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Buried viable seed in successional field and forest stands, Harvard Forest, Massachusetts

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LIVINGSTON, R. B. and M. L. ALLESSIO (Univ. of Mass., Amherst, and Rutgers Univ., Newark, N.J.), Buried viable seed in successional field and forest stands, Harvard Forest, Massachusetts. Bull. Torrey Bot. Club 95: 58–69, 1968.—Disruption of any community is usually followed by the almost immediate appearance of earlier successional species. This has been related to the presence of buried viable seed. To test for the presence of viable seed, soil samples were collected at Harvard Forest at 16 sites, representative of secondary succession in Massachusetts. These ranged from a 1-yr abandoned field to an 80-yr white pine stand that supported an understory of young hardwoods. When soil samples were collected, a list was compiled of all ground cover species at each site. Fifty-five ground cover species were recorded at the 16 stations, and of these, 41 were restricted to open fields and young pine stands, and 14 to a mature 80-yr pine stand. There were no ground cover plants in any of the fully-stocked, 21 to 47-yr pine stands. Germination tests of soils from all sites produced quantities of seedlings. In these tests 65 species, averaging 20 species per station were recorded. The 3474 seedlings recovered represented an average of 220 per square foot of soil surface sampled, with a low of 116 and a high of 466. Many of the field species occurred in essentially all soils tested, and 40 of the 64 which appeared in field samples produced 88.5% of the total seedling crop. The field species thus prevailed and dominated all samples except those from the mature pine stand. With maturation and opening of the stands, late successional and climax species appeared. Both short-lived and long-lived seed were among the seedlings recovered. The latter group included *Juncus tenuis, Panicum capillare, Rumex acetosella* and *Danthonia spicata*. It is proposed that viable seed in the forest soils had not been carried into the stands where they then filtered down through the litter-humus layers, but that they remained viable during long burial in the soils. The universality of secondary succession is assured by long term storage of seed in soils.

The disruption of succession by fire, cultivation, severe thinning or windthrow is usually followed almost immediately by the appearance of earlier successional species. This reappearance of successional species has been shown to be related to the presence of viable seed often long buried at the site (Brenchley, 1918; Oosting and Humphreys, 1940; Olmsted and Curtis, 1947).

In 1893, Peter (Molisch, 1938) studied the seed content of soils of forests that had been planted at given times. He found that there were fewer field plants as the age of the forest increased, but seed of many of the field species retained viability for a long period of time. Oosting and Humphreys (1940) studied the relations between buried seed and the past and future vegetation in old-field successional stands. Seedlings derived from buried viable seed from their plots showed species similar to those of the normal Piedmont succession.

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The study by Oosting and Humphreys is based on well documented knowledge of the successional pattern on the Piedmont of North Carolina, where the old-field broomsedge stage is early invaded by loblolly or short-leaf pine which forms fully-stocked stands. In central New England the successional development is variable. White pine may enter the sere by invasion of the oldfield *Solidago* or *Andropogon* stage, or it may invade the rather open gray birch-aspen stage. In either situation the development of a fully stocked pine stand may be delayed. Small openings may occur, with some persisting for relatively long periods. The small islands of oldfield herbaceous species may persist well into the succession. In order to avoid stands which may have had such openings, we selected fully stocked plantations at Harvard Forest, Petersham, Mass. These plantations had similar old field histories and all had been maintained as fully stocked stands. These plantations were of great value in our study and we wish to express our appreciation to the Harvard Forest Staff, and especially to Dr. Hugh Raup, for permission to use their facility in this study.

