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A Review of Some Water Systems and the Fish Pond Ecosystem

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Abstract: A review some water systems and the fish pond ecosystem was carried out to enlighten fish culturist the understanding of the hydrobiology of some water systems. Understanding the hydrobiology of some water systems the fish pond ecosystem is important in culture fisheries management and practices. Biotic characteristics, marine, estuarine and fresh water habitats, lakes, rivers, marshes, swamps, Springs: formation, types offspring outlets, flow, classification, water content, historic uses, sacred springs, modern uses, bogs: extent, types of bog and formation; streams: types of stream, parts of stream, source of stream, characteristics of stream, intermittent and ephemeral streams and drainage basins are aspect some water systems and the fish pond ecosystem reviewed in this article to provide the needed hydrobiology knowledge for effective culture fisheries management and practices.

Key words: Biotic characteristics, classification, formation, sources and uses, water systems

INTRODUCTION

The fish culturists need to have proper understanding of the aquatic environment for effective culture fisheries management and practices. The aquatic environment is mainly water and its study is hydrobiology (Vaccari, 2005). Hydrobiology is the science of life and life processes in water. Much of modern hydrobiology can be viewed as a sub-discipline of ecology but the sphere of hydrobiology includes taxonomy, economic biology, industrial biology, morphology, physiology etc. The one distinguishing aspect is that all relate to aquatic organisms. Much work is closely related to limnology and can be divided into lotic system ecology (flowing waters) and lentic system ecology (still waters) (USEPA, 2006). One of the significant areas of current research is eutrophication. Special attention is paid to biotic interactions in plankton assemblage including the microbial loop, the mechanism of influencing water blooms, phosphorus load and lake turnover (NRC, 1996). Another subject of research is the acidification of mountain lakes. Long-term studies are carried out on changes in the ionic composition of the water of rivers, lakes and reservoirs in connection with acid rain and fertilization (Moustakas and Karakassis, 2005).

One goal of current research is elucidation of the basic environmental functions of the ecosystem in reservoirs, which are important for water quality management and water supply (Mann and Lazier, 2006). Much of the early work of hydro biologists concentrated on the biological processes utilized in sewage treatment and water purification especially slow sand filters. Other historically important work sought to provide biotic indices for classifying waters according to the biotic communities that they supported. This work continues to this day in Europe in the development of classification tools for assessing water bodies for the EU water framework directive (Manahan, 2005).

Aquatic ecosystems perform many important environmental functions. For example, they recycle nutrients, purify water, attenuate floods, recharge ground water and provide habitats for wildlife. Aquatic ecosystems are also used for human recreation, and are very important to the tourism industry, especially in coastal regions (Loeb, 1994). The health of an aquatic ecosystem is degraded when the ecosystem's ability to absorb a stress has been exceeded. A stress on an aquatic ecosystem can be a result of physical, chemical or biological alterations of the environment. Physical alterations include changes in water temperature, water flow and light availability (Levner *et al*., 2005). Chemical alterations include changes in the loading rates of bio-stimulatory nutrients, oxygen consuming materials, and toxins. Biological alterations include the introduction of exotic species. Human populations can impose excessive stresses on aquatic ecosystems (Davenport, 2008).

An ecosystem is composed of biotic communities and abiotic environmental factors, which form a self-regulating and self-sustaining unit. Abiotic

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environmental factors of aquatic ecosystems include temperature, salinity, and flow (Daily, 1997). The amount of dissolved oxygen in a water body is frequently the key substance in determining the extent and kinds of organic life in the water body. Fish need dissolved oxygen to survive. Conversely, oxygen is fatal to many kinds of anaerobic bacteria. The salinity of the water body is also a determining factor in the kinds of species found in the water body (Chapman and Reiss, 1998). Organisms in marine ecosystems tolerate salinity, while many freshwater organisms are intolerant of salt. Freshwater used for irrigation purposes often absorb levels of salt that are harmful to freshwater organisms. Though, some salt can be good for organisms (Boyd *et al*., 2006).

A review of the characteristics of aquatic habitats, distribution interrelationships and adaptations in the various aquatic habitats may enhance effective management of culture fisheries. Biotic characteristics, marine, estuarine and fresh water habitats, lakes, rivers, marshes, swamps, Springs: formation, types offspring outlets, flow, classification, water content, historic uses, sacred springs, modern uses, bogs: extent, types of bog and formation; streams: types of stream, parts of stream, source of stream, characteristics of stream, intermittent and ephemeral streams and drainage basins are aspect some water systems and the fish pond ecosystem reviewed in this article to provide the needed hydrobiology knowledge for effective culture fisheries management and practices.

BIOTIC CHARACTERISTICS

The organisms (also called biota) found in aquatic ecosystems are either autotrophic or heterotrophic. Autotrophic organisms are producers that generate organic compounds from inorganic material. Algae use solar energy to generate biomass from carbon dioxide and are the most important autotrophic organisms in aquatic environments (USEPA, 2006). Chemosynthetic bacteria are found in benthic marine ecosystems. These organisms are able to feed on hydrogen sulfide in water that comes from volcanic vents. Great concentrations of animals that feed on these bacteria are found around volcanic vents. For example, there are giant tube worms (*Riftia pachyptila*) 1.5 m in length and clams (*Calyptogena magnifica*) 30 cm long (Alexander, 1999).

Heterotrophic organisms consume autotrophic organisms and use the organic compounds in their bodies as energy sources and as raw materials to create their own biomass. Euryhaline organisms are salt tolerant and can survive in marine ecosystems, while stenohaline or salt intolerant species can only live in freshwater environments (Vaccari, 2005).

Fishpond is a typical aquatic ecosystem. These are a specific type of freshwater ecosystems that are largely based on the autotrophic algae which provide the base trophic level for all life in the area (NRC, 1996). The largest predator in a pond ecosystem will normally be a fish and in-between range smaller insects and microorganisms (USEPA, 2006). It may have a scale of organisms from small bacteria to big creatures like water snakes, beetles, water bugs, frogs, tadpoles, and turtles. This is important for the environment. This can be marine, estuarine or freshwater.

Marine habitat: Marine ecosystems cover approximately 71% of the Earth's surface and contain approximately 97% of the planet's water (NRC, 1996). They generate 32% of the world's net primary production. They are distinguished from freshwater ecosystems by the presence of dissolved compounds, especially salts, in the water. Approximately 85% of the dissolved materials in seawater are sodium and chlorine (USEPA, 2006). Seawater has an average salinity of 35 parts per thousand (ppt) of water. Actual salinity varies among different marine ecosystems. Marine ecosystems can be divided into the following zones: oceanic (the open part of the ocean where animals such as whales, sharks, and tuna live); profundal (bottom or deep water); benthic (bottom substrates); intertidal (the area between high and low tides); estuaries; salt marshes; coral reefs; and hydrothermal vents (where chemosynthetic sulfur bacteria form the food base) (USEPA, 2006). Classes of organisms found in marine ecosystems include brown algae, dinoflagellates, corals, cephalopods, echinoderms, and sharks. Fish caught in marine ecosystems are the biggest source of commercial foods obtained from wild populations.

Environmental problems concerning marine ecosystems include unsustainable exploitation of marine resources (for example overfishing of certain species), marine pollution, climate change, and building on coastal areas (NRC, 1996). The shore and open sea make up a marine habitat. It can broadly be divided into littoral and benthic zones. The littoral zone is the region that extends over the continental shelf to a depth of about 200 m. Beyond this, the ocean floor can extend to a depth of 10,000 meters. This is the benthic zone (USEPA, 2006).

The littoral zone can be subdivided into splash zone, inter tidal zone and sub tidal zone. The splash zone is just above the high-tide mark and is wetted by the spray from breaking waves. The intertidal zone is covered with water during high tide and exposed to air during low tide. This happens twice a day. This zone is also exposed to wave action. The sub tidal zone extends from the low-tide mark to a depth of about 200 m (Vaccari, 2005).

The waters on the continental shelf are known as neritic, and that beyond the shelf, as oceanic. Light only penetrates the oceanic waters to a depth of 200 m. Beyond this, the waters are dark and cold (Loeb, 1994). The richest flora and fauna are found on a rocky shore. Barnacles, oysters, mussels and limpets are found on the intertidal zone of a rocky shore which is exposed and where, wave action is severe, while anemones, sponges and seaweeds are found on the sheltered parts. Sea urchins, sea cucumbers and seaweeds are found in rock crevices below the low-tide mark. Periwinkles (snails) and shore slates (crustaceans) are found on the splash zones (Moustakas and Karakassis, 2005).

