AgriLIFE RESEARCH
Texas A&M System

Assessing Impacts of Rangeland Conservation Practices prior to Implementation

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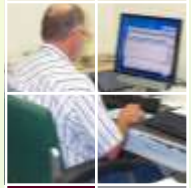
Improving Life through Science and Technology.

TEMPLE MODELS

- EPIC (Environmental Policy Integrated Climate)
- ALMANAC (Crop Model)
- APEX (Agricultural Policy / Environmental eXtender)
- SWAT (Soil and Water Assessment Tool)

Continuously updated and improved as a result of user interaction and feedback



APEX (Agricultural Policy/Environmental eXtender)

Whole Farm Management

Watershed Management

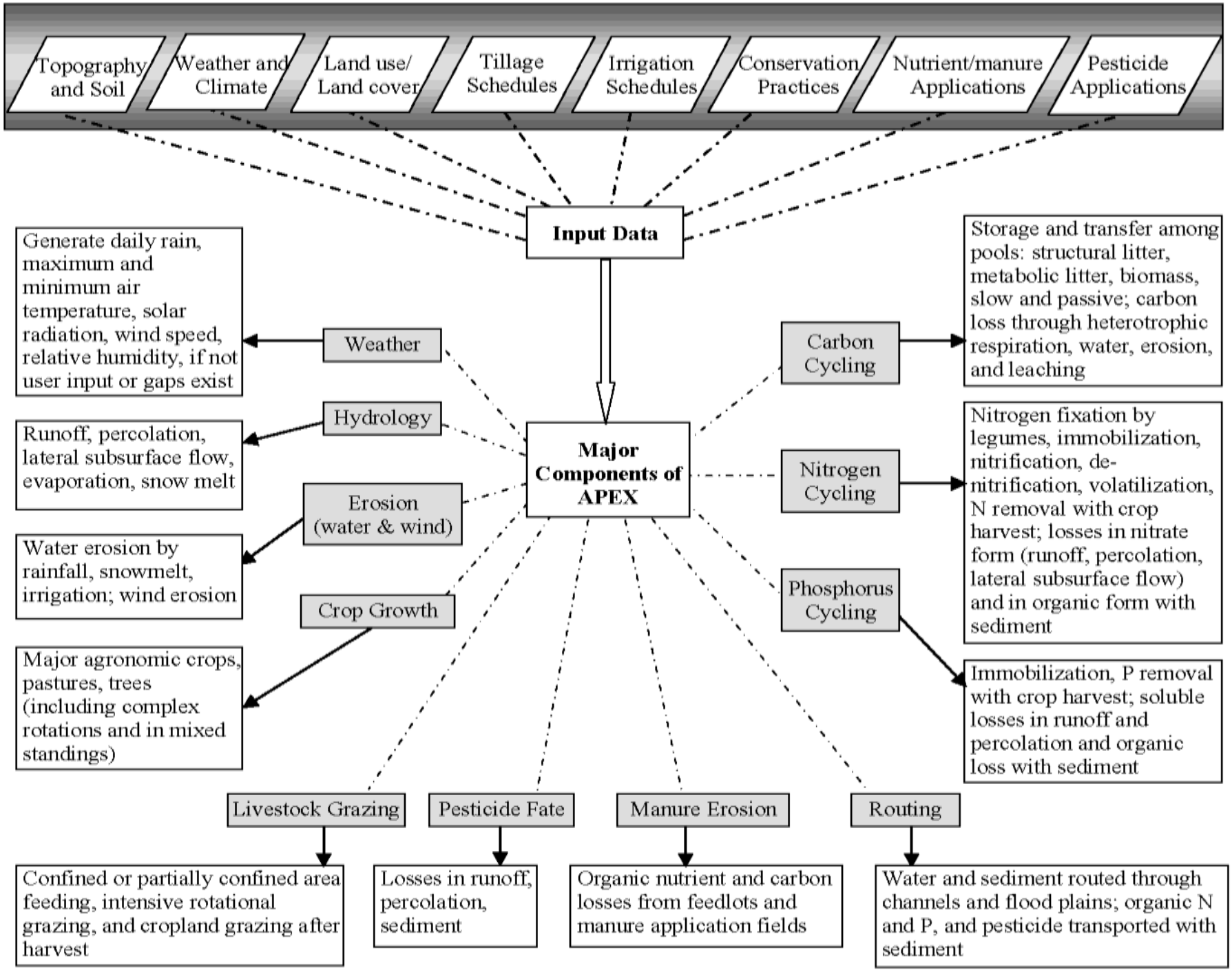
Farm or watershed may be subdivided into

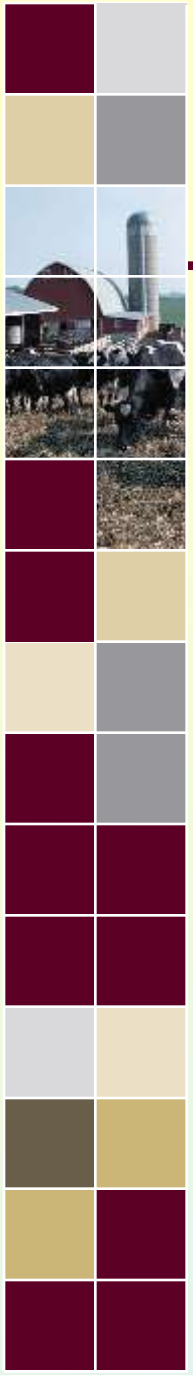
- fields
- soil types
- landscape positions
- land uses
- topography

