Epigeous Ectomycorrhizal Fungi of Oaks and Pines in Forests and on Surface Mines of Western Maryland

Peter R. Beckjord, John L. Melhuish, Jr., Jerry T. Crews, and David F. Farr

Former research forester, University of Maryland, College Park, MD; plant physiologist and soil scientist, USDA Forest Service, Northeastern Forest Experiment Station, Berea, KY; and mycologist, USDA Agricultural Research Service, Beltsville, MD

Epigeous basidiocarps of ectomycorrhizal fungi were collected for 2 years from oak (Quercus sp.) forests, 1 year from conifer (Pinus sp.) forests, and 1 year from oak and conifer reforested surface mines in western Maryland. Botanical, physiographic, and edaphic data were collected. Two hundred and ninety-one specimens, representing 18 genera and 33 identified species, were obtained. Possible ecological implications for the occurrence of these fungi on these sites are proposed. Tree Planters' Notes 41(1):15-23; 1990.

Reforestation of surface mines is a difficult process. The role of mycorrhizal fungi in aiding the establishment and growth of trees has been well documented (17). Trees that pioneer and invade surface mines and those that regenerate in forest understories usually become colonized in situ with indigenous mycorrhizal fungi. Seedlings to be used in reforestation efforts must also be provided with this vital symbiotic relationship. Seedlings may be raised in nurseries in conjunction with indigenous fungi, inoculated with a prescribed fungus prior to outplanting, or inoculated at the time of outplanting. Successful reforestation efforts depend on the selection of fungus, host, and site in proper combination (5, 6). However, the selection of fungi for specific hosts and site conditions is a process for which guidelines have yet to be established for many situations, especially for temperate eastern forest areas in the United States.

Several investigators have surveyed indigenous fungi and their associated hosts in an effort to explain the ecological implications and significance of the symbioses. Schramm's classic 20-year investigation (27) of pioneering fungi on black wastes from anthracite mining in Pennsylvania yielded valuable information concerning the ecologies of the flora and their interactions with the climate and edaphic properties of these wastes.

Recent studies have been made in beech-maple (*Fagus-Acer*) and conifer forests of Michigan (20), aging birch (*Betula*) forests in Great Britain (22), and in mature and burned jack pine (*Pinus banksiana* Lamb.) forests in Alberta (11). Additional studies have also explored how the rate of plant succession is regulated via mycorrhizae (1) and the contribution of specific and nonspecific plant-fungus associations to forest community dynamics (24).

Wilkins and Harris (30) investigated the influence of precipitation and temperature on the seasonal production of fungi in *Fagus* and *Pinus* forests. The study showed that although precipitation was not an exact equivalent of plant available moisture (PAM), and many fungal species were relatively indifferent to temperature fluctuations, minimum requirements for both precipitation and temperature had to be met before basidiocarps (that is, the fruiting bodies, in this case, mushrooms and puffballs) are produced. Last and others (21) determined a positive correlation between the fruiting of *Amanita muscaria* (F r.) Hooker and rainfall in *Pinus* plantations.

Allen and Hipps (2) found an increase in *Russula emetica* (Schaeff. ex Fr.) Pers. ex Fr. basidiocarps on Norway spruce (*Picea abies* (L.) Karst.) and

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Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) forests with high moisture, nitrogen, and carbon contents, and especially in shady areas with 29% light. Lange (18) related fruiting to timing and quantity of precipitation and soil water in a Danish forest, and Smarda (28) as reported by Lange (19) ascribed variations in the phenology of fleshy fungi to humidity. Menge and Grand (23) mention that physiological and edaphic factors (that is, soil-related factors) can influence the production of basidiocarps.

This paper describes natural associations between mycorrhizal fungi and their suspected hosts for two forests and two surface mines in western Maryland. Botanical, physiographic, and edaphic data were used to develop possible ecological reasons for the occurrence of these fungi on these sites.

Materials and Methods

Three geographical locations (macrosites) were selected in the two most western adjacent counties of Maryland: (a) Green Ridge State Forest, (b) Savage River State Forest, and (c) two surface mines bordering the Savage River State Forest.

