**Legend:**

**Profile Diagram of a Tropical Rainforest Site at Blue Creek, Southern Belize**
(site of Jason V Canopy Research Walkway), 40mX5m transect.

Numbers indicate percent (%) leaf area eaten by herbivores.

Species include: A – Anthurium, Ac – Acacia (Bullhorn acacia), Ag – Ant garden, An – Andira, And – Androlepis skinneri (Bromeliad), As – Astrocaryum mexicanum, A1 – Asplenium, B – Bachtris, Bf – Bernouvillia Flammea (Mapola), C – Clusia, Ca – Calophyllum, Ch – Chryosophila argentea, C1 – Clavija, D-Dialium guinensis, E-Eugenia, En – Entada, I – Inga, L – Lonchocarpus, Le – Legume, O – Orybignya (Cohune Palm), Pd – Pimenta dioecia, Ph – Philodendron, Pm – Pseudolmedia, Ps – Psychotria (wild coffee), lPt – Puteria torta, P – Pterocarpus, R – Rinorea, S – Sebastiana (Poinsonwood), S1 – Sloanea, Ta – Terminalia amazonica

# JASON V: ECOLOGY OF THE RAIN FOREST CANOPY IN BELIZE

Meg Lowman, Robin Foster, and Nathan Erwin - Scientists for Jason V, 1994

**Summary**

The Jason V expedition into the Rain Forest Canopy of Belize undertook to examine three aspects of canopy biology:

1. the biodiversity of plants at the Blue Creek Preserve in Belize
2. the grazing of foliage by insect herbivores (herbivory, leaf mining and galls), and
3. insect diversity and abundance in rain forests canopies of Belize.

Results of these components of the field study are summarized below.

**Introduction**

The rain forest canopy represents one of the last unstudied biological frontiers on the planet. In addition, this region of forest ecosystems is extremely important to life on Earth as we know it. The forest canopy contains the bulk of photosynthetic material, responsible for the oxygen/carbon dioxide exchange in our atmosphere; and the canopy reputedly contains over 75% of the organisms inhabiting the Earth, many of which are invertebrates. In addition, economically and ecologically important products and interactions, respectively, exist in the canopy.

To illustrate the importance of canopy biology to students in elementary and high schools throughout the US, Canada, Belize, Bermuda and UK, Jason V broadcast live segments of interactive telecommunication to "bring" students into the rain forest canopy.

Although the results of the canopy research will not be completed for several years, these preliminary summaries illustrate the complexity of life in these upper regions of the rain forest.

## General Methods

The canopy was accessed using two major techniques. A platform and suspension bridge systems was constructed to facilitate constant access to different horizontal regions of the canopy between 75 and 125 feet (Fig 1). And ropes, harnesses, and Bosun's chair were used collectively to give access to vertical transects through the canopy. Biologists and students assistants wore safety gear (harnesses and helmets), and carried field equipment into the canopy to conduct measurements of different aspects of plant-insect interactions in tree crowns (Fig. 2). Collecting devices, notebooks, and other field instruments comprised the gear utilized in these studies.

Prior to Jason, a botanical survey was conducted by two of us (ML, RF). A profile diagram was constructed to illustrate the structure and diversity of the vegetation at the walkway site (Fig. 3). In addition, a list of the plants in the profile were tabulated (Table 1). In total, over 350 plants were surveyed at the Blue Creek site, with over 25 species growing in close proximity to the walkway structure. This provided unprecedented access to representative tree canopies typical of moist subtropical rain forest in southern Belize.

