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KEY CONSIDERATIONS TO ENSURE DESIRED STOCKING IN BROADCAST SEEDING

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INTRODUCTION

Increased use of broadcast seeding is being advocated as one way to make more effective use of scarce silvicultural funds. Broadcast seeding (especially aerial seeding) is attractive because large areas can be treated quickly at relatively low cost. This attribute of broadcast seeding, although appealing, should not obscure the fact that careful planning and execution is required to establish a stand of the seeded species to a desirable level of stocking.

Precise predictions of stocking require the use of rather complex probabilistic models (Régnière 1982, Groot 1988) and detailed information on seedbeds. However, this complexity and detail can obscure some valuable general principles. The purpose of this note is to introduce these principles by providing an overview of the interacting elements that determine stocking in direct seeding. Increased understanding of these elements will help forest managers to improve their prescriptions for broadcast seeding.

ELEMENTS DETERMINING STOCKING

Regeneration stocking, the percentage of fixed-area plots on a forest cutover containing at least one seedling, varies from 0 to 100%. Fixed-area plots are typically 2-m by 2-m quadrats.

In broadcast seeding, three elements interact to determine regeneration stocking (Fig. 1). Seedbed receptivity, seed dispersion, and seedbed area must all be taken into account when developing broadcast seeding prescriptions.

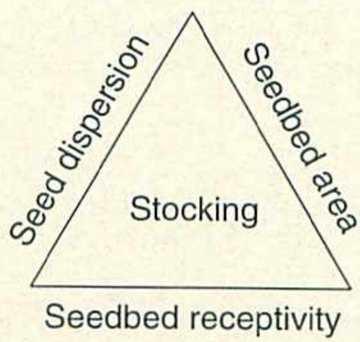

Figure 1. The three elements that determine stocking in broadcast seeding.

Seedbed Receptivity

Seedbed receptivity is best expressed by the establishment ratio, which is the number of established seedlings divided by the number of seeds sown. The establishment ratio varies from 0 to 1.0.

Establishment ratios depend on the tree species being sown, on weather during the establishment period, on site conditions (especially moisture regime), and on seedbed type. For example, establishment ratios for black spruce on different peatland seedbed types have been observed to range from 0.001 to 0.545 (i.e., from 0.1 to 54.5 seedlings per 100 seeds sown) (Groot 1988).

Stocking increases as the establishment ratio increases (Fig. 2), but the relationship is not linear. The curve rises steeply at first, but then becomes more and more flattened. Such diminishing returns typify the response of stocking to its three determinants.

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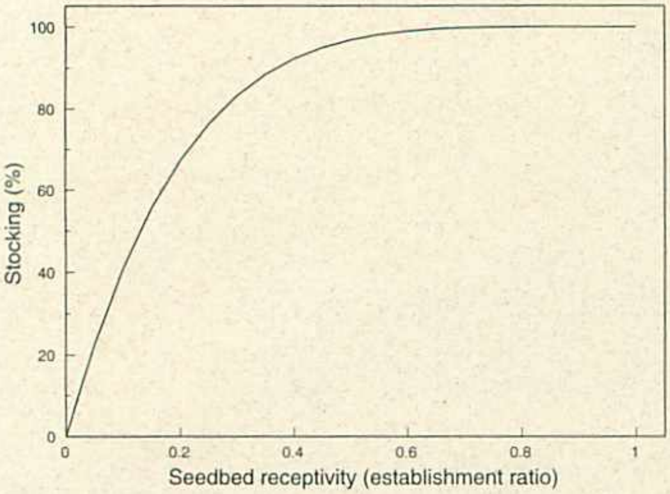

Figure 2. Effect of seedbed receptivity on stocking when five viable seeds fall on a receptive seedbed in each quadrat.

Forest managers can control several of the variables that influence establishment ratios. Obviously, tree species can be fully regulated. Similarly, site conditions can be controlled by determining the areas that are suitable or unsuitable for seeding. Desired seedbed types can be created or exposed through adequate site preparation. The main uncontrollable variable is weather.

Seed Dispersion

Spreading seed on the cutover is an essential step in broadcast seeding. Forest managers must select a seeding rate and attempt to distribute the seed as evenly as possible.

The seeding rate is one of the most easily controlled variables in broadcast seeding and has a direct effect on stocking (Fig. 3). The relationship between stocking and seeding rate again displays characteristics of nonlinearity and diminishing returns. Because of these characteristics, it is often impractical or even impossible to compensate for deficiencies in seedbed receptivity or seedbed availability by increasing the seeding rate.

