Vegetative Morphology of Woody Plants
Part I: Introduction
VEGETATIVE MORPHOLOGY

- The study of the shape and organization of the nonreproductive parts of a plant
  - Habit, leaves, stems, twigs, bark (roots)
    - Vegetative - relating to the nonreproductive parts of a plant
    - Morphology - the study of the shape and organization of an organism’s external form.
- Aid in the identification of woody plants
I. Habit

- Habit - overall growth form
  - Can be herb, shrub, tree or vine

- Herb
  - Non-woody plant

- Shrub
  - Woody plant
  - Shorter than tree, less than 5 meters (15 feet) at maturity
  - More branching lower on stem
  - May have more than one stem
- **Tree**
  - Woody plant
  - Taller than shrub, more than approximately 5 meters (13-15 feet) at maturity
  - Single plant with single stem (trunk)
  - 3 inches or more at dbh

- **Vines**
  - Woody or non woody
  - Liana - woody vine
    - Ex: poison ivy
  - Lack of supporting tissue, therefore trail or climb
  - Adapted for getting light without spending much energy
The basic growth form within a species is genetically controlled, but the ultimate architecture is also easily modified by habitat.

- Limited use for identification
- Open grown versus forest competition
  - Trees growing in the open tend to develop characteristic shapes that may be typical of species or genera
    - Open grown specimens have large crowns that may reach nearly to the ground, and the clear trunk is short, with considerable taper.
      - Crown - plant's aboveground parts, including stems, leaves and reproductive structures.
  - Under forest competition, the trunk is long, more cylindrical, often clear of branches for one-half or more of its length, and the crown is small
4 primary habits of trees:

- Excurrent - central dominant trunk and symmetrical, conical, or spirelike crown
  - Example: conifers, tulip tree

- Decurrent (deliquescent) - more rounded form with repeatedly forked stems giving rise to a spreading form; multiple **scaffold branches** (secondary trunk-like branches) or secondary trunks originating from the trunk
  - Example: oaks, maples

- Palm-like: unbranched trunk and leaves only in a top rosette
  - Example: palms, cycads

- Yucca-like: either with a basal rosette of long stiff leaves, a central tall flowering stalk, or an irregular branched thick trunk
  - Example: treelike yuccas, cacti
HABIT CAN BE HERBACEOUS OR WOODY

- **Herbaceous**
  - Herbaceous - non-woody plants

- **Woody**
  - Woody - wood plants accumulate wood
    - Wood - special tissue that develops through secondary growth

- **Woody plants differ from herbs.** Herbs die back every year. Woody plants growth proceeds from where it left off previous year.
DENDROLOGY

Vegetative Morphology of Woody Plants
Part II Leaves
II. LEAVES

- General Features
- Leaf Complexity
- Leaf Arrangements (phyllotaxy)
- Leaf Venation
- Leaf Shapes
- Overall Blade Shapes
- Apices
- Bases
- Leaf Margins
- Leaf Lobing
- Surface Features
- Conifer Leaves
LEAVES

- General features
  - "Pinna"
  - Single, most important defining characteristic.
  - Primary photosynthetic organs of trees.

- Leaves are formed on stems at regular intervals.
  - Node - point at which on a stem, that one or more leaves arise.
  - Internode - portion of stem between nodes.
Components

- Blade/lamina - expanded portion of the leaf
- Petiole - supporting stalk to the blade
  - Leaf stalk
  - Considered part of the leaf
  - May be short or long, slender or stout, terete, angular or laterally flattened.
- Petiolate - having a petiole
  - Petioles usually attached to stem just below an axillary bud
    - Axil - upper angle between stem and petiole
  - May be swollen at base and enclose the bud
    - Think leaf scars....
  - Petiole may be lacking entirely
- Sessile - petiole is lacking
  - Blade is attached directly to twig
- Stipules - small scale like or leaf like structures
  - May or may not occur, rare structure
  - Always paired
  - Attached either to the petiole base or the twig, one on either side of the petiole.
  - Usually drop off as leaf expands
  - Plants with stipules are *stipulate*
  - Plants without stipules are *estipulate*
  - Photosynthetic
  - Protect lamina as expanding
Orientation

