respects, *Cromeria* appears to agree with *Kneria*. There are, however, two notable discrepancies.

Kneria has 'the margin of the upper jaw formed by the intermaxillaries,' according to Dr. Günther, while in *Cromeria* Dr. Swinnerton found that 'both premaxilla and maxilla are small and edentulous,' and that 'the latter overlaps the former dorsally and enters largely into the formation of the gap.' In view of the very small size of the fishes and the ambiguous character of the mouth parts, the apparent difference may be rather nominal than real.

Kneria has its body 'covered with very small cycloid scales,' while *Cromeria* has the body 'naked.' Further, *Kneria* has a normal tail, while *Cromeria* has a membranous extension from the caudal above and below. It is possible that both of these characters may be indicative of immaturity (as analogous ones are in some other fishes) but it may be better for the present to assume that the two genera *Kneria* and *Cromeria* are distinct; that they are related there is little doubt.

The family, as represented by *Cromeria,* is so remarkably distinguished by osteological characters, especially the attachment of 'the greatly elongated arm of a bifurcated post-temporal to the supra-occipital bone,' that it should be isolated as the representative of a peculiar superfamily—Knerioidea. As Boulenger and Swinnerton have indicated, the scapular arch being destitute of a meso-coracoid, the group may provisionally be associated in the same great group as the pikes and killiefishes—Haplomi—or, perhaps better, in the group Iniomi, inasmuch as the family agrees with those fishes in their technical characters. Whether such an association would be natural will be for the future to determine.

THEO. GILL.

THE FLORA OF THE SERPENTINE BARRENS OF SOUTHEAST PENNSYLVANIA.

PARTS of Montgomery, Delaware, Chester and Lancaster Counties, Pennsylvania, are noted from a geologic standpoint for the presence of outcrops of serpentine rock. This rock formation is confined to the district southwest of the Schuylkill River, extending in a somewhat southwestward direction into Maryland, near the lower Susquehanna River. The largest outcrops near Philadelphia occur in the neighborhood of Lima, Delaware County, at Newtown Square, at places north and southwest of West Chester, while isolated patches exist south of Bryn Mawr and northwest of Media. There seems no doubt but that all the serpentines in southeast Pennsylvania are altered igneous rocks, either pyroxenites or peridotites.*

The flora of the serpentine exposures, which are always more or less barren in appearance, is peculiar. The eye of the botanist, or of the observant layman, is at once arrested by the association of the characteristic species which make up the serpentine flora, because it is sharply demarcated from the flora of the surrounding country. The botanist can identify the serpentine areas, where the rock is covered by a shallow soil, by the vegetation alone, for the species which are character plants, although occurring elsewhere in the region, are here grouped together in such a manner and in such number, as to delimit sharply these areas from the surrounding country. The serpentine plants taken together, therefore, form islands set down in a sea of other vegetation with a boundary as well characterized as the shore of an oceanic island, and with tension lines induced by the struggle for existence as sharply drawn as the shore line against which the storm waves beat. This sharp delimitation of the boundaries of the serpentine areas is emphasized by the fact that these areas are rarely cultivated, but are surrounded by rich cultivable land from which the original vegetation has been removed by man. Many of the plants found on the serpentines have survived, therefore, such vicissitudes and have persisted on the barrens, while the same species have been exterminated in the cleared land. This fact, however, does not militate against the unique character of the serpentine flora, because the forest, which exists on soils other than the serpentine, is

* Rand, Theodore D., 'Notes on the Geology of Southeastern Pennsylvania,' *Proc. Acad. Nat. Sci. Phila.*, 1900, p. 305.

of an open type with the presence of a large number of shade-loving plants, such as *Sanguinaria canadensis* L., etc., which are not found as constituents of the barren flora.

