2. METHODS

2.1. The Study Area

The present study was conducted in the Raleighvallen-Voltzberg Nature Reserve, a protected area of 56,000 ha that was established in 1961 and is currently managed by STINASU; the Surinam Nature Conservation Foundation. It is located on the east bank of the Coppename River in central Surinam (fig. 5) and is bordered on the north by the Kwama Creek and on the south by the Tanjimama Creek (fig. 14). It includes Raleighvallen, the boulder-strewn rapids and falls (fig. 15) that mark the limit of navigability of the Coppename River, and several granitic 'inselbergs', most notably the 240 m dome-shaped Voltzberg (fig. 16) and the Van Stockumberg. The headquarters of the Raleighvallen-Voltzberg Nature Reserve are on Foengoe Island, which is situated at the lower end of the Raleighvallen rapids. The island can be reached by plane or by boat. A three-hour trip by car followed by a three to five-hour trip by motorized dugout-canoe brings a visitor to Foengoe, situated about six kilometers from the Voltzberg. It has restricted facilities for tourists and researchers and it served as a main base during the present study.

In March 1976, together with the primatologist R.A. Mittermeier, a detailed reconnaissance was carried out and the borders of the *Voltzberg Study Area* were established. With the help of several Surinam field assistants a grid of main trails was cut at 500 m intervals, for a total of 15.5 km of trail. In the 130 ha area surrounding the camp and at the edge of a large granite plate, an additional 11.2 km of side trails were cut at 100 m intervals, parallel to the long axis of the study area. The finer grid was necessary in this area because it was the most important part of the spider monkey group home range.

The study area consisted of 10 blocks of 25 ha each, two incomplete blocks limited by the Voltzberg and together covering about 44 ha, and a final section of about 12 ha extending the study area to the start of the main tourist trail ascending the Voltzberg (fig. 14). When the surface of the two large, open-granite clearings in the study area is subtracted, the total forested habitat was almost

exactly 300 ha. This study area was used during the first year for gathering synecological data on all eight Surinam primates. In the meantime, a group of spider monkeys was selected and the boundaries of its home range determined very roughly. It soon became

