SHORT-TERM DISAPPEARANCE OF FOLIAR LITTER OF THREE TREE SPECIES NATIVE TO RAIN FORESTS OF PUERTO RICO

BY

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THESIS

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PREFACE

This document contains three sections, each of which pertains to a different aspect of the decomposition of foliage in the lower montane rain forest of Puerto Rico. The first section examines short-term decomposition rates of leaf litter from three tropical tree species before and after hurricane Hugo altered the forest structure. The second section examines decomposition of foliage attached to broken and fallen branches suspended above the forest floor, one consequence of hurricane disturbance. The third section examines decomposition of fragmented *versus* whole foliage of one species.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

TABLES (continued)

LIST OF ILLUSTRATIONS

ILLUSTRATIONS (continued)

ABSTRACT

SHORT-TERM DISAPPEARANCE OF FOLIAR LITTER OF THREE TREE SPECIES NATIVE TO RAIN FORESTS OF PUERTO RICO

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Abscised *Cyrilla racemiflora* and *Dacroydes excelsa* leaves and fresh *Prestoea montana* leaves were placed in litterbags before (1989) and after (1990) Hurricane Hugo. Biomass and nitrogen dynamics were compared among: i) species; ii) mid- and high-elevation forest types; iii) riparian and upland sites; and iv) among pre- and post-hurricane, disturbed environments. Biomass disappearance was compared using regression and negative exponential models in which the slopes estimated the decomposition rates and the y-intercepts are indices of initial weight loss (leaching). *C. racemiflora* leaves with high lignin (22.1 %) and low nitrogen (0.39 %) content decayed at a low rate and immobilized available nitrogen. *D. excelsa* leaves had moderate nitrogen (0.67 %) and lignin (16.6 %) contents, decayed at moderate rates, and maintained constant amounts of nitrogen. *P. montana* foliage had high nitrogen (1.76 %) and moderate lignin (16.7 %) contents and rapidly lost both mass and nitrogen. There were no significant differences among forest types and slope positions. Initial mass loss of *C. racemiflora* leaves was lower after hurricane disturbance but the overall decomposition rate did not change. Initial mass losses and the overall decomposition rates were lower in 1990 than in 1989 for *D. excelsa* samples. *D. excelsa* and *C. racemiflora* litter samples immobilized nitrogen in 1990 but released 10-15% of their initial N in 1989, *P. montana* released nitrogen in both years (25-40 %). Differences between years may have been due to

differences in the timing of precipitation. Foliar litter inputs during post-hurricane recovery of vegetation in Puerto Rico may serve to immobilize and conserve site nitrogen.

Fresh *C. racemiflora* and *D. excelsa* foliage attached to twigs were suspended above the forest floor in litterbags to simulate a hurricane effect. Decomposition rates of suspended leaves did not differ from forest floor foliar litter. Suspended litter released nitrogen that may have been retranslocated if senescence and abscission had occurred.

Decomposition of abscised and fragmented leaves was compared to whole-leaf decomposition for *D.excelsa* using a litterbag method. Biomass loss over 100 days did not differ among whole and fragmented leaves. Whole leaves immobilized nitrogen whereas fragmented foliage rapidly (<15 days) released about 10% of its initial nitrogen and held the remainder for the duration of the study.

SECTION I

Short-term Disappearance of Foliar Litter in a Hurricane Disturbed Tropical Rain Forest

I.1 Introduction

Hurricanes are an integral part of the ecosystems of Puerto Rico and other Caribbean islands. An average of 4.6 hurricanes pass through the Caribbean annually, the recurrence interval for Puerto Rico is about 20 years (Scatena and Larsen, 1991), and they alter the structure of forests of Puerto Rico (Weaver, 1986, 1987; Crow, 1980). However, documentation of ecosystem response to hurricane disturbance is limited (Brown *et al.*, 1983). Hurricane disturbance may influence decomposition dynamics by affecting the environment for biotic and abiotic agents of litter decay. Changes to the environment include: 1) increased organic matter content and altered carbon quality of the forest floor; 2) increased wind velocity at the forest floor (through decreased canopy); 3) increased substrate temperature; 4) increased insolation; and 5) altered moisture availability. Each of these factors has been shown to affect decomposition rates (Swift, *et al.*, 1979; Waring and Schlesinger, 1985; Day, 1983;Witkamp, 1961; Dwyer and Merriam, 1980; Smith, 1970); Bonner, 1960; Moore, 1986; Covington, 1981).

Hurricane Hugo passed over the northeast corner of Puerto Rico on 18 September 1989 (Figure 1). The recurrence intervals for wind velocity (148 km hr^{-1} at San Juan), stream discharge and precipitation were 50, 10 to 31, and 5 years, respectively (Scatena and Larsen, 1991). Compared to the five other hurricane force storms that passed over Puerto Rico since 1899, Hugo was moderate in intensity but was ranked second by Scatena and Larsen (1991) in terms of damage to the Luquillo Experimental Forest (LEF). Lodge *et al.* (1991) found that

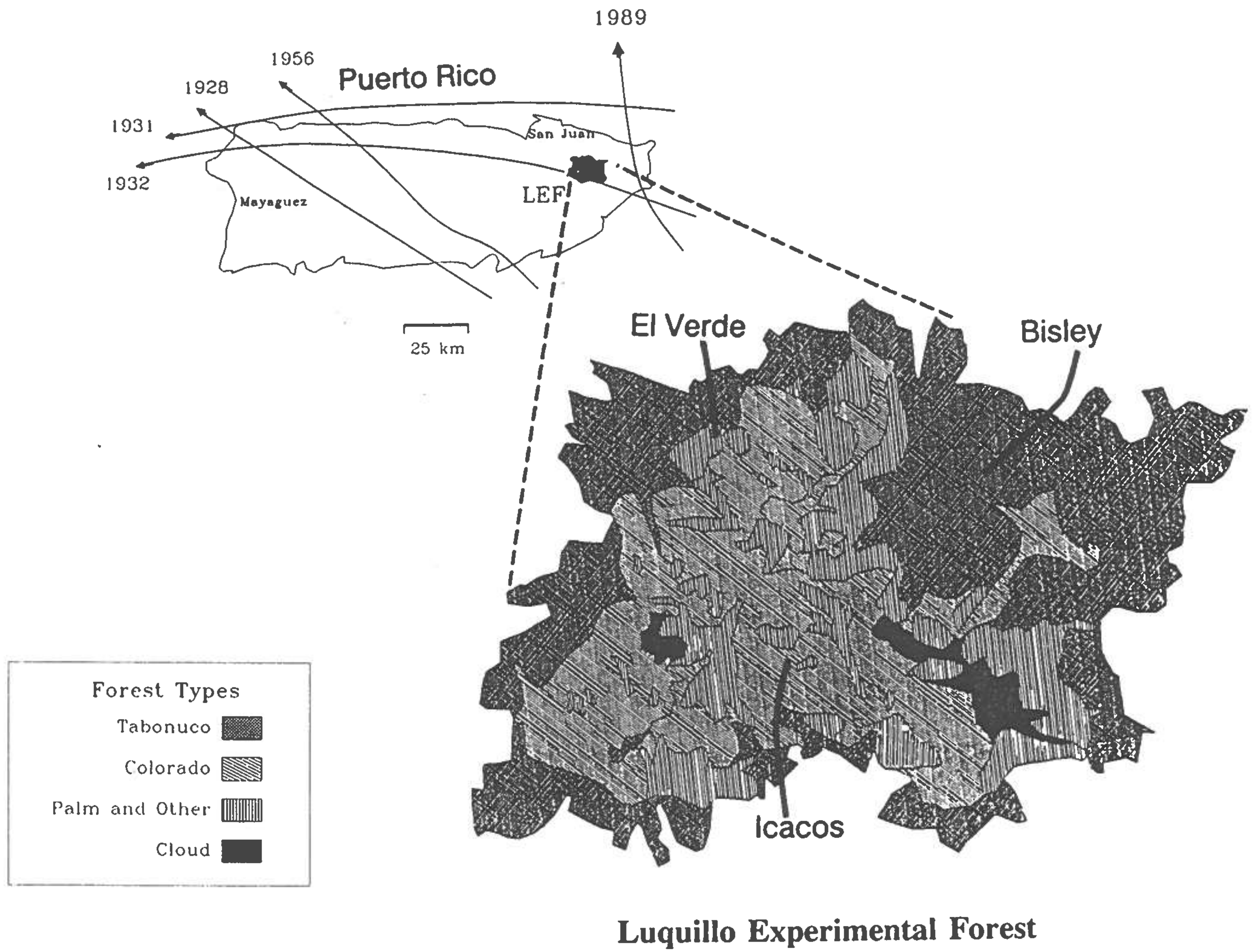

Figure 1: Recent history of hurricanes affecting Puerto Rico (adapted from Scatena and Larsen, 1991), forest types (adapted from Brown *et al.*,1983), and study site location in the Luquillo Experimental Forest.

the fine litterfall mass (1083+/-92 g m^{-2}) from hurricane Hugo was 400 times the mean daily pre-hurricane deposition rate and had a higher nitrogen concentration than normal litterfall.

This study was originally designed to examine the short-term foliage decomposition of three montane tree species in two forest types in concert with a study of riparian nitrogen cycling (McDowell *et al.*, in press; Bowden *et al.*, in press). One of the forest types included in this study, Tabonuco, has been examined extensively (*e.g.* Odum and Pigeon, 1970; Brown *et al.*, 1983), but another type, Colorado, has received much less attention. A litterbag decomposition study was conducted during the summer of 1989. Hurricane Hugo struck Puerto Rico about five weeks after the last sample collection. The hurricane provided a unique opportunity to study the effects of this type of natural disturbance on decomposition. With some modifications, the 1989 study was repeated in 1990.

The research design allowed for comparisons of short-term foliar litter biomass and nitrogen dynamics: 1) between the three tree species, *Prestoea montana* [R,grah] Nichols, *Dacroydes excelsa* [Vahl], and *Cyrilla racemiflora* L.; 2) between the Colorado and Tabonuco forest types; 3) between riparian and upland sites; and 4) between pre- and post-hurricane environments.

I.2 Materials and Methods

I.2.1 Site Selection

The range of elevations in Puerto Rico results in several vegetation types. This study included two vegetation types in the Luquillo Experimental Forest (LEF). Tabonuco forest was classified as a sub-tropical wet forest type (Holdridge System) and occurs at elevations of between 200 and 600 meters (Ewel and Whitmore, 1973). The Colorado forest type occurs at elevations greater than 600 meters and is in the sub-tropical lower montane wet forest association. About half of the LEF is the Colorado forest type (5927 ha) and about half is the Tabonuco type (5304 ha) (Brown *et al.*, 1983) (Figure 1). a study site was established in the Colorado forest at an elevation between 620 and 630 m within the Rio Icacos watershed and will henceforth be referred to as the "Icacos" plots (18.271° N, 65.783° W). Another study site was established in the Tabonuco forest within the Luquillo Long Term Ecological Research (LLTER) site in the Bisley watershed at an elevation of about 240 m (18.312° N, 65.750° W). The Bisley area is described by Scatena (1989), Brown *et al.*. (1983), and Basnet (1992). The Icacos area has not been studied extensively, although Brown *et al.* (1983) and Weaver (1987) describe the Colorado forest type. In general, the Bisley study plots are in an area with relatively steep slopes and poorly defined riparian zones. The Icacos area has steep slopes but well defined riparian zones. When the sites are referred to as Bisley or Icacos, the elevation/forest type is implicit, *i.e.* Bisley is mid-elevation, Tabonuco forest and Icacos is high elevation, Colorado forest.

Disturbance to the area around the Icacos site due to Hurricane Hugo was variable. Fallen trees created canopy gaps, trees of some areas were defoliated or had branches broken, and some areas were minimally disturbed. The forest surrounding the Bisley site was altered more uniformly and severely than the forest surrounding the Icacos site. Most trees were toppled and only the main stem remained of those that were not. It was necessary to establish some new study plots for the post-hurricane study to replace pre-hurricane plots that were inaccessible due to fallen trees.

I.2.2 Plot Layout

Riparian and upland study plots were established in each of the Colorado and Tabonuco study sites. Plots were organized as aggregations of adjacent 2 m by 2 m sub-plots. All sub-plots were assigned a number but not all sub-plots were utilized in the study, *i.e.* study sub-plots were selected randomly.

Study plots in the text and tables are referenced by site specific acronyms *i.e.* by watershed (Bisley and Icacos), slope position (Riparian and Upland), and study year (89 and 90) (Table 1). The same plot was used for the Icacos riparian site (IR89,90) for both years and it was bisected by a small stream (Figure 2), although litterbags were not placed within 3 m of the stream. The vegetation of the riparian site was intermittent grass and *Diffenbachia spp.*, palm *(P. montana)* as an intermediate and dominant species, Colorado *(C. racemiflora)* as a dominant emergent, and other broadleaved evergreens. The species composition was similar after the hurricane but canopy closure was incomplete since many trees had fallen and most trees suffered foliage and branch loss.

Disturbance to the vegetation of the Icacos upland plot by Hurricane Hugo was limited to defoliation and the trees had refoliated before the initiation of the post-hurricane study. This refoliated plot (IU89,90) was located north of the stream, about 10 m higher in elevation than the riparian plot. Vegetation included *C. racemiflora* and *Clusia sp.* during both the pre- and post-hurricane studies with sparse understory vegetation. To better study the effects of the hurricane, a second plot was added in 1990 in an area where most trees were toppled by the storm. This severely disturbed plot (Blowdown; IU90) was located south of the stream and was occupied by grasses and a small central thicket of broadleaved saplings.

The 1989 Bisley upland plot (BU89) was ~15 m higher than the 1989 riparian plot (BR89). In the Bisley watershed, *D. excelsa* is typically found along ridges and midslope catena positions (Basnet, 1992). The 1989 Bisley plots were occupied by large evergreen trees. These sites were inaccessible after the hurricane. Therefore, replacement plots for 1990 were located 15 to 20 m from the 1989 sites. The 1990 upland plot (BU90) was bordered by fallen boles and crowns and was populated by grasses in its center during the study period. The 1990 riparian plot (BR90) was occupied by intermittent grasses at the end near the stream intersection (Fig 3), a sparse thicket of ~1 m tall defoliated shrubs centrally, and dead branches and a large buttressed tree (with few branches) at the south end.

Table 1: Study plots, reference acronyms, and site and/or study year comparisons.

		Icacos			Bisley			
		Riparian	Upland	Upland	Riparian	Upland	Riparian	Upland
		1	2	3	4	5	6	7
	Acronym	IR89,90	IU89,90	IU90	BR89	BU89	BR90	BU90
1	IR89,90	Y	C	C	W	.	W	.
2	IU89,90		Y	Y,D	.	W	.	W
3	IU90			.	.	.	.	W
4	BR89				.	C	Y	.
5	BU89					.	.	Y
6	BR90						.	C

Comparison Codes -
Y = Between Pre and Post- Hurricane Study Years
W = Between Watersheds (Bisley and Icacos), by year.
C = Between Slope Positions, by year.
D = Between Disturbed and Less-Disturbed Post-Hurricane Plots

1. Defoliated
2. Blowdown

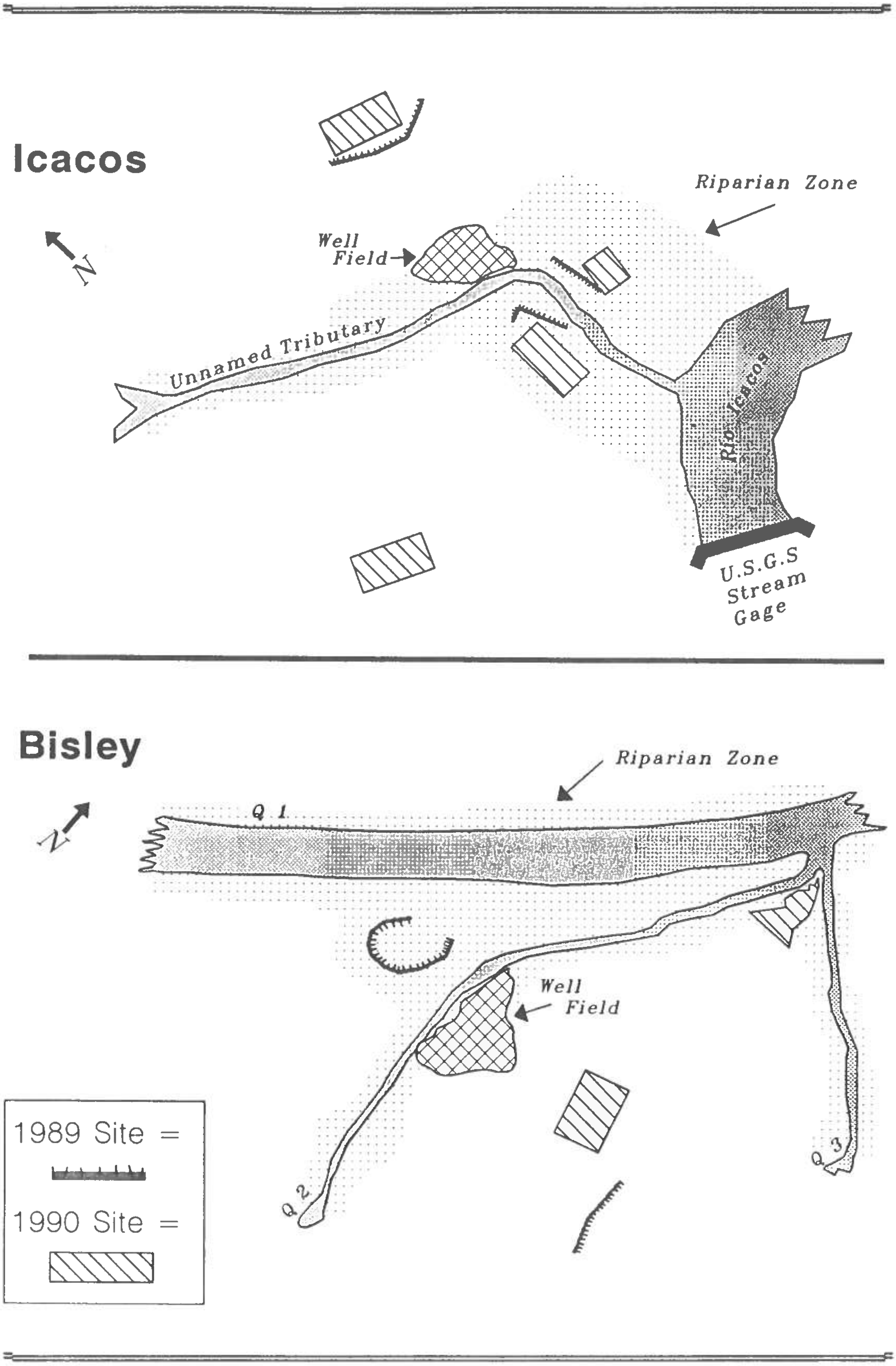

Figure 2: Pre and Post-Hurricane study plot locations relative to streams and well fields.

To summarize, there were two plots per watershed positioned in 1989 to allow comparisons of decomposition between riparian and upland plots within watersheds and between watersheds. In 1990, there were five plots located to compare results from both years for both watersheds, to compare slope positions, and to compare the 1990 Icacos blowdown upland plot (IU90) to the defoliated plot (IU89,90).

I.2.3 Species studied

The common names for the three tree species used in this study are Tabonuco (*Dacroydes excelsa*), Sierra Palm (*Prestoea montana*), and Palo Colorado (*Cyrilla racemiflora*). *P. montana* is a small to medium-sized palm (less than 15 m) that occurs on steep slopes and ridges and along upland streams (Little and Wadsworth, 1989) and is common in the Tabonuco and Colorado forest types. *P. montana* fronds can be 3 m in length, each consisting of many ~0.5 m by ~6 cm leaflets. The species is found on the Greater and Lesser Antilles from Cuba to Tobago. *D. excelsa* trees can attain a height of over 30 m and 1 to 1.5 m in diameter, and they were once the dominant tree species at low elevations in the Luquillo Forest. Tabonuco has declined in importance due to an inability to colonize disturbed sites (Little and Wadsworth, 1989). The pinnately compound leaves consist of 5 to 7 leaflets (~8 by 6 cm) that detach from the leaf during senescence. The range of *D. excelsa* extends from Puerto Rico to Grenada along the Lesser Antilles. *C. racemiflora* is found as a small tree or shrub along the coast of the southeast U.S. from Virginia to southeastern Texas but can grow to a height of 15 m and diameter of 2 m at higher elevations in the Greater Antilles (Little and Wadsworth, 1989). *C. racemiflora* is also found in southern Mexico, British Honduras, and from Venezuela to northern Brazil. The leaves of *C. racemiflora* are simple and about 2 by 5 cm.

I.2.4 Hurricane-Induced Litter Deposition

Fine litter (foliage, twigs, and branches < 1 cm diam.) was collected on 10 October 89 from 0.25 m^2 quadrats (6 for Bisley and 19 for Icacos) distributed along three transects at each site. Both suspended litter and litter on the forest floor were sampled. The samples were dried in Puerto Rico at 55°C, shipped to Durham, New Hampshire, separated into foliar, wood, and other (fruit, *etc.*) components, dried at 65°C for 72 hours, weighed, milled to pass a 1 mm sieve, and subsampled for total nitrogen determination (see below).

I.2.5 Litterbag Preparation

Recently abscised *D. excelsa* leaflets were collected for both study years from the forest floor near the El Verde field station (350 m elev.). Recently abscised *C. racemiflora* leaves were collected from the vicinity of the Icacos site for both years and also about 1.5 km south of the El Verde field station in 1990 (575 m elevation). Fresh palm fronds were collected near the Icacos site. Palm leaflets were stripped from the fronds and cut into 15-20 cm segments. The lignified rachi of the fronds were discarded. I chose to use fresh palm foliage due to the inconsistent way the species replaces fronds. Senescence, abscision, and eventual fall to the forest floor is gradual making it difficult to obtain uniform samples from anything but green fronds.

Foliage for the 1989 study was stored fresh for two days before being weighed and deployed in litterbags. Foliage collected for the 1990 study was stored under relatively dry conditions for three days before it was weighed and deployed in litterbags. An unknown amount of moisture was lost from litter during storage in 1990.

Foliage of a single species was weighed and placed in flat litterbags made of fiberglass (20 by 30 cm with ~1 mm mesh). Between 8 and 14 oven-dry g of foliage were placed in each litterbag, although by species and study year the dry-mass per litterbag varied by less than 1 g. A sample of about one in six litterbags (stratified across the processing period) was retained and dried to estimate the initial moisture, nitrogen, lignin, cellulose, and ash content of treatment samples.

For each species, litterbags were separated into sets of 4 in 1989 and sets of 5 in 1990. Fifteen sets (5 sets per species) were placed in randomly selected sub-plots within each plot (1 set per sub-plot). Litterbags were loosely tethered to an anchor on the forest floor within 1 m of the remaining litterbags of its set. The 1989 samples were distributed on 2 June and the 1990 samples were distributed on 7 July (Bisley) and 10 July (Icacos). The number of litterbags distributed in 1990 (375) was greater than that distributed in 1989 (240) due to an added study plot and a fifth collection.

I.2.6 Post-Treatment Collection

A single mesh envelope was collected from each subplot after: *i*) 14, 35, 52 (Bisley), 55 (Icacos), and 78 days in 1989, *ii*) 12, 23, 45, 73, and 102 days at Icacos plots in 1990, and *iii*) 11, 22, 42, 69, and 99 days at Bisley plots in 1990. This provided 4-5 replicates of each species at each study plot for both watersheds and from each "treatment" interval. To summarize the design:

Pre-Hurricane (1989):

(3 *sp*) × (2 *watersheds*) × (2 *slope positions*) × (5 *replicates*) × (4 *collections*) = 240 *Litterbags*

Post-Hurricane (1990):

(3 *sp*) × (2 *slope positions* + *disturbed plot* [=2.5]) × (2 *watersheds*) × (5 *replicates*) × (5 *collections*) = 375 *Litterbags*

I.2.7 Mass/Chemical Analyses -

Foliage samples were oven-dried on the day of collection, shipped to Durham, New Hampshire, redried (65°C), removed from the litterbag, separated from loose soil, weighed, and milled to pass a 1 mm sieve.

The ash content of samples was estimated after combustion (500°C for 6 hours) of a ~1 g sub-sample. Ash content was used to adjust the biomass and nitrogen values for soil contamination. This was accomplished by measuring the ash content of local surface soil, estimating the ash content of decaying foliage in the absence of soil, measuring the realized ash content of treatment samples, and partitioning treatment sample mass into its foliar and soil origin. Biomass disappearance rates were calculated on an ash-free basis.

Foliage subsamples were digested using a micro-Kjeldahl method employing potassium sulfate, copper sulfate, sulfuric acid, and hydrogen peroxide (Bremner and Mulvaney, 1973). Total Kjeldahl nitrogen (TKN) was measured as ammonium in the digestate using a nitroprusside-salicylate method on a Technicon Auto-Analyzer II (Technicon, 1983). Initial lignin and cellulose content was estimated using a Near Infrared Reflectance (NIR) spectrometer (Wessman *et al.*, 1985).

I.2.8 Data Analyses

The fraction of the initial biomass remaining (FBMR) and the fraction of initial nitrogen remaining (FNR) at various collection times were examined using three methods. First, simple linear regression was used to fit a negative exponential model ($y = e^{-kt}$; Jenny, 1947) for comparison of results from this study to other studies. Second, multivariate linear regression with categorical (dummy) variables was used to test for differences in biomass loss between species, watersheds, slope positions, and study plots Finally, Kruskall-Wallis ranked-sum tests were used to compare selected groups of nitrogen replicates. Detailed explanations and justifications for these methods follow.

I.2.8.1 Biomass :

Foliar litter generally displays a negative exponential pattern of disappearance during early stages of decomposition (Swift *et al.*, 1979; Wieder and Lang, 1982; Jenny, 1947) and the decomposition rate can be described by the model: $y = e^{-kt}$, where y = FBMR, t is elapsed time in years, and k is a constant. The log transform of this equation is linear [$\ln(y) = -kt$] and least squares regression (OLS) (CRC-STATA, 1990) may be used to estimate k with the assumption that the y intercept is 0. A y intercept of 0 is conceptually correct in that it assumes zero biomass loss (FBMR = 1.00) after no passage of time (*i.e.* ln(1.00) = 0). However, this simple model may not fit the data well near the y-intercept, especially if y = FBMR changes rapidly early in the experiment, *e.g.* as a consequence of leaching losses. Under these conditions, both the estimated value for slope (k = decomposition rate) and the confidence interval around this estimated value will be high and comparisons between slopes will be inaccurate.

To address this problem, the model used in this study to compare decomposition dynamics included a y-intercept term as follows: $\ln(y) = -k't + y_{(x0)}$; where $y_{(x0)}$ is an estimate of the y-intercept and k' is the slope. As before, the slope of this model is an estimate of the decomposition rate (k') and the y-intercept provides an index for the disappearance of biomass immediately following litterbag distribution. This value can be interpreted as the fresh mass lost by physical leaching. Categorical (dummy) variables were created for species, study year, and plots (Hamilton, 1990). A hierarchical analysis was conducted in which the data were separated into sub-sets that were progressively more descriptive regarding species, site, and study year. For example, the first level of the hierarchy factored all samples and used dummy variables to test for differences in *k'* (biomass loss) and y-intercept (leaching) between species. The second level of analysis used three regression models (one for each species) and factored dummy variables to test for differences between the Bisley and Icacos watersheds. In this way, the data could be sub-divided and dummy variables devised to address each of the objectives of the study

I.2.8.2 Nitrogen:

The fraction of nitrogen remaining over time was curvilinear and the degree of curvilinearity varied among sample groups. No single transformation technique would linearize the data for analyses using OLS regression. Consequently, non-parametric Kruskal-Wallis tests were used to compare nitrogen response [ln(FNR)] over time and between sites for each study year. Statistical comparisons between study years were complicated by unequal sampling intervals. To address this, the data were divided into groups with year, species, and treatment interval in common. The fraction of nitrogen remaining at a given sampling time in 1989 was compared to the closest two sampling times (before and after) in 1990, *e.g.* the 35 day samples from 1989 were compared to both 23 and 44 day samples from 1990.

The Inverse-linear relationship between the fraction of initial sample biomass remaining and its nitrogen content at collection (Aber *et al.* 1982, 1990; Melillo, 1982) was used with calculated decay coefficients to estimate the maximum N concentration and the timing of the change from net N immobilization to net N mineralization.

I.3 RESULTS

I.3.1 Hurricane Disturbance

Hurricane-induced litterfall at the Bisley site averaged 1442 g m^{-2} and at Icacos averaged 1627 g m^{-2} (Table 2). These values exceeded the forest-wide average (1083 g m^{-2}) reported by Lodge *et al.* (1991), but not significantly. Uniformity of the disturbance at Bisley is evident in the low variability among quadrats. Biomass deposits among quadrats at Bisley had a lower variance than those at Icacos, despite sampling a lower number of quadrats (6 *vs.* 19). Litterfall at the Bisley site had a greater suspended woody tissue content than did the Icacos site. The Bisley site also had more nitrogen deposited (16.91 *vs.* 10.39 g m^{-2}), especially from foliage.

Table 2: **Biomass and nitrogen content of fine litter (< 1 cm) collected from 0.25 m^2 plots in and around the Bisley and Icacos sites.**

			Suspended		Forest Floor			
			Foliage	Wood	Foliage	Wood	Other	Total
Bisley	(n=6)							
	Biomass	Mean g m^{-2}	45	337	656	252	152	1442
		SE	26	189	151	67	99	149
	Nitrogen	Mean g m^{-2}	0.59	2.14	11.38	1.68	1.12	16.91
		SE	0.34	1.10	2.72	0.50	0.62	2.53
	Percentage of 6 plots with litter to collect		33.3%	50.0%	83.3%	83.3%	66.7%	
Icacos	(n=19)							
	Biomass	Mean g m^{-2}	28	103	689	440	367	1627
		SE	20	52	81	76	111	164
	Nitrogen	Mean g m^{-2}	0.23	0.29	6.16	2.07	1.64	10.39
		SE	0.17	0.16	0.83	0.33	0.49	1.01
	Percentage of 19 plots with litter to collect		21.1%	21.1%	94.7%	89.5%	73.7%	

I.3.2 Initial Foliage Quality

Abscised *C. racemiflora* foliage contained relatively low concentrations of nitrogen and cellulose (0.38 and 26 %, respectively) and a relatively high lignin concentration (22%) (Table 3). The *D. excelsa* and *P. montana* initial state samples had similar lignin (17 %) and cellulose (43 %) concentrations. However, the abscised *D. excelsa* foliage had about 1/3 the N concentration of "green" *P. montana* (0.67 *vs.* 1.77 %). Thus, these species represent a range in litter quality.

Table 3: Initial quantities and qualities of foliage for pre- and post-hurricane litterbags. Sample quality entries are: mean percentage (standard deviation).

	C. racemiflora				*D. excelsa*				*P. montana*			
	1989		1990		1989		1990		1989		1990	
Quantity												
Mass per Litterbag (g dry)	11-12		8-9		10-11		12-13		9-10		13-14	
Leaves per Litterbag (approx.)	60				18				12			
Number of Litterbags Collected	69		115		87		124		83		125	
Quality (Percent)												
Nitrogen (TKN)	0.43	(0.03)	0.35	(0.02)	0.67	(0.02)	0.67	(0.03)	1.74	(0.14	1.79	(0.08)
Lignin (NIR)			22.1	(0.90)			16.6	(0.30)			16.7	(0.71)
Cellulose (NIR)			25.8	(0.58)			43.5	(1.04)			42.9	(0.63)
Ash	0.25	(0.13)	0.18	(0.08)	11.36	(0.70)	11.47	(0.78)	8.14	(0.90	7.33	(0.60)

I.3.3 Biomass Disappearance

The rate of biomass disappearance was lower in 1990 than in 1989 for most combinations of species, site, and slope position (Figures 3 through 6). Table 4 summarizes the estimated k' and the y-intercepts from dummy variable regressions by species, year, watershed, and slope position. Specific comparisons, *e.g.* between watersheds, sites, and years were made by statistical analyses of subsets of samples. Decay rates (*k'*), y-intercepts, and associated significance levels were derived by combining estimates from categorical regressions models

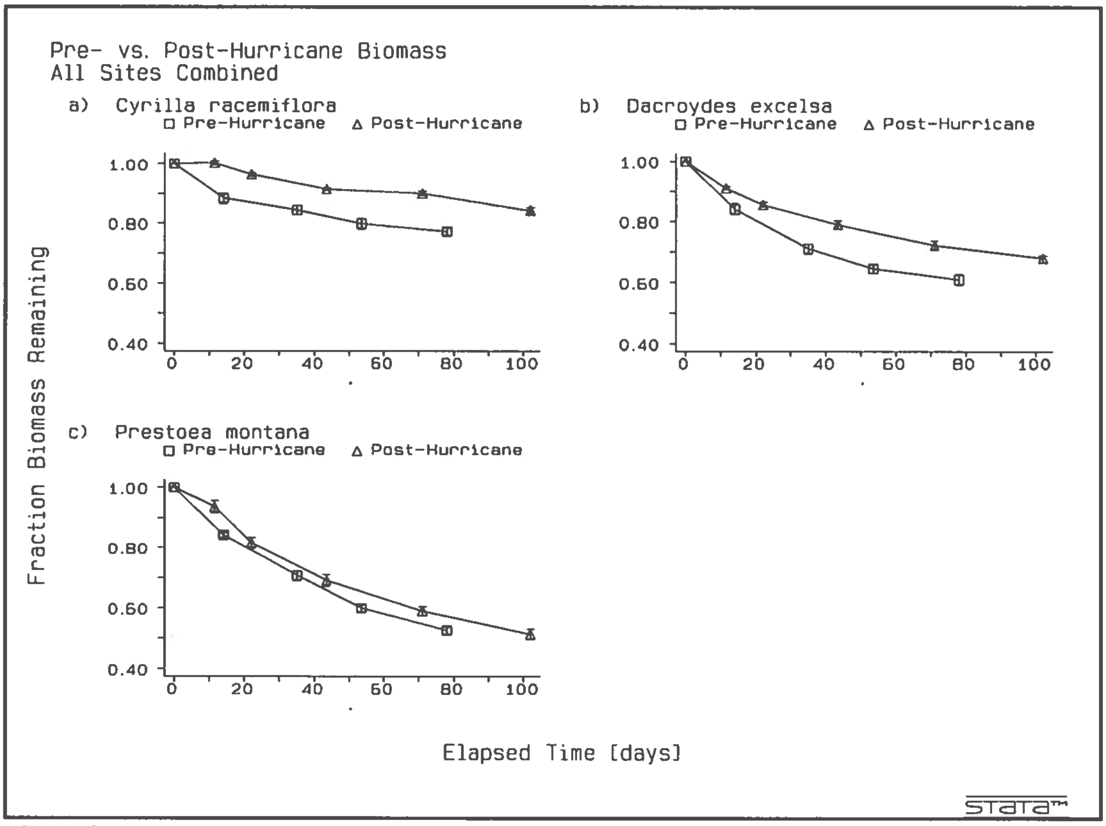

Figure 3: Pre- v. Post-Hurricane biomass disappearance by species, samples from all sites combined (Error bars +/- 1 standard error).

included in Appendix F (Tables 18, 19 and 20).

I.3.3.1 Statistical Comparisons of Biomass

I.3.3.1.1 Between Species

There were significant differences among the rates of disappearance of the three species over time. The slope of the regression model (*k'*) for *P.montana* was 1.84 times that of the *D.excelsa* model (-2.46 *vs.* -1.32, $P<0.001$) and about 4 times the slope of the *C.racemiflora* model (-0.62, $P<0.001$). The initial rate of biomass loss is underestimated for all three species by the negative exponential model as indicated by the negative y-intercepts that are significantly less than 0 ($P<0.0005$). The regression model with categorical variables (Appendix F; Table 18) explained

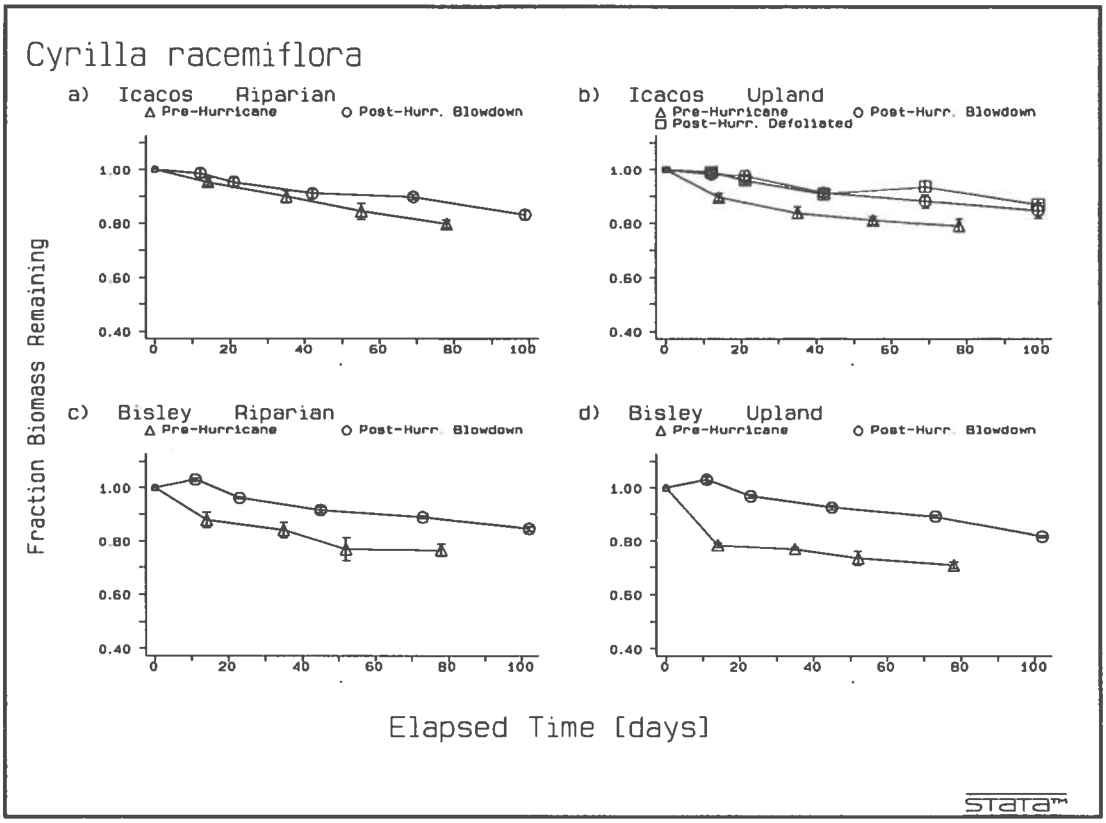

Figure 4: Pre- *versus* Post-hurricane *C. racemiflora* foliage disappearance by watershed and slope position (±1 SEM).