Ten representative serpentine barrens were studied by the writer, viz:*

A. Glenriddle, Delaware County, Pa., on the road leading to the borough town of Lima.

B. Serpentine in the valley west of Black Horse Hotel.

C. Serpentine east of Black Horse Hotel.

D. Serpentine at Williamson School.

E. Serpentine lying between Newtown Square and Darby Creek.

F. Serpentine opposite Castle Rock on east side of Crum Creek along Preston Run.

G. Serpentine near Westtown, Pa.

H. Pink Hill near Lima, Delaware County, Pa.

I. Brinton's Quarry near Westtown, Pa.

Ecologically the flora of the serpentine barrens belongs to the mixed deciduous forest and barren treeless formations. Several plant associations are recognizable, so that an ecologic classification of the plants is as follows:

MIXED DECIDUOUS FOREST FORMATION.
- *Juniperus-Acer-Nyssa-Quercus Association.*
- *Sassafras Association.*
- *Aspidium-Asplenium Association.*
- *Dicksonia Association.*

BARREN TREELESS FORMATION.
- *Cerastium Association.*
- *Phlox Association.*
- *Deschampsia Association.*
- *Carex-Eleocharis Association.*
- *Spiræa Association.*
- *Rosa Association.*
- *Rubus Association.*
- *Kalmia Association.*
- *Smilax Association.*

These formations and associations will be described as they exist on the several serpentine areas mentioned. They are controlled largely by edaphic conditions. Thus the forest type exists where the geologic formation is covered by a surface layer of soil of some depth. The barren treeless formation exists where the serpentine rock is exposed with little or no surface soil. Where springs occur and the soil is wet, the character of the associations is determined by the amount of soil water.

A. SERPENTINE AT GLENRIDDLE, PA.

The barren above Chester Creek at Glenriddle along the road leading from that place to Lima is distinguished by the dominance of *Quercus stellata* Wang. [*Q. minor* (Marsh.) Sarg.],* *Quercus nigra* L. [*Q. marylandica* Muench], *Quercus alba* L., *Acer rubrum* L., *Juniperus virginiana* L., *Castanea sativa* Mill. var. *Americana* Gray [*Castanea dentata* (Marsh.) Borkh.], *Sassafras officinale* Nees [*S. sassafras* (L.) Karst.], and *Cornus florida* L. (MIXED DECIDUOUS FORMATION *Juniperus-Acer-Nyssa-Quercus Association*). The secondary species beneath the shade formed by the above-mentioned are *Rhus glabra* L., *Viburnum dentatum* L., *Vaccinium stamineum* L. [*Polycodium stamineum* (L.) Greene], *Gaylussacia resinosa* Torr. & Gray [(Ait.) Torr. & Gray], *Vaccinium pennsylvanicum* Lam., *Viburnum acerifolium* L. and *Salix tristis* Ait. The lianes, or climbing plants that festoon the trees, are *Vitis æstivalis* Michx., *Smilax rotundifolia* L., *Smilax glauca* Walt., *Rhus toxicodendron* L. [*R. radicans* L.]. The herbs found here are *Hieracium venosum* L., *Pteris aquilina* L. [*Pteridium aquilinum* (L.) Kuhn], *Antennaria plantaginifolia* Hook. [(L.) Richards], *Baptisia tinctoria R. Br.* [(L.) R. Br.], *Rubus triflorus* Richardson [*R. Americanus* (Pers.) Britton], *Potentilla canadensis* L., *Rumex acetosella* L., *Veronica agrestis* L., *Hypoxis erecta* L. [*H. hirsuta* (L.) Coville], and *Lysimachia stricta* Ait. [*L. terrestris* (L.) B. S. P.], all species usually found in dry situations like the sandy pine barrens of New Jersey. In fact, there is a striking similarity in the floras

* The map used in this botanic survey accompanies Penn. Second Geological Survey, Delaware, Part. I., C. 5.

* Names according to Gray, sixth edition, with names in parenthesis according to Britton's 'Manual of the Flora of the Northern States.'

of the serpentine barrens and the pine barren region of New Jersey.