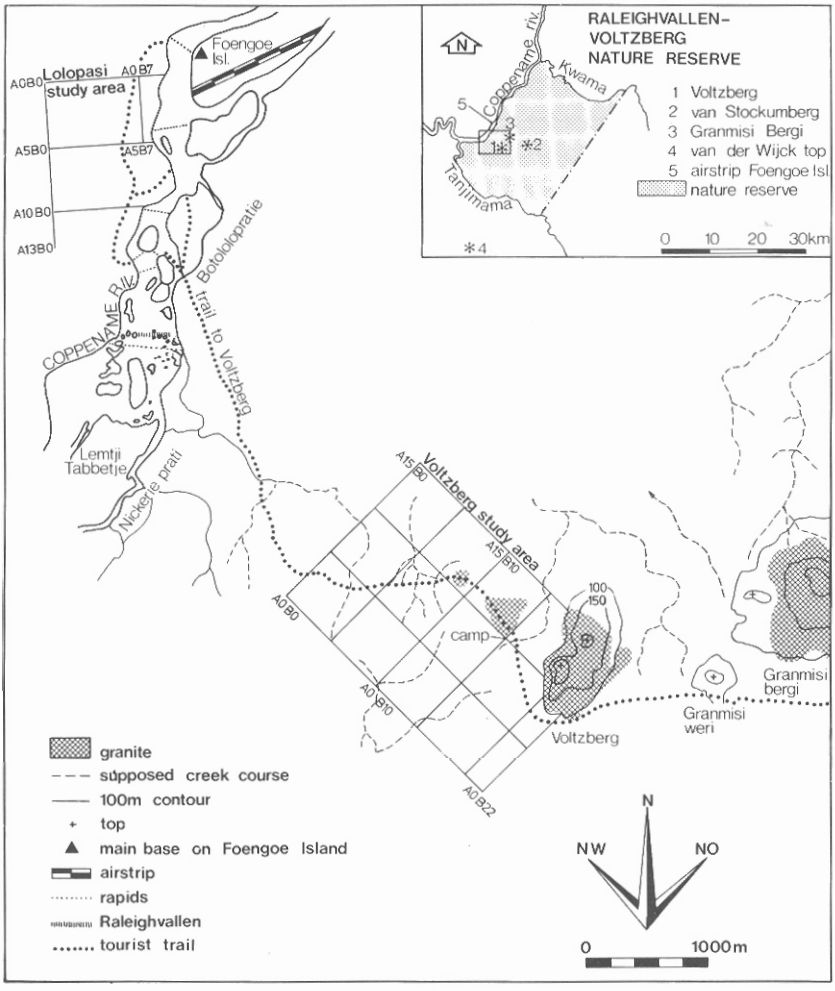

Figure 14 Map showing the location of both study areas in the Raleighvallen-Voltzberg Nature Reserve. The trail system of the Lolopasi study area was not completed since the group of spider monkeys living in the area was too difficult to follow. No progress was made in habituating them. This may have been due to light hunting pressure in the recent past. The main study area at the foot of the Voltzberg dome has only major trails at 500 m intervals indicated.

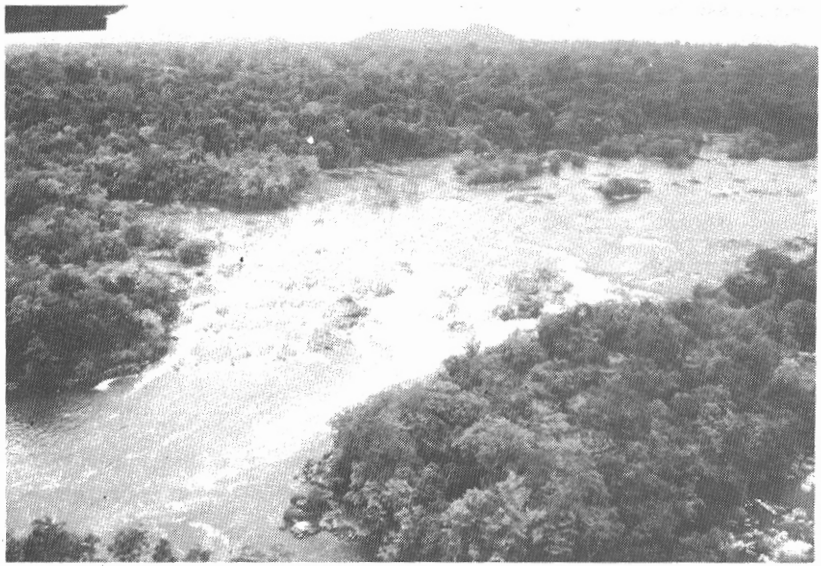

Figure 15 The 240 m Voltzberg (right in the background) and the 360 m Van Stockumberg (left in the background) seen from Raleighvallen rapids in the Coppename River about two kilometers upstream from Foengoe island.

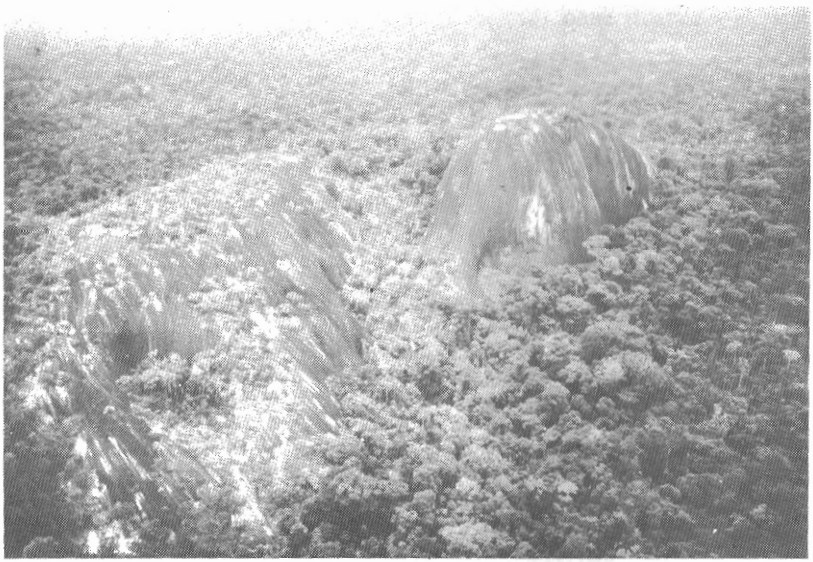

Figure 16 Aerial photograph of the Voltzberg. The forest in the foreground is part of the study area.

evident that the original study area had to be extended approximately 15 ha to the northeast and 25 ha to the southwest in order to cover the entire range of the group (fig. 17).