- Abaxial - under surface
  - Away from axis of plant
- Adaxial - upper surface
  - To, towards axis of plant
○ Longevity
  ▪ Deciduous - all leaves drop after one growing season
    ○ Meaning “to drop”
    ○ All of the leaves will fall from tree at certain time of year, while tree is still alive
    ○ Adaptive significance
    ○ Some deciduous leaves keep their leaves in a brown condition into the winter; this is a condition called *marcescent*
      • Beech and some oaks
  ▪ Evergreen - not all leaves drop at same time so appear green all year round
    ○ Only lose small portion of leaves at a time
    ○ Cycle leaves
Winter deciduous (a and b).
Drought deciduous (c and d).
Complexity
- Simple
  - Leaf with a single blade
- Compound
  - Leaf is divided into two or more blades attached to a common stalk.
    - Leaflets - individual blades of a compound leaf
    - Rachis - axis supporting the leaflets
  - The lateral bud is still in the axil of the petiole of the compound leaf, not in the axil of the leaflet.
  - May be pinnately or palmately compound
To distinguish between simple and pinnate look for the bud in the axil of the leaf (not leaflet). Also there is usually a color and/or textural difference between twig and petiole/rachis.
COMPOUND LEAVES

- Bipinnate
- Imparipinnate
- Palmate
- Paripinnate
- Trifoliolate
- Unifoliolate

- pinnately compound
- simple
- trifoliolate
- palmately compound
- bipinnately compound
- **Pinnately Compound** - leaflets are attached laterally along rachis
  - “feathers”
  - Leaflets may be sessile on the rachis or petiolule on stalk like structure

- Bipinnate - Twice Pinnately Compound
  - Leaflets are attached to second order rachis called rachilla

- Tripinnate
- **Sessile pinnate**
  - *Lomatia tasmanica*
  - A small, evergreen shrub

- **Petiolulate pinnate**

- **Petiolulate bipinnate**
- Palmately Compound - leaflets appear to radiate from the top of the petiole
  - Rachis may exist but be hard to see
  - *Trifoliate* - palmately compound leaf with 3 leaflets
Green circles show position of axillary buds.

1. **Pinnate compound leaf.** Hairy Rosewood *Dysoxylum rufum* and Native Tamarind *Diploglottis australis* are species with pinnate compound leaves.

2. **Bipinnate compound leaf.** An example for a bipinnate tree species is the Silky Oak *Grevillea robusta*.

3. **Tripinnate compound leaf.** The Australian White Cedar *Melia azedarach* is regarded as a compound leaf with tripinnate features if sometimes irregular.
Arrangement

- **Opposite** - paired at same height, one on each side of twig
  - 1 node = 2 leaves

- **Alternate** - 1 leaf at same height
  - 1 node = 1 leaf

- **Whorled** - more than two leaves at same height
  - 1 node = 3 or more leaves
  - Very rare

- **Subopposite** - leaves appear nearly but not quite opposite.
  - Examples: buckthorn, sweetleaf, and cascara
1. **Alternate** leaf arrangement on a **simple** leaf tree species. Sample shown in image 1 is the Black Plum *Diospyros australis*

2. **Opposite** leaf arrangement on a **simple** leaf tree species. Sample is the Native Guava *Rhodomyrtus psidioides*, see illustration 2.

3. **Whorl** leaf arrangement on a **simple** leaf tree species. Sample shown in photo 3 is the Brush Box *Lophostemon conferta*. Leaflets (compound) with a whorl like arrangement are called palmate, see Black Booyong *Argyrodictyon actinophyllum*.

4. **Alternate** leaf arrangement on a **compound** leaf tree species. Sample in illustration 4 is the Rosewood *Dysoxylum faserianum*

5. **Opposite** leaf arrangement on a **compound** leaf tree species. The Five-leaved Bonewood *Bosistoa floydii* is the example shown in image 5.
Leaf Venation

5 basic types of venation patterns in leaves

- **Pinnate** - single midrib and secondary veins branching off at intervals
  - Secondaries form a variety of patterns.

- **Palmate** - three or more primary veins arise at or near the base of the blade and spreading out like a fan

- **Pinnipalmate** - intermediate between pinnate and palmate
  - Lowermost pair of secondary veins, arising at or near the base of the midrib, is slightly larger than the other secondaries and with large tertiary veins going to the lower margins

- **Parallel** or **striate** - many equal veins nearly parallel to each other until they join near the apex.

- **Dichotomous** - repeated forking or Y-branching
  - Example: Ginkgo

- In the cycads and conifers, branch veins are rare.

- Hardwoods smaller veins form characteristic netted patterns
Position of center vein, lateral veins and net veins in a pinnate arrangement are demonstrated.

Other terms in use for center vein are; midrib and mid vein
Other terms for lateral veins are; secondary veins and cross veins.

The example to the left is the Brown Beech *Pennantia cunninghamii*. 
Venation patterns on simple and compound leaves can be useful when identifying tree species. Veins can be hardly visible to strongly raised and obvious on both leaf surfaces. Veins are categorized into a center or mid vein, lateral or cross veins which divide from the center vein and run to the leaf margin. Small net veins can connect lateral veins, but are not present on all tree species.

