Soil Erosion and Sedimentation

Geologic and accelerated erosion

-- Erosion is a “natural process”: stream development, landscape lowering
--“Geologic erosion”—rates vary with climate, but usually low (< 1 t/a/yr)
--“Accelerated erosion”—human disturbance of land cover: can be v. high rates (35 t/a/y)

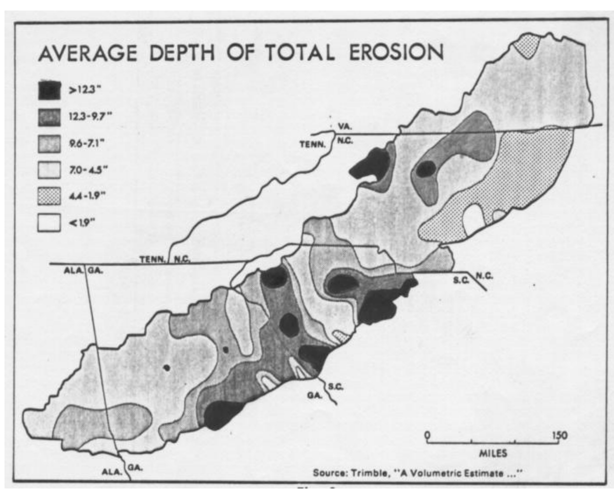
Remember: acre-6-inches (afs)= 1000 tons… at 35 t/a/y, lose 6” in 30 years…!

Role of erosion in early agriculture

--Accelerated erosion plagued many early civilizations
Ancient Greece, Middle East, China: erosion greatly hampered early agriculture (deforestation, over-grazing, cultivation)
--Results: gradual decline in yields, siltation of rivers & irrigation canals

: Erosion in colonial America also v. bad (Virginia): European farmers unfamiliar with steep slopes, intense rains = MORE erosion

Erosion in the SE US



: 100 years (1830-1930) years of cotton cultivation in the Piedmont region
--cotton is erosive crop (planted late, wide row spacing)
--rolling topography (4-15% slopes)
--intense rainfall

: Piedmont converted from cotton to pine trees in 1920's-1930's
  --soil depletion/yield reductions
  --boll weevil imported
  --Great Depression
> major migration of farmers (esp African-Americans) to urban areas
  (esp. in north—Chicago, New York)

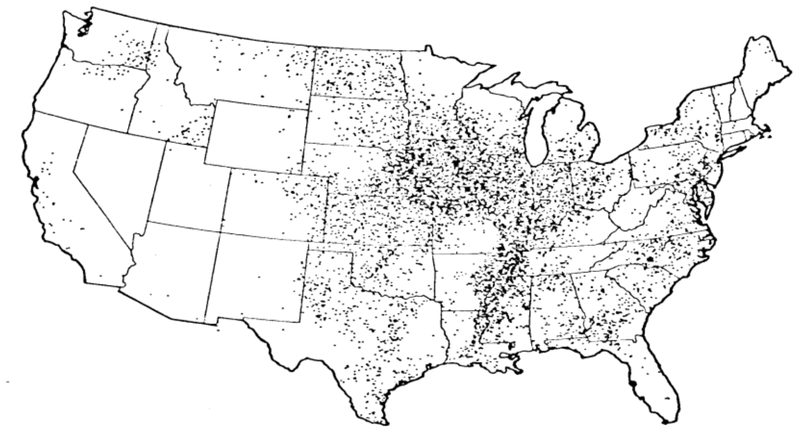
Results in Oconee-Clarke Counties:

Erosion Class	A Texture	Depth		Soy Yield (bu/ac)	Area of Clarke & Oconee
		A	Bt		
slight	s loam	10"	14"	41	2 %
moderate	s cl loam	6"	10"	28	44 %
severe	s clay	4"	4"	20	41 %

Dust Bowl (1932-1935: Southern Great Plains) **

: newly cultivated, flat landscapes + severe drought, high winds
: huge rates of erosion locally (entire A horizons in a 3-day "storm")
: initiated "Okie" migration to West ("Grapes of Wrath")
: Soil Erosion Service (later Soil Conservation Service, then Natural
  Resource Conservation Service) established in 1933

Modern-day Erosion



Soil Loss in the US, 1977 (density of dots indicates severity of erosion).

