Nursery Practices in Cold Storage of Conifer Seedlings in Canada and the United States:

A SURVEY

Drake Hocking
Canadian Forestry Service
Edmonton, 4tberta, Canada

Cold storage of conifer seedlings is of topical interest, as reflected in widespread discussions at recent meetings of nurserymen (2, 3, 4, 5). Proper storage enables foresters and nurserymen to improve their operations through better planning, control, and ordering of work schedules than was formerly possible.

Research in cold storage of conifer seedlings is the subject of a detailed review published elsewhere (Hocking and Nyland, 1971, Res. Rep. 6 Applied Forestry Research Institute, Syracuse, N.Y.), which includes references to other reviews. The most recent survey of nursery practice in cold storage was conducted in March, 1965. Since much has happened recently, we surveyed current storage practice hoping to detect present trends.

The Survey

In March, 1970, we circulated a questionnaire to 160 Federal, Provincial, State, and private forest nurseries in Canada and the United States (see Tree Planters Notes 75, 1965, for U.S. addresses). Information requested included:

- Name of respondent
- Name and address of nursery
- Seedling storage facility (cellar, cooler, etc.)
- Major species stored (in dicate age)
- Period of storage (days) - Temperature (indicate de gree of accuracy and con stancy) '
- Relative humidity (indi cate degree of accuracy and constancy)
- Roots mudded or not? Packed with moss or (indicate other)
- Size of seedling bundles
- Packing method and materials
- Special preparations
- Other species stored: (give information indicated above for each species, and age of seedling, on separate sheets)

Responses were received from 128 nurseries, an 80 percent return with a distribution approximating that of Abbott and Eliason (1) but also including every Canadian province.

Results

Survey responses were generally complete and detailed. A summary is presented in Tables 1 and 2, but the figures by themselves cannot give the whole picture. Text comments follow.

Type of storage facility. - Ninety-two percent of respondent nurseries used refrigerated storage facilities, either specially built or converted. All

TABLE 1.—Facilities and methods in use for cold storage of conifer seedlings: an analysis of questionnaire responses

Factor	Percent of respondents
Storage duration:[1]	
- less than 60 days (spring)	65
- 60 or more days (overwinter)	44
Storage temperature:	
- below 32°F	2
- 33-35°F	36
- 36-40°F	48
- above 40°F	4
- unstated	10
Precision of temperature control:	
- ± 2°F	32
- "close" (or ±15°F.)	20
- wide ranging or unstated	48
Storage relative humidity:	
- 95 to 100 percent	16
- 90 to 95 percent	21
- below 90 percent	24
- unstated	39
Precision of relative humidity control:	
- ± 5 percent	22
- close (or ± 10 percent)	8
- wide ranging or unstated	37
- uncontrolled	33
Moisture-retaining materials used as packing:	
- sphagnum or peat moss	84
- clay or mud	0
- other	8
- none	8
Types of packing[1]	
- tops exposed, roots in a waterproof wrapping (includes bales, jelly rolls, open bundles)	80
- tops exposed, roots in a non-waterproof wrapping (e.g. only burlap or heavy paper)	0
- totally enclosed in a waterproof wrapping (e.g. polyethylene-lined paper bags or wooden crates)	44
Age of stock stored:	
- 2-0, 3-0	88
- 2-2, 2-3	7
- unstated	5

[1]Some respondents used more than one type.

respondents who did not use a refrigerated facility stored stock for a maximum of 14 days. Half of them limited storage to 7 days or less. Several respondents who used a fully refrigerated facility also used other traditional methods of storage, such as heeling-in, for short-term storage or for holding excess stock. Generally, respondents commented that this was not as satisfactory as storing trees in a cooler with controlled temperature.

Temperature controls. Nearly all coolers were reportedly kept between 33 and 40'F. However, in one notable case, the nursery for 8 years had stored a wide range of species overwinter *(150* days) below freezing (28 to 30'F) with no serious problems. Several respondents mentioned trials with sub-freezing temperatures with varying success.

The degree of control, possible or practiced, over storage temperature is not as clear. Numerous respondents stated a temperature range, but many (48 percent) could not or did not state the degree of control.

Relative humidity controls. Specifications of relative humidity in coolers were much less precise than of temperature. Most respondents *(70* percent) either stated that relative humidity fluctuated between wide limits, or they could not or did not state the degree of control.

Moisture-retaining materials. Sphagnum or peat moss was the overwhelming choice, used by 84 percent of respondents. No respondent used a clay or mud root dip, and only 8 percent used other materials like shingle tow or shavings. Those who used no moisture-retaining materials (8 percent) packed the stock in totally enclosed waterproof packages.

