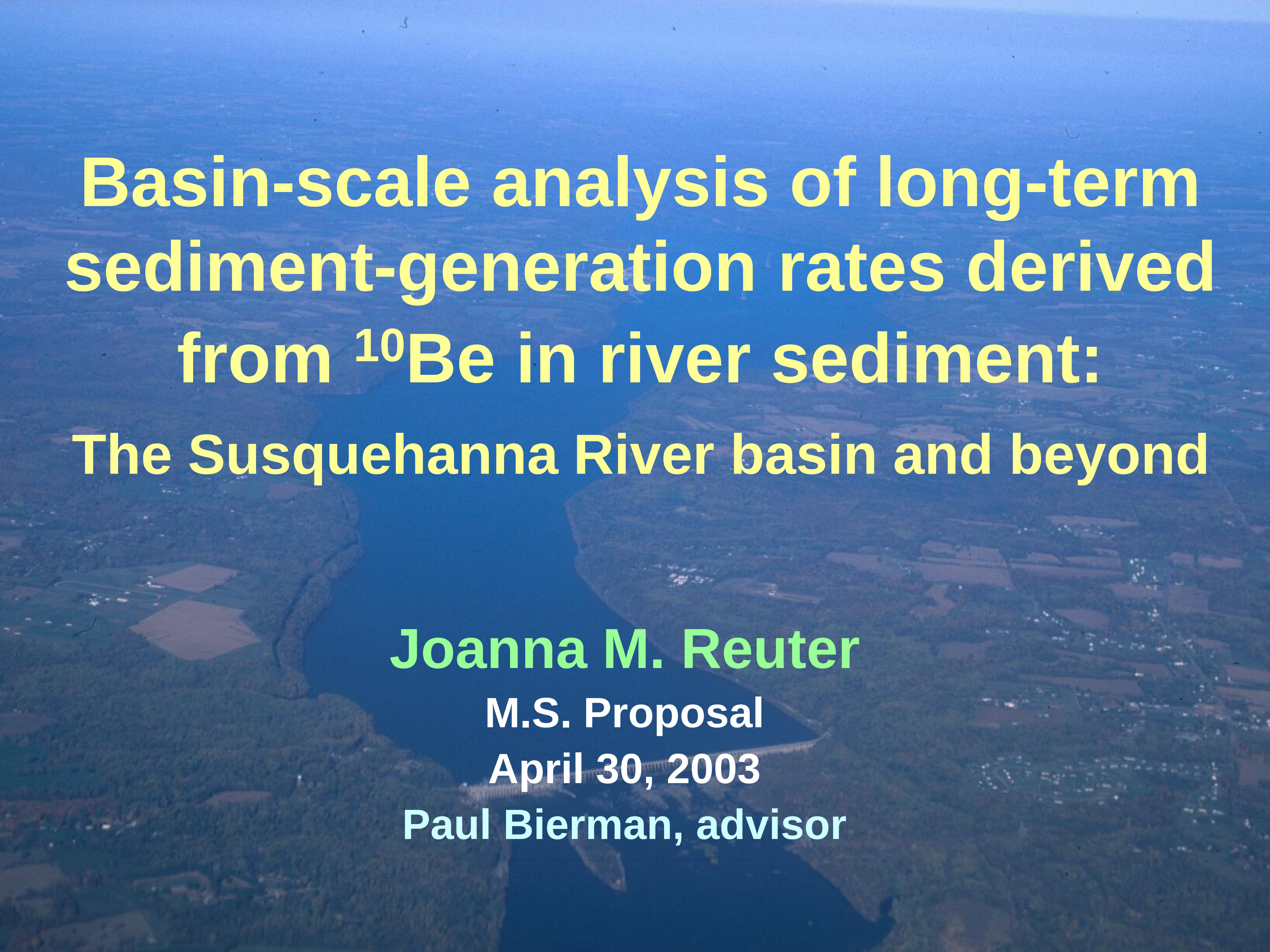


Basin-scale analysis of long-term sediment-generation rates derived from ^{10}Be in river sediment:

