LECTURE-10

Eutrophication Management in Lakes and Reservoirs

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NUTRIENTS, PRODUCTIVITY AND EUTROPHICATION

The presence of inorganic nutrients in water is directly related to plant productivity. The process by which water bodies become nutrient enriched, and hence more productive, is termed "Eutrophication'. Limnologists use the terms eutrophic (nutrient-rich), mesotrophic (nutrient-medium level) and oligotrophic (nutrient deficient) to describe the productivity state of a body of water. These terms were originally introduced by Weber (1907) to describe the qualitative situation of nutrients in German bogs referring to their relative states of organic matter production. Today engineers, ecologists and limnologists use the same terms to describe productivity states related to the nutrient enrichment of natural waters. There is no precise way to quantify these terns so that any body of water can be classified as either eutrophic, mesotrophic or oligotrophic. A general description of these terms is as follows:

- **Oligotrophic** indicates nonproductive water, is associated with low biological activity, and is usually related to geologically young bodies of water. Water quality is excellent in this case.
- **Mesotrophic** indicates a water with average productivity and is associated with some biological activity, but is still a balanced system. Water quality is good in this case.
- **Eutrophic** indicates a highly productive water. Excessive biological activity causes large fluctuations in environmental parameters. Water quality is usually significantly degraded.

A system that is moving progressively towards a eutrophic state exhibits severe water quality problems. In general, with the creation of large amounts of algal biomass, the water becomes very turbid and aesthetically unpleasant. If the algal form is shifted to blue-green algae, then various toxin, taste, and odour related problems start arising. If these waters are to be used for drinking, water treatment for making it potable could be very challenging, both technically and economically. A water body that has become eutrophic has wide fluctuations in oxygen level. This is owing to photosynthesis and respiration process by the algal growth. During the daylight hours, supersaturated levels of oxygen occur and at night the oxygen level is diminished near zero due to respiration. The fauna associated with such lake systems become severely stressed owing to these large fluctuations in the oxygen level. In addition, the heavy plant growth that occurs in the upper layers eventually dies and settles causing a high benthal oxygen demand. The dead plant cells not only require oxygen for stabilization, but they tend to create and build up a pool of mineralized nutrients.

The ecology of a water system undergoing eutrophication evolves, as does the trophic level. Plant forms that exhibit high growth rates usually dominate a eutrophic system, and often it is the blue green algae or other nuisance type of algae that develop. Fish associated with a eutrophic system are generally those that can tolerate wide fluctuations in oxygen level and heavy concentration of algae. In general, the ecosystem associated with a eutrophic water body has a low diversity and is unstable.

The eutrophication process is essentially initiated by addition of nutrients to water systems. Inputs of these nutrients come from domestic, industrial and agricultural waste. The nutrients required in large quantities for plant growth are: Carbon, Nitrogen, Phosphorous, Sulphur and Iron. In nature, each of these macronutrients undergoes cycling between the inorganic and organic state, and it is this natural cycling that is the basis for all life on earth.

STOICHIOMETRY OF ALGAL GROWTH

Odum (1971) proposed the following stoichiometry for photosynthesis:

$$106\ CO_2 + 16\ NO_3^- + HPO_4^- + 122\ H_2O + 18\ H^+ + \textit{trace elements and energy}$$

$$\uparrow \quad \downarrow$$

$$C_{106}\,H_{263}O_{110}\,N_{16}\,P_1 + 138\ O_2$$

When this stoichiometry operates in the forward direction, it is called photosynthesis and the reverse process is called respiration. Such models can be used to predict the amount of biomass that can be synthesized from the available nutrient concentration. On the other hand, the concept of limiting nutrients, that is, when one or more of the nutrients is present in such a low concentration that production is limited, can be employed for productivity control. One method that can be used for limiting the concentration of one or multiple nutrients is Riparian Zone Management.

