Annual Letter 2002-2003

United States
Department of
Agriculture

Forest Service
International Institute
of Tropical Forestry

Pacific Northwest
Research Station

General Technical
Report
IITF-GTR-31

December 2006

Cover

The cover is based on a drawing by W. Ellis Groben, Forest Service architect. He designed several Forest Service buildings including the one for the International Institute of Tropical Forestry. It depicts the front of the building from the northwest end.

Annual Letter
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U.S. Department of Agriculture
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International Institute of Tropical Forestry
Jardín Botánico Sur
1201 Calle Ceiba
San Juan, Puerto Rico 00926-1119
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Contents

Summary of Research Accomplishments for Soil Biology/Ecological Studies

Grizelle González
Research Ecologist

This has been a very active and extremely exciting year for the development of the research program centered in great part on two problems (of three) assigned to the research work unit: Problem 1–Improving the knowledge and predictive methods to understand the internal dynamics and external influences that affect tropical landscapes (P1-4, Studies of soil ecology in tropical landscapes), and Problem 2–Stand and landscape dynamics: insufficient knowledge on the spatial distribution of forest resources over time (P2-7, Landscape fragmentation and forest fuel accumulation).

Most of my research continues to be focused on the effects of soil organisms on ecosystem processes and functioning as related to study plan 2566. Additionally, I have initiated on the ground five new experiments. I am also within three distinct projects involving different collaborators. I am also making great progress on the development of two other studies: the characterization and ecology related to the soils of Mona Island (involving collaboration of students and facility of the University of Puerto Rico–Department of Biology) and the refinement of the use of glucose concentrations for estimating microbial biomass and activity by using substrate-induced respiration on tropical soils (part of a master's thesis).

Status of the Various Research Projects

Study Plan 2566–Soil Fauna, Microbes and Ecosystem Properties Along an Elevation and Climatic Gradient in Eastern Puerto Rico

During fiscal year 2003, I have continued the monthly monitoring of climate (temperature and rainfall), litterfall (quantity and quality), soil physical and chemical properties, and soil microarthropod abundances (by using pitfall trapping) in the network of 24 research sites, which encompass eight forest types along a climatic/elevational gradient in eastern Puerto Rico. Also, I focused on the standardization of the substrate-induced respiration (SIR) methodology to characterize functional groups of microbes along the elevational gradient. Substrate-induced respiration is a technique used for estimating microbial biomass in soils. In this technique, an easily assimilated substrate (usually glucose) is added to the sample, and the respiration response (rates of oxygen uptake and carbon dioxide production) is measured during an incubation period. It is assumed that the **initial maximum respiration rate** is proportional to the microbial biomass present. To apply this method, it is necessary to know the *minimum glucose concentration* required for achieving a *maximal respiration response* for each site. The main objective was to determine the amount of glucose needed to obtain a maximum microbial stimulation (initial maximum respiratory response) for a secondary lowland moist forest in Puerto Rico. Zalamea and González [1] have found that (1) minimal glucose amendment for achieving a maximal initial respiratory response is between 3 and 4 mg glu-C g soil^{-1}; (2) an initial time of approximately 4.5 hours of incubation is needed for stabilization of the samples; and (3) maximal respiratory response was achieved between 5 and 6 hours of incubation, which corresponds to the lag-phase (see figs. 1 and 2). During fiscal year 2004, we plan to (1) determine minimum glucose amendment for soils from the other sites of the elevational gradient through the Luquillo Mountains, (2) compare microbial biomass estimations derived from SIR with those obtained from chloroform fumigation and incubation in order to calculate the metabolic quotient ($q CO_2$), and (3) standardize the methods for selective inhibition of fungal and bacterial fractions.

Other Research Initiatives

Decomposition Experiment as Part of the Fire Project

Scientists from the International Institute of Tropical Forestry (IITF) are being supported by the Joint Fire Science Program to study fuel accumulation in fragmented landscapes in different ecosystem types that span our national lands from tropical to boreal forests. The study combines sites that have a longer history of fire research (Alaska and Idaho) with sites in Puerto Rico where fires are common but their importance has not been well recognized. We are studying the edge effect on fuel loads and wood decomposition in young and old, moist and dry forest fragments along the climatic gradient to better model and map fuel loads in fragmented forested ecosystems. The major objective of the decomposition experiment of this project is to determine the effects of fragmentation on wood decomposition rates as related to fragment size, forest age, and climate at the macro- and microscales.

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[1] Zalamea, M.; González, G. 2003. Unpublished data. On file with: G. González, Research Ecologist, USDA Forest Service, International Institute of Tropical Forestry, Jardín Botánico Sur, 1201 Calle Ceiba, San Juan, Puerto Rico 00926-1119.

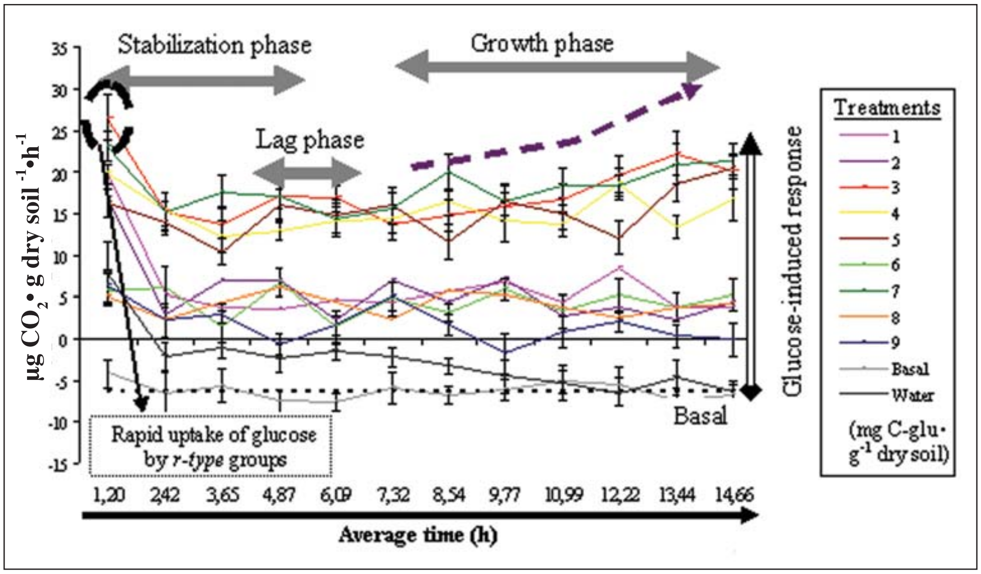

Figure 1—Basal respiration and respiratory response of a lowland moist forest soil through time after amendment with various concentrations of glucose and water (see footnote 1).

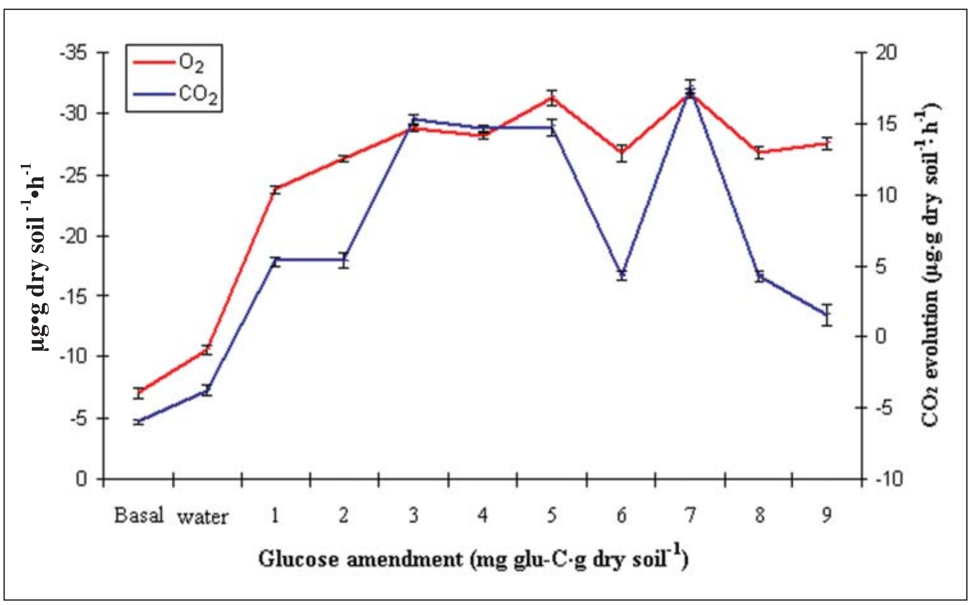

Figure 2—Oxygen consumption and respiratory response of a lowland moist forest vs. glucose amendments after 5 to 6 hours of inoculation (see footnote 1).

In June 2003, stakes of aspen wood were placed at sites that represent moist and dry fragmented forests of different sizes in Alaska, Idaho, Minnesota, and Puerto Rico. The wood stakes were placed in the center, the edge, and outside of the forest edge of each individual fragment. Control stakes were collected right after the experiment began to determine initial chemistry and physical properties as well as dry weight conversions (table 1).

Long-Term Ecological Research Activities

Invertebrate manipulation in the canopy trimming experiment—
The Canopy Trimming Experiment (CTE) is part of a research program proposed by the Luquillo Long-Term Ecological Research. The CTE involves the manipulation of the canopy litter to tease apart the effects of downed litter debris and microclimate effects to simulate a hurricane disturbance. The objective of the soil fauna manipulation within the CTE is to determine the effect of different groups of the soil fauna on the decay of fresh and senescent litter within the context of a hurricane scenario. In general, it is hypothesized that the absence of invertebrate fauna will have strong effects on detrital dynamics, retarding decomposition rates and related processes. Microclimatic changes associated with canopy opening will reinforce these effects, but the addition of detritus will buffer the effects of canopy opening. Since November 2002 and twice a month, senescent leaves (to be used in the decomposition experiment) have been collected as litterfall. Mixed litter to be used in the decomposition litterbags should include more than the five species that had been preselected from the Minority Research Centers of Excellence plots to account for a greater representation of species to the total litterfall (fig. 3, table 2).