The Susquehanna River basin and beyond

Joanna M. Reuter

M.S. Proposal

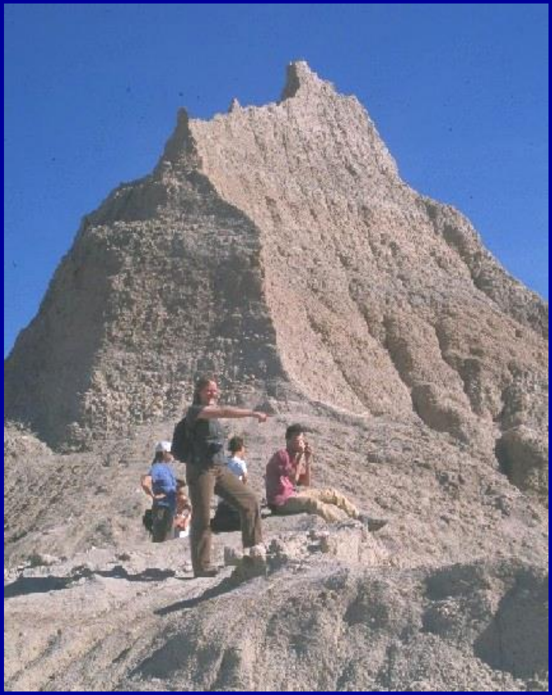
April 30, 2003

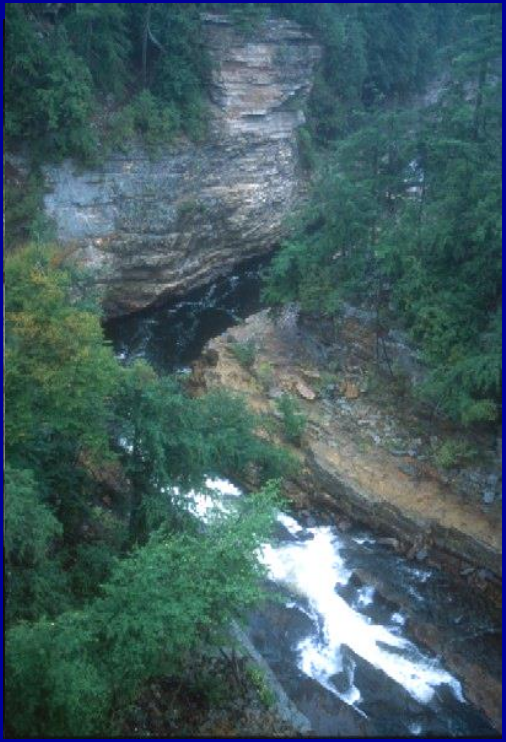
Paul Bierman, advisor

Outline

- Big picture questions
- Fundamentals of cosmogenic nuclide analysis of sediment
- Framework of study
- Susquehanna River
- Example: Drift Creek, Oregon Coast Range
  - Geographic Information Systems
  - Multivariate statistics
- Applications and summary

Where and how quickly does Earth’s surface erode?





