Part 2

THE COLLAPSE OF THE ECOSYSTEM

CHAPTER 3

SOIL: THE BASIS OF LIFE

The Organic Rights

All beings of the earth, from microbes to elephants exist in a web of organic energy flows. Everything in the material world is food and everything is excrement. Everything is part of the energy flow. Even edges of tectonic plates slide down into the magma, which is then spouted out of volcanoes. When the flow of energy comes from the sun to be consumed by the plant, this begins a succession of energy transformations called the food chain. Beings eat each other. This flow of solar energy undergoes many transformations. In addition to these connections in the food chain there are many more energy connections that are of a cooperative and contributory nature. Beings provide many services for one another that have nothing to do with eating each other. Bees pollinate flowers, birds transport and deposit seeds. Fungi combine with the root hairs of plants and the ensemble generates food for both plants and fungi that otherwise neither would be able to absorb. Each being, because it lives according to its nature, contributes to the smooth functioning of the whole.

There are beings such as elephants, tigers, humans and others whose consciousness is such that the intellectual function is well developed but the organic memory is not highly developed such as it is in animals like the earthworm or frog. Earthworms and frogs do not need to be taught what they are, their identity, they simply know what their nature is. The elephant, tiger or human, on the other hand have to be taught their culture by their parents or clan. This is shown by the fact that these animals, if raised in captivity and turned loose in their natural habitat, will starve, because they have not learned their culture. Many civilized people have starved in the midst of abundant food that native people utilize with ease. These beings, deprived of knowledge, do not know their organic identity.

For two to three million year's humans lived in clans and tribes as forager/hunters. In that culture we learned our personal identity within the clan and we learned that we had an organic identity as one among many beings of the earth. We learned of the other beings and their habits of life. We learned of life and the conditions for the growth of life.

This organic right, to know who and what we are and that we are located within a web of living energies must be a birthright of all humans. The earthworm conducts its life and contributes its excrement to help create the valuable humus of the soil. The bird visits one oasis in the desert and then transports seeds to another oasis. All beings must act responsibly and do their part for the world to function. For life to persist they must act according to their natures. For a being such as the human who can be so constructive or destructive this is important, important for the continuance of the human species so that they do not ignorantly destroy that which feeds them. All beings of earth have a vital interest in humans knowing their organic place in nature, because when humans do not know, they become organic psychotics and wantonly destroy other beings.

If the human species intends to exist in perpetuity, children must be provided with these organic rights. Most people in civilization grow up in boxes. Artificial environments and designer landscapes are most children's' formative, environmental experience. Even farm children do not have a sense of the beauty and complexity of a completely natural and unaltered environment. In order to give the human species a chance of survival, all children should have a right to the organic knowledge that they are an integral part of the life of earth. They need this knowledge in order to make rudimentary ethical and survival decisions. Children should at least be taught fully what soil is. Soil is the foundation of life of the planet, only the uninformed think of it as dirt, they pave it over, they dump poisons on it and they strip the vegetation so that the soil runs away without even realizing what they are doing.

Children should be told that soil must receive sustenance. This factor, the decline of the soil's food, applies to all of the land mass where civilization exists, not just farm fields but ballparks, golf courses, wetlands that are drained, houses, yards, pastures and any other place that has had the climax ecosystem removed. Anytime biomass is removed from the land in the form of cattle, logs, corn, vegetables or even grass clippings; the soil is deprived of that amount of feed.

Because civilized people do not know what they are, they talk politics, religion, and science and pursue material wealth while the basis of their life on earth, the soil, slips away beneath their feet.

The Soil

Soil is the gut of the earth, the principal digestive organ of planetary life. Soil is partially composed of rock chips, clay, sand, minerals and organic detritus, but it is also an interdependent living community of micro-organisms, insects, worms, small animals, reptiles and other organisms (even some birds) which live in, contribute to and feed on components of the soil. Like the bacterial community in the human gut that predigests the human food, the soil is a living community of organisms which produces the necessary conditions for the plant communities to exist. The excrement of the gut community feeds the human, and the excrement of the soil community feeds the vegetative community, which lives on the soil. Plants do not absorb earth**. Plants absorb nutrients that are in solution in the soil moisture**. These nutrient solutions are the result of many energy transformations as they pass through a number of organisms.

The creation of soil begins with an inert and infertile subsoil of clay, sand, rock chips and rocks. When the first pioneer or "first aid" plant germinates it begins to thrust its roots down into the hard compacted earth. It pumps moisture and minerals up from the earth to its stems and leaves. It drops its leaves and stems on the surface. The decomposers, small insects and microbes that live in the soil, eat the organic material that the plant has dropped.

The organic material, by covering the raw earth begins to shade it from the evaporative and oxidizing effect of direct sunlight. Moisture retention improves the habitat for small creatures that burrow, opening up the earth to more moisture and to oxygen that will allow more microorganisms to exist.

Porousness and organic build-up on and in the soil help increase the soil's fertility. The organic material on the surface feeds the soil community and other beings eat primary soil ingredients such as rock chips, roots and other micro beings, both dead and alive. As roots die and leave micro tunnels and as earthworms and others create tunnels, passageways are created for the infiltration of water and oxygen, two vital needs of the soil community. As the soil increases its fertility it becomes more porous, it retains more moisture and the temperature extremes are moderated.

As the soil builds, the richness and diversity of the habitat increases. More varieties of beings can find niches in the web of life. As the soil is opened up a succession of plants follow the pioneer species and find it easier to get their roots down into the soil. Bill Mollison, in his definitive work on Permaculture, *Permaculture: A Designers' Manual*, says of the living component in a typical soil: "50 per cent is fungi, 20 per cent is bacteria, 20 per cent yeast, algae, and protozoan, and only 10 per cent the larger fauna such as earthworms, nematodes, arthropods and mollusk fauna (the micro-and macro-fauna), and their larvae." He adds that, "Such classes of organisms are found in soils everywhere, in different proportions."[1]

The activities of the fungi are especially interesting. The body of the fungus stretches itself through the soil like a giant spider web. When the time comes for sexual reproduction most varieties of these fungi thrust up out of the soil, and produce what we call a mushroom. This is the sexual organ of the underground body. The web strands underground grow toward the root hairs of plants. As the threads of the fungi touch the root hair, the cells of the fungi invade the cells of the plant root. The fungus does not have the ability to translate solar energy into biomass (photosynthesis) but it can receive foods from the tree. The tree itself begins to absorb food from the cells of the fungi. Sir Albert Howard who wrote the historic treatise on organic agriculture, *The Soil and Health: A Study of Organic Agriculture*; explains that:

