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Seasonal and Spatial Biogeochemical Trends for Chaparral Vegetation and Soil Geochemistry in the Santa Monica Mountains National Recreation Area, CA

by

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This report presents the results of a biogeochemical study in the Santa Monica Mountains National Recreation Area conducted cooperatively by the National Park Service and the U. S. Geological Survey. The study involved the sampling and chemical analysis of foliage of *Rhus laurina* Nutt. (laurel sumac), and *Ceanothus megacarpus* Nutt. (big pod *Ceanothus* or California lilac), the bark of *Quercus agrifolia* Nee. (coast live oak), and surficial soils. Vegetation and soil samples were collected along several north-south trending traverses and along one east-west trending traverse. Two complementary field studies were conducted approximately six months apart at or near the beginning of the dry and wet seasons, May and December, 1986, respectively. This study was initiated to help define baseline elemental concentrations in selected plant species throughout the Santa Monica Mountains. The intent of this work was to examine spatial concentration trends during two seasons to provide information that would assist environmental management decisions and help direct future biogeochemical studies for the Santa Monica Mountains National Recreation Area.

Summary statistics are reported for elemental concentrations in plants and soils collected at 48 sites throughout the Santa Monica Mountains. Univariate and multivariate analyses were used to assess the seasonal and spatial variability of element concentrations in plants and spatial variability in soils.

Seasonal trends in elemental concentrations in plants were significant for nutrient elements and for several nonessential trace elements. Spatial variance of soil and plant chemistry was large at a localized scale (i.e. site-to-site). Only moderate correlations were found for an individual element between both plant species. More elements correlated among species in May than in December. Spatial trends with respect to northing for elements in plants and soils along N-S traverses are not obvious, although some influence of sea-salt spray on Na in foliage is indicated. Spatial trends with respect to easting for elements in plants and soils along all traverses indicate a potential anthropogenic influence on pH and Pb concentrations. Other elements that correlate with easting are likely to be a result of regional trends in geologic substrates. The results obtained suggest that there is an anthropogenic influence on the chemistry of chaparral vegetation in the Santa Monica Mountains National Recreation Area. Further biogeochemical research would help more clearly define this influence.

Form of Product. Product USGS Open-File Report 91-0005: Typed Report, 8½ x 11 inches, 121 pages, including 23 figures, 23 tables, and 14 appendices.

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INTRODUCTION

The Santa Monica Mountains National Recreation Area (SAMO) is located to the north and west of the Los Angeles basin and south and west of the San Fernando valley in California and is easily accessible to more than 14 million people. The region has been described as having the worst photochemical smog in the United States for the last several decades. However, little information is available on the effects of poor air quality on the vegetation in the National Recreation Area. This report presents the results of a biogeochemical study conducted cooperatively by the National Park Service and the U. S. Geological Survey. The study involved the sampling and chemical analysis of foliage of *Rhus laurina* Nutt.[1] (laurel sumac) and *Ceanothus megacarpus* Nutt. (big pod ceanothus), the bark of *Quercus agrifolia* Nee. (coast live oak), and surficial soils. Vegetation and soil samples were collected along several north-south trending traverses and along one east-west trending traverse. Two complementary field studies were conducted approximately six months apart at or near the beginning of the dry and wet seasons, May and December, 1986, respectively.

Purpose of the Study

This study was initiated to help define baseline elemental concentrations in selected plant species throughout the SAMO. The intent of this work was to examine spatial concentration trends during two seasons in order to provide information that would assist environmental management decisions and help direct future biogeochemical studies for the SAMO.

STUDY AREA DESCRIPTION

Santa Monica Mountains National Recreation Area

The SAMO was created in 1978 by Public Law 95-625 to "preserve and enhance its public health value as an airshed for the Southern California metropolitan area while providing for the recreational and educational need of the visiting public." The SAMO is composed of Federal, State, County, City, and private lands that extend eastward from Point Mugu on the Pacific Coast about 80 km (50 mi) to Griffith Park in the City of Los Angeles (Figure 1). The National Recreation Area encompasses about 60,700 hectares (150,000 acres). However, only about 6,500 hectares (16,000 acres) are currently federally owned. Point Mugu, Malibu Creek, and Topanga State Parks, Griffith Park (a Los Angeles city park), and numerous public beaches comprise the major parcels of land within the SAMO.

Climate

The SAMO climate is classified as Mediterranean with mild, wet winters and hot, dry summers. Precipitation varies, but is generally more than three times greater in the winter than

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[1] *Rhus laurina* has been renamed *Malosma laurina* Nutt. ex. Abrams (Conrad, 1987). However, the taxonomy throughout this report follows Munz and Keck (1970).

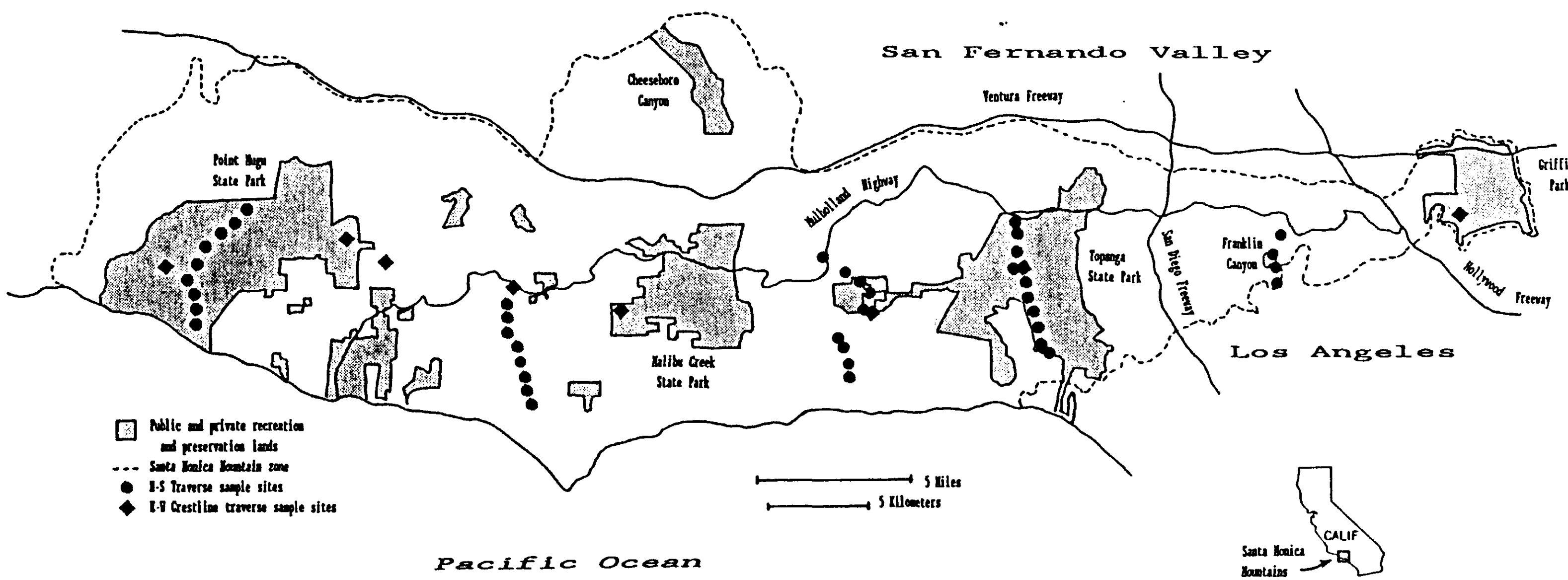


Figure 1. Map of the Santa Monica Mountains National Recreation Area.

in the summer (Rose and others, 1982). This climate is found in mid-latitudes along western coasts of North and South America (California and Central Chile), Europe, South Africa, and Australia.

The rapid rise of the Santa Monica Mountains from the seashore and the complex topography in the mountainous zone creates numerous micro-climates within the SAMO. Precipitation averages about 46-66 cm per year (18-26 in/yr) in the mountains with a mean of about 38 cm/yr (15 in/yr) in Los Angeles. The dry season generally extends from May through October followed by a wet season from November to April. Coastal fog frequently penetrates up the south-draining canyons.

Air Quality

The air quality in the SAMO varies seasonally and spatially depending upon climatic conditions, topography, and proximity to metropolitan areas and the ocean (Rose and others, 1982). Wind speeds are generally low throughout the year, averaging 10 km/hr (6 mi/hr). Summer months typically exhibit the highest winds with inland movement of the air from the ocean to the west and from southerly directions during the daytime. During the nighttime the wind direction is typically reversed and reduced in speed. Deviations from "normal" conditions are experienced wtih the Santa Anna wind conditions--producing easterly, dry, hot, fast winds. Winter months are distinguished by dominant northeasterly winds due to Santa Ana conditions.

Temperature inversions that trap emitted pollutants close to the land surface are common in this region of Southern California (Rose and others, 1982). During winter months inversions exist about two thirds of the days, but tend to dissipate in the afternoon. During the summer months the inversions are more persistent. In addition, the summer months typically experience the worst air quality due to the greatest solar radiation and its effect on atmospheric photochemical reactions.

Physiography

The Santa Monica Mountains are the southwestern-most range of the east-west trending Transverse Range Province of Southern California. They extend about 80 km (50 mi) eastward from the Oxnard Plain to the Los Angeles River. They average about 13 km (8 mi) wide at the western and central portions and narrow to the east to about 5 km (3 mi) wide at Griffith Park. The crest of the range attains a maximum elevation of 1933 m (3111 ft) at Sandstone Peak with an average elevation close to 600 m (2000 ft). The crest of the range is generally about 8 km (5 mi) from the coast resulting in long, deep, south-draining canyons extending from the crest to sea level and north-draining canyons that are shorter and less excised. At several locations the crest is apparently an old erosion surface of Cenozoic age which has caused the range to exhibit a flattened summit (Dibblee, 1982). At about the midpoint of the range it is dissected from north to south by Malibu Creek Canyon which drains the south slopes of the Simi Hills.

Geology

The Santa Monica Mountains are a melange of marine and non-marine sedimentary and volcanic rocks atop metamorphic and plutonic basement rocks (Figure 2). The eastern extent of the range has exposures of the basement rocks, Santa Monica Slate and granitic intrusives, whereas the major portion of the range is composed of two general divisions: a marine clastic sedimentary series of late Cretaceous and early Tertiary Age in the eastern and central regions and a thick, complex group of sedimentary and volcanic rocks of middle Tertiary Age in the central to western portions of the range (Dibblee, 1982). The range is basically a broad anticline that is bounded on the south by the east-west trending Malibu Coast and Santa Monica Faults. The range has undergone extensive tectonic activity with a great deal of faulting and folding and is currently undergoing uplift. The central portion of the range is dominated by low-angle thrust faults composed of Tuna Canyon, Zuma, and Malibu Bowl thrust sheets (Campbell and others, 1966).

The stratigraphy of the Santa Monica Mountains is extremely complex (Hoots, 1931; Bailey and Jahns, 1954; Durrell, 1954; Yerkes and Campbell, 1979, 1980; and Dibblee, 1982). Yerkes and Campbell (1979) have reviewed and updated the stratigraphic nomenclature used for the central Santa Monica Mountains. Their nomenclature is used herein.

The basement rocks are composed of Santa Monica slate and schist which have been intruded upon by granitic rocks during the Jurassic period. The slate is exposed in Topanga and Franklin Canyons and the granitic rocks are seen in Griffith Park (Hoots, 1931; and Dibblee, 1982).

The Tuna Canyon Formation is an upper Cretaceous marine sequence of sandstone, siltstone, and conglomerate which presumably overlays the basement rocks (Yerkes and Campbell, 1979). Simi(?) Conglomerate, Coal Canyon Formation, and Llajas(?) Formation are early Tertiary marine deposits composed of pebble conglomerates, sandstone, and siltstone. The first three of these four units appear to correspond to the Chico and Martinez Formations identified by Hoots (1931) and Durrell (1954) (Yerkes and Campbell, 1979).

Middle Tertiary sedimentary and volcanic rocks dominate the Santa Monica Mountains. The Sespe Formation of largely Oligocene age is a predominantly non-marine sequence of sandstone and mudstone which is overlain by the marine Vaqueros Formation (Yerkes and Campbell, 1979). The Vaqueros Formation is mostly sandstone and siltstone. Both formations are missing in the eastern portion of the range.

Yerkes and Campbell (1979) proposed new nomenclature for the extensive sequence of sedimentary and volcanic rocks that "total about 6100 m in thickness, underlies the entire northern flank of the range, and is readily divisible into three units." They named the three units the "Topanga Group" composed of the Calabasas Formation, the Conejo Volcanics, and the Topanga Canyon Formation. The Topanga Canyon Formation is a mixture of sandstone, marine and non-marine shalely siltstone, and algal(?) limestone. The Conejo Volcanics are composed of extrusive volcanic rocks up to 3000 m thick in the western portion of the range. They thin toward the central and eastern end of the range. The Calabasas Formation is predominantly marine sandstone, siltstone, and sedimentary breccias. "Siliceous shale predominates in western exposures, and siltstone and sandstone in eastern exposures (Dibblee, 1982)."

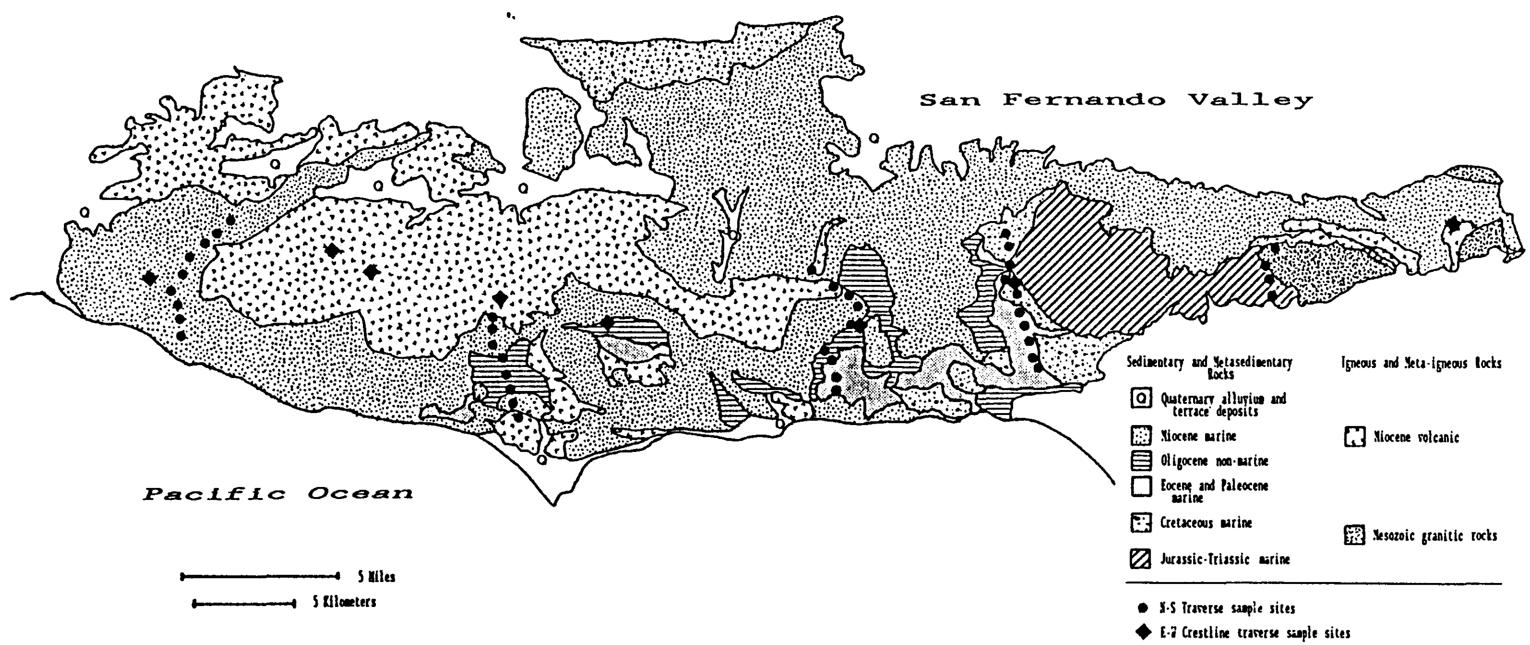


Figure 2. Generalized Geologic Map of the Santa Monica Mountains (after Jennings and Strand, 1969).

The Modelo Formation of upper Miocene age is a marine sequence of predominantly siliceous shale and sandstone. It is exposed on the north flank from the eastern to central portion of the range and uncomformably overlies the Topanga Group (Dibblee, 1982; Yerkes and Campbell, 1979). Pliocene Age sedimentary rocks are not found in the range.

Economic development of mineral deposits has been largely restricted to quarrying of rock materials for construction. Oil and gas have been found in basins adjacent to the Santa Monica Mountains. Exploratory drilling activities in the Santa Monica Mountains generally occurred from the 1920's through the 1950's with little present day activity or production (Dibblee, 1982).

Soils

The soils of the SAMO are as complex as the geology and topography in the region (Soil Conservation Service, 1967, 1969, 1970). Many of the soils occur on steep slopes and hence are shallow and easily eroded. The soils may have a non-wettable layer due to the presence of organic plant residues, especially after fires (DeBano, 1974). Five major soil associations predominate in the Santa Monica Mountains: Calleguas-Arnold, Gaviota-Millsholm, Hambright-Igneous Rock Land-Gilroy, San Andreas-San Benito, and Rock land-Rough broken land association (Rose and others, 1982)(Figure 3).

Calleguas-Arnold Association. The soils in this association occur in steep mountainous uplands (30-50% slopes) and are characterized by being developed on areas of sandstone and shale. The Calleguas soils are calcareous, shaley, clay loam and represent about 50% of the association. The Arnold soils are loamy sand and are about 35% of the association with the remainder of the group represented by small proportions of other soil series.

Gaviota-Millsholm Association. The Gaviota and Millsholm soils overlay shale and sandstone parent material and occur in steep mountainous uplands (15-75% slopes). They are sand and clay loams with frequent rock outcrops. Malibu and Los Osos series soils are also found with this association.

Hambright-Gilroy Association. The Gilroy series occurs largely in hilly uplands with the Hambright series occurring in much steeper, mountainous uplands. The association overlays basic igneous rocks with frequent volcanic outcrops. The Gilroy and Hambright series are clay loams with the Hambright series composing about 75% and igneous rock lands about 10% of the association.

San Andreas-San Benito Association. The San Andreas and San Benito series are sandy and clay loams which overlay sandstone or calcareous, sandy shale, respectively. They occur on steep uplands with the San Andreas series predominating.

Rock Land-Rough Broken Land Association. The Rock Land consists of steep and very steep areas of sedimentary (sandstone and shale) and igneous (basalt, andesite, and

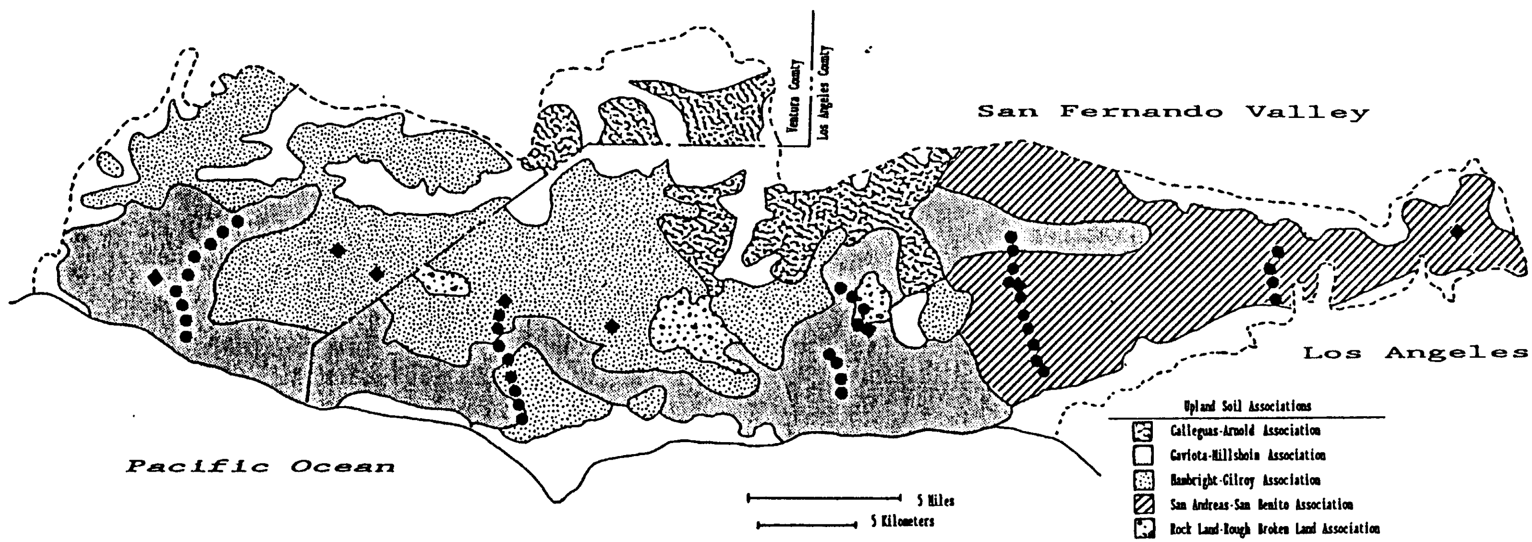


Figure 3. Generalized upland soil classification map of the Santa Monica Mountains (after Soil Conservation Service, 1967, 1969, 1970).

volcanic breccia) rocks with outcrops covering more than 25% of the area. The Rough Broken Land consists of softly consolidated sediments.

Vegetation

The vegetation of the Santa Monica Mountains has adapted to the Mediterranean-type climate of dry, hot summers followed by moist winters and frequent fires. The dominant plant communities are coastal salt marsh and strand, coastal sage scrub, north and south slope chaparral, southern oak woodland, valley oak savannah, valley grassland, and riparian woodlands (Rose and others, 1982; Dale, 1986; Hanes, 1974). The chaparral vegetation, the most extensive plant community in SAMO, is typified by broad-leaved sclerophyllous shrubs. Chaparral also covers about 5% of the state (Hanes, 1988).

The chaparral is a dense, almost impenetrable, one-layer evergreen canopy of predominantly chamise (*Adenostoma fasciculatum* H. & A.), buck brush (*Ceanothus* spp.), scrub oak (*Quercus* spp.), and occasional stands of manzanita (*Arctostaphylos* spp.). Coastal-desert orientation, slope aspect, elevation, substrate, fire history, and age of the stand are controlling factors on the nature of the chaparral at various sites (Hanes, 1988). The south facing, xeric slopes are dominated by *Ceanothus* and chamise chaparral. The *Ceanothus* chaparral is predominately big pod ceanothus (*C. megacarpus*) which often covers more than 50% of the southern slopes in the Santa Monica Mountains (Rose and others, 1982; Dale, 1986). The chamise chaparral is mainly chamise and black sage (*Salvia mellifera* Greene). North-facing, mesic slopes are more of a mixture of species with scrub oak, greenbark *Ceanothus* (*Ceanothus spinosus* Nutt.), other large shrubs, and a variety of woody vines. The dominant species constitute fifty to one-hundred percent of the total cover in the chamise and *Ceanothus* chaparral, whereas only 20-50% is covered by the dominant species in the scrub oak chaparral (Hanes, 1988). In general *Ceanothus* chaparral occurs on slightly more mesic sites with more complete crown cover than chamise chaparral. *Ceanothus* chaparral also develops its crown cover more quickly than chamise chaparral in the early years of a stand's growth (Hanes, 1988).

Coastal sage communities are prevalent along the lower elevation, south-facing coastal slopes, and on steep south-facing slopes inland (Rose and others, 1982). Coastal sagebrush (*Artemisia californica* Less.), purple sage (*Salvia leucophylla* Greene), and laurel sumac (*R. laurina*) are common in these communities. The transition from coastal sage elements to chaparral elements is a successional influence of fire history and a response to moisture regimes (Hanes, 1988; Mooney, 1988).

The riparian woodlands have more species diversity than the other communities and are dominated by trees. Western sycamore (*Platanus racemosa* Nutt.), willows (*Salix* spp.), coast live oak (*Quercus agrifolia*), California bays (*Umbellularia californica* (H. & A.) Nutt.), and big leaf maple (*Acer macrophyllum*) are common.

STUDY DESIGN

In order to study regional trends in elemental content of selected plant species two major study designs were considered. The two potential systematic sampling plans considered were a simple square grid design and multiple, linear traverses. In selecting a design several sampling constraints were considered:

1. The plant species selected had to be prevalent at a large proportion of the potential sites.
2. The sites had to be accessible.
3. The sites should be similar in physiographic characteristics (e.g. slope, aspect, surface soils, parent material, proximity to roads and structures).
4. The sampling sites had to occur on public or private conservation lands within the SAMO in order to insure the potential of resampling in the future.
5. The sites had to be distributed throughout the entire range of the SAMO.
6. The number of sites and the time required for collection had to be commensurate with the project budget.

Three factors are readily apparent in considering the sample design constraints in the SAMO: chaparral is the dominant plant community, the chaparral is impenetrable except along highways or roads, such as firebreaks, and trails, and the Santa Monica Mountains are an extremely complex physiographic melange. Thus a square grid design was considered impractical.

In order to optimally meet the sampling design constraints several linear sampling traverses were selected. However, even in the selection of traverses numerous compromises had to be made.

Big pod ceanothus, also commonly referred to as buck brush, and laurel sumac were chosen as the species to sample due to their wide prevalence on the southern flanks of the Santa Monica Mountains. In addition, coast live oak was sampled along one traverse. Surficial soils were also collected at each sample site.

Four major and one minor north-south trending traverses were selected. Each of these major traverses was 6.5-8 km (4-5 mi) in length. The traverses were separated by 11-18 km (7-11 mi) east to west (Figure 4). A sixth traverse, east-west trending along the crestline of the Santa Monica Mountains from Griffith Park to Point Mugu State Park, was also established. Crestline traverse sites averaged about 6.5-8 km (4-5 mi) apart except at the eastern end of the traverse. Samples along this traverse were collected from both north and south sides of the crest. Presence of *Ceanothus* chaparral, accessibility, and land ownership were the primary factors in selecting these traverses and the actual sites sampled.

An unbalanced, crossed-hierarchical analysis of variance (ANOVA) design was created to examine temporal and spatial variability of elemental concentrations in collected plant and soil materials. The plants were sampled in May, 1986 and then resampled in exactly the same fashion in December, 1986, hence the temporal aspect (crossed-element) of the sampling plan. Soils were only sampled in May, 1986. The spatial aspects were to be considered by the hierarchical nature of sampling among-traverse variability, among-site variability along a traverse, between-shrub variability at a site, within-shrub variability, and within-sample variability. This is discussed more thoroughly below. The unbalancing of the design provides for economy of sampling and analysis time without sacrificing statistical rigor (Leone and others, 1968).

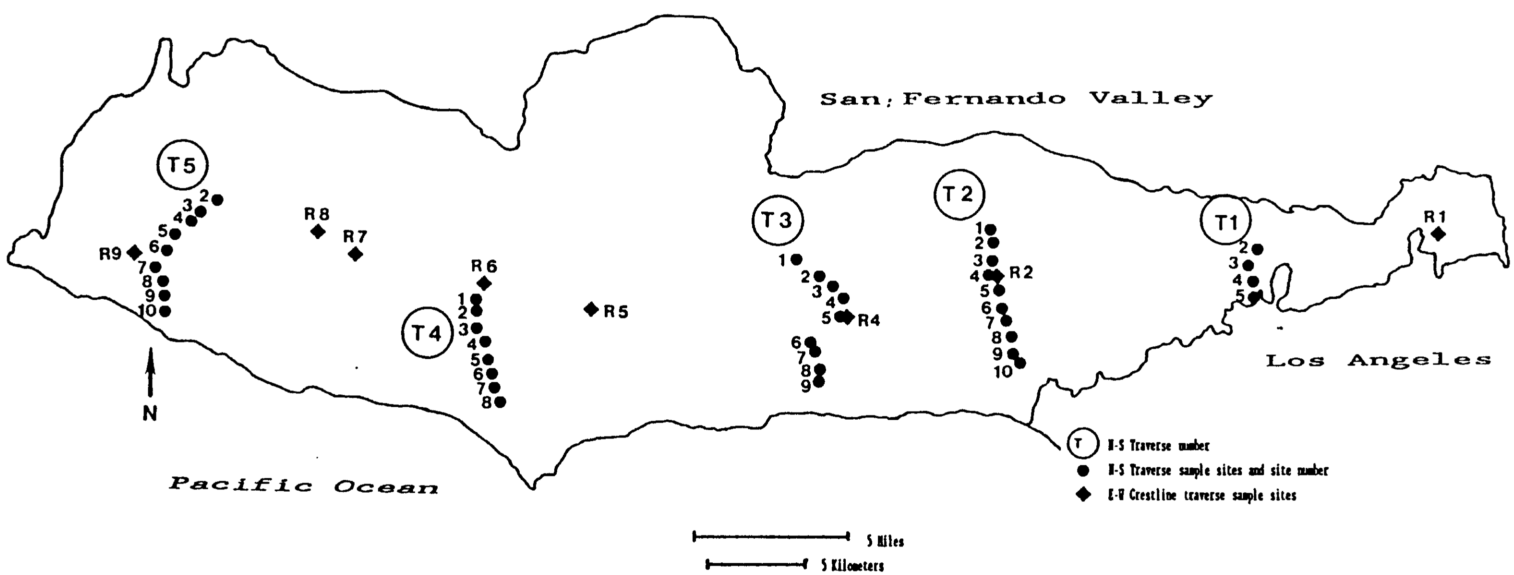


Figure 4. Traverse and sample site index map.

North-South Trending Traverses

Five north-south trending traverses were established with a total of 40 sample sites (Figure 4). Along each traverse, sample sites were established at approximately 0.8 km (1/2 mi) intervals. For each traverse, at each site a sample of *C. megacarpus*, *R. laurina* and surficial soil was collected. In addition, the unbalanced, hierarchical ANOVA design (Figure 5) required sampling of two separate shrubs of each species at 40-50% of the randomly selected sites along each traverse. These samples were identified as between-shrub replicates. One shrub of each species was also sampled at 40-50% of the randomly selected sites along each traverse. These samples were identified as within-shrub replicates. For uniformity, all shrub samples were collected from the south-side except when a within-shrub replicate was required and then the north-side was also sampled. In the laboratory an additional 10-15% of the total number of samples collected were split and analyzed separately. These samples were identified as laboratory replicates.

Along one traverse *Q. agrifolia* bark samples were collected in a similar hierarchical fashion as the other two plant species.

Soil samples were similarly collected. The design called for comparison among traverses, among sites, between pits at a site (30-50% of the sites), and laboratory replication (15% of the total). The schematic diagram in Figure 5 shows the relationship of each ANOVA level, but the diagram is for illustration purposes only and the samples collected did not correspond with the exact pattern of unbalancing shown.

A general description of each traverse follows:

<u>Traverse 1--Franklin Canyon.</u> Four traverse sites were established in chaparral on predominantly west-facing slopes along the eastern side of Franklin Canyon. Sites were located upslope from the canyon bottom, but generally well below the canyon rim. Traverse sites were numbered T1-2 through T1-5.

<u>Traverse 2--Topanga State Park.</u> Ten traverse sites were established in chaparral on predominantly south- and west-facing slopes along Fire Road #30 (Temescal Fire Road) in Topanga State Park. The sites were located near the crestline of the north-south trending ridge dividing Santa Ynez and Temescal Canyons. Traverse sites were numbered T2-1 through T2-10.

<u>Traverse 3--Calabasas-Saddle Peaks.</u> Nine traverse sites were established in chaparral on predominantly south- and west-facing slopes along north-south trending ridge crests from Calabasas Peak to Saddle Peak and then southward along Rambla Pacifico Road. Traverse sites were numbered T3-1 through T3-9.

<u>Traverse 4--Zuma-Trancas Ridge.</u> Eight traverse sites were established in chaparral on predominantly south- and west-facing slopes along the fire road that extends southward from about Saddle Rock along the north-south trending crestline that separates Zuma and Trancas Canyons. Traverse sites were numbered T4-1 through T4-8.

<u>Traverse 5--Big Sycamore Canyon.</u> Nine traverse sites were established in coastal sage, chaparral, and riparian woodlands on predominantly west-facing slopes and in the bottomlands of Big Sycamore Canyon in Point Mugu State Park. *C. megacarpus* and *R. laurina* samples were collected just upslope from the canyon bottom, well below the

canyon rim. *Q. agrifolia* samples were collected in the riparian woodlands of the canyon bottom. Traverse sites were numbered T5-2 through T5-10.

East-West Trending Crestline Traverse

One east-west trending traverse was established at the crestline of the Santa Monica Mountains extending from Griffith Park to Point Mugu State Park. At several locations the true crestline of the range was unsuitable for sampling and an east-west trending ridge crest closer to the ocean was chosen. Samples of *R. laurina* and surficial soils were collected from both north and south facing sides of the crestline at eight locations (Figure 4). The samples were collected using an unbalanced, hierarchical ANOVA design (Figure 6, Appendix Figure A1). Identical sampling was performed on each side of the crestline. Plants were sampled at east and west sites separated by about 20-30 m on each side and 10-20 m below the crestline. These samples were identified as east-west between-shrub replicates. An additional shrub was sampled within about 5 m of the original shrub at one of the east-west sites (randomly selected) on each side of the crestline. These samples were identified as between-shrub replicates. At the opposing east-west site the shrub was sampled from both upslope and downslope sides and these samples were identified as within-shrub replicates. Thus each side of the crestline had an east and west site sample, one between-shrub replicate, and one within-shrub replicate for a total of eight samples per traverse site. In the laboratory an additional 15% of the total number of plant samples collected were split and analyzed separately.

On each side of the crestline a soil sample was collected at either the east or west shrub location (based on random selection). Thus two soil samples were collected per traverse site. In the laboratory 15% of the total number of soil samples collected were split and analyzed separately. Sampling sites were labeled R1-R9.

STUDY METHODS

Sample Collection

Selection criteria for the north-south trending traverse sites were: (1) 30 m or more away, preferably upslope, from roads or other man-caused disturbances, (2) south- or west-facing aspect, (3) all shrubs of the selected population within 30 m of each other, and (4) robust, mature shrubs. *C. megacarpus* was absent at several locations along Traverses 1 and 5. For the crestline traverse, sample site selection criteria were generally the same as for the north-south trending traverses. In addition, sites had to have *R. laurina* that was located on both north and south sides of the east-west trending crestline. In crossing the crestline from south to north there is a distinct change in the chaparral community and *R. laurina* rapidly disappears. This caused some difficulty in establishing the crestline traverse sites. One potential site, R3 (to the west of Fernwood), was completely omitted from the study and at site R8, near Sandstone Peak, samples were only collected from the south side of the crestline.

Plant samples were collected at two different seasons during 1986. The first sample collection occurred between May 9-17, at the beginning of the dry season. The second sample collection occurred six months later on December 9-14, at the beginning of an apparently delayed

Figure 5. Schematics of the unbalanced, hierarchical ANOVA sampling designs for N-S trending traverses for surficial soils and for *R. laurina* and *C. megacarpus*. Diagrams do not represent exact unbalancing used.

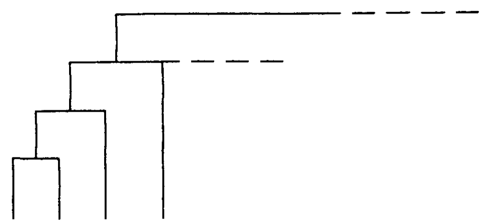
Surficial Soils ANOVA

Level 1--Among Traverses

Level 2--Among Sites

Level 3--Between Pits

Level 4--Lab Replicates



R. laurina and *C. megacarpus* ANOVA

Level 1--Among Traverses

Level 2--Among Sites

Level 3--Between Shrubs

Level 4--Within Shrubs

Level 5--Lab Replicates

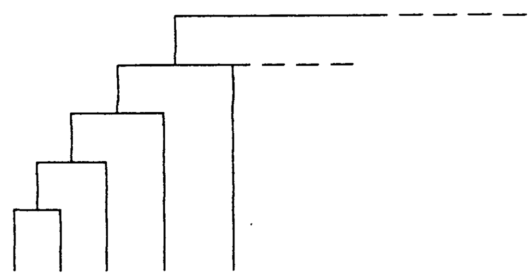


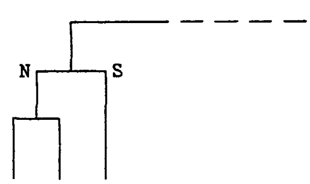
Figure 6. Schematics of the unbalanced, hierarchical ANOVA sampling designs for E-W trending crestline traverse for surficial soils and for *R. laurina*. Diagrams do not represent exact unbalancing used.

Surficial Soils ANOVA

Level 1--Among Sites

Level 2--N vs S Aspect

Level 3--Lab Replicates



R. laurina ANOVA

Level 1--Among Sites

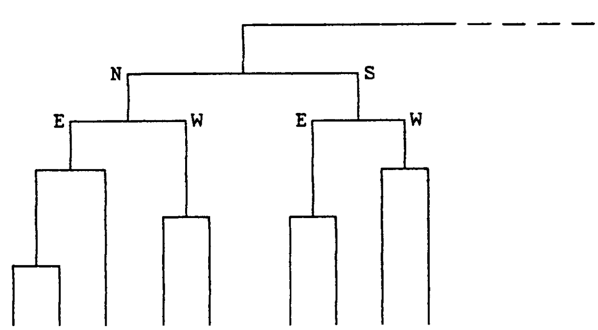
Level 2--N vs S Aspect

Level 3--E vs W

Level 4--Between Shrubs

Level 5--Within Shrubs

Level 6--Lab Replicates



wet season. The second collection was performed on the same shrubs as sampled in the first collection. Soil samples were only collected during the May collection period.

R. laurina is a dense 2-5 m tall evergreen shrub with 5 cm long, oblong, smooth, waxy leaves; it blooms in June and July. The terminal leaves and stems, approximately 5-30 cm from the tip, of mature *R. laurina* were collected by hand from numerous perimeter branches about 1-2 m above the ground on the south-facing side of the shrub. Within-shrub replicates were collected from the north-facing side of the shrub. In May the leaves were generally collected from branches with active growth and a developing flower head. For the December collection similar branches were sampled in which the remnants of the flower head were visible. The collected material, approximately 50-100 g, was placed in cloth bags, air-dried in the field, and stored at ambient temperatures.

C. megacarpus is an evergreen shrub growing approximately 2-5 m high with small, rough, waxy leaves. It blooms from January to April. The terminal leaves, approximately 5-10 cm from the tip, were collected by hand from numerous perimeter branches as described above. The collected material, approximately 20-50 g, was placed in cloth bags, air-dried in the field, and stored at ambient temperatures.

Bark from *Q. agrifolia* was collected with a draw knife approximately 2-3 m above the ground. After the highly dissected epidermis was removed from a 100-250 cm^2 area of a major laterally projecting lower limb, the moist reddish cortex was scraped and saved. The diameter of the branch sampled ranged from about 30-100 cm. The collected material, approximately 50-100 g, was stored in cloth bags, air-dried in the field, and stored at ambient temperatures.

All shrubs and trees sampled were marked with an aluminum tag and a sample identification number. For shrubs the tags were wired to terminal branches about 2 m high and for trees the tags were attached with galvanized nails to the trunk approximately 2.5 m high.

Surficial soil samples were collected with a stainless steel trowel to a depth of about 15 cm, after removing surface litter. Approximately 1-2 kg of soil were sieved through a stainless steel screen with 1 cm^2 openings. The sieved material was mixed by hand in a plastic pan. Approximately 0.5-1 kg of material was placed in a paper soil sample bag, air-dried in the field, and stored at ambient temperatures. The soil pit was generally located within 2-3 m of the primary *R. laurina* shrub sampled. Replicate soil pits were separated by about 10 m.

Sample Preparation

Prior to preparation and analysis samples were arranged in randomized suites with a maximum of 40 samples segregated by sample type. Analytical results and geocoding information are permanently archived in the U.S.G.S. Rock Analysis Storage System (RASS).

Plant samples were dried at 40°C for approximately 48 hr. The dried plant material was ground in a Wiley mill to pass a 2 mm screen. Soil samples were air-dried and disaggregated in a ceramic mortar to pass a 10 mesh (2 mm) sieve. The material passing through the sieve was further ground to pass a 100 mesh (0.15 mm) sieve using an agate shatter box.

Sample Analysis

All plant samples were ashed in Vicor crucibles at 450-500°C over an 18 hour period. One hundred milligrams of the ash were digested with mixed acids. After complete digestion of the plant ash, selected metals (Table 1) were determined by inductively coupled plasma atomic emission spectroscopy (ICP) (Lichte and others, 1987). Total sulfur was determined directly on 250 mg of the ground plant material by combustion at 1370°C in an oxygen atmosphere with infrared detection of evolved SO_2 (Jackson and others, 1985).

All soil samples were analyzed by ICP for the same suite of elements (Table 1) as the plants. Two hundred milligrams of ground material were completely digested with mixed acids. Total sulfur was determined in the soils by the same procedure used for the plants. Total carbon was determined by combustion of 0.25-1 g of ground material at 1370°C in an oxygen atmosphere with infrared detection of evolved CO_2 (Jackson and others, 1987). Carbonate carbon was determined by coulometric titration of acid-evolved CO_2 (Engleman and others, 1985). Organic carbon was determined by the difference of total and carbonate carbon.

The lower detection limits for all elements and species determined are shown in Table 1. The detection limit for elements in plant materials determined by ICP is twice as great as those for soils due to the use of the smaller sample size.

Table 1. Detection limits for the analysis of plants and soils.

Inductively-Coupled Plasma Emission					
Element	Plants	Soils	Element	Plants	Soils
Al %	0.1	0.05	Ga ppm	8	4
Ca %	0.1	0.05	Ho ppm	8	4
Fe %	0.1	0.05	La ppm	4	2
K %	0.1	0.05	Li ppm	4	2
Mg %	0.1	0.05	Mn ppm	8	4
Na %	0.01	0.005	Mo ppm	4	2
P %	0.01	0.005	Nb ppm	8	4
Ti %	0.01	0.005	Nd ppm	8	4
Ag ppm	4	2	Ni ppm	4	2
As ppm	20	10	Pb ppm	8	4
Au ppm	16	8	Sc ppm	4	2
Ba ppm	2	1	Sn ppm	20	10
Be ppm	2	1	Sr ppm	4	2
Bi ppm	20	10	Ta ppm	80	40
Cd ppm	4	2	Th ppm	8	4
Ce ppm	8	4	U ppm	200	100
Co ppm	2	1	V ppm	4	2
Cr ppm	2	1	Y ppm	4	2
Cu ppm	2	1	Yb ppm	2	1
Eu ppm	4	2	Zn ppm	4	2

Other Methods		
Element	Plants	Soils
Total C%	-	0.01
Inorg. C%	-	0.01
Total S%	0.01	0.01

Data Analysis

Data analysis has been performed using a variety of public domain and commercial software such as U.S.G.S. STATPAC (Grundy and Miesch, 1988) and Lotus 123.

The raw data as reported by the laboratory and stored in the RASS are found in Appendices II-XI. All soil data have been analyzed on a dry-weight basis (i.e. air-dried). For plants, S and ash are on a dry-weight basis (at 40°C) and all other elements are on an ash-weight basis. We feel that for plants the use of an ash-weight basis provides a more uniform comparison for inter- and intra-seasonal element concentrations. All data unless otherwise specified have been logarithmically (base 10) transformed prior to statistical analysis. Where appropriate, qualified data, that is those results below the analytical detection limit, have been replaced with 0.7 times the detection limit prior to statistical analysis. Elements with more than 33% qualified values have been excluded from any analyses. In general, limited replacement of qualified values has little influence on robust techniques such as ANOVA. However, appropriate caution should be used in interpreting correlation-based techniques where we have used replacement of qualified values.

The geometric means for elemental concentrations were determined as weighted averages of the transformed data due to the unbalanced nature of the sample design. The hierarchical ANOVA levels were used for weighting so that the lowest level, laboratory replicates, was averaged first and then each succeeding level upward through the hierarchical chain. Pooled geometric deviations were determined as the square root of the total variance determined in the unbalanced, hierarchical ANOVA. Geometric means and deviations were calculated for several elements which required replacement of some of the qualified values. This introduces a bias to these results, but it is important in order to allow comparisons to be made between different data sets to guide future research.

The sampling design was truly a crossed-hierarchical ANOVA design which incorporated both temporal and spatial aspects. However, software to appropriately analyze the unbalanced design was not available. Therefore the data have only been analyzed one season at a time by ANOVA. Inter-seasonal comparisons have been made by parametric analysis of the logarithmically transformed data as paired sets.

Hierarchical clustering analysis was performed on soils and plants using standardized variables (logarithmically transformed data were standardized to non-hierarchically weighted means of 0 and variances of 1). The incremental sum-of-squares technique was used for simplicity of graphical interpretation.

Exploratory factor analysis (R-mode) was performed on soils and plants using standardized variables for the logarithmically transformed data (Davis, 1986). In order not to overweight in the factor model the chemistry of those sites where laboratory and other within-site replicates were obtained all within-site replicates were hierarchically averaged to obtain site means. Those factors obtained with eigenvalues greater than one were extracted for varimax rotation to create the final factor model. The number of variables in the factor model could not exceed the number of samples.

Three types of absorption coefficients (Brooks, 1983) were calculated using hierarchically averaged, non-logarithmically transformed results appropriate for each specific coefficient. Temporal absorption coefficients (TAC) were determined using each individual plant sampled.

Within plant and laboratory replicates were averaged in order to obtain an individual plant arithmetic mean prior to calculation of the TAC. All TAC's were then averaged to obtain a grand mean. Relative absorption coefficients (RAC) were calculated using the hierarchically averaged mean for all samples of each species at a site. The biological absorption coefficient (BAC) was also calculated using the hierarchical average for all samples at a site.

RESULTS AND DISCUSSION

Summary Statistics and Analysis of Variance

N-S Traverses: Soils. Summary statistics, range, geometric mean and deviation for the soil samples, collected in May, 1986, for the north-south trending traverses are shown in Table 2. This table includes results from the unbalanced, hierarchical ANOVA. The ANOVA results are presented as percentages of the total variance accounted for by each level in the design assuming that the total variance is the sum of the variances for each level. In addition, those levels that were determined to be statistically significant using an F-test at the 0.05 probability level are indicated. In general, for those elements with a geometric mean concentration an order of magnitude or more above the detection limit most of the variance was accounted for at the ANOVA level "among sites along a traverse" with the next greatest amount of variance accounted for at the level "among traverses" followed by the level "between soil pits." For most elements these three levels are statistically different. As a result of the laboratory replicate analyses being performed on splits of material obtained from the ground and homogenized sample and the excellent precision for most analyses, the statistical significance of the difference between soil pits may not be important. Even though the pits are statistically different, very little of the total variance is attributable to differences between pits, and the replicate pits at a site were from the same general soil taxonomy units. Hierarchical clustering analysis of the soil chemical data generally shows that the laboratory replicates followed by the replicate soil pits are the most closely related samples (Figure 7).

N-S Traverses: *R. laurina*. Summary statistics and ANOVA results for the *R. laurina* collected in May and December, 1986, along the north-south trending traverses are shown in Tables 3 and 4, respectively. The sulfur and ash weight results are reported on a dry weight basis; and all other results are on an ash weight basis. In examining the ANOVA results for the major essential elements in Tables 3 and 4 there are some obvious trends. Regardless of season the majority of the variance occurs at the among site, between shrubs, and within shrub levels in descending order of magnitude. In general these differences are statistically significant. Only a few percent of the total variance is attributable to differences among traverses or between laboratory replicates. For the trace elements the variance is distributed less uniformly. Several elements, especially from the May collection, have a large proportion of their variance at the laboratory replicate level. These elements tend to have a concentration range that is small and less than an order of magnitude above the analytical detection limit. Pb, Zn, and several other elements display statistically significant differences at the between-traverse level with nearly 50% of their total variance at this level.

N-S Traverses: *C. megacarpus*. Summary statistics and ANOVA results are found in Tables 5 and 6 for the *C. megacarpus* collected in May and December at the same traverse locations as the *R. laurina* discussed above. The elemental results are reported on the same basis as the results for *R. laurina*.

The trends in the ANOVA results are similar in the *C. megacarpus* as for *R. laurina*. In general, the largest proportion of the variance for most elements is attributable to differences among sites. For most elements the among site, between shrubs, and within shrub ANOVA levels are significantly different than the next lower level at the 0.05 probability level. For major elements relatively little variance is found among traverses except for Na.

N-S Traverse 5: *Q. agrifolia*. Summary statistics and ANOVA results for elements in the bark from *Q. agrifolia* collected at sites along the canyon bottom of Traverse 5--Big Sycamore Canyon are shown in Tables 7 and 8. The results are reported on the same basis as for the other two plant species. Also, compared to the other species several additional elements are found at detectable levels and are shown in these tables.

The ANOVA results indicate that for most elements the majority of the variance is between trees at a single site. For many of the major elements, 90-98% of the variance is attributable to this level. The remainder of the variance is largely apportioned to the among site level. Only P, Mn, and Sr are significantly different at this level, whereas most elements are significantly different at the between tree level.

E-W Crestline: Soils. Summary statistics and ANOVA results are shown in Table 9 for soils collected in May, 1986 along the east-west trending crestline traverse (Figure 4). The ANOVA design was similar to that used for the soils collected along north-south trending traverses (Figures 5 and 6). However, no replicate pits on the north- or south-facing slopes were collected; therefore, there are only three hierarchical ANOVA levels. The ANOVA results indicate that the largest percentage of total variance was attributable to differences among sites and between north- and south-facing slopes. For many elements 80 to almost 100% of the variance was found at the among-sites level. Little variance was contributed by analytical imprecision. The differences for most elements at the among-sites level compared to the north versus south level were statistically significant. In addition, for more than one third of the elements, the differences at the north versus south level were statistically significant compared to laboratory replication. But caution should be used in the interpretation of this difference. No soil replicate samples were collected on an individual side of the crestline and it is not known how great the variability between site-replicated soil samples may be.

E-W Crestline: *R. laurina*. Summary statistics and ANOVA results for *R. laurina* collected in May and December along the crestline traverse are shown in Tables 10 and 11. Sixty-eight samples and replicates were analyzed in the December collection, but only 65 samples were analyzed in the May collection due to the loss of three samples in the field.

The ANOVA indicated that for many elements a large proportion of the total variance was attributable to differences among sites, whereas a much smaller percentage was attributable to differences between north- and south-facing slopes. In general, if the percentage variance at the traverse site level was 50% or greater this level was significantly different from the north-south aspect level. The variance exhibited between samples collected on the same side of the crestline was typically between 10-40% and for ¼-½ of the elements differences between this level and the between shrubs level were statistically significant.

Figure 7. Hierarchical cluster dendrogram for soils along N-S traverses.

