1995

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Forestry Research Applications

Canadian Forest Service–Sault Ste. Marie

Technical Note No. 85

A CONE CROP MONITORING AND DECISION SUPPORT SYSTEM FOR JACK PINE AND BLACK SPRUCE SEED ORCHARDS

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CATEGORY: Decision support
KEY WORDS: Decision making, information systems, database management, pest management, cones, seeds

INTRODUCTION

In Ontario, a large number of jack pine (*Pinus banksiana* Lamb.) and black spruce (*Picea mariana* [Mill.] B.S.P.) seed orchards have been established to supply genetically superior seed for reforestation. A primary objective of seed orchards is to optimize the supply of high quality seeds. Meeting seed production targets often requires careful monitoring of the cone crop to predict the quantity and quality of cones and seeds (Bramlett and Godbee 1982, Fleming et al. 1990, de Groot and Turgeon 1992, Fleming and de Groot 1992), and management of insect pests (Turgeon and de Groot 1992, 1994; de Groot and Fleming 1994; de Groot et al. 1994; Turgeon et al. 1994). Pest management decisions require accurate identification of the pest, knowledge of pest biology and damage, methods to prevent or control damage, and estimates of the size and value of the crop to be protected. Typically, pest management decisions are made under uncertain conditions by managers having varying degrees of experience, knowledge, and willingness to take risks; therefore, a system that assists appropriate decision making would be beneficial. Furthermore, automation of database files on insects and their control, of data collection and processing of cone crop yield estimates, and of decision-making procedures would help seed orchard managers.

This note briefly describes the cone crop monitoring, information management, and decision support systems developed under the Northern Forestry Program of the Northern Ontario Development Agreement. Although developed specifically for use in jack pine and black spruce seed orchards in Ontario, many of the procedures and much of the information are applicable to conifer seed orchards located throughout most of North America. A user manual that provides step-by-step instructions on the use of the systems on IBM-compatible PCs and a field data logger, and a copy of the software (DOS-based), can be obtained by contacting the Canadian Forest Service in Sault Ste. Marie. The developement of these systems owes much to the willing and helpful participation of Ontario's seed orchard managers and tree improvement specialists.

AN OVERVIEW OF THE THREE SYSTEMS

The Cone Crop Monitoring System (CCMS), Information Management System (IMS), and Decision Support System (DSS) for pest management are stand-alone programs that function independently. Both the CCMS and the IMS provide data and information for the DSS. The CCMS provides data on the size of the cone crop and expected damage. The IMS provides information on the damage potential of insect pests, pest control products registered in Canada for use against cone and seed insects, and estimates of the efficacy of the products (Fig. 1). The DSS uses this data and asks the user for additional information about protection costs and seed values to help calculate the consequences of various decisions.

CONE CROP MONITORING SYSTEM

The Cone Crop Monitoring System enables seed orchard managers to estimate and predict cone and seed crop size at various times from pollination to cone maturity and harvest. It also provides estimates of the impact of insects, together with other cone- and seed-mortality factors, such as diseases,

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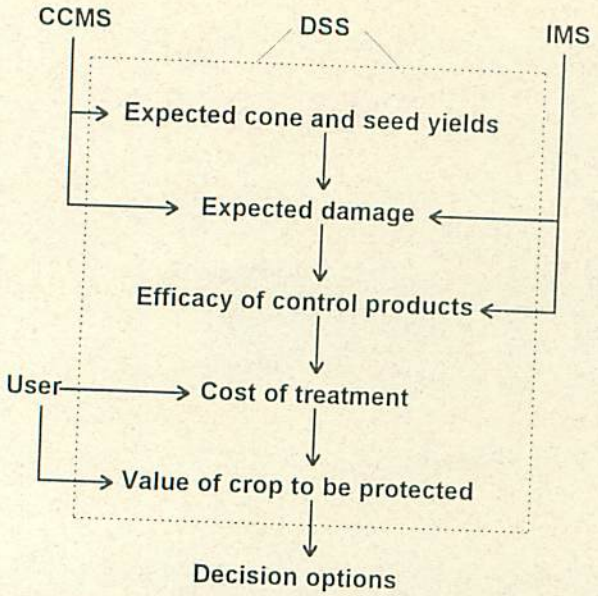

Figure 1. Data and information from the Cone Crop Monitoring System (CCMS), Information Management System (IMS), and the User into the Decision Support System (DSS).

natural abortion, squirrels, and frost. The CCMS may also be used to identify good and poor crop trees, families, or clones, and to estimate work load requirements for pest management and cone collection. This system is flexible and can be tailored to the specific needs of an orchard.