Table 1—Number of wood stakes to be analyzed during the decomposition experiment of the fire/forest fragmentation study

Collection	No. of daughter stakes	No. of controls	Date to ship to Forest Products Lab
Initial	108	108	July 2003
1	648	324	November 2003
2	648	324	June 2004
3	648	324	November 2004
4	648	324	June 2005

N= 9 for dry weight (using three stakes for ovendry conversion.
N = 6 for compression/sugars (total $_{\text{compression}}$ = 4,104; total $_{\text{sugars}}$ = 2,700).
N = 6 for nutrients.

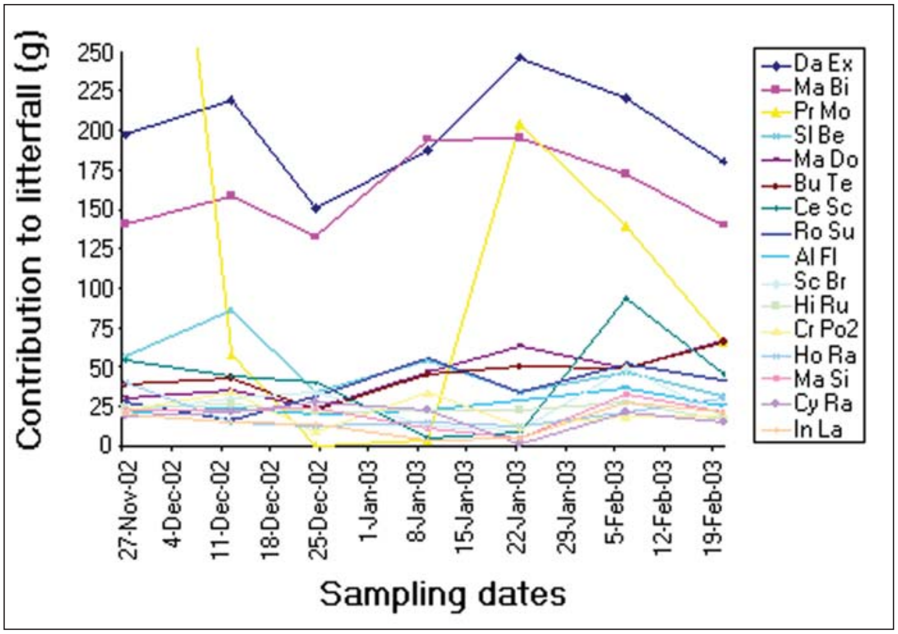

Figure 3—Temporal variation of litterfall for the 16 most abundant species in the Canopy Trimming Experiment. The species legend is as follows: Da Ex = *Dacryodes excelsa*; Ma Bi = *Manilkara bidentata*; Pr Mo = *Prestoea montana*; Sl Be = *Sloanea berteriana*; Ma Do = *Matayba domingensis*; Bu Te = *Buchenavia tetraphylla*; Ce Sc = *Cecropia schreberiana*; Ro Su = *Rourea surinamensis*; Al Fl = *Alchorneopsis floribunda*; Sc Br = *Schlegelia brachyantha*; Hi Ru = *Hirtella rugosa*; Cr Po2 = *Croton poecilanthus*; Ho Ra = *Homalium racemosum*; Ma Si = *Marcgravia sintenisii*; Cy Ra = *Cyrilla racemiflora*, and In La = *Inga laurina*.

Table 2—Preliminary data on the relative abundance and species composition of the litterfall in the Canopy Trimming Experiment (CTE) plots from November 2003 to February 2003 as compared to the Minority Research Centers of Excellence (MRCE) plots[a]

	Total production	
Species	**MRCE plots**	**CTE plots**
	Percent	
Dacryodes excelsa Vahl	34	16.73
Manilkara bidentata (A. DC.) A. Chev.	15	13.53
Cecropia schreberiana Miq.	4	3.46
Buchenavia tetraphylla (Aublet)	9	3.73
Sloanea berteriana Choisy	2	4.10
Subtotal	64	41.55
Others	36	58.45
Prestoea montana (R. Graham) Nichols.		13.4
Matayba domingensis (DC.) Radlk.		3.77
***Rourea surinamensis* Miq.**		3.07
Alchorneopsis floribunda (Benth.) Muell. Arg.		2.16
***Schlegelia brachyantha* Griseb.**		2.09
Subtotal		24.49
Total		66.07
Hirtella rugosa Pers.		1.91
Croton poecilanthus Urban		1.78
Homalium racemosum Jacq.		1.75
***Marcgravia sintenisii* Urban**		1.65
Cyrilla racemiflora L.		1.52
Inga laurina (Sus.) Willd.		1.28
Subtotal		9.89
Total		75.93
Others		24.07

[a] Vines (in bold) represent nearly 10 percent of the total litterfall.

Litter decomposition in the LTER network: gaps and bridges to synthesis (workshop and followup proposal)—
During the LTER all-scientist meeting in Seattle (September 2003), I co-led a workshop on the state of decomposition research in the LTER network to identify the gaps in data and study factors in sites within the network, and determine "bridge" questions in an effort to start the process of synthesis given available data. The workshop consisted of invited talks and discussion on synthesis and research

initiatives. Talks covered three main factors affecting litter decay: climate (I. Burke, Shortgrass Steppe LTER, Colorado), substrate quality (M. Harmon, Andrews Forest LTER, Oregon), and organisms (D. Coleman, Coweeta Hydrological Laboratory LTER, North Carolina), and we considered modeling (W.J. Parton, SGS; J. Moore, Arctic Tundra LTER, Alaska/Shortgrass Steppe LTER, Colorado) as an integral component of the synthesis effort. Participants represented 14 U.S. and 4 international (Taiwan, Korea, China, and Latvia) LTER sites.

Recommendations toward synthesis included updating the LTER bibliography of published studies. At the network level, there is a wealth of data related to nitrogen dynamics and organismal aspects of litter decay. Models incorporating long-term chemical data as well as organismal information are needed to accurately predict ecosystem functioning, particularly carbon and nitrogen dynamics. Participants agreed that this is an important theme on which to build cross-site and interdisciplinary synthesis, and the integration process will greatly advance the science of decomposition studies in the network.

The organizers of the workshop will pursue funding from the LTER network office for a followup workshop. The main objective of the followup workshop will be to draft for publication a synthesis paper on the current state of decomposition studies across the LTER and International LTER network. This paper will also identify key research questions for future studies and new research initiatives within the network.

Decomposition and Nutrient Mineralization in Pig and Goat Exclusion Plots in Mona Island, Puerto Rico. Subproject III: National Science Foundation-Centers for Research Excellence in Science and Technology (CREST)-University of Puerto Rico-Rio Piedras Campus: Population and Species Management Group: Effects of Exotic Species on Native Insular Biota

This research looks at excluding exotic feral ungulates in Mona Island to determine (1) the effect of exotic species on island native biota, and (2) management implications of eradicating exotics to native insular biota. We are combining periodic field surveys of plant and animal diversity, large-scale use of herbivore exclosures, and laboratory plant and soil analysis to address questions aimed at characterizing the potential controls by mammalian herbivory on the depression forests. I am collaborating with the Puerto Rico Department of Natural Resources and the Environment and University of Puerto Rico researchers in the development of a soil biology/biogeochemical component that looks at the effects of exotic biota on the nutrient cycling of the island dry forests. Three transects have been established in the platform and depression forests of Mona Island. A first set of soil samples comprising 17 points within each of the 6 transects was collected in September 2003. A total of 102 samples will be analyzed in the IITF chemistry laboratory for their chemical and physical properties during fiscal year 2004.

Biocomplexity of Frost-Boil Ecosystems (Teaching and New Experiments on the Decomposition of Dominant Graminoid Species)

One of the fundamental goals of our national science policy is to better integrate research and education. There is strong national interest in improving this integration at the graduate and undergraduate levels, with the general public, and (in the Arctic in particular) with indigenous people. Gould and González (IITF scientists) developed a project integrating well-defined research goals, an established field education program, and experienced personnel to create this unique research and educational opportunity. We have integrated an arctic field ecology course with research for the Biocomplexity of Arctic Frost-Boil Ecosystems project. In fiscal year 2004 and in collaboration with Skip Walker (University of Alaska, Fairbanks) principal investigator of this project and a team of 19 scientists and students from the United States and Canada, we completed the second field season investigating the effects of climate on frost-boil ecosystems. This summer the team established three research sites at Green Cabin in Aulavik National Park, Banks Island, and Mould Bay, Prince Patrick Island. In each of the sites, we monitor climate, thaw-layer depth, frost heave, soils, and vegetation characteristics.

Members of the research team included Howard Epstein and Alexia Kelly (University of Virginia); William Krantz (University of Cincinnati); Anja Kade, Chien-Lu Ping, Gary Michaelson, Martha Raynolds, Vladimir Romanovsky, and Skip Walker (University of Alaska Fairbanks); Sarah Harvey (VECO Polar Resources), and Charles Tarnocai (Agriculture and Agri-Food Canada). The students were participating in the Arctic Field Ecology course taught by William Gould and Grizelle González through the University of Minnesota. The students included Ronnie Daanan, Heather Fuller, Patrick Kuss, Noah Strom, Sean Rea, and Adriana Quijano.

In addition to the seminar and educational/field activity, I established a series of decomposition experiments to look at decay rates on boil and interboil areas along the climatic gradient and along a toposequence at Green Cabin and Prince Patrick Island.

