SURINAME FIELD COURSE ON FOREST RESEARCH METHODS

9-19 May 2011

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At CELOS we acknowledge that too much of our research is mostly descriptive and that more of a focus on problem solving is needed, hence our willingness to facilitate this course in Suriname. We also recognize that a 10-day field course can have only limited long-term impacts on the scientific capacities of the participants. That said, the opportunity to interact intensively with internationally renowned scientists and to practice science under their mentorship gave the participants a better sense of the characteristics of good science as well as improved skills in formulating hypotheses, designing experiments, analyzing data, and preparing publication-quality manuscripts. This last step in the research progress, the dissemination phase, is critical because otherwise the work will have been in vain. Data that are not shared or are shared with only a few people are not of much value to the scientific community or to society at large. Having prepared several drafts of several manuscripts during this short field course, participants are now more aware than ever of just how much effort needs to be invested in publishing our results. Overall we are certain that the course achieved the goal of increasing participant awareness of what constitutes good science and its importance.

This Course would not have been possible without the support of the Interim Board of CELOS, our secretariat: Ms. Grace Tjon and Ms. Lalita Mahadew; and our logistics team: Ms. Lydia Amatredjo and Mr. Johan Hardjopawiro.

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And finally, the efforts of all the course participants need to be acknowledged. I am certain you came out of this course enlightened about science and energized about your own research. I look forward to reading your publications in scientific journals in the near future.

Sincerely,

Verginia Wortel

Project Coordinator
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SURINAME FIELD COURSE ON FOREST RESEARCH METHODS

SYLLABUS

9-19 May 2011

Instructors: Francis E. Putz (fep@ufl.edu), Rory Fraser (rory.fraser@aamu.edu), and Alexander Shenkin (ashenkin@ufl.edu)

INTRODUCTION AND APPROACH

Using a combination of readings, lectures, discussions, and, most important, field exercises, course participants will hone their research skills from hypothesis formulation to manuscript preparation. Individual and small group field research projects will be designed and carried out on topics of relevance to forest ecology, conservation, and management. The collected data will be analyzed statistically and presented both orally and in a written form suitable for submission to an international, peer-reviewed journal (Forest Ecology and Management). An inter-disciplinary applied perspective will be employed throughout the course so that participants become more comfortable working in complex socio-ecological systems.

The pedagogical approach to be employed is "experiential" and will be discussed and evaluated throughout the course, especially if teachers are included among the participants. Course participants improve their abilities to design and implement scientific studies by doing science. Their ability to communicate the results of their science will be enhanced through repeated written and oral presentations with ample feedback.

A typical day during the course would include field-work in the morning, during which each participant individually or in small groups collects the data need to test a hypothesis formulated the night before. The early afternoon is dedicated to guided data graphing and analysis with time allocated for reading. Then come the oral presentations (3 minutes each), followed by time allocated for drafting a short (2-3 page) manuscript prepared as if for submission to Forest Ecology and Management. Each of these manuscripts is edited by course staff and returned to the author(s) for resubmission. After dinner there is a lecture/discussion that provides preparation for the next day's field problem including consideration of issues related to hypothesis formulation and experimental design.

Some topics appropriate for field projects include soil compaction (soil water infiltration rates), biodiversity assessments, estimation of above-ground tree biomass (i.e., allometry), matrix modeling to assess sustainability of harvesting (e.g., of a non-timber forest product), and estimation of the net present value (NPV) of different management scenarios, but there are many more options. During the last portion of the course, participants typically conduct a small research project on a topic of their own selection. After the manuscripts are reviewed and revised several times they will be compiled into an official "course book." These course books continue to be useful for participants and others long after the end of the course.

Pedagogical Goals and Philosophy: While we recognize that a single, short-duration field course can have only limited impacts on the scientific capacities of even the most dedicated participants, we are very proud of the progress made by participants in former courses. At the very least, all participants come away with an improved sense of what constitutes good science and an improved ability to design field research projects that closely match research objectives.

We also hope that the course experience provides a foundation for future collaboration among all researchers involved.

We claim no particularly inspired insights about how best to teach but will try to act in accordance with the following precepts and otherwise promote participatory, learner-centered training:

1. The extent to which adults learn new material varies with whether it is simply heard (20%), heard and seen (40%), or experienced (80%).
2. Experiential learning situations in which learners learn from each other and the trainer learns from the learners should be maximized while use of traditional transmission-based approaches should be minimized.
3. Participatory learning is active, not passive.
4. Adult learners prefer to be self-directed or at least to share responsibility for their own learning.
5. Motivation to learn increases when the topic under consideration fills an immediate need.
6. Maximum learning from an experience occurs when there is time to reflect back on it, draw conclusions, and derive principles for application to similar situations in the future.
7. Provide lots of corrective but supportive feedback.
8. Show respect for the learner and otherwise foster trust so as to assist the learning process.
9. Provide a safe, cheery, and comfortable atmosphere for learning.

Some topics to be covered in lecture/discussions, readings, and field work include:

A. Formulation of falsifiable hypotheses with the focus on critical thinking.
B. Experimental designs, data graphing, and statistical approaches.
C. Sample size determination and basic statistics.
D. Soil compaction and water infiltration.
E. Issues related to estimating carbon stocks and fluxes such as: allometry, permanent plot monitoring, estimates of necromass.
F. Plot-less sampling methods including point-centered quarters.
G. Analysis of sustainability using matrix projection methods.
H. Ecological economics for ecologists and foresters (e.g., opportunity costs, discounting, and basic cost-benefit analysis).
I. Sustainability from multiple perspectives.
J. Forest edge effects (e.g., bark thickness, soil temperature, litter depth, dead trees).

DAILY SCHEDULE:

9 May: Arrive at Field Station: Workshop on hypothesis formulation, statistics, and basic experimental design.

10 May: Field work on soil compaction and water infiltration rates. Full group data collection followed by small group hypothesis tests using the same methodologies. Oral presentations of results. Groups produce manuscripts based on their findings.

11 May: Hypothesis formulation: Each participant generates 20 falsifiable hypotheses in the Redi Doti savanna. Hypotheses discussed and brief research proposals for one from each participant prepared and further discussed. Plant collections.

12 May: Independent research projects on edge effects in the ETS logging area. Oral presentations of edge project results. Prepare first draft of manuscript. Soil compaction manuscripts returned with heavy edits.
13 May: Assessing plant species diversity in the savanna. Comparison of sampling methods followed by data analysis—species area curves, species abundance distributions, rarefaction. Introduction to matrix algebra.
14 May: Population harvesting sustainability. Field work on *Bactris* palm in the savanna followed by assembly of a transition matrix and post-multiplication by the stand vector. Stage-based Markov model.
15 May (Sunday—Day Off). Rest-and-relaxation by using a plot-less sampling method to assemble stand data, fell and weigh trees to calculate allometrical formulae, and use these data to estimate above-ground biomass in a logged forest near the CELOS Plots. Afternoon visit to the CELOS Plots.
16 May: Individual research in the ETS Concession. Second draft of edge manuscripts due. Prepare and present a brief talk on results from first day of independent research. Draft manuscript.
17 May: Continued field research on independent projects. First drafts of manuscript due. Workshop on resource economics (e.g., NPV, opportunity costs) based on Fisher et al. paper and Ruslandi et al. response (all in press in Frontiers in Ecology and the Environment).
18 May: Third drafts of manuscripts on independent research projects and improved Power Point slides for oral presentations due. Return to Paramaribo.
19 May: Research symposium in Paramaribo, award ceremony.

Evaluation Report

Suriname Field Course on Forest Research Methods
Redi Doti, Para District, Suriname, May 9th - 19th, 2011

Student's Name:

Personal History

Where were you born, grew up, and educated?

12 participants, Four countries represented Dominica (1), Trinidad (1), Guyana (3), and Suriname (7). Most grew up in the cities of their home country (one in Holland). Four had an Associate Degree or were completing a BSc in Forestry. Four had a BSc (Forestry, Agriculture, or Biology). Four had MSc. (2 Holland, 1 UK, and 1 Finland).

What is your work experience?

There was 150 (average 12.5) years of experience in the group - half of the time in Forestry and the rest of the time in a a mixture of Soils, Curation, Tissue Culture, Agroforestry, Conservation, and Ecology.

How were you selected for this course?

Most were selected by their supervisors and had an opportunity to talk to one of last year's participants. They were told that the course was rigorous but could help them understand statistics, research, and academic writing.

What were your expectations prior to participating in the course?

Most came expecting the course to be tough, with a great deal of writing. They all expected to have a better appreciation of statistics, research methods, and data analysis. Some came with expectations of training specific to their field of work - conservation/ecology, sampling techniques, biostatistics, transforming data into knowledge, and quantification of forest disturbance.

Were your expectations met? Unmet? Surpassed? Please explain briefly.

Most felt the course met their expectations, some even felt it exceeded expectations. However, some were a little disappointed because they felt the pace was too demanding for those with little training in or who infrequently use statistics. Others would have preferred a wider range of topics which included their areas of particular interest e.g. economics, zoology, etc. Some were very stressed by the demanding writing/rewriting and were at time confused by what seem to be contradictory comments/advice provided by the three instructors.

How do you think you might be different as a result of participating in this course?

All felt they benefitted from participation. Most felt they had a better understanding of field-based research and the importance of appropriate design and use of statistics. As a result, they felt they would think more critically about the research in which they were currently engaged. Some were inspired to think of potential research projects. All talked about using and encouraging their colleagues to use more statistics in their efforts. There seem to be a general sense that they needed to be more engaged in thinking about research in their field of work. One person said he was inspired to complete his BSc degree and go even further into research.

What would you: Add and/or Delete to improve the course?

Daily personal reflection time (one hour). Less emphasis on getting report ready for publication and more on research methods. A little more time. A short refresher course in statistics. More collaboration in data collection and writing .e.g one individual paper and two collaborative. Spend more time on developing hypotheses. More time for writing or less writing projects. Slower pace, less information, greater detail. Send course documents ahead of time to participants.

Evaluator's Notes:

Instructor's Approach

1. *Motivated topics*
2. *Challenged students without defeating them*
3. *Compared but did not denegrate students.*
4. *Offered constructive criticisms.*
5. *Set and kept a fast pace.*
6. *Clear, structured lectures each with practical field exercise.*
7. *Required multi-tasking - learn new while working on prior and thinking about what's coming.*
8. *Frequent check-ins with each student during lectures, field work, analyses, writing.*
9. *Provided subject references and encouraged collaboration with peers on similar topics.*
10. *Attentive to the mood, personal problems/difficulties and made flexible responses.*
11. *Held out models (including own) of successes and failures.*
12. *Stayed positive despite problems with power, water, and transportation.*
13. *Maintained a genial environments*

Would you recommend this course to friend/colleague? Who?

Everyone said they would recommend the course to a workmate or colleague. Some identified specific people, while others felt that SPB and other faculty in the University would benefit from attending the course. Some even expressed the view that this type of training should be required for all the people working in the forestry and conservation field.

Lesson Plans

SIMULATIONS OF SUSTAINABLE HARVESTING: MARKOV MODELS FOR A SAVANNA PALM

INTRODUCTION

While the sustainability is a term that is often used loosely, it can be assessed at the population level using quantitative simulation models. A family of models based on transition matrices was introduced in an hour-long workshop followed by 3 hours of field work, 1 hour of calculations, and an hour-long discussion. The focus was on a common, multiple-stemmed savanna palm in the genus *Bactris*. The scenarios simulated were for harvesting seeds, shoot tips for palm cabbage, and leaves for thatch. The goal of the rural community wanting to market these products is to achieve certification by demonstrating the sustainability of their harvests.

PROVISION OF BACKGROUND

1. Discuss what is meant by "sustainability" and clarify the discussion by considering the different products, processes, and services that are sustained.
2. Introduce the basics of matrix algebra: post-multiplying a matrix by a vector.
3. Use a "bubble and arrow" concept diagram in the form of a Markov process to explain a the transitions in a stage-based model (i.e., stay in the same stage, grow to the next stage, reproduce, or die).
4. Use the data in #2 to make a 4 x 4 transition matrix using the following stages: seed, seedling, juvenile, adult.
5. Post-multiply the transition matrix by a stand vector representing the number of individuals in each of these stages to estimate the population size and structure after one round of transitions.

FIELD WORK

1. Divide group into three, four-person teams.
2. Each team demarcates a 50 x 50 m plot (starting point selected at random with a compass and random number table) subdivided into four quadrants.
3. All palms in the plot are measured (estimated) for height and the presence of reproductive structures is noted.

DATA MANAGEMENT

1. Based on the abundance of palms of different height, divide the population into four height classes that will serve as 'stages' in the model:, 'stemless' seedlings (i.e., palms with no above-ground stem); >0 but < 1 m tall; 1-2 m tall; > 2 m tall.
2. Although this palm is clonal with up to 25 stems per individual (working definition = stems <20 cm apart), we disregarded this fact in our analysis and treated stems as individuals. A matrix incorporating the clonal structure of this population is feasible, but much more complicated and would involve many more unsupported assumptions (e.g., tradeoffs between ramet growth, reproduction, and vegetative expansion).
3. Due to lack of long-term permanent plot monitoring data, the values in the transition matrix need to be arrived at by starting with reasonable estimates based on the literature, putting the data in EXCEL, and then using an iterative process of adjustment to arrive at probabilities and reproductive outputs that are reasonable but serve to maintain the population.

4. Compile the data from each of the groups, average the abundance-per-stage data to arrive at per hectare estimates of population size and structure at time zero (t-0).

RESULTS

For reasons that are not clear but which include stochastic factors, the mean density of individuals in the second stage was higher than in the first stage. Given the introductory nature of this exercise, the values were adjusted and rounded to be more accommodating to calculator users

TRANSITION MATRIX

	Stemless	0-1 m tall	1-2 m tall	>2 m tall
Stemless	0.8	0.3	0.7	1.0
0-1 m tall	0.001	0.8	0	0
1-2 m tall	0	0.001	0.8	0
>2 m tall	0	0	0.001	0.8

PALM STAGE	**NUMBER OF INDIVIDUALS**	
	T-0	**T-1**
Stemless	750	990
>0 but <1 m tall	550	440
1-2 m tall	250	200
>2 m tall	50	40
TOTAL	1600	1671

SIMULATIONS OF HARVESTING SCENARIOS

Small groups of participants simulate the effects of different harvesting scenarios by manipulating the probabilities in the transition matrix. For example, harvesting the shoot tips of palms for cabbage is simulated by increasing the mortality rate in the harvested stage by reducing the probability of stasis (i.e., surviving but remaining in the same stage). Seed harvesting is simulated by reducing the reproductive outputs. Leaf harvesting for thatch is simulated by reducing the likelihood of making the transition from one stage to the next.

The two scenarios that were the most instructive both involved killing stems for their shoot tips. Due to differences in reproductive value of juvenile and adult stems, the same harvesting intensity has a much bigger effect if the younger individuals are removed.

An interesting observation was made about the palm thatch harvesting scenario. While from a population stability perspective, harvesting leaves from the largest palms would be preferable, we observed in the field that the tallest plants typically had smaller and often more tattered leaves, smaller diameter stems, and presumably smaller apical meristems. One possible explanation for this phenomenon is that the taller plants are adversely affected by wind, both through mechanical damage and physiological stress. The exponential increase of wind speeds with height above the ground was discussed.

BIODIVERSITY IN THE FIELD:
A SAVANNA IN SURINAME

Objectives

In a day, introduce participants to the conceptual foundations of biodiversity science via hands-on fieldwork, discussion, and analysis of collected data. Key topics include species richness, evenness and dominance, alpha- and beta-diversity, rank-abundance curves, species accumulation curves, estimating total species richness, and basic diversity indicies.

Fieldwork

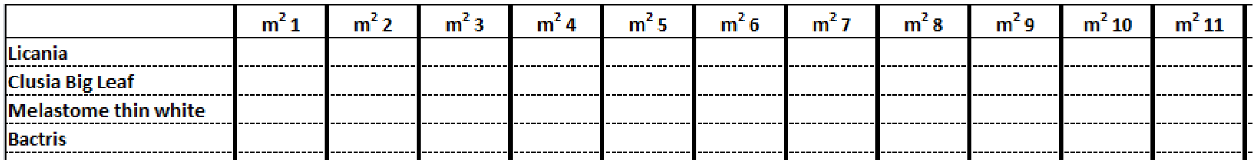
We conducted field work in the Blaka-watra Savanna in Suriname, approximately 2-hour's drive south from the capital Paramaibo. Two days prior to the lesson discussed herein we visited the site for a different lesson and took advantage of the opportunity to collect as many plant species as possible in about a half-hour. 48 species were collected, labeled with family or generic names when known (e.g. "Rubiaceae", "Lagnocarpus"), or with descriptive names when scientific names were not known or when there were more than one species from the family (e.g. "pointy sedge", "tiny Rubiaceae", "opposite pointy"). We decided to focus on vascular-plant diversity and hence discarded 3 non-vascular-plant samples (two terrestrial lichens and a Sphagnum species).

The plant collection was left on display at the camp for 1.5 days prior to the beginning of the lesson to allow participants opportunities to peruse the collection in their spare time (most participants studied the collection on the morning of the field work). Prior to leaving for field, team leaders took small samples from the master collection; participants took digital pictures of plant samples and their labels.

12 participants formed 4 groups and were furnished with 1-m sticks and flagging tape with which to mark 1-m^2 sampling plots. They were directed to record on a spreadsheet with 16 plots across the top and the 45 vascular-plant species along the left (see Fig. 1) percent cover for each species encountered in each plot. Percent cover was allowed to exceed 100% in the case of multiple layers of vegetation.

Since it often takes some time to train oneself to quickly and consistently estimate percent cover, we furnished the participants with an example sheet showing hypothetical squares with 5%, 10%, 20%, 30%, 40% and 80% plant cover (Fig. 2).

Each group was assigned one of 3 sampling methods: square (1 m^2 plots arranged to form a large square); plots in a line; and, two groups located plots at random by a stick toss and a random distance between 10 and 90 steps away (from a random number table).



	m^2 1	m^2 2	m^2 3	m^2 4	m^2 5	m^2 6	m^2 7	m^2 8	m^2 9	m^2 10	m^2 11
Licania											
Clusia Big Leaf											
Melastome thin white											
Bactris											

Fig. 1. Data-entry spreadsheet with plot number along the top and species name down the left

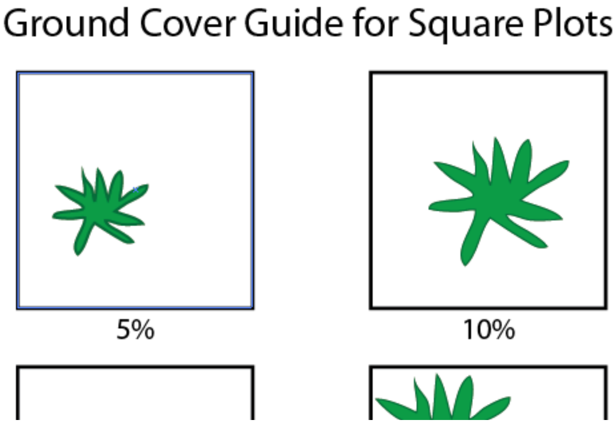


Fig. 2. Sheet to help students calibrate their eyes to measure percent ground cover.

Each group then proceeded to establish their plots and record the per-species ground cover percentage for each plot. The number of plots measured per group ranged 8 - 16 and was negatively correlated with the number of species encountered. When we returned from fieldwork (and a bath in the river), the participants entered their data (percent cover per species per plot) in a Microsoft Excel spreadsheet.

Discussion

I started the class session by posing a hypothetical situation in which The World Conservation Union (IUCN) wants to establish conservation priorities in Suriname. They have a lot of money for conservation projects, but want to spend it effectively. They come to you, the participant, and ask you, "how much diversity is there in the Blaka-watra Savanna?" What are you going to tell IUCN?

From there, I asked: what is "biodiversity"? We discussed species richness, the total number of species at a single site (however one might define "site"). I was relatively confident that we had found most of the vascular plant species (59) in the savanna given the collection in the field the day before as well as the new species found during the fieldwork. Since no one group found >30 species in their plots, I asked them what they were going to tell IUCN. Were they confident with their species counts? How else could they try to determine how many species were really in the savanna?

Each group then constructed a species accumulation curve from their own data, with plot on the x-axis (in the order that they were sampled) and species count on the y-axis. We plotted each group's species accumulation curve (which can also be seen as a species-area curve) on a whiteboard and compared them. The random plots produced the largest species counts, with the square plot the smallest.

We did not statistically extend the species accumulation curve, as we might have done, as we thought it would prove more confusing than instructive. We did, however, use the "Chao 1" (Magmurran, 2005) non-parametric estimator of species richness for each group's data to come up with an estimate of total species richness in the savanna. The Chao estimates ranged from 20-60 species.

With estimates of total species richness in hand, I then posed the following question: "Does species richness describe everything about the biodiversity of this savanna? What else might IUCN be interested in knowing?" We presented the following example: Imagine two sites with 100 individuals each. One site has 10 individuals of 10 species and the other has 91 individuals of one species, and 1 individual each of the other 9 species. Which is more "diverse"? Is a monodominant *Eperua falcata* white sand forest in Suriname more or less diverse than a mixed rainforest on clay loam?

Each group constructed rank-abundance curves with percent cover on the y-axis instead of the typical number of individuals. We plotted the first 10 species of each groups' curves on a graph in front of the class and discussed which seemed more even.

To introduce alpha- and beta-diversity, the following situation was presented: IUCN comes to you and says that they are interested in more than just the savanna. They are thinking about conserving larger landscapes and want to know the diversity of the savanna *and* the surrounding palm forests. What are you going to tell them? How would you approach the question? The discussion was guided towards the difference between alpha diversity (species richness at a point or site) and beta diversity (species turnover between habitats). We calculated three examples of Whittaker's Beta:

$\beta_w = S/\bar{\alpha}$, in which S = total number of species counted in all samples and $\bar{\alpha}$ = average sample diversity across habitats; this index varies from 1 for complete similarity between samples to 2 for no overlap in species between samples.