"Here we have a simple arrangement on the part of Nature by which the soil material on which these fungi feed can be joined up, as it were, with the sap of the tree. These fungous threads are very rich in protein and may contain as much as 10 per cent of organic nitrogen; this protein is easily digested by the ferments (enzymes) in the cells of the root; the resulting nitrogen complexes, which are readily soluble, are then passed into the sap current and so into the green leaf. An easy passage, as it were, has been provided for food material to move from soil to plant in the form of proteins and their digestion products, which latter in due course reach the green leaf. The marriage of a fertile soil and the tree it nourishes is thus arranged. Science calls these fungous

threads mycelium..., the whole process is known as the mycorrhizal association. This partnership is universal in the forest and is general throughout the vegetable kingdom."[2]

The soil breathes through the sponge-like passages in it. One cause of air movement is the lunar gravitational attraction. Just as the moon causes tides, it also pulls on aquifers and soil water. This water movement exhales and inhales air in the soil. Differentials of high and low pressure zones in the atmosphere passing overhead also effect the earth's breathing in the same way. As noted by Mollison, even such things as the bodies of worms pushing through the tubes, effect earth respiration.

As the soil becomes what we might call "mature" or climax, it is porous; it holds more water and air. As its diversity and richness increase, the vegetative cover grows richer and more diverse, thus feeding the soil more. Trees move in. They put out their feeder roots horizontally in the soil and the taproots deep into the subsoil. From the subsoil they bring up water that is transpired, improving the local microclimate. Minerals are also brought up from the deep, which go into leaf structure and finally end up on the soil surface. When the trees die, their decaying root systems leave deeper cavities. Within this enriching soil, the burrowing animals are working, churning the soil/subsoil, as other plants are growing and dying to deposit their dead bodies on the surface as food for the community. In this way the soil circulates toward increased fertility.

Mollison points out the high value of soils by reminding us that the only place that soils are conserved or increased are: in uncut forests, in the muck under quiet ponds or lakes, in prairies and meadows of permanent plants and where we grow plants with mulched or non-tillage systems.[3]

The general rule of thumb used by ecologists is that three hundred to one thousand years are required to build one inch of topsoil. This means that thousands of years of production can easily be wiped out in a season.

The Process of Soil Collapse

Soil injury and death is a severe health problem for the earth. Natural processes that severely injure or destroy soil over large areas are rare. They occur in geologic time spans such as the ice ages, vast climatic changes, earthquakes, volcanic eruptions and the movement of tectonic plates. On a smaller scale, intense fires, landslides, or floods can damage local soils. The history of "rapid" and large-scale soil injury is actually the history of the activities of civilization.

The process of soil collapse and destruction is essentially the reverse of soil build-up. When soil builds, it opens up, breathes and accumulates moisture. More and more niches are provided to expand the diversity of the soil community. As soil deteriorates these factors decline and soil degenerates toward a solid clay-like impervious mass that inhibits life activities.

Soil Exhaustion

The soil is in a continuous cycle that must be fed organic detritus continually. If this cycle is stopped, the primary food of the community ceases. If the food ceases and the plants continue to feed on the soil, as in a corn field, the soil will become exhausted. When cattle graze, they remove essential elements from the cycle. A ton of beef has depleted the soil of approximately 26 pounds of calcium, 54 pounds of nitrogen, 3 pounds of potassium, 15 pounds of phosphorus and many other trace elements.

This same situation obtains in a forest where the biomass is hauled away in the form of logs. Anything that detracts from the circulation of essential elements injures the soil. Any decline in the climax vegetation will cause a decline in the health of the soil community because of the decline of flow in the nutrient cycles.

When a forest is cleared or a prairie is plowed, soil health is impaired. The first growing season on this land may be highly productive, but after several years even with manuring and fallow periods, the soil can function only at a level considerably below its optimum. Agricultural soils that can be maintained over centuries, are generally heavy clay soils but even these erode, lose humus and become compacted. These soils must be maintained with great care to maintain sustainability at their greatly lowered level of health.

Unless large amounts of organic material are added each year, the soil will decline, because the soil community continues to feed, consuming the available organic and the biological nutrients until there is no more. At this point we have what farmers call "farmed out" land.

On a small piece of land near Willits, California a group of experimental gardeners called Ecology Action began to build soil on a hillside that was considered of "intermediate" value for grazing. They report that it was difficult to get a shovel into the original soil. After seventeen years of intense work, they have created a soil that will support luxurious plant growth through a method that they call "biointensive gardening." To increase soil fertility, they leave three-quarters of the soil in fallow crops of sunflowers, vetch, fava beans, wheat and rye. This experiment is deliberately a closed system, with no organic material being imported for compost (which would deprive other soils). This experiment gives us a rough standard to judge how much must be done to keep a soil sustainable and increasing in fertility. It means that three-quarters of the soil must be planted with plants that build up the soil while one-quarter are used by plants that feed on the soil and are then removed.[4]

A test conducted for 41 years, between 1894 and 1935 by the Ohio Agricultural Experiment Station at Wooster, Ohio, demonstrates the soil loss and yield on three sets of experimental plots devoted to continuous corn cultivation. This test shows the effect on the soil of "normal" farming methods.

Type of Crop	Type of Soil Treatment	Soil Loss in inches 1894-1935	Remaining (%) of original organic matter	Av. Annual yield (bushels per acre) 1894-5	Av. Annual yield (bushels per acre) 1931-5
corn	none	10.3	37%	26.3	6.5
corn	Artificial Fertilizer 500 lbs. Of 10-5-10 per acre	11.1	35%	44.4	28.9
corn	Manure 5 tons per acre	9.5	53%	43.1	30.0

(The table is taken from the Yearbook of Agriculture, 1938, USDA, p.102)

(10-5-10 is 10 nitrogen, 5 phosphate and 10-lbs. potassium per l00 lbs. total ingredients)

This study demonstrates that even with manuring, the soil suffers. In order to complement the nutrient cycle fully; so that the soil does not become depleted, even larger amounts of organic matter need to be applied. This is part of the problem of civilized agriculture. Where does the organic matter come from? In pre-industrial days, fallow periods were used. Plants were grown on the fields and then plowed into the soil. Manure from draft animals- cattle, pigs and chickens, was also applied to the soil. This slowed the depletion of the soil. Then came the tractor. The draft animal manure was lost. The land that was used to grow feed for the draft animals was turned to other crops. Vast fields of corn, wheat, soybeans or other monocrops were put in and fertilized artificially.

