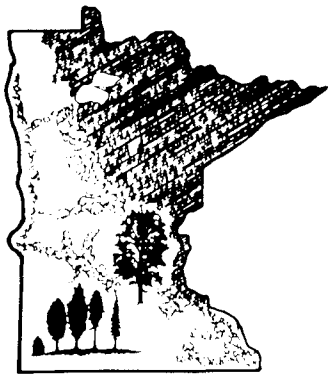

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BURIED SEED IN THE FOREST FLOOR OF THE BOUNDARY WATERS CANOE AREA

Clifford E. Ahlgren*

ABSTRACT

Seed was extracted in 11 areas from soils: beneath pine stands last burned from 3 to 200 years ago; beneath a mixed balsam fir stand, and beneath mature aspen stands. In all stands, seeds of species characteristic of recently disturbed land were found. Live plants of many of these species had not been detected on these sites for 6 or more years. Viability of the seed was determined.

INTRODUCTION

Approximately one-third of the pioneer plant species found on burned-over land in northeastern Minnesota are of seed origin (Ahlgren 1960). Seed of some species are wind disseminated after disturbance, but others, which produce heavier seeds dispersed in other ways, would not be introduced as rapidly after fire. Some of these species attain dominance on disturbed land and may influence later stages of succession through competition and allelopathic influences. Information about the source of these invaders is important to understanding post-disturbance plant succession. Viable buried seed with potential for site recolonization have been found in soils of old fields and northern conifer forest types (Moore and Wein 1977, Livingston and Allessio 1968). This study examines the extent to which such seed are present prior to disturbance in soils of various forests of the Boundary Waters Canoe Area (BWCA) Wilderness.

* Director, Wilderness Research Foundation, and Research Associate, College of Forestry, University of Minnesota.

STUDY AREAS

Young Burns: Two areas recently burned by wildfire are included. One, burned 13 years prior to sampling, contained a mature jack pine (*Pinus banksiana* Lamb.) stand before fire and is now regenerating to jack pine. The other, burned 3 years before sampling, was a mature red pine (*P. resinosa* Ait.) stand before fire and is now rapidly being covered with aspen (*Populus tremuloides* Michx.) sprouts.

Old Burns: One site, burned 30 years before sampling, supported a prefire jack pine forest with an overstory of scattered red pine; these species also make up the postfire stand. The second area, burned 40 years previous to sampling, supported an old jack pine stand and was restored to the same species following fire. The third area had been a white pine (*Pinus strobus* L.) forest with scattered jack pine. It was logged in the early 1900's and burned soon after. Following wildfire, it naturally regenerated to jack pine.

Old Red, White Pine: These three tracts show no signs of fire or cutting for more than 200 years.

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Budworm-Destroyed Balsam Fir: This tract was predominately balsam fir (*Abies balsamea* (L.) Mill.) mixed with some quaking aspen, paper birch (*Betula papyrifera* Marsh.), and white spruce (*Picea glauca* (Moench.) Voss) prior to severe budworm destruction which began 18 years before sampling. The area is regenerating to aspen with a balsam fir understory.

Aspen: These two areas contain aspen forest which developed after white pine logging in the early 1900's.

METHODS

On each area, vegetation data, including frequencies reported in Table 2, were obtained from 30 10-m^2 circular plots placed 30 m apart. Over a 23-year period vegetation data were gathered from the same plots at 1- to 8-year intervals depending on date of disturbance. Data on plant frequencies given in Table 2 were collected in 1977. Soil samples were gathered in 1977, using a metal cylinder 13.2 cm in diameter and sampling from surface litter to a depth of 2.5 cm into mineral soil. For each area, a composite sample of three cores was combined, sieved, and the seed extracted by hand. Seeds were identified by comparison with known samples, and number of seeds per hectare determined. Seed for all 11 study areas were combined with those from three areas described elsewhere (Ahlgren 1979) to obtain a sample large enough for viability tests (Table 1). These seed were stratified at 4.4°C for 3 months; planted in moist, sterile soil in the greenhouse; and grown until the plants were identifiable. The soils remaining after the seed were extracted were placed in cold storage for 3 months, put in flats, and kept moist in a greenhouse to determine if any seed had been overlooked during seed extraction. In these flats, fern prothallia (*Pteridium aquilinum* (L.) Kuhn), moss (*Hypnaceae* spp.), occasional grasses (*Gramineae* spp.), and bush honeysuckle (*Diervilla lonicera* Mill.) seedlings appeared in numbers too small to influence the results given in Tables 1 and 2. The seeds and seedlings reported do not represent the total viable seed content of the soil samples, since ideal germination and growth conditions for all species could not be supplied, and smaller seed were not extracted. However, the species found represent typical species of the areas.