The CCMS method is based on periodic observations of seed cones on sample trees selected from an orchard (Fig. 2). After the sample trees are chosen, all the seed cones on each tree are counted to provide estimates of the potential yield of cones and seeds from the orchard. Sample cones are permanently tagged and revisited periodically during the seed cone development period. On each visit, the cones are examined to determine the number of healthy, damaged, and dead cones, and the probable cause of death. The field data are collected on a data logger running CCMSDAT and downloaded onto a CCMS database on a PC. Using CCMSPC and previous cone and seed loss data from the orchard (or some best guess), the user can then make predictions on the cone and seed yield expected at harvest. After each visit, the predicted cone and seed yields are adjusted to reflect the current level of cone and seed losses. At harvest, sample cones are processed to determine seed potential, actual yield of filled seed, and seed losses. These data are used in future years as a basis for predictions of seed yield from the cone yield estimates. Seed germination values can also be incorporated into the CCMS to estimate seedling yields.

The main features of the CCMS are modules to collect, manage, store, retrieve, summarize, and analyze data. The **DATA COLLECTION** module collects and stores CCMS assessment data on hand-held data loggers. Downloading the data from the data logger into the database on the PC is performed by the **DATA TRANSFER** module. The **EDITING** module is used to modify data (e.g., make

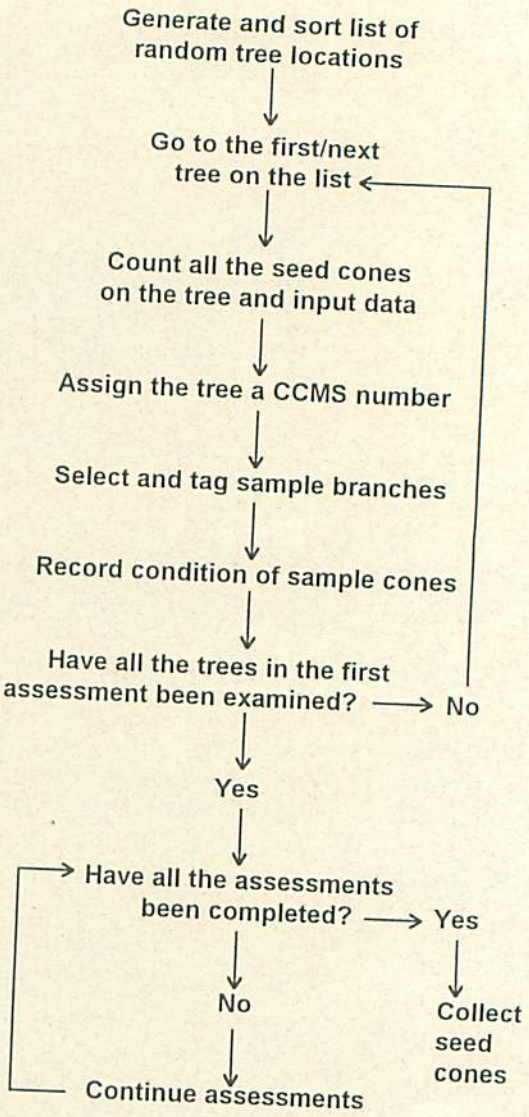

Figure 2. A flow chart outlining the field procedures for monitoring cone crops.

corrections) directly within the database. The **REPORT** module provides printed reports of raw data and of data summarized by tree clone/family and orchard. The calculation of cone and seed yield indices, predictions of seed yield, clone/family summaries, cone condition, and mortality factor summaries are done by the **CONE ANALYSIS** module (Fig. 3). The **GRAPHICS** module provides temporal and spatial trend analysis by graphically displaying the current and previous years' data. These latter three modules have several user-selected display formats. The final module, called **ASCII INTERFACE**, produces ASCII files of CCMS data for subsequent processing or analysis in commercial software packages.

