) Cell 13; o) Cell 14; p) Cell 15; q) Cell 16; r) Cell 17; s) Cell 18; t) Cell 19; u) Cell 20. Surveying and original graphics by Teague and Co., Tucson, AZ. Approximate scale: 1 cm = 0.6 m.

| | | | | |
|---|---|---|---|---|
| Cell 20 | Cell 19 | Cell 18 | Cell 17 | Cell 16 |
| Cell 15 | Cell 14 | Cell 13 | Cell 12 | Cell 11 |
| Cell 10 | Cell 9 | Cell 8 | Cell 7 | Cell 6 |
| Cell 5 | Cell 4 | Cell 3 | Cell 2 | Cell 1 |

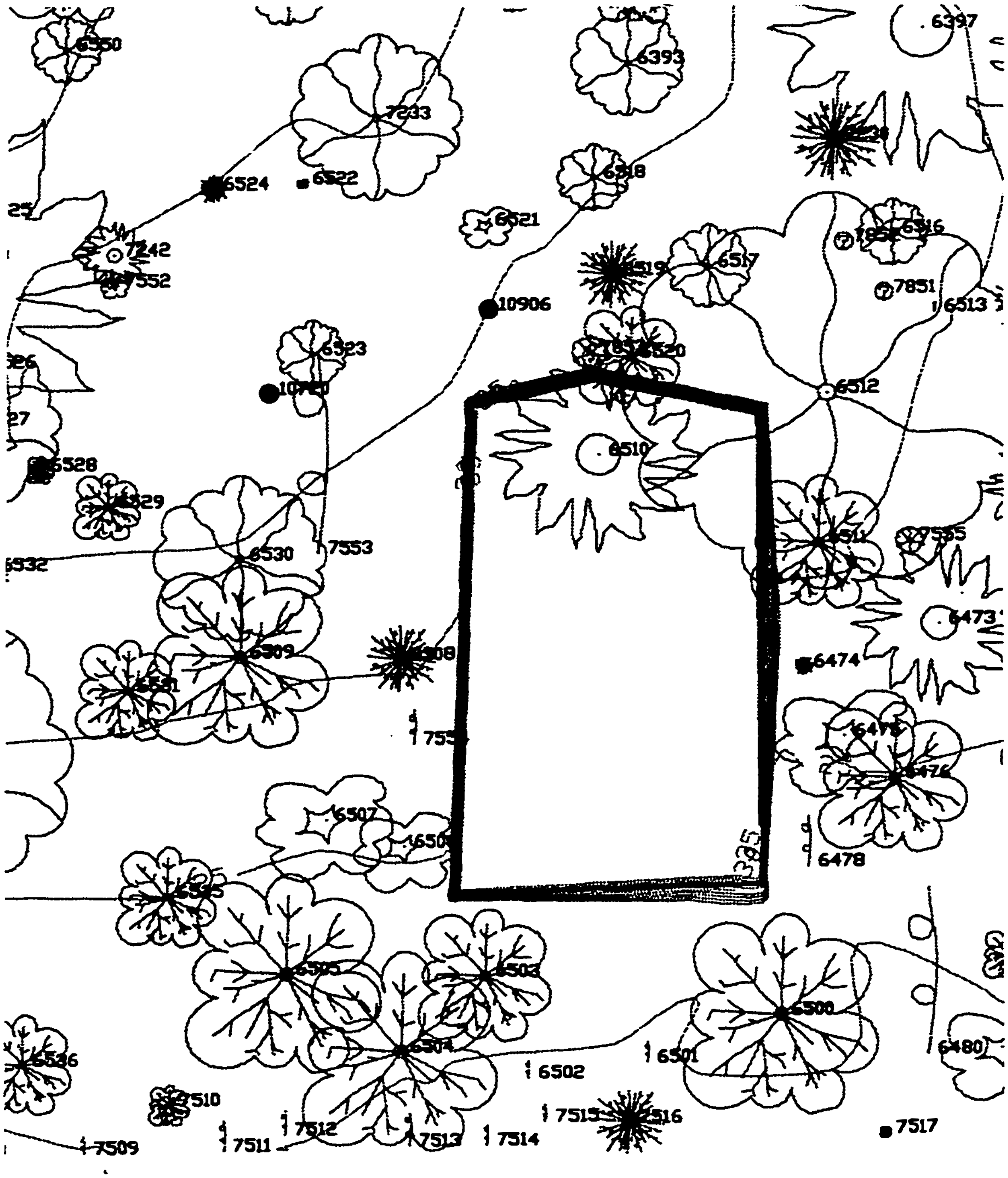
→ N

Figure A-1. Map cells showing the location of individual plants in the Biosphere 2 rainforest. See Table A-1 for corresponding list of species and survey of individuals. a) Key to the location of individual map cells within the rainforest; b) Cell 1; c) Cell 2; d) Cell 3; e) Cell 4; f) Cell 5; g) Cell 6; h) Cell 7; i) Cell 8; j) Cell 9; k) Cell 10; l) Cell 11; m) Cell 12; n) Cell 13; o) Cell 14; p) Cell 15; q) Cell 16; r) Cell 17; s) Cell 18; t) Cell 19; u) Cell 20. Surveying and original graphics by Teague and Co., Tucson, AZ. Approximate scale: 1 cm = 0.6 m.



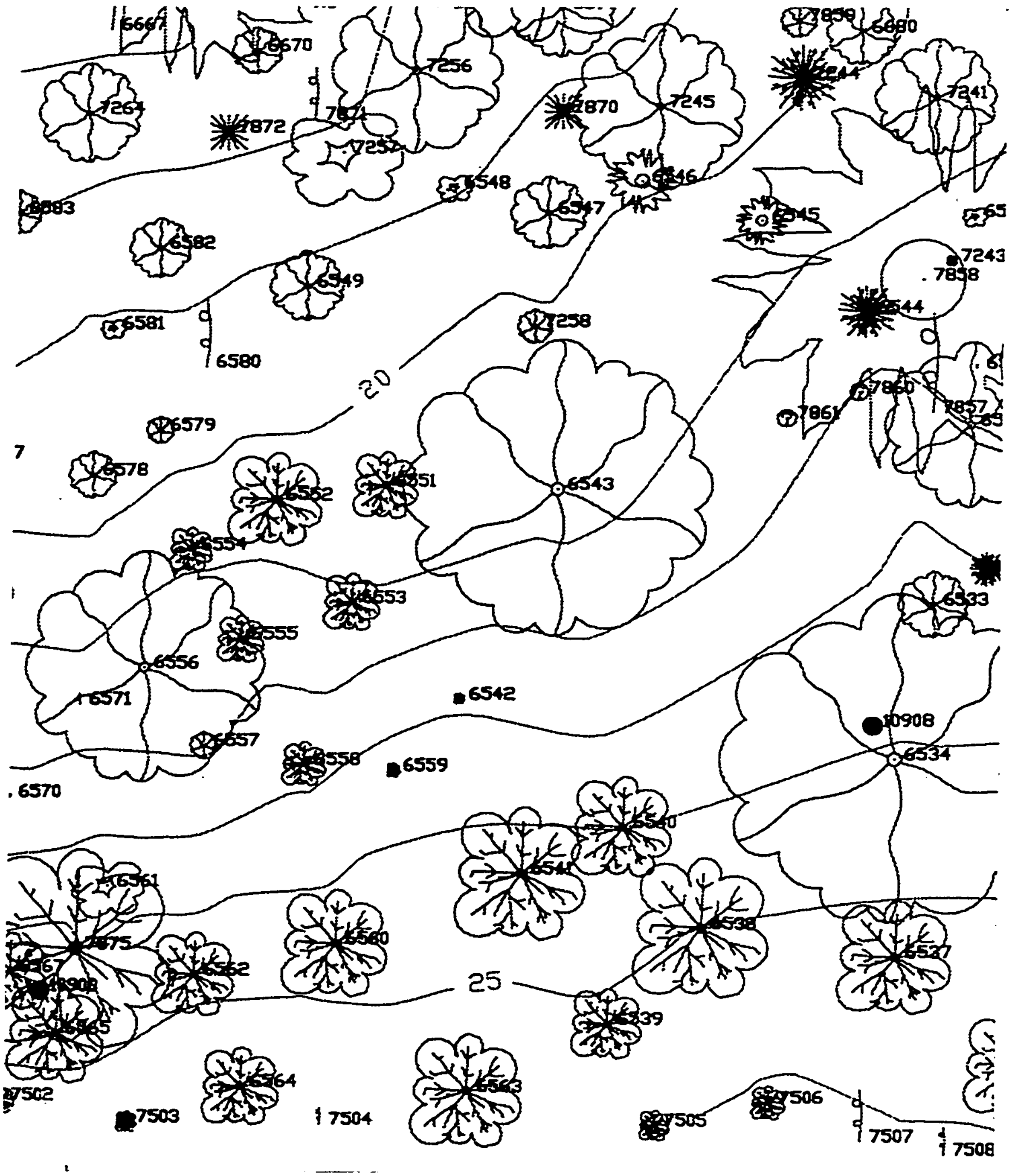
b) Cell 1

Figure A-1 -- continued.



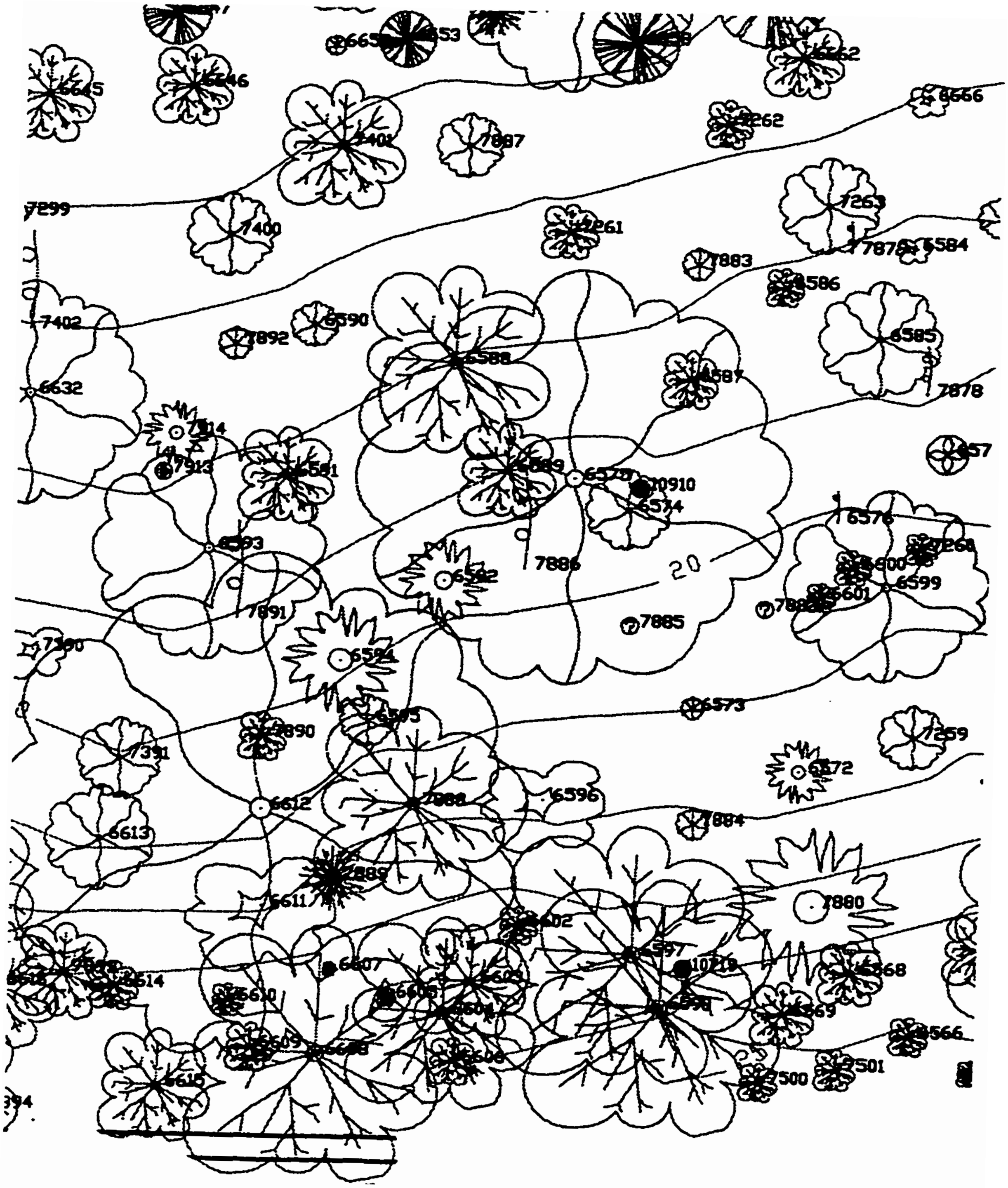

c) Cell 2

<u>Figure A-1 – continued.</u>



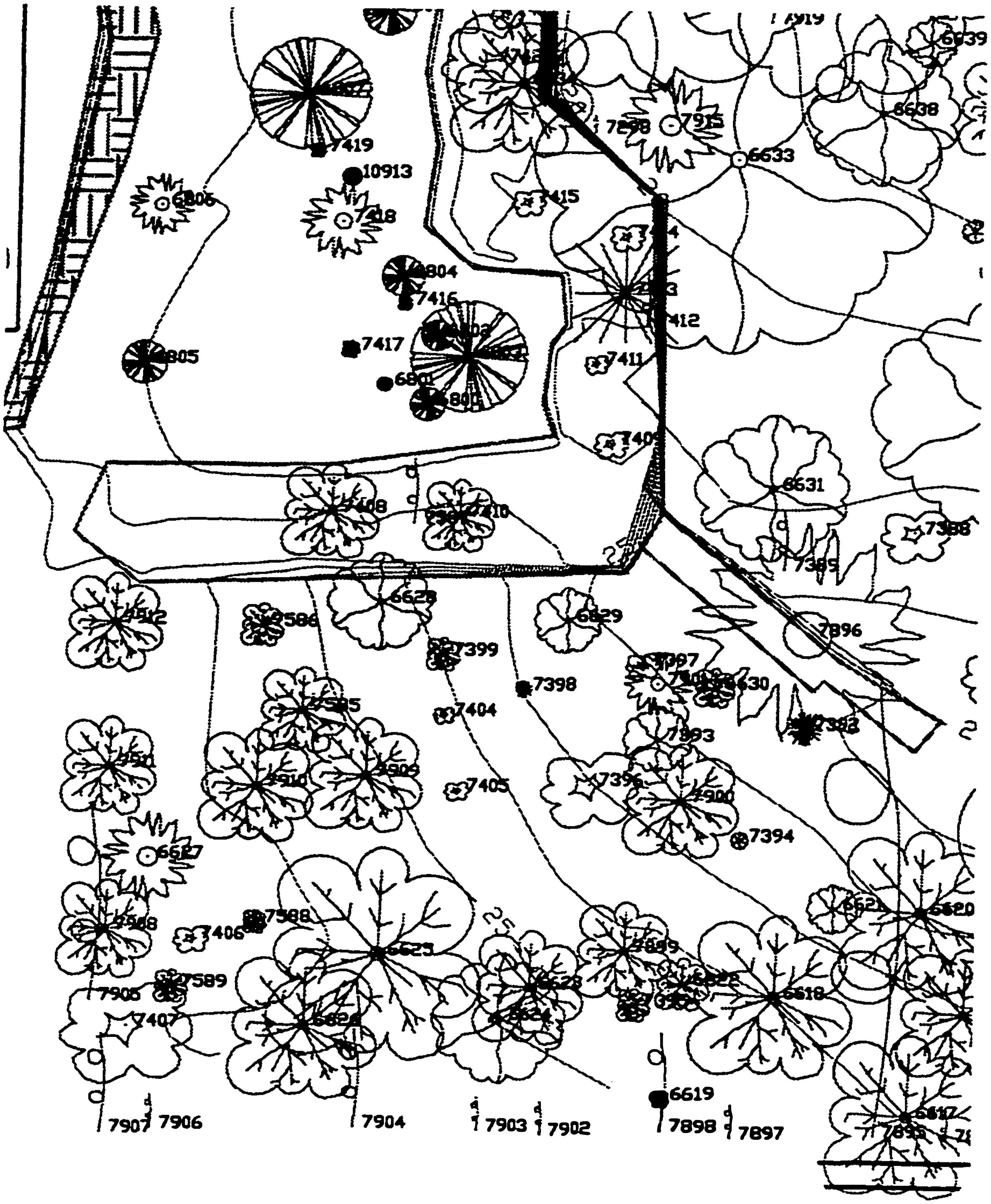

d) Cell 3

Figure A-1 -- continued.



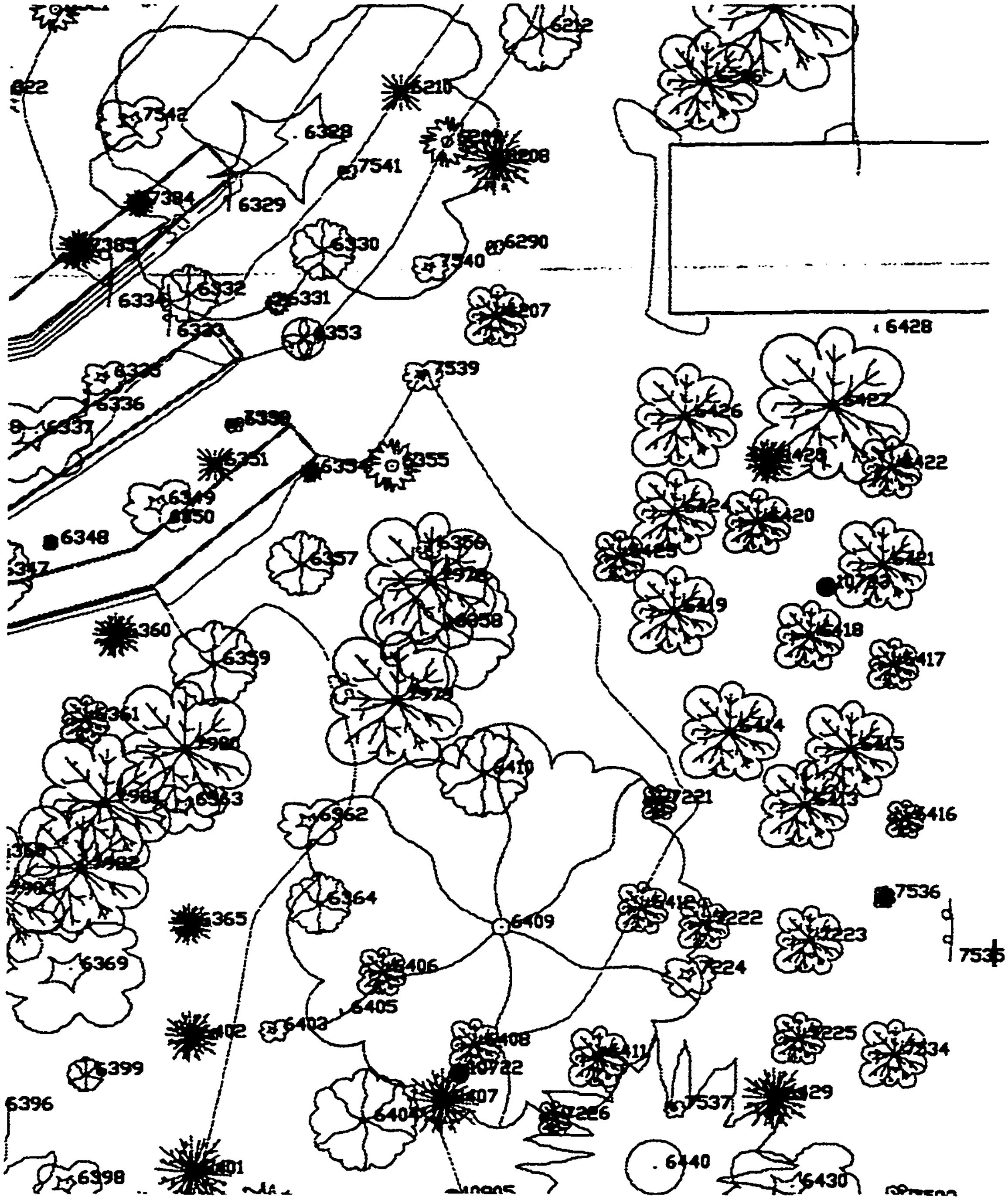
e) Cell 4

Figure A-1 -- continued.



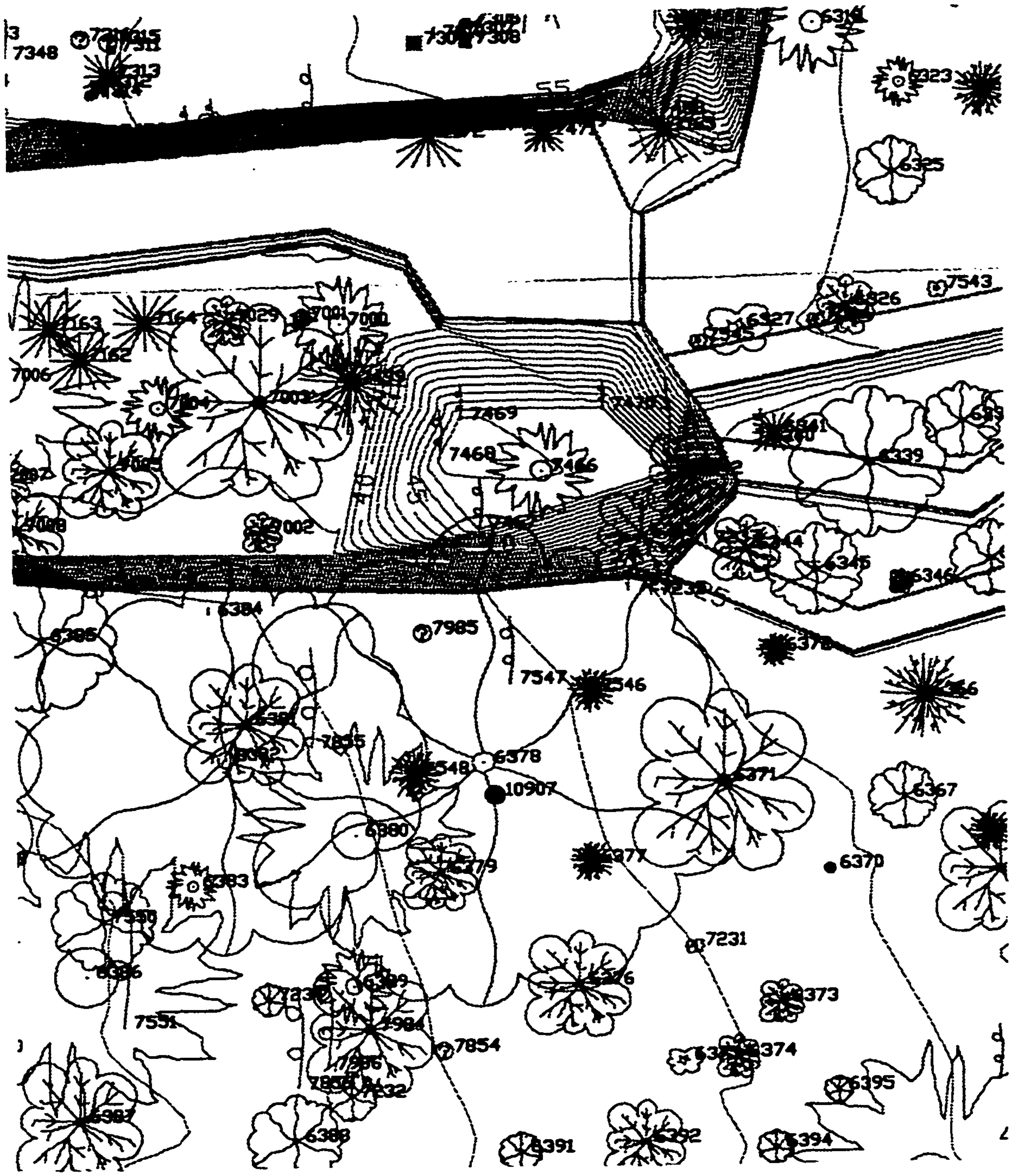

f) Cell 5

<u>Figure A-1 – continued.</u>



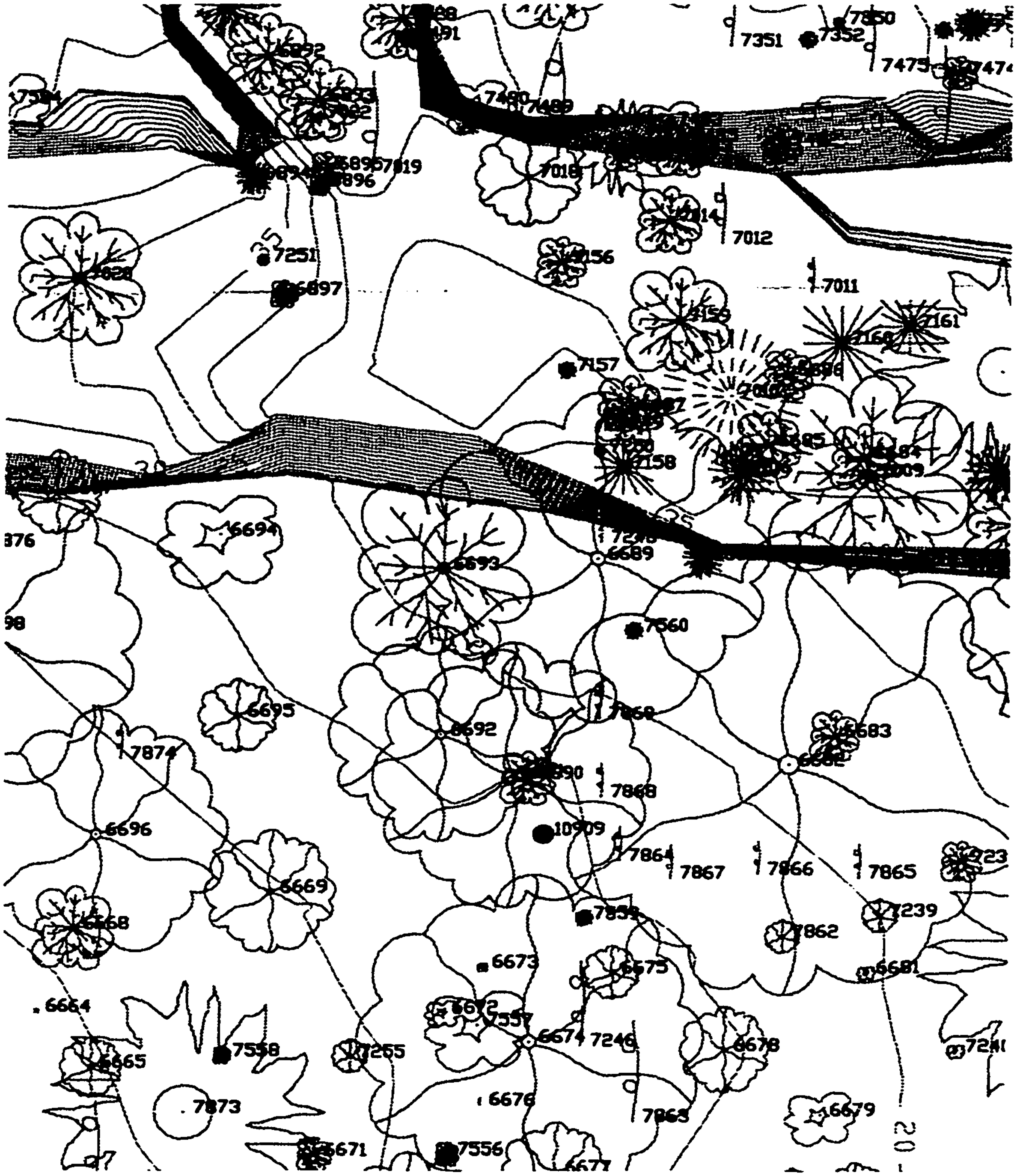
g) Cell 6

Figure A-1 – continued.



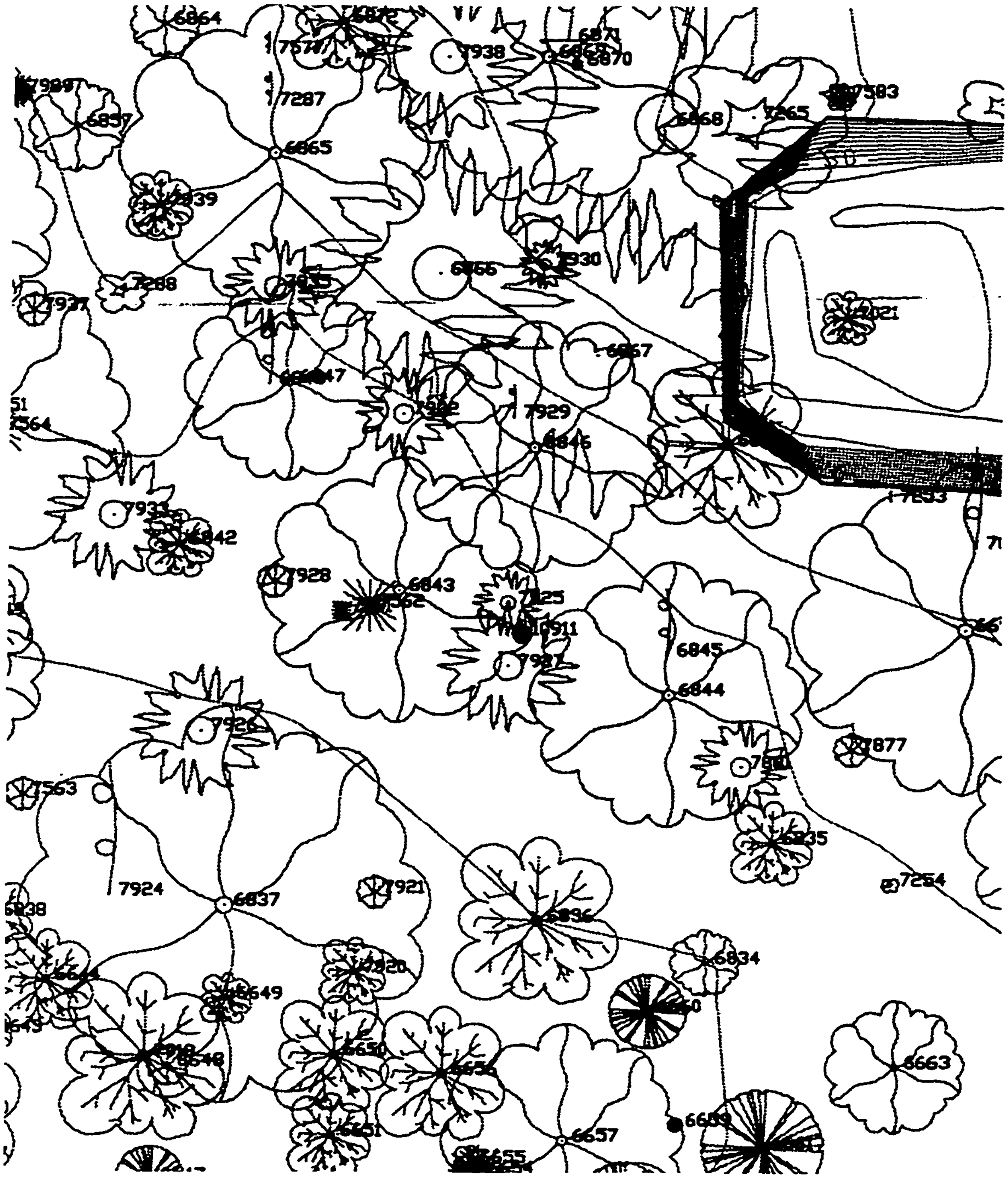

h) Cell 7

Figure A-1 -- continued.



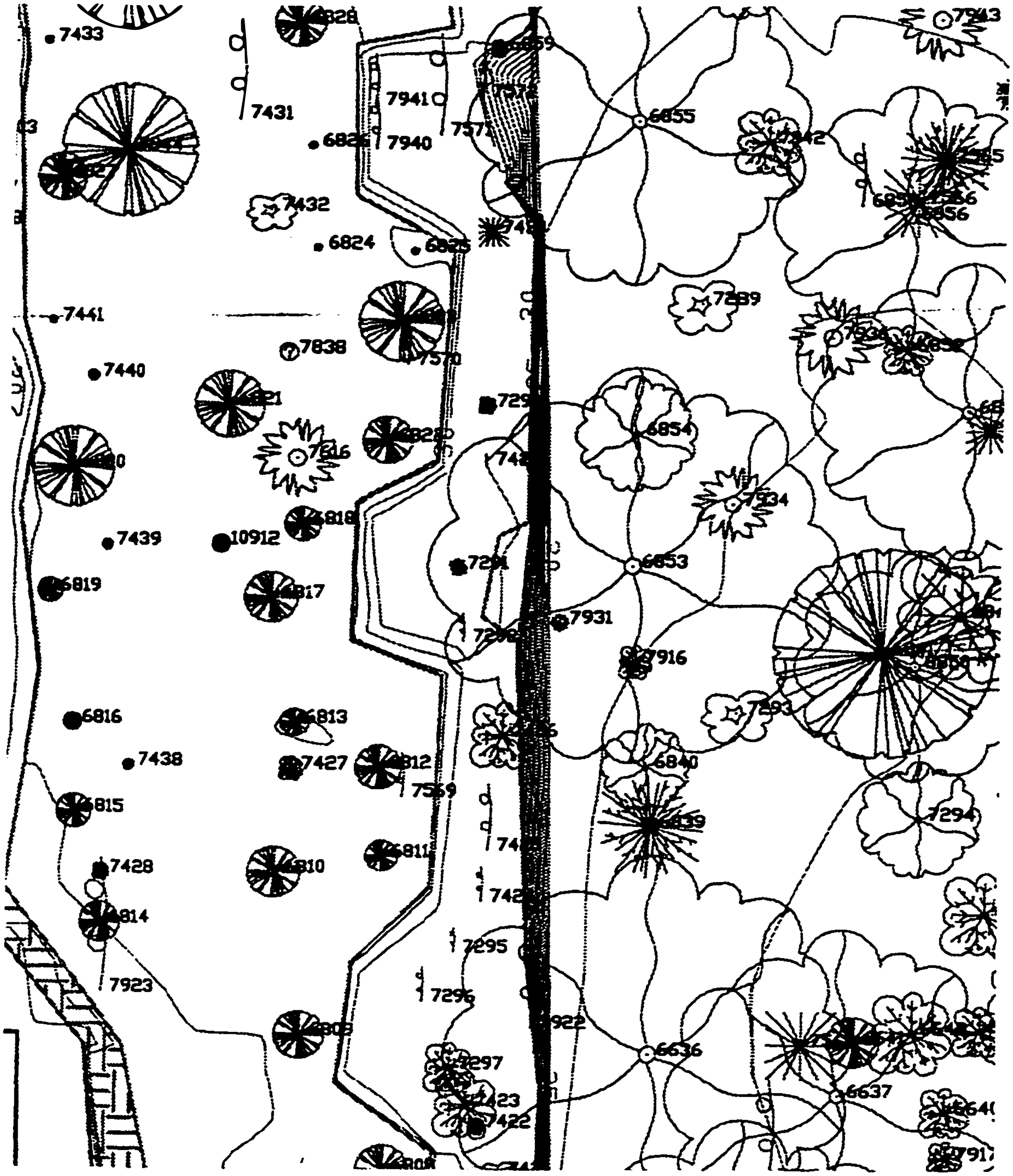

i) Cell 8

<u>Figure A-1 – continued.</u>



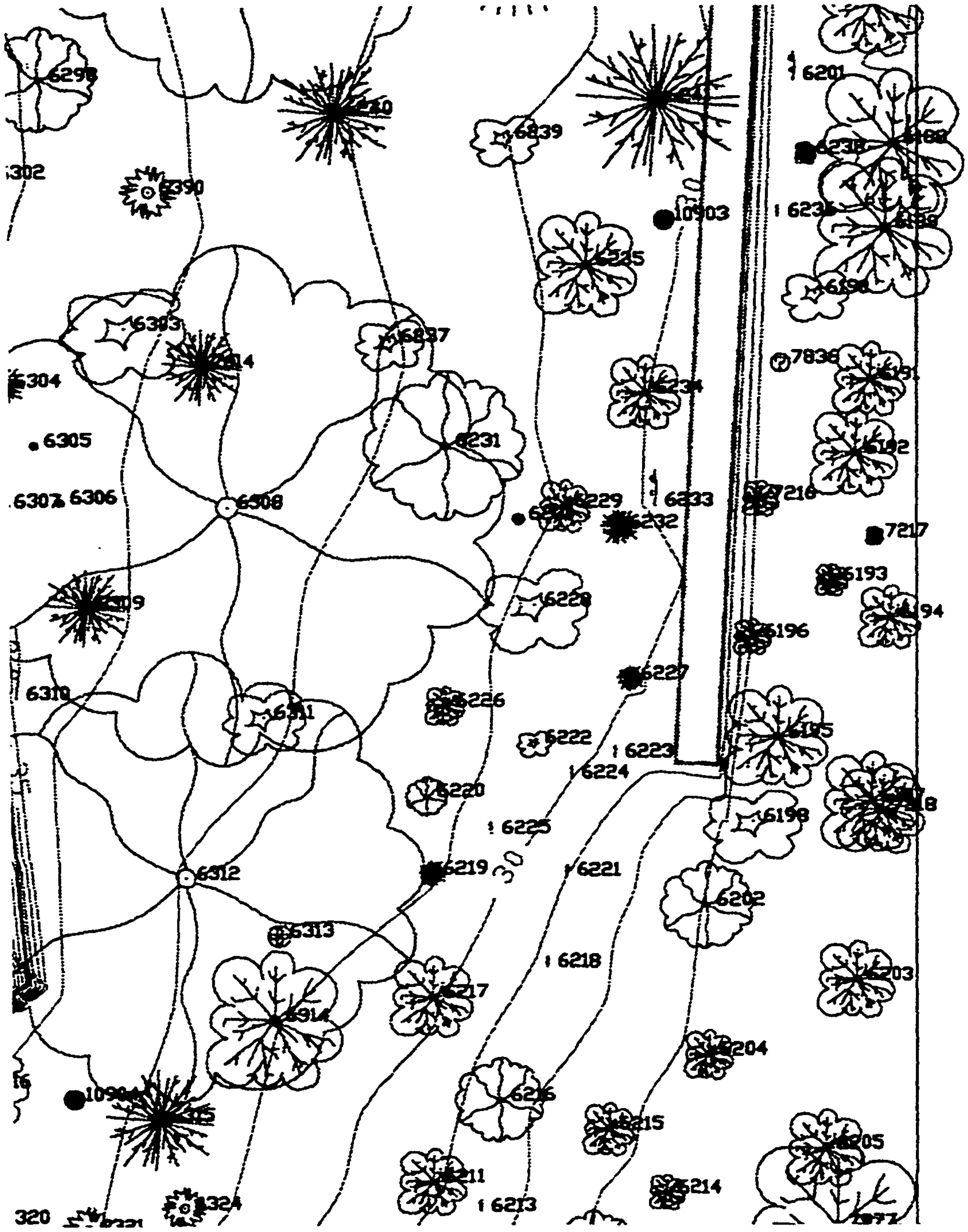
j) Cell 9

Figure A-1 – continued.



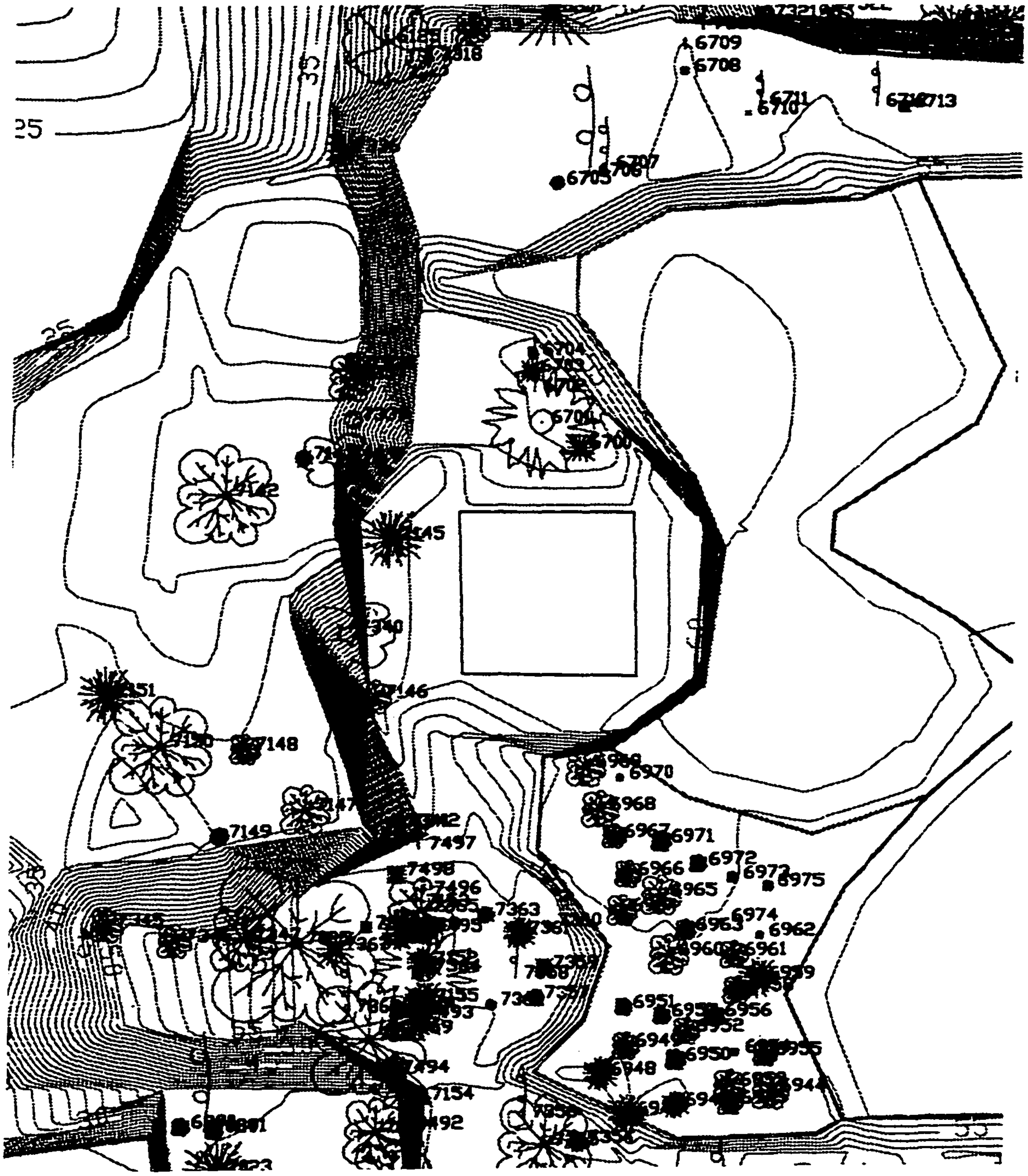

k) Cell 10

Figure A-1 – continued.



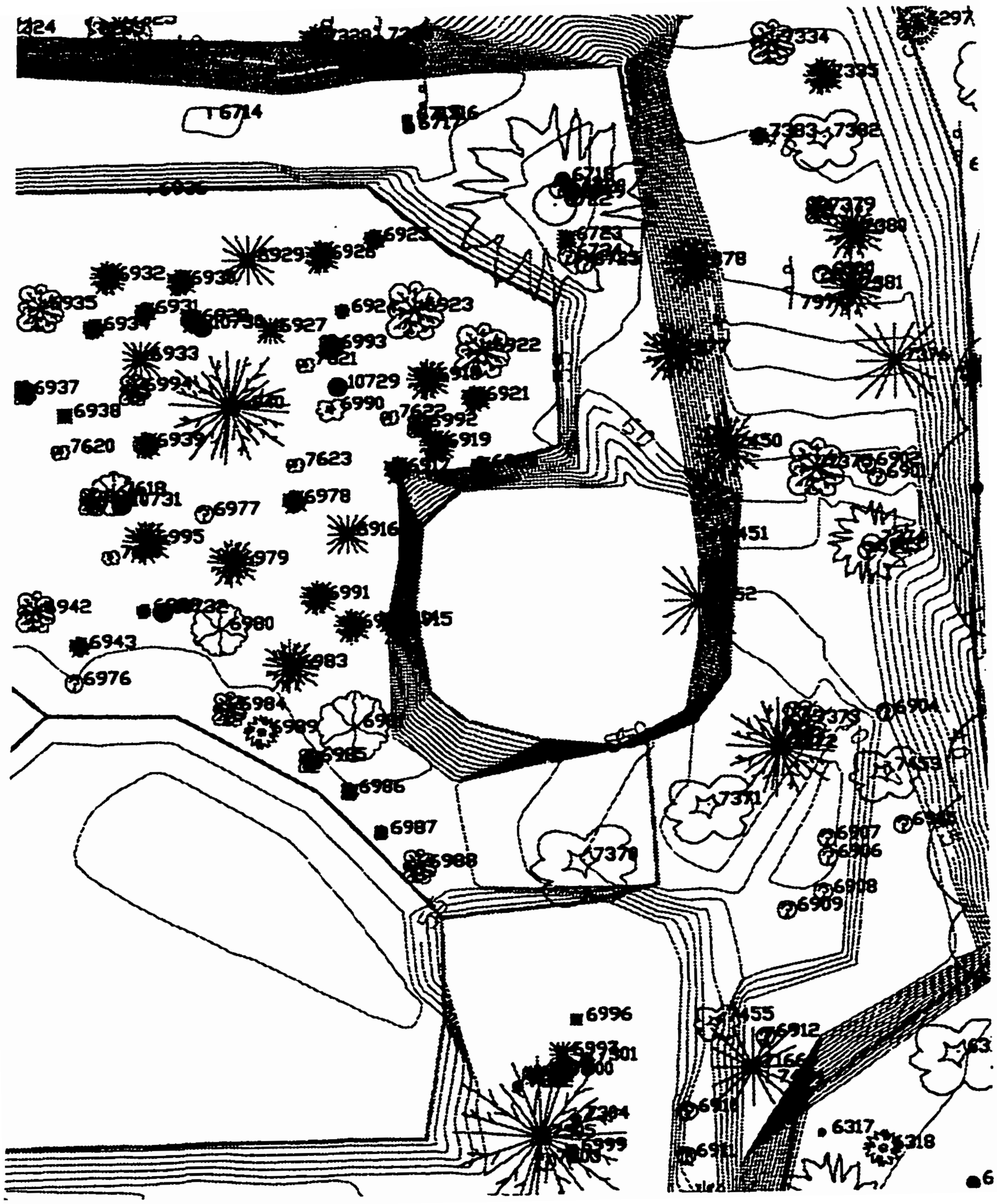

I) Cell 11

<u>Figure A-1 – continued.</u>



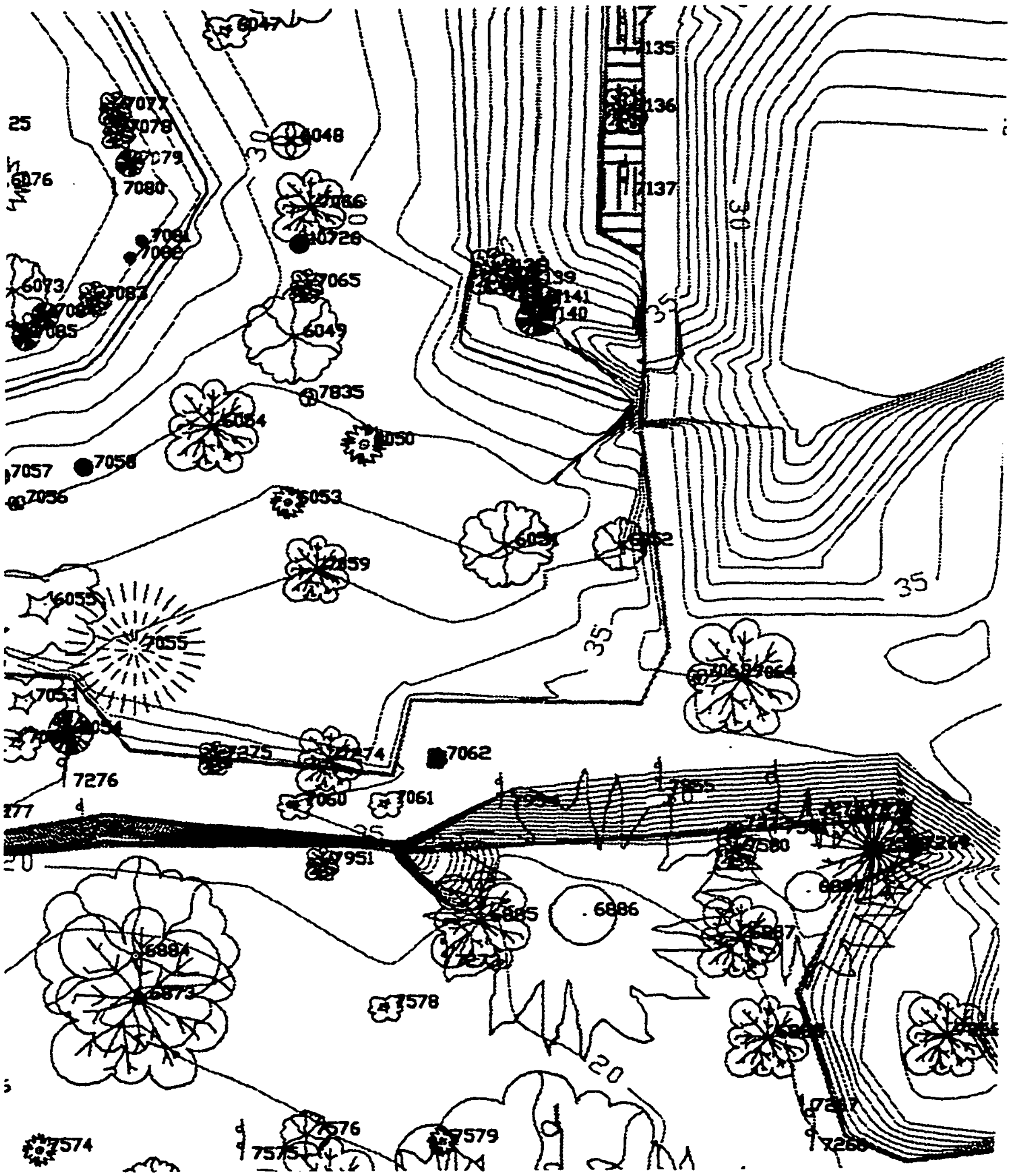
m) Cell 12

Figure A-1 – continued.



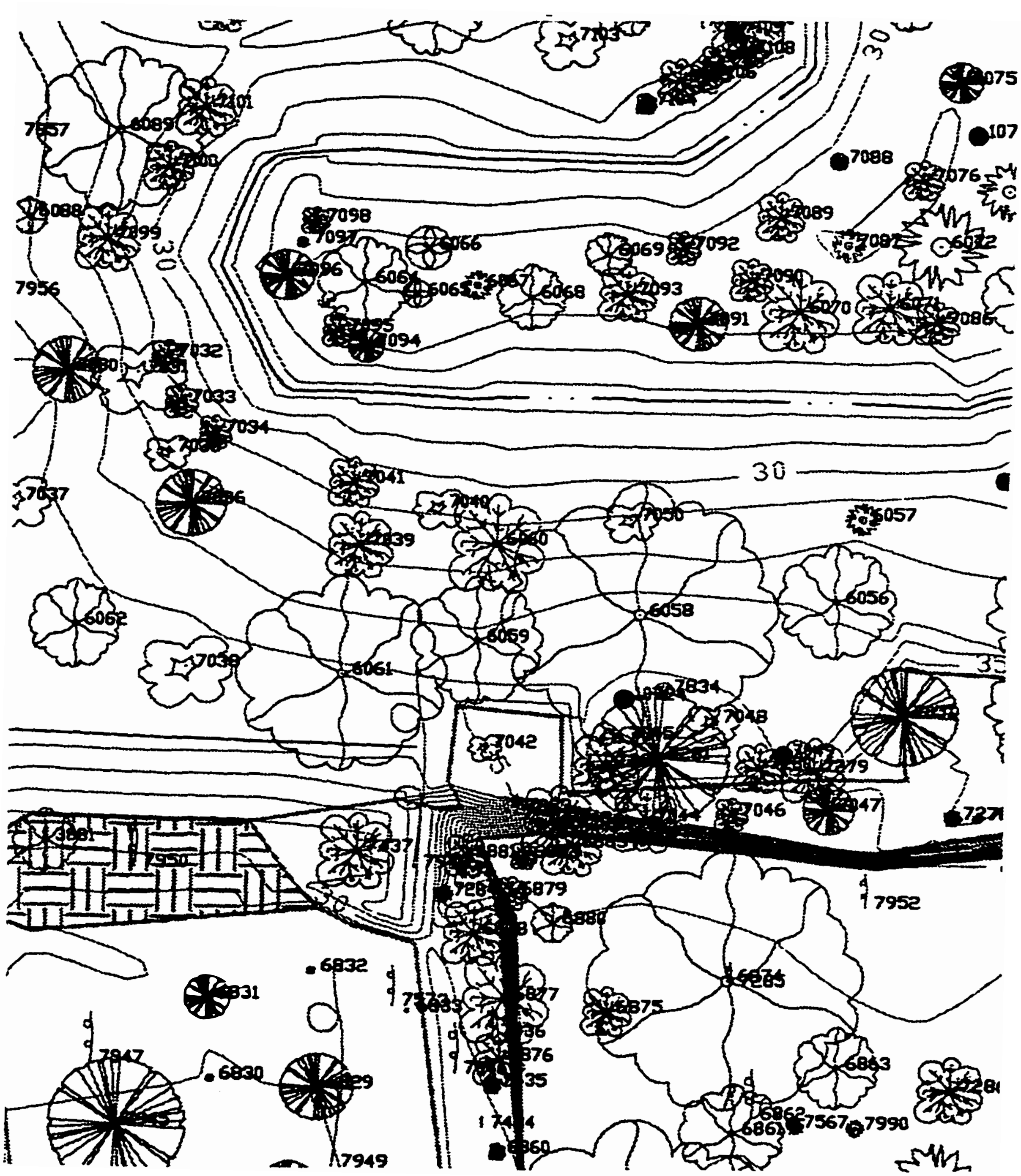

n) Cell 13

<u>Figure A-1 -- continued.</u>



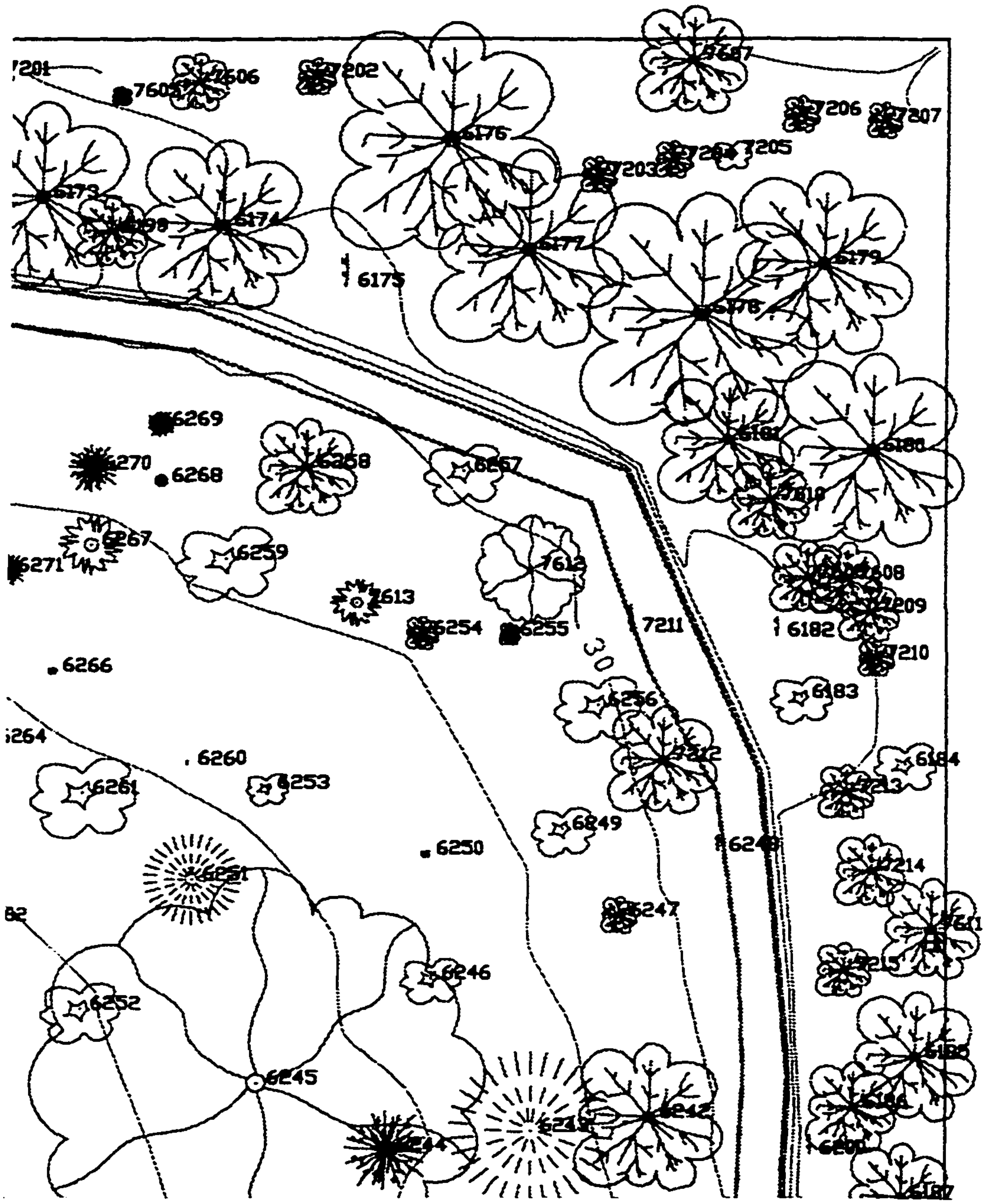
o) Cell 14

Figure A-1 – continued.