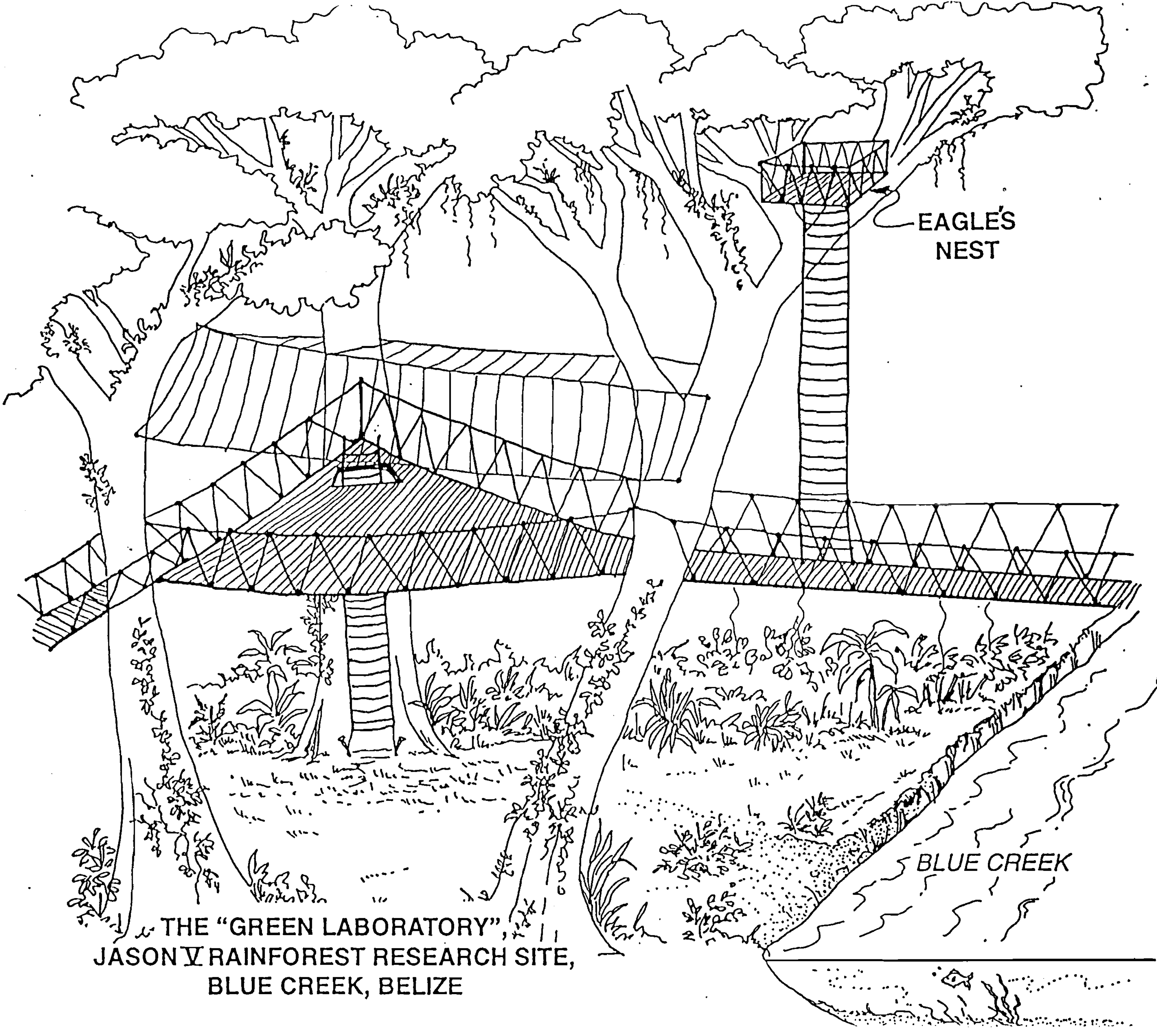


Figure 1. Schematic diagram of walkway at Blue Cree, Belize.