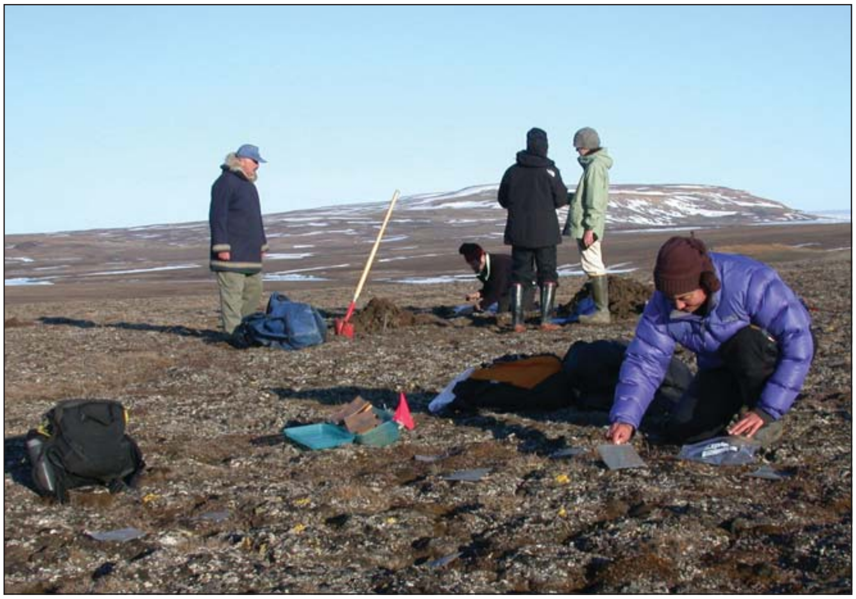

Figure 4—Placing litterbags on boil and interboil surfaces on Prince Patrick Island (subzone B).

Experiment 1. In 2002, we collected recently senesced litter of *Luzula nivalis* from Satellite Bay, Prince Patrick Island and created 20 mesh litterbags (2 by 2 mm) for placement in the field. These were placed in the field in 2003 at Mould Bay, Prince Patrick Island, on a series of boil and interboils within a 4- by 4-m quadrant (fig. 4). A set of controls was retrieved and weighed. These will be analyzed for litter chemistry at the IITF chemistry lab. The remaining litterbags will be retrieved in 2004 and 2005 to determine boil and interboil variation in percentage of mass loss, decay rate, and change in litter chemistry.

Experiment 2. In 2003, we collected freshly senesced litter of *Carex misandra* at the Green Cabin site on Banks Island (subzone C) and created 60 mesh litterbags (2 by 2 mm) (fig. 5). We took field weights and placed these bags along our biodiversity transects on boil and interboil surfaces and at 4-cm depths. A set of controls was retrieved and will be analyzed in the IITF chemistry lab. Remaining bags will be sampled in 2004 and 2005 to determine mass loss, decay rates, and changes in litter chemistry.

Experiment 3. We prepared 107 additional litterbags of *Carex misandra* for placement in boil and interboil areas along a toposequence at the Green Cabin site. Three replicate litter bags were placed on the surface and belowground at 4-cm depths within three replicate boils and interboils at ridge, slope, and valley

Figure 5—Sean Rea and Noah Strom repairing litterbags in the research tent at Green Cabin.

positions. These are at the same sites being used for nitrogen mineralization experiments by Alexia Kelly and Howie Epstein. Controls were retrieved after placement and additional bags will be retrieved in 2004 and 2005.

English Equivalents

When you know:	Multiply by:	To get:
Centimeters (cm)	0.394	Inches
Millimeters (mm)	.0393	Inches
Meters (m)	3.28	Feet
Grams (g)	.0352	Ounces

Additional Accomplishments

Presentations

Carrero, G.; Gould, W.A.; González, G. 2003. Native and non-native plant species in eight forest types in Puerto Rico. Presented at the Caribbean urban forestry conference: biodiversity and sustainability, Ponce Hilton Hotel, Ponce, Puerto Rico, June (oral).

Carrero, G.; Gould, W.A.; González, G.; Ramírez, J.L. 2003. Variation in endemic, native, non-native and critical plants in eight forest types in Puerto Rico. Presentation at the Luquillo Long-Term Ecological Research (LTER) all-scientists annual meeting, University of Puerto Rico, Rio Piedras, Puerto Rico, January (oral). [Published abstract].

González, G. 2003. A biotic manipulation within the Canopy Trimming Experiment. Presentation at the Luquillo LTER all-scientists annual meeting, University of Puerto Rico, Río Piedras, Puerto Rico, January (oral).

González, G. 2003. A proposal to modify the Canopy Trimming Experiment. Presentation at the Luquillo LTER all-scientists annual meeting, University of Puerto Rico, Río Piedras, Puerto Rico, January (oral).

González, G.; Gould, W.A. 2003. Biocomplexity of frost boil ecosystems: decomposition of dominant graminoid species, Banks Island expedition field seminar series, Banks Island, NWT, Canada, July (oral).

González, G.; Gould, W.A.; Hudak, A.; Hollingsworth, T. 2003. Wood decay and fragmented forests of different sizes in Alaska, Idaho, and Puerto Rico. Presentation at the 2nd workshop on landscape fragmentation and fuel load: effects of fragment size, age, and climate, IITF, Río Piedras, Puerto Rico, February (oral).

González, G.; Rivera, M.M.; Gould, W.A.; Ramírez, J.L. 2003. Soil fauna, microbes and ecosystem properties along an elevational gradient in eastern Puerto Rico. Presented at the LTER site review, El Portal, Luquillo, Puerto Rico, June (oral).

González, G.; Seastedt, T.R.; Donato, Z. 2002. Earthworms, arthropods and plant litter decomposition in aspen (*Populus tremuloides*) and lodgepole pine (*Pinus contorta*) forests in Colorado, USA. Presentation at the 7th international symposium on earthworm ecology. Cardiff, Wales, United Kingdom, September (oral). [Published abstract].

González, G.; Silver, W.; Lodge, J.D. 2003. Litter decomposition in the LTER network: gaps and bridges to synthesis. LTER-all-scientist meeting, Seattle, Washington, September (oral and workshop).

González, G.; Zou, X. 2003. A comparison of earthworm abundance and biomass in hurricane-damaged tropical wet and elfin forests in Puerto Rico. Presented at the annual symposium of the British Ecological Society–Biological diversity and function in soils, Lancaster University, United Kingdom, March (oral).

González, G.; Zou, X. 2003. A comparison of earthworm abundance and biomass in hurricane-damaged tropical wet and elfin forests in Puerto Rico. Presented at the LTER site review, El Portal, Luquillo, Puerto Rico, June (oral).

Gould, W.A.; González, G. 2003. Biocomplexity of frost boil ecosystems: educational component. Presented at the Banks Island expedition field seminar series, Banks Island, NWT, Canada, July (oral).

Gould, W.A.; González, G. 2003. Vegetation and soils in eight tropical forest types along an elevation gradient. Presented at the LTER site review, El Portal, Luquillo, Puerto Rico, June (oral).

Gould, W.A.; González, G. 2003. Vegetation and soils in eight tropical forest types along an elevation gradient. Presented at the annual symposium of the British Ecological Society–Biological diversity and function in soils, Lancaster University, United Kingdom, March (oral).

Gould, W.A.; González, G.; Walker, D.A. 2003. Biocomplexity of frost-boil ecosystems: integrating science and education. Presented at the Biocomplexity in the Environment Awardees meeting, Arlington, Virginia, September (oral).

Gould, W.A; Hudak, A.; González, G. 2003. Landscape fragmentation and forest fuel accumulation: effects of fragment size, age, and climate. Presentation at the 2nd workshop on landscape fragmentation and fuel load: effects of fragment size, age, and climate, IITF, Río Piedras, Puerto Rico, February (oral).

Gould, W.A.; Hudak, A.; González, G.; Hollingsworth, T. 2002. Variation in fragment edge effects along gradients of climate, fragment size, and forest age. Presentation at the U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry science seminar series, Río Piedras, Puerto Rico, December (oral).

Gould, W.A.; Hudak, A.; González, G.; Hollingsworth, T. 2003. Landscape fragmentation and forest fuel accumulation. Presented at the Joint Fire Science Program annual meeting, Phoenix, Arizona, February (oral).

Walker, D.A.; Kade, A.N.; Michaelson, G.; Ping, C.L.; Raynolds, M.K.; Romanovsky, V.E.; Epstein, H.E.; Kelley, A.M.; Gould, W.A.; Gonzalez, G.; Krantz, W.B.; Tarnocai, C.T. 2003. Biocomplexity of frost-boil ecosystems: self-organization across the Arctic Bioclimate Gradient. Presented at the Biocomplexity in the Environment Awardees meeting, Arlington, Virginia, September (oral).

Walker, D.A.; Kade, A.N.; Michaelson, G.; Ping, C.L.; Raynolds, M.K.; Romanovsky, V.E.; Epstein, H.E.; Kelley, A.M.; Gould, W.A.; González, G.; Krantz, W.B.; Tarnocai, C.T. 2003. Biocomplexity of frost boil ecosystems: 2003 expedition to Banks Island and Prince Patrick Island, Canada. Presented at the 54th arctic science conference, Fairbanks, Alaska, September (oral).

Zalamea, M.; González, G. 2003. Relative abundance and species composition of the litterfall in the canopy-trimming plots: preliminary data for the decomposition experiment and soil fauna manipulations. Presented at the LTER site review, El Portal, Luquillo, Puerto Rico, June (oral).

Zalamea, M.; González, G. 2003. Substrate-induced respiration (SIR): determination of the minimal glucose amendment for soils from a lowland moist forest in Puerto Rico. Presented at the LTER-all-scientist meeting, Seattle, Washington, September (oral).

