Week 8; Monday

Lecture: Monocots Part I: Some animal pollinated monocots

Monocots are monophyletic!

Traditional primary division is between Dicots and Monocots

<table>
<thead>
<tr>
<th>Trait</th>
<th>“Dicots”</th>
<th>Monocots</th>
</tr>
</thead>
<tbody>
<tr>
<td># cotyledons</td>
<td>2 cotyledons</td>
<td>1 cotyledon</td>
</tr>
<tr>
<td>stem</td>
<td>ring of vascular bundles</td>
<td>scattered vascular bundles</td>
</tr>
<tr>
<td></td>
<td>vascular cambium often present</td>
<td>no vascular cambium</td>
</tr>
<tr>
<td>habit</td>
<td>woody or herbaceous</td>
<td>primarily herbaceous</td>
</tr>
<tr>
<td></td>
<td>(no true wood)</td>
<td></td>
</tr>
<tr>
<td>leaves</td>
<td>simple or compound</td>
<td>usually simple</td>
</tr>
<tr>
<td>venation</td>
<td>net veined: pinnate, palmate</td>
<td>parallel (or striate)</td>
</tr>
<tr>
<td>leaf insertion</td>
<td>narrow</td>
<td>usually broad, often sheathing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(wrapping around the stem)</td>
</tr>
<tr>
<td>roots</td>
<td>primary --&gt; secondary</td>
<td>primary roots abort;</td>
</tr>
<tr>
<td></td>
<td>adventitious roots, too</td>
<td>adventitious roots only</td>
</tr>
<tr>
<td></td>
<td>taproot or fibrous</td>
<td>usually fibrous</td>
</tr>
<tr>
<td>flower parts</td>
<td>parts in 4’s, 5’s, or ∞ (rarely 3)</td>
<td>parts in 3’s</td>
</tr>
<tr>
<td>pollen</td>
<td>monosulcate or tricolpate</td>
<td>monosulcate</td>
</tr>
</tbody>
</table>

Today we will look at some of the more important families of animal pollinated monocots found in the temperate zone

Overhead of monocot phylogeny based on rbcL - distribution of monocot groups.  
Chase et al. 2000, overhead
Araceae - Arum family (109 gen/2830 spp)
1) herbs (some epiphytes)
2) lvs simple or compound; broad and having an apparent petiole (‘pseudo-lamina’) development not same as in a dicot leaf blade
3) calcium oxalate crystals usually present – physical deterrent to herbivory
4) Inflorescence consisting of
   - spathe - bract (often colorful) surrounding the flowers
   - spadix - axis on which the flowers are borne (male above; female below, when both present)
   - often with a sterile extension above called an ‘appendix’
5) Flowers
   - unisexual or bisexual (less common)
     - if unisexual, then monoecious or dioecious;
       - if monoecious, male fls above, female fls below
   - tepals 4-6, or 0, scale-like, or fused in a cup, inconspicuous
   - superior or inferior ovary
   - fetid odor (stinks!)
Floral formula: * Te 4-6 (or 0), 1-6 (12), 2-3 berry ovary inferior or superior [carpels fused]

“Liliaceae” - Lily family (288 gen/4950 spp)
This family is treated in a very broad sense in Hitchcock & Cronquist and in this class. However, it is apparent now that the family should be treated in a narrower sense and some of the members should form their own families. Judd et al. recognize the following families: Agavaceae, Alliaceae, Amaryllidaceae, Asparagaceae, Asphodelaceae, Colchicaceae, Hyacinthaceae, Liliaceae, Melanthiaceae, Ruscaceae, Smilacaceae, Themidaceae, Tofieldiaceae and more!!! (Help! I can’t keep track!)
1) herbs
2) stems often modified as underground rhizomes, corms, or bulbs
3) Flowers
   - 3-parted all the way
   - stamens 6 (in 2 whorls)
   - distinct sepals and petals or just tepals
   - ovary superior or inferior - this is sometimes used to segregate some families
Floral formula: * 3, 3, 6, 3 capsule or berry ovary inferior or superior [carpels fused]