In the above table, the greatest loss of organic matter occurred with the use of artificial fertilizers. The artificially fertilized soil lost even more than the plot with no treatment. This happens because the artificial fertilizers do spur plant growth and this in turn draws more energy out, thus causing the soil to lose even more organic matter.

This study points out a crucial, but seldom-noticed fact. Everywhere in the world where the industrial agricultural system and the "green revolution" have spread, this process is happening to the soil. Farmers physically take biomass off the soil and this breaks the nutrient cycle. But even though the soil health is declining, crops continue to be raised because artificial fertilizer is injected into the soil. To industrial agriculture the soil itself is irrelevant. In fact, many modern farmers say that all they need the soil for is to "prop up" the plants while they artificially inject the nutrients. While this is true, it is equally true that this process is masking the actual biological deterioration of the planet's soils. The short-term gain might be large, but if artificial

fertilizers become too costly to purchase, or if easily extracted petroleum energy from which artificial fertilizers and agricultural poisons are generated, becomes exhausted, the world will face starvation because the soils are dead. The final yield on the top line of the chart where no help was given to the soil shows about where the world population will be when the petroleum fueled fertilizer plants shut down. A billion and a half people in the world are now fed simply because of the added increase made possible with chemical fertilizers. If chemical fertilizers were eliminated, world agricultural production would drop by at least one-third.[5]

Soil Compaction

Compaction of soils is another common injury that occurs on and off the farm. Anytime weight is put on soil; the pores tend to be crushed. This causes the moisture holding ability to decline and decreases soil breathing. This also inhibits plant growth because plants must expend more effort in order to get their roots down into the soil. As compaction increases, less water infiltrates and more water runs off, which increases the erosion of the topsoil. Plowing causes compaction because it requires heavy equipment. Trampling by confined livestock also creates soil compaction.

The plow is probably the cause of more soil death than any other factor. When the iron bottom plow was invented, a great change occurred in agriculture. Light soils had earlier been worked with wooden plows, but when the iron bottom plow was created, deep, heavy, clay soils could be worked and this greatly expanded the area of civilized agriculture. Finally the moldboard plow was created which completely overturns the soil because of its increased curvature.

The plow historically has been associated with Indo-European field agriculture. It is associated with the Indo-European cultural value of increasing production and as such was used by the Roman Empire in their vast agricultural enterprises. Digging stick and hoe, often in slash and burn plots in forests had done prior planting. This method had minimal interference with the soil and usually the cover vegetation of small plants was not eliminated. With the plow it is possible to completely clear the land and in this way much more land can be worked. Plowing also has the result of burying the cover vegetation. When the open fields are disced or harrowed after plowing, which break up clods and level the soil, the planting can be much more "efficient" and therefore much more land can be farmed.

Plowing breaks up and collapses the soil pores and water/air passageways. When the soil is overturned the entire soil community and their relationships are overturned. After a forest is cleared and the land is first plowed, the soil still maintains its crumbly, granular nature. It is soft and friable. After a few seasons the crumb structure has broken down and the clay aspect of the soil begins to predominate. The plowing, which creates chunks and clods, impairs the soil's ability to receive soil moisture which "wicks" upward by capillary action.

Edward H. Faulkner who wrote the classic treatise, Plowman's Folly, has shown how plowing disturbs the capillary action and how the moldboard plow by completely overturning the soil, reinforces this disturbance.

After plowing, the layer of surface vegetation comes to lie upside down in the soil. Thus, a layer of loosely pressed organic matter is compressed under the soil surface. This breaks the capillary action. The capillary action occurs when moisture evaporates from the surface and draws moisture upward.[6]

The plowing of soil often results in the creation of a hardpan just below the bottom of the plow. As the plow goes through the soil year after year the layer created just below the foot of the plow becomes more and more compacted until it becomes an impervious layer. This allows water to accumulate and build-up to the level of the plant roots where it can drown the plants and kill the soil community by salinization. The layer of hardpan traps minerals held in the water so that they concentrate as the water slowly evaporates. Eventually this creates a dead soil that can only be reclaimed with great difficulty.

When the soil is plowed, the deeper layer that contains soil moisture is overturned and exposed to wind and sun. This dries out the soil. The effect of direct sunlight on raw soil is very destructive. The sunlight oxidizes the soil. When the soil oxidizes, chemicals combine with oxygen and decrease their use to the soil community. The effect is to dry it out and lessen its fertility. All of this prepares the soil to be carried away by the wind and water.

As the plowed soil deteriorates, its clayey nature begins to predominate. The surface becomes more and more impermeable. Less moisture infiltrates to the ailing soil community. Water running off soil is the beginning of the end. As water runs off, it begins to carry soil with it. As the more friable top layers go, lower layers with less water absorbency are exposed so that the water runs off faster. As this occurs even more soil is carried away. Even in an undisturbed environment there is some erosion of soil off the land but it is much less than the volume of soil build-up. The following figures show the comparisons of erosion in the same area that has different types of soil cover:

"In Ohio it was reckoned that 174,000 years would be required to remove from 7 to 8 inches of top-soil by runoff in a forested area, 29,000 years in a meadow, 100 years if the soil is wisely planted with crop rotation and 15 years if corn alone is planted " (Bennett, 1939).[7]

The phenomenon of leaching is a pivotal factor in soil conditioning. Rainforest soils are leached constantly by the heavy rains. The large volume of water carries minerals from the topsoil down into the subsoil, but in desert environments, soil moisture evaporates more rapidly than it can be leached downward. This results in a higher level of nutrient/mineral buildup, which can be exploited by irrigators. They can utilize the sandy soils, which have a relatively low concentration of humus but nonetheless are nutrient rich and grow substantial crops if water can be obtained. But buildup of nutrients in desert soils happens over a long period of time and soil can be exhausted quickly unless artificial fertilizers are applied. Organic feed for the soil could be applied, but in a desert environment the production of organic material is limited. In the formerly forested areas of Lebanon, now degraded to a semi-arid desert environment, people collect manure from the goats that graze the sparse brush in the mountains and transport it to Beirut and the coastal city, Tripoli, to the north, to fertilize orange and banana plantations.[8]

Soil Erosion

Soil can become exhausted in place and soil can be removed by erosion. Plow agriculture leads to soil erosion but there are also other civilized practices that create soil erosion. Grazing by livestock, deforestation, mining, and many other human activities all lead to erosion.

