Old-field succession on the New Jersey Piedmont — the first year

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Small, John A., Murray F. Buell, and Helen F. Buell (Rutgers Univ., New Brunswick, N.J.) and Thomas G. Siccama (Yale Univ., New Haven, Conn.) Old-field succession on the New Jersey Piedmont — the first year. Hutcheson Memorial Forest Bull. 2(4): 26-30. 1971. Field units (of 0.25 to 1 ha) were set aside for natural revegetation at 2-year intervals between 1958 and 1966. Some were plowed after the last crop was harvested, and some were not. Fourteen species were consistently present on the first-year fields regardless of the treatment. Plowing after the crop was harvested altered the composition of the first-year fields. The time of plowing, whether the fall after the crop was harvested or the following spring or summer, had an influence on the presence or absence or relative importance of the various species in terms of cover.

Old-field succession on the Piedmont of New Jersey, in broad terms, passes through a transitory dominance of annuals to broad-leaved perennial herbs to grasses to shrubs and various short-lived trees to long-lived forest species — a sequence elucidated by Bard in her studies some 20 years ago (Bard 1952). Like most other such studies, Bard's used fields whose age since last cultivation could be determined from the owners or from various records. The succession so constructed is based on the reasonable assumption that a field of any one age represents a condition through which any field either will pass or has passed. Although Bard replicated her fields, she recognized that environmental variables, particularly the vicissitudes of climate, might strongly influence the details of the succession. Such an influence at any one point in the succession might be felt through a more or less extended period of time. To illustrate the initiation of succession she studied four fields the first year after a crop had been last grown on them.

In contrast, our study examines the character of vegetation at initiation of succession on fields set aside for natural revegetation at various times during about a decade and extending through a period of variable climatic conditions. Furthermore, the first sampling on our fields was done after a variety of treatments, i.e., the year after a crop was harvested, in the summer after a spring plowing, etc. (Table 1).

The objective in this study of the composition of the initial stages of succession is the demonstration of the degree of consistency that occurs regardless of the vicissitudes of climate or pretreatment of fields.

The study was made on the Hutcheson Memorial Forest property at East Millstone, New Jersey. This is on soil developed from the Triassic red shale of the Brunswick Formation (Ugolini 1964), as were all of Bard's fields. Bard's fields were all within a 5-mile radius of our sites (referred to in this paper as "HMF" sites.)

Nomenclature follows Gray's Manual, eighth ed. (Fernald 1950), with the exception of the Compositae, in which nomenclature follows Gleason and Cronquist (1963). Voucher specimens are on file in the Chrysler Herbarium, Rutgers University. This study was supported in part by grants from the Research Council of Rutgers University.

Methods

Field units (in size from about 0.25 ha to 1 ha) (fig. 1) were set aside for natural revegetation at two-year intervals. The fields were abandoned either following harvest, or one of a pair of fields units was plowed and disced after harvest or in the following spring (Table 1). The vegetation was sampled the first year after the last crop.

