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AERIAL APPLICATION OF BLACK SPRUCE SEEDS

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INTRODUCTION

Aerial broadcast seeding (Fig. 1) can be an effective and relatively inexpensive option for regenerating black spruce (*Picea mariana* [Mill.] B.S.P.). To determine if aerial seeding is a feasible regeneration option, knowledge of the three elements that affect stocking is necessary; namely, seedbed receptivity, seedbed availability, and seed deposition (Groot 1994). The easiest element to control is seed deposition. This technical note, based on experience gained from many years of operational and experimental seeding programs, will focus on how black spruce seed deposition is affected by seed size, shape, and weight; aircraft/seeder combinations; seeding rates; flying procedures; and wind. In addition, it will illustrate calibration procedures that incorporate seed viability, seed metering, seeding rate, and deposition patterns.

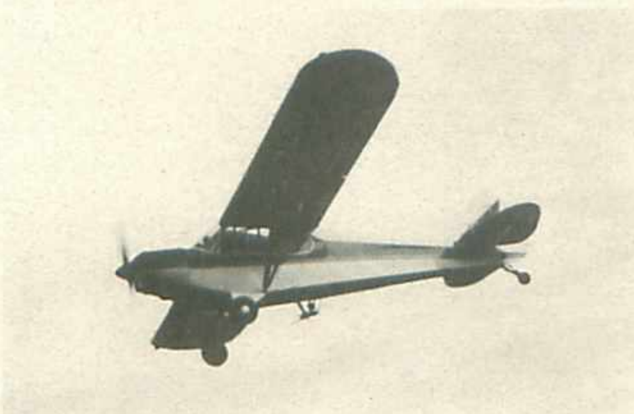

Figure 1. Brohm seeder on Piper PA-18 aircraft.

SEED HANDLING

Black spruce seed should be stored in sealed containers at temperatures ranging from -39 to +0.5°C and a relative humidity of 4–8%, so as to minimize deterioration of germinative capacity (Schopmeyer 1974). When exposed to field conditions in preparation for sowing, seeds absorb moisture from the ambient air and increase in weight by 10 to 30% (Silc and Winston 1979). Thus, the number of seeds per gram decreases between the time of storage and when seeder calibration and sowing are carried out. A single black spruce seed weighs slightly more than 1 milligram, with 830,000 (± 20%) viable seeds per kilogram (Schopmeyer 1974, Ontario Ministry of Natural Resources 1977). The small size and low weight of black spruce seeds creates a difficult technical problem when attempting to consistently meter them at rates as low as 2 g of seeds per second. Pelleting of black spruce seeds was attempted in the past to improve seed distribution. This procedure failed, however, because the seeding mechanisms could not handle pelleted seeds.

SEEDER CHARACTERISTICS

To date, all operational seeding of black spruce in Ontario has been done using seeders equipped with rotating slingers that disperse seed into the airstream. These include the prototype Spruce Falls Inc. self-contained seeder, which is carried on the cargo hook of a helicopter; the Alberta Forest Seeder, developed by the Alberta Forest Service for turbine-powered

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helicopters; and the Brohm seeder,[1] positioned on a Piper PA-18A airplane (the most commonly used seeder/aircraft combination) or one of the early Bell helicopters (such as the G-2 and G-4). Each of the seeders has a unique seed-metering mechanism. The Alberta Forest Seeder and the Spruce Falls Inc. prototype use rotating, large-diameter cylinders or wheels, with seed pick-up on the outer surface of the cylinder, to transfer seed from the hopper to the slinger. The Brohm seeder consists of a hopper from which the seed is metered by a variable-speed auger via a flexible duct to a constant-speed slinger beneath the aircraft. The tachometer-monitored auger speed is adjustable in flight by the pilot, thereby permitting a change in the rate of seed application between sites. Augers of differing pitches and number of lands[2] can be easily changed to accommodate different seed sizes and application rates when multiple seeding prescriptions are employed. The auger system makes efficient use of limited space in small aircraft. The characteristic surging output, with one surge per land for each rotation of the auger, translates into regular pulses of seeds along the flight line (Fleming et al. 1985). To achieve more uniform seed distribution, the number of lands on an auger can be increased, or a finer pitch can be created to permit operation of the auger at a higher rpm (to produce shorter surge cycles) at any given calibration. For example, a two-land auger of finer pitch will have six surge cycles/sec at 180 rpm versus one surge cycle/sec for a single-land auger operating at 60 rpm. At a ground speed of 145 km/h, the length of the recurring sine waves along the swath would be 7 m vs 40 m. Care must be taken to prevent damage to seeds due to any changes in auger design or operating speed.