Life on a sandy shore is not as rich as that on a rocky shore. Seaweeds are not present. Sandy shore dwellers include the slow-moving starfish, bivalves and annelids, and the agile ghost crabs. Ghost crabs are sandy colored and live in deep burrows just above the high-tide mark. They come out to hunt for food on the shore. Common organisms on muddy shores include small worms and crustaceans. All shores have a number of birds, which are especially numerous on muddy shores.

Most shore organisms have to withstand wave and tide action. Those living on rocky shore have adhesive structures. For example, the brown seaweeds, sargassium, is attached to rocks by holdfasts, barnacles are cemented to rocks and limpets hold onto rocks with their feet (Loeb, 1994). Organisms on sandy and muddy shores live in burrows and so escape being washed away by the waves and tides (Mann and Lazier, 2006).

Splash zone organisms are more adopted for living on both land and water. The periwinkle has lungs like the land snails; the ghost crab has gills for breathing in water and a spongy structure for breathing on land.

Inter tidal organisms are mainly adapted for an aquatic life. The main problem they face is exposure and the resultant drying out each time the tide ebbs. To overcome this, organisms in sandy and muddy shores burrow into the soft substratum (Loeb, 1994). Bivalves have specially adapted feet for digging into the sand or mud. Rocky shore organisms cannot burrow into the rocks. Instead, when the tide ebbs, many molluscs, barnacles and worms withdraw into protective shells or tubes, which hold some water. Sea anemones withdraw their tentacles and fill their body cavities with water. Some animals hid in rock crevices (Mann and Lazier, 2006).

Many shore organisms vary in their ability to withstand drying out. Those living near the splash zone have a wide tolerance range for drying out, while those near the low tide mark have a narrow range. This results in organisms being arranged in clear-cut bands or zones. Zonation is common in studies of habitats.

The sub tidal zone is also a favorable zone containing producer and consumer organisms. Most of the organisms present in the lower edge of the inter tidal zone are also present in the sub tidal zone (Loeb, 1994). Snails, crabs, lobsters and crawfish are some of the animals found near the floor of this zone. Two well-known fishes, the stingray and the sole, are also present in this zone (Mann and Lazier, 2006). They are specially adapted for living on the seafloor. The ray has a body that is flattened from top to bottom, the sole is a flat fish that lies on its lower side and has both its eyes on the upper side. They hunt for small animals living on the sea floor and often lie buried in the muddy or sandy sea floor.

The benthic zone is unfavorable for life. The water is dark, cold and contains very little oxygen. No producers are found here, but a number of animals live here. These deep-sea animals are specially adapted to live under conditions of great pressure. Their main source of food is the dead remains of the organisms from the surface waters above. The surface water of the ocean supports two main groups of organisms, plankton and nektons (Loeb, 1994).

The plankton consists of small to microscopic organisms, which float, draft passively or swim slowly in the surface waters. Both producers and consumers are present (Loeb, 1994). The important food producers of marine ecosystem are the photosynthetic plankton such as protests (especially diatoms) and algae (seaweeds). Consumer plankton includes protozoa, crustaceans (especially copepods), worms, larvae and molluscs. Most plankton has adaptation for staying afloat (Vaccari, 2005). These include:

- Oil globules inside the body, which acts as floats
- Gas-filed external floats and bubble rafts
- External spines and hair, which provide friction and prevent sinking

The nektons consist of actively moving or swimming animals like fishes, squids, crabs, prawns and whales. Fishes, with their streamlined muscular bodies, are especially adapted for moving swiftly in water. Most bony fishes also have gas-filled swim bladders (Boyd *et al*., 2006). They can adjust the amount of gas in their bladders and thus move to different depths in the water. Some common tropical open sea fishes include, shark, mackerel, sea catfish, bonga fish and croaker (Loeb, 1994). Deep-sea fish have various adaptations for attracting mates and luring prey, such as various types of light organs. Some have expandable mouths and stomachs for swallowing large prey, a meal that can last them for a long time before they come across their next prey. Most deep-sea animals feed on detritus.

Estuarine habitat: An estuary is a broad mouth (Plate 1) of a river into which the tide flows. It may have marshes, swamps, deltas and lagoons.

Estuaries and coastal waters are among the most productive ecosystems on Earth, providing numerous ecological, economic, cultural, and aesthetic benefits and services. They are also among the most threatened ecosystems, largely as a result of rapidly increasing growth and development (Mann and Lazier, 2006). About

Plate1: Estuary mouth, (http//:upload.wikimedia.orgwi kimdia /commons/b/b2estuary-mout.jpg)

half of the U.S. population now lives in coastal areas and coastal counties are growing three times faster than counties elsewhere in the Nation. Overuse of resources and poor land use practices have resulted in a host of human health and natural resource problems (Moustakas and Karakassis, 2005). Fresh water and seawater mix at estuaries, resulting in brackish water. Brackish water has a salinity, which fluctuates with the tides and, the wet and dry seasons (Boyd *et al*., 2006). Near the sea and inland, this fluctuation is slight, but between them, the salinity can change from that of fresh water to that of seawater within a few hours. The other factorsthat characterize an estuarine habitat are as follows:

- The water is shallow and there is no wave action
- The substratum is soft and muddy
- The habitat gets exposed and flooded periodically as the tide ebbs and flows

Only a restricted number of organisms are present in an estuarine habitat. These show zonation:

- Those in the zone near the sea are mainly marine organisms
- Those in the inland zone (up the river) are mainly freshwater organisms
- Those in the in-between zone are the truly estuarine organisms

Estuarine organisms cope with the fluctuating salinity in their habitat in the following ways:

- Some of them, such as, Arenicola, a burrowing worm, have cells, which have a wide tolerance range for salinity.
- Some have body surfaces that are fairly impermeable
- Some, like the mitten crab, have osmo-regulatory mechanisms that maintain the osmotic concentration of their body fluids slightly above that of the surrounding water.

As in marine habitation, the plankton is an important part of the estuarine ecosystem. Producer plankton includes protests like diatoms and filamentous algae, while consumer plankton are mainly copepods and larval forms (Loeb, 1994).

Mangrove forests are common in the tropical swamps. The white mangrove has salt excreting glands in the upper epidermis of its leaves. Thus, it controls the osmotic concentration of its cells by excreting the excess salt that its roots absorb (Boyd *et al*., 2006). Other adaptations of mangrove trees are:

- The soft muddy substratum is a difficult place for the growth of large plants. Hence, the roots of mangrove plants are shallow and spread out over a large area. Many like *Rhizophora* and *Pandanus* have prop roots for support.
- The waterlogged soil is low in oxygen content. The roots of mangrove plants have many devices for taking in atmospheric oxygen. Some like the *Avicenia* have air roots or *pneumatophores*. These grow vertically up above the mud and take in air when they are exposed. Some others have 'knee joints' in the roots that stick out of the mud. Air pores on these joints allow oxygen to diffuse into the plant.
- Mangrove plants have mechanisms for maintaining a high osmotic concentration in their cells, which is close to that of the water in their habitat. They do this by concentrating salts in their cells and reducing water loss by transpiration. Hence, the leaves of mangrove trees show xerophytes modifications. Avicennia has sunken stomata and hairs over the lower surface.
- The seeds of mangrove plants germinate while they are still on the parent tree (viviparous seedlings). When the seedlings drop they stick upright in the mud. Lateral roots grow quickly to establish the plant, thus preventing it from being washed away.

Many estuarine animals are burrowers, an adaptation to the soft substratum. Some common mangrove and lagoon animals include a tube-dwelling worm, *Mercierella*, and *Molluscs* like *Bankia* and *Littorina*. These are often found on the roots of mangrove trees. The mudskipper is an interesting fish found in lagoons and mangrove forests (Loeb, 1994). It can swim like all fishes, and use its modified pectoral fins to walk on land and climb trees. Its gills and gill slits are specially modified for breathing in water as well as on land.

In the lagoons, the salinity of the water increases during the dry season. When the rains come, the salinity decreases. Many animals flourish in the lagoons during the dry season and perish when the rains come. Such animals have to re-establish themselves in the lagoon, annually at the onset of the dry season (Mann and Lazier, 2006). The larvae from marine lancelet population settle in the lagoons at the end of the wet season and decolonize the lagoons.

