The Forest & Wood

Forest is the name for a considerable stretch of terrain covered with trees. Scientifically, however, it has a greater meaning than a simple collection of trees, as it is a question of a real vegetal society in which each individual fights of space, light and food, influencing its neighbours, in many ways. In the midst of this society, there are also epiphytic plants, bushes, grasses, mosses and other plants. The virgin forest represents the serenity of natural forces: it is balanced nature. Within it, trees of all ages and sizes live together, more or less mixed.

Like an independent being, the tree grows, reproduces and dies to make away for others. The annual growth of the whole is the same as its decrease by degeneration. However, it is only with difficulty that the forest escapes from the devastating effects of the elements. Sometimes there are hurricanes, which leave their mark on the mass of trees; other times there are fires, caused by lightning in some corner of the forest and which spread and devastate whole areas, and finally, of course, there are insects which attack and decimate the arboreal hosts. Nature repairs such devastation and repopulates the clearings with new individuals, which, although sometimes of different composition, finally take on character and irregular form of their predecessors.

With man comes a new agent of destruction for the forest. His methods of exploitation in recently discovered regions are brutal, as he only seeks to satisfy immediate needs, without a thought for the conservation of the forest. He is frequently guilty of causing fires, which seems to worry him very little. In any case, the vegetation gradually grows back if any seeds remain, and its development will not have been disturbed by the fire. However, the flames often continue their destruction.

In damp regions, the trees grow in dense masses which not even the sun manages to penetrate. In semi-arid areas, the vegetation is sparser, so that in many cases, the crowns of the trees do not even touch.

We can distinguish the following as types of characteristic forests or several categories of forest:

1) Tropical forest, also called virgin forest; its vegetation is perpetually

green and the trees often grow to a height of 40 or 50 metres, among which there are a lot of lianas and epiphytes.

2) The monsoon forest, characteristic of South East Asia with thick but intermittent vegetation, for when the dry season comes, it stops growing and the leaves fall.
3) The summer forest, native to mild climates, if it consists of a single type, it is normally known by that name, e.g., pine woods, oak or chestnut groves, etc. The leaves fall in winter.
4) Scrub or undergrowth is found in the area immediately below, in warm countries. In this type, bushes and xerophilous ligneous bushes predominate with deep roots and coriaceous leaves, like broom and thyme. This type of forest is also known as scrub and the land appears more or less covered by undergrowth bushes, beneath which a layer of hummus is formed, a vitally important material in the preservation of the ground, as it frees it from the catastrophic effects of erosion.

Humidity and atmospheric temperature conditions are of primordial importance for the forest's existence. The lack of humidity is responsible for the wide unwooded interior expanses in every continent, while low temperatures prevent the development of forests in septentrional latitude or at great altitude. Areas of high humidity have an almost uninterrupted covering of forest: here, clearings only appear due to adverse ground conditions or the action of destructive agents, such as fire, wind, or insects.

Different climate conditions and areas produce arboreal species which differ in size, wood, form, type, quantity and products. Where temperature and humidity conditions are more favourable, there will be a greater variety of species. Conversely, there will be fewer in the mountains and high latitudes. Conifers predominate in cold climates and semi-arid regions. Around the equator, and in sufficiently damp places, the number of species increases and the conifers decrease or completely disappear. In large, mild zones, the forests are made up of types of wood and conifers, with a predomination of one or the other depending on the local condition. In the tropics, and wherever there is heavy rain, the hard and leafy varieties develop differently and profusely.

Forests render countless services to man, directly or indirectly. Directly, they provide him with fundamental raw materials for the development of his existence: fruit, wood, coal, cellulose, alcohol, acetone, resins, essences, tannin, colourings, starches, waxes, cork, etc.

And, indirectly, they serve as indispensable regulators of the necessary climatic conditions for the development of agriculture and even for

Desert Ecosystem Structure and Function (I)

The phrase 'ecosystem structure and function' is frequently used in ecology, but its meaning, as used by different ecologists, is rather vague or at least ambiguous. It may be possible to distinguish two main interpretations: *sensu lato* and *sensu stricto* (Noy-Meir, 1980).