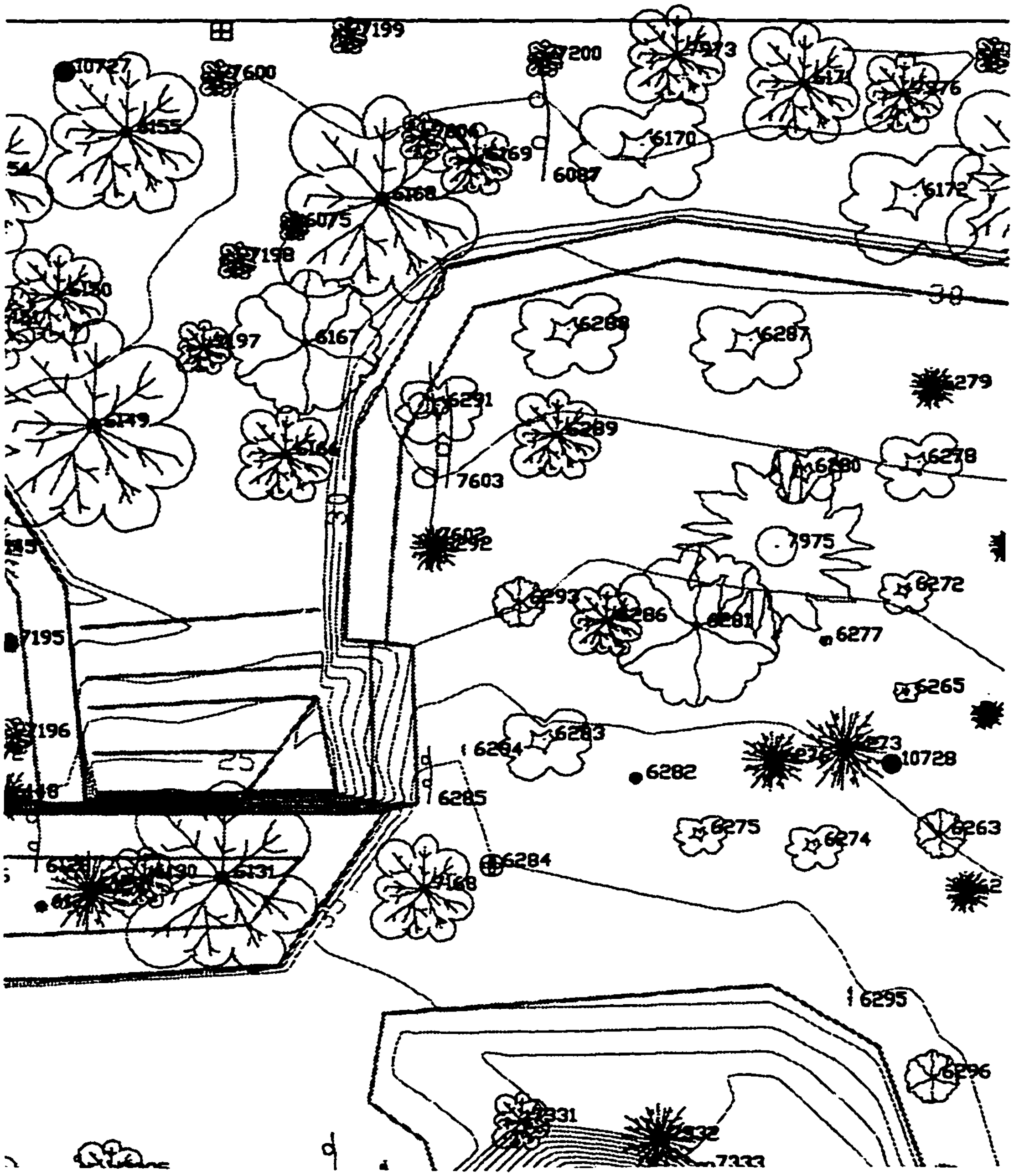

p) Cell 15

<u>Figure A-1 – continued.</u>



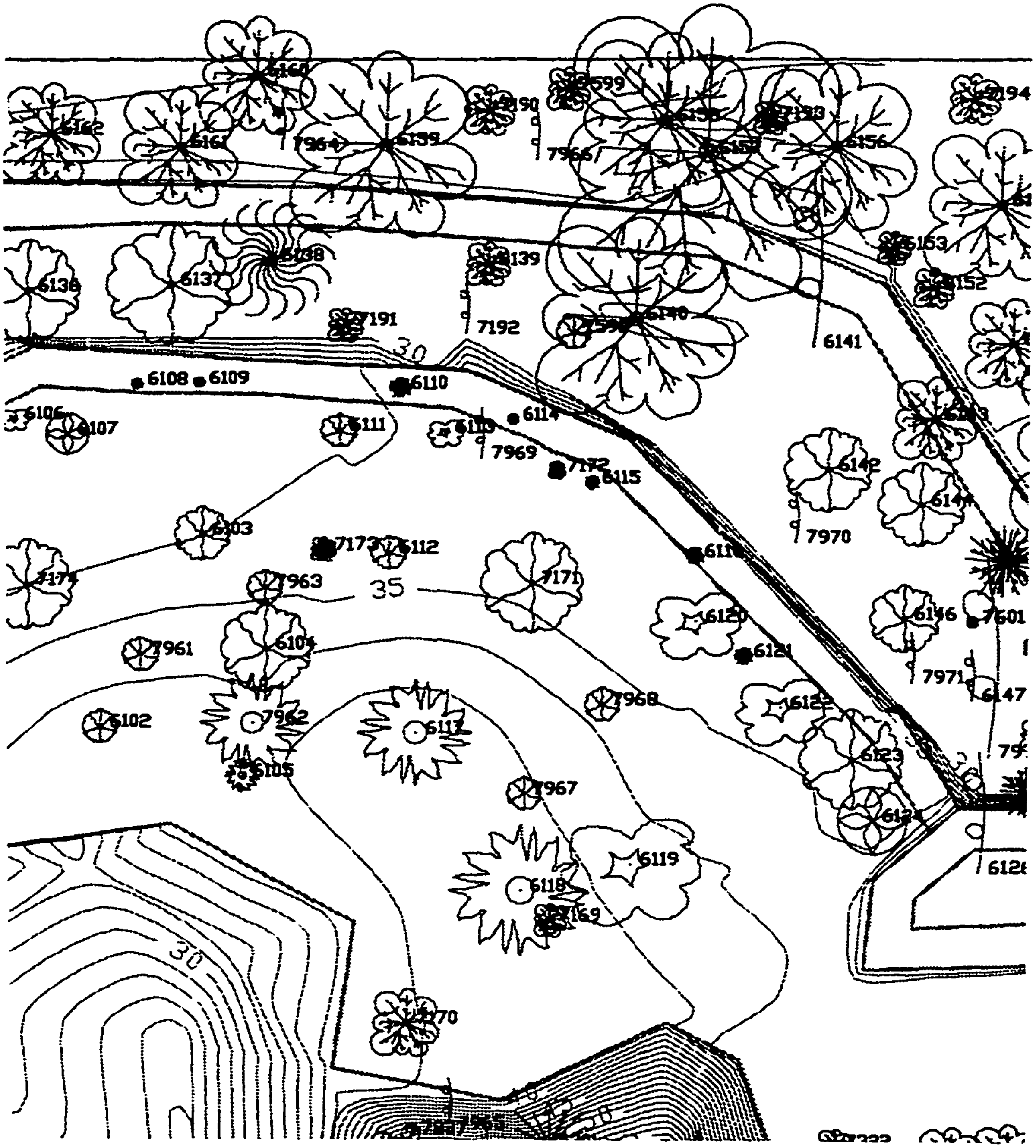

q) Cell 16

<u>Figure A-1 -- continued.</u>



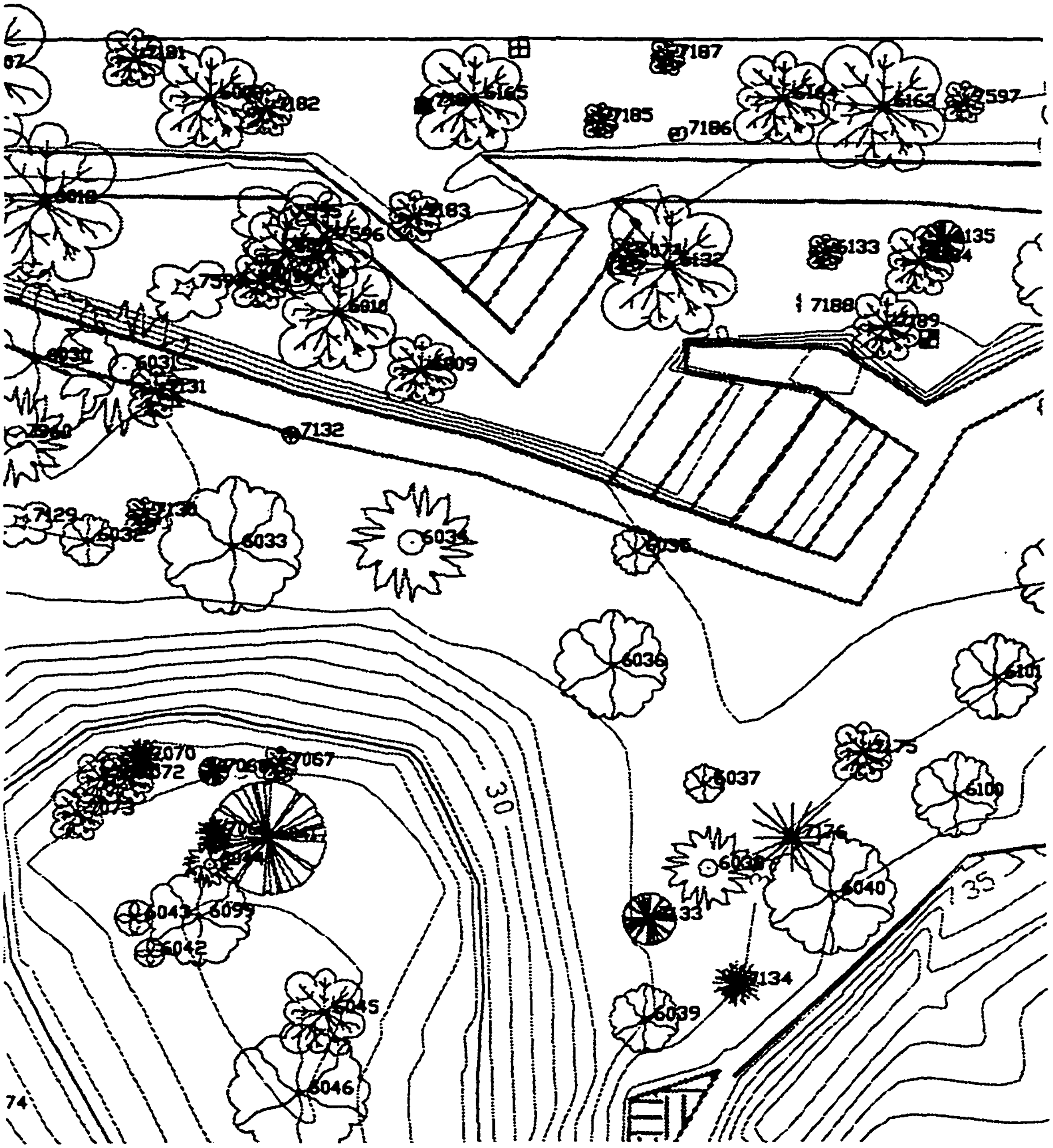

r) Cell 17

<u>Figure A-1 -- continued.</u>



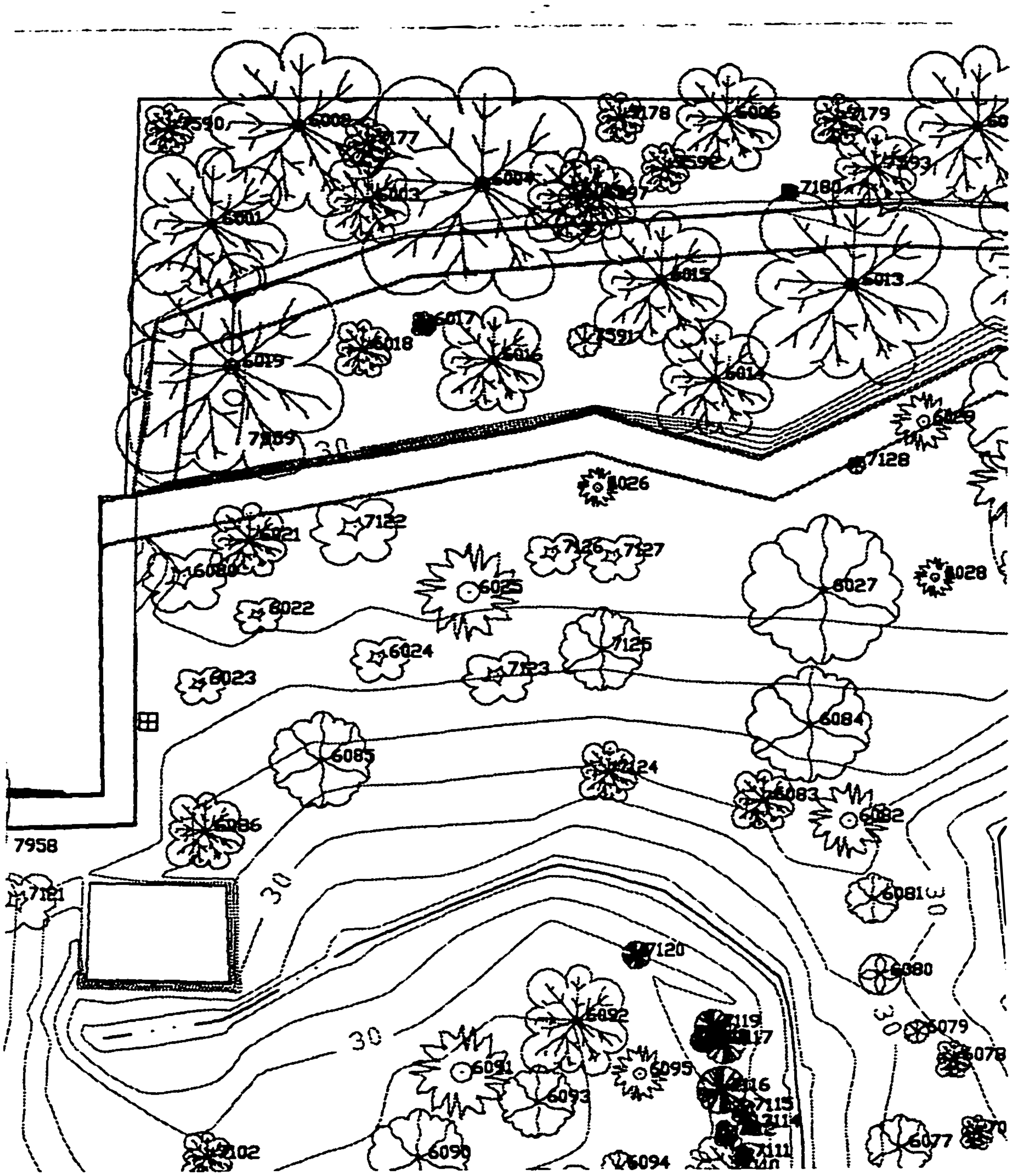

s) Cell 18

<u>Figure A-1 – continued.</u>




t) Cell 19

<u>Figure A-1 – continued.</u>




u) Cell 20

<u>Figure A-1 -- continued.</u>

# APPENDIX B
# BIOSPHERE 2 RAINFOREST PLANT LISTS

Table B-1. Biosphere 2 rainforest plant survey list. Planting: 1=pre-1991; 2=Oct.-Dec. 1993. GF=Growth form: T=Tree, S=Shrub, C=Climber, G=Giant Herb, P=Arboreal palm, R=Graminoid, A=Woody graminoid, such as bamboo, H=Herb, E=Epiphyte. A=Alive, D=Dead. Blank cells indicate information available.

Table B-2. Species from the first planting of the Biosphere 2 rainforest, with inventorieS from 1991, 1993, and 1996. T=Tree, S=Shrub, C=Climber, G=Giant Herb, P=Arboreal palm, R=Graminoid, A=Woody graminoid, such as bamboo, H=Herb, E=Epiphyte.

Table B-3. Species from the second planting of the Biosphere 2 rainforest, with inventories from 1993 and 1996, or self-propagated. T=Tree, S=Shrub, C=Climber, G=Giant Herb, P=Arboreal palm, R=Graminoid, A=Woody graminoid, such as bamboo, H=Herb, E=Epiphyte.

