A Watershed Modeling and Brush-management Study of the Upper Guadalupe River Basin

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In cooperation with Texas State Soil and Water Conservation Board (TSSWCB) and Upper Guadalupe River Authority (UGRA)

U.S. Department of the Interior
U.S. Geological Survey

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Outline

- Brush management background
- Project overview
- Study area
- Model development
- Model calibration
- Scenario analysis
- Potential future work

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Brush Management Background

- The selective removal of woody plants in an effort to:
  - Create desired plant communities
  - Manage erosion
  - Improve water quality
  - Improve wildlife habitat
  - Improve forage accessibility
  - Manage fuel loads
  - Enhance streamflow or water yield
- Ashe juniper (cedar) has spread because of fire suppression and overgrazing.
- Ashe juniper might intercept and use more water than native grasses.

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Project Overview

- Develop and calibrate a model of the Guadalupe River watershed upstream from Canyon Dam.
- Simulate the effects of brush management on water yields to Canyon Lake.
- Feasibility study: results will be taken into consideration by TSSWCB in their decisions regarding brush management.

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Prepared in cooperation with the Texas State Soil and Water Conservation Board and the Upper Guadalupe River Authority

Simulation of Streamflow and the Effects of Brush Management on Water Yields in the Upper Guadalupe River Watershed, South-Central Texas, 1995–2010

Scientific Investigations Report 2012–5051

U.S. Department of the Interior
U.S. Geological Survey

http://pubs.usgs.gov/sir/2012/5051

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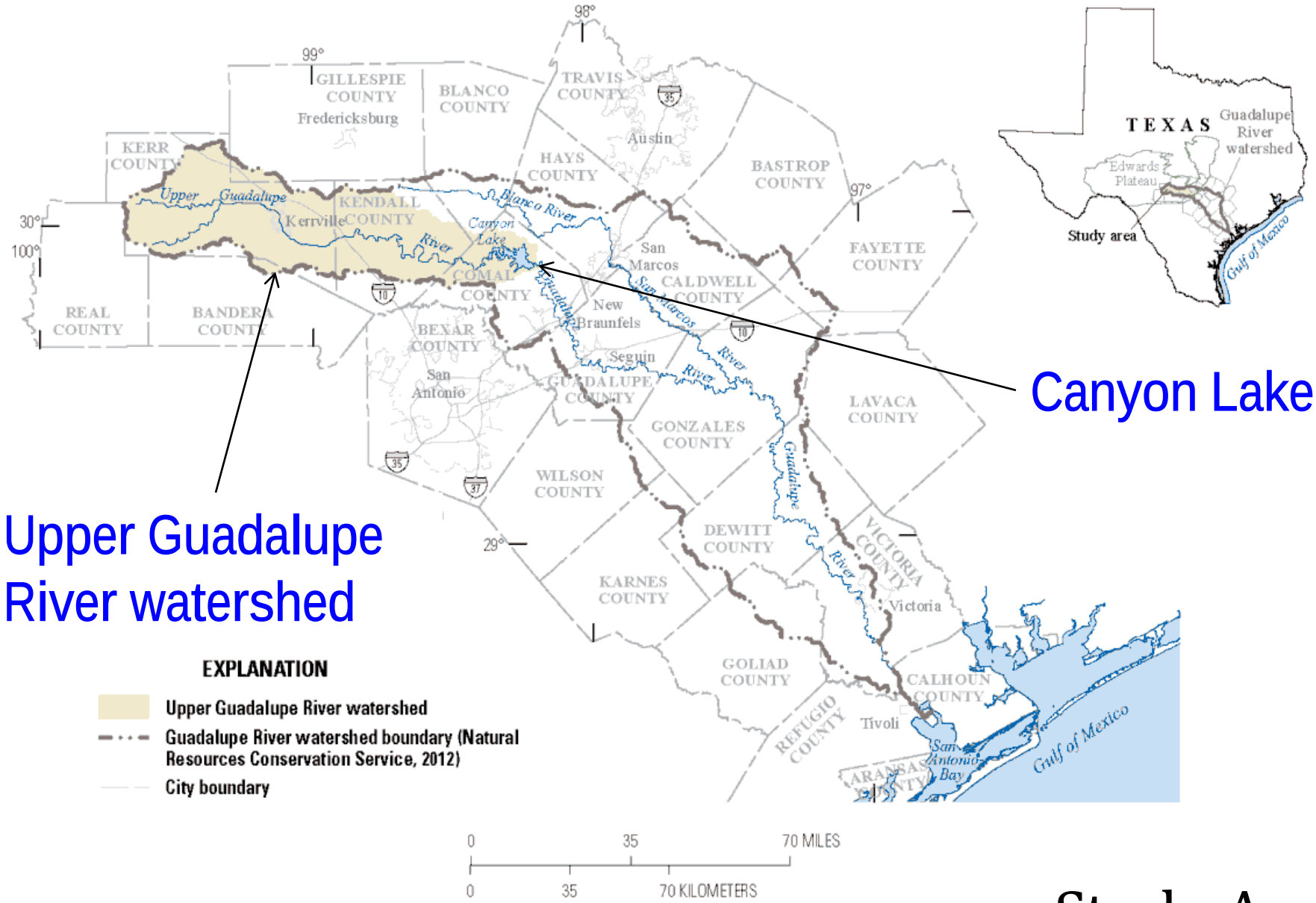

Canyon Lake
Upper Guadalupe River watershed
TEXAS
Guadalupe River watershed
Edwards Plateau
Study area
Gulf of Mexico
GILLESPIE COUNTY
Fredericksburg
BLANCO COUNTY
TRAVIS COUNTY
Austin
KERR COUNTY
HAYS COUNTY
BASTROP COUNTY
KENDALL COUNTY
Kerrville
Upper Guadalupe River
Blanco River
Canyon Lake
San Marcos
FAYETTE COUNTY
COMAL COUNTY
CALDWELL COUNTY
New Braunfels
San Marcos River
REAL COUNTY
BANDERA COUNTY
BEXAR COUNTY
Seguin
San Antonio
GUADALUPE COUNTY
LAVACA COUNTY
GONZALES COUNTY
WILSON COUNTY
DEWITT COUNTY
VICTORIA COUNTY
Victoria
KARNES COUNTY
GOLIAD COUNTY
CALHOUN COUNTY
Tivoli
REFUGIO COUNTY
ARANSAS COUNTY
San Antonio Bay
Gulf of Mexico
EXPLANATION
Upper Guadalupe River watershed
Guadalupe River watershed boundary (Natural Resources Conservation Service, 2012)
City boundary
0 35 70 MILES
0 35 70 KILOMETERS

