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# Evergreen Tree Species for Urban Use in Eastern Tennessee

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To the Graduate Council:

I am submitting herewith a thesis written by Vivian Orr Potter entitled "Evergreen Tree Species for Urban Use in Eastern Tennessee." I have examined the final electronic 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.

Frank W. Woods, Major Professor

We have read this thesis and recommend its acceptance:

Kenny F. Schell, D. B. Williams

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

I am submitting herewith a thesis written by Vivian Orr Potter entitled "The Suitability of Five Evergreen Tree Species for Urban Use in Eastern Tennessee." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Forestry.

Frank W. Woods

Frank W. Woods, Major Professor

We have read this thesis
and recommend its acceptance:

Kenny F. Schell

D B Williams

Accepted for the Council:

Hilton A. Smith

Vice Chancellor
Graduate Studies and Research

# THE SUITABILITY OF FIVE EVERGREEN TREE SPECIES FOR URBAN USE IN EASTERN TENNESSEE

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Vivian Orr Potter

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ABSTRACT

The objective of this study was to determine which of five tree species was best suited for urban conditions in eastern Tennessee with respect to certain criteria. The species included eastern white pine (Pinus strobus L.), eastern hemlock [Tsuga canadensis (L.) Carr.], Norway spruce [Picea abies (L.) Karst.], southern magnolia (Magnolia grandiflora L.), and eastern red-cedar (Juniperus virginiana L.). The criteria used for comparing the species were resistance to disease, resistance to insect pests, range of soil fertility adaptability, range of soil pH adaptability, and aesthetic appeal.

Questionnaires were sent to nurserymen and landscape architects in Tennessee and adjacent states to determine the importance rating of each criteria on a scale of 0 to 10. Questionnaires were sent to Tennessee nurserymen and landscape architects, ornamental horticulturists, plant pathologists, entomologists, and soil scientists, to determine the rating of each species on a scale of 1 to 5, with respect to all criteria except aesthetic appeal. Aesthetic appeal was determined by interviewing 500 people, using photographs. They were rated on a scale of 1 to 5. Data were evaluated by

quantitative ranking, where the species and criteria importance ratings were used to arrive at a species "score." The species with the highest score was deemed most suitable for urban planting in eastern Tennessee.

Southern magnolia was determined the most suitable tree for urban conditions in Knoxville, Tennessee.

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# INTRODUCTION

The city may be a partially forested area with something that rural forests do not have: skyscrapers, concrete, and asphalt. Trees are an essential part of urban life. They soften the hardness and rigidity of the visual environment, adding interest, color, and scale. But before a tree can play its role, it must withstand the extreme and harsh conditions of the city. Some conditions which can weaken the resistance of trees are smoke and soot on the leaves, insufficient moisture, insufficient room for roots to grow, high intensity reflected sunlight, high temperatures, injuries from pruning, injuries from activities around the tree, wind and ice damage, salt damage, and lack of humus renewal and mulch when litter is removed. Plants must be selected on their ability to tolerate the conditions at poor sites.

This study had as its objective to find one evergreen tree species out of the five most commonly planted evergreens in Knoxville, Tennessee, most adaptable to city conditions, with respect to certain criteria. This is not the only species that should be planted, by any means, but it is one that will be highly suitable for use in Knoxville with respect to certain criteria.

# CHAPTER I

## METHODS

### 1. INTRODUCTION

This study was carried out in several phases:

1. Selection of species to be used;

2. Selection of criteria to be used for rating the species;

3. Construction of the quantitative ranking chart;

4. Canvass of nurserymen and landscape architects to obtain ratings of the criteria used for rating the species as outlined in part 2. above;

5. Canvass of nurserymen, landscape architects, and appropriate professors to obtain ratings of each species with respect to four of the criteria cited in part 2. above;

6. Canvass of 500 persons for the purpose of rating each species as to its relative aesthetic appeal; and

7. Determination of the species which scores highest in the categories outlined in parts 4. and 5. and 6. shown above. The selection of the species and criteria to be used had to be accomplished before the ratings could be obtained for them. Not until ratings

were obtained for the species and criteria could the determination be made of which species scored the highest.

## 2. SPECIES SELECTION

It was decided that this study should deal with those species of trees which were already being used for urban planting in Knoxville. Five species of evergreen trees were selected as the most appropriate species to be studied. These were eastern white pine (Pinus strobus L.), eastern hemlock [Tsuga canadensis (L.) Carr.], Norway spruce [Picea abies (L.) Karst.], southern magnolia (Magnolia grandiflora L.), and eastern redcedar (Juniperus virginiana L.). These species were chosen for the following reasons: (1) evergreen species for their evergreen habit and aesthetic appeal in every season of the year; (2) they were determined to be the five most popular evergreen trees used for landscaping purposes in yards and on the street in Knoxville, Tennessee, by frequency of occurrence; and (3) these species were located in abundance in Knoxville and, therefore, were available for study. These five species were named by Dr. D. B. Williams, Head of the Department of Ornamental Horticulture and Landscape Design at The University of Tennessee in Knoxville, Tennessee. Through years of experience and study in Knoxville, he selected species of evergreens most commonly used for landscaping in Knoxville.

It was important to look at trees already in use for landscaping, instead of unknown species that would probably not be used even if discovered to be highly suitable for urban use. As these species were the most commonly found evergreens in Knoxville, there were many individual specimens available for study throughout the city.

## 3. CRITERIA FOR COMPARING SPECIES

The selection of criteria to be used in comparing these five evergreen species was the next phase. Of the many factors of the urban environment which could affect these tree species and determine their ultimate fate in the city environment, six criteria were selected:

1. Resistance to fatality or serious injury by disease.
2. Resistance to fatality or serious injury by insects.
3. Range of soil fertility adaptability.
4. Range of soil pH adaptability.
5. Aesthetic appeal.

Disease and insect resistance are necessary for the survival of any tree. Attacks by pathogens and insects can kill a healthy tree and especially one under the stress of urban conditions. Damage by wind, ice, pruning wounds, vandalism, and accidental wounds can weaken the

resistance of trees and provide entrances for pathogens and insects. Resistance to fatality or serious injury by diseases and insects is extremely important in determining a tree's chances of survival.

Soil fertility and soil pH adaptability, while they may not be as obviously important as disease and insect resistance, may determine the ultimate survival of a city tree. A tree with a narrow range of soil fertility requirements, such as a very rich, moist soil, will not grow well and may perhaps die on a dry, rocky site. Likewise, a species which can grow well only in very acidic soil, would not succeed in an area of alkaline soils. A species which can grow well on a wide range of soil fertility and soil pH is needed in city conditions, where extremes are common.

Aesthetic appeal is an intangible factor on which more and more emphasis is being placed in urban society. Aesthetics is a sense of the beautiful, which is a personal experience. A valuable urban tree is one which can touch the souls of those who pass by it and perhaps make their day go a little bit better for having seen it. The urban community has a limited number of trees, and those few must be aesthetically satisfying and appealing.

Other criteria, perhaps, could have been studied instead of those selected, such as: soil moisture adaptability, resistance to ice damage, wind damage,

salt damage, resistance to heat and glaring sun, and ability to withstand the lack of humus renewal. These factors should be considered along with those included in this study before a tree is placed in the urban community. Only those criteria considered most essential for survival were studied, mainly for reasons of time.

## 4. CONSTRUCTION OF THE QUANTITATIVE RANKING CHART

A simple procedure used in operations research that is used for ranking management objectives (Farmer, 1973; Churchman, 1957, p. 150) called "quantitative ranking" was adopted to integrate quantitative information and the opinions of experienced individuals around key elements of species selection. These key elements are the criteria by which each species is judged. For example, aesthetic appeal is a key element of species selection in this study. In quantitative ranking, certain criteria, such as the criteria chosen for comparing species, are rated numerically according to their importance, and these ratings are called importance values. Qualified individuals are asked to judge each criteria as to its importance for the particular use being undertaken on a scale. Each species is then rated numerically in the same manner, according to the judgment of qualified individuals or available quantitative information. These species ratings are then multiplied by importance values given to the

criteria, and the products summed to arrive at a score for each species. These figures are set up in a chart as shown in Figure 1. In this study, a numerical rating is assigned each criterion, on a scale of 0 to 10, with 10 being the highest rating. Each of the five species is assigned a rating with respect to each criterion. These species are rated on a scale of 1 to 5, with 5 being the highest rating.

## 5. RATING OF CRITERIA FOR COMPARING SPECIES

Persons with practical knowledge and experience were consulted to determine the five criteria for comparing species. These individuals are constantly in the process of dealing with urban trees, either planting them or advising others, and learn what is essential to the tree's survival. For this reason they are probably the best qualified to judge the importance of various criteria in determining the feasibility of city planting.

Questionnaires were sent to 162 Tennessee nurserymen, 18 out-of-state nurserymen, 25 Tennessee landscape architects, and 49 out-of-state landscape architects (see Appendix, page 81) to bring the total to 254. No reference was made to tree species in the questionnaire. The letter merely listed the five criteria for comparing the species and asked the individual to rate each on a scale of 0 to 10.

Table __.

| Species | Criteria | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Disease Resistance | | Insect Resistance | | Soil Fertility Adaptability | | pH Adaptability | | Aesthetic Appeal | | |
| | Average Rating | Importance Value | Average Rating | Importance Value | Average Rating | Importance Value | Average Rating | Importance Value | Average Rating | Importance Value | Total Score |
| White pine | | | | | | | | | | | |
| Eastern hemlock | | | | | | | | | | | |
| Norway spruce | | | | | | | | | | | |
| Southern magnolia | | | | | | | | | | | |
| Eastern redcedar | | | | | | | | | | | |

Figure 1. Ranking of five evergreen tree species for urban planting in eastern Tennessee.

Four other criteria were added to the list of criteria in the questionnaire in order to generate a more complete opinion: noise abatement, sulfur dioxide pollution resistance, nitrogen oxide pollution resistance, and use by wildlife. These criteria were never intended to be included in this study but were added to mask the five criteria of primary interest, giving these individuals a more complete list from which to select and assign accurate ratings. With the letter describing the study and giving instructions, which can be found in the Appendix, page 81, was included an addressed postcard which was coded to determine the group of which the respondent was a member.

## 6. RATING OF SPECIES WITH RESPECT TO FOUR OF THE CRITERIA

As with the selection criteria, the literature has extremely little to offer on the subject of comparison of species as to their disease resistance, insect resistance, soil fertility adaptability, and soil pH adaptability. Therefore, it was again necessary to turn to individuals qualified in their field, and who had a knowledge of these five species and the four criteria mentioned above. It was decided that university professors, nurserymen, and landscape architects would be the best qualified to compare these five species with respect

to the four criteria. Included were nurserymen and landscape architects from the state of Tennessee and ornamental horticulturists, entomologists, plant pathologists, and soil scientists from universities in the Southeast (U. S. Department of Agriculture, 1975). Each group of individuals received different questionnaires. Nurserymen, landscape architects, and ornamental horticulturists were requested to rate each species as to its disease resistance, insect resistance, soil fertility adaptability, and soil pH adaptability.

Plant pathologists were asked to rate each species as to its disease resistance. The entomologists were asked to judge each species as to its insect resistance, and soils professors were questioned concerning the two soils criteria. A total of 340 letters was sent.

Seventy-five ornamental horticulturists were sent a questionnaire which contained an explanatory letter, a form for rating the species, and a self-addressed, stamped envelope. Both the form and the letter can be found in the Appendix, pages 81 and 82.

In order to lend a greater degree of practicality and experience to the survey, the same Tennessee nurserymen and landscape architects who were contacted for rating the six criteria received a letter similar to that received by the ornamental horticulturists, requesting that they rate each species with respect to all four

criteria. One hundred sixty nurserymen and landscape architects in the state of Tennessee were sent a letter (see Appendix, page 83) requesting them to rate each species with respect to disease resistance, insect resistance, soil fertility adaptability, and soil pH adaptability. Each of 38 entomologists from universities in the same states as the ornamental horticulturists were questioned as to the resistance of the five tree species to insect attack (see Appendix, page 84). Each of 38 plant pathologists at these universities was requested to rate the species on the basis of their disease resistance (see Appendix, page 84).

It was necessary to seek out soil scientists who would have knowledge of these five species of trees and their soil fertility and pH adaptability ranges. Probably few soil scientists have knowledge of forest trees, except those who study forest soils or those who teach in Forestry departments. In all universities that were included in this study, only nine professors were listed in college directories as being forest soils professors. Only these were considered qualified to complete questionnaires requesting a rating for each species with respect to soil fertility adaptability and soil pH adaptability. These nine forest soil scientists were sent a letter (see Appendix, page 85).