Green Ridge State Forest is in Allegheny County, 6 miles east of the town of Flintstone, MD, on U.S. Route 40 in the Ridge and Valley Province of the Alleghany Mountains. The area consists of 14,000 hectares of an oak-hickory (*Quercus-Carya*) and pine *(Pinus*) forest. The soils are predominately shaly silt loams that are thin, dry, and moderately productive. Elevation ranges from 145 to 622 m. Savage River State Forest is in Garrett County, on the Allegheny Plateau. The area consists of 22,000 hectares of an oak-hickory and pine forest. The soils are predominately stony loams and stony silt loams that are thin, more moist than the soils of Green Ridge, and moderately productive. Elevation ranges from 427 to 938 m. The two surface mines are in Garrett County. They are privately owned and mining was completed in 1971. There was no soil reclamation, but the mines were planted with oaks and pines. The Beener mine is near Barton, MD, east of Savage River State Forest at an elevation of 482 m. The Turner-Clise mine is near Bittinger, MD, west of Savage River State Forest at an elevation of 762 m .

Several microsites were selected to represent the diversity of the forest of each macrosite. Microsites were approximately 0.14 hectares each but had irregular shapes due to physical or botanical parameters that excluded areas not compatible with predominant microsite characteristics. The oak micro-sites were surveyed periodically for 2 years (August 15, 1981 to August 15, 1983) and pine microsites, for 1 year (August 15, 1982 to August 15, 1983). Survey visits were conducted weekly in the spring and fall and biweekly in the summer, weather and transportation permitting. These areas were traversed and scanned for above-ground fruiting structures (that is, epigeous basidiocarps) of ectomycorrhizal fungi. Slightly raised clumps of leaves or debris were examined for hidden basidiocarps. Below-ground (hypogeous) fungi were noted only when erumpent and thus noticeable without systematic raking.

Basidiocarps (mushrooms and puffballs) were the fundamental specimens on which further detailed data collections were made. Basidiocarps that could be immediately identified were coded. Those not immediately identified were wrapped in waxed paper, stored in an ice chest, and taken to the laboratory for identification, both macroscopically and microscopically, then dried and kept as voucher specimens.

Plastic tags were stapled on the nearest suspected host tree to the basidiocarp location with a designated code of the fungus and date. A soil sample of approximately 500 cm^3 was collected directly under the location of each basidiocarp to a

depth of 15 cm. Soil samples were cleared of litter, humus, and stones greater than 2 cm in diameter during collection.

Individual soil samples from all oak and conifer sites were analyzed for soil texture (11, 12) and organic matter (3). The first-year and second-year collections of soil samples within each oak microsite were then combined for analysis of pH (25), base exchange capacity (13), water-soluble nitrate ($N0_3$-)-nitrogen (9), and selected elements (13). Plant available moisture (PAM) was determined by the difference in -'/$_3$ bar and -15 bar available moisture (26). Soil conductivity was measured by the procedure described by Bower and Wilcox (8). Sulfur was analyzed by the methods of Bremner and Tabatabai (10). Soil samples within each conifer microsite (second-year collections) were combined for analysis of all the parameters listed above.

General Results

On the oak forest and oak surface mine sites, 91 fungus specimens were collected the first year and 118 the second year, representing 32 ectomycorrhizal species in 15 genera (table 1). The oak forest sites of Green Ridge and Savage River provided 103 and 87 specimens, respectively, each having 22 species representing 10 genera, primarily *Russula, Lactarius*, and *Amanita*. The oak surface mine sites provided 19 specimens representing 5 genera. *Scleroderma citrinum* Pers. and *Pisolithus tinctorius* (Pers.) Coker and Couch were the most common fungus species on oak surface mine sites.

One-year collections from all pine forest and pine surface mine sites provided 82 specimens representing 17 ectomycorrhizal fungus species of 12 genera (table 1). The conifer forest sites of Green Ridge and Savage River provided 6 and 29 specimens, respectively, each having 4 and 12 species, representing 4 and 8 genera. *Lactarius* and *Amanita* were most common on Savage River conifer forest sites. Conifer surface mine sites provided 47 specimens representing 9 species of 7 genera where *S. citrinum*, *P. tinctorius*, *Amanita muscaria*, and *Suillus* species were most common.

Specific Results and Discussion

The following discussion refers to the data in tables 1-3, with particular reference to microsites (the codes are listed in table footnotes).

