

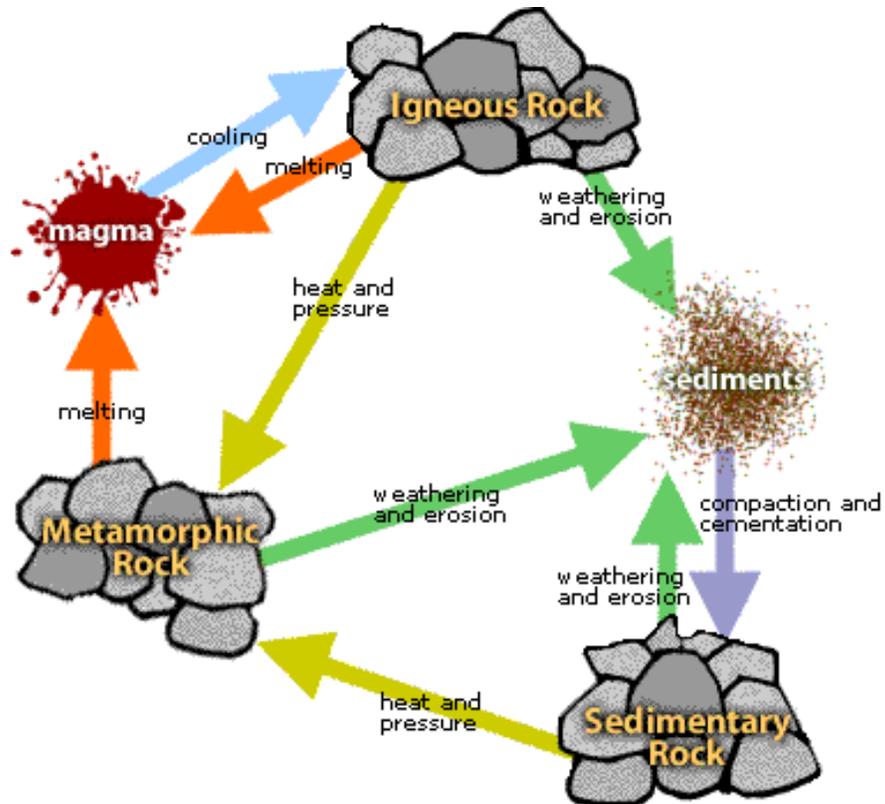
APES Ch. 8 Notes ~ Soil: Foundation for Land Ecosystems

