Limnology 08-15 Macrophytes

Aquatic Plants

Submersed Aquatic Vegetation (SAV)

Frog moss or moss

Seaweed

- Common taxa
- Morphological and biochemical adaptations to life underwater
- Ecological function
- Invasive species characteristics
- Management

Table 4.1. Annual production levels of fringing benthic plant communities. Average levels are compiled from all available data and represent a range of environments though data from very unfavourable sites is probably not included. The maximum values are the highest that could be located. The data are given in g organic matter (ash-free dry wt.) per m^2 per year.

Fringing community type	Average production	Maximum production
Bog	900	1500
Marshes, freshwater		
Typha, cattail	2700	3700
Carex, sedge	1000	1700
Phragmites, reed	2100	3000
Cyperus, papyrus	7500	15000
Freshwater, tidal	1600	2100
Marshes, salt water tidal		
Spartina	2500	6000
Other grasses	1500	8500
Salicornia	3000	
Swamps, freshwater		
Bog, spruce	500	
Cedar, Cypress	4000	
Hardwood	1600	
Swamps, salt water		
Mangrove	3000	
Benthic microphytes		
Freshwater, lake	170	1560
Freshwater, spring	3000	3500
Marine	200	850
Submerged macrophytes		
Freshwater, temperate	650	1300
tropical		1700
Marine		
sea grasses, tropical	2000	8500
macroalgae, kelp	3400	4250
rockweeds	750	2100
green algae, tropical		4000
Floating, freshwater		
Duckweed	150	1500
Water hyacinth (*Eichornia*)		3300

Evolution of aquatic plants

Marine, single-celled

⇓

Marine, multicelled

⇓

Terrestrial

⇓

Seed habit

⇓

Displaced gymnosperms

No longer need water for fertilization

⇓

Freshwater

1% of all angiosperms

Still have relics of terrestrial heritage

Thin cuticle, functionless stomata

Partially lignified xylem

Still often insect and wind pollinated

Some are only partially aquatic (cattails, reeds, other emergent wetland plants)

Some are highly specialized with underwater fertilization

Taxanomic classification

Macroalgae
- Nitella (Nitella gracilis)
- Stonewort or muskgrass (Chara vulgaris)
  - Taste and odor in drinking water/mosquito larvicide

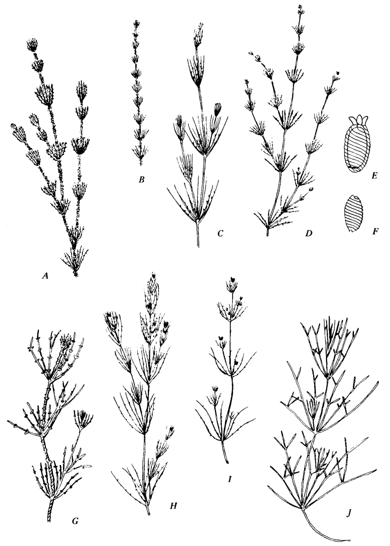


FIGURE 1. Typical members of the tribe Chareae of limnological interest. *A*, *Chara hispida; B*, *Ch. aspera; C*, *Ch. globularis; D*, *Ch. contraria; E*, intact oogonium of same showing three of the five cells of the coronula; *F*, the same as ordinarily fossilized; *G*, *Ch. tomentosa; H*, *Ch. rudis; I*, *Ch. denudata; J*, *Nitellopsis obtusa* (from British specimens, Groves and Bullock-Webster).