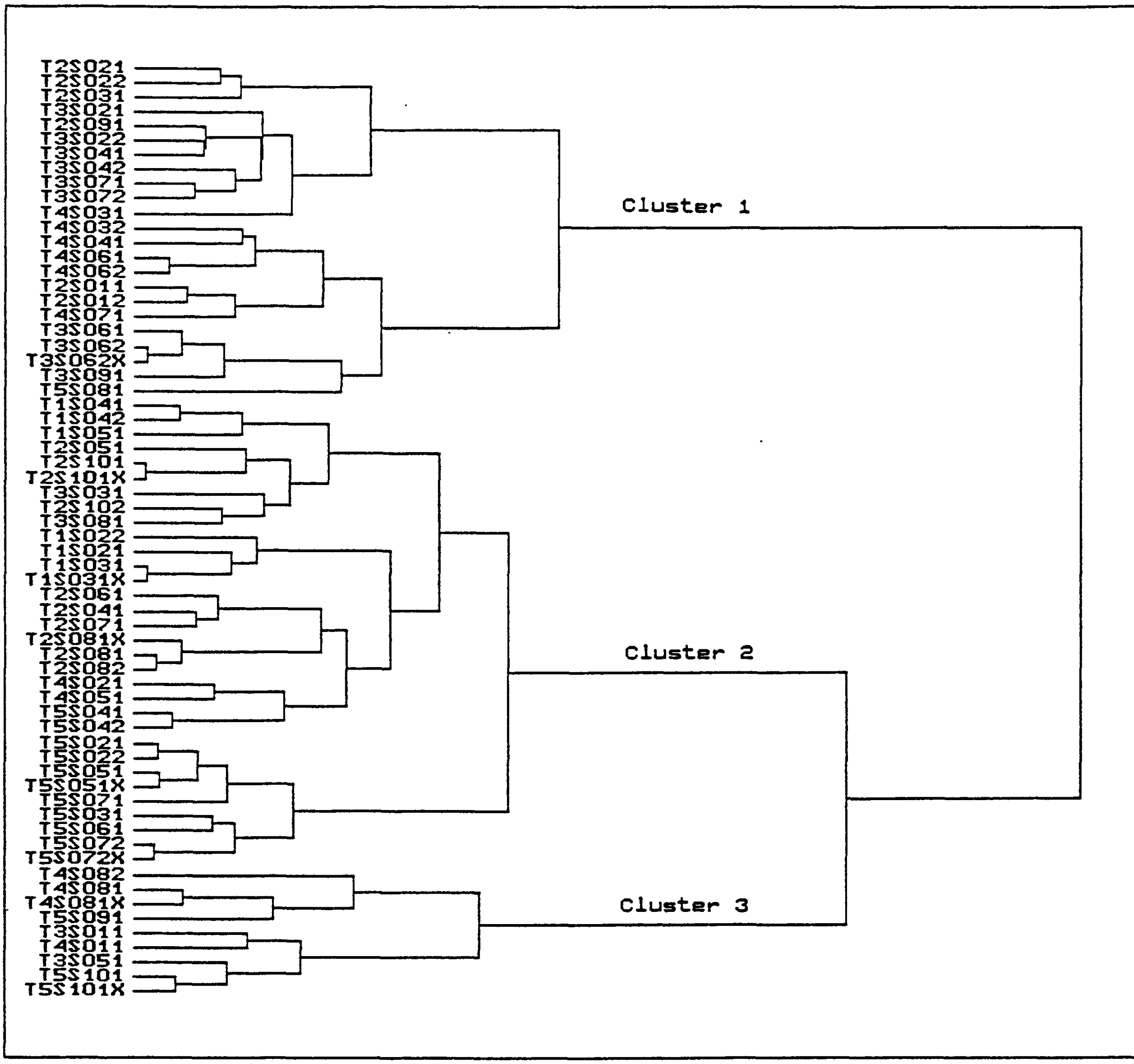


Table 2. Summary statistics and ANOVA results for soils from N-S traverses--May collection.

						Percentage Variance[1] at each ANOVA level			
Element	Ratio[2]	Minimum	Maximum	Geometric Mean	Geometric Deviation	Among Traverses	Among Sites	Between Pits	Laboratory Replicates
Total C%	64/64	0.35	7.18	2.20	2.09	0	56 *	44 *	0
Org. C%	64/64	0.35	7.15	2.07	2.10	0	56 *	44 *	0
Inorg. C%	24/64	< 0.01	3.76						
Total S%	50/64	< 0.01	0.03	0.01	1.67	0	56 *	0	44
pH	64/64	5.31	7.92	6.82	1.08	35 *	32 *	29 *	4
Al%	64/64	5.0	8.9	6.9	1.12	0	53 *	41 *	6
Ca%	64/64	0.48	12	1.5	2.00	0	87 *	13 *	0
Fe%	64/64	1.2	7.4	3.5	1.62	26 *	64 *	9 *	1
K%	64/64	0.41	3.3	1.7	1.75	21 *	74 *	3 *	2
Mg%	64/64	0.14	4.2	1.0	2.22	38 *	59 *	3 *	0
Na%	64/64	0.20	3.4	1.7	1.55	5	52 *	43 *	0
P%	64/64	0.02	0.27	0.06	1.79	1	85 *	7	7
Ti%	64/64	0.13	1.1	0.38	1.59	16 *	76 *	8 *	0
Mn ppm	64/64	220	1300	600	1.55	29 *	59 *	11 *	2
As ppm	14/64	< 10	50						
Ba ppm	64/64	190	1500	650	1.71	16 *	82 *	2 *	1
Be ppm	44/64	< 1	2	1	1.49	34 *	47 *	0	19
Cd ppm	11/64	< 2	8						
Ce ppm	64/64	7	90	46	1.77	16 *	79 *	3	3
Co ppm	64/64	4	45	15	2.02	34 *	56 *	9 *	0
Cr ppm	64/64	11	460	76	2.55	49 *	47 *	4 *	0
Cu ppm	64/64	4	71	22	2.25	34 *	53 *	12 *	0
Ga ppm	64/64	11	22	16	1.18	9	66 *	19 *	7
La ppm	64/64	4	47	24	1.78	12	82 *	5 *	1
Li ppm	64/64	7	75	24	1.76	51 *	42 *	6 *	1
Mo ppm	17/64	< 2	10						
Nb ppm	37/64	< 4	9						
Nd ppm	64/64	5	48	22	1.53	24 *	63 *	11 *	2
Ni ppm	64/64	6	200	38	2.70	53 *	42 *	4 *	1
Pb ppm	61/64	< 4	67	18	1.96	37 *	45 *	0	17
Sc ppm	64/64	3	29	11	1.78	39 *	55 *	6 *	1
Sr ppm	64/64	120	370	220	1.34	1	84 *	12 *	2
Th ppm	54/64	< 4	17	7	1.72	35 *	58 *	6 *	2
V ppm	64/64	21	190	88	1.80	32 *	63 *	5 *	0
Y ppm	64/64	8	43	18	1.38	22 *	51 *	26 *	2
Yb ppm	61/64	< 1	4	2	1.48	4	35	48 *	13
Zn ppm	64/64	20	160	67	1.61	32 *	57 *	10 *	1

[1]* significant at 0.05 probability level.
[2]Ratio of samples with detectable concentrations to the total number of samples.

Table 3. Summary statistics[1] and ANOVA results for *R. laurina* from N-S traverses--May collection.

Element	Ratio[3]	Minimum	Maximum	Geometric Mean	Geometric Deviation	Percentage Variance[2] at each ANOVA level: Among Traverses	Among Sites	Between Shrubs	Within Shrubs	Laboratory Replicates
Total S%[1]	87/87	0.11	0.21	0.15	1.14	0	60 *	16	14	10
Ash%[1]	87/87	2.49	4.96	3.84	1.14	0	35 *	37 *	22 *	6
Al%	87/87	0.11	0.53	0.23	1.41	0	53 *	26 *	19 *	1
Ca%	87/87	7.5	18	12	1.24	0	54 *	9	36 *	2
Fe%	87/87	0.12	0.41	0.23	1.29	5	52 *	26 *	15 *	1
K%	87/87	19	40	33	1.15	0	36 *	43 *	19 *	2
Mg%	87/87	1.5	7.8	3.4	1.35	5	38 *	52 *	5 *	0
Na%	87/87	0.13	5.2	0.38	2.04	28 *	44 *	0	28 *	0
P%	87/87	3.0	8.2	5.5	1.26	0	58 *	0	39 *	2
Ti%	87/87	0.01	0.04	0.01	1.56	6	23	24	0	47
Mn ppm	87/87	310	3900	1100	1.83	45 *	37 *	11 *	6 *	0
Ba ppm	87/87	30	550	99	2.25	38 *	43 *	13 *	5 *	0
Cd ppm	21/87	< 4	34							
Ce ppm	17/87	< 8	31							
Co ppm	85/87	< 2	6	3	1.35	5	18	28	20	28
Cr ppm	87/87	5	21	10	1.37	5	12	8	56 *	18
Cu ppm	87/87	70	240	140	1.32	0	39 *	35 *	26 *	1
La ppm	16/87	< 4	32							
Li ppm	42/87	< 4	280							
Mo ppm	29/87	< 4	19							
Nd ppm	2/87	< 8	13							
Ni ppm	87/87	10	140	52	1.76	0	49 *	46 *	4 *	1
Pb ppm	59/87	< 8	33	11	1.77	48 *	13	14	21 *	4
Sc ppm	0/87	< 4	< 4							
Sr ppm	87/87	64	690	200	1.66	14 *	28 *	45 *	12 *	0
V ppm	52/87	< 4	11							
Y ppm	9/87	< 4	36							
Zn ppm	87/87	320	1000	550	1.30	44 *	15	24 *	15 *	1

[1]Elements with summary statistics on a dry-weight basis, all other elements on an ash-weight basis.
[2]* significant at 0.05 probability level.
[3]Ratio of samples with detectable concentrations to the total number of samples.

Table 4. Summary statistics[1] and ANOVA results for *R. laurina* from N-S traverses--December collection.

Element	Ratio[3]	Minimum	Maximum	Geometric Mean	Geometric Deviation	Percentage Variance[2] at each ANOVA level: Among Traverses	Among Sites	Between Shrubs	Within Shrubs	Laboratory Replicates
Total S%[1]	87/87	0.06	0.13	0.09	1.20	11 *	40 *	0	24	24
Ash%[1]	87/87	2.72	6.06	3.92	1.22	14	73 *	7 *	6 *	0
Al%	87/87	0.09	0.50	0.22	1.44	0	43 *	42 *	13 *	2
Ca%	87/87	18	31	24	1.15	0	68 *	16	13 *	2
Fe%	87/87	0.07	0.41	0.19	1.40	3	54 *	29 *	13 *	1
K%	87/87	5.6	27	15	1.40	0	59 *	23 *	18 *	1
Mg%	87/87	2.5	11	5.4	1.38	0	51 *	34 *	13 *	2
Na%	87/87	0.09	3.7	0.29	2.12	3	79 *	0	17 *	1
P%	87/87	1.5	5.3	2.6	1.35	0	79 *	14 *	6 *	1
Ti%	66/87	< 0.01	0.04	0.01	1.68	4	46 *	3	0	47
Mn ppm	87/87	310	5400	1400	2.10	26 *	28 *	0	33 *	13
Ba ppm	87/87	38	940	160	2.94	25 *	49 *	0	26 *	0
Cd ppm	19/87	< 4	50							
Ce ppm	15/87	< 8	43							
Co ppm	87/87	3	9	4	1.37	5	19	19	0	57
Cr ppm	64/87	< 2	18	5	2.90	9 *	0	39	0	53
Cu ppm	87/87	33	690	71	1.97	0	19 *	0	0	81
La ppm	87/87	7	45	11	1.51	18 *	62 *	13 *	5 *	1
Li ppm	50/87	< 4	330							
Mo ppm	17/87	< 4	12							
Nd ppm	5/87	< 8	22							
Ni ppm	87/87	5	230	24	2.14	13	54 *	16	15 *	1
Pb ppm	70/87	< 8	47	13	2.00	33 *	29 *	0	0	38
Sc ppm	5/87	< 4	5							
Sr ppm	87/87	150	1500	460	1.60	6	55 *	33 *	5 *	1
V ppm	28/87	< 4	12							
Y ppm	22/87	< 4	23							
Zn ppm	87/87	160	860	400	1.40	16 *	39 *	25 *	3	18

[1]Elements with summary statistics on a dry-weight basis, all other elements on an ash-weight basis.
[2]* significant at 0.05 probability level.
[3]Ratio of samples with detectable concentrations to the total number of samples.

Table 5. Summary statistics[1] and ANOVA results for *C. megacarpus* from N-S traverses--May collection.

Element	Ratio[3]	Minimum	Maximum	Geometric Mean	Geometric Deviation	Percentage Variance[2] at each ANOVA level: Among Traverses	Among Sites	Between Shrubs	Within Shrubs	Laboratory Replicates
Total S%[1]	72/72	0.10	0.16	0.13	1.10	12	25	33 *	1	29
Ash%[1]	72/72	2.55	5.57	3.77	1.18	11	34	37 *	18 *	0
Al%	72/72	0.08	0.60	0.21	1.54	0	64 *	22 *	12 *	2
Ca%	72/72	16	30	22	1.19	0	47 *	45 *	6 *	2
Fe%	72/72	0.13	0.43	0.24	1.33	0	67 *	22 *	5	7
K%	72/72	12	31	20	1.27	2	56 *	33 *	9 *	1
Mg%	72/72	2.3	9.1	4.8	1.35	2	69 *	25 *	4 *	1
Na%	72/72	0.23	5.5	1.2	2.02	28 *	41 *	24 *	7 *	0
P%	72/72	2.5	7.4	4.3	1.28	0	68 *	16	14 *	2
Ti%	72/72	0.01	0.03	0.01	1.47	0	60 *	0	0	40
Mn ppm	72/72	260	3700	910	1.64	15	63 *	21 *	0	0
Ba ppm	72/72	54	1100	200	2.16	5	87 *	6 *	2 *	0
Cd ppm	2/72	< 4	5							
Ce ppm	14/72	< 8	16							
Co ppm	71/72	< 2	8	3	1.43	13	39 *	0	0	49
Cr ppm	72/72	4	110	9	1.60	0	78 *	12	6	5
Cu ppm	72/72	60	240	140	1.38	0	63 *	26 *	7 *	4
La ppm	22/72	< 4	26							
Li ppm	66/72	< 4	200	12	2.86	38 *	49 *	10 *	2 *	0
Mo ppm	24/72	< 4	58							
Nd ppm	0/72	< 8	< 8							
Ni ppm	72/72	12	210	58	2.13	0	93 *	2	4 *	1
Pb ppm	56/72	< 8	34	13	1.82	11	52 *	16	17 *	5
Sc ppm	0/72	< 4	< 4							
Sr ppm	72/72	150	1900	570	1.85	0	91 *	6 *	3 *	0
V ppm	28/72	< 4	12							
Y ppm	17/72	< 4	20							
Zn ppm	72/72	260	840	480	1.26	8	64 *	11	16 *	1

[1]Elements with summary statistics on a dry-weight basis, all other elements on an ash-weight basis.
[2]* significant at 0.05 probability level.
[3]Ratio of samples with detectable concentrations to the total number of samples.

Table 6. Summary statistics[1] and ANOVA results for *C. megacarpus* from N-S traverses--December collection.

Element	Ratio[3]	Minimum	Maximum	Geometric Mean	Geometric Deviation	Percentage Variance[2] at each ANOVA level: Among Traverses	Among Sites	Between Shrubs	Within Shrubs	Laboratory Replicates
Total S%[1]	72/72	0.08	0.13	0.10	1.10	8	0	23	47	21
Ash%[1]	72/72	2.50	6.61	3.80	1.22	11	49 *	23 *	16 *	0
Al%	72/72	0.13	0.76	0.35	1.54	15	40 *	30 *	11 *	3
Ca%	72/72	16	32	24	1.18	10	68 *	15 *	2	5
Fe%	72/72	0.13	0.58	0.31	1.41	12	44 *	29 *	10 *	4
K%	72/72	6.6	28	14	1.38	10	77 *	3	7 *	2
Mg%	72/72	2.0	12	5.2	1.41	16	63 *	13 *	8 *	0
Na%	72/72	0.21	4.9	1.1	2.14	36 *	22	30 *	0	13
P%	72/72	1.7	7.1	3.6	1.44	0	48 *	41 *	0	11
Ti%	70/72	< 0.01	0.05	0.02	1.62	5	25	53 *	12 *	5
Mn ppm	72/72	300	4800	1000	1.69	14	63 *	8	9	6
Ba ppm	72/72	64	1300	250	2.11	5	67 *	19 *	0	10
Cd ppm	0/72	< 4	< 4							
Ce ppm	17/72	< 8	18							
Co ppm	72/72	2	7	4	1.32	23 *	0	39 *	0	38
Cr ppm	72/72	4	27	12	1.45	7	35	33 *	12	13
Cu ppm	72/72	69	260	150	1.38	4	33	41 *	18 *	4
La ppm	72/72	6	26	11	1.46	16 *	19	43 *	4	18
Li ppm	66/72	< 4	300	17	3.19	38 *	45 *	0	16 *	1
Mo ppm	12/72	< 4	33							
Nd ppm	10/72	< 8	12							
Ni ppm	72/72	15	210	60	2.05	0	89 *	6 *	1	3
Pb ppm	71/72	< 8	93	22	1.72	35 *	30 *	17	12	7
Sc ppm	7/72	< 4	5							
Sr ppm	72/72	200	1800	610	1.71	0	84 *	11 *	3	2
V ppm	55/72	< 4	15	6	1.67	15	28	38 *	6	12
Y ppm	18/72	< 4	13							
Zn ppm	72/72	230	790	460	1.30	10	59 *	6	22 *	3

[1]Elements with summary statistics on a dry-weight basis, all other elements on an ash-weight basis.
[2]* significant at 0.05 probability level.
[3]Ratio of samples with detectable concentrations to the total number of samples.

Table 7. Summary statistics[1] and ANOVA results for *Q. agrifolia* from N-S traverse 5--May collection.

Element	Ratio[3]	Minimum	Maximum	Geometric Mean	Geometric Deviation	Percentage Variance[2] at each ANOVA level: Among Sites	Between Trees	Within Trees	Laboratory Replicates
Total S%[1]	23/23	0.05	0.13	0.07	1.23	33	43	15	9
Ash%[1]	23/23	4.72	12.0	7.41	1.25	0	90 *	9 *	1
Al%	23/23	0.69	3.7	1.7	1.65	0	94 *	3	3
Ca%	23/23	25	35	28	1.14	0	98 *	1	1
Fe%	23/23	0.47	2.3	1.1	1.61	3	91 *	5	2
K%	23/23	2.0	12	5.0	1.70	0	95 *	5 *	0
Mg%	23/23	3.2	6.3	4.5	1.28	27	70 *	3 *	0
Na%	23/23	0.32	1.3	0.68	1.46	44	50 *	3	2
P%	23/23	0.31	0.76	0.52	1.28	64 *	31 *	5 *	0
Ti%	23/23	0.04	0.19	0.10	1.64	0	96 *	0	4
Mn ppm	23/23	2700	22000	4700	1.83	75 *	20	4 *	0
Ba ppm	23/23	450	2800	1100	1.78	57	39 *	4 *	0
Cd ppm	20/23	< 4	57	7	2.55	19	79 *	1	0
Ce ppm	19/23	< 8	33	15					
Co ppm	23/23	6	24	12	1.47	39	53 *	5	3
Cr ppm	23/23	9	75	29	1.87	12	74 *	0	14
Cu ppm	23/23	49	180	99	1.34	14	66	19 *	1
Ga ppm	10/23	< 8	17						
La ppm	18/23	< 4	16	7	1.88	28	65 *	2	5
Li ppm	21/23	< 4	16	8	1.64	0	98 *	1	1
Mo ppm	0/23	< 4	< 4						
Nd ppm	6/23	< 8	16						
Ni ppm	23/23	25	130	58	1.55	41	55 *	3	2
Pb ppm	23/23	47	470	160	1.88	38	55 *	7 *	1
Sc ppm	10/23	< 4	8						
Sr ppm	23/23	530	1200	810	1.30	82 *	14	3	1
V ppm	23/23	15	100	36	1.66	30	62 *	6	2
Y ppm	18/23	< 4	13						
Zn ppm	23/23	78	410	170	1.62	59	33	7 *	1

[1]Elements with summary statistics on a dry-weight basis, all other elements on an ash-weight basis.
[2]* significant at 0.05 probability level.
[3]Ratio of samples with detectable concentrations to the total number of samples.

Table 8. Summary statistics[1] and ANOVA results for *Q. agrifolia* from N-S traverse 5--December collection.

Element	Ratio[3]	Minimum	Maximum	Geometric Mean	Geometric Deviation	Percentage Variance[2] at each ANOVA level: Among Sites	Between Trees	Within Trees	Laboratory Replicates
Total S%[1]	23/23	0.02	0.06	0.04	1.40	0	47	0	53
Ash%[1]	23/23	4.48	11.7	6.93	1.27	0	92 *	8 *	0
Al%	23/23	0.29	2.2	0.97	1.66	0	91 *	6	3
Ca%	23/23	17	35	27	1.20	0	97 *	2	1
Fe%	23/23	0.21	1.5	0.62	1.68	0	96 *	3	1
K%	23/23	3.1	24	7.6	1.89	0	95 *	5 *	0
Mg%	23/23	3.8	7.0	5.4	1.19	37	54 *	8 *	1
Na%	23/23	0.20	1.2	0.49	1.59	33	57 *	10 *	1
P%	23/23	0.31	0.87	0.59	1.36	67 *	24	9 *	1
Ti%	23/23	0.02	0.15	0.06	1.66	0	83	13	4
Mn ppm	23/23	1500	24000	3800	2.11	65 *	23	11 *	0
Ba ppm	23/23	220	2800	850	2.11	40	55 *	5 *	0
Cd ppm	20/23	< 4	71	8	2.69	35	63 *	1	1
Ce ppm	11/23	< 8	18						
Co ppm	23/23	5	16	9	1.33	2	83 *	7	9
Cr ppm	23/23	8	52	14	1.58	32	46	16	5
Cu ppm	23/23	42	160	88	1.45	31	54	14 *	1
Ga ppm	9/23	< 8	20						
La ppm	23/23	8	21	13	1.29	0	85 *	12 *	3
Li ppm	21/23	< 4	9	6	1.54	0	94 *	6	0
Mo ppm	0/23	< 4	< 4						
Nd ppm	2/23	< 8	9						
Ni ppm	23/23	15	94	35	1.51	21	72 *	7 *	1
Pb ppm	23/23	26	320	87	1.76	0	85 *	15 *	0
Sc ppm	16/23	< 4	7						
Sr ppm	23/23	430	1200	720	1.33	41	57 *	2 *	0
V ppm	23/23	5	50	19	1.68	11	83 *	5 *	1
Y ppm	7/23	< 4	7						
Zn ppm	23/23	76	300	110	1.41	1	60	37 *	2

[1]Elements with summary statistics on a dry-weight basis, all other elements on an ash-weight basis.
[2]* significant at 0.05 probability level.
[3]Ratio of samples with detectable concentrations to the total number of samples.

Table 9. Summary statistics and ANOVA results for soils from E-W crestline traverse-- May collection.

Element	Ratio[2]	Minimum	Maximum	Geometric Mean	Geometric Deviation	Variance[1] (%) at each ANOVA level: Among Sites	N vs S Aspect	Laboratory Replicates
Total C%	17/17	0.51	6.81	1.84	2.23	57 *	43 *	0
Org. C%	17/17	0.43	6.79	1.71	2.38	46	54 *	0
Inorg. C%	5/17	< 0.01	0.95					
Total S%	11/17	< 0.01	0.03					
pH	17/17	6.40	7.89	6.96	1.07	8	91 *	1
Al%	17/17	5.4	8.5	7.0	1.17	90 *	10 *	0
Ca%	17/17	0.25	6.5	1.2	2.83	63 *	37 *	0
Fe%	17/17	1.4	7.6	3.3	1.73	95 *	5	0
K%	17/17	0.67	7.4	1.8	2.03	84 *	12	4
Mg%	17/17	0.25	5.2	1.0	2.54	90 *	9	1
Na%	17/17	0.32	2.8	1.5	1.62	20	80 *	0
P%	17/17	0.02	0.13	0.05	1.56	19	81	0
Ti%	17/17	0.17	0.66	0.37	1.69	97 *	3	0
Mn ppm	17/17	260	1400	580	1.83	89 *	9	1
As ppm	2/17	< 10	70					
Ba ppm	17/17	240	1500	660	2.06	83 *	17 *	0
Be ppm	6/17	< 1	1					
Cd ppm	1/17	< 2	3					
Ce ppm	17/17	16	75	38	1.64	69 *	28	3
Co ppm	17/17	5	61	15	2.22	95 *	5	0
Cr ppm	17/17	14	370	63	2.79	94 *	5 *	0
Cu ppm	17/17	8	65	20	1.99	88 *	12 *	1
Ga ppm	17/17	10	20	16	1.29	85 *	10	5
La ppm	17/17	7	39	20	1.78	67 *	30	2
Li ppm	17/17	8	33	18	1.73	78 *	22 *	0
Mo ppm	1/17	< 2	3					
Nb ppm	8/17	< 4	6					
Nd ppm	17/17	8	27	18	1.43	30	70 *	0
Ni ppm	17/17	7	260	38	3.07	94 *	4	2
Pb ppm	16/17	< 4	100	13	2.55	64 *	36	0
Sc ppm	17/17	3	22	9	2.00	95 *	5	0
Sr ppm	17/17	140	380	220	1.33	90 *	8	2
Th ppm	11/17	< 4	14					
V ppm	17/17	32	170	70	1.75	95 *	4	1
Y ppm	17/17	10	23	14	1.30	60 *	40	0
Yb ppm	14/17	< 1	2	1	1.55	58 *	25	17
Zn ppm	17/17	20	140	50	1.74	70 *	30	0

[1]* significant at 0.05 probability level.
[2]Ratio of samples with detectable concentrations to the total number of samples.

Table 10. Summary statistics[1] and ANOVA results for *R. laurina* from E-W crestline traverse--May collection.

Element	Ratio[3]	Minimum	Maximum	Geometric Mean	Geometric Deviation	Percentage Variance[2] at each ANOVA level: Among Sites	N vs S Aspect	E vs W	Between Shrubs	Within Shrubs	Laboratory Replicates
Total S%[1]	65/65	0.10	0.21	0.15	1.18	0	26	0	63 *	7 *	4
Ash%[1]	65/65	2.82	4.82	3.88	1.12	9	0	19	28	16	27
Al%	65/65	0.09	0.74	0.21	1.56	57 *	0	5	0	37 *	1
Ca%	65/65	6.3	18	11	1.29	6	0	49 *	5	21	19
Fe%	65/65	0.14	0.56	0.21	1.33	66 *	0	0	5	26 *	2
K%	65/65	24	42	34	1.17	8	13	36 *	0	37 *	7
Mg%	65/65	2.2	8.3	3.7	1.32	9	28	37 *	0	23 *	4
Na%	65/65	0.10	2.5	0.34	1.81	35	17	10	0	31 *	8
P%	65/65	3.8	9.1	6.0	1.22	50 *	11	5	11	17 *	7
Ti%	65/65	0.01	0.05	0.01	1.55	50 *	0	14	0	21	14
Mn ppm	65/65	520	8300	1500	2.06	76 *	2	8	8	4 *	1
Ba ppm	65/65	26	830	100	2.58	70 *	0	12 *	9	0	10
Cd ppm	9/65	< 4	96								
Ce ppm	18/65	< 8	39								
Co ppm	63/65	< 2	16	4	1.68	56 *	0	16	8	4	17
Cr ppm	65/65	4	22	8	1.42	34 *	1	0	22	28	15
Cu ppm	65/65	78	210	140	1.33	0	9	38 *	26	7	20
La ppm	27/65	< 4	28								
Li ppm	23/65	< 4	36								
Mo ppm	9/65	< 4	7								
Nd ppm	1/65	< 8	17								
Ni ppm	65/65	19	150	53	1.73	17	5	23	36 *	0	19
Pb ppm	48/65	< 8	110	12	2.27	64 *	8 *	0	12 *	0	16
Sc ppm	0/65	< 4	< 4								
Sr ppm	65/65	63	1000	290	1.99	71 *	0	13 *	7	9 *	0
V ppm	26/65	< 4	13								
Y ppm	15/65	< 4	21								
Zn ppm	65/65	350	810	560	1.24	2	0	20	46	29 *	3

[1]Elements with summary statistics on a dry-weight basis, all other elements on an ash-weight basis.
[2]* significant at 0.05 probability level.
[3]Ratio of samples with detectable concentrations to the total number of samples.

Table 11. Summary statistics[1] and ANOVA results for *R. laurina* from E-W crestline traverse--December collection.

Element	Ratio[3]	Minimum	Maximum	Geometric Mean	Geometric Deviation	Percentage Variance[2] at each ANOVA level: Among Sites	N vs S Aspect	E vs W	Between Shrubs	Within Shrubs	Laboratory Replicates
Total S%[1]	68/68	0.05	0.12	0.07	1.21	0	10	11	58 *	13	7
Ash%[1]	68/68	2.46	5.44	3.64	1.21	22	0	36 *	19 *	0	23
Al%	68/68	0.06	0.43	0.15	1.52	47 *	8	0	21	21 *	3
Ca%	68/68	17	30	23	1.17	40 *	0	26 *	22 *	10 *	3
Fe%	68/68	0.07	0.41	0.16	1.45	48 *	4	19	0	24 *	5
K%	68/68	8.1	28	16	1.36	46 *	0	27 *	5	15 *	6
Mg%	68/68	3.7	13	6.2	1.30	0	48 *	12	31 *	8 *	0
Na%	68/68	0.06	1.5	0.24	2.26	33	25 *	3	0	39 *	0
P%	68/68	1.7	5.6	2.9	1.34	65 *	6	14 *	4	11 *	0
Ti%	37/68	< 0.01	0.04								
Mn ppm	68/68	670	11000	2100	2.10	80 *	8 *	2	8 *	3 *	0
Ba ppm	68/68	29	1400	190	2.87	74 *	6	14 *	3	3 *	0
Cd ppm	13/68	< 4	26								
Ce ppm	21/68	< 8	52								
Co ppm	68/68	3	28	5	1.83	65 *	0	16 *	13 *	5 *	1
Cr ppm	68/68	2	21	6	1.82	31 *	0	0	32 *	0	38
Cu ppm	68/68	40	170	75	1.36	18	0	36 *	12	0	34
La ppm	68/68	5	50	12	1.65	64 *	0	21 *	5	8 *	3
Li ppm	25/68	< 4	44								
Mo ppm	6/68	< 4	6								
Nd ppm	7/68	< 8	29								
Ni ppm	68/68	8	200	31	1.95	41	12	11	11	25 *	1
Pb ppm	41/68	< 8	160								
Sc ppm	18/68	< 4	7								
Sr ppm	68/68	190	2300	800	1.83	72 *	7	14 *	4 *	2 *	0
V ppm	12/68	< 4	9								
Y ppm	34/68	< 4	45								
Zn ppm	68/68	120	820	360	1.57	45 *	0	34 *	12	8 *	0

[1]Elements with summary statistics on a dry-weight basis, all other elements on an ash-weight basis.
[2]* significant at 0.05 probability level.
[3]Ratio of samples with detectable concentrations to the total number of samples.

Exploratory Factor and Hierarchical Cluster Analysis

<u>N-S Traverses: Soils</u>. Exploratory factor analysis was performed on a subset of the variables determined in the soil samples in order to reduce the dimensionality and examine the latent variables or factors inherent in the data. Our objective was to obtain "simple structure" or easily interpretable factors that explained an acceptable amount of the variance (about 70%). Several factors were expected a priori such as the nature of parent material (sandstone, shale, dolomite, etc.) and its environment of deposition; soil development; and the effect of organic matter.

A four factor model which explained about 85% of the total variance was obtained using a subset of 24 variables. The factor loadings greater than 0.5 are shown in Table 12 for the four factors. Factor 1 is predominantly comprised of major rock forming elements such as Al, Fe, Mg, Ti, and Mn, and several trace metals. Factor 2 is comprised mainly of negatively loaded variables related to carbonate rocks, pH, Ca, and Mg and positively loaded variables K, Ba, Li, Pb, and the rare earth elements Ce and La. The sign of the loadings is only relevant to the relationship of elements within a factor and does not imply absolute concentrations. Factors 3 and 4 are dominated by C and P and by Na and Sr, respectively.

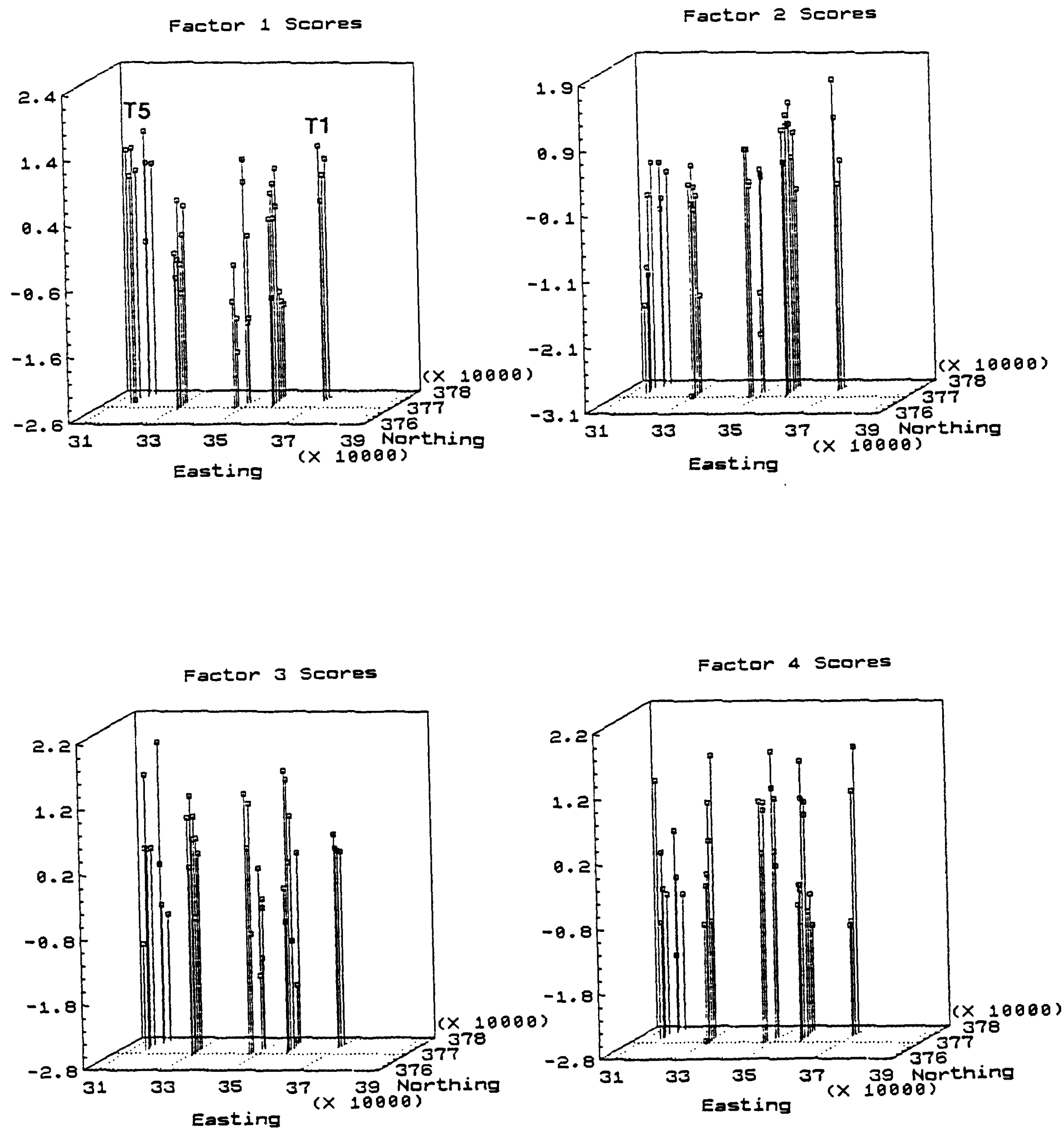
Table 12. Varimax rotated factor loadings for soils from N-S traverses--May collection.

	Factor Loadings > 0.50			
Variable	Factor 1	Factor 2	Factor 3	Factor 4
Total C			0.96	
Organic C			0.93	
pH		-0.53		
Al	0.69			0.52
Ca		-0.74		
Fe	0.95			
K		0.82		
Mg	0.76	-0.51		
Na				0.88
P			0.65	
Ti	0.88			
Mn	0.85			
Ba	-0.52	0.78		
Ce		0.93		
Co	0.88			
Cr	0.79			
Cu	0.88			
La		0.91		
Li	0.61	0.68		
Ni	0.76			
Pb		0.84		
Sr				0.83
V	0.94			
Zn	0.87			
Eigenvalue	11.0	4.7	2.5	2.1
% of total variance	46.0	19.6	10.4	8.6
Cumulative % variance	46.0	65.6	76.0	84.6

Figure 8 shows the varimax-rotated factor scores for the four factors at all of the N-S traverse sites. For factor 1, traverse 2, 3, and 4 scores, in particular, show a great deal of variability along a traverse and in general are lower scores than exhibited along traverses 1 or 5. The difference in scores may indicate more influence of sandstone parent material, less soil development, and/or presence of clays. These scores indicate the tremendous variability found in parent material-soil types throughout the SAMO and the great difficulty that would be encountered in interpreting north-south chemical trends along an individual heterogenous traverse. Plots of the other factor scores (Figure 8) further corroborate the great heterogeneity found along and among traverses. A plot of Factor 1 versus 2 scores (Figure 9) may be used to examine sample clusters and to compare results with the hierarchical cluster analysis to facilitate interpretation. Figure 9 indicates that whereas there is some obvious multivariate clustering of sample sites they do not cluster by traverse, as was seen from hierarchical cluster analysis (Figure 7). In addition, the plot identifies several outliers which are predominantly carbonate-rich soils, although carbonate content was not included in the factor analysis. Cluster 3, in general, appears to be separated in Figure 9 due to higher soil pH and Ca content and lower content of K and several trace metals such as Pb which may substitute for K (Thornton, 1983). Cluster 1 and 2 are separated primarily by negative and positive factor 1 scores, respectively. In this case, cluster 1 has less than average concentrations of a suite of elements associated with aluminosilicates (Al, Fe, Mg, Ti, Mn, and several di- and tri-valent trace metals), whereas cluster 2 has greater than average concentrations. These associations suggest that the two clusters are different due to the influence of parent material such as dilution by silica for cluster 1 or due to degree of weathering. However, because of the similarity of factor 2 scores for clusters 1 and 2, it appears that parent material as reflected by factor 1 scores may play the greater role in differentiating the soils. The factor 2 scores tend to increase in an easterly direction. This is partially due to higher soil pH (negative influence on factor score) and a general decrease in soil Pb levels (see Spatial Trends section below) in the more western sites.

N-S Traverses: *R. laurina*. Exploratory factor analysis with varimax rotation was performed on a subset of 16 variables using the site-level geometric means for both seasons combined. A three factor model accounted for 70% of the total variance. The factor loadings are shown in Table 13. The first factor is comprised of plant macronutrients, Ca, K, Mg, and P, micronutrients, Cu and Zn, and trace elements, Ni and Sr. The nutrients Ca and Mg and an additional alkaline earth element, Sr, are inversely related to the nutrients, K, P, Cu, and Zn. The second factor is comprised of several elements: Al, Fe, Na, Cr, and Pb, which may be associated due to pedological or plant physiological processes. The third factor, which represents the least variance of the three factors, is predominantly comprised of Mn, Ba, Pb, and Sr. Figure 10 shows the factor scores versus easting for the three factor model. The samples are distinctly separated by season according to their factor 1 scores. Based on a paired-t test, the May scores are significantly greater than the December scores at the 0.05 probability level. In addition, the samples collected in May are more tightly grouped than those collected in December. The seasonal difference in factor 1 scores is clearly the influence of nutrient cycling between the wet and dry seasons. The mean Ca and Mg concentrations approximately doubled from the May to the December collection (Tables 3 and 4), whereas the K, P, Cu, and Ni concentrations decreased by about half. Zn decreased by about a fourth in May to December.

Figure 8. Plots of factor scores versus sample location for soils from N-S traverses.



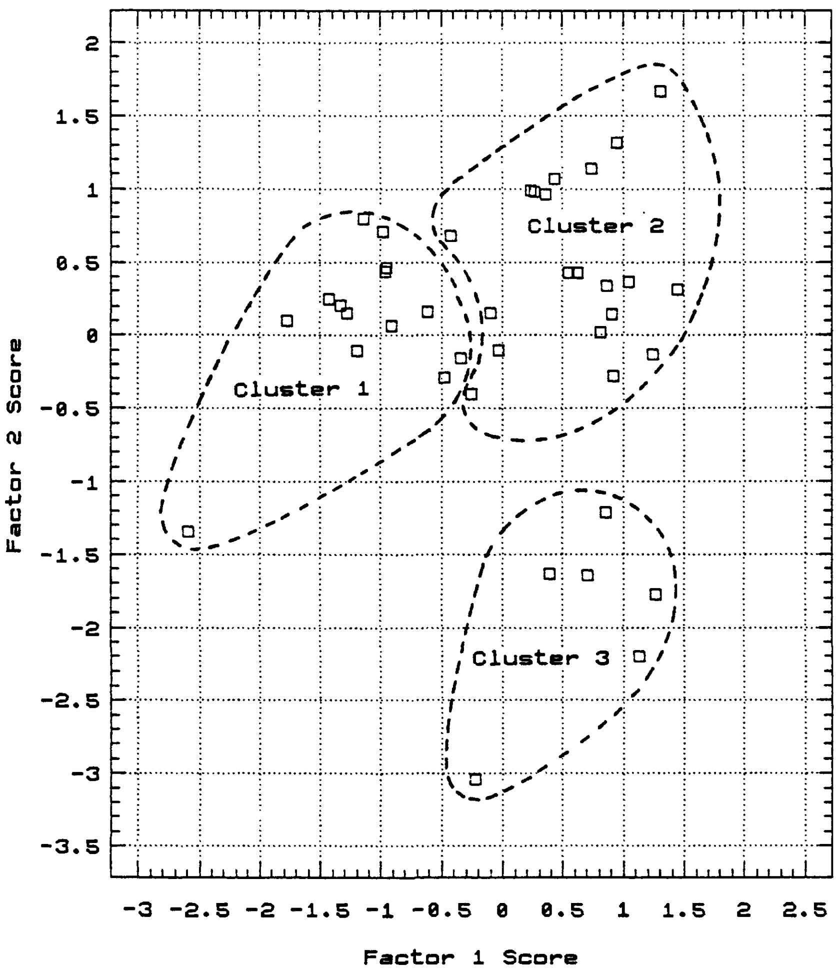


Figure 9. Factor 1 versus factor 2 scores for soils from N-S traverses.

Table 13. Varimax rotated factor loadings for *R. laurina* from N-S traverses--May and December collections combined.

	Factor Loadings > 0.50		
Variable	Factor 1	Factor 2	Factor 3
Ash			
Al		0.90	
Ca	-0.88		
Fe		0.87	
K	0.89		
Mg	-0.64		
Na		0.71	
P	0.86		
Mn			0.81
Ba			0.75
Cr		0.62	
Cu	0.86		
Ni	0.65		
Pb		0.50	0.66
Sr	-0.57		0.56
Zn	0.74		
Eigenvalue	6.0	3.4	1.9
% of total variance	37.6	21.2	11.7
Cumulative % variance	37.6	58.8	70.5

The greater intra-seasonal variation for the December collection factor 1 scores may be attributable to differences in plant stress due to nutrient availability and micro-climate.

There is no obvious separation between seasons based on factor 2 scores as seen in Figure 10 and a paired-t test indicates that they are statistically equivalent. However, the December collection does exhibit a wider range of values, both higher and lower. The differences may be due to element availability due to parent material or soil development and to greater dust contamination after the dry season.

Although factor 3 scores (Figure 10) are not as distinctly different as factor 1 scores for each season, a paired-t test indicated that at the 0.05 probability level the factor 3 scores for May were statistically lower than the December scores. Both season scores correlate (0.76-0.78) with easting, exhibiting an obvious increase from west to east.

When the results from each individual season are used to create factor models, five factors are obtained that explain about 75% of the total variance. The first factor represents about 30% of the variance and has an association of Al, Fe, Na, and Cr (Table 14). The December collection also has Pb associated with this factor. The second factor is comprised of the macro-nutrients Ca, K, and Mg and accounts for about 15-17% of the total variance. Thus factors which incorporate macro-nutrients are less important for intra-seasonal comparisons (Table 14) than for inter-seasonal comparisons (Table 13).

Hierarchical cluster analysis for the individual seasons shows that several groups of chemically related sites can be obtained (Figure 11), but plots of factor 1 and 2 scores do not show any clustering by these groups as was found for soils. There is a general correlation of the clusters with the most similarity with the soil clusters found (Figure 7). However, at

Table 14. Varimax rotated factor loadings for *R. laurina* from N-S traverses--May and December collections individually.

May Collection

Variable	Factor Loadings > 0.50 Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Ash		-0.55			
Al	0.88				
Ca		0.87			
Fe	0.84				
K		-0.95			
Mg		0.69			
Na	0.60				
P					0.88
Mn			0.70		
Ba			0.53	0.56	
Cr	0.82				
Cu					
Ni					
Pb			0.77		
Sr				0.86	
Zn			0.86		
Eigenvalue	4.7	2.7	2.3	1.2	0.9
% of total variance	29.5	16.8	14.4	7.8	5.8
Cumulative % variance	29.5	46.2	60.6	68.5	74.3

December Collection

Variable	Factor Loadings > 0.50 Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Ash			-0.66		
Al	0.90				
Ca		-0.84			
Fe	0.88				
K		0.88			
Mg					0.79
Na	0.66				
P		0.66		-0.52	
Mn				0.71	
Ba				0.82	
Cr	0.73				
Cu			0.69		
Ni			0.86		
Pb	0.64			0.50	
Sr					0.76
Zn			0.58		
Eigenvalue	5.2	2.4	2.3	1.3	1.1
% of total variance	32.4	15.1	14.5	7.9	6.8
Cumulative % variance	32.4	47.4	61.9	69.8	76.6

Figure 10. Factor scores for combined season factor model versus Easting for *R. laurina* from N-S traverses.

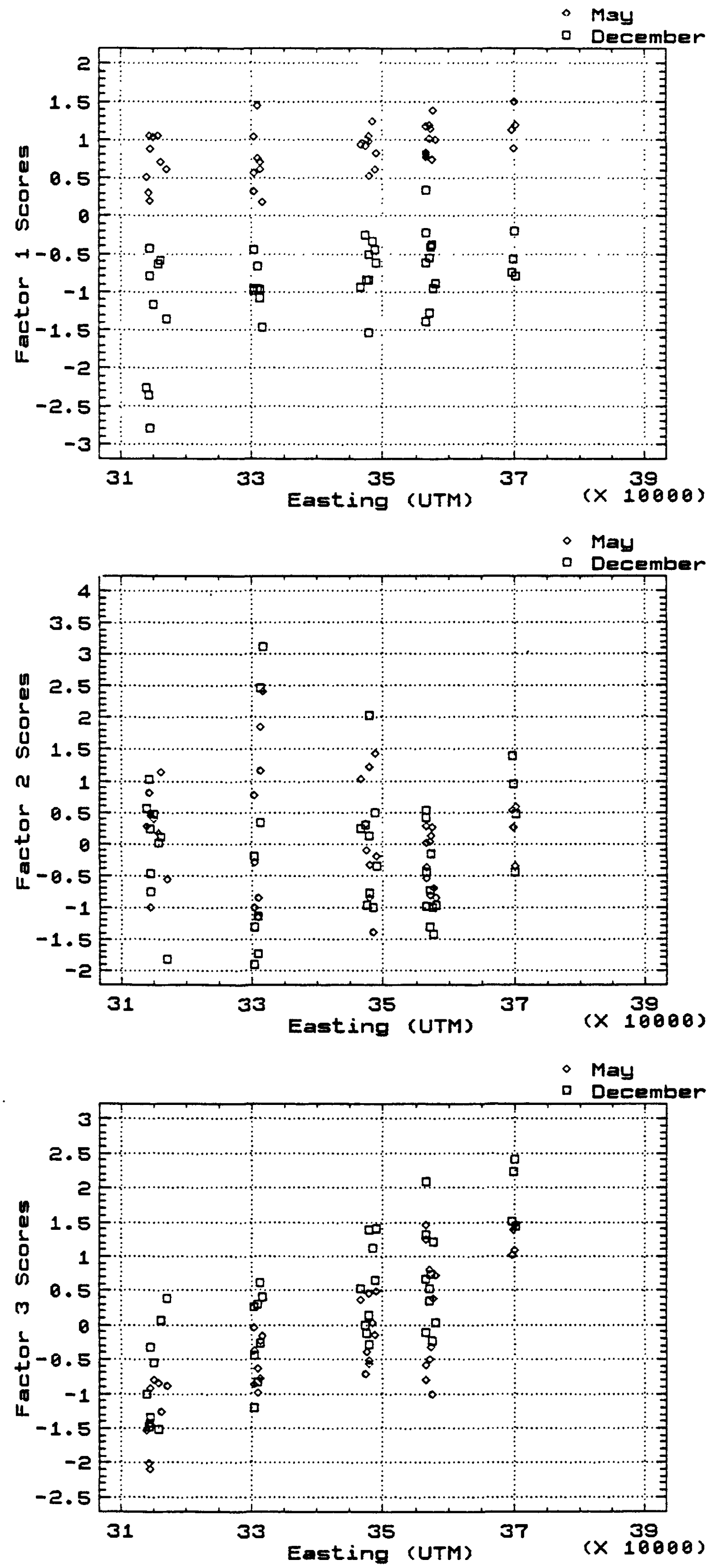
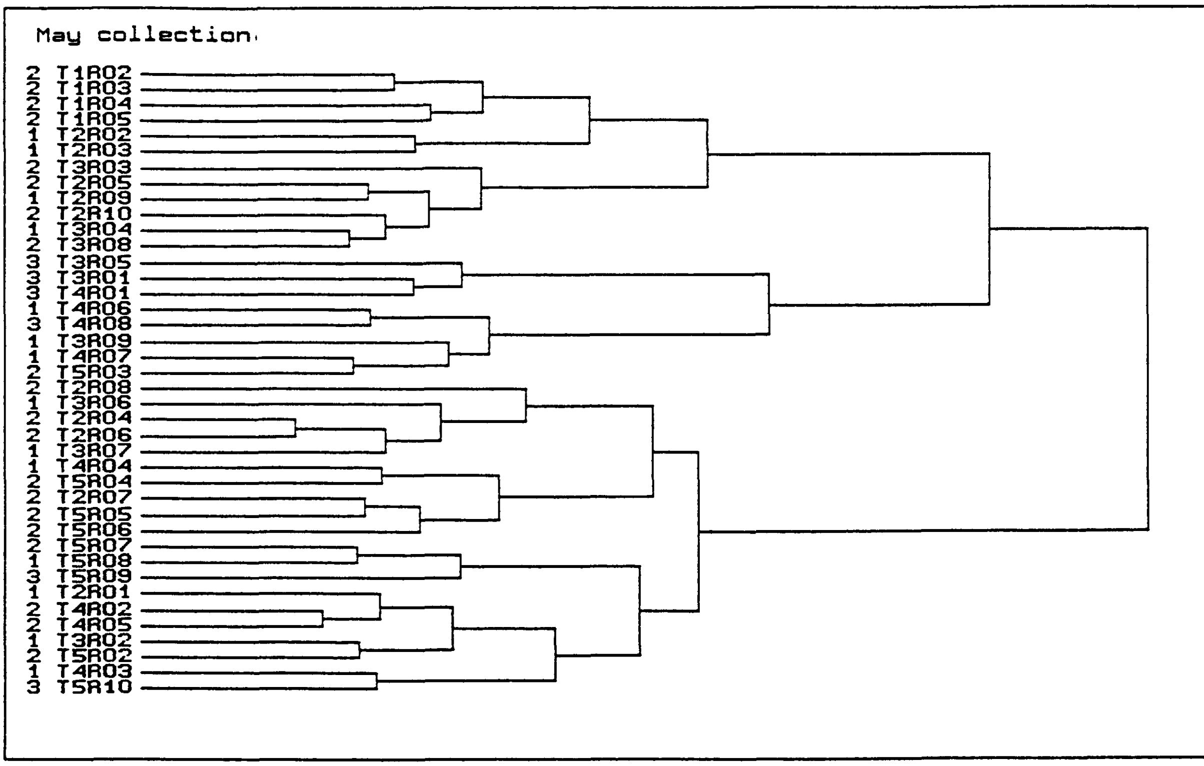
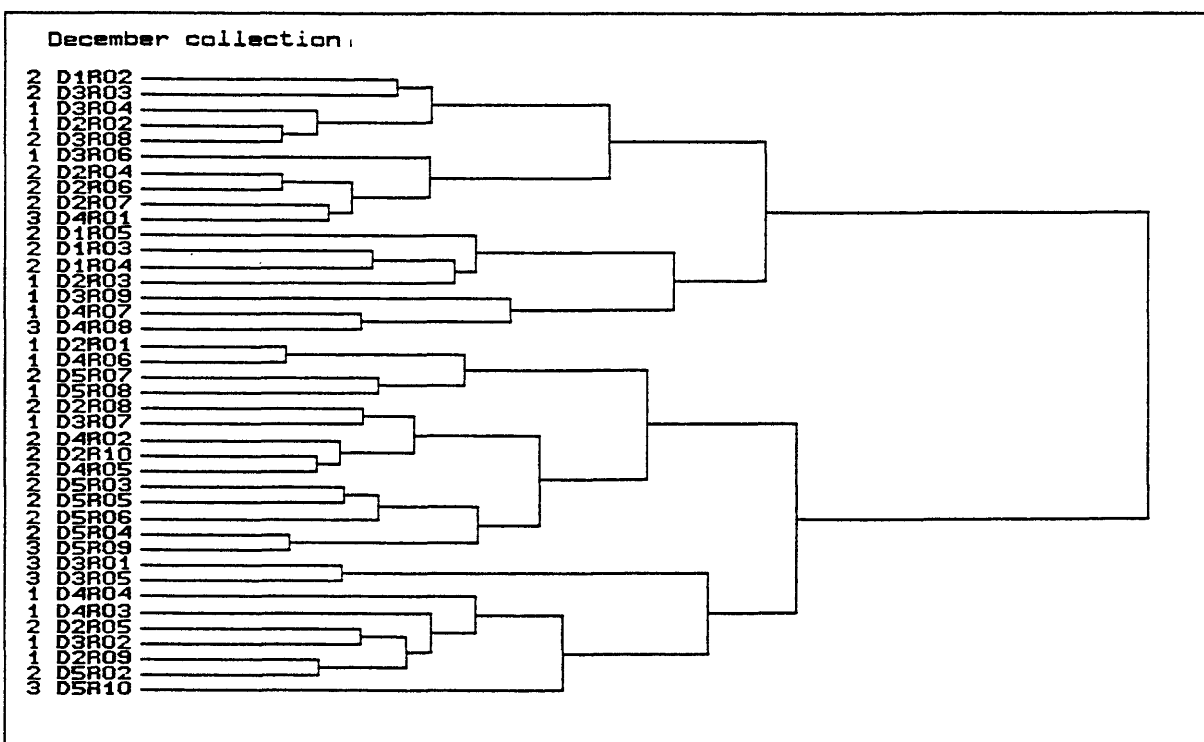


Figure 11. Hierarchical cluster dendrograms for *R. laurina* from N-S traverses--May and December collections individually. Sample numbers are preceded by soil cluster # (Fig. 7).





intermediate levels of similarity there appears to be little relationship of these broad soil chemistry groups to clustering of the *R. laurina*.

