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Using Diagnostic Plants To Evaluate Site Class

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Using Diagnostic Plants to Evaluate Site Class

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Introduction

Management of forestlands requires a thorough understanding of environmental relationships, site productive capacity, plant associations, and predictable succession patterns. Forest managers must use this knowledge to develop prescriptions that will accomplish the landowner's goals and objectives.

Understory herbaceous plants and shrubs give clues to a site's potential and its limitations. In northern Europe, diagnostic plants have been used for many years to classify sites, assess stand productivity, and predict woody plant succession (Moore 1927). Because boreal plant communities have fewer species than many other plant communities, identifying and using plant indicators has been simple and effective.

In the eastern United States, foresters recognize certain understory species as indicators of limestone strata or bedrock. These include redbud, maidenhair fern, beech fern, and eastern redcedar. Other plants, such as broomsedge grass and sheep sorrel, indicate acidic soils.

This beech fern is an indicator of limestone strata or bedrock.

With increasing emphasis on ecological relationships and the need to understand a site's limitations when making stand prescriptions, more knowledge of diagnostic plants, or groups of plants, can be of value in deciding best uses and objectives for each stand or forest unit.

This study of diagnostic plants was made in the Pittsburgh Low Plateau Sub-Section of the Allegheny Plateau Section in the Central Appalachian Plateau Broadleaf-Coniferous Forest/Meadow Province. The goal was to identify those herbaceous plants and shrubs that give insight into a site's potential for this particular area of the East. *Table 1* on Page 4 lists both the common and scientific names of the plants in this study.