71 % of the observed variance in biomass loss.

I.3.3.1.2 Between Watersheds

There were not significant differences in rates of biomass loss between the Icacos and Bisley sites (plots combined) for *D.excelsa* and *P. montana*. The log transformed biomass loss rate for *C. racemiflora* in 1990 was significantly greater ($P<0.014$) for Bisley samples (k'= -0.77) than for Icacos samples (k' = -0.58). In addition, the y-intercept for the *C. racemiflora* biomass loss differed significantly from zero in both 1989 and 1990 (-.16, $P<0.001$ and 0.03, $P<0.05$). These models generally explained 75 % of the variation among sites (forest types) by species, except for *C. racemiflora* and *D. excelsa* in 1989 (53 and 58 %, respectively).

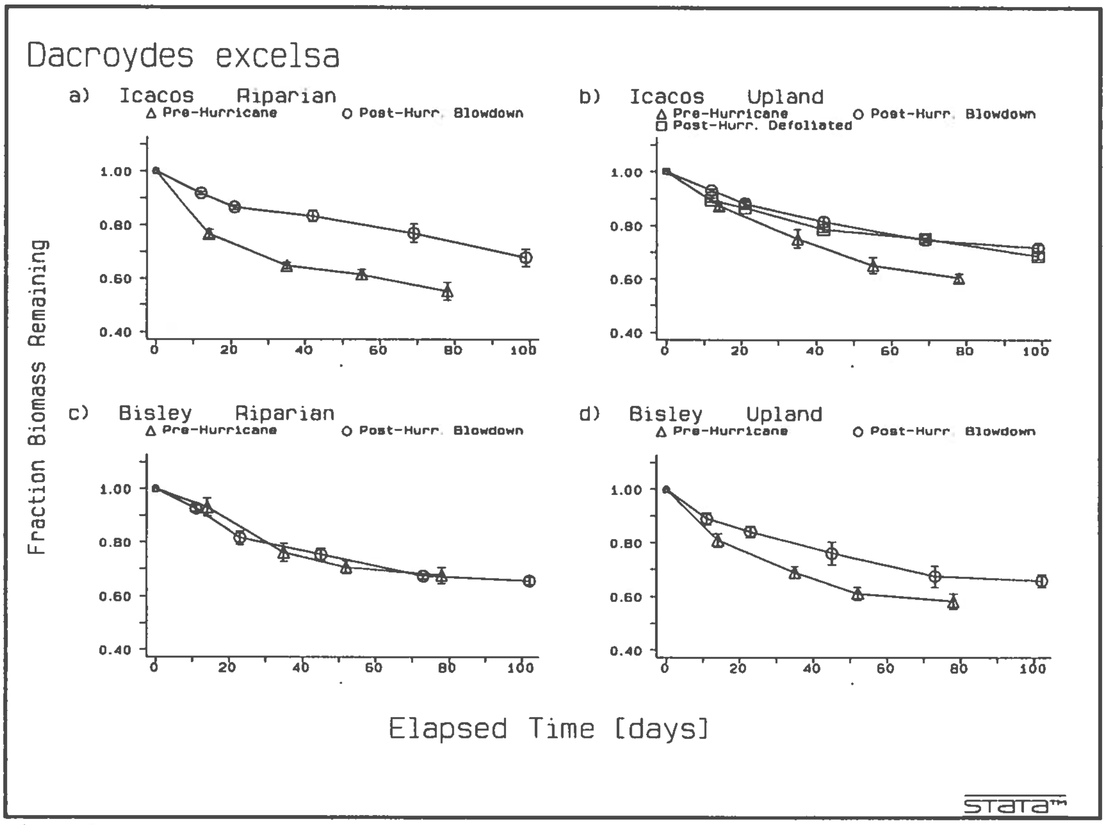

Figure 5: Pre- *vs.* Post-hurricane *D. excelsa* foliage disappearance by water shed and slope position (+/- 1 SEM).

I.3.3.1.3 Between Riparian and Upland Plots

The only significant differences in the regression models for biomass loss between riparian and upland sites by species, watersheds, and year occurred for *C. racemiflora* samples in 1989 where the intercept was lower for upland sites at both watersheds ($P < 0.05$). Thus, biomass loss did not seem to be affected by slope position. Although not significant, samples at the upland sites usually (9 of 12 sample groups) decayed at a lower rate than those at riparian sites.

I.3.3.1.4 Between Pre- to Post-Hurricane Sets

The data set was sorted in 27 different configurations to investigate factors that affected

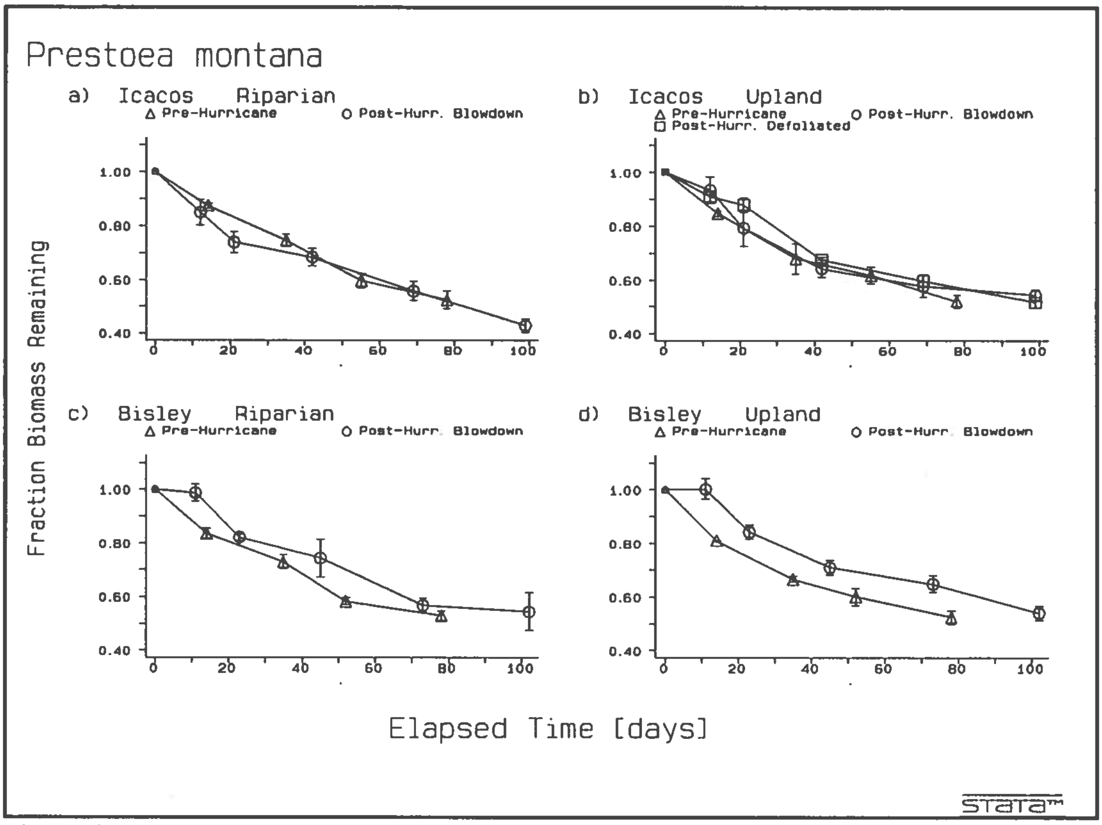

Figure 6: Pre- *vs.* Post-hurricane *P. montana* foliage disappearance by watershed and slope position (± 1 SEM).

decomposition before (1989) and after (1990) the hurricane. The data suggest a higher rate of decay in 26 of the 27 models in 1989 as compared to 1990, although the difference was significant in only twelve models. When modeled without regard to plot location, the disappearance rate for *D. excelsa* biomass in 1989 (k' = -1.84) was significantly greater ($P<0.05$) than 1990 (k' = -1.22) (Table 4). The y-intercepts for *D. excelsa* and *C. racemiflora* were significantly ($P<0.001$) lower in 1989 than in 1990 (-0.10 *vs.* 0.01 and -0.14 *vs.* -0.08, respectively). The differences in rate and intercept between study years for *P. montana* were not significant.

Sorting by species and introducing dummy variables for watershed and slope position shows that decay rate and intercept differences between years for *C. racemiflora* and *D. excelsa* were statistically significant for Icacos sites but not for Bisley. *P. montana* decay rates did not differ between years at any site. Rates for *C. racemiflora* models for the Bisley upland plot and for the Icacos riparian plot were significantly different between years ($P<0.001$ and $P<0.05$, respectively). The initial biomass loss (y-intercept) for the *D. excelsa* Icacos Riparian samples was significantly different between years ($P<0.05$).

Biomass disappearance on the plot that was only defoliated during the hurricane and had refoliated for the study in 1990 did not differ from the hurricane disturbed blowdown plot for all three species.

Table 4: Summary of litter disappearance rates (*k'*) and y-intercepts from regressions with categorical variables and standard error ( ).

		Bisley			Icacos				All Sites	
		Riparian	Upland	Bisley Both Plots	Riparian	Upland Defol-90	Upland Blowdown-90	Icacos All Plots	By Year	Both Years
Cyrilla racemiflora										
Slope (k')	89	-0.86 (0.30)	-0.59 (0.11)	-0.69 (.204)	-1.04 (0.17)	-0.71 (0.17)		-0.88 (.134)	-0.77 (.140)	-0.62 (.074)
	90	-0.72 (0.60)	-0.84 (0.05)	-0.78 (.038)	-0.65 (0.09)	-0.46 (0.10)	-0.65 (.120)	-0.58 (0.06)	-0.66 (.040)	
Intercept	89	-0.11 (.042)	-0.22 (.014)	-0.16 (.027)	0.01 (.024)	-0.10 (.025)		-0.05 (.019)	-0.10 (.019)	-0.04 (.011)
	90	0.02 (.009)	0.04 (.008)	0.03 (.006)	-0.00 (.014)	-0.01 (.017)	0.00 (.021)	-0.00 (.001)	0.01 (.006)	
Dacroydes excelsa										
Slope (k')	89	-1.72 (0.32)	-1.98 (0.31)	-1.72 (.268)	-1.82 (0.27)	-2.13 (0.27)		-1.96 (0.23)	-1.84 (.180)	-1.32 (.097)
	90	-1.32 (0.14)	-1.27 (0.21)	-1.29 (.122)	-1.21 (0.16)	-1.10 (0.06)	-1.09 (.090)	-1.14 (.064)	-1.22 (.070)	
Intercept	89	-0.06 (.047)	-0.17 (.041)	-0.13 (.037)	-0.22 (.039)	-0.08 (.039)		-0.15 (.033)	-0.14 (.026)	-0.12 (.015)
	90	-0.09 (.024)	-0.10 (.035)	-0.10 (.021)	-0.05 (.025)	-0.09 (.010)	-0.06 (.014)	-0.07 (0.01)	-0.08 (.011)	
Prestoea montana										
Slope (k')	89	-2.77 (0.26)	-2.46 (0.26)	-2.62 (.184)	-3.06 (0.32)	-2.67 (0.42)		-2.86 (.262)	-2.74 (.160)	-2.46 (.108)
	90	-2.49 (0.34)	-2.29 (0.23)	-2.38 (.199)	-2.71 (0.28)	-2.45 (0.18)	-2.14 (.340)	-2.43 (.167)	-2.41 (.130)	
Intercept	89	-0.08 (.035)	-0.14 (.037)	-0.11 (.025)	-0.02 (.045)	-0.09 (.059)		-0.08 (.037)	-0.09 (.022)	-0.07 (.016)
	90	-0.00 (.053)	0.00 (.038)	-0.00 (.032)	-0.10 (.044)	-0.04 (.029)	-0.10 (.055)	-0.08 (.027)	-0.05 (.021)	

I.3.3.1.5 Modelling all Factors

The regression models that factor all dummy variables by species (Table 5) characterize all of the relationships among watersheds, slope positions, and study years. There were not significant differences between watersheds and slope positions sites for any species. *C. racemiflora* differed in its y-intercept (difference = -0.11, $P<0.05$) but the decomposition rate did not (k' = -0.72 and -0.83 for 1990 and 1989, respectively). The decomposition rate and y-intercept for *D. excelsa* both differed significantly between years (k' difference = -0.62,

Table 5: Multivariate regression models to predict the natural log of biomass remaining over time. Dummy variables were factored to test simultaneously for differences among all sites and between study years by species.

			C. racemiflora			*D. excelsa*			*P. montana*		
			n = 184			n = 211			n = 208		
			Coef.	(SE)	P[3]	Coef.	(SE)	P	Coef.	(SE)	P
Base Coef.	k'(T)	1	-0.724	(0.094)	**	-1.174	(0.148)	**	-2.707	(0.197)	**
(`90, Ic, Rip)	b	2	0.044	(0.014)	*	-0.073	(0.023)	*	-0.042	(0.030)	ns
Change in Coef. due to:											
Study Year:	Dyr(T)	1	-0.119	(0.112)	ns	-0.619	(0.171)	**	-0.303	(0.231)	ns
1989	Dyr	2	-0.112	(0.016)	**	-0.063	(0.025)	*	-0.042	(0.034)	ns
Watershed:	Dw(T)	1	-0.025	(0.098)	ns	-0.102	(0.153)	ns	0.179	(0.205)	ns
Icacos	Dw	2	-0.029	(0.015)	ns	0.004	(0.024)	ns	0.020	(0.031)	ns
Slope Position:	Ds(T)	1	0.138	(0.098)	ns	0.002	(0.154)	ns	0.365	(0.206)	ns
Upland	Ds	2	-0.040	(0.015)	*	-0.009	(0.024)	ns	-0.023	(0.031)	ns
	R^2		0.70			0.68			0.75		

1. Slope 2. y-Intercept
3. * and ** indicate P>|t|<.05 and P>|t|< .001, respectively, ns = not significant.

P<0.001 and intercept difference = -0.06, P<.05). *P. montana* did not differ between years. The conclusions based on the regression models (Tables 4, 5, 18, 19, and 20) agree with the results of Kruskal-Wallis tests (included in Appendix E).

I.3.3.2 Decay Constants (k)

The fit of regression models based on the classic negative exponential equation without a y-intercept ($y=e^{-kt}$) improved as the sample sets become more site specific (R^2 of 0.707 to 0.964, although the R^2 is artificially inflated when an intercept is not estimated (T. Gregoire, pers. comm.)). Table 7 is a summary of *k* values for samples grouped by species, watershed, slope position, and study year. Due to the lack of an estimate of the y-intercept, the *k* values differ from corresponding *k'* values (Tables 4 and 5), nevertheless, *k* and *k'* suggest the same relationships between species and study years. The rate of litter biomass disappearance using *k* follows the progression *P. montana* > *D. excelsa* > *C. racemiflora*, and 1989 > 1990 for each species. Apparent differences between Upland and Riparian sites in 1989 were due to the statistical leverage of assuming a y-intercept of 0, the more rigorous *k'* models conclude these were not significantly different.

Table 6: Linear regression models for estimating decay coefficients (model: fraction biomass remaining = e^{-kt}; Jenny, 1947).

			Cyrilla racemiflora			*Dacroydes excelsa*			*Prestoea montana*		
			k	n	R^2	*k*	n	R^2	*k*	n	R^2
B	R	1989	-1.54	16	0.85	-2.08	22	0.90	-3.31	23	0.96
B	U	1989	-2.03	13	0.84	-3.08	24	0.91	-3.34	20	0.96
I	R	1989	-1.10	20	0.91	-3.22	20	0.92	-3.19	20	0.96
I	U	1989	-1.30	20	0.88	-2.60	21	0.95	-3.27	20	0.93
B	R	1990	-0.61	25	0.93	-1.76	25	0.94	-2.51	25	0.88
B	U	1990	-0.65	22	0.94	-1.78	25	0.88	-2.28	25	0.93
I	R	1990	-0.67	23	0.90	-1.49	25	0.91	-3.24	25	0.94
I	U	1990	-0.57	45	0.79	-1.48	49	0.95	-2.66	50	0.92

I.3.4 Results: Nitrogen

Nitrogen dynamics over time were curvilinear and differed between plots (Figures 8 through 11). Statistical analyses between plots by year showed few instances of significant difference (Figures 12 and 13) however there were significant differences between study years for these three species (Table 7 and Figure 7). In general, the fraction of nitrogen remaining overtime in 1990 exceeded that in 1989. *C. racemiflora* samples immobilized nitrogen beyond the end of the study in 1990 (110 % of the initial N at 102 days) whereas 1989 samples released ~10 % of the original nitrogen before the first collection then maintained 90% of the initial N mass for the remaining 78 days of the study. The *D. excelsa* 1989 samples maintained the original N mass for ~20 days and then declined gradually to ~82% of the original N mass.

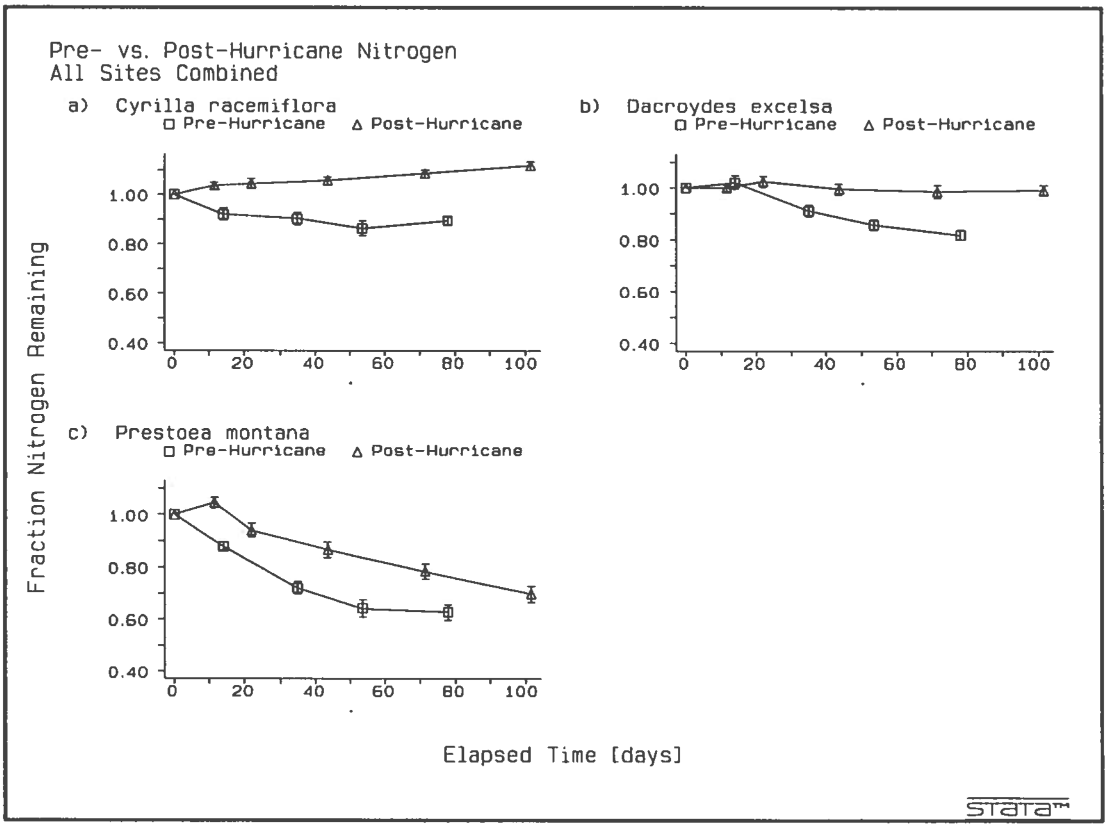

Figure 7: Pre- v. Post-hurricane nitrogen dynamics by species, samples from all sites combined.

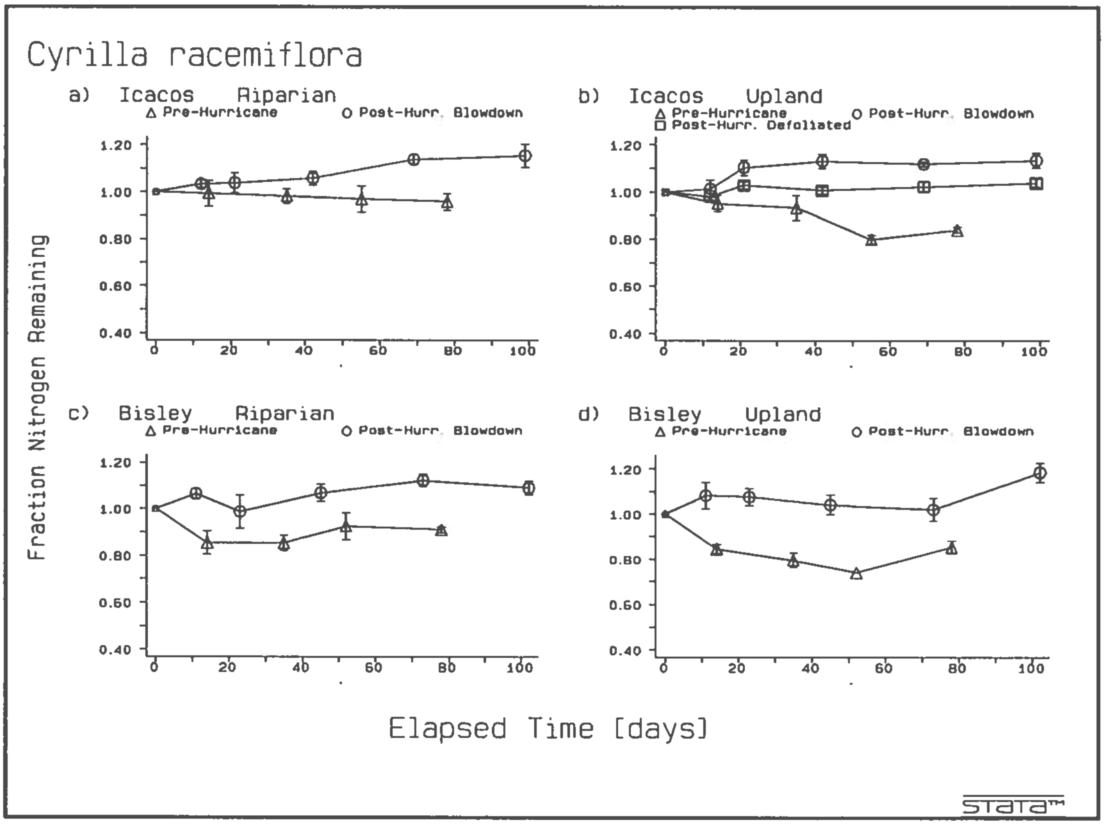

Figure 8: Pre- *vs.* Post-hurricane *C. racemiflora* nitrogen flux by watershed and slope position (±1 SEM).

The 1990 *D. excelsa* samples maintained the same N mass throughout the study. *P. montana* 1989 samples began to release N immediately and declined to 60 % of the initial N mass by the 78th day. Post-hurricane *P. montana* samples immobilized N briefly (105% at day 12) and declined at a rate similar to 1989 to 70% of the initial N.

When considered by site, between year relationships for *C. racemiflora* were similar for all sites, *i.e.* 1990 samples immobilized N and 1989 sample released N before the first collection. Although significant differences in N dynamics between 1989 and 1990 were observed, there were no significant differences between the 1990 blowdown and defoliated sites at Icacos (Figure 8).

The *D. excelsa* samples from Icacos riparian sites in 1990 were atypical for this species in that the N content was >100 percent of the initial content throughout the study, although this litter began to release N at 70 days (Figure 9). The 1989 Bisley *D. excelsa* riparian samples of the first collection displayed an unusually high and variable N mass (89 to 141% of the initial mass, standard deviation 21%), although the biomass results (87 to 101 %, standard deviation 7 %) for the same replicate set were similar to other plots. Samples from the hurricane blowdown and defoliated plots were essentially identical for nitrogen dynamics.

The variability in nitrogen content of *P.montana* (error bars for Figure 10) differed between sites and year. Variation among Bisley Riparian (Figure 10c) samples was consistent between replicate sets in 1990. Icacos riparian samples (Figure 10a) were most variable at the end of the study and did not differ from 1989 samples. Variance among replicate sets (error bars on Figures 3 - 10) suggests environmental variability among sub-plots. The brief period of immobilization that occurred in 1990 was minor at the Icacos sites but relatively large for Bisley sites. Once the immobilization period had passed, the rate of loss between years was similar.

Nitrogen dynamics between the 1990 defoliated and blowdown plots did not differ for *D. excelsa* and *P. montana*. *C. racemiflora* samples from the blowdown plot immobilized significantly more ($P < 0.05$) nitrogen (about 10 % of the initial nitrogen mass) than the defoliated plot.

I.3.4.1 Statistical Tests of Nitrogen Dynamics

The Kruskal-Wallis tests (Figures 11 and 12) show that within plots the nitrogen mass was not significantly different over time for *C. racemiflora* for both years. The first *D. excelsa* collections in 1989 often differed from lengthier decomposition periods, particularly at Bisley. There were few instances of significant differences between sites and collection periods for all three species in 1990 (Figure 12).

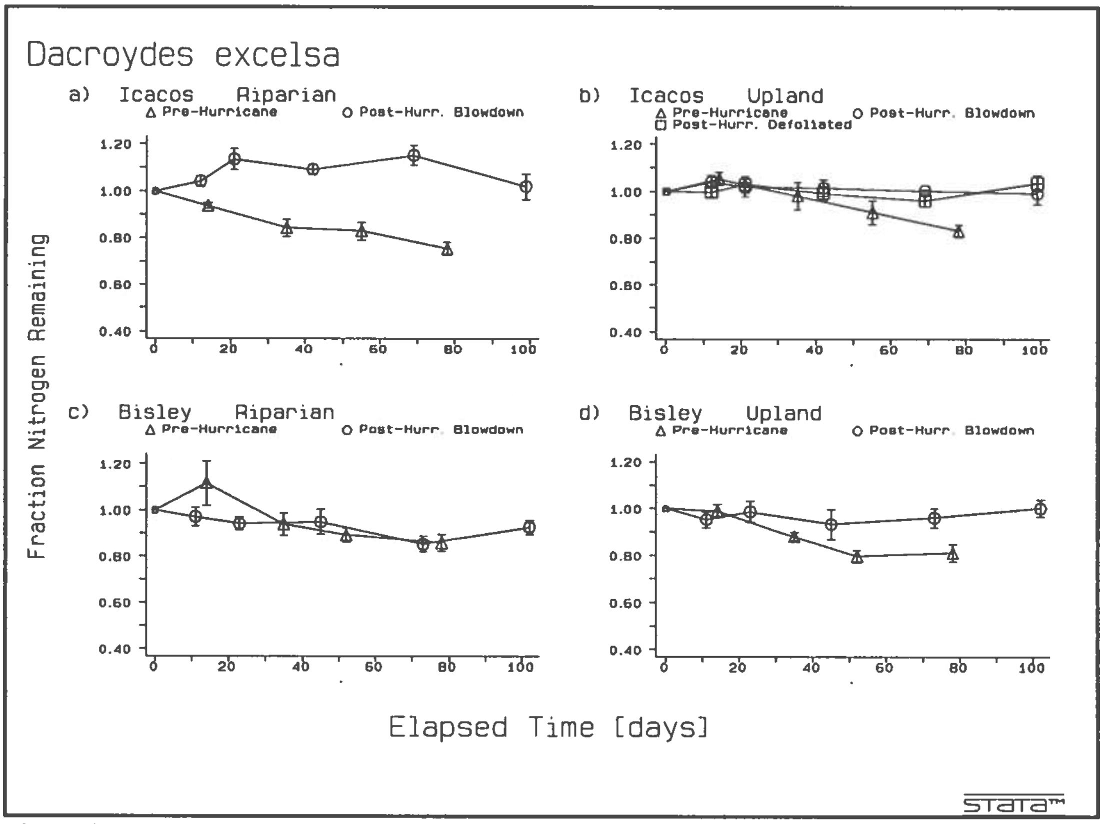

Figure 9: Pre- v. Post-hurricane *D. excelsa* nitrogen dynamics by watershed and slope position (±1 SEM).

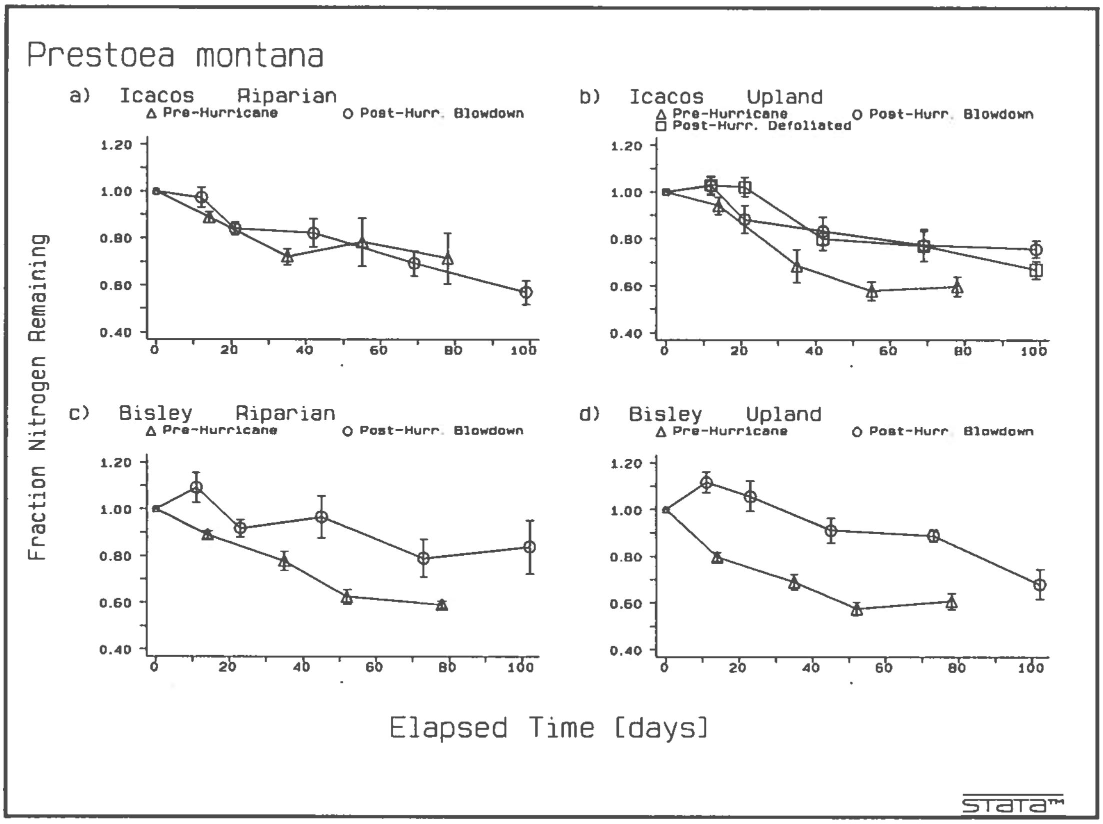

Figure 10: Pre- v. Post-hurricane *P. montana* nitrogen dynamics by watershed and slope position (±1 SEM).

Cyrilla racemiflora

Spec'es/Watershed/Catena

	CBR 14	CBR 35	CBR 52	CBR 78	CBU 14	CBU 35	CBU 52	CBU 78	CIR 14	CIR 35	CIR 52	CIR 78	CIU 14	CIU 35	CIU 52	CIU 78
CBR 14																
CBR 35	-															
CBR 52	-	-														
CBR 78	-	-	-													
CBU 14	-															
CBU 35		-			-											
CBU 52			-		-	-										
CBU 78				-	-	-	-									
CIR 14	-				*											
CIR 35		*				*			-							
CIR 52			-				-		-	-						
CIR 78				-				*	-	-	-					
CIU 14	-				*				-							
CIU 35		-				*				-			-			
CIU 52			*				-				*		*	*		
CIU 78				*				-				*	*	-	-	

Dacroydes excelsa

	DBR 14	DBR 35	DBR 52	DBR 78	DBU 14	DBU 35	DBU 52	DBU 78	DIR 14	DIR 35	DIR 52	DIR 78	DIU 14	DIU 35	DIU 52	DIU 78
DBR 14																
DBR 35	-															
DBR 52	*	-														
DBR 78	*	-	-													
DBU 14	-															
DBU 35		-			*											
DBU 52			*		*	*										
DBU 78				-	*	-	-									
DIR 14	-				*											
DIR 35		-				-			-							
DIR 52			-				-		-	-						
DIR 78				*				-	*	*	-					
DIU 14	-				-				-							
DIU 35		-				-				-			-			
DIU 52			-				-				-		*	-		
DIU 78				-				-				-	*	-	-	

Figure 11a,b: 1989 intra-specific comparison matrices of Kruskal-Wallis ranked sum tests for differences between replicate sets for *C. racemiflora* (a) and *D. excelsa* (b) fraction nitrogen remaining. Significant ($P < .05$) differences are indicated by asterisks, no difference is indicated by dash (-) and the absence of a symbol indicates that no test was performed.

Prestoea montana

	PBR 14	PBR 35	PBR 52	PBR 78	PBU 14	PBU 35	PBU 52	PBU 78	PIR 14	PIR 35	PIR 52	PIR 78	PIU 14	PIU 35	PIU 52	PIU 78
PBR 14																
PBR 35	*															
PBR 52	*	*														
PBR 78	*	*	-													
PBU 14	*															
PBU 35		-			*											
PBU 52			-		*	*										
PBU 78				-	*	-	-									
PIR 14	-				*											
PIR 35		-				-			*							
PIR 52			-				-		-	-						
PIR 78				-				-	-	-	-					
PIU 14	-				*				-							
PIU 35		-				-				-			*			
PIU 52			-				-				-		*	-		
PIU 78				-				-				-	*	-	-	

Figure 11c: 1989 intra-specific comparison matrices of Kruskal-Wallis ranked sum tests for differences between replicate sets for *P. montana*.

Cyrilla racemiflora

	CBF 11	CBR 23	CBR 45	CBR 73	CBR 102	CBU 11	CBU 23	CBU 45	CBU 73	CBU 102	CIR 12	CIR 21	CIR 42	CIR 69	CIR 99	CIUN 12	CIUN 21	CIUN 42	CIUN 69	CIUN 99	CIUS 12	CIUS 21	CIUS 42	CIUS 69	CIU 99
CBR 11																									
CBR 23	:																								
CBR 45	:	:																							
CBR 73	:	:	:																						
CBR 102	:	:	:	:																					
CBU 11	:																								
CBU 23		:				:																			
CBU 45			:			:	:																		
CBU 73				:		:	:	:																	
CBU 102					:	:	:	:	:																
CIR 12	:					:																			
CIR 21		:					:				:														
CIR 42			:					:			:	:													
CIR 69				:					:		*	:	:												
CIR 99					:					:	*	:	:	:											
CIUN 12	*					:					*														
CIUN 21		:					:					:				*									
CIUN 42			:					:					:			:	:								
CIUN 69				*					:					*		:	:	:							
CIUN 99					:					*					:	*	:	:	:						
CIUS 12	:					:					:					:									
CIUS 21		:					:					:					:				:				
CIUS 42			:					:					:					*			:	:			
CIUS 69				:					:					:					*		*	:	:		
CIUS 99					:					:					:					:	*	:	:	:	

Figure 12a: 1990 intra-specific comparison matrices of Kruskal-Wallis ranked sum tests for differences between replicate sets for *C. racemiflora* fraction nitrogen remaining. Significant ($P < .05$) differences are indicated by asterisks, no difference is indicated by dash (-) and the absence of a symbol indicates that no test was performed.