There are three basic types of erosion; these are gully, sheet and wind. Gully erosion results in the familiar "erosion canyons" that we see on hillsides. Sheet erosion is a more camouflaged type in which large areas of a hillside slowly creep downhill to a "slump" at the foot of the slope. This type of erosion is sometimes only apparent when closely examined or when a "slump" can be seen at the bottom of a hill. Sheet erosion is generally found on inclined, plowed fields and steeper grazed pastures. Wind erosion occurs when the soil simply blows away. In some areas, especially flatlands, this type of erosion can become the predominate source of deterioration.

Soil impermeability, the failure of rainwater to be absorbed and seep into the soil is the beginning of erosion. Deforestation, overgrazing, plowing, or other stripping of the vegetative cover lessens the possibility that rain will be slowed down and stopped so that it may seep into the soil, subsoil and the underground waterways. As more soil is carried away, the more impermeable subsoil layers are exposed which causes more volume of water to run off faster. Because the less fertile subsoil is exposed, the vegetation that is adapted to the topsoil has less chance to re-establish itself. This is the reason that the downward spiral, once triggered, is self-perpetuating. The rains continue to come, and continue to erode, but once the plants can no longer get a foothold the process will simply continue until it reaches bedrock or other impervious layer.

The failure of water to infiltrate to the level of the lower groundwater effects the hydrology of the entire region. Even in a semi-arid region, if the topsoil is intact and the vegetative cover exists to absorb a large percentage of the rainfall, the water will seep in to collect in the subsoil. There it will be held away from the heat and evaporative effects of the sun for the deeper plant roots. The water that drains further into the earth will come to reside in underground aquifers. In many cases these aquifers will drain out in springs in lower elevations, providing a slow dependable flow that energizes local ecosystems and creates a slow dependable year around stream flow in the area.

When soils are abused and the spiral of deterioration is triggered, the familiar flood/drought cycle begins. When the water runs off rapidly rather than infiltrating, floods are created. In the other half of the cycle, because the water is not retained by absorbent topsoil and as subsoil water, the springs dry up, the streams dry up and there is less vegetation to transpire moisture. Transpiration of moisture creates a more salubrious microclimate for small micro-ecosystems under trees and in thicker patches of vegetation.

As the unnatural floods begin, and increase in severity, erosion canyons are torn out of the earth. Narrow streambeds with well-vegetated banks are torn out and stream courses are widened. Anywhere that wide, primarily dry streambeds exist that are

filled with boulders, gravel and large, dry sandbars, severe erosion is taking place. This is the image of a stream that has suffered flooding because of upland abuse.

As the floodwaters rush down carrying sterile sand and gravel from an abused watershed, the erosion material begins to bury fertile lower elevation floodplains with this debris. The aquatic ecology of the stream is impaired or destroyed along with the fertile riparian (stream side, or canyon bottom) habitat. This is the history of civilization from China, to India, to the Caucuses of Central Asia, to Europe and now to the whole world. Civilization equals aridity.

The stark reality of this spiral of deterioration can be seen now in areas of India and in Southern Mexico where areas that were formerly rainforests are now desert in spite of occasional, heavy rains.

Researchers Anders Wijkman and Lloyd Timberlake in their study, *Natural Disasters: Acts of God or Acts of Man?;* find that drought and floods are the "natural" disasters that effect by far the largest number of people around the planet. As the planet deteriorates, the numbers rapidly increase. In the 1960's 18,500,000 people were effected by drought: in the 1970's 24,400,000 were effected. In the 1960's, floods effected 5,200,000 people and in the 1970's floods effected 15,400,000. [9]

Soil erosion is not an esoteric matter. Anywhere one is, it can be seen. It is possible to view any area and roughly conclude the erosion rate. In an uninjured climax condition, most waterways of the earth are, or were, clear. The discoloration of any stream or river means that the watershed is being abused. If the color of a body of water is green, it indicates that nutrients are eroding into the water causing a population explosion of plant organisms. If the color of the water tends toward brown, it is simply from gross movement of the soil and subsoil into the water.

Soil erosion is not a "glamour" issue with the world media but it is one of the most life- threatening problems on the planet. Erosion hot spots are U.S. grain lands, Eastern Mexico, Northeast Brazil, North Africa, Sahel, Botswana-Namibia, Middle East, Central Asia, Mongolia, Yangtze River watershed of northern China, Himalayan foothills, Baluchistan, Rajasthan and Australia. This listing is of regions with present erosion emergencies, it does not list for example, regions already lost to erosion such as the southeastern U.S. or most regions which are experiencing, not emergency depletion, but serious and steady erosion. In addition to exhaustion of the soil, half of all arable land on the planet is experiencing erosion over and above any build-up of soil.[10]

Erosion is a contributory mechanism in the loss of arable land on the earth. ***Erosion, desertification, toxification, and non-agricultural uses will eat up one fifth of the world's arable land between 1975 and 2000. Another one fifth will go by 2025***. These figures are for arable land and do not include the general erosion and degradation of lands all over the earth from human activities such as deforestation, overgrazing, fire, and other injudicious human occupancy.

Soil Abuse by Grazing: Herding the Hoofed Locusts

The herding of animals is the lowest possible productive use of the land, yet it is done over much of the planet. If the purpose were to feed people, rather than to pay off bank loans or make profits in the money economy- or in the pastoral, nomadic cultures, to inflate herd size and patriarchal egos- much better use of most lands could be instituted immediately.

The authors of *Forest Farming*, a permaculture textbook, report that herders can get an average of 200 pounds of meat from an acre of optimum grazing land. That same area of land could produce one and one-half tons of cereal grain, seven tons of apples, or 15-20 tons of flour from the pods of honey locust trees. Although there is no commercial market for it, honey locust flour is superior in nutritional value to any cereal grain.[11]

Much of the grassland, savanna, steppe-type area of the earth has evolved with wild grazing animals. The vegetation and the grazers perform many services for each other. The grazing animals act as seed transport and manuring agencies. When a herd of herbivores occasionally comes over an area their hooves churn up the topsoil, aerate it and press seeds into the soil so they can germinate. The hooves create small pockmarks in the soil where organic debris and water can collect- this is especially helpful in semi-arid areas. Given this moisture and the water or wind-borne mulch in the pockmark to retain water and to retard desiccation, the grass seed will have a good chance of germination. It is said that one could follow the bison herds of the Great Plains on their migration routes by tracking the kinds of grasses that they preferred. As the bison would travel these "highways of grass" each year they would also replant their preferred grasses.