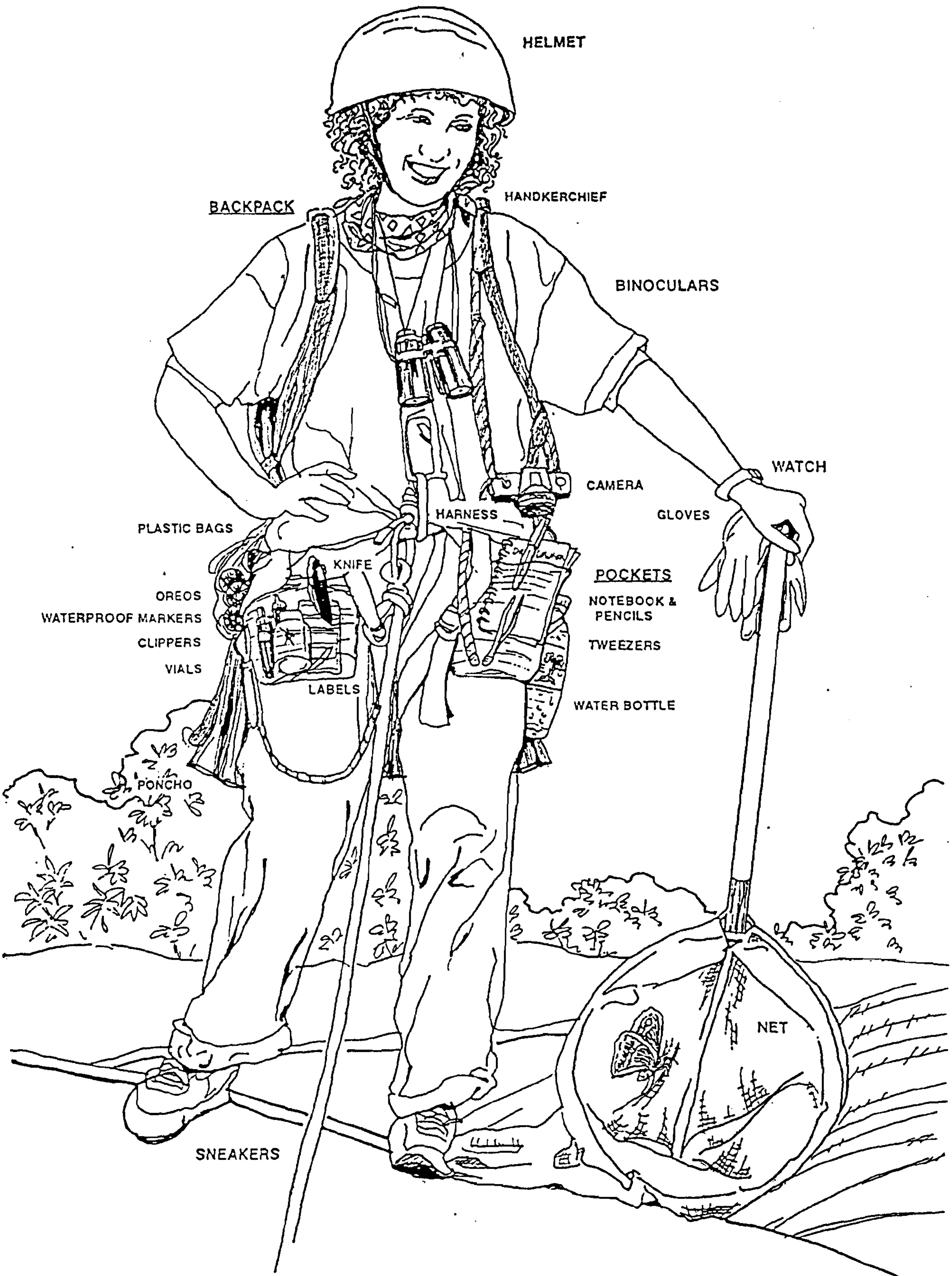


Figure 2 WHAT DO BIOLOGISTS TAKE INTO THE CANOPY? Field equipment required for a canopy biologist.


Figure 3. PROFILE DIAGRAM OF BLUE CREEK RAINFOREST, BELILZE (JASON V 1994)

Table 1. Plant List associated with Figure 3.

# Profile Diagram of a Tropical Rainforest Site at Blue Creek, Southern Belize (site of Jason V canopy research walkway), 40mX5m transect.

Species include:

| | |
|---|---|
| A | Anthurium |
| Ac | Acacia (Bullhorn acacia) |
| Ag | Ant garden |
| An | Andira |
| And | Androlepis skinneri (Bromeliad) |
| As | Astrocaryum mexicanum |
| As | Asplenium |
| B | Bachtris |
| B | Bernouvillia Flammea (Mapola) |
| C | Clusia |
| Ca | Calophyllum |
| Ch | Chryosophila argentea |
| Cl | Clavija |
| D | Dialium guinensis |
| E | Eugenia |
| En | Entada |
| I | Inga |
| L | Lonchocarpus |
| Le | Legume |
| O | Orybignya (Cohune Palm) |
| Pd | Pimenta dioecia |
| Ph | Philodendron |
| Pm | Pseudolmedia |
| Ps | Psychotria (wild coffee) |
| Pt | Pouteria torta |
| Pt | Pterocarpus |
| R | Rinorea |
| S | Sebastiana (Poisonwood) |
| Sl | Sloanea |
| Ta | Terminalia amazonica |

