

SOIL ACIDITY AT THE ROOTS OF SOME TENNESSEE PTERIDOPHYTES. II.

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This investigation is a continuation of the study began in 1935 and the same methods were followed as in that investigation (Woodruff, 1935, 1936). The study was made possible by a research grant allotted to the author by the Tennessee Academy of Science. The study was made during the summers and falls of 1936 and 1937. This work includes species that were not treated in the preceding paper (Woodruff, 1935, 1936) and adds data to the species that were not treated fully there.

STATIONS STUDIED

The stations are lettered as in the preceding paper (Woodruff, 1935, 1936) or have new letters when they are new stations.

Station EE was located in a pasture lot east of U. S. highway 70 alternate, one mile west of Crossville, Cumberland County. The date was June 20, 1936.

Station FF was along the roadside of state road 26 in Cumberland County near the Fentress-Cumberland County line, above Clear Creek. The station also included samples secured on the bank of this creek. The date was June 20, 1936.

Station GG was on the roadside of state road 26 and on the hill above Obey River near the bridge, Cumberland County. The date was June 20, 1936.

Station HH was located along Bear Pen Hollow Trail up Mt. Leconte from the New Found Gap Road. The date was July 3, 1936.

Station II was on the side of the hill along the railroad about 400 yards west of Kinzel Springs, in Blount County. The date was July 6, 1936.

Station JJ was located at the base of a bluff over the road at the bridge over the Clinch River about 500 yards from U. S. highway 70. The location is just west of Kingston in Roane County. The date was July 6, 1937.

Station KK was in the area immediately around and under Ozone Falls at Ozone in Cumberland County. The date was July 7, 1937.

Station LL was along the trail leading down from Morgan's Steep, out from Sewanee, in Franklin County. The date was July 28, 1936. Station MM was located on the bank of a small stream back of the gymnasium of The University of the South, Sewanee, in Franklin County. The date was July 28, 1936.

Station NN was located by a small brook about two miles north of Sewanee on the opposite side of the road from the farm of The University of the South. The date was July 28, 1936.

Station OO was in a swamp about 5.3 miles south of Sewanee in Franklin County. The date was July 28, 1936.

Station PP was situated on the mountain immediately northeast of the intersection of state highway 19W and the Nolichucky River and on the bank of the Nolichucky River just up the river toward Unaka Springs from the river bridge. The station was in Unicoi County and was studied on September 10, 1936, and September 10, 1937.

Station QQ was on and near the top of Roan Mountain in Carter County. The date was September 11, 1936.

Station RR was on the farm of Mr. E. C. Cole in a swamp in Shady Valley at about 2,800 feet elevation in Johnson County. The date was September 11, 1936.

Station SS was near the top of Holston Mountain on state highway 91, east of Bristol in Sullivan County. The date was September 13, 1936.

Station TT was on the trail near the Sinks along Little River above Townsend in the Great Smoky Mountains National Park at about 2,000 feet. The date was September 14, 1936.

Station UU was along the lower part of the Roaring Fork Creek Trail to Mt. Leconte in the Great Smoky Mountains National Park. The date was September 14, 1936.

Station VV was near Tremont in Blount County. The date was September 15, 1936.

Station WW was in the Dudley Creek valley, near Gatlinburg, at about 1,500 feet, in the Great Smoky Mountains National Park. The date of the study was September 14, 1936.

Station XX includes the Cosby Creek trail up to Low Gap (4,242 feet elevation), and southwest along the Appalachian Trail for approximately three and one-half miles and northeast approximately one and one-half miles. This station is in the northern part of the Great Smoky Mountains National Park in Cocke County. The dates were September 13, 1936, and September 11, 1937.

Station YY was in a marsh 2.5 miles on the road that turns east at Clark Range in Fentress County. The date was October 4, 1936.

Station ZZ was in a swamp about one mile east of Pleasant Hill on U. S. highway 70 alternate in Cumberland County. The date was October 4, 1936.

Station AB was at the base of the hill, north of the road that leads from the Russell Street entrance into Shelby Park in Davidson County. The date was September 10, 1936.

Station AC was near the base of the hill east of the road on the

east side of the Shelby Park lake in Shelby Park. The study was made in Davidson County on September 10, 1936.

Station AD was on the east bank of the French Broad River north of a bridge on highway 35 about 1.5 miles west of Newport in Cocke County. The date was September 10, 1937.

