To the Graduate Council:

I am submitting herewith a thesis written by Lisa S. Post entitled "Seed Management in Tennessee: Development of Seed Zones for Tennessee and Distribution and Protection of Northern Red Oak (*Quercus rubra* L.) Acorns". I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Forestry, Wildlife and Fisheries.

Scott E. Schlarbaum, Major Professor

We have read this thesis and
recommend its acceptance:

Accepted for the Council:

Associate Vice Chancellor
and Dean of The Graduate School

Seed Management in Tennessee: Development of Seed Zones for Tennessee and Distribution and Protection of Northern Red Oak (*Quercus rubra* L.) Acorns

A Thesis
Presented for the
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Abstract

Currently, seedlings of many hardwood species are grown at the East Tennessee State Nursery for reforestation purposes and distributed for planting throughout the state. Guidelines for hardwood seed movement through genetic testing are lacking in Tennessee, causing nurseries to distribute seedlings to sites that can have a very different environment than that of the seed origin. For instance, if seedlings are genetically predisposed to respond to certain levels of environmental factors, and those factors are limited, poor growth or even failure of establishment may result. A practical system for collecting seeds was developed to ensure seedling adaptability in the environments in which they are planted. The seed zone map for Tennessee was developed using a Geographic Information System that integrated weather, elevation and physiographic data, resulting in 21 zones within the state.

Models to predict acorn production in a given year would greatly benefit resource managers; however, acorn production varies on all levels from the individual to the population. The variation also occurs over time. Both biotic and abiotic factors have been ascribed as the causes of this variation, from the acorn weevil to regional weather patterns. The reproductive process of northern red oak (*Quercus rubra* L.) is a two-year event, which increases the chances of predation or lost signals between the unfertilized egg and the pollen. In northern red oak, no research has been conducted on the effects of crown competition on acorn distributions, which could also contribute to acorn production variation.

A two-year study was initiated using northern red oak seed orchard trees that originated as a progeny test in 1973. Branches with flowers and acornets were selected in each quadrant and in the upper and lower sections of the crown. The same branches were visited every three weeks during the growing seasons and the number of flowers and acornets on each branch was tallied. Varying levels of crown competition were demonstrated by use of open-grown trees and trees in a forest-like condition with heavy crown competition. Results indicate that open-grown trees tend to produce the majority of flowers and acornets in the south quadrant of the lower section of the crown. Other trees with varying levels of competition exhibited random flower and acornet distribution patterns throughout the crown quadrants. Competition did have an effect on distributions; however, more research needs to be conducted.

Weevils of the *Curculio* genus consume the cotyledonary tissue of maturing northern red oak acorns. Weevil damage reduces the number of viable acorns available for nursery planting if a significant portion of cotyledons is destroyed. In addition, seedling attributes, e.g., height, within northern red oak genetic families is proportional to the amount of cotyledonary tissue an acorn has at planting time. Protection of acorn crops from insect predation would increase the number of viable acorns for planting and reduce cotyledon damage within each acorn, resulting in more seedlings with better growth. A study was designed to evaluate the effectiveness of an insecticide on controlling weevil damage on two trees in a northern red oak seedling seed orchard. Each tree was divided in half using polyethylene tarps. An insecticide, Capture®, was applied to one half of the tree, and the other half was used as a control (unsprayed). The trees were sprayed every three weeks. After maturation, the acorns were collected, dissected, and evaluated for insect damage. Results indicate that acorns on the sprayed side had a greater amount of healthy cotyledon tissue than the acorns from the control side. Capture® was effective in protecting acorns from weevil infestation, but did not protect the acorns from any other damage agents classified, such as the stony gall wasp, (*Callirhytis fructuosa* Weld.). These other damaging agents, however, have not significantly affected acorn yields in this specific orchard.

Table of Contents

Part 1. Introduction

Part 2. Development of Seed Zones for Tennessee Using a Geographic Information System

Part 3. The Influence of Competition on Flowering and Acorn Maturation in Northern Red Oak (*Quercus Rubra* L.)

Table of Contents (Part 3, Continued)

Table of Contents (Part 3, Continued)

Table of Contents (Part 3, Continued)

Part 4. The Effect of Insecticide Applications on Acorn Quality in Northern Red Oak (*Quercus Rubra* L.)

Table of Contents (Continued)

List of Tables

List of Figures

Part 2. Development of Seed Zones for Tennessee Using a Geographic Information System

Part 3. The Influence of Competition on Flowering and Acorn Maturation in Northern Red Oak (*Quercus Rubra* L.)

Part 1

Introduction

General Background

Genetic testing is the foundation for proper movement of seeds used for reforestation purposes. Many valuable hardwood species have had no genetic testing and therefore, have no guidelines for seed or seedling movement in artificial regeneration. Nurseries commonly obtain seed from geographic locations that can be very different from the physiographic and climatic conditions of the planting site. Seed zones can be developed to guide seed collections, using ecological, physiographic and climatic databases, thereby ensuring seedling adaptation to the environments of the planting site (Campbell 1992). Until thorough genetic testing is conducted on these hardwood species and the resulting seed orchards are mature, a seed zone system can be utilized by resource managers for seed collection and reforestation with locally adapted seedlings.

Seed orchards provide seeds that are both genetically improved and adapted to local environments. Aside from black walnut (*Juglans nigra* L.), few productive seed orchards exist for heavy-seeded hardwood species. In Tennessee, reproductive biology and seed orchard management is being studied in a northern red oak (*Quercus rubra* L.) seedling seed orchard. The uneven distribution among trees in a seedling seed orchard affords an opportunity to study the effects of competition on reproductive processes. Flower and acorn distribution studies can be used in construction of prediction models for production in natural stands.

Many factors can arrest acorn development, from the time of flowering through the time of pollination and fertilization and to the time of maturation. Due to the length of time (two years) for acorn development in oaks of the subgenus *Erythrobalanus*, there can be different factors causing mortality during development. Biotic and abiotic factors have been ascribed to acorn mortality (Cecich 1992). Predation by insects, pathogens, or mammals can cause severe damage to developing acorns, resulting in a decrease in quality and in number available for reforestation or research. One of the most damaging insects is the acorn weevil (*Curculio* spp.), which oviposits during the last four months of acorn maturation and is believed to be the main factor of acorn mortality. Acorn weevils have significantly impacted acorn crops in the northern red oak seedling seed orchard (Barber et al. 1995). Studies of insecticide applications in the orchard will identify the positive and negative aspects of insect management, including higher acorn yields, increased seed quality, insect outbreaks, and economic considerations.

Research Objectives

To address issues of seed management, oak reproductive biology and acorn quality in seed orchards in Tennessee, a series of studies were initiated with the following specific objectives.

1) Develop guidelines for the movement of arborescent seed in the absence of genetic testing.
2) Evaluate the distribution of acorns within the canopy of northern red oak and the effect of competition.
3) Evaluate the effects of insecticide spray on seed quality.

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Part 2

Development of Seed Zones for Tennessee Using a Geographic Information System

Introduction

If a seedling is not planted where it is most likely to survive and thrive, overall productivity will be reduced (Wakeley 1963). In addition, if poorly adapted trees survive and reproduce, the overall adaptability and productivity of the next rotation of trees at that site could also be reduced by infiltration of non-local, undesirable genes (Wilson 1990). Nursery managers often produce seedlings of many hardwood species from seed of unspecified origin. The resulting seedlings are distributed for planting to sites that can have a very different environment than that of the seed origin. For instance, if seedlings are genetically predisposed to respond to certain levels of environmental factors, and those factors are limited, poor growth or even failure of establishment may result. Some environmental factors that affect plant growth and reproduction include the length of the growing season length, amount and seasonal pattern of precipitation, and minimum temperature. These factors can affect time of bud break, rate of growth, and cessation of growth.

Nursery production of hardwood seedlings in Tennessee can be used to illustrate this problem. Tennessee has a wide range of ecological regions, corresponding to physiographic and climatic variation across the state (Bailey 1980). The western boundary of the state is comprised of bottomlands associated with the Mississippi River Basin, whereas eastern Tennessee is mountainous, with elevations reaching over 5,800 feet (1,768 meters). Currently, 28 hardwood species are grown for reforestation purposes at the East Tennessee State Nursery. Many of these species, e.g., white oak (*Quercus alba* L.), are distributed for planting throughout the state. The majority of species have had no genetic testing to define guidelines for seed collection.

Genetic variation in the growth of numerous forest tree species has been demonstrated with seedlings that originated at different geographic locations within the natural range of the species and were grown at the same location (cf., Zobel and Talbert 1984). Studies have examined the interaction between site and genotype, in terms of adaptability and growth rates (Campbell et al. 1989, Rehfeldt 1989, Monserud and Rehfeldt 1990, Campbell 1992, Campbell and Sugano 1993, Ying and Liang 1994). Based on biological, climatological or geographical criteria, these studies indicate a need for seed collection guidelines for species in which there is no or limited information on genetic variation and adaptability to non-native sites. Therefore, a practical system for collecting seeds is needed to increase the likelihood that the resulting seedlings will be adapted to the local environments in which they are planted (Schubert and Pitcher 1973).

A Geographic Information System (GIS) is a relatively new technique used to evaluate environmental information in relation to large land areas, such as states or regions. This technology can provide a basis for making management decisions by integrating information to understand spatial relationships. Applications for GIS exist in many fields, such as land use planning, ecological research, and demographic research.

The objective of this study was to create a map of seed zones for Tennessee that could be readily used by resource managers to collect seed for reforestation of specific areas with locally adapted genotypes. A seed zone can be defined as homogeneous environments mapped across a region to indicate geographic variation (Campbell 1991).

Materials and Methods

Four layers of data were created and then combined using a geographic information system (GIS) Arc/Info®, to create a seed zone map for Tennessee. A layer consisted of attribute data, e.g., elevation, which was superimposed on the Tennessee land base. Initiation of bud break timing (as indicated by elevation), temperature, and precipitation were considered the most important variables that could be quantitatively measured to represent critical adaptive limitations. Three analyses were conducted to create seed zone maps with a progressive reduction in number of zones. Each generation included GIS layers of temperature, precipitation, elevation, and ecological/physiographic data. One layer of data included a calculated value based on temperature and precipitation for each county. We used a digital elevation model, developed by the U.S. Geological Survey for the conterminous United States that consisted of 1,035-m x 1,035-m grid cells. Thus, each cell represented elevation for an area slightly greater than 1 km^2. The 1:2,000,000-scale coverage of county boundaries also was acquired from the U.S. Geological Survey. All GIS coverages were in Albers equal area projection. Arc/Info® (ESRI, Redlands, Calif.) version 7 was used for all GIS analyses (ESRI 1994).

Temperature and Precipitation Data Source and Analyses

Temperature and precipitation data for 1961 to 1990 from 75 Tennessee weather stations were available from the National Oceanic and Atmospheric Administration (Owenby and Ezell 1992). The climatological normals were based on the monthly mean maximum and minimum temperature, and monthly total precipitation records. The climatological normals were used to create graphs of temperature and precipitation over time. If a county had two weather stations, then one data set was randomly deleted. Both temperature and precipitation data were available for 66 of the 95 counties in Tennessee. The temperature and precipitation means from surrounding counties were averaged and used for those counties without data.

To facilitate GIS analysis, the temperature and precipitation data were analyzed to produce a single standardized value to represent a county's weather history. The raw data were plotted with time as the x-axis, and temperature or precipitation as the y-axis for each county. The curves were grouped by use of a centroid hierarchical cluster analysis that revealed similar temperature or precipitation patterns over a 12-month period. The clusters were formed according to equation 1 (below) which considered both pattern and amount to identify similar counties.

Equation 1:

$$d_{ij} = 0.5*(1-r_{ij}) + 0.5*|(x_i - x_j)| / md$$

where:

r_{ij} = correlation between county i and county j

x_i = mean temperature or precipitation for county $_i$

md = maximum mean difference

i = county under consideration

j = county being compared

d_{ij} = climatic distance

The resulting distance values ranged from zero to one for both the temperature and precipitation variables. Counties with distance values near zero were highly correlated and had similar means, and were clustered together. Counties with distance values close to one had lower correlation values and different means, and were not clustered together.

The cluster analysis based on these distances formed 7 temperature clusters and 10 precipitation clusters. Each county was given a temperature and precipitation code according to the respective cluster in which the county was grouped. The code associated with a particular county joined other counties with the same code into one cluster. Once the temperature and precipitation data were represented by a single value for each county, the data could be used as digital GIS layers.

Elevation Analysis

In Tennessee, elevation ranges from approximately 100 to 5800 ft (30 to 1768 m). Generally, there is less area in the higher elevation groups. The area occupying each 100-foot interval within the different elevation ranges was calculated and classified into groups. The groups were formed by a visual inspection of the map embedded with knowledge of the different forest types in the state. The resulting elevation groups were assigned a value (1-5) (Table 2.1) and used as one of the GIS layers based on the area at each interval. By visually inspecting the results on the Tennessee map, the groups were distributed with less land in the upper and lower elevations and with more land in the middle elevation range.

Ecoregion Analysis

Physiographic provinces, called ecoregions by Bailey (1980), were used to further delineate seed zones. Bailey's classification system reflects vegetation, soil, landform, fauna and climate. Tennessee includes portions of 9 regions: the Mississippi Alluvial Basin, the Coastal Plain, the Upper Gulf Coastal Plain, the Interior Low Plateau Highland Rim, the

Table 2.1. Area comprising each assigned elevation group and the associated range of elevation used for the development of seed zones in Tennessee.

Elevation Group	*Range of Elevation*	*Area (thousands of acres)*
1	100-200 ft	1,271
2	300-1000 ft	17,022
3	1100-1900 ft	5,751
4	2000-3600 ft	1,022
5	3700-5800 ft	181

Northern Cumberland Plateau, the Southern Cumberland Mountains, the Central Ridge and Valley, the Northern Ridge and Valley, and the Blue Ridge Mountains.

Analysis One

Arc/Info® software was used to generate a Tennessee seed zone map using the precipitation layer (10 clusters), the temperature layer (7 clusters), the elevation layer (5 classes) and Bailey's ecoregions (9 regions). The layers were combined into a single GIS coverage for Tennessee.

Analysis Two

The temperature and precipitation data layers were revised to reduce the total number of clusters. Temperature and precipitation layers remained separate in this analysis. The elevation data were re-classified to create fewer groupings by combining the fourth and fifth group (Table 2.1). To reduce the potential number of seed zones, Bailey's ecoregions were used in the analysis, but were not treated as a layer. Precipitation, temperature, and elevation layers were superimposed on the ecoregions within Tennessee to generate a seed zone map.

Analysis Three

The temperature and precipitation variables were combined into one layer by multiplying the temperature variable by 100 and then adding them together. This union created a single set of data, henceforth referred to as the weather data. The weather data were then plotted over the same twelve-month period, previously used for temperature and precipitation data, and clustered together as described previously to form a weather layer. The elevation layer did not change from the second analysis. Weather and elevation layers were superimposed on each of Bailey's ecoregions as in the second analysis.

Results and Discussion

The precipitation and temperature layers combined in the first analysis generated more than 60 weather zones. These data, coupled with the five elevation groups and Bailey's nine ecoregions, resulted in over 300 seed zones. In the second analysis, the cluster program produced five temperature zones and six precipitation zones, yielding a possibility of 30 zones when combined. The GIS analysis again produced a large number of seed zones (175), despite reductions in the number of temperature, precipitation, and elevation zones, and eliminating Bailey's ecoregions as a variable. In the third analysis, the layering of weather and elevation zones over each of Bailey's ecoregions distinguished a total of 21 general seed zones across the Tennessee land base. Zones of the same color divided by an ecoregion boundary are not considered the same seed zone, but have similar attributes. Although this essentially subdivides the state into more seed zones, the total number is less than in the first and second analyses and provides guidance for making collections to provide seedlings for areas with a seed crop failure. Seeds from a neighboring ecoregion with the same zone may be used, as suggested by Schubert and Pitcher (1973), in the event that trees in a particular seed zone do not produce seeds.

The progressive reduction of layers and clusters within layers in the three analyses resulted in a corresponding reduction in seed zone numbers. The first two approaches generated too many seed zones to implement seed collections for practical application in nursery management and seedling distribution. The number of zones generated in the third analysis is small enough to allow Tennessee land managers to collect seed by zone to generate locally adapted seedlings for reforestation purposes.

The Tennessee seed zone map (Figure 2.1) is an initial step in a sequential process to develop data to construct a final map in the future and will be used until seed orchards are constructed. Using the current seed zone map as the first step, intensive sampling of natural stands will be conducted for each seed zone. Provenance/progeny testing of the seed zones in Figure 2.1 could be readily conducted by designating a sample of seedlings from each seed zone's reforestation crop for experimental plantings. Subsequent establishment of provenance/progeny tests to assess growth potential and other characteristics will be the second stage, and the seed zones will be refined based on these experimental plantings. As data from the plantings accumulate, analyses can be conducted on the growth, phenology, and frost hardiness data. The refined seed zones will be used until seed orchards can be constructed and can begin producing seed to meet reforestation needs.

Using seed zones for collection and distribution of seeds from species where zones have not been delineated by genetic testing will ensure the adaptability of the resulting seedlings to planting sites. When seed zone guidelines are not followed in artificial regeneration, the local ecotypes are being contaminated with non-local genes (Wilson 1990). Hardwood species, especially oaks (*Quercus* spp.), have not been regenerated artificially to the extent (or success) that conifers have, so gene contamination is probably minimal (McElwee 1970, Russell 1971). Implementation of a seed zone system may assure the survival and productivity of Tennessee forests for future generations.

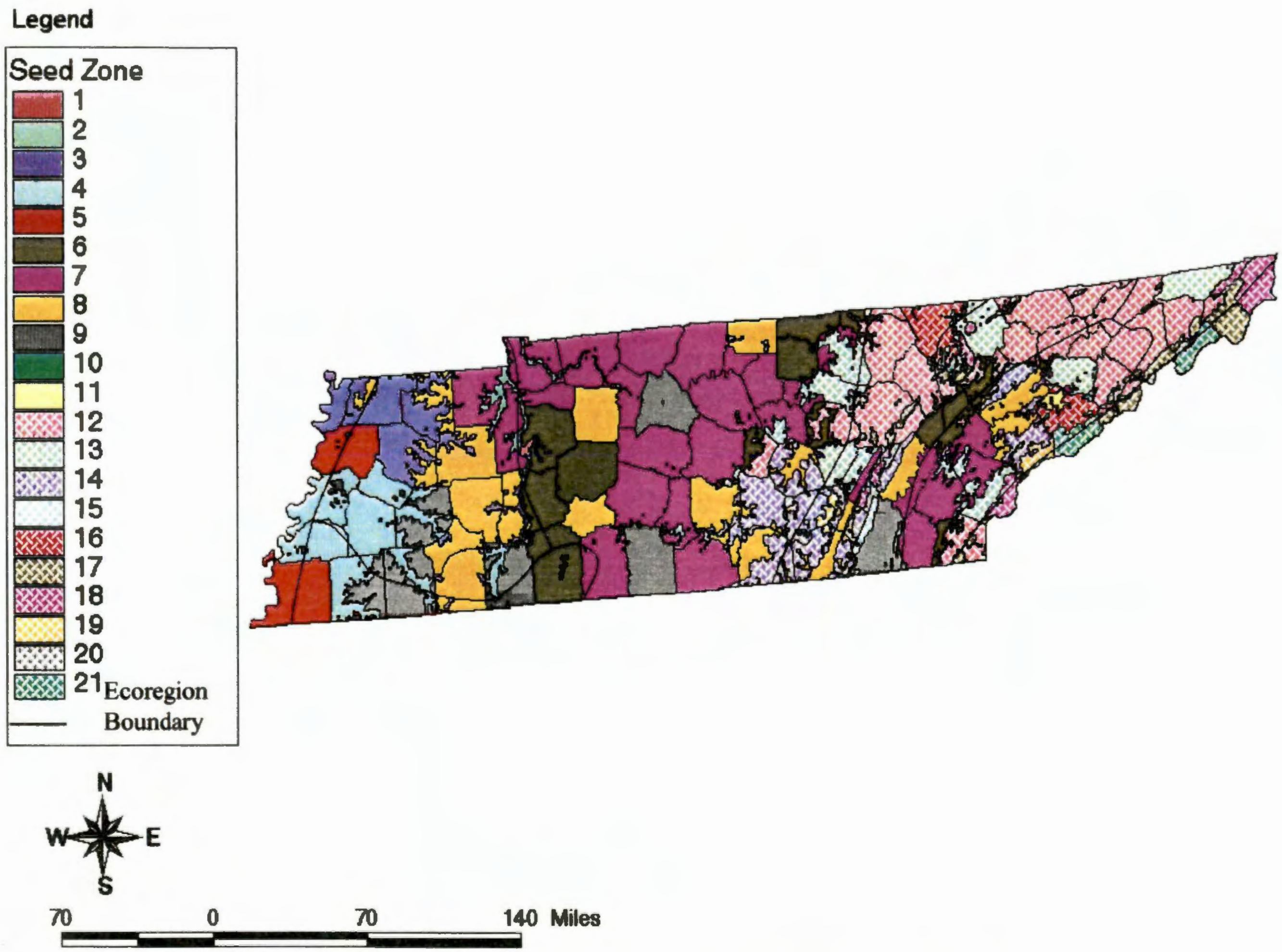

Figure 2.1. Tennessee seed zones based on temperature, precipitation, and elevation, developed using a geographic information system (GIS).

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Appendix, Part 2

A2.1. County weather zones for the Tennessee seed zones.

Weather Zone	County
1	Dyer, Shelby
2	Scott, Sevier, Unicoi
3	Crockett, Davidson, Fayette, Hamilton, Hardin, Haywood, Knox, Lauderdale, Madison, Tipton
4	Bedford, Blount, Carroll, Chester, Coffee, Decatur, Dickson, Franklin, Gibson, Giles, Grundy, Hardeman, Henderson, Lake, Lewis, Macon, Marion, McNairy, Moore, Obion, Rhea, Sequatchie, Warren, Weakley
5	Anderson, Bradley, Campbell, Carter, Claiborne, Clay, Cumberland, Greene, Hamblen, Hancock, Hawkins, Hickman, Humphreys, Morgan, Roane, Union, Washington, Wayne
6	Benton, Bledsoe, Cheatham, DeKalb, Henry, Houston, Jackson, Jefferson, Johnson, Lawrence, Lincoln, Loudon, Marshall, McMinn, Meigs, Monroe, Montgomery, Overton, Putnam, Robertson, Rutherford, Smith, Stewart, Sullivan, Sumner, Trousdale, Van Buren, Williamson, Wilson
7	Cannon, Cocke, Fentress, Grainger, Maury, Perry, Pickett, Polk, White

A2.3. Monthly mean temperature by station and county for the Tennessee seed zones*.

Station	County	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Allardt	Fentress	24.0	27.1	35.9	44.2	51.9	59.4	63.4	62.2	56.2	44.7	36.9	28.6
Athens	McMinn	24.4	27.2	35.8	43.9	52.3	60.6	64.7	63.9	57.7	44.1	36.1	28.1
Bolivar	Hardeman	27.1	31.0	39.5	47.9	56.1	64.2	68.0	65.9	59.6	46.3	38.5	30.9
Bristol	Sullivan	24.3	26.8	35.4	43.0	51.6	59.9	64.1	63.1	56.6	44.2	35.9	28.2
Brownsville	Haywood	26.6	30.4	40.4	49.9	58.2	65.9	69.7	67.7	61.1	48.3	39.9	31.2
Celina	Clay	21.5	24.2	33.0	41.8	50.6	59.7	63.7	62.4	55.9	42.4	34.4	26.3
Centerville	Hickman	23.4	26.3	34.6	42.7	51.3	59.2	63.2	62.0	55.7	42.7	34.8	27.5
Chattanooga	Hamilton	28.0	31.1	39.0	46.8	55.4	63.9	68.3	67.7	62.6	48.9	39.9	31.2
Cheatham	Cheatham	24.2	27.1	35.9	42.9	52.3	60.5	65.0	63.3	57.1	44.9	37.1	28.2
Clarksville	Montgomery	23.3	27.1	35.9	44.4	53.3	62.1	66.2	64.4	57.6	44.3	36.0	27.8
Cleveland	Bradley	25.8	28.9	36.7	44.1	52.6	60.9	65.1	64.4	58.0	44.6	36.3	29.5
Columbia	Maury	23.2	26.6	34.3	43.8	52.3	60.6	65.5	64.3	57.0	43.8	35.1	27.9
Cookville	Putnam	23.8	26.5	35.6	44.4	52.6	60.9	64.7	63.5	56.9	44.3	36.5	28.4
Copperhill	Polk	25.0	27.7	34.9	42.4	50.5	58.5	63.1	62.5	56.3	43.2	35.6	28.6
Covington	Tipton	25.9	29.6	39.1	48.9	57.3	65.2	68.7	66.5	59.9	47.5	39.2	30.4
Crossville 1	Cumberland	24.3	27.6	36.6	44.2	51.8	59.4	63.6	62.7	56.5	44.2	36.9	29.2
Crossville2	Cumberland	21.2	24.2	33.8	42.7	50.4	57.8	61.5	60.4	54.5	42.4	35.1	25.7
Dayton	Rhea	26.7	29.8	37.7	45.1	53.2	61.0	65.0	64.3	58.6	46.2	38.2	30.5
Dickson	Dickson	25.3	28.7	37.6	46.3	54.6	62.5	66.7	65.4	59.4	46.9	38.4	29.8
Dover	Stewart	22.3	25.7	36.2	45.4	53.3	61.9	65.6	63.9	57.1	43.7	36.6	27.2
Dresden	Weakley	23.3	27.3	37.3	46.9	55.5	63.5	66.9	64.9	58.5	45.9	37.6	28.3
Dyersburg	Dyer	28.1	32.3	41.8	51.2	59.6	67.4	70.9	68.9	62.3	50.4	41.8	32.8
Erwin	Unicoi	21.5	23.8	31.5	39.1	48.0	56.0	60.1	59.2	53.1	40.3	32.6	25.5
Fayetteville	Lincoln	24.5	27.8	36.5	44.0	52.7	60.5	64.7	63.4	57.4	44.0	36.2	28.8

A2.3. (Continued)