**Methods associated with Specific Studies**

**1. Biodiversity**

Three plots measuring 5 m x 5 m were sectioned off underneath the walkway region, and the abundance and of plants were tabulated. In each plot, the following groups of plants were quantified: trees, understory trees, palms, saplings, seedlings, ferns, lycopods, epiphytes, vines, and mosses-lichens. Numbers of individuals were counted (comprising abundance), and numbers of different species (diversity) were estimated according to obvious differences in morphology.

**2. Insect Grazing of Foliage by Insects**

Three types of leaf damage were measured throughout the tree canopies: herbivory by foliage chewers; leaf mining; and galls. For each sample collected, approximately 20 leaves were harvested randomly from one region of the crown. Samples were taken with respect to height, tree species, light condition, and age of leaves (young and unfolding = 1, young but unfolded = 2, middle aged = 3, old = 4). In most cases, leaf samples were collected from low and high regions of the tree crown, and from different age classes and light regimes wherever possible.

Herbivory was measured with a Li-Cor area meter (Model 2000), whereby both hole areas and total leaf area remaining were calculated. In addition, length and width were measured. Mining was calculated by drawing regions of miner tunnels on clear acetate sheets and measuring these portions in the area meter. Galls were tallied by eye. No other types of leaf damage were observed in the canopy during this survey.

Toughness was assessed using a penetrometer (see Curriculum, and also Lowman 1983), and repeated three times on at least three leaves per sample. In total, 21 canopy species were sampled during the period of Jason V, representing 600 leaves. Results were analyzed using Microsoft Access and Statistix software to calculate descriptive statistics and analyses of variance among samples.

**3. Insect diversity and abundance**

Insects were sampled both high and low in the canopy using a variety of techniques. Malaise traps were used to collect flying insects, with one trap situated at 25 m height in a Bernoullia flammea canopy, and one situated on the forest floor below. Replicate beating trays were also conducted, in pairs of low and high within different regions of the walkway. Foliage was shaken for 10 seconds, and all insects falling onto the 1 m2 cloth were tallied. This method selects for foliage insects, including Coleoptera, Collembola, Hemiptera, spiders, some Hymenoptera (ants), and larvae of other orders. And third, sweep netting was also conducted in pairs, with low and high samples of 10 sweeps each were collected. Nets tend to collect both flying and foliage insects, especially Diptera, Lepidoptera, and similar groups to the beating trays.

Because no single sampling technique alone estimated insect diversity and abundance, these different sampling methods were used collectively to examine the insect life at Blue Creek.

## Results

### 1. Biodiversity

The abundance of plants in the 5 x 5 m plots ranged from 348 to 1128, with an average of 701 individuals (Table 2). Estimated species ranged from 95 to 157, with a mean of 127. This may be a slight overestimate, since seedlings of different ages may have looked different but in actuality represent the same species. (The students conducting this work were not seedling taxonomists.)

The relative abundance and diversity of plants at the Blue Creek site is high, especially when compared to diversity in temperate ecosystems. For example, the species diversity was 6 for a forest in Toronto, Canada, and as high as 30 in California. In contrast, the abundance of plants for temperate sites ranged as high as 1799 (in California) when blades of grass and individual herbs were counted separately. (See Jason Results Curriculum, published by National Geographic). The problems of how and what to count in a biodiversity survey still represent a big challenge for field biologists, and the protocols are still intensely debated throughout scientific circles.

### 2. Grazing levels in the Rain Forest Canopy

Levels of defoliation were extremely variable among species, ranging from as little as 0% (expressed as percentage of leaf area eaten by herbivores) for two bromeliads (Aechmea and Androlepis skinneri) and as high as 35.6% for one section of Terminalia