Example 1: We take 2 samples: one in the savanna and one in the bordering forest. We find 50 species in savanna and 50 species in forest. 25 of the species occur in both. What is the beta diversity?
Answer: Bw = 75/50 = 1.5
Example 2: If there were only 10 shared species?
Answer: β_w= 90/50 = 1.8
Example 3: No shared species?
Answer: β_w= 100/50 = 2 (maximum beta diversity)
Example 4: All shared species?
Answer: β_w= 50/50 = 1 (minimum beta diversity)
What is alpha diversity in each plot?
Answer: 50 species.

Observations

In a site with no herbarium and for which the instructors had no previous knowledge, preparing the 48 plant samples took approximately 4 man-hours. Entering the data into Excel took approximately 20 minutes.

While they were almost an afterthought, the different sampling schemes (square, line and random) turned out to be particularly instructive. The random-plot scheme produced the smoothest and steepest species-abundance curves, with the most readily-imaginable asymptote. Participants agreed that the random plots best approximated the true species count. Participants also understood from the drawing of these curves that they could be extended to look for the true species count of the area without having to measure the entire savanna.

Room should be left on the data sheet for new species to be added during the field exercise. 14 new species were added in about 3 hours of fieldwork.

Student Evaluations

In a Likert-scale (“excellent”, “good”, “acceptable”, and “not good”) evaluation of the biodiversity fieldwork and classwork, students gave 13 “good” and 9 “acceptable” ratings (numbers combined for both instructors).

References Cited

Magmurran, A.E., 2005. Measuring Biological Diversity. Blackwell Science Ltd., Malden, MA.

ESTIMATING ABOVE-GROUND FOREST BIOMASS; A PLOTLESS TECHNIQUE AND AN INTRODUCTION TO ALLOMETRY

INTRODUCTION

Concerns about deforestation and deforestation in the tropics coupled with increasing awareness of the growing impacts of global climate change caused by anthropogenic emissions of atmospheric heat-trapping gases has created a need for accurate but cost-effective estimates of forest biomass. For countries likely to be eligible for payments for reduced emissions from deforestation and forest degradation and increased sequestration from improved management (REDD+), there is a great need for in-country expertise in carbon stock estimation and monitoring. To help this expertise to develop, we spent a day with the CELOS Carbon Team carrying out a pilot study of a plotless technique for estimating tree density, basal area, and above-ground biomass (AGB). We also destructively sampled 4 small tree to establish our own allometrical equation to use in estimating AGB from the data derived from our forest sampling.

POINT-CENTERED QUARTER SAMPLING

While most estimates of forest biomass are based on plot-based data on tree diameters and species coupled with allometrical equations, a number of plotless methods might be better, at least for estimation of forest carbon stocks. Among the many plotless techniques, point-centered quarter (PCQ) sampling is perhaps the most common. This technique involves sampling well-spaced points at random along transects through the area to be sampled. An imaginary line perpendicular to the transect at the selected sample point defines four quadrants. To estimate tree density and other forest characteristics, the distance to the nearest tree in each quadrant is measured.

Our use of PCQ sampling involved measuring the distance to the nearest tree in each of four diameter classes in each quadrant (5-10 cm, 10-20 cm, 20-40 cm, and >40 cm). The diameter of each tree sampled was measured and its species (or species group) was determined. Our points needed to be 40 m plus a random number of meters ranging 0-9 (from a random number table). To determine the average density of trees in each diameter class, the distance from the point to the nearest tree in that class in each quadrant is assumed to be equal to the radius of the area uniquely occupied by that tree. For example, an 8 cm dbh tree 3 m from the point would be assumed to occupy an area of 3^2 x 3.14 = 28.27 m^2. Given that a hectare is 10,000 m^2, that one tree would lead to an estimate of 353.7 trees 5-10 cm dbh per hectare. Obviously it takes many more than 1 tree from one quadrant to estimate tree density with any accuracy.

Several field and computer-simulation based comparisons of the time efficiency and accuracy of PCQ sampling and plot-based techniques all revealed advantages of the former. The efficiency of PCQ sampling derives from not having to survey in plot corners nor spend undue time on abundant but small trees that contribute little to overall forest basal area or biomass. The accuracy benefit of PCQ derives from sampling over a much larger area of forest per time invested than is possible with plot-based techniques. In contrast, permanent plots are better for monitoring forest dynamics and carbon fluxes.

OUR RESULTS

We divided our group of 15 scientists in five groups, four that carried out PCQ sampling and one that destructively harvested 4 understory trees to establish an allometrical equation for predicting AGB from dbh, height to the first branch, total height, and crown width.

ALLOMETRY
Species: *Paypayrola guianensis* (Violaceae)

DBH (cm)	HEIGHT (m)	CROWN WIDTH (m)	FRESH WEIGHT (kg)	DRY WEIGHT (kg = AGB)
4.0	6.6	2.3	11.3	7.0
7.0	9.7	3.4	29.1	20.4
2.0	4.2	1.0	1.3	0.9
12.4	17.7	3.8	91.6	64.1

In the absence of fresh-to-dry weight conversion factors, we assumed 30% moisture content. Our reasoning is that the moisture contents of leaves and wood are typically 50% and 25%, respectively, and 90% or more of the AGB of a tree is wood.

Plotting the dbh and AGB data revealed a very smooth exponential relationship that was fit with 95% confidence by a linear relationship.

STAND CHARACTERISTICS AS REVEALED BY PCQ SAMPLING

Recognizing that in our 2 hour field data collection blitz both the quality and the quantity of the collected data are wanting, we use them to estimate AGB.

TREE SIZE (dbh in cm)	DENSITY (#/ha)	AGB (Mg/ha)
5 -10	911	26
10-20	1158	83
20-40	160	24
>40	207	60
	TOTAL	193 Mg/ha

Group Project Papers

Effect of slope on infiltration rates in forest in Suriname

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Abstract

Ecotourism in many tropical forestry communities is an alternative source of income. With ecotourism comes infrastructure development in the form of roads, bridges, buildings walk paths etc. The possibility of erosion has to be considered when development works are to be undertaken on slopes. The aim of this study was to determine the water infiltration rates on sloping ground in the Redi Doti community which lies along the Suriname River. Infiltration rates (IR) on slopes were measured using an infiltrometer – 20 cm long PVC pipe. This was placed 10 cm into the ground at 14 points along the slope. The results indicated that the infiltration rates (IR) increased as the slope increased.

Key words: Infiltration, infiltrometer, slopes.

Introduction

A developmental project in the Redi Doti village requires information on the drainage capacity of the soils along the river bank. An overview of the area indicated that the area is characterized by undulating slopes, creeks, and swamps that affected by tidal effects. The process of infrastructure development in forested areas may include the use of machines. According to Kozlowski 2000, the use of machines may cause soil degradation in forest ecosystems along with the modification of soil structural characteristics. The rate of infiltration can have an effect on soil erosion and water runoff on slopes. According to Dickerson 1976, Cullen et al 1991 and Ballard 2000, the infiltration rates of undisturbed soils are lowered from 11.4cm/h to 1.1cm/h within wheel tracks. This investigation attempts to acquire data on water infiltration rates on slopes of varying degrees in the proposed area for development. In recent times the dangers of erosion was evident in Rio de Janeiro Brazil in the form of landslides which were as a result of deforestation and soil compaction thus less infiltration rates. Hence the goal of this study was to initiate data collection to measure the infiltration rates on slopes thereby foreseeing the impacts of machines on the soils within the proposed development.

Methods

Study area

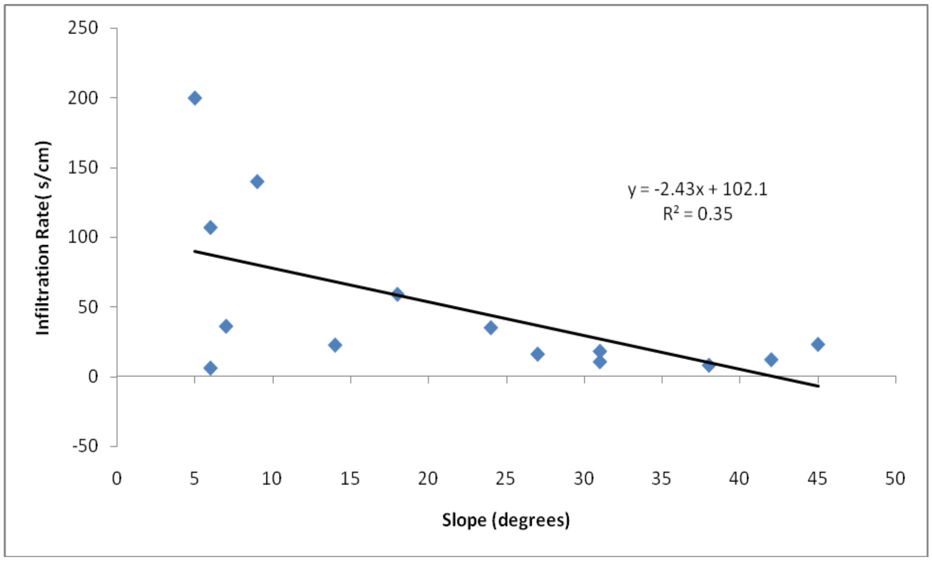
The proposed area of development – Redi Doti, lies at an elevation of 68m above sea level, on the right bank of the Suriname River with UTM coordinates 5^{0} $25^{'}$N 54^{0} $59^{'}$ W. The soil in the area was observed to be sandy loam with patches of clay along the slopes. There are *Pterocarpus spp* growing in the area and the litter fall was present. There were patches in the canopy in some parts of the study site.

Sampling design, data collection and analyses

In this study the materials used included clinometers, 6 infiltrometers (20cm long pvc tubes), bucket, watch, water, mallet and a ruler. The infiltrometers were hammered to a depth of 10 cm into the ground along a slope. Water was poured into each tube and the infiltration rates were measured using the ruler and stop watch. To acquire as many sampling points as possible a recommended 3 minute limitation was applied to measure the infiltration rate. A total of 14 points were sampled at different elevations on the slope and several factors such as creeks, roads, canopy openness etc. were noted. The data was statistically analyzed using a t-test with a 5% confidence interval. The weather conditions were partly rainy with high humidity

Results

Figure 1. Graph showing the relationship between infiltration rates and slope



Effect of slopes on infiltration rates

Of the fourteen points sampled/measured, a statistical analysis resulted in a 98% confidence limit (Anova). The results show that the infiltration rate increases as the degrees of slope increases.

Discussion

The method used was sufficient for a rapid assessment, however in order to determine the levels of infrastructure development for ecotourism, additional parameters such as soil cover, canopy openness etc. should be considers for measurement. It was observed that with partial canopy openess, higher infiltration rate was recorded. It is possible that higher evaporation rates due to canopy openness can explain this occurrence. The infiltration rate at the bottom of the slope was slower. It was observed that the soil was highly saturated due to heavy rainfall or soil type. A follow up study to the influence of the vegetation on the infiltration rate has to be conducted. As earlier mentioned the soil types of the slopes were sandy loam with patches of clay which are undisturbed hence frequent passage of machines in the proposed area of development can lead to unwanted soil compaction (Benthaus and Matthies, 1993). Advice must be given that care should be taken in using machines and other equipment to reduce the danger of erosion.

Recommendation

These are the results obtained and it is recommended that in order to have minimal effect on the infiltration rate the developer has to adjust the buildings to the slopes.

Acknowledgment

This research would not be possible without the help of many persons and organisations. We wish to thank our trainers; Professors F.Putz and R.Fraser, and A.Shenkin for their guidance. Thanks to TBI-Suriname, SBB, FAO and CELOS for their support.

Effects of litter on soil water infiltration rates in a tropical swamp forest in Suriname

Anand Roopsind, Mayra Esseboom, Gunovaino Marjanom, Albert Galljon, Rajindra Mahabir

ADD INSTITUTIONAL ADDRESSES OF ALL AUTHORS

Abstract

Many a~~A~~nthropogenic impacts ~~associated with development in~~ tropical forests result in soil compaction and reduced rates of water infiltration~~continue to alter forest ecosystems negatively~~. We assessed *ACTIVE VOICE, PASSIVE TENSE* ~~The research undertaken was done to assess~~ if~~ a management prescription of~~ by ~~-~~maintaining leaf litter, ~~- reduces~~ soil compaction on trails is reduced~~, thus maintaining infiltration rates in a swamp forest~~. We found~~The results indicated a positive relation of~~ that the presence of leaf litter served to ~~with~~ maintain~~ing~~ *AVOID GERUNDS—THE "ING" FORM OF VERBS* infiltration rates along forest paths, compared to areas from which ~~with no~~ leaf litter was removed, but found no benefit from doubling the leaf litter thickness before compaction.

Keywords: ~~Suriname; water infiltration; leaf litter;~~ T~~t~~ropical swamp forest; S~~s~~oil compaction; Erosion; Soil hydrology

1.~~0~~ Introduction

Tropical forests are threatened by~~because of~~ multiple human activities ~~anthropological reasons~~ including land conversion, logging, and mining activities~~ (ref)~~. Tropical swamp forests are especially susceptible to degradation because of their ~~high water inflows and~~ water~~-~~logged soils are especially sensitive to damage from heavy machinery and even pedestrian traffic.~~(ref)~~. Maintaining vegetation cover and leaf~~soi~~l litter on such sites should serve to protect the soil surface and thereby ~~would thus~~ minimize erosion~~ levels in forest ecosystems (ref. of such studies)~~.

We~~This study was designed to~~ assessed the effect of maintaining leaf litter on infiltration rates in a swamp forest in an area proposed for tourism development. Our motivation springs from the expectation that t~~T~~he site will~~is expected to~~ undergo increase levels of compaction, especially along current and proposed trails.~~ currently existing and proposed to be developed~~.

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2.~~0~~ Methods

2.1 Study site

The study area ~~is located~~ in Suriname (5◦25'N,54◦59'W) is at an elevation of 68 m near the~~, on~~ theeast~~ right~~ bank of the Suriname River. The area is in the district of Para in the Carolina Resort in the Amerindian village of Redi D~~d~~oti.

The sample sites were approximately 25 m~~eters~~ from the edge of the river but above the areas with signs of frequent ~~seasonal~~ inundation that were ~~associated with high water levels. The forest type is a riparian swamp forest,~~ dominated by *Pterocarpus officinalis* (~~W~~watra bebe) species. The -eight

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~~Eight random~~ sites were selected at random for the water infiltration study were in an area with nearly closed~~. The forest canopy and soil type was uniform at all eight sites with forest~~ canopy cover ~~being approximately(~~ 90%) and a clay~~-ey~~ loam soil~~ type dominating in the first 10 cm from a soil profile~~. At 30 x 30 cm each site we either left the leaf litter alone (control) or removed it and added it to another site (litter x 2) before

~~All eight sites were given the treatments of control, leaf litter removed, and leaf litter X2 (removed leaf litter added). Additionally, all the sample sites were compacted to~~ simulatinge pedestrian and machine traffic by stomping on the soil ten times.~~ that is projected to increase on the trails with the proposed development~~.

2.2 Data collection

~~The study was carried out by using 30 cm quadrants placed in the eight random sites.~~ Infiltratrometers~~or meters made of~~ constructed of 20 cm lengths of 10.5 cm diameter PVC were ~~with a diameter of 10.5 cm and a length of 20 cm was use to measure the infiltration rate in each sample site. Each infiltrator was embedded at the depth of~~ inserted 10 cm in the soil after the compaction treatment. Water was poured into the infiltrator and the absorption rate was timed and recorded in s~~measured at a rate of sec~~/cm; timing was stopped at~~ with a maximum time of~~ three minutes and the drainage rate was calculated.

2.3 Data analysis

The data summary statistics recorded at all eight sample sites (Table 1) were plotted into a histogram to show the distribution of infiltration rates (figure 1).

Control		***No Litter***		***Litter X2***	
Mean	**21.58**	**Mean**	**79.36**	**Mean**	**16.50**
Standard Error	5.61	Standard Error	16.78	Standard Error	4.54
Median	22.00	Median	89.50	Median	13.50
Mode	1.30	Mode	#N/A	Mode	9.00
Standard Deviation	**15.87**	**Standard Deviation**	**47.47**	**Standard Deviation**	**12.84**
Sample Variance	**251.93**	**Sample Variance**	**2,253.28**	**Sample Variance**	**164.86**
Kurtosis	-0.91	Kurtosis	-0.65	Kurtosis	-0.44
Skewness	0.04	Skewness	-0.60	Skewness	0.78
Range	44.70	Range	137.10	Range	36.00
Minimum	1.30	Minimum	3.90	Minimum	3.00
Maximum	46.00	Maximum	141.00	Maximum	39.00
Sum	172.60	Sum	634.90	Sum	132.00
Count	8.00	Count	8.00	Count	8.00

Table 1: Summary statistics from infiltration rates based on the 3 treatments

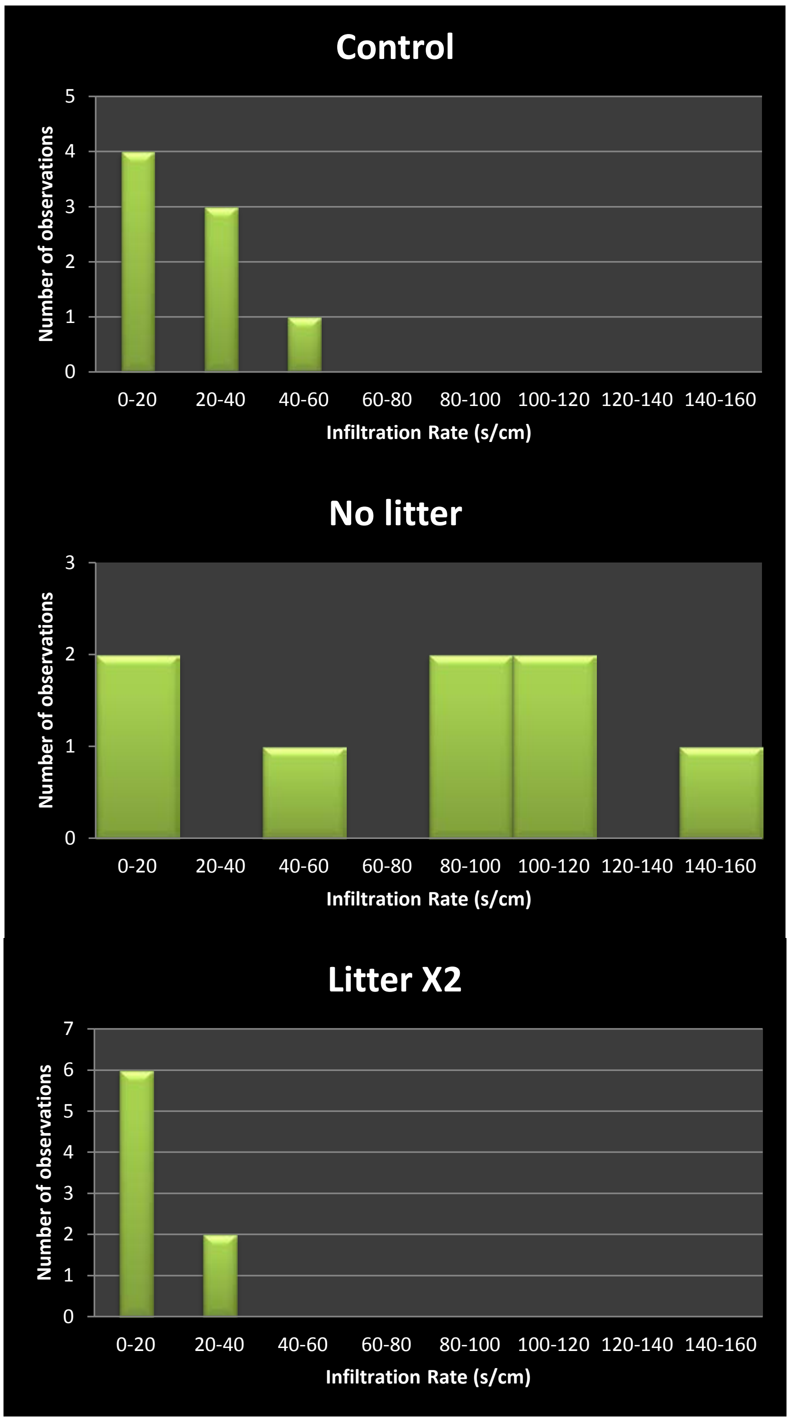

Fig.~~ure~~ 1.~~: Histogram distribution of values recorded from the three treatments~~ *A FIGURE AND ITS LEGEND NEED TO "STAND ALONE", BY WHICH I MEAN THAT THEY NEED TO BE COMPREHENSIBE WITHOUT REFERENCE TO THE TEXT.*

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Fig. 1. Rate of water infiltration into soils that were experimentally compacted after their leaf litter was removed, leaf litter was left intact, or leaf litter depth was doubled. ~~Infiltration rates of the different treatments from all eight sample areas were compared using a one tailed t-test. The T-test was one-tailed because hypothesis was in one direction~~.