N-S Traverses: *C. megacarpus*. Exploratory factor analysis was performed on the combined data for both seasons for the *C. megacarpus* in a similar fashion to that done for the *R. laurina*. The same subset of 16 variables was used. In the factor model for *R. laurina* only three factors were extracted and rotated based on eigenvalues greater than one. For *C. megacarpus* six factors had eigenvalues greater than one. A six factor model explained 83% of the total variance. A three factor model would have only explained 61% of the variance. The factor loadings and percent variance explained by each factor are shown in Table 15.

Table 15. Varimax rotated factor loadings for *C. megacarpus* from N-S traverses--May and December collections combined.

	Factor Loadings > 0.50					
Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Ash		-0.54		-0.52		
Al	0.93					
Ca		-0.88				
Fe	0.92					
K		0.93				
Mg	0.54			0.62		
Na						0.90
P				0.82		
Mn			0.74			
Ba					0.85	
Cr	0.72					
Cu	0.54		0.57			
Ni			0.86			
Pb	0.88					
Sr					0.81	
Zn						
Eigenvalue	4.9	3.0	1.8	1.3	1.2	1.0
% of total variance	30.9	19.1	10.9	8.4	7.3	6.3
Cumulative % variance	30.9	50.0	61.0	69.4	76.7	83.0

The first factor is comprised of major elements, Al, Fe, and Mg, and trace elements, Cr, Cu, and Pb--an association similar to that found in the individual season factor models for *R. laurina*. The second factor is predominately the macro-nutrients Ca and K, which are inversely related, and the ash content. The fourth factor is also predominantly macro-nutrients. Unlike the model for *R. laurina* there is not a distinct separation on a factor score plot of the *C. megacarpus* samples collected at different seasons due to macro-nutrient cycling. Whereas the six factor model separates several of the element associations such as dividing the macro-nutrients into two factors (factors 2 and 4), the majority of the variance is still attributable to what is probably pedological and nutrient differences between sites.

The factor 3 is comprised of the elements, Mn, Cu, and Ni. Mn and Cu are plant micro-nutrients. Ni which also loads heavily on this factor is not a micronutrient, but Cu and Ni are often associated geologically with Mn-oxides. Factor 5 is dominated by Ba and Sr, non-essential alkaline earths. Factor 6 is almost exclusively influenced by Na which is a non-essential element and is available from sea spray.

Factor scores for each season versus easting are shown in Figure 12. The seasonal effects are obviously much smaller for the *C. megacarpus* than for the *R. laurina*. However, paired-t tests indicate that for factors 1 and 5 May scores are less than December scores, for factors 2, 4, and 6 May scores are greater, and for factor 3 the seasonal scores are equivalent. Factor analysis of individual seasons results in relatively similar models to that obtained for the seasons jointly.

As was found for *R. laurina* hierarchical cluster analysis for *C. megacarpus* provides 3-4 broad groupings of sites which only moderately match the soil clusters for those samples with the most similarity (Figure 13).

N-S Traverse 5: *Q. agrifolia*. Exploratory factor analysis was performed on the oak bark data. A subset of 16 variables was used and four factors were extracted to account for 86% of the variance (Table 16). Factor 1 is comprised of a series of major and trace elements that seem to be associated in similar fashion to factor 1 found for the other two species. However, in addition, this factor has K and Na with large, inversely related loadings. Factors 2 and 3 tend to have many of the macro-nutrients and Factor 4 is characterized by Cu alone. A paired-t test indicated that factor 1 scores for May are statistically greater than December scores, whereas seasonal scores for the other 3 factors are equivalent. Based on factor 2 scores traverse site 2 appears to be considerably different than the other samples which is primarily due to elevated Mn levels. The December collection at site 10 also appears to be anomalous. In the single sample obtained at this site K is 2-5 times greater, whereas most other elements are less than one-half that found at other sites collected in the same season. K levels are also somewhat elevated in the May collection at this site. However, the May level is a factor of 2 smaller than the December level. The reason for this anomaly is unknown.

E-W Crestline: Soils. Exploratory factor analysis was performed on a subset of 13 variables for the 15 individual north- and south-facing samples. Laboratory replicates were averaged prior to the analysis. A three factor model accounted for 89% of the variance (Table 17). Similar to the factor model for soils collected along the N-S trending traverses, factor 1 was dominated by the major rock-forming elements and a series of trace elements. Organic carbon and Pb were related in the second factor and were inversely proportional to the soil pH. The last factor was predominantly comprised of Na, K, and Ca, with K inversely proportional to Na and Ca.

A plot of factor 1 and 2 scores and the hierarchical cluster dendrogram (Figure 14) indicate that there are two distinct clusters of samples. In the factor score plot the clusters are separated by positive versus negative factor 1 scores which may reflect the dilution of the soil by sandstone and the poor soil development that occurred at several of the crestline sites where rock outcrops were prominent. Soils along this traverse were low in carbonate C which may account for the absence of a third cluster as was found for the N-S traverses.

Figure 12. Factor scores for combined season factor model vesus Easting for *C. megacarpus* from N-S traverses.

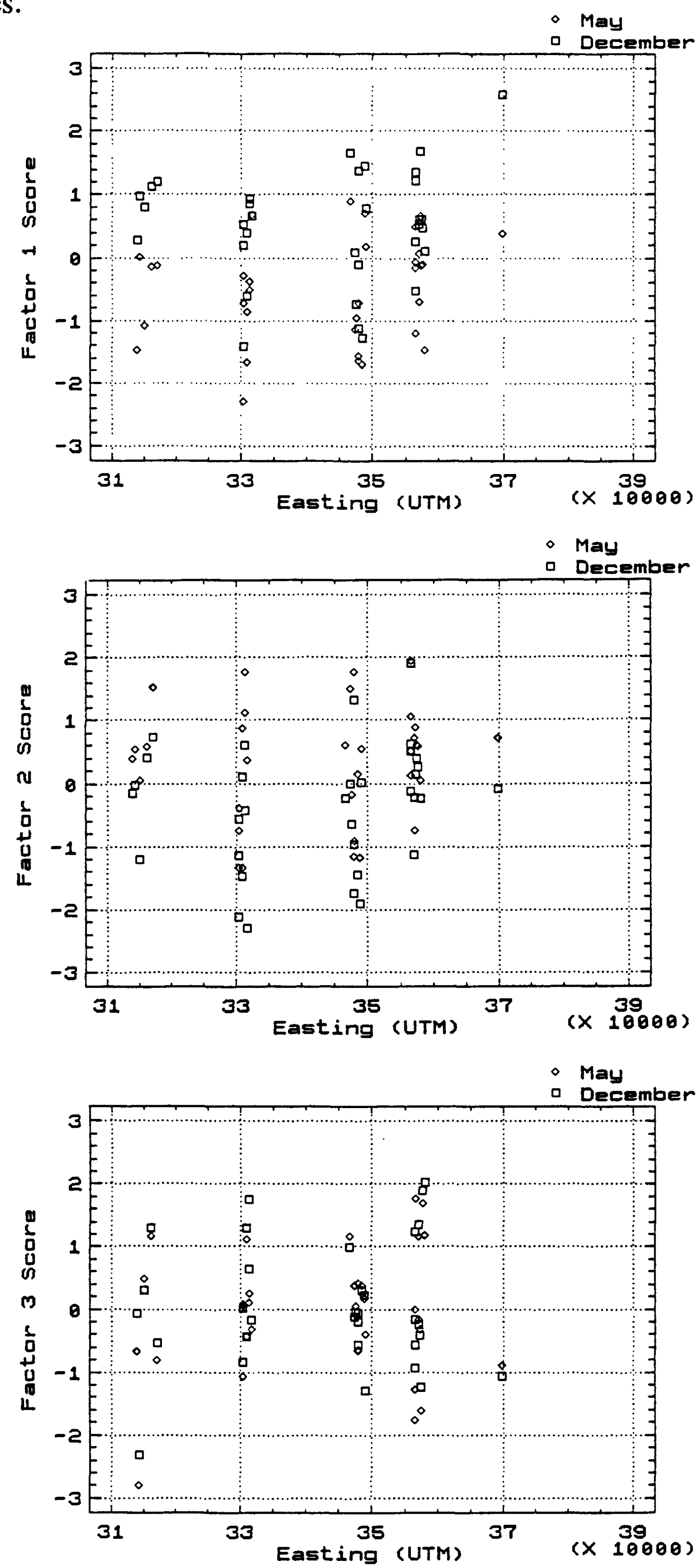
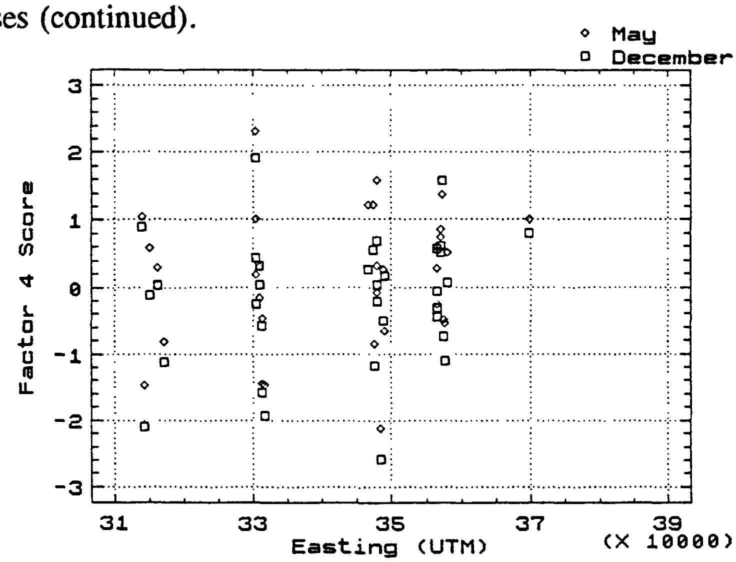
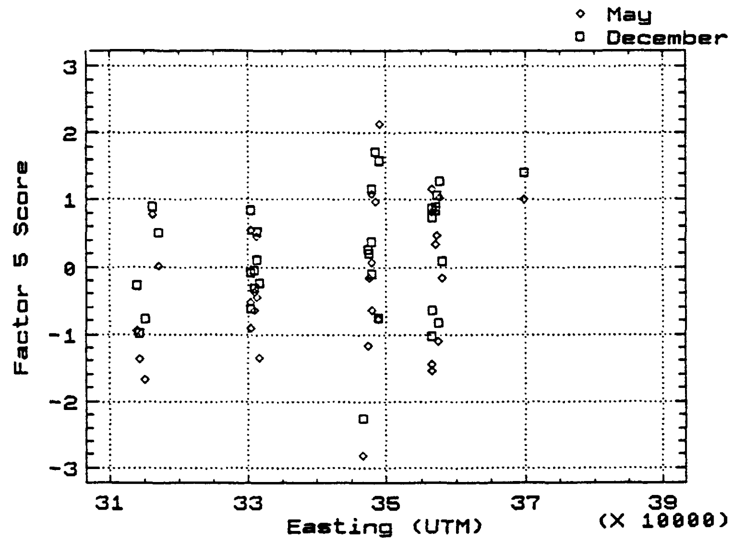


Figure 12. Factor scores for combined season factor model vesus Easting for *C. megacarpus* from N-S traverses (continued).





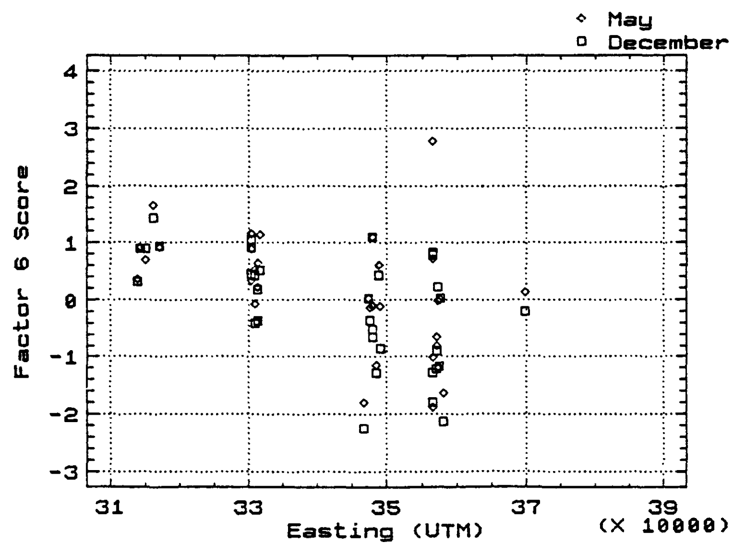
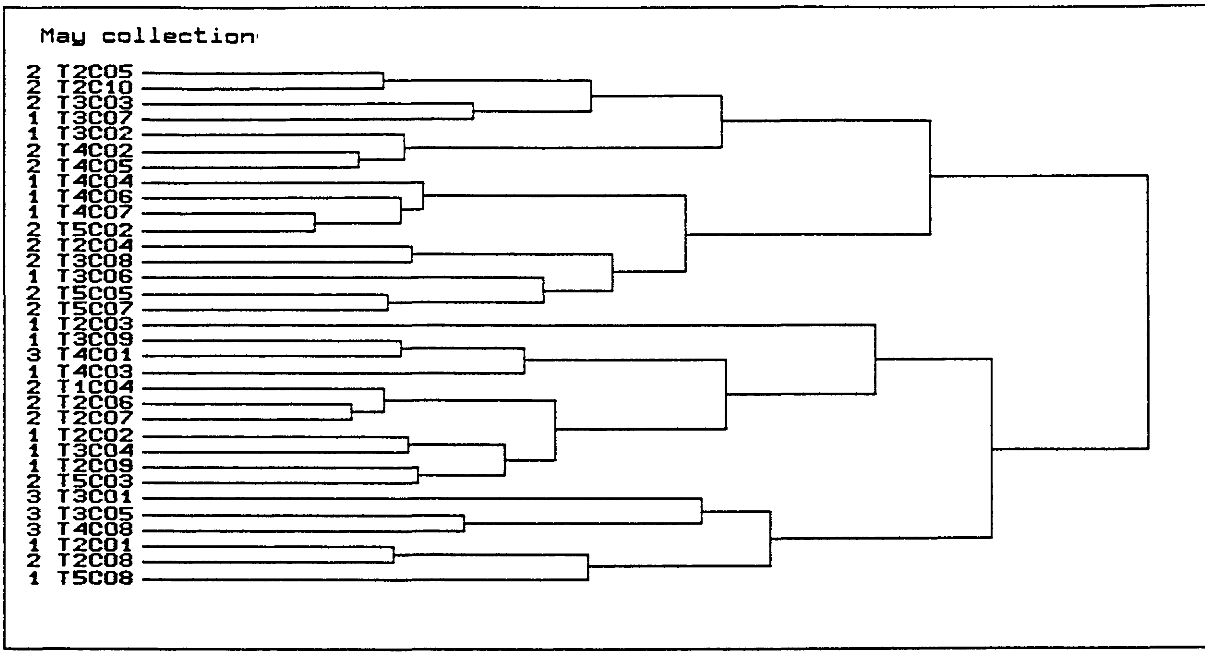


Figure 13. Hierarchical cluster dendrograms for *C. megacarpus* from N-S traverses--May and December collections individually. Sample numbers are preceded by soil cluster # (Fig. 7).



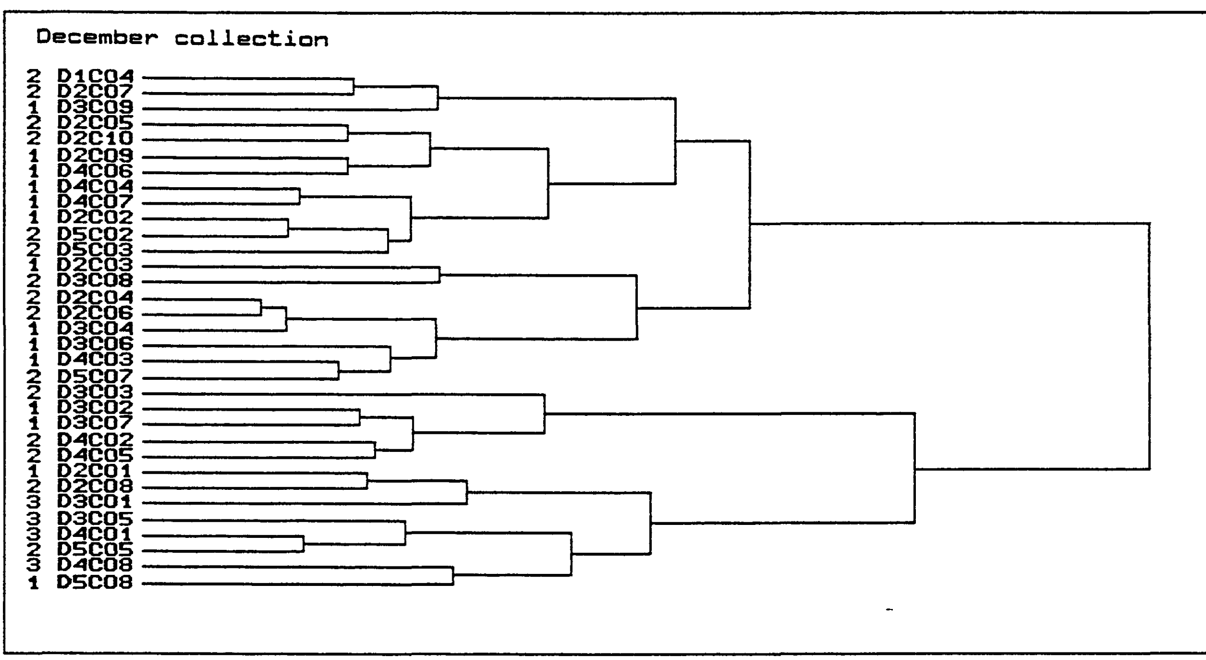


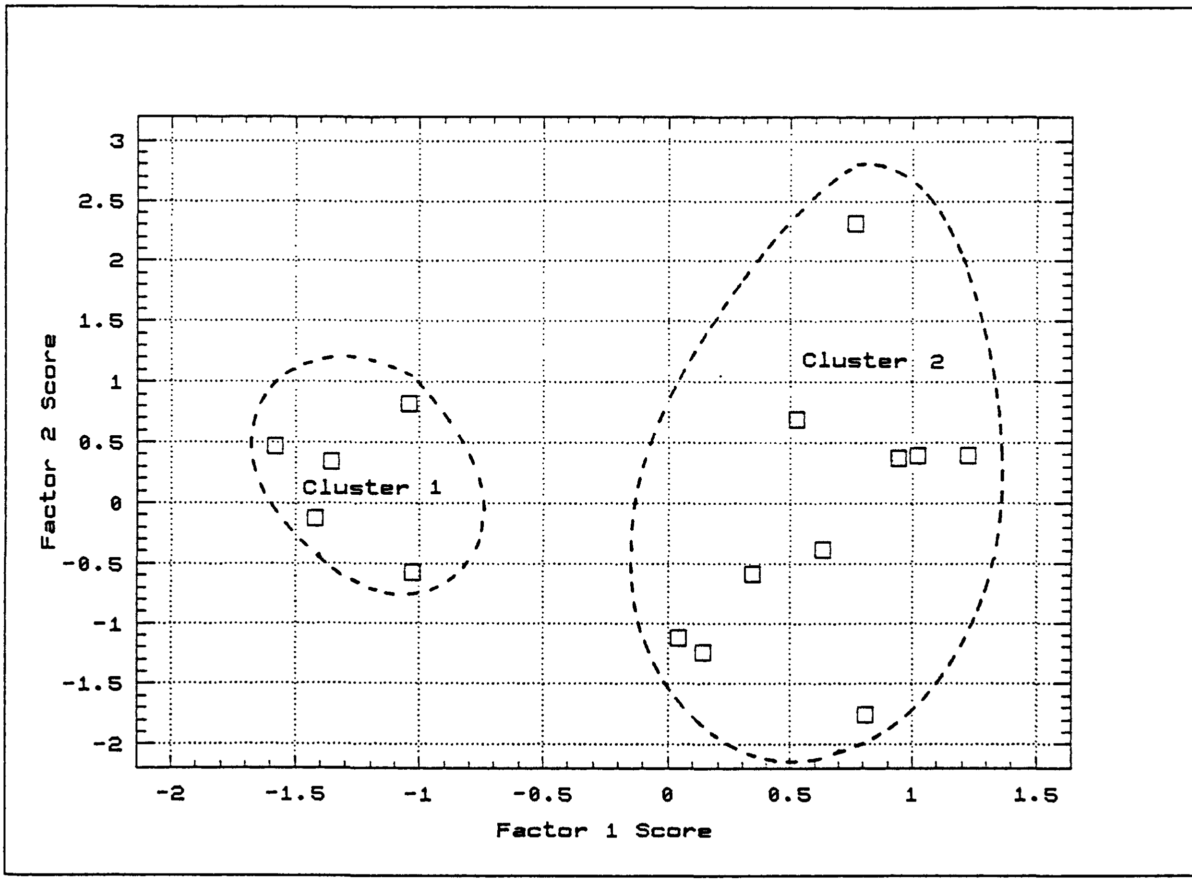
Table 16. Varimax rotated factor loadings for *Q. agrifolia* from N-S traverse 5--May and December collections combined.

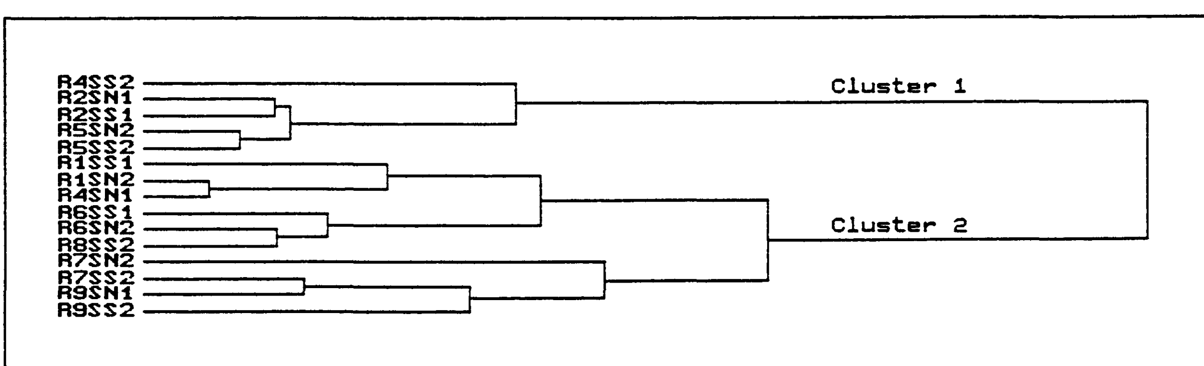
	Factor Loadings > 0.50			
Variable	Factor 1	Factor 2	Factor 3	Factor 4
Ash			-0.70	
Al	0.96			
Ca		0.83		
Fe	0.98			
K	-0.69			
Mg			0.78	
Na	0.60	-0.69		
P			0.76	
Mn		0.92		
Cd			0.72	
Cr	0.90			
Cu				0.92
Ni	0.96			
Pb	0.83			
V	0.98			
Zn	0.84			
Eigenvalue	7.2	2.7	2.2	1.6
% of total variance	45.3	16.9	13.9	10.2
Cumulative % variance	45.3	62.2	76.1	86.4

Table 17. Varimax rotated factor loadings for soils from E-W crestline traverse--May collection.

	Factor Loadings > 0.50		
Variable	Factor 1	Factor 2	Factor 3
Organic C		-0.76	
pH		0.74	
Al	0.80		
Ca	0.68		0.66
Fe	0.93		
K			-0.87
Mg	0.90		
Na			0.93
Cr	0.86		
Cu	0.93		
Ni	0.90		
Pb		-0.79	
Zn	0.92		
Eigenvalue	7.5	2.5	1.6
% of total variance	57.6	19.1	12.2
Cumulative % variance	57.6	76.7	89.0

Figure 14. Factor 1 versus factor 2 scores and hierarchical cluster dendrograms for soils from E-W crestline traverse.





E-W Crestline: *R. laurina*. Exploratory factor analysis was performed on the May and December collection results for a subset of 15 variables. Three factors were extracted which explained 79% of the variance. The factors obtained were very similar to those obtained for the *R. laurina* collected along north-south trending traverses (Tables 18, 13). Once again factor 1 is dominated by macronutrients, factor two has Al, Fe, Na, Cr, and Pb associated, and factor 3 is dominated by ash content (inversely related), Mn, and Sr. In addition, factor score plots were similar in that the seasonal collections were clearly separated by factor 1 scores and the December collection exhibited a wider range of factor 1 and 2 scores than the May collection.

Hierarchical cluster dendrograms (Figure 15) for sites along the E-W crestline traverse for both seasons indicated that the plants did not cluster in the same way as the soils, although there was some broad similarity in that crestline sites 2 and 5 tended to have high similarity and to be in a separate major cluster from sites 7, 8, and 9 for both plants and soils.

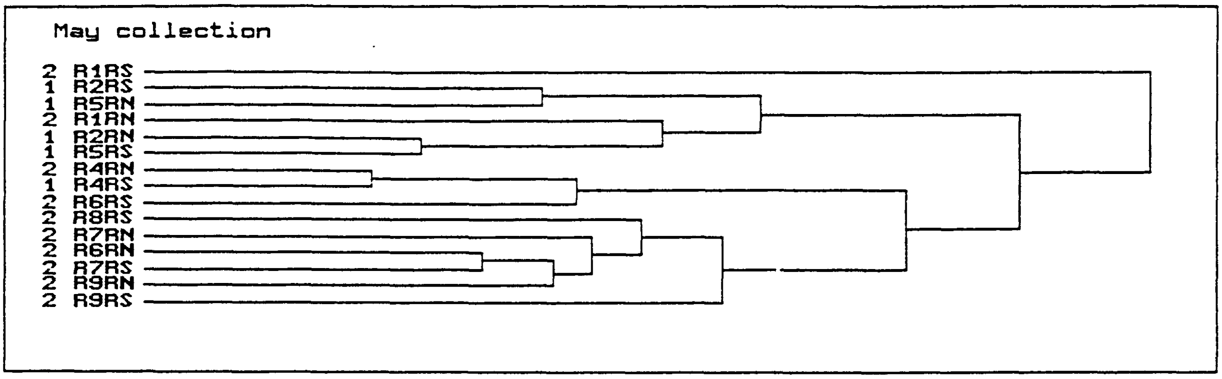
Table 18. Varimax rotated factor loadings for *R. laurina* from E-W crestline traverse--May and December collections combined.

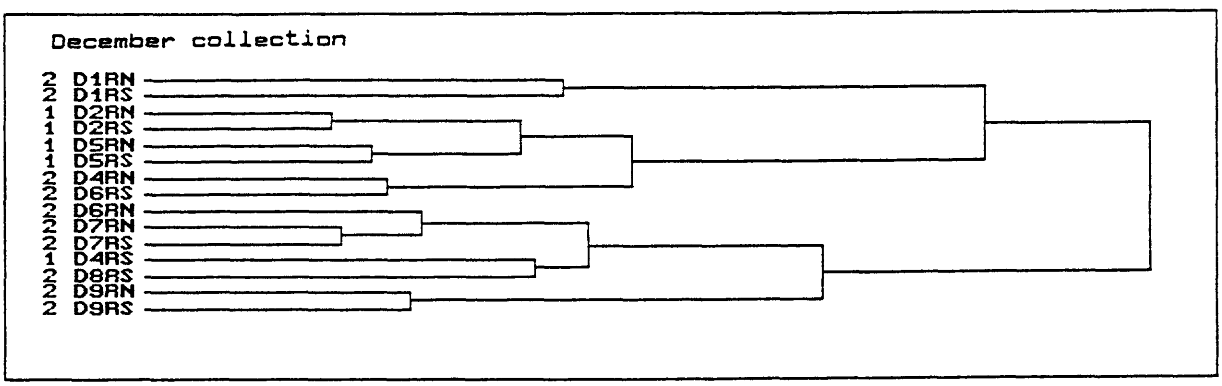
	Factor Loadings > 0.50		
Variable	Factor 1	Factor 2	Factor 3
Ash			-0.70
Al		0.94	
Ca	-0.94		
Fe		0.94	
K	0.97		
Mg	-0.77		
Na		0.68	
P	0.92		
Mn			0.83
Cr		0.86	
Cu	0.88		
Ni			
Pb		0.92	
Sr	-0.52		0.76
Zn	0.80		
Eigenvalue	6.5	3.4	1.9
% of total variance	43.4	23.0	12.9
Cumulative % variance	43.4	66.4	79.3

Seasonal Elemental Concentration Trends in Plants

Temporal changes in elemental concentrations in plant tissues can occur due to a variety of physiological processes. For example, concentrations vary greatly depending upon age. Young tissues generally have high concentrations of N, K, and P, whereas older tissues are typically elevated in Ca, Mn, Fe, and B (Mengel and Kirkby, 1978). Water availability and temporal variability in air quality may also bring about differences in elemental content.
The factor analysis models for *R. laurina* (Figure 10) clearly identify a seasonal difference between the macro-nutrients Ca and K, as well as their large contribution to the total variance

Figure 15. Hierarchical cluster dendrograms for *R. laurina* from E-W crestline traverse--May and December collections individually. Sample numbers are preceded by soil cluster # (Fig. 14).





of plant chemistry. The seasonal concentration differences were not as great for the other species and their contribution to the total variance was less. As discussed above, based on paired-t tests, the May scores for factors incorporating Ca and K tended to be greater than December scores. In addition, using a two-tailed, paired-t test most elements in all species were statistically different between seasons at the 0.05 probability level. However, the ash content for all three species was found to be equivalent for both the May and December collections. This was somewhat surprising; however, this lack of difference may be a reflection of the sclerophyllic nature of the plant species and their ability to cope with water stress through physiological changes which maintain the total mineral content constant with respect to total biomass.

In order to examine individual element trends, temporal absorption coefficients (TAC) (Brooks, 1983) were calculated for major and trace elements in the three species (Table 19). The TAC is the ratio of the element concentration in the growth period (May collection) divided by the concentration in the more dormant period (December collection).

Two macronutrients, K and Ca, would be expected to vary seasonally due to age and relative water availability. Both elements serve as cofactors in enzymatic reactions and influence the hydration of plasma colloids. K promotes higher cell turgor which in turn causes stomatal opening and affects CO_2 uptake; Ca is present in cell walls and affects membrane permeability (Bell and Coombe, 1976; Noggle and Fritz, 1983). For *R. laurina* there is an inverse relationship between K and Ca contents with average TAC's of 2.2 and 0.5, respectively. The seasonal difference is not as pronounced for *C. megacarpus* with K changing by about 40% and Ca changing very little between samplings. For the two species P and S have similar TAC's to K, and Mg is similar to Ca.

For the micronutrients, which are typically involved in enzymatic reactions, *R. laurina* exhibits considerable seasonal variability, whereas *C. megacarpus* has TAC's that are much closer to one. The TAC's for Fe, Cu, and Zn range from 1.2 to 2.1, whereas Mn is about 0.9 in *R. laurina*. Cr and Ni, non-essential elements, have both the highest average TAC's and the greatest variance. Generally, *R. laurina* has the largest TAC's obtained for living tissues with relatively similar results for the N-S traverse and E-W crestline populations. However, the larger N-S traverse population does exhibit a wider range of values.

Titanium, generally considered a non-essential element in plants, is typically present as detrital material in soils. Because of its non-essentiality and its resistance to weathering, its concentration in our unwashed plant materials may be an indication of eolian dust contamination. If the proportion of dust Ti were a significant fraction of the total Ti, if the dust contamination was truly worse after the extensive dry season, and if the temporal changes in Ti due to physiological processes were minimal, the TAC would be expected to be less than one. The TAC was less than one for the rough surfaced-leaf of *C. megacarpus* (TAC = 0.6), but not for *R. laurina* (TAC = 1.3), although the *R. laurina* did have a large variance. These results are somewhat surprising in that there was obvious dust contamination at several locations for the *R. laurina* in the December collection, whereas there was generally little if any visible contamination in the May collection. The *R. laurina* with its waxy cuticle and V-shaped leaf might be a good receptor for dust, albeit one that is easily rain washed. Unfortunately, with the ambiguity regarding seasonal Ti differences it is impossible to use element ratioing to Ti to evaluate seasonal differences due to dust versus physiological changes.

Table 19. Average temporal absorption coefficients for plants (TAC = ratio of May/December (wet/dry) concentrations for each shrub sampled, SD = standard deviation).

	Q. agrifolia		C. megacarpus		R. laurina N-S traverses		R. laurina E-W crestline	
Element	TAC (n=18)	SD	TAC (n=64)	SD	TAC (n=78)	SD	TAC (n=56)	SD
Total S	1.7	0.4	1.3	0.2	1.8	0.3	2.1	0.4
Ash	1.1	0.2	1.0	0.1	1.0	0.2	1.1	0.2
Al	1.8	1.2	0.6	0.2	1.1	0.3	1.4	0.4
Ca	1.0	0.2	0.9	0.1	0.5	0.1	0.5	0.1
Fe	1.8	1.1	0.8	0.2	1.2	0.4	1.4	0.3
K	0.7	0.3	1.4	0.3	2.2	0.7	2.2	0.6
Mg	0.8	0.2	0.9	0.1	0.6	0.1	0.6	0.1
Na	1.4	0.4	1.3	0.5	1.4	0.7	1.6	0.8
P	1.0	0.2	1.2	0.3	2.2	0.6	2.1	0.4
Ti	1.7	1.1	0.6	0.3	1.3	0.6	-	-
Mn	1.3	0.4	0.9	0.3	0.9	0.7	0.7	0.2
Ba	1.2	0.4	0.8	0.2	0.7	0.9	0.5	0.2
Cd	1.0	0.2	-	-	-	-	-	-
Co	1.4	0.5	0.8	0.2	0.8	0.2	0.8	0.2
Cr	2.3	1.6	0.9	1.6	2.8	2.5	1.6	0.8
Cu	1.2	0.3	0.9	0.3	2.1	0.9	1.9	0.6
La	0.6	0.3	-	-	-	-	-	-
Li	1.4	0.6	0.9	1.1	-	-	-	-
Ni	1.7	0.8	1.0	0.3	2.4	1.6	1.9	1.0
Pb	2.2	2.5	0.7	0.3	0.9	0.4	1.2	0.5
Sr	1.1	0.2	0.9	0.2	0.4	0.1	0.4	0.1
V	2.0	1.4	-	-	-	-	-	-
Zn	1.6	0.5	1.1	0.2	1.4	0.4	1.7	0.8

TAC's equal to one would be expected for oak cortex tissue in the absence of physiological or physico-chemical processes. The macronutrients Ca and P had TAC's of about one and K and Mg had values of 0.7 and 0.8, respectively. The micronutrients tended to have values greater than one. The TAC's for about one half of the elements in oak bark, including S, Al, Fe, Na, Ti, and some of the trace metals, were about 1.4 to 2.3. Although the variance associated with these measurements was relatively large, there seems to be a clear trend toward higher concentrations in the May collection. This is the opposite of what would be expected if the bark were acting solely as an inert, passive collector where eolian dust or other airborne particulates were a major source of elements. Whereas bark is frequently considered to act as a long term collector or integrator of inorganic exposure (Martin and Coughtrey, 1982), these data suggest that other processes may be occurring. Losses from the bark are generally considered to occur through leaching or washing action of rainfall which would not have been expected as a major cause of elemental loss for the samples collected in December versus those collected in May. However, acidic summer fogs may have caused significant leaching (Waldman and Hoffmann, 1988). Other possible explanations include physico-chemical translocation within the bark during the dry season or problems due to sample collection or analysis. The latter were controlled as much as possible in both the field and the laboratory.

Inter-species Elemental Concentration Trends

Relative absorption coefficients (RAC) were calculated to examine the inter-species relationships of elemental uptake. RAC is defined as the element mean concentration at a site in one species divided by the concentration of the same element in *R. laurina* for the same season. As discussed above the intra-species elemental concentrations varied with season which obviously has an impact on RAC and seasonal comparisons can not be made without referring to absolute concentrations (Tables 3-8). The average RAC's for *C. megacarpus* and *Q. agrifolia* versus *R. laurina* are listed in Table 20.

The ash yield RAC equaled one for both seasons for *C. megacarpus* as did several of the macronutrients for the December collection. Also for the December collection several of the non-essential trace metals, Ti, Cr, Ni, and Pb, were 2-3 times higher in the *C. megacarpus*. In general, the RAC's were much closer to one for the May collection. Thus it would appear that *C. megacarpus* collected at the end of the dry season should provide the better biomonitoring medium for these non-essential trace metals and potentially provide better spatial contrast.

The ash content in oak bark was 50-90% greater than in *R. laurina* for the two seasons and the RAC's for the non-essential metals ranged from about 2-30. The oak bark obviously concentrates through physiological processes or atmospheric deposit more than the *R. laurina* leaves. Also, several additional elements such as Cd and V were present in the bark at detectable levels. Although the bark appears to serve as an excellent collector, it is only found in relatively few areas in the SAMO and could not be used as a ubiquitous biomonitor.

Table 20. Average relative absorption coefficient (RAC) for *C. megacarpus* and *Q. agrifolia* versus *R. laurina* for N-S traverses (SD = standard deviation).

	C. megacarpus (n=33)				Q. agrifolia (n=9)			
	May		December		May		December	
Element	RAC	SD	RAC	SD	RAC	SD	RAC	SD
S	0.9	0.1	1.1	0.1	0.5	0.2	0.6	0.1
Ash	1.0	0.2	1.0	0.3	1.9	0.5	1.5	0.4
Al	0.9	0.3	1.8	0.7	8.4	4.8	5.0	1.8
Ca	1.9	0.3	1.0	0.2	2.5	0.4	1.1	0.2
Fe	1.1	0.2	1.7	0.6	5.7	2.6	3.7	1.3
K	0.6	0.1	1.0	0.4	0.2	0.1	0.9	1.2
Mg	1.5	0.5	1.0	0.3	1.4	0.4	1.1	0.6
Na	3.8	2.1	4.5	2.7	1.3	0.7	1.5	1.0
P	0.8	0.2	1.4	0.4	0.1	0.0	0.2	0.1
Ti	0.9	0.3	2.3	1.1	9.2	3.2	6.1	2.8
Mn	0.9	0.4	0.8	0.4	8.9	5.2	5.5	3.2
Ba	2.2	1.2	1.7	0.7	21.8	17.7	11.0	9.0
Co	1.0	0.2	1.0	0.2	4.3	2.4	2.2	0.6
Cr	1.4	3.0	2.9	2.1	3.1	1.7	3.0	2.2
Cu	1.0	0.3	2.3	0.9	0.7	0.2	1.7	1.2
Ni	1.3	0.7	2.8	1.8	1.8	2.0	3.1	3.0
Pb	1.3	0.5	2.0	0.7	29.5	17.4	11.3	5.4
Sr	3.3	1.9	1.5	0.8	5.0	1.7	1.6	0.6
Zn	0.9	0.2	1.2	0.4	0.5	0.2	0.4	0.1

Whereas the RAC provides a measure of the relative magnitudes of element concentrations between species, inter-species correlation of elements gives clues as to the degree of mutual uptake and utilization of these elements. Correlation coefficients for selected elements between *R. laurina* and *C. megacarpus* for N-S trending traverses are shown in Table 21. In general, the correlation of an individual element between species yielded larger coefficients for samples collected in May than in December. About one half of the major elements and most of the trace elements for the May collection have moderate correlations (0.5-0.7) between these species. These results suggest that during the growth period in May the plants appear to take up proportional amounts of these elements from the available element pool. However, differences in internal physiological processes such as element translocation and utilization, differences in leaf structure, and differences in root and foliar uptake may promote weak inter-species element correlations.

Table 21. Inter-species correlation coefficients for elements in *R. laurina* and *C. megacarpus* from N-S traverses (n=33).

	Correlation Coefficient				
Element	May	December	Element	May	December
Ash	0.32	0.25	Ba	0.76**	0.80**
Al	0.61**	0.34	Co	0.60**	0.51*
Ca	0.49*	0.38	Cr	-0.04	–[1]
Fe	0.62**	0.41	Cu	0.60**	0.31
K	0.46*	0.25	Ni	0.63**	0.55**
Mg	0.33	0.50*	Pb	–	–
Na	0.65**	0.55**	Sr	0.57**	0.57**
P	0.41	0.67**	Zn	0.63**	0.26
Mn	0.68**	0.37			

*significant at the 0.01 probability level.
**significant at the 0.001 probability level.
[1]correlation coefficient not calculated due to replacement of censored results.

Plant-Soil Elemental Relationships

In order to understand elemental concentration trends in plants it is important to understand the relationship of the element in soil to that in the plants. This is one important method of assisting in the distinction between whether an element concentration variation is natural or anthropogenically-induced. Although total element concentrations in soils do not provide a true picture of what is available to a plant, the relative concentration of an element in a plant to the total concentration in soil is useful for understanding general trends. The biological absorption coefficient (BAC) is the concentration in plant ash divided by the total concentration in soil (Brooks, 1983). We have calculated BAC's for various elements in all three plant species (Table 22). Also, we have calculated the BAC for both sample collection periods utilizing soil data from the May collection. We assume that the soil chemistry for a composite sample from 0-15cm in depth would generally be the same for both seasons and that any seasonal variability would probably be obscured by sampling variability.

BAC values ranged from about 0.03 to greater than 100. Generally only essential elements had values substantially greater than one, with the macronutrients being the largest. For *R. laurina* and *C. megacarpus* P had the greatest BAC which is not surprising considering that the soils in SAMO are generally depleted in P and N (Hanes, 1988). The smallest BAC values were associated with Al, Fe, and Ti. In addition, these elements tended to have the smallest relative standard deviation which is consistent with the general trend of larger RSD associated with larger BAC.

In the calculation of BAC values for *Q. agrifolia* along Traverse 5 (Big Sycamore Canyon) elemental concentrations in soils were from pits sampled along the side of the valley in the vicinity of the *R. laurina* shrub and are not truly representative of soils at the precise locations where the oaks were sampled. However, these results do allow some simple comparisons. As in previous comparisons the physiological difference in tissue sampled is apparent. Whereas the essential nutrients generally have values greater than one, the maximum value is not as great due to lower P concentrations in bark. In addition, Cd and Pb are elevated in the bark ash 5-20 times greater than the soil, but the variance associated with these values is large.

Table 22. Average biological absorption coefficient for the May collection (BAC = ratio of concentration in plant to soil, SD = standard deviation).

	Q. agrifolia		C. megacarpus		R. laurina	
element	BAC (n=9)	SD	BAC (n=33)	SD	BAC (n=40)	SD
S	5.4	2.5	11	4.7	13	5.7
Al	0.27	0.14	0.03	0.01	0.04	0.01
Ca	19	12	18	7.9	9.3	4.9
Fe	0.31	0.26	0.08	0.04	0.07	0.04
K	5.9	7.0	13	8.5	22	14
Mg	2.9	1.4	6.7	5.0	4.3	4.0
Na	0.45	0.24	1.1	1.4	0.40	1.1
P	9.6	5.3	93	42	113	59
Ti	0.28	0.23	0.04	0.03	0.04	0.02
Mn	8.1	7.9	2.0	1.5	2.5	2.6
Ba	2.6	1.7	0.35	0.26	0.21	0.20
Cd	4.7	4.3	-	-	-	-
Ce	0.48	0.24	-	-	-	-
Co	0.57	0.46	0.32	0.24	0.28	0.22
Cr	0.24	0.24	0.30	0.72	0.19	0.18
Cu	3.8	4.0	9.4	7.6	8.4	7.1
La	0.45	0.27	-	-	-	-
Li	0.34	0.22	0.89	1.2	-	-
Ni	0.90	1.1	3.0	4.1	2.2	2.5
Pb	21	22	1.1	1.2	0.80	0.94
Sr	4.5	2.1	3.0	1.7	1.1	0.70
V	0.39	0.31	-	-	-	-
Zn	2.9	2.0	8.9	4.5	9.1	4.3

Whereas the BAC provides information on the relative magnitude of the element concentrations in plants versus soils the correlation coefficient provides information on their interdependence. In general, an individual element in the plant does not correlate significantly with the same element in soil (Appendices XII-XIII). An exception is K which correlates moderately in the December sampling for all three species. However, in oak bark K is inversely correlated with soil K. In this case the plant K would be expected to preferentially occur in other tissues than bark.

Significant correlations (0.01 probability level) were found for a variety of elements in plants with other elements in soils (Appendices XII-XIII). For example, in several cases Mn was inversely correlated with soil Ca, which may be a physiological exclusion phenomenon. K in *R. laurina* was correlated with soil S and Pb. Soil K was also correlated with soil Pb. This association may be due to K and Pb adsorption on clays (Adriano, 1986) or possibly decaying organic matter serving as a major source of these two elements (Kabata-Pendias and Pendias, 1984). Also, Pb in *R. laurina* was inversely correlated with soil pH, which would be expected due to the formation of insoluble lead hydroxides at higher pH values.

Spatial Elemental Concentration Trends

N-S Traverses: Soils. Exploratory factor analysis was used to develop the spatially oriented factor score plots shown previously (Figure 8). As seen in these plots regional elemental trends in soils are difficult to discern and are largely obscured by the heterogeneous nature of the bedrock and other edaphic factors in the SAMO. There does, however, appear to be a increase in Factor 2 (pH, Ca, K, Mg, Ba, Ce, La, Li, and Pb) scores from west to east. In order to examine this more closely, correlation coefficients were computed for element concentrations with UTM coordinates (Appendix XIV). No significant correlations were obtained between elements in the soil and northing (expressed in UTM's). Seven elements did correlate moderately (0.01 probability level) with easting. K, Nd, Pb, and Th were correlated positively and pH, Cr, and Ni were negatively correlated (Figure 16).

Several possible explanations could account for these element correlations with easting. Changes in soil parent material from west to east could play a major role in elemental trends, directly by the weathering of the source rocks and indirectly by the influence on soil pH which in turn influences element mobility. For example, Pb concentration in shales is generally higher than sandstones or limestones which would directly influence soil concentrations. Worldwide average concentrations of the west-east correlated metals in a variety of rocks are shown in Table 23. Whereas total concentration and mineralogical form in parent material play a major role in soil concentrations, soil pH also has an important role in that it affects rock weathering and element mobility. For example, Ni is considered to be highly mobile in acidic environments and almost immobile in neutral to alkaline environments. The other metals are also affected by pH, but to a lesser degree. K and Pb are generally considered to have fairly low mobility, whereas Cr, Th, and rare earth elements are even less mobile (Thornton, 1983).

Clay content and clay mineralogy of the soils could influence these elements. Montmorillonite and illite, which are three-layer clays, are typically present in soils from semiarid regions (Krauskopf, 1979). These clays have large cation exchange capacities. Illite has K bound tightly between the layers and as a result generally has less cation substitution than montmorillonite. Pb is adsorbed by these clays although there are conflicting reports about the affinity for the different clay minerals (Kabata-Pendias and Pendias, 1984; Adriano, 1986).

Table 23. Worldwide average elemental concentrations in different rock types and soil (Thornton, 1983; Mason, 1966; Kabata-Pendias and Pendias, 1984).

Element	Basalt	Granite	Sandstone	Shale	Limestone	Soil
K%		2.6*	1.1	2.7	0.27	
Cr ppm	200	4	35	100	10	5-1000
Nd ppm		28*	37	24	4.7	28-35
Ni ppm	150	0.5	2	70	12	5-500
Pb ppm	5	20	7	20	8	2-200
Th ppm	2.2	17	1.7	12	2	13

*average concentration in igneous rocks.

Other factors influencing the distribution of these metals are the organic matter content and Fe and Mn oxide levels in soils. For example, organic matter-metal chelates are common, with stability generally increasing from $Zn^{2+} < Mn^{2+} < Co^{2+} < Ni^{2+} < Pb^{2+} < Fe^{2+} < Cu^{2+}$ and with increasing pH (Jones and Jarvis, 1981). Also, adsorption on Fe and Mn oxides is important. Pb is adsorbed preferentially on Mn oxides, whereas Ni is adsorbed on both metal oxides (Adriano, 1986; Jones and Jarvis, 1981).

In the SAMO from west to east there is a general change in geology (Figure 2). The western portion is dominated by mid-Tertiary Age sedimentary and volcanic rocks (i.e. Traverse 5 to Traverse 3). The eastern and central portions are mostly late Cretaceous and early Tertiary sedimentary rocks (i.e. Traverse 2) and the most eastern portion is slate with granitic intrusives (Traverse 1). These general trends in parent material are likely to be the controlling factors for the west to east trends observed for K, Nd, and Th, which are positively correlated, and pH, Cr, and Ni, which are negatively correlated. Also, other factors related to soil development such as clay, Fe and Mn oxide, and organic matter contents obviously contribute to the distribution of these elements. Whereas our study can not rule out the parent material as the controlling factor in the distribution of soil Pb, anthropogenic emissions and proximity to population centers may be the true causative agent. In addition, anthropogenic emissions may have an influence on soil pH (Canter, 1986).