## 7. RATING OF SPECIES WITH RESPECT TO AESTHETIC APPEAL

In an area like the city where trees are in limited supply, each one must be aesthetically beautiful to the majority of the people who see it. In order to determine how each of the five trees in this study rates with respect to aesthetic appeal, three photographs were taken of typical representatives of each tree species, the average height being 30 feet. The first set of photographs were made in black and white and were taken from a distance of 30 feet. The second set of photographs was also black and white and was taken at a distance of 12 feet. The third set of photographs was made in color and was taken approximately one foot away in order to show the foliage in detail (see Appendix, Figures 2-16).

A random sample of 500 members of the general public was deemed sufficient as an indicator of aesthetic preference. A sample of 300 individuals was questioned at Sears in Westown Shopping Mall in Knoxville, and a sample of 200 people was questioned at King's Department Store, Chapman Highway, in Knoxville. Individuals were questioned in the morning, afternoon, and evening on each day of the week at both locations.

Each individual was asked to look at each photograph and rate each tree on a scale of 1 to 5, with 5

being the best rating. After approximately 10 persons had completed the rating, the order of the five photographs in each group was changed; however, the order of the groups themselves did not change.

## 8. DETERMINING THE HIGHEST SCORING SPECIES

As discussed earlier in Section 4, page 6, "Construction of the Quantitative Ranking Chart," each criterion was weighted and then each species was rated with respect to each criteria. Results were placed in the quantitative ranking chart. For each tree, the species rating was multiplied with its respective criterion rating. The resulting sum of these five products produced the total score. After scores for all five species were tabulated, species which scored the highest were easily discernible.

# CHAPTER II

## RESULTS

All data were subjected to a Chi-Square test of independence. Two-dimensional contingency tables are presented for each comparison in this chapter. Data were programmed with whole integers but are presented as percentages to facilitate interpretation. Each test was performed at a 5 percent significance level.

Averaged ratings from each group and its total are presented in the Appendix (Tables 27-32). These figures are useful only in the final quantitative ranking chart (page 36).

### 1. RATINGS OF CRITERIA FOR COMPARING SPECIES

Of the 254 nurserymen and landscape architects contacted for the purpose of rating each of the five criteria on a scale of 0 to 10, 90 responded--31 Tennessee nurserymen, 5 out-of-state nurserymen, 18 Tennessee landscape architects, and 36 out-of-state landscape architects.

Table 1 presents ratings of the criteria by 31 Tennessee nurserymen. The criteria are listed in the left-hand column, and the ratings range from "No Knowledge" to "10" across the table. The values are percentages, with the highest being underlined. Disease resistance and

Table 1. Ratings of Criteria Importance Based on Evaluation by 31 Tennessee Nurserymen[a]: Values Are Percentages of All Respondents.

| Criteria | Ratings[b] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No Knowledge | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
| Disease resistance | 0.0 | 3.2 | 0.0 | 0.0 | 3.2 | 0.0 | 6.5 | 12.9 | 3.2 | 22.6 | 22.6 | <u>25.8</u> | 100.0 |
| Insect resistance | 3.2 | 3.2 | 0.0 | 0.0 | 3.2 | 0.0 | 3.2 | 6.5 | 12.9 | <u>29.1</u> | 22.6 | 16.1 | 100.0 |
| Soil fertility adaptability | 6.5 | 0.0 | 0.0 | 3.2 | 3.2 | 6.5 | <u>38.6</u> | 3.2 | 9.7 | 9.7 | 9.7 | 9.7 | 100.0 |
| Soil pH adaptability | 16.1 | 0.0 | 0.0 | 3.2 | 3.2 | 6.5 | <u>35.5</u> | 12.9 | 9.7 | 3.2 | 6.5 | 3.2 | 100.0 |
| Aesthetic appeal | 0.0 | 0.0 | 3.2 | 0.0 | 3.2 | 3.2 | 16.1 | 3.2 | 6.5 | 12.9 | 9.7 | <u>42.0</u> | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the criterion.

aesthetic appeal receive the highest rating (10), while soil fertility and soil pH receive the lowest (5).

The Chi-Square test on the data obtained from the five out-of-state nurserymen (Table 2) was not significant at the 5 percent level of significance. Table 3 presents the ratings of the five criteria as determined by 18 Tennessee landscape architects. Aesthetic appeal was rated highest, and soil pH was the lowest.

Table 4 represents the ratings obtained from 36 out-of-state landscape architects. Both soil fertility and aesthetic appeal receive the highest rating of 10 as does disease resistance, while soil pH is rated 5.

Table 5 is a combination of the ratings by all four groups, with respect to the importance of five criteria. The highest rated criteria is aesthetic appeal, with the highest percentage of ratings being 10. Soil fertility and soil pH are the poorest of the criteria, being rated 5 most frequently.

## 2. RATINGS OF SPECIES WITH RESPECT TO FOUR OF THE CRITERIA

Of the 340 questionnaires sent to professors, nurserymen, and landscape architects for the purpose of rating the five tree species with respect to disease resistance, insect resistance, soil fertility adaptability, and soil pH adaptability, 133 were returned.

Table 2. Ratings of Criteria Importance Based on Evaluation by Five Out-of-State Nurserymen[a]: Values Are Percentages of All Respondents.

| Criteria | Ratings[b] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No Knowledge | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
| Disease resistance | 0.0 | 20.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 20.0 | 40.0 | 0.0 | 40.0 | 100.0 |
| Insect resistance | 0.0 | 0.0 | 0.0 | 0.0 | 20.0 | 0.0 | 20.0 | 40.0 | 0.0 | 20.0 | 0.0 | 20.0 | 100.0 |
| Soil fertility adaptability | 0.0 | 0.0 | 20.0 | 0.0 | 0.0 | 20.0 | 40.0 | 0.0 | 0.0 | 0.0 | 0.0 | 20.0 | 100.0 |
| Soil pH adaptability | 0.0 | 0.0 | 40.0 | 20.0 | 0.0 | 0.0 | 20.0 | 0.0 | 0.0 | 0.0 | 0.0 | 20.0 | 100.0 |
| Aesthetic appeal | 20.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 20.0 | 60.0 | 100.0 |

[a]Not significant at the 0.05 level.

[b]Underlined percentages are the highest for the criterion.

Table 3. Ratings of Criteria Importance Based on Evaluation by 18 Tennessee Landscape Architects[a]: Values Are Percentages of All Respondents.

| Criteria | Ratings[b] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No Knowledge | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
| Disease resistance | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.3 | 0.0 | 5.3 | 47.4 | 26.3 | 15.7 | 100.0 |
| Insect resistance | 0.0 | 0.0 | 0.0 | 0.0 | 5.3 | 0.0 | 5.3 | 0.0 | 5.3 | 42.1 | 31.5 | 10.5 | 100.0 |
| Soil fertility adaptability | 10.5 | 0.0 | 5.3 | 0.0 | 15.8 | 5.3 | 10.5 | 10.5 | 26.3 | 10.5 | 0.0 | 5.3 | 100.0 |
| Soil pH adaptability | 0.0 | 0.0 | 5.3 | 5.3 | 15.8 | 0.0 | 26.3 | 5.3 | 15.7 | 5.3 | 15.7 | 5.3 | 100.0 |
| Aesthetic appeal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.3 | 15.7 | 10.5 | 68.4 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the criterion.

Table 4. Ratings of Criteria Importance Based on Evaluation by Out-of-State Landscape Architects[a]: Values Are Percentages of All Respondents.

| Criteria | Ratings[b] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No Knowledge | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
| Disease resistance | 0.0 | 0.0 | 0.0 | 0.0 | 2.8 | 0.0 | 13.9 | 0.0 | 13.9 | 19.4 | 22.2 | 27.8 | 100.0 |
| Insect resistance | 0.0 | 0.0 | 2.8 | 2.8 | 0.0 | 0.0 | 13.9 | 8.3 | 11.1 | 25.0 | 19.4 | 16.7 | 100.0 |
| Soil fertility adaptability | 2.7 | 8.3 | 5.6 | 5.6 | 8.3 | 11.1 | 11.1 | 2.8 | 13.9 | 5.6 | 8.3 | 16.7 | 100.0 |
| Soil pH adaptability | 0.0 | 5.6 | 8.3 | 0.0 | 16.7 | 8.3 | 24.9 | 5.6 | 11.1 | 13.9 | 0.0 | 5.6 | 100.0 |
| Aesthetic appeal | 0.0 | 0.0 | 2.8 | 0.0 | 2.8 | 2.8 | 0.0 | 2.8 | 2.8 | 8.3 | 16.7 | 61.1 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the criterion.

Table 5. Ratings of Criteria Importance Based on Evaluation by Tennessee Nurserymen, Out-of-State Nurserymen, Tennessee Landscape Architects, and Out-of-State Landscape Architects[a]: Values Are Percentages of All Respondents.

| Criteria | Ratings[b] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No Knowledge | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
| Disease resistance | 0.0 | 1.1 | 0.0 | 0.0 | 2.2 | 0.0 | 8.8 | 4.4 | 8.8 | 27.4 | 22.0 | 25.3 | 100.0 |
| Insect resistance | 1.1 | 1.1 | 1.1 | 1.1 | 2.2 | 0.0 | 8.8 | 7.7 | 9.9 | 29.7 | 22.0 | 15.3 | 100.0 |
| Soil fertility adaptability | 5.5 | 4.4 | 4.4 | 3.3 | 7.7 | 7.7 | 22.0 | 4.4 | 14.3 | 7.7 | 6.6 | 12.0 | 100.0 |
| Soil pH adaptability | 5.5 | 4.4 | 4.4 | 3.3 | 11.0 | 5.5 | 28.5 | 7.7 | 11.0 | 7.7 | 5.5 | 5.5 | 100.0 |
| Aesthetic appeal | 0.0 | 1.1 | 2.2 | 0.0 | 2.2 | 2.2 | 5.5 | 2.2 | 4.4 | 11.0 | 13.2 | 56.0 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the criterion.

## Disease Resistance

Table 6 presents the ratings of the five species by nurserymen and landscape architects. Magnolia and eastern redcedar received the highest rating of 5 most frequently, while hemlock received ratings of 2 and 4.

Table 7 presents species ratings for disease resistance by the ornamental horticulturists. Eastern redcedar received the best rating of 5, while white pine received the poorest rating of 1.

Presented in Table 8 are ratings of the five species by plant pathologists. Hemlock and magnolia were rated the highest, while the other three species were rated 2 most frequently.

Table 9 presents the ratings of all three groups combined, with respect to disease resistance. Magnolia and redcedar received the highest rating, while hemlock was rated 2, 3, and 4 most often.

## Insect Resistance

Table 10 shows the rating of the five tree species by nurserymen and landscape architects, with respect to insect resistance. Magnolia received the greatest percentage under 5, the highest rating. White pine received the greatest percentage under 2, which was the lowest rating.