Many water birds are common in marshes, deltas and lagoons. In fact, these habitats are important birds' sanctuaries. Bacteria and decaying organic matter form the basic food chains. Most of the invertebrates feed on fine particles of debris (Loeb, 1994). Many fish move into the estuaries at high tide to feed on shrimps, crabs and moll uses that live in the mud. The following are typical examples of estuarine food chain.

1. Detritus → Worm→ Mollusc → Bird
2. Detritus → Shrimp →Fis → Bird

Fresh water habitats: Although the marine habitats are the largest, the freshwater habitats are the most important because they supply our water needs. Freshwater ecosystems cover 0.80% of the Earth's surface and inhabit 0.009% of its total water. They generate nearly 3% of its net primary production. Freshwater ecosystems contain 41% of the world's known fish species. There are three basic types of freshwater ecosystems:

- **Lentic:** Slow-moving water, including pools, ponds, and lakes
- **Lotic:** rapidly-moving water, for example streams and rivers

Wetlands areas where the soil is saturated or inundated for at least part of the time. Lake ecosystems can be divided into zones: pelagic (open offshore waters); profundal; littoral (near shore shallow waters); and riparian (the area of land bordering a body of water). Two important subclasses of lakes are ponds, which typically are small lakes that intergraded with wetlands, and water reservoirs (Mann and Lazier, 2006). Many lakes, or bays within them, gradually become enriched by nutrients and fill in with organic sediments, a process called eutrophication. Eutrophication is accelerated by human activity within the water catchment area of the lake (Vaccari, 2005).

The major zones in river ecosystems are determined by the river bed's gradient or by the velocity of the current. Faster moving turbulent water typically contains greater concentrations of dissolved oxygen, which supports greater biodiversity than the slow moving water of pools. These distinction forms the basis for the division of rivers into upland and lowland rivers (Loeb, 1994). The food base of streams within riparian forests is mostly derived from the trees, but wider streams and those that lack a canopy derive the majority of their food base from algae. Anadromous fish are also an important source of nutrients. Environmental threats to rivers include loss of water, dams, chemical pollution and introduced species.

Wetlands are dominated by vascular plants that have adapted to saturated soil. Wetlands are the most productive natural ecosystems because of the proximity of water and soil. Due to their productivity, wetlands are often converted into dry land with dykes and drains and used for agricultural purposes. Their closeness to lakes and rivers means that they are often developed for human settlement (Boyd *et al*., 2006).

The main difference between freshwater and seawater is the concentration of mineral salts in them. These salts come mainly from the atmosphere and the soil. They are washed from these sources by rain and get into the water bodies. The salt concentration in fresh water is low. Fresh water organisms have adaptations to cope with the entry of excess water into their bodies from the surroundings (Moustakas and Karakassis, 2005).

There are two main types of fresh water habitats:

- Standing bodies of fresh water such as ponds and lakes
- Fresh water flowing over land such as streams and rivers

Both habitats have a littoral zone and a benthic zone. The surface waters are rich in both producers and consumers. The deeper regions of the water body contain fewer organisms, mainly consumers and decomposers (especially bacteria) (Loeb, 1994). Each freshwater habitat contains typical species, which are affected by abiotic factors such as:

- Degree of water movement
- Degree of turbidity
- Temperature
- Oxygen content
- Nature of the bed of the water body

Many lakes, ponds and streams dry up during the dry season. Animals living in such habitats must be able to live through such conditions or they must leave the habitat temporarily and return when the rains come (Levner *et al*., 2005). Some small animals' lay resistant eggs, which hatch when water is present. Small worms and crustaceans form resistant cysts around themselves and tide over the drought (Loeb, 1994). The African lungfish has 'lungs' besides gills, to breathe in air. During the drought, it digs a tunnel in the ground and builds a special cocoon in which it sleeps till the rains come.

With its lungs, it breathes in the air that enters the cocoon from the opening of the tunnel. During this time, it produces urea as a waste product instead of the normal ammonia, which is toxic. The larva of a certain midge (poly pendulum) has a remarkably large tolerance range for drying up. Its body cells lose water during the drought; when the rains come the cells absorb water and the larva becomes active again (Boyd *et al*., 2006).

Lake: A rich variety of living organisms are found in a lake, especially in the littoral zone and the surface waters. These organisms consist mainly of plankton, nektons, green plants and decomposers (Manahan, 2005). Lake animals can be divided into two main groups:

- Those that spend their whole life in water
- Those that only spend their larval stages in water, while the adults live mainly on land and come to the water to breed. Some reptiles and birds visit lakes to feed on aquatic organisms

The lake has a rich plant community, which includes:

- Rooted flowering plants like grasses and sedges that are common along the rim of the lake
- Rooted flowering plants with submerged leaves like *ceratophyllum*, and with floating leaves like the water lilies (*Nymphaea*)
- Free-floating plants such as duckweed, water lettuce, water hyacinth and salvinia, a water-fern

The photosynthetic plankton includes *protists* like diatoms, chlamydomonas and blue-green algae; and green filamentous algae like spirogyra. The latter often forms a thick green floating scum in the littoral zone. The consumer plankton consists mainly of tiny copepods, such as *Cyclops* and *Daphnia* (water flea), and other minute organisms like protozoa, rotifers, hydroids and insect larvae (Loeb, 1994). Many tiny animals in the littoral zone attach themselves on the aquatic plants. These include hydra, water snails, flatworms, tadpoles and insect larvae such as mayfly and dragonfly nymphs. While some, such as snails feed on plants, others like the dragon fly nymphs are carnivorous (Levner *et al*., 2005).

Some animals such as snails, leaches and insect larvae are found in the muddy floor of the lake, especially in the littoral zone. These animals usually burrow in the muddy bed and feed on detritus. The water at this depth has a low concentration of oxygen. As a result, many bottom- dwellers have adaptations for living in oxygen - poor environment (Loeb, 1994). For example, the bloodworm, which is an insect larva, has haemoglobin in its blood, which enables it to take in the oxygen in its environment efficiently. Some bottom dwellers in the shallow waters have long extensible breathing tubes that can reach the water surface to take in atmospheric oxygen (Boyd *et al*., 2006).

The nekton includes both invertebrates and vertebrates. Some insects such as the dragonfly hover over the water surface. Insects like the pond skater and the whirligig beetle live on the water surface, which is like an elastic film. The pond skater has long legs that allow it to glide rapidly on the water film, and the whirligig beetle has eyes that are divided into two halves so that it can see above and below the water surface at the same time (Loeb, 1994). Animals also live just under the water film. These include the mosquito larvae, which attach themselves to the surface film by means of their breathing siphons. The water boatman and giant water bug that also live below the water surface receive oxygen supply in air bubbles that are trapped on their body surfaces (Loeb, 1994).

Adult frogs and toads live on land and visit the lake regularly, especially to breed. Tadpoles are very common organisms found among the vegetation in the shallow waters of the lake (Moustakas and Karakassis, 2005). Besides frogs and toads, vertebrates like terrapins, turtles and water snakes are also found in the littoral zone. Hippopotamuses are a common sight in water holes. The most abundant vertebrates in the lake are the fishes. These include the mouth-breeding tilapia, the reed fish (*Calamoichthys calabaricus*), the lungfish, the nest-building fish, *Heterotis niloticu*s, and the snout fish (Manahan, 2005).

Water birds flock to ponds and feed on annelids, moll uses and fishes. Herons, darters, storks, flamingoes, grebes, lily-trotters, skimmers and African spoonbills are among the lake dwellers. The feet of some, like the grebes, are webbed enabling them to swim, while others like the herons have long legs to help them wade along the banks. The beaks of these birds are shaped to either scoop or spear food. Some water birds build nests on mounds by the reeds; others like the grebes build floating nests (Vaccari, 2005).

River: The types of organisms found in a river are determined by the speed of the water flow (Loeb, 1994). In the pool zone, where water flow is sluggish, the organisms are similar to those found in a lake. In the fast-moving zone, only organisms that have adaptations to cope with the water currents are found. These animals have streamlined flattened bodies that allow them to get under rocks and stones, and thus avoid being swept away (Moustakas and Karakassis, 2005). Some like snails and flatworms use mucous secretions to cling to the substratum, while others like insect larvae and oysters have suckers and hooks for attaching themselves to the substratum. Many fishes and prawns can jump up rapids and swim against the current (Boyd *et al*., 2006).
Some examples of fresh water food chains are:

Seaweed → Limpet → Carnivorous snails
Diatom → Copepod→Barnacle → Carnivorous snails
Diatoms Fish fry →Tilapia → Human
Detritus → Worm →Shrimp → BirdSpirogyra →
Tadpole → Carp → Kingfisher

MARSHES AND SWAMPS

Marshes and swamps are wetlands with vegetation found in temperate and tropical regions (Levner *et al*., 2005). The land is usually covered with shallow standing water or is water logged. The vegetation in marshes is mainly grasses, while that in swamps is mainly trees. Wetlands have vegetation composed of higher plants like most terrestrial habitats. However, part of the vegetation, especially the roots are in water logged soil or ground covered with standing water (Loeb, 1994). As a result, aquatic organisms and terrestrial organisms are common in wetland habitats. Bogs are common wetland in cold climates. There is no standing water in bogs, but the ground is wet and spongy, composed mainly of partially decayed organic matter (Levner *et al*., 2005).