Soil profile may be divided into 10 layers

Continuous simulation

Time step – daily or less

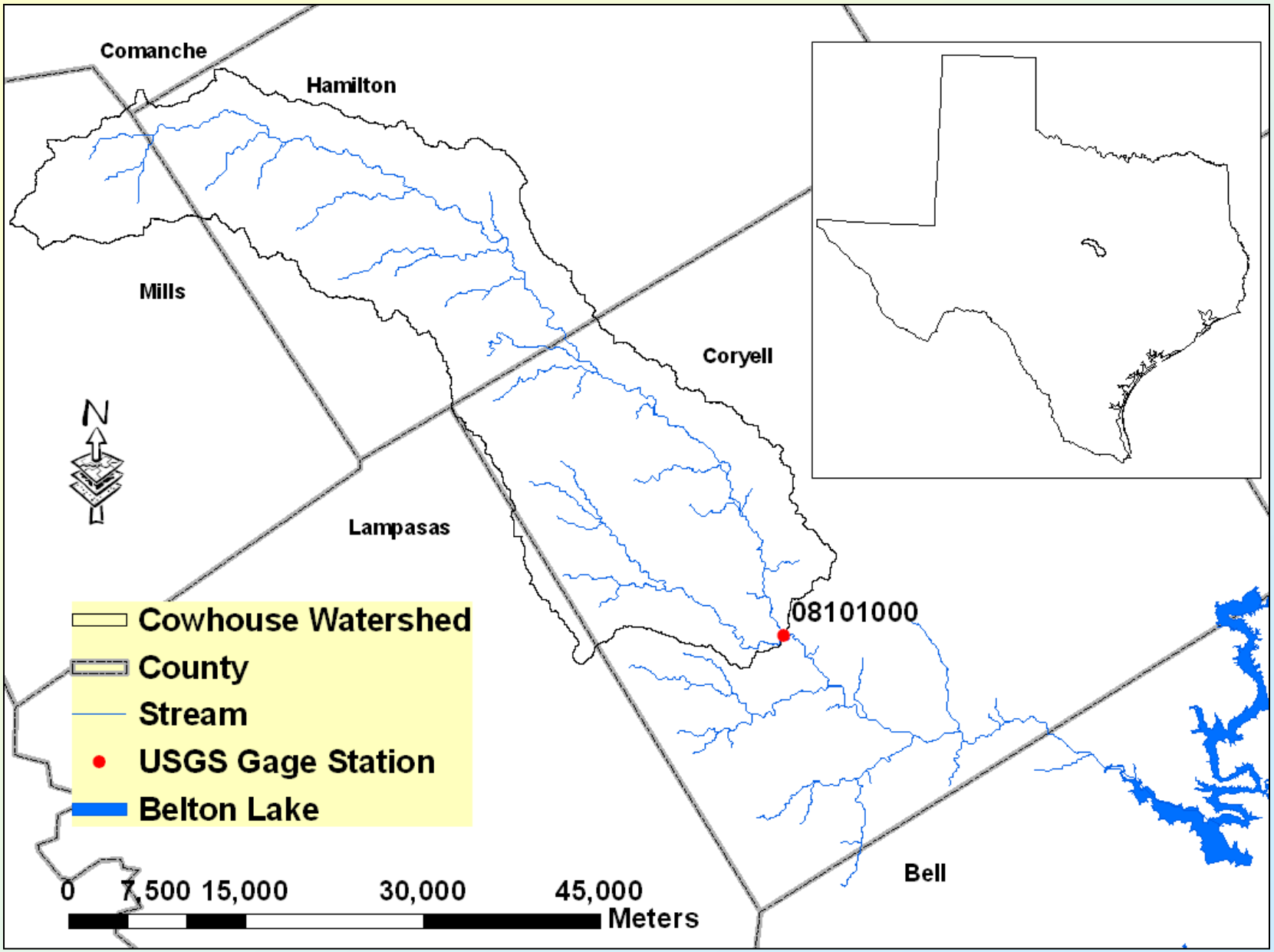

Topography and Soil
Weather and Climate
Land use/ Land cover
Tillage Schedules
Irrigation Schedules
Conservation Practices
Nutrient/manure Applications
Pesticide Applications
Input Data
Major Components of APEX
Weather
Generate daily rain, maximum and minimum air temperature, solar radiation, wind speed, relative humidity, if not user input or gaps exist
Hydrology
Runoff, percolation, lateral subsurface flow, evaporation, snow melt
Erosion (water & wind)
Water erosion by rainfall, snowmelt, irrigation; wind erosion
Crop Growth
Major agronomic crops, pastures, trees (including complex rotations and in mixed standings)
Carbon Cycling
Storage and transfer among pools: structural litter, metabolic litter, biomass, slow and passive; carbon loss through heterotrophic respiration, water, erosion, and leaching
Nitrogen Cycling
Nitrogen fixation by legumes, immobilization, nitrification, de-nitrification, volatilization, N removal with crop harvest; losses in nitrate form (runoff, percolation, lateral subsurface flow) and in organic form with sediment
Phosphorus Cycling
Immobilization, P removal with crop harvest; soluble losses in runoff and percolation and organic loss with sediment
Livestock Grazing
Confined or partially confined area feeding, intensive rotational grazing, and cropland grazing after harvest
Pesticide Fate
Losses in runoff, percolation, sediment
Manure Erosion
Organic nutrient and carbon losses from feedlots and manure application fields
Routing
Water and sediment routed through channels and flood plains; organic N and P, and pesticide transported with sediment



APEX Applications

- Evaluate effects of global climate/CO_2 changes
- Design environmentally safe, economic landfill sites
- Design biomass production systems for energy
- Livestock farm and nutrient management (manure and fertilizer)
- Forest management
- Evaluate effects of buffer strips nationally
- Simulate runoff, erosion/sediment yield, nutrient and pesticide losses

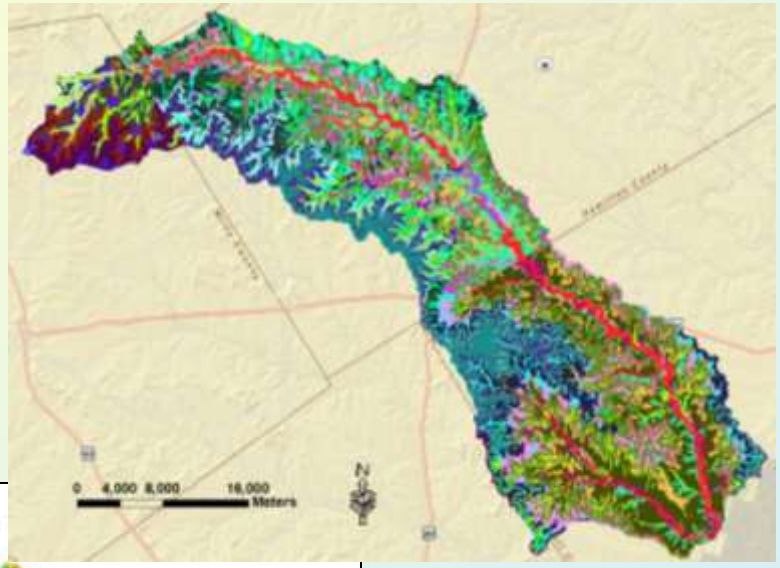
Cowhouse Creek watershed (1178 km^2)



Data used: 10 m x 10 m DEM;
Weather stations;