A. *Scleroderma citrinum* was most common on SM-1 and SMC-1. These adjacent sites had nearly identical weather patterns but dissimilar soils. Plant available moisture (PAM) values for these sites are of the lowest of all microsites. SM-2 also had low PAM, although *S. citrinum* was scarce there. SM-2 differs from SM-1 and SMC-1 in that the nutrients B, Si, Zn, Fe, Ni, P, Mn, Mg, K, and $N0_3$--nitrogen were lower in concentration. Therefore, although S. citrinum is a primary and aggressive pioneer species on surface mines as well as a resident of natural undisturbed temperate forests (5), it and/or its host may have required more available nutrients than found at SM-2.

B. *Pisolithus tinctorius* was found associated with oaks and pines but only on surface mines (SM-1, SM-2, and SMC-1). It is considered an aggressive pioneer and unlike *S. citrinum*, appeared to be site specific.

C. *Russula* species were most common on oak forest sites. Aluminum, iron, and silicon contents of oak site soils were very low compared to pine sites. GR-2 and GR-5 had low *Russula* populations and were unevenaged forests dominated with chestnut oaks (*Quercus prinus* L.). *Russula emetica* (Schaeff. ex Fr.) Pers. ex Fr. was scattered among both GR and SR oak forest sites, and in particular, was very common on GR-7 and SR-5. GR-7 had the lowest soil copper over the other GR's but had scarlet oaks (*Quercus coccinea* Muenchh.). SR-5 had highest calcium over other SR sites. The copper and calcium levels

Table 1—*Total number of ectomycorrhizae-forming fungi specimens collected on forest and surface mine sites of oaks and conifers in Western Maryland*

Ectomycorrhiza-forming fungus	Oak																Pine								Total specimens per species
	SM		GR							SR							SMC	GRC			SRC				
	1	2	1	2	3	4	5	7	8	1	2	3	4	5	6	8	1	1	2	3	1	2	4	5	6	
Amanita spp.				1				1																		2
A. brunnescens Atk.											1												1			2
**A. gemmata* (Fr.) Bertillon				1																						1
**A. caeserea* (Fr.) Schw.									1																	1
**A. chlorinosma* (Austin) Lloyd							1				1															2
**A. citrina* (Schaeff.) S.F. Gray					1			1					3			3										8
A. cokeri (Gilbert & Kuhner)												1														1
A. flavioconia Atk.																								1	6	7
**A. muscaria* (Fr.) S.F. Gray																	5				1				2	8
**A. phalloides* (Fr.) Secr.			1			1																				2
**A. vaginata* (Fr.) Vitt.			1					2				1														4
**A. virosa* Secr.			1	1	1		6			1	1													1	1	13
Boletus spp.												1				1										2
B. affinis Pk.				1		1																				2
**B. badius* Fr.																									1	1
**B. chrysenteron* Bull. ex St. Amans						1					1			1												3
**B. piperatus* Bull. ex Fr.																1									1	2
Calostoma cinnabarina Desvaux										2																2
Cantharellus cibarius Fr.			1																							1
**Cortinarius albo-violaceus* (Fr.) Fr.			1							1	1						1								2	6
Hebeloma spp.	1																									1
**Laccaria laccata* (Scop.:Fr.) Cooke																									2	2
Lactarius spp.			4					1					2			1										9
**L. chrysorheus* Fr.			1					1		2		5	1	1	2					2				6	1	22
**L. piperatus* (L. ex Fr.) S.F. Gray				2	4			4				1														11
Limacella spp.										2	1	1														4
**Phyllophorus rhodox-anthus* (Schw.) Bres.								1			1															2
**Pisolithus tinctorius* (Pers.) Coker & Couch	2	4															9									15
Pluteus spp.								1																		1
**Rhizopogon nigrescens* Coker & Couch																	1									1
Russula supp.	2		8	1	5	3	2	7	6	4	1	1	1	1		4										46
**R. emetica* (Fr.) Pers.		1	2	1	1	2		10		3	4	2		8	4											38
R. fallax (Fr.) Britz.							2	1		3				1						1						8
**R. virescens* (Schaeff. ex Krombh.) Fr.										1																1
**Scleroderma citrinum* Pers.	7	1	1	1	1				1	3							11		2		1					29
**Strobilomyces floc-copuss* (Vahl ex Fr.) Karst.								2	1									1								4
**Suillus granulatus* (L.: Fr.) O. Kuntze		1								2	1	1					6					1				12
**S. americanus* (Pk.) Snell ex Slipp & Snell																	7									7
**S. luteus* (Fr.) S.F. Gray																	4									4
**Thelephora terrestris* Ehrhart ex Fr.																	3								1	4
Total specimens/site	12	7	21	9	13	8	11	32	9	24	13	14	7	13	6	10	47	1	2	3	2	1	1	8	17	291

* = known ectomycorrhiza-forming fungi, others are suspected ectomycorrhiza-forming fungi.