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3.~~0~~ Results

The mean rate of water infiltration after experimental compaction into the control (mean = , s =) and litter x 2 plots (mean = , s =) did not differ (t = , $P>0.1$) but both were faster than into the litter removed plots (mean = , s = ; t = , $P<0.01$).~~The analysis of the values between the control-no litter and the litter X2-no litter treatments showed a significantly faster (s/cm) infiltration rate in the sites with leaf litter, the control and the litterX2 treatments. However, there was no statistically significant difference in the infiltration rates between the control and the litter X2 treatments.~~

~~The results thus indicate that generally leaf litter has a positive effect in maintaining soil infiltration rates after undergoing soil compaction related to traffic.~~

4.0 Discussion~~Conclusion~~

The presence of ~~analysis of the results implies that~~ leaf litter served to ~~has a positive effect on~~ maintain~~ing~~ water infiltration rates in soils subjected to compaction ~~in swampy riparian forests after undergoing soil compaction.~~ The cushioning effect of litter seems like the most likely explanation for this finding. It is less clear why doubling leaf litter thickness did not confer any additional benefits to the soil. Clearly, however, ~~Thus~~ leaf litter should ~~not be removed when constructing trials in forests, and as much as possible be maintained~~ retained during~~ any~~ establishment and use of forest trails.

~~The results though do not indicate any additionality with regards to faster infiltration rates when leaf litter is doubled. However, more in depth research is necessary to investigate how much litter should be added to have an effect on infiltration rates in compacted areas. Also the researchers' advice to do more sampling in order to make a more definite conclusion on the issue.~~ *THIS SORT OF WHINING/COMPLAINING IS ALWAYS POSSIBLE AND DOESN'T ADD ANYTHING MUCH TO THE STORY*

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Acknowledgements ***VERY GRACIOUS BUT TWICE AS LONG AS IT SHOULD BE…REMEMBER THAT PAGE CHARGES ARE HUGE, OFTEN HUNDREDS OF DOLLARS PER PAGE.***

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This research was part of the training Forest Research Methodology which took place in May 2011 in Suriname. We thank Verginia Wortel of the Centre of Agricultural Research in Suriname (CELOS) and Wedika Hanuman of Foundation for Forest Management and Production Control in Suriname (SBB) for organizing and giving us the privilege to participate in this training and to meet our colleagues. Gratitude should be given to Professor Francis Putz and Professor Rory Fraser and Alex Shenkin who provided us with new knowledge and new insights for forest research. Their guidance and patience have brought the authors on a higher level of practical research on forest related issues. Finally we are grateful to Tropenbos International-Suriname

(TBI) and the Food and Agriculture Organization (FAO) for providing funding for this field course.

~~References~~

Edge-Effect Papers

Snag density and decay decreases with canopy openness along a selectively logged forest in Suriname

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Abstract

Snag density was assessed along a forest road to investigate edge influence due to road building and associated changes in forest structure in a selectively logged forest in Suriname. I sampled a 20 m wide strip along the edge of a logging road and a parallel 20 m wide strip 50 m into the forest. The density of snags > 20 cm dbh and > 2 m tall was significantly higher (76 snags/ha) in the forest interior than on the logging road edge (21 snags/ha). Forest interior snags were also more decayed, ($\bar{X}$ decay class was 3.3) compared to along the logging road ($\bar{X}$=1.8). A regression analysis conducted on the combined data on canopy openness and decay for snags on the edge of the road and the forest interior found that the canopy closed snags were more decayed ($r^2 = 0.31$). It is likely that canopy closure offers protection and thus increases the amount of time snags remain standing.

Keywords: Edge influence, Forest structure, Logging

1. Introduction

Deforestation and degradation due to anthropogenic pressures and climate change constitutes the greatest threat to tropical forest biomes (Achard et al., 2002). Industrial logging is one such driver of forest loss (Laurance and Peres, 2006) with the potential to increase forest loss further due to the subsequent deterioration of the adjacent forests associated with the creation of forest edges.

Edge effects include a wide range of environmental and ecological changes that occur in forests near clearings (Brant et al., 2010). Forests near edges are generally hotter, drier and more likely to experience elevated wind turbulence than intact forests. These factors have been associated with increase tree mortality after forest edges have been created. Forest roads built during logging operations represent a major loss of living forest biomass directly from clearance and subsequently from tree mortality related to damage, increased desiccation and wind throw (Laurance et al., 1997). Trees adjacent to newly exposed edges, both from road construction and logging gaps, are highly susceptible to physiological stress, mechanical damage and death (Laurance et al., 1998), This has been associated with an increase in the abundance of snags along forest edges (Harper et al., 2005).

Given the large amount of tropical forest that is and will be exposed to anthropogenic forest edges in logging areas, and the associated carbon emissions, edge effects deserve further study. Most studies focus on the immediate creation of snags and tree mortality in recently logged forests, with little research on the magnitude of edge influence over time.

I examined snag density, decay and canopy openness along an 8-year-old logging road and 50 m within the logged forest. The main objectives of the study were to: (1) measure snag density along the logging road and the forest interior (2) determine if canopy openness is correlated with the wood decay class of snags observed.

2. Materials and methods

2.1 Study region

This study was undertaken in May 2011 in the district of Para in Suriname (5° 18’N, 18°59’W) at an elevation of 40 m within the Eco-Timber Suriname logging area (concession # 219). The forest is classified as lowland tropical forest on white sand and loamy soils. The area was logged approximately 8 years prior to the study during which logging was underway again. The road under study was upgraded from a main skidder track to a truck road in 2009. The area closest to the study site (Paramaribo) has a mean annual rainfall of about 1800 mm and is characterized by a bimodal pattern with more rain in May-June and December-January.

2.2 Sampling design

A point sampling technique was utilized in this study to estimate snag density per hectare along a 20 m strip running parallel to the road and a 20 m strip located 50 m into the forest interior. I defined a snag as a standing dead tree ≥ 20 cm diameter and ≥ 2 m tall.

Starting at a random point along the road, I observed for snags within the 20 m sampling strip. Once a snag was encountered, the distance walked was recorded. The start of subsequent sampling points was based on the previous distance walked plus a random number. The area (m^2) a snag occupied was calculated using the formula of a rectangle, the width being fixed at 20 m and the length equal to the distance walked. This was scaled up to estimate snags per hectare. This sampling method was repeated in the forest interior. A canopy openness class (1=0-20%, 2=20-40%, 3=40-60%, 4=60-80% and 5=80-100%) and a decay class (Table 1) was assigned to every snag recorded.

Decay Classes	**Value**
Twigs and bark intact	1
Bark loose and no twigs	2
Sapwood decayed	3
Bark falling off with sapwood	4
Rotten throughout	5

Table 1. Decay classes assigned to snags along a logging road and in the forest interior to assess snag persistence.

2.3 Data Analysis

The snag distance along the road and the forest interior were log10-transformed to utilize the student’s t to compare snag density. Regressions analysis was used to test for a relationship between canopy openness and snag decay.

3. Results

3.1 Snag density

Mean density of snags >20 cm per in the forest interior (76.0 ± 16.11 snags/ha; mean ± S.E) was almost 4 times higher than the mean snag density along the road (20. 6 ± 3.91 snags/ha; t=4.9, P<0.01). The maximum and minimum density of snags observed along the road was 83.3 and 7.5 snags/ha respectively whereas in the forest interior the values were 250.0 and 15.6 snags/ha respectively (Fig. 1).

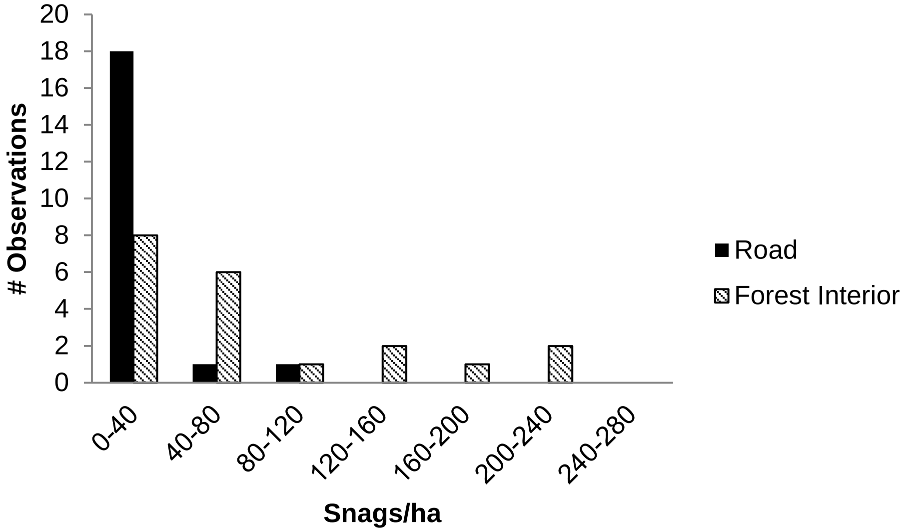

Fig.1 Snag density along an 8-year-old logging road and in the adjacent forest interior.

3.2 Canopy openness and snag decay class.

Canopy openness over snags along the road ($\bar{X}$3.35 ± 0.15; mean ± S.E) was greater than in the interior of the forest ($\bar{X}$1.15 ± 0.08; t=12.9, P<0.01). Snags were less decayed along the road ($\bar{X}$1.8 ± 0.16) than in the forest interior ($\bar{X}$3.25 ± 0.30; t=4.31, P<0.01).

All snags sampled in the forest interior had a canopy openness class below 3, whereas along the logging road the majority of snags (95%) had a canopy openness class between 3 and 5 (Fig. 2). Sixty-five percent of snags recorded in the forest interior were in decay classes 3-5, whereas sixty five-percent of snags recorded along the road were classified as being in decay classes 1-3 (Fig. 3). Regression analysis showed decay class of snags increased with decreasing canopy openness (r^2=0.31, P=0.0001).

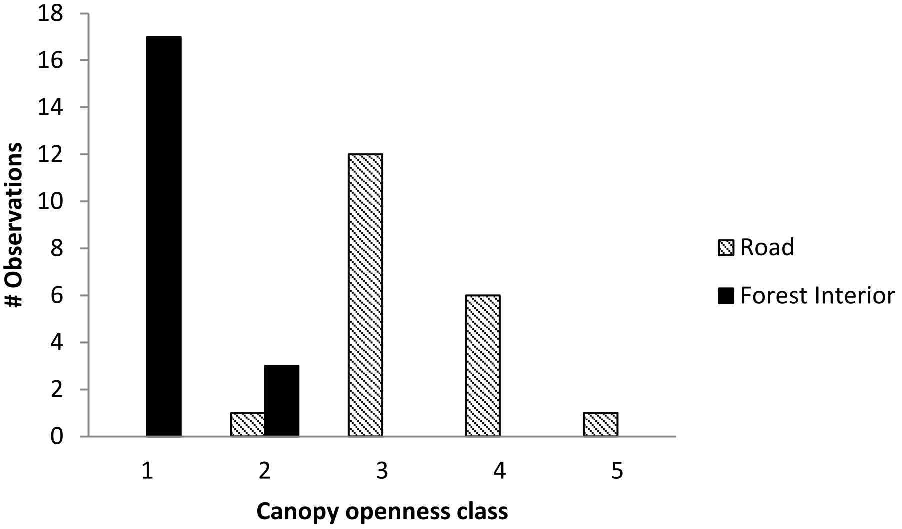

Fig. 2. Canopy openness class (1=0-20%, 2=20-40%, 3=40-60%, 4=60-80% and 5=80-100%) for snags.

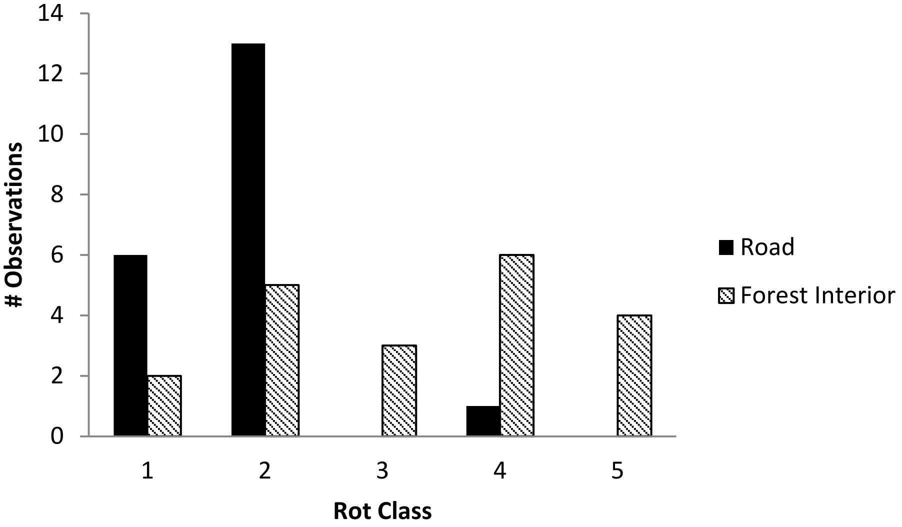

Fig. 3. Decay class (1=twigs and bark intact; 2=bark loose and no twigs; 3=sapwood decayed; 4=bark falling off with sapwood; 5=rotten throughout) for snags.

4. Discussion

The unexpected observation that snag density was higher in the forest interior than along the edge of the logging road, suggests that not many snags were created as a result of edge influence (EI). The magnitude of the EI was calculated using Burton's (2002) formula as -1.47. This contrasts with previous studies examining tree mortality after logging, which showed higher snag occurrence along such forest edges (Harper et al. 2005, Laurance et al. 1998). A softening of the magnitude of the EI reported in these studies would have been expected but not such a mark reversal.

4.1 Snag decay class: edge influence along roads vs. in the forest interior

The majority of snags recorded in the interior of the forest were more decayed, especially when found under a closed canopy. High canopy cover could offer protection to snags from wind turbulence. In contrast, snags along the road, which were mainly in the lower decay class, experienced higher canopy openness. These snags are most likely toppled by wind turbulence as they start to become structurally weak from decay. This phenomenon could be similar to the effect recorded by Burton (2002) regarding the magnitude and distance of EI for tree damage and wind throw relative to the edge orientation of the prevailing winds.

The proposed faster transition rate from standing snags to fallen coarse wood debris along the road could imply a higher rate of emissions from committed carbon associated with logging. Additionally, in the Guianas, which are characterized by low soil fertility and closed nutrient cycling system, this could mean faster growth rates by colonizer species along forest edges.

Although the study observed higher snags density in the forest interior than along the road, this could be a deviation from the standard EI of logging roads. As such, more studies need to be conducted to quantify the long term EI of logging roads on snag density through time.

Acknowledgments

This research was conducted as part of the training course on Forest Research Methods in Suriname. We thank the CELOS team for sponsoring the training and arranging all the logistics for the field work. We thank also Dr. Francis Putz, Alex Shenkin and Professor Rory Fraser for facilitating the course.

References

Achard, F., Eva, H., Stibig, H-J., Mayaux, P., Gallego, J., Richards, T., Malingreau, J-P. 2002. Determination of deforestation rates of the world’s humid tropical forests. Science 297:999-1002.

Briant, G., Gond, V., Laurance S.G.W. 2010. Habitat fragmentation and the desiccation of forest canopies: a case study from eastern Amazonia. Biological Conservation, doi:10.1016/j.biocon.2010.07.024.

Burton, P. J. 2002. Effects of clearcut edges on trees in the sub-boreal spruce zone of northwest-central British Columbia. Silva Fennica 36, 329-352.

Harper K.A., Macdonanld S.E., Burton, P.J., Chen, J., Brosofske, K.D., Saunders S.C., Euskirchen, E.S., Roberts, D., Jaiteh M. S., Esseen, P-D. 2005. Edge influence on forest structure and composition in fragmented Landscapes. Conservation Biology 19, 768-782.

Laurance, W.F., Bierregaard, R.O.J. 1997. Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities. The University of Chicago Press, Chicago.

Laurance, W.F., Ferreira, L.V., Rankin-de Merona, J.M., Laurance, S.G. 1998. Rain forest fragmentation and the dynamics of Amazonian tree communities. Ecology 79, 2032-2040.

Laurance, W.F., Peres C.A. (Eds.). 2006. Emerging Threats to Tropical Forests. University of Chicago Press, Chicago.

Edge effects on leaf litter along a forest road in Suriname

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ABSTRACT

Forest roads are an integral part of most logging operations and affect adjacent forests. In this study the effect on leaf litter depth of being near a road was investigated in a logging concession in Suriname. The depth of leaf litter was measured at five points (0, 1, 2, 4, 8 a nd16 m) along each of ten transects from at the road's edge into the forest interior. The depth of leaf litter decreased as the distance from the road edge increased.

Key words: Litter depth, Timber concession, Nutrient cycling, Tropical forestry.

1. Introduction

Humans are affecting tropical landscape in profound ways and no location has been unaffected by our species (Malhi & Phillips, 2004). For example, forest road construction disturbs natural forests directly and exposes the adjacent forests to various edge effects. Roads change the dynamics of adjacent forest, for example, due to increased sunlight penetration. This increased light may stimulate recruitment and allow established plants to increase their growth and leaf production. Due to lower humidity near edges, leaf decomposition rates may decline. Due to these changed conditions, leaf litter is expected to accumulate along road edges.

2. Study area

The study was conducted in highland forest within the concession of ETS Suriname (N05°18.5′; W55°0.04′). Sandy clay was the main soil type at this location.

3. Methods

Ten transects were established at 10 random intervals along roads, beginning from the first tree greater than 20cm dbh, then extended into the forest at 90° to the road. Litter depths from the soil level to the top of leaves were measured with a 30cm ruler at points 0, 1, 2, 4, 8 and 16 m along the transects.
Using MS Excel a linear regression analysis was used to analyze the data statistically.

Results

Leaf litter was thicker closer to the edges of roads than the forest understory (Fig.1 $p<0.05$, $R^2=0.23$). Plots at 0, 1, 2, and 4 m had thicker leaf litter than those at 8 and 16 m. The range between the highest and lowest values collected was 8.2 cm and 1.5 cm, respectively.

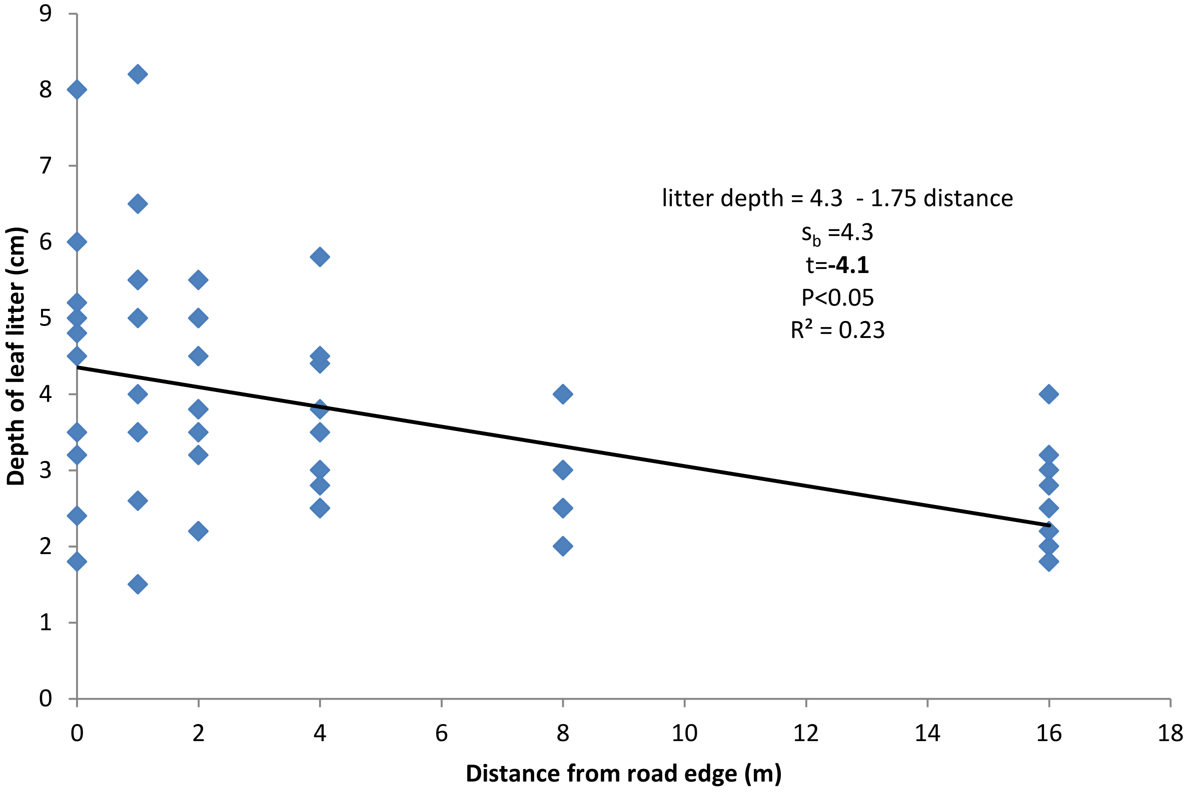

Fig.1. Leaf litter depth as a function of distance from the edge of an 8-year old logging road in Suriname.

4. Discussion

There was a decrease in leaf litter depth as the distance from the road into the forest understory increased. This result may be attributed to the higher moisture content in the understory litter which may be conducive to faster decomposition than along the bright, sunny, and dessication-prone road edge.

Acknowledgments

I thank Professors F. Putz and R. Fraser, and A. Shenkin for their guidance. Thanks to TBI-Suriname, SBB, FAO and CELOS for their support. Thanks to ETS for affording me the opportunity to use their concession to conduct this study.

References

Malhi, Y., Phillips, O.L. 2004. Tropical forests and global atmospheric change: a synthesis. Philosophical Transactions of the Royal Society

Tree crowns are wider towards the forest edge than towards the forest interior in Suriname

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ABSTRACT

Along a road through a logging concession in Suriname, I investigated crown width responses to a forest edge. Of 25 trees ≥ 20 cm dbh, crowns were an average of 13.7% wider towards the road than towards the forest interior. The crown width differences were between -4 to7.4 meters of 25 trees ≥ 20 cm dbh.