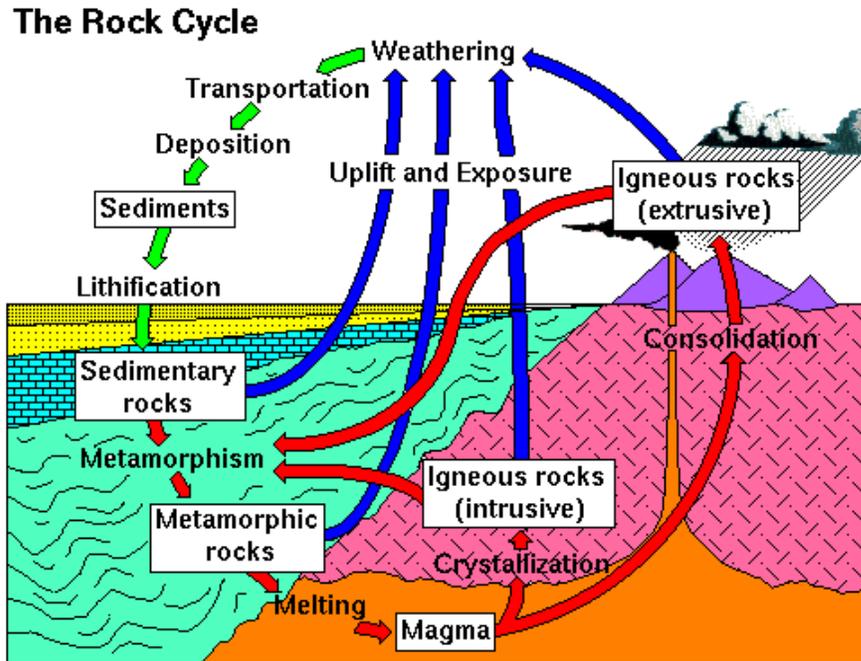
- I. Rocks
- A. **Igneous rocks** (“*fire-formed*”)—*from hardened magma and lava*
- 1) categories
 - a) **intrusive**—coarse-grained igneous rocks *below* the surface
 - b) **extrusive**—fine-grained igneous rocks *above* the surface
 - 2) composition
 - a) granite family—thick felsic magma; feldspar and quartz; light color
 - b) basalt family—thin mafic magma; iron and magnesium; dark color
 - c) diorite family—little or no quartz
 - 3) igneous rock structures
 - a) *intrusions—underground rock formations*
 - batholith—largest; makes up some mountain cores
 - stock—smaller batholith
 - laccolith— arc shapes
 - sill—hardened magma layer in between rock layers
 - dike—vertical magma channels
 - b) *extrusions—above-ground rock formations*
 - volcano—extrusive cone formed around a vent
 - volcanic neck—solidified central vent
 - lava flows—flat rock formations
 - lava plateau—lava flow from long large cracks
 - 4) examples: granite, obsidian, basalt, pumice, rhyolite
- B. **Sedimentary rocks** (“*settling*”)—*from sediment, being compacted and cemented*
- 1) background info.
 - a) **compaction**—weight pressing the pieces together
 - b) **cementation**— minerals gluing the pieces together
 - c) *types of sediment: sand, silt, clay, gravel, bone chips, pieces of shells, etc.*
 - 2) formation
 - a) *clastic—from sediment compaction and cementation*
 - gravel group
 - breccia—made of sharp pieces
 - conglomerate—made of round pebble pieces
 - sand grain group-- sandstone
 - clay particle group-- shale
 - b) *chemical—from water-soluble minerals*
 - *dissolving* materials in water, precipitation at different temperatures
 - “*evaporites*”—from evaporation of water, leaving the solids
 - c) *organic—from plant or animal remains (coal, limestone)*
 - 3) features
 - a) **stratification**—*layering* of different sediments
 - b) ripple marks and mud cracks
 - ripple marks—wind and water action on sand
 - mud cracks—shrinking and drying of mud
 - c) **fossils**—ancient plant or animal remains
 - d) concretions—“*nodules*” of different composition within the rock (geodes)
 - 4) examples: sandstone, shale, conglomerate, chert, limestone, gypsum

- C. **Metamorphic rocks** (“changed form”)—from *temperature* and *pressure* extremes, and *chemical* change
- 1) formation
 - a) **metamorphism**—a change in rock
 - b) **contact metamorphism**—affects a small area; local heating
 - c) **regional metamorphism**—affects a large area; tectonics
 - 2) classification
 - a) *foliation*
 - visible banding (stripes); from pressure or mineral separation; some can break into sheets
 - examples: gneiss, schist, slate
 - b) *unfoliated*—no banding
 - examples: marble, quartzite
 - 3) examples: marble, slate, quartzite, schist, gneiss

II. The Rock Cycle

- A. **rock cycle**—changes in rock forms, from one type to another type, by different
- B. summary of processes
 - 1) formation of *igneous* rock
 - a) melting and cooling any existing rock
 - b) hardening of magma or lava
 - 2) formation of *sedimentary* rock: weathering and erosion to form sediment; compaction and cementation
 - 3) formation of *metamorphic* rock: heating and pressurizing any existing rock





8.1 Notes

III.