Sites are coded by areas and site numbers. SM = surface mine, GR = Green Ridge State Forest. SR = Savage River State Forest. Some site numbers were omitted. Note where species names are not provided, spp. indicates fungi of known genus but unidentifiable species.

between these two sites (GR-7 and SR-5) were opposing, and almost all other variables were dissimilar except they had in common sandy loam soils. None of the other GR and SR sites had sandy loam soil except GR-5. GR-5, even though it had a sandy loam soil, had no R. *emetica* but the lowest plant available moisture (PAM) of all oak forest sites.

D. *Suillus* species were most common on SMC-1 and apparently were pioneer fungi with a preference for pine hosts and are not known to associate with hardwoods (29). Even though *Suillus granulatus* (L. ex Fr.) O. Kuntze was a resident of SR-1, SR-2, and SR-3, these three sites had a few scattered pine seedlings in the understory, suggesting that these might be the symbiotic link rather than the oaks.

E. *Lactarius chrysorheus* Fr. was most common on SR sites rather than GR sites, and even though PAMs were similar, SR sites were cooler (higher elevations) and received more precipitation. *Lactarius chrysorheus on* SR-3 and SRC-5 was abundant although these two microsites had a few variables in common. *Lactarius piperatus* (L. ex Fr.) S. F. Gray were more frequent on GR sites over SR sites which was in contrast to the presence of *L. chrysorheus for* these sites (table 1).

F. *Amanita* species primarily inhabited oak forests. *Amanita virosa* Secr. was common on GR-5, a site with the lowest PAM of all GR sites. *Amanita citrina* (Schaeff.) S. F. Gray populated SR-4 and SR-8 that had similar variables (chestnut oak hosts; PAM, K, pH and Na levels). However, *A. muscaria* pioneered on SMC-1, and *A. flaviconia* Atk. inhabited SRC-6, a site with the co-component dominating host as Norway spruce.

Conclusions

We can make no conclusions from these data without the use of pertinent phenological characterizations and repetitious samplings over a longer period of time. However, other authors [Arnolds (4) and Fogel (14), as reported by Bills et al. (7)] have concluded that up to 98% of the potential fungal species were observed in a 3-year period and Gardner and Malajczuk (15) determined that there is a close relationship between the fruiting of fungal species and the development of specific ectomycorrhizal root structures in *Eucalyptus marginata* J. Donn ex Sm. Tarrah. The occurrence of basidiocarps indicates a greater number of symbionts than the observations of mycorrhizae alone (11). Danielson also determined that estimates of mycorrhizal fungal numbers would be low unless collections were made over long periods of time.

It appears that ectomycorrhizal fungi may or may not be host specific and/or site specific (11, 16, 22), although Bills (7) reported fungal species diversity was greater in hardwoods. Thus, forest tree regeneration planning must not only consider the matching of tree species to the site but include the compatibility of the ectomycorrhizal fungi *in situ* or introduced to the host and site for effective symbioses. The evidence from this and other studies supports early and late successional mycorrhizal fungi, and that certain species characteristically occur in early stage development and others in late stage development. The question would be then whether to use earlier or latter succesional fungi. Further studies are warranted to categorize host fungus/site combinations for prescription planting or reforestation on surface mines and other disturbed sites.

Table 2—*Characteristics for oak forests on surface mine sites and two state forests in Western Maryland*

