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Geological substratum, herbaceous, shrub, and tree vegetation and floristic diversity of mature upland forest sites in northern New Jersey

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Summary: Data from forty stands of herbaceous and shrub plants and 29 stands of trees of upland forests in northern New Jersey were used to determine the impact of geological substratum on species diversity of herbaceous, shrub and tree plants. Ten different substrata were studied. The ten geological substrata were Kittatinny Limestone, Martinsburg Shale, Brunswick Shale, Triassic Conglomerate, Basalt, Longwood Shale, Gneiss (Byrum, Pochuck and Losee), High Falls Sandstone, Green Pond Conglomerate and Shawangunk Conglomerate. Greatest diversity was found in herbaceous plants on Gneiss (118 species), Martinsburg Shale (95), High Falls Sandstone (80) and Kittatinny Limestone (82).

Species, which were restricted to specific substrata, are discussed for herbaceous, shrub and tree species. These studies encompass 171 species of herbaceous plants.

For herbs, the ten geological substrata were Kittatinny Limestone (82 species per substratum), Martinsburg Shale (95), Brunswick Shale (18), Triassic Conglomerate (45), Basalt (68), Longwood Shale (25), Gneiss (Byrum, Pochuck and Losee 118), High Falls Sandstone (80), Green Pond Conglomerate (19), and Shawangunk Conglomerate (37).

For shrubs, the ten geological substrata were Kittatinny Limestone (15 species per substratum), Martinsburg Shale (23), Brunswick Shale (6), Triassic Conglomerate (19), Basalt (23), Longwood Shale (10), Gneiss (Byrum, Pochuck and Losee (31), High Falls Sandstone (21), Green Pond Conglomerate (14), and Shawangunk Conglomerate (9). Greatest diversity was over Gneiss. These studies encompass 45 shrub species.

For trees, the ten geological substrata were Kittatinny Limestone (24), Martinsburg Shale (22), Brunswick Formation (11), Triassic/Border Conglomerate (15), Basalt (24), Longwood Shale (12), Gneiss (no data available), High Falls Sandstone (24), Green Pond Conglomerate (11), and Shawangunk Conglomerate (14).

Keywords: geological substrata, trees, shrubs, herbs, upland forest, flora of New Jersey, species diversity

In DAVIDSON (2004a), Table 5 shows 39 taxa restricted to specific substrata or substrata not having restricted species of herbaceous plants. These substrata are:

Kittatinny Limestone	6 species
Basalt	1 species
Longwood Shale	1 species
Gneiss	15 species
High Falls Sandstone	7 species
Shawangunk Conglomerate	2 species
Martinsburg Shale	6 species
Triassic/Border Conglomerate	2 species

Substrata not having restricted species: Green Pond Conglomerate, Brunswick Formation.

In examining the list of 171 herbaceous plants which are shown in DAVIDSON (2004a: tab. 1) the author carefully examined the comments of each species relative to soil and habitat specificity of the species in GLEASON & CRONQUIST (1991) and many of these have specific substrate characteristics, such as rocky or sandy, rich soil, rich woods, bogs, and moist habitats (tables 1 & 2), but with the exceptions of *Asplenium trichomanes*, *Camptosorus rhizophyllus*, and *Senecio obovatus*, all growing from calcareous materials, none of the 171 herbaceous taxa can really be said to be identified with particular substrate based on this literature review. These studies of DAVIDSON (2004a), particularly Table 5 (39 species of herbs), do show specificity of herbaceous plants to ten geological substrata in northern New Jersey forests.

Thus, there is specificity of shrubs to ten geological substrata in northern New Jersey. These studies encompassed 45 species of shrubs. Greatest diversity was found in shrub plants on Limestone (31), Basalt (23), Martinsburg Shale (23), and High Falls Sandstone (21).

For trees, the nine geographical substrata were Kittatinny Limestone (24 species), Martinsburg Shale (22 species), Brunswick Shale (31), Triassic Conglomerate (15), Basalt (24), Longwood Shale (12), High Falls Sandstone (24), Green Pond Conglomerate (11), and Shawangunk Conglomerate (14).