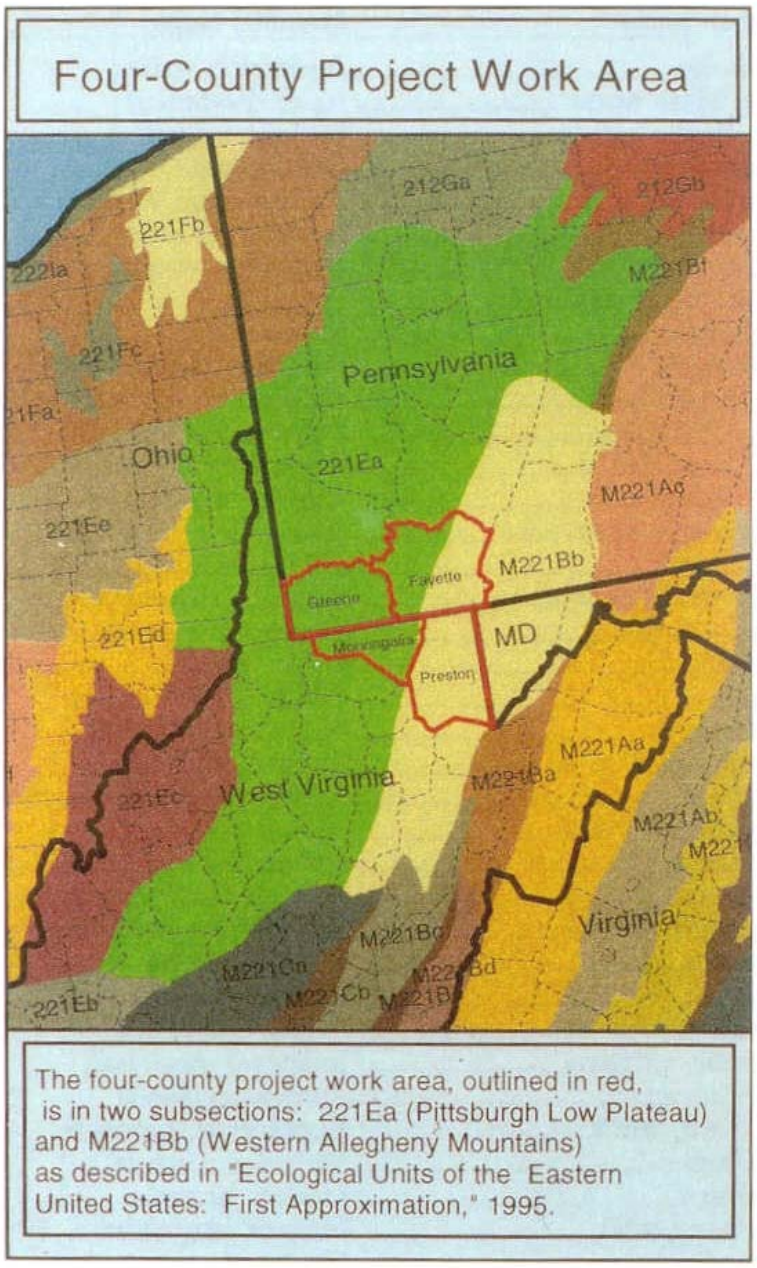
Field Inventory

Forty-eight 1/5-acre plots were established in Greene and Fayette Counties, Pennsylvania, and in Monongalia and Preston Counties, West Virginia (see map, *Figure 1*, next page). For each plot, slope position, percent slope, crown cover, soil depth, and A-horizon soil texture were determined. All trees 3.6 inches dbh (diameter at breast height) and larger were tallied by species, diameter, and crown class.

In this study,1/5-acre plots were used to assess general overstory and site characteristics. Four milacre subplots were established on each plot and all herbaceous plants were recorded based on their percent cover.

On each plot, four milacre subplots were established and all herbaceous plants recorded based on their percent cover. Tree seedlings, small saplings, and shrubs were tallied by species and 1-foot height class. In addition, the entire plot area was examined to detect other herbs or shrubs not present on the subplots that might be of diagnostic value.

Figure 1. *Map of Four-County Project Work Area.*



The four-county project work area, outlined in red, is in two subsections: 221Ea (Pittsburgh Low Plateau) and M221Bb (Western Allegheny Mountains) as described in "Ecological Units of the Eastern United States: First Approximation," 1995.

Table 1. *List of Common and Scientific Plant Names Used in Study.*

Common Name	Scientific Name
Agrimony	Agrimonia striata
Aster, white wood	Aster divaricatus
Basil, field	Satureja vulgaris
Bedstraw	Galium spp.
Broomsedge	Andropogon virginicus
Buttercup, common	Ranunculus acris
Chickweed, mouse ear	Cerastium viscosum
Cinquefoil, common	Potentilla simplex
Dewberry	Rubus hispida
Fern, bracken	Pteridium aquilinum
Fern, broad beech	Phegopteris hexagonoptera
Fern, Christmas	Polystichum acrostichoides
Fern, hay-scented	Dennstaedtia punctilobula
Fern, maidenhair	Adiantum pedatum
Fern, winter rattlesnake	Botrychium ternatum
Fern, wood	Dryopteris intermedia
Grass, deertongue	Panicum clandestinum
Grass, poverty	Danthonia spicata
Greenbrier	Smilax hispida, S. rotundifolia
Ground-ivy	Glechoma hederacea
Huckleberry	Gaylussacia baccata
Indian cucumber root	Medeola virginiana
Jewelweed	Impatiens capensis, I. flava
Knotweed, Virginia	Tovara virginiana
Loosestrife, whorled	Lysimachia quadrifolia
May-apple	Podophyllum peltatum
Moss, birdwheat	Polytrichum ohioense
Mountain laurel	Kalmia latifolia
Raceweed	Galinsoga ciliata
Redbud	Cercis canadensis
Redcedar, eastern	Juniperus virginiana
Sheep sorrel	Rumex acetosella
Snakeroot, white	Eupatorium rugosum
Speedwell	Veronica arvensis
Spicebush	Lindera benzoin
Strawberry, wild	Fragaria virginiana
Teaberry	Gaultheria procumbens
Trailing arbutus	Epigaea repens
Violet, common blue	Viola papilionacea
Yarrow	Achillea millefolium

Five site classes, or productivity classes, were recognized based on aspect and slope position as originally proposed by Weitzman and Trimble (1957), with slight modification to adapt to this study. *Figure 2* on Page 6 is a topographic representation of aspect and slope position according to the site classes recognized by this study. In selecting plot locations, attempts were made to obtain nearly equal representation from each site class in each county.

Analysis of Data and Results

Herbaceous and woody plants on the subplots were tabulated for each site class position. A species or herbaceous association needed to be present on 90 percent of the plots in a particular site class in order for it to be considered of diagnostic value. Plant species termed "ecologically plastic" or of "large amplitude," which were abundant on many or all of the site classes, were eliminated because they were determined to be of no diagnostic value.

The term, "ecologically rigid," is used to describe plants, such as teaberry, that occur only under very specific environmental conditions.