Soil and Plants

A. Soil characteristics

1) Soil profiles

a) **horizons**—horizontal soil layers

b) **soil profile**—vertical “slices” through soil layers

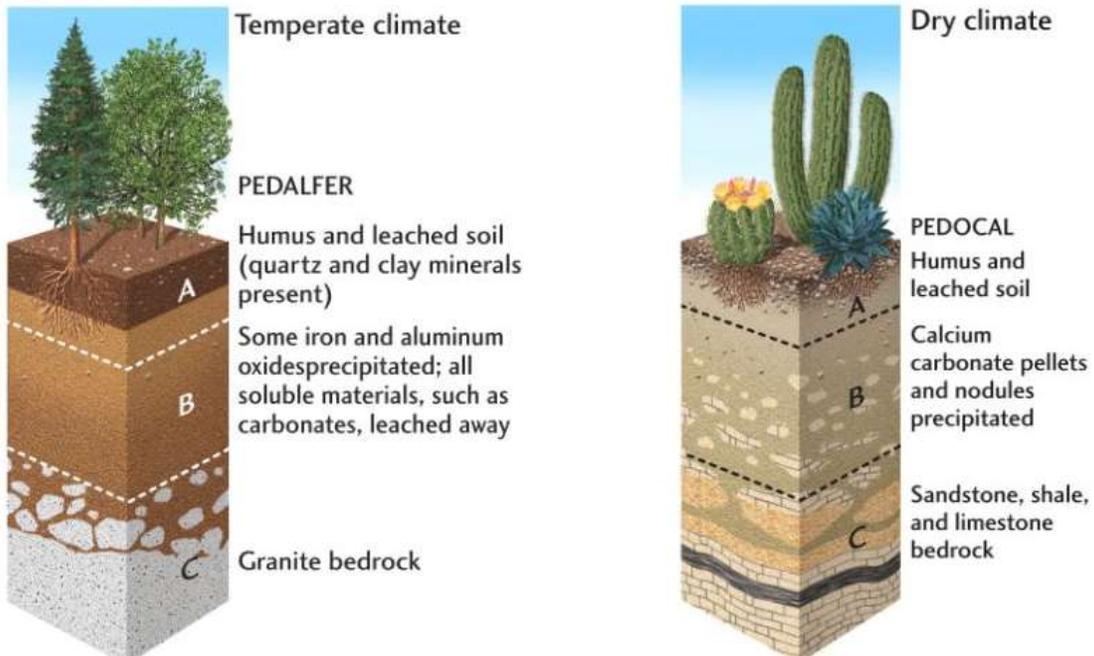
SOIL PROFILE (from www.seafriends.org and other sources)

Horizon

Description of detailed soil horizons

O	surface; humus —consists mainly of organic matter from vegetation, which accumulates under conditions of free aeration. Surface litter and/or leaf litter observed.
A	topsoil —horizon consisting mainly of weathered rock mixed with some humified (decomposed) organic matter
E	Zone of Leaching; mineral material; strongly eluviated (outwashed, leached) horizons having much less organic matter and/or iron and/or clay than the horizons underneath. Usually pale colored and high in quartz. Leaching varies with the porosity and permeability of the layer.
B	subsoil; illuvial (inwashed) horizon characterized by concentrations in clay, iron, aluminum compounds such as Al_2O_3 , or organic matter. Receives any leached minerals from E. Some lime may accumulate, but if the accumulation is excessive, the horizon is named K. [K horizon contains appreciable carbonate accumulation, usually mainly lime or calcium carbonate $CaCO_3$] [G “gleyed” or sticky clay horizons which form under reducing (anoxic) conditions with impede aeration, reflected in blue, green or grey colors]
C	weathered parent material lacking the properties of the solum (A & B horizons) and resembling more the fresh parent material (bedrock)
R	bedrock; regolith —the unconsolidated bedrock or parent material