Station AE extends along the trail between the Cherokee Orchard Trail and the Roaring Fork River Trail, and on the Roaring Fork River Trail above the junction of the trails toward Mt. Leconte. The locality is in the Great Smoky Mountains National Park near Gatlinburg and was studied on September 12, 1937.

Station AF was at Henderson Spring in Sevier County. The date was September 13, 1937.

Station AG was along the School House Gap Trail near the junction of the Middle Fork of Little River with Little River in Blount County. The date was September 13, 1937.

Station AH was at Pearse Fish Pond 2.9 miles northeast of Madisonville on highway 33 in Monroe County. The study was made on September 13, 1937.

Station AI was located in a swamp about five miles from Madisonville on highway 30 in Monroe County. The study was made on September 14, 1937.

Station AJ was 0.6 miles east of the Rhea-Cumberland County line on highway 68 along the banks of a stream and in the woods around the stream, in Rhea County. The study was made on September 14, 1937.

Station AK was at Snail Shell Cave about 2 miles off of state highway 99. The road leading to the cave leaves highway 99 about ten miles from Murfreesboro in Rutherford County. The date was September 8, 1937.

RESULTS

The data are listed under each species. The scientific name of the species, the common name, and the pH reading of each soil sample with the letter, or letters, in parentheses indicating the station at which the sample was collected, are given. The scientific names of the ferns are those given by W. A. Anderson, Jr. (1930, 1931), and the common names follow those given by Durand (1928). For the species not given by Durand, the first common name in Britton and Brown (1913) is used. The names used for the fern allies are those given by Britton and Brown.

Trichomanes Petersii A. Gray pH: 4.20(VV).

Woodsia obtusa (Spreng.) Torr. (Common Woodsia) pH: 7.35(KK), 6.69(AD).

Woodsia scopulina D. C. Eaton (Rocky Mountain Woodsia) pH: 6.09(PP), 5.56(PP), 5.39(PP), 5.15(PP).

Cystopteris bulbifera (L.) Bernh. (Berry Bladderfern) pH: 8.52(Y), 8.38(Y), 8.01(KK), 7.83(KK), 7.41(JJ), 7.38(J), 6.99(AD), 4.69(JJ).

Cystopteris fragilis (L.) Bernh. (Brittle Fern) pH: 7.77(PP), 7.33(AD), 6.69(XX), 6.61(AG).

Onoclea sensibilis L. (Sensitive Fern) pH: 8.28(Y), 7.32(Y), 6.41(WW), 5.13(ZZ), 5.11(ZZ), 5.11(RR), 4.68(ZZ).

Thelypteris palustris (Salisb.) Schott. var. *pubescens* (Lawson) Fernald pH: 6.88(AH), 6.17(AH).

Thelypteris noveboracensis (L.) Nieuwl. (New York Fern) pH: 7.18(AJ), 5.29(PP).

Thelypteris marginalis (L.) Nieuwl. (Leather Woodfern) pH: 6.23(XX), 5.86(PP), 5.50(AG).

Thelypteris spinulosa (O. F. Muell.) Nieuwl. var. *americana* (Fischer) Weatherby (Toothed Woodfern) pH: 5.57(PP), 4.58(QQ), 4.52(XX), 4.28(DD), 4.05(DD).

Thelypteris spinulosa (O. F. Muell.) Nieuwl. var. *intermedia* (Muhl.) Nieuwl. (Common Woodfern) pH: 6.43(UU), 6.21(AG), 5.91(PP), 5.32(RR), 5.06(XX), 4.54(DD), 4.50(QQ), 4.06(RR), 4.18(PP).

Thelypteris hexagonoptera (Michx.) Weatherby (Winged Beech Fern) pH: 6.14(XX).

Thelypteris cristata Nieuwl. (Crested Woodfern) pH: 5.53(RR), 4.78(RR).

Polystichum acrostichoides (Michx.) Schott. (Christmas Fern) pH: 7.56(AJ), 6.47(AG), 5.89(XX).

Dennstaedtia punctilobula (Michx.) Moore (Hayscented Fern) pH: 6.61(KK), 5.95(AJ), 5.89(XX), 5.78(DD), 5.77(PP), 5.75(AG), 4.65(DD), 4.52(MM), 4.35(HH), 4.32(MM), 3.98(JJ).

