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MODELS OF SEASONAL PRIMARY PRODUCTIVITY IN EASTERN TENNESSEE *FESTUCA* AND *ANDROPOGON* ECOSYSTEMS

(THESIS)

J. M. Kelly
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G. M. Van Dyne

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J. M. Kelly, P. A. Opstrup,

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Submitted as theses by J. M. Kelly and P. A. Opstrup to the Graduate Council of the University of Tennessee in partial fulfillment of the requirements for the degree of Master of Science.

JUNE 1969

OAK RIDGE NATIONAL LABORATORY
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ABSTRACT

Three purposes of study were: (1) to test various sampling and mathematical techniques in the analysis of grasslands typical of eastern Tennessee, (2) to explore the feasibility of increasing efficiency in future investigation, and (3) to use computer models for theoretical estimation of gross and net production and for mathematical description of transfer coefficients or functions in grasslands. Widely planted Kentucky-31 tall fescue (*Festuca elatior* var. *arundinacea* Schreb.) and the normal native old-field (or pasture) invader called "broomsedge" or "sagegrass" (*Andropogon virginicus* L.) dominated the areas studied on Clinch River terrace soils in Oak Ridge. Both communities had nearly equal annual net primary production (root plus top) but phenological cycles of dominant and minor species were quite different. Productivity estimates would have been biased on the low side without careful repeated sampling by species and/or allowance for losses of live material that occur simultaneously with growth. Present agreement between empirically and theoretically derived estimates suggests that results of both are nearly valid and complementary, but some improvements for future work are suggested.

At each sample date above-ground herbage in forty 1 m^2 plots was collected and a 0.25 m^2 sub-sample was sorted, dried and weighed. Twenty root core samples were taken from within the plots. Supplementary data on herbage mass were derived from an additional 100 unclipped plots that were measured with a capacitance meter; proportions of standing dead were visually estimated; a rank was assigned to the species according to its weight. Computer programs combining these data gave accurate estimates of the vegetation composition on a dry weight basis with a minimum of cutting and hand separating of samples. The ratio of "ranked only" plots to those clipped could be as high as 50 to 300:1 to allow for coverage of a much larger area without greatly disrupting the vegetation. Negligible differences between methods were found for species herbage biomass estimates when the vegetation was uniform, but when great variation was present the rapid-sampling method was better able to represent the irregularly distributed species. The estimation of total yield by the capacitance meter method did not detect significant differences ($P \leq 0.1$) compared with clipping for peak biomass values of the two communities. Estimated total yield values were 678 g/m^2 and 1012 g/m^2, respectively for the *Festuca* and *Andropogon* communities, as compared to the clipped values of 672 g/m^2 and 958 g/m^2 (including standing dead or attached litter as well as live material).

Positive changes in live biomass during phenologically appropriate periods were summed, giving 1001 and 892 g/m^2 as the first empirical estimates of cumulative annual oven dry organic production for *Festuca* and *Andropogon* communities. (Revisions adjusted slightly for possible sampling bias are given below.) Trends in standing (attached) dead above-ground vegetation differ: the maximum for *Festuca* (408 g/m^2) came in early summer, near time of flowering, while that for *Andropogon* (806 g/m^2) occurred just after frost killed most of the live tops. Detached

litter on the ground remained low and comparatively constant: near 114 and 181 g/m^2, respectively. High apparent daily mean production rates approximated by biomass changes varied seasonally: 1.21 to 3.29 $g/m^2 \cdot day$ (for intervals March 1 to April 27 and April 27 to May 15) for the Festuca community, and 1.05 to 3.34 $g/m^2 \cdot day$ (March 10 to June 7 and June 7 to August 7) for the more mixed Andropogon community. Declining biomass change for later dates presumably reflected increased losses as the mass of live and dead "compartments" increased, as well as declining carbon assimilation rates.

A 7-compartment model was designed in order to simulate plausible redistribution of biomass through major parts of the system. Transfer coefficients of the final model were constant or seasonally varying and were derived from observed rates of change, plus our ancillary studies or approximations from the literature. The seasonally varying coefficients were expressed as periodic or exponential functions of arbitrary inputs that were independent of the system's state variables, and seem related to biological cycles or environmental inputs. The data were fit well by successive approximations, but problems of predicting results with the model over several years were not treated with data for one year (1967). Due to an unusually wet July, an expected summer decline in growth of the cool-season Festuca did not occur; both it and the warm-season Andropogon may have been more productive than for years of average moisture, but depth of root penetration might have been less because water tables remained high.

From the model, gross production was estimated to be at least 1145 $g/m^2/yr$ for the Andropogon and 1220 $g/m^2/yr$ for the Festuca communities (probably higher). The net primary production of these two communities (gross production minus plant respiration) was estimated within upper and lower bounds that were derived according to whether the turnover in the root compartment (assumed near 25% per year) was due strictly to respiration or due to death of roots; realistic values should lie within the range given below unless this assumed root loss was too low. The net primary production in the Festuca community was thus estimated to be in the plausible range from 921 g/m^2 to 1115 g/m^2 as compared with adjusted clipping estimates of 992 g/m^2. For the Andropogon community the range was estimated to be from 853 g/m^2 to 1060 g/m^2 compared with 892 g/m^2 calculated from the clipped data.

This study provided improved results, or suggested needs for further refinements of technique, in several aspects of grassland herbage dynamics: (1) minimal limits on net production from biomass change in Festuca and Andropogon old-field communities appeared to be closer estimates of total community net production than most values found in the literature because (a) the sampling was sufficiently frequent to be close to peak mass for each significant taxon, (b) subsamples were separated into living and dead tops, (c) the detached (fallen) litter, and rates of input and decomposition for it were measured in a supporting study, and (d) root mass changes (ash-free) from 20 cores per collection give a means to obtain indirect estimates of mass translocation to and from root storage. (2) Estimates of some transfer rates still need to be quantified, especially losses due to animal consumption and respiration, translocation of soluble carbohydrates, and better approximations for turnover from roots. (3) Estimated rates of input to and loss from standing (attached) dead tops for the current year seem realistic, but could be refined if separate estimates for the previous year's dead tops could be made. (Many studies neglect or underestimate these transfers for both young and old dead material.) Satisfactory methods of identifying age classes and transfers for such material need further attention. (4) Input and decomposition rates for detached litter appear to be balanced so a steady-state was approximated surprisingly well; yet income and loss rates must both vary seasonally, and hence seem to be fairly well in phase with one another. For many ecosystems we should not expect such convenient balances and phasing. (5) Total live community biomass is still increasing (mostly as roots) in the young Festuca stand, while this total appears more nearly stabilized in the older, more mixed stand where Andropogon contributes only about half the above-ground production. Longer-term measurements are needed to relate slow trends to successional change (in which Festuca would normally be diluted by Andropogon, Rubus and more woody communities). (6) Root biomass (ash free g/m^2) in the top 20 cm of soil was much greater, and changed more seasonally, than in deeper layers: from 202 to 659 in November under Festuca, and from 377 to 659 (also) in late October under Andropogon. For 20-60 cm soil layers, roots increased from about 76 to 214 g/m^2 in July under Festuca and from 69 to 166 in August under Andropogon in 7.5 cm diameter hydraulic cores. Coefficients of variation were higher for the latter than for the 20 cm diameter cores, but the latter were practical only for 0.20 cm depths.

PREFACE

Modern ecological research emphasizes the analysis of ecosystems and requires non-traditional approaches to research in ecology. The processes and subject matter details in an ecosystem are sufficiently complex so as to preclude a meaningful analysis by a single individual. A 'team' approach, involving the inputs of many kinds of specialists in both the analytic and synthetic phases of study, appears to be one necessary means whereby such studies can be accomplished. The research team must study certain ecosystem processes simultaneously.

Aside from practical limitations of manpower and funds, there is an equally important constraint on teamwork; namely, attitude of the research workers. Ecologists trained in the Liberal Arts departments have traditionally emphasized individual research, and there will always be a need and place for complete self-sufficiency in many research areas. The 'loner' approach has been emphasized less in the training of applied ecologists--particularly in the areas of wildlife management, agriculture, and forestry where the nature of field problems require more collaboration. Frequently, however, research in these applied fields may focus on only a few aspects of the ecosystem without focusing on the scientifically challenging problems of its complexity.

The National Laboratory emphasizes multidisciplinary approaches to research and development. A tradition of collaborative effort, both within the Laboratory and with outside investigators, aids the development and utilization of the team approach to the analysis of ecosystems. The long experience of the National Laboratory with effective collaboration of university investigators and students provides the context for training of new ecologists desiring the multidisciplinary team approach to environmental problems.

This report is the result of an effort involving two graduate students in ecology and advisers from the University of Tennessee, a faculty consultant from Colorado State University, and staff scientists and facilities of the Oak Ridge National Laboratory. The challenge was the start of ecosystem analysis of part of a new old-field facility (Ecology Area 0800) recently established as part of ORNL's ongoing ecology program. This facility provided the opportunity to try, as a case study in training, to involve the efforts and talents of several individuals in this problem. Kelly was interested in and given responsibility for developing information on the field analysis of parameters governing the primary production of the grass species which dominate these ecosystems. Opstrup, whose interests lie mainly in the field of computers and systems analysis, was responsible for the synthesis and preliminary modeling efforts of this work. Van Dyne, Colorado State University, whose interests are in the analysis of grassland ecosystems, provided guidance and direction in experimental design, data gathering, and analytic phases after previously working with the students while on the ORNL staff. Olson, of ORNL's Radiation Ecology Section, provided coordination and guidance in the synthesis of data, successive approximations in modeling, and much of the thesis editing. Auerbach provided overall coordination, consultation, and facility support.

Both students worked together collecting data, assisting each other in the many field and laboratory tasks required for such a study. Their results, which were included in their M. S. theses in Botany at the University of Tennessee, are presented in this report in two parts--Part A representing the analysis of production by Kelly and Part B containing the preliminary modeling by Opstrup. While many limitations are inherent in any study limited to a single season, we believe that this report is evidence of this successful collaboration between two of the major types of research organizations in the country--the National Laboratory and Universities.

S. I. Auerbach
Chief, Radiation Ecology Section

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TABLE OF CONTENTS

Part A. **Production and Compartmental Transfers**

PAGE

TABLE OF CONTENTS

Part B. Preliminary Modeling and Systems Analysis

PAGE

LIST OF TABLES

Part A. Production and Compartmental Transfers

LIST OF TABLES

Part B. Preliminary Modeling and Systems Analysis

LIST OF FIGURES

Part A. Production and Compartmental Transfers

FIGURE PAGE

LIST OF FIGURES

Part B. Preliminary Modeling and Systems Analysis

A-I.

INTRODUCTION

Production and compartmental transfer studies are important in order to obtain more information for predictive understanding of the structure and function of ecosystems. A good knowledge of production and transfer estimates is essential to cope with such environmental hazards as radioactive nuclides, biocides and other environmental contaminants.

Production and transfer studies in herbaceous communities are of further interest on abandoned cropland as a step toward reactivation and maximum productive utilization for the future. The amount of productive arable land is decreasing; this makes an understanding of less productive areas imperative in order to cope with the increasing demand for food.

Research was conducted in two typical eastern Tennessee old-fields, one dominated by *Festuca elatior* var. *arundinacea*[1] and the other by *Andropogon virginicus*. The associated flora is similar, varying only in the degree of expression in each community. The objective was to measure the amount of above-ground production and compartmental transfer in the two communities and to gain needed information on the production and dynamics of root biomass. A further objective was to obtain improved production information by sampling more frequently and in conjunction with biomass peaks of significant species. Samples were collected at various intervals over one year in order to get a complete cycle.

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[1]Nomenclature follows Fernald (1950) except when quoting other authors where their nomenclature is used unchanged.

A-II.

LITERATURE REVIEW

Successional Patterns

Successional patterns on abandoned land in the Southeast are influenced by several factors. The passage of time, site factors, and proximity of seed source govern the pattern of old-field succession. The particular timing of the events in the life cycles of the first series of invaders greatly influences future dominant species (Keever 1950). Two general phases of old-field succession exist in the Southeast, succession of herbaceous plants and succession of trees. This review will be concerned only with the forms of herbaceous succession.

Three successional stages were formulated by Minckler (1946) who worked near Norris, Tennessee: (a) The pioneer stage persists one to six years after abandonment with a mean of 2.6 years; *Ambrosia elatior*, *Aster pilosus*, *Daucus carota*, *Erigeron philadelphicus* and *E. ramosus*, *Leptilon canadense*, *Lespedeza* spp., *Plantago aristata*, *Diodella teres*, *Aristida dichotoma* and *A. oligantha*, and *Syntherisma sanguinale* are found in various combinations or as essentially pure stands during the pioneer stage; (b) The intermediate stage has a mean of 4.2 years since abandonment; *Ambrosia elatior*, *Sassafras albidum*, *Rubus* spp., *Lespedeza* spp., *Phaethusa occidentalis*, and *Andropogon virginicus* share dominance in various combinations; and (c) The late stage, with a mean of 4.3 years since abandonment, is dominated by *Sassafras* and *Andropogon*. The rapidity of succession and the sequence of species involved from the pioneer stage to the late stage depends on the quality of the site.

The successional sequence from bare soil through the various arborescent stages for East Tennessee old-fields was investigated by Smith (1968). The herbaceous composition of the fields investigated varied with age up until about the 15th year of abandonment when arborescent species took over dominance. The first year dominant species were Diodia teres, Erigeron strigosus, and E. canadensis, with Digitaria, Ambrosia, Oenothera biennis, Aster, Solidago, Chrysantheum, Plantago, Rubus, and Smilax making significant contributions. The three to five year period was characterized by Erigeron strigosus, Lonicera japonica, Solidago altissima, and Aster pilosus. Other significant species in this stage were Solidago nemoralis, Andropogon, Verbesina occidentalis and Gnaphalium obtusifolium. Rhus, Sassafras, Lonicera, Andropogon, and other forbs dominated the eight to ten year fields. The 15-year fields were dominated primarily by Andropogon with some fields being dominated by Lonicera-Campsis combinations.

Studies of plant succession in fields varying in age from one to 25 years in the Central Basin of Tennessee were made by Quarterman (1957). The following sequence of dominants show that a similar pattern of succession occurs: first year, Erigeron strigosus, E. canadensis and Ambrosia artemissiifolia var. elatior; second year, Ambrosia artemisiifolia var. elatior, Erigeron strigosus, E. canadensis and many incidental species; third year, Aster pilosus, Solidago altissima, Bromus japonicus, and other tall weeds; fourth to eighth year, Andropogon virginicus and Aster pilosus; and the fifteenth year, open woods of Ulmus and Celtis with a herb layer of Andropogon virginicus, Solidago altissima, Aster pilosus and Panicum spp.

The early dominants decline in importance rapidly after the second year, although they may occasionally be found in older fields. Andropogon and Aster reach their peaks in the four to eight year fields, and Solidago in the older fields. All three occur in the first-year fields (Quarterman 1957).

The general trend of plant succession in abandoned fields of the Piedmont of North Carolina follow this pattern: Digitaria sanguinalis is usually dominant in fields during the fall following their last cultivation for the season, Leptilon canadense is usually dominant in the first year fields, and Aster pilosus is the usual dominant of second year fields. Andropogon virginicus assumes dominance the third year, and it maintains this dominance until it is replaced by pines a few years later (Keever 1950).

The following successional pattern was found on abandoned cropland in South Carolina. The first seven years the composites Leptilon canadensis, Haplopappus divarticatus, Gnaphalium purpureum and Heterotheca subaxillaris dominated the community along with the grass Digitaria sanguinalis. In the eighth year the dominance of the community changed from forbs to grasses with Andropogon virginicus becoming the most important plant (Golley and Gentry 1966).

In summation, the same general pattern of succession appears to occur throughout the Southeast with the early phase dominated by annual forbs including annual and perennial composites, the intermediate phase dominated by perennial forbs and composites, and the final grass phase dominated by perennial grasses and forbs. Andropogon virginicus appears to be the primary dominant in the final grass phase. Site factors such as fertility level, degree of erosion, light, available moisture, and proximity of seed source coupled with the life cycles of invading species appear to be the principal determinants of the rate and type of succession.

Andropogon and *Festuca* Grasses

Andropogon virginicus (broomsedge, sagegrass) is a tufted perennial grass 50 to 100 centimeters tall (Hitchcock 1950). Broomsedge has a wide natural distribution, occurring predominantly in the eastern United States. It produces vegetative cover for abandoned fields and soils of very low fertility (Stefferud 1948). Its growth is in the warm season, with flowering occurring in late summer and early fall (Hitchcock 1950).

Festuca elatior var. *arundinacea* (tall fescue, Kentucky 31), a perennial fescue, is closely related to meadow fescue (*Festuca elatior*). Tall fescue is distributed over most of the humid portions of the United States and is an important forage crop. It is well adapted to claypan and other shallow soils where moisture is often deficient or in excess. Best growth occurs on rich moist soils of heavy to medium texture. In old stands it develops a complete sod with clumps 50 to 120 centimeters tall. Tall fescue has a long growing season and remains green throughout the year provided moisture is sufficient. Flowering occurs in late spring and early summer (Hughes *et al*. 1951).

Definitions and Methods in Production Studies

Most measurements of productivity have been based on some indirect quantity, such as the amount of substance produced, the amount of raw material used or the amount of by-product released (Odum 1963). Gross primary productivity is the rate of photosynthesis including the organic matter used in respiration. Net primary productivity is the rate of storage of organic matter in excess of that used in respiration (Odum 1963).

The traditional measure of production has been the increase in standing crop during the growing season. Yield obtained from sampling the peak standing crop has been equated with net production on the area (Wiegert and Evans 1964). However, in a community with a diversified flora, the maturation and mortality occurring throughout the growing season leads to a condition in which peak standing crop has little relation to total production (Odum 1960). In order to circumvent this underestimate Odum (1960), Golley (1965), and Wiegert and Evans (1964) used the summation of peak biomass estimates of each taxon to arrive at an estimate of net community productivity. Current mortality and failure to take into account flower and seed production are two further sources of error (Golley 1965, Ovington 1963). Separation by taxa into living and dead material overcomes the effect of current mortality on production estimates (Olson 1964).

The most common method used in determining root biomass is to sample the standing crop of roots periodically and to estimate production from positive increases in biomass. Another method used is to measure actual increases in root length and diameter by the use of glass sided boxes (Schuurman and Goedewaagen 1965). Both methods give only estimates of net production since no allowance is made for root losses due to death.

In addition to the harvest method mentioned previously Odum (1963) lists five other methods for production measurement. Oxygen production and carbon dioxide uptake are used to measure gross primary production, but depends on adjustments for respiration loss. Disappearance of raw materials and radioisotope techniques are used to measure net primary production. The chlorophyll method is used as an indicator of potential primary production.

Estimates of Biomass Production in Herbaceous Communities

The amount of biomass harvested the first year after abandonment was generally higher than the amount in subsequent years (Table 1). The data of Golley and Gentry (1966) and Odum (1960) illustrate the drop in production after the first year and an increase in production when *Andropogon virginicus* becomes the dominant species about the fifth year of succession. Shanks and DeSelm (1963) encountered the same phenomenon on a highly fertile drained lake bed at Oak Ridge, Tennessee.

Community biomass production was studied by Golley (1965) for three consecutive years, during this period production dropped from 650 to 553 g/m^2 (grams per meter square). During this same period the peak crop of *Andropogon virginicus* dropped from 253 to 95 g/m^2 while the peak crop of herbs rose from 55 to 218 g/m^2. The increase in roots during this period remained fairly constant 157, 118, and 171 g/m^2 (Golley 1965).

In a Michigan old-field dominated by *Poa compressa* Golley (1960) found in a two-year study that the standing crop of roots remained the same both years, 1023 g/m^2, while production of tops declined from 385 to 251 g/m^2. Wiegert and Evans (1964) working in the same type of community in Michigan found the standing crop of roots sampled to 25 cm (centimeters) to be 685 g/m^2, a much lower figure than Golley's (1960) who sampled to approximately the same depth, while their above-ground biomass figure was equivalent. This difference in root biomass might be attributed to a site factor or to a less efficient root extraction technique.

Total community biomass production dropped from 2211 to 898 g/m^2 during the first two years of abandoment in a New Jersey old field. The

Table 1. Net Primary Production in Herbaceous Ecosystems in Grams Per Meter Square

Reference	Location	Age of Vegetation or Type of Community	Biomass
Odum (1960)	South Carolina	Field abandoned 1 year	494
		Field abandoned 2 years	331
		Field abandoned 3 years	283
		Field abandoned 5 years	309
Golley (1965)	South Carolina	_Andropogon_ dominated	
		(Total net production, root and shoot)	609 (3 year mean)
Harris (1966)	Tennessee	_Andropogon_ dominated	390
Golley and Gentry (1966)	South Carolina	Field abandoned 1 year	586
		Field abandoned 12 years	485
Malone (1968)	New Jersey	_Lolium_ dominated	
		(Total net production, root and shoot)	1544 (2 year mean)
Golley (1960)	Michigan	_Poa_ dominated upland	
		(Total net production, root and shoot)	1344 (2 year mean)
Wiegert and Evans (1964)	Michigan	_Poa_ dominated	320
Kilmer _et al._ (1960)	Alabama	_Festuca_ dominated	258
Gilbert and Chamblee (1959)	North Carolina	_Festuca_ dominated	214

Table 1. (continued)

Reference	Location	Age of Vegetation or Type of Community	Biomass
Wilson and Clark (1961)	Alberta	*Festuca* dominated	670 (5 year mean)
Harris (1966)	Tennessee	*Festuca* dominated	526

shoot harvest remained relatively constant, 267 to 296 g/m^2, while the standing crop of roots dropped from 1944 to 602 g/m^2 (Malone 1968).

Kilmer *et al*. (1960), testing the effect of soil moisture level on *Festuca* forage production, obtained above-ground yields ranging from 221 to 317 g/m^2 while the standing crop of roots ranged from 619 to 1010 g/m^2. In a similar study Gilbert and Chamblee (1959) varied the depth to the watertable from 15 to 60 centimeters for a nine-month period in the greenhouse. Above-ground yields ranged from 151 to 277 g/m^2 while below-ground standing crop ranged from 390 to 584 g/m^2. Greatest yields were obtained when the water table was at 15 cm and the soil was artificially aerated. This would tend to indicate that yields on wet soils are more a function of aeration than any other factor.

Daily Rates of Change in Above-Ground Biomass

Biomass increase, expressed in terms of average daily rates, fluctuates with the season, age, and floristic composition of the community. The higher daily production rates in the fall in fields abandoned for several years reflects the late summer and early fall growth of *Andropogon virginicus* (Table 2). Fields recently abandoned tend to have the highest production rates in the spring unless the community is dominated by a late-summer of fall-maturing plant as is the case with the forb-dominated field of Odum (1960).

The *Festuca*-dominated community has higher daily growth rates in the spring and fall with a lower rate of growth during the summer as shown by the data of Harris (1966).

Bliss (1966) reports production rates for a heath-rush and sedge meadow alpine environments on a daily basis ranged from 0.8 to 1.3 g/m^2

Table 2. Above Ground Biomass Daily Production Rates for Herbaceous Ecosystems in Grams Per Meter Square

Reference	Location	Age of Vegetation or Type of Community	Production Rate Spring	Summer	Fall	Growing Season
Golley and	South Carolina	Field abandoned 1 year	1.8	1.2	1.2	-
Gentry (1966)		Field abandoned 12 years	0.9	1.2	3.3	-
Odum (1960)	South Carolina	Forb dominated	1.0	0.7	5.4	-
		Field abandoned 6 years	1.6	1.4	1.9	-
		Field abandoned 15 years	2.2	1.5	1.8	-
		Tall grass prairie	-	-	-	3.0
		Short grass prairie	-	-	-	0.5
Wiegert and	Michigan	*Poa* dominated upland	-	-	-	0.4
Evans (1964)		*Poa* dominated swale	-	-	-	4.3
Harris (1966)	Tennessee	*Andropogon* dominated	2.9	3.2	1.5	-
		Festuca dominated	1.5	1.1	2.4	-

per day for the former and 2.0 to 4.3 g/m^2 for the latter. Olson (1964) feels that production rates up to 7 to 8 g/m^2 per day for the short growing season of the tundra are possible, but suggests this may in part be due to the upward translocation of stored food. The most fertile natural communities are capable of producing 10 to 20 g/m^2 per day for a period of six months or more according to Odum (1960).

The gross production rate of a South Carolina old-field as measured by the gas analysis technique averaged 2.7 g/m^2 per day (Golley 1965).

Production Rates Below Ground

Few data have been reported for production rates of underground organs of plants due to the difficulty and labor involved in the collection of such data.

Daily production rates for an *Andropogon* community were calculated from the seasonal production data of Golley (1965), see Table 3. In a four-year study production rates to a 25-cm depth for spring varied from 0.3 to 2.5 g/m^2 per day, summer rates ranged from 0.1 to 1.8 g/m^2, while fall values were 0.6 to 1.8 g/m^2 per day. The higher production rate in the spring is expected since very little shoot and flower stalk growth is taking place. The lower production rate of the summer reflects an increase in shoot and flowering stalk growth. The increased fall rate possibly reflects translocation of carbohydrates or increased root productivity after flowering. The data of Golley and Gentry (1966) for the field abandoned 12 years reflect the same general pattern with highest production rates in the spring and essentially no additional root material produced in the summer.

Table 3. Below Ground Biomass Daily Production Rates for Herbaceous Ecosystems in Grams Per Meter Square

Reference	Location	Age of Vegetation or Type of Community	Production Rate Spring	Summer	Fall	Growing Season
Golley (1965)	Georgia	*Andropogon* dominated	1.4	1.0	1.2	-
Golley and	South Carolina	Field abandoned 1 year	0.5	8.0	-	-
Gentry (1966)		Field abandoned 12 years	10.8	-	10.4	-
Sprague (1933)	New Jersey	*Poa* dominated	-	-	-	1.1
Malone (1968)	New Jersey	*Lolium* dominated	-	-	-	7.9

In a three-month study of *Poa pratensis* Sprague (1933) found root production to a depth of 23 cm was 1.1 g/m^2 per day. Malone (1968) working in the same state with a field dominated by *Lolium perenne* found production rates ranging from 3.2 to 12.7 g/m^2 per day in a 20-cm profile. The big difference between the rates appears to be a function of the age of the communities.

Andropogon gerardi and *A. scoparius* in a three-year study on Nebraska rangeland had an increase in root biomass from seedlings of 111 and 80 percent respectively (Weaver and Zink 1946).

Carbohydrate Translocation

In general it appears that a grass plant stores carbohydrates (sugars, fructosans, dextrins and starch) in the roots and leaf bases during the periods of slow herbage growth in spring, summer ana especially autumn (Troughton 1957). Weinmann (1940) considers the more complex carbohydrates, such as pentosans, hemicellulose and cellulose to be structural materials which cannot be further utilized by the plant. The soluble carbohydrate reserves are used during periods of rapid growth in the spring and to a lesser extend by any secondary herbage growth later in the season, as well as for respiration and growth during the winter (McCarty 1935). Great amounts of soluble carbohydrates are stored in the lower parts of the leaf blades and sheaths as well as in the roots (Sullivan and Sprague 1953).

The plant, during periods of rapid growth, has a greater capacity to deplete carbohydrate reserves than to add to them. Consequently the concentration of soluble carbohydrates in the roots during the early period of vegetative growth is lowered. The increase in the carbohydrate concentration coincident with the reduction in the growth rate appears to be related to a decline in the rate at which these substances are utilized, as well as an increased photosynthetic area (McCarty 1935).

An inverse relationship exists between growth rate and accumulation of reserve carbohydrates. When growth rates are high, such as in early vegetative growth and fruit production, there is a loss of soluble carbohydrates from the root; when growth processes slow there is an increase in the reserve carbohydrate content (McCarty 1935). The relative importance of corms, bulbs, rhizomes and leaf bases in the storage of soluble carbohydrates compared with the roots appears to vary with the species and possibly with the environment (Troughton 1957).

The data of Weinmann (1940) and McCarty (1935) show that there may be an increase of 25 to 50 percent in the carbohydrate reserve of the roots with a subsequent loss of an equivalent amount from the aboveground herbage in the late fall. This carbohydrate change demonstrates the transfer of soluble carbohydrates from the shoot to the root.

Root Distribution

Distribution of roots within the soil tends to follow the same general pattern in all herbaceous species, in that root biomass decreases rapidly with increasing depth. One of the most significant factors affecting root configuration and penetration is the oxygen content of the soil. An equally significant factor is that of available moisture (Sperry 1946). Soil texture greatly affects oxygen content and moisture availability. Weaver and Darland (1949) found 97 percent of the root material of *Andropogon furcatus* in the top 60 cm of a silty clay loam, while in a silt loam 91 percent of the total root biomass was present in the top 60 cm. There was a much more gradual decrease in root material in the silt loam 64 to 2 percent in 120 cm, as compared to 75 to less than one percent in 120 cm (Weaver and Darland 1949).

The proportion of root weight of *Andropogon scoparius* in the A horizon also varied with its thickness. When the A horizon was 28 cm thick 85 percent occurred there, and 91 percent where the A was 30 cm deep (Weaver and Darland 1949).

When seeded, *Festuca* takes several years for root establishment. In four years a *Festuca*-dominated pasture had 53 percent of the root biomass in the upper 15 cm; in six years 25 percent of the root biomass was above this depth (Long 1959).

The relation of hardpan to root penetration has been investigated by Weaver and Crist (1922). They concluded that although many native prairie species extend their roots into and through the hardpan, available water is the controlling factor since roots will not grow far into a dry soil, and very little water penetrates through the hardpan. It is logical that the same conclusion would hold true for an area with a fragipan.

Length of Life of Roots

Little is known about the life span of roots. In a study of five species of prairie grass the roots lived for at least a year and many in excess of two years (Stoddart 1935). *Agropyron smithii* roots had a survival rate of 42 percent after two years, while for *Andropogon furcatus* and *A. scoparius* after three years root survival was 81 and 10 percent respectively (Weaver and Zink 1945).

Root-Shoot Ratio

Root and shoot weights are maintained within a certain balance that is characteristic for the species. In general the root-shoot ratio decreases with increase in size, but it has been shown that a mathematically defineable pattern is maintained within a species (Monk 1966).

Species of dry sites tend to have larger root-shoot ratios than those of mesic and hydric sites (Monk 1966). The ratios of herbaceous annuals and perennials do not show a continual decline as earlier work has suggested (Parsons 1967). In general, forest trees have root-shoot ratios which are similar to those of older mesic to moist herbaceous plants with fruits (Bray 1963). No significant difference was found between the net total production of 28 herbaceous and four aboreal species suggesting that within a given climatic area mean forest and herbaceous root-shoot ratios may be nearly equal in magnitude (Bray 1963).

Species with smaller root-shoot ratios tend to be annuals, while larger ratios are represented by woody perennials. This change in root-shoot relations may give some insight into the mechanism of old-field succession (Monk 1966). The root-shoot ratio is greater for short-day plants and lower for long-day plants in comparison with normal-day plants (Crist and Stout 1929).

The root-shoot ratios of *Andropogon scoparius* and *A. gerardi* were found to be 0.22 to 0.45, while *Festuca pratensis* and *F. rubra* had root-shoot ratios of 1.44 and 2.43 (Bray 1963). The wide difference in the *Festuca* and *Andropogon* ratios are probably due to effects of amoist, cool site versus a warm, dry site.

Biomass Decomposition

Various factors such as geology, topography, climate, soil microflora and fauna, and vegetation and leaf properties are thought to control the rate and type of decomposition (Witkamp and Van Der Drift 1961). The higher the content of easily-mobile substances and the lower the lignin content, the more rapidly plant residues are humified (Koelling and Kucera 1965). During the first year of litter decay about 40 percent of the weight loss appears to be independent of microbial activity (Witkamp 1966). Considerable leaching or transfer of various materials has already occurred before most plant materials are deposited in the litter (Koelling and Kucera 1965).

The two most common techniques of investigating litter decomposition are the paired plot method of Wiegert and Evans (1964) and the mesh bags of Shanks and Olson (1961).

Wiegert and Evans (1964) found that the short-term rate of decomposition on an upland area varied from 8.4 mg/g per day to 1.3 mg/g per day. The highest rate of decomposition was in the early part of the growing season and decreased as the season progressed (Wiegert and Evans 1964). Koelling and Kucera (1965) over a two-year period found that there was a 60 percent loss in the dry weight of foliage litter of Andropogon species, compared to a 40 percent reduction for flower stalks during the same period.

Monthly decomposition rates calculated by Harris (1966) for Andropogon and Festuca communities were 45 and 47 g/m^2 per month. The annual decay in the same two communities was 693 and 581 g/m^2. The decay rate for a Georgia Andropogon community ranged from 300 to 600 g/m^2 (Golley 1965).

Little work has been done on root decomposition. The amount of root biomass lost over a year's time in the upper five centimeters of the soil was 200 g/m^2 for roots and 141 g/m^2 for rhizomes (Dahlman and Kucera 1965). A turnover rate of four years was found for the system as a whole, although certain underground parts may persist for a longer or shorter period of time (Dahlman and Kucera 1965). The factors influencing the decomposition rate of roots in the soil are essentially the same as those for above-ground decomposition (Kuranov 1959).

<u>Standing Dead and Litter</u>

Litter, with few exceptions, is the primary factor in determining infiltration of precipitation and in erosion prevention. Infiltration of water was two to three times greater on soils with 225 to 340 g/m^2 of surface mulch than on either bare soil, or soil with an equivalent amount of organic material incorporated into the top 8 centimeters of soil (Dyksterhuis and Schmutz 1947). Mulches also reduce water losses by evaporation and in some instances aid in germination and emergence of grass seedlings (Dyksterhuis and Schmutz 1947).

The litter compartment has two input sources; the standing dead from previous years and the annual input from green forbs and grasses (Golley 1965). The amount of dead material not yet incorporated into soil is at a minimum toward the end of the growing season and at a maximum after the killing frosts of late October and early November (Odum 1960). In old-fields contributions to the standing dead are made during the growing season as some plants die and at the end of the season when most shoots die (Golley 1965).

The standing crop of litter in grassland communities as reported in the literature ranges from 49 to 1365 g/m^2, while standing dead vegetation ranges from 11 to 382 g/m^2 (Table 4).

The standing crop of litter in a forb-dominated field varied from 70 to 200 g/m^2 during a year's time. In the same field two years later when Andropogon was the dominant the standing crop of litter had stabilized at 250 g/m^2 (Golley 1965). The standing crop of litter in the study by Wiegert and Evans (1964) on a Poa swale varied from 264 to 604 g/m^2 depending on the time of year and the year.

Litter Bag Techniques

The use of nylon mesh bags to determine the rate of leaf breakdown in forest communities was pioneered in this country by Shanks and Olson (1961). Since that time the technique has been used frequently.

Differences in breakdown are influenced by both the litter species and the environment in which the litter is decomposing. Because of the confinement of the leaves and their fragments, and restricted access of the larger forest floor fauna, the results are not absolute measurements of breakdown of litter under natural conditions (Shanks and Olson 1961). The loss prevented by the exclusion of the larger fauna may be offset somewhat by the greater moisture retention of the bagged leaves thus sustaining microbial decomposition for a greater length of time (Witkamp and Olson 1963).

Consumption by Insects and Animals

Consumption of plant materials by insects and animals often is overlooked when making determinations of net productivity. Crossley (1963)

Table 4. Mean Biomass Estimates of Litter and Standing Dead for Herbaceous Ecosystems in Grams Per Meter Square

Reference	Location	Age of Vegetation or Type of Community	Litter	Standing Dead
Golley (1965)	Georgia	Forb dominated	135	-
		Andropogon dominated	250	335
Odum (1960)	South Carolina	Forb dominated	300	-
		Field abandoned 15 years	500	-
Golley and	South Carolina	Field abandoned 1 year	309	11
Gentry (1966)		Field abandoned 12 years	480	189
Ovington *et al.*	Minnesota	Prairie	279	-
(1963)		Savanna	1365	-
Wiegert and Evans	Michigan	*Poa* dominated swale	434	-
(1964)		*Poa* dominated upland	202	-
Dkysterhuis and	Texas	Relict prairie	1082	-
Schmutz (1947)		Native hay meadow	333	-
		Range in excellent condition	697	-
		Range in fair condition	275	-
Harris (1966)	Tennessee	*Andropogon* dominated	258	382
		Festuca dominated	49	109

found that insect consumption for a 100-day growing season in a *Lespedeza-Salix* community would be approximately four to six percent of the plant biomass produced during the growing season.

Calculations made from Golley's (1960) data indicate that vegetation consumption by a *Microtus* population in a Michigan old-field community dominated by *Poa compressa* would be approximately 1.2 percent of the total biomass produced.

A-III.

EXPERIMENTAL AREA

Location

The study areas are located in Roane County, Tennessee, on the U. S. AEC Reservation. The two areas are directly adjacent to each other and separated only by a gravel roadway (Figure 1). Both fields have the same exposure and aspect with a gentle northward down-slope of two to three degrees. The average elevation is approximately 750 feet above sea level. The *Festuca* field is bordered on the north and east sides by a pine forest. The front border for both the *Festuca* and *Andropogon* areas is a managed *Festuca* field. The north and south sides of the *Andropogon* area are bordered by unmanaged *Festuca* areas. The rear is bounded by a Japanese honeysuckle-blackberry tangle and pine forest. Each field contains approximately two acres.

Land History

Both study areas were in agricultural use prior to 1942. After 1942 the *Festuca* field lay fallow until 1956 when it was planted in loblolly pine (*Pinus taeda*). Early in 1964 the pine trees were cleared from the present *Festuca* field and the stumps removed by breaking the tap root and lifting the stump out with a bulldozer. A "bush and bog" disk was used to break up the soil, cut the roots and slice the vegetation mat so that a furrow plow could be used. After plowing, a disk harrow and a drag were used for final smoothing of the area before seeding. The *Festuca* seed was drilled into the soil along with a light application of 10-10-10 fertilizer in the fall of 1964. Since that time the field has received no further treatment.

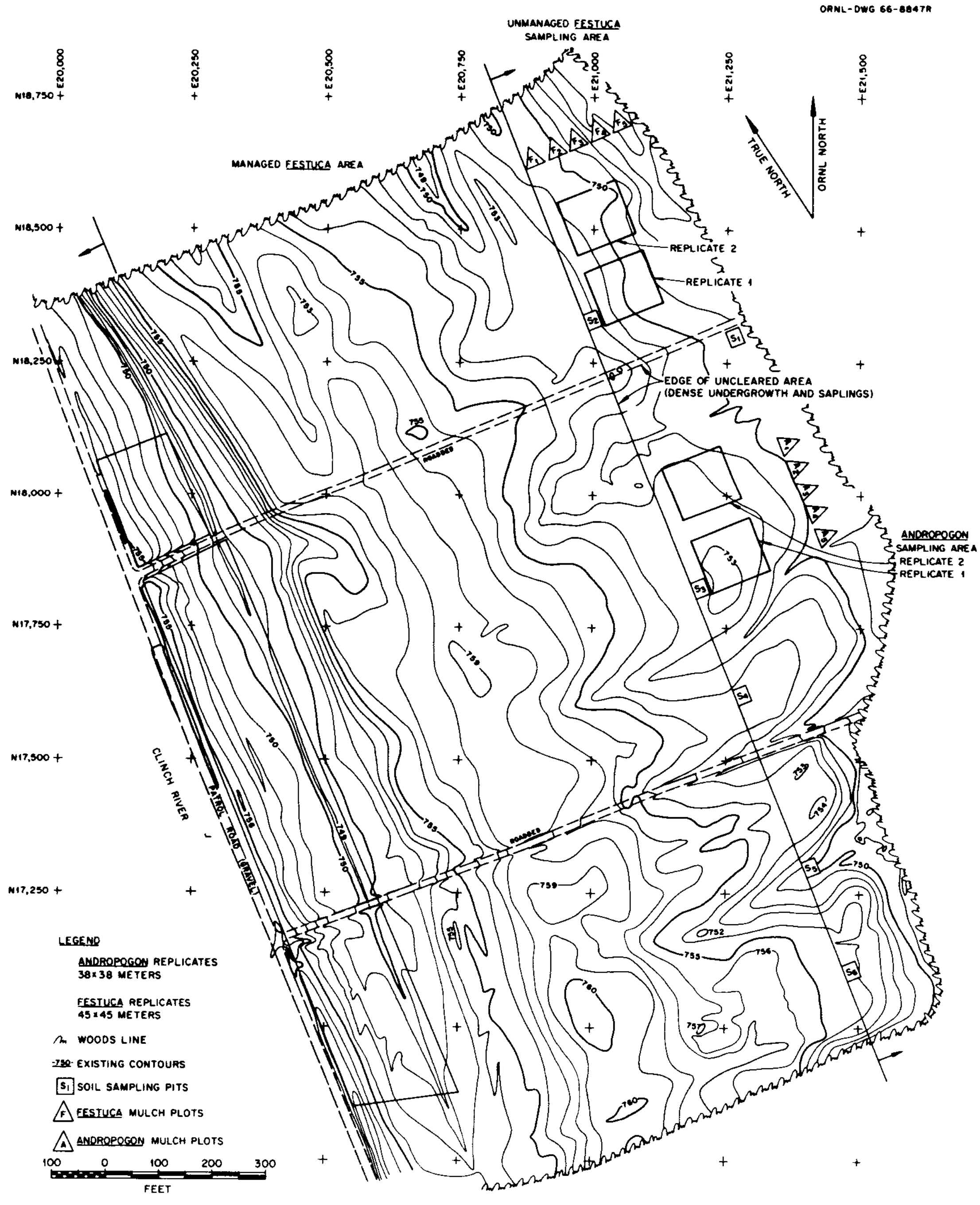

Figure 1. Contour map of sampling area showing the location of the two communities.

The *Andropogon* field remained fallow from 1942 until 1964 when preparation of the study site began. *Lonicera japonica*, *Rubus allegheniensis*, and scattered *Juniperus virginiana* formed thickets in the *Andropogon* field prior to site preparation (Figure 2). The *Andropogon* field received a blanket spraying of 2,4-D and 2,4,5-T in May of 1964. The dead vegetation was left standing in place, but by the summer of 1965 the previous vegetation was no longer detectable, with the exception of residual woody material. The field was spot-sprayed in the summer of 1965 to remove remaining *Lonicera japonica* and *Rubus*. With the exception of the spot-spraying in 1965 the field has received no further treatment since 1964.

Geology and Soils

The study area lies in the Ridge and Valley Province, an area characterized by a series of alternating ridges and valleys which extend in a southwest-northwest direction (Roane County Soil Survey 1942). The rock strata underlying the Ridge and Valley Province in this area are of Cambrian, Ordovician or Silurian Age. Late Cenozoic through pre-Pleistocene erosion cycles have reduced the area to its present low ridge-valley condition (Rodgers 1953). The ridges are underlain by either cherty dolomite or interbedded shale and sandstone. The valleys between the ridges are underlain by high-grade limestone, argillaceous limestones, or shale (Roane County Soil Survey 1942).

The two soils of the study area are low or intermediate terrace soils developed on old Clinch River alluvium. The alluvial material appears to be derived largely from uplands underlain by limestone and to

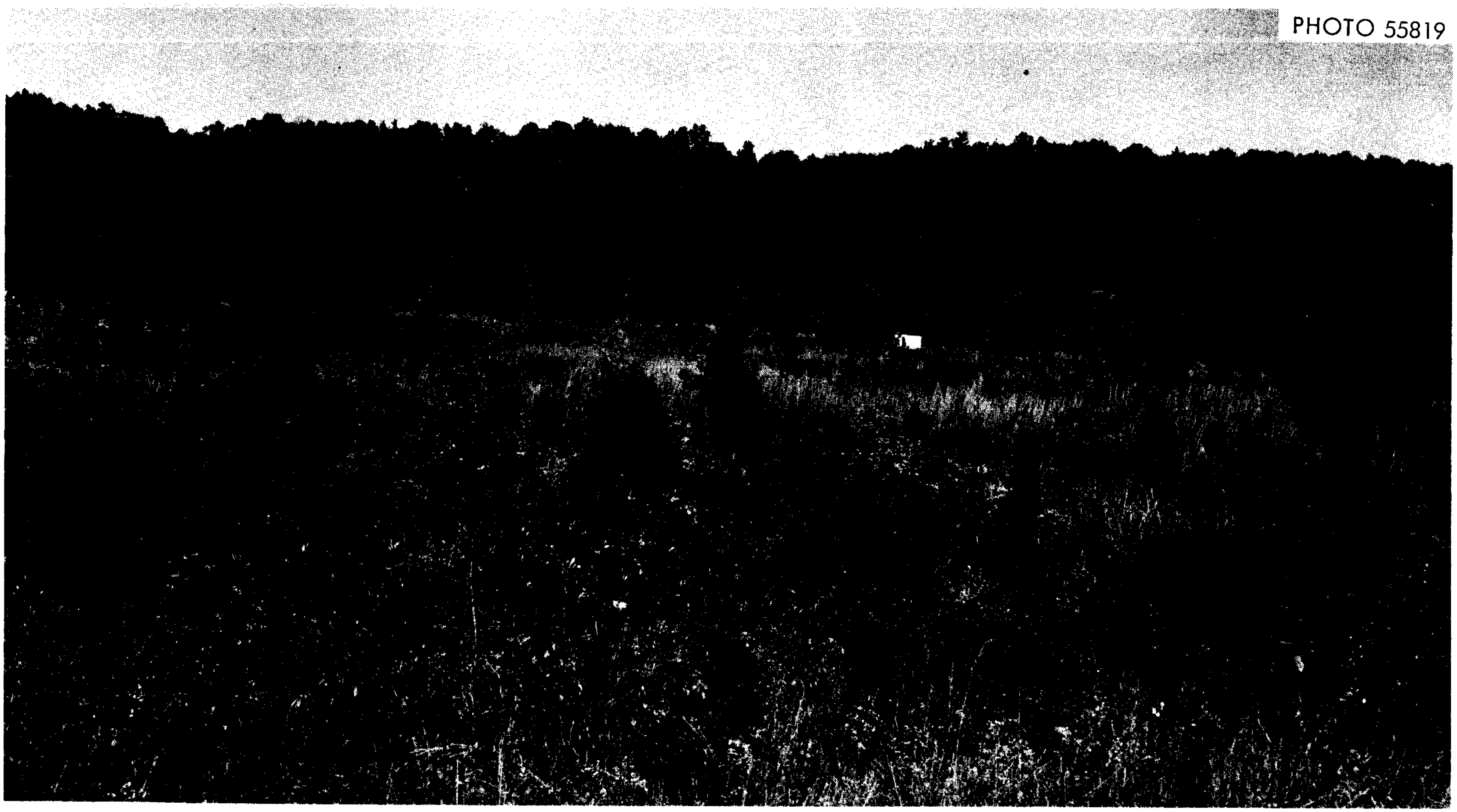

Fig. 2. Photograph of Study Area Prior to Site Preparation.

less extent from shale, sandstones and crystalline rocks (Roane County Soil Survey). The landscape is gently sloping to rolling with moderate to slow surface drainage. Erosion is slight.

The soil of the Festuca sampling area is Etowah silt loam. This is a moderately well developed terrace soil with moderate to medium granular structure, friable consistence when moist and loose when dry, and medium internal drainage. The color of the A is dark brown (10YR4/3) with a depth ranging from 18 to 23 centimeters. The B horizon has a strong brown color (7.5YR5/6) with a depth ranging from 50 to 60 centimeters below the A. The structure of the B is moderate to medium subangular blocking with pronounced clay skins. The C horizon has a strong brown color (7.5YR5/6) varigated with yellowish brown (10YR6/4), very pale brown (10YR8/3) and dark grayish brown (10YR3/2) colors. The horizon begins about 76 centimeters below the surface and becomes more sandy with depth. Structure of the C was not determined (Waller personal communication, 1966).

The soil of the Andropogon sampling area is Captina silt loam. This is a moderately well-drained terrace soil with a fragipan. The A horizon has a dark brown (10YR1/2) color with a friable fine to medium structure and a depth range from 16 to 25 centimeters. The upper B horizon is a silty clay loam, yellowish brown (10YR5/4) in color and with a strong to medium subangular blocky structure. Dark stains are common throughout. The depth of the uppper B horizon ranges from 25 to 30 centimeters. The lower B horizon or the fragipan area occurs at 53 to 60 centimeters below the surface. The color is a mottled yellow (10YR7/6) or olive yellow (2.5YR6/6). The moderate to strong subangular blocky structure appears to be massive. Vertical streaks, white (10YR8/2) in color and concretionary material are present throughout. This possibly could have been an old A horizon (Waller personal communication, 1966). The C horizon was not sampled. The position of the soil pits from which the descriptions of the previously mentioned soils were described are indicated in Figure 1 (p. 8) as S_2 and S_3.

Table 5 summarizes for the two study areas the fertility level, which was in both cases very low. The 0 to 20 centimeter increment approximates the depth of the A horizon in both areas, the remaining two increments are from the B horizon. The pH remains fairly constant in the total profile but differs slightly between the areas (Van Dyne 1968 unpublished).

Climate

The climate of Roane County is of the humid mesothermal type, with moderate summer and winter temperatures. Mean seasonal temperatures in ^oC are winter, 5; spring, 15; summer, 24; and fall, 14; with an average frost-free period of 196 days (Holland 1953). The frost-free period extends from mid-April to late October. The mean annual precipitation is about 124 cm and is well distributed throughout the year, with lightest precipitation in the autumn of about 23 cm. Winter is the wettest season with about 38 cm. Spring and summer are approximately equal with 33 and 30 cm respectively. Summer rains are in the form of heavy showers, otherwise rain falls in slow gentle showers that usually last for half a day or more (Holland 1953).

Vegetation and Flora

The Oak Ridge area is in the Ridge and Valley section, oak-chestnut part, of the eastern deciduous forest, according to Braun (1950). Oaks

Table 5. Chemical and Textural Analysis of the Soils in the *Andropogon* and *Festuca* Sampling Areas in 20-Centimeter Depth Increments (Values are in parts per million)[a,b]

Depth	Phosphorus	Phosphorus Level	Potassium	Potassium Level	Texture	pH
Andropogon						
0 to 20	1.9	Very Low	79	Moderate	Silt Loam	6.1
20 to 40	1.4	Very Low	82	Moderate	Silt Loam	6.1
40 to 60	1.9	Very Low	82	Moderate	Loam/Silt Loam	5.8
Festuca						
0 to 20	1.8	Very Low	76	Moderate	Silt Loam	6.3
20 to 40	1.7	Very Low	75	Moderate	Silt Loam	6.4
40 to 60	2.0	Very Low	74	Moderate	Loam/Silt Loam	6.2

[a]. Data in this table is from Van Dyne (1968) unpublished.

[b]. Phosphorus, potassium and pH determinations were made by the State of Tennessee Cooperative Extension Laboratory, Nashville, Tennessee.

were probably the dominant trees prior to the arrival of white men, white oak (Quercus alba) being the most common. A high amount of Chestnut (Castanea dentata) was present on the mesic slopes. Mixed mesophytic forests prevailed on the lower slopes as well as on the valley floors. Chestnut has now been replaced by yellow poplar (Liriodendron tulipifera). Other common deciduous species were hickory (Carya tomentosa), black walnut (Juglans nigra), sugar maple (Acer saccharinum), and dogwood (Cornus florida). Pines, especially Pinus echinata and P. virginiana were numerous in many old fields, with P. strobus more localized.

Over 1500 higher taxa contribute to the flora of counties surrounding the Oak Ridge area. Approximately 850 species were recorded in 1965 from work centering around the Oak Ridge Reservation (Olson et al. 1966). Of the total flora only a small percentage are old-field invaders.

A-IV.

METHODS

Sampling Frequency

The objective was to sample each community as closely as possible to the significant phenological events occurring in the community (Figure 3). The major sampling periods for both communities were defined as: the pre-growing season, the period of rapid vegetative growth and flowering, the late growing season, and the post-growing season.

Plot Size

A circular one square meter plot was chosen as the optimum sampling unit, optimum being defined as the size which will provide the smallest confidence limits of the mean for a given cost (Wiegert 1962). The circular shape was chosen over the square or rectangular forms because of the reduced ratio of perimeter to area, thus necessitating fewer decisions to include or exclude plant material per unit area (Harris *et al*. 1968). On an areal basis, larger plots require less time for clipping but increasing plot size beyond 1 m^2 (meter square) does not significantly improve efficiency (Harris *et al*. 1968).

In addition a square 0.25 m^2 plot was nested in the 1 m^2 circular plot to diminish the bulk of material to be handled for intensive work. The change from circular to square frames was necessitated by the use of the herbage meter which will be discussed later. Thus, on each sampling date 20 circular plots, 1 m^2, containing a 0.25 m^2 plot were clipped in each replicate. A total of 40 plots were clipped on each sampling date in each vegetation type.

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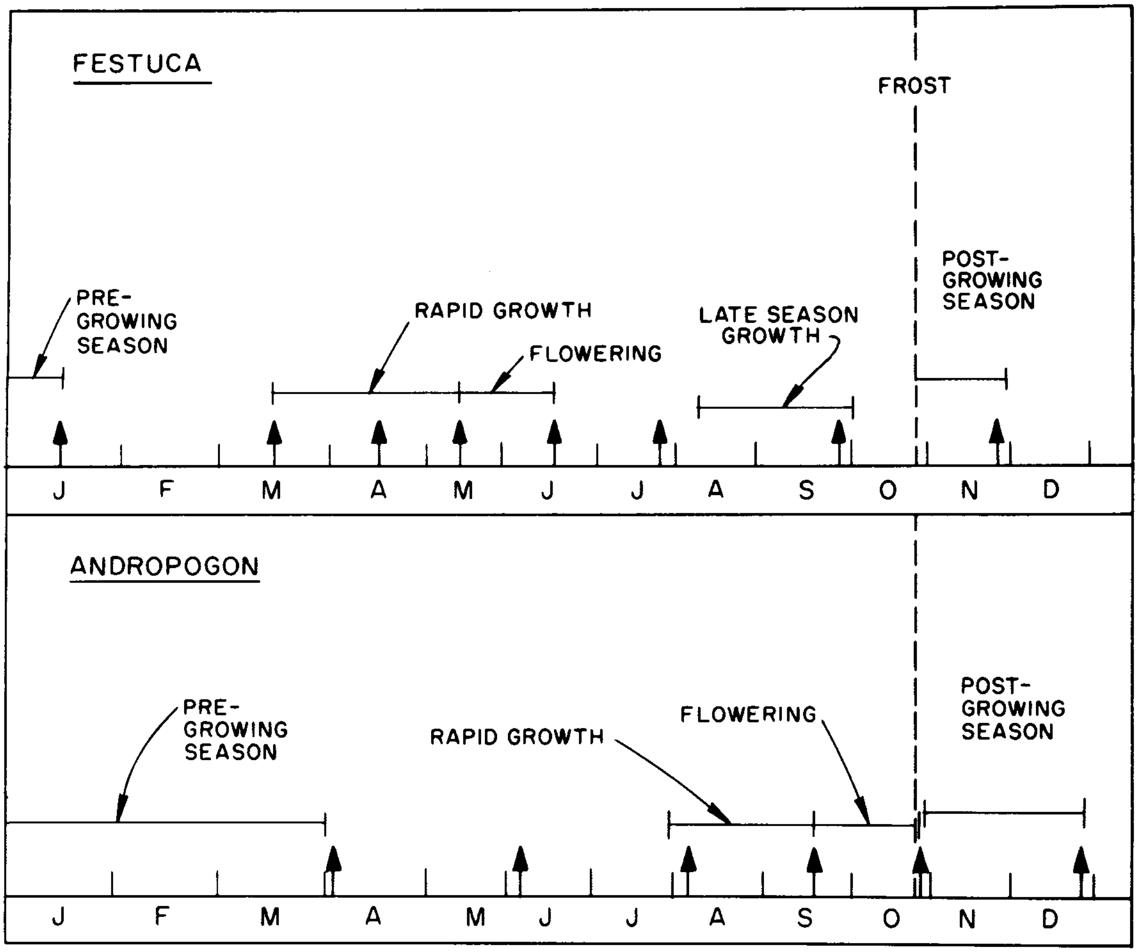

Figure 3. Sampling dates for the Festuca and Andropogon communities, arrows indicate the time of the sample.

Selection of Samples

In order to hold destruction and disturbance of future sampling areas to a minimum, a restricted randomized design was used. Plots were taken only within designated portions of the total sampling area, which was a nested set of "U-shaped" areas (Figure 4). Each "U" was 1.2 meters deep and extended around three sides of the sampling area. As samples were taken, the potential sampling area was moved inward to expand the area eligible for sampling. The location of plots within the "U" was at random. Each community contained two replicates which were established at least 6 meters away from the adjoining managed *Festuca* area in order to avoid any edge effect (Figure 1, p. 24).

Sample Treatment

Once the sample site had been located, the plot frames were laid in place and the vegetation was reworked so that only plants rooted in the plot would be clipped. Figure 5 presents in block diagram form the field and laboratory procedures. The 0.25 m^2 plot was clipped and the herbage placed in a plastic bag in order to keep the vegetation fresh until a green or fresh weight could be determined. The sample was then frozen to prevent loss by decay and respiration.

In the laboratory the clipped herbage was sorted to species and a distinction made between the live and standing dead material using the criteria of Harris (1966). The sorted species, both live and dead, were bagged separately and dried at 105°C (degrees centigrade) for 48 hours. Dry weights were determined to the nearest 0.1 of a gram.

The ground litter found on the 0.25 m^2 plot was harvested and brought back to the laboratory where it was freed of soil contamination by

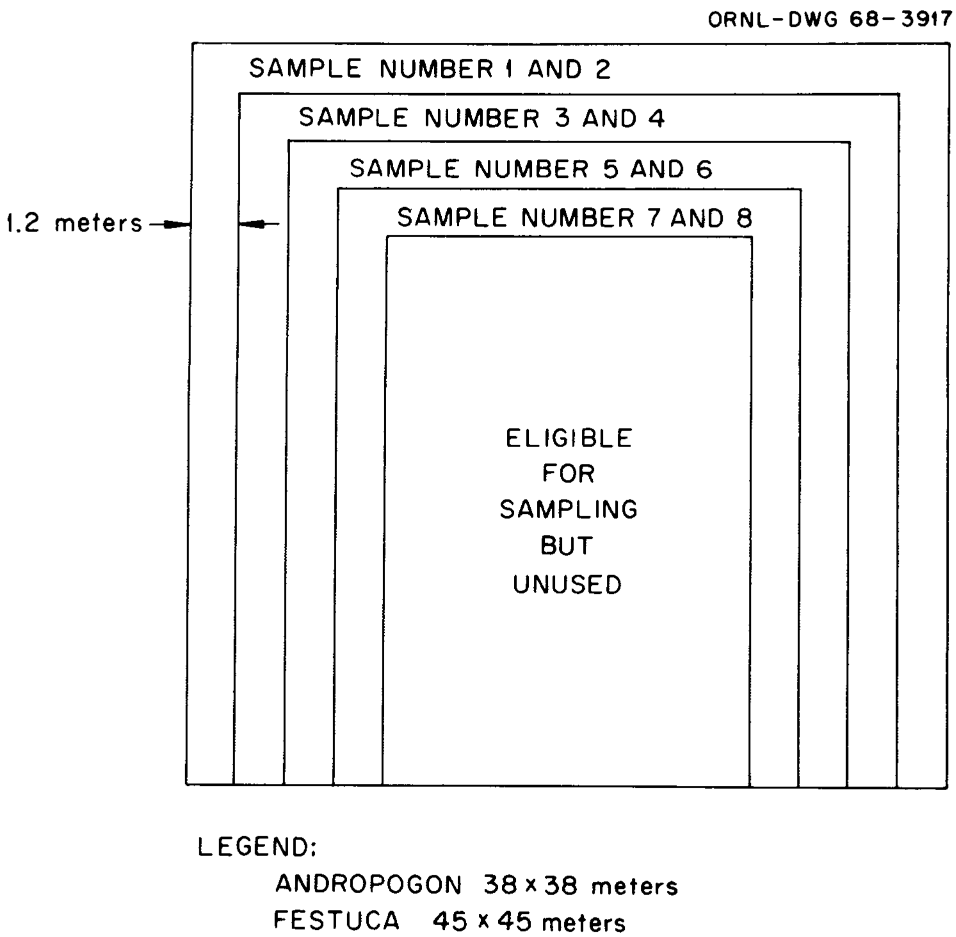

Figure 4. Diagram of nested "U-shaped" sampling areas.

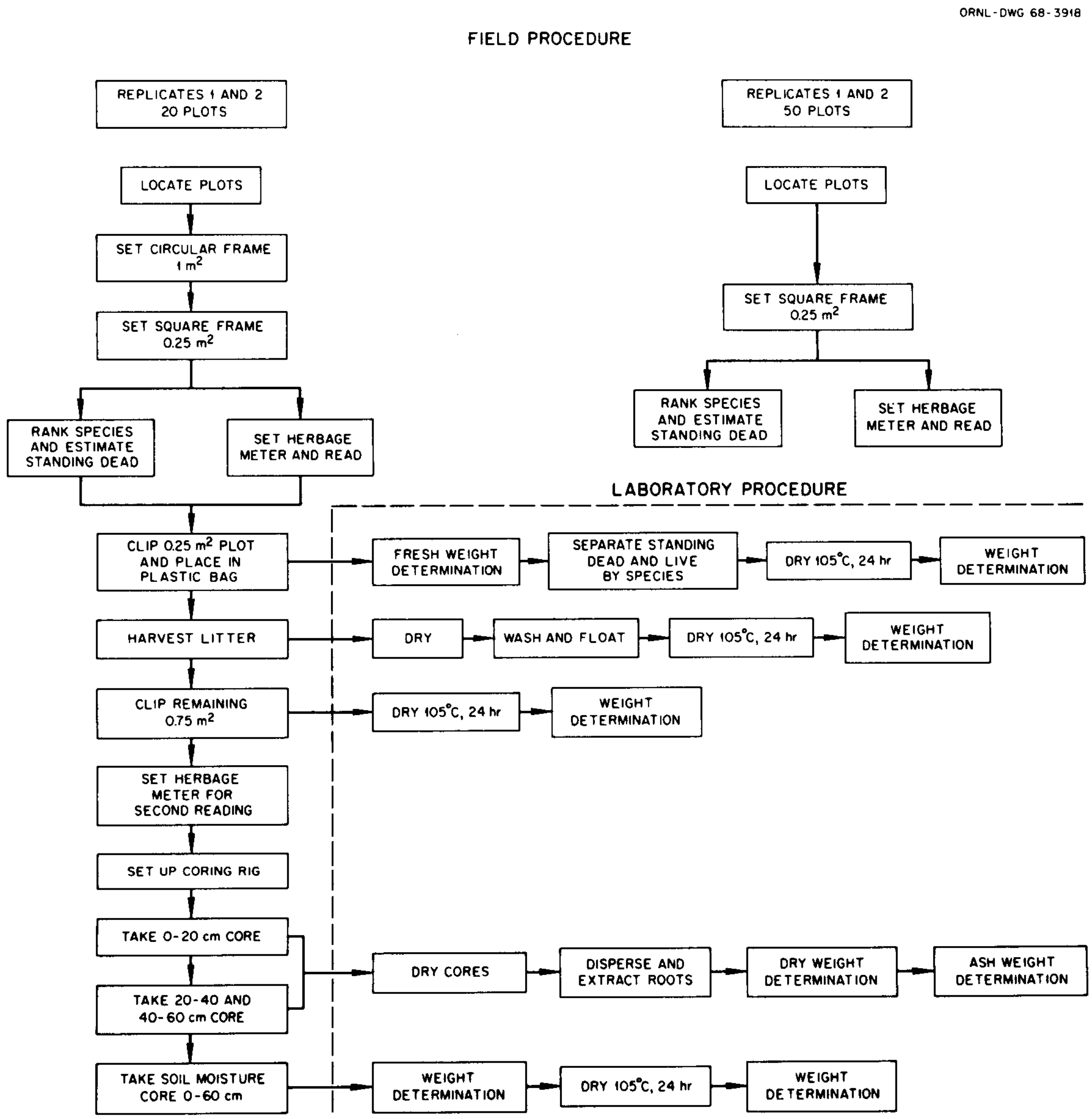

Figure 5. Block diagram of field and laboratory procedures.

flotation. After washing, the sample was dried at 105°C and the weight determination made to the nearest 0.1 gram.

The remaining three-quarters of the meter was clipped and dried at the previously mentioned temperature for 48 hours and a weight determination made (Figure 5, p. 35). The sum of the species weights added to the three-quarter meter weight gives the total biomass of the plot.

The total amount of field time required per plot was approximately 12 minutes of working time plus eight minutes of preparation. Laboratory time per sample averaged approximately 45 minutes per sample.

The dry weight rank method of Mannette and Haydock (1963) was used in conjunction with the clipped plots. In this method the species found in the 0.25 m^2 plots were listed and given a rank in the field. The rank was based on the amount of dry weight the species would contribute to the total dry weight of the plot. The species contributing the most was given the rank of one, and so on. The data were tabulated to give the proportions of plots in which each species received first, second, third, etc. These proportions were multiplied by a set of weighted multipliers to obtain proportions or percentages which each species would contribute. See Opstrup (1968) for a more detailed description of the calculations involved. The value of this method is that it allows one to sample a larger number of plots and obtain species information after clipping a few plots for calibration.

The other method used in conjunction with each plot was the capacitance meter or herbage meter approach (Van Dyne <u>et al</u>. 1968). This method makes use of the same 0.25 m^2 plot mentioned previously. Before the plot was clipped the herbage meter (Figure 6) was inserted into the

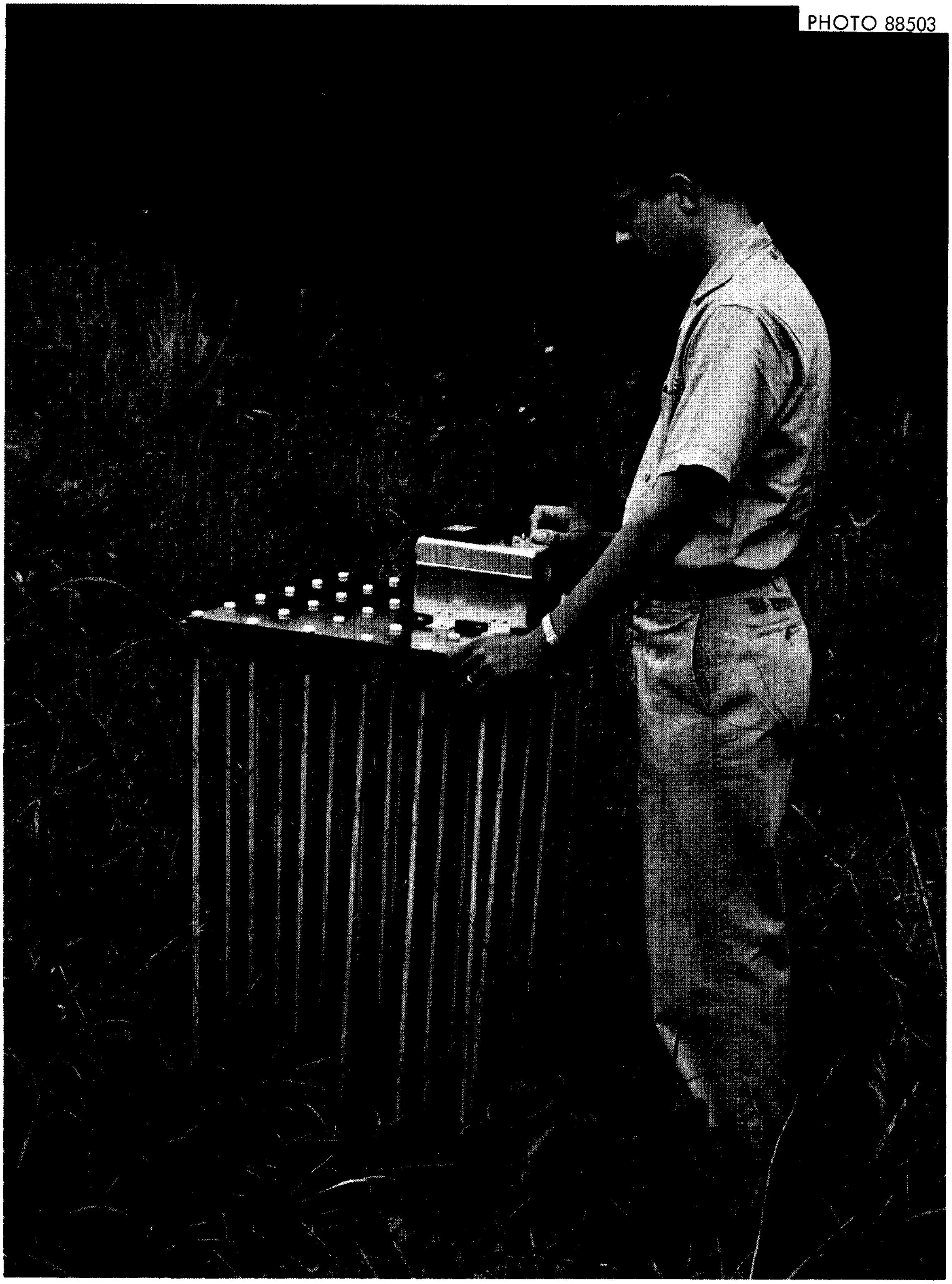

Fig. 6. Herbage Meter in Position for Reading.

standing vegetation and a reading taken. Opstrup (1968) describes the calculations involved in the conversion of the meter readings. This instrument allows one to take a large number of non-destructive samples after clipping a small number of plots for calibration. This method gives only an estimate of total biomass. However, when combined with the dry-weight rank method it is possible to put the data on a species basis.

Non-Clipped Plots

In addition to the 20 clipped plots taken in each replicate, 50 plots were selected at random within the replicate and evaluated by use of the herbage meter and dry weight rank method. Additional information on the use of these plots may be found in Opstrup (1968).

Root Biomass

After the vegetation and litter had been removed from the 20 plots, ten of the plots were chosen at random for root biomass samples. The sample was taken in the following manner.

A hydraulic coring device drove a 20-cm diameter tube to a 20-cm depth. This cylinder of soil was extracted from the earth and bagged for drying. Inside the hole made by the extraction of the 20 cm cylinder, two 7.5-cm tubes were driven to the depth of 60 cm. The soil taken from these two tubes was divided into two 20-cm segments and corresponding depth intervals from the two samples composited to form one sample each from the 20 to 40 and 40 to 60 cm levels. The arrangement of the samples and the amount of root material extracted from each level is illustrated by Figure 7.

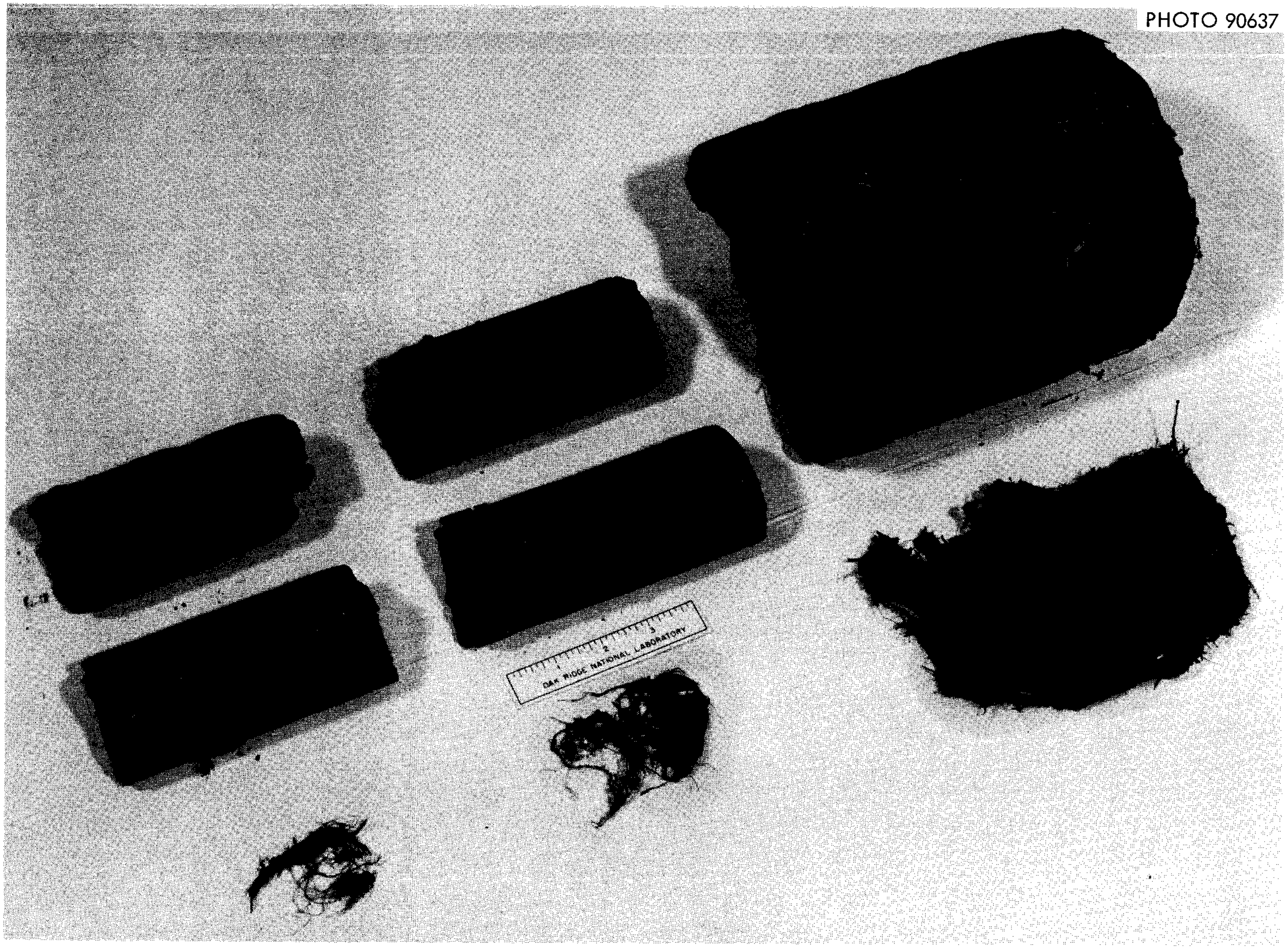

Fig. 7. Root Biomass Core Samples with Relative Amounts of Root Material Present in Each Depth Increment.

At the same time the other core samples were taken, a tube two centimeters in diameter was driven to a depth of 60 cm and a sample obtained for soil moisture content. This sample was placed in a sealed metal can until it could be weighed and dried at 105°C and reweighed. The difference between the wet and dry weights or soil moisture was expressed as a percentage of the dry weight of the sample.

It became obvious at the outset of the study that it would be impossible to process the root samples immediately after their extraction in the field. For this reason the cylinders of soil were dried for at least 48 hours at 105°C and then stored in a dry place until the extraction process could be completed.

Extraction of Roots

A quick and efficient method of root extraction was necessary due to the large number of samples to be processed. Several separation techniques are described in the literature (Schuurman and Goedewaagen 1965, Pavlychenko 1937, and McKell *et al.* 1961). These methods plus some of our own design were tried. Of the techniques tried, only two showed much promise for our work. The first was the use of an ultrasonic vibrator which will be discussed later. The second was a modification of the flotation method of McKell *et al.* (1961).

A "V" notch was cut into the top of a large plastic tub and the tub was so situated on the work surface that it slanted toward the notch. The cylinder of soil containing the roots was placed in the tub and the tub filled with water and allowed to stand overnight. Because water did not disperse the soil sufficiently to make extraction easy, three dispersing agents were tested: sodium hydroxide, calgon and sodium pyrophosphate.

The latter proved most satisfactory, with a concentration of 270 grams to 100 liters of water, as suggested by Schuurman and Goedewaagen (1965). The samples were allowed to soak overnight before the extraction process began.

Water under normal hydrant pressure was circulated through the tub containing the soil and out through the "V" notch in the side of the tub. The water flowing out of the tub passed through a 500-micron mesh sieve. The water circulating through the dispersed soil loosened the roots and allowed them to float to the surface where they were carried out by the circulating water and caught in the sieve. Clods that were resistant to dispersion were broken by hand. This process continued until no roots were visible in the soil remaining in the tub. The top 20 cm usually required 30 to 45 minutes of washing for separation. The samples from the lower depths usually required less than 20 minutes of washing for extraction. Any soil caught by the sieve was extracted by floating the roots in clean water and then decanting them into another container.

To clean the 0 to 20 cm samples of any clinging soil, they were placed in glass jars containing approximately 500 milliliters of sodium pyrophosphate solution. These jars were placed on a mechanical shaker for 30 minutes. After shaking the samples were rinsed with water and a one percent solution of sodium hypoclorite placed in the jar and shaken for an additional 15 minutes. The sodium hypochlorite was used as a bleach to remove any incorporated soil particles from the roots (Dahlman personal communication, 1967).

After completion of the washing process the extracted root samples were frozen until they could be dried. After drying at 105°C for 24 hours a dry weight was determined to the nearest 0.01 gram. After drying, eight of the ten samples from each depth and each replicate were ashed for 24 hours at 1125 degrees Fahrenheit and a weight determination made to the nearest 0.01 of a gram (Jackson 1958). The organic matter content was calculated by subtracting the ash weight from the dry weight of the sample. The remaining two samples were placed in storage for future chemical analysis not in the scope of the present study.

Ultrasonic Method

Ultrasonic cleaning devices are used in industry to remove by dispersion any foreign material from surfaces. For this reason it seemed feasible that this method might be fruitful for root extraction. The method was found to be unsatisfactory for the entire sample due to the time factor, in that the time required was too great to make total dispersion useful. However, this method was most promising in the final stages of cleaning for removing clinging soil particles. Unfortunately time and other commitments of the ultrasonic equipment prevented further experimentation. Since our work, a report has been published on the use of ultrasonics for dispersion of soil samples for mechanical analysis by Edwards and Bremmer (1967). This method has many promising aspects and should be investigated further.

Litter Plots and Litter Bags

Five permanent 1 m^2 plots were established in each community. The ground litter was removed from these plots at monthly intervals from March to December. The purpose of these plots was to give data from which a monthly or daily rate of litter fall could be calculated. The standing dead material in the Andropogon community plots was sprayed with a waterproof, weather-resistant transparent red ink. The purpose of this was to allow the previous year's standing dead material to be distinguished from the present year's growth. Unfortunately the ink did not persist and the sprayed material could not be identified when it reached the litter.

The standing crop of ground litter collected from the permanent litter plots was composited by community. Thirty-five litter bags, 20-cm by 20-cm, containing an amount of litter equivalent to the standing crop of litter on an area of equal size (Figure 8) were placed back in the community in contact with the mineral soil. An effort was made after placing the litter bag on the soil to return the vegetation to its natural position above the bag.

Four bags were collected at random in each community on a monthly basis from May through December. Loss of weight from the litter bags was used to estimate the decay loss in the litter.

The samples collected from the permanent litter plots were brought into the laboratory and washed by flotation to remove any soil contamination. The same process was also used on the litter bags. Both were then dried for 24 hours at $105^{\circ}C$ and weights determined to the nearest 0.1 gram.

Statistical Analysis

Mean values, standard deviations, standard errors, coefficients of variability, maximums, minimums, and ranges of the data were calculated for all above and below ground biomass values. Opstrup (1968) describes and illustrates the forms used in the field to collect the data and the computer programs used in the calculations.

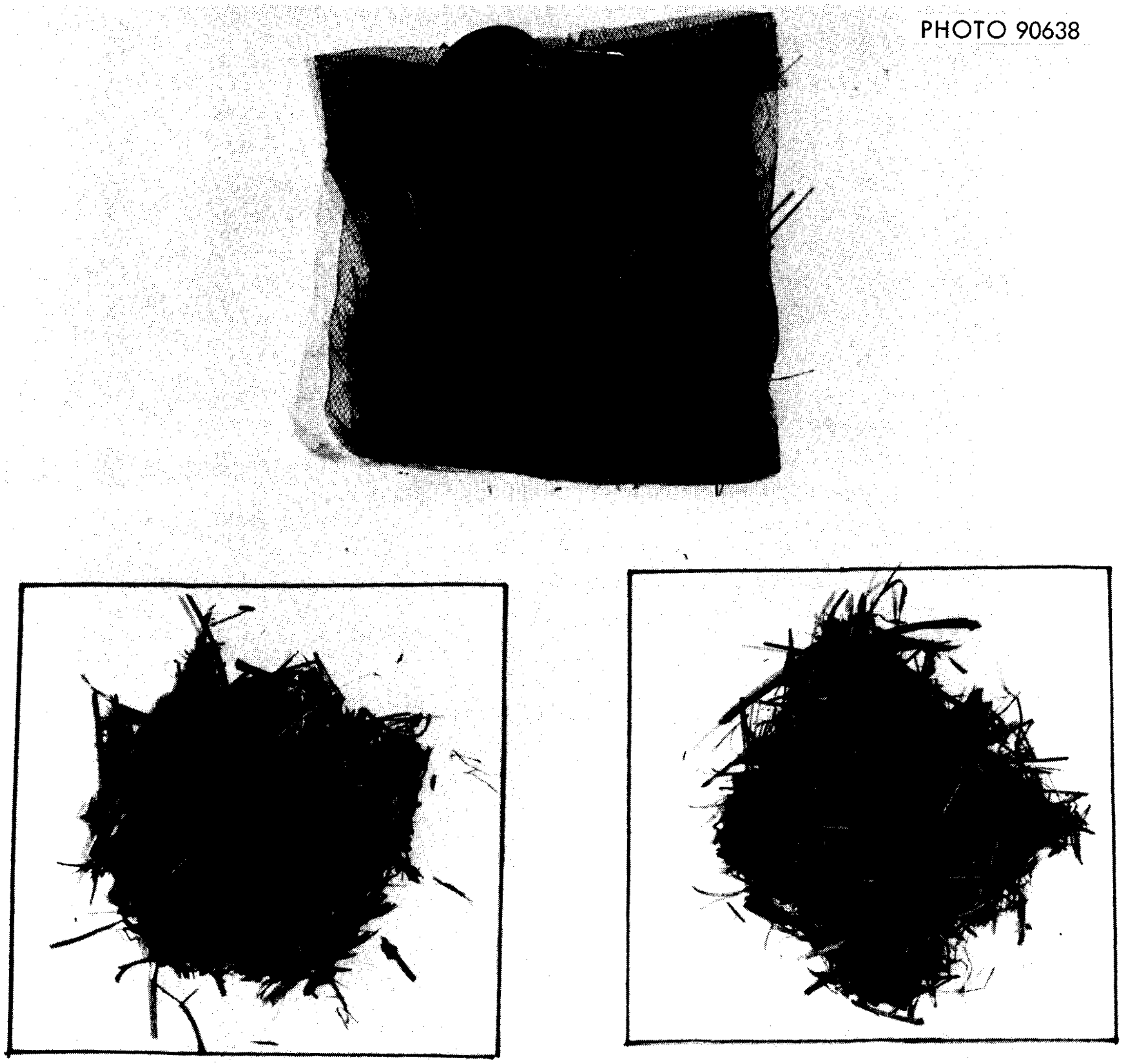

Fig. 8. Litter Bags Showing Varying Amounts of Decomposition as Well as the Amount of Original Litter.