The data presented in Table 11 are the ratings of

Table 6. Relative Disease Resistance of Five Tree Species According to 33 Nurserymen and Landscape Architects[a]: Values Are Percentages of All Respondents.

| | Ratings[b] | | | | | | |
|---|---|---|---|---|---|---|---|
| Species | No Knowledge | 1 | 2 | 3 | 4 | 5 | Total |
| White pine | 3.0 | 18.2 | 15.2 | 33.3 | 21.2 | 9.1 | 100.0 |
| Hemlock | 6.1 | 3.0 | 30.3 | 21.2 | 30.3 | 9.1 | 100.0 |
| Spruce | 3.0 | 21.2 | 15.2 | 21.2 | 24.2 | 15.2 | 100.0 |
| Magnolia | 0.0 | 15.2 | 6.0 | 9.1 | 12.1 | 57.6 | 100.0 |
| Redcedar | 12.1 | 12.1 | 3.0 | 24.3 | 18.2 | 30.3 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

Table 7. Relative Disease Resistance of Five Tree Species According to 37 Ornamental Horticulturists[a]: Values Are Percentages of All Respondents.

| | Ratings[b] | | | | | | |
|---|---|---|---|---|---|---|---|
| Species | No Knowledge | 1 | 2 | 3 | 4 | 5 | Total |
| White pine | 32.5 | 21.6 | 13.5 | 16.2 | 13.5 | 2.7 | 100.0 |
| Hemlock | 51.4 | 2.7 | 10.8 | 16.2 | 10.8 | 8.1 | 100.0 |
| Spruce | 54.1 | 10.8 | 2.7 | 16.2 | 10.8 | 5.4 | 100.0 |
| Magnolia | 10.8 | 0.0 | 0.0 | 8.1 | 37.8 | 43.3 | 100.0 |
| Redcedar | 8.1 | 5.4 | 13.5 | 16.2 | 32.5 | 24.3 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

Table 8. Relative Disease Resistance of Five Tree Species According to 32 Plant Pathologists[a]: Values Are Percentages of All Respondents.

| Species | No Knowledge | Ratings[b] 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|---|
| White pine | 18.2 | 24.2 | 27.3 | 18.2 | 12.1 | 0.0 | 100.0 |
| Hemlock | 21.2 | 18.2 | 12.1 | 15.2 | 12.1 | 21.2 | 100.0 |
| Spruce | 30.3 | 3.0 | 27.3 | 15.2 | 18.2 | 6.0 | 100.0 |
| Magnolia | 9.1 | 6.0 | 6.0 | 18.2 | 12.1 | 48.6 | 100.0 |
| Redcedar | 6.0 | 6.0 | 24.4 | 21.2 | 21.2 | 21.2 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

Table 9. Relative Disease Resistance of Five Tree Species According to Nurserymen, Landscape Architects, Ornamental Horticulturists, and Plant Pathologists[a]: Values Are Percentages of All Respondents.

| Species | No Knowledge | Ratings[b] 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|---|
| White pine | 18.5 | 21.4 | 18.5 | 22.3 | 15.5 | 3.8 | 100.0 |
| Hemlock | 27.2 | 7.7 | 17.5 | 17.5 | 17.5 | 12.6 | 100.0 |
| Spruce | 30.1 | 11.6 | 14.6 | 17.5 | 17.5 | 8.7 | 100.0 |
| Magnolia | 6.8 | 6.8 | 3.9 | 11.6 | 21.4 | 49.5 | 100.0 |
| Redcedar | 8.7 | 7.7 | 13.6 | 20.4 | 24.3 | 25.3 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

Table 10. Relative Insect Resistance of Five Tree Species According to 33 Nurserymen and Landscape Architects[a]: Values Are Percentages of All Respondents.

| Species | No Knowledge | Ratings[b] 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|---|
| White pine | 3.0 | 18.2 | 33.3 | 27.3 | 12.2 | 6.0 | 100.0 |
| Hemlock | 9.1 | 9.1 | 15.2 | 42.3 | 15.2 | 9.1 | 100.0 |
| Spruce | 9.1 | 6.0 | 24.2 | 24.2 | 27.4 | 9.1 | 100.0 |
| Magnolia | 0.0 | 12.1 | 0.0 | 12.1 | 18.2 | 57.6 | 100.0 |
| Redcedar | 9.1 | 18.2 | 9.1 | 27.3 | 15.2 | 21.1 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

Table 11. Relative Insect Resistance of Five Tree Species According to 37 Ornamental Horticulturists[a]: Values Are Percentages of All Respondents.

| Species | No Knowledge | Ratings[b] 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|---|
| White pine | 35.2 | 21.6 | 8.1 | 16.2 | 13.5 | 5.4 | 100.0 |
| Hemlock | 48.7 | 2.7 | 2.7 | 16.2 | 24.3 | 5.4 | 100.0 |
| Spruce | 51.4 | 8.1 | 8.1 | 18.9 | 13.5 | 0.0 | 100.0 |
| Magnolia | 10.8 | 0.0 | 0.0 | 8.1 | 35.1 | 46.0 | 100.0 |
| Redcedar | 8.1 | 8.1 | 18.9 | 29.8 | 21.6 | 13.5 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

the species by ornamental horticulturists, for relative insect resistance. Magnolia was again rated the highest, with white pine once again taking last place, being rated 1 most often.

Table 12 represents ratings by entomologists of the five species as to their insect resistance. Again magnolia was rated 5 most frequently to take first place, and white pine was rated 2 most frequently to take last place.

The combined rating of the three groups can be found in Table 13. Magnolia was rated 5 most frequently, while white pine was rated 2 and takes last place.

Soil Fertility Adaptability

Those ratings obtained from the nurserymen and landscape architects did not prove to be within the 5 percent significance level of the Chi-Square test (Table 14). Table 15 presents the species' ratings by ornamental horticulturists, with respect to soil fertility adaptability. Eastern redcedar was rated 5 most frequently and, therefore, was considered the best of the five species. Eastern hemlock was considered the poorest, as it was rated 2 most often.

As with the nurserymen and landscape architects, the soil scientists did not respond differently enough to satisfy the Chi-Square test of independence

Table 12. Relative Insect Resistance of Five Tree Species According to 26 Entomologists[a]: Values Are Percentages of All Respondents.

| Species | Ratings[b] | | | | | | |
|---|---|---|---|---|---|---|---|
| | No Knowledge | 1 | 2 | 3 | 4 | 5 | Total |
| White pine | 26.9 | 11.5 | 26.9 | 15.4 | 11.5 | 7.8 | 100.0 |
| Hemlock | 38.5 | 3.9 | 11.5 | 11.5 | 30.7 | 3.9 | 100.0 |
| Spruce | 34.7 | 0.0 | 15.4 | 19.2 | 19.2 | 11.5 | 100.0 |
| Magnolia | 19.1 | 3.9 | 3.9 | 15.4 | 15.4 | 42.3 | 100.0 |
| Redcedar | 15.4 | 11.5 | 15.4 | 7.7 | 42.3 | 7.7 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

Table 13. Relative Insect Resistance of Five Tree Species According to Nurserymen, Landscape Architects, Ornamental Horticulturists, and Entomologists[a]: Values Are Percentages of All Respondents.

| Species | Ratings[b] | | | | | | |
|---|---|---|---|---|---|---|---|
| | No Knowledge | 1 | 2 | 3 | 4 | 5 | Total |
| White pine | 21.9 | 17.7 | 21.9 | 19.8 | 12.5 | 6.2 | 100.0 |
| Hemlock | 32.3 | 5.2 | 9.4 | 24.0 | 22.9 | 6.2 | 100.0 |
| Spruce | 32.3 | 5.2 | 15.7 | 20.8 | 19.8 | 6.2 | 100.0 |
| Magnolia | 9.4 | 5.2 | 1.0 | 11.4 | 24.0 | 49.0 | 100.0 |
| Redcedar | 10.4 | 12.5 | 14.6 | 22.9 | 25.0 | 14.6 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

Table 14. Relative Soil Fertility Adaptability of Five Tree Species According to 33 Nurserymen and Landscape Architects[a]: Values Are Percentages of All Respondents.

| Species | Ratings[b] | | | | | | |
|---|---|---|---|---|---|---|---|
| | No Knowledge | 1 | 2 | 3 | 4 | 5 | Total |
| White pine | 3.0 | 12.1 | 21.2 | 15.2 | 36.4 | 12.1 | 100.0 |
| Hemlock | 9.1 | 9.1 | 27.3 | 27.3 | 18.1 | 9.1 | 100.0 |
| Spruce | 6.1 | 6.1 | 24.2 | 30.3 | 21.2 | 12.1 | 100.0 |
| Magnolia | 0.0 | 15.2 | 12.1 | 27.3 | 21.2 | 24.2 | 100.0 |
| Redcedar | 12.1 | 9.1 | 15.2 | 12.1 | 15.2 | 36.3 | 100.0 |

[a]Not significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

Table 15. Relative Soil Fertility Adaptability of Five Tree Species According to 37 Ornamental Horticulturists[a]: Values Are Percentages of All Respondents.

| Species | Ratings[b] | | | | | | |
|---|---|---|---|---|---|---|---|
| | No Knowledge | 1 | 2 | 3 | 4 | 5 | Total |
| White pine | 37.9 | 8.1 | 2.7 | 29.7 | 18.9 | 2.7 | 100.0 |
| Hemlock | 56.8 | 5.4 | 16.2 | 13.5 | 5.4 | 2.7 | 100.0 |
| Spruce | 56.8 | 10.8 | 5.4 | 18.9 | 8.1 | 0.0 | 100.0 |
| Magnolia | 10.9 | 8.1 | 8.1 | 29.7 | 21.6 | 21.6 | 100.0 |
| Redcedar | 10.9 | 0.0 | 16.2 | 10.8 | 21.6 | 51.5 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

(Table 16). Table 17 is a combination of the responses from all three groups. Redcedar was again rated the highest of the species, while hemlock again took last place with the most frequent ratings being 2 and 3.

Soil pH Adaptability

Table 18 represents the results of questionnaires sent to nurserymen and landscape architects, who rated each species as to its range of soil pH adaptability. Both magnolia and redcedar received the best rating, while hemlock and spruce received ratings of 3.

Table 19 shows the species' ratings for soil pH adaptability by the ornamental horticulturists. Redcedar received the rating of 5 most often. However, three species received the lowest rating which was 3--white pine, hemlock, and spruce.

The contributions of the soil scientists were not proven to have enough independence from each other, as determined by the Chi-Square test of independence (Table 20). All of the responses are combined in Table 21 to give a total picture of the species' adapting capabilities. Again redcedar stood alone as being the most highly rated species, with three other species having ratings of 3--white pine, hemlock, and spruce.

Table 16. Relative Soil Fertility Adaptability of Five Tree Species According to Five Soil Scientists[a]: Values Are Percentages of All Respondents.

| | Ratings[b] | | | | | | |
|---|---|---|---|---|---|---|---|
| Species | No Knowledge | 1 | 2 | 3 | 4 | 5 | Total |
| White pine | 20.0 | 0.0 | 20.0 | 20.0 | 20.0 | 20.0 | 100.0 |
| Hemlock | 20.0 | 20.0 | 20.0 | 40.0 | 0.0 | 0.0 | 100.0 |
| Spruce | 20.0 | 20.0 | 20.0 | 0.0 | 40.0 | 0.0 | 100.0 |
| Magnolia | 0.0 | 40.0 | 60.0 | 0.0 | 0.0 | 0.0 | 100.0 |
| Redcedar | 0.0 | 40.0 | 0.0 | 0.0 | 0.0 | 60.0 | 100.0 |

[a]Not significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

Table 17. Relative Soil Fertility Adaptability of Nurserymen, Landscape Architects, Ornamental Horticulturists, and Soil Scientists[a]: Values Are Percentages of All Respondents.

| | Ratings[b] | | | | | | |
|---|---|---|---|---|---|---|---|
| Species | No Knowledge | 1 | 2 | 3 | 4 | 5 | Total |
| White pine | 21.3 | 9.3 | 12.0 | 22.7 | 26.7 | 8.0 | 100.0 |
| Hemlock | 33.3 | 8.0 | 21.3 | 21.3 | 10.8 | 5.3 | 100.0 |
| Spruce | 32.0 | 9.3 | 14.7 | 22.7 | 16.0 | 5.3 | 100.0 |
| Magnolia | 5.3 | 13.3 | 13.3 | 26.8 | 20.0 | 21.3 | 100.0 |
| Redcedar | 10.8 | 6.7 | 9.3 | 10.8 | 17.2 | 45.3 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

Table 18. Relative Soil pH Adaptability of Five Tree Species According to 33 Nurserymen and Landscape Architects[a]: Values Are Percentages of All Respondents.

| | Ratings[b] | | | | | | |
|---|---|---|---|---|---|---|---|
| Species | No Knowledge | 1 | 2 | 3 | 4 | 5 | Total |
| White pine | 21.2 | 9.1 | 12.1 | 21.2 | 24.3 | 12.1 | 100.0 |
| Hemlock | 27.3 | 9.1 | 9.1 | 36.3 | 15.2 | 3.0 | 100.0 |
| Spruce | 21.2 | 3.0 | 18.2 | 39.4 | 12.1 | 6.1 | 100.0 |
| Magnolia | 15.1 | 6.1 | 15.1 | 24.3 | 15.1 | 24.3 | 100.0 |
| Redcedar | 24.3 | 12.1 | 3.0 | 12.1 | 6.1 | 42.4 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

Table 19. Relative Soil pH Adaptability of Five Tree Species According to 37 Ornamental Horticulturists[a]: Values Are Percentages of All Respondents.