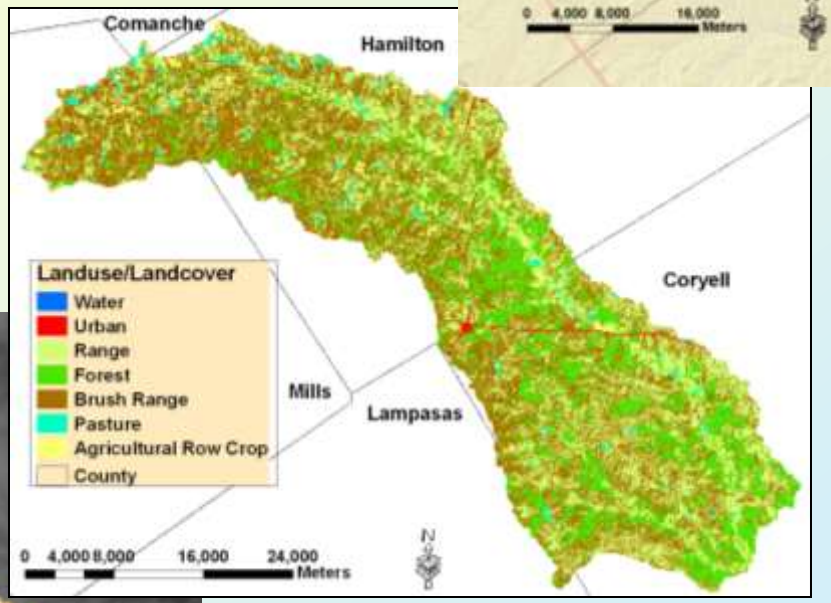
NRCS-NLCD (2001);

SSURGO soils

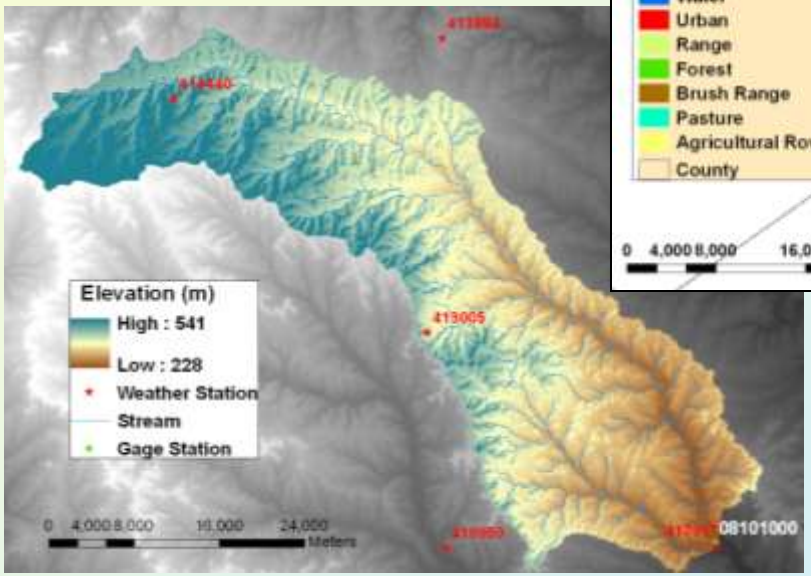


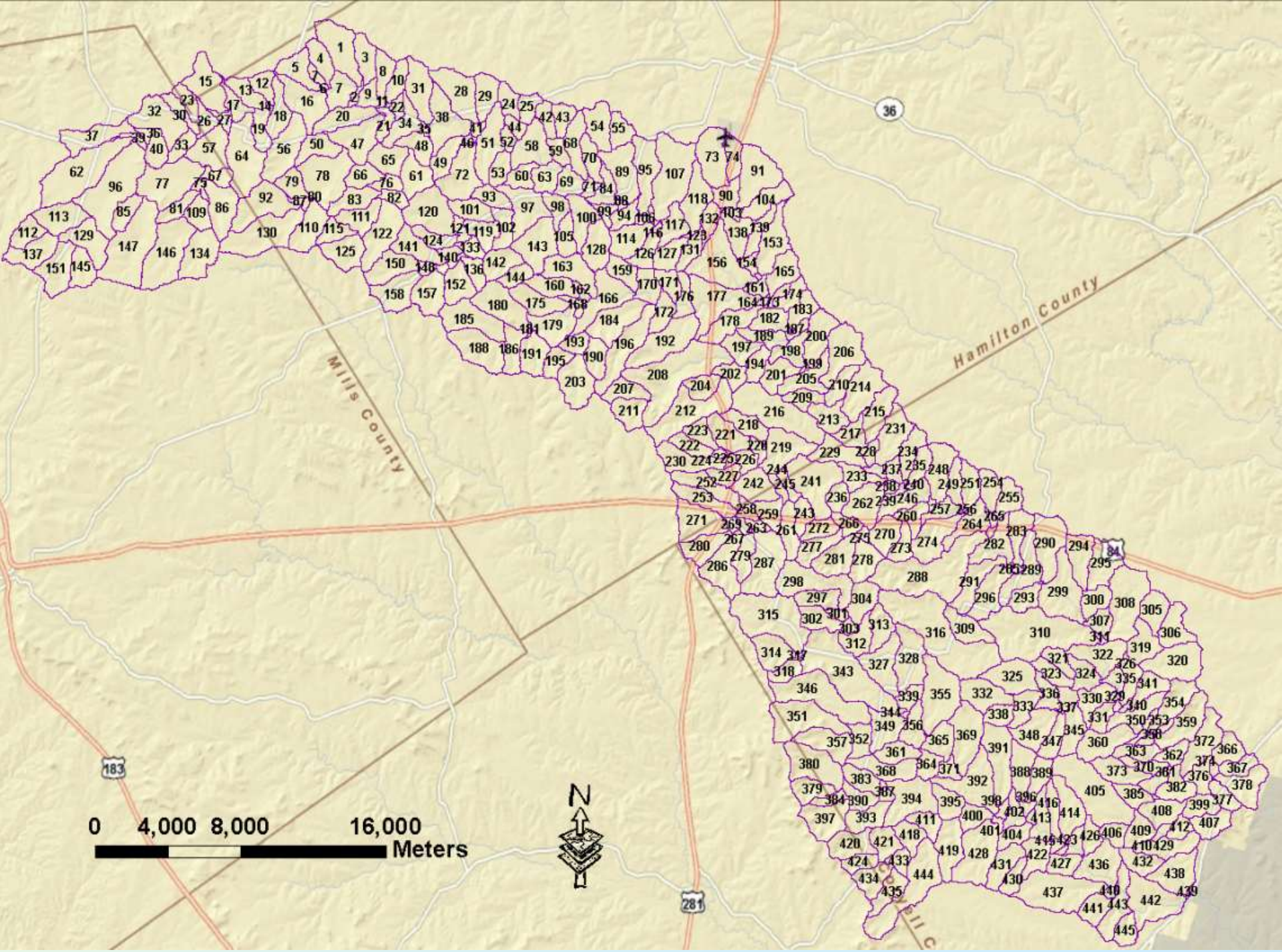
Major soils: Nuff, Doss, Topsey, Brackett, followed by Evant and Eckrant