A-V.

RESULTS AND DISCUSSION

I. ENVIRONMENTAL FACTORS

Temperature and Precipitation

Temperature and precipitation patterns are summarized graphically in Figures 9 and 10. The temperature and precipitation values recorded in 1967 are atypical. The mean seasonal temperatures for 1967 were: winter, 6; spring, 14, summer, 23; and fall, 13^{o}C. The long-term means for the same seasons as reported by Holland (1953) are 5, 15, 24, and 14^{o} respectively. The frost-free period of 1967 lasted from April 30th until October 27th, a total of 180 days. This is considerably shorter than the average frost-free period of 196 days (Holland 1953). The fall and winter temperatures were slightly warmer than average while the summer mean was slightly below average.

Precipitation seasonal means for 1967 exceeded the long-term seasonal means greatly. The total precipitation for 1967 was 165 cm, compared to the annual mean of 124 cm. Long-term seasonal means are: winter, 38; spring, 33; summer, 30; and fall 23 cm. The values recorded in 1967 were in every case higher than the average. The values were 41, 56, 89 and 43 cm. Precipitation by season on a percentage basis would be 30, 26, 25, and 18 for the 30-year mean compared to 25, 22, 35, and 17 for 1967. July was the wettest month with 36 cm. Most of the precipitation that fell during the summer came from heavy thunder showers. August with < 8 cm of precipitation was the dryest month. Precipitation in the form of snow and ice was negligible.

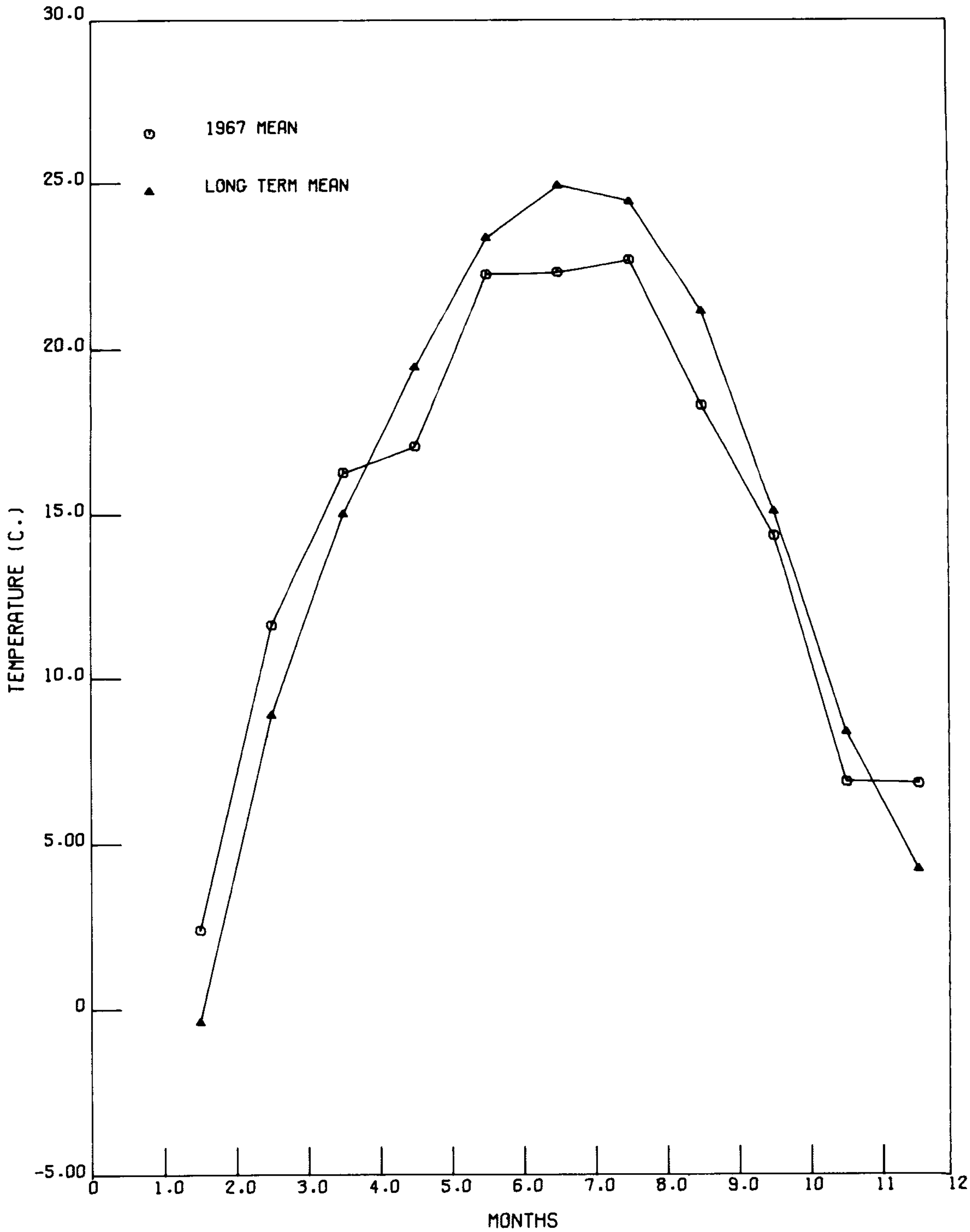

Figure 9. Monthly temperature values for 1967 and for the 30-year mean.

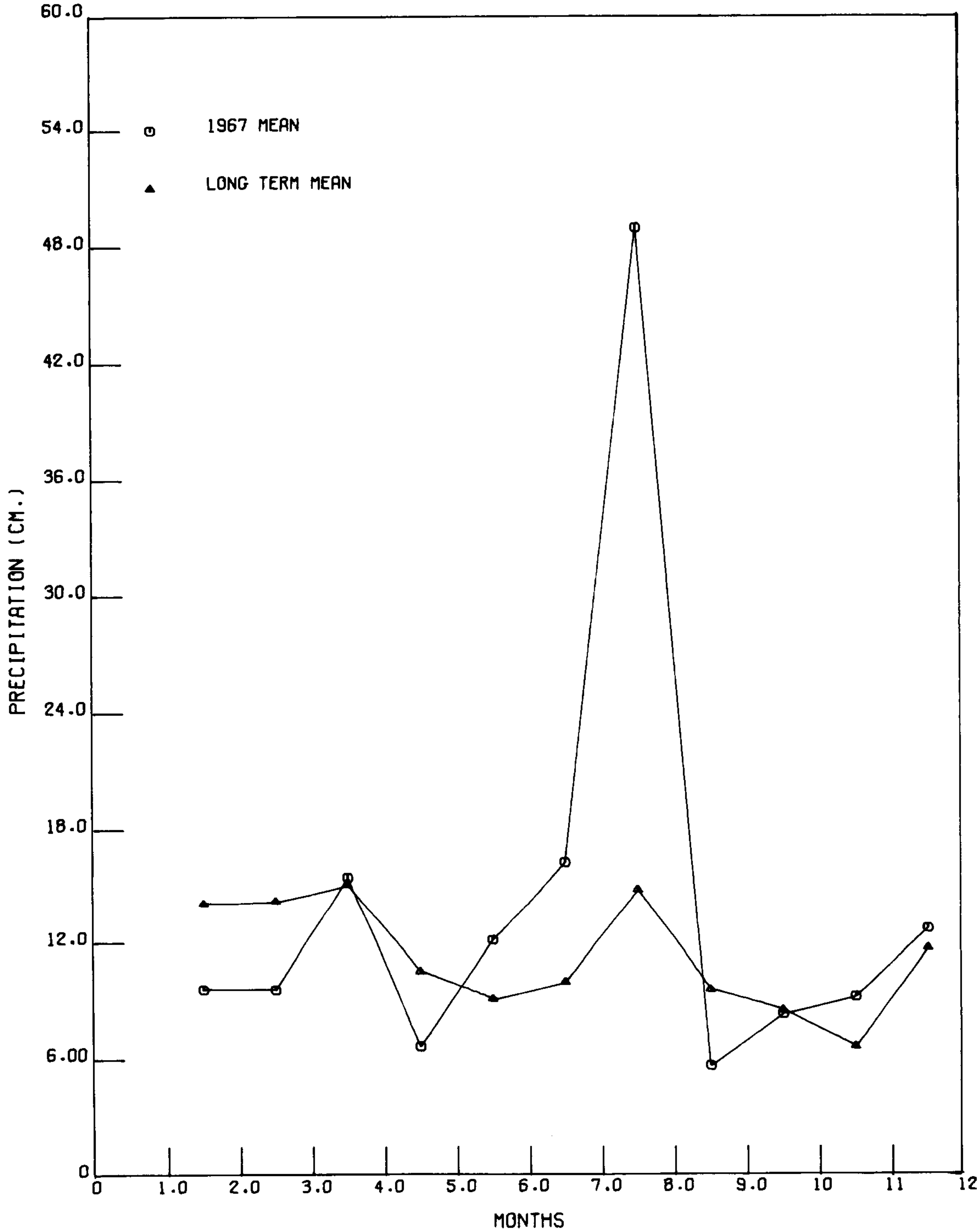

Figure 10. Monthly precipitation values for 1967 and for the 30-year mean.

Soil Moisture

Intimately related to temperature and precipitation is the factor of soil moisture. The mean values of each community sampling date are presented in Table 6. Field capacity of both communities was determined to be approximately 28 percent. It is very doubtful that a moisture stress developed at any time during the year due to the high amount of rainfall and the drainage characteristics of the soils. On numerous occasions the water table was found to be less than 60 cm below the surface. There was very little fluctuation in the moisture content of the soil through the year. Although the total profile reflects little fluctuation this was probably not true of the top 15 to 20 cm of the profile. Losses due to transpiration and evaporation were recharged rapidly by the above-average rainfall. The values equal to field capacity occurring in the *Andropogon* samples taken in late October and late December resulted when the input into the soil was not offset by evaporation and transpiration due to cool temperatures and little, if any, plant respiration. The effects of environmental factors on the various compartments of the community will be discussed later.

II. ABOVE GROUND LIVING BIOMASS

Net Above Ground Production

Net primary production as defined by Odum (1959) is gross primary production minus respiration. Net production estimates are common in the literature, but only rarely do they adhere to this definition. Most estimates more nearly represent gross primary production minus respiration losses, minus any unmeasured losses. The latter measures tend to be under-

Table 6. Soil Moisture Content to a Depth of 60 Centimeters Expressed as a Percentage of the Dry Weight of the Sample for the *Andropogon* and *Festuca* Communities

	Sampling Period							
Community	1	2	3	4	5	6	7	8
Andropogon	24	23	21	20	28	28		
Festuca	22	24	21	25	22	22	21	22

*Numbers correspond to the sampling dates found in Tables 7 and 8 (pp. 51 and 53).

estimates of net primary production, but will be used initially in this study to compare with net production estimates from elsewhere.

Estimates based on sums of positive biomass change for both communities are summarized in the Tables 7 and 8. The resulting estimate in the Andropogon community was 534 g/m^2 and 426 g/m^2 in the Festuca community. Thirty-one species contribute to total community production in the Andropogon community compared to 18 for the Festuca community. Only significant species are included in the tables, significant being defined as any species producing 1.0 or more g/m^2 per year. The contributions of these significant species accounted for about 97 percent and more than 99 percent of the above-ground production of the Andropogon and Festuca communities, respectively. The data in the tables are based on grams per quarter meter square from the 0.25 m^2 clipped plots converted to a grams per meter square basis by the use of a correction factor calculated for each sampling period. The use of a correction factor was necessary to offset the edge effect of the smaller plot in adjusting samples to match total biomass on 1 m^2 plots.

The resulting estimates in Tables 7 and 8 are based on the summation of positive changes in biomass for each species. The values for total net primary production of both communities, while being slightly higher than values of comparable communities, agree rather favorably with the values reported in the literature (Table 1, p. 8). The higher values from this study could be due to the more intensive sampling at the time of peak biomass.

Nevertheless, values estimated by summing species totals probably are underestimates of community productivity for the following reasons:

Table 7. Total Live Biomass by Species for the *Andropogon* Community in Grams Per Meter Square With Coefficients of Variability for Species Contributing Four Percent or More of Total Biomass

Taxa	Sampling Period: Early April 1	Early June 2	Early August 3	Mid-Sept. 4	Late Oct. 5	Late Dec. 6	Total Positive Increase	% of Positive Increase
Total	13	96	300	373	313	20	534	
Grass	3	48	102	191	240	16	267	50
Forbs	9	48	197	182	73	4	267	50
Andropogon virginicus	2 (7)	31 (4)	81 (10)	160 (17)	181 (25)	16 (2)	181	34
Panicum commutatum	0	0	10 (47)	21 (70)	32 (22)	0	32	6
Eupatorium fistulosum	0	0	9 (55)	19 (20)	0	0	19	4
Aster pilosus	0	<1 (68)	64 (79)	86 (6)	36 (33)	0	86	16
Diodia virginiana	0	0	22 (70)	12 (95)	2 (70)	1 (68)	22	4
Solidago altissima	0	17 (11)	37 (20)	34 (25)	10 (51)	0	37	7
Campsis radicans	3	14	18	9	7	1	18	3
Eulalia viminea	0	0	0	1	0	0	1	<1
Carex frankii	2	3	10	2	1	2	11	2
Senecio smallii	0	1	3	3	1	0	3	<1
Acalypha rhomboidea	0	0	2	8	1	0	8	1
Panicum nitidum	0	1	1	6	5	0	6	1
Galium tinctorium	<1	1	<1	2	<1	<1	3	<1
Rosa sp.	1	5	4	4	<1	1	5	1
Erigeron canadensis	0	0	0	7	0	0	7	1

Table 7. (continued)

Taxa	Sampling Period Early April 1	Early June 2	Early August 3	Mid-Sept. 4	Late Oct. 5	Late Dec. 6	Total Positive Increase	% of Positive Increase
Rubus allegheniensis	1	3	13	16	4	<1	16	3
Smilax glauca	<1	0	1	2	<1	0	2	<1
Cirsium arvense	0	0	<1	1	3	0	3	<1
Lonicera japonica	0	2	0	1	1	0	2	<1
Oenothera biennis	0	0	10	4	1	0	10	2
Achillea millefolium	0	0	0	2	0	0	2	<1
Panicum anceps	0	0	0	3	22	0	22	4
Panicum latifolium	0	2	11	0	0	0	11	2
Rumex acetosella	0	0	1	0	0	0	1	<1
Eragrostis hirsuta	1	3	0	0	0	0	3	<1
Gnaphalium purpureum	0	0	0	0	4	0	4	<1
Prunella vulgaris	0	0	0	0	1	0	1	<1
Allium sp.	1	0	0	0	0	0	1	<1
Festuca elatior	0	4	0	0	0	0	4	<1
Bromus japonicus	0	7	0	0	0	0	7	1
Unknown	0	0	2	0	0	0	2	<1

Table 8. Total Live Biomass by Species for the Festuca Community in Grams Per Meter Square with Coefficients of Variability for Species Contributing Four Percent or More of Total Biomass

Taxa	Sampling Period Mid-Jan. 1	Mid-March 2	Mid-April 3	Mid-May 4	Mid-June 5	Late July 6	Late Sept. 7	Late Nov. 8	Total Positive Increase	% of Positive Increase
Total	75	52	122	194	199	257	302	258	426	
Grass	74	52	103	169	155	202	240	243	300	70
Forbs	1	<1	19	23	43	55	63	14	126	30
Festuca elatior	74 (34)	52 (18)	103 (3)	167 (6)	154 (9)	198 (7)	237(1)	225 (7)	280	66
Aster pilosus	0	0	10 (46)	3 (50)	<1 (0)	8(22)	8(26)	<1 (50)	17	4
Solidago altissima	0	0	3 (48)	4 (25)	11 (35)	3(32)	15(85)	1 (50)	22	5
Andropogon virginicus	0	<1(50)	0	1(48)	1(50)	2(50)	3(80)	18(55)	18	4
Campsis radicans	0	0	1(50	1(60)	8(7)	17(73)	3(50)	1(50)	17	4
Rubus allegheniensis	0	0	0	2(48)	3(29)	8(17)	24(30)	3(40)	24	5
Lespedeza cuneata	0	0	0	0	1	2	1	7	8	2
Eupatorium fistulosum	0	0	0	0	0	0	9	1	9	2
Plantago major	0	0	0	0	3	2	<1	<1	3	<1
Daucus carota	0	0	0	0	<1	2	0	0	2	<1
Plantago rugelii	0	0	3	2	0	0	0	0	4	1
Ipomoea hederacea	0	0	2	6	9	9	<1	0	9	2
Carex frankii	0	0	<1	0	0	0	2	0	2	<1
Trifolium repens	0	<1	0	1	4	1	0	0	4	1
Panicum nitidum	0	0	0	0	0	2	<1	0	2	<1

Table 8. (continued)

Taxa	Sampling Period								Total Positive Increase	% of Positive Increase
	Mid-Jan. 1	Mid-March 2	Mid-April 3	Mid-May 4	Mid-June 5	Late July 6	Late Sept. 7	Late Nov. 8		
Oenothera biennis	0	0	0	4	1	0	0	0	4	< 1
Lonicera japonica	1	< 1	0	0	0	0	0	0	1	< 1
Solanum carolinense	0	0	0	0	2	1	0	0	2	< 1

the loss of weight after clipping due to respiration, the likelihood of sampling before or after a biomass peak, loss of plant parts between samples, bias from sampling techniques, and consumption by insects and animals (Harris 1966).

In designing the experiment an attempt was made to minimize or take into account the above-mentioned sources of error. Respiration losses after clipping were considered to be negligible because samples were either placed in plastic bags and frozen or oven-dried soon after clipping. Failure to sample at periods of biomass peak is a real possibility, but every effort was made to watch the most significant species and to catch them at their peaks.

Even while biomass is increasing abscission or loss of plant parts between samples was probably the major source of error, especially with regard to seed and rapidly-disseminating floral parts as well as some ephemeral forbs and grasses. Commonly there is a positive photosynthesis by green parts even during intervals when net amount of live material is decreased by transfer to standing dead. Losses from tops by translocation to roots are partly accounted for by our measures of root biomass, but would be underestimated by whatever loss rate is continuing from root to soil during all the sampling periods. Bias from the sampling technique was small due to the shape of the plots requiring few subjective decisions on whether to include or exclude material and the consistent field and laboratory techniques used in collecting data. Consumption by insects and animals is an unknown value. Consumption is probably small by comparison with losses directly to dead material, as little evidence of consumption or consumers was found. Studies of insect and animal consumption are continuing in the same area.

Net Production of Andropogon and Festuca

Andropogon virginicus produced approximately 181 g/m^2 or 34 percent of the estimated production in the stand it dominated. In contrast Festuca elatior contributed 280 g/m^2 or 66 percent of the net production in its stand.

The standing crop of living Andropogon virginicus in early April was 2 g/m^2 (Table 7, p. 51). There was an increase in live material through the summer and early fall with peak biomass (181 g/m^2) occurring in late October. By the end of December the standing crop of live material had decreased to 16 g/m^2. As would be expected, the peak standing crop of live material occurred at the time of flowering (Harris 1966, Golley 1965). The total positive increase value for Andropogon virginicus (Table 7) is probably an underestimate of net production. Harris (1966) found that peak standing crop is generally a poor estimate of net production due to the mortality concurrent with growth.

The two peaks in production generally associated with Festuca elatior were not as pronounced as is the usual case due to the unusually rainy year in which growth could be carried on during the summer months. The apparent drop in live biomass in mid-March could reflect a real excess of winter kill over new growth, but may only be due to sample variability, with samples taken by chance in areas where the stand was not quite as strong as in other areas. The early peak (167 g/m^2) occurred in May at the time of fruiting. Following fruiting there was a small decline in living biomass due to the almost instantaneous loss of fruiting stalks and seed to the litter and standing dead compartments. Then top biomass increased through the summer and into the fall with the second peak

(237 g/m^2) being reached in September (Table 8, p. 53). The positive increase in live top biomass (280 g/m^2) probably would have increased further because almost a month went by after the late September sample before the first killing frost occurred. Additionally, a large amount of soluble carbohydrates were being translocated to the roots as storage products.

The standing crop of live *Festuca elatior* (225 g/m^2) in late November and early December was much greater than the standing crop of live (74 g/m^2) in the previous January. Probably the *Festuca elatior* had not yet reached its peak in the community and was still establishing, but a drop in live biomass was indicated by the mid-winter appearance of the stand after the last sampling. The crop of standing dead material used as an indication of production would indicate that *Andropogon virginicus* has reached equilibrium or may be on the decline, as forbs and shrubs are adding to both communities.

Net Production of Associated Species

Thirty other species contribute to the net production of the *Andropogon* community (Table 7, p. 51). These 30 species contribute 66 percent of the biomass. Half of these 30 species contribute less than one percent each toward the total. Harris (1966) found only 17 species besides *Andropogon* in the *Andropogon* community he studied, and their contribution to total production was much smaller (40 percent). Of the principal associated species, *Aster pilosus* contributes the most (16 percent), followed by *Panicum commutatum* (6 percent), *Solidago altissima* (7 percent), *Eupatorium fistulosum* (4 percent), *Diodia virginiana* (4 percent), and *Panicum anceps* (4 percent). Most of these species reach their peak biomass during the fall, thus adding to the magnitude of the standing crop at this time.

The trend is reversed in the *Festuca* community with the associated species contributing a lesser 34 percent of the total (Table 8, p. 53). *Solidago altissima*, *Andropogon virginicus*, *Campsis radicans*, and *Rubus allegheniensis* all contribute over 4 percent each to the total, while the remaining 12 percent is contributed mostly by species constituting one percent or less. The reduced number of species (17) is probably due to the more complete cover of *Festuca elatior* reducing invading taxa, since a seed source for the other species is readily available and the field is now over three years old. In the *Festuca* community studied by Harris (1966) 76 percent of the biomass was contributed by the 17 associated species. The obvious difference in the amount of biomass produced by the associated species in the present study and the study of Harris (1966) appears to be a function of community age, the latter's community being much older.

As a general rule the biomass contributions of the associated species follow an orderly trend up to a peak and then drop off, sometimes very rapidly. However, some anomalies do occur as illustrated by *Diodia virginiana* (Table 7, p. 51). The sudden appearance of this species in the early August sample is the result of the two-month time period between the early June and early August samples, during which period it made its most significant growth from minute seedlings. The same explanation holds true for *Oenothera biennis*. In the case of *Lonicera japonica* the zero values are due to the localized clumped distribution of this species. As a result, although it was still present in the community it was possible that it did not occur in the sample. When peak biomass is reached by Panicum anceps and P. latifolium they move very rapidly to the standing dead compartment. In the Festuca community (Table 8, p. 53) apparent fluctuations in Aster pilosus, Solidago altissima and Lespedeza luneata are due to the uneven distribution of these species within the community. The rapid drop in Rubus allegheniensis after the late September sample is due to the loss of the leaves as a result of frost. Eupatorium fistulosum is a late-blooming species, and it could be possible that due to its distribution within the community it was not sampled until late September.

Statistical comparisons of biomass means for total community biomass, grass biomass, and forb biomass for both communities tend to follow the same general pattern (Tables 9 and 10). In the Andropogon community the first and last samples in each division are not significantly different; this is a further indication of the stability of the Andropogon community. The same general trend is found in the forb division of the Festuca as in the Andropogon community since for the most part the same forbs are involved. The means in the Festuca community appear to be slightly more separated possibly due to the smaller number of species and more sampling dates. The grasses have an entirely different pattern in the Festuca community, with a continued upward trend through time. This could be taken as an indication of the increasing biomass in the Festuca community.

Apparent Daily Above Ground Production Rates

Daily production estimates (Table 11) were obtained, as several authors have done, by dividing positive changes in biomass by the number of days in the period. The Andropogon community has its greatest

Table 9. Comparison of Biomass Means (g/m^2) from the Live Compartment of the *Andropogon* Community[a]

Total Biomass						
	(1)[b]	(6)	(2)	(3)	(5)	(4)
	13	20	96	300	313	373
				———	———	———
	———	———	———			
Grasses						
	(1)	(6)	(2)	(3)	(4)	(5)
	3	16	48	102	191	240
					———	———
			———	———		
	———	———	———			
Forbs						
	(6)	(1)	(2)	(5)	(4)	(3)
	4	9	48	73	182	197
			———	———	———	———
	———	———	———	———		

[a] Lines under means which are not significantly different by Tukey's "W" test (Steel and Torrie 1960) at the .05 level of significance.

[b] These numbers correspond to the sampling periods found in Table 8, page 53.

Table 10. Comparison of Biomass Means (g/m^2) from the Live Compartment of the *Festuca* Community

Total Biomass

(2)[a]	(1)	(3)	(4)	(5)	(6)	(8)	(7)
52	75	122	194	199	257	258	302
					———	———	———
			———	———	———		
		———	———				
———	———	———					

Grasses

(2)	(1)	(3)	(5)	(4)	(6)	(7)	(8)
52	74	103	155	169	202	240	243
					———	———	———
			———	———	———		
		———	———	———			
———	———	———					

Forbs

(2)	(1)	(8)	(3)	(4)	(5)	(6)	(7)
<1	1	14	19	23	43	55	63
					———	———	———
				———	———	———	
		———	———	———	———		
———	———	———	———	———			

[a] These numbers correspond to the sampling periods found in Table 8, page 53.

Table 11. Net Production Rates for Above Ground Biomass for *Andropogon virginicus*, *Festuca elatior*, *Andropogon* Communities and *Festuca* Communities in Grams Per Meter Square Per Day

Period	Number of Days	Species or Community	
		Festuca elatior	*Festuca* Community
3-1 to 4-28	58	0.88	1.21
4-28 to 5-15	20	3.24	3.29
6-19 to 7-24	35	1.24	1.66
7-24 to 9-26	33	1.18	1.38
		Andropogon virginicus	*Andropogon* Community
3-10 to 6-7	79	0.36	1.05
6-7 to 8-7	61	0.82	3.34
8-7 to 9-7	31	2.51	2.59
9-7 to 10-24	47	0.46	-

production rates in the late summer and early fall. This is a result of the warm-season growth of Andropogon virginicus plus the late-maturing perennials such as Aster pilosus and Solidago altissima. Andropogon virginicus appears to reach its peak daily growth rate during the late summer, with accelerated production of vegetative growth as well as flowering stalks.

The early spring growth rates of Festuca elatior (1.21 g/m^2 per day) are low in comparison to the late spring figure (3.29 g/m^2 per day). It is during the late spring that Festuca elatior has its highest growth rate. There is a period of rapid vegetative growth just prior to the production of fruiting stalks and seed. Fruiting stalks and seeds were found to constitute approximately 25 percent of the total live above ground biomass at the time of seed set. In contrast, the other species in the Festuca community show very little growth, only 0.05 g/m^2 per day. The normal trend in Festuca elatior is a sharp reduction in growth rate after production of seed. Due to an unusually wet and cool summer in 1967, Festuca production continued after a short period during which no measurable positive increase in biomass could be found. This period of no positive increase is probably an artifact, due to the system used to calculate the rates. The amount of vegetative material produced was not enough to offset the loss of seed and fruiting stalks to the litter and standing dead compartments.

The fall peak for Festuca occurring in late September marks the end of positive additions to the above-ground biomass. The next sampling period showed a reduction in weight of the live biomass, possibly due to translocation of carbohydrates to the roots, as well as the death of some leaves due to frost. The other species in the Festuca community had their highest growth rates during the late summer and fall, 0.42 and 0.20 g/m^2 per day respectively. Once again the late season perennials, Aster pilosus and Solidago altissima along with Rubus allegheniensis made the greatest contributions.

The values from the present study compare favorably with those for similar communities reported in the literature (Table 2, p. 11). The summer production rate of Harris (1966) for an Andropogon community is almost identical to the rate found in the present study. The agreement of Festuca community production rates are not as favorable, possibly due to the effects of an atypical growing season. The values reported by Golley (1965) for Andropogon are somewhat higher than those of the present study. This is probably due to the fact that the gas analysis procedure he used takes into account organic compounds used in respiration. Golley's (1965) rates for the months of April, June, July, August and September were 2.25, 3.06, 5.14, 1.35, and 1.91 respectively. It appears that the rates reported in the present study are generally in line with those reported previously in the literature (Table 2).

Phenology

Table 12 lists the species found in each community and the percent of the biomass they contribute toward the total. The percentages give some idea of the relative importance of the various species.

All seed plants have the same general life cycle consisting of the following stages: seed, seedling, juvenile, reproductive, senescence, and death. Within these various stages certain phenological events as dormancy, germination, flowering, fruiting, and decline occur (Pelton 1953).

Table 12. Comparison of Dominance in the Andropogon and Festuca Communities as Expressed by a Percent of Total Production of Each Taxon

Taxa	Percent Dominance Andropogon	Percent Dominance Festuca
Panicum commutatum	6.0	-
Eulalia viminea	0.2	-
Senecio smallii	0.6	-
Diodia virginiana	4.0	-
Acalypha romboidea	1.0	-
Galium tinctorium	0.5	-
Rosa sp.	0.8	-
Erigeron canadensis	3.0	-
Smilax glauca	0.4	-
Cirsium arvense	0.5	-
Achillea millefolium	0.3	-
Panicum anceps	4.0	-
Panicum latifolium	2.0	-
Rumex acetosella	0.2	-
Eragrostis hirsuta	0.6	-
Gnaphalium purpureum	0.6	-
Prunella vulgaris	0.2	-
Allium sp.	0.2	-
Bromus japonicus	1.3	-
Andropogon virginicus	34.0	4.0
Campsis radicans	3.0	4.0
Carex frankii	2.0	0.4
Eupatorium fistulosum	4.0	2.0
Aster pilosus	16.0	4.0
Solidago altissima	7.0	5.0
Panicum nitidum	1.0	0.4
Rubus allegheniensis	3.0	5.0
Lonicera japonica	0.3	0.3
Oenothera biennis	2.0	0.8
Solanum carolinense	-	0.4
Ipomoea hederacea	-	2.0
Daucus carota	-	1.0
Plantago rugelii	-	1.0
Trifolium repens	-	0.9
Lespedeza cuneata	-	2.0
Plantago major	-	0.6
Festuca elatior	-	66.0

The *Andropogon* community appears to be approaching the late successional stage as defined by Minckler (1946). The *Festuca* community does not appear to fit into strict old-field classification. However, at the present time, due to its recent prevalence in planted pasture and hay, tall fescue seems more common than abandoned cropland as predecessors of *Andropogon*.

The seedlings of *Andropogon virginicus* begin to germinate in March and continue to do so through September (Keever 1950). Flowering occurs in late August through October (Fernald 1950). *Festuca elatior* flowers and fruits in May through June depending on the management program used the previous year. From personal observation it appears that if the vegetative shoots have been cut in the previous year fruiting and seed set will occur earlier than in an uncut stand.

Four other species are common in both areas and are the principal contributors of biomass other than the major dominant of the community. *Aster pilosus* and *Solidago altissima* are common but do not appear to be moving toward dominance. The density of *Aster* seedlings is high in March and drops sharply throughout the summer. Most of the seedlings are held over and bloom in August through October of the following year. Plants with dead flowering stalks from the previous year generally bloom again in the fall (Keever 1950). From personal observation *Solidago altissima* seedlings first become noticeable in the late spring and early summer, making greatest growth just prior to blooming in August.

The principle invaders are *Rubus allegheniensis* and *Lonicera japonica*. Both species are not evenly distributed throughout the area but are clumped or localized into tangles, some of which appear to be expanding rapidly. *Rubus* shoots grow vegetatively for one year and flower in May and bear fruit generally in July of the second year (Fernald 1950). New leaves appear on the old briars in March and April with little further vegetative growth taking place after flowering. *Lonicera* germinates or begins vegetative growth in the very early spring with the production of new leaves and rapid elongation of existing and new vines. Flowering follows in late April through July with abundant fruit production by fall (Fernald 1950).

Climatic Effects on Live Biomass

The interaction of temperature and precipitation was vividly expressed in the production of biomass by *Festuca elatior*, a species adapted to growth under cool moist conditions. The cool moist summer experienced in 1967 probably enhanced the growth of *Festuca* greatly and lead to a bigger increase than would probably have been the case under normal conditions. In August when *Andropogon virginicus* began to put up flowering stalks the temperature was warm enough and moisture was in sufficient supply so that production of *Andropogon* was not retarded.

The retardation of growth in the fall by the drop in temperature results in frost burn on the *Festuca*. The process begins with the tip of the blade and causes a browning of the leaf. During the winter months the condition becomes more pronounced. Beddows and Jones (1958) observed that the "burnt" portion of the leaves has a low percentage of protein and high fiber and silica content; they also noted that long bladed herbage is especially liable to extensive burn. Browning is not due in all cases to freezing temperatures, but as suggested earlier, could be a major reason why positive biomass increments underestimate net primary productivity.

A water shortage at any stage of plant growth will result in reduced production. According to Salter and Drew (1965) grasses are especially sensitive to changes in soil moisture conditions during the period from flower initiation to full flower development. The sensitivity of the plant to moisture stress at the time of flowering appears to be related to the reduction in root growth that occurs at the time of reproduction. By stopping or reducing root growth, the plant must depend on the hydraulic conductivity of unsaturated soil, which in most cases is very poor, so stress quickly develops (Salter and Drew 1965). The effective rooting depth of eight cool season forage species investigated by Bennett and Doss (1960) decreased as soil moisture level increased. Limits on either root growth or depth will limit the capability of using nutrient elements that become available in the natural cycle, while limited nutrients may limit root use of soil moisture.

III. BELOW GROUND BIOMASS

Seasonal Changes

The seasonal or yearly changes in root biomass are presented in Tables 13 and 14. Both communities show a gradual or steady increase in total root biomass through the year. Unfortunately, extremely wet soil conditions prevented taking samples below 20 cm for the last two *Andropogon* sampling periods. Probably the peak biomass of the *Andropogon* community was achieved in late October (Table 13). The final *Andropogon* sample taken in late December shows a sizeable decline in biomass, possibly due to respiration of the roots or to root mortality and sloughing off of dead material. If this rate is fairly stable, then the root biomass should

Table 13. Andropogon Community Root Biomass Means in Grams of Organic Material per Meter Square with Coefficients of Variability

Sample Period	Depth in Centimeters 0 - 20		20 - 40		40 - 60		0 - 60
Early April	377	(45)	58	(40)	11	(40)	446
Early June	384	(52)	113	(105)	26	(85)	523
Early August	437	(46)	128	(202)	38	(110)	603
Mid-September	507	(34)	71	(50)	42	(154)	620
Late October	659	(86)	-		-		804*
Late December	519	(24)	-		-		633*

*These values are estimates of total biomass.

Table 14. *Festuca* Community Root Biomass Means in Grams of Organic Material Per Meter Square with Coefficients of Variability

Sample Period	Depth in Centimeters 0 - 20		20 - 40		40 - 60		0 - 60
Mid-January	202	(32)	60	(40)	16	(71)	278
Mid-March	377	(31)	90	(45)	22	(53)	489
Mid-April	436	(22)	99	(44)	34	(110)	569
Mid-May	476	(48)	135	(122)	42	(40)	653
Mid-June	492	(32)	90	(41)	106	(155)	588
Late July	551	(52)	118	(87)	96	(119)	765
Late September	598	(28)	81	(54)	27	(57)	706
Late November	659	(49)	96	(90)	39	(59)	794

continue to drop until reaching a value close to that of the standing crop sampled in early March. The high values recorded for the early June and early August samples in the 20 to 40-cm interval are probably due to sample variation more than any other factor since the sampling and separation procedure was the same as previous samples.

The estimates of 0 to 60-cm root biomass for the last two samples were obtained by finding the average ratio of root mass in the 20 to 60-cm level, to that in the 0 to 20-cm layer and adding this to the latter. It is uncertain whether this is an underestimate or an overestimate.

The seasonal trend in root biomass in the *Festuca* community is similar to that found in the *Andropogon*, in that there is an increase in biomass throughout the season (Table 14). The magnitude of the increase in biomass in the *Festuca* community is much greater than that of the *Andropogon* community. This is probably a reflection of the *Festuca elatior* expansion (Long 1959). Peak root biomass in the *Festuca* community occurred in late November. The root biomass of the *Festuca* community tends to follow the pattern described by McCarty (1935). When above-ground biomass production drops there is an increase in root biomass, as in sample number two. In contrast to McCarty's pattern, there is no noticeable drop in root biomass at the time of fruiting. There does however appear to be a late-season increase in root biomass as a result of translocation of soluble carbohydrates from the shoot to the roots.

Total root biomass figures for both communities appear to be somewhat lower than values for other grassland communities reported in the literature. Root production in a two year study of a Michigan old field dominated by *Poa* was 1023 g/m^2 (Golley 1960). The mean addition or growth to roots in an Andropogon virginicus dominated field in South Carolina was 149 g/m^2 (Golley 1965). Much higher values are reported for Andropogon virginicus, A. gerardi, Festuca pratensis, and F. rubra which produce 638, 1122, 1298 and 2244 g/m^2 respectively (Bray 1963). The values of Malone (1968) for a Lolium perene dominated old-field are of the same magnitude (602 and 1944 g/m^2). Because the reported values are from different climatic, edaphic and vegetational conditions, it is difficult to make a direct comparison to my data. A further complication is that the values for root biomass in the literature are not all on an organic weight basis as are the data from the present study.

Daily Root Production Rates

Daily production rates for both the Andropogon and Festuca communities are summarized (Table 15) and compared to those reported in the literature (Table 3, p. 13). The rates of Golley (1965) for an Andropogon community compare well with the values for the Andropogon community in this study, possibly due to the many similarities that exist between the two areas. The production estimates of Golley and Gentry (1966) are much higher than those of the present study, possibly due to the more complete dominance of Andropogon virginicus in the field they studied.

The highest root production rates in the 0 to 20-cm level in the Andropogon community occur in August and September. This appears to be in opposition to the findings of McCarty (1935) in that maximum root growth is going on concurrently with maximum shoot growth. Production rates for the depths below 20 cm remain fairly constant, this could in part be due to the large amount of precipitation ooth preventing root growth by reducing aeration in the lower depths, as well as making it unnecessary to expand the root system (Sperry 1946).

Table 15. Net Production Rates of Below Ground Biomass (Organic Material) of _Andropogon_ and _Festuca_ Communities (Calculations Are Based on Positive Changes in Biomass Expressed as Grams Per Meter Square Per Day)

Period	Sample Period	Days in Period	Depth in Centimeters			
			0 - 20	20 - 40	40 - 60	0 - 60
Andropogon						
3/10 to 6/7	1 - 2	79	0.08	0.69	0.19	0.97
6/7 to 8/7	2 - 3	61	0.86	0.24	0.20	1.31
8/7 to 9/7	3 - 4	31	2.25	*	0.13	0.55
9/7 to 10/24	4 - 5	47	3.23	-	-	-
10/24 to 12/27	5 - 6	63	*	-	-	-
Festuca						
1/12 to 3/1	1 - 2	47	3.72	0.63	0.13	4.48
3/1 to 4/28	2 - 3	58	1.01	0.16	0.21	1.38
4/28 to 5/18	3 - 4	20	*	3.65	*	3.65
5/18 to 6/19	4 - 5	32	1.78	*	2.21	1.43
6/19 to 7/24	5 - 6	35	1.68	0.80	*	2.20
7/24 to 9.26	6 - 7	33	1.42	*	*	*
9/26 to 11/27	7 - 8	61	1.00	0.24	0.20	1.44

*Indicates no positive increase in biomass.

Root production rates in the *Festuca* community were somewhat higher than those of the *Andropogon* community. The difference is probably due to the nearly continuous growth of *Festuca elatior*. The growth rates of the *Festuca* community are generally higher than those for *Andropogon* reported in the literature, but considerably less than the values of Malone (1968) and Golley and Gentry (1966) for their field abandoned 12 years.

The estimated root production rates for the 0 to 60-cm depth for the *Festuca* community are considerably higher than those of the *Andropogon* community due to the higher production rates in the depths below 20 cm. Internal drainage of the soil is better in the *Festuca* community, so presumably aeration is not as much a limiting factor as in the *Andropogon* community. The early spring rate is highest, probably due to the translocation of materials from the green shoots that are photosynthesizing on the warmer days during the early spring before total root mass (and death rates) have reached high values.

Changes in Biomass with Depth

The distribution of organic material occurring in each 15 cm increment of a 90-cm profile on the first sampling date (early April and mid-January) is presented in Table 16. Ninety-eight percent of the root biomass of the *Andropogon* community was found in the top 30 cm of the soil, compared to 85 percent in the same interval in the *Festuca* community. The amount of roots penetrating to depths greater than 30 cm is much greater in the *Festuca* community, 15 percent, compared to 1.5 percent in the *Andropogon* community.

The increase in biomass through the season is very small in both communities below 20 cm in comparison with the increase that takes place

Table 16. Percent of Total Root Biomass (Organic Material) Occurring in Each 15-Centimeter Depth Increment

	Community			
Depth	Andropogon		Festuca	
0 - 15	81	(82)[a]	62	(83)[b]
15 - 30	17	(11)	23	(12)
30 - 45	0.9	(7)	7	(5)
45 - 60	0.4		3	
60 - 75	0.2		4	
75 - 90	-		1	

a. Percentage distribution of organic material in 20-cm increments from the mid-September sample.

b. Percentage distribution of organic material in 20-cm increments from the late November sample.

in the top 20 cm (Figures 11 and 12). This differs from Long's (1959) results in which biomass increases significantly in the lower parts of the profile as the community matured. There appears to have been a much larger relative increase in root biomass in the depths below 20 cm than in the above 20 cm level by the time of the September sample in the *Andropogon* community. The increase in the above 20 cm level in the *Festuca* community is much greater, possibly due to the expansion of old clumps and establishment of new ones. The lower depths appear to have increased slightly. Table 17 summarizes one statistical (power function) model which smooths the root curves as a function of depth.

Root-Shoot Ratios

Root-shoot ratios were calculated from total organic material per meter square (Table 18). The mean root-shoot ratio for the *Andropogon* community is somewhat higher than the values reported by Bray (1963) for similar warm-season grasses. He reported values for *Andropogon scoparius* of 0.22, and for *A. gerardi* of 0.45. This difference probably is due to a greater number of species in the *Andropogon* community, whereas Bray (1963) reported single species values.

The mean root-shoot ratio of the *Festuca* community approaches the values reported for *Festuca pratensis* and *F. rubra*, 1.44 and 2.43 respectively (Bray 1963). The ratios of both the *Festuca* and *Andropogon* communities appear to be contrary to the observations of Monk (1966) who found that species of drier sites usually have higher root-shoot ratios than species of mesic sites. The *Festuca* makes its greatest gains in biomass during the moist, cool parts of the growing season, and it makes practically no growth during dry periods, while the greatest gain in

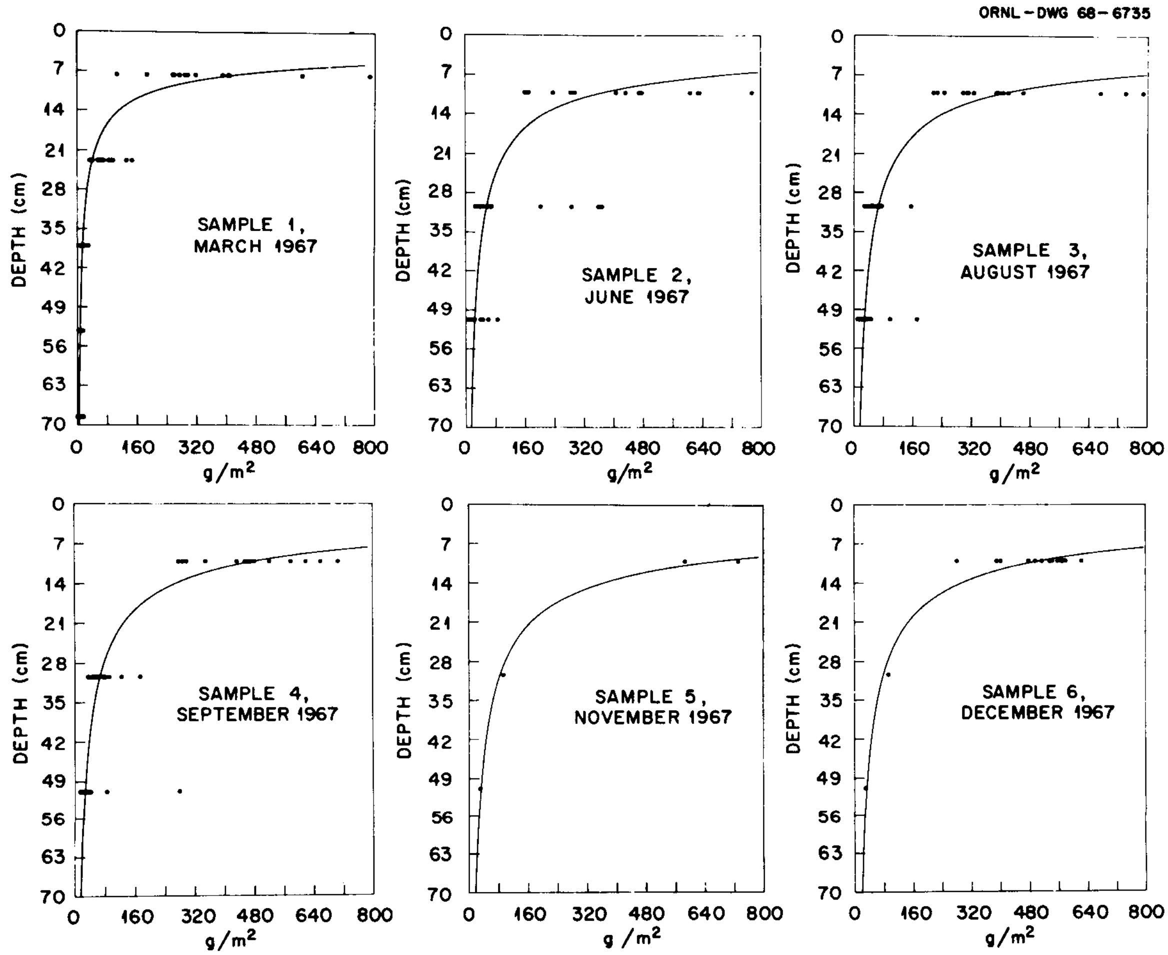

Figure 11. Change in distribution of root biomass in the Andropogon community through the year.

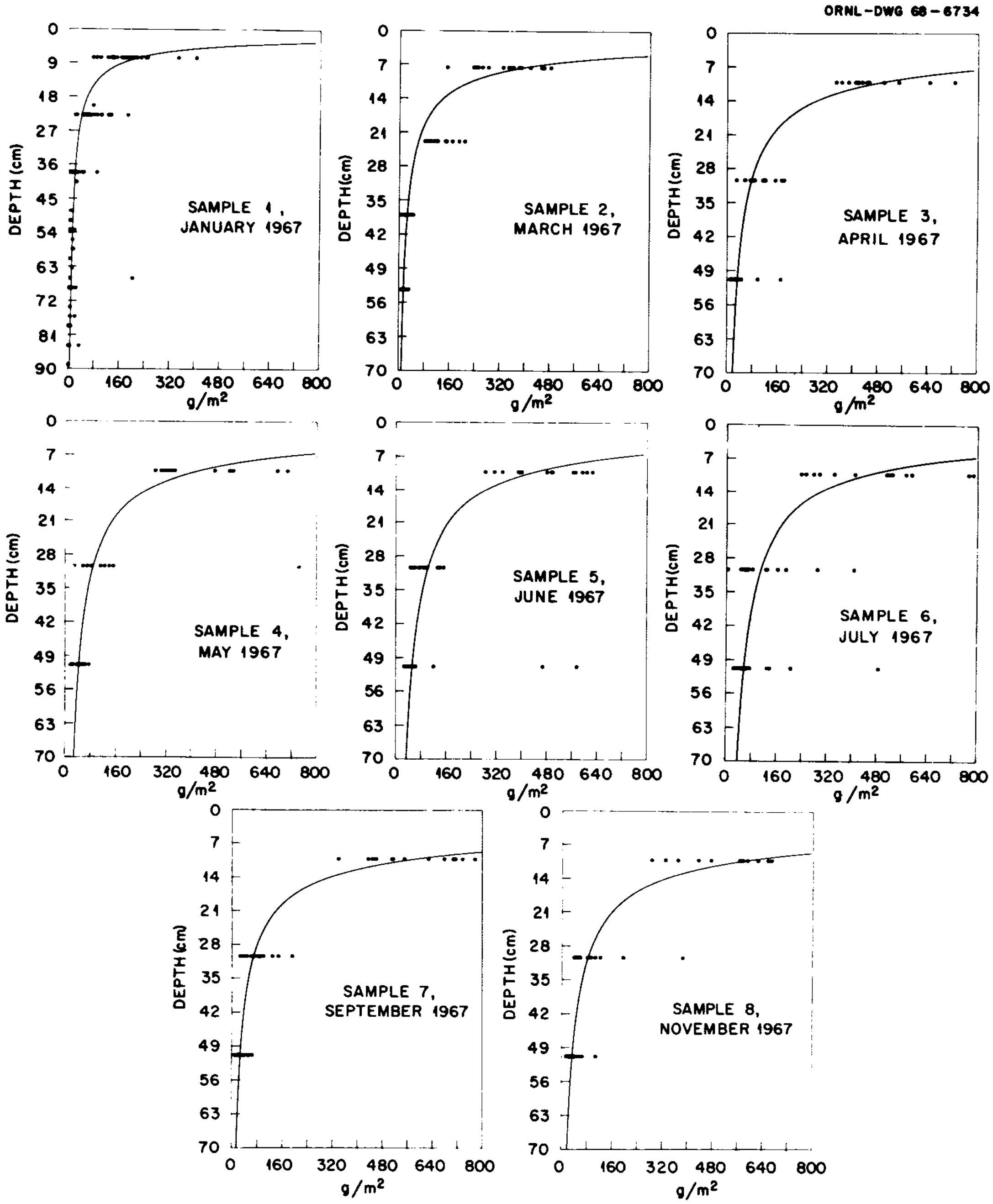

Figure 12. Change in distribution of root biomass in the *Festuca* community through the year.

Table 17. Characteristics of Regression Analysis of Roots (Ash Free) as a Function of Depth

Sampling Period	a Value	b Value	Standard Error of Estimate	R^2
Andropogon				
Early April	32,300	-2.15	1.95	86.34
Early June	19,540	-1.71	2.13	70.37
Early August	19,340	-1.66	2.00	72.85
Mid-September	31,230	-1.80	1.75	83.10
Late October	53,850	-1.90	1.16	99.40
Late December	26,170	-1.70	1.27	91.37
Festuca				
Mid-January	52,000	-1.57	2.17	72.73
Mid-March	13,190	-1.72	1.88	80.64
Mid-April	24,770	-1.69	1.79	79.84
Mid-May	12,180	-1.44	1.69	77.96
Mid-June	98,580	-1.34	1.86	68.41
Late July	92,290	-1.30	2.24	54.94
Late September	56,360	-1.96	1.63	88.29
Late November	38,110	-1.80	1.88	84.72

*The equation used in the regression analysis was of the form $Y = aX^b$.

Table 18. Root-Shoot Ratios for Andropogon and Festuca Communities Based on Total Organic Material Per Meter Square

Sample Number	Ratio
Andropogon	
Early April	0.62
Early June	0.89
Early August	0.85
Mid-September	0.79
Late October	0.80
Late December	0.74
Mean	0.78
Festuca	
Mid-January	0.86
Mid-March	1.93
Mid-April	1.39
Mid-May	1.23
Mid-June	1.52
Late July	1.48
Late September	1.23
Late November	1.60
Mean	1.40

biomass in the *Andropogon* community is made in the late summer or warm, dry part of the growing season. If this is correct then the *Andropogon* community should have a higher root-shoot ratio than that of the *Festuca* community.

The rates of root production to shoot production based on positive increases in biomass (Table 19) give a good indication of the relative rates or relationships between the production of roots and shoots. The production of roots and shoots in early spring and early summer in the *Andropogon* is almost equal. As the season progresses the amount of shoot material produced greatly exceeds the root production until late fall when no shoot production takes place and root production rises. This rise in root biomass may be the result of translocation of soluble carbohydrates and mineral nutrients from the shoots before they are killed by frost.

Early-season root production in the *Festuca* community is very high, in contrast to above-ground biomass. During the late spring and early summer the production of roots and shoots is nearly equal. Following seed production there appears to be an increase in root productivity. As mentioned previously, this high ratio may be an artifact due to the way that increases in biomass are calculated. Late season growth is again followed by a period during which root biomass increases due to translocation of soluble carbohydrates. These ratios of root production to shoot production appear to give better indications of the time when root and shoot production is taking place.

IV. STANDING DEAD

Standing dead material might more correctly be called the true dominant in both communities. Data in Tables 20 and 21 show that at no time

Table 19. Ratio of Root Production to Shoot Production Based on Positive Increases in Biomass

Sample Period	Root and Shoot Values	Ratio
Andropogon		
April-June	77/83	0.93
June-August	80/204	0.39
August-September	17/73	0.23
September-October	39/ 0*	-
October-December	0 / 0	-
Festuca		
January-March	211/ 0	-
March-April	80/70	1.10
April-May	73/72	1.01
May-June	46/ 5	9.20
June-July	77/58	1.33
July-September	0 /45	-
September-November	88/ 0	-

*Indicates that no positive addition was made in that compartment during the sampling period indicated.

Table 20. Total Dead Biomass by Species in Grams Per Meter Square for the *Andropogon* Community with Coefficients of Variability for Species Contributing Two Percent or More to Total Biomass

Taxa	Sampling Period: Early April 1	Early June 2	Early August 3	Mid-Sept. 4	Late Oct. 5	Late Dec. 6	Total Positive Increase	% of Positive Increase
Total	824	591	519	527	633	806	1143	
Grass	797	581	519	527	615	750	1052	92
Forbs	27	10	0	0	18	57	92	8
Andropogon virginicus	772 (2)	558 (4)	519 (13)	527 (7)	610 (1)	727 (3)	979	86
Campsis radicans	0	0	0	0	0	3	3	< 1
Panicum commutatum	0	0	0	0	4	0	4	< 1
Carex frankii	0	0	0	0	0	6	6	< 1
Aster pilosus	6 (28)	1 (47)	0	0	0	37 (17)	42	4
Diodia virginiana	0	0	0	0	2	5	5	< 1
Acalypha rhomboidea	0	0	0	0	0	< 1	< 1	< 1
Solidago altissima	5	9	0	0	0	5	9	< 1
Panicum nitidum	8	14	0	0	0	4	14	1
Cirsium arvense	0	0	0	0	15	0	15	1
Panicum anceps	0	0	0	0	0	18 (94)	18	2

Table 20. (continued)

Taxa	Sampling Period Early April 1	Early June 2	Early August 3	Mid-Sept. 4	Late Oct. 5	Late Dec. 6	Total Positive Increase	% of Positive Increase
Panicum latifolium	0	8	0	0	0	2	8	< 1
Rumex acetosella	0	0	0	0	0	5	5	< 1
Eragrostis hirsuta	15	1	0	0	0	0	15	1
Prunella vulgaris	0	0	0	0	1	0	1	< 1
Allium sp.	0	< 1	0	0	0	0	< 1	< 1
Festuca elatior	16	0	0	0	0	0	16	1

Table 21. Comparison of Biomass Means (g/m^2) from the Standing Dead Compartment of the *Andropogon* Community

Total Biomass

(3)[a]	(4)	(2)	(5)	(6)	(1)
519	527	591	632	806	824

Grasses

(3)	(4)	(2)	(5)	(6)	(1)
519	527	581	615	750	797

Forbs

(3)	(4)	(2)	(5)	(1)	(6)
0	0	10	18	27	57

[a]These numbers correspond to the sampling periods found in Table 20, page 83.

does living biomass exceed the weight of the standing dead biomass. The yearly trend in the amount of standing dead for the two communities is quite different.

The peak crop of standing dead material in the Andropogon community occurred in the late December sample (Table 20). The higher value recorded in the early April sample represents a carry-over from previous growing seasons. The amount of standing dead drops until a low point is reached in early August. Then there is a steady increase in weight of standing dead biomass until the peak is reached after the first killing frost. Tukey's "W" test (Steel and Torrie 1960) indicated that there was a significant difference between some of the sample means for the total community standing dead (Table 21). The lack of a significant difference between the first and last samples indicates that the community may have reached a point of equilibrium and is cycling uniformly through time. If this is so then the previous year's production could be estimated from the difference between the maximum and minimum crops of standing dead. However, only rarely will the peak standing crop be a true estimate of net production in a community due to mortality occurring throughout the growing season and rapid losses of some plant parts to the litter. When total standing dead biomass is divided into separate biomass weights for grasses and forbs, the same general trend is found. Both grass and forb standing dead are at the seasonal minimum in the Andropogon community at the time of the August sample, and at the maximum by the late December sample. In all three divisions the trends are of the type to be expected in a community dominated by plants that reach their peak biomass in late summer and early fall. The year-end peak is the result of frost or freezing temperatures killing the plants, which transfers the peak crop of living biomass almost immediately to the standing dead compartment. The peak crop of standing dead material is reduced as parts are transferred to the litter, consequently by August of the following year the previous year's standing dead material was at a minimum. Probably in the *Andropogon* community the standing dead crop loses approximately one-third to one-half of its biomass each year, this would indicate that a portion of the present crop of standing dead material was at least two years old (Golley 1965).

The values from the literature for standing dead material in *Andropogon* communities are summarized in Table 4 (p. 21). The general trends in standing dead biomass reported by Golley (1965) agree quite well with those of the present study. However, the absolute values from this study are almost 50 percent higher than those reported in the literature. The discrepancy appears to be due to the type of species and the contribution they make to the litter. Aside from the *Andropogon* standing dead two other species, *Aster pilosus* and *Solidago altissima*, are important and tend to remain in the standing dead compartment for extended periods of time. Whereas, in the communities mentioned previously the biomass contributed to the standing dead by species other than *Andropogon* is relatively small. The mean values reported in the literature are of the same magnitude as the present year's input from live to standing dead.

The trend in the standing dead material in the *Festuca* community was somewhat different from that of the *Andropogon* community. The minimum crop of standing dead material in the *Festuca* community (Table 22)

Table 22. Total Dead Biomass by Species in Grams Per Meter Square for the Festuca Community with Coefficients of Variability for Species Contributing One Percent or More to Total Biomass

Taxa	Sampling Period: Mid-Jan. 1	Mid-March 2	Mid-April 3	Mid-May 4	Mid-June 5	Late July 6	Late Sept. 7	Late Nov. 8	Total Positive Increase	% of Positive Increase
Total	300	245	354	408	335	333	356	309	538	
Grass	272	225	351	398	326	325	356	298	488	91
Forbs	28	21	3	11	9	7	0	11	50	9
Festuca elatior	264(7)	220(7)	351(3)	398(12)	325(12)	325(10)	356(7)	295(15)	473	88
Aster pilosus	18(16)	19(37)	3(49)	2(50)	2(48)	4(62)	0	2(13)	21	4
Solidago altissima	0	0	0	1(46)	2(25)	0	0	6(14)	6	1
Andropogon virginicus	3	0	0	0	1	0	0	0	3	1
Campsis radicans	1	1	0	0	0	0	0	< 1	1	< 1
Rubus allegheniensis	1	< 1	0	0	2	0	0	< 1	3	< 1
Lespedeza cuneata	0	0	0	0	0	0	0	1	1	< 1
Eupatorium fistulosum	0	0	0	0	0	0	0	1	1	< 1
Plantago major	0	0	0	0	< 1	0	0	0	< 1	< 1
Daucus carota	3(49)	< 1(40)	0	0	0	0	0	2(48)	5	1
Plantago rugelii	2	< 1	0	0	0	0	0	0	2	< 1

Table 22. (continued)

Taxa	Sampling Period								Total Positive Increase	% of Positive Increase
	Mid-Jan. 1	Mid-March 2	Mid-April 3	Mid-May 4	Mid-June 5	Late July 6	Late Sept. 7	Late Nov. 8		
Ipomoea hederacea	0	0	0	< 1	1	3	0	0	3	< 1
Trifolium repens	< 1	0	0	0	< 1	0	0	0	< 1	< 1
Panicum nitidum	1	2	0	0	0	0	0	0	2	< 1
Oenothera biennis	1(50)	0	0	8(13)	1(48)	0	0	0	8	1
Lonicera japonica	0	0	0	0	0	< 1	0	0	< 1	< 1

occurred at the time of the second sampling in mid-March. The peak standing dead crop was obtained in mid-June. This peak was the result of the addition of flowering stalks to the standing dead material. The standing dead biomass remains at approximately the same level through the summer and into the fall. Tukey's "W" test (Steel and Torrie 1960) indicated that no significant difference ($p < 0.05$) existed between any of the sample means for the total community standing dead (Table 23). The late November sample indicates a drop in standing dead biomass which compares with the value recorded in the sample at the beginning of the study.

The trend in the standing dead grass, as would be expected, was identical to that of the total community, however, there are significant differences between the biomass means for the grasses (Table 23). The grass yields are dominated by the contribution of Festuca elatior. Standing dead forbs drop in biomass through the mid-April sample and then reach a peak at the mid-May sample. This peak is an artifact due to the large contribution made by Oenothera biennis (8 g/m^2) standing dead which was dominant in the area prior to the establishment of the Festuca stand. The actual peak is reached after the first killing frost as recorded in the November sample. No standing dead forbs were found in the sampling in September indicating that the majority of the previous year's forbs had transferred to the litter.

The single value for Festuca community standing dead reported in the literature (Table 4, p. 21) again is substantially smaller than the mean value determined by this study, 109 compared to 330 g/m^2. The Festuca community studied by Harris (1966) was floristically poorer and had been mowed in the year prior to his study, which could account for his lower value than the one from the present study.

Table 23. Comparison of Biomass Means (g/m^2) from the Standing Dead Compartment of the *Festuca* Community

Total Biomass

(2)[a]	(1)	(8)	(6)	(5)	(3)	(7)	(4)
225	300	309	333	335	354	356	408

Grasses

(2)	(1)	(8)	(6)	(5)	(3)	(7)	(4)
225	272	298	325	326	351	356	398

Forbs

(7)	(3)	(6)	(5)	(4)	(8)	(2)	(1)
0	3	7	9	11	11	21	28

[a]These numbers correspond to the sampling periods found in Table 22, page 88.

V. LITTER

The standing crop of ground litter in the Andropogon community remained relatively constant throughout the study (Table 24). The maximum value for ground litter occurred in the early April sample. This peak is probably a reflection of the input that occurred at the end of the previous year's growing season. The slight rises in the September and October samples were probably due to an increase in the input from live or standing dead Andropogon virginicus and various forbs.

The mean value for litter in the Andropogon community (181 g/m^2) was considerably lower in all cases than values reported in the literature (Table 4, p. 21). The mean values reported by Odum (1960) and Golley and Gentry (1966) are over 50 percent higher than any of the previously-mentioned values. This is probably a result of the rapid movement of forbs and other species of grasses from the standing dead to the litter as mentioned previously.

The same general pattern of litter fluctuation exists in the Festuca community ground litter, but with only 32 grams difference between the maximum and minimum. Maximum litter occurred at the time of the November sampling and reflects an input from the standing dead. The mean value from the present study (113 g/m^2) is 50 percent greater than the value reported by Harris (1966) for a Festuca community. The Festuca community litter weights in the present study are near the magnitudes of forb-dominated or grass upland communities reported in the literature (compare Table 4 and Table 24). The present crop of litter could have been strongly influenced by previous years when forbs such as Oenothera biennis, Aster pilosus, and Solidago altissima were dominants in the community.

Table 24. Standing Crop of Ground Litter in the *Andropogon* and *Festuca* Communities in Grams Per Square Meter

Community	Sampling Period								Mean
	Early April	Early June	Early Aug.	Mid-Sept.	Late Oct.	Late Dec.			
Andropogon	218	161	162	198	184	163			181
	Sampling Period								
	Mid-Jan.	Mid-March	Mid-April	Mid-May	Mid-June	Late July	Late Sept.	Late Nov.	
Festuca	105	107	119	121	108	117	100	132	114

These species are very woody and as a result of their high content of materials that are more slowly decomposed, they may still be exerting an influence on the litter, this is especially true of *Oenothera biennis*.

Climatic Effects on Dead Biomass

The effects of climate on standing dead material, with the exception of leaching, is not well documented. Koelling and Kucera (1965) found that considerable leaching of water-soluble materials occurred while the plant materials were still standing. Aside from its leaching effect, precipitation could contribute significantly to disintegration of standing dead material especially when coupled with freezing temperatures. The pounding effect of raindrops could drive down standing dead material that is inclined at an angle into the litter. The effects of the weight of snow and ice cannot be overlooked as they increase the probable rates of this transfer in grasslands to the north and west of Oak Ridge.

Once the standing dead plant material reaches the litter, temperature and moisture become critical factors in determining the rate of decomposition. During the first year of litter decay about 40 percent of the weight loss appears to be independent of microbial activity (Witkamp 1966). This emphasizes the large amount of leaching and physical disintegration going on, especially in the *Andropogon virginicus* standing dead.

The higher the temperature, the more rapid is the decomposition of plant material as a whole, and of the ether-soluble substances, the hemicellulose and cellulose. The influence of temperature is especially marked upon the decomposition of the lignins. Decomposition in both communities studied progressed at a moderately rapid rate due to the warm temperature and moist conditions. However, when the litter becomes waterlogged, as was the condition at times during the summer months, anaerobic conditions may exist locally and as a result litter accumulates because the anaerobic organisms cannot decompose the plant materials as fast as they are added (Waksman and Gerretsen 1931). Thus climate modifies the nature and rapidity of decomposition of plant remains both on and in the soil and prior to the time that it reaches the soil.

VI. COMPARTMENTAL TRANSFERS

Transfers from Live to Standing Dead

Transfers from the living, above-ground biomass to the standing dead compartment may be approached in two ways--by summing the positive increases in standing dead biomass through the year, or by summing the losses from the live compartment through the year. Theoretically, these values should be similar if all living material was transferred through the standing dead compartment and if all were accounted for by periods of decreasing top mass.

However, this is not the case. By summing loss of live material from the Andropogon community live compartment, there is a total theoretical loss for the year of 417 g/m^2, of which 224 g/m^2 is contributed by grasses and 193 g/m^2 by forbs. Using the other approach of summing increases in actual standing dead, the losses are 231 g/m^2 for grasses and 57 g/m^2 for forbs, giving a total of 288 g/m^2. Obviously, there is quite a difference in the theoretical value and the measured increase of standing dead in the Andropogon community. Probably both values are underestimates of transfer, for several reasons.

In this case it would appear that not all the material lost from the live top compartment is necessarily going to the standing dead, but some is instead being translocated to the roots and/or going directly to the litter or remaining in the standing dead compartment for such a short period that it is not detected by the sampling scheme used. Additions noted earlier are being made to both standing dead and litter during periods when live tops are increasing: i.e. by amounts approximating the difference between net primary production and positive change in biomass for these periods. Also, since the sampling procedure used makes no distinction between translocation losses and direct losses to the litter, it might be assumed that the 129 g/m^2 difference was a minimal estimate of the combined effect of these two transfer losses. Harris (1966) encountered the same problem when comparing the theoretical input with the actual standing crop.

Upon closer examination it would appear that in the *Andropogon* community rapid transfer from the live forb compartment to litter was one cause of the difference since the theoretical forb value was three times larger than the actual value. The losses due to translocation for grasses in this community might seem negligible since the actual and theoretical values are almost the same. However, to neglect this would ignore the probable root losses that continue in periods of net root gain, thereby underestimating transfer from tops to roots.

The discrepancy in the *Festuca* community is reversed somewhat. Summation of measured losses from the live compartment totals 85 g/m^2, of which 35 g/m^2 is for grasses and 50 g/m^2 is for forbs. The total derived from summing the increases in standing dead is a considerably larger 223 g/m^2. Grasses contribute 204 g/m^2 and forbs 19 g/m^2. The theoretical value for grass production is obviously an underestimate. Through the season grass production is almost continuous and only occasionally does mortality exceed production. The same phenomenon appears to be occurring with forbs in the *Festuca* community as in the *Andropogon* community, namely the rapid transfer of the forb biomass of some species from live to litter.

This is expected since many of the same species of forbs live in both communities.

In both communities both kinds of field estimates are, at least, very poor indicators of the actual transfers. For this reason determination of true values for the transfer is highly difficult by direct measurement, and would in all probability be of questionable validity unless due allowance could be made for all the important income and loss terms that occur simultaneously.

Transfers from Standing Dead to Litter

The transfer of standing dead material to the litter compartment is somewhat easier to quantify than the transfers from live to standing dead. Once plant material has reached the standing dead compartment it can remain in this compartment for varying lengths of time, as in the case with most forbs. Eventually all material in the standing dead compartment must be transferred to the litter.

The standing dead material in the *Andropogon* community strongly dominates the total above-ground herbage biomass. The mean value for the rate of fall of standing dead in the *Andropogon* community is 0.98 g/m^2 per day. The values range from 0.47 to 1.57 g/m^2 per day (Table 25). The greatest rate of fall occurred in September when the community attained peak biomass. The rate of fall remains relatively constant throughout the year, with the exception of the months of August and September when the rate of fall is accelerated. The drop in the rate of fall in the October-November sample is the result of the slow transfer of *Andropogon virginicus* at this time. The easily-transferable forbs had already been transferred in the previous sample. The low point found in the

Table 25. Monthly Rates of Litter Decomposition and Fall in *Andropogon* and *Festuca* Communities in Grams Per Meter Square Per Day

	Community			
	Andropogon		*Festuca*	
Period	Fall	Decomposition	Fall	Decomposition
3/15 to 5/19	0.84	0.35	0.52	0.15
5/19 to 6/17	0.81	1.91	0.70	1.52
6/17 to 7/17	0.81	0.94	0.80	1.09
7/17 to 8/17	0.47	0.74	0.87	1.66
8/17 to 9/18	1.32	0.70	0.83	1.38
9/18 to 10/18	1.57	1.27	0.59	1.40
10/18 to 11/18	0.83	0.79	0.53	1.42
11/18 to 12/18	1.17	1.10	0.66	1.54
Mean	0.98	0.98	0.69	1.27

July-August sample is due to the loss of most of the previous year's standing dead in prior samples and the reduced number of species reaching maturity and consequently being transferred to the standing dead and litter.

The rates of fall for the Festuca community are lower than the values for the Andropogon community (Table 25). The mean rate of fall value for Festuca community was 0.69 g/m^2 per day with a range from 0.52 to 0.87 g/m^2 per day. The presence of the standing dead material in the Festuca community is not as striking or obvious as in the Andropogon community due to the growth form of the Festuca elatior. The blades that die, do so from the underside of the clump and are obscured from view by the green parts of the plant. It is sometimes difficult to decide what material is standing dead and what is litter in this species. Although the blade may still be attached to the plant, it may also be partially touching the litter or soil and is subject to decomposition. The rate of fall appears to remain fairly constant through the summer with slightly lower values in the spring and winter. This relative constancy indicates that mortality of plant parts is occurring at about the same rate throughout the growing season. The drop in the rate of fall in the September-October sample is probably the result of a reduced rate of input from the forbs as well as the usual input from the Festuca.

Flowering stalks of Festuca elatior contribute approximately 25 percent to the crop of standing dead material in the Festuca community in July. The flowering stalks move very rapidly from the standing dead to the litter and by the following month flowering stalks were no longer standing. Due to the nature of the leaf blades clasping the flowering stalk of Andropogon virginicus a distinction was not made between it and the vegetative parts. Both parts stand or fall together from the main late summer growth, but some transfers of low leaves to standing dead and to litter could be missed without an exacting study of clump morphology.

Litter Decomposition

The rate of litter decomposition was determined by the use of the mesh bag technique of Shanks and Olson (1961). Despite the various limitations of this technique, the values obtained give a relatively good indication of litter loss rates.

The trend in litter decomposition on a percentage basis for the *Andropogon* community is shown in Figure 13 in which each point is the mean value of four bags collected at that date. The values are based on cumulative loss. Therefore, the mean values for each successive date ideally should be equal to or greater than the previous date. However, this is not the case. The losses fluctuate widely between the first and third samples, and other fluctuations are within the standard errors of previous values. The true trend in percentage loss of biomass might be approximated by a curve. Actual weight lost to decomposition is presented on a grams per meter square per day basis in Table 25. It will be noted that decomposition is very low during the March to May period. Whether this is a true occurrence or only the result of a period of adjustment of the litter bags to the surrounding litter and soil is an open question.

Similar mean values for the decomposition rate and the input rate must account for the rather stable standing crop of litter. This stabilizing phenomenon was noticed in a similar *Andropogon* community by Golley (1965). The mean loss value from the present study on a monthly basis , 30 g/m^2, is only slightly lower than the value (46 g/m^2) reported

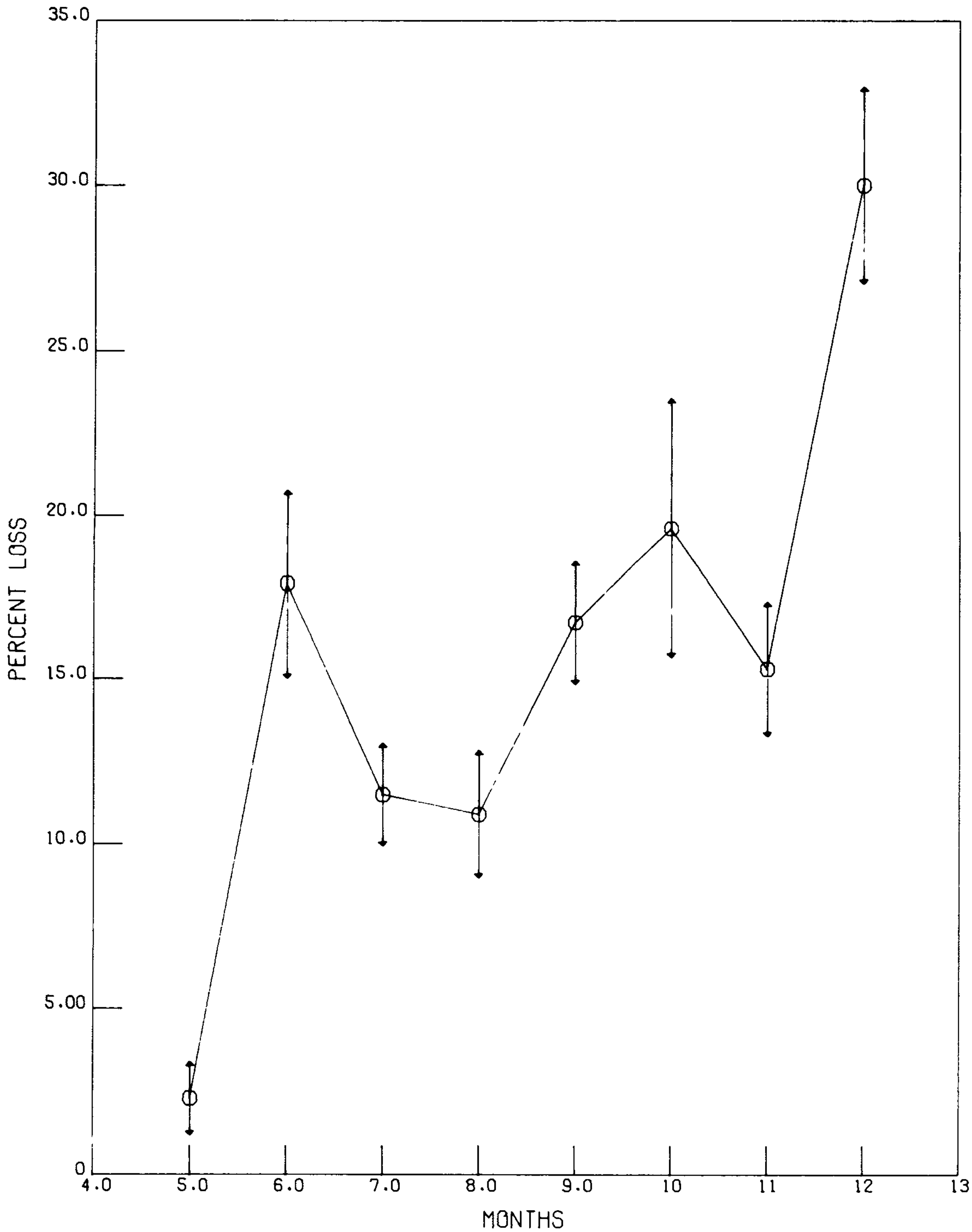

Figure 13. Andropogon community litter loss expressed as a percentage of the original weight.

by Harris (1966) in a similar nearby *Andropogon* community. *Andropogon* community litter loss on a yearly basis was inferred to be 425 g/m^2. This value compares favorably to the values reported by Harris (1966) and Golley (1965) (Table 4, p. 21).

The percentage of biomass lost with time in the *Festuca* community approaches a straight line as shown by Figure 14. The actual rates of decomposition are shown in Table 25. The mean value for decomposition is almost two times the minimal input rate from separate plots where litter was removed. Nevertheless, the standing crop of litter remains relatively constant throughout the year. Thus, the previous input estimate appears to be an underestimate of the actual input. The mean monthly value reported by Harris (1966) for a *Festuca* community is again greater than the value of 38 g/m^2 found in this study. Harris' (1966) yearly loss, 581 g/m^2, is considerably more than the 303 g/m^2 found in this study. The apparently low decomposition values from this study in comparison to those from the literature must be a function of local variation in decomposers or in their environmental habitat.

Summary of Compartmental Transfers

The various compartments and the transfers occurring in each are summarized in Figure 15. Transfers from the live to the standing dead and then to litter go on throughout the year. Transfers and especially net changes seem lowest during the mid-growing season, partly because there is near balance in both dead compartments at this time. The largest transfers to the standing dead and litter occur at the end of the growing season. The transfer of the *Festuca* flowering stalks to the standing dead and litter occurs very rapidly, requiring less than a month before they

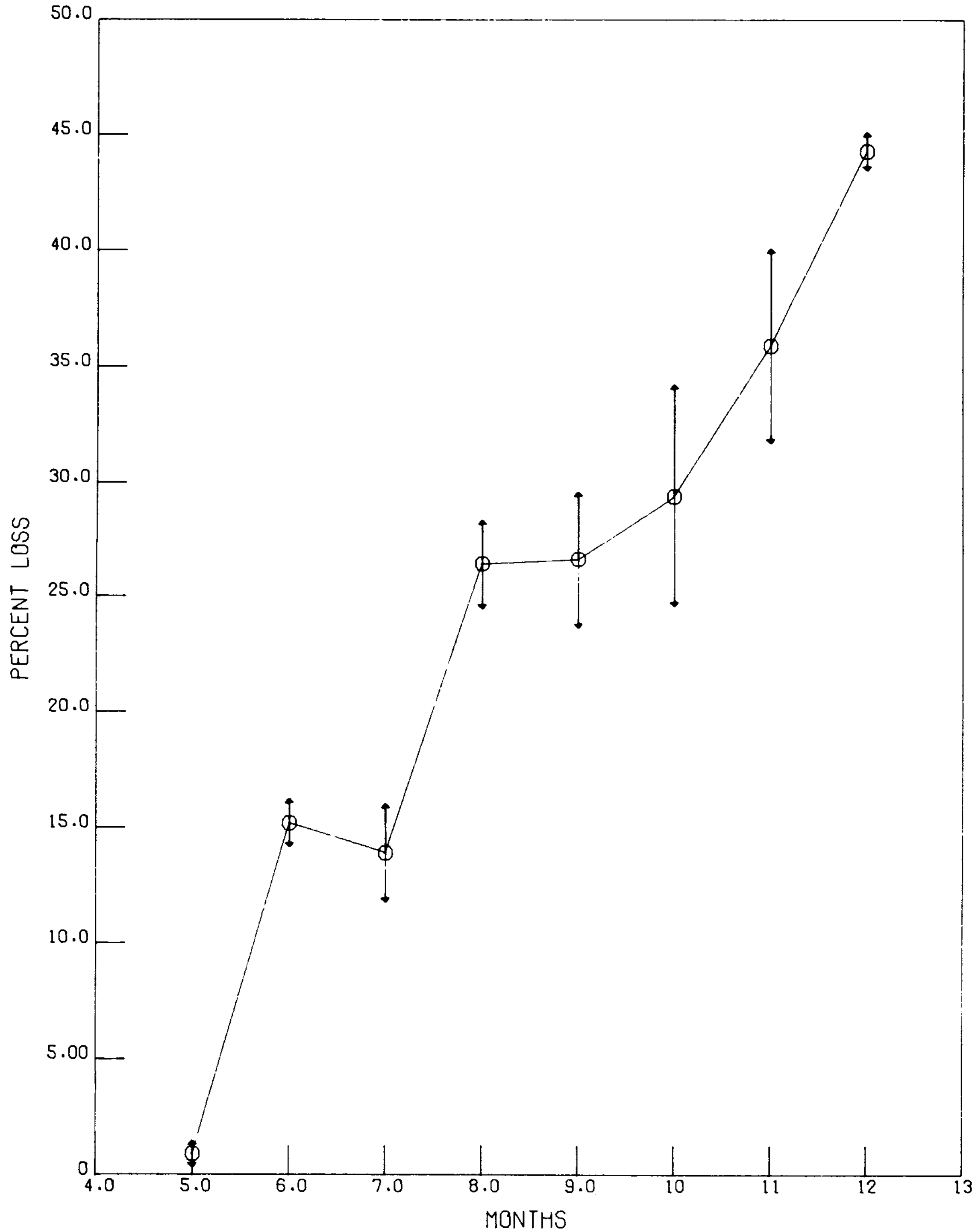

Figure 14. Festuca community litter loss expressed as a percentage of the original weight.

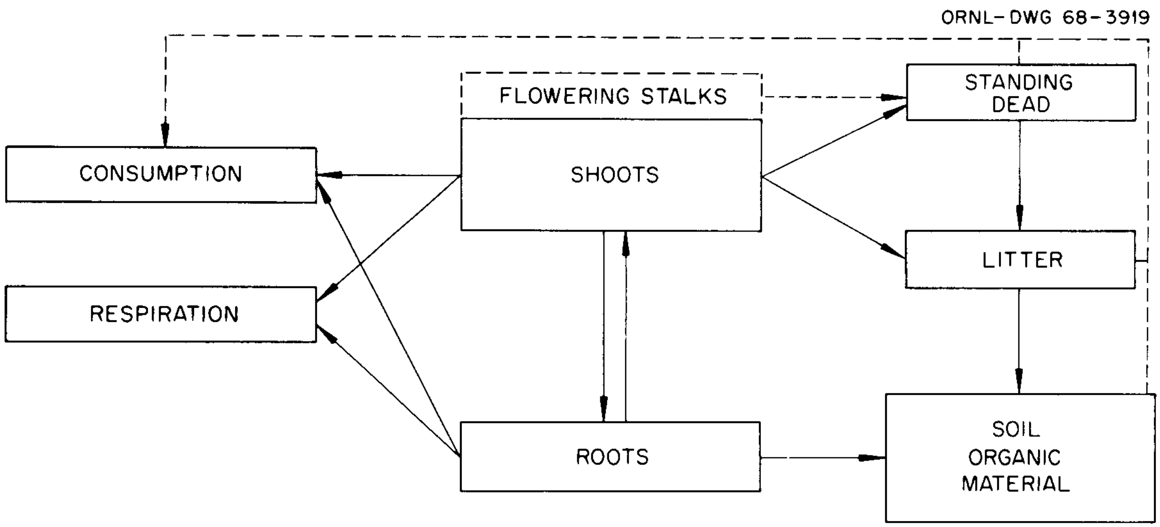

Figure 15. Block diagram of the various compartments showing the interrelationships and transfers of the compartments.

are no longer standing. The rate of transfer of Andropogon fruiting stalks is very slow.