Station	County	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Franklin Sew.	Williamson	23.6	26.2	35.3	44.0	52.5	60.8	65.1	63.6	57.0	43.8	35.9	28.0
Gatlinburg	Sevier	22.9	24.8	32.7	39.7	48.5	56.7	60.7	60.0	53.9	41.2	32.9	26.5
Greenville	Greene	22.8	25.4	33.8	41.6	51.0	59.5	63.8	62.6	56.2	42.8	34.3	26.3
Huntingdon	Carroll	24.0	27.4	36.9	46.5	54.6	63.0	67.2	65.0	58.1	44.8	37.0	28.4
Jackson FAA Ap.	Madison	27.3	31.2	40.4	49.4	57.7	65.6	69.3	67.4	60.9	48.3	40.0	31.5
Jackson Exp. Sta.	Madison	26.1	29.7	39.3	48.5	57.3	65.0	68.9	67.0	60.5	47.5	39.3	30.7
Kingsport	Sullivan	26.4	28.6	36.8	44.4	52.8	60.5	64.5	63.8	57.7	45.8	37.8	30.3
Kingston Springs	Cheatham	21.5	24.4	33.9	42.5	51.4	60.1	64.5	62.9	55.7	41.7	34.0	26.1
Knoxville WSO Ap.	Blount	26.0	29.1	36.6	44.6	53.1	61.8	66.0	65.3	59.0	46.0	37.5	30.0
Knoxville U.T.	Knox	28.5	31.5	40.1	48.4	56.8	64.2	68.4	68.0	62.2	49.2	40.9	32.7
Lafayette	Macon	25.4	28.9	37.9	46.2	54.1	61.8	65.3	63.7	57.5	45.8	38.4	29.8
Lawrenceburg	Lawrence	25.2	28.5	37.0	44.8	52.9	60.7	64.7	63.4	57.4	44.3	36.7	29.4
Lebanon	Wilson	22.8	25.8	35.6	44.7	53.0	61.8	65.8	64.3	57.1	43.6	36.1	27.7
Lenoir City	Loudon	25.0	27.2	35.8	44.1	53.0	61.7	65.7	64.9	58.3	44.8	36.6	28.7
Lewisburg	Marshall	23.9	26.8	35.6	44.2	52.7	61.4	65.6	63.9	57.3	44.2	36.4	28.2
Lexington	Henderson	25.2	27.4	37.1	46.2	55.1	63.9	67.8	66.5	60.2	46.8	38.7	29.7
Linden 2	Perry	22.8	26.0	34.5	43.6	52.5	60.7	65.1	63.4	56.5	42.6	35.1	27.2
Livingston	Overton	25.1	27.9	36.6	44.4	52.2	59.9	63.9	62.4	56.3	44.1	36.7	29.6
Martin	Weakley	23.1	26.6	37.0	47.1	55.7	63.9	67.5	65.3	58.2	45.9	37.3	28.2
McMinnville	Warren	27.4	30.5	38.7	46.4	54.1	61.8	65.7	64.9	59.1	46.5	38.9	31.6
Memphis	Shelby	30.9	34.8	43.0	52.4	61.2	68.9	72.9	71.1	64.5	51.9	42.7	34.8
Milan	Gibson	24.1	27.7	37.3	46.9	55.4	63.3	67.2	64.8	57.9	45.2	37.5	28.6
Monteagle	Grundy	24.7	28.3	37.1	46.3	54.2	61.5	64.8	64.1	58.9	47.3	38.4	29.2
Moscow	Fayette	27.9	31.7	40.7	49.1	57.0	64.4	68.0	65.8	59.5	46.5	39.3	31.7
Mt. Pleasant	Maury	24.5	27.4	36.6	45.1	53.2	61.4	65.7	64.3	57.3	45.0	37.0	28.7

A2.3. (Continued)

Station	County	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Murfreesboro	Rutherford	24.5	27.2	36.7	45.5	54.0	62.2	66.5	65.1	58.2	44.8	37.3	29.0
Nashville	Davidson	26.5	29.9	39.1	47.5	56.6	64.7	68.9	67.7	61.1	48.3	39.6	30.9
Newbern	Dyer	23.5	27.2	37.2	47.2	56.0	63.7	67.5	65.4	58.3	45.3	36.8	28.3
Newport	Cocke	23.8	26.4	34.7	43.1	51.8	60.4	64.5	63.6	56.8	43.2	34.8	26.8
Norris	Anderson	22.6	24.7	33.5	41.8	50.8	59.3	63.2	63.1	56.7	43.4	34.6	26.5
Oak Ridge	Anderson	25.1	27.7	35.7	43.5	52.2	60.5	64.9	64.3	58.0	44.8	36.2	28.7
Oneida	Scott	20.3	23.2	31.5	39.2	47.8	56.8	61.2	60.0	53.4	40.0	32.6	24.6
Paris	Henry	23.6	26.9	36.3	45.0	53.5	61.9	66.0	64.2	57.6	44.7	37.2	28.4
Pikeville	Bledsoe	26.5	29.3	37.5	44.7	52.8	60.8	65.0	64.0	58.0	45.0	37.2	29.9
Portland Sew.	Sumner	22.7	26.3	35.8	45.3	53.9	62.3	65.9	64.3	57.6	44.8	36.7	27.3
Pulaski Water	Giles	27.6	31.1	39.5	47.6	55.3	63.0	67.1	65.7	59.5	46.6	39.2	31.8
Ripley	Lauderdale	25.9	29.7	39.3	49.1	57.6	65.5	69.6	67.4	60.9	48.5	39.8	30.1
Rockwood 2	Roane	22.6	24.8	33.0	42.1	50.4	58.9	62.9	62.0	55.3	41.9	33.7	26.2
Rogersville	Hawkins	24.3	26.8	35.1	42.8	50.8	58.3	62.1	61.4	55.3	42.9	35.5	27.9
Samburg	Obion	24.7	28.8	39.0	48.1	56.4	64.5	68.2	65.9	59.4	47.0	39.0	29.5
Savannah	Hardin	27.7	31.2	40.0	48.2	55.9	63.5	67.3	66.0	60.0	47.5	40.1	32.1
Selmer	McNairy	25.3	28.7	37.7	45.8	54.4	62.1	65.9	64.1	58.0	44.7	37.4	29.6
Sevierville	Sevier	22.9	25.5	33.8	41.2	50.1	58.6	62.5	61.6	55.1	41.7	32.9	26.0
Shelbyville	Bedford	27.1	30.4	38.9	46.6	54.6	62.3	66.4	65.3	59.0	46.7	39.0	31.4
Sparta	White	25.4	27.9	36.5	43.6	51.2	59.4	63.5	62.0	55.8	43.1	35.9	29.3
Springfield	Robertson	22.7	25.9	35.5	44.8	53.5	61.9	65.6	63.9	57.4	45.1	37.0	27.6
Tullahoma	Coffee	27.2	30.7	38.8	47.0	54.8	62.3	66.4	65.4	59.4	47.1	39.2	31.6
Union City	Obion	23.3	27.3	37.3	47.1	56,0	64.1	67.8	64.8	57.7	45.0	37.1	28.4
Waverly	Humphreys	21.4	24.8	34.5	43.6	52.5	60.8	64.8	62.8	56.1	42.4	34.7	26.3
Waynesboro	Wayne	22.6	25.5	34.3	42.8	51.4	59.7	64.2	62.3	55.8	42.0	34.4	27.1

A2.3. (Continued)

Station	County	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Woodbury	Cannon	22.9	25.5	34.9	43.1	51.6	59.9	64.3	63.2	56.6	42.9	35.0	27.4
#75,59	Lake	24.1	28.0	38.1	47.8	56.5	64.6	68.6	66.8	58.8	46.2	37.9	28.9
#31,7,72,24,52	Crockett	26.4	30.3	39.8	49.3	57.7	65.5	69.3	67.2	60.6	48.1	39.8	30.8
#77,76,45,32,4	Chester	26.2	29.6	38.7	47.3	55.8	63.7	67.6	65.9	59.7	46.6	38.8	30.6
#68,30,85	Benton	23.0	26.4	35.9	45.0	53.5	61.9	66.0	64.0	57.3	43.9	36.3	27.7
#46,45,76	Decatur	25.2	28.2	37.2	46.0	54.5	62.7	66.7	65.3	58.9	45.6	38.0	29.7
#22,85,12,21	Houston	23.1	26.6	36.1	44.9	53.4	61.8	65.8	64.1	57.6	44.3	36.4	27.8
#86,40,56,9,46	Lewis	23.7	26.7	65.4	43.8	52.3	60.3	64.6	63.1	56.5	43.3	35.6	28.0
#26,79,83	Moore	26.2	29.6	38.1	45.9	54.0	61.7	65.8	64.7	58.6	45.9	38.1	30.6
#83,53,26	Franklin	25.5	28.9	37.5	45.8	53.9	61.4	65.3	64.3	58.6	46.1	37.9	29.9
#53,10	Marion	26.3	29.7	38.1	46.6	54.8	62.7	66.6	65.9	60.6	48.1	39.2	30.2
#50,80,69	Van Buren	26.4	29.2	34.2	44.9	52.7	60.7	64.7	63.6	57.6	44.9	37.3	30.3
#69,20,53,10	Sequatchie	26.5	29.6	37.8	45.5	53.6	61.5	65.5	64.7	59.1	46.4	41.1	30.2
#20,2,13,73	Meigs	24.8	27.7	35.8	43.8	52.1	60.4	64.4	63.7	57.4	44.2	36.1	28.6
#2,43,37,16	Monroe	25.1	27.8	35.8	43.8	52.2	60.7	64.9	64.2	57.8	44.5	36.5	28.9
#61,78,38	Jefferson	25.0	27.8	36.2	44.2	52.9	60.1	65.1	64.4	58.0	44.7	36.2	28.5
#61,29,74	Hamblen	23.6	26.2	34.5	42.3	51.2	59.4	63.5	62.5	56.1	43.0	34.8	27.0
#25,29,34,6,74	Washington	23.8	26.3	34.5	42.2	50.9	58.8	62.9	62.0	55.8	43.2	35.2	27.6
#25,6,34	Carter	24.0	26.4	34.6	42.2	50.8	58.8	62.9	62.0	55.8	43.4	35.4	28.0
#34,6	Johnson	25.3	27.7	36.1	43.7	52.2	60.2	64.3	63.5	57.2	45.0	36.9	29.3
Jeff.,Hamblen	Grainger	24.3	27.0	35.4	43.3	52.1	59.8	64.3	63.5	57.1	43.8	35.5	27.8
#66,62,74	Union	22.4	24.9	33.4	41.3	49.8	58.1	62.2	61.5	55.1	42.1	34.2	26.3
#62,74	Hancock	23.4	25.8	34.3	42.3	50.8	58.8	62.7	62.3	56.0	43.2	35.1	27.2
Hancock,Union	Claiborne	22.9	25.3	33.8	41.8	50.3	58.5	62.4	61.9	55.6	42.6	34.6	26.8
#66,64,73,1	Morgan	23.0	25.7	34.0	42.3	50.6	58.9	63.4	62.1	55.7	42.9	34.9	27.0

A2.3. (Continued)

Station	County	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
#1,48,8,	Pickett	23.5	26.4	35.2	43.5	51.6	59.7	63.7	62.3	56.1	43.7	36.0	28.2
#87,50,80,15	DeKalb	24.8	27.6	36.4	44.4	52.4	60.5	64.6	63.4	57.1	44.2	36.6	29.2
#39,41	Smith	24.1	27.4	36.8	45.5	53.6	61.8	65.6	64.0	57.3	44.7	37.3	28.8
#39,41	Trousdale	24.1	27.4	36.8	45.5	53.6	61.8	65.6	64.0	57.3	44.7	37.3	28.8

* Owenby, J.R., Ezell, D.S. 1992. Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1961-1990. Climatography of the United States No. 81. United States Department of Commerce. National Oceanic and Atmospheric Administration National Climatic Data Center. Asheville, North Carolina.

A2.4. Monthly mean precipitation by weather station and county for the Tennessee seed zones*.

Station	County	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Allardt	Fentress	4.4	4.21	5.28	4.46	5.11	4.69	5.16	4.36	4.15	3.35	4.39	4.81
Athens	Mcminn	5.6	4.92	6.32	4.71	4.89	3.74	4.91	4.19	4.37	3.66	4.79	5.59
Bolivar	Hardeman	4.0	4.49	5.47	5.25	5.4	3.66	3.71	3.45	3.93	3.09	4.86	5.65
Bristol	Sullivan	3.2	3.44	3.7	3.3	3.84	3.54	4.32	3.17	3.26	2.59	2.94	3.39
Brownsville	Haywood	3.9	4.53	5.34	5.38	5.47	3.46	4.17	3.14	3.76	2.97	4.78	5.61
Celina	Clay	4.1	4.35	5.13	4.2	4.77	4.16	4.96	3.67	4.05	3.14	4.56	5.01
Centerville	Hickman	4.0	4.39	5.43	4.92	5.23	3.72	4.57	3.29	3.58	3.14	5.07	5.45
Chattanooga	Hamilton	4.9	4.81	6.03	4.31	4.37	3.52	4.85	3.53	4.15	3.22	4.61	5.17
Cheatham	Maury	3.6	4.31	5.52	4.35	4.65	3.82	4.43	3.32	3.56	3.02	4.66	5.11
Clarksville	Montgomery	3.7	4.28	5.67	4.46	4.3	3.9	4.14	3.84	3.48	3.17	4.57	5.24
Cleveland	Bradley	4.9	4.7	6	4.38	4.89	4.05	4.85	3.5	4.16	3.47	4.49	5.3
Columbia	Maury	4.4	4.43	5.82	5.09	5.49	3.9	4.8	3.55	3.5	3.67	4.56	5.09
Cookeville	Putnam	4.7	4.49	5.81	4.66	5.42	4.14	5.37	4.23	4.22	3.36	4.77	5.39
Copperhill	Polk	5.4	5.35	6.28	4.79	5.17	4.45	5.33	4.53	4.42	3.67	4.56	5.21
Covington	Tipton	3.9	4.46	5.37	5.51	5.32	3.34	3.99	2.61	3.98	2.95	5.09	5.66
Crossville1	Cumberland	4.6	4.42	5.97	4.82	5.14	4.09	5.13	4.09	3.71	3.35	4.85	5.3
Crossville2	Cumberland	5.2	4.8	6.23	4.95	5.58	4.38	5.5	3.92	4.16	3.74	5.13	5.71
Dayton	Rhea	4.8	4.83	6.36	4.56	5.18	3.63	4.75	4.08	4.13	3.39	4.77	5.67
Dickson	Dickson	3.9	4.51	5.61	5.03	5.12	4.2	4.46	3.67	3.98	3.13	5.01	5.34
Dover	Stewart	3.9	4.55	5.41	4.92	4.61	3.88	4.48	3.7	3.84	3.39	4.98	5.26
Dresden	Weakley	4.0	4.49	5.28	5.09	5.03	4.16	5.12	3.88	3.78	3.18	4.96	5.3
Dyersburg	Dyer	3:5	4.36	4.99	4.69	4.83	3.92	4.32	3.26	3.54	2.95	4.81	5.3
Erwin	Unicoi	3.4	3.69	4.41	4.01	4.6	4.7	5.66	4.3	3.54	2.87	3.31	3.42
Fayetteville	Lincoln	4.7	4.37	6.17	4.67	5.04	3.75	4.56	3.15	3.78	3.56	4.84	5.54

A2.4. (Continued)

Station	County	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Franklin Sew	Williamson	4.1	4.34	5.56	4.46	5.07	3.72	4.64	3.79	3.91	3.29	4.75	5.29
Gatlinburg	Sevier	4.3	4.42	5.22	4.33	5.13	5.07	6.43	5.01	4.27	3.15	4.07	4.33
Greenville	Greene	3.3	3.36	4.02	3.4	3.96	3.75	4.88	3.5	3.26	2.65	3.05	3.11
Huntingdon	Carroll	3.9	4.59	5.29	4.69	5.06	3.99	4.59	3.35	4.36	3.54	4.9	5.58
Jackson Faa Ap	Madison	3.9	4.39	5.02	5.36	5.44	4.15	4.42	3.08	3.75	3.16	4.79	5.38
Jackson Exp Sta	Madison	3.9	4.37	5.04	5.1	5.47	4.09	4.23	2.91	3.91	3.26	4.84	5.37
Kingsport	Sullivan	3.7	3.71	3.93	3.48	3.98	3.67	4.74	3.69	3.27	2.92	3.19	3.51
Kingston Springs	Cheatham	3.8	4.58	5.58	4.51	4.72	3.9	4.18	3.68	3.9	3.25	4.71	5.12
Knoxville Wso	Blount	4.2	4.06	5.09	3.72	4.13	3.97	4.67	3.13	3.07	2.84	3.75	4.54
Knoxville Ut	Knox	4.3	4.01	4.91	3.62	4.42	4.11	4.49	3.74	3.23	3.04	3.97	4.54
Lafayette	Macon	4.3	4.28	5.51	4.47	5.23	4.42	5.07	3.98	4	3.45	4.85	5.72
Lawrenceburg	Lawrence	4.8	4.6	6.39	4.7	5.56	3.49	4.62	3.62	3.98	3.54	5.1	5.55
Lebanon	Wilson	4.0	4.22	5.32	4.47	4.78	4.11	4.58	4.12	3.76	3.26	4.54	5.03
Lenoir City	Loudon	4.72	4.56	5.86	4.2	4.68	4.04	5.08	3.88	3.3	3.19	4.19	5.09
Lewisburg	Marshall	4.49	4.12	5.97	4.67	5.66	3.85	5.19	3.25	3.79	3.81	4.85	5.05
Lexington	Henderson	3.64	4.28	5.27	4.62	5.07	3.74	4.64	3.01	3.67	3.32	4.59	5.05
Linden 2	Perry	4.61	4.64	5.74	4.87	5.51	4.16	4.6	3.62	3.64	3.24	5.13	5.95
Livingston	Overton	4.19	4.17	5.16	4.34	4.99	3.97	5.32	4.07	3.83	3.1	4.5	5.18
Martin	Weakley	3.67	4.3	5.27	5.04	4.8	4.31	4.91	3.41	3.73	3.5	4.86	5.3
Mcminnville	Warren	4.34	4.25	5.83	4.46	5.09	4.18	4.8	3.44	3.88	3.43	4.57	5.03
Memphis	Shelby	3.73	4.35	5.41	5.46	4.98	3.57	3.79	3.43	3.53	3.01	5.1	5.74
Milan	Gibson	3.94	4.46	5.22	4.98	5.33	4.55	4.46	3.51	4.3	3.21	4.85	5.67
Monteagle	Grundy	5.61	5.32	6.79	5.24	5.55	3.9	5.67	4.09	4.54	4.24	5.71	5.84
Moscow	Fayette	3.89	4.54	5.34	5.69	5.01	3.58	4.21	3.11	3.88	3.04	5.15	5.54
Mount Pleasant	Maury	4.29	4.47	6.01	5.1	5.59	3.49	4.78	3.61	3.77	3.52	4.94	5.3

A2.4. (Continued)

Station	County	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Murfreesboro	Rutherford	4.21	4.05	5.52	4.48	5.36	3.87	4.82	3.78	4.25	3.33	4.51	4.99
Nashville	Davidson	3.58	3.81	4.85	4.37	4.88	3.57	3.97	3.46	3.46	2.62	4.12	4.61
Newbern	Dyer	3.54	4.04	5.19	5.19	5.04	4.38	4.24	3.49	3.75	3.3	4.84	5.44
Newport	Cocke	3.51	3.56	4.32	3.6	4.59	3.62	4.49	3.83	3.33	2.56	3.18	3.42
Norris	Anderson	4.39	4.16	5.34	4.25	4.69	4.58	4.79	4.29	3.61	3.18	4.58	4.92
Oak Ridge	Anderson	4.57	4.34	5.68	4.08	4.68	4.34	5.45	3.7	3.86	3.18	4.59	5.3
Oneida	Scott	4.36	4.19	5.32	4.48	5.26	4.53	5.31	4.24	3.87	3.87	4.52	4.58
Paris	Henry	3.92	4.39	5.2	4.87	4.55	4.06	4.28	4.11	3.77	3.29	4.89	5.37
Pikeville	Bledsoe	4.79	4.49	5.83	4.47	4.86	3.75	4.62	3.6	3.92	3.11	4.56	5.13
Portland Sewage	Sumner	3.79	4.13	5.38	4.36	5.21	4.48	4.28	3.67	3.45	3.12	4.65	4.87
Pulaski Water	Giles	4.6	4.54	6.25	4.48	5.08	4.05	4.66	3.45	4.12	3.56	4.84	5.54
Ripley	Lauderdale	3.59	4.18	5.5	5.16	5.16	3.78	3.92	2.45	4.1	3.12	5.38	5.64
Rockwood 2	Roane	5.21	4.82	6.05	4.5	5.42	4.19	5.65	4.33	3.9	3.61	4.93	5.72
Rogersville	Hawkins	3.81	3.72	4.18	3.88	4.33	3.38	4.33	3.67	3.36	2.86	3.52	4.19
Samburg	Obion	3.49	4.13	5.03	4.93	5.35	3.93	3.73	3.43	3.27	3.27	4.64	5.15
Savannah	Hardin	4.57	4.84	6.05	5.42	5.78	4.07	4.31	3.3	3.9	3.32	5.53	5.99
Selmer	Mcnairy	4.58	4.73	5.93	5.42	5.74	3.83	4.62	2.67	4	3.31	5.51	5.86
Sevierville	Sevier	3.66	3.7	4.34	3.42	4.21	3.55	4.25	3.23	3.28	2.55	3.18	3.76
Shelbyville	Bedford	4.51	4.26	6.11	4.59	5.29	3.87	5.21	3.5	3.84	3.79	4.96	5.1
Sparta	White	4.56	4.32	5.69	4.59	5.33	3.93	5.31	3.85	3.97	3.51	4.88	5.34
Springfield	Robertson	3.6	4.11	5.16	4.31	4.88	4.12	4.29	3.37	3.41	2.99	4.45	4.92
Tullahoma	Coffee	4.9	4.73	6.34	4.9	5.22	3.91	4.99	3.45	3.87	3.82	5.04	5.66
Union City	Obion	3.71	4.13	5.34	4.81	4.91	4.39	4.16	3.38	3.59	3.66	4.92	5.11
Waverly	Humphreys	3.98	4.67	5.94	5	5.41	4.3	4.42	3.96	3.94	3.21	4.98	5.38

A2.4. (Continued)

Station	County	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Waynesboro	Wayne	4.76	4.73	6.28	5.35	5.55	3.81	5.19	3.64	3.62	3.64	5.58	5.74
Woodbury	Cannon	4.54	4.49	6.01	4.63	5.47	3.81	4.91	4.26	4.08	3.71	4.65	5.25
#75,59	Lake	3.52	4.085	5.11	5.06	5.195	4.155	3.985	3.46	3.51	3.285	4.74	5.295
#31,7,72,24,52	Crockett	3.77	4.384	5.214	5.114	5.246	3.972	4.258	3.088	3.89	3.082	4.922	5.52
#77,76,45,32,4	Chester	4.12	4.542	5.552	5.162	5.492	3.878	4.302	3.068	3.882	3.26	5.066	5.584
#68,30,85	Benton	3.92	4.55	5.48	4.85	5.01	4.12	4.43	3.81	4.02	3.35	4.92	5.44
#46,45,76	Decatur	4.27	4.586	5.687	4.97	5.45	3.99	4.52	3.31	3.73	3.29	5.08	5.66
#22,85,12,21	Houston	3.87	4.502	5.657	4.852	4.86	4.07	4.375	3.792	3.81	3.225	4.885	5.305
#86,40,56,9,46	Lewis	4.49	4.566	5.97	4.988	5.488	3.734	4.752	3.556	3.718	3.416	5.164	5.598
#26,79,83	Moore	4.71	4.45	6.21	4.72	5.18	3.84	4.92	3.367	3.837	3.72	4.95	5.4
#83,53,26	Franklin	5.08	4.81	6.43	4.94	5.27	3.85	5.07	3.56	4.06	3.87	5.19	5.68
#53,10	Marion	5.25	5.065	6.41	4.775	4.96	3.71	5.26	3.81	4.345	3.73	5.16	5.505
#50,80,69	Van Buren	4.56	4.35	5.78	4.51	5.09	3.95	4.91	3.63	3.92	3.35	4.67	5.17
#69,20,53,10	Sequatchie	5.03	4.86	6.25	4.645	4.99	3.7	4.97	3.825	4.18	3.49	4.91	5.45
#20,2,13,73	Meigs	5.12	4.82	6.18	4.54	5.095	3.9	5.04	4.025	4.14	3.53	4.75	5.57
#2,43,37,16	Monroe	4.95	4.72	5.88	4.35	4.72	4.05	4.99	3.93	3.79	3.34	4.32	5.11
#61,78,38	Jefferson	3.81	3.76	4.52	3.55	4.41	3.76	4.41	3.6	3.28	2.72	3.44	3.91
#61,29,74	Hamblen	3.54	3.55	4.17	3.62	4.29	3.58	4.567	3.67	3.32	2.69	3.25	3.57
#25,29,34,6,74	Washington	3.49	3.58	4.048	3.61	4.14	3.81	4.79	3.67	3.34	2.78	3.2	3.52
#25,6,34	Carter	3.45	3.61	4.01	3.6	4.14	3.97	4.91	3.72	3.36	2.79	3.15	3.44
#34,6	Johnson	3.5	3.575	3.82	3.39	4.73	3.61	4.53	3.43	3.27	2.76	3.07	3.45
Jeff,Hamblen	Grainger	3.67	3.655	4.345	3.585	4.35	3.67	4.49	3.64	3.3	2.71	3.35	3.74
#66,62,74	Union	4.19	4.02	4.95	4.2	4.76	4.16	4.81	4.1	3.61	3.3	4.21	4.56
#62,74	Hancock	4.1	3.94	4.76	4.07	4.51	3.98	4.56	3.98	3.49	3.02	4.05	4.56
Hancock,Union	Claiborne	4.15	3.98	4.86	4.14	4.64	4.07	4.69	4.04	3.55	3.16	4.13	4.56

A2.4. (Continued)

Station	County	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
#66,64,73,1	Morgan	4.62	4.39	5.58	4.38	5.12	4.44	5.39	4.16	3.95	3.5	4.61	5.1
#1,48,8,	Pickett	4.22	4.25	5.54	4.42	4.88	3.96	5.15	4.03	4.08	3.3	4.62	5
#87,50,80,15	Dekalb	4.54	4.39	5.84	4.59	5.33	4.02	5.1	3.95	4.04	3.5	4.72	5.25
#39,41	Smith	4.08	4.25	5.42	4.47	5.4	4.27	4.83	4.05	3.88	3.36	4.7	5.4
#39,41	Trousdale	4.08	4.25	5.42	4.47	5.4	4.27	4.83	4.05	3.88	3.36	4.7	5.4

* Owenby, J.R., Ezell, D.S. 1992. Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1961-1990. Climatography of the United States No. 81. United States Department of Commerce. National Oceanic and Atmospheric Administration National Climatic Data Center. Asheville, North Carolina.

A2.5. County abbreviations for implementation of the Tennessee seed zones.

County	Abbrev.	County	Abbrev.
Anderson	A1	Haywood	H7
Bedford	B1	Henderson	H8
Benton	B2	Henry	H9
Bledsoe	B3	Hickman	H10
Blount	B4	Houston	H11
Bradley	B5	Humphreys	H12
Campbell	C1	Jackson	J1
Cannon	C2	Jefferson	J2
Carroll	C3	Johnson	J3
Carter	C4	Knox	K1
Cheatham	C5	Lake	L1
Chester	C6	Lauderdale	L2
Claiborne	C7	Lawrence	L3
Clay	C8	Lewis	L4
Cocke	C9	Lincoln	L5
Coffee	C10	Loudon	L6
Crockett	C11	Macon	M1
Cumberland	C12	Madison	M2
Davidson	D1	Marion	M3
DeKalb	D2	Marshall	M4
Decatur	D3	Maury	M5
Dickson	D4	McMinn	M6
Dyer	D5	McNairy	M7
Fayette	F1	Meigs	M8
Fentress	F2	Monroe	M9
Franklin	F3	Montgomery	M10
Gibson	G1	Moore	M11
Giles	G2	Morgan	M12
Grainger	G3	Obion	O1
Greene	G4	Overton	O2
Grundy	G5	Perry	P1
Hamblen	H1	Pickett	P2
Hamilton	H2	Polk	P3
Hancock	H3	Putnam	P4
Hardeman	H4	Rhea	R1
Hardin	H5	Roane	R2
Hawkins	H6	Robertson	R3

A2.5. (Continued)

County	Abbrev.	County	Abbrev.
Rutherford	R4	Unicoi	U1
Scott	S1	Union	U2
Sequatchie	S2	Van Buren	V1
Sevier	S3	Warren	W1
Shelby	S4	Washington	W2
Smith	S5	Wayne	W3
Stewart	S6	Weakley	W4
Sullivan	S7	White	W5
Sumner	S8	Williamson	W6
Tipton	T1	Wilson	W7
Trousdale	T2		

A2.6. Species list of abbreviations for implementation of the Tennessee seed zones.