Marshes and swamps may have freshwater, brackish water or seawater. Fresh water marshes and swamps occur in areas where the drainage is poor. These include lowland regions, flood plains of rivers, and river mouths with extensive deltas. They are also formed when ponds and lakes fill up with soil from the surroundings and organic debris from the aquatic organisms that die. This is a very gradual process where an aquatic habitat is transformed to a wetland and finally to a dry terrestrial habitat (Levner *et al*., 2005). A succession of organisms inhabiting the habitat as it undergoes these changes until a stable terrestrial ecosystem is found.

Salt water and brackish water marshes and swamps are usually found in inter tidal areas, which are periodically flooded and drained by the tides. They are especially common along the coastal areas near estuaries and in the basins of big rivers (Loeb, 1994).

Salt marshes form along coastal regions and spread inland with the gradual rising of sea levels. This is a process that takes thousands of years. In regions of heavy rainfall, salt-water marshes progress through brackish water marshes to fresh water marshes. This happens because the grass roots slow down the drainage of rain water.

Marshes and swamps do decay. The flat land and vegetation slow down the flow of water in wetlands. Dead vegetation tends to settle at the bottom instead of being washed away (Manahan , 2005). Decomposers quickly use up the oxygen in the water as they bring about decay. This results in partial decay of organic matter, causing the water to become dark and acidic. Accumulation of partially decayed organic matter results in peat formation. Peat is formed in salt marshes and bogs, especially in cold regions where the low temperature slows down the decay of organic matter. Peat is mined, dried and used as fuel. Coal can be formed from partially decayed vegetation laid down in marshes and swamps (Levner *et al*., 2005).

In fresh water marshes and swamps, the important abiotic factors that organisms have to adapt to include:

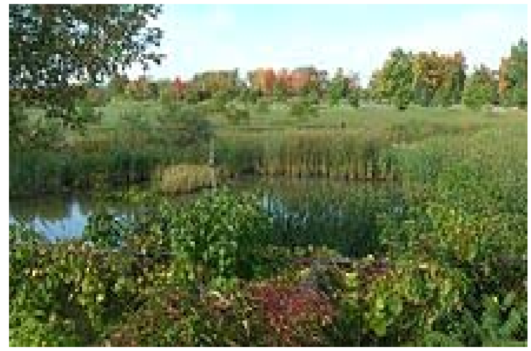


Plate 2 : Atypica marsh, (http//:en.wikimedia.org/wiki/file/ maroon_mash_image.ipg)

- Low oxygen level
- A soft substratum that offers poor support or anchorage

In addition to the above factors, organisms in brackish and saltwater marshes and swamps have to adapt to:

- Wide fluctuations in salinity in brackish water
- High salinity in salt water
- Periodic exposure and flooding due to the ebb and flow of the tide

Marshes: In geography, a marsh (Plate 2), or morass, is a type of wetland that is subject to frequent or continuous flood. Typically the water is shallow and features grasses, rushes, reeds, typhas, sedges, other herbaceous plants, and moss. Woody plants will be low-growing shrubs. A marsh is different from a swamp, which has a greater proportion of open water surface and may be deeper than a marsh. In North America, the term "swamp" is used for wetland dominated by trees rather than grasses and low herbs (Levner *et al*., 2005).

The various types of marshes have a worldwide distribution. Marsh plants include grasses, sedges and reeds or brushes. Papyrus and rice are important tropical freshwater marsh plants. Like aquatic plants, marsh plants have well-developed large interconnecting air spaces in their bodies. These transport air that diffuses in through the leaves to the submerged roots, which are in an oxygen-deficient medium. The air spaces, especially in the central portion of their roots, increase the size of the roots. This helps the roots to anchor in the soft soil (Levner *et al*., 2005).

A variety of invertebrates such as worms, crustaceans, insects and molluscs live in marshes. Most of them are burrowers. Insects are the main land invertebrates that shelter in the plants. The marshes also provide shelter for vertebrates such as frogs, turtles,

Plate 3: A swamp, (http://en. wikipedia.org/wiki/file:BE_swamp.jpg)

snakes, alligators and certain mammals. Aquatic birds like the crested grebe, heron and duck commonly nest and feed in marshes (Loeb, 1994).

Swamps: A swamp (Plate 3) is a wetland with some flooding of large areas of land by shallow bodies of water. A swamp generally has a large number of hammocks, or dry-land protrusions, covered by aquatic vegetation, or vegetation that tolerates periodical inundation. The two main types of swamp are "true" or swamp forests and "transitional" or shrub swamps (Loeb, 1994). The water of a swamp may be fresh water, brackish water or seawater. In North America, swamps are usually regarded as including a large amount of woody vegetation, but elsewhere this may not necessarily apply, such as in African swamps dominated by papyrus (Manahan, 2005). By contrast, a marsh in North America is a wetland without woody vegetation, or elsewhere, a wetland without woody vegetation which is shallower and has less open water surface than a swamp. A mire (or quagmire) is a low-lying wetland of deep, soft soil or mud that sinks underfoot with large algae covering the water's surface.

A common feature of swamps is water stagnation. Swamps are characterized by very slow-moving waters. They are usually associated with adjacent rivers or lakes. In some cases, rivers become swamps for a distance. Swamps are features of areas with very low topographic relief. Swamps were historically often drained to provide additional land for agriculture, and to reduce the threat of diseases born by swamp insects and similar animals. Swamps were generally seen as useless and even dangerous. This practice of swamp draining is nowadays seen as a destruction of a very valuable ecological habitat type of which large tracts have already disappeared in many countries.

Swamps and other wetlands have traditionally held a very low property value compared to fields, prairies, or woodlands (Levner *et al*., 2005). They have a reputation as being unproductive land that can't be easily utilized for human activities, other than perhaps hunting and trapping. Farmers for example typically drained swamps next to their fields so as to gain more land usable for planting crops (Loeb, 1994). Societies now generally understand that swamps are critically important in the processes of providing fresh water and oxygen to all life, and are often breeding grounds for a wide variety of life. Government environmental agencies are taking steps to protect and preserve swamps and other wetlands (Boyd *et al*., 2006).

However, the generally messy nature of swamps, with their diffuse boundaries and lack of enclosure, prevents humans from being able to collect and capitalize on their precious natural resources. Generally swamps are assessed as having low land value even while they are being protected from damage.

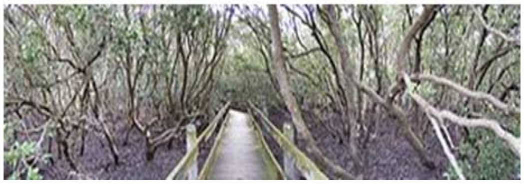
Swamp vegetation may be grouped as:

- Tropical freshwater swamp forests
- Temperate fresh water swamp forest
- Mangrove swamp forest found in tropical coastal and estuarine regions, which receive a high annual rainfall

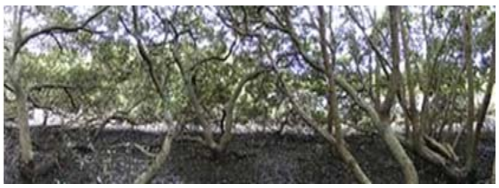
A wide variety of plants and animals live in freshwater swamps. The plant life is rich and includes evergreen trees, ferns, shrubs, vines, mosses, lichens and algae. Animals present include insects, fishes, frogs, crocodiles, snakes, turtles, birds and certain land mammals (Levner *et al*., 2005).