B. SERPENTINE IN THE VALLEY, WEST OF BLACK HORSE HOTEL.

Here is found a typical exposure of serpentine rock. The barren treeless areas (BARREN TREELESS FORMATION) are characterized by the clumps of *Cerastium oblongifolium* Torr. [*Cerastium arvense* L. var. *oblongifolium* Holl & Britt.] (*Cerastium Association*), *Panicum latifolium* L., *Rumex acetosella* L., *Trifolium rèpens* L. Near by on somewhat similar barren areas occur thickets of green briars *Smilax rotundifolia* L., *Smilax glauca* Walt. with *Juniperus Virginiana* L. and *Nyssa sylvatica* Marsh rising out, as solitary specimens, from the tangled mass of briars (*Smilax Association*). *Rubus villosus* Ait? (Gray) [*R. nigrobaccus* Bailey], *Rosa lucida* Ehrh. and *Spiræa salicifolia* L. form pure growths (*Rubus, Rosa, Spiræa Associations*), while separating these are grassy stretches, where the botanist finds *Œnothera fruticosa* L. [*Kneiffia fruticosa* (L.) Raimann], *Cerastium oblongifolium* Torr., *Arabis lyrata* L., *Deschampsia cæspitosa* Beauv. (*Deschampsia Association*), *Sisyrynchium angustifolium* Mill., *Senecio aureus* L. var. *balsamitæ* Torr. & Gray [*Senecio balsamitæ* Muhl.], *Geranium maculatum* L. The swampy areas, formed by springs, support *Carex utriculata* Boott., *Eleocharis ovata* R. Br., *Danthonia sericea* Nutt., *Tradescantia pilosa* Lehm. (*Carex-Eleocharis Association*).

In an adjacent barren (*C*), a stream flows through the woods formed by *Acer rubrum* L., *Liriodendron tulipifera* L., *Juniperus virginiana* L. and *Nyssa sylvatica* Marsh. Along the borders of this stream, and therefore in wet soil, grow *Lindera benzoin* Blume [*Benzoin benzoin* (L.) Coulter], *Aspidium acrostichoides* Swartz [*Dryopteris acrostichoides* (Michx.) Kuntze.] and *Asplenium trichomanes* L. (*Aspidium-Asplenium Associations*).

D. SERPENTINE AT WILLIAMSON SCHOOL.

The dominant trees on the serpentine barrens at Williamson School are *Quercus alba* L., *Quercus rubra* L., *Quercus stellata* Wang. [*Q. minor* (Marsh.) Sarg.], *Quercus nigra* L. [*Q. marylandica* Muench.], *Acer rubrum* L., and *Juniperus virginiana* L., while associated with these trees are *Sassafras officinale* Nees [*S. sassafras* (L.) Karst.], *Rhus glabra* L., *Kalmia latifolia* L. (*Kalmia Association*), *Salix tristis* Ait., and as lianes, *Vitis æstivalis* Michx., *Ampelopsis quinquefolia* Michx. [*Parthenocissus quinquefolia* (L.) Planch.] and *Smilax rotundifolia* L. The following herbaceous plants grow on the barrens here, *Pteris aquilina* L. [*Pteridium aquilinum* (L.) Kuhn], *Senecio aureus* L. var. *balsamitæ* Torr. & Gray [*Senecio balsamitæ* Muhl.], *Geranium maculatum* L., *Trifolium agrarium* L. [*Trifolium aureum* Poll.], *Aspidium acrostichoides* Swartz [*Dryopteris acrostichoides* (Michx.) Kuntze] and *Castilleia coccinea* Spreng [(L.) Spreng].

E. SERPENTINE AT NEWTOWN SQUARE.

The dominant trees of this serpentine outcrop consist of the chestnut *Castanea sativa* Mill. var. *Americana* Gray [*C. dentata* (Marsh.) Borkh.], the red maple, *Acer rubrum* L., the beech, *Fagus ferruginea* Ait. [*F. americana* Sweet], black cherry *Prunus serotina* Ehrh., *Quercus rubra* L., *Quercus alba* L., *Quercus nigra* L. [*Q. marylandica* Muench.] and *Juniperus virginiana* L. As secondary species of this forest occur *Amelanchier canadensis* L. [(L.) Medic.], *Sassafras officinale* Nees [*S. sassafras* (L.) Karst.], *Carpinus caroliniana* Walt., *Corylus americana* Walt., *Rosa lucida* Ehrh., while as climbing species *Smilax rotundifolia* L., *Vitis æstivalis* Michx., *Ampelopsis quinquefolia* Michx. [*Parthenocissus quinquefolia* (L.). Planch.] form impenetrable thickets. *Vaccinium pennsylvanicum* Lam., *Gaylussacia resinosa* Torr. & Gray [(Ait.) Torr. & Gray] form the undergrowth associated with three ferns, *Aspidium acrostichoides* Swartz [*Dryopteris acrostichoides* (Michx.) Kuntze], *Asplenium trichomanes* L. and *Dicksonia pilosiuscula* Willd. [*Dennstædtia punctilobula* (Michx.) Moore], *Galium aparine* L. (*Aspidium-Asplenium, Dicksonia Formations*). The treeless barrens support *Cerastium oblongifolium* Torr., *Senecio aureus* L. var. *balsamitæ* Torr. & Gray

[*Senecio balsamitæ* Muhl.] and *Erigeron* Pers. [(L.) Pers.] (Barren Treeless Formation. *Cerastium Association*).