Erosion is still a major issue in US….

--Areas of intensive cultivation (Corn Belt, Miss. Valley)

--Sediment is largest water quality issue in US (most from agriculture)

:Urban construction also important contribution

Erosion Processes and Mechanisms

Detachment: separation of fine particle from aggregates *

raindrop impact: energy disrupts aggregates

Transport: movement downslope

mostly thru overland flow, esp. in channels

Interrill (sheet) erosion: thin sheet overland flow

: crusting creates runoff, which carries fine particle downslope

Rill erosion: small (1-12” deep) cut in surface by concentrated flow

: carries larger particles, results in much higher erosion rates

Gully erosion: deep channels (>1’ deep) with very high erosion rates

***

Factors Affecting Erosion

RAINFALL: total amount, intensity, seasonality of rain
: high-intensity rain (thunderstorms) most erosive
: spring-early summer—most erosion in humid climates
SLOPE: affects water velocity, carrying capacity of flow (rills/gullies)
: 0-4%-- suitable for cultivation, limited erosion
: 4-10%-- increasing risk of high erosion losses
:>10%-- serious erosion likely without conservation measures
SOIL PROPERTIES: "erodibility" of different soils
: silt, fine sand—most erodible (easy to detach & transport)
:aggregate stability—determines detachment, crusting, runoff
SOIL COVER: plant canopy and mulch: reduce raindrop impact, crusting
: v. little erosion in the forest (canopy, litter layer)
: canopy, mulch intercept raindrop impact, prevent crusting/runoff

Predicting Erosion

The Universal Soil Loss Equation

$$A = R \cdot K \cdot LS \cdot C \cdot P$$

Predicts soil loss (t/a/y) based on numerical estimates of—

R: rainfall factor
K: soil erodibility factor
LS: slope factor
C: cropping (vegetative) factor
P: conservation practices factor

Used by NRCS to advise farmers on cropping to reduce erosion to "tolerable" levels (< 5 ta/y)

Preventing Erosion and Sedimentation

Vegetative Cover (plant selection, mulches: reduce raindrop impact)

--*Agricultural crops*: tend to be most erosive

“Conventional tillage”: plow/disking/plant/cultivate/harvest

---lots of exposed soil… especially in spring

“No-till”: plant in previous residue/harvest

---residue keeps exposed soil to minimum…. MUCH less erosion

--*Forestry*: erosion a hazard only during harvest, replanting

Burning slash/mechanical planting are most erosive

“Chopping” residue, leaving in place/hand planting: least erosion

--*Urban areas*: sediment from construction sites

Best Management Practices (BMP’s): mulch (short term), immediate re-vegetation (long term)

**

Mechanical Methods (slow//direct runoff and sediment)

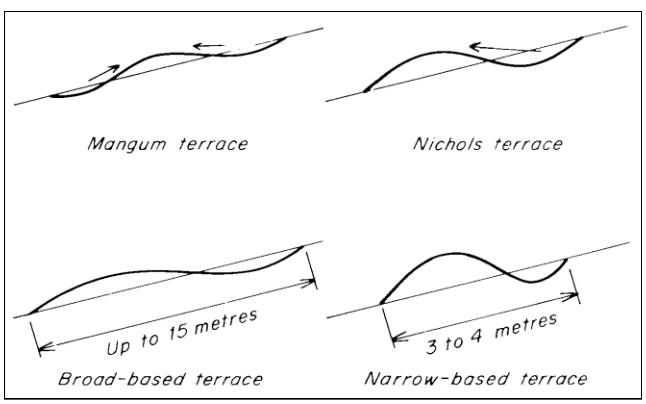
--*Contouring*: tillae/planting perpendicular to slope