Natural herbivores migrate, following the abundance of vegetation. With free-roaming animals in a natural setting there is no danger of overgrazing because when the vegetation is sparse in one area they simply move to another. Though this migration might appear to be casual, the life of the herbivore/vegetation association, evolving through tens of thousands of years, is a natural, potentiative system where all of the beings contribute to their collective survival.

The original herbivores in the Western U.S. were bison, elk, pronghorn, bighorn sheep, mule deer, blacktail deer, some small animals and some insects. Nancy and Denzel Ferguson, in their exposé of overgrazing, *Sacred Cows at the Public Trough,* write:

"Originally, between 5 and 10 million bison roamed the plains of Montana, Wyoming, Colorado, and the intermountain valleys and mountains of the West. Today the 11 western states (excluding Montana) support 495 bison-less than one ten-thousandth of the original number. Original pronghorn populations in the 11 western states numbered between 10 and 15 million compared with about 271,000 today, which is about 2 or 3 percent of the original number. Bighorn sheep have dropped from an estimated 1 to 2 million to 20,400 (perhaps 1 percent of the original number). Original populations of mule deer and blacktail deer are estimated at about 5 million (which may be high) as compared to about 3.6 million today. Finally, pristine populations of

elk, which probably numbered about 2 million, have dwindled to about 455,000, a decline of about 75 percent."[12]

Each of these herbivores ate different varieties of plants. As they roamed, they cropped the land evenly. When these animals were replaced with domesticated cows (and sheep), the ecosystem began to go downhill, and the topsoil began to go down the river.

In Africa, it has been shown that when cows are inserted in grasslands and the multiplicity of herbivores occurring naturally is eradicated, the production of meat goes down. According to a recent study, "... an untouched savanna is capable of an annual production of 24 to 37 tons of meat per square kilometer in the form of wild animals, while the best pasture-cattle systems in Africa can yield only eight tons of beef per square kilometer per year. Yet in the name of agricultural progress and the imperative of control, many ungulates are being threatened with extinction, and other herd sizes are being substantially reduced."[13]

The above comparison underlines a basic point. The insertion of civilized agriculture into natural systems always lowers the net photosynthetic production, simplifies the environment and in many cases the amount of food civilized systems realize is much lower than could be realized by forager/hunters from the very same area.

The reason that the natural system is so much more productive in terms of grazing animals is that the natural animals can migrate, sometimes long distances, to crop the most abundant growths. They also crop different types of plants in the same area. That is, the elk with its wide mouth is primarily a grass grazer, the deer with it narrower mouth pokes about in the brush and trees for food, the pronghorn is a grass grazer though its preferred grasses are different than the elk's. The mountain sheep prefers a different set of plants, as do the rabbits, rodents and other herbivores. In the natural setting the entire range of vegetation is grazed. In the cow-sheep operation, a few species of annual grasses are the predominate target, and the natural animals are killed off or driven away.

Livestock have species of plants that they prefer. These confined animals will graze their preferred grasses until they are all gone, after which they will then start on their second preference, and so forth. As the annual and perennial grasses are grazed out, pioneer plants, tough grasses, forbs and brush that are acclimated to more arid conditions, move in to rescue the situation as soil erosion increases.

The damaging characteristic of the cow, to graze its preferred grass until it is gone, is one of the reasons that the natural mix of grasses in an ecosystem is so severely altered by grazing of domesticated animals. Even where there is an abundant stand of grass it may be grass that has succeeded because it is not favored by the cow. This is damaging to the ecosystem because this alters the food availability of the natural herbivores (if any have survived) and alters the ecology of the entire area.

The confined cattle alter the mix of native vegetation and eliminate species. They trample vegetation and compact soil. Historically, the cow and sheep have been used to graze land that has some ecological health. Later when the land is driven to more arid conditions with little grass and a predominance of woody forbs and brush, the

goat will be brought in to crop that vegetation. Finally the land can be driven to the point that the goat can no longer benefit from it. There are millions of acres of the planet that began as forests or grasslands and are now in this condition of being so poor that they cannot even support goats.

The United States government, which controls most of the rangeland in the western United States, is standing by while the ranchers overgraze and destroy the lands of the American west. Because of overgrazing, millions of acres of the U.S. west have been invaded by exotic plants, which colonize the bare ground where native grasses formerly grew. One of these grasses is "cheat grass," also known as feathery brome.

Cheat grass is an annual that has invaded from Asia, possibly transported in the gut of an imported animal or brought in by some misguided herder. It has a peculiar strategy for preparing its habitat. It is a fire- adapted plant; that is, it uses fire to spread itself. With its fine lacy leaves and stems, it is considered to be 500 times more flammable than native grasses. The plant greens up early in the spring for about six weeks, sets seed and dies, covering the ranges with highly flammable material. Once it ignites, it burns rapidly, eliminating any other grass and vegetation that is not fire adapted. In this way other plants are burned off and new areas are opened for the spread of cheat grass. As with the exotic grasses planted by range management people such as crested wheat grass, few natural beings in the ecosystem are able to utilize cheat grass. Cows and domestic sheep can eat cheat grass for only about six weeks in the spring, when the plants are green. The bristle- like, spear-pointed covering of the seed of the cheat grass plant, called the awn, is designed to stick to animals and birds for transportation. If an animal grazes on the dried grass, there is danger of the seedheads of this grass imbedding themselves in the jowls of the animals and even in their ears and eyes. This causes infections and sometimes death.

Some of the damage caused by overgrazing in the U.S. west is readily apparent. One can observe the differences in grasses between the roadside right of ways and the grazed pastures. It is hard to miss the huge erosion canyons throughout the west. It takes considerable study however, to realize how many of the native and proper plants, which fit the natural array of the ecosystem, have disappeared. Many of the plants now covering western rangelands are either part of the pioneer "first aid team" of native plants which has come in to save the area or are exotics from other continents invading the greatly degraded ecology.

As overgrazing triggers erosion the familiar syndrome of drought/flood begins as the entire hydrology of the area changes for the worse.

Today, domesticated animals are grazing 70 per cent of the landmass of the 11 U.S. western states. Only 17 per cent of land that the U.S. Bureau of Land Management manages in the west is described as being in good to excellent condition- by the BLM's own "in house" study.[14] Given the predilection of government agencies to inflate estimates of their own good works, there is no doubt that the land is in even worse shape that this dismal assessment indicates. Nonetheless, we may take this as an indication of the condition of private lands and of other public lands in the western U.S., including wildlife refuges, military bases, wilderness areas, and national forests, all of which are grazed.