All 100 m and 500 m trails were provided with red-painted sticks at 50 m intervals. Each of these had aluminium tags showing their coordinates in relation to an A-axis directed NE and a B-axis directed SE from a point of origin at the western corner of the study area. After trail-cutting, a vegetation map was made by first pacing off vegetation boundaries along all the trails and marking them on the map. Then, each vegetation boundary was traced by compass and mapped. Obviously, vegetation mapping is most accurate where the trail system is most extensive, namely in the main part of the spider monkey home range.

The forest in the study area can be divided into four major types (fig. 17). High forest predominates, followed by liane forest and mountain savanna forest. Pina swamp forest grows along the small creeks that flow through the area. Low forest is present as a transitional type but hasn't been mapped, as it usually occurs in narrow strips along the borders of liane forest. The Voltzberg study area has a greater diversity of forest types and edge habitats than would usually be expected in a tract of similar size in the interior. This is probably caused by the abundant granite outcroppings that do not provide sufficient support for most tall forest trees, but do permit the growth of comparatively rare formations such as mountain savanna forest and liane forest.

Since spider monkeys never enter low forest or liane forest, these formations, together with open granite and rocksavanna, act as natural boundaries. As shown in figure 17, large liane forest complexes and the Voltzberg itself form a considerable part of the boundaries of the spider monkey home range, giving it a peninsula-like appearance.

Other animals present. All eight primate species were well represented. Besides *Ateles paniscus*, one could regularly observe *Saguinus midas, Saimiri sciureus, Cebus apella, Cebus nigrivittatus, Chiropotes satanas, Pithecia pithecia* and *Alouatta seniculus.* In addition to these primate species, a number of other mammals, as well as birds and reptiles, inhabit the Voltzberg study area. Larger rodents such as the agouti (*Dasyprocta leporina)* and the acouchi (*Myo-*