Athyrium angustifolium (Michx.) Milde. (Narrowleaf Spleenwort) pH: 7.16(Y), 6.61(AB), 5.90(AB).

Athyrium acrostichoides (Sw.) Diels. (Silvery Spleenwort) pH: 7.28(Z), 6.52(XX), 5.78(AG).

Athyrium asplenoidis (Michx.) Desv. (Lowland Lady Fern) pH: 7.37(AJ), 6.60(XX), 6.11(DD), 5.81(EE), 5.63(PP), 4.23(LL).

Camptosorus rhizophyllus (L.) Link (Walking Fern) pH: 7.74(FF), 7.62(JJ), 7.55(JJ), 7.40(Y), 7.28(PP), 7.27(AD), 7.14(FF), 7.11(Y), 6.74(PP), 6.49(AF), 6.25(LL), 6.23(AF).

Asplenium resiliens Kze. (Small Spleenwort) pH: 8.14(Y), 8.01(JJ), 7.67(KK), 7.30(JJ), 7.19(AD), 7.12(Y).

Asplenium platyneuron (L.) Oakes (Ebony Spleenwort) pH: 7.38(II), 7.38(AD), 6.52(PP), 5.80(XX), 5.65(LL).

Asplenium montanum Willd. (Mountain Spleenwort) pH: 5.67(KK), 4.94(PP), 4.94(GG), 4.89(PP), 4.86(LL), 4.58(Z), 4.46(LL), 4.46(LL), 4.42(AE), 4.37(DD), 4.33(DD), 4.21(JJ), 4.19(Z).

Asplenium trichomanes L. (Maidenhair Spleenwort) pH: 6.92(TT), 6.58(AF), 6.42(PP), 6.37(II), 6.26(II), 5.99(UU), 5.84(AG), 5.69(PP), 5.62(Z), 5.44(AE), 4.76(AE).

Asplenium pinnatifidum L. (Pinnatifid Spleenwort) pH: 4.71(LL).

Asplenium cryptolepis Fernald (Wall Rue Spleenwort) pH: 7.65(JJ), 6.83(JJ).

Woodwardia areolata (L.) Presl. (Narrowleaf Chainfern) pH: 6.29(FF), 5.65(BB), 5.64(NN), 5.27(NN), 5.12(ZZ), 4.03(OO).

Cheilanthes lanosa (Michx.) Watt. (Hairy Lipfern) pH: 6.45(II), 6.31(II).

Cheilanthes tomentosa Link (Woolly Lipfern) pH: 7.27(II), 6.98(II), 6.44(PP), 6.17(PP), 5.68(PP).

Adiantum pedatum L. (Maiden Hair Fern) pH: 7.81(AD), 6.42(AG), 5.86(PP), 5.33(PP), 4.08(PP).

Adiantum Capillus-Veneris L. (Southern Maiden Hair Fern) pH: 8.43(Y), 8.40(Y), 7.58(AK), 7.37(AK), 7.25(AK).

Pteridium latiusculum (Desv.) Hieron. var. *pseudocaudatum* (Clute) Maxon (Bracken Fern) pH: 6.12(AG), 5.20(SS), 4.98(XX), 4.57(PP), 4.55(PP).

Polypodium virginianum L. (Common Polypodium) pH: 6.29(PP), 5.63(AG), 5.56(SS), 5.44(AG), 5.21(LL), 4.88(Z), 4.80(PP), 4.78(RR), 4.29(HH), 4.28(DD), 4.24(DD).

Polypodium polypodioides (L.) Watt. (Resurrection Fern) pH: 7.56(AI), 7.37(AD), 6.84(JJ), 6.62(AF), 6.44(II), 6.08(II), 5.75(PP).

Lygodium palmatum (Bernh.) Sw. (Climbing fern) pH: 5.40(FF), 5.26(GG), 4.71(FF), 4.69(JJ), 3.82(Sb).

Osmunda regalis L. var. *spectabilis* (Willd.), Gray (Royal Fern) pH: 7.28(KK), 6.92(KK), 5.97(NN), 5.71(AJ), 4.59(YY), 4.49(OO), 4.29(SS), 4.22(YY).