In Australia large herbivores never existed until Europeans imported them. Recently, aborigines decided to get away from populated areas and back to their lands in the outback near Ernabella and Papunya in the semi-arid area of the continent. They found that 60 per cent of the food plants for which they traditionally had foraged were extinct, and the rest were greatly diminished in numbers. Overgrazing by unnatural herbivores that have gone wild has caused this destruction. Feral cattle, brumbies (wild horses), donkeys, camels, goats and rabbits are destroying Australia's interior.[15] Because these animals and the domesticated herbivores such as sheep and cattle are exotic; there are few pre-existing ecological relationships that they fit. For example, in areas that naturally host large grazing animals there are insects and microbes which inhabit and eat herbivore dung, break it down, bringing it into the food chain and into the soil as nutrient. In Australia none of this network has developed because there have never been large grazing animals. Every year, the nitrogen and other nutrients contained in many millions of tons of manure evaporate into the Australian air instead of enriching the soil, due to this lack, even though the introduction of these insects and micro lives has been attempted a number of times.[16]

In the semi-arid region of the Middle East, the stock population, consisting primarily of goats and camels, continues to eat up the remaining life. In their study of desertification, *Spreading Deserts - The Hand of Man*, Eric Eckholm and Lester Brown observe:

"The rangelands of northern Iraq, forage specialists figure, can safely sustain only 250,000 sheep without degradation - a far cry from the million or so that are currently eating away this resource base. Likewise, Syria's ranges currently feed triple the number of grazing animals they can safely support. In the initial stage of such degradation, inferior plant species replace more useful varieties. Then, sheep pastures become suitable only for the hardiest goats and camels. Finally, in the words of Ibrahim Nahal, 'In the advanced stage of deterioration the plant cover disappears as it is apparent in many of the steppe zones in Syria, Jordan, Iraq and the United Arab Emirates, etc., where the rangelands have turned into semi-arid deserts covered with a layer of gravel or into semi-sand deserts."[17]

Eckholm, in *Losing Ground*, documents land deterioration in the Rajastan, a semi-arid area of northwestern India, which has experienced the severe pressure of the human population explosion familiar throughout the world:

"The practical consequence of this pressure has been the extension of cropping to sub-marginal lands fit only for forestry or range management, helping to make this perhaps the world's dustiest area. Meanwhile, as the land available for grazing shrinks, the number of grazing animals swells-a sure-fire formula for overgrazing, wind erosion, and desertification. The area available exclusively for grazing in western Rajasthan dropped from thirteen million to eleven million hectares between 1951 and 1961, while the population of goats, sheep and cattle jumped from 9.4 million to 14.4 million. The livestock population has since continued to grow, while during the decade of the sixties the cropped area in western Rajasthan expanded further from 26 per cent to 38 per cent of the total area, squeezing the grazing even more."[18]

The experience of the Rajastan follows the basic pattern occurring on the grazed lands of the Earth. Despite all of the ballyhoo in the United States and other First World industrial nations about professional range management, technical expertise and technical solutions, grazed land everywhere is suffering. The overgrazing of the earth has nothing to do with range management, but has everything to do with money, political power and the values of empire culture.

Desertification

Deforestation and overgrazing eventually produce desertification. While the natural undisturbed deserts of the Earth are healthy, thriving, diverse ecosystems with many types of plants and animals, deserts created by poor land use are much more depleted of life. This is because the ecosystem has been shredded, unlike a natural desert where the organisms have mutually proliferated over tens of thousands of years.

The desertification of the planet is proceeding rapidly. Each year millions of new acres fall within the definition of "desert" to add to those already created. Destroying the vegetation of formerly semi-arid lands usually creates deserts but deserts are sometimes the result of deforestation.

The total drylands of the world are 3.2 billion hectares (7.9 billion acres). Of this area 61 per cent are desertified. This is defined as a loss of more than 25 per cent soil nutrient and the consequent decline of the productivity of biomass. In 1980 the percentage of some dryland areas that had become desertified were; Mediterranean Europe-30 per cent, N. America-40 per cent, S. America and Mexico-71 per cent, Southern Africa-80 per cent, Mediterranean Africa-83 per cent, West Asia-82 per cent, South Asia-70 per cent, (Asia) former U.S.S.R. area-55 per cent, China and Mongolia-69 per cent. The UN Environment Program estimates that desertification threatens one-third of the earth's land surface.[19]

While deforestation and devegetation caused by clearing land for the plow contribute to desertification, as does firewood gathering, the chief culprit is overgrazing. In every area of the world where herding is a significant industry, desertification is spreading. One thinks of the goats of the Middle East and the devegetation of the Sahel in Africa but in all semi-arid ecosystems on the planet, deserts are spreading.

A Council on Environmental Quality report, published by the U. S. government in 1981 states:

"Desertification in the arid United States is flagrant. Groundwater supplies beneath vast stretches of land are dropping precipitously. Whole river systems have dried up; others are choked with sediment washed from denuded land. Hundreds of thousands of acres of previously irrigated cropland have been abandoned to wind or weeds. Salts are building up steadily in some of the nation's most productive irrigated soils. Several million acres of natural grassland are, as a result of cultivation or overgrazing, eroding at unnaturally high rates. Soils from the Great Plains are ending up in the Atlantic Ocean.

"All total, about 225 million acres of land in the United States are undergoing severe desertification-an area roughly the size of the 13 original states."[20]

In many areas of the world, firewood gathering is contributing greatly to deforestation, devegetation and desertification. In many Third World nations, most of the people must rely on wood as the source of their heat and cooking. As the population explodes and urbanization rises, huge bare spots spread out for many dozens of miles from the cities as the country is gleaned of any combustibles. In many countries now the purchase of firewood takes a large share of the family income, in both rural and urban areas.

As a consequence of firewood shortage, people begin to use animal dung for fires. In the Andes, llama dung is used and in other areas sheep and cattle manure. As this dung is not returned to the soil, it represents another deprivation of the soil's fertility. "Between three hundred and four hundred million tons of wet dung-which shrink to sixty to eighty million tons when dried-are annually burned for fuel in India alone, robbing farmland of badly needed nutrients and organic matter. The plant nutrients wasted annually in this fashion in India equal more than a third of the country's chemical fertilizer use."[21]

Evapotranspiration is the phenomenon of moisture evaporation off the land. This moisture evaporates from soil and plants also transpire it. Bill Mollison, in his *Permaculture: A Designers' Manual*, says that soil moisture varies from 2 per cent to 40 per cent of soil volume.[22] It should be noted also that the tons-per-acre of micro-organisms in soil, contain water in their bodies and this contributes to soil water retention if the soil is healthy and has a high level of micro-organisms. As the natural cycles proceed, this moisture rising up from the land helps charge rain clouds by providing minute droplets of water which atmospheric moisture can condense around in the colder, higher altitudes. All of the fertile topsoil, worldwide, is a tremendous reservoir of water. The loss of topsoil and the progress of desertification lessens rainfall. As topsoil loss and desertification proceed the land itself becomes drier and a more desert type of plant regime becomes established. Civilization equals aridity.