Bromeliaceae – Bromeliad family (51/1520) (BIOL 317 family only)
Mostly tropical epiphytes, including spanish moss, but also includes some terrestrial plants, including pineapple.
**Iridaceae** - Iris family  (78 gen/1750 spp)
1) herbs, aquatic or terrestrial
2) underground stems as rhizomes, bulbs or corms
3) lvs mostly basal and linear, **2-ranked and ‘equitant’** (overlapping in 2 ranks)
4) inflorescence often subtended by a spathe-like bract
5) Flowers
   - actinomorphic or zygomorphic
   - distinct sepals and petals or just tepals – 6 total
   - **stamens 3**
   - ovary of 3 fused carpels, inferior; fruit a capsule
   - **3 petaloid styles in Iris** winged and showy; flap of tissue covers the stigmatic surface, so that an insect backing out of the flower will not transfer pollen from the stamen to its own stigma (check out Iris in lab today). In Iris, the stamens are in line with the petaloid style.

Floral formula: */X 3, 3, 3, 3 capsule ovary inferior [carpels fused]

**Orchidaceae** - Orchid family  (775 gen/19,500 spp)
perhaps the largest family of plants in terms of # of species (20,000 - 45,000) many tropical epiphytic orchid species probably still unknown
1) herbs, terrestrial or epiphytic
2) mycotrophic; many parasitic
**Epiphytic plants** - plants that are supported by some structure other than their own stem. (usually other plants)
   - very common in the tropical wet forests (mosses, lichens, ferns in temperate RF)
   - epiphytic habitat often imposes serious drought conditions on plants
   - modifications for drought resistance:
     - **sunked stomata**
     - **thick waxy cuticle**
     - **absorbent scales OR swollen stems or aerial roots** for water retention
     - swollen stems - ’pseudobulbs’
     - **thickened aerial roots** with multiple-layered epidermis called a ’velamen’
3) Flowers
   - bracteate
   - often resupinate (twisted 180° in development)
   - one petal modified as a ** ’labellum’** (lower lip)
   - pollen aggregated into **pollinia** (1 or 2 stamens)
   - style, stigma, and stamens fused to form the **column**
     - anther forms the tip of the column; stigmatic surface lower down
4) seeds minute, without endosperm, require a fungal relationship to germinate successfully
Floral formula: X 3, 3, 1-2, 3 capsule ovary inferior

Week 8; Wednesday
Week 8; Wednesday

**Announcements:** Lab Family ID final will be next Wednesday; the following Monday in lab will be keying practice and Keying final on Wednesday. 
**CLASS ON GRASS IDENTIFICATION THIS SUMMER!!!**

**Lecture:** Monocots, part II - some Wind Pollinated families

The various predominantly wind-pollinated families of monocots have been classified together in the subclass Commelinidae. As with the dicot subclass Hamamelidae, which primarily was composed of wind pollinated trees, this grouping has been found to be artificial. However, most of these families are +/- related and belong in the same general part of the monocot tree (unlike Hamamelidae!).

Here is one view: **Chase et al. overhead**

**Typhaceae** - Cattail family (2 gen/28 spp) – **LAB ONLY FAMILY**

- one genus and a handful of species, but world-wide in distribution
- 1) aquatic herbs
- 2) lvs simple, alternate, basal, linear
- 3) inflorescence a dense spike of male flowers at tip of shoot and female flowers at base of shoot - monoecious
- 4) flowers:
  - perianth of bract-like tepals or bristles
  - 1-6 stamens
  - 2 fused carpels, one ovule per carpel, and one carpel aborting --&gt; single-seeded follicle or drupe
  - superior ovary

Floral formula:  
**male - * Te 3-4, A 1-6**

**female - * Te 3-4, G 2**  
follicle or drupe  [carpels fused]
Three “Graminoid” families: rushes, sedges, and grasses

**Juncaceae** - Rush family  (6 gen/400 spp)
1) herbs (aquatic or terrestrial)
2) **stems typically round and solid**
3) **lvs basal, 3-ranked**, leaf sheaths open or closed
4) flowers
   - actinomorphic
   - 3-parted (wind pollinated, but look just like little lily flowers)
   - ovary of 3 fused carpels, usually with many ovules, superior

Floral formula: * 3, 3, 3 or 6, 3 capsule [carpels fused]