In the widest sense, 'ecosystem structure and function' is a description of that part of nature which has been defined as 'the ecosystem', the subject of study. Odum (1962) has listed three elements of structure: 1) composition of the biological community, 2) quantity and distribution of abiotic materials, and 3) range of physical conditions, and three elements of function: 1) energy flows, 2) nutrient flows and cycling, and 3) ecological regulation, both of organisms by environment and of environment by organisms. Thus, 'structure' refers to the static aspects, and 'function' to the dynamic aspects in a description of the ecosystem.

In a narrower, more specific sense, 'ecosystem structure and function' is understood to refer to those aspects which appear only at the level of the ecosystem, rather than its components–in particular those biological interactions and regulatory feedbacks which tie the system together and cause it to behave as a recognizable integrated system rather than as a collection of independent populations. This implicitly assumes that there is such a network of interactions and feedbacks connecting all species in a pattern which is consistent in time and space–the ecosystem. To discover the patterns of causal networks which are characteristic of hot deserts is then the meaning of elucidating their ecosystem structure and function.

Energy Flow

Primary Production

Productivity and Biomass Are Low. It is certainly true that the lowest extremes of plant biomass and productivity occur in deserts, and that, on the average, desert ecosystems are in these respects below most other ecosystems. However, at certain times and places, deserts show high levels of productivity and biomass that are well within the range of temperate and tropical grasslands, shrublands and woodlands.

Productivity Is Highly Variable and Highly Correlated With Rainfall. Plant productivity in most desert regions is extremely variable between years and between places, ranging from zero to several hundreds of grams per square meter. The main reason is the variability in time and space in rainfall, or more precisely in the effective water input to the root zone. A strong positive and nearly linear correlation between plant production (or biomass) and rainfall (or water input, or actual evapotranspiration) has often been reported in arid zones, over years at the same site, and over sites in the same region, landform and vegetation (Walter, 1962; Seely, 1978a; Breman et al., 1980; Rutherford, 1980; Zaban, 1981). A significant positive linear correlation is usually found also when sites with different desert vegetation and from different desert regions are compared, but deviations from the regression are considerable (see, for instance, Rosenzweig, 1968; Whittaker, 1970; Lieth, 1975; and Le Houérou and Hoste, 1977). ●

Thus, the ratio of primary production to rainfall (P/R), or the slope dP/dR (the 'marginal productivity' per additional unit of rainfall) may be a better parameter for characterizing and comparing different arid regions and vegetation types than the mean or range of primary productivity proper.

The range in which the slope of P against R is constant can be interpreted as the range where water is the main limiting factor for plant growth. Where, at higher rainfall, other factors (nutrients, light) also become scarce, the increase of P with R becomes more gradual and eventually may reach a plateau.

The P/R ratio depends on two main variables: the proportion of the rainfall water which is actually transpired by the plant community (T/R), the remainder being lost mainly by evaporation from the soil; and the productivity per unit water transpired (*P/T*), the 'water-use efficiency'.

The physical and physiological factors involved in determining water use efficiency in arid and semi-arid zones have been thoroughly discussed by Fischer and Turner (1978).

Consumption and Secondary Production

Utilization Efficiency of Plant Production by Herbivores Is Low. Theoretically, it may be expected that herbivores are able to utilize only a small proportion of plant production in deserts, because most herbivore populations cannot respond fast enough to the large and rapid variations in available plant biomass and water. Indeed low utilization of total biomass and of vegetative shoot biomass by herbivores (2-10%) has been reported in desert ecosystems (Chew and Chew, 1970; Soholt, 1973; Mispagel, 1978). Many other terrestrial ecosystems without domestic herbivores show similarly low values, perhaps for different reasons. On the other hand, a large proportion of seed production in deserts and semi-arid regions (up to 90-95%) may be taken by granivores (ants, rodents and birds) (Chew and Chew, 1970; Soholt, 1973). Thus, the overall proportion of plant production which is consumed by herbivores and granivores probably depends strongly on the mean reproductive effort (percent of production directed to seeds) of the plant community, and on the abundance of granivores. Both factors vary widely between deserts. As with previous parameters of community energy flow (production/rainfall, production/biomass, root/shoot), it seems that the consumption/production ratio is related mainly to the life-form spectrum of plants and animals in the community. Since the ecosystems classified as 'deserts' are quite variable in this respect, it is not clear whether there is any definite trend in utilization between them and less arid biomes.