Dacroydes excelsa

	DBR 11	DBR 23	DBR 45	DBR 73	DBR 102	DBU 11	DBU 23	DBU 45	DBU 73	DBU 102	DIR 12	DIR 21	DIR 42	DIR 69	DIR 99	DIUN 12	DIUN 21	DIUN 42	DIUN 69	DIUN 99	DIUS 12	DIUS 21	DIUS 42	DIUS 69	DIU 99
DBR 11																									
DBR 23	:																								
DBR 45	:	:																							
DBR 73	*	*	:																						
DBR 102	:	:	:	:																					
DBU 11	:																								
DBU 23		*				:																			
DBU 45			*			:	:																		
DBU 73				:		:	:	:																	
DBU 102					:	:	:	:	:																
DIR 12	:					:																			
DIR 21		:					*				:														
DIR 42			:					*			:	:													
DIR 69				*					:		:	:	:												
DIR 99					:					:	*	:	:	:											
DIUN 12	:					:					:														
DIUN 21		:					:					:				:									
DIUN 42			:					:					*			:	:								
DIUN 69				*					:					*		:	:	:							
DIUN 99					:					:					:	:	:	:	*						
DIUS 12	:					:					:					:									
DIUS 21		:					:					:					:				:				
DIUS 42			:					:					:					:			:	:			
DIUS 69				*					:					*					:		:	:	:		
DIUS 99					:					:					:					:	:	:	:	:	

Figure 12b: 1990 intra-specific comparison matrices of Kruskal-Wallis ranked sum tests for differences between replicate sets for *D. excelsa* fraction nitrogen remaining. Significant ($P<.05$) differences are indicated by asterisks, no difference is indicated by dash (-) and the absence of a symbol indicates that no test was performed.

Prestoea montana

	PBR 11	PBR 23	PBR 45	PBR 73	PBR 102	PBU 11	PBU 23	PBU 45	PBU 73	PBU 102	PIR 12	PIR 21	PIR 42	PIR 69	PIR 99	PIUN 12	PIUN 21	PIUN 42	PIUN 69	PIUN 99	PIUS 12	PIUS 21	PIUS 42	PIUS 69	PIU 99
PBR 11																									
PBR 23	:																								
PBR 45	:	:																							
PBR 73	*	*	:																						
PBR 102	:	:	:	:																					
PBU 11	:																								
PBU 23		:				:																			
PBU 45			:			:	:																		
PBU 73				:		:	:	:																	
PBU 102					:	:	:	:	:																
PIR 12	:					:																			
PIR 21		*					*				:														
PIR 42			*					*			:	:													
PIR 69				*					:		*	:	:												
PIR 99					:					:	:	:	:	:											
PIUN 12	:					:					:														
PIUN 21		:					:					:				:									
PIUN 42			:					:					*			:	:								
PIUN 69				*					:					*		:	:	:							
PIUN 99					:					:					:	:	:	:	*						
PIUS 12	:					:					:					:									
PIUS 21		:					:					:					:				:				
PIUS 42			:					:					:					:			:	:			
PIUS 69				*					:					*					:		:	:	:		
PIUS 99					:					:					:					:	:	:	:	:	

Figure 12c: 1990 intra-specific comparison matrices of Kruskal-Wallis ranked sum tests for differences between replicate sets for *P. montana* fraction nitrogen remaining. Significant ($P < .05$) differences are indicated by asterisks, no difference is indicated by dash (-) and the absence of a symbol indicates that no test was performed.

Table 7: Test results for differences in fraction nitrogen remaining between study years (Kruskal-Wallis rank sum). All sites were classified by study year, species, and collection interval. The 1989 sets were compared to adjacent and bracketing 1990 sets.

1989 Mean Elapsed Time (days)	n	1989 Mean Fraction Nitrogen Remaining	1990 Mean Elapsed Time (days)	n	1990 Mean Fraction Nitrogen Remaining	Kruskal-Wallis P value for test between Years
Cyrilla racemiflora						
14	18	0.92	12	13	1.03	0.0002
14	18	0.92	23	14	1.04	0.0010
35	19	0.90	23	14	1.04	0.0003
35	19	0.90	44	15	1.05	0.0001
54	14	0.86	44	15	1.05	0.0001
54	14	0.86	71	16	1.08	0.0001
78	17	0.89	71	16	1.08	0.0001
78	17	0.89	102	17	1.12	0.0001
Dacroydes excelsa						
14	22	1.02	12	18	1.00	0.8890
14	22	1.02	23	19	1.02	0.4954
35	21	0.91	23	19	1.02	0.0013
35	21	0.91	44	20	0.99	0.0062
54	21	0.85	44	20	0.99	0.0001
54	21	0.85	71	21	0.98	0.0005
78	23	0.82	71	21	0.98	0.0001
78	23	0.82	102	22	0.99	0.0001
Prestoea montana						
14	21	0.88	12	23	1.05	0.0001
14	21	0.88	23	24	0.94	0.0642
35	21	0.72	23	24	0.94	0.0001
35	21	0.72	44	25	0.87	0.0005
54	20	0.64	44	25	0.87	0.0001
54	20	0.64	71	26	0.78	0.0028
78	21	0.63	71	26	0.78	0.0014
78	21	0.63	102	27	0.70	0.0504

I.3.4.2 Inverse Linear Relationship and Nitrogen Release -

The Inverse-Linear-Relationship (ILR) and *k* values were used to estimate the timing of N release. The approach was especially useful for *C. racemiflora* samples which did not begin to release nitrogen during the period of this study. Using average N content and average biomass by site and year, the ILR predicts *C. racemiflora* would begin releasing N at about 75 days in 1989 and 205 days in 1990 (Table 11). The maximum N content (Xymax) *i.e.* the value that would be present when N release began is similar for both years (0.51 to 0.61 %). The ILR model for *D. excelsa* in 1989 was questionable since it predicted immediate N release at a mass that exceeds the initial mass. The ILR model for *D. excelsa* in 1990 predicted N release at 51 days. The immediate release of N by *P. montana* in 1989 shown in Figure 13 is reflected in the ILR prediction (-2 days). Although the brief period of N immobilization by *P. montana* in 1990 is reflected in the ILR model (30 days), the fit of the model is relatively poor (R^2 = 0.14 for Bisley and 0.22 for Icacos).

Table 8: Models for the relationship between current nitrogen concentration and fraction biomass remaining (Inverse-Linear [ILR] *sensu* Aber *et al.*, 1982). Predicted timing of nitrogen release using the ILR and *k* values (Table 9).

			Inverse Linear Relationship						Maximum percent N	Percent biomass at Max N	t at Max N
		n	Slope Coeff.	(P<t)	Intercept Coeff.	(P<t)	R^2	k	(Xymax)	(Yymax)	(days)
C. racemiflora	89	20	-1.395	0.017	1.496	0.000	0.24	-1.42	0.54	74.8	75
	90	36	-1.196	0.000	1.418	0.000	0.78	-0.61	0.59	70.9	205
D. excelsa	89	20	-1.595	0.000	2.082	0.000	0.88	-2.72	0.65	104.1	-5
	90	36	-0.938	0.000	1.597	0.000	0.72	-1.61	0.85	79.9	51
P. montana	89	20	-0.429	0.027	1.528	0.000	0.20	-3.28	1.78	76.4	30
	90	36	-0.595	0.000	2.025	0.000	0.62	-2.66	1.70	101.3	-2

I.4 DISCUSSION

Litterbags are commonly used in decomposition studies but it has been noted that the data derived from such studies may not describe true rates of decay (Wieder and Lang, 1982). The use of fine-mesh litterbags places the litter in an unnatural environment (Swift *et al.*, 1979). Anderson *et al.* (1983) found that foliage of two species confined within coarse mesh after 100 days lost about 5 percent more mass than foliage in fine-mesh litterbags. The mesh apparently excluded some animals that may interact deposit enzymes or physically fragment the litter and so accelerate decomposition (Stewart and Davies, 1989; Swift *et al.*, 1979). Alternatives to the use of confinement in fine-mesh litterbags include the use of coarse-mesh and the tethered-leaf method (non-confinement). The possibility of overestimating decomposition rates exists for these methods since leaf matter can become detached or fall out of the litterbag thereby reducing the mass and nutrients in the litterbag but not necessarily increasing the nutrients available for plant growth, export from the site, or immobilization by other substrates. The fine-mesh litterbag may underestimate decomposition rates but it does allow for comparison of species, site, and other treatment effects.

I.4.1 Decomposition and Litter Quality Between Species

The species chosen for this study represent a range of litter qualities from *C. racemiflora* (low) to *P. montana* (high). The differences in rates of biomass disappearance for the species are consistent with expectations based on the initial qualities of the foliage. The nitrogen and lignin concentrations of litter are important controllers of decomposition (Aber and Melillo, 1982; Melillo *et al*, 1982; Bosatta and Staff, 1982). Nitrogen is required for decomposers to grow but may be stored in vegetation in forms initially unusable by the organisms. It is energetically costly for decomposers to synthesize the enzymes necessary to decompose the complex chemical structure of lignin and not all decomposers are capable of this synthesis. The very low nitrogen content and relatively high lignin concentration of *C. racemiflora* foliage resulted in a low decay rate and N immobilization despite favorable moisture and temperature associated with tropical rain forests (La Caro and Rudd, 1985). The qualities of the foliage measured in this study (nitrogen, lignin, cellulose, and ash; Table 3) account for less than 50 % of the mass of *C. racemiflora* whereas these constituents account for about 70 % of the foliar mass of *D. excelsa* and *P. montana*. The components of the 20 % difference were not determined in this study but may be important in characterizing decomposition. For example, Ovington and Olson (1970) found *C. racemiflora* to contain about 5 times the phosphorous content of *D. excelsa* (0.35 v. 0.07%).

The *k* values for the three species of this study (-0.85 to -2.87) span ranges reported in other studies of foliar decomposition. Edwards (1982) characterized *k* values for neotropic sites as being between -1.1 and -1.7. Palm and Sanchez (1990) studied the decomposition of the green foliage of three tropical legumes of high and similar nitrogen concentrations (3.18 to 3.52%) but varied lignin and polyphenol content (9.7 to 16.3, and 1.04 to 3.43%). The lignin and polyphenol content of the foliage controlled the rate of decomposition (k = -0.91 to -3.45). The high nitrogen concentration of green *P. montana* foliage probably contributed to its relatively high disappearance rate. The palm foliage was placed in the litterbags green, *i.e.* before retranslocation of nutrients could occur.

I.4.2 Between Watersheds and Catena Positions

There were no significant differences in biomass or nitrogen dynamics between sites for either study year. Edwards (1977) found no significant differences in decomposition between ridge and valley sites in New Guinea (k = 1.04 and 1.55 respectively). Ewel (1976) found no differences in biomass loss between Guatemalan alluvial and upland sites but did find that nitrogen and phosphorus were lost from litter more rapidly on upland sites. The variation between Puerto Rican watersheds and catena positions that might have occurred as a result of differences in climate were masked by within-site variability. Part of the within-site variability may have been due to variation in the supply of decomposer inoculum. Mycelium were abundant in some litterbags, in several instances within two weeks, while others displayed few signs of fungi. Dwyer and Merriam (1981) found in their study that small differences in forest floor topography influenced moisture status and temperature of litter and ultimately its decomposition. Litter placed in 0.5 m depressions decayed more rapidly than litter on level and slightly elevated sites. Dwyer and Merriam conducted their study in a relatively severe climate (Ottawa, Canada) where the climatic variables were closer to levels that might limit decomposition, in contrast, temperature and moisture do not approach limiting levels for any of the microsites included in the Puerto Rico study.

I.4.3 Environment and Decomposition Between Study Years

The increase in light at the forest floor due to toppled trees, fewer branches, and reduced leaf area after the hurricane resulted in dense herbaceous ground cover. All plots with the exception of the Icacos "defoliated" plot, included sub-plots dominated by herbs. All Icacos Upland Blowdown sub-plots, all Bisley Upland sub-plots, most of the Icacos Riparian sub-plots, and half of the Bisley Riparian sub-plots were occupied by herbs. In effect, the canopy was lowered to the forest floor (Brokaw, 1985). Transpiration from the herbs coupled with reduced air circulation at the forest floor may have maintained high moisture contents in foliar litter and decreased the vapor pressure gradient from the litter to the atmosphere despite apparently increased insolation and temperatures. The herb layer may also have prevented litterbags from contact with the litter layer and sources of microbial inoculum.

The post-disturbance study began nine months after the hurricane. Though it may arguably have been better to begin the study immediately after the hurricane, a short-term study would have missed a potentially important stage of post-hurricane response. Recovery of vegetation after the hurricane was delayed, perhaps as a result of a period of drought lasting approximately 3 months caused by unusual regional weather patterns and microclimate changes induced by the hurricane (Scatena and Larsen, 1991). In late October 1989, shoots had just begun to develop from adventitious buds of fallen or standing stems and early successional woody or herbaceous species had not become established near the study sites (personal observation). However, the state of the forest changed rapidly. When the post-hurricane study was implemented, vines, grasses, and pioneer trees had become established. This early successional stage lasted longer than the unvegetated/defoliated stage. Most trees were defoliated by the hurricane, and thus could not produce litterfall until well after they had refoliated. Therefore, experimental deposition of foliar litter found at sites that experienced lower disturbance on hurricane disturbed study plots would be contradictory to a natural sequence of events. Refoliation prior to the 1990 study is evidenced by our ability to collect foliage near the Icacos plots.

To some extent, the pre- and post-hurricane decomposition dynamics of this study can be compared to studies designed to examine decomposition in natural and artificially cleared tropical sites. For example, Maheswaren and Gunatilleke (1988) found that a cleared tropical lowland forest that was subsequently populated by ferns resulted in lower biomass loss (20 %) rates than adjacent rainforest. Conversely, Ewel (1977) did not find any differences between stand ages of 1 to 14 years after clearing in Guatemala.

While the differences in slope positions and forest types did not produce statistically different decomposition responses, the changes in environmental conditions due to the hurricane were sufficient to significantly alter the decomposition of *C. racemiflora* and *D. excelsa*, particularly their nitrogen dynamics. Translocation of nutrients, leaching by precipitation, and the physical impact of rainfall may have interacted to cause differences in biomass loss between years. In this study, leaching from leaves may have occurred: 1) during abscission; 2) while on the forest floor before being collected and dried for use in litterbags; 3) and for a short period after the litterbags were distributed. Day (1983) found that *Acer rubrum* leaves lost 30.8 % of their biomass and 18.7 % of their nitrogen in a 93 hour leaching experiment. In this study, for example,fresh foliage from *D. excelsa* and *C. racemiflora* contain substantially more nitrogen (0.94% and 1.22%, respectively; Section II) than abscised leaves (0.35% and 0.67%). The relative proportions of leachable and non-leachable constituents is not known for this study.

In this Puerto Rican study, the amount and pattern of precipitation was similar (Figure 13) during the two study periods. There was a large rain event about 30 to 40 days after the beginning of both study periods. Events of this magnitude are not unusual. Stream discharge exceeded the maximum that occurred during the 1989 study period (1.30 m^3sec^{-1}) on 22 days during 1989 and 1990 weir records. Precipitation in 1989 was greater than in 1990 during the period in which foliage was being collected for use and for 2-3 days after litterbags were deployed. This corresponds to higher initial biomass loss rates for *C. racemiflora* and *D. excelsa*, both of these species were subjected to translocation and abscision. *P. montana* was collected "green" and therefore not subject to reabsorption and did not differ in early biomass loss between years.

Biomass and nitrogen disappearance between study initiation and the second collection was delayed in 1990, which corresponded to a period of low rainfall (Bisley) and low stream discharge (Icacos). The physical impact of precipitation immediately preceding the study may have caused leaves to fall to the forest floor before soluble compounds could be translocated to twig tissue (*e.g.* simple sugars, potassium, phosphorous) in which case apparent initial biomass losses might have been higher than would otherwise be the case.

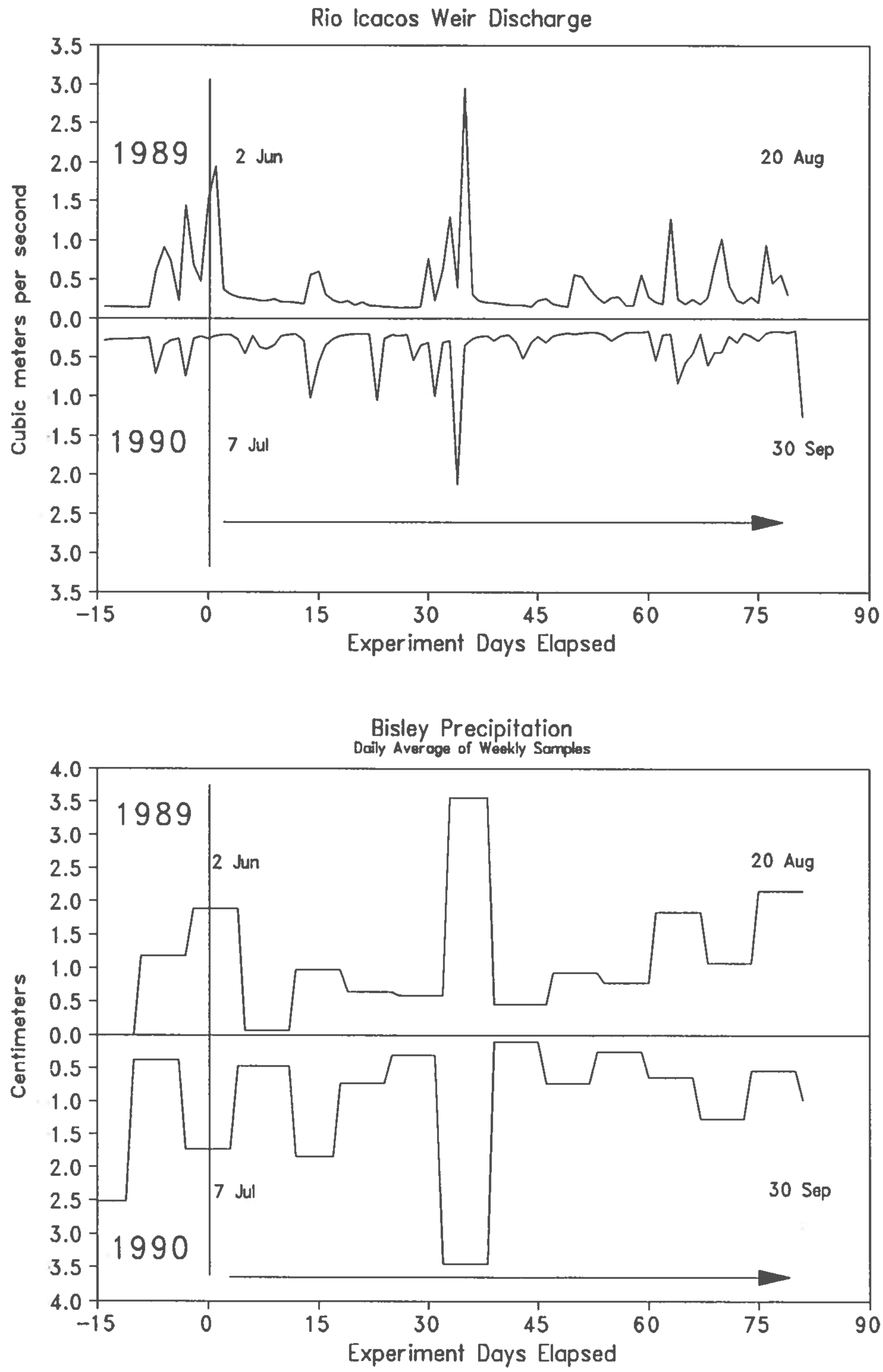

Figure 13: Daily Rio Icacos stream discharge (a) recorded at gauge 50075000 about 100 meters from the Icacos study sites (Curtis *et al*, 1990;1991) and (b) Bisley mean daily rainfall from weekly collections (F.N. Scatena, pers. comm.).

The notion that differences in precipitation early in the study periods contributed to the differences in decomposition is supported by the observation that samples from the 1990 defoliated plot and the 1990 blowdown plot did not differ in biomass loss.

The differences between pre- and post-hurricane nitrogen dynamics may have been due to a combination of precipitation and availability of nitrogen in the ecosystem. The brief period of apparent nitrogen immobilization displayed by *P. montana* in 1990 may have been due to low precipitation. The consistent nitrogen mass of *D. excelsa* and slight increase in nitrogen mass of *C. racemiflora* may have been related to the increased nitrate and ammonium levels in streams (McDowell, in prep.; Lodge *et al*, 1991). When nitrogen is available, some fungal species are capable of increasing nitrogen in mycelium by up to 20 times (Levi and Cowling reported by Swift *et al*, 1979). Contact between litterbags and monocots in disturbed sites and leaching from vegetation actively taking in nutrients may have increased nitrogen in litterbags. Covington (1981) characterized a temperate deciduous forest floor as a source of nutrients during the first fifteen years following clearing. Deposits of fresh litter with relatively simple carbon compounds may serve to immobilize and conserve nutrients on the site.

I.4.4 Implications for Future Studies

For decomposition, sub-plot differences seem to be greater than plot (watershed and catena position) differences. Explanation of this variation may require intense descriptions of micro-climate and local microbial populations over time. Indices of decomposition potential of substrates (morphological and chemical) may be a more useful approach for accounting for decay in integrated ecosystem models for tropical rainforests with high species diversity. Litterbag studies are labor and time intensive and the results are affected by climatic variation during the period in which the study is conducted. Examination of *in situ* forest floor properties over time may also be a better approach for ecosystems, *i.e.* it integrates litter types and species.

A large part of the difference between pre- and post-hurricane decomposition in this study apparently was due to differential initial leaching which may have been related to differences in precipitation. Exploration of the timing, frequency, and intensity of non-catastrophic precipitation | wind events, their affect on amounts of nutrient translocation during leaf senescence, their affect on leaching from fresh litter, and subsequent changes in nutrient export by groundwater | stream chemistry dynamics may have potential value in intensive ecosystem modeling.

I.4.5 Conclusions

In this study, abscised *Cyrilla racemiflora* leaves with high lignin and low nitrogen when abscised decayed at a low rate and immobilized available nitrogen. *Dacroydes excelsa* leaves with moderate nitrogen and lignin contents after abscision, decayed at moderate rates, and maintained constant amounts of nitrogen. Fresh *Prestoea montana* foliage (as would be deposited to the forest floor by catastrophic wind disturbance) initially had a high nitrogen content and rapidly lost both mass and nitrogen.

The short-term decomposition dynamics for the Colorado Forest Type sites (high elevation) did not differ significantly from the Tabonuco Forest Type Sites (mid-elevation). Likewise, riparian and upland sites were not significantly different.

C.racemiflora samples decayed at a similar rate before and after the hurricane but the initial biomass loss (leaching) was greater in 1989. *D. excelsa* leaves disappeared at a lower rate in 1990 than in 1989 and the initial biomass loss was less. These differences may have been due to the timing of precipitation. *P. montana* samples were not affected by the changes to the environment. Foliar litter inputs during post-hurricane recovery in Puerto Rico may serve to immobilize and conserve some of the nitrogen that may otherwise be lost from the system.

SECTION II

Suspended v. Forest Floor Foliar Litter Disappearance

II.1 Introduction

Foliage can remain attached to downed branches and suspended above the forest floor after a hurricane disturbance. A census of fallen litter in the Luquillo Experimental Forest after hurricane Hugo showed El Verde to have similar amounts of suspended (394 g m^{-2}) and forest floor (377 g m^{-2}) foliar litter (Lodge *et al*, 1991). A similar sampling protocol applied in and around the Bisley and Icacos study sites yielded higher average hurricane total litter mass but much lower amounts of suspended litter (Table 2). The ratio of suspended foliage to forest floor foliage was relatively low, 45:656 and 28:689 for Icacos and Bisley respectively. The local severity and duration of high winds could account for the differences in suspended foliar litter between El Verde, Bisley, and Icacos sites.

The objective of this aspect of the study was to examine the dynamics of suspended foliage disappearance and to compare this to coincident forest floor decomposition.

II.2 MATERIALS and METHODS

Fresh *C. racemiflora* twigs with attached leaves were collected on 9 July from understory branches on a ridge near the Icacos watershed well field (Figure 2). Green *D. excelsa* foliage and twigs were collected on 21 July from saplings adjacent to the El Verde field station. Several foliated twigs were weighed (mean green mass: 23.1 g for *C. racemiflora* and 24.9 g for *D.*

excelsa) and placed in 120 fiberglass ~1 mm mesh litterbags (20 by 30 cm). Each litterbag contained material of a single species. Ten additional samples per species were collected randomly during the weighing process to estimate initial moisture and nitrogen status. These initial state samples were dried and shipped to UNH for analysis.

On 15 July, sixty *C. racemiflora* litterbags were suspended at a height of 1.5 m adjacent to the riparian forest floor decomposition plot (Section I). On 23 July, sixty *D. excelsa* litterbags were suspended at a height of 1.5-2 m above the forest floor adjacent to the well field and across stream Q2 at the Bisley site.

Twelve *C. racemiflora* litterbags were collected 16, 38, 66, 95, and 148 days after distribution and twelve *D. excelsa* litterbags were collected 8, 29, 57, 86, and 132 days after distribution. The number of replicates (12) was relatively high compared to similar decomposition studies, but was required to provide a representative woody tissue sample and mass adequate for analyses. Sample sets were dried at about 55°C and shipped to UNH.

The twigs and foliage of each litterbag and initial state sample were separated, oven dried at 65°C, weighed, and milled to pass a 1 mm sieve. The twelve replicate litterbags were randomly grouped to produce four unique composite samples of three litterbags for both twig and foliar material. The resulting 40 composite field samples (five twig and five foliage composites for each species and for each of four collections) and 20 initial state samples were digested using a sulfuric acid-hydrogen peroxide method (Bremner and Mulvaney, 1973). Kjeldahl nitrogen (TKN) was measured in the digestate using a salicylate-nitroprusside method on a Technicon Autoanalyzer II (Technicon, 1983) (See Section I Methods).

The moisture contents of the initial-state samples were examined against processing order using regression to determine if the first samples processed differed predictably from subsequent samples. The initial state *D. excelsa* sample moisture content displayed a curvilinear relationship over processing sequence, therefore initial dry matter content (MCF see Appendix D) of field samples was estimated as:

$$MCF_{De} = 0.2055(ID) - 9.410(ID)^{1/2} + 108.0967$$

$$n = 10, \quad R^2 = .78, \quad P < 0.004$$

where ID is the assigned sample number (between 426 and 545). The *C. racemiflora* initial state samples varied in moisture content but showed no predictable relationship with processing order ($P < .68$), therefore the mean MCF (0.5177) was applied.

To simulate hurricane effects, foliage was left attached to twigs. It was not possible to measure separately the initial mass of the woody and foliar material that went into each litterbag, nor to keep the components in consistent ratios. Estimating the fraction of biomass remaining (and subsequently the nitrogen mass remaining) is by definition dependent on being able to accurately estimate the initial mass. Since the ratio of foliage to twigs differed between bags and each component would be expected to behave differently over time, a simple comparison of beginning to end weight of everything that went into each bag was inappropriate. Therefore estimates of initial mass by component was difficult. To examine changes in foliar biomass, woody tissue mass was assumed to remain unchanged over the short duration (102 days) of this study.

The Fraction biomass remaining (FBR) was estimated as:

$$FBR = \frac{FM_{tn}}{(ATM_{t0} - WM_{tn})}$$

where: FM_{tn} is the foliar dry-mass at collection time (n), ATM_{t0} is the estimated moisture adjusted total sample initial mass, and WM_{tn} is the woody tissue mass at collection time (n).

The fraction of foliar nitrogen remaining (FFNR) at collection was estimated as:

Where TKN_{t0} is the mean fraction foliar nitrogen measured in the initial state samples by species

$$FFNR = \frac{(FM_{tn} \times TKN_{tn})}{((ATM_{t0} - WM_{tn}) \times TKN_{t0})}$$

and TKN_{tn} is the fraction nitrogen measured in the composite samples.

Biomass and nitrogen results from the suspended samples were compared to the results of the forest floor study (Section I, this document) using data from post-hurricane riparian plots.

II.3 RESULTS and DISCUSSION

The N concentration for fresh foliage used in this suspended foliage study, (0.94 % for *C. racemiflora* and 1.22 % for *D. excelsa*, Table 9) was similar (0.83 % and 1.19 %) to that found by Ovington and Olson (1970).

The fraction of the original biomass remaining over time for suspended samples and forest floor samples was similar (Fig 14 a,b). Though the decay constant (k = -0.93) for suspended samples of *C. racemiflora* reflects a higher rate of disappearance than forest floor samples (k = -0.60) (Table 6), the difference in terms of biomass loss at these k values is only about 5 percent after 100 days.

If, contrary to the assumptions, stem tissue did decline in mass, the equation used to estimate the fraction of foliar biomass remaining over time would produce a low estimate, *i.e.* more foliar biomass would remain than is listed in Table 9 and depicted in Figure 14. The increase in the nitrogen concentration of stem tissue during the study is evidence that N mass did decline, that is, nitrogen would persist relative to compounds of greater mobility. Precipitation, throughfall, transport by insects, and nitrogen fixation are other explanations for the increase in N concentration of stems but the short term nature of the experiment reduces these impacts.

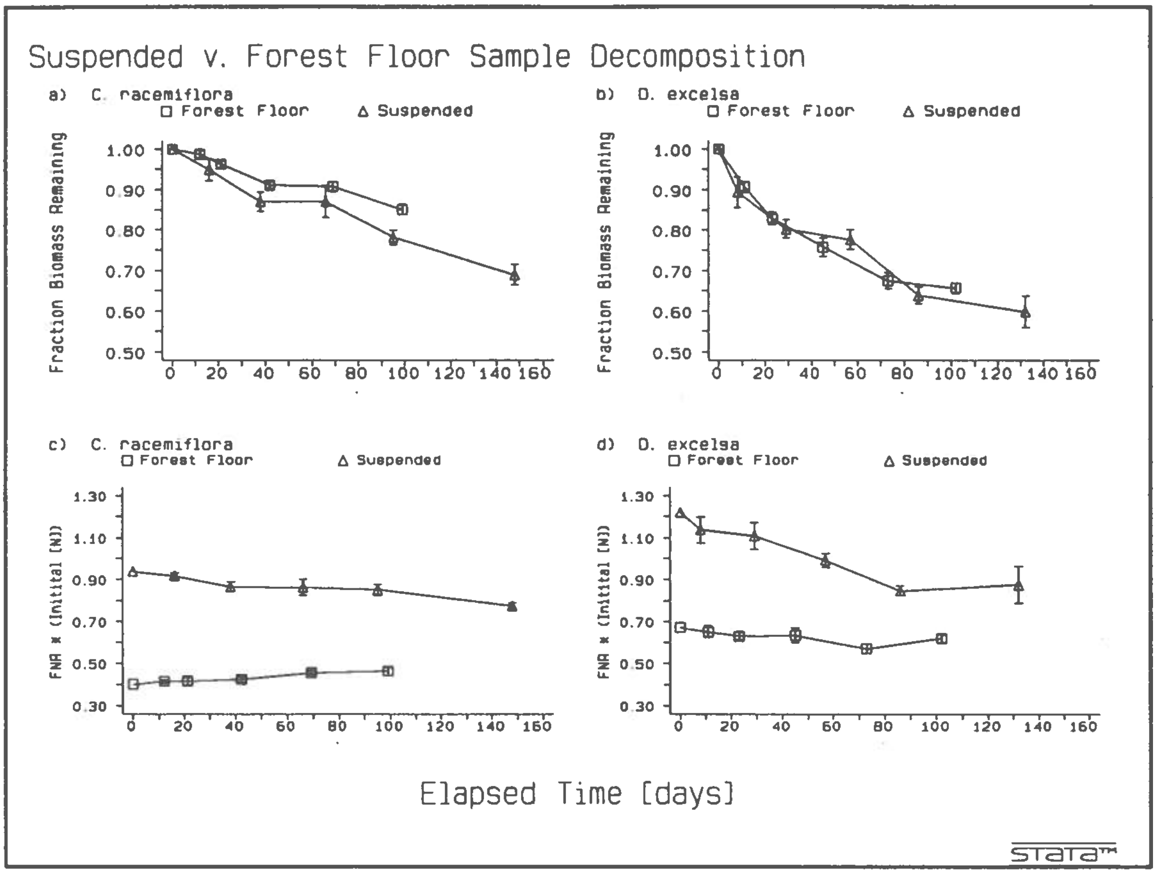

Figure 14: Suspended and forest floor foliar biomass (a,b) and nitrogen dynamics (c,d) (± SEM).

Table 9: Suspended foliage biomass loss and nitrogen concentration summary statistics.

Elapsed Time (days)	n	Mean Nitrogen Content (Percent) Foliar Tissue	SE	Wood Tissue	SE	Fraction Foliar Biomass Remaining n		SE
Cyrilla racemiflora								
0	5	0.938	(0.020)	0.478	(0.019)		1.000	
15	4	0.965	(0.013)	0.605	(0.013)	12	0.949	(0.027)
38	4	0.996	(0.034)	0.604	(0.024)	12	0.870	(0.024)
66	4	1.003	(0.039)	0.630	(0.022)	12	0.870	(0.040)
95	4	1.085	(0.048)	0.605	(0.026)	12	0.781	(0.018)
138	4	1.128	(0.038)	0.610	(0.019)	12	0.689	(0.025)
Dacroydes excelsa								
0	5	1.220	(0.035)	0.552	(0.022)		1.000	
8	4	1.283	(0.026)	0.708	(0.041)	12	0.894	(0.038)
29	4	1.358	(0.025)	0.793	(0.031)	9	0.802	(0.023)
57	4	1.293	(0.032)	0.763	(0.019)	12	0.776	(0.025)
86	4	1.340	(0.035)	0.780	(0.040)	12	0.639	(0.021)
132	4	1.455	(0.050)	0.808	(0.076)	11	0.599	(0.039)

The concentration of foliar N increased during the study by 0.23 and 0.19 percent for *D. excelsa* and *C. racemiflora*. The *D. excelsa* forest floor samples increased in N concentration similarly (by .22%) but the *C. racemiflora* increased by only half as much (.10%). The fraction of the original nitrogen mass remaining in the suspended foliage declined for both species while forest floor samples for *C. racemiflora* immobilized N and *D. excelsa* released N but at a slower rate (Fig. 14 c,d). Recently abscised *C. racemiflora* and *D. excelsa* foliage collected from the forest floor contained 0.40 and 0.67 percent nitrogen (Section I, Table 2), whereas green foliage attached to twigs contained 0.94 and 1.23 percent N (Table 9). These differences probably due to translocation during senescence. This large difference (about two fold) in N concentration between fresh and abscised foliage suggests several questions. How much of the N is reabsorbed before abscission and how much is leached after senescence begins but prior to abscission in undisturbed forest? Was there an external source of N contributing to the observed increase in concentration in foliage and twig tissue? One of the original justifications for this study was based on an anecdotal observation that dead foliage suspended from hurricane damaged branches decomposed more slowly than naturally senesced foliage once both reached the forest floor? Did the concentration of N in the previously suspended foliage limit decomposer organisms or did the foliar N concentration increase as a consequence of a higher rate of loss of other foliage components?

Due to design limitations, unequivocal conclusions regarding the decomposition of suspended foliage based on this study are impossible, but differences between the character of the foliage after the study treatments were observed if not quantified. Forest floor samples were skeletized and beginning to fragment whereas suspended samples were intact though brittle and darkened. In retrospect, field samples that were just foliage and some that were just twigs should have been included. Also, samples with senesced foliage, and some with green foliage (besides *P. montana*) applied directly to the forest floor should have been included.

SECTION III

Fragmented v. Whole Foliar Litter Disappearance

III.1 INTRODUCTION

The use of fine mesh litterbags in decomposition studies has often been criticized since fine mesh keeps some invertebrates from direct access to the litter (Swift *et al,* 1979; Wieder and Lang, 1982). Shredding and fragmenting by animals are important influences on litter decomposition. Different litterbag mesh-sizes (Stewart and Davies, 1989; Imbert and Pozo, 1989) and presence or absence of microarthropod populations (Wallace *et al,* 1991) have been shown to affect biomass loss in streams. Wind disturbance and grazing by animals may also fragment foliage. Decomposition of artificially fragmented foliage may be enhanced by an increase in litter surface area, increase in edges to weather, increase in the number of microbes, and reduction of natural barriers (*e.g.* cell walls and waxy cuticles). Since using litterbags still excludes larger animals, the influences of nutrient import and deposition and enzyme deposition are not factored.

The objective of this study was to compare the decomposition of *D.excelsa* whole foliage to that of artificially fragmented foliage.

III.2 MATERIALS and METHODS

This study was conducted in conjunction with the whole foliage decomposition study reviewed in Section I. Senesced *D. excelsa* foliage was collected for 50 litterbag samples. Air-dried leaflets were crushed manually until fragments were less than ~1 cm^2. Between 9 and 10 grams dry-weight of crushed leaves were placed in each litterbag. Seven samples were retained for estimating initial state, weighed, dried at 55°C, shipped to UNH, and stored. Initial state (IS) samples were re-dried at 65°C, weighed, milled, and sub-sampled for ash content and Kjeldahl nitrogen. Moisture content of the first IS samples retained was significantly lower ($P<0.001$) than the last samples retained, therefore the field samples initial dry mass (SDM_{t0}) was estimated as:

$$SDM_{t0} = ISM_{t0}\ x\ (-0.0002921(ID) + 1.027754)$$
$$r^2 = 0.37\ ,\ n = 7$$

where, ISM_{t0} is the initial foliage mass (green) and ID is the coincident litterbag number (between 476 and 525). Estimated fraction dry mass of samples ranged between 0.900 and 0.914. The initial nitrogen content for fragmented samples was 0.707 percent with a standard deviation of 0.026, whole foliage samples were 0.67 percent nitrogen (Section I).