In most instances, however, within each site class an association of two or three plants stood out as being diagnostic for that ecological site position. Therefore, these associations were determined to have diagnostic value, thus qualifying them as indicators of a particular site class. Such plants, occurring only under very specific environmental conditions, are considered "ecologically rigid."

Figure 2. *Topographic Representation of Aspect and Slope Position by Site Class.*

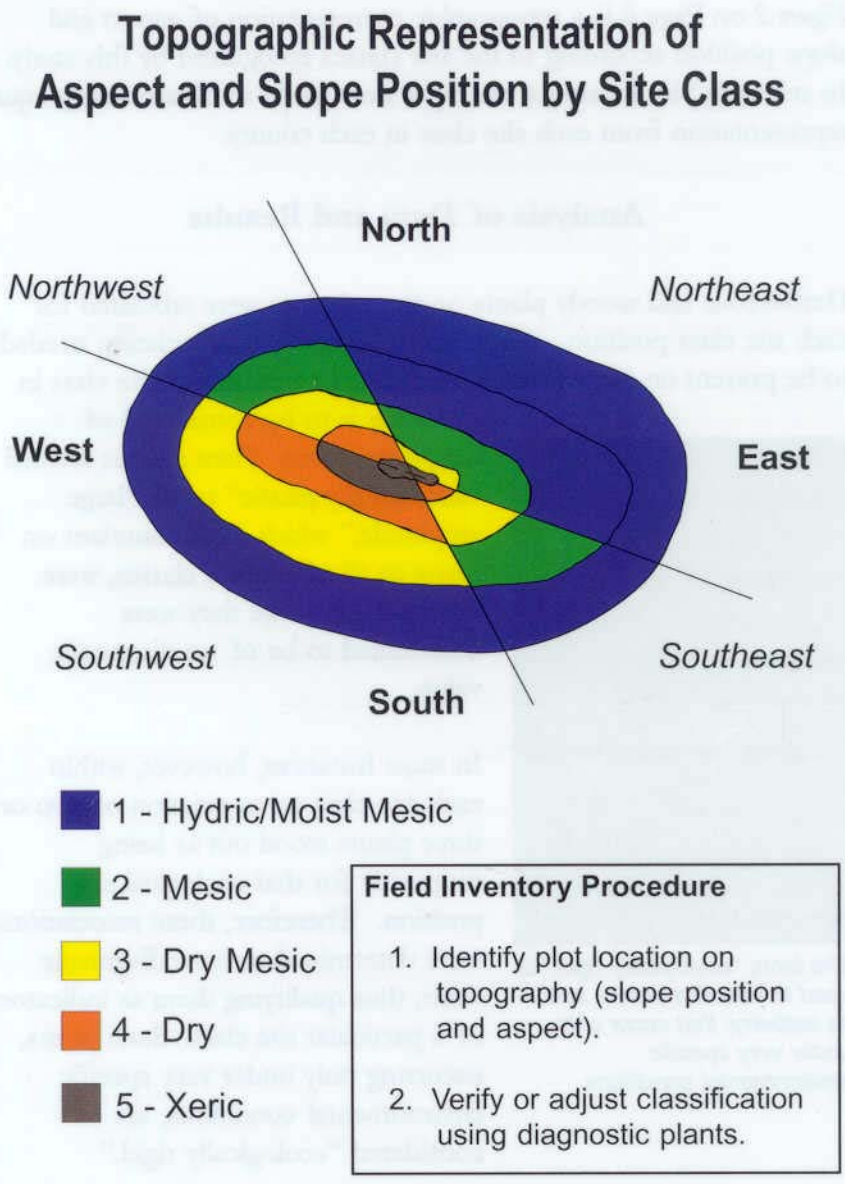


Table 2. *Diagnostic Plants and Associations by Site Class.*

Site Class	Aspect and Slope Position	Diagnostic Plants
1 (Hydric/ moist mesic)	Lower-third, NE-facing slopes; Bottomlands	Wood/Christmas fern Indian cucumber root Spicebush
2 (Mesic)	Middle-third, NE-facing slopes; Lower-third, NW&SE-facing slopes	Virginia knotweed Common blue violet
3 (Dry mesic)	Upper-third, NE-facing slopes; Middle-third, NW&SE-facing slopes; Lower-third, SW-facing slopes	Bedstraw White wood aster
4 (Dry)	Upper-third, NW&SE-slopes; Middle-third, SW-facing slopes	White snakeroot **and** Huckleberry
5 (Xeric)	Upper-third, SW-facing slopes; Ridgetops	Teaberry (Wintergreen) Mountain laurel Huckleberry

Evergreen ferns like the Christmas fern and wood fern are present throughout the year.