	SM		GR							SR						
Site characteristics	1	2	1	2	3	4	5	7	8	1	2	3	4	5	6	8
Elevation (m)	482	762	244	299	305	323	475	293	323	847	670	725	812	768	756	774
Slope (%)	5	5	10	8	5	20	6	18	3	4	6	4	12	8	9	5
Basal area (m^2/ha)	6	3	46	46	48	40	56	43	46	51	31	54	34	34	54	46
Aspect (degrees)	90	45	112	300	288	326	312	292	65	310	210	170	15	248	145	300
Tree (spp.)	RO	RO	RO	WOCO	WO	RO	CO	WOSO	WO	RO	WO	WO	CO	RO	RO	CO
Timber type	Sap	Sap	SmP	SmS	SmP	SmS	MxS	SmP	SmS	SmS	SmP	MaS	SmS	MxS	MxS	MeS
Silviculture activity	—	—	—	—	TSI	TSI	—	TSI	TSI	TSI	TSI	—	—	TSI	TSI	TSI
Age class	E	E	E	U	E	E	U	E	E	E	E	E	E	U	U	U
Soil texture	Ls	L-T1	T1	V	L-T1	T1	Y1	Y1-L	T1-L	V	C1	Vc	V	Y1-L	V	Vc
Organic matter (%)	2.4	2.9	3.3	5.1	6.0	1.7	4.0	2.8	6.6	6.7	5.2	5.2	7.0	6.8	5.4	6.9
pH	4.4	4.4	4.2	4.4	4.2	4.2	3.8	4.4	4.3	3.5	4.2	4.0	3.7	3.8	4.1	3.8
B (ppm)	.06	.01	.03	.02	.03	.03	0	0	.03	.11	.06	.08	0	0	0	.02
Si (ppm)	12.5	10.3	0	0	0	0	0	0	0	0	0	0	0	0	13.6	17.2
Hg (ppm)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.2	0
Zn (ppm)	.6	0	0	.5	.5	.5	.3	.2	1.7	.7	.4	.3	1.2	.6	.9	1.3
P (ppm)	55.0	.5	3.0	3.4	4.5	4.5	4.5	3.1	6.0	8.9	3.1	3.2	6.4	4.8	10.0	12.2
Fe (ppm)	10.6	9.6	2.6	2.9	4.6	4.6	3.1	2.5	5.3	4.0	2.1	62.5	6.5	6.6	12.8	24.0
Cu (ppm)	65	45	44	40	53	53	59	13	65	33	22	9	26	38	66	52
Mn (ppm)	287	3	67	126	112	112	38	74	163	18	113	76	65	105	175	87
Mg (ppm)	135	5	16	34	22	22	21	28	90	24	25	25	34	23	40	46
Na (ppm)	88	62	10	14	16	16	7	9	27	11	8	7	17	8	13	18
Co (ppm)	47.0	1.0	9.0	0	0	0	1.0	0	0	0	0	1.0	0	0	28.0	43.0
Al (ppm)	9	0	6	10	9	9	5	6	12	7	10	11	17	12	15	31
Ni (ppm)	1.3	.3	0	.1	.1	.1	0	.1	.2	0	0	0	0	0	.3	.2
Ca (ppm)	516	411	100	395	194	194	129	228	731	150	175	197	142	349	233	246
Cr (ppm)	.2	.2	0	0	0	0	0	0	0	0	0	0	0	0	.2	.2
K (ppm)	132	36	62	120	95	52	67	93	147	88	99	72	151	77	137	139
Ti (ppm)	5.2	5.3	0	0	0	0	0	0	0	0	0	0	0	0	4.9	5.2
Pb (ppm)	9.3	8.2	0	.8	1.5	0	.6	14	1.6	.9	0	.3	.7	1.4	8.9	10.7
S (%)	.14	.15	0	0	0	0	0	0	0	0	0	0	0	0	.06	.06
No_3–(ppm)	.5	.2	.6	1.4	.6	.3	1.4	.9	4.0	1.8	3.1	.9	.8	1.8	.9	.4
Saturation (%)	41	50	86	98	110	122	123	86	127	33	118	122	118	135	119	141
−⅓ bars (%)	13	19	36	41	39	25	25	37	44	25	41	42	38	38	37	33
−3 bars (%)	7	12	12	20	16	9	13	12	24	18	24	18	24	17	22	24
−15 bars (%)	6	11	11	11	16	8	13	12	11	12	18	18	16	15	20	13
−⅓ & −15 (PAM) (%)	7	8	25	30	23	17	12	25	33	13	23	24	22	23	17	20
Cond. (1:2 soil:-water) (mmhos/cm)	.10	.04	.14	.16	.19	.11	.18	.13	.21	.43	.18	.19	.35	.24	.27	.31
Base exchangeable cap. (me/100 g)	4.40	2.45	.83	2.61	1.46	1.35	1.01	1.65	4.88	1.19	1.36	1.40	1.44	2.17	1.90	2.04

Sites are coded by areas and site numbers. Some site numbers are omitted. SM = surface mine, GR = Green Ridge State Forest, SR = Savage River State Forest. RO, WO, CO, SO = red, white, chestnut, scarlet oaks. Sap, SmP, MeP, SmS, Mes, MaS, MxS: saplings, Sm = small, Me = medium, Ma = mature, Mx = mixed, P = poles, S = sawtimber. E even-aged, U = uneven-aged. TSI = Timber Stand Improvement. L, Ls, T1, Y1, C1, V, Vc = loam, loamy sand, silt loam, sandy loam, clay loam, variable, variable clays. PAM = plant available moisture. Cond. = conductivity.