Study Area

Model Development: SWAT

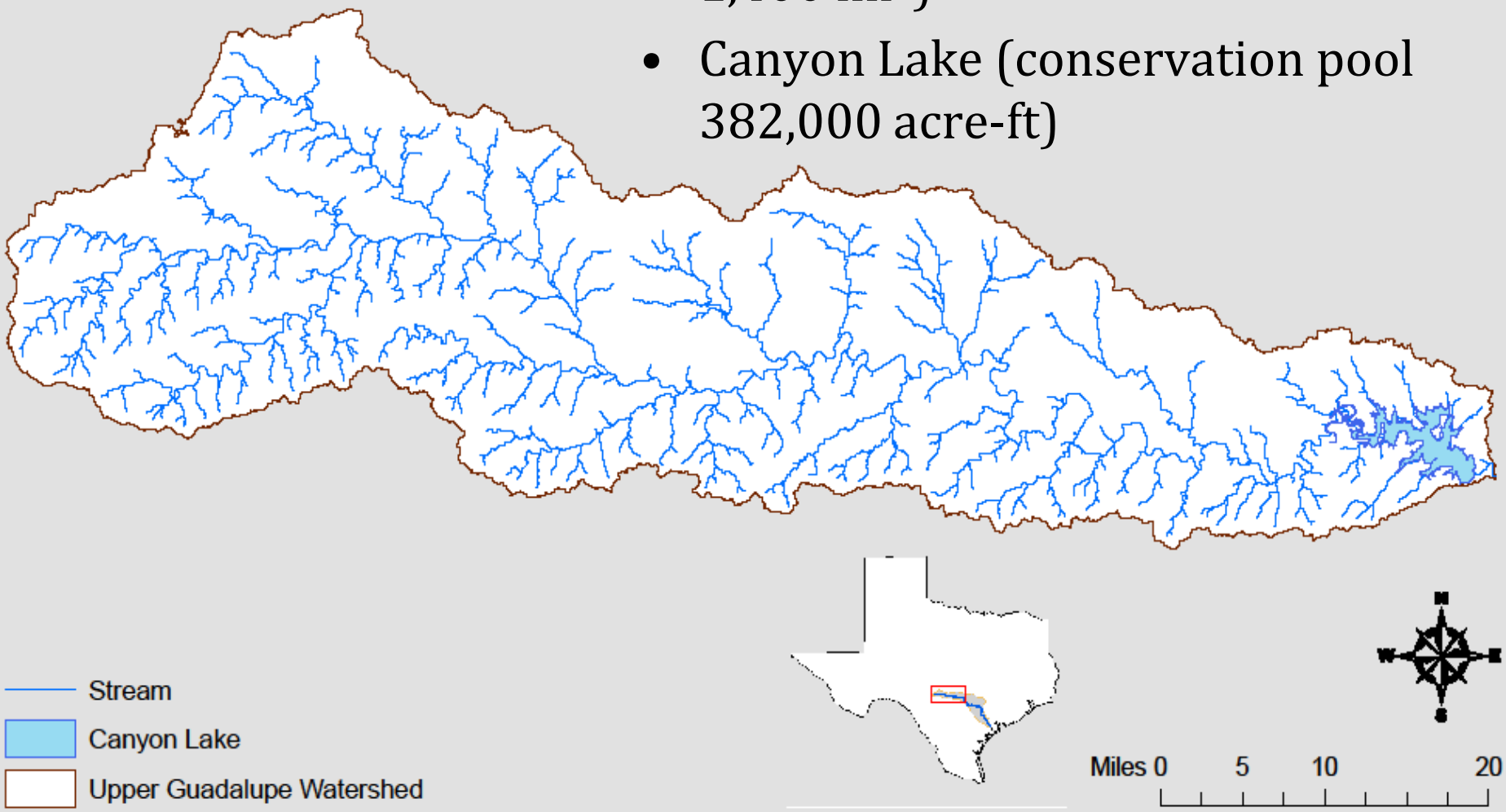
- Soil and Water Assessment Tool (SWAT) watershed model.
- A process-based, basin-scale continuous watershed model developed to quantify the hydrologic effects of land-management practices.
- Can simulate: Climate, hydrology, nutrients/pesticides, erosion, land cover/plant cycles, management practices
- SWAT setup:
  - Watershed divided into subbasins.
  - Subbasins are divided into hydrologic response units (HRUs) that consist of homogeneous land cover, soils, and slopes.
  - Model principally driven by atmospheric input

Model Development: Processes

- Example hydrologic equations:
  - Rainfall-runoff calculations (SCS curve number)
  - Evapotranspiration (Penman/Monteith)
  - Soil water storage and transport
  - Baseflow recession
  - Groundwater
  - Water routing (main channel and water bodies)
- Land-cover/plant growth-cycle equations
- Each equation contains variables that can be modified to set initial conditions and/or for model calibration.

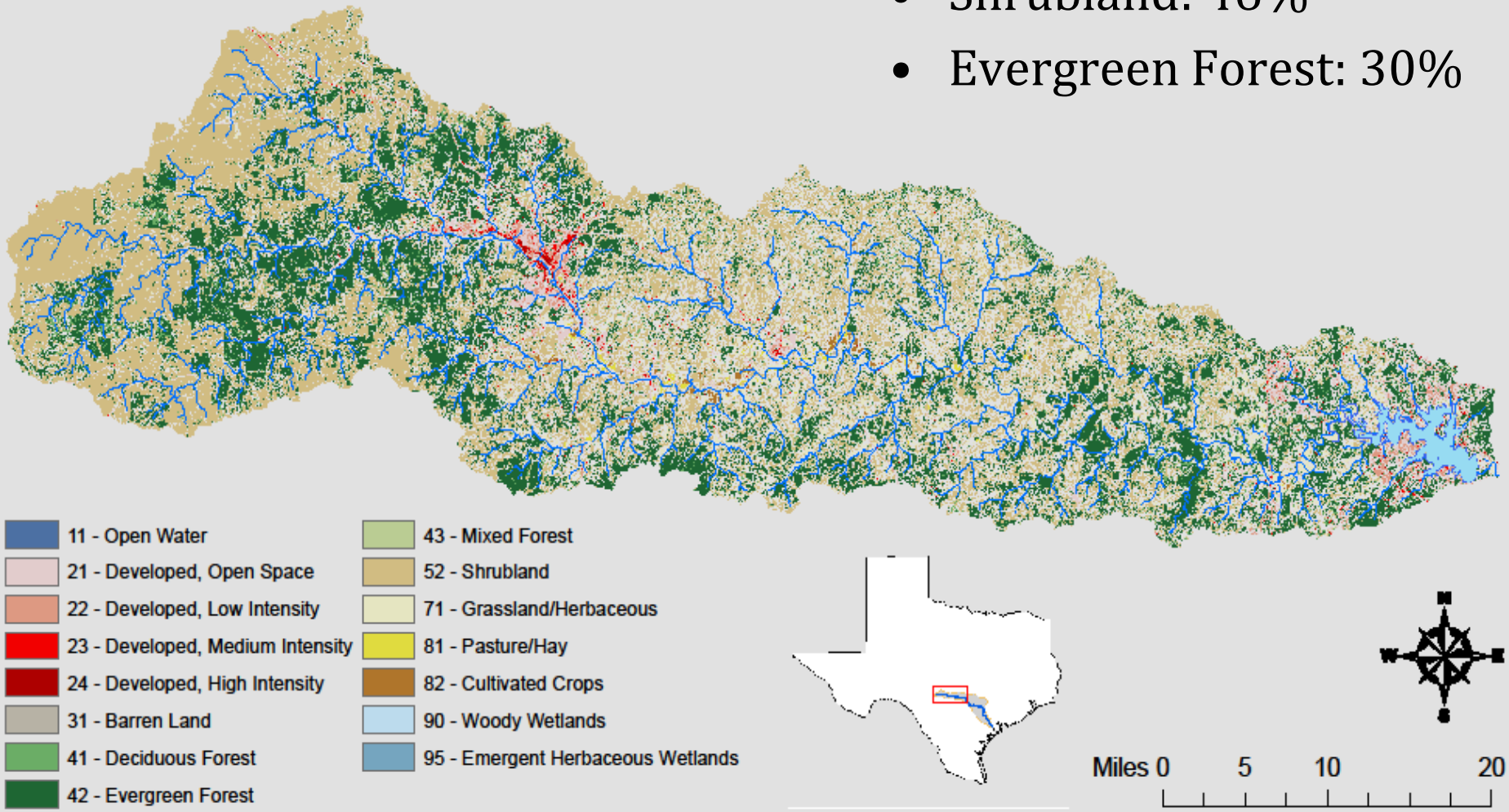
Model Development: Watershed

- UGW Area: 920,000 acres (about 1,400 mi^2)
- Canyon Lake (conservation pool 382,000 acre-ft)



