Frontline

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A MANAGEMENT-ORIENTED MODEL FOR ASSESSING EARLY STAND ESTABLISHMENT

by

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INTRODUCTION

In Ontario, artificial regeneration has been studied for many years, and some investigations have included both economic and biological considerations. However, interrelationships among the various factors that affect plantation performance have not been adequately addressed; the process of forest renewal needs to be understood as a whole by synthesizing the available information. Simulation modeling can help to achieve this understanding.

Research to develop a model for artificial regeneration systems in Ontario began at Forestry Canada, Ontario Region, in 1985 (Payandeh 1988). The latest result of this work is PLANT-PC, a management-oriented model that simulates the growth and survival of seedlings throughout the regeneration process from seed source selection through nursery production and outplanting to a point at which the stand is considered fully established (at 20 years of age).

The model simulates various regeneration systems based on a decision-tree approach and the user's specifications. It compares, ranks and optimizes the alternatives so generated, using an index that combines the total cost of production with growth, survival and the quality of the resulting stands. A manual with step-by-step instructions to facilitate use of the model by individual forest managers is being produced (Punch et al., manuscript in preparation). A copy of the manual will shortly be available from Forestry Canada, Ontario Region (address on the back of this note).

MODEL DEVELOPMENT

For the purpose of model development, the entire process of artificial regeneration is viewed as a system that begins with seed source selection and ends with successful plantation establishment. Three major phases in the regeneration process are recognized: stock production, seedling storage and plantation management.

Within each phase of the model, a decision tree is developed to outline the different management options in the regeneration process (Fig. 1). The various alternatives are simulated in parallel and their effects and costs are incorporated and accumulated. The results can then be

compared and ranked on the basis of the following index:

$$RCEI = C/(HSQ)$$

where RCEI is defined as Regeneration Cost Efficiency Index, C is the total cost of production, H is the average plantation height (m), S is the survival rate (%), and Q is the average quality index. (For average quality, Q=1, for below average, Q<1, and for above average, Q>1; Q values range from 0. 5 to 1. 5 in the model.) Thus, the degree of success is determined by a combination of biological and economic considerations.

DATA COLLECTION

The stock production data used in Phase I were obtained from greenhouse/nursery operations in Kirkland Lake, Thunder Bay, Dryden and Midhurst, Ontario. The limited seedling-storage data used in Phase II came from the literature. The plantation management data in Phase III are based on two major outplanting studies reported by Wood and Dominy (1985) and Sutton (1987), supplemented by data from 21 operational plantations in northern Ontario.

Stepwise regression analysis was used to screen for factors that affected seedling survival and growth. Significant variables that affected seedling performance were then used to develop appropriate nonlinear regression models. Equations were produced for each species to express survival and total height as functions of site factors and planting stock characteristics.

APPLICATION OF THE MODEL

The application of the model is demonstrated here by evaluating the performance of black spruce (*Picea mariana* [Mill.] B.S.P.) and white spruce (*P. glauca* [Moench] Voss) bareroot and container stock produced and planted under several different conditions.

For both species, bareroot stock was assumed to be transplants in the 1. 5 + 1. 5 age class and container stock was in the "medium" size class. Production costs were estimated at $150 per thousand seedlings for bareroot stock and $130 per thousand seedlings for container stock. At an average planting rate of 2,000 seedlings per ha, the stock costs are $300 and $260 per ha, respectively. For the sake of simplicity, neither storage nor its costs were included in the example.