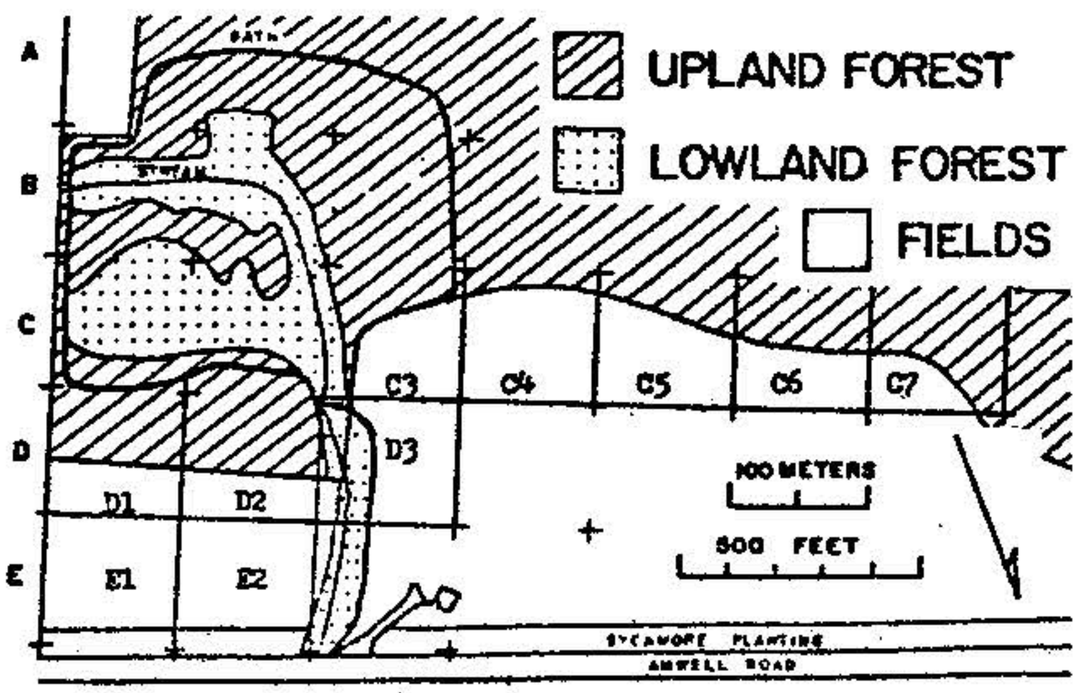

Figure 1. Map of a portion of the William L. Hutcheson Memorial Forest property showing the old-field units on which the study is based.

In each unit 40 to 48 permanent plots (0.5 by 2 m) were established. These were systematically located along several parallel lines establishing a grid throughout the field. Sampling consisted of estimating cover contributed by each species on each plot and counting tree seedlings. The sampling was done for the most part in late July and early August of each year.

Results

Regardless of the treatment, 14 species were consistently present on the fields the first year of sampling and 11 more were present on 75% or more of the

1971. William L. Hutcheson Memorial Forest Bulletin 2(4):26-30.

Table 1. History of abandonment and first sampling of fields at William L. Hutcheson Memorial Forest. Code designations appear on map, fig. 1.

Field code	Date of first sampling	No. of quadrats (1 m^2)	History
C3	1958	40	Plowed spring 1957; planted to soybeans & sorghum; abandoned after harvest.
D1	1958	40	Same as C3.
D2	1960	48	Plowed spring 1959; planted to soybeans & sorghum; abandoned after harvest.
D3	1960	48	Same as D2, with addition of plowing & discing in spring 1960; abandoned as bare ground.
E2	1962	48	Hayfield of orchard grass for several years; plowed June 1962; abandoned as bare ground.
C7	1964	48	Same as E2, but plowed & disced mid-April 1964; abandoned as bare ground.
C4	1966	48	Planted to soybeans 1965; after harvest plowed in late fall; abandoned as bare ground.
C5	1966	48	Same as C4, except not plowed after harvest.

fields (Table 2). This is out of a total of 94 species present on all fields. *Ambrosia artemisiifolia* was by far the single most important species, being consistently present and regularly contributing an appreciable amount of cover.