Table 2.
# BIODIVERSITY AT BLUE CREEK, BELIZE

| PLANTS | PLOT #1 | | PLOT #2 | | PLOT #3 | |
|---|---|---|---|---|---|---|
| | 1* | 2* | 1* | 2* | 1* | 2* |
| TREES | 2 | 2 | 2 | 2 | 1 | 1 |
| UNDERSTORY TREES | 4 | 3 | 15 | 9 | 4 | 4 |
| PALMS | 4 | 2 | 3 | 2 | 9 | 3 |
| SAPLINGS | 39 | 20 | 49 | 25 | 26 | 20 |
| SEEDLINGS | 197 | 81 | 736 | 90 | 364 | 51 |
| FERNS | 10 | 4 | 9 | 3 | 0 | 0 |
| LYCOPODS | 41 | 1 | 273 | 2 | 216 | 1 |
| EPIPHYTES | 44 | 12 | 24 | 12 | 9 | 8 |
| VINES | 0 | 0 | 6 | 3 | 2 | 2 |
| MOSSES | 60%<br>30% | 2(rock)<br>(trunks) | 20%<br>30% | 3(ground)<br>(trunks) | 30% | 1 |
| LICHENS | 5 %<br>60% | 3(rock)<br>(trunks) | 5 %<br>5 % | 6(ground)<br>(trunks) | 10% | 4 |
| TOTALS | 348 | 130 | 1128 | 157 | 626 | 95 |

1*=Abundance
2*=Species Diversity

amazonica (Table 3). Sebastiana sp. (commonly known as poisonwood) had relatively low levels of consumption, averaging 2.1% in the leaves growing in shady conditions, and 0.5% in leaves growing in the sun. The overall mean defoliation level throughout the entire canopy was7 0%. In general, epiphytes had very low levels of herbivory (<1%), whereas trees had higher levels (12%). Further measurements are necessary to corroborate this observation.

In general, leaves higher up in the canopy had lower levels of leaf area loss than leaves in the understory. Herbivory was not significantly different among different aspects of one tree (e.g. the mapola or flame tree, Bernoullia flammea) (Fig. 4), but it was significantly different between sun and shade, and between young and old leaves.

Herbivory throughout the walkway site was illustrated on the profile diagram to depict the patchiness of levels of grazing throughout the canopy region (Fig. 5). There are no distinct differences with respect to height or light, but rather between species. Within an individual species, herbivory tended to be higher for shaded young leaves than older sun leaves. More samples in this site are required to confirm these trends.

Leaf mining levels were lower than amounts of leaf surface area destroyed by direct consumption or herbivory (Table 4). The highest mining damage was 1.23% for Terminalia leaves at 32 m in the sun region of the canopy, but most samples were less than 1%. Mining was not measured for all samples throughout the Jason project, but averaged <1% for those six species surveyed.

**3. Insect diversity and abundance**

Table 3

# Jason V: Belize

## Herbivory: genus by height by light

*18-May-94*

| Genus Description | Height | Light | Percent defoliated |
|---|---|---|---|
| Aechmea | 15 | shade | 0.00 |
| Androlepis | 10 | shade | 0.00 |
| Anthurium | 10 | shade | 16.33 |
| Bernoullia | 25 | sun | 4.55 |
| Bernoullia | 29 | sun | 3.67 |
| Bernoullia | 30 | sun | 3.64 |
| Bernoullia | 32 | sun | 3.92 |
| Calophyllum | 22 | sun | 6.10 |
| Calophyllum | 28 | sun | 6.73 |
| Calophyllum | 33 | sun | 3.58 |
| Chrysopetalum | 4 | shade | 5.87 |
| Clavija | 2 | shade | 6.60 |
| Clusia | 12 | shade | 0.65 |
| Dracena | 5 | sun | 0.56 |
| Grias | 10 | shade | 3.96 |
| Inga | 2 | shade | 8.29 |

| Genus Description | Height | Light | Percent defoliated |
|---|---|---|---|
| Lonchocarpus | 27 | shade | 0.75 |
| Orbignya | 2 | shade | 0.57 |
| Pachira | 20 | sun | 11.29 |
| Poisonwood | 15 | shade | 0.42 |
| Psychotria | 2 | shade | 10.84 |
| Pterocarpus | 15 | shade | 18.63 |
| Randia | 2 | shade | 15.16 |
| Rondoletia | 4 | shade | 11.18 |
| Sebastiana | 20 | shade | 2.17 |
| Sebastiana | 25 | sun | 0.51 |
| Sloanea | 2 | shade | 5.82 |
| Terminalia | 18 | shade | 5.32 |
| Terminalia | 27 | shade | 6.37 |
| Terminalia | 30 | sun | 35.64 |
| Terminalia | 32 | sun | 15.63 |