Once the standing dead has reached the litter, decomposition begins and the material is incorporated into the soil at a moderate rate. There is also a transfer from the root compartment into the soil organic material, this quantity is an unknown value, but values in the literature indicate a turnover of about 25 percent per year (e.g. for Missouri prairie, Dahlman 1965). The transfers from the roots to the shoots and from the shoots to the roots of soluble carbohydrates were not measured in this study but could be of sizeable magnitude, especially in a species such as Festuca elatior which photosynthesizes and respires the year round. The amount of material lost in root and shoot respiration is unknown for these two communities and is certainly a point for further investigation.

Consumption losses occur in varying degrees in each compartment depending on the organisms carrying on the process. Consumption by insects is probably the biggest loss followed by the amount consumed by rodents and other herbivores. This particular aspect of the total transfer complex certainly needs to be further quantified since the estimates of 3 to 7 percent insect consumption on nearby White Oak Lakebed (Crossley 1963) were based on quite different communities than those reported in this study, and may have been conservative in estimated losses.

A-VI.

CONCLUSIONS

This study considers refinements of technique or results in several aspects of grassland study: (1) Minimal limits on net production from biomass change in Festuca and Andropogon old-field communities appear to be closer estimates of total community net production than most values found in the literature because (a) the sampling was sufficiently frequent to be close to peak biomass for each significant taxon, (b) the samples were separated into living and dead biomass for each species, (c) the standing crop of litter as well as litter input and decomposition were measured closely, (d) root biomass was determined by hydraulic coring and careful washing, to give a needed quantification to this compartment, as well as giving a means to obtain indirect limits on translocation to and from root storage. (2) Estimation of input to and loss from standing dead for the present year is confounded by previous year's standing dead material in both communities. Many studies neglect or underestimate both transfers. A satisfactory method of identification such as a more permanent dye needs to be developed to better quantify both income and loss for age classes in this compartment. (3) Input and decomposition of litter appear to be balanced so amounts are relatively stabilized in both communities. (4) Total live community biomass is still increasing in the Festuca elatior community, while total biomass appears to have stabilized in the Andropogon virginicus community. (5) There was not an increase in root biomass of a proportional magnitude below 20 cm compared to the great seasonal changes of roots in the top 20 cm (202 to

659 and 377 to 659 g/m^2 respectively). (6) Due to an unusually wet July the expected summer depression in Festuca production did not occur. (7) The estimates of compartmental transfer rates need to be further quantified, especially the losses due to consumption and respiration, as well as values for translocation of soluble carbohydrates. (8) Priority for more sampling periods would seem greatest during the late fall, especially just prior to and immediately after the time of killing frost. (9) An electrical device based on the principle of changing capacitance or resistance needs to be developed to make better estimates of root biomass with fewer samples.

A-VII.

SUMMARY

Two grassland communities were sampled periodically from January 1967 through December 1967. Forty meter-square plots were clipped on each sampling date; a total of 560 plots were clipped in both communities during the time of the study. A quarter meter square plot taken from the meter square plot was separated to species, living and dead. Twenty root biomass samples to a depth of 60 cm were taken at each sampling date in conjunction with the meter square plots. In addition to the clipped plots 100 unclipped plots were read with a capacitance meter and ranked by species.

Estimates of production as measured by positive biomass increases, in the Andropogon and Festuca communities, were 892 and 1001 g/m^2 respectively. The standing crop of litter in each community remained relatively constant at approximately 181 and 114 g/m^2. The trends in standing dead differ in both communities. The maximum value for the Andropogon community standing dead (806 g/m^2) occurs at the time of frost when most of the live material is transferred to the standing dead. The maximum value for the Festuca community standing dead is 408 g/m^2; this value is recorded in the early growing season. Apparent daily mean production rates vary from 1.05 (March 10-June 7) to 3.34 g/m^2 per day (June 7-August 7) for above-ground production in the Andropogon community and from 1.21 (March 1-April 28) to 3.29 g/m^2 per day (April 27-May 15) for the Festuca community. Estimated rates for below-ground biomass ranged from 0.55 (August 7-September 7) to 1.31 g/m^2 per day

(June 7-August 7) for the *Andropogon* community and 1.38 (March 1-April 28) to at least 4.02 g/m^2 per day (April 28-May 18) for the *Festuca* community.

This study has provided much needed quantification of root biomass for old-field grassland communities as a step toward additional, and possibly more valid, estimates of net production in herbaceous ecosystems, especially in terms of relating the phenology of contributions of the principal dominant and other species.

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Part A. Production and Compartmental Transfers

APPENDIX A

Table 26. Daily Precipitation and Temperature Values for 1967

Days	Precip-itation	Temper-ature	Days	Precip-itation	Temper-ature	Days	Precip-itation	Temper-ature	Days	Precip-itation	Temper-ature	Days	Precip-itation	Temper-ature	Days	Precip-itation	Temper-ature	Days	Precip-itation	Temper-ature
1	.06	45	61	0	43	121	.03	65	181	.10	75	241	0	69	301	0	46	361	.13	31
2	0	42	62	0	52	122	.30	55	182	.02	76	242	0	71	302	0	49	362	.52	35
3	0	47	63	0	60	123	0	53	183	.94	72	243	0	71	303	0	50	363	0	32
4	.03	39	64	.29	62	124	.15	50	184	0	71	244	0	64	304	.11	56	364	0	32
5	0	33	65	3.32	52	125	0	55	185	0	67	245	0	67	305	2.75	56	365	.40	36
6	0	38	66	0	34	126	.37	61	186	1.06	66	246	0	66	306	.45	51			
7	.35	49	67	0	37	127	1.71	55	187	3.53	69	247	.06	69	307	.04	50			
8	.09	42	68	0	47	128	.31	54	188	1.81	70	248	0	68	308	0	36			
9	0	34	69	0	52	129	0	51	189	0	71	249	0	70	309	0	34			
10	0	39	70	.31	67	130	0	50	190	0	73	250	0	71	310	0	32			
11	0	31	71	.01	69	131	0	63	191	2.38	71	251	.50	66	311	0	35			
12	0	34	72	0	68	132	.37	72	192	0	75	252	.03	71	312	0	36			
13	.34	37	73	0	73	133	.85	65	193	.85	74	253	0	72	313	0	43			
14	.21	44	74	.01	59	134	.04	70	194	.12	70	254	0	67	314	0	47			
15	0	35	75	0	45	135	.98	53	195	0	64	255	0	67	315	0	52			
16	0	29	76	0	33	136	0	54	196	0	64	256	0	68	316	0	61			
17	0	36	77	0	31	137	.04	54	197	0	66	257	0	69	317	0	48			
18	0	31	78	0	38	138	0	61	198	0	70	258	0	69	318	0	46			
19	.25	32	79	.35	50	139	.01	65	199	0	70	259	0	69	319	0	39			
20	0	35	80	.22	45	140	.01	68	200	0	72	260	0	70	320	0	39			
21	0	43	81	0	43	141	.14	57	201	0	74	261	0	74	321	0	46			
22	0	54	82	0	51	142	.21	61	202	0	75	262	0	75	322	0	47			
23	0	59	83	0	56	143	0	63	203	0	75	263	0	75	323	0	40			
24	0	60	84	0	61	144	0	64	204	0	77	264	.61	73	324	0	39			
25	0	56	85	0	65	145	0	71	205	.34	79	265	0	62	325	.18	45			
26	1.50	55	86	0	65	146	0	74	206	.52	75	266	0	60	326	.36	50			
27	.56	48	87	.92	59	147	0	73	207	.13	74	267	0	59	327	.06	43			
28	0	38	88	0	61	148	0	72	208	0	74	268	0	63	328	.64	47			
29	0	43	89	0	60	149	.31	70	209	.69	76	269	0	65	329	0	49			
30	0	55	90	0	62	150	.04	68	210	1.71	74	270	1.10	63	330	0	51			
31	0	49	91	0	62	151	.09	68	211	.01	74	271	.91	53	331	0	40			
32	0	62	92	0	63	152	.53	65	212	0	75	272	0	46	332	0	29			
33	.34	51	93	0	65	153	0	58	213	0	78	273	0	55	333	.49	33			
34	0	40	94	0	59	154	1.56	61	214	0	77	274	0	59	334	.43	43			
35	0	42	95	0	66	155	.19	66	215	.01	75	275	0	63	335	0	44			
36	0	42	96	0	75	156	0	70	216	0	79	276	0	66	336	.67	39			
37	.49	38	97	0	70	157	0	69	217	0	74	277	0	68	337	.04	38			
38	.21	24	98	0	63	158	0	68	218	0	73	278	0	68	338	0	39			
39	0	23	99	0	34	159	0	71	219	0	74	279	0	73	339	0	40			
40	0	24	100	.49	65	160	0	72	220	.01	77	280	.13	72	340	.01	47			
41	0	34	101	.03	57	161	0	72	221	.01	74	281	.31	69	341	0	51			
42	0	42	102	0	62	162	0	76	222	0	73	282	.32	56	342	0	51			
43	0	34	103	0	66	163	0	74	223	0	65	283	0	55	343	.02	55			
44	0	40	104	0	66	164	0	75	224	0	70	284	0	51	344	1.02	53			
45	0	46	105	0	71	165	0	80	225	0	67	285	0	55	345	.20	58			
46	0	57	106	0	67	166	0	79	226	0	67	286	0	57	346	0	43			
47	.19	48	107	.05	70	167	0	80	227	0	69	287	0	67	347	0	45			
48	.54	38	108	0	60	168	0	82	228	0	74	288	0	68	348	.08	46			
49	0	39	109	0	58	169	.15	80	229	.01	74	289	0	66	349	.04	41			
50	0	36	110	0	61	170	.16	78	230	0	76	290	.24	61	350	0	37			
51	1.18	40	111	.14	64	171	0	78	231	.06	73	291	.63	55	351	0	43			
52	0	32	112	.39	62	172	0	79	232	.01	74	292	0	49	352	1.97	54			
53	.01	31	113	.18	55	173	1.67	81	233	.21	72	293	0	50	353	.48	62			
54	0	31	114	.08	49	174	0	78	234	.16	73	294	0	56	354	0	61			
55	0	17	115	.18	49	175	.02	77	235	.05	72	295	0	55	355	.60	63			
56	0	11	116	1.20	54	176	1.59	77	236	.02	72	296	0	58	356	1.53	44			
57	0	22	117	0	47	177	0	73	237	0	71	297	.68	60	357	0	27			
58	.70	33	118	0	45	178	0	74	238	1.75	73	298	.36	50	358	0	32			
59	.02	32	119	0	51	179	.25	73	239	.10	68	299	0	49	359	0	42			
60	0	32	120	0	61	180	.07	73	240	0	66	300	.10	51	360	0	33			

Part A. Production and Compartmental Transfers

APPENDIX B

Table 27. Andropogon Community Above-Ground Biomass in Grams Per Meter Square

PLOT			.75 M	CAP	PCT H2O	DRY LIVE	DRY DEAD	EST DEAD	MULCH
1	1	1	599.0	3.5	.1965	3.4	258.7	85	73.6
1	1	2	405.0	4.0	.1327	0	294.0	90	52.8
1	1	3	535.0	3.0	.1566	4.9	290.3	90	41.5
1	1	4	500.0	4.0	.1664	0	240.9	85	69.8
1	1	5	570.0	2.5	.1867	0	150.2	90	43.7
1	1	6	561.0	4.0	.1606	11.0	298.2	90	29.6
1	1	7	782.0	2.5	.0837	10.8	220.1	90	51.4
1	1	8	774.0	4.5	.1117	0	295.8	95	31.3
1	1	9	604.0	7.0	.1645	2.3	350.3	90	33.0
1	1	10	590.0	5.5	.1824	0	297.6	90	28.7
1	1	11	504.0	4.0	.1106	0	251.7	90	39.7
1	1	12	522.0	3.0	.1453	0	294.0	95	35.2
1	1	13	452.0	2.0	.1266	0	269.0	85	36.4
1	1	14	488.0	2.5	.1007	9.3	245.2	80	57.1
1	1	15	773.0	3.0	.1390	12.2	318.4	75	52.7
1	1	16	571.0	4.5	.2765	10.6	300.5	80	48.9
1	1	17	459.0	3.0	.1303	22.9	272.8	85	68.4
1	1	18	678.0	3.5	.1223	14.7	397.8	90	56.1
1	1	19	666.0	2.5	.1418	8.0	269.2	90	76.5
1	1	20	303.0	1.5	.3855	5.8	189.6	90	117.7
2	1	1	538.0	2.0	.2589	17.3	236.9	90	81.2
2	1	2	484.0	4.0	.0455	.0	222.4	90	93.1
2	1	3	500.0	2.0	.0697	0	214.9	95	107.3
2	1	4	403.0	2.0	.1364	0	241.8	95	57.2
2	1	5	780.0	4.0	.0371	0	215.7	95	50.4
2	1	6	645.0	2.0	.1535	0	409.7	95	94.2
2	1	7	694.0	3.0	.0862	6.1	442.5	95	71.5
2	1	8	494.0	3.0	.1696	0	343.8	95	107.7
2	1	9	613.0	1.5	.0843	0	320.5	95	88.7
2	1	10	588.0	2.5	.0610	1.7	246.2	95	63.3
2	1	11	454.0	3.0	.1630	5.0	307.2	90	122.1
2	1	12	477.0	2.5	.0558	0	235.1	95	83.4
2	1	13	496.0	1.0	.0808	4.0	239.6	90	58.6
2	1	14	448.0	1.0	.1557	3.0	197.1	95	28.6
2	1	15	685.0	1.5	.0642	2.2	272.0	95	125.8
2	1	16	583.0	1.0	.0818	0	282.8	90	61.9
2	1	17	612.0	2.0	.0749	4.1	324.3	90	96.1
2	1	18	717.0	1.5	.0732	2.1	111.9	90	142.8
2	1	19	325.0	2.0	.0569	0	177.3	95	118.4
2	1	20	682.0	1.5	.0690	.3	230.6	90	133.2
1	2	2	319.0	2.5	.7451	26.2	34.2	45	62.0
1	2	5	422.0	4.0	.6039	62.8	69.1	20	50.7
1	2	7	525.0	3.0	.2757	22.6	212.8	70	35.1
1	2	10	474.0	3.0	.3199	24.9	179.8	80	33.8
1	2	11	465.0	2.5	.3607	28.8	177.7	60	32.3
1	2	13	549.0	3.0	.2450	5.8	219.2	95	30.5
1	2	15	410.0	3.5	.3226	34.7	270.8	50	31.3
1	2	16	539.0	2.0	.2069	12.0	230.7	15	43.3
1	2	19	524.0	3.5	.3418	37.5	178.4	60	29.3
1	2	22	461.0	2.0	.2350	27.2	187.0	80	39.9
1	2	67	325.0	2.0	.6879	46.1	31.3	60	39.6
1	2	69	606.0	2.0	.2921	23.6	181.7	65	37.4
1	2	71	466.0	2.0	.2397	21.8	274.7	95	34.3
1	2	73	598.0	2.0	.2471	13.9	139.7	80	43.2
1	2	74	412.0	4.5	.4222	97.7	84.3	40	54.6
1	2	75	428.0	2.0	.4227	35.3	91.7	65	32.6
1	2	76	362.0	2.5	.1945	12.7	281.3	90	51.4
1	2	80	343.0	4.0	.4222	35.5	104.9	45	16.1

PLOT			.75 M	CAP	PCT H2O	DRY LIVE	DRY DEAD	EST DEAD	MULCH
1	2	81	555.0	1.5	.2412	38.1	302.6	90	60.7
1	2	85	623.0	3.5	.2753	30.0	199.0	70	31.5
2	2	2	422.0	3.5	.3162	28.9	135.2	30	48.0
2	2	5	637.0	1.5	.0996	8.7	202.9	99	57.0
2	2	7	354.0	3.0	.1553	4.9	186.0	60	41.4
2	2	10	621.0	1.0	.1134	1.6	222.7	99	62.1
2	2	11	472.0	2.5	.2361	19.6	172.9	60	66.7
2	2	13	346.0	2.5	.2656	28.2	211.2	80	68.2
2	2	15	457.0	4.0	.3041	33.2	224.3	50	39.8
2	2	16	304.0	4.0	.2528	34.7	313.5	75	46.5
2	2	19	566.0	2.0	.5231	33.2	138.5	80	80.7
2	2	22	504.0	5.0	.4301	22.5	129.1	40	62.6
2	2	67	630.0	3.5	.4108	35.5	111.2	35	76.7
2	2	69	527.0	2.5	.2206	19.6	198.5	90	73.0
2	2	71	382.0	2.0	.2698	39.5	197.1	80	77.6
2	2	73	486.0	4.5	.2626	23.2	217.2	90	49.1
2	2	74	549.0	3.5	.4239	20.8	167.6	70	47.5
2	2	75	455.0	4.0	.3690	52.3	159.1	60	56.3
2	2	76	220.0	5.0	.4185	48.7	193.2	80	48.2
2	2	81	649.0	2.0	.3240	38.8	79.5	40	54.4
2	2	85	518.0	2.5	.1608	10.7	287.6	10	65.5
1	3	17	426.0	7.5	.6047	150.2	84.2	10	33.7
1	3	19	502.0	3.0	.5653	59.5	105.7	50	67.0
1	3	20	654.0	6.0	.5150	41.1	71.9	20	32.1
1	3	21	460.0	3.5	.3127	20.5	185.7	50	85.9
1	3	40	594.0	10.0	.6149	36.1	305.9	10	49.0
1	3	48	456.0	6.5	.6670	129.8	9.4	0	93.6
1	3	56	406.0	4.0	.6442	77.9	78.3	10	76.5
1	3	65	674.0	5.0	.6107	84.1	91.1	20	45.9
1	3	68	424.0	2.0	.4178	71.9	183.7	20	55.2
1	3	78	705.0	3.0	.4309	51.7	242.8	40	56.1
1	3	81	351.0	1.5	.2990	42.1	246.0	50	40.2
1	3	82	678.0	3.5	.2978	80.2	268.1	70	59.6
1	3	83	564.0	2.5	.3945	25.6	251.7	60	73.5
1	3	84	770.0	2.5	.3679	23.3	359.1	60	52.0
1	3	86	724.0	3.0	.4446	78.1	182.4	40	65.2
1	3	90	602.0	5.0	.3798	52.2	199.6	15	49.2
1	3	91	671.0	2.0	.2552	29.0	218.7	60	44.2
1	3	92	666.0	4.0	.7484	53.0	48.9	40	68.4
1	3	1	764.0	3.0	.3106	34.2	263.6	25	39.1
2	3	1	342.0	3.5	.7246	57.7	13.0	10	77.2
2	3	14	682.0	4.0	.4967	82.7	264.6	40	21.1
2	3	17	458.0	2.0	.6774	114.4	76.6	20	67.7
2	3	19	375.0	3.5	.5508	142.9	187.7	15	35.7
2	3	20	673.0	4.0	.5805	134.9	161.3	20	36.8
2	3	21	569.0	1.5	.4942	85.0	194.2	30	17.9
2	3	40	776.0	4.5	.5459	77.9	226.8	25	15.7
2	3	48	791.0	4.0	.4708	117.7	291.9	45	43.8
2	3	56	670.0	5.0	.6226	81.4	45.8	20	22.7
2	3	65	750.0	4.5	.5144	75.0	137.7	25	35.8
2	3	68	608.0	4.5	.5705	100.5	82.5	15	35.3
2	3	78	473.0	2.5	.4337	63.4	250.9	40	27.3
2	3	81	628.0	3.0	.5159	56.1	102.2	20	63.4
2	3	82	579.0	6.5	.5986	132.7	67.2	15	24.3
2	3	83	661.0	5.0	.5840	123.4	66.3	15	25.7
2	3	84	605.0	5.0	.6747	111.6	80.0	10	38.5
2	3	86	457.0	4.0	.5869	140.6	89.5	10	40.1
2	3	90	348.0	2.5	.5561	114.3	89.0	15	37.1

Table 27. (continued)

PLOT	.75 M	CAP	PCT H2O	DRY LIVE	DRY DEAD	EST DEAD	MULCH
2 3 91	456.0	4.0	.0325	84.1	71.7	10	18.7
2 3 92	779.0	6.0	.5828	118.9	113.9	20	45.0
1 4 1	363.0	5.0	.0297	278.5	0	1	125.6
1 4 2	634.0	5.5	.4813	220.9	79.5	5	50.9
1 4 4	644.0	1.5	.2578	27.9	234.1	20	48.7
1 4 5	879.0	2.0	.2890	14.6	290.4	80	59.0
1 4 6	822.0	2.5	.3435	34.4	310.9	70	46.3
1 4 7	745.0	5.0	.6149	102.0	39.7	2	84.9
1 4 9	593.0	5.0	.6297	157.5	59.1	3	30.9
1 4 11	409.0	3.0	.4780	61.6	113.8	10	65.9
1 4 12	787.0	2.5	.6775	103.5	51.3	3	66.8
1 4 13	680.0	3.0	1.4055	94.1	64.4	3	80.2
1 4 15	470.0	3.0	.6087	162.8	61.0	1	27.9
1 4 16	707.0	2.0	.4115	45.8	255.2	40	50.8
1 4 17	604.0	3.5	.4979	134.8	124.3	5	46.9
1 4 18	761.0	2.5	.4915	81.6	85.2	5	67.4
1 4 19	650.0	4.5	.5184	91.9	96.5	3	101.5
1 4 20	417.0	2.5	.4836	120.7	231.2	10	64.7
1 4 21	532.0	2.5	.5054	118.6	130.7	2	30.3
1 4 23	785.0	3.0	.4008	95.2	224.0	40	31.5
1 4 24	467.0	3.0	.3827	29.1	138.8	80	111.0
1 4 25	615.0	2.0	.3746	85.0	210.2	20	97.0
2 4 1	803.0	3.0	.6520	47.0	162.0	40	29.0
2 4 2	677.0	4.0	.6943	157.7	63.0	10	42.9
2 4 4	673.0	5.0	.5570	166.3	223.1	10	22.7
2 4 5	725.0	3.0	.4227	83.3	250.4	50	75.3
2 4 6	562.0	4.5	.5072	151.2	164.2	30	41.7
2 4 7	948.0	4.5	.5257	161.6	123.0	30	23.1
2 4 9	826.0	3.0	.5557	369.5	103.2	5	37.8
2 4 11	963.0	2.5	.4915	61.2	130.2	15	45.7
2 4 12	848.0	2.5	.4931	103.3	177.5	10	38.1
2 4 13	738.0	2.5	.3985	60.0	260.6	15	33.8
2 4 15	862.0	5.0	.4639	57.2	140.1	40	43.2
2 4 16	651.0	4.0	.4470	94.7	161.9	30	33.8
2 4 17	573.0	3.5	.5240	112.7	85.3	1	34.8
2 4 18	673.0	3.0	.6924	95.8	138.6	10	32.7
2 4 19	688.0	3.5	.5597	81.0	147.5	40	52.3
2 4 20	824.0	3.0	.4269	106.4	234.4	30	47.0
2 4 21	779.0	4.5	.4455	92.2	118.5	20	44.2
2 4 23	629.0	3.0	.6124	121.3	69.0	5	48.1
2 4 24	654.0	3.0	.5241	168.4	131.4	10	72.1
2 4 25	703.0	3.0	.5040	71.1	90.2	3	66.8
1 5 9	374.0	2.5	.4019	91.9	104.8	75	58.9
1 5 2	586.0	3.5	.4297	67.6	233.3	90	36.4
1 5 3	753.0	3.5	.4076	92.1	266.9	85	64.1
1 5 4	713.0	3.0	.4187	140.4	98.5	80	23.6
1 5 5	831.0	2.0	.5881	140.5	98.4	85	55.1
1 5 13	747.0	2.0	.3817	147.0	160.3	80	18.2
1 5 14	689.0	2.0	.3160	65.0	166.2	75	60.2
1 5 19	666.0	2.0	.1236	25.8	234.5	95	58.1
1 5 19	626.0	3.0	.6203	59.2	165.2	85	72.5
1 5 20	730.0	3.0	.4075	151.5	109.2	95	39.6
1 5 23	699.0	1.5	.4056	88.2	103.2	75	189.5
1 5 27	561.0	2.0	.4199	112.2	88.5	65	89.8
1 5 30	939.0	1.5	.2498	41.5	303.6	85	25.5
1 5 31	722.0	2.0	.4260	134.6	112.8	65	60.4
1 5 32	652.0	2.5	.4369	31.3	196.2	85	42.8
1 5 40	622.0	2.0	.4194	92.3	75.5	60	98.2
1 5 41	596.0	3.5	.5435	34.3	173.4	95	74.7
1 5 42	497.0	3.0	.5460	88.5	115.8	85	48.7
1 5 46	525.0	2.0	.3428	99.5	221.2	80	73.7
1 5 64	942.0	2.5	.4410	131.7	161.2	90	43.7
1 5 72	674.0	3.0	.4208	27.6	259.8	90	31.1
2 5 2	654.0	2.5	.4780	135.3	62.0	80	72.0
2 5 3	608.0	2.0	.3862	86.5	171.9	85	56.5
2 5 4	761.0	1.5	.4560	80.7	175.0	70	25.1
2 5 5	579.0	2.5	.3152	54.2	274.5	90	42.4
2 5 13	856.0	2.5	.4254	49.0	153.0	75	48.6
2 5 14	770.0	2.0	.3961	61.9	233.4	80	40.0
2 5 19	860.0	2.0	.4958	68.8	204.5	80	32.1
2 5 191	683.0	3.0	.3895	111.4	201.2	75	38.0
2 5 20	610.0	1.5	.4501	33.6	249.5	90	34.9
2 5 23	644.0	1.5	.3781	36.9	241.7	85	34.0
2 5 27	515.0	2.5	.4341	117.5	114.5	65	23.1
2 5 30	617.0	3.0	.4547	99.1	165.9	80	20.9
2 5 31	838.0	2.0	.4242	97.4	176.1	70	31.6
2 5 32	744.0	2.5	.3369	49.4	220.5	90	47.8
2 5 40	739.0	3.0	.5623	143.0	218.0	80	59.6
2 5 41	622.0	3.0	.4477	88.5	196.5	85	38.2
2 5 42	796.0	2.5	.4484	88.9	140.0	75	25.5
2 5 46	800.0	2.0	.4276	178.4	198.8	75	49.2
2 5 64	648.0	3.0	.4399	111.4	113.2	80	53.1
2 5 72	623.0	3.0	.4173	86.8	169.0	75	41.7
1 6 6	537.0	3.0	.2856	1.0	167.6	99	58.5
1 6 10	675.0	2.0	.3016	1.9	218.8	99	45.2
1 6 15	591.0	1.5	.2111	.0	249.3	99	90.8
1 6 17	698.0	2.5	.2013	5.7	134.6	99	47.5
1 6 18	565.0	4.0	.5678	10.4	227.3	95	61.2
1 6 21	748.0	1.0	.2439	.5	184.0	99	42.2
1 6 25	703.0	2.0	.3368	4.9	330.0	99	37.9
1 6 34	601.0	3.5	.6008	.0	239.5	99	39.0
1 6 50	580.0	3.5	.5555	4.8	149.0	98	69.3
1 6 62	556.0	2.5	.5219	4.3	255.8	99	38.8
1 6 74	641.0	3.0	.5314	10.3	299.0	99	33.3
1 6 75	646.0	2.0	.3633	2.4	313.4	99	55.7
1 6 76	524.0	4.0	.5951	15.0	242.4	99	49.5
1 6 85	735.0	2.5	.3632	9.2	179.3	98	65.0
1 6 83	351.0	2.5	.3236	1.7	167.4	99	13.0
1 6 84	590.0	2.0	.4014	15.2	200.3	99	28.2
1 6 90	481.0	3.0	.4182	7.4	289.3	99	54.0
1 6 91	524.0	2.0	.3390	7.3	167.2	99	57.0
1 6 93	472.0	1.5	.4587	5.1	338.6	99	38.8
1 6 95	608.0	.5	.2461	.7	285.8	99	58.5
2 6 6	716.0	1.5	.3208	7.2	241.4	99	38.7
2 6 10	680.0	3.5	.3241	6.4	268.0	99	36.5
2 6 17	662.0	2.0	.3763	10.1	297.4	95	38.0
2 6 18	667.0	3.0	0	6.9	230.4	99	20.9
2 6 21	713.0	2.5	.0634	1.2	393.1	99	48.4
2 6 25	578.0	1.0	.3166	.0	209.8	99	61.0
2 6 34	601.0	2.5	.5373	9.4	217.3	99	43.6
2 6 50	564.0	3.0	.5094	5.3	224.3	99	40.0
2 6 62	589.0	2.0	.4742	1.0	267.7	99	23.3
2 6 74	641.0	2.0	.6207	1.3	265.7	99	18.8
2 6 75	742.0	4.0	.3778	8.6	134.5	90	70.8
2 6 76	580.0	2.5	.5448	1.8	178.7	99	44.3
2 6 83	623.0	2.0	.5249	3.2	246.7	99	45.7

Table 27. (continued)

PLOT			.75 M	CAP	PCT H2O	DRY LIVE	DRY DEAD	EST DEAD	MULCH
2	6	84	665.0	1.5	.3527	8.3	265.5	99	71.9
2	6	85	582.0	2.0	.4887	7.2	240.8	99	37.1
2	6	90	558.0	3.0	.4236	11.2	243.0	99	60.9
2	6	91	707.0	2.0	.4076	8.6	232.5	99	35.9
2	6	93	434.0	4.5	.4362	4.1	147.0	99	59.8
2	6	95	578.0	1.5	.3099	3.2	225.9	99	38.6
2	6	15	510.0	2.0	.2095	17.5	233.1	99	59.5

Table 28. Festuca Community Above-Ground Biomass by Plot in Grams Per Meter Square

PLOT	.75 M	CAP	PCT H2O	DRY LIVE	DRY DEAD	EST DEAD	MULCH
1 1 4	194.8	2.0	.4282	9.5	38.7	60	57.4
1 1 10	204.8	1.0	.3936	9.7	47.3	70	20.5
1 1 14	347.8	0	.3121	11.5	73.8	60	33.8
1 1 29	268.8	1.5	.3437	10.5	72.2	70	33.4
1 1 31	225.8	2.5	.4381	11.0	55.3	65	34.2
1 1 42	355.8	2.5	.3646	38.7	146.2	40	38.9
1 1 43	350.8	2.0	.5157	48.4	114.8	50	25.6
1 1 68	345.8	1.5	.5450	32.0	146.8	50	22.4
1 1 77	372.8	2.5	.3338	36.7	111.2	40	50.7
1 1 88	392.8	1.0	.4991	.4	74.8	35	21.0
2 1 5	292.8	2.0	.4586	15.0	70.0	60	49.0
2 1 26	139.8	2.0	.4667	7.0	33.0	45	30.0
2 1 45	369.8	2.0	.3867	17.0	94.0	70	33.0
2 1 47	384.8	1.5	.4859	11.0	62.0	50	31.0
2 1 54	125.8	1.5	.3684	3.0	57.0	60	37.0
2 1 58	155.8	.5	.2286	5.0	49.0	98	23.0
2 1 66	288.8	3.0	.5000	6.0	53.0	50	37.0
2 1 82	219.8	2.5	.4652	27.0	96.0	40	34.0
2 1 89	222.8	4.0	.2581	7.0	39.0	60	27.0
2 1 99	223.8	5.0	.4491	17.0	75.0	40	43.0
1 2 3	175.0	5.0	.3391	27.8	142.9	60	50.0
1 2 13	196.0	2.0	.2886	9.2	71.9	80	28.0
1 2 17	277.0	3.0	.2694	21.9	76.0	70	39.0
1 2 23	152.0	3.0	.3730	13.8	55.8	60	48.0
1 2 28	299.0	1.5	.3071	3.5	65.1	90	28.0
1 2 30	138.0	2.5	.4038	7.5	55.1	90	41.0
1 2 35	97.0	4.0	.3883	33.2	113.6	70	29.0
1 2 49	179.0	2.0	.2460	8.8	104.3	95	67.0
1 2 62	179.0	2.0	.1245	30.3	94.9	90	61.0
1 2 64	202.0	3.0	.3182	12.7	62.3	85	40.0
1 2 70	249.0	3.5	.3743	15.3	69.8	80	53.0
1 2 74	224.0	2.0	.2875	12.7	72.8	70	40.0
1 2 79	70.0	1.0	.2785	3.3	43.6	85	26.0
1 2 80	143.0	3.0	.3486	15.6	78.2	80	36.0
1 2 93	152.0	1.0	.3411	8.3	39.8	60	28.0
1 2 94	108.0	1.0	.2750	5.7	34.9	50	20.0
1 2 95	105.0	1.0	.2839	6.5	37.9	30	18.0
1 2 103	105.0	2.0	.2892	10.0	68.9	50	37.0
1 2 106	284.0	2.0	.3261	13.8	92.0	65	39.0
1 2 109	226.0	2.0	.2783	8.2	91.4	70	54.0
2 2 3	98.0	2.5	.3000	11.5	71.1	60	38.0
2 2 13	67.0	2.5	.2531	7.4	53.1	30	20.0
2 2 17	211.0	3.5	.3466	16.1	70.8	50	38.0
2 2 23	107.0	2.5	.1273	5.8	51.8	40	31.0
2 2 28	124.0	2.5	.3248	19.2	84.1	60	24.0
2 2 30	211.0	2.5	.2654	11.3	84.2	70	22.0
2 2 35	222.0	2.5	.3051	13.9	82.0	60	59.0
2 2 49	214.0	3.0	.3981	20.3	106.1	50	43.0
2 2 62	161.0	1.0	.2212	5.7	82.3	50	14.0
2 2 64	149.0	1.0	.2819	9.1	74.2	40	37.0
2 2 70	263.0	2.5	.2381	11.0	101.0	80	48.0
2 2 74	155.0	2.5	.2813	18.2	142.8	75	25.0
2 2 79	269.0	3.5	.3066	18.7	138.0	40	33.0
2 2 80	275.0	3.0	.7353	.0	22.5	70	35.0
2 2 93	325.0	4.0	.4561	20.4	108.5	50	38.0
2 2 94	363.0	1.0	.3842	8.4	50.1	40	17.0
2 2 95	294.0	2.5	.4299	21.5	83.4	30	27.0
2 2 103	202.0	2.5	.3592	18.5	99.4	25	23.0
2 2 106	158.0	2.5	.3784	9.8	94.0	30	12.0
2 2 109	376.0	2.0	.3242	14.8	91.3	35	19.0
1 3 7	311.0	3.5	.5020	36.9	61.7	15	39.8
1 3 8	259.0	5.0	.8141	51.1	2.8	15	36.6
1 3 16	354.0	4.5	.4692	52.0	183.5	20	22.0
1 3 19	340.0	4.0	.6810	22.4	53.2	10	25.5
1 3 24	425.0	3.5	.2868	49.0	167.8	20	36.5
1 3 21	465.0	3.0	.4758	9.4	84.1	15	45.2
1 3 33	309.0	3.5	.3644	30.9	53.0	7	11.2
1 3 34	171.0	2.5	.5000	28.0	23.5	70	13.3
1 3 41	407.0	3.0	.5673	32.0	104.3	15	33.2
1 3 47	366.0	3.5	.3590	35.5	114.5	10	27.2
1 3 52	351.0	3.0	.6053	24.4	131.1	60	33.3
1 3 57	490.0	4.5	.6797	36.0	152.0	15	36.8
1 3 65	344.0	3.0	.6450	31.2	99.1	15	41.7
1 3 71	421.0	5.0	.6662	34.7	128.2	10	32.9
1 3 76	519.0	4.5	.6774	24.6	156.4	60	80.9
1 3 84	254.0	3.5	.5164	51.5	45.3	15	36.2
1 3 91	330.0	1.5	.3948	23.2	81.6	10	51.7
1 3 97	400.0	4.5	.4811	34.5	64.1	10	34.7
1 3 99	207.0	3.5	.5265	36.9	37.2	10	26.2
1 3 101	314.0	2.0	.4106	26.7	57.0	10	42.9
2 3 7	351.0	1.5	.3557	19.0	37.7	15	13.5
2 3 8	381.0	2.0	.3692	34.8	141.2	20	26.7
2 3 16	231.0	3.5	.4193	28.1	86.3	10	15.9
2 3 19	210.0	2.5	.4519	20.0	37.0	10	12.9
2 3 21	320.0	3.5	.4124	20.7	59.8	10	12.7
2 3 24	241.0	3.0	.4598	26.8	34.7	10	20.3
2 3 33	313.0	3.5	.3872	25.2	90.1	15	22.5
2 3 34	278.0	3.0	.3120	21.8	81.4	20	26.9
2 3 41	214.0	3.0	.4523	44.7	119.6	10	26.3
2 3 47	279.0	3.0	.4251	25.1	102.3	20	31.1
2 3 57	184.0	3.0	.5361	29.5	54.0	15	38.0
2 3 65	473.0	3.0	.2857	56.3	148.0	20	59.3
2 3 71	585.0	3.5	.4807	29.9	196.0	25	23.1
2 3 76	673.0	4.0	.4211	36.2	240.5	25	26.8
2 3 84	250.0	2.5	.6223	40.0	68.4	15	36.2
2 3 91	391.0	3.5	.5578	43.7	123.0	10	31.6
2 3 97	420.0	4.0	.5771	44.5	120.0	10	34.7
2 3 99	408.0	4.5	.6629	41.0	110.7	10	60.7
2 3 101	473.0	3.0	.5664	32.3	158.5	20	38.1
1 4 2	543.0	4.5	.5908	64.9	77.5	15	37.7
1 4 12	494.0	5.5	.6516	65.6	120.8	15	30.3
1 4 14	321.0	4.5	.5353	64.5	199.0	10	22.4
1 4 15	393.0	6.5	.4881	32.2	191.0	20	42.6
1 4 18	358.0	4.5	.5522	62.9	165.5	10	47.8
1 4 26	599.0	6.0	.5576	37.6	73.0	15	39.9
1 4 38	412.0	3.5	.5034	37.0	177.1	15	26.0
1 4 42	600.0	6.0	.5600	64.9	188.1	30	18.0
1 4 44	568.0	5.5	.5691	51.5	145.0	20	34.3
1 4 49	377.0	5.5	.5946	64.1	102.5	15	55.3
1 4 50	353.0	6.5	.5533	102.3	121.5	15	20.7
1 4 54	511.0	5.0	.6041	46.7	77.6	35	25.9
1 4 61	398.0	5.0	.5377	58.3	202.0	25	33.8
1 4 69	567.0	4.5	.2639	32.7	65.3	70	44.4
1 4 74	402.0	7.0	.7831	60.4	48.5	20	34.8
1 4 79	545.0	7.5	.6321	47.4	110.8	10	46.9
1 4 87	616.0	5.0	.5768	49.8	181.7	15	18.4

Table 28. (continued)

PLOT	.75 M	CAP	PCT H2O	DRY LIVE	DRY DEAD	EST DEAD	MULCH
1 4 93	498.0	5.0	.5935	39.1	73.9	70	25.2
1 4 97	391.0	5.0	.5760	41.7	62.6	5	34.9
1 4 103	509.0	3.5	.5048	30.1	53.1	20	44.5
2 4 2	428.0	3.5	.5747	35.3	67.2	15	22.7
2 4 12	399.0	5.5	.6816	31.1	52.0	10	11.7
2 4 14	352.0	4.5	.8664	56.1	132.4	20	18.9
2 4 15	461.0	5.0	.7377	12.2	27.4	2	43.0
2 4 18	311.0	6.5	.5178	50.3	177.8	15	16.3
2 4 26	304.0	6.0	.6384	50.2	59.2	5	30.5
2 4 38	366.0	5.5	.5793	56.7	128.4	10	42.6
2 4 42	529.0	3.5	.5517	34.4	108.6	10	21.0
2 4 44	471.0	3.5	.5586	69.2	171.8	15	47.3
2 4 49	345.0	5.0	.6627	62.4	33.4	5	22.2
2 4 50	443.0	5.0	.6082	66.3	106.5	5	33.4
2 4 54	349.0	4.0	.6913	50.7	55.8	5	40.7
2 4 61	395.0	4.0	.5991	44.2	89.7	5	12.8
2 4 69	489.0	4.5	.7220	66.9	153.8	20	23.8
2 4 74	508.0	5.0	.5548	52.8	134.2	10	33.5
2 4 79	505.0	6.0	.7370	51.5	140.0	15	29.7
2 4 87	503.0	4.5	.7801	48.6	44.2	10	13.6
2 4 93	373.0	3.5	.7509	57.7	65.1	5	53.5
2 4 97	461.0	3.5	.7524	37.0	45.2	5	37.1
2 4 103	417.0	4.5	.7255	48.8	123.6	10	36.6
1 5 6	629.0	4.5	.5755	73.4	141.4	10	20.7
1 5 9	275.0	6.5	.6773	110.0	140.4	30	51.1
1 5 11	366.0	6.0	.6123	94.6	135.7	15	84.6
1 5 13	400.0	6.5	.6201	177.6	46.9	25	37.7
1 5 19	461.0	6.0	.5919	45.9	49.4	10	23.3
1 5 20	479.0	6.5	.6801	95.7	122.8	10	52.4
1 5 44	521.0	7.5	.6715	113.0	138.6	30	43.3
1 5 46	669.0	9.0	.6438	62.6	95.9	15	52.5
1 5 52	513.0	6.0	.5815	61.0	126.5	15	27.2
1 5 53	501.0	6.0	.6468	82.4	109.4	10	50.9
1 5 60	434.0	7.0	.6109	82.8	121.5	20	24.9
1 5 61	510.0	6.5	.6102	80.6	156.0	20	33.5
1 5 67	479.0	6.0	.5716	86.1	149.5	20	49.6
1 5 71	350.0	9.0	.6491	121.9	107.6	10	33.6
1 5 76	437.0	7.5	.7084	60.6	114.9	20	50.1
1 5 81	628.0	5.0	.6112	56.8	31.0	10	22.3
1 5 82	359.0	5.0	.5830	56.8	63.3	2	22.7
1 5 84	272.0	6.5	.6137	80.0	27.0	1	16.7
1 5 85	589.0	4.5	.6058	81.0	135.0	15	19.5
1 5 92	507.0	6.0	.5348	65.9	119.7	15	25.5
2 5 6	503.0	6.0	.4132	66.5	142.4	20	29.4
2 5 9	341.0	5.0	.5127	61.1	72.9	15	49.9
2 5 11	369.0	3.5	.4943	72.2	150.3	15	25.3
2 5 13	419.0	6.0	.5268	51.7	69.5	50	26.1
2 5 19	360.0	5.0	.5057	54.8	41.1	10	37.8
2 5 20	269.0	5.5	.5545	72.8	84.0	40	33.7
2 5 44	427.0	11.5	.3405	101.0	228.1	15	34.0
2 5 46	418.0	12.0	.6006	115.9	73.4	10	34.8
2 5 52	363.0	8.0	.5287	108.2	62.4	10	26.2
2 5 53	446.0	4.0	.5111	64.6	72.3	15	29.5
2 5 60	184.0	4.0	.4425	60.4	28.8	5	25.1
2 5 61	133.0	4.5	.5822	36.3	13.3	1	24.7
2 5 67	414.0	9.5	.5620	69.6	113.2	20	38.8
2 5 71	557.0	5.0	.4045	49.1	69.4	5	26.1
2 5 76	499.0	6.0	.5722	85.9	126.3	15	39.9
2 5 81	486.0	5.0	.5117	67.5	91.2	5	24.2
2 5 82	361.0	5.5	.5126	47.6	33.8	10	11.0
2 5 84	281.0	4.5	.5396	60.5	59.2	70	33.0
2 5 85	185.0	4.5	.1348	82.4	14.5	5	21.2
2 5 92	348.0	6.0	.4657	82.4	47.5	10	40.8
1 6 5	514.0	7.0	.5508	102.9	178.3	40	19.5
1 6 11	548.0	9.0	.7634	64.9	82.0	25	52.5
1 6 12	485.0	5.5	.5274	65.8	118.5	40	26.1
1 6 13	567.0	6.0	.7384	130.5	102.3	40	39.5
1 6 18	665.0	8.0	.7399	60.1	58.0	20	22.0
1 6 20	361.0	9.0	.6149	81.4	61.1	20	39.7
1 6 22	565.0	9.5	.7624	77.0	56.3	25	18.0
1 6 40	488.0	8.5	.6777	116.4	81.8	30	44.6
1 6 47	461.0	5.0	.5611	76.0	87.7	20	34.1
1 6 48	515.0	10.0	.7615	105.2	130.9	30	42.0
1 6 52	436.0	7.0	.7576	42.6	29.4	25	85.1
1 6 54	446.0	6.0	.6188	71.8	68.1	30	39.0
1 6 65	595.0	4.5	.5004	49.4	78.3	25	29.0
1 6 70	607.0	10.0	.5604	95.0	140.6	35	25.0
1 6 79	338.0	10.0	.7713	88.5	95.6	20	37.5
1 6 80	411.0	9.0	.5524	58.5	61.0	30	53.3
1 6 83	254.0	5.0	.7150	63.8	79.0	40	22.5
1 6 87	388.0	7.5	.7491	63.2	76.8	25	23.8
1 6 89	546.0	5.5	.4658	75.7	158.6	50	18.3
1 6 96	362.0	4.0	.4405	50.0	91.0	25	17.5
2 6 5	442.0	7.0	.7772	21.2	71.7	20	13.9
2 6 11	361.0	7.0	.7400	71.4	111.4	3	24.3
2 6 12	423.0	7.0	.5257	52.0	18.2	10	15.0
2 6 13	315.0	7.0	.7182	46.8	39.7	20	25.1
2 6 18	355.0	7.0	.7134	57.2	103.5	35	30.2
2 6 20	249.0	5.0	.4597	55.1	95.1	20	20.9
2 6 22	312.0	8.5	.7052	96.6	73.8	20	26.4
2 6 40	494.0	6.0	.7517	73.0	104.5	30	36.2
2 6 47	481.0	9.5	.5504	56.5	61.3	30	41.3
2 6 48	556.0	8.5	.7709	84.9	89.7	30	33.6
2 6 52	434.0	8.5	.7417	85.6	118.2	20	21.4
2 6 54	351.0	6.0	.4956	67.1	71.1	25	31.3
2 6 65	361.0	7.0	.3772	85.6	78.2	30	29.6
2 6 70	356.0	7.0	.4934	73.0	95.2	40	24.4
2 6 78	525.0	7.0	.7638	74.6	147.7	20	34.7
2 6 80	343.0	4.0	.4932	48.7	63.8	30	34.9
2 6 83	395.0	6.0	.7256	89.5	60.3	25	19.7
2 6 87	390.0	9.0	1.0138	48.2	48.8	30	38.7
2 6 89	299.0	6.0	.4576	77.0	93.3	35	18.0
2 6 96	423.0	5.5	.5315	42.1	58.9	30	33.9
1 7 5	563.0	3.5	.7941	23.1	43.0	50	16.2
1 7 7	691.0	6.0	.5890	71.8	70.4	30	60.4
1 7 15	548.0	7.0	.6122	105.7	132.4	20	26.6
1 7 18	554.0	6.0	.5851	151.2	93.6	25	60.2
1 7 41	537.0	4.5	.2431	83.0	212.2	30	15.4
1 7 44	572.0	3.5	.5365	51.3	88.2	30	13.4
1 7 48	545.0	4.5	.5255	68.8	138.1	60	30.0
1 7 52	492.0	2.5	.4525	39.7	171.1	40	18.5
1 7 55	555.0	5.5	.5822	78.8	149.3	30	20.4
1 7 59	462.0	6.5	.7542	93.5	130.4	20	27.5
1 7 63	573.0	4.0	.4470	53.9	112.0	35	24.3
1 7 69	520.0	4.5	.4868	78.5	217.1	30	28.2
1 7 71	530.0	5.0	.6724	123.2	159.0	20	24.4

Table 28. (continued)

PLOT	.75 M	CAP	PCT H2O	DRY LIVE	DRY DEAD	EST DEAD	MULCH
1 7 76	437.0	6.0	.6110	73.0	39.8	15	43.2
1 7 79	520.0	7.0	.6728	46.0	33.5	10	36.8
1 7 80	561.0	6.0	.5764	90.3	87.2	15	21.1
1 7 81	485.0	5.5	.5754	67.0	74.4	10	26.4
1 7 86	295.0	4.0	.5462	82.4	83.7	40	12.9
1 7 91	433.0	7.0	.5131	85.3	122.1	20	46.3
2 7 5	492.0	7.5	.5496	184.2	120.3	10	25.0
2 7 7	538.0	7.0	.6456	95.7	82.2	15	21.3
2 7 9	390.0	5.0	.5192	70.9	102.2	15	18.1
2 7 15	354.0	5.0	.5929	61.9	35.6	50	20.8
2 7 18	418.0	5.0	.5404	73.7	67.4	15	24.3
2 7 41	451.0	8.0	.5943	165.2	89.2	15	24.5
2 7 44	562.0	7.5	.7077	93.3	139.4	15	26.3
2 7 48	575.0	4.0	.5030	51.8	82.9	25	25.7
2 7 52	453.0	6.0	.4953	108.9	105.6	20	19.8
2 7 55	475.0	6.0	.3695	89.4	75.8	20	30.0
2 7 59	356.0	5.0	.5095	77.3	109.1	15	29.0
2 7 63	438.0	5.0	.3786	54.6	102.5	25	25.7
2 7 69	491.0	11.5	.5308	77.3	91.6	10	21.1
2 7 71	502.0	5.0	.5869	62.3	105.5	15	24.3
2 7 76	420.0	5.0	.4753	85.8	122.0	20	24.2
2 7 79	532.0	8.5	.5473	75.3	133.0	20	26.7
2 7 80	519.0	4.5	.5256	48.0	57.8	25	24.9
2 7 81	455.0	7.0	.6635	77.6	64.4	45	25.0
2 7 86	440.0	5.5	.5428	65.8	60.3	20	29.3
2 7 91	531.0	7.0	.6267	44.8	95.2	20	29.9
1 8 9	374.0	2.5	.4019	51.9	104.8	75	58.9
1 8 6	567.0	2.5	.5657	76.3	52.7	60	58.4
1 8 11	380.0	1.5	.4009	55.3	75.3	70	60.2
1 8 13	376.0	2.5	.4214	84.6	96.5	60	50.9
1 8 14	448.0	3.0	.5102	68.4	138.8	65	21.7
1 8 43	232.0	7.0	.4683	136.6	133.5	65	93.4
1 8 46	545.0	3.0	.5234	75.8	103.4	65	34.2
1 8 51	340.0	4.0	.4596	103.8	104.8	70	45.8
1 8 53	554.0	1.5	.4852	60.5	117.1	70	27.3
1 8 57	321.0	7.0	.4575	126.8	126.0	50	42.3
1 8 59	453.0	3.5	.5710	110.7	146.7	55	22.4
1 8 62	377.0	4.0	.5474	62.7	117.0	75	72.6
1 8 69	475.0	1.5	.4414	48.5	129.7	70	77.5
1 8 71	413.0	5.0	.4578	78.3	82.2	65	57.3
1 8 74	491.0	3.5	.4888	77.4	91.3	60	54.0
1 8 78	525.0	1.5	.3939	42.2	97.2	70	22.9
1 8 80	317.0	4.0	.4633	74.1	76.7	60	36.2
1 8 82	541.0	1.5	.4965	37.2	93.7	75	13.8
1 8 86	380.0	2.0	.3348	32.3	118.7	75	28.5
1 8 93	397.0	4.0	.4805	147.7	171.3	45	18.8
2 8 6	300.0	6.0	.4997	102.8	83.8	50	44.8
2 8 9	305.0	2.0	.4601	69.2	70.1	60	24.9
2 8 11	448.0	3.0	.4988	82.4	87.1	65	29.2
2 8 13	352.0	2.5	.4080	69.5	137.1	55	49.5
2 8 14	309.0	3.0	.5378	39.5	22.9	40	23.9
2 8 43	312.0	2.0	.4502	88.6	39.6	60	25.2
2 8 46	322.0	9.0	.4954	97.2	87.5	65	39.9
2 8 51	462.0	2.0	.4217	38.8	97.1	65	18.6
2 8 53	355.0	3.0	.4618	38.0	46.5	70	41.7
2 8 57	436.0	2.5	.4766	74.2	73.4	70	27.8
2 8 59	451.0	2.0	.3170	110.7	39.1	75	29.9
2 8 62	385.0	3.5	.4893	46.4	63.4	60	22.5
2 8 69	436.0	4.0	.4329	76.0	86.2	60	46.4
2 8 71	506.0	4.5	.4196	65.5	150.4	55	42.6
2 8 74	383.0	3.0	.4225	44.9	70.6	65	53.5
2 8 79	303.0	3.0	.4288	138.8	77.1	65	23.2
2 8 80	363.0	2.0	.5104	69.8	76.6	65	19.6
2 8 82	319.0	4.0	.4793	109.1	86.7	60	33.7
2 8 86	370.0	2.5	.5216	86.1	95.7	65	30.5
2 8 93	424.0	4.0	.4759	84.9	76.0	60	43.8

Part A. Production and Compartmental Transfers

APPENDIX C

Table 29. Andropogon Community Below-Ground Biomass by Plot in Grams Per Meter Square

PLOT	DEPTH	DRY WT.	ASH WT.	ORG. WT.	PCT. ASH	PCT. ORG.
2 2 10	0 8	7.00	.50	6.50	.07	.93
2 2 13	0 8	8.70	.90	7.80	.10	.90
2 2 7	0 8	16.50	3.60	12.90	.22	.78
2 2 2	0 8	5.00	.50	4.50	.10	.90
2 2 73	0 8	12.60	1.40	11.20	.11	.89
1 2 2	0 8	5.30	.60	4.70	.11	.89
1 2 85	0 8	5.20	.80	4.40	.15	.85
1 2 76	0 8	8.70	.60	8.10	.07	.93
1 2 73	0 8	7.80	1.30	6.50	.17	.83
1 2 80	0 8	22.90	1.60	21.30	.07	.93
1 2 16	0 8	19.60	2.30	17.30	.12	.88
1 2 13	0 8	13.40	1.50	11.90	.11	.89
1 3 86	0 8	23.90	2.30	21.60	.10	.90
1 3 19	0 8	12.20	1.60	10.60	.13	.87
1 3 17	0 8	7.10	.90	6.20	.13	.87
1 3 81	0 8	10.70	1.80	8.90	.17	.83
1 3 21	0 8	12.50	1.40	11.10	.11	.89
1 3 20	0 8	25.10	2.90	22.20	.12	.88
1 3 90	0 8	7.50	.80	6.70	.11	.89
1 3 68	0 8	22.30	2.00	20.30	.09	.91
1 3 90	8 16	1.08	.54	.54	.50	.50
1 3 1	8 16	.54	.24	.30	.44	.56
1 3 17	8 16	1.33	.21	1.12	.16	.84
1 3 20	8 16	.76	.28	.48	.37	.63
1 3 21	8 16	.62	.09	.53	.15	.85
1 3 19	8 16	.69	.22	.47	.32	.68
1 3 81	8 16	.73	.32	.41	.44	.56
1 3 68	8 16	8.39	.49	7.90	.06	.94
1 3 91	16 24	.37	.18	.19	.49	.51
1 3 20	16 24	.33	.13	.20	.39	.61
1 3 19	16 24	.35	.10	.25	.29	.71
1 3 90	16 24	.31	.12	.19	.39	.61
1 3 68	16 24	.88	.17	.71	.19	.81
1 3 21	16 24	.41	.26	.15	.63	.37
1 3 17	16 24	.56	.23	.33	.41	.59
1 3 86	16 24	.47	.16	.31	.34	.66
2 3 86	0 8	9.30	1.20	8.10	.13	.87
2 3 17	0 8	7.70	1.80	5.90	.23	.77
2 3 19	0 8	9.50	1.00	8.50	.11	.89
2 3 21	0 8	22.30	3.90	18.40	.17	.83
2 3 68	0 8	9.60	1.20	8.40	.13	.88
2 3 1	0 8	13.80	2.30	11.50	.17	.83
2 3 81	0 8	14.60	2.00	12.60	.14	.86
2 3 91	0 8	11.60	.80	10.80	.07	.93
2 3 17	8 16	.44	.24	.20	.55	.45
2 3 20	8 16	.61	.25	.36	.41	.59
2 3 21	8 16	.75	.29	.46	.39	.61
2 3 81	8 16	.94	.41	.53	.44	.56
2 3 90	8 16	.47	.14	.33	.30	.70
2 3 86	8 16	.35	.12	.23	.34	.66
2 3 19	8 16	.62	.14	.48	.23	.77
2 3 68	8 16	.75	.26	.49	.35	.65
2 3 81	16 24	.32	.11	.21	.34	.66
2 3 86	16 24	2.08	.84	1.24	.40	.60
2 3 1	16 24	.18	.09	.09	.50	.50
2 3 17	16 24	.18	.07	.11	.39	.61
2 3 91	16 24	.14	.06	.08	.43	.57
2 3 20	16 24	.17	.06	.11	.35	.65

PLOT	DEPTH	DRY WT.	ASH WT.	ORG. WT.	PCT. ASH	PCT. ORG.
2 3 90	16 24	.09	.02	.07	.22	.78
2 3 68	16 24	.20	.08	.12	.40	.60
1 4 18	0 8	16.20	3.50	12.70	.22	.78
1 4 13	0 8	28.20	11.20	17.00	.40	.60
1 4 9	0 8	22.30	6.40	15.90	.29	.71
1 4 12	0 8	21.10	6.80	14.30	.32	.68
1 4 25	0 8	31.50	5.90	25.60	.19	.81
1 4 23	0 8	19.80	7.30	12.50	.37	.63
1 4 11	0 8	19.40	6.50	12.90	.34	.66
1 4 4	0 8	11.70	3.50	8.20	.30	.70
1 4 25	8 16	.61	.14	.47	.23	.77
1 4 2	8 16	.28	.03	.25	.11	.89
1 4 9	8 16	.30	.03	.27	.10	.90
1 4 17	8 16	.75	.18	.57	.24	.76
1 4 13	8 16	1.70	.44	1.26	.26	.74
1 4 4	8 16	.39	.06	.33	.15	.85
1 4 18	8 16	.76	.18	.58	.24	.76
1 4 12	8 16	1.40	.50	.90	.36	.64
1 4 12	16 24	.28	.05	.23	.18	.82
1 4 25	16 24	2.15	.13	2.02	.06	.94
1 4 18	16 24	.14	.04	.10	.29	.71
1 4 2	16 24	.14	.02	.12	.14	.86
1 4 11	16 24	.19	.05	.14	.26	.74
1 4 23	16 24	.17	.05	.12	.29	.71
1 4 4	16 24	.20	.07	.13	.35	.65
1 4 17	16 24	.24	.05	.19	.21	.79
2 4 17	0 8	24.40	5.00	19.40	.20	.80
2 4 11	0 8	28.00	9.90	18.10	.35	.65
2 4 9	0 8	23.40	7.50	15.90	.32	.68
2 4 18	0 8	13.90	4.30	9.60	.31	.69
2 4 12	0 8	9.60	1.70	7.90	.18	.82
2 4 2	0 8	20.80	7.60	13.20	.37	.63
2 4 25	0 8	10.80	3.20	7.60	.30	.70
2 4 4	0 8	19.90	8.00	11.90	.40	.60
2 4 12	8 16	.52	.17	.35	.33	.67
2 4 17	8 16	.53	.07	.46	.13	.87
2 4 2	8 16	.63	.20	.43	.32	.68
2 4 11	8 16	.43	.09	.34	.21	.79
2 4 4	8 16	.62	.19	.43	.31	.69
2 4 25	8 16	.75	.09	.66	.12	.88
2 4 18	8 16	.69	.15	.54	.22	.78
2 4 9	8 16	.45	.07	.38	.16	.84
2 4 23	16 24	.13	.03	.10	.23	.77
2 4 17	16 24	.19	.06	.13	.32	.68
2 4 4	16 24	.39	.13	.26	.33	.67
2 4 12	16 24	.40	.10	.30	.25	.75
2 4 11	16 24	.14	.03	.11	.21	.79
2 4 18	16 24	.66	.05	.61	.08	.92
2 4 9	16 24	.30	.04	.26	.13	.87
2 4 13	16 24	.10	.01	.09	.10	.90
2 5 -0	-0 8	19.60	3.50	16.10	.18	.82
1 5 4	-0 8	23.30	3.20	20.10	.14	.86
1 6 84	-0 8	13.60	2.90	10.70	.21	.79
1 6 6	-0 8	19.30	4.60	14.70	.24	.76
1 6 10	-0 8	15.40	4.40	11.00	.29	.71
1 6 17	-0 8	10.70	3.00	7.70	.28	.72
1 6 15	-0 8	17.40	3.30	14.10	.19	.81
1 6 95	-0 8	19.80	5.10	14.70	.26	.74

Table 29. (continued)

PLOT	DEPTH	DRY WT.	ASH WT.	ORG. WT.	PCT. ASH	PCT. ORG.	PLOT	DEPTH	DRY WT.	ASH WT.	ORG. WT.	PCT. ASH	PCT. ORG.
2 1 10	0 6	9.30	1.20	8.10	.13	.87	1 1 6	12 18	.12	.03	.09	.25	.75
2 1 5	0 6	8.00	.50	7.50	.06	.94	1 1 10	12 18	.07	.02	.05	.29	.71
2 1 6	0 6	7.40	.40	7.00	.05	.95	1 1 7	12 18	.14	.03	.11	.21	.79
2 1 2	0 6	11.50	.80	10.70	.07	.93	1 1 1	12 18	.14	.09	.05	.64	.36
2 1 1	0 6	12.00	.80	11.20	.07	.93	1 1 2	12 18	.16	.04	.12	.25	.75
2 1 3	0 6	17.80	1.20	16.60	.07	.93	1 1 8	12 18	.08	.01	.07	.13	.87
2 1 4	0 6	7.90	.80	7.10	.10	.90	1 1 1	18 24	.08	.03	.05	.38	.62
2 1 8	0 6	9.60	.90	8.70	.09	.91	1 1 2	18 24	.06	.02	.04	.33	.67
2 1 7	6 12	2.80	.20	2.60	.07	.93	1 1 3	18 24	.08	.03	.05	.38	.62
2 1 4	6 12	2.00	.20	1.80	.10	.90	1 1 4	18 24	.06	.03	.03	.50	.50
2 1 5	6 12	1.80	.20	1.60	.11	.89	1 1 5	18 24	.10	.04	.06	.40	.60
2 1 10	6 12	1.80	.20	1.60	.11	.89	1 1 6	18 24	.07	.02	.05	.29	.71
2 1 8	6 12	3.80	.20	3.60	.05	.95	1 1 7	18 24	.11	.03	.08	.27	.73
2 1 3	6 12	1.00	.10	.90	.10	.90	1 1 8	18 24	.09	.03	.06	.33	.67
2 1 9	6 12	1.60	.10	1.50	.06	.94	1 1 7	24 30	.13	.01	.12	.08	.92
2 1 2	6 12	2.70	.20	2.50	.07	.93	1 1 1	24 30	.02	.00	.02	.15	.85
2 1 3	12 18	.14	.02	.12	.14	.86	1 1 5	24 30	.05	.01	.04	.20	.80
2 1 2	12 18	.18	.06	.12	.33	.67	1 1 6	24 30	.05	.01	.04	.20	.80
2 1 4	12 18	.19	.07	.12	.37	.63	1 1 2	24 30	.00	.00	.00	.25	.75
2 1 7	12 18	.07	.02	.05	.29	.71	1 1 3	24 30	.03	.00	.03	.06	.94
2 1 5	12 18	.12	.02	.10	.17	.83	1 1 8	24 30	.03	.01	.02	.33	.67
2 1 6	12 18	.14	.02	.12	.14	.86	1 1 9	24 30	.07	.02	.05	.29	.71
2 1 10	12 18	.18	.05	.13	.28	.72	2 2 76	8 16	1.02	.52	.50	.51	.49
2 1 9	12 18	.11	.02	.09	.18	.82	2 2 10	8 16	1.90	.43	1.47	.23	.77
2 1 1	18 24	.09	.03	.06	.33	.67	2 2 85	8 16	.42	.12	.30	.29	.71
2 1 2	18 24	.10	.02	.08	.20	.80	2 2 73	8 16	.51	.17	.34	.33	.67
2 1 3	18 24	.04	.02	.02	.50	.50	2 2 8	8 16	.36	.10	.26	.28	.72
2 1 4	18 24	.13	.06	.07	.46	.54	2 2 13	8 16	.56	.25	.31	.45	.55
2 1 5	18 24	.04	.01	.03	.22	.77	2 2 7	8 16	.93	.46	.47	.49	.51
2 1 6	18 24	.03	.01	.02	.20	.80	2 2 16	8 16	3.00	.39	2.61	.13	.87
2 1 7	18 24	.06	.02	.04	.33	.67	2 2 7	16 24	.17	.07	.10	.41	.59
2 1 8	18 24	.17	.07	.10	.41	.59	2 2 85	16 24	.13	.04	.09	.31	.69
2 1 5	24 30	.01	.01	.01	.50	.50	2 2 76	16 24	.29	.12	.17	.41	.59
2 1 2	24 30	.03	.01	.02	.33	.67	2 2 73	16 24	.85	.23	.62	.27	.73
2 1 4	24 30	.03	.01	.02	.33	.67	2 2 69	16 24	.15	.06	.09	.40	.60
2 1 1	24 30	.06	.05	.01	.83	.17	2 2 16	16 24	.91	.62	.29	.68	.32
2 1 9	24 30	.01	.00	.01	.10	.90	2 2 10	16 24	.17	.06	.11	.35	.65
2 1 6	24 30	.03	.00	.03	.07	.93	2 2 13	16 24	.12	.04	.08	.33	.67
2 1 8	24 30	.08	.01	.07	.11	.89	1 2 73	8 16	.47	.19	.28	.40	.60
2 1 7	24 30	.01	.01	.00	.70	.30	1 2 16	8 16	3.25	.57	2.68	.18	.82
1 1 2	0 6	11.30	.60	10.70	.05	.95	1 2 10	8 16	.44	.14	.30	.32	.68
1 1 5	0 6	3.10	.20	2.90	.06	.94	1 2 85	8 16	2.47	.39	2.08	.16	.84
1 1 9	0 6	12.20	1.10	11.10	.09	.91	1 2 13	8 16	.91	.40	.51	.44	.56
1 1 6	0 6	8.10	.60	7.50	.07	.93	1 2 80	8 16	.67	.25	.42	.37	.63
1 1 8	0 6	8.70	.80	7.90	.09	.91	1 2 76	8 16	.87	.42	.45	.48	.52
1 1 7	0 6	5.60	.50	5.10	.09	.91	1 2 7	8 16	.30	.11	.19	.37	.63
1 1 10	0 6	26.50	4.90	21.60	.18	.82	1 2 64	16 24	.14	.11	.03	.79	.21
1 1 3	0 6	8.20	1.10	7.10	.13	.87	1 2 10	16 24	.12	.01	.11	.08	.92
1 1 10	6 12	1.70	.10	1.60	.06	.94	1 2 7	16 24	.11	.05	.06	.45	.55
1 1 3	6 12	4.70	.70	4.00	.15	.85	1 2 13	16 24	.67	.23	.44	.34	.66
1 1 9	6 12	2.40	.10	2.30	.04	.96	1 2 16	16 24	.19	.04	.15	.21	.79
1 1 5	6 12	1.20	.10	1.10	.08	.92	1 2 85	16 24	.18	.04	.14	.22	.78
1 1 6	6 12	2.20	.30	1.90	.14	.86	1 2 76	16 24	.54	.21	.33	.39	.61
1 1 1	6 12	2.00	.20	1.80	.10	.90	1 2 2	16 24	.24	.08	.16	.33	.67
1 1 12	6 12	1.40	.30	1.10	.21	.79	2 2 76	0 8	19.30	1.90	17.40	.10	.90
1 1 4	6 12	2.70	.40	2.30	.15	.85	2 2 16	0 8	18.20	1.50	16.70	.08	.92
1 1 9	12 18	.32	.11	.21	.34	.66	2 2 69	0 8	14.10	1.00	13.10	.07	.93
1 1 5	12 18	.17	.05	.12	.29	.71	2 2 85	0 8	5.30	.60	4.70	.11	.89

Table 29. (continued)

PLOT	DEPTH	DRY WT.	ASH WT.	ORG. WT.	PCT. ASH	PCT. ORG.
1 6 21	-0 8	20.00	4.70	15.30	.23	.76
1 6 75	-0 8	16.80	3.70	13.10	.22	.78
2 6 15	-0 8	21.60	6.00	15.60	.28	.72
2 6 75	-0 8	14.30	4.80	9.50	.34	.66
2 6 6	-0 8	18.40	4.80	13.60	.26	.74
2 6 91	-0 8	19.70	4.00	15.70	.20	.80
2 6 21	-0 8	27.40	4.60	22.80	.17	.83
2 6 95	-0 8	19.00	3.10	15.90	.16	.84
2 6 17	-0 8	21.90	4.80	17.10	.22	.78

Table 30. <u>Festuca</u> Community Below-Ground Biomass by Plot in Grams Per Meter Square

PLOT	DEPTH	DRY WT.	ASH WT.	ORG. WT.	PCT. ASH	PCT. ORG.	PLOT	DEPTH	DRY WT.	ASH WT.	ORG. WT.	PCT. ASH	PCT. ORG.
1 1 4	0 6	2.00	1.10	.90	.55	.45	1 2 74	0 6	6.80	.40	6.40	.06	.94
1 1 31	0 6	2.30	1.10	1.20	.48	.52	1 2 79	0 6	4.50	.40	4.10	.09	.91
1 1 68	0 6	4.00	1.90	2.10	.47	.52	1 2 13	0 6	11.00	4.20	6.80	.38	.62
1 1 29	0 6	1.50	.80	.70	.53	.47	1 2 74	6 12	2.80	.30	2.50	.11	.89
1 1 10	0 6	1.80	.70	1.10	.39	.61	1 2 64	6 12	3.60	.40	3.20	.11	.89
1 1 42	0 6	2.50	1.10	1.40	.44	.56	1 2 62	6 12	3.00	.60	2.40	.20	.80
1 1 88	0 6	2.00	.80	1.20	.40	.60	1 2 13	6 12	2.80	.20	2.60	.07	.93
1 1 43	0 6	2.70	.80	1.90	.30	.70	1 2 49	6 12	2.80	.20	2.60	.07	.93
1 1 77	0 6	3.00	1.40	1.60	.47	.53	1 2 3	6 12	3.40	.40	3.00	.12	.88
1 1 4	6 12	.80	.40	.40	.50	.50	1 2 23	6 12	3.00	.40	2.60	.13	.87
1 1 31	6 12	2.10	1.50	.60	.71	.29	1 2 70	6 12	2.50	.30	2.20	.12	.88
1 1 68	6 12	1.00	.60	.40	.60	.40	1 2 3	12 18	.36	.24	.12	.67	.33
1 1 29	6 12	1.00	.50	.50	.50	.50	1 2 13	12 18	.27	.11	.16	.41	.59
1 1 10	6 12	.60	.30	.30	.50	.50	1 2 17	12 18	.12	.03	.09	.25	.75
1 1 42	6 12	.80	.40	.40	.50	.50	1 2 23	12 18	.45	.13	.32	.29	.71
1 1 88	6 12	1.40	.60	.80	.43	.57	1 2 49	12 18	.19	.05	.14	.26	.74
1 1 43	6 12	.80	.20	.60	.25	.75	1 2 62	12 18	.12	.06	.06	.50	.50
1 1 77	6 12	.50	.20	.30	.40	.60	1 2 64	12 18	.19	.07	.12	.37	.63
1 1 4	12 18	.20	.10	.10	.50	.50	1 2 70	12 18	.24	.07	.17	.29	.71
1 1 31	12 18	.60	.20	.40	.33	.67	1 2 3	18 24	.17	.03	.14	.18	.82
1 1 68	12 18	.30	.10	.20	.33	.67	1 2 13	18 24	.14	.03	.11	.21	.79
1 1 29	12 18	.30	.20	.10	.67	.33	1 2 17	18 24	.16	.06	.10	.38	.62
1 1 10	12 18	.20	.10	.10	.50	.50	1 2 23	18 24	.24	.02	.22	.08	.92
1 1 42	12 18	.30	.20	.10	.67	.33	1 2 49	18 24	.33	.11	.22	.33	.67
1 1 88	12 18	.40	.20	.20	.50	.50	1 2 62	18 24	.07	.00	.07	.01	.99
1 1 43	12 18	.30	.10	.20	.33	.67	1 2 64	18 24	.06	.01	.05	.17	.83
1 1 77	12 18	.10	.10	0	1.00	0	1 2 70	18 24	.08	.02	.06	.25	.75
1 1 4	18 24	.10	.10	0	1.00	0	2 2 80	0 6	10.00	1.00	9.00	.10	.90
1 1 31	18 24	.30	.20	.10	.67	.33	2 2 74	0 6	11.80	1.20	10.60	.10	.90
1 1 68	18 26	.20	.10	.10	.50	.50	2 2 70	0 6	18.40	5.20	13.20	.28	.72
1 1 29	18 24	.20	.10	.10	.50	.50	2 2 49	0 6	9.30	1.60	7.70	.17	.83
1 1 10	18 24	.20	.20	0	1.00	0	2 2 17	0 6	21.80	9.20	12.60	.42	.58
1 1 42	18 24	.40	.20	.20	.50	.50	2 2 3	0 6	10.70	1.00	9.70	.09	.91
1 1 14	18 24	.10	.10	0	1.00	0	2 2 13	0 6	13.90	3.50	10.40	.25	.75
1 1 88	18 24	.20	.10	.10	.50	.50	2 2 23	0 6	12.80	1.40	11.40	.11	.89
1 1 43	18 24	.20	.10	.10	.50	.50	2 2 17	6 12	3.70	.40	3.30	.11	.89
1 1 77	18 24	.20	.10	.10	.50	.50	2 2 13	6 12	3.00	.30	2.70	.10	.90
2 1 47	0 6	2.50	1.00	1.50	.40	.60	2 2 3	6 12	6.30	.60	5.70	.10	.90
2 1 45	0 6	2.40	1.10	1.30	.46	.54	2 2 64	6 12	4.50	.40	4.10	.09	.91
2 1 26	0 6	1.70	.70	1.00	.41	.59	2 2 74	6 12	4.70	.70	4.00	.15	.85
2 1 8	0 6	1.60	.70	.90	.44	.56	2 2 79	6 12	2.50	.30	2.20	.12	.88
2 1 47	6 12	1.00	.50	.50	.50	.50	2 2 80	6 12	5.30	.70	4.60	.13	.87
2 1 45	6 12	1.40	.70	.70	.50	.50	2 2 49	6 12	5.80	.60	5.20	.10	.90
2 1 26	6 12	.50	.20	.30	.40	.60	2 2 62	12 18	.30	.16	.14	.53	.47
2 1 8	6 12	.90	.50	.40	.56	.44	2 2 64	12 18	.25	.13	.12	.52	.48
2 1 47	12 18	.30	.10	.20	.33	.67	2 2 70	12 18	.05	.03	.02	.60	.40
2 1 45	12 18	.20	.10	.10	.50	.50	2 2 74	12 18	.09	.04	.05	.44	.56
2 1 26	12 18	.30	.10	.20	.33	.67	2 2 49	12 18	.23	.10	.13	.43	.57
2 1 8	12 18	.30	.10	.20	.33	.67	2 2 17	12 18	.30	.05	.25	.17	.83
2 1 47	18 24	.10	.10	0	1.00	0	2 2 13	12 18	.21	.06	.15	.29	.71
2 1 45	18 24	0	0	0	0	0	2 2 3	12 18	.08	.03	.05	.38	.62
2 1 26	18 24	.10	0	.10	0	1.00	2 2 3	18 24	.12	.04	.08	.33	.67
2 1 8	18 24	.20	.10	.10	.50	.50	2 2 13	18 24	.20	.03	.17	.15	.85
1 2 17	0 6	9.30	2.10	7.20	.23	.77	2 2 17	18 24	.09	.03	.06	.33	.67
1 2 23	0 6	12.50	.10	12.40	.01	.99	2 2 40	18 24	.22	.04	.18	.18	.82
1 2 49	0 6	11.50	1.60	9.90	.14	.86	2 2 62	18 24	.13	.03	.10	.23	.77
1 2 62	0 6	15.20	5.70	9.50	.37	.63	2 2 64	18 24	.08	.02	.06	.25	.75
1 2 64	0 6	7.50	.90	6.60	.12	.88	2 2 70	18 24	.14	.03	.11	.21	.79

Table 30. (continued)

PLOT	DEPTH	DRY WT.	ASH WT.	ORG. WT.	PCT. ASH	PCT. ORG.	PLOT	DEPTH	DRY WT.	ASH WT.	ORG. WT.	PCT. ASH	PCT. ORG.
2 2 74	18 24	.13	.03	.10	.23	.77	1 4 18	8 16	1.40	.50	.90	.36	.64
1 3 47	0 8	11.10	1.10	10.00	.10	.90	1 4 44	8 16	1.50	.40	1.10	.27	.73
1 3 8	0 8	22.50	2.60	19.90	.12	.88	1 4 14	8 16	.80	.40	.40	.50	.50
1 3 34	0 8	12.70	1.20	11.50	.09	.91	1 4 38	8 16	.90	.30	.60	.33	.67
1 3 21	0 8	12.90	1.70	11.20	.13	.87	1 4 8	8 16	1.00	.20	.80	.20	.80
1 3 41	0 8	14.00	1.70	12.30	.12	.88	1 4 50	8 16	.60	.10	.50	.17	.83
1 3 24	0 8	19.90	2.20	17.70	.11	.89	1 4 42	8 16	.90	.10	.80	.11	.89
1 3 33	0 8	12.50	1.30	11.20	.10	.90	1 4 2	16 24	.63	.18	.45	.29	.71
1 3 19	0 8	12.90	1.50	11.40	.12	.88	1 4 74	16 24	.89	.35	.54	.39	.61
1 3 47	8 16	.67	.27	.40	.40	.60	1 4 44	16 24	.71	.31	.40	.44	.56
1 3 21	8 16	1.61	.79	.82	.49	.51	1 4 38	16 24	.90	.49	.41	.54	.46
1 3 41	8 16	.37	.16	.21	.43	.57	1 4 14	16 24	.48	.21	.27	.44	.56
1 3 33	8 16	2.67	1.36	1.31	.51	.49	1 4 50	16 24	.53	.17	.36	.32	.68
1 3 24	8 16	2.00	1.12	.88	.56	.44	1 4 87	16 24	.38	.12	.26	.32	.68
1 3 16	8 16	2.69	1.43	1.26	.53	.47	1 4 61	16 24	.23	.09	.14	.39	.61
1 3 7	8 16	1.70	.39	1.31	.23	.77	2 4 87	0 8	17.00	4.00	13.00	.24	.76
1 3 19	8 16	2.51	1.40	1.11	.56	.44	2 4 2	0 8	22.60	3.20	19.40	.14	.86
1 3 91	16 24	.37	.18	.19	.49	.51	2 4 61	0 8	10.80	2.00	8.80	.19	.81
1 3 20	16 24	.33	.13	.20	.39	.61	2 4 50	0 8	16.40	3.40	13.00	.21	.79
1 3 19	16 24	.35	.10	.25	.29	.71	2 4 74	0 8	17.40	2.80	14.60	.16	.84
1 3 90	16 24	.31	.12	.19	.39	.61	2 4 18	0 8	10.60	1.50	9.10	.14	.86
1 3 68	16 24	.88	.17	.71	.19	.81	2 4 38	0 8	10.80	2.20	8.60	.20	.80
1 3 21	16 24	.41	.26	.15	.63	.37	2 4 44	0 8	11.50	2.30	9.20	.20	.80
1 3 17	16 24	.56	.23	.33	.41	.59	2 4 2	8 16	1.00	.40	.60	.40	.60
1 3 86	16 24	.47	.16	.31	.34	.66	2 4 74	8 16	1.80	.70	1.10	.39	.61
2 3 19	0 8	11.70	1.10	10.60	.09	.91	2 4 44	8 16	1.70	.70	1.00	.41	.59
2 3 47	0 8	16.70	1.70	15.00	.10	.90	2 4 14	8 16	1.40	.60	.80	.43	.57
2 3 8	0 8	13.10	1.30	11.80	.10	.90	2 4 38	8 16	.30	.10	.20	.33	.67
2 3 19	0 8	11.70	1.10	10.60	.09	.91	2 4 50	8 16	.70	.20	.50	.29	.71
2 3 41	0 8	10.50	1.00	9.50	.10	.90	2 4 8	8 16	5.50	.10	5.40	.02	.98
2 3 24	0 8	13.60	1.20	12.40	.09	.91	2 4 18	8 16	.70	.30	.40	.43	.57
2 3 33	0 8	15.80	2.10	13.70	.13	.87	2 4 50	16 24	.59	.33	.26	.56	.44
2 3 7	0 8	13.60	1.40	12.20	.10	.90	2 4 38	16 24	.25	.08	.17	.32	.68
2 3 33	8 16	.59	.18	.41	.31	.69	2 4 74	16 24	.77	.37	.40	.48	.52
2 3 24	8 16	1.41	.78	.63	.55	.45	2 4 87	16 24	.50	.17	.33	.34	.66
2 3 7	8 16	1.86	.56	1.30	.30	.70	2 4 18	16 24	.37	.08	.29	.22	.78
2 3 41	8 16	.92	.30	.62	.33	.67	2 4 61	16 24	.18	.08	.10	.44	.56
2 3 16	8 16	.90	.37	.53	.41	.59	2 4 42	16 24	.64	.30	.34	.47	.53
2 3 34	8 16	1.34	.47	.87	.35	.65	2 4 14	16 24	.21	.05	.16	.24	.76
2 3 21	8 16	1.53	.67	.86	.44	.56	1 5 81	0 8	17.80	2.30	15.50	.13	.87
2 3 8	8 16	1.11	.55	.56	.50	.50	1 5 92	0 8	17.10	3.50	13.60	.20	.80
2 3 81	16 24	.32	.11	.21	.34	.66	1 5 52	0 8	12.70	1.90	10.80	.15	.85
2 3 86	16 24	2.08	.84	1.24	.40	.60	1 5 6	0 8	12.40	1.60	10.80	.13	.87
2 3 1	16 24	.18	.09	.09	.50	.50	1 5 85	0 8	19.90	3.60	16.30	.18	.82
2 3 17	16 24	.18	.07	.11	.39	.61	1 5 19	0 8	9.40	1.60	7.80	.17	.83
2 3 91	16 24	.14	.06	.08	.43	.57	1 5 11	0 8	10.50	1.20	9.30	.11	.89
2 3 20	16 24	.17	.06	.11	.35	.65	1 5 60	0 8	11.80	1.10	10.70	.09	.91
2 3 90	16 24	.09	.02	.07	.22	.78	1 5 71	0 8	9.80	1.20	8.60	.12	.88
2 3 68	16 24	.20	.08	.12	.40	.60	1 5 46	0 8	15.50	2.30	13.20	.15	.85
1 4 74	0 8	37.20	5.00	32.20	.13	.87	1 5 6	8 16	.78	.25	.53	.32	.68
1 4 44	0 8	20.90	2.40	18.50	.11	.89	1 5 46	8 16	1.18	.46	.72	.39	.61
1 4 87	0 8	8.80	1.00	7.80	.11	.89	1 5 60	8 16	.64	.20	.44	.31	.69
1 4 61	0 8	17.10	2.70	14.40	.16	.84	1 5 81	8 16	1.53	.57	.96	.37	.63
1 4 18	0 8	11.50	2.00	9.50	.17	.83	1 5 85	8 16	1.14	.45	.69	.39	.61
1 4 50	0 8	10.50	1.90	8.60	.18	.82	1 5 11	8 16	.78	.34	.44	.44	.56
1 4 44	0 8	16.00	1.70	14.30	.11	.89	1 5 71	8 16	1.60	.97	.63	.61	.39
1 4 38	0 8	9.50	1.20	8.30	.13	.87	1 5 52	8 16	.96	.56	.40	.58	.42
1 4 2	8 16	.80	.20	.60	.25	.75	1 5 11	16 24	.45	.17	.28	.38	.62