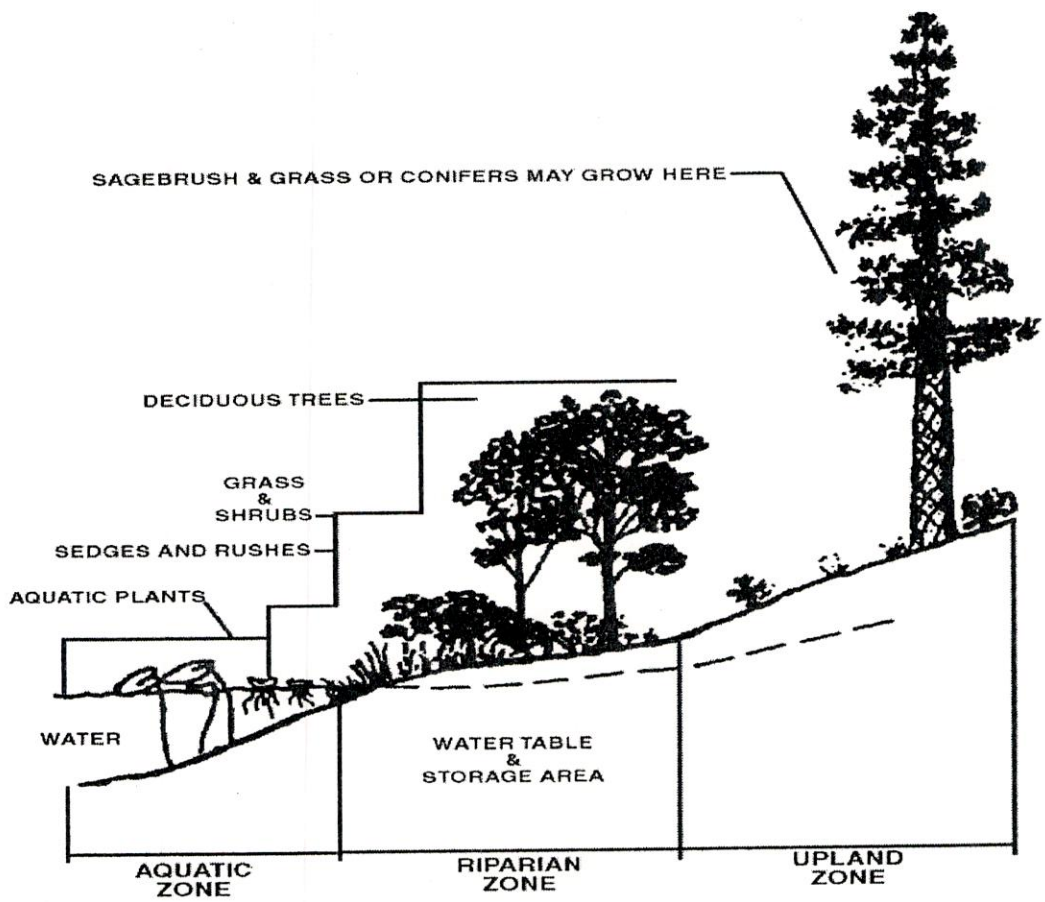
RIPARIAN ZONE MANAGEMENT

The word "riparian" is derived from Latin *ripa*, meaning river bank. A Riparian zone is the interface between land and a surface water body. Riparian habitat is the area adjacent to aquatic systems that contains elements of both aquatic and terrestrial ecosystems that mutually influence each other. Therefore, a riparian zone is an area composed of continuous riparian habitat, like the land on either side of a river bank or the area around a lake.

Riparian zones have the capacity to buffer surface water bodies from non point source runoff from agricultural, urban or other land uses. Healthy riparian zones can absorb sediments, chemical nutrients and other substances contained in non point source runoff. They also provide for aquifer recharge, diverse habitats and water storage and release. A healthy functioning riparian area and associated uplands dramatically increase benefits such as fish and wildlife habitat, erosion control, forage, late season stream flow besides improving water quality.

Research shows riparian zones are instrumental in water quality improvement for both surface runoff and water flowing into water bodies through subsurface or groundwater flow. Particularly the attenuation of nitrate or denitrification of the nitrates from fertilizer in this buffer zone is important. Riparian zones can play a vital role in lowering nitrate contamination in surface runoff from agricultural fields, which would otherwise damage ecosystems and human health. The use of wetland riparian zones shows a particularly high rate of removal of nitrate entering a stream and thus has a place in eutrophication management.

Riparian zones may be natural or engineered. These zones are important natural biofilters, protecting aquatic environments from excessive sedimentation, polluted surface runoff and erosion. They supply shelter and food for many aquatic animals and shade that is an important part of water body temperature regulation. When riparian zones are damaged by construction, agriculture or silviculture, biological restoration can take place, usually by human intervention in erosion control and revegetation. If the area adjacent to a watercourse has standing water or saturated soil for as long as a season, it is normally termed a wetland due to its hydric soil characteristics. Because of their prominent role in supporting a diversity of species, riparian zones are often the subject of national protection in a Biodiversity Action Plan.



Riparian zones are significant in ecology, environmental management and civil engineering due to their role in water quality management (through eutrophication control), soil conservation, their biodiversity and the influence they have on aquatic ecosystems. Some of the important functions of riparian zones are:

1. Dissipate stream energy: Meandering curves of a river, combined with vegetation and root systems dissipate stream energy, resulting in less soil erosion and a reduction in flood damage.
2. Trap sediment: Reduced suspended level creates less turbid water and replenishes soils and build stream banks.
3. Filter pollutants from surface runoff and enhance water quality via biofiltration.
4. Provide wildlife habitat, increase biodiversity and forage for wildlife and livestock.
5. Provide wildlife corridors: enable aquatic and riparian organisms to move along river systems avoiding isolated communities.
6. Provide native landscape irrigation by extending seasonal or perennial flows of water.

Riparian zones occur in many forms including grassland, woodland, wetland or even non-vegetative. In some regions the terms **riparian woodland, riparian forest, riparian buffer zone, riparian corridor** or **riparian strip** are used to characterize a riparian zone.

RIPARIAN VEGETATION

Plant communities in the riparian zone are called riparian vegetation, characterized by hydrophilic plants. The assortment of riparian zone trees varies from those of wetlands and typically consists of plants that either are emergent aquatic plants, or herbs, trees and shrubs that thrive in proximity to water. There can be several types of vegetative buffer zones:

- Grow zones (no mow)
- Native plant buffers
- Forested buffers

Typical riparian zone trees in the United States include:

- Cottonwood, *Populus deltoides*
- Silver maple, *Acer saccharinum*
- Boxelder, *Acer negundo*
- American elm, *Ulmus americana*
- American sycamore, *Platanus occidentalis*
- Butternut, *Juglans cinerea*
- Black walnut, *Juglans nigra*
- Black willow, *Salix nigra*
- River birch, *Betula nigra*
- Green ash, *Fraxinus pensylvanica*
- Honey locust, *Gleditsia triacanthos*
- Basswood, *Tilia americana*
- Red willow
- Jjuncus
- Grasses

- Sedges and
- Wingstem

In Asia the types of riparian vegetation are different, but the interactions between hydrology and ecology are similar.

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