Maps

Gould, W.; Edwards, B.; González, G. 2003. Roosevelt Roads natural resources and IITF research sites. Presented to committee drafting a bill to Congress for preservation of Roosevelt Roads area, Río Piedras, Puerto Rico, September 11, 2003.

Reports

Gould, W.; González, G. 2003. Report on arctic field ecology class field activities. Report to the Biocomplexity of Arctic Frost-Boil Ecosystems group, Fairbanks, AK, September 8, 2003.

Gould, W.; Hudak, A.; González, G. 2003. Status report: Joint Fire Science Program, landscape fragmentation and forest fuel accumulation: effects of fragment size, age, and climate. Annual Report to the Joint Fire Science Program, Moscow, ID, February.

Course Taught

A series of seminars on the biology, ecology, and nutrient cycling of arctic soils. 2003. Course: EEB 4852 through the University of Minnesota and biocomplexity grant to University of Alaska-Fairbanks, Alaska and Banks and Prince Patrick Islands in Canada, July.

Publications

González, G. 2002. Soil organisms and litter decomposition. In: Ambasht, R.S.; Ambasht, N.K., eds. Modern trends in applied terrestrial ecology. New York: Kluwer Academic/Plenum Press: 315-329.

González, G.; Seastedt, T.R.; Donato, Z. 2003. Earthworms, arthropods and plant litter decomposition in aspen (*Populus tremuloides*) and lodgepole pine (*Pinus contorta*) forests in Colorado, USA. Pedobiologia. 47: 863-869.

Analysis of Fires in Puerto Rico

Magaly Figueroa
Natural Resources Specialist

Introduction

Fire research around the world shows the following trends:

- Global estimates have established that 70 percent of forest fires occur in the tropics.
- Fires are the major cause of deforestation.
- Fires convert ecosystems into unsustainable and economically unstable systems.
- Global temperature increases and droughts increase the potential for frequency of fires with ecological and economic effects.
- Human activities make ecosystems more prone to fire. Timber harvesting, slash and burn agriculture, and development are examples of these activities.
- Ecosystems where human activities are present show alterations in the amount of available carbon, nutrient cycles, amount of fuel present in the system, and habitat characteristics.

Compared to regions in the United States, Puerto Rico lags in prediction of events, monitoring, education, prevention strategies, and study and analysis of fire effects on ecosystems and society. Furthermore, historical evidence in Puerto Rico suggests that there has not been an increase in overall fire incidence, yet there have been fire events reported in moist forests, which is a change in fire pattern. Through the years, there has been evidence of a dramatic change in land use and vegetation cover. Lands that in the past were used for agricultural purposes have become reforested naturally or by silvicultural practices.

Land Use History in Puerto Rico

In colonial times, land was subject to intense deforestation to establish agricultural crops. In more recent times,that's, the 20th century, with the advent of industry and manufacturing, agricultural land was abandoned (fig. 6). A reforestation process was initiated by using both natural regeneration and plantations. Over time, new vegetation cover and patterns of land use have emerged,for example, forest cover increased from 7 percent in 1949 to 31 percent in 1989.

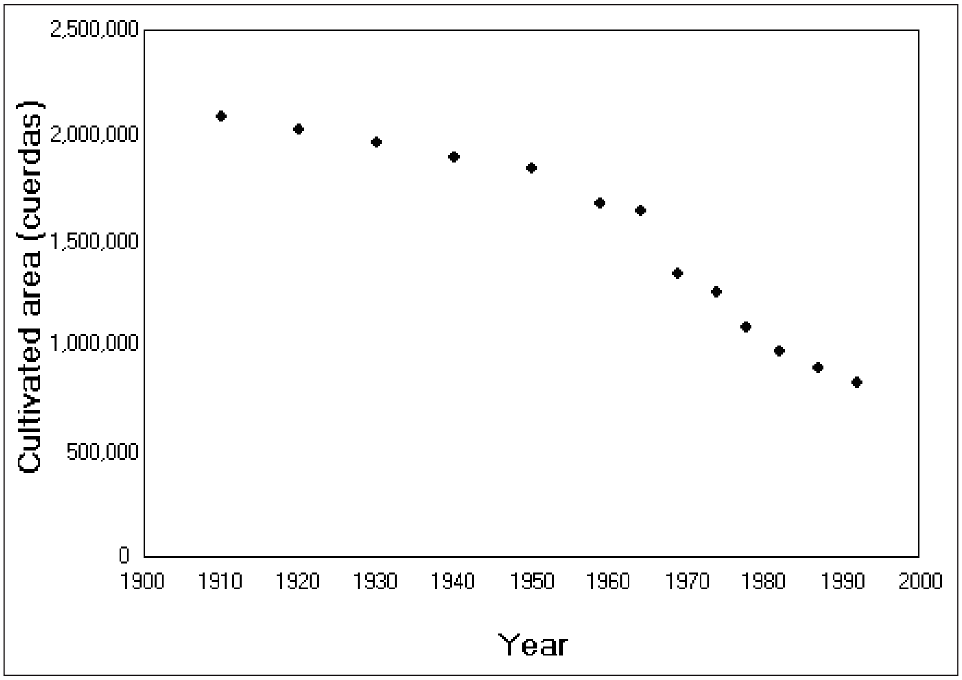

Figure 6—Cultivated area in Puerto Rico from 1910 to 1990. Note that the measurement is in "cuerdas," a surface measurement used in Puerto Rico equivalent to 0.971 acre.

At present, some of the factors that continue to change land use significantly are urban development and increases in human population. Abandonment of land, together with development and an increase in population increases areas of urban-rural interface, costs in fire control, and costs of damage by fire and restoration practices. Increases in population have caused deforestation and fragmentation of areas with trees and forests.

Forest Fragmentation

Forest fragmentation[1] is important because it has negative effects on ecological processes and conservation of biodiversity. Potential for fire events in these systems can be evaluated by using climatic variables and fuel[2] present at the site. Data compiled on the ecology of forest fragments suggest that composition, structure, and quantity of fuels are related to the morphology of the fragments, for example, area, form, and perimeter.

[1] For purposes of this paper we define fragmentation as the transformation of a large woody area into small remnant patches.

[2] Fuel is the sum of the biomass of thick woody debris with diameter >7.6 cm and biomass of fine woody debris from 0.25 cm to 7.6 cm and rubbish.

Forest fragments do not function as continuous forest does. Forest fragments created by clearcutting trees that are subsequently regenerated, differ from continuous forest in an increase in forest marginal zones and vary in proximity and connectivity of the fragments.

The number of margins in a forest system is important because environmental factors change along a gradient from the margin to the center. The structure of a margin affects the center of the fragment and vice versa. Differences between the margins and the center of a forest fragment can cause differences in terms of fire susceptibility, tree mortality, and total area. The structure of margins–open or closed–can significantly affect microclimates within fragments.

Research Needs

Research on land use change provides data for land management decisions and practices. Fire incidence and effects has become a component in the decisionmaking processes of land management.

Research should be done on a priority basis on the following topics:

- Changes in carbon storage from organic and inorganic sources.
- Changes in live biomass from organic and inorganic sources.
- Changes in live and dead biomass in response to fire incidence in urban areas, pastures, and forest fragments.
- Changes in species composition and altered habitat characteristics and quality in response to fires.
- Establishment of effective land management decisions that consider fuel accumulation.
- Design of effective land management practices that takes into consideration fuel accumulation, new fire regimes, and new species composition.

Puerto Rico Fire Department

The Puerto Rico Fire Department and the USDA Forest Service generated a map showing fire occurrence in Puerto Rico by using statistics from 1999 (fig. 7). The map shows that there is greater fire occurrence in the south of Puerto Rico, which tends to be drier than other areas on the island. There are several factors that increase fire incidence in Puerto Rico.

- Locations that have mean annual precipitation less than 1500 mm.
- Locations where mean annual precipitation is greater than 1500 mm but where mean monthly precipitation during the driest month is from 51 to 75 mm.
- Plantations of short and tall grasses, cultivated or abandoned sugar cane fields, other areas used for growing forage and straw and pastures.
- Certain types of vegetation.

Wherever there is a high incidence of fire, there is the potential for damage to the urban-rural interface, areas where human population has expanded and natural protected areas. It is therefore necessary to establish certain areas as high priority when developing land management policy. These areas include:

- Areas where there is high fire incidence.
- Areas where potential for fire incidence is increased because of low mean annual precipitation or mean monthly precipitation.
- Areas of specific kinds of pasture.
- Natural protected areas.
- The urban-rural interface.
- Areas exhibiting human expansion patterns.

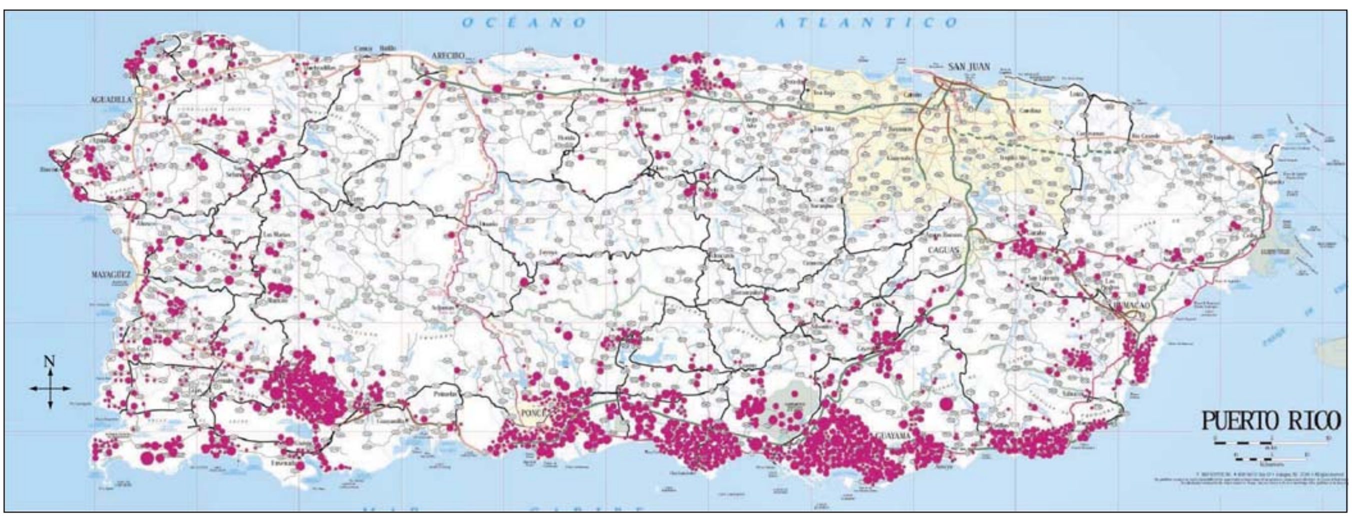

Figure 7—Fire incidence indicated by purple dots. Notice the high fire incidence in the south of the island, which tends to be drier than the north.