Irrigation Projects: Green Today, Gone Tomorrow

Farmers, government bureaucrats and bankers love irrigation projects. They usually appear to give everybody something for nothing except the taxpayer who finances them and who often pays the subsidy to grow the food on the irrigated land. Large dams, irrigation projects and the modern industrial farming methods that have come with them have swept the world.

Water loss caused by evaporation from dams in semi-arid regions averages 50 per cent. As the water is impounded in a dam and then runs for sometimes many miles through canals, the salts and minerals in the water are continually being concentrated. More evaporation takes place when the water is spread across the earth. As irrigation water is spread over the fields, the water that is not taken up by the plants sinks toward the subsoil. In many cases this excess water fills the subsoil aquifers under the fields and the groundwater begins to rise toward the plant roots. Once these saline water hits the plant roots, they die. The rising water table evaporates through the surface of the soil by capillary action in a kind of "wick effect," leaving the characteristic snowy salt covering of the "alkali flats."

Another contributing factor in creating waterlogged, salinized soils is the buildup of fine silt, which is brought into the fields by the irrigation water. This clay- like material often collects into an impervious layer well below the surface. When this "hard pan" effect occurs water will build up on top of it and begin to drown the plant roots.

Irrigators manage to keep the concentrated salts and minerals from killing their cultivated plants by running enough water through the system to "flush" the fields, draining the runoff into some lower-elevation area. In modern irrigation projects this often involves digging deep under the field to place perforated pipes that drain the subsoil water out of the area. This expensive solution can only be used in selected high-profit areas that can justify the cost, or in areas where taxpayer subsidy is available. Where funds are not available for drainage and the land is subject to waterlogging, the land is eventually ruined. These problems effect tens of millions of acres of the planet.

Irrigation runoff water from modern systems contains all of the chemicals used in industrial agriculture including nitrates from fertilizers as well as concentrations of heavy metals, in addition to the salts and minerals concentrated from the soil. These poisoned waters have been responsible for the epidemic deaths of many animals and birds in wetlands where it collects. As irrigation water runoff goes back into the streams and rivers it adds to the destruction of the ecology of these bodies of water. It also adds to the problems of other irrigators downstream who must try to irrigate with water that is more saline than normal and contains unknown quantities of fertilizer and poison. Runoff water from irrigated fields is often drained into natural wetlands and into low-lying "waste" areas. In these areas, the former life of the land tries to survive amid the whole inventory of life-killing effluent of industrial agriculture. The fish, frogs, birds and other life develop cancers, open sores, mutations, and other deadly afflictions. A recently-publicized case in point is the Kesterson Wildlife Refuge in the San Joaquin valley of California where wildlife, especially waterfowl, have been dying from concentrations of selenium and other poisons in the agricultural runoff that drains into the adjoining wetland refuge. Game officials have now closed the refuge and are trying to drive migrating waterfowl away from the area.

The San Joaquin valley in central California produces a large share of U.S. farm produce. A 1981 U.S. government publication states, "Today about 400,000 acres of irrigated farmland in the San Joaquin are affected by high, brackish water tables. Ultimately, by the year 2080, 1.1 million acres of San Joaquin farmland will become unproductive unless subsurface drainage systems are installed."[23] Many areas in the U.S. are losing land to salinization. As salinization increases, the land produces smaller and smaller crop yields over time. Eventually, when the soil community is completely destroyed, all farming will cease in these areas.

Irrigation projects are very expensive. In order to justify irrigating a new area, the entire mass production, mass marketing system must be brought in. In Third World countries, especially, this means eliminating subsistence farmers and indigenous tribal people. The industrial agriculture methods of the Green Revolution are inherently centralizing. They need large areas of land to which machines and industrial methods can be applied. This has the effect of strengthening the national elites and the hold of the transnationals in the countries where these methods are used.

The modern industrial practice of using wells for irrigation, which is now spreading worldwide with the Green Revolution, is fraught with problems. In the first place, most of these systems require motors that use fossil fuel which is in short supply and due to run out. Modern well irrigation salinizes the soil just as do other methods. But the most serious problem is that in many cases the irrigation well system is pumping the underlying aquifers dry. In some of these cases the land is subsiding, that is, it is cracking open in huge chasm rifts, or suddenly sinking a number of feet.

In the U.S., one fifth of the irrigated cropland is above the Ogallala aquifer that runs down the east side of the Rocky Mountains from South Dakota to Northwest Texas. The Ogallala contains water that was accumulated during Pleistocene times, fossil water. Since that time little additional accumulation has taken place. This aquifer is one half-gone under 2,223,900 acres. It is calculated that it will be substantially gone sometime early in the next century.

European countries currently use three times more water than returns to natural sources. In North America the groundwater outtake is twice the replenishment rate.[24] In areas of Northern China, Tamil Nadu, India, Israel, Arabian Gulf, Mexico City, Southwestern Soviet Union, Europe, and in North America on the Great Plains, southern Arizona, and California, the ground waters are dropping precipitously.[25]

While the underground waters decline, the soil on the surface suffers from salinity and waterlogging.

In Pakistan, according to Georg Bergstrom:

"An estimated area of over two million hectares, a fifth of the annually cultivated area of the Indus Plain was severely affected; either yields were significantly cut by waterlogging and/or salinity, or production had ceased altogether. As many as forty thousand additional hectares were falling into that category each year, a good share of them lost to cultivation altogether. And the productivity of many more millions of hectares was well below its potential level due to saline soils. Pakistan was losing a hectare of good agricultural land every twenty minutes, but gaining a new claimant on that land by birth every twenty-four seconds."[26]

Like the one-third of the arable land in Iraq that is still salinized and unusable from the Sumerian Empire, many currently irrigated acres will be permanently destroyed. Roughly one-third of the world's irrigated land is presently in danger.[27] Eckholm, quotes Soviet soil scientist V. Kovda, who estimates:

"60 to 80 percent of all irrigated lands are, due to inadequate drainage or canal lining, becoming gradually more saline and, hence, infertile. By (Kovda's) calculations, twenty to twenty-five million hectares of land have been laid waste over the centuries after the introduction of improperly managed irrigation, and two hundred thousand to three hundred thousand additional hectares-out of a total worldwide irrigated area of nearly two hundred million hectares-pass from cultivation each year due to waterlogging and salinity."[28]

Although touted as a "solution" to world food problems, irrigation has only short-term benefits and many long-term problems. The large-scale dams central to many irrigation projects are already causing some major problems.