The disposition of the other 69 species with respect to presence and percent cover (average for sample plots) is as follows: present on 4-5 fields, *Abutilon theophrasti* 0.5%, *Acer rubrum* 0.2%, *Amaranthus retroflexus* 0.2%, *Cerastium vulgatum* 0.2%, *Conyza canadensis* 0.5%, *Dactylis glomerata* 0.5%, *Erigeron annuus* 3.3%, *Hypericum* spp. *(perforatum* and *punctatum)* 0.2%, *Ipomoea hederacea* 0.2%, *Juncus* sp. 0.1%, *Lepidium campestre* 1.7%, *Oenothera biennis* 0.2% *Portulaca oleracea* 0.1%, *Rumex acetosella* 0.4%, *Trifolium repens** 0.1%, *Physalis subglabrata* 0.1%, *Potentilla simplex* 0.1%; present on 2-3 fields, *Agropyron repens* 1.0%, *Agrostis alba* 0.2%, *A. hyemalis* 0.1%, *Anagallis arvensis* 0.1%, *Bidens vulgata* 0.1%, *Chrysanthemum leucanthemum* 0.1%, *Cirsium arvense* 0.3%, *Cornus florida* 0.1%, *Galinsoga parviflora* 0.3%, *Glycine max* 0.1%, *Hibiscus trionum* 0.1%, *Lactuca scariola* 0.1%, *Linaria vulgaris* 0.1%, *Lobelia inflata 0.2%, Lolium multiflorum 1.9%, Medicago lupulina* 0.1%, *M. sativa* 0.1%, *Melilotus* spp. *(alba* and *officinalis)* 0.3%, *Phleum pratense* 0.1%, *Physalis heterophylla* 0.1%, *Polygonum convolvulus* 0.1%, *Potentilla norvegica* 0.1%, *Prunella vulgaris* 0.1%, *Sorgum vulgare* 0.1%, *Stellaria media* 0.1%; present on one field, *Antennaria neglecta* 0.1%, *Anthemis arvensis* 0.1%, *Arctium minus* 0.1%, *Aster simplex* 0.1%, *Carex* sp. 0.1%, *Cyperus* sp. 0.4%, *Dianthus armeria* 0.1%, *Hieracium pratense* 0.1%, *Juniperus virginiana* 0.1%, *Lactuca canadensis* 0.1%, *Muhlenbergia frondosa* 0.1%, *Panicum depauperatum* 0.1%, *Panicum* sp. 0.1%, *Phytolacca americana* 0.1%, *Poa compressa* 0.1%, *Polygonum scandens* 0.1%, *Potentilla recta* 0.1%, *Rhus glabra* 0.1%, *Rhus radicans* 0.1%, *Solidago* sp. 0.1%, *Specularia perfoliata* 0.2%, *Verbascum thapsus* 0.1%, *Veronica arvensis* 0.1%, *Vicia villosa* 0.1%. As only six of these species contribute as much as 1% cover and only one over 2% *(Erigeron annuus* 3.3%), plainly a majority of the species encountered are of slight importance in terms of cover in first-year fields.

*This species, and all others subsequently listed in this paragraph as having cover of 0.1%, averaged less than 0.1%, with the exception of *Physalis subglabrata, Chrysanthemum leucanthemum, Phleum pratense,* and *Stellaria media.*

Table 2. Principal species in the first year of succession, being species present in 75 to 100% of the fields sampled. Percent presence (P) and average percent cover (C) are given for 8 HMF fields and for the 4 fields for which Bard published data.

Species	HMF fields P	HMF fields C	Bard's fields[4] P	Bard's fields[4] C
Ambrosia artemisiifolia	100	26.6	100	31.7
Digitaria sanguinalis	100	17.2	25	0.8
Plantago rugelii	100	10.7	50	2.4
Barbarea vulgaris	100	9.8	—	—
Chenopodium album	100	7.4	—	—
Setaria spp.[1]	100	1.6	50	0.2
Polygonum spp.[2]	100	1.0	25	0.2
Trifolium hybridum	100	0.9	—	—
Plantago lanceolata	100	0.9	75	0.9
Oxalis stricta	100	0.8	50	0.4
Daucus carota	100	0.6	100	4.7
Solanum carolinense	100	0.6	50	0.3
Lychnis alba	100	0.5	—	—
Verbascum blattaria	100	0.4	25	⟨0.1
Raphanus raphanistrum	88	12.3	25	⟨0.1
Mollugo verticillata	88	5.8	—	—
Convolvulus sepium	88	2.6	75	1.0
Acalypha rhomboidea	88	1.2	100	0.4
Rumex crispus	88	0.5	25	⟨0.1
Trifolium pratense	88	0.3	—	—
Allium vineale	75	0.2	75	0.3
Euphorbia spp.[3]	75	0.1	—	—
Hedeoma pulegioides	75	0.1	50	1.7
Polygonum aviculare	75	0.4	—	—
Taraxacum officinale	75	0.2	25	⟨0.1

1 *Setaria glauca,* plus some *faberii.*

2 *Polygonum persicaria,* plus some *pensylvanicum* (not distinguished in early samplings.)