Table 30. (continued)

PLOT	DEPTH	DRY WT.	ASH WT.	ORG. WT.	PCT. ASH	PCT. ORG.	PLOT	DEPTH	DRY WT.	ASH WT.	ORG. WT.	PCT. ASH	PCT. ORG.
1 5 81	16 24	.25	.06	.19	.24	.76	2 6 80	0 8	24.90	3.70	21.20	.15	.85
1 5 46	16 24	4.30	.11	4.19	.03	.97	2 6 89	0 8	13.50	2.30	11.20	.17	.83
1 5 85	16 24	.39	.09	.30	.23	.77	2 3 96	0 8	17.00	2.50	14.50	.15	.85
1 5 6	16 24	.61	.24	.37	.39	.61	2 6 5	8 16	1.88	.51	1.37	.27	.73
1 5 19	16 24	.54	.13	.41	.24	.76	2 6 12	8 16	.67	.18	.49	.27	.73
1 5 71	16 24	.39	.14	.25	.36	.64	2 6 47	8 16	1.22	.62	.60	.51	.49
1 5 60	16 24	.32	.07	.25	.22	.78	2 6 54	8 16	1.61	.68	.93	.42	.58
2 5 6	0 8	18.00	2.30	15.70	.13	.87	2 6 65	8 16	.81	.40	.41	.49	.51
2 5 71	0 8	28.70	3.70	25.00	.13	.87	2 6 70	8 16	1.93	.75	1.18	.39	.61
2 5 85	0 8	15.60	4.60	11.00	.29	.71	2 6 89	8 16	.93	.33	.60	.35	.65
2 5 92	0 8	19.70	6.00	13.70	.30	.70	2 6 96	8 16	.85	.41	.44	.48	.52
2 5 81	0 8	20.10	2.90	17.20	.14	.86	2 6 5	16 24	.80	.30	.50	.38	.62
2 5 46	0 8	24.10	7.40	16.70	.31	.69	2 6 12	16 24	.33	.09	.24	.27	.73
2 5 60	8 16	.63	.29	.34	.46	.54	2 6 200	16 24	.60	.19	.41	.32	.68
2 5 92	8 16	.65	.32	.33	.49	.51	2 6 54	16 24	.74	.28	.46	.38	.62
2 5 19	8 16	.82	.27	.55	.33	.67	2 6 70	16 24	1.28	.28	1.00	.22	.78
2-0500 81	8 16	1.56	.59	.97	.38	.62	2 6 80	16 24	1.82	.33	1.49	.18	.82
2-0500 85	8 16	.79	.40	.39	.51	.49	2 6 89	16 24	1.23	.29	.94	.24	.76
2 5 6	8 16	1.49	.49	1.00	.33	.67	2 6 90	16 24	.84	.43	.41	.51	.49
2 5 46	8 16	1.85	.84	1.01	.45	.55	1 7 44	0 8	24.50	4.30	20.20	.18	.82
2 5 71	8 16	1.64	.54	1.10	.33	.67	1 7 9	0 8	13.90	1.60	12.30	.12	.88
2 5 19	16 24	.28	.09	.19	.32	.68	1 7 55	0 8	24.90	3.60	21.30	.14	.86
2 5 46	16 24	3.81	.41	3.40	.11	.89	1 7 76	0 8	17.00	3.00	14.00	.18	.82
2 5 71	16 24	1.13	.26	.87	.23	.77	1 7 910	0 8	21.20	4.00	17.20	.19	.81
2 5 11	16 24	.46	.20	.26	.43	.57	1 7 69	0 8	16.90	2.80	14.10	.17	.83
2 5 92	16 24	.48	.11	.37	.23	.77	1 7 15	0 8	17.70	2.60	15.10	.15	.85
2 5 81	16 24	.61	.15	.46	.25	.75	1 7 48	0 8	24.50	4.90	19.60	.20	.80
2 5 52	16 24	.39	.13	.26	.33	.67	1 7 48	8 16	.22	.04	.18	.18	.82
2 5 6	16 24	.36	.08	.28	.22	.78	1 7 55	8 16	.42	.08	.34	.19	.81
1 6 5	0 8	28.20	4.00	24.20	.14	.86	1 7 69	8 16	.63	.14	.49	.22	.78
1 6 12	0 8	9.00	.90	8.10	.10	.90	1 7 76	8 16	.37	.14	.23	.38	.62
1 6 20	0 8	16.20	2.10	14.10	.13	.87	1 7 9	8 16	.61	.17	.44	.28	.72
1 6 54	0 8	25.40	3.80	21.60	.15	.85	1 7 80	8 16	1.26	.33	.93	.26	.74
1 6 70	0 8	17.40	1.70	15.70	.10	.90	1 7 44	8 16	1.06	.34	.72	.32	.68
1 6 80	0 8	15.90	1.90	14.00	.12	.88	1 7 91	8 16	1.55	.16	1.39	.10	.90
1 6 89	0 8	42.20	5.60	36.60	.13	.87	1 7 69	16 24	.47	.08	.39	.17	.83
1 6 96	0 8	7.90	1.00	6.90	.13	.87	1 7 79	16 24	.50	.04	.46	.08	.92
1 6 12	8 16	5.12	2.17	2.95	.42	.58	1 7 48	16 24	.10	.02	.08	.20	.80
1 6 20	8 16	1.70	.79	.91	.46	.54	1 7 80	16 24	.35	.07	.28	.20	.80
1 6 54	8 16	.97	.47	.50	.48	.52	1 7 44	16 24	.24	.04	.20	.17	.83
1 6 65	8 16	2.33	.23	2.10	.10	.90	1 7 76	16 24	.07	.02	.05	.29	.71
1 6 70	8 16	.81	.78	.03	.96	.04	1 7 15	16 24	.18	.04	.14	.22	.78
1 6 80	8 16	1.00	.56	.44	.56	.44	1 7 9	16 24	.16	.03	.13	.19	.81
1 6 89	8 16	.52	.19	.33	.37	.63	2 7 80	0 8	16.70	2.70	14.00	.16	.84
1 6 96	8 16	.74	.28	.46	.38	.62	2 7 15	0 8	24.50	5.90	18.60	.24	.76
1 6 12	16 24	.41	.17	.24	.41	.59	2 7 48	0 8	15.40	2.80	12.60	.18	.82
1 6 47	16 24	3.66	.13	3.53	.04	.96	2 7 55	0 8	17.70	2.60	15.10	.15	.85
1 6 5	16 24	.63	.26	.37	.41	.59	2 7 69	0 8	11.90	2.60	9.30	.22	.78
1 6 54	16 24	.43	.11	.32	.26	.74	2 7 44	0 8	34.50	6.40	28.10	.19	.81
1 6 65	16 24	.28	.11	.17	.39	.61	2 7 76	0 8	15.10	3.20	11.90	.21	.79
1 6 80	16 24	.48	.13	.35	.27	.73	2 7 91	0 8	26.20	6.80	19.40	.26	.74
1 6 89	16 24	.36	.13	.23	.36	.64	2 7 48	8 16	.75	.15	.60	.20	.80
1 6 96	16 24	1.04	.50	.54	.48	.52	2 7 55	8 16	.34	.07	.27	.21	.79
2 6 5	0 8	18.70	2.50	16.20	.13	.87	2 7 29	8 16	.82	.19	.63	.23	.77
2 6 6	0 8	10.40	1.00	9.40	.10	.90	2 7 15	8 16	.60	.11	.49	.18	.62
2 6 47	0 8	7.20	.70	6.50	.10	.90	2 7 80	8 16	.55	.11	.44	.20	.80
2 6 54	0 8	16.40	2.00	14.40	.12	.88	2 7 9	8 16	.69	.13	.56	.19	.81
2 6 70	0 8	9.30	1.70	7.60	.18	.82	2 7 44	8 16	1.29	.22	1.07	.17	.83

Table 30. (continued)

PLOT	DEPTH	DRY WT.	ASH WT.	ORG. WT.	PCT. ASH	PCT. ORG.
2 7 69	8 16	.86	.20	.66	.23	.77
2 7 80	16 24	.28	.05	.23	.18	.82
2 7 44	16 24	.17	.03	.14	.18	.82
2 7 15	16 24	.20	.03	.17	.15	.85
2 7 69	16 24	.39	.04	.35	.10	.90
2 7 76	16 24	.27	.03	.24	.11	.89
2 7 79	16 24	.14	.02	.12	.14	.86
2 7 48	16 24	.10	.01	.09	.10	.90
2 7 9	16 24	.22	.04	.18	.18	.82
1 8 74	0 8	14.70	2.80	11.90	.19	.81
1 8 78	0 8	23.40	5.10	18.30	.22	.78
1 8 59	0 8	48.60	4.50	44.10	.09	.91
1 8 53	0 8	21.20	3.20	18.00	.15	.85
1 8 69	0 8	32.90	5.90	27.00	.18	.82
1 8 14	0 8	15.00	2.00	13.00	.13	.87
1 8 82	0 8	11.50	1.40	10.10	.12	.88
1 8 48	0 8	18.20	2.40	15.80	.13	.87
1 8 53	8 16	3.20	.41	2.79	.13	.87
1 8 74	8 16	.56	.15	.41	.27	.73
1 8 82	8 16	.36	.09	.27	.25	.75
1 8 93	8 16	1.00	.24	.76	.24	.76
1 8 69	8 16	.50	.10	.40	.20	.80
1 8 46	8 16	.79	.15	.64	.19	.81
1 8 6	8 16	.44	.12	.32	.27	.73
1 8 78	8 16	.77	.17	.60	.22	.78
1 8 74	16 24	.30	.05	.25	.17	.83
1 8 14	16 24	.44	.09	.35	.20	.80
1 8 69	16 24	.35	.06	.29	.17	.83
1 8 82	16 24	.18	.04	.14	.22	.78
1 8 59	16 24	.20	.03	.17	.15	.85
1 8 53	16 24	1.00	.22	.78	.22	.78
1 8 46	16 24	.32	.06	.26	.19	.81
1 8 78	16 24	.50	.08	.42	.16	.84
2 8 82	0 8	19.30	3.10	16.20	.16	.84
2 8 74	0 8	28.70	4.10	24.60	.14	.86
2 8 53	0 8	21.20	5.50	15.70	.26	.74
2 8 14	0 8	17.30	1.80	15.50	.10	.90
2 8 69	0 8	30.00	4.60	25.40	.15	.85
2 8 6	0 8	21.40	4.30	17.10	.20	.80
2 8 78	0 8	9.70	1.90	7.80	.20	.80
2 8 46	0 8	11.10	2.10	9.00	.19	.81
2 8 69	8 16	.49	.11	.38	.22	.78
2 8 59	8 16	.75	.09	.66	.12	.88
2 8 78	8 16	.39	.07	.32	.18	.82
2 8 46	8 16	.49	.09	.40	.18	.82
2 8 6	8 16	1.07	.19	.88	.18	.82
2 8 14	8 16	1.98	.57	1.41	.29	.71
2 8 53	8 16	.41	.09	.32	.22	.78
2 8 74	8 16	.72	.14	.58	.19	.81
2 8 82	16 24	.27	.05	.22	.19	.81
2 8 78	16 24	.23	.04	.19	.17	.83
2 8 53	16 24	.17	.03	.14	.18	.82
2 8 74	16 24	.24	.04	.20	.17	.83
2 8 59	16 24	.12	.02	.10	.17	.83
2 8 69	16 24	.29	.03	.26	.10	.90
2 8 93	16 24	.28	.04	.24	.14	.86
2 8 14	16 24	.57	.10	.47	.18	.82

B-I.

INTRODUCTION

In recent years, there has been a change in emphasis in ecological research from a purely descriptive approach to a functional one in which the observer may be interested in the production ability of the system rather than simply its floristic composition. The ecologist now is not only interested in what species are present, but in the amounts of material (biomass, nutrients, or energy) that are present in the different compartments of the plant community, i.e., what part of the total community do the live and dead material account for, or what percent do the leaves, stems, bark, roots, etc. comprise. This change in emphasis in ecological studies in part has led to the systems approach or modeling of an ecosystem.

The systems approach has placed a strain on the adequacy of current sampling techniques. In order to get statistically reliable estimates of the various compartments of a system, a large number of samples must be taken. Clipping has long been used by ecologists as a technique for estimating herbage weight, but this is a costly part of much ecological research (Van Dyne 1966a) as well as being destructive to the system involved. Several indirect methods have been used to estimate herbage yield and composition, e.g., visual estimation, height-weight relationships, leaf area index, stand count relations to yield. These indirect methods have not been fully adequate and have resulted in the accumulation of large amounts of data which, for the most part, make necessary simultaneous data analysis and sampling. This is time-consuming and might tend to lessen the number of samples that can be taken.

Data analysis concurrent with data collection has been facilitated with the application of computer techniques that allow for rapid analysis of the data being collected in the field and laboratory. One use of the computer in ecological studies is to reduce large amounts of data to manageable size. In addition, techniques that have long been neglected due to their complexity can now be applied. The result is that the researcher may still overwhelm himself with computer output to a point where it is almost impossible to relate all aspects of the data in as simple a manner as was normally expected before.

For better use of computer techniques, it has become necessary for an investigator to be oriented both biologically and mathematically, or to have participants from both orientations involved in the study. Such a study was initiated in the fall of 1966 at Oak Ridge National Laboratory. The purpose of the study was twofold: (1) to observe the production and transfer between parts of two old field communities; and (2) to apply various mathematical techniques to the sampling and analysis of the data in order to explore their feasibility for streamlining future investigations as well as the development of compartment models for the theoretical estimation of net and gross production.

The research reported here is concerned with the use of rapid-sampling techniques such as the use of capacitance meters to estimate total biomass (Van Dyne _et al_. 1968), dry weight rank methods to estimate botanical composition (Mannetje and Haydock 1963) and the optimizing of the time involved in the various aspects of data gathering (Van Dyne et al. 1968). A digital computer was used in the development of data processing schemes for field and laboratory data to ensure rapid and updated analysis of the data and to depict intraseasonal herbage dynamics through the use of compartmental modeling techniques.

The areas studied were two fields on the Oak Ridge National Laboratory reservation (Ecology 0800 Area) in Roane County, Tennessee. In appearance, the fields were typical of many found in eastern Tennessee but were different from each other. One of the fields had been seeded to Fescue elatior[1]. The other was a successional field dominated by Andropogon virginicus which had been sprayed to stop the growth of shrubs and to prolong this particular stage of succession.

The sampling scheme was on a monthly basis, except during times of peak production for the Festuca and Andropogon grasses when the sampling was done at two-week intervals. At each sampling 0.25 m^2 and 0.75 m^2 plots were clipped and bagged separately. Mulch was gathered and roots were collected from within the 0.25 m^2 plots. These data were supplemented with litter decay and rate of litter accumulation performed jointly with Kelly (1968).

The information thus obtained will be used to fill a gap in the literature resulting from too little investigation on intraseasonal change in old fields and to test the uses of various rapid sampling techniques as a valuable method for collecting large amounts of information.

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[1]Nomenclature follows Fernald (1950).

B-II.

LITERATURE REVIEW

Modeling in Ecology

For at least forty years, abstractions of biological systems have been modeled, e.g., Lotka (1924), Rosen (1958, 1959), Rashevsky (1960), and Ashby (1963). Recent advances in mathematical analysis procedures, i.e., computer applications, have offered more versatility in modeling in biology (Van Dyne 1966, Shirley and Baily 1966, Watt 1966). The purpose here will be to outline some of the approaches applied in solving ecological problems. The articles that follow are concerned only with recent applications.

Primary Production

For the complete assessment of the productivity of a plant community three main approaches may be taken: (i) determination of dry matter production through harvesting, (ii) calculation of the total photosynthesis and "net primary production" (dry matter intake - plant respiration), (iii) determination of the carbon dioxide flux (Monsi 1965). In recent years, considerable progress has been made concerning method (ii), which will be reviewed here.

One of the simplest models for net photosynthetic measurement is that of Kasanaga and Monsi (1954). The net photosynthetic activities of single leaves and the light intensities received by the leaves were combined into a model. The net photosynthetic rate, q, of the foliage was expressed as a function of the amount of photosynthetically active radiation received by the individual plants:

$$q = \frac{b\ I}{1 + aI} \qquad (1)$$

where a and b are constants and I is the light intensity in the foliage.

It is also possible to develop models considering the detailed evaluation of the interrelationship between solar energy, photosynthesis and other radiation effects in the plant community. A review of studies involving these variables by Monsi (1965) concludes that relationships between photosynthetic activity and plant growth or final yield involve the rate of translocation of assimilates and the rate of development of leaves, stems and roots, in parallel with ecological studies of community production and its environmental factors.

Duncan et al. (1967) have developed an extremely complex and detailed model for the simulation of photosynthesis in a plant community. The relationship between components of the plant community, leaf area, leaf angle, vertical position, light reflected from the leaves, light transmitted through the leaves, and the physiological relationship between illumination and photosynthesis (light response curve) were coupled with components of the plant environment in their model. Elevation of the sun above the horizon, solar intensity and sky brightness were also used to compute total photosynthesis of the community. It is beyond the scope of this paper to go into the actual calculations used by Duncan. The variables have been noted, and the complexity of their measurement and interrelations is obvious. Even though numerous calculations are required in such a model, a medium-size digital computer (IBM 7044) required only six seconds of internal computation time to perform the necessary calculations.

Successional Change and Population Buildup

Successional changes of vegetation over a long period of time can be viewed as a multicompartmental system where the transfer coefficients may be adjusted to express the probability of change in state on an annual basis (Olson 1965a). This approach to succession requires compiling a matrix of coefficients, $\underline{P}$, which represents the probable rates of change from one stage in succession to another. Allowing vector $\underline{V}$ to represent all the various successional stages, v_k, then the stage of $\underline{V}$ at any particular instant in time, t, is the product of $\underline{V}$'s previous stage times the probability matrix, $\underline{P}$:

$$\underline{V}^{(t)} = (v_k)^{(t)} = \underline{V}^{(t-1)}\underline{P} \qquad (2)$$

A mathematical approach can also be applied to successional change to indicate the buildup of a system to a steady state and finally the disruption of the system due to some external source (Bledsoe, unpublished data). Let Y be any given population, then:

$$Y = \frac{w}{1 + ke^{-g(t-t_o)}} \qquad (3)$$

where w, g, and k are constants. Equation (3) is the Logistic equation (Gause 1934) determining the growth of a population to a steady state at time increments of $t - t_o$. This may also be expressed as a differential equation:

$$Y^1 = k_1 + k_2Y + k_3Y^2 \qquad (4)$$

where k_1, k_2, and k_3 are constants.

The disruption of the steady state can be attributed to either mortality or, in a slightly less empirical sense, the increase transfer out of the compartment as time increases. In the use of mortality, if the growth curve is represented by the equation (4), the mortality function is:

$$X\ (t) = Y^1\ [1 - \int_{\infty}^{t} N\ (y,\ \sigma)\ dt] \qquad (5)$$

where N (y, σ) is the normal bell shaped curve with a standard deviation, σ, and a mean life expectancy, y, of the population. N (y, σ) is given by:

$$N\ (y,\ \sigma) = \frac{1}{\sigma \quad 2\pi}\ e^{-(x-y)^2/2\sigma^2} \qquad (6)$$

Management and Optimization

Goodall (1968) recently has developed a computer simulation program for relating plant and animal production to range management problems. This new technique in range management forecasts the effect on vegetation and animals of any proposed grazing intensity, of allowable differences in grazing intensity, of differential utilization of growth responses of different forage species, and of uneven distribution of moisture over the study area. This model can be used to forecast the optimum conditions for animal growth and for managing a plant community capable of maintaining that optimum.

Simulation of aquatic communities is a useful tool in management for optimizing a harvest routine for the plankton, consistent with maintenance of the community (Cole 1967). Optimizing food-chain relationships for greatest growth pattern (Patten 1966) and analyzing the significance of nutrient limitation in the sea (Dugdale 1967) are two other applications of community simulation techniques.

The cycling procedure is another application of computers in ecology, i.e., the development of mathematical models to trace isotopes through a systems (Sheppard 1962). Fairly simple compartment models have been used to describe the movement of radioactive elements through a system (Olson 1963, 1965; Ledley 1965). Both authors used linear transfer coefficients, although Olson suggested that income and transfer coefficients may change through the year. The result is a system of linear equations with discontinuous or nearly-continuous transfer rates. The general form of the equations used by Olson and Ledley expresses the net rate of change as the sum of the income terms minus the sum of the loss terms:

$$\frac{dq_i}{dt} = \Sigma\lambda_{ji}q_j - q_i\Sigma\lambda_{ij} \qquad (7)$$

where $\frac{dq_i}{dt}$ is the instantaneous rate of change in compartment qi with respect to time. The λ_{ij} here follow the conventional meaning of transfer coefficients from the i-th to the j-th compartments. The application of computer techniques may also help simplify the handling of complex transfer coefficients, as illustrated by Patten and Witkamp (1967). Their five compartment model was a first order linear approximation with a total of 25 possible transfer functions, λ_{ij}, most of which were considered to be zero in the final form. The general equation that describes the interaction between compartments is:

$$X_j = \Sigma\lambda_{ij} \frac{Xi}{mi} - \Sigma\lambda_{ji} \frac{Xi}{mj} \quad (8)$$

In equation (8) the transfer from any compartment, i, to any other compartment j is assumed to be directly proportional to the amount in the i-compartment, $\frac{Xi}{mi}$, where Xi is the total amount of radionuclide in the i-compartment and mi is the mass of the compartment.

One objective in modeling problems is to estimate fractional turnover rates. The evaluation of these coefficients in larger problems is generally handled by a high-speed digital computer which performs iterative trials automatically (Bledsoe and Van Dyne 1968). Analog computers can be utilized advantageously for smaller problems, as described by Neel and Olson (1962) and Olson (1963).

Dry and Organic Matter Cycling

Only a few of the large number of papers that have appeared on dry and/or organic matter production contain sufficient ratios of transfer and source amounts to allow direct estimation of transfer coefficients in compartment models. A list of several papers in this category is included in a report by Olson and Williams (1968). Two papers in which a model has been fitted to production data are cited here.

The compartment models of Gore and Olson (1967) examined the accumulation of peat in a British bog over a long period of time (5600 years), the production of vegetation, the cycling of nutrients and their interaction. In Williams and Murdock (1968) the production and decomposition of <u>Juncus</u> was modeled incorporating the effects of temperature, solar energy and their interactions on the compartments. The approach in this model allowed the energy influx to the live compartment, X_1, to vary as a function of air temperature and solar energy. A combination of sine and cosine equations was jointly used to express this relationship:

$$\frac{dx_1}{dT} = a\ [1 + \text{sine}\ (2\pi b) - c\ [1 - d \cos\ (2\pi b)] \qquad (9)$$

where a, b, c, and d are constants. The authors also suggested seasonally varying transfer coefficients between the live and dead, X_2, compartments. This was expressed as a cosine relation (Olson 1963, Fig. 6),

$$\frac{dx_2}{dt} = C\ [1 - d \cdot \cos\ (2\pi b)]\ X_1 - FX_2 \qquad (10)$$

Both papers were involved with simple models, seven and three compartments respectively, but the accuracy of the predicted values to that of the actual data was considered "compatible" by Gore and Olson and "in good agreement" by Williams and Murdock.

B-III.

METHODS

I. BIOMASS METHODS

The methods used in the field and laboratory to collect these data are described in detail by Kelly (1968). Described below are the mathematical and computer techniques used to evaluate the data.

Standard Forms - Field

Use of a standard form for recording field and laboratory data simplified analysis. Use of this form is described below, but first, clarification of physical sampling detail is necessary.

At each sampling date and in each replicate of each community, 20 plots were located by restricted randomization as described by Kelly (1968). Circular 1 m^2 plots were located and a square 0.25 m^2 plot was set within each 1 m^2 plot. Clipped materials from the 0.25 m^2 and 0.75 m^2 portions of the plots were handled separately.

The following data were recorded in the field on the data forms, an example of which is shown in Figure 1: (i) the plot number was a three-part coded number which designates replication, area, and plot; (ii) the area was either a *Festuca* or *Andropogon* community; (iii) the names of the species present in the 0.25 m^2 plot were recorded by code and a rank number assigned to each species depending upon the visually-estimated relative amount of dry material, both live and dead; (iv) capacitance meter readings (Van Dyne *et al.* 1968) were recorded before the

ORNL-DWG 68-13443

INTERSEASONAL DYNAMICS STUDY

PLOT NO.	AREA	DATE
3-2-5	F	3/4/67

SPECIES PRESENT	RANK	DRY WT. OF SPECIES
FEZL	1	97.6
SΦL	2	32.8
PLLA	3	2.1

SOIL MOISTURE WET	SOIL MOISTURE DRY	% MOISTURE

.75 METER	DRY WEIGHT .25 METER	TOTAL WEIGHT
600.	132.5	732.5

DRY WEIGHT OF ROOTS BY SOIL HORIZON

CORE 1 HORIZON	CORE 1 WEIGHT	CORE 2 HORIZON	CORE 2 WEIGHT

NOTES

HERBAGE METER DATA

FRESH WEIGHT .25 METER	READING BEFORE CLIP	READING AFTER CLIP	% H_2O
250.	3.5	1.0	60
DRY WEIGHT LIVE	**DRY WEIGHT DEAD**	**% STANDING DEAD**	**MULCH**
29 6	102.9	70	37.0

NOTES

Figure 1. Sample data form used for the recording of information gathered in both the field and laboratory.

plot was clipped; and (v) the amount of standing dead vegetation for each plot was estimated to the nearest percent of the herbage biomass on a dry weight basis.

Standard Forms - Laboratory

The form in Figure 1 was also used in the laboratory and the following information was recorded: (i) the net dry weight of each species after separation to the nearest 0.1 gram; (ii) the dry weight of the total herbage, 0.25 m^2 and 0.75 m^2 plots, both live and dead, separately; (iii) "Total Weight" was the summation of the subplot yields; (iv) "Fresh Weight 0.25 Meter" was the weight of the 0.25 m^2 plot before drying and includes both the live and dead material; (v) the percent water, "%H_2O", in the 0.25 m^2 plot on a fresh-weight basis; (vi) dry weight of the live vegetation, standing dead vegetation, and litter were recorded separately.

Personnel Allocation

The capacitance readings, clipping and gathering of mulch were done by both Opstrup and Kelly. Any bias that may occur can be considered constant since this requires no great amount of expertise in technique, and performance does not improve with time. The ranking of the species in the plots and the estimation of the standing dead were done by Kelly each time so that any bias which might occur would remain constant through the sampling.

Root Data

For a typical sampling date in a given community, data were obtained at each of ten points in each of two replicates. They were the same points at which clipped herbage samples were collected. During the first sampling period, root and soil samples were obtained from 3-inch cores by taking 6-inch increments to a depth of 24 inches. Subsequently, an 8-inch diameter core probe was used to sample to an 8-inch depth; then two 3-inch probes were used within this hole for two additional 8-inch depth segments (Kelly 1968).

Programs were written to process the raw data and are listed in Appendix A along with all the other programs described herein. ROOT 6[2] put data in tabular form and computed simple statistical values for these root cores taken at 6-inch intervals. ROOT 8 was the same as ROOT 6 but for root cores taken at 8-inch intervals. The input to these programs consisted of the plot number, depth of core (e.g., 6 to 12", 8 to 16"), dry weight and ash weight.

These programs converted the data to a square meter basis and determined on a plot basis the amount of organic matter and the percent ash. Percent dry weight, ash weight, and organic matter were also calculated on a depth basis. The mean, standard deviation, standard error, coefficient of variation, maximum and minimum values and the range of the data for ash weight, dry weight, organic matter weight,

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[2]Computer program and subroutine names herein are given with up to six uppercase letters. All programs were written in FORTRAN-63 and run on a CDC 1604 computer.

and percent ash were computed as well as the simple linear correlation of these variables.

Shoot Data

A series of programs (Appendix A) were written to process the shoot data according to the scheme shown in Figure 2.

Given an initial species name, program LISTER searched the data and listed all the different species present. The primary purpose of LISTER was to check the data for erroneous species names, as well as to compile a list of species present.

Program FREQ determined the frequency of the various species in the sampling period for all plots in both replicates as well as the percent of the total weight each species contributed. The input consisted of species names, previously corrected by LISTER, and the plot numbers in which they occurred. The output consisted of a list of the species present and the associated frequency and weight vectors, i.e., the percent of the plots in which each species was found and the percent of the total weight for which each species accounted.

Program RANK determined a rank matrix $\underline{R}$ and a weight vector $\underline{W}$, where r_{ij} was the proportion of the plots in which the i-th species (i=1,2,..., m species) was given the j-th rank (j=1,2,..., n ranks) and w_i was the percent of the total weight the i-th species accounted for. The rank matrix was determined from a total of 140 plots for each date for each community. Of the total of 140 plots, 40 of the plots were clipped and ranked and 100 plots were only ranked. The input to RANK consisted of the species names, ranks and weights.

ORNL-DWG 68-5986

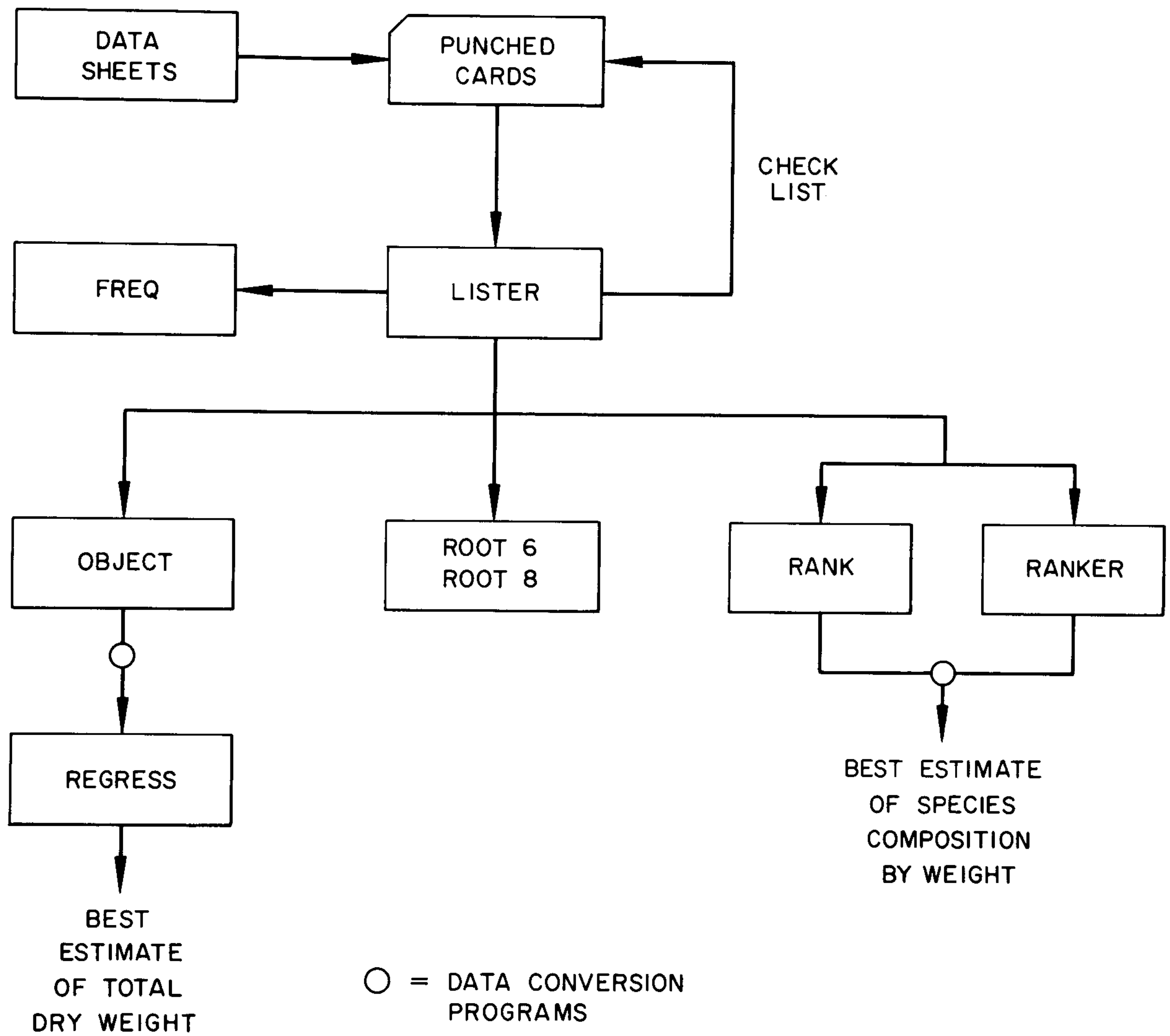

Figure 2. Flow diagram of the data processing programs.

Program RANKER was based on the premise that a more precise estimate, overall, of the total biomass of an area could be obtained by ranking a large number of plots and clipping a few than by only clipping a small number (Mannetje and Haydock 1963). This may be true provided a sufficient number of plots can be clipped to get a good estimate of the correlation between observed values (dry weight g/m^2) and predicted values.

The input to program RANKER consisted of the species names and their ranks and the rank and weight vectors as described in program RANK. Additional input included an estimate of costs of the slow measurement, fixed measurement and fast measurement. Time in minutes was used as the cost value. Here the "slow" cost included the cost per sample of estimating and clipping the plots in the field, sacking the sample, handling the sample in the drying and sorting processes, and weighing. The "fixed" cost was that time alloted for plot location per sample whether clipping or ranking was done in the field. The "fast" cost was simply the cost of ranking the sample in the field.

The purpose of the dry weight-rank method is to produce a vector of coefficients, $\underline{\sigma}$, such that when the corresponding rank matrix, $\underline{R}$, is multiplied by $\underline{\sigma}$ the result will be an estimate of the proportion of the total weight, $\underline{V}$, each species accounted for, i.e., $\underline{R} \cdot \underline{\sigma} = \underline{V}$ (Van Dyne 1966b).

The purpose of program RANKER was to provide not only the vector of coefficients, $\underline{\sigma}$, but also information on the correlations of observed and predicted values, and to calculate the optimum ratio of fast to slow measurements. This program and this technique (Van Dyne 1968) provided for calculation of simple and weighted correlations and the optimum ratios. Weighting was accomplished by assuming information on a given species had worth proportional to its weight proportion determined from the clipped samples.

The optimum ratio was calculated by the method of Van Dyne *et al.* (1968)

$$\text{Optimum Ratio} = \frac{\text{fast}}{\text{slow}} = \frac{c_s}{c_f + c_t} \cdot \sqrt{\frac{R^2}{1 - R^2}} \qquad (11)$$

where R^2 is the square of the correlation between predicted and observed values and c_s, c_f, and c_t are the slow, fast and fixed costs described above respectively.

Provision was made in RANKER to calculate coefficients, σ_j, for varying numbers of j. $\underline{\sigma}$ was solved for by a constrained, least-square technique using the method of Lagrangian multipliers. Provision was also made to make a selected number of analyses with a given number of subsets from any set of data.

The vector of coefficients was then used in conjunction with the rank vector determined by program RANK to give the best possible estimate of species composition by weight, i.e., $\underline{R} \cdot \underline{\sigma}$ = best estimate of species weight.

Capacitance Equations

Regressions were run with program REGRESS (Van Dyne 1965) to determine the best equation for converting capacitance readings and auxiliary data into dry matter estimates. The function used was a multiple linear regression equation whose variables are listed in Table 1.

Program OBJECT was used to adjust the amount of standing dead values that were estimated in the field to correct the tendency of the estimator either to overestimate or underestimate (Tiwari *et al.* 1963). The input consisted of the actual amount of standing dead, calculated from the data, and the values that were estimated in the field. The relationship between the actual and the estimated values for the standing dead followed the form of a cubic curve, $Y = AX + BX^2 + CX^3$ (Tiwari *et al.* Fig. 1), such that the coefficients A, B, and C summed to 1.0 or 100 percent, depending upon the scale of the input.

The sequence of uses of these correction equations and adjustment of the 0.25 m^2 and 0.75 m^2 subplots to a 1 m^2 basis are outlined as follows: (i) the prediction equation, $Y = X1 + X2 + X3 + X4 + X5$, was used to get replicate values of total yield; (ii) average values for clipped vegetation for replication and date were calculated; (iii) yield values were adjusted to a standard 1 m^2 basis using the following correction factor:

$$1 \text{ m}^2 \text{ yield} = 0.25 \text{ m}^2 \text{ yield}_{\text{avg.}} + 0.75 \text{ m}^2 \text{ yield}_{\text{avg.}} \qquad (12)$$

then,

$$\text{correction factor} = \frac{1 \text{ m}^2 \text{ yield}}{(0.25 \text{ m}^2 \text{ yield}_{\text{avg.}}) \cdot 4} \qquad (13)$$

the correction factor (c.f.) in most cases was less than 1 since there is a positive edge bias in yield when clipping the 0.25 m^2 plot. This

Table 1. Identification of Variables Used in Capacitance Prediction Equation

Code	Meaning
X1	Capacitance reading
X2	Capacitance reading squared
X3	Percent water in vegetation on a fresh weight basis (constant)
X4	Adjusted estimate of percent standing dead vegetation
X5	Ground litter (g/0.25 m^2) (constant)
Y	Dry matter (g/0.25 m^2)

correction factor was used to correct to 0.25 m^2 live, dead and litter yields.

$$0.25\ m^2 \text{ yield x c.f.} = \text{adjusted yield} \qquad (14)$$

The assumption here was that the degree of bias for one factor was the same for all factors (W. F. Harris, G. M. Van Dyne, H. R. DeSelm, unpublished manuscript).

The best estimate of species yield was calculated from the estimate of species composition, based on 140 plots, times the total yield estimate described above.

II. MODELING METHODS

Any compartmental system is a dynamic system in which the activity of one part influences in some way the behavior of all the other parts. The system may be partitioned into various blocks or compartments through which flow energy, material, or, in this case, organic matter (Figure 3). The flow of matter may be represented as a series of losses from a compartment or gains by the receiving compartment (Table 2). The losses or gains are here expressed as a fractional loss per unit of time (Jenny _et al._ 1941; Olson 1963; Berman 1964) multiplied by the mass of material in the donor compartment going to loss. The net change, per unit time, in the compartment is the difference between income and loss. Constant coefficient models assume first order loss rates from all compartments. This may be written as the difference equation:

$$\frac{\Delta V}{\Delta t} = I - V\lambda_{ij} \qquad (15)$$

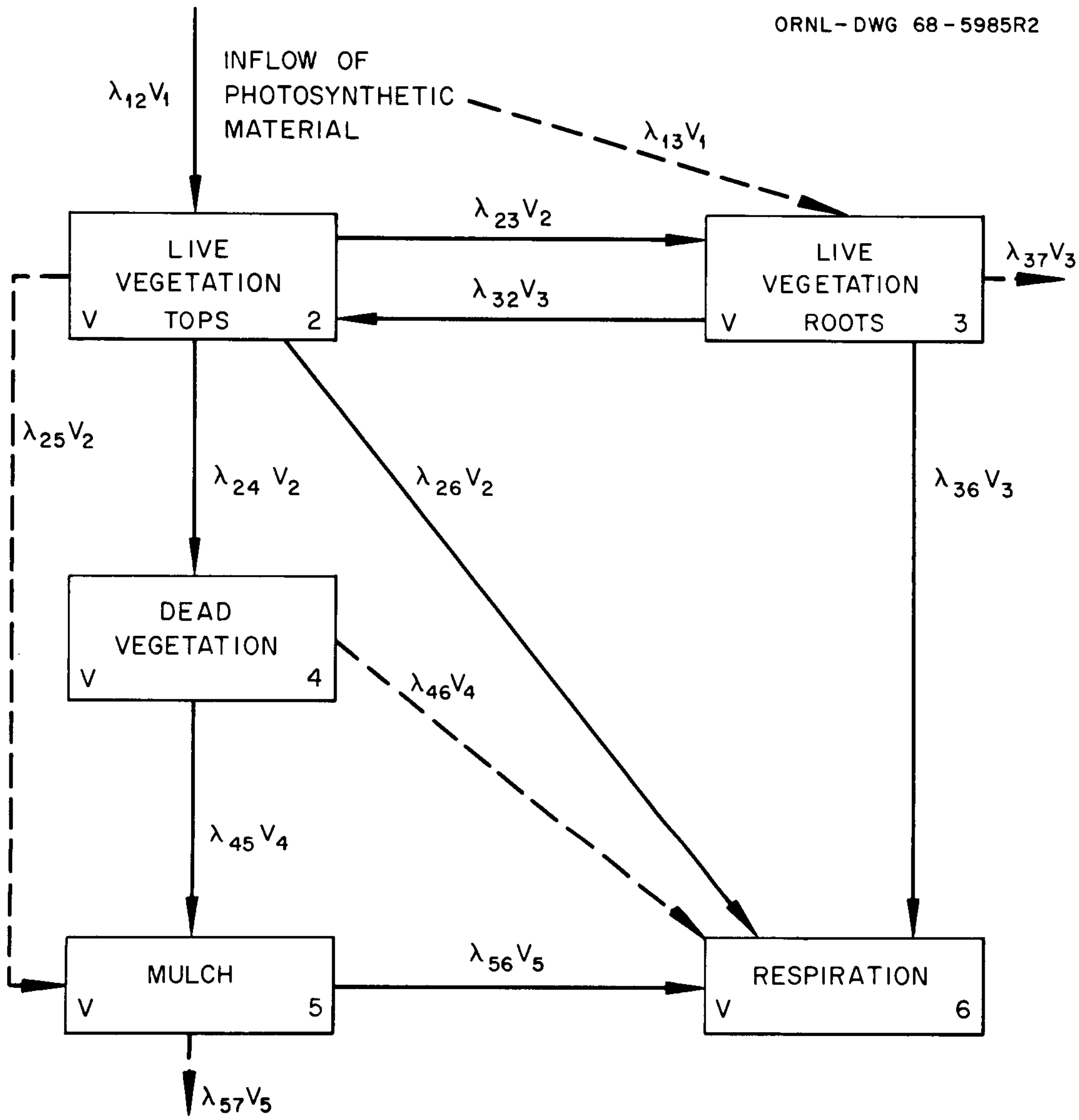

Figure 3. A simple compartment model of an Old Field Ecosystem. Solid lines denote transfers of original model. Dashed lines denote additions, applied and theoretical.

Table 2. Definition of Symbols Used in Old Field Ecosystem Model (Figure 3)

Symbol	Meaning
λ_{12}	Transfer from source to live (top) compartments
λ_{13}	Transfer from source to root compartments
λ_{23}	Transfer from top to root compartments
λ_{24}	Transfer from top to dead compartments
λ_{25}	Transfer from top to mulch compartments
λ_{26}	Transfer from top to respiration compartments
λ_{32}	Transfer from roots to live compartments
λ_{36}	Transfer from roots to respiration compartments
λ_{37}	Transfer from roots to organic matter compartments
λ_{45}	Transfer from dead to mulch compartments
λ_{46}	Transfer from dead to respiration compartments
λ_{56}	Transfer from mulch to respiration compartments
λ_{57}	Transfer from mulch to organic matter compartments
V_1	Source compartment (not shown)
V_2	Live top compartment
V_3	Live root compartment
V_4	Standing dead compartment
V_5	Mulch compartment
V_6	Respiration compartment
V_7	Organic matter compartment (not shown)

or the net rate of change with respect to time, $\frac{\Delta V}{\Delta t}$, is equal to income, I, minus loss, $V\lambda_{ij}$. Here λ_{ij} is the fractional transfer from the i-th (whose change is being considered) to the j-th compartment. These partial transfer coefficients describe how the total material is lost by one compartment and partitioned to the others. It should be noted that the λ's need not be constant, but they may be mathematical functions. Such functions could be sinusoidal approximations of the solar radiation or other seasonal variations noted earlier. The λ's could be dependent upon extraneous conditions such as precipitation or available amount of a given nutrient.

Equation (15) may be expanded to show the total amount of material occurring in a given compartment through time. This may be written as:

$$\frac{\Delta Vi}{\Delta t} = Vi + I - \sum_{i=1}^{n} \lambda_{ij} V_i , \qquad (16)$$

or the present amount equals the previous amount plus income minus loss.

A compartmental system may be represented as a series of differential equations of the form:

$$\frac{\Delta Vi}{\Delta t} = Vi + \sum_{j=1}^{m} \lambda_{ji} V_j - \sum_{i=1}^{n} \lambda_{ij} V_i \qquad (17)$$

where $\frac{\Delta Vi}{\Delta t}$ is the change in the i-th compartment value with respect to time, $\sum_{j=1}^{m} \lambda_{ji} V_j$ is the total income from all other compartments, $\sum_{i=1}^{n} \lambda_{ij} V_i$, is the total loss to all other compartments, and V_i is the initial value.

Examples of use of compartmental systems and methods of solution are given by Berman (1964), Neel and Olson (1962), Berman et al. (1962a), Patten (1964), Serge (1965), Berman (1962), and Watt (1966).

A compartmental model simulator, COMSYS (Bledsoe and Olson 1968), has been developed which is basically a means of describing the consequences of a set of assumed transfer coefficients, both linear and nonlinear, about the behavior of a system. The results are given in both tabular and graphic form. This program has been used extensively and modified in this research.

Two options are available in COMSYS which allow, through the use of subroutines, for manipulation of the compartments and transfer coefficients by mathematical functions or restraints. These two subroutines, MATX for manipulation of the transfer coefficient and OPTION for compartmental variation, may be modified independently of the main program (Appendix A).

Subroutine MATX allows variation of the matrix of transfer functions with respect to time. The transfer functions may be made to vary according to some particular mathematical equation, e.g., $Y = aX + bX^2 + c \log (X)$ or $Y = Ae^{bx}$, or may be made to vary as a function of the donor or receiver compartments or both. This subroutine may also be used to incorporate various climatic variables (precipitation, temperature) or the Q_{10} factor into the transfer coefficients to influence their rates.

Subroutine OPTION is used if it is desirable to calculate, through time, the courses of one or more compartments to a particular formula other than the standard differential equation. For example, it may be desirable to force the source compartment (V1) to take the form of a sinusoidal curve to approximate the yearly variation of solar input, e.g., $V1 = (1 - \cos(3.28x))a$.

The actual modifications of these subroutines are listed in Appendix A. The reasons for the particular modifications incorporated are discussed in the Results and Discussion section on modeling.

B-IV.

RESULTS AND DISCUSSION

I. DRY-WEIGHT-RANK METHOD

Predicted vs Observed Values

The correlations between the observed and the predicted values of species composition by weight were in all instances highly significant ($P < .01$); the correlation values all were ≥ 0.94 (Table 3). The high correlation values in both the *Festuca* and *Andropogon* communities indicated that the set of multipliers (Table 4) used for converting species rank to percent weight were very useful in determining species composition. Actual and estimated values of the percent of the total weight that a particular species accounted for in any given sample period were usually within one or two percent of each other (Tables 5 and 6). The estimated values for each replicate were based on 20 clipped plots and 50 "ranked only" plots. The actual values were based on the 20 clipped plots. Only the dominant taxa are listed, i.e., any species that accounted for at least one percent of the total weight in any given sample period was included.

The 12 species listed in Table 5 for replication 1 and the 14 species for replication 2 were selected from a total of 29 different species that were found in the *Festuca* community. Although only half of the species present are recorded, they comprised approximately 99 percent of the biomass. In the *Andropogon* community (Table 6) 16 species are listed for the first replication and 22 species for the second

Table 3. The Correlation Coefficients for the Observed Versus the Predicted Values in the Estimation of Species Composition for the *Festuca* and *Andropogon* Communities.

Community	Sampling Period			
	June	July	Sept.	Nov.
Festuca, replication 1	.96	.98	.97	.99
Festuca, replication 2	.96	.96	.98	.97
	Aug.	Sept.	Oct.	Dec.
Andropogon, replication 1	.97	.94	.97	.99
Andropogon, replication 2	.98	.95	.98	.99

Table 4. List of the Rank Multipliers, σ_{ij}, for the *Festuca* and *Andropogon* Communities.

Community	Sample	Rank Multipliers								
		1	2	3	4	5	6	7	8	9
Festuca	5	.897	.048	.044	.019	-.011	.005	-	-	-
Festuca	6	.886	.089	-.013	.007	.002	.008	.005	.019	-.003
Festuca	7	.901	.083	.021	-.017	.005	.007	.001	-	-
Festuca	8	.931	.036	.005	-.002	.024	.001	-.002	-	-
Andropogon	3	.952	.031	.019	.008	.088	-.21	.010	.006	-
Andropogon	4	.779	.149	.108	-.018	.000	.021	.010	.006	-
Andropogon	5	.831	.181	.008	.013	-.006	.045	.000	-	-
Andropogon	6	.935	.108	-.068	-.002	.028	-	-	-	-

Table 5. Relationships Between Clipped (C) and Estimated (E) Percent of the Total Biomass Oven-Dry Weight as Determined by Dry-Weight-Rank Method for the Festuca Community

	June		July		Sept.		Nov.	
	C	E	C	E	C	E	C	E
Replication 1								
Festuca elatior	91	91	88	87	90	90	95	94
Aster pilosus	0	1	3	3	1	2	0	1
Solidago altissima	3	3	1	1	3	2	1	1
Andropogon virginicus	-	-	1	2	-	-	1	0
Campsis radicans	1	1	5	3	1	1	-	-
Rubus allegheniensis	1	0	1	1	2	3	1	3
Eupatorium fistulosum	-	-	-	-	2	1	-	-
Sorgum halepense	-	-	-	-	-	-	1	0
Daucus carota	-	-	-	-	-	-	1	0
Ipomoea hederacea	1	1	1	1	-	-	-	-
Oenothera biennis	1	0	-	-	-	-	-	-
Solanum carolinense	-	-	0	1	-	-	-	-
Replication 2								
Festuca elatior	88	88	89	88	90	90	88	88
Aster pilosus	1	1	1	1	1	2	1	1
Solidago altissima	-	-	0	1	1	2	2	2
Andropogon virginicus	0	1	-	-	1	0	5	3
Campsis radicans	2	2	1	0	-	-	-	-
Rubus allegheniensis	1	1	2	4	5	3	0	4
Ipomoea hederacea	3	3	4	3	-	-	-	-
Plantago major	1	1	1	0	-	-	-	-
Trifolium repens	1	1	0	1	-	-	-	-
Panicum nitidum	1	0	-	-	-	-	-	-
Lespedeza cuspidata	1	0	1	0	0	1	3	1
Solanum carolinense	1	0	-	-	-	-	-	-
Eupatorium fistulosum		-	-	-	1	1	1	0
Carex frankii	-	-	-	-	1	0	-	-

Table 6. Relationships Between Clipped (C) and Estimated (E) Percent of the Total Biomass Oven-Dry Weight as Determined by the Dry-Weight-Rank Method for the Andropogon Community

	Aug.		Sept.		Oct.		Dec.	
	C	E	C	E	C	E	C	E
Replication 1								
Andropogon virginicus	80	61	79	82	88	84	93	93
Aster pilosus	2	9	10	7	3	4	3	1
Panicum latifolium	2	1	-	-	-	-	-	-
Campsis radicans	2	1	1	1	1	1	1	0
Carex frankii	2	3	-	-	-	-	1	1
Eupatorium fistulosum	2	7	1	1	-	-	-	-
Rubus allegheniensis	1	5	-	-	0	3	-	-
Solidago altissima	6	3	3	4	2	1	-	-
Panicum commutatum	1	0	1	0	5	2	-	-
Rosa sp.	0	1	-	-	-	-	-	-
Oenothera biennis	2	3	-	-	-	-	-	-
Senecio smallii	1	0	1	0	0	1	-	-
Erigeron candensis	-	-	2	1	-	-	-	-
Eulalia viminea	-	-	0	1	-	-	-	-
Panicum anceps	-	-	-	-	0	3	1	0
Galium tinctorium	-	-	-	-	0	1	-	-
Replication 2								
Andropogon viginicus	66	59	68	55	78	78	85	81
Aster pilosus	14	11	9	13	5	5	5	5
Panicum latifolium	1	6	-	-	-	-	0	3
Campsis radicans	3	0	1	2	0	1	0	4
Eupatorium fistulosum	0	4	1	2	-	-	-	-
Rubus allegheniensis	0	5	3	3	0	2	-	-
Carex frankii	1	0	-	-	-	-	2	0
Solidago altissima	4	3	4	3	2	0	1	2
Panicum nitidum	-	-	1	1	1	1	1	0
Oenothera biennis	1	2	1	1	-	-	-	-
Diodia virginiana	5	5	2	0	1	1	1	0

Table 6. (continued)

	Aug.		Sept.		Oct.		Dec.	
	C	E	C	E	C	E	C	E
Replication 2 (continued)								
Acalypha rhomboidea	-	-	0	2	-	-	-	-
Rosa sp.	1	0	1	4	0	1	-	-
Panicum commutatum	2	3	3	8	3	2	-	-
Solanum carolinense	0	1	0	1	-	-	-	-
Senecio smalii	3	0	-	-	0	1	-	-
Panicum anceps	-	-	1	0	4	3	4	4
Erigeron canadensis	-	-	1	0	1	0	-	-
Cirsium arvense	-	-	-	-	3	1	-	-
Oxalis stricta	-	-	-	-	1	0	-	-
Gnaphalium purpureum	-	-	-	-	1	0	-	-
Vernonia altissima	-	-	-	-	-	-	0	2

replication. The species accounted for less than half of the 55 species that were present in this community, but still they represented 97 percent of the total biomass.

Festuca elatior accounted for a minimum of 87 percent of the herbage weight in the Festuca community (Table 5, page 30). Relatively little change occurred between the observed and the estimated values. This agreed with the species composition of that community. Festuca uniformly dominated the field for the entire year and was the first-ranked species in all the clipped and estimated plots.

The Andropogon community was not as uniformly distributed over the sample area as the Festuca. The total number of species present in the Andropogon community was double that in the Festuca community. Andropogon virginicus accounted for a minimum of 59 percent of the herbage weight in the Andropogon community (Table 6, page 31). The field contained small areas nearly dominated by Oenothera biennis, Aster pilosus, Solidago altissima, Eupatorium fistulosum, and Rubus allegheniensis. The increase in the actual over the predicted composition values for such species was usually in the range of 1 to 4 percent, though higher changes did occur.

The change in the composition of Andropogon virginicus between the observed and estimated values was very large in the first sample, an average of 12 percent over both replications. The first sample in the dry weight rank method occurred in July, the third sampling date of the Andropogon field. These data suggest that differences this large, if not larger, probably would have occurred earlier in the season.

Panicum nitidum accounted for approximately 5 percent of the total weight in the first sample and dominated areas of several square meters. This would have been emphasized more if the rapid-sampling method had been initiated earlier. The large difference between the observed and estimated values was not as prominent as the year progressed as Andropogon virginicus reached its peak production (Table 6, page 31).

These results suggest that estimates of species composition can be improved appreciably by using the dry-weight rank method as an adjunct to clipping plots. Greatest gains will be made when (a) the dominance in the communities changes greatly over time and (b) where the species are not uniformly distributed in area.

Time Factors and Area Sampled

The time necessary for clipping, sorting, drying and weighing of each plot was estimated at 45 minutes. This time compared to the time necessary to rank a plot, 3 minutes, is one distinctive advantage of the rapid-sampling technique. Ideally, for every plot clipped, the optimum ratio, i.e., the number of plots ranked for every clipped plot, ranged from 102 to 383 in the Festuca community and from 53 to 142 in the Andropogon community (Table 7). In other words, taking into account the time factors (fast to slow measurements) and the correlation coefficients between the actual and predicted values as determined with program RANKER, one could then rank from 53 to 383 plots for each one clipped and still be confident that the final estimate of relative species composition by weight was equal to, if not more realistic than, that provided by the clipped data alone. The reason for this is obvious if the total area covered is considered.

Table 7. The Optimum Ratios of Plots to be "Ranked Only" to Plots to be Clipped for the *Festuca* and *Andropogon* Communities

Community	Sampling Period			
	June	July	Sept.	Nov.
Festuca, replication 1	383	288	179	191
Festuca, replication 2	256	391	105	102
	Aug.	Sept.	Oct.	Dec.
Andropogon, replication 1	53	92	94	143
Andropogon, replication 2	122	56	89	77

The total number of plots clipped on any one date was 40 (20 per replication). These were meter square plots of which only a quarter meter subsample was sorted. Therefore, the total area for which an actual weight per species was obtained amounted to 10 square meters as opposed to the total area of each field, approximately 0.8 hectare. This small portion of the total field could not accurately account for a wide variety of species composition, as was the case in the Andropogon community. The rapid-sampling technique covered an area three times that of the clipped plots. Although this area was still small relative to the total area, the rapid-sampling technique was non-destructive, and it was not limited to a given segment of the field at any given sample period as were the clipped plots in the stratified sampling design which was used.

The full significance of the dry weight rank method is not obvious from its use in this study. Only three plots were ranked for every plot that was clipped. Ideally, taking the smallest optimum ratio, an area fifty times as large should have been ranked for each unit area that was clipped. This much larger area would have encountered more variety in the vegetation than did the standard method used and would have better accounted for species which were not uniformly distributed.

Estimation of Error

The primary purpose of the rapid-sampling technique is to estimate as closely as possible the composition of the major species. The difference between the clipped (C) and the estimated (E) values should therefore be as small as possible. An attempt was made to evaluate the difference between the actual and the estimated values for the species composition scaled for the importance of the plant, i.e.,

$$\frac{\text{percent difference}}{\text{relative importance}} = \frac{100 * (C\text{-}E)}{E} = \text{measure of error} \quad (18)$$

The measure of error was plotted against percent composition for the species of the *Festuca* and *Andropogon* communities (Fig. 4). The results indicate that the smaller the percent composition a particular species accounts for the larger the corresponding measure of error, even if the difference between the actual and the estimated values is smaller than that of some other species whose percent composition is greater. The rapid-sample technique used here is very precise in estimating the composition of the major species.

Special Advantages of Rapid-Sampling Methods

The advantages of the dry weight rank method as a rapid-sampling technique are twofold. First, it allows for the optimum allocation of time for getting the largest possible sample. Here the cost factor was time, but several other factors could be used. For example, the cost could vary for different activities. This method could be used to determine how to best utilize money available and at the same time get the best possible estimate of species weight composition. Reducing hours of work can also be applied to field work. When working in radionuclide contaminated areas, where samples cannot be taken and the amount of time spent in the area is critical, the rapid-sampling method allows for quick sampling without the clipping of plots within the area.

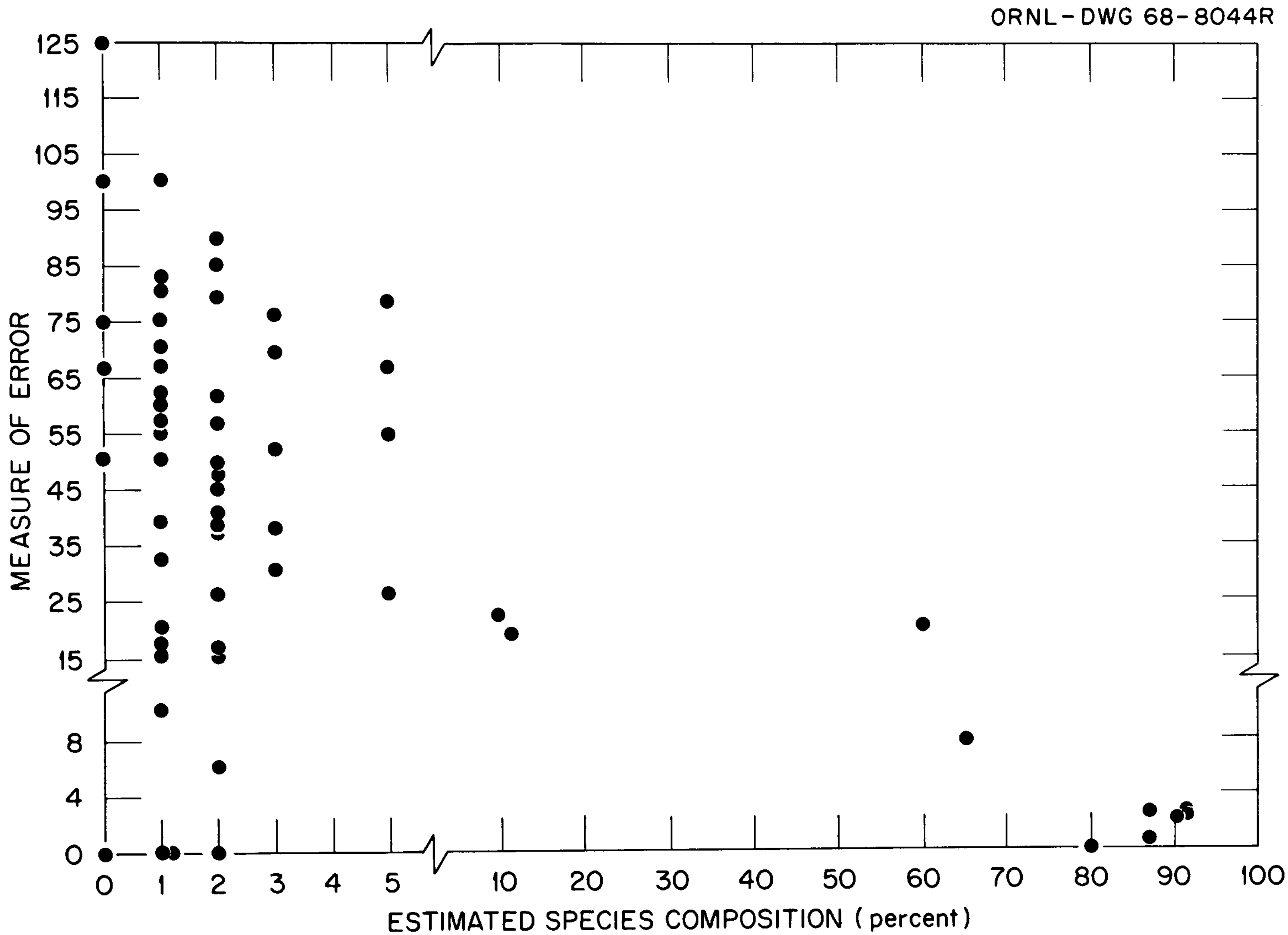

Figure 4. The percent difference between estimated and clipped percent species composition scaled for the importance of the plant for the *Festuca* and *Andropogon* communities.

This may be accomplished by clipping for calibration outside the area in similar vegetation that has not been contaminated.

The second advantage in using the rapid-sampling technique is in reducing the amount of laboratory work (weighing, sorting, and drying). This is desirable when the space for sorting is at a minimum or the facilities available for drying and weighing are limited or taxed.

II. USE OF CAPACITANCE METER TO MEASURE TOTAL HERBAGE

Ecologists have long used clipping as a technique for estimating herbage weight. Clipping herbage to determine yield is the most costly part of many ecological experiments (Van Dyne 1966a). Clipping is destructive to the system under study and requires a relatively large number of samples to obtain an accurate estimate of total yield. Other methods have been employed to determine herbage yield, e.g., visual estimates, height-weight relationships, and ground cover relations to herbage yield, but these methods have not proved fully adequate. Fletcher and Robinson (1956) drew upon results of moisture content of cereal grains, cotton bales, butter and soils to construct a capacitance meter for estimating forage weight. The capacitance meter (herbage meter, vegeometer) described by Van Dyne *et al*. (1968) was used in this study to test another technique to supplement clipping.

Prediction Equation

The equation used for the estimation of total dry matter yield is of the general form:

$$Y = a + bX1 + cX2 + dX3 + eX4 + fX5 \qquad (19)$$

The dependent and independent variables are listed in Table 1 (page 20) and the coefficients, a, b, c, d, e, and f, in Table 8.

The multiple correlation between observed values of herbage yield and estimates predicted from the capacitance and associated measurements is used herein as a measure of adequacy of the capacitance technique. The multiple correlation values for the Andropogon and Festuca communities (Table 8) appear to be lower than many previous values reported in the literature (Table 9), but the values reported here are still within the limits accepted for gaining some predictability of forage weight from quick sampling. The lower values here can, in part, be attributed to the composition of the estimated variable, total dry weight (g/m^2) of live and dead above-ground biomass. The capacitance meter primarily measures the water content of the vegetation. It was assumed that there existed a linear relationship between the amount of water present and the total amount of dry matter. In reality, however, a large part of the total yield was due to the standing dead present, which was never less than 50 percent at any sample period. The standing dead herbage has a much lower water content than does live herbage.

Some error may have resulted from the reading of the meter itself, because the capacitance values were rounded to the nearest half microampere. Difference in the circuitry of the probe used compared with those in the literature and the precision with which the clipping was done were also inherent sources of error. The basic difference, however, was the heterogeneous vegetation in which the capacitance meter was used as compared to the uniform single-species vegetation measured in the studies reported in the literature.

Table 8. Regression Coefficients and Correlation Values for the Capacitance Prediction Equations of Total Yield for the Festuca and Andropogon Communities

Date	a	b	c	d	e	f	R Value
Festuca Community							
June	73.	-11.	1.3	11.	200.	.64	.74
July	110.	8.6	-.13	-36.	86.	-.89	.31
Sept.	180.	34.	-1.8	-300.	77.	-.44	.57
Nov.	170.	30.	-1.8	-4.6	-82.	-.01	.48
Andropogon Community							
Aug.	440.	-29.	3.4	-310.	84.	-98.	.70
Sept.	480.	-94.	14.	-120.	32.	-.65	.47
Oct.	570.	-180.	38.	-150.	-2.5	-.70	.53
Dec.	-210.	19.	-6.8	-4.3	470.	-.40	.35

Table 9. Equations from the Literature for Predicting Herbage Yield from Capacitance (Van Dyne *et al*., 1966)

Reference	Equation form and correlations	Remarks
Campbell *et al*. 1962	DW = a-b (log meter) $r^2 \times 100 \simeq 90\%$ DW = a-b (log meter) = c (Moisture%)	Herbage yield from about 15 to 190 g per quadrat
Alcock 1964	meter reading (MR) = a + dry weight (DW) x $\frac{\text{total water (TW)}}{\text{dry weight (DW)}}$ $r^2 \times 100 = 97\%$	
	meter reading - a+bDW + $b_2 (\frac{TW}{DW})^2$ $r^2 \times 100 = 98\%$ DW = a (MR + b-c $\frac{TW}{DW}$) [∴DW = aMR + (ab) - (ac) $\frac{TW}{DW}$]	Herbage yield about 948 to 4032 lb/ac (dry weight) (Electronics described by Hyde *et al*. 1964)
Dowling *et al*. 1965	dm yield - $b_o + b_1$ (cap.) r values = .52, .59, .73, .89, .90, .96 for clover .64, .72, .87, .90, .87	Herbage yields 1000 to 8000 lb/ac dry matter
Johns, *et al*. 1965	DW = a + bMR $r^2 \times 100$ values 59-93% DW - a + bMR = $c(MR)^2$	300 to 10900 lb/ac dry matter
Neal & Neal 1965	Meter Reading = b(DW) r = 0.94 to 0.96	Herbage yield 20-145g/plot (same meter discussed by Morse 1967)

Table 9. (continued)

Reference	Equation form and correlations		Remarks
Alcock and Lovett 1967	$MR = a + b\ DW$ $MR = a + b\ DW + c(DW)^2$ $MR = a + b\ DW + c\frac{TW}{DW}$ $\log MR = a + b \log DW + c \log \frac{TW}{DW}$ $DW = a + b\ \frac{TW}{DW} + cMR$	$r = 0.73$ to 0.96	65 to 4878 lb/ac dry weight

Considering the costs for fixed, fast and slow measurements in this study, 3, 1, and 45 minutes respectively, a curve was constructed to show the optimum ratio of fast to slow measurements as a function of the multiple correlation coefficient. The curve in Figure 5 suggests that if a capacitance meter is available, the multiple correlation coefficients of the prediction equation need be only 0.3 or more before the use of a capacitance meter becomes a helpful supplement to clipping. At the lower limit of 0.3 the optimum ratio is 1:1; therefore, for every plot clipped, one plot should be read with the capacitance meter.

Predicted Values

The estimated values were close to the clipped yields for the sample periods (Table 10). A t-test with $N_1 + N_2 - 2$ degrees of freedom (N_1 and N_2 being the sample means of the predicted and clipped data) was used to compare sample means. The results showed a difference ($p \leq 0.10$) existed between the estimated and clipped yields for the June and October samples in the *Festuca* community. Though differences existed between the methods for these two dates, the estimated value of the October sample differed by only 36 grams from the clipped value.

Some of the error in the June sample was due to the number of plots in which only a capacitance meter reading was taken (2.5 plots were read for every plot clipped). This is less than the 4:1 ratio suggested by the optimum ratio (Table 10). By reading a larger number of plots, a wider variation in the herbage yield and moisture content could have been encountered. This larger variation probably would improve gain in the predictability from the equation (Van Dyne *et al*. 1968).

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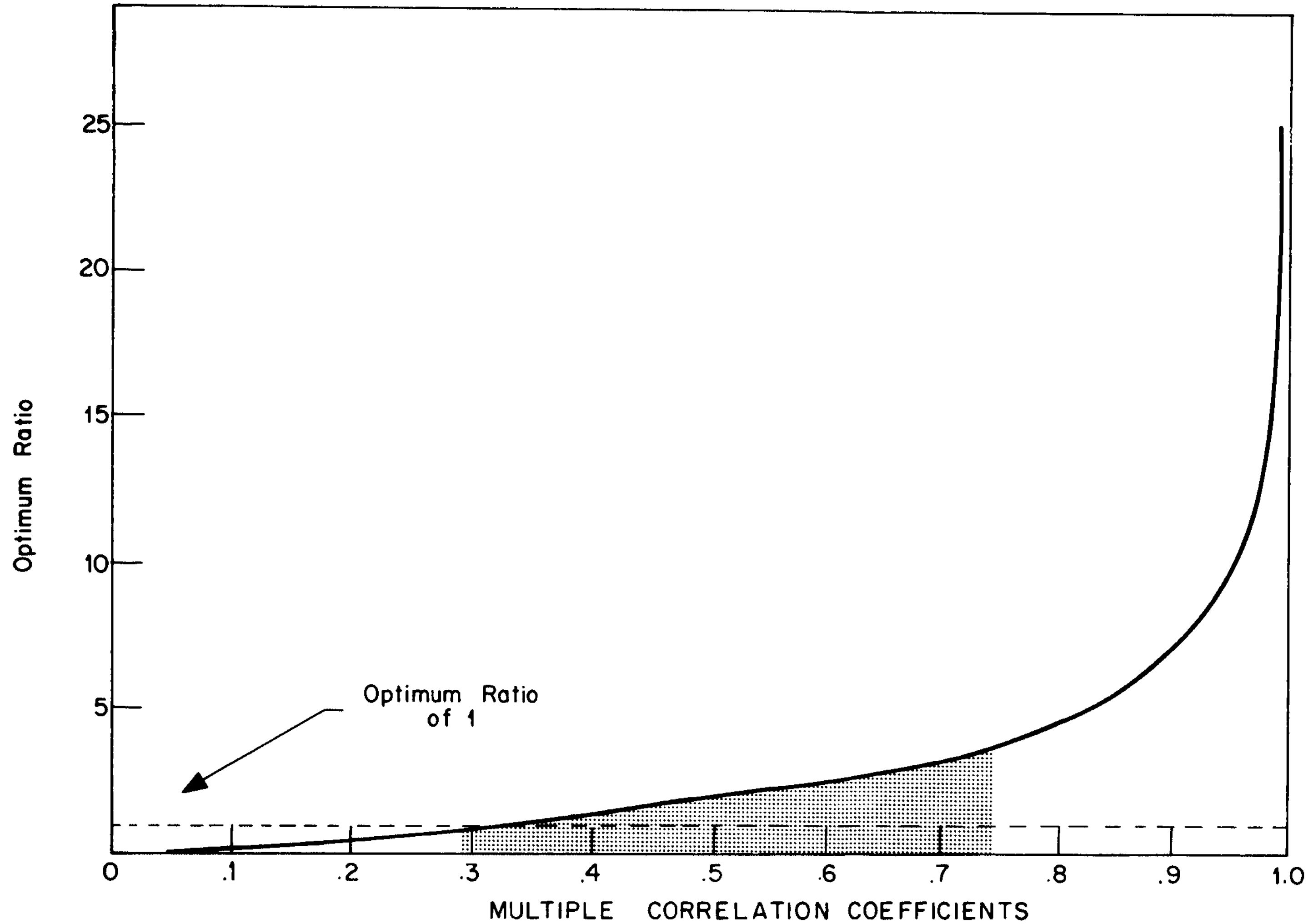

Figure 5. Relationship between the multiple correlation values and the Optimum Ratio based on the 1967 data for the _Festuca_ and _Andropogon_ communities. Stippled area represents range of author's data.

Table 10. Estimated Yield, Clipped Yield, Mean Estimate of Total Yield, and Optimum Ratio for the *Festuca* and *Andropogon* Communities

Sample Date	Estimated Yield (g/m^2)	Clipped Yield (g/m^2)	Mean of Yield (g/m^2)	Optimum Ratio
Festuca Community				
June*	456	589	523	4
July	592	593	592	1
Sept.	678	672	675	2
Nov.*	608	572	590	2
Andropogon Community				
Aug.	813	826	820	4
Sept.	969	946	958	2
Oct.	1012	958	985	2
Dec.	815	845	830	1

*Significant difference ($p \leq .10$) between estimated mean and clipped mean.

In the November sample the water content of the herbage was less than 50 percent. Since the capacitance meter reading is based primarily on water content of the herbage this low value could have had a pronounced effect on the results.

III. MEAN ESTIMATE OF TOTAL YIELD

The mean estimate of total yield was taken here to be the simple average of the estimated and clipped values for the total biomass (Table 9, page 42). The maximum change observed in the mean estimate, as compared to the estimate from the clipped plots alone, was in the June sample from the *Festuca* community. Here the estimate of herbage biomass decreased by approximately 60 g/m^2, though in most cases the mean amount of biomass was increased (Figure 6).

The estimated values followed the observed growth pattern of both communities well, reaching a peak in September for the *Festuca* community and in October for the *Andropogon* community. The overall growth pattern of both communities was made more pronounced, i.e., the minimum values were lower and the peak values were higher.

IV. ADJUSTED ESTIMATE OF SPECIES YIELD

The adjusted estimates of species yield (Tables 11 and 12) were obtained from the product of the mean estimate of total yield (Table 9, page 42) and the best estimate of species composition (Tables 5 and 6, pages 30 and 31). Only those species which are recorded in Tables 5 and 6 are listed. The pattern of weight distribution follows that of

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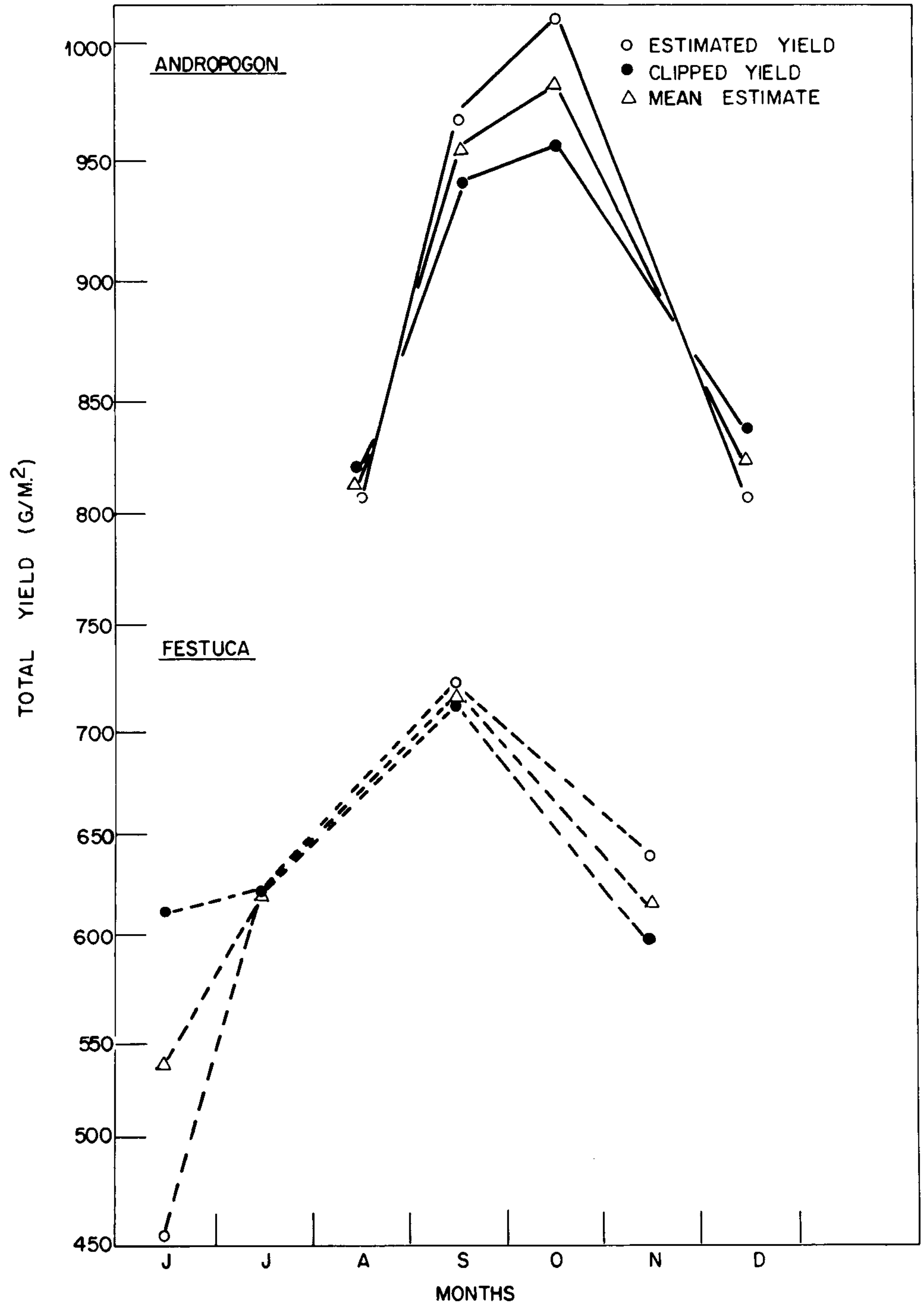

Figure 6. Comparison of estimated yield, clipped yield and mean estimate of yield (g/m^2) for the Festuca and Andropogon communities.

Table 11. Comparison Between Clipped (C) and Estimated (E) Yields (g/m^2) for Individual Species in the *Festuca* Community

Species	June		July		Sept.		Nov.	
	C	E	C	E	C	E	C	E
Festuca elatior	479	469	523	519	593	608	523	537
Aster pilosus	3	7	12	14	8	11	3	2
Solidago altissima	13	9	3	6	15	13	7	14
Andropogon virginicus	2	1	2	4	3	3	18	11
Campsis radicans	8	7	17	12	3	3	-	-
Rubus allegheniensis	6	6	8	15	24	23	4	17
Eupatorium fistulosum	-	-	-	-	9	6	2	6
Sorghum halepense	-	-	-	-	-	-	3	1
Daucus carota	0	2	2	3	-	-	2	0
Ipomoea hederacea	10	11	12	9	-	-	-	-
Oenothera biennis	2	2	-	-	-	-	-	-
Solanum carolinense	2	1	1	2	-	-	-	-
Panicum nitidum	-	-	2	2	0	1	-	-
Plantago major	3	2	2	0	-	-	-	-
Lespedeza cuspidata	1	1	2	2	-	-	-	-
Carex frankii	-	-	-	-	2	0	-	-
Trifolium repense	4	3	1	4	-	-	-	-

Table 12. Comparison Between Clipped (C) and Estimated (E) Yields (g/m^2) for Individual Species in the Andropogon Community

Species	Aug.		Sept.		Oct.		Dec.	
	C	E	C	E	C	E	C	E
Andropogon virginicus	600	498	697	642	792	792	743	720
Aster pilosus	64	83	86	105	36	49	37	41
Panicum latifolium	11	6	-	-	-	-	2	18
Campsis radicans	18	29	9	21	7	7	3	8
Carex frankii	10	12	2	2	1	4	9	4
Eupatorium fistulosum	9	42	19	15	-	-	-	-
Rubus allegheniensis	13	40	16	18	4	19	1	17
Solidago altissima	37	23	34	33	10	16	5	5
Panicum commutatum	10	21	21	47	37	20	-	-
Rosa sp.	4	9	4	9	0	4	1	0
Oenothera biennis	10	17	4	2	1	1	-	-
Sencio smallii	3	2	3	1	-	-	-	-
Erigeron canadensis	-	-	7	6	-	-	-	-
Eulalia viminea	0	7	12	7	-	-	-	-
Panicum anceps	-	-	3	1	22	32	18	18
Galium tinctorium	0	2	2	5	-	-	-	-
Diodia virginiana	22	21	12	14	4	5	5	3
Panicum nitidum	1	0	6	7	5	8	4	0
Acalypha rhomboidea	2	0	8	7	1	1	-	-
Solanum carolinense	1	5	1	2	-	-	-	-
Cirsium arvense	-	-	1	2	18	4	-	-

Table 12. (continued)

Species	Aug.		Sept.		Oct.		Dec.	
	C	E	C	E	C	E	C	E
Oxalis stricta	-	-	0	1	0	1	-	-
Gnaphalium purpureum	-	-	-	-	4	3	-	-
Vernonia altissima	-	-	-	-	-	-	1	0

species composition (Tables 5 and 6, pages 30 and 31) which has been previously described. The total amount of weight accounted for by the adjusted estimates of species yield in the Festuca community was a minimum of 99 percent and in the Andropogon community a minimum of 97 percent.