<u>N-S Traverses: *R. laurina*</u>. Based on factor scores north-south trends in element concentrations in *R. laurina* along individual traverses are unclear, just as found in the soils. This is apparently due to the heterogeneous nature of the soils, the melange of geology, and the variety of micro-climates found from site to site. However, some oceanic influence is discernable. The southern most sites of traverses 2-5 are within 1-3 km of the ocean and one would expect an obvious influence of sea salt spray on the foliar Na concentrations. In fact the southern most sites tend to have higher Na compared to more northern sites. This is most obvious for traverses 3 and 4 where there is a general decrease in Na as one proceeds northward along the traverses (Figure 17). The trend is apparent for both May and December collections, but is more apparent in the later sampling. Pb in the December collection for Traverses 3 and 4 also appears elevated compared to more northern sites located farther from the Pacific Coast

Highway. Based on examination of individual element and factor score plots no other obvious elemental south-north trends are evident.

In examining the traverses from west to east using the correlation coefficient for easting versus concentration in the plant ash there are several trends that are detectable (Appendix XIV). Ba, Mn, Pb, and Zn correlate positively with easting for both seasons and Na is negatively correlated for the May collection (Figure 17). The negative correlation with distance for Na may be a sea-salt effect as discussed above. For the metals positively correlated with distance their availability or interaction with other soil constituents may be the controlling factors influencing their concentration in the plant. This may be especially true for the micronutrients, Mn and Zn. The trend for Pb, on the other hand, may very well be a result of anthropogenic influences. If the Pb is the product of automotive emissions it is possible that the trend for Zn has the same source (Adriano, 1986).

N-S Traverses: *C. megacarpus*. There are no obvious general trends in elemental concentrations from south to north based on examination of factor score plots. But as was found for *R. laurina* there are several elements in *C. megacarpus* that correlate with distance from west to east. Na was negatively correlated for both collections (Figure 18) and may be a sea-salt effect as noted for *R. laurina*. Lead was positively correlated with easting for both collections, whereas Co was also positively correlated for the December collection. Once again the trend in Pb concentration may be a result of anthropogenic emissions, whereas the association of Co concentration with distance is unclear.

N-S Traverse 5: *Q. agrifolia*. Traverse 5 in Big Sycamore Canyon trends northward from the coast for about 4 km and then trends to the north-east. Thus generalized south-north trends in element concentrations may be correlated with both easting and northing. For example, Na in the oak bark collected in December was correlated negatively with both easting and northing at the 0.01 probability level. However, in order to simplify our interpretations we consider the traverse to be essentially N-S trending and examine element trends only with respect to northing.

Na concentration does decrease in a northward direction for both seasons (Figure 19) with the greatest differences between sites occurring in May. For the May collection three sites, 3,4, and 9, have Na concentrations which appear to be higher than expected for a simple linear trend based on the remaining sites. This trend of having generally higher concentrations for sites 3 and 9, in particular, tends to occur for most elements except ash content in the May collection (Figure 19). The cause of these higher concentrations for these two sites is unknown. It does not appear to be related to whether the bark sample collected was smooth or hard and corky. These sites were near the juncture of Big Sycamore Canyon and a major side canyon. In addition, site 3 was near an active residence.

As discussed above with respect to TAC there is a general decrease in trace element concentration between the May and December collection. Spatially this is most obvious for the sites nearest the ends of the traverse. These sites may experience different climatic and wind patterns than the more interior sites within the canyon. In addition, the central portion of the canyon also is predominately Middle Miocene sediments whereas the upper and lower reaches of the canyon are Lower Miocene sediments (Jennings and Strand, 1969). Differences in soil parent material may influence element availability; however, there was no correlation between an element in the bark and in the soil.

For the May collection the Pb concentration at site 10, the closest site to the coast and State Park campground, was about 10-times-higher than the December collection. Whereas we can not identify the true cause of this decrease, the elevated concentration may be a result of the proximity to traffic as has been generally noted for the other species collected throughout the SAMO.

E-W Crestline: Soils. The E-W Crestline Traverse soils would be expected to exhibit trends similar to the N-S traverse soils. The ANOVA results indicate that, when compared to the laboratory replicates, there was significant difference between north and south aspects at an individual traverse site. As discussed above it is not clear from a physical point of view that these soils are truly chemically different. Paired-t tests indicated that the soils were not different at the 0.05 probability level. Hence, the focus of our examination of spatial trends is west to east along the traverse.

For the N-S traverses several elements in soils were found to correlate positively and negatively with easting. With a probability level of 0.01 only Pb and Sr were correlated with easting for the crestline traverse. Both elements increased from west to east along the traverse (Figure 20). This is similar to the trend found for Pb in the N-S traverse soils. The Pb in these soils was positively and negatively correlated with organic C and pH, respectively (Table 17). The Pb, Zn, and organic C content of the soil from the south aspect at the eastern most site were particularly elevated. It is unclear whether the increase in Pb from west to east is attributable to changes in the soil characteristics such as pH or organic carbon, differences in bedrock geology, or in the distance from major areas of automotive traffic.

E-W Crestline: ***R. laurina***. The ANOVA results for the E-W crestline traverse samples of *R. laurina* indicated that the differences in north and south aspect contributed little spatial variance and that, compared to E-W orientations with the same aspect, there was no significant difference. As was found for the crestline soils there were significant differences between sites. Significant correlations were found for Al, Fe, Pb, and Sr with easting. Al, Fe, Cr, and Sr correlated for the December collection. Qualified values (26%) were replaced with 0.7 times the detection limit for Pb in the May collection, whereas for the December collection more than 33% of the values were qualified and correlations were not computed. Thus the Pb and location correlation for May must be interpreted with caution.

The increase in Al and Fe from west to east may be due to soil pH controlling their availability. There is a general decrease in soil pH in the same direction and more acidic soils promote mobilization of Al and Fe (Figure 21). This is also true for Pb (Adriano, 1986).

Figure 16. Selected elements in soils from N-S traverses versus location.

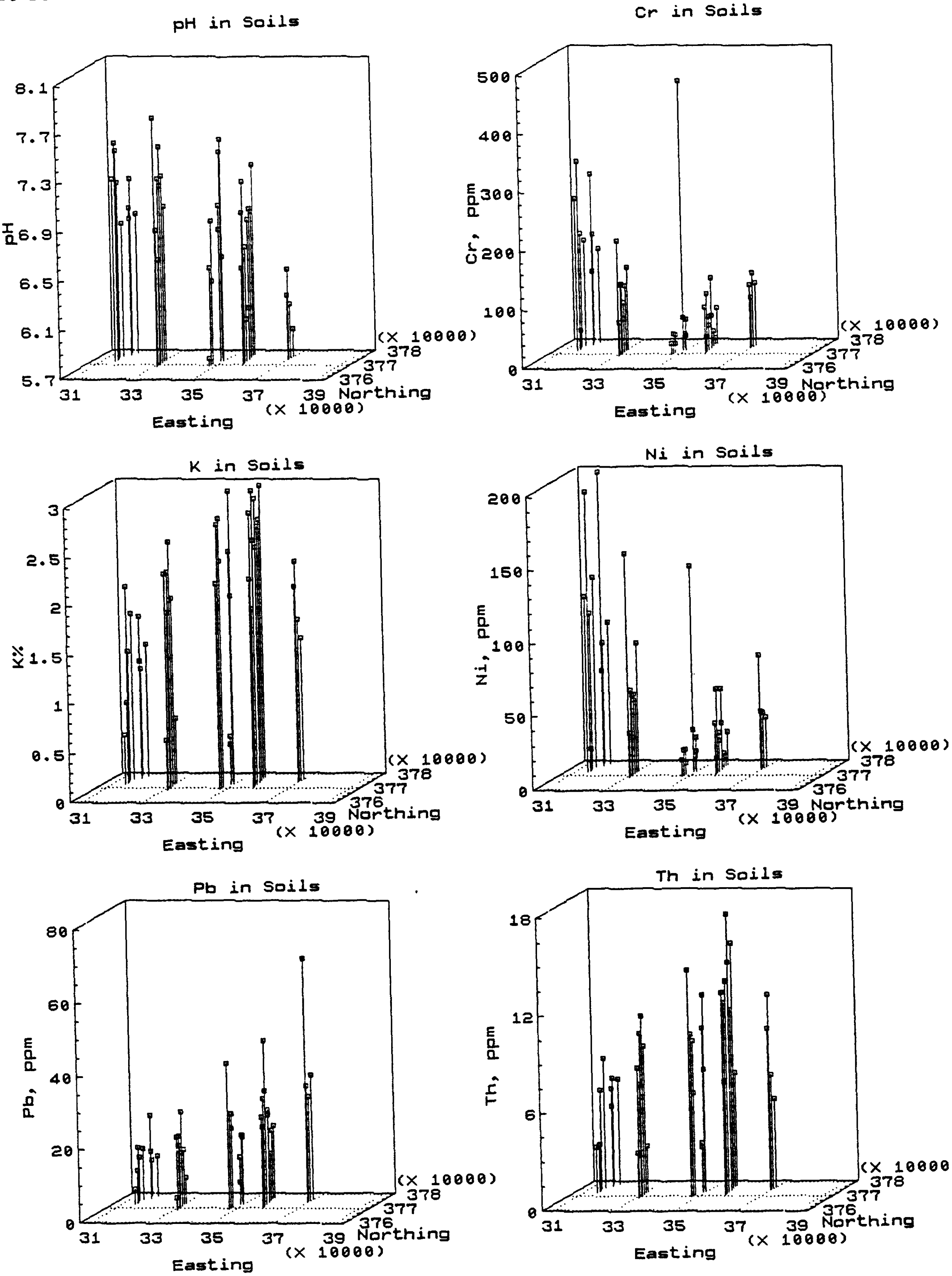


Figure 17. Selected elements in *R. laurina* from N-S traverses versus location.

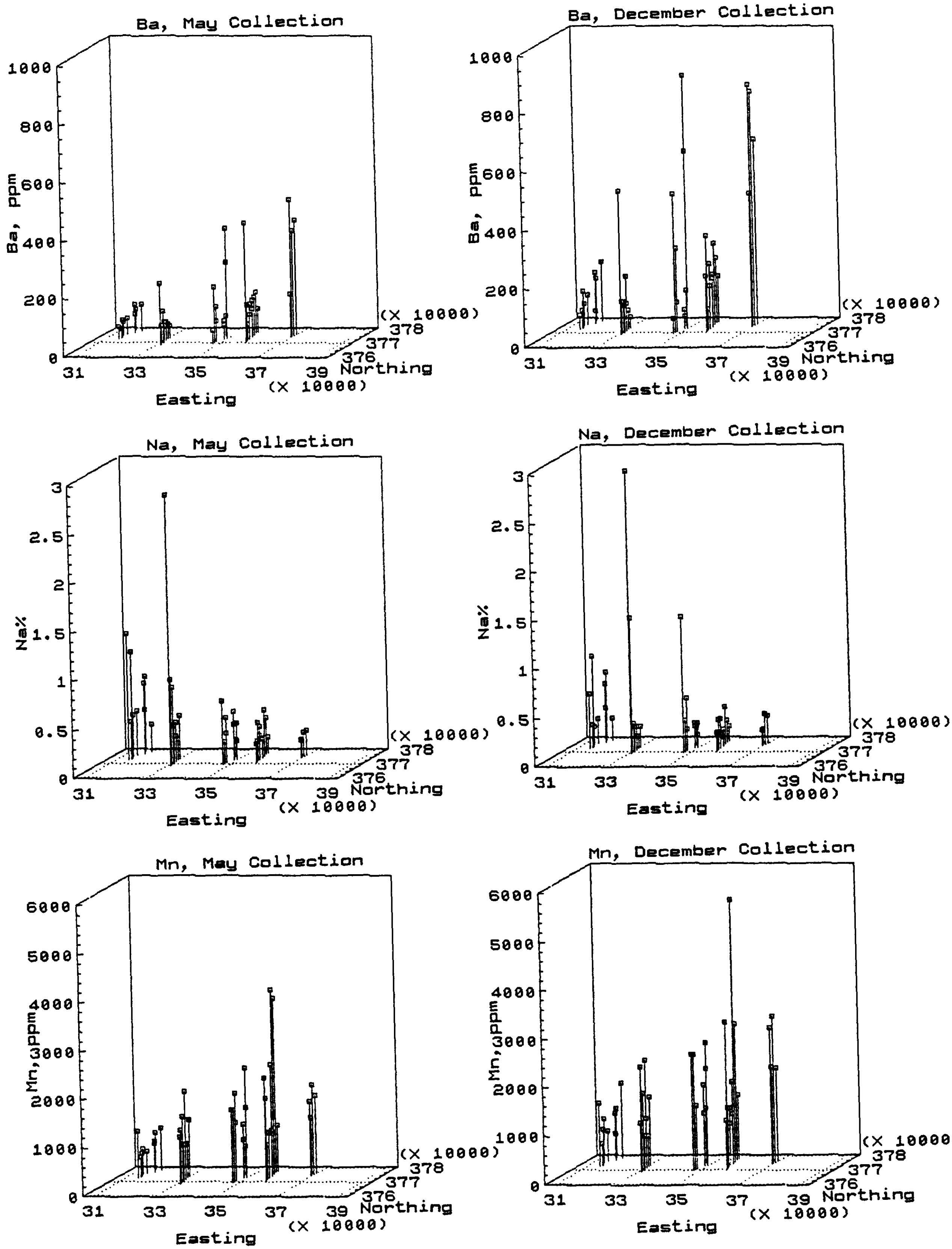


Figure 17. Selected elements in *R. laurina* from N-S traverses versus location (continued).

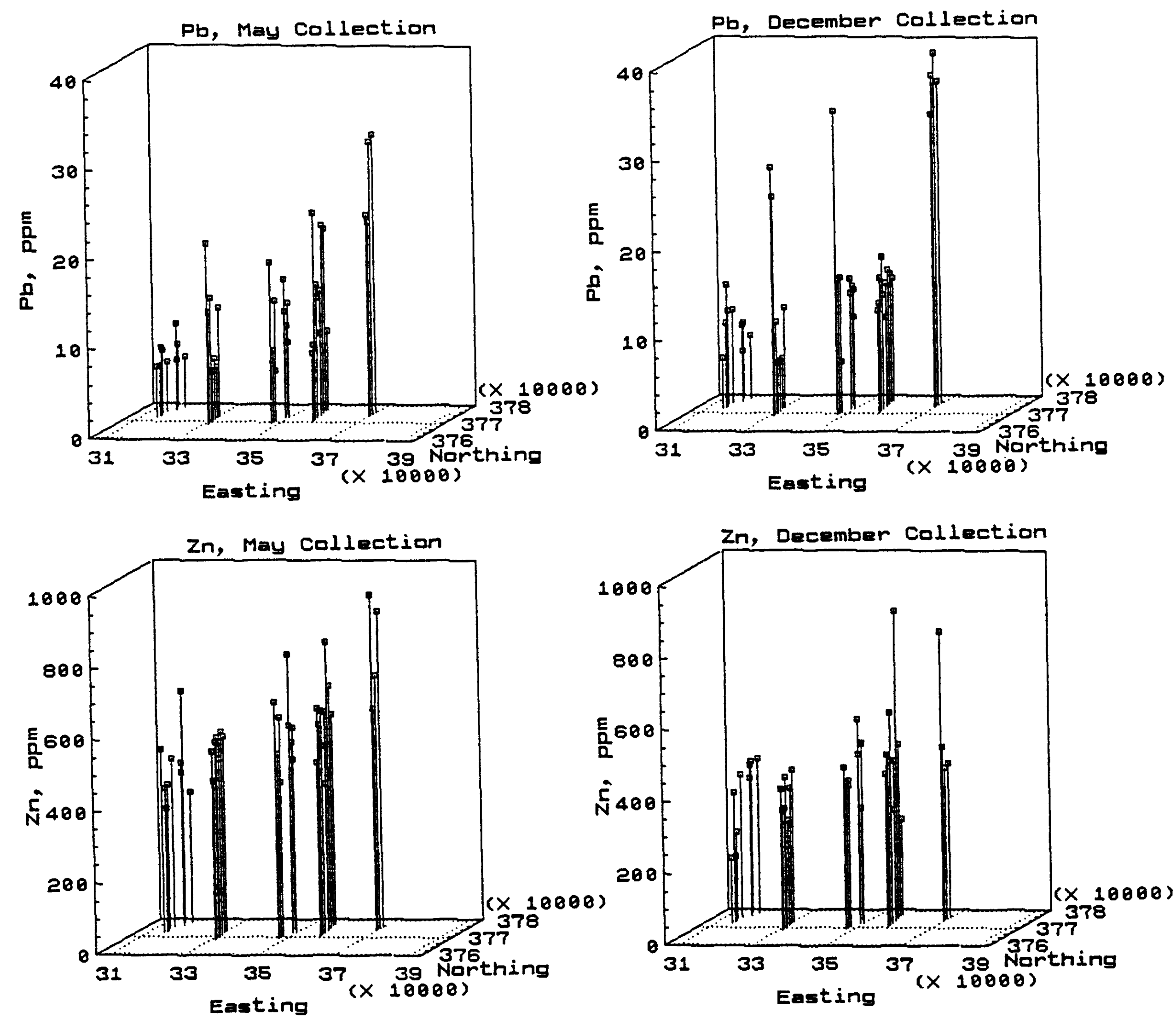


Figure 18. Na and Pb in *C. megacarpus* from N-S traverses versus location.

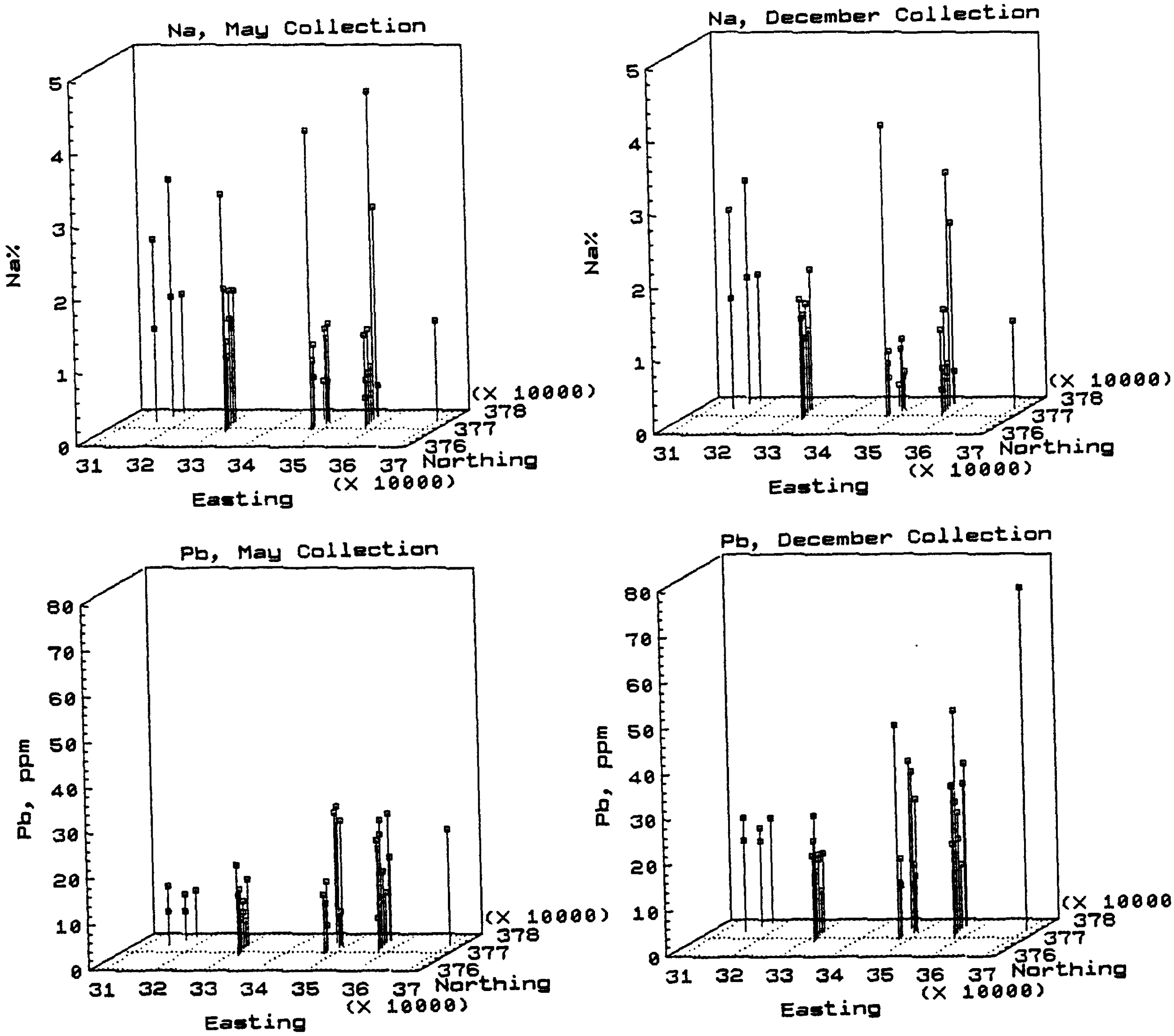


Figure 19. Selected elements in *Q. agrifolia* versus northing for Traverse 5.

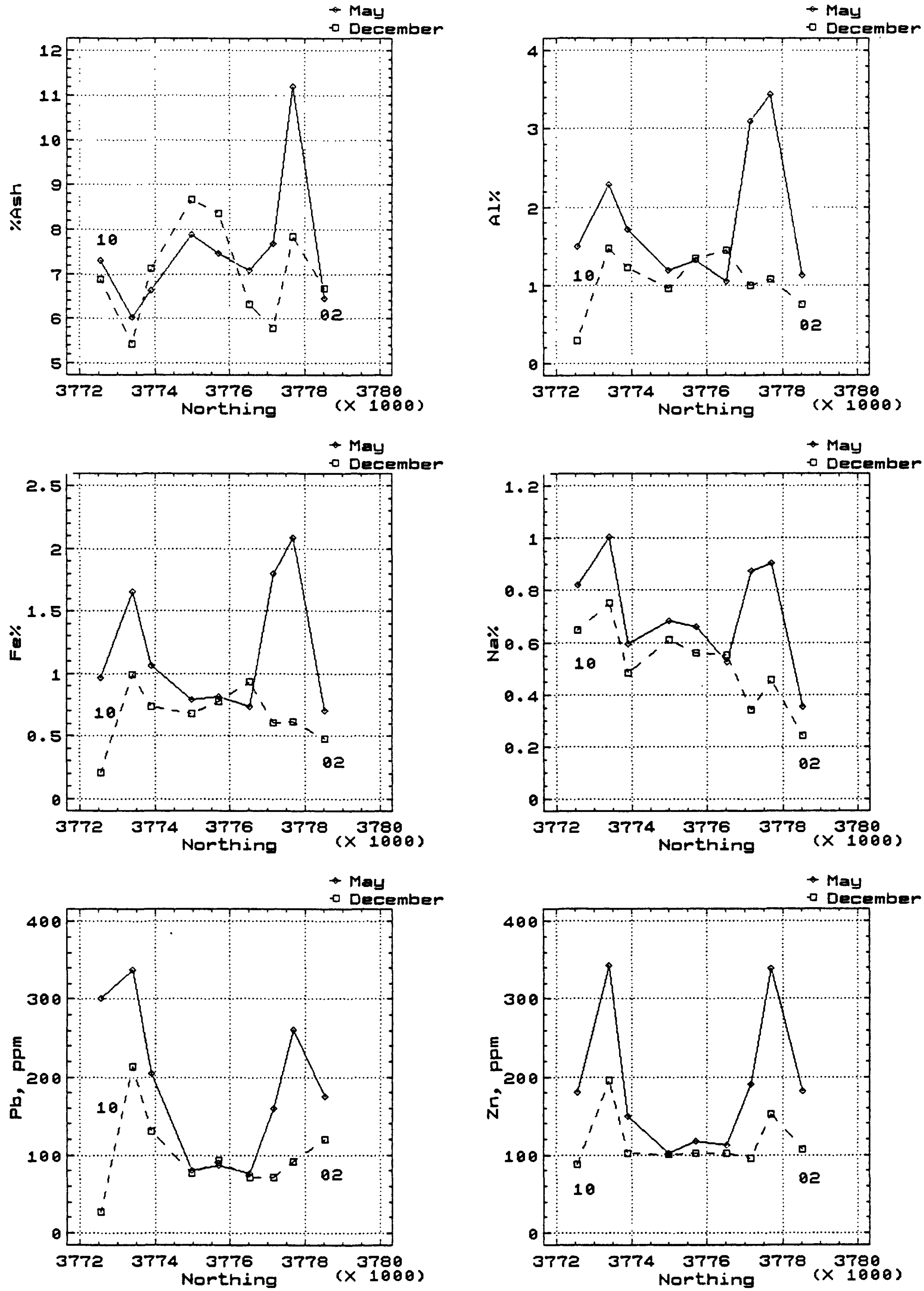


Figure 20. Selected elements in soils from the E-W crestline traverse versus easting.

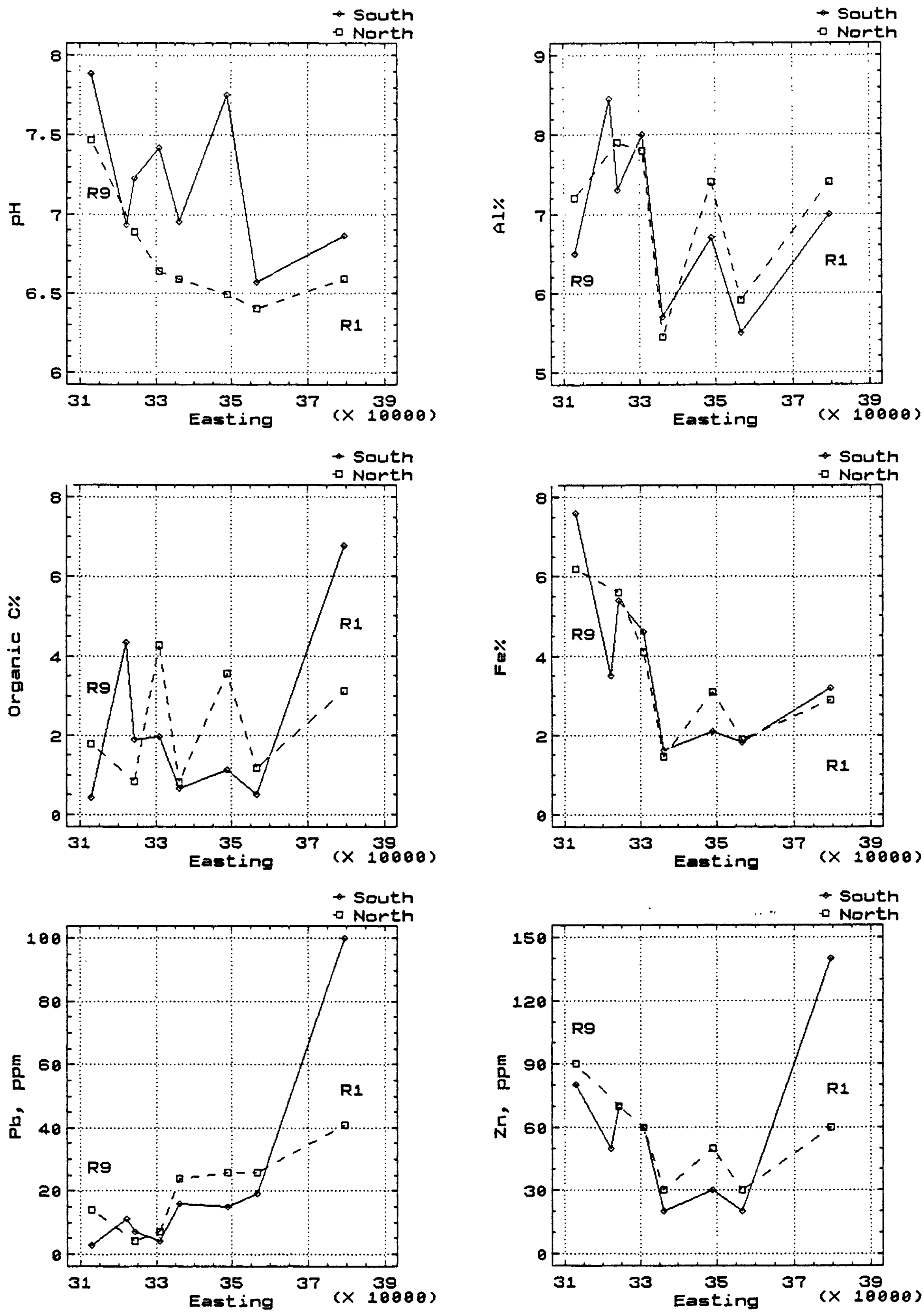


Figure 21. Selected elements in *R. laurina* from the E-W crestline traverse versus easting.

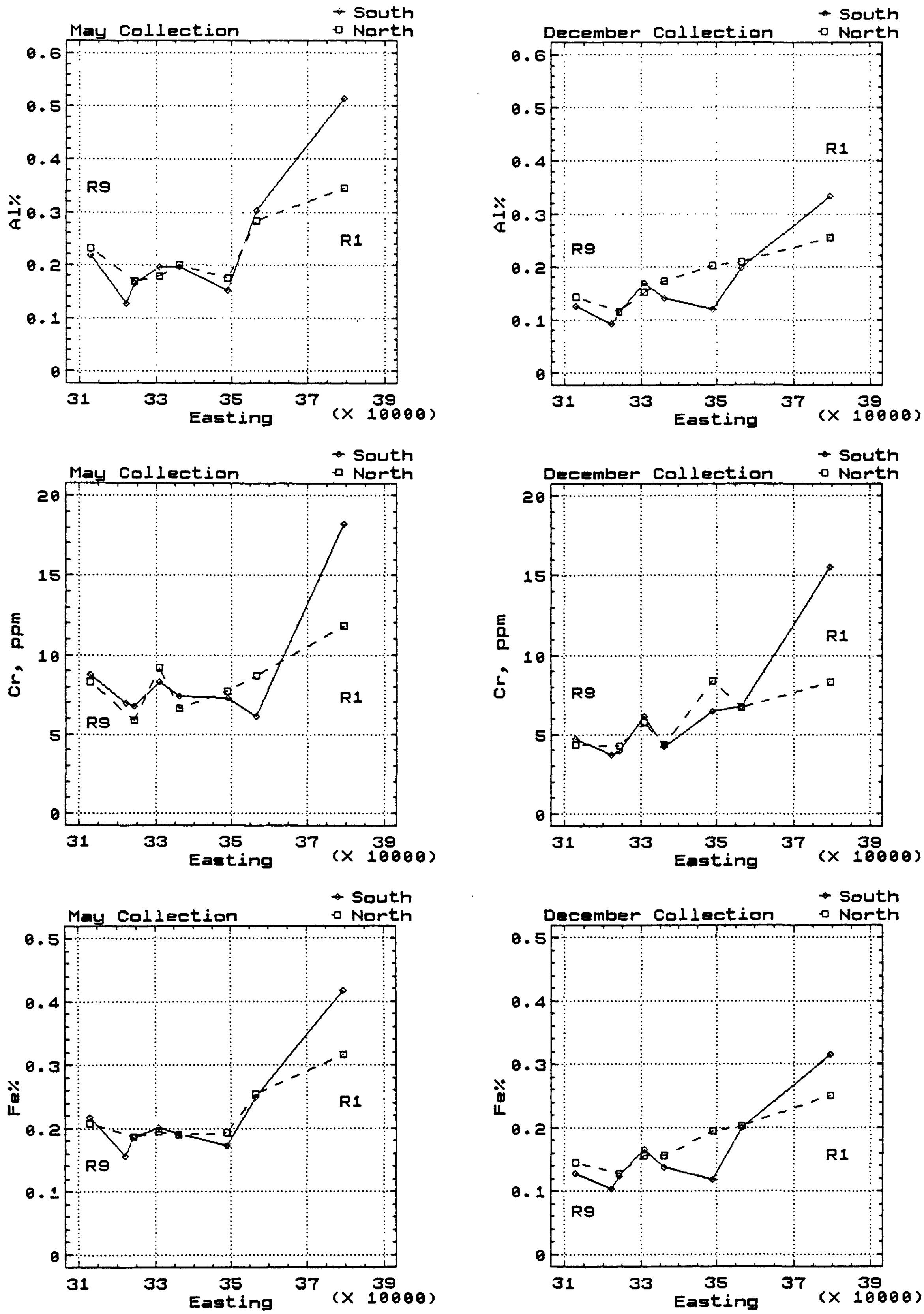
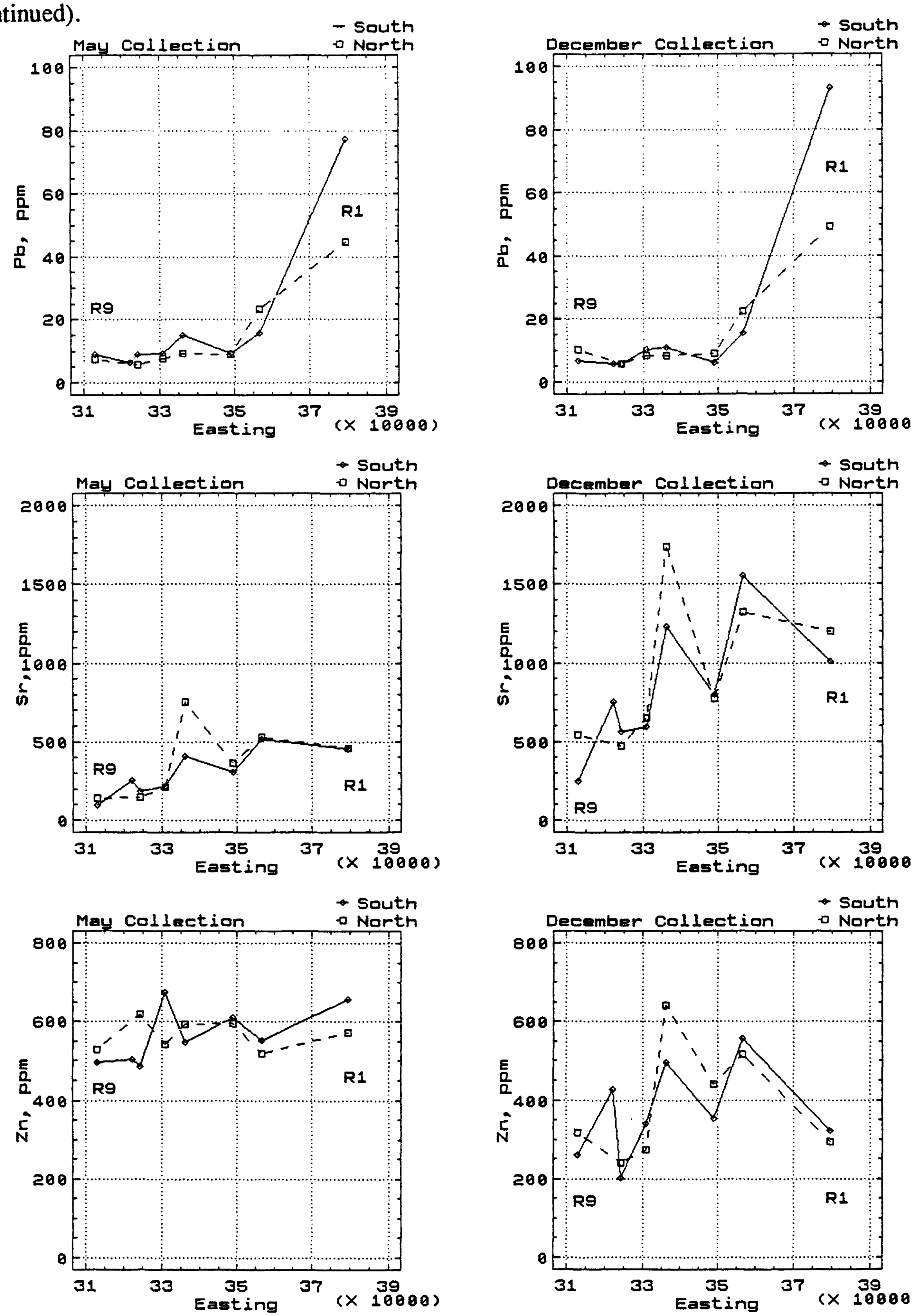


Figure 21. Selected elements in *R. laurina* from the E-W crestline traverse versus easting (continued).



INTEGRATED RESULTS AND DISCUSSION

Univariate and multivariate analysis of bulk soil and foliage chemistry were performed to meet several objectives: (1) geometric means and deviations were calculated to determine baseline elemental concentrations; (2) hierarchical ANOVA was used to assess the spatial scale of variability of element concentrations; (3) cluster analysis was used to classify sample sites into homogeneous groups based on similarity of soil or plant chemistry; and (4) exploratory factor analysis was performed to identify a few scientifically meaningful, underlying factors from numerous difficult-to-interpret, individually correlated variables. The results for the various sample media and sampling designs are integrated in this section.

For soils the mean concentrations for all elements are well within the ranges found for soils in the western United States (Shacklette and Boerngen, 1984). Published elemental concentrations for *R. laurina* and *C. megacarpus* are not available except for a few studies of nutrient cycling in chaparral vegetation where macro-nutrients have been measured. For example, Gray (1982) determined mean concentrations of macro-nutrients in *C. megacarpus* for 24 monthly collections. After converting our geometric mean results to a dry-weight basis and averaging the two collections, we found similar results to Gray:

	P%	K%	Ca%	Mg%
Gray	0.08	0.45	0.87	0.16
our work	0.15	0.64	0.87	0.19

Our results for P and K were somewhat higher. However, Schlesinger and Gill (1980) and Schlesinger and Hasey (1981) have also reported slightly higher results for these macro-nutrients in *C. megacarpus*. Trace essential and non-essential element concentrations have generally not been reported.

Baseline ranges for individual elements have been defined in numerous ways such as the expected 95% concentration range (geometric mean/(geometric deviation)^2 to geometric mean x (geometric deviation)^2, Tidball and Ebans, 1976). Frequently the baseline ranges that are measured only represent a specific point in time as do the results determined in this report. Because of the large seasonal differences found in element concentrations in the plants that we sampled, we have not calculated baseline concentration ranges, but have only presented summary data as seen in Tables 2-11. Future comparisons with these results should be made with caution due to the many ecosystem variables, such as climate or plant age that have not been measured or controlled in this work.

The micro-climate, aspect, and elevation are variables that have an influence on soil moisture regimes which in turn influence plant distribution and chemistry. Evergreen shrubs are predominant above 300 m, whereas shrubs with seasonally dimorphic leaves are found below this elevation which is possibly a response to differences in water availability and use and carbon fixation (Schlesinger and Hasey, 1981). *Ceanothus* and chamise chaparral both tend to occur on steep south-facing slopes. However, *Ceanothus* chaparral is generally found on more mesic coastal sites (Hanes, 1988). Moisture regimes apparently change with stand age, location within a stand, and foliage-area index (Poole and Miller, 1981; Schlesinger and Gill, 1980). Ecotonal boundaries within the chaparral have also been attributed to differences in substrate which may have an influence on moisture and nutrient availability (Cole, 1980; Mooney, 1988). Chaparral is generally more prevalent on sandstone substrates and coastal sage on more argillaceous or shaley substrates. Substrate and soil development control nutrient availability, as well. Zinke (1982) found higher amounts of exchangeable Ca and Mg and higher cation exchange capacity, in general, in soils under *Ceanothus* than under scrub oak. Additionally, fire history influences chaparral growth through nutrient cycling and changes in demographic structure (Debano and Conrad, 1978; Montygierd-Loyba and Keeley, 1987; Rundel, 1983; Rundel and Parsons, 1980; Schlesinger and Gill, 1978).

The univariate ANOVA results for the soils, *R. laurina*, and *C. megacarpus* are similar in that they indicate that a large portion of the spatial variance was attributable to differences between sites--sites that for the N-S trending traverses are only 0.8 km apart. Whereas the coastal or southern slopes of the Santa Monica Mountains are dominated by one broad vegetative type and have similar general climate, the ANOVA results are indicative of the importance of site specific micro-climate, aspect, elevation, edaphic properties, vegetative properties such as age, and fire history in controlling plant chemistry. Thus, with the number of factors that influence chaparral growth, the melange of substrates and differences in micro-climate throughout the SAMO, it is not surprising that we found large differences in foliage chemistry from site to site. The occurrence of large localized variability obscures broad regional trends in plant chemistry. This is also demonstrated in the examination of multivariate factor scores and cluster dendrograms with respect to location.

Hierarchical clustering analysis indicated some broad groupings of soils and plants. The differences in soil clustering may be largely due to differences in parent material (e.g. amount of quartz or carbonate) and soil development. However, the plant clusters do not appear to be strongly related to the soil clusters. Unfortunately, the cluster analysis does not indicate an easily interpretable classification scheme for individual sites for both plants and soils.

Factor models for soil chemistry along the N-S traverses and the E-W crestline traverse are not directly comparable, but do exhibit some similarities. For both sample suites the first factor, which explains the most variance in the data, is dominated by major rock forming elements such as Al and Fe and trace metals such as Cr, Cu, Ni, and Zn. Alkaline and alkaline earth elements, C, and Pb load most prominently on other factors. For soils along the N-S traverses the second factor has associations of pH, Ca, and Mg inversely related to K, Ba, Ce, La, Li, and Pb. Factor 1 and 2 scores support the grouping of N-S traverse soils into three suites as found using cluster analysis. Factor one scores are likely to be a reflection of differences in non-carbonate parent material and the degree of soil development. Whereas variations in factor 2 scores suggest differences in carbonate substrate or differences in clay minerals. For example, Li and rare earth elements are commonly concentrated in argillaceous sediments (Kabata-Pendias and Pendias, 1984). Li concentrations may indicate greater presence of kaolinite clay than montmorillonite or illite (Horstman, 1957). This factor may also reflect an influence of pollution on soil pH and Pb concentration. Although the second factor for the E-W crestline traverse soils had a slightly different association of elements (organic C, pH, and Pb), factor 2 scores for this suite may also indicate a pollution influence, as well as a difference in carbonate parent material.

Factor models for *R. laurina* and *C. megacarpus*, which were produced using the combined data for the two seasons, had two similar major factors. One factor was dominated by macronutrients, Ca and K. Another factor was heavily loaded by Al, Fe, Cr, and Pb. The later factor may be pedologically associated. For *R. laurina* the macronutrient factor explained the most variability and provided a clear separation of samples based on collection season. For *C. megacarpus* the Al, Fe, Cr, and Pb factor explained more total variability than the macronutrient factor. However, there was still a seasonal difference in macronutrient scores, although it was graphically less distinct. A factor model for each individual season for *R. laurina* produced a similar factor order as the combined-season model for *C. megacarpus*. Thus, the seasonal effects of nutrient cycling are more important for *R. laurina* than for *C. megacarpus*. Although for both species, site specific variables which influence plant levels of Al, Fe, Cr, and Pb appear to play a major role in spatial variance. The importance of site specific differences in moisture regimes may be enhanced at the end of the drought season as suggested by the greater scatter in factor scores for the December versus May collections for both species.

The wider range of temporal absorption coefficients for *R. laurina* and *C. megacarpus* indicated that seasonal changes in plant chemistry are greater in *R. laurina* than *C. megacarpus*, just as was found by factor analysis. Gray (1982) noted that the variation of macronutrients for *C. megacarpus* was relatively low for a two year period (12-20% RSD). The changes in nutrient levels that occur in *R. laurina* also appear to influence the levels of several non-essential elements, such as Cr, Ni, and Pb which were at lower concentrations in December. For *C. megacarpus* the concentration of these metals was more constant between seasons, but levels in *C. megacarpus* were 2-3 times greater than in *R. laurina* for the December collection.

Considerable research has been done on nutrient cycling in chaparral vegetation and on different components and inputs to the cycles. Fires obviously play a major role through volatilization of nutrients and ash deposition, surface erosion and soil chemical changes, and changes in plant demographics (Debano and Conrad, 1978; Rundel, 1983; Rundel and Parsons, 1980; Schlesinger and Gill, 1980). Fires also influence the recycling of nutrients through burning of leaf litter which is normally an important conservative source of nutrients in chaparral (Schlesinger, 1985; Schlesinger and Hasey, 1981). In the SAMO most areas have burned more than once in the last 70 years with coastal areas from Los Flores Canyon westward past the Ventura County line averaging burn frequencies of 12-21 years (Radtke and others, 1982). From 1970 through 1986 the fires were largely concentrated in the central portion of the SAMO. Samples sites at the southern end of N-S traverses 2 and 3 and along the entire traverse 4 were within burn areas from this period (P. Rose, pers. comm.). Although none of the sites sampled in our study had been burned recently and mature shrubs were generally sampled, the influence of fire history on plant and soil chemistry in our study is unclear.

In addition to the influence of fire, atmospheric input of nutrients has also been studied. In this environment dryfall is an extremely important component with more than 90% of the deposition of acidic compounds occurring through dryfall mechanisms (Bytnerowicz and others, 1987). Schlesinger and coworkers studied deposition to mature stands of *C. megacarpus* in the Santa Ynez Mountains and concluded that the atmospheric input of Ca, K, and N (NO_3^-, NH_4^+) was mostly from dryfall with Ca and K largely from continental dust and N from anthropogenic sources (Schlesinger and Gray, 1982; Schlesinger and others, 1982). They also concluded that Na, Mg, and SO_4^{2-}-S were important in both dryfall and rainfall with Na and Mg predominantly coming from a marine source and with S being anthropogenically enriched in addition to a marine source. Bytnerowicz and others (1987) studied nutrient dry deposition to *Ceanothus* *crassifolius* in the San Gabriel Mountains and found that N species were higher in concentration than S species which is contrary to results commonly obtained in the eastern US.

Interception of fog and low-lying stratus clouds also serve as a source of atmospheric nutrient input. In the Los Angeles basin and surrounding environs extremely acid fog and cloudwater with high concentrations of N and S have been measured (Brewer and others, 1983, Jacob and others, 1984, 1985; Munger and others, 1983, 1989; Waldman and others, 1985). In fogwater Fe and Pb concentrations have been measured at 0.1 and 0.01 mM (Munger and others, 1983). Sulfate has been found to accumulate in aerosols due to the sea breeze/land breeze circulation which causes recycling of air masses over coastal emission sources (Cass and Shair, 1984). This suggests that metals may accumulate as well and have a direct influence on air quality in the SAMO. The influence of fog interception on trace metal cycling in chaparral vegetation has not been studied, although some work has been done on effects of fog on forests (Azevedo and Morgan, 1974; Waldman and Hoffmann, 1988). Acidic fogwater appears to leach nutrients as well as serve as a nutrient source. In addition, the acidic water may solubilize deposited soil dust and sea salt (Waldman and Hoffmann, 1988). The interception of summertime fogs and stem flow may account for the general lowering of element concentrations in oak bark between the May and December collections that we observed. Whereas this may affect foliar metal concentrations in *R. laurina* and *C. megacarpus* seasonal differences in physiological processes may dominate.

Climatic conditions vary greatly between wet, winter months and dry, summer months with a resultant change in the movement of pollutants in the region and a general deterioration of the air quality in the summer. The summertime combination of weak, cool sea breezes and hot, dry desert air create strong stable temperature inversions which limit vertical mixing of air. The month of September has historically exhibited the worst photochemical smog (Zeldin and others, 1988). The flux of pollutants to vegetation in the SAMO is thus seasonally influenced and could be reflected in foliar chemistry. However, adaptations in the plants to withstand the seasonal drought may reduce foliar absorption so that there is actually less uptake of elements during the most polluted season.

Although measurements of trace metals in Los Angeles air and source apportionment have been made (Miller and others, 1972; Saltzman and others, 1985), little work has been performed on atmospheric metal deposition to chaparral (Zinke, 1980). Cd, Cr, Mn, Ni, Pb, V, and Zn occur in the Los Angeles atmosphere (Bruland and others, 1974; Finlayson and Pitts, 1976; Saltzman and others, 1985). Pb and V are normally attributed to automobile emissions and fuel oil combustion, respectively. Cd and Zn may come from incinerators; additionally Zn may come from automobile tire wear. Cr, Mn, and Ni do not appear to be anthropogenically enriched (Bruland and others, 1974; Saltzman and others, 1985).

In our work no atmospheric measurements of element concentrations were made. Instead we must infer anthropogenic influences from the spatial distribution trends of various elements in plants and soils. As discussed above, the great site-to-site heterogeneity and seasonal effects of nutrient cycling obfuscate anthropogenic influences. In addition, the sampling design is not optimal for examining spatial trends throughout the SAMO. However, there does appear to be a decrease in soil pH and an increase in Pb in soils and plants from west to east in the SAMO that may represent an anthropogenic influence. Although most automotive Pb appears to be deposited within very short distances of highways (e.g. 150 m, Page and others, 1971), Pb deposition attributed to primarily regional automobile emissions as opposed to local emissions has been measured in more remote areas (Davidson and others, 1985; Hirao and Patterson, 1974).

Whereas we can only infer that the spatial trends in soil pH and soil and plant Pb concentration are anthropogenically induced, it seems reasonable to expect that at least a portion of the increase observed in the vicinity of the major population centers is due to automobiles and not solely a result of regional differences in geologic substrates (Figure 22). Although Pb in soils did not correlate with Pb in either plant species, this does not obviate our conclusion that Pb in both soils and plants has an atmospheric component. Pb is generally immobile in soils and is not readily translocated from roots to leaves in plants (Kabata-Pendias and Pendias, 1984; Adriano, 1986). Decreasing soil pH does promote Pb uptake (Adriano, 1986). Thus, acid deposition may have a synergistic effect on foliar Pb concentrations. Spatial trends for few other elements that were noted are likely due to differences in substrate and/or soil pH. Additional biogeochemical studies are required to both to validate the spatial trends and to clarify the sources of the elements such as Pb in this environment.

CONCLUSIONS AND RECOMMENDATIONS

Our general conclusions are:

Seasonal trends in elemental concentrations in plants were found to be significant for nutrient elements and for several nonessential trace elements.

Spatial variance of soil and plant chemistry is large at a localized scale (i.e. site-to-site).

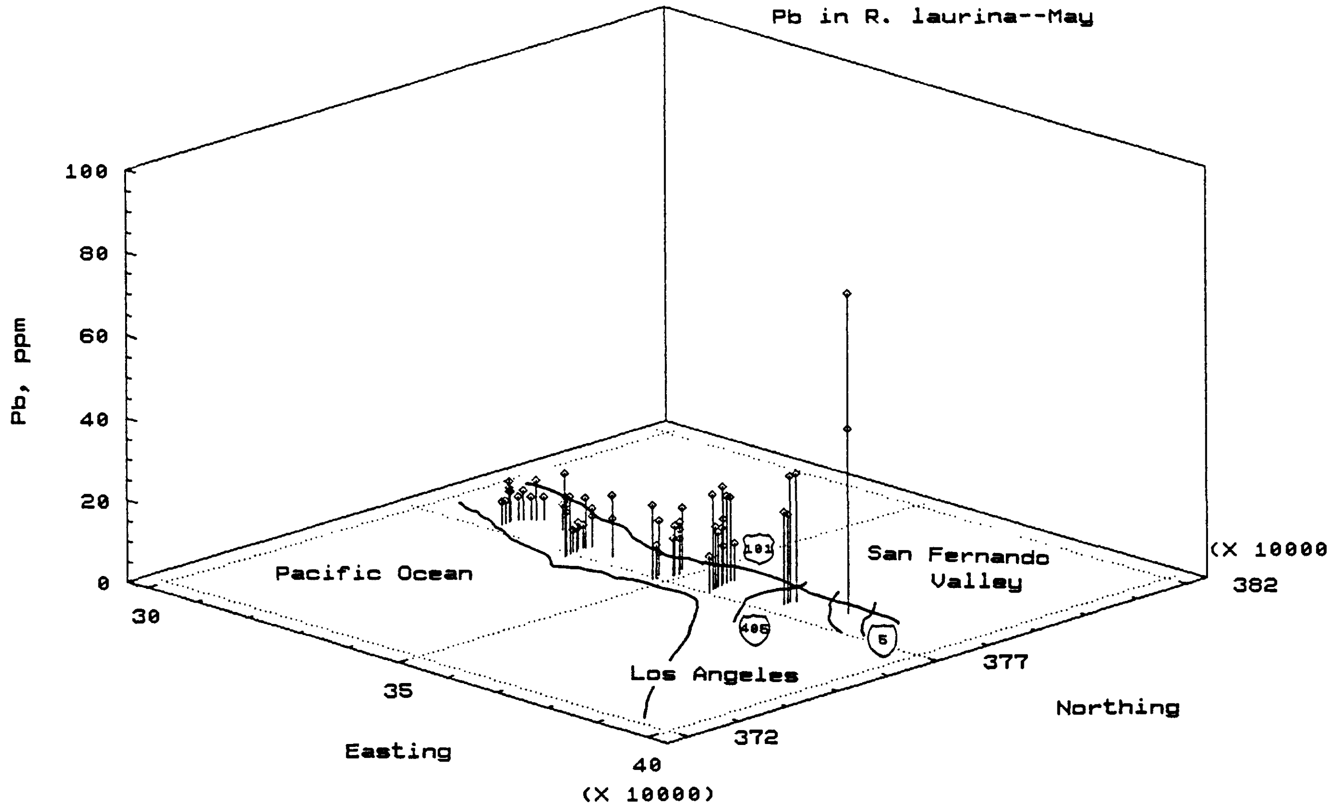
Only moderate correlations were found for an individual element between both plant species. Positive correlations between species were more prevalent in May than in December.