| | Ratings[b] | | | | | | |
|---|---|---|---|---|---|---|---|
| Species | No Knowledge | 1 | 2 | 3 | 4 | 5 | Total |
| White pine | 40.5 | 5.4 | 8.1 | 27.1 | 13.5 | 5.4 | 100.0 |
| Hemlock | 54.1 | 5.4 | 13.5 | 16.2 | 10.8 | 0.0 | 100.0 |
| Spruce | 64.9 | 5.4 | 0.0 | 16.2 | 13.5 | 0.0 | 100.0 |
| Magnolia | 16.2 | 8.1 | 0.0 | 18.9 | 35.2 | 21.6 | 100.0 |
| Redcedar | 13.5 | 8.1 | 10.8 | 16.2 | 16.2 | 35.2 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

Table 20. Relative Soil pH Adaptability of Five Tree Species According to Five Soil Scientists[a]: Values Are Percentages of All Respondents.

| Species | No Knowledge | Ratings[b] 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|---|
| White pine | 20.0 | 0.0 | 40.0 | 20.0 | 0.0 | 20.0 | 100.0 |
| Hemlock | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 0.0 | 100.0 |
| Spruce | 20.0 | 20.0 | 20.0 | 0.0 | 40.0 | 0.0 | 100.0 |
| Magnolia | 0.0 | 40.0 | 20.0 | 40.0 | 0.0 | 0.0 | 100.0 |
| Redcedar | 0.0 | 40.0 | 0.0 | 0.0 | 0.0 | 60.0 | 100.0 |

[a]Not significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

Table 21. Relative Soil pH Adaptability of Five Tree Species According to Nurserymen, Landscape Architects, Ornamental Horticulturists and Soil Scientists[a]: Values Are Percentages of All Respondents.

| Species | No Knowledge | Ratings[b] 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|---|
| White pine | 30.7 | 6.7 | 12.0 | 24.0 | 17.3 | 9.3 | 100.0 |
| Hemlock | 40.0 | 8.0 | 12.0 | 25.4 | 13.3 | 1.3 | 100.0 |
| Spruce | 42.7 | 5.3 | 9.3 | 25.4 | 14.7 | 2.6 | 100.0 |
| Magnolia | 14.7 | 9.3 | 8.0 | 22.7 | 24.0 | 21.3 | 100.0 |
| Redcedar | 17.3 | 12.0 | 6.7 | 13.7 | 10.7 | 40.0 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

## 3. RATINGS OF SPECIES WITH RESPECT TO AESTHETIC APPEAL

Table 22 presents results of rankings obtained from 500 people who were asked to rate each species in distance group A, which was 30 feet, with respect to its aesthetic appeal. Spruce was rated highest more often than any other species, while redcedar was rated the lowest, rated 2 more than any other rating.

Presented in Table 23 are the ratings of the five species, gathered from the 500 individuals who were asked to rate each species in distance group B, which was 12 feet. White pine, hemlock, spruce, and magnolia all held the highest position by being rated 4 most frequently. Only redcedar dropped below this by being rated 2 most frequently.

Table 24 presents species' ratings at a distance of one foot. White pine, hemlock, and magnolia were rated highest in this group, with their most frequent ratings being 5. Although spruce and redcedar were rated lower, the rating of 4 was assigned most frequently.

Table 25 is a compilation of the responses of the individuals for all three distance groups. Magnolia had the highest rating, which was 5, when all responses were averaged. Redcedar was rated the lowest, by receiving a rating of 3 most often.

Table 22. Relative Aesthetic Appeal of Five Tree Species at 30 Feet[a]: Values Are Percentages of All Respondents.

| Species | Ratings[b] 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| White pine | 9.4 | 19.2 | 26.8 | 26.4 | 18.2 | 100.0 |
| Hemlock | 3.4 | 12.2 | 26.8 | 35.2 | 20.4 | 100.0 |
| Spruce | 4.2 | 9.4 | 16.4 | 33.0 | 37.0 | 100.0 |
| Magnolia | 7.0 | 21.2 | 25.4 | 28.2 | 18.2 | 100.0 |
| Redcedar | 14.0 | 26.2 | 25.4 | 22.2 | 12.2 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

Table 23. Relative Aesthetic Appeal of Five Tree Species at 12 Feet[a]: Values Are Percentages of All Respondents.

| Species | Ratings[b] 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| White pine | 5.2 | 10.4 | 21.6 | 34.8 | 28.0 | 100.0 |
| Hemlock | 1.6 | 7.8 | 21.2 | 38.8 | 30.6 | 100.0 |
| Spruce | 8.4 | 18.4 | 21.6 | 27.0 | 24.6 | 100.0 |
| Magnolia | 7.6 | 18.0 | 23.0 | 27.0 | 24.4 | 100.0 |
| Redcedar | 22.8 | 28.2 | 27.2 | 14.4 | 7.4 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

Table 24. Relative Aesthetic Appeal of Five Tree Species at One Foot[a]: Values Are Percentages of All Respondents.

| Species | Ratings[b] 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| White pine | 0.8 | 6.0 | 11.6 | 33.6 | 48.0 | 100.0 |
| Hemlock | 0.8 | 3.4 | 13.8 | 39.4 | 42.6 | 100.0 |
| Spruce | 8.0 | 20.8 | 25.8 | 29.4 | 16.0 | 100.0 |
| Magnolia | 1.4 | 7.2 | 7.8 | 31.4 | 52.2 | 100.0 |
| Redcedar | 7.8 | 17.8 | 22.6 | 33.4 | 18.4 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

Table 25. Relative Aesthetic Appeal of Five Tree Species at 30 Feet, 12 Feet, and One Foot[a]: Values Are Percentages of All Respondents.

| Species | Ratings[b] 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| White pine | 5.1 | 11.9 | 20.0 | 31.6 | 31.4 | 100.0 |
| Hemlock | 1.9 | 7.8 | 21.3 | 37.8 | 31.2 | 100.0 |
| Spruce | 6.9 | 16.2 | 21.3 | 29.8 | 25.8 | 100.0 |
| Magnolia | 5.3 | 15.5 | 18.7 | 28.9 | 31.6 | 100.0 |
| Redcedar | 14.9 | 24.2 | 25.0 | 23.3 | 12.6 | 100.0 |

[a]Significant at the 0.05 level.

[b]Underlined percentages are the highest for the species.

## 4. DETERMINING THE HIGHEST SCORING SPECIES

The completed quantitative ranking chart is shown in Table 26 and is a compilation of averages taken from the Appendix, Tables 27-32. This chart presents the criteria and their ratings, and the species and their ratings, with respect to each criteria. Each species' score was derived by multiplying each species' rating by the importance value and adding them together. Southern magnolia was by far the highest scoring species. Eastern redcedar was in second place, followed by hemlock, spruce, and white pine.

Table 26. Ranking[a] of Five Evergreen Tree Species for Urban Planting in Eastern Tennessee.[b]

| Species | Disease Resistance | | Insect Resistance | | Soil Fertility Adaptability | | Soil pH Adaptability | | Aesthetic Appeal | | Total Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Average Rating | Importance Value | Average Rating | Importance Value | Average Rating | Importance Value | Average Rating | Importance Value | Average Rating | Importance Value | |
| Southern magnolia | 4.1 | 8.2 | 4.2 | 7.5 | 2.8 | 5.3 | 3.1 | 4.6 | 3.6 | 8.4 | 124.4 |
| Eastern redcedar | 3.5 | 8.2 | 3.2 | 7.5 | 3.8 | 5.3 | 3.6 | 4.6 | 3.1 | 8.4 | 115.4 |
| Eastern hemlock | 3.1 | 8.2 | 3.3 | 7.5 | 2.6 | 5.3 | 2.8 | 4.6 | 3.9 | 8.4 | 109.6 |
| Norway spruce | 3.0 | 8.2 | 3.1 | 7.5 | 2.8 | 5.3 | 2.9 | 4.6 | 3.5 | 8.4 | 105.3 |
| Eastern white pine | 2.5 | 8.2 | 2.6 | 7.5 | 3.3 | 5.3 | 3.1 | 4.6 | 3.7 | 8.4 | 102.9 |

[a]Total Score for each species is obtained by multiplying the Average Rating with the Importance Value for each criteria. The sum of these products for each species is the Total Score.

[b]This data have not been tested for statistical significance.

# CHAPTER III

# DISCUSSION

## 1. CRITERIA FOR COMPARING SPECIES

In order to assign an importance rating to each criterion, it was necessary to accept the opinions of knowledgeable individuals. With all responses totaled (Table 5, page 20), disease resistance is rated 8 most frequently. These high ratings for disease resistance indicate that this criterion is considered above average by these individuals.

Insect resistance is rated 8 more than any other rating in all four tables (Tables 1-5, pages 15, 17, 18, 19, and 20, respectively). This also indicates a strong preference for this criterion by the nurserymen and landscape architects, who rate it above average.

Soil fertility adaptability is rated 10 most often by the out-of-state landscape architects (Table 4, page 19), 7 by the Tennessee landscape architects (Table 3, page 18), and 5 by the Tennessee nurserymen (Table 2, page 17). When all responses are combined, soil fertility is found to be rated 5 most frequently (Table 5, page 20). These results imply average importance. Although rated 10 in Table 4, there is a much smaller percentage for the rating of 10 than for the 5 rating in Table 1, page 15.

These individuals see this criterion as having average importance in determining placement of trees in the city. The reason for this average rating could be explained by the fact that the fertility of the soil can be easily altered by fertilization. Therefore, a tree's ability to adapt to different levels of fertility is not as essential as being resistant to insects and diseases.

Soil pH is a factor that is not as easily altered as soil fertility, although it could be done. It is not as critical an element in the tree's ability to survive as is disease resistance but nevertheless is important. Soil pH adaptability receives a rating of 5 from each group of individuals. This indicates average importance, as with soil fertility, but having no ratings higher than 5 places this criterion slightly behind soil fertility in importance. The statement could be made that soil pH is the criterion of least importance. However, soil fertility is rated so similarly that they could both be considered the criteria of least importance.

Aesthetic appeal is by far the most important criteria in determining which trees are used in the city, according to these four groups of individuals. When all responses are combined (Table 5, page 20), by far the highest percentage in the table is under the rating of 10 for aesthetic appeal. Aesthetic appeal is by far the most popular criteria.

## 2. DISEASE RESISTANCE

The degree to which a tree is resistant to fatality or serious injury by disease must be taken into consideration when screening tree species for placement in the urban environment. A particular tree can be one which is best suited for a particular location, but if it is not fairly resistant to infection by disease, it is not a practical choice.

### Eastern White Pine

Tables 6-9, pages 22 and 23, present ratings of the species obtained from the three groups of individuals. White pine receives a rating of 3 most frequently, considering all three groups as a whole (Table 9). White pine is rated 3 most often but is rated 1 almost as frequently.

The U. S. Forest Service called white pine blister rust caused by the fungus Cronartium ribicola Fischer, "The most important disease on white pine in the United States" (U. S. Forest Service, 1972, p. 48). In another study (U. S. Forest Service, 1965, p. 334), the Forest Service wrote that white pine blister rust was highly active throughout the range of white pine. Trees were susceptible from the seedling stage through maturity. The disease caused high losses both in regeneration and in immature timber stands. H. R. Powers conducted a study

which followed the spread of blister rust in a natural stand of white pine in North Carolina, observing the disease impact over a period of 20 years. Ten years after the initial infection, seedlings and saplings suffered heavy losses and were virtually eliminated from the stand. Mortality of older trees increased steadily during the 20 years with almost half of the largest and most valuable trees dead or dying from the disease (Powers, 1971). E. G. Kuhlman inoculated 16 white pine seedlings in the nursery with Fomes annosus (Fr.) Karst. and reported that the mortality rate was 64 percent (Kuhlman, 1970).

Red ring rot, which is caused by Fomes pini (Thore ex Fr.) Pilat is the most important heart rot of white pine, according to the U. S. Forest Service. The fungus enters through wounds, dead limbs, or tips killed by white pine weevils (Pissodes strobi Peck). Losses were greater in older trees but did not build up rapidly. They also wrote, "Stereum sanguinolentum Alb. et Schw. ex Fr., a wound parasite, is probably the third most destructive fungus associated with white pine. It usually enters through pruning wounds" (U. S. Forest Service, 1965, p. 334). A. C. Costonis considered the Lophodermium needle cast disease a serious problem for eastern white pine (Costonis, 1964).

These references are similar in that they discuss

various pathogens which infect white pine but say nothing about white pine's relative resistance to them. Powers writes that the white pines in his study in North Carolina were very susceptible to white pine blister rust. Occurrences of red ring rot and needle cast disease are destructive according to the U. S. Forest Service and Costonis, but how resistant are white pines to infection? The results indicate that white pine has less than average resistance to serious injury by disease. Although the majority of the ratings are 3, which indicates average resistance, there are almost as many ratings of 1 assigned to the species.