V. RAPID-SAMPLE TECHNIQUES FOR THE FIRST HALF OF THE SAMPLE PERIOD

The rapid-sample techniques that were used in the last four sample dates of the Festuca and Andropogon were also employed in the first four samples, though the extra series of plots, in which the vegetation was "ranked only" and capacitance meter readings were recorded, were not collected. Even though the data were not available for application of prediction equations, the correlation between the prediction equations and the clipped data would be of interest.

In determining the species composition by use of a set of multipliers generated by program RANKER, the correlation values between the predicted values (using the clipped data as estimates) and the actual values were never less than 0.96. This demonstrates that the method involved in determining species composition was also desirable to use during the early part of the growing season as well as during the latter part.

The equation used to convert capacitance readings to total yield estimates for the early part of the year had generally higher correlation values than did the latter equations. This can be attributed in part to the uniformity of the vegetation present before the flush of spring growth had begun.

The results of the correlation values of the prediction equations used in the early growing season suggest that the rapid-sampling methods are reliable not only during the latter part of the growing season (during peak production), but also during the initial part. The application of these methods could then be employed on a year round basis rather than at specific time periods.

VI. STRUCTURE OF THE CONSTANT COEFFICIENT MODEL

The basic model was designed with the primary purpose of being as simple as possible, but yet being flexible enough to allow accurate duplication of the system. A seven-compartment system was constructed (Figure 3, page 22) in which potential dry matter input driven by solar energy was treated as a "source" compartment of input function. This procedure facilitated subsequent use of the digital computer program COMSYS for the study of the model. Initially, there were eight non-zero transfer coefficients (Figure 3; and Table 2, page 23), two of which were derived from separate experiments, two abstracted from the literature, and the remaining four derived empirically to make the computer simulation approximate the observed data.

Source Compartment

The input function, V_1, was related to the total amount and seasonal rate of energy that was necessary to approximate observed changes in dry matter production. In this model it was actually scaled as a "potential" rate of biomass input ($g/m^2/day$) that would be assimilated as net primary production for the plant system during a 1-year period (Olson 1964). Calculated values for the system were taken to be the sum of the total biomass, i.e., live, standing dead, roots and litter. These sums were later adjusted for plausible estimates of the amount of respiration and decay that had occurred over the growing season in each of these compartments. Estimates for the seasonal transfer in yearly units for the root compartments (Dahlman 1967; Lundegardh 1931), respiration of the live top vegetation (Lundegardh 1931), and decay of the mulch (Kelly 1968) were assumed to be 25, 50 and 60 percent respectively in the *Festuca* community and 25, 50, and 45 percent in the *Andropogon* community. Simulations were made in 365 daily steps: 0.00068, 0.00137, 0.00164; 0.00068, 0.00137, 0.00123 percent per day average loss in turnover. The decay and respiration were calculated for each sample date and were added to the total biomass for that date to suggest the order of magnitude of the gross production of the system (Table 13). This needs to be estimated by local, seasonal experimental data on photosynthesis and was not within the scope of the present harvest study.

A curve of the form

$$Y = a + \sin(b + x) * c \qquad (20)$$

where a, b, and c are constants and x is the time expressed as radians, was fitted to the data in order to simulate the solar input function for the system. This was later modified to fit the timing for the two systems being modeled (Figures 7 and 8).

The total amount of photosynthetic input to the *Festuca* community estimated from the modified form of equation (20) was 801 g/m^2/year and

Table 13. Seasonal Change for the Cumulative Biomass (g/m^2) in the *Festuca* and *Andropogon* Communities as Calculated From the Clipped Data, With and Without Estimates of Shoot and Root Respiration

Community	Month							
	Jan.[a]	Mar.	Apr.	May	June	July	Sept.	Nov.
Festuca, without respiration	924	1022	1459	1548	1511	1642	1643	1651
Festuca, with respiration	934	1070	1584	1737	1830	2074	2287	2467
	Mar.[a]	June	Aug.	Sept.	Oct.	Dec.		
Andropogon, without respiration	1516	1455	1583	2009	1944	1620		
Andropogon, with respiration	1555	1573	1833	2476	2531	2544		

[a]Initial values carried over from previous season.

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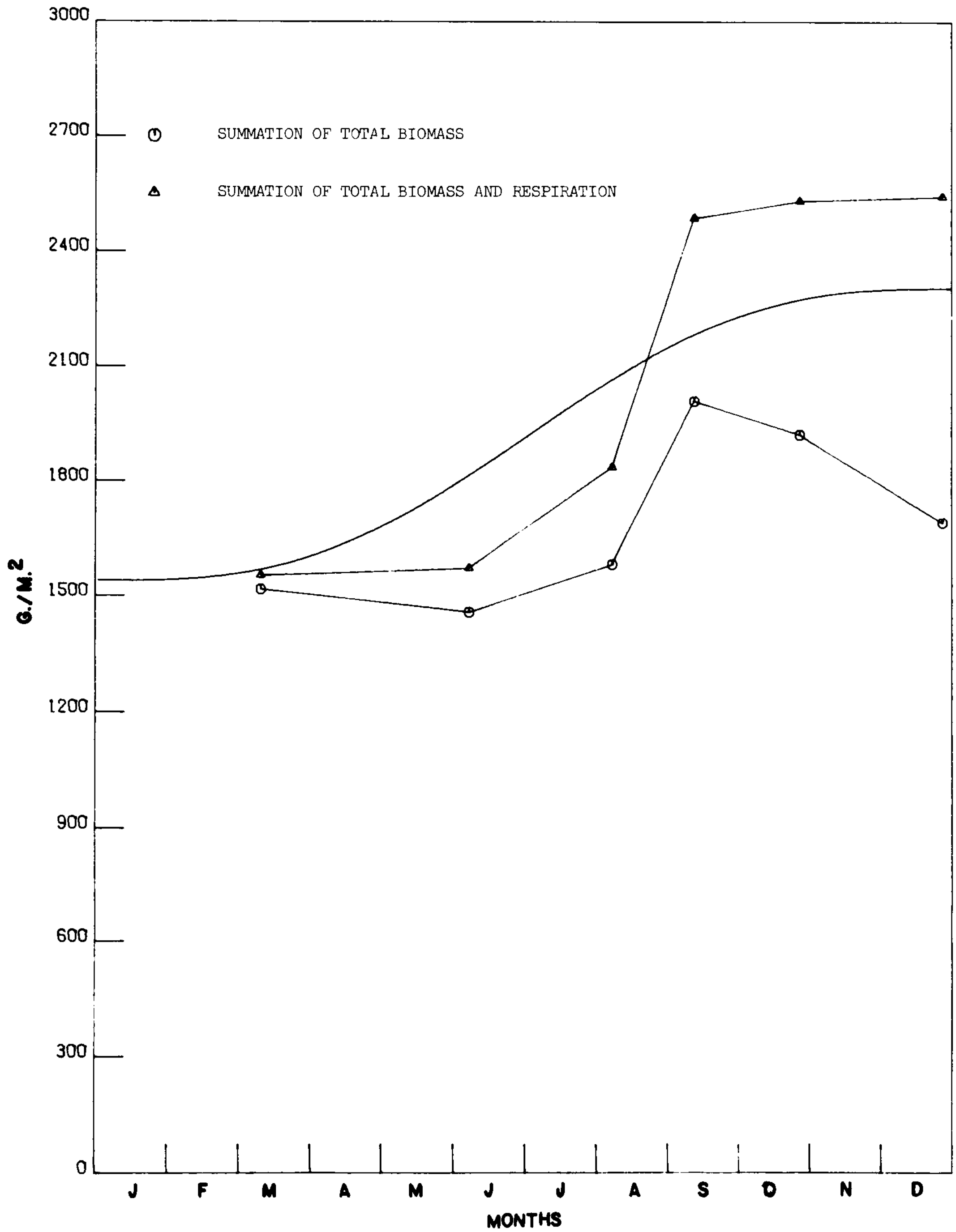

Figure 7. Comparison of the cumulative photosynthetic input, dry matter (g/m^2), to the *Andropogon* constant coefficient model (smooth line) and the estimated production (g/m^2) of the *Andropogon* community (connected points).

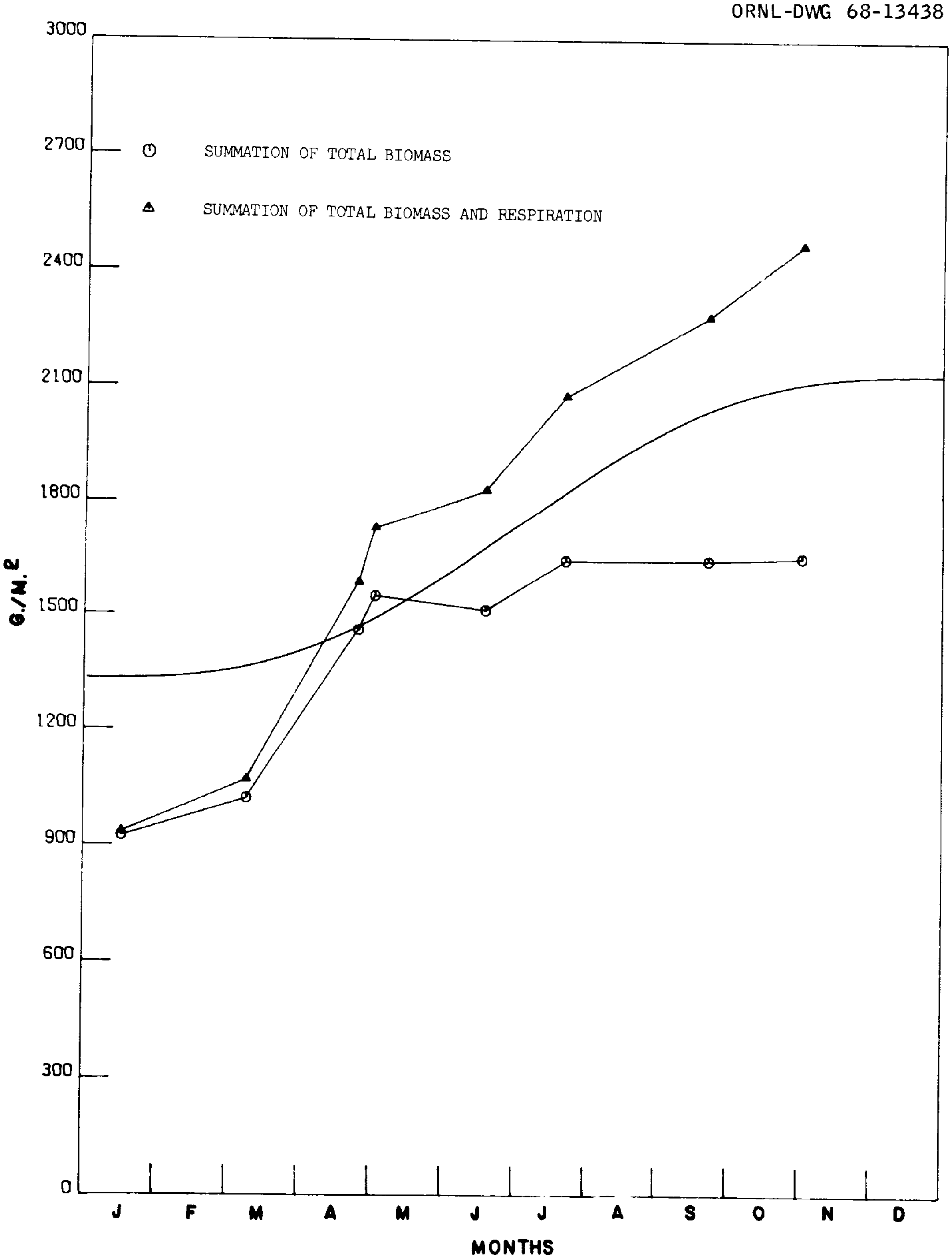

Figure 8. Comparison of the cumulative photosynthetic input, dry matter (g/m^2), to the <u>Festuca</u> constant coefficient model (smooth line) and the estimated production (g/m^2) of the <u>Festuca</u> community.

for the *Andropogon* community, 785 g/m^2/year as compared to the calculated values, 1533 g/m^2/year and 999 g/m^2/year. The large difference between the estimated value and the calculated value of input to the *Festuca* model, 732 g, was due to the large differences in the initial value for the root compartment. The initial value for the root compartment in the constant coefficient model was 850 g as compared to 423 g that was calculated from the data. The larger value used in the modeling was necessary for the overall approximation of the root compartment (see below).

Initial Conditions

The initial conditions (Table 14) in both the *Festuca* and *Andropogon* communities were abstracted from the herbage yield data (Figures 9 and 10). The first *Festuca* sample was only 16 days from the beginning of the year, i.e., the starting point of the modeling time. The initial conditions for each of the compartments was taken to be equal to the clipped values of the first sample, except for the root compartment. In the root compartment the difference between the first and third samples was 437 g. In the constant coefficient model it was not possible to account for this large increase in biomass. The first root samples were considered an underestimation of the total root biomass since only 3 inch diameter cores were used to take soil cores as opposed to the 8 inch diameter cores that were used during the other sample dates. The initial trials in root washing procedure used could have led to root biomass losses. The initial condition was then changed to be equal to the mean value of the root compartments for samples 3 through 8. This

Table 14. Initial Condition Values Used in the Modeling of the *Festuca* and *Andropogon* Communities (g/m^2)

Compartment	*Festuca*	*Andropogon*
Live Top	65	20
Live Root	500	650
Standing Dead	300	600
Mulch	130	180

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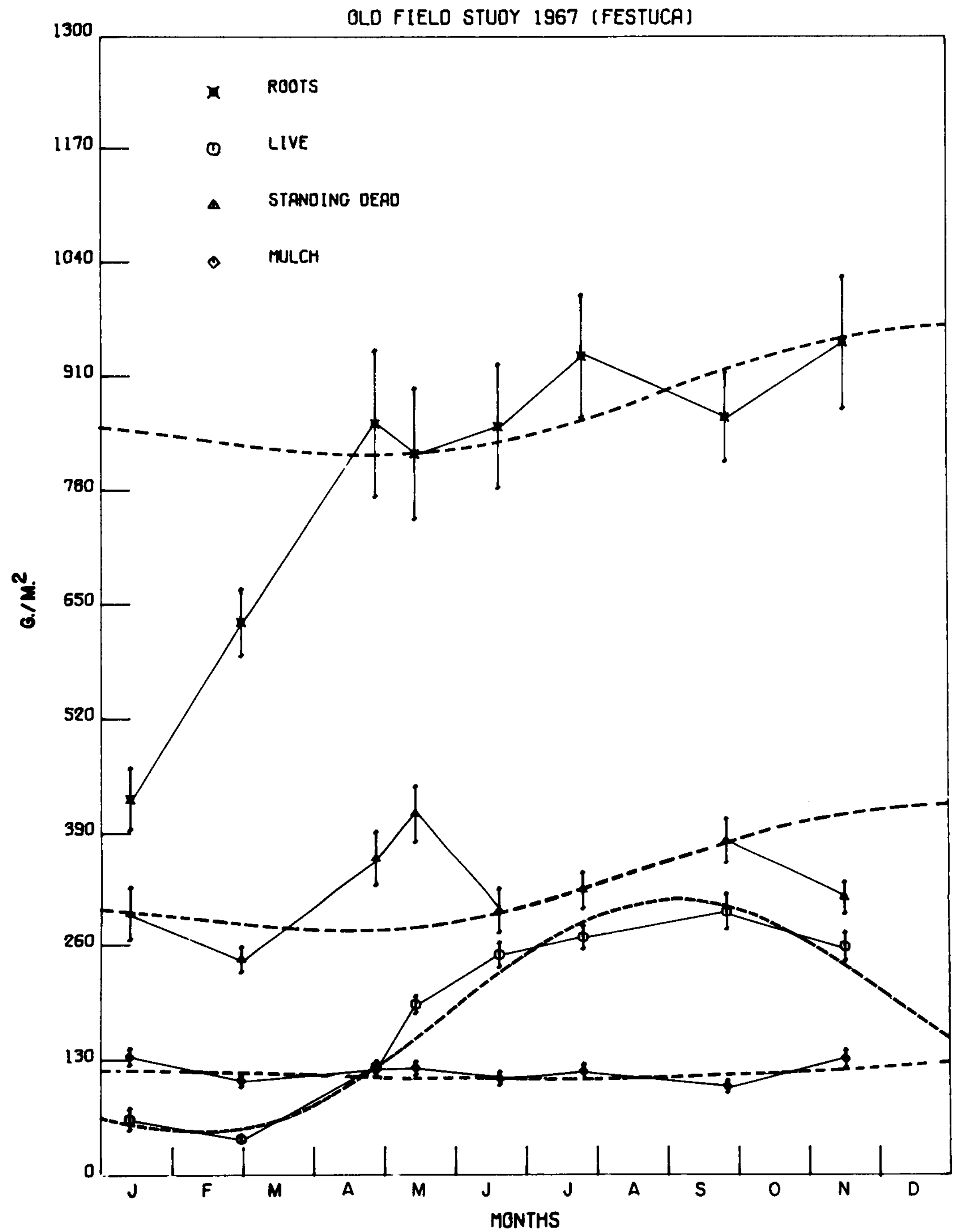

Figure 9. Comparison of the final constant coefficient model (dashed lines) with the 1967 field data (connected points) for the Festuca community ($\dot{g}/m^2$ ± S.E.).

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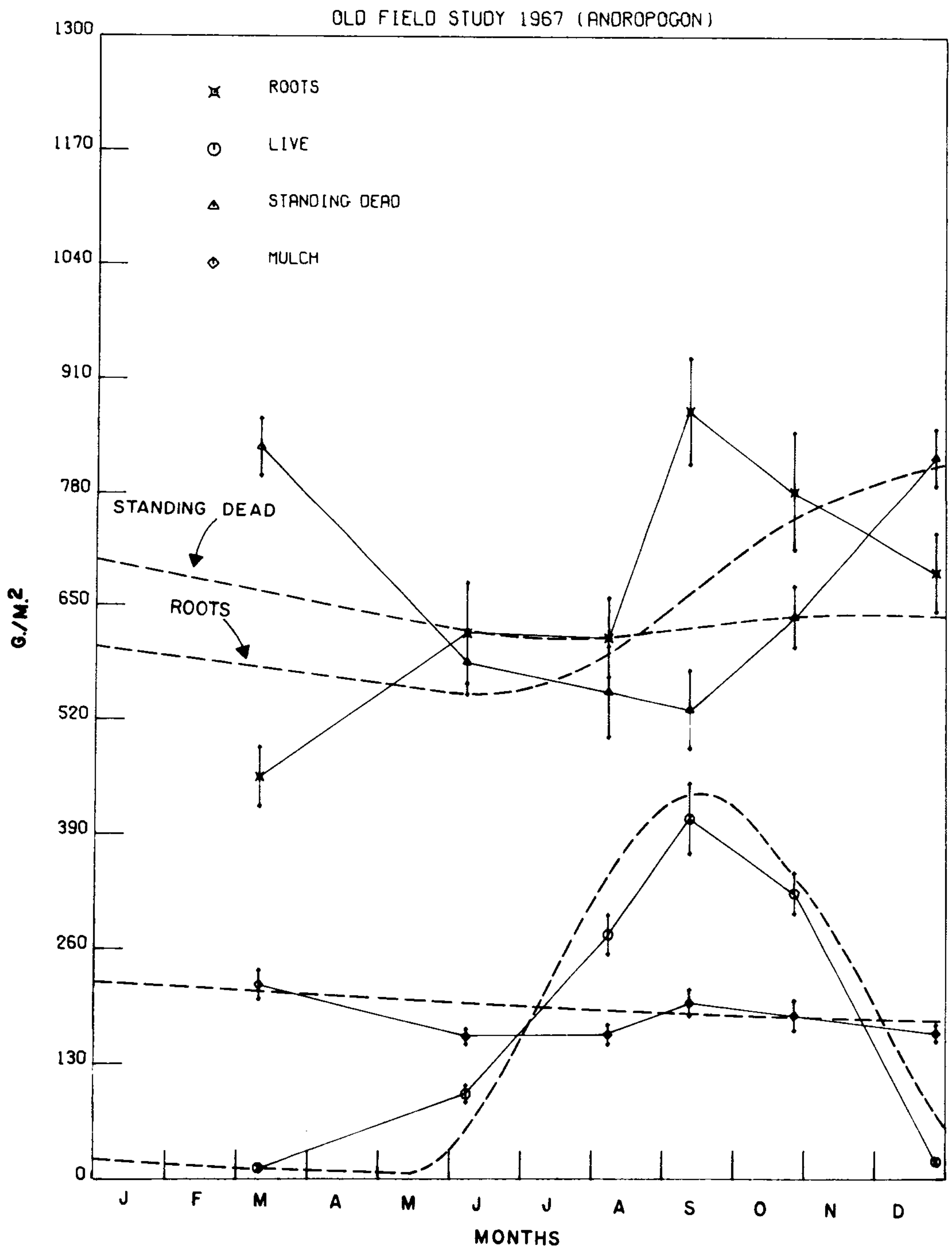

Figure 10. Comparison of the final constant coefficient model (dashed lines) with the 1967 field data (connected points) for the *Andropogon* community (g/m^2 ± S.E.).

allowed for surprisingly close approximation of all compartments for sample periods 3 through 8, but the model root values for sample times 1 and 2 were probably much higher than would be reasonable even from adjusted data (Figure 9).

Transfer Coefficients

The values used for initially approximating system behavior with a constant coefficient model here were determined from the literature, separate experimental studies or empirically from model adjustments (Table 15).

Two separate studies were conducted to determine transfer rates from the standing dead vegetation to the mulch and the decay rate of the mulch (Kelly 1968). The average rate of fall of the dry matter from the standing dead vegetation to the ground litter was 84 percent per year in the *Festuca* community and 61 percent in the *Andropogon* community (respectively .0023 percent and .0017 percent per day). These values were only taken as initial estimates for purposes of modeling.

The transfer rate for the turnover of root biomass was assumed to be 25 percent of the compartment per year (Dahlman 1967; Lundegardh 1931) and the respiration of the live top vegetation was estimated to be at least 50 percent per year (Lundegardh 1931). The other transfer coefficients, i.e., live to dead, live to roots, and source to live, were determined in relation to known or estimated transfer rates and were modified when necessary to improve the fit to the data where possible. No loss from the system was attributed to consumption by

Table 15. The Transfer Coefficients (%/Day) for the Constant Coefficient Form of the *Festuca* and *Andropogon* Models

Coefficient	*Festuca*	*Andropogon*
Source to Live Top (λ_{12})	1.0	1.0
Live Top to Live Root (λ_{23})	0.005	0.004
Live Top to Standing Dead (λ_{24})	0.005	0.002
Live Top to Respiration (λ_{26})	0.0014	0.0014
Live Root to Live Top (λ_{32})[a]	combined in transfer coefficient λ_{23}	
Live Root to Respiration (λ_{36})	0.0007	0.0007
Standing Dead to Mulch (λ_{45})	0.0018	0.001
Mulch to Respiration (λ_{56})	0.005	0.002

[a]Specifying an upward flow proportional to root mass would alter the systems behavior and require a compensating increase in λ_{23}. Both would require seasonally varying regulators and were not attempted at this stage.

herbivores. Also, the transfer coefficient from the roots to the live (top) compartment, although noted in Figure 3 (page 22), was merely subtracted from the assumed transfer from live (top) to roots. This clearly does not satisfy the biology of upward translocation.

An attempt was made at various intervals during the sampling period to obtain an estimation of upward translocation. One week after the regular samples had been collected, several plots were reclipped in order to record the amount of regrowth that had occurred: 0.81 ± 0.10 and 1.06 ± 0.11 g/m^2/week (± SE) for the Festuca community, samples 4 and 5, and 0.83 ± 0.13 and 0.97 ± 0.09 for the Andropogon community, samples 2 and 3. Not all the biomass present would be the direct result of upward translocation since some photosynthesis would occur even in this short time. The rate of biomass increase in all the samples collected, in both the Festuca and Andropogon communities, averaged less than 1.1 g/m^2/week. The transfer from the roots to the live (top) was combined with the transfer from the live (top) to the root compartments. Separate treatment could give further refinements in the modeling, but changes would be smaller than some other adjustments made later (e.g., in introduction of prompt storage $\lambda_{13} > 0$).

Revised Form of the Constant Coefficient Model

The final form of the constant coefficient models is summarized in Table 15 and Figures 9 and 10 (pages 60 and 61). The basic flow of the model was controlled by the input from the source to live compartments. The subsequent transfers were then varied to improve the overall fit to the data, still assuming a "steady flow" condition, i.e., the daily coefficients of transfer from one compartment to another were constant fractions of the donor compartment. Since these compartments varied, the flux of transferred material changed as a function of the size of the donor compartment. No steady state was assumed, except for the litter compartment (see below). The models obviously needed further modification, for the large increase in the root compartments in both the *Festuca* and *Andropogon* models and the rapid decrease in the standing dead compartment of the *Andropogon* model could not be accounted for by the constant coefficient systems (Figures 9 and 10, pages 60 and 61).

VII. CONVERSION OF THE CONSTANT COEFFICIENT MODEL TO A SEASONAL COEFFICIENT MODEL

The constant coefficient model was converted to a model of seasonally varying coefficients by altering the control of certain transfer functions (Tables 16 and 17) which appeared to be dependent on variables other than compartment size. Thus, the flux of material between compartments was no longer a constant proportion of the donor compartment. The difference equations for the variable and nonvariable models are summarized in Table 18. The source compartment for both forms of the models was approximated by a sinusoidal function. However, the total amount of input to the nonlinear models was greater. The phase of the sine oscillations was different in the *Festuca* and *Andropogon* forms (Figures 11 and 12). This was necessary in order to adjust seasonal variation of the live compartment for the expected differences between "cool season" and "warm season" growth patterns.

Table 16. Seasonally Varying Transfer Coefficients for the <u>Andropogon</u> Model ($1 \leq t \leq 365$) (%/Day)

Coefficient	Equation(s)
Source to Live Tops (λ_{12})	1.0
Live Top to Live Root (λ_{23})	$(.002 + .002\text{Sine}(2t-0.7)1.4)4.2$
Live Top to Standing Dead (λ_{24})	$0.00027e^{0.012t}$
Live Top to Respiration (λ_{26})	0.0014
Live Root to Live Top (λ_{32})	combined in transfer coefficient λ_{23}.
Live Root to Respiration (λ_{36})	$(0.0005\pm0.01\text{Sine}(t+2.))1.1$ $\quad 1 \leq t \leq 280$ $(0.0005+0.01\text{Sine}(t+2.))(365-t)0.01$ $\quad 281 \leq t \leq 365$
Standing Dead to Mulch (λ_{45})	$0.0018(1.+\text{Sine}(2t-1.56))$
Mulch to Respiration (λ_{56})	$(\lambda_{45}V_4-180.+V_5)/V_5$

Table 17. Seasonally Varying Coefficients (%/Day) for the *Festuca* Model ($1 < t \leq 365$)

Coefficient	Equation(s)
Source to Live Top (λ_{12})	1.0
Source to Live Root (λ_{13})	$0.169t-0.0014t^2$ $t < 120$; 0.0 $t \geq 120$.
Live Top to Standing Dead (λ_{24})	0.005
Live Top to Respiration (λ_{26})	0.0014
Live Root to Live Top (λ_{32})	combined in transfer coefficient λ_{23}.
Live Root to Respiration (λ_{36})	0.0007
Standing Dead to Mulch (λ_{45})	0.0018
Mulch to Respiration (λ_{56})	$(\lambda_{45}V_4-117.+V_5)/V_5$

Table 18. General Form of the Difference Equations for the *Festuca* and *Andropogon* Models[a] (See Table 2 for Symbol Definitions)

Compartment	Equation
Source (V_1)	$f+\text{Sine}(g+0.0172t)h$ (f,g, and h are constants)
Live Top (V_2)	$V_1+\lambda_{32}V_3-(\lambda_{24}+\lambda_{23}+\lambda_{26})V_2$
Live Root (V_3)	$\lambda_{23}V_3-(\lambda_{36}+\lambda_{32})V_3$
Standing Dead (V_4)	$\lambda_{24}V_2-\lambda_{45}V_4$
Mulch (V_5)	$\lambda_{45}V_4-\lambda_{56}V_6$
Respiration (V_6)	$\lambda_{56}V_5+\lambda_{26}V_6+\lambda_{36}V_3$

[a] λ_{ij} represents both constant and seasonal varying coefficients.

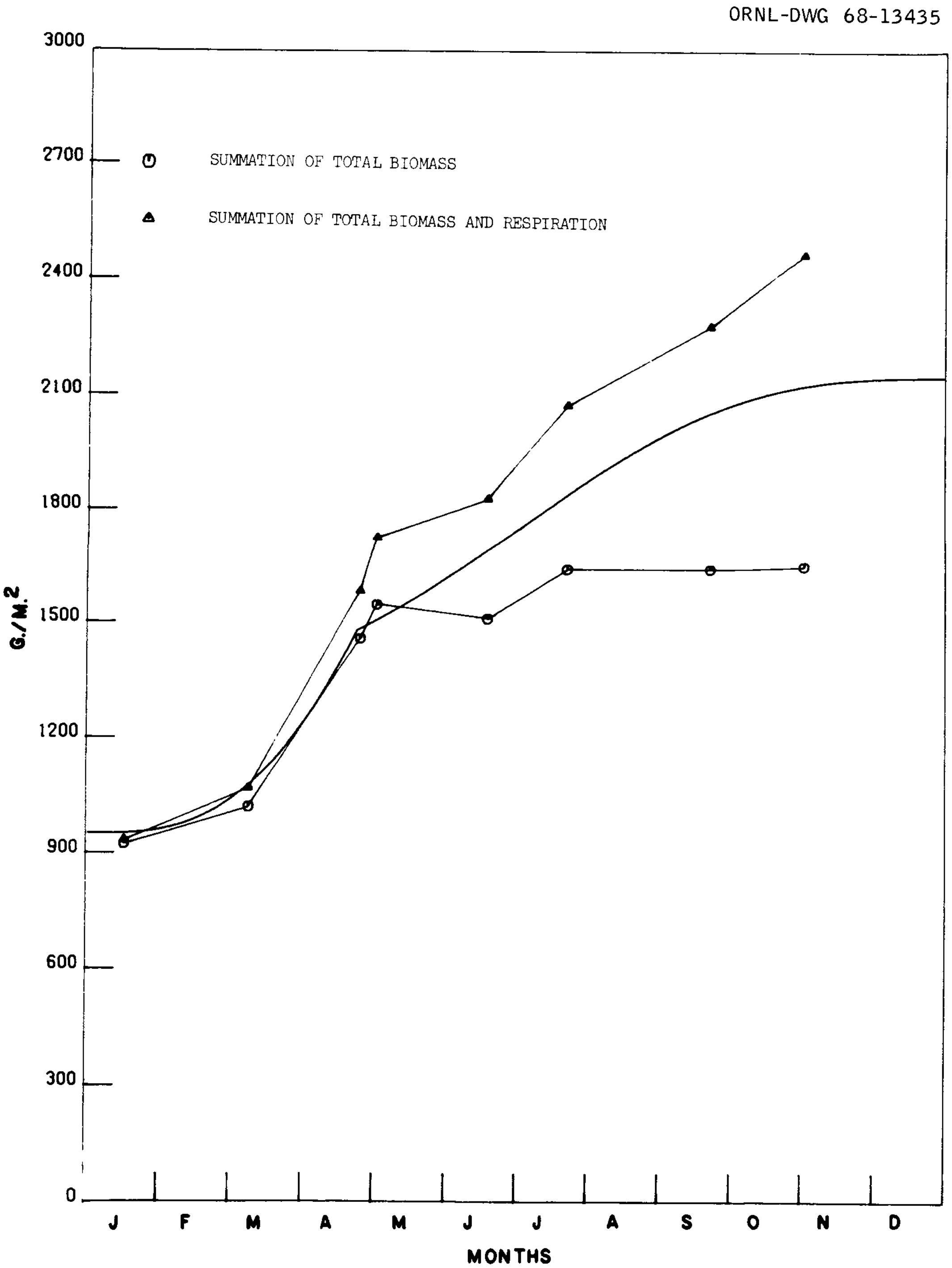

Figure 11. Comparison of the cumulative photosynthetic input (g/m^2) to the *Festuca* seasonal coefficient model (smooth line) and the estimated production (g/m^2) of the *Festuca* community (connected points).

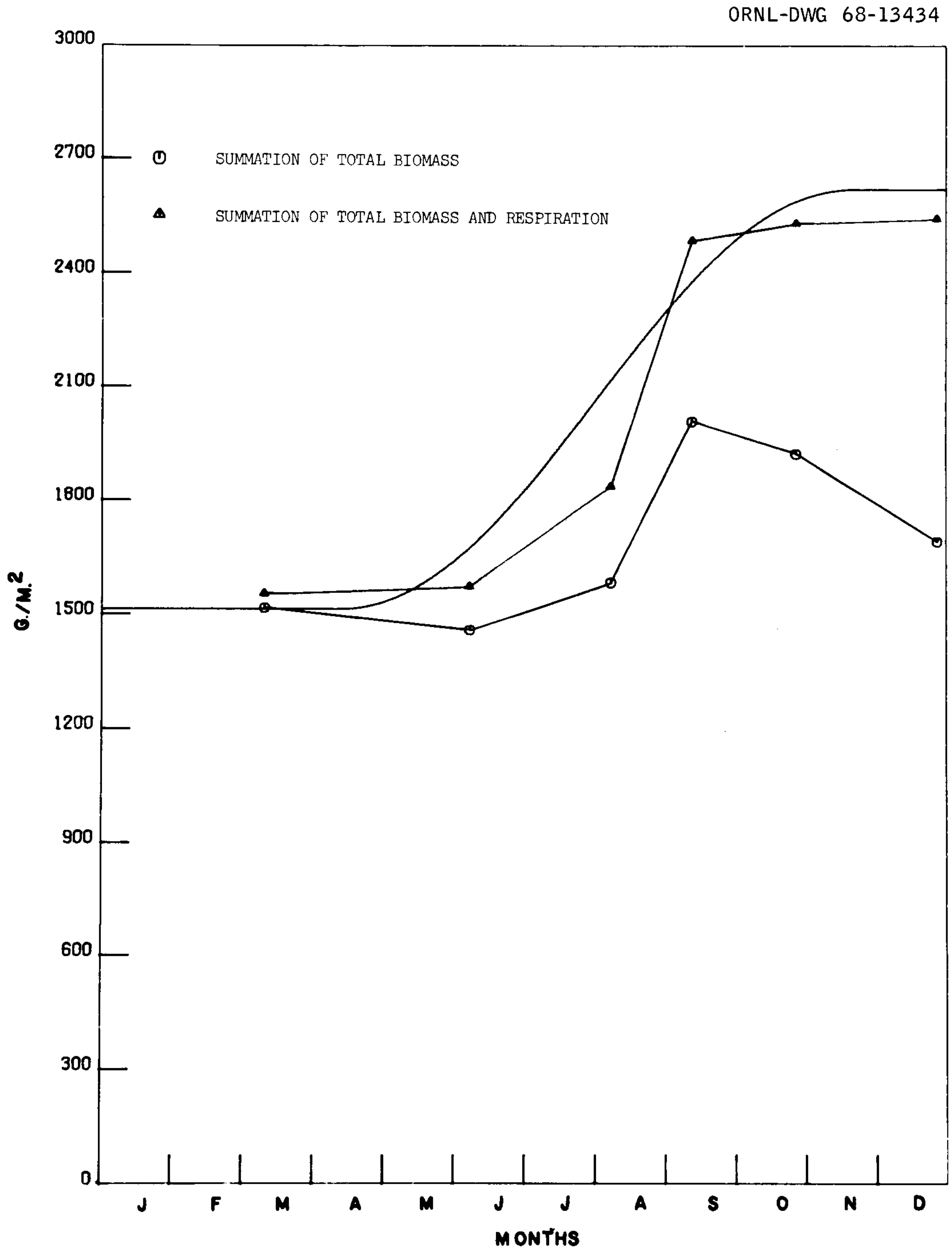

Figure 12. Comparison of the cumulative photosynthetic input (g/m^2) to the *Andropogon* seasonal coefficient model (smooth line) and the estimated production (g/m^2) of the *Andropogon* community (connected points).

Festuca Model

Results of the constant coefficient model (Figure 9, page 60) showed that while the seasonal variation of the different compartments of the Festuca community could be accounted for fairly well by constant coefficients, a major discrepancy between model predictions and actual data was the gross overestimation of the amount of root biomass present in the first two sampling periods.

Root compartment. It was assumed that in the early, cool part of the growing season, up to the beginning of flowering, a large percent of the solar input was translocated to the roots. This accounted for the large increase in the root biomass between the first and third sampling dates. It was not possible to account for this large transfer as proportional to the live top compartment, without greatly disrupting the model. Instead, a new coefficient, λ_{13}, accounted for a transfer of material directly from the source compartment to roots during each day's photosynthesis. It is accepted that the roots of these species are not capable of photosynthesis, but during the day-night time interval for which the transfer coefficients are considered, translocation is quite likely. Photosynthates, on warm winter and cool spring days, could be produced in the tops and translocated directly to the roots, all within a twenty-four hour period (Biddolph et al. 1956).

Somewhat arbitrarily, this phenomenon was first incorporated in the model by the use of a decreasing quadratic function for the transfer variable from the source to the root compartments:

$$\lambda_{13} = 0.169\ t - 0.0014\ t^2 \qquad (21)$$

where t is the time in days and constrained to the limits of $1 \leq t \leq 120$.

The decreasing quadratic function was chosen primarily because it allowed for the necessary increase in the root compartment while the transfer coefficient approached 0 as t approached 120. The maximum time value, 120, was chosen because it corresponded with the beginning of flowering. The parameters were derived to provide for the rapid increase in the root compartment while λ_{13} approached 0. The final transfer values were derived to give a "best fit" to the data.

In addition to using the quadratic function for the transfer of material between the live and root compartments for the early part of the growing season, the initial condition value of the root compartment was also modified to a lower value approximating that of the first sample, 390 grams, as compared to the 850 grams that was used as the initial condition for the constant coefficient model. This then allowed for closer approximation of the model for the first two samples. This setting and the seasonal adjustment probably led to simulated values that were lower instead of higher than collected values.

Mulch compartment. Although the mulch compartment was closely approximated in the linear model (Figure 9, page 60), it was felt that the transfer coefficient first used was too large. The value used was 150 percent per year (0.005 percent per day) as compared to 80 percent per year (0.002 percent per day) derived from the litter bag experiment (Kelly 1968). The flux of the litter compartment was not considered dependent upon a constant fractional decay rate, but the flux rate

(g/m^2/day) of the input from the standing dead compartment. The need for some adjustment is apparent if the amount of change that occurred in the standing dead compartment, V_4, is compared to the relatively constant value of the mulch compartment, V_3. There was no statistically significant difference in the amount of ground litter collected through the entire sampling period (Kelly 1968), but the hint of some damped variation suggested that exact equality of income and loss was an oversimplified approximation.

If the amount of litter really remained constant, even though large changes occurred in the standing dead compartment, it followed that the rate of decay varied with the rate of fall of the dead material. Therefore, a large litter fall would have to be compensated for by a synchronized increase in the litter decay rate. The rapid increase in the litter decay rate was necessary in order to keep the litter compartment at some mean value, 117 g/m^2.

Microorganisms are primarily responsible for the breakup and decomposition of the mulch. The size of the habitat available to the decay organisms is primarily governed by the amount of the mulch layer that is in direct contact with the mineral soil. With a large influx of dead material, which may result from the shattering of the flower stalks or dead leaves, or the beating down of the standing dead vegetation due to heavy rains, the weight of the mulch compartment is proportionally increased. This increase in weight causes more litter to come in contact with the mineral soil. Thus the size of the habitat available to the decomposers is increased, in turn allowing for rapid (exponential) growth of the decomposer population. These conditions compensate for the large influx of material, and the compartment is kept near its mean value.

The decay rate of the mulch compartment, λ_{56}, was expressed as a function of the input to the compartment, $\lambda_{45} V_4$, and the mean value of the compartment, 117 g/m^2:

$$\lambda_{56} = \frac{(\lambda_{45} V_4 - 117 + V_5)}{V_5} \qquad (22)$$

where V_5 is the mulch compartment (Figure 13). The transfer rate, λ_{56}, as expressed in equation (22) was here solely dependent upon the rate of income. The actual rate of decomposition was also influenced by precipitation and temperature, as well as by the chemical composition of the dead material, and these influences, if measured, could be utilized later in improved models.

Andropogon Model

The constant coefficient form of the Andropogon model could not account for the large seasonal variation that resulted in most of the compartments through the study period. It was necessary to introduce several variable coefficients to help account for the large seasonal changes that did occur.

Standing dead compartment. This compartment varied drastically during the growing season, inversely with the live compartment. The maximum value for the dead compartment occurred in March as opposed to September for the live compartment. This type of seasonal variation

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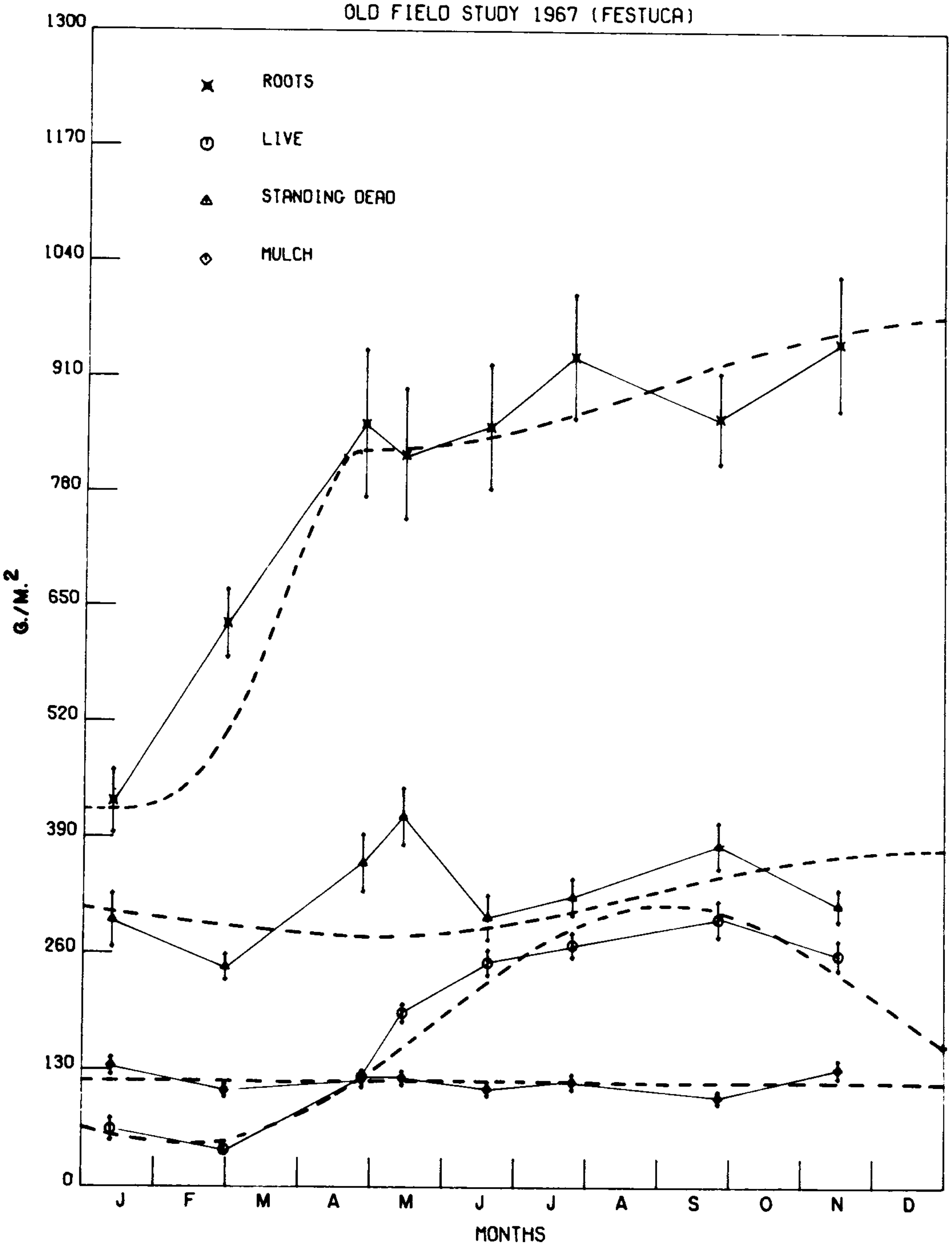

Figure 13. Comparison of the final seasonally varying coefficient model (dashed lines) with the 1967 field data (connected points) for the *Festuca* community (g/m^2 ± S.E.).

precluded a constant transfer coefficient of material from the live to the dead compartments through the year. Instead, a large transfer occurred soon after peak production, and was attributed to the obvious autumn dying of the flowering stalks (Harris 1967). This was also suggested by the rapid increase in the dead compartment soon after flowering. In order to account for this larger flux in the latter part of the growing season, an exponential function was used for the transfer of material from the live to the dead compartments:

$$\lambda_{24} = 0.00027e^{0.012t} \qquad (23)$$

where t is the time in days ($1 \leq t \leq 365$). This function arbitrarily allowed for the almost constant transfer for most of the growing season and the rapid increase in the transfer rate as peak production was attained. The constants in equation (23) were arbitrarily chosen to allow for the sudden influx to the standing dead compartment and to approximate the yearly transfer of the constant coefficient model.

The transfer from the standing dead compartment to the mulch compartment was converted to a nonlinear function in order to account for the rapid decrease that occurred in the standing dead material in the beginning of the growing season. A sinusoidal function was used to approximate the seasonal variation in the rate of litter fall:

$$\lambda_{45} = 0.00185(1.+\text{Sine}(2t-1.56)) \qquad (24)$$

where t is the time expressed as radian, $0 \leq t \leq 365$. This allowed for the minimum rate of fall to occur in the late fall when the dead flowering stalks were fresh and stiff and the maximum rate to be during middle spring when weakening by decay would increase. Winter snow was light (0.2 inches), but in other years could lead to earlier, approximately random acceleration of transfer to the litter material. The combination of these two transfer coefficients allowed for very close estimation of the standing dead compartment (Figure 14).

Mulch compartment. It was felt that the mulch compartment in the *Andropogon* field was controlled by the same set of conditions that were outlined for the mulch compartment in the *Festuca* field. This is shown well when the changes in the mulch compartment are compared to the changes in the standing dead compartment (Figure 14). The large decrease in the standing dead biomass did not appreciably change the amount of ground litter present. The rate of transfer from the mulch is described by equation (22) with the only difference being the mean value of the compartment, 180 g/m^2. This larger value is due to the different decay rates of the *Festuca* and *Andropogon* litter, 87 percent per year and 63 percent per year respectively. The lower decay rate of the *Andropogon* accounted for the larger buildup of the litter layer.

Root compartment. The root biomass demonstrated a marked seasonal flux. There was a late spring and early summer buildup to a recorded peak of 873 g/m^2 in early September. This corresponded with the peak value in the live compartment. The large buildup of the root compartment, 429 grams, between the first and third samples was similar to the increase that was recorded in the *Festuca* community, but it occurred over a longer period of time and was much later in the year. Because of

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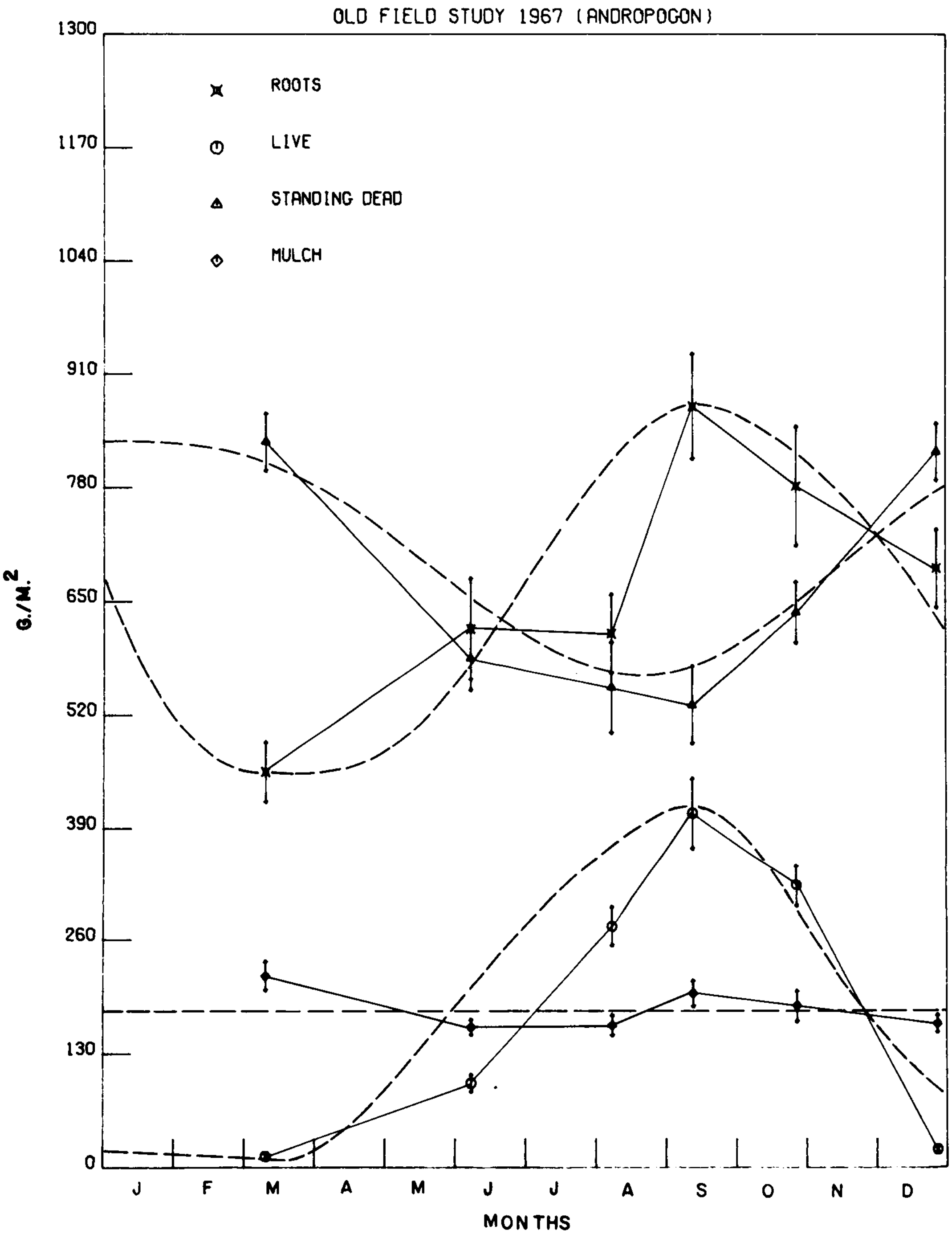

Figure 14. Comparison of the final seasonally varying coefficient model (dashed lines) with the 1967 field data (connected points) for the Andropogon community (g/m^2 ± S.E.).

the longer period covered and the later occurrence, it was not necessary, as in the *Festuca* model, to add the transfer coefficient λ_{13}, though the total amount of input was increased over the entire year. If this were added to the model, other coefficients would have to be and could be adjusted accordingly.

A sinusoidal function was used to account for the buildup of the root compartment as was the case in the *Festuca* model. This was of the form:

$$\lambda_{23} = (0.002 \pm 0.002\text{Sine}(2t-0.7)1.4)4.2 \tag{25}$$

where t is the time in days, $1 \leq t \leq 365$. This transfer from the live top to the root compartments was a seasonally varying function with maximum transfer occurring during the initial growth of the live top compartment, up to the time of flowering, and then decreasing for the remainder of the year. λ_{23}'s minimum value was arbitrarily chosen to be 0.001.

The decrease in the root compartment was incorporated into the system by another sinusoidal function:

$$\lambda_{36} = (.0005 + 0.01 \text{ Sine } (t+2))1.1 \tag{26}$$

where t is the time in days, $1 \leq t \leq 280$. Equation (26) was arbitrarily modified by the decreasing function $(365-t)/110$ for the time interval $280 \leq t \leq 365$. This then allowed for the maximum turnover of the root compartment to occur during the period after peak production was obtained. The minimum value of λ_{36} was 0.0036. This allowed for some turnover of the live root compartment to occur throughout the winter months.

Live top compartment. No attempt was made to control the live above-ground vegetation, other than the sinusoidal input from the source compartment. The input flux was increased to account for the larger amount of photosynthetic input that was used in the case of the seasonally varying coefficient form of the system. Also, the period over which the input to the system was greater than zero, or the photosynthetic process was going on, was lessened in order to account for the abrupt increase and decrease in the live (top) compartment (Figure 14, page 78). The warm-season grass, *Andropogon*, unlike *Festuca*, has neither the green foliage nor the temperature threshold to produce much photosynthate on warm winter days.

The nonlinear transfers that were used to compensate for the seasonal difference in the root and standing dead compartments did affect the pattern of seasonal variation of the live compartment advantageously. This closer approximation of the live compartment resulting from the use of these two transfers strengthened the mutual consistency of assumptions that were used for determining the variable coefficients λ_{23} and λ_{24}.

VIII. COMPARISON OF THE *FESTUCA* AND *ANDROPOGON* MODELS

The major similarity between the *Festuca* and *Andropogon* communities was the relatively constant value of the ground litter. The mechanisms involved in keeping the apparent steady state condition of the ground litter seem to be identical in both cases. From the modeling approach they imply increased decay rate at times of increased input. The differences that exist between communities and the reasons for them lie in the following areas, and may well be subject to further change in some details for mathematical or biological reasons.

Source Compartment

In both communities a sinusoidal function was used to approximate the solar input to the systems. This was not an approximation of solar energy received, for then the curves would have been identical, but rather an estimation of the utilization of the solar energy to represent the cool and warm season communities (Figure 15). The input to the *Andropogon* model was equal to zero for the winter months. This was based on the assumption that little growth occurred in the *Andropogon* community during the winter months even on warm days, although there were winter annuals of negligible mass (Kelly 1968). The initial and final dates for the production of photosynthetic material (Figure 15) coresponded with the last and first day for which the daily mean temperature was above 50° F. The maximum daily production occurred during the time when the warmest temperatures were recorded, late August. Therefore, an environmental control depending strongly on temperature would seem more relevant than one based primarily on solar energy.

The source compartment of the *Festuca* model had a slightly different phase. Here the maximum production occurred in June, corresponding more closely to the peak values for the amount of solar radiation received. Though the daily production in the *Festuca* community was not as great as that of the *Andropogon* community in the late summer (during flower stalk formation), it did continue into the winter. The model allowed for

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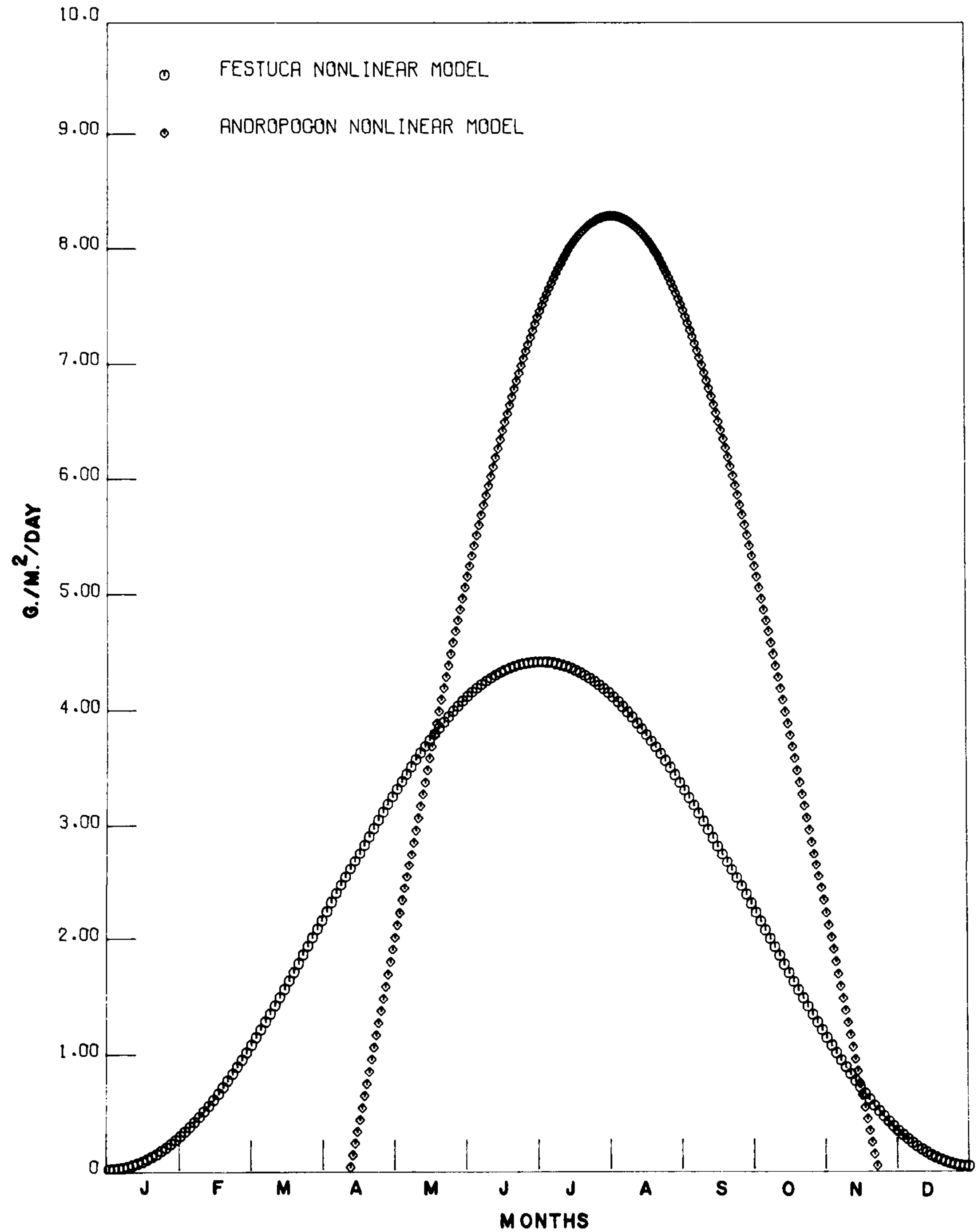

Figure 15. Comparison of daily production rates ($g/m^2/day$) as derived from the seasonal coefficient models for the Festuca and Andropogon communities.

production of photosynthetic material to occur the entire year, as would be expected to happen on warm winter days, since chlorophyll is abundant near the base of frost-nipped leaves. The temperature threshold for photosynthesis is lower in Festuca than in Andropogon, but the precise control by temperature and solar radiation is not yet clear.

Live Top Compartment

The live compartment reflected the different periodicity of the input from the source compartment, as well as the effect of the transfers to the root and standing dead compartments. In the Festuca model the live compartment demonstrated a uniform increase and decrease resulting from almost constant transfer coefficients from that compartment. An exception is the rapid shattering of flower stalks noted below.

In contrast, the live top compartment of the Andropogon model reflected a longer dormant period before growth began, a sharp increase and a sharp decline soon after peak production was attained. The sharp drop resulted from the shattering of many of the flower stalks and flower parts into the mulch and standing dead compartments.

Standing Dead Compartment

Probably the greatest difference between these two grass communities was in the seasonal variation of the dead compartments. In the Festuca community, the amount of standing dead vegetation did not fluctuate greatly during the growing season. Visible fluctuations resulted from the weight of the flowering stalks.

There was not as much death over a short period of time as was the case in the Andropogon community, but rather a gradual dying of the tips of the leaves as the bases continued to grow. The result was a continuing transfer of material into the dead compartment which was a constant fractional loss here, but this transfer could be made more random. Andropogon death came at the end of the growing season, with a more discrete time point than Festuca which died throughout the entire season.

The second factor that contributed to the uniformity of the standing dead compartment was the small proportion of the total weight that the flowering stalks accounted for (less than 2 percent). The death of this portion of the live vegetation soon after flowering did not greatly influence the amount of standing dead vegetation (Figure 13, page 75) even though it had a conspicuous effect on the community's appearance.

The dead compartment of the Andropogon community was the opposite of the Festuca community. A large part of the live mass was contained in the flower stalks in Andropogon virginicus. This together with the nonuniform pattern of dying of the live vegetation (Harris 1967) caused a rapid increase in the dead compartment soon after flowering occurred (Figure 14, page 78).

The difference in these two grass communities was reflected in the different transfer functions that were used to regulate the dead compartment (Tables 3 and 4, pages 28 and 29). The Festuca model involved a constant transfer for the growing season, whereas the Andropogon model involved the uses of varying functions to define the seasonality of the standing dead compartment, and these should ultimately be related to temperature or photosynthesis control.

Root Compartment

The root compartment may be associated with the annual change of the above-ground vegetation. In the *Festuca* community there was a large increase in the total root biomass in the early spring, even preceding much early growth of the live vegetation, up to the time of flowering. There was a relatively constant value for the rest of the growing season. This constant state, with no recorded decrease at the end of the year, might be accounted for in two ways. First, the two earliest sampling periods might have been underestimations of the total root biomass. Second, the *Festuca* community may not have attained a steady-state condition in the amount of live vegetation, roots and tops. The latter explanation would be in agreement with the overall increase in the live vegetation at the end of the year. Some dying of roots (as well as tops that feed them) was expected, but measurements or modeling was not continued to determine whether the midwinter minimum was as low as in the preceding year.

The root compartment of the *Andropogon* community also followed the pattern of growth of the live compartment. The increase in the root compartment occurred later in the year, as did the live vegetation, with the peak value being attained at the time of flowering. Then there was a decrease for the rest of the year. This larger seasonality in the roots in part can be attributed to the difference in the two grass communities in that the successional *Andropogon* had attained a condition of approximately maximum development. This assumption is reinforced by the observed large seasonal variation of all the compartments. The final values of the different compartments in each year were either close to the initial values of the system, or at least moving in the expected direction.

IX. YEARLY NET PRIMARY PRODUCTION: MODEL FUNCTIONS AND FIELD DATA

Net production is generally defined to mean gross primary production minus respiration (Odum 1959; Ovington 1962, 1965). Estimates of net production are commonly found in the literature, but too often do not fulfill the meaning of this definition.

Most estimates, based on biomass or its changes, give gross primary production minus respiration losses, minus certain additional unmeasured losses. Results tend to underestimate net primary production unless corrections are made for these losses (Olson 1964). Net primary production estimates based on the sum of positive increments for each species were used by Kelly (1968) so that estimates of our field data could easily be compared with those based on biomass results in the literature.

The object here was to go one step further and obtain an estimate of net primary production as defined by Odum and others. This was done by using the estimates of input to the seasonal coefficient models (gross production) and subtracting from this preliminary estimates of respiration that occurred in the live vegetation (roots and shoots) derived from the transfer coefficients for live top and root respiration.

From the seasonal coefficient model of the *Festuca* community gross primary production was calculated to be at least 1220 g/m^2 per year. Net primary production was estimated to range from 921 g/m^2 to

1116 g/m^2 per year depending upon whether the turnover in the root compartment was due entirely to death of the roots or only to respiration. The two extreme cases were used so that a limit could be placed on net primary production and the actual value would therefore lie somewhere between these limits, if certain assumptions were applicable to the local case.

The calculated value for positive biomass increments determined from the field data was 992 g/m^2 per year. This fell within the limits set by the model estimates. Since this was accepted to be an underestimation, the true net production then was probably closer to the upper limit of the two bounds suggested here.

The estimate of gross primary production in the Andropogon seasonal coefficient model was 1145 g/m^2 per year, and the range of net production was from 853 g/m^2 per year to 1060 g/m^2 per year. The calculated value from the clipped data, 892 g/m^2 per year fell within limits derived from the model.

The estimates obtained from the seasonally varying model for the gross production of the two communities probably were underestimates. The yearly respiration rate for the live top vegetation was chosen to be 0.0014 percent of live top per day or 50 percent on a per year basis. This estimate (Lundegardh 1931) for warm summer days when photosynthesis is at a maximum, probably underestimated the actual rate of respiration occurring under certain conditions, such as times of rapid tissue growth in early spring.

The turnover rate of the root compartment was estimated to be 0.0007 percent per day or 25 percent per year. This rate more correctly reflected the decay of the roots, but as much as another 50 percent per year might have been attributed to respiration. If the transfer rates used in the seasonally varying model were increased accordingly, the gross primary production would also have to be increased to compensate for this. Since the seasonal variations in respiration rate (as related to tissue mass or to rate of photosynthesis) may have different phasing relations than the top or root mass, direct measurements of parameters would be desirable for important periods.

X. DAILY PRODUCTION RATES: MODELLED vs CLIPPED DATA

Our preference of the seasonal coefficient model over the constant coefficient model was not just its ability to approximate the field data on mass/area, but also the ability to approximate the production rates and patterns that occurred between successive sample periods. It is this predictive ability that would make the seasonal coefficient model a useful tool in describing yearly variation of various ecosystems, even if typical rate data are used. Listed in Table 19 are the daily production estimates between sample dates for the Festuca and Andropogon communities as obtained from the field data and estimates from the seasonal coefficient model for the live top and root compartments.

In most cases the two values are in agreement with each other, especially in the live compartment. The discrepancy that does occur can partially be attributed to the large standard error about the sample means (Figures 13 and 14, pages 75 and 78). The size of the production rates agrees with those reported by Harris (1967).

Table 19. Daily Positive Biomass Change Rates as Obtained from the Field Data (F) and Estimated by the Seasonal Coefficient Model (M), g/m²/day, for the Festuca and Andropogon Communities

Sample Dates	Field			Model		
	Top	Root	Total	Top	Root	Total
Festuca Community						
1/12 - 3/10	-	3.44	3.00	0.03	2.59	2.62
3/10 - 4/28	1.67	4.63	6.30	1.30	5.76	7.06
4/28 - 5/18	3.50	-	2.31	2.20	0.28	2.48
5/18 - 6/19	1.75	1.00	2.75	2.06	0.32	2.38
6/19 - 7/24	0.54	2.28	2.82	1.67	0.71	2.38
7/24 - 9/26	0.88	-	-	0.30	0.93	1.23
9/26 - 11/27	-	1.37	0.73	-	0.68	0.27
Andropogon Community						
3/10 - 6/17	1.05	2.06	3.11	1.76	1.57	3.33
6/17 - 8/7	2.95	-	2.83	2.85	2.88	5.73
8/7 - 9/7	3.50	8.41	11.91	1.22	4.58	5.80
9/7 - 10/24	-	-	-	-	-	-
10/24 - 12/21	-	-	-	-	-	-

The agreement of the daily net production rates, as estimated by the seasonal coefficient model, with the field data and those in the literature tends to strengthen the purely mathematical equations that were used to approximate compartmental transfers as reasonable expressions of the relationships that exist between the compartments.

XI. ADDITIONAL TRANSFER COEFFICIENTS

Of the thirteen transfer coefficients shown in Figure 3 (page 22) only nine were incorporated into the seasonal coefficient model. The remaining four coefficients, λ_{37}, λ_{25}, λ_{46}, and λ_{57}, were omitted due to the vagueness in prior knowledge of the rates and the initial purpose of developing the simplest reasonably accurate model covering major trends. Though these four coefficients were excluded they are not necessarily unimportant and will be discussed briefly for the guidance of future work.

The movement of live vegetation directly into the mulch layer, λ_{25}, may come as a result of prompt molding of lower leaves, seed shattering, or the breaking off of flower stalks and leaves due to heavy rains, hail or glaze. The effect of the latter is probably not as important in the grass communities as it would be in a forest ecosystem. Seed shattering might result in some direct transfer for a short period of time soon after flowering, though the actual effect on the mulch compartment would not be significant, since, at least in the *Festuca* community, the weight of the flowering stalks was generally less than 2 percent of the total weight. The flowering bodies in the *Andropogon* community comprised a larger proportion of the total weight, 15 percent, but this was due primarily to the stalk itself, and this was known to withstand weathering well in our area. In the grasslands with heavy or early (wet) snow and/or strong winds this transfer could be quite important. A model treating such changes ideally would be related to the probability of such weather events.

A major transfer could result from the decay and respiration of the standing dead material, λ_{46}. This could have accounted for appreciable changes in the standing dead vegetation of the *Festuca* community where there was a simultaneous growth and death of the leaves. In this situation, the dead portion of the leaf would remain supported above the ground by the live lower part. Respiration of microorganisms on the leaf could continue for a long period of time so that only a fraction of their mass would remain to enter litter. The flower stalks of the *Andropogon* community are stiff and hard, and they remain standing into the next growing season, before being weakened enough to fall. Over this period of time, assuming that the flower stalks are not battered down due to heavy snow in the winter months, the weight loss due to microbial respiration could approach the amount actually reaching the litter until the stalks weaken enough to be transferred to the litter.

In the final form of the seasonal coefficient model the turnover of the mulch compartment, λ_{56}, was transferred to compartment V_6, respiration. It should be noted that the "respiration" compartment of the model thus was more of a "catch all" into which respiration and decay losses were transferred. Additional compartments were added (though not shown in Figure 3, page 22) to allow for the accounting of respiration losses separate from decay losses. Though some respiration of the litter compartment does occur, some portion of its loss would add directly to soil organic matter. In actuality, the transfer function represented by λ_{56} does account for this, but no attempt was made to measure or model humus changes for such a short period.

The turnover of the root compartment, λ_{36}, was estimated to be 0.0007 percent per day or about 25 percent per year of the total root biomass. This was mentioned in the section on gross and net production and was probably completely due to decay of the root system rather than to respiration of its living tissues. In future models this transfer could be supplemented by an additional function, λ_{37}, to account for the respiration of the root system independently of the decay. It is generally considered that organic matter transferred from roots to humus is much more important for grassland soils than contributions from litter. Further model studies could show how widely the coefficients of transfer could vary, and still fulfill this hypothesis. Results of the combined input from roots and litter to humus could then be related to accumulation of the latter over long periods, as considered by Neel and Olson (1962), Olson (1963), and Gore and Olson (1967).

B-V.

CONCLUSIONS

The rapid sampling methods tested in this study proved to be useful in supplementing the standard clipping procedure, even though some destructive clipping was necessary for calibration. The dry-weight-rank and capacitance methods gave a more complete picture of the vegetation composition, both by species distribution and the amount of total biomass (live and dead) present than was possible with the destructive clipping of plots in the stratified sampling scheme that was employed. The non-destructiveness of this method gives the sampler an opportunity to resample areas several times in a single growing season. Also, the large number of samples can be taken without the time-consuming laboratory chores of sorting, weighing and drying.

In the evaluation of the rapid-sampling methods used here a major burden was the large number of plots (40 per sample date) that were used for calibration of the prediction equations. However, results show how it could often be desirable to clip a smaller number of plots initially, and use the time saved for additional rapid sampling measurements. Where vegetation composition is irregular this may not be possible, so each kind of vegetation needs some preliminary evaluation like that used here. The dry-weight-rank procedure was most useful when measuring the floristic composition (percent weight composition) of a highly diversified community. The capacitance method proved most useful when the vegetation was uniform in its composition. Thus, a systems analysis of the research operation itself is useful, and may repay the initial effort manyfold in later economies of effort.

The modeling approach to the description of intraseasonal dynamics is a systems analysis of the ecosystem itself. It allows for the expression of the interrelations of the various compartments as mathematical equations and coefficients. The equations used in the seasonally varying coefficient model are by no means final, but they did allow for close approximation of the field data. Since 1967 was an extremely wet year in east Tennessee, stresses that normally would have been present during the midsummer months, even in a humid region, did not occur. This probably modified certain transfer rates, which in turn would affect the various compartment sizes. Because of this, it was not necessary to account for soil moisture stress on the system, but that refinement would be desirable in many years, especially in arid regions. This did simplify the modeling procedure here, but leaves many hints for later refinement in modeling.

One purpose of the modeling was to obtain estimates of gross and net primary production that allowed for simultaneous losses of living and dead organic material. The range of values obtained straddled those calculated from the clipped data based on summations of positive increments between clipping. These results probably placed a lower limit on the gross and net production of the system, since the arbitrary assumptions (e.g., on respiration and root turnover) seemed to be conservative.

Future studies for obtaining data for modeling should place more emphasis on obtaining data over periods of time longer than one growing season. This would improve the estimation of transfer coefficients as periodic functions rather than formulas that are restricted to one year. Also, initiation of short term studies to obtain estimates of transfers that occur only within specific time periods (e.g., flowering, seed shattering, snow effect on standing vegetation) could be more important in other grasslands than they were here. Part of the losses from live materials (especially roots) would be input to soil humus, and longer-term studies would be desirable for the soil carbon/nitrogen relations of humid grasslands, comparable with those of natural prairie and dune soils (Dahlman, Olson, and Doxtader 1968).

B-VI.

SUMMARY

Two grassland communities, one dominated by Kentucky-31 fescue (Festuca elatior - var. arundinaria Schreb.) and the other by broomsedge (Andropogon virginicus L.), were sampled periodically through 1967. At each sampling forty 1 m^2 plots were collected of which a 0.25 m^2 subsample was sorted, dried and weighed. Twenty root core samples were taken from within the plots. In addition 100 unclipped plots were read with a capacitance meter, the amount of standing dead vegetation was visually estimated and a rank was assigned to the vegetation present according to its weight proportion.

There were two purposes for the study: (1) to apply various mathematical techniques to the sampling and analysis of the data and to explore their feasibility for streamlining future investigations; (2) to develop computer models for the theoretical estimation of gross and net primary production and for the mathematical description of transfer coefficients.

Two rapid sampling methods were involved: (1) the dry-weight-rank method for fast estimation of botanical composition on a dry weight basis and (2) the use of a capacitance meter for measuring the standing crop of herbaceous vegetation. The dry-weight-rank method gives an accurate estimate of the botanical make-up of a grassland on a dry weight basis, with a minimum of cutting and hand-separation of samples. The visual estimates of species composition were multiplied by a set

of correction coefficients to give the dry weight percentages of each species.

This method was tested by comparing the results with those of the hand separated clipped plots. It was found that negligible differences occurred between the two methods when the vegetation was uniform, but when large species variation occurred the dry-weight-rank method was better able to account for the variation than the clipped plot method.

The capacitance meter method gives an accurate estimate of the total herbage biomass without the necessity of clipping large numbers of plots. In a series of plots only capacitance readings and visual estimates of the percent standing dead vegetation were taken. These estimates plus mean values for mulch weight (g/m^2) and percent water in the vegetation obtained from the clipped vegetation were run in a five variable multiple regression prediction equation. The estimates from the equation were compared to the clipped data. The total yield by the capacitance method did not detect significant differences ($p < 0.1$) when compared with the clipped peak biomass values of the two communities. Estimated values for the Festuca and Andropogon communities were 678 g/m^2 and 1012 g/m^2 respectively as compared to the clipped values of 672 g/m^2 and 958 g/m^2 including standing dead as well as live material.

A seven-compartment model was designed to simulate the redistribution of dry matter through the system. The transfer coefficients of the final model were both constant and seasonally varying values. The constant values were derived from separate studies or abstracted from the literature. The seasonally varying coefficients were expressed as mathematical functions independent of the system, but were related to biological or environmental phenomena. A close fit to the data resulted.

Gross and net primary production of the two grassland communities was estimated from the model. Gross production for the *Andropogon* community was estimated to be 1146 g/m^2 per year and 1220 g/m^2 per year for the *Festuca* community. The net production of these two communities was calculated to be gross primary production minus respiration. An upper and lower bound were derived depending upon whether the estimated turnover in the root compartment, 0.0014 percent per day (25 percent per year), was completely due to respiration or death of roots. The net production of the *Festuca* community was estimated to range from 921 g/m^2 per year to 1115 g/m^2 per year as compared to the clipped value of 992 g/m^2 per year. The range of estimated net production for the *Andropogon* community was 853 g/m^2 per year to 1060 g/m^2 per year as compared to 892 g/m^2 per year for the clipped data.