Source: Hutchinson 1975

TABLE 3. *Survivorship of* Aedes *larvae in water in which various Charophyceae are growing*

Species of Charophyceae	Initial no. of *Aedes* larvae	Number after 30 hr	Number after 60 hr	Number after 120 hr
Chara globularis	10	10	10	9
Ch. corallina	10	8	6	2
Ch. zeylanica	10	9	5	4
Nitella flexilis	10	0	0	0
N. rigida	10	2	0	0
N. mucronata	10	4	1	1
Control, no plants	10	10	9	8

Source: Hutchinson 1975

Bryophytes

<u>Liverworts</u>

Riccia spp. primarily in eutrophic lakes – Corps reservoir

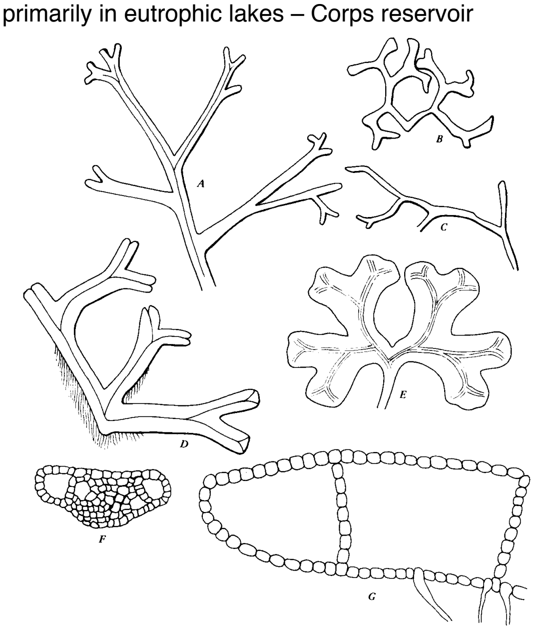


FIGURE 22. *A*, *Riccia fluitans* typical aquatic form; *B*, *C*, *R. rhenana*, typical aquatic forms, from Munich; *D*, *R. fluitans* terrestrial form; *E*, part of *B* cultivated terrestrially; *F*, cross-section of part of *C*; *G*, cross-section of part of *E* (*A–E*, ×3.75; *F*, *G*, ×7.5, Watson, Müller).

Source: Hutchinson 1975

Mosses

Order: Spagnales.

Typically in calcium-poor habitats ranging from damp cleaings in woodlands to littoral zone of lakes. Many species with distinct zonation

FIGURE 24. Aquatic mosses. *A*, *Sphagnum cuspidatum; B*, *S. cuspidatum f. plumosum; C*, *Scorpidium scorpioides; D*, *Fissidens julianus; E*, *F. grandifrons; F*, *Eurhynchium rusciforme; G*, *Fontinalis antipyretica* ($\times\frac{1}{2}$); *H*, *F. dalecarlica; I*, *Drepanocladus fluitans; J*, *Amblystegium riparium* (all natural size except G; Paul and Mönkemeyer slightly modified, all presumably based on European material).

Source: Hutchinson 1975

Order: Bryales

Ordinary mosses can be a major component of lake flora and production – very common in Corps of Engineers reservoirs surveyed in 1999 (Fontinalis antipyretica)

Mosses and liverworts can be a major component of the flora in oligotrophic lakes. Mosses and liverworts can grow deeper than angiosperms, which are limited by pressure to depth less than 11 m. Mosses and liverworts can grow as deep as 164 m, e.g., Waldo Lake, Crater Lake, Tahoe.

Major growth forms
- Pleustophytes: free floating
- Rhizophytes: rooted in the sediment

A general classification scheme

Emergent – stems and leaves held above the water surface, usually rooted. Found on exposed soil at lake margin to 150 cm.
- Purple loosestrife (Lythrum salicaria)
- Cattails (Tyha latifolia)
- Common reed (Phragmites australis)

Submersed – stems and leaves entirely underwater (may have emergent flowers), rooted in the sediment.
- Eurasian watermilfoil (Myriophyllum spicatum)
- Brazilian elodea (Egeria densa)
- Narrow-leaf pondweed (P. pussilus)

Floating – leaves on the water surface, submersed leaves may also be present, rooted in the sediment.
- Water lilies (Nuphar polysepalum, Nymphaea alba)
- American pondweed (Potamogeton nodosus)
- Big-leaf pondweed (P. natans)
- Water shield (Brasenia schreberi)

Free-floating – plants not rooted in the sediment
- With emergent or floating leaves
  - Water hyacinth (Eichhornia crassipes)
  - Duckweed (Lemna minor, L. trisulca)
- With submersed leaves
  - Coontail (Ceratophyllum demersum)
  - Bladderwort (Utricularia vulgaris)