Table 3—*Characteristics for pine forests on surface mine sites and two state forests in Western Maryland*

	SMC	GRC		SRC					
Site characteristics	1	1	2	3	1	2	4	5	6
Elevation (m)	482	311	378	230	415	415	745	762	777
Slope (%)	5	2	1	1	5	5	5	6	5
Basal area (m^2/ha)	6	29	43	56	40	51	40	51	29
Aspect (degrees)	90	112	270	156	180	290	19	341	334
Tree (spp.)	WRPR	WP	VPTP	WPVP	WP	RP	RP	WPRP	WPNS
Timber type	Sap	SmP	MeS	MaS	SmS	MeP	SmP	SmS	MeP
Silviculture activity	—	—	—	—	—	—	—	Thin	—
Age class	E	E	E	E	E	E	E	E	E
Soil texture	L	T1	T1	T1	L	L	T1	T1	T1
Organic matter (%)	3.5	2.4	2.3	2.4	3.6	3.1	3.8	3.6	3.2
pH	4.3	4.4	4.4	4.6	7.5	4.3	4.6	4.3	5.5
B (ppm)	.25	.17	.47	.55	1.11	.34	.46	.46	.96
Si (ppm)	30.7	12.2	21.2	20.9	29.0	84.2	42.0	17.9	48.3
Hg (ppm)	0	0	0	0	0	0	0	0	0
Zn (ppm)	2.9	2.3	2.9	2.6	4.2	3.9	9.3	4.0	1.9
P (ppm)	3.4	7.3	6.7	3.2	12.0	8.3	10.8	14.8	4.7
Fe (ppm)	153	273	122	114	80.8	181	161	233	202
Cu (ppm)	5	2	3	3	3	4	2	2	3
Mn (ppm)	16	103	234	215	176	178	250	395	182
Mg (ppm)	170	10	147	141	571	16	15	18	46
Na (ppm)	6	4	10	10	11	6	7	6	17
Co (ppm)	.6	.4	.5	.5	3.1	1.5	1.1	.9	1.2
Al (ppm)	186	491	573	528	490	873	1217	925	570
Ni (ppm)	.8	.4	2.2	2.0	1.7	.6	1.3	.7	.7
Ca (ppm)	286	45	360	327	4762	55	171	103	1636
Cr (ppm)	0	0	0	0	0	0	0	0	0
K (ppm)	63	45	82	77	156	67	68	117	99
Ti (ppm)	0	0	0	0	0	0	0	0	0
Pb (ppm)	4	1.0	1.1	.8	5.0	3.1	.3	.5	2.7
S (%)	.25	0	0	.01	0	0	.01	.01	.01
No_3-(ppm)	.5	.4	.5	.5	1.3	.5	.6	.5	.5
Saturation (%)	38	?	?	?	?	?	?	?	?
−1/3 bars (%)	15	30	24	31	?	27	24	23	28
−3 bars (%)	11	?	?	?	?	?	?	?	?
−15 bars (%)	7	12	9	16	?	12	16	13	13
−1/3 & −15 (PAM) (%)	8	18	15	15	?	15	8	15	15
Cond. (1:2 soil: water) (mmhos/cm)	.09	.09	.08	.09	.24	.11	.11	.29	.15
Base exchangeable cap. (me/100 g)	3.00	.56	3.25	3.03	28.9	.57	1.17	.98	8.86

Sites are coded by areas and site numbers. Some site numbers are omitted. SM = surface mine, GR = Green Ridge State Forest, SR = Savage River State Forest. WP, RP, VP, TP = white, red, Virginia, table-mountain pines. NS = Norway spruce. Sap, SmP, MeP, SmS, Mes, MaS, MxS: saplings, Sm = small, Me = medium, Ma = mature, Mx = mixed, P = poles, S = sawtimber. E = even-aged, U = uneven-aged. TSI = Timber Stand Improvements. L, T1 = loam, silt loam. PAM = plant available moisture. Cond. = conductivity.

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