3 *Euphorbia supina & maculata* (not distinguished in early samplings).

4 *Oenothera parviflora & Rumex acetosella* would be included in a list of Bard's species having ⟩ 75% P.

A break-down of the data on the more important species, showing percent frequency and percent cover on fields having different treatments, is of interent. In Table 3 the fields are arranged in two groups — 1) those plowed before abandonment (placed according

Table 3. Principal species of Table 2, plus a few of lesser importance having special interest. Percent frequency (F) and percent cover (C) are shown for each species in fields arranged according to time of last plowing (first group) or to crop preceding abandonment (second group). Figures for markedly high F and C are in boldface; for low F and C are in italics.

	Plowed before abandonment								Abandoned from harvest			
Field name & year	C7 '64		D3 '60		E2 '62		C4 '66		C3 & D1 '58, D2 '603		C5 '66	
Last treatment	Apr. '64		May '60		Jun. '62		Fall '65 S1		Fall '57 & '59 SS2		Fall '65 S4	
Species	F	C	F	C	F	C	F	C	F	C	F	C
Acalypha rhomboidea	88	6.6	73	0.6	56	0.2	*17*	*0.1*	33	0.7	23	0.1
Chenopodium album	100	10.8	88	2.4	90	1.5	96	18.2	60	2.2	92	20.0
*Polygonum aviculare**	35	1.1	6	0.1	—	—	8	0.2	4	⟨0.1	31	1.4
Polygonum spp.	71	3.0	69	1.9	*2*	*⟨0.1*	44	2.0	51	0.4	8	0.1
Setaria spp.	60	2.2	27	0.2	38	0.7	*17*	*0.5*	46	2.2	52	2.8
Ambrosia artemisiifolia	100	54.4	100	73.0	*35*	*0.2*	96	16.0	96	19.3	83	5.7
Barbarea vulgaris	81	3.9	94	5.4	52	0.2	90	10.8	73	10.2	90	26.2
Daucus carota	*4*	*⟨0.1*	67	1.1	*4*	*0.1*	*8*	*0.1*	46	1;0	*10*	*0.1*
Mollugo verticillata	10	⟨0.1	98	31.8	75	14.3	*4*	*⟨0.1*	12	⟨0.1	*4*	*⟨0.1*
Plantago lanceolata	*8*	*0.1*	73	2.1	*6*	*0.1*	27	0.6	61	1.4	*6*	*0.2*
Verbascum blattaria	35	0.4	92	1.8	13	0.1	*6*	*⟨0.1*	25	0.2	27	0.6
Digitaria sanguinalis	52	2.8	96	20.6	100	88.4	58	3.6	52	2.6	96	14.6
Euphorbia spp.	6	1.9	19	0.2	83	1.2	—	—	9	⟨0.1	2	⟨0.1
Portulaca oleracea	38	0.2	79	0.5	88	5.4	2	⟨0.1	—	—	6	⟨0.1
*Rumex acetosella*B*	—	—	13	0.2	44	2.2	2	0.1	16	0.4	—	—
Taraxacum officinale	10	0.1	6	0.1	50	1.1	—	—	8	⟨0.1	4	0.1
Convolvulus sepium	—	—	38	1.2	31	0.8	67	6.4	27	2.1	52	5.8
Lychnis alba	40	0.5	42	0.1	29	0.2	48	1.3	*8*	*0.1*	44	1.6
Raphanus raphanistrum	90	30.8	40	0.5	46	0.2	98	37.0	48	6.1	77	11.9
Allium vineale	—	—	—	—	2	⟨0.1	2	⟨0.1	26	0.5	19	0.2
*Erigeron annuus*B*	6	0.2	19	⟨0.1	15	⟨0.1	—	—	32	8.7	—	—
Hedeoma pulegioides	2	⟨0.1	—	—	—	—	6	⟨0.1	42	0.2	17	0.3
Lolium multiflorum	—	—	—	—	—	—	—	—	53	5.0	—	—
Oxalis stricta	85	1.6	65	0.7	15	0.1	23	0.1	87	1.1	40	0.2
Plantago rugelii	73	10.1	52	0.8	8	0.2	10	0.2	98	24.4	19	0.6
Rumex crispus	8	0.1	4	⟨0.1	15	0.1	4	⟨0.1	27	1.3	—	—
Solanum carolinense	31	0.7	35	0.3	10	0.4	13	0.6	38	0.9	19	1.7
Trifolium hybridum	35	0.3	15	0.1	*4*	*⟨0.1*	*2*	*⟨0.1*	59	2.1	*2*	*⟨0.1*
T. pratense	4	⟨0.1	21	0.1	4	0.1	—	—	62	0.8	2	⟨0.1