Spatial trends with respect to northing for elements in plants and soils along N-S traverses are not obvious, although some influence of sea-salt spray on Na in foliage is indicated.

Spatial trends with respect to easting for elements in plants and soils along all traverses indicate a potential anthropogenic influence on pH and Pb concentrations. Other elements that correlate with easting are likely to be a result of regional trends in geologic substrates.

Additional biogeochemical studies are required in order to clearly define processes influencing foliar chemistry and to differentiate between natural and anthropogenic sources of elements in chaparral vegetation. We recommend that future studies incorporate a more holistic approach which measures elemental inputs, cycling within plants and soils, and ecosystem losses at a few selected sites throughout the SAMO. An emphasis should be placed on chemical characterization of soil parent materials and soils which includes element availability as well as bulk chemical and mineralogical properties and a chemical characterization of various plant parts to examine nutrient cycling between ecosystem components and translocation within the plant. Studies which focus on the natural sources and forms of Pb and other trace metals in the soils and on or in the plants can help differentiate between naturally occurring and anthropogenically induced metals. Atmospheric inputs from both dryfall and wetfall should be measured and include an assessment of trace elements as well as macronutrients. Future analyses of *R. laurina* and *C. megacarpus* at the sites we have sampled may be used to assess long term environmental changes. However, caution should be used in interpreting subtle changes which may be due to methodological differences or uncontrolled environmental variables.

Figure 22. Pb in *R. laurina* and soils and soil pH for all sample sites.



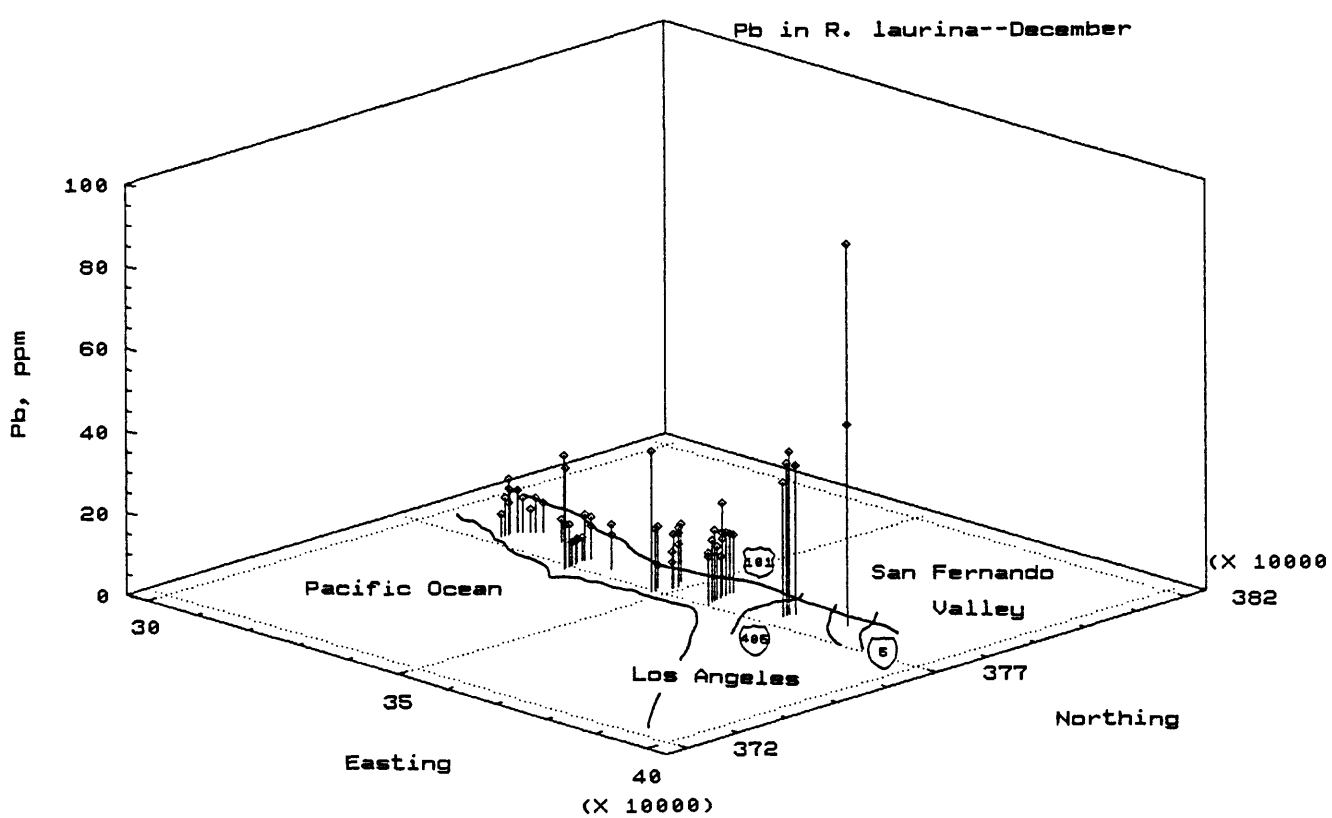
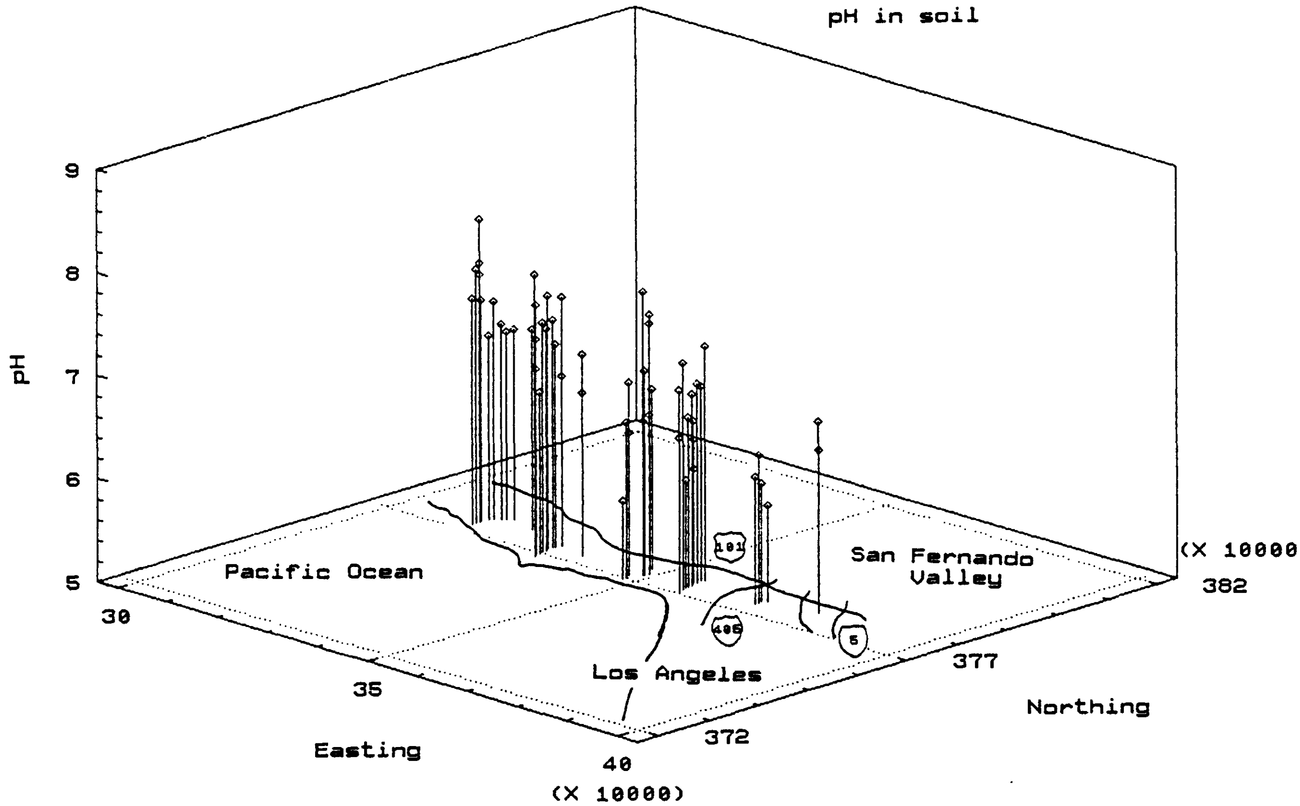
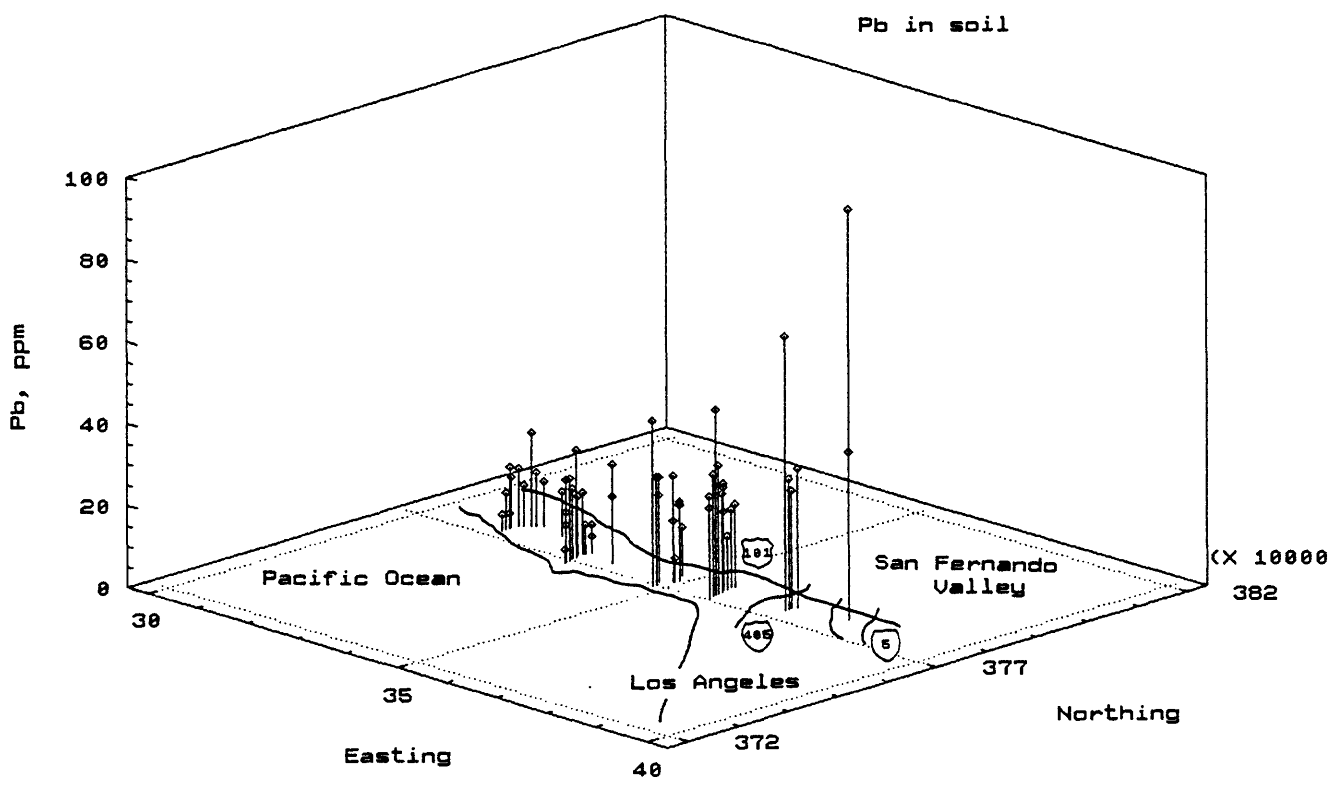


Figure 22. Pb in *R. laurina* and soils and soil pH for all sample sites (continued).





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Appendix I. Sample field number encoding.

<u>Soils along N-S traverses</u>

Field number = A1B234C

A = collection season, T = May (only one season sampled)

1 = N-S traverse number (1-5)

B = sample type, S = soil

23 = site number along traverse (01-10)

4 = between-pit replication at a site (1-2)

C = laboratory split, blank = primary sample, X = second sample split

Example: T5S101 = Soil sampled at N-S traverse 5, site 10

R. laurina and *C. megacarpus* along N-S traverses

Field number: A1B34567

A = collection season, T = May, D = December

1 = N-S traverse number (1-5)

B = plant specie, R = *R. laurina*, C = *C. megacarpus*, Q = *Q. agrifolia*

34 = site number along traverse (01-10)

5 = between-shrub replicate (1-2)

6 = within-shrub replicate, 1 = south aspect sample, 2 = north aspect sample

7 = laboratory split (1-2), not used in the field

Example: T3R05122 = *R. laurina* sampled in May at N-S traverse 3, site 05, primary shrub at the site, within-shrub replicate from north side, laboratory sample split.

Appendix I. Sample field number encoding (continued).

<u>Soils along E-W crestline traverse</u>

Field number: A1BC2D

A = collection season, R = May (only one season sampled)

1 = crestline site number (1-9)

B = sample type, S = soil

C = aspect, N = north-facing, S = south-facing

2 = east or west site on each side of crestline, 1 = west, 2 = east

D = laboratory split, blank = primary sample, X = second sample split

Example: R8SS2X = Soil sampled in May at E-W crestline traverse site 8 from south side near eastern most shrub, laboratory sample split

R. laurina along E-W crestline traverse

Field number: A1BC2345

A = collection season, R = May, D = December

1 = crestline site number (1-9)

B = sample type, R = *R. laurina*

C = aspect, N = north-facing, S = south-facing

2 = east or west site on each side of crestline, 1 = west, 2 = east

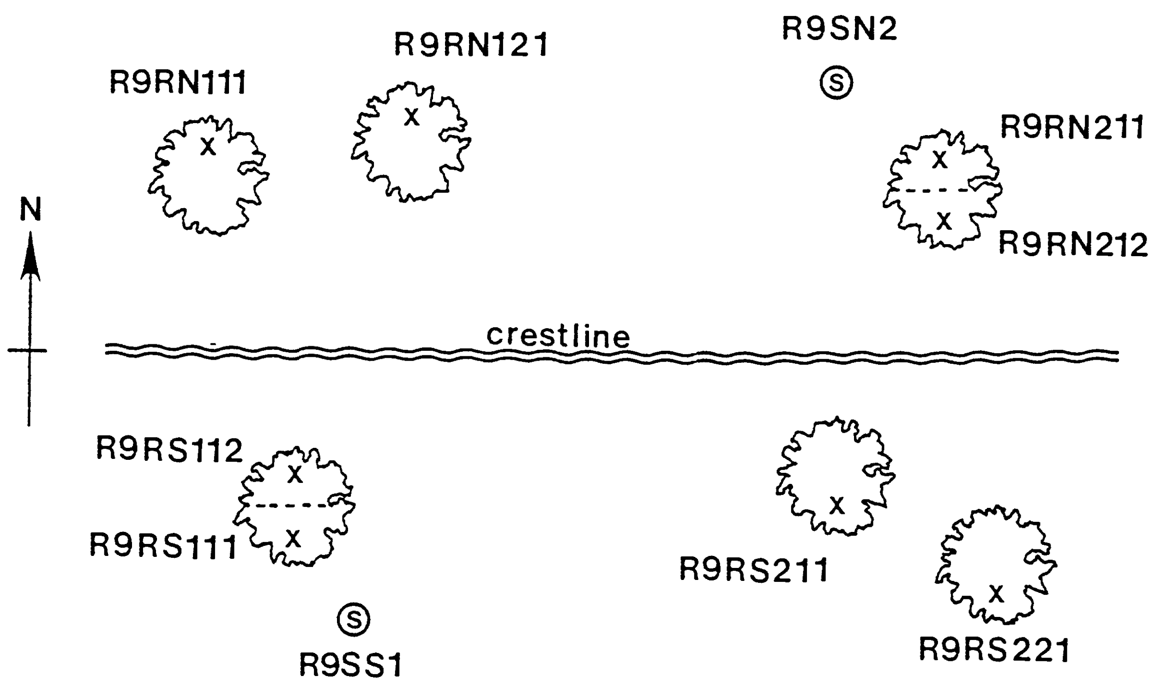
3 = between-shrub replicate, 1 = west shrub, 2 = east shrub

4 = within-shrub replicate, 1 = downslope sample, 2 = upslope sample

5 = laboratory split (1-2), not used in the field

Example: D9RN2121 = *R. laurina* sampled in December at E-W crestline traverse site 9 from north side, eastern most shrub, within-shrub replicate from upslope side

Figure A1. Example of field numbering system for E-W crestline traverse samples. (S = soil sample; X = plant sample)



Appendix II. Elemental concentrations in soils from N-S traverses--May collection.

Field#	Lab#	Lat	Long	pH	Percent											
					C, total	C, org	C, crbnt	S	Al	Ca	Fe	K	Mg	Na	P	Ti
T1S021	D-275709	340708	1182430	6.62	1.29	1.29	< 0.01	0.01	8.2	2.9	5.7	1.5	1.9	2.0	0.07	0.62
T1S022	D-275660	340708	1182430	5.31	3.28	3.25	0.03	< 0.01	8.1	3.1	4.1	1.4	1.5	2.4	0.08	0.44
T1S031	D-275730	340641	1182447	6.11	2.30	2.30	< 0.01	0.01	7.6	3.4	5.1	1.7	2.1	2.0	0.07	0.56
T1S031X	D-275689	340650	1182447	6.18	2.22	2.22	< 0.01	0.01	7.7	3.4	5.2	1.6	2.2	2.0	0.08	0.58
T1S041	D-275708	340615	1182440	6.42	1.99	1.99	< 0.01	0.01	6.6	0.79	4.1	2.3	0.88	0.84	0.08	0.42
T1S042	D-275707	340615	1182440	6.45	2.56	2.56	< 0.01	0.02	7.0	1.0	4.3	2.2	1.0	1.0	0.10	0.44
T1S051	D-275711	340549	1182434	6.23	2.97	2.97	< 0.01	0.02	7.2	0.62	5.2	2.0	1.3	1.0	0.1	0.41
T2S011	D-275717	340732	1183322	7.36	2.49	2.19	0.30	0.03	5.4	1.3	1.7	2.8	0.83	1.2	0.04	0.23
T2S012	D-275694	340732	1183322	7.16	1.97	1.84	0.13	0.03	6.1	1.1	2.0	3.2	0.76	1.4	0.05	0.26
T2S021	D-275729	340712	1183317	6.87	0.80	0.80	< 0.01	< 0.01	5.5	0.48	2.0	2.7	0.27	1.9	0.02	0.15
T2S022	D-275653	340712	1183317	6.90	0.69	0.69	< 0.01	0.01	6.6	0.89	2.8	2.6	0.37	2.0	0.03	0.21
T2S031	D-275655	340640	1183317	6.92	0.35	0.35	< 0.01	< 0.01	6.2	0.79	2.1	2.6	0.44	1.8	0.02	0.19
T2S041	D-275718	340615	1183318	6.12	3.42	3.42	< 0.01	0.02	7.3	1.5	3.9	2.4	1.0	1.8	0.08	0.39
T2S051	D-275693	340553	1183303	6.85	1.40	1.40	< 0.01	0.01	8.9	1.2	4.5	2.9	1.2	2.0	0.03	0.46
T2S061	D-275665	340522	1183258	6.64	2.28	2.28	< 0.01	0.01	8.4	1.5	4.2	3.0	1.1	1.8	0.09	0.46
T2S071	D-275687	340503	1183246	6.05	5.66	5.66	< 0.01	0.02	7.8	1.5	3.6	2.5	1.1	2.2	0.08	0.44
T2S081	D-275674	340435	1183237	7.32	6.96	6.81	0.15	0.02	7.3	3.0	4.9	1.9	1.6	1.1	0.11	0.48
T2S081X	D-275692	340435	1183237	7.13	6.86	6.72	0.14	0.03	7.9	3.2	5.6	2.2	1.9	1.2	0.1	0.48
T2S082	D-275672	340435	1183237	7.15	5.85	5.79	0.06	0.02	7.4	2.5	5.0	1.6	1.6	1.1	0.10	0.48
T2S091	D-275667	340407	1183230	6.94	1.27	1.27	< 0.01	0.01	6.1	0.62	2.2	2.8	0.36	1.7	0.03	0.21
T2S101	D-275716	340350	1183215	6.47	1.55	1.55	< 0.01	0.01	7.4	0.83	3.7	2.4	0.94	1.3	0.03	0.34
T2S101X	D-275719	340350	1183215	6.31	1.59	1.59	< 0.01	0.01	7.4	0.82	3.7	2.4	0.94	1.3	0.03	0.34
T2S102	D-275686	340350	1183215	6.61	4.38	4.38	< 0.01	0.02	7.0	1.1	3.4	1.9	0.82	1.3	0.05	0.32
T3S011	D-275723	340635	1183946	6.75	2.21	2.21	< 0.01	< 0.01	6.9	2.8	7.4	0.45	1.9	3.3	0.07	1.1
T3S021	D-275720	349610	1183900	7.73	0.75	0.44	0.31	< 0.01	6.5	1.6	1.5	2.4	0.14	1.9	0.04	0.19
T3S022	D-275712	340610	1183900	7.07	0.99	0.96	0.03	< 0.01	7.0	0.68	2.3	2.3	0.19	1.9	0.03	0.26
T3S031	D-275658	340552	1183833	7.50	1.56	1.07	0.49	0.01	7.6	2.7	3.4	1.9	0.57	1.4	0.06	0.37
T3S041	D-275705	340533	1183814	6.65	1.14	1.14	< 0.01	0.01	6.6	0.80	2.0	2.7	0.38	1.9	0.03	0.22
T3S042	D-275727	340533	1183814	6.45	1.73	1.73	< 0.01	0.01	7.6	0.77	1.8	3.3	0.35	2.4	0.03	0.19
T3S051	D-275678	340506	1183817	6.98	0.69	0.69	< 0.01	< 0.01	7.7	3.7	6.6	0.41	4.2	2.7	0.03	0.77
T3S061	D-275699	340415	1183915	6.42	4.34	4.34	< 0.01	0.02	6.5	1.1	1.7	2.3	0.38	2.6	0.06	0.25
T3S062	D-275683	340415	1183915	6.26	4.54	4.54	< 0.01	0.02	6.8	1.1	2.0	2.3	0.45	2.5	0.08	0.30
T3S062X	D-275668	340415	1183915	6.42	4.55	4.53	0.02	0.01	6.7	1.1	2.0	2.3	0.44	2.5	0.08	0.29
T3S071	D-275725	340405	1183907	6.63	1.10	1.10	< 0.01	0.01	6.3	0.92	1.5	3.0	0.45	2.0	0.02	0.20
T3S072	D-275662	340405	1183907	7.12	0.72	0.72	< 0.01	< 0.01	6.3	0.87	1.7	2.5	0.46	2.1	0.03	0.20
T3S081	D-275671	340334	1183855	6.50	2.89	2.89	< 0.01	0.02	6.9	1.0	2.9	2.7	0.54	1.5	0.05	0.30
T3S091	D-275677	340312	1183855	5.76	4.78	4.77	0.01	0.02	6.3	1.1	2.3	2.1	0.47	2.3	0.06	0.26
T4S011	D-275679	340520	1185016	6.96	2.82	2.82	< 0.01	0.02	7.9	2.4	4.4	0.66	2.1	3.4	0.07	0.55
T4S021	D-275661	340500	1185018	7.21	1.85	1.80	0.05	0.01	6.2	1.5	3.5	1.9	0.79	1.3	0.27	0.35
T4S031	D-275690	340430	1185015	7.45	0.41	0.41	< 0.01	< 0.01	7.3	0.81	2.2	2.1	1.1	3.0	0.04	0.25
T4S032	D-275659	340430	1185015	7.47	2.64	2.62	0.02	0.01	7.1	1.5	3.1	1.7	1.9	2.6	0.07	0.37
T4S041	D-275691	340408	1184957	7.15	3.99	3.99	< 0.01	0.02	6.6	1.0	2.5	2.5	0.93	2.0	0.03	0.28
T4S051	D-275676	340340	1184952	7.22	2.39	2.37	0.02	0.03	7.5	1.7	4.3	2.2	1.3	1.7	0.27	0.46

Appendix II. Elemental concentrations in soils from N-S traverses--Mav collection (continued).

Field#	Lab#	Lat	Long	Percent												
				pH	C, total	C, org	C, crbnt	S	Al	Ca	Fe	K	Mg	Na	P	Ti
T4S061	D-275670	340315	1184941	6.66	4.68	4.65	0.03	< 0.01	6.5	1.2	3.2	1.9	1.1	1.6	0.04	0.39
T4S062	D-275657	340315	1184941	6.47	6.80	6.80	< 0.01	< 0.01	6.4	1.3	3.3	1.7	1.1	1.6	0.05	0.38
T4S071	D-275654	340252	1184938	6.81	2.35	2.35	< 0.01	0.01	5.9	0.84	2.6	2.2	0.81	1.2	0.03	0.29
T4S081	D-275669	340415	1183915	7.76	3.72	1.87	1.85	0.01	6.7	6.6	6.0	0.51	3.8	0.85	0.06	0.64
T4S081X	D-275698	340228	1184927	7.92	3.81	1.94	1.87	0.01	6.5	6.5	6.2	0.53	3.9	0.81	0.04	0.62
T4S082	D-275713	340228	1184927	7.64	5.79	2.03	3.76	0.01	5.0	12	4.3	0.49	3.4	0.20	0.04	0.50
T5S021	D-275700	340800	1185858	6.84	1.53	1.53	< 0.01	0.02	7.1	0.77	5.2	1.3	1.2	1.4	0.03	0.55
T5S022	D-275664	340800	1185858	6.84	1.65	1.65	< 0.01	0.01	7.2	0.80	5.3	1.4	1.2	1.5	0.04	0.55
T5S031	D-275701	340705	1185935	6.82	2.63	2.63	< 0.01	0.02	7.1	0.95	6.3	1.2	2.1	0.92	0.05	0.51
T5S041	D-275652	340717	1185312	6.80	7.18	7.15	0.03	0.03	6.3	2.2	3.1	1.7	1.4	2.2	0.18	0.39
T5S042	D-275706	340717	1185948	7.00	4.93	4.89	0.04	0.02	6.4	2.1	3.4	1.6	1.4	2.0	0.16	0.40
T5S051	D-275703	340656	1190020	7.22	1.80	1.80	< 0.01	0.02	7.2	1.2	5.7	1.2	1.5	1.7	0.03	0.55
T5S051X	D-275650	340656	1190020	7.02	1.78	1.78	< 0.01	0.02	7.3	1.2	5.6	1.0	1.5	1.8	0.04	0.53
T5S061	D-275724	340628	1190038	6.79	2.69	2.69	< 0.01	0.02	6.7	1.1	4.9	1.7	1.6	1.7	0.07	0.43
T5S071	D-275681	340600	1190100	7.17	1.87	1.87	< 0.01	0.01	7.8	1.6	6.4	1.1	2.4	1.7	0.07	0.63
T5S072	D-275688	340600	1190100	7.08	5.48	5.44	0.04	0.01	7.2	1.8	6.0	1.5	2.1	1.5	0.10	0.58
T5S072X	D-275702	340600	1190100	7.12	5.40	5.36	0.04	0.03	7.0	1.8	6.1	1.7	2.2	1.5	0.08	0.55
T5S081	D-275728	340536	1190045	7.40	4.07	2.83	1.24	0.02	5.7	5.1	1.2	2.0	0.64	2.0	0.09	0.13
T5S091	D-275682	340512	1190040	7.47	2.84	1.82	1.02	< 0.01	6.6	6.3	5.9	0.82	3.1	1.4	0.06	0.50
T5S101	D-275715	340445	1190040	7.25	0.98	0.98	< 0.01	< 0.01	7.7	3.6	6.7	0.50	3.1	2.8	0.04	0.91
T5S101X	D-275666	340445	1190040	7.13	1.01	1.01	< 0.01	< 0.01	8.1	3.7	6.8	0.50	3.2	2.9	0.05	0.94

Appendix II. Elemental concentrations in soils from N-S traverses--May collection (continued).

	ppm																							
Field#	Mn	As	Ba	Be	Cd	Ce	Co	Cr	Cu	Ga	La	Li	Mo	Nb	Nd	Ni	Pb	Sc	Sr	Th	V	Y	Yb	Zn
T1S021	1100	< 10	750	< 1	< 2	40	23	120	68	20	19	44	2	4	19	40	23	22	290	6	160	27	3	120
T1S022	680	< 10	720	< 1	< 2	28	18	95	42	16	14	32	< 2	< 4	17	28	50	16	310	5	130	18	2	120
T1S031	800	10	590	< 1	< 2	33	23	120	20	17	15	31	< 2	< 4	19	37	29	20	230	7	160	22	3	90
T1S031X	830	< 10	600	< 1	< 2	34	24	130	21	16	16	32	< 2	4	18	38	28	21	230	7	170	23	2	90
T1S041	400	50	860	2	< 2	68	11	86	39	17	36	34	< 2	8	31	38	26	13	150	12	120	18	1	100
T1S042	500	40	870	2	< 2	72	13	87	37	17	38	39	< 2	9	32	40	39	13	180	12	120	15	1	110
T1S051	810	< 10	770	1	< 2	90	25	110	71	18	41	50	2	6	39	78	67	17	140	10	160	26	3	160
T2S011	440	< 10	980	1	< 2	40	5	56	8	12	22	17	2	< 4	17	21	21	6	170	7	59	14	1	40
T2S012	490	< 10	1100	1	< 2	45	6	69	10	13	24	19	2	< 4	18	25	19	7	190	7	69	16	2	50
T2S021	360	10	690	2	< 2	68	4	11	5	15	35	25	< 2	5	30	8	18	6	120	15	21	27	3	60
T2S022	460	< 10	650	2	< 2	78	6	12	5	17	45	39	< 2	5	48	6	20	7	150	15	27	43	4	70
T2S031	260	< 10	790	1	< 2	56	7	26	7	13	26	32	< 2	< 4	23	10	13	8	120	11	44	17	2	40
T2S041	720	< 10	810	1	< 2	86	16	55	34	18	45	41	< 2	8	34	31	25	11	310	14	91	21	2	80
T2S051	480	20	940	2	< 2	83	15	120	16	22	47	75	< 2	9	37	55	24	13	240	17	120	24	2	90
T2S061	700	< 10	900	2	< 2	72	17	57	31	22	37	49	< 2	8	32	26	31	10	280	13	110	20	2	110
T2S071	500	< 10	870	2	< 2	71	16	43	42	20	38	32	< 2	9	37	21	45	9	340	13	86	31	3	90
T2S081	640	< 10	580	1	< 2	71	22	100	42	19	35	35	< 2	6	34	54	28	13	220	11	130	24	2	90
T2S081X	790	< 10	670	2	< 2	75	25	100	46	21	39	41	< 2	8	33	71	32	15	260	12	140	27	3	110
T2S082	690	10	600	1	< 2	75	22	100	42	18	38	37	< 2	8	36	52	29	14	220	12	150	28	3	90
T2S091	450	< 10	930	1	< 2	61	10	27	14	12	31	16	< 2	< 4	25	11	22	6	200	7	54	13	1	60
T2S101	500	20	770	2	< 2	66	13	80	14	19	34	66	< 2	7	28	38	19	11	150	13	93	18	2	80
T2S101X	490	20	770	2	< 2	64	12	80	15	19	33	66	< 2	7	27	38	19	11	150	13	93	16	2	80
T2S102	460	10	740	2	< 2	60	12	78	15	17	31	55	< 2	7	28	32	33	10	160	12	89	16	2	80
T3S011	1000	< 10	200	< 1	< 2	16	28	49	35	21	6	12	< 2	< 4	12	26	12	20	250	< 4	170	27	3	110
T3S021	290	< 10	1100	1	< 2	54	4	20	5	14	31	17	< 2	< 4	22	7	16	5	220	9	35	14	1	30
T3S022	370	10	980	1	< 2	67	7	26	7	16	38	18	< 2	6	29	11	21	7	210	11	52	19	2	40
T3S031	690	< 10	750	2	< 2	71	14	49	20	18	36	19	< 2	6	31	22	18	10	210	12	81	23	2	70
T3S041	400	< 10	1200	1	< 2	43	8	24	11	14	27	14	< 2	5	17	14	16	5	260	7	46	11	1	30
T3S042	340	< 10	1500	1	< 2	41	6	23	4	15	22	15	< 2	< 4	15	12	22	4	300	8	51	8	< 1	30
T3S051	1000	< 10	190	< 1	< 2	10	45	460	24	18	5	14	< 2	< 4	9	140	6	19	240	< 4	130	12	2	90
T3S061	380	10	1100	1	< 2	49	6	25	9	14	25	13	< 2	5	19	16	27	5	270	6	39	15	1	40
T3S062	400	< 10	990	1	2	54	8	38	12	13	28	16	2	6	23	18	25	6	260	7	50	17	2	50
T3S062X	400	< 10	960	1	< 2	54	8	38	11	14	28	15	2	6	22	17	23	6	260	6	49	17	2	50
T3S071	260	< 10	1300	1	< 2	52	4	14	5	14	28	13	< 2	4	19	8	20	3	340	9	31	9	< 1	30
T3S072	390	< 10	1300	1	< 2	60	6	17	6	13	32	13	< 2	< 4	23	7	23	4	310	10	31	12	1	30
T3S081	480	< 10	900	1	< 2	62	12	34	24	15	34	25	< 2	7	27	17	26	7	240	10	66	16	2	60
T3S091	490	< 10	870	1	< 2	85	9	20	13	13	45	15	< 2	7	33	11	40	7	260	14	57	21	2	50
T4S011	790	< 10	250	< 1	< 2	16	26	140	34	17	9	15	< 2	< 4	11	87	7	14	310	< 4	110	13	2	60
T4S021	690	10	600	1	8	45	13	110	21	15	24	19	10	5	21	47	15	9	180	9	100	17	2	110
T4S031	420	< 10	880	1	< 2	59	9	54	8	15	32	17	< 2	< 4	24	32	14	7	370	7	51	18	2	30
T4S032	490	< 10	650	1	< 2	49	18	130	24	15	26	18	< 2	< 4	22	77	15	10	300	5	75	16	2	50
T4S041	470	< 10	1400	1	< 2	59	12	58	19	14	31	18	< 2	< 4	21	54	26	6	330	11	54	12	1	30
T4S051	600	10	630	1	5	68	17	120	24	18	36	29	8	7	30	54	17	13	200	10	110	25	2	130

Appendix II. Elemental concentrations in soils from N-S traverses--May collection (continued).

	PPM																							
Field#	Mn	As	Ba	Be	Cd	Ce	Co	Cr	Cu	Ga	La	Li	Mo	Nb	Nd	Ni	Pb	Sc	Sr	Th	V	Y	Yb	Zn
T4S061	550	< 10	780	< 1	< 2	46	18	120	23	14	25	17	< 2	< 4	21	57	19	10	200	8	76	15	2	40
T4S062	620	< 10	770	< 1	< 2	44	18	120	24	14	24	18	< 2	< 4	20	60	21	9	210	6	77	15	1	50
T4SC71	870	< 10	800	1	< 2	62	12	57	18	13	31	20	< 2	6	24	30	20	6	200	8	57	16	2	40
T4S081	690	< 10	210	< 1	< 2	9	41	240	42	14	6	11	< 2	< 4	9	170	6	20	170	< 4	130	13	2	60
T4S081X	760	< 10	220	< 1	< 2	13	40	220	43	15	6	12	< 2	< 4	8	190	< 4	21	180	< 4	140	14	2	60
T4S082	530	< 10	190	< 1	< 2	7	28	170	33	11	4	7	< 2	< 4	5	130	< 4	16	120	< 4	110	9	1	40
T5S021	740	< 10	570	1	< 2	43	27	150	38	18	22	37	4	4	19	100	10	15	170	6	140	20	2	70
T5S022	780	< 10	580	1	< 2	43	30	170	41	16	22	35	3	< 4	21	93	12	15	160	7	130	19	2	80
T5S031	1200	< 10	620	1	2	45	37	290	70	19	25	46	7	5	22	200	13	20	140	6	190	23	2	100
T5S041	570	< 10	580	< 1	2	39	19	130	19	14	21	20	< 2	5	20	57	27	10	290	4	79	17	2	70
T5S042	680	< 10	590	1	< 2	43	19	120	21	14	24	23	< 2	5	20	72	19	12	300	6	79	20	2	70
T5S051	910	< 10	470	< 1	3	39	26	170	39	18	20	27	6	< 4	18	88	9	20	170	7	160	22	2	90
T5S051X	850	< 10	450	< 1	4	38	27	200	39	18	19	26	5	< 4	19	76	11	20	170	6	150	23	2	90
T5S061	950	10	670	1	3	55	27	180	48	18	32	39	5	6	27	130	14	15	190	8	140	25	2	90
T5S071	1100	< 10	400	< 1	2	35	37	200	52	19	17	48	3	6	20	110	9	21	190	5	170	21	2	80
T5S072	1200	< 10	460	1	2	41	33	200	56	18	20	44	2	< 4	21	95	17	21	160	8	170	22	2	100
T5S072X	1300	< 10	480	1	< 2	43	32	180	55	19	20	45	3	5	18	110	15	22	160	7	160	23	2	110
T5S081	220	< 10	730	< 1	< 2	35	5	31	6	11	20	9	< 2	< 4	14	14	15	4	290	< 4	31	11	< 1	20
T5S091	1000	< 10	330	< 1	3	29	40	320	60	16	16	28	< 2	< 4	17	190	9	21	180	< 4	130	22	2	80
T5S101	1200	< 10	200	< 1	< 2	21	39	250	41	17	10	18	< 2	5	12	130	< 4	29	290	< 4	180	20	2	80
T5S101X	1200	< 10	200	< 1	< 2	19	41	270	44	18	9	17	< 2	< 4	13	110	6	28	280	< 4	190	19	2	80

Appendix III. Elemental concentrations in *R. laurina* from N-S traverses--May collection.

				%, Dry weight		%, Ash weight							
Field #	Lab #	Lat	Long	Ash	S	Al	Ca	Fe	K	Mg	Na	P	Ti
T1R02111	D-276681	340708	1182430	3.55	0.15	0.29	15	0.28	29	3.1	0.24	5.3	0.02
T1R02211	D-276824	340708	1182430	3.46	0.14	0.33	17	0.32	28	3.0	0.28	5.3	0.02
T1R03111	D-276720	340641	1182447	4.53	0.13	0.26	9.8	0.25	38	3.1	0.23	4.1	0.02
T1R03211	D-276823	340641	1182447	3.53	0.15	0.33	12	0.32	32	5.0	0.26	5.8	0.02
T1R04111	D-276652	340615	1182440	3.29	0.12	0.30	9.8	0.31	35	4.4	0.19	5.3	0.02
T1R04121	D-276680	340615	1182440	3.00	0.11	0.26	12	0.26	33	4.8	0.19	4.8	0.02
T1R05111	D-276738	340549	1182434	3.94	0.15	0.21	8.1	0.22	37	4.3	0.17	6.6	0.02
T1R05121	D-276679	340549	1182434	4.10	0.16	0.26	8.1	0.27	37	4.9	0.21	7.3	0.02
T2R01111	D-276731	340732	1183322	4.03	0.17	0.18	14	0.18	30	3.7	0.19	5.8	0.01
T2R01121	D-276735	340732	1183322	4.46	0.16	0.16	14	0.15	35	3.0	0.13	4.7	0.01
T2R01211	D-276645	340732	1183322	4.00	0.15	0.28	12	0.23	35	3.4	0.19	4.9	0.01
T2R02111	D-276674	340712	1183317	3.04	0.15	0.24	15	0.24	27	3.9	0.40	5.4	0.01
T2R02121	D-276756	340712	1183317	2.95	0.15	0.26	17	0.25	25	3.9	0.36	4.9	0.02
T2R03111	D-276661	340640	1183317	3.47	0.16	0.22	13	0.23	30	4.0	0.47	3.9	0.01
T2R04111	D-276747	340615	1183318	4.00	0.16	0.27	8.6	0.24	37	2.5	0.21	5.4	0.02
T2R04121	D-276670	340615	1183318	4.22	0.17	0.28	8.6	0.26	38	2.5	0.22	5.2	0.02
T2R04211	D-276754	340615	1183318	4.62	0.15	0.16	11	0.18	37	2.7	0.18	4.9	0.01
T2R05111	D-276732	340553	1183300	3.83	0.16	0.17	16	0.19	29	3.4	0.20	5.9	0.01
T2R06111	D-276664	340522	1183258	4.15	0.15	0.30	9.3	0.23	37	2.2	0.29	6.1	0.02
T2R06211	D-276734	340522	1183258	3.72	0.13	0.23	9.6	0.20	37	2.9	0.21	5.7	0.02
T2R07111	D-276676	340503	1183246	4.23	0.19	0.25	9.9	0.23	36	3.0	0.35	6.9	0.02
T2R08111	D-276648	340435	1183237	4.90	0.15	0.24	11	0.22	39	1.8	0.41	3.1	0.01
T2R08112	D-276717	340435	1183237	4.71	0.14	0.22	11	0.21	37	1.7	0.39	3.2	0.02
T2R09111	D-276733	340407	1183230	3.39	0.16	0.22	9.7	0.23	36	3.8	0.24	6.0	0.02
T2R09121	D-276740	340407	1183230	3.56	0.16	0.25	10	0.25	36	3.9	0.33	5.5	0.02
T2R09211	D-276750	340407	1183230	4.40	0.16	0.16	12	0.21	31	3.8	0.17	5.7	0.01
T2R10111	D-276719	340350	1183215	3.91	0.14	0.17	11	0.18	35	4.0	0.15	5.2	0.01
T2R10121	D-276741	340350	1183215	3.37	0.14	0.24	14	0.21	32	4.4	0.26	4.7	0.02
T2R10122	D-276656	340350	1183215	3.78	0.13	0.25	14	0.20	32	4.5	0.26	4.4	0.01
T3R01111	D-276663	340635	1183946	2.93	0.14	0.30	17	0.34	23	5.1	0.31	6.3	0.02
T3R01121	D-276667	340635	1183946	3.08	0.14	0.30	16	0.36	25	5.0	0.35	5.6	0.02
T3R02111	D-276746	340610	1183900	4.34	0.15	0.24	14	0.23	34	3.8	0.19	4.8	0.02
T3R02211	D-276666	340610	1183900	3.78	0.14	0.19	13	0.18	33	3.6	0.18	4.2	0.01
T3R03111	D-276722	340552	1183833	4.64	0.21	0.15	9.8	0.17	39	2.5	0.17	6.5	0.01
T3R03121	D-276644	340552	1183833	3.95	0.17	0.16	15	0.15	32	2.3	0.18	3.6	0.01
T3R04111	D-276718	340533	1183814	3.88	0.15	0.31	13	0.25	33	3.3	0.53	5.5	0.02
T3R04112	D-276742	340533	1183814	4.07	0.15	0.29	13	0.24	33	3.3	0.52	5.4	0.02
T3R04121	D-276669	340533	1183814	4.13	0.15	0.25	14	0.21	30	3.7	0.34	4.5	0.01
T3R04211	D-276752	340533	1183814	4.08	0.15	0.21	10	0.21	35	2.7	0.31	6.6	0.01
T3R05111	D-276671	340506	1183817	3.64	0.15	0.33	16	0.35	25	5.8	0.50	6.3	0.02
T3R05112	D-276653	340506	1183817	3.58	0.15	0.34	16	0.34	25	5.8	0.50	6.4	0.02
T3R06111	D-276659	340415	1183915	4.00	0.15	0.35	9.7	0.28	38	2.9	0.30	6.0	0.01
T3R07111	D-276725	340405	1183907	4.22	0.13	0.20	13	0.20	34	2.6	0.40	6.4	0.01

Appendix III. Elemental concentrations in *R. laurina* from N-S traverses--May collection (continued).