Climate

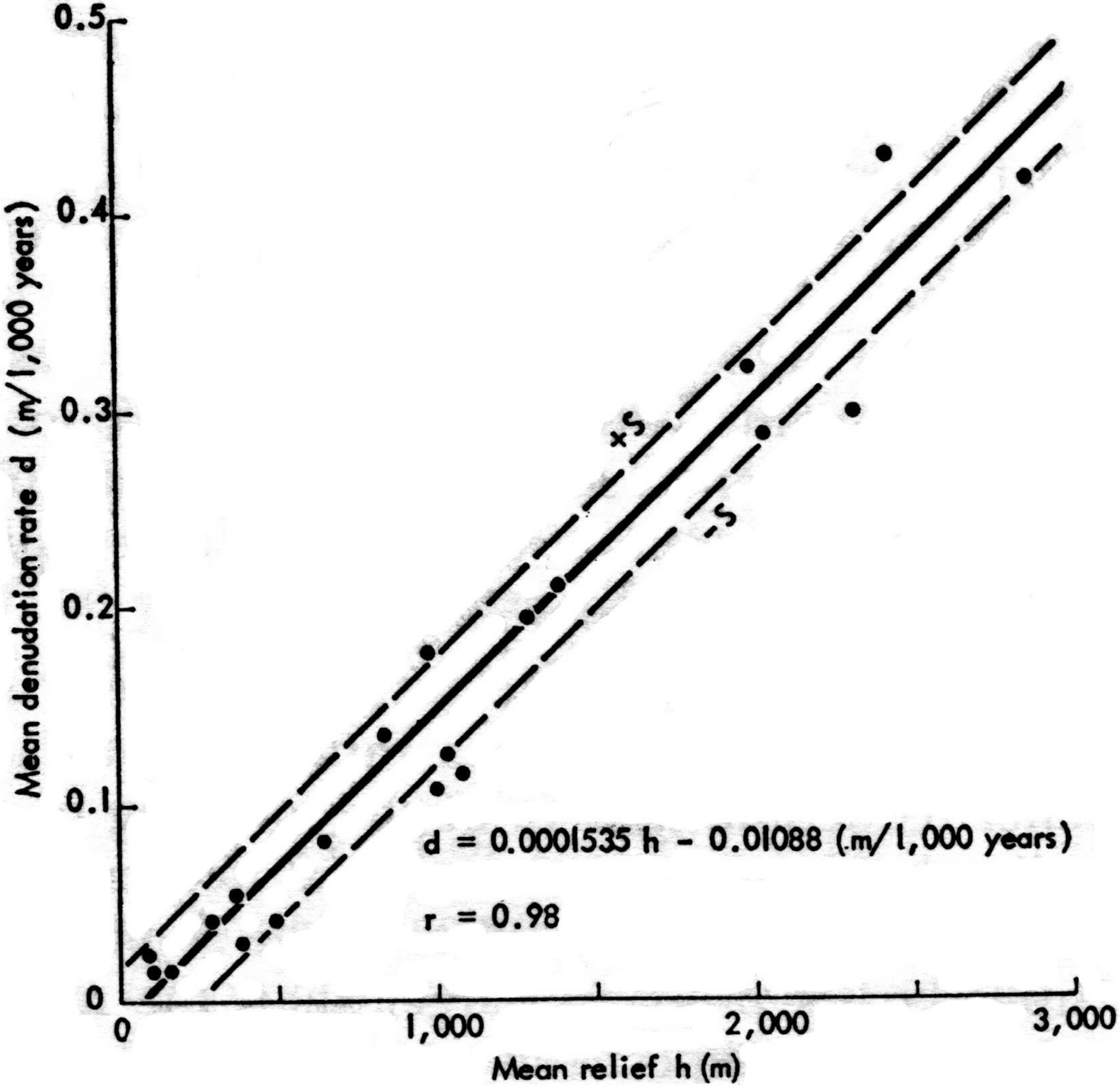
Tectonics

Sediment generation

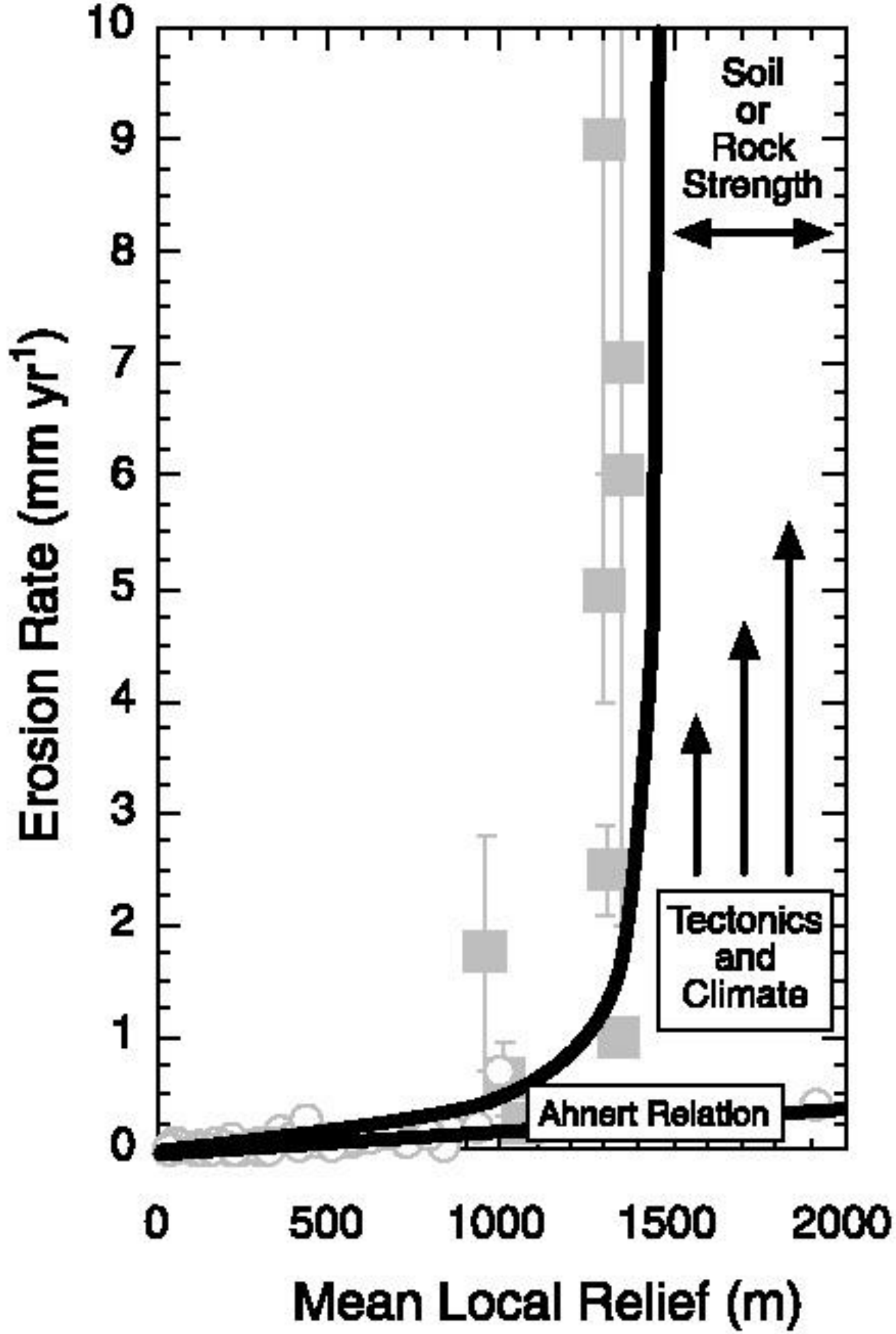
Biota

Topography

Local geology



From:
Ahnert, 1970



From:
Montgomery and Brandon, 2002

Climate

- Precipitation
- Temperature

Tectonics

- Tectonic setting

Sediment generation

Biota

- Land cover

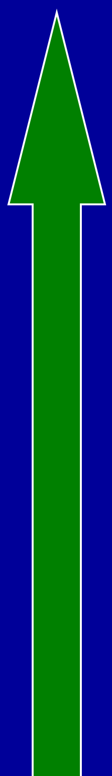
Topography

- Relief