1 Soybean crop, plowed late fall.
2 Soybean-sorghum crop, harvested early fall.
3 Average of figures for three fields.
4 Soybean crop, harvested late fall.
* Less than 75% presence on HMF fields.
B High presence on Bard's fields.

to the month of plowing), and 2) those abandoned after harvest, the first column being averages of the three fields abandoned after a soybean-sorghum crop. (The soybean-sorghum crop is harvested green for ensilage early in the fall, while a soybean crop, which is allowed to mature, is not harvested until late October or early November. Thus after a soybean-sorghum crop the ground cover is removed much earlier than after the soybeans.) The species considered, those having a presence of 75% or more (Table 2) (plus a few others of special interest with relation to Bard's 1951 work), are in boldface and arranged according to the month of treatment which produced the highest percent frequency. (In some cases where another is nearly as high these figures are also in boldface.) Notably low frequencies are also stressed by use of italics.

Discussion

The figures presented in Table 3 serve to point up the great importance of the time of last plowing for at least some of the first-year old-field species. For example, *Acalypha rhomboidea, Chenopodium album, Polygonum* spp. and *Setaria* spp. appear to have been favored by early spring plowing. Of these the *Polygonum* species were strongly reduced in numbers following the May plowing, which presumably destroyed the seedlings, but *Acalypha rhomboidea* and *Setaria* spp., likewise annuals, had their greatest reduction following late fall plowing. We have no explanation to offer for this latter reduction, or for the high presence of *Chenopodium* under all conditions, with the lowest following early fall harvest of the soybean-sorghum crop.

Ambrosia artemisiifolia appears to offer an example of destruction of competition prior to germination, with May plowing thus favoring ragweed dominance, and destruction of its seedlings by June plowing, thus producing a low figure for ragweed. In fact, all of those species showing high presence following May plowing show a reduced importance following June plowing. Those which overwinter in the vegetative state — particularly *Barbarea vulgaris, Daucus carota, Plantago lanceolata, Rumex acetosella,* and *Taraxacum officinale* — appear to suffer a reduction of the overwintering plants by April plowing either by being killed outright or by being set back by damage to the plants. *Raphanus raphanistrum,* while it shows highest frequency and cover following fall plowing, is nearly as high following April plowing, and it, like *Chenopodium* and *Digitaria sanguinalis* (all annuals), shows a consistently high frequency under all treatments.

Particularly interesting are those species which show their highest frequency and cover in fields harvested in early fall following the soybean-sorghum harvests. Several of these — notably *Allium vineale, Erigeron annuus, Lolium multiflorum, Plantago rugelii,* and the two *Trifoliums* — make extensive growth during the fall and to some extent throughout the winter and are presumably favored by the early removal of the competing crop. *Barbarea vulgaris* (placed in Table 3 with those species having highest frequency following May plowing) in addition produces winter rosettes and appears to have made good response to late removal of the soybean crop.

The records for those HMF fields which were abandoned following a crop are of interest with relation to Bard's study. We do not know the history of her fields prior to abandonment (with the exception that one had had a corn crop (Bard 1951, fig. 2), but we may assume that they were abandoned following cropping, not plowing. All of Bard's species listed in our Table 2 (except *Taraxacum)* were present with at least 25% frequency on HMF fields which followed soybean-sorghum harvest. This pattern holds for some of the species recorded by Bard (marked by asterisk on Table 3) which occurred with less than 75% presence on our eight fields. The most notable exceptions to this pattern are *Taraxacum officinale* and *Rumex acetosella,* which in HMF fields had their greatest frequency in June-plowed fields — probably because June is the time of maximum seed dispersal.