Keywords: Tree crowns, Savanna forest, Forest edge, Edge effects

1. Introduction

Tropical forests are threatened by many human activities including logging. Even selective logging requires the construction of roads, which changes the landscape structure and creates forest edges. Towards forest edges light availability increases, which may stimulate growth.
Crown trees are strongly asymmetrical away from near neighbors (Young and Hubbell, 1990). To determine the effect of being on a forest edge created by a road influences the crowns of trees, I measured the crown widths towards and away from the road opening.

2. Materials and methods

2.1. Study Area

The study area is located along an 8-year old road through the ETS (Eco Timber Suriname) logging concession at an elevation of 40 m (5°18'N, 55°43'W) in the District of Para in Suriname. The soil is sandy to loam and the forest type is mixed tropical rainforest.

2.2. Experimental design and data analysis

Trees with ≥ 20 cm dbh were picked at random along the road. Crown radii were measured towards the edge and towards the interior, the length of the crown was measured with a measure tape and clinometers. The recorded data was analyzed with t-test paired and one tailed.

3. Results

Tree crowns were on average 1.28 times wider in the direction of the road than in the opposite direction towards the forest interior ($t_{\text{paired}} = 2.6$, $P < 0.05$, d.f.= 24; Fig. 1)

4. Discussion

Tree crowns are wider towards roads than towards forest interior. Open habitat, in this case the road, tends to allow more sunlight to reach tree crowns that also experience greater temperature extremes and lower humidities that may also have effects on their growth. Growth also can depend on tree species, leaf size, neighborhood, wind directions, and other factors.

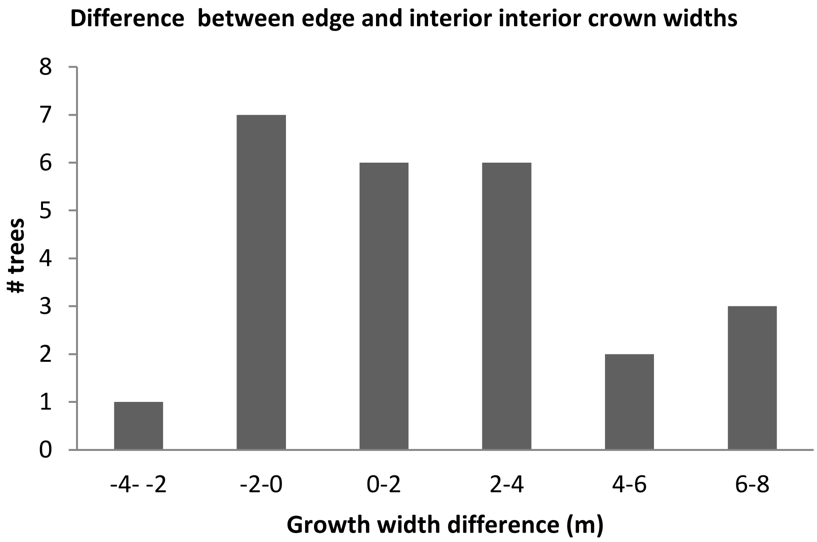

Fig. 1. Crown width difference (towards road-towards forest) along a logging road in Suriname.

Acknowledgments

I thank F. Putz, A. Shenkin, and R. Fraser for their guidance and patience. Also Mr. Solikin of ETS for his assistance in the field.

References

Young, T., Hubbell,S. 1991. Crown asymmetry, treefalls, and repeat disturbance of broad-leaved forest gaps. Ecology 72, 1464-1471.

Edge effects on coarse woody debris and mushroom density in a logged forest in Suriname

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ABSTRACT
Logging is increasing in Suriname and more study is needed to understand its effects on forests. I studied the density of fallen logs > 20 c m diameter and presence of fungal fruiting bodies (macrofungi) on the edge of a forest logging road and 25 m into the interior of the. While log density did not vary, fungal fruity bodies were twice as often at the edge than in the interior.

Key words: Macrofungi, Coarse woody debris, decomposition rates, tropical ecology

1. Introduction

Logging activities have increased recently in Suriname, but little is known of the effects of these activities on forest ecosystems. For example, logging road construction creates forest edges near which there are many possible abiotic and biotic environmental changes (Ghazoul and Sheil, 2009).

Fungi, which are important decomposers of wood, may respond to edge effects that influence coarse woody debris abundance and moisture contents. To assess these potential effects, I evaluated the abundance of coarse woody debris and the presence of fungal fruiting bodies (i.e., mushrooms) near and away from a logging road.

2. Study area

This study was conducted in the early rainy season in the EcoTimber Concession Suriname (5^0 18’N, 55^0 W) in dry land forest at an elevation of 40 m. The weather conditions at the time of the study were mostly rainy with high humidity. The concession is certified as well managed by the Forest Stewardship Council and reduced-impact logging guidelines are followed. I sampled along an approximately 15 m wide logging road created during the first round of logging some 8-10 years prior to my study.

3. Methods

The density of fallen logs > 20 cm diameter was estimated by measuring the distance between logs on transects parallel to the road at 5 and 50 m into the forest. Fungal fruiting bodies (=mushrooms) on 2 m sections of the encountered log were counted. Log densities near and far from the road wee compared using a t-test and the presence or absence of mushrooms was analyzed using a chi-square test.

4. Results

The density of fallen logs > 20 cm diameter was not higher on in the forest edge than in the interior (variance $_{edge}$ = 3.8; variance $_{interior}$=3.7; mean$_{edge}$= 3.6; mean$_{interior}$=3.8).

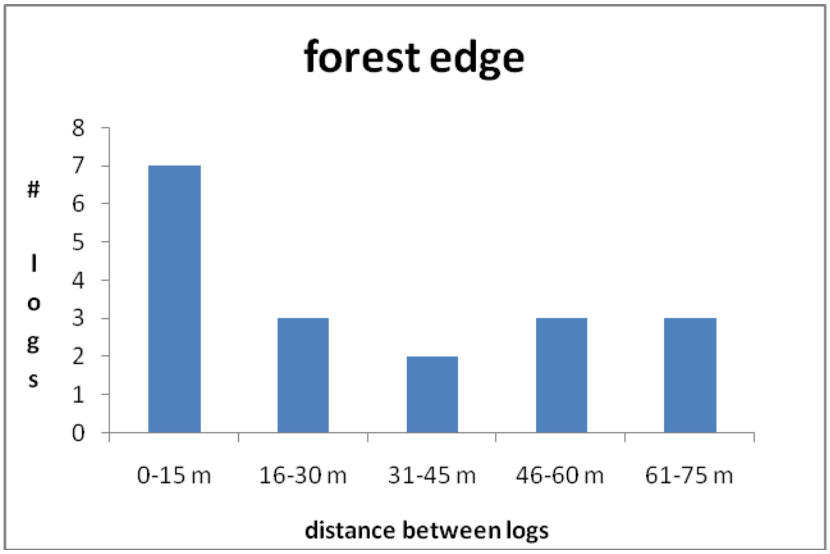

Fig.1. Distances between logs on the edge of a logging road.

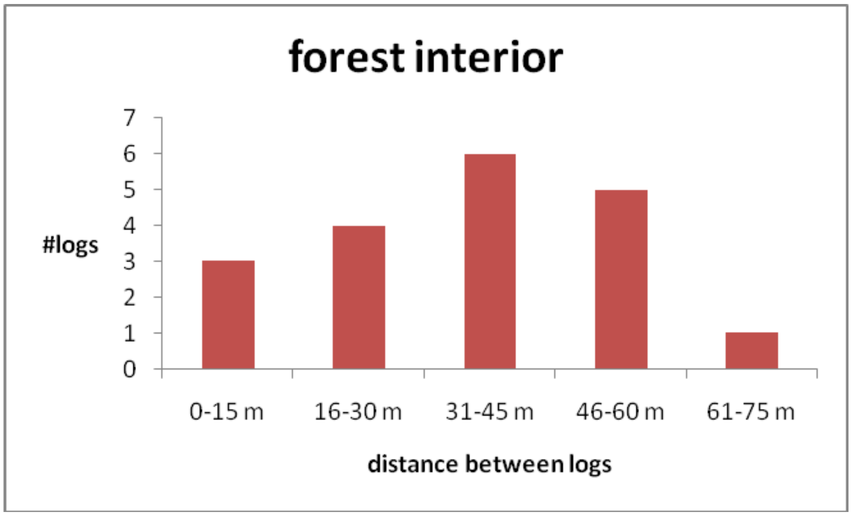

Fig.2. Distances between logs in the forest interior.

Table 1. Presence and absence of fungal fruiting bodies on 2 m-long sections of fallen logs > 20 cm diameter on the forest edge and the forest interior.

	Edge	Interior	Total
mushrooms	10	4	14
no mushrooms	10	16	26
total	20	20	40

The incidence of mushrooms on 2 m section of fallen logs on the forest edge was twice that observed the forest interior (X^2=3.9, $P<0.05$).

5. Discussion

Edge effects of forests are previously not studied in Suriname. Research conducted elsewhere in the tropics (e.g., Briant et al. 2010) indicates that these impacts should be taken seriously. The findings of this research can be used in future studies on decomposition and the production of edible and otherwise useful mushrooms.

Acknowledgments

I wish to thank Professors F.Putz and R.Fraser, and A.Shenkin for their guidance and TBI-Suriname, SBB, FAO and CELOS for their support.

References

Ghazoul J., Sheil D., 2009.Tropical Rain Forest Ecology, Diversity, and Conservation. Oxford University Press, Oxford, U.K.

Impacts of forest fragmentation on seedling density in a mixed lowland tropical rainforest in Suriname

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ABSTRACT

To evaluate the impacts of forest fragmentation on seedling densities along the edge, I measured the regeneration of all woody seedlings <1 m tall in a forest bisected by a logging road in Suriname. Seven 4 m plots were established along six transects that started at the edge and progressed 2.5, 5, 10, 20, 30, and 40 m into the forest. Seedling densities peaked at intermediate distances from the edge. Low seedling density near the road may have been due to reduced seed input and the effects of logging road maintenance. Low seedling densities further into the forest may have been due to low light availability.

Keywords: Edges effect, Seedling density, Fragmentation

1. INTRODUCTION

Seedlings under closed canopy are often the most important source of regeneration for shade tolerant tree species (Denslow, 1987; Withmore, 1989; Martinez- Ramos & Soto- Castro, 1993). The abundance, distribution, and composition of seedlings can be affected by disturbances such as gap formation, logging road construction, skid trail development, herbivory, and even litter fall. According to Kapos (1989), forest fragmentation leads to environmental changes that drastically influence understory conditions. When an edge is created, seedlings are forced to cope with abruptly modified environmental conditions (Williams-Linera 1996). I tested if forest fragmentation of a mixed lowland tropical rainforest by a logging road influenced seedling regeneration along the edge.

2. METHODS

2.1 Study site

This study was conducted in Block 219 of the Eco Timber Suriname logging concession (N 05^0 18.5’, W 55^0 00’) at approximately 40 m above sea level. The forest is classified as a mixed lowland tropical forest on white sand and loamy soils. The area was selectively logged 8-10 years before this study, and it was heavily logged again with Forest Stewardship Council certification .

2.2 Sampling design and data collection and analyses

Plots of 4m^2 were established at 0, 2.5, 5, 10, 20, 30 and 40 m into the forest from the road edge along transects that were located at random. All woody plants < 1 m tall were counted and the relationship between distance into the forest and seedling density was assessed using regression analysis. . Before analysis, the count data from each transect were relativized and expressed as a proportion of seedlings per plot per transect since I was only interested in how edges modified regeneration, not total regeneration.

3. RESULTS

Polynomial regression revealed an increasing then decreasing pattern for seedling density from road edge to 40 m into the forest interior. The forest edge effect ended approximately 10 m from the road edge (Fig.1) which means that seedling density increased to 10 m within of the forest edge. Beyond 20 m into the forest seedling density decreased again.

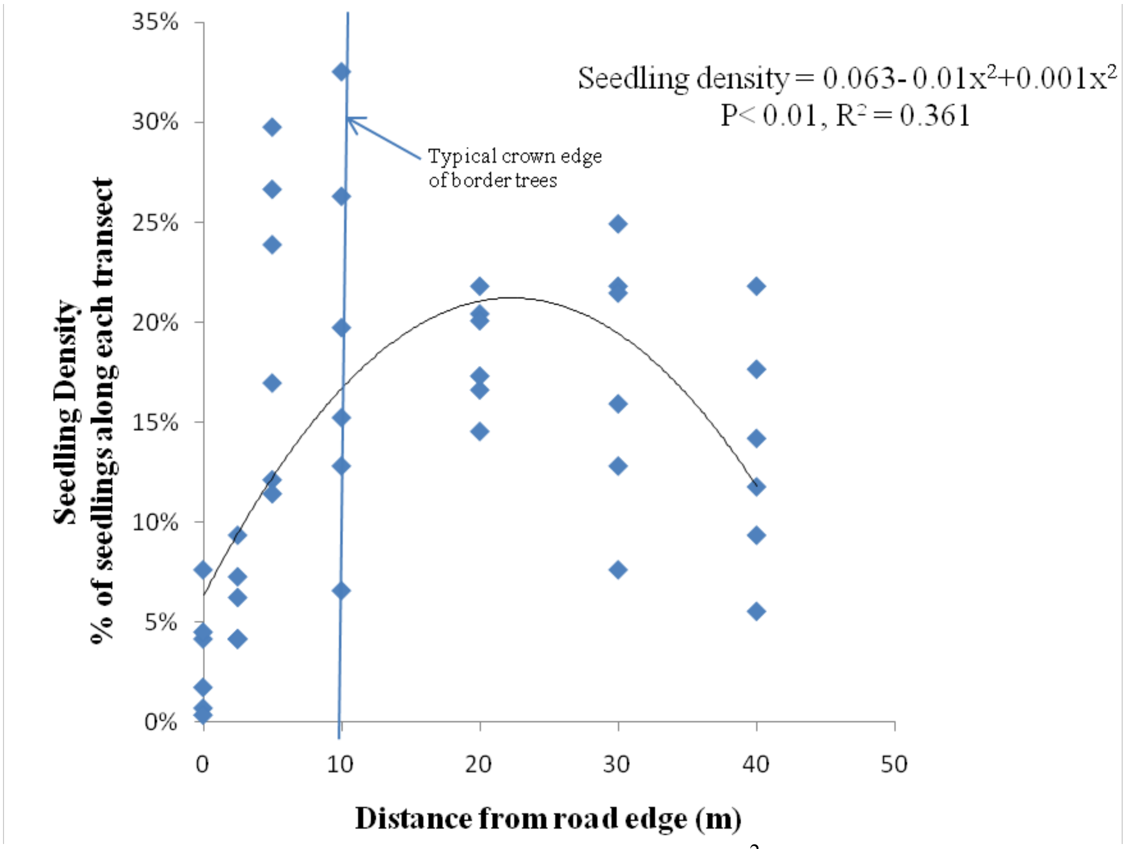

Fig. 1. Percentage of all woody seedlings < 1 m tall in 4 m^2 plots along 6 transects running from a logging road edge into the adjacent mixed tropical lowland forest in Suriname.

4. DISCUSSION

Woody seedling densities on the road edge and at 40 m into the forest were much lower than at intermediate distances. Loss of pollinators, road construction and maintenance activities, changes in tree phenology, and increases in vertebrate herbivore activity are all potential reasons for low densities on the edge. Adequate side light is a possible reason for the higher densities at intermediate distances into forest. Further into the forest I suspect that deep shade results in low seedling densities.

Decreased seedling density along edges of forest fragments suggests that stand characteristics in the future could be affected. There is limited knowledge about seedling density and composition along edges of fragments, but Alvarez- Buylla et al. (1996) have posited that tropical trees are particularly vulnerable to change in seedling density. Fragmentation reduces the population sizes of tropical trees and the animals on which they depend on for pollination and dispersal, which may limit recruitment of new individuals.

4. CONCLUSION

Proximity to the forest edge along a logging road along transects into the forest from the edge, densities through mixed lowland tropical forest in Suriname is associated with lower seedling densities. Seedling densities increased and then decrease at approximately 40 m into the forest. Increased seedling and sapling densities in the interior of forest fragments appear to be more important than the effects of the edges.

ACKNOWLEDGMENTS

Special thanks to ETS for hosting this study and CELOS and FAO for funding the project. I also like to thank Jack Putz, Alex Shenkin, and Rory Fraser for their edits and other inputs.

REFERENCES

Alvarez- Buylla, E.R., R. Garcia-Barrios, C. Lara- Moreno, and M. Martinez- Ramos. 1996. Demographic and genetic models in conservation biology: application and perspectives for tropical rain forest tree species. Annual Review of Ecology and Systematics 27: 387- 421.

Denslow, J. S. 1987. Tropical rain Forest gaps and tree species diversity. Annual Review of Ecology and Systematics 18: 432- 452.

Kapos, V. 1989. Effects of isolation on water status of forest patches in the Brazilian Amazon. Journal of Tropical Ecology 5:173- 185.

Martinez- Ramos, M. and A. Soto- Castro 1993.Seed rain and advanced regeneration in a tropical rain forest. Vegetation: 108-318.

Whitmore, T. C. 1989. Canopy gaps and two major groups of forest trees. Ecology 70: 536-538.

Williams-Linera, G.1990a. Origin and early development of forest edge vegetation in Panama. Biotropica 22: 235-241.

Williams-Linera, G.1990b. Vegetation structure and environmental conditions of forest edges in Panama. Journal of Ecology 78, 356-573.

Percent cover of herbaceous weedy plants decreases with distance into the forest from a road edge

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Abstract
Forest edge effects (EI) continues to be a topic of active research and discussion. I established six 1 m^2 plots extending up to 16 m into a forest in Suriname from edge of a logging road. While herbaceous weedy plants were more prevalent in plots closer to the logging road, the trend overall was not significant.

Key words: Edge effects, Herbaceous plants, Skid trails, Tropical forest management

1. Introduction

Invasive plant research in tropical forests is of importance to a variety of researchers, managers, and conservationists. It is unknown whether selective logging operations contribute to the vulnerability of natural forests to these invasion, hence, this study attempts to contribute to this body of knowledge.

It is expected that near forest openings, such as those created by logging roads, increased sunlight and exposure to wind action will allow aggressive invasive herbaceous weedy species to thrive. If these infestations are left unchecked, the adjacent forest may be in jeopardy. Understanding what happens on forest edges is thus critical.

2. Study Area

This study was conducted along a logging road through upland mixed forest in the Eco Timbers Suriname concession (5°18’ N, 55° 0’W) in north central Suriname. The study area was first logged 10 years prior to this study, during which it was being logged again.

3. Method

Circular plots 1 m^2 were established along a transect running perpendicular from the road's edge 1, 2, 3, 4, 5 and 16 m into the forest. Woody plants 0.5-2.0 m tall and herbaceous weedy plants <0.30 cm tall were counted in each plot and the proportion that were herbaceous was calculated. The data were analyzed using linear regression with distance from the road as the independent variable and percent herbaceous plants as the response variable.

4. Results

The proportion of plants that were herbaceous decreased with distance into the forest (Fig. 1). The plot 16 m into the forest supported an unusual number of herbaceous plants perhaps because it was near a canopy gap.

5. Discussion

The data show that herbaceous weedy plants are common on the sides of a logging road, as they are along skid trails, footpaths, and other disturbed sites with open canopies. More in-depth research is needed to clarify the factors responsible for this distribution pattern.

6. **Conclusions**

The phenomenon of edge effects still has many other facets that deserve investigation. Furthermore, global climate change, increased frequency of tropical disturbances, and a wide variety of human impacts will continue to dictate the magnitude and distances of edge impacts..

Acknowledgments

The assistance of the SBB and CELOS staff, the guidance of Professors F. Putz, R. Fraser, and A Shenkin, and the encouragement of my fellow course mates are all much appreciated.

Reference

Harper et al. 2005. Edge influence on forest structure and composition in fragmented landscapes. Conservation Biology 19, 768-782.

Reis, L., Sisk, T.D. 2004. A predictitive model on edge effects.

Tarbarlli, M., Lopes, A.V., Peres, C. Edge-effects drive tropical forest fragments towards an early-successional system.

Broken and sprouted trees on a logging road edge and in a forest interior in Suriname

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Abstract

Crown damage and bole breakage are common in both natural and logged forest. I analyzed the difference in densities of sound and broken and resprouted trees 10 – 20 cm and > 20 cm dbh along a logging road and in the forest interior. Broken and resprouted trees of both size classes were rare both along forest edges and in the forest interior and the differences in densities were not significant.

Key words: Canopy gaps, forest fragmentation, coppicing

1. Introduction

The roads needed in logging areas to transport logs may have impacts on the adjacent forest that extend far beyond road edges. During road construction, big trees that are pushed over can damage nearby trees in the adjacent forest. After a while, the edges tends to change in species composition and structure, but some of the broken trees may sprout and not die. To explore the dynamics of forest edges and interior I compared the proportion of broken and resprouted trees on the edge of a logging road and in the forest interior.

2. Methods

2.1 Study area

This study was conducted in selectively logged mixed upland forest in the E-Timber Suriname concession near the Suriname River (N55^0 18’ W055^0 00’). The study area has undulating terrain at an altitude of approximately 34 m and the soil is a patch work of loam and white sand. The forest roads in the study area were constructed 8-10 years prior to this study.

2.2 Sampling design

The study was carried out within 20 m of the edge of a logging road and 50 m into the interior of the adjacent forest. Broken and sprouted trees were counted in 20 m wide strips of a variable length. Trees > 20 cm dbh that were not broken (sound) and broken but resprouted were counted until observation on 50 trees along the edge and 50 trees in the interior were assembled. This procedure was then repeated for trees 10 – 20 cm dbh.