- Slope
- Aspect
- Stream network
- Sinuosity

Local geology

- Lithology

Temporal Scale:
Methods for Inferring Erosion Rates



Time scale

Apatite fission track, (U-Th)/He thermochronometry

10^6 – 10^8 years

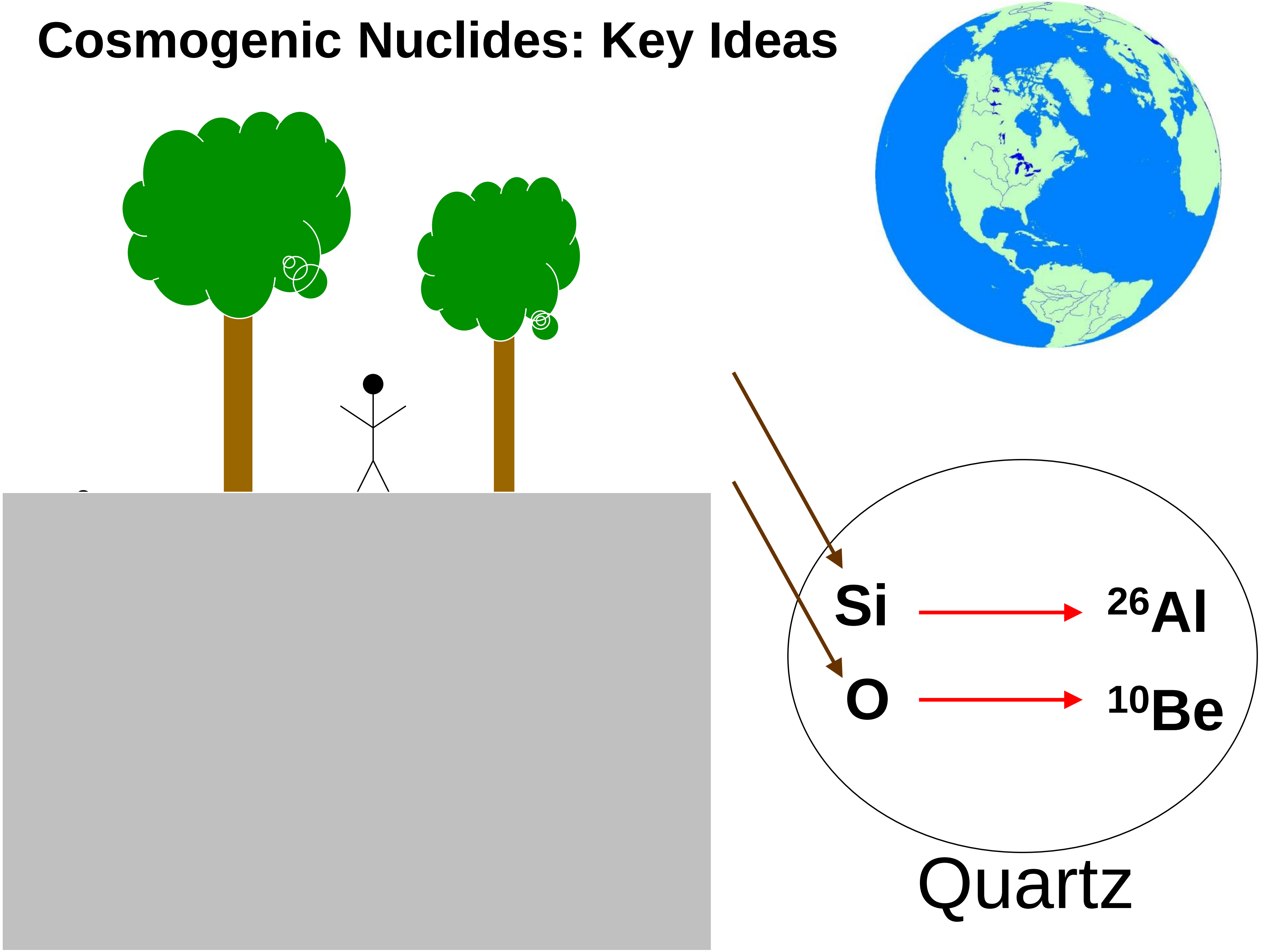
Cosmogenic nuclide analysis of sediment

10^3 – 10^6 years

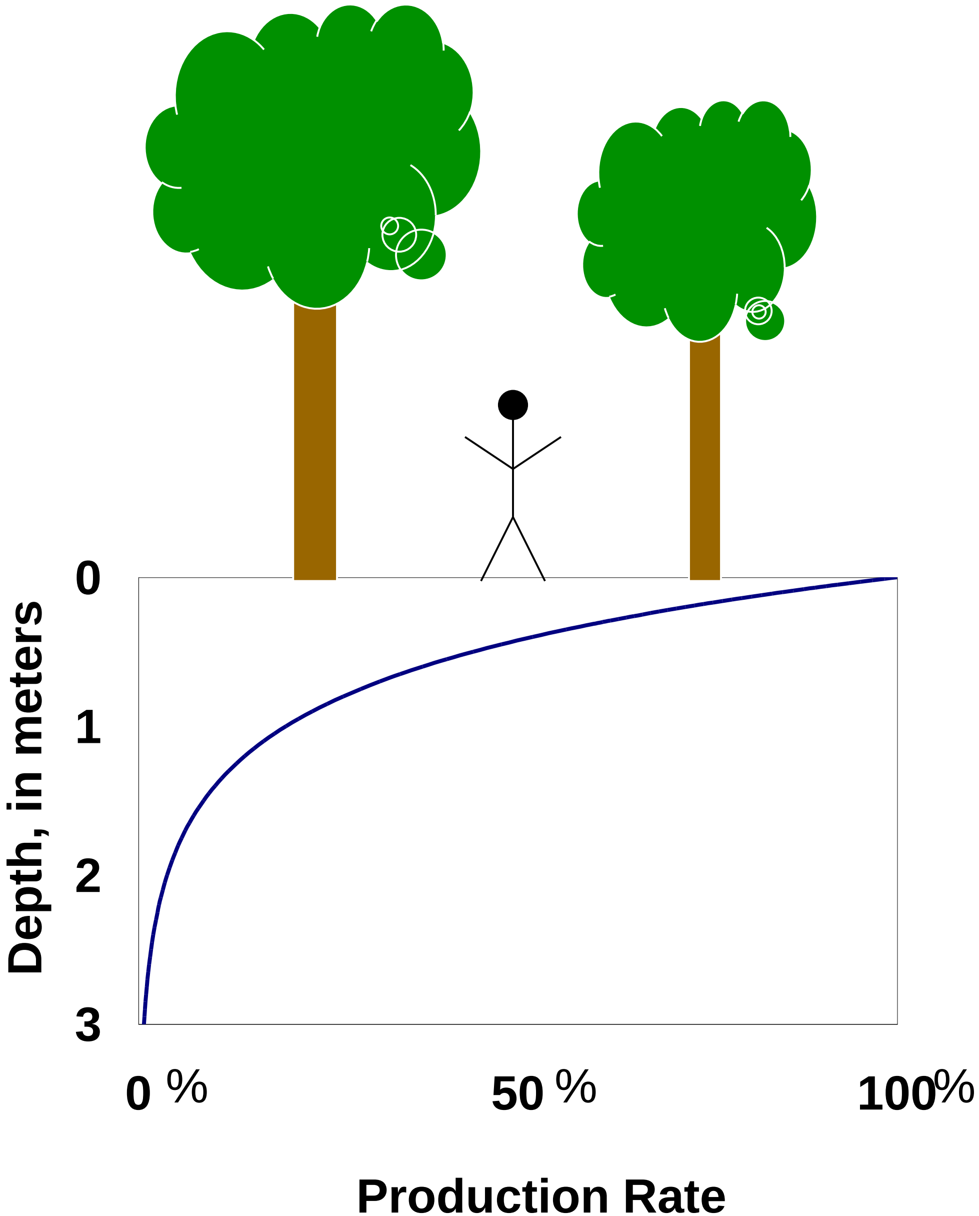
Measurement of present day sediment yield