Mangrove swamps (Plate 4 a and b) are forests of small evergreen broad-leaved trees. Common mangrove trees include *Avicennia* (white mangrove), *Rhizophora* (red mangrove), Pandarus (screw pine) and *Raphia*. The mangrove forest shows zonation. The zone closest to the sea consists of trees such as Rh*zophora*. Their roots are covered by the tides most of the time (Levner *et al*., 2005). The muddy substratum is unsettled, allowing only a few type of plants such as the *Rhizophora* which has prop roots to grow. The middle zone consists of Avicennia. The tides cover only the roots, and the substratum is stable. The landward zone consists of *Pandanus* and *Raphia*. The salinity is low in this zone. A great variety of plants are found here (Manahan, 2005).

Most of the animal life in mangrove swamps is associated with the mangrove trees. Polychaete worms, oysters, mussels, barnacles, prawns, shrimps and mudskippers are some of the animals found on the roots of mangrove trees. Burrowing animals like clams, fiddler crabs and bristle worms are common in the muddy substratum. All these animals are similar to those found in estuarine habitats (Loeb, 1994). Animals associated with the parts of the mangrove trees above water include various insects, snakes and aquatic birds such as the kingfisher, sand piper, black tern and skimmer. Other aquatic birds include waders, ducks and herons (Levner *et al*., 2005).



(a)



(b)

Plate 4: Mangrove swamps, (http://en.wikipedia.org/wiki/file:saltpancrk12 &1a.jpg)

Plate 5: Big Spring in Missouri, (http://en.wikipedia.org/wiki/file:big_ spring_missouri_1-02Aug08.jpg)

Plate 6: Unrise at Middle Spring, Fish Springs National Wildlife Refuge (http://en.wikipedia.org/wiki/file:middle.spring.jpg)

The plants and decaying organic matter form the basis of food chains in the various marshes and swamps. Many of the small invertebrates are filter feeders. Birds and fishes are usually the final consumers. Some examples of food chains in wetlands are as follows:

Detritus → Worm→ Wader
Plant → Insect→ Frog→ Alligator

The importance of wetlands cannot be undermined. Wetlands hold large quantities of fresh water and slowly allow it to drain into the ground and replenish supplies of ground water. Without such water hoarding areas, most of the rainwater would run off into rivers and seas, and be lost. Inland marshes and swamps also prevent flooding by holding back the rainwater after heavy rainfall (Levner *et al*., 2005).

Economic products of wetlands include timber, peal, shellfish and fish. Wetlands harbor a wide variety of animal and plant life that cannot grow in other habitats. They are especially important as nesting and feeding areas for waterfowls. Many swamps and marshes are being conserved now in an effort to protect their wildlife and scenic value. Such preserved and well-managed wetlands are important recreational sites that attract many tourists (Loeb, 1994). Above all, these can be developed and used for fish culture.

Spring: A spring (Plate 5) also known as a rising or resurgence is a component of the hydrosphere. Specifically, it is any natural situation where water flows to the surface of the earth from underground (Manahan, 2005). Thus, a spring is a site where the aquifer surface meets the ground surface. Nearly 300 million gallons of water issue from Big Spring in Missouri at a rate of 465 cfs in one day

Formation: A spring may be the result of karsts topography where surface water has infiltrated the Earth's surface (recharge area), becoming part of the area groundwater. The groundwater then travels through a network of cracks and fissures-openings ranging from inter granular spaces to large caves (Loeb, 1994). The water eventually emerges from below the surface, in the form of a spring (Plate 6 and 7).

The forcing of the spring to the surface can be the result of a confined aquifer in which the recharge area of the spring water table rests at a higher elevation than that of the outlet. Spring water forced to the surface by elevated sources are artesian wells. This is possible even if the outlet is in the form of a 300-foot-deep (91 m) cave. In this case the cave is used like a hose by the higher elevated recharge area of groundwater to exit through the lower elevation opening (Levner *et al*., 2005).

Non-artesian springs may simply flow from a higher elevation through the earth to a lower elevation and exit in the form of a spring, using the ground like a drainage pipe (Levner *et al*., 2005). Still other springs are the result of pressure from an underground source in the earth, in the form of volcanic activity (Loeb, 1994). The result can be water at elevated temperature such as a hot spring. The action of the groundwater continually

Plate 7: A natural spring on Mackinac Island in Michigan, (http://en.wikipedia.org/wiki/file:Nacentemackinac.jpg)

Plate 8: A uge sinkhole in Missouri resurfaces at Mammoth Spring in Arkansas, (http://en.wikipedia.org/wiki/file: Grand_Gulf_cave_1-02Aug7.jpg)

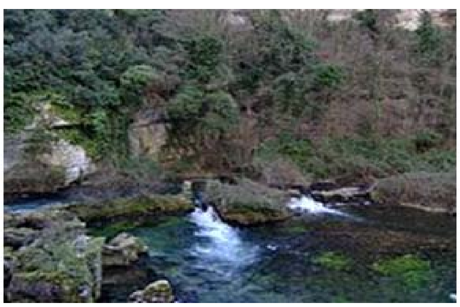


Plate 9: Fontaine de Vaucluse or Spring of Vaucluse in France, (http://en.wikipedia. rg/wiki/file:La_Sorgue_ Fontaine-de-Vaucluse.jpg)

dissolves permeable bedrock such as limestone and dolomite creating vast cave systems.

Types of spring outlets:

Seepage or filtration spring: The term seep refers to springs with small flow rates in which the source water has filtered into permeable earth (Levner *et al*., 2005). Fracture springs, discharge from faults, joints, or fissures in the earth, in which springs have followed a natural course of voids or weaknesses in the bedrock. Tubular springs are essentially water dissolved and created underground channels, basically cave systems (Loeb, 1994).

Flow: The stream flowing into this cave at the bottom of Grand Gulf, a huge sinkhole in Missouri, resurfaces at

Table 1: Spring classification by the volume of the water they discharge

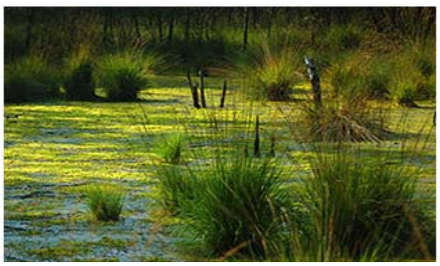
Magnitude	Flow (ft³/s, gal/min, pint/min)	Flow (L/s)
1st magnitude	> 100 ft³/s	2800 L/s
2nd magnitude	10 to 100 ft³/s	280 to 2800 L/s
3rd magnitude	1 to 10 ft³/s	28 to 280 L/s
4th magnitude	100 US gal/min to 1 ft³/s(448 US gal/min)	6.3 to 28 L/s
5th magnitude	10 to 100 gal/min	0.63 to 6.3 L/s
6th magnitude	1 to 10 gal/min	63 to 630 mL/s
7th magnitude	1 pint to 1 gal/min	8 to 63 mL/s
8th magnitude	Less than 1 pint/min	8 mL/s
0 magnitude	no flow (sites of past/historic flow)	

Plate 10: Pruess Lake is entirely spring-fed in the arid Snake Valley (GreatBasin), (http://en.wikipedia. org/wiki/file: PeruessLake.jpg)

Mammoth Spring in Arkansas (Plate 8). Spring discharge, or resurgence, is determined by the spring's recharge basin (Levner *et al*., 2005). Factors that affect the recharge include the size of the area in which groundwater is captured, the amount of precipitation, the size of capture points, and the size of the spring outlet. Water may leak into the underground system from many sources including permeable earth, sinkholes, and losing streams (Manahan, 2005). In some cases entire creeks seemingly disappear as the water sinks into the ground via the stream bed. Grand Gulf State Park in Missouri is an example of an entire creek vanishing into the groundwater system. The water emerges nine miles away, forming some of the discharge of Mammoth Spring in Arkansas. Human activity may also affect a spring's discharge-withdraw of groundwater reduces the water pressure in an aquifer, decreasing the volume of flow (Loeb, 1994).