Five groups of 5 litterbags were placed in separate sub-plots of each of the Icacos hurricane disturbed riparian and upland plots on the same day whole foliage litterbags were distributed (10 July, 1990).

One litterbag was collected from each occupied sub-plot on each collection date (*i.e.* 12, 23, 45, 73, and 102 days after distribution) providing 5 replicate samples of fragmented foliage.

The collected litterbag samples were dried and otherwise treated as described for IS samples. Data adjustments were the same as those for whole foliage samples, except litterbag samples were combined to provide 2-3 composite samples per replicate group for N measurement. Nitrogen and fraction biomass remaining values were adjusted for soil contamination using ash content and the methods outlined in Appendix D.

III.3 RESULTS and DISCUSSION

Biomass loss of fragmented foliage was not significantly different than whole foliage (Figure 15). Approximately 70 percent of the mass remained after 100 days. Fragmented foliage released 5 to 10 percent of its original nitrogen by the second collection (23 days) and maintained this nitrogen concentration throughout the remainder of the study (Figure 15b). During this same period, whole *D. excelsa* riparian foliage immobilized nitrogen from external sources(+10%) and upland samples maintained the original N mass.

Exposure of intercellular material, increased edges, and the altered quality of exposed edges (*e.g.* ragged *vs.* smooth) by fragmentation may have increased the initial leaching of nitrogen. Without fragmentation, nitrogen might have been immobilized by microbial organisms before leaching loss could occur.

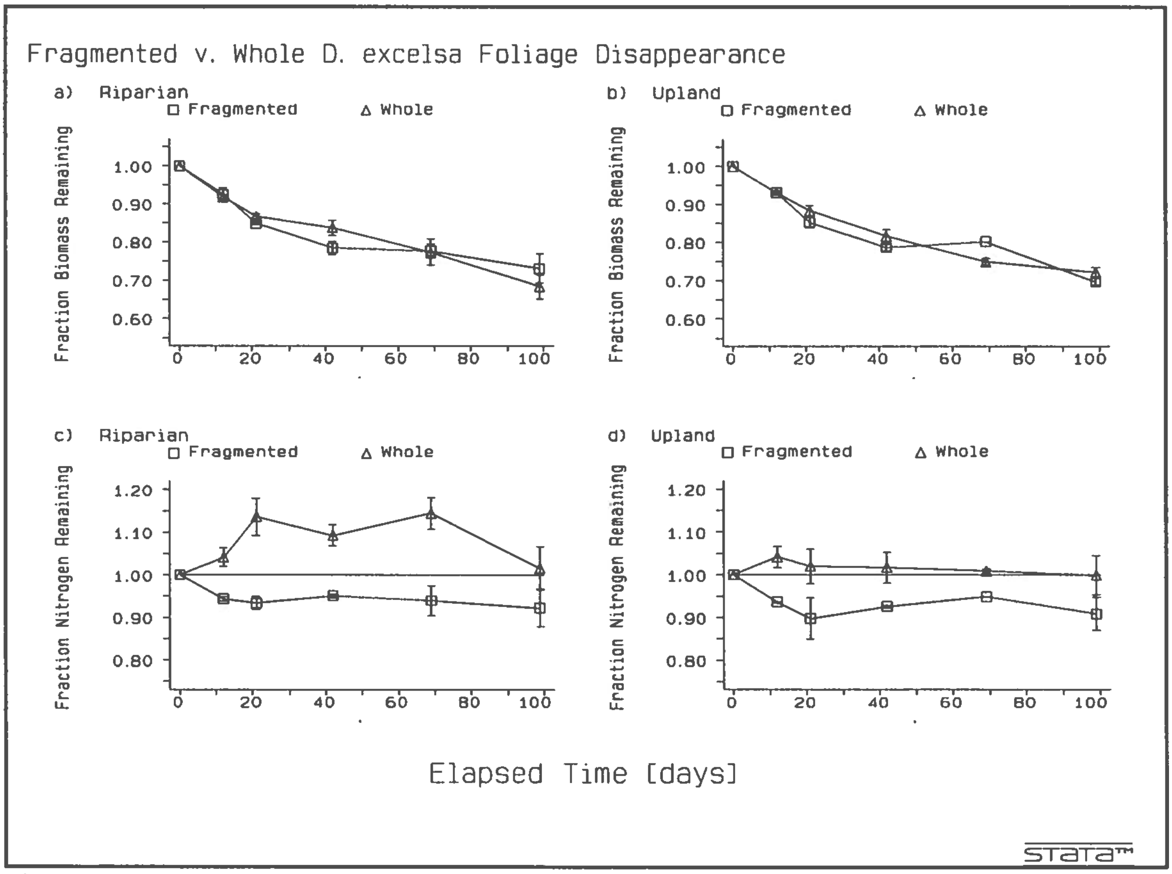

Figure 15: Fragmented and whole foliage biomass (a,b) and nitrogen dynamics (c,d) (±1 SEM).

APPENDIX A

Field Methods

This section is a detailed description of methods and materials used up to the point of sample collection. Plot design, sample preparation, and sample collection are considered. The 1989 methods are described in detail and design changes made for 1990 are discussed.

A.1 Sample Preparation

A.1.1 Litterbag Construction -

The litterbags were made of fiberglass screen material with ~1 mm openings. The bags were about 22 cm by 30 cm in size and sewn closed on three sides. The fourth side (20 cm) was constructed so that it formed an overlapping flap to impede animal entry and litter loss. The 1989 and 1990 studies required 240 and 545 mesh bags respectively. Once filled with leaves, the open side was closed and stapled.

A.1.2 Pre-Experiment Litter Collection -

In 1989, recently senesced *C. racemiflora* leaves were collected from the forest floor in the vicinity of the Icacos site. Leaves displaying secondary coloration (red) were considered to be recently senesced. The leaves were collected over a 2 day period in June 1989.

The time required for foliage collection (7 days) was greater in 1990 because more bags were used and fewer trees were producing foliage after the hurricane. About half of the *C. racemiflora* leaves were collected from the vicinity of the Icacos site and the remainder were collected adjacent to the Espiritu Santu river about 1 km from the El Verde Field Station. In 1990, it was noted that if we returned to an area from which we had already collected leaves, after two days enough leaves had fallen to justify returning to the area to collect more leaves. For both 1989 and 1990, *D. excelsa* leaflets were collected from the forest floor between the El Verde Field Station and the Sonadora River. This required 1 day in 1989 and 2 days in 1990.

Sierra palm (*P. montana*) was chosen for the study because it is abundant in the forest and is common to both the tabonuco and colorado forest types. This species required two comprises in the methods. The first compromise was the use of fresh foliage. *P. montana* senescence is gradual, therefore collecting dead fronds that would soon be deposited on the forest floor was difficult. For both years, living fronds were stripped from several trees near the Icacos site. The second compromise regarded the size of the fronds (over 2 meters). Leaflets were separated from the rachis and cut into small enough pieces to fit into the bags (15 to 20 cm).

Though the use of fresh *P. montana* leaflets is a compromise, it proved to be a fortunate decision. Placing green foliage on the forest floor simulates the effects of hurricane disturbance.

A.1.3 Moisture Status -

The 1989 foliage was not air-dried prior to weighing. A detailed discussion of the moisture content of the foliage is included in Appendix D. In general, the moisture content of the foliage used to fill the bags decreased over the time required to prepare all of the litterbags. In 1990, the weather was such that a brief period of air drying was possible before processing. The leaves were subjected to warm, arid conditions for several hours. This accounts for the lower apparent moisture content of the 1990 leaves in relation to the 1989 samples.

A.1.4 Initial Mass -

The mass (0.01 g resolution) of each empty litterbag was noted for use if decomposed litter was difficult to remove intact from the bags. Foliage was placed in each bag and the mass of the bag and the foliage was recorded. Table 3 generalizes the number of leaves and the dry weight of foliage placed in each bag. At least 10 percent of the foliage samples were retained and dried for assessing their initial moisture, ash, and nitrogen status (sub-sampling is detailed in Appendix B).

Litterbags were grouped in sets of 4 bags for 1989 and 5 bags for 1990. In 1989, the bags of each set were linked together with cord leaving about 40 cm between bags. One end of the cord was anchored to a fixed object in the forest and the bags were placed on the forest floor. The site of each set is henceforth referred to as a sub-plot. Sub-plots were spaced 1 to 2 m apart along a transect. In 1990, the litterbags of a set were not interconnected. One end of a cord was attached to each bag and the other end was attached to a central point in each sub-plot.

A.2 Plot Locations

The locations of the 1989 and 1990 plots are shown in Figure 2. Figure 16 summarizes the allocation of litterbags for 1989. The 240 bags were divided between the Icacos and the Bisley watersheds. Within each watershed, half (60) were placed in the riparian zone and half were placed at an upland site. This provided 20 bags of each combination of species, watershed, and slope position.

The number, distribution, and plot assignment of litterbags for post-hurricane (1990) measurements was influenced by the condition of the forest floor and is summarized in Figure 17. The plot locations for Bisley were changed because the 1989 positions were not easily accessible. The sub-plots were arranged in blocks (*vs.* transects) to reduce the amount of space required for the greater number of bags. The blocks were divided into 2 m by 2 m sub-plots. Random number tables were used to select sub-plots to be used and to select the set of litterbags that would occupy those sub-plots.

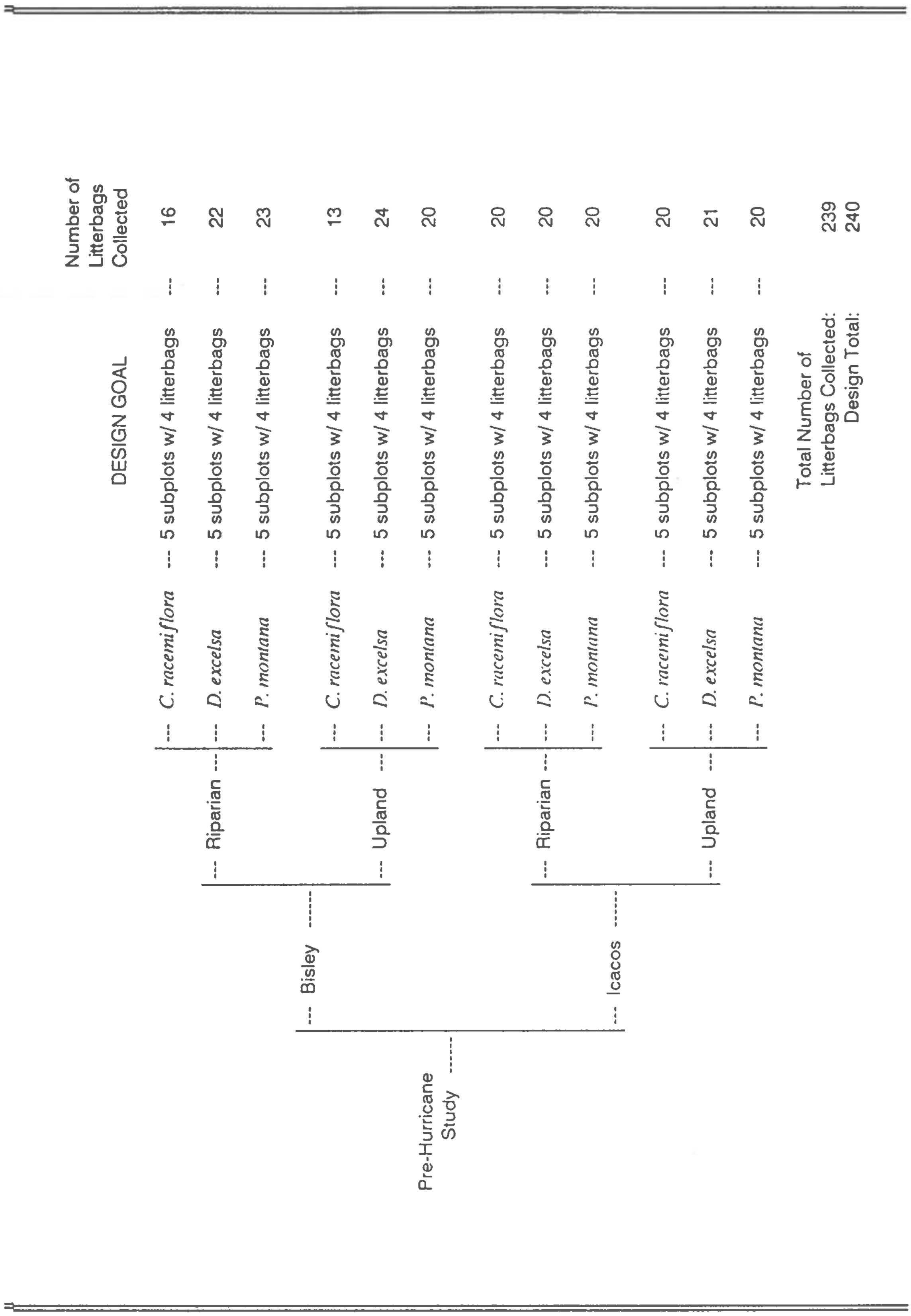

Figure 16: Pre-hurricane (1989) study organization.

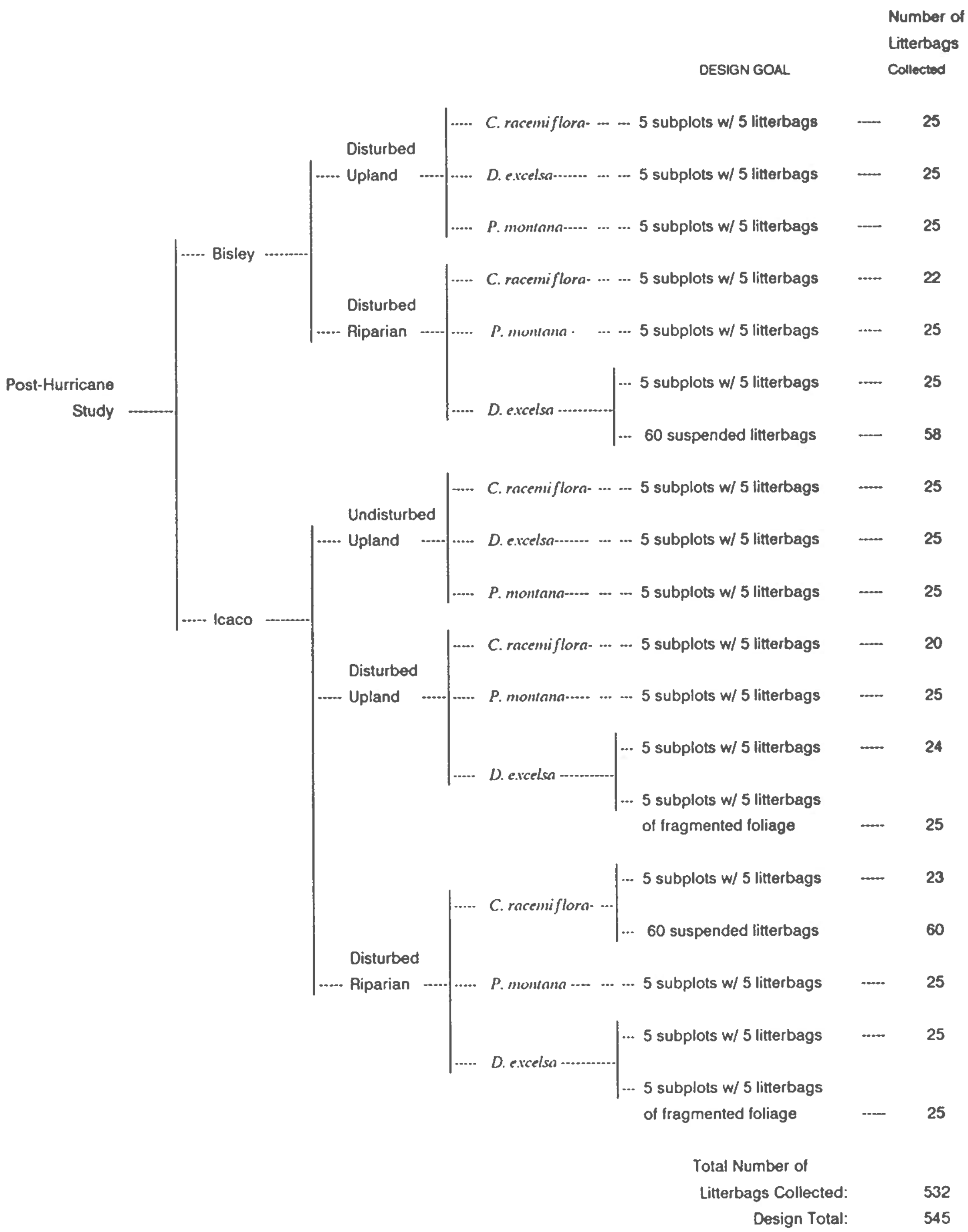

Figure 17: Post-hurricane (1990) study organization.

APPENDIX B

Nitrogen Content, Quality Assurance, and Measurement Variability.

Biomass, litter sample ash mass, soil ash mass, and soil nitrogen measurement and variability are addressed in the Appendix D. TKN methods for all decomposition and NIR comparison samples are addressed below.

B.1 Digest Methods

The following list summarizes the materials and treatments used for nitrogen measurement by micro-Kjeldahl digestion.

Equipment:
- 75 ml volumetric digest tubes
- Technicon BD-40 Block Digestor

Per Tube:
- 0.1005 +/-.0005 g sample
- 2 or 3 teflon boiling chips
- 2.6 g K_2SO_4
- 0.9 ml .19m $CuSO_4$
- 4.4 ml H_2SO_4
- 2.5 to 3.5 ml 30% H_2O_2 in 0.5 ml alliquots at 2 minute intervals until digestate cleared.

Digestion Duration:
- 370 C Digestion temperature
- 90 minutes after last H_2O_2 addition

B.2 Digestion Quality Assurance

A digest "set" for this study consisted of two racks of 40 digest tubes. One heating block was used. The second rack was placed in the block within 15 minutes of the completion of the first rack. Included in each digest set were:

2 blanks
5 inorganic standards (1,5,10,20, and 30 mg N L^{-1} from a 7500 mg $(NH_4)_2SO_4$-N L^{-1} stock solution
2 organic standards (usually an ivy in-house standard, also NBS citrus leaves)
4 initial state samples (these were also used as a quality assurance benchmark, N content of initial state samples did not vary greatly)
67 samples (typically 3 or 4 reruns or replicates from the same digest set or a previous set).

B.3 Measurement of Nitrogen in Digestate

Ammonium-N in the digestate was measured using a salicylate-nitroprusside method on a Technicon Autoanalyzer II (Technicon, 1983). Inorganic undigested standards were mixed from a 30 mg $(NH_4)_2SO_4$-N L^{-1} stock solution.

All samples (standards and litter sample digestate) were diluted in 4 ml sample cups, 1 part (0.300 ml digestate) and 9 parts wash solution (2.70 ml 4% H_2SO_4). Usually 4 or 5 dilution replicates were run, however repeated inorganic standards also tracked dilution variability. When replicate inorganic standards were run, new dilutions were used, *i.e.* the same cup was not used twice. Using the same cup would track instrument drift but not dilution variation.

Running a digest set through the auto-analyzer roughly followed the sequence:

- blank and a range of 5 inorganic digested standards
- 5 inorganic undigested standards
- baseline check, (wash solution)
- 10 digested samples
- baseline check
- 5 digested samples
- 1 digested inorganic standard (10 or 20 mg N l^{-1})
- 1 undigested inorganic standard
- 10 digested samples
- baseline check
- blank and a range of 5 inorganic digested standards
- 10 digested samples

- 1 digested inorganic standard
- *etc.*
- after all samples of a digest set were run, all digested and undigested inorganic standards were run.
- a digestion set entailed a run of about 110 4 ml cups

B.4 TKN Inference

The peak heights on the strip charts produced by the autoanalyzer were measured using a PC and digitizing pad. Peak height values were labeled and sorted. Separate regression models were calculated using i) digested inorganic standards and ii) undigested inorganic standards. Estimates of nitrogen content for each sample were made using both models. The success of each regression for predicting percent nitrogen was determined by examining: 1) the fit of the regression line (checking for outliers), 2) the r^2 of the regression models, and 3) the predictions for organic standards and initial state samples. Measurements of N by digested inorganic standards and undigested inorganic standards usually were within 0.1% N of the "known" organic standard N and of each other. When they were not, the criteria above were considered in deciding if individual standard peaks should be removed from the regression models. In all but one of the 17 digest sets the digested inorganic standards were used for the reported results.

The quality assurance methods listed above were the minimum employed. Usually the digest sets included a greater number of replicates and organic standards.

B.5 Variability

A summary of the results of variability analysis are listed in Table 10. Relative mean error (RME) is calculated by dividing the mean of the absolute differences between the measured values and the "known" value by the mean value. In a study of interlaboratory variability, McClellan *et al* (1991) found the relative mean error for TKN to be about 5 percent. Ivy and citrus standards in this study showed similar interset variability. The high RME of the *C. racemiflora* samples is due to the low nitrogen value, and the high RME for *D. excelsa* and *P. montana* was expected since the samples were not from a single homogenous source as were the Ivy and Citrus foliage.

Table 10: Variability of organic standard sample and initial state sample Kjehldahl nitrogen (Bremner and Mulvaney, 1982).

Species	"Benchmark" Mean %	n	Digested Mean % N	Standard Deviation	Relative Mean Error %
IVY	2.25	25	2.220	0.110	3.61
Citrus	2.86	2	2.860	0.060	2.10
C. racemiflora	-	32	0.381	0.054	9.45
D. excelsa	-	22	0.672	0.034	4.72
P. montana	-	23	1.832	0.170	5.50

APPENDIX C

Statistical Analyses

C.1 General Methods and Tests

Three techniques were used to examine the data: 1) multivariate regression using categorical (dummy) variables was the principle method used for biomass analysis, 2) Kruskal-Wallis rank-sum tests were used to compare selected groups of nitrogen replicates, 3) regression analysis with a y intercept of 0 was used to estimate biomass decay coefficients (k of $y = e^{-kt}$). Analyses were conducted using a PC based statistical software package (CRC-STATA v. 3.0, 1992). The untransformed data were portrayed graphically using the mean and the standard error of groups of replicates. The samples were separated into 123 groups of replicates, each group having study year, species, watershed, slope position, and collection date in common. There were between 2 and 7 (mean = 4.9, STD = .63) observations (litterbags) per group of replicates. The distribution of sample sizes is listed in Table 11.

The distributions of the measured variables within replicate groups were non-normal, heteroscedastic, and curvilinear when plotted against elapsed time. The distributions were adjusted by log (natural) transforming the fraction of biomass and fraction of nitrogen remaining per sample.

Table 11: Distribution of sample sizes (n) per plot specific replicate set.

Number of Litterbags	Frequency
1	1
3	2
4	19
5	89
6	10
7	2

C.2 Multiple Regression with Dummy Independent Variables

Regression models were fit to predict the natural log of the biomass remaining over time. Multivariate regression techniques (an example application follows) can be used to compare categories (Hamilton, 1990). The steps for this technique are:

Step 1: A dummy variable is created by coding categorical variables. When there are two possible values for a categorical variable, a single dummy variable can be used. A dummy variable for distinguishing between study years could be coded as: 1989 = 1 and 1990 = 0. When there are more than two possible values for a categorical variable (*e.g.* *C. racemiflora*, *D. excelsa*, or *P. montana* for species) each category is assigned a separate dummy variable. For example, a dummy variable for each species was assigned to each mesh bag sample, but each sample can only be of one species. Therefore, a *C. racemiflora* dummy variable for a sample would be coded 1 (true) if the foliage in the bag was *C. racemiflora*. The *D. excelsa* and *P. montana* dummy variables for that sample would be coded 0 (false). This dummy variable can be used to test for the difference in y-intercept between categories. However, when factoring dummy variables when there are more than 2 responses, one is omitted from the model since the value of the third response is determined by the other two (STATA automatically drops one dummy variable if the user does not).

Step 2: Slope dummy variables are generated to test if there is a significant influence between categories on the slope coefficients. For each case, the intercept dummy variable (step 1) is multiplied by an independent variable (*e.g.* dummy variable by elapsed time).

Step 3: Multivariate regression techniques are used to predict a dependent variable (*e.g.* biomass remaining) from an original independent variable (*e.g.* elapsed time) and the created independent dummy variables (*e.g.* Year dummy, and Year dummy*elapsed time).

For the decomposition study, dummy variables were created for species, study year, watershed, and slope position. Multiple regression was applied to the data with progressively more detailed models. Differences between species were tested, differences between years by species was tested, differences between watersheds by species by year were tested, *etc.* Appendix C.3 is an example of the application and interpretation of regression with dummy variables.

C.3 Example Regression Interpretation

The following is an example interpretation of the multivariate regression models (Appendix F) using categorical independent variables (dummy) to test for statistical differences among categories. The regression model for *C. racemiflora* biomass loss with a dummy variable for testing between study years is:

$$y = -0.6605(T_{yr}) - 0.1131(T_{yr} \times D_{yr}) - 0.1105(D_{yr}) + 0.0097$$

$$n = 184, \quad R^2 = .67$$

where:

y = ln *fraction biomass remaining*
T_{yr} = *elapsed time* [*years*]
D_{yr} = *dummy variable*: 1989 = 1, 1990 = 0

If the dummy variable for 1990 is applied, the model is:

$$y = -0.6605\ (T_{yr}) + 0.0097$$

with a significant slope ($P < .01$) and a y intercept that is not significantly different from 0 *i.e.* the fraction of biomass remaining at $T_{yr} = 0$ is not significantly different than y = ln 0 or 1/1 which is the actual fraction of biomass remaining after no passage of time. If the dummy variable for 1989 is applied, the model becomes:

$$y = -0.6605(T_{yr}) - 0.1131(T_{yr}) - 0.1105 + 0.0097$$

$$= -0.7736(T_{yr}) - 0.1108$$

For 1989, the rate of decomposition is greater, *i.e.* the slope is changed by -0.1131 but the difference is not significant ($P < .337$). The change in the intercept (-0.1103) is highly significant ($P < .01$). When the regression equations are reduced the slope coefficient is similar to *k*, but differs because the line is not forced through $y = \ln 0$ when $T_{yr} = 0$.

The coefficients are more difficult to interpret when more than one dummy variable is modeled. The amount of change due to a single categorical variable (*e.g.* between study years) holds true only if all other dummy variables are held constant, but the interpretation for statistical difference is the same.

C.4 Kruskal-Wallis Tests

A non-parametric test, Kruskal-Wallis rank-sum, was used for detailed comparisons between groups of replicates by year for biomass and nitrogen. However, comparison between years was not appropriate since lengths of time that bags were on the forest floor did not match, *e.g.* for 1989 there was a collection after 78 days but for 1990 the nearest collections were at 69 and 99 days. Two basic issues were addressed using this method. The first was for differences over time by replicate group. Each group of replicates was tested against groups of replicates of the same species, year, watershed, and slope position, *i.e.* *D. excelsa* replicates from the Bisley riparian zone collected after 11 days in 1990 was tested against *D. excelsa* replicates from the Bisley riparian zone collected after 21, 42, 72, and 102 days. All possible comparisons were conducted. Log transformed fractions biomass and nitrogen remaining were subjected to this test, the biomass results served to verify the results of the regression analysis.

The second major issue addressed with rank-sum tests was comparisons among sites, *i.e.*

each group of replicates was tested against groups of replicates collected on the same date. For example, the *D. excelsa* replicate group collected from the Icacos riparian site on day 14 was tested against 14 day sets from: 1) the Icacos upland site, 2) the Bisley riparian site, and 3) the Bisley upland site.

C.5 Regression for Decay Constants

A regression model with a y-intercept of zero was fit to the relationship between the log of the fraction of biomass remaining and time in years. The data was separated into progressively smaller subsets and regression models were fit to allow detailed comparisons. *i.e.* by species, by species and year, by sp, year, and watershed, *etc.* The slope coefficients of these regression models is "*k*" of the commonly used model: $y = e^{-kt}$ where y is the fraction biomass remaining and t is the elapsed time in years.

APPENDIX D
Adjustments for Moisture Content and Soil Contamination

D.1 Introduction

This appendix first describes and justifies the methods used to estimate the initial state of each treatment sample followed by descriptions of the values, calculations, and adjustments for samples that were placed on the forest floor. Tables of raw data and estimates that resulted from the adjustments are in Appendix E.

An example of the calculations is included in the text and is listed in Table 12.

The first column of the raw Data Tables (Appendix E) lists the individual case number [ID] assigned to each litterbag (1 through 240 for 1989, 1 through 375 for 1990 forest floor, 376 through 425 for fragmented foliage, and 426 through 545 for suspended foliage). This is important because the ID number corresponds to the order in which foliage was placed in the bags. The next several columns describe the sample: Watershed {I = Icacos, B = Bisley}; Slope Position {U = Upland, R = Riparian}; Species {C = *C. racemiflora*, D = *D. excelsa*, and P = *P. montana*}; and for 1990 Icacos {N = North plot [Defoliated] and S = South plot [Blowdown]}. The cell ID indicates subplot. The column labeled "time" is the number of days

Table 12: Calculations and adjustments example results. (1989 forest floor decomposition sample # 2).

INITIAL STATE ANALYSES

Initial Litter Weight	MCF Grn:Dry Adj. Factor*	Est. Initial Dry wt.	Fraction Ash	Estimated Ash-Free Initial Dry Wt.	Est. Initial Fraction Nitrogen	Est. Initial N Mass (mg)
ISMt0	MCF	SDMt0	FASHt0	AFDMt0	TKNt0	VNMt0
63.35	0.281	17.78	0.0814	16.33	0.0174	309

POST-TREATMENT

Elapsed Time (days)	Measured Dry Wt.	Fraction Ash	Est. Fraction Veg Ash. (Regr)	Soil Adj. Veg. Mass	Ash Free Veg Mass	Fraction Mass Remaining
t	SDMt	FASHt	FVAt	DMt	FDMt	FBMRt
35	14.00	0.1553	0.0732	12.40	11.37	69.6%

NITROGEN

Fraction	Mass (mg)	Est. Soil Mass (mg)	Estimated Soil TKN Mass (mg)	Veg N Mass (mg)	Veg Fraction TKN	Fraction Nitrogen Remaining
STKNt	SNMt	SSMt	SNMt	VNMt	FVNt	FNMRt
0.0157	220	1.15	4.39	215	0.0174	0.693

the litterbag remained on the forest floor.

D.2 Initial State

An accurate estimate of the initial dry-mass, ash content, and nitrogen content of each sample was necessary to determine the changes that occurred during the treatment period.

During the process of weighing and placing foliage in litterbags, a sub-sample was retained for Initial State [IS] analysis. The IS samples were selected using a stratified random design. A table of random integers between 6 and 10 determined the number of treatment samples processed between IS samples. The treatment sample ID immediately preceding the IS sample was noted. Table 13 summarizes the IS sampling intensity by species and year. The IS samples were dried, shipped to Durham, and stored.

Table 13: Sampling intensity of initial state samples.

		Number of Treatment Samples	Number of Initial State Samples	Sampling Intensity
Pre-Hurricane 1989	*C. racemiflora*	69	8	11.6%
	D. excelsa	87	11	12.6%
	P. montana	83	10	12.0%
Post-Hurricane 1990	*C. racemiflora*	115	18	15.7%
	D. excelsa	124	18	14.5%
	P. montana	125	17	13.6%

The next column [ISM_0] lists the initial measured mass of sample foliage placed in the litterbags. IS samples were used to adjust the ISM_0 to estimate treatment sample dry mass. The IS samples were dried at 65°C for 24 hours and weighed.

D.2.1 Moisture Compensation Factor

The measured dry mass of IS samples were divided by their "green" mass to produce a factor that expresses the fraction of sample that is not moisture, henceforth termed Moisture Compensation

Factor [MCF].

In 1989, foliage was placed in the 240 bags over a period of two days. The foliage was not air-dried prior to weighing. In 1990, foliage was placed in the 375 litterbags over a period of one week. The foliage dried to some extent before weighing. The different drying regimes account for the difference in MCFs between 1989 and 1990 (Table 14).

The relationship between processing order expressed as sample ID and the MCF was examined using linear regression. Figures 18 and 19 show MCF against sequence (ID number). Table 14 lists the mean MCF and the regression models for the plotted lines.

A regression model with a positive slope indicates that moisture content declined in IS samples, and by inference in the treatment litterbag sample population as well, during the weighing procedure. The predicted Moisture Compensation Factor [MCF_P] modeled in Table 14 were applied to the samples. For 1989, models for *C. racemiflora* and *D. excelsa* were not significant (slope $P > .10$), however the regression model was applied to the treatment samples. The 1990 *D. excelsa* and *C. racemiflora* samples were relatively homogenous with respect to moisture content, therefore the mean MCF was applied. The *P. montana* samples displayed two distinct relationships (Figure 19), the mean MCF was used for one group and the regression model was applied to the other.

Treatment sample initial dry mass (SDM_{t0}) was estimated as:

$$SDM_{t0} = (MCF_P)(ISM_{t0}) \qquad \text{Eqn 1.}$$

For example,

$$SDM_{t0} = (63.35g)(0.281) = 17.78g$$

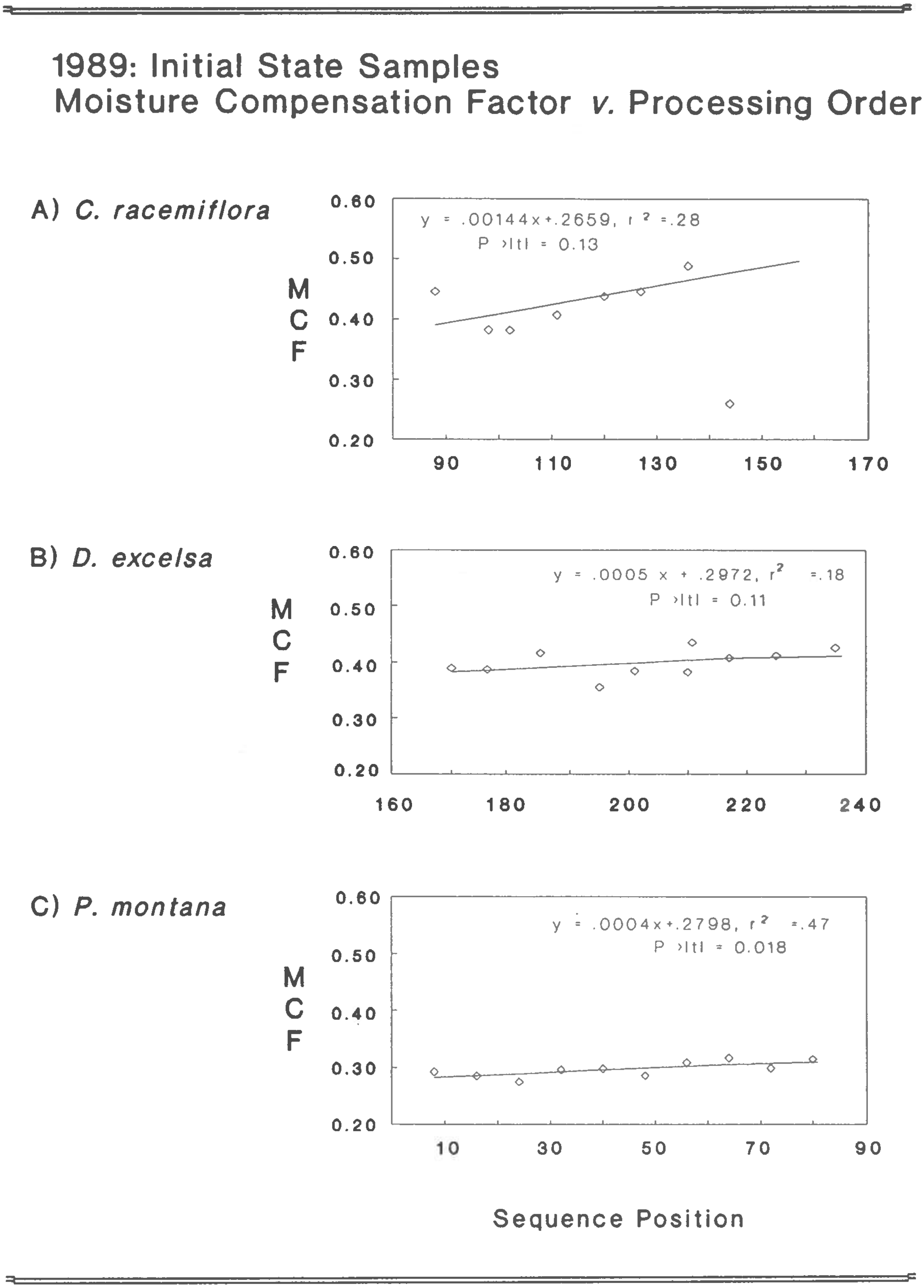

Figure 18: 1989 Moisture Compensation Factor [MCF = 1-(green mass/dry mass)] over processing sequence expressed as assigned field sample ID number.