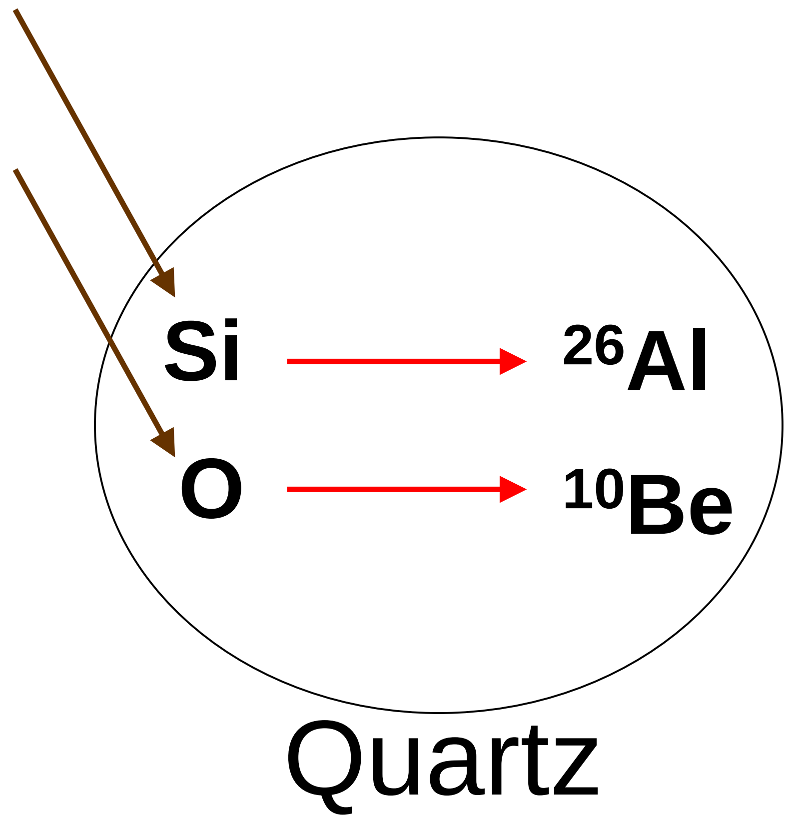
10^0 – 10^2 years

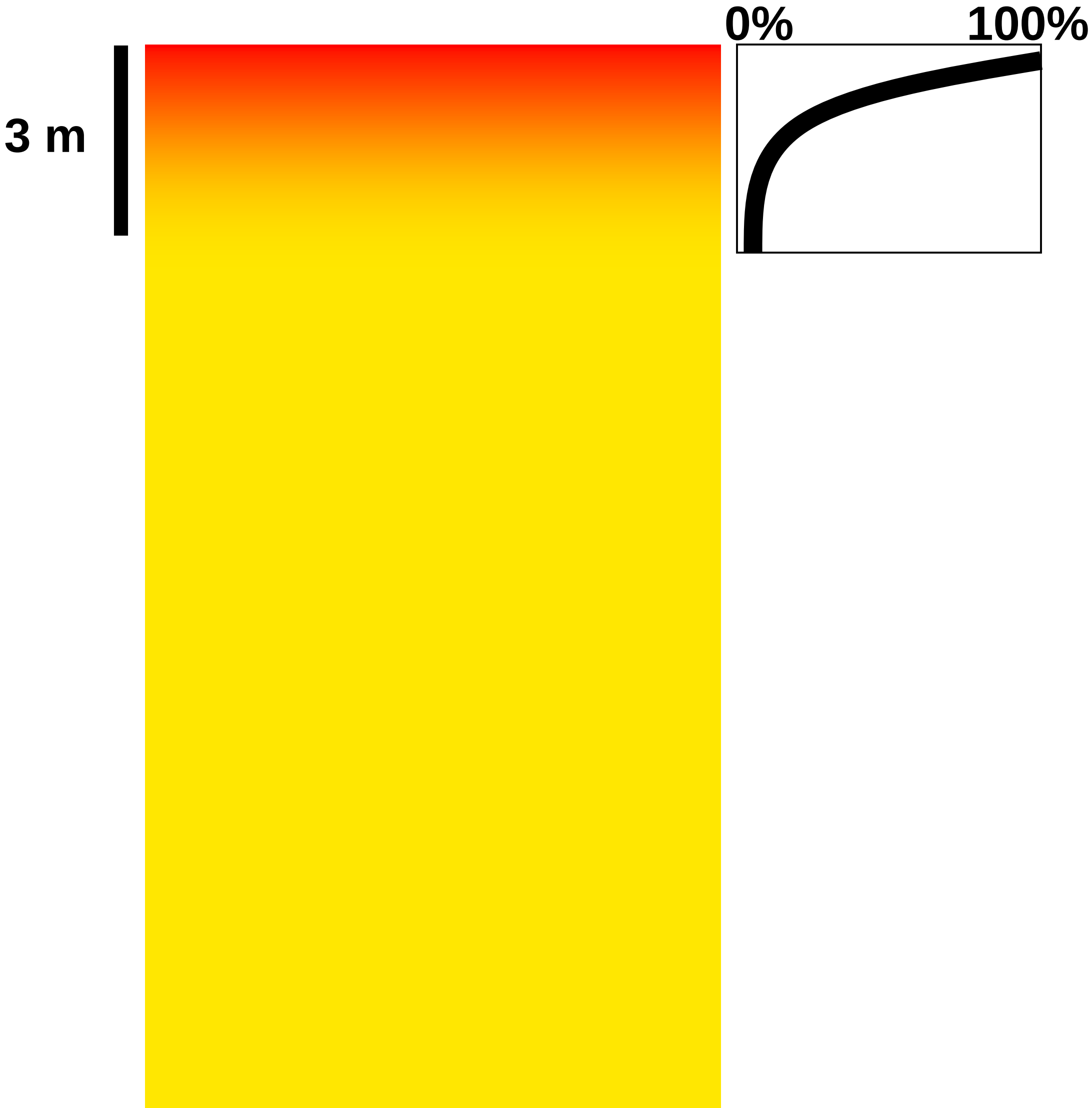
Cosmogenic Nuclides: Key Ideas



Cosmogenic Nuclides: Key Ideas