Classification: Fontaine de Vaucluse or Spring of Vaucluse in France (Plate 9) discharges about 470 million gallons (1.8 billion L) of water per day at a rate of 727 cubic feet (21 m^3) per second. Springs are often classified by the volume of the water they discharge (Levner *et al*., 2005). The largest springs are called "first-magnitude," defined as springs that discharge water at a rate of at least 2800 L or 100 cubic feet (2.8 m^3) of water per second. Some locations contain

Plat 11: Trout fishing on Maramec Spring in Missouri, (http://en.wikipedia.org/wiki/file:Maramec_Spring_fishing_Is.jpg)



(a)

(b)

Plate 12: Bogs, (a) Lütt-Witt Moor, a bog in Henstedt-Ulzburg in Northern Germany, (http://en.wikipedia.org/wiki/file:L%C3%BCtt-Witt_M oor-2.jpg), (b) Viru Bog, located in Lahemaa National Park in northern Estonia, (http://en.wikipedia.org/wiki/file:La_Sorgue,_Fontaine-de-Vaucluse.jpg)

many first-magnitude springs, such as Central Florida where there are 33 known to be that size, the southern Missouri Ozarks (11 known of first-magnitude), and 11 more in the Thousand Springs area along the Snake River in Idaho. The scale for spring flow is as follows (Table 1):

Water content: Pruess Lake (Plate 10) is entirely spring-fed in the arid Snake Valley (Great Basin). Minerals become dissolved in the water as it moves through the underground rocks (Levner *et al*., 2005). This may give the water flavor and even carbon dioxide bubbles, depending on the nature of the geology through which it passes. This is why spring water is often bottled and sold as mineral water, although the term is often the subject of deceptive advertising. Springs that contain significant amounts of minerals are sometimes called 'mineral springs'. Springs that contain large amounts of dissolved sodium salts, mostly sodium carbonate, are called 'soda springs'. Many resorts have developed around mineral springs and are known as spa towns (Manahan, 2005). Water from springs are usually clear. However some springs may be colored by the minerals that are dissolved in the water. Iron and tannins often give spring water an orange color.

A stream carrying the outflow of a spring to a nearby primary stream is called a spring branch or run. Groundwater tends to maintain a relatively long-term average temperature of its aquifer; so flow from a spring may be cooler than a summer day, but remain unfrozen in the winter. The cool water of a spring and its branch may harbor species such as certain trout that are otherwise ill-suited to a warmer local climate (Levner *et al*., 2005).

Historic uses: Springs have been used for a variety of human needs including drinking water, powering of mills, and navigation, and more recently some have been used for electricity generation (Plate 11).

Sacred springs: A sacred spring, or holy well, is a small body of water emerging from underground and revered either in a pagan or a Christian context, often both. The lore and mythology of ancient Greece was replete with sacred and storied springs-notably, the Corycian, Pierian and Castalian. In medieval Europe, holy wells were frequently pagan sacred sites that later became Christianized. The term "holy well" is commonly employed to refer to any water source of limited size (i.e. not a lake or river, but including pools and natural springs and seeps), which has some significance in the folklore of the local are (Manahan, 2005). This can take the form of a particular name, an associated legend, the attribution of healing qualities to the water through the numinous presence of its guardian spirit or Christian saint, or a ceremony or ritual centred on the well site. In Christian legend, the spring water is often said to have been made to flow by the action of a saint, a familiar theme especially in the hagiography of Celtic saints (Levner *et al*., 2005).

Modern uses: Present-day uses include recreational activities, such as trout-fishing, swimming, and floating. The water is also used for livestock and fish hatcheries.

BOG: A bog (Plate 12a and b), quagmire or mire is a wetland that accumulates acidic peat, a deposit of dead plant material-often mosses or, in Arctic climates, lichens (Loeb, 1994). Bogs occur where the water at the ground surface is acidic, either from acidic ground water, or where water is derived entirely from precipitation,

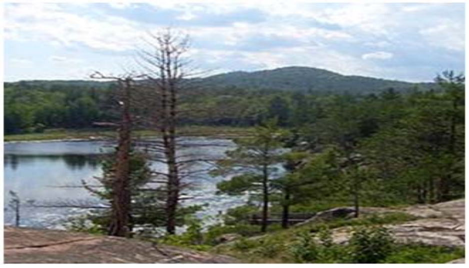


Plate 13: Wetmore pond, located in the Huron Mountain range in the upper Peninsula of Michigan, (http://en.wikipedia.org/wiki/file:Hogback_huron.jpg)

when they are termed ombrotrophic (rain-fed). Water flowing out of bogs has a characteristic brown color, from dissolved peat tannins. Bogs are very sensitive habitats, of high importance for biodiversity (Levner *et al*., 2005).

Distribution and extent: Bogs are widely distributed in cold, temperate climes, mostly in the northern hemisphere (boreal) (Loeb, 1994). The world's largest wetlands are the bogs of the Western Siberian Lowlands in Russia, which cover more than 600,000 square kilometres. Sphagnum bogs were widespread in northern Europe: Ireland was more than 15% bog (Achill Island off Ireland is 87% bog), Scotland, Denmark, Estonia (20% bog lands), Finland (26%), northern Germany, Latvia (10%), the Netherlands, Norway and Sweden. There are extensive bogs in Canada and Alaska (called muskeg) (Manahan, 2005). There are also bogs in Patagonia and the Falkland Islands in the southern hemisphere. Ombrotrophic wetlands (of which bogs are an example) are also found in the tropics, with notable areas documented in Kalimantan; these habitats are forested so would be better called acidic swamps (Levner *et al*., 2005).

Types of bog and formation: Wetmore Pond, located in the Huron Mountain Range in the Upper Peninsula of Michigan (Plate 13), is an example of quaking bog formation. Bog habitats may develop in various situations, depending on the climate and topography (see also hydro sere succession). In the 19th century it was thought that the bog itself somehow 'attracted' the rain that sustained it (Levner *et al*., 2005). The main types are:

(a)

(b)

Plate 14: The trees cover is not typical of bogs, (a) Virgin boreal acid bogs at Brown's Lake Bog, Ohio, (http://en.wikipedia.org/wiki/file:Brown_Lake_OH. jpg), (b) Sphagnum bog vegetation, *Tříjezerní slať*, Šumava, (http://en.wikipedia.org/wiki/file:Raselink.jpg)

Plate 15: Bog Huckleberry at Polly's Cove, Nova Scotia, (http://en.wikipedia.org/wiki/file:BogHBy.jpg)

- **Valley bog:** These develop in gently sloping valleys or hollows. A layer of peat fills the deepest part of the valley, and a stream may run through the surface of the bog. Valley bogs may develop in relatively dry and warm climates, but because they rely on ground or surface water, they only occur on acidic substrates (Levner *et al*., 2005).
- **Raised bog:** These develop from a lake or flat marshy area, over either non-acidic or acidic substrates. Over centuries there is a progression from open lake, to marsh, then fen (or on acidic substrates, valley bog) and Carr, as silt or peat fill the lake. Eventually peat builds up to a level where the land surface is too flat for ground or surface water to reach the center of the wetland (Levner *et al*., 2005). This part therefore becomes wholly rain-fed (ombrotrophic), and the resulting acidic conditions allow the development of bog (even if the substrate is non-acidic) (Loeb, 1994). The bog continues to form peat, and over time a shallow dome of bog peat develops: a raised bog. The dome is typically a few meters high in the center, and is often surrounded by strips of fen or other wetland vegetation at the edges or along stream sides, where ground water can percolate into the wetland (Levner *et al*., 2005).

Plate 16: Bog-wood and boulders at the Stumpy Knowe near South Auchenmade, Ayrshire, Scotland (http://en.wikipedia.org/wiki/file:Bog_oak_and_boulders_at_Stumpy_Knowe.jpg)

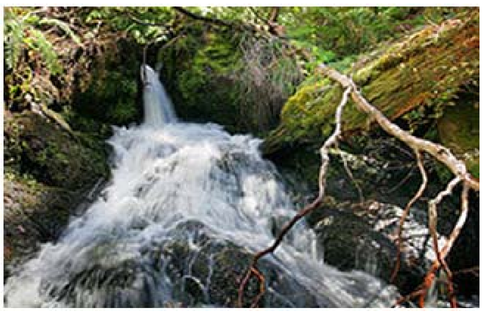


Plate 17: Butchers Creek, Omeo, Victoria, Australia, (http://en.wikipedia.org/wiki/file:Butchers_creek_omeo13.jpg)

- **Blanket bog:** In cool climates with consistently high rainfall, the ground surface may remain waterlogged for much of the time, providing conditions for the development of bog vegetation. In these circumstances bog develops as a layer "blanketing" much of the land, including hilltops and slopes (Manahan, 2005). Although blanket bog is more common on acidic substrates, under some conditions it may also develop on neutral or even alkaline ones, if abundant acidic rainwater predominates over the ground water (Levner *et al*., 2005). Blanket bog cannot occur in drier or warmer climates, because under those conditions hilltops and sloping ground dry out too often for peat to form - in intermediate climates blanket bog may be limited to areas which are shaded from direct sunshine. In peri-glacial climates a patterned form of blanket bog may occur: string bog.
- **Quaking bog:** Quaking bog or schwingmoor is a form of bog occurring in wetter parts of valley bogs and raised bogs, and sometimes around the edges of acidic lakes where bog is beginning to form (Levner *et al*., 2005). The bog vegetation forms a mat half a meter or so thick, floats over water or very wet peat. Walking on this surface causes it to move – larger movements may cause visible ripples of the surface, or they may even make trees sway.