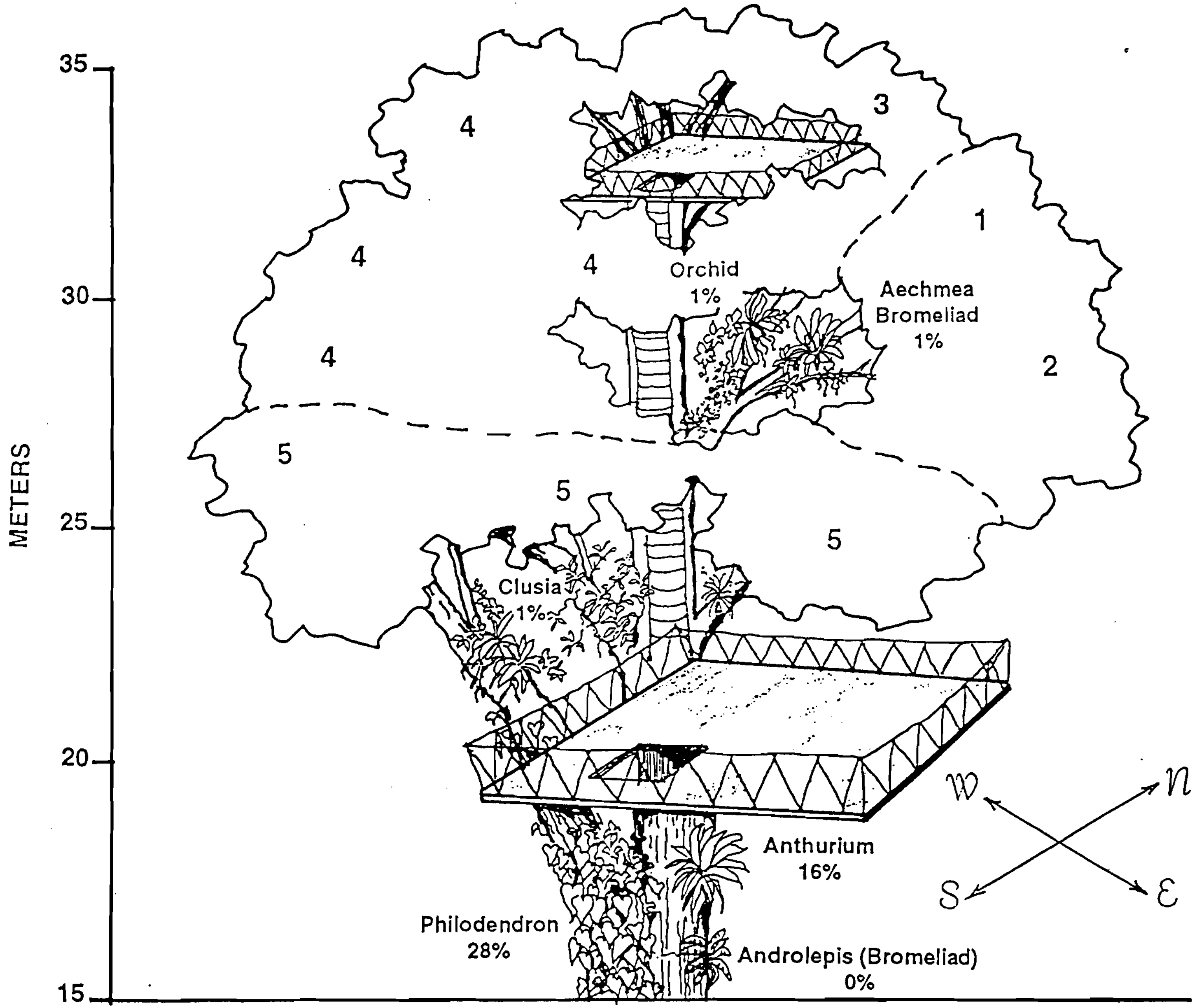


Figure 4. HERBIVORY IN THE CANOPY OF A MAPOLA TREE
(*Bernoullia fiammea*)
BLUE CREEK, BELIZE


Figure 5. HERBIVORY IN THE CANOPY OF BLUE CREEK RAINFOREST, BELIZE (JASON V 1994)

The insect data show that more organisms congregated in the lower canopy and forest floor region than in the tree crowns (Table 4). In addition, the beating trays were the most effective technique for collecting both abundance and diversity of insect life. More insect analyses will be forthcoming, but the identifications require more time to complete.