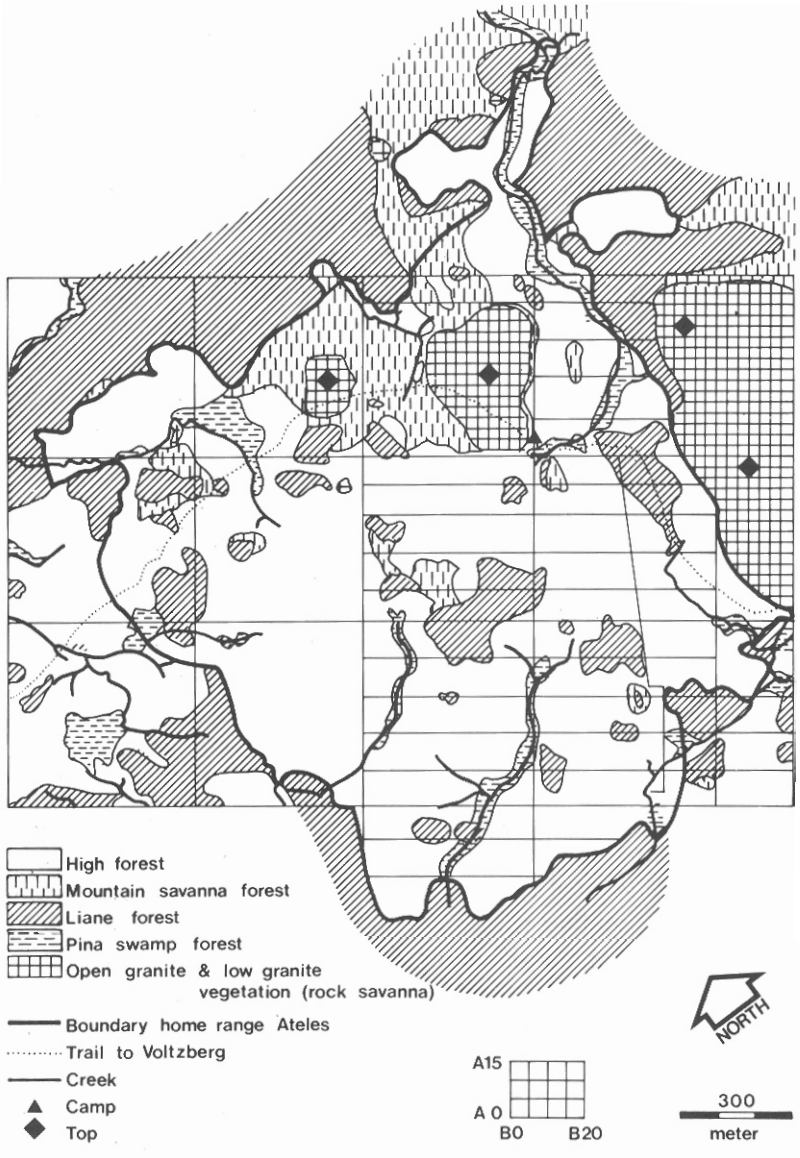

Figure 17 Map of the Voltzberg study area showing distribution of forest types and trail system. The areas of open granite, low granite vegetation ("rock savanna") and liane forest were not used by the spider monkeys. The large area of open granite at the right is the Voltzberg dome with its two tops. The camp is situated at the edge of the larger of the two granite plates. The perimeter of the spider monkey group range is marked by a heavy line.

procta exilis) are commom. Two kinds of squirreel (*Sciurillus pusillus, Sciurus aestuans)* and the prehensile-tailed porcupine (*Coendou prehensilis)* also occur, but are rarely seen. The carnivores are represented by one or two jaguars *(Panthera onca)*, several ocelots (*Felis pardalis)* and a number of tayras (*Eira barbara*). Edentates include the giant armadillo, *(Priodontes giganteus)*, the nine-banded armadillo *(Dasypus novemcinctus)*, the tamandua (*Tamandua longicaudata*), the giant anteater *(Myrmecophaga tridactyla)*, and two kinds of sloth (*Choloepus didactylus, Bradypus tridactylus).* The common opossum (*Didelphis marsupialis*) and several smaller marsupials (e.g., *Marmosa* spp.) are present. Ungulates are represented by several collared peccaries (*Tayassu tajacu)* and at least one tapir *(Tapirus terrestris).*

Many species of bird live in the study area and a comprehensive list is given in Mittermeier and Milton (1976) and in the field checklist of the Birds of the Guianas (Davis, 1966). The most conspicuous are large species such as the black curassow *(Crax alector)*, the marail guan (*Penelope marail*), the gray-winged trumpeter (*Psophia crepitans)* and the tinamous (*Tinamus spp.*). Cocks-of-the-rock (*Rupicola rupicola)* are surprisingly abundant. An important lek area and many nesting sites were found within and nearby the study area. In the canopy are scarlet macaws (*Ara macao)*, toucans (*Ramphastos* spp.), aracaris (*Pteroglossus* spp.) and a variety of parrots, especially red fan parrots (*(Deroptyus accipitrinus)*, orange-winged parrots (*Amazona amazonica)* and mealy parrots (*Amazona farinosa*). A number of raptors, including the harpy eagle (*Harpia harpyja)*, occasionally visit the study area as well.

Frogs, lizards and snakes are common, and the turtles are represented by two abundant tortoises (*Geochelone carbonaria* and *G. denticulata).*

Insect life is varied and abundant, but mosquitos are rare. Insect discomfort usually is caused by chiggers and a number of stinging and biting ants.

2.2. Data Collection

2.2.1. **Habituation of spider monkeys.** During the first year, when the synecological part of the study took place, a group of spider monkeys was selected for the detailed autecological study that was

planned for the second year (May 1977 - May 1978). Since the area had been undisturbed for at least several decades, the animals were not particularly shy. From time to time, tourist groups walk along the main trail to the Voltzberg thorough part of the group's range. Therefore it is likely that each member of the *Ateles* group saw people before this study began. In any case, the animals in the groups, except for one old male, no longer responded to people with the screaming - branchshaking and dropping - defecating display typical of *Ateles* that have had no contact with humans. They also didn't flee at the first glimpse of humans as do spider monkeys where they are hunted.