Methods and materials. Soil samples were collected in and near the Harvard Forest, Petersham, Mass. One series of samples was taken at each of 16 stations during September and October 1961, prior to the cold season, and another series from 5 of the stations in May 1962 after the cold season. The sites sampled were:

Oldfield White Pine series:
- Station 1. Horseweed field (*Erigeron canadensis*), abandoned 1 year
- Station 2. Goldenrod field (*Solidago* spp), abandoned 2 years
- Station 3. Andropogon field (*Andropogon scoparius*), abandoned about 8 years
- Station 4. 5-yr white pine (*Pinus strobus*) in abandoned field
- Station 5. 7-yr white pine stand
- Station 8. 25-yr white pine plantation
- Station 11. 37-yr white pine plantation
- Station 13. 42-yr white pine plantation
- Station 15. 47-yr white pine plantation
- Station 16. 80-yr white pine stand with hardwoods understory

Other Conifer Plantations:
- Station 6. 15-yr red pine (*Pinus resinosa*)
- Station 7. 21-yr red pine
- Station 10. 36-yr red pine
- Station 12. 41-yr red pine
- Station 14. 47-yr red pine
- Station 9. 35-yr red spruce (*Picea rubens*)

The white pine series is representative of secondary successional trends in the Northern Transitional Forest Region (Lutz, 1928). The red pine and red spruce plantations were sampled to determine possible differences in the amounts and kinds of viable seed in adjacent plantations which supported different overstory trees. Soils at all sites were uniformly fine sandy-loam upland till, and none showed any recent disturbance.

When the samples were collected in the fall a floristic survey was made at each station and a list compiled of all woody seedling and herbaceous ground cover species.

A modified golf cup-cutter cylinder was used to obtain soil samples uniform in area and volume. The cylinder was 4 inches in diameter, 4½ inches in height, with a volume of 56.5 cubic inches. Twenty samples were taken along a 100-foot transect at predetermined points selected from a set of random numbers. At each sample point all litter and humus down to the mineral soil was removed with care to avoid any surface contamination. At each site the 20 samples were consolidated on a clean plastic sheet, thoroughly mixed and quartered. Two of the quarters were designated for germination tests and each placed in a large plastic bag, which in turn was placed in a heavy Kraft bag to exclude light. The two were equal in volume to 10 of the 4 inch samples and represented a surface area of 0.87 square feet. A small sample of about 1 quart was taken from the remainder and stored for chemical tests which were performed at the Soil Testing Laboratory of the University of Massachusetts according to the Morgan Testing System (Lunt, 1950). The fall collected samples taken in 1961 were stored in a cool basement until all had been procured. All were planted on October 22, 1961. The spring samples were stored for 5 months in a cold room at a temperature of 37°F until the date of planting on September 30, 1962. Prior to planting the samples were sieved through a ¼-inch mesh screen to remove stones, roots, rhizomes, etc., and the sample was then spread into a wooden flat to a depth of about 1¼ inches. Control flats, prepared with heat-sterilized greenhouse loam, provided a check on air- or water-borne seed contaminants. The fall samples in duplicate were placed in a greenhouse where one was exposed to normal short-day fall and winter light conditions while the other received supplemental incandescent illumination that provided long-day conditions of about 16 hours. Positioning of the flats on the greenhouse benches was randomized with a set of random numbers. All samples were watered twice daily to prevent drying and were supplied with a dilute 20-20-20 liquid fertilizer at intervals of about 3 weeks. Hygrothermograph records showed that air temperature and humidity conditions were essentially identical for the two greenhouse locations.

Seedlings appeared in most samples within two weeks, and the first seedlings were identified and removed after about 6 weeks. As soon as plants could be identified they were removed in order to reduce overcrowding and competition. In most cases seedlings could be accurately identified on the basis of vegetative characters; however, when immediate identification was impossible the seedlings were transplanted to pots and raised to maturity. Plant nomenclature is from Gray's New Manual of Botany (Fernald, 1950).

The soils samples collected in the fall were not given a cold treatment before planting. Since Darlington (1931) had found that there was a significant increase in germination when the seed from Beal's experiment were dug in the spring rather than in the fall, we made spring collections from 5 representative stations. Germination tests for these samples were made in growth chambers instead of in the greenhouse. To simulate the photoperiod conditions of the greenhouse studies, one chamber was programmed for a 16-hour photoperiod, the other for an 11-hour period. Temperature was maintained at 75°F during the day from 6:00 a.m. to 6:00 p.m. and at 65°F during the night.