3. Results

Of 50 trees >20 cm dbh along the edge, 48 were sound and 2 were broken-sprouted recorded. In the interior there were 50 sound and 0 broken and sprouted trees. Using á Chi-square test, this difference is not significant (X^2 = 2.04, P >0.1). Along the edge I encountered 34 sound and 16 broken- and -sprouted trees 10 – 20 cm dbh. In the interior there were 36 sound and 12 broken and sprouted trees. The difference is not significant ($X^2 = 0.76$, $P > 0.1$).

4. Discussion

The densities of sprouting of broken trees were low overall and did not vary with tree location relative to a logging road edge in Suriname. Smaller trees are more likely to break and then to sprout. Most large trees in contrast, are unlikely to sprout after being broken. Differentiating trees that broke and sprouted > 20 years ago from sound trees is a challenge that needs to be taken in consideration.

Acknowledgments

This research would not be possible without the help of many persons and organizations. I wish to thank , in particular, Professors F.Putz and R.Fraser, and A.Shenkin for their guidance. Thanks also to TBI-Suriname, SBB, FAO and CELOS for their support of our course.

Palms fruit more on a forest edge in Suriname

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ABSTRACT

Proximity to forest edge often increases resource (e.g., light and nutrients) availability for nearby trees. Palms in a selectively logged forest in Suriname that were close to an 8-year old logging road were more often reproductive than palms in the forest interior. Mostly *Attalea maripa* and *Oenocarpus bacaba* appeared in the forest edge as well as forest interior. In the forest edge 65% of the palms fruited compared to 35% in the forest interior. Increased forest degradation along the forest edge may permit more light penetration and increased access to nutrient, which favors palm reproduction.

Keywords: Tropical Forest, Reproductive palms, Forest interior, Non-timber forest products, Phenology

1. Introduction

Many authors have reported that forest edges influence the structure and composition of forests sometimes causing forest degradation (Harper et al., 2004). Given that many palms are important non-timber forest products (NTFPs) for people in forest communities, investigating the influence of forest edges on their reproduction may be of importance. I therefore assessed the likelihood of reproduction of palms adjacent to a logging road and further into the forest interior in a logging area in Suriname.

2. Methods

2.1 Study site

The study site in Suriname (5˚18’N, 55˚43’W) is at an elevation of 40 m above sea level. The road along which this study was conducted was 8 years old, 10 m wide, and runs through selectively logged upland forest on white sand and loam.

2.2 Data collection and analyses

On 1.5 km of both sites of the road all palms > 8 m tall were recorded as reproductive or not. In the forest edge (< 20 m from the road) and along a transect in the forest interior, palms signs of fruiting (flowering, fruits and seeds).The data were analyzed with a χ^2 contingency test.

3. Results

Of 40 palms observed15 were reproductive on the forest edge. In contrast, only 8 of 40 palms were reproductive in the forest interior. This difference was highly significant ($\chi^{2=}8.32$; $\rho<0.005$) compared to the palms in the interior of the forest. Of *Attalea maripa* 10% (n=8) and respectively of *Oenocarpus bacaba* 40% (n=32) were observed in the forest edge compared to 30% (n=24) resp. 20% (n=16) in the forest interior.

4. Discussion

The observed higher proportion of reproductive palms on a forest edges than in the forest interior suggests the presence of necessary resources for reproduction on the edge. Although wind force can increase mortality of trees near the edge, forest edges can have positive effects on the availability of nutrients and sunlight. The implications of the results for other economic trees can be relevant especially for rural forest related communities in the proximity of forest edges. For livelihood strategies and management practices for rural communities in depth research on both issues is necessary.

5. Conclusion

The results indicate that rural communities can continue use of NTFPs. For management implications more research is recommended.

Acknowledgments

The researcher thanks CELOS, SBB, ETS and the received subsidy of FAO and TBI. A special thanks to Professors F. Putz and R. Fraser as well as A. Shenkin for their guidance.

References

Harper, K. S. MacDonald, P. Buton, J. Chen, K. Brosofske, S. Saunders, E. Euskirchen, D. Roberts, M. Jaiteh and P. Esseen. 2005, Edge influence on forest structure and composition in fragmented landscapes. *Conservation Biology* 19, 768-782

Increased insect population density on a forest edge in Suriname

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Abstract

Insect abundance, as measured by sweep netting in the understory, decreased slightly with increasing distance into the forest along a logging road in Suriname. The only moderate increase in the number of insects collected on the forest edge may have been due to factors such as intermittent rain showers during the sampling period.

Keywords: Biodiversity, Invertebrates, Entomology, Tropical forest

1. Introduction

Forest edges are created by disturbances such as road construction and logging. Along such edges, modified environmental conditions include increased temperatures, light intensities, and wind speeds. In response to these changes, plant species composition often changes along with plant growth rates. In response to changes in environmental conditions and food availability, the insect fauna may also change. To investigate the magnitude of edge effects on insect abundance and the distance into the forest that the effect continues, I conducted a sweep netting study along a logging road in Surimame.

2. Methods

2.1 Study site

The area of the study was located along a logging road opened 8 years previously by the Eco Logging Company (N 5° 19’, W 55° .043’) at 40 m above sea level in a tropical forest in Suriname. The weather was overcast with intermittent showers at the time of the study.

2.2 Data collection

Sampling was conducted along the road by setting 7 randomly placed transects from the edge of the road proceeding into the forest at total distance of 16 m. Ten sweeps of a 30 cm diameter net were made at intervals on the edge of the road and then at 2 , 4, 8, and 16 m into the forest. From each collection, all insects >1 mm body length were counted and classified to order.

3. Results

Insect density decreased slightly but not significantly from the road edge into the forest. Insect caught, in order of decreasing abundance, were Hymenoptera, Diptera, Coleoptera, Orthoptera, Homoptera, Lepidoptera and Hemiptera.

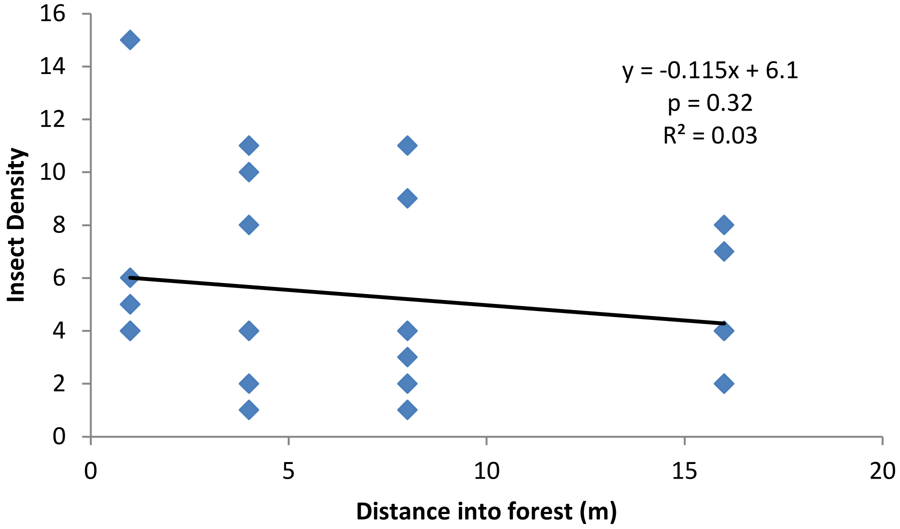

Fig. 1. Density of insects caught with 10 sweeps of a 30 cm diameter net along 16 m transects from the road edge into the forest interior in Suriname.

4. Discussion

Increased abundance of insects near roads could be due to the fact that these edges are exposed to a greater amounts of sunlight, frequent soil disturbances, and reduced root competition. These factors stimulate plant growth, which results in more food for herbivorous insects. In contrast, under closed canopy forest, low light levels due to denser canopy cover limits plant productivity and hence insect abundance.

Acknowledgments

This project was made possible by Professor Jack Putz and improved by discussions with Professor Rory Frazer and Alex Shenkin.

References

Blanchard, J., D. 1992. Light, Vegetation, Structure, and Fruit Production on Edges of Clearcut Sand Pine Scrub in Ocala National Forest, Florida. Msc Thesis, University of Florida, Gainsville, Florida, USA.

Individual Project Papers

Collateral damage by tree felling in a FSC-certified forest in Suriname

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Abstract

The logging damage was assessed by estimating the aboveground biomass (AGB) of damaged trees by the felling of seventeen timber trees. The damaged trees were classified on the basis of the degree of damage to estimate whether they represented immediate or potential future committed carbon emissions. Sixty-eight percent of the trees affected by felling were classified as contributing immediate committed carbon emission (i.e. a high probability of dying). Using Chave's allometric equation for moist tropical forest in combination with an average wood density for trees in the Guiana's ($0.65 g/cm^3$), the AGB of both harvested trees and collaterally damaged trees were calculated. A regression analysis was used to measure the strength of the relationship between the AGB of the tree harvested and the resulting damage. While collateral damage increased with the size of the felled tree ($P=0.075$), the low co-efficiency suggests that many other factors contribute to the amount of collateral damage.

Keywords: Committed carbon emissions, REDD, selective logging, RIL, Sustainable forest management

1. Introduction

Tropical forests are being degraded and cleared at alarming rates, as forests are logged and cleared to supply local, regional, national, and global markets for wood products, cattle, agricultural produce, and biofuels (Alianca da Terra, 2007). Reducing tropical deforestation and forest degradation could play an important role in the overall reduction of greenhouse gas emissions in addition to maintaining other ecosystem services such as biodiversity. Public consciousness about climate change and forest-related emissions has led to a demand for lumber from responsibly managed forests.

Tropical forests managed for timber offer substantial ecosystem benefits, especially related to carbon storage, if damage to the residual stand is reduced through the adoption of good logging practices (Pinard and Putz, 1996). Understanding the patterns of degradation affecting carbon stocks though needs to be continually assessed as carbon savings depend on how well reduce-impact logging practices (RIL) are implemented (Pinard and Putz, 1996). Certification schemes such as that of the Forest Stewardship Council represent a third party assessment of compliance with improve logging practices guidelines.

Greater scrutiny of logging practices and additional research are needed to quantify carbon storage and fluxes in these production forests. This study was undertaken to quantify the damage to aboveground biomass (AGB) in an FSC certified selectively logged forest in Suriname. I examined the committed carbon emissions from collateral damage related to felling trees in the Eco-Timber Suriname concession. The main objectives of the study were to: (1) estimate the aboveground tree biomass killed immediately by felling operations and the biomass of trees put at risk of becoming committed carbon emissions, (2) determine if the diameter and AGB of harvested trees is correlated with the AGB of the collateral damaged trees. Information from studies like this one is needed to predict carbon emissions related to logging practices.

2. Methods

2.1 Study region

This study was carried out in the early rainy season (May 2011) in the District of Para in Suriname (5° 18'N, 18°59'W, 40 m above sea level) within the 20,000 ha FSC certified Eco-Timber Suriname logging concession. The forest is classified as lowland tropical forest on white sand and loamy soils. The area has an estimated mean annual rainfall of 1800 mm with rainy seasons in May-June and December-January. The area was selectively logged 2 months prior to the study, after being logged in 2003.

2.2 Sampling design

Skidding trails were walked and observed for stumps of harvested trees, which resulted in the selection of 17 stumps. At each site (area of influence around felled tree), the diameter (dbh) of the tree stump and all trees ≥10 cm dbh which had damaged were recorded. The damaged trees were ranked based on the probability of dying, if they were not already dead, with a high numerical rank indicating a more severe damage condition (Table 1).

Table 1 Classification of trees damaged during the felling operations

Tree Status	1 = standing alive; 2 = leaning alive; 3 = uprooted alive; 4 = uprooted dead; 5 = standing dead; 6 = cut dead
Stem Form	0 = no cambium opening; cambium opening
Crown Form	0 = no crown damage; 1 – partially broken crown; 2 – broken top no corwn

2.3 Aboveground biomass damage

To estimate the collateral damage from felling, in terms of AGB i.e. committed and likely future carbon emissions, Chave's ABG allometric equation (Fig.1) for moist tropical forests was utilized (Chave et al., 2005) with wood density assumed to be 0.65 g/cm^3.because no species specific information was collected in this study:

$(AGB)_{est} = \rho \text{ x } \exp(-1.499 + 2.148 \ln(D) + 0.207 \ln(D))^2 - 0.0281*(\ln(D))^3$ in which: D=dbh and ρ = wood density (0.65).

Regression analysis was used to estimate the relationship between dbh and AGB of harvested and damaged trees (i.e. collateral damage).

3. Results

3.1 Logging damage

A total of 140 trees ≥10 cm were recorded as having some form of damage associated with felling of 17 timber trees. Diameters of felled trees ranged from 47-100 cm dbh ($\bar{X}$ 71.8). The mean dbh of damaged trees was 23.4 cm (range of 10- 80 cm). The average number of trees ≥10 cm damaged from one harvested tree was 8.2 ± 0.57 ($\bar{X}$ ± SE), with damaged trees classified as committed carbon (tree status 4-6) accounting for 68% of all damaged trees, with the remainder classified as being at risk of emitting carbon in the near future (tree status 1-3).

3.2 Aboveground biomass

The mean ABG of harvested trees was 7.3 ± 0.79 Mg ($\bar{X}$ ± SE) with a mean ABG of trees killed (committed carbon) of 0.6 ± 0.11 Mg ($\bar{X}$ ± SE). The ABG of trees at risk of emitting their carbon in the near future, i.e. damaged but living trees with an increased probability of dying was 0.76 ± 0.13 Mg ($\bar{X}$ ± SE). Regression analysis (Fig.1) revealed a positive relationship between AGB harvested and the total AGB of damaged trees (R^2= 0.20, P=0.075), but the unexplained variation was large. A second regression analysis (Fig. 2) of the relationship between DBH of felled trees and the AGB of trees damaged was also weak (R^2= 0.17, P=0.01).

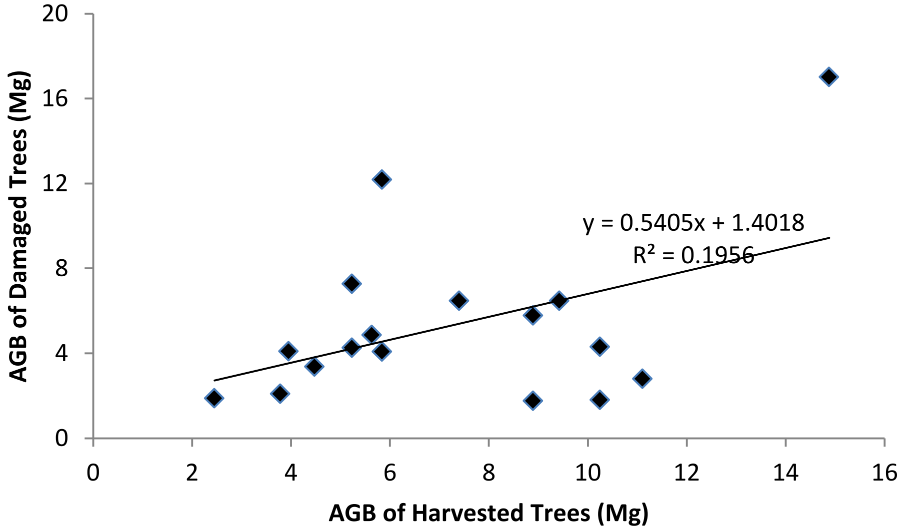

Fig. 1. AGB of trees damaged by the felling of timber trees.

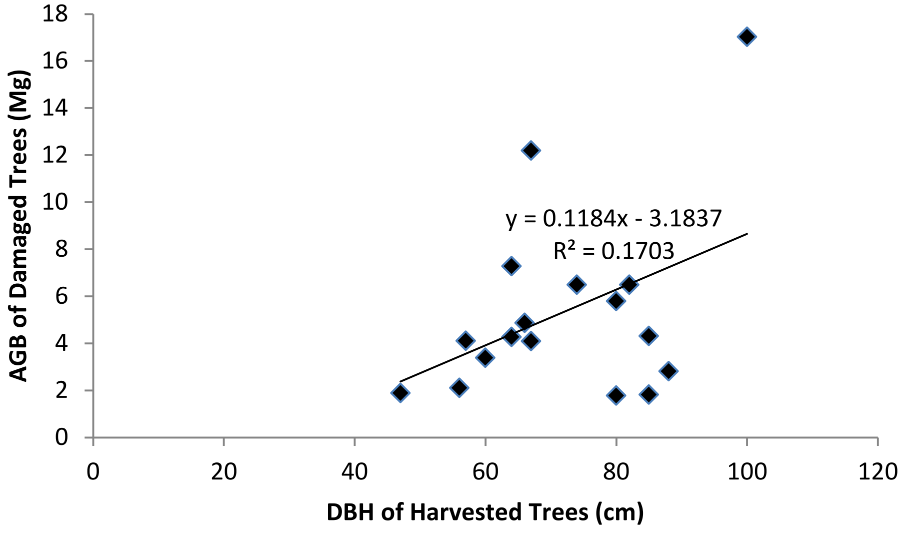

Fig. 2. AGB of all damaged trees as a function of the diameter of felled trees.

4. Discussion

In a selectively logged forest in Suriname, collateral felling damage to trees ≥10 cm dbh increased with the AGB of the felled tree. Thus the future levels of carbon emissions from logged forests will vary depending on the way a forest is harvested. Emphasis should be placed on improved harvesting techniques such as RIL for the purpose of minimizing future carbon emissions related to collateral damage from logging. The application and enforcement of harvest limits (m^3/ha) and harvesting cycles are important to maintain the forest structure and limit carbon emissions associated with logging.

The reduced emissions from logging would help to maintain forest carbon stocks and qualify for schemes such as REDD+. Certification is a means by which compliance with improved harvesting guidelines is assessed in production forests could be linked to carbon storage functions and other ecosystem services such as biodiversity protection.

Acknowledgments

This research was conducted as part of a training course on Forest Research Methods in Suriname. I thank the CELOS team for sponsoring the training and arranging all the logistics for the field work in the Eco-Timber Suriname concession. I thank also F. E. Putz, A. Shenkin, and R. Fraser for facilitating the course.

References

Alianca da Terra, 2007. Three essential strategies for reducing deforestation. Instituto Centro de Vida – ICV.

Chave, J., Andalo, C., Brown, S., Cairns, M. A., Chambers, J. Q., Eamus, D., Folster, H., Fromard, F., Higuchi, N. Kira, T. Lescure, J-P., Nelson B. W., Ogawa, H., Puig H., Riera, B., Yamakura, T. 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia 145, 87-99.

Pinard, M. A, Putz, F.E. 1996. Retaining forest biomass by reducing logging damage. Biotropica 28, 278-295.

Clustered seedlings as an indicator of the absence of seed-dispersing mammals

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Abstract

Whether a clustered spatial seedling pattern can be used as a quick indicator of the scarcity of large-bodied seed-dispersing animals due to hunting pressure was tested in a Surinamese forest. I compared seedling densities immediately beneath the crowns of reproductively mature palm trees near a logging road, where increased hunting pressure and thus clustered seedlings were expected, and back from the road in the forest interior. My results were opposite those expected; based on low local seedling densities, palm seeds were apparently better dispersed near the road than farther back in the forest.

Keywords: Seedling density, Seed dispersal, Hunting, *Attalea maripa*, *Oenocarpus bacaba*

1. Introduction

The importance of animal seed dispersal for healthy ecosystems is generally accepted. Numerous studies have shown that hunting of seed-dispersing mammals in the tropics affects seed dispersal and spatial patterns of seedling recruitment (Peres and Palacios 2007 in Ghazoul and Sheil 2009). The general assumption is that a high seedling densities underneath mature trees implies lack of dispersal which can indicate the absence of dispersing mammals, often due to overhunting. In many logged forest hunting is concentrated along access roads. To the extent that this is the case, seedling densities of mammal dispersed species should be higher under parent trees near roads than deeper in the forest.

2. Methods

2.1.Site description

The study area is located in North Central Suriname (5^0 18'N 55 ^{0} 43'W) where average monthly rainfall varies from 307 mm in June to 100 mm in October with mean daily temperature extremes of 22^0 C and 32^0 C. Soils in the study area included both sandy and loamy soil.

2.2.Sampling design and data collection

Twenty reproductively mature palms within 50 m of a logging road and 20 palms >100 m into the forest were sampled.Seedling densities of randomly picked *Attalea. maripa* and *Oenocarpus.bacaba* trees were measured in 1 m radius plots around the tree base.

3. Results

Contrary to my expectation based on the assumption of higher hunting pressure and hence less seed dispersal, seedling densities were greater deep in the forest than near the logging road (Fig.1; U'= 311, $p < 0.05$).

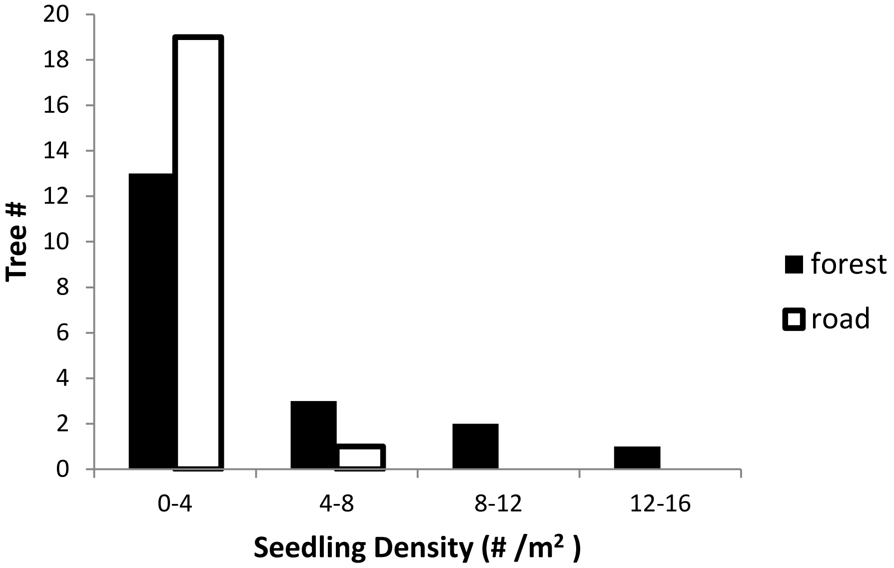

Fig. 1 Palm seedling densities in 1 m radius plots around the bases of *A. maripa* and *O.bacaba* trees near a logging road (< 50 m) and far (> 100 m) into the forest.