While studyings synecology of the eight Surinam primate species during the first year, many census walks were made of the entire study area. Data were collected while looking for 'target' species or tracking them. During this period, many contacts were made with all members of the spider monkey study group and occasionally with members of two other groups that touched the study area. Every time spider monkeys were located, first sighting data were collected for synecological purposes and the animals were followed for as long as possible. When the animals were lost, the observer returned to the trail and again used the trail system to search for other monkeys. The cutting of palm leaves, saplings and lianes seemed to disturb the monkeys most, but after a while the observer got very experienced in zigzagging through the shrub layer with minimal cutting.

From February through April 1977, attemps were made to follow spider monkey subgroups as long as possible. After many attempts, and aided by the observer's growing experience in walking freely through the forest while keeping visual and especially auditory contact, it became possible by the beginning of April 1977 to track spider monkeys day after day without noticeably disturbing either their ranging behavior or activity patterns. Working alone seemed to be essential for this. When accompanied by one or more observers, it was hard to maintain contact and the monkeys' behavior seemed to be influenced significantly.

2.2.2. **The synecological part.** The synecological study in the Voltzberg study area was initiated in March, 1976. Synecological data were gathered on all eight primate species for 10-15 days each

month until April, 1977. A total of 132 field days were spent studying synecology only. During the first phase and later on, my colleague R.A. Mittermeier also collected data on synecology. We gathered data during 12 census walks of the entire study area, spread over a year, and while while looking for and tracking 'target' species selected for a given day. The following kinds of information were recorded every time a group was encountered: time, location in the study area, forest type, edge or non-edge habitat, activity (e.g., resting, traveling, feeding on plant food, foraging for or feeding on insects), height and level in the forest, how located (e.g., spontaneously seen, heard vocalizing, heard crashing, heard dropping fruit or faeces), path-animal distance and observer-animal distance (both for census purposes), group size and, if possible, group composition and direction of travel. All data on preferences for different forest types, vertical stratification, activity and location of the group were based on first sightings only, in order to avoid possible bias caused by the presence of the observer. When first sighted, the visible members of a subgroup were usually all engaged in the same activity, at the same level and in the same forest type, especially in the case of spider monkeys. In order to avoid confusion, first-sighting data were based on the first individual actually seen, which is essentially an instantaneous focal-animal sample.

A sighting was considered an edge when the first animal seen was within 20 m of a clearing or another forest type. Feeding on plant food was considered the activity when the first animal seen was eating fruits, leaves, flowers or vegetable matter. Foraging for or feeding on insects was considered the activity when the first animal seen was eating or actively searching for insects or other animal life.

For stratification, observations the forest was divided into six levels : shrub layer (0-3 m), understory (3—15 m), lower part of the canopy (15-20 m), middle part of the canopy (20-25 m), upper part of the canopy (25-30 m), and emergents (30-60 m). It was usually impossible to estimate the height of emergents accurately because of intervening vegetation and the limitations of the clinometer. However, it was usually quite easy to determine whether or not a tree was an emergent simply by its relationship to surrounding trees.

Location within the study area was determined by using the markers situated at 50 intervals along the trails. Measuring the dis-

tance from a particular tree to the nearest marker gave quite accurate coordinates for each sighting.

Synecological data continued to be gathered during the second part of the field study on spider monkey autecology. At this time *Ateles* became the 'target' species, and synecological data were only collected while searching for spider monkeys or when encountering other species while tracking spider monkeys.

2.2.3. **The autecological part.** The study on the autecology of spider monkeys in a strict sense was started in the Voltzberg study area at the end of April 1977, and lasted until the beginning of May 1978. For each month of attempt this full year an attemp was made to observe spider monkeys for seven full days, but in several months only five or six days were possible. A total of 135 days was spent in the field during this period, resulting in over 865 hours of observing only spider monkeys. Usually 10-14 days had to be spent each month in the study area, divided into two sessions of 5-7 days each. As a rule, the first and the third week of each month were spent in the study area, but sometimes the second and the fourth week were chosen.