Results. It had been anticipated that exposure to a cold period, as encountered by seed taken in the spring collection, would produce a different complex of seedlings than had the fall samples. Although there were minor variations in the number of seedlings recorded, there was no significant difference in the species recovered at any station. Thus, it appears that all the cold-requiring seed had been adequately acclimated and that the effect had not been lost during the summer and fall storage. Inasmuch as the spring species list closely duplicated the fall list it is not included in this report.

The fall-collected soil samples produced a total of 3910 seedlings from Dec. 12, 1961 to Aug. 2, 1962. Of the 65 species recorded only *Oxalis corniculata* occurred in the control flats. Because of its presence in the controls flats, we assume that contamination occurred in the greenhouse during the course of the study; the data on *Oxalis* were therefore discarded and the corrected total is 3474 seedlings.

The germination test data are presented in Table 1. Additional data in Table 1 relates to the recovery of ground cover species in the germination tests. Those woody seedling and herbaceous ground cover species originally noted in the field survey are designated with an asterisk. A total of 55 species were recorded in the original survey, with 41 noted in the field and young pine stands (Stations 1–6) and the remaining 14 restricted to the 80-yr pine stand at Station 16. Of the 55 species listed, forty-one were recovered in the germination tests, with thirty-eight from Stations 1–6 and five from the more mature pine stands, especially at Station 16. The 3 ground cover species noted at Stations 1–6, but not recovered were *Barbarea vulgaris, Fragaria virginiana* and *Sorghastrum nutans.* Of the 10 species not recovered from Station 16, most were late successional or climax species, including *Gaultheria procumbens, Goodyera pubescens, Taxus canadensis, Viburnum acerifolium, Tsuga canadensis, Acer saccharum, Fagus grandifolia, Quercus rubra* and *Carpinus caroliniana.* In all probability seed of the late successional and climax species would have been deposited in the litter and not recovered from the soil samples. Large-seeded species such as *Quercus* and *Fagus* would not have been recovered even had they been in the soil for they would have been removed when the sample was sieved.

Results from the soil tests are given in Table 2. A fairly consistent pattern associated with increasing age of the stand is shown. There is a general decline in pH and in the fertility of the soils, except for a slight increase in ammonia. These data can be correlated with seed germination data, but we attribute little significance to this, for germination would be only slightly, if at all, affected by the variation in soil chemistry shown here.

Discussion and conclusions.—1. SEEDLING RECORD. With the exception of *Oxalis,* which we assume to be a contaminant, the only species occurring in all sites sampled were *Juncus tenuis* and *Danthonia spicata* (Table 1). Species noted in all but a few scattered samples include *Panicum capillare, Rubus* spp, *Juncus effusus, Carex* spp, *Rumex acetosella, Agrostis hyemalis, Panicum lanuginosum* and *Potentilla canadensis.* A few relatively short-lived species such as *Mollugo verticillata, Portulaca oleracea* and *Phytolacca americana* are found only in recently abandoned fields. Others, limited to mature stands, are represented by *Diervilla lonicera, Aster acuminatus* and *Mitchella repens.* Some sporadics are noted in small numbers at a few sites.

To determine whether different overstory species influence the longevity or kind of buried seed, samples were taken from contiguous stands of white pine, red pine and red spruce of similar ages. Comparable sites are: Stations 7 and 8; 9, 10 and 11; 12 and 13; and 14 and 15. Data from these stations show no general trend so it is assumed that these three species have no differential effect on the type or longevity of seed present.

Seedlings of few woody plants developed in the samples. The paucity of woody seedlings derived from buried seed was also noted by Oosting and Humphreys (1940). Leavitt (1963) however, found that seed of woody species were well represented in the litter and humus layers of maturing pine stands.