Table B-1. Biosphere 2 rainforest plant survey list. Planting: 1= pre-1991; 2 = Oct.-Dec. 1993. T=Tree, GF = Growth form: S=Shrub, C=Climber, G=Giant Herb, P=Arboreal palm, R=Graminoid, A=Woody graminoid, such as bamboo, H=Herb, E=Epiphyte. A=Alive, D=Dead. Blank cells indicate no information available.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C81 | 3199 | ANNONA | MURICATA | ANNONACEAE | T | 6-Dec-93 | A | D |
| 2 | C74 | 3209 | ANNONA | MURICATA | ANNONACEAE | T | 6-Dec-93 | A | D |
| 2 | C86 | 3326 | INGA | EDULIS | FABACEAE | T | 6-Dec-93 | A | NF |
| 2 | C69 | 3440 | CARICA | SP. | CARICACEAE | T | | | NF |
| 1 | C80 | 3441 | COSTUS | SP. | ZINGIBERACEAE | H | 26-Sep-92 | A | A |
| 1 | C80 | 3442 | COSTUS | SP. | ZINGIBERACEAE | H | 26-Sep-92 | A | A |
| 2 | C87 | 3443 | GARCINIA | MANGOSTANA | CLUSIACEAE | T | 6-Dec-93 | D | D |
| 2 | C86 | 3444 | GARCINIA | MANGOSTANA | CLUSIACEAE | T | 6-Dec-93 | A | D |
| 2 | C86 | 3445 | SYZYGIUM | AQUEUM | MYRTACEAE | T | 6-Dec-93 | A | NF |
| 2 | C80 | 3446 | GARCINIA | MANGOSTANA | CLUSIACEAE | T | 6-Dec-93 | A | NF |
| 2 | C81 | 3447 | AECHMEA | FASCIATA | BROMELIACEAE | E | 7-Dec-93 | A | NF |
| 2 | C72 | 3448 | INGA | EDULIS | FABACEAE | T | 6-Dec-93 | A | NF |
| 2 | C86 | 3449 | GARCINIA | MANGOSTANA | CLUSIACEAE | T | 6-Dec-93 | NF | NF |
| 1 | C64 | 3881 | PSIDIUM | GUAJAVA | MYRTACEAE | T | 29-Nov-90 | A | A |
| 1 | C78 | 4401 | UNKNOWN | UNKNOWN | UNKNOWN | U | 26-Sep-92 | A | NF |
| 2 | C93 | 4409 | THEOBROMA | CACAO | STERCULIACEAE | S | 6-Dec-93 | A | D |
| 2 | C94 | 4410 | THEOBROMA | CACAO | STERCULIACEAE | S | 7-Dec-93 | A | NF |
| 2 | C88 | 4411 | SYZYGIUM | MALACCENSE | MYRTACEAE | T | 6-Dec-93 | A | A |
| 2 | C79 | 4412 | PSIDIUM | GUAJAVA | MYRTACEAE | T | 8-Dec-93 | A | NF |
| 2 | C80 | 4413 | ANNONA | MURICATA | ANNONACEAE | T | 6-Dec-93 | A | NF |
| 2 | C79 | 4414 | ANNONA | MURICATA | ANNONACEAE | T | 6-Dec-93 | A | NF |
| 1 | C72 | 4439 | IPOMOEA | BATATAS | CONVOLVULACEAE | H | 26-Sep-92 | D | NF |
| 2 | C74 | 4449 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 20-Nov-93 | A | NF |
| 2 | C73 | 4450 | CALATHEA | ORNATA | MARANTACEAE | H | 20-Nov-93 | A | NF |
| 2 | C72 | 4451 | CALATHEA | ORNATA | MARANTACEAE | H | 20-Nov-93 | A | A |
| 2 | C80 | 4452 | ZINGIBER | OFFICINALE | ZINGIBERACEAE | H | 20-Nov-93 | A | NF |
| 2 | C93 | 4453 | CANNA | EDULIS | CANNACEAE | G | 20-Nov-93 | A | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C94 | 4454 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 20-Nov-93 | A | D |
| 2 | C73 | 4455 | CANNA | EDULIS | CANNACEAE | G | 20-Nov-93 | A | NF |
| 2 | C71 | 4456 | ZINGIBER | OFFICINALE | ZINGIBERACEAE | H | 20-Nov-93 | A | NF |
| 2 | C71 | 4457 | ZINGIBER | OFFICINALE | ZINGIBERACEAE | H | 20-Nov-93 | A | NF |
| 2 | C79 | 4458 | ZINGIBER | OFFICINALE | ZINGIBERACEAE | H | 20-Nov-93 | A | NF |
| 2 | C86 | 4459 | ZINGIBER | OFFICINALE | ZINGIBERACEAE | H | 20-Nov-93 | A | NF |
| 2 | C95 | 4460 | ZINGIBER | OFFICINALE | ZINGIBERACEAE | H | 20-Nov-93 | A | NF |
| 2 | C87 | 4461 | ZINGIBER | OFFICINALE | ZINGIBERACEAE | H | 20-Nov-93 | A | NF |
| 2 | C79 | 4462 | ZINGIBER | OFFICINALE | ZINGIBERACEAE | H | 20-Nov-93 | D | NF |
| 2 | C72 | 4463 | CANNA | EDULIS | CANNACEAE | G | 20-Nov-93 | A | NF |
| 2 | C87 | 4464 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C74 | 4465 | SPATHIPHYLLUM | CANNIFOLIUM | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C79 | 4466 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 20-Nov-93 | A | NF |
| 2 | C73 | 4467 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 20-Nov-93 | A | NF |
| 2 | C72 | 4468 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 20-Nov-93 | A | NF |
| 2 | C72 | 4469 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 20-Nov-93 | A | A |
| 2 | C92 | 4470 | MONSTERA | DELICIOSA | ARACEAE | C | 20-Nov-93 | A | A |
| 2 | C87 | 4471 | MONSTERA | DELICIOSA | ARACEAE | C | 20-Nov-93 | A | NF |
| 2 | C87 | 4472 | MARANTA | ARUNDINACEA | MARANTACEAE | H | 20-Nov-93 | A | NF |
| 2 | C87 | 4473 | PASSIFLORA | DIGITATA | PASSIFLORACEAE | C | 20-Nov-93 | D | D |
| 2 | C72 | 4474 | SPATHIPHYLLUM | CANNIFOLIUM | ARACEAE | H | 20-Nov-93 | A | D |
| 2 | C81 | 4475 | QUASSIA | TULAE | SIMAROUBACEAE | U | 20-Nov-93 | A | D |
| 2 | C87 | 4476 | CANNA | EDULIS | CANNACEAE | G | 20-Nov-93 | A | NF |
| 2 | C80 | 4477 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 20-Nov-93 | A | NF |
| 2 | C88 | 4478 | CANNA | EDULIS | CANNACEAE | G | 20-Nov-93 | A | NF |
| 2 | C80 | 4479 | CALATHEA | PICTURATA | MARANTACEAE | H | 20-Nov-93 | A | NF |
| 2 | C80 | 4480 | CALATHEA | PICTURATA | MARANTACEAE | H | 20-Nov-93 | A | A |
| 2 | C80 | 4481 | CALATHEA | PICTURATA | MARANTACEAE | H | 20-Nov-93 | A | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C87 | 4482 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 20-Nov-93 | A | D |
| 2 | C95 | 4483 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 20-Nov-93 | A | NF |
| 2 | C79 | 4484 | CALATHEA | SP. | MARANTACEAE | H | 20-Nov-93 | A | D |
| 2 | C80 | 4487 | CALATHEA | ALLOUIA | MARANTACEAE | H | 20-Nov-93 | A | NF |
| 2 | C87 | 4488 | SPATHIPHYLLUM | CANNIFOLIUM | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C94 | 4489 | SYZYGIUM | JAMBOS | MYRTACEAE | T | 20-Nov-93 | A | NF |
| 2 | C79 | 4490 | MARANTA | ARUNDINACEA | MARANTACEAE | H | 20-Nov-93 | A | D |
| 2 | C79 | 4491 | CALATHEA | PICTURATA | MARANTACEAE | H | 20-Nov-93 | A | D |
| 2 | C87 | 4492 | MARANTA | ARUNDINACEA | MARANTACEAE | H | 20-Nov-93 | A | D |
| 2 | C74 | 4493 | SPATHIPHYLLUM | CANNIFOLIUM | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C87 | 4494 | MARANTA | ARUNDINACEA | MARANTACEAE | H | 20-Nov-93 | A | D |
| 2 | C87 | 4495 | MARANTA | ARUNDINACEA | MARANTACEAE | H | 20-Nov-93 | A | D |
| 2 | C87 | 4496 | SPATHIPHYLLUM | CANNIFOLIUM | ARACEAE | H | 20-Nov-93 | A | D |
| 2 | C71 | 4497 | QUASSIA | TULAE | SIMAROUBACEAE | U | 20-Nov-93 | A | D |
| 2 | C80 | 4498 | CANNA | EDULIS | CANNACEAE | G | 20-Nov-93 | A | NF |
| 2 | C87 | 4499 | MUSA | SP. | MUSACEAE | G | 20-Nov-93 | A | D |
| 2 | C71 | 4754 | DIOSCOREA | SP. | DIOSCOREACEAE | C | 20-Nov-93 | A | D |
| 2 | C69 | 4755 | MUSA | SP. | MUSACEAE | G | 20-Nov-93 | A | A |
| 2 | C94 | 4756 | COCOS | NUCIFERA | ARECACEAE | P | 5-Dec-93 | A | D |
| 2 | C74 | 4758 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C83 | 4759 | MUSA | SP. | MUSACEAE | G | 20-Nov-93 | A | A |
| 2 | C83 | 4760 | MUSA | SP. | MUSACEAE | G | 20-Nov-93 | A | A |
| 2 | C88 | 4761 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | NF |
| 2 | C83 | 4762 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C87 | 4763 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C94 | 4763 | MUSA | SP. | MUSACEAE | G | | | NF |
| 2 | C93 | 4764 | MUSA | SP. | MUSACEAE | G | 20-Nov-93 | A | A |
| 2 | C91 | 4765 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C93 | 4766 | MUSA | SP. | MUSACEAE | G | 20-Nov-93 | A | A |
| 2 | C90 | 4767 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C81 | 4769 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C81 | 4770 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C83 | 4771 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C83 | 4773 | MUSA | SP. | MUSACEAE | G | 20-Nov-93 | A | A |
| 2 | C69 | 4774 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | NF |
| 2 | C90 | 4775 | COCOS | NUCIFERA | ARECACEAE | P | 5-Dec-93 | A | D |
| 2 | C88 | 4776 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C68 | 4777 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | NF |
| 2 | C83 | 4778 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C88 | 4779 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C74 | 4781 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C87 | 4782 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C94 | 4783 | MUSA | SP. | MUSACEAE | G | 20-Nov-93 | A | NF |
| 2 | C76 | 4784 | MUSA | SP. | MUSACEAE | G | 20-Nov-93 | A | D |
| 2 | C91 | 4785 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | D |
| 2 | C83 | 4786 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C83 | 4787 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C69 | 4788 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | NF |
| 2 | C74 | 4789 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | D |
| 2 | C81 | 4790 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C88 | 4791 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C81 | 4792 | MUSA | SP. | MUSACEAE | G | 5-Dec-93 | A | A |
| 2 | C78 | 4794 | DIOSCOREA | SP. | DIOSCOREACEAE | C | 20-Nov-93 | A | NF |
| 2 | C71 | 4796 | DIOSCOREA | SP. | DIOSCOREACEAE | C | 20-Nov-93 | A | D |
| 2 | C78 | 4797 | DIOSCOREA | SP. | DIOSCOREACEAE | C | 20-Nov-93 | A | A |
| 2 | C71 | 4798 | DIOSCOREA | ALATA | DIOSCOREACEAE | C | 20-Nov-93 | A | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C78 | 4799 | DIOSCOREA | SP. | DIOSCOREACEAE | C | 20-Nov-93 | A | A |
| 2 | C71 | 4800 | DIOSCOREA | SP. | DIOSCOREACEAE | C | 20-Nov-93 | A | NF |
| 2 | C93 | 5001 | ARTOCARPUS | HETEROPHYLLUS | MORACEAE | T | 20-Nov-93 | A | D |
| 2 | C93 | 5002 | ARTOCARPUS | HETEROPHYLLUS | MORACEAE | T | 20-Nov-93 | A | D |
| 2 | C90 | 5004 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | | | ?? |
| 2 | C71 | 5005 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 20-Nov-93 | A | A |
| 2 | C70 | 5007 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C70 | 5008 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C94 | 5009 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C70 | 5010 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C93 | 5011 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | D |
| 2 | C70 | 5012 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C93 | 5013 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | D |
| 2 | C70 | 5014 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C70 | 5016 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C70 | 5017 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C88 | 5021 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C72 | 5022 | COUROUPITA | GUIANENSIS | LECYTHIDACEAE | T | 20-Nov-93 | A | A |
| 2 | C87 | 5023 | RHAPIS | EXCELSA | ARECACEAE | P | 20-Nov-93 | A | A |
| 2 | C80 | 5024 | SWIETENIA | MACROPHYLLA | MELIACEAE | T | 20-Nov-93 | A | D |
| 2 | C73 | 5025 | FICUS | NITIDA | MORACEAE | C | 20-Nov-93 | A | A |
| 2 | C79 | 5026 | PSYCHOTRIA | SP. | RUBIACEAE | T | 20-Nov-93 | A | A |
| 2 | C74 | 5027 | BRUNFELSIA | SP. | SOLANACEAE | S | 20-Nov-93 | A | NF |
| 2 | C72 | 5064 | UNKNOWN | UNKNOWN | MYRTACEAE | U | 20-Nov-93 | A | D |
| 2 | C85 | 5073 | SYZYGIUM | MALACCENSE | MYRTACEAE | T | 20-Nov-93 | A | D |
| 2 | C86 | 5074 | PIMENTA | DIOICA | MYRTACEAE | T | 20-Nov-93 | A | A |
| 2 | C76 | 5075 | COFFEA | ARABICA | RUBIACEAE | S | 20-Nov-93 | A | D |
| 2 | C91 | 5076 | AVERRHOA | CARAMBOLA | OXALIDACEAE | T | 20-Nov-93 | A | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C92 | 5077 | ARTOCARPUS | SP. | MORACEAE | T | 20-Nov-93 | A | NF |
| 2 | C85 | 5078 | MALPIGHIA | EMARGINATA | MALPIGHIACEAE | T | 20-Nov-93 | A | NF |
| 2 | C86 | 5079 | MALPIGHIA | EMARGINATA | MALPIGHIACEAE | T | 20-Nov-93 | A | NF |
| 2 | C91 | 5080 | AVERRHOA | CARAMBOLA | OXALIDACEAE | T | 20-Nov-93 | D | D |
| 2 | C81 | 5082 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 20-Nov-93 | A | D |
| 2 | C87 | 5083 | COFFEA | ARABICA | RUBIACEAE | S | 20-Nov-93 | A | A |
| 2 | C95 | 5084 | CINNAMOMUM | ZEYLANICUM | LAURACEAE | T | 20-Nov-93 | A | NF |
| 2 | C87 | 5085 | THEOBROMA | CACAO | STERCULIACEAE | S | 20-Nov-93 | A | D |
| 2 | C84 | 5086 | SPONDIAS | MOMBIN | ANACARDIACEAE | T | 20-Nov-93 | A | NF |
| 2 | C92 | 5087 | AVERRHOA | CARAMBOLA | OXALIDACEAE | T | 20-Nov-93 | A | NF |
| 2 | C88 | 5088 | PARMENTIERA | EDULIS | BIGNONIACEAE | T | 20-Nov-93 | A | A |
| 2 | C86 | 5089 | CHRYSOPHYLLUM | SP. | SAPOTACEAE | T | 20-Nov-93 | A | A |
| 2 | C78 | 5091 | ARTOCARPUS | HETEROPHYLLUS | MORACEAE | T | 20-Nov-93 | A | A |
| 2 | C80 | 5092 | THEOBROMA | CACAO | STERCULIACEAE | S | 20-Nov-93 | A | NF |
| 2 | C73 | 5093 | CAMELLIA | SINENSIS | THEACEAE | S | 20-Nov-93 | A | NF |
| 2 | C80 | 5094 | HIBISCUS | ELATUS | MALVACEAE | S | 20-Nov-93 | A | A |
| 2 | C72 | 5095 | BIXA | ORELLANA | BIXACEAE | T | 20-Nov-93 | A | A |
| 2 | C74 | 5096 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | D |
| 2 | C80 | 5097 | HIBISCUS | ELATUS | MALVACEAE | S | 20-Nov-93 | A | A |
| 2 | C72 | 5098 | PSYCHOTRIA | VIRIDIS | RUBIACEAE | T | 20-Nov-93 | A | A |
| 2 | C79 | 5099 | COUROUPITA | GUIANENSIS | LECYTHIDACEAE | T | 20-Nov-93 | A | D |
| 2 | C80 | 5100 | HIBISCUS | ELATUS | MALVACEAE | S | 20-Nov-93 | A | A |
| 2 | C71 | 5401 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C88 | 5402 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 20-Nov-93 | A | NF |
| 2 | C78 | 5403 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | D |
| 2 | C80 | 5404 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C88 | 5405 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | A |
| 2 | C93 | 5406 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | A |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C72 | 5407 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | A |
| 2 | C79 | 5408 | HIBISCUS | ELATUS | MALVACEAE | S | 20-Nov-93 | A | NF |
| 2 | C81 | 5409 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | A |
| 2 | C72 | 5410 | HIBISCUS | ELATUS | MALVACEAE | S | 20-Nov-93 | A | A |
| 2 | C71 | 5412 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 20-Nov-93 | A | D |
| 2 | C71 | 5413 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 20-Nov-93 | A | NF |
| 2 | C73 | 5414 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 20-Nov-93 | A | A |
| 2 | C85 | 5415 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | ?? | ?? | A |
| 2 | C84 | 5416 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | A |
| 2 | C91 | 5417 | ANNONA | SQUAMOSA | ANNONACEAE | T | 20-Nov-93 | A | NF |
| 2 | C83 | 5418 | CARICA | PAPAYA | CARICACEAE | T | 20-Nov-93 | A | NF |
| 2 | C91 | 5419 | INGA | SP. | FABACEAE | T | 20-Nov-93 | A | D |
| 2 | C83 | 5420 | CARICA | PAPAYA | CARICACEAE | T | 20-Nov-93 | A | NF |
| 2 | C84 | 5421 | CARICA | PAPAYA | CARICACEAE | T | 20-Nov-93 | A | NF |
| 2 | C90 | 5422 | ANNONA | MURICATA | ANNONACEAE | T | 20-Nov-93 | A | D |
| 2 | C85 | 5423 | ANNONA | MURICATA | ANNONACEAE | T | 20-Nov-93 | A | D |
| 2 | C83 | 5424 | CARICA | PAPAYA | CARICACEAE | T | 20-Nov-93 | A | NF |
| 2 | C83 | 5425 | CARICA | PAPAYA | CARICACEAE | T | 20-Nov-93 | A | NF |
| 2 | C83 | 5426 | CARICA | PAPAYA | CARICACEAE | T | 20-Nov-93 | A | NF |
| 2 | C71 | 5427 | MUSA | SP. | MUSACEAE | G | 1-Jan-94 | A | A |
| 2 | C72 | 5428 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C76 | 5429 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 20-Nov-93 | A | A |
| 1 | C84 | 5431 | COFFEA | ARABICA | RUBIACEAE | S | 26-Sep-92 | A | A |
| 1 | C69 | 5432 | CAESALPINIA | SP. | FABACEAE | T | 26-Sep-91 | A | A |
| 2 | C76 | 5433 | CARICA | SP. | CARICACEAE | T | 26-Sep-93 | A | NF |
| 1 | C76 | 5434 | CARICA | SP. | CARICACEAE | T | 26-Sep-92 | A | NF |
| 2 | C86 | 5451 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 20-Nov-93 | A | NF |
| 2 | C77 | 5452 | PIMENTA | DIOICA | MYRTACEAE | T | 20-Nov-93 | A | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C87 | 5453 | THEOBROMA | CACAO | STERCULIACEAE | S | 20-Nov-93 | A | D |
| 2 | C72 | 5454 | EUTERPE | PRECATORIA | ARECACEAE | P | | | D |
| 2 | C71 | 5455 | EUTERPE | PRECATORIA | ARECACEAE | P | 20-Nov-93 | A | NF |
| 2 | C95 | 5457 | THEOBROMA | CACAO | STERCULIACEAE | S | 20-Nov-93 | A | NF |
| 2 | C79 | 5458 | SYNSEPALUM | DULCIFICUM | SAPOTACEAE | T | 20-Nov-93 | A | |
| 2 | C72 | 5459 | SYZYGIUM | JAMBOS | MYRTACEAE | T | 20-Nov-93 | A | A |
| 2 | C74 | 5460 | QUASSIA | TULAE | SIMAROUBACEAE | U | 20-Nov-93 | A | NF |
| 2 | C92 | 5461 | CANNA | EDULIS | CANNACEAE | G | 20-Nov-93 | A | NF |
| 2 | C87 | 5462 | CALATHEA | ORNATA | MARANTACEAE | H | 20-Nov-93 | A | D |
| 2 | C78 | 5463 | CYMBOPOGON | CITRATUS | POACEAE | R | 20-Nov-93 | A | NF |
| 2 | C79 | 5464 | CYMBOPOGON | CITRATUS | POACEAE | R | 20-Nov-93 | A | D |
| 2 | C74 | 5465 | ANNONA | SQUAMOSA | ANNONACEAE | T | 20-Nov-93 | A | NF |
| 2 | C83 | 5467 | CAMELLIA | SINENSIS | THEACEAE | S | 20-Nov-93 | A | D |
| 2 | C79 | 5468 | SPATHIPHYLLUM | CANNIFOLIUM | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C87 | 5497 | MARANTA | ARUNDINACEA | MARANTACEAE | H | 20-Nov-93 | A | NF |
| 2 | C92 | 5498 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C69 | 5499 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 20-Nov-93 | A | A |
| 1 | C62 | 6001 | HELICONIA | LONGIFLORA | HELICONIACEAE | G | 12-Oct-90 | NF | NF |
| 1 | C61 | 6002 | MUSA | SP. | MUSACEAE | G | 12-Oct-90 | A | A |
| 1 | C62 | 6003 | COPAIFERA | SP. | FABACEAE | T | 12-Oct-90 | NF | NF |
| 1 | C69 | 6004 | MUSA | TEXTILIS | MUSACEAE | G | 12-Oct-90 | A | A |
| 1 | C69 | 6005 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | NF | NF |
| 1 | C68 | 6006 | HELICONIA | BOURGAEANA | HELICONIACEAE | G | 12-Oct-90 | | NF |
| 1 | C68 | 6007 | CANNA | EDULIS | CANNACEAE | G | 12-Oct-90 | A | NF |
| 1 | C69 | 6008 | ZINGIBER | OFFICINALE | ZINGIBERACEAE | H | 12-Oct-90 | NF | NF |
| 1 | C69 | 6009 | SPATHOGLOTTIS | PLICATA | ORCHIDACEAE | H | 12-Oct-90 | NF | NF |
| 1 | C69 | 6010 | HELICONIA | LONGIFLORA | HELICONIACEAE | G | 12-Oct-90 | A | NF |
| 1 | C69 | 6011 | CURCUMA | DOMESTICA | ZINGIBERACEAE | H | 12-Oct-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C69 | 6012 | ALPINIA | ZERUMBET | ZINGIBERACEAE | G | 12-Oct-90 | A | A |
| 1 | C69 | 6013 | CANNA | EDULIS | CANNACEAE | G | 12-Oct-90 | D | NF |
| 1 | C69 | 6014 | MUSA | SP. | MUSACEAE | G | 12-Oct-90 | A | NF |
| 1 | C69 | 6015 | ZINGIBER | OFFICINALE | ZINGIBERACEAE | H | 12-Oct-90 | A | NF |
| 1 | C69 | 6016 | HELICONIA | BOURGAEANA | HELICONIACEAE | G | 12-Oct-90 | A | NF |
| 1 | C62 | 6017 | CURCUMA | ROSCOEANA | ZINGIBERACEAE | H | 12-Oct-90 | NF | NF |
| 1 | C62 | 6018 | COSTUS | BARBATUS | ZINGIBERACEAE | H | 12-Oct-90 | D | D |
| 1 | C62 | 6019 | CANNA | INDICA | CANNACEAE | G | 12-Oct-90 | A | A |
| 1 | C62 | 6020 | HIBISCUS | ROSA-SINENSIS | MALVACEAE | S | 12-Oct-90 | A | A |
| 1 | C62 | 6021 | DIEFFENBACHIA | SP. | ARACEAE | H | 12-Oct-90 | NF | NF |
| 1 | C62 | 6022 | HEIMIA | SALICIFOLIA | LYTHRACEAE | S | 12-Oct-90 | A | NF |
| 1 | C62 | 6023 | WITHANIA | SOMNIFERA | SOLANACEAE | S | 12-Oct-90 | NF | NF |
| 1 | C62 | 6024 | WITHANIA | SOMNIFERA | SOLANACEAE | S | 12-Oct-90 | NF | NF |
| 1 | C69 | 6025 | EUTERPE | SP. | ARECACEAE | P | 12-Oct-90 | A | A |
| 1 | C69 | 6026 | OENOCARPUS | MAPORA | ARECACEAE | P | 12-Oct-90 | NF | NF |
| 1 | C69 | 6027 | PHYTOLACCA | DIOICA | PHYTOLACCACEAE | T | 12-Oct-90 | A | A |
| 1 | C69 | 6028 | ARENGA | PINNATA | ARECACEAE | P | 12-Oct-90 | A | A |
| 1 | C69 | 6029 | MAURITIA | FLEXUOSA | ARECACEAE | P | 12-Oct-90 | NF | NF |
| 1 | C69 | 6030 | INGA | SP. | FABACEAE | T | 12-Oct-90 | A | NF |
| 1 | C69 | 6031 | WODYETIA | BIFURCATA | ARECACEAE | P | 12-Oct-90 | NF | NF |
| 1 | C69 | 6032 | MAURITIA | FLEXUOSA | ARECACEAE | P | 12-Oct-90 | NF | NF |
| 1 | C69 | 6033 | INGA | SP. | FABACEAE | T | 12-Oct-90 | A | A |
| 1 | C69 | 6034 | WODYETIA | BIFURCATA | ARECACEAE | P | 12-Oct-90 | A | A |
| 1 | C69 | 6035 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | A | NF |
| 1 | C69 | 6036 | SPATHODEA | CAMPANULATA | BIGNONIACEAE | T | 12-Oct-90 | A | A |
| 1 | C76 | 6037 | MANGIFERA | INDICA | ANACARDIACEAE | T | 12-Oct-90 | A | D |
| 1 | C76 | 6038 | JESSENIA | BATAUA | ARECACEAE | P | 12-Oct-90 | A | NF |
| 1 | C70 | 6039 | SYZYGIUM | JAMBOS | MYRTACEAE | T | 12-Oct-90 | A | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C77 | 6040 | INGA | SP. | FABACEAE | T | 12-Oct-90 | A | A |
| 1 | C69 | 6041 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 12-Oct-90 | A | A |
| 1 | C70 | 6042 | UNKNOWN | UNKNOWN | LILIACEAE | U | 12-Oct-90 | NF | NF |
| 1 | C70 | 6043 | UNKNOWN | UNKNOWN | LILIACEAE | U | 12-Oct-90 | NF | NF |
| 1 | C69 | 6044 | CHAMAEDOREA | MICROSPADIX | ARECACEAE | S | 12-Oct-90 | NF | NF |
| 1 | C70 | 6045 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | A | NF |
| 1 | C70 | 6046 | PHYTOLACCA | DIOICA | PHYTOLACCACEAE | T | 12-Oct-90 | A | A |
| 1 | C70 | 6047 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 12-Oct-90 | A | A |
| 1 | C70 | 6048 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 12-Oct-90 | NF | NF |
| 1 | C70 | 6049 | PACHIRA | AQUATICA | BOMBACACEAE | T | 12-Oct-90 | A | A |
| 1 | C70 | 6050 | CHAMAEDOREA | MICROSPADIX | ARECACEAE | S | 12-Oct-90 | NF | NF |
| 1 | C71 | 6051 | EUGENIA | AGGREGATA | MYRTACEAE | T | 12-Oct-90 | D | NF |
| 1 | C71 | 6052 | PACHIRA | AQUATICA | BOMBACACEAE | T | 12-Oct-90 | D | NF |
| 1 | C70 | 6053 | JESSENIA | BATAUA | ARECACEAE | P | 12-Oct-90 | NF | NF |
| 1 | C70 | 6054 | COLOCASIA | ESCULENTA | ARACEAE | H | 12-Oct-90 | A | A |
| 1 | C71 | 6055 | PHILLYREA | AUGUSTIFOLIA | OLEACEAE | T | 12-Oct-90 | D | NF |
| 1 | C71 | 6056 | PHYTOLACCA | DIOICA | PHYTOLACCACEAE | T | 12-Oct-90 | A | A |
| 1 | C70 | 6057 | JESSENIA | BATAUA | ARECACEAE | P | 12-Oct-90 | NF | NF |
| 1 | C71 | 6058 | PTEROCARPUS | INDICUS | FABACEAE | T | 12-Oct-90 | A | A |
| 1 | C71 | 6059 | PSYCHOTRIA | SP. | RUBIACEAE | T | 12-Oct-90 | A | A |
| 1 | C71 | 6060 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | A | NF |
| 1 | C64 | 6061 | PSIDIUM | GUAJAVA | MYRTACEAE | T | 12-Oct-90 | A | A |
| 1 | C64 | 6062 | PHYTOLACCA | DIOICA | PHYTOLACCACEAE | T | 12-Oct-90 | A | A |
| 1 | C64 | 6063 | CHAMAEDOREA | MICROSPADIX | ARECACEAE | S | 12-Oct-90 | NF | NF |
| 1 | C63 | 6064 | PACHIRA | AQUATICA | BOMBACACEAE | T | 12-Oct-90 | A | D |
| 1 | C63 | 6065 | HEIMIA | SALICIFOLIA | LYTHRACEAE | S | 12-Oct-90 | NF | D |
| 1 | C63 | 6066 | HEIMIA | SALICIFOLIA | LYTHRACEAE | S | 12-Oct-90 | NF | D |
| 1 | C70 | 6067 | CHAMAEDOREA | MICROSPADIX | ARECACEAE | S | 12-Oct-90 | NF | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C70 | 6068 | SYZYGIUM | JAMBOS | MYRTACEAE | T | 12-Oct-90 | A | D |
| 1 | C70 | 6069 | PACHIRA | AQUATICA | BOMBACACEAE | T | 12-Oct-90 | A | A |
| 1 | C70 | 6070 | COSTUS | SP. | ZINGIBERACEAE | H | 12-Oct-90 | A | A |
| 1 | C70 | 6071 | SPARTINA | SP. | POACEAE | R | 12-Oct-90 | NF | NF |
| 1 | C70 | 6072 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | NF | A |
| 1 | C70 | 6073 | PACHIRA | AQUATICA | BOMBACACEAE | T | 12-Oct-90 | A | A |
| 1 | C69 | 6074 | CURCUMA | DOMESTICA | ZINGIBERACEAE | H | 12-Oct-90 | NF | A |
| 1 | C83 | 6075 | COSTUS | SCABER | ZINGIBERACEAE | H | 12-Oct-90 | NF | A |
| 1 | C70 | 6076 | MAURITIA | FLEXUOSA | ARECACEAE | P | 12-Oct-90 | NF | NF |
| 1 | C70 | 6077 | PACHIRA | AQUATICA | BOMBACACEAE | T | 12-Oct-90 | A | A |
| 1 | C70 | 6078 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 12-Oct-90 | A | A |
| 1 | C70 | 6079 | PTEROCARPUS | INDICUS | FABACEAE | T | 12-Oct-90 | A | A |
| 1 | C70 | 6080 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | NF | NF |
| 1 | C69 | 6081 | PACHIRA | AQUATICA | BOMBACACEAE | T | 12-Oct-90 | A | A |
| 1 | C69 | 6082 | CHAMAEDOREA | MICROSPADIX | ARECACEAE | S | 12-Oct-90 | A | A |
| 1 | C69 | 6083 | DIEFFENBACHIA | SP. | ARACEAE | H | 12-Oct-90 | A | A |
| 1 | C69 | 6084 | SYZYGIUM | JAMBOS | MYRTACEAE | T | 12-Oct-90 | A | D |
| 1 | C62 | 6085 | EUGENIA | AGGREGATA | MYRTACEAE | T | 12-Oct-90 | NF | NF |
| 1 | C62 | 6086 | DIEFFENBACHIA | SP. | ARACEAE | H | 12-Oct-90 | A | NF |
| 1 | C83 | 6087 | PASSIFLORA | MALIFORMIS | PASSIFLORACEAE | C | 12-Oct-90 | NF | D |
| 1 | C63 | 6088 | MANGIFERA | INDICA | ANACARDIACEAE | T | 12-Oct-90 | A | D |
| 1 | C63 | 6089 | BIXA | ORELLANA | BIXACEAE | T | 12-Oct-90 | A | A |
| 1 | C63 | 6090 | PHYTOLACCA | DIOICA | PHYTOLACCACEAE | T | 12-Oct-90 | A | A |
| 1 | C70 | 6091 | SOCRATEA | EXORRHIZA | ARECACEAE | P | 12-Oct-90 | A | NF |
| 1 | C70 | 6092 | SPATHIPHYLLUM | SP. | ARACEAE | H | 12-Oct-90 | A | A |
| 1 | C70 | 6093 | SYZYGIUM | JAMBOS | MYRTACEAE | T | 12-Oct-90 | A | A |
| 1 | C70 | 6094 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | A | A |
| 1 | C70 | 6095 | JESSENIA | BATAUA | ARECACEAE | P | 12-Oct-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C69 | 6096 | GLOBBA | SP. | ZINGIBERACEAE | H | 12-Oct-90 | NF | NF |
| 1 | C69 | 6097 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | NF | NF |
| 1 | C70 | 6099 | SYZYGIUM | JAMBOS | MYRTACEAE | T | 12-Oct-90 | NF | NF |
| 1 | C76 | 6100 | PHYTOLACCA | DIOICA | PHYTOLACCACEAE | T | 12-Oct-90 | NF | NF |
| 1 | C76 | 6101 | MALPIGHIA | GLABRA | MALPIGHIACEAE | S | 12-Oct-90 | A | A |
| 1 | C76 | 6102 | TABEBUIA | HETEROPHYLLA | BIGNONIACEAE | T | 12-Oct-90 | A | NF |
| 1 | C76 | 6103 | MANILKARA | ZAPOTA | SAPOTACEAE | T | 12-Oct-90 | A | A |
| 1 | C76 | 6104 | ELAEAGNUS | PHILIPPENSIS | ELAEAGNACEAE | T | 12-Oct-90 | A | NF |
| 1 | C76 | 6105 | OENOCARPUS | BACABA | ARECACEAE | P | 12-Oct-90 | NF | NF |
| 1 | C76 | 6106 | BRUNFELSIA | UNDULATA | SOLANACEAE | S | 12-Oct-90 | A | A |
| 1 | C76 | 6107 | HEIMIA | SALICIFOLIA | LYTHRACEAE | S | 12-Oct-90 | D | NF |
| 1 | C76 | 6108 | DICHORISANDRA | THYRSIFLORA | COMMELINACEAE | H | 12-Oct-90 | A | NF |
| 1 | C76 | 6109 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | NF | D |
| 1 | C76 | 6110 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | NF | NF |
| 1 | C76 | 6111 | TABEBUIA | HETEROPHYLLA | BIGNONIACEAE | T | 12-Oct-90 | A | D |
| 1 | C76 | 6112 | GARCINIA | TINCTORIA | CLUSIACEAE | T | 12-Oct-90 | A | A |
| 1 | C76 | 6113 | HIBISCUS | ROSA-SINENSIS | MALVACEAE | S | 12-Oct-90 | A | A |
| 1 | C76 | 6114 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | NF | NF |
| 1 | C76 | 6115 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | NF | NF |
| 1 | C76 | 6116 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | NF | NF |
| 1 | C76 | 6117 | BACTRIS | GASIPAES | ARECACEAE | P | 12-Oct-90 | NF | NF |
| 1 | C77 | 6118 | BACTRIS | GASIPAES | ARECACEAE | P | 12-Oct-90 | NF | D |
| 1 | C76 | 6119 | PHILLYREA | AUGUSTIFOLIA | OLEACEAE | T | 12-Oct-90 | A | D |
| 1 | C76 | 6120 | COFFEA | ARABICA | RUBIACEAE | S | 12-Oct-90 | A | A |
| 1 | C76 | 6121 | DICHORISANDRA | THYRSIFLORA | COMMELINACEAE | H | 12-Oct-90 | | NF |
| 1 | C76 | 6122 | ALLAMANDA | CATHARTICA | APOCYNACEAE | S | 12-Oct-90 | A | A |
| 1 | C76 | 6123 | CEDRELA | SP. | MELIACEAE | T | 12-Oct-90 | A | D |
| 1 | C76 | 6124 | ASPARAGUS | DENSIFLORUS | ASPARAGACEAE | H | 12-Oct-90 | NF | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C77 | 6125 | SYZYGIUM | JAMBOS | MYRTACEAE | T | 12-Oct-90 | NF | D |
| 1 | C83 | 6126 | CISSUS | GONGYLODES | VITACEAE | C | 12-Oct-90 | A | A |
| 1 | C84 | 6127 | DICHORISANDRA | THYRSIFLORA | COMMELINACEAE | H | 12-Oct-90 | A | NF |
| 1 | C83 | 6128 | CALOPOGONIUM | MUCUNOIDES | FABACEAE | H | 12-Oct-90 | NF | D |
| 1 | C83 | 6129 | PTERIS | LONGIFOLIA | ADIANTACEAE | H | 12-Oct-90 | NF | D |
| 1 | C83 | 6130 | SCINDAPSUS | AUREUS | ARACEAE | C | 12-Oct-90 | NF | A |
| 1 | C83 | 6131 | PHILODENDRON | SP. | ARACEAE | C | 12-Oct-90 | A | A |
| 1 | C69 | 6132 | HELICONIA | BOURGAEANA | HELICONIACEAE | G | 12-Oct-90 | A | A |
| 1 | C76 | 6133 | RHAPIS | EXCELSA | ARECACEAE | P | 12-Oct-90 | NF | NF |
| 1 | C76 | 6134 | COSTUS | SP. | ZINGIBERACEAE | H | 12-Oct-90 | NF | |
| 1 | C76 | 6135 | UNKNOWN | UNKNOWN | UNKNOWN | U | 29-Oct-90 | NF | NF |
| 1 | C76 | 6136 | AVERRHOA | CARAMBOLA | OXALIDACEAE | T | 12-Oct-90 | NF | D |
| 1 | C76 | 6137 | AVERRHOA | CARAMBOLA | OXALIDACEAE | T | 12-Oct-90 | A | A |
| 1 | C76 | 6138 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 12-Oct-90 | NF | D |
| 1 | C76 | 6139 | COSTUS | SCABER | ZINGIBERACEAE | H | 12-Oct-90 | A | A |
| 1 | C76 | 6140 | CANNA | EDULIS | CANNACEAE | G | 12-Oct-90 | NF | NF |
| 1 | C76 | 6141 | PALISOTA | SCHWEINFURTHII | COMMELINACEAE | H | 12-Oct-90 | NF | NF |
| 1 | C76 | 6142 | ALEURITES | MOLUCCANA | EUPHORBIACEAE | T | 12-Oct-90 | A | D |
| 1 | C83 | 6143 | REBUTIA | SP. | CACTACEAE | E | 12-Oct-90 | NF | D |
| 1 | C83 | 6144 | ALEURITES | MOLUCCANA | EUPHORBIACEAE | T | 12-Oct-90 | A | A |
| 1 | C83 | 6145 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | NF | NF |
| 1 | C83 | 6146 | ALEURITES | MOLUCCANA | EUPHORBIACEAE | T | 12-Oct-90 | A | A |
| 1 | C83 | 6147 | PASSIFLORA | CORIACEA | PASSIFLORACEAE | C | 12-Oct-90 | NF | D |
| 1 | C83 | 6148 | UNKNOWN | UNKNOWN | FABACEAE | H | 12-Oct-90 | NF | D |
| 1 | C83 | 6149 | HELICONIA | LONGIFLORA | HELICONIACEAE | G | 12-Oct-90 | NF | D |
| 1 | C83 | 6150 | HELICONIA | SP. | HELICONIACEAE | G | 12-Oct-90 | NF | NF |
| 1 | C83 | 6151 | CURCUMA | ROSCOEANA | ZINGIBERACEAE | H | 12-Oct-90 | NF | D |
| 1 | C83 | 6152 | CURCUMA | ROSCOEANA | ZINGIBERACEAE | H | 12-Oct-90 | NF | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C76 | 6153 | GLOBBA | SP. | ZINGIBERACEAE | H | 12-Oct-90 | NF | NF |
| 1 | C83 | 6154 | CANNA | EDULIS | CANNACEAE | G | 12-Oct-90 | A | D |
| 1 | C83 | 6155 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 12-Oct-90 | A | A |
| 1 | C76 | 6156 | ZINGIBER | OFFICINALE | ZINGIBERACEAE | H | 12-Oct-90 | A | NF |
| 1 | C76 | 6157 | MUSA | SAPIENTUM | MUSACEAE | G | 12-Oct-90 | A | A |
| 1 | C76 | 6158 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 12-Oct-90 | A | NF |
| 1 | C76 | 6159 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 12-Oct-90 | A | NF |
| 1 | C75 | 6160 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 12-Oct-90 | A | NF |
| 1 | C76 | 6161 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 12-Oct-90 | A | A |
| 1 | C76 | 6162 | HELICONIA | LONGIFLORA | HELICONIACEAE | G | 12-Oct-90 | A | D |
| 1 | C76 | 6163 | ZINGIBER | OFFICINALE | ZINGIBERACEAE | H | 12-Oct-90 | A | NF |
| 1 | C76 | 6164 | CURCUMA | DOMESTICA | ZINGIBERACEAE | H | 12-Oct-90 | NF | NF |
| 1 | C69 | 6165 | ZINGIBER | OFFICINALE | ZINGIBERACEAE | H | 12-Oct-90 | NF | NF |
| 1 | C83 | 6166 | MUSA | SP. | MUSACEAE | G | 12-Oct-90 | NF | NF |
| 1 | C83 | 6167 | MALPIGHIA | GLABRA | MALPIGHIACEAE | S | 12-Oct-90 | NF | NF |
| 1 | C83 | 6168 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 12-Oct-90 | A | A |
| 1 | C83 | 6169 | GLOBBA | SP. | ZINGIBERACEAE | H | 12-Oct-90 | NF | NF |
| 1 | C83 | 6170 | BRUGMANSIA | SUAVEOLENS | SOLANACEAE | S | 12-Oct-90 | A | A |
| 1 | C83 | 6171 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 12-Oct-90 | A | A |
| 1 | C83 | 6172 | BRUGMANSIA | SUAVEOLENS | SOLANACEAE | S | 12-Oct-90 | A | A |
| 1 | C83 | 6173 | CANNA | EDULIS | CANNACEAE | G | 12-Oct-90 | NF | NF |
| 1 | C90 | 6174 | CURCUMA | DOMESTICA | ZINGIBERACEAE | H | 12-Oct-90 | | NF |
| 1 | C90 | 6175 | PASSIFLORA | MALIFORMIS | PASSIFLORACEAE | C | 12-Oct-90 | D | NF |
| 1 | C90 | 6176 | CANNA | EDULIS | CANNACEAE | G | 12-Oct-90 | A | A |
| 1 | C90 | 6177 | MUSA | SP. | MUSACEAE | G | 12-Oct-90 | A | A |
| 1 | C90 | 6178 | THALIA | GENICULATA | MARANTACEAE | H | 12-Oct-90 | D | NF |
| 1 | C90 | 6179 | MUSA | TEXTILIS | MUSACEAE | G | 12-Oct-90 | D | A |
| 1 | C90 | 6180 | MUSA | TEXTILIS | MUSACEAE | G | 12-Oct-90 | A | A |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C90 | 6181 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | NF | NF |
| 1 | C90 | 6182 | PASSIFLORA | EDULIS | PASSIFLORACEAE | C | 12-Oct-90 | D | NF |
| 1 | C90 | 6183 | CARICA | SP. | CARICACEAE | T | 12-Oct-90 | NF | NF |
| 1 | C90 | 6184 | CARICA | SP. | CARICACEAE | T | 12-Oct-90 | NF | NF |
| 1 | C91 | 6185 | HEDYCHIUM | SP. | ZINGIBERACEAE | G | 12-Oct-90 | A | A |
| 1 | C91 | 6186 | ZINGIBER | SPECTABILE | ZINGIBERACEAE | G | 12-Oct-90 | A | A |
| 1 | C91 | 6187 | HEDYCHIUM | CORNATUM | ZINGIBERACEAE | G | 12-Oct-90 | NF | A |
| 1 | C91 | 6188 | HEDYCHIUM | CORNATUM | ZINGIBERACEAE | G | 13-Oct-90 | A | A |
| 1 | C91 | 6189 | HEDYCHIUM | SP. | ZINGIBERACEAE | G | 13-Oct-90 | NF | NF |
| 1 | C91 | 6190 | SANCHEZIA | SPECIOSA | ACANTHACEAE | S | 13-Oct-90 | NF | D |
| 1 | C91 | 6191 | ZINGIBER | SPECTABILE | ZINGIBERACEAE | G | 13-Oct-90 | NF | D |
| 1 | C91 | 6192 | COSTUS | SP. | ZINGIBERACEAE | H | 13-Oct-90 | A | A |
| 1 | C92 | 6193 | UNKNOWN | UNKNOWN | UNKNOWN | U | 13-Oct-90 | NF | NF |
| 1 | C92 | 6194 | HELICONIA | CARIBAEA | HELICONIACEAE | G | 13-Oct-90 | A | A |
| 1 | C92 | 6195 | COSTUS | SP. | ZINGIBERACEAE | H | 13-Oct-90 | A | NF |
| 1 | C92 | 6196 | HELICONIA | SP. | HELICONIACEAE | G | 13-Oct-90 | NF | A |
| 1 | C92 | 6197 | UNKNOWN | UNKNOWN | UNKNOWN | U | 13-Oct-90 | A | D |
| 1 | C92 | 6198 | NORANTEA | GUIANENSIS | MARCGRAVIACEAE | C | 13-Oct-90 | NF | NF |
| 1 | C83 | 6199 | CURCUMA | DOMESTICA | ZINGIBERACEAE | H | 12-Oct-90 | NF | D |
| 1 | C91 | 6200 | PASSIFLORA | MALIFORMIS | PASSIFLORACEAE | C | 13-Oct-90 | NF | D |
| 1 | C91 | 6201 | BASELLA | ALBA | BASELLACEAE | C | 13-Oct-90 | NF | D |
| 1 | C92 | 6202 | CERATONIA | SILIQUA | FABACEAE | T | 13-Oct-90 | D | NF |
| 1 | C92 | 6203 | MUSA | SP. | MUSACEAE | G | 13-Oct-90 | A | A |
| 1 | C92 | 6204 | MUSA | SP. | MUSACEAE | G | 13-Oct-90 | NF | A |
| 1 | C92 | 6205 | MUSA | SP. | MUSACEAE | G | 13-Oct-90 | NF | A |
| 1 | C92 | 6206 | ALPINIA | SANDERAE | ZINGIBERACEAE | G | 13-Oct-90 | A | A |
| 1 | C93 | 6207 | ALPINIA | ZERUMBET | ZINGIBERACEAE | G | 13-Oct-90 | A | A |
| 1 | C93 | 6208 | UNKNOWN | UNKNOWN | UNKNOWN | U | 13-Oct-90 | NF | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C93 | 6209 | ROYSTONEA | REGIA | ARECACEAE | P | 13-Oct-90 | A | A |
| 1 | C92 | 6210 | ANANAS | SP. | BROMELIACEAE | H | 13-Oct-90 | NF | NF |
| 1 | C92 | 6211 | UNKNOWN | UNKNOWN | ASCLEPIADACEAE | U | 13-Oct-90 | A | NF |
| 1 | C92 | 6212 | PHYTOLACCA | DIOICA | PHYTOLACCACEAE | T | 13-Oct-90 | A | A |
| 1 | C92 | 6213 | CALOPOGONIUM | MUCUNOIDES | FABACEAE | H | 13-Oct-90 | NF | NF |
| 1 | C92 | 6214 | HELICONIA | BICOLOR | HELICONIACEAE | G | 13-Oct-90 | A | NF |
| 1 | C92 | 6215 | HELICONIA | BICOLOR | HELICONIACEAE | G | 13-Oct-90 | A | D |
| 1 | C92 | 6216 | PHYTOLACCA | DIOICA | PHYTOLACCACEAE | T | 13-Oct-90 | A | A |
| 1 | C92 | 6217 | ALPINIA | PURPURATA | ZINGIBERACEAE | G | 13-Oct-90 | A | A |
| 1 | C92 | 6218 | CALOPOGONIUM | MUCUNOIDES | FABACEAE | H | 13-Oct-90 | NF | NF |
| 1 | C92 | 6219 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 13-Oct-90 | NF | NF |
| 1 | C92 | 6220 | ANNONA | MURICATA | ANNONACEAE | T | 13-Oct-90 | NF | D |
| 1 | C92 | 6221 | UNKNOWN | UNKNOWN | ARACEAE | U | 13-Oct-90 | | NF |
| 1 | C92 | 6222 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 13-Oct-90 | A | A |
| 1 | C92 | 6223 | UNKNOWN | UNKNOWN | ARACEAE | U | 13-Oct-90 | | NF |
| 1 | C92 | 6224 | UNKNOWN | UNKNOWN | ARACEAE | U | 13-Oct-90 | | NF |
| 1 | C92 | 6225 | UNKNOWN | UNKNOWN | ARACEAE | U | 13-Oct-90 | | NF |
| 1 | C92 | 6226 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 13-Oct-90 | A | D |
| 1 | C92 | 6227 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 13-Oct-90 | D | NF |
| 1 | C92 | 6228 | MELIA | AZEDARACH | MELIACEAE | T | 13-Oct-90 | D | NF |
| 1 | C91 | 6229 | HEDYCHIUM | CORNATUM | ZINGIBERACEAE | G | 13-Oct-90 | A | D |
| 1 | C91 | 6230 | ANNONA | MURICATA | ANNONACEAE | T | 13-Oct-90 | A | D |
| 1 | C91 | 6231 | CORDIA | ALLIODORA | BORAGINACEAE | T | 13-Oct-90 | D | D |
| 1 | C91 | 6232 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 13-Oct-90 | NF | D |
| 1 | C91 | 6233 | BASELLA | ALBA | BASELLACEAE | C | 13-Oct-90 | NF | D |
| 1 | C91 | 6234 | COSTUS | SP. | ZINGIBERACEAE | H | 13-Oct-90 | NF | A |
| 1 | C91 | 6235 | COSTUS | SP. | ZINGIBERACEAE | H | 13-Oct-90 | A | A |
| 1 | C91 | 6236 | PASSIFLORA | MALIFORMIS | PASSIFLORACEAE | C | 13-Oct-90 | NF | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C91 | 6237 | HIBISCUS | ROSA-SINENSIS | MALVACEAE | S | 13-Oct-90 | A | D |
| 1 | C91 | 6238 | HEDYCHIUM | AURANTIACA | ZINGIBERACEAE | G | 13-Oct-90 | NF | NF |
| 1 | C91 | 6239 | BIXA | ORELLANA | BIXACEAE | T | 13-Oct-90 | A | D |
| 1 | C91 | 6240 | UNKNOWN | UNKNOWN | UNKNOWN | U | 13-Oct-90 | D | D |
| 1 | C91 | 6241 | ASPLENIUM | NIDUS | ASPLENIACEAE | E | 13-Oct-90 | D | D |
| 1 | C91 | 6242 | COSTUS | SP. | ZINGIBERACEAE | H | 12-Oct-90 | A | A |
| 1 | C91 | 6243 | CYATHEA | COOPERI | CYATHEACEAE | P | 12-Oct-90 | NF | NF |
| 1 | C91 | 6244 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 12-Oct-90 | NF | NF |
| 1 | C91 | 6245 | LEUCAENA | GLAUCA | FABACEAE | T | 12-Oct-90 | A | A |
| 1 | C91 | 6246 | PSIDIUM | GUAJAVA | MYRTACEAE | T | 12-Oct-90 | NF | D |
| 1 | C90 | 6247 | HELICONIA | SP. | HELICONIACEAE | G | 12-Oct-90 | NF | NF |
| 1 | C90 | 6248 | BASELLA | ALBA | BASELLACEAE | C | 12-Oct-90 | NF | NF |
| 1 | C90 | 6249 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 12-Oct-90 | A | D |
| 1 | C90 | 6250 | ALLAMANDA | CATHARTICA | APOCYNACEAE | S | 12-Oct-90 | NF | NF |
| 1 | C90 | 6251 | CARLUDOVICA | PALMATA | CYCLANTHACEAE | P | 12-Oct-90 | A | A |
| 1 | C84 | 6252 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 12-Oct-90 | A | A |
| 1 | C90 | 6253 | ANNONA | MURICATA | ANNONACEAE | T | 12-Oct-90 | A | NF |
| 1 | C90 | 6254 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 12-Oct-90 | A | A |
| 1 | C90 | 6255 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 12-Oct-90 | A | D |
| 1 | C90 | 6256 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 12-Oct-90 | A | NF |
| 1 | C90 | 6257 | PSIDIUM | GUAJAVA | MYRTACEAE | T | 12-Oct-90 | NF | NF |
| 1 | C90 | 6258 | COSTUS | GLOBOSUS | ZINGIBERACEAE | H | 12-Oct-90 | A | D |
| 1 | C90 | 6259 | BIXA | ORELLANA | BIXACEAE | T | 12-Oct-90 | D | NF |
| 1 | C90 | 6260 | PHILODENDRON | ANGUSTATUM | ARACEAE | C | 12-Oct-90 | NF | NF |
| 1 | C83 | 6261 | ANNONA | MURICATA | ANNONACEAE | T | 12-Oct-90 | A | A |
| 1 | C83 | 6262 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 12-Oct-90 | NF | D |
| 1 | C83 | 6263 | PERSEA | AMERICANA | LAURACEAE | T | 12-Oct-90 | D | D |
| 1 | C83 | 6264 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C83 | 6265 | CRESCENTIA | CUJETE | BIGNONIACEAE | T | 12-Oct-90 | A | A |
| 1 | C83 | 6266 | CARICA | PENTAGONA | CARICACEAE | T | 12-Oct-90 | NF | D |
| 1 | C83 | 6267 | CARLUDOVICA | PALMATA | CYCLANTHACEAE | P | 12-Oct-90 | A | A |
| 1 | C83 | 6268 | HYMENAEA | COURBARIL | FABACEAE | T | 12-Oct-90 | NF | D |
| 1 | C83 | 6269 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 12-Oct-90 | NF | D |
| 1 | C83 | 6270 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 12-Oct-90 | NF | D |
| 1 | C83 | 6271 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | NF | D |
| 1 | C83 | 6272 | ALLAMANDA | CATHARTICA | APOCYNACEAE | S | 12-Oct-90 | NF | NF |
| 1 | C83 | 6273 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | NF | NF |
| 1 | C83 | 6274 | TIBOUCHINA | INTEROMALLA | MELASTOMATACEAE | S | 12-Oct-90 | NF | D |
| 1 | C83 | 6275 | HEIMIA | SALICIFOLIA | LYTHRACEAE | S | 12-Oct-90 | NF | NF |
| 1 | C83 | 6276 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | NF | NF |
| 1 | C83 | 6277 | CARICA | PENTAGONA | CARICACEAE | T | 12-Oct-90 | NF | D |
| 1 | C83 | 6278 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 12-Oct-90 | A | D |
| 1 | C83 | 6279 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | NF | D |
| 1 | C83 | 6280 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 12-Oct-90 | A | D |
| 1 | C83 | 6281 | CEDRELA | SP. | MELIACEAE | T | 12-Oct-90 | A | A |
| 1 | C83 | 6282 | BUCHENAVIA | CAPITATA | COMBRETACEAE | T | 12-Oct-90 | NF | D |
| 1 | C83 | 6283 | CASIMIROA | EDULIS | RUTACEAE | T | 12-Oct-90 | D | D |
| 1 | C83 | 6284 | WITHANIA | SOMNIFERA | SOLANACEAE | S | 12-Oct-90 | NF | NF |
| 1 | C83 | 6285 | DERRIS | ELLIPTICA | FABACEAE | C | 12-Oct-90 | A | A |
| 1 | C83 | 6286 | MUSA | PARADISIACA | MUSACEAE | G | 12-Oct-90 | A | A |
| 1 | C83 | 6287 | MELIA | AZEDARACH | MELIACEAE | T | 12-Oct-90 | A | A |
| 1 | C83 | 6288 | UNKNOWN | UNKNOWN | UNKNOWN | U | 12-Oct-90 | A | A |
| 1 | C83 | 6289 | MUSA | PARADISIACA | MUSACEAE | G | 12-Oct-90 | A | A |
| 1 | C93 | 6290 | SANCHEZIA | SPECIOSA | ACANTHACEAE | S | 12-Oct-90 | A | D |
| 1 | C83 | 6291 | MELIA | AZEDARACH | MELIACEAE | T | 12-Oct-90 | A | A |
| 1 | C83 | 6292 | BAUHINIA | SP. | FABACEAE | T | 12-Oct-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C83 | 6293 | PERSEA | AMERICANA | LAURACEAE | T | 12-Oct-90 | A | A |
| 1 | C83 | 6294 | PHILODENDRON | ANGUSTATUM | ARACEAE | C | 12-Oct-90 | NF | A |
| 1 | C84 | 6295 | GNETUM | SP. | GNETACEAE | T | 12-Oct-90 | NF | NF |
| 1 | C84 | 6296 | ANNONA | MURICATA | ANNONACEAE | T | 12-Oct-90 | A | A |
| 1 | C84 | 6297 | CYATHEA | ARBOREA | CYATHEACEAE | P | 12-Oct-90 | NF | NF |
| 1 | C84 | 6298 | INGA | SP. | FABACEAE | T | 12-Oct-90 | A | A |
| 1 | C84 | 6299 | CALLISIA | FRAGRANS | COMMELINACEAE | H | 12-Oct-90 | NF | F |
| 1 | C84 | 6300 | CALLISIA | FRAGRANS | COMMELINACEAE | H | 12-Oct-90 | NF | NF |
| 1 | C77 | 6301 | UNKNOWN | UNKNOWN | FABACEAE | H | 12-Oct-90 | NF | D |
| 1 | C84 | 6302 | MARCGRAVIA | RECTIFLORA | MARCGRAVIACEAE | C | 13-Oct-90 | NF | NF |
| 1 | C84 | 6303 | CRESCENTIA | CUJETE | BIGNONIACEAE | T | 13-Oct-90 | A | A |
| 1 | C84 | 6304 | UNKNOWN | UNKNOWN | UNKNOWN | U | 13-Oct-90 | NF | NF |
| 1 | C84 | 6305 | CNEMIDARIA | HORRIDA | CYATHEACEAE | P | 13-Oct-90 | NF | NF |
| 1 | C84 | 6306 | UNKNOWN | UNKNOWN | UNKNOWN | U | 13-Oct-90 | NF | NF |
| 1 | C84 | 6307 | BEGONIA | SP. | BEGONIACEAE | H | 13-Oct-90 | NF | NF |
| 1 | C91 | 6308 | LEUCAENA | GLAUCA | FABACEAE | T | 13-Oct-90 | A | A |
| 1 | C85 | 6309 | UNKNOWN | UNKNOWN | UNKNOWN | U | 13-Oct-90 | NF | D |
| 1 | C85 | 6310 | BASELLA | ALBA | BASELLACEAE | C | 13-Oct-90 | NF | NF |
| 1 | C92 | 6311 | HIBISCUS | ROSA-SINENSIS | MALVACEAE | S | 13-Oct-90 | A | A |
| 1 | C92 | 6312 | CLITORIA | RACEMOSA | FABACEAE | T | 13-Oct-90 | A | A |
| 1 | C92 | 6313 | HEIMIA | SALICIFOLIA | LYTHRACEAE | S | 13-Oct-90 | NF | NF |
| 1 | C92 | 6314 | PHILODENDRON | CV 'WEND-IMBE' | ARACEAE | C | 13-Oct-90 | A | A |
| 1 | C85 | 6315 | UNKNOWN | UNKNOWN | UNKNOWN | U | 14-Oct-90 | A | NF |
| 1 | C85 | 6316 | UNKNOWN | UNKNOWN | UNKNOWN | U | 14-Oct-90 | A | A |
| 1 | C85 | 6317 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 14-Oct-90 | NF | D |
| 1 | C85 | 6318 | MAURITIA | FLEXUOSA | ARECACEAE | P | 14-Oct-90 | NF | NF |
| 1 | C85 | 6319 | CAJANUS | CAJAN | FABACEAE | H | 14-Oct-90 | NF | D |
| 1 | C85 | 6320 | BRUGMANSIA | SUAVEOLENS | SOLANACEAE | S | 14-Oct-90 | A | A |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C85 | 6321 | MAURITIA | FLEXUOSA | ARECACEAE | P | 14-Oct-90 | NF | NF |
| 1 | C85 | 6322 | UNKNOWN | UNKNOWN | UNKNOWN | U | 14-Oct-90 | NF | NF |
| 1 | C85 | 6323 | MAURITIA | FLEXUOSA | ARECACEAE | P | 14-Oct-90 | NF | NF |
| 1 | C92 | 6324 | ROYSTONEA | REGIA | ARECACEAE | P | 14-Oct-90 | A | A |
| 1 | C86 | 6325 | LEUCAENA | GLAUCA | FABACEAE | T | 14-Oct-90 | A | D |
| 1 | C86 | 6326 | PHILODENDRON | RUBENS | ARACEAE | C | 14-Oct-90 | A | A |
| 1 | C86 | 6327 | UNKNOWN | UNKNOWN | UNKNOWN | U | 14-Oct-90 | NF | NF |
| 1 | C93 | 6328 | UNKNOWN | UNKNOWN | UNKNOWN | U | 14-Oct-90 | NF | D |
| 1 | C93 | 6329 | PHILODENDRON | GRAZIELAE | ARACEAE | C | 14-Oct-90 | NF | D |
| 1 | C93 | 6330 | PERSEA | AMERICANA | LAURACEAE | T | 14-Oct-90 | NF | D |
| 1 | C93 | 6331 | ROYSTONEA | REGIA | ARECACEAE | P | 14-Oct-90 | A | A |
| 1 | C93 | 6332 | CARICA | PAPAYA | CARICACEAE | T | 14-Oct-90 | NF | D |
| 1 | C93 | 6333 | CALOPOGONIUM | MUCUNOIDES | FABACEAE | H | 14-Oct-90 | NF | D |
| 1 | C86 | 6334 | DIOSCOREA | ALATA | DIOSCOREACEAE | C | 14-Oct-90 | NF | NF |
| 1 | C86 | 6335 | CARICA | PAPAYA | CARICACEAE | T | 14-Oct-90 | NF | NF |
| 1 | C86 | 6336 | EPHEDRA | SP. | EPHEDRACEAE | S | 14-Oct-90 | NF | NF |
| 1 | C86 | 6337 | BRUGMANSIA | SUAVEOLENS | SOLANACEAE | S | 14-Oct-90 | A | A |
| 1 | C86 | 6338 | ANNONA | MURICATA | ANNONACEAE | T | 14-Oct-90 | A | NF |
| 1 | C86 | 6339 | CEIBA | PENTANDRA | BOMBACACEAE | T | 14-Oct-90 | A | A |
| 1 | C86 | 6340 | CALOPOGONIUM | MUCUNOIDES | FABACEAE | H | 14-Oct-90 | NF | NF |
| 1 | C86 | 6341 | UNKNOWN | UNKNOWN | ASCLEPIADACEAE | U | 14-Oct-90 | NF | NF |
| 1 | C86 | 6342 | UNKNOWN | UNKNOWN | UNKNOWN | U | 14-Oct-90 | NF | NF |
| 1 | C86 | 6343 | UNKNOWN | UNKNOWN | UNKNOWN | U | 14-Oct-90 | NF | NF |
| 1 | C86 | 6344 | PHILODENDRON | RUBENS | ARACEAE | C | 14-Oct-90 | A | D |
| 1 | C86 | 6345 | ANNONA | MURICATA | ANNONACEAE | T | 14-Oct-90 | A | D |
| 1 | C86 | 6346 | PHILODENDRON | ANGUSTATUM | ARACEAE | C | 14-Oct-90 | NF | NF |
| 1 | C86 | 6347 | ANNONA | MURICATA | ANNONACEAE | T | 14-Oct-90 | A | D |
| 1 | C86 | 6348 | PHILODENDRON | GRAZIELAE | ARACEAE | C | 14-Oct-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C93 | 6349 | UNKNOWN | UNKNOWN | UNKNOWN | U | 14-Oct-90 | NF | D |
| 1 | C93 | 6350 | PHILODENDRON | ANGUSTATUM | ARACEAE | C | 14-Oct-90 | NF | D |
| 1 | C93 | 6351 | UNKNOWN | UNKNOWN | ASCLEPIADACEAE | U | 14-Oct-90 | NF | D |
| 1 | C93 | 6352 | CARICA | PAPAYA | CARICACEAE | T | 14-Oct-90 | NF | D |
| 1 | C93 | 6353 | DICHORISANDRA | THYRSIFLORA | COMMELINACEAE | H | 14-Oct-90 |  | D |
| 1 | C93 | 6354 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 14-Oct-90 | NF | D |
| 1 | C93 | 6355 | OENOCARPUS | BACABA | ARECACEAE | P | 14-Oct-90 | A | A |
| 1 | C93 | 6356 | SANCHEZIA | SPECIOSA | ACANTHACEAE | S | 14-Oct-90 | NF | A |
| 1 | C93 | 6357 | ENTEROLOBIUM | CYCLOCARPUM | FABACEAE | T | 14-Oct-90 | A | A |
| 1 | C93 | 6358 | CLITORIA | RACEMOSA | FABACEAE | T | 14-Oct-90 | A | D |
| 1 | C93 | 6359 | ANACARDIUM | OCCIDENTALE | ANACARDIACEAE | T | 14-Oct-90 | A | D |
| 1 | C86 | 6360 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 14-Oct-90 | NF | NF |
| 1 | C86 | 6361 | ZAMIOCULCAS | ZAMIIFOLIA | ARACEAE | H | 14-Oct-90 | A | A |
| 1 | C93 | 6362 | CERATONIA | SILIQUA | FABACEAE | T | 14-Oct-90 | NF | D |
| 1 | C93 | 6363 | BRUNFELSIA | UNDULATA | SOLANACEAE | S | 14-Oct-90 | D | D |
| 1 | C94 | 6364 | MANGIFERA | INDICA | ANACARDIACEAE | T | 14-Oct-90 | D | NF |
| 1 | C94 | 6365 | UNKNOWN | UNKNOWN | UNKNOWN | U | 14-Oct-90 | NF | NF |
| 1 | C86 | 6366 | ASPLENIUM | NIDUS | ASPLENIACEAE | E | 14-Oct-90 | A | D |
| 1 | C86 | 6367 | PERSEA | AMERICANA | LAURACEAE | T | 14-Oct-90 | A | NF |