Long-term annual precipitation: 775 mm



Brush range: 62%
Range glass: 34%



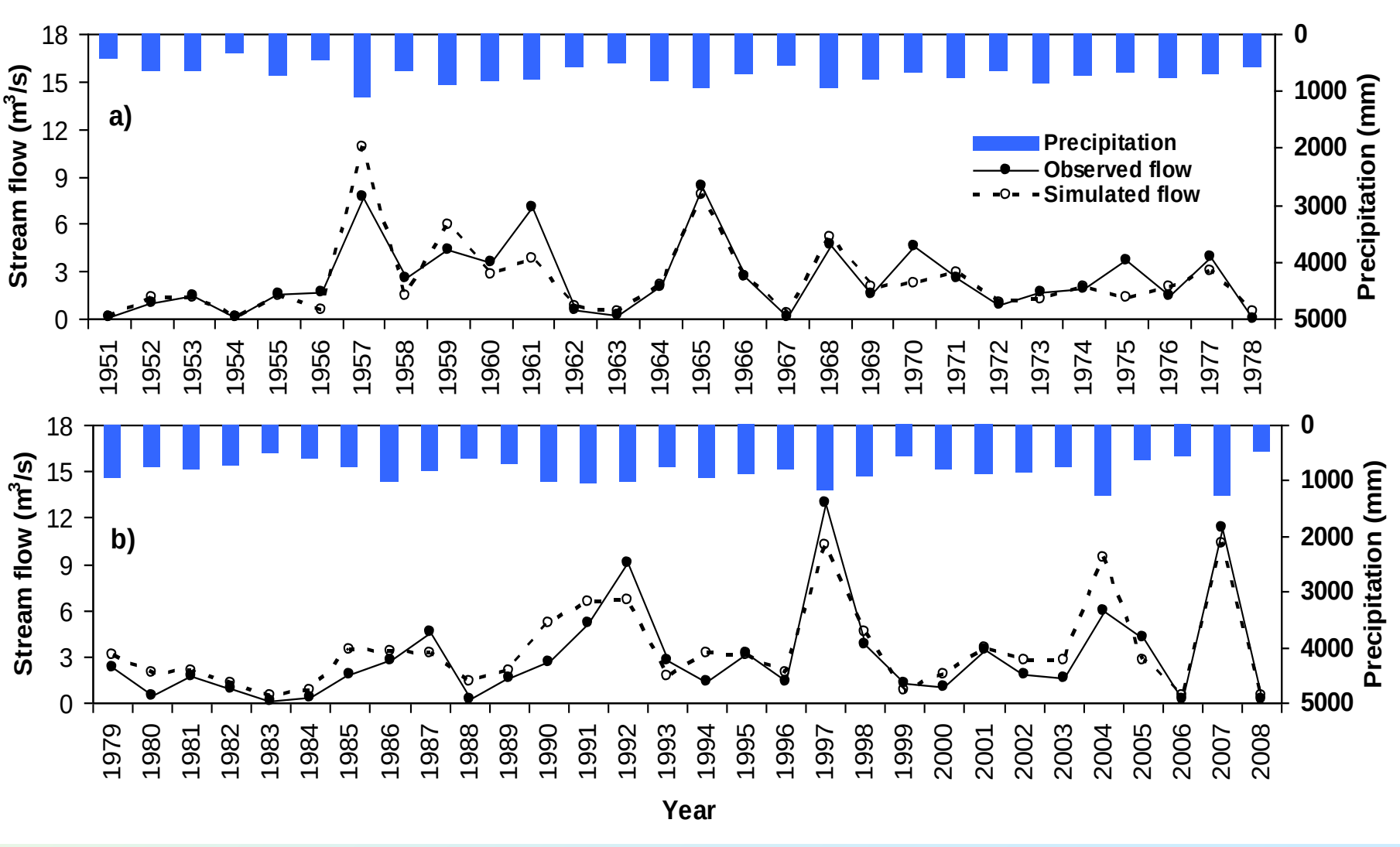

Mills County
Hamilton County
36
183
281
84
0 4,000 8,000 16,000
Meters
N

Calibrated parameter	Parameter description	Used value
LUN	Land use number for looking up Curve Number values	3 for cropland 21 for range 29 for forest
CNIC	CN index coefficient	1.5
RFPO	Return flow ratio: (Return flow)/ (Return flow + Deep percolation)	0.5
CVRSc	RUSLE C factor exponential residue coef.	1.0
CVCHc	RUSLE C factor exponential crop height coef. in biomass factor	0.015
SPCON	Potential sediment concentration when flow velocity is 1.0 m/s	0.005
SPEXP	Sediment routing exponent	1.5