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Part B. Preliminary Modeling and Systems Analysis

APPENDIX A

```
      PROGRAM LISTER
      DIMENSION TYPE(200)
C*****CONTROL CARDS NEEDED...
C*****1. LIST OF SPECIES NAMES TO BE CHECKED, (PLANT) FORMAT A8, VARIABLE NO.
C*****        OF DATA CARDS
C*****2.BLANK CARD, 1 CARD
C*****3. NUMBER OF SPECIES IN ORGINAL LIST (N), FORMAT I3, N MUST BE AT LEAST
C*****4 ORGINAL SPECIES LIST, FORMAT A8, N CARDS
      TYPE INTEGER ZZZ
C*****ZZZ, DUMMY VARIABLE USED IN CHECK FOR LAST DATA CARD
      ZZZ=20202020202020208
C*****SET COUNTER, MAX, EQUAL TO 0
123   MAX=0
C*****TAPE 56, STANDARD INPUT TAPE
      REWIND 56
C*****READ IN LIST OF SPECIES NAMES TO BE COMPARED AND WRITE ON TAPE 56
1     READ100,PLANT
C*****CHECK FOR LAST CARD (BLANK) IN DATA DECK, IF NOT LAST CARD WRITE
C*****SPECIES NAME ON TAPE 56
      IF(PAJO(PLANT,ZZZ))2,3
2     WRITE(56,100) PLANT
C*****COUNT NUMBER OF SPECIES READ FROM TAPE 56
      MAX=MAX+1
      GO TO 1
3     REWIND 56
C*****ITEM, DUMMY VARIABLE TO COUNT NUMBER OF NAMES READ FROM TAPE 56
      ITEM=0
C*****READ THE NUMBER OF SPECIES IN ORGINAL LIST, N
      READ 200,N
C*****READ ORGINAL LIST OF N SPECIES AND STARE IN TYPE
      READ 201,TYPE(I)
      REWIND 56
11    CONTINUE
C*****READ SPECIES NAME FROM TAPE 56, CHECK TO SEE IF ALREADY PRESENT, IF
C*****NO, ADD TO LIST, IF PRESENT READ NEW NAME
      READ(56,100),PLANT
      DO 13 I=1,N
C*****FUNCTION PAJO, USED TO COMPARE TO ALPHANUMERIC CHARACTERS
      IF(PAJO(PLANT,TYPE(I)))13,12
13    CONTINUE
      N=N+1
      TYPE(N)=PLANT
12    CONTINUE
C*****SEE IF ALL SPECIES NAMES HAVE BEEN CHECKED
      ITEM=ITEM+1
      IF(ITEM-MAX)11,17,17
17    CONTINUE
```

```
C****(PRINT TOTAL NUMBER OF DIFFERENT SPECIES AND THEIR NAMES
      PRINT 300,N
      PRINT 301,(TYPE(I),I=1,N)
      GO TO 123

C*****FORMATS
100   FORMAT(A8)
200   FORMAT(I3)
201   FORMAT(A8)
300   FORMAT(1H1,= NUMBER OF DIFFERENT SPECIES=, I8)
301   FORMAT(1H ,A8)
      END
```

```
      FUNCTION PAJO(A,B)
C*****PAJO USED TO COMPARE ALPHANUMERIC CHARACTERS
      PAJO=(.NOT.A.AND.B).OR.(.NOT.B.AND.A)
      RETURN
      END
```

```
      PROGRAM FREQ
      DIMENSION WEED(50),R(50)
C     THE PURPOSE OF THIS PROGRAM IS TO DETERMINE THE FREQUENCY OF THE
C     DIFFERENT SPECIES  PRESENT IN EACH SAMPLING PERIOD
      TYPE INTEGER SQ
      TYPE INTEGER WEED, SP

C     CONTROL CARDS NEEDED
C     1. NUMBER OF SPECIES (N), 1 CARD, FORMAT I4
C     2. TOTAL NUMBER OF PLOTS (TOTAL) 1 CARD, FORMAT F10,0
C     3. SPECIES REFERENCE LIST, N CARDS, FORMAT A8
C     4. DATA ,SPECIES NAMES FOUND IN EACH PLOT
C     5. BLANK CARD

C     WEED, REFERENCE LIST OF DIFFERENT SPECIES
C     R, ARRAY TO CONTAIN THE FREQUENCY OF THE DIFFERENT SPECIES
      SQ, DUMMY VARIABLE USED IN CHECKING FOR LAST DATA CARD
      SQ=2020202020202020B

C     READ ROWS (N,SPECIES)
C     READ THE NUMBER OF SPECIES, N
99    READ100  ,N

C     READ THE TOTAL NUMBER OF PLOTS CLIPPED
      READ 999,TOTAL

C     READ IN SPP. REF. LIST
      DO 1 I=1,N
1     READ 101,WEED(I)

C     ZERO OUT R MATRIX
      DO 2 I=1,N
2     R(I)=0

C     READ IN DATA, CHECK FOR SPECIES NAME.
C     ADD 1 TO APPROPIATE POSITION IN R
20    READ 102,SP,WT
C     CHECK FOR LAST CARD IN DATA
      IF(PAJO(SP,SQ))21,5

C     DETERMINE THE FREQUENCY OF THE DIFFERENT SPECIES
21    DO 3 I=1,N
      IF(PAJO(SP,WEED(I)))3,4
3     CONTINUE
4     R(I)=R(I)+1.
      GO TO 20
5     CONTINUE

C     PRINT OUT THE NUMBER OF DIFFERENT SPECIES
      DO 10 I=1,N
10    R(I)=R(I)/TOTAL
8     CONTINUE
C     PRINT SPECIES LIST AND ASSOCIATED FREQUENCY
      PRINT 500
      DO 109I=1,N
      PRINT 202,WEED(I),  R(I)
```

```
109    CONTINUE
       GO TO 99
C      FORMATS
202    FORMAT(1H ,A8,F10.8,5X,F10.8)
500    FORMAT(1H ,.SPECIES  FREQUENCY        PCT. WT.../)
102    FORMAT(8X,A8,2X,F10.0)
101    FORMAT(A8)
999    FORMAT(F10.0)
100    FORMAT( I4)
       END
```

```
      PROGRAM RANK
      DIMENSION WEED(30),R(30,20),W(30)
      COMMON WEED, R, W, N, M
C     PROGRAM RANK CALCULATES A MATRIX OF THE PROPORTION OF TIMES THE I-TH
C     SPECIE RECEIVED THE J-TH RANK

C     CONTROL CARDS NEEDED
C     1. NUMBER OF RANKS (M), AND NUMBER OF ROWS (N), 1 CARD, FORMAT 2I4
C     2) SPECIES REFERENCE LIST, N CARDS, FORMAT A8
C     3. DATA YSPECIES NAME, RANK AND WEIGHT)  VARIABLE NO. OF CARDS
C     4. BLANK CARD, 1 CARD

C     WEED, REFERENCE LIST OF DIFFERENT SPECIES
C     R, SPECIES X RANK MATRIX
C     W, VECTOR OF SPECIES DRY WEIGHT EXPRESSED AS A PROPORTION OF THE
C     TOTAL WEIGHT

C     READ ROWS (N,SPECIES), COLS. (M,RANKS)
99    READ100,M,N

C     ZERO OUT R AND W MATRICES
      DO 2 I=1,N
      DO 2 J=1,M
2     R(I,J)=W(I)=0

C     READ IN SPP. REF. LIST
      DO 1 I=1,N
1     READ 101,WEED(I)
C     READ IN DATA, CHECK FOR SP. AND RANK. PUT INTO
C     APPROPRIATE POSITION IN R AND W MATRICES
20    READ 102,SP,IR,WT
C     CHECK FOR LAST CARD IN DATA DECK
      IF(WT.EQ.0.AND.IR.EQ.0)5,21
C     DETERMINE COLUMN POSITION, I
21    DO 3 I=1,N
C     FUNCTION FOR COMPARING TWO ALPHA NU,ERIC CHARACTERS
      IF(PAJO(SP,WEED(I)))3,4
3     CONTINUE
      PRINT 300,SP,IR,WT
      GO TO 20
C     IR = ROW POSITION
4     R(I,IR)=R(I,IR)+1.
C     ADD WEIGHT TO WEIGHT VECTOR
      W(I)=W(I)+WT
      GO TO 20
5     CONTINUE
C     DUMMY STORAGE VARIABLE, USED TO MAKE PROPORTIONS OF DRY WEIGHTS
      TOTAL=0
      DO 6 I=1,N
C     KEEP COUNT OF THE NUMBER OF TIMES A GIVEN SPECIES RECEIVED
C     A PARTICULAR RANK

C     CHANGE WEIGHT MATRIX TO PROPORTION
6     TOTAL=TOTAL+W(I)
      DO 7 I=1,N
7     W(I)=W(I)/TOTAL
```

```
C       CHANGE RANK MATRIX TO PROPORTION
        DO 8 J=1,M
        TOTAL=0
        DO 9 I=1,N
9       TOTAL=TOTAL+R(I,J)
        DO 10 I=1,N
10      R(I,J)=R(I,J)/TOTAL
8       CONTINUE

C       PRINT OUT NUMBER OF SPECIES (N) AND NUMBER OF RANKS (M)
        PRINT 200, N,M

C       PRINT HEADING
        PRINT 201, (I,I=1,M)
        DO 109I=1,N

C       PRINT SPECIES REFERENCE LIST, RANK MATRIX AND WEIGHT VECTOR
        PRINT 202,WEED(I),( R(I,J),J=1,M, W(I))
109     CONTINUE
        GO TO 99

C       FORMATS
100     FORMAT(2I4)
101     FORMAT(A8)
102     FORMAT(8X,A8,I2,F10.0)
200     FORMAT(1H1,2I4,/)
201     FORMAT(1H ,8X,10(I6,4X),/)
202     FORMAT(1H ,A8,11F10.8)
300     FORMAT(1H ,*SPECIES NOT ON LIST*,4X,A8,I2,F10.3)
303     FORMAT(1H ,A8,5X,I2,F10.4,*(((((****)))))*
        END
```

```
      PROGRAM ROOTS 8
      DIMENSION ID(7)
      DIMENSION KONTROL(11)
      DIMENSION          ID2(100),ID3A(100),        DRY(100),ASH(100),
     1DIFF(100),         ID3B(100),X(3)
     2  ,I1(100),I2(100),I3(100),I4(100),I5(100),D1(100),D2(100),D3(100
     3),D4(100),D5(100),D6(100),D7(100),D8(100),D9(100),D10(100),D11(100)
     4),D12(100),D13(100),D14(100),D15(100)

C     CONTROL CARDS NEEDED... 1, NUMBER OF DATA POINTS, 1 CARD (I4)
C                             2, DATA CARDS
C                             3, IDENTIFICATION, 1 CARD (7A8)
C                             4, NAMES OF VARIABLES, 1 OR 2 CARDS, (10A8)
C                             5, OUT PUT FORMAT, 1 CARD (10A8)

C*****ID2 IS THE PLOT NUMBER
C*****ID3 IS THE SOIL DEPTH
C*****DRY IS THE DRY WEIGHT OF THE SAMPLE
C*****ASH IS THE ASH WEIGHT OF THE SAMPLE
C*****DIFF IF THE ORGANIC MATTER CONTENT OF THE SAMPLE
C*****ALL OTHER DIMENSIONED VARIABLES ARE DUMMY ARRAYS

C*****VARIABLES ARE ZEROED OUT
      SQ=SUM=0,
      DR1=DR2=DR3=DR4=SR5=DF1=DF2=DF3=DF4=DF5=DRSQ1=DRSQ2=DRSQ3=SRSQ4=DR
     1SQ5=DFSQ1=DFSQ2=DFSQ3=DFSQ4=DFSQ5=0.
      S1=SS1=SQ1=S2=SS2=SQ2=S3=SS3=SQ3=S4=SS4=SQ4=S5
     1=SS5=SQ5=0,
      DO 22,I=1,100
      I1(I)=I2(I)=I3(I)=I4(I)=I5(I)=D1(I)=D4(I)=D7(I)=D10(I)=D15(I)=
     1D13(I)=D2(I)=D5(I)=D8(I)=D11(I)=D14(I)=D3(I)=D6(I)=D9(I)=D12(I)=0,
22    CONTINUE

C     M IS THE NUMBER OF SAMPLES
976   READ 99,M

C*****READ IN DATA AND DETERMINE ORGANIC MATTER CONTENT
      DO 1 I=1, M
      READ 100,ID2(I),ID3A(I),ID3B(I),DRY(I),ASH(I)
1     DIFF(I)=DRY(I)-ASH(I)

C*****THE AMOUNT OF DRY MATERIAL, ASH AND ORGANIC MATTER IS CALCULATED FOR
C*****EACH PLOT AND FOR THE TOTAL SAMPLE ON A DEPTH BASIS,
      DO99J=1,M
C*****ERRORS IN DATA ARE CHECKED FOR
      IF(ASH(J).GT.DRY(J).OR.ASH(J).LT.0.OR.DRY(J).LT.0)50,51
50    PRINT 502,ID2(J),DRY(J),ASH(J),DIFF(J)
      GO TO 99
51    CONTINUE

C*****CHECK TO SEE IF CORE IS IN THE 0 TO 8 INCH DEPTH
      IF(ID3A(J).EQ.0)8,9
8     S1=S1+1. $ I=S1
C*****PUT DATA ON METER SQUARE BASIS AND STORE IN DUMMY ARRAYS
      I1(I)=ID2(J) $ D1(I)=DRY(J)*36.429  $ D2(I)=ASH(J)*36.429
      D3(I)=DIFF(J)*36.429
```

```
      DR1=DR1+DRY(J) $ DF1=DF1+DIFF(J)
      SS1=SS1+ASH(J)
C*****CALCULATE SUM AND SUM OF SQUARES FOR THE ASH, DRY AND ORG, MAT, WT,
      DRSQ1=DRSQ1+DRY(J)**2 $ DFSQ1=DFSQ1+DIFF(J)**2
      SQ1=SQ1+ASH(J)**2
      GO TO 99

C*****CHECK TO SEE IF CORE IS IN THE 8 TO 16INCH DEPTH
9     IF(ID3A(J).EQ.8)10,11
10    S2=S2+1. $ I=S2
C*****PUT DATA ON METER SQUARE BASIS AND STORE IN DUMMY ARRAYS
      I2(I)=ID2(J) $ D4(I)=DRY(J)*137,747 $ D5(I)=ASH(J)*137,747
      D6(I)=DIFF(J)*137,747
C*****CALCULATE SUM AND SUM OF SQUARES FOR THE ASH, DRY AND ORG, MAT, WT,
      DR2=DR2+DRY(J) $ DF2=DF2+DIFF(J)
      SS2=SS2+ASH(J)
      DRSQ2=DRSQ2+DRY(J)**2 $ DFSQ2=DFSQ2+DIFF(J)**2
      SQ2=SQ2+ASH(J)**2
      GOTO99

C*****CHECK TO SEE IF CORE IS IN THE 16 TO 24 INCH DEPTH
11    IF(ID3A(J).EQ.16)12,99
12    S3=S3+1. $ I=S3
C*****PUT DATA ON METER SQUARE BASIS AND STORE IN DUMMY ARRAYS
      I3(I)=ID2(J)$ D7(I)=DRY(J)*137,747 $ D8(I)=ASH(J)*137,747
      D9(I)=DIFF(J)*137,747
C*****CALCULATE SUM AND SUM OF SQUARES FOR THE ASH, DRY AND ORG, MAT, WT,
      DR3=DR3+DRY(J) $ DF3=DF3+DIFF(J)
      SS3=SS3+ASH(J)
      DRSQ3=DRSQ3+DRY(J)**2 $ DFSQ3=DFSQ3+DIFF(J)**2
      SQ3=SQ3+ASH(J)**2
99    CONTINUE

C*****CALCULATE PCT MATERIAL (DRY, ASH,ORGANIC MATTER) FOR EACH EIGHT
C*****INCH INTERVAL
      TOTAL=SS1+SS2+SS3
      DOTAL=DR1+DR2+DR3          $ DITAL=DF1+DF2+DF3
      A=SS1/TOTAL $ B=SS2/TOTAL $ C=SS3/TOTAL
      F=DR1/DOTAL $ G=DR2/DOTAL $ O=DR3/DOTAL
      R=DF1/DITAL$ S=DF2/DITAL $ T=DF3/DITAL

C*****PRINT OUT RESULTS
      PRINT 499
      PRINT 500,A,F,R,B,G,S,C,O,T

      PRINT 498
      PRINT501
      REWIND 4
C*****IJ = NUMBER OF SAMPLES
      IJ=X(3)

      DO 20, I=1,IJ
C*****DETERMINE PERCENT ASH IN EACH SAMPLE
C*****PCT ASH=ASH/DRY
      DA1   =D2(I)/D1(I) $ DA2   =D5(I)/D4(I) $ DA3   =D8(I)/D7(I)
      WRITE (4,600),D1(I),D2(I),D3(I),D4(I),D5(I),D6(I),D7(I),D8(I),
```

```
     1D9(I),DA1,DA2,DA3

C*****PRINT OUT RESULTS
20     PRINT 301,I1(I),I2(I),I3(I),                  D1(I),D4(I),D7(I),
      1       D2(I),D5(I),D8(I),                      D3(I),D6(I),D9(I),
      2DA1,DA2,DA3

C      CALL MODIFIED REGRESS PROGRAM FOR STATISTICAL ANALYSIS
C*****CONTROL VARIABLES FOR SUBROUTINE REGRESS, SEE ORNL-TM-1288
       KONTROL(1)=-1 $KONTROL(2)=8 $KONTROL(3)=KONTROL(4)=12 $
       KONTROL(5)=KONTROL(6)=KONTROL(7)=KONTROL(8)=KONTROL(10)=KONTROL(11
      1)=0$KONTROL(8)=12$KONTROL(9)=1
       READ 161,(ID(I),I=1,7)
       CALL REGRESS2(KONTROL,ID)
       GO TO 976

C*****FORMATS
99     FORMAT(2I4)
100    FORMAT(I8,2I2,2F10.0)
161    FORMAT(7A8)
201    FORMAT(1H ,=DOES NO OCCUR WITHIN THE SURFACE 24 INCHES= ,2I8,2I4)
301    FORMAT(1H ,/,3(I8,21X),/,3(=DRY=,7X,F8.3,11X),/,3(=ASH=,7X,F8.3,11
      1X),/,3(=ORG. MAT. =,F8.3,11X) ,/,3(=PERCENT ASH=,F7.3,    11X))
498    FORMAT(1H ,///)
499    FORMAT(1H1     ,=PERCENT ROOTS IN EACH 8 INCHES=,/,11X,=ASH        D
      1RY      ORG. MAT.=)
501    FORMAT(1H ,12X,3H0-8,25X,4H8-16,24X,5H16-24)
502    FORMAT(1H ,=ERROR IN THESE DATA=,I8,3F10.3)
500    FORMAT(1H ,=0-8  =,3F10.6,/,= 8-16 =,3F10.6,/,= 16-24=,3F10.6 )
600    FORMAT(12F8.3)
       END
```

```
      PROGRAM OBJECT
C     CORRECTION OF VISUAL ESTIMATES OF BOTANICAL COMPOSITION
C     BASED ON PUBLICATION BY TIWARI ET AL.  1963  AGRONOMY J. V. 55  226-228
C     USING A CONSTRAINED LEAST SQUARES TECHNIQUE
C
C SOLVES FOR B,C, AND D IN THE MODEL
C     Y = BX + CXX + DXXX   AND B + C + D = 1
C
      DIMENSION A(5,5),B(5,5),NSCALE(5),         ZY(4),ZX(4),DX(100),
     1DY(100),TITLE(10),ZZ(6),CODE(2),NOTE(2),YOUR(2),JANE(2),PETE(2),
     2HARY(2)
      COMMON NUMBER,A,B,C,LAMBDA,R,ZZ,RDET
C

C     SEQUENCE OD INPUT CARDS
C     1. LABLE FOR PRINTTED AND PLOTTED OUT PUT, 1 CARD, FORMAT 10A8
C     2. NUMBER OF DATA POINTS, 1 CARD FORMAT I4
C     3. SCALE FACTORS FOR GRAPH VARIABLE FORMAT
C     4. DATA CARDS

C     A( ,) AND B(,) ARRAYS USED FOR STORING SUM OF SQUARES, SUM X*Y ET.
C     DX, ARRAY FOR STORING VISUAL ESTIMATIONS
C      DY, ARRAY FOR STORING ESTIMATED VALUES FOR STANDING DEAD
C      CODE, NOTE, YOUR, JANE, PETE HARY, DUMMY ARRAYS FOR LABLING GRAPH
C      TITLE, STORAGE ARRAY FOR GRAPH LABLE
C     ALL OTHER ARRAYS ARE TEMPORARY DUMMY ARRAYS
C     NUMBER, NUMBER OF DATA POINTS

C     DUMMY VARIABLES AND SCALE FACTORS
      BCDD = 1H*
      BCD = 1H,
      NSCALE(1) = 1
      NSCALE(2) = 0
      NSCALE(3) = 2
      NSCALE(4) = 0
      NSCALE(5) = 2
      NHL = 10
      NSBH = 5
      NVL = 10
      NSBV = 10
      IDATA = 1
      NDATA = 4
      NCHAR = 33
C
C     TITLE, ARRAY FOR STORING GRAPH LABEL
11111  READ 5,TITLE
C     NUMBER, NUMBER OF DATA POINTS
      READ 8, NUMBER
C     READ SCALE FACTORS FOR GRAPH
      READ 333,XMIN,DELX,INTX,YMIN,DELY,INTY

C     DRAW AND LABLE GRAPH, SEE ORNL-TM-3447
      CALL SETPEN(9)
      CALL LINEAR(YMIN,DELY,INTY,XMIN,DELX,INTX,-7.5,9,ZZ)
      CALL SYMBOL(1.5,10.0,.17 ,TITLE(1),0.0,80)
      CALL LETTER(1,8,8HOBSERVED,.2,ZZ)

       CALL LETTER(2, 9,9HCORRECTED,.2,ZZ)
C  SET ARRAY =0.
C

       SSYY = 0,0
       DO 1 J = 1, 5
```

```
      DO 1 K = 1, 5
    1 A(J,K) = 0.0
C
C  READ DATA, STORE IN ARRAYS, GET SS AND CP
      DO 2 I = 1, NUMBER
      READ 969,X1,X2,Y
969   FORMAT(21X,F7.0,34X,2F6.0)
      X=Y/100.
      Y=X2/X1

C     DETERMINE NORMAL EQUATION
C     B*X*X + C*X*X*X + D*X*X*X*X = X*Y
C     B*X*X*X + C*X*X*X*X + D*X*X*X*X*X = X*X*Y
C     B*X*X*X*X + C*X*X*X*X*X + D*X*X*X*X*X*X = X*X*X*Y
C     B + C + D = 1
      DY(I) = Y
      DX(I) = X
      SSYY = SSYY + Y*Y
      TEMP = X*X
      A(1,1) = A(1,1) + TEMP
      TEMP = TEMP*X
      A(1,2) = A(1,2) + TEMP
      TEMP = TEMP *X
      A(1,3) = A(1,3) + TEMP
      TEMP = TEMP *X
      A(2,3) = A(2,3) + TEMP
      TEMP = TEMP*X
      A(3,3) = A(3,3) + TEMP
      TEMP = X*Y
      A(1,5) = A(1,5) + TEMP
      TEMP = TEMP *X
      A(2,5) = A(2,5) + TEMP
      TEMP = TEMP*X
    2 A(3,5) = A(3,5) + TEMP
C
C  MAKE ARRAY SYMETRIC
C
      A(2,2) = A(1,3)
      A(3,1) = A(1,3)
      A(2,1) = A(1,2)
      A(3,2) = A(2,3)
      A(1,4) = 1.0
      A(2,4) = 1.0
      A(3,4) = 1.0
      A(4,1) = 1.0
      A(4,2) = 1.0
      A(4,3) = 1.0
      A(4,5) = 1.0
      B(1,5) = A(1,5)
      B(2,5) = A(2,5)
      B(3,5) = A(3,5)
```

```
C      INVERT THE MATRIX
C
       DO 40 K = 1, 4
       X = 1.0/A(K,K)
       DO 41 J = 1, 5
   41  A(K,J) = A(K,J) * X
       A(K,K) = X
       DO 42 I = 1, 4
       IF (I - K) 50, 42, 50
   50  Y = A(I,K)
       A(I,K) = 0.0
       DO 43 J = 1, 5
   43  A(I,J) = A(I,J) - Y*A(K,J)
   42  CONTINUE
   40  CONTINUE

C   CALCULATE REGRESSION STATISTICS.
C      SSRESD = RESIDUAL SS
C      SSMODL = SS DUE TO MODEL
C      SSYY = TOTAL SS
C      R = MULTIPLE CORRELATION
C      RDET = R SQUARE VALUE
       SSMODL = A(1,5)*B(1,5)+A(2,5)*B(2,5)+A(3,5)*B(3,5)+A(4,5)
       SSRESD = SSYY - SSMODL
       RDET=(SSMODL/SSYY)*100.
       R=SQRTF(RDET/100.)
C      LABLE GRAPH
       ENCODE ( 8,104,PETE) R
       CALL SYMBOL (2.,8.0,.17,PETE,0.0, 8)
       ENCODE (11,105,HARY) RDET
       CALL SYMBOL (2.,7.5,.17,HARY,0.0,11)
       ENCODE (13,100,CODE) A(1,5)
       CALL SYMBOL (2.,9.5,.17,CODE,0.0,13)
       ENCODE (13,101,NOTE) A(2,5)
       CALL SYMBOL (2.,9.,.17,NOTE,0.0,13)
       ENCODE (13,102,YOUR) A(3,5)
       CALL SYMBOL (2.,8.5,.17,YOUR,0.0,13)

C      COEFFICIENTS B,C,AND D ARE STORED IN A(1,5), A(2,5), AND A(3,5)
       PRINT                 988,(A(K,5),K=1,4),SSRESD,SSMODL,SSYY
C      PRINT HEADINGS
       PRINT 987
       ZX(1) = .01
       ZX(2) = .26
       ZX(3) = .51
       ZX(4) = .76
C       DETERMINE CORRECTED VALUE, ZY, ACCORDING TO CUBIC EQUATION
       DO 200 I = 1, 25
       DO 199 J = 1,4
  199  ZY(J)=A(1,5)*ZX(J)+A(2,5)*ZX(J)*ZX(J)+A(3,5)*ZX(J)*ZX(J)*ZX(J)

C      PRINT OBSERVED AND PREDICITED VALUES
C      ZX=VISUAL ESTIMATE.  ZY= CORRECTED ESTIMATE
       PRINT 986,(ZY(J),ZX(J),J=1,4)
       DO 198 J = 1, 4
```

```
  198 ZX(J) = ZX(J) + .01
  200 CONTINUE
C      DRAW CURVE
       DO 369 I=1,500
       PX=I
       PX=PX/500.
       PY= A(1,5)*PX+A(2,5)*PX*PX+A(3,5)*PX*PX*PX
       CALL CURVE(LK,PX,PY,ZZ)
369    CONTINUE
C      PLOT DATA POINTS
       DO 300 I = 1,NUMBER
       X = DX(I)
       Y = DY(I)
       CALL POINT(I, X, Y, 1, .08, 0., 1, Z7)
  300 CONTINUE
       CALL ADVANCE(ZZ)
       GO TO 11111
C      FORMATS
333    FORMAT(2F10.0,2X,I8,2F10.0,2X,I8)
8      FORMAT(I4)
998    FORMAT(2F10.0)
  988 FORMAT(1H ,40X2HB=,F10.5/1H ,40X2HC=,F10.5/1H ,40X2HD=,F10.5/1H ,3
     15X7HLAMBDA=,F10.5/1H0,30X12HRESIDUAL SS=,F14.8/1H ,26X16HSS DUE TO
     2 MODEL=,F14.8/1H ,33X9HTOTAL SS=,F14.8///)
C
  987 FORMAT(1H ,40X42HX=VISUAL ESTIMATE     Y=CORRECTED ESTIMATE/1H0,4(
     19X1HX9X1HY9X)//)
C
  986 FORMAT(1H ,4(F10.3,F10.2,9X))
100    FORMAT(=B= =F10.5)
101    FORMAT(=C= =F10.5)
102    FORMAT(=D= =F10.5)
103    FORMAT(=LAMBDA= =F8.5)
104    FORMAT(=R= =F4.3)
105    FORMAT(=R SQ.= =F4.0 )
2127   FORMAT(3F10.5)
       END
```

```
      PROGRAM RANKER
C     PROGRAM WRITTEN BY L. J. BLEDSOE AND G. M. VAN DYNE, COLLEGE OF FORESTRY
C     AND NATURAL RESOURCES, COLORADO STATE UNIVERSITY, FORT COLLINS, COLORADO
C     THE OBJECT OF RANKER IS TO CALCULATE A VECTOR OF MULTIPLIERS SUCH THAT
C     WHEN A MATRIX CONTAINING THE PROPORTION OF TIMES A LIST OF SPECIES
C     WAS GIVE A PRTICULAR RANK, THE RESULT WILL BE A VECTOR OF THE PROPORTION
C     OF THE TOTAL WEIGHT A GIVEN SPECIES ACCOUNTED FOR
      COMMON/C1/R(90,30),W(90,1),N,M,RT(30,90),C(30,30),D(30,1),E(30,1),
     1CS,CT,CF,P(90,1),CORR,CORRW,RCS,RCW
      DIMENSION NUM(100),DFMT(10),RFMT(10),DATA(60,30),NRANK(60,30),ID(5
     10),NR(60,30),NDUM(100,60),CR(100,4),KEY(100),EE(100,30),DD(60,30),
     2CFMT(10),VFMT(10),ODFMT(20),ORFMT(20),ONUM(10),OVFMT(30)
      COMMON DATA, NRANK
      TYPE INTEGER READOP,WGTOP,SAMPOP,SMPSIZ,SUMCOL,RWGT,PNCHOP
C     ======================================================================
C     N=NO OF SPECIES CONSIDERED (MAX N=85)
C     M=NO OF RANKS CONSIDERED (MAX M=17)
C     KK=NO OF PLOTS SAMPLED (MAX KK=59)
C     KKL=LOWER LIMIT ON THE NUMBER OF PLOTS THAT MAY BE USED FOR A RUN.
C     LIM=NO OF RUNS TO MAKE, (LESS THAN OR EQUAL TO 100)
C     IF READOP=1, READ DATA OFF CARDS.  IF READOP=0, READ TAPE
C     IF WGTOP=1, WEIGHT DATA,  IF WGTOP=0. DO NOT WEIGHT DATA.
C     IF SAMPOP=0, USE ALL THE DATA AND MAKE ONE RUN, SETTING LIM=1,
C     IF SAMPOP=1, RANDOMLY SELECT LIM SUBSAMPLES AND MAKE A RUN WITH EACH.
C     IF SMPSIZ=0, RANDOMLY SELECT THE SIZES OF SUBSAMPLES.
C     IF SMPSIZ=1, READ THE SUBSAMPLES SIZES OFF CARDS.
C     IF SUMCOL=0, COLUMNS OF R MATRIX SUM TO 1.
C     IF SUMCOL=1, COLUMNS OF R MATRIX MAY NOT SUM TO 1.
C     IF RWGT=1, READ WEIGHT DATA IN G/4.8 FT2.
C     IF RWGT=-1, READ WEIGHT DATA IN LB/ACRE.
C     IF PNCHOP=-1, DO NOT PUNCH MULTIPLIERS.
C     IF PNCHOP=0, PUNCH ONLY THE MULTIPLIERS FROM LAST RUN (LARGEST SUBSAMPLE).
C     IF PNCHOP=1, PUNCH THE RESULTING MULTIPLIERS FROM ALL LIM RUNS.
C     CS= COST OF THE SLOW PROCESS
C     CT= COST OF THE SET PROCEDURE
C     CF= COST OF THE FAST PROCEDURE
C     DFMT = DATA INPUT FORMAT  (1 CARD)
C     RFMT = RANK INPUT FORMAT (1 CARD)
C     CFMT = PUNCH FORMAT FOR MULTIPLIERS. (1 CARD)
C     ODFMT = PRINT-OUT FORMAT FOR FULL WEIGHT DATA (2 CARDS)
C     ORFMT = PRINT-OUT FORMAT FOR FULL RANK DATA (2 CARDS)
C     OVFMT = PRINT OUT FORMAT FOR CORR, OPT, RATIO, MULTIPLIERS, ETC. (3 CARDS)
C     ONUM = PRINT-OUT FORMAT FOR PLOT NUMBERS USED (1 CARD)
C     VFMT=PREDICTED AND OBSERVED WEIGHTS OUTPUT FORMAT (1 CARD)
C     ID= IDENTIFICATION OF RANK DATA (5 CARDS).
C     PUNCH THE FIRST CARD OF ID ONE COLUMN TO THE LEFT OF THE OTHER CARDS.
C     ======================================================================
      DO 741 I=1,60
      DO 741 J=1,30
      NRANK(I,J)=0
      DATA(I,J)=0.
741   CONTINUE
C=======================================================================
   99 READ 100,N,M,KK,KKL,LIM,READOP,WGTOP,SAMPOP,SMPSIZ,SUMCOL,RWGT,
     1PNCHOP
      READ 102, CS,CT,CF
```

```
      READ 101,DFMT,RFMT,CFMT,ODFMT,ORFMT,OVFMT,ONUM,VFMT,ID
      IF (SMPSIZ) 26,27,26
   26 READ 103, (NUM(I),I=1,M)
27    CALL SETUP
      IF (RWGT) 58,58,57
C     CONVERT DATA FROM G/4.8 FT2 TO LB/ACRE.
   57 DO 4 I=1,KK
      DO 4 J=1,N
    4 DATA(I,J)=DATA(I,J)*20.
   58 CONTINUE
C     PRINT OUT TABLES OF COMPLETE WT AND RANKS DATA.
      PRINT 205, (ID(J),J=1,50)
      PRINT 207, LIM
      PRINT ODFMT, ((I,(DATA(I,J),J=1,N),I=1,KK))
      PRINT ORFMT, (I,(NRANK(I,J),J=1,N),I=1,KK)
      PRINT 203, CS,CT,CF
      IF (SAMPOP) 25,45,25
   25 CONTINUE
      IF (SMPSIZ) 29,28,29
C     RANDOMLY SELECT THE NO OF PLOTS TO USE FOR EACH RUN.
   28 X=RANF(1.)
      DO 6 I=1,LIM
    5 K=RANF(X)*100.
      IF (K.LT.KK.AND.K.GE.KKL) 6,5
    6 NUM(I)=K
      CALL SORT (NUM,KEY,LIM)
      NUM(LIM)=KK
   29 CONTINUE
C     SELECT NUM(I) PLOTS AT RANDOM FOR THE I-TH RUN
      DO 98 I=1,LIM
      DO 65 J=1,KK
   65 NDUM(I,J)=0
      NO=NUM(I)
      DO 10 J=1,NO
    7 K=RANF(X)*100.
      IF (K.LE.KK) 8,7
    8 DO 9 KI=1,J
      IF (K.EQ.NDUM(I,KI)) 7,9
    9 CONTINUE
      NDUM(I,J)=K
      DO 10 LL=1,N
      NR(J,LL)=NRANK(K,LL)
   10 DD(J,LL)=DATA(K,LL)
      GO TO 47
   45 CONTINUE
      NO=KK
      DO 46 J=1,KK
      DO 46 K=1,N
      NR(J,K)=NRANK(J,K)
   46 DD(J,K)=DATA(J,K)
      I=1
      NUM(I)=KK
   47 CONTINUE
C     COMPUTE RANK MATRIX (PROPORTION OF TIMES RANK J IS GIVEN SPECIES K).
C     R(K,J)= MATRIX OF RANKS
      DO 48 J=1,M
```

```
      KT=0
      DO 13 K=1,N
      KOUNT=0
      DO 12 L=1,NO
      IF (NR(L,K).EQ.J) 11,12
   11 KOUNT=KOUNT+1
      KT=KT+1
   12 CONTINUE
   13 R(K,J)=FLOAT(KOUNT)
      IF (KT) 49,48,49
   49 IF (SUMCOL) 50,51,50
   50 KT=NO
   51 DO 48 K=1,N
      R(K,J)=R(K,J)/KT
   48 CONTINUE
C     COMPUTE  WT MATRIX (SPECIES < PROPORTION OF TOTAL WT),
C     W(K,1)= MATRIX OF WEIGHT PROPORTIONS
      TOTWT=0.
      DO 15 K=1,N
      W(K,1)=0.
      DO 14 J=1,NO
   14 W(K,1)=W(K,1)+DD(J,K)
   15 TOTWT=TOTWT+W(K,1)
      DO 16 K=1,N
   16 W(K,1)=W(K,1)/TOTWT
      IF (WGTOP) 18,19,18
C     WEIGHT THE DATA.
   18 DO 21 K=1,N
      DO 17 J=1,M
   17 R(K,J)=R(K,J)*W(K,1)
   21 W(K,1)=W(K,1)**2
   19 CONTINUE
      CALL LAG
      CALL RATIO
      IF (PNCHOP) 32,31,30
   31 IF (I.EQ.LIM) 30,32
   30 PUNCH CFMT, NUM(I), (E(J,1),J=1,M)
   32 CONTINUE
      M=M+1
      DO 20 J=1,M
   20 EE(I,J)=E(J,1)
      M=M-1
      CR(I,1)=CORR**2
      CR(I,2)=CORRW**2
      CR(I,3)=RCS
   98 CR(I,4)=RCW
      M=M+1
      PRINT 228  , (ID(I),I=1,16)
      PRINT OVFMT, ((NUM(I),(CR(I,J),J=1,4),(EE(I,K),K=1,M)),I=1,LIM)
      PRINT VFMT, ((P(I,1),W(I,1)),I=1,N)
      IF (SUMCOL) 67,68,67
   67 PRINT 232
      GO TO 69
   68 PRINT 233
   69 CONTINUE
      IF (WGTOP) 70,71,70
```

```
   70 PRINT 234
      GO TO 72
   71 PRINT 235
   72 CONTINUE
      IF (SAMPOP) 52,99,52
   52 PRINT 229
      PRINT ONUM, ((NUM(I),(NDUM(I,J),J=1,KK)),I=1,LIM)
      GO TO 99
  100 FORMAT (12I3)
  101 FORMAT (10A8)
  102 FORMAT(3F10.0)
  103 FORMAT (40I2/40I2/20I2)
  203 FORMAT(1H0,=COSTS--SLOW,FIXED, AND FAST=/1H ,3F10.4)
  205 FORMAT (1H1,5(10R8/)///)
  207 FORMAT (1H ,=THIS IS THE ORIGINAL DATA FROM WHICH THE FOLLOWING =,
     1I3,= RUN(S) WILL BE MADE=//)
  228 FORMAT (1H1,2(10R8/)  ///)
  229 FORMAT (=1PLOTS USED=//= NO         PLOTS=/)
  232 FORMAT (= UNWEIGHTED R MATRIX COLUMNS MAY NOT SUM TO 1.0=/)
  233 FORMAT (= UNWEIGHTED R MATRIX COLUMNS SUM TO 1.0=/)
  234 FORMAT (= THIS WAS A WEIGHTED REGRESSION=/)
  235 FORMAT (= THIS WAS AN UNWEIGHTED REGRESSION=/)
      END



      SUBROUTINE LAG
      COMMON/C1/R(90,30),W(90,1),N,M,RT(30,90),C(30,30),D(30,1),E(30,1),
     1CS,CT,CF,P(90,1),CORR,CORRW,RCS,RCW
C     ******************************************************************
C     R= RANK AND SPPS MATRIX
C     W= WEIGHT MATRIX
C     RT= R TRANSPOSE MATRIX
C     C= PRODUCT MATRIX OF RT*R
C     ******************************************************************
C     TRANSPOSE R TO RT
      CALL TRSPSE(R, RT,N,M)
C     C = RT*R
      CALL MATMP(RT,R,C,M,N,M,30,90,30)
C     D = RT*W
      CALL MATMP (RT,W,D,M,N,1,30,90,1)
C     ADJOIN CONSTRAINT TO SYSTEM OF EQUATIONS    RT*R*E = RT*W
C     CONSTRAINT IS      E1 + E2 + . . . + EM = 1.0
C     TO MAKE THE RESULTING SYSTEM SOLVABLE, ADD ANOTHER UNKNOWN, THE
C             LAGRANGIAN MULTIPLIER.
      M=M+1
      DO 1 J=1,M
      C(J,M)=C(M,J)=1.
      C(M,M)=0.
      D(M,1)=1.
C     INVERT C = RT*R (ADJOINT)
      CALL INVERT (C,M,30)
```

```
      SUBROUTINE INVERT (A,N,MM)
C     MATRIX INVERSION BY GAUSS-JORDAN ELIMINATION
C     INVERT A OF DIMENSION N AND PUT A INVERSE IN A
C     MM IS THE MAIN PROGRAM DIMENSION OF A.
      DIMENSION A(MM,MM),B(60),C(60),LZ(60)
      DO 10 J=1,N
   10 LZ(J)=J
      DO 20 I=1,N
      K=I
      Y=A(I,I)
      L=I-1
      LP=I+1
      IF(N-LP)14,11,11
   11 DO 13 J=LP,N
      W=A(I,J)
      IF(ABSF(W)-ABSF(Y))13,13,12
   12 K=J
      Y=W
   13 CONTINUE
   14 DO 15 J=1,N
      C(J)=A(J,K)
      A(J,K)=A(J,I)
      A(J,I)=-C(J)/Y
      A(I,J)=A(I,J)/Y
   15 B(J)=A(I,J)
      A(I,I)=1.0/Y
      J=LZ(I)
      LZ(I)=LZ(K)
      LZ(K)=J
      DO 19 K=1,N
      IF(I-K)16,19,16
   16 DO 18 J=1,N
      IF(I-J)17,18,17
   17 A(K,J)=A(K,J)-B(J)*C(K)
   18 CONTINUE
   19 CONTINUE
   20 CONTINUE
      DO 200 I=1,N
      IF(I-LZ(I))100,200,100
  100 K=I+1
      DO 500 J=K,N
      IF(I-LZ(J))500,600,500
  600 M=LZ(I)
      LZ(I)=LZ(J)
      LZ(J)=M
      DO 700 L=1,N
      C(L)=A(I,L)
      A(I,L)=A(J,L)
  700 A(J,L)=C(L)
  500 CONTINUE
  200 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE RATIO
      COMMON/C1/R(90,30),W(90,1),N,M,RT(30,90),C(30,30),D(30,1),E(30,1)
     1CS,CT,CF,P(90,1),CORR,CORRW,RCS,RCW
C     W IS THE VECTOR OF WEIGHT PROPORTIONS
C     E IS THE VECTOR OF MULTIPLIERS
C     R IS THE MATRIX OF RANKS
C     CS IS THE COST OF THE SLOW PROCESS
C     CF IS THE COST OF THE FAST PROCESS
C     CT IS THE FIXED COST PER SAMPLE
C     GET PREDICTED VALUES
      M=M-1
      DO 1 I=1,N
      P(I,1)=0.
      DO 1 J=1,M
    1 P(I,1)=P(I,1)+E(J,1)*R(I,J)
C     GET SIMPLE CORRELATION OF OBS AND PRED
      PW=0.$ PP=0.$ WW=0.$ SUMP=0.$ SUMW=0.
      DO 2 I=1,N
      PW=PW+P(I,1)*W(I,1)
      PP=PP+P(I,1)*P(I,1)
      WW=WW+W(I,1)*W(I,1)
      SUMP=SUMP+P(I,1)
    2 SUMW=SUMW+W(I,1)
      CORR=(PW-SUMP*SUMW/N)/SQRT((PP-(SUMP**2)/N)*(WW-(SUMW**2)/N))
C     GET WEIGHTED CORRELATION
      PWW=0.$ PPW=0.$ WWW=0.$ SUMPW=0.$ SUMWW=0.$ WT=0.
      DO 3 I=1,N
      PWW=PWW+P(I,1)*W(I,1)*W(I,1)
      PPW=PPW+P(I,1)*P(I,1)*W(I,1)
    3 WWW=WWW+W(I,1)**3
      SUMPW=PW
      SUMWW=WW
      WT=SUMW
      CORRW=(PWW-SUMPW*SUMWW/WT)/SQRT((PPW-(SUMPW**2)/WT)*(WWW-(SUMWW**2
     1)/WT))
      IF (CORR.GE.1.0) 5,6
    5 CORR=0.999999
    6 IF (CORRW.GE.1.0)  7,8
    7 CORRW=0.999999
      GO TO 8
    8 CONTINUE
C     GET OPTIMUM RATIO WITH SIMPLE CORRELATION
      RCS=SQRT((CS/(CF+CT))*(CORR**2/(1-CORR**2)))
C     GET OPTIMUM RATIO WITH WEIGHTED CORRELATION
      RCW=SQRT((CS/(CF+CT))*(CORRW**2/(1-CORRW**2)))
      RETURN
      END
```

```
      SUBROUTINE TRSPSE(P,R,M,N)
C     TRANSPOSE MATRIX P INTO MATRIX R
      DIMENSION P(90,30),R(30,90)
      DO 55 I=1,M
      DO 55 J=1,N
55    R(J,I)=P(I,J)
      RETURN
      END
```

```
      SUBROUTINE SORT (X,KEY,NO)
C     ACCEPT AN ARRAY OF N (NO) VALUES (X) AND SORT THEM INTO ASCENDING ORDER.
C     STORE THEIR ORIGINAL SUBSCRIPTS IN ARRAY KEY.
      DIMENSION KEY(1),X(1)
      TYPE INTEGER X
      DO 1 I=1,NO
    1 KEY (I)=I
      MO=NO
    2 IF(MO-15) 3,3,5
    3 IF(MO-1) 11,11,4
    4 MO=2*(MO/4)+1
      GO TO 6
    5 MO=2*(MO/8)+1
    6 KO=NO-MO
      JO=1
    7 I=JO
    8 KK=I+MO
      IF(X(I)-X(KK)) 10,10,9
    9 TEMP=X(I)
      X(I)=X(KK)
      X(KK)=TEMP
      KEMP=KEY(I)
      KEY(I)=KEY(KK)
      KEY(KK)=KEMP
      I=I-MO
      IF(I-1) 10,8,8
   10 JO=JO+1
      IF(JO-KO) 7,7,2
   11 RETURN
      END
```

```
      SUBROUTINE MATMP(A,B,C,M,N,L,MM,NN,LL)
C     MULTIPLY MATRICIES A AND B AND PUT RESULTS INTO C
C     MM,NN,LL ARE THE MAIN-PROGRAM DIMENSIONS OF THE ARRAYS GIVEN AS A,B,C.
C     M,N,L ARE THE LIMITS OF MULTIPLICATION OF THE ARRAYS A,B,C.
      DIMENSION A(MM,NN),B(NN,LL),C(MM,LL)
      DO 20 I=1,M
      DO 20 J=1,L
      SUM=0.
      DO 30 K=1,N
30    SUM=SUM+A(I,K)*B(K,J)
20    C(I,J)=SUM
      RETURN
      END
```

```
      SUBROUTINE SETUP
      COMMON DATA, NRANK
      DIMENSION PLOT(40),WEED(40)
      DIMENSION DATA(60,30), NRANK(60,30)
      TYPE INTEGER PLOT,PL
C     MN, THE NUMBER OF PLOTS,..NP, THE NUMBER OF PLANTS
      DO 81 I=1,60
      DO 81 J=1,30
81    DATA(I,J)=NRANK(I,J)=0
      PRINT 733
733   FORMAT(1H1)
      READ 76,MN,NP
76    FORMAT(2I4)
      READ 100,(PLOT(I),I=1,MN)
100   FORMAT(I8)
      READ 101 ,(WEED(I),I=1,NP)
101   FORMAT(A8)
      PRINT 600,(I,PLOT(I),I=1,MN)
600   FORMAT(1H ,I2,10X,I8)
      PRINT 601,(I,WEED(I),I=1,NP)
601   FORMAT(1H ,I2, 10X, A8)
654   READ 102,PL,SP,IR,WT
102   FORMAT(I8,A8,I2,F10.0)
      IF(PL.EQ.0)57,8
8     DO 2 J=1,MN
      IF(PLOT(J).EQ.PL)1,2
2     CONTINUE
1     DO 3  I=1,NP
      IF(PAJO(SP,WEED(I)))3,4
3      CONTINUE
4     NRANK(J,I)=IR+NRANK(J,I)
      DATA(J,I)=WT +DATA(J,I)
      GO TO 654
C     CHECK TO SEE IF ROWS AND COLUMNS OF NRANK AND DATA MATRICES ARE GT. THAN 0
C     CHECK ROWS
57    DO 11I=1,MN
      NWT=QWT=0.
      DO 22J=1,NP
      NWT=NRANK(I,J) + NWT
      QWT=DATA(I,J) + QWT
22    CONTINUE
      IF(NWT.GT.0)33,44
44    PRINT 1100, I
1100  FORMAT(1H , =ROW=, I4, =  DOES NOT SUM TO GREATER THAN ZERO IN NRA
     1NK=
33    IF(QWT.GT.0)11,6
6     PRINT 1101, J
1101  FORMAT(1H , =ROW=, I4, =  DOES NOT SUM TO GREATER THAN ZERO IN DAT
     1A=)
11     CONTINUE
C     CHECK COLUMNS
      DO 10 J=1,NP
      NWT=QWT=0.
      DO 20I=1,MN
      NWT=NRANK(I,J) + NWT
      QWT=DATA(I,J) + QWT
```

```
20     CONTINUE
       IF(NWT.GT.0)30,40
40      PRINT 200, I
200    FORMAT(1H , *COL*, I4, *  DOES NOT SUM TO GREATER THAN ZERO IN NRA
      1NK*)
30     IF(QWT.GT.0)10,60
60      PRINT 201, J
201    FORMAT(1H , *C/L*, I4, *  DOES NOT SUM TO GREATER THAN ZERO IN DAT
      1A*)
10      CONTINUE
       END
```

```
      FUNCTION PAJO(A,B)
C     PAJO, FUNCTION FOR COMPARING TWO ALPHA NUMERIC CHARACTERS
      PAJO=(.NOT.A.AND.B).OR.(.NOT.B.AND.A)
      RETURN
      END
```

```
      SUBROUTINE OPTION(II,TT,LIO)
      DIMENSION V(20),CF(21,20),VPRM(20)
      COMMON /OPTION/TD,TM,V,CF,VPRM
C      EQUATION USED FOR ESTIMATION OF DAILY PRODUCTION IN THE
C     CONSTANT COEFFICIENT ANDROPOGON MODEL

C      CONVERT TIME (T) TO RADIANS
      X=(3.14*(T-1.)/364.)
      X=X*2.
C     V(1), SOURCE COMPARTMENT
      V(1)=-2.5+COSF(2.7+X)*10.1
      RETURN
      END




      SUBROUTINE OPTION(II,TT,LIO)
      DIMENSION V(20),CF(21,20),VPRM(20)
      COMMON /OPTION/TD,TM,V,CF,VPRM
C      EQUATION USED FOR ESTIMATION OF DAILY PRODUCTION IN THE
C     CONSTANT COEFFICIENT FESTUCA MODEL

C      CONVERT TIME (T) TO RADIANS
      X=(3.14*(T-1.)/364.)
      X=X*2.
C     V(1), SOURCE COMPARTMENT
      V(1)=(2.+2.*SINF(4.7     +X))  *1.1

      RETURN
      END
```

```
      SUBROUTINE OPTION(II,TT,LIO)
      DIMENSION V(20),CF(21,20),VPRM(20)
      COMMON /OPTION/TD,TM,V,CF,VPRM
C      EQUATION USED FOR ESTIMATION OF DAILY PRODUCTION IN THE
C     SEASONAL COEFFICIENT ANDROPOGON MODEL
C      CONVERT TIME (T) TO RADIANS
2     X=3.1415927*(T-1.)/364.
C     V(1), SOURCE COMPARTMENT
      V(1)=(3.0+COSF(3.1+2.*X) *8.5 )/1.4
      RETURN
      END
```

```
      SUBROUTINE OPTION(II,TT,LIO)
      DIMENSION V(20),CF(21,20),VPRM(20)
      COMMON /OPTION/TD,TM,V,CF,VPRM
C      EQUATION USED FOR ESTIMATION OF DAILY PRODUCTION IN THE
C     SEASONAL COEFFICIENT FESTUCA MODEL

C      CONVERT TIME (T) TO RADIANS
2     X=(3.14*(T-1.)/365.)
      X=X*2.
C     V(1), SOURCE COMPARTMENT
22    V(1)=(2.+2.*SINF(4.68793+X)) *1.1
23    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE MATX(T,V,F)
      DIMENSION V(9),F(21,20)
C     SUBROUTIN  ALLOWS FOR NON LINEAR VARIATION OF TRANSFER COEFFICIENTS F(I,J
C      IN THE ANDROPOGON MODEL

C      CONVERT TIME (T) TO RADIANS
9     Y=3.142*(T-1.)/364.
      X=2.*Y

C      F(2,4), TRANSFER COEFFICIENT FROM LIVE TOPS TO STANDING DEAD
      Q=T/85.
      F(2,4)=.00027*EXPF(Q)

C     F(2,3), TRANSFER COEFFICIENT FOR LIVE TOPS TO ROOTS
      F(2,3)=(.002 +.002 *SIN(2.*Y-.7)*1.4 )
      IF(F(2,3).LT.0.001)86,87
86    F(2,3)=0.001
87    F(2,3)=F(2,3)*4.2

C     F(4,5), TRANSFER COEFFICIENT FROM STANDING DEAD TO MULCH
      F(4,5)=.00185*(1.+SINF(2.*Y-1.56))

C     F(5,6), TRANSFER COEFFICIENT FROM MULCH TO RESPIRATION
      F(5,6)=(V(4)*F(4,5)+V(5)-180.)/V(5)

C      F(3,6), TRANSFER COEFFICIENT FROM ROOTS TO RESPIRATION
      F(3,6)=(.0005+.010*SINF(X+2. ) )
      IF(F(3,6).LT..00036)96,97
96    F(3,6)= .00036
97    F(3,6)=F(3,6)*1.1
      IF(T.GT.280)76,77
76    F(3,6)=F(3,6)*(365.-T)/110.
77    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE MATX(T,V,F)
      DIMENSION V(9),F(21,20)
C     SUBROUTINR ALLOWS FOR NON LINEAR VARIATION OF TRANSFER COEFFICIENTS F(I,J)
C     IN TH FESTUCA MODEL

C      CONVERT TIME (T) TO RADIANS
2     X=(3.14*(T-1.)/365.)
      X=X*2.
      IF(T.LT.120)20,21
20    F(1,3)=.168571*T-.00142857*T*T
      IF(F(1,3).LT.0)21,22
21     F(1,3)=.0
22    CONTINUE

C      F(1,3), TRANSFER COEFFICIENT FROM SOURCE TO ROOTS

C      F(5,6), TRANSFER COEFFICIENT FROM MULCH TO RESPIRATION
      F(5,6)=(F(4,5)*V(4)- 117.+V(5))/V(5)
      RETURN
      END
```

Part B. Preliminary Modeling and Systems Analysis

APPENDIX B

Table 20. Identification of Coded Species Names Used in Tables 21, 22, 23, and 24.

Code	Species Name	Code	Species Name
ACMI	Achillea millefolium	ONION	Allium sp.
ACRH	Acalypha rhomboidea	OXST	Oxalis stricta
ANVI	Andropogon virginica	PAAN	Panicum anceps
ASTER	Aster pilosus	PACL	Panicum clandestinum
BRJA	Bromus japonicus	PACO	Panicum commutatum
CAFR	Carex frankii	PALA	Panicum latifolia
CARA	Campsis radicans	PANI	Panicum nitidum
CIAR	Cirsium arvense	PLLA	Plantago lanceolata
COMP	Composite	PLMA	Plantago major
CRLE	Chrysanthemum leucanthemum	PLRU	Plantago rugelii
DACA	Daucus carota	PRVU	Prunella vulgaris
DIVI	Diodia virginiana	ROSA	Rosa sp.
ERAN	Erigeron annuus	RUAL	Rubus allegheniensis
ERCA	Erigeron canadensis	RUCA	Rumex acetosella
ERHI	Eragrostis hirsuta	RUHI	Rudbeckia hirta
EUFI	Eupatorium fistulosum	SESM	Senecio smallii
EUVI	Eulalia viminea	SMGL	Smilax glauca
FEEL	Festuca elatior	SOCA	Solanum carolinense
GATI	Galium tinctorium	SOHA	Sorghum halepense
GECA	Geranium carolinianum	SOL	Solidago altissima
GNPU	Gnaphalium purpureum	SUMAC	Rhus glarra
IPHE	Ipomoea hederacea	TAOF	Taraxacum officinale
JUTE	Juncus tenuis	TRPR	Trifolium pratense
LECU	Lespedeza cuneata	TRRE	Trifolium repense
LOJA	Lonicera japonica	VEAL	Vernonia altissima
OEBI	Oenothera biennis		

Table 21. Summary of Rapid Sample Data on Species Composition, State of Species (L, Live; D, Dead), Capacitance Readings (CAP) and Visual Estimation of Percent Standing Dead (DEAD) for 100 Unclipped Plots in the *Festuca* Community Samples (DATE) 5 through 8[a].

DATE	REP	SPECIES	RANK	CAP	DEAD
5	1	FEEL	1	4.5	10
5	1	PALA	2	4.5	10
5	1	SOL	3	4.5	10
5	1	FEEL	1	5.0	5
5	1	CARA	4	5.0	5
5	1	SOL	3	5.0	5
5	1	ASTER	2	5.0	5
5	1	FEEL	1	6.0	5
5	1	ASTER	2	6.0	5
5	1	SOL	3	6.0	5
5	1	FEEL	1	5.5	10
5	1	SOL	3	5.5	10
5	1	ASTER	2	5.5	10
5	1	SOCA	4	5.5	10
5	1	FEEL	1	5.0	5
5	1	ASTER	2	5.0	5
5	1	PALA	3	5.0	5
5	1	SOL	4	5.0	5
5	1	FEEL	1	5.5	5
5	1	PALA	3	5.5	5
5	1	SOL	4	5.5	5
5	1	LOJA	2	5.5	5
5	1	FEEL	1	5.0	10
5	1	RUAL	3	5.0	10
5	1	ASTER	2	5.0	10
5	1	FEEL	1	5.5	10
5	1	SOL	2	5.5	10
5	1	ASTER	3	5.5	10
5	1	FEEL	1	6.0	10
5	1	ASTER	3	6.0	10
5	1	SOL	2	6.0	10
5	1	FEEL	1	4.5	5
5	1	SOL	3	4.5	5
5	1	ASTER	2	4.5	5
5	1	SOCA	4	4.5	5
5	1	FEEL	1	6.0	5
5	1	PALA	2	6.0	5
5	1	ASTER	3	6.0	5
5	1	FEEL	1	6.5	10
5	1	SOL	2	6.5	10
5	1	CARA	3	6.5	10
5	1	ASTER	4	6.5	10
5	1	FEEL	1	7.0	5
5	1	ASTER	2	7.0	5
5	1	FEEL	1	7.0	5
5	1	RUAL	2	7.0	5
5	1	SOL	3	7.0	5
5	1	FEEL	1	5.5	5
5	1	SOL	2	5.5	5
5	1	RUAL	3	5.5	5
5	1	FEEL	1	5.0	5
5	1	SOL	2	5.0	5
5	1	PLMI	3	5.0	5
5	1	FEEL	1	6.0	1
5	1	DACA	2	6.0	1
5	1	FEEL	1	6.0	3
5	1	FEEL	1	7.0	10
5	1	ASTER	2	7.0	10

DATE	REP	SPECIES	RANK	CAP	DEAD
5	1	PALA	3	7.0	10
5	1	DACA	4	7.0	10
5	1	FEEL	1	6.0	5
5	1	DACA	3	6.0	5
5	1	FEEL	1	5.5	5
5	1	SOL	2	5.5	5
5	1	IPHF	3	5.5	5
5	1	FFEL	1	8.0	3
5	1	RUAL	2	8.0	3
5	1	ASTER	3	8.0	3
5	1	DALA	4	8.0	3
5	1	FEEL	1	8.5	10
5	1	ASTER	3	8.5	10
5	1	LOJA	2	8.5	10
5	1	FEEL	1	7.0	5
5	1	RUAL	3	7.0	5
5	1	ASTER	2	7.0	5
5	1	SOL	4	7.0	5
5	1	FEEL	1	7.5	5
5	1	ASTER	2	7.5	5
5	1	SOL	3	7.5	5
5	1	FEEL	1	6.5	10
5	1	SOL	2	6.5	10
5	1	ASTER	3	6.5	10
5	1	FEEL	1	7.5	3
5	1	SOL	2	7.5	3
5	1	ASTER	3	7.5	3
5	1	FEEL	1	7.5	5
5	1	IPHE	2	7.5	5
5	1	RUAL	3	7.5	5
5	1	FEEL	1	6.5	3
5	1	PALA	3	6.5	3
5	1	OEBI	5	6.5	3
5	1	ERHI	2	6.5	3
5	1	DACA	6	6.5	3
5	1	RUAL	4	6.5	3
5	1	FEEL	1	7.0	10
5	1	RUAL	3	7.0	10
5	1	CARA	2	7.0	10
5	1	FFEL	1	10.0	5
5	1	SOCA	2	10.0	5
5	1	FEEL	1	10.5	5
5	1	SOL	2	10.5	5
5	1	ASTER	3	10.5	5
5	1	FEEL	1	8.0	10
5	1	SOL	2	8.0	10
5	1	IPHE	3	8.0	10
5	1	FEEL	1	6.0	3
5	1	IPHE	2	6.0	3
5	1	FEEL	1	12.0	1
5	1	IPHF	2	12.0	1
5	1	FEEL	1	10.	1
5	1	CARA	2	10.	1
5	1	ASTER	3	10.	1
5	1	FEEL	1	7.0	5
5	1	CARA	2	7.0	5
5	1	OEBI	3	7.0	5

DATE	REP	SPECIES	RANK	CAP	DEAD
5	1	FEEL	1	9.5	5
5	1	CARA	2	9.5	5
5	1	OEBI	3	9.5	5
5	1	FEEL	1	8.0	10
5	1	CARA	2	8.0	10
5	1	FEEL	1	7.5	3
5	1	IPHE	2	7.5	3
5	1	FEEL	1	7.0	15
5	1	CARA	2	7.0	15
5	1	FFEL	1	6.0	5
5	1	FEEL	1	7.5	10
5	1	IPHE	2	7.5	10
5	1	CARA	3	7.5	10
5	1	FEEL	1	9.5	10
5	1	SOL	2	9.5	10
5	1	IPHE	3	9.5	10
5	1	FEEL	1	8.5	10
5	1	IPHE	2	8.5	10
5	1	FEEL	1	6.5	5
5	1	SOL	2	6.5	5
5	1	ERAN	4	6.5	5
5	1	IPHE	5	6.5	5
5	1	DACA	3	6.5	5
5	1	FEEL	1	10.5	15
5	1	IPHE	2	10.5	15
5	1	ASTER	3	10.5	15
5	1	FEEL	1	4.5	3
5	1	SOL	2	4.5	3
5	1	TRRE	3	4.5	3
5	1	PLMI	4	4.5	3
5	1	FEEL	1	6.0	1
5	1	ERAN	4	6.0	1
5	1	LECU	3	6.0	1
5	1	ERHI	2	6.0	1
5	1	FEEL	1	5.5	15
5	1	IPHE	2	5.5	15
5	2	FEEL	1	14.0	20
5	2	IPHE	3	14.0	20
5	2	OEBI	2	14.0	20
5	2	FEEL	1	8.5	10
5	2	IPHE	2	8.5	10
5	2	SOCA	3	8.5	10
5	2	FEEL	1	5.5	10
5	2	IPHF	3	5.5	10
5	2	ERHI	2	5.5	10
5	2	FEEL	1	5.0	3
5	2	FEEL	1	7.0	10
5	2	IPHE	3	7.0	10
5	2	OEBI	2	7.0	10
5	2	FFEL	1	6.0	10
5	2	IPHE	2	6.0	10
5	2	PRVU	3	6.0	10
5	2	FFEL	1	4.0	10
5	2	ANVI	2	4.0	10
5	2	ERAN	3	4.0	10
5	2	FEEL	1	6.0	10
5	2	TRRE	3	6.0	10

Table 21. (continued)

DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD
5	2	IPHE	4	6.0	10	5	2	FEEL	1	7.5	3	5	2	CARA	3	5.0	10
5	2	OEBI	2	6.0	10	5	2	CARA	2	7.5	3	5	2	FEEL	1	7.0	5
5	2	DACA	5	6.0	10	5	2	IPHE	4	7.5	3	5	2	IPHE	2	7.0	5
5	2	FEEL	1	7.5	5	5	2	ASTER	3	7.5	3	5	2	ASTER	3	7.0	5
5	2	DACA	2	7.5	5	5	2	FEEL	1	6.0	3	5	2	FEEL	1	5.5	5
5	2	IPHE	3	7.5	5	5	2	RUAL	2	6.0	3	5	2	OEBI	2	5.5	5
5	2	PALA	4	7.5	5	5	2	IPHE	3	6.0	3	5	2	FEEL	1	5.5	10
5	2	FEEL	1	5.0	5	5	2	FEEL	1	8.0	3	5	2	IPHE	2	5.5	10
5	2	PLLA	3	5.0	5	5	2	IPHE	3	8.0	3	5	2	CARA	3	5.5	10
5	2	LOJA	2	5.0	5	5	2	RUAL	2	8.0	3	5	2	FEEL	1	9.0	5
5	2	IPHE	4	5.0	5	5	2	FEEL	1	6.5	5	5	2	CARA	2	9.0	5
5	2	FEEL	1	6.5	10	5	2	SOCA	3	6.5	5	5	2	IPHE	3	9.0	5
5	2	IPHE	2	6.5	10	5	2	TRRE	2	6.5	5	5	2	FEEL	1	6.0	2
5	2	RUAL	3	6.5	10	5	2	FEEL	1	11.0	5	5	2	TRRE	3	6.0	2
5	2	FEEL	1	7.5	5	5	2	RUAL	2	11.0	5	5	2	CARA	2	6.0	2
5	2	RUAL	2	7.5	5	5	2	ASTER	3	11.0	5	5	2	FEEL	1	6.0	2
5	2	IPHE	3	7.5	5	5	2	FEEL	1	11.0	5	5	2	CARA	3	6.0	2
5	2	PLMI	4	7.5	5	5	2	IPHE	2	11.0	5	5	2	TRRE	2	6.0	2
5	2	TRRE	5	7.5	5	5	2	RUAL	3	11.0	5	5	2	FEEL	1	5.0	15
5	2	FEEL	1	6.5	1	5	2	FEEL	1	7.5	10	5	2	ANVI	3	5.0	15
5	2	ERAN	4	6.5	1	5	2	CARA	3	7.5	10	5	2	ASTER	2	5.0	15
5	2	TRPR	3	6.5	1	5	2	IPHE	4	7.5	10	5	2	FEEL	1	6.0	5
5	2	TRRE	5	6.5	1	5	2	FEEL	1	6.5	5	5	2	SOL	2	6.0	5
5	2	ASTER	2	6.5	1	5	2	IPHE	3	6.5	5	5	2	RUAL	3	6.0	5
5	2	FEEL	1	6.0	5	5	2	RUAL	2	7.5	10	5	2	FEEL	1	7.0	3
5	2	IPHE	2	6.0	5	5	2	CARA	2	6.5	5	5	2	DALA	3	7.0	3
5	2	ERAN	4	6.0	5	5	2	FEEL	1	8.5	5	5	2	RUAL	2	7.0	3
5	2	ASTER	3	6.0	5	5	2	IPHE	2	8.5	5	5	2	FEEL	1	5.0	10
5	2	FEEL	1	6.0	10	5	2	FEEL	1	7.0	5	5	2	TRPR	2	5.0	10
5	2	CARA	2	6.0	10	5	2	IPHE	2	7.0	5	5	2	FEEL	1	5.5	10
5	2	IPHE	3	6.0	10	5	2	RUAL	4	7.0	5	5	2	IPHE	2	5.5	10
5	2	FEEL	1	6.0	5	5	2	CARA	3	7.0	5	6	1	FEEL	1	6.0	20
5	2	SOL	2	6.0	5	5	2	FEEL	1	6.0	10	6	1	SOL	2	6.0	20
5	2	IPHE	3	6.0	5	5	2	SOL	2	6.0	10	6	1	RUAL	4	6.0	20
5	2	TRRE	4	6.0	5	5	2	RUAL	3	6.0	10	6	1	LECU	3	6.0	20
5	2	FEEL	1	7.5	10	5	2	FEEL	1	4.5	10	6	1	FEEL	2	5.5	20
5	2	IPHE	3	7.5	10	5	2	TRRE	4	4.5	10	6	1	ANVI	1	5.5	20
5	2	ASTER	2	7.5	10	5	2	ASTER	2	4.5	10	6	1	TRRE	4	5.5	20
5	2	FEEL	1	7.0	5	5	2	CARA	3	4.5	10	6	1	SOL	3	5.5	20
5	2	ASTER	3	7.0	5	5	2	FEEL	1	6.0	5	6	1	FEEL	1	5.0	25
5	2	TRRE	4	7.0	5	5	2	TRRE	2	6.0	5	6	1	TRRE	2	5.0	25
5	2	PLMI	5	7.0	5	5	2	OEBI	3	6.0	5	6	1	ASTER	3	5.0	25
5	2	CARA	7	7.0	5	5	2	ASTER	4	6.0	5	6	1	PLMI	4	5.0	25
5	2	SESM	6	7.0	5	5	2	FEEL	1	5.0	10	6	1	FEEL	1	7.0	15
5	2	IPHE	2	7.0	5	5	2	TRRE	2	5.0	10	6	1	TRRE	2	7.0	15
5	2	FEEL	1	7.5	5	5	2	CARA	3	5.0	10	6	1	FEEL	1	6.5	20
5	2	SOL	2	7.5	5	5	2	FEEL	1	5.5	3	6	1	SOL	2	6.5	20
5	2	IPHE	3	7.5	5	5	2	TRRE	2	5.5	3	6	1	FEEL	1	8.5	15
5	2	RUAL	4	7.5	5	5	2	PLMI	4	5.5	3	6	1	PLMI	3	8.5	15
5	2	TRPR	5	7.5	5	5	2	SESM	3	5.5	3	6	1	DACA	4	8.5	15
5	2	PLMI	6	7.5	5	5	2	ERAN	5	5.5	3	6	1	ASTER	2	8.5	15
5	2	FEEL	1	5.5	10	5	2	FEEL	1	8.5	15	6	1	FEEL	1	8.0	10
5	2	IPHE	2	5.5	10	5	2	ASTER	2	8.5	15	6	1	CARA	3	8.0	10
5	2	PLMI	4	5.5	10	5	2	CARA	3	8.5	15	6	1	SOL	2	8.0	10
5	2	SOL	3	5.5	10	5	2	FEEL	1	8.0	5	6	1	ASTER	4	8.0	10
5	2	TRRE	5	5.5	10	5	2	ASTER	2	8.0	5	6	1	PLMI	5	8.0	10
5	2	FEEL	1	6.5	3	5	2	FEEL	1	5.0	10	6	1	TRRE	6	8.0	10
5	2	IPHE	2	6.5	3	5	2	RUAL	2	5.0	10						

Table 21. (continued)

DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD
6	1	FEEL	1	8.0	15	6	1	RUAL	3	10.5	15	6	1	CARA	3	7.5	30
6	1	FEEL	1	11.0	20	6	1	FEEL	1	7.0	20	6	1	OEBI	4	7.5	30
6	1	ASTER	2	11.0	20	6	1	ASTER	2	7.0	20	6	1	FEEL	1	9.5	25
6	1	FEEL	1	10.5	20	6	1	FEEL	1	6.0	25	6	2	SOL	2	9.5	25
6	1	ASTER	2	10.5	20	6	1	RUAL	2	6.0	25	6	2	CARA	3	9.5	25
6	1	FEEL	1	5.0	30	6	1	IPHE	3	6.0	25	6	2	FEEL	1	8.5	30
6	1	RUAL	2	5.0	30	6	1	FEEL	1	8.0	10	6	2	IPHE	4	8.5	30
6	1	SOL	3	5.0	30	6	1	FEEL	1	8.0	20	6	2	CARA	3	8.5	30
6	1	FEEL	1	6.0	20	6	1	CARA	2	8.0	20	6	2	SOL	2	8.5	30
6	1	DACA	3	6.0	20	6	1	OEBI	3	8.0	20	6	2	FEEL	1	10.0	15
6	1	CARA	2	6.0	20	6	1	FEEL	1	8.0	20	6	2	FEEL	1	6.0	30
6	1	FEEL	1	3.5	40	6	1	IPHE	2	8.0	20	6	2	CARA	3	6.0	30
6	1	SOL	2	3.5	40	6	1	FEEL	1	9.5	25	6	2	RUAL	2	6.0	30
6	1	DACA	4	3.5	40	6	1	IPHE	2	9.5	25	6	2	FEEL	1	8.0	
6	1	ASTER	3	3.5	40	6	1	UALA	3	9.5	25	6	2	IPHE	3	8.0	
6	1	FEEL	1	8.5	20	6	1	SOCA	4	9.5	25	6	2	SOL	2	8.0	
6	1	ERHI	2	8.5	20	6	1	FEEL	1	9.0	15	6	2	FEEL	1	12.0	20
6	1	ASTER	3	8.5	20	6	1	ASTER	2	9.0	15	6	2	FEEL	1	7.0	30
6	1	FEEL	1	7.0	25	6	1	FEEL	1	6.5	20	6	2	FEEL	1	7.0	25
6	1	PRVU	2	7.0	25	6	1	ERAN	2	6.5	20	6	2	IPHE	2	7.0	25
6	1	DACA	6	7.0	25	6	1	ASTER	3	6.5	20	6	2	FEEL	1	8.0	25
6	1	PLMI	3	7.0	25	6	1	FEEL	1	7.0	20	6	2	RUAL	2	8.0	25
6	1	TRRE	5	7.0	25	6	1	IPHE	2	7.0	20	6	2	FEEL	1	8.0	15
6	1	ASTER	4	7.0	25	6	1	FEEL	1	10.0	15	6	2	CARA	2	8.0	15
6	1	FEEL	1	5.5	30	6	1	CARA	2	10.0	15	6	2	RUAL	3	8.0	15
6	1	OEBI	2	5.5	30	6	1	FEEL	1	8.5	20	6	2	SOL	4	8.0	15
6	1	FEEL	1	10.0	25	6	1	RUAL	2	8.5	20	6	2	FEEL	1	5.0	25
6	1	SOCA	3	10.0	25	6	1	IPHE	3	8.5	20	6	2	IPHE	3	5.0	25
6	1	IPHE	2	10.0	25	6	1	FEEL	1	11.5	15	6	2	TRRE	2	5.0	25
6	1	DACA	4	10.0	25	6	1	FEEL	1	7.0	25	6	2	FEEL	1	9.0	20
6	1	FEEL	1	5.0	20	6	1	DACA	3	7.0	25	6	2	RUAL	3	9.0	20
6	1	SOL	2	5.0	20	6	1	CARA	2	7.0	25	6	2	ASTER	2	9.0	20
6	1	TRPR	3	5.0	20	6	1	FEEL	1	11.5	10	6	2	FEEL	1	6.0	20
6	1	FEEL	1	5.0	20	6	1	CARA	2	11.5	10	6	2	SOL	2	6.0	20
6	1	SOL	2	5.0	20	6	1	IPHE	3	11.5	10	6	2	RUAL	3	6.0	20
6	1	SOCA	5	5.0	20	6	1	FEEL	1	8.5	30	6	2	DLMI	4	6.0	20
6	1	DLLA	4	5.0	20	6	1	CARA	2	8.5	30	6	2	FEEL	1	6.0	15
6	1	ASTER	3	5.0	20	6	1	FEEL	1	6.0	35	6	2	IPHE	4	6.0	15
6	1	FEEL	1	7.0	30	6	1	DACA	2	6.0	35	6	2	PLMI	3	6.0	15
6	1	IPHE	2	7.0	30	6	1	SOL	3	6.0	35	6	2	TRRE	2	6.0	15
6	1	ASTER	3	7.0	30	6	1	FEEL	1	11.5		6	2	DACA	5	6.0	15
6	1	FEEL	1	6.5	35	6	1	IPHE	3	11.5		6	2	FEEL	1	8.0	20
6	1	ASTER	2	6.5	35	6	1	ASTER	2	11.5		6	2	ASTER	2	8.0	20
6	1	FEEL	1	6.5	20	6	1	FEEL	1	10.5		6	2	RUAL	3	8.0	20
6	1	FEEL	1	5.0	35	6	1	SOCA	2	10.5		6	2	FEEL	1	7.5	25
6	1	ASTER	2	5.0	35	6	1	FEEL	1	9.0	25	6	2	IPHE	2	7.5	25
6	1	FEEL	1	4.5	20	6	1	RUAL	2	9.0	25	6	2	TRRE	3	7.5	25
6	1	RUAL	2	4.5	20	6	1	FEEL	1	9.5	20	6	2	FEEL	1	6.0	20
6	1	OEBI	3	4.5	20	6	1	DACA	2	9.5	20	6	2	IPHE	2	6.0	20
6	1	ASTER	4	4.5	20	6	1	FEEL	1	10.5	20	6	2	TRPR	3	6.0	20
6	1	FEEL	1	6.5	15	6	1	RUAL	2	10.5	20	6	2	FEEL	1	12.0	15
6	1	LECU	2	6.5	15	6	1	ASTER	3	10.5	20	6	2	SOCA	3	12.0	15
6	1	RUAL	3	6.5	15	6	1	TRPR	4	10.5	20	6	2	ASTER	2	12.0	15
6	1	FEEL	1	14.5	10	6	1	FEEL	1	8.5	25	6	2	FEEL	1	7.0	15
6	1	IPHE	3	14.5	10	6	1	CARA	2	8.5	25	6	2	RUAL	2	7.0	15
6	1	ASTER	2	14.5	10	6	1	IPHE	3	8.5	25	6	2	IPHE	3	7.0	15
6	1	FEEL	1	10.5	15	6	1	FEEL	1	7.5	30	6	2	FEEL	1	10.5	15
6	1	SOL	2	10.5	15	6	1	ASTER	2	7.5	30						

Table 21. (continued)

DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD
6	2	RUAL	2	10.5	15	6	2	RUAL	2	10.0	15	7	1	SOL	2	5.5	20
6	2	IPHE	3	10.5	15	6	2	FEEL	1	7.0	15	7	1	ASTER	3	5.5	20
6	2	FEEL	1	7.0	30	6	2	RUAL	2	7.0	15	7	1	FEEL	1	7.0	25
6	2	CARA	2	7.0	30	6	2	IPHE	3	7.0	15	7	1	SOL	2	7.0	25
6	2	IPHE	3	7.0	30	6	2	FEEL	2	7.0	10	7	1	ASTER	3	7.0	25
6	2	RUAL	4	7.0	30	6	2	RUAL	1	7.0	10	7	1	FEEL	1	6.0	20
6	2	FEEL	1	8.5	25	6	2	FEEL	1	7.0	15	7	1	SOL	2	6.0	20
6	2	CARA	2	8.5	25	6	2	SOL	3	7.0	15	7	1	ASTER	3	6.0	20
6	2	IPHE	3	8.5	25	6	2	CARA	4	7.0	15	7	1	ANVI	4	6.0	20
6	2	FEEL	1	5.0	20	6	2	ASTER	2	7.0	15	7	1	FEEL	1	5.0	25
6	2	SOL	3	5.0	20	6	2	FEEL	1	8.5	15	7	1	LECU	2	5.0	25
6	2	OLLA	4	5.0	20	6	2	RUAL	2	8.5	15	7	1	RUAL	3	5.0	25
6	2	ASTER	2	5.0	20	6	2	SOCA	3	8.5	15	7	1	FEEL	1	4.5	20
6	2	FEEL	1	7.0	20	6	2	IPHE	4	8.5	15	7	1	SOL	2	4.5	20
6	2	RUAL	2	7.0	20	6	2	FEEL	1	8.0	40	7	1	ASTER	3	4.5	20
6	2	IPHE	3	7.0	20	6	2	IPHE	2	8.0	40	7	1	FEEL	1	5.5	15
6	2	TRRE	4	7.0	20	6	2	FEEL	1	10.	20	7	1	LECU	2	5.5	15
6	2	FEEL	1	4.0	35	6	2	RUAL	2	10.	20	7	1	SOL	3	5.5	15
6	2	SOL	3	4.0	35	6	2	SOL	3	10.	20	7	1	FEEL	1	5.5	30
6	2	RUAL	4	4.0	35	6	2	CARA	4	10.	20	7	1	DIVI	2	5.5	30
6	2	ASTER	2	4.0	35	6	2	FEEL	1	8.5	25	7	1	FEEL	1	7.5	25
6	2	FEEL	1	10.0	15	6	2	CARA	2	8.5	25	7	1	EUFI	2	7.5	25
6	2	SMGL	2	10.0	15	6	2	IPHE	3	8.5	25	7	1	SOL	3	7.5	25
6	2	TRPR	4	10.0	15	6	2	FEEL	1	7.0	35	7	1	FEEL	1	5.5	20
6	2	RUAL	6	10.0	15	6	2	SOL	2	7.0	35	7	1	RUAL	2	5.5	20
6	2	ERAN	3	10.0	15	6	2	IPHE	3	7.0	35	7	1	FEEL	1	6.0	15
6	2	TRRE	5	10.0	15	6	2	RUAL	4	7.0	35	7	1	SOL	2	6.0	15
6	2	FEEL	1	5.5	20	6	2	FEEL	1	8.0	10	7	1	ASTER	3	6.0	15
6	2	RUAL	2	5.5	20	6	2	LECU	2	8.0	10	7	1	RUAL	4	6.0	15
6	2	ASTER	3	5.5	20	6	2	RUAL	3	8.0	10	7	1	FEEL	1	7.5	40
6	2	IPHE	4	5.5	20	6	2	SOL	4	8.0	10	7	1	RUAL	2	7.5	40
6	2	FEEL	1	6.5	15	6	2	IPHE	3	10.	20	7	1	FEEL	1	6.5	30
6	2	IPHE	5	6.5	15	6	2	RUAL	2	10.	20	7	1	FEEL	1	4.5	25
6	2	ERAN	2	6.5	15	6	2	FEEL	1	10.	20	7	1	RUAL	2	4.5	25
6	2	RUAL	4	6.5	15	6	2	DACA	4	10.	20	7	1	EUFI	3	4.5	25
6	2	CARA	3	6.5	15	6	2	FEEL	1	8.5	20	7	1	SOL	4	4.5	25
6	2	FEEL	1	9.5	10	6	2	ASTER	3	8.5	20	7	1	FEEL	1	4.5	20
6	2	LECU	2	9.5	10	6	2	RUAL	2	8.5	20	7	1	SOL	2	4.5	20
6	2	PHVU	3	9.5	10	6	2	IPHE	4	8.5	20	7	1	ASTER	4	4.5	20
6	2	IPHE	4	9.5	10	6	2	FEEL	1	10.0	15	7	1	RUAL	3	4.5	20
6	2	FEEL	1	7.	15	6	2	IPHE	2	10.0	15	7	1	FEEL	1	4.0	40
6	2	ERAN	3	7.	15	6	2	ASTER	3	10.0	15	7	1	IPHE	2	4.0	40
6	2	ASTER	2	7.	15	6	2	FEEL	1	9.0	35	7	1	FEEL	1	4.0	45
6	2	CARA	4	7.	15	6	2	RUAL	2	9.0	35	7	1	RUAL	2	4.0	45
6	2	IPHE	5	7.	15	6	2	IPHE	3	9.0	35	7	1	ASTER	3	4.0	45
6	2	FEEL	1	8.0	15	6	2	FEEL	1	6.0	15	7	1	FEEL	1	8.0	20
6	2	ASTER	2	8.0	15	6	2	SOL	2	6.0	15	7	1	SOL	2	8.0	20
6	2	CARA	4	8.0	15	6	2	RUAL	3	6.0	15	7	1	ASTER	3	8.0	20
6	2	RUAL	3	8.0	15	6	2	FEEL	1	10.	20	7	1	FEEL	1	4.5	25
6	2	RUHI	5	8.0	15	6	2	IPHE	2	10.	20	7	1	ANVI	2	4.5	25
6	2	FEEL	1	11.0	10	6	2	FEEL	1	8.0	15	7	1	RUAL	3	4.5	25
6	2	IPHE	2	11.0	10	6	2	LECU	2	8.0	15	7	1	FEEL	1	4.0	25
6	2	FEEL	1	6.0	20	6	2	SMGL	3	8.0	15	7	1	IPHE	3	4.0	25
6	2	RUAL	2	6.0	20	6	2	RUAL	4	8.0	15	7	1	RUAL	2	4.0	25
6	2	ASTER	3	6.0	20	7	1	FEEL	1	7.5	20	7	1	FEEL	1	7.0	20
6	2	IPHE	4	6.0	20	7	1	ASTER	2	7.5	20	7	1	RUAL	2	7.0	20
6	2	FEEL	1	10.0	15	7	1	FEEL	1	5.5	20	7	1	FEEL	1	7.5	30
6	2	IPHE	3	10.0	15							7	1	RUAL	2	7.5	30

Table 21. (continued)

DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD
7	1	FEEL	1	5.0	30	7	1	PACO	2	7.0	20	7	2	RUAL	2	6.5	30
7	1	RUAL	2	5.0	30	7	1	ASTER	3	7.0	20	7	2	SOCA	4	6.5	30
7	1	ASTER	3	5.0	30	7	2	FEEL	1	5.5	25	7	2	LECU	3	6.5	30
7	1	FEEL	1	5.0	15	7	2	EUFI	2	5.5	25	7	2	FEEL	1	5.0	25
7	1	RUAL	2	5.0	15	7	2	FEEL	1	6.5	20	7	2	SOL	2	5.0	25
7	1	FEEL	1	6.0	20	7	2	FEEL	1	4.5	40	7	2	LECU	3	5.0	25
7	1	RUAL	2	6.0	20	7	2	ASTER	2	4.5	40	7	2	FEEL	1	5.0	40
7	1	FEEL	1	3.5	30	7	2	FEEL	1	5.0		7	2	RUAL	2	5.0	40
7	1	RUAL	2	3.5	30	7	2	SOL	2	5.0		7	2	FEEL	1	6.5	25
7	1	SOL	3	3.5	30	7	2	FEEL	1	5.5	20	7	2	ANVI	2	6.5	25
7	1	FEEL	1	6.0	20	7	2	RUAL	2	5.5	20	7	2	LECU	3	6.5	25
7	1	RUAL	2	6.0	20	7	2	ASTER	3	5.5	20	7	2	FEEL	1	9.5	35
7	1	DACA	3	6.0	20	7	2	FEEL	1	5.0	35	7	2	SMGL	2	9.5	35
7	1	FEEL	1	8.0	20	7	2	SOL	2	5.0	35	7	2	FEEL	1	9.5	30
7	1	SOL	2	8.0	20	7	2	FEEL	1	5.5	35	7	2	RUAL	2	9.5	30
7	1	FEEL	1	8.0	25	7	2	RUAL	2	5.5	35	7	2	SOL	3	9.5	30
7	1	FEEL	1	7.0	35	7	2	FEEL	1	4.5	30	7	2	FEEL	1	6.5	20
7	1	RUAL	2	7.0	35	7	2	SOL	2	4.5	30	7	2	LECU	2	6.5	20
7	1	IPHE	4	7.0	35	7	2	ANVI	3	4.5	30	7	2	SOL	3	6.5	20
7	1	SOL	3	7.0	35	7	2	FEEL	1	3.5	20	7	2	FEEL	1	8.0	20
7	1	FEEL	1	6.5	25	7	2	LECU	2	3.5	20	7	2	FEEL	1	6.0	25
7	1	EUFI	2	6.5	25	7	2	ASTER	3	3.5	20	7	2	LECU	2	6.0	25
7	1	CARA	3	6.5	25	7	2	FEEL	1	6.0	25	7	2	FEEL	1	6.0	25
7	1	FEEL	1	8.0	30	7	2	ANVI	2	6.0	25	7	2	RUAL	2	6.0	25
7	1	EUFI	2	8.0	30	7	2	DIVI	3	6.0	25	7	2	FEEL	1	8.5	30
7	1	FEEL	1	10.0	20	7	2	FEEL	1	4.0	40	7	2	FEEL	1	7.0	30
7	1	FEEL	1	11.0	20	7	2	SOL	2	4.0	40	7	2	SOL	2	7.0	30
7	1	FEEL	1	5.5	40	7	2	FEEL	1	5.0	30	7	2	DIVI	3	7.0	30
7	1	FEEL	1	3.5	35	7	2	EUFI	2	5.0	30	7	2	FEEL	1	8.0	20
7	1	ASTER	2	3.5	35	7	2	FEEL	1	5.0	20	7	2	RUAL	2	8.0	20
7	1	FEEL	1	4.0	30	7	2	EUFI	2	5.0	20	7	2	FEEL	1	8.0	25
7	1	SOL	2	4.0	30	7	2	RUAL	3	5.0	20	7	2	RUAL	2	8.0	25
7	1	FEEL	1	6.5	20	7	2	FEEL	1	5.5	25	7	2	FEEL	1	8.0	20
7	1	ASTER	2	6.5	20	7	2	RUAL	3	5.5	25	7	2	RUAL	2	8.0	20
7	1	FEEL	1	5.5	25	7	2	SOL	2	5.5	25	7	2	FEEL	1	5.5	35
7	1	DACA	4	5.5	25	7	2	FEEL	1	8.5	20	7	2	RUAL	2	5.5	35
7	1	SOL	2	5.5	25	7	2	RUAL	2	8.5	20	7	2	FEEL	1	8.5	20
7	1	RUAL	3	5.5	25	7	2	FEEL	1	9.0	25	7	2	ASTER	2	8.5	20
7	1	FEEL	1	6.5	30	7	2	EUFI	2	9.0	25	7	2	FEEL	1	5.0	40
7	1	SOL	2	6.5	30	7	2	FEEL	1	5.0	35	7	2	ASTER	2	5.0	40
7	1	FEEL	1	4.5	20	7	2	RUAL	2	5.0	35	7	2	FEEL	1	5.0	30
7	1	ASTER	2	4.5	20	7	2	ASTER	3	5.0	35	7	2	RUAL	3	5.0	30
7	1	EUFI	3	4.5	20	7	2	FEEL	1	6.5	20	7	2	EUFI	2	5.0	30
7	1	FEEL	1	4.0	40	7	2	RUAL	2	6.5	20	7	2	FEEL	1	7.0	30
7	1	FEEL	1	4.5	35	7	2	FEEL	1	6.0	20	7	2	RUAL	2	7.0	30
7	1	FEEL	1	4.5	30	7	2	SOL	2	6.0	20	7	2	LECU	3	7.0	30
7	1	ASTER	2	4.5	30	7	2	FEEL	1	7.0	15	7	2	FEEL	1	8.5	35
7	1	FEEL	1	4.5	40	7	2	LECU	2	7.0	15	7	2	FEEL	1	7.0	40
7	1	RUAL	2	4.5	40	7	2	FEEL	1	5.0	20	7	2	FEEL	1	7.5	30
7	1	ASTER	3	4.5	40	7	2	RUAL	2	5.0	20	7	2	ASTER	2	7.5	30
7	1	FEEL	1	7.0	40	7	2	FEEL	1	7.5	45	7	2	FEEL	1	5.5	35
7	1	FEEL	1	5.0	30	7	2	RUAL	2	7.5	45	7	2	RUAL	2	5.5	35
7	1	IPHE	3	5.0	30	7	2	FEEL	1	6.0	40	7	2	FEEL	1	5.5	35
7	1	ASTER	2	5.0	30	7	2	FEEL	1	6.0	30	7	2	ASTER	2	5.5	35
7	1	FEEL	1	8.5	20	7	2	LECU	2	6.0	30	7	2	FEEL	1	8.0	25
7	1	RUAL	2	8.5	20	7	2	SMGL	3	6.0	30	8	1	FEEL	1	3.0	60
7	1	FEEL	1	8.0	20	7	2	FEEL	1	6.5	30	8	1	EUFI	2	3.0	60
7	1	FEEL	1	7.0	20												

Table 21. (continued)

DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD
8	1	FEEL	1	6.5	50	8	1	FEEL	1	5.0	75	8	2	FEEL	1	4.0	50
8	1	FEEL	1	4.0	70	8	1	FEEL	1	4.0	50	8	2	RUAL	2	4.0	50
8	1	RUAL	2	4.0	70	8	1	FEEL	1	4.0	65	8	2	FEEL	1	2.0	60
8	1	ASTER	3	4.0	70	8	1	FEEL	1	4.5	70	8	2	FEEL	1	4.5	70
8	1	FEEL	1	3.5	50	8	1	ASTER	2	4.5	70	8	2	RUAL	2	4.5	70
8	1	SOL	2	3.5	50	8	1	FEEL	1	3.5	65	8	2	FEEL	1	4.0	60
8	1	FEEL	1	4.0	50	8	1	ASTER	2	3.5	65	8	2	LESE	2	4.0	60
8	1	FEEL	1	2.0	60	8	1	FEEL	1	5.0	70	8	2	FEEL	1	2.0	65
8	1	SOL	2	2.0	60	8	1	RUAL	2	5.0	70	8	2	SMGL	2	2.0	65
8	1	RUAL	3	2.0	60	8	1	FEEL	1	2.5		8	2	FEEL	1	3.0	60
8	1	FEEL	1	3.5	60	8	1	EUFI	2	2.5		8	2	SOL	2	3.0	60
8	1	EUFI	2	3.5	60	8	1	RUAL	3	2.5		8	2	PANI	3	3.0	60
8	1	SOL	3	3.5	60	8	1	FEEL	1	4.0	60	8	2	FEEL	1	2.5	50
8	1	FEEL	1	2.5	70	8	1	EUFI	2	4.0	60	8	2	RUAL	2	2.5	50
8	1	RUAL	2	2.5	70	8	1	FEEL	1	5.0	65	8	2	LESE	3	2.5	50
8	1	PANI	4	2.5	70	8	1	TRFL	2	5.0	65	8	2	FEEL	1	3.0	60
8	1	ASTER	3	2.5	70	8	1	FEEL	1	2.0	70	8	2	FEEL	1	3.0	65
8	1	FEEL	1	2.5	55	8	1	RUAL	2	2.0	70	8	2	ANVI	2	3.0	65
8	1	ANVI	3	2.5	55	8	1	ASTER	3	2.0	70	8	2	FEEL	1	4.0	60
8	1	RUAL	2	2.5	55	8	1	FEEL	1	5.0	60	8	2	FEEL	1	4.0	70
8	1	FEEL	1	5.0	65	8	1	ANVI	2	5.0	60	8	2	SOL	2	4.0	70
8	1	EUFI	2	5.0	65	8	1	PRVU	3	5.0	60	8	2	FEEL	1	2.5	75
8	1	ASTER	3	5.0	65	8	1	FEEL	1	4.0	60	8	2	SOL	2	2.5	75
8	1	FEEL	1	3.0	75	8	1	SOL	2	4.0	60	8	2	FEEL	1	2.5	75
8	1	PANI	2	3.0	75	8	1	FEEL	1	5.0	60	8	2	FEEL	1	2.0	55
8	1	FEEL	1	3.5	45	8	1	ANVI	2	5.0	60	8	2	FEEL	1	2.0	70
8	1	SOL	2	3.5	45	8	1	FEEL	1	3.0	55	8	2	RUAL	2	2.0	70
8	1	FEEL	1	3.5	45	8	1	EUFI	3	3.0	55	8	2	FEEL	1	3.5	40
8	1	SOL	2	3.5	45	8	1	SOL	2	3.0	55	8	2	SOL	2	3.5	40
8	1	FEEL	1	2.0	70	8	1	FEEL	1	3.0	65	8	2	FEEL	1	3.0	75
8	1	ASTER	3	2.0	70	8	1	SOL	2	3.0	65	8	2	FEEL	1	4.0	
8	1	ANVI	2	2.0	70	8	1	ASTER	3	3.0	65	8	2	FEEL	1	2.0	50
8	1	FEEL	1	3.5	50	8	1	FEEL	1	2.5	70	8	2	DACA	2	2.0	50
8	1	SOL	2	3.5	50	8	1	EUFI	2	2.5	70	8	2	FEEL	1	3.0	
8	1	FEEL	1	2.0	75	8	1	FEEL	1	2.0	45	8	2	FEEL	1	2.0	50
8	1	ASTER	2	2.0	75	8	1	LESE	2	2.0	45	8	2	ANVI	2	2.0	50
8	1	FEEL	1	2.5	60	8	1	FEEL	1	3.0	60	8	2	FEEL	1	2.5	65
8	1	FEEL	1	3.5	70	8	1	LESE	2	3.0	60	8	2	SOHA	2	2.5	65
8	1	RUAL	2	3.5	70	8	1	EUFI	3	3.0	60	8	2	FEEL	1	3.0	40
8	1	FEEL	1	2.5	55	8	1	FEEL	1	1.5	50	8	2	LESE	2	3.0	40
8	1	RUAL	3	2.5	55	8	1	ANVI	2	1.5	50	8	2	FEEL	1	2.5	60
8	1	SOL	2	2.5	55	8	1	EUFI	3	1.5	50	8	2	LESE	2	2.5	60
8	1	FEEL	1	4.0	65	8	1	FEEL	1	3.5	60	8	2	FEEL	1	3.0	60
8	1	SOL	2	4.0	65	8	1	EUFI	2	3.5	60	8	2	RUAL	2	3.0	60
8	1	FEEL	1	3.5	65	8	1	RUAL	3	3.5	60	8	2	SOL	3	3.0	60
8	1	RUAL	1	3.5	65	8	1	FEEL	1	3.0	60	8	2	FEEL	1	5.0	60
8	1	FEEL	1	3.0	70	8	1	LESE	2	3.0	60	8	2	LESE	2	5.0	60
8	1	RUAL	2	3.0	70	8	1	RUAL	3	3.0	60	8	2	SOL	3	5.0	60
8	1	SOL	3	3.0	70	8	1	FEEL	1	4.0	70	8	2	FEEL	1	3.0	60
8	1	FEEL	1	2.5	70	8	1	ANVI	2	4.0	70	8	2	FEEL	1	2.5	60
8	1	RUAL	2	2.5	70	8	1	LESE	3	4.0	70	8	2	FEEL	1	5.5	50
8	1	FEEL	1	2.5	60	8	2	FEEL	1	2.5	65	8	2	SOL	2	5.5	50
8	1	FEEL	1	4.5	60	8	2	RUAL	2	2.5	65	8	2	FEEL	1	3.0	60
8	1	FEEL	1	4.0	75	8	2	LESE	3	2.5	65	8	2	FEEL	1	2.0	65
8	1	RUAL	2	4.0	75	8	2	FEEL	1	2.5	65	8	2	FEEL	1	2.0	75
8	1	FEEL	1	2.5	60	8	2	LESE	2	2.5	65	8	2	RUAL	2	2.0	75
8	1	FEEL	1	4.0	70	8	2	FEEL	1	6.0	75	8	2	FEEL	1	2.5	65
8	1	RUAL	2	4.0	70							8	2	ANVI	2	2.5	65

[a]Species identified by code, see Table 20 (page 134).