| 1 | C86 | 6368 | ASPLENIUM | NIDUS | ASPLENIACEAE | E | 14-Oct-90 | NF | NF |
| 1 | C87 | 6369 | PSIDIUM | GUAJAVA | MYRTACEAE | T | 14-Oct-90 | D | D |
| 1 | C86 | 6370 | CEIBA | PENTANDRA | BOMBACACEAE | T | 14-Oct-90 | A | A |
| 1 | C86 | 6371 | PHILODENDRON | SELLOUM | ARACEAE | C | 14-Oct-90 | A | D |
| 1 | C86 | 6372 | PTERIS | CRETICA | ADIANTACEAE | H | 14-Oct-90 | NF | NF |
| 1 | C87 | 6373 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 14-Oct-90 | A | A |
| 1 | C87 | 6374 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 14-Oct-90 | A | A |
| 1 | C87 | 6375 | PITHECOCTENIUM | SP. | BIGNONIACEAE | C | 14-Oct-90 | A | D |
| 1 | C87 | 6376 | POGOSTEMON | HEYNEANUS | LAMIACEAE | S | 14-Oct-90 | NF | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C86 | 6377 | PTERIS | CRETICA | ADIANTACEAE | H | 14-Oct-90 | NF | D |
| 1 | C86 | 6378 | CLITORIA | RACEMOSA | FABACEAE | T | 15-Oct-90 | A | A |
| 1 | C86 | 6379 | CHAMAEDOREA | MICROSPADIX | ARECACEAE | S | 15-Oct-90 | A | A |
| 1 | C86 | 6380 | UNKNOWN | UNKNOWN | ARECACEAE | P | 15-Oct-90 | A | A |
| 1 | C86 | 6381 | PHILODENDRON | CV 'WEND-IMBE' | ARACEAE | C | 15-Oct-90 | A | A |
| 1 | C86 | 6382 | UNKNOWN | UNKNOWN | FABACEAE | H | 15-Oct-90 | A | D |
| 1 | C87 | 6383 | CHAMAEDOREA | MICROSPADIX | ARECACEAE | S | 15-Oct-90 | A | A |
| 1 | C86 | 6384 | PANICUM | SP. | POACEAE | R | 15-Oct-90 | NF | NF |
| 1 | C86 | 6385 | AVERRHOA | CARAMBOLA | OXALIDACEAE | T | 15-Oct-90 | D | NF |
| 1 | C87 | 6386 | CYATHEA | COOPERI | CYATHEACEAE | P | 15-Oct-90 | D | D |
| 1 | C87 | 6387 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 15-Oct-90 | A | A |
| 1 | C87 | 6388 | HAMELIA | PATENS | RUBIACEAE | S | 15-Oct-90 | D | D |
| 1 | C87 | 6389 | UNKNOWN | UNKNOWN | FABACEAE | H | 15-Oct-90 | A | NF |
| 1 | C84 | 6390 | CHAMAEDOREA | MICROSPADIX | ARECACEAE | S | 15-Oct-90 | NF | NF |
| 1 | C87 | 6391 | PERSEA | AMERICANA | LAURACEAE | T | 15-Oct-90 | A | A |
| 1 | C87 | 6392 | POGOSTEMON | CABLIN | LAMIACEAE | S | 15-Oct-90 | NF | NF |
| 1 | C87 | 6393 | CECROPIA | SCHREBERIANA | CECROPIACEAE | T | 15-Oct-90 | A | A |
| 1 | C87 | 6394 | PERSEA | AMERICANA | LAURACEAE | T | 15-Oct-90 | NF | NF |
| 1 | C87 | 6395 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | A | NF |
| 1 | C87 | 6396 | BAUHINIA | SP. | FABACEAE | S | 15-Oct-90 | NF | NF |
| 1 | C87 | 6397 | ARENGA | PINNATA | ARECACEAE | P | 15-Oct-90 | A | A |
| 1 | C87 | 6398 | PRUNUS | TOMENTOSA | ROSACEAE | T | 15-Oct-90 | NF | NF |
| 1 | C87 | 6399 | LEUCAENA | GLAUCA | FABACEAE | T | 15-Oct-90 | A | D |
| 1 | C87 | 6400 | ARENGA | PINNATA | ARECACEAE | P | 15-Oct-90 | A | A |
| 1 | C94 | 6401 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | D | NF |
| 1 | C94 | 6402 | ASPLENIUM | NIDUS | ASPLENIACEAE | E | 15-Oct-90 | NF | NF |
| 1 | C94 | 6403 | SANCHEZIA | SPECIOSA | ACANTHACEAE | S | 15-Oct-90 | A | A |
| 1 | C94 | 6404 | ROLLINIA | MUCOSA | ANNONACEAE | T | 15-Oct-90 | A | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C94 | 6405 | PEPEROMIA | SP. | PIPERACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C94 | 6406 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 15-Oct-90 | A | A |
| 1 | C94 | 6407 | ALPINIA | PURPURATA | ZINGIBERACEAE | G | 15-Oct-90 | A | A |
| 1 | C94 | 6408 | HELICONIA | PSITTACORUM | HELICONIACEAE | G | 15-Oct-90 | A | D |
| 1 | C94 | 6409 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | A | A |
| 1 | C93 | 6410 | ROLLINIA | MUCOSA | ANNONACEAE | T | 15-Oct-90 | A | D |
| 1 | C94 | 6411 | CALATHEA | ZEBRINA | MARANTACEAE | H | 15-Oct-90 | A | NF |
| 1 | C94 | 6412 | ALPINIA | SANDERAE | ZINGIBERACEAE | G | 15-Oct-90 | NF | NF |
| 1 | C93 | 6413 | CALATHEA | PANAMENSIS | MARANTACEAE | H | 15-Oct-90 | A | A |
| 1 | C93 | 6414 | ALPINIA | ZERUMBET | ZINGIBERACEAE | G | 15-Oct-90 | A | A |
| 1 | C93 | 6415 | UNKNOWN | UNKNOWN | MARANTACEAE | | 15-Oct-90 | NF | D |
| 1 | C93 | 6416 | UNKNOWN | UNKNOWN | MARANTACEAE | H | 15-Oct-90 | A | A |
| 1 | C93 | 6417 | HELICONIA | BICOLOR | HELICONIACEAE | G | 15-Oct-90 | NF | D |
| 1 | C93 | 6418 | CALATHEA | PANAMENSIS | MARANTACEAE | H | 15-Oct-90 | A | A |
| 1 | C93 | 6419 | CALATHEA | PANAMENSIS | MARANTACEAE | H | 15-Oct-90 | A | A |
| 1 | C93 | 6420 | UNKNOWN | UNKNOWN | MARANTACEAE | | 15-Oct-90 | A | D |
| 1 | C93 | 6421 | COSTUS | SP. | ZINGIBERACEAE | H | 15-Oct-90 | A | A |
| 1 | C93 | 6422 | RENEALMIA | BATTENBERGIANA | ZINGIBERACEAE | H | 15-Oct-90 | NF | D |
| 1 | C93 | 6423 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 15-Oct-90 | NF | D |
| 1 | C93 | 6424 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | A | D |
| 1 | C93 | 6425 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 15-Oct-90 | NF | D |
| 1 | C93 | 6426 | CANNA | INDICA | CANNACEAE | G | 15-Oct-90 | NF | D |
| 1 | C93 | 6427 | MUSA | TEXTILIS | MUSACEAE | G | 15-Oct-90 | A | A |
| 1 | C93 | 6428 | PHILODENDRON | SP. | ARACEAE | C | 15-Oct-90 | A | D |
| 1 | C94 | 6429 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C94 | 6430 | LYCIANTHES | RANTONNETII | SOLANACEAE | S | 15-Oct-90 | A | A |
| 1 | C94 | 6431 | CALOPOGONIUM | MUCUNOIDES | FABACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C94 | 6432 | RENEALMIA | ALPINIA | ZINGIBERACEAE | G | 15-Oct-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C94 | 6433 | PASSIFLORA | EDULIS | PASSIFLORACEAE | C | 15-Oct-90 | NF | NF |
| 1 | C94 | 6434 | COUROUPITA | GUIANENSIS | LECYTHIDACEAE | T | 15-Oct-90 | A | A |
| 1 | C94 | 6435 | KAEMPFERIA | ROTUNDA | ZINGIBERACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C94 | 6436 | CANNA | INDICA | CANNACEAE | G | 15-Oct-90 | NF | NF |
| 1 | C94 | 6437 | ZAMIOCULCAS | ZAMIIFOLIA | ARACEAE | H | 15-Oct-90 | A | A |
| 1 | C94 | 6438 | CALOPOGONIUM | MUCUNOIDES | FABACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C94 | 6439 | MANILKARA | ZAPOTA | SAPOTACEAE | T | 15-Oct-90 | NF | NF |
| 1 | C94 | 6440 | ARENGA | PINNATA | ARECACEAE | P | 15-Oct-90 | A | A |
| 1 | C94 | 6441 | OENOCARPUS | MAPORA | ARECACEAE | P | 15-Oct-90 | A | NF |
| 1 | C94 | 6442 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | D | NF |
| 1 | C94 | 6443 | RICINUS | COMMUNIS | EUPHORBIACEAE | T | 15-Oct-90 | A | NF |
| 1 | C94 | 6444 | ILEX | PARAGUARIENSIS | AQUIFOLIACEAE | T | 15-Oct-90 | NF | NF |
| 1 | C94 | 6445 | HYDROCOTYLE | ASIATICA | APIACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C94 | 6446 | ANTHURIUM | DIGITATUM | ARACEAE | H | 15-Oct-90 | A | A |
| 1 | C94 | 6447 | COMMELINA | TUBEROSA | COMMELINACEAE | H | 15-Oct-90 | | NF |
| 1 | C94 | 6448 | AVERRHOA | CARAMBOLA | OXALIDACEAE | T | 15-Oct-90 | A | A |
| 1 | C94 | 6449 | ARENGA | PINNATA | ARECACEAE | P | 15-Oct-90 | A | A |
| 1 | C94 | 6450 | CEIBA | PENTANDRA | BOMBACACEAE | T | 15-Oct-90 | A | A |
| 1 | C94 | 6451 | MAURITIA | FLEXUOSA | ARECACEAE | P | 15-Oct-90 | A | A |
| 1 | C94 | 6452 | ANNONA | SP. | ANNONACEAE | T | 15-Oct-90 | NF | NF |
| 1 | C94 | 6453 | CEDRELA | SP. | MELIACEAE | T | 15-Oct-90 | A | A |
| 1 | C94 | 6454 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | A | D |
| 1 | C94 | 6455 | COMMELINA | TUBEROSA | COMMELINACEAE | H | 15-Oct-90 | | NF |
| 1 | C95 | 6456 | COSTUS | ELATUS | ZINGIBERACEAE | H | 15-Oct-90 | NF | D |
| 1 | C95 | 6457 | CARICA | PENTAGONA | CARICACEAE | T | 15-Oct-90 | NF | NF |
| 1 | C95 | 6458 | HELICONIA | SP. | HELICONIACEAE | G | 15-Oct-90 | A | A |
| 1 | C95 | 6459 | PIPER | NIGRUM | PIPERACEAE | C | 15-Oct-90 | NF | D |
| 1 | C95 | 6460 | BIXA | ORELLANA | BIXACEAE | T | 15-Oct-90 | A | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C95 | 6461 | CARICA | PENTAGONA | CARICACEAE | T | 15-Oct-90 | NF | NF |
| 1 | C95 | 6462 | PHOENIX | ROEBELENII | ARECACEAE | P | 15-Oct-90 | A | A |
| 1 | C95 | 6463 | CALOPOGONIUM | MUCUNOIDES | FABACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C95 | 6464 | COSTUS | ELATUS | ZINGIBERACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C95 | 6465 | BIXA | ORELLANA | BIXACEAE | T | 15-Oct-90 | A | D |
| 1 | C95 | 6466 | KAEMPFERIA | ELEGANS | ZINGIBERACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C95 | 6467 | CINNAMOMUM | ZEYLANICUM | LAURACEAE | T | 15-Oct-90 | A | A |
| 1 | C95 | 6468 | CYATHEA | COOPERI | CYATHEACEAE | P | 15-Oct-90 | NF | NF |
| 1 | C95 | 6469 | CALOPOGONIUM | MUCUNOIDES | FABACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C87 | 6470 | PTERIS | CRETICA | ADIANTACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C88 | 6471 | BACTRIS | GASIPAES | ARECACEAE | P | 15-Oct-90 | A | NF |
| 1 | C88 | 6472 | UNKNOWN | UNKNOWN | ASCLEPIADACEAE | U | 15-Oct-90 | A | A |
| 1 | C88 | 6473 | UNKNOWN | UNKNOWN | ASCLEPIADACEAE | U | 15-Oct-90 | A | A |
| 1 | C88 | 6474 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C88 | 6475 | PITHECOCTENIUM | SP. | BIGNONIACEAE | C | 15-Oct-90 | A | D |
| 1 | C88 | 6476 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C88 | 6477 | HYDROCOTYLE | ASIATICA | APIACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C88 | 6478 | PASSIFLORA | CORIACEA | PASSIFLORACEAE | C | 15-Oct-90 | A | NF |
| 1 | C88 | 6479 | CALOPOGONIUM | MUCUNOIDES | FABACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C88 | 6480 | PASSIFLORA | EDULIS | PASSIFLORACEAE | C | 15-Oct-90 | A | NF |
| 1 | C88 | 6481 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 15-Oct-90 | A | A |
| 1 | C88 | 6482 | KAEMPFERIA | ROTUNDA | ZINGIBERACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C88 | 6483 | ALPINIA | ZERUMBET | ZINGIBERACEAE | G | 15-Oct-90 | A | A |
| 1 | C88 | 6484 | DIOSCOREA | ALATA | DIOSCOREACEAE | C | 15-Oct-90 | NF | A |
| 1 | C95 | 6485 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 15-Oct-90 | NF | NF |
| 1 | C95 | 6486 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C95 | 6487 | HYDROCOTYLE | ASIATICA | APIACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C95 | 6488 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 15-Oct-90 | A | A |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C95 | 6489 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 15-Oct-90 | A | A |
| 1 | C95 | 6490 | MANIHOT | ESCULENTA | EUPHORBIACEAE | S | 15-Oct-90 | A | A |
| 1 | C95 | 6491 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 15-Oct-90 | A | A |
| 1 | C95 | 6492 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C95 | 6493 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 15-Oct-90 | A | A |
| 1 | C95 | 6494 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 15-Oct-90 | A | A |
| 1 | C95 | 6495 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C95 | 6496 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 15-Oct-90 | A | A |
| 1 | C95 | 6497 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C95 | 6498 | BRUGMANSIA | SUAVEOLENS | SOLANACEAE | S | 15-Oct-90 | A | A |
| 1 | C95 | 6499 | BRUGMANSIA | SUAVEOLENS | SOLANACEAE | S | 15-Oct-90 | A | A |
| 1 | C88 | 6500 | HELICONIA | LONGIFLORA | HELICONIACEAE | G | 15-Oct-90 | A | NF |
| 1 | C88 | 6501 | PASSIFLORA | MALIFORMIS | PASSIFLORACEAE | C | 15-Oct-90 | NF | NF |
| 1 | C88 | 6502 | CALOPOGONIUM | MUCUNOIDES | FABACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C88 | 6503 | MUSA | SP. | MUSACEAE | G | 15-Oct-90 | D | NF |
| 1 | C88 | 6504 | ALPINIA | ZERUMBET | ZINGIBERACEAE | G | 15-Oct-90 | A | A |
| 1 | C88 | 6505 | HELICONIA | CARIBAEA | HELICONIACEAE | G | 15-Oct-90 | A | A |
| 1 | C88 | 6506 | CATHARANTHUS | ROSEUS | APOCYNACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C88 | 6507 | PITHECOCTENIUM | SP. | BIGNONIACEAE | C | 15-Oct-90 | D | NF |
| 1 | C88 | 6508 | PTERIS | LONGIFOLIA | ADIANTACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C88 | 6509 | ALPINIA | ZERUMBET | ZINGIBERACEAE | G | 15-Oct-90 | A | A |
| 1 | C87 | 6510 | CHRYSALIDOCARPUS | LUTESCENS | ARECACEAE | S | 18-Oct-90 | D | D |
| 1 | C88 | 6511 | MONSTERA | DELICIOSA | ARACEAE | C | 15-Oct-90 | A | NF |
| 1 | C87 | 6512 | LEUCAENA | GLAUCA | FABACEAE | T | 18-Oct-90 | A | D |
| 1 | C87 | 6513 | CALOPOGONIUM | MUCUNOIDES | FABACEAE | H | 18-Oct-90 | NF | NF |
| 1 | C87 | 6514 | PTERIS | CRETICA | ADIANTACEAE | H | 18-Oct-90 | NF | NF |
| 1 | C87 | 6515 | SANCHEZIA | SPECIOSA | ACANTHACEAE | S | 18-Oct-90 | A | D |
| 1 | C87 | 6516 | PERSEA | AMERICANA | LAURACEAE | T | 18-Oct-90 | NF | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C87 | 6517 | PERSEA | AMERICANA | LAURACEAE | T | 18-Oct-90 | NF | D |
| 1 | C87 | 6518 | DILLENIA | INDICA | DILLENIACEAE | T | 18-Oct-90 | NF | D |
| 1 | C87 | 6519 | UNKNOWN | UNKNOWN | UNKNOWN | U | 18-Oct-90 | A | NF |
| 1 | C87 | 6520 | MONSTERA | DELICIOSA | ARACEAE | C | 18-Oct-90 | A | NF |
| 1 | C87 | 6521 | PSIDIUM | GUAJAVA | MYRTACEAE | T | 18-Oct-90 | D | D |
| 1 | C87 | 6522 | SANCHEZIA | SPECIOSA | ACANTHACEAE | S | 15-Oct-90 | A | A |
| 1 | C87 | 6523 | MALPIGHIA | EMARGINATA | MALPIGHIACEAE | T | 15-Oct-90 | A | D |
| 1 | C87 | 6524 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C87 | 6525 | QUASSIA | AMARA | SIMAROUBACEAE | S | 15-Oct-90 | NF | NF |
| 1 | C87 | 6526 | PANICUM | SP. | POACEAE | R | 15-Oct-90 | NF | D |
| 1 | C87 | 6527 | LEUCAENA | LEUCOCEPHALA | FABACEAE | T | 15-Oct-90 | A | D |
| 1 | C87 | 6528 | ETLINGERA | ELATIOR | ZINGIBERACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C88 | 6529 | ETLINGERA | ELATIOR | ZINGIBERACEAE | H | 15-Oct-90 | A | NF |
| 1 | C88 | 6530 | CECROPIA | SCHREBERIANA | CECROPIACEAE | T | 15-Oct-90 | A | A |
| 1 | C88 | 6531 | MUSA | SP. | MUSACEAE | G | 15-Oct-90 | A | D |
| 1 | C88 | 6532 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C88 | 6533 | PERSEA | AMERICANA | LAURACEAE | T | 15-Oct-90 | NF | D |
| 1 | C81 | 6534 | LEUCAENA | GLAUCA | FABACEAE | T | 15-Oct-90 | A | D |
| 1 | C88 | 6535 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 15-Oct-90 | NF | D |
| 1 | C88 | 6536 | CANNA | EDULIS | CANNACEAE | G | 15-Oct-90 | NF | A |
| 1 | C81 | 6537 | HELICONIA | SP. | HELICONIACEAE | G | 15-Oct-90 | A | A |
| 1 | C81 | 6538 | MUSA | SP. | MUSACEAE | G | 15-Oct-90 | A | A |
| 1 | C81 | 6539 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 15-Oct-90 | NF | D |
| 1 | C81 | 6540 | MUSA | SP. | MUSACEAE | G | 15-Oct-90 | A | A |
| 1 | C81 | 6541 | MUSA | SP. | MUSACEAE | G | 15-Oct-90 | A | A |
| 1 | C81 | 6542 | MUSA | PARADISIACA | MUSACEAE | G | 15-Oct-90 | NF | D |
| 1 | C81 | 6543 | CLITORIA | RACEMOSA | FABACEAE | T | 15-Oct-90 | A | A |
| 1 | C80 | 6544 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C80 | 6545 | ARCHONTOPHOENIX | SP. | ARECACEAE | P | 15-Oct-90 | A | A |
| 1 | C80 | 6546 | BLECHNUM | BRASILIENSE | BLECHNACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C80 | 6547 | TECTONA | GRANDIS | VERBENACEAE | T | 15-Oct-90 | NF | NF |
| 1 | C80 | 6548 | DIOSPYROS | DIGYNA | EBENACEAE | T | 15-Oct-90 | A | NF |
| 1 | C80 | 6549 | CASIMIROA | EDULIS | RUTACEAE | T | 15-Oct-90 | NF | NF |
| 1 | C87 | 6550 | LEUCAENA | GLAUCA | FABACEAE | T | 15-Oct-90 | A | D |
| 1 | C81 | 6551 | HELICONIA | BICOLOR | HELICONIACEAE | G | 15-Oct-90 | NF | D |
| 1 | C81 | 6552 | HELICONIA | BICOLOR | HELICONIACEAE | G | 15-Oct-90 | NF | D |
| 1 | C81 | 6553 | HELICONIA | BICOLOR | HELICONIACEAE | G | 15-Oct-90 | NF | D |
| 1 | C81 | 6554 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 15-Oct-90 | NF | D |
| 1 | C81 | 6555 | HELICONIA | BICOLOR | HELICONIACEAE | G | 15-Oct-90 | NF | D |
| 1 | C81 | 6556 | LEUCAENA | GLAUCA | FABACEAE | T | 15-Oct-90 | NF | D |
| 1 | C81 | 6557 | HEVEA | BRASILIENSIS | EUPHORBIACEAE | T | 15-Oct-90 | NF | D |
| 1 | C81 | 6558 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 15-Oct-90 | NF | A |
| 1 | C81 | 6559 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 15-Oct-90 | A | A |
| 1 | C81 | 6560 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 15-Oct-90 | NF | D |
| 1 | C81 | 6561 | BIXA | ORELLANA | BIXACEAE | T | 15-Oct-90 | A | NF |
| 1 | C81 | 6562 | UNKNOWN | UNKNOWN | ASCLEPIADACEAE | U | 15-Oct-90 | NF | D |
| 1 | C81 | 6563 | CANNA | INDICA | CANNACEAE | G | 15-Oct-90 | A | A |
| 1 | C81 | 6564 | UNKNOWN | UNKNOWN | FABACEAE | H | 15-Oct-90 | NF | D |
| 1 | C81 | 6565 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 15-Oct-90 | A | D |
| 1 | C81 | 6566 | ZINGIBER | SPECTABILE | ZINGIBERACEAE | G | 15-Oct-90 | A | A |
| 1 | C81 | 6567 | ZINGIBER | SPECTABILE | ZINGIBERACEAE | G | 15-Oct-90 | A | A |
| 1 | C81 | 6568 | ZINGIBER | SPECTABILE | ZINGIBERACEAE | G | 15-Oct-90 | A | D |
| 1 | C81 | 6569 | UNKNOWN | UNKNOWN | MARANTACEAE | H | 15-Oct-90 | NF | D |
| 1 | C81 | 6570 | MUSA | PARADISIACA | MUSACEAE | G | 15-Oct-90 | NF | A |
| 1 | C81 | 6571 | BAUHINIA | SP. | FABACEAE | S | 15-Oct-90 | NF | D |
| 1 | C81 | 6572 | CARLUDOVICA | PALMATA | CYCLANTHACEAE | P | 15-Oct-90 | A | A |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C81 | 6573 | MANGIFERA | INDICA | ANACARDIACEAE | T | 15-Oct-90 | NF | NF |
| 1 | C74 | 6574 | LEUCAENA | LEUCOCEPHALA | FABACEAE | T | 15-Oct-90 | D | D |
| 1 | C74 | 6575 | CLITORIA | RACEMOSA | FABACEAE | T | 15-Oct-90 | A | A |
| 1 | C81 | 6576 | PHILODENDRON | RUBENS | ARACEAE | C | 15-Oct-90 | NF | NF |
| 1 | C80 | 6577 | WITHANIA | SOMNIFERA | SOLANACEAE | S | 15-Oct-90 | NF | NF |
| 1 | C80 | 6578 | HYMENAEA | COURBARIL | FABACEAE | T | 15-Oct-90 | A | A |
| 1 | C80 | 6579 | ALEURITES | MOLUCCANA | EUPHORBIACEAE | T | 15-Oct-90 | A | A |
| 1 | C80 | 6580 | JUSTICIA | CALIFORNICA | ACANTHACEAE | S | 15-Oct-90 | NF | NF |
| 1 | C80 | 6581 | HEIMIA | SALICIFOLIA | LYTHRACEAE | S | 15-Oct-90 | D | NF |
| 1 | C80 | 6582 | CASIMIROA | EDULIS | RUTACEAE | T | 15-Oct-90 | NF | NF |
| 1 | C80 | 6583 | BARRINGTONIA | ASIATICA | LECYTHIDACEAE | T | 15-Oct-90 | A | A |
| 1 | C80 | 6584 | HEIMIA | SALICIFOLIA | LYTHRACEAE | S | 15-Oct-90 | NF | NF |
| 1 | C80 | 6585 | CEIBA | PENTANDRA | BOMBACACEAE | T | 15-Oct-90 | A | A |
| 1 | C80 | 6586 | COSTUS | SP. | ZINGIBERACEAE | H | 15-Oct-90 | NF | A |
| 1 | C80 | 6587 | AGLAONEMA | SP. | ARACEAE | H | 15-Oct-90 | A | A |
| 1 | C73 | 6588 | PHILODENDRON | SELLOUM | ARACEAE | C | 15-Oct-90 | A | D |
| 1 | C74 | 6589 | CALATHEA | GIGANTEA | MARANTACEAE | H | 15-Oct-90 | A | A |
| 1 | C73 | 6590 | HURA | CREPITANS | EUPHORBIACEAE | T | 15-Oct-90 | A | D |
| 1 | C74 | 6591 | CALATHEA | GIGANTEA | MARANTACEAE | H | 15-Oct-90 | A | A |
| 1 | C74 | 6592 | APHANES | CARYOTAEFOLIAE | ROSACEAE | U | 15-Oct-90 | A | A |
| 1 | C74 | 6593 | HURA | CREPITANS | EUPHORBIACEAE | T | 15-Oct-90 | A | A |
| 1 | C74 | 6594 | APHANES | CARYOTAEFOLIAE | ROSACEAE | U | 15-Oct-90 | A | A |
| 1 | C74 | 6595 | TAMARINDUS | INDICA | FABACEAE | T | 15-Oct-90 | NF | NF |
| 1 | C74 | 6596 | BIXA | ORELLANA | BIXACEAE | T | 15-Oct-90 | NF | NF |
| 1 | C74 | 6597 | MUSA | SP. | MUSACEAE | G | 15-Oct-90 | NF | A |
| 1 | C81 | 6598 | MUSA | SP. | MUSACEAE | G | 15-Oct-90 | A | A |
| 1 | C81 | 6599 | PHYLLANTHUS | PULCHER | EUPHORBIACEAE | T | 15-Oct-90 | A | A |
| 1 | C81 | 6600 | PHILODENDRON | TRIPARTITUM | ARACEAE | C | 15-Oct-90 | NF | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C81 | 6601 | HELICONIA | PSITTACORUM | HELICONIACEAE | G | 15-Oct-90 | NF | D |
| 1 | C74 | 6602 | CURCUMA | DOMESTICA | ZINGIBERACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C74 | 6603 | MUSA | SP. | MUSACEAE | G | 15-Oct-90 | A | A |
| 1 | C74 | 6604 | MUSA | SP. | MUSACEAE | G | 15-Oct-90 | A | A |
| 1 | C74 | 6605 | PELLIONIA | DAVEAUANA | URTICACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C74 | 6606 | CURCUMA | DOMESTICA | ZINGIBERACEAE | H | 15-Oct-90 | A | NF |
| 1 | C74 | 6607 | ALPINIA | ZERUMBET | ZINGIBERACEAE | G | 15-Oct-90 | A | A |
| 1 | C74 | 6608 | MUSA | SP. | MUSACEAE | G | 15-Oct-90 | A | A |
| 1 | C74 | 6609 | HEDYCHIUM | AURANTIACA | ZINGIBERACEAE | G | 15-Oct-90 | NF | NF |
| 1 | C74 | 6610 | HEDYCHIUM | SP. | ZINGIBERACEAE | G | 15-Oct-90 | NF | NF |
| 1 | C74 | 6611 | BIXA | ORELLANA | BIXACEAE | T | 15-Oct-90 | A | NF |
| 1 | C74 | 6612 | LEUCAENA | GLAUCA | FABACEAE | T | 15-Oct-90 | A | D |
| 1 | C74 | 6613 | CAESALPINIA | SP. | FABACEAE | T | 15-Oct-90 | NF | NF |
| 1 | C74 | 6614 | CURCUMA | DOMESTICA | ZINGIBERACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C74 | 6615 | COSTUS | ELATUS | ZINGIBERACEAE | H | 15-Oct-90 | A | A |
| 1 | C74 | 6616 | HELICONIA | LONGIFLORA | HELICONIACEAE | G | 15-Oct-90 | A | A |
| 1 | C74 | 6617 | THALIA | GENICULATA | MARANTACEAE | H | 15-Oct-90 | A | NF |
| 1 | C74 | 6618 | ETLINGERA | ELATIOR | ZINGIBERACEAE | H | 18-Oct-90 | A | A |
| 1 | C74 | 6619 | CURCUMA | DOMESTICA | ZINGIBERACEAE | H | 18-Oct-90 | A | NF |
| 1 | C74 | 6620 | HELICONIA | SP. | HELICONIACEAE | G | 18-Oct-90 | NF | NF |
| 1 | C74 | 6621 | HURA | CREPITANS | EUPHORBIACEAE | T | 18-Oct-90 | A | NF |
| 1 | C74 | 6622 | CURCUMA | ROSCOEANA | ZINGIBERACEAE | H | 18-Oct-90 | NF | NF |
| 1 | C74 | 6623 | MUSA | SP. | MUSACEAE | G | 18-Oct-90 | A | A |
| 1 | C74 | 6624 | LEUCAENA | GLAUCA | FABACEAE | T | 18-Oct-90 | A | A |
| 1 | C67 | 6625 | MUSA | SP. | MUSACEAE | G | 18-Oct-90 | A | A |
| 1 | C67 | 6626 | MUSA | TEXTILIS | MUSACEAE | G | 18-Oct-90 | A | A |
| 1 | C67 | 6627 | CHRYSALIDOCARPUS | LUTESCENS | ARECACEAE | S | 18-Oct-90 | A | A |
| 1 | C67 | 6628 | CAESALPINIA | SP. | FABACEAE | T | 18-Oct-90 | A | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C74 | 6629 | CAESALPINIA | SP. | FABACEAE | T | 18-Oct-90 | NF | NF |
| 1 | C74 | 6630 | UNKNOWN | UNKNOWN | UNKNOWN | U | 18-Oct-90 | NF | NF |
| 1 | C74 | 6631 | CECROPIA | SCHREBERIANA | CECROPIACEAE | T | 18-Oct-90 | A | A |
| 1 | C73 | 6632 | CLITORIA | RACEMOSA | FABACEAE | T | 18-Oct-90 | A | A |
| 1 | C73 | 6633 | MORINGA | OLEIFERA | MORINGACEAE | T | 18-Oct-90 | D | D |
| 1 | C73 | 6634 | DICHORISANDRA | THYRSIFLORA | COMMELINACEAE | H | 17-Oct-90 | NF | NF |
| 1 | C73 | 6636 | LEUCAENA | GLAUCA | FABACEAE | T | 17-Oct-90 | D | D |
| 1 | C73 | 6637 | INGA | FEUILLEI | FABACEAE | T | 17-Oct-90 | A | A |
| 1 | C73 | 6638 | PACHIRA | AQUATICA | BOMBACACEAE | T | 17-Oct-90 | A | A |
| 1 | C73 | 6639 | PACHIRA | AQUATICA | BOMBACACEAE | T | 17-Oct-90 | A | A |
| 1 | C73 | 6640 | HELICONIA | BICOLOR | HELICONIACEAE | G | 17-Oct-90 | NF | NF |
| 1 | C73 | 6641 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 17-Oct-90 | A | A |
| 1 | C73 | 6642 | HELICONIA | BICOLOR | HELICONIACEAE | G | 17-Oct-90 | NF | NF |
| 1 | C73 | 6643 | HELICONIA | BICOLOR | HELICONIACEAE | G | 17-Oct-90 | NF | NF |
| 1 | C73 | 6644 | CANNA | EDULIS | CANNACEAE | G | 17-Oct-90 | NF | NF |
| 1 | C73 | 6645 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | NF | NF |
| 1 | C73 | 6646 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | A | A |
| 1 | C73 | 6647 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 17-Oct-90 | NF | NF |
| 1 | C73 | 6648 | PTEROCARPUS | INDICUS | FABACEAE | T | 17-Oct-90 | NF | NF |
| 1 | C73 | 6649 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | A | NF |
| 1 | C73 | 6650 | CANNA | EDULIS | CANNACEAE | G | 17-Oct-90 | A | A |
| 1 | C73 | 6651 | CANNA | EDULIS | CANNACEAE | G | 17-Oct-90 | A | A |
| 1 | C73 | 6652 | PTEROCARPUS | INDICUS | FABACEAE | T | 17-Oct-90 | NF | NF |
| 1 | C73 | 6653 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 17-Oct-90 | A | A |
| 1 | C73 | 6654 | DICHORISANDRA | THYRSIFLORA | COMMELINACEAE | H | 17-Oct-90 | NF | NF |
| 1 | C73 | 6655 | UNKNOWN | UNKNOWN | UNKNOWN | U | 17-Oct-90 | NF | NF |
| 1 | C73 | 6656 | CANNA | EDULIS | CANNACEAE | G | 17-Oct-90 | NF | NF |
| 1 | C73 | 6657 | FICUS | BUXIFOLIA | MORACEAE | T | 17-Oct-90 | A | A |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C73 | 6658 | SETARIA | PALMIFOLIA | POACEAE | R | 17-Oct-90 | A | NF |
| 1 | C73 | 6659 | UNKNOWN | UNKNOWN | UNKNOWN | U | 17-Oct-90 | NF | NF |
| 1 | C73 | 6660 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 17-Oct-90 | A | A |
| 1 | C80 | 6661 | SETARIA | PALMIFOLIA | POACEAE | R | 17-Oct-90 | A | NF |
| 1 | C80 | 6662 | DIEFFENBACHIA | SP. | ARACEAE | H | 17-Oct-90 | A | A |
| 1 | C80 | 6663 | UNKNOWN | UNKNOWN | UNKNOWN | U | 17-Oct-90 | A | D |
| 1 | C80 | 6664 | PTEROCARPUS | INDICUS | FABACEAE | T | 17-Oct-90 | D | NF |
| 1 | C80 | 6665 | PERSEA | AMERICANA | LAURACEAE | T | 17-Oct-90 | D | NF |
| 1 | C80 | 6666 | WITHANIA | SOMNIFERA | SOLANACEAE | S | 17-Oct-90 | NF | NF |
| 1 | C80 | 6667 | BAUHINIA | SP. | FABACEAE | S | 17-Oct-90 | D | NF |
| 1 | C80 | 6668 | ALPINIA | PURPURATA | ZINGIBERACEAE | G | 17-Oct-90 | A | A |
| 1 | C80 | 6669 | UNKNOWN | UNKNOWN | UNKNOWN | U | 17-Oct-90 | D | NF |
| 1 | C80 | 6670 | LEUCAENA | LEUCOCEPHALA | FABACEAE | T | 17-Oct-90 | | D |
| 1 | C80 | 6671 | CANNA | INDICA | CANNACEAE | G | 17-Oct-90 | NF | NF |
| 1 | C80 | 6672 | BRUNFELSIA | JAMAICENSIS | SOLANACEAE | S | 17-Oct-90 | NF | D |
| 1 | C80 | 6673 | BRUNFELSIA | JAMAICENSIS | SOLANACEAE | S | 17-Oct-90 | NF | NF |
| 1 | C80 | 6674 | LEUCAENA | GLAUCA | FABACEAE | T | 17-Oct-90 | A | D |
| 1 | C80 | 6675 | PAULLINIA | SP. | SAPINDACEAE | C | 17-Oct-90 | NF | NF |
| 1 | C80 | 6676 | PASSIFLORA | COCCINEA | PASSIFLORACEAE | C | 17-Oct-90 | NF | NF |
| 1 | C80 | 6677 | PASPALUM | PLICATULUM | POACEAE | R | 17-Oct-90 | A | A |
| 1 | C80 | 6678 | ANNONA | MURICATA | ANNONACEAE | T | 17-Oct-90 | A | A |
| 1 | C80 | 6679 | BRUNFELSIA | JAMAICENSIS | SOLANACEAE | S | 17-Oct-90 | A | NF |
| 1 | C80 | 6680 | DILLENIA | INDICA | DILLENIACEAE | T | 17-Oct-90 | NF | NF |
| 1 | C80 | 6681 | PITHECOCTENIUM | SP. | BIGNONIACEAE | C | 17-Oct-90 | NF | NF |
| 1 | C79 | 6682 | ENTEROLOBIUM | CYCLOCARPUM | FABACEAE | T | 17-Oct-90 | A | D |
| 1 | C79 | 6683 | SCHOTIA | LATIFOLIA | FABACEAE | T | 17-Oct-90 | NF | NF |
| 1 | C79 | 6684 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | NF | NF |
| 1 | C79 | 6685 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C79 | 6686 | COLOCASIA | ANTIQUORUM | ARACEAE | H | 17-Oct-90 | NF | NF |
| 1 | C79 | 6687 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | NF | NF |
| 1 | C79 | 6688 | UNKNOWN | UNKNOWN | UNKNOWN | U | 17-Oct-90 | NF | NF |
| 1 | C79 | 6689 | AVERRHOA | CARAMBOLA | OXALIDACEAE | T | 17-Oct-90 | D | NF |
| 1 | C79 | 6690 | HELICONIA | PSITTACORUM | HELICONIACEAE | G | 17-Oct-90 | NF | NF |
| 1 | C79 | 6691 | CECROPIA | SCHREBERIANA | CECROPIACEAE | T | 17-Oct-90 | D | D |
| 1 | C79 | 6692 | UNKNOWN | UNKNOWN | UNKNOWN | U | 17-Oct-90 | D | NF |
| 1 | C79 | 6693 | PHILODENDRON | SELLOUM | ARACEAE | C | 17-Oct-90 | A | A |
| 1 | C79 | 6694 | BRUNFELSIA | AMERICANA | SOLANACEAE | S | 17-Oct-90 | A | A |
| 1 | C79 | 6695 | TECTONA | GRANDIS | VERBENACEAE | T | 17-Oct-90 | NF | NF |
| 1 | C79 | 6696 | CECROPIA | SCHREBERIANA | CECROPIACEAE | T | 17-Oct-90 | A | A |
| 1 | C79 | 6697 | HEVEA | BRASILIENSIS | EUPHORBIACEAE | T | 17-Oct-90 | NF | NF |
| 1 | C79 | 6698 | CLITORIA | RACEMOSA | FABACEAE | T | 17-Oct-90 | A | A |
| 1 | C79 | 6699 | PHILODENDRON | SELLOUM | ARACEAE | C | 17-Oct-90 | A | NF |
| 1 | C77 | 6700 | TILLANDSIA | SP. | BROMELIACEAE | E | 1-Nov-90 | NF | D |
| 1 | C77 | 6701 | CYATHEA | COOPERI | CYATHEACEAE | P | 1-Nov-90 | D | D |
| 1 | C77 | 6702 | MARCGRAVIA | RECTIFLORA | MARCGRAVIACEAE | C | 1-Nov-90 | A | A |
| 1 | C77 | 6703 | TILLANDSIA | SP. | BROMELIACEAE | E | 1-Nov-90 | NF | D |
| 1 | C77 | 6704 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | D |
| 1 | C77 | 6705 | CYATHEA | COOPERI | CYATHEACEAE | P | 1-Nov-90 | NF | D |
| 1 | C77 | 6706 | PHILODENDRON | TRIPARTITUM | ARACEAE | C | 1-Nov-90 | NF | D |
| 1 | C77 | 6707 | FICUS | PUMILA | MORACEAE | C | 1-Nov-90 | A | A |
| 1 | C77 | 6708 | TILLANDSIA | SP. | BROMELIACEAE | E | 1-Nov-90 | NF | D |
| 1 | C77 | 6709 | MARCGRAVIA | RECTIFLORA | MARCGRAVIACEAE | C | 1-Nov-90 | NF | D |
| 1 | C77 | 6710 | TILLANDSIA | SP. | BROMELIACEAE | E | 1-Nov-90 | NF | D |
| 1 | C77 | 6711 | FICUS | PUMILA | MORACEAE | C | 1-Nov-90 | A | A |
| 1 | C77 | 6712 | MARCGRAVIA | RECTIFLORA | MARCGRAVIACEAE | C | 1-Nov-90 | NF | D |
| 1 | C84 | 6713 | TILLANDSIA | SP. | BROMELIACEAE | E | 1-Nov-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C84 | 6714 | PHILODENDRON | ANGUSTATUM | ARACEAE | C | 1-Nov-90 | NF | NF |
| 1 | C84 | 6715 | TILLANDSIA | SP. | BROMELIACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C84 | 6716 | MARCGRAVIA | RECTIFLORA | MARCGRAVIACEAE | C | 1-Nov-90 | NF | D |
| 1 | C84 | 6717 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | A | NF |
| 1 | C84 | 6718 | SELAGINELLA | SP. | SELAGINELLACEAE | H | 15-Oct-90 | NF | NF |
| 1 | C84 | 6719 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | A | NF |
| 1 | C84 | 6720 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C84 | 6721 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C84 | 6722 | CYATHEA | COOPERI | CYATHEACEAE | P | 15-Oct-90 | NF | NF |
| 1 | C84 | 6723 | UNKNOWN | UNKNOWN | ORCHIDACEAE | E | 15-Oct-90 | NF | NF |
| 1 | C84 | 6724 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C84 | 6725 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C72 | 6726 | EUCHARIS | GRANDIFLORA | AMARYLLIDACEAE | H | 26-Sep-91 | A | NF |
| 1 | C72 | 6727 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 26-Sep-91 | A | A |
| 1 | C62 | 6728 | COSTUS | SP. | ZINGIBERACEAE | H | 26-Sep-91 | A | A |
| 1 | C62 | 6729 | COSTUS | SP. | ZINGIBERACEAE | H | 26-Sep-91 | A | A |
| 1 | C62 | 6730 | COSTUS | SP. | ZINGIBERACEAE | H | 26-Sep-91 | A | A |
| 2 | C62 | 6731 | UNKNOWN | UNKNOWN | UNKNOWN | U | | | NF |
| 1 | C62 | 6732 | COSTUS | SP. | ZINGIBERACEAE | H | 26-Sep-91 | A | NF |
| 1 | C72 | 6733 | DIEFFENBACHIA | SP. | ARACEAE | H | 26-Sep-91 | A | A |
| 1 | C72 | 6734 | DIEFFENBACHIA | SP. | ARACEAE | H | 26-Sep-91 | A | A |
| 1 | C72 | 6735 | COFFEA | ARABICA | RUBIACEAE | S | 26-Sep-92 | A | A |
| 1 | C72 | 6736 | PIPER | SP. | PIPERACEAE | H | 26-Sep-91 | A | NF |
| 1 | C72 | 6737 | UNKNOWN | UNKNOWN | ARECACEAE | P | 26-Sep-92 | A | NF |
| 2 | C62 | 6738 | DIEFFENBACHIA | SP. | ARACEAE | H | | | A |
| 1 | C62 | 6739 | CAPPARIS | SPINOSA | CAPPARACEAE | T | 26-Sep-91 | A | NF |
| 2 | C62 | 6740 | UNKNOWN | UNKNOWN | UNKNOWN | U | 28-Sep-93 | A | NF |
| 2 | C62 | 6741 | UNKNOWN | UNKNOWN | UNKNOWN | U | 28-Sep-93 | A | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C62 | 6742 | UNKNOWN | UNKNOWN | UNKNOWN | U | 28-Sep-93 | A | NF |
| 2 | C62 | 6743 | UNKNOWN | UNKNOWN | UNKNOWN | U | 28-Sep-93 | A | NF |
| 1 | C62 | 6744 | UNKNOWN | UNKNOWN | UNKNOWN | U | 26-Sep-92 | A | NF |
| 1 | C62 | 6747 | HEIMIA | SALICIFOLIA | LYTHRACEAE | S | 26-Sep-91 | A | NF |
| 1 | C69 | 6748 | CARICA | SP. | CARICACEAE | T | 26-Sep-91 | A | NF |
| 1 | C62 | 6749 | CEDRELA | SP. | MELIACEAE | T | 26-Sep-91 | A | D |
| 1 | C72 | 6750 | EUCHARIS | GRANDIFLORA | AMARYLLIDACEAE | H | 26-Sep-91 | A | NF |
| 1 | C72 | 6751 | UNKNOWN | UNKNOWN | ACANTHACEAE | U | 26-Sep-92 | A | A |
| 1 | C72 | 6752 | UNKNOWN | UNKNOWN | ACANTHACEAE | U | 26-Sep-92 | A | NF |
| 1 | C72 | 6753 | UNKNOWN | UNKNOWN | ARACEAE | U | 26-Sep-92 | A | |
| 1 | C72 | 6754 | EUCHARIS | GRANDIFLORA | AMARYLLIDACEAE | H | 26-Sep-91 | A | A |
| 1 | C72 | 6755 | UNKNOWN | UNKNOWN | ARECACEAE | P | 26-Sep-92 | A | A |
| 1 | C72 | 6756 | UNKNOWN | UNKNOWN | ARECACEAE | P | 26-Sep-92 | A | A |
| 1 | C72 | 6757 | DIEFFENBACHIA | SP. | ARACEAE | H | 26-Sep-91 | A | A |
| 1 | C72 | 6758 | LEUCAENA | LEUCOCEPHALA | FABACEAE | T | 26-Sep-91 | A | D |
| 1 | C72 | 6759 | LEUCAENA | LEUCOCEPHALA | FABACEAE | T | 26-Sep-91 | A | D |
| 1 | C79 | 6760 | SYNGONIUM | PODOPHYLLUM | ARACEAE | C | 26-Sep-91 | A | |
| 1 | C72 | 6761 | MARANTA | SP. | MARANTACEAE | H | 26-Sep-92 | A | NF |
| 1 | C89 | 6762 | RICINUS | COMMUNIS | EUPHORBIACEAE | T | 26-Sep-91 | A | NF |
| 1 | C90 | 6763 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 26-Sep-91 | A | A |
| 1 | C73 | 6764 | SETARIA | PALMIFOLIA | POACEAE | R | 26-Sep-91 | A | NF |
| 1 | C71 | 6765 | DIEFFENBACHIA | SP. | ARACEAE | H | 26-Sep-91 | A | A |
| 1 | C71 | 6766 | DIEFFENBACHIA | SP. | ARACEAE | H | 26-Sep-91 | A | A |
| 1 | C71 | 6767 | PHILODENDRON | SP. | ARACEAE | C | 26-Sep-91 | A | A |
| 1 | C71 | 6768 | DIEFFENBACHIA | SP. | ARACEAE | H | 26-Sep-91 | A | NF |
| 1 | C71 | 6769 | DIEFFENBACHIA | SP. | ARACEAE | H | 26-Sep-91 | A | NF |
| 1 | C71 | 6770 | LEUCAENA | SP. | FABACEAE | T | 26-Sep-91 | A | D |
| 1 | C71 | 6771 | PACHIRA | AQUATICA | BOMBACACEAE | T | 26-Sep-91 | A | A |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C71 | 6772 | PHILODENDRON | SP. | ARACEAE | C | 26-Sep-91 | A | NF |
| 1 | C80 | 6773 | LEUCAENA | SP. | FABACEAE | T | 26-Sep-92 | A | D |
| 1 | C91 | 6774 | LEUCAENA | SP. | FABACEAE | T | 26-Sep-91 | A | D |
| 1 | C70 | 6775 | COLOCASIA | SP. | ARACEAE | H | 26-Sep-91 | A | A |
| 1 | C70 | 6776 | UNKNOWN | UNKNOWN | ARACEAE | U | 26-Sep-92 | A | NF |
| 2 | C70 | 6777 | UNKNOWN | UNKNOWN | UNKNOWN | U | | | NF |
| 1 | C70 | 6778 | COSTUS | SP. | ZINGIBERACEAE | H | 26-Sep-91 | A | D |
| 1 | C86 | 6779 | UNKNOWN | UNKNOWN | ORCHIDACEAE | E | 26-Sep-92 | A | NF |
| 1 | C70 | 6780 | SPATHIPHYLLUM | SP. | ARACEAE | H | 26-Sep-92 | A | A |
| 1 | C92 | 6781 | UNKNOWN | UNKNOWN | BROMELIACEAE | U | 26-Sep-92 | A | NF |
| 1 | C91 | 6782 | COFFEA | ARABICA | RUBIACEAE | S | 26-Sep-92 | A | D |
| 1 | C91 | 6783 | AGLAONEMA | SP. | ARACEAE | H | 26-Sep-91 | A | A |
| 1 | C69 | 6784 | LEUCAENA | GLAUCA | FABACEAE | T | 26-Sep-91 | A | A |
| 1 | C69 | 6785 | CARICA | SP. | CARICACEAE | T | 26-Sep-92 | A | NF |
| 1 | C69 | 6786 | COFFEA | ARABICA | RUBIACEAE | S | 26-Sep-92 | A | A |
| 1 | C69 | 6787 | COFFEA | ARABICA | RUBIACEAE | S | 26-Sep-92 | A | NF |
| 1 | C69 | 6788 | MUSA | SP. | MUSACEAE | G | 26-Sep-92 | A | A |
| 1 | C69 | 6789 | LEUCAENA | GLAUCA | FABACEAE | T | 26-Sep-91 | A | A |
| 1 | C69 | 6790 | DERRIS | ELLIPTICA | FABACEAE | C | 26-Sep-91 | A | NF |
| 1 | C79 | 6791 | DIEFFENBACHIA | SP. | ARACEAE | H | 26-Sep-91 | A | A |
| 1 | C80 | 6793 | LEUCAENA | SP. | FABACEAE | T | 26-Sep-91 | A | NF |
| 1 | C73 | 6794 | UNKNOWN | UNKNOWN | UNKNOWN | U | 26-Sep-92 | A | NF |
| 2 | C90 | 6795 | AECHMEA | LAMARCHEI | BROMELIACEAE | H | | | NF |
| 1 | C90 | 6796 | MUSA | SP. | MUSACEAE | G | 26-Sep-92 | A | A |
| 1 | C90 | 6797 | DIEFFENBACHIA | SP. | ARACEAE | H | 26-Sep-91 | A | A |
| 1 | C90 | 6798 | RICINUS | COMMUNIS | EUPHORBIACEAE | T | 26-Sep-91 | A | D |
| 1 | C90 | 6799 | CECROPIA | SCHREBERIANA | CECROPIACEAE | T | 26-Sep-91 | A | A |
| 1 | C66 | 6800 | BAMBUSA | MULTIPLEX | POACEAE | A | 24-Nov-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C66 | 6801 | BAMBUSA | MULTIPLEX | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C66 | 6802 | BAMBUSA | MULTIPLEX | POACEAE | A | 24-Nov-90 | NF | NF |
| 1 | C73 | 6803 | BAMBUSA | OLDHAMII | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C66 | 6804 | BAMBUSA | MULTIPLEX | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C66 | 6805 | UNKNOWN | UNKNOWN | POACEAE | U | 24-Nov-90 | A | A |
| 1 | C66 | 6806 | COCOS | NUCIFERA | ARECACEAE | P | 24-Nov-90 | A | A |
| 1 | C66 | 6807 | UNKNOWN | UNKNOWN | POACEAE | U | 24-Nov-90 | A | D |
| 1 | C66 | 6808 | BAMBUSA | MULTIPLEX | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C66 | 6809 | BAMBUSA | MULTIPLEX | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C65 | 6810 | UNKNOWN | UNKNOWN | POACEAE | U | 24-Nov-90 | A | A |
| 1 | C65 | 6811 | UNKNOWN | UNKNOWN | POACEAE | U | 24-Nov-90 | A | A |
| 1 | C65 | 6812 | UNKNOWN | UNKNOWN | POACEAE | U | 24-Nov-90 | A | A |
| 1 | C65 | 6813 | BAMBUSA | MULTIPLEX | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C66 | 6814 | UNKNOWN | UNKNOWN | POACEAE | U | 24-Nov-90 | A | A |
| 1 | C65 | 6815 | BAMBUSA | GLAUCESCENS | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C65 | 6816 | BAMBUSA | MULTIPLEX | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C65 | 6817 | BAMBUSA | MULTIPLEX | POACEAE | A | 24-Nov-90 | NF | NF |
| 1 | C65 | 6818 | BAMBUSA | TULDOIDES | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C65 | 6819 | BAMBUSA | MULTIPLEX | POACEAE | A | 24-Nov-90 | NF | A |
| 1 | C65 | 6820 | UNKNOWN | UNKNOWN | POACEAE | U | 24-Nov-90 | A | A |
| 1 | C65 | 6821 | BAMBUSA | MULTIPLEX | POACEAE | A | 24-Nov-90 | NF | NF |
| 1 | C65 | 6822 | BAMBUSA | MULTIPLEX | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C65 | 6823 | BAMBUSA | TULDOIDES | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C65 | 6824 | BAMBUSA | MULTIPLEX | POACEAE | A | 24-Nov-90 | NF | D |
| 1 | C65 | 6825 | BAMBUSA | TULDOIDES | POACEAE | A | 24-Nov-90 | A | NF |
| 1 | C65 | 6826 | BAMBUSA | TULDOIDES | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C65 | 6827 | BAMBUSA | MULTIPLEX | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C64 | 6828 | BAMBUSA | MULTIPLEX | POACEAE | A | 24-Nov-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C64 | 6829 | BAMBUSA | SP. | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C64 | 6830 | BAMBUSA | TULDOIDES | POACEAE | A | 24-Nov-90 | NF | NF |
| 1 | C64 | 6831 | BAMBUSA | TULDOIDES | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C64 | 6832 | BAMBUSA | TULDOIDES | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C64 | 6833 | BAMBUSA | TULDOIDES | POACEAE | A | 24-Nov-90 | A | A |
| 1 | C80 | 6834 | PACHIRA | AQUATICA | BOMBACACEAE | T | 17-Oct-90 | A | A |
| 1 | C79 | 6835 | ZINGIBER | OFFICINALE | ZINGIBERACEAE | H | 17-Oct-90 | NF | NF |
| 1 | C73 | 6836 | CANNA | INDICA | CANNACEAE | G | 17-Oct-90 | A | NF |
| 1 | C73 | 6837 | CLITORIA | RACEMOSA | FABACEAE | T | 17-Oct-90 | A | D |
| 1 | C73 | 6838 | HELICONIA | PSITTACORUM | HELICONIACEAE | G | 17-Oct-90 | NF | NF |
| 1 | C72 | 6839 | UNKNOWN | UNKNOWN | UNKNOWN | U | 17-Oct-90 | NF | NF |
| 1 | C72 | 6840 | BARRINGTONIA | ASIATICA | LECYTHIDACEAE | T | 17-Oct-90 | A | A |
| 1 | C72 | 6841 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 17-Oct-90 | A | A |
| 1 | C72 | 6842 | COLOCASIA | ANTIQUORUM | ARACEAE | H | 17-Oct-90 | NF | NF |
| 1 | C72 | 6843 | MORINGA | OLEIFERA | MORINGACEAE | T | 17-Oct-90 | D | D |
| 1 | C72 | 6844 | PACHIRA | AQUATICA | BOMBACACEAE | T | 17-Oct-90 | A | A |
| 1 | C72 | 6845 | PHILODENDRON | GLANDULIFERUM | ARACEAE | H | 17-Oct-90 | A | NF |
| 1 | C72 | 6846 | CEIBA | PENTANDRA | BOMBACACEAE | T | 17-Oct-90 | A | A |
| 1 | C72 | 6847 | MYRCIARIA | CAULIFLORA | MYRTACEAE | T | 17-Oct-90 | A | A |
| 1 | C72 | 6848 | PHILODENDRON | CV 'WEND-IMBE' | ARACEAE | C | 17-Oct-90 | A | A |
| 1 | C72 | 6849 | ARUNDINARIA | PYGMAEA | POACEAE | A | 17-Oct-90 | NF | NF |
| 1 | C72 | 6850 | CASIMIROA | EDULIS | RUTACEAE | T | 17-Oct-90 | D | D |
| 1 | C72 | 6851 | CLITORIA | RACEMOSA | FABACEAE | T | 17-Oct-90 | A | A |
| 1 | C72 | 6852 | AGLAONEMA | CRISPUM | ARACEAE | H | 17-Oct-90 | A | A |
| 1 | C72 | 6853 | LEUCAENA | GLAUCA | FABACEAE | T | 17-Oct-90 | A | NF |
| 1 | C72 | 6854 | INGA | SP. | FABACEAE | T | 17-Oct-90 | D | NF |
| 1 | C72 | 6855 | LEUCAENA | GLAUCA | FABACEAE | T | 17-Oct-90 | A | NF |
| 1 | C72 | 6856 | MORINGA | SP. | MORINGACEAE | T | 17-Oct-90 | A | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C72 | 6857 | COFFEA | ARABICA | RUBIACEAE | S | 17-Oct-90 | A | A |
| 1 | C72 | 6858 | COMMELINA | TUBEROSA | COMMELINACEAE | H | 17-Oct-90 | NF | NF |
| 1 | C71 | 6859 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | A | A |
| 1 | C71 | 6860 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | NF | NF |
| 1 | C71 | 6861 | ILEX | PARAGUARIENSIS | AQUIFOLIACEAE | T | 17-Oct-90 | A | NF |
| 1 | C71 | 6862 | COMMELINA | TUBEROSA | COMMELINACEAE | H | 17-Oct-90 | | NF |
| 1 | C71 | 6863 | HIBISCUS | ELATUS | MALVACEAE | S | 17-Oct-90 | A | A |
| 1 | C71 | 6864 | HIBISCUS | ELATUS | MALVACEAE | S | 17-Oct-90 | A | NF |
| 1 | C72 | 6865 | LEUCAENA | GLAUCA | FABACEAE | T | 17-Oct-90 | D | D |
| 1 | C72 | 6866 | VERSCHAFFELTIA | SPLENDIDA | ARECACEAE | P | 17-Oct-90 | A | D |
| 1 | C72 | 6867 | VERSCHAFFELTIA | SPLENDIDA | ARECACEAE | P | 17-Oct-90 | A | A |
| 1 | C72 | 6868 | VERSCHAFFELTIA | SPLENDIDA | ARECACEAE | P | 17-Oct-90 | A | A |
| 1 | C71 | 6869 | PLUMERIA | RUBRA | APOCYNACEAE | T | 17-Oct-90 | A | A |
| 1 | C71 | 6870 | RUELLIA | BREVIFOLIA | ACANTHACEAE | S | 17-Oct-90 | NF | NF |
| 1 | C71 | 6871 | UNKNOWN | UNKNOWN | UNKNOWN | U | 17-Oct-90 | NF | NF |
| 1 | C71 | 6872 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | NF | NF |
| 1 | C71 | 6873 | PHILODENDRON | CV 'WEND-IMBE' | ARACEAE | C | 17-Oct-90 | A | A |
| 1 | C71 | 6874 | LEUCAENA | GLAUCA | FABACEAE | T | 17-Oct-90 | D | D |
| 1 | C71 | 6875 | UNKNOWN | UNKNOWN | UNKNOWN | U | 17-Oct-90 | NF | NF |
| 1 | C71 | 6876 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | A | NF |
| 1 | C71 | 6877 | COLOCASIA | ANTIQUORUM | ARACEAE | H | 17-Oct-90 | A | A |
| 1 | C71 | 6878 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | A | A |
| 1 | C71 | 6879 | COLOCASIA | ANTIQUORUM | ARACEAE | H | 17-Oct-90 | A | D |
| 1 | C71 | 6880 | INGA | SP. | FABACEAE | T | 17-Oct-90 | D | NF |
| 1 | C71 | 6881 | COLOCASIA | ANTIQUORUM | ARACEAE | H | 17-Oct-90 | A | A |
| 1 | C71 | 6882 | COLOCASIA | ANTIQUORUM | ARACEAE | H | 17-Oct-90 | A | D |
| 1 | C71 | 6883 | DIEFFENBACHIA | SP. | ARACEAE | H | 17-Oct-90 | A | A |
| 1 | C71 | 6884 | CECROPIA | SCHREBERIANA | CECROPIACEAE | T | 17-Oct-90 | A | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C71 | 6885 | DIEFFENBACHIA | SP. | ARACEAE | H | 17-Oct-90 | A | A |
| 1 | C71 | 6886 | VERSCHAFFELTIA | SPLENDIDA | ARECACEAE | P | 17-Oct-90 | A | A |
| 1 | C78 | 6887 | DIEFFENBACHIA | SP. | ARACEAE | H | 17-Oct-90 | A | A |
| 1 | C78 | 6888 | DIEFFENBACHIA | SP. | ARACEAE | H | 17-Oct-90 | A | A |
| 1 | C78 | 6889 | VERSCHAFFELTIA | SPLENDIDA | ARECACEAE | P | 17-Oct-90 | NF | NF |
| 1 | C78 | 6890 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | NF | NF |
| 1 | C78 | 6891 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | NF | NF |
| 1 | C78 | 6892 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | NF | NF |
| 1 | C78 | 6893 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | NF | NF |
| 1 | C79 | 6894 | UNKNOWN | UNKNOWN | UNKNOWN | U | 17-Oct-90 | NF | NF |
| 1 | C79 | 6895 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | A | NF |
| 1 | C79 | 6896 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | D | NF |
| 1 | C79 | 6897 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 17-Oct-90 | A | NF |
| 1 | C84 | 6900 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C84 | 6901 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C84 | 6902 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | A | NF |
| 1 | C85 | 6903 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C85 | 6904 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | A | NF |
| 1 | C85 | 6905 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C85 | 6906 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C85 | 6907 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C85 | 6908 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C85 | 6909 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C85 | 6910 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | A | NF |
| 1 | C85 | 6911 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | A | NF |
| 1 | C85 | 6912 | UNKNOWN | UNKNOWN | UNKNOWN | U | 15-Oct-90 | NF | NF |
| 1 | C85 | 6913 | DICHORISANDRA | THYRSIFLORA | COMMELINACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 6914 | UNKNOWN | UNKNOWN | ORCHIDACEAE | E | 1-Nov-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C85 | 6915 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C85 | 6916 | UNKNOWN | UNKNOWN | ORCHIDACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C84 | 6917 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C84 | 6918 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C84 | 6919 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C84 | 6920 | POLYPODIUM | CRASSIFOLIUM | POLYPODIACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C84 | 6921 | POLYPODIUM | CRASSIFOLIUM | POLYPODIACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C84 | 6922 | CALLISIA | FRAGRANS | COMMELINACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C84 | 6923 | HELICONIA | CARIBAEA | HELICONIACEAE | G | 1-Nov-90 | A | NF |
| 1 | C84 | 6924 | UNKNOWN | UNKNOWN | RUBIACEAE | U | 1-Nov-90 | NF | NF |
| 1 | C84 | 6925 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C84 | 6926 | POLYPODIUM | CRASSIFOLIUM | POLYPODIACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C84 | 6927 | UNKNOWN | UNKNOWN | ORCHIDACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C84 | 6928 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C84 | 6929 | HELICONIA | CARIBAEA | HELICONIACEAE | G | 1-Nov-90 | A | NF |
| 1 | C84 | 6930 | UNKNOWN | UNKNOWN | FABACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C84 | 6931 | UNKNOWN | UNKNOWN | FABACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C84 | 6932 | SELAGINELLA | SP. | SELAGINELLACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C84 | 6933 | SELAGINELLA | SP. | SELAGINELLACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C84 | 6934 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C84 | 6935 | CALLISIA | FRAGRANS | COMMELINACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C84 | 6936 | VANILLA | SP. | ORCHIDACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C84 | 6937 | CALLISIA | FRAGRANS | COMMELINACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C84 | 6938 | UNKNOWN | UNKNOWN | ORCHIDACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C84 | 6939 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C84 | 6940 | CYATHEA | COOPERI | CYATHEACEAE | P | 1-Nov-90 | NF | NF |
| 1 | C84 | 6941 | UNKNOWN | UNKNOWN | ORCHIDACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C85 | 6942 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C85 | 6943 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6944 | HELICONIA | CARIBAEA | HELICONIACEAE | G | 1-Nov-90 | A | NF |
| 1 | C78 | 6945 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6946 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6947 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6948 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6949 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6950 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6951 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6952 | UNKNOWN | UNKNOWN | RUBIACEAE | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6953 | HELICONIA | CARIBAEA | HELICONIACEAE | G | 1-Nov-90 | NF | NF |