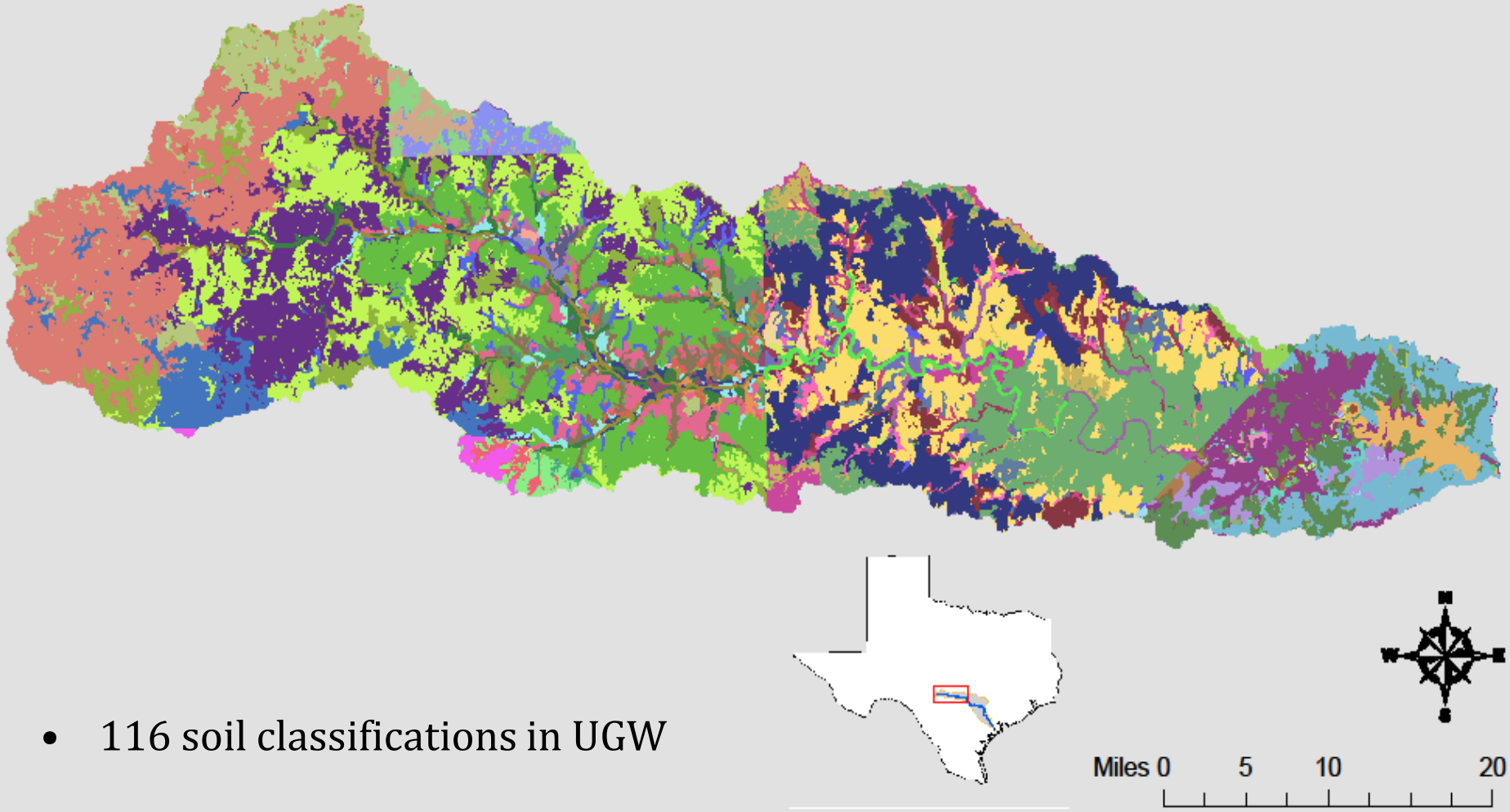
Model Development: Land Cover

- NLCD 2006
- Shrubland: 46%
- Evergreen Forest: 30%



Model Development: Soils

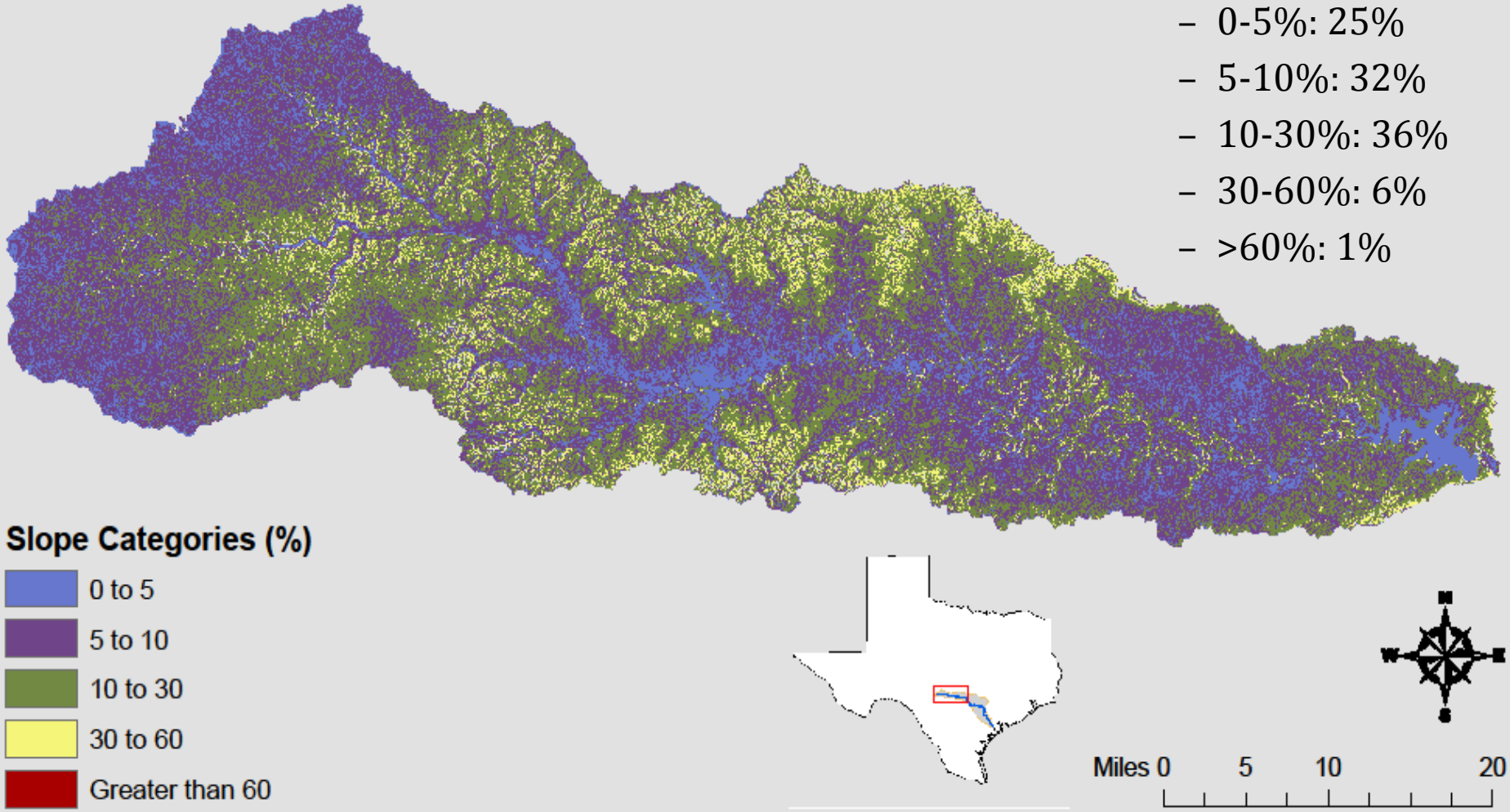
- SSURGO: County-level soil classification (1:24K; Soil Survey Geographic Database)