The Damn Dams

No dam will last indefinitely. Sooner or later, they will all silt up. The industrialists who profit by building them never mention this fact. Some dams in eroding watersheds in Latin America have an expected life of ten to fifteen years; others built in more ecologically stable areas may be expected to last as long as several hundred years. Silted up dams become wetlands or simply large banks of earth. Since the present dams are now constructed in the most optimum places on each river, there is little chance their benefit can be replaced by building more dams in less desirable sites. As the dams fill up with erosion material their use for hydroelectric generators is lessened because the flow of water cannot be maintained.

Large dams are such a bonanza- such a massive physical (if temporary) answer to immediate problems- that everybody recommends them, even though the dams of the planet will eventually choke much of the aquatic life flow system. Not only do dams feed the industrialist, the banker, the politician and the temporary laborer, but they are also an instrument of cultural transformation. The whole mass production regime of industrial agriculture with its fuels, fertilizers, and machines must be inserted with them. This means markets, profits, and realization of political strategies, centralization of power, and the continued marginalization of the poor. With enough money and guns, industrialists can ignore any consideration of the people, earth or cosmos -for awhile.

The water in freshwater lakes above the Panama Canal is used to regulate the level of the locks in the canal. Deforestation and destruction of the rainforest watershed above these lakes is causing them to silt up so that there is not enough volume to even out the wet/dry cycles. Eventually there will only be water during the rains. Ultimately, there will not be enough water to fill the locks of the canal during the dry season. This is an example of the types of problems that develop with large-scale waterworks when large-scale ecological destruction is occurring.

The Aswan Dam in Egypt shows other problems with large-scale waterworks. For millennia the annual flooding of the Nile has refertilized the fields of the Egyptians. Its biological circulation is so rich that even after the ancient Egyptians destroyed the watershed's incredibly rich natural wetland ecology; an empire has been able to exist in this area for thousands of years. The huge Aswan dam, built in modern times by engineers of the former U.S.S.R., is finally succeeding in depleting and destroying what remains of Egypt's survival systems. The engineers planned two results of the $1.3 billion dam that halted the flooding of the Nile: irrigation and hydroelectric generation. Though the dam project is hailed for producing half of the country's electrical "needs," the authors of Gaia: An Atlas of Planet Management report on some of the problems it has created:

"Over one hundred tons of silt, clay, and sand, which once fertilized downstream fields during periods of flooding, are now silting up Lake Nasser, forcing increased imports of fertilizers. This lock-up of silt also hit downstream industries, starving

Cairo brickmakers of a vital raw material, while the offshore sardine fisheries, which depended on the flow of nutrients from the Nile, were early casualties. The Nile Delta itself is in retreat. Simultaneously, problems of soil salinity and waterlogging have been accentuated. An FAO (Food and Agricultural Organization) study concluded that 35 per cent of Egypt's cultivated surface is afflicted by salinity and nearly 90 per cent by waterlogging. To crown all this, the water-based parasitic disease schistosomiasis has exploded among people living around Lake Nasser."[29]

An investigation revealed that the sandstone bottom of Lake Nasser, the artificial lake created behind the dam, did not seal but allowed considerable seepage through the lake floor. Evaporation from the surface of the 200-mile long Lake Nasser, and from the extensive system of irrigation ditches is high and there is less total water available for use than before the dam was built.

Worldwide, an estimated 250 million people are infected by schistosomiasis. The parasite that causes the disease, a blood/liver fluke, lives in snails part of its life cycle but lays its eggs in humans. The mature parasite, a fork-tailed worm, affixes itself to humans when the people enter the water of irrigation ditches or the river. The worm bores into the human and seeks out the liver where it lays its eggs. The eggs pass from the person by excretion. As they enter the waterways, they are ingested by the snails in the form of larvae. The parasites drain their human hosts' physical energy. Persons infected in these agricultural countries are able to work only a few hours each day.

The alternate flooding and drying of the land near the Nile formerly controlled snail populations who host part of the worms' life cycle. The flooding washed them out to sea. Since the building of the dam, the snails have multiplied. It is estimated that 70 per cent of the population of Egypt is now infected with schistosomiasis.

Sharp declines in agricultural production among a population with one of the worlds' low ranking, average annual incomes, already close to starvation levels, forced the Egyptian government to use a part of the electrical power produced by the new dam to operate fertilizer plants. The application of chemical fertilizers has, to some extent, temporarily offset the losses, but yield is still 20 per cent less than in pre-Aswan days.

A result of the new industrial agricultural techniques has been to inject herbicides, insecticides and chemical fertilizers into the now nutrient-poor Nile, through irrigation runoff. This effluent plus the lack of nutrient flow once provided by the river has damaged the five shallow lakes in the Nile Delta. One of these lakes alone formerly yielded 15,000 tons of fish annually for this protein-starved nation. The lakes themselves were created when sediments carried by the flooding river created sandbars in the delta, which in turn caused the large shallow lakes behind them. Now that the annual deposition is filling Lake Nasser rather than flowing downstream, the ocean is eroding the sandbars and soon there will be no lakes. Nineteen thousand people live in this area and are dependent upon the fishing industry in those lakes.

For many years, a sizable fishing industry had existed off the Mediterranean coast of Egypt. Nearly half of the 18,000-ton annual catch consisted of sardines. When the nutrients of the Nile ceased to be injected into the marine ecology, the Egyptian fish exportation dropped by one-half and the sardine catch went down 500 tons.

Now that the waters of the Nile are either evaporating from Lake Nasser or seeping into its sandstone floor, the Mediterranean is deprived of an important fresh water supply. Because of this, the salinity of the entire Mediterranean is rising and threatening all fishing industries of the area.[30]

In this review of irrigation we see that in many areas it is only a short-term gain. The long-term deficits will arrive in the next decades for us to deal with just as the exploding human population is overwhelming food supplies.

NOTES

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