When selecting plants and associations for diagnostic purposes, preference was given to plants present throughout the year, such as Christmas fern. However, herbaceous plants present and easily identified throughout most of the growing season were also included.

When using these diagnostic species, the site class may be identified if only one of the named species is present, except for Site Class 4 (white snakeroot and huckleberry) where **both** species must occur. Wherever diagnostic species from two classes appear on a unit, the area is classified using the most predominant (occupying the largest area) species.

White snakeroot

Huckleberry

Site Class 4 requires that both diagnostic species – white snakeroot (shown above) and huckleberry (right) – be present for site class identification.

Understory plants on Site Classes 1, 2, and 3 consist primarily of dense ground cover of herbaceous species. In contrast, Site Classes 4 and 5 characteristically have a sparse ground cover with few herbaceous species, but a comparatively larger shrub component.

Discussion

The boundaries between areas of different site classes are often hard to distinguish. From one site class to another, plant communities gradually intergrade. Thus, there are many areas of the forest where diagnostic plants for two site classes intermingle. Such transitional areas, generally referred to by foresters as "tension zones" or "ecotones," are common throughout a forest.

This spicebush and white wood aster are an example of two diagnostic plants from different site classes existing together.

Understories of most old-field origin, pole-stage stands contain a number of herbaceous species that were early invaders in the old field before it seeded in with woody plants. These pioneers can persist for years in understocked stands.

In contrast, most early invading herbaceous plants are shaded out quickly in extremely dense young stands on old-field sites. The herbaceous mixture includes a strong component of remnants from the old-field stage (Virginia knotweed and bedstraw), plus later-arriving, typical forest understory species. All diagnostic herbaceous plants listed in *Table 2* on Page 7 will remain in the stand understory for many years.

Old-field remnants of herbaceous vegetation, like this Virginia knotweed, will inhabit the new stand.

Table 3, next page, presents a list of old-field plants commonly found in pole-stage stand understories in this study. Plants with an asterisk are early invaders that persist.

Certain herbaceous plants have long been recognized as indicators of specific site conditions. In worn-out old fields, it is not uncommon to find poverty-grass and broomsedge forming an incomplete ground cover. In between these plant clumps, various lichens and mosses are often conspicuous. This condition is a clue to low potential site productivity. When encountered, this condition should not be ignored in selecting tree species to plant, or natural regeneration to encourage.

Poverty grass and broomsedge.

Moss and lichens

Poverty-grass and broomsedge (shown above) found forming an incomplete ground cover in worn-out old fields is a warning that the site productivity is low. Often lichens and mosses (right) are present, too.

Table 3. *Old-Field Plants Persisting in Forest Understories.*

Plant Species	Site Productivity Classes				
	1	2	3	4	5
Agrimony	•				
Basil, field			•		
Bedstraw*	•		•	•	
Buttercup, common			•		
Chickweed, mouse ear		•			
Cinquefoil, common	•				
Dewberry	•	•	•		•
Fern, bracken		•			
Fern, hay-scented	•	•	•		•
Fern, winter rattlesnake	•	•			
Grass, deertongue			•		
Grass, poverty				•	•
Greenbrier	•	•	•		•
Ground-ivy	•	•			
Jewelweed		•	•		
Knotweed, Virginia*	•	•			
Loosestrife, whorled	•	•	•		
May-apple		•	•	•	
Raceweed			•		
Speedwell			•		
Strawberry, wild	•				
Trailing arbutus				•	
Yarrow			•		

* These were found to be diagnostic species.

The redbud growing on this limestone cutbank indicates its affinity for limestone soils. When redbud and eastern redcedar are found growing in abundance, the site may be more productive than aspect and slope position indicate.

Eastern redcedar and redbud, where abundant, are reliable indicators of subsurface limestone strata. Where these are plentiful, it may indicate that the site is more productive than aspect and slope position indicate. Limestone soils have been found to have higher site productivity, particularly on the drier aspects (Yawney 1964).

Field Application

This guide is useful for the following field applications:

Stand Prescriptions. Diagnostic plants are useful in making prescriptions for individual stands to determine the site class and thus evaluate the site's potential and its limitations. It is always important to examine the complete area of each stand thoroughly before making judgments based on diagnostic plants. Incomplete knowledge of the total stand's ecological position and site conditions can result in unrealistic management decisions.