| 1 | C78 | 6954 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6955 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6956 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6957 | UNKNOWN | UNKNOWN | RUBIACEAE | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6958 | UNKNOWN | UNKNOWN | RUBIACEAE | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6959 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6960 | POLYPODIUM | CRASSIFOLIUM | POLYPODIACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C78 | 6961 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6962 | UNKNOWN | UNKNOWN | RUBIACEAE | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6963 | UNKNOWN | UNKNOWN | RUBIACEAE | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6964 | UNKNOWN | UNKNOWN | FABACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C78 | 6965 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6966 | POLYPODIUM | CRASSIFOLIUM | POLYPODIACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C78 | 6967 | POLYPODIUM | CRASSIFOLIUM | POLYPODIACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C78 | 6968 | HELICONIA | CARIBAEA | HELICONIACEAE | G | 1-Nov-90 | NF | NF |
| 1 | C78 | 6969 | HELICONIA | CARIBAEA | HELICONIACEAE | G | 1-Nov-90 | NF | NF |
| 1 | C78 | 6970 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C78 | 6971 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6972 | UNKNOWN | UNKNOWN | RUBIACEAE | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6973 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 6974 | SARRACENIA | PURPUREA | SARRACENIACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C78 | 6975 | DIOSCOREA | SP. | DIOSCOREACEAE | C | 1-Nov-90 | NF | NF |
| 1 | C85 | 6976 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C84 | 6977 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C84 | 6978 | DOODIA | CAUDATA | BLECHNACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 6979 | POLYPODIUM | AUREUM | POLYPODIACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 6980 | CAMELLIA | SINENSIS | THEACEAE | S | 1-Nov-90 | A | NF |
| 1 | C85 | 6981 | CAMELLIA | SINENSIS | THEACEAE | S | 1-Nov-90 | NF | NF |
| 1 | C85 | 6982 | UNKNOWN | UNKNOWN | RUBIACEAE | U | 1-Nov-90 | NF | NF |
| 1 | C85 | 6983 | UNKNOWN | UNKNOWN | RUBIACEAE | U | 1-Nov-90 | NF | NF |
| 1 | C85 | 6984 | KAEMPFERIA | PULCHRA | ZINGIBERACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 6985 | KAEMPFERIA | PULCHRA | ZINGIBERACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 6986 | KAEMPFERIA | PULCHRA | ZINGIBERACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 6987 | KAEMPFERIA | PULCHRA | ZINGIBERACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 6988 | KAEMPFERIA | PULCHRA | ZINGIBERACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 6989 | ELAEIS | GUINEENSIS | ARECACEAE | P | 1-Nov-90 | NF | NF |
| 1 | C84 | 6990 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C85 | 6991 | UNKNOWN | UNKNOWN | RUBIACEAE | U | 1-Nov-90 | NF | NF |
| 1 | C84 | 6992 | SARRACENIA | PURPUREA | SARRACENIACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C84 | 6993 | SARRACENIA | PURPUREA | SARRACENIACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C84 | 6994 | SARRACENIA | PURPUREA | SARRACENIACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 6995 | BLECHNUM | OCCIDENTALE | BLECHNACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 6996 | TILLANDSIA | SP. | BROMELIACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C85 | 6997 | UNKNOWN | UNKNOWN | ORCHIDACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C85 | 6998 | TILLANDSIA | SP. | BROMELIACEAE | E | 1-Nov-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C85 | 6999 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C86 | 7000 | BACTRIS | GASIPAES | ARECACEAE | P | 18-Oct-90 | A | A |
| 1 | C86 | 7001 | HEIMIA | SALICIFOLIA | LYTHRACEAE | S | 18-Oct-90 | A | NF |
| 1 | C86 | 7002 | PHALARIS | ARUNDINACEA | POACEAE | R | 18-Oct-90 | NF | NF |
| 1 | C86 | 7003 | PHILODENDRON | SELLOUM | ARACEAE | C | 18-Oct-90 | A | A |
| 1 | C86 | 7004 | BACTRIS | GASIPAES | ARECACEAE | P | 18-Oct-90 | A | A |
| 1 | C86 | 7005 | UNKNOWN | UNKNOWN | ARACEAE | U | 18-Oct-90 | A | NF |
| 1 | C86 | 7006 | CYATHEA | COOPERI | CYATHEACEAE | P | 18-Oct-90 | D | NF |
| 1 | C86 | 7007 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 18-Oct-90 | D | NF |
| 1 | C86 | 7008 | UNKNOWN | UNKNOWN | UNKNOWN | U | 18-Oct-90 | NF | NF |
| 1 | C79 | 7009 | PHILODENDRON | SELLOUM | ARACEAE | C | 18-Oct-90 | NF | NF |
| 1 | C79 | 7010 | CHRYSALIDOCARPUS | LUTESCENS | ARECACEAE | S | 18-Oct-90 | A | A |
| 1 | C79 | 7011 | RUBUS | SP. | ROSACEAE | S | 18-Oct-90 | NF | NF |
| 1 | C79 | 7012 | RUBUS | SP. | ROSACEAE | S | 18-Oct-90 | NF | NF |
| 1 | C79 | 7013 | COLOCASIA | ANTIQUORUM | ARACEAE | H | 18-Oct-90 | NF | NF |
| 1 | C79 | 7014 | COLOCASIA | ANTIQUORUM | ARACEAE | H | 18-Oct-90 | NF | NF |
| 1 | C79 | 7015 | BACTRIS | GASIPAES | ARECACEAE | P | 18-Oct-90 | A | A |
| 1 | C79 | 7016 | DAVALLIA | SOLIDA | DAVALLIACEAE | H | 18-Oct-90 | NF | NF |
| 1 | C79 | 7017 | PHILODENDRON | SP. | ARACEAE | C | 18-Oct-90 | A | D |
| 1 | C79 | 7018 | CEDRELA | SP. | MELIACEAE | T | 18-Oct-90 | A | A |
| 1 | C79 | 7019 | DIOSCOREA | ALATA | DIOSCOREACEAE | C | 18-Oct-90 | NF | NF |
| 1 | C79 | 7020 | PHILODENDRON | SELLOUM | ARACEAE | C | 18-Oct-90 | A | A |
| 1 | C79 | 7021 | PHILODENDRON | RUBENS | ARACEAE | C | 18-Oct-90 | A | A |
| 1 | C79 | 7022 | TIBOUCHINA | INTEROMALLA | MELASTOMATACEAE | S | 18-Oct-90 | NF | NF |
| 1 | C78 | 7023 | PHILODENDRON | SELLOUM | ARACEAE | C | 18-Oct-90 | A | A |
| 1 | C78 | 7024 | IPOMOEA | BATATAS | CONVOLVULACEAE | H | 18-Oct-90 | NF | NF |
| 1 | C78 | 7025 | PHILODENDRON | SELLOUM | ARACEAE | C | 18-Oct-90 | NF | A |
| 1 | C78 | 7026 | UNKNOWN | UNKNOWN | UNKNOWN | U | 18-Oct-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C78 | 7027 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 18-Oct-90 | NF | NF |
| 1 | C78 | 7028 | COLOCASIA | ANTIQUORUM | ARACEAE | H | 18-Oct-90 | NF | NF |
| 1 | C86 | 7029 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 18-Oct-90 | NF | NF |
| 1 | C63 | 7030 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | NF | NF |
| 1 | C63 | 7031 | BREYNIA | DISTICHA | EUPHORBIACEAE | H | 31-Oct-90 | A | A |
| 1 | C63 | 7032 | CALATHEA | LOUISAE | MARANTACEAE | H | 31-Oct-90 | NF | D |
| 1 | C63 | 7033 | CALATHEA | LOUISAE | MARANTACEAE | H | 31-Oct-90 | NF | D |
| 1 | C63 | 7034 | CALATHEA | LOUISAE | MARANTACEAE | H | 31-Oct-90 | NF | D |
| 1 | C63 | 7035 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | D | D |
| 1 | C63 | 7036 | BAMBUSA | MULTIPLEX | POACEAE | A | 31-Oct-90 | A | D |
| 1 | C63 | 7037 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | A | A |
| 1 | C64 | 7038 | BREYNIA | DISTICHA | EUPHORBIACEAE | H | 31-Oct-90 | A | A |
| 1 | C64 | 7039 | UNKNOWN | UNKNOWN | ARACEAE | U | 31-Oct-90 | A | A |
| 1 | C63 | 7040 | CALATHEA | VIOLACEA | MARANTACEAE | H | 31-Oct-90 | NF | A |
| 1 | C63 | 7041 | CALATHEA | VIOLACEA | MARANTACEAE | H | 31-Oct-90 | A | A |
| 1 | C71 | 7042 | PIPER | SP. | PIPERACEAE | H | 31-Oct-90 | A | A |
| 1 | C71 | 7043 | PHILODENDRON | RUBENS | ARACEAE | C | 31-Oct-90 | A | A |
| 1 | C71 | 7044 | MONSTERA | DELICIOSA | ARACEAE | C | 31-Oct-90 | A | A |
| 1 | C71 | 7045 | PIPER | SP. | PIPERACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C71 | 7046 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | NF | NF |
| 1 | C71 | 7047 | ALPINIA | SANDERAE | ZINGIBERACEAE | G | 31-Oct-90 | A | NF |
| 1 | C71 | 7048 | PSIDIUM | GUAJAVA | MYRTACEAE | T | 31-Oct-90 | NF | NF |
| 1 | C71 | 7049 | UNKNOWN | UNKNOWN | LORANTHACEAE | U | 31-Oct-90 | D | NF |
| 1 | C70 | 7050 | CROTON | SP. | EUPHORBIACEAE | H | 31-Oct-90 | A | NF |
| 1 | C71 | 7051 | SETARIA | PALMIFOLIA | POACEAE | R | 31-Oct-90 | A | A |
| 1 | C71 | 7052 | EUGENIA | AGGREGATA | MYRTACEAE | T | 31-Oct-90 | A | NF |
| 1 | C71 | 7053 | ANNONA | MURICATA | ANNONACEAE | T | 31-Oct-90 | A | A |
| 1 | C71 | 7054 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 31-Oct-90 | A | A |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C71 | 7055 | ARCHONTOPHOENIX | SP. | ARECACEAE | P | 31-Oct-90 | A | A |
| 1 | C70 | 7056 | PITHECOCTENIUM | SP. | BIGNONIACEAE | C | 31-Oct-90 | NF | NF |
| 1 | C70 | 7057 | ACORUS | CALAMUS | ARACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7058 | ACORUS | CALAMUS | ARACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C71 | 7060 | BRUGMANSIA | SUAVEOLENS | SOLANACEAE | S | 31-Oct-90 | A | A |
| 1 | C71 | 7061 | ALLAMANDA | CATHARTICA | APOCYNACEAE | S | 31-Oct-90 | A | A |
| 1 | C71 | 7062 | BEGONIA | SP. | BEGONIACEAE | H | 31-Oct-90 | D | NF |
| 1 | C78 | 7063 | SANCHEZIA | SPECIOSA | ACANTHACEAE | S | 31-Oct-90 | A | A |
| 1 | C78 | 7064 | SCINDAPSUS | AUREUS | ARACEAE | C | 31-Oct-90 | A | A |
| 1 | C70 | 7065 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 31-Oct-90 | A | A |
| 1 | C70 | 7066 | CANNA | SP. | CANNACEAE | G | 31-Oct-90 | NF | NF |
| 1 | C69 | 7067 | SAGITTARIA | LATIFOLIA | ALISMATACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C69 | 7068 | EQUISETUM | HYEMALE | EQUISETACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C69 | 7069 | ASPLENIUM | NIDUS | ASPLENIACEAE | E | 31-Oct-90 | NF | NF |
| 1 | C69 | 7070 | HYDROCOTYLE | VERTICILLATA | APIACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C69 | 7071 | SAGITTARIA | LATIFOLIA | ALISMATACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C69 | 7072 | ACROSTICHUM | AUREUM | PTERIDACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C69 | 7073 | DICHORISANDRA | THYRSIFLORA | COMMELINACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7074 | PONTEDERIA | CORDATA | PONTEDERIACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7075 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | NF | NF |
| 1 | C70 | 7076 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 31-Oct-90 | A | A |
| 1 | C70 | 7077 | NYMPHAEA | SP. | NYMPHAEACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7078 | MARSILEA | MUTICA | MARSILEACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7079 | NYMPHAEA | SP. | NYMPHAEACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7080 | COMMELINA | TUBEROSA | COMMELINACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7081 | TYPHA | ANGUSTIFOLIA | TYPHACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7082 | TYPHA | ANGUSTIFOLIA | TYPHACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7083 | NYMPHAEA | SP. | NYMPHAEACEAE | H | 31-Oct-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C70 | 7084 | NYMPHAEA | SP. | NYMPHAEACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7085 | NYMPHAEA | SP. | NYMPHAEACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7086 | DIEFFENBACHIA | SP. | ARACEAE | H | 31-Oct-90 | A | A |
| 1 | C70 | 7087 | DICHORISANDRA | THYRSIFLORA | COMMELINACEAE | H | 31-Oct-90 | A | NF |
| 1 | C70 | 7088 | ACORUS | CALAMUS | ARACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7089 | DICHORISANDRA | THYRSIFLORA | COMMELINACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7090 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 31-Oct-90 | A | D |
| 1 | C70 | 7091 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 31-Oct-90 | NF | NF |
| 1 | C70 | 7092 | SPARTINA | SP. | POACEAE | R | 31-Oct-90 | NF | NF |
| 1 | C70 | 7093 | MUSA | SP. | MUSACEAE | G | 31-Oct-90 | A | NF |
| 1 | C63 | 7094 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 31-Oct-90 | A | D |
| 1 | C63 | 7095 | SAGITTARIA | LANCIFOLIA | ALISMATACEAE | H | 31-Oct-90 | NF | D |
| 1 | C63 | 7096 | NYMPHAEA | SP. | NYMPHAEACEAE | H | 31-Oct-90 | NF | D |
| 1 | C63 | 7097 | PONTEDERIA | CORDATA | PONTEDERIACEAE | H | 31-Oct-90 | NF | D |
| 1 | C63 | 7098 | SAGITTARIA | LATIFOLIA | ALISMATACEAE | H | 31-Oct-90 | NF | D |
| 1 | C63 | 7099 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 31-Oct-90 | A | D |
| 1 | C63 | 7100 | CALATHEA | LOUISAE | MARANTACEAE | H | 31-Oct-90 | A | D |
| 1 | C63 | 7101 | CALATHEA | VIOLACEA | MARANTACEAE | H | 31-Oct-90 | A | A |
| 1 | C63 | 7102 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 31-Oct-90 | A | D |
| 1 | C70 | 7103 | HEIMIA | SALICIFOLIA | LYTHRACEAE | S | 31-Oct-90 | | NF |
| 1 | C70 | 7104 | SAGITTARIA | RUBRUM | ALISMATACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7105 | PONTEDERIA | CORDATA | PONTEDERIACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7106 | PONTEDERIA | CORDATA | PONTEDERIACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7107 | PONTEDERIA | CORDATA | PONTEDERIACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7108 | NYMPHAEA | SP. | NYMPHAEACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7109 | SAGITTARIA | LATIFOLIA | ALISMATACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7110 | PONTEDERIA | CORDATA | PONTEDERIACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7111 | SAGITTARIA | LATIFOLIA | ALISMATACEAE | H | 31-Oct-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C70 | 7112 | PONTEDERIA | CORDATA | PONTEDERIACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7113 | NYMPHAEA | SP. | NYMPHAEACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7114 | SAGITTARIA | LATIFOLIA | ALISMATACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7115 | SAGITTARIA | RUBRUM | ALISMATACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7116 | HYMENOCALLIS | SP. | AMARYLLIDACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7117 | CYPERUS | HASPERIS | CYPERACEAE | R | 31-Oct-90 | NF | NF |
| 1 | C70 | 7118 | NYMPHAEA | SP. | NYMPHAEACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7119 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 31-Oct-90 | A | NF |
| 1 | C70 | 7120 | EQUISETUM | HYEMALE | EQUISETACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C62 | 7121 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | A | NF |
| 1 | C62 | 7122 | ALLAMANDA | CATHARTICA | APOCYNACEAE | S | 31-Oct-90 | NF | A |
| 1 | C69 | 7123 | PSIDIUM | GUAJAVA | MYRTACEAE | T | 31-Oct-90 | A | D |
| 1 | C69 | 7124 | CALATHEA | VIOLACEA | MARANTACEAE | H | 31-Oct-90 | NF | A |
| 1 | C69 | 7125 | SYZYGIUM | JAMBOS | MYRTACEAE | T | 31-Oct-90 | A | A |
| 1 | C69 | 7126 | CAPSICUM | SP. | SOLANACEAE | H | 31-Oct-90 | D | NF |
| 1 | C69 | 7127 | CAESALPINIA | SP. | FABACEAE | T | 31-Oct-90 | A | NF |
| 1 | C69 | 7128 | LEUCAENA | GLAUCA | FABACEAE | T | 31-Oct-90 | A | NF |
| 1 | C69 | 7129 | CAPSICUM | SP. | SOLANACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C69 | 7130 | SANCHEZIA | SPECIOSA | ACANTHACEAE | S | 31-Oct-90 | A | NF |
| 1 | C69 | 7131 | CANNA | GENERALIS | CANNACEAE | G | 31-Oct-90 | NF | NF |
| 1 | C69 | 7132 | TABEBUIA | HETEROPHYLLA | BIGNONIACEAE | T | 31-Oct-90 | A | NF |
| 1 | C70 | 7133 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 31-Oct-90 | A | NF |
| 1 | C77 | 7134 | BLECHNUM | ORIENTALE | BLECHNACEAE | H | 31-Oct-90 | NF | D |
| 1 | C70 | 7135 | FICUS | PUMILA | MORACEAE | C | 31-Oct-90 | NF | NF |
| 1 | C70 | 7136 | DICHORISANDRA | THYRSIFLORA | COMMELINACEAE | H | 31-Oct-90 | NF | D |
| 1 | C70 | 7137 | TRADESCANTIA | PALLIDA | COMMELINACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7138 | CANNA | SP. | CANNACEAE | G | 31-Oct-90 | NF | NF |
| 1 | C70 | 7139 | BACOPA | MONNIERI | SCROPHULARIACEAE | H | 31-Oct-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C70 | 7140 | SAGITTARIA | GRAMINEA | ALISMATACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C70 | 7141 | TYPHA | DOMINGENSIS | TYPHACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C77 | 7142 | DIETES | BICOLOR | IRIDACEAE | H | 31-Oct-90 | A | D |
| 1 | C77 | 7143 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 31-Oct-90 | NF | D |
| 1 | C77 | 7144 | CLUSIA | SP. | CLUSIACEAE | T | 31-Oct-90 | NF | D |
| 1 | C78 | 7145 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | NF | NF |
| 1 | C78 | 7146 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 31-Oct-90 | A | A |
| 1 | C78 | 7147 | UNKNOWN | UNKNOWN | ARACEAE | U | 31-Oct-90 | NF | NF |
| 1 | C78 | 7148 | ACORUS | CALAMUS | ARACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C78 | 7149 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | NF | NF |
| 1 | C78 | 7150 | UNKNOWN | UNKNOWN | FABACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C78 | 7151 | PLATYCERIUM | SUPERBUM | POLYPODIACEAE | E | 31-Oct-90 | NF | NF |
| 1 | C78 | 7152 | UNKNOWN | UNKNOWN | FABACEAE | U | 31-Oct-90 | NF | NF |
| 1 | C78 | 7153 | TRADESCANTIA | PALLIDA | COMMELINACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C78 | 7154 | UNKNOWN | UNKNOWN | BROMELIACEAE | U | 31-Oct-90 | NF | NF |
| 1 | C78 | 7155 | UNKNOWN | UNKNOWN | FABACEAE | U | 31-Oct-90 | NF | NF |
| 1 | C79 | 7156 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | NF |
| 1 | C79 | 7157 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 2-Nov-90 | D | NF |
| 1 | C79 | 7158 | GUZMANIA | BERTERONIANA | BROMELIACEAE | E | 2-Nov-90 | NF | NF |
| 1 | C79 | 7159 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | A |
| 1 | C79 | 7160 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | A | A |
| 1 | C79 | 7161 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | A | A |
| 1 | C86 | 7162 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | A | A |
| 1 | C86 | 7163 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | A | NF |
| 1 | C86 | 7164 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | A |
| 1 | C86 | 7165 | UNKNOWN | UNKNOWN | BROMELIACEAE | U | 2-Nov-90 | NF | NF |
| 1 | C85 | 7166 | AECHMEA | ORLANDIANA | BROMELIACEAE | E | 2-Nov-90 | NF | NF |
| 1 | C83 | 7168 | RHAPIS | EXCELSA | ARECACEAE | P | 2-Nov-90 | D | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C77 | 7169 | CLUSIA | SP. | CLUSIACEAE | T | 1-Nov-90 | NF | D |
| 1 | C77 | 7170 | AGLAONEMA | CRISPUM | ARACEAE | H | 1-Nov-90 | A | A |
| 1 | C76 | 7171 | DICHORISANDRA | THYRSIFLORA | COMMELINACEAE | H | 1-Nov-90 | A | D |
| 1 | C76 | 7172 | PHILODENDRON | ERUBESCENS | ARACEAE | C | 1-Nov-90 | NF | NF |
| 1 | C76 | 7173 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | A | NF |
| 1 | C76 | 7174 | CEDRELA | SP. | MELIACEAE | T | 1-Nov-90 | A | D |
| 1 | C76 | 7175 | SCINDAPSUS | AUREUS | ARACEAE | C | 1-Nov-90 | | A |
| 1 | C76 | 7176 | BILLBERGIA | PYRAMIDALIS | BROMELIACEAE | E | 1-Nov-90 | A | NF |
| 1 | C61 | 7177 | CANNA | GENERALIS | CANNACEAE | G | 31-Oct-90 | NF | A |
| 1 | C68 | 7178 | CANNA | GENERALIS | CANNACEAE | G | 31-Oct-90 | A | NF |
| 1 | C68 | 7179 | CANNA | GENERALIS | CANNACEAE | G | 31-Oct-90 | NF | NF |
| 1 | C69 | 7180 | CANNA | INDICA | CANNACEAE | G | 31-Oct-90 | NF | NF |
| 1 | C68 | 7181 | HEDYCHIUM | CORNATUM | ZINGIBERACEAE | G | 31-Oct-90 | NF | NF |
| 1 | C69 | 7182 | COSTUS | SP. | ZINGIBERACEAE | H | 31-Oct-90 | A | A |
| 1 | C69 | 7183 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | A | A |
| 1 | C69 | 7184 | GLOBBA | SP. | ZINGIBERACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C69 | 7185 | CANNA | GENERALIS | CANNACEAE | G | 31-Oct-90 | A | A |
| 1 | C69 | 7186 | CANANGA | ODORATA | ANNONACEAE | T | 31-Oct-90 | NF | NF |
| 1 | C68 | 7187 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | A | NF |
| 1 | C76 | 7188 | CALOPOGONIUM | MUCUNOIDES | FABACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C76 | 7189 | CANNA | GENERALIS | CANNACEAE | G | 31-Oct-90 | NF | NF |
| 1 | C75 | 7190 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | NF | NF |
| 1 | C76 | 7191 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | A | D |
| 1 | C76 | 7192 | PASSIFLORA | EDULIS | PASSIFLORACEAE | C | 31-Oct-90 | A | NF |
| 1 | C76 | 7193 | CANNA | GENERALIS | CANNACEAE | G | 31-Oct-90 | A | NF |
| 1 | C82 | 7194 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | A | NF |
| 1 | C83 | 7195 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | A | A |
| 1 | C83 | 7196 | SPARTINA | SP. | POACEAE | R | 31-Oct-90 | A | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C83 | 7197 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | NF | NF |
| 1 | C83 | 7198 | CANNA | INDICA | CANNACEAE | G | 31-Oct-90 | NF | NF |
| 1 | C82 | 7199 | MUSA | SP. | MUSACEAE | G | 31-Oct-90 | A | A |
| 1 | C82 | 7200 | HELICONIA | PSITTACORUM | HELICONIACEAE | G | 31-Oct-90 | NF | NF |
| 1 | C82 | 7201 | HELICONIA | PSITTACORUM | HELICONIACEAE | G | 31-Oct-90 | NF | NF |
| 1 | C89 | 7202 | MUSA | SP. | MUSACEAE | G | 31-Oct-90 | A | A |
| 1 | C90 | 7203 | MUSA | SP. | MUSACEAE | G | 31-Oct-90 | NF | A |
| 1 | C90 | 7204 | CANNA | INDICA | CANNACEAE | G | 31-Oct-90 | A | D |
| 1 | C90 | 7205 | BRUGMANSIA | SUAVEOLENS | SOLANACEAE | S | 31-Oct-90 | A | A |
| 1 | C90 | 7206 | HEDYCHIUM | CORONARIUM | ZINGIBERACEAE | G | 31-Oct-90 | A | A |
| 1 | C90 | 7207 | COSTUS | SP. | ZINGIBERACEAE | H | 2-Nov-90 | A | D |
| 1 | C90 | 7209 | ALPINIA | SANDERAE | ZINGIBERACEAE | G | 2-Nov-90 | NF | NF |
| 1 | C90 | 7210 | CANNA | INDICA | CANNACEAE | G | 2-Nov-90 | A | NF |
| 1 | C90 | 7211 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | NF |
| 1 | C90 | 7212 | HEDYCHIUM | SP. | ZINGIBERACEAE | G | 2-Nov-90 | NF | NF |
| 1 | C90 | 7213 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | NF |
| 1 | C90 | 7214 | CURCUMA | LONGA | ZINGIBERACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C91 | 7215 | CANNA | GENERALIS | CANNACEAE | G | 2-Nov-90 | NF | D |
| 1 | C91 | 7216 | ALPINIA | PURPURATA | ZINGIBERACEAE | G | 2-Nov-90 | NF | A |
| 1 | C92 | 7217 | ALPINIA | SANDERAE | ZINGIBERACEAE | G | 2-Nov-90 | NF | NF |
| 1 | C92 | 7218 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | NF |
| 1 | C93 | 7221 | CANNA | INDICA | CANNACEAE | G | 2-Nov-90 | NF | D |
| 1 | C94 | 7222 | CANNA | GENERALIS | CANNACEAE | G | 2-Nov-90 | NF | NF |
| 1 | C94 | 7223 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | NF |
| 1 | C94 | 7224 | CAPSICUM | SP. | SOLANACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C94 | 7225 | CANNA | INDICA | CANNACEAE | G | 2-Nov-90 | A | NF |
| 1 | C94 | 7226 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | | NF |
| 1 | C94 | 7227 | CRESCENTIA | CUJETE | BIGNONIACEAE | T | 2-Nov-90 | A | A |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C94 | 7228 | CAPSICUM | SP. | SOLANACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C94 | 7229 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | A | NF |
| 1 | C87 | 7230 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | NF |
| 1 | C87 | 7231 | GUAREA | TRICHILIODES | MELIACEAE | T | 2-Nov-90 | NF | D |
| 1 | C87 | 7232 | CEIBA | PENTANDRA | BOMBACACEAE | T | 2-Nov-90 | A | D |
| 1 | C87 | 7233 | ALEURITES | MOLUCCANA | EUPHORBIACEAE | T | 2-Nov-90 | A | D |
| 1 | C87 | 7234 | LECYTHIS | ZABUCAJO | LECYTHIDACEAE | T | 2-Nov-90 | A | NF |
| 1 | C86 | 7235 | PASSIFLORA | QUADRANGULARIS | PASSIFLORACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C86 | 7236 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | NF |
| 1 | C86 | 7237 | CISSUS | SICYOIDES | VITACEAE | C | 2-Nov-90 | A | D |
| 1 | C86 | 7238 | POGOSTEMON | HEYNEANUS | LAMIACEAE | S | 2-Nov-90 | NF | NF |
| 1 | C80 | 7239 | BUCHENAVIA | CAPITATA | COMBRETACEAE | T | 2-Nov-90 | NF | NF |
| 1 | C87 | 7240 | COFFEA | ARABICA | RUBIACEAE | S | 2-Nov-90 | A | A |
| 1 | C87 | 7241 | ALEURITES | MOLUCCANA | EUPHORBIACEAE | T | 2-Nov-90 | D | D |
| 1 | C87 | 7242 | CYATHEA | SP. | CYATHEACEAE | P | 2-Nov-90 | D | D |
| 1 | C87 | 7243 | ERYNGIUM | FOETIDUM | APIACEAE | H | 2-Nov-90 | NF | D |
| 1 | C80 | 7244 | DIPLAZIUM | L'HERMINIERI | ASPLENIACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C80 | 7245 | CLITORIA | RACEMOSA | FABACEAE | T | 2-Nov-90 | A | NF |
| 1 | C80 | 7246 | CANAVALIA | ENSIFORMIS | FABACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C79 | 7248 | PASSIFLORA | QUADRANGULARIS | PASSIFLORACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C79 | 7249 | IPOMOEA | BATATAS | CONVOLVULACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C79 | 7250 | SELAGINELLA | VERSICOLOR | SELAGINELLACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C79 | 7251 | SELAGINELLA | VERSICOLOR | SELAGINELLACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C79 | 7252 | PASSIFLORA | TRIFASCIATA | PASSIFLORACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C79 | 7253 | IPOMOEA | BATATAS | CONVOLVULACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C80 | 7254 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | NF |
| 1 | C80 | 7255 | GUAREA | TRICHILIODES | MELIACEAE | T | 2-Nov-90 | A | NF |
| 1 | C80 | 7256 | CORDIA | ALLIODORA | BORAGINACEAE | T | 2-Nov-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C80 | 7257 | MELIA | AZEDARACH | MELIACEAE | T | 2-Nov-90 | A | A |
| 1 | C80 | 7258 | LECYTHIS | ZABUCAJO | LECYTHIDACEAE | T | 2-Nov-90 | NF | NF |
| 1 | C81 | 7259 | ANNONA | MURICATA | ANNONACEAE | T | 2-Nov-90 | A | D |
| 1 | C81 | 7260 | HELICONIA | PSITTACORUM | HELICONIACEAE | G | 2-Nov-90 | NF | D |
| 1 | C73 | 7261 | POGOSTEMON | HEYNEANUS | LAMIACEAE | S | 2-Nov-90 | NF | NF |
| 1 | C80 | 7262 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 2-Nov-90 | A | A |
| 1 | C80 | 7263 | ALEURITES | MOLUCCANA | EUPHORBIACEAE | T | 2-Nov-90 | A | NF |
| 1 | C80 | 7264 | SPONDIAS | MOMBIN | ANACARDIACEAE | T | 2-Nov-90 | A | NF |
| 1 | C79 | 7265 | BUDDLEJA | DIVERSIFOLIA | BUDDLEJACEAE | T | 2-Nov-90 | D | NF |
| 1 | C78 | 7266 | PASSIFLORA | CORIACEA | PASSIFLORACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C78 | 7267 | PASSIFLORA | CORIACEA | PASSIFLORACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C78 | 7268 | PHILODENDRON | RUBENS | ARACEAE | C | 2-Nov-90 | A | A |
| 1 | C78 | 7269 | SELAGINELLA | VERSICOLOR | SELAGINELLACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C78 | 7270 | ASCLEPIAS | CURASSAVICA | ASCLEPIADACEAE | H | 2-Nov-90 | NF | A |
| 1 | C78 | 7271 | FICUS | PUMILA | MORACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C78 | 7272 | ASCLEPIAS | CURASSAVICA | ASCLEPIADACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C71 | 7273 | FICUS | PUMILA | MORACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C71 | 7274 | UNKNOWN | UNKNOWN | ARACEAE | U | 2-Nov-90 | D | NF |
| 1 | C71 | 7275 | UNKNOWN | UNKNOWN | ARACEAE | U | 2-Nov-90 | A | D |
| 1 | C71 | 7276 | SCINDAPSUS | AUREUS | ARACEAE | C | 2-Nov-90 | A | NF |
| 1 | C71 | 7277 | ASCLEPIAS | CURASSAVICA | ASCLEPIADACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C71 | 7278 | SELAGINELLA | VICTORIAE | SELAGINELLACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C71 | 7279 | UNKNOWN | UNKNOWN | ARACEAE | U | 2-Nov-90 | D | NF |
| 1 | C71 | 7280 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | D | NF |
| 1 | C71 | 7281 | DIETES | GRANDIFLORA | IRIDACEAE | H | 2-Nov-90 | D | NF |
| 1 | C71 | 7282 | UNKNOWN | UNKNOWN | POACEAE | U | 2-Nov-90 | A | NF |
| 1 | C71 | 7283 | PASSIFLORA | CORIACEA | PASSIFLORACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C64 | 7284 | SELAGINELLA | VERSICOLOR | SELAGINELLACEAE | H | 2-Nov-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C71 | 7285 | PASSIFLORA | QUADRANGULARIS | PASSIFLORACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C71 | 7286 | PHILODENDRON | CV 'WEND-IMBE' | ARACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C71 | 7287 | IPOMOEA | BATATAS | CONVOLVULACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C72 | 7288 | TABERNAEMONTANA | DIVARICATA | APOCYNACEAE | S | 2-Nov-90 | NF | NF |
| 1 | C72 | 7289 | BAUHINIA | SP. | FABACEAE | S | 2-Nov-90 | D | NF |
| 1 | C72 | 7290 | ACORUS | CALAMUS | ARACEAE | H | 2-Nov-90 | D | NF |
| 1 | C72 | 7291 | SELAGINELLA | VERSICOLOR | SELAGINELLACEAE | H | 2-Nov-90 | D | NF |
| 1 | C72 | 7292 | CISSUS | SICYOIDES | VITACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C72 | 7293 | UNKNOWN | UNKNOWN | MELASTOMATACEAE | U | 2-Nov-90 | NF | NF |
| 1 | C72 | 7294 | ELAEAGNUS | PHILIPPENSIS | ELAEAGNACEAE | T | 2-Nov-90 | NF | NF |
| 1 | C73 | 7295 | PASSIFLORA | QUADRANGULARIS | PASSIFLORACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C66 | 7296 | FICUS | PUMILA | MORACEAE | C | 2-Nov-90 | NF | D |
| 1 | C73 | 7297 | DRACUNCULUS | CANARIENSIS | ARACEAE | H | 2-Nov-90 | A | A |
| 1 | C73 | 7298 | PASSIFLORA | QUADRANGULARIS | PASSIFLORACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C73 | 7299 | GUAREA | TRICHILIODES | MELIACEAE | T | 2-Nov-90 | A | D |
| 1 | C85 | 7300 | ADIANTUM | RADDIANUM | ADIANTACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 7301 | POLYTAENIUM | FEEI | ADIANTACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 7302 | POLYTAENIUM | FEEI | ADIANTACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 7303 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C85 | 7304 | POLYTAENIUM | FEEI | ADIANTACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 7305 | CYATHEA | COOPERI | CYATHEACEAE | P | 1-Nov-90 | NF | NF |
| 1 | C85 | 7306 | ADIANTUM | RADDIANUM | ADIANTACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 7307 | POLYTAENIUM | FEEI | ADIANTACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 7308 | TILLANDSIA | SP. | BROMELIACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C85 | 7309 | TILLANDSIA | SP. | BROMELIACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C85 | 7310 | COCCOCYPSELUM | HERBACEUM | RUBIACEAE | S | 1-Nov-90 | A | NF |
| 1 | C85 | 7311 | TILLANDSIA | SP. | BROMELIACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C85 | 7312 | TILLANDSIA | SP. | BROMELIACEAE | E | 1-Nov-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C85 | 7313 | TILLANDSIA | SP. | BROMELIACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C85 | 7314 | POLYTAENIUM | FEEI | ADIANTACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C85 | 7315 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C85 | 7316 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C77 | 7318 | CLUSIA | SP. | CLUSIACEAE | T | 31-Oct-90 | NF | D |
| 1 | C77 | 7319 | COSTUS | SP. | ZINGIBERACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C77 | 7320 | CALLISIA | FRAGRANS | COMMELINACEAE | H | 31-Oct-90 | NF | D |
| 1 | C77 | 7321 | RHIPSALIS | BACCIFERA | CACTACEAE | E | 31-Oct-90 | NF | D |
| 1 | C77 | 7322 | RHIPSALIS | BACCIFERA | CACTACEAE | E | 31-Oct-90 | NF | D |
| 1 | C84 | 7323 | CALLISIA | FRAGRANS | COMMELINACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C84 | 7324 | CALLISIA | FRAGRANS | COMMELINACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C84 | 7325 | CALLISIA | FRAGRANS | COMMELINACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C84 | 7326 | CLUSIA | SP. | CLUSIACEAE | T | 31-Oct-90 | NF | NF |
| 1 | C84 | 7327 | CLUSIA | SP. | CLUSIACEAE | T | 31-Oct-90 | NF | NF |
| 1 | C84 | 7328 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 31-Oct-90 | NF | NF |
| 1 | C84 | 7329 | FICUS | PUMILA | MORACEAE | C | 31-Oct-90 | NF | A |
| 1 | C84 | 7330 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | NF | NF |
| 1 | C84 | 7331 | COCCOCYPSELUM | HERBACEUM | RUBIACEAE | S | 2-Nov-90 | NF | NF |
| 1 | C84 | 7332 | CYATHEA | ARBOREA | CYATHEACEAE | P | 2-Nov-90 | NF | NF |
| 1 | C84 | 7333 | CLUSIA | SP. | CLUSIACEAE | T | 2-Nov-90 | NF | NF |
| 1 | C84 | 7334 | HELICONIA | PSITTACORUM | HELICONIACEAE | G | 2-Nov-90 | A | A |
| 1 | C84 | 7335 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C77 | 7336 | TILLANDSIA | SP. | BROMELIACEAE | E | 31-Oct-90 | NF | D |
| 1 | C77 | 7337 | UNKNOWN | UNKNOWN | FABACEAE | H | 31-Oct-90 | NF | D |
| 1 | C77 | 7338 | PHILODENDRON | SP. | ARACEAE | C | 31-Oct-90 | NF | D |
| 1 | C77 | 7339 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | NF | D |
| 1 | C78 | 7340 | CLUSIA | SP. | CLUSIACEAE | T | 31-Oct-90 | NF | NF |
| 1 | C78 | 7341 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C78 | 7342 | UNKNOWN | UNKNOWN | UNKNOWN | U | 31-Oct-90 | NF | NF |
| 1 | C78 | 7343 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 31-Oct-90 | D | D |
| 1 | C78 | 7344 | UNKNOWN | UNKNOWN | BROMELIACEAE | U | 31-Oct-90 | NF | NF |
| 1 | C78 | 7345 | RHIPSALIS | BACCIFERA | CACTACEAE | E | 31-Oct-90 | NF | NF |
| 1 | C78 | 7346 | RHIPSALIS | BACCIFERA | CACTACEAE | E | 31-Oct-90 | NF | NF |
| 1 | C78 | 7347 | RHIPSALIS | BACCIFERA | CACTACEAE | E | 31-Oct-90 | NF | NF |
| 1 | C85 | 7348 | FICUS | PUMILA | MORACEAE | C | 1-Nov-90 | NF | NF |
| 1 | C85 | 7349 | ADIANTUM | RADDIANUM | ADIANTACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C78 | 7350 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 7351 | PHILODENDRON | SP. | ARACEAE | C | 1-Nov-90 | NF | NF |
| 1 | C78 | 7352 | CYATHEA | COOPERI | CYATHEACEAE | P | 1-Nov-90 | D | D |
| 1 | C85 | 7353 | ADIANTUM | RADDIANUM | ADIANTACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C78 | 7354 | ADIANTUM | RADDIANUM | ADIANTACEAE | H | 1-Nov-90 | NF | NF |
| 1 | C78 | 7355 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | A | NF |
| 1 | C78 | 7356 | FICUS | PUMILA | MORACEAE | C | 1-Nov-90 | A | A |
| 1 | C78 | 7357 | UNKNOWN | UNKNOWN | RUBIACEAE | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 7358 | FICUS | PUMILA | MORACEAE | C | 1-Nov-90 | NF | A |
| 1 | C78 | 7359 | TILLANDSIA | SP. | BROMELIACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C78 | 7360 | PHILODENDRON | SP. | ARACEAE | C | 1-Nov-90 | NF | NF |
| 1 | C78 | 7361 | TILLANDSIA | SP. | BROMELIACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C78 | 7362 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 7363 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 7364 | UNKNOWN | UNKNOWN | UNKNOWN | U | 1-Nov-90 | NF | NF |
| 1 | C78 | 7365 | PHILODENDRON | SP. | ARACEAE | C | 1-Nov-90 | NF | NF |
| 1 | C78 | 7366 | TILLANDSIA | SP. | BROMELIACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C78 | 7367 | UNKNOWN | UNKNOWN | ORCHIDACEAE | E | 1-Nov-90 | NF | NF |
| 1 | C78 | 7368 | FICUS | PUMILA | MORACEAE | C | 1-Nov-90 | NF | NF |
| 1 | C85 | 7370 | CAMELLIA | SINENSIS | THEACEAE | S | 2-Nov-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C85 | 7371 | CAMELLIA | SINENSIS | THEACEAE | S | 2-Nov-90 | NF | NF |
| 1 | C85 | 7372 | POLYPODIUM | PUNCTATUM | POLYPODIACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C85 | 7373 | UNKNOWN | UNKNOWN | FABACEAE | H | 2-Nov-90 | A | NF |
| 1 | C85 | 7374 | CYATHEA | ARBOREA | CYATHEACEAE | P | 2-Nov-90 | NF | NF |
| 1 | C84 | 7375 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | NF |
| 1 | C84 | 7376 | UNKNOWN | UNKNOWN | BROMELIACEAE | U | 2-Nov-90 | NF | NF |
| 1 | C84 | 7377 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 2-Nov-90 | D | D |
| 1 | C84 | 7378 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 2-Nov-90 | D | D |
| 1 | C84 | 7379 | ANTHURIUM | DIGITATUM | ARACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C84 | 7380 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 2-Nov-90 | D | NF |
| 1 | C84 | 7381 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 2-Nov-90 | D | NF |
| 1 | C84 | 7382 | CLUSIA | SP. | CLUSIACEAE | T | 2-Nov-90 | NF | NF |
| 1 | C84 | 7383 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 2-Nov-90 | D | NF |
| 1 | C86 | 7384 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 2-Nov-90 | A | NF |
| 1 | C86 | 7385 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 2-Nov-90 | A | NF |
| 1 | C73 | 7387 | COUROUPITA | AMAZONICA | LECYTHIDACEAE | T | 2-Nov-90 | A | A |
| 1 | C74 | 7388 | PRUNUS | TOMENTOSA | ROSACEAE | T | 2-Nov-90 | NF | NF |
| 1 | C74 | 7389 | SCINDAPSUS | AUREUS | ARACEAE | C | 2-Nov-90 | NF | A |
| 1 | C74 | 7390 | POGOSTEMON | CABLIN | LAMIACEAE | S | 2-Nov-90 | NF | NF |
| 1 | C74 | 7391 | CLITORIA | RACEMOSA | FABACEAE | T | 2-Nov-90 | A | A |
| 1 | C74 | 7392 | POLYPODIUM | PUNCTATUM | POLYPODIACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C74 | 7393 | CECROPIA | SCHREBERIANA | CECROPIACEAE | T | 2-Nov-90 | NF | NF |
| 1 | C74 | 7394 | SANCHEZIA | SPECIOSA | ACANTHACEAE | S | 2-Nov-90 | NF | NF |
| 1 | C74 | 7395 | UNKNOWN | UNKNOWN | MARANTACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C74 | 7396 | CRESCENTIA | CUJETE | BIGNONIACEAE | T | 2-Nov-90 | NF | A |
| 1 | C74 | 7397 | ALLAMANDA | CATHARTICA | APOCYNACEAE | S | 2-Nov-90 | NF | NF |
| 1 | C74 | 7398 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C74 | 7399 | SETARIA | PALMIFOLIA | POACEAE | R | 2-Nov-90 | NF | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C73 | 7400 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | D |
| 1 | C73 | 7401 | UNKNOWN | UNKNOWN | ARACEAE | U | 2-Nov-90 | A | A |
| 1 | C73 | 7402 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | NF |
| 1 | C74 | 7404 | CRESCENTIA | CUJETE | BIGNONIACEAE | T | 2-Nov-90 | NF | FN |
| 1 | C74 | 7405 | CAPSICUM | SP. | SOLANACEAE | H | 2-Nov-90 | NF | FN |
| 1 | C67 | 7406 | CAPSICUM | SP. | SOLANACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C67 | 7407 | HIBISCUS | CALYPHYLLUS | MALVACEAE | S | 2-Nov-90 | A | A |
| 1 | C67 | 7408 | PHILODENDRON | SP. | ARACEAE | C | 2-Nov-90 | A | A |
| 1 | C73 | 7409 | SOLANDRA | MAXIMA | SOLANACEAE | C | 20-Nov-90 | A | A |
| 1 | C74 | 7410 | DRACUNCULUS | CANARIENSIS | ARACEAE | H | 20-Nov-90 | A | A |
| 1 | C73 | 7411 | SANCHEZIA | SPECIOSA | ACANTHACEAE | S | 20-Nov-90 | A | A |
| 1 | C73 | 7412 | PHILODENDRON | RUBENS | ARACEAE | C | 20-Nov-90 | A | NF |
| 1 | C73 | 7413 | UNKNOWN | UNKNOWN | UNKNOWN | U | 20-Nov-90 | NF | NF |
| 1 | C73 | 7414 | SOLANDRA | MAXIMA | SOLANACEAE | C | 20-Nov-90 | NF | NF |
| 1 | C73 | 7415 | ALLAMANDA | CATHARTICA | APOCYNACEAE | S | 20-Nov-90 | A | A |
| 1 | C66 | 7416 | COLEUS | BLUMEI | LAMIACEAE | H | 20-Nov-90 | NF | D |
| 1 | C66 | 7417 | UNKNOWN | UNKNOWN | UNKNOWN | U | 20-Nov-90 | NF | D |
| 1 | C66 | 7418 | CHRYSALIDOCARPUS | LUTESCENS | ARECACEAE | S | 20-Nov-90 | A | A |
| 1 | C66 | 7419 | COLEUS | BLUMEI | LAMIACEAE | H | 20-Nov-90 | NF | D |
| 1 | C73 | 7420 | ALLAMANDA | CATHARTICA | APOCYNACEAE | S | 20-Nov-90 | A | A |
| 1 | C73 | 7421 | SOLANDRA | MAXIMA | SOLANACEAE | C | 20-Nov-90 | NF | NF |
| 1 | C73 | 7422 | COLEUS | BLUMEI | LAMIACEAE | H | 20-Nov-90 | NF | NF |
| 1 | C73 | 7423 | PHILODENDRON | RUBENS | ARACEAE | C | 20-Nov-90 | A | A |
| 1 | C73 | 7424 | CISSUS | GONGYLODES | VITACEAE | C | 20-Nov-90 | NF | NF |
| 1 | C72 | 7425 | CALLISIA | FRAGRANS | COMMELINACEAE | H | 20-Nov-90 | A | NF |
| 1 | C72 | 7426 | PHILODENDRON | RUBENS | ARACEAE | C | 20-Nov-90 | NF | A |
| 1 | C65 | 7427 | COLEUS | BLUMEI | LAMIACEAE | H | 20-Nov-90 | NF | D |
| 1 | C65 | 7428 | COLEUS | BLUMEI | LAMIACEAE | H | 20-Nov-90 | NF | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C72 | 7429 | PASSIFLORA | EDULIS | PASSIFLORACEAE | C | 20-Nov-90 | A | NF |
| 1 | C72 | 7430 | UNKNOWN | UNKNOWN | SAPOTACEAE | U | 20-Nov-90 | NF | NF |
| 1 | C64 | 7431 | TRADESCANTIA | SP. | COMMELINACEAE | H | 20-Nov-90 | | NF |
| 1 | C64 | 7433 | BAMBUSA | MULTIPLEX | POACEAE | A | 20-Nov-90 | NF | NF |
| 1 | C71 | 7434 | IPOMOEA | BATATAS | CONVOLVULACEAE | H | 20-Nov-90 | NF | NF |
| 1 | C71 | 7435 | PHILODENDRON | ERUBESCENS | ARACEAE | C | 20-Nov-90 | NF | NF |
| 1 | C71 | 7436 | PASSIFLORA | QUADRANGULARIS | PASSIFLORACEAE | C | 20-Nov-90 | A | NF |
| 1 | C64 | 7437 | UNKNOWN | UNKNOWN | ARACEAE | U | 20-Nov-90 | A | A |
| 1 | C65 | 7438 | BACCHARIS | HALIMIFOLIA | ASTERACEAE | S | 20-Nov-90 | NF | D |
| 1 | C65 | 7439 | UNKNOWN | UNKNOWN | UNKNOWN | U | 20-Nov-90 | A | D |
| 1 | C65 | 7440 | BACCHARIS | HALIMIFOLIA | ASTERACEAE | S | 20-Nov-90 | NF | D |
| 1 | C65 | 7441 | BACCHARIS | HALIMIFOLIA | ASTERACEAE | S | 20-Nov-90 | NF | D |
| 1 | C84 | 7450 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 2-Nov-90 | D | D |
| 1 | C85 | 7451 | UNKNOWN | UNKNOWN | RUBIACEAE | U | 2-Nov-90 | NF | NF |
| 1 | C85 | 7452 | UNKNOWN | UNKNOWN | BROMELIACEAE | U | 2-Nov-90 | NF | NF |
| 1 | C85 | 7453 | CLUSIA | SP. | CLUSIACEAE | T | 2-Nov-90 | A | NF |
| 1 | C85 | 7454 | PHILODENDRON | SP. | ARACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C85 | 7455 | CLUSIA | SP. | CLUSIACEAE | T | 2-Nov-90 | NF | NF |
| 1 | C85 | 7456 | THELYPTERIS | SP. | THELYPTERIDACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C85 | 7457 | PHILODENDRON | ERUBESCENS | ARACEAE | C | 2-Nov-90 | NF | A |
| 1 | C85 | 7458 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | NF |
| 1 | C86 | 7459 | UNKNOWN | UNKNOWN | BROMELIACEAE | U | 2-Nov-90 | NF | NF |
| 1 | C86 | 7460 | UNKNOWN | UNKNOWN | BROMELIACEAE | U | 2-Nov-90 | NF | NF |
| 1 | C85 | 7461 | PHILODENDRON | ERUBESCENS | ARACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C86 | 7462 | CALLISIA | FRAGRANS | COMMELINACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C86 | 7463 | PHILODENDRON | ERUBESCENS | ARACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C86 | 7464 | PHILODENDRON | ERUBESCENS | ARACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C86 | 7465 | ASPARAGUS | DENSIFLORUS | ASPARAGACEAE | H | 2-Nov-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C86 | 7466 | CYATHEA | COOPERI | CYATHEACEAE | P | 2-Nov-90 | D | NF |
| 1 | C86 | 7467 | TRADESCANTIA | PALLIDA | COMMELINACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C86 | 7468 | TRADESCANTIA | PALLIDA | COMMELINACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C86 | 7469 | TRADESCANTIA | PALLIDA | COMMELINACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C86 | 7470 | PHILODENDRON | SP. | ARACEAE | C | 2-Nov-90 | A | NF |
| 1 | C86 | 7471 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | NF |
| 1 | C86 | 7472 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | NF |
| 1 | C86 | 7473 | IPOMOEA | BATATAS | CONVOLVULACEAE | H | 2-Nov-90 | A | NF |
| 1 | C85 | 7474 | UNKNOWN | UNKNOWN | FABACEAE | U | 2-Nov-90 | NF | NF |
| 1 | C78 | 7475 | CALLISIA | FRAGRANS | COMMELINACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C86 | 7476 | MARCGRAVIA | SINTENISII | MARCGRAVIACEAE | C | 2-Nov-90 | A | NF |
| 1 | C86 | 7477 | PHILODENDRON | RUBENS | ARACEAE | C | 2-Nov-90 | A | NF |
| 1 | C86 | 7478 | PASSIFLORA | CORIACEA | PASSIFLORACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C86 | 7479 | ASCLEPIAS | CURASSAVICA | ASCLEPIADACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C86 | 7480 | PASSIFLORA | CORIACEA | PASSIFLORACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C86 | 7481 | UNKNOWN | UNKNOWN | ARACEAE | U | 2-Nov-90 | NF | NF |
| 1 | C79 | 7482 | PHILODENDRON | ERUBESCENS | ARACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C79 | 7483 | CLUSIA | SP. | CLUSIACEAE | T | 2-Nov-90 | NF | NF |
| 1 | C79 | 7484 | PASSIFLORA | CORIACEA | PASSIFLORACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C79 | 7485 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | NF |
| 1 | C79 | 7486 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | NF | NF |
| 1 | C79 | 7487 | PHILODENDRON | SP. | ARACEAE | C | 2-Nov-90 | A | NF |
| 1 | C79 | 7488 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | | NF |
| 1 | C78 | 7489 | PHILODENDRON | ANGUSTATUM | ARACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C78 | 7490 | CLUSIA | SP. | CLUSIACEAE | T | 2-Nov-90 | NF | NF |
| 1 | C78 | 7491 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C78 | 7492 | PHILODENDRON | SP. | ARACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C78 | 7493 | UNKNOWN | UNKNOWN | BROMELIACEAE | U | 2-Nov-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C78 | 7494 | UNKNOWN | UNKNOWN | BROMELIACEAE | U | 2-Nov-90 | NF | NF |
| 1 | C78 | 7495 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C78 | 7496 | PHILODENDRON | SP. | ARACEAE | C | 2-Nov-90 | NF | NF |
| 1 | C78 | 7497 | TRADESCANTIA | PALLIDA | COMMELINACEAE | H | 2-Nov-90 | NF | NF |
| 1 | C78 | 7498 | UNKNOWN | UNKNOWN | UNKNOWN | U | 2-Nov-90 | | |
| 1 | C86 | 7499 | PLATYCERIUM | SUPERBUM | POLYPODIACEAE | E | 2-Nov-90 | D | NF |
| 1 | C81 | 7500 | HELICONIA | SP. | HELICONIACEAE | G | 29-Nov-90 | NF | D |
| 1 | C81 | 7501 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 29-Nov-90 | A | A |
| 1 | C81 | 7502 | KAEMPFERIA | ROTUNDA | ZINGIBERACEAE | H | 29-Nov-90 | NF | D |
| 1 | C81 | 7503 | KAEMPFERIA | ROTUNDA | ZINGIBERACEAE | H | 29-Nov-90 | A | D |
| 1 | C81 | 7504 | SCINDAPSUS | AUREUS | ARACEAE | C | 29-Nov-90 | A | A |
| 1 | C81 | 7505 | HEDYCHIUM | AURANTIACA | ZINGIBERACEAE | G | 29-Nov-90 | NF | D |
| 1 | C81 | 7506 | KAEMPFERIA | PULCHRA | ZINGIBERACEAE | H | 29-Nov-90 | A | D |
| 1 | C81 | 7507 | SCINDAPSUS | AUREUS | ARACEAE | C | 29-Nov-90 | A | A |
| 1 | C88 | 7508 | UNKNOWN | UNKNOWN | UNKNOWN | U | 29-Nov-90 | A | NF |
| 1 | C88 | 7509 | UNKNOWN | UNKNOWN | UNKNOWN | U | 29-Nov-90 | NF | NF |
| 1 | C88 | 7510 | UNKNOWN | UNKNOWN | UNKNOWN | U | 29-Nov-90 | A | D |
| 1 | C88 | 7511 | UNKNOWN | UNKNOWN | UNKNOWN | U | 29-Nov-90 | NF | NF |
| 1 | C88 | 7512 | UNKNOWN | UNKNOWN | UNKNOWN | U | 29-Nov-90 | A | NF |
| 1 | C88 | 7513 | UNKNOWN | UNKNOWN | UNKNOWN | U | 29-Nov-90 | NF | NF |
| 1 | C88 | 7514 | UNKNOWN | UNKNOWN | UNKNOWN | U | 29-Nov-90 | NF | D |
| 1 | C88 | 7515 | STROMANTHE | AMABILIS | MARANTACEAE | H | 29-Nov-90 | A | A |
| 1 | C88 | 7516 | PTERIS | LONGIFOLIA | ADIANTACEAE | H | 29-Nov-90 | NF | NF |
| 1 | C88 | 7517 | GLOBBA | SP. | ZINGIBERACEAE | H | 29-Nov-90 | NF | NF |
| 1 | C88 | 7518 | KAEMPFERIA | ROTUNDA | ZINGIBERACEAE | H | 29-Nov-90 | A | D |
| 1 | C88 | 7519 | KAEMPFERIA | DECORA | ZINGIBERACEAE | H | 29-Nov-90 | NF | NF |
| 1 | C95 | 7520 | SCINDAPSUS | AUREUS | ARACEAE | C | 29-Nov-90 | NF | NF |
| 1 | C95 | 7521 | SCINDAPSUS | AUREUS | ARACEAE | C | 29-Nov-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C95 | 7522 | SCINDAPSUS | AUREUS | ARACEAE | C | 29-Nov-90 | NF | NF |
| 1 | C95 | 7523 | KAEMPFERIA | ROTUNDA | ZINGIBERACEAE | H | 29-Nov-90 | NF | NF |
| 1 | C95 | 7524 | SCINDAPSUS | AUREUS | ARACEAE | C | 29-Nov-90 | NF | NF |
| 1 | C95 | 7525 | KAEMPFERIA | ROTUNDA | ZINGIBERACEAE | H | 29-Nov-90 | NF | NF |
| 1 | C95 | 7526 | HELICONIA | PSITTACORUM | HELICONIACEAE | G | 29-Nov-90 | NF | D |