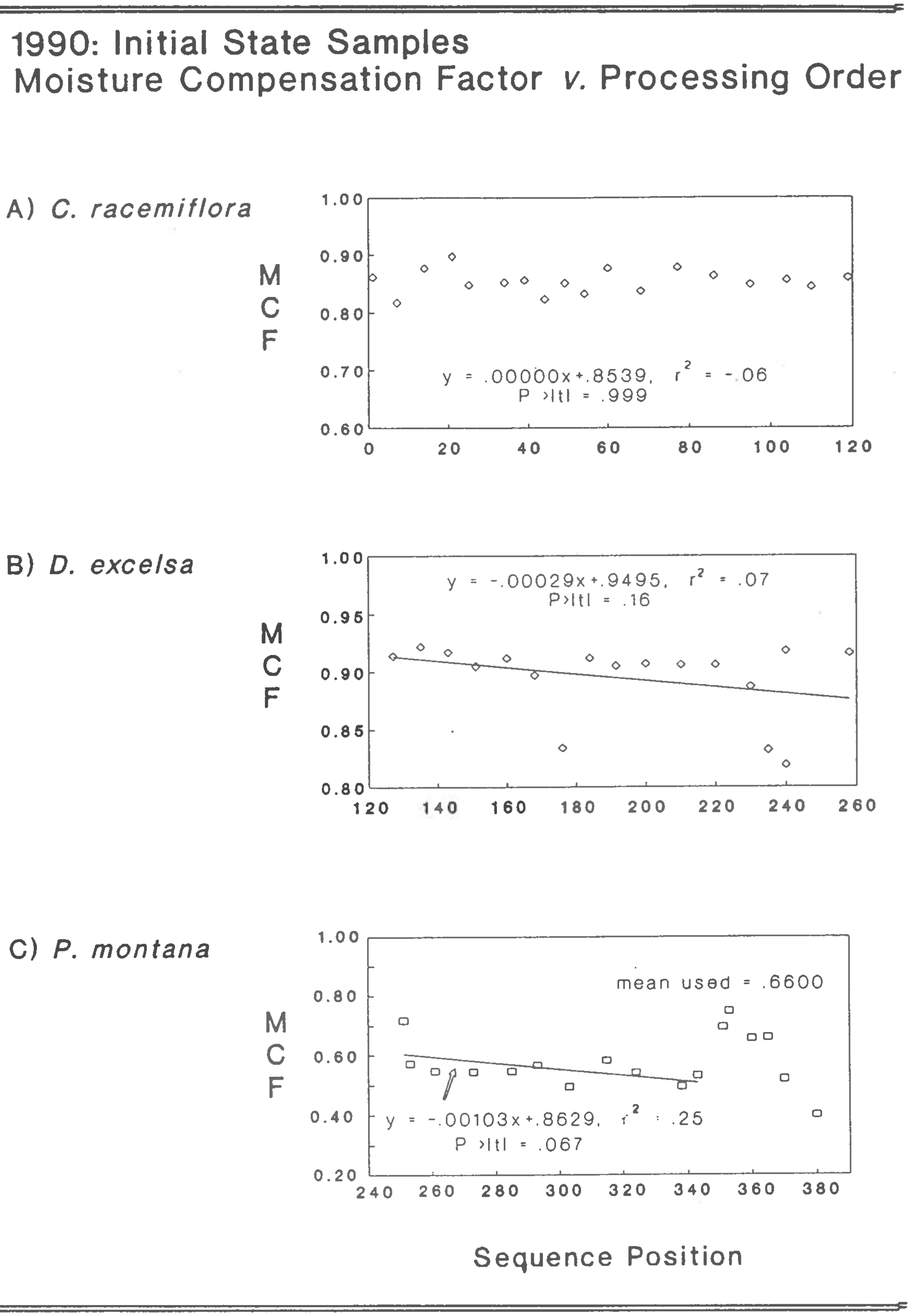

Figure 19: 1990 Moisture Compensation Factor [MCF = 1-(green mass/dry mass)] over processing sequence expressed as assigned field sample ID number.

Table 14: Regression models predicting MCF (fraction dry mass) over handling sequence (assigned sample number).

					REGRESSION				Range of Applied MCF [3]	
		n	Mean MCF	STD DEV	Slope Coeff.	(P>t)	Intercept [1]	R^2 [2]	Min	Max
Pre-Hurricane 1989	*C. racemiflora*	8 [4]	0.427	0.039	0.0014	0.128	0.2659	0.28	0.383	0.482
	D. excelsa	11	0.397	0.023	0.0002	0.106	0.2972	0.18	0.373	0.417
	P. montana	10	0.298	0.013	0.0004	0.018	0.2798	0.47	0.280	0.312
Post-Hurricane 1990	*C. racemiflora*	18	0.854	0.020	0.0000	0.999	0.8539	-0.06	0.854 [5]	
	D. excelsa	17	0.895	0.031	-0.0003	0.162	0.9495	0.07	0.895 [5]	
	P. montana [6]	11	0.544	0.057	-0.0010	0.067	0.8629	0.25	0.525	0.563
	P. montana [6]	6	0.615	0.119	-0.0113	0.004	4.7090	0.89	0.660 [7]	

1. all intercept values are significant (P>t = .001).
2. R-square adjusted for degrees of freedom.
3. range of MCF applied to treatment samples.
4. one initial state sample eliminated from analysis
5. outliers disregarded, mean MCF applied to treatment samples.
6. two distinct MCF groups, therefore P. montana was separated.
7. although the slope is highly significant and R is high, the last sample was disregarded and the mean MCF applied.

D.2.2 Ash Content

The data were analyzed on an ash-free basis because soil accumulated in some litterbags. Ash values for IS samples were used to partition the vegetation mass (See section D.3.1)from the soil mass. The IS samples were subsampled (1 g +/- .0001 g) and subjected to 500°C for 6 hours. The residual ash mass was divided by the precombustion sub-sample mass to determine the fraction of ash [$FASH_{t0}$; Table 15]. The estimated treatment sample ash-free dry mass [$AFDM_{t0}$] was calculated as:

$$AFDM_{t0} = SDM_{t0}(1 - FASH_{t0}) \qquad \text{Eqn 2.}$$

For example,

$$AFDM_{t0} = 17.78g(1 - 0.0814) = 16.33g$$

Table 15: Initial state sub-sample ash content (6 hours at 500°C).

		n	Mean Fraction Ash	STD DEV.
Pre-Hurricane 1989	*C. racemiflora*	5[1]	0.0025	0.0013
	D. excelsa	11	0.1136	0.0070
	P. montana	10	0.0814	0.0090
Post-Hurricane 1990	*C. racemiflora*	18	0.0181	0.0008
	D. excelsa	18	0.1147	0.0078
	P. montana	17	0.0733	0.0059

1. IS samples composited due to low mass.

D.2.3 Nitrogen Content

Initial nitrogen fraction [TKN_{t0}] was estimated by subjecting IS subsamples to micro-Kjeldahl digestion (Appendices B,D). Mean TKN_{t0} are reported in Table 16. Fraction N is not reported on an ash free basis, *i.e.* mass of nitrogen was divided by the mass of foliage adjusted for soil contamination but with ash. Initial vegetation sample nitrogen mass [VNM_{t0}] in mg was calculated as:

$$VNM_{t0} = (SDM_{t0})(TKN_{t0}) \qquad \text{Eqn 3.}$$

For example,

$$VNM_{t0}mg = (17.78g)(0.0174g\ N\ g^{-1})(1000mg\ g^{-1}) = 309\,mgN$$

Table 16: Initial state sub-sample nitrogen content (Kjeldahl).

		n	Mean Fraction TKN	STD DEV.
Pre-Hurricane 1989	*C. racemiflora*	11	0.0043	0.0003
	D. excelsa	8	0.0067	0.0002
	P. montana	9	0.0174	0.0014
Post-Hurricane 1990	*C. racemiflora*	18	0.0035	0.0002
	D. excelsa	17	0.0067	0.0003
	P. montana	16	0.0179	0.0008

D.3 Post Treatment

Treatment samples were collected from the field sites, oven dried at 55°C, and shipped to Durham. The samples were further dried at 65°C and allowed to cool. The foliage was removed from the litterbags and their mass measured [SDM_t]. Insects and loose soil clods were removed prior to weighing.

D.3.1 Ash and Soil Adjustment -

The treatment samples were sub-sampled for ash content [$FASH_t$]. The residual ash after combustion consisted of ash that originated from vegetation plus ash from soil that could not be dissociated from the litter. Substantial amounts of soil became incorporated in some litterbags, especially Icacos Riparian samples. In general, $FASH_t$ values that exceeded $FASH_{t0}$ were used to indicate that soil contamination had occurred. Soil sediment samples were collected from the Icacos floodplain to establish a relationship between soil mass and soil ash mass. The mean fraction of ash [$FASH_{soil}$] for three soil samples was 0.7921 with a standard deviation of 0.0105. To partition the $FASH_t$ between soil and litter sources, the vegetation ash content had to be determined. Vegetation ash during decomposition in litterbags could be expected to behave in one of three ways: 1) the fraction of vegetation ash could increase, *i.e.* the ash constituents might decline in mass at a rate less than the overall biomass, 2) the fraction vegetation ash could decrease, *i.e.* ash constituents might disappear at a faster rate than biomass, and 3) the fraction ash could remain the same, *i.e.* ash and biomass might disappear at the same rate.

Ash disappearance relative to mass loss in the absence of soil contamination was examined in litter samples by eliminating that were probably contaminated with soil (highest 25% $FASH_t$ values). FASH of the remaining 75% of samples was plotted over time and modeled using regression by species and year ($FASH_t = m(time_{days}) + b$). The regression equations and the decisions for usage are listed in Table 17.

Table 17: Regression models for predicting ash fraction ($FASH_{t0}$) by elapsed time (days) in the absence of soil contaminants. Samples with high ash content were assumed to have contained ash of soil origin and excluded from the models.

Sample Subset	n	REGRESSION Slope Coeff.	P>t	Intercept[1]	R^2	Decision
			Pre-Hurricane (1989)			
Cr B	27	0.00005	0.135	0.0238	0.05	ns, mean FASHt0 applied
Cr I	25	0.00003	0.447	0.0246	0.02	ns, mean FASHt0 applied
De B	36	0.00035	0.000	0.1190	0.42	model applied to 1989 D.ex samples
De I	29	0.00022	0.004	0.1288	0.25	
Pm B	40	-0.00021	0.015	0.0791	0.12	
Pm I	23	-0.00028	0.031	0.0830	0.17	model applied to 1989 P.mo samples
			Post-Hurricane (1990)			
Cr B R	16	0.00003	0.015	0.0172	0.31	
Cr B U	20	0.00003	0.114	0.0154	0.09	model applied to 1990 C.ra samples
Cr I R	9	0.00002	0.292	0.0171	0.04	
Cr I U	39	0.00002	0.025	0.0158	0.10	
De B R	18	0.00027	0.000	0.1195	0.62	
De B U	20	0.00021	0.130	0.1190	0.07	
De I R	15	0.00044	0.086	0.1141	0.16	model applied to 1990 D.ex samples
De I U	48	0.00021	0.000	0.1144	0.37	
Pm B R	18	0.00008	0.166	0.0599	0.06	ns, mean FASHt0 applied
Pm B U	20	-0.00001	0.839	0.0615	0.05	ns, mean FASHt0 applied
Pm I R	12	0.00011	0.398	0.0627	0.02	ns, mean FASHt0 applied
Pm I U	41	0.00003	0.309	0.0573	0.00	ns, mean FASHt0 applied

1. all intercept values highly significant (P>t = .0005)

The need to adjust ash for time and the differences in the way each species behaved with respect to ash loss is supported by the 1989 regressions. The *C. racemiflora* regression produced a slope not significantly different from zero, *D. excelsa* yielded a positive slope (fraction increasing over time), and *P. montana* yielded a negative slope. If soil ash addition was prevalent for the lower 75% $FASH_t$ of the samples then all species would display a positive slope.

The decisions applied to the treatment samples are a compromise between the significance of the relationship (or the ability to model the relationship) and the objectives of the study. If significant relationships were modelled and a regression line was fit to each species/year combination, applying all of the models would tend to introduce or amplify differences in site responses, *i.e.* to compare Bisley results to Icacos results when each was calculated using different regressions seemed inappropriate.

The results of applying the regression models in estimating vegetation ash to the treatment samples are in the column labelled FVA_t. The mean $FASH_t$ was used for 1989 *C. racemiflora* and 1990 *P. montana* since slopes did not differ significantly from zero.

D.3.2 Partitioning Vegetation Mass from Soil Mass -

The ratios of soil ash mass to total soil mass (0.7921) and the estimated vegetation ash mass to vegetation foliage mass were used to estimate vegetation mass at collection. The total measured sample ash [A_T] is the sum of plant ash [A_P] plus soil ash [A_S]. The factor [*f*] used to estimate the fraction of the sample that was derived from plant matter was calculated as:

$$\left(\frac{A_T}{M_T}\right) = (f)\left(\frac{A_P}{M_P}\right) + (1-f)\left(\frac{A_S}{M_S}\right)$$

where: M_T = Total Mass of Sample
M_S = Soil Mass
M_S = Plant Mass (Vegetation)

Solving for *f*:

$$f = \left(\frac{(\frac{A_T}{M_T}) - (\frac{A_S}{M_S})}{(\frac{A_P}{M_P}) - (\frac{A_S}{M_S})} \right)$$

When the foliage is not contaminated with soil, *f* is 1; if soil is present, *f* is less than 1. The equation can be simplified using previously calculated constants and variables, *i.e.*

$$f = \left(\frac{(FASH_{t0}) - (FASH_{soil})}{(FVA_t) - (FASH_{soil})} \right) \qquad \text{Eqn 4.}$$

$$f = \left(\frac{(0.155) - (0.7921)}{(0.0737) - (0.7921)} \right) = 0.8863$$

Multiplying SDM_t (total sample mass at collection time t) by *f* produces an estimate of vegetation dry mass at collection [DM_t] e.g. (0.8863)(14.0 g) = 12.40 g. The ash free dry mass [$AFDM_t$] was calculated as:

$$AFDM_t = (DM_t) - (DM_t)(FVA_t) \qquad \text{Eqn 5.}$$

$$AFDM_t = (12.40\ g) - (12.40\ g)\ (0.0732) = 11.49\ g$$

The fraction of biomass remaining [$FBMR_t$], that is, the values on which statistical analysis was performed, was estimated as:

$$FBMR_t = \left(\frac{AFDM_t}{AFDM_{t0}} \right) \qquad \text{Eqn 6.}$$

$$FBMR_t = \left(\frac{11.49\ g}{16.33\ g} \right) = 0.704$$

D.3.3 Nitrogen

The fraction of treatment samples that was nitrogen [$STKN_t$] was measured using micro

Kjeldahl digestion. Sample nitrogen mass [SNM_t] was calculated as:

$$SNM_t = (STKN_t)\ (SDM_t) \qquad \text{Eqn 7.}$$

$$SNM_t = (0.0157)\ (14.00g)\ (1000 mg g^{-1}) = 220\ mg\ N$$

However, since treatment samples may have been contaminated by soil, the N values needed to be adjusted. The same three soil samples that were use for estimating soil ash content were subjected to TKN analysis (mean fraction N = .00382, standard deviation .00037.

Sample soil mass [SSM_t] was estimated using ash and mass values, *i.e.*

$$SSM_t = (FASH_t - FVA_t)\left(\frac{1}{0.7921}\right)(SDM_t) \qquad \text{Eqn 8.}$$

$$SSM_t = (0.155 - .0732)\left(\frac{1}{0.7921}\right)(14.00\ g)\ (1000\ mg g^{-1}) = 1446\ mg$$

Treatment sample nitrogen mass of vegetation origin [VNM_t] was estimated by subtracting the estimated soil nitrogen mass from sample nitrogen mass or:

$$VNM_t = (SNM_t) - (SSM_t)\ (0.00382\ g\ N\ g_{soil}^{-1}) \qquad \text{Eqn 9.}$$

$$VNM_t = (\ 220\ mg\ N\ ) - (1446\ mg\ N\ )\ (0.00382\ g\ N\ g_{soil}^{-1}) = 214\ mg\ N$$

Fraction vegetation nitrogen [FVN_t] and fraction nitrogen remaining [$FNMR_t$] were estimated as:

$$FVN_t = \left(\frac{VNM_t}{DM_t}\right) \qquad \text{Eqn 10.}$$

$$FVN_t = \left(\frac{214\ mg\ N}{12.4\ g}\right) = 0.0173$$

and

$$FNMR_t = \left(\frac{VNM_t}{VNM_{t0}}\right) \qquad \text{Eqn 11.}$$

$$FNMR_t = \left(\frac{214\ mg\ N}{309\ mg\ N}\right) = 0.693$$

Appendix E: Data Tables

1989 Forest Floor Decomposition Data

1990 Forest Floor Decomposition Data

1990 Suspended Foliage Data

1990 Fragmented Foliage Data

Puerto Rico 1989 forest floor decomposition data. ID = watershed, slope position, species, sub-plot code.

Bag/ Process Sample Number	ID	INITIAL STATE ANALYSES: Initial Litter Weight	Est. Initial Dry wt.	Est. Ash-Free Initial Dry Wt.	Est. Initial N Mass (mg)	POST TREATMENT: Elapsed Time (days)	Measured Dry Wt.	Fract. Ash	Estimated Non-soil Fraction Veg Ash.	Soil Adjusted Veg Mass	Ash Free Veg Mass	Fraction BioMass Remainin	MEASURED TKN: Fraction	Mass (mg)	Est. Veg N Mass (mg)	Fraction Nitrogen Remaining
		ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SNMt	VNMt	FNMRt
1	I R P 1	88.69	24.85	22.83	432	14	21.57	0.081	0.0791	21.50	19.67	0.862	0.0179	386	386	0.018
2	I R P 1	63.35	17.78	16.33	309	35	14.00	0.155	0.0732	12.40	11.37	0.696	0.0157	220	215	0.017
3	I R P 1	96.93	27.24	25.02	474	55	19.85	0.162	0.0676	17.25	15.85	0.633	0.0167	331	324	0.019
4	I R P 1	79.76	22.44	20.62	391	78	15.91	0.346	0.0611	9.70	8.93	0.433	0.0133	212	194	0.020
5	I R P 2	89.85	25.32	23.26	441	14	22.15	0.070	0.0791	22.43	20.52	0.882	0.0183	405	406	0.018
6	I R P 2	94.09	26.55	24.39	462	35	18.48	0.064	0.0732	18.73	17.17	0.704	0.0149	275	276	0.015
7	I R P 2	56.77	16.04	14.74	279	55	12.17	0.306	0.0676	8.16	7.50	0.509	0.0131	159	148	0.018
8	I R P 2	69.73	19.73	18.13	343	78	17.58	0.418	0.0611	8.99	8.28	0.457	0.0112	196	172	0.019
9	I R P 3	44.11	12.50	11.48	218	14	11.60	0.094	0.0791	11.36	10.40	0.905	0.0169	195	195	0.017
10	I R P 3	50.55	14.35	13.18	250	35	11.52	0.057	0.0732	11.79	10.81	0.820	0.0159	183	184	0.016
11	I R P 3	43.77	12.44	11.43	216	55	7.62	0.091	0.0676	7.37	6.77	0.593	0.0185	141	140	0.019
12	I R P 3	46.26	13.17	12.09	229	78	8.38	0.112	0.0611	7.80	7.18	0.594	0.0174	146	144	0.018
13	I R P 4	30.30	8.64	7.93	150	14	7.47	0.084	0.0791	7.42	6.79	0.855	0.0162	121	120	0.016
14	I R P 4	38.64	11.03	10.13	192	35	8.30	0.075	0.0732	8.28	7.59	0.749	0.0178	148	148	0.018
15	I R P 4	34.36	9.82	9.02	171	55	8.38	0.230	0.0676	6.50	5.97	0.662	0.0213	178	173	0.027
16	I R P 4	35.50	10.16	9.33	177	78	8.84	0.295	0.0611	6.01	5.53	0.593	0.0202	179	171	0.028
17	I R P 5	34.15	9.79	8.99	170	14	8.53	0.082	0.0791	8.49	7.77	0.864	0.0186	159	159	0.019
18	I R P 5	34.17	9.81	9.01	171	35	8.22	0.141	0.0732	7.44	6.82	0.758	0.0166	136	134	0.018
19	I R P 5	33.02	9.49	8.72	165	55	7.76	0.275	0.0676	5.54	5.09	0.584	0.0229	178	172	0.031
20	I R P 5	35.77	10.30	9.46	179	78	9.55	0.363	0.0611	5.61	5.17	0.546	0.0194	185	174	0.031
21	I U P 6	32.76	9.44	8.67	164	14	8.48	0.095	0.0791	8.29	7.59	0.875	0.0194	165	164	0.020
22	I U P 6	33.29	9.61	8.83	167	35	7.65	0.058	0.0732	7.82	7.17	0.812	0.0181	138	139	0.018
23	I U P 6	35.84	10.36	9.52	180	55	7.09	0.120	0.0676	6.58	6.04	0.635	0.0164	116	115	0.017
24	I U P 6	32.52	9.41	8.65	164	78	5.45	0.201	0.0611	4.41	4.06	0.469	0.0199	108	106	0.024
25	I U P 7	32.28	9.36	8.59	163	14	7.70	0.081	0.0791	7.68	7.03	0.818	0.0210	161	161	0.021

1989 Forest Floor Data (continued)

		ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SNMt	VNMt	FNMRt
26	I U P 7	34.52	10.02	9.20	174	35	7.13	0.103	0.0732	6.83	6.26	0.680	0.0174	124	123	0.018
27	I U P 7	32.43	9.42	8.66	164	55	5.78	0.082	0.0676	5.67	5.21	0.602	0.0188	108	108	0.019
28	I U P 7	32.41	9.43	8.66	164	78	5.85	0.182	0.0611	4.88	4.49	0.519	0.0186	109	106	0.022
29	I U P 8	31.38	9.14	8.40	159	14	7.66	0.085	0.0791	7.60	6.95	0.828	0.0180	138	138	0.018
30	I U P 8	33.35	9.73	8.94	169	35	7.77	0.084	0.0732	7.66	7.02	0.785	0.0178	138	138	0.018
31	I U P 8	32.32	9.44	8.68	164	55	6.63	0.063	0.0676	6.67	6.13	0.707	0.0123	81	81	0.012
32	I U P 8	32.06	9.38	8.62	163	78	5.77	0.070	0.0611	5.70	5.25	0.609	0.0181	104	104	0.018
33	I U P 9	33.15	9.71	8.92	169	14	8.50	0.093	0.0791	8.34	7.63	0.855	0.0199	169	169	0.020
34	I U P 9	34.04	9.99	9.17	174	35	6.28	0.080	0.0732	6.22	5.70	0.622	0.0171	107	107	0.017
35	I U P 9	32.25	9.48	8.70	165	55	5.95	0.058	0.0676	6.03	5.54	0.637	0.0172	102	103	0.017
36	I U P 9	33.79	9.94	9.13	173	78	5.13	0.079	0.0611	5.01	4.61	0.505	0.0214	110	109	0.022
37	I U P 10	33.46	9.86	9.06	172	14	8.56	0.085	0.0791	8.49	7.77	0.858	0.0169	144	144	0.017
38	I U P 10	33.71	9.94	9.14	173	35	4.84	0.053	0.0732	4.98	4.56	0.500	0.0159	77	77	0.016
39	I U P 10	34.86	10.30	9.46	179	55	5.11	0.049	0.0676	5.24	4.82	0.509	0.0167	85	86	0.016
40	I U P 10	32.21	9.53	8.75	166	78	4.71	0.046	0.0611	4.80	4.42	0.505	0.0155	73	73	0.015
41	B R P 11	32.86	9.73	8.94	169	14	8.17	0.088	0.0791	8.07	7.38	0.826	0.0181	148	148	0.018
42	B R P 11	32.43	9.62	8.84	167	35	7.02	0.056	0.0732	7.19	6.59	0.746	0.0198	139	139	0.019
43	B R P 11	32.54	9.66	8.88	168	52	5.88	0.053	0.0684	6.00	5.51	0.621	0.0192	113	113	0.019
44	B R P 11	33.48	9.96	9.15	173	78	5.46	0.081	0.0611	5.31	4.89	0.535	0.0174	95	95	0.018
45	B R P 11	33.02	9.83	9.03	171	14	9.12	0.095	0.0791	8.91	8.15	0.903	0.0156	142	142	0.016
46	B R P 11	32.95	9.83	9.03	171	35	7.52	0.072	0.0732	7.54	6.91	0.766	0.0196	147	147	0.020
47	B R P 11	33.06	9.87	9.07	172	52	5.24	0.063	0.0684	5.28	4.85	0.534	0.0159	83	83	0.016
48	B R P 11	34.76	10.39	9.55	181	78	5.28	0.107	0.0611	4.95	4.56	0.477	0.0212	112	111	0.022
49	B R P 11	33.60	10.06	9.24	175	14	9.02	0.089	0.0791	8.85	8.13	0.880	0.0185	167	167	0.019
50	B R P 11	32.26	9.67	8.88	168	35	7.92	0.077	0.0732	7.87	7.22	0.813	0.0187	148	148	0.019
51	B R P 11	34.25	10.28	9.45	179	52	6.11	0.083	0.0684	5.99	5.50	0.582	0.0202	123	123	0.021
52	B R P 11	33.58	10.09	9.27	176	78	5.31	0.064	0.0611	5.29	4.87	0.526	0.0210	112	111	0.021
53	B R P 11	33.07	9.95	9.14	173	14	8.31	0.087	0.0791	8.21	7.55	0.825	0.0190	158	158	0.019
54	B R P 11	34.17	10.30	9.46	179	35	6.33	0.050	0.0732	6.53	5.99	0.633	0.0202	128	128	0.020
55	B R P 14	34.16	10.31	9.47	179	52	6.11	0.066	0.0684	6.13	5.63	0.594	0.0180	110	110	0.018
56	B R P 14	32.60	9.85	9.05	171	78	5.96	0.078	0.0611	5.82	5.36	0.592	0.0172	103	102	0.018
57	B R P 15	32.41	9.81	9.01	171	14	7.80	0.085	0.0791	7.73	7.08	0.785	0.0195	152	152	0.020
58	B R P 15	34.16	10.35	9.51	180	35	6.92	0.056	0.0732	7.09	6.50	0.683	0.0158	109	110	0.015
59	B R P 15	32.52	9.87	9.06	172	52	5.62	0.082	0.0684	5.51	5.06	0.559	0.0184	103	103	0.019
60	B R P 15	31.93	9.70	8.91	169	78	5.00	0.066	0.0611	4.96	4.57	0.513	0.0188	94	94	0.019
61	B U P 16	33.43	10.17	9.34	177	14	8.38	0.090	0.0791	8.26	7.55	0.808	0.0177	148	148	0.018
62	B U P 16	34.17	10.41	9.56	181	35	6.89	0.073	0.0732	6.89	6.31	0.660	0.0182	125	125	0.018
63	B U P 16	34.54	10.54	9.68	183	52	6.53	0.060	0.0684	6.60	6.07	0.627	0.0178	116	116	0.018

1989 Forest Floor Data (continued)

		ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SNMt	VNMt	FNMRt
64	B U P 16	35.17	10.74	9.87	187	78	5.93	0.095	0.0611	5.66	5.21	0.528	0.0226	134	133	0.024
65	B U P 17	33.02	10.10	9.28	176	14	8.21	0.084	0.0791	8.15	7.46	0.804	0.0179	147	147	0.018
66	B U P 17	32.39	9.92	9.11	173	35	6.63	0.063	0.0732	6.73	6.17	0.677	0.0163	108	108	0.016
67	B U P 17	32.48	9.96	9.15	173	52	5.10	0.056	0.0684	5.19	4.76	0.521	0.0174	89	89	0.017
68	B U P 17	32.49	9.97	9.16	174	78	4.93	0.064	0.0611	4.91	4.52	0.493	0.0188	93	93	0.019
69	B U P 18	32.75	10.07	9.25	175	14	8.35	0.083	0.0791	8.31	7.60	0.822	0.0162	135	135	0.016
70	B U P 18	33.25	10.23	9.40	178	35	7.08	0.073	0.0732	7.08	6.49	0.690	0.0171	121	121	0.017
71	B U P 18	32.17	9.92	9.11	173	52	5.68	0.051	0.0684	5.81	5.34	0.586	0.0171	97	97	0.017
72	B U P 18	32.41	10.00	9.19	174	78	5.15	0.051	0.0611	5.22	4.81	0.523	0.0233	120	120	0.023
73	B U P 19	33.67	10.40	9.56	181	14	8.3	0.070	0.0791	8.41	7.69	0.805	0.0170	141	141	0.017
74	B U P 19	32.97	10.20	9.37	178	35	6.74	0.056	0.0732	6.90	6.33	0.675	0.0169	114	114	0.017
75	B U P 19	36.62	11.35	10.42	197	78	6	0.088	0.0611	5.78	5.32	0.511	0.0191	115	114	0.020
76	B U P 19	33.00	10.24	9.40	178	78	4.7	0.069	0.0611	4.65	4.28	0.455	0.0191	90	90	0.019
77	B U P 20	35.28	10.96	10.07	191	78	6.88	0.056	0.0611	6.92	6.38	0.633	0.0178	122	123	0.018
78	B U P 20	32.71	10.17	9.35	177	35	6.48	0.079	0.0732	6.42	5.89	0.630	0.0221	143	143	0.022
79	B U P 20	32.85	10.23	9.40	178	52	6.82	0.064	0.0684	6.87	6.31	0.671	0.0150	102	102	0.015
80	B U P 20	32.88	10.25	9.42	178	14	8.41	0.084	0.0791	8.35	7.64	0.811	0.0159	134	134	0.016
81	I R C 21	24.59	9.41	9.20	40	14	9.03	0.025	0.0225	9.00	8.80	0.957	0.0049	44	44	0.005
82	I R C 21	24.92	9.57	9.35	41	35	9.25	0.035	0.0225	9.10	8.89	0.951	0.0046	43	42	0.005
83	I R C 21	25.20	9.71	9.49	42	55	9.8	0.093	0.0225	8.91	8.71	0.917	0.0047	46	43	0.005
84	I R C 21	25.51	9.87	9.65	42	78	8.38	0.037	0.0225	8.22	8.04	0.833	0.0054	45	45	0.005
85	I R C 22	25.03	9.72	9.50	42	78	8.97	0.133	0.0225	7.68	7.51	0.790	0.0044	39	36	0.005
86	I R C 22	25.13	9.79	9.57	42	35	9.15	0.029	0.0225	9.08	8.87	0.927	0.0048	44	44	0.005
87	I R C 22	29.59	11.58	11.32	50	14	11.69	0.024	0.0225	11.67	11.41	1.008	0.0040	47	47	0.004
88	I R C 22	26.70	10.48	10.25	45	35	8.73	0.049	0.0225	8.43	8.24	0.804	0.0045	39	38	0.005
89	I R C 23	25.44	10.03	9.80	43	78	10.08	0.162	0.0225	8.25	8.06	0.823	0.0048	48	43	0.005
90	I R C 23	24.58	9.72	9.50	42	14	9.22	0.029	0.0225	9.14	8.93	0.940	0.0042	39	38	0.004
91	I R C 23	27.27	10.83	10.58	47	35	9.84	0.055	0.0225	9.42	9.21	0.870	0.0046	45	44	0.005
92	I R C 23	24.54	9.78	9.56	42	55	9.08	0.078	0.0225	8.43	8.24	0.862	0.0042	38	36	0.004
93	I R C 24	25.87	10.34	10.11	44	14	9.74	0.028	0.0225	9.68	9.46	0.935	0.0040	39	39	0.004
94	I R C 24	25.07	10.06	9.83	43	55	8.56	0.072	0.0225	8.01	7.83	0.796	.		.	.
95	I R C 24	25.88	10.42	10.19	45	35	9.55	0.040	0.0225	9.33	9.12	0.895	0.0046	44	43	0.005
96	I R C 24	27.58	11.15	10.90	48	78	9.43	0.104	0.0225	8.43	8.24	0.756	0.0050	47	44	0.005
97	I R C 25	24.74	10.03	9.81	43	14	9.46	0.033	0.0225	9.33	9.12	0.930	0.0053	50	50	0.005
98	I R C 25	24.18	9.84	9.62	42	35	10.00	0.075	0.0225	9.31	9.10	0.946	0.0047	47	45	0.005
99	I R C 25	24.88	10.16	9.93	44	78	9.12	0.124	0.0225	7.91	7.74	0.779	0.0050	46	42	0.005
100	I R C 25	28.29	11.60	11.34	50	55	10.71	0.124	0.0225	9.29	9.08	0.801	0.0051	55	50	0.005
101	I U C 26	24.79	10.20	9.97	44	14	9.34	0.025	0.0225	9.31	9.10	0.913	0.0046	43	43	0.005

1989 Forest Floor Data (continued)

		ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SNMt	VNMt	FNMRt
102	I U C 26	25.07	10.35	10.12	45	55	8.24	0.026	0.0225	8.21	8.02	0.793	0.0040	33	33	0.004
103	I U C 26	25.24	10.46	10.22	45	78	9.05	0.046	0.0225	8.77	8.57	0.839	0.0041	37	36	0.004
104	I U C 26	24.52	10.19	9.96	44	35	8.77	0.043	0.0225	8.54	8.35	0.838	0.0044	39	38	0.004
105	I U C 27	26.23	10.94	10.69	47	14	10.03	0.023	0.0225	10.02	9.80	0.916	0.0041	41	41	0.004
106	I U C 27	26.05	10.90	10.66	47	35	9.54	0.018	0.0225	9.59	9.38	0.880	0.0041	39	39	0.004
107	I U C 27	25.32	10.63	10.40	46	55	8.92	0.019	0.0225	8.97	8.76	0.843	0.0042	37	38	0.004
108	I U C 27	30.62	12.90	12.61	55	78	9.81	0.025	0.0225	9.78	9.56	0.758	0.0049	48	48	0.005
109	I U C 28	27.30	11.54	11.28	50	35	8.89	0.029	0.0225	8.81	8.62	0.763	0.0054	48	48	0.005
110	I U C 28	25.47	10.81	10.56	46	14	9.45	0.023	0.0225	9.45	9.24	0.874	0.0045	43	43	0.005
111	I U C 28	26.90	11.45	11.20	49	55	9.70	0.065	0.0225	9.16	8.96	0.800	0.0044	43	41	0.004
112	I U C 28	26.43	11.29	11.04	49	78	8.46	0.033	0.0225	8.35	8.16	0.739	0.0047	40	39	0.005
113	I U C 29	25.34	10.86	10.62	47	14	9.23	0.021	0.0225	9.24	9.03	0.851	0.0047	43	43	0.005
114	I U C 29	25.15	10.82	10.57	47	35	9.05	0.026	0.0225	9.01	8.81	0.833	0.0045	41	41	0.005
115	I U C 29	25.18	10.87	10.62	47	55	8.41	0.021	0.0225	8.42	8.23	0.775	0.0043	36	36	0.004
116	I U C 29	26.32	11.40	11.14	49	78	9.82	0.024	0.0225	9.81	9.58	0.860	0.0043	42	42	0.004
117	I U C 30	26.17	11.37	11.11	49	78	8.72	0.027	0.0225	8.67	8.48	0.763	0.0048	42	42	0.005
118	I U C 30	27.15	11.83	11.57	51	55	10.01	0.022	0.0225	10.02	9.79	0.847	0.0042	42	42	0.004
119	I U C 30	28.16	12.31	12.04	53	35	10.84	0.023	0.0225	10.83	10.59	0.879	0.0055	60	60	0.006
120	I U C 30	27.10	11.89	11.62	51	14	11.09	0.022	0.0225	11.09	10.84	0.933	0.0049	54	54	0.005
121	B R C 31	26.64	11.73	11.46	50	52	9.40	0.024	0.0225	9.38	9.17	0.800	0.0052	49	49	0.005
122	B R C 31	27.04	11.94	11.67	51	78	9.58	0.028	0.0225	9.51	9.29	0.796	0.0048	46	46	0.005
123	B R C 31	27.20	12.05	11.78	52	35	11.08	0.023	0.0225	11.07	10.83	0.919	0.0041	45	45	0.004
124	B R C 31	26.17	11.63	11.37	50	14	10.73	0.024	0.0225	10.71	10.47	0.921	0.0040	43	43	0.004
125	B R C 32	25.88	11.54	11.28	50	78	9.39	0.024	0.0225	9.37	9.16	0.812	0.0047	44	44	0.005
126	B R C 32	26.40	11.81	11.54	51	14	10.40	0.028	0.0225	10.32	10.09	0.874	0.0035	36	36	0.004
127	B R C 32	27.57	12.37	12.10	53	35	10.49	0.022	0.0225	10.49	10.26	0.848	0.0039	41	41	0.004
128	B R C 32	26.24	11.81	11.55	51	52	10.44	0.031	0.0225	10.32	10.09	0.874	0.0052	54	54	0.005
129	B R C 33	28.87	13.04	12.75	56	52	9.25	0.040	0.0225	9.04	8.84	0.693	0.0050	46	46	0.005
130	B R C 33	23.29	10.55	10.32	45	78	8.50	0.091	0.0225	7.74	7.57	0.734	0.0052	44	42	0.005
131	B R C 33	27.47	12.49	12.21	54	14	11.56	0.026	0.0225	11.50	11.24	0.921	0.0042	49	48	0.004
132	B R C 33	26.26	11.97	11.71	51	35	9.73	0.026	0.0225	9.69	9.47	0.809	0.0045	44	44	0.005
133	B R C 34	25.83	11.82	11.55	51	14	9.65	0.041	0.0225	9.41	9.20	0.797	0.0051	49	49	0.005
134	B R C 34	30.30	13.90	13.59	60	52	9.93	0.032	0.0225	9.80	9.58	0.705	0.0052	52	51	0.005
135	B R C 34	30.94	14.24	13.92	61	35	11.24	0.024	0.0225	11.22	10.97	0.788	0.0050	56	56	0.005
136	B R C 34	26.65	12.31	12.03	53	78	8.91	0.030	0.0225	8.83	8.63	0.717	0.0056	50	50	0.006
138	B U C 35	28.40	13.20	12.90	57	78	9.61	0.027	0.0225	9.55	9.34	0.724	0.0054	52	52	0.005
139	B U C 35	27.59	12.86	12.57	55	14	10.02	0.028	0.0225	9.94	9.72	0.773	0.0049	49	49	0.005
140	B U C 35	29.09	13.60	13.29	58	35	10.56	0.023	0.0225	10.55	10.31	0.776	0.0047	50	50	0.005