Crops need to be adapted to the area. Many experiment stations evaluate common crop hybrid and variety performance annually. Best-adapted varieties commonly outyield poorer ones by 50% to 75% or more (Walters, 1978). Farming and ranching success is not assured even by efficient water use. Several drought years often succeed one another in dry land areas and reduce current production and income below that necessary to meet even minimum living requirements and farm expenses. Accordingly, dry land farmers must accumulate reserves during favorable years.

Farmers with livestock face additional difficult problems. Water supplies in some areas are adequate in favorable years but deficient in dry periods. In other areas, water is a perennial problem. Extra effort to obtain and store water is needed. Deeper wells may solve the problem, or ponds and dugouts to store runoff water and snowmelt may help. Reserve feed is more difficult and often more expensive to accumulate and store, specially in hotter climatic areas. Planting a crop on a fallowed field each year specifically for animal forage has much to commend it in the higher latitudes of temperate regions where summer fallow is common. This is specially true if cereal grains are used that can be harvested as grain if not needed for forage.

Drought continued for four to seven consecutive years in parts of the Great Plains and Canadian Prairies during the 1930s and 1950s. This suggests that the best livestock venture for a dry land farm is one that can be cut back quickly when a drought occurs and can be built up speedily when more normal weather returns.

Interception

Vegetation intercepts and holds some rain during each storm. This water evaporates into the air without ever touching the ground, but it has little effect on water availability for crop use, because the energy used to evaporate free water from the surface of plants is not available to evaporate water from the plant or from the soil.

Runoff

Some of the rain that penetrates the vegetative canopy runs off the land instead of soaking into the soil. Runoff from individual sites ranges from zero on highly permeable, level, and vegetated soils to over 75% of the rain on impermeable, steeply sloping, poorly vegetated sites. Runoff from watersheds (including both surface runoff and subsurface flow) in the continental United States ranges from more than 50% in some humid areas to less than 5% in the dry lands. Runoff is affected by the soil properties, rainfall intensity, soil configuration, and vegetative cover.

Coarse-textured and well-aggregated soils have high infiltration rates; fine-textured, poorly aggregated soils have low infiltration rates. Runoff rates are therefore higher from fine-textured, poorly aggregated soils than from coarse-textured or well-aggregated soils. Infiltration rates are usually higher at the beginning of a storm, when the soil is dry, but they drop off quickly as the soils become wet.

Increasing slope gradient increases the amount and velocity of runoff; surface soil depressions hold water and permit local water, and even runoff from other areas, to be absorbed. Vegetation, both living plants and dead crop residues, reduces the number of raindrops that hit the soil directly. This reduces soil compaction and helps keep the infiltration rate high.

Evaporation

A saturated soil loses water by evaporation as fast as a free water surface. Soil water evaporates whenever the relative humidity is less than 100%. Losses by evaporation often exceed 50% of the annual rainfall in dry land areas. Hot areas have greater evaporation losses than cold areas. The world's dry lands with their low relative humidities and high wind velocities lose a larger proportion of rainfall by evaporation than do humid regions. Dark-colored soils absorb more heat than light soils, so they are hotter and lose more water by evaporation. When the surface soil is dry, evaporation is reduced to the rate that water vapor moves upward through the dry layer. South-facing slopes in the northern hemisphere are warmer and have higher evaporation rates than north-facing slopes. Living and dead vegetation reduces evaporation, because it acts as an insulator to heat change and a barrier to wind.

Understanding Your Watershed (I)

Watershed Management

This phrase evokes a variety of images for citizens, urban planners and environmentalists. For some, it suggests a picture of volunteers monitoring water quality from their canoes; for others, an image of the department of public works installing catch basins. Some may hear it as a call for new open spaces in the community, or perhaps it simply conjures up the joy of children swimming and playing in a nearby lake.

Given that watershed management means different things to different people, is it possible to coordinate efforts so that the result is satisfactory to everyone? Absolutely! But it takes knowledge and cooperation to achieve this goal. The good news is this: a fundamental understanding of natural resources and watershed management processes is usually all it takes for locally-based decision to produce the desired results.