In natural habitats, spider monkeys are usually observed in small subgroups of variable size and composition. The subgroups within a group interact peacefully with one another, but groups are separated from one another by agonistic interactions, particularly between the males who appeared to act territorially and to respect quite clearcut boundaries. In order to spot a 'target' subgroup at the start of a session, several methods could be used. On returning to the study area after an absence of 7-10 days the situation had always drastically changed. Changes in the fruit-producing plant species and also in individual plants usually resulted in completely different foraging routes for the monkeys. A fresh start had to be made every time. Therefore, at the start, part of trail system was covered until a subgroup was encountered. The searching could last for hours or sometimes for as much as a full day. A long call by a male spider monkey, which was somentimes performed in response to imitation calls, helped in saving time. The calling male or 'his" subgroup could then be found using a compass, or at least efforts could be concentrated on a more defined area. In case of prolonged lack of success, the Voltzberg could be climbed in the late afternoon in the

hope of seeing spider monkeys entering one of the huge, usually leafless or early flushing sleeping trees. If so, the tree was located before returning to camp and the next day an attempt was made to be present at the foot of this tree at 5.45 h. It was then necessary to remain continuously with the animals until evening, between 17.00 - 18.30 h, when they entered another sleeping tree. If contact with a subgroup was lost, it was necessary to return to the nearest trail and try to find this or another subgroup as soon as possible.

The following data were collected while tracking spider monkey subgroups. At five-minute intervals the composition of the subgroup was recorded, the activity of all members of the subgroup, and the stratum and forest type occupied. The coordinates of every trail crossing were recorded by pacing the distance to the nearest marker. When the animals were feeding complete samples (e.g., infructescences, inflorescences, leaves and/or bark) were collected whenever possible. Usually several visits to a particular food plant were needed, as spider monkeys generally show a very economic use of food resources. When the monkeys didn't drop a complete sample of the food plant, a collection was made as soon as possible by a native tree climber from the Surinam Forest Service. Each food plant actually used by the monkeys was marked with a numbered aluminium tag and a piece of red-fluorescent plastic flagging tape, nailed on just after the monkey(s) left the tree. Using a water-resistant pencil, date and monkey species were written on the plastic tape and, later, the coordinates of the food plant were determined. Food samples were collected in plastic bags sealed by a piece of plastic tape on which time and tag number were written. Back in the Voltzberg camp, a picture of all items eaten that day was taken with a Nikkormat EL camera, using a 52 mm macro lens. The samples were preserved by adding some formaldehyde (2% sulotion) and were then labelled. Upon returning to the base camp on Foengoe Island, all samples were identified if possible, using the book on the fruits of Surinam (Van Roosmalen, 1977) and monographs of certain plant families and genera (Berg, 1975; Wessels-Boer, 1965). After making a drawing of each new food item, including cross-sections and other details, all samples were put in jars, labelled and stored.

Faeces were also collected and preserved. Spider monkey faeces usually consisted mainly of undisgested and unharmed seeds

and stones (seeds protected by a hard endocarp), especially during the wet seasons. Consequently, the faeces were not compact and when they fell to the forest floor the seeds dispersed over quite a wide area. If this happened, as many of the seeds and/or stones as possible were collected.

Data on phenology of trees and lianes of many species, especially those used by monkeys, were gathered in the following manner. While searching for or tracking spider monkey subgroups, the observer visited almost every part of the groupu's range over the course of a few days. During these walks throughout the year, the presence of fresh flowers, fruits or fruit-parts on the forest floor was noted, and new species were collected and identified. In this way, timing and length of flowering and fruiting periods were determined for many plants, not only on a species but also on a individual level.