Mapping Site Classes. Large forest areas can be mapped to delineate site classes based on diagnostic plants alone. Field methods similar to those traditionally used for type mapping forest stands are used. In such operations, parallel transect lines would be spaced at 300-foot intervals. Along transect lines, changes in occurrence of diagnostic plant associations would be mapped on grid paper, extending these observations on either side of each transect so that the entire area is evaluated.

On abandoned agricultural land that is reverting to forest, use of this guide can improve the quality of reforestation prescriptions. Where forest understory plants are invading these old fields, they provide valuable productivity clues.

Plants from two different site classes occupy this area. Because white snakeroot is diagnostic only when huckleberry is also present, it has no significance in the evaluation of this site. The Christmas fern is a Site Class 1 plant. The Virginia knotweed and common blue violet both represent Site Class 2. Since they occupy the largest part of the area of consideration, this site should be classified as Site Class 2.

Holistic Approach. More effective site class mapping using diagnostic plants can be done if their use is combined with observations of aspect, slope position, and depth of soil to help locate type boundaries, particularly in tension zone areas. As in traditional forest stand type mapping, boundaries between types will be difficult to define, but more accurate placement can be made using a combination of factors rather than one of these criteria alone.

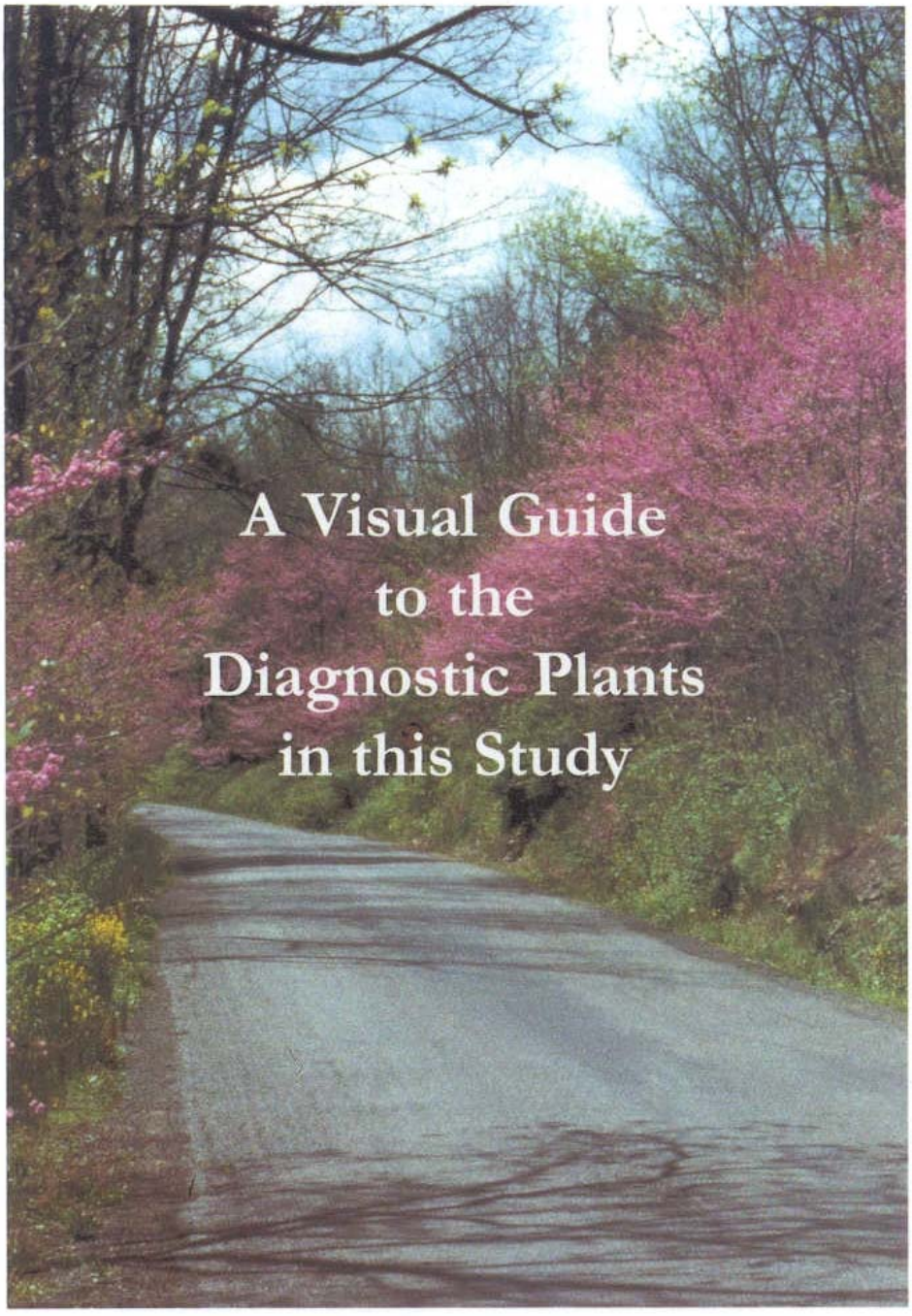
Diagnostic plants can be a valuable field tool in establishing more accurate site class boundaries and evaluating site potential, but they are best used from a holistic approach, combined with other observations, for accurate site class determinations.