General classification schemes, by their nature, cannot capture all the potential variations in growth form, but they do provide a quick reference to ecology and function of the plants in the ecosystem

Examples of problem plants in this classification scheme

Parrotfeather (Myriophyllum aquaticum) – submersed in winter, emergent in spring, free-floating in summer

Water hyacinth (Eichhornia crassipes) – seedlings germinate on exposed mudflats, remain rooted in shallow water, become free-floating in deep water

Emergent

Typha latifolia
Broadleaved cattail

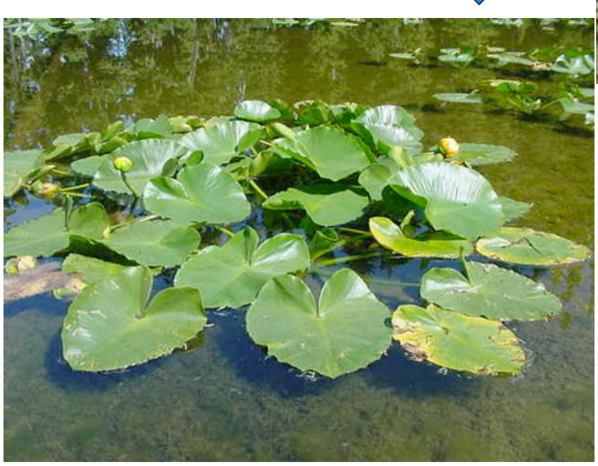
Iris psuedacorus
Yellow flag iris

Lythrum salicaria
Purple loosestrife

Floating leaf, rooted

Nymphaea odorata

Nuphar polysepalum

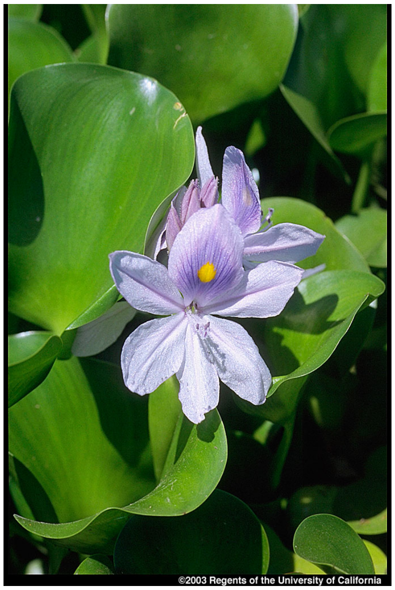


Floating leaf, rooted Potamogeton natans

Submersed – rooted   Hydrilla verticillata

Floating leaf-unrooted
in water column

Water hyacinth
(Eichhornia crassipes)



Submersed – not rooted

Ceratophyllum demersum

Lemna trisulca

Floating – not rooted in sediment

Ferns

Azolla (Water velvet) – floating, red thallus that contains symbionic cyanobacteria Anabaena azollae, a nitrogen-fixing organism.

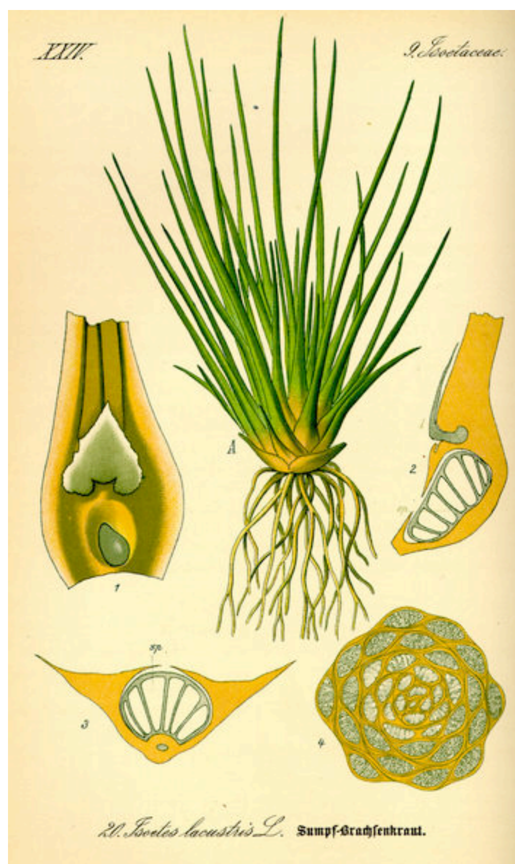
Salvinia (Water fern) – S. molesta, S. minima are introduced, weedy species