Part B. Preliminary Modeling and Systems Analysis

APPENDIX C

Table 22. Summary of Rapid Sample Data on Species Composition, State of Species (L, Live; D, Dead), Capacitance Readings (CAP) and Visual Estimation of Percent Standing Dead (DEAD) for 100 Unclipped Plots in the *Andropogon* Community Samples (DATE) 3 through 6[b].

DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD
3	1	ANVI	1	4.5	25	3	1	ERHI	1	10.0	10	3	1	PRVL	2	8.0	15
3	1	SOL	2	4.5	25	3	1	RUAL	2	10.0	10	3	1	SOL	3	8.0	15
3	1	DIVI	4	4.5	25	3	1	SOL	3	10.0	10	3	1	PACP	5	8.0	15
3	1	PACP	3	4.5	25	3	1	ANVI	1	2.5	25	3	1	ROSA	5	8.0	15
3	1	ROSA	5	4.5	25	3	1	CARA	2	2.5	25	3	1	ANVI	4	8.0	15
3	1	ANVI	3	5.5	5	3	1	SESM	3	2.5	25	3	1	SOL	1	11.0	5
3	1	RUAL	4	5.5	5	3	1	ANVI	1	3.0	10	3	1	ASTER	2	11.0	5
3	1	PACP	1	5.5	5	3	1	ASTER	2	3.0	10	3	1	SMGL	3	11.0	5
3	1	ASTER	2	5.5	5	3	1	CARA	3	3.0	10	3	1	PACP	4	11.0	5
3	1	DIVI	5	5.5	5	3	1	ANVI	1	10.0	10	3	1	DIVI	5	11.0	5
3	1	ANVI	1	3.0	25	3	1	SOL	2	10.0	10	3	1	ANVI	3	4.0	15
3	1	DIVI	2	3.0	25	3	1	RUAC	3	10.0	10	3	1	ASTER	1	4.0	15
3	1	ERAN	4	3.0	25	3	1	ANVI	1	4.0	10	3	1	SMGL	2	4.0	15
3	1	CARA	3	3.0	25	3	1	SESM	2	4.0	10	3	1	ROSA	4	4.0	15
3	1	ANVI	1	5.0	40	3	1	CARA	3	4.0	10	3	1	ANVI	1	3.5	10
3	1	SOL	2	5.0	40	3	1	ANVI	1	3.0	10	3	1	SOL	2	3.5	10
3	1	DIVI	3	5.0	40	3	1	ASTER	2	3.0	10	3	1	CARA	4	3.5	10
3	1	PACP	4	5.0	40	3	1	GATI	3	3.0	10	3	1	ROSA	5	3.5	10
3	1	ANVI	1	4.0	10	3	1	CARA	4	3.0	10	3	1	ANVI	3	5.5	20
3	1	SOL	2	4.0	10	3	1	ANVI	1	4.0	20	3	1	PACP	4	5.5	20
3	1	DIVI	3	4.0	10	3	1	SOL	2	4.0	20	3	1	ROSA	5	5.5	20
3	1	CARA	4	4.0	10	3	1	SMCA	4	4.0	20	3	1	SOL	2	5.5	20
3	1	ANVI	1	3.0	20	3	1	EUFI	3	4.0	20	3	1	ASTER	1	5.5	20
3	1	RUAL	2	3.0	20	3	1	CARA	5	4.0	20	3	1	ANVI	1	5.0	25
3	1	DIVI	3	3.0	20	3	1	ANVI	1	3.0	10	3	1	PRVL	2	5.0	25
3	1	ANVI	1	6.5	20	3	1	DIVI	3	3.0	10	3	1	ROSA	3	5.0	25
3	1	RUAL	2	6.5	20	3	1	ASTER	2	3.0	10	3	1	ASTER	1	6.5	10
3	1	DIVI	4	6.5	20	3	1	PACP	4	3.0	10	3	1	SMGL	2	6.5	10
3	1	PACP	3	6.5	20	3	1	ROSA	5	3.0	10	3	1	SOL	3	6.5	10
3	1	ANVI	1	5.0	15	3	1	ANVI	1	4.0	5	3	1	ROSA	4	6.5	10
3	1	PACP	2	5.0	15	3	1	SMGL	2	4.0	5	3	1	DIVI	5	6.5	10
3	1	ROSA	3	5.0	15	3	1	ASTER	3	4.0	5	3	1	ANVI	1	7.0	15
3	1	CARA	4	5.0	15	3	1	CARA	5	4.0	5	3	1	ASTER	3	7.0	15
3	1	ANVI	1	6.0	10	3	1	ROSA	4	4.0	5	3	1	PACP	4	7.0	15
3	1	DIVI	2	6.0	10	3	1	ANVI	1	6.0	40	3	1	CARA	5	7.0	15
3	1	SOL	3	6.0	10	3	1	ROSA	2	6.0	40	3	1	RUAL	2	7.0	15
3	1	PACP	4	6.0	10	3	1	CARA	3	6.0	40	3	1	ASTER	1	9.5	10
3	1	ANVI	1	2.5	30	3	1	ASTER	2	6.5	10	3	1	DIVI	3	9.5	10
3	1	DIVI	3	2.5	30	3	1	DIVI	3	6.5	10	3	1	ANVI	2	9.5	10
3	1	PACP	2	2.5	30	3	1	DEBI	1	6.5	10	3	1	PACP	4	9.5	10
3	1	CARA	4	2.5	30	3	1	ROSA	4	6.5	10	3	1	ANVI	3	4.0	10
3	1	ANVI	1	4.0	10	3	1	ANVI	2	4.5	20	3	1	RUAL	1	4.0	10
3	1	ASTER	2	4.0	10	3	1	EUFI	1	4.5	20	3	1	CARA	2	4.0	10
3	1	CARA	3	4.0	10	3	1	DIVI	4	4.5	20	3	1	PACP	4	4.0	10
3	1	PACP	4	4.0	10	3	1	ASTER	3	4.5	20	3	1	RUAL	2	6.0	10
3	1	CAFR	3	4.0	10	3	1	ANVI	1	4.5	15	3	1	ASTER	3	6.0	10
3	1	ANVI	1	4.0	10	3	1	ASTER	2	4.5	15	3	1	PACP	4	6.0	10
3	1	SOL	2	4.0	10	3	1	CIAR	4	4.5	15	3	1	EUFI	1	6.0	10
3	1	CARA	3	4.0	10	3	1	DIVI	5	4.5	15	3	1	EUFI	1	7.0	10
3	1	GATI	4	4.0	10	3	1	ROSA	3	4.5	15	3	1	RUAL	2	7.0	10
3	1	ANVI	1	3.0	15	3	1	ASTER	1	6.0	5	3	1	PACP	3	7.0	10
3	1	CARA	2	3.0	15	3	1	ANVI	2	6.0	5	3	1	SOL	4	7.0	10
3	1	DIVI	3	3.0	15	3	1	SMGL	3	6.0	5	3	1	ANVI	2	11.5	25
3	1	ANVI	1	1.5	5	3	1	DIVI	4	6.0	5	3	1	EUFI	1	11.5	25
3	1	ASTER	2	1.5	5	3	1	ASTER	1	8.0	15	3	1	ASTER	3	11.5	25

Table 22. (continued)

DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD
3	1	CARA	4	11.5	25	3	2	PACP	5	3.0	25	3	2	CARA	3	3.0	25
3	1	ANVI	1	3.5	35	3	2	ASTER	3	3.0	25	3	2	ASTER	2	3.0	25
3	1	CARA	3	3.5	35	3	2	ANVI	2	4.5	15	3	2	ASTER	1	6.0	15
3	1	PACP	2	3.5	35	3	2	ASTER	1	4.5	15	3	2	ANVI	2	6.0	15
3	1	DIVI	4	3.5	35	3	2	PACP	3	4.5	15	3	2	PACP	3	8.0	15
3	1	PACP	1	3.5	0	3	2	ASTER	1	3.5	15	3	2	CARA	4	6.0	15
3	1	CAFE	2	3.5	0	3	2	DIVI	2	3.5	15	3	2	ANVI	2	5.0	30
3	1	CARA	3	3.5	0	3	2	ROSA	3	3.5	15	3	2	CARA	1	5.0	30
3	1	EUFI	1	4.5	0	3	2	CARA	4	3.5	15	3	2	PACP	3	5.0	30
3	1	CARA	2	4.5	0	3	2	ANVI	1	4.5	25	3	2	ANVI	1	7.0	20
3	1	RUAL	3	4.5	0	3	2	PACP	2	4.5	25	3	2	ASTER	2	7.0	20
3	1	ASTER	4	4.5	0	3	2	DIVI	3	4.5	25	3	2	DALA	3	7.0	20
3	1	CAFE	5	4.5	0	3	2	SOL	4	4.5	25	3	2	ANVI	1	9.0	15
3	1	ANVI	3	3.5	5	3	2	ANVI	1	6.0	15	3	2	PACP	2	9.0	15
3	1	CAFE	1	3.5	5	3	2	SOL	2	6.0	15	3	2	IPHE	4	9.0	15
3	1	RUAL	2	3.5	5	3	2	PACP	3	6.0	15	3	2	SOCA	5	9.0	15
3	1	PACP	4	3.5	5	3	2	SOCA	4	6.0	15	3	2	RUAL	3	9.0	15
3	1	ANVI	1	4.5	15	3	2	ANVI	1	2.5	20	3	2	ANVI	1	8.0	20
3	1	ASTER	2	4.5	15	3	2	RUAL	2	2.5	20	3	2	RUAL	2	8.0	20
3	1	PACP	3	4.5	15	3	2	SOL	3	2.5	20	3	2	DIVI	3	8.0	20
3	1	RUAL	1	6.0	5	3	2	PACP	4	2.5	20	3	2	ANVI	1	3.0	20
3	1	ANVI	2	6.0	5	3	2	ANVI	1	3.0	40	3	2	ASTER	2	3.0	20
3	1	ASTER	3	3.0	5	3	2	RUAL	2	3.0	40	3	2	GATI	4	3.0	20
3	1	CAFE	1	3.0	5	3	2	CARA	3	3.0	40	3	2	CARA	3	3.0	20
3	1	ANVI	4	3.0	5	3	2	ANVI	2	6.0	20	3	2	ANVI	1	4.0	20
3	1	PACP	2	3.0	5	3	2	ASTER	1	6.0	20	3	2	PACP	3	4.0	20
3	1	RUAL	1	4.5	5	3	2	DIVI	3	6.0	20	3	2	CARA	2	4.0	20
3	1	CAFE	2	4.5	5	3	2	PACP	5	6.0	20	3	2	ANVI	1	4.0	10
3	1	PACP	3	4.5	5	3	2	CARA	4	6.0	20	3	2	GATI	4	4.0	10
3	1	ASTER	4	4.5	5	3	2	ANVI	1	3.5	40	3	2	DIVI	3	4.0	10
3	1	ANVI	1	4.0	30	3	2	ASTER	4	3.5	40	3	2	SOL	5	4.0	10
3	1	RUAL	2	4.0	30	3	2	SOL	5	3.5	40	3	2	ASTER	2	4.0	10
3	1	CARA	3	4.0	30	3	2	PACP	2	3.5	40	3	2	ANVI	2	4.0	15
3	2	ANVI	1	3.0	30	3	2	DIVI	3	3.5	40	3	2	RUAL	1	4.0	15
3	2	DIVI	5	3.0	30	3	2	ANVI	1	5.0	10	3	2	ASTER	3	4.0	15
3	2	ASTER	2	3.0	30	3	2	GATI	4	5.0	10	3	2	ANVI	1	5.0	50
3	2	PACP	3	3.0	30	3	2	SOL	3	5.0	10	3	2	ASTER	2	5.0	50
3	2	CARA	4	3.0	30	3	2	DIVI	5	5.0	10	3	2	CARA	3	5.0	50
3	2	ANVI	2	0.5	15	3	2	ASTER	5	5.0	10	3	2	ANVI	1	3.0	20
3	2	ASTER	1	0.5	15	3	2	EUFI	2	5.0	10	3	2	ASTER	2	3.0	20
3	2	PACP	3	0.5	15	3	2	ANVI	1	3.0	20	3	2	GATI	4	3.0	20
3	2	ANVI	1	2.5	35	3	2	DALA	2	3.0	20	3	2	CARA	3	3.0	20
3	2	CARA	2	2.5	35	3	2	SOCA	4	3.0	20	3	2	ANVI	1	9.0	15
3	2	ASTER	3	2.5	35	3	2	CARA	3	3.0	20	3	2	PACP	2	9.0	15
3	2	ANVI	1	4.0	20	3	2	ANVI	2	4.0	10	3	2	IPHE	4	9.0	15
3	2	PACP	3	4.0	20	3	2	DALA	1	4.0	10	3	2	SOCA	5	9.0	15
3	2	DIVI	2	4.0	20	3	2	CARA	3	4.0	10	3	2	RUAL	3	9.0	15
3	2	CARA	4	4.0	20	3	2	ANVI	1	4.5	15	3	2	ANVI	2	4.0	10
3	2	ANVI	1	5.0	35	3	2	DALA	2	4.5	15	3	2	DALA	1	4.0	10
3	2	RUAL	2	0.0	35	3	2	CARA	3	4.5	15	3	2	CARA	3	4.0	10
3	2	CARA	4	0.0	35	3	2	ASTER	2	3.5	10	3	2	ANVI	1	3.0	25
3	2	PACP	3	6.0	35	3	2	EUFI	1	3.5	10	3	2	CARA	3	3.0	25
3	2	ANVI	1	3.0	25	3	2	DIVI	4	3.5	10	3	2	ASTER	2	3.0	25
3	2	RUAL	2	3.0	25	3	2	ANVI	3	3.5	10	3	2	ANVI	1	7.0	25
3	2	DIVI	4	3.0	25	3	2	ANVI	1	3.0	25	3	2	ASTER	2	7.0	25

Table 22. (continued)

DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD
3	2	DALA	3	7.0	25	4	1	ASTER	2	4.0	35	4	1	ANVI	1	3.5	20
3	2	ANVI	2	5.0	30	4	1	CARA	3	4.0	35	4	1	CARA	4	3.5	20
3	2	CARA	1	5.0	30	4	1	ANVI	1	1.5	35	4	1	ASTER	2	3.5	20
3	2	PACP	3	5.0	30	4	1	PACP	2	1.5	35	4	1	ANVI	1	3.0	20
3	2	ANVI	2	4.0	15	4	1	PANI	4	1.5	35	4	1	GNPL	3	3.0	20
3	2	RUAL	1	4.0	15	4	1	CARA	3	1.5	35	4	1	ASTER	2	3.0	20
3	2	ASTER	3	4.0	15	4	1	ANVI	1	6.0	40	4	1	TRFL	4	3.0	20
3	2	ANVI	1	4.5	15	4	1	PACP	2	6.0	40	4	1	ANVI	1	2.5	20
3	2	DALA	2	4.5	15	4	1	BXST	3	6.0	40	4	1	ANVI	1	2.0	30
3	2	CARA	3	4.5	15	4	1	EUVI	1	3.0	5	4	1	CARA	2	2.0	30
3	2	ANVI	1	6.0	20	4	1	ANVI	2	3.0	5	4	1	ANVI	1	3.5	30
3	2	RUAL	2	6.0	20	4	1	SOCA	3	3.0	5	4	1	SOL	2	3.5	30
3	2	DIVI	3	6.0	20	4	1	ANVI	1	4.5	30	4	1	ANVI	1	3.0	10
3	2	ANVI	1	4.0	20	4	1	RUAL	2	4.5	30	4	1	SOL	2	3.0	10
3	2	PACP	3	4.0	20	4	1	CARA	3	4.5	30	4	1	DIVI	3	3.0	10
3	2	CARA	2	4.0	20	4	1	PACP	4	4.5	30	4	1	SOCA	4	3.0	10
3	2	ANVI	1	7.0	20	4	1	ANVI	1	2.0	30	4	1	ANVI	1	2.0	10
3	2	ASTER	2	7.0	20	4	1	CAPA	2	2.0	30	4	1	ASTER	3	2.0	10
3	2	PALA	3	7.0	20	4	1	RUAL	3	2.0	30	4	1	SOL	2	2.0	10
3	2	ANVI	1	4.0	10	4	1	PANI	4	2.0	30	4	1	DIVI	4	2.0	10
3	2	GATI	4	4.0	10	4	1	ANVI	1	3.5	40	4	1	ROSA	5	2.0	10
3	2	DIVI	3	4.0	10	4	1	SOCA	3	3.5	40	4	1	SOCA	5	2.0	10
3	2	SOL	5	4.0	10	4	1	EUFI	2	3.5	40	4	1	ANVI	2	4.0	25
3	2	ASTER	2	4.0	10	4	1	ANVI	1	1.5	40	4	1	ASTER	1	4.0	25
3	2	ASTER	2	3.5	10	4	1	GATI	2	1.5	40	4	1	PRVL	4	4.0	25
3	2	EUFI	1	3.5	10	4	1	CARA	3	1.5	40	4	1	SMGL	3	4.0	25
3	2	DIVI	4	3.5	10	4	1	ANVI	1	2.0	35	4	1	ANVI	2	5.0	40
3	2	ANVI	3	3.5	10	4	1	CARA	2	2.0	35	4	1	ASTER	1	5.0	40
3	2	ANVI	1	5.0	50	4	1	TRFL	3	2.0	35	4	1	SMGL	3	5.0	40
3	2	ASTER	2	5.0	50	4	1	ANVI	1	3.5	20	4	1	ANVI	1	4.0	20
3	2	CARA	3	5.0	50	4	1	GATI	2	3.5	20	4	1	ASTER	2	4.0	20
3	2	ANVI	2	4.0	15	4	1	TRFL	3	3.5	20	4	1	SMGL	4	4.0	20
3	2	RUAL	1	4.0	15	4	1	ANVI	1	1.5	70	4	1	ACRH	5	4.0	20
3	2	ASTER	3	4.0	15	4	1	GATI	2	1.5	70	4	1	DIVI	5	4.0	20
3	2	ANVI	1	4.5	15	4	1	CARA	3	1.5	70	4	1	ANVI	2	3.5	20
3	2	DIVI	4	4.5	15	4	1	ANVI	1	4.0	20	4	1	SOL	1	3.5	20
3	2	ROSA	3	4.5	15	4	1	ANVI	1	2.5	40	4	1	DIVI	3	3.5	20
3	2	ASTER	2	4.5	15	4	1	CARA	2	2.5	40	4	1	SOCA	5	3.5	20
3	2	ANVI	1	4.5	15	4	1	ANVI	1	2.0	60	4	1	ROSA	4	3.5	20
3	2	CARA	3	4.5	15	4	1	CARA	3	2.0	60	4	1	ANVI	1	3.5	15
3	2	ASTER	2	4.5	15	4	1	RUAL	2	2.0	60	4	1	DIVI	2	3.5	15
3	2	DIVI	4	4.5	15	4	1	ANVI	1	4.0	10	4	1	CARA	3	3.5	15
3	2	ANVI	1	5.5	5	4	1	ASTER	2	4.0	10	4	1	ANVI	1	4.5	20
3	2	DIVI	3	5.5	5	4	1	TRFL	3	4.0	10	4	1	SOL	2	4.5	20
3	2	ASTER	2	5.5	5	4	1	ANVI	1	3.0	10	4	1	DIVI	4	4.5	20
3	2	ANVI	3	7.0	5	4	1	SESM	2	3.0	10	4	1	LOJA	5	4.5	20
3	2	SOL	2	7.0	5	4	1	ANVI	1	2.0	10	4	1	PANI	3	4.5	20
3	2	DEBI	1	7.0	5	4	1	ASTER	2	2.0	10	4	1	ANVI	1	3.0	20
3	2	DIVI	4	7.0	5	4	1	ANVI	1	2.5	30	4	1	LOJA	2	3.0	20
3	2	CARA	5	7.0	5	4	1	ASTER	2	2.5	30	4	1	ASTER	3	3.0	20
3	2	ANVI	2	4.0	30	4	1	GATI	3	2.5	30	4	1	GATI	4	3.0	20
3	2	EUFI	1	4.0	30	4	1	ANVI	1	4.5	30	4	1	ANVI	1	3.5	15
3	2	ASTER	3	4.0	30	4	1	PACP	3	4.5	30	4	1	ASTER	3	3.5	15
3	2	GATI	4	4.0	30	4	1	ASTER	2	4.5	30	4	1	DIVI	2	3.5	15
4	1	ANVI	1	4.0	35	4	1	CARA	4	4.5	30	4	1	CARA	4	3.5	15

Table 22. (continued)

DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD
4	1	ANVI	1	4.0	30	4	2	TRFL	2	2.0	30	4	2	PACP	4	4.5	20
4	1	SML	2	4.0	30	4	2	RMSA	3	2.0	30	4	2	ANVI	1	3.5	10
4	1	ACRE	4	4.0	30	4	2	CARA	4	2.0	30	4	2	ANVI	1	1.5	20
4	1	RJAL	3	4.0	30	4	2	ANVI	1	2.5	20	4	2	TRFL	2	1.5	20
4	1	PACP	5	4.0	30	4	2	TRFL	2	2.5	20	4	2	CARA	3	1.5	20
4	1	ANVI	1	2.5	40	4	2	PACP	3	2.5	20	4	2	ANVI	2	2.5	20
4	1	ANVI	1	3.0	10	4	2	SML	4	2.5	20	4	2	ACRE	3	2.5	20
4	1	GATI	4	3.0	10	4	2	RMSA	5	2.5	20	4	2	SESP	4	2.5	20
4	1	DIVI	3	3.0	10	4	2	ANVI	1	3.0	20	4	2	PANI	5	2.5	20
4	1	SML	2	3.0	10	4	2	PACP	4	3.0	20	4	2	RMSA	5	2.5	20
4	1	ANVI	1	3.5	20	4	2	ASTER	3	3.0	20	4	2	ASTER	1	2.5	20
4	1	ASTER	3	3.5	20	4	2	RMSA	5	3.0	20	4	2	ANVI	3	4.0	20
4	1	ACRE	4	3.5	20	4	2	ANVI	1	3.0	20	4	2	RMSA	2	4.0	20
4	1	PACP	5	3.5	25	4	2	TRFL	2	3.0	20	4	2	ASTER	1	4.0	20
4	1	SML	2	3.5	20	4	2	ASTER	3	3.0	20	4	2	EUFI	1	5.5	20
4	1	ANVI	1	3.0	30	4	2	ANVI	1	2.0	30	4	2	ACRE	2	5.5	20
4	1	SMGL	2	3.0	30	4	2	TRFL	2	2.0	30	4	2	DIVI	3	5.5	20
4	1	SML	3	3.0	30	4	2	ASTER	3	2.0	30	4	2	ANVI	2	5.0	20
4	1	PACP	4	3.0	30	4	2	SMCA	4	2.0	30	4	2	ASTER	1	5.0	20
4	1	ANVI	1	4.0	40	4	2	ANVI	1	3.0	20	4	2	CARA	3	5.0	20
4	1	ASTER	2	4.0	40	4	2	TRFL	2	3.0	20	4	2	ANVI	1	2.5	25
4	1	RJAL	3	4.0	40	4	2	DIVI	4	3.0	20	4	2	ACRE	2	2.5	25
4	1	PACP	4	4.0	40	4	2	PACP	3	3.0	20	4	2	OXST	4	2.5	25
4	1	ANVI	1	2.0	10	4	2	ANVI	1	3.0	40	4	2	CARA	3	2.5	25
4	1	ANVI	1	1.5	35	4	2	TRFL	2	3.0	40	4	2	ANVI	1	2.5	30
4	1	CARA	2	1.5	35	4	2	CARA	3	3.0	40	4	2	CARA	2	2.5	30
4	1	RJAL	3	1.5	35	4	2	ANVI	1	1.5	20	4	2	PACP	3	2.5	30
4	1	ANVI	1	3.0	10	4	2	RUAL	2	1.5	20	4	2	ASTER	1	4.5	20
4	1	ASTER	2	3.0	10	4	2	SML	4	1.5	20	4	2	ANVI	2	4.5	20
4	1	RUAL	3	3.0	10	4	2	OXST	5	1.5	20	4	2	ANVI	1	5.0	20
4	1	ANVI	1	2.0	10	4	2	DIVI	3	1.5	20	4	2	SML	3	5.0	20
4	1	ANVI	1	3.5	10	4	2	ANVI	1	3.0	10	4	2	ANVI	1	3.0	10
4	1	SML	2	3.5	10	4	2	PANI	2	3.0	10	4	2	SML	2	3.0	10
4	1	ANVI	1	2.5	25	4	2	PACP	4	3.0	10	4	2	SECA	5	3.0	10
4	1	GATI	2	2.5	25	4	2	DIVI	3	3.0	10	4	2	DIVI	3	3.0	10
4	1	ANVI	1	5.0	30	4	2	EUMA	5	3.0	10	4	2	ANVI	1	3.0	35
4	1	PACP	3	5.0	30	4	2	ANVI	1	1.5	20	4	2	DEBI	2	3.0	35
4	1	ASTER	2	5.0	30	4	2	ACRE	4	1.5	20	4	2	SML	3	3.0	35
4	1	ANVI	1	2.0	30	4	2	DIVI	2	1.5	20	4	2	THISTLE	4	3.0	35
4	1	ASTER	2	2.0	30	4	2	PACP	3	1.5	20	4	2	ANVI	2	4.0	10
4	1	GATI	3	2.0	30	4	2	ANVI	2	3.5	10	4	2	PACP	1	4.0	10
4	1	ANVI	1	3.0	10	4	2	PACP	1	3.5	10	4	2	SML	3	4.0	10
4	1	GNFL	2	3.0	10	4	2	DIVI	3	3.5	10	4	2	ASTER	4	4.0	10
4	1	CARA	3	3.0	10	4	2	ANVI	1	3.0	15	4	2	ANVI	1	3.0	5
4	1	TRFL	3	3.5	20	4	2	DIVI	3	3.0	15	4	2	ASTER	2	3.0	5
4	1	TRFL	2	4.0	20	4	2	ASTER	2	3.0	15	4	2	RMSA	3	3.0	5
4	1	TRFL	2	3.0	20	4	2	ACRE	4	3.0	15	4	2	PANI	4	3.0	5
4	1	CIAR	3	4.0	20	4	2	ANVI	1	2.5	30	4	2	ANVI	1	2.5	10
4	1	CIAR	4	3.0	10	4	2	CARA	3	2.5	30	4	2	ASTER	2	2.5	10
4	1	CIAR	2	2.0	20	4	2	DIVI	2	2.5	30	4	2	PACP	4	2.5	10
4	2	ANVI	1	1.0	40	4	2	ANVI	2	3.0	15	4	2	DIVI	3	2.5	10
4	2	PACP	4	1.0	40	4	2	ACRE	1	3.0	15	4	2	ANVI	1	4.5	5
4	2	CARA	3	1.0	40	4	2	ANVI	2	4.5	20	4	2	ASTER	2	4.5	5
4	2	RMSA	2	1.0	40	4	2	EUFI	3	4.5	20	4	2	LAJA	3	4.5	5
4	2	ANVI	1	2.0	30	4	2	ASTER	1	4.5	20	4	2	ANVI	1	4.5	20

Table 22. (continued)

DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD
4	2	SML	2	4.5	20	4	2	PACP	3	3.0	35	5	1	ANVI	1	3.0	90
4	2	PACP	3	4.5	20	4	2	ANVI	1	4.0	40	5	1	CARA	2	3.0	90
4	2	LIVI	4	4.5	20	4	2	ASTER	2	4.0	40	5	1	ANVI	1	3.0	90
4	2	ANVI	1	2.5	10	4	2	PANI	3	4.0	40	5	1	SMCA	2	3.0	90
4	2	SMGL	2	2.5	10	5	1	ANVI	1	4.0	65	5	1	CARA	3	3.0	90
4	2	PACP	3	2.5	10	5	1	ANVI	1	2.0	70	5	1	ANVI	1	2.0	85
4	2	ANVI	1	5.0	20	5	1	CAFR	2	2.0	70	5	1	CATI	2	2.0	85
4	2	RMSA	3	5.0	20	5	1	ASTER	3	2.0	70	5	1	ANVI	1	2.0	80
4	2	ASTER	2	5.0	20	5	1	ANVI	1	1.5	85	5	1	ASTER	2	2.0	80
4	2	ANVI	3	5.0	25	5	1	ANVI	1	2.0	65	5	1	FRVL	3	2.0	80
4	2	RMSA	2	5.0	25	5	1	SESM	2	2.0	65	5	1	ANVI	1	2.5	90
4	2	ASTER	1	5.0	25	5	1	ANVI	1	2.0	75	5	1	SML	2	2.5	90
4	2	CARA	4	5.0	25	5	1	ASTER	2	2.0	75	5	1	ANVI	2	2.0	80
4	2	ANVI	2	3.0	30	5	1	PACP	3	2.0	75	5	1	PAAN	1	2.0	80
4	2	FRVL	3	3.0	30	5	1	ANVI	1	3.5	75	5	1	ANVI	1	3.5	85
4	2	RMSA	1	3.0	30	5	1	RUAL	2	3.5	75	5	1	CARA	2	3.5	85
4	2	CARA	4	3.0	30	5	1	PANI	3	3.5	75	5	1	ANVI	1	1.5	90
4	2	SML	5	3.0	30	5	1	ANVI	1	2.0	65	5	1	ANVI	1	1.5	85
4	2	PACP	1	3.0	1	5	1	CAFF	2	2.0	65	5	1	RMSA	2	1.5	85
4	2	ANVI	2	3.0	1	5	1	SMCA	3	2.0	65	5	1	CARA	3	1.5	85
4	2	ANVI	1	5.0	5	5	1	ANVI	1	4.0	70	5	1	ANVI	1	3.0	80
4	2	ASTER	2	5.0	5	5	1	PANI	2	4.0	70	5	1	CIAR	2	3.0	80
4	2	PACP	3	5.0	5	5	1	CAFF	3	4.0	70	5	1	RMSA	3	3.0	80
4	2	PACP	1	5.0	1	5	1	ANVI	1	3.0	80	5	1	ANVI	1	2.5	65
4	2	ASTER	2	5.0	1	5	1	CAFF	2	3.0	80	5	1	SESM	3	2.5	65
4	2	RUAL	3	5.0	1	5	1	ANVI	1	4.0	75	5	1	ASTER	2	2.5	65
4	2	PACP	1	4.5	10	5	1	CAFF	3	4.0	75	5	1	ANVI	1	3.0	80
4	2	EUFI	2	4.5	10	5	1	PACP	4	4.0	75	5	1	PACP	3	3.0	80
4	2	ACRE	3	4.5	10	5	1	ASTER	2	4.0	75	5	1	ASTER	4	3.0	80
4	2	RUAL	4	4.5	10	5	1	ANVI	1	2.0	85	5	1	DIVI	5	3.0	80
4	2	ANVI	1	3.0	30	5	1	PACP	2	2.0	85	5	1	EUFI	2	3.0	80
4	2	RUAL	2	3.0	30	5	1	ANVI	1	2.5	80	5	1	ANVI	1	2.5	90
4	2	CAFR	3	3.0	30	5	1	ASTER	2	2.5	80	5	1	ANVI	1	2.5	80
4	2	PACP	4	3.0	30	5	1	SESM	3	2.5	80	5	1	DIVI	4	2.5	80
4	2	PACP	1	4.5	1	5	1	ANVI	1	2.5	80	5	1	PANI	3	2.5	80
4	2	RUAL	2	4.5	1	5	1	SESM	2	2.5	80	5	1	ASTER	2	2.5	80
4	2	RUAL	1	6.0	1	5	1	ANVI	1	2.0	80	5	1	ANVI	1	2.0	85
4	2	ANVI	2	6.0	1	5	1	ASTER	2	2.0	80	5	1	GNPL	2	2.0	85
4	2	ANVI	1	3.0	5	5	1	ANVI	1	2.0	80	5	1	ACRE	3	2.0	85
4	2	RUAL	2	3.0	5	5	1	SESM	3	2.0	80	5	1	ANVI	1	3.0	85
4	2	PACP	3	3.0	5	5	1	SML	2	2.0	80	5	1	PAAN	2	3.0	85
4	2	ANVI	1	2.5	70	5	1	ANVI	3	4.0	70	5	1	ANVI	1	3.0	75
4	2	PANI	2	2.5	70	5	1	EUFI	2	4.0	70	5	1	ANVI	1	2.5	75
4	2	ANVI	1	1.5	80	5	1	SML	4	4.0	70	5	1	SMCA	3	2.5	75
4	2	PACP	2	1.5	80	5	1	ASTER	1	4.0	70	5	1	RUAL	2	2.5	75
4	2	SMCA	3	1.5	80	5	1	ANVI	1	2.5	80	5	1	ANVI	1	2.5	90
4	2	ANVI	1	3.0	30	5	1	ASTER	2	2.5	80	5	1	RUAL	2	2.5	90
4	2	ASTER	2	3.0	30	5	1	RUAL	3	2.5	80	5	1	ANVI	2	2.5	75
4	2	PACP	3	3.0	30	5	1	ANVI	1	2.0	90	5	1	PAAN	1	2.5	75
4	2	ANVI	2	4.0	30	5	1	RUAL	2	2.0	90	5	1	ANVI	1	3.5	95
4	2	ASTER	1	4.0	30	5	1	CAFR	3	2.0	90	5	1	RUAL	2	3.5	95
4	2	RMSA	3	4.0	30	5	1	ANVI	1	4.5	85	5	1	PACP	3	3.5	95
4	2	CARA	4	4.0	30	5	1	SML	2	4.5	85	5	1	ANVI	1	3.0	85
4	2	ANVI	1	3.0	35	5	1	PACP	3	4.5	85	5	1	PACP	2	3.0	85
4	2	ASTER	2	3.0	35	5	1	ANVI	1	3.0	95	5	1	PANI	3	3.0	85

Table 22. (continued)

DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD
5	1	ANVI	1	2.5	70	5	2	GNPU	2	3.0	90	5	2	ASTER	2	4.0	70
5	1	CIAR	2	2.5	70	5	2	ANVI	1	2.5	85	5	2	PACP	3	4.0	70
5	1	ANVI	1	3.5	90	5	2	EUFI	2	2.5	85	5	2	ANVI	1	2.5	80
5	1	PACP	3	3.5	90	5	2	PACP	3	2.5	85	5	2	SOL	2	2.5	80
5	1	SOL	2	3.5	90	5	2	ANVI	1	2.0	90	5	2	ASTER	3	2.5	60
5	1	ANVI	1	2.5	85	5	2	RUAL	2	2.0	90	5	2	ANVI	1	1.5	65
5	1	PACP	2	2.5	85	5	2	ANVI	1	1.5	90	5	2	ROSA	2	1.5	65
5	1	ANVI	1	3.0	90	5	2	RUAL	2	1.5	90	5	2	ANVI	1	4.0	70
5	1	GATI	2	3.0	90	5	2	ANVI	1	1.5	85	5	2	DIVI	2	4.0	70
5	1	ANVI	1	3.0	80	5	2	PAAN	2	1.5	85	5	2	ANVI	2	3.5	70
5	1	ASTER	2	3.0	80	5	2	ASTER	3	1.5	85	5	2	SOL	1	3.5	70
5	1	ACRF	4	3.0	80	5	2	ANVI	1	2.5	95	5	2	PACP	3	3.5	70
5	1	LOJA	3	3.0	80	5	2	PAAN	2	2.5	95	5	2	ANVI	1	3.0	90
5	2	ANVI	1	2.0	80	5	2	ANVI	1	4.5	80	5	2	PACP	3	3.0	90
5	2	ASTER	2	2.0	80	5	2	ASTER	2	4.5	80	5	2	ASTER	2	3.0	90
5	2	GATI	3	2.0	80	5	2	PAAN	3	4.5	60	5	2	ANVI	1	3.5	90
5	2	ANVI	1	2.5	80	5	2	ANVI	1	4.0	85	5	2	RUAL	2	3.5	90
5	2	PACP	3	2.5	80	5	2	ASTER	2	4.0	85	5	2	ANVI	1	3.0	75
5	2	ASTER	2	2.5	80	5	2	ANVI	1	3.0	90	5	2	PACP	2	3.0	75
5	2	ANVI	3	3.0	80	5	2	ASTER	3	3.0	90	5	2	ANVI	1	2.0	60
5	2	PACP	2	3.0	80	5	2	PAAN	2	3.0	90	5	2	SOL	3	2.0	60
5	2	RUAL	1	3.0	80	5	2	ANVI	1	3.0	95	5	2	ASTER	2	2.0	60
5	2	DIVI	2	2.5	90	5	2	PAAN	2	3.0	95	5	2	ANVI	1	3.0	90
5	2	PANI	3	2.5	90	5	2	PACP	3	3.0	95	5	2	RUAL	2	3.0	90
5	2	ANVI	1	2.5	75	5	2	ANVI	1	2.0	95	5	2	PACP	3	3.0	90
5	2	ASTER	2	2.5	75	5	2	PAAN	2	2.0	95	5	2	ANVI	1	2.0	95
5	2	ANVI	1	2.0	90	5	2	PACP	3	2.0	95	5	2	SOL	2	2.0	95
5	2	DIVI	2	2.0	90	5	2	ANVI	1	2.0	90	5	2	ANVI	1	1.5	90
5	2	ASTER	3	2.0	90	5	2	ASTER	3	2.0	90	5	2	RUAL	2	1.5	90
5	2	ANVI	1	3.5	85	5	2	PAAN	2	2.0	90	5	2	CARA	3	1.5	90
5	2	ASTER	2	3.5	85	5	2	ANVI	1	1.5	95	5	2	ANVI	1	3.5	90
5	2	ANVI	1	2.0	90	5	2	ANVI	1	2.5	90	5	2	RUAL	2	3.5	90
5	2	PAAN	2	2.0	90	5	2	ROSA	2	1.5	95	5	2	ANVI	1	2.5	85
5	2	ANVI	1	3.0	95	5	2	ANVI	1	2.5	90	5	2	RUAL	2	2.5	85
5	2	PACP	2	3.0	95	5	2	SOL	2	2.5	90	5	2	ASTER	3	2.5	85
5	2	ANVI	1	2.0	85	5	2	RUAL	3	2.5	90	6	1	ANVI	1	1.5	95
5	2	ASTER	2	2.0	85	5	2	ANVI	1	3.0	90	6	1	LOJA	2	1.5	95
5	2	ANVI	1	2.0	90	5	2	RUAL	2	3.0	90	6	1	ANVI	1	2.0	90
5	2	PAAN	2	2.0	90	5	2	ASTER	3	3.0	90	6	1	LOJA	3	2.0	90
5	2	CARA	3	2.0	90	5	2	DIVI	4	3.0	90	6	1	ASTER	2	2.0	90
5	2	ANVI	1	1.5	90	5	2	ANVI	1	2.5	90	6	1	DIVI	4	2.0	90
5	2	PACP	3	1.5	90	5	2	PANI	2	2.5	90	6	1	ANVI	1	2.0	99
5	2	ASTER	2	1.5	90	5	2	OXST	4	2.5	90	6	1	ANVI	1	2.0	85
5	2	ANVI	1	1.5	85	5	2	DIVI	3	2.5	90	6	1	LOJA	2	2.0	85
5	2	ASTER	2	1.5	85	5	2	ANVI	1	3.5	95	6	1	ANVI	1	2.0	99
5	2	ANVI	1	2.5	90	5	2	SOL	2	3.5	95	6	1	EUFI	2	2.0	99
5	2	ASTER	2	2.5	90	5	2	ANVI	1	6.0	90	6	1	ANVI	1	2.0	99
5	2	ANVI	1	2.0	90	5	2	SOL	2	6.0	90	6	1	ASTER	2	2.0	99
5	2	ROSA	2	2.0	90	5	2	PACP	3	6.0	90	6	1	ANVI	1	3.0	99
5	2	ANVI	1	1.5	90	5	2	ANVI	1	2.0	85	6	1	ANVI	1	2.0	99
5	2	ANVI	1	4.5	90	5	2	ASTER	2	2.0	85	6	1	ASTER	2	2.0	99
5	2	LOJA	2	4.5	90	5	2	ANVI	1	2.0	60	6	1	ANVI	1	1.5	97
5	2	EUFI	3	4.5	90	5	2	ANVI	1	2.0	80	6	1	ASTER	2	1.5	97
5	2	ANVI	1	1.5	90	5	2	ASTER	2	2.0	80	6	1	ANVI	1	2.0	97
5	2	ANVI	1	3.0	90	5	2	ANVI	1	4.0	70	6	1	PALA	2	2.0	97

Table 22. (continued)

DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD	DATE	REP	SPECIES	RANK	CAP	DEAD
6	1	ANVI	1	4.5	99	6	1	CAFR	2	3.0	95	6	2	ASTER	2	2.0	99
6	1	ASTER	2	4.5	99	6	1	ANVI	1	2.5	95	6	2	ANVI	1	2.0	99
6	1	ANVI	-0	2.5	99	6	1	PALA	2	2.5	95	6	2	DIVI	2	2.0	99
6	1	ASTER	-0	2.5	99	6	1	CAFR	3	2.5	95	6	2	ANVI	1	1.5	99
6	1	ANVI	1	2.5	99	6	1	ANVI	1	2.0	99	6	2	LOJA	2	1.5	99
6	1	ASTER	2	2.5	99	6	1	PALA	2	2.0	99	6	2	ASTER	3	1.5	99
6	1	ANVI	1	1.0	99	6	1	ANVI	1	2.0	95	6	2	ANVI	1	2.0	99
6	1	LOJA	2	1.0	99	6	1	CAFR	2	2.0	95	6	2	ASTER	2	2.0	99
6	1	ANVI	1	.5	99	6	1	ANVI	1	4.0	99	6	2	ANVI	1	2.0	99
6	1	ANVI	1	4.0	99	6	1	ANVI	1	1.0	95	6	2	ASTER	2	2.0	99
6	1	ASTER	2	4.0	99	6	1	CAFR	2	1.0	95	6	2	ANVI	1	2.0	95
6	1	ANVI	1	1.0	99	6	1	SOL	3	1.0	95	6	2	SOL	2	2.0	95
6	1	CAFR	3	1.0	99	6	1	ANVI	1	3.0	90	6	2	RUAL	3	2.0	95
6	1	ASTER	2	1.0	99	6	1	ANVI	1	2.5	99	6	2	ANVI	1	3.0	99
6	1	ANVI	1	1.0	99	6	1	EUFI	2	2.5	99	6	2	PALA	2	.5	95
6	1	ANVI	1	1.5	99	6	1	ANVI	1	3.0	95	6	2	ASTER	1	.5	95
6	1	ANVI	1	1.0	99	6	1	PANI	2	3.0	95	6	2	ANVI	1	2.5	97
6	1	ASTER	2	1.0	99	6	1	CAFR	3	3.0	95	6	2	ASTER	2	2.5	98
6	1	ANVI	1	2.5	99	6	1	GNPU	4	3.0	95	6	2	LOJA	3	.5	95
6	1	ASTER	2	2.5	99	6	1	ANVI	1	3.0	90	6	2	ANVI	1	2.0	90
6	1	ANVI	1	1.0	99	6	1	EUFI	2	3.0	99	6	2	SMGL	2	2.0	90
6	1	ANVI	1	1.5	99	6	2	ANVI	1	1.5	99	6	2	SESP	3	2.0	90
6	1	ANVI	1	1.0	99	6	2	CAFR	2	1.5	90	6	2	ANVI	1	2.0	95
6	1	ASTER	2	1.0	99	6	2	ANVI	1	3.0	95	6	2	LOJA	2	2.0	95
6	1	SOL	3	1.0	99	6	2	CAFR	2	3.0	95	6	2	DIVI	3	2.0	95
6	1	ANVI	1	2.0	95	6	2	PALA	3	3.0	95	6	2	ANVI	1	2.0	95
6	1	ASTER	2	2.0	95	6	2	ANVI	1	2.5	90	6	2	SMGL	2	2.0	95
6	1	ROSA	3	2.0	95	6	2	CAFR	2	2.5	90	6	2	ASTER	3	2.0	95
6	1	ANVI	1	2.0	99	6	2	ANVI	-0	2.0	90	6	2	ANVI	1	2.0	99
6	1	ANVI	1	4.5	99	6	2	ASTER	-0	2.0	90	6	2	SMGL	2	2.0	99
6	1	ASTER	2	4.5	99	6	2	CAFR	-0	2.0	90	6	2	ANVI	1	1.0	99
6	1	ANVI	1	1.5	99	6	2	ANVI	1	5.0	99	6	2	ASTER	2	1.0	99
6	1	ASTER	2	1.5	99	6	2	PAAN	3	5.0	99	6	2	SMGL	3	1.0	99
6	1	ANVI	1	2.0	99	6	2	ASTER	2	5.0	99	6	2	DIVI	4	1.0	99
6	1	ANVI	1	1.5	95	6	2	ANVI	1	2.0	95	6	2	ANVI	1	2.0	99
6	1	CAFR	3	1.5	95	6	2	RUAL	2	2.0	95	6	2	ASTER	2	2.0	99
6	1	ASTER	2	1.5	95	6	2	PAAN	3	2.0	95	6	2	ANVI	1	2.5	99
6	1	ANVI	1	2.5	99	6	2	ANVI	1	2.0	99	6	2	ANVI	1	3.0	99
6	1	PALA	2	2.5	99	6	2	RUAL	2	2.0	99	6	2	DIVI	2	3.0	99
6	1	ANVI	1	1.5	99	6	2	ASTER	3	2.0	99	6	2	ANVI	1	2.5	99
6	1	ANVI	1	2.5	99	6	2	PAAN	1	3.0	99	6	2	ASTER	2	2.5	99
6	1	ASTER	2	2.5	99	6	2	PALA	2	3.0	90	6	2	ANVI	1	1.5	95
6	1	ANVI	1	2.0	99	6	2	ANVI	3	3.0	99	6	2	RUAL	2	1.5	95
6	1	ASTER	2	2.0	99	6	2	ANVI	1	1.5	95	6	2	DIVI	3	1.5	95
6	1	ANVI	1	1.5	99	6	2	RUAL	2	1.5	95	6	2	ANVI	1	1.5	99
6	1	ASTER	2	1.5	99	6	2	PALA	1	4.0	95	6	2	PAAN	2	1.5	99
6	1	ANVI	1	2.0	99	6	2	RUAL	2	4.0	95	6	2	ANVI	2	1.0	80
6	1	ASTER	2	2.0	99	6	2	ANVI	3	4.0	95	6	2	RUAL	1	1.0	60
6	1	ANVI	1	4.0	99	6	2	PALA	1	4.0	99	6	2	PAAN	1	2.0	99
6	1	ASTER	2	4.0	99	6	2	ANVI	2	4.0	99	6	2	ANVI	1	1.5	95
6	1	ANVI	1	2.0	99	6	2	SOL	1	1.0	85	6	2	RUAL	2	1.5	95
6	1	ASTER	2	2.0	99	6	2	ANVI	3	1.0	85	6	2	ANVI	1	2.0	99
6	1	ANVI	1	2.5	99	6	2	LOJA	2	1.0	85	6	2	ASTER	2	2.0	99
6	1	PAAN	2	2.5	99	6	2	ASTER	4	1.0	85	6	2	DIVI	3	2.0	99
6	1	ANVI	1	3.0	95	6	2	ANVI	1	2.0	99	6	2	ANVI	1	2.0	95

[b]Species identified by code, see Table 20 (page 134).

Part B. Preliminary Modeling and Systems Analysis

APPENDIX D

Table 23. Summary of Standing Crop for Clipped Plots (PLOT) in the *Festuca* Community. Species Are Listed in Descending Rank per Plot with Live (L), Dead (D), and Flower Stalk (S) Dry Weights (g/0.25 m^2)[c]

PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT
1 1 4	FEEL	1	L	9.50	2 1 54	ASTER	2	D	24.00	1 2 79	ANVI	2	D	8.00
1 1 4	FEEL	1	D	34.80	2 1 54	PLRU	3	L	2.00	1 2 79	PANI	3	L	2.00
1 1 4	CARA	2	D	2.40	2 1 54	PALA	4	D	1.00	1 2 79	ASTER	4	L	6.00
1 1 4	PLRU	3	D	.90	2 1 58	FEEL	1	L	5.00	1 2 80	FEEL	1	L	15.00
1 1 4	PALA	4	D	.60	2 1 58	FEEL	1	D	41.00	1 2 80	FEEL	1	D	78.00
1 1 10	FEEL	1	L	9.70	2 1 58	ASTER	2	D	5.00	1 2 93	FEEL	1	L	8.00
1 1 10	FEEL	1	D	41.50	2 1 58	RUAL	3	L	.90	1 2 93	FEEL	1	D	39.00
1 1 10	PLRU	2	D	3.30	2 1 66	FEEL	1	L	6.00	1 2 94	FEEL	1	L	5.00
1 1 10	THRE	3	D	.30	2 1 66	FEEL	1	D	47.00	1 2 94	FEEL	1	D	31.00
1 1 14	PLRU	4	D	2.60	2 1 66	ASTER	2	D	5.00	1 2 94	ASTER	2	D	3.00
1 1 14	FEEL	1	L	11.50	2 1 66	SESM	3	D	.90	1 2 95	FEEL	1	L	5.00
1 1 14	FEEL	1	D	49.20	2 1 82	FEEL	1	L	27.00	1 2 95	FEEL	1	D	22.00
1 1 14	ASTER	2	D	17.10	2 1 82	FEEL	1	D	96.00	1 2 95	ASTER	2	D	15.00
1 1 14	PANI	3	D	1.90	2 1 89	FEEL	1	L	7.00	1 2 95	THRE	3	L	1.00
1 1 29	FEEL	1	L	10.50	2 1 89	FEEL	1	D	37.00	1 2 103	FEEL	1	L	10.00
1 1 29	FEEL	1	D	36.20	2 1 89	PALA	2	D	1.00	1 2 103	FEEL	1	D	55.00
1 1 29	ASTER	2	D	15.70	2 1 99	FEEL	1	L	17.00	1 2 103	ASTER	2	D	13.00
1 1 29	DEBI	3	D	6.40	2 1 99	FEEL	1	D	63.00	1 2 106	FEEL	1	L	13.00
1 1 29	PLLA	4	D	9.60	2 1 99	ASTER	2	D	9.00	1 2 106	FEEL	1	D	92.00
1 1 31	FEEL	1	L	11.00	2 1 99	PLLA	3	D	.90	1 2 109	FEEL	1	L	8.00
1 1 31	FEEL	1	D	44.50	1 2 3	FEEL	1	L	27.00	1 2 109	FEEL	1	D	83.00
1 1 31	ASTER	2	D	7.70	1 2 3	FEEL	1	D	138.00	1 2 109	ASTER	2	D	7.00
1 1 31	THRE	3	D	.50	1 2 3	ASTER	2	D	4.00	1 2 109	PANI	3	D	0
1 1 42	FEEL	1	L	38.70	1 2 13	FEEL	1	L	9.00	2 2 3	FEEL	1	L	11.00
1 1 42	FEEL	1	D	118.10	1 2 13	FEEL	1	D	71.00	2 2 3	FEEL	1	D	71.00
1 1 42	DACA	2	D	16.90	1 2 13	PANI	2	D	0	2 2 13	FEEL	1	L	7.00
1 1 43	FEEL	1	L	48.40	1 2 17	FEEL	1	L	12.00	2 2 13	FEEL	1	D	47.00
1 1 43	FEEL	1	D	113.00	1 2 17	FEEL	1	D	70.00	2 2 13	ASTER	2	D	4.00
1 1 43	PLRU	2	L	1.80	1 2 17	RUAL	2	D	3.00	2 2 13	PANI	3	D	1.00
1 1 68	FEEL	1	L	32.00	1 2 17	CARA	3	D	9.00	2 2 17	FEEL	1	L	63.00
1 1 68	FEEL	1	D	143.00	1 2 17	ASTER	4	D	5.00	2 2 17	FEEL	1	L	16.00
1 1 68	PLLA	2	D	.30	1 2 23	FEEL	1	L	11.00	2 2 17	ASTER	2	D	7.00
1 1 77	FEEL	1	L	53.70	1 2 23	FEEL	1	D	52.00	2 2 23	FEEL	1	L	5.00
1 1 77	FEEL	1	D	85.40	1 2 23	ASTER	2	D	3.00	2 2 23	FEEL	1	D	23.00
1 1 77	LOJA	2	D	2.10	1 2 23	PLRU	3	L	3.00	2 2 23	ASTER	2	D	28.00
1 1 77	PANI	3	D	1.60	1 2 28	FEEL	1	L	3.00	2 2 28	FEEL	1	L	19.00
1 1 88	FEEL	1	L	40.40	1 2 28	FEEL	1	D	53.00	2 2 28	FEEL	1	D	81.00
1 1 88	FEEL	1	D	69.90	1 2 28	ASTER	2	D	11.00	2 2 28	PANI	2	D	2.00
1 1 88	LOJA	2	D	1.00	1 2 30	FEEL	1	L	7.00	2 2 30	FEEL	1	L	11.00
2 1 8	FEEL	1	L	15.00	1 2 30	FEEL	1	D	55.00	2 2 30	FEEL	1	D	74.00
2 1 8	FEEL	1	D	65.00	1 2 35	FEEL	1	L	30.00	2 2 30	ASTER	2	D	9.00
2 1 8	ASTER	2	D	1.00	1 2 35	FEEL	1	D	80.00	2 2 35	FEEL	1	L	13.00
2 1 8	PLLA	3	D	1.00	1 2 35	ANVI	2	L	2.00	2 2 35	FEEL	1	D	82.00
2 1 25	FEEL	1	L	7.00	1 2 35	ANVI	2	D	32.00	2 2 49	FEEL	1	L	20.00
2 1 25	FEEL	1	D	30.00	1 2 49	FEEL	1	L	8.00	2 2 49	FEEL	1	D	106.00
2 1 25	ASTER	2	D	2.00	1 2 49	FEEL	1	D	101.00	2 2 62	FEEL	1	L	5.00
2 1 25	PALA	3	D	30.90	1 2 49	DACA	2	D	3.00	2 2 62	FEEL	1	D	29.00
2 1 45	FEEL	1	L	17.00	1 2 62	FEEL	1	L	30.00	2 2 62	ASTER	2	D	52.00
2 1 45	FEEL	1	D	87.00	1 2 62	FEEL	1	D	94.00	2 2 64	FEEL	1	L	9.00
2 1 45	CARA	2	D	.90	1 2 64	FEEL	1	L	12.00	2 2 64	FEEL	1	D	67.00
2 1 45	PALA	3	D	.60	1 2 64	FEEL	1	D	62.00	2 2 64	ASTER	2	D	6.00
2 1 45	RUAL	4	D	1.00	1 2 70	FEEL	1	L	15.00	2 2 70	FEEL	1	L	11.00
2 1 47	FEEL	1	L	11.00	1 2 70	FEEL	1	D	62.00	2 2 70	FEEL	1	D	101.00
2 1 47	FEEL	1	D	55.00	1 2 70	ASTER	2	D	7.00	2 2 74	FEEL	1	L	18.00
2 1 47	ASTER	2	D	3.00	1 2 74	FEEL	1	L	12.00	2 2 74	FEEL	1	D	134.00
2 1 47	RUAL	3	D	.90	1 2 74	FEEL	1	D	72.00	2 2 74	ASTER	2	D	8.00
2 1 54	FEEL	1	L	3.00	1 2 79	FEEL	1	L	3.00	2 2 79	FEEL	1	L	18.00
2 1 54	FEEL	1	D	30.00	1 2 79	FEEL	1	D	26.00	2 2 79	FEEL	1	D	138.00

Table 23. (continued)

PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT
2 2 80	FEEL	1	L	20.00	1 3 68	FEEL	1	U	99.00	2 3 47	FEEL	1	L	27.00
2 2 80	FEEL	1	U	106.00	1 3 68	IPHE	2	L	2.00	2 3 47	FEEL	1	U	102.00
2 2 93	FEEL	1	L	20.00	1 3 71	FEEL	1	L	34.00	2 3 47	IPHE	2	L	2.00
2 2 93	FEEL	1	U	101.00	1 3 71	FEEL	1	U	128.00	2 3 52	FEEL	1	L	15.00
2 2 93	ASTER	2	U	7.00	1 3 76	FEEL	1	L	21.00	2 3 52	FEEL	1	U	39.00
2 2 94	FEEL	1	L	8.00	1 3 76	FEEL	1	U	156.00	2 3 52	ASTER	2	L	8.00
2 2 94	FEEL	1	U	50.00	1 3 76	IPHE	2	L	2.00	2 3 52	SOL	3	L	1.00
2 2 95	FEEL	1	L	21.00	1 3 84	FEEL	1	L	32.00	2 3 52	IPHE	4	L	2.00
2 2 95	FEEL	1	U	83.00	1 3 84	FEEL	1	U	45.00	2 3 57	FEEL	1	L	25.00
2 2 103	FEEL	1	L	80.00	1 3 84	ASTER	2	L	11.00	2 3 57	FEEL	1	U	54.00
2 2 103	FEEL	1	U	18.00	1 3 84	PLLA	3	L	3.00	2 3 57	ASTER	2	L	3.00
2 2 103	ASTER	2	U	19.00	1 3 84	IPHE	4	L	1.00	2 3 68	FEEL	1	L	52.00
2 2 105	FEEL	1	L	9.00	1 3 84	CARA	5	L	2.00	2 3 68	FEEL	1	U	148.00
2 2 105	FEEL	1	U	79.00	1 3 91	FEEL	1	L	19.00	2 3 68	SOL	2	L	3.00
2 2 105	ASTER	2	U	14.00	1 3 91	FEEL	1	U	81.00	2 3 71	FEEL	1	L	29.00
2 2 109	FEEL	1	L	14.00	1 3 91	CARA	2	L	3.00	2 3 71	FEEL	1	U	196.00
2 2 109	FEEL	1	U	82.00	1 3 97	FEEL	1	L	27.00	2 3 76	FEEL	1	L	35.00
2 2 109	ASTER	2	L	8.00	1 3 97	FEEL	1	U	64.00	2 3 76	FEEL	1	U	240.00
1 3 7	FEEL	1	L	33.00	1 3 97	SOL	2	L	2.00	2 3 76	IPHE	2	L	0
1 3 7	FEEL	1	U	61.00	1 3 97	ASTER	3	L	2.00	2 3 84	FEEL	1	L	32.00
1 3 7	PLRU	2	L	3.00	1 3 97	IPHE	4	L	2.00	2 3 84	FEEL	1	U	68.00
1 3 9	FEEL	1	L	42.00	1 3 99	FEEL	1	L	20.00	2 3 84	ASTER	2	L	6.00
1 3 9	FEEL	1	U	2.00	1 3 99	FEEL	1	U	37.00	2 3 84	SOL	3	L	0
1 3 9	ASTER	2	L	9.00	1 3 99	IPHE	2	L	2.00	2 3 91	FEEL	1	L	43.00
1 3 15	FEEL	1	L	42.00	1 3 99	ASTER	3	L	8.00	2 3 91	FEEL	1	U	123.00
1 3 16	FEEL	1	U	183.00	1 3 99	PLRU	4	L	4.00	2 3 97	FEEL	1	L	35.00
1 3 15	ASTER	2	L	6.00	1 3 101	FEEL	1	L	21.00	2 3 97	FEEL	1	U	120.00
1 3 15	ROSA	3	L	3.00	1 3 101	FEEL	1	U	57.00	2 3 97	ASTER	2	L	3.00
1 3 19	FEEL	1	L	19.00	1 3 101	PLRU	2	L	1.00	2 3 97	SOL	3	L	1.00
1 3 19	FEEL	1	U	53.00	1 3 101	CARA	3	L	3.00	2 3 97	CAFR	4	L	2.00
1 3 19	ASTER	2	L	2.00	2 3 7	FEEL	1	L	13.00	2 3 97	IPHE	5	L	1.00
1 3 21	FEEL	1	L	9.00	2 3 7	FEEL	1	U	37.00	2 3 99	FEEL	1	L	41.00
1 3 21	FEEL	1	U	42.00	2 3 7	SOL	2	L	5.70	2 3 99	FEEL	1	U	110.00
1 3 21	ASTER	2	U	30.00	2 3 9	FEEL	1	L	33.00	2 3 101	FEEL	1	L	32.00
1 3 24	FEEL	1	L	29.00	2 3 9	FEEL	1	U	141.00	2 3 101	FEEL	1	U	158.00
1 3 24	FEEL	1	U	167.00	2 3 9	PLLA	2	L	1.00	1 4 2	FEEL	1	L	50.00
1 3 24	ASTER	2	L	19.00	2 3 16	FEEL	1	L	26.00	1 4 2	FEEL	1	U	78.00
1 3 33	FEEL	1	L	17.00	2 3 16	FEEL	1	U	86.00	1 4 2	DERI	2	U	12.00
1 3 33	FEEL	1	U	53.00	2 3 15	PLRU	2	L	2.00	1 4 2	PALA	3	L	1.00
1 3 33	SOL	2	L	8.00	2 3 19	FEEL	1	L	13.00	1 4 12	FEEL	1	L	65.00
1 3 33	PLRU	3	L	4.00	2 3 19	FEEL	1	U	37.00	1 4 12	FEEL	1	U	120.00
1 3 34	FEEL	1	L	8.00	2 3 19	THPR	2	L	3.00	1 4 14	FEEL	1	L	62.00
1 3 34	FEEL	1	U	23.00	2 3 19	PLRU	3	L	3.00	1 4 14	FEEL	1	U	199.00
1 3 34	ASTER	2	L	12.00	2 3 21	FEEL	1	L	19.00	1 4 14	IPHE	2	L	1.00
1 3 34	PLRU	3	L	5.00	2 3 21	FEEL	1	U	59.00	1 4 15	FEEL	1	L	29.00
1 3 34	THPR	4	L	2.00	2 3 21	IPHE	2	L	1.00	1 4 15	FEEL	1	U	191.00
1 3 41	FEEL	1	L	32.00	2 3 24	FEEL	1	L	15.00	1 4 15	IPHE	2	L	1.00
1 3 41	FEEL	1	U	104.00	2 3 24	FEEL	1	U	34.00	1 4 15	SOL	3	L	1.00
1 3 47	FEEL	1	L	32.00	2 3 24	PLRU	2	L	2.00	1 4 18	FEEL	1	L	62.00
1 3 47	FEEL	1	U	114.00	2 3 24	IPHE	3	L	3.00	1 4 18	FEEL	1	U	165.00
1 3 47	CARA	2	L	3.00	2 3 24	ASTER	4	L	6.00	1 4 26	FEEL	1	L	31.00
1 3 52	FEEL	1	L	24.00	2 3 33	FEEL	1	L	25.00	1 4 25	FEEL	1	U	73.00
1 3 52	FEEL	1	U	131.00	2 3 33	FEEL	1	U	90.00	1 4 25	PLRU	2	L	2.00
1 3 57	FEEL	1	L	31.00	2 3 34	FEEL	1	L	21.00	1 4 25	SOL	3	L	2.00
1 3 57	FEEL	1	U	152.00	2 3 34	FEEL	1	U	81.00	1 4 25	THPR	4	L	1.00
1 3 57	CARA	2	L	2.00	2 3 41	FEEL	1	L	41.00	1 4 38	FEEL	1	L	37.00
1 3 57	IPHE	3	L	2.00	2 3 41	FEEL	1	U	119.00	1 4 39	FEEL	1	U	144.00
1 3 68	FEEL	1	L	29.00	2 3 41	SOL	2	L	2.00	1 4 38	ASTER	2	U	22.00

Table 23. (continued)

PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT
1 4 42	FEEL	1	L	64.00	2 4 14	IPHE	3	L	3.00	2 4 69	RUAL	4	L	1.00
1 4 42	FEEL	1	U	188.00	2 4 14	THRE	4	L	3.00	2 4 74	FEEL	1	L	46.00
1 4 44	FEEL	1	L	51.00	2 4 15	FEEL	1	L	3.00	2 4 74	FEEL	1	U	134.00
1 4 44	FEEL	1	U	122.00	2 4 15	FEEL	1	U	18.00	2 4 74	SOL	2	L	4.00
1 4 44	OERI	2	U	22.00	2 4 15	CARA	2	L	2.00	2 4 74	IPHE	3	L	2.00
1 4 49	FEEL	1	L	64.00	2 4 15	SESM	3	L	9.00	2 4 79	FEEL	1	L	47.00
1 4 49	FEEL	1	U	102.00	2 4 15	IPHE	4	L	3.00	2 4 79	FEEL	1	U	140.00
1 4 50	FEEL	1	L	62.00	2 4 15	PLRU	5	L	1.00	2 4 79	CARA	2	L	2.00
1 4 50	FEEL	1	U	121.00	2 4 15	THRE	6	L	1.00	2 4 79	IPHE	3	L	1.00
1 4 50	OERI	2	L	40.00	2 4 18	FEEL	1	L	42.00	2 4 87	FEEL	1	L	48.00
1 4 54	FEEL	1	L	46.00	2 4 18	FEEL	1	U	160.00	2 4 87	FEEL	1	U	44.00
1 4 54	FEEL	1	U	77.00	2 4 18	IPHE	2	L	4.00	2 4 93	FEEL	1	L	48.00
1 4 61	FEEL	1	L	56.00	2 4 18	PHVU	3	L	2.00	2 4 93	FEEL	1	U	58.00
1 4 61	FEEL	1	U	202.00	2 4 18	CARA	4	L	1.00	2 4 93	IPHE	2	L	6.00
1 4 61	IPHE	2	L	2.00	2 4 26	FEEL	1	L	33.00	2 4 93	SOL	3	L	2.30
1 4 69	FEEL	1	L	28.00	2 4 26	FEEL	1	U	59.00	2 4 93	PLRU	4	L	1.00
1 4 69	FEEL	1	U	65.00	2 4 26	IPHE	2	L	6.00	2 4 97	FEEL	1	L	35.00
1 4 69	IPHE	2	L	2.00	2 4 26	PLRU	3	L	1.00	2 4 97	FEEL	1	U	37.00
1 4 69	SOL	3	L	2.00	2 4 26	ASTER	4	L	5.00	2 4 97	PLRU	2	L	1.00
1 4 74	FEEL	1	L	57.00	2 4 26	SOL	5	L	2.00	2 4 97	ASTER	3	L	1.60
1 4 74	FEEL	1	U	48.00	2 4 38	FEEL	1	L	53.00	2 4 97	IPHE	4	L	2.00
1 4 74	IPHE	2	L	3.00	2 4 38	FEEL	1	U	128.00	2 4 97	SOL	5	L	1.90
1 4 79	FEEL	1	L	40.00	2 4 38	IPHE	2	L	3.00	2 4 97	TRPR	6	L	1.00
1 4 79	FEEL	1	U	110.00	2 4 42	FEEL	1	L	34.00	2 4 103	FEEL	1	L	42.00
1 4 79	IPHE	2	L	6.00	2 4 42	FEEL	1	U	106.00	2 4 103	FEEL	1	U	123.00
1 4 87	FEEL	1	L	47.00	2 4 42	ASTER	2	L	2.00	2 4 103	SOL	2	L	6.00
1 4 87	FEEL	1	U	181.00	2 4 44	FEEL	1	L	56.00	1 5 6	FEEL	1	S	24.00
1 4 87	CARA	2	L	2.00	2 4 44	FEEL	1	U	164.00	1 5 6	FEEL	1	L	38.00
1 4 93	FEEL	1	L	37.00	2 4 44	RUAL	2	L	10.00	1 5 6	FEEL	1	U	130.00
1 4 93	FEEL	1	U	72.00	2 4 44	SOL	3	U	7.00	1 5 6	ANVI	2	L	3.90
1 4 93	IPHE	2	L	1.00	2 4 44	IPHE	4	L	1.00	1 5 6	ANVI	2	U	7.00
1 4 93	CARA	3	L	1.00	2 4 49	FEEL	1	L	32.00	1 5 6	SOL	3	L	2.00
1 4 97	FEEL	1	L	33.00	2 4 49	FEEL	1	U	33.00	1 5 6	DACA	4	L	4.00
1 4 97	FEEL	1	U	62.00	2 4 49	ANVI	2	L	12.00	1 5 9	FEEL	1	S	46.00
1 4 97	IPHE	2	L	1.00	2 4 49	PLRU	3	L	2.00	1 5 9	FEEL	1	L	61.00
1 4 97	THRE	3	L	1.00	2 4 49	IPHE	4	L	3.00	1 5 9	FEEL	1	U	140.00
1 4 97	PLRU	4	L	0	2 4 49	ASTER	5	L	8.00	1 5 9	SOL	2	L	2.00
1 4 97	SOL	5	L	4.00	2 4 49	SOL	6	L	1.00	1 5 11	FEEL	1	S	25.00
1 4 103	FEEL	1	L	21.00	2 4 49	CARA	7	L	1.00	1 5 11	FEEL	1	L	57.00
1 4 103	FEEL	1	U	53.00	2 4 50	FEEL	1	L	62.00	1 5 11	FEEL	1	U	116.00
1 4 103	PLRU	2	L	1.00	2 4 50	FEEL	1	U	106.00	1 5 11	CARA	2	L	11.00
1 4 103	SOL	3	L	6.00	2 4 50	IPHE	2	L	3.00	1 5 11	OERI	3	U	19.00
2 4 2	FEEL	1	L	29.00	2 4 54	FEEL	1	L	36.00	1 5 13	FEEL	1	S	17.00
2 4 2	FEEL	1	U	67.00	2 4 54	FEEL	1	U	52.00	1 5 13	FEEL	1	L	133.00
2 4 2	IPHE	2	L	2.00	2 4 54	SOL	2	L	7.00	1 5 13	FEEL	1	U	44.00
2 4 2	SOL	3	L	2.00	2 4 54	IPHE	3	U	2.00	1 5 13	SOL	2	L	22.00
2 4 2	PLRU	4	L	1.00	2 4 54	CARA	4	L	4.00	1 5 13	IPHE	3	L	4.00
2 4 2	THRE	5	L	1.00	2 4 54	RUAL	5	L	2.00	1 5 13	CARA	4	L	2.00
2 4 2	RUAL	6	L	2.00	2 4 61	FEEL	1	L	33.00	1 5 19	FEEL	1	S	7.00
2 4 12	FEEL	1	L	23.00	2 4 61	FEEL	1	U	89.00	1 5 19	FEEL	1	L	23.00
2 4 12	FEEL	1	U	49.00	2 4 61	ASTER	2	L	1.00	1 5 19	FEEL	1	U	49.00
2 4 12	PLRU	2	L	1.00	2 4 61	PLRU	3	L	4.00	1 5 19	SOL	2	L	8.00
2 4 12	RUAL	3	L	2.00	2 4 61	THRE	4	L	4.00	1 5 19	PLMI	3	L	2.00
2 4 12	THRE	4	L	3.00	2 4 61	IPHE	5	L	0	1 5 19	ROSA	4	L	2.00
2 4 12	IPHE	5	U	2.00	2 4 69	FEEL	1	L	63.00	1 5 19	THRE	5	L	2.00
2 4 14	FEEL	1	L	42.00	2 4 69	FEEL	1	U	108.00	1 5 20	FEEL	1	S	23.00
2 4 14	FEEL	1	U	132.00	2 4 69	OEBI	2	U	44.00	1 5 20	FEEL	1	L	63.00
2 4 14	ASTER	2	L	6.00	2 4 69	IPHE	3	L	1.00	1 5 20	FEEL	1	U	122.00

Table 23. (continued)

PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT
1 5 20	SOL	2	L	6.00	1 5 82	RUAL	4	L	3.00	2 5 44	FEEL	1	U	73.00
1 5 20	RUAL	3	L	2.00	1 5 82	TRRE	5	L	4.00	2 5 44	CARA	2	L	8.00
1 5 44	FEEL	1	S	18.00	1 5 84	FEEL	1	S	7.00	2 5 44	RUAL	3	L	3.00
1 5 44	FEEL	1	L	73.00	1 5 84	FEEL	1	L	26.00	2 5 44	IPHE	4	L	8.00
1 5 44	FEEL	1	U	138.00	1 5 84	FEEL	1	U	27.00	2 5 45	FEEL	1	S	22.00
1 5 44	CARA	2	L	21.00	1 5 84	SOL	2	L	34.00	2 5 46	FEEL	1	L	74.00
1 5 45	FEEL	1	S	18.00	1 5 84	THRE	3	L	9.00	2 5 45	FEEL	1	U	64.00
1 5 45	FEEL	1	L	39.00	1 5 84	SOCA	4	L	2.00	2 5 46	CARA	2	L	8.00
1 5 45	FEEL	1	U	95.00	1 5 85	FEEL	1	S	13.00	2 5 46	SOL	3	L	5.00
1 5 46	SOL	2	L	2.00	1 5 85	FEEL	1	L	62.00	2 5 46	IPHE	4	L	5.00
1 5 45	CARA	3	L	2.00	1 5 85	FEEL	1	U	124.00	2 5 45	ASTER	5	U	9.00
1 5 52	FEEL	1	S	11.00	1 5 85	CARA	2	L	4.00	2 5 52	FEEL	1	S	21.00
1 5 52	FEEL	1	L	46.00	1 5 85	RUAL	3	U	10.00	2 5 52	FEEL	1	L	60.00
1 5 52	FEEL	1	U	126.00	1 5 92	FEEL	1	S	11.00	2 5 52	FEEL	1	U	62.00
1 5 52	SOL	2	L	2.00	1 5 92	FEEL	1	L	48.00	2 5 52	CARA	2	L	4.00
1 5 53	FEEL	1	S	11.00	1 5 92	FEEL	1	U	119.00	2 5 52	SOL	3	L	7.00
1 5 53	FEEL	1	L	68.00	1 5 92	TRRE	2	L	3.00	2 5 52	LECU	4	L	9.00
1 5 53	FEEL	1	U	109.00	1 5 92	IPHE	3	L	2.00	2 5 52	IPHE	5	L	2.00
1 5 53	SOL	2	L	2.00	2 5 6	FEEL	1	S	22.00	2 5 52	RUAL	6	L	2.00
1 5 60	FEEL	1	S	10.00	2 5 6	FEEL	1	L	43.00	2 5 53	FEEL	1	S	11.00
1 5 60	FEEL	1	L	56.00	2 5 6	FEEL	1	U	131.00	2 5 53	FEEL	1	L	26.00
1 5 60	FEEL	1	U	121.00	2 5 6	IPHE	2	L	5.00	2 5 53	FEEL	1	U	72.00
1 5 60	IPHE	2	L	8.00	2 5 6	RUAL	3	L	5.00	2 5 53	RUAL	2	L	15.00
1 5 60	ERAN	3	L	2.00	2 5 9	FEEL	1	S	10.00	2 5 53	CARA	3	L	4.00
1 5 60	SOL	4	L	5.00	2 5 9	FEEL	1	L	29.00	2 5 53	IPHE	4	L	3.00
1 5 61	FEEL	1	S	14.00	2 5 9	FEEL	1	U	72.00	2 5 53	SOL	5	L	2.00
1 5 61	FEEL	1	L	53.00	2 5 9	CARA	2	L	2.00	2 5 60	FEEL	1	S	6.00
1 5 61	FEEL	1	U	156.00	2 5 9	IPHE	3	L	4.00	2 5 60	FEEL	1	L	22.00
1 5 61	IPHE	2	L	6.00	2 5 9	ERAN	4	L	3.00	2 5 60	FEEL	1	U	28.00
1 5 61	RUAL	3	L	7.00	2 5 9	PLMI	5	L	7.00	2 5 60	ANVI	2	L	11.00
1 5 67	FEEL	1	S	24.00	2 5 9	PANI	6	L	3.00	2 5 60	TRRE	3	L	2.00
1 5 67	FEEL	1	L	54.00	2 5 11	FEEL	1	S	13.00	2 5 60	SOCA	4	L	18.00
1 5 67	FEEL	1	U	129.00	2 5 11	FEEL	1	L	51.00	2 5 61	FEEL	1	S	5.00
1 5 67	OEBI	2	L	5.00	2 5 11	FEEL	1	U	150.00	2 5 61	FEEL	1	L	25.00
1 5 67	IPHE	3	L	2.00	2 5 11	PLMI	2	L	3.00	2 5 61	FEEL	1	U	13.00
1 5 67	RUAL	4	U	20.00	2 5 11	IPHE	3	L	3.00	2 5 61	TRRE	2	L	3.00
1 5 71	FEEL	1	S	37.00	2 5 13	FEEL	1	S	13.00	2 5 61	PLMI	3	L	1.00
1 5 71	FEEL	1	L	72.00	2 5 13	FEEL	1	L	27.00	2 5 67	FEEL	1	S	9.00
1 5 71	FEEL	1	U	107.00	2 5 13	FEEL	1	U	69.00	2 5 67	FEEL	1	L	57.00
1 5 71	CARA	2	L	4.00	2 5 13	CARA	2	L	4.00	2 5 67	FEEL	1	U	113.00
1 5 71	RUAL	3	L	3.00	2 5 13	PLMI	3	L	3.00	2 5 67	IPHE	2	L	4.00
1 5 71	IPHE	4	L	4.00	2 5 13	IPHE	4	L	3.00	2 5 67	SOL	3	L	3.00
1 5 76	FEEL	1	S	4.50	2 5 19	FEEL	1	S	17.00	2 5 71	FEEL	1	S	9.00
1 5 75	FEEL	1	L	42.00	2 5 19	FEEL	1	L	17.00	2 5 71	FEEL	1	L	28.00
1 5 75	FEEL	1	U	105.00	2 5 19	FEEL	1	U	30.00	2 5 71	FEEL	1	U	47.00
1 5 75	IPHE	2	L	13.00	2 5 19	TRRE	2	L	11.00	2 5 71	OEBI	2	L	3.00
1 5 75	ASTER	3	L	2.00	2 5 19	IPHE	3	L	5.00	2 5 71	ASTER	3	L	2.00
1 5 76	SOL	4	U	9.00	2 5 19	ASTER	4	U	9.00	2 5 71	SOL	4	U	14.00
1 5 81	FEEL	1	S	1.00	2 5 19	PLMI	5	L	3.00	2 5 71	IPHE	5	U	7.00
1 5 81	FEEL	1	L	50.00	2 5 20	FEEL	1	S	13.00	2 5 71	PLMI	6	L	3.00
1 5 81	FEEL	1	U	31.00	2 5 20	FEEL	1	L	48.00	2 5 71	CARA	7	L	2.00
1 5 81	IPHE	2	L	2.00	2 5 20	FEEL	1	U	81.00	2 5 76	FEEL	1	S	21.00
1 5 81	PLMI	3	L	2.00	2 5 20	CARA	2	L	5.00	2 5 76	FEEL	1	L	55.00
1 5 82	FEEL	1	S	8.00	2 5 20	IPHE	3	L	2.00	2 5 75	FEEL	1	U	126.00
1 5 82	FEEL	1	L	35.00	2 5 20	TRRE	4	L	3.00	2 5 76	SOL	2	L	5.00
1 5 82	FEEL	1	U	59.00	2 5 20	PLMI	5	L	2.00	2 5 76	IPHE	3	L	3.00
1 5 82	PLMI	2	U	2.00	2 5 44	FEEL	1	S	11.00	2 5 81	FEEL	1	S	14.00
1 5 82	SOL	3	L	7.00	2 5 44	FEEL	1	L	69.00	2 5 81	FEEL	1	L	46.00

Table 23. (continued)

PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT
2 5 81	FEEL	1	U	91.00	1 6 20	RUAL	2	L	7.00	1 6 87	FEEL	1	U	76.00
2 5 81	IPHE	2	L	3.00	1 6 22	FEEL	1	L	44.00	1 6 87	IPHE	2	L	3.00
2 5 81	CARA	3	L	3.00	1 6 22	FEEL	1	U	56.00	1 6 89	FEEL	1	S	14.00
2 5 82	FEEL	1	S	17.00	1 6 22	ASTER	2	L	20.00	1 6 89	FEEL	1	L	46.00
2 5 82	FEEL	1	L	22.00	1 6 22	RUAL	3	L	4.00	1 6 89	FEEL	1	U	158.00
2 5 82	FEEL	1	U	24.00	1 6 22	SOL	4	L	7.00	1 6 89	LOJA	2	L	13.00
2 5 82	ASTER	2	U	9.00	1 6 40	FEEL	1	L	48.00	1 6 89	IPHE	3	L	1.00
2 5 82	CARA	3	L	4.00	1 6 40	FEEL	1	U	81.00	1 6 96	FEEL	1	S	7.00
2 5 82	THRE	4	L	1.00	1 6 40	CARA	2	L	68.00	1 6 96	FEEL	1	L	34.00
2 5 82	IPHE	5	L	2.00	1 6 47	FEEL	1	S	2.00	1 6 96	FEEL	1	U	77.00
2 5 84	FEEL	1	S	13.00	1 6 47	FEEL	1	L	57.00	1 6 96	ASTER	2	U	14.00
2 5 84	FEEL	1	L	41.00	1 6 47	FEEL	1	U	87.00	1 6 96	PACA	3	L	2.00
2 5 84	FEEL	1	U	59.00	1 6 47	CARA	2	L	11.00	1 6 96	CARA	4	L	2.00
2 5 84	IPHE	2	L	3.00	1 6 47	PLMI	3	L	1.00	1 6 96	PLMI	5	L	2.00
2 5 84	THRE	3	L	2.00	1 6 47	PANI	4	L	3.00	1 6 96	IPHE	6	L	2.00
2 5 85	FEEL	1	S	4.00	1 6 48	FEEL	1	S	6.00	2 6 5	FEEL	1	S	3.00
2 5 85	FEEL	1	L	18.00	1 6 48	FEEL	1	L	80.00	2 6 5	FEEL	1	L	71.00
2 5 85	FEEL	1	U	14.00	1 6 48	FEEL	1	U	130.00	2 6 5	FEEL	1	U	4.00
2 5 85	LECU	2	L	5.00	1 6 48	CARA	2	L	16.00	2 6 5	RUAL	2	L	12.00
2 5 85	THRE	3	L	5.00	1 6 48	SOCA	3	L	2.00	2 6 5	IPHE	3	L	5.00
2 5 85	PLLA	4	L	4.00	1 6 52	FEEL	1	L	38.00	2 6 11	FEEL	1	S	4.00
2 5 85	PLMI	5	L	2.00	1 6 52	FEEL	1	U	29.00	2 6 11	FEEL	1	L	57.00
2 5 92	FEEL	1	S	17.00	1 6 52	CARA	2	L	2.00	2 6 11	FEEL	1	U	111.00
2 5 92	FEEL	1	L	40.00	1 6 52	DACA	3	L	1.00	2 6 11	ASTER	2	L	2.00
2 5 92	FEEL	1	U	47.00	1 6 54	FEEL	1	L	66.00	2 6 11	IPHE	3	L	1.00
2 5 92	IPHE	2	L	4.00	1 6 54	FEEL	1	U	68.00	2 6 11	SOL	4	L	2.00
2 5 92	SOL	3	L	17.00	1 6 54	ASTER	2	L	2.00	2 6 11	RUAL	5	L	1.00
2 5 92	THRE	4	L	2.00	1 6 54	SUMAC	3	L	2.00	2 6 12	FEEL	1	S	1.50
1 6 5	FEEL	1	L	77.00	1 6 65	FEEL	1	S	3.00	2 6 12	FEEL	1	L	21.00
1 6 5	FEEL	1	U	178.00	1 6 65	FEEL	1	L	43.00	2 6 12	FEEL	1	U	18.00
1 6 5	SOL	2	L	12.00	1 6 65	FEEL	1	U	78.00	2 6 12	RUAL	2	L	8.00
1 6 5	RUAL	3	L	7.00	1 6 65	IPHE	2	L	2.00	2 6 12	SOL	3	L	3.00
1 6 5	CARA	4	L	6.00	1 6 70	FEEL	1	S	5.00	2 6 12	THRE	4	L	4.00
1 6 11	FEEL	1	L	52.00	1 6 70	FEEL	1	L	79.00	2 6 12	PLMI	5	L	2.00
1 6 11	FEEL	1	U	82.00	1 6 70	FEEL	1	U	140.00	2 6 12	IPHE	6	L	3.00
1 6 11	RUAL	2	L	12.00	1 6 70	IPHE	2	L	7.00	2 6 12	SOCA	7	L	1.00
1 6 12	FEEL	1	S	12.00	1 6 70	DACA	3	L	2.00	2 6 12	ASTER	8	L	2.00
1 6 12	FEEL	1	L	47.00	1 6 78	FEEL	1	S	4.00	2 6 12	CARA	9	L	2.00
1 6 12	FEEL	1	U	98.00	1 6 78	FEEL	1	L	73.00	2 6 13	FEEL	1	S	3.00
1 6 12	DACA	2	L	4.00	1 6 78	FEEL	1	U	95.00	2 6 13	FEEL	1	L	30.00
1 6 12	ASTER	3	U	20.00	1 6 78	CARA	2	L	6.00	2 6 13	FEEL	1	U	39.00
1 6 12	RUAL	4	L	2.00	1 6 78	IPHE	3	L	2.00	2 6 13	PLMI	2	L	2.00
1 6 13	FEEL	1	S	4.00	1 6 78	SOCA	4	L	1.00	2 6 13	THRE	3	L	2.00
1 6 13	FEEL	1	L	70.00	1 6 80	FEEL	1	S	3.00	2 6 13	RUAL	4	L	3.00
1 6 13	FEEL	1	U	102.00	1 6 80	FEEL	1	L	43.00	2 6 13	PANI	5	L	4.00
1 6 13	CARA	2	L	36.00	1 6 80	FEEL	1	U	61.00	2 6 18	FEEL	1	S	7.00
1 6 13	ASTER	3	L	17.00	1 6 80	IPHE	2	L	5.00	2 6 18	FEEL	1	L	32.00
1 6 13	DACA	4	L	1.00	1 6 80	DACA	3	L	3.00	2 6 18	FEEL	1	U	103.00
1 6 18	FEEL	1	S	1.00	1 6 80	SOCA	4	L	1.00	2 6 18	IPHE	2	L	5.00
1 6 18	FEEL	1	L	42.00	1 6 80	PANI	5	L	2.00	2 6 18	ASTER	3	L	2.00
1 6 18	FEEL	1	U	58.00	1 6 83	FEEL	1	S	3.00	2 6 18	PLLA	4	L	4.00
1 6 18	ASTER	2	L	7.00	1 6 83	FEEL	1	L	32.00	2 6 18	PLMI	5	L	1.00
1 6 18	RUAL	3	L	3.00	1 6 83	FEEL	1	U	79.00	2 6 18	THRE	6	L	1.00
1 6 18	PANI	4	L	2.00	1 6 83	ANVI	2	L	21.00	2 6 18	PANI	7	L	2.00
1 6 18	SOCA	5	L	1.00	1 6 83	ASTER	3	L	2.00	2 6 20	FEEL	1	S	5.00
1 6 18	PLMI	6	L	1.00	1 6 83	SOL	4	L	2.00	2 6 20	FEEL	1	L	42.00
1 6 20	FEEL	1	L	74.00	1 6 83	CARA	5	L	1.00	2 6 20	FEEL	1	U	95.00
1 6 20	FEEL	1	U	61.00	1 6 87	FEEL	1	L	59.00	2 6 20	IPHE	2	L	6.00

Table 23. (continued)

PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT
2 6 20	THRE	3	L	2.00	2 6 80	IPHE	2	L	7.00	1 7 55	ASTER	3	L	1.00
2 6 22	FEEL	1	S	4.00	2 6 80	CARA	3	L	2.00	1 7 59	FEEL	1	L	87.00
2 6 22	FEEL	1	L	65.00	2 6 83	FEEL	1	S	11.00	1 7 59	FEEL	1	D	130.00
2 6 22	FEEL	1	D	55.00	2 6 83	FEEL	1	L	46.00	1 7 59	RUAL	2	L	3.00
2 6 22	SOL	2	L	2.00	2 6 83	FEEL	1	D	60.00	1 7 59	ASTER	3	L	2.00
2 6 22	ASTER	3	L	2.00	2 6 83	LECU	2	L	25.00	1 7 63	FEEL	1	L	46.00
2 6 22	PLMI	4	L	13.00	2 6 83	CARA	3	L	4.00	1 7 63	FEEL	1	D	112.00
2 6 22	IPHE	5	D	18.00	2 6 83	SOCA	4	L	2.00	1 7 63	RUAL	2	L	1.00
2 6 22	THRE	6	L	3.00	2 6 87	FEEL	1	S	11.00	1 7 63	SOL	3	L	1.00
2 6 22	DACA	7	L	2.00	2 6 87	FEEL	1	L	33.00	1 7 63	ASTER	4	L	2.00
2 6 22	CARA	8	L	1.00	2 6 87	FEEL	1	D	46.00	1 7 63	CARA	5	L	2.00
2 6 40	FEEL	1	S	6.00	2 6 87	CARA	2	L	3.00	1 7 69	FEEL	1	L	78.00
2 6 40	FEEL	1	L	57.00	2 6 89	FEEL	1	S	4.00	1 7 69	FEEL	1	D	217.00
2 6 40	FEEL	1	L	104.00	2 6 89	FEEL	1	L	66.00	1 7 71	FEEL	1	L	93.00
2 6 40	CARA	2	L	2.00	2 6 89	FEEL	1	D	93.00	1 7 71	FEEL	1	D	138.00
2 6 40	IPHE	3	L	6.00	2 6 89	CARA	2	L	2.00	1 7 71	RUAL	2	L	24.00
2 6 47	FEEL	1	L	48.00	2 6 89	SOCA	3	L	1.00	1 7 71	SOCA	3	L	.10
2 6 47	FEEL	1	D	61.00	2 6 89	SOL	4	L	1.90	1 7 71	ASTER	4	L	5.00
2 6 47	IPHE	2	L	5.00	2 6 96	FEEL	1	S	3.00	1 7 76	FEEL	1	L	35.00
2 6 47	ASTER	3	L	2.00	2 6 96	FEEL	1	L	59.00	1 7 76	FEEL	1	D	39.00
2 6 48	FEEL	1	S	2.00	2 6 96	FEEL	1	D	58.00	1 7 76	EUFI	2	L	19.00
2 6 48	FEEL	1	L	63.00	1 7 5	FEEL	1	L	44.00	1 7 76	RUAL	3	L	7.00
2 6 48	FEEL	1	D	89.00	1 7 5	FEEL	1	D	23.00	1 7 76	ASTER	4	L	8.00
2 6 48	CARA	2	L	4.00	1 7 7	FEEL	1	L	61.00	1 7 76	PANI	5	L	1.00
2 6 48	IPHE	3	L	14.00	1 7 7	FEEL	1	D	70.00	1 7 79	FEEL	1	L	36.00
2 6 52	FEEL	1	S	11.00	1 7 7	RUAL	2	L	2.00	1 7 79	FEEL	1	D	33.00
2 6 52	FEEL	1	L	52.00	1 7 7	SOL	3	L	8.00	1 7 79	SOL	2	L	10.00
2 6 52	FEEL	1	D	105.00	1 7 15	FEEL	1	L	96.00	1 7 80	FEEL	1	L	78.00
2 6 52	RUAL	2	L	13.00	1 7 15	FEEL	1	D	132.00	1 7 80	FEEL	1	D	87.00
2 6 52	ASTER	3	L	8.00	1 7 15	ASTER	2	L	8.00	1 7 80	SOL	2	L	10.00
2 6 52	IPHE	4	D	13.00	1 7 15	RUAL	3	L	1.00	1 7 80	RUAL	3	L	0
2 6 54	FEEL	1	S	8.00	1 7 18	FEEL	1	L	58.00	1 7 81	FEEL	1	L	63.00
2 6 54	FEEL	1	L	53.00	1 7 18	FEEL	1	D	93.00	1 7 81	FEEL	1	D	74.00
2 6 54	FEEL	1	D	71.00	1 7 18	SOL	2	L	78.00	1 7 81	ASTER	2	L	4.00
2 6 54	RUAL	2	L	2.00	1 7 18	ASTER	3	L	4.00	1 7 86	FEEL	1	L	51.00
2 6 54	IPHE	3	L	2.00	1 7 18	RUAL	4	L	3.00	1 7 86	FEEL	1	D	83.00
2 6 65	FEEL	1	S	3.00	1 7 18	THFL	5	L	2.00	1 7 86	ASTER	2	L	14.00
2 6 65	FEEL	1	L	43.00	1 7 18	CARA	6	L	3.00	1 7 86	SOL	3	L	5.00
2 6 65	FEEL	1	D	78.00	1 7 18	PANI	7	L	0	1 7 86	PLMI	4	L	1.00
2 6 65	ASTER	2	L	12.00	1 7 41	FEEL	1	L	80.00	1 7 86	THFL	5	L	7.00
2 6 65	RUAL	3	L	3.00	1 7 41	FEEL	1	D	212.00	1 7 86	ANVI	6	L	2.00
2 6 65	DACA	4	L	2.00	1 7 41	RUAL	2	L	2.00	1 7 86	DACA	7	L	0
2 6 65	PANI	5	L	2.00	1 7 44	FEEL	1	L	14.00	1 7 91	FEEL	1	L	122.00
2 6 70	FEEL	1	S	1.00	1 7 44	FEEL	1	D	88.00	1 7 91	FEEL	1	L	82.00
2 6 70	FEEL	1	L	62.00	1 7 44	RUAL	2	L	22.00	1 7 91	LOJA	2	L	3.00
2 6 70	FEEL	1	D	95.00	1 7 44	IPHE	3	L	2.00	2 7 5	FEEL	1	L	97.00
2 6 70	IPHE	2	L	6.00	1 7 44	CARA	4	L	9.00	2 7 5	FEEL	1	D	103.00
2 6 70	CARA	3	L	2.00	1 7 44	CAIR	5	L	2.00	2 7 5	EUFI	2	L	41.00
2 6 78	FEEL	1	S	4.00	1 7 48	FEEL	1	L	55.00	2 7 5	RUAL	3	L	27.50
2 6 78	FEEL	1	L	52.00	1 7 48	FEEL	1	D	138.00	2 7 5	CAFR	4	L	1.00
2 6 78	FEEL	1	D	139.00	1 7 48	CARA	2	L	13.00	2 7 7	FEEL	1	L	82.00
2 6 78	RUAL	2	L	6.00	1 7 52	FEEL	1	L	29.00	2 7 7	FEEL	1	D	82.00
2 6 78	IPHE	3	L	8.00	1 7 52	FEEL	1	D	171.00	2 7 7	EUMA	2	L	4.50
2 6 78	ASTER	4	D	8.00	1 7 52	RUAL	2	L	17.00	2 7 7	CAFR	3	L	9.00
2 6 78	SOCA	5	L	2.00	1 7 52	CARA	3	L	2.00	2 7 9	FEEL	1	L	63.00
2 6 80	FEEL	1	S	3.00	1 7 55	FEEL	1	L	40.00	2 7 9	FEEL	1	D	102.00
2 6 80	FEEL	1	L	34.00	1 7 55	FEEL	1	L	149.00	2 7 9	RUAL	2	L	3.00
2 6 80	FEEL	1	D	63.00	1 7 55	EUFI	2	L	37.00	2 7 9	ASTER	3	L	2.00

Table 23. (continued)

PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT
2 7 9	CAFR	4	L	2.00	2 7 81	FEEL	1	U	64.00	1 8 82	FEEL	1	L	37.00
2 7 15	FEEL	1	L	35.00	2 7 81	SOCA	2	L	.10	1 8 82	FEEL	1	U	78.00
2 7 15	FEEL	1	U	35.00	2 7 86	FEEL	1	L	65.00	1 8 82	SOL	2	U	14.00
2 7 15	SOL	2	L	13.00	2 7 86	FEEL	1	U	60.00	1 8 82	ASTER	3	U	1.00
2 7 15	RUAL	3	L	6.00	2 7 91	FEEL	1	L	44.00	1 8 86	FEEL	1	L	32.00
2 7 15	PLLA	4	L	6.00	2 7 91	FEEL	1	U	95.00	1 8 86	FEEL	1	U	78.00
2 7 18	FEEL	1	L	63.00	2 7 91	RUAL	2	L	0	1 8 86	SOHA	2	U	36.00
2 7 18	FEEL	1	U	67.00	1 8 6	FEEL	1	L	63.00	1 8 86	SOL	3	U	3.00
2 7 18	RUAL	2	L	5.30	1 8 6	FEEL	1	U	52.00	1 8 93	FEEL	1	L	147.00
2 7 18	ANVI	3	L	4.90	1 8 6	CARA	2	L	11.00	1 8 93	FEEL	1	U	171.00
2 7 18	PLMI	4	L	0	1 8 6	SOHA	3	L	1.00	2 8 6	FEEL	1	L	96.00
2 7 41	FEEL	1	L	82.00	1 8 9	FEEL	1	L	41.00	2 8 6	FEEL	1	U	83.00
2 7 41	FEEL	1	U	79.00	1 8 9	FEEL	1	U	88.00	2 8 6	ASTER	2	L	6.00
2 7 41	RUAL	2	L	58.00	1 8 9	RUAL	2	L	10.00	2 8 9	FEEL	1	L	48.00
2 7 41	SOL	3	L	13.00	1 8 9	DACA	3	U	15.00	2 8 9	FEEL	1	U	62.00
2 7 41	CAFR	4	L	4.00	1 8 9	PRVU	4	U	0	2 8 9	SOL	2	U	3.00
2 7 41	DIVI	5	L	5.50	1 8 11	FEEL	1	L	39.00	2 8 9	ANVI	3	L	21.00
2 7 44	FEEL	1	L	60.00	1 8 11	FEEL	1	U	70.00	2 8 9	CARA	4	L	4.00
2 7 44	FEEL	1	U	139.00	1 8 11	RUAL	2	L	16.00	2 8 11	FEEL	1	L	82.00
2 7 44	RUAL	2	L	31.00	1 8 11	ASTER	3	U	4.00	2 8 11	FEEL	1	U	74.00
2 7 44	IPHE	3	L	1.00	1 8 13	FEEL	1	L	84.00	2 8 11	RUAL	2	U	3.00
2 7 48	FEEL	1	L	49.00	1 8 13	FEEL	1	U	96.00	2 8 11	ASTER	3	U	9.00
2 7 48	FEEL	1	U	82.00	1 8 14	FEEL	1	L	68.00	2 8 13	FEEL	1	L	69.00
2 7 48	ASTER	2	L	2.00	1 8 14	FEEL	1	U	138.00	2 8 13	FEEL	1	U	98.00
2 7 48	CAFR	3	L	0	1 8 43	FEEL	1	L	88.00	2 8 13	SOL	2	U	38.00
2 7 52	FEEL	1	L	64.00	1 8 43	FEEL	1	U	128.00	2 8 14	FEEL	1	L	34.00
2 7 52	FEEL	1	U	105.00	1 8 43	ANVI	2	L	47.00	2 8 14	FEEL	1	U	22.00
2 7 52	RUAL	2	L	38.20	1 8 43	SOL	3	U	5.00	2 8 14	SOL	2	L	4.00
2 7 52	ASTER	3	L	5.20	1 8 46	FEEL	1	L	75.00	2 8 14	RUAL	3	L	11.00
2 7 52	IPHE	4	L	0	1 8 46	FEEL	1	U	103.00	2 8 43	FEEL	1	L	32.00
2 7 55	FEEL	1	L	40.00	1 8 51	FEEL	1	L	103.00	2 8 43	FEEL	1	U	33.00
2 7 55	FEEL	1	U	75.00	1 8 51	FEEL	1	U	101.00	2 8 43	ANVI	2	L	55.00
2 7 55	SOL	2	L	14.00	1 8 51	CARA	2	U	3.00	2 8 43	ASTER	3	U	5.00
2 7 55	LECU	3	L	13.00	1 8 53	FEEL	1	L	60.00	2 8 46	FEEL	1	L	96.00
2 7 55	ANVI	4	L	21.00	1 8 53	FEEL	1	L	107.00	2 8 46	FEEL	1	U	87.00
2 7 59	FEEL	1	L	75.00	1 8 53	SOL	2	U	5.00	2 8 46	RUHI	2	L	1.00
2 7 59	FEEL	1	U	109.00	1 8 53	DACA	3	U	4.00	2 8 51	FEEL	1	L	38.00
2 7 59	ASTER	2	L	0	1 8 57	FEEL	1	L	126.00	2 8 51	FEEL	1	U	79.00
2 7 59	PLLA	3	L	1.00	1 8 57	FEEL	1	U	126.00	2 8 51	LECU	2	U	17.00
2 7 63	FEEL	1	L	50.00	1 8 59	FEEL	1	L	110.00	2 8 51	SOL	3	U	0
2 7 63	FEEL	1	U	102.00	1 8 59	FEEL	1	U	146.00	2 8 53	FEEL	1	L	33.00
2 7 63	ASTER	2	L	2.00	1 8 62	FEEL	1	L	62.00	2 8 53	FEEL	1	U	46.00
2 7 63	CAFR	3	L	1.00	1 8 62	FEEL	1	U	117.00	2 8 53	LECU	2	L	0
2 7 63	PLMI	4	L	0	1 8 69	FEEL	1	L	47.00	2 8 53	SOL	3	L	4.00
2 7 69	FEEL	1	L	76.00	1 8 69	FEEL	1	U	125.00	2 8 57	FEEL	1	L	45.00
2 7 69	FEEL	1	U	91.00	1 8 69	ASTER	2	U	4.00	2 8 57	FEEL	1	U	67.00
2 7 69	CAFR	2	L	0	1 8 69	RUAL	3	L	0	2 8 57	ANVI	2	L	28.00
2 7 71	FEEL	1	L	62.00	1 8 71	FEEL	1	L	78.00	2 8 57	EUFI	3	U	5.00
2 7 71	FEEL	1	U	106.00	1 8 71	FEEL	1	U	80.00	2 8 59	FEEL	1	L	26.00
2 7 71	ASTER	2	L	.10	1 8 71	ASTER	2	U	1.00	2 8 59	FEEL	1	U	39.00
2 7 75	FEEL	1	L	67.00	1 8 74	FEEL	1	L	77.00	2 8 59	LECU	2	L	84.00
2 7 75	FEEL	1	U	122.00	1 8 74	FEEL	1	U	87.00	2 8 62	FEEL	1	L	43.00
2 7 75	ASTER	2	L	18.00	1 8 74	SOL	2	U	3.00	2 8 62	FEEL	1	U	62.00
2 7 79	FEEL	1	L	75.00	1 8 78	FEEL	1	L	42.00	2 8 62	ASTER	2	U	1.00
2 7 79	FEEL	1	U	133.00	1 8 78	FEEL	1	U	97.00	2 8 62	PLMI	3	L	2.00
2 7 80	FEEL	1	L	48.00	1 8 80	FEEL	1	L	74.00	2 8 69	FEEL	1	L	60.00
2 7 80	FEEL	1	U	57.00	1 8 80	FEEL	1	U	75.00	2 8 69	FEEL	1	U	86.00
2 7 81	FEEL	1	L	77.00	1 8 80	ASTER	2	L	0	2 8 69	EUFI	2	L	12.00

[c]Species identified by code, see Table 20 (page 134).

Part B. Preliminary Modeling and Systems Analysis

APPENDIX E

Table 24. Summary of Standing Crop for Clipped Plots (PLOT) in the *Andropogon* Community. Species Are Listed in Descending Rank per Plot with Live (L), Dead (D), and Flower Stalk (S) Dry Weights (g/0.25 m^2)[a]

PLOT	SPECIES	RANK	STATE	WEIGHT
1 1 1	ANVI	1	[illegible]	248.00
1 1 1	ASTER	2	[illegible]	9.00
1 1 1	ONION	3	L	2.00
1 1 1	PACL	4	[illegible]	0
1 1 1	ERHI	5	L	0
1 1 2	ANVI	1	[illegible]	294.00
1 1 3	ANVI	1	[illegible]	4.00
1 1 3	ANVI	1	[illegible]	287.00
1 1 3	SOL	2	[illegible]	3.00
1 1 3	PACL	3	[illegible]	0
1 1 4	ANVI	1	L	2.00
1 1 4	ANVI	1	[illegible]	238.00
1 1 4	ERHI	2	L	0
1 1 5	ANVI	1	[illegible]	146.00
1 1 5	ONION	2	L	0
1 1 5	ERHI	3	[illegible]	3.00
1 1 6	ANVI	1	[illegible]	298.00
1 1 6	ONION	2	[illegible]	3.00
1 1 6	RUAL	3	L	7.00
1 1 7	FEEL	1	[illegible]	208.00
1 1 7	RUAL	2	L	10.00
1 1 7	ERHI	3	L	11.00
1 1 8	ANVI	1	[illegible]	269.00
1 1 8	PACL	2	[illegible]	26.00
1 1 9	ANVI	1	[illegible]	340.00
1 1 9	ERHI	2	[illegible]	9.00
1 1 9	ONION	3	L	2.00
1 1 10	ANVI	1	[illegible]	252.00
1 1 10	ERHI	2	[illegible]	55.00
1 1 11	ANVI	1	[illegible]	185.00
1 1 11	ERHI	2	[illegible]	42.00
1 1 11	ASTER	3	[illegible]	24.00
1 1 12	ANVI	1	[illegible]	263.00
1 1 12	ERHI	2	[illegible]	30.00
1 1 13	ANVI	1	[illegible]	227.00
1 1 13	ERHI	2	[illegible]	41.00
1 1 14	ANVI	1	L	0
1 1 14	ANVI	1	[illegible]	243.00
1 1 14	ONION	2	L	2.00
1 1 14	SMGL	3	L	5.00
1 1 15	ANVI	1	[illegible]	264.00
1 1 15	SOL	2	[illegible]	36.00
1 1 15	CARA	3	L	12.00
1 1 15	ASTER	4	[illegible]	17.00
1 1 16	ANVI	1	[illegible]	300.00
1 1 16	CAFR	2	L	10.00
1 1 17	ANVI	1	[illegible]	272.00
1 1 17	CAFR	2	L	7.00
1 1 17	ROSA	3	L	9.00
1 1 17	CARA	4	L	5.00
1 1 18	ANVI	1	[illegible]	397.00
1 1 18	CAFR	2	L	3.00
1 1 18	CARA	3	L	11.00
1 1 19	ANVI	1	[illegible]	269.00
1 1 19	CAFR	2	L	8.00
1 1 20	ANVI	1	L	4.00
1 1 20	ANVI	1	[illegible]	185.00
1 1 20	GATI	2	L	1.00
1 1 20	SOL	3		3.00
1 1 20	ONION	4	[illegible]	0
2 1 1	ANVI	1	[illegible]	229.00
2 1 1	CARA	2	L	7.00
2 1 1	SOL	3	[illegible]	7.00
2 1 1	PACL	4	L	10.00
2 1 2	ANVI	1	[illegible]	222.00
2 1 3	ANVI	1	[illegible]	186.00
2 1 3	PANI	2	L	28.00
2 1 4	ANVI	1	[illegible]	212.00
2 1 4	ASTER	2	[illegible]	9.00
2 1 4	PANI	3	[illegible]	20.00
2 1 5	ANVI	1	[illegible]	158.00
2 1 5	PANI	2	[illegible]	56.00
2 1 6	ANVI	1	[illegible]	409.00
2 1 7	ANVI	1	[illegible]	404.00
2 1 7	SOL	2	[illegible]	20.10
2 1 7	CARA	3	L	6.00
2 1 8	ANVI	1	[illegible]	343.00
2 1 9	ANVI	1	[illegible]	320.00
2 1 10	ANVI	1	L	1.00
2 1 10	ANVI	1	[illegible]	246.00
2 1 11	ANVI	1	L	4.00
2 1 11	ANVI	1	[illegible]	307.00
2 1 11	ONION	2	L	1.00
2 1 12	ANVI	1	[illegible]	235.00
2 1 13	ANVI	1	[illegible]	239.00
2 1 13	ERHI	2	L	4.00
2 1 14	ANVI	1	L	3.00
2 1 14	ANVI	1	[illegible]	197.00
2 1 15	ANVI	1	[illegible]	272.00
2 1 15	ROSA	2	L	2.20
2 1 16	ANVI	1	[illegible]	281.00
2 1 16	ERHI	2	[illegible]	1.00
2 1 17	ANVI	1	L	4.00
2 1 17	ANVI	1	[illegible]	306.00
2 1 17	ASTER	2	[illegible]	17.00
2 1 18	ANVI	1	L	0
2 1 18	ANVI	1	[illegible]	111.00
2 1 18	ONION	2	L	0
2 1 18	GATI	3	L	0
2 1 19	ANVI	1	[illegible]	177.00
2 1 20	ANVI	1	[illegible]	230.00
2 1 20	ONION	2	L	0
1 2 2	ANVI	1	L	13.00
1 2 2	ANVI	1	[illegible]	34.00
1 2 2	PANI	2	L	10.00
1 2 2	CARA	3	L	2.00
1 2 5	PALA	1	[illegible]	69.00
1 2 5	SOL	2	L	39.00
1 2 5	CARA	3	L	10.00
1 2 5	ERHI	4	L	6.00
1 2 5	LOJA	5	L	2.00
1 2 5	ANVI	6	[illegible]	3.00
1 2 7	ANVI	1	L	6.00
1 2 7	ANVI	1	[illegible]	212.00
1 2 7	CARA	2	L	8.00
1 2 7	RUAL	3	L	7.00
1 2 10	ANVI	1	L	11.00
1 2 10	ANVI	1	[illegible]	179.00
1 2 10	CAFR	2	L	8.00
1 2 10	CARA	3	L	2.00
1 2 10	GECA	4	L	3.00
1 2 11	ANVI	1	L	8.00
1 2 11	ANVI	1	[illegible]	152.00
1 2 11	PANI	2	[illegible]	25.00
1 2 11	SOL	3	L	8.00
1 2 11	PACL	4	L	4.00
1 2 11	CARA	5	L	4.00
1 2 11	LOJA	6	L	2.00
1 2 13	ANVI	1	L	2.00
1 2 13	ANVI	1	[illegible]	219.00
1 2 13	ONION	2	L	3.00
1 2 15	ANVI	1	L	18.00
1 2 15	ANVI	1	[illegible]	270.00
1 2 15	ERHI	2	L	7.00
1 2 15	CARA	3	L	5.90
1 2 15	SOL	4	L	2.00
1 2 16	ANVI	1	L	6.00
1 2 16	ANVI	1	[illegible]	230.00
1 2 16	ERHI	2	L	2.00
1 2 16	RUAL	3	L	2.00
1 2 19	ANVI	1	L	16.00
1 2 19	ANVI	1	[illegible]	178.00
1 2 19	PALA	2	L	6.20
1 2 19	CARA	3	L	6.00
1 2 19	SOL	4	L	8.00
1 2 22	ANVI	1	[illegible]	167.00
1 2 22	ANVI	1	L	9.00
1 2 22	CARA	2	L	15.00
1 2 22	LOJA	3	L	2.00
1 2 67	ANVI	1	L	10.00
1 2 67	ANVI	1	[illegible]	31.00
1 2 67	CAFR	2	L	9.00
1 2 67	CARA	3	L	6.00
1 2 67	SOL	4	L	13.00
1 2 67	ROSA	5	L	3.00
1 2 67	LOJA	6	L	3.00
1 2 69	ANVI	1	L	10.00
1 2 69	ANVI	1	[illegible]	181.00
1 2 69	CARA	2	L	6.00
1 2 69	LOJA	3	L	3.00
1 2 69	SOL	4	L	3.00
1 2 71	ANVI	1	L	11.00
1 2 71	ANVI	1	[illegible]	274.00
1 2 71	CARA	2	L	6.00
1 2 71	ROSA	3	L	4.00
1 2 73	ANVI	1	L	7.00
1 2 73	ANVI	1	[illegible]	133.00
1 2 73	ERHI	2	[illegible]	6.00
1 2 73	SOL	3	L	2.00
1 2 73	GECA	4	L	2.00
1 2 73	CARA	5	L	1.00
1 2 74	ANVI	1	L	6.00
1 2 74	ANVI	1	[illegible]	84.00
1 2 74	FEEL	2	L	42.00

Table 24. (continued)

PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT
1 2 74	SOL	3	L	11.00	2 2 15	SOL	4	L	9.00	2 2 81	CARA	4	L	3.00
1 2 74	SOL	4	L	13.90	2 2 16	ANVI	1	L	22.00	2 2 81	OXST	5	L	3.00
1 2 74	ERHI	5	L	9.50	2 2 16	ANVI	1	L	313.00	2 2 81	PANI	6	L	4.00
1 2 74	CARA	6	L	14.00	2 2 16	ERJA	2	L	3.00	2 2 85	ANVI	1	L	4.00
1 2 75	ANVI	1	L	18.00	2 2 16	CARA	3	L	3.00	2 2 85	ANVI	1	L	287.00
1 2 75	SOL	2	L	91.00	2 2 16	SESM	4	L	2.00	2 2 85	CARA	2	L	3.00
1 2 75	ASTER	3	L	5.00	2 2 16	THPR	5	L	3.00	2 2 85	SOL	3	L	3.00
1 2 75	ERJA	4	L	7.00	2 2 19	ANVI	1	L	6.00	1 3 1	PALA	2	L	21.00
1 2 75	ROSA	5	L	4.00	2 2 19	ANVI	1	L	38.00	1 3 1	SOCA	3	L	2.00
1 2 76	ANVI	1	L	12.00	2 2 19	RUAL	2	L	17.00	1 3 1	CARA	4	L	2.00
1 2 76	ANVI	1	L	281.00	2 2 19	SOL	3	L	9.00	1 3 14	ANVI	1	L	320.00
1 2 80	ANVI	1	L	4.00	2 2 22	ANVI	1	L	6.00	1 3 14	CARA	2	L	5.00
1 2 80	ANVI	1	L	91.00	2 2 22	ANVI	1	L	111.00	1 3 17	ANVI	1	L	19.00
1 2 80	CARA	2	L	5.00	2 2 22	SOL	2	L	18.00	1 3 17	ANVI	1	L	84.00
1 2 80	ASTER	3	L	13.00	2 2 22	CARA	3	L	4.00	1 3 17	EUFI	2	L	37.00
1 2 80	LOJA	4	L	5.00	2 2 22	HRJA	4	L	11.00	1 3 17	PALA	3	L	60.00
1 2 80	GATI	5	L	9.00	2 2 67	ANVI	1	L	6.00	1 3 17	ASTER	4	L	25.00
1 2 80	SOL	6	L	5.00	2 2 67	ANVI	1	L	111.00	1 3 17	RUAL	5	L	4.00
1 2 80	ERHI	7	L	2.00	2 2 67	SOL	2	L	13.00	1 3 17	CARA	6	L	0
1 2 80	GECA	8	L	2.00	2 2 67	CARA	3	L	11.00	1 3 17	SOCA	7	L	0
1 2 80	TAOF	9	L	2.00	2 2 67	HRJA	4	L	4.00	1 3 19	ANVI	1	L	0
1 2 81	ANVI	1	L	9.00	2 2 69	ANVI	1	L	6.00	1 3 19	ANVI	1	L	105.00
1 2 81	ANVI	1	L	302.00	2 2 69	ANVI	1	L	198.00	1 3 19	CAFR	2	L	2.00
1 2 81	ROSA	2	L	21.00	2 2 69	ERJA	2	L	11.00	1 3 19	EUFI	3	L	23.00
1 2 81	CARA	3	L	3.00	2 2 69	OXST	3	L	2.00	1 3 19	SOCA	4	L	3.00
1 2 81	SOL	4	L	2.00	2 2 71	ANVI	1	L	19.00	1 3 19	RUAL	5	L	4.00
1 2 85	ANVI	1	L	9.00	2 2 71	ANVI	1	L	197.00	1 3 19	IPHE	6	L	1.00
1 2 85	ANVI	1	L	199.00	2 2 71	CARA	2	L	12.00	1 3 19	SOL	7	L	23.00
1 2 85	CARA	2	L	3.00	2 2 71	SESM	3	L	5.00	1 3 20	ANVI	1	L	25.00
1 2 85	SOCA	3	L	2.00	2 2 71	GATI	4	L	2.00	1 3 20	ANVI	1	L	71.00
1 2 85	ERJA	4	L	8.00	2 2 73	ANVI	1	L	13.00	1 3 20	ASTER	2	L	12.00
1 2 85	PALA	5	L	4.00	2 2 73	ANVI	1	L	217.00	1 3 20	CARA	3	L	3.00
1 2 85	SOL	6	L	2.00	2 2 73	SOL	2	L	6.00	1 3 20	PACO	4	L	0
2 2 2	CAFR	2	L	21.00	2 2 73	CARA	3	L	3.00	1 3 20	SOL	5	L	0
2 2 2	CARA	3	L	2.00	2 2 74	ANVI	1	L	3.00	1 3 21	ANVI	1	L	3.00
2 2 2	PANI	4	L	15.00	2 2 74	ANVI	1	L	167.00	1 3 21	ANVI	1	L	185.00
2 2 5	ANVI	1	L	8.00	2 2 74	SOL	2	L	3.00	1 3 21	CARA	2	L	7.00
2 2 5	ANVI	1	L	129.00	2 2 74	CARA	3	L	4.00	1 3 21	CAFR	3	L	0
2 2 5	PANI	2	L	73.00	2 2 74	ROSA	4	L	10.00	1 3 21	ACRH	4	L	2.00
2 2 7	ANVI	1	L	4.00	2 2 75	ANVI	1	L	23.00	1 3 21	RUAC	5	L	7.00
2 2 7	ANVI	1	L	128.00	2 2 75	ANVI	1	L	159.00	1 3 21	SESM	6	L	0
2 2 7	PANI	2	L	54.00	2 2 75	CARA	2	L	5.00	1 3 40	SOL	1	L	218.00
2 2 7	SOL	3	L	3.00	2 2 75	ROSA	3	L	10.00	1 3 40	ANVI	2	L	12.00
2 2 10	ANVI	1	L	191.00	2 2 75	SOL	4	L	2.00	1 3 40	ANVI	2	L	87.00
2 2 10	PALA	2	L	31.00	2 2 75	ERJA	5	L	9.00	1 3 40	CARA	3	L	1.00
2 2 10	CARA	3	L	1.00	2 2 76	ANVI	1	L	17.00	1 3 40	PACO	4	L	2.00
2 2 11	ANVI	1	L	3.00	2 2 76	ANVI	1	L	193.00	1 3 40	ROSA	5	L	15.00
2 2 11	ANVI	1	L	172.00	2 2 76	SOL	2	L	30.00	1 3 40	CAFR	6	L	4.00
2 2 11	ERHI	2	L	7.00	2 2 76	RUAL	3	L	6.00	1 3 48	OERI	1	L	82.00
2 2 11	SOL	3	L	8.00	2 2 76	CARA	4	L	2.00	1 3 48	CAFR	2	L	9.00
2 2 13	ANVI	1	L	7.00	2 2 76	SESM	5	L	2.00	1 3 48	SOL	3	L	5.00
2 2 13	ANVI	1	L	211.00	2 2 80	ANVI	1	L	9.00	1 3 48	PACO	4	L	2.00
2 2 13	ERJA	2	L	16.00	2 2 80	ANVI	1	L	326.00	1 3 48	ANVI	5	L	34.00
2 2 13	SESM	3	L	4.00	2 2 80	CARA	2	L	6.00	1 3 48	PANI	6	L	4.00
2 2 15	ANVI	1	L	5.00	2 2 81	ANVI	1	L	6.00	1 3 56	ANVI	1	L	27.00
2 2 15	ANVI	1	L	224.00	2 2 81	ANVI	1	L	79.00	1 3 56	ANVI	1	L	78.00
2 2 15	PALA	2	L	11.00	2 2 81	HRJA	2	L	15.00	1 3 56	EUFI	2	L	16.00
2 2 15	CARA	3	L	6.00	2 2 81	ERHI	3	L	4.00	1 3 56	ASTER	3	L	12.00

Table 24. (continued)

PLOT	SPECIES	RANK	STATE	WEIGHT
1 3 56	CAFR	4	L	10.00
1 3 56	CARA	5	L	8.00
1 3 56	PANI	6	L	1.00
1 3 65	ANVI	1	L	20.00
1 3 65	ANVI	1	D	90.00
1 3 65	COMPOSIT	2	L	23.00
1 3 65	SESP	3	L	32.00
1 3 65	RUAL	4	L	7.00
1 3 65	CARA	5	L	0
1 3 68	ANVI	1	L	67.00
1 3 68	ANVI	1	D	183.00
1 3 68	CARA	2	L	4.00
1 3 78	ANVI	1	L	48.00
1 3 78	ANVI	1	D	247.00
1 3 78	RUAL	2	L	2.00
1 3 78	CARA	3	L	1.00
1 3 81	ANVI	1	L	28.00
1 3 81	ANVI	1	D	246.00
1 3 81	SOL	2	L	11.00
1 3 81	CAFR	3	L	2.00
1 3 82	ANVI	1	L	4.00
1 3 82	ANVI	1	D	158.00
1 3 82	CAFR	2	L	61.00
1 3 82	CARA	3	L	9.00
1 3 82	RUAC	4	L	4.00
1 3 83	ANVI	1	L	10.00
1 3 83	ANVI	1	D	251.00
1 3 83	RUAL	2	L	11.00
1 3 83	CARA	3	L	3.00
1 3 83	SOL	4	L	0
1 3 83	PACO	5	L	0
1 3 84	ANVI	1	L	23.00
1 3 84	ANVI	1	D	342.00
1 3 84	PACO	2	L	8.00
1 3 84	CARA	3	L	9.00
1 3 86	ANVI	1	L	14.00
1 3 86	ANVI	1	D	182.00
1 3 86	PACO	2	L	16.00
1 3 86	CARA	3	L	17.00
1 3 86	ACRH	4	L	3.00
1 3 86	ASTER	5	L	25.00
1 3 90	ANVI	1	L	33.00
1 3 90	ANVI	1	D	199.00
1 3 90	PACO	2	L	0
1 3 90	ACRH	3	L	16.00
1 3 90	CARA	4	L	1.00
1 3 90	ASTER	5	L	0
1 3 91	ANVI	1	L	27.00
1 3 91	ANVI	1	D	218.00
1 3 91	CARA	2	L	0
1 3 91	PALA	3	L	0
1 3 92	ANVI	1	L	46.00
1 3 92	ANVI	1	D	48.00
1 3 92	CARA	2	L	4.00
1 3 92	SOL	3	L	2.00
2 3 1	ASTER	1	L	23.00
2 3 1	ANVI	2	L	11.00
2 3 1	ANVI	2	D	13.00
2 3 1	PALA	3	L	14.00
2 3 1	CARA	4	L	8.00
2 3 14	ANVI	1	L	72.00
2 3 14	ANVI	1	D	264.00
2 3 14	PACH	2	L	4.00
2 3 14	CARA	3	L	4.00
2 3 14	SOCA	4	L	1.00
2 3 17	ANVI	1	L	19.00
2 3 17	ANVI	1	D	161.00
2 3 17	ASTER	2	L	85.00
2 3 17	PALA	3	L	9.00
2 3 17	CARA	4	L	9.00
2 3 17	SESH	5	L	0
2 3 19	ANVI	1	L	38.00
2 3 19	ANVI	1	D	187.00
2 3 19	RUAL	2	L	64.00
2 3 19	ASTER	3	L	20.00
2 3 19	PALA	4	L	7.00
2 3 19	DIVI	5	L	3.90
2 3 19	CARA	6	L	7.00
2 3 20	ANVI	1	L	38.50
2 3 20	ANVI	1	D	161.30
2 3 20	ASTER	2	L	69.00
2 3 20	RUHI	3	L	7.00
2 3 20	PALA	4	L	6.00
2 3 20	ERHI	5	L	0
2 3 20	CARA	6	L	8.00
2 3 20	SOL	7	L	5.00
2 3 21	ANVI	1	L	32.00
2 3 21	ANVI	1	D	194.00
2 3 21	ASTER	2	L	6.00
2 3 21	DIVI	3	L	17.00
2 3 21	CARA	4	L	20.00
2 3 21	PACH	5	L	8.00
2 3 40	ANVI	1	L	32.00
2 3 40	ANVI	1	D	226.00
2 3 40	EUFI	2	L	18.00
2 3 40	PACO	3	L	15.00
2 3 40	CARA	4	L	7.00
2 3 40	CAFR	5	L	4.00
2 3 40	CIAR	6	L	0
2 3 48	ASTER	1	L	65.00
2 3 48	ANVI	2	D	291.00
2 3 48	ANVI	2	L	14.00
2 3 48	RUAL	3	L	15.00
2 3 48	DIVI	4	L	13.00
2 3 48	CARA	5	L	9.00
2 3 56	ANVI	1	L	7.00
2 3 56	ANVI	1	D	45.00
2 3 56	SOL	2	L	35.00
2 3 56	PACO	3	L	14.00
2 3 56	DIVI	4	L	6.00
2 3 56	CARA	5	L	0
2 3 56	ASTER	6	L	14.00
2 3 56	RUAL	7	L	4.00
2 3 65	ANVI	1	L	15.00
2 3 65	ANVI	1	D	137.00
2 3 65	PACO	2	L	33.00
2 3 65	DIVI	3	L	4.00
2 3 65	ASTER	4	L	21.00
2 3 68	ANVI	1	L	25.00
2 3 68	ANVI	1	D	82.00
2 3 68	SOL	2	L	56.00
2 3 68	CARA	3	L	4.00
2 3 68	CAFR	4	L	2.00
2 3 68	DIVI	5	L	11.00
2 3 68	OXST	6	L	0
2 3 78	ANVI	1	L	19.00
2 3 78	ANVI	1	D	250.00
2 3 78	ASTER	2	L	17.00
2 3 78	RUAL	3	L	6.00
2 3 78	PACO	4	L	1.00
2 3 78	DIVI	5	L	15.00
2 3 78	CARA	6	L	4.00
2 3 81	ANVI	1	L	102.00
2 3 81	ANVI	1	D	5.00
2 3 81	ASTER	2	L	27.00
2 3 81	RUAL	3	L	5.00
2 3 81	DIVI	4	L	11.00
2 3 81	CARA	5	L	3.00
2 3 81	CAFR	6	L	2.00
2 3 82	ANVI	1	L	10.00
2 3 82	ANVI	1	D	67.00
2 3 82	ASTER	2	L	23.00
2 3 82	DIVI	3	L	76.00
2 3 82	CAFR	4	L	9.00
2 3 82	SOL	5	L	0
2 3 82	RUAL	6	L	8.00
2 3 82	CARA	7	L	2.00
2 3 82	SESH	8	L	0
2 3 83	ANVI	1	L	19.00
2 3 83	ANVI	1	D	66.00
2 3 83	ASTER	2	L	54.00
2 3 83	SOL	3	L	14.00
2 3 83	DIVI	4	L	28.00
2 3 83	RUAL	5	L	3.00
2 3 83	CARA	6	L	1.00
2 3 83	PANI	7	L	1.00
2 3 84	ANVI	1	D	80.00
2 3 84	ANVI	1	L	41.00
2 3 84	ASTER	2	L	39.00
2 3 84	DIVI	3	L	10.00
2 3 84	SNGL	4	L	2.00
2 3 84	RUAL	5	L	8.00
2 3 84	CARA	6	L	7.00
2 3 84	SOCA	7	L	0
2 3 84	GATI	8	L	1.00
2 3 86	ANVI	1	L	46.00
2 3 86	ANVI	1	D	89.00
2 3 86	ASTER	2	L	50.00
2 3 86	SOL	3	L	10.00
2 3 86	DIVI	4	L	22.00
2 3 86	CARA	5	L	5.00
2 3 86	CAFR	6	L	5.00
2 3 90	ANVI	1	L	13.00
2 3 90	ANVI	1	D	89.00

Table 24. (continued)

PLOT			SPECIES	RANK	STATE	WEIGHT
2	3	90	ASTER	2	L	65.00
2	3	90	ROSA	3	L	10.00
2	3	90	SPGL	4	L	7.00
2	3	90	DIVI	5	L	13.00
2	3	90	PACO	6	L	1.00
2	3	90	CARA	7	L	1.00
2	3	90	JUTE	8	L	0
2	3	91	ASTER	1	L	42.00
2	3	91	ANVI	2	L	9.20
2	3	91	ANVI	2	[illegible]	44.00
2	3	91	PACO	3	L	4.00
2	3	91	ROSA	4	L	6.00
2	3	91	PERI	5	L	27.00
2	3	91	CARA	6	L	15.00
2	3	91	EUFI	7	L	3.00
2	3	91	DIVI	8	L	2.00
2	3	92	ANVI	1	L	9.00
2	3	92	ANVI	1	[illegible]	113.00
2	3	92	SOL	2	L	46.00
2	3	92	ASTER	3	L	29.00
2	3	92	ROSA	4	L	16.00
2	3	92	DIVI	5	L	11.00
2	3	92	CARA	6	L	3.00
2	3	92	PERI	7	L	1.00
1	4	1	ASTER	1	L	162.00
1	4	1	SOL	2	L	66.00
1	4	1	PACO	3	L	27.00
1	4	1	ANVI	4	L	2.00
1	4	2	EUFI	1	L	127.00
1	4	2	ASTER	2	L	63.00
1	4	2	CAFR	3	L	12.00
1	4	2	ANVI	4	L	32.20
1	4	2	ANVI	4	[illegible]	79.50
1	4	2	SOL	5	L	1.00
1	4	2	PACO	6	L	3.00
1	4	4	ANVI	1	L	23.00
1	4	4	ANVI	1	[illegible]	234.00
1	4	4	RUAL	2	L	1.00
1	4	4	PACO	3	L	3.00
1	4	5	ANVI	1	L	5.00
1	4	5	ANVI	1	[illegible]	290.00
1	4	5	CARA	2	L	8.00
1	4	6	ANVI	1	L	15.00
1	4	6	ANVI	1	[illegible]	310.00
1	4	6	SOL	2	L	15.00
1	4	6	CARA	3	L	1.00
1	4	6	ROSA	4	L	1.00
1	4	6	SOHA	5	L	0
1	4	7	ANVI	1	L	52.00
1	4	7	ANVI	1	[illegible]	39.00
1	4	7	ASTER	2	L	43.00
1	4	7	ERCA	3	L	2.00
1	4	7	PACO	4	L	1.00
1	4	7	GATI	5	L	1.00
1	4	7	ROSA	6	L	2.00
1	4	9	ANVI	1	L	90.00
1	4	9	ANVI	1	[illegible]	59.00
1	4	9	ERCA	2	L	51.00
1	4	9	ASTER	3	L	3.00
1	4	9	GATI	4	L	10.00
1	4	9	OXST	5	L	0
1	4	9	CARA	6	L	0
1	4	9	RUAL	7	L	3.00
1	4	11	ANVI	1	L	42.00
1	4	11	ANVI	1	[illegible]	113.00
1	4	11	SESM	2	L	17.00
1	4	11	ERCA	3	L	1.00
1	4	11	CARA	4	L	0
1	4	12	ANVI	1	L	97.00
1	4	12	ANVI	1	[illegible]	51.00
1	4	12	CARA	2	L	2.00
1	4	12	ERCA	3	L	2.00
1	4	12	GATI	4	L	0
1	4	13	ANVI	1	L	93.00
1	4	13	ANVI	1	[illegible]	64.00
1	4	13	CARA	2	L	0
1	4	15	ANVI	1	L	137.00
1	4	15	ANVI	1	[illegible]	61.00
1	4	15	ERCA	2	L	15.00
1	4	15	ASTER	3	L	0
1	4	15	CAFR	4	L	7.00
1	4	15	SESM	5	L	1.00
1	4	16	ANVI	1	L	39.00
1	4	16	ANVI	1	[illegible]	205.00
1	4	16	CARA	2	L	5.00
1	4	16	PANI	3	L	0
1	4	17	ANVI	1	L	79.00
1	4	17	ANVI	1	[illegible]	124.00
1	4	17	ASTER	2	L	52.00
1	4	17	CARA	3	L	2.00
1	4	18	ANVI	1	L	53.00
1	4	18	ANVI	1	L	85.00
1	4	18	ASTER	2	L	27.00
1	4	18	CAFR	3	L	1.00
1	4	19	ANVI	1	L	77.00
1	4	19	ANVI	1	[illegible]	96.00
1	4	19	ASTER	2	L	1.00
1	4	19	DIVI	3	L	2.00
1	4	19	SESM	4	L	5.00
1	4	19	SOL	5	L	4.00
1	4	20	ANVI	1	L	98.00
1	4	20	ANVI	1	[illegible]	231.00
1	4	20	EUVI	2	L	11.00
1	4	20	CARA	3	L	6.00
1	4	20	SOHA	4	L	5.00
1	4	20	CAFR	5	L	2.00
1	4	20	SESM	6	L	3.00
1	4	21	ANVI	1	L	46.00
1	4	21	ANVI	1	[illegible]	130.00
1	4	21	SOL	2	L	49.00
1	4	23	ANVI	1	L	22.00
1	4	23	ANVI	1	[illegible]	224.00
1	4	23	ASTER	2	L	72.00
1	4	23	PACO	3	L	0
1	4	24	ANVI	1	L	16.00
1	4	24	ANVI	1	[illegible]	138.00
1	4	24	SOL	2	L	7.00
1	4	24	ROSA	3	L	2.00
1	4	24	CARA	4	L	3.00
1	4	24	SESM	5	L	0
1	4	25	ANVI	1	L	58.00
1	4	25	ANVI	1	[illegible]	210.00
1	4	25	CARA	2	L	24.00
1	4	25	PACO	3	L	1.40
2	4	1	ANVI	1	L	25.00
2	4	1	ANVI	1	[illegible]	162.00
2	4	1	ASTER	2	L	11.00
2	4	1	EUVI	3	L	1.00
2	4	1	PANI	4	L	8.00
2	4	2	ANVI	1	L	35.00
2	4	2	ANVI	1	[illegible]	63.00
2	4	2	ASTER	2	L	100.00
2	4	2	SOL	3	L	6.00
2	4	2	PACO	4	L	6.00
2	4	2	ACRH	5	L	0
2	4	2	CARA	6	L	9.00
2	4	4	ANVI	1	L	55.00
2	4	4	ANVI	1	[illegible]	223.00
2	4	4	EUFI	2	L	79.00
2	4	4	ASTER	3	L	18.00
2	4	4	DIVI	4	L	11.00
2	4	4	CARA	5	L	1.00
2	4	5	ANVI	1	L	8.00
2	4	5	ANVI	1	[illegible]	250.00
2	4	5	PAAN	2	L	28.00
2	4	5	ASTER	3	L	37.00
2	4	5	CARA	4	L	4.00
2	4	5	OXST	5	L	0
2	4	5	PACO	6	L	4.00
2	4	6	ANVI	1	L	43.00
2	4	6	ANVI	1	[illegible]	164.00
2	4	6	ASTER	2	L	78.00
2	4	6	PACO	3	L	27.30
2	4	6	CARA	4	L	1.00
2	4	6	CIAR	5	L	0
2	4	7	ANVI	1	L	52.00
2	4	7	ANVI	1	[illegible]	123.00
2	4	7	PACO	2	L	96.00
2	4	7	DIVI	3	L	12.00
2	4	9	ANVI	1	L	47.00
2	4	9	ANVI	1	[illegible]	103.00
2	4	9	ASTER	2	L	100.00
2	4	9	ERCA	3	L	74.00
2	4	9	DIVI	4	L	3.00
2	4	9	SOL	5	L	9.00
2	4	9	RUAL	6	L	120.00
2	4	9	PACO	7	L	7.00
2	4	9	IPHE	8	L	4.00
2	4	11	ANVI	1	L	45.00
2	4	11	ANVI	1	[illegible]	130.00
2	4	11	DIVI	2	L	10.00
2	4	11	CARA	3	L	0
2	4	11	PACO	4	L	4.00
2	4	12	ANVI	1	L	12.00

Table 24. (continued)

PLOT	SPECIES	RANK	ST-TE	WEIGHT	PLOT	SPECIES	RANK	ST-TE	WEIGHT	PLOT	SPECIES	RANK	ST-TE	WEIGHT
2 4 12	ANVI	1	L	177.00	2 4 21	LEJA	5	L	15.00	1 5 19	CARA	2	L	7.00
2 4 12	FLAL	2	L	35.00	2 4 23	ANVI	1	L	46.00	1 5 19	GATI	3	L	0
2 4 12	ACMI	3	L	20.00	2 4 23	ANVI	1		69.00	1 5 20	ANVI	1	L	151.00
2 4 12	LIVI	4	L	26.00	2 4 23	CERI	2	L	38.00	1 5 20	ANVI	1		109.00
2 4 12	IPHE	5	L	4.00	2 4 23	ASTER	3	L	12.00	1 5 23	ANVI	1	L	88.00
2 4 12	CARA	6	L	4.00	2 4 23	CIAR	4	L	9.00	1 5 23	ANVI	1		103.00
2 4 13	ANVI	1	L	15.00	2 4 23	CARA	5	L	9.00	1 5 27	ANVI	1	L	110.00
2 4 13	ANVI	1		260.00	2 4 23	LIVI	6	L	5.00	1 5 27	ANVI	1		68.00
2 4 13	SCL	2	L	10.00	2 4 24	ANVI	1	L	94.00	1 5 27	SESP	2	L	1.00
2 4 13	DIVI	3	L	7.00	2 4 24	ANVI	1		131.00	1 5 30	ANVI	1	L	41.00
2 4 13	ROSA	4	L	13.00	2 4 24	SCL	2	L	26.00	1 5 30	ANVI	1		298.00
2 4 13	FACO	5	L	8.00	2 4 24	DIVI	3	L	7.00	1 5 30	CARA	2	L	4.00
2 4 13	ACRH	6	L	4.00	2 4 24	GATI	4	L	6.00	1 5 31	ANVI	1	L	129.00
2 4 15	ANVI	1	L	2.00	2 4 24	ASTER	5	L	26.00	1 5 31	ANVI	1		112.00
2 4 15	ANVI	1		140.00	2 4 24	ROSA	6	L	4.00	1 5 31	SESH	2	L	4.00
2 4 15	SCCA	2	L	3.00	2 4 24	CARA	7	L	3.00	1 5 31	CARA	3	L	1.00
2 4 15	PANI	3	L	13.00	2 4 24	SESP	8	L	1.00	1 5 32	ANVI	1	L	13.00
2 4 15	FACO	4	L	23.00	2 4 25	ANVI	1	L	50.00	1 5 32	ANVI	1		196.00
2 4 15	ACRH	5	L	6.00	2 4 25	ANVI	1		90.00	1 5 32	FACO	2	L	16.00
2 4 15	CARA	6	L	8.00	2 4 25	SEGL	2	L	12.00	1 5 32	GATI	3	L	0
2 4 16	ANVI	1	L	17.00	2 4 25	CIAR	3	L	0	1 5 32	CARA	4	L	2.00
2 4 16	ANVI	1		161.00	2 4 25	CARA	4	L	2.00	1 5 40	ANVI	1	L	92.00
2 4 16	SOL	2	L	51.00	2 4 25	FACO	5	L	1.00	1 5 40	ANVI	1		75.00
2 4 16	PANI	3	L	7.00	2 4 25	HUAL	6	L	4.00	1 5 41	ANVI	1	L	11.80
2 4 16	SCCA	4	L	4.00	1 5 2	ANVI	1	L	39.00	1 5 41	ANVI	1		173.00
2 4 16	ASTER	5	L	14.00	1 5 2	ANVI	1		185.00	1 5 41	HUAL	2	L	3.00
2 4 17	ANVI	1	L	33.00	1 5 2	SCL	2	L	23.00	1 5 41	FACO	3	L	19.00
2 4 17	ANVI	1		85.00	1 5 2	FACO	3	L	47.00	1 5 42	ANVI	1	L	36.00
2 4 17	SOL	2	L	56.00	1 5 2	CAFR	4	L	3.00	1 5 42	ANVI	1		115.00
2 4 17	ASTER	3	L	3.00	1 5 2	PANI	5	L	1.00	1 5 42	PACO	2	L	48.00
2 4 17	DIVI	4	L	10.00	1 5 3	ANVI	1	L	61.00	1 5 42	SESH	3	L	1.00
2 4 17	ROSA	5	L	8.80	1 5 3	ANVI	1		266.00	1 5 42	ACRH	4	L	0
2 4 18	ANVI	1	L	42.00	1 5 3	CARA	2	L	27.00	1 5 42	CARA	5	L	1.00
2 4 18	ANVI	1		138.00	1 5 3	PANI	3	L	2.00	1 5 46	ANVI	1	L	41.00
2 4 18	ASTER	2	L	26.00	1 5 3	GATI	4	L	0	1 5 46	ANVI	1		221.00
2 4 18	ROSA	3	L	6.00	1 5 4	ANVI	1	L	1.30	1 5 46	ASTER	2	L	55.00
2 4 18	SEGL	4	L	11.00	1 5 4	ANVI	1		98.50	1 5 46	CARA	3	L	2.00
2 4 18	PACO	5	L	4.00	1 5 4	FACO	2	L	80.00	1 5 64	ANVI	1	L	61.00
2 4 18	PANI	6	L	5.00	1 5 4	ASTER	3	L	48.00	1 5 64	ANVI	1		161.00
2 4 19	ANVI	1	L	4.00	1 5 4	CAFR	4	L	3.00	1 5 64	SOL	2	L	50.00
2 4 19	ANVI	1		147.00	1 5 4	SCL	5	L	7.00	1 5 72	ANVI	1	L	23.00
2 4 19	ASTER	2	L	56.00	1 5 5	ANVI	1	L	115.00	1 5 72	ANVI	1		259.00
2 4 19	SOL	3	L	10.00	1 5 5	ANVI	1		171.00	1 5 72	GATI	2	L	1.00
2 4 19	GATI	4	L	1.00	1 5 5	GATI	2	L	1.00	1 5 72	CARA	3	L	2.00
2 4 19	SCCA	5	L	1.00	1 5 5	FRVU	3	L	14.00	1 5 191	ANVI	1	L	8.10
2 4 19	ROSA	6	L	6.00	1 5 5	ASTER	4	L	8.00	1 5 191	ANVI	1		165.20
2 4 19	PANI	7	L	0	1 5 13	ANVI	1	L	130.00	1 5 19	PACO	2	L	27.00
2 4 20	ANVI	1	L	57.00	1 5 13	ANVI	1		149.00	1 5 19	PANI	3	L	17.00
2 4 20	ANVI	1		234.00	1 5 13	ASTER	2	L	17.00	1 5 19	CAFR	4	L	2.00
2 4 20	SCL	2	L	37.00	1 5 13	FRVU	3		10.00	1 5 19	FAAN	5	L	3.00
2 4 20	PANI	3	L	9.00	1 5 14	ANVI	1	L	33.00	2 5 2	ANVI	1	L	28.20
2 4 20	DIVI	4	L	2.00	1 5 14	ANVI	1		166.00	2 5 2	ANVI	1		62.00
2 4 20	CARA	5	L	0	1 5 14	FACO	2	L	22.00	2 5 2	ASTER	2	L	55.70
2 4 21	ANVI	1	L	8.00	1 5 14	CAFR	3	L	1.00	2 5 2	FACO	3	L	30.20
2 4 21	ANVI	1		118.00	1 5 14	CARA	4	L	2.00	2 5 2	LIVI	4	L	12.00
2 4 21	SOL	2	L	19.00	1 5 14	PANI	5	L	5.00	2 5 2	PANI	5	L	8.00
2 4 21	PANI	3	L	20.00	1 5 19	ANVI	1	L	17.00	2 5 2	FAAN	6	L	3.00
2 4 21	DIVI	4	L	28.00	1 5 19	ANVI	1		234.00	2 5 3	ANVI	1	L	19.50

Table 24. (continued)

PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT	PLOT	SPECIES	RANK	STATE	WEIGHT
2 5 31	LOJA	3	L	0	2 5 3	ANVI	1		171.00	1 6 17	CAFR	2	L	3.50
2 5 31	CIAR	4	L	15.00	2 5 3	GLPU	2	L	41.20	1 6 18	ANVI	1	L	1.20
2 5 31	CARA	5	L	3.00	2 5 3	ACRH	3	L	14.20	1 6 18	ANVI	1	D	178.70
2 5 31	PANI	6	L	1.00	2 5 3	ASTER	4	L	9.00	1 6 18	FALA	2	L	46.50
2 5 32	ANVI	1	L	16.00	2 5 3	PANI	5	L	1.00	1 6 18	CAFR	3	L	9.20
2 5 32	ANVI	1	D	220.00	2 5 4	ANVI	1	L	25.20	1 6 18	CARA	4	L	2.20
2 5 32	FUAL	2	L	25.00	2 5 4	ANVI	1	D	175.00	1 6 21	ANVI	1	L	.50
2 5 32	DIVI	3	L	1.00	2 5 4	PAAN	2	L	42.00	1 6 21	ANVI	1	D	167.70
2 5 32	CARA	4	L	5.00	2 5 4	PANI	3	L	6.00	1 6 21	PALA	2	L	16.30
2 5 32	PANI	5	L	0	2 5 4	PACO	4	L	4.00	1 6 25	ANVI	1	L	3.60
2 5 40	ANVI	1	L	73.10	2 5 4	FUAL	5	L	1.10	1 6 25	ANVI	1	D	330.00
2 5 40	ANVI	1		218.00	2 5 4	ASTER	6	L	1.00	1 6 25	CARA	2	L	1.30
2 5 40	ASTER	2	L	22.00	2 5 5	ANVI	1	L	50.00	1 6 34	ANVI	1	L	239.50
2 5 40	PACO	3	L	42.00	2 5 5	ANVI	1	D	125.00	1 6 50	ANVI	1	L	4.50
2 5 40	DIVI	4	L	4.50	2 5 5	CIAR	2		149.00	1 6 50	ANVI	1	D	121.90
2 5 40	ROSA	5	L	.50	2 5 5	DIVI	3	L	2.00	1 6 50	SOL	2	D	27.10
2 5 41	ANVI	1	L	25.00	2 5 5	CARA	4	L	1.00	1 6 50	CAFR	3	L	.30
2 5 41	ANVI	1	D	196.00	2 5 13	ANVI	1	L	14.00	1 6 62	ANVI	1	L	4.30
2 5 41	PAAN	2	L	44.00	2 5 13	UNKOWN	2	L	22.00	1 6 62	ANVI	1	D	252.20
2 5 41	UNKOWN	3	L	9.00	2 5 13	FUAL	3	L	7.00	1 6 62	CRVU	2	L	2.10
2 5 41	FUAL	4	L	4.00	2 5 13	HACA	4	L	4.00	1 6 62	CARA	3	L	1.50
2 5 41	PACO	5	L	5.40	2 5 13	LOJA	5	L	0	1 6 74	ANVI	1	L	10.30
2 5 42	ANVI	1	L	30.70	2 5 14	ANVI	1	L	48.00	1 6 74	ANVI	1	D	297.30
2 5 42	ANVI	1	D	140.00	2 5 14	ANVI	1	D	233.40	1 6 74	DIVI	2	D	1.50
2 5 42	PAAN	2	L	56.00	2 5 14	PAAN	2	L	13.00	1 6 75	ANVI	1	L	2.40
2 5 42	PACO	3	L	1.00	2 5 19	ANVI	1	L	14.00	1 6 75	ANVI	1	D	295.00
2 5 46	ANVI	1	L	56.00	2 5 19	ANVI	1	D	204.00	1 6 75	ASTER	2	L	12.00
2 5 46	ANVI	1	D	198.00	2 5 19	UNKOWN	2	L	33.00	1 6 75	PRVU	3	L	-0
2 5 46	LOJA	2	L	3.00	2 5 19	PANI	3	L	11.00	1 6 75	CARA	4	L	6.40
2 5 46	SOL	3	L	8.00	2 5 19	PACO	4	L	7.00	1 6 76	ANVI	1	L	15.00
2 5 46	SHGL	4	L	4.00	2 5 19	ASTER	5	L	1.00	1 6 76	ANVI	1	D	216.00
2 5 46	PACO	5	L	27.00	2 5 19	SESM	6	L	0	1 6 76	DIVI	2	D	1.10
2 5 46	ASTER	6	L	73.00	2 5 20	ANVI	1	L	22.00	1 6 76	ASTER	3	L	25.30
2 5 46	DIVI	7	L	4.00	2 5 20	ANVI	1	D	249.00	1 6 83	ANVI	1	L	1.70
2 5 64	ANVI	1	L	13.00	2 5 20	CARA	2	L	9.00	1 6 83	ANVI	1	D	161.30
2 5 64	ANVI	1	D	113.00	2 5 20	ASTER	3	L	1.00	1 6 83	DIVI	2	D	6.10
2 5 64	ASTER	2	L	70.00	2 5 20	CXST	4	L	0	1 6 84	ANVI	1	L	15.20
2 5 64	LOJA	3	L	3.00	2 5 23	ANVI	1	L	12.00	1 6 84	ANVI	2	D	200.30
2 5 64	ACRH	4	L	1.00	2 5 23	ANVI	1	D	241.00	1 6 85	ANVI	1	L	8.80
2 5 64	CIAR	5	L	9.00	2 5 23	ROSA	2	L	2.00	1 6 85	ANVI	1	D	179.10
2 5 64	PACO	6	L	12.00	2 5 23	ASTER	3	L	17.00	1 6 85	CAFR	2	L	.40
2 5 64	HACA	7	L	0	2 5 23	CARA	4	L	3.00	1 6 85	DIVI	3	L	.20
2 5 72	ANVI	1	L	9.00	2 5 23	PANI	5	L	1.00	1 6 90	ANVI	1	L	4.90
2 5 72	ANVI	1	D	169.00	2 5 27	ANVI	1	L	96.20	1 6 90	ANVI	1	D	222.50
2 5 72	PAAN	2	L	57.00	2 5 27	ANVI	1	D	114.00	1 6 90	ASTER	2	L	61.90
2 5 72	CRLE	3	L	3.00	2 5 27	ASTER	2	L	17.60	1 6 90	CAFR	3	L	2.50
2 5 72	DIVI	4	L	16.00	2 5 27	SESM	3	L	.90	1 6 90	DIVI	4	L	4.90
2 5 191	ANVI	1	L	83.60	2 5 27	PACO	4	L	2.00	1 6 91	ANVI	1	L	7.30
2 5 191	ANVI	1	D	201.20	2 5 27	ROSA	5	L	0	1 6 91	ANVI	1	D	167.20
2 5 191	PAAN	2	L	21.70	2 5 30	ANVI	1	L	56.00	1 6 93	ANVI	1	L	5.10
2 5 191	PACO	3	L	6.10	2 5 30	ANVI	1	D	165.00	1 6 93	ANVI	1	D	308.10
1 6 6	ANVI	1	L	1.00	2 5 30	CIAR	2	L	22.40	1 6 93	ASTER	2	L	17.30
1 6 6	ANVI	1	D	167.60	2 5 30	LOJA	3	L	0	1 6 93	CARA	3	L	13.20
1 6 10	ANVI	1	L	1.90	2 5 30	SOL	4	L	17.00	1 6 95	ANVI	1	L	.70
1 6 10	ANVI	1	D	218.80	2 5 30	PANI	5	L	1.00	1 6 95	ANVI	1	D	227.60
1 6 15	ANVI	1	D	249.30	2 5 31	ANVI	1	L	63.00	1 6 95	ASTER	2	L	58.20
1 6 17	ANVI	1	L	2.20	2 5 31	ANVI	1	D	176.00	2 6 6	ANVI	1	L	6.60
1 6 17	ANVI	1	D	134.60	2 5 31	PERI	2	L	12.00	2 6 6	ANVI	1	D	234.80

Table 24. (continued)

PLOT			SPECIES	RANK	STATE	WEIGHT
2	6	6	PALA	2	D	6.60
2	6	6	GATI	3	L	.60
2	6	10	ANVI	1	L	6.40
2	6	10	ANVI	1	D	257.40
2	6	10	PAAN	2	D	10.60
2	6	10	DIVI	3	L	0
2	6	15	ANVI	1	L	17.00
2	6	15	ANVI	1	D	180.50
2	6	15	PANI	2	D	32.30
2	6	15	ASTER	3	L	1.80
2	6	15	DIVI	4	D	18.50
2	6	15	CARA	5	L	.50
2	6	17	ANVI	1	L	3.60
2	6	17	ANVI	1	D	301.00
2	6	17	FUAL	2	L	6.50
2	6	18	ANVI	1	L	6.90
2	6	18	ANVI	1	D	210.60
2	6	18	ASTER	2	D	18.20
2	6	18	PANI	3	L	1.60
2	6	21	ANVI	1	L	1.20
2	6	21	ANVI	1	D	241.20
2	6	21	ASTER	2	D	44.70
2	6	21	DIVI	3	D	4.30
2	6	25	PAAN	1	D	193.70
2	6	25	ASTER	2	D	16.10
2	6	34	ANVI	1	L	9.40
2	6	34	ANVI	1	D	202.00
2	6	34	PALA	2	D	10.60
2	6	34	ASTER	3	D	4.20
2	6	34	DIVI	4	D	.50
2	6	50	ANVI	1	L	2.10
2	6	50	ANVI	1	D	214.40
2	6	50	ROSA	2	L	3.20
2	6	50	CARA	3	D	.90
2	6	50	VEAL	4	D	9.00
2	6	62	ANVI	1	L	1.00
2	6	62	ANVI	1	D	226.50
2	6	62	ASTER	2	D	23.70
2	6	62	DIVI	3	D	17.50
2	6	74	ANVI	1	L	.30
2	6	74	ANVI	1	D	237.70
2	6	74	ROSA	2	L	1.00
2	6	74	SOL	3	D	26.20
2	6	74	CARA	4	D	1.80
2	6	75	CAFR	1	L	8.60
2	6	75	CAFR	1	D	72.80
2	6	75	ANVI	2	D	52.40
2	6	75	PANI	3	D	6.20
2	6	75	ACRH	4	D	2.50
2	6	75	DIVI	5	D	.60
2	6	76	ANVI	1	L	1.80
2	6	76	ANVI	1	D	178.70
2	6	83	ANVI	1	L	3.20
2	6	83	ANVI	1	D	228.30
2	6	83	ASTER	2	D	18.40
2	6	84	ANVI	1	L	8.30
2	6	84	ANVI	1	D	240.20
2	6	84	ASTER	2	D	24.10

PLOT			SPECIES	RANK	STATE	WEIGHT
2	6	84	DIVI	3	L	1.20
2	6	85	ANVI	1	L	3.20
2	6	85	ANVI	1	D	238.00
2	6	85	ASTER	2	D	2.80
2	6	85	ROSA	3	L	4.00
2	6	90	ANVI	1	L	8.50
2	6	90	ANVI	1	D	239.10
2	6	90	ASTER	2	D	3.90
2	6	90	ROSA	3	L	2.70
2	6	91	ANVI	1	L	8.60
2	6	91	ANVI	1	D	221.60
2	6	91	ASTER	2	D	7.80
2	6	91	DIVI	3	L	3.10
2	6	93	ANVI	1	L	2.60
2	6	93	ANVI	1	D	121.30
2	6	93	ASTER	2	D	21.10
2	6	93	CARA	3	D	4.60
2	6	93	ROSA	4	L	1.50
2	6	95	ANVI	1	L	3.20
2	6	95	ANVI	1	D	165.70
2	6	95	ASTER	2	D	59.60
2	6	95	DIVI	3	D	.60
2	6	93	ASTER	2	D	21.10
2	6	93	CARA	3	D	4.60
2	6	93	ROSA	4	L	1.50
2	6	95	ANVI	1	L	3.20
2	6	95	ANVI	1	D	165.70
2	6	95	ASTER	2	D	59.60
2	6	95	DIVI	3	D	.60
2	6	90	ANVI	1	L	8.50
2	6	90	ANVI	1	D	239.10
2	6	90	ASTER	2	D	3.90
2	6	90	ROSA	3	L	2.70
2	6	91	ANVI	1	L	8.60
2	6	91	ANVI	1	D	221.60
2	6	91	ASTER	2	D	7.80
2	6	91	DIVI	3	L	3.10
2	6	93	ANVI	1	L	2.60
2	6	93	ANVI	1	D	121.30
2	6	93	ASTER	2	D	21.10
2	6	93	CARA	3	D	4.60
2	6	93	ROSA	4	L	1.50
2	6	95	ANVI	1	L	3.20
2	6	95	ANVI	1	D	165.70
2	6	95	ASTER	2	D	59.60
2	6	95	DIVI	3	D	.60

[d]Species identified by code, see Table 20 (page 134).

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