Scientific Name	Common Name	Abbreviation
Conifers		
Taxodium distichum	Baldcyress	CYP
Tsuga canadensis	Eastern Hemlock	HEM
Picea spp.	Spruce	SPR
Juniperous virginiana	Eastern Red Cedar	ERC
Pinus Strobus	Eastern White Pine	EWP
Pinus Taeda	Loblolly Pine	LLP
Pinus echinata	Shortleaf Pine	SLP
Pinus virginiana	Virginia Pine	VP
Pinus rigida	Pitch Pine	PP
Pinus sylvestris	Scotch Pine	SP
Hardwoods		
Quercus alba	White Oak	WO
Quercus rubra	Northern Red Oak	NRO
Quercus nuttallii	Nuttall Oak	NO
Quercus shumardii	Shumard Oak	SO
Quercus michauxii	Swamp Chestnut Oak	SCO
Quercus nigra	Water Oak	WTO
Quercus falcata var. pagodifolia	Cherrybark Oak	CBO
Quercus palustris	Pin Oak	PO
Quercus phellos	Willow Oak	WLO
Quercus lyrata	Overcup Oak	OCO
Quercus acuttisima	Sawtooth Oak	STO
Carya illinoensis	Pecan	PEC
Carya aquatica	Water Hickory	WH
Carya laciniosa	Shellbark Hickory	SBH
Diospyros virginiana	Persimmon	PER
Acer saccharum	Sugar Maple	SUM
Acer rubrum	Red Maple	RDM
Acer negundo	Boxelder	BEL
Fagus grandifolia	American Beech	AMB
Liquidambar styraciflua	Sweetgum	SWG
Nyssa sylvatica	Blackgum	BKG
Fraxinus americana	White Ash	WHA
Fraxinus pennsylvanica	Green Ash	GRA
Platanus occidentalis	American Sycamore	ASY
Populus deltoides	Eastern Cottonwood	ECW

Table A.6 (Continued)

Scientific Name	Common Name	Abbreviation
Tilia americana	American Basswood	ABW
Magnolia grandiflora	Southern Magnolia	SMG
Magnolia virginiana	Sweetbay	SWB
Salix nigra	Black Willow	BKW
Salix babylonica	Weeping Willow	WW
Juglans nigra	Black Walnut	BWN
Prunus serotina	Black Cherry	BC
Ulmus americana	American Elm	AE
Betula nigra	River Birch	RBR
Celtis occidentalis	Hackberry	HBY
Robinia pseudoacacia	Black Locust	BLC
Sassafras albidum	Sassafras	SAS
Cornus florida	Flowering Dogwood	FDW
Ilex opaca	American Holly	AMH
Elaeagnus angustifolia	Russian Olive	RUO
Paulownia tomentosa	Royal Paulownia	PAU
Malus angustifolia	Southern Crab Apple	SCA

A2.7. Area in square meters (km^2) comprising each of the Tennessee seed zones.

Zone	Area
1	126,528
2	856,272
3	4,639,574
4	6,738,858
5	3,387,544
6	10,009,049
7	24,633,908
8	14,129,469
9	8,469,548
10	11,771
11	212,407
12	13,965,909
13	6,984,108
14	6,276,349
15	296,300
16	1,958,675
17	2,344,789
18	1,867,226
19	819,366
20	6,111
21	1,300,048

PART 3

The Influence of Competition on Flowering and Acorn Maturation in Northern Red Oak (*Quercus rubra* L.)

Introduction

Variation in annual production of acorns by oak species (*Quercus* L.) in North America is well documented (Downs and McQuilken 1944, Sharp and Chisman 1961, Sharp and Sprague 1967, Goodrum et al. 1971, Olson and Boyce 1971). Various hypotheses have been proposed to explain causes of annual variation in production, ranging from the influence of insects to flower numbers to annual weather patterns (Cecich 1992, Sork et al. 1993, Koenig et al. 1994, 1996, Koenig and Knops 1995). A single explanation, however, has not been generally accepted (Cecich 1992, Koenig and Knops 1995).

Many authors (Sharp and Chisman 1961, Sharp and Sprague 1967, Goodrum et al. 1971, Olson and Boyce 1971, Kearby et al. 1986, Koenig and Knops 1995) have noted the importance of acorns in forest regeneration and as wildlife food. Prediction of acorn crops can be difficult due to the variation in annual production of acorns on individual and population levels. Gysel (1958) and Olson and Boyce (1971) suggested a need for the development of a production index to predict mast from oak species for wildlife food and natural regeneration. Development of a production index, however, would require a better understanding of oak reproductive biology and the causes of pistillate flower abortion (Farmer 1981, Cecich 1992). Flower to acorn survival data, knowledge of the past reproductive history of individual trees, and inter-tree competition are examples of information that could be used in constructing an acorn production model.

Floral development and pollination are the most significant processes that determine the size of the resulting acorn crop in a particular year (Larsen and Cecich

1997). Pistillate flower survival in *Quercus* L. is affected by many factors that hinder development into acorns. A large flower crop does not ensure an abundant acorn crop (Sharp and Sprague 1967, Cecich 1992), and limited research has been conducted on flowering variability and its relationship to the variation of acorn yields (Merkle et al. 1980, Larsen and Cecich 1997). Some authors have identified weather as the primary factor that affects flowering and subsequent pollination (Sharp and Chisman 1961, Olson and Boyce 1971, Sork et al. 1993, Koenig et al. 1994, Cecich 1997). Cecich (1992) reported temperature to be the primary factor affecting receptivity of pistillate flowers in the genus *Quercus* through influencing flower emergence. Rain can affect pollen dispersal and subsequent fertilization (Cecich 1994). In contrast, Koenig et al. (1996) found no relationship between weather and mean annual acorn production in *Quercus kelloggii* K. in the central coast region of California.

Insects are suspected of being a significant cause of abortion of pistillate flowers after pollination and prior to fertilization (Barber et al. 1995, Cecich 1992, 1997). Kearby et al. (1986) identified insects that impact acorn crops, such as the acorn weevil (*Curculio* spp.), which oviposits in August (Stanton 1994). Another group of insects that may impact flower survival and subsequent development into acorns are treehoppers (Family Membracidae), which have been observed feeding on oak pistillate flowers in May and June (Cecich 1992).

Most research on flowering and premature acorn abscission has concentrated on white oak species (subgenus Lepidobalanus) rather than on red oak species (subgenus Erythrobalanus) (Sharp and Chisman 1961, Sharp and Sprague 1966, Williamson 1966, Merkle et al. 1980, Farmer 1981, and Feret et al. 1982). Larson and Cecich (1997) have developed a stochastic model for evaluating factors that hinder pistillate flower survival in white oak (*Quercus alba* L.) through oak flowering dynamics. The model evaluates weather, insect populations, genetic factors, and crop intervals (Larson and Cecich 1997).

Cecich (1994, 1997) has examined northern red oak (*Quercus rubra* L.) flower survival and physiology. However, no research has been conducted on pistillate flower distribution or the effects of crown competition on flower to acorn survival in this species. In a northern red oak seedling seed orchard, a study was designed to: 1) investigate the distribution patterns of flowers and second-year acorns (acornets) within the crowns and 2) determine the effect of inter-tree competition on flower and acornet distribution on acorn crops.

Materials and Methods

Study Location and Experimental Material

The study was located in a northern red oak seedling seed orchard on the Watauga Ranger District of the Cherokee National Forest in northeastern Tennessee. The Tennessee Valley Authority (TVA) established a northern red oak progeny test containing 220 open-pollinated families with eight replications of four tree plots in 1973 on 16.2 acres of abandoned farmland. After the TVA discontinued tree improvement research in 1982, the USDA Forest Service, Southern Region assumed responsibility, and the Regional Genetic Resources Program converted the progeny test to a seedling seed orchard in 1987 (La Farge and Lewis 1987).

The orchard trees were evaluated using binoculars to assess second year acorn production in the late winter of 1997. Those trees with acornets were considered to be sexually mature and likely to produce flowers in the spring. Initially, 22 trees were selected based on the estimates of high numbers of acornets (approximately >3000) and spacing among trees (Table 3.1). Within this selected group of trees, a combination of single trees and groups of two and three trees with crown overlap, i.e., competition, were chosen for study. The three single trees had no crown competition with other trees. Other trees in the study had various degrees of competition from surrounding trees (Table 3.1).

Competition was defined as the interaction between two study trees or a study tree with an adjacent tree in close proximity where a portion of the crowns were overlapping and significant shading occurred to the upper and lower crown of the study tree(s). Competition was evaluated in each tree by cardinal direction and was scored as: 0= no competition, 1= the lower crown had competition, and 2= upper and lower crown had competition (Table 3.2).

Data Collection

In the northern red oak seedling seed orchard, flowering began in early May. A bucket truck was used for all flower counts, which began on May 27, 1997. Branches with flowers were selected on each tree from the upper and lower sections of the crown along the four cardinal directions, thus dividing the tree into four quadrants. Each quadrant was 45 degrees wide (Figure 3.1). The upper section of the tree was defined by

Table 3.1. Origin of northern red oak trees evaluated for the influence of competition on flowering and acorn maturation. Letters indicate side of crown overlap or competition, not applicable (None) for single trees.

Competition Group	Origin	Crown Overlap
Single Trees		
8-9-630	Campbell Co, TN	None
6-12-628**a**	Campbell Co, TN	None
5-2-582**a**	Claiborne Co, TN	None
7-5-520**b**	Campbell Co, TN	None
Paired Trees		
6-17-882	Madison Co, AL	W
6-15-855	Overton Co, TN	E
8-20-903	Henderson Co, TN	S
8-21-728	Franklin Co, TN	N
8-13-530	Morgan Co, TN	W
8-12-705	Anderson Co, TN	E
7-8-916	Henderson Co, TN	W
7-7-2457	Campbell Co, TN	E
8-4-540	Union Co, TN	N
8-2-914	Henderson Co, TN	S
8-12-701	Anderson Co, TN	W
8-11-732	Franklin Co, TN	E
7-26-323**a**	Clarksville, TN	N
6-8-903**a**	Henderson Co, TN	S
5-22-905**b**	Henderson Co, TN	S
5-23-913**b**	Henderson Co, TN	N
Three Trees Group		
8-20-884-1	Huntsville, AL	W
8-20-884-2	Huntsville, AL	E
8-21-888	Huntsville, AL	E, W
8-17-625	Henderson, NC	E
8-17-510	Anderson Co, TN	W
8-18-617**b**	Monroe Co, TN	N

a Indicates trees dropped from study on May 29, 1997
b Indicates trees added to study on June 3, 1997

Table 3.2. Competition by cardinal direction between selected trees with adjacent trees. 0=no competition, 1=competition affecting lower section(s), and 2=competition affecting upper and lower section(s).

Competition group	Cardinal Direction*			
	N	S	E	W
6-17-882	0	0	0	2*
6-15-855	0	0	2*	0
8-20-903	0	2*	0	0
8-21-728	2*	0	0	0
8-13-530	0	2	2	2*
8-12-705	2	0	2*	1
7-8-916	0	0	0	2*
7-7-2457	1	0	2*	0
8-4-540	1*	2	1	2
8-2-914	0	1*	0	2
8-12-701	0	1	0	2*
8-11-732	0	0	2*	0
7-23-323	2*	0	0	2
6-8-903	0	2*	2	2
8-17-510	2	1	0	2*
8-17-625	0	2	2*	0
8-20-884-1	2	0	2	1*
8-20-884-2	0	1	2*	0
8-21-888	2	0	1*	1*

*** Matched Quadrants.**

a visual assessment of each tree's canopy, which was then bisected from the top of the crown to the bottom branches. The lower section included the branches below the visualized bisecting line in the canopy (Figure 3.1). After the initial inventory and selection of branches on each tree, the directions in which the crowns were overlapping in paired and three tree groups were noted.

The selected branches were assessed approximately every three weeks for the number of flowers and acornets present on each branch. Branches with flowers on all trees, except 8-17-625 and 8-17-510, were selected and marked with metal tags. Trees 8-17-625 and 8-17-510 were sampled by selecting one branch from each cardinal direction due to an abundant flower crop. The flower and acornet counts continued until September 3, 1997. In 1998, observations from the same trees and branches began on May 12th and continued through August 27th. Only acornets from the previous year's flower crop were tallied in the second observation season. A total of 12 inventories occurred over both seasons, six in each year (Table 3.3).

Four trees initially selected did not produce flowers, so they were replaced on June 6, 1997, which was the third inventory date in the first year of study. For the final analysis, there were 22 trees, including three single trees, eight groups of paired trees, and one group of three trees.

Statistical Analyses

Chi-square analyses were used to detect differences in the distribution of flowers and acornets across quadrants among single trees and among trees with different types or degrees of competition (SAS Institute 1996) (α=0.05). Trees with competition were

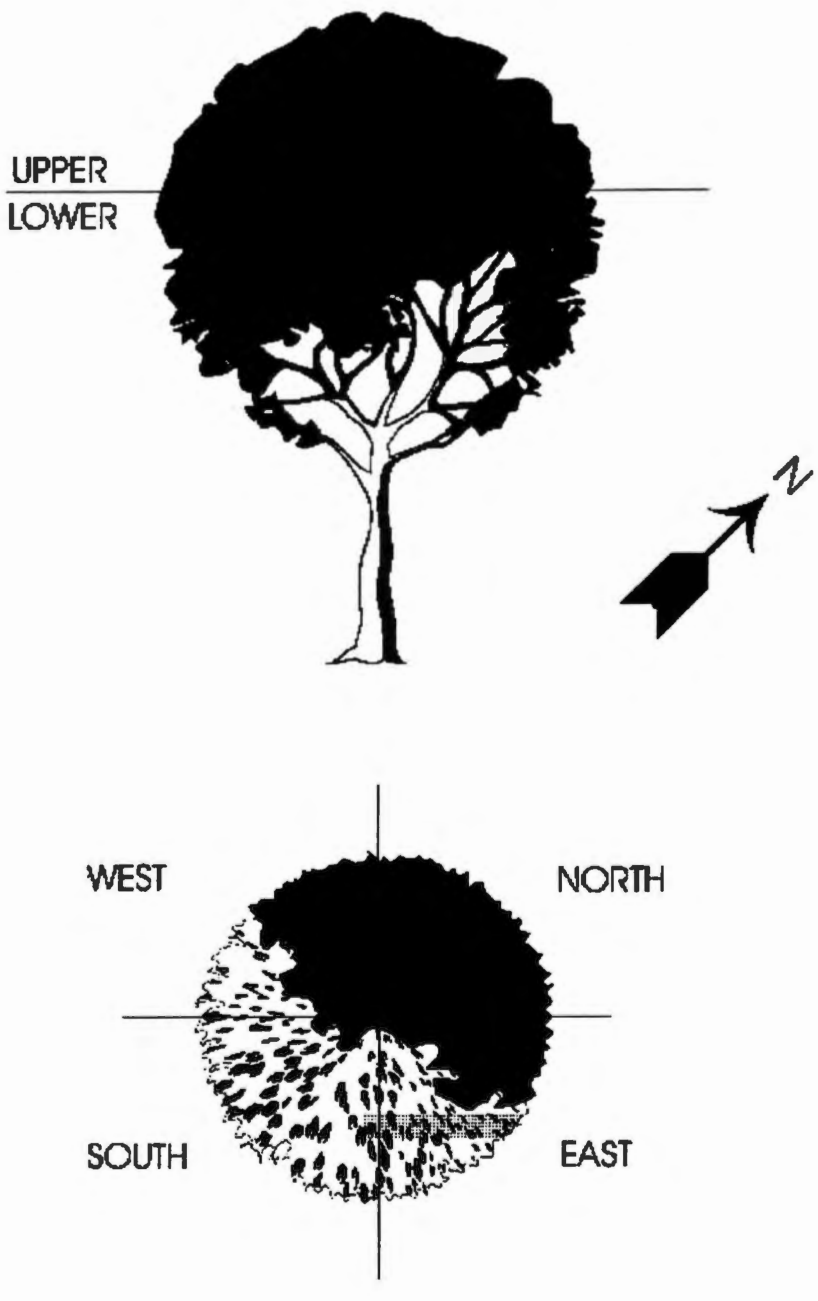

Figure 3.1. Visual representation of upper and lower branch selection and quadrant delineation. Drawn by D.T. Barrett.

Table 3.3. List of inventory dates and experimental material surveyed.

Inventory #	Date	Surveyed
1	5/27/97	Flowers/Acornets
2	6/17/97	Flowers/Acornets
3	6/30/97	Flowers/Acornets
4	7/27/97	Flowers/Acornets
5	8/14/97	Flowers/Acornets
6	9/3/97	Flowers/Acornets
7	5/12/98	Acornets
8	6/3/98	Acornets
9	6/23/98	Acornets
10	7/13/98	Acornets
11	8/3/98	Acornets
12	8/27/98	Acornets

divided into three types, 1) trees with competition in one quadrant, 2) a three-tree group, and 3) all trees with competition, each type having a different degree of competition. Trees with competition in one quadrant were further subdivided: 1) trees with competition in only the west quadrant, 2) trees with competition primarily in the west quadrant, and 3) trees with competition primarily in the east quadrant. For each classification type, separate analyses were conducted on the 1997 flowers (inventories 1-6), 1997 acornets (inventories 1-6) and 1998 acornets (inventories 7-12) by the upper tree crown, the lower tree crown, and for the combined crown.

Differences in 1997 flower and 1997-98 acornet distribution between upper and lower crowns across quadrants for the combined single trees were studied using chi-square analyses. Differences in flower and acornet numbers between the upper and lower crowns for each classification (e.g., all trees with competition) were also analyzed to detect if the flowers and acornets were equally divided between the upper and lower crowns.

Chi-square analyses also were conducted to detect differences in the distribution of flowers and acornets across quadrants between single trees as a group and trees with different levels of competition, grouped as classified above. The analyses were conducted in the same systematic manner as above with separate analyses on the 1997 flowers and 1997-8 acornets by upper, lower, and combined sections of the crown. Trees were deleted from the analyses when all flowers or acornets were completely lost, as there was no distribution to evaluate.

Results

Inventory dates one and two were not analyzed in some instances, as some trees had no flowers and were replaced by bearing trees at the third inventory. Results from the third and seventh inventories are usually presented as the numbers of flowers and acornets declined throughout the growing season and occasionally made statistical evaluations invalid.

Single Trees

Crown Distributions of Flowers and Acornets

There were significant differences in 1997 flower and 1997-98 acornet distributions between the upper and lower sections of the crown across quadrants for each grouping. The percentages of 1997 flowers and 1997-98 acornets in the lower sections and south quadrants of the single trees were higher than the percentage produced in the upper section and south quadrant of the upper crown. The south quadrant in the lower section of the crown consistently had the highest percentage of flowers and acornets (A3.1.).

Upper Crown

1997 Flower Inventory: Significant differences were found among trees for flower distributions across quadrants for the third, fourth, fifth and sixth inventory dates (A3.2.). The distribution of flowers among quadrants remained relatively unchanged at each inventory date. Many flowers were produced in the west and south quadrants of tree 5-2-582, whereas, tree 6-12-628 had the majority of its crop in the north and east quadrants. Tree 8-9-630 had a fairly even distribution of flowers across the quadrants with slightly more in the east and west quadrants.

1997 Acornet Inventory: Significant differences were found for the acornet distribution among trees across quadrants for all inventory dates (A3.2.). For the third inventory date, each tree differed in the distribution of acornets. Trees 5-2-582 and 6-12-682 had the majority of the acornet crop in the north quadrant, whereas, the majority of acornets on tree 8-9-630 were in the east quadrant. For all three trees, the south quadrant had the second greatest percentage of acornets, whereas, the west quadrant contained the lowest percentage of acornets. The same distribution pattern existed for the other inventory dates.

1998 Acornet Inventory: Significant differences in acornet distribution among trees across quadrants were found for all inventory dates (A3.2.). For the seventh inventory, the majority of acornets on tree 5-2-582 were in the south and west quadrants. Conversely, tree 6-12-628 produced most of its acornets in the east and north quadrants and had none in the west. Tree 8-9-630 had a generally equal distribution of acornets across quadrants with slightly more acorns in the east quadrant.

Lower Crown

1997 Flower Inventory: Significant differences were found for flower distribution among trees across quadrants for all inventory dates (A3.3.). A large percentage of the flowers were located in the south quadrant for all three trees. Two trees had an absence of flowers in at least one of the quadrants. The west quadrant did not produce many flowers on any tree. The same distribution pattern was present for all inventory dates.

1997 Acornet Inventory: Chi-square analysis showed significant differences for acornet distribution among trees across quadrants for all inventory dates (A3.3.). For the third inventory date, tree 5-2-582 had an equal distribution of acornets on the north and south quadrants and a greater percentage of acorns in the east quadrant than the west quadrant. Trees 6-12-682 and 8-9-630 had the majority of the acornets on the south quadrant and an absence of acorns in the other quadrants for the third inventory date. The trees had similar distribution patterns for the remaining inventory dates.

1998 Acornet Inventory: Significant differences in acornet distributions were found among trees across quadrants for inventory dates seven through 12 (A3.3.). The majority of the acornets on all three trees occurred in the south quadrant. Differences in acornet distribution in other quadrants occurred among trees. Tree 5-2-582 had some production in the west and east quadrants, while tree 8-9-630 had a low percentage in the west quadrant and none in the east quadrant. This distribution pattern remained the same over the other inventory dates.

Combined Crown

1997 Flower Inventory: The chi-square analysis for the third inventory date showed significant differences among trees for flower distributions across quadrants (A3.4.). Most of the flowers were on the south and west quadrants of tree 5-2-582. Tree 6-12-628 had the majority of the flowers distributed on the south quadrant, as were the flowers on tree 8-9-630. For inventories four through six, the families differed in distribution across the quadrants for the 1997 flower crop ($P<0.001$).

1997 Acornet Inventory: The third inventory date showed significant differences for acornet distribution among trees across quadrants (A3.4.). Tree 5-2-582 acornets were distributed fairly evenly among quadrants with slightly more on the north quadrant. Trees 6-12-628 and 8-9-630 had the majority of the acornets distributed in the south quadrant. There were acornet distribution differences among trees in quadrants not containing the majority of acornets. For example, tree 6-12-682 did not have many acornets in either the east or west quadrants, while tree 5-2-582 had 17% of the acornets on the west quadrant. The distribution patterns remained constant and significantly different for inventories four through six ($P<0.001$).

1998 Acornet Inventory: The seventh inventory showed significant differences among trees across quadrants for acornet distribution for the single trees (A3.4.). Acornets were more heavily distributed on the south and west quadrants of tree 5-2-582 and the south quadrant for trees 6-12-682 and 8-9-630. Tree 6-12-682 did not have any acornets on the west quadrant, whereas, trees 5-2-582 and 8-9-630 produced a fairly heavy crop in the west side. These distribution patterns remained statistically significant and consistent for the remaining inventories eight through twelve.

West Competition Trees (6-17-882, 7-8-916)

Upper Crown

1997 Flower Inventory: Significant differences in flower distribution were found between trees across quadrants for all inventory dates (A3.5.). Distribution trends differed with tree 6-17-882 producing a higher proportion of flowers in the north quadrant, and tree 7-8-916 producing the majority of flowers in the east quadrant.

1997 Acornet Inventory: Differences in acornet distribution were found between trees across quadrants for the second through the sixth inventories (A3.5.). Trends in acornet distribution differed with more acornets distributed in the north quadrant of both trees; however, tree 6-17-882 also had a majority of acornets in the west quadrant.

1998 Acornet Inventory: Significant differences in acornet distribution were found between trees across quadrants for all inventory dates (A3.5.). The distribution trend for tree 6-17-882 was higher in the north quadrant, whereas the proportion of acornets on tree 7-8-916 was greatest in the east quadrant in the seventh inventory, but shifted to the west later in the season as the number of acornets declined.

Lower Crown

All Inventories: Neither tree had a crop in the lower section of the crowns; therefore, statistical tests were not conducted.

Combined Crown

1997 Flower Inventory: Flower distributions were significantly different between trees across quadrants for all inventory dates (A3.6.). Flower distributions were proportionally greater in the north and east quadrants for trees 6-17-882 and 7-8-916, respectively.

1997 Acornet Inventory: Significant differences in acornet distribution were found between trees across quadrants for all inventory dates (A3.6.). The distribution trends differed with tree 6-17-882 producing more acornets in the north and west quadrants, and tree 7-8-916 producing more acornets in the north and east quadrants.

1998 Acornet Inventory: For all inventory dates, significant differences in acornet distribution were found between trees across quadrants (A3.6.). More acornets were produced in the north and east quadrants in tree 6-17-882, but the distribution shifted in the last three inventories so that the east and west quadrants contained the majority of acornets.

West2 Competition Trees (6-17-882, 7-8-916, and 8-12-701)

Upper Crown

1997 Flower Inventory: Differences in flower distributions were found among trees across quadrants for all inventory dates (A3.7.). Trends for each tree differed with the greatest flower production in the north quadrant in tree 6-17-882, and the east quadrant in tree 7-8-916. Early inventories of tree 8-12-701 showed the majority of production in the west quadrant, with a shift in the later inventories to the east quadrant.

1997 Acornet Inventory: Significant differences in acornet distribution were found among trees across quadrants in only the second inventory (A3.7.). The majority of acorns in this inventory were found in the north quadrant for tree 7-8-916, and the west quadrant for tree 8-12-701 and the north and west quadrants for trees 6-17-882. Declining acornet numbers prohibited meaningful analyses for inventories three through six.

1998 Acornet Inventory: Differences in acornet distribution were found among trees across quadrants for the seventh and eighth inventory (A3.7.). The majority of acornets was found in the north quadrant for tree 6-17-882, and in the east quadrant for trees 7-8-916 and 8-12-701. As acornets declined in number over time, analyses were not conducted for inventories nine through 12.

Lower Crown

All Inventories: Significant differences were found in all distributions among trees across quadrants for all inventory dates (A3.8.). No data was associated with tree 6-17-882, as it did not produce a crop in the lower section of the crown. The majority of flowers/acornets were found in the east quadrant in tree 7-8-916 and the west quadrant in tree 8-12-701. Low sample numbers prevented statistical analyses of 1997 acornet inventories three through six and 1998 acornet inventories nine through 12.

Combined Crown

1997 Flower and 1998 Acornet Inventories: Flower and acornet distributions were found to be significantly different among trees across quadrants for all inventory dates (A3.9.). The majority of flowers were distributed in the north, east and west quadrants in trees 6-17-882, 7-8-916, 8-12-701, respectively. The acornets were distributed in the same patterns over all inventories, except on tree 7-8-916, where a slight shift from the north quadrant to the west quadrant occurred as numbers declined.