Angiosperm

Lemna spp (duckweeds)

Isoetids - “fern allies”

Typical in oligotrophic lakes, evergreen, slow-growing, long-lived leaves



Angiosperms (Vacular hydrophytes)

Aquatic angiosperm flora is enriched in monocots relative to terrestrial flora

monocot;dicot ratio

1:1 in aquatic flora

1: 4–5 in terrestrial flora

Many families, but few species/ family

Monocots

Hydrocharitaceae

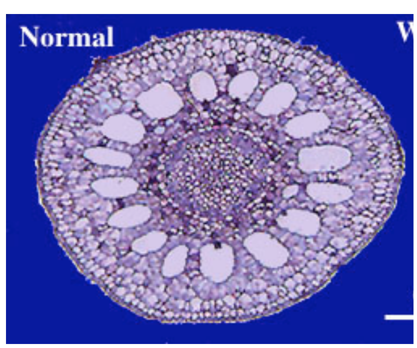
Egeria densa

Elodea canadensis

Hydrilla verticillata

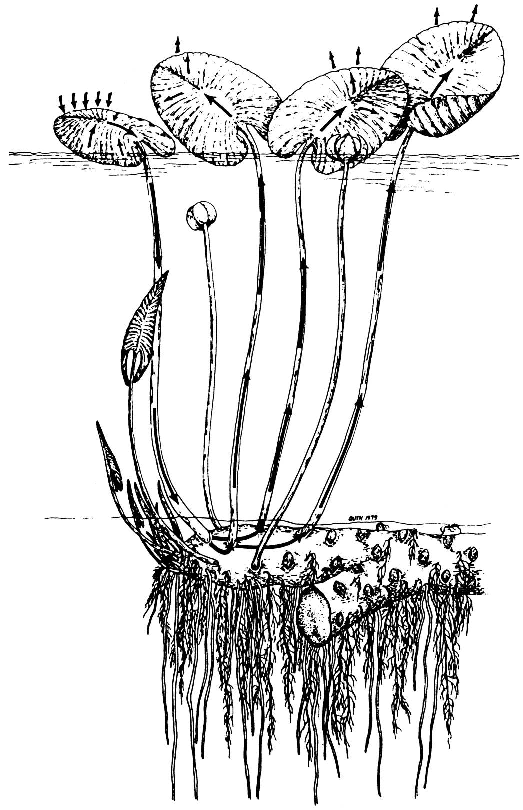
Environmental influences on aquatic plant growth

- Density
  - Buoyancy due to aerenchyma tissue
    - Reduced requirement for structural tissues