According to Dr. D. B. Williams, Head of the Department of Ornamental Horticulture and Landscape Design; Dr. K. F. Schell, Associate Professor of Forestry; and Dr. Charles Hadden,[1] Associate Professor of Agricultural Biology, all of The University of Tennessee, Knoxville, white pine blister rust is not a serious pathogen in Knoxville and does little damage to white pine in the city due to a lack of Ribes species. It can also be noted that Fomes annosus (Fr.) Karst is only a serious disease in forest stands where cutting has occurred. The fungi infect the cut stumps and infect nearby standing trees by way of the root system.

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[1]Personal communications.

Therefore, this pathogen would not be prominent in the city. The conclusion can be drawn that white pine does well in Knoxville, Tennessee, and is not susceptible to serious infection by diseases. However, the results of questionnaires sent to nurserymen, landscape architects, horticulturists, and plant pathologists show white pine below average in resisting ability. This indicates that white pine shows only average resistance in the region of the Southeast, but in Knoxville, disease is not a problem. White pine is a suitable urban tree for Knoxville, as far as resistance to disease is concerned.

Eastern Hemlock

Hemlock is rated 2, 3, and 4 most frequently (Table 9, page 23). This does not give a clear indication of how resistant these individuals consider the species. The next most frequent rating is 5. The plant pathologists give the high rating of 5 most frequently (Table 8, page 23), while the nurserymen give the low rating of 2 most often (Table 6, page 22). The fact that the highest percentage was split between three distinct ratings indicates some disagreement. The rating of 4 indicates the tree is more resistant to disease, while a rating of 2 indicates less resistance. So there can be no definite conclusion about hemlock's resistance, as far as the study results are concerned.

The U. S. Forest Service mentions red ring rot, the velvet top root rot (caused by Polyporus schweinitzii Fr.), the brown butt rot (caused by Polyporus balsameus Pk.), and the white root conk [caused by Poria subacida (Pk.) Sacc.] as being the most important diseases which infect hemlock. They also include the honey fungus [Armillaria mellea (Vahl) Quel.] as an occasional enemy of hemlock (U. S. Forest Service, 1965, p. 708).

There is little information to be gained from the literature concerning hemlock; and, therefore, no conclusions can be drawn from that source. The opinions of Dr. D. B. Williams and Dr. Charles Hadden[2] indicate that there are no serious pathogens affecting eastern hemlock trees in Knoxville, Tennessee. Therefore, the conclusion can be made that hemlock is a desirable tree for urban use in Knoxville, with respect to its disease resistance. The results from the survey show a wide diversity of ratings for hemlock, making any sort of conclusion about the Southeast region impossible. These professors agree that Knoxville harbors no harmful pathogens for eastern hemlock.

Norway Spruce

Norway spruce is rated 3 and 4 more than any other (Table 9, page 23). This would indicate that the

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[2]Personal communications.

nurserymen, horticulturists and pathologists are in disagreement and that no definite conclusion can be drawn from these results. The fact that 4 was one of the most frequent ratings indicates that the species may be slightly better than average in resisting ability, but there is so much disagreement between the groups questioned that no clear-cut answer can be found. The pathologists rate the species 2 most often (Table 8, page 23), while the horticulturists rate it 3 (Table 7, page 22), and the nurserymen rate it 4 (Table 6, page 22). The opinions are obviously divided.

According to the U. S. Forest Service, the brown cubical butt rot, which is caused by Polyporus schweinitzii Fr. enters Norway spruce through damaged roots and wounds near the base of the tree (U. S. Forest Service, 1972, p. 56). This brown cubical butt rot could be a problem to Norway spruce trees planted in the city. In the urban environment, tree wounds are common, due to pruning, lawn mowers, vandalism, and accidents, just to mention a few. This pathogen could prove to be serious, since it enters so readily through wounds in the bole. No serious pathogens attack Norway spruce in the city of Knoxville.[3] It can be said that Norway spruce is a very suitable urban species for use in Knoxville as far as disease resistance

[3]Information obtained through interviews.

is concerned. However, no conclusions can be drawn from the survey results, due to the great diversity of opinions.

Southern Magnolia

Southern magnolia receives ratings of 5 most frequently from all three groups of individuals (Tables 6-9, pages 22 and 23). They are all in complete agreement to the fact that magnolia is very resistant to infection by disease. The rating of 5 receives a very high percentage. The only reference from the literature concerned the blemishing of leaves. There is no indication of mortality or serious injury from this disease. A number of fungi caused leaf spots on southern magnolia. F. A. Haasis reported Isariopsis leaf spot of one- and two-year-old magnolia seedlings in North Carolina (Haasis, 1960, p. 637).

The lack of literature indicates that few studies have been conducted on the diseases affecting magnolia. This lack of literature could indicate either a lack of pathogens infecting the species, or a lack of interest on the part of researchers. Considering the unanimous decision by the three groups of individuals surveyed to rate magnolia 5 so frequently, a definite conclusion can be made. Southern magnolia is an extremely desirable tree for planting in the city, with respect to its disease resistance.

In Knoxville, no serious pathogens affect

magnolia.[4] This hardy species is ideal for use in the city.

Eastern Redcedar

Eastern redcedar is rated 5 most frequently when all three groups are combined (Table 9, page 23), but this is not so when each group is considered independently. The pathologists assign a rating of 2 most often (Table 8, page 23), but this is followed closely by 3, 4, and 5. Horticulturists rate it 4 (Table 7, page 22), while the nurserymen rate it 5 (Table 6, page 22). There is an obvious difference in opinion among the groups, but when these opinions are all averaged together, 5 is the most frequent rating, followed very closely by 4. This would indicate that redcedar is not extremely resistant to disease but better than average. This is not a clear-cut conclusion, but the only one that can be drawn from this data.

In 1971, A. S. Graves did a study on the infection of Arizona cypress (Cupressus arizonica Greene) and eastern redcedar by Monochaetia unicornis (Cke. and Ell.) Sacc. in South Carolina and reported the following results. Eastern redcedar developed cankers when wound-inoculated with the fungus, but non-wounded trees were not infected. In the absence of artificial wounds, the fungus did not

[4] Information obtained through interviews.

appear to infect redcedar, but it entered through artificial wounds, such as those that may be incurred in the city. Pruning, shaping, and other activities could serve as a means by which the fungus could enter (Graves, 1971, p. 811). Monochaetia unicornis (Cke. and Ell.) Sacc. could be a problem in the city, as it enters the tree through artificial wounds. These wounds are often incurred in the city, as previously mentioned (page 44). The indication from the results obtained from nurserymen, horticulturists, and pathologists is that redcedar is suitable for urban use throughout the states surrounding Tennessee. It can also be noted that no significant pathogens infect eastern redcedar trees in Knoxville[5] and, therefore, the species is very suitable for use with respect to its lack of disease problems.

## Conclusions

The opinions of nurserymen, horticulturists, and pathologists indicate that regionally, southern magnolia outranks the other four species in disease-resisting ability. That is the only species over which there is no disagreement among the nurserymen, horticulturists, and pathologists. Every group questioned appears to rank eastern redcedar in second place, as it is rated 5 most often when the average of the groups is considered, but

[5]Information obtained through interviews.

received the same percentage of ratings for 2, 4, and 5 by pathologists, horticulturists, and nurserymen, respectively. This places redcedar slightly behind magnolia in ranking. The other three species are in a group together below redcedar. There are great differences of opinion among the three groups, and no definite separations can be made between white pine, hemlock, and spruce.

In Knoxville, it appears that all five species have the same level of disease resistance. Consultation with Dr. D. B. Williams and Dr. Charles Hadden[6] revealed that no serious pathogens damage any of these species. Therefore, the statement can be made that each of these species is suitable for placement in Knoxville, Tennessee.

## Limitations

The major limitation with all of the questionnaires concerns geographic location. Those individuals from states surrounding Tennessee were asked to rate these five species as to their disease resistance, as well as other factors in some cases. They could answer only for their particular location. For instance, magnolia may be rated 5 by a professor from Clemson University, but if he were asked to rate these trees as to their resistance in Knox County, Tennessee, his answer might be totally

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[6]Personal communications.

different, if he could come up with one at all. These people stated how these trees would do in another state, not Tennessee. What grows well in Georgia may not grow as well in Tennessee. A southern magnolia planted in a colder climate may be subject to greater attack by disease than one planted in Knoxville.

## 3. INSECT RESISTANCE

The degree of insect resistance which a tree has is an important factor in determining whether or not it should be placed in the urban community. The resistance of urban trees is often low, due to many factors previously discussed, and the trees are, therefore, open for insect attacks. It is essential that insect resistant trees be used in the city, as they will become aesthetically unappealing if they are attacked.

### Eastern White Pine

White pine is rated 2 most often, when the responses of nurserymen, horticulturists, and pathologists are combined (Table 13, page 26). When taken independently, only one group, the horticulturists, do not rate the species 2 most often. They assign the rating of 1 to white pine (Table 11, page 24). Therefore, there is very little difference of opinion among these groups. The conclusion can be drawn from these results that white pine is below average in resistance.

The literature cites only one major pest of white pine, the white pine weevil (Pissodes strobi Peck). The U. S. Forest Service writes, "The white pine weevil is generally regarded as the most serious insect pest of white pine." Although the weevil does not usually cause mortality, trees suffering from repeated attacks become stunted and deformed (U. S. Forest Service, 1972, p. 36). In another study, the Forest Service reports that the white pine weevil kills the terminal shoot and thus affects two or three years' growth. The tree is seldom killed, however (U. S. Forest Service, 1965, p. 334). A. D. Rhodes explains that the lateral branches from the highest live whorl turn upward to produce new terminal shoots. Results of the injury are bole crook and loss of stem length (Rhodes, 1963). Bark thickness is a factor in relative resistance of white pine to the weevil, according to H. B. Kriebel. He examined five even-aged stands of white pine, using the number of weevil injuries as a measure of susceptibility. He found that bark thickness was significantly related to susceptibility. Trees with thick bark were more susceptible than those with thinner bark (Kriebel, 1954). J. P. Buijtenen found that resin crystallization was related to weevil resistance in white pine. He compared weevil attacks on trees containing crystallizing and non-crystallizing resin. Among 20 white pines which were non-crystallizers,

only three trees were successfully attacked by the weevil. Fifty percent of the remaining population was successfully attacked. Therefore, he said that resin crystallization can be used as a characteristic to screen for resistance to the white pine weevil (Buijtenen, 1972).

The literature indicates that this weevil is a serious pest. However, according to Dr. D. B. Williams, Dr. K. F. Schell, and Dr. Harry Williams,[7] Associate Professor of Agricultural Biology at The University of Tennessee, Knoxville, the white pine weevil is not a serious pest in Knoxville, although there are cases of its having attacked trees. On the other hand, these individuals consider the white pine bark aphid (Cinara strobi Fitch) a dangerous pest of white pine in Knoxville. They consider this pest, which attacks the bark on the branches of white pines, the most destructive in the city. This aphid would probably not be a destructive pest in a forest situation, where insect predators would be more common. White pine is susceptible to damaging insect attack in Knoxville, Tennessee, and is susceptible to attack by the white pine weevil in other parts of the region. The white pine weevil prefers a narrow range of temperature and humidity which Knoxville apparently does not offer. The results in Tables 10-13, pages 24 and

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[7]Personal communications.

26, indicate that white pine is more susceptible to attack in the rest of the Southeast, having below average resistance.

Eastern Hemlock

Eastern hemlock is rated 3 most frequently when all three groups are averaged together (Table 13, page 26). However, there are differing opinions among the four groups. The horticulturists and entomologists favor 4 (Tables 11 and 12, pages 24 and 26, respectively) while the nurserymen assign more ratings of 3 (Table 10, page 24). This varied response makes any conclusions about resistance impossible, except to say that the species appears slightly above average, due to the frequency of 4 ratings.

Few studies have been conducted on hemlock. The U. S. Forest Service has reported, "Two species of hemlock loopers, Lambdina fiscellaria fiscellaria Guen. and Lambdina athasaria athasaria Wlkr. may defoliate hemlock; they sometimes cause sporadic or local tree mortality." Of 24 insects which hemlock hosts, these two loopers and the hemlock borer Melanophila fulvoguttata Harr. which usually attacks only weakened trees are the only species of economic importance (U. S. Forest Service, 1965, p. 708).

