SOIL EROSION AND CONSERVATION: PREDICTION AND MANAGEMENT

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SOIL EROSION IS GLOBAL PROBLEM

- 1/3 WORLD’S ARABLE LAND LOST SINCE 1950
- MOST IN ASIA, AFRICA, S. AMERICA
  - 13-18 t/a/yr
- 30% OF US FARMLAND ABANDONED
  - EROSION
  - SALINIZATION
  - WATER-LOGGING
- 90% OF US CROPLAND LOSING SOIL FASTER THAN IT IS REPLACED
  - >1 t/a/yr

PIMENTEL ET AL., 1995
SIGNIFICANT SOIL LOSS IN THE USA

WATER
3.5 X 10^9 T/yr

WIND
1.5 X 10^9 T/yr
EROSION IS A WISCONSIN PROBLEM

- DEGRADATION OF THE RESOURCE
  - FERTILITY
  - ORGANIC MATTER
  - TILTH

- WATER QUALITY
  - SEDIMENT
  - NUTRIENTS

- PROGRAM COST
  - CHEAPER TO PREVENT
  - STILL EXPENSIVE

Near Blue River
EROSION EFFECTS ON PRODUCTIVITY

- SHALLOW ROOTING ZONE
- LOWER AVAILABLE WATER
- LOSS OF NUTRIENTS AND O.M.
- FARMING THE SUBSOIL
  - POORER TILTH
  - GREATER PENETRATION RESISTANCE
- INCREASED HYDRAULIC COND.
  - “STRONGER” AGGREGATES
- LOWER LAND VALUE
- REQUIRES GRADING TO FILL RUTS
THREE MECHANISMS OF SOIL MOVEMENT

Erosion is the process of detachment and transport of soil particles by erosive agents (Ellison, 1944)

Erosion is a natural geologic process

- WATER EROSION
- WIND EROSION
- TILLAGE TRANSLOCATION
WIND EROSION

- Saltation detaches particles
- Smaller particles suspended
- Larger particles creep
- Sandy and silty soils most susceptible
- Soil accumulation in ditches and fence rows
WIND EROSION CAN BE SIGNIFICANT

Near Mitchell, SD
REDUCING WIND EROSION

- MAINTAIN SURFACE COVER
  - CROP RESIDUE
  - COVER CROPS
- INCREASE STUBBLE HEIGHT
- INSTALL WINDBREAKS
  - EFFECTIVE 15x HEIGHT
- IRRIGATE
- STRIP CROPS PERPENDICULAR TO PREVAILING WIND
TILLAGE TRANSLOCATION

- NET DOWNHILL MOVEMENT BY TILLAGE
- RESULTS IN SMOOTHING OF SURFACE
- WATER EROSION INCREASES RELIEF INTENSITY
- BOUNDARIES STOP MOVEMENT
- NOT ACCOUNTED FOR BY RUSLE
- INCREASES SOIL VARIABILITY
COMPARING WATER EROSION AND TILLAGE TRANSLOCATION

TILLAGE TRANLOCATION: EFFECTS PRONOUNCED ON CONVEX SHOULDERS. RESULTS IN SMOOTHING OF LANDSCAPE.

WATER EROSION: EFFECTS PRONOUNCED ON BACKSLOPE. CUTTING ALONG SLOPE FACE WITH DEPOSITION ON TOESLOPE.
WATER EROSION PROCESS

- Begins with raindrops striking bare soil dislodging particles
- Intense rains seal surface
- When rainfall exceeds infiltration water is stored in small depressions
- Once depressions are filled, runoff begins
WATER EROSION PROCESS

• INITIALLY WATER FLOWS IN A DISCONTINUOUS SHEET
• EVENTUALLY IT CONCENTRATES INTO SMALL CHANNELS OR RILLS. THE RUNOFF NOW HAS ENERGY TO BREAK OFF PARTICLES AND CUT DEEPER
• THE AMOUNT OF EROSION CAUSED BY SHEET AND RILL EROSION INCREASES WITH SLOPE AND DISTANCE
• RILLS MAY EVENTUALLY FORM GULLIES
THE SOIL WATER EROSION PROCESS