In September 1977, together with a native tree specialist and an assistant, a marking program was initiated, which lasted about seven months. By this time, almost all important food species of *Ateles* had been determined, and many of them had already been collected during the synecological part of the study. A list of 120 important species, including food trees, easily recognizable lianes and some sleeping trees, was compiled using vernacular names. When a species was not known to the tree specialist, samples from several individuals were shown to him so that he could learn its special properties such as type of habit, colour, taste and texture of bark and/or wood, presence of latex, type of leaves, etc. Each species was given a code number. The most important part of the spider monkey group range, approximately 205 ha, was inventoried. For this purpose, new transects were cut at 50 m intervals, perpendicular to the 100 m trails, resulting in about 370 rectangular blocks of half a hectare each (fig. 8). All individual trees and lianes belonging to the listed species were marked with an aluminium tag different from the kind used to mark trees which the spider monkeys were actually seen feeding. In this way, block after block was inventoried and the location of each numbered plant was approximately determined by its place in a certain half-hectare block. Trees below 12 m were not included, as this was determined to be the lower limit of the spider monkey vertical range. For the purpose of

this study, tagging and plotting was restricted to those individual plants that had obviously reached their own preferred stratum and this, in general, implies that they would flower and fruit. Plants which provided the monkeys with only edible leaves were plotted when they reached 12 m or more, regardless of whether they had reached their preferred stratum.

A total of about 10,000 trees and lianes were marked and plotted in special maps in order to determine their density and pattern of distribution (Appendix). In this way most of the trees and lianes, which had been marked when spider monkeys fed on them, were marked again, thus giving a double check of identification and location. Also, this provided an idea of the reliability of the tree specialist, which turned out to be high.

For measurement of dietary composition, the frequency with which different foods were chosen was used. If a subgroup or a solitary ranging animal was seen feeding on a single food plant, one observation was scored. If a subgroup or individual moved to another tree of the same species, another observation was scored. If a subgroup or individual moved to a different food plant species, one observation was scored for that species. If identifiable seeds or stones of a given species, which had not been seen being eaten that day, were found in the faeces of a monkey, one observation was scored for that species. This method may seem to be somewhat crude, but it a gave a good estimate of the relative importance of different food plant species and families in spider monkey diet. This method is preferred to determining the total feeding time for each species, because feeding rate can vary widely between foods. Some fruits are swallowed whole, others are woody and indehiscent and have to be opened first. Some fruits contain a lot of nutritions pulp and comparatively small seeds or stones; others produce very little pulp or are eaten only for a minuscule aril. Measurement of the proportion of feeding time spent on different foods has also the disadvantage that analysis of faecal samples cannot be taken into account. Faecal samples can give much information, particularly for spider monkeys, since the animals swallow and do not digest seeds and stones in 93.5% of all fruit-feeding observations. The method of quantification used in this study produces some bias towards foods that are eaten regularly but in small amounts, and towards plant species that

produce several edible items at the same time. Both features, however, are rare in the case of spider monkeys and consequently this bias is of little importance. A relatively more important bias may be that produced towards species that grow at high densities. For example, *Virola melinonii* (Myristicaceae) can be overestimated in this method because it is found locally in great abundance. When feeding on a particular tree of this species, the monkeys will also visit nearby trees, each of which provides only a small crop of fruit. If these trees were more widely dispersed, they would probably be ignored because of the small energy yield per tree.

2.3. **The General Survey**

Some other localities were investigated during the general survey, and these added data to the distribution map the habitat table for *Ateles*.

2.3.1. **Lolopasi, west bank Coppename River, Raleighvallen-Voltzberg Nature Reserve.** Lolopasi is located directly across the Coppename River from Foengoe Island, site of the headquarters of Raleighvallen-Voltzberg Nature Reserve. A trail of 2.9 km has been cut through the forest to enable visitors to reach the Moedervallen, largest of the Raleighvallen rapids. During the first part of this study, additional trails at 500 m intervals were cut to the west, roughly perpendicular to the riverbank and 600-1,000 m inland (fig. 14). The trail system has not been finished, but a total of 7 km of trail were cut before the area was abandoned as a study site.

The Lolopasi area consists almost entirely of riverbank high forest and high forest, except for a narrow strip of marsh forest close to the riverbank. Pina swamp forest and some liane forest are present, but no mountain savanna forest occurs.

All eight Surinam monkey species were encountered in the area, but some of them, particularly *Ateles*, were very shy, probably because of recent hunting. It was impossible to keep track of spider monkeys for more than half an hour. No progress could be made in the habituation of the spider monkeys, but a rough idea of the population size and some dietary data were obtained.

2.3.2 **Kayser Mountains.** The Kayser Mountains are located in the interior, in southewestern Surinam. The Surinam Geological Servi-