4. Discussion

The observed higher seedling densities around the base of adult palms in the forest away from the roads suggest that hunters have not extirpated seed dispersing mammals near roads. This result is contrary to my expectation but might be explained by higher temperatures and lower humidity underneath trees along the road leading to seed and seedling mortality.

Acknowledgments

Thanks go to Professors Francis Putz, Rory Fraser and Alex Shenkin for sharing their knowledge and for their patience throughout the training.

References

Ghazoul J., Sheil D.,2009; Tropical Rain Forest Ecology, Diversity, and Conservation, Oxford University Press Inc., New York.

Teunissen P., Noordam D., Boven K., Nieuwendam J., Janki K. 2005. Management Plan Boven-Coesewijne Nature Reserve Volume 1 Text, Ministry of Phisical Planning Land and Forest Management, Suriname Forest Service, Nature Conservation Division.

Comparison of harvest tree inventory methods in Suriname

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ABSTRACT
Pre-harvest inventory coordinates for harvestable trees obtained by GPS were expected to be no less accurate than coordinates estimated by traditional forest inventory methods. Using a hand-held GPS unit in a dense tropical forest, mapped coordinates obtained using the traditional methods were more accurate (mean error=1.4 m) than those obtained with a GPS (mean error=9.8 m).

Key words: Pre-Harvest Inventory, Stock Maps, Global Positioning System (GPS), Tropical forestry, Selective logging

1. Introduction

According to the Guyana Forestry Commission pre-harvest inventories (also called stock surveys or stock mapping) are surveys conducted in areas about to be selectively harvested for timber. The data collected are used to produce maps that aid harvesting teams in carrying out reduced-impact logging.

Some forest concessioners have complained about the inaccuracy and high costs of 100% inventories of harvestable trees in tropical forests to be selectively logged. With dropping prices and recent improvements in the accuracy of Global Positioning System (GPS) handset/ units eg., (Garmin 60csx), some concessionaires have opted for the ostensibly cheaper method of GPS mapping that only requires cutting lines around the perimeter of 100 ha blocks. In this study I compared the accuracy of conventional 5-person team tree inventory method with a 2-person team GPS aided method to conduct tree coordinate collection during inventory.

2. Study area

The study was conducted in upland forest within the concession of ETS Suriname (N05°18.5′, W55°0.04′) at approximately 40 m above sea level. Sandy clay was the main soil type and canopy cover was typically > 90%.

3. Methods

A pre-harvest inventory of eleven trees > 20 cm dbh was conducted within a forested area measuring 25 m x 50 m using three methods for mapping x and y coordinates. The GPS was first used to obtain tree coordinates. Second, estimates of distances for the offsets (x coordinates) and y coordinates were made without the aid of measuring tapes as is currently typical for inventory teams. To obtain accurate x and y coordinates for each tree, I used a measuring tape.

Using Microsoft Excel, inventory data were entered and exported to ESRI Arc Map. A map was prepared with the locations of trees using the three methods and the differences in distances measured (estimated- measured and GPS- measured). A paired t-test was used to analyze the difference in accuracy of the two mapping methods.

Results

Average distances from the “true” coordinates were lower for estimated tree locations than for GPS coordinates. The means were 1.4 m for estimated measurements and 9.8 m for GPS mapping when compared with the accuracy tape measured coordinates.

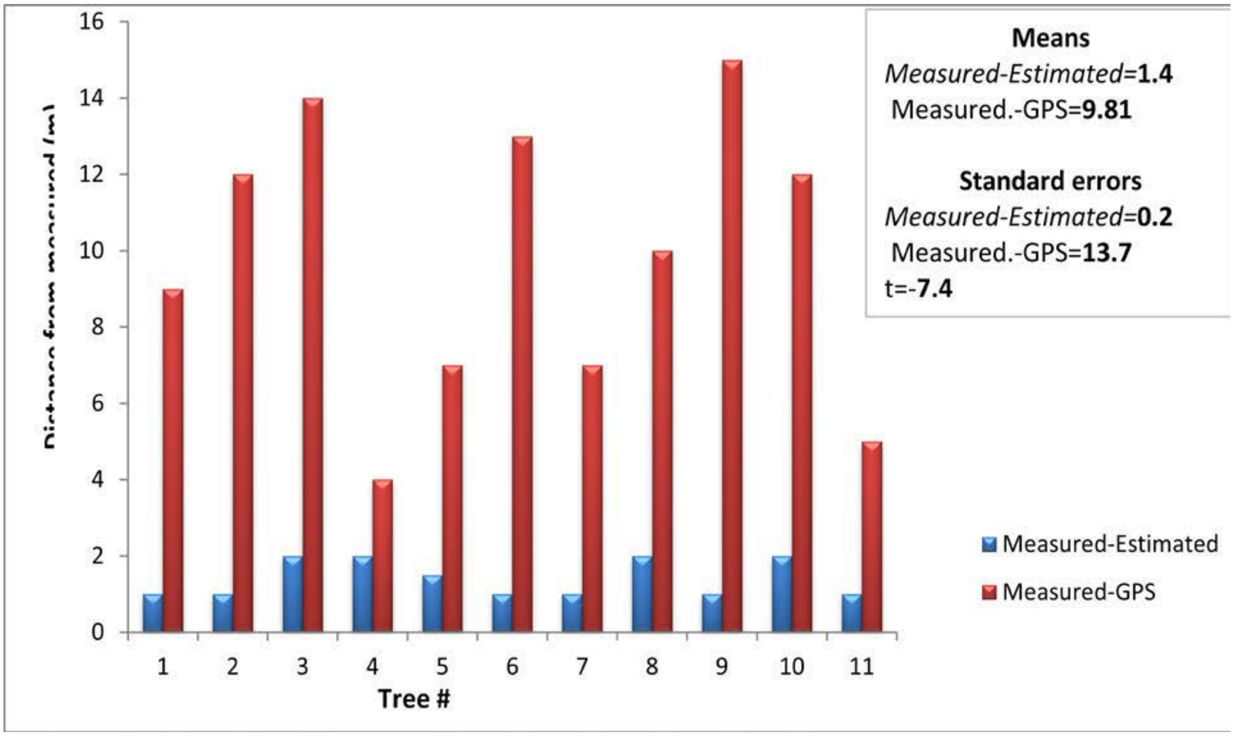

Fig.1. Errors in tree location coordinates using a GPS and visual estimation.

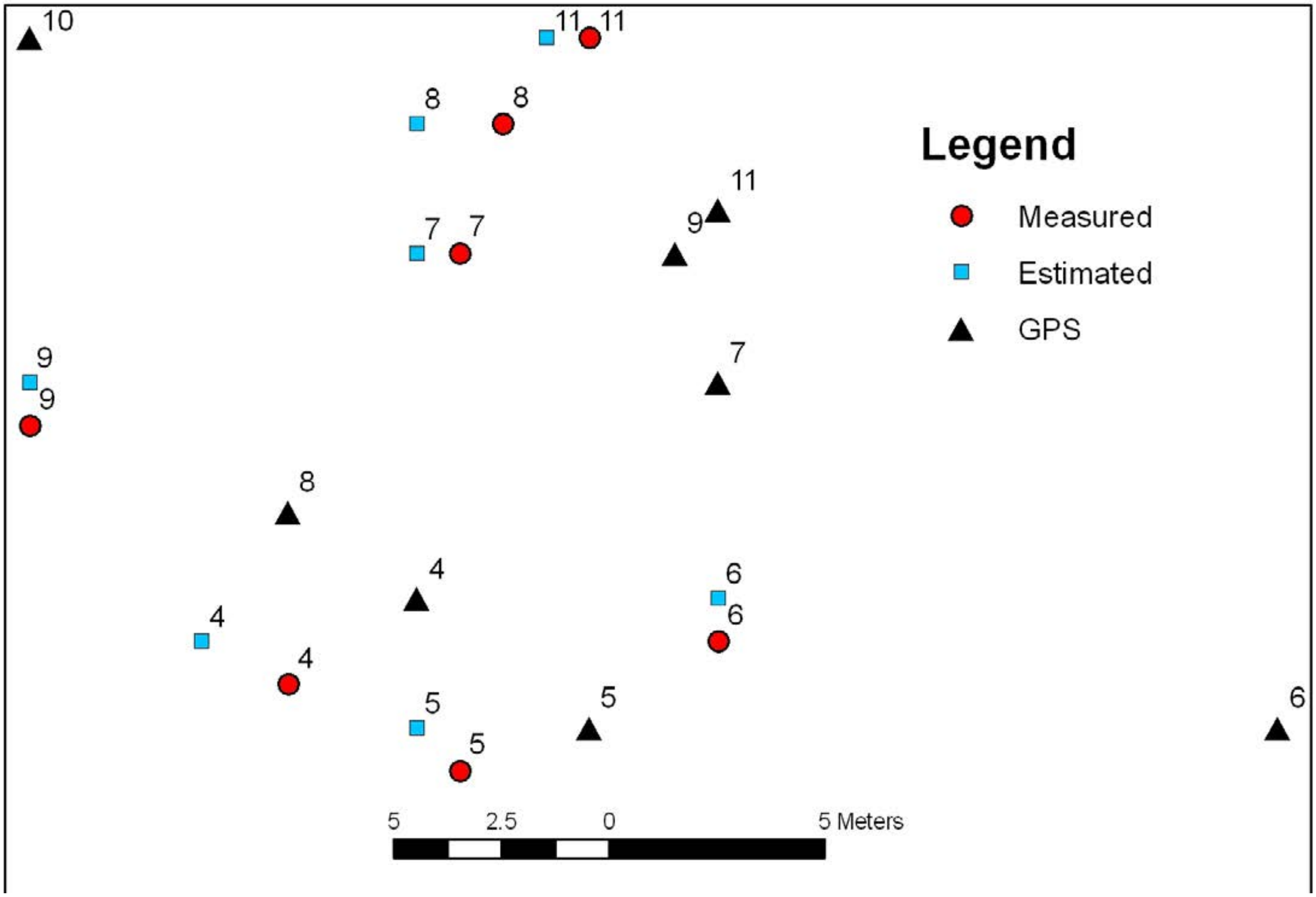

Fig. 2. Mapped locations of trees using three methods.

4. Discussion

Errors in the estimated coordinates of trees fell within the allowable limits of ±5 m prescribed by the Guyana Forestry Commission guidelines. In contrast, tree locations based on G PS coordinates were generally less accurate. These large errors may be attributed to a heavy cloud cover with intermittent showers at the time of data collection.

Acknowledgments

I thank Professors F.Putz and R. Fraser, and A.Shenkin, for their guidance. Thank to TBI-Suriname, SBB, FAO and CELOS for their support and to ETS for affording me the opportunity to use their concession to conduct this study.

References

Guyana Forestry Commission, 2010. Pre-harvest inventory procedure. Georgetown, Guyana

Leaf size is not a good predictor of crown width eccentricity of trees on a forest edge

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ABSTRACT

The ratio of crown width towards and away from a logging road in Suriname was hypothesized to decrease with increasing leaf size. Thirty-two roadside trees were selected at random and crown width radii ratios were computed. Basic crown width differences were by analyzed by paired t-tests and leaf size was regressed against the crown width ratio. Of 32 trees ≥ 20 dbh, crowns were 19% wider towards the roads than towards the forest interior; leaf areas ranged 3.5 – 131.88 cm^2. The magnitude of the crown radii ratio was not related to leaf size.

Keywords: Tree crowns, Leaf size, Forest edge, Edge effect

1. Introduction

Tropical forests are threatened by many human activities including logging. Even selective logging requires the construction of roads, which changes the landscape structure and create forest edges. Light availability in increased on forest edges, which may stimulate growth and directional crown expansion (Young and Hubbell, 1991). Crown eccentricity creates shade and changes wind direction and humidity under the tree on the edge.

To determine how being on a forest edge created by a road influences the crowns of trees, I measured the crown widths towards and away from a road opening. To determine if trees with large leaves are less architecturally plastic than trees with small leaves, I measured both for trees growing on a logging road edge in Suriname.

2. Methods

2.1. Study Area

The study area was along an 8-year old road through the ETS (Eco Timber Suriname) logging concession at an elevation of 40 m (5°18'N, 55°43'W) in the District of Para in Suriname. The soil is sandy loam and the forest type is mixed tropical rainforest. The annual rainfall in this region in about 1800 mm.

2.2. Experimental design and data analysis

Trees ≥ 20 cm dbh were picked at random along the road. Crown radii were measured towards the road opening and towards the forest interior with a measure tape and clinometer. Leaf lengths and widths were measured with the ruler and converted into area using the formula for an ellipse. The crown width differences were assessed with the paired t-test. The relationship between leaf size and crown width ratio was tested with regression analysis.

3. Results

Crown radii in the direction of the road were on average 1.37 times larger than towards the forest interior ($t_{paired} = 4.8$, $P < 0.0005$, d.f.= 31; Fig. 1). There was no relationship between leaf size and tree crown radii ratios (Fig. 2).

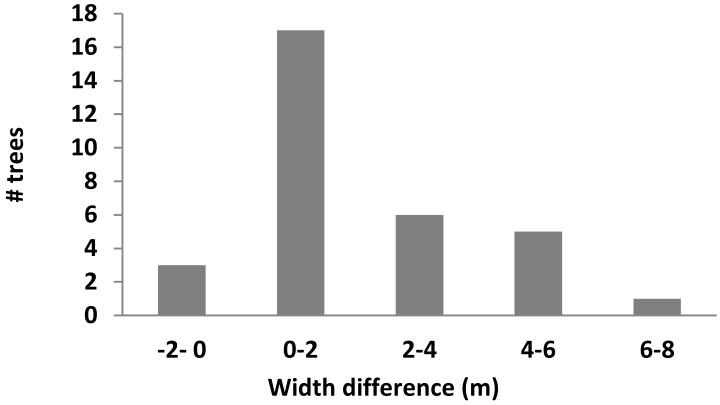

Fig. 1. Crown width difference (towards road-towards forest) along a logging road in Suriname.

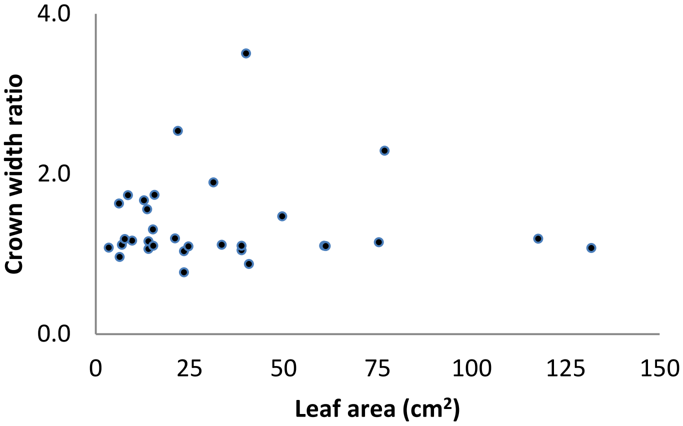

Fig. 2. Leaf area versus the crown width ratio (towards the road opening/towards the forest interior) of trees along a logging road.

4. Discussion

Along an 8- year old logging road in Suriname, tree crowns were wider towards the road than towards the forest interior. Differential crown expansion may result because the edge–facing portion of the tree crown experiences more sunlight, greater temperature extremes, and lower humidity. My hypothesis that this response is associated with leaf size was not supported; leaf size was not related with the crown width ratio. Light is not the only factor that contributes to crown development. Herbivory, branch fall, water stress, wind and storm damage, belowground processes, physical abrasion by neighbors, and space availability may also affect the lateral extension growth of tree crowns (Young and Hubbell, 1991). As such, more studies need to be conducted to investigate which factor(s) caused the crown expansion toward the road.

Acknowledgments

I thank F. Putz, A. Shenkin, and R. Fraser for their guidance, patience and their feedback.

References

Young T., Hubbell S., 1991, Crown asymmetry, treefalls, and repeat disturbance of broad-leaved forest gaps. Ecology 72, 1464-1471.

Collateral damage during selective logging does not vary with the diameter of felled trees

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Abstract

The amount of collateral damage to the residual stand is expected to increase with the diameter of the felled tree. This hypothesis was tested by counting trees that were uprooted, broken, or otherwise scarred around 14 felled trees that were 60-100 cm dbh. Contrary to my expectation, the number of damaged trees did not vary with the diameter of the felled tree.

Key words: Logging damage Damaged trees, Collateral damage, Tropical forestry

1. Introduction

It is often assumed that there is a correlation between the diameter of a harvested tree and the collateral damages that occurs to residual standing trees (Unver & Acar, 2009, Sist et al. 1998). To the extent that this is true, it is a concern to biologist, botanists and environmentalist worried about the impacts of logging on biodiversity and natural habitats. I investigated this hypothesis by testing it in a selectively logged forest in Suriname.

2. Study Area

The Eco Timbers Suriname Forests is ($5^{o}18'$N, 55^{o} 0.4'W) in north central Suriname. The soils in the study area are mixed white sand and loam, receives approximately 1800 mm/year of precipitation, and has undulating terrain with slopes up to 25^{o} .The dominant species harvested is *Eperua falcata*. The concessionaire began harvesting the study area in 2002 with this particular logging site being logged one year ago. A main road with connecting skid trails was widened in 2010, one year prior to this study. The logging operations are certified by Forestry Stewardship Council.

3. Method

I in the 14 felling gaps I surveyed I measured the diameters of the felled trees and counted how many trees >10 cm dbh suffered collateral damage (i.e., broken or uprooted stems, bark removal, and root damage). Trees damaged by skidding were excluded. The relationship between the dbh of the felled tree and the number of trees damaged was analyzed with linear regression (Fig. 1).

4. Results

The felling of 14 trees caused damage to an additional 69 trees. The diameters of harvested trees ranged from 60-100 cm and the felling of one tree caused damage to 12 others. The number of trees damaged did not increase with the diameter of the felled tree ($P = 0.6$). *40.5 %* of the collateral damaged trees were in the 80 cm dbh class, while *47.8%* were in the 60 cm dbh class.

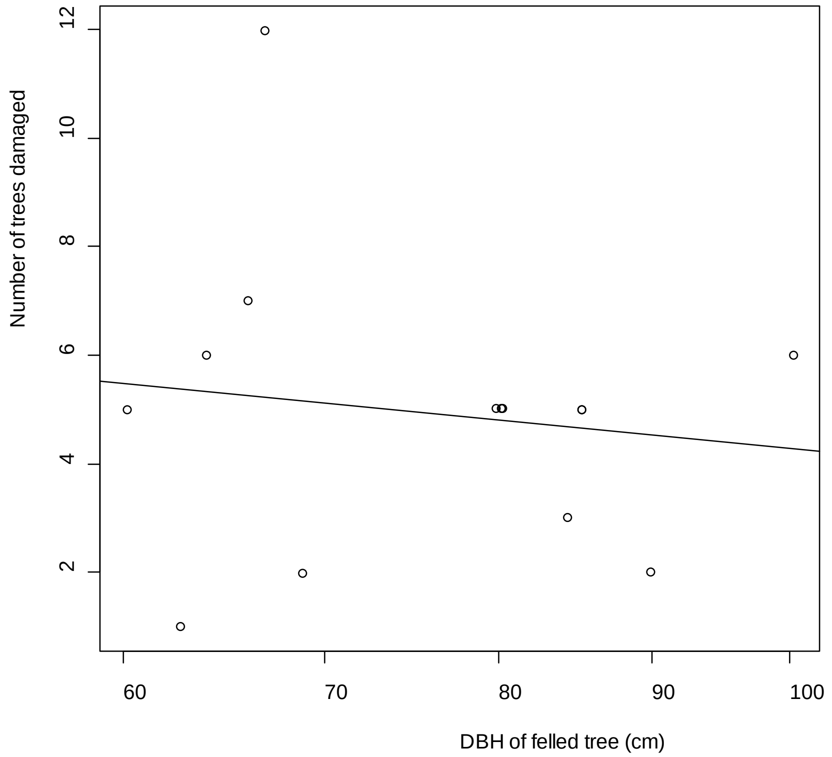

Fig. 1 – Number of trees damaged (y-axis) versus DBH of felled tree (x-axis).

Further analysis revealed that only *2 %* were in the 90 cm dbh class while *8.6%* were in the 100 cm dbh class. The average of number of trees suffering collateral damage was 4 damaged trees to one tree felled.

5. Discussion

There was no relation between the dbh of felled trees and the number of damaged trees. Instead, the amount of collateral damage could be due to the presence of lianas or the crown architectures of the felled trees and their neighbors.

6. Conclusions

There is the need to observe the actual felling operations to ascertain whether proper felling techniques are implemented. This effort would reduce the human error in attributing damage to felling or skidding and otherwise facilitate study of this important phenomenon.

Acknowledgments

The guidance and encouragement of Professors F. Putz and R. Frazer, A. Shenkin, the ETS Concessionaire, SBB, CELOS staff, and my fellow course-mates are appreciated.

References

Unver, S., Acar, H. 2009. Evaluation of residual tree damage due to harvesting operations.

Sist P, Nolan T, Bertault J.G, Dykstra, D. 1998 Harvesting intensity versus sustainability in Indonesia. Forest Ecol. Manage. 108, 251-260.