Ken Carvell (right) observes the interest of someone learning about the significance of using diagnostic plants to evaluate site productivity.

Foresters in this country are just beginning to realize and appreciate the role diagnostic plants can play in classifying sites, assessing stand productivity, and predicting woody plant succession.

More research is needed in this area before there can be broad acceptance and use of this emerging technology, but the information presented in this guide is a start in the study area it covers.

> ***Note:*** *At the back of this guide you will find a laminated quick reference that can be removed and taken to the field. It explains the field inventory procedures for using diagnostic plants to determine site class.*


A Visual Guide
to the
Diagnostic Plants
in this Study

Christmas Fern

(Polystichum acrostichoides)

Site Class 1

Appearance: Leathery fronds, dark green throughout the winter, characterize this plant. It grows up to 2.5 feet tall.

Comments: Arising in clumps, the evergreen fronds gradually die back after winter as new fronds appear in the spring. The upper pinnae of the tallest fronds is often much reduced since they bear spores on their back surface.

Indian Cucumber Root

(Medeola virginiana)

Site Class 1

Appearance: The non-blooming herb has a terminal whorl of leaves. Those plants that do bloom send up a second stalk from the top of the terminal whorl, producing a smaller leaf whorl from which dangles greenish-yellow flowers that become blue-colored berries. Plants grow 1-3 feet tall.

Comments: The plants pictured here are starting to color-up for the fall.

Spicebush

(Lindera benzoin)

Site Class 1

Appearance: This deciduous, spice-scented shrub has elliptical, dark green leaves. Its small yellow flowers appear in early spring, producing red berries by late summer. It grows up to 12 feet tall.

Comments: In understory shade, the shrub usually grows no more than 4-6 feet tall.

Wood Fern

(Dryopteris intermedia)

Site Class 1

Appearance: This plant has shiny, evergreen, dark green foliage with pinnae at right angles to the stem. It grows up to 3 feet in height.

Comments: The fronds arise in clumps. Stems are chaffy.

Common Blue Violet

(Viola papilionacea)

Site Class 2

Appearance: Leaves are heart-shaped; flowers are purple with five petals.

Comments: Plants occur in low clumps; flowers from separate stalks.

Virginia Knotweed

(Tovara virginiana)

Site Class 2

Appearance: This plant has a tubular sheath at the base of each alternate leaf. Its leaves are broad and hairy; topped by a raceme of small white flowers closely hugging the stem. In the spring, its leaves are marked with a red-purple to black inverted V-mark, which is often still visible in summer. Most flowering plants reach 2-3 feet in height.

Comments: When pressure is applied to the seeds, they appear to jump from the stem; hence the local name "jump-seed" (See Page 10).

Bedstraw

(Galium spp.)

Site Class 3

Appearance: This plant has whorled, linear leaves and white flowers.

Comments: There are several similar species, noted by their weak stems and ranks of whorled, linear leaves. Those growing beneath a forest canopy are usually less than 1 foot tall and rarely ever flower.

White Wood Aster

(Aster divaricatus)

Site Class 3

Appearance: The alternate leaves are heart shaped, coarsely toothed, and have long petioles. Ray flowers are white; disc flowers are yellow. This plant grows up to 2.5 feet tall.

Comments: Flowers are usually not showy.