Fire-Wise Communities

The purpose of this program is to promote and recognize communities that want to minimize fire damage to homes and the environment. The program emphasizes prevention, teaching participating communities how to prepare for fires before they happen. The program is designed for all kinds of communities from small to larger developments. Fire management personnel from federal, state, and local agencies interact with communities and provide information on how to prevent or mitigate fire effects. The community identifies risk factors and creates a network of effective communication between residents, agencies, and organizations. The community also identifies and implements management practices. Resources are available to communities through the Fire-Wise program, such as videos and photographs along with specialized training designed to guide communities through the establishment phase of their projects. There is an interactive Web site at www.firewise.org/communities where experts are available to answer questions and provide information. The Caribbean Resource Conservation and Development Council received a grant of $10,000 to establish an educational program for prevention of fire in communities.

English Equivalents

When you know:	Multiply by:	To get:
Centimeters (cm)	0.394	Inches
Millimeters (mm)	.0394	Inches

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Cooperative Fire Program

Terry Hueth
State and Private Forestry Team Leader

and

Magaly Figueroa
Natural Resources Specialist

Cooperative Fire Program in the U.S. Virgin Islands

State and Private Forestry Programs provide financial and technical assistance to the Puerto Rico and U.S. Virgin Islands Fire Departments for Incident Command System and wildland fire suppression training, equipment and supply purchases, and fire prevention programs (fig. 8 and 9).

All of the U.S. Virgin Islands can be classified as wildland-urban interface. Suppression of wildland fires on the Islands comes with unique challenges: continually drying trade winds, limited freshwater sources, fuel buildup associated with dry tropical forests (fig. 10); narrow steep roads, difficult access; and lack of proper equipment and training. The emphasis of the program is to provide a

Figure 8—(a) Fire engines purchased for the Virgin Islands and Puerto Rico fire program. The smaller engines are well suited for conditions in urban and rural areas, e.g., narrow roads with sharp turns. (b) Newly purchased vehicles for the Virgin Islands fire program with fire department personnel receiving associated training.

Figure 9—Smokey helps “kick off” Fire Prevention Week for 3,000 kindergarten through 6th grade students in the U.S. Virgin Islands. Most fires are human caused, and the Virgin Islands Fire Prevention Program and Safety are high emphasis programs for the Fire Service.

Figure 10—Typical scrub type vegetation of tropical dry forest.

wildland fire training component for the fire department, along with proper equipment and technical and financial assistance in developing freshwater resources (dry hydrants). The Cooperative Fire Program and the National Fire Plan have provided funds for financial assistance to improve wildland suppression capabilities.

Cooperative Fire Program in Puerto Rico

The Puerto Rico Fire Department (Bomberos de Puerto Rico) is responsible for suppression of both structural and wildland fires. Wildland fire training has been an important part of the Bomberos fire program for the last few years. A partnership with the U.S. Forest Service International Institute of Tropical Forestry and the Puerto Rico Fire Department has resulted in both technical and financial assistance in meeting their long-term goals in wildland fire prevention and suppression (fig. 11).

Annually, there is an average of 3,000 to 5,000 fire starts, so fire prevention is a key program for success (figs. 12 and 13). The Resource Conservation and Development Council for the southern part of the island is assisting in prevention through the “Firewise” community program and has developed pamphlets and bumper stickers teaching prevention.

Figure 11—Future wildland fire trainers of Puerto Rico. They have just completed a wildland engine course along with safety and Incident Command System training.

Figure 12—A fire start in one of the small communities on the southern exposures on Puerto Rico. Fire scars from past fires are also visible.

Figure 13—Aviation resources are looked at as an initial attack tool for both Puerto Rico and the U.S. Virgin Islands.

Facts From Puerto Rico and the Tropics

- Half of the world's forests are tropical.
- There are more types of tropical forests than forests from other latitudes combined.
- The Caribbean National Forest (CNF) is also the Luquillo Experimental Forest (LEF), the only national forest that is also an experimental forest.
- The CNF/LEF is the oldest public forest in the hemisphere, preceding the USDA Forest Service.
- The Caribbean National Forest has more tree species than the rest of the National Forest System combined.

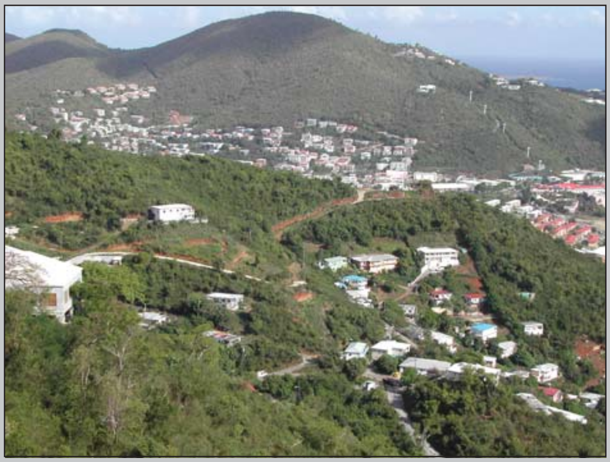

Figure 14—Population density along with steep narrow roads, rugged terrain, and inaccessible areas provide a challenge for firefighting; therefore, prevention is a key part of the program.

- Puerto Rico has an area of approximately 3,700 mi^2 (2,367,868 acres) and a population of 4 million people.
- The Virgin Islands has an area of 135 mi^2 (86,395 ac) and a population of 170,000 people (fig. 14).
- Puerto Rico has the same number of tree species as all of North America.
- Puerto Rico and the U.S. Virgin Islands have more than a million visitors a year.
- At one time, the International Institute of Tropical Forestry was the only place where Latin American foresters could be trained in tropical forestry.

Mapping Land Cover and Forest Formations in the Insular Caribbean With Landsat Satellite Imagery

Eileen Helmer
Research Ecologist

A pioneering international effort that will map land cover and forest formations of Caribbean islands with Landsat imagery began field data collection in 2003 for five eastern Caribbean countries. During fiscal year 2003, we completed field work for the islands of St. Kitts, Nevis, Grenada, and Barbados, and we developed a classification legend that is robust yet extremely relevant to the many natural resource issues that Caribbean islands face. We expect to complete fieldwork and maps for St. Lucia, St. Vincent, and the Grenadines during fiscal year 2004. This project, which collaborates with the U.S. Geological Survey Earth Resources Observation Systems Data Center, The Nature Conservancy, and Agricultural Ministry staff from each country, is using over 100 Landsat 7 ETM+ images provided by the National Aeronautics and Space Administration Global Observation of Forest Cover Program during 2004.

During fieldwork, International Institute of Tropical Forestry staff demonstrated to forestry professionals from St. Kitts, Nevis and Grenada a new field data collection system. The system relies on integrating a global positioning system (GPS) receiver with a laptop computer (with a daylight-viewable image display) running the Earth Resources Data Analysis System Imagine software's[1] GPS tool. In addition, we provided forestry professionals in Grenada and a World Bank consultant with recommendations on mapping approaches, imagery, and classification schemes for the Grenada Dry Forest Biodiversity Project, which is funded by the Global Environment Facility. We also provided easy-to-use formats of satellite imagery delivered to Grenada Department of Forestry and National Parks, including both geotiff files and hardcopy maps with georeferenced grids.

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[1] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Research and Teaching in Landscape and Vegetation Ecology

Bill Gould
Research Ecologist

I have been involved in planning for the new geographical information systems facilities and in developing integrated spatial data sets that can be useful for a variety of International Institute of Tropical Forestry (IITF) research projects and products. I have been promoting research, education, and outreach by engaging visiting scientists, students, and volunteers in a variety of research activities at the institute. Additionally, G. González and I have organized a second year of monthly research seminars at the institute.

This year I have been working on four research projects that include the development of vertebrate distribution and habitat models for mapping and analysis biodiversity patterns, description of tropical forest and arctic tundra vegetation structural and compositional characteristics, forest fragment distributions and characteristics, fragment edge effects on fuel loads, vegetation mapping, and integrating field research and education. The studies range in scale from plot-level descriptions of species composition to mapping vegetation and ecosystem properties of the circumpolar Arctic. Study sites are located in Puerto Rico, Idaho, Washington, Minnesota, Alaska, and Canada. This research has been presented in four maps, five journal articles, eight talks, eight posters, and four reports. Descriptions of the four major research projects follow.

The Puerto Rico Gap Analysis Project (PR-GAP)

This is the state-level representative of the National Gap Analysis Program sponsored by the Biological Resources Division of the United States Geological Survey. Our work includes conducting land cover, vegetation, and vertebrate diversity mapping and analyses of diversity and management patterns for Puerto Rico. I am working in collaboration with Jaime Collazo (North Carolina State University-U.S. Geological Survey) and José Chabert (Puerto Rico Department of Natural Resources and Environment).