xs of Myriophyllum spicatum leaf

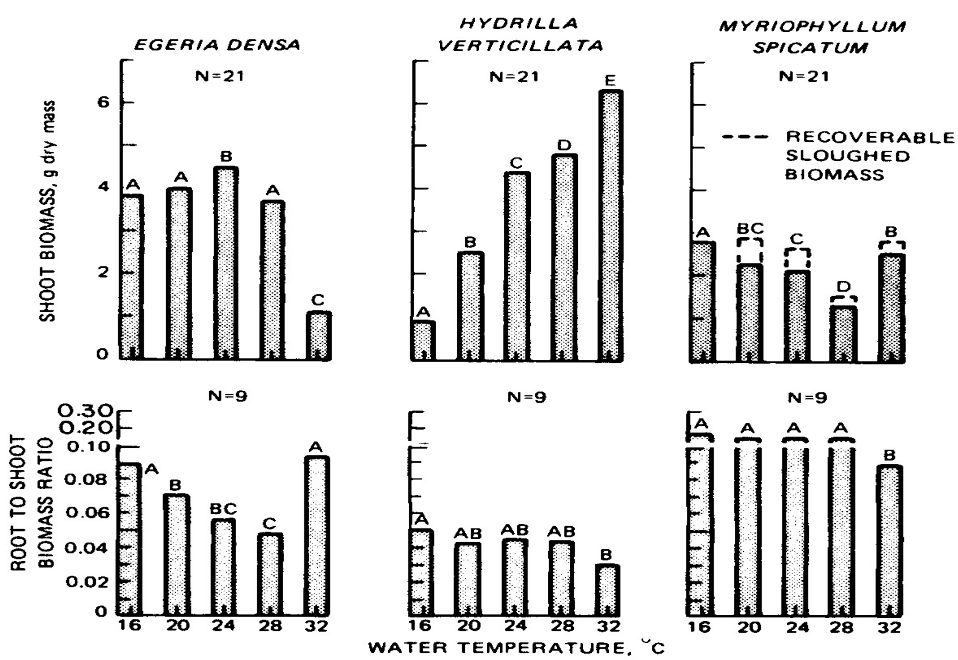
Aerenchyma tissue allows the transport of gasses to roots and rhizomes in anaerobic sediments



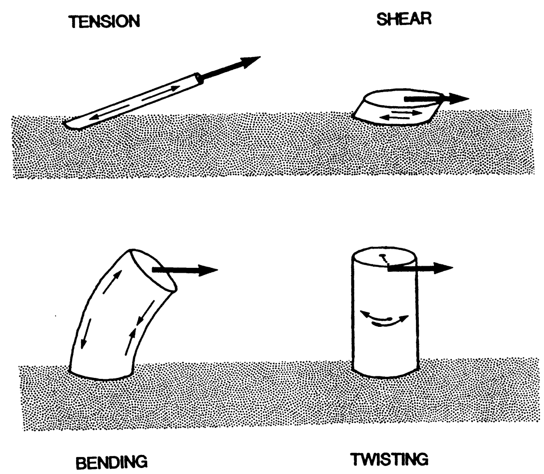
Pressurized ventilation in water lilies is driven by counterbalancing Leaf temperature and internal water vapor effects on diffusion of gases from the dryer atmosphere

See Dacey, 1981, Ecology 62: 1137-1147

Growth and allocation of biomass influenced by temperature (species dependent)

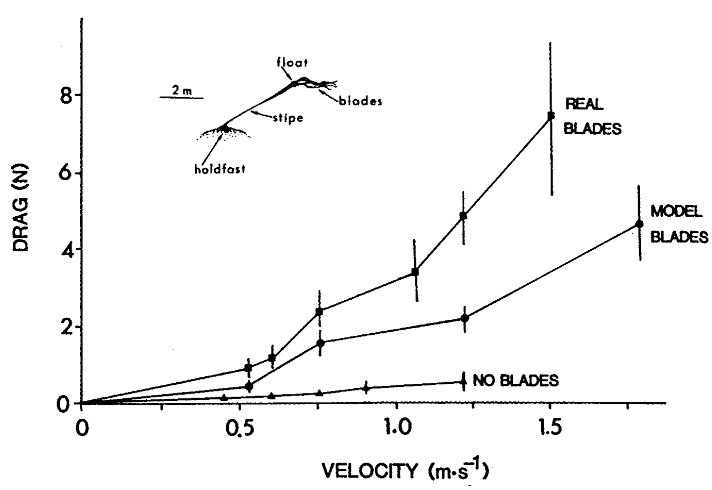


- Viscocity effects
  - Submersed aquatic plants are subject to tensional stresses while terrestrial plants are subject to compressional stresses due to gravity