As its title suggests, this unit focuses on a watershed management approach to urban runoff. Though urban runoff is not the only source of water pollution, it may be the most important one for local decision makers. Federal regulations have addressed industrial and other point source pollution, but urban runoff is a diffuse source that community and environmental planners must focus on across jurisdictional lines.

The effects of urban runoff help citizens realize that actions at one site can affect other areas and remediation may require the cooperation and support of multiple jurisdictions. It quickly becomes apparent to anyone who studies urban runoff that meeting its complex challenge requires accurate knowledge about the sources of environmental stressors and their impacts; the ability to project future outcomes under different scenarios; and a method for selecting priorities.

Knowledge of current technologies is important, but cannot be used unless it is accurately grounded. In practice, our plans must be constantly revised as the process evolves and produces new data.

As natural resource stewards, you need to understand the interdependent relationships of elements that affect our natural resources. The long-term viability and quality of our environment depend on dynamic and complex interactions among air, water, land, plants, animals, and culture. Water is particularly significant, because it constitutes 70% of our environment. Its presence or absence can profoundly influence other resources. Thus, a good basis for managing natural resources is to understand the water environment. Some important elements include the hydrological cycle, the watershed, and the factors that influence watershed health.

The Hydrologic Cycle

Water moves through the environment in a pattern known as the hydrologic cycle. Through a process including evaporation, transpiration, and condensation, surface waters become clouds, which, in turn, release their contents as rain or snow. This precipitation will dissipate through several different routes once it reaches the ground. Initially some of the water will be absorbed into the topsoil. Once the topsoil has absorbed the maximum amount of water it can hold, the excess may infiltrate into the underlying groundwater. In addition, the water may begin to run off the land as surface flow, following the forces of gravity. The runoff will eventually find its way back into the surface waters. The hydrologic cycle is shown in Fig. 8-1.

The hydrologic cycle, in combination with other natural cycles, forms a complex system within distinct areas of the landscape called watersheds. A watershed is an area above and below the landscape that drains to an associated water resource such as a wetland, river, lake, aquifer, or estuary. Watersheds can contain numerous tributaries and ponding areas. A practical approach to water management is based on the watershed as the fundamental organizing unit.

Factors Influencing Watershed Health

Four primary factors affect the quality and function of resources in the watershed:

- water quality;
- flow regime;
- habitat (structure and function); and
- energy source.