AIRCRAFT

Light, single-engine, high-wing aircraft have been used to successfully carry the seeder and seed to the seeding chance. The volume and weight of seeds are within the flying capabilities and economics of light aircraft such as the Piper PA-18A (Super Cub). This aircraft is well suited to aerial seeding because of its fuel economy, dependability, range, and ability to operate from short runways (Worgan 1973). Helicopters with similar carrying capacities have been used when greater maneuverability has been required in small treatment blocks or in areas of sensitive terrain. Helicopters ranging in size from small, piston-engine, two-seaters to larger, turbine-powered, five to seven passenger models have been used with success.

SEEDER TESTING

Airflow patterns in and around the wake of an aircraft are sufficiently different that each type and series of aircraft requires testing and calibration with each seeder and seed species used. Almost any change in the aircraft or surface characteristics of the seed (shape, size, or weight) will change the seed distribution pattern on the ground. Each combination of seed species/aircraft model/seeder should be tested separately to determine swath width and seed deposition characteristics (*cf.* Armstrong 1978). Seeding coverage is determined by seed distribution across and along the swath and the precision with which swaths are flown. The latter is a function of aircraft deviation from the prescribed flight line, variation of aircraft ground speed and flying height, and wind. A standard testing procedure is currently being developed by the Canadian Forest Service–Ontario.[3]

Calibration Procedures for a Brohm Seeder/ PA-18A Aircraft Combination

At commonly prescribed application rates of 50,000–300,000 viable seeds/ha (Foreman and Riley 1979, Regnière 1982, Groot 1988, Fleming 1994), approximately 40 to 360 g of seeds/ha are applied. Calibration of the seed-metering device involves determining the number of viable seeds/g. This information is provided by the seed plant for each seed batch under cool storage and low relative humidity conditions—it is advisable to condition the seed to the local ambient field condition relative humidity and then determine the number of seeds/g, based on the weight of 0.1 g. Also, the swath width and the aircraft ground speed are required. A ground speed of 145 km/h (90 mph) and a swath width of 15 m gives a coverage of 3.625 ha/minute of actual sowing time. To apply 50,000 viable seeds/ha, 3,018 viable seeds per second must be sown. If at the time of sowing the seed lot contains 1,106 viable seeds per gram, then 2.728 grams per second must be sown. By testing the seeder on the ground and collecting the metered seed during 30-second intervals, the auger speed setting required to deliver 81.84 g of seed can be determined. For accuracy, a stopwatch and a sensitive gram balance should be used to carry out all calibrations. Fleming et al. (1985) have found that auger speeds for single-land augers should be maintained above 75 rpm for smooth operation. In practice, one may select and use an auger that is the best compromise of the number of lands, the pitch, and the rpm range, so as to accommodate the particular characteristics of the seed lots to be sown and the seeding prescription.

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[1] The Brohm seeder, used most extensively in Ontario, has been evaluated by the Canadian Forest Service–Ontario (Fleming et al. 1985). For this reason, this note provides specific, experience-based information on it, but not on the other systems mentioned. However, this does not constitute an exclusive endorsement of the Brohm seeder by the Canadian Forest Service.

[2] Land is the name given to each spiral along the axis of a screw conveyor; a screw conveyor may have one to three lands, but very rarely more than this.

[3] Leblanc, J.-D. Manual of standard assessment procedures for calibrating seed/seeder/aircraft combinations for aerial seeding. Nat. Resour. Can., Canadian Forest Service–Ontario, Sault Ste. Marie, ON. In prep.