**Cyperaceae** - Sedge family  (122 gen/4500 spp)
One of the most important families of wetland plants; one genus, *Carex*, contains
   between 1,000 and 2,000 species. >500 species of *Carex* in N. Am. more than any other genus
1) herbs (many aquatic, but terrestrial, too)
2) **lvs triangular, solid or hollow** – “sedges have edges”
3) **lvs 3-ranked; sheath closed**
   - **ligule** - flap of tissue at junction of blade and sheath, present only in *Carex*
4) Inflorescence a **spikelet** of many small flowers (found also in grasses - Poaceae)
   **Each flower subtended by a bract** and one empty bract at base of spikelet
5) Flowers
   - bisexual or unisexual (then usually monoecious)
   - technically actinomorphic
   - perianth absent or reduced to hairs or small bracts
   - usually 3 stamens; sometimes only 1 or 2
   - ovary of 2-3 fused carpels, but always reduced to contain a single ovule
   - fruit an **achene**
   - ovary surrounded by a structure called a **perigynium** in *Carex* and related genera

Floral formula: * 0, 0, 1-3, 2-3 achene superior ovary [fused carpels]
Poaceae - Grass family (650 gen/8700 spp) also called Gramineae

The grass family is the most important family of plants economically, containing all of the cereal grains: wheat, rice, maize, barley, sorghum, millet, rye, oats, etc.

1) herbs, though bamboo achieves tree-like proportions
2) stems circular and usually hollow but sometimes solid
3) lvs 2-ranked; leaf sheaths open (overlapping), ligule present at junction of sheath and blade
4) growth by intercalary meristem, which is at base of internodes and leaf sheathes, rather than at tip of stem. This allows regeneration when tip is cut, as in grazing or mowing of prairies/lawns. Hypotheses of coevolution of grazers and grassland
5) Inflorescence a spikelet of many small flowers (as in sedges)
   - Sometimes only one floret per spikelet
   - Each spikelet subtended by two empty bracts called glumes
   - Each individual flower (floret) enclosed by two bracts:
     - lemma - bract at base of individual floret
     - palea - bract that faces the lemma thereby enclosing the floret
6) Flowers (individual flowers called florets)
   - technically zygomorphic
   - lodicules - very reduced perianth; little more than swollen bit of tissue
   - 1-3 stamens
   - ovary of 2-3 fused carpels, but reduced to a single locule with one ovule
   - superior ovary
Floral formula: X 0, 0, 1-3, 2-3, grain or caryopsis [carpels fused]

Disarticulation - the process by which the spikelet breaks apart into separate 1 seeded units for dispersal; may be above or below the glumes.

Arecaceae – Palm family (200/2780) (BIOL 317 only)

Most tree-like of monocots. Mostly tropical
Summary of comparison between grasses, sedges and rushes

<table>
<thead>
<tr>
<th></th>
<th>Juncaceae</th>
<th>Cyperaceae</th>
<th>Poaceae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floral perianth</td>
<td>3-parted</td>
<td>Reduced or absent</td>
<td>Reduced or absent</td>
</tr>
<tr>
<td>Stem X-sect</td>
<td>round</td>
<td>triangle</td>
<td>round</td>
</tr>
<tr>
<td>Stem center</td>
<td>solid</td>
<td>solid or hollow</td>
<td>hollow (rarely solid)</td>
</tr>
<tr>
<td>Leaf orientation</td>
<td>3-ranked</td>
<td>3-ranked</td>
<td>2-ranked</td>
</tr>
<tr>
<td>ligule</td>
<td>no ligule</td>
<td>usually no ligule</td>
<td>ligule present</td>
</tr>
<tr>
<td></td>
<td><em>Carex</em> is exception</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Week 8; Friday

Announcements: Key final in lab Wednesday (practice keying in lab today)

Guest Lecture: Sarah Reichard, UW Botanic Gardens, Center for Urban Horticulture

**Alien Invasive plants in the Pacific Northwest.**

"**Native Plant**" – Definition must include reference to time and place. Most people consider ‘native’ to mean pre-European settlement, so we can refer to plants that are native to Washington, the Pacific Northwest, or North America, meaning those plants found in these regions prior to settlement by Europeans.

**Invasive, non-native species** are those that can or have spread into native wilderness or managed ecosystems, develop self-sustaining populations, and become dominant or disruptive to those systems.