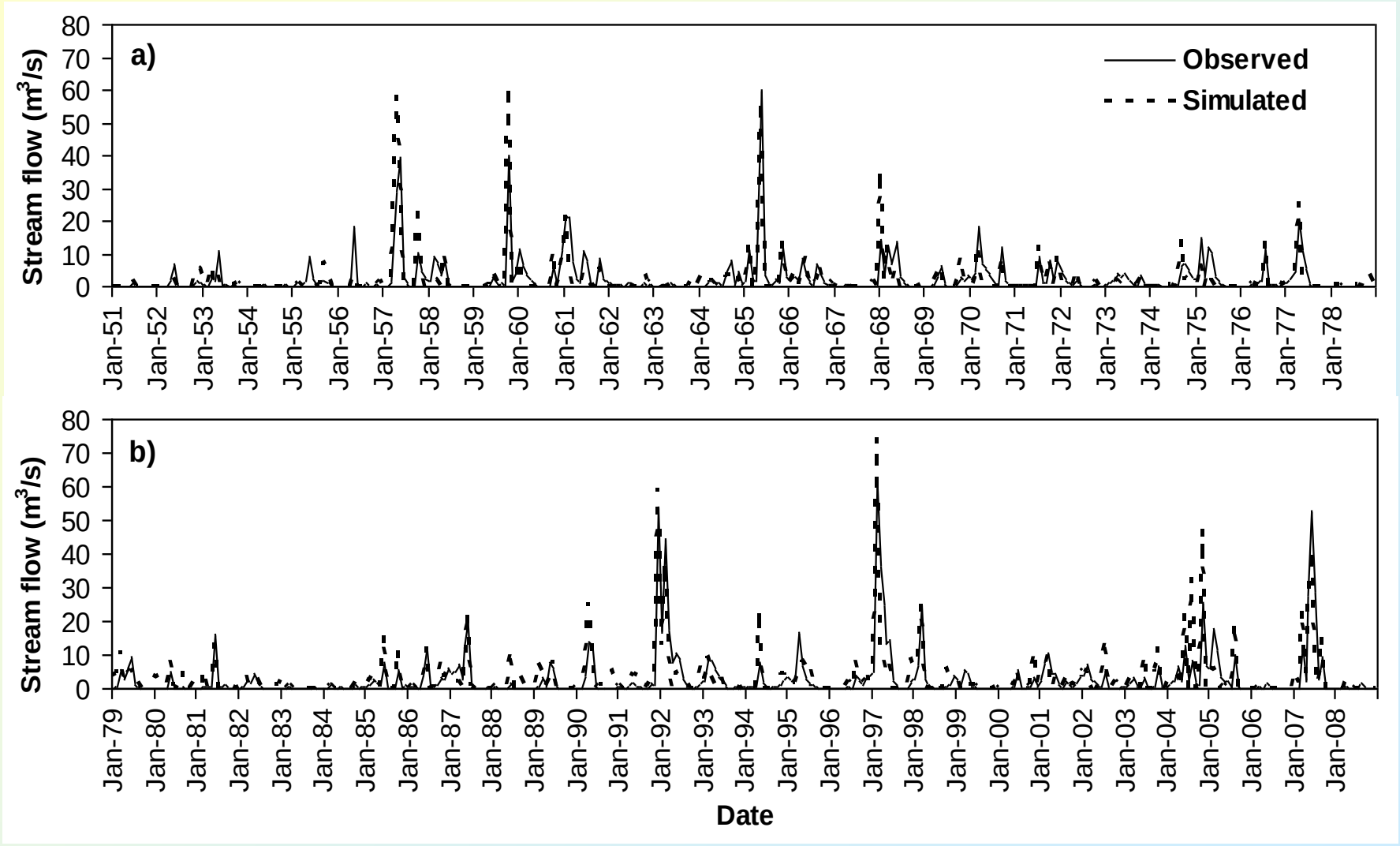
Annual & monthly streamflow calibration and validation for the Cowhouse Creek watershed at the USGS gauging # 08101000

		Observed mean (m^3/s)	Simulated mean (m^3/s)	NSE	R^2
Calibration 1/1951 – 12/1978	Annual	2.59	2.39	**0.71**	**0.76**
	Monthly	2.58	2.34	**0.67**	**0.76**
Validation 1/1979 – 12/2008	Annual	3.00	3.38	**0.81**	**0.83**
	Monthly	3.03	3.35	**0.71**	**0.74**

Precipitation vs. observed and simulated annual stream flow for a) calibration period (1951-1978) & b) validation period (1979-2008)

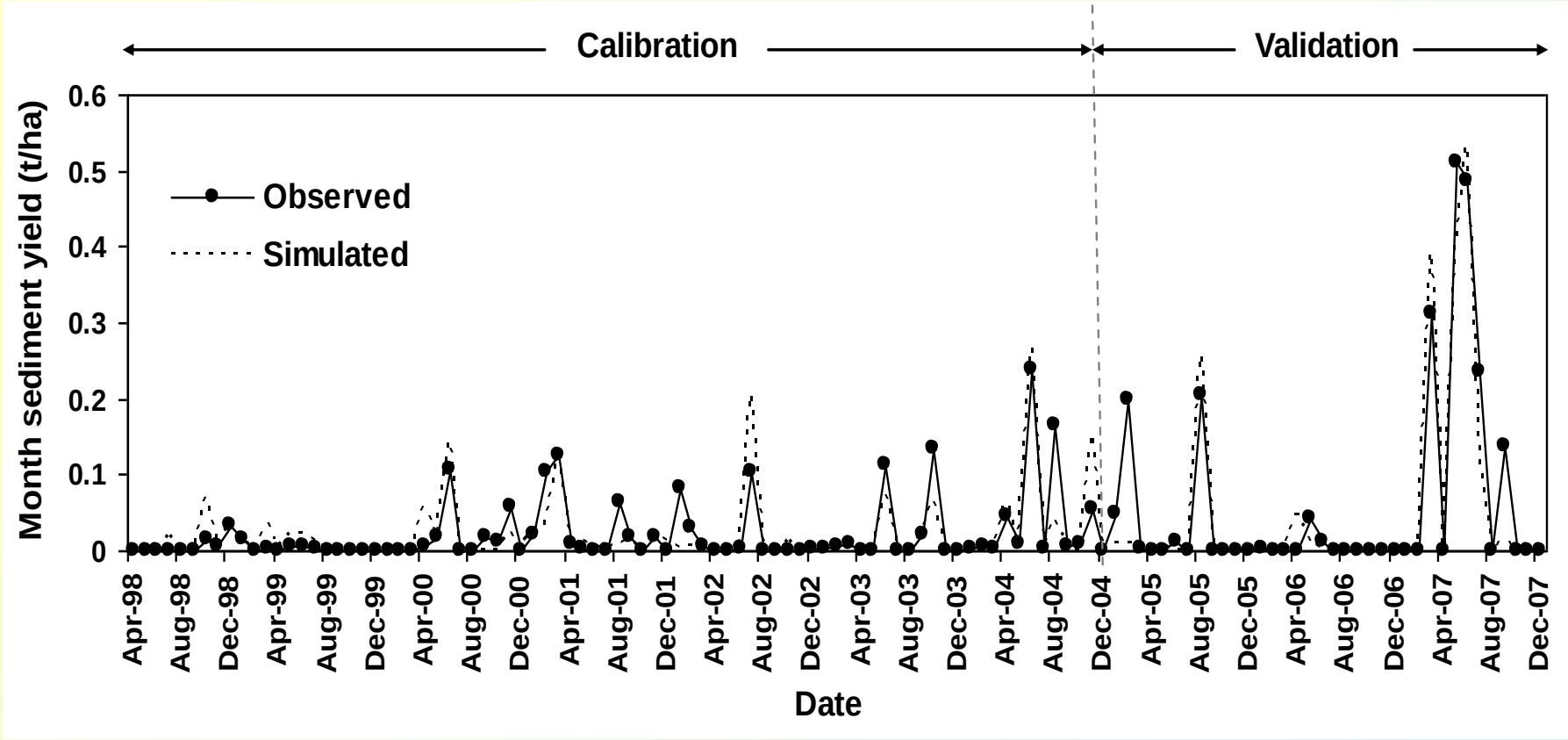


Observed and simulated monthly stream flow for a) calibration period & b) validation period