| 1 | C95 | 7527 | SCINDAPSUS | AUREUS | ARACEAE | C | 29-Nov-90 | A | NF |
| 1 | C95 | 7528 | UNKNOWN | UNKNOWN | UNKNOWN | U | 29-Nov-90 | NF | NF |
| 1 | C95 | 7529 | RENEALMIA | ALPINIA | ZINGIBERACEAE | G | 29-Nov-90 | NF | A |
| 1 | C94 | 7530 | EUGENIA | BOQUERONENSIS | MYRTACEAE | T | 29-Nov-90 | NF | NF |
| 1 | C94 | 7531 | UNKNOWN | UNKNOWN | UNKNOWN | U | 29-Nov-90 | NF | NF |
| 1 | C94 | 7532 | HEDYCHIUM | AURANTIACA | ZINGIBERACEAE | G | 29-Nov-90 | NF | NF |
| 1 | C94 | 7533 | ALPINIA | ZERUMBET | ZINGIBERACEAE | G | 29-Nov-90 | A | A |
| 1 | C94 | 7534 | UNKNOWN | UNKNOWN | UNKNOWN | U | 29-Nov-90 | NF | NF |
| 1 | C94 | 7535 | SCINDAPSUS | AUREUS | ARACEAE | C | 29-Nov-90 | A | NF |
| 1 | C94 | 7536 | HEDYCHIUM | AURANTIACA | ZINGIBERACEAE | G | 29-Nov-90 | NF | A |
| 1 | C94 | 7537 | DATURA | STRAMONIUM | SOLANACEAE | H | 29-Nov-90 | NF | NF |
| 1 | C93 | 7538 | CARICA | PAPAYA | CARICACEAE | T | 29-Nov-90 | NF | D |
| 1 | C93 | 7539 | UNKNOWN | UNKNOWN | LORANTHACEAE | U | 29-Nov-90 | NF | D |
| 1 | C93 | 7540 | CLUSIA | SP. | CLUSIACEAE | T | 29-Nov-90 | NF | D |
| 1 | C93 | 7541 | COFFEA | ARABICA | RUBIACEAE | S | 29-Nov-90 | D | D |
| 1 | C86 | 7542 | MANGIFERA | INDICA | ANACARDIACEAE | T | 29-Nov-90 | NF | NF |
| 1 | C86 | 7543 | GARCINIA | SP. | CLUSIACEAE | T | 29-Nov-90 | A | NF |
| 1 | C86 | 7544 | GARCINIA | SP. | CLUSIACEAE | T | 29-Nov-90 | A | A |
| 1 | C86 | 7545 | GARCINIA | SP. | CLUSIACEAE | T | 29-Nov-90 | A | NF |
| 1 | C86 | 7546 | ASPLENIUM | DAUCIFOLIUM | ASPLENIACEAE | H | 29-Nov-90 | NF | NF |
| 1 | C86 | 7547 | PAULLINIA | SP. | SAPINDACEAE | C | 29-Nov-90 | NF | NF |
| 1 | C86 | 7548 | BLECHNUM | ORIENTALE | BLECHNACEAE | H | 29-Nov-90 | D | NF |
| 1 | C86 | 7549 | JUSTICIA | PECTORALIS | ACANTHACEAE | H | 29-Nov-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C87 | 7550 | CEDRELA | ODORATA | MELIACEAE | T | 29-Nov-90 | A | D |
| 1 | C87 | 7551 | UNKNOWN | UNKNOWN | ARACEAE | U | 29-Nov-90 | A | D |
| 1 | C87 | 7552 | SALVIA | DIVINORUM | LAMIACEAE | S | 29-Nov-90 | NF | D |
| 1 | C88 | 7553 | PHILODENDRON | ANGUSTATUM | ARACEAE | C | 29-Nov-90 | NF | D |
| 1 | C88 | 7554 | UNKNOWN | UNKNOWN | UNKNOWN | U | 29-Nov-90 | A | D |
| 1 | C88 | 7555 | LECYTHIS | ZABUCAJO | LECYTHIDACEAE | T | 29-Nov-90 | NF | D |
| 1 | C80 | 7556 | SALVIA | DIVINORUM | LAMIACEAE | S | 29-Nov-90 | NF | NF |
| 1 | C80 | 7557 | PHILODENDRON | SP. | ARACEAE | C | 29-Nov-90 | A | A |
| 1 | C80 | 7558 | SALVIA | DIVINORUM | LAMIACEAE | S | 29-Nov-90 | NF | NF |
| 1 | C80 | 7559 | LYCOPODIUM | CERNUUM | LYCOPODIACEAE | H | 29-Nov-90 | D | NF |
| 1 | C79 | 7560 | PELLAEA | VIRIDIS | ADIANTACEAE | H | 29-Nov-90 | D | NF |
| 1 | C72 | 7561 | BRACHIONIDIUM | SP. | ORCHIDACEAE | S | 29-Nov-90 | D | NF |
| 1 | C72 | 7562 | DICHORISANDRA | THYRSIFLORA | COMMELINACEAE | H | 29-Nov-90 | NF | NF |
| 1 | C72 | 7563 | ARTOCARPUS | HETEROPHYLLUS | MORACEAE | T | 29-Nov-90 | A | NF |
| 1 | C72 | 7564 | GUZMANIA | MONOSTACHIA | BROMELIACEAE | E | 29-Nov-90 | D | NF |
| 1 | C72 | 7565 | TRADESCANTIA | SP. | COMMELINACEAE | H | 29-Nov-90 |  | NF |
| 1 | C72 | 7566 | GUZMANIA | MONOSTACHIA | BROMELIACEAE | E | 29-Nov-90 | A | NF |
| 1 | C71 | 7567 | LYCOPODIUM | CERNUUM | LYCOPODIACEAE | H | 29-Nov-90 | D | NF |
| 1 | C73 | 7568 | UNKNOWN | UNKNOWN | UNKNOWN | U | 29-Nov-90 | NF | NF |
| 1 | C65 | 7569 | SYNGONIUM | PODOPHYLLUM | ARACEAE | C | 29-Nov-90 | NF | D |
| 1 | C65 | 7570 | SCINDAPSUS | AUREUS | ARACEAE | C | 29-Nov-90 | A | A |
| 1 | C65 | 7571 | SCINDAPSUS | AUREUS | ARACEAE | C | 29-Nov-90 |  |  |
| 1 | C71 | 7572 | IPOMOEA | BATATAS | CONVOLVULACEAE | H | 29-Nov-90 | NF | NF |
| 1 | C64 | 7573 | CALLISIA | FRAGRANS | COMMELINACEAE | H | 29-Nov-90 |  | NF |
| 1 | C71 | 7574 | ELAEIS | GUINEENSIS | ARECACEAE | P | 29-Nov-90 | A | A |
| 1 | C71 | 7575 | UNKNOWN | UNKNOWN | UNKNOWN | U | 29-Nov-90 | NF | NF |
| 1 | C71 | 7576 | ARTOCARPUS | HETEROPHYLLUS | MORACEAE | T | 29-Nov-90 | A | NF |
| 1 | C71 | 7577 | ANDROPOGON | SP. | POACEAE | R | 29-Nov-90 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C71 | 7578 | COFFEA | ARABICA | RUBIACEAE | S | 29-Nov-90 | A | A |
| 1 | C71 | 7579 | ELAEIS | GUINEENSIS | ARECACEAE | P | 29-Nov-90 | A | A |
| 1 | C78 | 7580 | PHILODENDRON | TRIPARTITUM | ARACEAE | C | 29-Nov-90 | NF | NF |
| 1 | C78 | 7581 | PHILODENDRON | GRAZIELAE | ARACEAE | C | 29-Nov-90 | NF | NF |
| 1 | C78 | 7582 | UNKNOWN | UNKNOWN | FABACEAE | U | 29-Nov-90 | NF | NF |
| 1 | C78 | 7583 | JUSTICIA | PECTORALIS | ACANTHACEAE | H | 29-Nov-90 | NF | NF |
| 1 | C78 | 7584 | MALPIGHIA | GLABRA | MALPIGHIACEAE | S | 29-Nov-90 | NF | NF |
| 1 | C67 | 7585 | POGOSTEMON | HEYNEANUS | LAMIACEAE | S | 29-Nov-90 | NF | NF |
| 1 | C67 | 7586 | CANNA | INDICA | CANNACEAE | G | 29-Nov-90 | A | A |
| 1 | C67 | 7587 | PASSIFLORA | QUADRANGULARIS | PASSIFLORACEAE | C | 29-Nov-90 | A | NF |
| 1 | C67 | 7588 | ALPINIA | SANDERAE | ZINGIBERACEAE | G | 29-Nov-90 | NF | NF |
| 1 | C67 | 7589 | ALPINIA | SANDERAE | ZINGIBERACEAE | G | 29-Nov-90 | NF | NF |
| 1 | C61 | 7590 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 29-Nov-90 | A | A |
| 1 | C69 | 7591 | THEOBROMA | CACAO | STERCULIACEAE | S | 29-Nov-90 | A | NF |
| 1 | C69 | 7592 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 29-Nov-90 | A | A |
| 1 | C69 | 7593 | COSTUS | SP. | ZINGIBERACEAE | H | 29-Nov-90 | NF | NF |
| 1 | C69 | 7594 | SINNINGIA | REGINA | GESNERIACEAE | S | 29-Nov-90 | NF | NF |
| 1 | C69 | 7595 | PALICOUREA | SP. | RUBIACEAE | T | 29-Nov-90 | NF | NF |
| 1 | C69 | 7596 | UNKNOWN | UNKNOWN | FABACEAE | H | 29-Nov-90 | NF | NF |
| 1 | C76 | 7597 | UNKNOWN | UNKNOWN | ARACEAE | U | 29-Nov-90 | NF | NF |
| 1 | C76 | 7598 | THEOBROMA | CACAO | STERCULIACEAE | S | 29-Nov-90 | A | NF |
| 1 | C75 | 7599 | CANNA | GENERALIS | CANNACEAE | G | 29-Nov-90 | A | NF |
| 1 | C83 | 7600 | ZINGIBER | OFFICINALE | ZINGIBERACEAE | H | 29-Nov-90 | NF | NF |
| 1 | C83 | 7601 | UNKNOWN | UNKNOWN | ARACEAE | U | 29-Nov-90 | NF | D |
| 1 | C83 | 7602 | EPHEDRA | SP. | EPHEDRACEAE | S | 29-Nov-90 | NF | NF |
| 1 | C83 | 7603 | ANTIGONON | LEPTOPUS | POLYGONACEAE | C | 29-Nov-90 | NF | NF |
| 1 | C83 | 7604 | ALPINIA | SANDERAE | ZINGIBERACEAE | G | 29-Nov-90 | NF | NF |
| 1 | C82 | 7605 | ALPINIA | SANDERAE | ZINGIBERACEAE | G | 29-Nov-90 | A | A |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C89 | 7606 | HELICONIA | MUTISIANA | HELICONIACEAE | G | 29-Nov-90 | NF | NF |
| 1 | C89 | 7607 | ETLINGERA | ELATIOR | ZINGIBERACEAE | H | 29-Nov-90 | NF | NF |
| 1 | C90 | 7608 | HELICONIA | PSITTACORUM | HELICONIACEAE | G | 29-Nov-90 | NF | NF |
| 1 | C90 | 7609 | HELICONIA | PSITTACORUM | HELICONIACEAE | G | 29-Nov-90 | NF | NF |
| 1 | C90 | 7610 | DICHORISANDRA | THYRSIFLORA | COMMELINACEAE | H | 29-Nov-90 | NF | NF |
| 1 | C91 | 7611 | COSTUS | SP. | ZINGIBERACEAE | H | 29-Nov-90 | A | A |
| 1 | C90 | 7612 | LEUCAENA | GLAUCA | FABACEAE | T | 29-Nov-90 | D | NF |
| 1 | C90 | 7613 | CYATHEA | SP. | CYATHEACEAE | P | 29-Nov-90 | D | NF |
| 1 | C91 | 7614 | PTERIS | CRETICA | ADIANTACEAE | H | 29-Nov-90 | NF | D |
| 1 | C65 | 7616 | COCOS | NUCIFERA | ARECACEAE | P | 29-Nov-90 | A | A |
| 1 | C84 | 7618 | ANNONA | MURICATA | ANNONACEAE | T | 29-Nov-90 | NF | NF |
| 1 | C85 | 7619 | EUGENIA | BOQUERONENSIS | MYRTACEAE | T | 29-Nov-90 | NF | NF |
| 1 | C84 | 7620 | EUGENIA | BOQUERONENSIS | MYRTACEAE | T | 29-Nov-90 | NF | NF |
| 1 | C84 | 7621 | EUGENIA | BOQUERONENSIS | MYRTACEAE | T | 29-Nov-90 | NF | NF |
| 1 | C84 | 7622 | EUGENIA | BOQUERONENSIS | MYRTACEAE | T | 29-Nov-90 | NF | NF |
| 1 | C84 | 7623 | EUGENIA | BOQUERONENSIS | MYRTACEAE | T | 29-Nov-90 | NF | NF |
| 1 | C67 | 7703 | AGLAONEMA | SP. | ARACEAE | H | 26-Sep-91 | A | A |
| 1 | C67 | 7704 | FICUS | PUMILA | MORACEAE | C | 26-Sep-91 | A | A |
| 1 | C67 | 7705 | FICUS | PUMILA | MORACEAE | C | 26-Sep-91 | A | NF |
| 1 | C67 | 7706 | FICUS | PUMILA | MORACEAE | C | 26-Sep-91 | A | A |
| 1 | C67 | 7707 | HIBISCUS | CALYPHYLLUS | MALVACEAE | S | 26-Sep-91 | A | A |
| 1 | C66 | 7708 | THALIA | GENICULATA | MARANTACEAE | H | 26-Sep-91 | A | A |
| 1 | C65 | 7709 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 26-Sep-91 | A | A |
| 1 | C64 | 7711 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 26-Sep-91 | A | A |
| 1 | C64 | 7712 | LEUCAENA | SP. | FABACEAE | T | 26-Sep-91 | A | A |
| 1 | C64 | 7713 | PHILODENDRON | SP. | ARACEAE | C | 26-Sep-91 | A | A |
| 1 | C64 | 7714 | COSTUS | SP. | ZINGIBERACEAE | H | 26-Sep-91 | A | A |
| 1 | C64 | 7715 | HIBISCUS | CALYPHYLLUS | MALVACEAE | S | 26-Sep-91 | A | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C63 | 7716 | HEIMIA | SALICIFOLIA | LYTHRACEAE | S | 26-Sep-91 | A | D |
| 1 | C63 | 7717 | BREYNIA | DISTICHA | EUPHORBIACEAE | H | 26-Sep-92 | A | A |
| 1 | C63 | 7718 | BREYNIA | DISTICHA | EUPHORBIACEAE | H | 26-Sep-92 | A | A |
| 1 | C76 | 7719 | COFFEA | ARABICA | RUBIACEAE | S | 26-Sep-92 | A | A |
| 1 | C76 | 7720 | CARICA | PAPAYA | CARICACEAE | T | 26-Sep-92 | A | D |
| 1 | C76 | 7721 | CARICA | PAPAYA | CARICACEAE | T | 26-Sep-92 | A | D |
| 1 | C76 | 7722 | COFFEA | ARABICA | RUBIACEAE | S | 26-Sep-92 | A | A |
| 1 | C76 | 7723 | COFFEA | ARABICA | RUBIACEAE | S | 26-Sep-92 | A | A |
| 1 | C76 | 7724 | COFFEA | ARABICA | RUBIACEAE | S | 26-Sep-92 | A | A |
| 1 | C76 | 7725 | CARICA | PAPAYA | CARICACEAE | T | 26-Sep-92 | A | NF |
| 1 | C76 | 7726 | CARICA | PAPAYA | CARICACEAE | T | 26-Sep-92 | A | D |
| 1 | C76 | 7727 | CARICA | PAPAYA | CARICACEAE | T | 26-Sep-92 | A | D |
| 1 | C76 | 7728 | CARICA | PAPAYA | CARICACEAE | T | 26-Sep-92 | A | D |
| 1 | C76 | 7729 | PIPER | SP. | PIPERACEAE | H | 26-Sep-91 | A | A |
| 1 | C76 | 7730 | PIPER | SP. | PIPERACEAE | H | 26-Sep-91 | A | D |
| 1 | C76 | 7731 | COFFEA | ARABICA | RUBIACEAE | S | 26-Sep-92 | A | D |
| 1 | C76 | 7732 | CARICA | PAPAYA | CARICACEAE | T | 26-Sep-92 | ?? | D |
| 1 | C76 | 7733 | COFFEA | ARABICA | RUBIACEAE | S | 26-Sep-92 | A | A |
| 1 | C76 | 7734 | CARICA | PAPAYA | CARICACEAE | T | 26-Sep-92 | A | NF |
| 1 | C76 | 7735 | PLATYCERIUM | SUPERBUM | POLYPODIACEAE | E | 26-Sep-92 | A | NF |
| 1 | C76 | 7737 | COFFEA | ARABICA | RUBIACEAE | S | 26-Sep-92 | A | NF |
| 1 | C76 | 7738 | CARICA | PAPAYA | CARICACEAE | T | 26-Sep-92 | A | D |
| 1 | C76 | 7739 | CARICA | PAPAYA | CARICACEAE | T | 26-Sep-92 | A | NF |
| 1 | C76 | 7740 | THEOBROMA | CACAO | STERCULIACEAE | S | 26-Sep-91 | A | D |
| 1 | C76 | 7741 | COSTUS | SP. | ZINGIBERACEAE | H | 26-Sep-91 | A | A |
| 1 | C76 | 7742 | MUSA | SP. | MUSACEAE | G | 26-Sep-92 | A | A |
| 1 | C74 | 7744 | LEUCAENA | SP. | FABACEAE | T | 26-Sep-92 | A | NF |
| 1 | C74 | 7745 | MUSA | SP. | MUSACEAE | G | 26-Sep-91 | A | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C83 | 7746 | BRUGMANSIA | SUAVEOLENS | SOLANACEAE | S | | | A |
| 1 | C75 | 7747 | MUSA | SP. | MUSACEAE | G | 26-Sep-92 | NF | NF |
| 1 | C83 | 7748 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 26-Sep-91 | A | NF |
| 1 | C83 | 7749 | COSTUS | SP. | ZINGIBERACEAE | H | 26-Sep-92 | A | A |
| 1 | C83 | 7751 | COFFEA | ARABICA | RUBIACEAE | S | 26-Sep-91 | A | A |
| 1 | C83 | 7752 | RICINUS | COMMUNIS | EUPHORBIACEAE | T | 26-Sep-91 | D | D |
| 1 | C83 | 7753 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 26-Sep-91 | A | A |
| 1 | C83 | 7755 | STRELITZIA | SP. | STRELITZIACEAE | G | 26-Sep-92 | A | A |
| 1 | C83 | 7756 | CURCUMA | DOMESTICA | ZINGIBERACEAE | H | 26-Sep-91 | A | NF |
| 1 | C83 | 7757 | COSTUS | SP. | ZINGIBERACEAE | H | 26-Sep-92 | A | A |
| 1 | C83 | 7758 | MUSA | SP. | MUSACEAE | G | 26-Sep-92 | A | A |
| 1 | C83 | 7759 | COSTUS | SP. | ZINGIBERACEAE | H | 26-Sep-92 | A | A |
| 1 | C74 | 7760 | LEUCAENA | SP. | FABACEAE | T | 26-Sep-92 | A | A |
| 1 | C74 | 7761 | LEUCAENA | SP. | FABACEAE | T | 26-Oct-92 | A | NF |
| 1 | C74 | 7762 | AGLAONEMA | SP. | ARACEAE | H | 26-Sep-92 | A | A |
| 1 | C81 | 7763 | HEDYCHIUM | SP. | ZINGIBERACEAE | G | 26-Sep-92 | A | A |
| 1 | C81 | 7764 | LEUCAENA | LEUCOCEPHALA | FABACEAE | T | 26-Sep-91 | A | D |
| 1 | C81 | 7765 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 26-Sep-91 | A | A |
| 1 | C81 | 7766 | STRELITZIA | SP. | STRELITZIACEAE | G | 26-Sep-92 | A | NF |
| 1 | C81 | 7767 | COLOCASIA | SP. | ARACEAE | H | 26-Sep-92 | A | A |
| 1 | C81 | 7768 | HEIMIA | SP. | LYTHRACEAE | S | 26-Sep-91 | A | D |
| 1 | C81 | 7769 | STRELITZIA | SP. | STRELITZIACEAE | G | 26-Sep-92 | A | D |
| 1 | C81 | 7770 | MUSA | SP. | MUSACEAE | G | 26-Sep-92 | A | A |
| 1 | C81 | 7771 | LEUCAENA | LEUCOCEPHALA | FABACEAE | T | 26-Sep-91 | A | A |
| 1 | C88 | 7772 | COSTUS | SP. | ZINGIBERACEAE | H | 26-Sep-92 | A | NF |
| 1 | C88 | 7773 | LEUCAENA | SP. | FABACEAE | T | 26-Sep-91 | A | NF |
| 1 | C88 | 7774 | LEUCAENA | SP. | FABACEAE | T | 26-Sep-91 | A | NF |
| 1 | C88 | 7775 | LEUCAENA | SP. | FABACEAE | T | 26-Sep-91 | A | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C88 | 7776 | MUSA | SP. | MUSACEAE | G | 26-Sep-92 | A | A |
| 1 | C88 | 7777 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 26-Sep-91 | A | A |
| 1 | C88 | 7778 | LUDWIGIA | OCTOVALVIS | ONAGRACEAE | H | 26-Sep-92 | A | NF |
| 1 | C88 | 7779 | SOLANDRA | MAXIMA | SOLANACEAE | C | 26-Sep-91 | A | NF |
| 1 | C88 | 7780 | SOLANDRA | NITIDA | SOLANACEAE | C | 26-Sep-92 | A | NF |
| 2 | C88 | 7781 | MONSTERA | DELICIOSA | ARACEAE | C | 26-Sep-93 | A | A |
| 1 | C88 | 7782 | COLOCASIA | SP. | ARACEAE | H | 26-Sep-92 | A | A |
| 1 | C85 | 7783 | SACCHARUM | OFFICINARUM | POACEAE | A | 26-Sep-91 | A | A |
| 1 | C88 | 7784 | MONSTERA | DELICIOSA | ARACEAE | C | 26-Sep-91 | A | A |
| 1 | C88 | 7785 | UNKNOWN | UNKNOWN | BROMELIACEAE | U | 26-Sep-92 | A | A |
| 1 | C88 | 7786 | COLOCASIA | SP. | ARACEAE | H | 26-Sep-92 | A | A |
| 1 | C88 | 7787 | MONSTERA | DELICIOSA | ARACEAE | C | 26-Sep-91 | A | A |
| 1 | C95 | 7788 | UNKNOWN | UNKNOWN | ZINGIBERACEAE | H | 26-Sep-92 | A | A |
| 1 | C95 | 7789 | COLOCASIA | SP. | ARACEAE | H | 26-Sep-92 | A | A |
| 1 | C95 | 7790 | BRUGMANSIA | SUAVEOLENS | SOLANACEAE | S | 26-Sep-91 | A | A |
| 1 | C95 | 7791 | HELICONIA | LONGIFLORA | HELICONIACEAE | G | 26-Sep-91 | A | A |
| 1 | C95 | 7792 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 26-Sep-91 | A | A |
| 1 | C95 | 7793 | PIPER | SP. | PIPERACEAE | H | 26-Sep-91 | A | A |
| 1 | C83 | 7794 | BRUGMANSIA | SUAVEOLENS | SOLANACEAE | S | 26-Sep-91 | A | NF |
| 1 | C95 | 7794 | BRUGMANSIA | SUAVEOLENS | SOLANACEAE | S | 26-Sep-91 | | NF |
| 1 | C95 | 7795 | BRUGMANSIA | SUAVEOLENS | SOLANACEAE | S | 26-Sep-91 | A | NF |
| 1 | C85 | 7796 | SACCHARUM | OFFICINARUM | POACEAE | A | 26-Sep-91 | A | A |
| 1 | C85 | 7798 | SACCHARUM | OFFICINARUM | POACEAE | A | 26-Sep-91 | A | A |
| 1 | C85 | 7800 | LUDWIGIA | SP. | ONAGRACEAE | S | 26-Sep-92 | A | A |
| 1 | C86 | 7801 | CISSUS | SICYOIDES | VITACEAE | C | 26-Sep-91 | A | A |
| 1 | C86 | 7802 | LEUCAENA | GLAUCA | FABACEAE | T | 26-Sep-91 | A | NF |
| 1 | C86 | 7803 | LEUCAENA | GLAUCA | FABACEAE | T | 26-Sep-91 | A | NF |
| 1 | C86 | 7804 | LEUCAENA | GLAUCA | FABACEAE | T | 26-Sep-91 | A | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C86 | 7805 | LEUCAENA | GLAUCA | FABACEAE | T | 26-Sep-91 | D | NF |
| 1 | C86 | 7806 | LEUCAENA | GLAUCA | FABACEAE | T | 26-Sep-91 | D | D |
| 1 | C86 | 7807 | DIEFFENBACHIA | SP. | ARACEAE | H | 26-Sep-91 | A | NF |
| 1 | C86 | 7808 | NEPHROLEPIS | EXALTATA | DAVALLIACEAE | H | 26-Sep-91 | A | NF |
| 1 | C86 | 7809 | UNKNOWN | UNKNOWN | BROMELIACEAE | U | 26-Sep-92 | A | NF |
| 1 | C87 | 7810 | COLOCASIA | SP. | ARACEAE | H | 26-Sep-92 | A | NF |
| 1 | C87 | 7811 | UNKNOWN | UNKNOWN | ORCHIDACEAE | E | 26-Sep-92 | A | D |
| 1 | C87 | 7812 | SANCHEZIA | SPECIOSA | ACANTHACEAE | S | 26-Sep-91 | A | A |
| 1 | C93 | 7813 | CANNA | INDICA | CANNACEAE | G | 26-Sep-91 | A | D |
| 1 | C77 | 7814 | SACCHARUM | OFFICINARUM | POACEAE | A | 26-Sep-91 | A | NF |
| 1 | C78 | 7815 | UNKNOWN | UNKNOWN | ARACEAE | U | 26-Sep-92 | A | NF |
| 1 | C78 | 7816 | UNKNOWN | UNKNOWN | ASCLEPIADACEAE | U | 26-Sep-92 | A | A |
| 1 | C78 | 7817 | CANNA | GENERALIS | CANNACEAE | G | 26-Sep-91 | A | NF |
| 1 | C84 | 7818 | ANANAS | SP. | BROMELIACEAE | H | 26-Sep-91 | A | NF |
| 1 | C84 | 7819 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 26-Sep-91 | A | A |
| 1 | C84 | 7820 | HELICONIA | PSITTACORUM | HELICONIACEAE | G | 26-Sep-91 | A | A |
| 1 | C77 | 7821 | CARICA | SP. | CARICACEAE | T | 26-Sep-91 | A | NF |
| 1 | C77 | 7822 | SCINDAPSUS | AUREUS | ARACEAE | C | 26-Sep-91 | A | A |
| 1 | C94 | 7823 | KAEMPFERIA | ROTUNDA | ZINGIBERACEAE | H | 26-Sep-91 | A | NF |
| 1 | C94 | 7824 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 26-Sep-91 | A | NF |
| 1 | C94 | 7825 | SETARIA | PALMIFOLIA | POACEAE | R | 26-Sep-91 | A | A |
| 1 | C94 | 7826 | PHILODENDRON | SP. | ARACEAE | C | 26-Sep-92 | A | A |
| 1 | C93 | 7827 | COLOCASIA | SP. | ARACEAE | H | 26-Sep-92 | A | A |
| 1 | C93 | 7828 | COLOCASIA | SP. | ARACEAE | H | 26-Sep-92 | A | D |
| 1 | C94 | 7829 | DIEFFENBACHIA | SP. | ARACEAE | H | 26-Sep-91 | A | A |
| 1 | C94 | 7830 | ARENGA | SP. | ARECACEAE | P | 26-Sep-91 | A | A |
| 1 | C94 | 7831 | UNKNOWN | UNKNOWN | ARACEAE | U | 26-Sep-92 | A | A |
| 1 | C94 | 7832 | RICINUS | COMMUNIS | EUPHORBIACEAE | T | 26-Sep-91 | A | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C87 | 7833 | BAMBUSA | SP. | POACEAE | A | 26-Sep-92 | A | A |
| 1 | | 7835 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | NF | NF |
| 1 | | 7836 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | NF | D |
| 1 | | 7837 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | NF | D |
| 1 | | 7838 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | NF | D |
| 1 | C94 | 7839 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 30-Apr-91 | A | A |
| 1 | C95 | 7840 | STRELITZIA | NICOLAI | STRELITZIACEAE | G | 30-Apr-91 | NF | NF |
| 1 | C95 | 7841 | STRELITZIA | NICOLAI | STRELITZIACEAE | G | 30-Apr-91 | NF | NF |
| 1 | C95 | 7842 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C95 | 7843 | PHOENIX | ROEBELENII | ARECACEAE | P | 30-Apr-91 | A | D |
| 1 | C95 | 7844 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C95 | 7845 | STRELITZIA | NICOLAI | STRELITZIACEAE | G | 30-Apr-91 | NF | NF |
| 1 | C95 | 7846 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 30-Apr-91 | NF | NF |
| 1 | C95 | 7847 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 30-Apr-91 | A | A |
| 1 | C95 | 7848 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C94 | 7849 | PHOENIX | ROEBELENII | ARECACEAE | P | 30-Apr-91 | NF | NF |
| 1 | C94 | 7850 | THEOBROMA | CACAO | STERCULIACEAE | S | 30-Apr-91 | NF | NF |
| 1 | C87 | 7851 | EUCHARIS | GRANDIFLORA | AMARYLLIDACEAE | H | 30-Apr-91 | A | A |
| 1 | C87 | 7852 | EUCHARIS | GRANDIFLORA | AMARYLLIDACEAE | H | 30-Apr-91 | A | A |
| 1 | C87 | 7853 | THEOBROMA | CACAO | STERCULIACEAE | S | 30-Apr-91 | NF | D |
| 1 | C87 | 7854 | CHAMAEDOREA | MICROSPADIX | ARECACEAE | S | 30-Apr-91 | A | A |
| 1 | C86 | 7855 | THUNBERGIA | MYSORENSIS | ACANTHACEAE | C | 30-Apr-91 | NF | D |
| 1 | C87 | 7856 | THUNBERGIA | MYSORENSIS | ACANTHACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C87 | 7857 | THUNBERGIA | MYSORENSIS | ACANTHACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C87 | 7858 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | A | A |
| 1 | C80 | 7859 | CECROPIA | SCHREBERIANA | CECROPIACEAE | T | 30-Apr-91 | NF | NF |
| 1 | C80 | 7860 | EUCHARIS | GRANDIFLORA | AMARYLLIDACEAE | H | 30-Apr-91 | A | A |
| 1 | C80 | 7861 | EUCHARIS | GRANDIFLORA | AMARYLLIDACEAE | H | 30-Apr-91 | A | A |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C80 | 7862 | THEOBROMA | CACAO | STERCULIACEAE | S | 30-Apr-91 | NF | NF |
| 1 | C80 | 7863 | THUNBERGIA | MYSORENSIS | ACANTHACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C79 | 7864 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | NF | NF |
| 1 | C79 | 7865 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C79 | 7866 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C79 | 7867 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C79 | 7868 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C79 | 7869 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C80 | 7870 | SPATHOGLOTTIS | PLICATA | ORCHIDACEAE | H | 30-Apr-91 | NF | NF |
| 1 | C80 | 7871 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C80 | 7872 | SPATHOGLOTTIS | PLICATA | ORCHIDACEAE | H | 30-Apr-91 | NF | NF |
| 1 | C80 | 7873 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | A | A |
| 1 | C79 | 7874 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C81 | 7875 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 30-Apr-91 | NF | A |
| 1 | C79 | 7876 | THUNBERGIA | MYSORENSIS | ACANTHACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C79 | 7877 | THEOBROMA | CACAO | STERCULIACEAE | S | 30-Apr-91 | NF | NF |
| 1 | C80 | 7878 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C80 | 7879 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C81 | 7880 | PHOENIX | ROEBELENII | ARECACEAE | P | 30-Apr-91 | NF | D |
| 1 | C79 | 7881 | ZAMIA | FURFURACEA | ZAMIACEAE | S | 30-Apr-91 | NF | A |
| 1 | C80 | 7883 | THEOBROMA | CACAO | STERCULIACEAE | S | 30-Apr-91 | NF | NF |
| 1 | C81 | 7884 | THEOBROMA | CACAO | STERCULIACEAE | S | 30-Apr-91 | NF | D |
| 1 | C74 | 7886 | THUNBERGIA | MYSORENSIS | ACANTHACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C73 | 7887 | CECROPIA | SCHREBERIANA | CECROPIACEAE | T | 30-Apr-91 | NF | NF |
| 1 | C74 | 7888 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 30-Apr-91 | A | A |
| 1 | C74 | 7889 | BRACHYCHILUM | HORSFIELDII | ZINGIBERACEAE | H | 30-Apr-91 | NF | NF |
| 1 | C74 | 7890 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | NF | NF |
| 1 | C74 | 7891 | THUNBERGIA | MYSORENSIS | ACANTHACEAE | C | 30-Apr-91 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C73 | 7892 | CECROPIA | SCHREBERIANA | CECROPIACEAE | T | 30-Apr-91 | D | NF |
| 1 | C74 | 7893 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 30-Apr-91 | A | NF |
| 1 | C74 | 7894 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | D |
| 1 | C74 | 7895 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C74 | 7896 | EUTERPE | SP. | ARECACEAE | P | 30-Apr-91 | A | D |
| 1 | C74 | 7897 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C74 | 7898 | THUNBERGIA | MYSORENSIS | ACANTHACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C74 | 7899 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 30-Apr-91 | A | A |
| 1 | C74 | 7900 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 30-Apr-91 | A | NF |
| 1 | C74 | 7901 | ARECA | CATECHU | ARECACEAE | P | 30-Apr-91 | NF | NF |
| 1 | C74 | 7902 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C74 | 7903 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C67 | 7904 | THUNBERGIA | MYSORENSIS | ACANTHACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C67 | 7905 | PANDOREA | PANDORANA | BIGNONIACEAE | C | 30-Apr-91 | A | D |
| 1 | C67 | 7906 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C67 | 7907 | THUNBERGIA | MYSORENSIS | ACANTHACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C67 | 7908 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 30-Apr-91 | A | A |
| 1 | C67 | 7909 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 30-Apr-91 | A | A |
| 1 | C67 | 7910 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 30-Apr-91 | A | A |
| 1 | C67 | 7911 | STRELITZIA | NICOLAI | STRELITZIACEAE | G | 30-Apr-91 | A | A |
| 1 | C67 | 7912 | STRELITZIA | NICOLAI | STRELITZIACEAE | G | 30-Apr-91 | A | A |
| 1 | C74 | 7913 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | A | NF |
| 1 | C73 | 7914 | ARECA | CATECHU | ARECACEAE | P | 30-Apr-91 | A | A |
| 1 | C73 | 7915 | ZAMIA | FURFURACEA | ZAMIACEAE | S | 30-Apr-91 | D | NF |
| 1 | C72 | 7916 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | | NF |
| 1 | C73 | 7917 | EUCHARIS | GRANDIFLORA | AMARYLLIDACEAE | H | 30-Apr-91 | NF | A |
| 1 | C73 | 7918 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 30-Apr-91 | NF | NF |
| 1 | C73 | 7919 | THUNBERGIA | MYSORENSIS | ACANTHACEAE | C | 30-Apr-91 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C73 | 7920 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | NF | NF |
| 1 | C73 | 7921 | MYRISTICA | FRAGRANS | MYRISTICACEAE | T | 30-Apr-91 | NF | NF |
| 1 | C73 | 7922 | THUNBERGIA | MYSORENSIS | ACANTHACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C66 | 7923 | PANDOREA | PANDORANA | BIGNONIACEAE | C | 30-Apr-91 | D | D |
| 1 | C73 | 7924 | PANDOREA | PANDORANA | BIGNONIACEAE | C | 30-Apr-91 | D | NF |
| 1 | C72 | 7925 | ARECA | CATECHU | ARECACEAE | P | 30-Apr-91 | NF | NF |
| 1 | C72 | 7926 | EUTERPE | SP. | ARECACEAE | P | 30-Apr-91 | D | NF |
| 1 | C72 | 7927 | EUTERPE | SP. | ARECACEAE | P | 30-Apr-91 | NF | NF |
| 1 | C72 | 7928 | MYRISTICA | FRAGRANS | MYRISTICACEAE | T | 30-Apr-91 | NF | NF |
| 1 | C72 | 7929 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C72 | 7930 | ZAMIA | FURFURACEA | ZAMIACEAE | S | 30-Apr-91 | A | A |
| 1 | C72 | 7931 | PRESTOEA | MONTANA | ARECACEAE | P | 30-Apr-91 | NF | NF |
| 1 | C72 | 7932 | ZAMIA | FURFURACEA | ZAMIACEAE | S | 30-Apr-91 | A | A |
| 1 | C72 | 7933 | ZAMIA | FURFURACEA | ZAMIACEAE | S | 30-Apr-91 | A | A |
| 1 | C72 | 7934 | ZAMIA | FISCHERI | ZAMIACEAE | S | 30-Apr-91 | A | A |
| 1 | C72 | 7935 | ZAMIA | FURFURACEA | ZAMIACEAE | S | 30-Apr-91 | NF | D |
| 1 | C72 | 7936 | ZAMIA | FISCHERI | ZAMIACEAE | S | 30-Apr-91 | A | A |
| 1 | C72 | 7937 | MYRISTICA | FRAGRANS | MYRISTICACEAE | T | 30-Apr-91 | NF | NF |
| 1 | C71 | 7938 | EUTERPE | SP. | ARECACEAE | P | 30-Apr-91 | NF | NF |
| 1 | C72 | 7939 | EUCHARIS | GRANDIFLORA | AMARYLLIDACEAE | H | 30-Apr-91 | A | A |
| 1 | C65 | 7940 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | | |
| 1 | C64 | 7941 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C72 | 7942 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | | NF |
| 1 | C71 | 7943 | ZAMIA | FURFURACEA | ZAMIACEAE | S | 30-Apr-91 | A | A |
| 1 | C65 | 7944 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | | D |
| 1 | C64 | 7945 | BAMBUSA | VULGARIS | POACEAE | A | 30-Apr-91 | A | A |
| 1 | C71 | 7946 | FICUS | PUMILA | MORACEAE | C | 30-Apr-91 | A | NF |
| 1 | C64 | 7947 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C64 | 7948 | PANDOREA | PANDORANA | BIGNONIACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C64 | 7949 | PANDOREA | PANDORANA | BIGNONIACEAE | C | 30-Apr-91 | NF | A |
| 1 | C64 | 7950 | PANDOREA | PANDORANA | BIGNONIACEAE | C | 30-Apr-91 | A | D |
| 1 | C71 | 7951 | EUCHARIS | GRANDIFLORA | AMARYLLIDACEAE | H | 30-Apr-91 | A | A |
| 1 | C71 | 7952 | FICUS | PUMILA | MORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C71 | 7953 | FICUS | PUMILA | MORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C71 | 7954 | FICUS | PUMILA | MORACEAE | C | 30-Apr-91 | D | NF |
| 1 | C71 | 7955 | FICUS | PUMILA | MORACEAE | C | 30-Apr-91 | D | A |
| 1 | C63 | 7956 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | D |
| 1 | C63 | 7957 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | D |
| 1 | C62 | 7958 | PANDOREA | PANDORANA | BIGNONIACEAE | C | 30-Apr-91 | A | NF |
| 1 | C62 | 7959 | PANDOREA | PANDORANA | BIGNONIACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C69 | 7960 | EUTERPE | SP. | ARECACEAE | P | 30-Apr-91 | NF | NF |
| 1 | C76 | 7961 | THEOBROMA | CACAO | STERCULIACEAE | S | 30-Apr-91 | NF | NF |
| 1 | C76 | 7962 | EUTERPE | SP. | ARECACEAE | P | 30-Apr-91 | NF | NF |
| 1 | C76 | 7963 | MYRISTICA | FRAGRANS | MYRISTICACEAE | T | 30-Apr-91 | NF | NF |
| 1 | C76 | 7964 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C77 | 7965 | PANDOREA | PANDORANA | BIGNONIACEAE | C | 30-Apr-91 | NF | D |
| 1 | C76 | 7966 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C76 | 7967 | THEOBROMA | CACAO | STERCULIACEAE | S | 30-Apr-91 | NF | NF |
| 1 | C76 | 7968 | MYRISTICA | FRAGRANS | MYRISTICACEAE | T | 30-Apr-91 | NF | NF |
| 1 | C76 | 7969 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C76 | 7970 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C83 | 7971 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C83 | 7972 | PANDOREA | PANDORANA | BIGNONIACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C82 | 7973 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 30-Apr-91 | A | A |
| 1 | C84 | 7974 | PASSIFLORA | MOLLISSIMA | PASSIFLORACEAE | C | 30-Apr-91 | NF | D |
| 1 | C83 | 7975 | EUTERPE | SP. | ARECACEAE | P | 30-Apr-91 | NF | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C83 | 7976 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 30-Apr-91 | A | A |
| 1 | C92 | 7977 | STRELITZIA | REGINAE | STRELITZIACEAE | G | 30-Apr-91 | A | A |
| 1 | C93 | 7978 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | NF | D |
| 1 | C93 | 7979 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | A | D |
| 1 | C93 | 7980 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | A | D |
| 1 | C86 | 7981 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | | NF |
| 1 | C86 | 7982 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | NF | NF |
| 1 | C86 | 7983 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | NF | NF |
| 1 | C87 | 7984 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | NF | NF |
| 1 | C86 | 7985 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | NF | NF |
| 1 | C87 | 7986 | THUNBERGIA | MYSORENSIS | ACANTHACEAE | C | 30-Apr-91 | NF | NF |
| 1 | C95 | 7987 | THUNBERGIA | MYSORENSIS | ACANTHACEAE | C | 30-Apr-91 | A | NF |
| 1 | C95 | 7988 | THUNBERGIA | MYSORENSIS | ACANTHACEAE | C | 30-Apr-91 | A | NF |
| 1 | C71 | 7989 | ADIANTUM | HISPIDULUM | ADIANTACEAE | H | 30-Apr-91 | | D |
| 1 | C71 | 7990 | UNKNOWN | UNKNOWN | UNKNOWN | U | 30-Apr-91 | NF | NF |
| 1 | C62 | 9808 | CANNA | INDICA | CANNACEAE | G | 26-Sep-91 | A | A |
| 2 | C80 | 9810 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 20-Nov-93 | A | NF |
| 2 | C78 | 10413 | POUTERIA | OBOVATA | SAPOTACEAE | T | 30-Dec-93 | A | NF |
| 1 | C85 | 10414 | SACCHARUM | OFFICINARUM | POACEAE | A | 26-Sep-91 | A | A |
| 1 | C85 | 10415 | SACCHARUM | OFFICINARUM | POACEAE | A | 26-Sep-91 | A | A |
| 2 | C88 | 10416 | DIOSCOREA | ALATA | DIOSCOREACEAE | C | 21-Dec-93 | A | NF |
| 2 | C78 | 10417 | DIOSCOREA | ALATA | DIOSCOREACEAE | C | 21-Dec-93 | A | A |
| 2 | C83 | 10418 | DIOSCOREA | ALATA | DIOSCOREACEAE | C | 21-Dec-93 | A | NF |
| 2 | C70 | 10420 | DIOSCOREA | ALATA | DIOSCOREACEAE | C | 21-Dec-93 | A | D |
| 2 | C88 | 10422 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 21-Dec-93 | A | NF |
| 2 | C81 | 10423 | XANTHOSOMA | SP. | ARACEAE | H | 21-Dec-93 | A | A |
| 2 | C74 | 10424 | XANTHOSOMA | SP. | ARACEAE | H | 21-Dec-93 | A | NF |
| 2 | C73 | 10425 | XANTHOSOMA | SP. | ARACEAE | H | 21-Dec-93 | A | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C74 | 10426 | XANTHOSOMA | SP. | ARACEAE | H | 21-Dec-93 | A | D |
| 2 | C74 | 10427 | COLOCASIA | SP. | ARACEAE | H | 21-Dec-93 | A | NF |
| 2 | C88 | 10431 | COLOCASIA | ESCULENTA | ARACEAE | H | 21-Dec-93 | A | D |
| 2 | C92 | 10432 | COLOCASIA | ESCULENTA | ARACEAE | H | 23-Dec-93 | A | NF |
| 2 | C91 | 10433 | COLOCASIA | ESCULENTA | ARACEAE | H | 21-Dec-93 | D | D |
| 2 | C89 | 10435 | UNKNOWN | UNKNOWN | UNKNOWN | U | 7-Aug-96 | | NF |
| 2 | C78 | 10436 | ARTOCARPUS | ALTILIS | MORACEAE | T | 21-Dec-93 | A | A |
| 2 | C78 | 10437 | ARTOCARPUS | ALTILIS | MORACEAE | T | 21-Dec-93 | D | D |
| 2 | C85 | 10440 | COLOCASIA | ESCULENTA | ARACEAE | H | 21-Dec-93 | A | D |
| 2 | C78 | 10441 | COLOCASIA | ESCULENTA | ARACEAE | H | 21-Dec-93 | A | D |
| 2 | C91 | 10444 | COLOCASIA | ESCULENTA | ARACEAE | H | 18-Dec-93 | A | D |
| 2 | C90 | 10445 | COLOCASIA | ESCULENTA | ARACEAE | H | | | NF |
| 2 | C83 | 10446 | COLOCASIA | ESCULENTA | ARACEAE | H | 18-Dec-93 | A | A |
| 2 | C82 | 10447 | COLOCASIA | ESCULENTA | ARACEAE | H | | | NF |
| 2 | C83 | 10448 | COLOCASIA | ESCULENTA | ARACEAE | H | 18-Dec-93 | A | A |
| 2 | C76 | 10449 | COLOCASIA | ESCULENTA | ARACEAE | H | 18-Dec-93 | A | NF |
| 2 | C74 | 10449 | SPATHIPHYLLUM | CANNIFOLIUM | ARACEAE | H | | | D |
| 2 | C75 | 10450 | COLOCASIA | ESCULENTA | ARACEAE | H | | | A |
| 2 | C76 | 10450 | COLOCASIA | ESCULENTA | ARACEAE | H | | | A |
| 1 | C71 | 10451 | COFFEA | DEWEVREI | RUBIACEAE | S | 26-Sep-92 | A | A |
| 1 | C74 | 10452 | TRADESCANTIA | PALLIDA | COMMELINACEAE | H | 26-Sep-91 | NF | A |
| 1 | C72 | 10453 | CALLISIA | FRAGRANS | COMMELINACEAE | H | 26-Sep-91 | A | A |
| 1 | C66 | 10454 | CALLISIA | FRAGRANS | COMMELINACEAE | H | 26-Sep-91 | A | A |
| 1 | C72 | 10455 | GUZMANIA | SP. | BROMELIACEAE | E | 26-Sep-91 | A | NF |
| 2 | C75 | 10456 | COLOCASIA | ESCULENTA | ARACEAE | H | | | NF |
| 2 | C68 | 10458 | COLOCASIA | ESCULENTA | ARACEAE | H | 18-Dec-93 | A | NF |
| 2 | C69 | 10459 | COLOCASIA | ESCULENTA | ARACEAE | H | 18-Dec-93 | A | NF |
| 2 | C68 | 10460 | COLOCASIA | ESCULENTA | ARACEAE | H | 18-Dec-93 | A | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C79 | 10484 | PACHIRA | AQUATICA | BOMBACACEAE | T | 26-Sep-91 | A | NF |
| 1 | C73 | 10485 | PACHIRA | AQUATICA | BOMBACACEAE | T | 26-Sep-91 | A | NF |
| 1 | C79 | 10486 | PACHIRA | AQUATICA | BOMBACACEAE | T | 26-Sep-91 | A | A |
| 1 | C79 | 10487 | PACHIRA | AQUATICA | BOMBACACEAE | T | 26-Sep-91 | A | NF |
| 1 | C72 | 10488 | CISSUS | RHOMBIFOLIA | VITACEAE | C | 26-Sep-92 | A | NF |
| 2 | C85 | 10489 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 20-Nov-93 | A | D |
| 2 | C71 | 10490 | DIOSCOREA | ALATA | DIOSCOREACEAE | C | 20-Nov-93 | A | D |
| 2 | C84 | 10491 | ARTOCARPUS | HETEROPHYLLUS | MORACEAE | T | 20-Nov-93 | A | NF |
| 2 | C83 | 10492 | AVERRHOA | CARAMBOLA | OXALIDACEAE | T | 20-Nov-93 | A | D |
| 2 | C74 | 10493 | XANTHOSOMA | SP. | ARACEAE | H | 20-Nov-93 | A | A |
| 2 | C73 | 10494 | IPOMOEA | BATATAS | CONVOLVULACEAE | H | 20-Nov-93 | A | D |
| 1 | C65 | 10495 | CYPERUS | ALTERNIFOLIUS | CYPERACEAE | R | 26-Sep-91 | A | A |
| 1 | C76 | 10496 | LEUCAENA | SP. | FABACEAE | T | 26-Sep-91 | A | NF |
| 1 | C69 | 10497 | LEUCAENA | GLAUCA | FABACEAE | T | 26-Sep-91 | A | A |
| 1 | C83 | 10499 | XANTHOSOMA | SAGITTIFOLIUM | ARACEAE | H | 26-Sep-92 | A | NF |
| 1 | C80 | 10500 | XANTHOSOMA | SP. | ARACEAE | H | 26-Sep-92 | A | NF |
| 2 | C81 | 11001 | PRESTOEA | MONTANA | ARECACEAE | P | 23-Feb-94 | A | D |
| 2 | C81 | 11002 | PRESTOEA | MONTANA | ARECACEAE | P | 23-Feb-94 | A | D |
| 2 | C81 | 11003 | PRESTOEA | MONTANA | ARECACEAE | P | 23-Feb-94 | A | D |
| 2 | C74 | 11004 | PRESTOEA | MONTANA | ARECACEAE | P | 23-Feb-94 | A | NF |
| 2 | C73 | 11005 | PRESTOEA | MONTANA | ARECACEAE | P | 23-Feb-94 | A | NF |
| 2 | C72 | 11006 | PRESTOEA | MONTANA | ARECACEAE | P | 23-Feb-94 | A | A |
| 2 | C72 | 11007 | PRESTOEA | MONTANA | ARECACEAE | P | 23-Feb-94 | A | NF |
| 2 | C72 | 11008 | PRESTOEA | MONTANA | ARECACEAE | P | 23-Feb-94 | A | NF |
| 2 | C72 | 11009 | PRESTOEA | MONTANA | ARECACEAE | P | 23-Feb-94 | A | NF |
| 2 | C79 | 11010 | PRESTOEA | MONTANA | ARECACEAE | P | 23-Feb-94 | A | D |
| 2 | C80 | 11011 | PRESTOEA | MONTANA | ARECACEAE | P | 23-Feb-94 | A | NF |
| 2 | C78 | 11012 | PRESTOEA | MONTANA | ARECACEAE | P | 23-Feb-94 | A | D |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C85 | 11013 | NELUMBO | NUCIFERA | NELUMBONACEAE | H | 1-Mar-94 | A | NF |
| 2 | C85 | 11013 | NELUMBO | NUCIFERA | NELUMBONACEAE | H | 1-Mar-94 | NF | NF |
| 2 | C70 | 11017 | NEPTUNIA | OLERACEA | FABACEAE | H | 1-Mar-94 | A | NF |
| 2 | C70 | 11018 | CYPERUS | HASPAN | CYPERACEAE | R | 1-Mar-94 | A | NF |
| 2 | C80 | 11022 | CANANGA | ODORATA | ANNONACEAE | T | 2-Mar-94 | A | NF |
| 2 | C80 | 11024 | CANANGA | ODORATA | ANNONACEAE | T | 2-Mar-94 | A | NF |
| 2 | C93 | 11025 | MORINGA | OLEIFERA | MORINGACEAE | T | 2-Mar-94 | A | D |
| 2 | C93 | 11025 | MORINGA | OLEIFERA | MORINGACEAE | T | 2-Mar-94 | A | D |
| 2 | C78 | 11026 | MORINGA | OLEIFERA | MORINGACEAE | T | 2-Mar-94 | A | NF |
| 2 | C91 | 11027 | MORINGA | OLEIFERA | MORINGACEAE | T | 2-Mar-94 | A | NF |
| 2 | C80 | 11028 | MORINGA | OLEIFERA | MORINGACEAE | T | 2-Mar-94 | A | NF |
| 2 | C81 | 11029 | MORINGA | OLEIFERA | MORINGACEAE | T | 2-Mar-94 | A | D |
| 2 | C81 | 11030 | MORINGA | OLEIFERA | MORINGACEAE | T | 2-Mar-94 | A | D |
| 2 | C86 | 11031 | VANDA | TRICUSPIDATA | ORCHIDACEAE | E | 2-Mar-94 | A | D |
| 2 | C87 | 11032 | VANDA | TRICUSPIDATA | ORCHIDACEAE | E | 2-Mar-94 | A | D |
| 2 | C80 | 11033 | PLATYCERIUM | WILLINCKII | POLYPODIACEAE | E | 2-Mar-94 | A | NF |
| 2 | C81 | 11034 | VANDA | TRICUSPIDATA | ORCHIDACEAE | E | 2-Mar-94 | A | D |
| 2 | C70 | 11035 | BARRINGTONIA | RACEMOSA | LECYTHIDACEAE | T | 2-Mar-94 | A | NF |
| 2 | C62 | 11036 | BARRINGTONIA | RACEMOSA | LECYTHIDACEAE | T | 3-Mar-94 | A | NF |
| 2 | C86 | 11037 | PLATYCERIUM | BIFURCATUM | POLYPODIACEAE | E | 3-Mar-94 | A | NF |
| 2 | C87 | 11038 | PLATYCERIUM | BIFURCATUM | POLYPODIACEAE | E | 3-Mar-94 | A | NF |
| 2 | C70 | 11039 | BARRINGTONIA | RACEMOSA | LECYTHIDACEAE | T | 3-Mar-94 | A | NF |
| 2 | C74 | 11040 | PLATYCERIUM | VASSEI | POLYPODIACEAE | E | 3-Mar-94 | A | D |
| 2 | C74 | 11041 | PLATYCERIUM | VASSEI | POLYPODIACEAE | E | 3-Mar-94 | | NF |
| 2 | C74 | 11042 | PLATYCERIUM | VEITCHII | POLYPODIACEAE | E | 3-Mar-94 | A | NF |
| 2 | C72 | 11043 | PLATYCERIUM | VEITCHII | POLYPODIACEAE | E | 3-Mar-94 | A | NF |
| 2 | C71 | 11044 | PLATYCERIUM | HILLII | POLYPODIACEAE | E | 3-Mar-94 | A | D |
| 2 | C72 | 11045 | PLATYCERIUM | HILLII | POLYPODIACEAE | E | 3-Mar-94 | A | NF |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C72 | 11046 | PLATYCERIUM | WILLINCKII | POLYPODIACEAE | E | 3-Mar-94 | A | NF |
| 2 | C74 | 11047 | PLATYCERIUM | WILLINCKII | POLYPODIACEAE | E | 3-Mar-94 | A | NF |
| 2 | C87 | 11048 | DRYNARIA | QUERCIFOLIA | POLYPODIACEAE | E | 3-Mar-94 | A | A |
| 2 | C91 | 11049 | CTENITIS | SLOANII | ASPLENIACEAE | H | | | |
| 2 | C85 | 11050 | CTENITIS | SLOANII | ASPLENIACEAE | H | 3-Mar-94 | A | NF |
| 2 | C84 | 11051 | CTENITIS | SLOANII | ASPLENIACEAE | H | 3-Mar-94 | A | NF |
| 2 | C86 | 11052 | CYATHEA | ARBOREA | CYATHEACEAE | P | 3-Mar-94 | A | NF |
| 2 | C94 | 11053 | ANGIOPTERIS | EVECTA | MARATTIACEAE | H | 3-Mar-94 | A | D |
| 2 | C84 | 11054 | NYMPHAEA | SP. | NYMPHAEACEAE | H | 3-Mar-94 | A | NF |
| 2 | C94 | 11055 | DIPLAZIUM | PROLIFERUM | ASPLENIACEAE | E | 3-Mar-94 | A | A |
| 2 | C86 | 11056 | DIPLAZIUM | PROLIFERUM | ASPLENIACEAE | E | 3-Mar-94 | A | NF |
| 2 | C78 | 11057 | UNKNOWN | UNKNOWN | UNKNOWN | U | | | |
| 2 | C70 | 11059 | MAURITIA | FLEXUOSA | ARECACEAE | P | 3-Mar-94 | A | NF |
| 2 | C85 | 11060 | EUTERPE | OLERACEA | ARECACEAE | P | 3-Mar-94 | D | NF |
| 2 | C62 | 11061 | EUTERPE | OLERACEA | ARECACEAE | P | 3-Mar-94 | A | NF |
| 2 | C69 | 11062 | EUTERPE | OLERACEA | ARECACEAE | P | 3-Mar-94 | A | NF |
| 2 | C78 | 11063 | EUTERPE | OLERACEA | ARECACEAE | P | 3-Mar-94 | A | NF |
| 2 | C70 | 11064 | EUTERPE | EDULIS | ARECACEAE | P | 3-Mar-94 | A | NF |
| 2 | C70 | 11064 | EUTERPE | EDULIS | ARECACEAE | P | 3-Mar-94 | A | NF |
| 2 | C70 | 11065 | EUTERPE | EDULIS | ARECACEAE | P | 3-Mar-94 | A | NF |
| 2 | C84 | 11066 | EUTERPE | EDULIS | ARECACEAE | P | 3-Mar-94 | A | NF |
| 2 | C63 | 11067 | EUTERPE | EDULIS | ARECACEAE | P | 3-Mar-94 | A | D |
| 2 | C70 | 11068 | EUTERPE | EDULIS | ARECACEAE | P | 3-Mar-94 | A | D |
| 2 | C81 | 11069 | AECHMEA | LAMARCHEI | BROMELIACEAE | H | 3-Mar-94 | A | A |
| 2 | C81 | 11070 | AECHMEA | LAMARCHEI | BROMELIACEAE | H | 4-Mar-94 | A | A |
| 2 | C86 | 11071 | AECHMEA | FASCIATA | BROMELIACEAE | E | 4-Mar-94 | A | D |
| 2 | C73 | 11072 | AECHMEA | FOSTERIANA | BROMELIACEAE | E | 4-Mar-94 | A | A |
| 2 | C72 | 11072 | AECHMEA | FOSTERIANA | BROMELIACEAE | E | | | A |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C73 | 11073 | AECHMEA | RAMOSA | BROMELIACEAE | E | 4-Mar-94 | A | A |
| 2 | C81 | 11074 | AECHMEA | CAUDATA | BROMELIACEAE | H | 4-Mar-94 | A | NF |
| 2 | C81 | 11075 | AECHMEA | NUDICAULIS | BROMELIACEAE | E | 4-Mar-94 | A | A |
| 2 | C79 | 11076 | AECHMEA | NUDICAULIS | BROMELIACEAE | E | 4-Mar-94 | A | A |
| 2 | C80 | 11077 | AECHMEA | NUDICAULIS | BROMELIACEAE | E | 4-Mar-94 | A | NF |
| 2 | C72 | 11078 | BILLBERGIA | HORRIDA | BROMELIACEAE | E | 4-Mar-94 | A | A |
| 2 | C83 | 11079 | BILLBERGIA | HORRIDA | BROMELIACEAE | E | 4-Mar-94 | A | D |
| 2 | C77 | 11080 | BILLBERGIA | HORRIDA | BROMELIACEAE | E | 4-Mar-94 | A | D |
| 2 | C72 | 11081 | AECHMEA | CYLINDRATA | BROMELIACEAE | E | | | A |
| 2 | C83 | 11081 | AECHMEA | PENDULIFLORA | BROMELIACEAE | E | 4-Mar-94 | A | D |
| 2 | C83 | 11082 | AECHMEA | RACINAE | BROMELIACEAE | E | 4-Mar-94 | A | A |
| 2 | C76 | 11083 | GUZMANIA | LINGULATA | BROMELIACEAE | E | 4-Mar-94 | A | NF |
| 2 | C76 | 11083 | GUZMANIA | LINGULATA | BROMELIACEAE | E | 4-Mar-94 | | NF |
| 2 | C91 | 11084 | AECHMEA | CALYCALATA | BROMELIACEAE | E | 4-Mar-94 | A | A |
| 2 | C92 | 11085 | AECHMEA | PINELIANA | BROMELIACEAE | E | 4-Mar-94 | A | A |
| 2 | C92 | 11086 | GUZMANIA | LINGULATA | BROMELIACEAE | E | 4-Mar-94 | A | A |
| 2 | C73 | 11087 | AECHMEA | CYLINDRATA | BROMELIACEAE | E | 4-Mar-94 | A | NF |
| 2 | C87 | 11088 | VANILLA | PLANIFOLIA | ORCHIDACEAE | E | 5-Mar-94 | A | NF |
| 2 | C79 | 11089 | VANILLA | PLANIFOLIA | ORCHIDACEAE | E | 5-Mar-94 | A | ?? |
| 2 | C72 | 11090 | VANILLA | PLANIFOLIA | ORCHIDACEAE | E | 5-Mar-94 | D | NF |
| 2 | C73 | 11091 | EPIDENDRUM | IBAGUENSE | ORCHIDACEAE | E | 5-Mar-94 | A | NF |
| 2 | C76 | 11092 | VANILLA | PLANIFOLIA | ORCHIDACEAE | E | 5-Mar-94 | A | D |
| 2 | C77 | 11093 | EPIDENDRUM | IBAGUENSE | ORCHIDACEAE | E | 5-Mar-94 | A | D |
| 2 | C69 | 11094 | EPIDENDRUM | IBAGUENSE | ORCHIDACEAE | E | 5-Mar-94 | A | D |
| 2 | C83 | 11095 | EPIDENDRUM | IBAGUENSE | ORCHIDACEAE | E | 5-Mar-94 | A | D |
| 2 | C91 | 11096 | EPIDENDRUM | IBAGUENSE | ORCHIDACEAE | E | 5-Mar-94 | A | D |
| 2 | C62 | 11097 | NEPTUNIA | OLERACEA | FABACEAE | H | 5-Mar-94 | A | NF |
| 2 | C72 | 11100 | OENOCARPUS | MAPORA | ARECACEAE | P | | | A |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C72 | 11102 | CHAMAEDOREA | SP. | ARECACEAE | S | | | A |
| 2 | C78 | 11102 | UNKNOWN | UNKNOWN | UNKNOWN | U | | | |
| 2 | C70 | 11103 | UNKNOWN | UNKNOWN | UNKNOWN | U | | | NF |
| 2 | C70 | 11104 | UNKNOWN | UNKNOWN | UNKNOWN | U | | | NF |
| 2 | C70 | 11105 | UNKNOWN | UNKNOWN | UNKNOWN | U | | | NF |
| 2 | C93 | 11119 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | D |
| 2 | C88 | 11120 | COLOCASIA | ESCULENTA | ARACEAE | H | 20-Nov-93 | A | A |
| 2 | C82 | 11127 | COLOCASIA | ESCULENTA | ARACEAE | H | | | A |
| 2 | C82 | 11128 | COLOCASIA | ESCULENTA | ARACEAE | H | | | A |
| 2 | C82 | 11129 | COLOCASIA | ESCULENTA | ARACEAE | H | | | A |
| 2 | C90 | 11131 | UNKNOWN | UNKNOWN | UNKNOWN | U | | | NF |
| 2 | C89 | 11132 | UNKNOWN | UNKNOWN | UNKNOWN | U | 7-Aug-96 | | NF |
| 2 | C89 | 11133 | UNKNOWN | UNKNOWN | UNKNOWN | U | 7-Aug-96 | | NF |
| 2 | C90 | 11134 | UNKNOWN | UNKNOWN | UNKNOWN | U | | | NF |
| 2 | C89 | 11135 | UNKNOWN | UNKNOWN | UNKNOWN | U | 7-Aug-96 | | NF |
| 2 | C89 | 11136 | UNKNOWN | UNKNOWN | UNKNOWN | U | 7-Aug-96 | | NF |
| 2 | C89 | 11137 | UNKNOWN | UNKNOWN | UNKNOWN | U | 7-Aug-96 | | NF |
| 2 | C79 | 20011 | PACHIRA | AQUATICA | BOMBACACEAE | T | ?-Jul-96 | | A |
| 2 | C80 | 20015 | COSTUS | SP. | ZINGIBERACEAE | H | 1-Jul-96 | | A |
| 2 | C87 | 20017 | UNKNOWN | UNKNOWN | ARECACEAE | P | | | A |
| 2 | C95 | 20018 | UNKNOWN | UNKNOWN | ARACEAE | U | 20-Jul-96 | | A |
| 2 | C85 | 20020 | MUSA | SP. | MUSACEAE | G | 4-Aug-96 | | A |
| 2 | C69 | 20021 | HIBISCUS | ROSA-SINENSIS | MALVACEAE | S | | | A |
| 2 | C72 | 20022 | COLOCASIA | SP. | ARACEAE | H | 1-Jul-96 | | A |
| 2 | C79 | 20023 | UNKNOWN | UNKNOWN | ARACEAE | U | ?-Jul-96 | | A |
| 2 | C88 | 20028 | UNKNOWN | UNKNOWN | ARECACEAE | P | 9-Aug-96 | | A |
| 2 | C92 | 20034 | ALPINIA | PURPURATA | ZINGIBERACEAE | G | 26-Jul-96 | | A |
| 2 | C69 | 20035 | HIBISCUS | ROSA-SINENSIS | MALVACEAE | S | | | A |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C85 | 20036 | PHILODENDRON | SP. | ARACEAE | C | 4-Aug-96 | | A |
| 2 | C64 | 20037 | LEUCAENA | SP. | FABACEAE | T | 30-Jul-96 | | A |
| 2 | C78 | 20040 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | | | A |
| 2 | C90 | 20042 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 4-Aug-96 | | A |
| 2 | C90 | 20043 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 4-Aug-96 | | A |
| 2 | C80 | 20044 | EUCHARIS | GRANDIFLORA | AMARYLLIDACEAE | H | 1-Jul-96 | | A |
| 2 | C90 | 20045 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 4-Aug-96 | | A |
| 2 | C80 | 20049 | PACHIRA | AQUATICA | BOMBACACEAE | T | 1-Jul-96 | | A |
| 2 | C80 | 20051 | PACHIRA | AQUATICA | BOMBACACEAE | T | 1-Jul-96 | | A |
| 2 | C92 | 20054 | MUSA | SP. | MUSACEAE | G | 26-Jul-96 | | A |
| 2 | C90 | 20056 | MUSA | SP. | MUSACEAE | G | 4-Aug-96 | | A |
| 2 | C94 | 20057 | COLOCASIA | ESCULENTA | ARACEAE | H | 24-Jul-96 | | A |
| 2 | C80 | 20060 | PACHIRA | AQUATICA | BOMBACACEAE | T | 1-Jul-96 | | A |
| 2 | C80 | 20061 | PACHIRA | AQUATICA | BOMBACACEAE | T | 1-Jul-96 | | A |
| 2 | C80 | 20062 | PACHIRA | AQUATICA | BOMBACACEAE | T | 1-Jul-96 | | A |
| 2 | C80 | 20063 | PACHIRA | AQUATICA | BOMBACACEAE | T | 1-Jul-96 | | A |
| 2 | C94 | 20064 | COLOCASIA | ESCULENTA | ARACEAE | H | 24-Jul-96 | | A |
| 2 | C80 | 20066 | PACHIRA | AQUATICA | BOMBACACEAE | T | 1-Jul-96 | | A |
| 2 | C80 | 20067 | PACHIRA | AQUATICA | BOMBACACEAE | T | 1-Jul-96 | | A |
| 2 | C79 | 20068 | EUCHARIS | GRANDIFLORA | AMARYLLIDACEAE | H | ?-Jul-96 | | A |
| 2 | C73 | 20069 | COFFEA | SP. | RUBIACEAE | S | 3-Jul-96 | - | A |
| 2 | C73 | 20074 | XANTHOSOMA | SAGGITTIFOLIA | ARACEAE | H | 3-Jul-96 | - | A |
| 2 | C92 | 20075 | ALPINIA | PURPURATA | ZINGIBERACEAE | G | 26-Jul-96 | | A |
| 2 | C88 | 20076 | UNKNOWN | UNKNOWN | ARECACEAE | P | 9-Aug-96 | | A |
| 2 | C90 | 20077 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 4-Aug-96 | | A |
| 2 | C90 | 20078 | PHENAKOSPERMUM | GUYANENSE | STRELITZIACEAE | G | 4-Aug-96 | | A |
| 2 | C95 | 20079 | UNKNOWN | UNKNOWN | ARACEAE | U | 20-Jul-96 | | A |
| 2 | C94 | 20080 | COSTUS | SP. | ZINGIBERACEAE | H | 25-Jul-96 | | A |