Stresses caused by water viscocity on sessile organisms

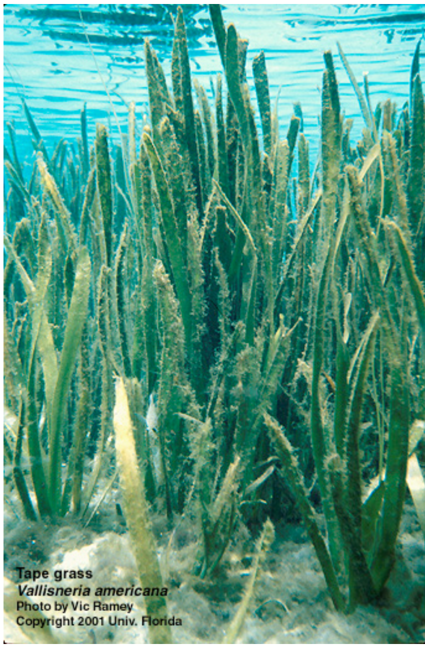
Source:Vogel. Life in Moving Fluids.



Drag force measured on a Nereocystis leuteana (squares), on a stipe and pneumatocyst (float) after the fronds had been removed (triangles) and on the stipe an pneumatocyst plus plastic fronds (no ruffles as on blades).

Source: Koehl.

Strap-like leaves of Vallisneria americana and Stuckenia pectinata reduce drag in high-flow environments



Dissected leaves of eurasian watermifoil (*Myriophyllum spicatum and Cabomba caroliniana*) limit distribution to low-flow environments

–Gas diffusion is slow in water

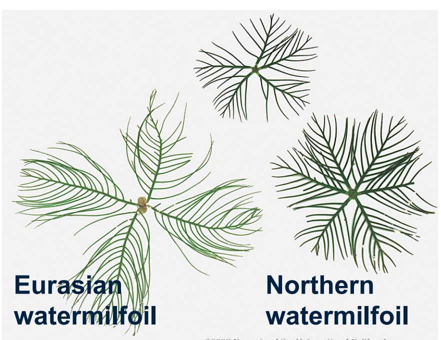
D_{CO2} in air = 1.47 x 10^{-5} m^2/s
D_{CO2} in water = 1.8 x 10^{-9} m^2/s

D_{O2} in air = 0.188 X 10^{-4} m^2/s
D_{O2} in water = 2 X 10^{-10} to 1.2 10^{-9} m^2/s

Low diffusion rates result in CO2 depletion and O2 accumulation near leaves during photosynthesis, with consequences for photorespiration and carbon-fixation rates

Adaptations to reduce boundary layer effect

- Increase surface to volume ratio
- Thin and dissected leaves
- Wavy leaves
- Emergent leaves
- Biochemical



Dissected , thin, and narrow leaves result in high surface to volume ratio, which maximizes surface availale for gas exchange