- 116 soil classifications in UGW

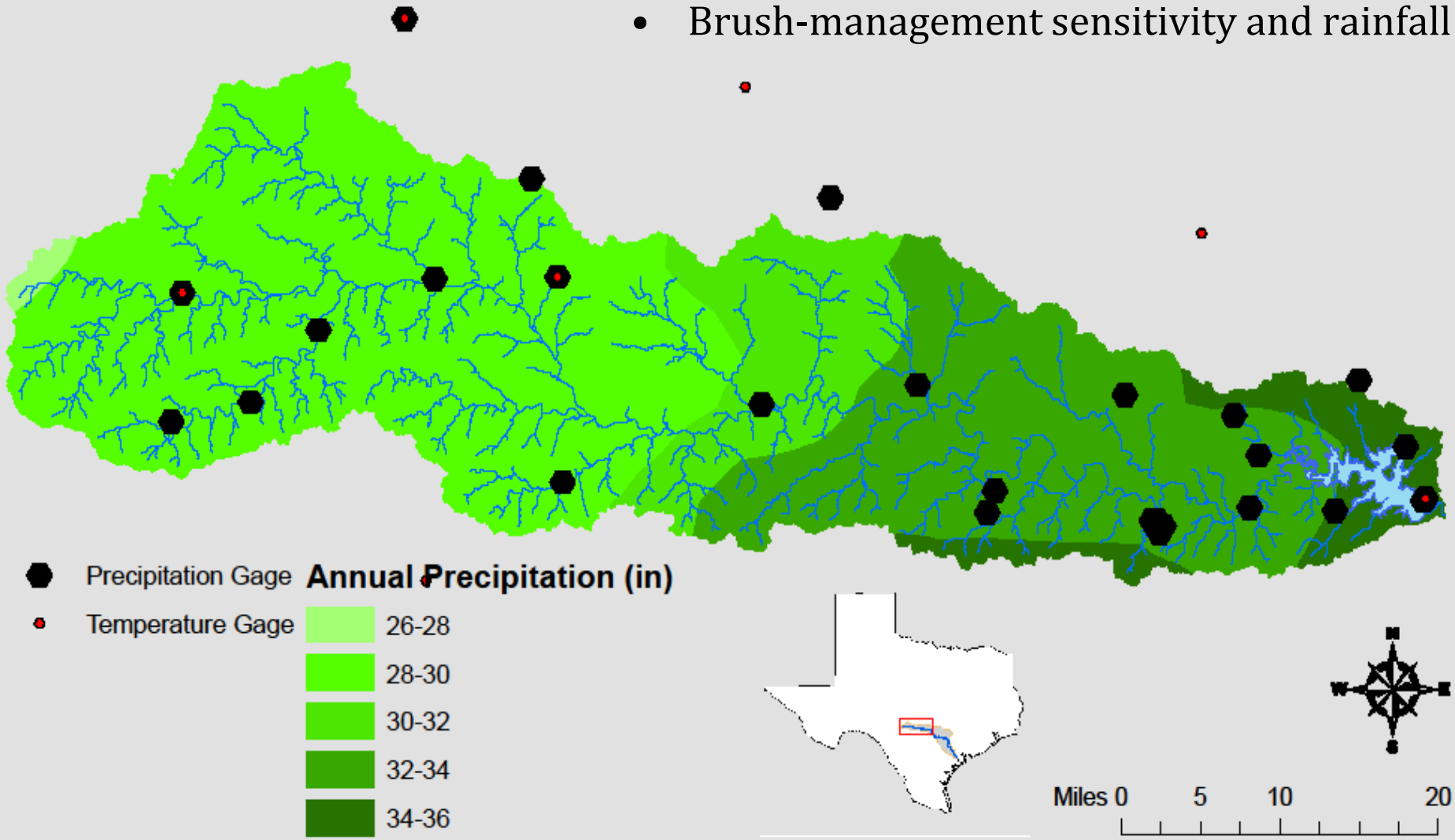
Model Development: Slopes

- Five slope classifications
- Areal slope distribution:
  - 0-5%: 25%
  - 5-10%: 32%
  - 10-30%: 36%
  - 30-60%: 6%
  - >60%: 1%



Model Development: Atmospheric Data

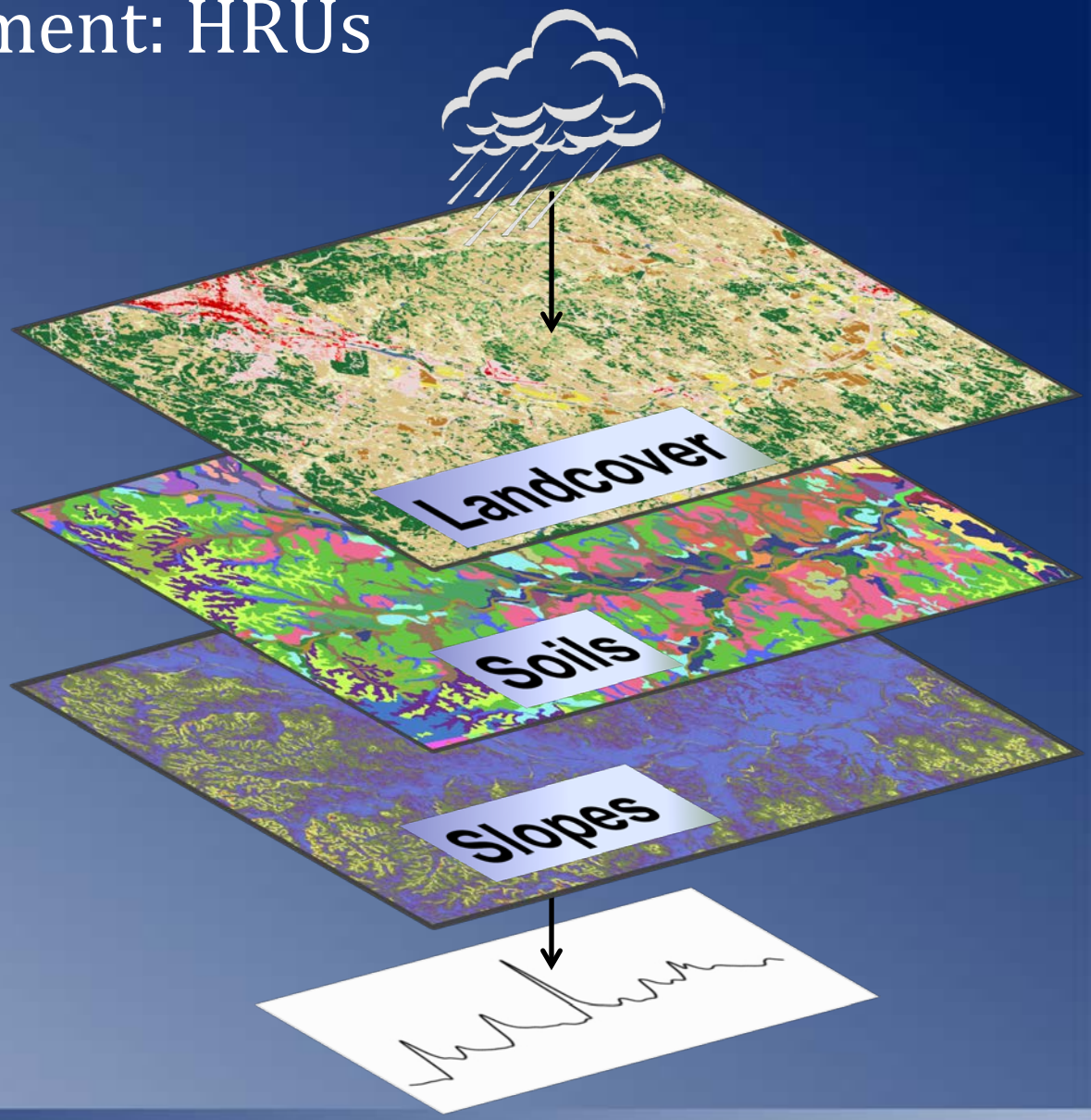
- Increased rainfall west to east
- Brush-management sensitivity and rainfall



Model Development: HRUs

- HRUs developed by intersecting landcover, soil, and slope

- HRUs management model responses (runoff, infiltration, evapotranspiration, etc…)