Why the concern with European settlement as a starting point?
- Natural seed dispersal is a very slow phenomenon
- Europeans exploration and colonization represented the beginning of frequent and wide travel by people from one part of the planet to all other parts.
- They purposefully carried many plants with them and accidentally carried many more.

Example – Hawaii
- Native plant colonization rate: 1 species per 100,000 years
- After Polynesian settlement: 1/50,000 years
- After European settlement: 4/year (now more like 5/year)
- 1000 species have arrived in the last 200 years of a total of 5000 estimated colonization events in the entire geologic history of the islands.

**How do Invasive plants drive out other species?**

By **competition for resources.**
1. Light – eg, Kudzu (*Pueraria lobata*) and English Ivy (*Hedera helix/H. hibernica*) grow over other plants and cut off their light source
2. Water, nutrients – Many invasive plants can make better use of water and minerals in the soil, thus leaving too little for native plants
3. Attract pollinators or dispersers away from native species so that the natives do not reproduces as effectively. For example, purple loosestrife (*Lythrum salicaria*) outcompetes native plants, including native loosestrife for bees as pollinators, thus reducing reproduction by natives.
Allelopathy – producing secondary chemical compounds that inhibit, or ‘poison’ other plants. *Geranium robertianum* (Herb Robert or Stinky Bob) is an example.

**By engineering communities**

1. **Adding nitrogen to soils**
   - increases rate of succession
   - permits more alien species to colonize
   - makes natives that are adapted to the nutrient poor soils uncompetitive
   
   Example: *Morella faya* in Hawaii growing on sterile lava flows
   
   Example: Scot’s broom (*Cytisus scoparius*) in the Puget Sound Prairies, where this legume with nitrogen-fixing bacteria in its root nodules, increases the N content of the soils, permitting more aliens to colonize and increasing the rate of succession to forest
   
   Counter example: Knotweed (*Polygonum* spp.) has the reverse effect in riparian areas here in Western Washington. It translocates N from leaves to rhizomes at the end of the growing season and then moves it back into new leaves in the spring. Native plants (alders and willows) deposit lots of N into the streams and streamside ecosystems in the leaves each year contributing to the nutrients available for invertebrates and, indirectly, to trout and other salmon.

2. **Sending down deep roots and lowering the water table so native plants can’t get sufficient water.** Tamarisk (*Tamarix ramocissima*) is particularly bad for this along rivers in the desert SW, but also now known in eastern Washington. Tamarisk also traps sediments and organic material thus stabilizing banks and channelizing rivers, thus destroying flood plain habitats.

3. **Stabilizing habitats in areas that are naturally disturbed**
   - beach and salt-marsh grasses, such as *Spartina alterniflora*, can stabilize mud flats and catch sediments, thus converting shallow estuaries into stable land (almost like filling a wetland). Example: Willapa Bay in SW Washington

4. **Increasing the frequency and intensity of fires**
   - by increasing fuel load (some grasses that die each year) or by being a fast-burning plant (*gorse – Ulex europaeus*), fires can become more common or more intense, thus altering the native plant community. *Pennisetum setaceum* is a grass that invades dry forests in Hawaii and helps spread fires in habitats where fires were rare before.

5. **Vines adding weight to tree canopies.** English Ivy has thick, evergreen leaves, which adds a lot of weight to deciduous tree canopies in the winter when they don’t usually have the weight of leaves and causes trees to fall in wind storms.

Some invasive plants can be harmful or even deadly. For example, Giant Hogweed - *Heracleum mantegazzianum* can cause harmful burns on the skin from the sap in the stems and leaves. This is a class “A” noxious weed, which means that all means of eradicating it should be taken (this designation is generally used only for weeds that
are still limited enough that eradication is feasible). [“Revenge of the Giant Hogweed” by Genesis]

Hybridization with non-native plants also can dilute gene pools and in some cases even extirpate native species (eg, rainbow trout hybridizing with and eliminating cutthroat trout from throughout most of the native range of cutthroat trout).

**Causes of endangerment of imperiled species in the US:**

- Habitat destruction 81%
- Non-native species 57%
- Pollution 19%
- Overharvest 45%
- Disease 1%

**Positive impacts of Invasive plants (these usually are outweighed by their negative impacts)**

- Food or shelter for animals
- Erosion control – many species planted during ‘dust bowl’ in 1930’s have become invasive
- Aesthetically pleasing – many were first introduced for ornamental purposes
- Some species can produce useful goods for people (fruit, wood, etc.)
- Useful for pollination or other ecological services – the Honey bee is an introduced species.