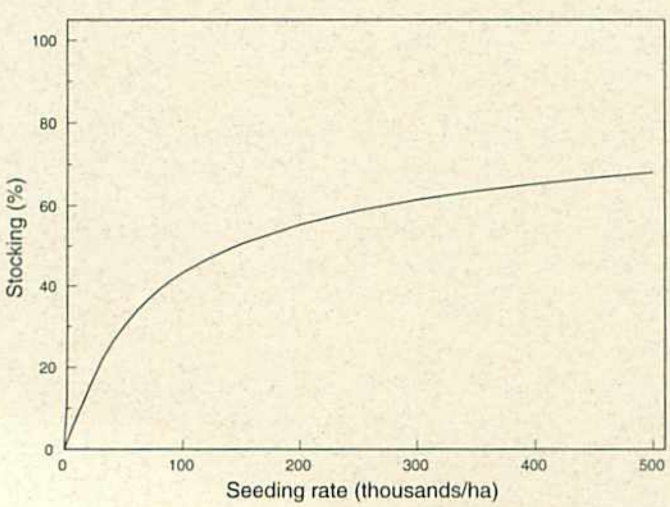

Figure 3. Effect of seeding rate on stocking, based on 4-m² quadrats, each with 12.5% receptive seedbed cover and an establishment ratio of 0.2 for the receptive seedbed.

Highest stocking would be obtained with regular, or uniform, seed distribution in which each quadrat receives the same number of seeds. However, random distribution around the mean seeding rate is the best obtainable pattern with most broadcast seeding devices. When seed is dispersed randomly, the distribution pattern of the number of seeds per quadrat becomes less spread out as seeding rate decreases (Fig. 4). Nevertheless, at low seeding rates (e.g., less than 50,000 seeds/ha) the proportion of quadrats receiving very low numbers of seeds may be unacceptable. Fortunately, random seed distribution produces only slightly lower stocking than regular distribution for a broad range of circumstances.

Particulars of the seeding operation can have major effects on seed distribution. For example, wide flight line spacing and low auger speeds increase the variability (clumping) of seed distribution in aerial seeding of black spruce (Fleming et al. 1985).

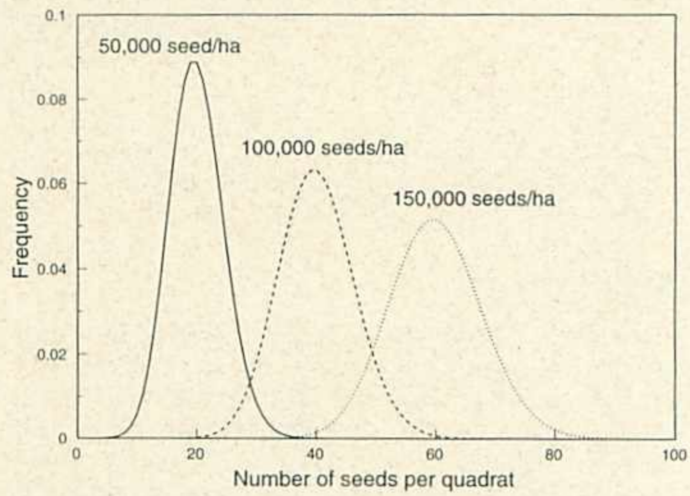

Figure 4. Frequency distribution of number of seeds per 4-m² quadrat, for three broadcast seeding rates with random seed distribution.

An extreme example of the effects of seed distribution variability on stocking can be obtained from the information on which Figure 3 is based. With random distribution, a seeding rate of 250,000 seeds per ha produces a stocking level of 59%. The same average seeding rate would result if half the quadrats received 500,000 seeds per ha and the other half 0 seeds per ha. Averaging the corresponding stocking values, 68 and 0%, yields 34% stocking, an indication of the negative effect that poorly distributed seed can have on stocking.

It should be remembered that the seed applied in the broadcast seeding operation is always complemented by natural seed sources, including seed dispersed from residual trees, forest edges, and from cones present on the cutover. These natural seed sources can contribute substantial amounts of seed and should be taken into account when developing seeding rate prescriptions.

Perhaps because it is the most readily controlled element, the seeding rate is sometimes overemphasized by forest managers when developing prescriptions for broadcast seeding. In fact, all elements are of equal importance in determining stocking.

Seedbed Area

A number of seedbed types are usually present on cutovers and the area of these seedbeds is most simply expressed as a fraction. Fractional area is the proportion of a fixed-area plot covered by the seedbed type and ranges from 0 to 1.0.

The relationship between stocking and fractional seedbed area is once again nonlinear and subject to the law of diminishing returns (Fig. 5). The law of diminishing returns is intensified in this relationship because of variability within seedbed types. Distinct seedbed types can be identified, but variability exists within each one (Groot 1988). Within an identified type, some areas of seedbed will have much lower than average receptivity and other areas will have higher than average receptivity. The areas of lower than average receptivity limit increases in stocking when seedbed area is increased.