Curlyleaf pondweed
Potamogeton crispus

Wavey leaves break up
boundary layer

Heterophylly is an adaptation to limits on gas diffusion

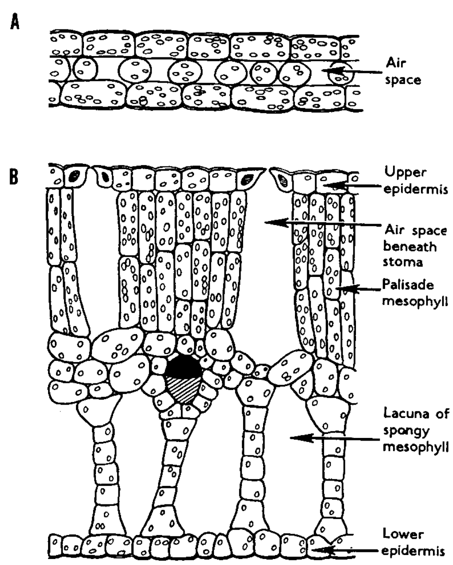
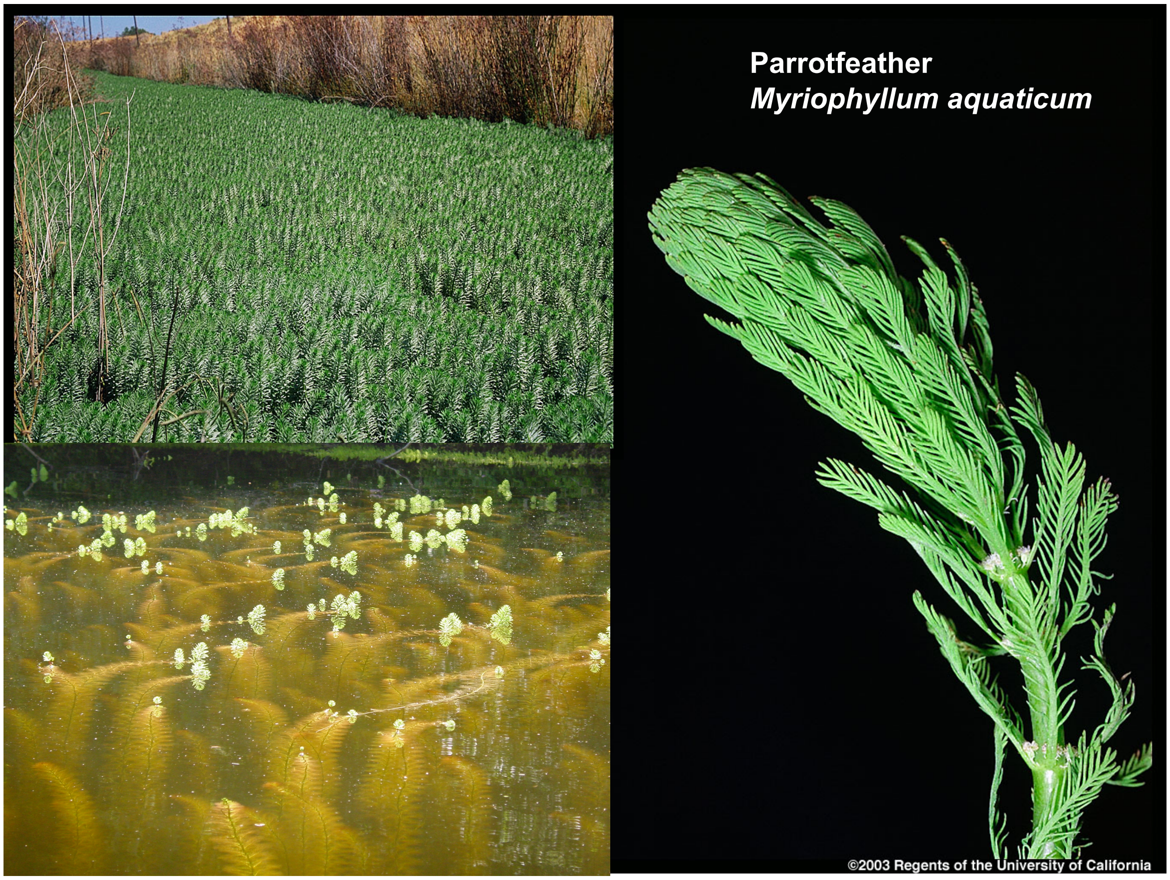


FIG. 8.10. *Potamogeton nodosus*: T.S. parts of submerged ribbon leaf (A) and floating leaf-blade (B), showing contrasting anatomy. Note reduction of submerged leaf to three cell layers with abundant epidermal chloroplasts: floating leaf with stomata in the upper epidermis, few epidermal chloroplasts, and well differentiated mesophyll; xylem of vascular bundle in solid black, phloem shaded (A, ×240; B, ×180) (after Streitberg, 1954).

Source: Sculthorpe



- Effect of Light attenuation
  - Submersed plants are "shade plants", net photosynthesis is saturated at < 1/2 full-sun
  - Low photosynthesis rates - light and CO_2 saturated photosyn. rates rarely exceed 100 umol/mg Chla/hr
  - At naturally occurring DIC conc. Rates are closer to 10-20 umol/mg Chla/hr
  - pH effects on DIC availabilitymay be more important than light in determining PS rates