SETTING PRIORITIES FOR TREE IMPROVEMENT

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Abstract: A priority ranking system was developed utilizing seven categories within a formula to assist in the choosing of species that should be genetically improved. The categories include: opinion; seed per pound; minimum seed bearing age in years; maximum interval between seed crops; average stumpage value; insect and disease susceptibility; and natural distribution. The species selected in priority order are: black walnut, silver maple, eastern cottonwood, tulip poplar, sycamore, white oak, white ash, river birch, American basswood, and eastern hackberry.

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It is essential that the correct species must be chosen for genetic improvement and priorities set as to which species should be given priority over other possible candidates. Farmer (1973) indicates that extreme care must be given to the proper selection of species because the decision will have long term effects and involve major commitments to breeding, silviculture and management programs. Economic value, ability to use genetic information and improved material in future forest management systems, and the overall cost of the system that produces the improved stock must be considered.

Although it is impossible to predict the exact demand for individual species one hundred years into the future, an educated estimate can be drawn from history and current trends. It will be important that there exists a ready market for the species that will be improved.

The cost of production should be considered. How difficult is the species to establish in plantations? Does it have physiological, insect, or disease problems that will raise the production costs? How prolific is the species? Will it require one hundred acres of seed orchards or will one acre do the job?

The economic value or stumpage price will affect priorities. One would rather sell black walnut (*Juglans nigra* L.) at one dollar per board foot than red elm (*Ulmus* rubra Muhl.) at thirty cents. Although a ready market is available for both, the economic law of supply and demand will dictate the price. It follows then that the economic value will affect the priority.

Major factors can be expressed as numerical figures and weighted as to their importance. A formula would be developed that will produce a total value or numerical representation as to the species priorical relationship for quantitative ranking. We present and explain here each part of the formula and the weights to be assigned to the total.

METHODS

To determine the future demand of a species one must be guided primarily by opinion. Anyone can present their viewpoint; however, persons dealing with the day-to-day buying and selling of forest products would be more

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credible. It is generally accepted that the local markets (sawmills and pulp-mills) purchase the majority of Illinois-grown products. Their opinion should be considered as they represent the future markets for the species that might be improved.

A survey of the forty largest sawmills (twenty-seven returns) revealed a diversity of views but with general trends quite apparent. They were asked to list in priority the ten species of forest trees that were most important to them and their industry and that they believed should be improved genetically.

In all, twenty-seven species were listed. For every first place vote a species received, it was credited with ten points; second place received nine points, third place, eight points; on down to one point for tenth place. The place totals were accumulated into a grand total for each species, representing a ranking of species by the sawmill operators.

Because they deal directly with forest land owners and the sawmills, field foresters within the state were sent a similar ranking questionnaire. The foresters' opinions were treated in the same manner as the industry response. Although the results were not exactly the same as the industry survey, they were very similar. There were twenty-seven foresters polled and eighteen responded. A total of twenty-seven species were mentioned as being important. However, nine of the species mentioned were different than those listed by the mill survey. Of these nine, seven were conifers. This may reflect the foresters' understanding of the potential value of these species while the industry tends to reflect the past and present market. Sixty percent of the species in both surveys were the same, although differences in ranking appeared.

David Funk, Project Leader at the North Central Forest Experiment Station Unit in Carbondale surveyed U.S. Forest Service personnel, state agencies, Universities, and industry throughout the Midwest asking for "the direction of future genetics and breeding research at Carbondale." Over sixty replies were received and from these, the following ranking and priorities were set.1/

1. Walnut (Juglans nigra L.)2/
2. White ash (Fraxinus americana L.)
3. White oak (Quercus alba L.)
4. Tulip poplar (Liriodendron tulipifera L.)
5. Silver maple (Acer saccharinum L.)
6. Pecan (Carya illinoesis (Wang) K. Koch)
7. Black cherry (Prunus serotina Ehrh.)
8. Sycamore (Plantanus occidentalis L.)
9. Red maple (Acer rubrum Walt.)
10. Hackberry (Celtis occidentalis L.)

This survey gives yet another opinion to integrate into the ranking formula. Researchers were very influential in formulation of this ranking which represents another segment of the forest user.

1/ Personal communications with Dr. David Funk.

2/ Walnut had been given a number one priority previous to the survey.

The combination of the three polls are brought together to formulate the first portion of the ranking formula. Other sources of opinions may also be appropriate; however, in an effort to keep the formula from becoming unwieldy, these three representatives were deemed sufficient in the Illinois situation.

Consideration must also be given to the problematical expense involved in the improvement process of the species. One criteria of measurement is how many seeds will one tree produce. The more viable seed produced per tree, the fewer acres of seed orchards will need to be developed. For example, Limstrom (1965) suggests that one seed tree of European black alder (Alnus glutinosa (L.) Gaertn.) will produce enough seed for 100,000 seedlings and 50 black walnut trees are needed to accomplish similar results.