White Snakeroot

(Eupatorium rugosum)

Site Class 4

Appearance: This plant has thin, opposite, dentate, broadly ovate leaves; cordate at base. Leaves are 3-nerved. It flowers in open heads that are bright white, and it grows up to 3 feet tall.

Comments: It is a smooth, much-branched herbaceous plant.

Huckleberry

(Gaylussacia baccata)

Site Classes 4 and 5

Appearance: These low-branching shrubs have small, entire, oval, resin-dotted leaves. The flowers are pink in one-sided racemes. The black or bluish fruit is sweet, but seedy. Twigs are green-colored.

Comments: The foliage in fall turns a dark red color.

Teaberry

(Gaultheria procumbens)

Site Class 5

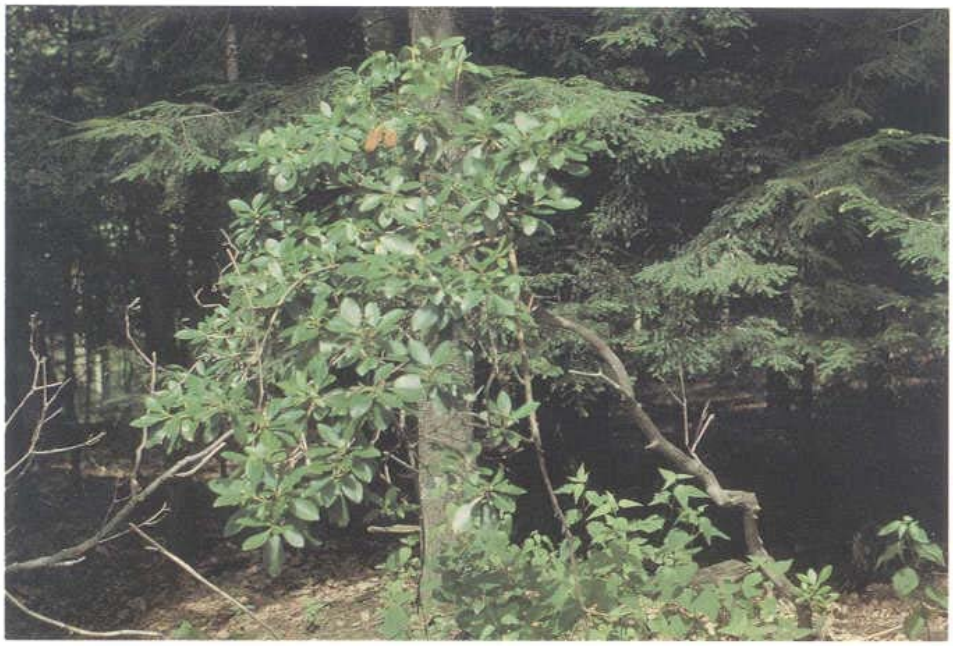
Appearance: This evergreen plant is less than 6 inches tall with leathery, dark green, aromatic leaves. Its axillary, nodding, urn-shaped flowers turn into spicy, bright-red, berry-like fruits that usually persist on the plant from fall to spring.

Comments: This plant is also known as Wintergreen or Checker-berry. Its leaves are used to make oil of wintergreen, an aromatic extract.

Mountain Laurel

(Kalmia latifolia)

Site Class 5



Appearance: The leaves of this plant are entire. shiny, bright-green, and leathery. Showy terminal clusters of pink or white flowers appear in late June. It grows 3-10 feet tall.

Comments: It grows as an evergreen shrub, often forming dense thickets.

Literature Cited

Moore, B. 1927. Cajander's theory of forest types. Ecology 8:135-136.

Weitzman, S. and G. R. Trimble, Jr. 1957. Some factors that govern the management of oaks. USDA For. Serv. Stn. Pap. NE-88. 40 pp.

Yawney, H. W. 1964. Oak site index on Belmont limestone soils in the Allegheny Mountains of West Virginia. USDA For. Serv., Northeastern For. Expt. Stn. Res. Pap. NE-30. 16 pp.