				%, Dry weight		%, Ash weight							
Field #	Lab #	Lat	Long	Ash	S	Al	Ca	Fe	K	Mg	Na	P	Ti
T3R07211	D-276728	340405	1183907	4.31	0.14	0.22	10	0.21	36	2.2	0.54	6.7	0.02
T3R08111	D-276646	340334	1183855	3.23	0.11	0.19	8.6	0.20	37	3.9	0.23	5.1	0.01
T3R08121	D-276828	340334	1183855	3.35	0.13	0.24	10	0.27	36	3.8	0.34	5.7	0.01
T3R08211	D-276743	340334	1183855	3.32	0.14	0.13	12	0.17	35	4.3	0.19	6.4	0.01
T3R09111	D-276721	340312	1183855	3.53	0.17	0.31	12	0.28	34	2.8	0.65	5.9	0.02
T4R01111	D-276726	340520	1185016	2.49	0.14	0.33	18	0.32	19	7.8	0.82	4.3	0.03
T4R01211	D-276678	340220	1185016	3.47	0.13	0.17	12	0.24	34	3.8	0.24	5.1	0.01
T4R02111	D-276730	340500	1185018	4.09	0.15	0.14	15	0.15	31	3.4	0.14	7.3	0.01
T4R02121	D-276673	340500	1185018	3.94	0.15	0.14	15	0.14	30	3.3	0.17	7.2	0.01
T4R02211	D-276744	340500	1185018	4.05	0.17	0.20	15	0.19	31	2.8	0.31	7.3	0.01
T4R03111	D-276650	340430	1185015	4.00	0.16	0.21	15	0.22	25	5.0	0.38	6.6	0.01
T4R03211	D-276672	340430	1185015	4.51	0.16	0.18	14	0.21	28	4.6	0.41	6.8	0.01
T4R04111	D-276665	340408	1184957	3.82	0.15	0.15	7.5	0.17	36	3.2	0.40	5.2	0.01
T4R04121	D-276827	340408	1184957	3.57	0.15	0.11	12	0.15	35	3.8	0.18	6.2	0.01
T4R05111	D-276737	340340	1184952	4.27	0.16	0.14	12	0.19	35	3.7	0.37	6.3	0.01
T4R05211	D-276662	340340	1184952	4.31	0.15	0.14	14	0.19	31	3.8	0.40	5.9	0.01
T4R06111	D-276682	340315	1184941	3.64	0.16	0.48	11	0.33	33	3.3	0.78	4.8	0.03
T4R06112	D-276736	340315	1184941	3.61	0.16	0.53	12	0.36	34	3.3	0.80	5.2	0.04
T4R07111	D-276654	340252	1184938	3.65	0.12	0.32	9.1	0.28	36	3.3	0.88	3.5	0.02
T4R07121	D-276649	340252	1184938	3.95	0.13	0.28	8.1	0.26	38	3.0	0.87	3.8	0.01
T4R08111	D-276749	340228	1184927	4.03	0.15	0.50	13	0.41	29	4.1	5.2	3.0	0.04
T4R08121	D-276748	330228	1184927	3.16	0.13	0.33	11	0.32	33	4.2	1.5	4.6	0.03
T4R08122	D-276727	340228	1184927	3.14	0.13	0.32	11	0.32	34	4.4	1.5	4.7	0.02
T5R02111	D-276651	340800	1185858	4.28	0.18	0.21	11	0.20	37	3.2	0.37	4.6	0.01
T5R02121	D-276822	340800	1185858	4.96	0.19	0.18	14	0.17	32	3.3	0.21	4.2	0.01
T5R03111	D-276739	340705	1185935	4.19	0.14	0.28	11	0.24	38	2.1	0.47	6.5	0.02
T5R03211	D-276826	340705	1185935	3.32	0.11	0.37	11	0.30	34	3.0	1.1	5.1	0.02
T5R03212	D-276657	340705	1185935	3.35	0.11	0.38	11	0.29	34	3.1	1.1	4.8	0.02
T5R04111	D-276658	340717	1185948	3.81	0.13	0.27	10	0.22	35	2.8	0.45	4.4	0.01
T5R04112	D-276755	340717	1185948	3.74	0.15	0.25	11	0.21	36	2.8	0.44	4.7	0.02
T5R05111	D-276647	340656	1190020	3.90	0.18	0.29	12	0.25	33	3.8	1.3	6.3	0.01
T5R05121	D-276729	340656	1190020	4.20	0.21	0.20	13	0.22	32	4.3	0.45	8.1	0.01
T5R06111	D-276745	340628	1190038	4.37	0.17	0.28	9.2	0.22	36	3.2	0.44	8.0	0.01
T5R06211	D-276825	340628	1190038	4.18	0.17	0.29	11	0.23	35	3.2	0.48	7.3	0.02
T5R07111	D-276643	340600	1190100	4.35	0.18	0.23	12	0.17	29	4.2	0.39	6.7	0.01
T5R07211	D-276675	340600	1190100	3.84	0.17	0.27	10	0.22	32	4.6	0.47	7.1	0.01
T5R08111	D-276668	340536	1190045	4.05	0.15	0.22	9.2	0.20	36	2.5	0.87	6.2	0.01
T5R08121	D-276655	340536	1190045	4.26	0.14	0.29	9.9	0.22	34	2.3	1.6	5.5	0.01
T5R08211	D-276660	340536	1190045	3.44	0.13	0.24	11	0.20	34	3.5	1.0	4.9	0.01
T5R09111	D-276753	340512	1190040	4.34	0.13	0.12	9.3	0.12	39	1.7	0.49	6.8	0.01
T5R09112	D-276677	340512	1190040	4.47	0.13	0.12	9.1	0.12	40	1.7	0.50	6.5	0.01
T5R09121	D-276724	340512	1190040	4.41	0.14	0.14	9.0	0.13	39	1.5	0.37	6.5	0.01
T5R09211	D-276751	340512	1190040	4.03	0.16	0.11	11	0.19	33	3.5	0.35	8.2	0.01
T5R10111	D-276723	340445	1190040	3.87	0.15	0.21	18	0.22	25	4.8	1.3	5.5	0.01

Appendix III. Elemental concentrations in *R. laurina* from N-S traverses--May collection (continued).

	ppm, Ash weight																	
Field #	Mn	Ba	Cd	Ce	Co	Cr	Cu	La	Li	Mo	Nd	Ni	Pb	Sc	Sr	V	Y	Zn
T1R0211	1600	430	< 4	< 8	4	9	210	< 4	< 4	< 4	< 8	69	30	< 4	310	5	< 4	1000
T1R0221	1600	360	< 4	< 8	4	18	210	< 4	< 4	< 4	< 8	74	32	< 4	310	6	< 4	780
T1R0311	1700	350	< 4	9	5	9	160	< 4	7	< 4	< 8	50	33	< 4	170	6	< 4	760
T1R0321	2000	370	< 4	< 8	5	20	180	< 4	6	< 4	< 8	60	28	< 4	150	7	< 4	660
T1R0411	1100	400	12	< 8	4	13	150	< 4	8	< 4	< 8	53	22	< 4	480	5	< 4	590
T1R0412	1300	550	< 4	< 8	4	9	130	< 4	8	< 4	< 8	54	21	< 4	620	5	< 4	650
T1R0511	1500	140	< 4	< 8	4	9	160	< 4	< 4	< 4	< 8	60	21	< 4	420	< 4	< 4	890
T1R0512	1600	160	< 4	< 8	5	11	170	< 4	4	< 4	< 8	49	24	< 4	440	5	< 4	990
T2R0111	1100	92	< 4	9	3	10	100	< 4	4	6	< 8	40	11	< 4	120	< 4	< 4	580
T2R0112	910	81	< 4	< 8	2	6	110	< 4	< 4	5	< 8	37	9	< 4	110	< 4	< 4	490
T2R0121	940	85	< 4	< 8	3	7	110	< 4	4	4	< 8	18	8	< 4	100	5	< 4	650
T2R0211	3900	140	< 4	13	5	9	160	13	120	< 4	< 8	79	18	< 4	380	5	12	730
T2R0212	3300	150	< 4	13	4	10	160	32	73	< 4	13	53	23	< 4	460	5	36	620
T2R0311	3800	130	< 4	31	6	6	200	23	280	< 4	10	91	21	< 4	170	< 4	19	800
T2R0411	950	110	< 4	< 8	2	11	110	< 4	14	< 4	< 8	25	10	< 4	190	4	< 4	480
T2R0412	890	99	< 4	< 8	3	13	120	< 4	15	< 4	< 8	26	11	< 4	180	5	< 4	460
T2R0421	920	90	< 4	< 8	3	10	110	< 4	8	< 4	< 8	30	8	< 4	250	< 4	< 4	350
T2R0511	2300	130	< 4	< 8	3	10	190	4	< 4	< 4	< 8	70	14	< 4	310	4	< 4	610
T2R0611	1300	130	< 4	< 8	3	9	110	< 4	8	< 4	< 8	33	15	< 4	170	4	< 4	550
T2R0621	660	110	< 4	< 8	3	12	110	< 4	15	< 4	< 8	40	12	< 4	130	4	< 4	490
T2R0711	940	86	< 4	< 8	3	11	190	< 4	5	< 4	< 8	34	15	< 4	250	4	< 4	620
T2R0811	710	59	< 4	9	4	9	94	< 4	< 4	4	< 8	49	24	< 4	120	5	< 4	600
T2R0811	710	53	< 4	< 8	3	9	94	6	< 4	4	< 8	53	22	< 4	120	4	< 4	570
T2R0911	1000	69	< 4	< 8	3	10	230	< 4	6	< 4	< 8	62	13	< 4	120	4	< 4	720
T2R0912	1300	78	< 4	< 8	4	9	180	< 4	10	< 4	< 8	64	13	< 4	120	5	< 4	700
T2R0921	2500	220	< 4	< 8	6	5	200	5	9	< 4	< 8	89	< 8	< 4	340	< 4	< 4	570
T2R1011	1800	360	< 4	< 8	3	8	110	< 4	7	< 4	< 8	93	< 8	< 4	160	< 4	< 4	470
T2R1012	2500	460	< 4	< 8	3	7	110	< 4	13	< 4	< 8	120	10	< 4	240	< 4	< 4	510
T2R1012	2500	470	< 4	< 8	4	5	110	< 4	13	< 4	< 8	110	11	< 4	230	< 4	< 4	500
T3R0111	1100	52	< 4	< 8	4	13	240	< 4	< 4	< 4	< 8	68	15	< 4	180	6	< 4	740
T3R0112	950	49	< 4	< 8	5	8	230	< 4	4	< 4	< 8	71	15	< 4	150	7	< 4	790
T3R0211	570	67	< 4	< 8	3	13	120	< 4	< 4	8	< 8	56	10	< 4	270	5	< 4	680
T3R0221	650	72	< 4	10	3	9	83	< 4	< 4	19	< 8	29	10	< 4	420	< 4	< 4	400
T3R0311	1400	270	< 4	< 8	< 2	8	230	< 4	< 4	6	< 8	23	< 8	< 4	140	< 4	< 4	650
T3R0312	1400	520	< 4	< 8	3	7	120	< 4	< 4	6	< 8	27	12	< 4	160	< 4	< 4	490
T3R0411	2500	370	< 4	9	4	10	100	6	12	< 4	< 8	49	18	< 4	600	5	< 4	410
T3R0411	2400	380	< 4	11	4	11	99	5	12	< 4	< 8	47	17	< 4	620	6	4	400
T3R0412	2600	380	< 4	< 8	5	6	89	10	14	< 4	< 8	47	12	< 4	690	4	6	390
T3R0421	2000	180	< 4	9	5	9	190	4	9	< 4	< 8	52	11	< 4	210	4	< 4	580
T3R0511	790	49	6	< 8	4	21	170	< 4	< 4	< 4	< 8	130	11	< 4	260	5	< 4	570
T3R0511	810	51	5	< 8	4	19	170	< 4	< 4	< 4	< 8	130	13	< 4	250	6	< 4	590
T3R0611	1200	71	9	< 8	3	8	75	< 4	< 4	< 4	< 8	59	< 8	< 4	150	5	< 4	610
T3R0711	1900	150	< 4	10	3	7	110	5	10	< 4	< 8	68	12	< 4	180	< 4	< 4	450

Appendix III. Elemental concentrations in *R. laurina* from N-S traverses--May collection (continued).

	ppm, Ash weight																	
Field #	Mn	Ba	Cd	Ce	Co	Cr	Cu	La	Li	Mo	Nd	Ni	Pb	Sc	Sr	V	Y	Zn
T3R0721	1700	100	< 4	< 8	3	11	120	< 4	6	< 4	< 8	74	15	< 4	100	< 4	< 4	410
T3R0811	1500	200	< 4	8	6	6	150	7	< 4	< 4	< 8	52	9	< 4	350	< 4	< 4	510
T3R0812	1900	210	< 4	18	6	17	150	9	4	< 4	< 8	60	15	< 4	380	5	< 4	540
T3R0821	1300	180	< 4	< 8	2	6	120	< 4	4	< 4	< 8	33	< 8	< 4	350	< 4	< 4	500
T3R0911	1500	47	< 4	< 8	3	14	120	< 4	< 4	< 4	< 8	48	18	< 4	64	6	< 4	660
T4R0111	1000	58	< 4	< 8	3	14	100	< 4	4	4	< 8	49	26	< 4	310	7	< 4	450
T4R0121	1400	32	< 4	< 8	3	9	150	< 4	< 4	< 4	< 8	29	< 8	< 4	180	< 4	< 4	660
T4R0211	690	35	17	< 8	3	8	140	< 4	< 4	17	< 8	41	< 8	< 4	170	< 4	< 4	540
T4R0212	700	44	20	< 8	3	8	120	< 4	< 4	19	< 8	46	< 8	< 4	210	< 4	< 4	550
T4R0221	700	65	34	< 8	3	10	120	< 4	< 4	13	< 8	63	< 8	< 4	240	< 4	< 4	580
T4R0311	2500	50	4	< 8	5	9	110	< 4	9	12	< 8	110	< 8	< 4	140	< 4	< 4	570
T4R0321	1300	80	8	< 8	3	8	89	5	7	14	< 8	36	8	< 4	270	< 4	5	420
T4R0411	610	57	< 4	< 8	3	8	160	< 4	4	< 4	< 8	82	< 8	< 4	140	< 4	< 4	550
T4R0412	870	78	< 4	< 8	3	13	140	< 4	7	< 4	< 8	110	< 8	< 4	220	< 4	4	530
T4R0511	730	52	12	< 8	2	6	140	< 4	8	10	< 8	37	< 8	< 4	140	< 4	< 4	530
T4R0521	780	90	29	< 8	3	8	70	< 4	8	10	< 8	37	< 8	< 4	220	< 4	< 4	580
T4R0611	1300	110	< 4	8	4	11	160	4	< 4	< 4	< 8	69	13	< 4	130	7	4	540
T4R0611	1400	110	< 4	11	4	13	160	4	5	< 4	< 8	78	15	< 4	140	9	5	550
T4R0711	1200	72	< 4	< 8	3	11	160	< 4	6	< 4	< 8	47	14	< 4	170	5	< 4	450
T4R0712	1000	58	< 4	< 8	3	12	170	< 4	7	< 4	< 8	41	11	< 4	160	5	< 4	430
T4R0811	760	270	< 4	< 8	4	12	140	< 4	5	9	< 8	53	33	< 4	290	11	< 4	460
T4R0812	1200	170	< 4	< 8	4	14	180	< 4	< 4	8	< 8	67	14	< 4	150	8	< 4	590
T4R0812	1300	170	< 4	< 8	4	13	190	< 4	< 4	8	< 8	69	11	< 4	150	6	< 4	620
T5R0211	760	110	9	< 8	3	8	170	< 4	< 4	< 4	< 8	57	< 8	< 4	250	< 4	< 4	410
T5R0212	1000	77	17	< 8	3	12	130	< 4	< 4	< 4	< 8	44	< 8	< 4	300	< 4	< 4	320
T5R0311	560	43	< 4	< 8	3	12	160	< 4	< 4	< 4	< 8	28	10	< 4	110	5	< 4	440
T5R0321	710	100	6	< 8	4	18	140	< 4	< 4	4	< 8	81	8	< 4	220	7	< 4	410
T5R0321	680	100	6	< 8	4	14	130	< 4	< 4	4	< 8	76	11	< 4	210	7	< 4	420
T5R0411	570	98	8	< 8	3	12	160	< 4	< 4	< 4	< 8	130	< 8	< 4	210	5	< 4	450
T5R0411	590	93	8	< 8	2	9	160	< 4	< 4	< 4	< 8	140	< 8	< 4	210	4	< 4	450
T5R0511	720	80	21	< 8	5	12	170	< 4	< 4	6	< 8	59	< 8	< 4	150	6	< 4	560
T5R0512	780	65	13	< 8	5	9	210	< 4	< 4	9	< 8	63	9	< 4	150	< 4	< 4	740
T5R0611	440	51	5	< 8	3	17	140	< 4	< 4	6	< 8	95	< 8	< 4	160	6	< 4	420
T5R0621	490	61	10	< 8	3	18	150	< 4	< 4	6	< 8	74	< 8	< 4	200	6	< 4	530
T5R0711	470	38	< 4	< 8	3	9	130	< 4	< 4	5	< 8	17	< 8	< 4	110	< 4	< 4	390
T5R0721	640	58	< 4	< 8	3	13	150	< 4	< 4	4	< 8	41	9	< 4	130	< 4	< 4	410
T5R0811	380	54	< 4	9	4	11	130	< 4	< 4	< 4	< 8	29	9	< 4	96	4	< 4	370
T5R0812	380	70	< 4	< 8	4	12	120	< 4	< 4	< 4	< 8	25	11	< 4	110	5	< 4	330
T5R0821	590	56	< 4	< 8	3	9	97	< 4	< 4	< 4	< 8	22	< 8	< 4	100	5	< 4	330
T5R0911	340	30	< 4	< 8	< 2	8	100	< 4	< 4	< 4	< 8	11	< 8	< 4	110	< 4	< 4	400
T5R0911	330	31	< 4	< 8	2	8	100	< 4	< 4	< 4	< 8	11	< 8	< 4	120	< 4	< 4	400
T5R0912	310	30	< 4	11	3	9	110	< 4	< 4	< 4	< 8	10	< 8	< 4	110	< 4	< 4	390
T5R0921	510	32	< 4	< 8	2	8	150	< 4	< 4	< 4	< 8	27	< 8	< 4	220	< 4	< 4	400
T5R1011	970	42	< 4	< 8	3	9	140	< 4	< 4	5	< 8	49	< 8	< 4	280	4	< 4	510

Appendix IV. Elemental concentrations in *R. laurina* from N-S traverses--December collection.

				%, Dry weight		%, Ash weight							
Field #	Lab #	Lat	Long	Ash	S	Al	Ca	Fe	K	Mg	Na	P	Ti
D1R02111	D-280606	340708	1182430	3.83	0.10	0.26	28	0.24	15	4.2	0.28	2.0	0.02
D1R02211	D-280610	340708	1182430	4.00	0.09	0.27	28	0.25	14	4.0	0.29	2.1	0.02
D1R03111	D-280573	340641	1182447	3.79	0.09	0.43	19	0.39	20	5.3	0.36	2.2	0.03
D1R03211	D-280574	340641	1182447	3.86	0.09	0.27	24	0.27	16	6.1	0.27	2.5	0.02
D1R04111	D-280577	340615	1182440	3.27	0.07	0.41	21	0.33	16	9.4	0.17	3.0	0.02
D1R04121	D-280567	340615	1182440	2.94	0.08	0.34	20	0.30	24	6.7	0.17	3.1	0.02
D1R05111	D-280588	340549	1182434	3.81	0.07	0.19	19	0.17	18	11	0.16	4.9	0.01
D1R05121	D-280620	340549	1182434	4.13	0.08	0.27	21	0.25	16	11	0.19	4.1	0.02
D2R01111	D-280558	340732	1183322	4.19	0.09	0.28	24	0.22	17	5.5	0.16	2.3	0.02
D2R01121	D-280563	340732	1183322	3.83	0.08	0.20	24	0.18	18	5.8	0.15	2.2	0.01
D2R01211	D-280562	340732	1183322	3.68	0.10	0.33	26	0.24	13	6.5	0.17	2.3	0.02
D2R02111	D-280616	340712	1183317	3.27	0.07	0.18	24	0.14	18	5.0	0.24	2.2	< 0.01
D2R02121	D-280560	340712	1183317	3.52	0.10	0.17	24	0.15	15	5.5	0.23	2.2	< 0.01
D2R03111	D-280549	340640	1183317	3.07	0.09	0.30	21	0.25	19	6.3	0.38	2.7	0.01
D2R04111	D-280589	340615	1183318	2.88	0.08	0.23	20	0.20	26	4.7	0.17	3.0	0.01
D2R04121	D-280617	340615	1183318	2.72	0.09	0.24	18	0.22	27	4.3	0.22	3.2	0.02
D2R04211	D-280581	340615	1183318	3.38	0.09	0.22	21	0.21	18	4.7	0.15	2.9	0.01
D2R05111	D-280568	340553	1183300	4.65	0.09	0.14	28	0.13	11	6.8	0.10	2.1	< 0.01
D2R06111	D-280596	340522	1183258	3.58	0.09	0.16	24	0.15	19	5.6	0.10	2.4	0.01
D2R06211	D-280609	340522	1183258	3.22	0.08	0.30	23	0.23	11	3.2	0.19	3.2	0.02
D2R07111	D-280590	340503	1183246	3.20	0.10	0.22	22	0.20	19	6.0	0.31	4.0	0.01
D2R08111	D-280550	340435	1183237	4.15	0.10	0.14	22	0.15	25	3.7	0.34	2.2	< 0.01
D2R08112	D-280611	340435	1183237	4.18	0.08	0.12	22	0.15	26	3.3	0.28	2.1	< 0.01
D2R09111	D-280619	340407	1183230	4.41	0.08	0.19	28	0.17	12	7.4	0.17	2.2	0.01
D2R09121	D-280626	340407	1183230	4.93	0.09	0.20	28	0.21	12	8.0	0.24	2.1	0.01
D2R09211	D-280600	340407	1183230	4.57	0.07	0.12	27	0.14	15	5.9	0.18	1.8	< 0.01
D2R10111	D-280585	340350	1183215	4.77	0.09	0.17	27	0.13	17	4.0	0.10	3.1	0.01
D2R10121	D-280591	340350	1183215	4.53	0.11	0.24	26	0.21	14	6.3	0.38	2.3	0.02
D2R10122	D-280605	340350	1183215	4.51	0.11	0.23	26	0.19	15	6.2	0.37	2.2	0.01
D3R01111	D-280548	340635	1183946	3.67	0.09	0.23	31	0.23	5.6	7.2	0.23	2.2	0.02
D3R01121	D-280571	340635	1183946	3.88	0.09	0.18	31	0.19	6.9	7.3	0.20	2.3	0.01
D3R02111	D-280545	340610	1183900	4.10	0.10	0.32	25	0.24	15	6.0	0.23	2.1	0.02
D3R02211	D-280612	340610	1183900	4.56	0.09	0.24	29	0.21	10	6.4	0.14	1.8	0.02
D3R03111	D-280563	340552	1183833	3.64	0.08	0.20	24	0.17	18	3.7	0.12	1.7	0.01
D3R03121	D-280554	340552	1183833	3.63	0.09	0.17	23	0.15	19	3.6	0.11	1.8	0.01
D3R04111	D-280564	340533	1183814	4.30	0.10	0.26	24	0.23	15	6.1	0.23	2.9	0.01
D3R04112	D-280543	340533	1183814	4.20	0.11	0.28	24	0.25	15	6.2	0.23	2.9	0.02
D3R04121	D-280575	340533	1183814	3.92	0.11	0.29	24	0.27	15	4.6	0.23	2.7	0.02
D3R04211	D-280594	340533	1183814	4.04	0.09	0.22	24	0.20	19	4.5	0.26	2.8	0.01
D3R05111	D-280621	340506	1183817	3.17	0.10	0.23	28	0.25	12	7.3	0.20	2.8	0.02
D3R05112	D-280556	340506	1183817	3.15	0.10	0.22	27	0.24	11	7.0	0.19	2.8	0.01
D3R05121	D-280566	340506	1183817	3.02	0.10	0.22	29	0.23	7.9	7.1	0.27	2.6	0.01
D3R06111	D-280592	340415	1183915	2.91	0.08	0.32	19	0.29	26	3.8	0.22	3.4	0.02
D3R07111	D-280555	340405	1183907	5.23	0.09	0.17	28	0.13	14	4.5	0.57	2.8	< 0.01

Appendix IV. Elemental concentrations in *R. laurina* from N-S traverses--December collection (continued).

				%, Dry weight		%, Ash weight							
Field #	Lab #	Lat	Long	Ash	S	Al	Ca	Fe	K	Mg	Na	P	Ti
D3R07211	D-280582	340405	1183907	4.40	0.09	0.14	25	0.10	19	4.1	0.51	4.1	< 0.01
D3R08111	D-280595	340334	1183855	3.12	0.08	0.18	21	0.17	23	5.9	0.30	2.7	0.01
D3R08121	D-280557	340334	1183855	3.19	0.09	0.19	20	0.17	22	5.3	0.49	2.8	0.01
D3R08211	D-280561	340334	1183855	3.47	0.09	0.12	22	0.15	15	6.3	0.28	2.6	< 0.01
D3R09111	D-280542	340312	1183855	3.55	0.10	0.32	26	0.27	17	3.3	1.4	2.8	0.02
D4R01111	D-280607	340520	1185016	3.11	0.10	0.18	22	0.18	17	9.4	0.18	3.1	0.01
D4R01211	D-280576	340220	1185016	3.03	0.09	0.23	21	0.22	19	4.9	0.26	3.0	0.01
D4R02111	D-280580	340500	1185018	5.23	0.12	0.17	29	0.14	12	4.1	0.09	3.1	0.01
D4R02121	D-280586	340500	1185018	5.47	0.10	0.18	28	0.12	18	4.1	0.11	3.2	< 0.01
D4R02211	D-280541	340500	1185018	5.44	0.13	0.19	25	0.16	17	3.0	0.15	2.7	< 0.01
D4R03111	D-280614	340430	1185015	5.89	0.08	0.09	29	0.07	9.9	5.8	0.17	3.4	< 0.01
D4R03211	D-280569	340430	1185015	4.85	0.08	0.16	25	0.14	14	6.5	0.33	4.2	< 0.01
D4R04111	D-280540	340408	1184957	3.00	0.09	0.15	20	0.12	19	7.4	0.23	2.2	< 0.01
D4R04121	D-280598	340408	1184957	3.40	0.07	0.09	26	0.10	16	6.8	0.09	2.0	< 0.01
D4R05111	D-280608	340340	1184952	4.16	0.09	0.18	24	0.16	20	5.4	0.25	2.9	0.01
D4R05211	D-280599	340340	1184952	4.17	0.11	0.17	23	0.16	21	4.9	0.27	3.2	0.01
D4R06111	D-280604	340315	1184941	3.48	0.08	0.28	25	0.20	18	4.4	0.29	2.3	0.02
D4R06112	D-280565	340315	1184941	3.52	0.10	0.30	24	0.21	18	4.3	0.32	2.2	0.01
D4R07111	D-280547	340252	1184938	2.76	0.08	0.41	19	0.36	23	5.3	1.2	1.9	0.02
D4R07121	D-280578	340252	1184938	2.89	0.06	0.40	21	0.31	19	6.8	1.6	1.7	0.02
D4R08111	D-280544	340228	1184927	3.46	0.10	0.50	22	0.41	14	6.6	3.7	2.3	0.03
D4R08121	D-280572	330228	1184927	3.50	0.08	0.46	22	0.41	15	7.0	2.3	2.2	0.03
D4R08122	D-280625	340228	1184927	3.45	0.08	0.42	23	0.41	15	7.5	2.3	2.3	0.04
D5R02111	D-280618	340800	1185858	4.89	0.10	0.13	30	0.13	11	6.7	0.22	2.2	< 0.01
D5R02121	D-280613	340800	1185858	5.17	0.11	0.14	31	0.13	7.1	6.0	0.22	2.1	< 0.01
D5R03111	D-280622	340705	1185935	3.57	0.07	0.15	24	0.14	21	4.6	0.36	2.1	< 0.01
D5R03211	D-280570	340705	1185935	3.29	0.07	0.29	24	0.24	17	4.3	1.0	2.8	0.01
D5R04111	D-280624	340717	1185948	4.05	0.06	0.22	25	0.19	19	3.1	0.38	4.2	0.01
D5R04112	D-280603	340717	1185948	4.00	0.07	0.22	25	0.19	18	2.9	0.32	4.2	0.01
D5R05111	D-280584	340656	1190020	4.64	0.09	0.24	25	0.22	15	7.0	0.69	3.0	0.02
D5R05121	D-280552	340656	1190020	4.82	0.11	0.22	25	0.20	15	6.4	0.71	3.1	0.01
D5R06111	D-280601	340628	1190038	4.43	0.07	0.28	23	0.24	18	5.4	0.40	5.3	0.02
D5R06211	D-280597	340628	1190038	4.32	0.08	0.25	23	0.24	18	5.6	0.17	5.2	0.01
D5R07111	D-280615	340600	1190100	6.04	0.08	0.29	30	0.22	6.4	8.2	0.18	1.9	0.02
D5R07211	D-280546	340600	1190100	4.98	0.08	0.28	26	0.20	9.4	8.5	0.21	2.4	0.02
D5R08111	D-280553	340536	1190045	5.33	0.08	0.33	29	0.24	11	4.1	0.84	1.5	0.02
D5R08121	D-280579	340536	1190045	4.88	0.06	0.37	30	0.25	10	4.5	0.73	1.6	0.03
D5R08211	D-280623	340536	1190045	4.79	0.06	0.17	26	0.14	17	5.9	1.1	1.8	0.01
D5R09111	D-280551	340512	1190040	4.77	0.08	0.17	22	0.15	20	2.7	0.23	4.6	< 0.01
D5R09112	D-280567	340512	1190040	4.82	0.08	0.16	21	0.14	21	2.7	0.23	4.6	< 0.01
D5R09121	D-280559	340512	1190040	4.49	0.07	0.14	20	0.12	21	2.5	0.31	4.3	< 0.01
D5R09211	D-280593	340512	1190040	4.63	0.08	0.21	24	0.18	19	5.6	0.20	3.1	0.01
D5R10111	D-280602	340445	1190040	6.06	0.07	0.15	31	0.14	6.0	7.3	0.56	1.5	0.01

Appendix IV. Elemental concentrations in *R. laurina* from N-S traverses--December collection (continued).

	ppm, Ash weight																	
Field #	Mn	Ba	Cd	Ce	Co	Cr	Cu	La	Li	Mo	Nd	Ni	Pb	Sc	Sr	V	Y	Zn
D1R02111	1600	690	< 4	< 8	5	14	67	11	4	< 4	< 8	75	36	< 4	560	< 4	8	440
D1R02211	2300	580	< 4	< 8	4	3	77	11	< 4	< 4	< 8	46	36	< 4	540	4	6	420
D1R03111	2600	750	< 4	< 8	5	17	120	15	14	< 4	< 8	19	47	< 4	350	7	4	460
D1R03211	3500	860	< 4	< 8	5	15	85	14	13	< 4	< 8	19	33	< 4	350	5	9	380
D1R04111	2200	940	< 4	< 8	6	18	71	13	14	< 4	< 8	39	38	4	1100	7	7	440
D1R04121	1800	730	< 4	12	7	6	94	11	39	< 4	< 8	37	36	< 4	900	5	9	530
D1R05111	2200	450	< 4	< 8	5	5	94	9	5	< 4	< 8	30	29	< 4	1200	< 4	< 4	790
D1R05121	3600	470	< 4	< 8	6	10	92	10	5	< 4	< 8	27	37	4	1400	4	< 4	830
D2R01111	1300	160	< 4	< 8	3	14	54	9	8	< 4	< 8	16	12	< 4	260	4	< 4	260
D2R01121	1100	130	< 4	10	3	< 2	56	9	13	5	< 8	21	12	< 4	210	< 4	< 4	260
D2R01211	1500	180	< 4	< 8	3	12	49	10	13	< 4	< 8	9	16	< 4	280	5	< 4	280
D2R02111	1900	210	< 4	10	4	< 2	72	29	75	< 4	11	27	15	< 4	790	< 4	23	480
D2R02121	4200	240	< 4	11	5	10	65	32	120	< 4	14	31	14	< 4	790	< 4	23	480
D2R03111	5400	280	< 4	35	9	12	140	41	330	< 4	22	78	15	< 4	350	< 4	21	860
D2R04111	630	220	< 4	< 8	4	< 2	92	14	26	< 4	< 8	27	12	< 4	500	< 4	< 4	460
D2R04121	1200	170	< 4	< 8	4	3	91	14	37	< 4	< 8	23	15	< 4	440	< 4	< 4	490
D2R04211	1200	140	< 4	9	3	3	140	15	9	< 4	< 8	24	14	< 4	580	< 4	< 4	410
D2R05111	1700	180	< 4	< 8	4	9	42	14	5	< 4	< 8	26	10	< 4	570	< 4	< 4	310
D2R06111	1000	290	< 4	< 8	3	< 2	91	14	16	< 4	< 8	27	10	< 4	420	< 4	< 4	440
D2R06211	760	170	< 4	< 8	4	4	79	13	9	< 4	< 8	19	16	< 4	530	< 4	< 4	460
D2R07111	1200	150	< 4	9	4	4	110	12	12	< 4	< 8	10	17	< 4	630	< 4	< 4	590
D2R08111	1400	82	< 4	< 8	5	10	72	9	< 4	< 4	< 8	21	17	< 4	310	< 4	< 4	490
D2R08112	1100	67	< 4	< 8	5	< 2	61	9	< 4	< 4	< 8	21	13	< 4	280	< 4	< 4	460
D2R09111	1900	180	< 4	< 8	4	< 2	63	12	7	< 4	< 8	19	11	< 4	400	< 4	5	470
D2R09121	2500	220	< 4	< 8	4	4	63	13	13	< 4	< 8	20	14	< 4	500	< 4	< 4	480
D2R09211	4200	540	< 4	11	8	< 2	59	15	25	< 4	< 8	45	12	< 4	700	< 4	9	480
D2R10111	310	43	20	< 8	3	2	36	9	< 4	8	< 8	14	< 8	< 4	310	< 4	< 4	370
D2R10121	3900	860	< 4	11	6	3	74	10	9	< 4	< 8	57	27	< 4	370	< 4	< 4	490
D2R10122	2900	890	< 4	< 8	3	< 2	77	10	9	< 4	< 8	58	21	< 4	370	< 4	< 4	500
D3R01111	1800	58	< 4	< 8	4	10	90	9	5	< 4	< 8	48	14	< 4	310	4	< 4	490
D3R01121	1400	48	< 4	< 8	5	14	90	8	5	< 4	< 8	51	14	< 4	310	< 4	< 4	630
D3R02111	1000	110	< 4	< 8	4	10	59	9	< 4	9	< 8	43	15	< 4	450	5	< 4	460
D3R02211	1300	140	< 4	< 8	4	< 2	54	10	7	10	< 8	15	12	< 4	880	< 4	< 4	210
D3R03111	2400	900	< 4	< 8	4	8	72	10	< 4	< 4	< 8	16	10	< 4	450	< 4	< 4	570
D3R03121	1600	830	< 4	< 8	4	10	56	11	< 4	5	< 8	37	10	< 4	290	< 4	< 4	430
D3R04111	3900	790	< 4	8	5	12	65	22	15	< 4	< 8	26	13	5	1500	< 4	8	370
D3R04112	4100	770	< 4	12	5	16	73	22	16	< 4	< 8	28	17	5	1400	< 4	9	390
D3R04121	3500	570	< 4	11	5	13	85	21	14	< 4	< 8	22	17	4	1300	5	7	490
D3R04211	1700	550	< 4	< 8	7	< 2	84	17	15	< 4	< 8	27	11	< 4	700	< 4	6	570
D3R05111	1000	50	< 4	< 8	4	8	110	9	< 4	< 4	< 8	160	13	< 4	480	< 4	4	520
D3R05112	1000	47	< 4	< 8	4	14	100	9	< 4	< 4	< 8	150	13	< 4	460	< 4	4	490
D3R05121	1200	39	6	< 8	4	14	110	9	< 4	< 4	< 8	230	13	< 4	450	< 4	< 4	440
D3R06111	1300	100	16	< 8	3	4	66	12	4	< 4	< 8	36	< 8	< 4	380	5	< 4	390
D3R07111	2600	290	< 4	< 8	3	11	57	13	22	< 4	< 8	12	15	< 4	410	< 4	< 4	400

Appendix IV. Elemental concentrations in *R. laurina* from N-S traverses--December collection (continued).

	ppm, Ash weight																	
Field #	Mn	Ba	Cd	Ce	Co	Cr	Cu	La	Li	Mo	Nd	Ni	Pb	Sc	Sr	V	Y	Zn
D3R07211	660	280	< 4	< 8	4	< 2	67	12	11	< 4	< 8	20	15	< 4	310	< 4	< 4	410
D3R08111	2300	610	< 4	43	7	< 2	110	38	< 4	< 4	14	31	17	< 4	1100	< 4	9	430
D3R08121	3500	550	< 4	39	9	11	130	45	4	< 4	16	37	20	< 4	980	< 4	9	470
D3R08211	2000	390	< 4	< 8	5	9	71	21	4	< 4	< 8	18	12	< 4	840	< 4	< 4	360
D3R09111	2400	52	< 4	< 8	5	14	75	12	4	< 4	< 8	20	34	< 4	150	7	< 4	450
D4R01111	1300	39	< 4	< 8	4	< 2	120	7	< 4	< 4	< 8	35	9	< 4	430	< 4	< 4	460
D4R01211	1500	38	< 4	< 8	4	14	98	8	< 4	< 4	< 8	19	14	< 4	420	4	< 4	390
D4R02111	940	41	19	< 8	4	< 2	36	8	< 4	12	< 8	14	< 8	< 4	330	< 4	< 4	300
D4R02121	330	49	23	< 8	3	< 2	37	8	< 4	8	< 8	11	< 8	< 4	310	< 4	< 4	380
D4R02211	720	96	50	< 8	4	11	50	10	< 4	8	< 8	21	< 8	< 4	470	< 4	< 4	420
D4R03111	2300	73	4	< 8	4	< 2	44	8	16	< 4	< 8	46	< 8	< 4	320	< 4	< 4	310
D4R03211	2100	120	5	< 8	3	11	75	13	11	5	< 8	11	< 8	< 4	520	< 4	6	270
D4R04111	980	210	< 4	< 8	3	11	80	23	8	< 4	< 8	60	< 8	< 4	540	< 4	11	250
D4R04121	1100	170	< 4	< 8	4	< 2	71	16	9	< 4	< 8	64	< 8	< 4	540	< 4	10	230
D4R05111	810	67	21	< 8	3	< 2	34	7	17	6	< 8	11	< 8	< 4	250	< 4	< 4	360
D4R05211	590	130	24	< 8	3	< 2	51	8	24	7	< 8	15	< 8	< 4	380	< 4	< 4	480
D4R06111	1400	110	< 4	< 8	3	< 2	68	10	11	< 4	< 8	12	12	< 4	230	< 4	< 4	340
D4R06112	1800	110	< 4	< 8	4	11	64	11	11	< 4	< 8	11	9	< 4	230	4	< 4	330
D4R07111	2300	100	< 4	< 8	4	16	120	15	10	< 4	< 8	61	22	< 4	410	7	< 4	330
D4R07121	2000	130	< 4	< 8	5	11	91	11	29	< 4	< 8	50	27	< 4	480	9	< 4	330
D4R08111	1000	510	< 4	< 8	5	18	94	10	6	6	< 8	29	33	< 4	500	12	< 4	390
D4R08121	1100	470	< 4	< 8	6	17	90	10	< 4	6	< 8	27	25	< 4	480	11	< 4	390
D4R08122	1000	480	< 4	< 8	6	9	94	9	< 4	7	< 8	27	22	< 4	500	10	< 4	410
D5R02111	1300	260	17	< 8	4	< 2	78	11	< 4	< 4	< 8	21	9	< 4	870	< 4	< 4	470
D5R02121	1800	160	25	< 8	5	< 2	51	10	< 4	< 4	< 8	17	< 8	< 4	820	< 4	< 4	390
D5R03111	780	180	18	< 8	3	4	73	8	< 4	< 4	< 8	56	< 8	< 4	560	< 4	< 4	420
D5R03211	1200	170	12	< 8	5	13	77	10	< 4	< 4	< 8	51	13	< 4	530	6	< 4	420
D5R04111	880	42	< 4	< 8	3	9	75	8	< 4	< 4	< 8	10	< 8	< 4	370	4	< 4	380
D5R04112	330	41	< 4	< 8	4	8	74	7	< 4	< 4	< 8	13	< 8	< 4	350	< 4	< 4	380
D5R05111	950	140	32	< 8	3	8	80	8	< 4	< 4	< 8	18	8	< 4	390	< 4	< 4	450
D5R05121	1100	150	29	< 8	5	10	51	9	< 4	4	< 8	17	9	< 4	370	4	< 4	390
D5R06111	760	95	12	< 8	5	9	65	8	< 4	4	< 8	50	11	< 4	500	4	< 4	310
D5R06211	550	110	20	< 8	4	7	110	9	< 4	4	< 8	51	10	< 4	520	< 4	< 4	510
D5R07111	780	54	< 4	< 8	4	8	48	7	< 4	< 4	< 8	6	10	< 4	270	5	< 4	220
D5R07211	1100	110	< 4	< 8	4	10	40	10	< 4	< 4	< 8	12	11	< 4	410	5	< 4	270
D5R08111	730	150	< 4	< 8	5	11	39	9	< 4	< 4	< 8	9	17	< 4	430	7	< 4	160
D5R08121	700	160	< 4	< 8	4	11	42	9	4	< 4	< 8	10	14	< 4	440	7	< 4	160
D5R08211	740	100	< 4	< 8	4	5	50	7	< 4	< 4	< 8	7	12	< 4	350	< 4	< 4	200
D5R09111	500	58	< 4	< 8	3	14	60	8	< 4	< 4	< 8	5	< 8	< 4	310	< 4	< 4	470
D5R09112	460	55	< 4	< 8	5	12	690	8	< 4	< 4	< 8	6	28	< 4	300	< 4	< 4	820
D5R09121	400	48	< 4	< 8	4	11	55	10	< 4	< 4	< 8	6	8	< 4	280	< 4	< 4	360
D5R09211	440	69	< 4	8	4	7	52	8	< 4	< 4	< 8	9	9	< 4	700	< 4	< 4	270
D5R10111	1300	48	6	< 8	4	< 2	33	7	< 4	< 4	< 8	14	< 8	< 4	520	< 4	< 4	180

Appendix V. Elemental concentrations in *C. megacarpus* from N-S traverses--May collection.

				%, Dry weight		%, Ash weight							
Field #	Lab #	Lat	Long	Ash	S	Al	Ca	Fe	K	Mg	Na	P	Ti
T1C04111	D-276712	340615	1182440	3.21	0.15	0.24	18	0.25	21	9.1	1.6	5.0	0.01
T1C04121	D-276619	340615	1182440	3.67	0.13	0.24	20	0.29	21	7.5	1.2	4.7	0.02
T2C01111	D-276635	340732	1183322	3.31	0.13	0.21	19	0.21	25	5.4	0.41	4.7	0.02
T2C01112	D-276611	340732	1183322	3.32	0.13	0.21	18	0.22	25	5.9	0.45	5.4	0.01
T2C01121	D-276708	340732	1183322	4.00	0.13	0.30	19	0.24	26	4.7	0.59	4.3	0.01
T2C01211	D-276687	340732	1183322	3.58	0.13	0.21	24	0.21	19	5.4	0.36	5.4	0.01
T2C02111	D-276704	340712	1183317	3.00	0.12	0.25	23	0.26	17	5.2	3.2	3.4	0.01
T2C02121	D-276627	340712	1183317	3.13	0.11	0.19	23	0.26	19	4.9	2.6	3.8	0.01
T2C03111	D-276639	340640	1183317	3.19	0.13	0.20	16	0.41	27	4.2	4.5	4.4	0.01
T2C04111	D-276612	340615	1183318	4.51	0.15	0.08	23	0.15	21	4.1	0.23	5.0	0.01
T2C04121	D-276636	340615	1183318	4.81	0.13	0.09	25	0.13	20	3.8	0.26	4.1	0.01
T2C04211	D-276632	340615	1183318	3.48	0.13	0.19	20	0.25	23	4.4	0.55	5.4	0.01
T2C04212	D-276697	340615	1183318	3.51	0.13	0.17	20	0.20	23	4.3	0.54	5.4	0.01
T2C05111	D-276692	340553	1183300	4.00	0.14	0.18	25	0.22	17	7.1	0.76	3.9	0.01
T2C06111	D-276638	340522	1183258	2.55	0.12	0.27	18	0.31	25	4.8	0.84	7.0	0.02
T2C06211	D-276603	340522	1183258	3.81	0.12	0.20	24	0.27	19	6.7	0.57	4.0	0.01
T2C07111	D-276642	340503	1183246	2.82	0.13	0.35	18	0.33	20	7.1	1.3	5.5	0.03
T2C08111	D-276701	340435	1183237	4.36	0.15	0.19	24	0.21	21	4.0	0.64	3.6	0.01
T2C09111	D-276711	340407	1183230	3.61	0.13	0.35	23	0.30	20	3.8	0.82	3.7	0.02
T2C09112	D-276621	340407	1183230	3.61	0.12	0.29	23	0.27	21	3.9	0.82	3.8	0.02
T2C09121	D-276613	340407	1183230	3.39	0.12	0.31	23	0.31	21	4.1	0.95	3.8	0.02
T2C09211	D-276709	340407	1183230	3.23	0.13	0.29	20	0.26	24	4.8	1.8	3.7	0.02
T2C10111	D-276623	340350	1183215	3.86	0.14	0.11	25	0.19	19	5.3	0.41	4.5	0.01
T2C10121	D-276699	340350	1183215	3.65	0.14	0.15	23	0.20	19	5.4	0.44	4.7	0.01
T2C10122	D-276715	340350	1183215	3.63	0.15	0.14	24	0.19	20	5.5	0.44	4.7	0.01
T3C01111	D-276626	340635	1183946	2.89	0.12	0.31	21	0.41	20	7.3	0.57	5.1	0.02
T3C01121	D-276690	340635	1183946	3.00	0.12	0.31	22	0.36	17	7.3	0.49	4.6	0.02
T3C02111	D-276610	340610	1183900	4.24	0.13	0.13	29	0.17	12	4.4	1.5	3.4	0.01
T3C02112	D-276640	340610	1183900	4.24	0.13	0.13	30	0.19	12	4.4	1.5	3.4	0.01
T3C02211	D-276710	340610	1183900	4.00	0.14	0.12	27	0.16	15	3.9	0.84	3.9	0.01
T3C03111	D-276629	340552	1183833	5.07	0.13	0.13	26	0.16	18	2.9	0.51	2.6	0.01
T3C03121	D-276615	340552	1183833	4.51	0.12	0.11	27	0.17	20	2.9	0.58	2.5	0.01
T3C04111	D-276714	340533	1183814	4.23	0.13	0.24	27	0.22	15	4.8	0.92	3.0	0.02
T3C04112	D-276634	340533	1183814	4.20	0.12	0.23	27	0.23	15	4.9	0.95	3.0	0.01
T3C04121	D-276641	340533	1183814	3.90	0.12	0.26	25	0.26	18	4.9	1.0	3.7	0.02
T3C04211	D-276696	340533	1183814	3.45	0.10	0.25	19	0.21	23	4.5	1.9	3.2	0.01
T3C05111	D-276630	340506	1183817	4.16	0.13	0.33	27	0.36	13	5.0	1.3	4.0	0.02
T3C06111	D-276614	340415	1183915	3.37	0.15	0.21	17	0.26	27	4.1	0.68	7.4	0.01
T3C07111	D-276624	340405	1183907	3.68	0.12	0.15	23	0.18	22	4.3	0.80	3.9	0.01
T3C07211	D-276698	340405	1183907	4.13	0.12	0.23	28	0.22	14	3.3	1.6	3.0	0.01
T3C08111	D-276625	340334	1183855	3.43	0.12	0.14	18	0.18	27	4.8	0.94	5.5	0.01
T3C08121	D-276700	340334	1183855	3.34	0.12	0.15	17	0.17	29	5.0	0.87	4.5	0.01
T3C08211	D-276707	340334	1183855	4.21	0.14	0.09	16	0.15	31	2.7	0.96	5.4	0.01
T3C09111	D-276622	340312	1183855	3.35	0.11	0.17	26	0.21	12	6.9	4.1	4.6	0.01

Appendix V. Elemental concentrations in *C. megacarpus* from N-S traverses--May collection (continued).

				%, Dry weight		%, Ash weight							
Field #	Lab #	Lat	Long	Ash	S	Al	Ca	Fe	K	Mg	Na	P	Ti
T4C01111	D-276694	340520	1185016	4.24	0.13	0.26	25	0.28	15	5.3	1.8	4.2	0.01
T4C01211	D-276684	340520	1185016	3.64	0.12	0.18	27	0.20	13	5.3	1.8	4.6	0.01
T4C02111	D-276689	340500	1185018	4.77	0.14	0.11	27	0.14	16	2.6	1.4	5.3	0.01
T4C02112	D-276686	340500	1185018	4.66	0.14	0.11	28	0.14	16	2.7	1.4	5.6	0.01
T4C02121	D-276702	340500	1185018	5.14	0.13	0.12	29	0.15	14	2.3	1.9	4.7	0.01
T4C02211	D-276608	340500	1185018	4.10	0.13	0.09	30	0.19	14	3.2	1.2	4.4	0.01
T4C03111	D-276695	340430	1185015	3.43	0.16	0.24	19	0.27	18	7.3	1.9	6.4	0.01
T4C03211	D-276617	340430	1185015	3.53	0.14	0.19	24	0.25	14	7.0	1.8	6.8	0.01
T4C04111	D-276618	340408	1184957	3.92	0.13	0.15	19	0.22	24	5.7	1.2	3.6	0.01
T4C04121	D-276620	340408	1184957	4.03	0.13	0.22	20	0.27	24	5.7	1.8	3.1	0.01
T4C05111	D-276713	340340	1184952	5.29	0.16	0.15	28	0.19	14	4.1	1.1	5.4	0.01
T4C05211	D-276631	340340	1184952	5.47	0.14	0.11	29	0.17	14	3.4	0.88	3.9	0.01
T4C06111	D-276685	340315	1184941	3.88	0.14	0.28	16	0.23	30	3.1	1.2	3.5	0.01
T4C07111	D-276633	340252	1184938	3.50	0.13	0.22	19	0.24	24	6.4	1.9	3.5	0.02
T4C07121	D-276691	340252	1184938	3.51	0.13	0.25	17	0.25	25	6.0	2.0	3.3	0.01
T4C08111	D-276693	340228	1184927	5.08	0.14	0.33	23	0.31	18	3.9	2.2	4.3	0.02
T4C08121	D-276705	340228	1184927	5.57	0.16	0.60	22	0.43	15	3.7	4.8	3.7	0.03
T5C02111	D-276605	340800	1185858	3.62	0.12	0.26	19	0.28	28	5.1	1.4	3.4	0.02
T5C02121	D-276688	340800	1185858	3.83	0.13	0.30	17	0.26	27	4.7	1.9	3.5	0.01
T5C03111	D-276604	340705	1185935	2.92	0.11	0.28	21	0.33	19	5.8	1.9	4.8	0.01
T5C03211	D-276616	340705	1185935	2.90	0.12	0.34	19	0.34	20	5.7	5.5	4.4	0.01
T5C05111	D-276609	340656	1190020	3.75	0.15	0.20	20	0.25	23	6.1	1.7	4.9	0.01
T5C05121	D-276683	340656	1190020	4.93	0.15	0.20	23	0.20	19	6.0	1.5	3.7	0.01
T5C07111	D-276706	340600	1190100	3.93	0.14	0.12	21	0.15	21	5.2	1.1	6.3	0.01
T5C07211	D-276607	340600	1190100	3.74	0.12	0.14	21	0.19	22	5.4	1.4	6.1	0.01
T5C08111	D-276637	340536	1190045	4.30	0.11	0.31	25	0.26	19	3.2	2.7	2.7	0.02
T5C08121	D-276703	340536	1190045	4.25	0.13	0.31	25	0.24	18	3.0	2.3	3.0	0.02
T5C08122	D-276628	340536	1190045	4.22	0.11	0.29	26	0.26	18	3.1	2.3	3.1	0.02

Appendix V. Elemental concentrations in *C. megacarpus* from N-S traverses--May collection (continued).

	ppm, Ash weight																	
Field #	Mn	Ba	Cd	Ce	Co	Cr	Cu	La	Li	Mo	Nd	Ni	Pb	Sc	Sr	V	Y	Zn
T1C04111	500	370	< 4	< 8	7	11	160	< 4	35	< 4	< 8	72	22	< 4	1000	< 4	7	520
T1C04121	560	500	< 4	8	6	11	140	< 4	26	< 4	< 8	57	29	< 4	1200	5	4	500
T2C01111	670	110	< 4	< 8	3	8	120	< 4	6	10	< 8	23	17	< 4	160	< 4	< 4	480
T2C01112	730	110	< 4	< 8	3	11	130	< 4	7	11	< 8	27	17	< 4	150	< 4	< 4	520
T2C01121	650	140	< 4	< 8	2	10	110	< 4	7	14	< 8	18	28	< 4	180	4	< 4	410
T2C01211	810	140	< 4	< 8	3	9	150	< 4	6	< 4	< 8	20	15	< 4	200	< 4	< 4	560
T2C02111	1400	230	< 4	13	4	9	140	22	99	< 4	< 8	37	34	< 4	1300	4	18	620
T2C02121	1500	220	< 4	9	2	7	130	26	130	< 4	< 8	40	23	< 4	1200	< 4	20	600
T2C03111	1800	160	< 4	< 8	8	110	210	15	200	< 4	< 8	210	11	< 4	390	< 4	8	680
T2C04111	580	270	< 4	< 8	3	5	100	< 4	9	< 4	< 8	22	< 8	< 4	830	< 4	< 4	450
T2C04121	580	310	< 4	< 8	3	9	95	< 4	10	< 4	< 8	14	< 8	< 4	1000	< 4	< 4	380
T2C04211	760	340	< 4	< 8	3	9	110	< 4	15	< 4	< 8	20	17	< 4	1100	< 4	< 4	410
T2C04212	730	380	< 4	< 8	2	9	130	5	15	< 4	< 8	18	17	< 4	1000	< 4	< 4	410
T2C05111	1600	320	5	< 8	5	6	150	16	74	< 4	< 8	99	16	< 4	1000	< 4	7	540
T2C06111	1100	290	< 4	9	4	13	170	5	20	< 4	< 8	70	32	< 4	560	6	< 4	680
T2C06211	900	370	< 4	< 8	4	9	100	< 4	40	< 4	< 8	77	19	< 4	800	< 4	< 4	500
T2C07111	1200	210	< 4	< 8	3	12	170	6	28	< 4	< 8	46	28	< 4	840	7	5	580
T2C08111	420	110	< 4	< 8	3	9	150	< 4	4	< 4	< 8	21	22	< 4	370	< 4	< 4	460
T2C09111	1700	430	< 4	10	4	9	190	13	28	< 4	< 8	110	28	< 4	820	6	10	600
T2C09112	1700	430	< 4	9	4	8	170	9	26	< 4	< 8	120	25	< 4	850	5	10	600
T2C09121	1700	400	< 4	< 8	4	8	170	10	29	< 4	< 8	130	23	< 4	810	6	10	570
T2C09211	3700	450	< 4	< 8	5	8	200	9	84	< 4	< 8	190	24	< 4	840	< 4	7	520
T2C10111	1500	400	< 4	< 8	3	5	140	< 4	67	< 4	< 8	83	< 8	< 4	470	< 4	< 4	580
T2C10121	1400	340	< 4	< 8	4	5	160	< 4	58	< 4	< 8	87	11	< 4	420	< 4	< 4	610
T2C10122	1400	370	< 4	< 8	4	5	160	< 4	59	< 4	< 8	85	9	< 4	450	< 4	< 4	600
T3C01111	710	59	< 4	< 8	4	13	220	< 4	< 4	< 4	< 8	160	30	< 4	180	8	< 4	840
T3C01121	770	60	< 4	< 8	4	11	240	< 4	< 4	< 4	< 8	140	27	< 4	220	6	< 4	820
T3C02111	700	130	< 4	< 8	3	5	84	< 4	5	57	< 8	22	< 8	< 4	480	< 4	< 4	430
T3C02112	710	130	< 4	< 8	3	5	87	< 4	5	58	< 8	24	< 8	< 4	490	< 4	< 4	430
T3C02211	730	110	< 4	< 8	3	5	110	< 4	6	30	< 8	25	< 8	< 4	450	< 4	< 4	410
T3C03111	1300	950	< 4	< 8	3	4	130	< 4	6	8	< 8	49	10	< 4	440	< 4	< 4	400
T3C03121	1200	940	< 4	< 8	3	4	110	< 4	5	4	< 8	51	< 8	< 4	470	< 4	< 4	410
T3C04111	860	1000	< 4	14	6	7	140	21	9	< 4	< 8	30	27	< 4	1800	4	7	390
T3C04112	900	1100	< 4	16	6	8	130	19	9	< 4	< 8	32	28	< 4	1900	5	6	390
T3C04121	840	930	< 4	14	7	9	190	17	9	< 4	< 8	41	28	< 4	1600	5	6	450
T3C04211	1400	710	< 4	13	4	11	220	17	18	< 4	< 8	39	27	< 4	1100	< 4	8	520
T3C05111	590	90	< 4	< 8	4	16	150	< 4	5	< 4	< 8	130	31	< 4	690	6	< 4	410
T3C06111	1000	140	< 4	8	3	10	130	< 4	10	< 4	< 8	100	< 8	< 4	490	4	< 4	680
T3C07111	1900	240	< 4	< 8	3	7	110	6	15	< 4	< 8	57	11	< 4	460	< 4	< 4	300
T3C07211	1300	140	< 4	< 8	3	6	110	< 4	21	< 4	< 8	30	21	< 4	250	< 4	< 4	410
T3C08111	1400	460	< 4	12	4	6	130	8	15	< 4	< 8	31	12	< 4	950	< 4	< 4	500
T3C08121	1400	460	< 4	12	4	6	130	10	17	< 4	< 8	34	18	< 4	850	< 4	< 4	430
T3C08211	1100	410	< 4	< 8	3	6	140	< 4	10	< 4	< 8	35	8	< 4	780	< 4	< 4	450
T3C09111	1500	110	< 4	< 8	3	8	150	17	29	< 4	< 8	34	13	< 4	780	< 4	10	480

Appendix V. Elemental concentrations in *C. megacarpus* from N-S traverses--May collection (continued).

	ppm, Ash weight																	
Field #	Mn	Ba	Cd	Ce	Co	Cr	Cu	La	Li	Mo	Nd	Ni	Pb	Sc	Sr	V	Y	Zn
T4C01111	610	79	< 4	< 8	3	11	160	< 4	5	< 4	< 8	47	14	< 4	690	4	< 4	480
T4C01211	580	73	< 4	< 8	3	7	200	< 4	6	< 4	< 8	75	15	< 4	760	< 4	< 4	590
T4C02111	830	110	< 4	< 8	3	6	93	< 4	< 4	30	< 8	79	< 8	< 4	560	< 4	< 4	330
T4C02112	870	99	< 4	< 8	< 2	6	97	< 4	< 4	31	< 8	83	9	< 4	590	< 4	< 4	340
T4C02121	750	140	< 4	< 8	2	7	73	< 4	5	22	< 8	75	< 8	< 4	810	< 4	< 4	260
T4C02211	1100	71	< 4	< 8	3	5	73	< 4	6	50	< 8	63	< 8	< 4	540	< 4	< 4	340
T4C03111	1000	150	< 4	< 8	3	10	60	< 4	12	7	< 8	30	10	< 4	850	< 4	< 4	570
T4C03211	960	240	< 4	< 8	3	8	87	< 4	12	12	< 8	30	11	< 4	1200	< 4	< 4	550
T4C04111	970	130	< 4	< 8	2	4	210	7	8	< 4	< 8	110	< 8	< 4	520	< 4	< 4	600
T4C04121	1000	170	< 4	< 8	3	6	200	9	10	< 4	< 8	90	12	< 4	610	5	4	560
T4C05111	590	140	< 4	< 8	3	12	100	< 4	8	39	< 8	81	9	< 4	670	< 4	< 4	370
T4C05211	490	200	< 4	< 8	3	5	61	< 4	6	23	< 8	67	< 8	< 4	720	< 4	< 4	440
T4C06111	940	170	< 4	< 8	3	7	180	< 4	6	< 4	< 8	92	14	< 4	460	4	< 4	450
T4C07111	1100	310	< 4	< 8	4	8	140	< 4	11	< 4	< 8	70	13	< 4	610	5	< 4	420
T4C07121	1100	280	4	< 8	2	7	150	6	13	< 4	< 8	72	13	< 4	540	< 4	< 4	400
T4C08111	450	190	< 4	< 8	5	13	170	< 4	< 4	6	< 8	95	15	< 4	220	7	< 4	470
T4C08121	460	220	< 4	< 8	5	16	150	< 4	5	4	< 8	78	26	< 4	250	12	< 4	430
T5C02111	520	270	< 4	< 8	3	11	140	< 4	7	< 4	< 8	77	8	< 4	610	6	< 4	400
T5C02121	550	240	< 4	8	3	10	140	< 4	7	< 4	< 8	53	13	< 4	560	6	< 4	390
T5C03111	1100	580	< 4	< 8	4	10	170	< 4	8	5	< 8	160	9	< 4	900	6	< 4	460
T5C03211	1400	400	< 4	< 8	3	11	150	< 4	14	< 4	< 8	200	11	< 4	740	6	< 4	540
T5C05111	900	54	< 4	< 8	3	8	140	< 4	6	< 4	< 8	89	< 8	< 4	350	< 4	< 4	520
T5C05121	930	62	< 4	< 8	3	10	130	< 4	6	< 4	< 8	60	< 8	< 4	460	< 4	< 4	410
T5C07111	660	110	< 4	< 8	3	8	140	< 4	< 4	9	< 8	40	9	< 4	460	< 4	< 4	400
T5C07211	680	100	< 4	< 8	3	8	120	< 4	4	10	< 8	45	< 8	< 4	440	< 4	< 4	360
T5C08111	280	100	< 4	< 8	3	9	75	< 4	5	5	< 8	13	11	< 4	220	6	< 4	330
T5C08121	260	93	< 4	< 8	5	12	91	< 4	5	5	< 8	12	15	< 4	230	6	< 4	390
T5C08122	270	96	< 4	< 8	3	10	84	< 4	6	5	< 8	12	15	< 4	240	7	< 4	390

Appendix VI. Elemental concentrations in *C. megacarpus* from N-S traverses--December collection.