Wind and Flying Height

The bell-shaped distribution pattern of black spruce seeds across a swath produced by the Brohm seeder/PA-18A aircraft combination was found to be reasonably consistent for all rates of application used (Fleming et al.1985). With no wind, the distribution is skewed about 2 m to the left of the aircraft track. Flying heights between 25 and 35 m have little effect on the across-swath distribution. Wind displaces the seed signature position relative to the aircraft track, and changes the distribution shape. Both displacement and change of shape increase with increasing wind speed and/or flying height.

FIELD APPLICATION

Suitable aerial photos and maps annotated with the prescriptions should be supplied to both the pilot and ground crew. Adherence to the prescribed swath width will be improved by radio communication between the pilot and the two ground crew (flagpersons) identifying the flight lines. At a convenient time prior to sowing, it is suggested that a field visit be made to mark flag stations and to set out seed traps. This will allow for the best seed distribution. Calm weather for seeding usually occurs at sunrise or sunset; therefore, ground support crews must be prepared for rapid mobilization. Acceptable conditions for sowing occur only sporadically, in the order of 7–10 hours per week. Both the aircraft and the pilot must wait for appropriate conditions but, when they occur, may sow up to 400 or 500 hectares in a single 4–5 hour flight, on sites that may be 80–160 km from the airstrip. Access for ground crews may require hours of travel time on poor roads to sites that the aircraft may reach in minutes.

Seeding Standards

Accountability requires a measurement of performance against a standard. A suggested achievable aerial seeding standard is that at least 90% of the area sown should catch seed at rates greater than 50% of the prescription, i.e., the half value (Ballard and Will 1971, Riley 1980, Fleming et al. 1985). Figure 2 presents half values for perfect flying requirements, and random deviations of ± 2 m, 5 m, and 10 m from the flight path at selected swath widths when flying with no ground-crew guidance. Competent pilots may maintain a free-flying error level of ± 5 m, although it is unlikely that error levels can be maintained at ± 2 m. Thus, if a low half value is to be achieved, either ground guidance or an aircraft-mounted, precise geographic positioning system is necessary.

Monitoring

An adequate number of seed traps should be positioned throughout the seeding chance. These should be set out as closely as possible to the time of seeding and assessed as quickly as possible afterward (seed traps are rapidly contaminated by other seeds and debris). Seed traps will satisfy the need to monitor the operation and also provide information necessary to assess the job (Cameron and Foreman 1995).

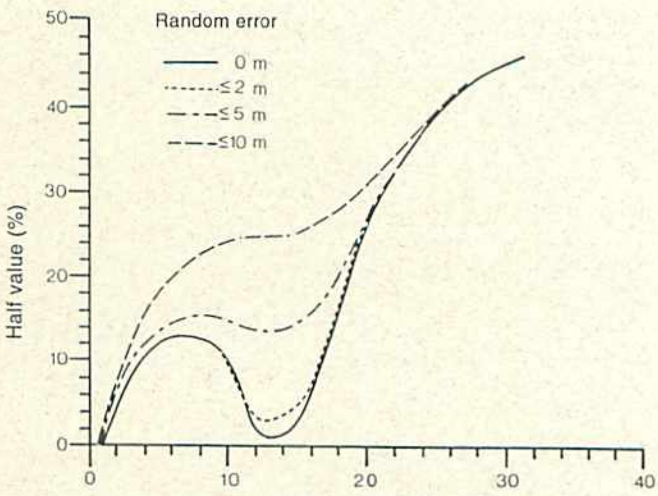

Figure 2. Effect of random deviations of the aircraft from the prescribed flight path on expected half values at various inter-pass spacings and a seeding rate of 150,000 seeds/ha.

KEY RECOMMENDATIONS

For successful aerial seeding, forest managers should keep the following points in mind:

- Aerial broadcast application of black spruce seeds requires precise and accurate calibration of the metering device and auger speed settings.
- A swath width of 15 m should be maintained using either flagpersons or an aircraft ground guidance system.
- Sowing should be carried out only when wind speeds at 1.5 m above ground level are ≤10 km/h. Never sow when winds are shifting in direction or variable in speed, and fly at a constant altitude of 25 to 35 m and at a constant ground speed.
- Above all, calibration and flying procedures must be carried out carefully and consistently if satisfactory black spruce seed deposition and distribution are to be realized.

All aspects of aerial seeding are covered in a publication now in preparation by the Canadian Forest Service–Ontario.[4]

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