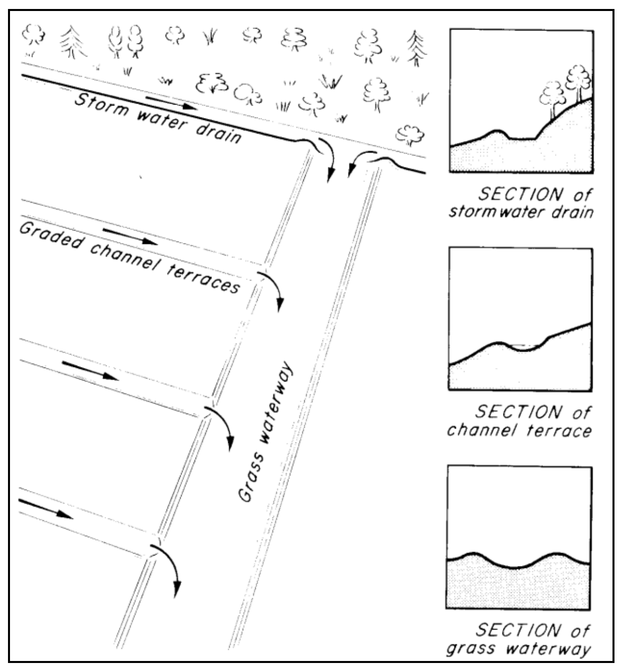
Slows runoff, allows deposition of sediment

--*Terraces:* channels cut across slope to collect, divert runoff water

Shortens length of slope… collects runoff/sediment in channel

Grassed waterways: collect runoff from terraces, protect channels *





Wind Erosion

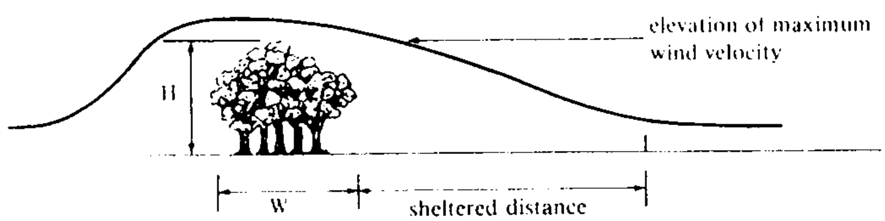
Problem only on DRY soils with LEVEL topography…

Occasional issue in S. Ga. during dry spells

Control:

Crop residues level in field ("stubble")

Windbreaks (shelter belts): keeps wind velocity low down wind



Sediment as a Water Quality Problem

Sediment is by far the largest water quality problem in Ga surface waters

--Must be removed from drinking water

-- Make water unappealing for recreation

--Direct impact on fish survival

--Fine particles degrade habitat, ruin spawning areas for aquatics

--Deposition fills reservoirs, aggrades stream channels, impedes drainage

Sediment Sources:

>Agriculture used to be by far the largest source (pre-1930)

>Today: other sources predominate

--*Urban construction*: v. high rates/acre

: Sediment Control Act—marginally enforced to require BMP's

--*Roads, abandoned land, forest harvesting*

: Important locally

--*Streambank erosion:* "legacy sediments" being re-eroded

: Cotton-era sediments in floodplains being cut thru by modern stream flow…

Radionuclide Exposure from Nuclear Power Accidents

"radionuclide": element with unstable nucleus that decays over time to
a more stable form by particle (alpha, beta) or energy (gamma) emissions

U, Pu—compose the actual nuclear fuel: seldom released into environment
: alpha emitters, v. toxic, but insoluble in water, not very volatile
: v. long half-lives

Soluble and/or volatile fission products are more dangerous:
:produced as byproducts from fission reactions
:escape as gases, fine particulates or in steam/water leaking from reactors
: high-energy beta and gamma emitters with short half-lives
: deposited on leaves, or enter soil or water
: major risk is increase in cancer rates, birth defects

I-131:
--volatile and water soluble
--anionic (I^-): behaves similarly to Cl
--easily taken up by plants, transferred to food chain (produce, animals)
--half-life=8 days: dissipates rapidly

Cs-137:
--cesium: chemistry similar to K^+
--half-life: 30 yrs… more long-term threat
--readily taken up by plants, soluble in water, enters food chain
--mitigate uptake by using large amounts of K fertilizers; also, remove
top inch of soil, or deep plow to dilute Cs content

Sr-90:
--strontium: chemistry similar to Ca^{+2}
--half-life: 29 yrs
--also readily plant available, soluble
--liming helps inhibit uptake