1. **Elliptical** or longitudinal. Veins start in one point at the base and join again at the apex of the leaf with the widest spacing being at the center.

2. **Parallel**. Veins that are running parallel along the length of a leaf without joining.
3. **Palmate**. A palmate vein arrangement branches out at the base of the leaf into five or more main veins.

4. **Pinnate**. Veins dissect from the center vein and run to the leaf margin in an alternate or opposite manner.
Leaf Shapes

- Characteristic of the species
- General shape is found by outlining the leaf
  - This is easy for a simple leaf. For a compound leaf or lobed leaf is produced by running an imaginary line around the tips of the leaflets or lobes.

Leaf shapes include:

- Blade shape (overall leaf shape)
- Shapes of Apices
- Shapes of Bases
- Leaf Margins
Overall Blade Shape

- **Acicular** - needlelike; very long and slender

- **Subulate** - narrow lanceolate, flat, stiff, sharp-pointed, usually less than 12mm long

- **Scale** - small, sharp-pointed, broadened at the base, usually appressed and imbricated.
- **Linear** - many times longer than broad; narrow, with approximately parallel sides
- **Oblong** - longer than broad, with parallel sides
- **Lanceolate** - lance shaped; several times longer than broad, widest at a point about a third or less of the distance from the base, and tapering to the apex
- **Oblanceolate** - the reverse of lanceolate; with the widest point about a third or less of the distance from the apex, and tapering to the base.
- **Ovate** - egg-shaped outline, with the widest point below the middle
- **Obovate** - the reverse of ovate, with the widest point above the middle
- **Elliptical** - like an eclipse with the widest point at the center
- **Oval** - broadly elliptical, with the width greater than one-half the length
- **Orbicular** - circular or nearly so
- **Reniform** - kidney-shaped; as broad or broader than long with a wide cordate base
- **Deltate** - triangular; delta shaped
- **Rhombic** - diamond-shaped; more or less symmetrical with the widest point at the center and the sides more or less straight to the apex and base
- **Spatulate** - narrower than obovate; shaped like a spatula with a broad apex and tapering to the base
- **Flabellate** - fan shaped.

- **Cordate** - heart shaped
- **Obcordate** - reverse of heart shaped
LEAF SHAPES - APICES

- **Acuminate** - shaped like an acute angle with a long attenuated point
  - **Attenuated** - drawn out

- **Acute** - shaped like an acute angle but not attenuated
- Mucronate - abruptly tipped with a bristly mucro (midrib extension)

- Cuspidate - tip concavely constricted into an elongated sharp, rigid point
- **Obtuse** - blunt; the sides forming an angle more than 90 degrees

- **Rounded** - a full sweeping arc
◆ Retuse - with a shallow, narrow notch
  □ Shallow depression

◆ Emarginate - with a shallow, broad notch
  □ notched
Truncate - as though cut off at right angles to the midrib
LEAF SHAPES - BASES

- Cuneate - wedge-shaped, acuminate; tapering evenly to a narrow base

- Acute - shaped like an acute angle but not attenuated
○ Cordate - heart shaped; inversely indented

○ Inequilateral, oblique - asymmetrical, the two sides different in shape
- Obtuse - blunt, narrowly rounded
- Rounded - a full sweeping arc
- **Truncate** - as though cut off at right angles to the midrib

- **Auriculate** - with earlike lobes pointing downward
LEAF MARGINS

- The edge of the leaf is called the margin
  - Revolute - rolled under just at the margin
  - Entire - smooth
  - Repand/undulate - slightly and irregularly wavy
  - Sinuate - shallowly indented; wavy in a horizontal plane
  - Undulate (or crisped) - wavy in a vertical plane
  - Crenate - with rounded to blunt teeth
  - Crenulate - small crenations
  - Serrate - with sharp teeth pointing toward the apex of the blade
  - Serrulate - small serrations
- Doubly serrate - with the large serrations again serrated on their margins
- Dentate - with sharp teeth pointing outward
- Denticulate - small dentations
- Aculeate - spiny margined with the teeth long and prickly
MARGINS

- Ciliate
- Crenate
- Crenulate
- Dentate
- Denticulate
- Entire
- Incised
- Lobed
- Palmately lobed
- Pinnately lobed
- Pinnatisect
- Serrate
- Serrulate
- Sinuate
- Spinose
- Undulate
LEAF LOBING

- When the blade margins are indented one-quarter to one half the distance to the midrib or base, it is considered a lobed leaf.
  - If indented just over one half, it is cleft.
  - If cut deeply to near the midrib or base, it is incised.
- HOWEVER, lobes is used in a broad sense to include any degree of indentation.
- Lobing is pinnate, if the indentation is toward the midrib (pinnately lobed)
- Lobing is palmate, if the indentation is toward the base of the blade (palmately lobed)
Pinnately Lobed

Palmately Lobed
Pinnately lobed
Palmately lobed
Several features of foliar micromorphology can be used to help identify woody plants.