INFORMATION MANAGEMENT SYSTEM

A fundamental requirement for effective pest management in seed orchards is a knowledge of the damage, biology, prevention, and control of various insects. The Information

Cone Crop Monitoring System 06/28/1994

Cone Efficiency (CE) Analysis

OTIB Zone: 1 CCMS Study: 1
CCMS Year: 1994 Orchard: Morson Sb

	Assessments				
	1	2	3	4	Final
Predicted CE %	90	75	65	55	50
Actual CE %	84	73	62		
Revised Final CE %	44	48	47		

Revised final CE: 47%
Predicted cone yield: 423,000
Total # hectolitres: 14.84
Pred. orch. seed yield: 10,152,000
Pred. extrac. seed yield: 9,136,800
Predicted seedling yield: 7,766,280

Seed potential: 48
Seed efficiency: 50%
Cones/hl: 28,500
Extraction effic: 90%
Germination effic: 85%

Figure 3. Sample output from the Cone Crop Monitoring System for the Morson black spruce seed orchard showing the predicted yields of cones, seeds, and seedlings after the third assessment.

Management System provides this essential information on the insect pests of pine and spruce in eastern Canada. There are three main modules in the IMS program. The **DIAGNOSIS** module helps the user key out the pest or pests causing damage to the cone and seeds on the basis of damage characteristics. Once these variables have been determined, the system identifies the pest and the user can then view or print selected information about it. The **PEST** module provides information on the hosts, importance and distribution of the pests, a description of the damage and all the life stages of the pest, and the current control methods (Fig. 4). The **CONTROL** module provides information on the pest control products registered by Agriculture Canada for use against cone and seed insects. This information includes the product name, registration number, registrant and Canadian agent, location of use, market type, formulation type, precautions, first aid, environmental hazards, spill cleanup, toxicology, storage and disposal instructions, directions for use, active ingredient, insect(s) controlled, and estimates of the efficacy of the product.

DECISION SUPPORT SYSTEM

The Decision Support System helps to ensure that economically and environmentally appropriate pest and crop management decisions are made easily. The DSS program provides analyses of possible pest management options and their costs (Fig. 5), and helps users deal with uncertainty in product values, pest damage, control efficacy, and interest rates.

Information Management System 06/28/1994

Name: Spruce cone maggot (*Strobilomyia neanthracina*)

Print output options	DISTRIB	*<Spacebar> to Tag/Untag*
	HOSTS	
	EGGS	
	LARVA	
	PUPA	
	ADULT	
	DAMAGE	
	DETECT	
	MONITOR	*<Enter> to accept*
	CONTROL	

Figure 4. Sample of print output options on pest information from the Information Management System.

Decision Support System 06/28/1994

Cost Analysis

OTIB Zone: 1 CCMS Study: 1
CCMS Year: 1994 Orchard: Morson Sb

	Scenario		
	1	2	3
Cost of protection ($)	000	3,850	4,900
Predicted cone yield ('000's)	423	495	504
Predicted seeds/cone	24	24	24
Predicted seed yield ('000's)	10,152	11,880	12,096
Predicted seed crop value ($)	25,380	29,700	30,240
Gain in seed yield/$ protection	0	449	397
Gain in seed crop value minus cost of protection ($)	0	+ 470	– 40

Figure 5. Sample output from the Decision Support System.

Among other variables, the DSS program requires users to input interest rate, current cone crop size, cost of pest management, and the expected gain in cone and seed yields from pest management. The users can run many simulations and, when finished, can print graphical and tabular displays of the results specific to their needs.

SUMMARY AND CONCLUSIONS

The CCMS, IMS, and DSS provide seed orchard managers with automated tools to collect, process, and store data and information about cone crops and insect pests, and aid in pest management decision making. The systems are flexible and can be tailored to the needs of a specific orchard.

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The preparation of this note was funded under the Northern Ontario Development Agreement's Northern Forestry Program.

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Catalogue No. Fo 29-29/85E
ISBN 0-662-23601-7
ISSN 1183-2762

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