RESULTS

Seed of cranesbill (*Geranium bicknellii* Britt.) and bindweed (*Polygonum cilinode* Michx.) were found in all areas, although plants of these species were frequently absent (Table 2). Both species are temporary disturbance-followers, achieving dominance within the first five post-disturbance years and declining by the seventh year (Ahlgren 1960). In the old pine forests some of these seed must be more than 10 years old since these species were not represented in vegetation tallies 10 years prior to soil sampling.

Both plants and seeds of raspberry (*Rubus* spp.) were found in all areas, but seed and plant frequencies were highest on recent burns. Increased raspberry growth and fruiting on land released through fire, cutting, and blowdown are well known; the larger numbers found on recently burned land are undoubtedly related to this release stimulus. In the old pine forests and older burns, the 2,500,000 to 5,000,000 seed per hectare found (if partially viable) could be important in early revegetation should disturbance occur.

On young burns, sedge seed (*Carex* spp.) were abundant and plant frequency was 38 percent. On older burns, although plant frequencies were much lower, seed quantities were still high indicating maintenance of a seed reserve. In the old pine forests, a small seed supply despite a 40 percent plant frequency may indicate low fruiting under the shadier conditions. Apparently the aspen sites and those damaged by budworm were not conducive to sedge growth.

In contrast to the sedges, grass was present in all areas both as seeds and as plants. The higher seed number on the young burns undoubtedly was related to increased light which stimulated fruiting in those areas.

Strawberry (*Fragaria* spp.) seeds were found only on recently disturbed lands. These seeds had low viability and must not remain long in the soil. The shrubs bush honeysuckle and Canada honeysuckle (*Lonicera canadensis* Bartr.) were present in all areas, but seeds were found only on old burns, suggesting a possible period of heavy fruit production more than 13 years after fire. Re-establishment of these species from residual seed from other areas is also possible.

Pine and spruce seeds were found where seed trees were available. However, soil-stored seed of these species were of low viability, as reported elsewhere (Frank and Safford 1970). Balsam fir and birch seed, found in all areas except recent burns, were undoubtedly shed recently from trees in the areas and also had low viability.

Total number of seeds per hectare for all species combined (Table 2, bottom) was highest on the most recently disturbed lands (budworm-damaged and young burns), intermediate on the vigorous forests of the 30 or more year-old burns, and lowest in the old pine forest. Moore and Wein (1977) report that soils of deciduous-dominated forests have more viable seed than those of conifer-dominated lands. In the BWCA, this trend is not evident, especially if birch seed is omitted from the totals because of its low viability and low seedling survival. Without birch seed, total seed in the aspen stand was low and similar to that of the old pine forest.

CONCLUSION

Although the numbers of seed in the soil decreased strikingly with time since disturbance, substantial numbers of seed were still present in soil of old pine forests. Included are seeds of species characteristic of recently disturbed lands: bindweed, cranesbill, and raspberry, plants of which were absent or infrequent and nonfruiting in the old forest. Because seed viability was determined for all plots combined (Table 1), viability of seed in the old growth stands is not known. If the seed is viable, considerable early post-disturbance vegetation may originate from seeds in the soil before the disturbance, possibly since the last disturbance. This source of seed for the initial stages of post-disturbance plant succession must not be overlooked.

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Table 1. Viability of seed extracted from soil of forests last disturbed 3 to 200+ years ago. The sample includes the 11 sites in this study and the 3 described by Ahlgren (1979).