## Discussion

The two week duration of Jason V was much too short to produce definitive results of plant-insect interactions in this rain forest canopy. It is obvious, however, from this rapid "snap-shot" survey, that the impact of herbivores in the canopy is extremely variable and that the insect life in the tree crowns is very patchy. Further surveys - over different seasons, years and throughout different canopy regions - are needed. Specific topics of interest would include: differences in herbivory between tree foliage and epiphytes; herbivory levels between different levels of individual tree crowns; distribution of insect herbivores in relation to the tastiest leaves (young, shade leaves); and further surveys of leaf miners, which do not appear to be significant at this site.

In general, although the rain forest canopy appears to be a region of vast green homogeneous food for herbivores, this is not the case. There is a wide range of different foliage available, all having different susceptibilities to insect consumption (Fig. 6). More samples are required to further classify the leaf material preferred by different groups of

Table 4

# Jason V: Belize

## Mining: genus by height by light

*09-May-94*

| Genus Description | Height | Light | Percent mined |
|---|---|---|---|
| Anthurium | 10 | shade | 0.00 |
| Calophyllum | 22 | sun | 0.00 |
| Calophyllum | 28 | sun | 0.04 |
| Calophyllum | 33 | sun | 0.25 |
| Lonchocarpus | 27 | shade | 0.89 |
| Poisonwood | 15 | shade | 0.00 |
| Sebastiana | 20 | shade | 0.07 |
| Sebastiana | 25 | sun | 0.47 |
| Sloanea | 2 | shade | 0.27 |
| Terminalia | 18 | shade | 0.30 |
| Terminalia | 27 | shade | 0.12 |
| Terminalia | 27 | sun | 0.68 |
| Terminalia | 30 | sun | 0.90 |
| Terminalia | 32 | sun | 1.23 |

Table 5

# MALAISE TRAPPING IN BLUE CREEK, BELIZE

| | DAY | | NIGHT | |
|---|---|---|---|---|
| | GROUND | CANOPY | GROUND | CANOPY |
| DAY 1 | 0 | 0 | 72 | 28 |
| DAY 2 | 17 | 18 | 97 | 17 |
| DAY 3 | 7 | 31 | 56 | 10 |
| DAY 4 | 419 | 45 | 97 | 40 |
| TOTALS | 443 | 94 | 322 | 95 |

**GROUND > CANOPY**

insect grazers, and to understand the important process of herbivory within the rain forest canopy.

## REFERENCES

Lowman, M.D. and J. D. Box 1983. Variation in leaf toughness and phenolic content among 5 species of Australian rain forest trees. Austr. J. Ecol. 8: 17-25/

Jason Curriculum - Jason V. 1993. National Science Teachers Association, Washington DC.

Results From Jason V, Curriculum Supplement. 1994. National Geographic Publ.

Standley, P.C. and S.J. Record. 1936. The Forests and Flora of British Honduras. Field Museum of Natural History Publ 350, Chicago IL.