Table B-1-- continued.

| Planting | Cell | Survey No. | Genus | Specific epithet | Family | GF | Intro Date | 93-4 | 96 |
|---|---|---|---|---|---|---|---|---|---|
| 2 | C94 | 20089 | COSTUS | SP. | ZINGIBERACEAE | H | 25-Jul-96 | | A |
| 2 | C94 | 20094 | COSTUS | SP. | ZINGIBERACEAE | H | 25-Jul-96 | | A |
| 2 | C92 | 20097 | DIEFFENBACHIA | SP. | ARACEAE | H | 26-Jul-96 | | A |

Table B-2. Species from the first planting of the Biosphere 2 rainforest, with inventories from 1991, 1993 and 1996. T = Tree, S = Shrub, P = Arboreal palm, S = Shrub, R = Graminoid, C = Climber, A = Woody graminoid, such as bamboo, H = Herb, G = Giant herb, E = Epiphyte.

| | | | Number of plants | | |
|---|---|---|---|---|---|
| Family | Species | Growth form | 1991 | 1993 | 1996 |
| Acanthaceae | *Justicia californica* (Benth.) D.N. Gibson | S | 1 | 0 | 0 |
| | *Justicia pectoralis* Jacq. | H | 2 | 0 | 0 |
| | *Ruellia brevifolia* (Pohl) C. Ezcurra | S | 1 | 0 | 0 |
| | *Sanchezia speciosa* Leonard | S | 11 | 9 | 6 |
| | *Thunbergia mysorensis* (Wight) T. Anderson ex Bedd. | C | 15 | 2 | 0 |
| Adiantaceae | *Adiantum hispidulum* | H | 1 | 0 | 0 |
| | *Adiantum raddianum* C. Presl | H | 5 | 0 | 0 |
| | *Pellaea viridis* (Forssk.) Prantl | H | 1 | 0 | 0 |
| | *Polytaenium feei* (W. Schaffn. ex Fée) Maxon | H | 5 | 0 | 0 |
| | *Pteris cretica* L. | H | 5 | 0 | 0 |
| | *Pteris longifolia* L. | H | 3 | 0 | 0 |
| Alismataceae | *Sagittaria graminea* Michx. | H | 1 | 0 | 0 |
| | *Sagittaria lancifolia* L. | H | 1 | 0 | 0 |
| | *Sagittaria latifolia* Willd. | H | 6 | 0 | 0 |
| | *Sagittaria rubrum* | H | 2 | 0 | 0 |
| Amaryllidaceae | *Eucharis grandiflora* Planch. & Linden | H | 10 | 10 | 8 |
| | *Hymenocallis sp.* | H | 1 | 0 | 0 |
| Anacardiaceae | *Anacardium occidentale* L. | T | 1 | 1 | 0 |
| | *Mangifera indica* L. | T | 5 | 2 | 0 |
| | *Spondias mombin L.* | T | 1 | 1 | 0 |

Table B-2 -- continued.

| Family | Species | Growth form | 1991 | 1993 | 1996 |
|---|---|---|---|---|---|
| | *Annona sp.* | T | 1 | 0 | 0 |
| | *Cananga odorata* (Lam.) Hook. f. & Thomson | T | 1 | 0 | 0 |
| | *Rollinia mucosa* (Jacq.) Baill. | T | 2 | 2 | 0 |
| Apiaceae | *Eryngium foetidum* L. | H | 1 | 0 | 0 |
| | *Hydrocotyle asiatica* L. | H | 3 | 0 | 0 |
| | *Hydrocotyle verticillata* Thunb. | H | 1 | 0 | 0 |
| Apocynaceae | *Allamanda cathartica* L. | S | 8 | 5 | 5 |
| | *Catharanthus roseus* (L.) G. Don | H | 1 | 0 | 0 |
| | *Plumeria rubra* L. | T | 1 | 1 | 1 |
| | *Tabernaemontana divaricata* (L.) R. Br. ex Roem. & Schult. | S | 1 | 0 | 0 |
| Aquifoliaceae | *Ilex paraguariensis* J. St.-Hil. (chk) | T | 2 | 1 | 0 |
| Araceae | *Acorus calamus* L. | H | 5 | 0 | 0 |
| | *Aglaonema crispum* (Pitcher & Manda) Nicolson | H | 2 | 2 | 2 |
| | *Aglaonema sp.* | H | 4 | 4 | 4 |
| | *Anthurium digitatum* (Jacq.) Schott | H | 2 | 1 | 1 |
| | *Colocasia antiquorum* Schott | H | 9 | 4 | 2 |
| | *Colocasia esculenta* (L.) Schott | H | 1 | 1 | 1 |
| | *Colocasia sp.* | H | 8 | 8 | 6 |
| | *Dieffenbachia sp.* | H | 20 | 19 | 15 |
| | *Dracunculus canariensis* Kunth | H | 2 | 2 | 2 |
| | *Monstera deliciosa* Liebm. | C | 5 | 5 | 3 |
| | *Philodendron angustatum* Schott | C | 7 | 1 | 1 |
| | *Philodendron erubescens* K. Koch & Augustin | C | 7 | 1 | 1 |

Table B-2 -- continued.

| Family | Species | Growth form | 1991 | 1993 | 1996 |
|---|---|---|---|---|---|
| | *Philodendron glanduliferum* Matuda | H | 1 | 1 | 0 |
| | *Philodendron grazielae* G.S. Bunting | C | 3 | 0 | 0 |
| | *Philodendron rubens* Schott | C | 10 | 9 | 6 |
| | *Philodendron selloum* K. Koch | C | 9 | 8 | 5 |
| | *Philodendron tripartitum* (Jacq.) Schott | C | 3 | 0 | 0 |
| | *Philodendron* cv *wend-embi* | C | 5 | 4 | 4 |
| | *Philodendron sp.* | C | 18 | 10 | 6 |
| | *Scindapsus aureus* (Linden & André) Engl. & K. Krause | C | 16 | 11 | 8 |
| | *Spathiphyllum sp.* | H | 2 | 2 | 2 |
| | *Syngonium podophyllum* Schott | C | 2 | 1 | 0 |
| | *Xanthosoma sagittifolium* (L.) Schott | H | 25 | 11 | 5 |
| | *Xanthosoma sp.* | H | 1 | 1 | 0 |
| | *Zamioculcas zamiifolia* Engl. | H | 2 | 2 | 2 |
| Arecaceae | *Archontophoenix sp.* | P | 2 | 2 | 2 |
| | *Areca catechu* L. | P | 3 | 1 | 1 |
| | *Arenga pinnata* (Wurmb) Merr. | P | 5 | 5 | 5 |
| | *Arenga sp.* | P | 1 | 1 | 1 |
| | *Bactris gasipaes* Kunth | P | 6 | 4 | 3 |
| | *Chamaedorea microspadix* Burret | S | 9 | 4 | 4 |
| | *Chrysalidocarpus lutescens* H. Wendl. | S | 4 | 3 | 3 |
| | *Cocos nucifera* L. | P | 2 | 2 | 2 |
| | *Elaeis guineensis* Jacq. | P | 3 | 2 | 2 |
| | *Euterpe sp.* | P | 8 | 2 | 1 |
| | *Jessenia bataua* (Mart.) Burret | P | 4 | 1 | 0 |
| | *Mauritia flexuosa* L. f. | P | 7 | 1 | 1 |
| | *Oenocarpus bacaba* Mart. | P | 2 | 1 | 1 |

Table B-2 -- continued.

| Family | Species | Growth form | 1991 | 1993 | 1996 |
|---|---|---|---|---|---|
| | *Oenocarpus mapora* H. Karst. | P | 2 | 1 | 0 |
| | *Phoenix roebelenii* O'Brien | P | 4 | 2 | 1 |
| | *Prestoea montana* (Graham) G. Nicholson | P | 1 | 0 | 0 |
| | *Rhapis excelsa* (Thunb.) A. Henry ex Rehder | P | 2 | 0 | 0 |
| | *Roystonea regia* (Kunth) O.F. Cook | P | 3 | 3 | 3 |
| | *Socratea exorrhiza* (Mart.) H. Wendl. | P | 1 | 1 | 0 |
| | *Verschaffeltia splendida* H. Wendl. | P | 5 | 4 | 3 |
| | *Wodyetia bifurcata* I.K. Irvine | P | 2 | 1 | 1 |
| Asclepiadaceae | *Asclepias curassavica* L. | H | 4 | 1 | 1 |
| Asparagaceae | *Asparagus densiflorus* (Kunth) Jessop | H | 2 | 0 | 0 |
| Aspleniaceae | *Asplenium daucifolium* Lam. | H | 1 | 0 | 0 |
| | *Asplenium nidus* L. | E | 5 | 1 | 0 |
| | *Diplazium l'herminieri* Hieron. | H | 1 | 0 | 0 |
| Asteraceae | *Baccharis halimifolia* L. | S | 3 | 0 | 0 |
| Basellaceae | *Basella alba* L. | C | 4 | 0 | 0 |
| Begoniaceae | *Begonia sp.* | H | 2 | 0 | 0 |
| Bignoniaceae | *Crescentia cujete* L. | T | 5 | 4 | 4 |
| | *Pandorea pandorana* (Andr.) Steenis | C | 10 | 4 | 1 |
| | *Pithecoctenium sp.* | C | 5 | 2 | 0 |
| | *Spathodea campanulata* P. Beauv. | T | 1 | 1 | 1 |
| | *Tabebuia heterophylla* (DC.) Britton | T | 3 | 3 | 0 |

Table B-2 -- continued.

| Family | Species | Growth form | 1991 | 1993 | 1996 |
|---|---|---|---|---|---|
| Bixaceae | *Bixa orellana* L. | T | 8 | 6 | 1 |
| Blechnaceae | *Blechnum brasiliense* Desv. | H | 1 | 0 | 0 |
| | *Blechnum occidentale* L. | H | 1 | 0 | 0 |
| | *Blechnum orientale* L. | H | 2 | 0 | 0 |
| | *Doodia caudata* (Cav.) R. Br. | H | 1 | 0 | 0 |
| Bombacaceae | *Ceiba pentandra* (L.) Gaertn. | T | 6 | 6 | 5 |
| | *Pachira aquatica* Aubl. | T | 16 | 15 | 11 |
| Boraginaceae | *Cordia alliodora* (Ruiz & Pav.) Oken | T | 2 | 0 | 0 |
| Bromeliaceae | *Aechmea orlandiana* L.B. Sm. | E | 1 | 0 | 0 |
| | *Ananas sp.* | H | 2 | 1 | 0 |
| | *Billbergia pyramidalis* (Sims) Lindl. | E | 1 | 1 | 0 |
| | *Guzmania berteroniana* (Schult. & Schult.) Mez | E | 1 | 0 | 0 |
| | *Guzmania monostachia* (L.) Rusby ex Mez | E | 2 | 1 | 0 |
| | *Guzmania sp.* | E | 1 | 1 | 0 |
| | *Tillandsia sp.* | E | 17 | 0 | 0 |
| Buddlejaceae | *Buddleja diversifolia* Vahl | T | 1 | 0 | 0 |
| Cactaceae | *Rebutia sp.* | E | 1 | 0 | 0 |
| | *Rhipsalis baccifera* (J.S. Muell.) Stearn | E | 5 | 0 | 0 |
| Cannaceae | *Canna edulis* Ker Gawl. | G | 11 | 6 | 4 |
| | *Canna generalis* L.H. Bailey | G | 11 | 6 | 2 |
| | *Canna indica* L. | G | 15 | 9 | 4 |
| | *Canna sp.* | G | 2 | 0 | 0 |

Table B-2 -- continued.

| Family | Species | Growth form | 1991 | 1993 | 1996 |
|---|---|---|---|---|---|
| Capparaceae | *Capparis spinosa* L. | T | 1 | 1 | 0 |
| Caricaceae | *Carica papaya* L. | T | 14 | 9 | 0 |
| | *Carica pentagona* Heilborn | T | 4 | 0 | 0 |
| | *Carica sp.* | T | 6 | 4 | 0 |
| Cecropiaceae | *Cecropia schreberiana* Miq. | T | 11 | 6 | 5 |
| Clusiaceae | *Clusia sp.* | T | 13 | 1 | 0 |
| | *Garcinia tinctoria* (DC.) Dunn | T | 1 | 1 | 1 |
| | *Garcinia sp.* | T | 3 | 3 | 1 |
| Combretaceae | *Buchenavia capitata* (Vahl) Eichler | T | 2 | 0 | 0 |
| Commelinaceae | *Callisia fragrans* (Lindl.) Woodson | H | 15 | 3 | 2 |
| | *Commelina tuberosa* L. | H | 5 | 0 | 0 |
| | *Dichorisandra thyrsiflora* J.C. Mikan | H | 14 | 4 | 0 |
| | *Palisota schweinfurthii* C.B. Clarke | H | 1 | 0 | 0 |
| | *Tradescantia pallida* (Rose) D.R. Hunt | H | 7 | 1 | 1 |
| | *Tradescantia sp.* | H | 2 | 0 | 0 |
| Convolvulaceae | *Ipomoea batatas* (L.) Lam. | C | 8 | 1 | 0 |
| Cyatheaceae | *Cnemidaria horrida* (L.) C. Presl | P | 1 | 0 | 0 |
| | *Cyathea arborea* (L.) Sm. | P | 3 | 0 | 0 |
| | *Cyathea cooperi* (F. Muell.) Domin | P | 11 | 0 | 0 |
| | *Cyathea sp.* | P | 2 | 0 | 0 |

Table B-2 -- continued.

| Family | Species | Growth form | 1991 | 1993 | 1996 |
|---|---|---|---|---|---|
| Cyclanthaceae | *Carludovica palmata* Ruiz & Pav. | G | 3 | 3 | 3 |
| Cyperaceae | *Cyperus alternifolius* L. | R | 20 | 17 | 14 |
| | *Cyperus hasperis* | R | 1 | 0 | 0 |
| Davalliaceae | *Davallia solida* (G. Forst.) Sw. | H | 1 | 0 | 0 |
| | *Nephrolepis exaltata* (L.) Schott | H | 32 | 4 | 0 |
| Dilleniaceae | *Dillenia indica* L. | T | 2 | 0 | 0 |
| Dioscoreaceae | *Dioscorea alata* L. | C | 3 | 1 | 1 |
| | *Dioscorea sp.* | C | 1 | 0 | 0 |
| Ebenaceae | *Diospyros digyna* Jacq. | T | 1 | 1 | 0 |
| Elaeagnaceae | *Elaeagnus philippensis* Perrottet | T | 2 | 1 | 0 |
| Ephedraceae | *Ephedra sp.* | S | 2 | 0 | 0 |
| Equisetaceae | *Equisetum hyemale* L. | H | 2 | 0 | 0 |
| Euphorbiaceae | *Aleurites moluccana* (L.) Willd. | T | 7 | 6 | 3 |
| | *Breynia disticha* J.R. Forst. & G. Forst. | H | 4 | 4 | 4 |
| | *Croton sp.* | H | 1 | 1 | 0 |
| | *Hevea brasiliensis* (Willd. ex A. Juss.) Müll. Arg. | T | 2 | 0 | 0 |
| | *Hura crepitans* L. | T | 3 | 3 | 1 |

Table B-2 -- continued.

| Family | Species | Growth form | 1991 | 1993 | 1996 |
|---|---|---|---|---|---|
| | *Manihot esculenta* Crantz | S | 10 | 9 | 5 |
| | *Phyllanthus pulcher* Wall. ex Müll. Arg. | T | 1 | 1 | 1 |
| | *Ricinus communis* L. | T | 5 | 4 | 0 |
| Fabaceae | *Bauhinia sp.* | S | 5 | 0 | 0 |
| | *Caesalpinia sp.* | T | 5 | 3 | 1 |
| | *Cajanus cajan* (L.) Millsp. | H | 1 | 0 | 0 |
| | *Calopogonium mucunoides* Desv. | H | 13 | 0 | 0 |
| | *Canavalia ensiformis* (L.) DC. | H | 1 | 0 | 0 |
| | *Ceratonia siliqua* L. | T | 2 | 0 | 0 |
| | *Clitoria racemosa* Sessé & Moç. | T | 11 | 11 | 8 |
| | *Copaifera sp.* | T | 1 | 0 | 0 |
| | *Derris elliptica* (Roxb.) Benth. | C | 2 | 2 | 1 |
| | *Enterolobium cyclocarpum* (Jacq.) Griseb. | T | 2 | 2 | 1 |
| | *Hymenaea courbaril* L. | T | 2 | 1 | 1 |
| | *Inga feuillei* DC. | T | 1 | 1 | 1 |
| | *Inga sp.* | T | 6 | 4 | 3 |
| | *Leucaena glauca* Benth. | T | 26 | 19 | 6 |
| | *Leucaena leucocephala* (Lam.) de Wit | T | 7 | 5 | 1 |
| | *Leucaena sp.* | T | 12 | 12 | 2 |
| | *Pterocarpus indicus* Willd. | T | 5 | 2 | 2 |
| | *Schotia latifolia* Jacq. | T | 1 | 0 | 0 |
| | *Tamarindus indica* L. | T | 1 | 0 | 0 |
| Gesneriaceae | *Sinningia regina* Sprague | S | 1 | 0 | 0 |
| Gnetaceae | *Gnetum sp.* | T | 1 | 0 | 0 |

Table B-2 -- continued.

| Family | Species | Growth form | 1991 | 1993 | 1996 |
|---|---|---|---|---|---|
| Heliconiaceae | *Heliconia bicolor* Klotzsch | G | 10 | 2 | 0 |
| | *Heliconia bourgaeana* Petersen | G | 3 | 2 | 1 |
| | *Heliconia caribaea* Lam. | G | 8 | 5 | 2 |
| | *Heliconia longiflora* R.R. Sm. | G | 7 | 5 | 2 |
| | *Heliconia mutisiana* Cuatrec. | G | 1 | 0 | 0 |
| | *Heliconia psittacorum* L. f. | G | 12 | 3 | 2 |
| | *Heliconia sp.* | G | 7 | 3 | 3 |
| Iridaceae | *Dietes bicolor* (Steud.) Sweet ex Klatt | H | 1 | 1 | 0 |
| | *Dietes grandiflora* N.E. Br. | H | 1 | 0 | 0 |
| Lamiaceae | *Coleus blumei* Benth. | H | 5 | 0 | 0 |
| | *Pogostemon cablin* (Blanco) Benth. | S | 2 | 0 | 0 |
| | *Pogostemon heyneanus* Benth. | S | 4 | 0 | 0 |
| | *Salvia divinorum* Epling & Játiva | S | 3 | 0 | 0 |
| Lauraceae | *Cinnamomum zeylanicum* Breyn. | T | 1 | 1 | 1 |
| | *Persea americana* Mill. | T | 10 | 3 | 2 |
| Lecythidaceae | *Barringtonia asiatica* (L.) Kurz | T | 2 | 2 | 2 |
| | *Couroupita amazonica* R. Knuth | T | 1 | 1 | 1 |
| | *Couroupita guianensis* Aubl. | T | 1 | 1 | 1 |
| | *Lecythis zabucajo* Aubl. | T | 3 | 1 | 0 |
| Lycopodiaceae | *Lycopodium cernuum* L. | H | 2 | 0 | 0 |
| Lythraceae | *Heimia salicifolia* (Kunth) Link | S | 12 | 4 | 0 |
| | *Heimia sp.* | S | 1 | 1 | 0 |

Table B-2 -- continued.

| Family | Species | Growth form | 1991 | 1993 | 1996 |
| --- | --- | --- | --- | --- | --- |
| Malpighiaceae | *Malpighia emarginata* DC. | T | 1 | 1 | 0 |
| | *Malpighia glabra* L. | S | 3 | 1 | 1 |
| Malvaceae | *Hibiscus calyphyllus* Cav. | S | 3 | 3 | 2 |
| | *Hibiscus elatus* Sw. | S | 2 | 2 | 1 |
| | *Hibiscus rosa-sinensis* L. | S | 4 | 4 | 3 |
| Marantaceae | *Calathea gigantea* | H | 2 | 2 | 2 |
| | *Calathea louisae* | H | 4 | 1 | 0 |
| | *Calathea panamensis* Rowlee ex Standl. | H | 3 | 3 | 3 |
| | *Calathea violacea* Lindl. | H | 4 | 4 | 4 |
| | *Calathea zebrina* (Sims) Lindl. | H | 1 | 1 | 0 |
| | *Maranta sp.* | H | 1 | 1 | 0 |
| | *Stromanthe amabilis* E. Morren | H | 1 | 1 | 1 |
| | *Thalia geniculata* L. | H | 3 | 2 | 1 |
| Marcgraviaceae | *Marcgravia rectiflora* Triana & Planch. | C | 5 | 1 | 1 |
| | *Marcgravia sintenisii* Urb. | C | 1 | 1 | 0 |
| | *Norantea guianensis* Aubl. | C | 1 | 0 | 0 |
| Marsileaceae | *Marsilea mutica* | H | 1 | 0 | 0 |
| Melastomataceae | *Tibouchina interomalla* | S | 2 | 0 | 0 |
| Meliaceae | *Cedrela odorata* L. | T | 1 | 1 | 0 |
| | *Cedrela sp.* | T | 6 | 6 | 3 |
| | *Guarea trichilioides* C. DC. (check) | T | 3 | 2 | 0 |
| | *Melia azedarach* L. | T | 4 | 3 | 3 |

Table B-2 -- continued.

| Family | Species | Growth form | 1991 | 1993 | 1996 |
|---|---|---|---|---|---|
| Moraceae | *Artocarpus heterophyllus* Lam. | T | 2 | 2 | 0 |
| | *Ficus buxifolia* De Wild. | T | 1 | 1 | 1 |
| | *Ficus pumila* L. | C | 19 | 10 | 8 |
| Moringaceae | *Moringa oleifera* Lam. | T | 2 | 0 | 0 |
| | *Moringa sp.* | T | 1 | 1 | 0 |
| Musaceae | *Musa paradisiaca* L. | G | 4 | 3 | 3 |
| | *Musa sapientum* L. | G | 1 | 1 | 1 |
| | *Musa textilis* Née | G | 5 | 5 | 5 |
| | *Musa sp.* | G | 31 | 28 | 24 |
| Myristicaceae | *Myristica fragrans* Houtt. | T | 5 | 0 | 0 |
| Myrtaceae | *Eugenia aggregata* (Velloso) Kiaersk. | T | 3 | 1 | 0 |
| | *Eugenia boqueronensis* Britton | T | 6 | 0 | 0 |
| | *Myrciaria cauliflora* (Mart.) O. Berg | T | 1 | 1 | 1 |
| | *Psidium guajava* L. | T | 8 | 3 | 2 |
| | *Syzygium jambos* (L.) Alston | T | 7 | 5 | 2 |
| Nymphaeaceae | *Nymphaea sp.* | H | 9 | 0 | 0 |
| Oleaceae | *Phillyrea angustifolia* L. | T | 2 | 1 | 0 |
| Onagraceae | *Ludwigia octovalvis* (Jacq.) P.H. Raven | H | 1 | 1 | 0 |
| | *Ludwigia sp.* | S | 1 | 1 | 1 |

Table B-2 -- continued.

| Family | Species | Growth form | 1991 | 1993 | 1996 |
|---|---|---|---|---|---|
| Orchidaceae | *Brachionidium sp.* | E | 1 | 0 | 0 |
| | *Spathoglottis plicata* Blume | H | 3 | 0 | 0 |
| | *Vanilla sp.* | E | 1 | 0 | 0 |
| Oxalidaceae | *Averrhoa carambola* L. | T | 5 | 2 | 2 |
| Passifloraceae | *Passiflora coccinea* Aubl. | C | 1 | 0 | 0 |
| | *Passiflora coriacea* Juss. | C | 8 | 1 | 0 |
| | *Passiflora edulis* Sims | C | 5 | 3 | 0 |
| | *Passiflora maliformis* L. | C | 5 | 0 | 0 |
| | *Passiflora mollissima* (Kunth) Bailey | C | 30 | 0 | 0 |
| | *Passiflora quadrangularis* L. | C | 7 | 2 | 0 |
| | *Passiflora trifasciata* Lem. | C | 1 | 0 | 0 |
| Phytolaccaceae | *Phytolacca dioica* L. | T | 8 | 7 | 7 |
| Piperaceae | *Peperomia sp.* | H | 1 | 0 | 0 |
| | *Piper nigrum* L. | C | 1 | 0 | 0 |
| | *Piper sp.* | H | 6 | 5 | 3 |
| Poaceae | *Andropogon sp.* | R | 1 | 0 | 0 |
| | *Arundinaria pygmaea* (Miq.) Asch. & Graebn. | A | 1 | 0 | 0 |
| | *Bambusa glaucescens* (Willd.) Merr. | A | 1 | 1 | 1 |
| | *Bambusa multiplex* (Lour.) Raeusch. ex Schult. & Schult. f. | A | 17 | 10 | 9 |
| | *Bambusa oldhamii* Munro | A | 1 | 1 | 1 |
| | *Bambusa tuldoides* Munro | A | 8 | 7 | 6 |
| | *Bambusa vulgaris* Schrad. ex J.C. Wendl. | A | 1 | 1 | 1 |

Table B-2 -- continued.

| Family | Species | Growth form | 1991 | 1993 | 1996 |
|---|---|---|---|---|---|
| | *Bambusa sp.* | A | 2 | 2 | 2 |
| | *Panicum sp.* | R | 2 | 0 | 0 |
| | *Paspalum plicatulum* Michx. | R | 1 | 1 | 1 |
| | *Phalaris arundinacea* L. | R | 1 | 0 | 0 |
| | *Saccharum officinarum* L. | A | 6 | 6 | 5 |
| | *Setaria palmifolia* (J. König) Stapf | R | 6 | 5 | 2 |
| | *Spartina sp.* | R | 3 | 1 | 0 |
| Polygonaceae | *Antigonon leptopus* Hook. & Arn. | C | 1 | 0 | 0 |
| Polypodiaceae | *Platycerium superbum* | E | 3 | 1 | 0 |
| | *Polypodium aureum* L. | H | 1 | 0 | 0 |
| | *Polypodium crassifolium* L. | E | 6 | 0 | 0 |
| | *Polypodium punctatum* Thunb. | H | 2 | 0 | 0 |
| Pontederiaceae | *Pontederia cordata* L. | H | 7 | 0 | 0 |
| Pteridaceae | *Acrostichum aureum* L. | H | 1 | 0 | 0 |
| Rosaceae | *Aphanes caryotaefolia* | S | 2 | 2 | 2 |
| | *Prunus tomentosa* Thunb. | T | 2 | 0 | 0 |
| | *Rubus sp.* | S | 2 | 0 | 0 |
| Rubiaceae | *Coccocypselum herbaceum* P. Browne | S | 2 | 1 | 0 |
| | *Coffea arabica* L. | T | 18 | 17 | 13 |
| | *Coffea dewevrei* De Wild. & T. Durand | T | 1 | 1 | 1 |
| | *Hamelia patens* Jacq. | S | 1 | 0 | 0 |

Table B-2 -- continued.

| Family | Species | Growth form | 1991 | 1993 | 1996 |
|---|---|---|---|---|---|
| | *Palicourea sp.* | T | 1 | 0 | 0 |
| | *Psychotria sp.* | T | 1 | 1 | 1 |
| Rutaceae | *Casimiroa edulis* La Llave & Lex. | T | 4 | 0 | 0 |
| Sapindaceae | *Paullinia sp.* | C | 2 | 0 | 0 |
| Sapotaceae | *Manilkara zapota* (L.) P. Royen | T | 2 | 1 | 1 |
| Sarraceniaceae | *Sarracenia purpurea* L. | H | 4 | 0 | 0 |
| Scrophulariaceae | *Bacopa monnieri* (L.) Wettst. | H | 1 | 0 | 0 |
| Selaginellaceae | *Selaginella versicolor* Spring | H | 5 | 0 | 0 |
| | *Selaginella victoriae* | H | 1 | 0 | 0 |
| | *Selaginella sp.* | H | 3 | 0 | 0 |
| Simaroubaceae | *Quassia amara* L. | S | 1 | 0 | 0 |
| Solanaceae | *Brugmansia suaveolens* (Willd.) Bercht. & J. Presl | S | 12 | 11 | 9 |
| | *Brunfelsia americana* L. | S | 1 | 1 | 1 |
| | *Brunfelsia jamaicensis* Griseb. | S | 3 | 1 | 0 |
| | *Brunfelsia undulata* Sw. | S | 2 | 1 | 1 |
| | *Capsicum sp.* | H | 6 | 0 | 0 |
| | *Datura stramonium* L. | H | 1 | 0 | 0 |
| | *Lycianthes rantonnetii* (Carrière) Bitter | S | 1 | 1 | 1 |
| | *Solandra maxima* (Sessé & Moç.) P.S. Green | C | 4 | 2 | 1 |

Table B-2 -- continued.

| Family | Species | Growth form | 1991 | 1993 | 1996 |
|---|---|---|---|---|---|
| | *Solandra nitida* Zuccagni | C | 1 | 1 | 0 |
| | *Withania somnifera* (L.) Dunal | S | 5 | 0 | 0 |
| Sterculiaceae | *Theobroma cacao* L. | T | 11 | 3 | 0 |
| Strelitziaceae | *Phenakospermum guyanense* (Rich.) Endl. | G | 14 | 14 | 11 |
| | *Strelitzia nicolai* Regel & Körn. | G | 5 | 2 | 2 |
| | *Strelitzia reginae* Aiton | G | 22 | 20 | 18 |
| | *Strelitzia sp.* | G | 3 | 3 | 1 |
| Theaceae | *Camellia sinensis* (L.) Kuntze | S | 4 | 1 | 0 |
| Thelypteridaceae | *Thelypteris sp.* | H | 1 | 0 | 0 |
| Typhaceae | *Typha angustifolia* L. | H | 2 | 0 | 0 |
| | *Typha domingensis* Pers. | H | 1 | 0 | 0 |
| Urticaceae | *Pellionia daveauana* N.E. Br. | H | 1 | 0 | 0 |
| Verbenaceae | *Tectona grandis* L. f. | T | 2 | 0 | 0 |
| Vitaceae | *Cissus gongylodes* (Burch. ex Baker) Planch. | C | 2 | 1 | 1 |
| | *Cissus rhombifolia* Vahl | C | 1 | 1 | 0 |
| | *Cissus sicyoides* L. | C | 3 | 2 | 1 |
| Zamiaceae | *Zamia fischeri* Miq. | S | 2 | 2 | 2 |
| | *Zamia furfuracea* L. f. | S | 7 | 5 | 5 |

Table B-2 -- continued.

| Family | Species | Growth form | 1991 | 1993 | 1996 |
|---|---|---|---|---|---|
| Zingiberaceae | *Alpinia purpurata* (Vieill.) ex K. Schum. | G | 4 | 4 | 4 |
| | *Alpinia sanderae* Sand | G | 9 | 3 | 2 |
| | *Alpinia zerumbet* (Pers.) B.L. Burtt & R.M. Sm. | G | 8 | 8 | 8 |
| | *Brachychilum horsfieldii* (Wall.) Petersen | H | 1 | 0 | 0 |
| | *Costus barbatus* Suess. | H | 1 | 0 | 0 |
| | *Costus elatus* | H | 3 | 1 | 1 |
| | *Costus globosus* | H | 1 | 1 | 0 |
| | *Costus scaber* Ruiz & Pav. | H | 2 | 2 | 2 |
| | *Costus sp.* | H | 27 | 24 | 19 |
| | *Curcuma domestica* Lour. | H | 10 | 4 | 1 |
| | *Curcuma longa* L. | H | 1 | 0 | 0 |
| | *Curcuma roscoena* | H | 4 | 0 | 0 |
| | *Etlingera elatior* (Jack) R.M. Sm. | H | 4 | 2 | 1 |
| | *Globba sp.* | H | 5 | 0 | 0 |
| | *Hedychium aurantiaca* | G | 5 | 1 | 1 |
| | *Hedychium cornatum* | G | 4 | 3 | 2 |
| | *Hedychium coronarium* Koenig | G | 19 | 14 | 8 |
| | *Hedychium sp.* | G | 5 | 2 | 2 |
| | *Kaempferia decora* | H | 1 | 0 | 0 |
| | *Kaempferia elegans* (Wall.) Baker | H | 1 | 0 | 0 |
| | *Kaempferia pulchra* Ridl. | H | 6 | 1 | 0 |
| | *Kaempferia rotunda* L. | H | 8 | 3 | 0 |
| | *Renealmia alpinia* (Rottb.) Maas | G | 2 | 1 | 1 |
| | *Renealmia battenbergiana* Cummins ex Baker | H | 1 | 0 | 0 |

Table B-2 -- continued.

| Family | Species | Growth form | 1991 | 1993 | 1996 |
|---|---|---|---|---|---|
| | *Zingiber officinale* Roscoe | H | 7 | 3 | 0 |
| | *Zingiber spectabile* Griff. | G | 5 | 4 | 3 |
| | | | | | |
| | Unknown | | 315 | 89 | 35 |
| | TOTAL | | 1890 | 872 | 529 |

Table B-3. Species from the second planting of the Biosphere 2 rainforest, with inventories from 1993 and 1996, or self-propagated. T = Tree, S = Shrub, P = Arboreal palm, S = Shrub, R = Graminoid, C = Climber, A = Woody graminoid, such as bamboo, H = Herb, G = Giant herb, E = Epiphyte.

| Family | Species | Growth form | New in '93-'94 | Alive in 96 | New in '96 | Total in '96 |
|---|---|---|---|---|---|---|
| Amaryllidaceae | *Eucharis grandiflora* Planch. & Linden | H | 0 | 0 | 2 | 2 |
| Anacardiaceae | *Spondias mombin* L. | T | 7 | 0 | 0 | 0 |
| Annonaceae | *Annona muricata* L. | T | 6 | 0 | 0 | 0 |
| | *Annona squamosa* L. | T | 2 | 0 | 0 | 0 |
| | *Cananga odorata* (Lam.) Hook. f. & Thomson | T | 2 | 0 | 0 | 0 |
| Araceae | *Colocasia esculenta* (L.) Schott | H | 30 | 10 | 7 | 17 |
| | *Colocasia sp.* | H | 1 | 0 | 1 | 1 |
| | *Dieffenbachia sp.* | H | 0 | 0 | 2 | 2 |
| | *Monstera deliciosa* Liebm. | C | 3 | 2 | 0 | 2 |
| | *Philodendron sp.* | C | 0 | 0 | 1 | 1 |
| | *Spathiphyllum cannifolium* (Dryand.) Schott | H | 6 | 0 | 0 | 0 |
| | *Xanthosoma sagittifolium* (L.) Schott | H | 14 | 4 | 1 | 5 |
| | *Xanthosoma sp.* | H | 5 | 2 | 0 | 2 |
| Arecaceae | *Chamaedorea sp.* | S | 1 | 1 | 0 | 1 |
| | *Cocos nucifera* L. | P | 2 | 0 | 0 | 0 |
| | *Euterpe edulis* Mart. | P | 6 | 0 | 0 | 0 |
| | *Euterpe oleracea* Mart. | P | 3 | 0 | 0 | 0 |
| | *Euterpe precatoria* Mart. | P | 2 | 0 | 0 | 0 |
| | *Mauritia flexuosa* L. f. | P | 1 | 0 | 0 | 0 |
| | *Oenocarpus mapora* H. Karst. | P | 1 | 0 | 1 | 1 |

Table B-3 -- continued.

| Family | Species | Growth form | New in '93-'94 | Alive in 96 | New in '96 | Total in '96 |
|---|---|---|---|---|---|---|
| Aspleniaceae | *Ctenitis sloanei* (Poepp. ex Spreng.) C.V. Morton | H | 3 | 0 | 0 | 0 |
| | *Diplazium proliferum (Lam.) Kaulf.* | E | 2 | 1 | 0 | 1 |
| Bignoniaceae | *Parmentiera edulis* DC. | T | 1 | 1 | 0 | 1 |
| Bixaceae | *Bixa orellana* L. | T | 1 | 1 | 0 | 1 |
| Bombacaceae | *Pachira aquatica* Aubl. | T | 0 | 0 | 9 | 9 |
| Bromeliaceae | *Aechmea calyculata* (E. Morren) Baker | E | 1 | 1 | 0 | 1 |
| | *Aechmea caudata* Lindm. | H | 1 | 0 | 0 | 0 |
| | *Aechmea cylindrata* Lindm. | E | 2 | 1 | 0 | 1 |
| | *Aechmea fasciata* (Lindl.) Baker | E | 2 | 0 | 0 | 0 |
| | *Aechmea fosteriana* L.B. Sm. | E | 1 | 1 | 0 | 1 |
| | *Aechmea lamarchei* Mez | E | 2 | 2 | 0 | 2 |
| | *Aechmea nudicaulis* (L.) Griseb. | E | 3 | 2 | 0 | 2 |
| | *Aechmea penduliflora* André | E | 1 | 0 | 0 | 0 |
| | *Aechmea pineliana* (Brongn. ex Planch.) Baker | E | 1 | 1 | 0 | 1 |
| | *Aechmea racinae* L.B. Sm. | E | 1 | 1 | 0 | 1 |
| | *Aechmea ramosa* Mart. ex Schult. f. | E | 1 | 1 | 0 | 1 |
| | *Billbergia horrida* Regel | E | 3 | 1 | 0 | 1 |
| | *Guzmania lingulata* (L.) Mez | E | 3 | 1 | 0 | 1 |
| Cannaceae | *Canna edulis* Ker Gawl. | G | 7 | 0 | 0 | 0 |
| Caricaceae | *Carica papaya* L. | T | 6 | 0 | 0 | 0 |
| | *Carica sp.* | T | 1 | 0 | 0 | 0 |

Table B-3 -- continued.

| Family | Species | Growth form | New in '93-'94 | Alive in 96 | New in '96 | Total in '96 |
|---|---|---|---|---|---|---|
| Clusiaceae | *Garcinia mangostana* L. | T | 2 | 0 | 0 | 0 |
| Convolvulaceae | *Ipomoea batatas* (L.) Lam. | C | 1 | 0 | 0 | 0 |
| Cyatheaceae | *Cyathea arborea* (L.) Sm. | P | 1 | 0 | 0 | 0 |
| Cyperaceae | *Cyperus haspan* L. | R | 1 | 0 | 0 | 0 |
| Dioscoreaceae | *Dioscorea alata* L. | C | 6 | 1 | 0 | 1 |
| | *Dioscorea sp.* | C | 6 | 2 | 0 | 2 |
| Euphorbiaceae | *Manihot esculenta* Crantz | S | 13 | 1 | 0 | 1 |
| Fabaceae | *Inga edulis* Mart. | T | 2 | 0 | 0 | 0 |
| | *Inga sp.* | T | 1 | 0 | 0 | 0 |
| | *Leucaena sp.* | T | 0 | 0 | 1 | 1 |
| | *Neptunia oleracea* Lour. | H | 2 | 0 | 0 | 0 |
| Lauraceae | *Cinnamomum zeylanicum* Breyn. | T | 1 | 0 | 0 | 0 |
| Lecythidaceae | *Barringtonia asiatica* (L.) Kurz | T | 3 | 0 | 0 | 0 |
| | *Couroupita guianensis* Aubl. | T | 2 | 1 | 0 | 0 |
| Malpighiaceae | *Malpighia emarginata* DC. | T | 2 | 0 | 0 | 0 |
| Malvaceae | *Hibiscus elatus* Sw. | S | 5 | 4 | 0 | 4 |
| | *Hibiscus rosa-sinensis* L. | S | 0 | 0 | 2 | 2 |

Table B-3 -- continued.

| Family | Species | Growth form | New in '93-'94 | Alive in 96 | New in '96 | Total in '96 |
|---|---|---|---|---|---|---|
| Marantaceae | *Calathea allouia* (Aubl.) Lindl. | H | 1 | 0 | 0 | 0 |
| | *Calathea ornata* (Lindl.) Körn. | H | 3 | 1 | 0 | 1 |
| | *Calathea picturata* (Linden) Koch & Linden | H | 4 | 1 | 0 | 1 |
| | *Calathea sp.* | H | 1 | 0 | 0 | 0 |
| | *Maranta arundinacea* L. | H | 6 | 0 | 0 | 0 |
| Marattiaceae | *Angiopteris evecta* (G. Forst.) Hoffm. | C | 1 | 0 | 0 | 0 |
| Meliaceae | *Swietenia macrophylla* King | T | 1 | 0 | 0 | 0 |
| Moraceae | *Artocarpus altilis* (Parkinson) Fosberg | T | 1 | 1 | 0 | 1 |
| | *Artocarpus heterophyllus* Lam. | T | 4 | 1 | 0 | 1 |
| | *Artocarpus sp.* | T | 1 | 0 | 0 | 0 |
| | *Ficus nitida* Thunb. | C | 1 | 1 | 0 | 1 |
| Moringaceae | *Moringa oleifera* Lam. | T | 7 | 0 | 0 | 0 |
| Musaceae | *Musa sp.* | G | 34 | 25 | 3 | 28 |
| Myrtaceae | *Eugenia aggregata* (Velloso) Kiaersk. | T | 2 | 1 | 0 | 1 |
| | *Eugenia boqueronensis* Britton | T | 1 | 0 | 0 | 0 |
| | *Myrciaria cauliflora* (Mart.) O. Berg | T | 1 | 0 | 0 | 0 |
| | *Psidium guajava* L. | T | 2 | 1 | 0 | 1 |
| | *Syzygium jambos* (L.) Alston | T | 2 | 1 | 0 | 1 |
| Nelumbonaceae | *Nelumbo nucifera* Gaertn. | H | 1 | 0 | 0 | 0 |

Table B-3 -- continued.

| Family | Species | Growth form | New in '93-'94 | Alive in 96 | New in '96 | Total in '96 |
|---|---|---|---|---|---|---|
| Nymphaeaceae | *Nymphaea sp.* | H | 1 | 0 | 0 | 0 |
| Orchidaceae | *Epidendrum ibaguense* Kunth | E | 5 | 0 | 0 | 0 |
| | *Vanda tricuspidata* J.J. Sm. | E | 3 | 0 | 0 | 0 |
| | *Vanilla planifolia* Jacks. ex Andrews | E | 3 | 0 | 0 | 0 |
| Oxalidaceae | *Averrhoa carambola* L. | T | 4 | 0 | 0 | 0 |
| Poaceae | *Cymbopogon citratus* (DC.) Stapf | R | 2 | 0 | 0 | 0 |
| Polypodiaceae | *Drynaria quercifolia* (L.) J. Sm. | E | 1 | 1 | 0 | 1 |
| | *Platycerium bifurcatum* C. Chr. | E | 2 | 0 | 0 | 0 |
| | *Platycerium hillii* | E | 2 | 0 | 0 | 0 |
| | *Platycerium vassei* | E | 2 | 0 | 0 | 0 |
| | *Platycerium veitchii* | E | 2 | 0 | 0 | 0 |
| | *Platycerium willinckii* | E | 3 | 0 | 0 | 0 |
| Rubiaceae | *Coffea arabica* L. | T | 2 | 1 | 0 | 1 |
| | *Coffea sp.* | T | 0 | 0 | 1 | 1 |
| | *Psychotria viridis* Ruiz & Pav. | T | 1 | 1 | 0 | 1 |
| | *Psychotria sp.* | S | 1 | 1 | 0 | 1 |
| Sapotaceae | *Chrysophyllum sp.* | T | 1 | 1 | 0 | 1 |
| | *Pouteria obovata* (R. Br.) Baehni | | 1 | 0 | 0 | 0 |
| | *Synsepalum dulcificum* (Schumach. & Thonn.) Daniell | | 1 | 0 | 0 | 0 |

Table B-3 -- continued.

| Family | Species | Growth form | New in '93-'94 | Alive in 96 | New in '96 | Total in '96 |
|---|---|---|---|---|---|---|
| Simaroubaceae | *Quassia tulae* | | 3 | 0 | 0 | 0 |
| Solanaceae | *Brugmansia suaveolens* (Willd.) Bercht. & J. Presl | T | 1 | 1 | 0 | 1 |
| | *Brunfelsia sp.* | T | 1 | 0 | 0 | 0 |
| Sterculiaceae | *Theobroma cacao* L. | T | 6 | 0 | 0 | 0 |
| Strelitziaceae | *Phenakospermum guyanense* (Rich.) Endl. | G | 0 | 0 | 6 | 6 |
| Theaceae | *Camellia sinensis* (L.) Kuntze | S | 2 | 0 | 0 | 0 |
| Zingiberaceae | *Alpinia purpurata* (Vieill.) K. Schum. | H | 0 | 0 | 2 | 2 |
| | *Costus sp.* | H | 0 | 0 | 4 | 4 |
| | *Zingiber officinale* Roscoe | H | 1 | 0 | 0 | 0 |
| | Unknown | | 15 | 1 | 5 | 6 |
| | TOTAL | | 339 | 86 | 48 | 134 |

# APPENDIX C
# PRODUCTION AND BIOMASS MINIMODEL

Table C-1. EXCEL spreadsheet used to calculate coefficients for Biosphere rainforest production and biomass minimodel under predicted steady-state conditions.

Table C-2. Program in QUICKBASIC for the simulation of metabolism of the rainforest in Biosphere 2, model B2METAB in Figure 3-19.

Figure C-1. One-hundred-year simulation of Biosphere 2 rainforest production and biomass minimodel, B2METAB, with light increased 20% over baseline. Final values for plant biomass are on the right side of their graphs. $g/m^2$=grams per square meter, dry weight for biomass.

Figure C-2. One-hundred-year simulation of Biosphere 2 rainforest production and biomass minimodel, B2METAB, with no weedy biomass. Final values for plant biomass are on the right side of their graphs. $g/m^2$=grams per square meter, dry weight for biomass.

Figure C-3. One-hundred-year simulation of Biosphere 2 rainforest production and biomass minimodel, B2METAB, where all pruned biomass is put onto the soil. Final values for plant biomass are on the right side of their graphs. $g/m^2$=grams per square meter, dry weight for biomass.

Figure C-4. One-hundred-year simulation of Biosphere 2 rainforest production and biomass minimodel, B2METAB with no pruning by humans. Final values for plant biomass are on the right side of their graphs. $g/m^2$=grams per square meter, dry weight for biomass.

Figure C-5. One-hundred-year simulation of Biosphere 2 rainforest production and biomass minimodel, B2METAB, human effort is reduced to .75 of the baseline. Final values for plant biomass are on the right side of their graphs. $g/m^2$=grams per square meter, dry weight for biomass.

Figure C-6. One-hundred-year simulation of Biosphere 2 rainforest production and biomass minimodel, B2METAB, human effort is reduced to .85 of the baseline. Final values for plant biomass are on the right side of their graphs. $g/m^2$=grams per square meter, dry weight for biomass.

Figure C-7. One-hundred-year simulation of Biosphere 2 rainforest production and biomass minimodel, B2METAB, with airflow cut off from the rest of the Biosphere. $g/m^2$=grams per square meter, dry weight for biomass.