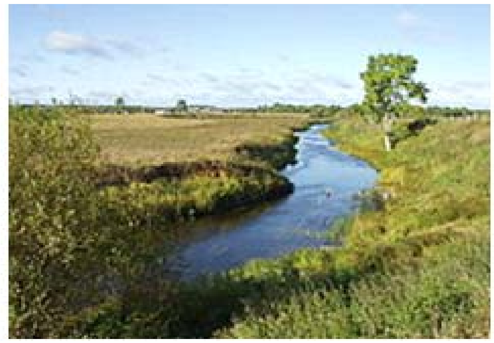


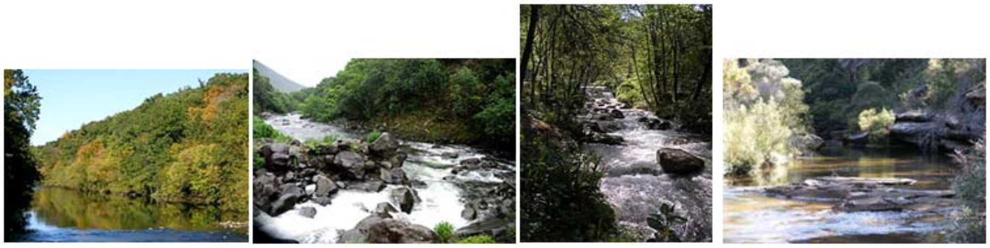
Plate 18: River in Arkhangelsk Oblast, Russia, (http://en.wikipedia.org/wiki/file:Arkhangelskasia_oblast_plesetskiy_Raion.jpg)

Bog habitats: The tree cover is not typical of a bog (Plate 14). There are many highly specialized animals and plants associated with bog habitat. The species restricted to bogs are known as tyrphobionts and species characteristic of bogs but not confined to them are called tyrphophiles (Levner *et al*., 2005). Bogs are recognized as a significant/specific habitat type by a number of governmental and conservation agencies. For example, the United Kingdom in its Biodiversity Action Plan establishes bog habitats as a priority for conservation (Loeb, 1994).

Bogs are challenging environments for plant life because they are very acidic and low in nutrients. Characteristic plants are tolerant of acidic conditions: they include species of Vaccinium and royal fern (*Osmunda regalis*). Carnivorous plants such as sundews (Drosera) and butterworts (Pinguicula) have adapted to the low-nutrient conditions by using invertebrates as a nutrient source (Manahan, 2005). The high acidity of bogs and the absorption of water by sphagnum moss reduce the amount of water available for plants. Some bog plants, such as Leather leaf, have waxy leaves to help retain moisture. Bogs also offer a unique environment for animals. For instance, English bogs give a home to the bog hopper beetle and a yellow fly called the hairy canary fly (*Phaonia jaroschewskii*) (Levner *et al*., 2005).

Uses:

Industrial uses: A bog is a very early stage in the formation of coal deposits. In fact, bogs can catch fire (see Burns Bog, for instance) and often sustain long-lasting smoldering blazes analogous to a coal seam fire, producing smoke and carbon dioxide which can cause health and environmental problems (Loeb, 1994). After drying, peat is used as a fuel. More than 20% of home heat in Ireland comes from peat, and it is also used for fuel in Finland, Scotland, Germany, and Russia. Russia is the leading exporter of peat for fuel at more than 90



a b c d

Plate 19: Various streams and creeks, (a) The Perkiomen Creek in Perkiomenville, Pennsylvania, United States, (http://en.wikipedia.org/wiki/file:Perkiomen_Creek. Jpg), (b) A rocky stream in Hawaii, United States, (http://en.wikipedia.org/wiki/file:Hawaii_Creek. Jpg), (c) Ambro torrent, Italy, (http://en.wikipedia.org/wiki/file:Ambro-creek. Jpg), (d) A creek in Australia, (http://en.wikipedia.org/wiki/file:2007_0731klklk0071.jpg)

million metric tons per year. Ireland's Bord na Móna ("peat board") was one of the first companies to mechanically harvest peat (Levner *et al.*, 2005).

The other major use of dried peat is as a soil amendment (sold as moss peat or sphagnum peat) to increase the soil's capacity to retain moisture and enrich the soil. It is also used as a mulch. Some distilleries, notably Laphroaig, use peat fires to smoke the barley used in making Scotch whisky. More than 90% of the bogs in England have been damaged or destroyed (Boyd *et al*., 2006).

Other uses: Blueberries, cranberries, cloudberries, huckleberries (Plate 15) and lingonberries are harvested from the wild in bogs. Bog oak, wood that has been partially preserved by bogs, has been used in manufacture of furniture. Sphagnum bogs are also used for sport, but this can be damaging (Levner *et al*., 2005). All-terrain vehicles are especially damaging to bogs. Bog snorkeling is popular in England and Wales. Llanwrtyd Wells, the smallest town in Wales, hosts the World Bog Snorkelling Championships. In this event, competitors with mask, snorkel, and scuba fins swim along a trench cut through a peat bog.

Archaeology: The anaerobic environment and presence of tannic acids within bogs can result in the remarkable preservation of organic material. Finds of such material have been made in Denmark, Germany, Ireland and the United Kingdom (Levner *et al*., 2005). Some bogs have preserved ancient oak logs (Plate 16) useful in dendrochronology, and they have yielded extremely well preserved bog bodies, with organs, skin, and hair intact, buried there thousands of years ago after apparent Germanic and Celtic human sacrifice. Excellent examples of such human specimens are Haraldskær Woman and Tollund Man in Denmark, and Lindow man found at Lindow Common in England. At Céide Fields in County Mayo in Ireland, a 5,000 year old neolithic farming landscape has been found preserved under a blanket bog, complete with field walls and hut sites (Loeb, 1994). One ancient artifact found in bogs in many places is bog butter, large masses of fat, usually in wooden containers. These are thought to have been food stores, of both butter and tallow.

Stream: A stream is a body of water with a current, confined within a bed and stream banks. Depending on its locale or certain characteristics, a stream may be referred to as a branch, brook, beck, burn, creek, "crick", gill (occasionally ghyll), kill, lick, rill, river, Skye, bayou, rivulet, stream age, wash, run or rune (Plate 17).Streams are important as conduits in the water cycle, instruments in groundwater recharge, and corridors for fish and wildlife migration (Manahan, 2005). The biological habitat in the immediate vicinity of a stream is called a riparian zone. Given the status of the ongoing Holocene extinction, streams play an important corridor role in connecting fragmented habitats and thus in conserving biodiversity. The study of streams and waterways in general is known as surface hydrology and is a core element of environmental geography (Loeb, 1994).

Types: Streams are of various types:

- **River:** A large natural stream, which may be a waterway (Plate18).
- **Creek:** In North America, Australia and New Zealand, a small to medium sized natural stream (Plate 19). Sometimes navigable by motor craft and may be intermittent. In parts of New England, the UK and India, a tidal inlet, typically in a salt marsh or mangrove swamp, or between enclosed and drained former salt marshes or swamps (e.g. Port Creek separating Portsea Island from the mainland). In these cases, the stream is the tidal stream, the course of the seawater through the creek channel at low and high tide (Loeb, 1994).
- **Tributary:** A contributory stream or a stream which does not reach the sea but joins another river (a parent river). It can also call a branch or fork.

(a)

(b)

Plate 20: Brooks, (a) Wyming Brook in Sheffield, UK, (http://en.wikipedia.org/wiki/file:WymingBrook.Jpg), (b) A brook in the Bay of Fundy, Nova Scotia, Canada, (http://en.wikipedia.org/wiki/file:Brook.Jpg)

- **Brook:** A stream smaller than a creek, especially one that is fed by a spring or seep. It is usually small and easily forded. A brook (Plate 20) is characterized by its shallowness and its bed being composed primarily of rocks.