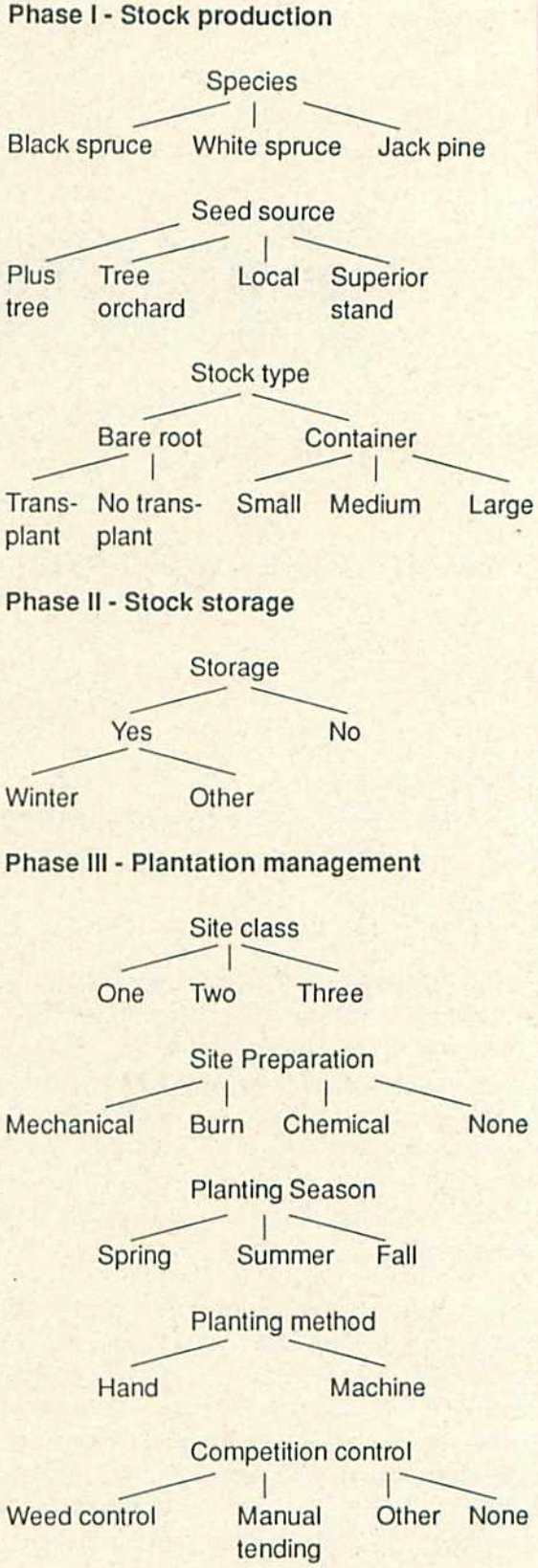

Figure 1. A schematic of the decision-tree approach used by PLANT-PC.

The hypothetical site was rated as site class 2 for both black spruce and white spruce. Two options were considered feasible for site preparation: shearblading, at $300/ha, or prescribed burning, at $200/ha. Hand planting of bareroot stock took place in the spring at a cost of $520/ha and container stock planting occurred in early summer at a cost of $390/ha.

Aerial herbicide spraying may or may not be carried out in year two at a cost of $100/ha. For stands treated with herbicide, a growth improvement of 10% because of spraying was assumed.

Table 1 shows the output of the foregoing example, with the top five regeneration systems ranked in order of increasing RCEI. In addition to the RCEI, the top portion of this table provides other vital statistics for each plantation, including percent survival, height at 20 years, quality index and total production cost per thousand surviving trees.

The lower portion of Table 1 summarizes the main features of the five top ranking regeneration systems. In this example, the best combination of treatments was prescribed burning, followed by spring planting of bareroot black spruce, with no subsequent herbicide spraying. The second-best alternative was the same site preparation followed by early-summer planting of medium-grade white spruce container stock. The remaining alternatives may be interpreted in a similar fashion.

SUMMARY AND CONCLUSIONS

PLANT-PC is a management-oriented computer model that simulates the growth and survival of seedlings from selection of the seed source until 20 years after outplanting, based on input provided by the user. The model compares and ranks alternative regeneration systems using an index that combines the total cost of production with the survival, growth and quality of the resulting stands. It summarizes up to five of the top-ranked alternatives in tabular form. PLANT-PC is a useful tool to assist the forest manager in making decisions about regeneration alternatives. Perhaps its most attractive feature is that input estimates are provided by the user and can be changed at will, enabling the user to quickly determine the impact various inputs will have on the results. Furthermore, if sufficient local data is available, the model itself can be calibrated for regional use.

Table 1. Summary of the top five regeneration systems for the example.

	Rank (based on RCEI)				
Item	1	2	3	4	5
RCEI ($/m)	1.09	1.24	1.42	1.43	1.71
Survival (%)	85.0	62.5	57.5	70.0	81.3
Total height (m) at 20 years	6.19	6.31	9.33	6.34	5.75
Quality index (Q)	1.11	1.08	1.07	1.02	1.02
Production cost ($/1000)	6757	7192	9391	7540	8676
Species	black spruce	white spruce	white spruce	white spruce	black spruce
Stock type	bareroot	container	bareroot	container	bareroot
Site preparation	burn	burn	burn	mechanical	mechanical
Planting season	spring	summer	spring	summer	spring
Planting method	hand	hand	hand	hand	hand
Herbicide treatment	no	no	no	no	no

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