The Ecology of Freshwaters

LECTURE 3 – Plants in freshwaters.

Introductory remarks: Although plant life evolved in water, the multicellular plants to be found in freshwaters all have a terrestrial origin. In many respects, therefore, they are similar to terrestrial plants but, because of the density of the medium they inhabit, they often show a different growth habit and/or method of reproduction.

Slide One: Title slide.

Slide Two: This slide illustrates the crucial role of plants and other non-animal species in aquatic systems—primary production on the one hand and the decomposition of dead matter on the other. In either case, the organisms that perform these roles form the base of the food web in freshwaters.

Slide Three: The bacteria of freshwaters are an extremely diverse group, that until recently was largely overlooked. The development of new genetic techniques has helped to resolve the very difficult problem of species identification. However, it is still the case that most ecological studies of freshwaters ignore bacteria and the abundant photosynthetic cyanobacteria (blue-green algae).

Slide Four: There is a wide range of photosynthetic organism in the plankton and some have animal and plant characteristics. Although technically plants, some have flagellae and are motile. This again illustrates the difficulty of working with organisms to which the traditional taxonomic rules of higher organisms do not apply.

Slide Five: Diatoms are unicellular algae, capable of photosynthesis and possessing an internal skeletal structure of silica. The skeletons persist after death and may form a large proportion of the ooze or muds on lakebeds. Diatoms can be used to interpret changes in lake conditions. For example, diatom fossils are used to infer past pH in studies on acid rain.

Slide Six: Viewed with an electron microscope, the complex and beautiful structure of diatoms becomes clear. They are preserved as fossils in a wide variety of sediments and are of great value to palaeontology.

Slide Seven: There are both motile and non-motile forms of colonial algae. In this swimming form, each cell bears cilia that contribute to the overall swimming effort. Unlike *Volvox*, which is spherical, this is a disc shaped form.

Slide Eight: Filamentous algae, such as this *Cladophora* species can form dense blankets, often buoyed up by oxygen bubbles produced by their own photosynthesis. It is readily colonized by epiphytic diatoms and other algae, and provides a protected foraging environment for protozoans, worms, small crustaceans and insect larvae.

Slide Nine: The chloroplasts of *Spirogyra* are arranged in a spiral that winds itself around the inside surface of the cell wall. The plant itself produces a mucilaginous secretion that deters other algae or animals from attaching.

Slide Ten: *Enteromorpha* species are highly salt-tolerant and are found in all salinities from 100% freshwater to completely marine. It is also highly tolerant of temperature variations and, possibly for this reason, has become a pest species and responsible for weed fouling on boats and other submerged structures.

Slide Eleven: Aquatic fungi. There are four major groups of fungi containing aquatic species: Zygomyceta (the true fungi), Ascomyceta (the sac fungi), Basidiomyceta (the club fungi), and Deuteromyceta (the fungi imperfecti). They are major decomposers of the leaf litter, particularly in acidic waters (see Lecture 7 for an example of their importance in forest stream ecology). In non-acidic waters bacteria are the major decomposers. Many aquatic fungi produce drought-tolerant spores to enable the species to persist when waters dry out.

Slide Twelve: Aquatic macrophytes form much of the physical structure on which animals depend, both above and below the surface. They are vascular plants and may be submersed, emersed or floating. The image is the bank of the Rio Japura, Brazil and shows a highly water adapted flora. The dominant weedy trees are *Cecropia* species.

Slide Thirteen: For obvious reasons, floating plants that have no attached roots are able to disperse easily on currents. They can therefore become pests of waterways etc. Adaptations to the floating habit include chloroplasts and stomata only on the upper surface of the leaves, a waxy cuticle and air-filled cavities within the leaf for buoyancy.

Slide Fourteen: Some plants root into the lake or riverbed but float their leaves at the surface. Plants with leaves of this size are restricted to standing water as clearly, the drag on the leaves from even a slow moving current could be enough to uproot the plant.

Slide Fifteen: *Elodea nuttalli* and *Ceratophyllum demersum* are a typical submerged plants. Plants of this type grow rapidly and can choke waterways if not controlled. They spread by vegetative reproduction although they will also flower.

Slide Sixteen: Many aquatic species are emergent, taking advantage of the aquatic environment to provide a continuous supply of nutrients to the roots, whilst keeping their leaves and flowers in the air, where light conditions are better, more oxygen is available and insects have access for pollination.

Slide Seventeen: Aquatic macrophytes perform many roles in aquatic systems, as listed here. Without such plants lakes and rivers would have the appearance of the reservoirs shown in Lecture 1 (Slides 54 & 55).