F. East Side Crum Creek along Preston Run.

A large part of this exposure is treeless, and upon the broken-down serpentine rock grow mats of *Phlox subulata* L. (*Phlox Association*), *Trifolium agrarium* L. [*T. aureum* Poll.] *Pteris aquilina* L. [*Pteridium aquilinum* (L.) Karst.], *Verbascum blattaria* L., *Panicum latifolium* L., *Potentilla canadensis* L. and *Cerastium oblongifolium* Torr. (*Cerastium Association*). The trees are the same as the botanist finds on the other serpentine barrens mentioned. Thickets of green briars are also characteristic of the treeless areas here.

A study of the flora of these rocky exposures reveals the fact that the same association of species is not found on all of the serpentine barrens. The several component species differ as the localities differ, although the same general character of the vegetation is preserved by the presence of several dominant plants, found on all of the barrens. The red cedar *Juniperus virginiana* L., the barren oak, *Quercus nigra* L. [*Q. marylandica* Muench.] the white oak, *Quercus alba* L., the sour gum, *Nyssa sylvatica* Marsh., the sassafras, *Sassafras officinale* Nees [*S. sassafras* (L.) Karst.], the smooth upland sumac, *Rhus glabra* L., the red maple, *Acer rubrum* L., may be said to be the dominant character species, while on most of the barrens, although not found on all, occurs the chestnut, *Castanea sativa* Mill. var. *americana* Gray [*C. dentata* (Marsh.) Borkh.]. When the growth of these trees is dense the serpentine areas are rendered impenetrable in many places by the green briars, *Smilax rotundifolia* L., *Smilax glauca* Walt., the lianes, *Vitis æstivalis* Michx. and the Virginia creeper, *Ampelopsis quinquefolia* Michx. [*Parthenocissus quinquefolia* (L) Planch], which festoon the trees and intertwine with each other to form a dark gloomy forest inhabited by the cotton-tail rabbit. Where the ground is too barren to support trees, which usually grow in situations where there is considerable surface soil, the green briar, *Smilax rotundifolia* L. associated with *Smilax glauca* Walt. covers the ground with a dense growth separated by intervals of grass, where the botanist finds the small sundrops, *Œnothera fruticosa* L. [*Kneiffia fruticosa* (L.) Raimann], tufted hair grass, *Deschampsia cæspitosa* Beauv., associated with the blackberry, *Rubus villosus* Ait? (Gray) [*R. nigrobaccus* Bailey], and meadow-sweet, *Spiræa salicifolia* L. These treeless areas can be distinguished at a distance by the clumps of briars, by the presence of sentinel-like red cedars, and by an occasional sour-gum tree.

The one herb found on all of the serpentine exposures is the barren chickweed, *Cerastium oblongifolium* Torr. [*C. arvense* L. var. *oblongifolium* Holl & Britt.], which varies from a dwarf cespitose herb to one that, taller and more distinctly branched, covers acres of ground. Some of the barrens are distinguished by the presence of matted growths of the moss pink, *Phlox subulata* L. Such are the barrens at Pink Hill (*H*) and along Preston Run (*F*), where extensive areas are covered by this herb associated with the barren chickweed and the wooly blue violet, *Viola ovata* Nutt. Upon one or two of the barrens, viz., Westtown, Pa. (*G*), and Edgmont, Pa.,* grows the fame flower, *Talinum teretifolium* Pursh. This plant is clearly controlled in its distribution by edaphic conditions, for it is found, and its nearly related species, *Talinum rugospermum* Holzinger, on a variety of rock formations throughout the eastern United States.† The barren at the Williamson School is noted for a growth of laurel, *Kalmia latifolia* L., dwarf willow, *Salix tristis* Ait., and until recently was visited by botanists for the scarlet painted-cup, *Castilleia coccinea* Spreng [(L.) Spreng].