A comparison of the germination test results with the original field survey results are presented in Figure 1. Only the Horseweed field at Station 1 supported a larger number of species in the field than were recovered from buried seed germinated in the greenhouse tests. The decrease in species of ground cover plants from Station 1 to 6, and the complete absence of any ground cover species at Stations 7–15 is rather typical of the normal succession. In this sequence the ground cover species show a sharp decline from a high of twenty-one in the 1-yr horseweed field to four in the 15-yr red pine, and to zero in the 21-yr white pine stand. No ground cover species or woody seedlings were noted from Station 7 to 15. However, with maturation and opening of the stand, woody seedlings and ground cover species reappear in the 80-yr pine stand at Station 16.

The germination data present a very different picture than that of the ground cover survey. The number of species recovered remains fairly constant, averaging 20 per station. The number of seedlings recovered in the germination tests is variable, fluctuating widely from Station 1 to 8, with an average of 265, then dropping to about 135 at Stations 9 through 13, and increasing to an average of 220 per station in the older stands as late successional and climax species make their appearance.

2. ORIGIN OF SEED. The fact that 44.6% of all seedlings grew in soils taken at sites where there were no ground cover plants is positive evidence for the presence of buried viable seed at these sites. The number of seed-

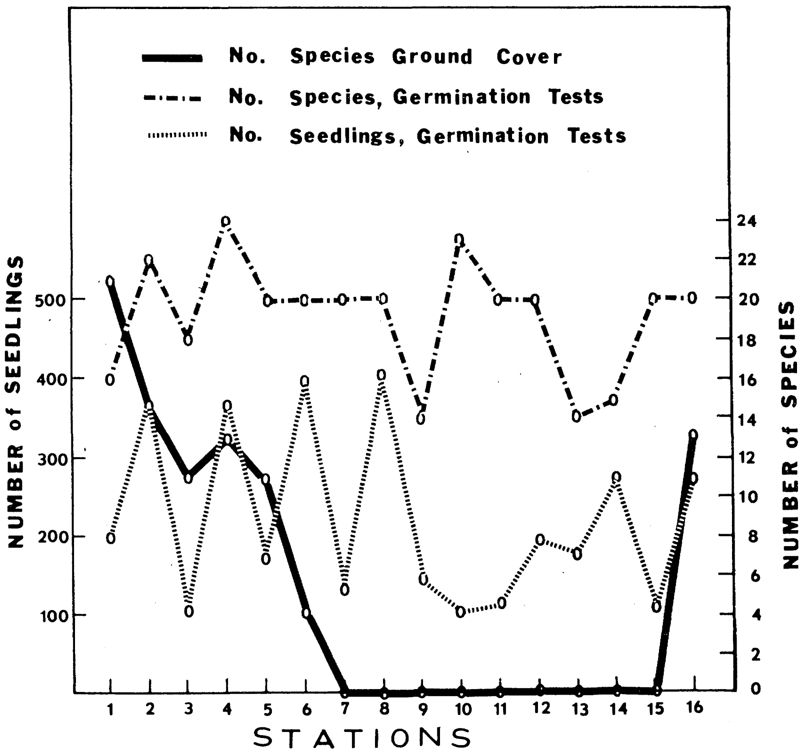

Figure 1. Comparison of ground cover species (including woody seedlings) with germination test results. Solid line = ground cover species recorded in field survey. Broken lines = germination test results, including the number of species and number of seedlings recovered.

lings per square foot of surface sampled at the 16 sites averaged 220, with a low of 116 in the 36-yr red pine stand and a high of 466 in the 25-yr white pine stand. The number of seedlings per acre varied from 5,052,960 to 20,298,960. The 40 species which first appeared in the oldfield stands (Stations 1–4) produced 88.5% of the total seedling crop and included more than half the species recorded (Table 3). Plants recorded from forested sites only are either late successional, climax or sporadic species which

Table 1. Germination test results. Species recovered in tests are listed in an age-successional sequence. Plants recovered from soils of the 1-yr abandoned field (Station 1) listed first, followed by those first appearing in soils from successively older stands. Species from each station (1 to 16) are arranged in order from those with shortest apparent longevity to those with greatest. Asterisk signifies that the species was recorded at the station of record as a woody seedling or herbaceous ground cover species in the original field survey.