Influence of forest canopy openings on the presence of mushrooms on logs

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ABSTRACT

Logging is increasing in Suriname and studies of its effects on forests are needed. In this study fungal fruiting bodies are hypothesized to be more abundant on coarse woody debris where the canopy is more open. Canopy openness above thirty three pieces of coarse woody debris > 20 cm diameter was measured and presence/absence of fruiting bodies was recorded. Canopy openness above each downed log was measured. Fungal fruiting bodies were more likely to be present on logs with more than 20 % canopy openness than on those with less openness.

Keywords: Fungal Fruiting Bodies, Canopy Openness

1. Introduction

Logging activities have increased recently in Suriname, but little is known of the effects about these activities on forest ecosystems. Felling trees creates canopy openings and this can influence abiotic and biotic environmental changes. Light availability is perhaps the most important factor explaining variation in rain forest plants. Although exposed canopies get full sun, the understory can be deeply shaded (Ghazoul and Sheil, 2009).

Residuals of felled trees that were pushed over in logging activities are decomposed by micro-organisms such as bacteria and fungi. Bacterial and fungal spores are omnipresent in the air and the water, and are usually present on (and often in) dead material before it is dead. By decomposing organic material, these microorganisms produce carbon dioxide, water and inorganic nutrients (Begon, Townsend and Harper, 2006). Little is known of fungi as components of tropical rain forest biodiversity, and yet they can control many of the most vital processes on which these rain forest ecosystems depend (Hawksworth and Colwell 1992).

Logging produces residual coarse woody debris, and this residual is eventually respired into the atmosphere. Understanding the factors that influence this process of greenhouse gas emission is of utmost importance. In this study I investigated whether canopy openness influences the fruiting of fungi on coarse woody debris, an especially important component of logged forests.

2. Study area and Method

This study was conducted in the early rainy season (May, 2011) in the EcoTimber concession (5^0 $18^{'}$N, 55^0 0'W) in Suriname, a high dry land forest at an elevation of 40 m. When this study was conducted, it was mostly rainy and humid. The concession is certified and logging is done according to these regulations. The road consists of white sand with a layer of organic material.

I conducted transects at 50 m and a 100 m into the forest, measured from the edge of a forest road. The amount of fallen trees with a diameter > 20 cm with or without fungal fruiting bodies in these transects were noted and the canopy openness above these logs were estimated. For this estimation canopy openness was divided into five classes; class 1was from 0-20 %, class 2 from 21-40 %, class 3 was from 41-60 %, class 4 from 61-80 % and class 5 from 81-100 %. The data on the canopy openness and presence of fungal fruiting bodies was analyzed using a t-test.

3. Results

A two sample t-test, assuming unequal variances, showed that the mean canopy openness between logs with mushrooms present and logs with mushrooms absent was not significantly different (mean canopy openness of logs with no mushrooms was 35.6 %; mean with mushrooms present was 25.0 %; t-critical = 1.7; p = 0.2).

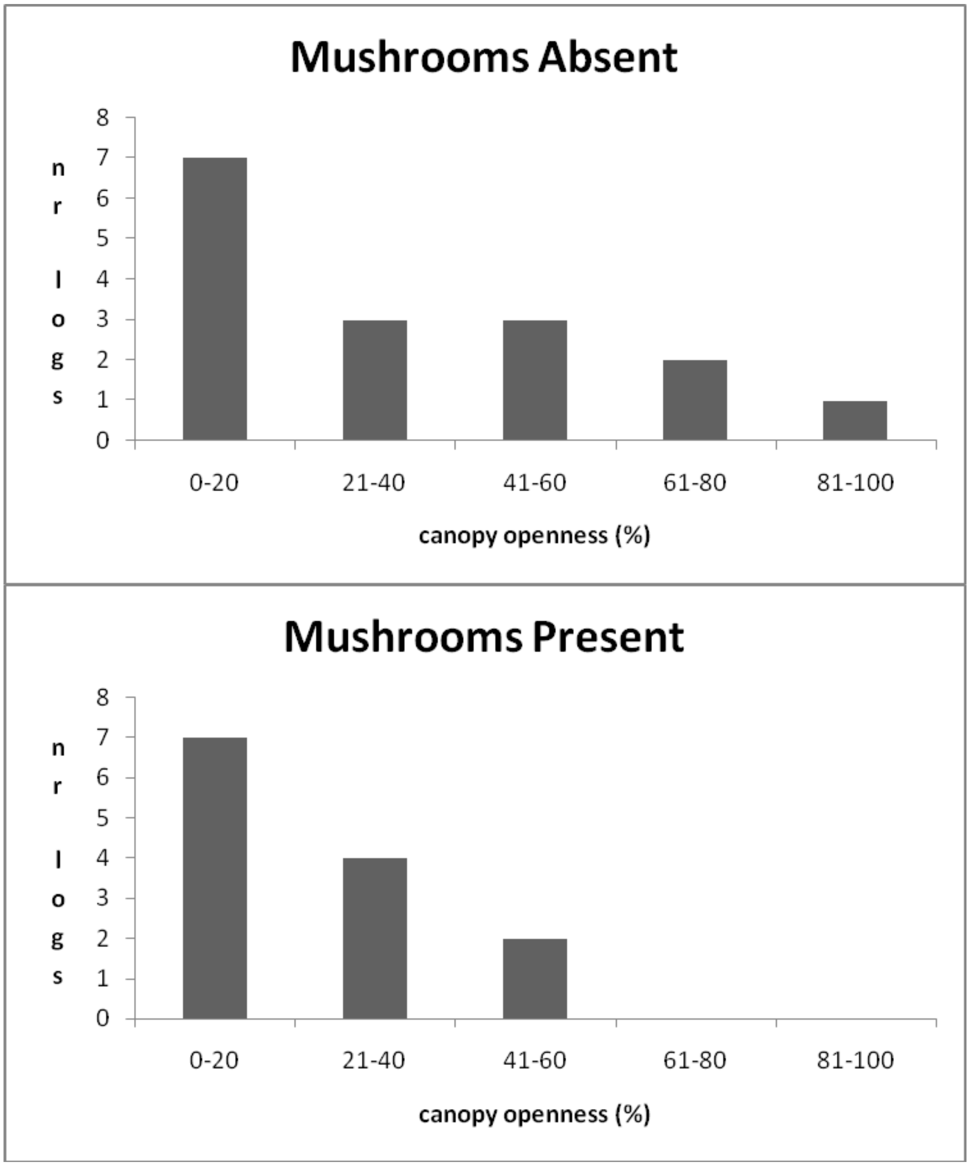

Fig.1: Graph on the absence / presence of mushrooms and the average canopy openness.

4. Discussion

The data acquired within this study showed that greater canopy openness does not mean a higher presence of fungal fruiting bodies on fallen logs > 20 cm diameter. Research has been done in other countries, on fungal diversity (Hawksworth and Colwell, 1992) and it would advisable to look into their findings, if there is any information on canopy openness in relation to fungal fruiting. Also the wood variety on which the fungi grows may be of influence in mushroom occurrence. Recognition of the importance of microorganisms for the decomposition, especially fungi, these data would help to estimate the condition of the forest.

Acknowledgment

This research would not be possible without the help of many persons and organisations. I wish to thank our trainers; Professors F.Putz and R.Fraser, and A.Shenkin for their guidance and TBI-Suriname, SBB, FAO and CELOS for their support.

References

Ghazoul J. and Sheil D., 2009.Tropical Rain Forest Ecology, Diversity, and Conservation. Oxford University Press, New York.Page 197
Hawksworth, D. L. and Colwell, R. R., 1992. Microbial diversity21: Biodiversity amongst microorganisms and its relevance. *Biodiversity and Conservation* **1** , 221–226.
Begon M, Townsend C. R., Harper J. L., 2006. United Kingdom. Ecology from Individuals to Ecosystems.
Black well Publishing 4 th edition. Page 326-327

Factors influencing tadpole depositions in puddles

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ABSTRACT

Although some logging activities adversely affect anurans, others may benefit them. For example, puddles created by heavy machines can be used as reproductive sites for anurans. This study tested whether puddle characteristics affect the likelihood of anuran presence. Water depth, bottom coverage by organic matter, canopy cover, size and shape of puddle, distance to the next puddle, and distance to the closest forest edge of 24 puddles were measured. None of these measured puddle characteristics affected the presence or absence of tadpoles, which suggests that anurans select puddles opportunistically.

Keywords: Anurans, biodiversity impact, selective logging

1. INTRODUCTION

Previous impact studies on anurans have indicated that logging has deleterious impacts on anurans. Increased drought conditions and habitat destruction are the main impacts identified, which may eventually lead to less suitable living environments and reproduction sites (Ernst et al., 2006; Ernst et al., 2007; Lemckert, 1999). These impact studies mostly focused on the wood extraction phase of the logging activities. Other logging activities that also affect anurans are those related to the use of heavy machinery for log yarding and hauling, especially as they relate to soil compaction and ponding (Pinard et al., 2000). Tracks of these heavy machines create small to medium-sized depressions that fill with water during rainy periods. These puddles can serve as reproduction sites for anurans. To determine the factors influencing tadpole occurrence, puddle characteristics were assessed in a selective logged forest in Suriname.

2. METHOD

Study area

The study was conducted in Block 219 of the Eco Timber Suriname logging concession in Suriname(05°18’N, 55°00’W) at approximately 40 m above sea level. The forest is classified as mixed lowland tropical forest on white sand and loamy soils. The area was selectively logged 8-10 years prior this study during which it was being logged again under Forest Stewardship Council certification.

Sampling design and data collection

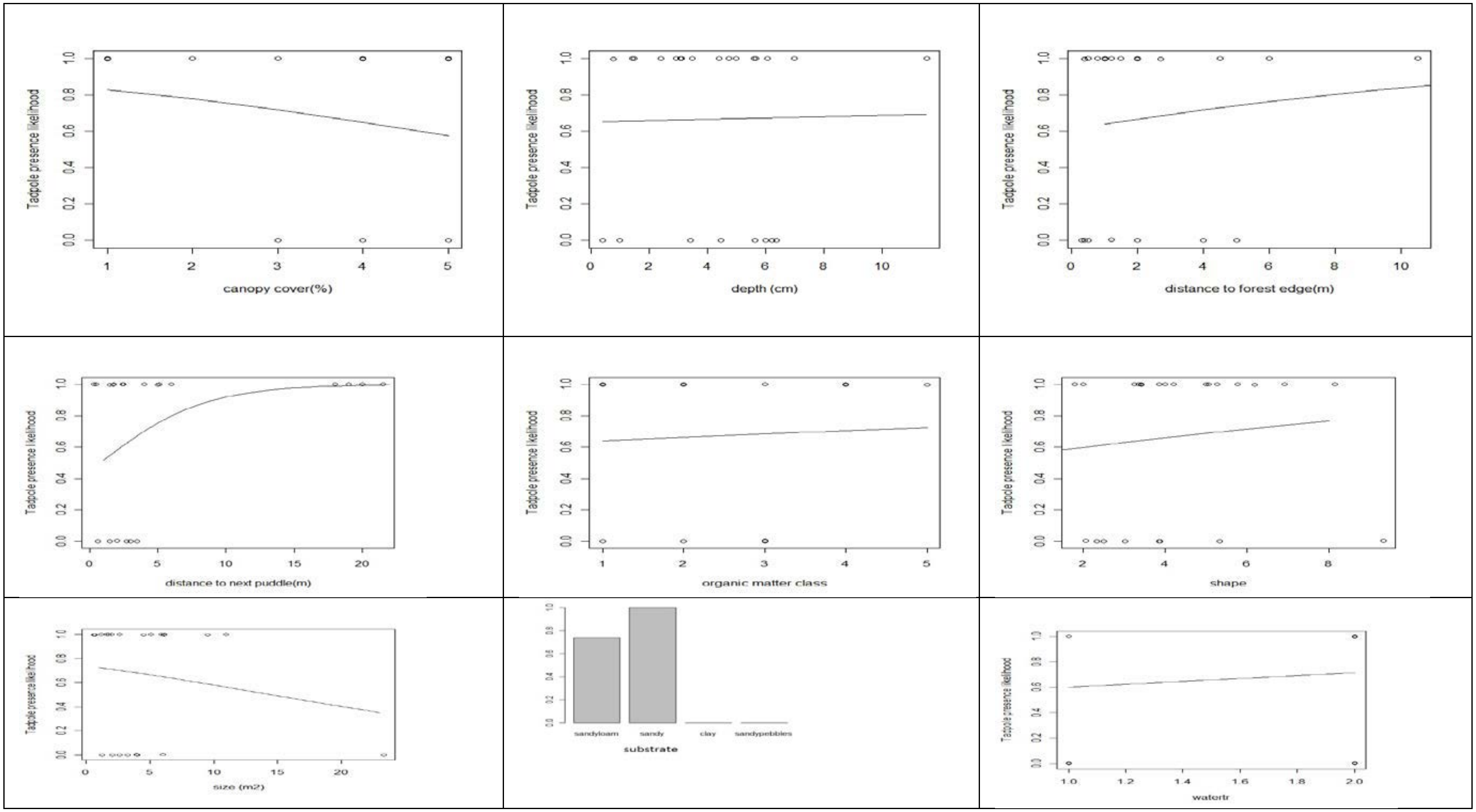
Puddles randomly selected along two skid trails and on the main road were described in term of their longest and shortest lengths, depth (mean of 3 measurements), substrate type, distance to the nearest forest edge, distance to the next puddle, % organic matter in the puddle, % canopy cover, and transparency of the water. Percentages of organic matter and canopy cover were converted into 5 percentage classes prior to analyses. Shape was described as the length/width ratio and size was estimated using the formula for an ellipse. Tadpoles presence or absence was determined by visually inspecting the puddles.

Logistic multiple regression was used to determine which characteristics influence the presence or absence of tadpoles. Statistical analyses were conducted using ‘R’ (R version 2.12.1; 2011-03-05).

3. RESULTS

The 24 puddles assessed (19 in skid trails and 5 on the main road), from which 8 lacked tadpoles, two of the puddles had juveniles, and one puddle had both juveniles and tadpoles. None of the eight measured parameters describing puddle characteristics was related to tadpole presence or absence (Fig 1).

Fig 1. Relation between tadpole presence/absence and puddle characteristics. No relationships were revealed by logistic regression.



4. DISCUSSION

Water is a requirement for successful reproduction of most anurans, but the sites they use for reproduction vary. While some species have narrowly defined sites, like water-filled holes in trees, others use a wide variety of aquatic sites they find opportunistically. The latter also occurs when aquatic sites are scarce in the area and anurans have to use alternative aquatic sites to deposit their eggs (Ernst et al., 2007). Aichinger (1991) also found in an area that lacked aquatic sites that some of Aromobatidae make use of permanent puddles and even transport their tadpoles over some distance to these puddles. From my results I conclude that puddle selection by anurans in my study site is opportunistic and characteristics of the puddle play a minimal role. Nevertheless, it might be worthwhile to look at other parameters that might determine tadpole presence or absence in puddles.

REFERENCES

Aichinger, M., 1991. Tadpole transport in relation to rainfall, fecundicity and body size in five species of poison-dart frogs from Amazonian Peru. Amphibia-Reptilia 12, 49-55.

Ernst, R., Linsenmair, K.E., Rödel, M.O., 2006. Diversity erosion beyond the species level: dramatic loss of functional diversity after selective logging in two tropical amphibian communities. Biol. Conserv. 133,145-155.

Ernst, R., Konrad, T., Linsenmair, K.E., Rödel, M.O., 2007. The impacts of selective logging in a Central Guyana rainforest. Amphibia-Reptilia 28, 51-64.

Lemckert, F., 1999. Impacts of selective logging on frogs in a forested area of Northern New South Wales. Biol. Conserv. 89, 321-328.

Pinard, M.A., Barker, M.G., Tay, J. 2000. Soil disturbance and post-logging forest recovery on bulldozer paths in Sabah, Malaysia. For. Ecol. Manage. 130, 213-225

Edge effect on lianas in a forest in Suriname

Iflaw C.Hasselnook

Abstract
Along a logging road through a selectively harvested forest in Suriname, lianas in the canapés of trees were observed. Although lianas were expected to be more common along the forest edge, this pattern was not observed.

1. Introduction

Lianas are important in logging areas. When trees are killed for harvesting or road clearing, lianas can pull down or damage their neighbors and endanger workers. I expected to confirm the finding of Putz (1984) that lianas in Panama increase along canopy gap edges but in my case on the edges of a logging road through a selectively harvested forest in Suriname.

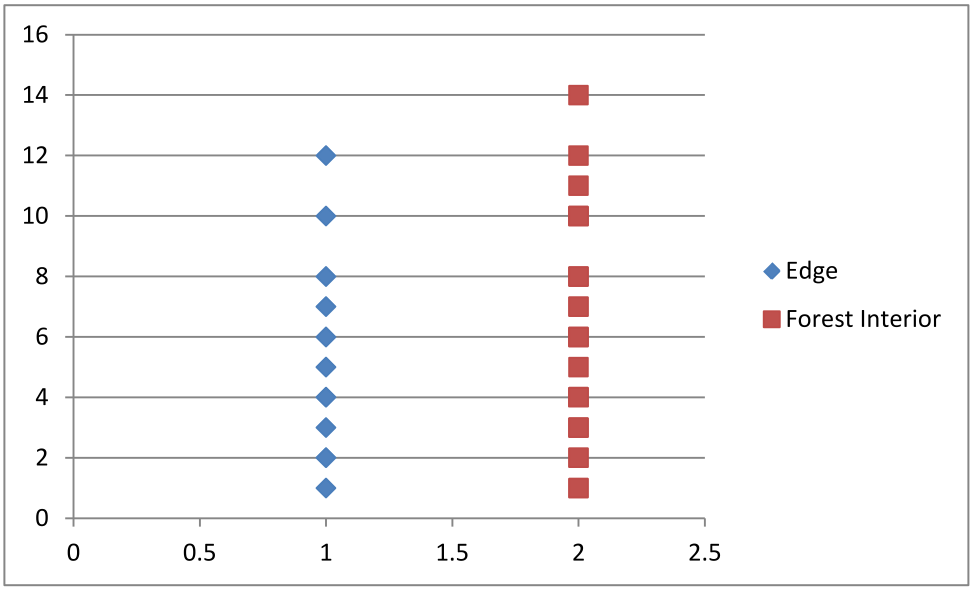
2. Study Site and Methods

The research was conducted in the timber concession of E-timber along the Suriname River in the south-east of Suriname. The soil in the study area is mixed sand and sandy loam. The road was previously a skid trail that was recently upgraded for truck traffic.

I surveyed 32 trees >40 cm dbh that were <20 m from the road edge along both sides of 1 km of the logging road and checked for the presence and numbers of lianas in the crowns. I then repeated this process along a transect parallel to the road 50 m into the forest.

3. Results

On the 32 trees I observed, I found a total of 174 lianas yielding a mean of 5.4 lianas per liana infested tree (variance = 9.16). In the forest I found 28 trees with a total of 175 lianas yielding a mean of 6.25 lianas per tree (variance = 12.1). According to a t- test, this difference was not significant (P<0.1).



4. Discussion

The unexpected outcome of this research wants explanation. Certainly more data are needed, but there is also the possibility that lianas in Suriname do not respond to the presence of forest edges the way they do elsewhere in the tropics. Furthermore the particular species presence and low soil fertility in the study area might have affected the result that lianas do not proliferate on forest edge trees in the forest I studied in Suriname.

Acknowledgments

The outcome of this research would not be possible without the help of the many organizations who are in charge of this course. I wish to thank the professors F. Putz and R. Fraser and A. Shenkin for their guidance. Thanks to Tropenbos International Suriname, the Foundation for Forest Management and Production control (SBB), Food and Agriculture Organization (FAO) and the Centre for Agriculture Research in Suriname (CELOS) for their support.

Effects of canopy closure and litter depth on seedling density in a mixed lowland tropical rainforest in Suriname

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ABSTRACT

Canopy closure and litter depth effects on seedling density (plants <1 m tall) in a forest in Suriname were measured by estimating canopy closure over randomly selected 4- m^2 plots using a spherical densitometer. Litter depth was also measured. Seedling density decreased with increasing canopy closure and increased with depth.

Key Words: Regeneration niche, seedling recruitment, leaf litter

1. INTRODUCTION

All green plants need and compete for, the same resources: light water and nutrients. These demands shape eco-physiological adaptations in all ecosystems including tropical rain forest. Seedlings under closed canopy are often the most important source of regeneration for shade tolerant tree species (Denslow, 1987; Withmore, 1989; Martinez- Ramos & Soto- Castro, 1993). The abundance, distribution, and composition of seedlings are affected by processes such as gap formation, gap closure, and even litter fall. Illumination levels in tropical rain forest understories range from < 0.5 % to 100 % of full sunlight. For most of their life, rain forest trees are limited by light (Graham et al., 2003). I examined the effects of canopy closure and litter depth on seedling densities in a mixed lowland tropical rain forest. Litter depth was seen as important to this study since it is assumed that litter add nutrients to the soil that can promote regeneration.

2. METHODS

2.1 *Study site*

This study was conducted in Block 219 of the Eco Timber Suriname logging concession (N 05^0 18’, W 55^0 00’), a mixed lowland tropical forest on white sand and loamy soils at approximately 40 m above sea level. The area was selectively logged 8-10 years before this study, and it was undergoing a second cut at the time of this study with Forest Stewardship Council certification.

2.2 *Sampling design and data collection and analyses*

In 4 m^2 plots established at random, all woody plants <1 m tall were counted and the effects of canopy closure and litter depth on seedling density were assessed using regression analyses.

3. RESULTS

Seedling density decreased with increasing canopy closure (Fig. 1; $R^2 = 0.11$, $P = 0.03$). In contrast seedling density increased with increasing litter depth (Fig. 2; $R^2 = 0.12$, $P < 0.05$).