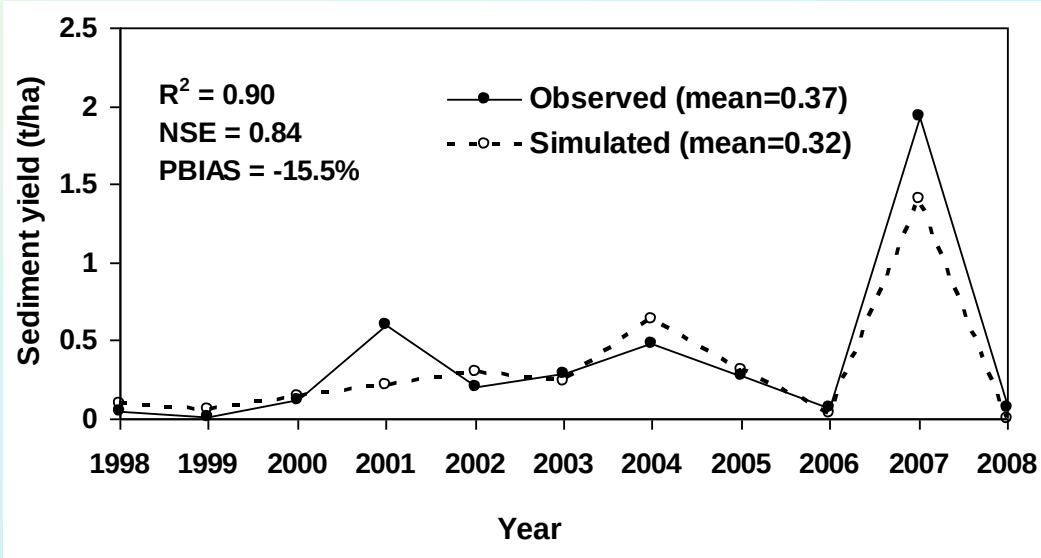


Sediment yield calibration/validation at the monitoring location near the USGS gauging# 08101000

	Observed mean (t/ha/mon)	**Simulated mean (t/ha/mon)**	**NSE**	**R^2**
Calibration (4/1998 – 12/2004)	0.02	0.02	**0.58**	**0.70**
Validation (1/2005-12/2008)	0.05	0.04	**0.84**	**0.85**