Hemlock is susceptible to attack by mites, the red

spider mite (Paratetranychus ilicis McG.) in particular.[8] These are found in great quantity on hemlocks growing in urban conditions but not upon those in forest stands. Mites are a definite problem on hemlock. This pest is very destructive to hemlock in Knoxville. It could be said that because of its susceptibility to mites, hemlock is not very suitable for use in Knoxville. No conclusions can be drawn from the nurserymen, horticulturists, and entomologists about the region as a whole, since their responses are so varied.

Norway Spruce

Norway spruce is rated 3 most often in Table 13, page 26, where the responses of all three groups are averaged together. The responses among groups vary greatly, however. The nurserymen favor 4 most often (Table 10, page 24), while the horticulturists favor 3 (Table 11, page 24), and the entomologists choose both 3 and 4 more than any other (Table 12, page 26). No definite conclusion can be drawn from this type of response. That the species is slightly above average in its ability to resist insects is all that can be said.

There is only one reference of any importance concerning Norway spruce. W. H. Parry concludes his study by stating that Norway spruce is somewhat

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[8]Information obtained through interviews.

susceptible to attack by the green spruce aphid Chermes abietis L. (Parry, 1974).

Norway spruce is not susceptible to any damaging insects in Knoxville. There is occasional mite and bagworm (Thyridopteryx ephemerae formis Haw.) damage, but not enough to seriously injure this tree.[9] Therefore, the conclusion can be made that Norway spruce is very suitable for use in Knoxville, as far as insect resistance is concerned. The species is above average in resistance in the Southeast as indicated by the responses in Tables 10-13, pages 24 and 26.

Southern Magnolia

Southern magnolia is consistently rated 5 most frequently by all three groups (Tables 10-13). There is a consensus of opinion that magnolia is very resistant to attack by insects. Magnolia is rated 5 a high percentage of the time.

There are no references pertaining to any serious insect pests of magnolia. The fact that no literature is available may be an indication of the lack of serious pests of southern magnolia in the city of Knoxville.[10] Magnolia is an ideal urban tree and very resistant to disease. Therefore, the conclusion can be made that

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[9]Information obtained through interviews.

[10]Information obtained through interviews.

southern magnolia is a very suitable tree for urban use, not only in the city of Knoxville, but also throughout the states surrounding Tennessee, as indicated by the consistently high ratings from nurserymen, horticulturists, and entomologists.

Eastern Redcedar

Eastern redcedar is rated 4 most often when all of the groups' responses are combined (Table 13, page 26) and is rated 4 by the entomologists in Table 12, page 26. However, the other two groups consider redcedar less resistant and assign it a rating of 3 most frequently. This difference of opinion makes a definite conclusion impossible, but the statement could be made that the species shows above average resistance due to the ratings of 4 being most prominent.

The only literature reference pertaining to eastern redcedar is written by the U. S. Forest Service, who named bagworms as a pest of eastern redcedar, but not a particularly serious one (U. S. Forest Service, 1972, p. 215). Bagworms are significant pests of redcedars in Knoxville, but in urban areas only.[11] This can perhaps be explained by the fact that there are more bagworm predators, such as birds, in the country than in the city; and, therefore, the incidence of attack is greater in the

[11]Information obtained through interviews.

city. These individuals do not consider redcedar host to any other serious pests. The conclusion is that eastern redcedar is above average in resisting abilities in Knoxville, being susceptible to only one major pest in the city. It is suitable not only in Knoxville, but in the region as well, in both urban and rural settings.

## Conclusions

The results obtained from nurserymen, horticulturists, and entomologists (Tables 10-13, pages 24 and 26) indicate that southern magnolia is by far the favored species for its insect resistance. All three groups rate it 5, 50 percent of the time. This species is without question the most suitable for urban use according to these individuals. The ratings for eastern redcedar are between 3 and 4, which makes it difficult to come to any conclusion about the species. However, it seems to be rated higher on the whole than Norway spruce, eastern hemlock, and white pine but lower than southern magnolia, and, therefore, should be placed second in the ranking. The other three species are indistinguishable and must be considered together in third place.

In Knoxville, both Norway spruce and southern magnolia are not susceptible to any serious insects. White pine is susceptible to the white pine bark aphid, hemlock is susceptible to mites, and redcedar is susceptible to bagworms. These species do not have as great a

resistance to insects as the first two species mentioned.

## 4. SOIL FERTILITY ADAPTABILITY

Soil fertility can be an important factor in determining whether or not a tree will be able to survive. If it is a species with narrow tolerance limits and requires that the soil be of a certain fertility, then it may not survive in other conditions. A tree that can grow equally well in soils of varying fertility levels is an ideal urban tree. In this study, five species of trees are compared on the basis of which can grow well with the widest range of soil fertility.

### Eastern White Pine

The results of questionnaires sent to nurserymen and landscape architects, ornamental horticulturists, and soil scientists are presented in Tables 14-17, pages 27 and 29. Only those ratings by the ornamental horticulturists were found to be significant, but the ratings obtained from all three groups are included in Table 17. White pine receives a rating of 4 the most by all three groups and a rating of 3 by the ornamental horticulturists. This difference of opinion makes conclusions difficult, but the statement could be made that white pine is better than average in adaptability to soil fertility.

"White pine has grown on practically all the

soils within its range," writes the U. S. Forest Service. They go on to say, "It is, however, most closely associated with well-drained sandy soils. . . . Thickness of the A horizon had the greatest influence on rate of growth. . . . White pine often grows better than some of its associates on poor soils or sites. . . . In a comparison of site index and growth of 10 species in the southern Appalachians, white pine's growth exceeded all species, except on the best sites where yellow-poplar (Liriodendron tulipifera L.) out-ranked it in height only" (U. S. Forest Service, 1965, p. 330). The U. S. Department of Agriculture reports, "White pine will grow in almost any location but nevertheless it likes best a rich, well-drained soil" (U. S. Department of Agriculture, 1949, p. 58). Therefore, there is agreement on the fact that white pine is an average species when it comes to adapting to differing amounts of soil fertility.

From the references and the results shown here, a very general conclusion can be made. White pine is slightly above average in its adaptability to different soil fertility levels. According to the literature, it can grow well on other than the ideal rich, well-drained site.

Eastern Hemlock

The ornamental horticulturists rate hemlock as low as 2 (Table 15, page 27). All groups together give

hemlock a rating of both 2 and 3 most often (Table 17, page 29). Concerning the soil fertility requirement of hemlock, the U. S. Forest Service writes, "The species is very adaptable; in the Northeastern states and Canada it grows on rock . . . and loams and silt loams . . . on moist benches, flats, and swamp borders that are less well drained" (U. S. Forest Service, 1965, p. 704). The U. S. Department of Agriculture states, "The hemlock grows slowly and prefers a shady or sheltered location with moist soil. It may be grown in various types of soil, however, but will not be successful in an exposed site with dry, poor soil" (U. S. Department of Agriculture, 1949, p. 58). The literature does not particularly agree with the information gathered through the questionnaires. The only conclusion that can be made is that hemlock is average in its ability to adapt to different soil fertility types.

Norway Spruce

Norway spruce is another species similar to hemlock and white pine that can grow fairly well on different soils. Almost every species would grow its best on a rich site, but if it can grow reasonably well on a poor site also, it is usable for varying urban conditions. Three is the rating assigned to spruce by the ornamental horticulturists and by all groups combined (Tables 15 and 17,

pages 27 and 29). Spruce can grow adequately on poorer sites. No conclusion can be made about spruce except to say that it is average in adaptability.

Southern Magnolia

Southern magnolia is adaptable to many sites. As with spruce, southern magnolia is rated 3 most often for soil fertility adaptability. According to the U. S. Forest Service, "Southern magnolia grows best in moist, well-drained soils located along streams or near swamps in the coastal plain. Also, it is found in low, moist sites in upland areas. Numerous ornamental plantings throughout the South demonstrate that the species will thrive on a variety of sites" (U. S. Forest Service, 1965, p. 274). The U. S. Department of Agriculture states that magnolia is, "tolerant of varying conditions except poor drainage and . . . severely cold weather" (U. S. Department of Agriculture, 1949, p. 61). Magnolia prefers a rich site but does well on a variety of sites. It is average in adaptability.

Eastern Redcedar

Eastern redcedar is the first place choice by far. It is rated 5 by the ornamental horticulturists and by all groups combined (Tables 15 and 17, pages 27 and 29). The U. S. Forest Service states, "The species grow on a variety of soils ranging from dry rock outcrops to swampy

land. It is frequently found on thin soils with limestone and dolomite outcrops, or other dry rocky sites. . . . Natural stands occur on sites that vary from deep alluvial soil to very shallow upland soil. . . . Eastern redcedar frequently grows on dry, exposed sites and in abandoned fields. In the hills and mountains of Arkansas, Missouri, Kentucky, and Tennessee, eastern redcedar frequently grows in rocky limestone and dolomite areas" (U. S. Forest Service, 1965, p. 213). Redcedar is found on a great variety of soils, from very fertile to very poor. This species would do very well in the city where it can grow well on almost any site to which it is introduced. Eastern redcedar is a very good choice for planting in the urban community where adaptability to a wide range of soil fertility is the goal.

## Conclusions

Eastern redcedar is the favored species for its adaptability to different soil fertility types. Fifty percent of ratings are 5 in both tables. The other four species are grouped together since their abilities are similar. These species all have average abilities at adapting to different levels of soil fertility. They are suitable for placement in the city but not as much so as eastern redcedar.

Limitations

The major limitation of this survey was the fact that only nine soil scientists were questioned. This could not be helped due to the fact that only these professors were believed to be knowledgeable in the area of forest soils, and the data were not large enough to be significant.

## 5. SOIL PH ADAPTABILITY

The ability of a species to be able to grow well in a wide range of soil pH is extremely important when choosing a species which is best suited for urban conditions. A tree which requires a very basic soil is not suited for a situation where the soil may have a low pH. Urban conditions are such that a species must be able to take different pH levels without having its growth impaired. Without this ability, a tree should not be recommended for city planting.

Eastern White Pine

The results of species ratings for range of soil pH adaptability are presented in Tables 18-21, pages 30 and 31. White pine is rated 4 most often by the nurserymen and landscape architects and 3 by the ornamental horticulturists. When all responses are combined, the species is rated 3 most often. These varied opinions

make the formation of a definite conclusion difficult. The statement could be made that white pine has average pH adaptability.

Eastern Hemlock

Hemlock receives a rating of 3 most often with respect to soil pH adaptability in all three tables (Tables 18, 19, and 21, pages 30 and 31). This indicates average ability to withstand different acidity conditions. According to the U. S. Forest Service, "The high acidity of hemlock litter fosters leaching or podolization of the upper soil layers when the species predominates over long periods under a cool moist climate. The upper soil horizons under hemlock stands tend to be strongly acid, even where the soils are derived from basic geologic materials" (U. S. Forest Service, 1965, p. 704). Hemlock demands an acid site in order to do well, although it can grow in less acid situations. Like white pine, hemlock is average in adapting abilities.

Norway Spruce

Norway spruce is similar to white pine and hemlock in its adapting abilities. Spruce is rated 3 most often by each group of individuals (Tables 18, 19, and 21). This indicates an average ability to adapt to different levels of acidity.

Southern Magnolia

Southern magnolia is rated 4 by the ornamental horticulturists (Table 19, page 30), both 3 and 4 by the nurserymen and landscape architects (Table 18, page 30), and both 3 and 4 by all of the groups together (Table 21, page 31). These higher ratings indicate that magnolia is considered more adaptable to different soil acidity levels than the first three species.

Eastern Redcedar

Eastern redcedar is rated 5 most frequently by all of the groups (Tables 18, 19, and 21). This indicates that redcedar is the most adaptable to a wide range of soil pH and would be very desirable for city planting, with respect to this criterion. The U. S. Forest Service comments, "Eastern redcedar grows in soils that vary rather widely in acidity. Natural stands have been found where the pH values ranged from 4.7 to 7.8. Although the species will grow on sites that are slightly alkaline, it is not particularly alkali tolerant. In fact, in comparative tests of alkali tolerance of drought-hardy trees and shrubs, eastern redcedar rated in the least tolerant class. That the soils under redcedar stands are near neutral or slightly alkaline probably results from the fact that the trees tend to make the soil more alkaline" (U. S. Forest Service, 1965, p. 213). Eastern

redcedar is, therefore, very suitable for urban use since it has a great deal of adaptability to different soil pH levels.