1997 Acornet Inventory: For all inventory dates, significant differences in distribution were found among trees across quadrants (A3.9.). A greater percentage of acornets were distributed in the east and west quadrants in tree 6-17-882 and the west quadrant in tree 8-12-701. The majority of flowers on tree 7-8-916 was in the west quadrant at the first inventory, but shifted to the east and north (slightly) quadrants in later inventories.

East Competition Trees (6-15-855, 7-7-2457)

Upper Crown

1997 Flower Inventory: No differences in flower distribution were found between trees across quadrants for the first inventory, as the majority of flowers were in the west quadrant in both trees (A3.10.). The majority of flowers shifted to the east quadrant in tree 7-7-2457 in the second and third inventories with an associated increase in probability values. Declining flower numbers prevented further analysis of the fourth, fifth and sixth inventories.

1997 Acornet Inventory: Significant differences in acornet distribution were found between trees across quadrants for all inventory dates (A3.10.). The majority of acornets in tree 6-15-855 was found in the east quadrant, whereas, the south quadrant of tree 7-7-2457 had the greatest proportion of flowers. Both trees showed a shift in acornet distribution later in the season.

1998 Acornet Inventory: Differences in acornet distribution were found for the seventh and eighth inventories between trees across quadrants (A3.10.). The majority of acornets were produced in the west quadrant for tree 6-15-855, whereas a higher proportion of acornets was produced in the east quadrant for tree 7-7-2457. Low acornet numbers prevented statistical analyses of the remaining inventories.

Lower Crown

All Inventories: Significant differences in distributions were found between trees across quadrants for the first inventories in each category with the crops predominantly in the west quadrant of tree 6-15-855 and in the north quadrant of tree 7-7-2457 (A3.11.).

Combined Crown

1997 Flower Inventory: Flower distributions were found to be different between trees across quadrants for the first three inventories (A3.12.). The west quadrant of tree 6-17-882 had the greatest proportion of flowers. The north and west quadrants of tree 7-7-2457 initially contained the most flowers but the distribution shifted to the east quadrant in inventories two and three. Declining sample numbers prevented analysis of the remaining inventories.

1997 Acornet Inventory: Significant differences in acornet distribution were found between trees across quadrants for all inventory dates (A3.12.). Different distribution trends occurred with the majority of acornets produced in the east and west quadrants for tree 6-17-855. Tree 7-7-2457 maintained the majority of acornets in the south quadrant in inventories 1-4, with the majority shifting to the north quadrant in later inventories.

1998 Acornet Inventory: Significant differences in acornet distribution were shown at the seventh inventory between trees across quadrants (A3.12.). The distribution pattern for tree 6-15-855 was very different from tree 7-7-2457. As acornet numbers declined later in the season, chi-square analyses could not be conducted.

<u>Three-Tree Group (8-20-884-1, 8-20-884-2, and 8-21-888)</u>

Analyses for the 1997 acornets were not conducted because no tree had an acornet crop in 1997.

Upper Crown

1997 Flower and 1998 Acornet Inventories: Significant differences in distribution were found among trees across quadrants for all 1997 flower inventories and for the first 1998 acornet inventory (A3.13.). The greatest proportion of flowers and acornets were produced in the south and south/west quadrants in trees 8-21-888 and 8-20-884-1, respectively. In contrast, the distribution for tree 8-20-884-2 was very different with the majority of flowers and acornets produced in the north quadrant. Because of declining acornet numbers in 1998, statistical tests could not be computed.

Lower Crown

1997 Flower and 1998 Acornet Inventories: Significant differences in flower and acornet distributions were found among trees across quadrants for all inventory dates (A3.14.). Tree 8-20-884-1 did not produce a flower or acornet crop in 1997 or 1998 in the lower section of the crown. The majority of flowers and acornets on tree 8-21-888 were found in the west quadrant. The majority of flowers and acornets on tree 8-20-884-

2 were produced in the south quadrant. As acornet numbers declined in 1998, statistical analyses were not possible.

Combined Crown

1997 Flower and 1998 Acornet Inventories: Significant differences in distribution across quadrants were found among trees for the 1997 flowers and 1998 acornets (A3.15.). The distribution patterns were similar across inventory dates for each tree. Tree 8-21-888 had the majority of flowers and acornets in the west quadrant. However, tree 8-20-884-1 produced the majority of flowers in the south and west quadrants and the majority of acornets in the south quadrant. Tree 8-20-884-2 had a different distribution with a higher proportion of flowers and acornets produced in the north quadrant.

<u>All Trees with Competition</u>

Upper, Lower and Combined Crowns

1997 Flower, 1997 and 1998 Acornet Inventories: Significant differences in 1997 flower and 1997-98 acornet distributions across quadrants were found among all trees with competition for all inventory dates (A3.16., A3.17., and A3.18.). Distribution trends greatly varied among the trees.

<u>Single Trees versus West Competition Trees (7-8-916, 6-17-882)</u>

Probability values for the first two inventory dates in 1997 were not conducted because of low sample sizes and late additions of trees to the study.

Upper Crown

1997 Flower Inventory: Differences in distribution across the quadrants were not found between groups for the third inventory date; however, significant differences were found between groups for the fourth, fifth and sixth inventories (A3.19.). The majority of flowers was found in the south and west quadrants of the single trees and in the east quadrant of the trees with west competition.

1997 Acornet Inventory: Significant differences in acornet distributions were found between groups across quadrants for all dates inventoried (A3.19.). The majority of acornets were distributed in the north quadrant for the single trees and the north and west quadrants for the west competition trees.

1998 Acornet Inventory: Significant differences in acornet distribution were found between groups across quadrants for early inventory dates, but lost significance later in the season as acornet numbers declined (A3.19.). The majority of acornets were in the south and west quadrants for the single trees. In contrast, the majority of acornets initially were found in the east quadrant, shifting to the west quadrants, in later inventories for the west competition trees.

Lower Crown

All Inventories: Significant differences in flower and acornet distributions were found between groups across quadrants for all inventory dates (A3.20.). The majority of flowers and acornets was greater in the south quadrant for the single trees, but were in the east quadrant for the trees with west competition.

Combined Crown

All Inventories: Significant differences in distributions were found between groups across quadrants for all inventory dates (A3.21.). Distribution trends were the same for flowers and acornets in the single trees with the majority of flowers and acornets in the south quadrant. However, the pattern of flower and acornet distribution for the trees with west competition varied from season to season with a slight tendency to produce more in the east quadrants.

Single Trees versus West2 Competition Trees (7-8-916, 6-16-882, and 8-12-701)

Statistical tests were not possible for the first two inventories as sample numbers were too low due to late additions of trees.

Upper Crown

1997 Flower Inventory: Significant differences were found between groups across quadrants for the fourth, fifth and sixth inventories (A3.22.). The distribution patterns were different between the groups with the majority of flowers occurring in the south and west quadrants and east quadrants for the single and west2 competition trees, respectively.

1997 Acornet Inventory: Significant differences in distribution of acornets were found between groups across quadrants for all dates inventoried (A3.22.). Distribution trends were different with the single trees producing more acornets in the north quadrant, and the west2 competition trees producing more acornets in the west quadrant.

1998 Acornet Inventory: Significant differences were found for the seventh through tenth inventories between groups across quadrants (A3.22.). The majority of flowers in the single trees were found in the south and west quadrants, whereas the west2 competition trees initially had a higher proportion of acornets in the east quadrant, which later shifted to the west quadrant. Declining acornet numbers may account for the lack of significance in the later inventory dates.

Lower Crown

All Inventories: Significant differences in flower and acornet distributions were found between groups across quadrants for all inventories (A3.23.). The majority of the flowers and acornets were distributed in the south quadrant of the single trees, whereas the distribution trend was toward the east to east/west for the west2 competition trees.

Combined Crown

All Inventories: Significant differences in flower and acornet distributions were found between groups across quadrants for all dates inventoried (A3.24.). A greater amount of flowers and acornets were produced in the south quadrant for the single trees. The majority of flowers and acornets in the west2 competition trees varied from east to west.

<u>Single Trees versus East Competition Trees (6-15-855, 7-7-2457)</u>

Upper Crown

1997 Flower Inventory: Significant differences in flower distribution were found among the groupings across the quadrants for the fourth, fifth and sixth inventory dates, but not the third inventory date (A3.25.). The south and west quadrants of the single trees contained the highest proportion of flowers, while the east and west quadrants of the east competition trees had the greatest number of flowers.

1997 Acornet Inventory: Differences in acornet distribution were found between groups across quadrants for all the inventory dates (A3.25.). The distribution patterns differed between the groups at each inventory date.

1998 Acornet Inventory: No differences in acornet distribution were found for the first two inventory dates (A3.25.). Declining numbers prevented statistical tests from being conducted for the later inventories.

Lower Crown

All Inventories: Significant differences in flower and acornet distributions were found between groups across quadrants for all inventory dates (A3.26.). The majority of flowers were in the south quadrant for the single trees and varied between the west and north quadrants for the trees with east competition.

Combined Crown

1997 Flower and Acornet Inventories: Flower and acornet distributions were significantly different between groups across quadrants for all inventory dates (A3.27.). The tendency for maximum production in the single trees was in the south quadrant. The trees with east competition generally had the majority of flowers and acornets in the west quadrant.

1998 Acornet Inventory: Significant differences in acornet distribution were found between groups across quadrants for the seventh, eighth, tenth and eleventh inventory dates (A3.27.). The proportion of acornets in the single trees was greater in the south quadrant, and higher in west quadrant for the trees with east competition.

Single Trees versus Three-Tree Group

Upper Crown

1997 Flower Inventory: Significant differences in flower distributions were found between groups across quadrants for only the third inventory date (A3.28.). The production tendency for the single trees and the three-tree group was similar with the greatest proportion of flowers in the south and west quadrants.

1997 Acornet Inventory: No significant differences in acornet distribution were found between groups across quadrants for any of the inventory dates. Both groups produced the majority of acornets in the north quadrant (A3.28.).

1998 Acornet Inventory: Significant differences in acornet distribution were not found between groups across quadrants for any inventory date (A3.28.). The majority of acornets was distributed in the south and west quadrants of the single trees, while the three-tree group produced the majority of acornets in the south quadrant.

Lower Crown

1997 Flower and 1998 Acornet Inventories: Significant differences in flower and acornet distributions were found between groups across quadrants for all inventory dates (A3.29.). The majority of flowers and acornets were produced in the south quadrants of the single trees and in the south and west quadrants of the three-tree group. Comparisons were not made between the two groups for the 1997 acornets, as the three-tree group did not have any acornets in the 1997 season.

Combined Crown

All Inventories: Significant differences in flower and acornet distributions were found between the groups for all inventory dates with the exception of the sixth inventory for the 1997 acornets (A3.30.). The south quadrant produced the majority of flowers for the single trees, whereas the distribution pattern varied for the three-tree group.

<u>Single Trees versus All Trees with Competition</u>

Upper Crown

1997 Flower Inventory: For the flower distributions, significant differences were found between groups across quadrants for all inventory dates (A3.31.). The single trees had the majority of flowers distributed in the south and west quadrants, whereas the majority of flowers for all trees with competition was greater in the west quadrants.

1997 Acornet Inventory: Significant differences in acornet distribution were found between groups across quadrants for all but the sixth inventory date (A3.31.). For the single trees, the north quadrant had a higher proportion of flowers. For the trees with competition, the greatest number of flowers was found in the north and the west quadrants.

1998 Acornet Inventory: Differences in acornet distribution were statistically significant between groups across quadrants for all the inventory dates (A3.31.). The south and west quadrants had the majority of the acornets on the single trees, whereas, there was no discernable distribution trend in the competition trees.

Lower Crown

All Inventories: Significant differences in flower and acornet distributions were found between groups across quadrants for all inventory dates (Table 3.35). The distribution pattern for flowers and acornets were different between the two groups.

Combined Crown

1997 Flower Inventory: Significant differences in flower distribution were found between groups across quadrants for all inventory dates (Table 3.36). The single tree group produced the majority of flowers in the south quadrant, whereas, the all tree group produced flowers in approximately the same proportions in each quadrant for the third inventory, but the distribution shifted in later inventories with most of the production in the west quadrant.

1997 Acornet Inventory: Significant differences in acornet distribution were found between groups across quadrants for all inventory dates (Table 3.36). The majority of acornets on the single trees were produced in the north and south quadrants. The distribution pattern of the competition trees varied widely among inventory dates.

1998 Acornet Inventory: Significant differences were found in acornet distributions between groups across quadrants for all inventory dates (Table 3.36). The proportion of acornets was greater in the south quadrants in the single tree group, whereas, the majority of acornets in the competition trees varied between the west and east quadrants.

Discussion

Single Trees

Flower and acornet distributions among the single trees were not uniform across quadrants. Overall, the percentage of flowers and acornets in the south quadrant were higher only in the lower crowns. The upper crowns showed a variable distribution pattern among trees, with the majority of flowers and acornets occurring in the south, west or north quadrants. Despite the different distribution patterns between the upper and lower crowns, the overall tendency for production in each tree was in the south quadrant.

A study on slash pine (*Pinus elliottii* Engelm. var. *elliottii*) showed similar trends, where overall flowering and cone production was greater in the south and east quadrants (DeBarr et al. 1975). The higher frequency of flowers and acornets in the south quadrant indicates a possible physiological response to photosynthetic input on the south side.

Competition

One Direction

Trees with competition in one quadrant (e.g. west, west2, or east) did not have similar flower and acornet distributions. Each tree had a tendency to produce a higher percentage of flowers and acornets in one quadrant, but that quadrant varied from tree to tree. None of the trees with competition in one quadrant had the majority of flowers and acornets in the south quadrant, as was the case in trees with no competition. In addition, the three groups of trees with competition on a single side each had a significantly different distribution pattern than found in single trees. Competition, therefore, does alter distribution patterns even if the competition is only on one side.

Multi-direction

Three-tree group: When flower and acornet distributions were compared between the single trees and the three-tree group, no significant differences were found in the upper crown. This indicates that competition among trees can produce flower and acornet distributions similar to the upper crown of a single tree. The resemblance disappears when lower crown distribution patterns are compared, as significant differences were found between the two groups.

All trees: Although the trees in this analysis were not contiguously distributed, the competition effects could resemble conditions found in a forest, where a tree would have varying levels of competition in any quadrant. The distributions of flowers and acornets differed from tree to tree and fluctuated from quadrant to quadrant. When compared to the single trees, competition changed the distributions from the south quadrant to a non-discernable pattern.

Olson and Boyce (1971) observed that open-grown trees did not produce more flowers or acorns than did trees in a closed stand. Distribution differences were studied by Sharp and Sprague (1967), who observed that open-grown trees produced acorns more uniformly over the crown, but that trees in a closed stand produced acorns only on the branches exposed to sunlight. However, the findings from the current study showed that flowers and acorns did not occur uniformly on the open-grown trees, as there was a high occurrence of flowers and acorns in the lower sections of the crowns on the south sides of the single trees. Trees that were in competition (closed stand) in the current study did tend to produce flowers and acorns on branches exposed to sunlight.

Conclusions

The distribution patterns for flowers and acornets of the trees without competition were different than the patterns of the trees with competition. For the single trees, a marked tendency to produce flowers and acornets in the south quadrant of the lower crown was revealed. This pattern changed when trees were subjected to competition. Additional research is needed to generalize about flower and acornet distributions over time. Two years of data are not sufficient to make broad conclusions about the influence of competition on flowering and fruiting in northern red oak given the probable influences of other factors, such as fluctuation of insect populations or weather that can affect the reproductive process. With additional research, models on acorn production may be accurately constructed.

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Appendix, Part 3

A3.1. Percentages within each quadrant of the crown on the single trees (x^2=P<0.001): E=east, W=west, N=north, and S=south.

Crown Section	*Quadrant* E	N	S	W
a. 1997 Flowers				
Lower	11	8	72	9
Upper	23	17	30	30
b. 1997 Acornets				
Lower	18	22	50	10
Upper	22	40	26	12
c. 1998 Acornets				
Lower	7	10	76	7
Upper	20	17	33	30

A3.2. Chi-square probability values for the upper crown of the single trees with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Tree ID*		
Upper Crown 1997 Flower		*Distribution Trend*		
Inventory	**Probability**	**5-2-582**	**6-12-628**	**8-9-630**
1	----	----	----	----
2	----	----	----	----
3	0.001	S/W	E/N	E/W
4	0.001	S/W	E/N	E/W
5	0.001	S/W	E	None
6	0.001	S/W	E/N	None

Crop		*Tree ID*		
Upper Crown 1997 Acornet		*Distribution Trend*		
Inventory	**Probability**	**5-2-582**	**6-12-628**	**8-9-630**
1	----	----	----	----
2	----	----	----	----
3	0.001	N	N	E
4	0.001	N	N/S	E
5	0.001	N	N/S	E
6	0.001	N	S	E

Crop		*Tree ID*		
Upper Crown 1998 Acornet		*Distribution Trend*		
Inventory	**Probability**	**5-2-582**	**6-12-628**	**8-9-630**
7	0.001	S/W	E	None
8	0.001	S/W	E	E
9	0.001	S/W	E	None
10	0.001	S/W	E/N	E
11	0.001	S/W	E/N	E
12	0.001	S/W	E	None

A3.3. Chi-square probability values for the lower crown of the single trees with the distribution trend: E=east, W=west, N=north, and S=south.

Crop			*Tree ID*	
Lower Crown 1997 Flower			*Distribution Trend*	
Inventory	**Probability**	**5-2-582**	**6-12-628**	**8-9-630**
1	----	----	----	----
2	----	----	----	----
3	0.001	S	S	S
4	0.001	S	S	S
5	0.001	S	S	S
6	0.001	S	S	S

Crop			*Tree ID*	
Lower Crown 1997 Acornet			*Distribution Trend*	
Inventory	**Probability**	**5-2-582**	**6-12-628**	**8-9-630**
1	----	----	----	----
2	----	----	----	----
3	0.001	E	S	S
4	0.001	E	S	S
5	0.001	E	S	S
6	0.001	E	S	S

Crop			*Tree ID*	
Lower Crown 1998 Acornet			*Distribution Trend*	
Inventory	**Probability**	**5-2-582**	**6-12-628**	**8-9-630**
7	0.001	S	S	S
8	0.001	S	S	S
9	0.001	S	S	S
10	0.001	S	S	S
11	0.001	S	S	S
12	0.001	S	S	S

A3.4. Chi-square probability values for the combined crown of the single trees with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Tree ID*		
Combined Crown 1997 Flower		*Distribution Trend*		
Inventory	**Probability**	**5-2-582**	**6-12-628**	**8-9-630**
1	----	----	----	----
2	----	----	----	----
3	0.001	S/W	S	S
4	0.001	S/W	S	S
5	0.001	S/W	S	S
6	0.001	S/W	S	S

Crop		*Tree ID*		
Combined Crown 1997 Acornet		*Distribution Trend*		
Inventory	**Probability**	**5-2-582**	**6-12-628**	**8-9-630**
1	----	----	----	----
2	----	----	----	----
3	0.001	N	S	S
4	0.001	N	S	S
5	0.001	N	S	S
6	0.001	N	S	S

Crop		*Tree ID*		
Combined Crown 1998 Acornet		*Distribution Trend*		
Inventory	**Probability**	**5-2-582**	**6-12-628**	**8-9-630**
7	0.001	S/W	S	S
8	0.001	S/W	S	S
9	0.001	S/W	S	S
10	0.001	S/W	S	S
11	0.001	S/W	S	S
12	0.001	S/W	S	N/S

A3.5. Chi-square probability values for the upper crown of trees with west competition with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Tree ID*	
Upper Crown 1997 Flower		*Distribution Trend*	
Inventory	**Probability**	**6-17-882**	**7-8-916**
1	0.001	N	E
2	0.001	N	E
3	0.001	N	E
4	0.001	N	E
5	0.001	N	E
6	0.001	N	E

Crop		*Tree ID*	
Upper Crown 1997 Acornet		*Distribution Trend*	
Inventory	**Probability**	**6-17-882**	**7-8-916**
1	0.071	N/W	N/W
2	0.001	N/W	N
3	0.001	N/W	N
4	0.003	N/W	N
5	0.001	N/W	N
6	0.001	N/W	N

Crop		*Tree ID*	
Upper Crown 1998 Acornet		*Distribution Trend*	
Inventory	**Probability**	**6-17-882**	**7-8-916**
7	0.001	N	E
8	0.001	N	E
9	0.001	N	E
10	0.001	N	E/W
11	0.002	N	W
12	0.004	N	W

A3.6. Chi-square probability values for the combined crown of trees with west competition with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Tree ID*	
Combined Crown 1997 Flower		*Distribution Trend*	
Inventory	**Probability**	**6-17-882**	**7-8-916**
1	0.001	N	E
2	0.001	N	E
3	0.001	N	E
4	0.001	N	E
5	0.001	N	E
6	0.001	N	E

Crop		*Tree ID*	
Combined Crown 1997 Acornet		*Distribution Trend*	
Inventory	**Probability**	**6-17-882**	**7-8-916**
1	0.002	N/W	N/W
2	0.001	N/W	N/E
3	0.001	N/W	N/E
4	0.001	N/W	N/E
5	0.001	N/W	N/E
6	0.001	N/W	N/E

Crop		*Tree ID*	
Combined Crown 1998 Acornet		*Distribution Trend*	
Inventory	**Probability**	**6-17-882**	**7-8-916**
7	0.001	N	E
8	0.001	N	E
9	0.001	N	E
10	0.001	N	E/W
11	0.001	N	E/W
12	0.002	N	W

A3.7. Chi-square probability values for the upper crown of trees with west2 competition with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Tree ID*		
Upper Crown 1997 Flower		*Distribution Trend*		
Inventory	**Probability**	**6-17-882**	**7-8-916**	**8-12-701**
1	0.001	N	E	W
2	0.001	N	E	W
3	0.001	N	E	E/W
4	0.001	N	E	E
5	0.001	N	E	E
6	0.001	N	E	E

Crop		*Tree ID*		
Upper Crown 1997 Acornet		*Distribution Trend*		
Inventory	**Probability**	**6-17-882**	**7-8-916**	**8-12-701**
1	0.243	N/W	W	W
2	0.004	N/W	N	W
3	----	----	----	----
4	----	----	----	----
5	----	----	----	----
6	----	----	----	----

Crop		*Tree ID*		
Upper Crown 1998 Acornet		*Distribution Trend*		
Inventory	**Probability**	**6-17-882**	**7-8-916**	**8-12-701**
7	0.001	N	E	E
8	0.001	N	E	E
9	----	----	----	----
10	----	----	----	----
11	----	----	----	----
12	----	----	----	----

A3.8. Chi-square probability values for the lower crown of trees with west2 competition with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Tree ID*		
Lower Crown 1997 Flower		*Distribution Trend*		
Inventory	**Probability**	**6-17-882**	**7-8-916**	**8-12-701**
1	0.001	----	E	W
2	0.001	----	E	W
3	0.001	----	E	W
4	0.001	----	E	W
5	0.001	----	E	W
6	0.001	----	E	W

Crop		*Tree ID*		
Lower Crown 1997 Acornet		*Distribution Trend*		
Inventory	**Probability**	**6-17-882**	**7-8-916**	**8-12-701**
1	0.001	----	E	W
2	0.001	----	E	W
3	0.001	----	E	W
4	0.001	----	E	W
5	0.001	----	E	W
6	0.001	----	E	W

Crop		*Tree ID*		
Lower Crown 1998 Acornet		*Distribution Trend*		
Inventory	**Probability**	**6-17-882**	**7-8-916**	**8-12-701**
7	0.011	----	E	W
8	----	----	----	----
9	----	----	----	----
10	----	----	----	----
11	----	----	----	----
12	----	----	----	----

A3.9. Chi-square probability values for the combined crown of trees with west2 competition with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Tree ID*		
Combined Crown 1997 Flower		*Distribution Trend*		
Inventory	**Probability**	**6-17-882**	**7-8-916**	**8-12-701**
1	0.001	N	E	W
2	0.001	N	E	W
3	0.001	N	E	W
4	0.001	N	E	W
5	0.001	N	E	W
6	0.001	N	E	W

Crop		*Tree ID*		
Combined Crown 1997 Acornet		*Distribution Trend*		
Inventory	**Probability**	**6-17-882**	**7-8-916**	**8-12-701**
1	0.001	E/W	W	W
2	0.001	E/W	E/N	W
3	0.001	E/W	E	W
4	0.002	E/W	E	W
5	0.001	E/W	E	W
6	0.001	W	E/N	W

Crop		*Tree ID*		
Combined Crown 1998 Acornet		*Distribution Trend*		
Inventory	**Probability**	**6-17-882**	**7-8-916**	**8-12-701**
7	0.001	N	E	W
8	0.001	N	E	W
9	0.001	N	E	W
10	0.001	N	E	W
11	0.003	N	W	W
12	0.008	N	E/W	W

A3.10. Chi-square probability values for the upper crown of trees with east competition with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Tree ID*	
Upper Crown 1997 Flower		*Distribution Trend*	
Inventory	**Probability**	**6-15-855**	**7-7-2457**
1	0.255	W	W
2	0.005	W	E
3	0.001	W	E
4	----	----	----
5	----	----	----
6	----	----	----

Crop		*Tree ID*	
Upper Crown 1997 Acornet		*Distribution Trend*	
Inventory	**Probability**	**6-15-855**	**7-7-2457**
1	0.001	E	S
2	0.001	E	S
3	0.001	E	S
4	0.001	E	S
5	0.001	E/W	N/S
6	0.001	E/W	N/S

Crop		*Tree ID*	
Upper Crown 1998 Acornets		*Distribution Trend*	
Inventory	**Probability**	**6-15-855**	**7-7-2457**
7	0.025	W	E
8	0.046	W	E
9	----	----	----
10	----	----	----
11	----	----	----
12	----	----	----

A3.11. Chi-square probability values for the lower crown of trees with east competition with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Tree ID*	
Lower Crown 1997 Flowers		*Distribution Trend*	
Inventory	**Probability**	**6-15-855**	**7-7-2457**
1	0.001	W	N
2	----	----	----
3	----	----	----
4	----	----	----
5	----	----	----
6	----	----	----

Crop		*Tree ID*	
Lower Crown 1997 Acornet		*Distribution Trend*	
Inventory	**Probability**	**6-15-855**	**7-7-2457**
1	0.001	W	N
2	----	----	----
3	----	----	----
4	----	----	----
5	----	----	----
6	----	----	----

Crop		*Tree ID*	
Lower Crown 1998 Acornet		*Distribution Trend*	
Inventory	**Probability**	**6-15-855**	**7-7-2457**
7	0.046	W	N
8	0.083	W	N
9	0.083	W	N
10	----	----	----
11	----	----	----
12	----	----	----

A3.12. Chi-square probability values for combined crown of trees with east competition with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Tree ID*	
Combined Crown 1997 Flower		*Distribution Trend*	
Inventory	**Probability**	**6-17-855**	**7-7-2457**
1	0.001	W	N/W
2	0.001	W	E
3	0.001	W	E
4	----	----	----
5	----	----	----
6	----	----	----

Crop		*Tree ID*	
Combined Crown 1997 Acornet		*Distribution Trend*	
Inventory	**Probability**	**6-17-855**	**7-7-2457**
1	0.001	E/W	S
2	0.001	E/W	S
3	0.001	E/W	S
4	0.001	E/W	S
5	0.001	E/W	N/S
6	0.001	E/W	N/S

Crop		*Tree ID*	
Combined Crown 1998 Acornet		*Distribution Trend*	
Inventory	**Probability**	**6-17-855**	**7-7-2457**
7	0.011	W	E/N
8	----	----	----
9	----	----	----
10	----	----	----
11	----	----	----
12	----	----	----

A3.13. Chi-square probability values for the upper crown of the three-tree group with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Tree ID*		
Upper Crown 1997 Flower		*Distribution Trend*		
Inventory	**Probability**	**8-21-888**	**8-20-884-1**	**8-20-884-2**
1	----	----	----	----
2	----	----	----	----
3	0.001	S	S/W	N
4	0.001	S	S/W	N/E
5	0.022	S	S/W	N
6	0.007	S	S/W	N

Crop		*Tree ID*		
Upper Crown 1998 Acornet		*Distribution Trend*		
Inventory	**Probability**	**8-21-888**	**8-20-884-1**	**8-20-884-2**
7	0.010	S	S/W	N
8	0.067	S	S	N
9	0.220	S	S	N
10	----	----	----	----
11	----	----	----	----
12	----	----	----	----

A3.14. Chi-square probability values for the lower section of the three-tree group with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Tree ID*	
Lower Crown 1997 Flower		*Distribution Trend*	
Inventory	**Probability**	**8-21-888**	**8-20-884-2**
1	----	----	----
2	----	----	----
3	0.001	W	S
4	0.001	W	S
5	0.001	W	S
6	0.001	W	S

Crop		*Tree ID*	
Lower Crown 1998 Acornet		*Distribution Trend*	
Inventory	**Probability**	**8-21-888**	**8-20-884-2**
7	0.001	W	S
8	0.001	W	S
9	0.001	W	S
10	----	----	----
11	----	----	----
12	----	----	----

A3.15. Chi-square probability values for combined crown of the three-tree group with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Tree ID*		
Combined Crown 1997 Flower		*Distribution Trend*		
Inventory	**Probability**	**8-21-888**	**8-20-884-1**	**8-20-884-2**
1	----	----	----	----
2	----	----	----	----
3	0.001	W	S/W	N/S
4	0.002	W	S/W	S
5	0.008	W	S/W	S
6	0.036	W	S/W	S

Crop		*Tree ID*		
Combined Crown 1998 Acornets		*Distribution Trend*		
Inventory	**Probability**	**8-21-888**	**8-20-884-1**	**8-20-884-2**
7	0.096	W	S/W	S
8	0.061	W	S	N/S
9	0.018	W	S	N
10	0.017	W	S	N
11	0.013	W	S	N
12	0.039	W/E	S	N

A3.16. Chi-square probability values for the upper crown of all trees (n=14) with competition with the distribution trend: E=east, W=west, N=north, and S=south.