* On the authority of Mr. Benjamin H. Smith, who ascertained the locality from Mr. Witmer Stone.

† Harshberger, J. W., 'An Ecological Study of the Genus Talinum,' *Bulletin Torrey Bot. Club*, XXIV., p. 182.

Holzinger, J. M., 'The Geographical Distribution of the Teretifolium Group of Talinum,' *Asa Gray Bulletin*, VIII., p. 36.

One fact is proved abundantly by a study of the flora of the serpentine barrens, and that is that the chemical character of the soil derived from a disintegration of the serpentine plays an unimportant part in the distribution of the plants mentioned. The distribution of such species is due rather to the physical conditions of the soil, especially with reference to water conductivity and water storage capacity (edaphic conditions). The variation in the character of the plant associations described above is in the main due to the character of the soil. If the soil is present as a well-marked surface layer, then tree associations are found; if on the other hand the rock is exposed, herbaceous associations are the rule. The surface layers of serpentine rock are broken by weathering into angular fragments, which, lying loosely together, permit the percolation of the rain water down into the seams of the underlying rock. Such exposures, therefore, support plants that have adapted themselves to living in dry situations and have structural arrangements which prevent a rapid loss of water.

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THE AMOUNTS OF READILY WATER SOLUBLE SALTS FOUND IN SOILS UNDER FIELD CONDITIONS.

IN the investigations of the Division of Soil Management, in the Bureau of Soils, relating to the influence of soil moisture in crop production it has been found essential to take into consideration not only the varying amounts of available moisture in the soil but also the readily water soluble salts which this moisture carries in solution.

The sensitive and rapid methods which have been devised or adapted for this work enable us to determine the K, Ca, Mg, NO_3, HPO_4, SO_4, Cl, HCO_3 and SiO_2 in the soil with an accuracy of duplication ranging usually from one to five parts per million of the dry weight of the soil examined and with rapidity such that eight men are able to complete the nine sets of determinations on twenty samples daily between 9 A.M. and 4 P.M.

As these methods are now used in our soil investigations, those for the K, Cl and HCO_3 have been devised and adapted under the direction of Dr. F. K. Cameron; that for NO_3 by A. R. Whitson of Wisconsin and the writer; that for HPO_4 and SiO_2 by Dr. Oswald Schreiner; those for Ca and Mg by Dr. Schreiner and W. S. Ferris, and that for SO_4 by J. O. Belz. The clear soil solutions for examination are obtained by using the effective filter devised by Dr. Lyman Briggs.

After extended observations it has been found that to recover the maximum amount of the readily water soluble salts which are present in the soil it is necessary to first render the sample water free by drying at a temperature of 110° to 120° C., as soils are dried for moisture determinations. Mr. J. O. Belz and the writer found, for example, that after ten times washing 50 grams of a coarse, clean sand containing 4.125 mg. of potassium nitrate, that the same sample oven dried after having been ten times washed in 100 c.c. of distilled water yielded when worked in the disulphonic acid a large additional amount of nitrates. Our actual figures are given below, where from 50 grams of sand we recovered:

By 1st washing of three minutes	....	3.12100 mg.
" 2d " " " "	....	.32840 "
" 3d " " " "	....	.04515 "
" 4th " " " "	....	.01736 "
" 5th " " " "	....	.01380 "
" 6th " " " "	....	.01280 "
" 7th " " " "	....	.01109 "
" 8th " " " "	....	.01100 "
" 9th " " " "	....	.01100 "
" 10th " " " "	....	.01101 "
After drying	.....	.76290 "
Total recovered	.....	4.34551 "
Amount present	.....	4.12500 "

These observations were made in February, 1902. Later in the season, in September, we made an examination of thirty-two samples of soil, representing eight soil types, determining the amounts of NO_3, SO_4, HPO_4, HCO_3, Cl and SiO_3 which could be recovered by washing 100 grams three minutes in 500 c.c. of distilled water as they came fresh from the field, and again by washing in the same manner 100 grams of the water free sample direct from the oven.