There is obviously a great variation in seed production among the species and development costs can be reduced by first considering the trees whose seed is very small. However, the seed size alone would not provide a good judgment because a species that produces large numbers of seed may have little value in the market, have low germination capacity, or it may have a serious insect or disease problem.

Stumpage prices reflect the supply and demand of a particular species. Although future prices are hard to predict, an average of the last five years stumpage prices will smooth out fluctuations in the demand and a relative measure can be attained. The Illinois Crop Reporting Services furnishes reports twice a year for the average stumpage prices paid over the previous six months. Selected individual sawmills report directly to the Crop Reporting Service which in turn compiles and publishes the results.

Certain tree species are susceptible to insect and disease problems of epidemic proportions, such as the American elm and the American chestnut (Castanea dentata (Marsh.) Borkh). Although occasionally some susceptibilities can be bred out of a particular species, it seems logical to consider susceptibility to the insects or disease in computing the priority ranking of the species. If the tree species does not have any major pathogenic susceptibility, the cost of improvement will be less than that of a species that has major susceptibilities.

Of course, all tree species host a variety of pests and none escape completely from damage. For the most part, however, pests and hosts live together with only minor difficulty. When the pests cause significant growth loss or death of the majority of a particular species, a question of tree improvement priority should be raised for tree improvement of such a species.

The last portion of the ranking formula will represent a component weighted by the natural distribution of the tree species within the State of Illinois. This is desirable because a species that is adapted to only a small portion of the state would be less beneficial to produce because of its limited use. A species that can be commercially grown throughout the state would be less beneficial to produce because of its limited use. Although the natural range does not necessarily represent the entire area in which the species can be grown commercially, it does give a good indication of the extent of the area for potential planting.

Many nonindigenous species have been grown successfully and may have specific purposes for which they are adapted. However, the researchers must test these exotics extensively before they can be incorporated into an active tree improvement plan. Pinus species are a good example of essentially exotic species that may prove to be of greater future potential.

RESULTS

The ranking formula then will consist of seven components that are numerical representations of the surveys, insect and disease susceptibilities, seed quantities per pound, minimum seed bearing age, seed crop intervals, and the average stumpage prices per species. Values from one to five are assigned to a portion of the total range within each section of the ranking formula.

Category I, the opinion polls, have a value assigned which represents a combination of all the polls. Although all three polls are valid, we feel that at present the sawmill operators and the foresters are more locally oriented and their opinions will deserve more points. In the future, as our research programs yield more comprehensive foundation data, we may wish to give all three opinion polls equal ranking. If the species is represented in all three polls, 5 points will be assigned in the ranking formula for the species. Appearance on the sawmill operators and foresters poll will earn the species 4 points and 3 points will be earned if the species is on either of the other two combinations of surveys. Two points will be earned if the species was recommended by only one of the surveys. Species that do not appear on any of the surveys would not receive points in this category.

Category II, the average number of seeds per pound per species, will have a number assigned from one to five. Species that contain 60,000 seeds per pound or more will receive 5 points. The range of 40,001 to 60,000 will receive 4 points; 20,001 to 40,000, 3 points; 5,001 to 20,000, 2 points; and under 5,000 will receive only 1 point. The more seed per pound, the more seed per tree is obtainable, and the fewer number of seed trees will be necessary to fulfill the seeding requirements.

Category III, the minimum seed bearing age, ranges from a minimum of 5 years to produce seed to 26 years plus to bear the seed. There are ways to reduce the time required to produce seed such as the use of cuttings, fertilization, grafts placed on mature root stock, chemical treatments, etc. However, by starting with species capable of producing seed at an early age, further reductions can be accomplished in an even shorter period of time. Therefore, production costs can be kept at a minimum.

On the other hand, the species that are frequent seed bearers should be given a priority over others. Even though a species produces at an early age, it may not keep production costs at a minimum if the interval between seed years is great. Obviously certain species are inconsistent seed bearers and predictions are difficult. For Category IV, interval between seed crops, five points will be given to the species that exhibit a seed bearing interval average of 1 year; 4 points for a 2 year interval; 3 points for a 3 year interval; 2 points for a 4 year interval; and 1 point for a 5 year or more interval.