Landscape Fragmentation and Forest Fuel Accumulation: Effects of Fragment Size, Age, and Climate

This is supported by six agencies in the Joint Fire Science Program from the U.S. Department of the Interior and the U.S. Department of Agriculture. Cooperative Principal Investigators (CoPIs) include A. Hudak and G. González. Research involves remote sensing and field measures and analyses of fuel load characteristics in fragmented forests along climatic and moisture gradients in Puerto Rico, Idaho, Washington, Minnesota, and Alaska.

Biocomplexity in Biogeochemical Cycles of Arctic Frost-Boil Ecosystems

This is supported by the National Science Foundation. The Principal Investigator (PI) is D.A. Walker and I am a coPI with W. Krantz, R. Peterson, H. Epstein, C. Ping, and V. Romanovsky. My work, in collaboration with G. González, involves developing a program integrating undergraduate field education with the research component of the study and also investigating biodiversity patterns associated with frost-boil ecosystems. We have established 11 study sites in 5 bioclimatic subzones in the Arctic, ranging from near treeline in northern Alaska to nearly 80 degrees north in the Canadian High Arctic.

Climate, Substrate, and Vegetation: Distribution and Causes of Moist Nonacidic Tundra

This is supported by the National Science Foundation. The PI is D.A. Walker and I am coPI with H. Epstein. My work involves mapping vegetation of the Canadian Arctic and the synthesis of a circumpolar Arctic vegetation map. We have just published a map of circumpolar Arctic vegetation in collaboration with the U.S. Fish and Wildlife Service.

Project details and findings

Puerto Rico Gap Analysis Project (PR-GAP)

The goal of this study is to map terrestrial vertebrate distribution and diversity patterns for Puerto Rico and analyze these patterns with respect to conservation management strategies. We are doing this by developing an extensive vertebrate database to model animal distributions based on species-habitat relationships and by mapping land cover/habitat by using the most recent Landsat imagery. Products to date include techniques to create a nearly cloud-free mosaic of the Island using 18 images acquired between 1999 and 2003. We combined the high-resolution (15-m pixel size) panchromatic band with other Landsat bands to create better resolution than we have had in the past. This resolution has worked well for classifying urban cover for the island and we have produced new estimates of urban cover based on these methods.

We have developed a hierarchical land cover legend that takes into consideration the controls of climate, substrate, topography, and disturbance on plant community composition. To map these cover classes, we are using existing data on soils and geology as well as maps we have created of slope position and Landsat spectral signal for single images and multidate comparisons of seasonal variability. We are using this new landform map to conduct land cover change analyses stratified by landform in order to see how topography has been affecting land use in recent decades.

A final vegetation/habitat map is expected this year. It will be linked to vertebrate distributions by modeling species-habitat relationships for nearly all the terrestrial vertebrate species in Puerto Rico. We have set up a database of 423 species, and we are in the process of populating that database with information on species distributions and habitat relationships. We have developed a series of Microsoft Access electronic forms that volunteers and collaborators can use to enter data and have it reviewed for inclusion in the database. This information is being used to create an initial set of distribution maps, indicating known ranges of each species within a grid of 2400-ha hexagons. These distribution maps are sent to vertebrate experts for a review process. Final species distribution maps will be modeled with 15 m resolution based on habitat occurrence within known ranges and use the species-habitat affinity models and our finished land cover map.

One component of developing our species habitat models is interpreting a wide variety of comments in the literature and from experts on species-habitat affinities and distribution information. A typical comment on ranges may be that a species occurs “in the Luquillo Mountains ,” “in the Central Cordillera” or “in Sierra Bermeja.” Although these features are located on many maps, we found few well-known landmarks delimited by a lower elevation boundary to create a defined polygon. Consequently, we are creating a polygon map of landscape features of Puerto Rico that includes plains, hills, and mountains (with submontane foothills and montane slopes and peaks). These will be subdivided by known ranges and landmarks and will be useful as an element to intersect with our hexagon range maps, and I think they will be a generally useful product as well.

Landscape Fragmentation and Forest Fuel Accumulation: Effects of Fragment Size, Age, and Climate

This study will help in our understanding of fragment ecology and allow us to compare fragmentation effects along a large climatic gradient, particularly in terms of wildland fuel accumulation. Final maps, models, manuscripts, and reports will aid in management of fragmented forest ecosystems.

Our experimental design involves sampling along transects from nonforested areas, across fragment edges, and into forested interiors. The goal is to determine whether differences occur between forest edges and fragment interiors in terms of fuel load. We are conducting fieldwork in six regions: cold-moist (Northern Minnesota), cold-dry (Bonanza Creek Long-Term Ecological Research plots near Fairbanks, Alaska), intermediate-moist (northern Idaho), intermediate-dry (southern Idaho and eastern Washington), warm-moist (northeastern Puerto Rico), and warm-dry (southwestern Puerto Rico). Within each of these locations, we have categorized forest as open or closed. For each region and each forest age class (12 forest types in all) we have 60 transects. In Puerto Rico we sampled 240 transects. Along each transect we measured downed woody debris, canopy characteristics, and herbaceous cover, and we tallied live and standing dead trees. For all trees tallied we recorded species, diameter at breast height, height, and crown dimensions. Additionally, we measured the litter and organic matter layer depths, and collected subsamples of litter and organic layers. Our goal is to characterize the dead organic material, live biomass, and forest structural characteristics from nonforests, across fragment edges, and into fragment interiors.

We also initiated a multiyear decomposition experiment that has been placed in a subset of these transects. The goal is to determine patterns of decomposition in coarse woody debris along gradients of location (outside, edge, or interior), climate, forest age, and fragment size. In collaboration with the Forest Products Laboratory, 5,000 aspen sticks were prepared and placed along 108 transects in summer 2003.

Biocomplexity in Biogeochemical Cycles of Arctic Frost-Boil Ecosystems

A team of 19 scientists and students from the United States and Canada completed its second field season investigating the effects of climate on frost-boil ecosystems. Frost-boils, also called mud boils, nonsorted circles, and spotted tundra, develop through the process of cryoturbation[1] in permafrost regions. They are typically circular barren patches, about 1 m in diameter, that develop in level terrain with fine-grained sediments.

The team is funded under the National Science Foundation Biocomplexity in the Environment Initiative. This summer the team established three research sites at Green Cabin in Aulavik National Park, Banks Island, and Mould Bay, Prince Patrick Island. The goal of this research is to understand the links between biogeochemical cycles, vegetation, disturbance, and climate across the full summer temperature gradient in the Arctic in order to better predict ecosystem responses to changing climate. We have established sites in Alaska and Canada to measure frost-boil morphology (thaw depths), dynamics (frost heave), vegetation and soil characteristics, and climate relationships, and to test models of frost-boil initiation and interaction with vegetation and nutrient cycling. One objective is to see how the decreased activity of vegetation in colder climates affects frost heave processes, and the size and spacing of frost boils. Other key factors being studied are the role of cryoturbation in sequestering soil carbon, and how biogeochemical cycling of carbon and nitrogen is affected by cryoturbation. Members of the research team included Howard Epstein and Alexia Kelly (University of Virginia); William Gould and Grizelle González (International Institute of Tropical Forestry); William Krantz (University of Cincinnati); Anja Kade, Chien-Lu Ping, Gary Michaelson, Martha Raynolds, Vladimir Romanovsky, and Skip Walker (University of Alaska Fairbanks); Sarah Harvey (VECO Polar Resources); and Charles Tarnocai (Agriculture and Agri-Food Canada). The students were participating in an Arctic Field Ecology course taught by William Gould and Grizelle González through the University of Minnesota. The students included Ronnie Daanan, Heather Fuller, Patrick Kuss, Noah Strom, Sean Rea, and Adriana Quijano. Logistics for the field camp were supported by VECO Polar Resources. Next summer the team will return to Mould Bay, and also establish a field site at Isachsen on Ellef Ringnes Island.

We focus on frost-boils because (1) the processes involved in their self-organization drive biogeochemical cycling and vegetation succession over extensive arctic areas; (2) frost-boil-dominated areas contain diverse and ecologically important ecosystems in the Arctic and are important to global carbon budgets; (3) the complex relationships between patterned ground formation, biogeochemical cycles, and vegetation and the significance of these relationships at multiple scales has not

[1] Cryoturbation refers to the process of stirring, heaving, and thrusting of the earth's mantle by frost action, including frost heaving and differential mass movements.

been studied; and (4) the responses of the system to changes in temperature can be understood and modeled by examining the relative strengths of feedbacks between the components of the system at several sites along the natural arctic temperature gradient.

The University of Minnesota field course “Arctic Field Ecology” has a history of integrating research, undergraduate education, and indigenous knowledge. The course is designed to introduce undergraduate and graduate students to field studies in the Arctic and to gain an understanding of the structure and function of arctic ecosystems and the current state of Arctic research. This is accomplished through daily seminars, examination and discussion of important publications of Arctic research, integration of student activities with the Biocomplexity research program, and active participation in field sampling and analyses for ongoing biodiversity and decomposition studies. Each student develops and presents a research proposal focused on answering important ecological questions in the region.

In 2003, six students from the United States, Europe, and the Caribbean spent 3 weeks on Banks Island in the Canadian Arctic. The course had two components: (1) interacting with the research team investigating frost-boils during a 2-week field season; and (2) investigating the ecology of Aulavik National Park while kayaking along the Thomsen River. The overall experience was a unique and successful integration of research and education. Students benefited from the interaction with the working scientists, and gained interest in field research through the excitement of exploration and discovery in the Arctic landscape.