1989 Forest Floor Data (continued)

		ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SNMt	VNMt	FNMRt
141	B U C 36	25.48	11.95	11.68	51	52	9.11	0.024	0.0225	9.09	8.89	0.761	0.0042	38	38	0.004
142	B U C 36	27.21	12.80	12.51	55	35	9.68	0.022	0.0225	9.68	9.46	0.756	0.0043	42	42	0.004
143	B U C 36	26.97	12.73	12.44	55	14	9.89	0.025	0.0225	9.86	9.64	0.775	0.0049	48	48	0.005
144	B U C 36	24.10	11.41	11.15	49	78	7.85	0.028	0.0225	7.79	7.62	0.683	0.0052	41	41	0.005
145	B U C 37	23.97	11.38	11.12	49	52	8.05	0.020	0.0225	8.07	7.89	0.709	0.0045	36	36	0.004
146	B U C 37	24.08	11.47	11.21	49	78	8.31	0.028	0.0225	8.25	8.07	0.720	0.0049	41	41	0.005
147	B U C 37	27.68	13.22	12.92	57	14	10.67	0.022	0.0225	10.68	10.44	0.808	0.0043	46	46	0.004
148	B U C 37	25.00	11.98	11.71	51	35	9.24	0.022	0.0225	9.24	9.04	0.772	0.0040	37	37	0.004
149	B U C 38	25.55	12.28	12.00	53	14	9.57	0.025	0.0225	9.54	9.33	0.777	0.0045	43	43	0.005
150	B U C 38	24.81	11.96	11.69	51	35	9.31	0.025	0.0225	9.28	9.07	0.776	0.0047	44	44	0.005
151	B R T 39	15.29	5.70	5.05	38	14	5.75	0.121	0.1238	5.78	5.12	1.014	0.0083	48	48	0.008
152	B R T 39	17.09	6.38	5.65	43	35	5.55	0.125	0.1312	5.60	4.97	0.878	0.0084	47	47	0.008
153	B R T 39	14.54	5.43	4.82	36	78	4.23	0.137	0.1462	4.29	3.80	0.789	0.0085	36	36	0.008
154	B R T 39	14.84	5.55	4.92	37	52	4.34	0.128	0.1371	4.40	3.90	0.793	0.0084	36	37	0.008
155	B R T 39	13.31	4.99	4.42	33	78	3.35	0.145	0.1462	3.36	2.98	0.673	0.0085	28	28	0.008
156	B R T 41	13.37	5.02	4.45	34	78	4.05	0.170	0.1462	3.90	3.46	0.777	0.0083	34	33	0.009
157	B R T 41	12.77	4.80	4.25	32	14	4.92	0.134	0.1238	4.85	4.30	1.010	0.0093	46	46	0.009
158	B R P 40	15.16	4.59	4.22	80	14	3.60	0.072	0.0791	3.64	3.33	0.788	0.0197	71	71	0.020
159	B R P 40	18.72	5.67	5.21	99	35	4.09	0.054	0.0732	4.20	3.85	0.738	0.0185	76	76	0.018
160	B R P 40	16.64	5.04	4.63	88	52	3.04	0.062	0.0684	3.07	2.82	0.608	0.0197	60	60	0.020
161	B R T 41	30.13	11.38	10.09	76	35	9.25	0.150	0.1312	8.98	7.96	0.789	0.0080	74	73	0.008
162	B R T 41	30.53	11.54	10.23	77	52	7.53	0.133	0.1371	7.58	6.72	0.657	0.0094	71	71	0.009
163	B R T 42	30.77	11.65	10.33	78	78	7.51	0.137	0.1462	7.62	6.75	0.654	0.0079	59	60	0.008
164	B R T 42	30.34	11.50	10.20	77	52	8.13	0.160	0.1371	7.85	6.96	0.682	0.0079	64	64	0.008
165	B R T 42	30.57	11.60	10.29	78	14	10.09	0.116	0.1238	10.20	9.04	0.879	0.0068	69	69	0.007
166	B R T 42	30.60	11.63	10.31	78	35	8.56	0.138	0.1312	8.47	7.50	0.728	0.0074	63	63	0.007
167	B R T 43	30.93	11.77	10.44	79	14	10.30	0.127	0.1238	10.25	9.08	0.871	0.0079	81	81	0.008
168	B R T 43	30.86	11.76	10.43	79	35	8.27	0.144	0.1312	8.11	7.19	0.690	0.0082	68	67	0.008
169	B R T 43	31.13	11.88	10.53	80	52	8.51	0.159	0.1371	8.22	7.29	0.692	0.0085	72	72	0.009
170	B R T 43	30.36	11.60	10.28	78	78	7.31	0.155	0.1462	7.21	6.39	0.622	0.0082	60	60	0.008
171	B R T 43	29.42	11.26	9.98	75	78	6.50	0.149	0.1462	6.47	5.74	0.575	0.0095	62	62	0.010
172	B R T 44	30.44	11.66	10.34	78	14	10.20	0.120	0.1238	10.26	9.10	0.880	0.0076	78	78	0.008
173	B R T 44	30.85	11.83	10.49	79	78	7.60	0.142	0.1462	7.65	6.78	0.646	0.0085	65	65	0.008
174	B R T 44	31.04	11.92	10.57	80	35	8.96	0.156	0.1312	8.63	7.65	0.724	0.0087	78	77	0.009
175	B R T 44	29.58	11.38	10.08	76	52	8.11	0.140	0.1371	8.08	7.16	0.710	0.0078	63	63	0.008
176	B U T 45	30.92	11.91	10.56	80	78	6.96	0.159	0.1462	6.82	6.04	0.572	0.0094	65	65	0.010
177	B U T 45	30.63	11.81	10.47	79	52	7.41	0.245	0.1371	6.19	5.48	0.524	0.0088	65	62	0.010
178	B U T 45	31.46	12.15	10.77	81	35	8.90	0.254	0.1312	7.24	6.42	0.596	0.0081	72	68	0.009

1989 Forest Floor Data (continued)

		ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SNMt	VNMt	FNMRt
179	B U T 45	23.58	9.12	8.08	61	14	7.50	0.225	0.1238	6.36	5.64	0.698	0.0071	53	50	0.008
180	B U T 46	29.65	11.48	10.17	77	14	9.93	0.111	0.1238	10.12	8.97	0.882	0.0078	77	78	0.008
181	B U T 46	31.41	12.18	10.79	82	78	8.09	0.162	0.1462	7.90	7.00	0.648	0.0091	74	73	0.009
182	B U T 46	29.97	11.63	10.31	78	52	7.52	0.131	0.1371	7.59	6.73	0.653	0.0081	61	61	0.008
183	B U T 46	30.59	11.89	10.54	80	35	8.79	0.139	0.1312	8.68	7.70	0.730	0.0083	73	73	0.008
184	B U T 47	30.98	12.05	10.69	81	14	10.10	0.113	0.1238	10.27	9.10	0.852	0.0083	84	84	0.008
185	B U T 47	31.77	12.38	10.97	83	35	9.10	0.125	0.1312	9.18	8.14	0.742	0.0086	78	78	0.009
186	B U T 47	30.64	11.95	10.60	80	52	7.00	0.144	0.1371	6.92	6.14	0.579	0.0093	65	65	0.009
187	B U T 47	29.70	11.60	10.28	78	78	6.09	0.181	0.1462	5.76	5.11	0.497	0.0095	58	57	0.010
188	B U T 48	30.73	12.02	10.65	81	14	9.78	0.108	0.1238	10.01	8.87	0.833	0.0086	84	85	0.008
189	B U T 48	29.94	11.73	10.39	79	35	8.00	0.134	0.1312	7.97	7.06	0.679	0.0084	67	67	0.008
190	B U T 48	30.64	12.01	10.65	80	52	8.02	0.133	0.1371	8.06	7.15	0.671	0.0073	59	59	0.007
191	B U T 48	30.03	11.79	10.45	79	78	6.55	0.157	0.1462	6.44	5.71	0.546	0.0087	57	57	0.009
192	B U T 49	31.79	12.50	11.08	84	78	7.99	0.138	0.1462	8.09	7.17	0.648	0.0092	74	74	0.009
193	B U T 49	31.42	12.37	10.96	83	52	8.25	0.141	0.1371	8.20	7.27	0.663	0.0092	76	76	0.009
194	B U T 49	30.23	11.91	10.56	80	35	8.64	0.139	0.1312	8.53	7.56	0.716	0.0081	70	70	0.008
195	B U T 49	31.19	12.31	10.91	82	14	10.18	0.120	0.1238	10.24	9.08	0.832	0.0081	82	83	0.008
196	B U T 50	31.56	12.47	11.05	84	14	9.31	0.125	0.1238	9.29	8.24	0.745	0.0090	84	84	0.009
197	B U T 50	31.35	12.40	10.99	83	14	10.01	0.116	0.1238	10.13	8.98	0.817	0.0083	83	83	0.008
198	B U T 50	31.91	12.64	11.20	85	52	7.57	0.159	0.1371	7.32	6.49	0.579	0.0085	64	64	0.009
199	B U T 50	30.52	12.10	10.73	81	35	8.35	0.145	0.1312	8.17	7.25	0.675	0.0085	71	71	0.009
200	I R T 51	31.49	12.51	11.08	84	14	9.58	0.134	0.1238	9.43	8.36	0.754	0.0083	80	79	0.008
201	I R T 51	30.75	12.23	10.84	82	78	8.57	0.333	0.1462	6.09	5.40	0.498	0.0078	67	61	0.010
202	I R T 51	30.13	12.00	10.63	80	55	7.86	0.130	0.1382	7.96	7.05	0.663	0.0084	66	66	0.008
203	I R T 51	30.87	12.31	10.91	82	35	8.66	0.168	0.1312	8.17	7.25	0.664	0.0094	81	80	0.010
204	I R T 52	31.09	12.41	11.00	83	55	7.63	0.205	0.1382	6.85	6.08	0.552	0.0086	66	64	0.009
205	I R T 52	32.71	13.07	11.59	88	35	9.26	0.195	0.1312	8.36	7.41	0.640	0.0078	72	70	0.008
206	I R T 52	32.17	12.87	11.41	86	14	10.09	0.140	0.1238	9.84	8.73	0.765	0.0084	85	84	0.009
207	I R T 52	33.13	13.27	11.76	89	78	8.22	0.295	0.1462	6.32	5.61	0.477	0.0077	63	59	0.009
208	I R T 53	30.42	12.20	10.82	82	78	7.26	0.191	0.1462	6.76	5.99	0.554	0.0088	64	63	0.009
209	I R T 53	31.30	12.57	11.14	84	55	8.27	0.174	0.1382	7.82	6.93	0.622	0.0101	84	82	0.011
210	I R T 53	31.61	12.71	11.27	85	35	8.19	0.151	0.1312	7.95	7.04	0.625	0.0082	67	67	0.008
211	I R T 53	30.26	12.18	10.80	82	14	9.30	0.137	0.1238	9.12	8.08	0.749	0.0082	76	76	0.008
212	I R T 54	31.27	12.61	11.17	84	14	10.63	0.135	0.1238	10.46	9.27	0.830	0.0072	77	76	0.007
213	I R T 54	32.01	12.92	11.45	87	35	8.91	0.139	0.1312	8.81	7.81	0.682	0.0086	77	76	0.009
214	I R T 54	31.97	12.92	11.45	87	55	8.41	0.147	0.1382	8.29	7.35	0.642	0.0083	70	70	0.008
215	I R T 54	31.79	12.86	11.40	86	78	8.72	0.159	0.1462	8.54	7.57	0.664	0.0083	72	72	0.008
216	I R T 55	30.89	12.51	11.09	84	14	9.33	0.132	0.1238	9.22	8.17	0.737	0.0085	79	79	0.009

1989 Forest Floor Data (continued)

		ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SNMt	VNMt	FNMRt
217	I R T 55	32.09	13.02	11.54	87	35	8.36	0.151	0.1312	8.11	7.19	0.623	0.0082	69	68	0.008
218	I R T 55	31.91	12.96	11.49	87	55	8.48	0.204	0.1382	7.63	6.76	0.589	0.0081	69	67	0.009
219	I U T 56	32.95	13.40	11.88	90	78	7.45	0.141	0.1462	7.50	6.65	0.560	0.0087	65	65	0.009
220	I U T 56	30.69	12.49	11.08	84	35	8.92	0.131	0.1312	8.92	7.91	0.714	0.0085	76	76	0.008
221	I U T 56	30.30	12.35	10.95	83	55	7.99	0.149	0.1382	7.86	6.96	0.636	0.0082	66	65	0.008
222	I U T 56	30.16	12.31	10.91	82	14	10.62	0.116	0.1238	10.74	9.52	0.873	0.0081	86	86	0.008
223	I R T 55	31.27	12.78	11.33	86	78	7.44	0.164	0.1462	7.23	6.41	0.566	0.0088	65	65	0.009
224	I U T 57	29.52	12.08	10.71	81	14	10.72	0.131	0.1238	10.60	9.39	0.878	0.0084	90	90	0.008
225	I U T 57	30.18	12.36	10.96	83	78	10.94	0.389	0.1462	6.82	6.05	0.552	0.0073	80	70	0.010
226	I U T 57	32.12	13.17	11.68	88	35	9.70	0.145	0.1312	9.49	8.41	0.721	0.0076	74	73	0.008
227	I U T 57	32.20	13.22	11.72	89	55	9.08	0.275	0.1382	7.19	6.37	0.544	0.0099	90	85	0.012
228	I U T 58	29.48	12.12	10.74	81	78	7.32	0.132	0.1462	7.49	6.64	0.618	0.0092	67	68	0.009
229	I U T 58	30.52	12.56	11.14	84	35	8.65	0.142	0.1312	8.51	7.55	0.678	0.0091	79	78	0.009
230	I U T 58	31.07	12.80	11.35	86	55	9.40	0.145	0.1382	9.30	8.24	0.726	0.0094	88	88	0.009
231	I U T 58	29.96	12.36	10.96	83	14	10.36	0.132	0.1238	10.24	9.08	0.828	0.0080	83	83	0.008
232	I U T 59	30.30	12.52	11.10	84	14	10.63	0.119	0.1238	10.71	9.49	0.856	0.0088	94	94	0.009
233	I U T 59	30.60	12.66	11.22	85	55	8.88	0.148	0.1382	8.75	7.75	0.691	0.0095	84	84	0.010
234	I U T 59	29.46	12.20	10.81	82	78	7.48	0.153	0.1462	7.40	6.56	0.607	0.0096	72	72	0.010
235	I U T 59	29.69	12.31	10.91	82	35	9.35	0.134	0.1312	9.32	8.26	0.757	0.0098	92	92	0.010
236	I U T 60	29.35	12.18	10.80	82	78	7.62	0.142	0.1462	7.67	6.80	0.630	0.0089	68	68	0.009
237	I U T 60	31.95	13.28	11.77	89	78	8.56	0.141	0.1462	8.63	7.65	0.650	0.0092	79	79	0.009
238	I U T 60	32.98	13.72	12.16	92	55	9.05	0.143	0.1382	8.99	7.97	0.655	0.0079	71	71	0.008
239	I U T 60	27.04	11.27	9.99	75	35	9.95	0.133	0.1312	9.93	8.80	0.881	0.0085	85	85	0.009
240	I U T 60	30.39	12.68	11.24	85	14	11.61	0.115	0.1238	11.76	10.43	0.928	0.0071	82	83	0.007

1990 forest floor decomposition raw data, meaurements, and calculations.

Bag/ Process Sample Number	ID	INITIAL STATE ANALYSES Initial Litter Weight	Est. Initial Dry wt.	Est. Ash-Free Initial Dry Wt.	Est. Initial N Mass (mg)	POST TREATMENT Elapsed Time (days)	Measured Dry Wt.	Fract. Ash	Estimated Non-soil Fraction Veg Ash.	Soil Adjusted Veg Mass	Ash Free Veg Mass	Fraction BioMass Remaining	MEASURED TKN Fraction	Mass (mg)	Est. Veg Mass (mg)	Fraction Nitrogen Remaining
		ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SN	VN	FNMRt
1	I U N C 2	15.09	12.89	12.65	45.6	99	10.25	0.0167	0.0184	10.27	10.08	0.797	0.0043	44	44	0.968
2	I U N C 2	15.06	12.86	12.63	45.5	42	11.35	0.0155	0.0167	11.37	11.18	0.885	0.0038	43	43	0.949
3	I U N C 2	15.01	12.82	12.59	45.4	12	11.98	0.0142	0.0158	12.00	11.81	0.938	0.0035	42	42	0.926
4	I U N C 2	15.05	12.85	12.62	45.5	21	11.64	0.0144	0.0160	11.66	11.48	0.909	0.0038	44	44	0.974
5	I U N C 2	15.06	12.86	12.63	45.5	69	11.26	0.0180	0.0175	11.25	11.06	0.875	0.0039	44	44	0.965
6	I U N C 6	15.16	12.95	12.71	45.8	99	11.40	0.0188	0.0184	11.39	11.18	0.880	0.0043	49	49	1.070
7	I U N C 6	15.04	12.84	12.61	45.5	21	12.27	0.0143	0.0160	12.30	12.10	0.960	0.0038	47	47	1.027
8	I U N C 6	15.01	12.82	12.59	45.4	42	11.33	0.0142	0.0167	11.37	11.18	0.888	0.0040	45	45	1.001
9	I U N C 6	15.00	12.81	12.58	45.3	12	12.76	0.0154	0.0158	12.77	12.56	0.999	0.0036	46	46	1.015
10	I U N C 6	15.01	12.82	12.59	45.4	69	11.68	0.0132	0.0175	11.74	11.54	0.917	0.0040	47	47	1.034
11	I U N C 10	15.00	12.81	12.58	45.3	42	11.60	0.0155	0.0167	11.62	11.42	0.908	0.0040	46	46	1.026
12	I U N C 10	15.09	12.89	12.65	45.6	21	12.49	0.0143	0.0160	12.52	12.32	0.974	0.0039	49	49	1.071
13	I U N C 10	15.00	12.81	12.58	45.3	99	11.64	0.0274	0.0184	11.50	11.29	0.898	0.0042	49	48	1.068
14	I U N C 10	15.00	12.81	12.58	45.3	12	12.81	0.0155	0.0158	12.81	12.61	1.003	0.0035	45	45	0.990
15	I U N C 10	15.05	12.85	12.62	45.5	69	11.86	0.0150	0.0175	11.90	11.69	0.926	0.0038	45	45	0.994
16	I U N C 12	15.00	12.81	12.58	45.3	42	12.00	0.0296	0.0167	11.80	11.60	0.922	0.0039	47	46	1.017
17	I U N C 12	15.03	12.83	12.60	45.4	21	12.42	0.0140	0.0160	12.45	12.25	0.972	0.0038	47	47	1.042
18	I U N C 12	15.00	12.81	12.58	45.3	12	12.94	0.0144	0.0158	12.96	12.76	1.014	0.0035	45	45	1.002
19	I U N C 12	15.08	12.88	12.64	45.6	69	12.85	0.0145	0.0175	12.90	12.67	1.003	0.0038	49	49	1.075
20	I U N C 12	15.06	12.86	12.63	45.5	99	11.87	0.0227	0.0184	11.80	11.59	0.917	0.0040	47	47	1.038
21	I U N C 22	15.05	12.85	12.62	45.5	42	12.10	0.0172	0.0167	12.09	11.89	0.942	0.0039	47	47	1.036
22	I U N C 22	15.09	12.89	12.65	45.6	21	12.66	0.0151	0.0160	12.68	12.47	0.986	0.0037	47	47	1.028
23	I U N C 22	15.04	12.84	12.61	45.5	99	10.93	0.0167	0.0184	10.95	10.75	0.853	0.0043	47	47	1.035
24	I U N C 22	15.06	12.86	12.63	45.5	69	12.34	0.0137	0.0175	12.40	12.18	0.965	0.0039	48	48	1.063

(continued) 1990 forest floor data

		ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SN	VN	FNMRt
25	I U N C 22	15.04	12.84	12.61	45.5	12	12.92	0.0159	0.0158	12.92	12.71	1.008	0.0034	44	44	0.965
26	I U S C 3	15.00	12.81	12.58	45.3	69	11.89	0.0183	0.0175	11.88	11.67	0.928	0.0042	50	50	1.101
27	I U S C 3	15.04	12.84	12.61	45.5	12	13.22	0.0175	0.0158	13.19	12.98	1.030	0.0038	50	50	1.102
28	I U S C 3	15.00	12.81	12.58	45.3	99	11.24	0.0196	0.0184	11.22	11.02	0.876	0.0041	46	46	1.016
29	I U S C 3	15.00	12.81	12.58	45.3	21	12.76	0.0175	0.0160	12.74	12.53	0.996	0.0039	50	50	1.097
30	I U S C 3	15.09	12.89	12.65	45.6	99	11.47	0.0180	0.0184	11.48	11.26	0.890	0.0047	54	54	1.183
31	I U S C 11	15.04	12.84	12.61	45.5	69	11.65	0.0148	0.0175	11.69	11.49	0.911	0.0043	50	50	1.104
32	I U S C 11	15.02	12.83	12.59	45.4	12	12.24	0.0162	0.0158	12.23	12.04	0.956	0.0037	45	45	0.997
33	I U S C 11	15.04	12.84	12.61	45.5	21	13.13	0.0168	0.0160	13.12	12.91	1.024	0.0041	54	54	1.182
34	I U S C 11	15.01	12.82	12.59	45.4	99	11.49	0.0187	0.0184	11.49	11.27	0.895	0.0047	54	54	1.189
35	I U S C 11	15.06	12.86	12.63	45.5	42	11.55	0.0261	0.0167	11.41	11.22	0.888	0.0043	50	49	1.080
36	I U S C 22	15.07	12.87	12.64	45.5	12	12.73	0.0172	0.0158	12.71	12.51	0.989	0.0037	47	47	1.033
37	I U S C 22	15.00	12.81	12.58	45.3	21	11.85	0.0154	0.0160	11.86	11.67	0.928	0.0039	46	46	1.021
38	I U S C 22	15.01	12.82	12.59	45.4	42	11.87	0.0160	0.0167	11.88	11.68	0.928	0.0043	51	51	1.125
39	I U S C 22	15.00	12.81	12.58	45.3	99	11.05	0.1284	0.0184	9.48	9.30	0.740	0.0050	55	49	1.090
40	I U S C 22	15.08	12.88	12.64	45.6	69	11.25	0.0709	0.0175	10.47	10.29	0.814	0.0048	54	51	1.121
41	I U S C 28	15.01	12.82	12.59	45.4	21	12.24	0.0155	0.0160	12.25	12.05	0.957	0.0041	50	50	1.106
42	I U S C 28	15.07	12.87	12.64	45.5	12	12.38	0.0189	0.0158	12.33	12.14	0.960	0.0034	42	42	0.921
43	I U S C 28	15.02	12.83	12.59	45.4	69	11.21	0.0161	0.0175	11.23	11.03	0.876	0.0046	52	52	1.137
44	I U S C 28	15.02	12.83	12.59	45.4	42	11.90	0.0201	0.0167	11.85	11.65	0.925	0.0045	54	53	1.175
45	I U S C 28	15.09	12.89	12.65	45.6	99	10.78	0.0180	0.0184	10.79	10.59	0.837	0.0049	53	53	1.159
46	I R S C 2	15.02	12.83	12.59	45.4	99	12.03	0.1362	0.0184	10.20	10.01	0.795	0.0045	54	47	1.042
47	I R S C 2	15.07	12.87	12.64	45.5	42	12.63	0.0372	0.0167	12.30	12.09	0.957	0.0042	53	52	1.138
48	I R S C 2	15.01	12.82	12.59	45.4	21	12.51	0.0225	0.0160	12.41	12.21	0.970	0.0039	49	48	1.066
49	I R S C 2	15.07	12.87	12.64	45.5	12	13.68	0.0356	0.0158	13.33	13.12	1.038	0.0035	48	47	1.024
50	I R S C 2	15.03	12.83	12.60	45.4	69	13.55	0.1432	0.0175	11.35	11.15	0.885	0.0043	58	50	1.102
51	I R S C 17	15.04	12.84	12.61	45.5	69	11.77	0.0194	0.0175	11.74	11.54	0.915	0.0043	51	51	1.110
52	I R S C 17	15.02	12.83	12.59	45.4	12	12.72	0.0186	0.0158	12.67	12.47	0.991	0.0036	46	46	1.005
53	I R S C 17	15.01	12.82	12.59	45.4	21	11.67	0.0166	0.0160	11.66	11.47	0.911	0.0036	42	42	0.925
54	I R S C 17	15.03	12.83	12.60	45.4	99	11.46	0.0477	0.0184	11.03	10.82	0.859	0.0045	52	50	1.100
55	I R S C 17	15.04	12.84	12.61	45.5	42	10.96	0.0174	0.0167	10.95	10.77	0.854	0.0040	44	44	0.963
56	I R S C 21	15.09	12.89	12.65	45.6	21	12.28	0.0162	0.0160	12.28	12.08	0.955	0.0038	47	47	1.023
57	I R S C 21	15.00	12.81	12.58	45.3	99	10.52	0.0300	0.0184	10.36	10.17	0.809	0.0056	59	58	1.287
58	I R S C 21	15.05	12.85	12.62	45.5	42	11.73	0.0173	0.0167	11.72	11.53	0.913	0.0042	49	49	1.082

(continued) 1990 forest floor data

						ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SN	VN	FNMRt
59	I	R	S	C	21	15.09	12.89	12.65	45.6	69	11.66	0.0425	0.0175	11.28	11.09	0.876	0.0044	51	50	1.094
60	I	R	S	C	21	15.04	12.84	12.61	45.5	12	12.55	0.0174	0.0158	12.52	12.33	0.977	0.0040	50	50	1.101
61	I	R	N	C	5	15.00	12.81	12.58	45.3	99	13.43	0.1553	0.0184	11.05	10.85	0.862	0.0044	59	50	1.109
62	I	R	N	C	5	15.01	12.82	12.59	45.4	12	12.01	0.0181	0.0158	11.97	11.79	0.936	0.0039	47	47	1.029
63	I	R	N	C	5	15.07	12.87	12.64	45.5	69	11.91	0.0179	0.0175	11.90	11.70	0.925	0.0043	51	51	1.125
64	I	R	N	C	5	15.02	12.83	12.59	45.4	21	12.63	0.0239	0.0160	12.50	12.30	0.977	0.0041	52	51	1.130
65	I	R	N	C	5	15.08	12.88	12.64	45.6	42	11.93	0.0325	0.0167	11.69	11.49	0.909	0.0040	48	47	1.027
66	I	R	N	C	16	15.01	12.82	12.59	45.4	42	12.41	0.0599	0.0167	11.72	11.52	0.915	0.0041	51	48	1.064
68	I	R	N	C	16	15.07	12.87	12.64	45.5	12	12.78	0.0214	0.0158	12.69	12.49	0.988	0.0036	46	46	1.004
69	I	R	N	C	16	15.03	12.83	12.60	45.4	69	13.33	0.1312	0.0175	11.37	11.17	0.887	0.0046	61	54	1.190
71	B	R		C	3	15.06	12.86	12.63	45.5	45	11.90	0.0198	0.0168	11.85	11.65	0.923	0.0041	49	49	1.068
72	B	R		C	3	15.04	12.84	12.61	45.5	23	12.35	0.0222	0.0161	12.25	12.06	0.956	0.0029	36	35	0.779
73	B	R		C	3	15.08	12.88	12.64	45.6	102	11.61	0.0558	0.0185	11.05	10.85	0.858	0.0042	49	47	1.023
74	B	R		C	3	15.04	12.84	12.61	45.5	73	11.68	0.0342	0.0176	11.43	11.23	0.890	0.0041	48	47	1.032
75	B	R		C	3	15.00	12.81	12.58	45.3	11	13.29	0.0163	0.0157	13.28	13.07	1.039	0.0034	45	45	0.997
76	B	R		C	9	15.04	12.84	12.61	45.5	102	11.17	0.0187	0.0185	11.17	10.96	0.869	0.0041	46	46	1.006
77	B	R		C	9	15.06	12.86	12.63	45.5	23	12.57	0.0183	0.0161	12.53	12.33	0.976	0.0042	53	53	1.157
78	B	R		C	9	15.02	12.83	12.59	45.4	73	11.45	0.0218	0.0176	11.39	11.19	0.889	0.0047	54	54	1.180
79	B	R		C	9	15.08	12.88	12.64	45.6	45	12.28	0.0182	0.0168	12.26	12.05	0.953	0.0043	53	53	1.156
80	B	R		C	9	15.03	12.83	12.60	45.4	11	12.97	0.0162	0.0157	12.96	12.76	1.013	0.0036	47	47	1.028
81	B	R		C	12	15.04	12.84	12.61	45.5	102	10.72	0.0238	0.0185	10.65	10.45	0.829	0.0048	51	51	1.125
82	B	R		C	12	15.03	12.83	12.60	45.4	23	12.23	0.0178	0.0161	12.20	12.01	0.953	0.0038	46	46	1.021
83	B	R		C	12	15.05	12.85	12.62	45.5	73	11.65	0.0216	0.0176	11.59	11.39	0.902	0.0043	50	50	1.096
84	B	R		C	12	15.04	12.84	12.61	45.5	45	11.48	0.0182	0.0168	11.46	11.27	0.893	0.0044	51	50	1.108
85	B	R		C	12	15.05	12.85	12.62	45.5	11	13.23	0.0176	0.0157	13.20	12.99	1.029	0.0038	50	50	1.102
86	B	R		C	15	15.02	12.83	12.59	45.4	73	11.43	0.0211	0.0176	11.38	11.18	0.888	0.0045	51	51	1.129
87	B	R		C	15	15.02	12.83	12.59	45.4	11	13.17	0.0179	0.0157	13.13	12.93	1.027	0.0038	50	50	1.099
88	B	R		C	15	15.00	12.81	12.58	45.3	45	11.72	0.0214	0.0168	11.65	11.45	0.911	0.0041	48	48	1.055
89	B	R		C	15	15.00	12.81	12.58	45.3	102	11.09	0.0472	0.0185	10.68	10.48	0.833	0.0048	53	52	1.141
90	B	R		C	15	15.02	12.83	12.59	45.4	23	12.37	0.0197	0.0161	12.31	12.11	0.962	0.0041	51	51	1.112
91	B	R		C	19	15.04	12.84	12.61	45.5	73	11.19	0.0187	0.0176	11.17	10.98	0.871	0.0047	53	53	1.155
92	B	R		C	19	15.05	12.85	12.62	45.5	102	11.47	0.0720	0.0185	10.68	10.48	0.830	0.0047	54	51	1.120
93	B	R		C	19	15.07	12.87	12.64	45.5	23	12.35	0.0174	0.0161	12.33	12.13	0.960	0.0032	40	39	0.867
94	B	R		C	19	15.08	12.88	12.64	45.6	11	13.43	0.0164	0.0157	13.42	13.21	1.045	0.0037	50	50	1.089

(continued) 1990 forest floor data

		ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SN	VN	FNMRt
95	B R C 19	15.09	12.89	12.65	45.6	45	11.62	0.0206	0.0168	11.56	11.37	0.899	0.0037	43	43	0.938
96	B U C 1	15.02	12.83	12.59	45.4	73	11.57	0.0191	0.0176	11.55	11.34	0.901	0.0038	44	44	0.967
97	B U C 1	15.02	12.83	12.59	45.4	23	12.58	0.0194	0.0161	12.53	12.32	0.979	0.0037	47	46	1.021
98	B U C 1	15.01	12.82	12.59	45.4	102	10.57	0.0192	0.0185	10.56	10.36	0.823	0.0048	51	51	1.117
99	B U C 1	15.03	12.83	12.60	45.4	45	12.00	0.0172	0.0168	11.99	11.79	0.936	0.0037	44	44	0.977
100	B U C 1	15.08	12.88	12.64	45.6	11	13.54	0.0179	0.0157	13.50	13.29	1.051	0.0039	53	53	1.155
101	B U C 3	15.01	12.82	12.59	45.4	45	11.68	0.0195	0.0168	11.64	11.44	0.909	0.0046	54	54	1.180
102	B U C 3	15.07	12.87	12.64	45.5	73	11.56	0.0202	0.0176	11.52	11.32	0.895	0.0045	52	52	1.140
103	B U C 3	15.04	12.84	12.61	45.5	11	13.37	0.0173	0.0157	13.34	13.13	1.041	0.0041	55	55	1.203
104	B U C 3	15.03	12.83	12.60	45.4	23	12.28	0.0130	0.0161	12.33	12.13	0.963	0.0044	54	54	1.194
105	B U C 3	15.07	12.87	12.64	45.5	102	10.53	0.0198	0.0185	10.51	10.32	0.816	0.0054	57	57	1.248
106	B U C 11	15.03	12.83	12.60	45.4	45	11.80	0.0135	0.0168	11.85	11.65	0.925	0.0036	42	43	0.940
107	B U C 11	15.09	12.89	12.65	45.6	23	12.43	0.0091	0.0161	12.54	12.34	0.976	0.0038	47	48	1.045
108	B U C 11	15.07	12.87	12.64	45.5	11	13.08	0.0168	0.0157	13.06	12.86	1.017	0.0036	47	47	1.033
109	B U C 11	15.01	12.82	12.59	45.4	73	11.40	0.0167	0.0176	11.41	11.21	0.891	0.0034	39	39	0.855
110	B U C 11	15.00	12.81	12.58	45.3	102	10.50	0.0263	0.0185	10.39	10.20	0.811	0.0055	58	57	1.266
111	B U C 14	15.02	12.83	12.59	45.4	11	12.96	0.0180	0.0157	12.92	12.72	1.010	0.0033	43	43	0.939
112	B U C 14	15.07	12.87	12.64	45.5	23	12.24	0.0157	0.0161	12.25	12.05	0.953	0.0039	48	48	1.050
113	B U C 14	15.08	12.88	12.64	45.6	45	11.68	0.0172	0.0168	11.67	11.48	0.908	0.0043	50	50	1.101
114	B U C 14	15.00	12.81	12.58	45.3	102	10.40	0.0216	0.0185	10.36	10.17	0.808	0.0048	50	50	1.099
115	B U C 14	15.03	12.83	12.60	45.4	73	11.56	0.0164	0.0176	11.58	11.37	0.903	0.0044	51	51	1.122
116	B U C 18	15.03	12.83	12.60	45.4	45	12.12	0.0167	0.0168	12.12	11.92	0.946	0.0038	46	46	1.015
117	B U C 18	15.02	12.83	12.59	45.4	73	11.14	0.0160	0.0176	11.16	10.97	0.871	0.0041	46	46	1.008
126	I U N D 7	9.04	8.21	7.27	55.1	12	7.35	0.1140	0.1194	7.41	6.52	0.897	0.0083	61	61	1.111
127	I U N D 7	9.11	8.28	7.33	55.6	69	6.42	0.1394	0.1445	6.47	5.54	0.755	0.0082	53	53	0.950
128	I U N D 7	9.14	8.30	7.35	55.7	99	5.99	0.1282	0.1577	6.27	5.28	0.718	0.0091	55	55	0.994
129	I U N D 7	9.15	8.31	7.36	55.8	42	6.64	0.1430	0.1326	6.54	5.67	0.770	0.0081	54	53	0.958
130	I U N D 7	9.03	8.20	7.26	55.1	21	7.06	0.1134	0.1233	7.16	6.28	0.865	0.0072	51	51	0.929
131	I U N D 9	9.01	8.19	7.25	54.9	21	7.15	0.1045	0.1233	7.35	6.44	0.889	0.0084	60	61	1.106
132	I U N D 9	9.18	8.34	7.38	56.0	12	7.45	0.1130	0.1194	7.52	6.62	0.897	0.0074	55	55	0.989
133	I U N D 9	9.25	8.40	7.44	56.4	42	6.78	0.1512	0.1326	6.59	5.72	0.768	0.0084	57	56	0.999
134	I U N D 9	9.35	8.49	7.52	57.0	99	5.93	0.1369	0.1577	6.12	5.16	0.686	0.0096	57	58	1.009
135	I U N D 9	9.21	8.37	7.41	56.2	69	6.42	0.1323	0.1445	6.54	5.60	0.755	0.0080	51	52	0.921
136	I U N D 20	9.07	8.24	7.29	55.3	12	7.50	0.1135	0.1194	7.57	6.66	0.914	0.0074	56	56	1.007