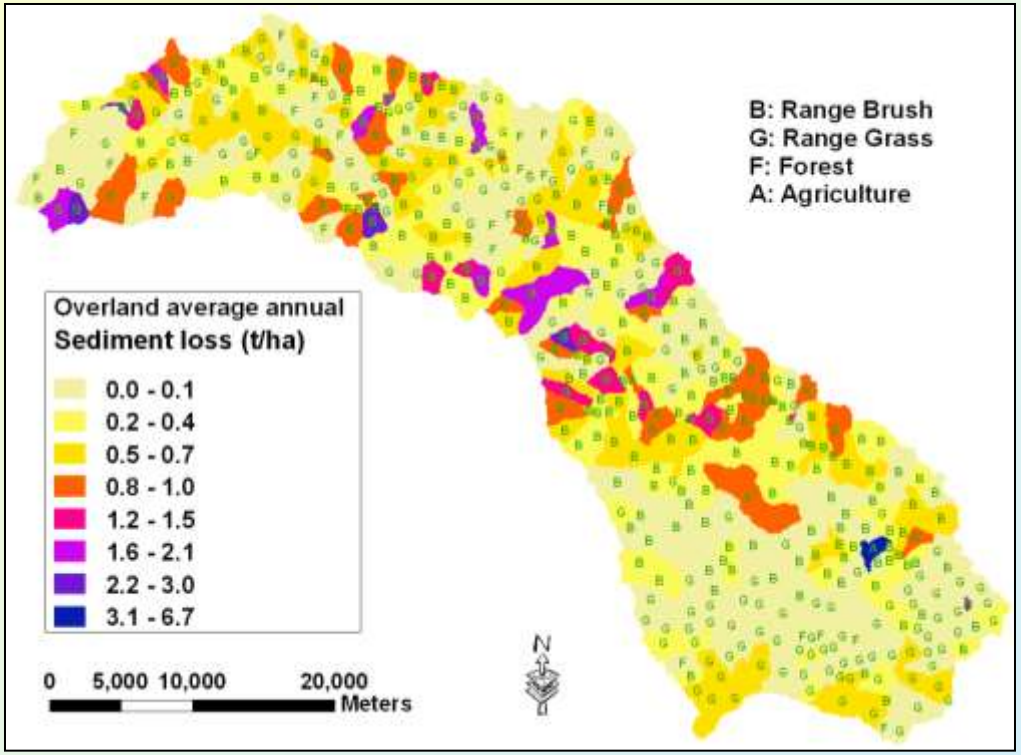
Observed and simulated sediment yield

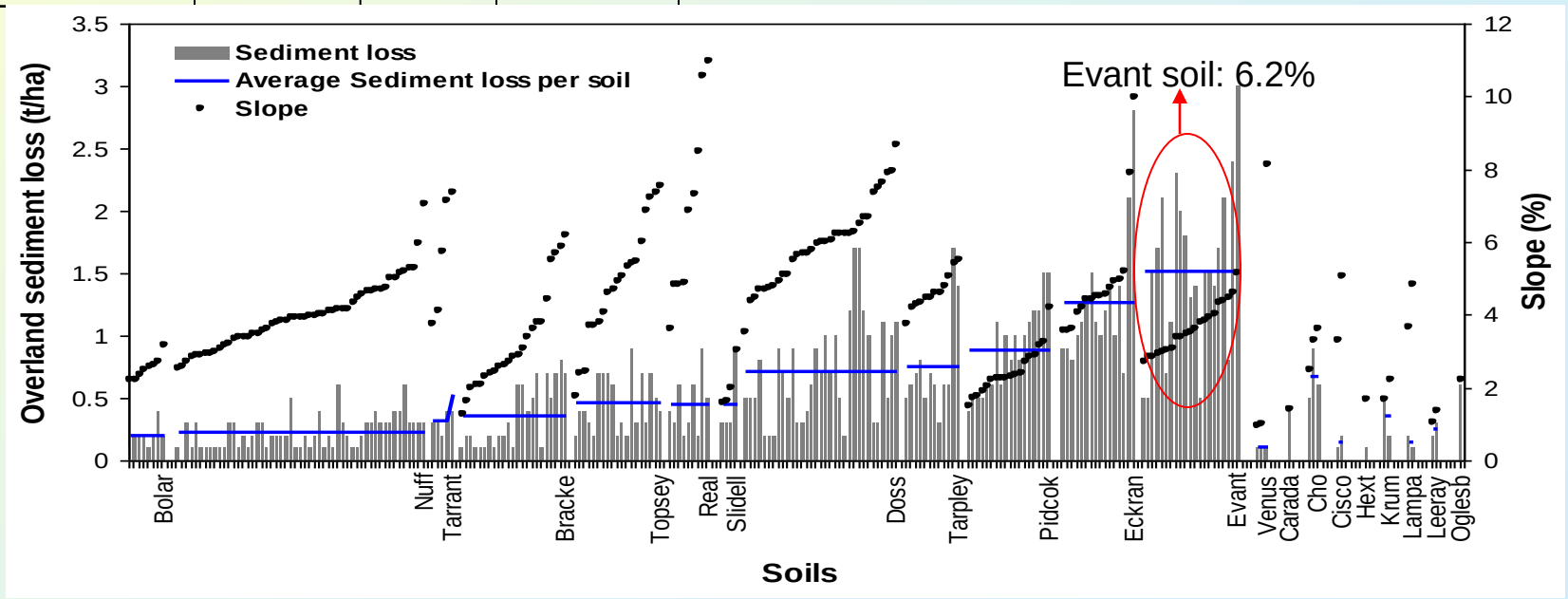


Scenario Analysis

using long-term simulation to target critical areas

Land use	Number of subareas	Overland sediment loss (t/ha)	
		Mean	Standard deviation
Agriculture (<0.1%)	2	5.25	3.18
Forest (4%)	25	0.01	0.03
Range grass (34%)	169	0.29	0.27
Range brush (63%)	249	0.86	0.83





Predicted effects of rangeland management practices (1951-2008)

Scenarios **(% of treated area)**			Sediment loading to watershed outlet		Avg. overland sediment loss reduction for treated areas, %
			t/year	Reduction, %	
Baseline			34,060	-	-
Conversion of range brush to range grass	Range brush on Evant soil to range grass	6%	31,719	-6.9	-58.8
	Range brush on Evant and Eckrant soils to range grass	11%	29,840	-12.4	-53.8
	All range brush to range grass	62%	24,769	-27.3	-48.5
Reduction of stocking rate	Stocking rate on range brush & range grass from 10 to 15 ha/herd	96%	32,541	-4.5	-6.3
	Stocking rate on range brush & range grass from 10 to 20 ha/herd	96%	31,949	-6.2	-7.9
Combined	Stocking rate from 10 to 15 ha/herd and range brush on Evant and Eckrant soils to range grass	96%	28,021	-17.7	-29.5

Conclusions

- APEX was able to realistically estimate monthly runoff and sediment load:
  - R^2 within 0.70-0.85
  - Nash–Sutcliffe efficiencies within 0.58-0.84

- Critical areas with relative high sediment loss were targeted to be range brush in Evant and Eckrant soils.

- Converting range brush to range grass in targeted areas result in substantial reduction in sediment loss with an average reduction of 54% from treated areas.

- Combining brush conversion for targeted soils and reducing stocking rate result in sediment yield reduction of 18% at the watershed outlet.

- The modeling process provides land managers the ability to test land management considerations prior to allocation of resources.

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Thank You

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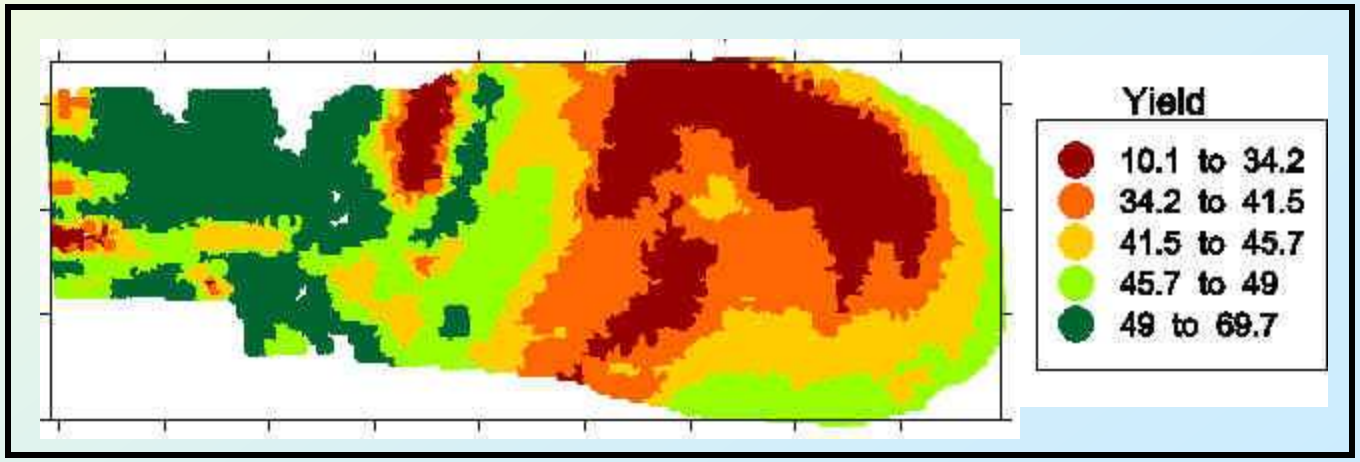
New EPIC/APEX Developments

CENTURY CARBON

- Replaced previous mineralization-immobilization component with CENTURY equations.
- Tested with several data sets and reported by Izaurralde.
- Used in National CASMGS runs by Jay Atwood (NRCS).
- Used in National CEAP runs by Jay Atwood.