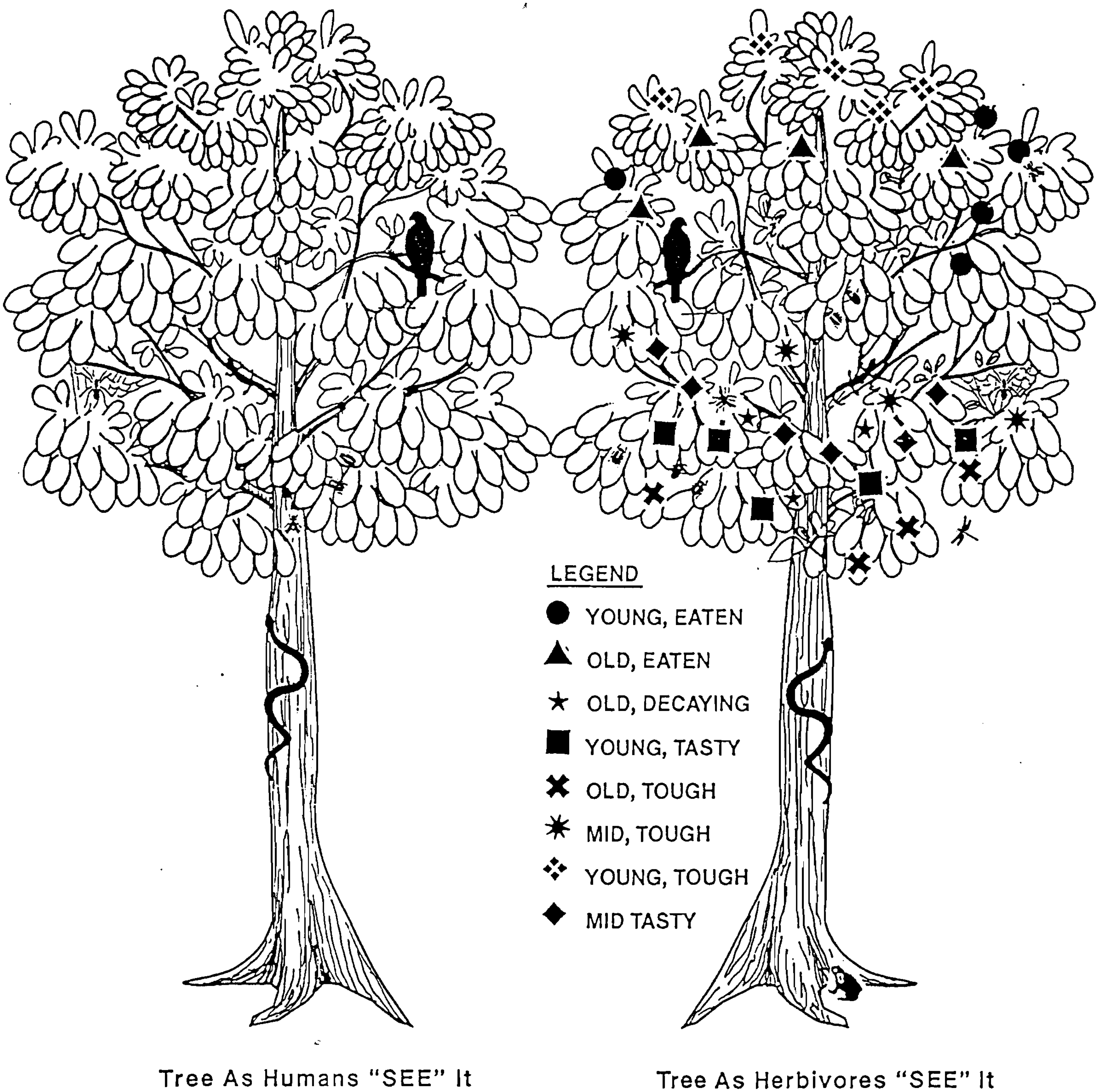


Figure 6. THE WORLD IS GREEN
(Or Is It?)

# Profile Diagram of a Tropical Rainforest Site at Blue Creek, Southern Belize
(site of Jason V canopy research walkway), 40mX5m transect.

<u>Species include:</u>

| | |
|---|---|
| A | Anthurium |
| Ac | Acacia (Bullhorn acacia) |
| Ag | Ant garden |
| An | Andira |
| And | Androlepis skinneri (Bromeliad) |
| As | Astrocaryum mexicanum |
| Al | Asplenium |
| B | Bachtris |
| Bf | Bernouvillia Flammea (Mapola) |
| C | Clusia |
| Ca | Calophyllum |
| Ch | Chryosophila argentea |
| Cl | Clavija |
| D | Dialium guinensis |
| E | Eugenia |
| En | Entada |
| I | Inga |
| L | Lonchocarpus |
| Le | Legume |
| O | Orybignya (Cohune Palm) |
| Pd | Pimenta dioecia |
| Ph | Philodendron |
| Pm | Pseudolmedia |
| Ps | Psychotria (wild coffee) |
| Pt | Pouteria torta |
| P | Pterocarpus |
| R | Rinorea |
| S | Sebastiana (Poisonwood) |
| Sl | Sloanea |
| Ta | Terminalia amazonica |