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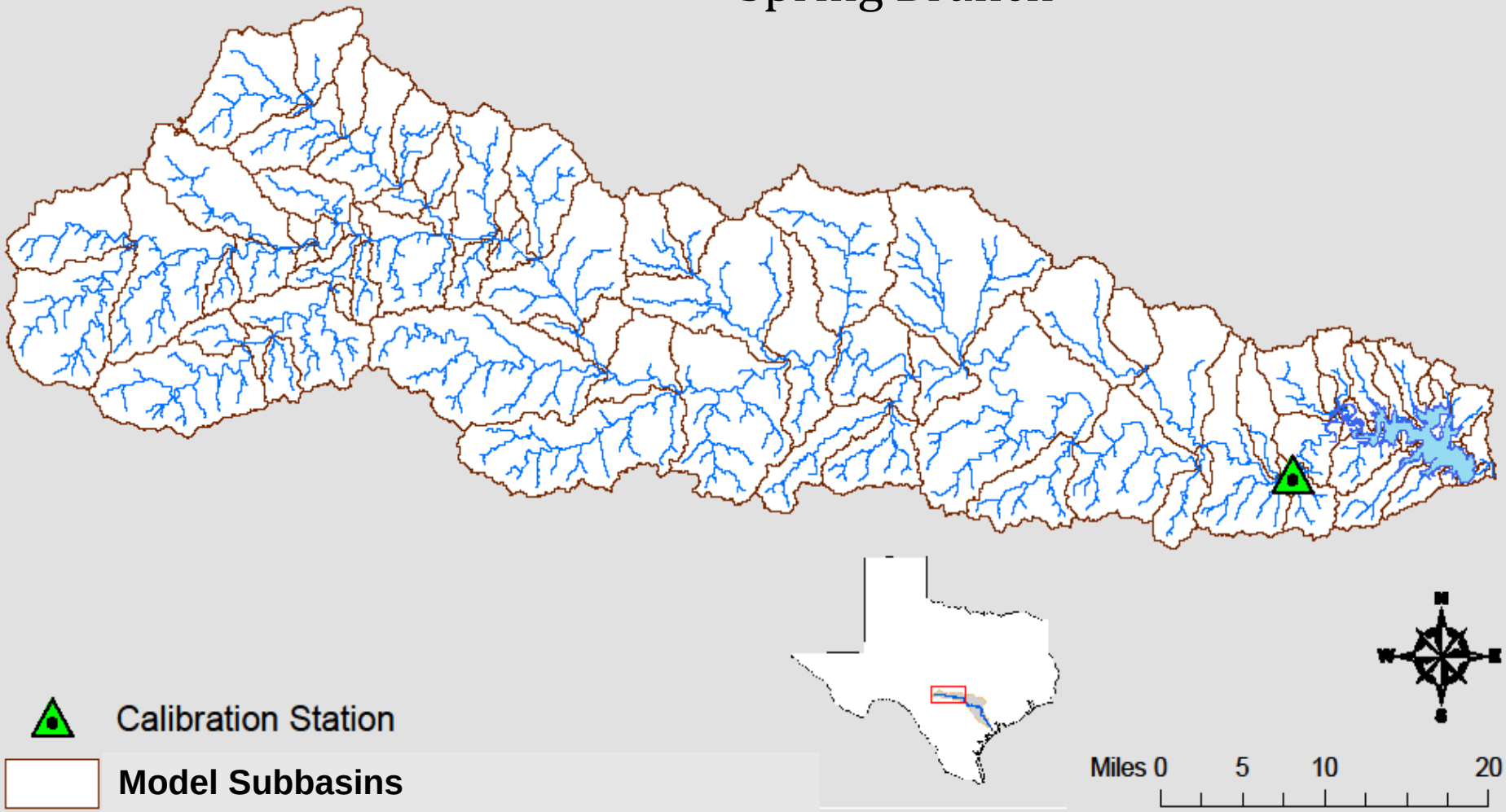
Model Calibration: Data

- Calibration: Guadalupe River at Spring Branch



Model Calibration: Parameters

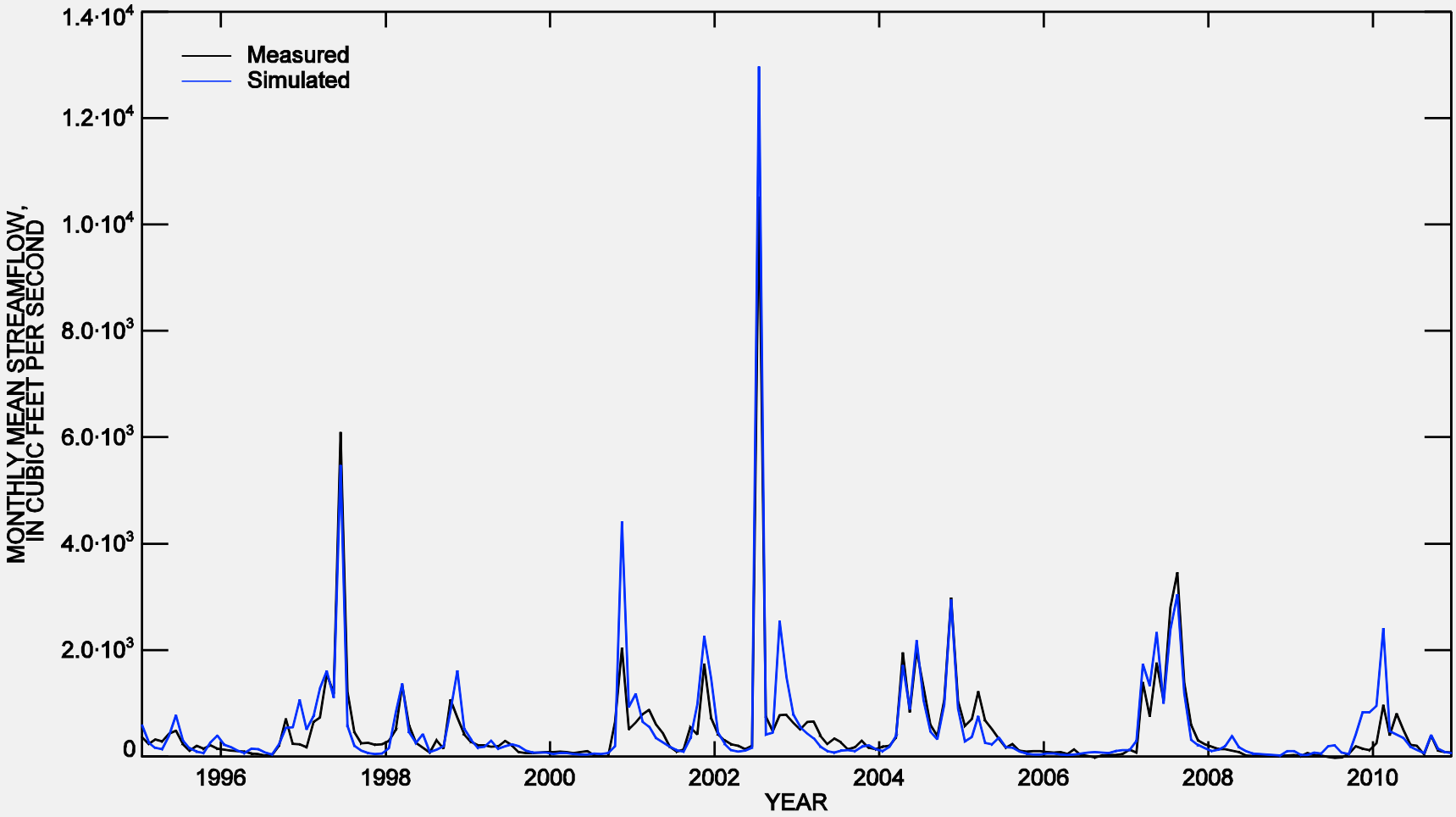
- Daily CN values calculated as a function of plant ET due to shallow soils in the watershed.