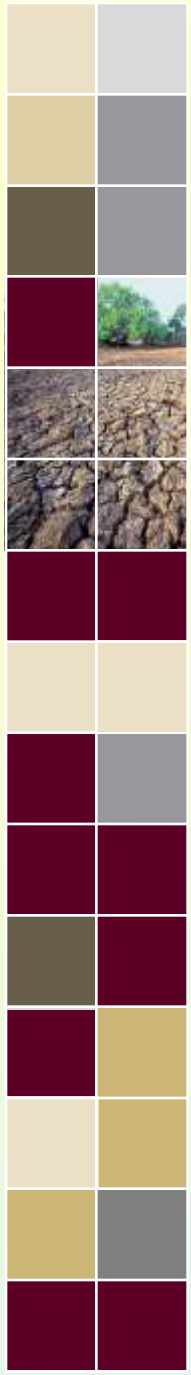
GEPIC

- GIS EPIC recently developed by Junguo Liu (Switzerland/China).
- Used to simulate and map world wide crop yields.



HAIL OCCURRENCE/DAMAGE COMPONENT

- Developed the hail model as a part of EPIC in cooperation with Drs. Wang and Little of Tarleton State University.
- Model simulates hail occurrence based on daily probabilities.
- Simulates hail damage based on long-term means and standard deviations.
- The model was applied to the state of Kansas and produced realistic results for five major crops in all nine districts of the state.
- Developed for use in crop insurance.



SOUTHERN OSCILLATION INDEX WEATHER SIMULATOR

- EPIC weather simulator has the option to consider the five phases of the SOI in generating rainfall.
- The model generates from one of five monthly weather parameter files depending on the phase of the SOI.
- Particularly useful in drought studies and real time simulation.

EPIC DYNAMICS-SOIL, ATMOSPHERIC CO_2, TECHNOLOGY

- Rawls equations use to calculate field capacity and bulk density as carbon changes.
- Soil layer thickness changes as bulk density/carbon change.
- Atmospheric CO_2 changes with time--Izaurralde.
- Developed a linear technology change that affects the crop harvest index.
- All of these relationships can be set static or dynamic.

EPIC MANAGEMENT

- Drip irrigation was added as an another irrigation option.
- Water is applied automatically at a specified soil depth.
- Rice paddys--constructed as large furrow dike. Puddling operation added (reduces saturated conductivity of second soil layer).
- Plastic mulch cover added--reduces evaporation; increases runoff.
- Automatic mowing operation added--lawns and golf courses.

APEX FLOOD ROUTING

- Added hydrograph development and flood routing component.
- Uses a storage depletion method for hydrograph development and the variable storage coefficient flood routing method.
- Hydrographs are routed at any user selected time interval.
- Provides for stream flow simulation not just daily water yield. This feature allows operation on much larger watersheds than previous versions.
- Hydrographs provide potential increased accuracy for routing sediment, nutrients, and pesticides.

APEX SPATIAL RAINFALL SIMULATOR

- Generates storm centroid (draws uniform random number on X and Y axis).
- Generates rainfall amount from parameters of station nearest storm centroid.
- Rainfall amounts of other subareas a function of distance from storm centroid, rainfall duration, and N-S and E-W gradients.
- Final rainfall amounts adjusted with stochastic component.

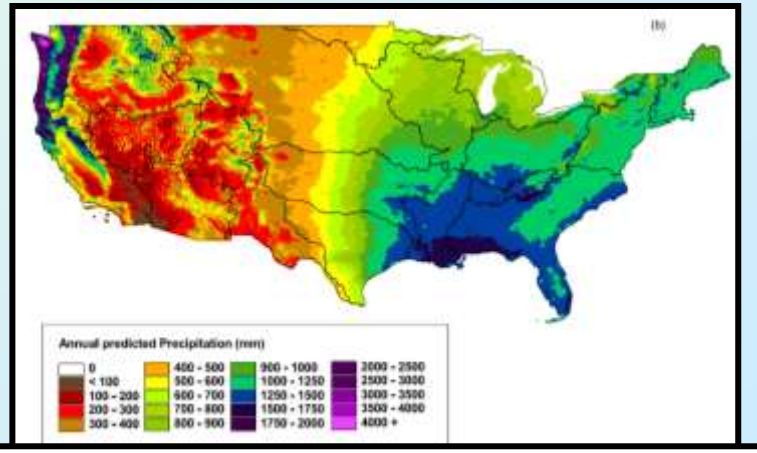


FIG. 7. (b) Annual average predicted precipitation in the period 1960-2001.

APEX PLAYA RESERVIORS

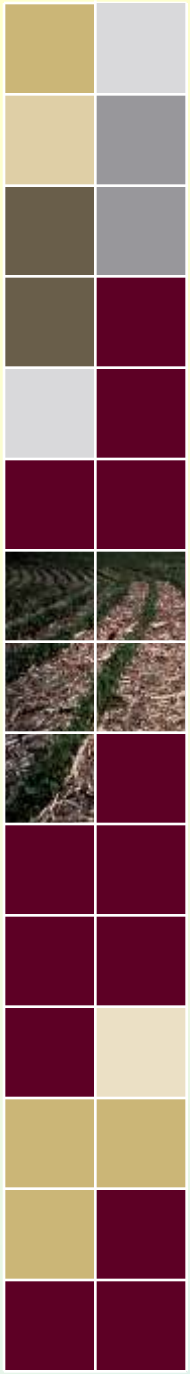
- Worked with researchers at Texas Tech University in developing APEX reservoir component for application to playas.
- Playas have no spillways--losses are from evaporation and seepage.
- Modified model to reduce storage with deposited sediment.
- Used to determine water availability for ducks and geese.

APEX POINT SOURCES

- A point source can be entered in each subarea.
- Inputs are daily flow and soluble N and P.

RUSLE

- A modified version of RUSLE was added to EPIC and APEX.
- The RUSLE slope length equation performed well on steep slopes in China.
- The RUSLE C factor equations simulate erosion realistically over a range in tillage (no till/conventional till).



Calibrated parameter	Parameter description	Used value
LUN	Land use number for looking up Curve Number values	3 for cropland 21 for range 29 for forest
CNIC	CN index coefficient $S = S_{prev} + PET \times \exp(-CNIC \times \frac{S_{prev}}{S_{\max}}) - P + Q$	1.5
RFPO	Return flow ratio: (Return flow)/ (Return flow + Deep percolation)	0.5
CVRSc	RUSLE C factor exponential residue coef. $C = \exp(-0.026 \times (RRUF - 6.1)) \times FRSD \times FBIO$ $FRSD = \exp(-CVRSc \times CVRS)$	1.0
	Potential sediment concentration when flow velocity is 1.0 m/s	0.005
a	Sediment routing exponent $CY_U = CY_1 \times V_{ch}^{\ a}$	1.5