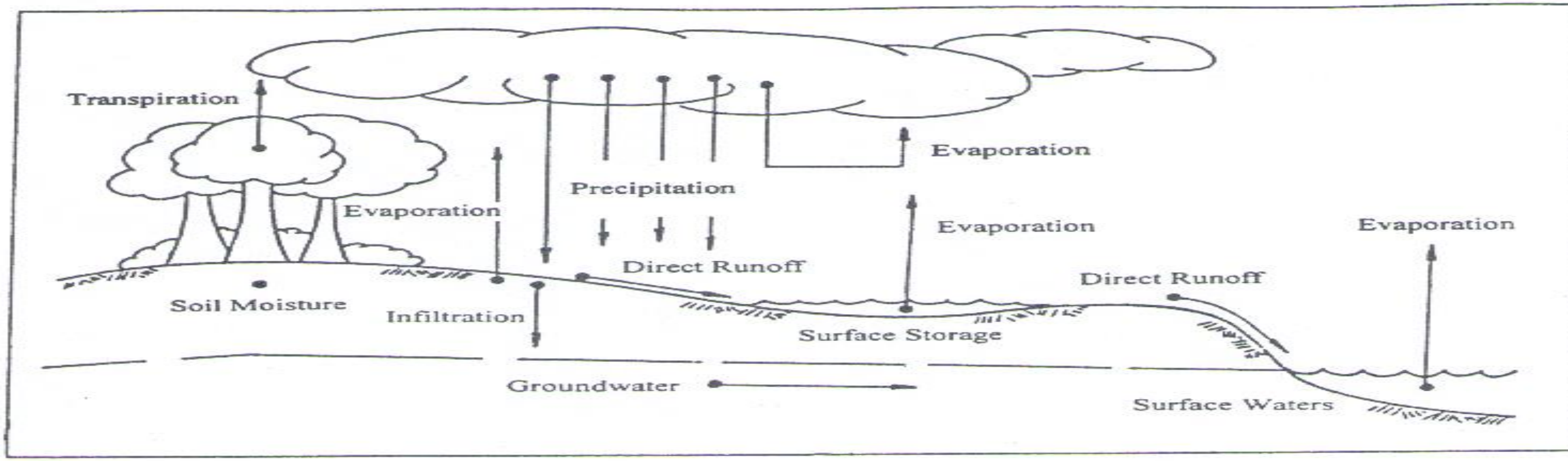

Fig. 8-1. The hydrologic cycle.(Source: J. J. Skupien, in Horner et al., 1994)

These factors act independently and interdependently to influence the overall health and viability of the water resource. Influences or stress on a single factor can elicit change in another. This process is illustrated in Fig. 8-2.

1. The term 'water quality' refers to the physical and chemical characteristics of the water; it includes temperature, turbidity, dissolved oxygen nutrients, pH, and the possible presence of organic and inorganic chemicals, heavy metals, and toxic substances.

2. 'Flow regime' includes water volume, temporal distribution of floods and low flows, and water velocity.

3. Aquatic and nearshore habitat structure includes substrate, water depth, current velocity, spawning and nursery places, riparian stability, and habitat diversity.

4. Energy sources include the organic material entering a water resource from the banks and upland areas, commonly referred to as the riparian zone: the process of photosynthesis, and the seasonal pattern of available energy from sunlight.

Some resource managers and scientists include the communities of living beings–the biota–in the watershed as a fifth environmental factor or indicator of resource conditions; and you will sometimes refer to biological