STATIONS	Horseweed field	Goldenrod field	Andropogon field	5-yr white pine stand	7-yr white pine stand	15-yr red pine plantation	21-yr red pine plantation	25-yr white pine plantation	35-yr red spruce plantation	36-yr red pine planation	37-yr white pine plantation	41-yr red pine plantation	42-yr white pine plantation	47-yr red pine plantation	47-yr white pine plantation	80-yr white pine stand	Control	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
SPECIES	Species first appearing in germination tests for 1-yr Horseweed field, Station 1																	
Mollugo verticillata	17*	1																18
Portulaca oleracea	19*	22																41
Phytolacca americana	1			1	1													3
Erigeron canadensis	28*	10			1	1												40
Trifolium repens	4*	6			1		1											12
Erigeron annuus	1*	6		3		8				1								19
Poa pratensis	1			9	9*	3	19	4		3		1						49
Potentilla norvegica	69*	26	2	4	3		5	2	1	1	1	3						117
Panicum capillare	39*	87		4	6	21	2	5		1		1		2	1			169
Juncus effusus	1			1*	1	1	2	2	9	10	15	1	2	1	1	2		48
Rubus spp	4		*	1*		*	2		3		6	2	1	34	22	69		144
Hypericum perforatum	1*	1*		2	28*		6	10	12	17	1	3			3			84
Carex spp	5	1	2	*	*	33	2	17	12	2	3	8	7	3	6	26*		127
Rumex acetosella	6*	14*	16*	5*	15*	2*	24	9		2	2	54	62	38	17	7		273
Danthonia spicata	2	1	10	3*	10	10	7	1	46	1	34	47	15	102	14	1		304
Juncus tenuis	3	98	15	103	37*	84	19	168	24	30	31	28	24	54	25	41		784
SUBTOTAL	201	273	45	136	112	163	89	218	107	68	93	148	111	232	90	147		2232
	Species first appearing in germination tests for Goldenrod field, Station 2																	
Gnaphalium uliginosum	*	4																4
Cerastium vulgatum		5		4														9
Chrysanthemum leucanthemum	*	8*		3	1													12
Hieracium aurantiacum	*	1	4	6	2													13
Solidago canadensis	*	34*	*	12*	1*	3*												50
Solidago graminifolia		2				1				2								5
Chenopodium album	*	3	1		1					2	1							8
Solidago rugosa		26*		45	3					2	1							77
Agrostis hyemalis	*	1	4	58*	8	2	1	12	1		1	1		1				90
Agrostis perennans		4	10	35*	23	2		25	3			20			2			124
Panicum lanuginosum	*	8	3	31	2	156	10	11		2	2			2	1			228
SUBTOTAL		96	22	194	41	164	11	48	4	11	5	21		3	3			620
	Species first appearing in germination tests for Andropogon field, Station 3																	
Daucus carota			3															3
Geranium robertianum			1								4							5
Aralia hispida			1										1	2		4		8
Dactylis glomerata			2*										1		5	8		16
Andropogon scoparius			24*	*	*	1*	2	8		5	1							41
Panicum clandestinum			2						3					1		1		7
Cyperus spp			1	*		20		1	3		1	3	4	3	3	14		53
Potentilla canadensis	*		2	8*	2	5	13	6	7	10	2	1	2		1			59
SUBTOTAL			36	8	2	25	15	15	13	15	8	4	8	6	9	27		192
	Species first appearing in germination tests for 5-yr white pine stand, Station 4																	
Commelina communis				7														7
Spiranthes cernua				7														7
Aster pilosus			*	10	*													10
Achillea millefolium			*	2	1*													3
Luzula multiflora				2	4													6
SUBTOTAL				28	5													33