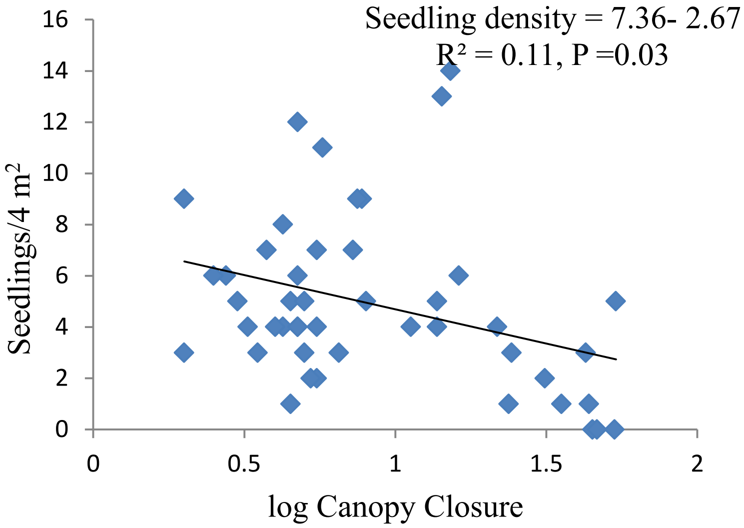

Fig. 1. Relationship between seedling density (seedlings < 1 m tall) tall and canopy closure over 4 m^2 plots in a mixed tropical lowland forest in Suriname.

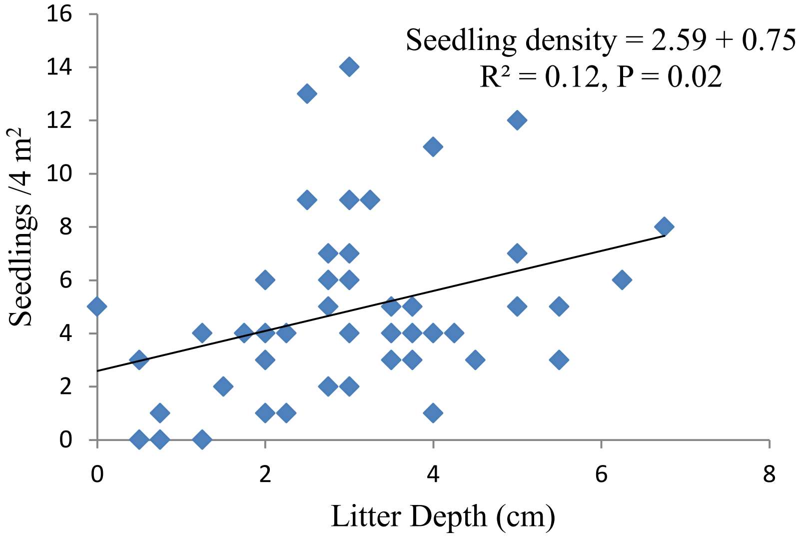

Fig. 2. Relationship between seedling densities and litter depth (seedlings < 1 m tall) in 4 m^2 plots in a mixed tropical lowland forest in Suriname.

4. DISCUSSION

The observation that seedling densities decreased with canopy closure might be explained by light limitations. In contrast, Graham et al. (2003) posited that shade tolerant species are able to draw, for a time, on the seed resources and survive under a closed canopy. Understory plants also develop various strategies and means which influence their ability to capture light and this allows them to maximize light capture in low light and in the understory.

Seedling density increased with increasing litter especially in closed canopy areas. FAO (2001) states that a significant amount of nutrients occur in the top few centimetres of soil. It is possible that increasing litter depth adds to the nutrient bank and promotes regeneration.

ACKNOWLEDGMENTS

Special thanks to ETS for hosting this study and CELOS and FAO for funding the project. I also like to thank Jack Putz, Alex Shenkin, and Rory Fraser for their edits and inputs.

REFERENCES

Denslow, J. S. 1987. Tropical rain forest gaps and tree species diversity. Annual Review of Ecology and Systematics 18,432- 452.

FAO. (2001). Lecture notes on the major soils of the world. Food and Agricultural Organization of the United Nations, Rome, Italy.

Graham, E.A., Mulkey, S.S., Kitajima, K., Phillips, N. G., Wright, S. G. 2003. Cloud cover limits net CO_2 uptake and growth of a rain forest tree during tropical rainy seasons. Proceedings of the Nation al Academy of Sciences of the United States of America 100, 572-576.

Martinez- Ramos, M., Soto- Castro, A.1993.Seed rain and advanced regeneration in a tropical rain forest. Vegetation 108, 318- 324.

Whitmore, T. C. 1989. Canopy gaps and two major groups of forest trees. Ecology 70, 526-538.

Crown openness and stem height increase fruiting of *Attalea maripa* in Suriname

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ABSTRACT

Crown openness, height, location (forest edge compared to interior), distance to nearest conspecific, soil, and slope position may all affect the fruiting of palms. The associations of these factors with reproduction by *Attalea maripa* were assessed in a selectively logged forest in Suriname. Whether or not Attalea stem > 6 m tall showed signs of recent reproduction did not vary with distance to the nearest conspecific, soil type, location, or slope position. In contrast, crown openness, height, and the interaction between these two factors were related to fruiting ($P<0.029$, $P<0.0084$, and $P<0.0035$, respectively).

Keywords: Tropical forest, Reproductive palms, *Attalea maripa*, Phenology, Non-timber forest products, NTFPs.

1. Introduction

Many palms are crucial food resources for animals and economically important to people in tropical rain forests (Arroyo-Rodríguez et al., 2007). Palms that provide seeds, fruits and other non-timber forest products (NTFPs) are often important contributors to the livelihoods of rural people in the tropics. Factors influencing palm reproduction are thus critical for the maintenance of these livelihoods. A previous study showed that palms on the forest edge are more likely to fruit than palms in the forest interior (Esseboom, 2011). But further research was necessary on the variables influencing its reproduction to inform the development of forest management strategies for rural communities.

2. Methods

2.1 Study Site

The study site is in a mixed tropical rain forest in Suriname (5˚18’N, 55˚43’W), 40 m above sea level. The road and the skid trials along which this study was conducted run through upland forest on white sand and loam, which was selectively logged 8 years and again several months prior to the study.

2.2 Data collection

Along the logging road and, skid trails in the forest interior, *Attalea maripa* palms > 6 m tall were recorded as showing signs of fruiting (flowers, fruits, and seeds) or not. Crown openness, stem height, distance to nearest conspecific adult (maximum = 50 m), soil (white sand or loam), and slope position (ridge or valley) were described for each palm.

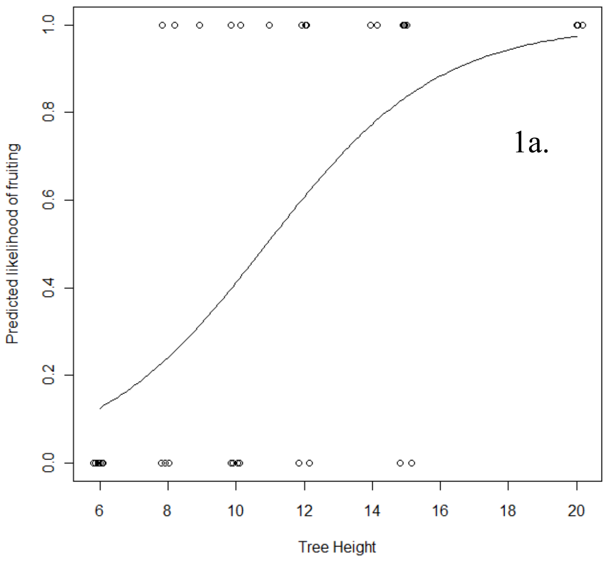
2.3 Data analyses

To assess the importance of the estimated factors to the reproduction of the censured palm, the data were analyzed with logistic regression. A multiple logistic regression was used in the 'R' statistical package (R version 2.12.1; 2011-03-05).

3. Results

Of 38 *Attalea* palms observed, 19 were reproductive. Soil type, slope position and location were not significant predictors of *Attalea* fruiting. In contrast, the likelihood of a palm being reproductive increased with height (z-value = 2.19; $\rho<0.05$; Fig.1a) and canopy openness (z-value = 2.64; $\rho<0.008$; Fig.1b). Both variables combined resulted in a strong (z-value = 2.92; $\rho<0.0035$) relationship with fruiting. Since canopy openness is likely correlated with stem height, two models were tested: one with both canopy openness and stem height and, one with just canopy openness. ΔAIC between the two models was 4.09 (both predictors being superior), and canopy openness remained strongly significant when stem height was included, so we chose the model with both predictors.

Fig. 1. a. The likelihood of *Attalea* fruiting increases with stem height (z-value = 2.19; $\rho<0.029$). **b**. Palm reproduction increases with crown openness (z-value = 2.64; $\rho<0.0085$).



1b.

4. Discussion

The observed increase Attalea fruiting with increasing canopy openness and stem height suggests that reproduction increases with more sunlight. In contrast, soil type and slope position which may related to nutrient and water availability, were not associated with the likelihood of palm fruiting. While a previous study (Esseboom, 2011) showed edge effect on fruiting of two palm species in the same study area, this effect was eliminated if the data were analyzed per palm species. The implications of the results for other economic palms may be relevant especially for rural forest communities. Livelihood strategies for rural communities, in-depth research for other economic palms is necessary.

Acknowledgments

I thank CELOS, SBB, ETS and the received subsidy of FAO and TBI. Special thanks to Professors F. Putz and R. Fraser as well as A. Shenkin for their guidance.

References

Arroyo- Rodríguez,V., Aguirreb, A., Benı´tez-Malvidoc,L., Mandujano, S., 2007. Impact of rain forest fragmentation on the population size of a structurally important palm species: *Astrocaryum mexicanum* at Los Tuxtlas, Mexico. *Biological Conservation,* 138,198-206.

Esseboom, M., 2011 Palms fruit more on a forest edge in Suriname. This volume

Canopy openness discourages beetle infestation of fallen logs

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Abstract

Canopy cover was hypothesized to influence beetle infestation of logs in a Surinamese forest. I also hypothesized that beetles more often enter logs near the cut than far from it. I tested these hypotheses using 10 randomly selected logs from trees that felled within the last three months. I inspected each log for larval entry holes, beetle larvae, and beetle adults within 30 cm from the cut and 1 m down the log from the cut. Percent canopy cover over each log was also recorded. Regression analysis revealed that beetle presence in logs decreases with canopy opening. There was no difference the incidence of beetles near and far from the cut.

Keywords: Decomposition, Woodborers, Canopy cover, Tropical forest, Decomposition, Coarse Woody Debris

1. **Introduction**

Beetles comprise around 350,000 recognized species from which Buprestidae and Cerambycidae are major contributors to wood damage They can also function as wood decomposers due to their feeding habits at the larval stages. Trees felled and left on the ground for extended periods are liable to be infested by both larval and adult beetles. I hypothesized that infestation would decrease with canopy openness. Furthermore, I hypothesized that beetles because beetles are attracted to logs by compounds emitted from damaged tissues, they would preferentially invade logs near the cut as opposed to away from it.

2. Methods

2.1 Study site

The study was conducted in May 2011 at the Eco Logging Company (N 5° 19', W 55° 43') at 40 m above sea level in a selectively logged mixed tropical forest on sandy and loam soils in Suriname. The weather was overcast with intermittent showers at the time of study.

2.2 Data collection

Ten logs were selected along a skid trail with canopy openness ranging from 15% to 45%. Logs were checked for beetles at the cut end and 100 cm away within areas of 10 cm x 30 cm. I looked for larval entry holes, larvae and adults both above and beneath the bark. The total number of adults, larvae, and holes were totaled at each distance.

3. Results

There was a strong negative correlation between beetle infestation density and canopy openness over the log (Fig. 1). The 6 of 10 logs with beetles yielded 60 entry holes, 34 larvae, and 7 adults.

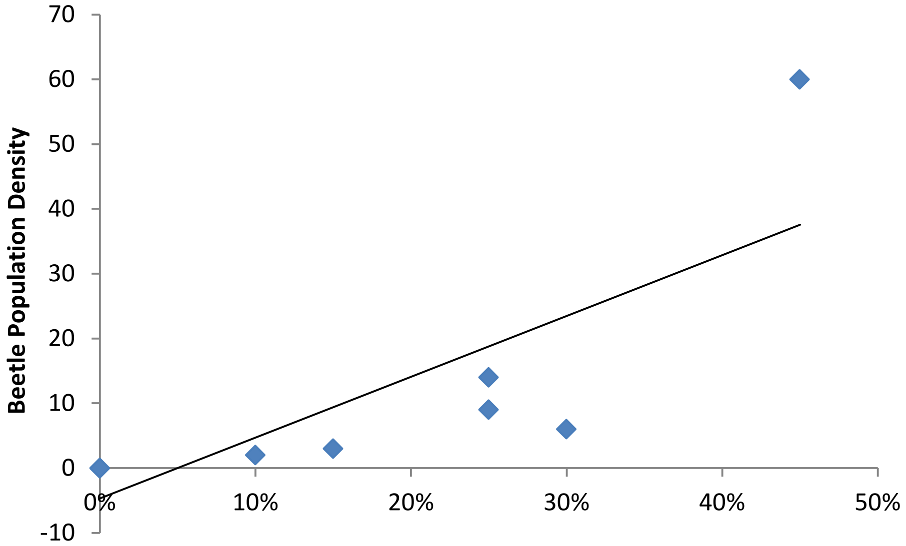

Fig. 1. Density of beetles (entry holes, adult larvae, adults) per 600 cm^2 of bark as a function of % of canopy openness over logs.

4. Discussion

The observed decrease in beetle infestation of fallen logs with increasing canopy openness could be due to the fact that greater direct sunlight causes moisture loss in the logs. Moisture limitation may impede beetle larvae by limiting food availability. I also observed that bark-less areas along the logs showed no signs of beetle infestations. It is also possible that bark protects larvae against desiccation. Furthermore, eggs deposited on logs with bark are less likely to be detected by predators because they are well camouflaged. Further investigation into this subject could be useful for prevention of beetle infestation on valuable logs temporarily left in the forest.

Acknowledgments

I thank Francis Putz along with Alex Shenkin and Rory Fraser. Also to thank the host CELOS for uproviding this training opportunity.

References

Filder, A., Wilson, E. O. 1987. Call of the Amazon: Tropical Rain Forest Ecology, Diversity and Conservation.

Bark thickness on trees growing on white sand and a loamy soil in Suriname

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Abstract

A comparison of bark thickness of trees growing on white sand and a loamy soil in Suriname revealed no difference. A comparison of *Chaetacarpus schomburgkianus* tree bark in the western Amazon Basin and in my study site in Suriname revealed that barks were twice as thick in the former site. This difference could be the result of higher fire frequencies in Brazil than in Suriname.

Key words: Fire regime, Phloem, Fire ecology, Cambial damage

1. Introduction

Forest fires are common in tropical forest in Brazil but comparatively rare in similar forests in Suriname. If fires select for thicker bark, then trees in Brazil should have thicker bark than trees in Suriname. Within Suriname, if the rare fires are more likely on drought-prone forest on white san soil than in forests on clay loam, then trees in the former should have thicker bark.

2. Methods

2.1 Study area

This study was conducted in selectively logged mixed upland forest in the E-Timber Suriname concession near the Suriname River (N05^0 18’ W055^0 00’). The study area has undulating terrain at an altitude of approximately 34 m and the soil is a patchwork of loam and white sand. The annual rainfall is about 1800 mm/year.

2.2 Sampling design

Twenty trees > 5 cm dbh were randomly selected in a forest on loamy soils and a nearby forest on white. From each tree a 5 X 5 cm bark was extracted with a machete and thickness was measured with a vernier caliper. For the comparison of *Chaetacarpus schomburgkianus* bark thickness in Brazil (from Brando et al. in review) and my site in Suriname, 16 additional trees of this species were sampled. Bark thickness data were corrected for tree diameter before analysis using linear regression.

3. Results

There was no difference in bark thickness of trees on white sand and loam (Fig.1) between the two soil types in Suriname. The comparison of *Chaetacarpus schomburgkianus* bark thickness in Suriname and Brasil (Fig. 2) revealed that bark was twice as thick in Brazil.

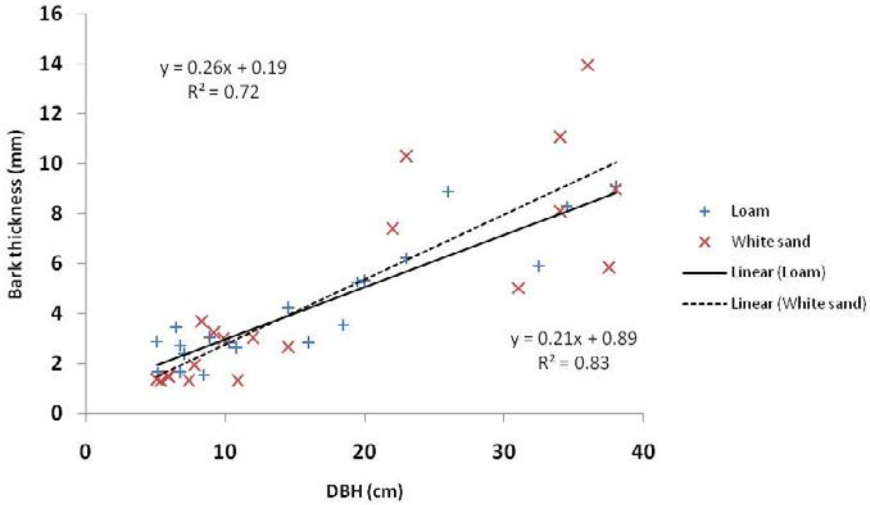

Fig.1. The relationship between bark thickness of and tree stem diameter on white sand and loam soil in Suriname.

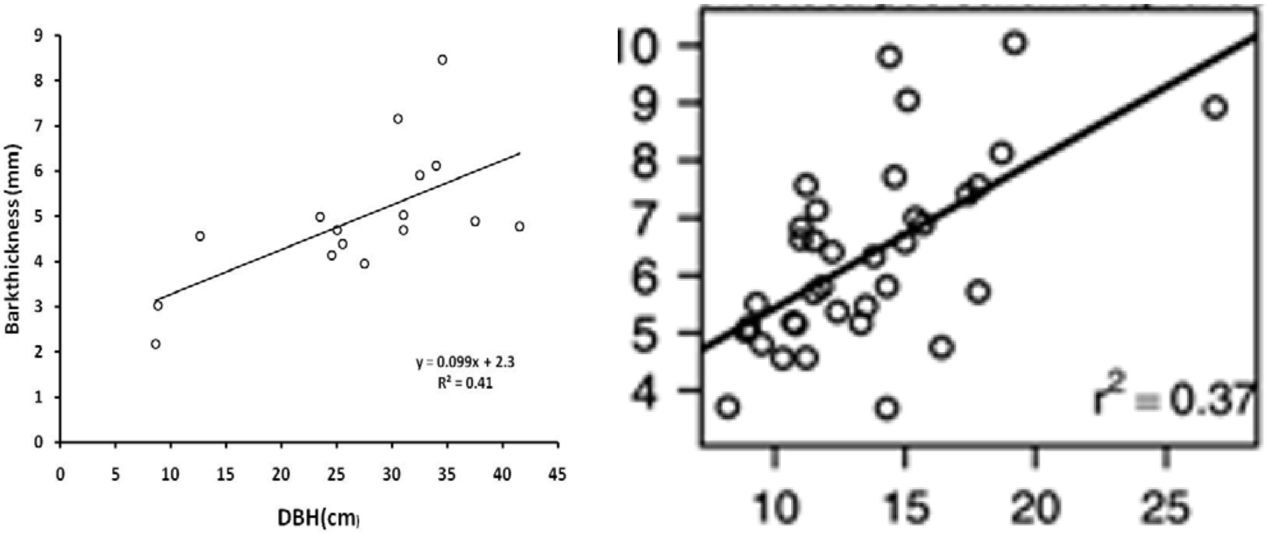

Fig. 2. Bark thickness versus DBH of *Chaetacarpus schomburgkianus* in Suriname (left) and Brazil (right). The bark is almost twice as thick in Brazil.

4. Discussion

The observed lack of difference in bark thickness between trees on white sand and loam in Suriname suggests that fire is not an evolutionary force on either soil type. In contrast, the observed large difference in bark thickness on the same species in Suriname and Brazil suggest that frequent fires in the latter have selected over evolutionary time for thick bark.

Acknowledgment

I thank Professors F.Putz and R.Fraser, and A.Shenkin for their guidance. Thanks also to TBI-Suriname, SBB, FAO, and CELOS for their financial support of our field course.

REFERENCES

Brando, P.M. Fire-induced tree mortality in a neotropical forest: the roles of bark traits, tree size, wood density, and fire behavior. Global ChaNge Biology (in review).

Photo Gallery


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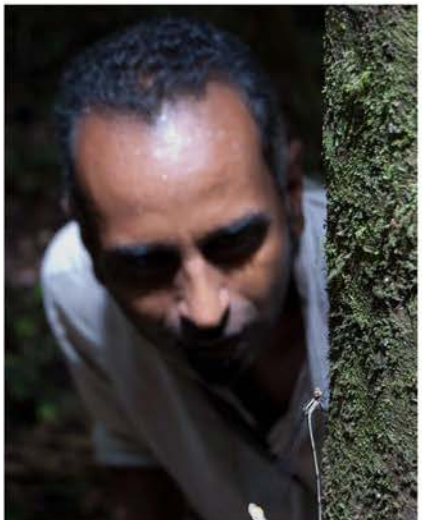


CELOS MANAGEMENT SYSTEM
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