Conclusions

Eastern redcedar is the favored species of the five for its ability to adapt to a wide range of soil pH levels. The species is rated 5 by each group of respondents, which leaves no doubt as to their opinions. Eastern redcedar is favored as the most adaptable of the five. Southern magnolia should be rated second, since it was consistently rated 3 and 4 by each group. The other species considered as a group are suitable for use in the city but are not as much so as redcedar or magnolia.

## 6. AESTHETIC APPEAL

Aesthetics is the perception of the beautiful, and beauty is the judgment of the observer. The concept of aesthetics is hard to define and give a monetary value, but it is an essential part of living. Every aesthetic experience is a personal experience. An aesthetic experience to one person may be seeing a dogwood (Cornus florida L.) in full bloom, while another may be deeply moved by the sight of a hemlock covered with snow. The experience of nature is deeply engrained inside everyone, and when locked inside a huge metropolis, one

loses that precious touch with nature. The sight of perhaps a single tree can fill a person with a sense of beauty. The degree of aesthetic appeal which a tree species possesses is an extremely important factor in selection. Without aesthetic appeal the species is not an ideal urban tree. The five most commonly planted evergreen trees in the city of Knoxville have been compared on the basis of their aesthetic appeal to the average citizen.

Eastern White Pine

Tables 22-25, pages 33 and 34, present the ratings of the species in the photographs at 30 feet, 12 feet, and one foot, with respect to the aesthetic appeal of the species. White pine is rated both 3 and 4 most frequently at a distance of 30 feet (Table 22, page 33), 5 at a distance of one foot (Table 24, page 34), and 4 most often in the other two tables (Tables 23 and 25, pages 33 and 34). This indicates that the species is approved of aesthetically from all distances, but especially at a distance of one foot. It would be deemed very suitable for city use as far as aesthetic attractiveness is concerned.

Eastern Hemlock

Eastern hemlock is rated similarly to white pine, and the same conclusions may be drawn. Hemlock receives

a rating of 4 most frequently from all distances except the one foot distance, where the species is rated 5 more than any other rating (Table 24, page 34). As with white pine, the foliage of hemlock could possibly be its most appealing feature. The tiny cones are also noticed when viewed at a close range.

Norway Spruce

Norway spruce receives similar ratings to hemlock, but this species is rated 5 most often at a distance of 30 feet (Table 22, page 33). The other tables present ratings of 4 most frequently (Tables 23-25, pages 33 and 34). This indicates that spruce is as popular aesthetically as hemlock and white pine, but is more popular from a distance than close up.

Southern Magnolia

Southern magnolia is rated 4 most often at distances on 30 and 12 feet (Tables 22 and 23) and 5 at a distance of one foot (Table 24). Magnolia is also the only species to receive a rating of 5 in Table 25, where all distances are combined. Magnolia is obviously admired for its shiny, broad leaves.

Eastern Redcedar

Eastern redcedar is by far the lowest rated species in most categories. At 30 feet, redcedar is rated 2 more

than any other, with 3 close behind (Table 22, page 33). It is similarly rated in Table 23, page 33, where 2 is the most frequent rating, with 3 not far behind. The species receives its highest rating in Table 24, page 34, with 4 but drops back to 3 in Table 25, page 34, with 2 close behind. This species is obviously not admired for its shape and only somewhat for its foliage. Therefore, its desirability for city planting would not be great with respect to aesthetic appeal.

## Conclusions

White pine, hemlock, spruce, and magnolia receive generally the same ratings at all distances. No one species can be set apart from the others as having greater aesthetic appeal. However, redcedar is definitely set apart from the others as having poor aesthetic quality. Therefore, the other four species are suitable for urban use with respect to aesthetic appeal, while eastern redcedar is less suitable.

## Limitations

Many biases and limitations were apparent in this study. The major limitation was the fact that photographs of the trees were used. People sometimes tended to judge the photograph instead of the tree. It would have perhaps been more desirable if the individuals had been questioned about the species without the photographs, but they may

not have been familiar with the species. Another limitation was the choice of facilities. These two department stores were chosen in order to sample individuals of all income levels, ages, sex, and race. However, more members of the lower- and middle-income groups, as well as more females, were subsequently questioned. These stores were frequented most often by lower- and middle-income groups, in my opinion.

Another bias concerned the state of the photographs. All ratings in group C, which was the one foot distance, tended to be higher than those in the other two groups, the reason being that group C pictures were in color, while the other two were in black and white. After leafing through two groups of black and white pictures, the individual was suddenly confronted with color, and this always seemed to look better, with one exception. The photograph of Norway spruce in group C was made with too much light and appeared wilted and dried out. Consequently, it was rated consistently lower than the other color photographs.

## 7. HIGHEST SCORING SPECIES

Table 26, page 36, is the culmination of all of the ratings assigned to the criteria and the species in this study. The data from which these averages are derived are presented in Tables 27-32 in the Appendix.

White pine is rated higher under those criteria which received the lowest ratings from the nurserymen and landscape architects, except for aesthetic appeal. The criteria which were rated highest by the nurserymen and landscape architects were disease resistance, insect resistance, and aesthetic appeal (Tables 1-5, pages 15, 17, 18, 19, and 20, respectively). Soil fertility and soil pH were rated much lower on the whole. Hemlock is rated higher under these highly rated criteria and, therefore, receives a respectable score. Spruce is rated higher under both low and highly rated criteria and, therefore, is assigned a less than average score. Eastern redcedar receives high ratings under every criteria. The ratings are equally high for low and highly rated criteria, which enables the species to obtain a high species score. Magnolia is rated even higher under each criteria than redcedar, and the highest ratings are assigned to the most highly rated criteria, which are disease resistance, insect resistance, and aesthetic appeal. Therefore, the highest numbers are multiplied together in the quantitative ranking chart to give magnolia the highest score. This implies that southern magnolia is the best species to plant in the urban environment, with respect to disease resistance, insect resistance, soil fertility adaptability, soil pH adaptability, and aesthetic appeal. Magnolia has been

compared to four other commonly planted evergreens in Knoxville, Tennessee, and has been determined the best tree for use in the urban environment.

# CHAPTER IV

## SUMMARY AND CONCLUSIONS

The objective of this study was to choose from among five species of evergreen trees, one which was most suitable for use in eastern Tennessee, with respect to several criteria. The five species were eastern white pine, eastern hemlock, Norway spruce, southern magnolia, and eastern redcedar. These species were compared on the basis of several criteria: disease resistance, insect resistance, soil fertility adaptability, soil pH adaptability, and aesthetic appeal.

Southern magnolia was found to have superior disease and insect resistance. Eastern redcedar was deemed to have superior soil fertility and soil pH adaptability. With respect to aesthetic appeal, no tree was clearly superior, the highest position being shared by magnolia, white pine, hemlock, and spruce.

Through use of a quantitative ranking chart, each species' "score" was determined, with southern magnolia the superior species. Magnolia is strongly recommended for use in eastern Tennessee and in the region of the Southeast. This species has excellent resistance to diseases and insects, average soil fertility and soil pH adaptability, and average aesthetic appeal. This is not

to say that only this species should be planted in eastern Tennessee, but widespread use would be feasible. Urban foresters have a limited number of trees in the urban "forest" and must, therefore, carefully select which species can tolerate the harsh conditions in the city and be aesthetically appealing at the same time.

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## LITERATURE CITED


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# APPENDIXES

## APPENDIX A

Table 27. Importance Values (0 - 10) of Five Criteria for Comparing Species: 10 Is Highest Value.

| Source of Data | Criteria | | | | |
|---|---|---|---|---|---|
| | Disease Resistance | Insect Resistance | Soil Fertility Adaptability | Soil pH Adaptability | Aesthetic Appeal |
| Tennessee nurserymen | 7.9 | 7.5 | 6.0 | 4.8 | 7.7 |
| Out-of-state nurserymen | 8.6 | 7.0 | 4.2 | 3.4 | 7.8 |
| Tennessee landscape architects | 8.4 | 8.1 | 5.4 | 5.6 | 9.4 |
| Out-of-state landscape architects | 8.1 | 7.5 | 5.6 | 4.8 | 8.9 |
| Average | 8.2 | 7.5 | 5.3 | 4.6 | 8.4 |

Table 28. Importance Values (1 - 5) of Five Tree Species with Respect to Disease Resistance: 5 Is Highest Value.

| Source of Data | Species | | | | |
|---|---|---|---|---|---|
| | White Pine | Eastern Hemlock | Norway Spruce | Southern Magnolia | Eastern Redcedar |
| Nurserymen and landscape architects | 2.9 | 3.1 | 3.0 | 3.9 | 3.6 |
| Ornamental horticulturists | 2.4 | 3.2 | 2.9 | 4.4 | 3.6 |
| Plant pathologists | 2.2 | 3.1 | 3.0 | 4.0 | 3.3 |
| Average | 2.5 | 3.1 | 3.0 | 4.1 | 3.5 |

Table 29. Importance Values (1 - 5) of Five Tree Species with Respect to Insect Resistance: 5 Is Highest Value

| Source of Data | Species | | | | |
|---|---|---|---|---|---|
| | White Pine | Eastern Hemlock | Norway Spruce | Southern Magnolia | Eastern Redcedar |
| Nurserymen and landscape architects | 2.5 | 3.0 | 3.1 | 4.1 | 3.1 |
| Ornamental horticulturists | 2.6 | 3.5 | 2.8 | 4.4 | 3.2 |
| Entomologists | 2.7 | 3.3 | 3.4 | 4.1 | 3.3 |
| Average | 2.6 | 3.3 | 3.1 | 4.2 | 3.2 |

Table 30. Importance Values (1 - 5) of Five Tree Species with Respect to Soil Fertility Adaptability: 5 Is Highest Value.

| Source of Data | Species | | | | |
|---|---|---|---|---|---|
| | White Pine | Eastern Hemlock | Norway Spruce | Southern Magnolia | Eastern Redcedar |
| Nurserymen and landscape architects | 3.2 | 2.9 | 3.1 | 3.3 | 3.6 |
| Ornamental horticulturists | 3.1 | 2.6 | 2.6 | 3.5 | 4.3 |
| Soil scientists | 3.5 | 2.2 | 2.8 | 1.6 | 3.4 |
| Average | 3.3 | 2.6 | 2.8 | 2.8 | 3.8 |

Table 31. Importance Values (1 - 5) of Five Tree Species with Respect to Soil pH Adaptability: 5 Is Highest Value.

| Source of Data | Species | | | | |
|---|---|---|---|---|---|
| | White Pine | Eastern Hemlock | Norway Spruce | Southern Magnolia | Eastern Redcedar |
| Nurserymen and landscape architects | 3.2 | 2.9 | 3.0 | 3.5 | 3.8 |
| Ornamental horticulturists | 3.1 | 2.7 | 3.1 | 3.7 | 3.7 |
| Soil scientists | 3.0 | 2.5 | 2.8 | 2.0 | 3.4 |
| Average | 3.1 | 2.8 | 2.9 | 3.1 | 3.6 |

Table 32. Importance Values (1 - 5) of Five Tree Species with Respect to Aesthetic Appeal: 5 Is Highest Value.

| Distance | Species | | | | |
|---|---|---|---|---|---|
| | White Pine | Eastern Hemlock | Norway Spruce | Southern Magnolia | Eastern Redcedar |
| 30 feet (Group A) | 3.2 | 3.6 | 3.9 | 3.9 | 2.9 |
| 12 feet (Group B) | 3.7 | 3.9 | 3.4 | 3.4 | 2.6 |
| One foot (Group C) | 4.2 | 4.2 | 3.2 | 4.2 | 3.8 |
| Average | 3.7 | 3.9 | 3.5 | 3.6 | 3.1 |

# APPENDIX B

## CORRESPONDENCE

### 1. TEXT OF LETTER TO NURSERYMEN AND LANDSCAPE ARCHITECTS CONCERNING CRITERIA FOR COMPARING SPECIES

We are working on a research project which deals with the use of trees for landscaping in urban areas. Specifically, we are trying to find out what tree species is most adaptable to urban conditions. The first step in this project is to determine what characteristics are the most important considerations for planting in cities. At the end of the project, which will include studies of pollution endurance and noise abatement, we hope to be able to make firm recommendations to city dwellers.

Would you help us by taking a minute to fill out the attached postal card, assigning an importance rating (a "0" rating for no importance, and a "10" rating for extreme importance) to each of the factors on the card? As an example, noise abatement and insect resistance might both carry an importance rating of 9, while use by wildlife might have an importance rating of only 1.