Upper Crown 1997 Flowers

Inventory	Probability
1	----
2	----
3	0.001
4	0.001
5	0.001
6	0.001

Upper Crown 1997 Acornets

Inventory	Probability
1	----
2	----
3	0.001
4	0.001
5	0.001
6	0.001

Upper Crown 1998 Acornets

Inventory	Probability
7	0.001
8	0.001
9	0.001
10	0.001
11	0.001
12	0.001

A3.17. Chi-square probability values for the lower crown of all trees (n=14) with competition with the distribution trend: E=east, W=west, N=north, and S=south.

Lower Crown 1997 Flowers

Inventory	Probability
1	----
2	----
3	0.001
4	0.001
5	0.001
6	0.001

Lower Crown 1997 Acornets

Inventory	Probability
1	----
2	----
3	0.001
4	0.001
5	0.001
6	0.001

Lower Crown 1998 Acornets

Inventory	Probability
7	0.001
8	0.001
9	0.001
10	0.001
11	0.001
12	0.001

A3.18. Chi-square probability values for the combined crown of all trees (n=14) with competition with the distribution trend: E=east, W=west, N=north, and S=south.

Combined Crown 1997 Flowers	
Inventory	**Probability**
1	----
2	----
3	0.001
4	0.001
5	0.001
6	0.001

Combined Crown 1997 Acornets	
Inventory	**Probability**
1	----
2	----
3	0.001
4	0.001
5	0.001
6	0.001

Combined Crown 1998 Acornets	
Inventory	**Probability**
7	0.001
8	0.001
9	0.001
10	0.001
11	0.001
12	0.001

A3.19. Chi-square probability values for the upper crown of single trees versus west competition trees with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Competition Group*	
Upper Crown 1997 Flowers		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West Trees (n=3)**
1	----	----	----
2	----	----	----
3	0.159	S/W	E
4	0.004	S/W	E
5	0.001	S/W	E
6	0.002	S/W	E

Crop		*Competition Group*	
Upper Crown 1997 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West Trees (n=3)**
1	----	----	----
2	----	----	----
3	0.001	N	N
4	0.001	N	N/W
5	0.001	N	W
6	0.001	N	N

Crop		*Competition Group*	
Upper Crown 1998 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West Trees (n=3)**
7	0.007	S	E
8	0.001	S/W	E
9	0.001	S/W	E
10	0.032	S/W	E
11	0.617	S/W	W
12	0.880	S/W	W

A3.20. Chi-square probability values for the lower crown of single trees versus west competition trees with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Competition Group*	
Lower Crown 1997 Flowers		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West Trees (n=3)**
1	----	----	----
2	----	----	----
3	0.001	S	E
4	0.001	S	E
5	0.001	S	E
6	0.001	S	E

Crop		*Competition Group*	
Lower Crown 1997 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West Trees (n=3)**
1	----	----	----
2	----	----	----
3	0.001	S	E
4	0.001	S	E
5	0.001	S	E
6	0.001	S	E

Crop		*Competition Group*	
Lower Crown 1998 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West Trees (n=3)**
7	0.001	S	E
8	0.001	S	E
9	0.001	S	E
10	0.001	S	E
11	0.001	S	E
12	0.001	S	E

A3.21. Chi-square probability values for combined crown of single trees versus west competition trees with distribution trends; E=east, W=west, N=north, and S=south.

Crop		*Competition Group*	
Combined Crown 1997 Flowers		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West Trees (n=3)**
1	----	----	----
2	----	----	----
3	0.001	S	E
4	0.001	S	E
5	0.001	S	E
6	0.001	S	E

Crop		*Competition Group*	
Combined Crown 1997 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West Trees (n=3)**
1	----	----	----
2	----	----	----
3	0.001	S	N/W
4	0.001	S	N/W
5	0.001	S	W
6	0.001	S	N/W

Crop		*Competition Group*	
Combined Crown 1998 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West Trees (n=3)**
7	0.001	S	E
8	0.001	S	E
9	0.001	S	E
10	0.001	S	E
11	0.001	S	W
12	0.001	S	W

A3.22. Chi-square probability values for the upper crown of single trees versus west2 competition trees with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Competition Group*	
Upper Crown 1997 Flowers		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West2 Trees (n=2)**
1	----	----	----
2	----	----	----
3	0.127	S/W	E
4	0.002	S/W	E
5	0.001	S/W	E
6	0.001	S/W	E

Crop		*Competition Group*	
Upper Crown 1997 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West2 Trees (n=2)**
1	----	----	----
2	----	----	----
3	0.001	N	W
4	0.001	N	N/W
5	0.001	N	W
6	0.001	N	W

Crop		*Competition Group*	
Upper Crown 1998 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West2 Trees (n=2)**
7	0.003	S	E
8	0.001	S/W	E
9	0.001	S/W	E
10	0.032	S/W	E
11	0.617	S/W	W
12	0.880	S/W	W

A3.23. Chi-square probability values for the lower crown of single trees versus west2 competition trees with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Competition Group*	
Lower Crown 1997 Flowers		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West2 Trees (n=2)**
1	----	----	----
2	----	----	----
3	0.001	S	E
4	0.001	S	E
5	0.001	S	E
6	0.001	S	E

Crop		*Competition Group*	
Lower Crown 1997 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West2 Trees (n=2)**
1	----	----	----
2	----	----	----
3	0.001	S	E
4	0.001	S	E
5	0.001	S	E
6	0.001	S	E

Crop		*Competition Group*	
Lower Crown 1998 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West2 Trees (n=2)**
7	0.001	S	E/W
8	0.001	S	E/W
9	0.001	S	E/W
10	0.001	S	E/W
11	0.001	S	E/W
12	0.001	S	E/W

A3.24. Chi-square probability values for the combined crown of single trees versus west2 competition trees with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Competition Group*	
Combined Crown 1997 Flowers		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West2 Trees (n=3)**
1	----	----	----
2	----	----	----
3	0.001	S	E
4	0.001	S	E
5	0.001	S	E
6	0.001	S	E

Crop		*Competition Group*	
Combined Crown 1997 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West2 Trees (n=3)**
1	----	----	----
2	----	----	----
3	0.001	S	W
4	0.001	S	W
5	0.001	S	W
6	0.001	S	W

Crop		*Competition Group*	
Combined Crown 1998 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**West2 Trees (n=3)**
7	0.001	S	E
8	0.001	S	E
9	0.001	S	E
10	0.001	S	E
11	0.001	S	W
12	0.001	S	W

A3.25. Chi-square probability values for the upper crown of single trees versus east competition trees with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Competition Group*	
Upper Crown 1997 Flowers		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**East Trees (n=2)**
1	----	----	----
2	----	----	----
3	0.145	S/W	W
4	0.032	S/W	E/W
5	0.034	S/W	E/W
6	0.046	S/W	E/W

Crop		*Competition Group*	
Upper Crown 1997 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**East Trees (n=2)**
1	----	----	----
2	----	----	----
3	0.001	N	E
4	0.003	N	E
5	0.007	N	E/W
6	0.015	N	W

Crop		*Competition Group*	
Upper Crown 1998 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**East Trees (n=2)**
7	0.182	S	E/W
8	0.588	S/W	W
9	----	----	----
10	----	----	----
11	----	----	----
12	----	----	----

A3.26. Chi-square probability values for the lower crown of single trees versus east competition trees with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Competition Group*	
Lower Crown 1997 Flowers		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**East Trees (n=2)**
1	----	----	----
2	----	----	----
3	0.001	S	W/N
4	0.001	S	W/N
5	0.001	S	W/N
6	0.001	S	W/N

Crop		*Competition Group*	
Lower Crown 1997 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**East Trees (n=2)**
1	----	----	----
2	----	----	----
3	0.001	S	W/N
4	0.001	S	W/N
5	0.001	S	W/N
6	0.001	S	W/N

Crop		*Competition Group*	
Lower Crown 1998 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**East Trees (n=2)**
7	0.001	S	N/W
8	0.001	S	W/N
9	0.001	S	W/N
10	0.001	S	W
11	0.001	S	W
12	0.010	S	W

A3.27. Chi-square probability values for combined crown of single trees versus east competition trees with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Competition Group*	
Combined Crown 1997 Flowers		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**East Trees (n=2)**
1	----	----	----
2	----	----	----
3	0.001	S	W
4	0.001	S	W
5	0.001	S	W
6	0.001	S	W

Crop		*Competition Group*	
Combined Crown 1997 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**East Trees (n=2)**
1	----	----	----
2	----	----	----
3	0.001	S	E
4	0.001	S	E
5	0.001	S	W
6	0.001	S	W

Crop		*Competition Group*	
Combined Crown 1998 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**East Trees (n=2)**
7	0.008	S	W
8	0.038	S	W
9	0.079	S	W
10	0.039	S	W
11	0.029	S	W
12	0.308	S	W

A3.28. Chi-square probability values for the upper crown of single trees versus three-tree group with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Competition Group*	
Upper Crown 1997 Flower		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**Three-Tree (n=3)**
1	----	----	----
2	----	----	----
3	0.038	S/W	N/S
4	0.585	S/W	S
5	0.296	S/W	S/W
6	0.499	S/W	S/W

Crop		*Competition Group*	
Upper Crown 1997 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**Three-Tree (n=3)**
1	----	----	----
2	----	----	----
3	0.256	N	N
4	0.237	N	N
5	0.213	N	N
6	0.633	N	N

Crop		*Competition Group*	
Upper Crown 1998 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**Three-Tree (n=3)**
7	0.301	S/W	S/W
8	0.226	S/W	S
9	0.128	S/W	S
10	0.067	S/W	S
11	0.061	S/W	S
12	0.078	S/W	S

A3.29. Chi-square probability values for the lower crown of single trees versus the three-tree group with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Competition Group*	
Lower Crown 1997 Flowers		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**Three-Tree (n=3)**
1	----	----	----
2	----	----	----
3	0.001	S	S/W
4	0.001	S	S/W
5	0.001	S	S/W
6	0.001	S	S/W

Crop		*Competition Group*	
Lower Crown 1998 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**Three-Tree (n=3)**
7	0.001	S	W
8	0.001	S	W
9	0.001	S	W
10	0.001	S	W
11	0.001	S	W
12	0.001	S	W

A3.30. Chi-square probability values for the combined crown of single trees versus the three-tree group with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Competition Group*	
Combined Crown 1997 Flowers		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**Three-Tree (n=3)**
1	----	----	----
2	----	----	----
3	0.001	S	S/W
4	0.009	S	S/W
5	0.005	S	S/W
6	0.001	S	S/W

Crop		*Competition Group*	
Combined Crown 1997 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**Three-Tree (n=3)**
1	----	----	----
2	----	----	----
3	0.167	S	N/S
4	0.072	S	N
5	0.070	S	N
6	0.460	S	N

Crop		*Competition Group*	
Combined Crown 1998 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**Three-Tree (n=3)**
7	0.001	S	S/W
8	0.003	S	S/W
9	0.001	S	W
10	0.001	S	W
11	0.001	S	W
12	0.005	S	W

A3.31. Chi-square probability values for the upper crown of single trees versus all trees with competition with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Competition Group*	
Upper Crown 1997 Flowers		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**All Trees (n=14)**
1	----	----	----
2	----	----	----
3	0.005	S/W	W
4	0.004	S/W	W
5	0.008	S/W	W
6	0.010	S/W	W

Crop		*Competition Group*	
Upper Crown 1997 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**All Trees (n=14)**
1	----	----	----
2	----	----	----
3	0.001	N	N
4	0.003	N	N
5	0.013	N	N/W
6	0.077	N	N/W

Crop		*Competition Group*	
Upper Crown 1998 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**All Trees (n=14)**
7	0.001	S	W
8	0.001	S/W	W
9	0.001	S/W	None
10	0.001	S/W	E/W
11	0.004	S/W	None
12	0.001	S/W	E

A3.32. Chi-square probability values for the lower crown of single trees versus all trees with competition with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		***Competition Group***	
Lower Crown 1997 Flowers		***Distribution Trend***	
Inventory	**Probability**	**Single (n=3)**	**All Trees (n=14)**
1	----	----	----
2	----	----	----
3	0.001	S	W
4	0.001	S	W
5	0.001	S	E/W
6	0.001	S	E/W

Crop		***Competition Group***	
Lower Crown 1997 Acornets		***Distribution Trend***	
Inventory	**Probability**	**Single (n=3)**	**All Trees (n=14)**
1	----	----	----
2	----	----	----
3	0.001	S	E
4	0.001	S	E
5	0.001	S	E
6	0.001	S	E

Crop		***Competition Group***	
Lower Crown 1998 Acornets		***Distribution Trend***	
Inventory	**Probability**	**Single (n=3)**	**All Trees (n=14)**
7	0.001	S	W
8	0.001	S	W/E
9	0.001	S	W/E
10	0.001	S	W/E
11	0.001	S	W
12	0.001	S	W/E

A3.33. Chi-square probability values for the combined crown of single trees versus all trees with competition with the distribution trend: E=east, W=west, N=north, and S=south.

Crop		*Competition Group*	
Combined Crown 1997 Flowers		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**All Trees (n=14)**
1	----	----	----
2	----	----	----
3	0.001	S	None
4	0.001	S	W
5	0.001	S	W
6	0.001	S	W

Crop		*Competition Group*	
Combined Crown 1997 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**All Trees (n=14)**
1	----	----	----
2	----	----	----
3	0.001	N/S	E/N
4	0.001	N/S	N
5	0.001	N/S	None
6	0.001	N/S	E/N

Crop		*Competition Group*	
Combined Crown 1998 Acornets		*Distribution Trend*	
Inventory	**Probability**	**Single (n=3)**	**All Trees (n=14)**
7	0.001	S	W
8	0.001	S	W
9	0.001	S	W
10	0.001	S	E/W
11	0.001	S	W
12	0.001	S	E

A3.34. 1997 flower and acornet counts for tree 6-17-882 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	N	U	11	0	3	0	3	0	3	0	3	0	3	0
2	N	U	2	0	2	0	2	0	2	0	2	0	2	0
3	N	U	0	9	0	8	0	7	0	7	0	4	0	4
4	N	U	0	8	0	8	0	8	0	7	0	7	0	6
5	N	U	0	1	0	1	0	1	0	1	0	1	0	1
6	N	U	6	0	1	0	1	0	0	0	0	0	0	0
7	N	U	2	0	0	0	0	0	0	0	0	0	0	0
8	N	U	0	2	0	2	0	2	0	2	0	1	0	1
9	N	U	4	0	2	0	2	0	2	0	2	0	2	0
10	N	U	9	0	2	0	2	0	2	0	2	0	2	0
11	N	U	0	2	0	2	0	2	0	2	0	1	0	1
12	W	U	3	0	0	0	0	0	0	0	0	0	0	0
13	W	U	0	4	0	4	0	4	0	4	0	2	0	1
14	W	U	3	8	2	8	2	8	2	8	0	6	0	6
15	W	U	0	8	0	9	0	8	0	8	0	8	0	8
16	W	U	0	2	0	2	0	2	0	2	0	1	0	1
17	W	U	0	4	0	4	0	4	0	4	0	4	0	4
18	W	U	0	3	1	3	1	3	0	3	0	3	0	3
19	E	U	9	0	2	1	2	1	3	1	3	1	3	0
20	E	U	3	0	0	0	0	0	0	0	0	0	0	0
21	S	U	3	7	0	5	0	5	0	5	0	5	0	5
22	N	U	0	0	0	0	2	0	2	0	2	0	2	0
	TOTALS		**55**	**58**	**15**	**57**	**17**	**55**	**16**	**54**	**14**	**44**	**14**	**41**

A3.35. 1998 flower counts for tree 6-17-882 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	N	U	3	2	2	0	0	0
2	N	U	2	2	2	2	2	2
3	N	U	0	0	0	0	0	0
4	N	U	0	0	0	0	0	0
5	N	U	0	0	0	0	0	0
6	N	U	0	0	0	0	0	0
7	N	U	0	0	0	0	0	0
8	N	U	0	0	0	0	0	0
9	N	U	2	2	1	0	0	0
10	N	U	2	2	2	1	1	1
11	N	U	0	0	0	0	0	0
12	W	U	0	0	0	0	0	0
13	W	U	0	0	0	0	0	0
14	W	U	0	0	0	0	0	0
15	W	U	0	0	0	0	0	0
16	W	U	0	0	0	0	0	0
17	W	U	0	0	0	0	0	0
18	W	U	0	0	0	0	0	0
19	E	U	3	3	3	0	0	0
20	E	U	0	0	0	0	0	0
21	S	U	0	0	0	0	0	0
22	N	U	2	2	2	1	1	0
	TOTALS		14	13	12	4	4	3

A3.36. 1997 flower and acornet counts for tree 6-15-855 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	N	U	4	8	0	5	0	4	0	3	0	2	0	2
2	N	U	0	3	0	2	0	2	0	0	0	0	0	0
3	N	U	0	4	0	4	0	4	0	4	0	4	0	4
4	N	U	0	11	0	11	0	11	0	11	0	11	0	10
5	W	U	7	8	2	0	2	0	2	0	2	0	2	0
6	W	U	0	11	0	11	0	11	0	11	0	10	0	11
7	W	U	0	1	0	1	0	1	0	1	0	1	0	0
8	W	U	0	8	0	8	0	8	0	7	0	7	0	7
9	W	U	13	0	8	0	7	0	5	0	5	0	3	0
10	W	U	0	5	0	5	0	3	0	3	0	3	0	3
11	W	U	0	2	0	2	0	2	0	2	0	2	0	2
12	E	U	7	7	1	8	1	8	0	6	0	0	0	0
13	E	U	0	7	0	7	0	7	0	4	0	4	0	4
14	E	U	0	4	0	2	0	2	0	2	0	0	0	0
15	E	U	0	4	0	3	0	3	0	3	0	3	0	3
16	E	U	0	3	0	3	0	2	0	1	0	1	0	1
17	E	U	0	19	0	13	0	13	0	12	0	12	0	8
18	E	U	0	5	0	5	0	5	0	3	0	3	0	2
19	W	L	8	0	2	0	2	0	1	0	1	0	1	0
20	W	L	8	0	5	0	3	0	3	0	1	0	1	0
21	W	L	2	0	1	0	0	0	0	0	0	0	0	0
22	W	L	0	8	0	8	0	8	0	5	0	2	0	1
23	W	L	0	2	0	2	0	1	0	1	0	1	0	1
24	S	L	2	0	0	0	0	0	0	0	0	0	0	0
25	S	L	3	0	0	0	0	0	0	0	0	0	0	0
26	S	L	4	1	0	3	0	0	0	0	0	0	0	0
	TOTALS		**58**	**121**	**19**	**103**	**15**	**95**	**11**	**79**	**9**	**66**	**7**	**59**

A3.37. 1998 flower counts for tree 6-15-855 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	N	U	0	0	0	0	0	0
2	N	U	0	0	0	0	0	0
3	N	U	0	0	0	0	0	0
4	N	U	0	0	0	0	0	0
5	W	U	2	1	0	0	0	0
6	W	U	0	0	0	0	0	0
7	W	U	0	0	0	0	0	0
8	W	U	0	0	0	0	0	0
9	W	U	1	0	0	0	0	0
10	W	U	0	0	0	0	0	0
11	W	U	0	0	0	0	0	0
12	E	U	0	0	0	0	0	0
13	E	U	0	0	0	0	0	0
14	E	U	0	0	0	0	0	0
15	E	U	0	0	0	0	0	0
16	E	U	0	0	0	0	0	0
17	E	U	0	0	0	0	0	0
18	E	U	0	0	0	0	0	0
19	W	L	1	1	1	1	1	1
20	W	L	1	1	1	1	1	0
21	W	L	0	0	0	0	0	0
22	W	L	0	0	0	0	0	0
23	W	L	0	0	0	0	0	0
24	S	L	0	0	0	0	0	0
25	S	L	0	0	0	0	0	0
26	S	L	0	0	0	0	0	0
	TOTALS		**5**	**3**	**2**	**2**	**2**	**1**

A3.38. 1997 flower and acornet counts for tree 8-20-903 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	E	U	10	2	3	2	3	2	3	0	3	0	0	0
2	E	U	3	1	0	0	0	0	0	0	0	0	0	0
3	E	U	4	0	0	0	0	0	0	0	0	0	0	0
4	N	U	2	5	1	3	1	3	0	0	0	0	0	0
	TOTALS		**19**	**8**	**4**	**5**	**4**	**5**	**3**	**0**	**3**	**0**	**0**	**0**

A3.39. 1998 flower counts for tree 8-20-903 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	E	U	0	0	0	0	0	0
2	E	U	0	0	0	0	0	0
3	E	U	0	0	0	0	0	0
4	N	U	0	0	0	0	0	0
	TOTALS		**0**	**0**	**0**	**0**	**0**	**0**

A3.40. 1997 flower and acornet counts for tree 8-21-728 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	S	L	5	0	1	0	0	0	0	0	0	0	0	0
2	S	L	3	0	2	0	2	0	2	0	2	0	2	0
3	S	L	2	0	1	0	1	0	1	0	1	0	1	0
4	S	L	0	12	0	12	0	12	0	10	0	9	0	9
5	S	L	0	10	0	10	0	10	0	10	0	4	0	4
6	S	L	6	6	3	5	3	5	3	5	0	5	2	4
7	S	L	2	0	0	0	0	0	0	0	0	0	0	0
8	S	L	6	0	0	0	0	0	0	0	0	0	0	0
9	S	L	5	0	2	0	2	0	2	0	2	0	2	0
10	S	L	3	0	1	0	1	0	1	0	1	0	1	0
11	S	L	2	3	0	3	0	3	0	3	0	3	0	3
12	S	L	0	4	0	4	2	4	0	4	0	4	0	4
13	S	L	6	0	4	0	4	0	4	0	4	0	4	0
14	S	L	7	3	5	3	4	3	4	3	5	3	5	2
15	S	L	0	4	0	4	0	4	0	4	0	2	0	2
16	S	L	2	8	1	7	0	8	0	8	0	4	0	3
17	S	L	0	7	0	7	0	7	0	7	0	6	0	6
18	S	L	0	5	0	4	0	5	0	4	0	3	0	3
19	N	L	3	0	0	0	0	0	0	0	0	0	0	0
20	N	L	0	6	0	5	0	5	0	4	0	3	0	0
21	N	L	0	3	0	3	0	3	0	3	0	3	0	2
22	N	L	0	5	0	2	0	0	0	0	0	0	0	0
23	N	L	0	2	0	0	0	0	0	0	0	0	0	0
24	N	L	0	6	0	5	0	4	0	4	0	3	0	3
25	N	L	3	0	2	0	2	0	2	0	2	0	2	0
26	W	L	5	0	5	0	5	0	5	0	5	0	5	0
27	W	L	3	0	1	0	0	0	0	0	0	0	0	0

A3.40. 1997 flower and acornet counts for tree 8-21-728 (Continued).

Tag #	Bearing	Crown Section	Flower Count 1	Acornet Count 1	Flower Count 2	Acornet Count 2	Flower Count 3	Acornet Count 3	Flower Count 4	Acornet Count 4	Flower Count 5	Acornet Count 5	Flower Count 6	Acornet Count 6
28	W	L	0	2	0	2	0	2	0	2	0	2	0	2
29	W	L	6	0	5	0	5	0	5	0	4	0	5	0
30	W	L	3	0	2	0	1	0	1	0	1	0	1	0
31	W	L	10	0	6	0	5	0	5	0	6	0	6	0
32	W	L	3	0	0	0	0	0	0	0	0	0	0	0
33	W	L	4	0	0	0	0	0	0	0	0	0	0	0
34	S	L	0	0	0	0	6	0	6	0	5	0	5	0
35	S	L	0	0	0	0	8	0	8	0	8	0	8	0
36	S	L	0	0	0	0	2	0	2	0	2	0	2	0
37	S	L	0	0	0	0	2	0	2	0	2	0	2	0
	TOTALS		89	85	41	76	55	75	53	71	50	54	53	47

A3.41. 1998 flower counts for tree 8-21-728 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	S	L	0	0	0	0	0	0
2	S	L	2	2	2	2	1	1
3	S	L	1	1	1	1	1	1
4	S	L	0	0	0	0	0	0
5	S	L	0	0	0	0	0	0
6	S	L	2	2	2	1	1	1
7	S	L	0	0	0	0	0	0
8	S	L	0	0	0	0	0	0
9	S	L	2	2	2	2	2	1
10	S	L	1	1	1	1	1	1
11	S	L	0	0	0	0	0	0
12	S	L	0	0	0	0	0	0
13	S	L	4	4	4	4	4	3
14	S	L	5	5	4	3	3	2
15	S	L	0	0	0	0	0	0
16	S	L	0	0	0	0	0	0
17	S	L	0	0	0	0	0	0
18	S	L	0	0	0	0	0	0
19	N	L	0	0	0	0	0	0
20	N	L	0	0	0	0	0	0
21	N	L	0	0	0	0	0	0
22	N	L	0	0	0	0	0	0
23	N	L	0	0	0	0	0	0
24	N	L	0	0	0	0	0	0
25	N	L	2	1	1	1	1	0
26	W	L	5	5	5	5	5	5
27	W	L	0	0	0	0	0	0

A3.41. 1998 flower counts for tree 8-21-728 (Continued).