Table 1. Continued

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
Species first appearing in germination tests for 7-yr white pine stand, Station 5																		
Oenothera biennis	*				3													3
Agrostis alba		*	*	*	5*			8					1					14
Polygonum convolvulus					1					1								2
Spiraea latifolia		*		*	1*			2				11	4	1	2			21
SUBTOTAL					10			10		1		11	5	1	2			40
Species first appearing in germination tests for 15-yr red pine plantation, Station 6																		
Setaria viridis	*	*				31												31
Ambrosia artemisii-folia	*					4				2								6
Aquilegia canadensis						5						1			2			8
SUBTOTAL						40				2		1			2			45
Species first appearing in germination tests for 21-yr red pine plantation, Station 7																		
Potentilla argentea	*						8											8
Erechtites hieraci-folia							1		1	1						1		4
Helianthemum canadense							3		20	1		1	1		1			27
SUBTOTAL							12		21	2		1	1		1	1		39
Species first appearing in germination tests for 25-yr white pine plantation, Station 8																		
Acalypha virginiea								4										4
Verbascum thapsus		*						1			1	3				4		9
Houstonia caerulea								110						28				138
SUBTOTAL								115			1	3		28		4		151
Species first appearing in germination tests for 35-yr red spruce plantation, Station 9																		
Gnaphalium obtusi-folium		*							1		4					1		6
Species first appearing in germination tests for 36-yr red pine plantation, Station 10																		
Sisyrinchium angusti-folium										1								1
Polygonum persicaria										2	1							3
SUBTOTAL										3	1							4
Species first appearing in germination tests for 37-yr white pine plantation, Station 11																		
Betula papyrifera											1	4		2	1	*		8
Species first appearing in germination tests for 41-yr red pine plantation, Station 12																		
Poa compressa												2						2
Species first appearing in germination tests for 42-yr white pine plantation, Station 13																		
Diervilla lonicera													1		2	86*		89
Species first appearing in germination tests for 47-yr red pine plantation, Station 14																		
Aster acuminatus														1	1	*		2
Species first appearing in germination tests for 80-yr white pine stand, Station 16																		
Corydalis sempervirens																2		2
Mitchella repens																1*		1
Hieracium pratense																2		2
Oryzopsis asperifolia																1		1
SUBTOTAL																6		6
Unidentified species appearing in germination tests																		
Unknown					1	1	2							1				5
Greenhouse contaminant, only species appearing in Control sample, #17																		
Oxalis corniculata	16	8	40	23	25	13	30	13	18	52	33	27	10	34	18	50	26	436
SUMMARIES																		
Total species identified	17	23	19	25	21	21	21	21	15	24	21	21	15	16	20	20	1	65
Total seedlings, minus Oxalis	201	369	103	365	171	394	129	406	143	102	113	195	126	274	111	272		3474
Ave. seedlings per square foot soil surface sampled	232	424	117	419	196	453	147	466	164	116	130	224	145	315	125	311		220

collectively produced only 11.5% of the total seedling crop. The late successional and climax species are introduced as the stand opens during maturation and make their appearance in the 37-yr pine stand at Station 11. Seed of the forest species such as *Betula papyrifera, Diervilla lonicera, Aster acuminatus* and *Mitchella repens* must have been transported into the stand by wind or animals. Wind is responsible for the dissemination of fruit of birch, many composites, and for some small seeded species, but larger seed or fruit must have been carried by birds, rodents or other

Table 2. Soil tests results. Tests made by the Soil Testing Laboratory of the Massachusetts Agricultural Experiment Station, University of Massachusetts, Amherst. H = high; MH = medium high; M = medium; L = low; VL = very low.