As a component of the biocomplexity research, the students were involved in a study relating frost-boil characteristics with plant and animal diversity patterns. At each of the cryoturbation sites, we collected data for a project investigating plant and soil organism diversity patterns on frost boils and interboils. Our sampling involved three 20-m transects at each site where we measured ground surface profiles, active layer depths, and surface cover (e.g., bare, vegetated, or cryptogamic crust) at 10-cm intervals. Additionally, we located five frost-boil and five interboil areas along each transect. At each of these locations we measured soil moisture, soil temperature at 10-cm depths, air temperature at 10 cm above the ground surface, vegetation composition within 25- by 25-cm quadrants, obtained soil samples for analyses, and placed pitfall traps for 1 to 4 days in order to collect surface-active soil insects. We sampled soil and vegetation from 75 frost-boil and 75 interboil quadrants and collected insects from 90 pitfall traps. Analyses of soil, vegetation, and insects will be conducted at the International Institute of Tropical Forestry in Rio Piedras, Puerto Rico.

Climate, Substrate, and Vegetation: Distribution and Causes of Moist Nonacidic Tundra

This study is an integral part of the National Science Foundation's Arctic Transitions in Land, Atmosphere, and Sea program and will provide a basis for circumpolar extrapolation of ecosystem processes being studied in this program. We completed a two-sided circumpolar Arctic vegetation map (figs. 34 and 35) that has been printed by the U.S. Fish and Wildlife Service. A final workshop will be held by the circumpolar mapping group in Tromso, Norway, summer 2004 to present regional maps and vegetation analyses to be compiled in a book on the subject of Arctic vegetation.

Acknowledgments

Much of the work presented here is in progress and is the result of much effort by all the authors cited in the talks and posters below. Many thanks to all of them, particularly Matthew Anderson, Gloryvee Carrero, Brook Edwards, Brick Fevold, Sebastián Martinuzzi, Adriana Quijano, Olga Ramos, Juan Ramírez, Marcos Rodriguez, Iván Vicéns, and Grizelle González. Two of the maps below are the work of Brook Edwards and Olga Ramos in the GIS lab.

English Equivalents

When you know:	Multiply by:	To get:
Centimeters (cm)	0.3927	Inches
Meters (m)	3.28	Feet
Hectares (ha)	2.47	Acres

Additional Accomplishments

Maps

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Gould, W.A.; Walker, D.A.; Raynolds, M.; Maier, H. 2003. Vegetation, plant biomass, and net primary productivity patterns in the Canadian Arctic. Journal of Geophysical Research-Atmospheres. 108(D2): 8167, doi:10.1029/2001JD000948, 2003.

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Gould, W. 2002. Puerto Rico Gap Analysis Project: mapping biodiversity in Puerto Rico. Presented at the IITF Science Seminar Series, October 18, 2002, Río Piedras, PR (oral).

Gould, W. 2003. Integrating field studies and landscape analyses in mapping ecosystem properties. Presented at the Biology Departmental Seminar, University of Puerto Rico. April 2, 2003, Río Piedras, PR (oral).

Gould, W.; Hudak, A.; González, G. 2003. Landscape fragmentation and forest fuel accumulation: effects of fragment size, age, and climate. Presented at the second workshop on forest fragmentation and fuel load, February, Río Piedras, PR (oral).

Gould, W.; Hudak, A.; González, G.; Hollingsworth, T. 2003. Landscape fragmentation and forest fuel accumulation. Presented at the Joint Fire Science Program annual meeting, February, 2003, Phoenix, AZ (oral and poster).

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Walker, D.A.; Kade, A.N.; Michaelson, G.; Ping, C.L.; Raynolds, M.; Romanovsky, V.E. (all at University of Alaska Fairbanks, 99775: ffdaw@uaf.edu, anja_kade@yahoo.com, pngjm@uaa.alaska.edu, pfclp@uaa.alaska.edu, fnmkr@uaf.edu, ffver@uaf.edu); **Epstein, H.E.; Kelley, A.M.** (both at University of Virginia, Department of Environmental Sciences: hee2b@virginia.edu, amk5d@virginia.edu); **Gould, W.A.; Gonzalez, G.** (both at International Institute of Tropical Forestry, USDA Forest Service, San Juan, PR: iitf_coop@upr.edu); **Krantz, W. B.** (University of Cincinnati, Department of Chemical Engineering: bkrantz@alpha.che.uc.edu); **Tarnocai, C.T.** (Agriculture and Agri-Food Canada: tarnocaict@agri.gc.ca). **2003.** Biocomplexity of frost boil ecosystems: 2003 Expedition to Banks Island and Prince Patrick Island, Canada. Presented at 54th Arctic science conference, September 22-24, 2003, Fairbanks, AK (oral).

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Walker, D.A.; Kade, A.N.; Michaelson, G.; Ping, C.L.; Raynolds, M.K.; Romanovsky, V.E. (all at University of Alaska Fairbanks, 99775: ffdaw@uaf.edu, anja_kade@yahoo.com, pngjm@uaa.alaska.edu, pfclp@uaa.alaska.edu, fnmkr@uaf.edu, ffver@uaf.edu); **Epstein, H.E.; Kelley, A.M.** (both at University of Virginia, Department of Environmental Sciences: hee2b@virginia.edu, amk5d@virginia.edu); **Gould, W.A.; González, G.** (both at International Institute of Tropical Forestry, USDA Forest Service, San Juan, PR: iitf_coop@upr.edu); **Krantz, W. B.** (University of Cincinnati, Department of Chemical Engineering: bkrantz@alpha.che.uc.edu); **Tarnocai, C.T.** (Agriculture and Agri-Food Canada: tarnocaict@agri.gc.ca). **2003.** Biocomplexity of frost-boil eco-systems: self-organization across the Arctic bioclimate gradient. Presented at the Biocomplexity in the Environment awardees meeting. September, 2003. Arlington, VA,

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Gould, W.; Martinuzzi, S.; Ramos, O. 2003. Image analysis and land cover mapping for Puerto Rico. Presented at the national GAP annual meeting. October 6-9, 2003. Fort Collins, CO.

Martinuzzi, S.; Gould, W.; Ramos, O. 2003. Cloud and cloud shadow removal in the creation of a cloud free composite Landsat ETM scene in tropical landscapes. Presented at the national GAP annual meeting. October 6-9, 2003. Fort Collins, CO.

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Gould, W.; Hudak, A.; González, G. 2003. Status report: Joint Fire Science Program, landscape fragmentation and forest fuel accumulation: effects of fragment size, age, and climate. Annual report to the Joint Fire Science Program, Moscow, ID, February, 2003.

Gould, W. 2005. Research and teaching in landscape and vegetation ecology. In: U.S. Department of Agriculture, Forest Service. Annual letter 2001-2002. Gen. Tech. Rep. IITF-GTR-29. San Juan, PR: International Institute of Tropical Forestry: 19-20.

IITF Seminar Series

The seminars this year were all well prepared and interesting presentations with typically a small audience and good discussions. They were attended by IITF scientists and staff as well as University of Puerto Rico and Universidad Metropolitana faculty and students.

Blanco, F. (University of Puerto Rico at Río Piedras). **2003.** Linking behavior and population properties in a migratory snail in Puerto Rican streams. Presented at the IITF monthly seminar series, April 11, 2003.

Chin-Yu Huang (Taiwan University). **2003.** The relationships among litter amphibians, invertebrates, and decomposition in a subtropical forest of Taiwan. Presented at the IITF monthly seminar series, May 16, 2003.

Chinea, J.D. (University of Puerto Rico at Mayagüez). **2003.** The distribution and characteristics of the old-growth forests of the northern karst in Puerto Rico. Presented at the IITF monthly seminar series, September 26, 2003.

Grogan, J. (Yale School of Forestry and Environmental Science). **2003.** Big-leaf mahogany across the Brazilian Amazon: management options under different density, population structure, and land-use scenarios. Presented at the IITF monthly seminar series, March 14, 2003.

Kaspari, M. (Associate Professor, Department of Zoology, University of Oklahoma). **2003.** Toward understanding patterns of diversity and abundance in litter communities. Presented at the IITF monthly seminar series, August 26, 2003.

Lugo, A.E. (Director, U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry, Río Piedras). **2003.** The ecosystem concept. Presented at the IITF monthly seminar series, September 11, 2003.

McDowell, W. (University of New Hampshire). **2003.** From hill slope to globe: controls on DOC flux at multiple spatial scales. Presented at the IITF monthly seminar series, January 24, 2003.

Meléndez, E. (Institute for Tropical Ecosystem Studies, University of Puerto Rico at Río Piedras). **2003.** Mona Island project. Presented at the IITF monthly seminar series, November 21, 2003.

Ramírez, A. (Institute for Tropical Ecosystem Studies, University of Puerto Rico at Río Piedras). **2003.** The role of aquatic insects in stream ecosystems in the Luquillo Mountains. Presented at the IITF monthly seminar series, August 15, 2003.

Santiago, E. (Puerto Rico Botanical Garden and University of Puerto Rico at Río Piedras). **2003.** Applying phylogenetics to elucidate the evolutionary relationships of Caribbean plant groups: the case of *Goetzea elegans*. Presented at the IITF monthly seminar series, February 21, 2003.

Sotomayor-Ramirez, D. (University of Puerto Rico at Mayagüez). **2003.** Nutrient discharges from sub-watersheds within the Río Grande de Añasco Watershed. Presented at the IITF monthly seminar series, October 17, 2003.

Ward, S. (University of Puerto Rico at Río Piedras). **2003.** Genetic trials for mahogany and Spanish cedar in the Yucatan: conservation and tree improvement. Presented at the IITF monthly seminar series, June 6, 2003.

Wunderle, J.M., Jr. (U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry). **2003.** Struggling out of a bottleneck: recovery of the Puerto Rican Parrot 1973-2000. Presented at the IITF monthly seminar series, December 12, 2003.

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Helmer, E.H.; Ramos, O.; López, T.M.; Quiñones, M.; Díaz, W. 2002. Mapping the forest type and land cover of Puerto Rico: a component of the Caribbean biodiversity hotspot. Caribbean Journal of Science. 38(3-4): 165–183.