(continued) 1990 forest floor data

		ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SN	VN	FNMRt
137	I U N D 20	9.43	8.57	7.58	57.5	42	6.66	0.1217	0.1326	6.77	5.87	0.775	0.0092	61	62	1.072
138	I U N D 20	9.16	8.32	7.37	55.9	69	6.43	0.1359	0.1445	6.51	5.57	0.756	0.0082	53	53	0.948
139	I U N D 20	9.19	8.35	7.39	56.0	21	7.19	0.1212	0.1233	7.21	6.32	0.856	0.0080	58	58	1.028
140	I U N D 20	9.06	8.23	7.29	55.2	99	5.80	0.1440	0.1577	5.92	4.99	0.685	0.0093	54	54	0.984
141	I U N D 26	9.12	8.29	7.34	55.6	99	5.93	0.1257	0.1577	6.23	5.25	0.715	0.0105	62	63	1.136
142	I U N D 26	9.03	8.20	7.26	55.1	42	6.60	0.1175	0.1326	6.75	5.86	0.807	0.0075	49	50	0.907
143	I U N D 26	9.38	8.52	7.54	57.2	21	7.41	0.1154	0.1233	7.50	6.57	0.872	0.0085	63	63	1.106
144	I U N D 26	9.44	8.58	7.59	57.6	12	7.76	0.1159	0.1194	7.80	6.87	0.905	0.0070	54	54	0.945
145	I U N D 26	9.19	8.35	7.39	56.0	69	6.45	0.1344	0.1445	6.55	5.60	0.758	0.0092	59	60	1.065
146	I U N D 32	9.31	8.46	7.49	56.8	12	7.52	0.1151	0.1194	7.57	6.66	0.890	0.0074	56	56	0.982
147	I U N D 32	9.17	8.33	7.38	55.9	42	6.78	0.1152	0.1326	6.96	6.04	0.818	0.0085	58	58	1.041
148	I U N D 32	9.36	8.50	7.53	57.1	21	7.40	0.1270	0.1233	7.36	6.45	0.857	0.0076	56	56	0.983
149	I U N D 32	9.18	8.34	7.38	56.0	69	6.10	0.1065	0.1445	6.46	5.52	0.749	0.0087	53	54	0.968
150	I U N D 32	9.27	8.42	7.46	56.5	99	5.52	0.1320	0.1577	5.74	4.84	0.648	0.0112	62	63	1.106
151	I U S D 8	9.03	8.20	7.26	55.1	42	7.13	0.1137	0.1326	7.33	6.36	0.876	0.0088	63	63	1.151
152	I U S D 8	9.02	8.19	7.25	55.0	12	7.74	0.1176	0.1194	7.76	6.83	0.943	0.0074	57	57	1.043
153	I U S D 8	9.16	8.32	7.37	55.9	21	7.46	0.1211	0.1233	7.48	6.56	0.890	0.0079	59	59	1.056
154	I U S D 8	9.29	8.44	7.47	56.6	99	6.19	0.1266	0.1577	6.49	5.47	0.732	0.0104	64	65	1.154
155	I U S D 8	9.13	8.29	7.34	55.7	99	5.90	0.1420	0.1577	6.05	5.09	0.694	0.0085	50	51	0.908
156	I U S D 13	9.26	8.41	7.45	56.5	12	7.90	0.1173	0.1194	7.92	6.98	0.937	0.0077	61	61	1.078
157	I U S D 13	9.32	8.47	7.50	56.8	21	7.74	0.1141	0.1233	7.85	6.88	0.917	0.0080	62	62	1.096
158	I U S D 13	9.43	8.57	7.58	57.5	69	6.38	0.1344	0.1445	6.48	5.54	0.731	0.0090	57	58	1.004
159	I U S D 13	9.03	8.20	7.26	55.1	42	6.81	0.1267	0.1326	6.87	5.96	0.821	0.0079	54	54	0.980
160	I U S D 13	8.95	8.13	7.20	54.6	99	5.80	0.1368	0.1577	5.99	5.05	0.701	0.0090	52	53	0.967
161	I U S D 15	9.11	8.28	7.33	55.6	12	7.71	0.1118	0.1194	7.80	6.87	0.937	0.0080	62	62	1.114
162	I U S D 15	9.10	8.27	7.32	55.5	69	6.19	0.1178	0.1445	6.44	5.51	0.753	0.0090	56	57	1.018
163	I U S D 15	9.10	8.27	7.32	55.5	99	6.83	0.1709	0.1577	6.69	5.63	0.770	0.0086	59	58	1.050
164	I U S D 15	9.20	8.36	7.40	56.1	42	6.52	0.1216	0.1326	6.63	5.75	0.777	0.0083	54	54	0.971
165	I U S D 15	9.03	8.20	7.26	55.1	21	7.39	0.1271	0.1233	7.35	6.44	0.887	0.0067	50	49	0.896
166	I U S D 18	9.24	8.39	7.43	56.3	12	7.83	0.1243	0.1194	7.77	6.84	0.921	0.0071	56	55	0.984
167	I U S D 18	9.17	8.33	7.38	55.9	21	7.43	0.1208	0.1233	7.46	6.54	0.886	0.0082	61	61	1.092
168	I U S D 18	9.06	8.23	7.29	55.2	69	6.33	0.1192	0.1445	6.58	5.63	0.772	0.0086	54	55	1.000
169	I U S D 18	9.15	8.31	7.36	55.8	42	6.89	0.1266	0.1326	6.95	6.03	0.819	0.0077	53	53	0.954
171	I U S D 24	9.18	8.34	7.38	56.0	99	6.06	0.1410	0.1577	6.22	5.24	0.710	0.0084	51	51	0.918

(continued) 1990 forest floor data

		ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SN	VN	FNMRt
172	I U S D 24	9.02	8.19	7.25	55.0	69	6.24	0.1386	0.1445	6.30	5.39	0.743	0.0089	56	56	1.013
173	I U S D 24	9.10	8.27	7.32	55.5	21	7.02	0.1280	0.1233	6.97	6.11	0.835	0.0076	53	53	0.958
174	I U S D 24	9.16	8.32	7.37	55.9	42	6.59	0.1246	0.1326	6.67	5.79	0.785	0.0087	57	58	1.030
175	I U S D 24	9.07	8.24	7.29	55.3	12	7.44	0.1073	0.1194	7.57	6.67	0.915	0.0073	54	55	0.990
176	I R S D 7	9.17	8.33	7.38	55.9	99	7.13	0.2097	0.1577	6.55	5.51	0.747	0.0080	57	55	0.988
177	I R S D 7	9.33	8.48	7.50	56.9	12	7.72	0.1120	0.1194	7.80	6.87	0.916	0.0073	56	57	0.995
178	I R S D 7	9.24	8.39	7.43	56.3	21	7.42	0.1116	0.1233	7.55	6.62	0.891	0.0079	59	59	1.049
179	I R S D 7	9.09	8.26	7.31	55.4	69	6.04	0.1487	0.1445	6.00	5.13	0.702	0.0106	64	64	1.153
180	I R S D 7	9.31	8.46	7.49	56.8	42	7.87	0.1389	0.1326	7.79	6.76	0.903	0.0081	64	64	1.118
181	I R S D 10	9.22	8.38	7.42	56.2	42	6.79	0.1310	0.1326	6.81	5.90	0.796	0.0090	61	61	1.088
182	I R S D 10	9.17	8.33	7.38	55.9	99	6.22	0.1696	0.1577	6.10	5.14	0.697	0.0099	62	61	1.095
183	I R S D 10	9.10	8.27	7.32	55.5	21	7.13	0.1160	0.1233	7.21	6.32	0.863	0.0082	58	59	1.058
184	I R S D 10	9.12	8.29	7.34	55.6	69	6.56	0.1906	0.1445	6.09	5.21	0.710	0.0095	62	61	1.095
185	I R S D 10	9.04	8.21	7.27	55.1	12	7.41	0.0963	0.1194	7.66	6.75	0.928	0.0074	55	56	1.010
186	I R S D 19	9.31	8.46	7.49	56.8	69	9.15	0.2383	0.1445	7.82	6.69	0.894	0.0071	65	61	1.071
187	I R S D 19	9.28	8.43	7.46	56.6	12	7.70	0.1275	0.1194	7.61	6.70	0.898	0.0075	58	57	1.015
188	I R S D 19	9.39	8.53	7.55	57.3	99	5.20	0.1747	0.1577	5.06	4.26	0.565	0.0093	48	48	0.837
189	I R S D 19	9.14	8.30	7.35	55.7	21	7.30	0.1415	0.1233	7.10	6.23	0.847	0.0097	71	70	1.260
190	I R S D 19	9.43	8.57	7.58	57.5	42	7.16	0.1283	0.1326	7.21	6.25	0.825	0.0089	64	64	1.111
191	I R N D 8	9.27	8.42	7.46	56.5	99	8.92	0.3289	0.1577	6.51	5.49	0.735	0.0079	70	63	1.117
192	I R N D 8	9.28	8.43	7.46	56.6	12	8.18	0.1427	0.1194	7.90	6.95	0.932	0.0078	64	63	1.111
193	I R N D 8	9.36	8.50	7.53	57.1	42	7.76	0.1993	0.1326	6.97	6.05	0.803	0.0077	60	57	1.003
194	I R N D 8	9.14	8.30	7.35	55.7	21	7.52	0.1455	0.1233	7.27	6.37	0.867	0.0082	62	61	1.093
195	I R N D 8	9.39	8.53	7.55	57.3	69	8.07	0.2439	0.1445	6.83	5.84	0.774	0.0084	68	64	1.115
196	I R N D 12	9.40	8.54	7.56	57.3	12	7.75	0.1105	0.1194	7.85	6.91	0.915	0.0079	61	62	1.074
197	I R N D 12	9.32	8.47	7.50	56.8	21	7.35	0.1181	0.1233	7.41	6.49	0.866	0.0094	69	69	1.220
198	I R N D 12	9.05	8.22	7.28	55.2	42	7.04	0.1175	0.1326	7.20	6.25	0.858	0.0089	63	63	1.144
199	I R N D 12	9.14	8.30	7.35	55.7	99	8.12	0.3336	0.1577	5.87	4.94	0.673	0.0080	65	58	1.043
200	I R N D 12	9.19	8.35	7.39	56.0	69	9.80	0.3436	0.1445	6.79	5.81	0.786	0.0083	81	72	1.284
201	B R D 1	9.25	8.40	7.44	56.4	102	6.56	0.2165	0.1590	5.96	5.02	0.674	0.0087	57	55	0.980
202	B R D 1	9.06	8.23	7.29	55.2	102	5.95	0.1507	0.1590	6.03	5.07	0.695	0.0093	55	56	1.007
203	B R D 1	9.12	8.29	7.34	55.6	11	8.09	0.1297	0.1189	7.96	7.01	0.956	0.0076	61	61	1.098
204	B R D 1	9.34	8.49	7.51	57.0	73	5.99	0.1547	0.1462	5.91	5.05	0.672	0.0088	53	52	0.920
205	B R D 1	9.19	8.35	7.39	56.0	45	6.75	0.1263	0.1339	6.83	5.91	0.800	0.0085	57	58	1.029

(continued) 1990 forest floor data

			ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SN	VN	FNMRt
206	B R	D 4	9.10	8.27	7.32	55.5	23	7.13	0.1305	0.1242	7.06	6.19	0.845	0.0079	56	56	1.011
207	B R	D 4	9.10	8.27	7.32	55.5	73	5.65	0.1260	0.1462	5.83	4.97	0.680	0.0089	50	51	0.916
208	B R	D 4	9.10	8.27	7.32	55.5	45	6.81	0.1235	0.1339	6.92	5.99	0.818	0.0090	61	62	1.110
209	B R	D 4	9.08	8.25	7.30	55.4	11	7.91	0.1182	0.1189	7.92	6.98	0.956	0.0062	49	49	0.886
210	B R	D 4	9.29	8.44	7.47	56.6	102	5.84	0.1500	0.1590	5.92	4.98	0.667	0.0098	57	57	1.016
211	B R	D 6	9.25	8.40	7.44	56.4	73	6.42	0.1707	0.1462	6.18	5.27	0.709	0.0076	49	48	0.852
212	B R	D 6	9.36	8.50	7.53	57.1	23	7.40	0.1215	0.1242	7.43	6.51	0.864	0.0071	53	53	0.922
213	B R	D 6	9.84	8.94	7.91	60.0	45	7.14	0.1626	0.1339	6.83	5.91	0.748	0.0069	49	48	0.805
214	B R	D 6	9.80	8.90	7.88	59.8	102	6.44	0.1522	0.1590	6.51	5.47	0.695	0.0079	51	51	0.854
215	B R	D 6	9.54	8.67	7.67	58.2	11	7.80	0.1152	0.1189	7.84	6.91	0.901	0.0070	55	55	0.941
216	B R	D 13	9.44	8.58	7.59	57.6	23	7.13	0.1345	0.1242	7.02	6.15	0.810	0.0077	55	55	0.947
217	B R	D 13	9.41	8.55	7.57	57.4	102	5.40	0.1348	0.1590	5.61	4.71	0.623	0.0093	50	51	0.886
218	B R	D 13	9.77	8.88	7.86	59.6	73	6.49	0.1969	0.1462	5.98	5.11	0.650	0.0081	53	51	0.855
219	B R	D 13	9.51	8.64	7.65	58.0	45	6.61	0.1782	0.1339	6.17	5.34	0.698	0.0078	52	50	0.865
220	B R	D 13	9.50	8.63	7.64	57.9	11	8.06	0.1287	0.1189	7.94	7.00	0.916	0.0066	53	53	0.912
221	B R	D 18	9.48	8.61	7.62	57.8	11	7.88	0.1205	0.1189	7.86	6.93	0.909	0.0075	59	59	1.021
222	B R	D 18	9.51	8.64	7.65	58.0	73	6.02	0.1368	0.1462	6.11	5.21	0.682	0.0071	43	43	0.742
223	B R	D 18	9.30	8.45	7.48	56.7	45	7.02	0.2134	0.1339	6.17	5.35	0.715	0.0080	56	53	0.943
224	B R	D 18	9.49	8.62	7.63	57.9	102	5.48	0.1497	0.1590	5.56	4.68	0.613	0.0090	49	50	0.856
225	B R	D 18	9.83	8.93	7.91	59.9	23	7.31	0.1752	0.1242	6.75	5.91	0.748	0.0074	54	52	0.873
226	B U	D 2	9.77	8.88	7.86	59.6	23	6.99	0.1247	0.1242	6.98	6.12	0.778	0.0070	49	49	0.821
227	B U	D 2	9.47	8.60	7.62	57.7	102	5.38	0.1608	0.1590	5.36	4.51	0.592	0.0100	54	54	0.932
228	B U	D 2	9.68	8.79	7.79	59.0	45	6.59	0.0627	0.1339	7.30	6.33	0.812	0.0072	47	50	0.843
229	B U	D 2	9.89	8.99	7.95	60.3	73	5.73	0.1571	0.1462	5.63	4.81	0.605	0.0096	55	55	0.907
230	B U	D 2	9.83	8.93	7.91	59.9	11	7.71	0.1228	0.1189	7.67	6.75	0.854	0.0078	60	60	1.002
231	B U	D 8	9.46	8.59	7.61	57.7	23	7.03	0.1187	0.1242	7.09	6.21	0.816	0.0079	56	56	0.966
232	B U	D 8	9.63	8.75	7.75	58.7	102	5.83	0.1384	0.1590	6.02	5.06	0.653	0.0091	53	54	0.914
233	B U	D 8	9.59	8.71	7.71	58.5	11	7.32	0.1253	0.1189	7.25	6.39	0.829	0.0079	58	58	0.985
234	B U	D 8	10.09	9.17	8.12	61.5	45	5.71	0.1416	0.1339	5.64	4.89	0.602	0.0080	46	45	0.739
235	B U	D 8	9.82	8.92	7.90	59.9	73	5.44	0.1563	0.1462	5.36	4.57	0.579	0.0096	52	52	0.867
236	B U	D 13	9.12	8.29	7.34	55.6	11	7.95	0.1458	0.1189	7.63	6.72	0.916	0.0065	52	51	0.911
237	B U	D 13	9.12	8.29	7.34	55.6	73	6.85	0.1451	0.1462	6.86	5.86	0.798	0.0090	62	62	1.109
238	B U	D 13	9.08	8.25	7.30	55.4	102	6.33	0.1522	0.1590	6.40	5.38	0.737	0.0095	60	60	1.089
239	B U	D 13	9.40	8.54	7.56	57.3	23	7.43	0.1225	0.1242	7.45	6.52	0.863	0.0083	62	62	1.077

(continued) 1990 forest floor data

			ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SN	VN	FNMRt
240	B U	D 13	9.45	8.59	7.60	57.6	45	6.99	0.1372	0.1339	6.95	6.02	0.793	0.0082	57	57	0.993
241	B U	D 15	9.31	8.46	7.49	56.8	102	5.76	0.1385	0.1590	5.95	5.00	0.668	0.0104	60	60	1.065
242	B U	D 15	9.20	8.36	7.40	56.1	23	7.54	0.1197	0.1242	7.59	6.65	0.898	0.0077	58	58	1.038
243	B U	D 15	9.30	8.45	7.48	56.7	45	7.00	0.1098	0.1339	7.26	6.28	0.840	0.0089	62	63	1.113
244	B U	D 15	9.51	8.64	7.65	58.0	11	7.65	0.1155	0.1189	7.69	6.77	0.886	0.0064	49	49	0.846
245	B U	D 15	9.39	8.53	7.55	57.3	73	6.29	0.1411	0.1462	6.34	5.41	0.717	0.0088	55	56	0.969
246	B U	D 19	9.14	8.30	7.35	55.7	102	5.90	0.1624	0.1590	5.87	4.94	0.671	0.0100	59	59	1.057
247	B U	D 19	9.49	8.62	7.63	57.9	73	6.34	0.1573	0.1462	6.23	5.32	0.697	0.0090	57	57	0.980
248	B U	D 19	9.18	8.34	7.38	56.0	23	7.17	0.1226	0.1242	7.19	6.29	0.853	0.0082	59	59	1.051
249	B U	D 19	9.14	8.30	7.35	55.7	11	8.13	0.1294	0.1189	8.00	7.05	0.959	0.0071	58	57	1.029
250	B U	D 19	9.16	8.32	7.37	55.9	45	6.68	0.1480	0.1339	6.54	5.66	0.768	0.0084	56	56	0.996
251	B R	P 5	15.55	8.45	7.85	152.9	102	6.05	0.0719	0.0708	6.04	5.61	0.715	0.0273	165	165	1.080
252	B R	P 5	19.06	10.35	9.62	187.4	23	8.63	0.0542	0.0708	8.83	8.20	0.853	0.0215	186	186	0.994
253	B R	P 5	25.52	13.86	12.88	250.9	73	6.85	0.0786	0.0708	6.78	6.30	0.489	0.0224	153	153	0.611
254	B R	P 5	25.12	13.64	12.68	246.9	45	13.54	0.0634	0.0708	13.68	12.71	1.002	0.0233	315	316	1.280
255	B R	P 5	26.00	14.12	13.12	255.6	11	13.57	0.0538	0.0708	13.89	12.91	0.984	0.0171	232	233	0.912
256	B R	P 8	25.63	13.92	13.35	252.0	45	8.58	0.0633	0.0708	8.67	8.06	0.603	0.0291	250	250	0.992
257	B R	P 8	25.41	13.80	12.82	249.8	73	8.15	0.0548	0.0708	8.33	7.74	0.604	0.0296	241	242	0.968
258	B R	P 8	24.99	13.57	12.61	245.7	102	8.37	0.0802	0.0708	8.26	7.68	0.609	0.0288	241	241	0.980
259	B R	P 8	25.21	13.69	12.72	247.8	23	10.52	0.0643	0.0708	10.61	9.86	0.775	0.0193	203	203	0.821
260	B R	P 8	25.36	13.77	12.80	249.3	11	14.63	0.0761	0.0708	14.52	13.49	1.054	0.0208	304	304	1.219
261	B R	P 10	25.72	13.97	12.98	252.8	23	11.63	0.0489	0.0708	11.98	11.13	0.858	0.0214	249	250	0.989
262	B R	P 10	25.74	13.98	12.99	253.0	73	9.31	0.1521	0.0708	8.26	7.68	0.591	0.0207	193	189	0.747
263	B R	P 10	25.81	14.02	13.03	253.7	11	14.53	0.0665	0.0708	14.62	13.58	1.042	0.0215	312	313	1.233
264	B R	P 10	26.32	14.29	13.28	258.7	23	11.49	0.0667	0.0708	11.56	10.74	0.809	0.0206	237	237	0.916
265	B R	P 10	27.59	14.98	13.92	271.2	45	10.58	0.0662	0.0708	10.65	9.89	0.711	0.0185	196	196	0.723
266	B R	P 17	25.55	13.88	12.89	251.2	23	11.43	0.0634	0.0708	11.55	10.73	0.832	0.0220	251	252	1.003
267	B R	P 17	25.89	14.06	13.07	254.5	45	10.89	0.0729	0.0708	10.86	10.09	0.772	0.0223	243	243	0.954
268	B R	P 17	26.16	14.21	13.20	257.2	102	7.92	0.2167	0.0708	6.32	5.87	0.445	0.0225	178	173	0.671
269	B R	P 17	25.67	13.94	12.95	252.3	11	12.17	0.0741	0.0708	12.11	11.26	0.869	0.0206	251	251	0.993
270	B R	P 17	25.14	13.65		247.1	73	7.20	0.0615	0.0708	7.29	6.78	ERR	0.0215	155	155	0.628
271	B R	P 20	26.17	14.21	13.21	257.3	23	11.37	0.0588	0.0708	11.56	10.74	0.813	0.0178	202	203	0.789
272	B R	P 20	25.20	13.69	12.72	247.7	45	8.75	0.0956	0.0708	8.45	7.85	0.617	0.0253	221	220	0.889
273	B R	P 20	25.79	14.01	13.02	253.5	73	8.75	0.0659	0.0708	8.81	8.19	0.629	0.0287	251	251	0.991

(continued) 1990 forest floor data

			ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SN	VN	FNMRt
274	B R	P 20	25.60	13.90	12.92	251.7	11	13.84	0.0716	0.0708	13.82	12.85	0.994	0.0203	281	281	1.116
275	B R	P 20	26.06	14.15	13.15	256.2	102	5.86	0.0717	0.0708	5.85	5.44	0.414	0.0272	159	159	0.622
276	B U	P 4	23.65	12.84	11.94	232.5	11	13.30	0.0575	0.0708	13.55	12.59	1.054	0.0223	297	297	1.279
277	B U	P 4	25.68	13.95	12.96	252.4	23	12.77	0.0663	0.0708	12.85	11.94	0.921	0.0227	290	290	1.150
278	B U	P 4	26.54	14.41	13.39	260.9	102	8.49	0.0607	0.0708	8.61	8.00	0.597	0.0276	234	235	0.900
279	B U	P 4	25.60	13.90	12.92	251.7	73	9.41	0.0574	0.0708	9.58	8.91	0.689	0.0248	233	234	0.930
280	B U	P 4	27.07	14.70	13.66	266.1	45	10.50	0.0496	0.0708	10.81	10.04	0.735	0.0201	211	212	0.797
281	B U	P 7	26.15	14.20	13.20	257.1	11	13.49	0.0584	0.0708	13.72	12.75	0.966	0.0196	264	265	1.032
282	B U	P 7	25.47	13.83	12.85	250.4	73	7.77	0.0782	0.0708	7.69	7.15	0.556	0.0261	203	203	0.809
283	B U	P 7	25.69	13.95	12.96	252.5	45	8.27	0.0625	0.0708	8.37	7.77	0.600	0.0242	200	200	0.794
284	B U	P 7	25.57	13.89	12.90	251.4	102	7.83	0.0804	0.0708	7.73	7.18	0.556	0.0223	175	174	0.693
285	B U	P 7	26.52	14.40	13.38	260.7	23	10.99	0.0685	0.0708	11.03	10.24	0.766	0.0216	237	238	0.911
286	B U	P 9	28.53	15.50	14.40	280.5	73	10.76	0.0709	0.0708	10.76	10.00	0.694	0.0231	249	249	0.886
287	B U	P 9	25.69	13.95	12.96	252.5	11	14.56	0.0625	0.0708	14.73	13.68	1.056	0.0187	272	273	1.081
288	B U	P 9	29.40	15.97	14.84	289.0	102	8.88	0.0723	0.0708	8.86	8.23	0.555	0.0228	202	202	0.700
289	B U	P 9	26.23	14.25	13.24	257.9	23	12.37	0.0558	0.0708	12.63	11.73	0.886	0.0258	319	320	1.241
290	B U	P 9	25.81	14.02	13.03	253.7	45	10.64	0.0681	0.0708	10.68	9.92	0.762	0.0255	271	271	1.070
291	B U	P 17	26.51	14.40	13.38	260.6	45	10.44	0.0526	0.0708	10.70	9.95	0.743	0.0226	236	237	0.909
292	B U	P 17	26.04	14.14	13.14	256.0	73	9.85	0.0534	0.0708	10.09	9.37	0.713	0.0248	244	245	0.957
293	B U	P 17	25.50	13.85	12.87	250.7	102	5.91	0.0486	0.0708	6.09	5.66	0.440	0.0219	129	130	0.519
294	B U	P 17	27.29	14.82	13.77	268.3	23	11.95	0.0636	0.0708	12.07	11.21	0.814	0.0237	283	284	1.057
295	B U	P 17	25.29	13.74	12.76	248.6	11	14.56	0.0619	0.0708	14.74	13.70	1.073	0.0191	278	279	1.121
296	B U	P 20	26.57	14.43	13.41	261.2	23	12.15	0.0774	0.0708	12.04	11.19	0.834	0.0198	241	240	0.920
297	B U	P 20	27.71	15.05	13.98	272.4	11	12.92	0.0608	0.0708	13.10	12.17	0.871	0.0225	291	291	1.069
298	B U	P 20	25.76	13.99	13.00	253.2	102	7.86	0.0747	0.0708	7.82	7.26	0.559	0.0190	149	149	0.589
299	B U	P 20	25.85	14.04	13.05	254.1	45	10.05	0.0699	0.0708	10.06	9.35	0.716	0.0248	249	249	0.981
300	B U	P 20	27.22	14.78	13.74	267.6	73	9.06	0.0885	0.0708	8.84	8.21	0.598	0.0252	228	228	0.850
301	I U N	P 3	25.71	13.96	12.97	252.7	12	12.20	0.0595	0.0708	12.39	11.51	0.888	0.0212	259	259	1.026
302	I U N	P 3	26.63	14.46	13.44	261.8	21	12.64	0.0718	0.0708	12.62	11.73	0.873	0.0209	264	264	1.009
303	I U N	P 3	25.80	14.01	13.02	253.6	42	9.59	0.0777	0.0708	9.50	8.83	0.678	0.0254	244	243	0.959
304	I U N	P 3	27.30	14.83	13.78	268.4	99	7.60	0.0819	0.0708	7.48	6.95	0.505	0.0262	199	199	0.740
305	I U N	P 3	27.41	14.89	13.83	269.5	69	9.32	0.0874	0.0708	9.11	8.46	0.612	0.0264	246	245	0.910
306	I U N	P 8	26.56	14.43	13.40	261.1	21	11.34	0.0546	0.0708	11.59	10.77	0.804	0.0215	244	245	0.937
307	I U N	P 8	25.34	13.76	12.79	249.1	99	7.28	0.0601	0.0708	7.39	6.86	0.537	0.0234	170	171	0.685

(continued) 1990 forest floor data

		ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SN	VN	FNMRt
308	I U N P 8	27.30	14.83	13.78	268.4	12	12.44	0.0468	0.0708	12.85	11.94	0.867	0.0203	253	254	0.946
309	I U N P 8	27.00	14.66	13.63	265.4	69	8.80	0.0475	0.0708	9.08	8.44	0.619	0.0219	193	194	0.730
310	I U N P 8	27.10	14.72	13.68	266.4	42	10.15	0.0577	0.0708	10.33	9.60	0.702	0.0209	212	213	0.799
311	I U N P 13	26.51	14.40	13.38	260.6	42	9.12	0.0491	0.0708	9.39	8.73	0.652	0.0198	181	182	0.697
312	I U N P 13	26.07	14.16	13.16	256.3	99	6.19	0.0580	0.0708	6.30	5.85	0.445	0.0223	138	138	0.540
313	I U N P 13	27.77	15.08	14.01	273.0	21	13.27	0.0561	0.0708	13.54	12.58	0.898	0.0194	257	258	0.946
314	I U N P 13	25.82	14.02	13.03	253.8	69	7.02	0.0606	0.0708	7.12	6.62	0.508	0.0200	140	141	0.555
315	I U N P 13	26.91	14.62	13.58	264.5	12	13.44	0.0571	0.0708	13.70	12.73	0.937	0.0197	265	266	1.004
316	I U N P 28	25.42	13.81	12.83	249.9	99	7.39	0.0601	0.0708	7.50	6.97	0.543	0.0217	160	161	0.643
317	I U N P 28	25.36	13.77	12.80	249.3	69	8.84	0.0720	0.0708	8.83	8.20	0.641	0.0249	220	220	0.883
318	I U N P 28	27.80	15.10	14.03	273.3	42	9.70	0.0529	0.0708	9.94	9.24	0.658	0.0196	190	191	0.699
319	I U N P 28	27.90	15.15	14.08	274.3	12	14.55	0.0651	0.0708	14.66	13.63	0.968	0.0220	320	320	1.168
320	I U N P 28	26.51	14.40	13.38	260.6	21	12.25	0.0579	0.0708	12.47	11.59	0.866	0.0223	273	274	1.051
321	I U N P 31	27.76	15.08	14.01	272.9	69	9.10	0.0602	0.0708	9.23	8.58	0.612	0.0230	209	210	0.769
322	I U N P 31	29.39	15.96	14.83	288.9	12	13.89	0.0514	0.0708	14.26	13.25	0.894	0.0209	290	292	1.009
323	I U N P 31	25.96	14.10	13.10	255.2	99	7.80	0.0580	0.0708	7.94	7.38	0.563	0.0241	188	188	0.738
324	I U N P 31	27.01	14.67	13.63	265.5	21	13.75	0.0516	0.0708	14.12	13.12	0.962	0.0224	308	309	1.165
325	I U N P 31	25.17	13.67	12.70	247.4	42	9.27	0.0548	0.0708	9.48	8.80	0.693	0.0227	210	211	0.853
326	I U S P 2	25.70	13.96	12.97	252.6	69	9.46	0.0765	0.0708	9.39	8.72	0.672	0.0236	223	223	0.883
327	I U S P 2	25.98	14.11	13.11	255.4	12	14.87	0.0524	0.0708	15.25	14.17	1.081	0.0175	260	262	1.024
328	I U S P 2	25.27	13.72	12.75	248.4	99	7.35	0.0559	0.0708	7.50	6.97	0.547	0.0259	190	191	0.768
329	I U S P 2	25.89	14.06	13.07	254.5	42	8.90	0.1091	0.0708	8.43	7.83	0.599	0.0179	159	158	0.620
330	I U S P 2	26.70	14.50	13.47	262.5	21	11.49	0.0519	0.0708	11.79	10.96	0.813	0.0202	232	233	0.888
331	I U S P 9	26.93	14.63	13.59	264.7	12	12.28	0.0551	0.0708	12.55	11.66	0.858	0.0211	259	260	0.982
332	I U S P 9	27.05	14.69	13.65	265.9	99	9.20	0.0747	0.0708	9.15	8.50	0.623	0.0259	238	238	0.895
333	I U S P 9	26.13	14.19	13.19	256.9	21	14.31	0.0689	0.0708	14.35	13.33	1.011	0.0174	249	249	0.970
334	I U S P 9	25.51	13.85	12.87	250.8	69	8.76	0.0507	0.0708	9.00	8.37	0.650	0.0257	225	226	0.901
335	I U S P 9	25.68	13.95	12.96	252.4	42	8.57	0.0631	0.0708	8.66	8.05	0.621	0.0244	209	209	0.830
336	I U S P 12	26.47	14.38	13.36	260.2	12	14.48	0.0573	0.0708	14.75	13.71	1.026	0.0208	301	302	1.161
337	I U S P 12	26.24	14.25	13.24	258.0	21	10.43	0.0637	0.0708	10.53	9.79	0.739	0.0206	215	215	0.834
338	I U S P 12	25.69	13.95	12.96	252.5	42	9.59	0.0623	0.0708	9.70	9.02	0.696	0.0241	231	232	0.917
339	I U S P 12	25.18	13.68	12.71	247.5	99	6.98	0.0660	0.0708	7.03	6.53	0.514	0.0247	172	173	0.697
340	I U S P 12	26.04	14.14	13.14	256.0	69	8.20	0.0636	0.0708	8.28	7.70	0.586	0.0254	208	209	0.815
341	I U S P 14	25.45	13.82	12.84	250.2	21	11.02	0.0577	0.0708	11.22	10.43	0.812	0.0234	258	259	1.033

(continued) 1990 forest floor data

						ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SN	VN	FNMRt
342	I	U	S	P	14	26.25	14.26	13.25	258.0	42	10.52	0.0677	0.0708	10.57	9.82	0.741	0.0238	250	251	0.971
343	I	U	S	P	14	26.11	14.18	13.18	256.7	99	7.71	0.0937	0.0708	7.47	6.94	0.526	0.0236	182	181	0.706
344	I	U	S	P	14	25.00	17.35	16.12	314.0	12	14.39	0.0630	0.0708	14.55	13.52	0.838	0.0222	319	320	1.019
345	I	U	S	P	14	25.27	17.51	16.27	316.9	69	9.43	0.0717	0.0708	9.42	8.75	0.538	0.0248	234	234	0.738
346	I	U	S	P	29	26.09	18.06	16.78	326.8	42	10.07	0.0595	0.0708	10.23	9.50	0.566	0.0267	269	269	0.824
347	I	U	S	P	29	25.05	17.31	16.09	313.4	69	7.79	0.0784	0.0708	7.71	7.16	0.445	0.0213	166	166	0.529
348	I	U	S	P	29	25.79	17.80	16.41	322.2	12	15.30	0.0611	0.0780	15.66	14.44	0.880	0.0198	303	304	0.944
349	I	U	S	P	29	25.07	17.28	15.93	302.5	99	9.33	0.1117	0.0780	8.89	8.20	0.515	0.0231	216	214	0.707
350	I	U	S	P	29	24.33	16.75	15.44	293.1	21	9.73	0.0530	0.0780	10.07	9.29	0.601	0.0209	203	205	0.698
351	I	R	S	P	9	25.18	17.31	15.96	303.0	69	13.15	0.1966	0.0780	10.97	10.11	0.633	0.0179	235	228	0.752
352	I	R	S	P	9	26.87	18.45	17.01	322.9	12	15.30	0.0558	0.0780	15.78	14.55	0.855	0.0227	347	349	1.081
353	I	R	S	P	9	23.65	16.22	14.95	283.8	42	10.87	0.0781	0.0780	10.87	10.02	0.670	0.0234	254	254	0.896
354	I	R	S	P	9	21.38	14.64	13.50	256.3	99	6.46	0.1926	0.0780	5.42	5.00	0.370	0.0183	118	115	0.447
355	I	R	S	P	9	21.99	15.04	13.87	263.2	21	11.05	0.0662	0.0780	11.23	10.36	0.747	0.0204	225	226	0.859
356	I	R	S	P	15	20.29	13.86	12.78	242.6	42	9.63	0.0687	0.0780	9.76	8.99	0.704	0.0225	217	217	0.895
357	I	R	S	P	15	22.35	15.25	14.06	266.9	12	11.10	0.0650	0.0780	11.30	10.42	0.741	0.0204	226	227	0.851
358	I	R	S	P	15	20.32	13.85	12.77	242.3	69	9.78	0.1749	0.0780	8.45	7.79	0.610	0.0208	203	199	0.821
359	I	R	S	P	15	20.96	14.26	13.15	249.6	99	7.80	0.2451	0.0780	5.97	5.51	0.419	0.0177	138	132	0.528
360	I	R	S	P	15	20.22	13.74	12.67	240.5	21	10.01	0.0811	0.0780	9.97	9.19	0.725	0.0212	212	212	0.882
361	I	R	S	P	23	20.04	13.60	12.54	238.0	42	7.79	0.0627	0.0780	7.96	7.34	0.585	0.0197	153	154	0.647
362	I	R	S	P	23	20.23	13.71	12.64	240.0	69	6.61	0.0744	0.0780	6.64	6.13	0.485	0.0200	132	132	0.551
363	I	R	S	P	23	20.75	14.05	12.95	245.8	12	10.79	0.0619	0.0780	11.03	10.17	0.786	0.0205	221	222	0.903
364	I	R	S	P	23	20.91	14.14	13.03	247.4	99	8.17	0.1457	0.0780	7.40	6.82	0.523	0.0231	189	186	0.752
365	I	R	S	P	23	20.62	13.92	12.84	243.6	21	9.83	0.0722	0.0780	9.91	9.14	0.712	0.0211	207	208	0.853
366	I	R	N	P	1	20.29	13.68	12.61	239.4	21	8.66	0.0676	0.0780	8.79	8.10	0.642	0.0201	174	175	0.729
367	I	R	N	P	1	20.35	13.70	12.63	239.8	99	5.41	0.0768	0.0780	5.42	5.00	0.396	0.0237	128	128	0.535
368	I	R	N	P	1	19.71	13.25	12.22	232.0	69	8.45	0.1082	0.0780	8.09	7.46	0.611	0.0211	178	177	0.763
369	I	R	N	P	1	20.27	13.61	12.55	238.2	12	13.65	0.0595	0.0780	14.00	12.91	1.029	0.0181	247	248	1.042
370	I	R	N	P	1	21.01	14.09	12.99	246.6	42	9.59	0.0683	0.0780	9.72	8.96	0.690	0.0185	177	178	0.721
371	I	R	N	P	7	21.03	14.09	12.99	246.5	12	11.98	0.0726	0.0780	12.07	11.13	0.857	0.0204	244	245	0.993
372	I	R	N	P	7	22.37	14.96	13.80	261.9	42	11.95	0.0902	0.0780	11.75	10.83	0.785	0.0212	253	253	0.965
373	I	R	N	P	7	20.89	13.96	12.87	244.2	21	12.09	0.0611	0.0780	12.38	11.41	0.887	0.0177	214	215	0.880
374	I	R	N	P	7	22.74	15.17	13.99	265.5	99	8.31	0.2116	0.0780	6.76	6.23	0.445	0.0194	161	156	0.587
375	I	R	N	P	7	21.78	14.51	13.38	253.9	69	7.39	0.1433	0.0780	6.71	6.19	0.463	0.0203	150	148	0.582

1990 suspended foliage data and calculations sorted by nitrogen analysis composites sample .