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
28	W	L	0	0	0	0	0	0
29	W	L	5	3	3	3	2	2
30	W	L	1	1	1	1	1	1
31	W	L	6	4	4	4	2	2
32	W	L	0	0	0	0	0	0
33	W	L	0	0	0	0	0	0
34	S	L	5	5	5	5	3	1
35	S	L	8	8	8	8	8	7
36	S	L	2	2	2	2	2	0
37	S	L	2	0	0	0	0	0
	TOTALS		**53**	**46**	**45**	**43**	**37**	**28**

A3.42. 1997 flower and acornet counts for tree 8-13-530 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	E	U	4	0	1	0	1	0	1	0	1	0	0	0
2	S	U	4	0	0	0	0	0	0	0	0	0	0	0
3	S	U	8	0	3	0	3	0	3	0	3	0	3	0
4	S	U	12	0	4	0	5	0	5	0	5	0	5	0
5	S	U	4	0	2	0	2	0	2	0	2	0	2	0
6	S	U	12	0	5	0	5	0	5	0	5	0	4	0
7	W	L	3	0	0	0	0	0	0	0	0	0	0	0
8	W	U	3	0	4	0	4	0	4	0	4	0	2	0
9	W	U	9	0	5	0	5	0	5	0	4	0	4	0
10	N	U	11	0	4	0	3	0	1	0	0	0	0	0
11	N	U	6	0	3	0	1	0	1	0	1	0	1	0
12	N	U	8	0	4	0	4	0	4	0	4	0	4	0
13	N	U	5	0	2	0	2	0	2	0	2	0	2	0
14	W	L	0	0	0	0	3	0	2	0	2	2	2	0
15	W	L	0	0	0	0	2	0	0	0	0	0	0	0
16	W	L	0	0	0	0	6	0	6	0	6	2	5	2
	TOTALS		89	0	37	0	46	0	41	0	39	4	34	2

A3.43. 1998 flower counts for tree 8-13-530 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	E	U	0	0	0	0	0	0
2	S	U	0	0	0	0	0	0
3	S	U	3	3	2	1	1	1
4	S	U	4	2	1	1	1	1
5	S	U	2	2	1	0	0	0
6	S	U	4	5	1	0	0	0
7	W	L	0	0	0	0	0	0
8	W	U	2	2	1	0	0	0
9	W	U	3	2	1	1	1	1
10	N	U	0	0	0	0	0	0
11	N	U	1	1	1	1	1	1
12	N	U	4	4	3	2	2	2
13	N	U	2	1	1	1	1	1
14	W	L	2	0	0	0	0	0
15	W	L	0	0	0	0	0	0
16	W	L	4	2	2	4	3	3
	TOTALS		31	24	14	11	10	10

A3.44. 1997 flower and acornet counts for tree 8-12-705 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	E	U	5	0	4	0	4	0	2	0	3	0	3	0
2	E	U	10	0	5	0	5	0	5	0	5	0	4	0
3	E	U	3	0	2	0	2	0	2	0	2	0	2	0
4	N	U	13	0	6	0	5	0	5	0	6	0	6	0
5	N	U	4	0	3	0	3	0	3	0	3	0	3	0
6	N	U	2	0	0	0	1	0	1	0	1	0	1	0
7	W	U	9	0	7	0	7	0	7	0	7	0	7	0
8	W	U	6	0	2	0	2	0	2	0	2	0	2	0
9	W	U	12	0	7	0	8	0	8	0	8	0	8	0
10	W	U	4	0	2	0	2	0	2	0	2	0	2	0
11	W	U	12	0	7	0	5	0	5	0	5	0	5	0
12	W	U	0	2	0	1	0	1	0	1	0	0	0	0
13	S	U	12	0	8	0	6	0	6	0	6	0	6	0
14	S	U	0	3	0	3	0	2	0	1	0	1	0	0
15	W	L	3	0	2	0	2	0	2	0	2	0	2	0
16	W	L	2	0	2	0	2	0	2	0	2	0	2	0
	TOTALS		97	5	57	4	54	3	52	2	54	1	53	0

A3.45. 1998 flower counts for tree 8-12-705 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	E	U	2	1	0	0	0	0
2	E	U	5	5	4	0	0	0
3	E	U	2	2	2	2	0	0
4	N	U	5	5	5	4	0	0
5	N	U	0	0	0	0	0	0
6	N	U	0	0	0	0	0	0
7	W	U	7	7	4	2	2	1
8	W	U	2	2	2	2	1	1
9	W	U	7	7	6	3	2	2
10	W	U	2	2	2	2	2	1
11	W	U	4	4	4	2	1	1
12	W	U	0	0	0	0	0	0
13	S	U	4	4	4	1	0	0
14	S	U	0	0	0	0	0	0
15	W	L	2	2	0	0	0	0
16	W	L	2	2	2	1	1	1
	TOTALS		**44**	**43**	**35**	**19**	**9**	**7**

A3.46. 1997 flower and acornet counts for tree 8-20-884-1 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	W	U	9	0	3	0	3	0	2	0	2	0	2	0
2	W	U	12	0	7	0	7	0	7	0	6	0	7	0
3	W	U	8	0	3	0	3	0	3	0	2	0	2	0
4	W	U	3	0	2	0	0	0	0	0	0	0	0	0
5	N	U	5	0	2	0	2	0	2	0	2	0	0	0
6	N	U	5	0	2	0	2	0	2	0	2	0	1	0
7	N	U	4	0	1	0	1	0	1	0	1	0	1	0
8	N	U	2	0	1	0	1	0	1	0	1	0	1	0
9	N	U	0	6	0	6	0	5	0	3	0	3	0	1
10	E	U	2	0	1	0	1	0	1	0	0	0	0	0
11	E	U	8	0	3	0	2	0	1	0	0	0	0	0
12	E	U	6	0	3	0	2	0	2	0	2	0	2	0
13	E	U	4	0	2	0	1	0	2	0	2	0	1	0
14	S	U	2	0	1	0	1	0	1	0	1	0	1	0
15	S	U	3	0	2	0	0	0	0	0	0	0	0	0
16	S	U	0	4	0	3	0	3	0	0	0	0	0	0
17	S	U	11	0	7	0	5	0	5	0	5	0	3	0
18	S	U	3	0	2	0	2	0	2	0	1	0	1	0
19	S	U	6	0	4	0	2	0	2	0	2	0	2	0
20	S	U	2	0	1	0	1	0	1	0	1	0	1	0
21	S	U	5	0	3	0	3	0	3	0	2	0	2	0
	TOTALS		**100**	**10**	**50**	**9**	**39**	**8**	**38**	**3**	**32**	**3**	**27**	**1**

A3.47. 1998 flower counts for tree 8-20-884-1 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	W	U	2	1	0	0	0	0
2	W	U	5	1	0	0	0	0
3	W	U	2	2	1	0	0	0
4	W	U	0	0	0	0	0	0
5	N	U	0	0	0	0	0	0
6	N	U	1	1	1	0	0	0
7	N	U	1	1	1	0	0	0
8	N	U	1	1	1	0	0	0
9	N	U	0	0	0	0	0	0
10	E	U	0	0	0	0	0	0
11	E	U	0	0	0	0	0	0
12	E	U	1	1	1	0	0	0
13	E	U	1	1	0	0	0	0
14	S	U	1	1	1	0	0	0
15	S	U	0	0	0	0	0	0
16	S	U	0	0	0	0	0	0
17	S	U	3	2	2	1	1	1
18	S	U	1	1	0	0	0	0
19	S	U	2	2	2	0	0	0
20	S	U	1	0	0	0	0	0
21	S	U	2	0	0	0	0	0
	TOTALS		**24**	**15**	**10**	**1**	**1**	**1**

A3.48. 1997 flower and acornet counts for tree 8-20-884-2 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	E	U	3	0	2	0	2	0	2	0	0	0	0	0
2	E	U	6	0	4	0	4	0	4	0	2	0	2	0
3	N	U	14	0	2	0	2	0	0	0	0	0	0	0
4	N	U	19	0	13	0	13	0	8	0	5	0	5	0
5	W	U	8	0	3	0	3	0	3	0	3	0	3	0
6	S	U	3	0	0	0	0	0	0	0	0	0	0	0
7	S	U	3	0	2	0	0	0	0	0	0	0	0	0
8	S	L	0	0	0	0	11	0	10	0	10	0	8	0
9	S	L	0	0	0	0	4	0	4	0	2	0	0	0
10	S	L	0	0	0	0	2	0	2	0	2	0	2	0
	TOTALS		**56**	**0**	**26**	**0**	**41**	**0**	**33**	**0**	**24**	**0**	**20**	**0**

A3.49. 1998 flower counts for tree 8-20-884-2 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	E	U	0	0	0	0	0	0
2	E	U	2	0	0	0	0	0
3	N	U	0	0	0	0	0	0
4	N	U	5	3	2	1	1	1
5	W	U	3	1	1	0	0	0
6	S	U	0	0	0	0	0	0
7	S	U	0	0	0	0	0	0
8	S	L	5	1	0	0	0	0
9	S	L	0	0	0	0	0	0
10	S	L	2	1	1	0	0	0
	TOTALS		**17**	**6**	**4**	**1**	**1**	**1**

A3.50. 1997 flower and acornet counts for tree 8-21-888 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	N	L	3	0	0	0	0	0	0	0	0	0	0	0
2	N	L	3	0	2	0	0	0	0	0	0	0	0	0
3	S	U	6	0	4	0	4	0	4	0	4	0	4	0
4	S	U	2	0	0	0	0	0	0	0	0	0	0	0
5	W	L	4	0	2	0	2	0	2	0	2	0	2	0
6	W	L	3	0	0	0	0	0	0	0	0	0	0	0
7	W	L	3	0	2	0	2	0	2	0	2	0	2	0
8	W	L	2	0	2	0	2	0	2	0	2	0	2	0
9	W	L	3	0	2	0	2	0	2	0	2	0	2	0
10	W	L	3	0	2	0	2	0	2	0	1	0	1	0
11	S	L	3	0	2	0	2	0	2	0	2	0	2	0
12	E	L	3	0	2	0	2	0	2	0	2	0	2	0
13	E	L	9	0	6	0	4	0	6	0	6	0	4	0
14	N	L	0	0	0	0	4	0	1	0	1	0	1	0
15	N	L	0	0	0	0	2	0	2	0	2	0	2	0
16	W	L	0	0	0	0	1	0	1	0	1	0	1	0
17	W	L	0	0	0	0	4	0	4	0	4	0	4	0
18	W	L	0	0	0	0	6	0	6	0	4	0	6	0
	TOTALS		**47**	**0**	**26**	**0**	**39**	**0**	**38**	**0**	**35**	**0**	**35**	**0**

A3.51. 1998 flower counts for tree 8-21-888 taken on six separate inventory dates.

Tag #	Bearing	Crown Section	Flower Count 7	Flower Count 8	Flower Count 9	Flower Count 10	Flower Count 11	Flower Count 12
1	N	L	0	0	0	0	0	0
2	N	L	0	0	0	0	0	0
3	S	U	4	4	4	4	4	4
4	S	U	0	0	0	0	0	0
5	W	L	1	1	1	1	1	1
6	W	L	0	0	0	0	0	0
7	W	L	2	2	2	2	2	2
8	W	L	2	1	1	0	0	0
9	W	L	2	1	1	0	0	0
10	W	L	0	0	0	0	0	0
11	S	L	2	0	0	0	0	0
12	E	L	2	2	2	2	2	2
13	E	L	4	4	4	4	4	4
14	N	L	1	0	0	0	0	0
15	N	L	2	2	1	1	1	1
16	W	L	1	0	0	0	0	0
17	W	L	4	4	4	4	4	0
18	W	L	5	5	5	4	5	5
	TOTALS		32	26	25	22	23	19

A3.52. 1997 flower and acornet counts for tree 8-17-625 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	E	L	6	0	2	0	2	0	2	0	2	0	2	0
2	E	L	0	8	0	8	0	7	0	6	0	6	0	3
3	E	U	15	0	7	0	7	0	5	0	6	0	6	0
4	E	U	10	0	3	0	2	0	2	0	2	0	2	0
5	E	U	9	0	5	0	5	0	2	0	2	0	2	0
6	E	U	13	0	4	0	4	0	2	0	2	0	2	0
7	S	U	15	0	10	0	8	0	8	0	7	0	7	0
8	S	U	8	0	3	0	4	0	4	0	4	0	3	0
9	S	U	3	0	2	0	2	0	2	0	2	0	2	0
10	S	U	12	0	5	0	4	0	4	0	3	0	3	0
11	S	U	8	0	2	0	2	0	2	0	2	0	2	0
12	S	U	16	0	6	0	5	0	5	0	5	0	5	0
13	S	U	9	0	4	0	3	0	4	0	4	0	4	0
14	W	L	5	0	3	0	3	0	2	0	1	0	1	0
15	W	L	7	0	0	0	0	0	0	0	0	0	0	0
16	W	L	14	0	4	0	3	0	2	0	2	0	2	0
17	W	L	6	0	3	0	3	0	1	0	1	0	1	0
18	W	L	0	7	0	0	0	0	0	0	0	0	0	0
19	W	U	4	0	2	0	2	0	2	0	2	0	2	0
20	W	U	10	0	5	0	4	0	4	0	4	0	4	0
21	W	U	3	0	1	0	1	0	2	0	1	0	1	0
22	W	U	7	0	4	0	4	0	3	0	2	0	1	0
23	W	U	5	0	3	0	3	0	2	0	1	0	1	0
24	W	U	8	0	5	0	3	0	3	0	3	0	3	0
25	W	U	2	0	1	0	1	0	1	0	1	0	1	0
26	W	U	19	0	11	0	11	0	11	0	11	0	10	0
27	W	U	11	0	6	0	4	0	4	0	4	0	4	0

A3.53. 1997 flower and acornet counts for tree 8-17-625 (Continued).

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
28	W	U	0	5	0	5	0	4	0	3	0	2	0	1
29	N	U	3	0	2	0	2	0	0	0	0	0	0	0
30	N	U	10	0	8	0	5	0	5	0	3	0	3	0
31	N	U	3	0	2	0	1	0	1	0	1	0	1	0
32	N	U	3	0	0	0	0	0	0	0	0	0	0	0
33	N	U	5	0	0	0	0	0	0	0	0	0	0	0
34	N	U	0	9	0	7	0	7	0	5	0	5	0	4
35	S	L	4	2	1	2	1	2	1	1	1	1	0	1
36	S	L	2	5	1	5	0	5	0	5	0	5	0	4
	TOTALS		255	36	115	27	99	25	86	20	79	19	75	13

A3.54. 1998 flower counts for tree 8-17-625 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	E	L	1	2	2	1	1	0
2	E	L	0	0	0	0	0	0
3	E	U	4	2	1	1	1	1
4	E	U	2	2	2	1	1	1
5	E	U	2	2	2	2	2	2
6	E	U	2	1	1	1	1	0
7	S	U	7	5	5	4	3	3
8	S	U	3	3	1	1	1	1
9	S	U	2	1	1	1	1	1
10	S	U	1	1	0	0	0	0
11	S	U	0	0	0	0	0	0
12	S	U	5	3	3	3	3	3
13	S	U	4	4	3	0	0	0
14	W	L	1	1	1	1	1	1
15	W	L	0	0	0	0	0	0
16	W	L	1	2	2	2	2	2
17	W	L	1	0	0	0	0	0
18	W	L	0	0	0	0	0	0
19	W	U	2	0	0	0	0	0
20	W	U	4	4	3	2	0	0
21	W	U	1	1	1	1	0	0
22	W	U	1	1	1	1	0	0
23	W	U	1	1	1	1	0	0
24	W	U	3	3	3	1	1	1
25	W	U	1	1	1	1	1	1
26	W	U	11	9	5	2	1	1
27	W	U	4	2	1	0	0	0

A3.54. 1998 flower counts for tree 8-17-625 (Continued).

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
28	W	U	0	0	0	0	0	0
29	N	U	0	0	0	0	0	0
30	N	U	1	1	1	1	1	1
31	N	U	0	0	0	0	0	0
32	N	U	0	0	0	0	0	0
33	N	U	0	0	0	0	0	0
34	N	U	0	0	0	0	0	0
35	S	L	0	0	0	0	0	0
36	S	L	0	0	0	0	0	0
	TOTALS		65	52	41	28	21	19

A3.55 1997 flower and acornet counts for tree 8-17-510 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	S	U	24	0	9	0	9	0	9	0	9	0	7	0
2	S	U	2	0	0	0	0	0	0	0	0	0	0	0
3	S	U	6	0	0	0	0	0	0	0	0	0	0	0
4	S	U	13	0	7	0	7	0	7	0	7	0	7	0
5	S	U	12	0	8	0	8	0	8	0	8	0	8	0
6	S	U	11	0	5	0	4	0	4	0	4	0	4	0
7	S	U	9	0	2	0	2	0	2	0	2	0	2	0
8	E	U	4	0	2	0	2	0	2	0	2	0	2	0
9	E	U	20	0	9	0	9	0	9	0	9	0	7	0
10	E	U	24	0	13	0	12	0	12	0	12	0	12	0
11	E	U	12	0	5	0	5	0	5	0	5	0	5	0
12	E	U	13	0	3	0	2	0	2	0	2	0	2	0
13	E	U	2	0	1	0	1	0	1	0	1	0	1	0
14	E	U	4	0	0	3	0	3	0	2	0	1	0	1
15	E	U	5	0	4	0	4	0	4	0	4	0	4	0
16	E	L	3	0	0	0	0	0	0	0	0	0	0	0
17	E	L	3	0	2	0	2	0	2	0	2	0	2	0
18	E	L	0	2	0	2	0	2	0	2	0	1	0	1
19	E	L	2	0	2	0	2	0	2	0	2	0	2	0
20	N	U	11	0	7	0	7	0	7	0	7	0	7	0
21	N	U	10	0	7	0	7	0	7	0	7	0	7	0
22	N	U	7	0	5	0	5	0	5	0	5	0	5	0
23	N	U	3	0	2	0	2	0	2	0	2	0	2	0
24	N	U	18	0	8	0	6	0	6	0	6	0	6	0
25	N	U	16	0	9	0	7	0	7	0	7	0	7	0
26	N	U	11	0	7	0	5	0	5	0	5	0	5	0
27	N	U	6	0	2	0	1	0	2	0	2	0	2	0

A3.55. 1997 flower and acornet counts for tree 8-17-510 (Continued).

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
28	N	U	12	0	7	0	7	0	7	0	7	0	7	0
29	N	U	18	0	5	0	4	0	4	0	4	0	4	0
30	N	U	7	0	2	0	2	0	2	0	2	0	2	0
31	N	U	11	0	10	0	8	0	7	0	7	0	6	0
32	N	U	11	0	5	0	5	0	5	0	5	0	5	0
33	N	U	12	0	6	0	5	0	5	0	5	0	5	0
34	N	L	9	0	3	0	3	0	3	0	3	0	3	0
35	N	L	3	0	1	0	1	0	1	0	1	0	0	0
36	W	U	16	0	2	0	2	0	2	0	2	0	1	0
37	W	U	6	0	2	0	2	0	2	0	2	0	2	0
38	W	U	21	0	5	0	5	0	4	0	4	0	3	0
39	W	U	9	0	4	0	4	0	3	0	3	0	1	0
40	W	U	17	0	12	0	12	0	12	0	12	0	12	0
41	W	U	12	0	2	0	2	0	2	0	2	0	2	0
42	W	U	24	0	17	0	16	0	14	0	15	0	14	0
43	W	U	23	0	10	0	10	0	10	0	10	0	10	0
44	W	U	20	0	12	0	11	0	10	0	11	0	11	0
45	W	U	20	0	8	0	7	0	7	0	7	0	7	0
46	W	U	6	0	3	0	3	0	2	0	2	0	2	0
47	W	U	22	0	12	0	11	0	11	0	11	0	11	0
48	W	L	6	4	3	4	3	4	0	3	0	2	0	2
49	W	L	9	0	5	0	4	0	2	0	2	0	2	0
	TOTALS		**545**	**6**	**255**	**9**	**236**	**9**	**225**	**7**	**227**	**4**	**216**	**4**

A3.56. 1998 flower counts for tree 8-17-510 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	S	U	4	0	0	0	0	0
2	S	U	0	0	0	0	0	0
3	S	U	0	0	0	0	0	0
4	S	U	6	4	2	0	0	0
5	S	U	6	2	2	2	2	2
6	S	U	2	2	2	2	2	2
7	S	U	1	1	1	0	0	0
8	E	U	2	2	2	2	1	1
9	E	U	7	5	5	3	3	2
10	E	U	12	12	10	6	6	7
11	E	U	5	5	5	5	5	5
12	E	U	2	2	2	1	1	1
13	E	U	1	1	1	0	0	0
14	E	U	0	0	0	0	0	0
15	E	U	4	3	3	1	0	0
16	E	L	0	0	0	0	0	0
17	E	L	0	0	0	0	0	0
18	E	L	0	0	0	0	0	0
19	E	L	2	2	2	1	1	1
20	N	U	7	6	6	4	3	3
21	N	U	6	4	4	3	3	2
22	N	U	5	5	4	3	3	3
23	N	U	2	2	2	0	0	0
24	N	U	6	5	5	1	0	0
25	N	U	7	7	7	5	4	4
26	N	U	3	4	3	2	2	2
27	N	U	1	0	0	0	0	0

A3.56. 1998 flower counts for tree 8-17-510 (Continued).

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
28	N	U	7	5	4	3	0	0
29	N	U	3	3	3	3	3	3
30	N	U	2	2	1	0	0	0
31	N	U	3	2	2	1	1	1
32	N	U	5	5	4	1	1	0
33	N	U	4	2	1	1	1	1
34	N	L	0	0	0	0	0	0
35	N	L	0	0	0	0	0	0
36	W	U	0	0	0	0	0	0
37	W	U	2	2	2	2	2	0
38	W	U	3	2	2	0	0	0
39	W	U	1	0	0	0	0	0
40	W	U	11	7	7	6	1	0
41	W	U	2	2	2	1	1	0
42	W	U	14	10	7	2	2	0
43	W	U	8	8	6	4	1	0
44	W	U	10	8	6	4	4	0
45	W	U	5	2	2	1	1	0
46	W	U	1	1	1	0	0	0
47	W	U	8	4	3	2	1	0
48	W	L	0	0	0	0	0	0
49	W	L	0	0	0	0	0	0
	TOTALS		**180**	**139**	**121**	**72**	**55**	**40**

A3.57. 1997 flower and acornet counts for tree 7-8-916 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	W	U	12	14	5	0	5	0	5	0	0	0	4	0
2	W	U	21	14	10	0	10	0	9	0	0	0	10	0
3	W	U	15	14	9	0	10	0	6	0	0	0	7	0
4	W	U	4	14	2	14	2	14	1	14	0	0	0	0
5	W	U	6	14	2	0	1	0	1	0	0	0	1	0
6	S	U	16	0	8	0	7	0	4	0	4	0	1	0
7	S	U	19	0	11	0	10	0	10	0	10	0	9	0
8	S	U	1	0	0	0	0	0	0	0	0	0	0	0
9	S	U	6	0	4	0	3	0	4	0	4	0	4	0
10	S	U	4	0	1	0	1	0	1	0	0	0	0	0
11	S	U	9	0	4	0	11	0	4	0	4	0	4	0
12	S	U	0	8	0	7	0	7	0	7	0	4	0	3
13	E	L	12	3	9	3	9	0	9	3	9	1	9	1
14	E	L	0	2	0	2	0	2	0	2	0	2	0	2
15	E	L	1	12	1	12	1	12	0	11	0	8	0	8
16	E	U	23	0	13	0	13	0	13	0	11	0	13	0
17	E	U	14	0	9	0	9	0	9	0	10	0	10	0
18	E	U	3	0	2	0	2	0	2	0	2	0	2	0
19	E	U	6	0	2	0	1	0	1	0	1	0	1	0

A3.57. 1997 flower and acornet counts for tree 7-8-916 (Continued).

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
20	E	U	7	0	6	0	3	0	5	0	5	0	2	0
21	E	U	8	0	5	0	4	0	4	0	4	0	4	0
22	E	U	9	0	6	0	5	0	6	0	6	0	5	0
23	E	U	0	10	0	10	0	10	0	9	0	4	0	5
24	N	U	10	0	7	0	7	0	5	0	0	0	3	0
25	N	U	3	0	0	0	0	0	0	0	0	0	0	0
26	N	U	0	15	0	14	0	13	0	9	0	0	0	6
27	N	U	3	15	1	15	0	15	0	15	0	0	0	7
28	N	U	0	9	0	9	0	9	0	6	0	0	0	2
	TOTALS		212	144	117	86	114	82	99	76	70	19	89	34

A3.58. 1998 flower counts for tree 7-8-916 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	W	U	3	3	3	3	2	0
2	W	U	10	9	9	8	7	5
3	W	U	5	3	3	3	2	2
4	W	U	0	0	0	0	0	0
5	W	U	1	1	1	1	0	0
6	S	U	0	0	0	0	0	0
7	S	U	8	7	6	5	4	3
8	S	U	0	0	0	0	0	0
9	S	U	4	4	2	2	2	2
10	S	U	0	0	0	0	0	0
11	S	U	3	3	3	3	0	0
12	S	U	0	0	0	0	0	0
13	E	L	5	6	6	5	2	2
14	E	L	0	0	0	0	0	0
15	E	L	0	0	0	0	0	0
16	E	U	12	13	12	11	2	1
17	E	U	9	8	6	5	0	0
18	E	U	2	1	1	1	1	1
19	E	U	1	0	0	0	0	0

A3.58. 1998 flower counts for tree 7-8-916 (Continued).