Annual Letter Contribution for International Cooperation and Collaborators

Peter L. Weaver
Research Forester

Mexico

Mahogany (*Swietenia* spp.) and Spanish cedar (*Cedrela odorata* L.) are important for industries in the United States and Mexico. In the Yucatan Peninsula of Mexico, however, as in other parts of their natural ranges, these species have been cut indiscriminately rather than managed sustainably, leading to increasing scarcity and diminishing trade (Cornelius and Wightman 2002). Reforestation programs in the region have been largely unsuccessful in developing plantations owing to poor seedling quality and difficulties associated with plantation maintenence. From 1999 through 2001, with financial support from the USDA Foreign Agricultural Service, Research and Scientific Exchange Division (RSED), the Centre for Tropical Agricultural Research and Education (CATIE), and the USDA International Institute for Tropical Forestry (IITF), together with Mexican counterparts, considerable progress was made in the domestication of mahogany and Spanish cedar. This included the development and implementation of techniques for the planting and cultivation of both species, including genetic improvement. The present agreement allowed the consolidation and continuation of these activities. One mahogany trial was thinned beginning its conversion to a seed orchard. Other trials were measured, pruned, and maintained. A locally based forestry professional was given practical and theoretical training in tree improvement increasing local capacity to continue with the development of these important germplasm resources. Extension materials were made available to local students and stakeholders.

Panama

Activities in Panama were the result of cooperation among the IITF, USAID-Panama, the nongovernment organization Centro de Estudios y Acción Social Panameño (CEASPA), and other cooperating Panamanian government and nongovernmental organizations.

Big-Leaf Mahogany

The isthmus of Panama, first used by Indians as a route between North and South America, was soon recognized by Europeans as an important crossroads linking two oceans and two continents (Weaver and Bauer 2003). With Panama's colonization and settlement, the availability of big-leaf mahogany (*Swietenia macrophylla* King) declined in readily accessible areas as early as 1670. The species remained common, however, in the interior through the beginning of the 20th century. Panama's low population density, concentrated along the canal and south of the topographic divide from Panama City west to the Costa Rican border, was a major factor that helped protect much of the forest land. No sawmills existed before work began on the canal; by 1913, 13 mills, mainly using big-leaf mahogany, had been established. Forests covered 86 percent of the country in 1900, declining to 70 percent in 1947, 58 percent in 1960, 53 percent in 1970, 47 percent in 1980, 40 percent in 1990, and 37 percent in 1998. In the early 1950s, the volume of big-leaf mahogany was estimated at 60 million board feet in the Darién and 75 million board feet in the entire country. During the early 1990s, the forest industry supported 50 sawmills, 3 plywood factories, and 600 furniture shops. In 1992, as forest resources continued to decline, Panama prohibited the export of big-leaf mahogany, Spanish cedar, and select hardwoods as roundwood or sawnwood. Also during the 1990s, Panama passed laws providing incentives for reforestation, establishing forestry legislation, and creating Autoridad Nacional del Ambiente (ANAM), the national environmental authority. Today, most of Panama's remaining undisturbed forests are concentrated along the Caribbean coast and east of the canal. Big-leaf mahogany, once common, is now largely confined to scattered trees west of the canal, and to natural stands in the provinces of Panama and Darién east of the canal. The eastern forests are being harvested today by consessionaires with approved management plans.

San Lorenzo Protected Area

A program of 80 slides presents the 12 000 ha-San Lorenzo Protected Area (SLPA), formerly Fort Sherman, to viewers. The SLPA, located at the northwestern entrance to the Panama Canal, is currently part of the Mesoamerican corridor of protected areas extending from Guatemala to the Colombian border (Weaver and Bauer 2003). The SLPA contains two forts built for similar protective functions: Fort San Lorenzo at the mouth of the Chagres River, first initiated by the Spanish in 1597 to protect the "Camino de las Cruces," the gold route over the isthmus; and Fort Sherman, started in 1911 to protect the northern entrance to the Panama Canal, the 20th century's "royal corridor" through Panama. Both forts successfully fulfilled their military objectives; Fort Sherman simultaneously protected the area's natural resources during the 20th century. This report highlights the SLPA's setting as a major crossroads, and briefly describes pre-Columbian activities, the Spanish conquest, the legacy of fortune seekers and the Chagres River including pirates and shipwrecks, the building of the Panama railroad, the efforts of France and the United States on the Panama Canal, and early agricultural activities. It also mentions the military history of Forts San Lorenzo and Sherman, and current knowledge on the geology, soils, flora, fauna, marine resources, ecological research, and proposed conservation of the SLPA, including ecotourism. Relevant environmental legislation is outlined along with the major functions of all entities that are cooperating with programs on the SLPA. A chronology of major historical events related to the San Lorenzo Protected Area is included.

Nicaragua

Mombacho Reserve

The Mombacho Volcano Nature Reserve, a dormant volcano with scattered fumaroles, occupies 2487 ha and is situated about 40 km southeast of Managua (Weaver and Díaz Santos 2002). The reserve is managed by Foundation Cocibolca, a nongovernment organization, to conserve its geomorphological landscape, scenic vistas, wildlife habitat, biodiversity, water resources, and cultural heritage. From Mombacho's summits, Lake Nicaragua, the Pacific lowlands, and other volcanoes in the Pacific chain are visible. The flora includes four ecological life zones and at least 457 species of plants, more than 100 of them orchids. Wildlife is abundant. Among the better known birds are a variety of toucans and parrots. The mammals include white-throated capuchin (*Cebus capucinus*) and mantled howler (*Alouatta palliata*) monkeys, white-tailed deer (*Odocoileus virginianus*), coyotes (*Canis latrans*), and four species of cats—the mountain lion (*Felis concolor*), ocelot (*F. pardalis*), margay (*F. tigrina*), and jagouaroundi (*F. yagouaroundi*). At lower elevations, below 850 m, typical coffee haciendas cover much of the landscape. Currently, numerous studies are underway including the dynamics of permanent forest plots at upper elevations, and of bird populations in coffee shade forests at lower elevations. According to Mombacho's zoning plan, approved activities include research, education and tourism, and sustainable use of resources by local communities.

USAID Country Report

A biodiversity assessment was compiled for USAID-Nicaragua considering the following topics: policy and legislation; forest conservation and biodiversity;

protected areas; research and education; forestry and management; tourism; awareness and communication; and investments in biodiversity (Weaver et al. 2003). The report contains reference information and recommendations for programs in Nicaragua during the next 5 years.

Forest Cover in Caribbean Islands

Of the 36 islands in the Caribbean Basin, 27 have elevations above 300 m, and 13 have elevations above 800 m (Weaver 2002). Persistent trade winds rise over the summits of these islands depositing rainfall and condensed cloud moisture in upland watersheds. The combined effects of elevation and climate produce a characteristic sequence of natural forest types ranging from lower montane rain forest at low elevations to dwarf rain forest at the summits. As island populations continue to grow, greater demands are placed on the limited water supplies originating in the mountains. Many of the islands today are experiencing water shortages during the dry season highlighting the need for upland watershed protection. The importance of past watershed protection is evident from experiences in Puerto Rico dating back to the 1930s when parts of the interior highlands were set aside for future water supplies. Today's population of 4 million benefits from those conservation measures initiated 60 years ago.

Other major activities:

- Two grants received for research:
  1. Secondary forest recovery at Tinaja in the Laguna Cartegena Wildlife Refuge with the Fish and Wildlife Service for $15,000
  2. Cinnamon Bay permanent plot monitoring with the U.S. Park Service for $8,000
- Reviewed of numerous research papers and manuscripts including the shrub manual
- Assisted with the centennial time line development with the national forest
- Cooperated with USAID—Dominican Republic
- Edited the Caribbean foresters proceedings held in St. Thomas
- Presented at the Ducks Unlimited course en La Reserva, Mexico
- Attended the Urban forestry conference in Ponce and presented a paper on forest monitoring
- Helped Martin Barriteau, Forestry Department of Grenada, with Grenada's poster at the urban forestry conference

English Equivalents

When you know:	Multiply by:	To get:
Meters (m)	3.28	Feet
Kilometers (km)	.6215	Miles
Hectares (ha)	2.47	Acres

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Appendix : Recent Publications of the IITF

01 **Various authors**. **1985–1999.** IITF silvics manual. SO-ITF-SM 1–88. Rio Piedras, PR: U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry. Sectionally numbered. [Complete silvics manual available in English, has detailed silvicultural descriptions for 88 species of trees, e.g., *Swietenia macrophylla, Khaya senegalensis, Pterocarpus macrocarpus*, others]. [**Note**: this was translated into one volume in Spanish and is available as *Bioecología de árboles nativos y exóticos de Puerto Rico e Indias Occidentales*, traducido al español y disponible bajo este otro titulo, Gen. Tech. Rep. IITF-15].

02 **Anderson, R.L.; Birdsey, R.A.; Barry, P.J. 1982.** Incidence of damage and cull in Puerto Rico's timber resource, 1980. Resour. Bull. SO-88. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Institute of Tropical Forestry. 13 p.

03 **Arendt, W.J**. **1988.** Range expansion of the cattle egret (*Bubulcus ibis*) in the greater Caribbean basin. Colonial Waterbirds. 11(2): 252-262.

04 **Arendt, W.J.; Arendt, A.I. 1988.** Aspects of the breeding of the cattle egret (*Bubulcus ibis*) in Monserrat, West Indies, and its impact on nest vegetation. Colonial Waterbirds. 11(1): 72-84.

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13 **Chinea, J.D. 1999**. Changes in the herbaceous and vine communities at the Bisley Experimental Watersheds, Puerto Rico, following Hurricane Hugo. Canadian Journal of Forestry Research. 29(9): 1433-1437.

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