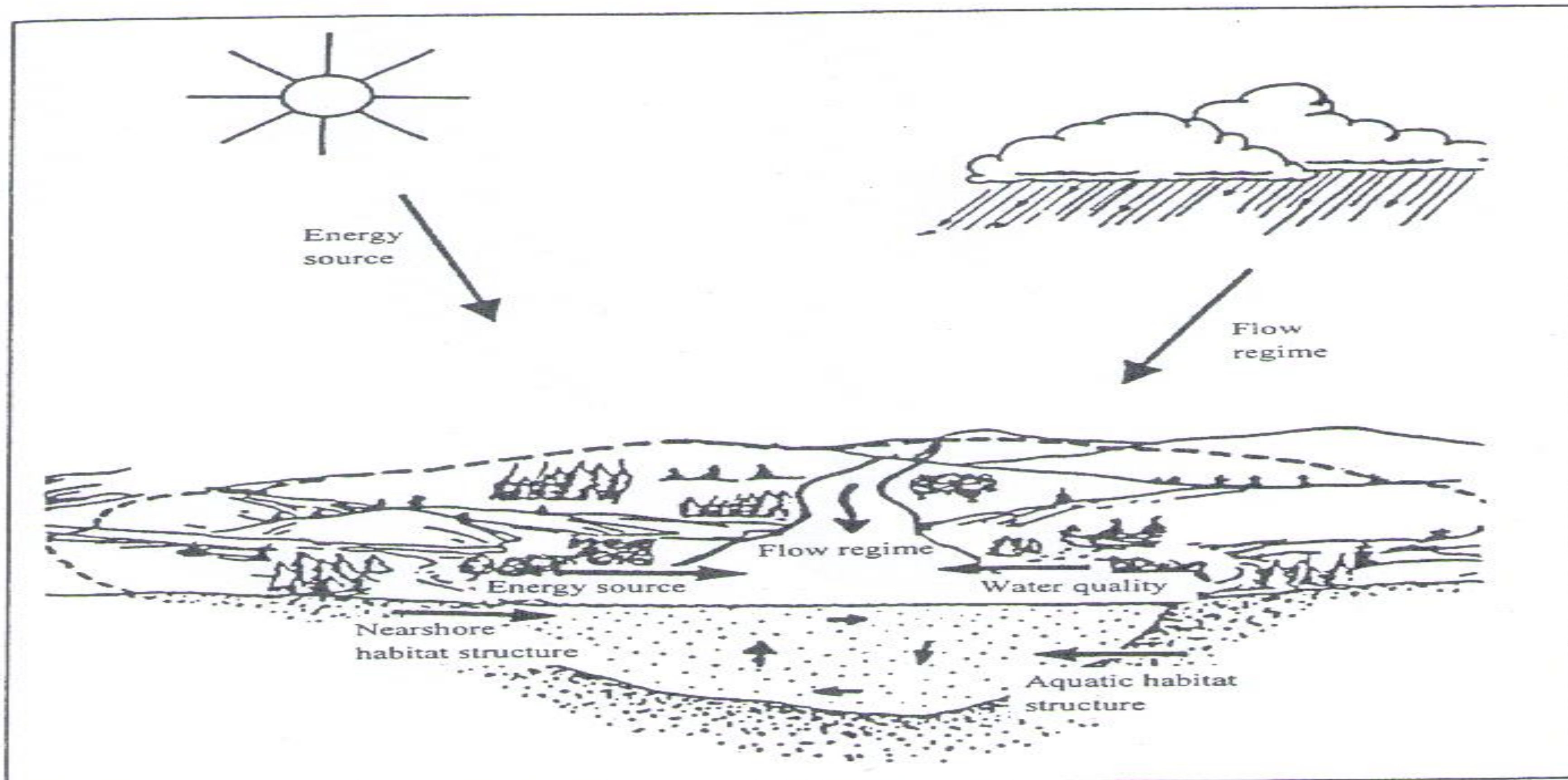

Fig. 8-2. Factors affecting watershed health.

Understanding Your Watershed (II)

Water Quality

Water quality is impaired by land uses that contribute pollutants to groundwater or runoff. The following conditions adversely affect water quality:

- elevated nutrient inputs;
- too many solids, such as sediment;
- pathogens;
- toxic substances, such as heavy metals, pesticides, oil, road salt, and synthetic organic chemicals;
- elevated levels of organic matter;
- litter and rubbish along streambanks;
- lower levels of dissolved oxygen; and
- alterations in stream temperature.

Nutrients

Contaminants. Phosphorus and nitrogen.

Sources. Septic systems (sewage, detergents), agricultural runoff (fertilizers, animal waste), urban landscape runoff (fertilizers, detergents, plant debris), and atmospheric deposition (wet and dry).

Effects. Phosphorus is typically the primary nutrient of concern in freshwater systems, while nitrogen is associated with saltwater systems. These nutrients encourage algal growth that can contribute to greater turbidity and lower dissolved oxygen concentrations. Lower dissolved oxygen can cause the release of other substances (pollutants) into the water column. Higher levels of nitrogen (nitrates) in groundwater are most commonly associated with agricultural practices and malfunctioning septic systems.

Impacts. Elevated nutrient inputs can limit recreational values (swimming, boating, and fishing), contribute to eutrophication, reduce animal habitat, lower dissolved oxygen levels, and contaminate water supplies.

Solids

Contaminants. Sediment (clean and contaminated) and floatable wastes. Solids may be suspended in water or deposited.

Sources. Construction sites, agricultural lands, harvested or converted forest lands, and other disturbed or nonvegetated lands, including eroding streambanks. Floatable wastes are contributed from street litter and careless disposal practices on land and water.

Effects. Increased turbidity and sediment deposits.

Impacts. When deposited, clean sediment can decrease storage capacity in waterbodies, alter flow paths, destroy benthic habitat (including animal nesting and spawning areas), and smother benthic organisms. Suspended solids can decrease transmission of light through water and interfere with animal respiration and digestion. Contaminated sediment acts as a reservoir for particulate forms of pollutants, such as organic matter, phosphorus, or metals that can be released later. These pollutants can be toxic, or they can decrease dissolved oxygen levels through the process of sediment oxygen demand (SOD). Floatable wastes reduce the aesthetic value of the resource and cause clogging.

Flow Regime

The watershed's 'flow regime' is determined by the site's physical characteristics, such as the amount of impervious and vegetative cover, and slope characteristics. In addition, drainage devices such as gutters and pipes can affect the flow of water in the area. Changes in any of these factors can have the following results:

- an increased *velocity* of runoff, which may also increase the frequency and severity of flooding, accelerate channel erosion both locally and downstream, contribute to sedimentation, and alter streambed composition;
- an increased *volume* of runoff, which, when combined with higher velocity, can accelerate the rate of channel erosion and changes in streambed composition; destroy animal habitat and disrupt stream ecology; or
- reduced *infiltration* into the ground, commonly called a decrease in

base flow. Less infiltration decreases groundwater recharge, which may, in turn, lower the level of surface water in the surrounding lakes, streams, and wetlands.