Parts of a stream:

- **Bar:** A shoal that develops at the mouth of a river as sediment carried by the river is deposited as the current slows or is impeded by wave action. The Temperance River on Lake Superior's north shore is so named because it is one of the few rivers flowing into the lake that does not have a bar at its mouth.
- **Spring:** The point at which, a stream emerges from an underground course through unconsolidated sediments or through caves. A stream can, especially with caves, flow aboveground for part of its course, and underground for part of its course.
- **Source:** The spring from which, the stream originates, or other point of origin of a stream.
- **Headwaters:** The part of a stream or river proximate to its source. The word is most commonly used in the plural where there is no single point source.
- **Confluence:** The point at which the two streams merge. If the two tributaries are of approximately equal size, the confluence may be called a fork.
- **Run:** A somewhat smoothly flowing segment of the stream.
- **Pool:** A segment where the water is deeper and slower moving.
- **Riffle:** A segment where the flow is shallower and more turbulent.
- **Channel:** A depression created by constant erosion that carries the stream's flow.
- **Floodplain:** Lands adjacent to the stream that are subject to flooding when a stream overflows its banks.
- **Stream bed:** The bottom of a stream.
- **Gauging station:** A point of demarcation, along the route of a stream or river, used for reference marking or water monitoring.
- **Thalweg:** The river's longitudinal section, or the line joining the deepest point in the channel at each stage from source to mouth.
- **Wetted perimeter:** The line on which the stream's surface meets the channel walls.
- **Knick point:** The point on a stream's profile where a sudden change in stream gradient occurs.
- **Waterfall or cascade:** The fall of water where the stream goes over a sudden drop called a nick point; some nick points are formed by erosion when water flows over an especially resistant stratum, followed by one less so. The stream expends kinetic energy in "trying" to eliminate the nick point.
- **Mouth:** The point at which the stream discharges, possibly via an estuary or delta, into a static body of water such as a lake or ocean.
- **Sources:** Streams typically derive most of their water from precipitation in the form of rain and snow (Loeb, 1994). Most of this water re-enters the atmosphere by evaporation from soil and water bodies, or by the evapo-transpiration of plants. Some of the water proceeds to sink into the earth by infiltration and becomes groundwater, much of which eventually enters streams (Manahan, 2005). Some precipitated water is temporarily locked up in snow fields and glaciers, to be released later by evaporation or melting. The rest of the water flows off the land as runoff, the proportion of which varies according to many factors, such as wind, humidity, vegetation, rock types, and relief. This runoff starts as a thin film called sheet wash, combined with a network of tiny rills, together constituting sheet runoff; when this water is concentrated in a channel, a stream has its birth.

CHARACTERISTICS

Ranking: To qualify as a stream it must be either recurring or perennial. Recurring streams have water in the channel for at least part of the year. A stream of the first order is a stream which does not have any other

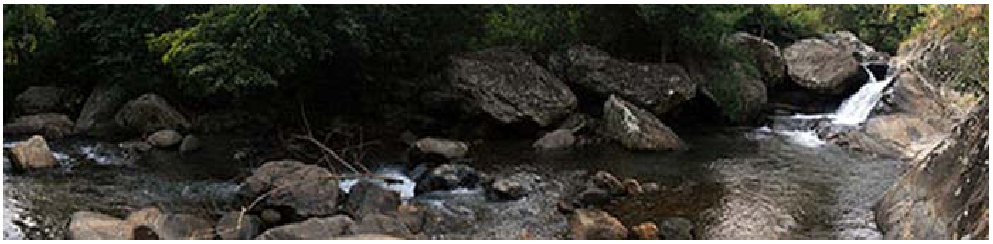


Plate 21: A tributary on the Uluguru Mountains which joins to the River Ruvu, (http://en.wikipedia.org/wiki/file:Waterfall_ Bahati_Camp_ Uluguru_Morogoro.jpg)

Plate 22: An Australian creek, low in the dry season, carrying little water, (http://en.wikipedia.org/wiki/file:Low_ creek.jpg)

stream feeding into it. When two first-order streams come together, they form a second-order stream (Loeb, 1994). When two second-order streams come together, they form a third-order stream. Streams of lower order joining a higher order stream do not change the order of the higher stream (Plate 21). Thus, if a first-order stream joins a second-order stream, it remains a second-order stream. It is not until a second-order stream combines with another second-order stream that it becomes a third-order stream (Levner *et al*., 2005).

Gradient: The gradient of a stream is a critical factor in determining its character and is entirely determined by its base level of erosion. The base level of erosion is the point at which the stream either enters the ocean, a lake or pond, or enters a stretch in which it has a much lower gradient, and may be specifically applied to any particular stretch of a stream (Boyd *et al*., 2006).

In geologic terms, the stream will erode down through its bed to achieve the base level of erosion throughout its course. If this base level is low, then the stream will rapidly cut through underlying strata and have a steep gradient, and if the base level is relatively high, then the stream will form a flood plain and meander.

Meander: Meanders are looping changes of direction of a stream caused by the erosion and deposition of bank materials. These are typically serpentine in form. Typically, over time the meanders gradually migrate downstream (Manahan, 2005). If some resistant material slows or stops the downstream movement of a meander, a stream may erode through the neck between two legs of a meander to become temporarily straighter, leaving behind an arc-shaped body of water termed an oxbow lake or bayou. A flood may also cause a meander to be cut through in this way (Loeb, 1994).

Profile: Typically, streams are said to have a particular profile, beginning with steep gradients, no flood plain, and little shifting of channels, eventually evolving into streams with low gradients, wide flood plains, and extensive meanders. The initial stage is sometimes termed a "young" or "immature" stream, and the later state a "mature" or "old" stream. However, a stream may meander for some distance before falling into a "young" stream condition.

Intermittent and ephemeral streams: A perennial stream (Plate 22) is one which flows continuously all year. In the United States, an intermittent or seasonal stream is one that only flows for part of the year and is marked on topographic maps with a line of blue dashes and dots. A wash or desert wash is normally a dry streambed in the deserts of the American Southwest which flows only after significant rainfall (Boyd *et al*., 2006). Washes can fill up quickly during rains, and there may be a sudden torrent of water after a thunderstorm begins upstream, such as during monsoonal conditions.

These flash floods often catch travelers by surprise. An intermittent stream can also be called an arroyo in Latin America, a winterbourne in Britain, or a wadi in the Arabic-speaking world (Levner *et al*., 2005).

In Italy an intermittent stream is termed a torrent (Italian torrente). In full flood the stream may or may not be "torrential" in the dramatic sense of the word, but there will be one or more seasons in which the flow is reduced to a trickle or less. Typically torrents have Apennine rather than Alpine sources, and in the summer they are fed by little precipitation and no melting snow. In this case the maximum discharge will be during the spring and autumn. However there are also glacial torrents with a different seasonal regime (Loeb, 1994).

The energetic flow of the stream had, in flood, moved finer sediment further downstream. There is a pool to lower right and a riffle to upper left of the photograph.
A blue-line stream is one which flows for most or all of the year and is marked on topographic maps with a solid blue line (Levner *et al*., 2005). In Australia, an intermittent stream is usually called a creek and marked on topographic maps with a solid blue line. Generally, streams that flow only during and immediately after precipitation are termed ephemeral. There is no clear demarcation between surface runoff and an ephemeral stream (Manahan, 2005).

Drainage basins: The extent of land basin drained by a stream is termed its drainage basin (also known in North America as the watershed and, in British English, as a catchment). A basin may also be composed of smaller basins. For instance, the Continental Divide in North America divides the mainly easterly-draining Atlantic Ocean and Arctic Ocean basins from the largely westerly-flowing Pacific Ocean basin (Loeb, 1994). The Atlantic Ocean basin, however, may be further subdivided into the Atlantic Ocean and Gulf of Mexico drainages. (This delineation is termed the Eastern Continental Divide) Similarly, the Gulf of Mexico basin may be divided into the Mississippi River basin and several smaller basins, such as the Tombigbee River basin. Continuing in this vein, a component of the Mississippi River basin is the Ohio River basin, which in turn includes the Kentucky River basin, and so forth (Levner *et al.*, 2005).

CONCLUSION

Biotic characteristics, marine, estuarine and fresh water habitats, lakes, rivers, marshes, swamps, Springs: formation, types offspring outlets, flow, classification, water content, historic uses, sacred springs, modern uses, bogs: extent, types of bog and formation; streams: types of stream, parts of stream, source of stream, characteristics of stream, intermittent and ephemeral streams and drainage basins are aspect some water systems and the fish pond ecosystem are aspects of fish pond hydrology the fish culturist need to know for effective culture fisheries management and practices.

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