Type of packaging.-Most respondents (80 percent) packed at least some stock in one of the traditional packages (bale, jelly roll, bundle, etc.), using some type of waterproof barrier to enclose the root portion of the package. Many (44 percent) also used to some degree or exclusively, a totally enclosed polyethylene-lined package, either a crate or a multi-walled kraft paper bag. This was the packaging method used by almost two-thirds of respondents reporting the longest storage for a species (Table 2).

Duration of storage.-Most species reported on have been successfully stored for 4 to 7 months, the main exceptions being the southern pines, with storage limited to 1 or 2 months. Most respondents *(65* percent) stored stock for less than *60* days, a period corresponding to the spring shipping season. Overwinter storage, for *60* days or more, was practiced by 44 percent of respondents.

Age of stock stored.-Eightyeight percent of respondents stored 2-0 or 3-0 seedlings and 7 percent stored 2-2 or 2-3 transplants.

Discussion

Between March 1965 and March 1970, the percentage of

TABLE 2.—Species stored, with maximum period of storage and condition of storage

Species successfully stored	Maximum storage period	Conditions Mentioned		Packaging
		Temp.	R.H.	
	(days)	*(°F.)*	*Pct.*	
Eastern white pine	150	28-30	90-100	Steel crate with moss
Western white pine	30	33-35	95+	K-P bags
Red pine	150	28-30	90-100	Steel crate with moss
Austrian pine	150	28-30	90-100	Steel crate with moss
Scotch pine	200	34	95	Poly-lined crate, no moss
Ponderosa pine	135	34	90	Bale with moss
Lodgepole pine	190	34	95	K-P bags
Jack pine	200	34	95	K-P bags
Sugar pine	30	33-35	95+	K-P bags
Jeffrey pine	30	36	–	K-P bags or poly bales
Loblolly pine	60	40-45	20-25	K-P bags
Slash pine	30	35-40	90	K-P bags
Shortleaf pine	28	34-38	50-60	Bale with moss
Virginia pine	70	36-38	85-90	Bale with moss
Longleaf pine	30	36	–	K-P bags
Monterey pine	56	35	–	Poly-lined crate
Coulter pine	56	35	–	Poly-lined crate
White spruce	200	34	95	Poly-lined crate
Norway spruce	150	28-30	90-100	Steel crate with moss
Sitka spruce	30	33-35	95+	K-P bags
Engelmann spruce	135	34	90	Bale with moss
Black spruce	190	34	95	K-P bags
Colorado spruce	200	34	95	Poly-lined crate
Douglas fir	150	28-30	90-100	Steel crate with moss
White fir	135	34	90	Bale with moss
Balsam fir	150	28-30	90-100	Steel crate with moss
Grand fir	30	33-35	95+	K-P bags
Noble fir	30	33-35	95+	K-P bags
True fir	120	31-38	95-100	K-P bags
Shasta red fir	30	33-35	95	K-P bags
Silver fir	30	33-35	95+	K-P bags
Japanese larch	120	36	90	Bale with moss
Siberian larch	190	34	95	K-P bags
Western red cedar	120	32-34	–	Bale with moss
Eastern red cedar	90	34-36	85-95	Poly-lined crate
Western hemlock	30	33-35	95+	K-P bags
White cedar	30	38	60-70	Bale with moss
Rocky Mountain juniper	90	34-36	85-95	Poly-lined crate

nurseries using cold storage overwinter has doubled. Spring storage has tripled. This increase in the use of cold storage likely has come about for several reasons, including improved nursery capitalization, better dissemination of better information, and modern technology in materials and refrigeration.

In sharp contrast is the seeming lack of precise control or monitoring of storage conditions. Only 32 percent of respondents claimed to control temperature within ±2F, and only 22 percent claimed to control relative humidity within ±5 percent. None gave any indication of differences with position in storage building or within packages.

Relative humidity is technically difficult both to control and to monitor, especially at the low temperatures maintained in most seedling-storage buildings. But because of the trend toward totally enclosing stock in waterproof wrappings, precise humidity control may have become less important than formerly.

Accurate and complete information on temperature variation with time and position, however, is relatively simple to obtain. Such information is essential to the proper understanding of cold storage. Temperatures should be monitored within seedling packages in several well-distributed locations in the building. Without such information, the best research cannot overcome the problems of pathological or physiological deterioration associated with cold storage of conifer seedlings.

Summary

Most nurseries are equipped with refrigerated cold-storage facilities wherein temperature is kept in the range of 33 to 40° F. ; Little attempt seems to be made to monitor and control temperature or relative humidity within narrow limits. Stored stock is always packaged with roots in a waterproof wrapping and for longer storage periods is usually totally enclosed in a polyethylene-lined paper bag or wooden crate. Roots are usually packed with sphagnum or peat moss. Most species have been successfully stored 4 to 7 months overwinter, except southern pines, which are usually stored for a maximum of 1 to 2 months.