c) types of soil from www.gly.fsu.edu



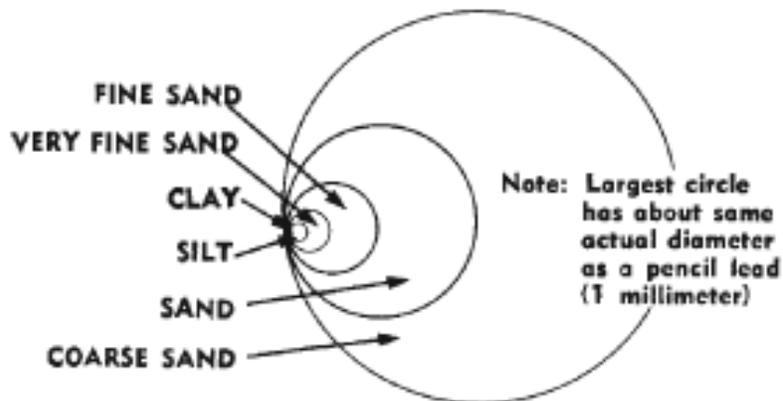
d) soil statistics from seafriends.org

- soil and topsoil are produced naturally at a rate of 1 mm every 200-400 years
- a full soil profile develops in 2,000 - 10,000 years
- agricultural soil is lost at a rate 10-40 times faster than its natural replacement
- the USA lost 80 mm since farming began
- world-wide loss of agricultural land is 6 million ha (hectare; 1 ha = 10,000 m²) per year, from a world-wide total of 1200 million ha