Table C-1. Spreadsheet used to calculate coefficients for Biosphere rainforest production and biomass minimodel under predicted steady state conditions.

| Note | Item | Value | Units | Pathway Value | Coefficient Value |
|---|---|---|---|---|---|
| Sources for calibration: | | | | | |
| R | Unused sunlight | 2.60E+02 | kcal/m²/day | | |
| H | Human effort | 1.00E+00 | unitless | | |
| Im | Mean insolation about which sin wave varies | 2.60E+03 | kcal/m²/day | | |
| Ir | Annual range of insolation | 5.00E+02 | kcal/m²/day | | |
| Ja | Air flow | 1.00E+00 | g/m², $CO_2$ | | |
| Storages for calibration: | | | | | |
| W | Weedy plant biomass | 1.00E+03 | g/m², dry weight | | |
| M | Mature plant biomass | 9.00E+03 | g/m², dry weight | | |
| N | $CO_2$ in atmosphere | 1.80E+01 | g/m², $CO_2$ | | |
| S | Soil organic matter | 2.84E+04 | g/m², dry weight | | |
| B | Biomass stored | 2.30E+04 | g/m², dry weight | | |
| C | Consumers | 1.00E+00 | g/m², dry weight | | |
| Calculation products: | | | | | |
| | | N*W = 1.80E+04 | | | |
| | | N*M = 1.62E+05 | | | |
| | | N*W*R = 4.68E+06 | | | |
| | | N*M*R = 4.21E+07 | | | |
| | | W*H = 1.00E+03 | | | |
| 1 | Sunlight to weedy plants | | | K1*N*W*R = 2.340E+02 | K1 = 5.000E-05 |
| 2 | Sunlight to mature plants | | | K2*N*M*R = 2.106E+03 | K2 = 5.000E-05 |
| 3 | Weedy plants feedback to production | | | K3*N*W*R = 3.000E-01 | K3 = 6.410E-08 |
| 4 | Gross production of weedy plants | | | K4*N*W*R = 1.200E+00 | K4 = 2.564E-07 |

Table C-1 -- continued.

| Note | Item | Pathway Value | Coefficient Value |
|---|---|---|---|
| 5 | Mature plants feedback to production | K5*N*M*R = 4.150E+00 | K5 = 9.853E-08 |
| 6 | Gross production of mature plants | K6*N*M*R = 1.080E+01 | K6 = 2.564E-07 |
| 7 | Weedy biomass pruned and stored | K7*W*H = 1.500E-01 | K7 = 1.500E-04 |
| 8 | Biomass loss due to weedy plant respiration | K8*W = 3.000E-01 | K8 = 3.000E-04 |
| 9 | $CO_2$ to atmosphere from weedy plant respiration | K9*W = 7.320E-02 | K9 = 7.320E-05 |
| 10 | Weedy biomass pruned and applied to rainforest soil | K10*W*H = 1.500E-01 | K10 = 1.500E-04 |
| 11 | Weedy biomass prunings added to soil organic matter | K11*W*H = 1.500E-01 | K11 = 1.500E-04 |
| 12 | Natural litterfall from weedy plants | K12*W = 3.000E-01 | K12 = 3.000E-04 |
| 13 | Organic matter entering soil from weedy plant litterfall | K13*W = 3.000E-01 | K13 = 3.000E-04 |
| 14 | Natural litterfall from mature plants | K14*M = 2.500E+00 | K14 = 2.778E-04 |
| 15 | Organic matter entering soil from mature plant litterfall | K15*M = 2.500E+00 | K15 = 2.778E-04 |
| 16 | Biomass loss due to mature plant respiration | K16*M = 4.150E+00 | K16 = 4.611E-04 |
| 17 | $CO_2$ to atmosphere from respiration of mature plants | K17*M = 1.010E+00 | K17 = 1.122E-04 |
| 18 | Pruned weedy plant biomass stored in basement | K18*W*H = 1.500E-01 | K18 = 1.500E-04 |
| 19 | Human effort dedicated to pruning for storage | K19*H = 1.000E+00 | K19 = 1.000E+00 |
| 20 | Human effort dedicated to pruning for addition to soil | K20*H = 1.000E+00 | K20 = 1.000E+00 |
| 21 | $CO_2$ leaving rainforest in airflow | K21*N = 1.000E+00 | K21 = 5.556E-02 |
| 22 | Microbial consumption of soil organic matter | K22*S = 1.950E+00 | K22 = 6.866E-05 |
| 23 | $CO_2$ from microbial respiration | K23*S = 4.758E-01 | K23 = 1.675E-05 |
| 24 | $CO_2$ uptake by weedy plants | K24*N*W*R = 1.910E-01 | K24 = 4.080E-08 |
| 25 | $CO_2$ uptake by mature plants | K25*N*M*R = 1.407E+00 | K25 = 3.341E-08 |
| 26 | Stored biomass lost by slow decomposition | K26*B = 1.500E-01 | K26 = 6.522E-06 |
| 27 | Consumption of soil organic matter by animals | K27*C*S = 1.000E+00 | K27 = 3.521E-05 |
| 28 | $CO_2$ from detritivore respiration | K28*C = 2.440E-03 | K28 = 2.440E-03 |
| 29 | $CO_2$ from decomposition of stored biomass | K29*B = 3.660E-02 | K29 = 1.591E-06 |
| 30 | Organic matter used for non-microbe consumer respiration | K30*C = 1.000E-02 | K30 = 1.000E-02 |
| 31 | Consumer growth | K31*S*C = 1.000E-02 | K31 = 3.521E-07 |

Table C-1 -- continued.

| Note | |
|---|---|
| I, R | Total average outside sunlight for 24 hour period is 5200 kcal/$m^2$/day (Romer, 1985). One-half (2600 kcal/$m^2$/day) is reflected or absorbed by the spaceframe structure or glass covering of the Biosphere. One tenth of the incoming sunlight (260 kcal/$m^2$/day) is unused by producers, falling on bare ground or structure. |
| N | Assumes average atmospheric $CO_2$ in 20 year steady state condition as 500 ppmv. (500 $cm^3/m^3$)(34,690 $m^3$)(44 g $CO_2$/mole)(1 mole/22,400 $cm^3$)(1/1900 $m^2$) = 17.93 g $CO_2/m^2$ |
| S | Soil organic matter as measured in 1993 in the top 60 cm of rainforest soil of Biosphere 2 (Scott, 1998). |
| B | Biomass stored after 20 years approximated as 23,000 g/$m^2$ based on actual weedy plant harvest rates of 2250 kgdw per year in Biosphere 2 rainforest. |
| C | Consumers estimated to be .01% of total plant biomass, or 1 g/$m^2$. |
| 1,2 | Of the 2340 kcal/$m^2$/day used by producers, one-tenth (234 kcal/$m^2$/day) is used by weedy plants and nine-tenths (2106 kcal/$m^2$/day) by mature plants. |
| 3,8 | Weedy plant respiration is the sum of 2 pathways - that which feeds back to weedy plant growth (K3) and that which puts $CO_2$ back into the atmosphere (K8). The ratio of gross production to respiration is considered to be 2 for weedy plants - thus the sum of the respiration pathways is 1.2/R = 2, or 0.6. Half of this, 0.3, is considered to feed back to plant growth (K3) and the other half to go directly into the atmosphere (K8). |
| 4,6 | Gross production is set close to 1/3 of the gross production of the tabonuco forest at El Verde in Puerto Rico (Odum, 1970), or 12 grams dry weight per square meter per day. One tenth of that total (K4=1.2 gdw) is gross production by weedy species, nine tenths (K6=10.8 gdw) is gross production by mature species. |
| 5,16 | Mature plant respiration is the sum of 2 pathways - that which feeds back to mature plant growth (K5 and that which puts $CO_2$ back into the atmosphere (K16). The ratio of gross production to respiration is considered to be 1.3 for mature plants - thus the sum of the respiration pathways is 10.8/R=1.3, or 8.31. Half of this is considered to be fed back to plant growth (K5), half goes directly into the atmosphere (K16). |
| 6 | See 4. |

Table C-1 -- continued.

| Note | |
|---|---|
| 7,10 | To calibrate model at steady state, the sum of weedy biomass loss by pruning and litterfall equals gross production minus total respiration of weedy plants (see 12). Pruning (K7+K10) and litterfall (K12) use equal amounts of biomass. Half of the pruned biomass is considered to have been added to the piles of dried biomass stored in the rainforest basement (K7) and half applied to the rainforest soil (K10). |
| 8 | See 3. |
| 9 | The stoichiometric relationship between organic matter (glucose) and carbon dioxide is as follows: $CO_2$ = (0.244) organic matter, or organic matter = (4.09) $CO_2$. Therefore (0.300 gdw)(0.244 g $CO_2$/ gdw) = 0.0732 g $CO_2$ |
| 10 | See 7. |
| 11 | All of pruned biomass added to soil is considered to end up as soil organic matter. |
| 12 | Calculated for steady state, the amount of biomass lost to litterfall and pruning must equal net production. |
| 13 | Hence, for weedy plants, K12 + K7 + K10 = K4 - (K3 + K8) = 0.60 gdw. Biomass loss due to natural litterfall (K12) is considered to be half of the total biomass loss, and the other half is due to pruning (K7 + K10). The average litterfall in the mature Biosphere 2 rainforest (2.31 gdw/$m^2$/day) is roughly equal to that measured in the mature tabonuco forest of El Verde in Puerto Rico (2.27 gdw/$m^2$/day (Odum 1970)). |
| 13 | All of natural litterfall from weedy plants is considered to end up as soil organic matter. |
| 14 | Calculated to maintain steady state. See 12. |
| 15 | All of natural litterfall from mature plants is considered to end up as soil organic matter. |
| 16 | See 5. |
| 17 | (4.15 gdw)(0.244 g $CO_2$/ gdw) = 1.01 g $CO_2$ |

Table C-1 -- continued.

| Note | |
|---|---|
| 18 | See 7. |
| 19 | Temporary, unitless placeholder used. |
| 20 | Temporary, unitless placeholder used. |
| 21 | Temporary, unitless placeholder used. |
| 22 | At steady state, the amount of litterfall is equal to the amount used by soil biota. Half is allocated to microbial and half to non-microbial consumers. 2.95 gdw)(0.5) = 1.475 gdw |
| 23 | (1.475 gdw)(0.244 g $CO_2$/gdw) = 0.36 g $CO_2$ |
| 24 | The $CO_2$ uptake by weedy plants is stoichiometrically related to the gross production of weedy plants (K4), minus the amount of $CO_2$ provided by the feedback process (K3).<br>(1.2 gdw)(0.244 g $CO_2$/gdw) - (0.30 gdw)(0.244 g $CO_2$/gdw) = 0.22 g $CO_2$ |
| 25 | The $CO_2$ uptake by mature plants is stoichiometrically related to the gross production of mature plants (K6), minus the amount of $CO_2$ provided by the feedback process (K5).<br>(10.8 gdw)(0.244 g $CO_2$/gdw) - (4.15 gdw)(0.244 g $CO_2$/gdw) = 1.623 g $CO_2$ |
| 26 | Decomposition of stored and dried biomass will occur at slow rate, resulting in continued increase in biomass storage through time; however for calibration this was set for steady state condition. |
| 27 | At steady state, the amount of litterfall is equal to the amount of soil organic matter consumed by soil biota. Half goes to microbial and half non-microbial consumers. (2.95 gdw)(0.5) = 1.475 gdw |
| 28 | (1.475 gdw)(0.244 g $CO_2$/gdw) = 0.36 g $CO_2$ |
| 29 | (0.150 gdw)(0.244 g $CO_2$/gdw) = 0.0366 g $CO_2$ |
| 21 | At steady state, equal to the amount consumed. |
| 31 | Organic matter used in the production of consumers. |

Table C-2. Program in BASIC for the simulation of metabolism of the rainforest in Biosphere 2, Model B2METAB.bas in Figure 3-19.

| Line | Code |
|---|---|
| 10 | REM B2METAB - 18 APR 1999 |
| 11 | REM Autocatalytic consumers C |
| 12 | REM Set for 100 years' run |
| 13 | REM started with high soil organics, low plants |
| 15 | LINE (0,5) - (400,90),,B |
| 20 | LINE (0,110) - (400,190),,B |
| 25 | LINE (0,210) - (400,290),,B |
| 30 | LINE (0,310) - (400,350),,B |
| 35 | LINE (0,370)-(400,410),,B |
| 40 | LINE (0,330)-(400, 330),3 |
| | |
| 44 | REM Outside Sources |
| 45 | Im = 2600:REM mean insolation about which sine wave varies |
| 46 | Ir = 500:REM annual range of insolation |
| 47 | H = 1 |
| 48 | Ja = 1 |
| | |
| 50 | REM Initial storages |
| 55 | W = 100: REM Calibrated at 1000 |
| 60 | M = 900:REM Calibrated at 9000 |
| 70 | N = 18: REM Calibrated at 18 |
| 80 | S = 28400!:REM Calibrated at 28400 |
| 90 | B = 0:REM: calibrated at 23000 |
| 95 | C = .1:REM: calibrated at 1 |
| | |
| 100 | REM COEFFICIENTS |
| 110 | K1 = .00005 |
| 120 | K2 = .00005 |
| 130 | K3 = 6.41E-08 |
| 140 | K4 = 2.564E-07 |
| 150 | K5 = 9.853E-08 |
| 160 | K6 = 2.564E-07 |
| 170 | K7 = .00015 |
| 180 | K8 = .0003 |
| 190 | K9 = .0000732 |
| 200 | K10 = .00015 |
| 210 | K11 = .00015 |
| 220 | K12 = .0003 |
| 230 | K13 = .0003 |
| 240 | K14 = .0002778 |
| 250 | K15 = .0002778 |
| 260 | K16 = .0004611 |
| 270 | K17 = .0001122 |
| 280 | K18 = .00015 |

Table C-2 — continued.

| Line | Code |
|---|---|
| 290 | K19 = 1 |
| 300 | K20 = 1 |
| 310 | K21 = .055556 |
| 320 | K22 = 6.866E-05 |
| 325 | K23 = 1.675E-05 |
| 330 | K24 = 4.08E-08 |
| 335 | K25 = 3.341E-08 |
| 340 | K26 = 6.522E-06 |
| 345 | K27 = 3.521E-05:REM K27*C*S = 1. (C=1,S=28400) |
| 350 | K28 = .00244 |
| 355 | K29 = 1.591E-06 |
| 360 | K30 = .01:REM If K30*C = .01 where C = 1 |
| 370 | K31 = 3.521E-07:REM 3.5E-7 since K27*C*S = .01 (C=1,S=28400) |
| 375 | t = 100 |
| | |
| 400 | REM Scaling Factors |
| 410 | T0 = .01: REM When T0 = .1, 3650 days = 10 years |
| 420 | DT = 10 |
| 430 | M0 = .007 |
| 440 | W0 = .007 |
| 450 | N0 = 1.75 |
| 460 | S0 = .002 |
| 470 | B0 = .002 |
| 480 | C0 = 6 |
| 490 | I0 = .0225 |
| 495 | Pr0 = 40 |
| | |
| 500 | REM Equations |
| 502 | Pg = K4*R*N*W +K6*R*N*M:REM Total Gross Production Rate |
| 504 | Rp = K3*R*N*W + K5*R*N*M + K8*W +K16*M +K22*S+K27*S*C |
| 505 | REM Total Respiratory Consumption |
| 506 | PR = Pg/Rp |
| 508 | I = Im + Ir*SIN (.017*t) |
| 510 | R = I/(1+K1*N*W+K2*N*M) |
| 520 | DW = K4*N*R*W-K3*N*R*W-K7*W*H-K10*W*H-K12*W-K8*W |
| 530 | DM = K6*N*R*M-K5*N*R*M-K14*M-K16*M |
| 540 | DN = K9*W+K17*M+K23*S+K28*C+Ja+K29*B-K25*N*R*M-<br>K24*N*R*W- K21*N |
| 550 | DS = K11*H*W+K13*W+K15*M-K27*S*C-K22*S |
| 560 | DB = K18*H*W-K26*B |
| 570 | DC = K31*S*C-K30*C |
| 580 | W = W+DW*DT |
| 590 | M = M+DM*DT |
| 600 | N = N+DN*DT |
| 610 | S = S+DS*DT |

Table C-2 — continued.

| Line | Code |
|---|---|
| 620 | B = B+DB*DT |
| 630 | C = C+DC*DT |
| | |
| 700 | REM Plotting |
| 710 | PSET (t*T0, 90-I*I0) |
| 720 | PSET (t*T0,190-W*W0) |
| 730 | PSET (t*T0,190-M*M0) |
| 740 | PSET (t*T0,90-N*N0) |
| 750 | PSET (t*T0,290-S*S0) |
| 760 | PSET (t*T0,290-B*B0) |
| 770 | PSET (t*T0,410-C*C0) |
| 780 | PSET (t*T0, 330-(PR-1)*Pr0) |
| 800 | t = t + DT |
| 805 | IF t*T0<400 GOTO 500 |

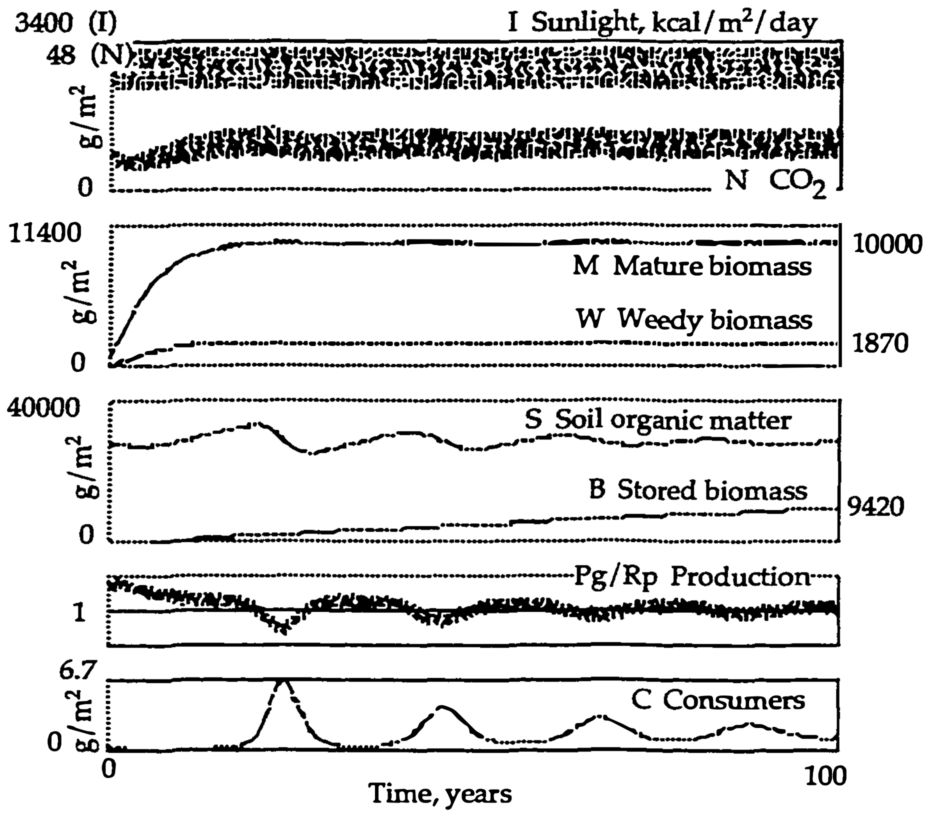



Figure C-1. One-hundred-year simulation of Biosphere 2 rainforest production and biomass minimodel, B2METAB, with light increased 20% over baseline. Final values for plant biomass are on the right side of their graphs. g/m2 = grams per square meter, dry weight for biomass.

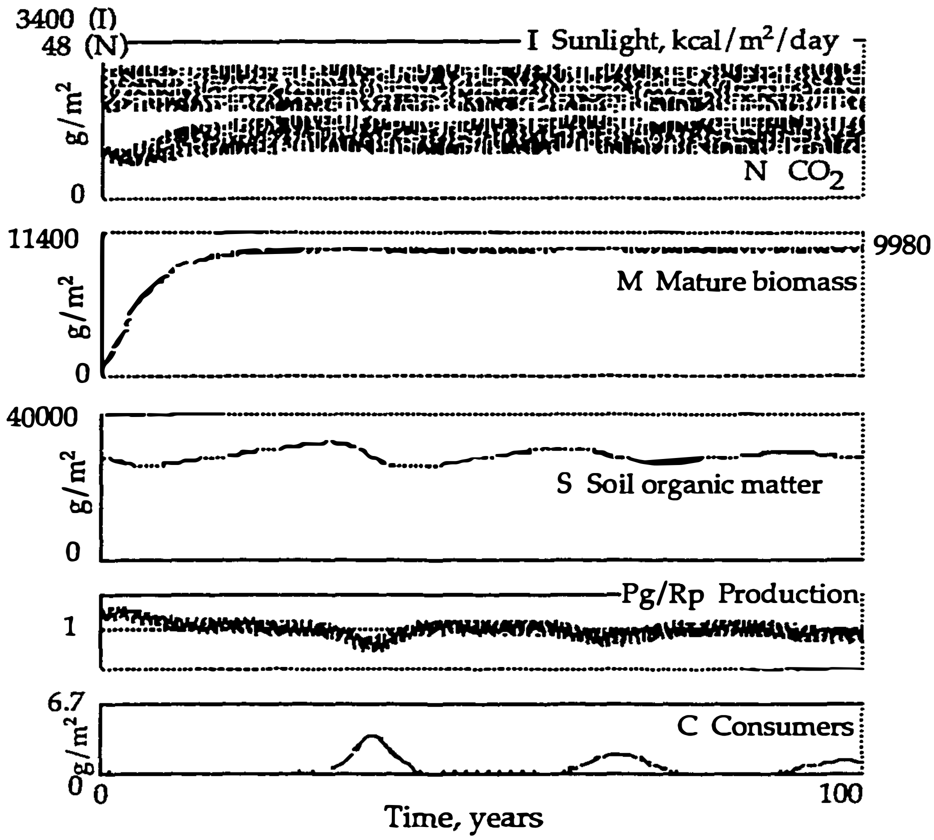



Figure C-2. One-hundred-year simulation of Biosphere 2 rainforest minimodel, B2METAB, with no weedy biomass. Final values for plant biomassare on the right side of their graphs. $g/m^2$ = grams per square meter, dry weight for biomass.

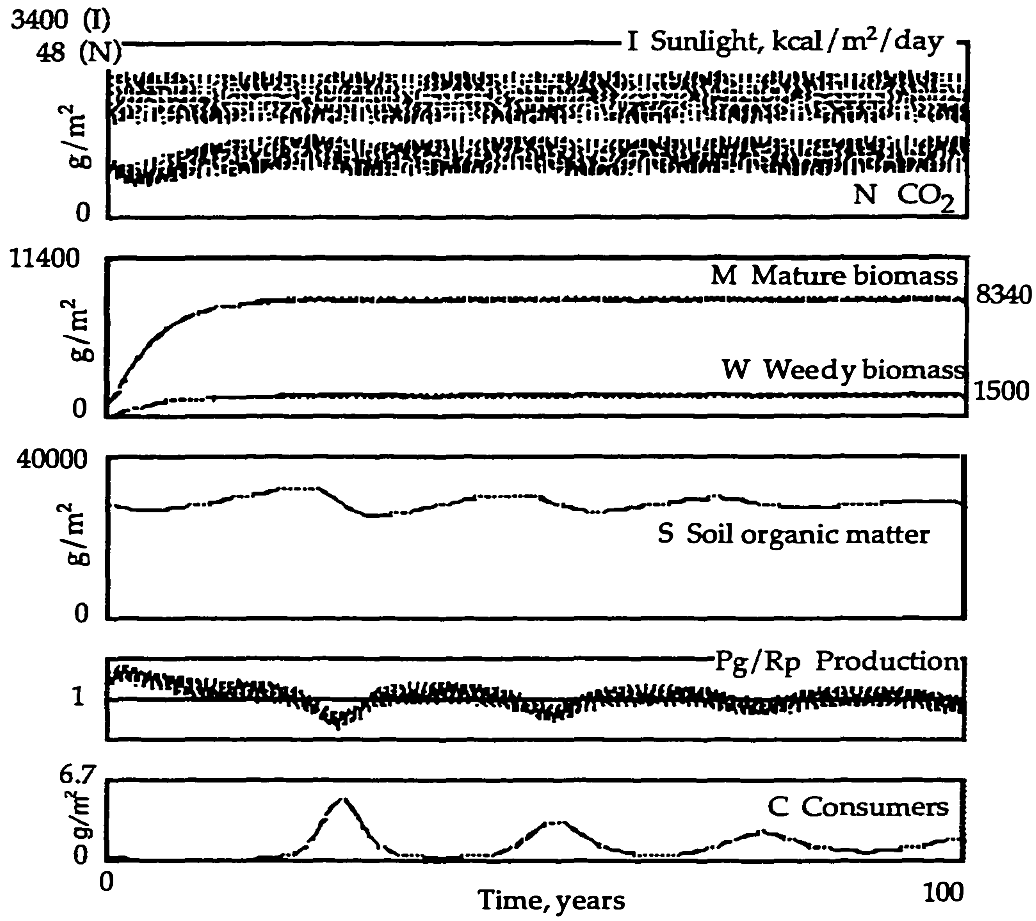



Figure C-3. One-hundred-year simulation of Biosphere 2 rainforest production and biomass minimodel, B2METAB, where all pruned biomass is put onto the soil. Final values for plant biomass are on the right side of their graphs. $g/m^2$ = grams per square meter, dry weight for biomass.

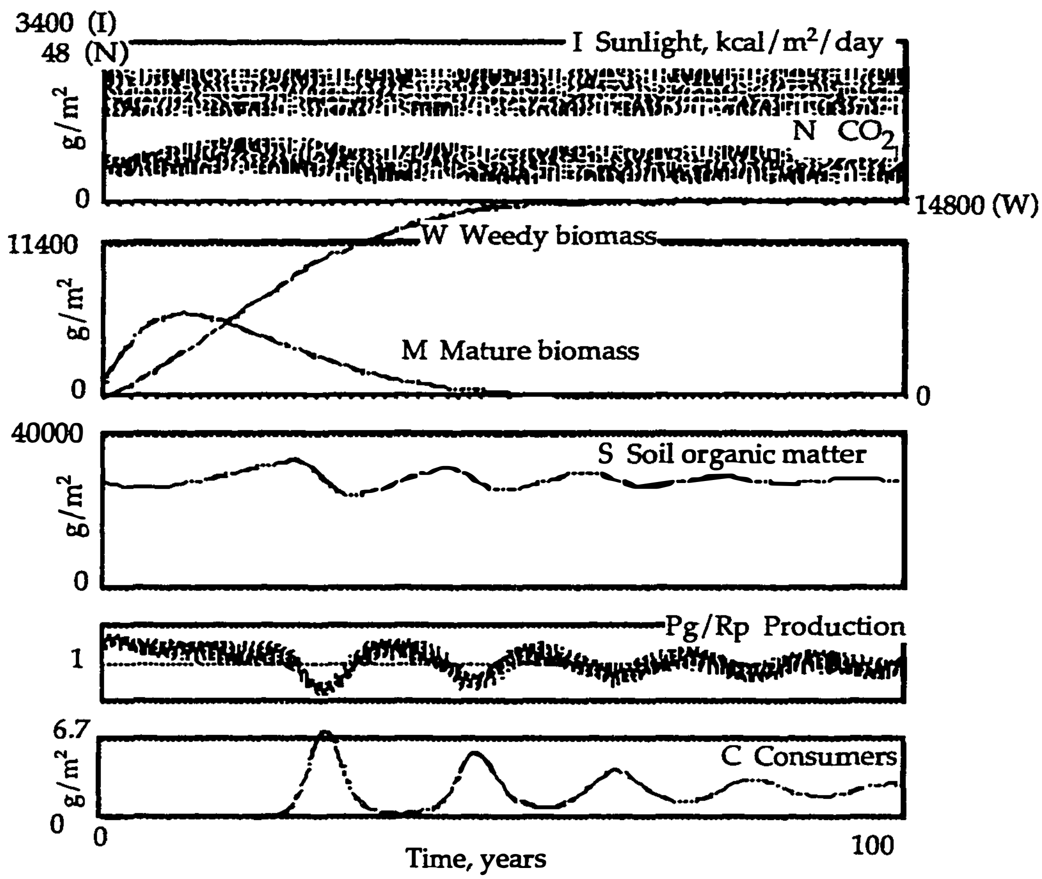



Figure C-4. One-hundred-year simulation of Biosphere 2 production and biomass minimodel, B2METAB, with with no pruning by humans. Final values for plant biomass are on the right side of their graphs. $g/m^2$ = grams per square meter, dry weight for biomass.

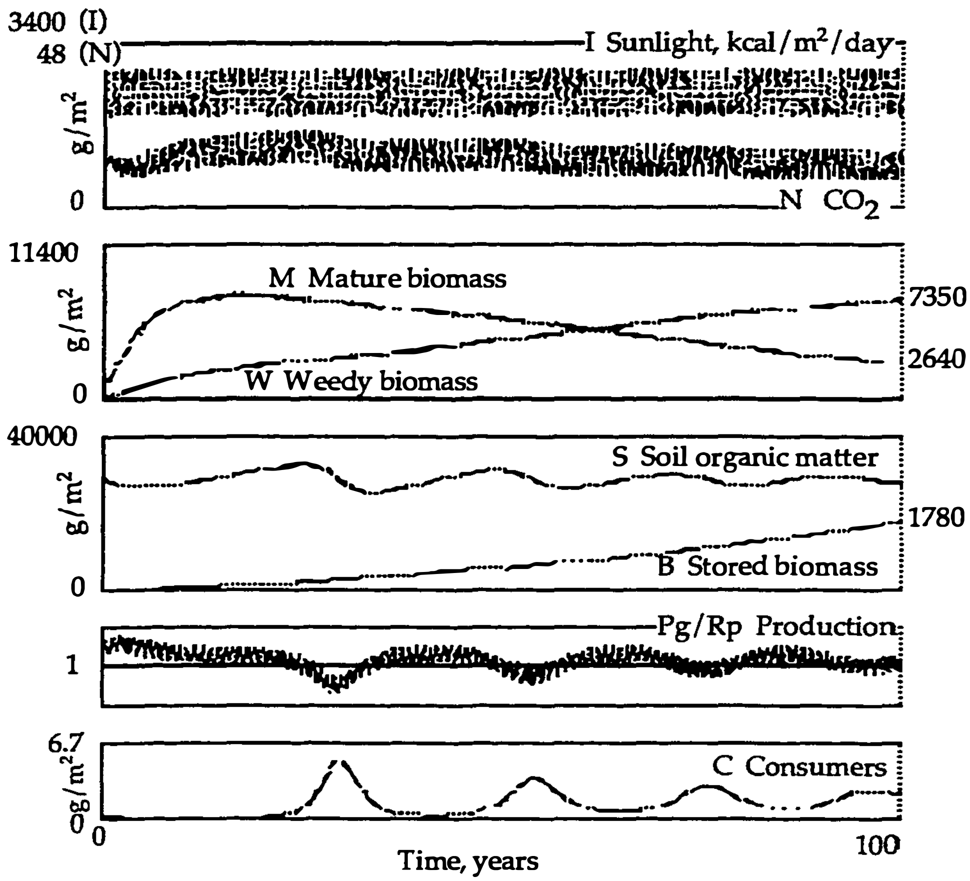



Figure C-5. One-hundred-year simulation of Biosphere 2 rainforest production and biomass minimodel, B2METAB, where human effort is reduced to .75 of baseline. Final values for plant biomass are on the right side of their graphs. $g/m^2$ = grams per square meter, dry weight for biomass.

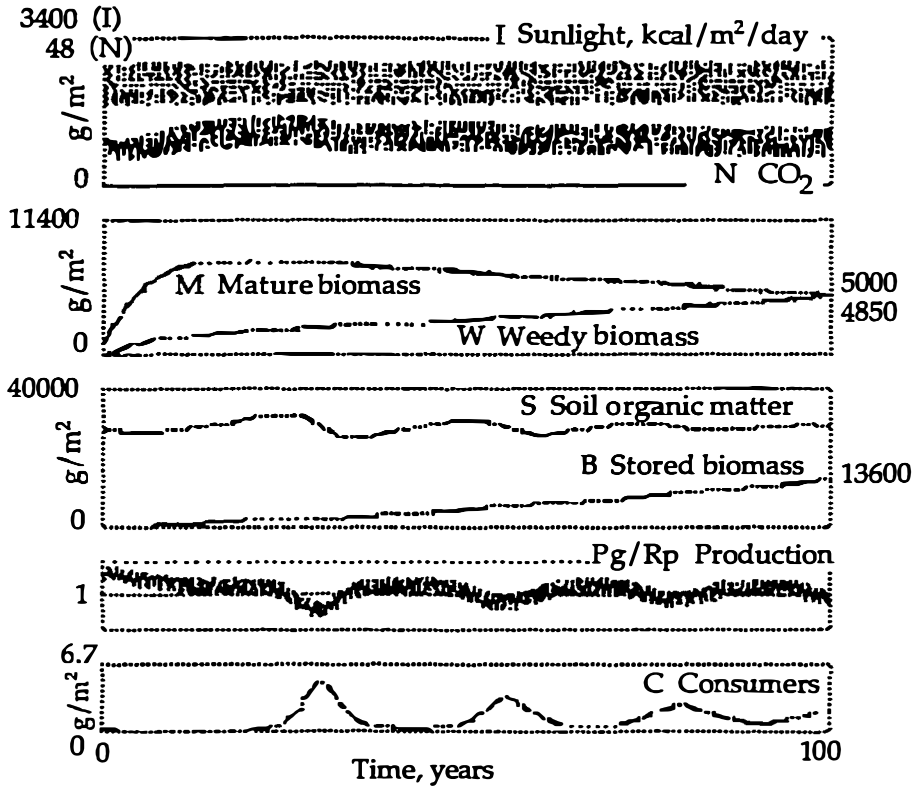



Figure C-6. One-hundred-year simulation of Biosphere 2 rainforest minimodel, B2METAB, where human effort in pruning is reduced to .85 of baseline. Final values for plant biomass are on the right side of their graphs. g/m2 = grams per square meter, dry weight for biomass.

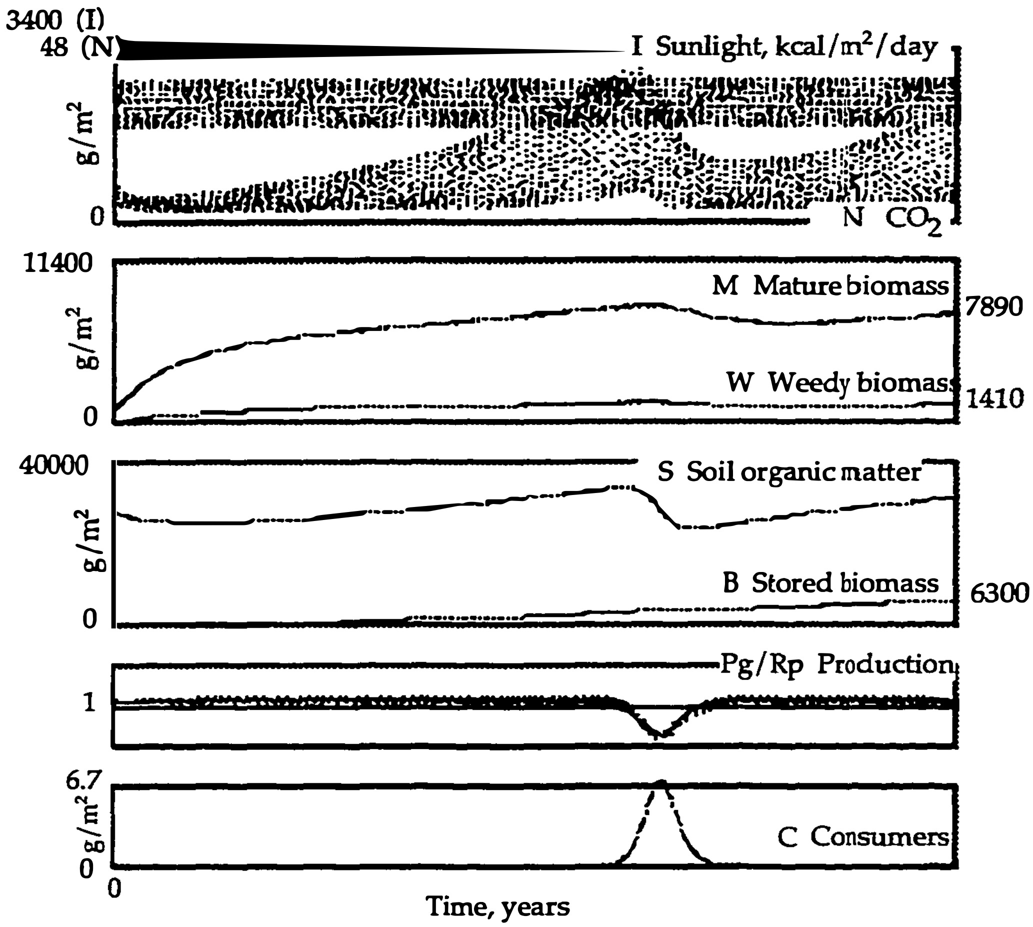



Figure C-7. One-hundred-year simulation of Biosphere 2 rainforest production and biomass minimodel with airflow cut off from the rest of the Biosphere. Final values for plant biomass are on the right side of their graphs.
$g/m^2$ = grams per square meter, dry weight for biomass.

# APPENDIX D
# PRODUCTION AND DIVERSITY MINIMODEL

Table D-1. EXCEL spreadsheet used to calculate coefficients for Biosphere 2 rainforest production and diversity minimodel SPDIV.

Table D-2. Program in QUICKBASIC for the simulation of production and diversity in the Biosphere 2 rainforest, model SPDIV in Figure 3-28.

Figure D-1. Simulation of Biosphere 2 rainforest with continuous additions of 5 and 20 species per year over 10 years. Final values for plant biomass and species are on the right side of their graphs. $g/m^2$=grams of dry biomass per square meter.

Figure D-2. Simulation of Biosphere 2 rainforest with continuous additions of 5 and 20 species per year over 100 years. Final values for plant biomass and species are on the right side of their graphs. $g/m^2$=grams of dry biomass per square meter.

Figure D-3. Simulation of Biosphere 2 rainforest when 50 species are added after the second year. Final velues for plant biomass and species are on the right side of their graphs. $g/m^2$=grams of dry biomass per square meter.

Table D-1. Spreadsheet used to calculate coefficients for Biosphere 2 rainforest diversity and production minimodel, SPDIV.

| Note | Item | Pathway | Value | Units | Coefficient Value |
|---|---|---|---|---|---|
| Sources for calibration: | | | | | |
| Ir | Annual range of insolation | Ir = | 5.00E+02 | kcal m$^{-2}$ d$^{-1}$ | |
| Im | Mean insolation about which sin wave varies | Im = | 2.60E+03 | kcal m$^{-2}$ d$^{-1}$ | |
| R | Unused sunlight | R = | 2.60E+02 | kcal m$^{-2}$ d$^{-1}$ | |
| | | S = | 0 | | |
| Storages for calibration: | | | | | |
| B | Biomass | B = | 10000 | g m$^{-2}$ | |
| E | Established species | E = | 60 | species 1900 m$^{-2}$ | |
| N | Transient species | N = | 300 | species 1900 m$^{-2}$ | |
| 1 | Sunlight to plants with diversity interaction | K1*R*E = | 5.40E+02 | kcal m$^{-2}$ d$^{-1}$ | K1 = 3.46E-02 |
| 2 | Sunlight to plants with biomass feedback | K2*R*B = | 1.80E+03 | kcal m$^{-2}$ d$^{-1}$ | K2 = 6.92E-04 |
| 3 | Gross productivity of plants interacting with diversity | K3*R*E = | 4.00E+00 | gdw m$^{-2}$ d$^{-1}$ | K3 = 2.56E-04 |
| 4 | Biomass feedback to production | K4*R*B = | 2.00E+00 | gdw m$^{-2}$ d$^{-1}$ | K4 = 7.69E-07 |
| 5 | Gross productivity of plants with biomass feedback | K5*R*B = | 8.00E+00 | gdw m$^{-2}$ d$^{-1}$ | K5 = 3.08E-06 |
| 6 | Flow controlling biomass used for information support | K6*E*E = | 1.00E-03 | species | K6 = 2.78E-07 |
| 7 | Return flow of pathway K6*E*E | K7*E*E = | 1.00E-03 | species | K7 = 2.78E-07 |
| 8 | Flow from transient species to interaction with biomass | K8*N*B = | 8.00E-01 | species m$^{-2}$ d$^{-1}$ | K8 = 2.67E-07 |
| 9 | Flow from interaction to established species | K9*B*N = | 8.00E-01 | species m$^{-2}$ d$^{-1}$ | K9 = 2.67E-07 |
| 10 | Transient species extinction | K10*N = | 3.16E-01 | species m$^{-2}$ d$^{-1}$ | K10 = 1.05E-03 |
| 11 | Biomass loss due to system respiration | K11*B = | 8.55E+00 | g m$^{-2}$ d$^{-1}$ | K11 = 8.55E-04 |
| 12 | Energy flow from biomass for support information | K12*B*E*E = | 1.45E+00 | g m$^{-2}$ d$^{-1}$ | K12 = 4.04E-08 |
| 13 | Species extinction from interactions with other species | K13*B*E*E = | 1.03E-03 | species m$^{-2}$ d$^{-1}$ | K13 = 2.85E-11 |
| 14 | Species extinction due to other things | K14*E = | 1.03E-03 | species m$^{-2}$ d$^{-1}$ | K14 = 1.71E-05 |
| 15 | Flow from species source to inside Biosphere 2 | Ja = | 0.00E+00 | species m$^{-2}$ d$^{-1}$ | |

Table D-1 – continued.

| Note | |
|---|---|
| Im | Total average outside insolation for 24 hour period is 5200 kcal $m^{-2}$ $d^{-1}$ for Tucson, Arizona (Romer 1985). One-half (2600 kcal $m^{-2}$ $d^{-1}$) is reflected or absorbed by the glass and steel spaceframe structure of the Biosphere. |
| Ir | The annual range of insolation used is 500 kcal $m^{-2}$ $d^{-1}$ . |
| R | One tenth of the incoming sunlight (260 kcal $m^{-2}$ $d^{-1}$) is estimated as unused by producers, falling on bare ground or other internal structure. |
| S | Species source is the earth, since in the case of plants evolution would probably not have time to occur over the 100 year planned life of Biosphere 2. The first planting to the Biosphere rainforest from external sources was during the year prior to closure, in 1990 – 1991. |
| B | The projected standing aboveground biomass of the Biosphere 2 rainforest after 20 years is 10,000 g $m^{-2}$, based on measured increases in the first 2 years (Bierner 1994). |
| E | There were initially no plants considered to be established. As plants developed connections with the environment and other plants, they were considered established. The sum of established and transient plants at any time would yield a list of all of the species in the Biosphere. |
| N | The initial input of species to Biosphere – approximately 300 – were considered to be transient for purposes of model calibration. |
| 1,2 | Total insolation entering the rainforest is 2600 kcal $m^{-2}$ $d^{-1}$ of which 260 is not used by plants, leaving 2340 kcal $m^{-2}$ $d^{-1}$ for the production process. |
| 3,5 | Gross productivity is set at approximately 1/3 of the measured value of gross productivity of the tabonuco forest at El Verde in Puerto Rico, or 12 grams dry weight per square meter per day. |
| 4,11, 12 | To calibrate the model for steady state, gross productivity and respiration flows were set to be equal. Therefore, the sum of these three pathways equals a loss of 12 grams dry weight per square meter per day for respiration and system maintenance. |

Table D-1 – continued.

| Note | |
|---|---|
| 6, 7 | Flow 6 controls the amount of biomass used for the maintenance of information of species in the system, with flow 7 returning to the species diversity tank. Since there is no increase of species information through evolution on the time scale represented, the 2 flow are set equal to each other. |
| 8, 10 | The initial value of transient species at closure in 1991 was 300 species per 1900 square meters of rainforest. To estimate the losses due to extinction and losses due to establishment, a value of species lost per square meter per day was calculated ((300 species)/(1900 $m^{-2}$)/(365 days)/(20 years), and the result divided between the 2 pathways from the transient species tank. Changes were made in the orders of magnitude of these values to obtain a model that would duplicate the first period of measurement of the system. |
| 9 | The flow on this pathway is the same as that of 8. |
| 13, 14 | The flows for extinction of established species were set so that the model would duplicate the first period of measurement of the system. |
| 15 | The flow from the species source and consisted of approximately 300 species, which is the number used to calibrate the minimodel. The system was materially closed to new species during 1991-1993. |

Table D-2. Program in BASIC for the simulation of production and diversity in the Biosphere 2 rainforest, Model SPDIV in Figure 3-25.

| Line | Code |
|---|---|
| 10 | REM SPDIV – 2 May 1999 |
| 11 | REM Species diversity decline in Biosphere 2 |
| 12 | REM Set for 25 years' run |
| 13 | REM started with high transient species, low established plants |
| 15 | LINE (0,5) - (360,80),,B |
| 15 | LINE (0,100) - (360,180),,B |
| 15 | LINE (0,200) - (360,300),,B |
| | |
| 44 | REM Outside Sources |
| 45 | Im = 2600!:REM mean insolation about which sine wave varies |
| 46 | Ir = 500:REM annual range of insolation |
| 47 | S = 1 |
| 48 | Ja = 0 |
| | |
| 50 | REM Initial Storages |
| 55 | B = 1000 : REM Starting biomass |
| 60 | N = 300: REM Starting transient species diversity |
| 70 | E = 10: REM Established species at start |
| 80 | C = 30: REM Carrying capacity for species in system |
| 90 | X = 1 |
| | |
| 100 | REM Coefficients |
| 110 | K1 = .0346 |
| 120 | K2 = .000692 |
| 130 | K3 = .000256 |
| 140 | K4 = 7.69E-07 |
| 150 | K5 = 3.08E-06 |
| 160 | K6 = 2.78E-07 |
| 170 | K7 = 2.78E-07 |
| 180 | K8 = 2.67E-07:REM calibrated for N = 300 |
| 190 | K9 = 2.67E-07:REM same as K8 |
| 200 | K10 = .00105 |
| 210 | K11 = .000855 |
| 220 | K12 = 4.04E-08 |
| 230 | K13 = 2.85E-11 |
| 240 | K14 = .0000171 |
| 400 | REM Scaling Factors |
| 410 | T0 = .04: REM When T0 = .1, 3650 days = 10 years |
| 420 | DT = 10 |
| 430 | B0 = .01 |
| 440 | N0 = .2 |
| 450 | E0 = .2 |
| 460 | I0 = .02 |

Table D-2 — continued.

| Line | Code |
|---|---|
| 500 | REM Equations |
| 508 | I = Im + Ir*SIN (.017*T) |
| 510 | R = I/(1+K1*E*+K2*B) |
| 520 | DB = K3*E*R +K5*B*R -K4*B*R -K11*B-K12*E*E*B |
| 530 | DN = Ja-K10*N-K8*N*B |
| 540 | DE = K9*N*B-K14*X*E-K13*X*B*E*E:REM K6 = 0 |
| 551 | IF E>C THEN X=1 |
| 552 | IF E<C THEN X=0 |
| 580 | B = B +DB*DT |
| 590 | N = N +DN*DT |
| 595 | IF N < 0 THEN N = 0 |
| 600 | E = E +DE*DT |
| | |
| 700 | REM Plotting |
| 710 | PSET (T*T0, 80-I*I0) |
| 720 | PSET (T*T0,180-B*B0) |
| 730 | PSET (T*T0,300-N*N0) |
| 740 | PSET (T*T0,300-E*E0) |
| 800 | T = T + DT |
| 805 | IF T*T0<360 GOTO 500 |

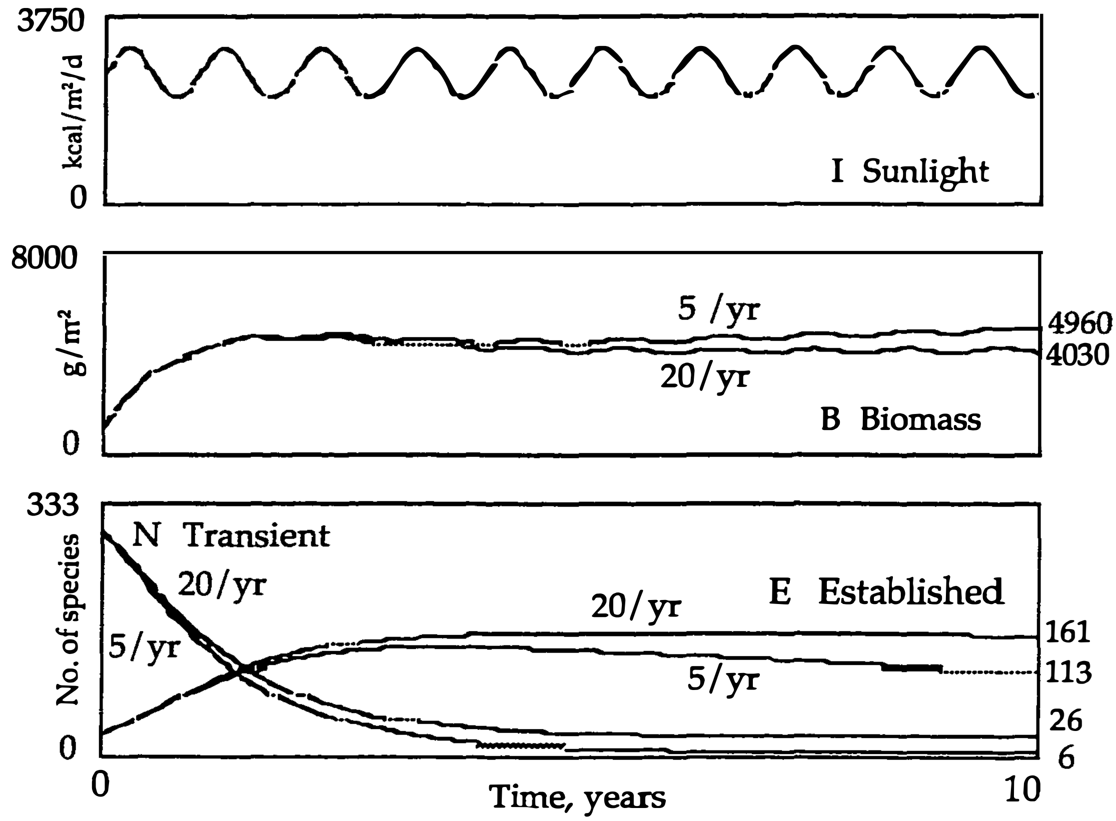



Figure D-1. Simulation of Biosphere 2 rainforest with continuous additions of 5 and 20 species per year over 10 years. Final values for plant biomass and species are on the right sides of their graphs. $g/m^2$ = grams of dry biomass per square meter.

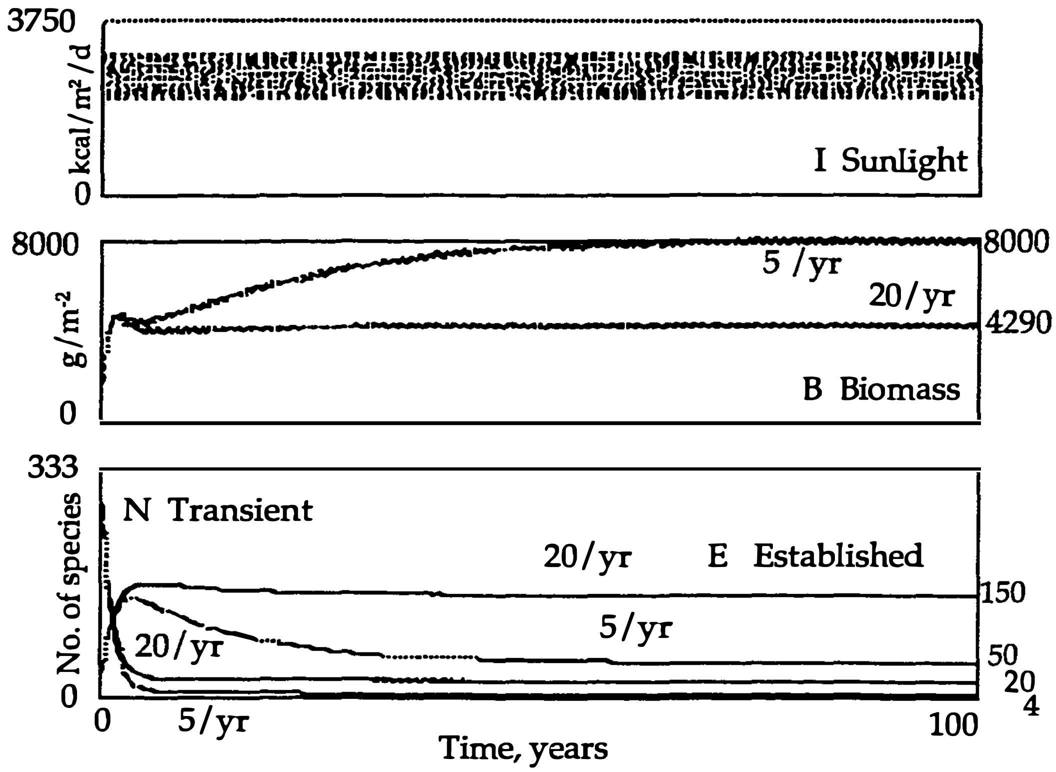



Figure D-2. Simulation of Biosphere 2 rainforest with continuous additions of 5 and 20 species per year over 100 years. Final values for plant biomass and species are on the right sides of their graphs. $g/m^2$ = grams of dry biomass per square meter.

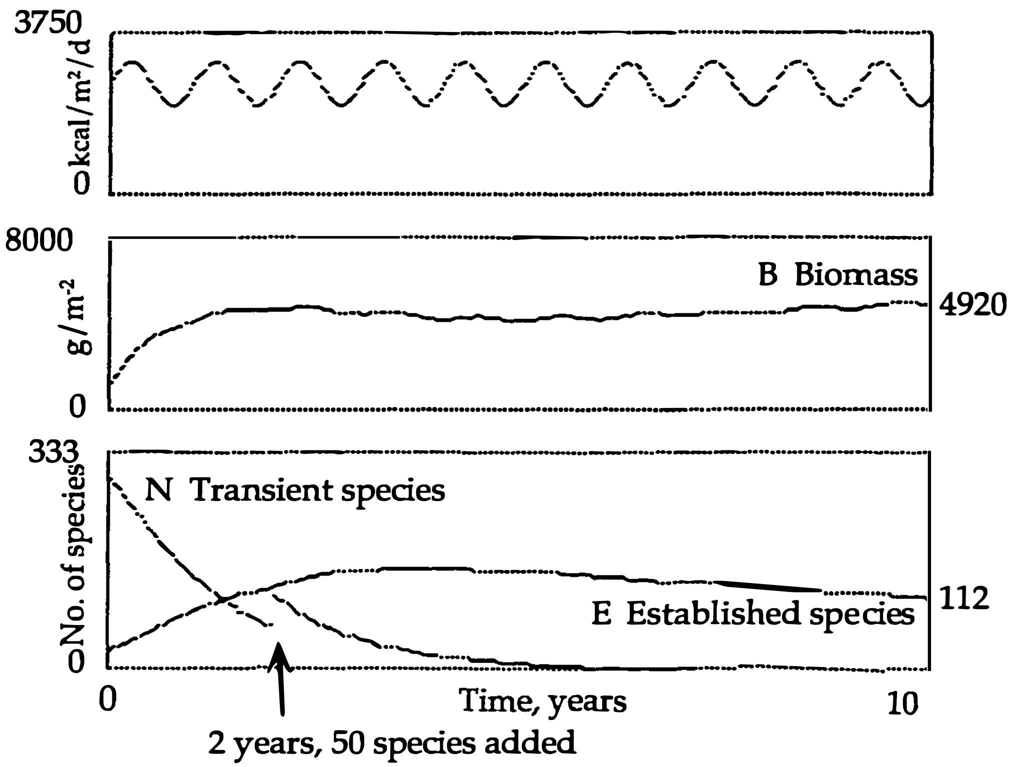



Figure D-3. Simulation of Biosphere 2 rainforest when 50 species are added after the second year. Final values for plant biomass and species are on the right side of their graphs. $g/m^2$ = grams of dry biomass per square meter.

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# BIOGRAPHICAL SKETCH

Linda Leigh grew up in Racine, Wisconsin. She attended the University of Wisconsin in Madison, where she studied botany, and The Evergreen State College from which she earned a bachelor of science degree in ecology and field botany. She studied range management at the University of Arizona, at the same time studying the productivity of Sonoran Desert legume trees and their potential as agricultural crops.

Linda's work with the 1.25 hectare mesocosm called Biosphere 2 began during the design phase in 1985. She coordinated the design teams for the rainforest, savannah, and desert ecosystems; lived for 3 weeks under material closure in the experimental model called the Test Module; and was one of the original Biospherians who lived for 2 years under material closure inside Biosphere 2, from 1991 to 1993. Linda's home is Tucson, Arizona, where she works with the Drylands Institute.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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