				%, Dry weight		%, Ash weight							
Field #	Lab #	Lat	Long	Ash	S	Al	Ca	Fe	K	Mg	Na	P	Ti
D1C04111	D-280747	340615	1182440	3.33	0.11	0.76	18	0.58	12	12	1.7	3.8	0.05
D1C04121	D-280759	340615	1182440	3.58	0.10	0.59	19	0.44	12	11	0.84	3.6	0.04
D2C01111	D-280743	340732	1183322	3.74	0.10	0.59	24	0.47	14	6.6	0.53	3.5	0.04
D2C01112	D-280762	340732	1183322	3.72	0.11	0.60	24	0.49	14	6.7	0.54	3.5	0.04
D2C01121	D-280697	340732	1183322	3.89	0.10	0.59	24	0.46	15	5.9	0.46	3.4	0.04
D2C01211	D-280738	340732	1183322	3.75	0.08	0.41	26	0.35	14	5.5	0.40	4.0	0.03
D2C02111	D-280741	340712	1183317	3.49	0.09	0.57	20	0.43	20	4.5	2.2	2.8	0.04
D2C02121	D-280704	340712	1183317	2.90	0.09	0.41	22	0.37	16	5.8	2.8	3.3	0.03
D2C03111	D-280730	340640	1183317	3.24	0.11	0.22	16	0.25	27	4.7	3.2	4.5	0.02
D2C04111	D-280700	340615	1183318	3.73	0.09	0.20	23	0.20	18	5.2	0.21	5.1	0.01
D2C04121	D-280712	340615	1183318	3.57	0.13	0.18	23	0.20	20	5.1	0.22	5.3	0.01
D2C04211	D-280731	340615	1183318	3.09	0.11	0.46	21	0.34	17	5.4	1.3	3.5	0.03
D2C04212	D-280751	340615	1183318	3.02	0.12	0.41	20	0.37	20	5.5	0.47	5.4	0.02
D2C05111	D-280720	340553	1183300	3.59	0.10	0.34	25	0.29	12	7.9	0.63	3.5	0.02
D2C06111	D-280710	340522	1183258	4.35	0.10	0.28	26	0.27	15	6.4	0.40	3.2	0.02
D2C06211	D-280734	340522	1183258	2.88	0.10	0.40	21	0.35	16	5.5	0.53	6.6	0.03
D2C07111	D-280740	340503	1183246	2.81	0.09	0.60	19	0.45	15	8.6	1.4	5.8	0.03
D2C08111	D-280748	340435	1183237	3.90	0.12	0.27	25	0.26	19	4.3	0.62	3.2	0.02
D2C09111	D-280717	340407	1183230	3.98	0.10	0.50	24	0.40	20	4.1	0.76	2.9	0.03
D2C09112	D-280749	340407	1183230	4.10	0.10	0.42	22	0.34	21	3.9	0.76	2.7	0.03
D2C09121	D-280744	340407	1183230	4.23	0.09	0.46	25	0.37	17	4.0	0.83	2.5	0.03
D2C09211	D-280705	340407	1183230	3.09	0.11	0.36	20	0.32	22	5.2	1.7	3.5	0.02
D2C10111	D-280756	340350	1183215	3.89	0.10	0.25	25	0.28	15	5.8	0.33	4.1	0.02
D2C10121	D-280713	340350	1183215	3.61	0.10	0.30	25	0.29	16	6.4	0.36	4.2	0.02
D2C10122	D-280702	340350	1183215	3.69	0.10	0.29	23	0.30	16	6.2	0.37	3.9	0.02
D3C01111	D-280763	340635	1183946	3.21	0.10	0.53	23	0.53	13	6.9	0.37	3.3	0.04
D3C01121	D-280703	340635	1183946	3.61	0.10	0.34	24	0.39	13	7.0	0.24	2.8	0.03
D3C02111	D-280726	340610	1183900	4.16	0.09	0.28	31	0.25	7.6	5.0	1.3	2.9	0.02
D3C02211	D-280719	340610	1183900	4.46	0.10	0.22	31	0.20	9.9	4.6	0.68	2.5	0.02
D3C03111	D-280718	340552	1183833	5.97	0.10	0.13	32	0.13	11	2.9	0.39	1.7	0.02
D3C03121	D-280750	340552	1183833	4.76	0.10	0.18	31	0.18	11	3.3	0.49	2.0	0.01
D3C04111	D-280725	340533	1183814	4.20	0.11	0.37	25	0.32	17	4.9	0.62	3.8	0.03
D3C04112	D-280706	340533	1183814	4.25	0.11	0.33	24	0.29	17	4.7	0.61	3.6	0.03
D3C04121	D-280709	340533	1183814	4.32	0.11	0.33	26	0.28	15	4.8	0.60	3.2	0.03
D3C04211	D-280733	340533	1183814	3.55	0.09	0.36	21	0.33	16	5.6	0.45	5.4	0.03
D3C05111	D-280761	340506	1183817	4.74	0.10	0.40	28	0.38	9.8	5.1	0.84	2.7	0.03
D3C05121	D-280722	340506	1183817	4.37	0.11	0.51	28	0.48	8.1	4.9	0.89	2.7	0.04
D3C06111	D-280695	340415	1183915	3.65	0.10	0.46	21	0.38	17	4.4	0.50	5.7	0.03
D3C07111	D-280708	340405	1183907	4.22	0.09	0.17	28	0.17	15	4.5	0.62	2.9	0.01
D3C07211	D-280732	340405	1183907	4.19	0.10	0.24	28	0.23	16	2.7	1.2	3.0	0.02
D3C08111	D-280739	340334	1183855	3.81	0.11	0.16	17	0.17	28	4.5	0.72	5.1	0.01
D3C08121	D-280721	340334	1183855	4.03	0.10	0.17	19	0.19	25	4.6	0.66	4.1	0.01
D3C08211	D-280715	340334	1183855	3.94	0.12	0.16	19	0.20	24	2.9	0.78	5.7	< 0.01
D3C09111	D-280760	340312	1183855	3.59	0.10	0.51	24	0.39	9.9	5.9	4.0	4.0	0.03

Appendix VI. Elemental concentrations in *C. megacarpus* from N-S traverses--December collection (continued).

				%, Dry weight		%, Ash weight							
Field #	Lab #	Lat	Long	Ash	S	Al	Ca	Fe	K	Mg	Na	P	Ti
D4C01111	D-280752	340520	1185016	3.91	0.10	0.34	27	0.31	12	5.2	1.6	3.2	0.02
D4C01211	D-280754	340520	1185016	3.37	0.10	0.42	26	0.38	11	5.4	2.3	3.8	0.03
D4C02111	D-280764	340500	1185018	5.29	0.10	0.18	32	0.17	7.7	3.1	1.6	6.0	0.01
D4C02112	D-280698	340500	1185018	5.23	0.11	0.17	31	0.17	7.5	3.1	1.5	5.8	0.01
D4C02121	D-280707	340500	1185018	5.06	0.10	0.16	31	0.16	10	2.0	1.0	5.4	< 0.01
D4C02211	D-280745	340500	1185018	4.36	0.11	0.19	31	0.20	11	3.0	1.0	3.2	0.02
D4C03111	D-280737	340430	1185015	3.75	0.10	0.35	22	0.32	14	7.3	1.5	5.4	0.02
D4C03211	D-280767	340430	1185015	3.46	0.10	0.31	22	0.26	13	6.6	1.5	7.1	0.02
D4C04111	D-280701	340408	1184957	3.48	0.09	0.31	21	0.28	18	7.6	1.1	3.0	0.02
D4C04121	D-280716	340408	1184957	3.53	0.10	0.30	22	0.29	18	8.1	1.0	3.0	0.02
D4C05111	D-280735	340340	1184952	5.10	0.10	0.27	27	0.23	12	3.7	1.1	6.2	0.02
D4C05211	D-280765	340340	1184952	5.21	0.10	0.25	29	0.22	11	3.8	1.0	3.9	0.02
D4C06111	D-280736	340315	1184941	4.15	0.09	0.58	25	0.38	15	5.5	1.4	2.2	0.04
D4C07111	D-280714	340252	1184938	3.39	0.08	0.33	22	0.30	18	6.6	0.98	2.8	0.02
D4C07121	D-280711	340252	1184938	2.93	0.09	0.55	19	0.43	22	6.8	1.9	3.0	0.04
D4C08111	D-280753	340228	1184927	6.61	0.10	0.31	32	0.30	6.9	3.7	1.3	1.9	0.03
D4C08121	D-280746	340228	1184927	6.35	0.11	0.43	31	0.41	6.6	4.3	2.1	2.0	0.03
D5C02111	D-280742	340800	1185858	3.54	0.09	0.55	21	0.43	21	4.8	2.3	2.9	0.04
D5C02121	D-280727	340800	1185858	3.40	0.10	0.54	21	0.44	19	4.8	1.3	2.9	0.04
D5C03111	D-280755	340705	1185935	2.50	0.09	0.41	22	0.35	18	5.3	1.9	4.5	0.03
D5C03211	D-280728	340705	1185935	2.69	0.09	0.70	19	0.55	13	6.1	4.9	3.8	0.05
D5C05111	D-280729	340656	1190020	3.72	0.10	0.51	23	0.44	13	7.3	1.8	3.4	0.04
D5C05121	D-280699	340656	1190020	5.00	0.10	0.41	25	0.35	11	6.9	1.6	2.7	0.03
D5C07111	D-280723	340600	1190100	3.55	0.09	0.22	24	0.22	14	6.4	0.90	7.1	0.01
D5C07211	D-280724	340600	1190100	3.30	0.09	0.42	22	0.37	17	5.4	2.5	4.8	0.03
D5C08111	D-280696	340536	1190045	4.23	0.09	0.40	28	0.34	13	3.0	2.7	2.2	0.03
D5C08121	D-280766	340536	1190045	4.49	0.09	0.39	26	0.31	14	2.8	2.7	2.0	0.03
D5C08122	D-280758	340536	1190045	4.50	0.09	0.46	27	0.36	14	2.9	2.8	2.1	0.03

Appendix VI. Elemental concentrations in *C. megacarpus* from N-S traverses--December collection (continued).

Field #	ppm, Ash weight																	
	Mn	Ba	Cd	Ce	Co	Cr	Cu	La	Li	Mo	Nd	Ni	Pb	Sc	Sr	V	Y	Zn
D1C04111	590	520	< 4	9	7	26	200	13	90	< 4	< 8	71	93	4	1100	13	7	570
D1C04121	530	560	< 4	9	6	18	150	11	52	< 4	< 8	45	61	4	1200	9	6	490
D2C01111	1300	190	< 4	< 8	5	15	120	10	11	7	< 8	24	43	< 4	210	10	< 4	430
D2C01112	1400	190	< 4	< 8	4	18	130	10	12	7	8	25	45	< 4	210	11	< 4	430
D2C01121	1400	210	< 4	< 8	5	22	140	9	8	5	< 8	27	46	< 4	200	10	< 4	440
D2C01211	990	170	< 4	< 8	4	13	170	9	11	< 4	< 8	27	28	< 4	210	7	< 4	550
D2C02111	600	350	< 4	< 8	4	17	140	10	11	< 4	< 8	69	24	< 4	710	12	< 4	400
D2C02121	1400	240	< 4	10	5	11	220	22	200	< 4	< 8	47	41	4	1100	7	13	770
D2C03111	1600	180	< 4	< 8	5	8	190	15	300	< 4	< 8	110	14	< 4	390	< 4	5	690
D2C04111	620	300	< 4	< 8	4	9	120	8	12	< 4	< 8	27	13	< 4	780	< 4	< 4	450
D2C04121	760	270	< 4	< 8	5	8	180	8	15	< 4	< 8	24	14	< 4	760	< 4	< 4	480
D2C04211	1300	830	< 4	9	6	13	180	21	17	< 4	< 8	44	25	< 4	1200	7	8	500
D2C04212	850	350	< 4	< 8	4	13	190	12	20	< 4	< 8	28	34	< 4	930	7	< 4	520
D2C05111	1600	370	< 4	< 8	5	12	200	20	110	< 4	< 8	120	26	< 4	1000	5	6	510
D2C06111	860	420	< 4	< 8	5	7	110	11	50	< 4	< 8	58	22	< 4	870	< 4	< 4	420
D2C06211	1300	390	< 4	< 8	4	15	220	13	39	< 4	< 8	52	37	< 4	730	7	< 4	530
D2C07111	1200	280	< 4	14	5	17	180	14	54	< 4	8	54	49	4	1100	11	7	510
D2C08111	600	130	< 4	< 8	4	13	160	8	6	< 4	9	25	33	< 4	350	6	< 4	430
D2C09111	2100	500	< 4	11	6	11	160	17	43	< 4	9	140	34	< 4	820	9	8	540
D2C09112	2100	480	< 4	< 8	4	10	150	17	42	< 4	10	130	31	< 4	780	7	7	500
D2C09121	2300	560	< 4	16	6	10	140	17	43	< 4	9	120	33	< 4	910	8	8	520
D2C09211	4800	460	< 4	13	6	11	230	14	150	< 4	< 8	210	33	< 4	790	5	8	490
D2C10111	2400	570	< 4	< 8	4	8	210	8	180	< 4	< 8	140	18	< 4	460	< 4	< 4	680
D2C10121	1900	520	< 4	< 8	6	9	240	8	150	< 4	< 8	140	26	< 4	420	< 4	< 4	710
D2C10122	2200	530	< 4	< 8	5	13	210	8	150	< 4	< 8	130	21	< 4	420	5	< 4	640
D3C01111	770	88	< 4	< 8	4	21	260	10	< 4	< 4	< 8	120	50	< 4	260	10	< 4	790
D3C01121	750	64	< 4	< 8	4	14	220	7	< 4	< 4	< 8	110	27	< 4	250	8	< 4	630
D3C02111	780	160	< 4	< 8	4	11	100	9	7	33	< 8	23	16	< 4	500	6	< 4	390
D3C02211	810	190	< 4	< 8	4	6	160	9	14	14	< 8	20	13	< 4	530	< 4	< 4	450
D3C03111	1300	1300	< 4	< 8	5	4	96	8	8	< 4	< 8	47	10	< 4	580	< 4	< 4	270
D3C03121	1500	1000	< 4	< 8	4	5	110	9	9	< 4	< 8	47	14	< 4	530	< 4	< 4	320
D3C04111	860	1000	< 4	15	6	15	140	25	11	< 4	11	34	34	5	1700	8	8	420
D3C04112	830	1000	< 4	17	6	12	140	24	11	< 4	12	33	31	5	1600	7	7	390
D3C04121	500	1200	< 4	10	6	9	150	25	9	< 4	< 8	30	26	5	1800	4	6	400
D3C04211	830	330	< 4	< 8	5	16	170	10	19	< 4	< 8	25	29	< 4	940	6	< 4	500
D3C05111	590	92	< 4	< 8	5	27	160	11	6	< 4	< 8	130	33	< 4	700	7	< 4	350
D3C05121	510	90	< 4	< 8	6	23	160	10	7	< 4	< 8	140	38	< 4	660	9	< 4	350
D3C06111	1300	260	< 4	< 8	4	14	110	11	16	< 4	< 8	71	11	< 4	730	7	< 4	450
D3C07111	2000	350	< 4	< 8	4	7	98	15	20	< 4	< 8	40	14	< 4	570	< 4	< 4	310
D3C07211	1400	160	< 4	< 8	3	10	110	10	21	< 4	< 8	32	21	< 4	270	5	< 4	390
D3C08111	1700	500	< 4	18	5	7	170	14	18	< 4	< 8	35	15	< 4	830	< 4	< 4	600
D3C08121	1400	720	< 4	16	5	9	150	16	18	< 4	< 8	36	15	< 4	1000	< 4	< 4	490
D3C08211	1500	530	< 4	< 8	4	7	110	11	16	< 4	< 8	44	10	< 4	880	< 4	< 4	660
D3C09111	1300	160	< 4	8	4	17	160	26	29	< 4	10	38	47	< 4	790	10	9	570

Appendix VI. Elemental concentrations in *C. megacarpus* from N-S traverses--December collection (continued).

	ppm, Ash weight																	
Field #	Mn	Ba	Cd	Ce	Co	Cr	Cu	La	Li	Mo	Nd	Ni	Pb	Sc	Sr	V	Y	Zn
D4C01111	680	87	< 4	< 8	2	10	130	9	6	< 4	< 8	51	14	< 4	720	5	< 4	380
D4C01211	700	86	< 4	< 8	4	16	160	11	9	< 4	< 8	92	21	< 4	650	7	< 4	500
D4C02111	1200	190	< 4	< 8	4	10	73	7	4	8	< 8	100	8	< 4	880	< 4	< 4	240
D4C02112	1000	190	< 4	< 8	4	9	69	6	< 4	7	< 8	97	< 8	< 4	880	< 4	< 4	230
D4C02121	1100	100	< 4	< 8	3	10	100	6	< 4	13	< 8	63	9	< 4	610	< 4	< 4	270
D4C02211	1100	95	< 4	< 8	4	9	110	10	10	12	< 8	46	11	< 4	610	< 4	< 4	260
D4C03111	1200	200	< 4	< 8	3	14	150	8	22	< 4	< 8	24	19	< 4	1100	6	< 4	580
D4C03211	1200	250	< 4	< 8	3	14	98	8	18	< 4	< 8	26	16	< 4	1200	6	< 4	490
D4C04111	1100	180	< 4	< 8	4	12	250	14	12	< 4	< 8	120	19	< 4	600	5	6	520
D4C04121	1100	180	< 4	< 8	4	9	230	14	12	< 4	< 8	130	15	< 4	620	5	5	510
D4C05111	850	190	< 4	< 8	4	12	110	8	9	13	< 8	66	16	< 4	700	6	< 4	390
D4C05211	690	210	< 4	< 8	3	10	70	7	8	8	< 8	57	13	< 4	680	5	< 4	500
D4C06111	2400	260	< 4	12	3	9	210	12	22	< 4	< 8	98	27	< 4	420	9	< 4	490
D4C07111	1400	340	< 4	< 8	4	13	180	10	17	< 4	< 8	81	16	< 4	680	5	< 4	480
D4C07121	1300	320	< 4	8	5	13	190	15	23	< 4	< 8	100	29	< 4	560	10	4	430
D4C08111	440	320	< 4	< 8	5	12	94	8	< 4	< 4	< 8	54	14	< 4	380	7	< 4	370
D4C08121	790	330	< 4	< 8	4	17	97	8	< 4	< 4	< 8	65	25	< 4	370	10	< 4	440
D5C02111	640	350	< 4	9	4	15	150	10	12	< 4	9	73	26	< 4	730	12	< 4	430
D5C02121	580	330	< 4	< 8	4	15	140	9	12	< 4	< 8	91	20	< 4	670	11	< 4	410
D5C03111	1100	640	< 4	< 8	3	11	220	9	13	< 4	< 8	200	16	< 4	920	8	< 4	420
D5C03211	1400	410	< 4	< 8	6	23	220	10	21	< 4	< 8	200	29	< 4	740	15	< 4	610
D5C05111	1100	94	< 4	< 8	4	17	130	7	9	< 4	< 8	80	20	< 4	430	10	< 4	400
D5C05121	1000	86	< 4	< 8	5	15	130	6	9	< 4	< 8	72	16	< 4	480	9	< 4	320
D5C07111	900	130	< 4	< 8	3	15	150	7	6	< 4	< 8	45	15	< 4	530	5	< 4	420
D5C07211	1300	220	< 4	< 8	5	15	230	8	8	4	< 8	54	25	< 4	530	9	< 4	410
D5C08111	330	120	< 4	< 8	5	14	82	9	7	< 4	< 8	15	24	< 4	280	9	< 4	370
D5C08121	300	120	< 4	< 8	4	13	110	8	7	< 4	< 8	15	24	< 4	250	9	< 4	370
D5C08122	320	130	< 4	< 8	4	15	130	7	7	< 4	< 8	17	27	< 4	260	10	< 4	400

Appendix VII. Elemental concentrations in *Q. agrifolia* from N-S traverse 5--May collection.

Field #	Lab #	Lat	Long	% Dry weight		% Ash weight							
				Ash	S	Al	Ca	Fe	K	Mg	Na	P	Ti
T5Q02111	D-276836	340800	1185858	6.50	0.07	0.98	33	0.61	4.5	4.0	0.32	0.46	0.06
T5Q02121	D-276842	340800	1185858	6.47	0.07	1.4	31	0.88	4.3	3.6	0.42	0.46	0.08
T5Q02122	D-276846	340800	1185858	6.31	0.07	1.2	32	0.76	4.2	3.7	0.36	0.45	0.06
T5Q03111	D-276833	340705	1185935	10.5	0.09	3.2	26	1.9	3.4	3.2	0.91	0.58	0.17
T5Q03211	D-276843	340705	1185935	12.0	0.13	3.7	25	2.3	2.0	3.2	0.90	0.60	0.19
T5Q04111	D-276850	340717	1185948	7.76	0.08	3.1	25	1.8	3.9	4.4	0.88	0.57	0.18
T5Q04112	D-276832	340717	1185948	7.61	0.07	3.1	25	1.8	4.1	4.5	0.87	0.58	0.18
T5Q05111	D-276849	340656	1190020	7.32	0.10	1.0	30	0.74	7.6	5.8	0.50	0.76	0.06
T5Q05121	D-276838	340656	1190020	6.86	0.08	1.1	30	0.73	7.2	5.9	0.56	0.69	0.06
T5Q05122	D-276831	340656	1190020	6.85	0.08	1.1	30	0.74	7.2	5.9	0.55	0.69	0.06
T5Q06111	D-276844	340628	1190038	6.07	0.07	0.69	33	0.47	4.9	6.3	0.51	0.50	0.04
T5Q06211	D-276845	340628	1190038	9.17	0.07	2.5	26	1.4	4.4	5.1	0.85	0.47	0.14
T5Q07111	D-276830	340628	1190038	6.23	0.05	1.8	26	1.2	11	3.3	0.89	0.32	0.12
T5Q07112	D-276834	340600	1190100	6.30	0.05	2.0	26	1.3	11	3.3	0.94	0.31	0.13
T5Q07211	D-276847	340600	1190100	9.95	0.07	0.74	35	0.50	2.7	6.0	0.51	0.47	0.05
T5Q08111	D-276829	340536	1190045	6.52	0.07	1.7	32	1.1	3.4	4.0	0.59	0.57	0.1
T5Q08121	D-276837	340536	1190045	6.87	0.07	1.7	32	1.0	3.4	3.8	0.59	0.55	0.10
T5Q08122	D-276851	340536	1190045	6.62	0.06	1.4	33	0.91	3.3	3.8	0.54	0.54	0.09
T5Q08211	D-276839	340536	1190045	6.62	0.07	1.6	29	1.1	6.2	3.6	0.61	0.58	0.11
T5Q09111	D-276835	340512	1190040	5.75	0.07	2.8	25	2.1	3.5	5.8	1.2	0.57	0.19
T5Q09121	D-276841	340512	1190040	4.72	0.06	2.7	25	2.1	5.0	6.0	1.3	0.65	0.18
T5Q09211	D-276848	340512	1190040	6.98	0.08	1.9	29	1.3	4.4	5.4	0.81	0.73	0.12
T5Q10111	D-276840	340445	1190040	7.30	0.06	1.5	27	0.97	12	4.4	0.82	0.37	0.1

Field #	ppm, Ash weight																		
	Mn	Ba	Cd	Ce	Co	Cr	Cu	Ga	La	Li	Mo	Nd	Ni	Pb	Sc	Sr	V	Y	Zn
T5Q02111	15000	2100	5	15	10	17	110	12	5	7	< 4	< 8	48	170	< 4	1200	20	5	170
T5Q02121	21000	2700	7	19	12	16	150	17	8	8	< 4	< 8	59	190	< 4	1000	31	8	200
T5Q02122	22000	2800	6	15	12	16	140	17	7	7	< 4	< 8	53	170	< 4	1100	26	7	190
T5Q03111	3000	740	4	28	18	64	96	8	14	13	< 4	12	84	220	7	990	79	10	280
T5Q03211	6700	2000	7	33	24	42	130	14	16	16	< 4	16	120	310	8	1200	100	13	410
T5Q04111	3000	810	9	30	16	55	98	8	15	12	< 4	12	66	160	6	730	58	11	190
T5Q04112	3000	810	9	27	17	55	95	8	14	11	< 4	10	63	160	6	730	58	11	190
T5Q05111	4300	1400	53	< 8	11	18	93	< 8	< 4	5	< 4	< 8	46	91	< 4	870	32	< 4	130
T5Q05121	4400	1600	52	< 8	9	14	94	< 8	< 4	5	< 4	< 8	39	65	< 4	870	28	< 4	100
T5Q05122	4300	1600	57	< 8	9	27	89	< 8	< 4	5	< 4	< 8	40	64	< 4	880	28	< 4	96
T5Q06111	4500	870	10	< 8	6	9	49	< 8	< 4	< 4	< 4	< 8	28	47	< 4	540	15	< 4	82
T5Q06211	5400	770	< 4	23	12	26	88	< 8	12	9	< 4	< 8	61	160	5	530	42	8	170
T5Q07111	3400	450	7	16	10	49	110	< 8	6	8	< 4	< 8	49	130	4	790	33	5	130
T5Q07112	3400	460	7	15	12	43	110	< 8	8	8	< 4	< 8	51	130	5	780	36	6	140
T5Q07211	3900	710	5	8	7	17	66	< 8	< 4	< 4	< 4	< 8	25	49	< 4	930	16	< 4	78
T5Q08111	4600	980	20	16	10	27	97	< 8	6	7	< 4	< 8	57	220	< 4	620	32	4	170
T5Q08121	4300	940	22	14	10	21	92	< 8	7	6	< 4	< 8	55	210	< 4	620	32	4	160
T5Q08122	4800	960	20	12	10	29	89	< 8	5	6	< 4	< 8	49	190	< 4	610	28	4	140
T5Q08211	4300	910	< 4	14	7	25	75	< 8	7	8	< 4	< 8	51	200	< 4	550	33	4	140
T5Q09111	3600	1500	5	23	22	72	140	10	14	12	< 4	13	120	330	7	920	71	9	350
T5Q09121	3600	1600	5	28	20	75	180	10	16	11	< 4	11	130	470	7	890	71	10	410
T5Q09211	6200	2800	10	16	17	30	140	8	10	10	< 4	< 8	110	290	4	1100	45	6	310
T5Q10111	2700	520	< 4	16	10	36	100	< 8	8	7	< 4	< 8	55	300	< 4	760	27	5	180

Appendix VIII. Elemental concentrations in *Q. agrifolia* from N-S traverse 5--December collection.

				% Dry weight		% Ash weight							
Field #	Lab #	Lat	Long	Ash	S	Al	Ca	Fe	K	Mg	Na	P	Ti
D5Q02111	D-280772	340800	1185858	6.89	0.05	0.90	33	0.54	5.2	4.6	0.28	0.44	0.06
D5Q02121	D-280776	340800	1185858	6.46	0.04	0.67	33	0.44	6.0	4.6	0.22	0.48	0.04
D5Q02122	D-280790	340800	1185858	6.46	0.05	0.60	33	0.40	5.6	4.4	0.20	0.47	0.03
D5Q03111	D-280782	340705	1185935	6.81	0.05	0.76	25	0.44	14	5.8	0.46	0.78	0.05
D5Q03211	D-280783	340705	1185935	9.03	0.06	1.5	30	0.86	4.8	5.2	0.45	0.51	0.08
D5Q04111	D-280784	340717	1185948	5.80	0.04	1.0	29	0.61	6.6	6.7	0.34	0.86	0.06
D5Q04112	D-280780	340717	1185948	5.77	0.03	1.0	29	0.60	6.9	6.8	0.34	0.87	0.06
D5Q05111	D-280771	340656	1190020	5.86	0.05	1.3	28	0.88	11	5.8	0.48	0.66	0.08
D5Q05121	D-280778	340656	1190020	6.76	0.06	1.6	27	1.0	8.1	5.6	0.64	0.69	0.09
D5Q05122	D-280769	340656	1190020	6.81	0.06	1.6	27	1.0	8.2	5.7	0.63	0.70	0.09
D5Q06111	D-280781	340628	1190038	8.27	0.06	1.0	33	0.62	3.2	5.2	0.49	0.44	0.06
D5Q06211	D-280774	340628	1190038	8.46	0.05	1.8	29	0.97	4.6	5.9	0.64	0.45	0.10
D5Q07111	D-280773	340628	1190038	6.45	0.03	1.7	25	1.2	13	3.8	0.88	0.33	0.12
D5Q07112	D-280770	340600	1190100	6.40	0.03	1.4	24	1.1	13	3.8	0.85	0.31	0.12
D5Q07211	D-280777	340600	1190100	11.7	0.06	0.60	35	0.40	3.1	5.6	0.43	0.38	0.04
D5Q08111	D-280787	340536	1190045	7.83	0.04	1.0	32	0.61	5.2	4.9	0.44	0.56	0.07
D5Q08121	D-280788	340536	1190045	7.84	0.02	0.95	33	0.58	5.2	5.5	0.41	0.61	0.06
D5Q08122	D-280789	340536	1190045	7.95	0.04	1.1	32	0.64	5.2	5.5	0.44	0.62	0.07
D5Q08211	D-280786	340536	1190045	6.47	0.05	1.5	25	0.89	11	4.9	0.54	0.74	0.1
D5Q09111	D-280785	340512	1190040	4.48	0.04	2.2	25	1.5	7.1	7.0	1.1	0.66	0.15
D5Q09121	D-280768	340512	1190040	4.96	0.05	2.2	23	1.5	9.5	6.4	1.2	0.51	0.15
D5Q09211	D-280779	340512	1190040	6.22	0.04	0.98	31	0.65	5.9	6.7	0.49	0.74	0.07
D5Q10111	D-280775	340445	1190040	6.88	0.03	0.29	17	0.21	24	4.8	0.65	0.74	0.02

	ppm, Ash weight																	
Field #	Mn	Ba	Cd	Ce	Co	Cr	Cu	Ga	La	Li	Mo	Nd	Ni	Pb	Sc	Sr	V	Y	Zn
D5Q02111	12000	1800	5	< 8	8	11	93	13	14	8	< 4	< 8	32	130	5	1100	17	< 4	96
D5Q02121	23000	2800	5	< 8	9	12	130	19	14	6	< 4	< 8	37	110	4	1000	14	< 4	120
D5Q02122	24000	2800	6	< 8	10	10	120	20	13	6	< 4	< 8	36	110	4	1000	12	< 4	120
D5Q03111	1800	380	< 4	10	7	12	69	< 8	11	5	< 4	< 8	23	53	< 4	750	15	< 4	110
D5Q03211	6500	2300	7	11	13	16	92	9	15	8	< 4	< 8	56	160	6	1200	35	4	210
D5Q04111	2300	540	10	< 8	8	10	78	< 8	12	5	< 4	< 8	28	71	4	760	19	< 4	92
D5Q04112	2300	550	11	10	7	8	75	< 8	13	5	< 4	< 8	28	71	4	770	19	< 4	100
D5Q05111	4400	1500	71	< 8	11	17	100	9	12	7	< 4	< 8	47	62	5	770	28	< 4	100
D5Q05121	4400	1700	53	9	12	17	100	< 8	14	7	< 4	< 8	44	83	5	780	34	< 4	100
D5Q05122	4500	1700	51	< 8	11	17	99	9	13	7	< 4	< 8	46	84	5	770	34	4	110
D5Q06111	4800	840	10	< 8	7	15	42	< 8	12	5	< 4	< 8	31	67	< 4	540	19	< 4	81
D5Q06211	5500	680	< 4	15	10	19	72	10	17	7	< 4	< 8	50	130	4	520	28	5	130
D5Q07111	3300	440	6	9	12	19	110	< 8	17	7	< 4	< 8	43	140	6	700	32	6	140
D5Q07112	3400	430	7	10	10	17	110	< 8	17	7	< 4	9	40	130	5	680	29	5	130
D5Q07211	3600	660	5	< 8	7	23	59	< 8	10	< 4	< 4	< 8	24	43	< 4	920	13	< 4	76
D5Q08111	2200	590	23	< 8	8	11	55	< 8	13	4	< 4	< 8	34	120	< 4	610	18	< 4	97
D5Q08121	2300	640	22	< 8	7	8	49	< 8	14	4	< 4	< 8	31	90	< 4	610	16	< 4	78
D5Q08122	2100	610	22	< 8	7	9	45	< 8	13	4	< 4	< 8	32	94	< 4	600	17	< 4	76
D5Q08211	3600	840	4	13	9	14	70	< 8	16	8	< 4	< 8	45	160	4	450	25	< 4	120
D5Q08111	3700	1600	5	18	16	29	140	9	21	9	< 4	< 8	94	320	7	840	50	7	300
D5Q09121	3000	1400	4	15	13	52	110	10	16	9	< 4	9	69	200	7	770	44	6	170
D5Q09211	5100	2700	10	8	11	15	96	< 8	13	7	< 4	< 8	66	180	5	1100	21	< 4	170
D5Q10111	1500	220	< 4	< 8	5	8	160	< 8	8	< 4	< 4	< 8	15	26	< 4	430	5	< 4	88

Appendix IX. Elemental concentrations in soils from E-W crestline traverse--May collection.

Field #	Lab #	Lat	Long	pH	C, total	C, org	C, crbnt	S	Al	Ca	Fe	K	Mg	Na	P	Ti
					Percent											
R1SH2	D-275704	340740	1181830	6.59	3.12	3.12	< 0.01	0.02	7.4	2.0	2.9	2.2	0.72	1.9	0.06	0.36
R1SS1	D-275722	340740	1181830	6.86	6.81	6.79	0.02	0.03	7.0	2.7	3.2	1.6	1.1	1.7	0.13	0.35
R2SH1	D-275656	340618	1183322	6.40	1.16	1.16	< 0.01	< 0.01	5.9	0.46	1.9	2.9	0.43	1.2	0.03	0.17
R2SS1	D-275680	340618	1183322	6.57	0.51	0.51	< 0.01	< 0.01	5.5	0.37	1.8	2.8	0.38	0.90	0.03	0.21
R4SH1	D-275695	340500	1183817	6.49	3.56	3.56	< 0.01	0.02	7.4	1.7	3.1	1.9	0.87	2.3	0.07	0.33
R4SS2	D-275697	340500	1183817	7.75	1.11	1.11	< 0.01	0.01	6.7	0.90	2.1	1.6	0.69	2.8	0.04	0.27
R5SH2	D-275714	340507	1184630	6.55	0.81	0.81	< 0.01	0.01	5.5	0.27	1.5	3.4	0.28	1.6	0.03	0.18
R5SH2X	D-275685	340507	1184630	6.62	0.82	0.82	< 0.01	0.01	5.4	0.26	1.4	2.6	0.25	1.6	0.03	0.17
R5SS2	D-275663	340507	1184630	6.95	0.67	0.67	< 0.01	< 0.01	5.7	0.25	1.6	3.0	0.28	1.6	0.04	0.19
R6SH2	D-275684	340548	1185003	6.64	4.29	4.27	0.02	< 0.01	7.8	2.4	4.1	0.76	2.0	2.2	0.07	0.61
R6SS1	D-275721	340548	1185003	7.42	1.96	1.96	< 0.01	0.01	8.0	1.9	4.6	0.88	1.9	1.8	0.05	0.64
R7SH2	D-275710	340630	1185420	6.89	0.84	0.84	< 0.01	< 0.01	7.9	0.33	5.6	7.4	2.0	0.32	0.02	0.60
R7SS2	D-275726	340630	1185420	7.23	1.89	1.89	< 0.01	0.01	7.3	1.9	5.4	3.8	3.1	1.6	0.06	0.66
R8SS2	D-275651	340712	1185538	6.92	4.28	4.26	0.02	0.02	8.4	2.2	3.5	0.79	1.0	1.9	0.05	0.42
R8SS2X	D-275673	340712	1185538	6.95	4.44	4.42	0.02	0.02	8.5	2.2	3.5	0.80	1.1	2.0	0.05	0.42
R9SH1	D-275675	340625	1190140	7.47	1.79	1.79	< 0.01	0.02	7.2	1.5	6.2	1.4	2.1	1.5	0.04	0.53
R9SS2	D-275696	340625	1190140	7.89	1.38	0.43	0.95	< 0.01	6.5	6.5	7.6	0.67	5.2	1.6	0.04	0.61

Field #	Mn	As	Ba	Ba	Cd	Ce	Co	Cr	Cu	Ga	La	Li	Mo	Nb	Nd	Ni	Pb	Sc	Sr	Th	V	Y	Yb	Zn
	ppm																							
R1SH2	430	< 10	810	1	< 2	50	12	45	16	16	28	27	< 2	6	21	30	41	7	380	8	66	12	1	60
R1SS1	480	< 10	580	1	< 2	45	15	66	28	17	25	29	< 2	5	20	50	100	9	350	5	67	13	1	140
R2SH1	280	< 10	1400	1	< 2	75	6	14	11	12	39	11	< 2	5	27	7	26	4	200	12	35	12	1	30
R2SS1	310	< 10	1400	< 1	< 2	66	7	24	9	10	36	9	< 2	4	27	10	19	4	170	12	38	10	1	20
R4SH1	710	< 10	1000	1	< 2	64	10	43	15	18	34	32	< 2	6	24	26	26	7	340	9	62	17	2	50
R4SS2	360	< 10	1100	1	< 2	45	9	45	8	14	24	14	< 2	< 4	16	27	15	5	280	7	44	10	< 1	30
R5SH2	300	< 10	1400	< 1	< 2	66	5	18	10	11	38	8	< 2	< 4	26	12	24	3	200	14	35	10	< 1	30
R5SH2X	260	< 10	1300	< 1	< 2	56	5	19	9	10	32	8	< 2	< 4	25	9	24	3	190	12	32	10	1	30
R5SS2	290	< 10	1300	< 1	< 2	62	6	20	9	11	34	8	< 2	< 4	23	10	16	4	190	12	36	10	< 1	20
R6SH2	730	< 10	240	< 1	< 2	22	23	130	27	17	13	14	< 2	5	16	60	7	12	230	< 4	99	13	2	60
R6SS1	860	< 10	250	< 1	< 2	31	25	130	29	20	14	17	< 2	6	15	76	4	15	200	< 4	100	16	2	60
R7SH2	1300	70	1500	< 1	< 2	20	33	130	38	20	9	27	< 2	< 4	11	120	4	15	220	< 4	130	17	2	70
R7SS2	1200	50	680	< 1	< 2	23	32	200	35	19	10	33	< 2	5	13	130	7	16	240	< 4	120	16	2	70
R8SS2	530	< 10	300	< 1	< 2	29	17	50	25	17	14	25	< 2	< 4	14	33	11	10	200	< 4	73	13	1	50
R8SS2X	540	< 10	300	< 1	< 2	30	17	52	25	18	14	26	< 2	< 4	14	34	11	10	210	4	74	13	1	50
R9SH1	1100	< 10	560	1	3	40	35	230	65	18	23	28	3	< 4	23	120	14	21	140	6	170	23	2	90
R9SS2	1400	< 10	260	< 1	< 2	16	61	370	49	17	7	19	< 2	< 4	8	260	< 4	22	160	< 4	130	19	2	80

Appendix X. Elemental concentrations in *R. laurina* from E-W crestline traverse--May collection.

				%, Dry weight		%, Ash weight							
Field #	Lab #	Lat	Long	Ash	S	Al	Ca	Fe	K	Mg	Na	P	Ti
R1RN1111	D-276789	340740	1181830	3.62	0.16	0.37	17	0.34	29	3.8	0.31	4.8	0.03
R1RN1211	D-276773	340740	1181830	4.31	0.17	0.39	13	0.35	34	3.3	0.35	5.0	0.03
R1RN2111	D-276774	340740	1181830	4.31	0.16	0.32	12	0.30	38	2.3	0.41	5.2	0.02
R1RN2112	D-276762	340740	1181830	4.30	0.16	0.33	12	0.30	39	2.3	0.41	5.3	0.02
R1RN2121	D-276757	340740	1181830	3.78	0.15	0.30	12	0.28	36	2.6	0.25	5.6	0.02
R1RS1211	D-276760	340740	1181830	3.33	0.14	0.50	15	0.41	24	8.3	0.68	5.6	0.03
R1RS2111	D-276763	340740	1181830	3.67	0.16	0.74	14	0.56	31	4.5	0.93	4.6	0.05
R1RS2121	D-276771	340740	1181830	4.17	0.16	0.38	13	0.32	34	4.3	0.29	5.1	0.03
R2RN1111	D-276807	340618	1183322	4.13	0.17	0.25	8.5	0.23	35	3.7	0.30	6.6	0.01
R2RN2111	D-276786	340618	1183322	4.36	0.17	0.30	8.6	0.27	39	2.7	0.60	6.5	0.02
R2RN2121	D-276793	340618	1183322	3.50	0.15	0.35	13	0.29	31	4.4	0.74	4.9	0.02
R2RS1111	D-276761	340618	1183322	3.72	0.13	0.41	6.7	0.30	42	3.0	0.45	4.8	0.02
R2RS1112	D-276811	340618	1183322	4.18	0.14	0.41	6.3	0.29	37	2.9	0.43	4.4	0.02
R2RS1211	D-276810	340618	1183322	3.67	0.15	0.23	8.2	0.21	36	3.4	0.21	4.9	0.02
R2RS2111	D-276782	340618	1183322	3.67	0.12	0.30	13	0.27	34	4.6	0.35	4.5	0.02
R2RS2121	D-276778	340618	1183322	3.77	0.11	0.30	13	0.23	35	4.0	0.28	3.8	0.02
R4RN1111	D-276809	340500	1183817	4.00	0.21	0.15	15	0.18	25	4.6	0.29	8.3	0.01
R4RN1112	D-276779	340500	1183817	3.95	0.21	0.16	16	0.19	26	4.6	0.30	8.7	0.01
R4RN1211	D-276784	340500	1183817	3.23	0.13	0.22	17	0.22	25	4.5	0.37	6.7	0.02
R4RN2111	D-276803	340500	1183817	3.73	0.16	0.18	13	0.19	29	4.8	0.23	7.4	0.01
R4RN2121	D-276781	340500	1183817	3.86	0.18	0.15	10	0.18	33	4.3	0.22	9.1	0.01
R4RS1111	D-276785	340500	1183817	3.40	0.17	0.16	13	0.16	32	4.7	0.19	7.6	0.01
R4RS1112	D-276808	340500	1183817	4.16	0.17	0.17	8.2	0.18	35	3.8	0.39	6.3	0.01
R4RS1121	D-276813	340500	1183817	3.26	0.17	0.19	16	0.18	24	6.0	0.23	7.9	0.01
R4RS2111	D-276758	340500	1183817	3.58	0.18	0.13	11	0.17	36	4.9	0.1	8.5	0.01
R4RS2211	D-276791	340500	1183817	3.30	0.15	0.13	13	0.17	30	5.6	0.28	6.9	0.01
R5RN1111	D-276806	340507	1184630	4.28	0.17	0.17	8.1	0.15	37	3.4	0.23	6.0	0.01
R5RN1211	D-276766	340507	1184630	4.13	0.15	0.24	9.7	0.19	35	5.1	0.23	6.1	0.02
R5RN2111	D-276799	340507	1184630	3.74	0.12	0.15	14	0.19	30	5.7	0.25	5.0	0.01
R5RN2112	D-276765	340500	1184630	3.71	0.12	0.15	15	0.19	31	5.6	0.25	5.1	0.01
R5RN2121	D-276792	340507	1184630	3.48	0.12	0.26	15	0.24	29	5.9	0.40	4.5	0.02
R5RS1111	D-276767	340507	1184630	4.00	0.17	0.19	9.0	0.20	40	4.1	0.41	6.9	0.01
R5RS1121	D-276817	340507	1184630	4.17	0.17	0.17	9.4	0.19	34	4.3	0.43	6.2	0.01
R5RS2111	D-276776	340507	1184630	4.82	0.19	0.18	8.2	0.17	39	3.8	0.57	5.6	0.01
R5RS2211	D-276790	340507	1184630	3.79	0.16	0.26	12	0.21	35	3.6	0.67	5.8	0.02
R5RS2212	D-276821	340500	1184630	3.95	0.16	0.25	12	0.21	34	3.6	0.67	5.7	0.02

Appendix X. Elemental concentrations in *R. laurina* from E-W crestline traverse--May collection (continued).

				%, Dry weight		%, Ash weight							
Field #	Lab #	Lat	Long	Ash	S	Al	Ca	Fe	K	Mg	Na	P	Ti
R6RN1111	D-276794	340548	1185003	3.07	0.14	0.22	13	0.23	33	3.5	0.32	6.5	0.02
R6RN2111	D-276800	340548	1185003	4.22	0.17	0.14	7.5	0.17	40	2.6	0.19	7.4	0.01
R6RN2112	D-276797	340548	1185003	4.67	0.17	0.15	7.5	0.16	40	2.5	0.19	7.3	0.01
R6RS1111	D-276802	340548	1185003	3.60	0.15	0.19	12	0.19	35	3.3	0.26	6.2	0.01
R6RS1211	D-276775	340548	1185003	4.25	0.18	0.23	14	0.24	32	4.8	0.36	6.8	0.01
R6RS2111	D-276788	340548	1185003	3.02	0.11	0.21	9.7	0.20	37	3.0	0.40	6.8	0.01
R6RS2121	D-276787	340548	1185003	2.82	0.10	0.16	9.6	0.18	38	3.1	0.25	7.2	0.01
R7RN1111	D-276770	340630	1185420	3.81	0.16	0.15	9.5	0.20	40	3.6	0.23	6.4	0.01
R7RN1211	D-276805	340630	1185420	4.23	0.17	0.12	10	0.20	36	3.7	0.18	5.5	0.01
R7RN2111	D-276804	340630	1185420	4.49	0.19	0.34	13	0.18	32	4.8	0.19	5.7	0.02
R7RN2121	D-276819	340630	1185420	4.16	0.18	0.13	13	0.17	31	5.2	0.39	5.7	0.01
R7RS1111	D-276795	340630	1185420	3.74	0.15	0.23	13	0.25	33	3.7	0.56	5.9	0.02
R7RS1121	D-276772	340630	1185420	3.58	0.13	0.14	12	0.16	36	3.8	0.21	6.0	0.01
R7RS2111	D-276764	340630	1185420	4.26	0.16	0.14	8.2	0.19	41	3.5	0.25	8.4	0.01
R7RS2211	D-276798	340630	1185420	4.61	0.16	0.16	11	0.16	36	3.5	0.31	5.6	0.01
R8RS1111	D-276759	340712	1185538	4.09	0.15	0.20	12	0.19	38	3.0	0.38	6.8	0.01
R8RS1211	D-276818	340712	1185538	4.73	0.17	0.12	7.8	0.14	38	2.2	0.26	6.8	0.01
R8RS2111	D-276780	340712	1185538	4.28	0.15	0.12	13	0.16	37	2.6	0.17	6.5	0.01
R8RS2121	D-276820	340712	1185538	4.43	0.16	0.09	12	0.14	36	2.5	0.15	6.2	0.01
R9RN1111	D-276801	340625	1190140	3.66	0.15	0.25	10	0.20	35	3.3	1.3	6.2	0.02
R9RN1211	D-276814	340625	1190140	4.17	0.16	0.36	9.9	0.29	32	3.2	2.5	5.8	0.02
R9RN2111	D-276783	340625	1190140	4.48	0.16	0.17	8.8	0.17	39	3.2	0.53	5.3	0.01
R9RN2121	D-276768	340625	1190140	3.82	0.15	0.19	11	0.19	40	4.1	0.80	6.1	0.01
R9RS1111	D-276769	340625	1190140	3.53	0.14	0.24	18	0.20	30	3.7	0.77	4.2	0.02
R9RS1112	D-276777	340625	1190140	3.57	0.13	0.23	18	0.20	28	3.6	0.75	4.0	0.01
R9RS1121	D-276796	340625	1190140	3.83	0.13	0.20	12	0.18	36	2.9	0.51	4.8	0.01
R9RS2111	D-276815	340625	1190140	3.54	0.15	0.20	13	0.28	30	4.6	0.44	6.4	0.01
R9RS2211	D-276816	340625	1190140	3.62	0.12	0.23	16	0.21	26	5.0	0.74	5.5	0.01
R9RS2212	D-276812	340625	1190140	3.68	0.13	0.26	16	0.23	26	5.0	0.77	5.6	0.01

Appendix X. Elemental concentrations in *R. laurina* from E-W crestline traverse--May collection (continued).