Mollugo verticillata and *Portulaca oleracea,* which in HMF fields had a marked dominance only following summer plowing, were absent, as might be expected, from Bard's list.

The most puzzling differences between our findings and Bard's are in those species which occur with high percent presence and cover in one set of data but which are absent from or low in the other. *Barbarea vulgaris* and *Chenopodium album* were found on all HMF fields, with percent cover of 0.2-26.2 and 0.1-20 respectively; Bard found none. Similarly Bard recorded *Oenothera parviflora* in all of her fields, with cover of 10%, while we found *O. biennis* in four fields with cover of 0.2%.

Thus, obviously, by no means all the differences between our findings and Bard's, as well as the differences between our fields, can be attributed to differences in time of last plowing. Probably the most important other factor is climate — particularly moisture relations during the growing season. Also winter temperatures and snow cover are important factors in the growth of some plants, since low temperatures without snow cover are detrimental to winter rosettes, while moderate temperatures without snow cover permit significant winter growth of some species, among which *Barbarea vulgaris* and *Allium vineale* are the two most conspicuous examples. The period of our study covers a wide variation in precepitation, including drought years (Table 4), but there appears to be no clear-cut correlation between the differences in rainfall and the differences in fields.

Although the influence of climate as a cause of variation between fields is not clearly evident, differences in floristic diversity in fields sampled in different years may in some instances be due to rainfall differences. The figures for species number for

Table 4. Monthly precipitation in inches recorded at the U. S. Weather Bureau at New Brunswick.

	April	May	June	July	Aug.	Sept.	Oct.	Total May-Jul.	Total Apr.-Oct.
1958	5.97	4.09	2.99	5.86	3.27	3.28	6.26	12.94	31.72
1959	2.53	1.26	3.60	7.32	5.92	0.78	3.33	12.18	24.75
1960	3.67	4.25	1.17	11.10	3.92	7.84	1.84	16.52	33.79
1961	5.55	*3.46	3.10	5.58	6.32	2.60	2.81	12.14	29.42
1962	3.92	2.06	3.92	2.65	4.11	4.46	2.39	8.63	23.51
1963	0.65	1.83	1.21	3.64	1.57	6.09	0.25	6.68	15.24
1964	4.49	1.34	2.37	7.37	0.82	2.86	2.20	11.08	21.45
1965	2.77	1.22	0.89	2.40	2.98	3.09	1.81	4.51	15.16
1966	3.16	5.94	0.58	1.22	2.92	10.96	5.09	7.74	29.87

*Somerville data

the two fields initiated in 1958 are 50 and 44; 1960, 47 and 45; 1962 (1 field), 42; 1964 (1 field), 49; and 1966, 33 and 42. There may be a relation between the low number of species found in the 1966 fields and the low rainfall of that and the preceding years (Table 4).

And although the substratum and topography are relatively consistent from field to field, there are minor differences discernible. Both E2 and D3 have a thin soil mantle, and in addition E2 has a slight western exposure, resulting in a droughty soil. This droughty soil, plus the low rainfall of 1962, may well account for the low number of species in the field (E2) initiated in 1962. If these slight variations in substratum and topography produce detectible variations in species abundance, it is to be expected that greater difference, producing greater variations in species composition and abundance, might exist between HMF fields and Bard's.

Other factors, combining with climatic, soil, and topographic differences, might be expected to be of considerable variety and complexity of interaction: seed source, the ability of seed to lie dormant in the soil, fertilization practices (including the use of weedy manure), the crops that had preceded the sampling, the cultivation methods used on the last crop, the time the last crop was harvested, and the time of the last plowing and cultivation.

Our conclusion is that one can anticipate, within reasonable limits, the presence of a certain group of dominants in first-year fields, regardless of previous soil treatment or vicissitudes of climate; with these a diverse assortment from a more or less predictable group of associated species in various combinations will be present, their presence often being influenced by land treatment or climatic conditions.

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