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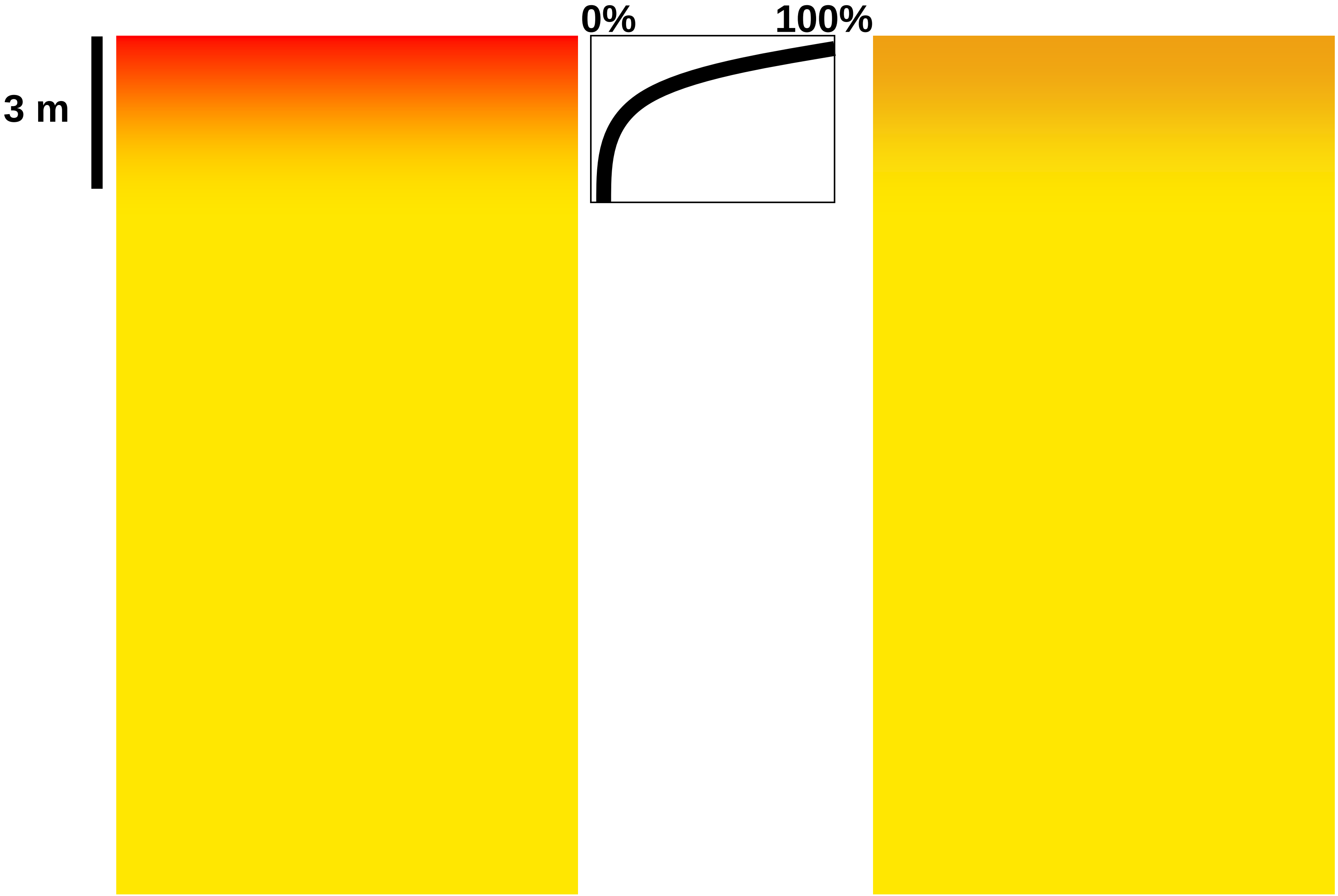
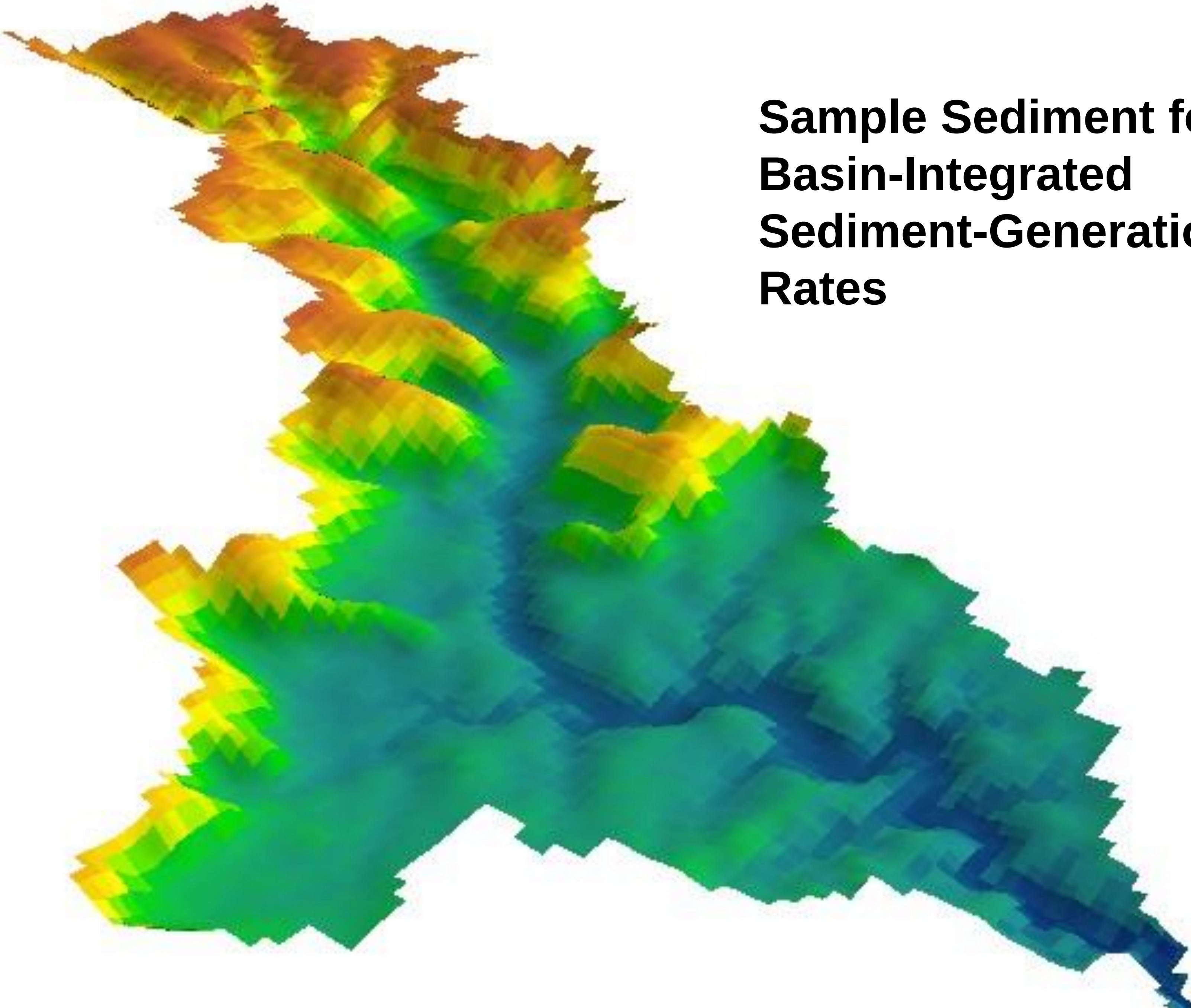