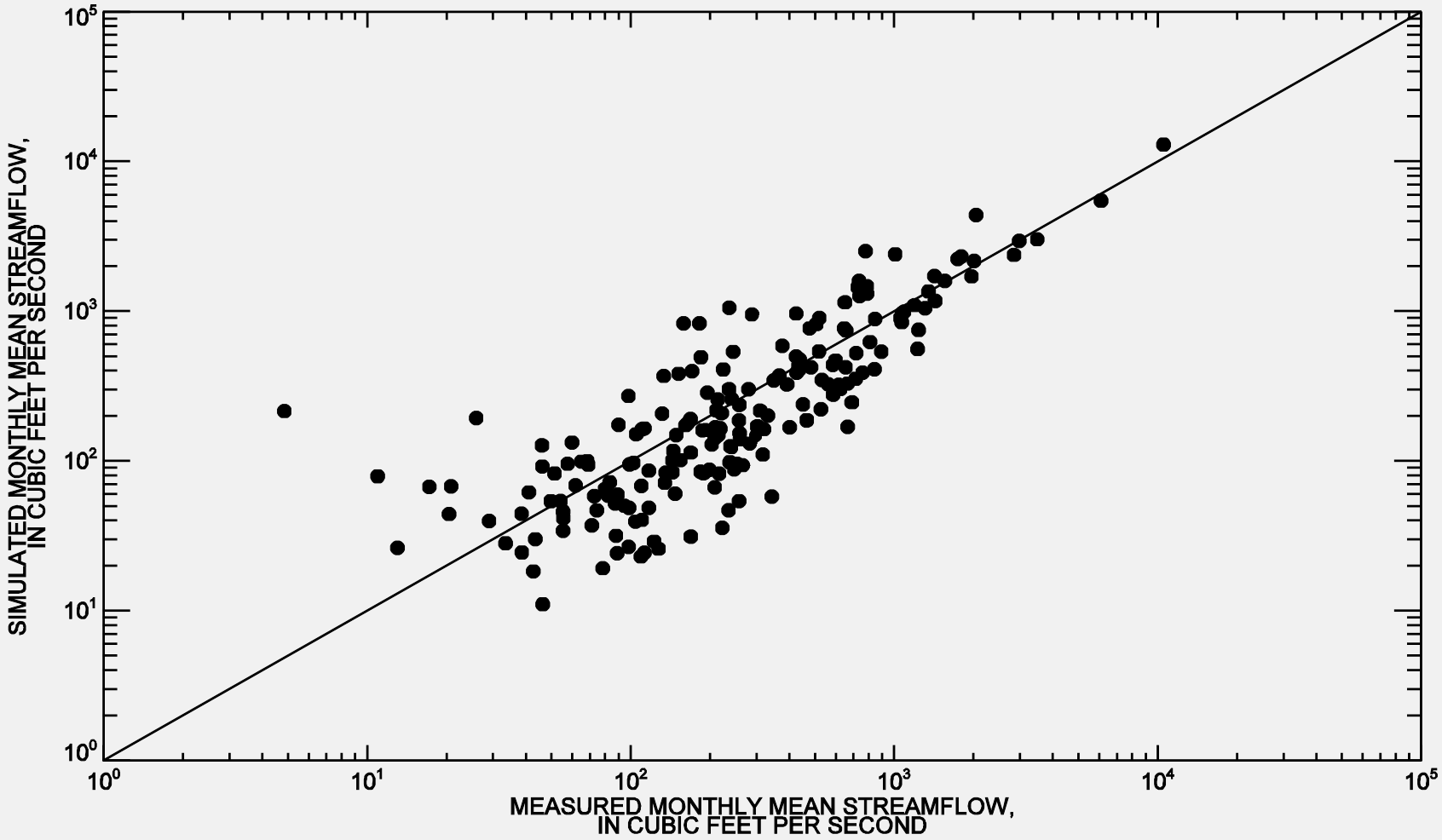
Parameter	Description (units)	SWAT input file location	Calibrated parameter value	Default parameter value
ALPHA_BF	Base-flow recession constant (days)	*.gw	0.15	0.048
CANMX	Maximum canopy storage (mm)	*.hru	+20	**
CH_K2	Effective hydraulic conductivity in main channel alluvium (mm/hour)	*.rte	13	0
CN2	Initial SCS curve number (--)	*.mgt	All Range and Forest categories decreased by 7%	**
GW_DELAY	Groundwater delay time (days)	*.gw	15	30
GW_REVAP	Represents water movement from the shallow aquifer to the root zone (--)	*.gw	0.2	0.02
GWQMN	Threshold depth for water in the shallow aquifer for return flow to occur (mm)	*.gw	60	0
RCHRG_DP	Deep aquifer percolation factor (--)	*.gw	0.46	0
REVAPMN	Threshold depth for water in the shallow aquifer for percolation to the deep aquifer to occur (mm)	*.gw	0	1
SURLAG	Surface runoff lag coefficient (--)	.bsn	1	4

Model Calibration: Metrics

- Numerous parameters in each HRU to use for calibration
- Good Fit:
  - Percent Bias: < ±10%
  - Monthly Nash-Sutcliffe (NS) model efficiency coefficient: > 0.60

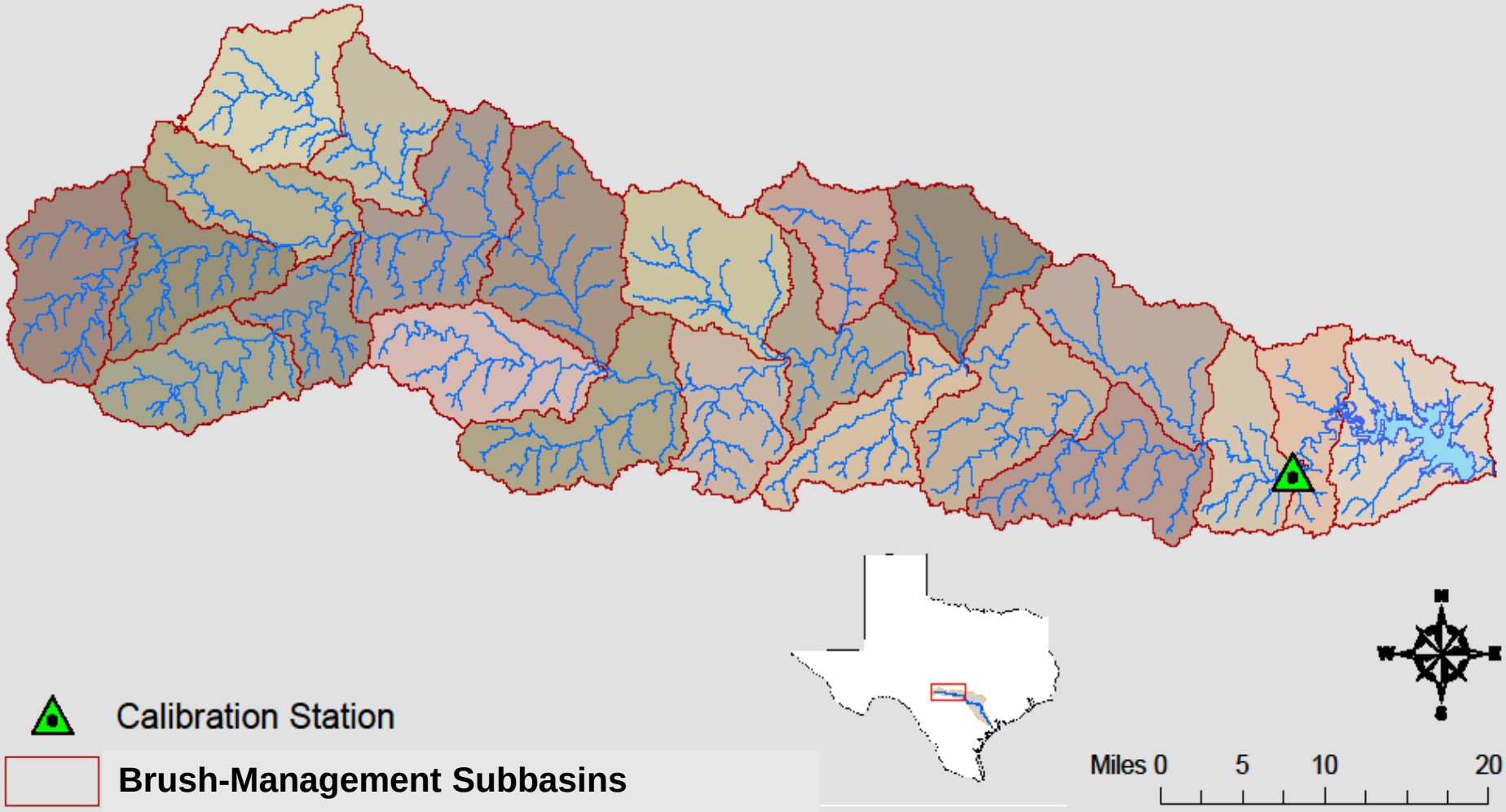
Watershed	Calibration record	Calibration Gage	Volume Deviation	Daily NS	Monthly NS	Annual NS
Upper Guadalupe	1995 - 2010	Guadalupe River at Spring Branch, Tex.	-5%	0.71	0.85	0.90