Table I. Summary of values assigned for each category in the ranking formula

Category		Range Limit	Value Assigned
I	Opinion	Does not appear on surveys	1
		Appears on only one survey	2
		Appears on any two surveys	3
		Appears on foresters and sawmill operators survey	4
		Appears on all three surveys	5
II	Seed per pound	20 - 5,000	1
		5,001 - 20,000	2
		20,001 - 40,000	3
		40,001 - 60,000	4
		60,001 +	5
III	Minimum seed bearing age in years	26+	1
		21 - 25	2
		16 - 20	3
		11 - 15	4
		5 - 10	5
IV	Maximum interval between seed crops in years	5+	1
		4	2
		3	3
		2	4
		1	5
V	Average stumpage value in dollars per M Bd. ft.	20 - 25	1
		26 - 30	2
		31 - 35	3
		36 - 40	4
		41+	5
VI	Insects and disease	Major pests uncontrollable	1
		Major pests controlled uneconomically	2
		Major pests controlled with pesticides	3
		Major pests allowed if related only to weather	4
		No major pests	5
VII	Distribution throughout the state	Nonindigenous to the state	1
		Indigenous in very localized areas	2
		Indigenous in ½ of the state	3
		Indigenous to parts of the state with a range that is both north and south of Illinois	4
		Indigenous throughout Illinois	5

As previously mentioned, economic value of a species is very important when considering the species to be selected for genetic improvement. Category V, the average stumpage value, is added to the ranking formula for the monetary value input. Over the past five years, stumpage prices have ranged from $15 per 1000 board feet for elm to $800 per 1000 board feet for black walnut. Five points will be given to those species that sold for $41 per 1000 board feet or more (stumpage); 4 points for $36 to $40; 3 points for $31 to $35; 2 points for $26 to $30; and 1 point for $25 or less.

Insects and disease, Category VI, is assigned values on the basis of major pests that may attack the species and the ease with which control is obtained. If the species has no major pests currently associated with it in Illinois, 5 points will be assigned to the ranking formula, e.g., hackberry. If a disease or insect pest is directly related to local weather conditions, only 4 points will be awarded, such as anthracnose (Gnomonia veneta Sacc. & Speg.) on sycamore. Three points will be given to species which have a major insect or disease pest that is easily controlled, e.g., bagworms (Thyridopteryx ephemeraeformis Haw.) on Eastern redcedar. Species that have pests that can be controlled, but not economically so at this time, will be given 2 points because an economical solution is closer at hand than if no control is known, e.g., Zimmerman pine moth (Dioryctria zimmermani Grote). Uncontrollable major pests for species will be given only 1 point, e.g., Dutch elm disease (Ceratocystis ulmi Buism).

The last category of the ranking formula will be VII, distribution of the species. A species that has statewide distribution will be given 5 points. If a species is indigenous in parts of the state and has a natural range that extends both north and south of Illinois, it will be given 4 points. The chances are that an adaptable seed source can be found. Species whose range covers only half of the state will receive 3 points and 2 points will be given to indigenous species with a very limited range within the state of Illinois. Nonindigenous species will receive 1 point. The highest number of points attainable is 35.

The total formula will be the sum of all categories:

I + II + III + IV + V + VI + VII = Gross Rank Value

The species with the highest rank value should be the species considered first in a tree improvement program. If two or more species receive the same numerical ranking, the species that has the highest average stumpage value would be given a higher ranking. If the stumpage values are the same, the species that receives the highest average ranking from the 3 polls will be given priority.

CONCLUSIONS

As funds become available, the next highest ranking species would be considered and so on until the top ten species are genetically improved and seed orchards or clonal banks are established making sure that the superior material is readily available to the tree planting public. This is not to say that other species should not be improved, but that these ten represent those that should be done first because of ease of improvement and their relatively high

economic value to the timber grower. We would recommend that before initiating a full scale tree improvement program, any new information concerning the economics, insect and disease factors, tree improvement potentials and/or research results, or basic species information be considered. Updating the formula with the latest and most comprehensive information available would help to assure the development of a tree improvement program with the highest possible benefits.

Table II — Point talley and summary by species and category to determine priority for tree improvement scheduling

Species	I	II	III	IV	V	VI	VII	Total Points	Priority Number
Black walnut	5	1	4	3	5	5	5	28	1
Silver maple	5	1	4	5	3	4	5	27	2
Eastern cottonwood	4	5	5	5	1	2	5	27	3
Tulip poplar	3	2	3	5	4	5	4	26	4
Sycamore	2	5	5	4	1	4	5	26	5
White oak	5	1	3	1	5	5	5	25	6
White ash	5	2	3	2	4	4	5	25	7
River birch	1	5	5	5	1	3	5	25	8
American basswood	1	1	4	5	2	5	5	23	9
Hackberry	2	1	4	5	1	5	5	23	10
Bur oak	2	1	1	3	5	5	5	22	11
Wild black cherry	2	2	5	1	2	5	5	22	12
Chinkapin oak	1	1	3	1	5	5	5	21	13
Honeylocust	1	1	5	5	1	3	5	21	14
Eastern redcedar	1	4	5	1	1	4	5	21	15
Northern red oak	4	1	2	1	5	2	5	20	16
Pecan	2	1	4	4	1	5	3	20	17
Sweetgum	2	5	2	3	1	4	3	20	18
Butternut	1	1	3	3	2	4	5	19	19
Slippery elm	2	4	4	2	1	1	5	19	20

LITERATURE CITED

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