- **Foliar** - having to do with leaves
- **Micro** - small; difficult or impossible to see with the unaided eye.
- **Morphology** - shape or form

The surface of leaf blades are not usually completely smooth

- If examine with microscope or hand lens may be able to see details
- A leaf that is completely smooth will appear shiny and dark green
SURFACE FEATURES

Possible observations include:

- Raised veins
- Sunken veins (called rugose if very pronounced)
- Surface cells may appear convex (bulging out)
- Projections, striations (stripes) or ridges may be visible.
- Flaky, white wax may be on top of cells

© 2010 Gary Fewless
Leaves may have epicuticular wax
- Epi - meaning above, over, on top of, nearby
- Cuticular - of the cuticle
  - Cuticle - outer layer of cells, protective in nature

This wax will make the leaf appear white or pale.
- You can test for this by scraping your fingernail across the surface of the leaf. If the “white” material comes off it is epicuticular wax.
- Leaves with a lot of wax are called glaucous
- Leaves with a little wax are called glaucescent
SURFACE FEATURES

- Glaucous

- Kusunohakaede
  - Flying moth tree
  - *Acer oblongum*

- Urajiro-itaya

- Hananoki
  - *Acer pycnanthum*

- *Acer saccharinum*
  - Silver maple

Mrs. Averett - Dendrologist
Some leaves will have hairs on the upper or lower surfaces. Leaf hairs are called trichomes. Many different types of hairs possible:
- Some leaves will have more than one type of the same leaf.
- Amount (density) of hairs varies also
- Can be used to help identify woody plants
  - Observe with naked eye or hand lens in the field
SURFACE FEATURE TERMS

- **Glabrous** - without hairs of any type; smooth
- **Glabrate** - becoming glabrous, occurs with age
SURFACE FEATURE TERMS

- Puberulent - tiny hairs visible with hand lens or microscope
Pubescent - general term meaning hairy; more specifically used to indicate fine, soft, short hairs.
**SURFACE FEATURES**

- Villous - long, silky, straight hairs
SURFACE FEATURES

- Tomentose - curled, matted, woolly hairs
SURFACE FEATURES

- Scabrous - rough and scratchy with short bristly hairs
SURFACE FEATURES

- Glandular - many glandular hairs; sessile or stalked
SURFACE FEATURES

- Lepidote - many minute, scalelike hairs
SURFACE FEATURES

- Stellate - hairs in star like pattern, rays parallel with the surface
SURFACE FEATURES

- Leaf blades may be thick and leathery
  - Coriaceous
- Leaf blades may be thin and flexible
  - Membranous
Conifer - gymnosperm bearing cones
- The conifers are the most numerous gymnosperms today.
- Familiar examples are pine, spruce, fir, juniper, cedar, cypress, and redwood.

Seeds of gymnosperms are not enclosed; instead, they are open to the surrounding environment. This type of unprotected seed is a naked seed.
- The name gymnosperm means "naked seed." In contrast, seeds of angiosperms are enclosed in a special structure that at maturity is called the fruit.
Conifers can have four different leaf types

- **Acicular - needle**
  - Long and slender

- **Linear**
  - Shorter than acicular
  - Flat, triangular, or square in cross section

- **Subulate**
  - Short and narrow
  - Tapered to a sharp point
  - Flat and stiff

- **Scale**
  - Small
  - Usually appressed and imbricated
ACICULAR CONIFER LEAVES
LINEAR CONIFER LEAVES
SUBULATE CONIFER LEAVES
SCALE CONIFER LEAVES
CONIFER LEAVES

- 4 variations
  - Sessile
  - Sessile on a peg
  - Petiolate
  - Petiolate on a peg

- When pegs are present, the abscission layer is between the peg and leaf blade so the pegs persist on the twig after leaf dehiscence.
  - Abscission layer
  - Dehiscence
SESSILE (ABIES SPECIES)
SESSILE ON A PEG (PIECE A SPECIES)
PETIOLATE (PSEUDOTSUGA)
PETIOLATE ON A PEG (TSUGA)
In many conifers the leaves are attached and extend down the stem for some distance below the point of divergence.

This is called a decurrent leaf base.
CONIFER LEAVES

- Pine species have fascicles
  - Contains one to five needles
  - Has a very short stem
  - Located in the axil of a scale like leaf
    - This is called the primary leaf
    - The needles are therefore the secondary leaves
  - Fascicle is wrapped at the base in overlapping bud scales
    - This forms the fascicle sheath