Station	Site	pH	Ca	K	P	Mg	NO_3	NH_4
1	Horseweed field	6.0	H	L	H	MH	H	L
2	Goldenrod field	5.8	M	MH	M	M	H	L
3	Andropogon field	4.8	VL	L	L	L	L	L
4	5-yr white pine stand	5.1	VL	L	L	L	L	L
5	7-yr white pine stand	5.0	L	VL	L	L	M	L
6	15-yr red pine stand	4.8	L	VL	L	L	L	L
7	20-yr red pine stand	5.1	L	VL	L	L	L	L
8	25-yr white pine stand	4.9	L	L	L	L	M	L
9	35-yr red spruce stand	4.5	VL	L	L	L	L	L
10	36-yr red pine stand	5.0	L	L	L	L	L	L
11	37-yr white pine stand	4.8	L	VL	L	L	L	M
12	41-yr red pine stand	4.5	L	VL	L	L	L	M
13	42-yr white pine stand	4.5	L	VL	L	L	MH	M
14	47-yr red pine stand	4.4	L	VL	L	L	L	M
15	47-yr white pine stand	4.5	L	VL	L	L	L	M
16	80-yr white pine stand	4.6	L	VL	L	L	L	M

animals. Both wind- and animal-disseminated seed could be carried into all stands, young or old, but few wind- or bird-disseminated seed carried into the stands at Station 6–15 could sift down through the litter and humus. At these stations the litter-humus layers varied in thickness from about 1 to 3 inches, and was often so compacted that it would prevent direct movement of seed down into the mineral soil. It is possible that seed deposited in the litter of one stage could subsequently appear in the fermentation zone of a later stage, in the humus at a still later stage, and finally in the soil as the humus is incorporated into the mineral soil of the A_1 horizon. The sifting of seed downward in this manner is a possibility, but seed transport by burrowing animals is more probable. A few mice runs were noted in some of the more mature stands, but an effort was made to exclude any sample which included either new or old mice runs. Thus we are reasonably certain that our forest site samples did not contain seed carried by mice, except at Station 16 where rodent activity was extensive.

Oosting and Humphreys (1940) point out that seed reaching the damp mycelial mat of the fermentation zone would encounter conditions favorable for germination. However, if wind- or bird-transported seed did germinate in these forested sites, it would be necessary for the seedlings to adapt to shaded conditions, and few of the field species would be able to mature, flower and fruit under such conditions. Accordingly, there appears little possibility of recently produced seed entering the soil until late in the sere when stand opening and humus removal or disruption might permit seed germination. It should also be recalled that no ground cover plants

Table 3. Germination summary for species first appearing in germination tests in soils taken at field stations 1 to 4. (Total seedlings from 16 stations = 3474.)

Station	Site	No. Seedlings	% Total Seedlings	No. Species	% Species
1.	Horseweed field	2232	64.2	16	25.0
2.	Goldenrod field	620	17.9	11	17.2
3.	Andropogon field	192	5.5	8	12.5
4.	5-yr white pine stand	33	0.9	5	7.8
	Totals	3077	88.5	40	62.5

were noted in forested sites from Station 7 in the 21-yr pine stand, through Station 15 in the 47-yr white pine stand.

We conclude that seed from the field species were probably incorporated into the soil during cultivation or soon after the fields were abandoned, but before the development of a forest stand with well developed humus. Undoubtedly, many seed are carried into forested sites and come to rest in the litter. Leavitt (1963), in a study of the distribution of seed in depth in forest stands, has shown that the litter and humus is a rich source of seed, but not those from old field species.

3. LONGEVITY. Seed of some of the characteristic garden weeds such as *Mollugo verticillata* appear to be very short-lived. Others such as *Juncus tenuis, Panicum capillare, Rumex acetosella, Danthonia spicata* and *Rubus* spp appear to be long-lived for they reappear in samples taken throughout the sere, yet none occurred as ground cover plants in the forested stands, Station 7 (21-yr) to Station 16 (80-yr). On the basis of these records *Pani-*

cum capillare is especially long-lived for it was noted as a ground cover plant at Station 1 only. Seed with medium longevity include those of *Solidago, Chenopodium* and *Andropogon* species.

The absolute proof of longevity of seed is not possible on the basis of this study alone. However, the occurrence of viable seed in soils of forest stands of increasing age, together with the complete absence of the same species as ground cover plants is certainly indicative of their longevity.