Field #	ppm, Ash weight																	
	Mn	Ba	Cd	Ce	Co	Cr	Cu	La	Li	Mo	Nd	Ni	Pb	Sc	Sr	V	Y	Zn
R1RN1111	1200	170	< 4	< 8	7	9	110	6	< 4	< 4	< 8	66	51	< 4	540	6	< 4	540
R1RN1211	1300	180	< 4	< 8	8	13	130	6	6	5	< 8	89	52	< 4	430	7	< 4	700
R1RN2111	1300	120	< 4	< 8	5	10	140	5	7	< 4	< 8	90	40	< 4	400	5	< 4	500
R1RN2112	1300	120	< 4	< 8	6	11	150	< 4	8	< 4	< 8	93	40	< 4	420	6	< 4	510
R1RN2121	1500	150	< 4	8	7	16	160	6	5	< 4	< 8	88	38	< 4	480	5	< 4	560
R1RS1211	1300	170	< 4	< 8	7	22	130	6	8	< 4	< 8	99	81	< 4	540	9	< 4	740
R1RS2111	1300	200	< 4	10	5	19	150	9	7	< 4	< 8	88	110	< 4	410	13	< 4	610
R1RS2121	1100	120	62	< 8	4	12	110	< 4	< 4	< 4	< 8	52	50	< 4	350	7	< 4	560
R2RN1111	2800	150	< 4	11	4	8	170	6	9	< 4	< 8	44	17	< 4	400	< 4	5	550
R2RN2111	2300	160	< 4	27	6	11	160	8	17	< 4	< 8	49	31	< 4	500	6	8	480
R2RN2121	4800	370	< 4	26	15	8	120	16	36	< 4	< 8	62	33	< 4	1000	6	21	500
R2RS1111	2900	200	< 4	< 8	7	8	110	8	8	< 4	< 8	25	22	< 4	340	6	< 4	520
R2RS1112	290G	200	< 4	< 8	6	9	97	7	7	< 4	< 8	25	23	< 4	310	5	< 4	490
R2RS1211	3000	380	< 4	10	5	7	83	6	5	< 4	< 8	19	13	< 4	490	< 4	< 4	500
R2RS2111	2700	330	< 4	< 8	5	6	120	< 4	18	< 4	< 8	30	15	< 4	620	4	< 4	590
R2RS2121	4000	350	< 4	9	5	4	130	5	18	< 4	< 8	27	14	< 4	730	< 4	< 4	630
R4RN1111	3800	180	< 4	< 8	4	7	97	6	< 4	< 4	< 8	40	8	< 4	500	< 4	< 4	670
R4RN1112	3700	180	4	< 8	3	9	110	5	< 4	< 4	< 8	43	18	< 4	520	< 4	< 4	670
R4RN1211	1500	100	96	< 8	4	7	100	5	5	< 4	< 8	48	9	< 4	480	< 4	< 4	430
R4RN2111	1400	55	< 4	< 8	3	8	160	6	11	4	< 8	37	11	< 4	310	< 4	< 4	630
R4RN2121	1200	51	< 4	< 8	3	8	200	< 4	8	4	< 8	44	< 8	< 4	230	< 4	< 4	700
R4RS1111	1600	69	21	< 8	3	7	120	< 4	< 4	< 4	< 8	40	< 8	< 4	330	< 4	< 4	550
R4RS1112	2300	240	< 4	9	4	9	190	4	< 4	< 4	< 8	110	17	< 4	340	< 4	10	540
R4RS1121	1800	59	< 4	< 8	3	7	120	5	< 4	< 4	< 8	83	11	< 4	430	< 4	4	450
R4RS2111	820	34	< 4	< 8	3	10	78	< 4	< 4	< 4	< 8	28	< 8	< 4	180	< 4	< 4	760
R4RS2211	970	53	< 4	< 8	3	5	110	< 4	5	< 4	< 8	28	12	< 4	330	< 4	< 4	750
R5RN1111	6000	160	< 4	19	16	6	150	12	< 4	< 4	< 8	100	< 8	< 4	630	< 4	10	650
R5RN1211	8300	370	< 4	39	11	9	130	28	< 4	< 4	17	68	10	< 4	920	< 4	19	700
R5RN2111	5700	610	< 4	< 8	6	5	81	4	< 4	< 4	< 8	35	10	< 4	650	< 4	< 4	600
R5RN2112	5500	600	< 4	< 8	6	7	87	< 4	< 4	< 4	< 8	35	11	< 4	670	< 4	< 4	590
R5RN2121	4600	830	< 4	22	9	6	82	11	6	< 4	< 8	39	12	< 4	850	4	9	460
R5RS1111	2300	260	< 4	8	4	8	210	< 4	< 4	< 4	< 8	120	13	< 4	380	< 4	10	590
R5RS1121	2500	320	< 4	10	4	9	170	7	< 4	< 4	< 8	110	13	< 4	440	< 4	13	510
R5RS2111	4900	190	< 4	14	7	5	160	14	4	< 4	< 8	97	14	< 4	320	< 4	10	670
R5RS2211	4500	400	< 4	22	8	8	140	9	6	< 4	< 8	58	22	< 4	520	5	6	440
R5RS2212	4700	400	< 4	12	7	9	120	10	5	< 4	< 8	58	21	< 4	500	5	5	450

Appendix X. Elemental concentrations in *R. laurina* from E-W crestline traverse--May collection (continued).

	ppm, Ash weight																	
Field #	Mn	Ba	Cd	Ce	Co	Cr	Cu	La	Li	Mo	Nd	Ni	Pb	Sc	Sr	V	Y	Zn
R6RN1111	660	54	< 4	< 8	3	10	130	< 4	< 4	< 4	< 8	130	10	< 4	300	< 4	< 4	500
R6RN2111	530	31	< 4	< 8	< 2	9	160	< 4	< 4	< 4	< 8	52	< 8	< 4	140	< 4	< 4	630
R6RN2112	520	33	< 4	< 8	3	8	150	< 4	< 4	< 4	< 8	49	< 8	< 4	150	< 4	< 4	550
R6RS1111	1100	69	< 4	< 8	3	7	150	< 4	< 4	< 4	< 8	68	10	< 4	270	< 4	< 4	750
R6RS1211	1100	48	< 4	< 8	3	12	170	< 4	< 4	< 4	< 8	46	9	< 4	270	4	< 4	670
R6RS2111	1100	37	< 4	< 8	3	7	140	< 4	< 4	< 4	< 8	21	9	< 4	170	4	< 4	630
R6RS2121	1100	33	< 4	< 8	2	8	140	< 4	< 4	< 4	< 8	20	9	< 4	170	< 4	< 4	660
R7RN1111	2200	100	< 4	< 8	5	5	170	< 4	< 4	< 4	< 8	150	< 8	< 4	110	< 4	6	590
R7RN1211	1200	76	< 4	< 8	3	6	160	< 4	< 4	< 4	< 8	68	< 8	< 4	90	< 4	5	750
R7RN2111	1000	33	< 4	< 8	4	8	210	< 4	< 4	< 4	< 8	68	< 8	< 4	200	< 4	< 4	690
R7RN2121	920	46	< 4	< 8	3	5	130	< 4	< 4	< 4	< 8	62	< 8	< 4	220	< 4	< 4	480
R7RS1111	1500	67	< 4	< 8	4	10	82	< 4	< 4	< 4	< 8	49	12	< 4	180	5	< 4	380
R7RS1121	1500	56	< 4	< 8	4	6	82	< 4	< 4	< 4	< 8	43	9	< 4	170	< 4	< 4	350
R7RS2111	1100	31	< 4	< 8	2	5	180	< 4	< 4	< 4	< 8	110	< 8	< 4	170	< 4	< 4	810
R7RS2211	1000	38	< 4	< 8	2	7	120	< 4	< 4	< 4	< 8	35	11	< 4	210	< 4	< 4	520
R8RS1111	700	75	< 4	< 8	3	7	210	< 4	< 4	< 4	< 8	53	< 8	< 4	230	< 4	< 4	640
R8RS1211	680	43	< 4	< 8	< 2	7	150	< 4	< 4	< 4	< 8	43	9	< 4	130	< 4	< 4	480
R8RS2111	1300	120	< 4	< 8	4	6	180	< 4	< 4	< 4	< 8	21	< 8	< 4	400	< 4	< 4	460
R8RS2121	1100	110	< 4	< 8	3	8	170	< 4	< 4	< 4	< 8	22	< 8	< 4	340	< 4	< 4	460
R9RN1111	980	55	8	10	2	8	150	< 4	< 4	< 4	< 8	76	9	< 4	97	4	< 4	570
R9RN1211	650	90	9	8	4	14	100	< 4	4	< 4	< 8	76	10	< 4	160	6	< 4	480
R9RN2111	740	68	< 4	< 8	3	6	150	< 4	< 4	< 4	< 8	57	< 8	< 4	150	4	< 4	460
R9RN2121	940	79	5	< 8	4	7	160	< 4	< 4	< 4	< 8	56	< 8	< 4	170	5	< 4	630
R9RS1111	790	80	5	< 8	3	6	90	< 4	< 4	5	< 8	55	9	< 4	160	5	< 4	390
R9RS1112	760	80	5	< 8	3	6	90	< 4	< 4	4	< 8	54	9	< 4	160	4	< 4	380
R9RS1121	770	78	< 4	< 8	3	9	100	< 4	< 4	5	< 8	65	10	< 4	94	< 4	< 4	420
R9RS2111	780	26	< 4	< 8	5	12	190	< 4	< 4	7	< 8	93	< 8	< 4	63	< 4	< 4	650
R9RS2211	950	46	< 4	< 8	3	8	110	< 4	< 4	6	< 8	52	12	< 4	95	< 4	< 4	580
R9RS2212	960	49	< 4	< 8	3	10	120	< 4	< 4	6	< 8	54	12	< 4	97	5	< 4	580

Appendix XI. Elemental concentrations in *R. laurina* from E-W crestline traverse--December collection.

				%, Dry weight		%, Ash weight							
Field #	Lab #	Lat	Long	Ash	S	Al	Ca	Fe	K	Mg	Na	P	Ti
D1RN1111	D-280682	340740	1181830	4.04	0.07	0.23	27	0.22	9.7	5.8	0.20	2.2	0.02
D1RN1211	D-280676	340740	1181830	3.62	0.08	0.35	25	0.33	14	4.7	0.35	2.3	0.03
D1RN2111	D-280638	340740	1181830	3.28	0.08	0.30	29	0.31	16	3.7	0.47	1.9	0.02
D1RN2112	D-280678	340740	1181830	4.29	0.08	0.26	27	0.26	14	3.7	0.45	1.9	0.02
D1RN2121	D-280679	340740	1181830	4.48	0.08	0.19	28	0.19	13	4.0	0.23	2.0	0.02
D1RS1111	D-280667	340740	1181830	3.67	0.08	0.43	21	0.41	9.9	13	1.5	2.2	0.04
D1RS1211	D-280690	340740	1181830	4.15	0.08	0.27	24	0.24	8.1	12	0.67	1.9	0.02
D1RS2111	D-280659	340740	1181830	3.80	0.09	0.36	27	0.37	13	6.7	0.99	2.3	0.03
D1RS2121	D-280692	340740	1181830	3.80	0.09	0.30	24	0.27	15	6.9	0.20	2.3	0.02
D2RN1111	D-280670	340618	1183322	3.07	0.06	0.23	18	0.23	26	5.8	0.39	3.2	0.02
D2RN2111	D-280639	340618	1183322	3.54	0.09	0.21	23	0.20	21	7.4	0.46	2.9	0.01
D2RN2121	D-280685	340618	1183322	3.51	0.08	0.17	20	0.16	20	7.7	0.31	2.9	0.01
D2RS1111	D-280633	340618	1183322	2.85	0.07	0.24	23	0.21	19	6.6	0.45	2.6	0.01
D2RS1112	D-280658	340618	1183322	2.80	0.07	0.24	22	0.21	15	6.6	0.44	2.6	0.02
D2RS1211	D-280691	340618	1183322	3.58	0.08	0.15	22	0.17	17	6.8	0.17	2.2	< 0.01
D2RS2111	D-280664	340618	1183322	3.00	0.08	0.23	17	0.25	28	5.8	0.29	3.2	0.01
D2RS2121	D-280671	340618	1183322	3.37	0.07	0.18	20	0.18	21	6.8	0.15	2.4	0.01
D4RN1111	D-280637	340500	1183817	3.58	0.12	0.23	25	0.19	16	6.3	0.34	5.6	0.01
D4RN1112	D-280642	340500	1183817	3.58	0.12	0.25	25	0.20	15	6.3	0.34	5.6	0.02
D4RN1211	D-280683	340500	1183817	3.38	0.06	0.16	26	0.19	13	6.9	0.15	4.5	0.01
D4RN2111	D-280652	340500	1183817	3.03	0.07	0.25	20	0.24	15	6.7	0.40	4.8	0.01
D4RN2121	D-280656	340500	1183817	3.25	0.07	0.17	21	0.16	17	5.8	0.19	4.3	0.02
D4RS1111	D-280693	340500	1183817	5.44	0.11	0.08	24	0.09	14	6.1	0.09	3.6	< 0.01
D4RS1112	D-280643	340500	1183817	4.06	0.11	0.10	26	0.11	15	6.1	0.10	3.7	< 0.01
D4RS1121	D-280672	340500	1183817	4.58	0.11	0.12	26	0.11	11	8.0	0.08	3.2	< 0.01
D4RS2111	D-280632	340500	1183817	2.83	0.07	0.17	24	0.15	12	7.8	0.10	4.5	0.01
D4RS2211	D-280630	340500	1183817	3.28	0.08	0.11	26	0.12	15	7.3	0.09	3.4	< 0.01
D5RN1111	D-280628	340507	1184630	2.46	0.06	0.17	19	0.15	24	5.9	0.20	3.0	< 0.01
D5RN1211	D-280641	340507	1184630	2.87	0.07	0.17	20	0.13	18	9.5	0.14	3.8	< 0.01
D5RN2111	D-280655	340507	1184630	3.62	0.06	0.22	25	0.19	15	7.8	0.22	2.2	0.01
D5RN2112	D-280651	340500	1184630	3.63	0.06	0.21	25	0.19	15	7.9	0.22	2.3	0.01
D5RN2121	D-280687	340507	1184630	3.59	0.06	0.14	23	0.16	12	7.9	0.15	2.3	< 0.01
D5RS1111	D-280668	340507	1184630	3.12	0.07	0.17	20	0.17	22	6.6	0.83	3.1	0.01
D5RS1121	D-280648	340507	1184630	3.13	0.07	0.13	21	0.13	20	7.0	0.29	3.3	< 0.01
D5RS2111	D-280634	340507	1184630	3.59	0.08	0.09	18	0.11	21	6.8	0.40	3.0	< 0.01
D5RS2211	D-280650	340507	1184630	3.73	0.10	0.19	23	0.13	15	6.6	0.24	3.0	< 0.01
D5RS2212	D-280640	340500	1184630	3.84	0.10	0.20	23	0.16	17	6.6	0.23	3.1	0.01

Appendix XI. Elemental concentrations in *R. laurina* from E-W crestline traverse--December collection (continued).

				%, Dry weight		%, Ash weight							
Field #	Lab #	Lat	Long	Ash	S	Al	Ca	Fe	K	Mg	Na	P	Ti
D6RN1111	D-280688	340548	1185003	3.19	0.06	0.15	27	0.14	11	5.7	0.20	2.4	0.01
D6RN1121	D-280689	340548	1185003	3.63	0.06	0.11	24	0.12	15	5.5	0.15	2.4	< 0.01
D6RN2111	D-280646	340548	1185003	3.60	0.09	0.16	22	0.18	23	4.9	0.16	3.0	0.01
D6RN2112	D-280645	340548	1185003	3.63	0.09	0.14	22	0.18	21	4.9	0.16	3.0	< 0.01
D6RN2211	D-280657	340548	1185003	3.27	0.08	0.21	21	0.20	24	4.1	0.24	3.4	0.01
D6RS1111	D-280631	340548	1185003	3.59	0.08	0.21	19	0.20	20	4.5	0.40	3.7	0.02
D6RS1211	D-280644	340548	1185003	4.00	0.09	0.17	26	0.17	16	8.1	0.20	2.9	0.01
D6RS2111	D-280684	340548	1185003	2.85	0.07	0.14	21	0.15	24	5.1	0.51	3.7	0.01
D6RS2121	D-280686	340548	1185003	2.83	0.06	0.16	21	0.15	16	5.3	0.40	3.4	< 0.01
D7RN1111	D-280662	340630	1185420	2.50	0.07	0.16	21	0.16	15	6.8	0.17	3.0	< 0.01
D7RN1211	D-280635	340630	1185420	3.37	0.07	0.14	22	0.16	18	6.8	0.16	2.9	< 0.01
D7RN2111	D-280677	340630	1185420	3.91	0.06	0.11	25	0.13	12	8.2	0.15	2.3	< 0.01
D7RN2121	D-280669	340630	1185420	4.41	0.08	0.07	25	0.08	14	8.0	0.16	3.4	< 0.01
D7RS1111	D-280663	340630	1185420	4.29	0.06	0.14	30	0.13	14	5.5	0.32	3.0	< 0.01
D7RS1121	D-280629	340630	1185420	4.04	0.08	0.12	28	0.13	14	6.2	0.08	3.1	< 0.01
D7RS2111	D-280649	340630	1185420	3.16	0.07	0.09	19	0.13	23	6.6	0.13	3.8	< 0.01
D7RS2211	D-280681	340630	1185420	3.83	0.08	0.11	23	0.11	17	7.4	0.15	3.7	< 0.01
D8RS1111	D-280680	340712	1185538	3.69	0.08	0.15	21	0.19	25	4.1	0.14	2.8	0.01
D8RS1211	D-280665	340712	1185538	3.47	0.07	0.11	21	0.11	23	4.6	0.07	3.3	< 0.01
D8RS2111	D-280673	340712	1185538	4.21	0.07	0.06	25	0.07	20	4.3	0.06	3.3	< 0.01
D8RS2121	D-280627	340712	1185538	4.11	0.07	0.07	25	0.08	20	4.3	0.07	3.1	< 0.01
D9RN1111	D-280675	340625	1190140	4.65	0.08	0.18	27	0.17	12	6.3	1.1	2.1	0.01
D9RN1211	D-280653	340625	1190140	5.04	0.08	0.21	29	0.22	9.9	7.3	1.2	2.2	0.01
D9RN2111	D-280636	340625	1190140	5.24	0.09	0.12	29	0.12	11	8.4	0.65	1.8	< 0.01
D9RN2121	D-280694	340625	1190140	5.42	0.10	0.09	27	0.10	10	8.5	0.29	2.1	< 0.01
D9RS1111	D-280660	340625	1190140	4.01	0.05	0.12	29	0.14	14	5.3	0.47	1.7	< 0.01
D9RS1112	D-280661	340625	1190140	4.01	0.06	0.12	28	0.13	14	5.2	0.47	1.7	< 0.01
D9RS1121	D-280674	340625	1190140	4.40	0.06	0.11	29	0.09	12	5.1	0.49	1.7	< 0.01
D9RS2111	D-280654	340625	1190140	3.84	0.06	0.11	28	0.13	14	6.1	0.41	2.2	< 0.01
D9RS2211	D-280666	340625	1190140	4.07	0.07	0.16	28	0.16	11	8.4	0.66	2.6	0.01
D9RS2212	D-280647	340625	1190140	4.14	0.08	0.17	28	0.17	11	8.2	0.64	2.6	0.01

Appendix XI. Elemental concentrations in *R. laurina* from E-W crestline traverse--December collection (continued).

	ppm, Ash weight																	
Field #	Mn	Ba	Cd	Ce	Co	Cr	Cu	La	Li	Mo	Nd	Ni	Pb	Sc	Sr	V	Y	Zn
D1RN1111	1600	230	< 4	< 8	6	7	72	14	< 4	< 4	< 8	40	45	< 4	1100	< 4	4	230
D1RN1211	2300	320	< 4	9	11	11	72	12	6	6	< 8	52	60	< 4	1000	7	< 4	290
D1RN2111	1400	280	< 4	8	6	13	83	19	10	< 4	< 8	66	56	5	1400	5	4	350
D1RN2112	1500	270	< 4	9	6	8	81	16	10	< 4	< 8	73	57	4	1300	5	5	350
D1RN2121	1900	300	< 4	< 8	5	6	67	15	5	< 4	< 8	59	38	4	1400	< 4	4	320
D1RS1111	1200	190	< 4	< 8	9	21	110	15	7	< 4	< 8	77	160	4	1100	9	6	440
D1RS1211	1700	210	< 4	< 8	6	12	66	10	6	< 4	< 8	48	77	< 4	990	5	6	220
D1RS2111	1600	240	< 4	< 8	6	21	100	15	5	< 4	< 8	68	110	< 4	980	7	< 4	370
D1RS2121	1600	230	< 4	< 8	5	11	89	10	< 4	< 4	< 8	62	55	< 4	980	5	< 4	300
D2RN1111	4700	200	< 4	22	6	9	88	22	9	< 4	< 8	17	30	< 4	1000	4	19	580
D2RN2111	5100	580	< 4	< 8	12	5	84	18	35	< 4	< 8	37	20	5	1700	< 4	11	470
D2RN2121	7600	790	< 4	9	18	5	73	15	44	< 4	< 8	30	14	5	1800	< 4	12	450
D2RS1111	3800	620	< 4	15	6	7	80	11	44	< 4	< 8	16	17	5	1500	< 4	9	400
D2RS1112	3800	610	< 4	< 8	6	8	170	13	44	< 4	< 8	14	19	5	1500	< 4	8	450
D2RS1211	6100	860	< 4	11	11	7	87	12	33	< 4	< 8	16	11	5	1800	< 4	9	620
D2RS2111	4700	660	< 4	26	14	8	130	22	12	< 4	< 8	21	18	4	1200	< 4	9	650
D2RS2121	5100	1400	< 4	19	13	5	88	25	15	< 4	< 8	10	16	5	1800	< 4	8	560
D4RN1111	2500	280	5	< 8	4	13	61	14	4	< 4	< 8	24	16	< 4	980	< 4	6	390
D4RN1112	2600	270	< 4	< 8	4	8	60	14	5	< 4	< 8	22	16	< 4	990	< 4	5	390
D4RN1211	1900	200	< 4	< 8	4	6	51	11	5	< 4	< 8	24	< 8	< 4	1100	< 4	6	290
D4RN2111	1900	100	< 4	< 8	5	9	97	13	18	5	< 8	18	12	< 4	550	< 4	< 4	550
D4RN2121	2000	100	< 4	< 8	5	9	110	13	14	4	< 8	10	< 8	< 4	600	< 4	< 4	600
D4RS1111	1800	120	< 4	< 8	4	6	54	9	< 4	< 4	< 8	13	< 8	< 4	870	< 4	< 4	390
D4RS1112	1800	120	< 4	< 8	4	4	60	11	< 4	< 4	< 8	12	< 8	< 4	910	< 4	< 4	410
D4RS1121	2100	79	< 4	< 8	4	6	40	12	< 4	< 4	< 8	38	< 8	< 4	870	< 4	7	250
D4RS2111	1200	100	< 4	< 8	3	10	76	11	5	< 4	< 8	18	8	< 4	770	< 4	< 4	460
D4RS2211	1100	71	< 4	< 8	3	6	61	11	< 4	< 4	< 8	8	< 8	< 4	680	< 4	< 4	340
D5RN1111	11000	480	< 4	52	28	5	100	36	< 4	< 4	29	77	< 8	6	1900	< 4	40	800
D5RN1211	11000	990	5	50	14	4	110	41	< 4	< 4	29	60	9	7	2300	< 4	29	820
D5RN2111	7300	1200	< 4	15	12	4	67	17	7	< 4	< 8	21	10	5	1500	< 4	7	490
D5RN2112	7300	1300	< 4	16	11	5	64	16	7	< 4	< 8	20	13	5	1500	< 4	7	500
D5RN2121	7600	1200	< 4	13	10	4	58	14	< 4	< 4	< 8	22	8	< 4	1400	< 4	7	520
D5RS1111	4300	850	< 4	24	6	7	66	17	< 4	< 4	12	75	19	4	1300	< 4	45	480
D5RS1121	3800	700	< 4	29	5	5	74	16	< 4	< 4	11	75	10	< 4	1200	< 4	43	510
D5RS2111	6900	640	< 4	41	11	2	90	50	13	< 4	25	46	< 8	< 4	1100	< 4	44	530
D5RS2211	6600	980	< 4	39	17	4	79	28	< 4	< 4	10	44	13	4	1300	< 4	19	470
D5RS2212	7700	970	< 4	41	16	5	76	27	< 4	< 4	13	45	12	4	1400	< 4	19	460

Appendix XI. Elemental concentrations in *R. laurina* from E-W crestline traverse--December collection (continued).

	ppm, Ash weight																	
Field #	Mn	Ba	Cd	Ce	Co	Cr	Cu	La	Li	Mo	Nd	Ni	Pb	Sc	Sr	V	Y	Zn
D6RN1111	1100	69	< 4	< 8	4	4	66	9	< 4	< 4	< 8	110	9	< 4	720	< 4	< 4	200
D6RN1121	910	79	< 4	< 8	3	4	62	7	< 4	< 4	< 8	45	< 8	< 4	700	< 4	< 4	280
D6RN2111	890	65	< 4	< 8	4	10	76	8	< 4	< 4	< 8	39	10	< 4	600	< 4	< 4	310
D6RN2112	930	65	< 4	< 8	4	7	74	8	< 4	< 4	< 8	38	< 8	< 4	590	< 4	< 4	310
D6RN2211	670	69	< 4	< 8	3	8	96	9	< 4	< 4	< 8	67	12	< 4	590	< 4	< 4	320
D6RS1111	1600	110	< 4	< 8	3	12	100	10	< 4	< 4	< 8	30	13	< 4	570	5	< 4	410
D6RS1211	1300	76	< 4	12	3	4	71	9	< 4	< 4	< 8	19	10	< 4	810	< 4	< 4	260
D6RS2111	1700	50	< 4	< 8	5	6	93	8	< 4	< 4	< 8	32	9	< 4	500	< 4	< 4	330
D6RS2121	1700	48	< 4	< 8	3	5	94	6	< 4	< 4	< 8	21	9	< 4	540	< 4	< 4	380
D7RN1111	3600	400	< 4	9	6	4	110	13	7	< 4	< 8	200	< 8	< 4	380	< 4	33	380
D7RN1211	1500	220	< 4	< 8	4	7	89	9	< 4	< 4	< 8	40	< 8	< 4	340	< 4	16	440
D7RN2111	1600	81	< 4	< 8	3	3	57	9	< 4	< 4	< 8	69	< 8	< 4	650	< 4	6	140
D7RN2121	1700	110	< 4	< 8	3	4	54	11	< 4	< 4	< 8	82	< 8	< 4	600	< 4	8	140
D7RS1111	1500	150	< 4	< 8	4	4	65	9	< 4	< 4	< 8	26	< 8	< 4	560	< 4	< 4	150
D7RS1121	2200	130	< 4	< 8	4	4	61	9	< 4	< 4	< 8	29	< 8	< 4	510	< 4	< 4	120
D7RS2111	1700	66	< 4	< 8	4	3	100	11	< 4	< 4	< 8	59	< 8	< 4	560	< 4	4	320
D7RS2211	1600	67	< 4	< 8	3	5	85	7	< 4	< 4	< 8	40	< 8	< 4	610	< 4	< 4	280
D8RS1111	880	120	< 4	< 8	4	4	84	7	< 4	< 4	< 8	27	< 8	< 4	540	< 4	< 4	610
D8RS1211	900	93	< 4	< 8	3	8	89	9	< 4	< 4	< 8	27	< 8	< 4	540	< 4	< 4	520
D8RS2111	1700	260	< 4	< 8	4	3	64	11	< 4	< 4	< 8	14	< 8	< 4	1100	< 4	4	340
D8RS2121	1600	230	4	< 8	4	2	73	11	< 4	< 4	< 8	14	< 8	< 4	1000	< 4	< 4	310
D9RN1111	2100	130	26	< 8	5	5	53	7	< 4	< 4	< 8	37	17	< 4	320	5	< 4	300
D9RN1211	1400	200	21	< 8	5	3	43	8	< 4	< 4	< 8	16	12	< 4	570	4	< 4	280
D9RN2111	1900	210	20	< 8	3	6	76	8	< 4	< 4	< 8	31	9	< 4	690	< 4	< 4	330
D9RN2121	1600	200	16	< 8	4	4	65	5	< 4	< 4	< 8	24	< 8	< 4	700	< 4	< 4	360
D9RS1111	1000	81	5	< 8	3	5	59	9	< 4	< 4	< 8	19	< 8	< 4	290	< 4	< 4	220
D9RS1112	1000	79	5	< 8	4	7	58	8	< 4	< 4	< 8	16	< 8	< 4	290	< 4	< 4	220
D9RS1121	930	110	8	< 8	3	5	49	6	< 4	< 4	< 8	15	< 8	< 4	300	< 4	< 4	210
D9RS2111	1300	29	5	< 8	4	3	56	8	< 4	6	< 8	36	< 8	< 4	230	< 4	< 4	280
D9RS2211	1100	47	4	< 8	4	3	65	8	< 4	6	< 8	36	12	< 4	190	< 4	< 4	360
D9RS2212	1100	47	4	< 8	4	10	67	9	< 4	6	< 8	31	11	< 4	190	5	< 4	360

Appendix XIIa. Correlation coefficients for *R. laurina* (R)--May collection with soils (S) for N-S traverses.

Soil*R. laurina*	R-S	R-Al	R-Ca	R-Fe	R-K	R-Mg	R-Na	R-P	R-Ti	R-Mn	R-Ba	R-Co	R-Cr	R-Cu	R-Ni	R-Pb	R-Sr	R-Zn
S-S	0.07	-0.12	**-0.43***	-0.21	**0.48***	-0.21	-0.10	0.03	-0.16	-0.34	-0.12	-0.30	-0.02	-0.32	-0.18	-0.24	-0.21	-0.13
S-Al	0.17	-0.13	0.23	-0.05	-0.19	0.09	-0.30	0.19	0.02	0.05	0.11	-0.09	0.15	0.09	-0.03	0.11	0.26	0.17
S-Ca	-0.10	0.09	0.20	0.16	-0.23	-0.03	**0.42***	-0.11	0.17	**-0.43***	-0.16	-0.21	0.26	0.02	-0.25	0.03	-0.23	-0.13
S-Fe	0.07	0.09	0.19	0.22	-0.26	0.24	0.10	0.13	0.27	-0.29	-0.11	0.00	0.39	0.36	0.03	0.07	0.16	0.12
S-K	0.06	-0.26	**-0.42***	**-0.44***	**0.56****	**-0.42***	**-0.51****	-0.01	-0.27	0.34	0.35	-0.06	**-0.42***	-0.27	-0.08	0.04	0.01	0.02
S-Mg	-0.04	0.16	0.13	0.26	-0.29	0.23	0.37	0.11	0.26	-0.40	-0.24	-0.06	**0.45***	0.22	0.02	-0.01	-0.07	-0.07
S-Na	0.18	-0.08	0.38	0.02	**-0.45***	0.20	-0.15	0.31	-0.22	0.14	-0.32	0.00	0.02	0.00	0.14	-0.16	-0.06	0.10
S-P	-0.03	-0.07	-0.15	-0.11	0.19	-0.18	-0.14	0.19	0.05	**-0.47***	-0.13	-0.36	0.04	-0.28	-0.26	-0.15	-0.10	0.00
S-Ti	0.05	0.16	0.27	0.30	-0.34	0.28	0.13	0.11	0.29	-0.32	-0.16	-0.07	0.40	0.31	0.05	0.03	0.10	0.12
S-Mn	0.08	0.13	0.07	0.17	-0.16	0.11	0.14	0.17	0.21	**-0.41***	-0.27	-0.16	**0.45***	0.28	-0.08	-0.09	-0.02	-0.01
S-Ba	0.03	-0.20	**-0.45***	-0.38	**0.60****	**-0.45***	**-0.49***	0.02	-0.22	0.29	0.35	-0.05	-0.32	-0.26	-0.02	0.02	-0.01	0.00
S-Co	0.09	0.12	0.07	0.22	-0.19	0.20	0.27	0.13	0.27	**-0.42***	-0.23	-0.06	**0.45***	0.32	0.03	-0.06	0.04	-0.03
S-Cr	0.04	0.07	0.12	0.10	-0.16	0.21	0.26	0.13	0.12	**-0.50****	-0.24	-0.14	**0.41***	0.15	0.03	-0.21	0.02	-0.15
S-Cu	0.07	0.07	-0.15	0.13	0.05	0.04	0.08	0.18	0.29	**-0.45***	-0.13	-0.13	0.37	0.26	-0.13	-0.00	0.10	0.04
S-Ni	0.03	0.05	0.01	0.07	-0.11	0.17	0.31	0.14	0.12	**-0.53****	-0.30	-0.18	**0.41***	0.10	0.02	-0.26	0.02	-0.22
S-Pb	-0.01	-0.05	**-0.48***	-0.13	**0.55****	-0.36	**-0.61****	0.07	0.10	0.27	0.37	0.00	-0.13	-0.07	0.01	0.32	0.05	0.34
S-Sr	-0.03	-0.07	0.02	-0.04	-0.04	-0.16	-0.04	0.16	-0.02	-0.11	-0.17	-0.28	0.13	-0.20	-0.03	-0.12	-0.11	-0.16
S-Zn	0.11	-0.01	0.11	0.08	-0.09	0.11	-0.28	0.25	0.20	-0.13	0.08	-0.03	0.18	0.27	0.01	0.14	0.26	0.36
S-C total	-0.06	0.23	**-0.54****	0.09	**0.51****	-0.35	0.14	-0.05	0.29	**-0.46***	-0.10	-0.34	0.22	-0.21	-0.21	-0.06	-0.33	-0.17
S-C organic	-0.05	0.23	**-0.52****	0.10	**0.49***	-0.33	0.04	0.01	0.26	-0.39	-0.12	-0.29	0.22	-0.19	-0.12	-0.06	-0.30	-0.12
S-pH	0.04	-0.36	0.23	-0.36	-0.21	0.06	0.28	-0.12	-0.40	-0.36	-0.34	-0.22	-0.26	-0.16	-0.16	**-0.45***	-0.13	-0.38

*Significant at 0.01 probability level.

**Significant at 0.001 probability level.

Appendix XIIb. Correlation coefficients for *R. laurina* (R)--December collection with soils (S) for N-S traverses.

Soil\R. laurina	R-S	R-Al	R-Ca	R-Fe	R-K	R-Mg	R-Na	R-P	R-Ti	R-Mn	R-Ba	R-Co	R-Cr	R-Cu	R-Ni	R-Pb	R-Sr	R-Zn
S-S	-0.09	-0.03	-0.34	0.02	0.43*	-0.08	0.04	0.32	-0.02	-0.28	-0.09	-0.21	-0.09	-0.01	-0.22	-0.09	-0.06	-0.03
S-Al	0.23	-0.31	0.12	-0.20	-0.21	0.12	-0.43*	0.03	-0.16	-0.01	0.02	-0.15	-0.21	-0.03	0.08	-0.07	0.17	0.11
S-Ca	-0.06	0.14	0.14	0.19	-0.19	-0.16	0.28	-0.19	0.26	-0.44*	-0.22	-0.12	0.28	-0.04	-0.20	0.05	-0.29	-0.29
S-Fe	0.07	-0.06	0.12	0.07	-0.33	0.25	-0.08	0.08	0.02	-0.24	-0.16	-0.00	0.10	0.08	0.12	0.01	0.09	0.15
S-K	0.00	-0.07	-0.31	-0.17	0.50**	-0.23	-0.29	0.10	-0.16	0.27	0.41*	0.02	-0.23	-0.08	-0.16	0.06	0.11	0.10
S-Mg	-0.10	-0.01	0.11	0.08	-0.29	0.20	0.15	0.11	0.07	-0.39	-0.29	-0.15	0.21	0.07	0.01	-0.04	-0.10	-0.13
S-Na	0.09	-0.31	0.33	-0.28	-0.30	-0.06	-0.27	0.05	-0.22	0.09	-0.43*	-0.25	-0.18	-0.04	0.04	-0.29	-0.19	-0.13
S-P	-0.00	0.04	-0.13	0.05	0.20	-0.31	-0.16	0.32	0.10	-0.48*	-0.23	-0.27	-0.08	-0.18	-0.38	-0.11	-0.16	-0.00
S-Ti	0.11	-0.03	0.20	0.11	-0.42*	0.23	-0.06	0.03	0.10	-0.26	-0.26	-0.12	0.09	0.06	0.09	-0.04	-0.03	0.04
S-Mn	-0.06	-0.01	0.10	0.10	-0.27	0.11	-0.01	0.03	0.07	-0.29	-0.28	-0.17	0.11	0.06	0.09	-0.05	-0.02	-0.01
S-Ba	-0.01	-0.07	-0.27	-0.17	0.49*	-0.24	-0.25	0.10	-0.12	0.26	0.44*	-0.02	-0.20	-0.05	-0.06	0.06	0.13	0.06
S-Co	-0.04	-0.05	0.10	0.08	-0.30	0.20	0.06	0.11	0.03	-0.33	-0.26	-0.04	0.12	0.12	0.07	-0.08	0.03	0.04
S-Cr	-0.06	-0.01	0.12	0.05	-0.23	0.18	0.01	0.10	0.04	-0.47*	-0.29	-0.19	0.12	-0.09	0.01	-0.20	-0.02	-0.18
S-Cu	-0.09	-0.02	-0.09	0.09	-0.09	0.19	-0.02	0.20	0.05	-0.31	-0.10	-0.00	0.06	0.14	0.00	0.05	0.16	0.12
S-Ni	-0.14	-0.06	0.05	0.00	-0.18	0.20	0.05	0.17	-0.02	-0.50*	-0.31	-0.20	0.10	-0.05	0.01	-0.25	0.04	-0.19
S-Pb	-0.00	-0.01	-0.34	-0.02	0.47*	-0.20	-0.31	0.24	0.00	0.28	0.35	0.04	-0.05	0.14	-0.05	0.35	0.11	0.33
S-Sr	-0.03	-0.28	0.13	-0.24	-0.05	-0.24	-0.07	0.04	-0.11	-0.15	-0.23	-0.37	-0.19	-0.01	-0.13	-0.15	-0.13	-0.33
S-Zn	0.16	-0.08	0.00	0.04	-0.10	0.10	-0.32	0.24	-0.03	-0.16	-0.02	-0.02	-0.03	0.02	0.06	0.09	0.15	0.39
S-C total	-0.17	0.19	-0.32	0.21	0.37	-0.28	0.19	0.19	0.26	-0.42*	-0.16	-0.26	0.08	0.05	-0.38	0.07	-0.22	-0.15
S-C organic	-0.15	0.11	-0.31	0.15	0.37	-0.27	0.10	0.24	0.18	-0.35	-0.20	-0.27	0.00	0.06	-0.33	0.03	-0.21	-0.10
S-pH	-0.15	-0.26	0.25	-0.33	-0.24	0.10	0.03	-0.27	-0.24	-0.36	-0.23	-0.18	-0.05	-0.41*	-0.16	-0.51**	-0.10	-0.43*

*Significant at 0.01 probability level.

**Significant at 0.001 probability level.

Appendix XIIIa. Correlation coefficients for *C. megacarpus* (C)--May collection with soils (S) for N-S traverses.

Soil\C. megacarpus	C-S	C-Al	C-Ca	C-Fe	C-K	C-Mg	C-Na	C-P	C-Ti	C-Mn	C-Ba	C-Co	C-Cr	C-Cu	C-Li	C-Ni	C-Pb	C-Sr	C-Zn
S-S	0.11	-0.15	-0.03	-0.28	0.07	0.06	-0.15	0.21	-0.14	-0.30	-0.08	-0.36	-0.18	-0.13	-0.18	-0.34	-0.23	-0.03	-0.10
S-Al	0.16	-0.19	0.14	-0.11	-0.14	0.30	-0.39	0.20	-0.12	0.00	0.14	0.04	-0.14	0.04	0.00	0.11	0.01	0.40	0.12
S-Ca	0.16	0.25	0.38	0.16	-0.35	-0.27	-0.05	-0.11	0.43	**-0.67****	-0.35	0.00	0.07	-0.12	**-0.60****	-0.14	0.13	**-0.50***	-0.21
S-Fe	0.25	0.11	0.03	0.19	-0.09	0.30	-0.14	0.21	0.13	-0.25	-0.12	0.06	0.05	0.23	-0.31	0.40	0.09	0.05	0.05
S-K	-0.08	-0.41	-0.18	-0.42	0.32	-0.09	-0.16	-0.03	-0.36	0.44	**0.46***	-0.06	-0.19	-0.23	**0.55****	-0.32	-0.14	0.32	-0.02
S-Mg	0.30	0.35	0.03	0.33	-0.13	0.25	-0.01	0.22	0.27	**-0.46***	-0.28	0.01	0.15	0.13	-0.44	0.27	0.17	-0.16	-0.04
S-Na	-0.27	-0.08	0.11	0.01	-0.19	0.21	-0.12	0.16	-0.10	0.17	-0.34	-0.18	0.00	0.01	0.08	-0.05	0.04	0.19	0.30
S-P	0.21	-0.29	0.31	-0.30	-0.25	-0.20	-0.24	0.34	-0.00	**-0.47***	-0.20	-0.28	-0.19	**-0.49***	-0.41	-0.22	-0.20	-0.02	-0.25
S-Ti	0.28	0.17	0.03	0.22	-0.12	0.32	-0.24	0.27	0.21	-0.31	-0.23	0.01	0.02	0.24	**-0.44***	0.38	0.11	-0.07	0.09
S-Mn	0.08	0.05	0.03	0.04	-0.05	0.22	-0.15	0.17	0.03	-0.17	-0.12	-0.26	-0.14	0.16	**-0.47***	0.30	-0.02	0.02	-0.11
S-Ba	-0.12	-0.34	-0.22	-0.39	0.34	-0.06	-0.14	-0.08	-0.36	0.44	**0.47***	-0.10	-0.25	-0.15	**0.45***	-0.28	-0.19	0.29	-0.02
S-Co	0.24	0.23	-0.02	0.24	-0.05	0.19	-0.02	0.16	0.21	-0.30	-0.15	0.01	0.07	0.24	-0.44	0.40	0.05	-0.00	-0.05
S-Cr	0.41	0.17	0.07	0.14	-0.09	0.11	-0.03	0.15	0.07	-0.42	-0.19	-0.02	0.03	0.01	**-0.46***	0.32	-0.11	-0.07	-0.23
S-Cu	0.27	0.13	-0.18	0.12	0.11	0.26	-0.12	0.28	0.17	-0.29	-0.03	-0.06	-0.03	0.21	-0.38	0.27	0.01	0.06	-0.03
S-Li	0.17	-0.33	-0.17	-0.16	0.23	0.32	-0.25	0.24	-0.33	0.21	0.32	0.10	-0.02	0.04	**0.44***	0.11	-0.11	0.39	0.12
S-Ni	0.38	0.20	0.01	0.15	-0.06	0.14	0.04	0.14	0.05	-0.43	-0.16	-0.07	-0.01	0.06	**-0.48***	0.31	-0.12	-0.04	-0.18
S-Pb	-0.12	-0.33	-0.19	-0.33	0.25	0.18	-0.33	0.12	-0.20	0.38	0.32	-0.15	-0.29	-0.02	0.44	-0.27	0.04	0.33	0.18
S-Sr	-0.12	-0.01	0.14	-0.15	-0.16	0.09	-0.28	0.07	0.12	-0.08	-0.10	-0.32	-0.31	-0.14	-0.21	-0.37	0.13	0.14	-0.01
S-Zn	0.23	-0.14	0.12	0.00	-0.12	0.24	-0.31	0.35	0.03	-0.04	0.00	0.03	-0.03	0.03	-0.03	0.32	0.07	0.21	0.08
S-C total	0.17	0.09	-0.14	-0.16	0.17	-0.02	-0.19	0.17	0.14	-0.37	-0.10	-0.37	-0.33	0.08	-0.40	-0.23	-0.05	-0.17	-0.05
S-C organic	0.14	0.03	-0.20	-0.18	0.23	0.08	-0.23	0.25	0.05	-0.28	-0.11	-0.40	-0.33	0.11	-0.32	-0.19	-0.05	-0.05	0.01
S-pH	0.26	0.01	0.34	-0.03	-0.18	-0.35	0.09	-0.32	-0.02	-0.34	-0.19	-0.05	-0.04	-0.33	-0.42	-0.03	-0.20	-0.44	-0.28

*Significant at 0.01 probability level.

**Significant at 0.001 probability level.

Appendix XIIIb. Correlation coefficients for *C. megacarpus* (C)--December collection with soils (S) for N-S traverses.

Soil\C. megacarpus	C-S	C-Al	C-Ca	C-Fe	C-K	C-Mg	C-Na	C-P	C-Ti	C-Mn	C-Ba	C-Co	C-Cr	C-Cu	C-Li	C-Ni	C-Pb	C-Sr	C-Zn
S-S	0.04	0.13	-0.12	0.09	0.11	0.04	0.04	0.30	-0.01	-0.20	-0.05	-0.06	0.19	-0.13	-0.15	-0.20	0.04	-0.02	0.02
S-Al	0.23	-0.09	0.01	-0.09	-0.07	0.30	-0.34	0.32	-0.16	-0.03	0.10	-0.01	0.01	0.16	0.09	0.15	0.03	0.43	-0.01
S-Ca	0.20	-0.08	**0.58****	-0.03	**-0.57****	-0.32	-0.07	-0.39	0.01	**-0.57****	-0.35	-0.12	0.14	-0.37	**-0.64****	-0.20	-0.03	-0.43	-0.36
S-Fe	0.23	0.15	0.04	0.24	-0.24	0.29	-0.10	0.03	0.16	-0.19	-0.13	-0.00	0.33	0.26	-0.27	**0.46***	0.14	0.07	-0.02
S-K	-0.10	-0.21	-0.32	-0.34	**0.49***	0.00	-0.10	0.33	-0.31	0.42	**0.48***	0.17	-0.43	0.00	**0.59****	-0.30	-0.04	0.28	0.16
S-Mg	0.10	0.24	0.13	0.32	-0.31	0.23	0.02	-0.02	0.23	-0.32	-0.30	-0.15	**0.48***	0.12	-0.40	0.31	0.15	-0.11	-0.10
S-Na	-0.09	0.03	-0.09	0.03	0.12	0.11	-0.09	0.27	-0.05	0.04	-0.41	-0.26	0.06	0.13	0.06	-0.05	0.01	0.15	0.15
S-P	0.22	-0.13	0.27	-0.18	-0.28	-0.23	-0.12	0.31	-0.18	-0.32	-0.18	-0.26	0.04	-0.40	-0.37	-0.27	-0.09	0.03	
S-Ti	0.19	0.18	0.12	0.27	-0.32	0.30	-0.22	0.02	0.18	-0.21	-0.22	-0.10	0.36	0.20	-0.39	0.40	0.15	-0.01	-0.04
S-Mn	-0.01	0.15	0.10	0.21	-0.17	0.19	-0.10	0.02	0.13	-0.07	-0.13	-0.15	0.28	0.24	-0.43	0.41	0.03	0.04	-0.18
S-Ba	-0.16	-0.15	-0.29	-0.29	**0.45***	0.06	-0.11	0.25	-0.24	0.42	**0.48***	0.13	-0.40	0.04	**0.51***	-0.27	-0.05	0.27	0.12
S-Co	0.17	0.17	0.08	0.25	-0.24	0.19	0.01	-0.03	0.16	-0.18	-0.16	-0.10	0.33	0.20	-0.37	**0.45***	0.06	0.05	-0.11
S-Cr	0.07	0.19	0.21	0.23	-0.35	0.15	0.04	-0.05	0.21	-0.23	-0.19	-0.11	0.36	0.06	-0.35	0.38	-0.02	-0.03	-0.27
S-Cu	0.17	0.20	-0.09	0.25	-0.10	0.30	-0.02	0.12	0.11	-0.13	-0.01	-0.04	0.29	0.22	-0.27	0.35	0.14	0.14	-0.05
S-Li	0.09	-0.02	-0.39	-0.02	0.34	0.38	-0.11	0.43	-0.12	0.23	0.34	0.22	-0.05	0.42	**0.53***	0.26	0.10	0.33	0.28
S-Ni	0.04	0.22	0.16	0.25	-0.31	0.19	0.09	-0.05	0.21	-0.25	-0.16	-0.19	0.37	0.09	-0.39	0.38	-0.04	0.01	-0.22
S-Pb	-0.02	-0.00	-0.37	-0.10	0.42	0.26	-0.24	0.37	-0.18	0.37	0.35	0.18	-0.19	0.25	**0.51***	-0.19	0.28	0.30	0.31
S-Sr	0.02	-0.07	0.11	-0.12	-0.03	0.06	-0.29	0.17	-0.24	-0.10	-0.15	-0.25	-0.01	-0.11	-0.19	-0.37	0.05	0.21	-0.09
S-Zn	0.29	0.06	-0.02	0.11	-0.14	0.21	-0.21	0.27	0.02	-0.02	0.01	0.14	0.21	0.16	-0.01	0.38	0.18	0.22	-0.00
S-C total	-0.05	0.26	0.05	0.20	-0.07	0.09	-0.07	0.04	0.10	-0.11	-0.01	-0.21	0.16	0.04	-0.31	-0.13	0.16	-0.10	0.01
S-C organic	-0.06	0.30	-0.09	0.24	0.07	0.19	-0.09	0.19	0.10	-0.03	-0.04	-0.22	0.20	0.16	-0.21	-0.06	0.21	-0.00	0.10
S-pH	-0.04	-0.34	**0.52***	-0.33	-0.30	-0.38	0.05	-0.44	-0.14	-0.26	-0.21	-0.23	-0.20	-0.41	**-0.45***	-0.12	-0.42	-0.43	**-0.46***

*Significant at 0.01 probability level.

**Significant at 0.001 probability level.

Appendix XIV. Correlation coefficients of elemental concentrations in soil and plants versus easting, along N-S traverses.

	Soil	*R. laurina*		*C. megacarpus*	
	May	May	December	May	December
S	-0.12	-0.16	0.28	0.00	0.40
C, total	-0.16	--	--	--	--
C, org.	-0.11	--	--	--	--
pH	**-0.54****	--	--	--	--
Al	0.20	0.08	0.13	-0.08	-0.07
Ca	-0.25	0.00	-0.27	-0.02	-0.20
Fe	-0.16	0.21	0.21	0.06	-0.04
K	0.40	0.06	0.23	0.01	0.15
Mg	-0.33	0.03	0.08	0.17	0.22
Na	-0.01	**-0.58****	-0.33	-0.40	**-0.48***
P	-0.10	-0.18	-0.01	0.09	0.14
Ti	-0.16	0.29	0.15	0.07	-0.10
Mn	-0.30	**0.63****	**0.60****	0.35	0.23
Ba	0.37	**0.62****	**0.54****	0.33	0.32
Ce	0.34	--	--	--	--
Co	-0.35	0.34	0.32	0.38	**0.51***
Cr	**-0.44***	-0.14	0.05	0.10	-0.11
Cu	-0.20	0.11	0.33	0.26	0.23
Ga	0.14	--	--	--	--
La	0.29	--	--	--	--
Li	0.24	--	--	**0.56****	**0.52***
Nd	0.40	--	--	--	--
Ni	**-0.52****	0.13	0.32	-0.02	-0.05
Pb	**0.62****	**0.70****	**0.62****	**0.48***	0.40
Sc	-0.18	--	--	--	--
Sr	0.01	0.31	0.19	0.22	0.18
Th	**0.51****	--	--	--	--
V	-0.14	--	--	--	--
Y	0.11	--	--	--	--
Zn	0.18	**0.66****	**0.55****	0.42	0.38

*significant at the 0.01 probability level.

**significant at the 0.001 probability level.