2) **Soil texture**—classification based on particle size

a) **soil separates**—rock fragments of varying size

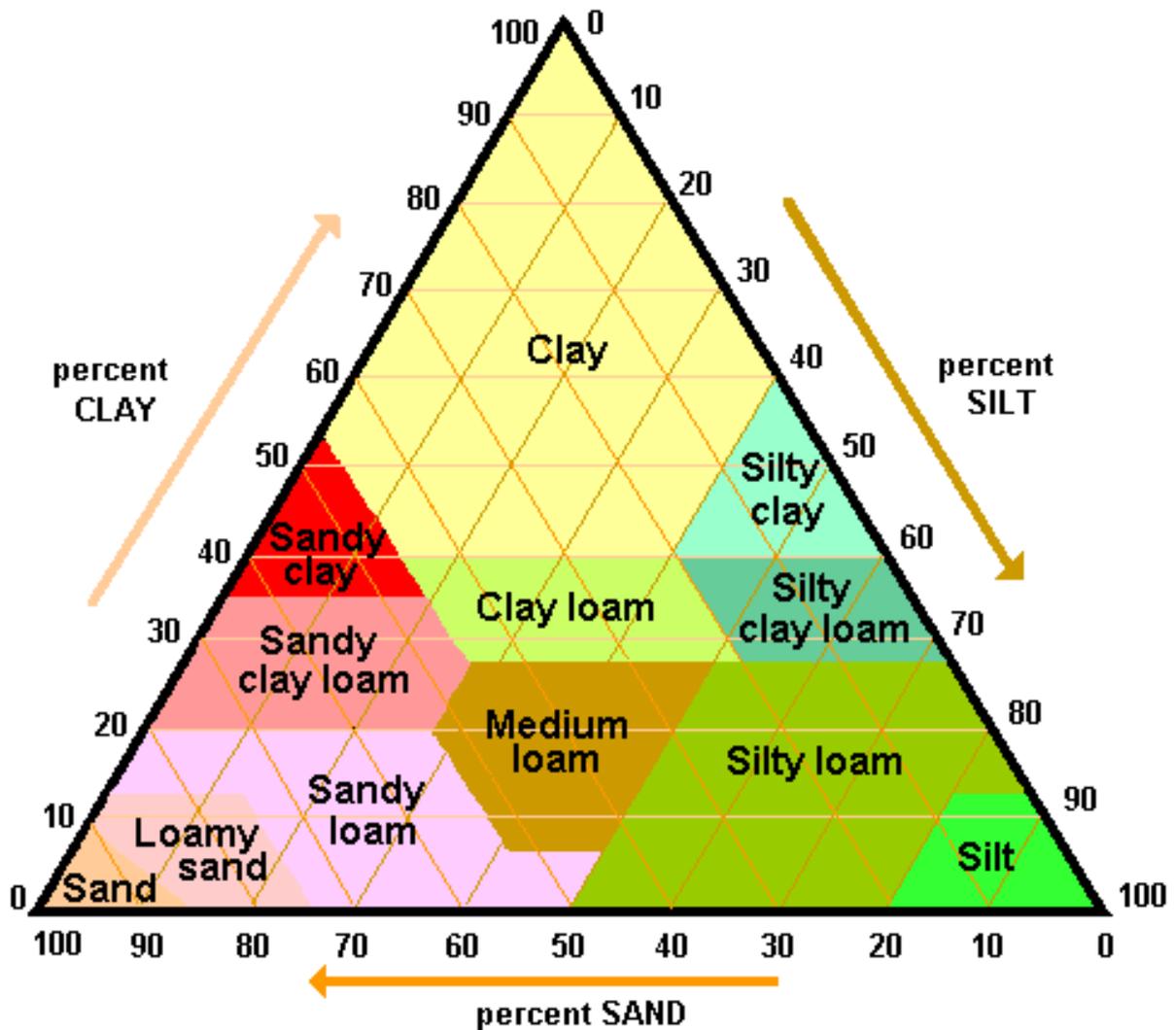
- Sand, Silt, Clay



Size of sand, silt and clay particles	
Name	Particle Diameter
Very coarse sand	2.0 to 1.0 millimeters
Coarse sand	1.0 to 0.5 millimeters
Medium sand	0.5 to .25 millimeters

Fine sand	0.25 to 0.10 millimeters
Very fine sand	0.10 to 0.05 millimeters
Silt	0.05 to 0.002 millimeters
Clay	below 0.002 millimeters

- b) *loam*—common soil type: 40% sand, 40% silt, and 20% clay
c) **soil triangle** or **soil texture triangle**—*diagram used to classify soil type*



- d) *soil attributes* (to be defined shortly)
- **infiltration**
 - **nutrient-holding capacity** (*sometimes called ion-holding capacity*) and **water-holding capacity**
 - **aeration**
 - **workability**—*how easy soil is cultivated*

- 3) Soil classes (hundreds exist in the taxonomy) – highlights:
a) *mollisols*—*large A horizon, dark, rich; temperate grassland*

- b) *oxisols—small O horizon; not rich; rain forest*
- c) *alfisols—well-developed horizons; can be good growing soil with supplements; temperate forest*
- d) *aridisols—dryland/desert; not a well-developed profile*

THE 12 SOIL ORDERS from <http://soils.ag.uidaho.edu>

1. Gelisols - soils with permafrost within 2 m of the surface
2. Histosols - organic soils
3. Spodosols - acid forest soils with a subsurface accumulation of metal-humus complexes
4. Andisols - soils formed in volcanic ash
5. Oxisols - intensely weathered soils of tropical and subtropical environments
6. Vertisols - clayey soils with high shrink/swell capacity
7. Aridisols - CaCO₃-containing soils of arid environments with subsurface horizon development
8. Ultisols - strongly leached soils with a subsurface zone of clay accumulation and < 35% base saturation
9. Mollisols - grassland soils with high base status
10. Alfisols - moderately leached soils with a subsurface zone of clay accumulation and > 35% base saturation
11. Inceptisols - soils with weakly developed subsurface horizons
12. Entisols - soils with little or no morphological development

B. Soil and plant growth

1) Mineral nutrients and nutrient-holding capacity

- a) **weathering**— *breaking up of the crust; the wearing down of rock, liberating minerals*
 - **physical (mechanical) weathering**—*from wind, water, weather, or other environmental events*
 - **chemical weathering**—*from chemical reactions between water and atmospheric gases and bedrock*
 - **biological weathering**—*from activities of organisms*
- b) **leaching**—*water washing away soluble materials from the soil*
- c) **nutrient-holding capacity (ion-holding capacity)**— *how the soil can “hold on” to important ions (calcium, potassium, phosphate)*
- d) **fertilizer**
 - *organic fertilizer—from plant/animal waste*
 - *inorganic fertilizer—chemicals only*

2) Water and **water-holding capacity**

- a) **transpiration**—*plants emitting water through their stomata*
- b) **irrigation**—*controlled introduction of water to an area*
- c) relevant soil attributes
 - **infiltration**—*water seeping into an area*
 - **water-holding capacity**—*the ability of soil to retain infiltrated water*
 - **evaporative water loss**—*controlled by the O-horizon*