4. PHOTOPERIODIC EFFECTS. Results obtained in the long-day, short-day greenhouse germination tests initially suggested a photoperiodic effect on seed germination. Eleven of the species germinated only when given long-day supplemental incandescent illumination, while three species germinated only under the typical short-day conditions of winter and early spring. The germination data for the period from Dec. 12, to April 1, 1962 support the idea of a strong photoperiodic effect. During that time a germination count of 1593 under long-day conditions was nearly three times as great as the count of 631 under short-day conditions of winter and spring.

Inasmuch as the supplemental illumination was provided by 300 watt bulbs placed 2 feet above the flats, we recognized that the germination difference might well have been caused by thermal, rather than by photoperiodic effects. Records of temperatures under the lights showed an increase of 5°F at the surface, and 4°F at a point 1 cm. under the surface when the evening air temperature in the greenhouse was 70°F. These temperatures must have been responsible for the increased germination under long-day conditions, since subsequent tests of the spring samples under precisely controlled temperature conditions in growth chambers failed to show any differential effect of photoperiod on germination.

5. SUCCESSIONAL INFERENCE. The disruption of any community at essentially any stage of succession is almost immediately followed by the appearance of successional species formerly present at that site. That this occurs is assured by the burial of viable seed from the various stages of succession. Upon disruption of the community these seeds are exposed to conditions favorable for germination, and growth and successional development are reinstated. Annuals representative of early oldfield stages dominate initially but are quickly replaced by perennial herbs. Trees such as pine or birch from seed which have been deposited in the litter follow. Thus, seed of most species of earlier successional stages need not be carried into a disturbed area since they are usually present, often long buried at the site. Accordingly, the mature climax community contains within itself viable seed of most successional species, from pioneer to climax.

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Notes on Mexican grasses VIII. Miscellaneous chromosome numbers—2[1]

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REEDER, JOHN R. (Yale University, New Haven, Conn.). Notes on Mexican grasses VIII. Miscellaneous chromosome numbers—2. Bull. Torrey Bot. Club 95: 69–86. 1968. —Chromosome numbers are reported for 134 collections which represent 91 species belonging to 31 genera. The record for *Pereilema* is new for this genus as are the counts for the following 32 species: *Agrostis rosei, Eragrostis glutinosa, E. intermedia, Erioneuron grandiflorum, Muhlenbergia arizonica, M. articulata, M. brevis, M. ciliata, M. confusa, M. crispiseta, M. filiformis* var. *fortis, M. flaviseta, M. grandis, M. involuta, M. leptoura, M. montana, M. parviglumis, M. pulcherrima, M. robusta, M. setifolia, M. spiciformis, M. stricta, M. strictior, M. texana, M. vaginata, M. wolfii, Pereilema ciliatum, Sporobolus macrospermus, S. spiciformis, Echinochloa holciformis, Lasiacis sloanei,* and *Paspalum prostratum.* The records of $2n = 40$ for *Bouteloua scorpioides,* $2n = 16$ for *Eleusine tristachya,* $2n = 60$ for *Eragrostis neomexicana,* $2n = 28$ and $2n = 22$ for *Muhlenbergia asperifolia,* $2n = 26$ for *M. lindheimeri,* $2n = 40$ for *M. macrotis,* $2n = 28$ and $2n = 24$ for *M. macroura,* $2n = 80$ for *M. minutissima,* $2n = 24$ for *M. porteri,* $2n = 30$ for *M. pubigluma,* $2n = 52$ for *M. reederorum,* $2n = 20$ for *M. reverchonii,* $2n = 40$, $2n = 20$ and $2n = 21$ for *M. virescens,* and $2n =$ ca. 60 for *Tridens albescens* are different from any published report for the same taxon. Cytological information on Mexican material of the following nine species: *Cottea pappophorioides, Eragrostis neomexicana, Erioneuron pulchellum, Muhlenbergia asperifolia, Sclerópogon brevifolius, Spartina spartinae, Tridens albescens, Oplismenus setarius,* and *Panicum maximum* is here presented for the first time.

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