Measured
Simulated
MONTHLY MEAN STREAMFLOW, IN CUBIC FEET PER SECOND
1.4·10^4
1.2·10^4
1.0·10^4
8.0·10^3
6.0·10^3
4.0·10^3
2.0·10^3
0
1996
1998
2000
2002
2004
2006
2008
2010
YEAR


SIMULATED MONTHLY MEAN STREAMFLOW, IN CUBIC FEET PER SECOND
MEASURED MONTHLY MEAN STREAMFLOW, IN CUBIC FEET PER SECOND
10^0
10^1
10^2
10^3
10^4
10^5

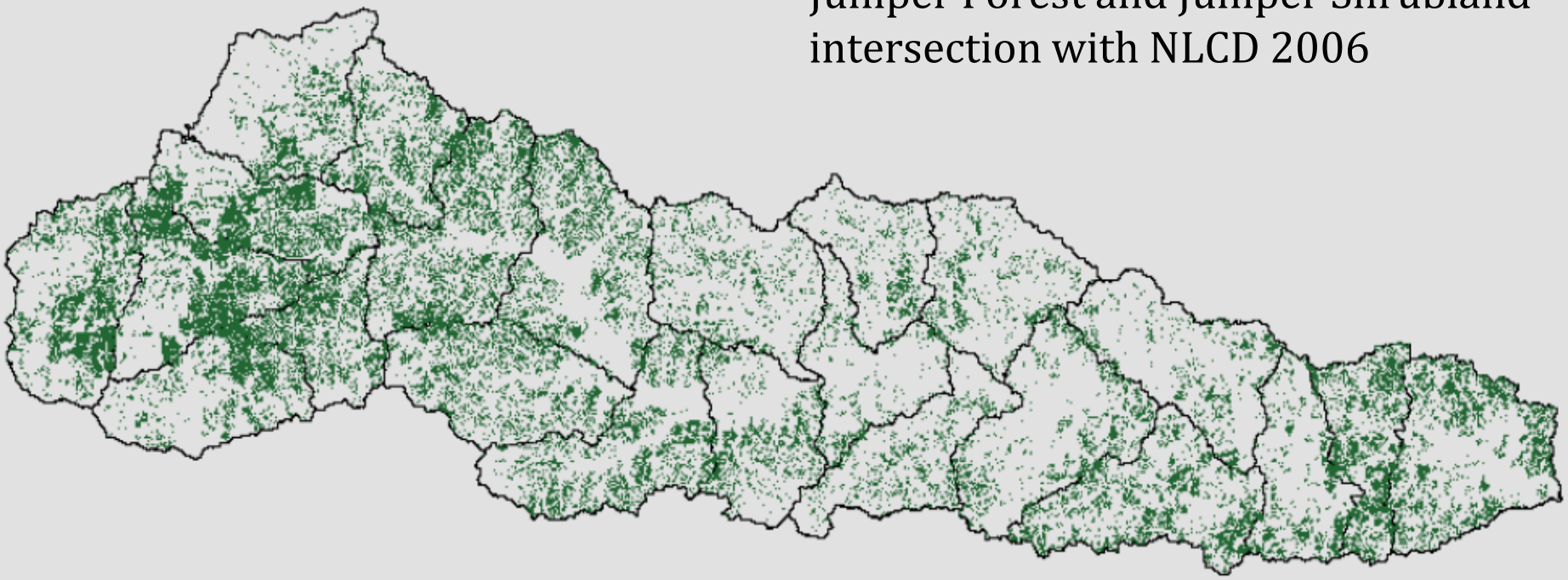
Scenario Analysis: Subbasins

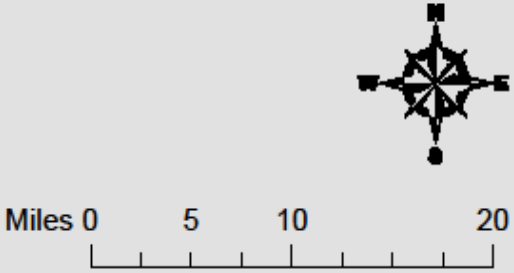
- 23 brush-management subbasins



Scenario Analysis: Brush Removal

- Texas Ecological Systems dataset: Juniper Forest and Juniper Shrubland intersection with NLCD 2006





- Treatable brush replaced with grasses in each subbasin for a total of 23 simulations.

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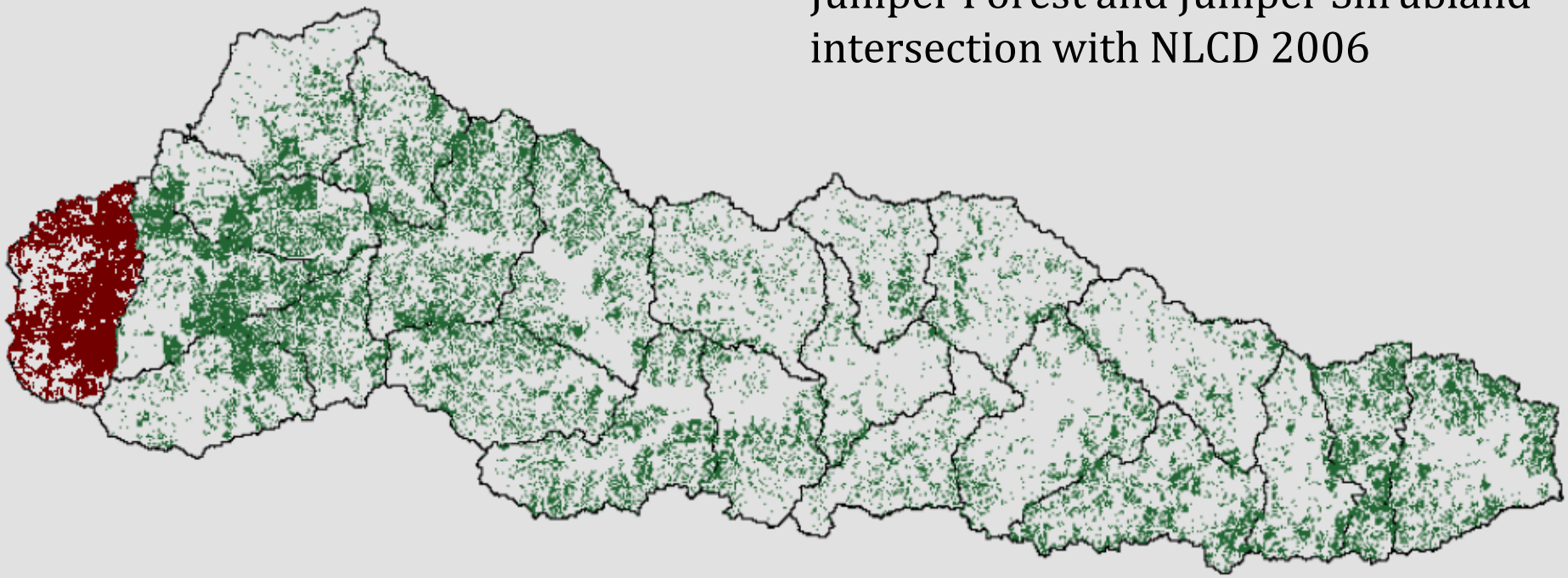