3) Aeration

- a) **soil aeration**—*allowing gases to diffuse in and out of the soil*
- b) **compaction**—*pressing down; decreases pore space*

4) **Relative acidity (pH)**

- a) $pH = -\log [H^+]$
- b) *0-14 scale*

- c) *acid pH < 7 neutral pH = 7 base pH > 7*
 - d) *soil pH close to neutral is optimal for most plants and animals*
- 5) Salt and water uptake—water can be drawn out of plant roots if the soil is too salty

C. The Soil Community

- 1) Detritus, soil organisms, humus, and topsoil
 - a) *bacteria—base of the soil food web*
 - b) **humus**—*decomposed organic material; dark and rich*
 - c) **composting**—*producing humus in controlled conditions*
 - d) *castings— earthworm excrement forming soil clumps*
 - e) **soil structure**—*particle arrangement*
 - f) soil is considered a *detritus-based ecosystem* - p. 215
 - g) symbiosis
 - plant roots and mycorrhizae fungus
 - nitrogen-fixing and denitrifying bacteria
- 2) Soil enrichment or mineralization
 - a) *action of green plants*
 - *protection against erosion*
 - *reduction of evaporation*
 - b) **mineralization**—*loss of humus and breakdown of topsoil*
 - results in decreased plant growth
 - can be improved by adding substantial amounts of compost and organic matter

8.2 Notes

II. *Soil Degradation—begins with depletion of topsoil*

A. *GLASOD = Global Assessment of Soil Degradation maps*

- 1) made from 1987-1990
- 2) some say they are outdated, but it is used as a reference point
- 3) one Millennium Ecosystem Assessment goal – to update the maps

From the MEA <http://www.maweb.org/en/about.overview.aspx>

“The Millennium Ecosystem Assessment (MA) is an international work program designed to meet the needs of decision makers and the public for scientific information concerning the consequences of ecosystem change for human well-being and options for responding to those changes. The MA was launched by U.N. Secretary- General Kofi Annan in June 2001 and was completed in March 2005... If the MA proves to be useful to its stakeholders, it is anticipated that such integrated assessments will be repeated every 5–10 years and that ecosystem assessments will be regularly conducted at national or sub-national scales... The four ‘foundation’ reports of the Millennium Ecosystem Assessment were released on January 19, 2006. These 500-800 page reports are the products of the four MA working groups and examine Current State and Trends; Scenarios; Policy Responses; and Multi-Scale Assessments.”

B. Erosion and desertification

- 1) **erosion**—*movement of weathered particles (usually by wind and running water, sometimes by glaciation)*
 - a) **splash erosion**—*from raindrops*
 - b) **sheet erosion**—*from heavier water flow and runoff*
 - c) **gully erosion**—*from stream flow*
- 2) **desertification**—*the process of converting areas to deserts (drylands) by soil degradation*
- 3) **desert pavement** serves to protect the underlying soil from erosion, but when crushed by traffic, further erosion occurs

C. Drylands and desertification

- 1) **drylands**—*arid and semiarid regions with ~10-30 in. rainfall per yr.*
- 2) **UNCCD**—*United Nations Coalition to Combat Desertification, 1996*
<http://www.unccd.int/> COP (Conference of the Parties) meetings