**DETACHMENT**
- Detachment
- Sediment Load
- Sediment Transport

**DEPOSITION**
- Sediment Load
- Deposition
EFFECTS ON ENVIRONMENTAL QUALITY AND PRODUCTIVITY

• LOSS OF OM, CLAY, AND NUTRIENTS REDUCES PRODUCTIVITY

• DAMAGE TO PLANTS

• FORMATION OF RILLS AND GULLIES AFFECTS MANAGEMENT

• SEDIMENTATION IN WATERWAYS, DIVERSIONS, TERRACES, DITCHES

• DELIVERY OF NUTRIENTS TO SURFACE WATER
UNIVERSAL SOIL LOSS EQUATION

Soil Loss (t/a) = R x K x LS x C x P

- **R** = RAINFALL INTENSITY AND AMOUNT
- **K** = SOIL EROSIVITY
  - TEXTURE
  - STRUCTURE
- **LS** = SLOPE LENGTH, GRADE, SHAPE
- **C** = CULTURAL PRACTICES
  - ROTATION
  - TILLAGE
- **P** = SUPPORTING PRACTICES
  - TERRACES
  - CONTOURS
  - BUFFERS
PURPOSE OF EROSION AN PREDICTION MODEL

• DEVELOP A REASONABLE ESTIMATE OF SOIL LOSS BASED ON SCIENTIFIC INFORMATION
• GUIDE MANAGEMENT DECISIONS
• EVALUATE MANAGEMENT IMPACTS
• DETERMINE PRACTICE COST: BENEFIT
• ASSESS RESOURCE INVENTORY
WHAT IS RUSLE 2

• “GREAT GRANDSON” OF USLE
• MODEL TO PREDICT SOIL LOSS
  – WHERE OVERLAND FLOW OCCURS
  – COMPUTES ANNUAL SHEET/RILL EROSION
  – COMPUTES PARTICLE DISTRIBUTION AND RUNOFF
• CROPLAND, FOREST, LANDFILLS, CONSTRUCTION SITES, SURFACE MINES
• WINDOWS “PULL DOWN” MENUS
WHO AND WHAT OF RUSLE 2

- USDA-ARS, USDA-NRCS, VARIOUS UNIVERSITIES
- ON-GOING PROCESS OVER 70 YEARS
- THOUSANDS OF RESEARCH DATA
- SET UP WITH VARYING LEVELS OF COMPLEXITY
- COMPUTER REQUIREMENTS
  - WINDOWS 98
  - INTERNET EXPLORER BROWSER
  - 64 MB RAM
- DOWNLOAD
  - HTTP://BIOENGR.AG.UTK.EDU/RUSLE2/
APPLICABILITY OF RUSLE 2

- ESTIMATES INTER-RILL AND RILL EROSION
- ESTIMATES SEDIMENT YIELD FROM OVERLAND FLOW AND TERRACE CHANNELS
- DOES NOT ESTIMATE EPHEMERAL OR PERMANENT GULLIES, MASS WASTING, OR STREAM CHANNEL EROSION
- BEST SUITED TO CROPLAND, BUT IS USEFUL FOR CONSTRUCTION SITES, LANDFILLS, RECLAMATION PROJECTS, AND DISTURBED FOREST LAND
APPLICABILITY OF RUSLE 2 (cont.)