Species	Number of Sites*	Number of Seeds	Germination (percent)
Geranium bicknellii	14	196	30
Polygonum cilinode	8	229	35
Rubus spp.	14	718	29
Carex spp.	10	222	52
Gramineae spp.	8	71	50
Prunus pensylvanica	4	17	9
Cornus rugosa	2	15	0
Diervilla lonicera	1	15	28
Lonicera canadensis	1	4	0
Sambucus pubens	1	2	25
Plantago major	1	1	0
Taraxacum officinale	1	1	0
Vicia americana	5	129	10
Fragaria spp.	4	21	2
Aralia nudicaulis	4	28	18
Cornus canadensis	2	8	4
Maianthemum canadense	2	5	0
Corydalis sempervirens	1	13	35
Acer rubrum	1	1	0
Pinus strobus	2	21	0
Pinus resinosa	1	45	0
Pinus banksiana	1	1	0
Abies balsamea	9	115	3
Picea glauca	8	45	2
Betula papyrifera	9	2,412	1
Thuja occidentalis	1	18	0

* The sample was from the 11 sites in this study and the 3 described in Ahlgren (1979).

Table 2. Seed density and plant frequency from forests last disturbed 3 to 200+ years ago. All sites are in the Boundary Waters Canoe Area, Minnesota

	Stands Burned 3 and 13 Years Ago		Stands Burned 30 and 70+ Years Ago		Old Red and White Pine Stands		Budworm-destroyed Balsam Fir		Mature Aspen Stands	
	Plant frequency (percent)*	Seed/ha (thousands)**	Plant frequency (percent)	Seed/ha (thousands)	Plant frequency (percent)	Seed/ha (thousands)	Plant frequency (percent)	Seed/ha (thousands)	Plant frequency (percent)	Seed/ha (thousands)
Geranium bicknellii	47	3,509	0	1,775	0	4,437	0	2,178	0	5,082
Polygonum cilinode	18	14,520	0	3,146	0	242	3	1,694	0	726
Rubus spp.	90	52,393	28	2,501	60	5,324	43	5,324	50	5,687
Carex spp.	38	4,719	3	4,356	40	1,855	3	0	2	0
Gramineae spp.	53	5,929	49	161	70	323	33	726	97	847
Prunus pensylvanica	22	0	10	807	8	0	30	242	0	363
Cornus rugosa	0	0	10	0	1	0	27	0	60	1,815
Diervilla lonicera	35	0	43	1,210	17	0	33	0	72	0
Lonicera canadensis	20	0	8	323	53	0	60	0	37	0
Sambucus pubens	0	0	0	0	0	0	0	484	0	0
Plantago major	0	242	0	0	0	0	0	242	0	0
Taraxacum officinale	1	242	0	0	0	0	1	242	0	0
Vicia americana	68	12,221	24	161	20	1,855	7	0	23	363
Fragaria spp.	3	242	2	0	0	0	7	968	22	0
Aralia nudicaulis	53	121	52	1,855	83	0	70	242	92	0
Cornus canadensis	60	0	27	0	62	0	3	242	7	0
Maianthemum canadense	60	0	69	323	90	81	60	0	82	0
Corydalis sempervirens	0	0	1	1,049	0	0	0	0	0	0
Acer rubrum	3	0	3	0	3	0	0	0	45	121
Pinus strobus	0	0	4	0	57	1,533	20	0	13	0
Pinus resinosa	0	0	6	2,017	48	0	0	0	5	0
Pinus banksiana	33	0	37	81	0	0	0	0	0	0
Abies balsamea	2	0	44	1,855	97	3,227	100	6,534	73	4,961
Picea glauca	12	363	67	2,339	35	2,420	0	2,420	17	121
Betula papyrifera	14	0	39	24,200	62	1,936	93	48,400	83	36,300
Thuja occidentalis	0	0	0	0	3	0	50	4,356	0	0
TOTAL		94,501		48,158		23,232		74,294		56,386

* Figures are based on 30 plots.

** Each seed found is equal to 242,000 seed per hectare.

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