D. Causing and correcting erosion

U.S. National Resource Conservation Service <http://www.nrcs.usda.gov>

- 1) **overcultivation**—*frequent plowing*
 - a) **crop rotation**—*alternating the type of crops grown*
 - b) **no-till agriculture**—*weed control, planting, and covering up all at once*
(low-till farming—decrease the amount of tilling)
 - c) **contour-strip cropping**—*cultivation along sloping ground*
 - d) **shelter belts**—*“belts” of trees planted around farmland to reduce wind erosion*
 - e) problems with fertilizers
 - *inorganic chemical fertilizer does not replenish organic material*
 - *mineral content remains high but soil degrades anyway*
- 2) **overgrazing**—*animals stripping vegetation at a rate too fast for natural growth patterns to counteract it*
 - a) **public lands**
 - BLM, Bureau of Land Management <http://www.blm.gov>
 - BLM leases grazing land
 - the acceptable amount of grazing animals is high
- 3) **deforestation**—*depletion of forest land*
U.N. Food & Agriculture Organization (FAO) <http://www.fao.org>
 - a) *causes increased leaching and erosion*
 - b) *worst-case scenario—layers above the subsoil are gone*
- 4) the other end of the erosion problem: Where do the particles go?
displaced sediments can wash into rivers and streams

E. Irrigation and Salinization

- 1) **irrigation**—*controlled introduction of water to an area*
 - a) *flood irrigation—diverted canals*
 - b) *central-pivot irrigation—water pumped from a central area*
- 2) **salinization**—*salts accumulating in and on the soil, hindering plant growth*

From the Environmental Literacy Council:

“Salt buildup is an existing or potential hazard on almost all of the 42 million acres of irrigated farmland in the United States. Much of the world’s unused land is in arid and semiarid regions where irrigation will be necessary. Water contains a small amount of salt and over time this salt accumulates in the soil. A small amount of salt in the soil will not affect the germination and growth of crops. However, as salt concentrations increase, negative impacts occur. Eventually salt concentrations will affect the germination of seeds. Excessive salinity is presently costing the U.S. billions of dollars in lost food crops.”

8.3 Notes

III. Addressing Soil Degradation: through public policy and at the individual level

A. *public policy* and soils

- 1) *money and profit* are usually the priorities
- 2) **sustainable agriculture (SA)**— a relatively new approach (~ 20 yrs.)

- a) characteristics
 - *topsoil integrity*
 - *food quality*
 - *chemical pesticide reduction*
 - *farming's financial feasibility*
- b) main goals
 - *economic profitability*: sustain the economic viability of farm operations
 - *human nutrition*: satisfy human food and fiber needs
 - *environmental health*: enhance environmental quality and the natural resource base upon which the agricultural economy depends
 - *resource management*: make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls
 - *social and economic equity*: enhance the quality of life for farmers and society as a whole
- 3) *SARE (Sustainable Agriculture Research and Education)*—funding for education about SA
- 4) LISA program (Low Input Sustainable Agriculture), 1988
- 5) CRP (Conservation Reserve Program), 1985

From <http://www.nrcs.usda.gov/programs/crp/>

The Conservation Reserve Program (CRP) provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. The program provides assistance to farmers and ranchers in complying with Federal, State, and tribal environmental laws, and encourages environmental enhancement...

The Conservation Reserve Program reduces soil erosion, protects the nation's ability to produce food and fiber, reduces sedimentation in streams and lakes, improves water quality, establishes wildlife habitat, and enhances forest and wetland resources.

It encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as tame or native grasses, wildlife plantings, trees, filterstrips, or riparian buffers. Farmers receive an annual rental payment for the term of the multi-year contract. Cost sharing is provided to establish the vegetative cover practices.

6) Food Security Act of 1985

From http://www.thecre.com/fedlaw/legal14coast/food_security_act_of_1985_legal_matters.htm

- 7) *FAIR (Federal Agricultural Improvement and Reform Act), 1996*
- 8) *WRP (Wetlands Reserve Program)*

“SUMMARY: The 1985 Act contains provisions designed to discourage the conversion of wetlands into non-wetland areas. These provision collectively, are commonly referred to as the “Swampbuster” provisions (Food Security Act of 1985 (Title XII, Subtitle C)). *Swampbuster provisions denied Federal farm program benefits to producers who converted wetlands after December 23, 1985. The Food, Agriculture, Conservation, and Trade Act of 1990 strengthened Swampbuster by making violators ineligible for farm program benefits for that year and subsequent years. The Act also created a system for inadvertent violations allowing farmers to regain lost Federal benefits if they restore converted wetlands.*