Slide Eighteen: Some species can be almost solely responsible for the creation of entire habitats. *Sphagnum* species do this by continual growth in aquatic systems, and by trapping wind-blown dust and other matter. Eventually, wetland develops where once water stood. Sphagnum is the climax vegetation in many high rainfall-low evaporation regions of the planet.

Slide Nineteen: The sponge-like characteristics of *Sphagnum* are explained in this slide, water fills the interstices between the filaments and is retained during dry periods.

Slide Twenty: Floating ferns – this slide illustrates the diversity of pteridophytes in aquatic systems. Some fern species are pests, e.g. *Salvinia* sp.

Slide Twenty-one: *Salvinia* identification.

Slide Twenty-two: *Azolla* identification

Slide Twenty-three: Flowering plants – introductory pictures.

Slide Twenty-four: *Lemna* has reduced the body of a flower plant to the minimum possible. The reproductive parts are usually a pair of stamens and a single pistil in a membranous saclike spathe, hidden away inside budding pouches. Flowers are uncommon and most reproduction is vegetative. This is one of the commonest floating plant groups on the planet.

Slide Twenty-five: The lilies are another very important aquatic group of flowering plants. *Victoria amazonica*. The leaves of this plant may be 1.5 – 2m in diameter and can support the weight of a small child. The flowers themselves are 20-30cm across and exhibit a very brief and complex flowering routine before submerging again for seed formation.

Slide Twenty-six: Getting and keeping flowers at the surface requires special adaptations; water lilies have waxy, bowl-shaped flowers that float like a boat.

Slide Twenty-seven: While plants such as duckweed and water lilies are adapted to still or slow moving water other flowering plants such as *Potamogeton* and *Ranunculus* species grow in shallow, swiftly flowing streams.

Slide Twenty-eight: *Paspalum* is a floating grass, with stems about 50cm long. It grows to form extremely dense mats, so dense that they can almost support the weight of a man. In this image Professor Hamilton is standing in a canoe. These so-called 'floating lawns' harbour many other species (see methods lecture for a picture of fish sampled from this habitat by seining).

Slide Twenty-nine: The annual flooding of the Amazon basin, referred to in Lecture 1 (Slide 15) results in this type of inundation forest in which the trees survive, submerged, or partially submerged, for many months every year. In some low-lying areas the trees may even stay in water for a number of consecutive years.

Slide Thirty: …This image shows the underwater leaves of igapo trees. In this habitat fish nest in trees!

Slide Thirty-one: Where soils are very low in nutrients or where continual inundation washes away nutrients, as in many aquatic systems, plants need to develop other strategies to obtain nitrogen, carnivory being one of them. Note that some floating plants e.g. bladderwort also capture small crustaceans in underwater bladders for the same reason.

Slide Thirty-two: Aquatic macrophytes tend to replace sexual reproduction with vegetative reproduction. Vegetative, or asexual, reproduction is a vital key to survival among the aquatic plants. Some species rarely generate viable seeds. As a result, some species can become pests. The primary cause of nuisance from aquatic plants are a) through fouling of underwater structures and boats/ships and b) through the congestion of waterways by large quantities of vegetation. Chemical treatment in aquatic systems is not usually an option and most clearance schemes have opted for mechanical removal or, more recently, biological control.

Slide Thirty-four: Fast rivers have low, encrusting forms such as mosses and lichens whereas… Where the water is stationary or slow moving, species with larger leaf forms can grow without being uprooted.

Slide Thirty-six: Because of the low light levels under forest canopies, few macrophytes are found in forest streams.

Slide Thirty-seven: With low nutrient loads diverse communities of higher and lower plants may develop as we have seen in these slides. However, if nutrient levels increase, algal blooms can develop, effectively cutting off the light supply to plants beneath them.

Slide Thirty-eight: The differing habitat requirements of different species, the tendency for some species to create habitat through sediment trapping and successional processes all lead to zonation on river and lake banks.

Slide Thirty-nine: A plant succession in aquatic environments is called a *hydrosere*, it is not immediately obvious whether the zonation is due to seral processes but it is very striking nevertheless.

Take home message:

Plants create the habitat for most other aquatic species. As well as being the primary producers, they also provide structure and are also instrumental in habitat creation. The structure of plants is closely allied to they type of water body they are found in and aquatic plants usually disperse vegetatively, again reflecting the attributes of their environment. Other non-animal species in water, bacteria and fungi are important, indeed dominant decomposers.