Sample/ Process/ ID	Composite ID	SP	Whole Sample Initial Mass	Est. Dry Mass	POST-TREATMENT Elapsed Time (days	Foliage Mass	Wood Tissue Mass	Estimated Initial Foliage Mass	Fraction Foliage Remainin	Nitrogen Concentration Wood	
ID	Compl	Sp	ISMt0	SDMt0	t	FMt	TMt	EstFM	FFRt	FN%	TN%
444	20	C	20.53	10.63	16	6.88	2.89	7.74	0.889	0.60	0.97
445	20	C	21.21	10.98	16	6.42	3.45	7.53	0.853		
465	20	C	27.13	14.05	16	10.90	3.78	10.27	1.062		
431	21	C	17.73	9.18	38	5.69	2.54	6.64	0.857	0.57	0.99
441	21	C	24.00	12.42	16	7.26	4.11	8.31	0.873		
476	21	C	23.67	12.26	16	9.84	1.74	10.52	0.936		
437	22	C	27.71	14.35	16	10.57	2.45	11.90	0.889	0.62	0.93
468	22	C	24.72	12.80	16	10.66	2.82	9.98	1.068		
478	22	C	23.89	12.37	16	8.93	2.97	9.40	0.950		
432	23	C	17.66	9.15	16	5.39	2.57	6.58	0.820	0.63	0.97
452	23	C	23.27	12.05	16	8.39	3.24	8.81	0.953		
471	23	C	22.77	11.79	16	10.78	2.16	9.63	1.119		
477	23	C	23.02	11.92	16	9.30	2.42	9.50	0.979		
455	24	C	22.24	11.51	38	7.46	2.56	8.95	0.833	0.68	0.98
462	24	C	24.47	12.67	38	9.69	3.16	9.51	1.019		
474	24	C	24.81	12.85	38	9.62	1.86	10.99	0.876		
427	25	C	15.15	7.85	38	4.65	2.14	5.71	0.815	0.57	0.94
451	25	C	20.49	10.61	38	7.41	2.66	7.95	0.933		
480	25	C	23.55	12.19	38	8.40	2.35	9.84	0.853		
453	26	C	27.43	14.20	38	7.18	4.02	10.18	0.705	0.58	1.11
464	26	C	24.91	12.90	38	9.13	3.38	9.52	0.960		
473	26	C	26.63	13.78	38	9.73	2.62	11.17	0.871		
436	27	C	20.50	10.61	38	6.86	2.06	8.55	0.802	0.62	0.96
479	27	C	23.89	12.37	38	9.54	1.98	10.39	0.919		
461	28	C	26.75	13.85	66	10.67	2.95	10.90	0.979		
470	28	C	20.29	10.50	66	8.64	3.06	7.44	1.161	0.65	0.90
482	28	C	27.11	14.04	66	9.94	2.35	11.69	0.851		
428	29	C	18.15	9.40	66	6.02	1.63	7.77	0.775	0.57	0.99
447	29	C	27.07	14.02	66	8.22	3.22	10.80	0.761		
484	29	C	28.15	14.57	66	9.79	1.83	12.74	0.768		
426	30	C	21.70	11.23	66	7.73	3.28	7.96	0.972	0.67	1.04
438	30	C	25.44	13.17	66	8.96	1.83	11.34	0.790		
450	30	C	22.45	11.62	66	6.64	2.77	8.85	0.750		
433	31	C	19.37	10.03	66	6.06	2.7	7.33	0.827	0.63	1.08
457	31	C	23.26	12.04	66	6.95	2.82	9.22	0.754		
469	31	C	21.25	11.00	66	9.43	2.03	8.97	1.051		

(cont.) 1990 Suspended foliage data.

ID	Compl	Sp	ISMt0	SDMt0	t	FMt	TMt	EstFM	FFRt	FN%	TN%
429	32	C	18.55	9.60	95	5.53	2.63	6.97	0.793	0.64	1.09
472	32	C	23.12	11.97	95	6.05	3.85	8.12	0.745		
475	32	C	27.56	14.27	95	9.52	2.58	11.69	0.815		
435	33	C	18.64	9.65	95	5.13	3.02	6.63	0.774	0.62	0.98
448	33	C	25.49	13.19	95	8.62	3.29	9.91	0.870		
467	33	C	23.20	12.01	95	8.54	1.9	10.11	0.845		
440	34	C	26.59	13.77	95	6.07	4.78	8.99	0.676	0.53	1.06
442	34	C	23.03	11.92	95	5.75	3.85	8.07	0.712		
466	34	C	25.93	13.42	95	9.35	2.55	10.87	0.860		
454	35	C	23.15	11.98	95	6.33	3.36	8.62	0.734	0.63	1.21
458	35	C	22.78	11.79	95	6.00	3.6	8.19	0.732		
481	35	C	23.06	11.94	95	7.68	2.46	9.48	0.810		
443	36	C	22.28	11.53	148	5.27	3.79	7.74	0.681	0.65	1.13
460	36	C	26.83	13.89	148	7.72	2.65	11.24	0.687		
485	36	C	23.99	12.42	148	6.97	2.45	9.97	0.699		
456	37	C	23.00	11.90	148	4.74	2.06	9.85	0.481	0.61	1.17
463	37	C	21.97	11.37	148	6.10	4.02	7.35	0.829		
483	37	C	25.90	13.41	148	8.75	1.85	11.56	0.757		
434	38	C	19.57	10.13	148	5.33	2.46	7.67	0.695	0.62	1.02
439	38	C	20.40	10.56	148	4.64	3.5	7.06	0.657		
446	38	C	21.20	10.98	148	6.50	2.8	8.18	0.795		
430	39	C	19.32	10.00	148	4.18	3.99	6.01	0.695	0.56	1.19
449	39	C	23.37	12.10	148	5.89	2.61	9.49	0.621		
459	39	C	22.71	11.76	148	6.49	2.16	9.60	0.676		
486	40	D	19.03	9.57	8	6.62	0.82	8.75	0.756	0.59	1.25
501	40	D	24.47	9.99	8	6.98	2.17	7.82	0.892		
516	40	D	25.64	9.25	8	7.15	1.72	7.53	0.949		
513	41	D	25.54	9.36	8	7.32	1.75	7.61	0.962	0.72	1.31
541	41	D	27.72	10.56	8	9.36	2.33	8.23	1.137		
543	41	D	22.28	8.64	8	6.37	1.7	6.94	0.918		
502	42	D	28.33	11.44	8	8.31	1.48	9.96	0.835	0.75	1.23
515	42	D	36.63	13.28	8	9.16	2.43	10.85	0.844		
531	42	D	22.02	7.89	8	6.26	1.34	6.55	0.956		
498	43	D	25.54	10.81	8	5.66	1.19	9.62	0.588	0.77	1.34
533	43	D	28.17	10.18	8	8.25	1.33	8.85	0.932		
536	43	D	20.81	7.64	8	6.57	0.82	6.83	0.963		
525	44	D	20.04	7.09	29	5.92	0.68	6.42	0.923	0.87	1.39
535	44	D	25.08	9.16	29	7.05	1.13	8.03	0.878		

1990 Suspended foliage data.

ID	Compl	Sp	ISMt0	SDMt0	t	FMt	TMt	EstFM	FFRt	FN%	TN%
506	45	D	28.01	10.85	29	6.95	1.1	9.75	0.713	0.76	1.29
508	45	D	22.11	8.41	29	6.04	0.96	7.45	0.811		
491	46	D	20.21	9.42	29	5.92	1.22	8.20	0.722	0.81	1.35
507	46	D	28.37	10.89	29	7.33	1.16	9.73	0.754		
529	46	D	25.06	8.93	29	5.86	1.71	7.22	0.812		
494	47	D	27.89	12.45	29	7.81	.	.	.		
521	47	D	24.48	8.69	29	6.20	1.25	7.44	0.833	0.73	1.40
540	47	D	28.06	10.60	29	6.98	1.54	9.06	0.770		
500	48	D	20.82	8.60	57	6.68	0.96	7.64	0.874	0.81	1.32
518	48	D	34.88	12.48	57	8.33	1.41	11.07	0.752		
539	48	D	25.75	9.66	57	7.01	1.61	8.05	0.871		
509	49	D	20.34	7.67	57	5.14	0.72	6.95	0.739	0.77	1.24
510	49	D	34.84	13.04	57	7.37	1.85	11.19	0.659		
542	49	D	27.56	10.59	57	8.07	1.49	9.10	0.887		
497	50	D	19.60	8.41	57	6.64	0.85	7.56	0.879	0.72	1.24
519	50	D	32.28	11.51	57	6.88	1.32	10.19	0.675		
522	50	D	26.08	9.25	57	6.21	1.08	8.17	0.760		
490	51	D	19.20	9.08	57	4.84	1.6	7.48	0.647	0.75	1.37
528	51	D	23.10	8.21	57	5.53	1.34	6.87	0.805		
537	51	D	24.25	8.97	57	5.72	1.51	7.46	0.767		
489	52	D	21.35	10.25	86	5.87	1.11	9.14	0.642	0.87	1.26
524	52	D	25.09	8.88	86	6.21	1.12	7.76	0.800		
532	52	D	24.38	8.77	86	5.54	0.96	7.81	0.709		
492	53	D	26.49	12.17	86	6.15	1.3	10.87	0.566	0.74	1.31
517	53	D	24.48	8.80	86	5.00	0.74	8.06	0.621		
527	53	D	24.62	8.73	86	4.63	1.39	7.34	0.631		
487	54	D	19.77	9.79	86	4.68	0.94	8.85	0.529	0.69	1.42
496	54	D	20.79	9.03	86	5.80	0.77	8.26	0.702		
504	54	D	27.53	10.88	86	5.60	1.05	9.83	0.570		
505	55	D	28.16	11.01	86	5.90	1.21	9.80	0.602	0.82	1.37
526	55	D	21.63	7.66	86	4.61	0.77	6.89	0.669		
544	55	D	23.74	9.29	86	5.39	0.65	8.64	0.624		
503	56	D	20.74	8.28	132	3.81	0.51	7.77	0.490	0.85	1.44
520	56	D	23.36	8.31	132	4.98	0.56	7.75	0.643		
530	56	D	23.63	8.44	132	4.07	0.82	7.62	0.534		
495	57	D	27.37	12.06	132	5.45	0.8	11.26	0.484	0.76	1.48
512	57	D	23.93	8.83	132	4.88	0.56	8.27	0.590		
523	57	D	25.52	9.04	132	5.41	0.93	8.11	0.667		
534	58	D	31.06	11.28	132	6.13	0.82	10.46	0.586	0.99	1.57

(cont.) 1990 Suspended foliage data.

ID	Compl	Sp	ISMt0	SDMt0	t	FMt	TMt	EstFM	FFRt	FN%	TN%
545	58	D	20.35	8.04	132	6.54	0.92	7.12	0.918		
493	59	D	22.79	10.32	132	4.30	1.1	9.22	0.466	0.63	1.33
499	59	D	23.63	9.88	132	5.08	0.44	9.44	0.538		
538	59	D	24.19	9.00	132	5.17	1.3	7.70	0.671		

1990 fragmented foliage data sorted by composite ID.

			INITIAL STATE ANALYSES				POST TREATMENT							TKN			
Bag/ Process Sample Number	ID	Comp ID	Initial Litter Weight	Est. Initial Dry wt.	Est. Ash-Free Initial Dry Wt.	Est. Initial N Mass (mg)	Elapsed Time (days)	Measured Dry Wt.	Fract. Ash	Estimated Non-soil Fraction Veg Ash.	Soil Adjusted Veg Mass	Ash Free Veg Mass	Fraction BioMass Remainin	Measured Fraction Nitrogen	Mass (mg)	Est. Veg Mass (mg)	Fraction Nitrogen Remaining
			ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SN	VN	FNMRt
394	I U S D 6	1	10.12	9.20	8.14	64	12	8.43									
396	I U S D 8	1	10.55	9.58	8.48	67	12	8.23									
		mea			8.31	66	12	8.33	0.0595	0.05404	8.268	7.822	0.942	0.75	62	62	0.939
411	I U S D 5	2	10.48	9.47	8.46	69	12	8.02									
420	I U S D 6	2	10.89	9.81	8.77	72	12	8.81									
		mea			8.61	71	12	8.42	0.0456	0.05404	8.511	8.051	0.935	0.77	66	66	0.934
401	I U S D 1	3	10.36	9.39	8.39	67	12	8.20									
422	I U S D 7	3	10.35	9.32	8.33	69	12	8.08									
407	I U S D 4	3	10.30	9.32	8.33	67	12	8.03									
		mea			8.35	68	12	8.10	0.0468	0.05404	8.183	7.741	0.927	0.77	63	63	0.937
384	I R S D 4	4	10.56	9.63	8.52	66	21	7.33									
398	I R S D 8	4	10.52	9.55	8.45	67	21	7.79									
		mea			8.48	67	21	7.56	0.0523	0.05565	7.594	7.172	0.846	0.83	63	63	0.948
388	I R S D 5	5	10.36	9.43	8.34	65	21	7.87									
392	I R S D 6	5	10.99	9.99	8.84	70	21	7.89									
379	I R S D 3	5	10.20	9.31	8.24	63	21	7.43									
		mea			8.48	66	21	7.73	0.0663	0.05565	7.618	7.194	0.849	0.80	61	61	0.919
418	I U S D 6	6	10.51	9.48	8.46	70	21	7.53									
423	I U S D 7	6	10.86	9.78	8.73	73	21	7.68									
		mea			8.60	71	21	7.61	0.0528	0.05565	7.634	7.210	0.838	0.79	60	60	0.849
413	I U S D 5	7	10.41	9.40	8.40	68	21	7.62									
403	I U S D 1	7	10.31	9.34	8.34	67	21	7.84									
408	I U S D 4	7	10.64	9.62	8.60	69	21	7.77									
		mea			8.45	68	21	7.74	0.0547	0.05565	7.753	7.322	0.867	0.83	64	64	0.946

(cont.) 1990 Fragmented foliage data.

			ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SN	VN	FNMRt
381	I R S D 4	8	10.95	9.99	8.84	68	42	7.11									
400	I R S D 8	8	10.40	9.43	8.34	67	42	6.97									
		mean			8.59	67	42	7.04	0.0633	0.06064	7.014	6.589	0.767	0.91	64	64	0.946
389	I R S D 5	9	10.12	9.21	8.15	64	42	7.26									
380	I R S D 3	9	10.66	9.73	8.61	66	42	6.90									
393	I R S D 6	9	10.12	9.20	8.14	64	42	7.04									
		mean			8.30	65	42	7.07	0.0584	0.06064	7.088	6.658	0.802	0.87	62	62	0.955
419	I U S D 6	10	10.08	9.09	8.12	67	42	6.88									
405	I U S D 1	10	10.61	9.61	8.58	69	42	6.91									
421	I U S D 7	10	10.41	9.38	8.38	69	42	7.18									
		mean			8.36	68	42	6.99	0.0531	0.06064	7.062	6.634	0.794	0.89	63	63	0.923
406	I U S D 4	11	10.54	9.54	8.52	68	42	7.22									
415	I U S D 5	11	10.00	9.03	8.06	66	42	6.58									
		mean			8.29	68	42	6.90	0.0639	0.06064	6.869	6.453	0.778	0.92	63	63	0.928
386	I R S D 5	12	10.63	9.68	8.57	67	69	7.36									
397	I R S D 8	12	10.25	9.30	8.23	65	69	6.98									
		mean			8.40	66	69	7.17	0.0678	0.06962	7.188	6.688	0.796	0.83	60	60	0.905
376	I R S D 3	13	9.40	8.59	7.60	58	69	6.54									
391	I R S D 6	13	10.46	9.51	8.42	66	69	7.52									
382	I R S D 4	13	10.73	9.79	8.66	67	69	6.45									
		mean			8.23	64	69	6.84	0.0833	0.06962	6.707	6.240	0.759	0.93	62	62	0.975
414	I U S D 5	14	10.68	9.64	8.61	70	69	7.10									
409	I U S D 4	14	10.22	9.24	8.26	67	69	7.27									
		mean			8.43	68	69	7.19	0.061	0.06962	7.271	6.765	0.802	0.89	65	65	0.949
377	I R S D 3	15	10.11	9.24	8.17	62	99	7.35									
399	I R S D 8	15	10.62	9.63	8.52	68	99	5.72									
		mean			8.35	65	99	6.54	0.1079	0.08296	6.305	5.782	0.693	0.92	58	57	0.878

(cont.) 1990 Fragmented foliage data.

			ISMt0	SDMt0	AFDMt0	VNMt0	t	SDMt	FASHt	FVAt	(f)SDMt	AFDMt	FBMRt	STKNt	SN	VN	FNMRt
387	I R S D 5	16	10.80	9.84	8.70	68	99	7.80									
395	I R S D 6	16	10.95	9.95	8.80	70	99	6.29									
383	I R S D 4	16	10.12	9.23	8.16	63	99	8.64									
		mean			8.56	67	99	7.58	0.1206	0.08296	7.174	6.579	0.769	0.92	66	65	0.967
425	I U S D 7	17	10.06	9.05	8.08	67	99	5.64									
402	I U S D 1	17	10.94	9.92	8.86	71	99	6.25									
410	I U S D 4	17	10.68	9.65	8.62	70	99	8.23									
		mean			8.52	69	99	6.71	0.0923	0.08296	6.618	6.069	0.712	0.95	63	63	0.903
404	I U S D 1	18	10.90	9.87	8.82	71	99	5.99									
416	I U S D 6	18	10.89	9.83	8.78	72	99	6.73									
		mean			8.80	71	99	6.36	0.0645	0.08296	6.526	5.984	0.680	1.06	69	70	0.979
412	I U S D 5	19	10.70	9.67	8.63	70	99	7.11									
417	I U S D 6	19	10.85	9.79	8.74	72	99	6.26									
		mean			8.69	71	99	6.69	0.091	0.08296	6.609	6.061	0.698	0.91	60	60	0.844
378	I R S D 3	20	10.17	9.29	8.22	63	12	8.63									
390	I R S D 5	20	10.91	9.93	8.78	69	12	8.07									
385	I R S D 4	20	10.16	9.26	8.19	63	12	7.74									
		mean			8.40	65	12	8.15	0.0623	0.05404	8.055	7.620	0.907	0.77	62	62	0.949
424	I U S D 7	.	10.05	9.04	8.08	67	LOST										

APPENDIX F

Biomass Results Detail

F.1 Biomass Comparisons by Non-Parametric Methods

In this study, as sets of samples become more site specific, the number of observations per set declines to a degree that the OLS requirement of normality and homoscedasticity is threatened in some sets. Therefore to verify regression conclusions, a less sensitive method (Kruskal-Wallis rank-sum) was applied to test for differences between replicate sets and between collection intervals within sites.

Kruskal-Wallis tests between replicate sets (Figures 20 and 21) test for differences between subsequent sample collections at the same plot and concurrent collections from other plots. Rank-sum tests support the regression conclusions for site comparisons. The higher variability in estimated initial dry mass is perhaps responsible for the reduced ability to detect change in biomass over time in 1989 versus 1990. Contrary to the expectation that higher variability in replicate sets for 1989 would result in fewer instances of significant differences between sets, there are in fact fewer instances of significant differences in the 1990 comparisons between plots for all three species. One notable exception is the 1989 and 1990 Bisley riparian plots where *D. excelsa* often differs significantly from Icacos sites. In 1989 the instances of significant differences are scattered though some occur between Icacos riparian sets for *C. racemiflora* and *D. excelsa*. *P. montana* Kruskall-Wallis matrices show significant differences over time but seldom between plots for both years.

Cyrilla racemiflora

*Species/Watershed/Catena Position Acronym * Days on Forest Floor*

	CBR 14	CBR 35	CBR 52	CBR 78	CBU 14	CBU 35	CBU 52	CBU 78	CIR 14	CIR 35	CIR 52	CIR 78	CIU 14	CIU 35	CIU 52	CIU 78
CBR 14																
CBR 35	-															
CBR 52	-	-														
CBR 78	*	-	-													
CBU 14	*															
CBU 35		*			-											
CBU 52			-		-	-										
CBU 78				-	*	*	-									
CIR 14	*				*											
CIR 35		-				*			-							
CIR 52			-				-		*	-						
CIR 78				-				*	*	*	-					
CIU 14	-				*				*							
CIU 35		-				-				-			-			
CIU 52			-				-				-		*	-		
CIU 78				-				*				-	*	-	-	

Dacroydes excelsa

	DBR 14	DBR 35	DBR 52	DBR 78	DBU 14	DBU 35	DBU 52	DBU 78	DIR 14	DIR 35	DIR 52	DIR 78	DIU 14	DIU 35	DIU 52	DIU 78
DBR 14																
DBR 35	*															
DBR 52	*	-														
DBR 78	*	-	-													
DBU 14	*															
DBU 35		-			*											
DBU 52			*		*	*										
DBU 78				-	*	*	-									
DIR 14	*				-											
DIR 35		*				-			*							
DIR 52			*				-		*	-						
DIR 78				*				-	*	-	-					
DIU 14	-				-				*							
DIU 35		-				-				*			-			
DIU 52			-				-				-		*	-		
DIU 78				*				-				-	*	*	-	

Figure 20a,b: 1989 intra-specific comparison matrices of Kruskal-Wallis ranked sum tests for differences between biomass replicate sets for *C. racemiflora* and *D. excelsa*. Significant differences are indicated by (*), no difference (-), and the lack of a symbol indicates no test was conducted.

Prestoea montana

	PBR 14	PBR 35	PBR 52	PBR 78	PBU 14	PBU 35	PBU 52	PBU 78	PIR 14	PIR 35	PIR 52	PIR 78	PIU 14	PIU 35	PIU 52	PIU 78
PBR 14																
PBR 35	*															
PBR 52	*	*														
PBR 78	*	*	*													
PBU 14	-															
PBU 35		-			*											
PBU 52			-		*	*										
PBU 78				-	*	*	-									
PIR 14	-				*											
PIR 35		-				*			*							
PIR 52			-				-		*	*						
PIR 78				-				-	*	*	-					
PIU 14	-				*				-							
PIU 35		-				-				-			*			
PIU 52			-				-				-		*	-		
PIU 78				-				-				-	*	-	*	

Figure 20c: 1989 intra-specific comparison matrices of Kruskal-Wallis ranked sum tests for differences between biomass replicate sets for *P. montana*. Significant differences are indicated by (*), no difference (-), and the lack of a symbol indicates no test was conducted.

Cyrilla racemiflora

	CBR 11	CBR 23	CBR 45	CBR 73	CBR 102	CBU 11	CBU 23	CBU 45	CBU 73	CBU 102	CIR 12	CIR 21	CIR 42	CIR 69	CIR 99	CIUN 12	CIUN 21	CIUN 42	CIUN 69	CIUN 99	CIUS 12	CIUS 21	CIUS 42	CIUS 69	CIU 99
CBR 11																									
CBR 23	*																								
CBR 45	*	*																							
CBR 73	*	*	*																						
CBR 102	*	*	*	*																					
CBU 11	-																								
CBU 23		-				*																			
CBU 45			-			*	*																		
CBU 73				-		*	*	*																	
CBU 102					*	*	*	*	*																
CIR 12	*					*																			
CIR 21		-					-				-														
CIR 42			-					-			*	-													
CIR 69				-					-		*	*	-												
CIR 99					-					-	*	*	*	*											
CIUN 12	*					*					-														
CIUN 21		-					-					-				-									
CIUN 42			-					-					-			*	*								
CIUN 69				-					-					-		*	-	-							
CIUN 99					-					-					-	*	*	-	-						
CIUS 12	-					-					-					-									
CIUS 21		-					-					-					-				-				
CIUS 42			-					-					-					-			*	-			
CIUS 69				*					-					-					-		*	*	-		
CIUS 99					-					-					-					-	*	*	-	-	

Figure 21a: 1990 intra-specific comparison matrices of Kruskal-Wallis ranked sum tests for differences between biomass replicate sets for *C. racemiflora*. Significant differences are indicated by (*), no difference (-), and the lack of a symbol indicates no test was conducted.

Dacroydes excelsa

		DBR 11	DBR 23	DBR 45	DBR 73	DBR 102	DBU 11	DBU 23	DBU 45	DBU 73	DBU 102	DIR 12	DIR 21	DIR 42	DIR 69	DIR 99	DIUN 12	DIUN 21	DIUN 42	DIUN 69	DIUN 99	DIUS 12	DIUS 21	DIUS 42	DIUS 69	DIU 99
DBR	11																									
DBR	23	*																								
DBR	45	*	-																							
DBR	73	*	*	*																						
DBR	102	*	*	*	-																					
DBU	11	-																								
DBU	23		-				*																			
DBU	45			-			*	-																		
DBU	73				-		*	*	-																	
DBU	102					-	*	*	-	-																
DIR	12	-					*																			
DIR	21		*					-				*														
DIR	42			*					-			*	-													
DIR	69				*					-		*	-	-												
DIR	99					-					-	*	*	*	-											
DIFN	12	*					-					*														
DIFN	21		*					-					-				*									
DIFN	42			-					-					-			*	*								
DIFN	69				*					-					-		*	*	*							
DIFN	99					-					-					-	*	*	*	*						
DIUS	12	-					-					-					*									
DIUS	21		*					-					-					-				*				
DIUS	42			-					-					-					-			*	*			
DIUS	69				*					-					-					-		*	*	*		
DIUS	99					*					-					-					-	*	*	*	-	

Figure 21b: 1990 intra-specific comparison matrices of Kruskal-Wallis ranked sum tests for differences between biomass replicate sets for *D. excelsa*. Significant differences are indicated by (*), no difference (-), and the lack of a symbol indicates no test was conducted.

Prestoea montana

		PBR 11	PBR 23	PBR 45	PBR 73	PBR 102	PBU 11	PBU 23	PBU 45	PBU 73	PBU 102	PIR 12	PIR 21	PIR 42	PIR 69	PIR 99	PIUN 12	PIUN 21	PIUN 42	PIUN 69	PIUN 99	PIUS 12	PIUS 21	PIUS 42	PIUS 69	PIU 99
PBR	11																									
PBR	23	*																								
PBR	45	*	-																							
PBR	73	*	*	*																						
PBR	102	*	*	-	-																					
PBU	11	-																								
PBU	23		-				*																			
PBU	45			-			*	*																		
PBU	73				-		*	*	*																	
PBU	102					-	*	*	*	*																
PIR	12	*					*																			
PIR	21		-					*				*														
PIR	42			-					-			*	-													
PIR	69				-					-		*	*	*												
PIR	99					-					*	*	*	*	*											
PIUN	12	-					-					-														
PIUN	21		-					-					*				-									
PIUN	42			-					-					-			*	*								
PIUN	69				-					-					-		*	*	*							
PIUN	99					-					-					*	*	*	*	*						
PIUS	12	-					-					-					-									
PIUS	21		-					-					-					-				*				
PIUS	42			-					-					-					-			*	-			
PIUS	69				-					-					-					-		*	*	-		
PIUS	99					-					-					*					-	*	*	*	-	

Figure 21c: 1990 intra-specific comparison matrices of Kruskal-Wallis ranked sum tests for differences between biomass replicate sets for *P. montana*. Significant differences are indicated by (*), no difference (-), and the lack of a symbol indicates no test was conducted.

F.2 Categorical Regression Results

Reconstruction of *k'* reported in Table 4 from the tables of dummy variable regression models (Tables 18-20) is complicated by differences in statistical leverage that is present under different circumstances. For example, the *k'* for *C. racemiflora* in 1989 was -0.66 and for 1990 it was -0.77. Contrary to the expectation that the rate for combined year data would be between these values, it was lower than both (-0.62). This occurred because the regression line is pulled down at low x values by the 1989 data and it is pulled upward at higher x values by the 1990 data resulting in a flatter slope. Also, in order to estimate the error terms for the coefficients in Table 4 the data were separated by category combination. Therefore, small differences in *k'* may be found when the categorical models are reduced to the categories reported in Table 4.

Table 18: Multivariate regression models for predicting the natural log of biomass remaining over time with dummy variables for testing for differences among species (see Appendix C for an interpretation).

		D. excelsa (Dde)		P. montana (Dpm)			
	k'	Dde(T)	Dde	Dpm(T)	Dpm	b	R^2
Between Species							
n = 603	-0.6183	-0.705	-0.078	-1.85	-0.03	-0.0424	0.7
P>t	**	**	**	**	**	*	

Full Model:

ln(FBMR) = k'(T) + Dyr(T) + Dw(T) + Ds(T) + Dde(T) + Dpm(T) + Dyr + Dw + Ds + Dde + Dpm + b

where: FBMR = Fraction Biomass Remaining
k' = Decay rate when all dummy variables = 0
T = Elapsed time in years
b = y-intercept when all dummy variables = 0
Dummy variables:

Dyr	(Year)	1989 = 1, 1990 = 0
Dw	(Watershed)	Bisley = 1, Icacos = 0
Ds	(Slope Position)	Upland = 1, Riparian = 0
Dde	(*D. excelsa*)	1 if true, 0 if another species
Dpm	(*P. montana*)	1 if true, 0 if another species

(if Dde = Dpm = 0, then by default species is C. racemiflora)

Table 19: Multivariate regression models to predict the natural log of biomass remaining over time. These sample populations were selected and dummy variables factored to test for differences among study sites.

Sample Population Subset	n	k'	P	Watershed (Dw) Dw(T)	P	Dw	P	Slope Position (Ds) Ds(T)	P	Ds	P	Intercept b	P	R^2
a) Between watersheds by Study Year														
C 1990	115	-0.5797	**	-0.1974	*	0.0334	*					-0.0037		0.72
C 1989	69	-0.8800	**	0.1904		-0.1110	*					-0.0507	*	0.53
D 1990	124	-1.1350	**	-0.1555		-0.0301						-0.0671	*	0.76
D 1989	87	-1.9561	**	0.2406		0.0190						-0.1503	*	0.56
P 1990	125	-2.4232	**	0.0522		0.0781						-0.0795	*	0.75
P 1989	83	-2.8636	**	0.2398		-0.0522						-0.0574		0.78
b) Between Slope Positions by Watershed and Study Year														
C B 1990	47	-0.7244	**					-0.1168		0.0137		0.0235	*	0.90
C I 1990	68	-0.6451	**					0.0920		0.0008		-0.0038		0.58
C B 1989	29	-0.8566	**					0.2636		-0.1097	*	-0.1061	*	0.48
C I 1989	40	-1.0404	**					0.3352		-0.0859	*	-0.0089		0.60
D B 1990	50	-1.3152	**					0.0486		-0.0115		-0.0913	*	0.68
D I 1990	74	-1.2103	**					0.1132		-0.0201		-0.0537	*	0.81
D B 1989	46	-1.7156	**					-0.2515		-0.1069		-0.0605		0.64
D I 1989	41	-1.8238	**					-0.3040		0.1448		-0.2212	*	0.75
P B 1990	50	-2.4929	**					0.1988		0.0064		-0.0032		0.74
P I 1990	75	-2.7108	**					0.4170		0.0318		-0.1007	*	0.77
P B 1989	43	-2.7692	**					0.3106		-0.0600		-0.0822	*	0.83
P I 1989	40	-3.0560	**					0.3847		-0.0739		-0.0205		0.75

1. if ** then P<.001, if * then P<.05
2. C = C. racemiflora, D = D. Excelsa, P = P.montana, B = Bisley, I = Icaocs, R = Riparian, U = Upland.

Dummy variables:

Dyr	(Year)	1989 = 1, 1990 = 0
Dw	(Watershed)	Bisley = 1, Icacos = 0
Ds	(Slope Position)	Upland = 1, Riparian = 0

Table 20: Multivariate regression models to predict the natural log of biomass remaining over time. These sample populations are selected and dummy variables factored to test for differences between pre- and post-hurricane results. (Coding follows the nomenclature of Table 5).

Sample Population Subset	n	k'	P	1989 = 1, 1990 = 0 Study Year (Dyr) Dyr(T)	P	Dyr	P	Bisley = 1, Icacos = 0 Watershed (Dw) Dw(T)	P	Dw	P	Upland = 1, Riparian = 0 Slope Position (Ds) Ds(T)	P	Ds	P	Intercept b	P	R^2
a) Between years by species																		
C. racemiflora	184	-0.6605	**	-0.1131		-0.1105	**									0.0097		0.67
D. excelsa	211	-1.2184	**	-0.6224	*	-0.0622	**									-0.0768	**	0.69
P. montana	208	-2.4070	**	-0.3292		-0.0639										-0.0488	*	0.74
b) Between years and watersheds by species																		
C. racemiflora	184	-0.6377	**	-0.1266		-0.1085	**	-0.0429		-0.0237						0.0167		0.69
D. excelsa	211	-1.1736	**	-0.6179	**	-0.0620	*	-0.0973		0.0037						-0.0788	**	0.68
P. montana	208	-2.4690	**	-0.3368		-0.0399		0.1462		0.0221						-0.0573	*	0.75
c) Between years and slope positions by species and watershed																		
C B	76	-0.7928	**	0.0664		-0.1893	**					0.0391		-0.0367		0.0464	*	0.84
C I	108	-0.6996	**	-0.2673	*	-0.0527	*					0.1772		-0.0327		0.0180		0.65
D B	96	-1.3354	**	-0.4709		-0.0273						0.0585		-0.0756	*	-0.0569		0.63
D I	115	-1.1240	**	-0.8345	**	-0.0759	*					-0.0189		0.0399		-0.0937	**	0.82
P B	93	-2.5180	**	-0.1282		-0.1088	*					0.2592		-0.0257		0.0120		0.78
P I	115	-2.7282	**	-0.3569		-0.0199						0.4432		-0.0127		-0.0710		0.75
d) Between years by species, watershed, and slope position																		
C B R	41	-0.7244	**	-0.1297		0.0235	*									-0.1322		0.75
C B U	35	-0.8412	**	-0.2531	**	0.0372	**									0.2481	*	0.97
C I R	43	-0.6451	**	-0.3953	*	-0.0051										-0.0038		0.70
C I U	65	-0.5531	**	-0.1521		-0.0918	**									-0.0030		0.66
D B R	47	-1.3152	**	-0.4005		-0.0308										-0.0913	**	0.67
D B U	49	-1.2660	**	-0.7006		-0.0645										-0.1028	*	0.66
D I R	45	-1.2103	**	-0.6135	**	-0.1675	*									-0.0537	*	0.83
D I U	70	-1.0971	**	-1.0307	**	-0.0026										-0.0738	**	0.85
P B R	45	-2.2941	**	-0.1645		-0.1454	*									0.0032		0.83
P B U	48	-2.4929	**	-0.2763		-0.0790										-0.0032		0.74
P I R	45	-2.7110	**	-0.3452		0.0802										-0.1007	*	0.80
P I U	70	-2.2938	**	-0.3775		-0.0255										-0.0689	*	0.72

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5 November 1993

Dr. E. Raymond Heithaus, Editor
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Dear Dr. Heithaus,

Enclosed please find three copies of a manuscript entitled "Fates for $^{15}NH_4$ in the Riparian Zone of a Tropical Rain Forest", which we submit for consideration in BIOTROPICA. No part of this manuscript is under consideration for publication in any other form.

We believe that this manuscript will be of interest to both tropical and general ecologists and biogeochemists. The findings reported here should be of general interest to those interested in nitrogen dynamics within the riparian zone, an area of ecosystem research that is of increasing interest. Tropical ecologists and biogeochemists should be especially interested in this report as the research was done at the Luquillo Experimental Forest, in conjunction with the Long-Term Ecological Research Program there. This paper complements earlier work done at the same research site and reported by McDowell *et al*. (1992) and Bowden *et al*. (1992). We believe that the results reported in these papers have broad implications for other tropical sites.

Please note that I will be on sabbatic leave in New Zealand from 10 December 1993 until 8 August 1994. I may be reached directly by any of the means indicated on the attached page. Alternatively, you may contact Dr. McDowell, the second co-author, here at UNH.

Thank you for your consideration of this manuscript.

Sincerely,

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