Table 1: Specificity of herbaceous plants from 40 stands, in search of any specific substrate requirements and possible herb evolution (GLEASON & CRONQUIST 1991).

Adiantum pedatum L.	Moist woods and stream sides, in circum neutral soil
Aralia racemosa L.	Rich woods
Asarum canadense L.	Rich woods
Asplenium platyneuron (L.) Oakes	Woods, banks and rocks, in circum neutral soil
Asplenium trichomanes L.	On shaded, mostly calcareous rocks
Bromus purgans L.	Rich, moist woods
Camptosorus rhizophyllus (L.) Link.	Mostly on rocks, especially on limestone
Claytonia virginica L.	Rich woods and fields
Collinsonia canadensis L.	Rich woods
Desmodium glutinosum (Muhl.) Wood.	Rich woods
Desmodium nudiflorum (L.) DC.	Rich woods
Medeola virginiana L.	Rich woods
Monotropa uniflora L.	Rich woods
Polygala paucifolia Willd.	Moist, rich woods
Sanguinaria canadensis L.	Rich woods
Senecio obovatus Muhl.	Rich woods and rocky outcrops, especially in calcareous situations
Smilacina racemosa (L.) Desf.	Rich woods
Trientalis borealis Raf.	Rich woods and bogs
Viola pensylvanica Michx.	Rich woods, or sometimes in meadows
Viola pubescens Ait.	Rich woods, or sometimes in meadows
Viola rotundifolia Michx.	Deep, rich, usually coniferous woods

Table 2: Search for specificity of species of New Jersey Shrubs from 40 stands, in search of any specific substrate requirements and possible shrub evolution (GLEASON & CRONQUIST 1991).

Celastrus scandens L.	Rich soil
Cornus alternifolia L.	Rich woods
Lindera benzoin (L.) Blume	Abundant in rich, moist woods
Viburnum rafinesquianum Schultes	Dry, especially calcareous woods

The increase in species represented with increased sampling suggests, that, of all substrata studied, Limestone may support the greatest diversity of tree species. PEARSON (1960a,b) showed 32 tree species occurring in 17 stands on Kittatinny Limestone. DAVIDSON (2004a) was only able to locate three additional stands that PEARSON had not located in 1960.

Lists of trees, shrubs, and herbs were prepared from 106,480 individual taxonomic determinations by D. W. Davidson on plant materials to a great extent in the vegetative state. (DAVIDSON 1973). This figure is considered quite minimal because many of the determinations were evaluated simply by presence of a herb, shrub or tree in the forest.

Trees:
The tree species are in general quite deeply rooted, and therefore they would not likely to have speciation taking place rapidly on specific rock types over the last 10,000 years since the last Wisconsin ice age (see DAVIDSON 2005).

Shrubs:
The shrubs are less deeply rooted than the trees (DAVIDSON et al. 1989; Davidson: unpublished observations) and therefore speciation on the ten substrata could be determined to be taking place more rapidly on the soils since Wisconsin glaciation (see DAVIDSON 2004b tab. 4).

Herbs:
Herbs are shallowly rooted in the forest (DAVIDSON et al. 1989; Davidson: unpublished observations) and therefore speciation could be said to be occurring more rapidly on the soil types with herbs since the last Wisconsin glaciation (see DAVIDSON 2004a tab. 5).

More speciation in herbs and shrubs is hypothesized to have taken place in herbs and shrubs than in trees. There has also been greater specificity in herbs and shrubs on geological substrata than in trees (six).

Conclusions

The striking features of the western serpentine vegetation (KRUCKEBERG 1954; WALKER 1954; WHITTAKER 1954) were not found in the stands and species here studied in northern New Jersey. Nor were the striking results of BILLINGS (1950) in dry Nevada, shown by the herbaceous flora of the upland forests of northern New Jersey. Northern New Jersey, with more than 10 different geological substrata, has the same type of setting as the Nevada and California sites of BILLINGS (1950), as these are juxtaposed on quite different geological substrata each with a different complement of soil series (as shown by TEDROW 1986). These substrata, as did those of BILLINGS with the altered and unaltered Andesite, provide the opportunity to compare endemic species on these soils and substrata.

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