- BEST WHERE RAINFALL IS REGULAR AND EXCEEDS 20”/YR.
- MEDIUM-FINE TEXTURED SOILS
- SLOPES 3-20% AND LESS THAN 600 FT.
- BEST AT CALCULATING “AVERAGE ANNUAL SOIL LOSS”, NOT RECOMMENDED FOR SINGLE STORM EVENTS
RUSLE 2 FACTORS

\[ A = R \times K \times LS \times C \times P \]

- CLIMATE (R) AND SOIL (K) FACTORS ARE SET FOR A GIVEN FIELD
- SLOPE GRADE (S) AND LENGTH (L) CAN BE ADJUSTED WITH DIFFICULTY
- MOST FLEXIBILITY WITH COVER MGT. (C) AND SUPPORTING PRACTICES (P)
CROP RESIDUE IS STILL THE BEST EROSION PREVENTION TOOL

- REDUCED DETACHMENT
- HINDERS OVERLAND FLOW
- IMPROVED INFILTRATION
- ROTATIONS MAINTAIN STRUCTURE
EROSION CONTROL PRACTICES

Structures: diversions, terraces, waterways

- Reduce slope length
- Slow runoff velocity
- Divert excess water safely
- Avoid runoff over barnyard, feedlots, etc.
DIVERSION AND SURFACE INLET

Fond du Lac, Co.
(Note cover crop)
CONTOUR TERRACES

Grant Co.
WATERWAY MANAGEMENT?

Columbia, Co.
EROSION CONTROL PRACTICES

Management practices

- Cover crops
- Crop residue management
  - 30% residue reduces erosion 50-60%
- Contour tillage
  - Slope < 8% and 300’ long
- Contour strip cropping and buffers
  - Alternating sod strip for steep land
CONTOUR STRIP CROPPING

Crawford Co.
CONTOUR BUFFER STRIPS

Chippewa Co.
WHAT IS A RIPARIAN FILTER STRIP

- A PLANTED OR NATURAL VEGETATIVE BUFFER IN THE AREA THAT LINKS TERRESTRIAL AND AQUATIC HABITATS
- SERVES AS: FILTER, TRANSFORMER, SINK
FEATURES BENEFITING FROM VEGETATIVE FILTER STRIPS

- PERENNIAL AND EMPHEMERAL STREAMS OR DITCHES
- LAKES AND PONDS
- WETLANDS
- KARST FEATURES AND CREVICED BEDROCK
- WELLS
FILTER STRIP GOALS
- FILTER SEDIMENT
- STABILIZE BANKS
- WILDLIFE HABITAT
FILTERING SEDIMENT IS THE MOST IMPORTANT FUNCTION

- As flow velocity slows, sediment settles out
- Sheet flow required
- Need to remove suspended clay
- Filtering affected by:
  - Soil porosity
  - Vegetation type
  - Slope
  - Age
  - Management
  - Runoff volume
FILTER STRIPS ARE A LIVING SILT FENCE
MECHANISMS THAT REMOVE POLLUTANTS IN FILTER STRIPS

• NUTRIENTS STORED IN SOIL
• PHOSPHORUS FIXED ON MINERAL SITES
• NITRATE-N DENITRIFIES
• PLANT UPTAKE
• STORAGE IN PLANT TISSUE (ESPECIALLY TREES)
  – HARVESTED AND REMOVED
  – MAY BE RELEASED FROM VEGETATION
• MICROBES BREAKDOWN ORGANICS
SITE PRIOR TO ESTABLISHMENT
MAY, 1999
FOLLOWING CLIPPING
AUGUST, 1999
Ashwaubenon Creek Tributary, Brown Co. (Source: Bill Hafs)

Before

Two years later
EFFECT OF BUFFER WIDTH ON SEDIMENT DEPOSITION

Smith, 1992
# VEGETATION TYPE AND NUTRIENT REMOVAL

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LEE et al., 1999
MANAGEMENT OF FILTER STRIPS

• PROTECT FROM GRAZING
  • FENCE MAINTENANCE, FLOOD DAMAGE
  • CATTLE CROSSINGS
  • MANAGED GRAZING

• MOW
  • BRUSH CONTROL
  • HARVEST GRASS

• AVOID VEHICLE TRAFFIC IN FILTER STRIP
OTHER CONSIDERATIONS

COMBINE WITH UPLAND PRACTICES

SITE IN THE UPPER PART OF WATERSHEDS