Energy Sources

The energy sources within the watershed depend on two processes: photosynthesis (the conversion of light energy to chemical energy) and metabolism (the use of chemical energy to sustain life forms). Photosynthesis takes place in plants; metabolism occurs in all living things. These processes are disrupted when light energy is not effectively transmitted, or when chemical energy in the form of organic materials and nutrients is not present in sufficient quantities to sustain the food web.

A good basis for managing natural resources is to understand the water environment: the hydrologic cycle, the watershed, and the factors that influence watershed health.

In lakes, streams, and wetlands, certain areas (submerged areas, banks, and upland areas) contain natural vegetation that provides food in the form of organic materials and nutrients. These waterbodies also contain nutrient sources in the form of algae and small organisms called plankton. Organisms within the food web ingest these materials and in the process release proteins, sugars, and minerals into the water. The resulting debris, organic

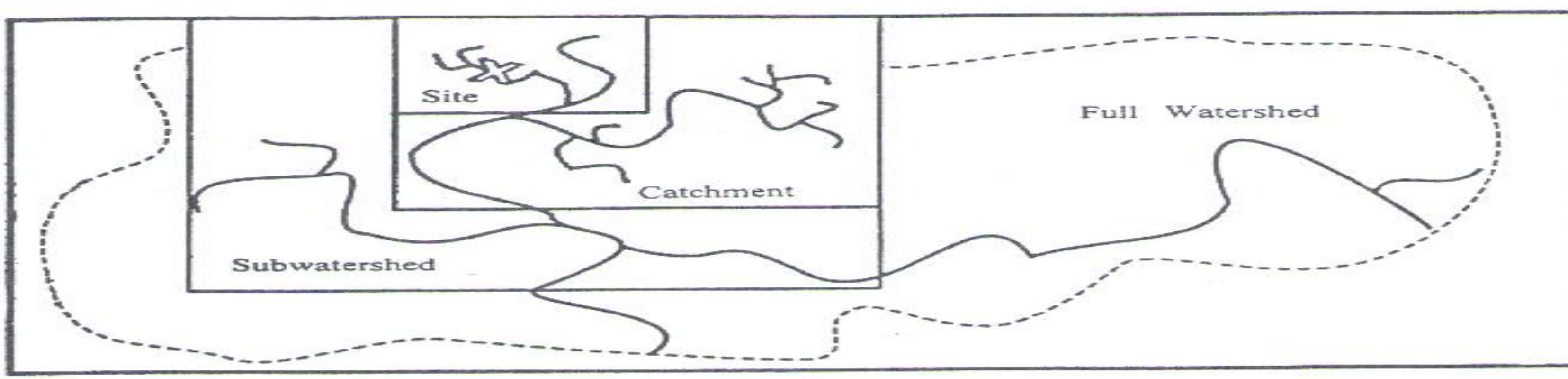

Fig. 8-3. Relationship of site to watershed.

materials, and nutrients create the detritus on which other organisms live and multiply.

Thus, the food web depends on maintaining a sufficient supply of energy in the system. Changes to the energy sources within a system may have serious consequences:

- food scarcity;
- genetic deterioration of fish and animal species;
- invertebrate deficits; and
- plant and animal species redistribution.

Considerations of Scale in Watershed Management

As you consider increased development or other land use changes within the watershed, remember that each modification can influence one or more of these factors: water quality, flow regime habitat structure and function, and energy. The magnitude of the effects will generally be determined by the type of change proposed (perhaps a new use), the permanence of the change, and its location relative to the resource area.

These considerations are specially important to site planning, which tends to occur on a very limited scale. Frequently, as different parts of the watershed are affected by a change, the influence of the change on the four factors increases to the point at which permanent degradation may occur. As decision makers, you must consider the potential, cumulative effect of small, incremental developments.

Keep in mind that the small changes involved in site planning can affect the entire watershed. Fig. 8-3 shows the relationship of the site to the larger catchment area, to the still larger subwatershed, and finally to the full watershed.

Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

.... 1. Water quality is damaged by land uses that contribute pollutants to groundwater or runoff.

.... 2. Phosphorus and nitrogen discourage algal growth that can con-

Use of Geographic Information Systems

Many definitions have been developed to describe Geographic Information Systems (GIS), but basically GIS is a computerized, integrated system used to compile and store spatial and attribute data (i.e. the mass of information about a certain point or place). By manipulating the GIS, you can produce a series of maps. For example, your town's drinking water well is located in a particular place such as 12 Central Street (a spatial datum), and pumps 20,000 gallons per day to 100 people (attribute datum). The GIS replaces map files, display tables, colored pencils, and tax assessors' books with computerized versions of this information.

What does a GIS do for you? It allows you to display information as geographically referenced maps.

Using computer modeling techniques, planners can manipulate variables such as water levels, land uses and the effects of management techniques to estimate impacts under different scenarios. Fig. 9-9 shows how the data are compiled. The information is contained in layers and the layers are then combined in various ways to display the information you want.

At first, GIS was used by only a small group of researchers; now it is used to help model all kinds of community decisions–public safety, traffic flow, environmental resources and various other enterprises that have a geographic component.

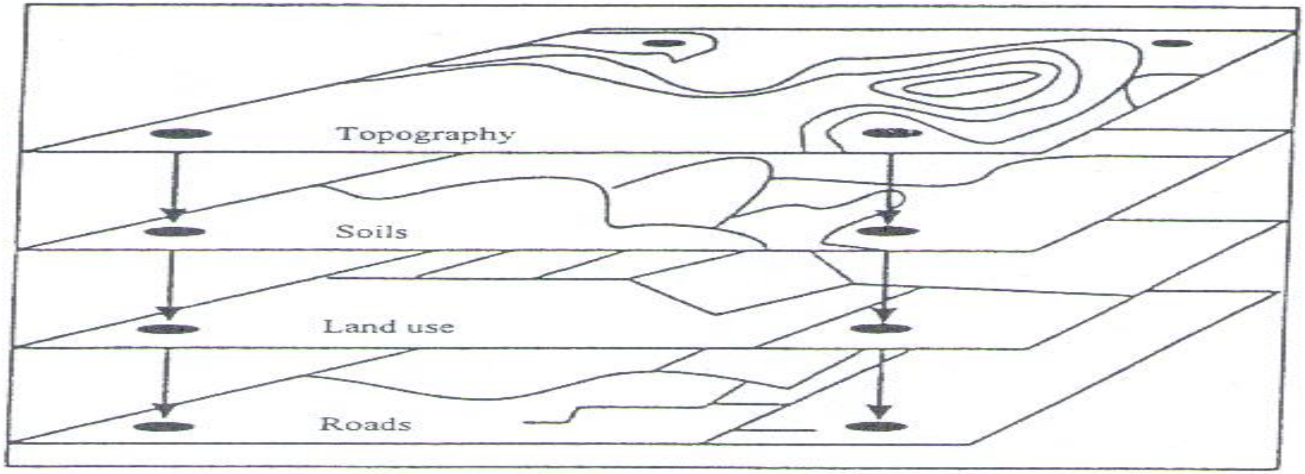

Fig. 9-9. Conceptual model of a GIS.

Using GIS for watershed projects can help your partnership select design specifications to accommodate conditions relevant to your site. Such matters as the slope of the land, soil types, depth to groundwater, and areal dimensions will affect the degree to which particular management practices can best remove pollutants from runoff.

For example, if you install a practice to promote infiltration (with assumed treatment), you need to know the depth to groundwater at the site. If the practice is located too close to groundwater, you may solve the runoff problem at the risk of contaminating groundwater. Modeling your project using GIS as a tool can raise your level of confidence–not to mention your success.

If you wish to use GIS to enhance your watershed management projects, plan ahead. Identify the people and agencies in the watershed who can bring GIS-related experience or skills to your project. Keep in mind the following points:

- GIS is data and labor intensive.
- GIS requires a computer system and trained technicians.
- GIS results will be only as good as your original data.
- GIS maps represent conditions in the watershed at specific times.