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
20	E	U	1	1	1	0	0	0
21	E	U	4	4	4	2	2	1
22	E	U	3	3	3	0	0	0
23	E	U	0	0	0	0	0	0
24	N	U	3	3	3	3	3	1
25	N	U	0	0	0	0	0	0
26	N	U	0	0	0	0	0	0
27	N	U	0	0	0	0	0	0
28	N	U	0	0	0	0	0	0
	TOTALS		**74**	**69**	**63**	**52**	**27**	**18**

A3.59. 1997 flower and acornet counts for tree 7-7-2457 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	S	U	3	10	1	9	1	9	0	9	0	7	0	7
2	E	U	6	0	4	0	4	0	4	0	4	0	4	0
3	E	U	3	9	2	9	2	7	2	0	2	0	2	0
4	N	U	2	0	0	0	0	0	0	0	0	0	0	0
5	N	U	3	8	1	8	1	8	1	8	1	8	1	8
6	N	L	3	0	2	0	0	0	1	0	2	0	2	0
7	N	L	6	0	1	0	1	0	1	0	1	0	1	0
8	N	L	2	0	0	0	0	0	0	0	0	0	0	0
9	N	L	3	3	0	3	0	3	0	3	0	3	0	3
10	W	U	4	0	0	0	0	0	0	0	0	0	0	0
11	W	U	2	0	1	0	0	0	0	0	0	0	0	0
12	W	U	5	0	0	0	0	0	0	0	0	0	0	0
13	S	U	0	7	0	6	2	6	0	5	0	1	0	2
14	W	U	4	0	0	0	0	0	0	0	0	0	0	0
	TOTALS		**46**	**37**	**12**	**35**	**11**	**33**	**9**	**25**	**10**	**19**	**10**	**20**

A3.60. 1998 flower counts for tree 7-7-2457 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	S	U	0	0	0	0	0	0
2	E	U	2	0	0	0	0	0
3	E	U	0	0	0	0	0	0
4	N	U	0	0	0	0	0	0
5	N	U	0	0	0	0	0	0
6	N	L	1	0	0	0	0	0
7	N	L	1	1	1	0	0	0
8	N	L	0	0	0	0	0	0
9	N	L	0	0	0	0	0	0
10	W	U	0	0	0	0	0	0
11	W	U	0	0	0	0	0	0
12	W	U	0	0	0	0	0	0
13	S	U	0	0	0	0	0	0
14	W	U	0	0	0	0	0	0
	TOTALS		**4**	**1**	**1**	**0**	**0**	**0**

A3.61. 1997 flower and acornet counts for tree 8-4-540 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	W	U	3	0	1	0	1	0	1	0	1	0	0	0
2	W	U	11	0	4	0	4	0	1	0	3	0	3	0
3	W	L	3	0	0	0	0	0	0	0	0	0	0	0
5	E	U	3	0	1	0	1	0	1	0	1	0	1	0
6	E	U	0	11	0	11	0	10	0	4	0	2	0	2
7	E	L	6	0	0	0	0	0	0	0	0	0	0	0
8	E	L	0	1	0	1	0	1	0	1	0	0	0	0
9	S	U	4	0	1	0	1	0	0	0	0	0	0	0
10	S	L	3	0	1	0	0	0	0	0	0	0	0	0
11	S	L	0	6	0	6	0	6	0	0	0	0	0	0
12	N	U	3	0	3	0	3	0	0	0	0	0	0	0
13	E	L	0	0	0	0	4	8	4	0	4	0	4	0
14	S	U	0	0	0	0	2	0	2	0	2	0	2	0
15	S	U	0	0	0	0	2	0	1	0	1	0	1	0
	TOTALS		36	18	11	18	18	25	10	5	12	2	11	2

A3.62. 1998 flower counts for tree 8-4-540 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	W	U	0	0	0	0	0	0
2	W	U	1	1	1	0	0	0
3	W	L	0	0	0	0	0	0
5	E	U	1	1	1	0	0	0
6	E	U	0	0	0	0	0	0
7	E	L	0	0	0	0	0	0
8	E	L	0	0	0	0	0	0
9	S	U	0	0	0	0	0	0
10	S	L	0	0	0	0	0	0
11	S	L	0	0	0	0	0	0
12	N	U	0	0	0	0	0	0
13	E	L	4	3	3	0	0	0
14	S	U	2	1	0	0	0	0
15	S	U	1	0	0	0	0	0
	TOTALS		**9**	**6**	**5**	**0**	**0**	**0**

A3.63. 1997 flower and acornet counts for tree 8-2-914 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	S	U	12	0	7	0	7	0	5	0	5	0	6	0
2	S	U	0	3	0	3	0	2	0	2	0	0	0	0
3	W	U	8	0	4	0	5	0	4	0	5	0	4	0
4	W	U	8	0	3	0	3	0	3	0	3	0	3	0
5	W	U	0	1	0	1	0	1	0	1	0	0	0	0
6	N	U	3	0	3	0	2	0	2	0	2	0	2	0
7	N	U	0	7	0	7	0	1	0	0	0	0	0	0
9	E	U	10	0	4	0	3	0	1	0	1	0	1	0
10	E	U	6	0	3	0	3	0	2	0	0	0	0	0
11	E	L	2	0	1	0	1	0	1	0	1	0	0	0
12	E	L	0	6	0	5	0	5	0	5	0	4	0	4
	TOTALS		**49**	**17**	**25**	**16**	**24**	**9**	**18**	**8**	**17**	**4**	**16**	**4**

A3.64. 1998 flower counts for tree 8-2-914 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	S	U	4	3	2	2	1	1
2	S	U	0	0	0	0	0	0
3	W	U	2	1	1	1	0	0
4	W	U	0	0	0	0	0	0
5	W	U	0	0	0	0	0	0
6	N	U	2	2	1	1	0	0
7	N	U	0	0	0	0	0	0
9	E	U	1	1	1	1	1	1
10	E	U	0	0	0	0	0	0
11	E	L	0	0	0	0	0	0
12	E	L	0	0	0	0	0	0
	TOTALS		**9**	**7**	**5**	**5**	**2**	**2**

A3.65. 1997 flower and acornet counts for tree 8-12-701 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	W	U	9	0	1	0	0	0	0	0	0	0	0	0
2	W	U	0	1	0	1	0	0	0	0	0	0	0	0
3	W	L	6	0	0	0	0	0	0	0	0	0	0	0
4	W	L	0	6	0	6	0	0	0	0	0	0	0	0
5	W	L	16	0	2	0	2	0	2	0	0	0	0	0
6	W	L	14	0	2	0	2	0	2	0	2	0	2	0
7	W	U	9	0	2	0	2	0	0	0	0	0	0	0
8	E	U	3	0	2	0	2	0	2	0	2	0	2	0
10	S	L	2	0	1	0	1	0	1	0	1	0	1	0
11	S	U	8	0	0	0	0	0	0	0	0	0	0	0
12	S	U	5	0	0	0	0	0	0	0	0	0	0	0
13	S	U	2	0	0	0	0	0	0	0	0	0	0	0
14	N	U	3	0	0	0	0	0	0	0	0	0	0	0
15	W	L	0	0	0	0	1	2	1	2	1	2	1	2
16	W	L	0	0	0	0	1	0	1	0	1	0	1	0
	TOTALS		77	7	10	7	11	2	9	2	7	2	7	2

A3.66. 1998 flower counts for tree 8-12-701 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	W	U	0	0	0	0	0	0
2	W	U	0	0	0	0	0	0
3	W	L	0	0	0	0	0	0
4	W	L	0	0	0	0	0	0
5	W	L	0	0	0	0	0	0
6	W	L	2	1	1	1	1	0
7	W	U	0	0	0	0	0	0
8	E	U	2	1	0	0	0	0
10	S	L	1	0	0	0	0	0
11	S	U	0	0	0	0	0	0
12	S	U	0	0	0	0	0	0
13	S	U	0	0	0	0	0	0
14	N	U	0	0	0	0	0	0
15	W	L	1	1	1	1	1	1
16	W	L	0	0	0	0	0	0
	TOTALS		**6**	**3**	**2**	**2**	**2**	**1**

A3.67. 1997 flower and acornet counts for tree 8-11-732 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	N	U	7	0	0	0	0	0	0	0	0	0	0	0
2	N	U	0	10	0	11	0	11	0	11	0	8	0	8
4	W	U	3	0	0	0	0	0	0	0	0	0	0	0
5	W	U	0	4	0	4	0	4	0	4	0	1	0	1
6	S	U	6	0	3	0	3	0	1	0	1	0	1	0
7	S	U	6	0	3	0	2	0	2	0	2	0	2	0
8	S	U	0	2	0	2	0	2	0	2	0	2	0	2
9	S	L	5	0	0	0	0	0	0	0	0	0	0	0
10	S	L	0	8	0	7	0	7	0	7	0	6	0	5
11	E	U	2	0	1	0	1	0	1	0	1	0	1	0
12	E	U	0	10	10	1	0	10	0	8	0	8	0	5
	TOTALS		**29**	**34**	**17**	**25**	**6**	**34**	**4**	**32**	**4**	**25**	**4**	**21**

A3.68. 1998 flower counts for tree 8-11-732 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	N	U	0	0	0	0	0	0
2	N	U	0	0	0	0	0	0
4	W	U	0	0	0	0	0	0
5	W	U	0	0	0	0	0	0
6	S	U	1	1	0	0	0	0
7	S	U	0	0	0	0	0	0
8	S	U	0	0	0	0	0	0
9	S	L	0	0	0	0	0	0
10	S	L	0	0	0	0	0	0
11	E	U	1	0	0	0	0	0
12	E	U	0	0	0	0	0	0
	TOTALS		**2**	**1**	**0**	**0**	**0**	**0**

A3.69. 1997 flower and acornet counts for tree 8-9-630 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	N	U	14	0	8	0	7	0	7	0	7	0	6	0
2	N	U	22	0	11	0	11	0	11	0	10	0	10	0
3	N	U	0	6	0	6	0	4	0	4	0	3	0	2
4	W	U	9	0	1	0	1	0	1	0	1	0	1	0
5	W	U	2	0	0	0	0	0	0	0	0	0	0	0
6	W	U	20	0	8	0	7	0	6	0	5	0	6	0
7	W	L	2	0	1	0	1	0	1	0	0	0	0	0
8	W	L	2	0	1	0	1	0	1	0	1	0	1	0
9	W	L	2	0	1	0	1	0	1	0	0	0	0	0
10	W	L	0	1	0	1	0	1	0	1	0	0	0	0
11	W	L	2	0	1	0	1	0	1	0	0	0	0	0
12	N	L	7	0	5	0	5	0	2	0	2	0	1	0
13	N	L	0	12	0	11	0	7	0	7	0	5	0	5
14	E	U	8	0	1	0	1	0	1	0	1	0	1	0
15	E	U	4	0	2	0	2	0	2	0	2	0	2	0
16	E	U	3	0	0	0	0	0	0	0	0	0	0	0
17	E	U	0	2	0	2	0	1	0	1	0	1	0	1
18	S	U	4	0	0	0	0	0	1	0	0	0	0	0
19	S	U	4	0	0	0	0	0	0	0	0	0	0	0
20	S	U	7	0	4	0	3	0	3	0	3	0	3	0
21	S	U	4	0	1	0	0	0	0	0	0	0	0	0
22	S	U	0	9	0	9	0	3	0	3	0	2	0	2
23	S	L	12	0	8	0	8	0	8	0	8	0	6	0
24	S	L	0	3	0	3	0	3	0	3	0	3	0	1
25	S	L	0	0	0	0	6	13	6	13	6	8	5	6
26	S	L	0	0	0	0	6	6	4	5	4	2	2	1
27	W	U	0	0	0	0	10	0	9	0	5	0	5	0

A3.69. 1997 flower and acornet counts for tree 8-9-630 (Continued).

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
28	W	U	0	0	0	0	8	1	6	0	5	0	5	0
29	N	L	0	0	0	0	12	5	12	3	10	2	12	1
30	E	U	0	0	0	0	6	10	6	10	3	9	3	8
31	E	U	0	0	0	0	14	0	12	0	13	2	13	2
32	S	U	0	0	0	0	4	0	3	2	2	0	2	0
33	S	U	0	0	0	0	6	0	5	0	4	0	5	0
34	S	L	0	0	0	0	5	8	5	6	5	3	4	3
35	S	L	0	0	0	0	35	9	34	5	33	2	33	0
	TOTALS		**128**	**33**	**53**	**32**	**161**	**71**	**148**	**63**	**130**	**42**	**126**	**32**

A3.70. 1998 flower counts for tree 8-9-630 taken on six separate inventory dates.

Tag #	Bearing	Crown Section	Flower Count 7	Flower Count 8	Flower Count 9	Flower Count 10	Flower Count 11	Flower Count 12
1	N	U	4	3	3	3	2	2
2	N	U	8	5	4	4	4	4
3	N	U	0	0	0	0	0	0
4	W	U	1	0	0	0	0	0
5	W	U	0	0	0	0	0	0
6	W	U	5	4	4	4	2	1
7	W	L	0	0	0	0	0	0
8	W	L	1	1	1	1	1	1
9	W	L	0	0	0	0	0	0
10	W	L	0	0	0	0	0	0
11	W	L	0	0	0	0	0	0
12	N	L	1	1	1	0	0	0
13	N	L	0	0	0	0	0	0
14	E	U	1	1	0	0	0	0
15	E	U	2	2	2	2	2	2
16	E	U	0	0	0	0	0	0
17	E	U	0	0	0	0	0	0
18	S	U	0	0	0	0	0	0
19	S	U	0	0	0	0	0	0
20	S	U	2	1	1	0	0	0
21	S	U	0	0	0	0	0	0
22	S	U	0	0	0	0	0	0
23	S	L	6	4	3	3	3	3
24	S	L	0	0	0	0	0	0
25	S	L	4	4	4	4	4	4
26	S	L	2	0	0	0	0	0
27	W	U	4	4	3	3	0	3

A3.70. 1998 flower counts for tree 8-9-630 (Continued).

Tag #	Bearing	Crown Section	Flower Count 7	Flower Count 8	Flower Count 9	Flower Count 10	Flower Count 11	Flower Count 12
28	W	U	1	0	0	0	0	0
29	N	L	11	11	11	11	12	10
30	E	U	1	1	1	1	1	1
31	E	U	9	6	6	7	7	1
32	S	U	2	1	1	1	1	1
33	S	U	4	3	3	3	2	1
34	S	L	2	2	2	2	2	2
35	S	L	31	27	27	20	14	7
	TOTALS		102	81	77	69	57	43

A3.71. 1997 flower and acornet counts for tree 6-12-628 taken on four separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	S	L	*	*	*	*	48	22	40	19	40	19	35	17
2	S	L	*	*	*	*	35	6	34	6	30	6	24	5
3	S	U	*	*	*	*	6	0	5	0	5	0	5	0
4	S	U	*	*	*	*	6	0	5	0	4	0	5	0
5	S	U	*	*	*	*	8	1	8	1	8	1	5	1
6	S	U	*	*	*	*	0	7	0	7	0	6	0	6
8	N	U	*	*	*	*	2	0	2	0	2	0	2	0
9	N	U	*	*	*	*	2	0	2	0	2	0	2	0
10	N	U	*	*	*	*	6	0	6	0	6	0	6	0
11	N	U	*	*	*	*	3	0	2	0	3	0	3	0
12	E	L	*	*	*	*	8	0	8	0	7	0	3	0
13	S	L	*	*	*	*	11	0	10	0	11	0	11	0
14	S	L	*	*	*	*	4	0	4	0	4	0	4	0
15	S	L	*	*	*	*	5	0	5	0	5	0	5	0
16	S	L	*	*	*	*	12	0	11	0	11	0	11	0
17	E	U	*	*	*	*	10	0	10	0	13	0	8	0
18	E	U	*	*	*	*	12	2	12	2	13	2	10	1
19	E	U	*	*	*	*	5	1	5	1	4	1	5	1
20	N	U	*	*	*	*	10	14	10	9	8	6	10	4
	TOTALS						**193**	**53**	**179**	**45**	**176**	**41**	**154**	**35**

*** No data taken for those inventory dates.**

A3.72. 1998 flower counts for tree 6-12-628 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	S	L	28	25	25	21	20	17
2	S	L	22	12	14	13	12	11
3	S	U	5	3	3	0	0	0
4	S	U	4	2	2	2	2	2
5	S	U	6	6	6	5	2	0
6	S	U	0	0	0	0	0	0
8	N	U	2	2	2	2	2	2
9	N	U	1	0	0	0	0	0
10	N	U	6	3	2	2	1	1
11	N	U	2	1	1	2	1	1
12	E	L	4	1	0	0	0	0
13	S	L	11	9	9	6	6	5
14	S	L	3	2	2	1	1	1
15	S	L	5	4	3	3	4	3
16	S	L	11	7	7	7	7	7
17	E	U	12	7	7	6	6	5
18	E	U	10	7	7	7	5	5
19	E	U	3	3	3	2	2	2
20	N	U	10	7	8	7	7	2
	TOTALS		**145**	**101**	**101**	**86**	**78**	**64**

A3.73. 1997 flower and acornet counts for tree 7-26-323 taken on four separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	E	U	*	*	*	*	7	0	7	0	6	0	6	0
2	E	U	*	*	*	*	4	0	4	0	3	0	3	0
3	E	U	*	*	*	*	2	0	1	0	1	0	1	0
4	E	U	*	*	*	*	7	0	6	0	7	0	4	0
5	N	U	*	*	*	*	8	9	8	8	8	8	8	5
6	N	U	*	*	*	*	2	0	1	0	0	0	0	0
7	N	U	*	*	*	*	1	4	1	4	1	4	1	3
8	W	U	*	*	*	*	2	6	2	5	2	1	1	0
9	W	U	*	*	*	*	8	0	7	0	8	0	6	0
10	W	U	*	*	*	*	6	3	6	2	5	2	5	1
11	W	U	*	*	*	*	16	4	13	4	10	4	11	2
12	S	U	*	*	*	*	2	2	2	2	2	0	2	0
13	S	U	*	*	*	*	2	3	2	3	2	1	2	0
14	S	U	*	*	*	*	13	4	12	4	12	1	12	0
15	S	U	*	*	*	*	7	7	4	4	6	4	6	0
16	S	L	*	*	*	*	3	2	3	1	3	1	2	0
17	S	L	*	*	*	*	5	3	3	3	3	2	3	2
18	E	L	*	*	*	*	2	0	2	0	2	0	1	0
19	W	L	*	*	*	*	4	6	3	5	4	4	2	3
20	W	L	*	*	*	*	1	0	1	0	1	0	1	0
	TOTALS						**102**	**53**	**88**	**45**	**86**	**32**	**77**	**16**

*** No data taken for those inventory dates.**

A3.74. 1998 flower and acornet counts for tree 7-26-323 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	E	U	4	4	3	3	1	0
2	E	U	3	2	2	2	2	0
3	E	U	1	0	0	0	0	0
4	E	U	3	3	2	2	1	0
5	N	U	8	6	1	0	0	0
6	N	U	0	0	0	0	0	0
7	N	U	1	0	0	0	0	0
8	W	U	1	1	1	0	0	0
9	W	U	6	6	6	1	1	0
10	W	U	5	6	5	3	1	1
11	W	U	9	6	3	0	0	0
12	S	U	0	0	0	0	0	0
13	S	U	2	2	2	0	0	0
14	S	U	11	9	9	5	2	1
15	S	U	6	4	3	1	0	0
16	S	L	3	2	2	2	1	1
17	S	L	3	0	0	0	0	0
18	E	L	1	0	0	0	0	0
19	W	L	3	2	2	1	1	1
20	W	L	1	1	1	1	1	1
	TOTALS		**71**	**54**	**42**	**21**	**11**	**5**

A3.75. 1997 flower and acornet counts for tree 6-8-903 taken on four separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
1	W	L	*	*	*	*	4	0	4	0	4	0	4	0
2	W	L	*	*	*	*	6	0	6	0	2	0	2	0
3	W	L	*	*	*	*	12	2	8	2	4	2	2	2
4	W	U	*	*	*	*	5	10	3	10	2	8	0	8
5	W	U	*	*	*	*	12	0	7	0	7	0	6	0
6	W	U	*	*	*	*	5	2	5	2	5	2	4	2
7	S	L	*	*	*	*	3	1	3	1	3	1	3	1
8	S	L	*	*	*	*	1	3	1	3	0	2	1	1
9	S	L	*	*	*	*	1	0	1	0	1	0	1	0
10	S	L	*	*	*	*	2	0	2	0	2	0	2	0
11	S	U	*	*	*	*	7	8	7	8	6	8	5	8
12	S	U	*	*	*	*	3	0	4	0	3	0	2	0
13	S	U	*	*	*	*	11	8	9	8	10	7	9	7
14	S	U	*	*	*	*	8	0	6	0	8	0	8	0
15	S	U	*	*	*	*	8	0	5	0	3	10	3	8
16	S	U	*	*	*	*	2	0	2	0	2	0	1	0
17	E	U	*	*	*	*	17	4	17	4	16	4	15	4
18	E	U	*	*	*	*	2	10	2	10	0	8	0	8
19	E	U	*	*	*	*	6	1	6	1	3	0	1	0
20	E	U	*	*	*	*	5	0	5	0	4	0	5	0
21	N	U	*	*	*	*	9	6	7	6	6	3	7	2
22	N	U	*	*	*	*	5	0	5	0	5	0	5	0
23	N	U	*	*	*	*	6	0	6	0	6	0	6	0
24	N	L	*	*	*	*	20	6	20	5	15	4	16	4
25	N	L	*	*	*	*	1	10	1	10	1	8	1	5
26	N	L	*	*	*	*	5	8	4	7	4	2	4	2

A3.75. 1997 flower and acornet counts for tree 6-8-903 (Continued).

Tag #	*Bearing*	*Crown Section*	*Flower Count 1*	*Acornet Count 1*	*Flower Count 2*	*Acornet Count 2*	*Flower Count 3*	*Acornet Count 3*	*Flower Count 4*	*Acornet Count 4*	*Flower Count 5*	*Acornet Count 5*	*Flower Count 6*	*Acornet Count 6*
27	N	L	*	*	*	*	10	3	10	3	10	2	8	1
28	E	L	*	*	*	*	8	1	7	1	7	1	5	1
29	E	L	*	*	*	*	2	4	2	4	2	3	2	3
30	E	L	*	*	*	*	10	0	9	0	9	0	7	0
31	E	L	*	*	*	*	6	14	6	14	6	13	6	11
	TOTALS						**202**	**101**	**180**	**99**	**156**	**88**	**141**	**78**

*** No data taken for those inventory dates.**

A3.76. 1998 flower counts for tree 6-8-903 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	W	L	4	3	3	3	3	1
2	W	L	1	0	0	0	0	0
3	W	L	0	0	0	0	0	0
4	W	U	0	0	0	0	0	0
5	W	U	4	5	5	5	5	5
6	W	U	2	1	1	1	0	0
7	S	L	1	1	0	0	0	0
8	S	L	1	1	0	0	0	0
9	S	L	1	1	1	1	1	0
10	S	L	2	2	2	2	2	0
11	S	U	2	1	1	1	0	0
12	S	U	2	2	2	2	0	0
13	S	U	9	7	7	7	6	5
14	S	U	7	6	6	6	5	0
15	S	U	0	0	0	0	0	0
16	S	U	1	1	1	1	1	0
17	E	U	14	10	12	11	11	11
18	E	U	0	0	0	0	0	0
19	E	U	1	1	1	1	0	0
20	E	U	5	5	5	4	2	2
21	N	U	4	4	4	3	2	0
22	N	U	5	5	5	4	3	0
23	N	U	4	5	5	5	2	0
24	N	L	16	15	14	7	3	1
25	N	L	0	0	0	0	0	0
26	N	L	4	2	2	2	2	2
27	N	L	8	6	6	5	3	2

A3.76. 1998 flower counts for tree 6-8-903 (Continued).

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
28	E	L	4	4	3	3	1	1
29	E	L	2	0	0	0	0	0
30	E	L	5	3	3	3	1	1
31	E	L	6	4	4	2	2	1
	TOTALS		**115**	**95**	**93**	**79**	**55**	**32**

A3.77. 1997 flower and acornet counts for tree 5-2-582 taken on four inventory dates.

Tag #	Bearing	Crown Section	Flower Count 1	Acornet Count 1	Flower Count 2	Acornet Count 2	Flower Count 3	Acornet Count 3	Flower Count 4	Acornet Count 4	Flower Count 5	Acornet Count 5	Flower Count 6	Acornet Count 6
1	W	U	*	*	*	*	34	1	34	1	29	1	29	1
2	W	U	*	*	*	*	16	14	16	14	17	13	15	12
3	W	U	*	*	*	*	29	0	24	0	23	0	26	0
4	W	L	*	*	*	*	4	0	4	0	4	0	4	0
5	W	L	*	*	*	*	1	2	0	2	0	2	0	2
6	W	L	*	*	*	*	3	1	3	1	3	1	3	1
7	W	L	*	*	*	*	8	4	7	3	6	3	6	3
8	W	L	*	*	*	*	4	0	4	0	4	0	4	0
9	W	L	*	*	*	*	4	5	4	5	3	4	3	4
10	E	U	*	*	*	*	13	14	13	10	13	10	13	10
11	E	U	*	*	*	*	10	2	8	2	8	2	8	2
12	E	L	*	*	*	*	4	8	2	7	3	7	3	7
13	E	L	*	*	*	*	3	8	3	7	3	7	3	7
14	E	L	*	*	*	*	12	5	12	5	12	4	12	4
15	E	L	*	*	*	*	6	6	5	5	5	5	5	5
16	N	L	*	*	*	*	2	9	2	8	2	8	2	7
17	N	L	*	*	*	*	2	6	2	6	2	6	2	5
18	N	L	*	*	*	*	4	1	5	1	4	1	3	1
19	N	U	*	*	*	*	5	12	4	12	4	12	3	11
20	N	U	*	*	*	*	3	11	3	11	1	9	2	7
21	N	U	*	*	*	*	5	17	5	14	5	13	3	12
22	S	L	*	*	*	*	15	5	13	5	15	4	15	4
23	S	L	*	*	*	*	8	0	8	0	8	0	8	0
24	S	L	*	*	*	*	6	7	6	5	6	7	6	7
25	S	L	*	*	*	*	5	0	5	2	6	2	4	2
26	S	L	*	*	*	*	6	2	0	0	0	0	0	0
27	S	L	*	*	*	*	2	2	2	2	2	2	2	2

A3.77. 1997 flower and acornet counts for tree 5-2-582 (Continued).

Tag #	Bearing	Crown Section	Flower Count 1	Acornet Count 1	Flower Count 2	Acornet Count 2	Flower Count 3	Acornet Count 3	Flower Count 4	Acornet Count 4	Flower Count 5	Acornet Count 5	Flower Count 6	Acornet Count 6
28	S	U	*	*	*	*	3	5	3	4	3	4	3	3
29	S	U	*	*	*	*	27	0	22	0	24	0	22	0
30	S	U	*	*	*	*	20	1	20	1	19	0	17	0
31	S	U	*	*	*	*	7	7	7	7	7	7	7	7
32	S	U	*	*	*	*	9	7	9	7	8	6	7	6
	TOTALS						280	162	255	147	249	140	240	132

* No data taken for those inventory dates.

A3.78. 1998 flower counts for tree 5-2-582 taken on six separate inventory dates.

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
1	W	U	26	24	20	20	19	16
2	W	U	12	10	5	3	2	2
3	W	U	17	17	16	14	14	13
4	W	L	4	2	0	0	0	0
5	W	L	0	0	0	0	0	0
6	W	L	1	1	0	0	0	0
7	W	L	6	5	4	4	3	3
8	W	L	4	3	3	3	3	3
9	W	L	2	0	0	0	0	0
10	E	U	13	3	0	0	0	0
11	E	U	8	3	1	0	0	0
12	E	L	1	1	1	1	1	0
13	E	L	1	1	1	1	1	1
14	E	L	12	6	5	5	5	0
15	E	L	5	3	2	2	2	1
16	N	L	2	0	0	0	0	0
17	N	L	2	2	2	2	2	2
18	N	L	3	3	2	0	0	0
19	N	U	2	2	2	2	2	1
20	N	U	0	0	0	0	0	0
21	N	U	4	4	4	3	4	2
22	S	L	12	11	11	10	8	4
23	S	L	6	5	5	5	5	4
24	S	L	6	5	4	5	5	3
25	S	L	5	4	4	4	4	2
26	S	L	0	0	0	0	0	0
27	S	L	2	2	2	2	2	2

A3.78. 1998 flower counts for tree 5-2-582 (Continued).