**How do alien introductions occur?**

Estimated source of woody plant invasives:

- Landscape plants – 82% of all woody invasive plants (ca. 2/3 or all alien plants)
  - Overall, ca. 65% of invasive plants are introduced this way (herbs are less likely to be invaders)
- Agriculture – 14% of woody plants
- Erosion control – 3% of woody plants
- Accidental contamination – 1% of woody plants, but this is much higher for many herbaceous plants, especially those that come in as seed contaminants in agricultural shipments

“The 10s Rule” – Potential for new weed species (estimate by Rappaport 1991)

With ca. 260,000 species of flowering plants and about 10% of those as good colonizers, that makes about 26,000 potential weeds. There are now about 10,000 species recognized as weeds and, of them, about 4,000 have spread to other continents. So even with a conservative estimate of 10% of the remaining species becoming successful weeds, that leaves more than 2,000 more potential weeds.

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Cars and people are major vectors of invasive plants, boats and boat trailers are important vectors for spreading aquatic aliens.

Phases of an invasion.
1) Establishment (“lag phase” - slowly spreading; invasives as “sleeper” populations); can be a real of perceived period between introduction and expansion
2) Expansion (dramatic take-off in population size)
3) Saturation (this is mostly theoretical and most invasives in the PNW may not have reached this phase)

What triggers the expansion following the lag phase?
1) Major disturbance (e.g., hurricane or forest fire)
2) Staging areas (e.g., new horticultural introductions often are distributed slowly among gardens before they become popular); e.g., *Verbena bonariensis* - “purple top”
3) New genotypes or hybrids (a hybrid between diploid European and North American species of *Spartina* has produced a tetraploid species, *S. anglica*, which has become invasive where the parental species have not)
4) Human perception! It may be that there is no ‘lag phase,’ but only that no one was aware of it until it became quite widespread and then was recognized everywhere.

**Q:** Why do aliens succeed?
**A:** They “cheat death” and they are effective migrants

Population sizes of all species can be modeled mathematically by the following simple equation:

\[ N_{t+1} = N_t + B - D + I - E \]

\( N_t = \) population at starting point (time “t”)  
\( N_{t+1} = \) population after some time has elapsed  
\( B = \) births; \( D = \) deaths (e.g., stress tolerance); \( I = \) immigrants; \( E = \) emigrants

**Traits of invasive plant species**
- Vegetative growth (e.g., rhizomes of riparian plants may spread by floods)
- Early seed production/fast growth
- Long flowering/fruiting times
- Easy seed germination
- Nitrogen fixers
- Semi-evergreen (in western U.S., especially in semi-arid regions)
Establishing standards to prevent introduction of new invasive species.

In Australia: Australian Weed Risk Assessment (WRA) is a system of 49 questions in 8 categories for evaluating the potential risk for a given species. This has been 90% accurate for species that become invasive, but only 70% effective for predicting non-invaders.

What you can do:
St. Louis Declaration (2001) – identifies what various interest groups can/should do to help prevent the spread of alien plants.
This “Declaration” provides a “Code of Conduct” for nurseries, botanical gardens, landscape architects, government agencies, and the Gardening public.

Gardeners Code of Conduct (from St. Louis Declaration)
- Ask nurseries for non-invasive species
- Don’t trade invasives with other gardeners
- Remove invasives from your property
- Ask gardens to display only non-invasives
- Help educate others about invasives
- Request that garden writers not promote invasive species
- Volunteer with groups to help remove invasive species
- Learn which agencies regulate invasive species in your area and report problem species to them (King Co. Noxious Weed Board: http://www.kingcounty.gov/environment/animalsandplants/noxious-weeds.aspx).
- Help your garden club create policies about invasive species.

A pilot program in Seattle area asked 5 commercial nurseries to discourage the sale of invasive species and to promote alternatives. A booklet is available “Garden Wise” that describes alternatives to Invasive species.

Be sure to remove seeds from socks and other clothes and clean your hiking boots before leaving an area with weeds
Don’t drive off road in areas with weed infestations.
Clean your boat well before leaving a lake or river with weeds in it to avoid spreading weeds to other bodies of water.