The 1996 Farm Bill, (*Federal Agriculture Improvement and Reform Act of 1996*, PL 104-127) contains numerous provisions that purportedly modify the operation of certain agricultural programs. In particular, Subtitle C, Wetland Conservation, modifies Sections 1221 and 1222 (16 USC 3821, and 16 USC 3822) of the Food Security Act of 1985 regarding program ineligibility, wetland delineation, consultation and cooperation requirements, and clarifies the definition of agricultural lands in the Memorandum of Agreement signed with the Department of the Army, the Department of Interior, and the Environmental Protection Agency, January 6, 1994. It also authorizes the Secretary of Agriculture to *operate a pilot program for mitigation banking of wetlands to assist persons to increase the efficiency of agricultural operations while protecting wetland functions and values.*

The *Conservation Reserve Program* (Title XII) (16 USC 3831) *authorizes the Federal government to enter into contracts with agricultural producers to remove highly erodible cropland from production, in return for annual rental payments.* The *Wetlands Reserve Program* (16 USC 3837) authorizes enrollment of wetlands for protection and restoration through permanent and temporary (30 year) easements.”

- 9) *2002 Farm Bill* (FAIR successor)
 - a) *dealt with FAIR issues whose deadlines were reached*
 - b) *increased funding for WHIP (Wildlife Habitat Incentives Program) and EQUIP (Environmental Quality Incentives Program)*

From <http://www.nrcs.usda.gov/Programs/whip/>

“*The Wildlife Habitat Incentives Program (WHIP) is a voluntary program for people who want to develop and improve wildlife habitat primarily on private land.* Through WHIP USDA's Natural Resources Conservation Service provides both technical assistance and up to 75 percent cost-share assistance to establish and improve fish and wildlife habitat. WHIP agreements between NRCS and the participant generally last from 5 to 10 years from the date the agreement is signed.

WHIP has proven to be a highly effective and widely accepted program across the country. By targeting wildlife habitat projects on all lands and aquatic areas, WHIP provides assistance to conservation minded landowners.

The Farm Security and Rural Investment Act of 2002 reauthorized WHIP as a voluntary approach to improving wildlife habitat in our Nation. Program administration of WHIP is provided under the Natural Resources Conservation Service.”

B. helping individual landholders

FARM (Farmer-centered Agriculture Resource Management)

1) mission

“Support improved sustainable agriculture resource management and the attainment of household security through innovative approaches in rainfed areas in Asia.”

- 2) members: China, India, Indonesia, Nepal, Philippines, Sri Lanka, Thailand and Vietnam

From <http://dbtindia.nic.in/farm/page1.htm>

...”The FARM Program was launched in September 1993 in New Delhi... The main area of concern of the Program is *how to achieve sustainable use and management of natural resources in agriculture and the attainment of household food security through innovative approaches.* The focus of the Program is in rainfed areas.

To achieve its goals, FARM is working on FARM demonstration sites, supporting farmer to farmer training, training of government officers and NGO staff in gender sensitive participatory approaches to sustainable agriculture and natural resource management.

It also supports the promotion of sustainable development policy options in rainfed areas based on the innovative modalities experienced in the thirteen demonstrations sites.

3) **Farmer Field Schools (a FARM project)**

From http://dbtindia.nic.in/farm/page3_5.htm#2

...“Training in the field school follows the seasonal cycle, and the field is the primary learning venue. *Farmers learn by carrying out for themselves the various activities related to the particular farming practice they want to learn about. Their training is based on comparative studies and on-farm trials. Training includes communication skills, skills in identification and problem solving, in leadership, and in interaction and discussion methods.*

The approach assists the farm communities to improve soil management. The field school offers farmers the opportunity to learn by doing, by being involved in experimentation, discussion and decision making. This strengthens the role of farmers in the researcher-extensionist-farmer chain. It also improves the sense of ownership of rural communities in technological packages and new knowledge and skills.”

“Development will bring food security only if it is people centered, if it is environmentally sound, if it is participatory and if it builds local and national capacity of self reliance.”

-- James Gustave Speth , 1994