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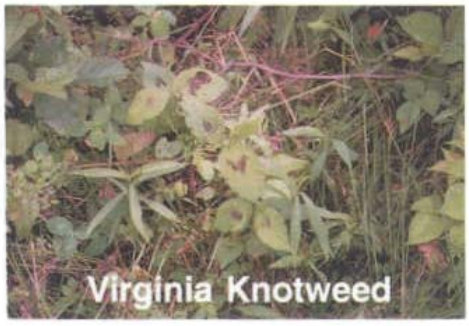
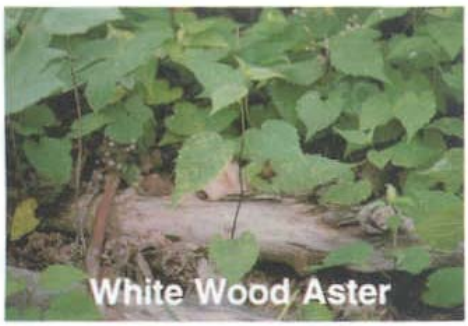
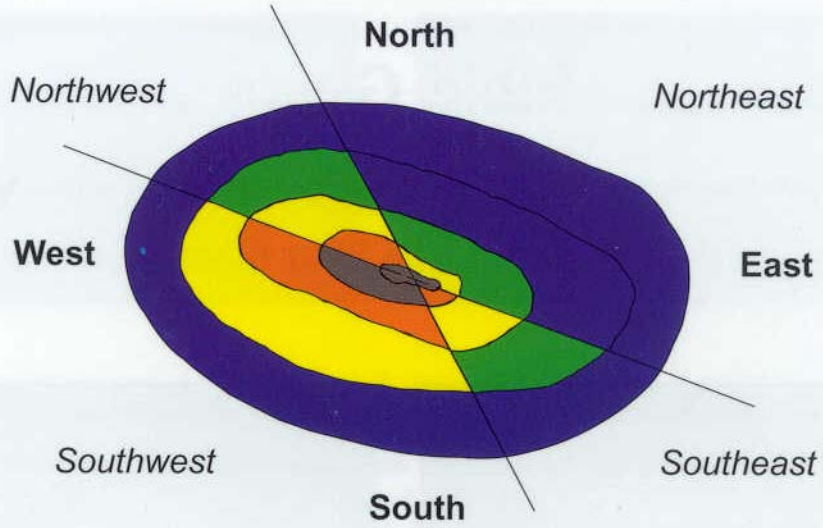


Field Guide

Using Diagnostic Plants To Evaluate Site Class



Topographic Representation of Aspect and Slope Position by Site Class



- 1 - Hydric/Moist Mesic
- 2 - Mesic
- 3 - Dry Mesic
- 4 - Dry
- 5 - Xeric

Field Inventory Procedure

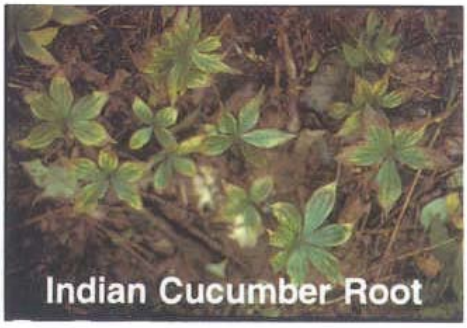
1. Identify plot location on topography (slope position and aspect).
2. Verify or adjust classification using diagnostic plants.

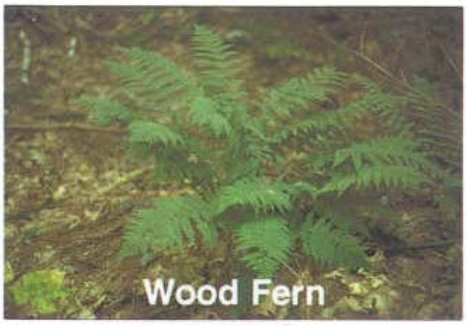
Site Classes

Site Class	Aspect and Slope Position	Diagnostic Plants
1 Hydric/ Moist Mesic	L/3,NE slopes Bottomlands	Wood/Xmas fern Ind. cucumber root Spicebush
2 Mesic	M/3, NE slopes L/3, NW and SE slopes	Virginia knotweed Common blue violet
3 Dry Mesic	U/3, NE slopes M/3, NW and SE slopes L/3, SW slopes	Bedstraw White wood aster
4 Dry	U/3, NW and SE slopes M/3, SW slopes	White snakeroot and Huckleberry
5 Xeric	U/3, SW slopes Ridgetops	Teaberry Mountain laurel Huckleberry

Notes:

- L/3 = Lower Third; M/3 = Middle Third; U/3 = Upper Third
- Diagnostic species may be present alone or in any combination
- Monongalia and Preston Counties in West Virginia
  Greene and Fayette Counties in Pennsylvania





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