We will appreciate your cooperation. No signature is necessary, but if you would like to receive a copy of the results of this survey, put your name and address on the postal card.

### 2. LETTER TO ORNAMENTAL HORTICULTURISTS

We are working on a research project which deals with the use of trees for landscaping in urban areas. Specifically, we are trying to find out which of five selected trees is most adaptable to urban conditions: Eastern white pine (Pinus strobus), Eastern hemlock (Tsuga canadensis), Norway spruce (Picea abies), Southern magnolia (Magnolia grandiflora), and Eastern redcedar (Juniperus virginiana). Of these five trees, we would like to find one (or more) species which:

1. Is the most resistant to fatality or serious injury by disease.
2. Is the most resistant to fatality or serious injury by insects.

3. Has the widest range of soil fertility requirement.

4. Is most adaptable to a wide range of soil pH.

Would you help us by taking a minute to fill out the attached sheet, rating each tree species under each of the four categories (a "5" for the most desirable rating and a "1" for the least desirable rating)? As an example, white pine and hemlock might both carry a rating of "4" while magnolia might have a rating of "3." A self-addressed, stamped envelope is enclosed for your convenience.

We will appreciate your cooperation. No signature is necessary, but if you would like to receive a copy of the results of this survey, put your name and address on the letter.

## 3. TEXT OF FORM TO ORNAMENTAL HORTICULTURISTS, NURSERYMEN, AND LANDSCAPE ARCHITECTS

Please Rate the Following Trees
Under Each Category

(5 = most desirable rating; 1 = least desirable rating)

I. Resistance to fatality or serious injury by disease.

| | Rating | No Knowledge |
|---|---|---|
| Eastern white pine | _____ | _____ |
| Eastern hemlock | _____ | _____ |
| Norway spruce | _____ | _____ |
| Southern magnolia | _____ | _____ |
| Eastern redcedar | _____ | _____ |

II. Resistance to fatality or serious injury by insects.

| | Rating | No Knowledge |
|---|---|---|
| Eastern white pine | _____ | _____ |
| Eastern hemlock | _____ | _____ |
| Norway spruce | _____ | _____ |
| Southern magnolia | _____ | _____ |
| Eastern redcedar | _____ | _____ |

III. Widest range of soil fertility requirement.

| | Rating | No Knowledge |
|---|---|---|
| Eastern white pine | _____ | _____ |
| Eastern hemlock | _____ | _____ |
| Norway spruce | _____ | _____ |
| Southern magnolia | _____ | _____ |
| Eastern redcedar | _____ | _____ |

IV. Adaptability to a wide range of soil pH.

| | Rating | No Knowledge |
|---|---|---|
| Eastern white pine | _____ | _____ |
| Eastern hemlock | _____ | _____ |
| Norway spruce | _____ | _____ |
| Southern magnolia | _____ | _____ |
| Eastern redcedar | _____ | _____ |

## 4. TEXT OF LETTER TO NURSERYMEN AND LANDSCAPE ARCHITECTS

We greatly appreciate your cooperation in responding to our questionnaire. If you will remember, we asked you to assign an importance rating to 10 urban environmental factors. We were interested in finding out which factors you considered to be the most important considerations for planting in cities. Here are the results of that survey:

| | Rating |
|---|---|
| Aesthetic appeal | 9 |
| Disease resistance | 8 |
| Insect resistance | 8 |
| Noise abatement | 6 |
| Low soil fertility requirement | 6 |
| Ozone pollution resistance | 6 |
| Sulfur dioxide pollution resistance | 6 |
| Nitrogen oxide pollution resistance | 6 |
| Soil acidity adaptability | 5 |
| Use by wildlife | 3 |

We would now like to go a step farther and try to find out which of five selected tree species seems to be most adaptable to urban conditions: Eastern white pine (*Pinus strobus* L.), Eastern hemlock [*Tsuga canadensis* (L.) Carr.], Norway spruce [*Picea abies* (L.) Karst.], Southern magnolia (*Magnolia grandiflora* L.), and Eastern redcedar (*Juniperus virginiana* L.). Would you please give us your opinion as to how each species rates on a scale of 1 to 5, with respect to the four categories which are given on the enclosed form? A self-addressed, stamped envelope is enclosed for your convenience.

We will appreciate your response. No signature is necessary, but if you would like to receive a copy of the results of this survey, put your name and address on the form.

## 5. TEXT OF LETTER TO ENTOMOLOGISTS

We are working on a research project which deals with the use of trees for landscaping in urban areas. Specifically, we are trying to find out which of five selected trees is most adaptable to urban conditions: Eastern white pine (Pinus strobus L.), Eastern hemlock [Tsuga canadensis (L.) Carr.], Norway spruce [Picea abies (L.) Karst.], Southern magnolia (Magnolia grandiflora L.) and Eastern redcedar (Juniperus virginiana L.). Of these five trees, we would like to find one (or more) species which is most resistant to fatality or serious injury by Insects.

Would you help us by taking a minute to fill out the enclosed card, rating each tree species (a "5" for the most desirable rating and a "1" for the least desirable rating)? As an example, white pine and hemlock might both carry a rating of "4" while magnolia might have a rating of "3." A self-addressed postcard is enclosed for your convenience.

We will appreciate your cooperation. No signature is necessary, but if you would like to receive a copy of the results of this survey, put your name and address on the postal card.

## 6. TEXT OF LETTER TO PLANT PATHOLOGISTS

We are working on a research project which deals with the use of trees for landscaping in urban areas. Specifically, we are trying to find out which of five selected trees is most adaptable to urban conditions: Eastern white pine (Pinus strobus L.), Eastern hemlock [Tsuga canadensis (L.) Carr.], Norway spruce [Picea abies (L.) Karst.], Southern magnolia (Magnolia grandiflora L.), and Eastern redcedar (Juniperus virginiana L.). Of these five trees, we would like to find one (or more) species which is most resistant to fatality or serious injury by Disease.

Would you help us by taking a minute to fill out the enclosed card, rating each tree species (a "5" for the most desirable rating and a "1" for the least desirable rating)? As an example, white pine and hemlock might both carry a rating of "4" while magnolia might have a rating of "3." A self-addressed postcard is enclosed for your convenience.

We will appreciate your cooperation. No signature is necessary, but if you would like to receive a copy of the results of this survey, put your name and address on the postal card.

## 7. TEXT OF LETTER TO SOIL SCIENTISTS

We are working on a research project which deals with the use of trees for landscaping in urban areas. Specifically, we are trying to find out which of five selected trees is most adaptable to urban conditions: Eastern white pine (Pinus strobus L.), Eastern hemlock [Tsuga canadensis (L.) Carr.], Norway spruce [Picea abies (L.) Karst.], Southern magnolia (Magnolia grandiflora L.), and Eastern redcedar (Juniperus virginiana L.). Of these five trees, we would like to find one (or more) species which:

1. Has the widest range of soil fertility requirement.
2. Is most adaptable to a wide range of soil pH.

Would you help us by taking a minute to fill out the enclosed card, rating each tree species (a "5" for the most desirable rating and a "1" for the least desirable rating)? As an example, white pine and hemlock might both carry a rating of "4" while magnolia might have a rating of "3." A self-addressed post card is enclosed for your convenience.

We will appreciate your cooperation. No signature is necessary, but if you would like to receive a copy of the results of this survey, put your name and address on the postal card.

# APPENDIX C

Figure 2. Eastern white pine from 30 feet.

Figure 3. Eastern hemlock from 30 feet.

Figure 4. Norway spruce from 30 feet.

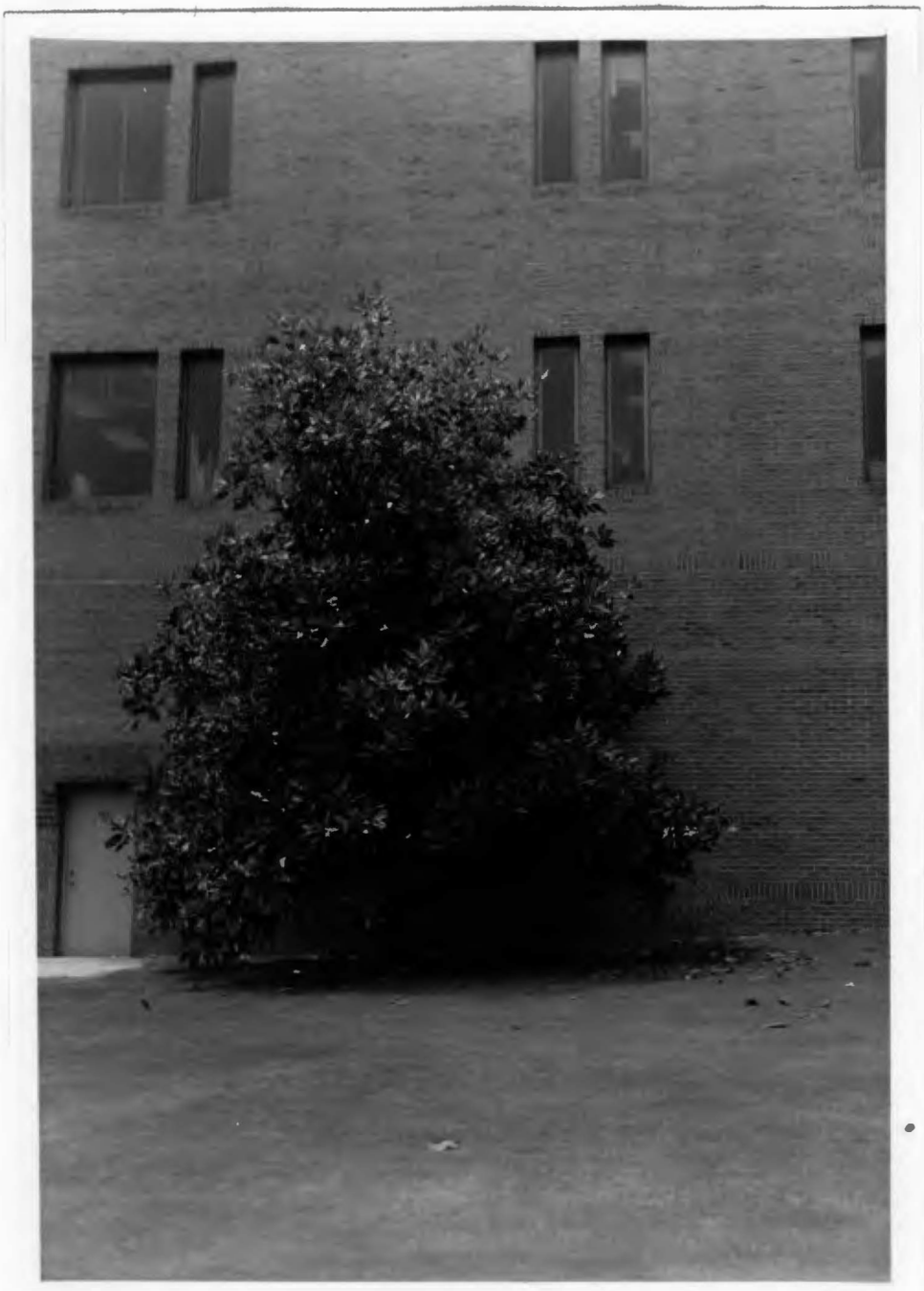

Figure 5. Southern magnolia from 30 feet.

Figure 6. Eastern redcedar from 30 feet.

Figure 7. Eastern white pine from 12 feet.

Figure 8. Eastern hemlock from 12 feet.

Figure 9. Norway spruce from 12 feet.

Figure 10. Southern magnolia from 12 feet.

Figure 11. Eastern redcedar from 12 feet.

Figure 12. Eastern white pine from one foot.

Figure 14. Norway spruce from one foot.

Figure 15. Southern magnolia from one foot.

Figure 16. Eastern redcedar from one foot.

# VITA

Vivian Orr Potter was born in Savannah, Georgia, on September 3, 1953. She attended elementary school in that city and was graduated from Savannah Country Day School in 1971. The following September she entered The University of Tennessee, and in June 1974, she received a Bachelor of Science degree in Forestry. In the fall of 1974, she accepted a graduate research assistantship at The University of Tennessee and began study toward a Master's degree. She received this degree in August, 1976. She is a member of the Society of American Foresters, Phi Kappa Phi, Gamma Sigma Delta, and Xi Sigma Pi. She is married to James R. Potter, also a graduate student in Forestry, from Oak Ridge, Tennessee.