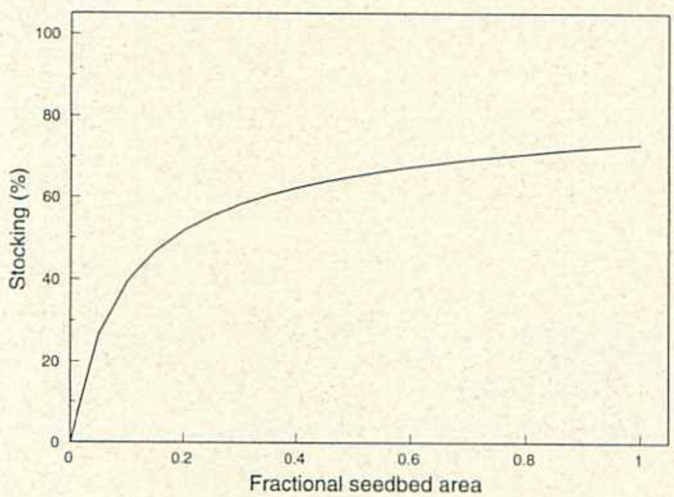

Figure 5. Effect of fractional seedbed area on stocking, based on 4-m² quadrats, a seedbed receptivity of 0.2, and a seeding rate of 100,000 seeds per ha.

Forest managers can control the area and distribution of seedbeds through site preparation. On uniform upland sites that are largely free of impediments to machinery, and where the desired seedbed can be obtained by exposing a certain layer of the soil, it may be possible to achieve nearly regular distribution of seedbeds. However, usually some variability of seedbed areas will occur from quadrat to quadrat. On peatlands, where the distribution of seedbeds is considerably controlled by the naturally occurring mosaic of mosses, even more variability may be present.

Interactions

The relationships of stocking to seedbed receptivity, seed dispersion, and seedbed area have been examined individually in this note. The interaction of these relationships produces many combinations that will produce a particular stocking value.

A seeding manual is currently being developed by the Canadian Forest Service – Ontario. This manual will include software to perform calculations of regeneration stocking and density for any combination of seedbed receptivity, seed dispersion, and seedbed area.

ELEMENTS CONTROLLING DENSITY

Much of this note has focused on the nonlinear relationships of stocking to seedbed receptivity, seeding rate, and seedbed area. The same elements also control seedling density (seedlings per ha), but the relationship of density to these elements is linear. Increases in any one of the three elements translates into a proportional increase in seedling density.

The difference between the stocking and density relationships has significant implications for the clumping of seedlings in a regenerating stand. Continuing along the stocking curve into the flattened zone increases the clumping of regeneration. Here stocking increases only slightly, but density continues to increase at a constant rate. For example, the relationship portrayed in Figure 3 corresponds to an increase in the mean number of seedlings per stocked quadrat as the seeding rate increases (Fig. 6).

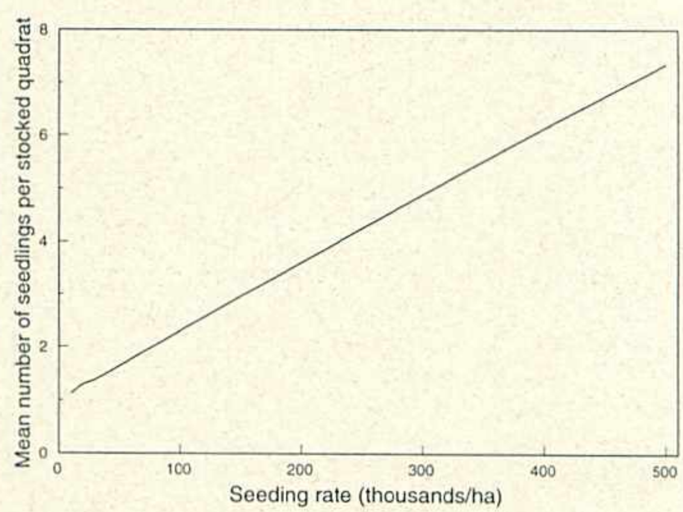

Figure 6. Effect of seeding rate on mean number of seedlings per stocked quadrat, based on 4-m² quadrats, each with 12.5% receptive seedbed cover, and an establishment ratio of 0.2 for the receptive seedbed.

PRINCIPLES

The considerations outlined here do not provide sufficient basis for making detailed broadcast seeding prescriptions, but they do highlight several principles that should be observed when planning broadcast seeding:

1. Consider all the determinants of stocking when developing broadcast seeding prescriptions. In particular, remember that seedbed receptivity and area are as important as seeding rate.

2. Attempt to randomly distribute seeds when broadcast seeding.

3. Create or expose well-distributed seedbeds of high receptivity.

4. Reduce clumping of regeneration by avoiding the flattened portions of stocking curves.

REFERENCES AND FURTHER READING

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Dr. Arthur Groot, a research scientist with the Canadian Forest Service – Ontario, conducts research on black spruce silviculture, seedling ecophysiology, and the forest's physical environment.

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