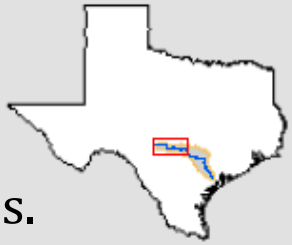

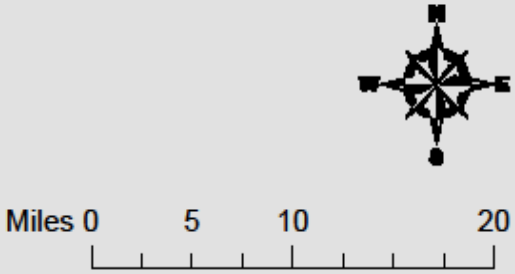

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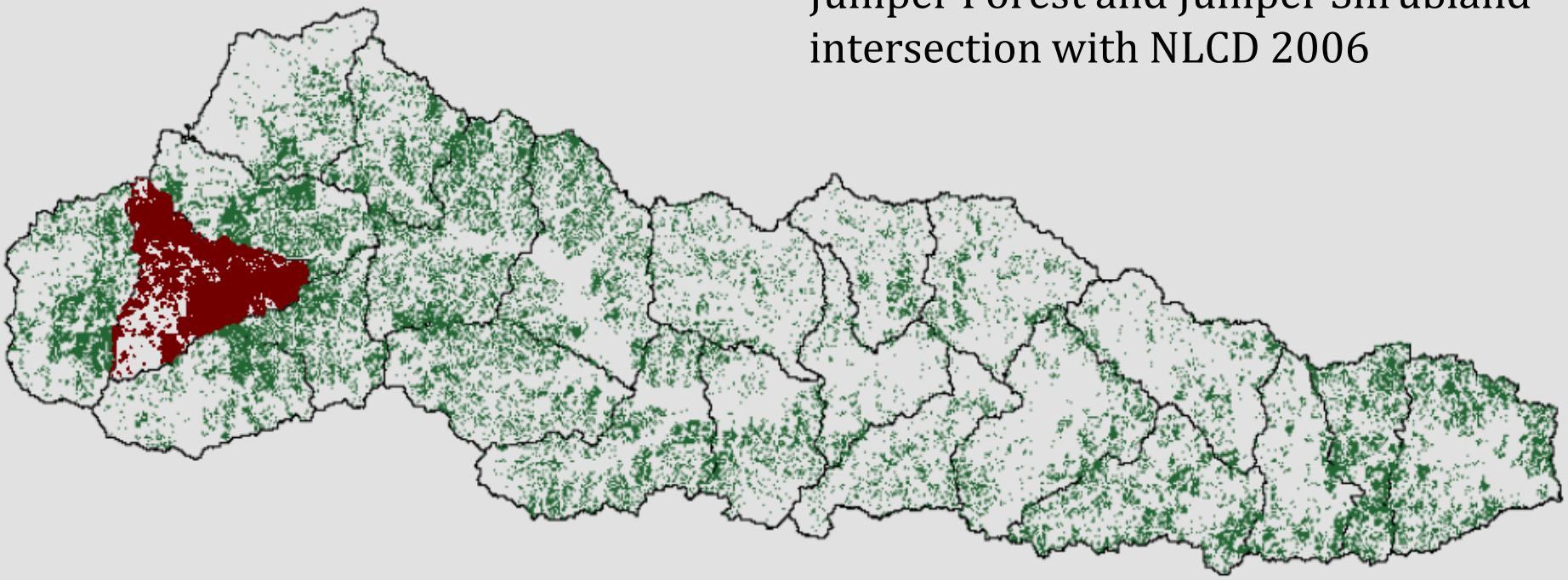

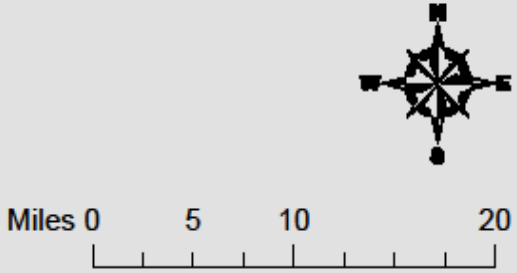

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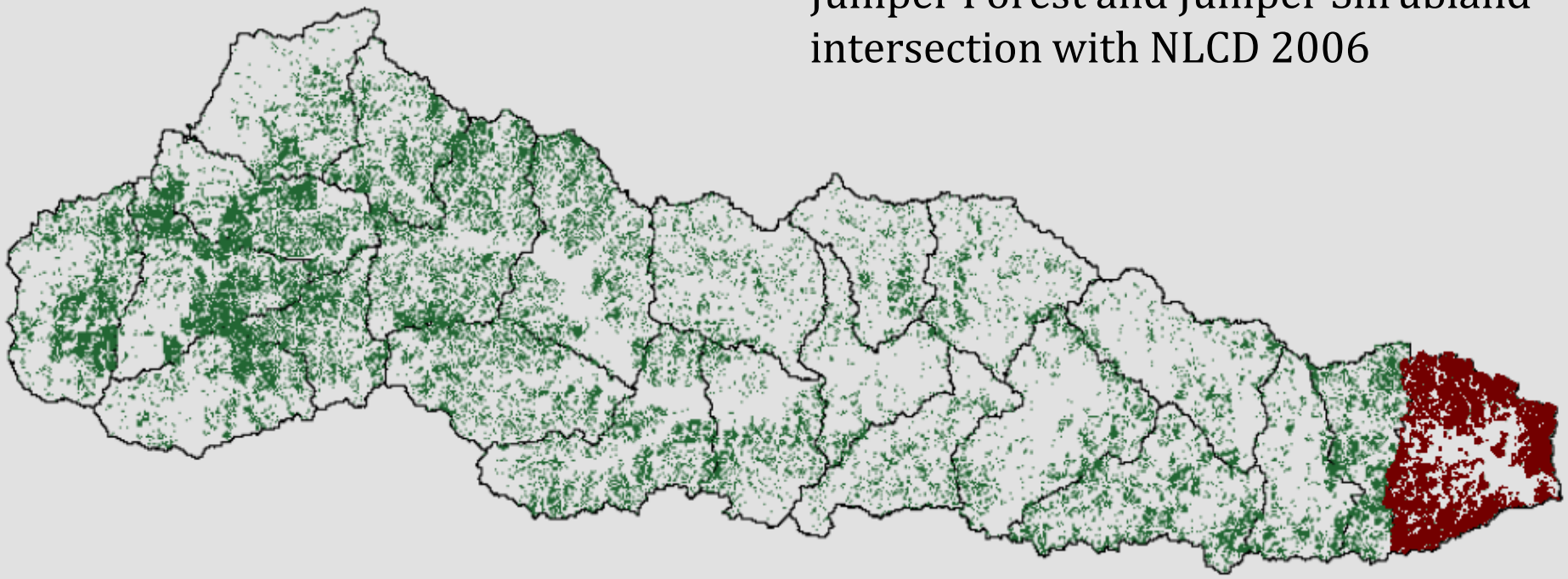

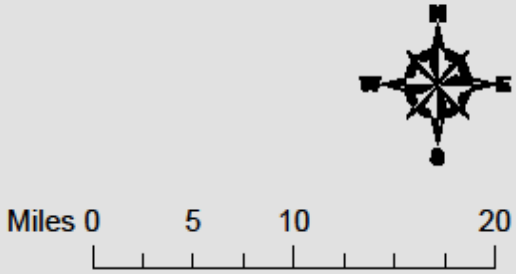

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Potential Future Work

- Develop models to compliment site-scale data collection efforts to better isolate and understand watershed processes.
- Link watershed models to water-resource management models to understand how simulated water-yield changes translate to water availability.
- Correlate subbasin yields with subbasin characteristics such as annual precipitation amounts, predominant soil types, plant density, etc…
- Evaluate the potential for brush management as an erosion-control method.

Questions?

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