Tag #	*Bearing*	*Crown Section*	*Flower Count 7*	*Flower Count 8*	*Flower Count 9*	*Flower Count 10*	*Flower Count 11*	*Flower Count 12*
28	S	U	3	3	2	2	2	2
29	S	U	27	14	17	15	12	11
30	S	U	19	14	14	10	10	10
31	S	U	4	4	4	4	4	4
32	S	U	4	4	4	4	4	3
	TOTALS		**213**	**156**	**135**	**121**	**114**	**89**

Part 4

The Effect of Insecticide Applications on Acorn Quality in Northern Red Oak (*Quercus rubra* L.)

Introduction

Improvements in seed yields have been made over the last 30 years as a result of insect control methods, insecticide products and registration, and management strategies (DeBarr 1993). Past seed orchard research generally has concentrated on coniferous species because of the prevalence of seed orchards of various ages and the difficulty of establishing grafted orchards of some hardwood species, particularly *Quercus* species in the Erythrobalanus subgenus. In North America, efforts to establish productive grafted seed orchards of northern red oak (*Quercus rubra* L.) have been highly variable. The grafted clones can experience delayed incompatibility problems, poor growth, and often do not flower (Schlarbaum et al. 1993). Within the past ten years, oak seedling seed orchards have been created from progeny tests as an alternative to grafted orchards (Schlarbaum et al. 1993).

Insects, disease, and other pests commonly attack seed orchard trees and can greatly affect yields of genetically improved seed. Insect predation on acorns has been observed to cause moderate to severe damage to the cotyledonary tissue (Downs and McQuilkin 1944, Beck and Olson 1968, Barber et al. 1995) and can destroy the entire food supply of the future seedling (Korstian 1927). Weevils of the *Curculio* species cause the greatest loss to acorn yields (Downs and McQuilkin 1944, Beck and Olson 1968, Kearby et al. 1986, Gribko 1995) and have the potential to reduce the cotyledons entirely to granular frass (Olson and Boyce 1971, Gibson 1982, Crocker and Morgan

1983, Barber et al. 1995, Gribko and Jones 1995). Most weevil damage occurs in the last stages of the developing acorn, as larvae are typically observed feeding on cotyledonary tissue at the time of acorn collection (Kearby et al. 1986, Bonner and Vozzo 1987). In a northern red oak seedling seed orchard, predation by acorn weevils (*Curculio* spp.) and other insects have impacted developing acorns in the second year of growth (Barber et al. 1995).

The standard method for ascertaining acorn quality is to immerse acorns in water; a sinking acorn is considered viable (Olson 1974). Dissection studies of northern red oak acorns, however, revealed that many of the sinking acorns had variable levels of damage to the cotyledons (Kormanik, personal communication, Gribko and Jones 1995, Barber et al. 1995). Gribko and Jones (1995) found the float test to be more variable for soundness when acorns were infested with weevils as opposed to other damaging insects or pathogens. These studies indicated that the float test is only a crude test for acorn quality, although the majority of the sinking acorns will germinate. Most commercial nurseries commonly use this method to separate "viable" versus "non-viable" acorns before sowing.

In a recent study, Asana XL® insecticide was applied in a northern red oak seedling seed orchard. Acorns were collected from sprayed and control (non-sprayed) half-siblings and evaluated for weevil damage (Barber et al. 1995). Second-year acorn survival on trees treated with Asana XL® was greater compared with untreated trees.

Flower loss over time was demonstrated, with the largest losses occurring in May. Asana XL® did not prevent flower loss, and the causes of which remain undetermined. Large losses of second-year acorns occurring on untreated trees in September are thought to be due to the oviposition period of the acorn weevil (Kearby et al. 1986, Bonner and Vozzo 1987). Barber et al.'s study (1995) showed evidence that spraying an insecticide is effective for controlling losses to second-year acorns.

The Asana XL® study conducted by Barber et al. (1995) compared results between half-siblings of different northern red oak genotypes. An insect population study showed differences in weevil numbers between and within different genetic families of northern red oak (Stanton 1994). This study suggested the amount of weevil damage could be confounded with preference for certain tree genotypes.

A study was designed to remove the genetic variability from an insecticide trial by erecting a partition to divide a tree in half. Specific objectives were to determine: 1) presence and types of damage in acorns from sprayed and control halves of two trees; 2) effectiveness of spraying for damage control; and 3) severity of damage to the cotyledons within individual acorns from sprayed and control treatments.

Materials and Methods

Study Location and Experimental Material

The Tennessee Valley Authority (TVA) established a northern red oak progeny test containing 220 open-pollinated families with eight replications of four tree plots in

1973. Located on the Watauga Ranger District of the Cherokee National Forest, the plantation was situated on 16.2 acres of abandoned farmland in northeast Tennessee. After the TVA discontinued tree improvement research in 1982, the USDA Forest Service, Southern Region assumed responsibility, and the progeny test was converted to a seedling seed orchard in 1987 (La Farge and Lewis 1987).

The orchard was assessed for second-year acorn production prior to bud break in 1997. Two trees with large amounts of second-year acorns were selected for the study. Tree 4-27-100 came from Wise County, VA and was 35 feet (10.6 meters) tall. Anderson County, TN was the origin for tree 8-5-702, which was 40 feet (12.2 meters) tall. Each tree could be readily divided in half by a barrier, thereby creating an opportunity to design an experiment with a spray (insecticide) and control (unsprayed) treatments. Polyethylene tarpaulins were stretched vertically on wires through the approximate middle of each tree and attached to posts on either side of the tree. The tarpaulins were then attached to the trunk of the tree dividing the tree into two halves. The barrier was erected so that the insecticide would not drift to the control side of the tree.

<u>Insecticide Application</u>

One-half of each tree was sprayed with Capture® 2EC Insecticide/Miticide (EPA Reg. No. 279-3069), a synthetic pyrethroid, at the rate of 7.9 ml of Capture® per 2.5 gallons of water. Capture® was selected because of the long-term effectiveness of most synthetic pyrethroid insecticides (Lowe et al. 1994). A common garden sprayer (2.5 gal.) was used to apply the insecticide. Using a 55-ft. bucket truck, spraying began on July 24, 1997 as adult acorn weevils were emerging and ended on September 22, 1997 when emergence generally had ceased. The insecticide was applied only if the wind was less than 10 miles an hour and if no precipitation was expected within thirty minutes after completion. There were a total of four applications, occurring approximately 21 days apart.

Acorn Collection

In mid-September nets were vertically attached to the bottom of the tarpaulins and anchored to the ground using nails and washers. This method was used to keep the falling acorns separate by treatment. The acorns were allowed to mature and fall naturally. Upon removal from the nets, the acorns were submersed in water, and the floating and sinking acorns were separated (Olson 1974). The acorns were collected twice a week (15 collection dates total), bagged, labeled, and kept in cold storage at 2°C (40°F) until dissection.

Acorn Dissection

For each collection date, 50 percent of the floating and sinking acorns were dissected and evaluated for type and severity of damage to the cotyledons. The exterior of each acorn was assessed for the presence of squirrel damage prior to dissection. The acorns were dissected by cutting them in half lengthwise with pruning shears.

Damage to the cotyledons was classified as follows: acorn weevil (*Curculio* spp.), filbertworm [*Cydia latiferreana* (Walsingham)], stony gall wasp, (*Callirhytis fructuosa* Weld.), pip gall wasp [*Callirhytis operator* (O.S.) Beutm.], an unknown species of midge (Family Cecidomyiieae), fungus, and an unspecified disease. The presence of air pockets was also considered to be a specific type of damage. The visual indicators used to assess weevil damage to the cotyledons were presence of frass, weevil larvae, and exit holes in the shell of the acorn. Filbertworm was identified by the presence of larvae and frass. Yellow to brown discoloration indicated disease (unspecified), white mycelium indicated fungus, and white, brittle larval tunnels indicated the presence of stony gall wasp. Midge damage was identified by a brown discoloration of the cotyledon with larvae present. A diamond-shaped scar left beneath the cap identified pip gall. Air pockets were evident inside the acorn as spaces of air between the cotyledon and the pericarp.

The severity of damage was quantified by estimating the percentage of the cotyledon surface area that was either discolored by disease/fungus or consumed by insects. Aborted or undeveloped acorns with shriveled cotyledons were noted but not analyzed. If damage was not present, an acorn was judged as healthy.

Statistical Analyses

Floating/Sinking Acorn Differences

Chi-square analyses were used to evaluate differences in the percentage of floating and sinking acorns between spray and control treatments (α=0.05) (SAS Institute

1996). Analyses were conducted for each tree separately and both trees combined.

Combined Damage

Acorn damage was evaluated for the floating and sinking acorns within treatment (spray and control) for individual trees and the trees combined. Damage was scored as either damage present (1) or no damage (0) for all analyses. Data were analyzed by use of chi-square tests to detect differences in damage for all pests combined ($\alpha=0.05$) (SAS Institute 1996).

Differences in Specific Damage Types

Chi-square tests were used to analyze acorn dissection data for differences in the occurrence of specific damaging agents, as described above, in acorns from the spray and control sides of each tree and for combined trees ($\alpha=0.05$). Damage was scored as either damage present (1) or no damage (0) for each specific type. An additional variable was used to evaluate acorn damage by agents other than weevils.

Differences in the Degree of Damage

General Linear Models (GLM) were used to determine if variation occurred in the percentage of damaged cotyledons between treatments (spray and control) for each tree and combined trees ($\alpha=0.05$) (SAS Institute 1996). Separate analyses were conducted or each damage agent (e.g., acorn weevil) and for all agents combined. Least square means were used to separate the means for each of the seven damage classifications.

Results

Statistical Analyses

Floating/Sinking Acorn Differences

More floaters occurred on the control side for tree 8-5-702 (Table 4.1, test 1, $P<0.0001$). The percentage of sinking acorns on tree 8-5-702 was significantly greater on the spray side (Table 4.1, test 2, $P<0.0001$). No significant differences between sinkers and floaters were found on tree 4-27-100 (Table 4.1, tests 3 and 4, $P=0.129$). However, the results for this tree show 51% of the dissected acorns on the spray side were classified as sinking acorns, compared to 35% on the control side (Table 4.1, test 4, $P=0.129$).

The results from the combined trees were significant for floating and sinking acorn differences, with 53% of the acorns in the spray treatment classified as sinkers (Table 4.1, test 6, $P<0.0001$). In contrast, on the control side, only 28% of the acorns were classified as sinkers. The percentage of floaters on the control side was significantly greater when the trees were combined (Table 4.1, test 5, $P<0.0001$).

Combined Damage

The overall damage to the floating acorns from trees 8-5-702 and 4-27-100 on the spray treatment was significantly lower than the damage on the control side (94% and

Table 4.1. Chi-square analysis of spray and control treatments for percentage of floating and sinking acorns of northern red oak by tree and combined trees.

		Test		***Percentage***		
Tree ID	*Test #*	*Spray*	*Control*	*Spray*	*Control*	*Probability Value*
8-5-702	1	Floaters	Floaters	43	77	5.58E-05
8-5-702	2	Sinkers	Sinkers	56	23	5.58E-05
4-27-100	3	Floaters	Floaters	48	64	0.129
4-27-100	4	Sinkers	Sinkers	51	35	0.129
Combined	5	Floaters	Floaters	46	71	3.39E-05
Combined	6	Sinkers	Sinkers	53	28	3.39E-05

90%, respectively) (Table 4.2, tests 7 and 9, $P<0.0001$ and $P<0.0001$, respectively). Damage to the sinking acorns collected from tree 8-5-702 was significantly greater on the control side than the damage found on the spray treatment (Table 4.2, test 8, $P<0.0001$). In contrast, there was no difference in damage among sinking acorns for the spray and control sides of tree 4-27-100 (Table 4.2, test 10, $P=0.351$). When damage types were combined for both trees, significant differences were found between the spray and control treatments for sinkers and floaters. Significantly less floating acorns were damaged on the spray sides than on the control sides (Table 4.2, test 11, $P<0.0001$). Additionally, there was more damage to the sinking acorns on the control sides than on the spray sides (Table 4.2, test 12, $P<0.0001$).

Differences in Specific Damage Types

The amount of damage varied among different damage types. Floating acorns had significantly less damage by weevils on the spray side (17%) compared with 72% on

Table 4.2. Chi-square analysis of percent damage to floating and sinking acorns of northern red oak by tree and combined trees by damage type and spray and control treatments.

		Test			*Percentage*		
Tree ID	*Test #*	*Spray*	*Control*	*Damage*	*Spray*	*Control*	*Probability Value*
8-5-702	7	floaters	floaters	Overall	50	94	4.66E-06
8-5-702	8	sinkers	sinkers	Overall	25	79	4.74E-04
4-27-100	9	floaters	floaters	Overall	19	90	1.07E-08
4-27-100	10	sinkers	sinkers	Overall	29	44	0.351
Combined	11	floaters	floaters	Overall	36	92	1.21E-13
Combined	12	sinkers	sinkers	Overall	27	60	1.76E-03
8-5-702	13	floaters	floaters	Weevil	17	72	3.81E-07
8-5-702	14	sinkers	sinkers	Weevil	0	29	1.48E-03
4-27-100	15	floaters	floaters	Weevil	3	62	1.03E-07
4-27-100	16	sinkers	sinkers	Weevil	2	13	0.206
Combined	17	floaters	floaters	Weevil	10	68	1.18E-13
Combined	18	sinkers	sinkers	Weevil	1	20	9.80E-04
8-5-702	19	floaters	floaters	Filbert	0	0	error
8-5-702	20	sinkers	sinkers	Filbert	0	0	error
4-27-100	21	floaters	floaters	Filbert	0	3	0.446
4-27-100	22	sinkers	sinkers	Filbert	0	0	error
Combined	23	floaters	floaters	Filbert	0	1	1.000
Combined	24	sinkers	sinkers	Filbert	0	0	error
8-5-702	25	floaters	floaters	Stone gall	0	2	1.000
8-5-702	26	sinkers	sinkers	Stone gall	0	0	error
4-27-100	27	floaters	floaters	Stone gall	11	14	1.000
4-27-100	28	sinkers	sinkers	Stone gall	0	0	error
Combined	29	floaters	floaters	Stone gall	5	7	1.000
Combined	30	sinkers	sinkers	Stone gall	0	0	error
8-5-702	31	floaters	floaters	Disease	28	32	0.815
8-5-702	32	sinkers	sinkers	Disease	25	57	0.049
4-27-100	33	floaters	floaters	Disease	8	21	0.278
4-27-100	34	sinkers	sinkers	Disease	24	38	0.333
Combined	35	floaters	floaters	Disease	18	28	0.248
Combined	36	sinkers	sinkers	Disease	25	47	0.037

Table 4.2. (Continued).

		Test			Percentage		
Tree ID	*Test #*	*Control*	*Spray*	*Damage*	*% Spray*	*% Control*	*Probability Value*
8-5-702	37	floaters	floaters	Pip gall	0	2	1.000
8-5-702	38	sinkers	sinkers	Pip gall	0	0	error
4-27-100	39	floaters	floaters	Pip gall	0	0	error
4-27-100	40	sinkers	sinkers	Pip gall	0	0	error
Combined	41	floaters	floaters	Pip gall	0	1	1.000
Combined	42	sinkers	sinkers	Pip gall	0	0	error
8-5-702	43	floaters	floaters	Air pocket	43	40	1.000
8-5-702	44	sinkers	sinkers	Air pocket	2	0	1.000
4-27-100	45	floaters	floaters	Air pocket	39	31	0.605
4-27-100	46	sinkers	sinkers	Air pocket	3	0	1.000
Combined	47	floaters	floaters	Air pocket	41	37	0.739
Combined	48	sinkers	sinkers	Air pocket	2	0	1.000
8-5-702	49	floaters	floaters	Fungus	0	4	0.497
8-5-702	50	sinkers	sinkers	Fungus	0	0	error
4-27-100	51	floaters	floaters	Fungus	0	0	error
4-27-100	52	sinkers	sinkers	Fungus	2	0	1.000
Combined	53	floaters	floaters	Fungus	0	3	0.497
Combined	54	sinkers	sinkers	Fungus	1	0	1.000
8-5-702	55	floaters	floaters	All-w/o weevil	58	62	0.827
8-5-702	56	sinkers	sinkers	All-w/o weevil	27	57	0.056
4-27-100	57	floaters	floaters	All-w/o weevil	56	45	0.459
4-27-100	58	sinkers	sinkers	All-w/o weevil	26	37	0.517
Combined	59	floaters	floaters	All-w/o weevil	57	55	1.000
Combined	60	sinkers	sinkers	All-w/o weevil	27	47	0.069

the control side of tree 8-5-702 (Table 4.2, test 13, P<0.0001). No weevil damage was found in the sinking acorns on the spray side of tree 8-5-702, while 29% of the sinkers on the control side were damaged (Table 4.2, test 14, P<0.0001). Significant differences were found on the spray side of tree 4-27-100, where only 3% of the floaters were damaged, compared with 62% damage on the control side (Table 4.2, test 15, P<0.0001). No differences in weevil damage to the sinking acorns were found between treatments for tree 4-27-100 (Table 4.2, test16, P=0.206). When data from both trees were combined, there were differences between treatments in weevil damage for both floating and sinking acorns (Table 4.2, tests 17 and 18, P<0.0001 and P<0.0001, respectively).

Disease damage to the sinking acorns was greater on the spray side than the control for tree 8-5-702 (Table 4.2, test 31, P=0.049) and in the combined trees test (Table 4.2, test 36, P=0.037). The other damage classifications, filbertworm, stone gall, pip gall, air pockets, and fungus, did not cause enough damage in either treatment to conduct a valid test. Combined damage excluding weevil effects was not different for floaters or sinkers on either tree or treatment or when the trees were combined.

Differences in the Degree of Damage

Differences were found between trees for weevil damage (P<0.05). The mean amount of weevil damage for tree 8-5-702 was significantly higher than for tree 4-27-100. Treatment effects were significant, with less weevil damage occurring on the spray sides of each tree than the control sides (P<0.0001). The other damage types showed no significant differences between the sprayed side and the control side. Differences were found between sinkers and floaters, with more floaters having weevil damage ($P<0.05$). More floating acorns had weevil damage and stone gall damage than the sinking acorns, and the interaction between treatment and sinkers or floaters was significant for weevil damage ($P<0.0001$).

Discussion

Weevils of the Curculio genus were found to be the primary damaging agents of second-year acorns. This insect decreased the proportion of sinking acorns by consuming maturing cotyledonary tissues. As weevil larvae fed on cotyledons, tunnels were formed and frass was produced, causing the acorns to desiccate (Gribko and Jones 1995). Whether an acorn sank or floated depended on the degree of weevil damage and the presence of exit holes made by the larvae (Gribko and Jones 1995). The overall acorn yield for planting will be reduced as infestation increases, since acorns that float in the water test will be discarded.

Damage from other sources had a negligible effect on acorn yields in either treatment, although the damage caused by these insects can be severe to individual acorns. The insecticide schedule used in this study targeted acorn weevils that emerged in late August (Stanton 1994). Insect populations fluctuate over time, and may be responsible for the lack of damage observed by insects other than weevils. Certain insect populations could have been low when this study was conducted, thereby accounting for a low proportion of damage. Alternatively, populations could have been high prior to acorn collections, and the damaged acorns had already fallen from the trees before collections. Barber et al.'s study (1995) showed a drop in acorn numbers from the start of the growing season to the time of collection, indicating mortality from unknown sources.

Capture® was effective in reducing weevil damage to the acorns in this study, thereby increasing the amount of acorns available for planting. Past research on insecticide control of weevils (Kearby et al. 1986) showed that the insecticides desiccated the acorn tissue. Although some acorns had air pockets, this study revealed no significant differences for air pockets between treatments, indicating that Capture® did not desiccate the cotyledons.

The loss of cotyledonary tissue by insects will affect northern red oak seedling vigor and subsequent growth (Gribko 1995). Protection of acorns from insect damage resulted in more cotyledonary tissue for subsequent germination. In northern red oak, seedling attributes (e.g., height and basal root caliper) are critical to successful regeneration and are proportional to the amount of cotyledonary tissue an acorn has at planting time (Kormanik et al. in press). If an acorn crop were protected from insect predation, the resulting seedlings could develop to its greatest potential under appropriate nursery protocols (Kormanik et al. 1994).

The small amount of weevil damage on the spray side was probably related to the use of a hand sprayer rather than a hydraulic sprayer, and some acorns may have been missed at one time or another. Weevil presence on the spray side may also be due to the spray intervals of approximately 21 days. Tests for effective intervals have not been conducted. Research on pine species shows that monthly sprays are effective for controlling cone insects (Lowe et al. 1994).

Differences in weevil damage to the acorn crop of each tree, as shown by the GLM analysis, validate the findings of Stanton (1994) who found that weevils prefer certain genotypes and support the unique design of the study. Weevil damage was more severe on the control sides of each tree and more severe to the floating acorns in both insecticide and control treatments. Damage assessment was a quantitative measure, whereas floating and sinking acorn categories were qualitative in nature. When evaluating the effectiveness of different insecticides, an analysis to detect quantitative differences among treatments should be conducted rather than evaluation based on qualitative differences. Small differences in insecticide formulations may be detected by the quantitative analysis, which would not be shown by the qualitative analysis. Refinements in chemical formulation of insecticides could be made to increase efficiency. For practical application, however, differences between insecticides must be found among the percentages of sinking acorns, which are the only acorns that will be planted.

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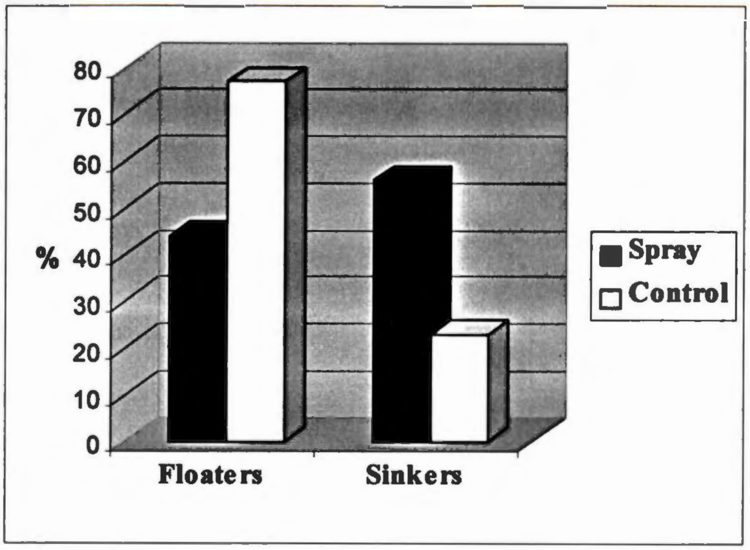
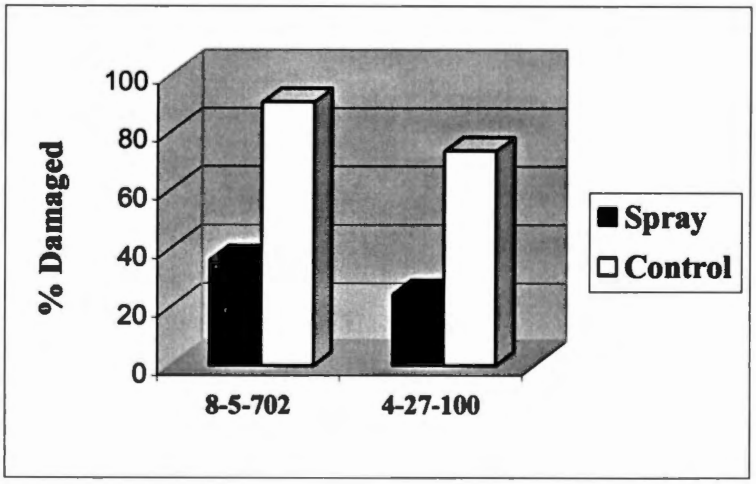
Appendix, Part 4

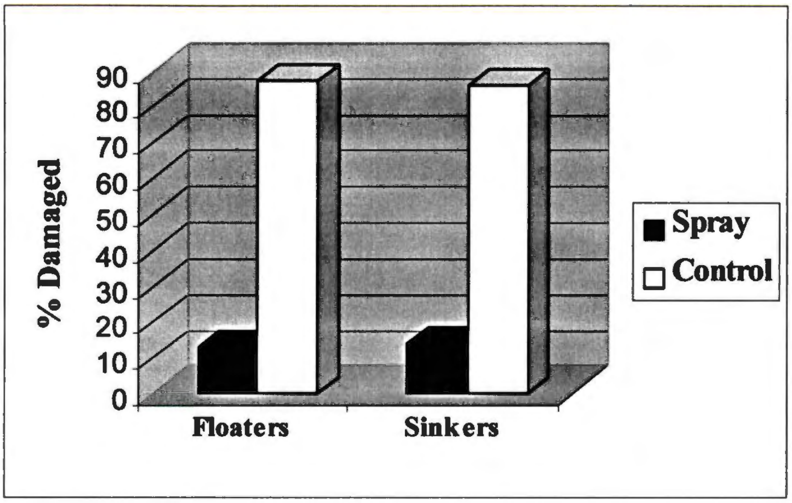
A4.1. Percentage of sinkers and floaters from tree 8-5-702.



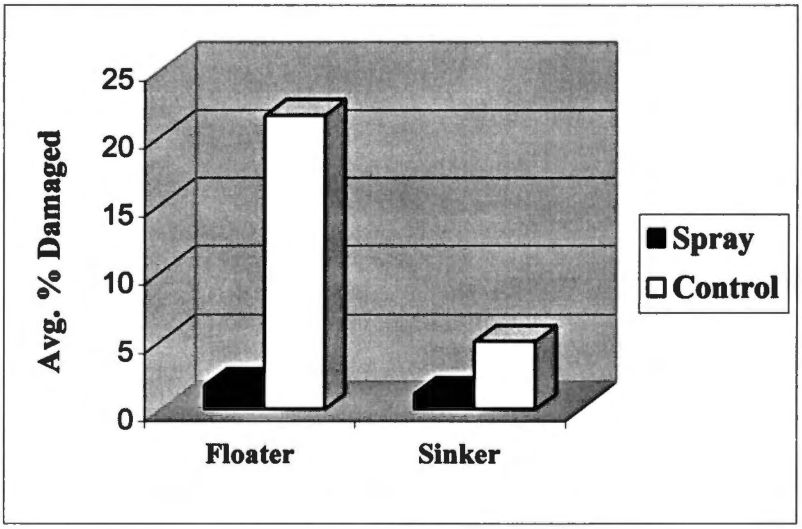
A4.2. Combined damage classifications by tree.



A4.3. Weevil damage for combined trees.



A4.4. Degree of weevil damage for combined trees.



Vita

Lisa Suzanne Post was born on August 5, 1974 in Memphis, Tennessee. She graduated from The Hutchison School in May of 1992. In the Fall of that year, Lisa entered The University of Tennessee in Knoxville, Tennessee, where she graduated in December of 1996 with a Bachelor of Science degree in Forestry, Wildlife and Fisheries. Directly after graduation, she accepted a research assistantship position with the Tennessee Tree Improvement Program under the direction of Dr. Scott Schlarbaum.

Lisa Suzanne Post is certified with the USDA Forest Service as a bucket truck operator and a member of Xi Sigma Pi, a forestry honorary society. She is currently pursuing a career in Forestry.

"SHe wrote one helluva monograph on acorns a few years back, then ... nothin'."