Botrychium dissectum Spreng. and *B. dissectum* var. *obliquum* (Muhl.) Clute (Grapefern) pH: 6.75(AB), 6.49(AC), 6.39(XX), 6.29(AC), 6.29(AC), 6.24(AB), 6.15(AC), 6.14(XX), 5.93(AJ), 5.50(GG), 5.48(GG), 5.37(AJ), 4.87(GG).

Botrychium virginianum (L.) Sw. (Rattlesnake Fern) pH: 7.25(AD), 6.26(XX).

Equisetum arvense L. (Field Horsetail) pH: 8.32(Y), 8.18(JJ), 7.00(Z), 6.99(Z), 6.78(JJ).

Equisetum hyemale L. var. *robustum* A. A. Eaton (Stout Scouring-rush) pH: 7.87(EE), 7.61(EE), 7.29(AD), 7.27(EE), 7.26(AD).

Selaginella rupestris (L.) Spring (Rock Selaginella) pH: 6.24(PP), 5.63(PP), 5.33(PP), 4.71(PP), 4.64(PP).

Lycopodium lucidum L. (Shining Club-moss) pH: 5.40(QQ), 4.24(XX), 4.24(DD), 3.98(XX).

Lycopodium obscurum L. (Ground Pine) pH: 5.63(XX), 5.42(XX), 4.52(HH), 4.40(HH), 4.25(KK), 4.25(KK), 4.22(XX), 4.14(KK), 4.08(XX), 3.88(KK).

Lycopodium clavatum L. (Running-pine) pH: 4.74(XX), 4.47(XX), 4.41(XX).

Lycopodium porophilum Lloyd and Underw. (Lloyd's Club-moss) pH: 5.34(Z), 4.52(Z).

Lycopodium Selago L. (Fir Club-moss) pH: 4.54(QQ).

Lycopodium alopecuroides L. (Bog or Marsh Club-moss) pH: 4.59(YY), 4.56(YY), 4.41(YY).

Lycopodium tristachyum Pursh (Ground Pine) pH: 4.76(XX), 4.64(PP), 4.46(PP), 4.30(PP), 3.65(PP).

DISCUSSION

The soil samples of fifteen species reported in this paper gave pH readings that occurred in the pH range reported in the previous paper (Woodruff, 1935, 1936) for the respective species.

The soil samples of eight species gave reactions which were more acid than was reported by Woodruff (1935, 1936); the soil samples of nine species gave reactions that were less acid or more alkaline than was reported by Woodruff (1935, 1936); the soil samples of

TABLE 1. Summary of the soil acidity found at the roots of some Tennessee Pteridophytes in this and the preceding study (Woodruff, 1935, 1936).

SPECIES	NUMBER OF SOIL SAMPLES	NUMBER OF STATIONS AND SUBSTATIONS	PH RANGE
Trichomanes Petersii.....	1	1	4.20
Woodsia obtusa.....	68	22	8.69-5.28
Woodsia scopulina.....	4	1	6.09-5.15
Cystopteris bulbifera.....	23	8	9.05-4.69
Cystopteris fragilis.....	61	14	8.68-6.61
Onoclea sensibilis.....	26	10	8.28-4.62
Thelypteris palustris var. pubescens.....	14	3	8.26-5.53
Thelypteris noveboracensis.....	27	12	8.29-3.98
Thelypteris marginalis.....	18	10	7.87-4.11
Thelypteris Goldiana.....	5	2	7.63-6.50
Thelypteris spinulosa var. americana.....	12	7	6.87-4.05
Thelypteris spinulosa var. intermedia.....	15	9	6.80-4.06
Thelypteris hexagonoptera.....	26	12	7.80-4.35
Thelypteris cristata.....	2	1	5.53-4.78
Polystichum acrostichoides.....	43	19	8.14-4.71
Dennstaedtia punctilobula.....	20	12	6.61-3.45
Athyrium angustifolium.....	14	7	8.17-5.90
Athyrium acrostichoides.....	14	7	7.82-4.79
Athyrium asplenoides.....	46	19	8.63-4.18
Camptosorus rhizophyllus.....	21	11	8.50-6.23
Asplenium resiliens.....	14	9	8.14-6.39
Asplenium platyneuron.....	66	29	8.51-5.18
Asplenium montanum.....	22	13	5.69-3.90
Asplenium Trichomanes.....	11	8	6.92-4.76
Asplenium pinnatifidum.....	1	1	4.71
Asplenium cryptolepis.....	5	2	7.95-6.83
Woodwardia areolata.....	21	11	6.29-3.88
Pellea atropurpurea.....	30	10	8.96-6.57
Cheilanthes lanosa.....	10	4	8.43-6.31
Cheilanthes alabamensis.....	2	1	7.11-6.94
Cheilanthes tomentosa.....	5	2	7.27-5.68
Adiantum pedatum.....	37	13	8.75-4.08
Adiantum Capillus-Veneris.....	6	2	8.43-7.25
Pteridium latiusculum var. pseudocaudatum.....	24	12	7.19-3.67
Polypodium virginianum.....	19	13	6.29-3.95
Polypodium polypodioides.....	23	12	7.95-4.86
Lygodium palmatum.....	10	6	5.26-3.82
Osmunda regalis var. spectabilis.....	23	11	7.53-4.03
Osmunda Claytonia.....	4	1	7.73-7.20
Osmunda cinnamomea.....	16	12	6.81-3.54
Botrychium dissectum var. obliquum.....	15	7	6.75-4.87
Botrychium virginianum.....	30	12	8.68-4.66
Equisetum arvense.....	12	5	8.32-6.79
Equisetum hyemale var. robustum.....	5	2	7.87-7.26
Selaginella apus.....	2	1	8.34-7.01
Selaginella rupestris.....	5	1	6.24-4.64
Lycopodium lucidulum.....	7	3	5.40-3.98
Lycopodium obscurum.....	15	5	5.63-3.88
Lycopodium clavatum.....	3	1	4.78-4.41
Lycopodium porophyllum.....	3	2	5.34-4.52
Lycopodium Selago.....	1	1	4.54
Lycopodium alopecuroides.....	3	1	4.59-4.41
Lycopodium tristachyum.....	5	2	4.76-3.65

three species gave reactions that were both more acid and less acid than the pH range reported by Woodruff (1935, 1936).

The pH range of fourteen species are reported in the present paper that were not studied in the previous investigation (Woodruff, 1935, 1936).

In Table 1, there is a summation of the species studied in the present paper and in the earlier investigation (Woodruff, 1935, 1936). Table 1 gives the name of the species, the total number of soil samples tested from each species, the total number of stations and substations from which the soil samples were secured, and the pH range resulting from the reactions of the soil samples. The pH range gives the highest and lowest acidity (or alkalinity) of each species.

The writer wishes to correct the following errors in the preceding paper (Woodruff, 1935, 1936): the species listed as *Osmunda regalis* L. (Royal Fern) is probably the variety of the species and should have been listed as *Osmunda regalis* L. var. *spectabilis* (Willd.) Gray (Royal Fern); the soil samples of *Lycopodium prophilum* reported from Station CC were incorrect as this species was not found at Station CC.

SUMMARY

1. The hydrogen-ion concentration of the soils around the roots of thirty-nine species of ferns, two species of *Equisetum*, two species of *Selaginella*, and seven species of *Lycopodium* found in Tennessee were determined electrometrically. Two hundred and forty soil samples were collected and tested.

2. From the data presented in this paper and the earlier one by Woodruff (1935, 1936) *Asplenium cryptolepis*, *Adiantum Capillus-Veneris*, *Osmunda Claytoniana*, *Equisetum arvense*, *Equisetum hyemale* var. *robustum*, and *Selaginella apus* grow in neutral or alkaline soil.

3. From the data presented in this paper and the earlier one by Woodruff (1935, 1936) *Woodsia scopulina*, *Thelypteris spinulosa* var. *americana*, *Thelypteris spinulosa* var. *intermedia*, *Thelypteris cristata*, *Dennstaedtia punctilobula*, *Asplenium montanum*, *Asplenium Trichomanes*, *Asplenium pinnatifidum*, *Woodwardia areolata*, *Pteridium latiusculum* var. *pseudocaudatum*, *Polypodium virginianum*, *Lygodium palmatum*, *Osmunda cinnamomea*, *Botrychium dissectum* var. *obliquum*, *Selaginella rupestris*, *Lycopodium lucidulum*, *Lycopodium obscurum*, *Lycopodium clavatum*, *Lycopodium porophilum*, *Lycopodium Selago*, *Lycopodium alopecuroides*, *Lycopodium tristachyum*, and *Trichomanes Petersii* were found only in acid soil.

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