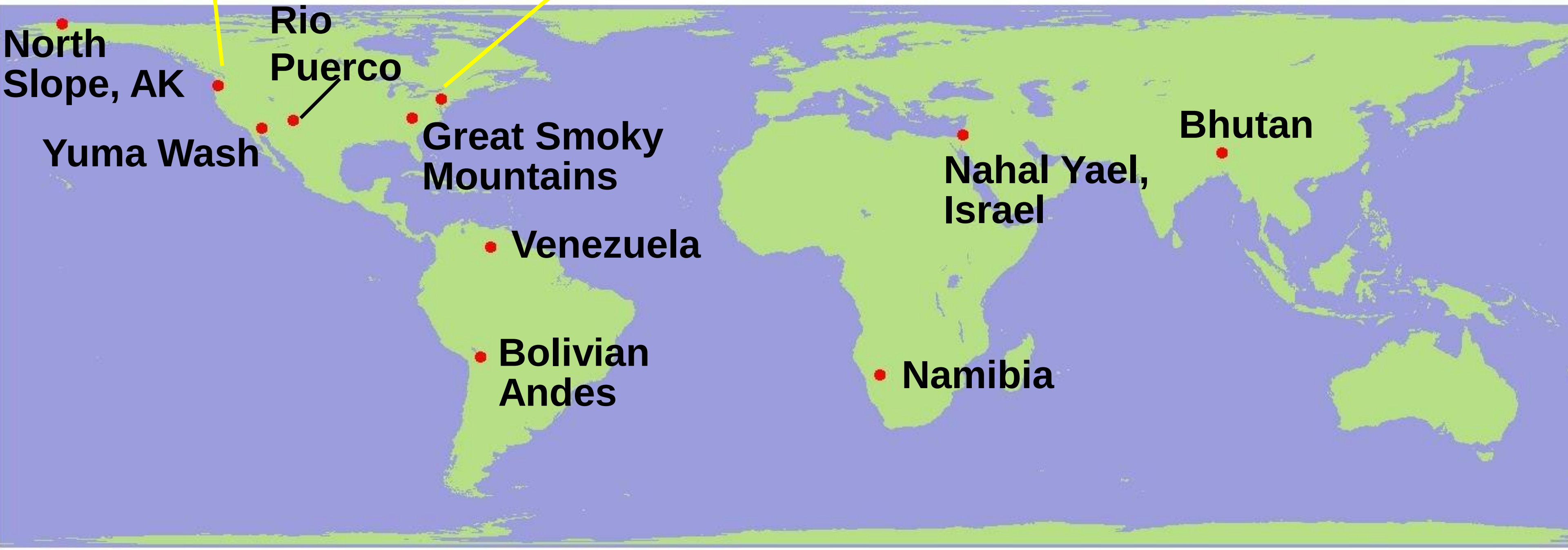
^{10}Be is a proxy for erosion rate



Sample Sediment for Basin-Integrated Sediment-Generation Rates

Spatial Distribution:

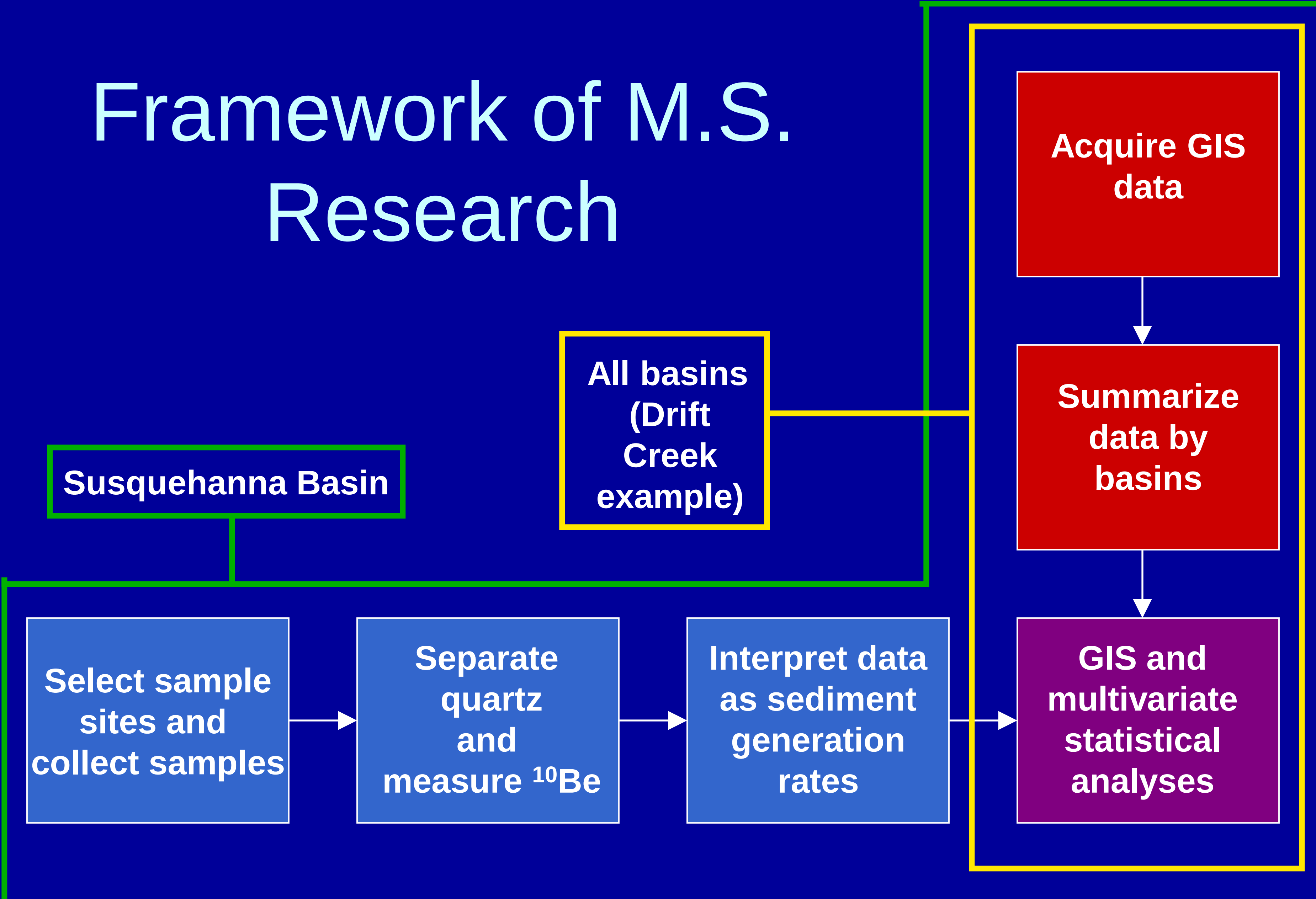
Cosmogenic Sediment Data



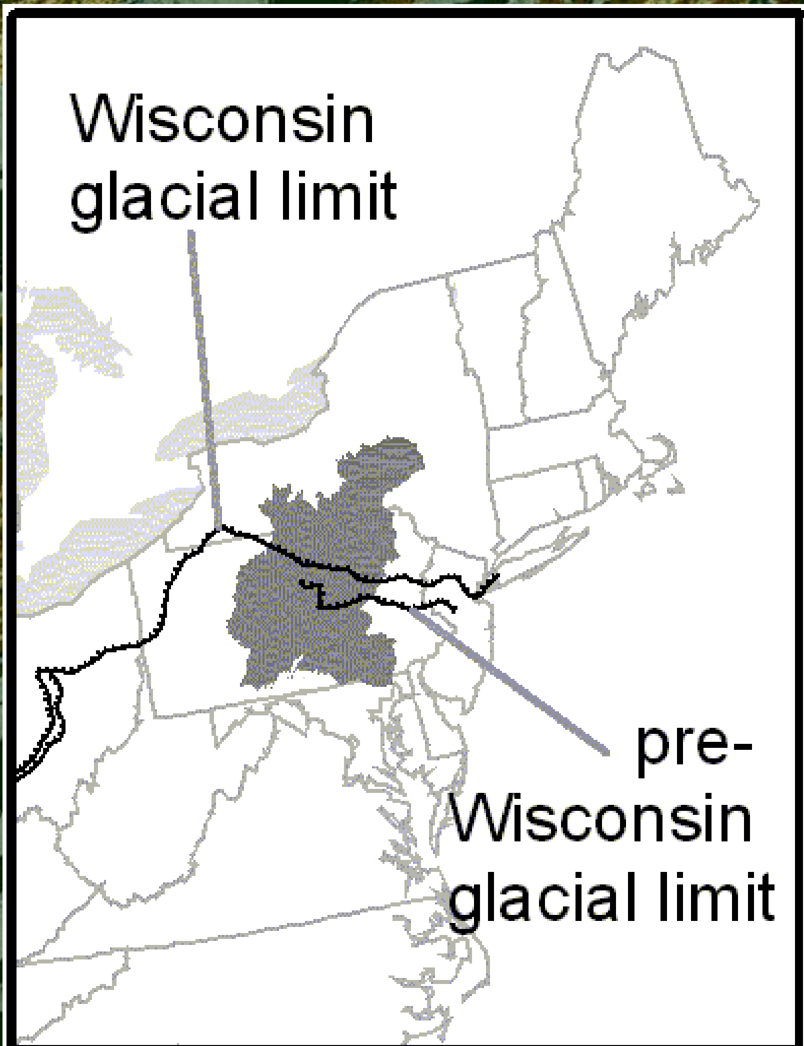
Drift Creek, OR: Bierman et al., 2001
Yuma Wash: Clapp et al., 2002
Rio Puerco: Clapp et al., 2001, Bierman et al., 2001
Great Smoky Mountains: Matmon et al., 2003
Nahal Yael, Israel: Clapp et al., 2000

Climate
Tectonics
Erosion
Biota
Topography
Local geology

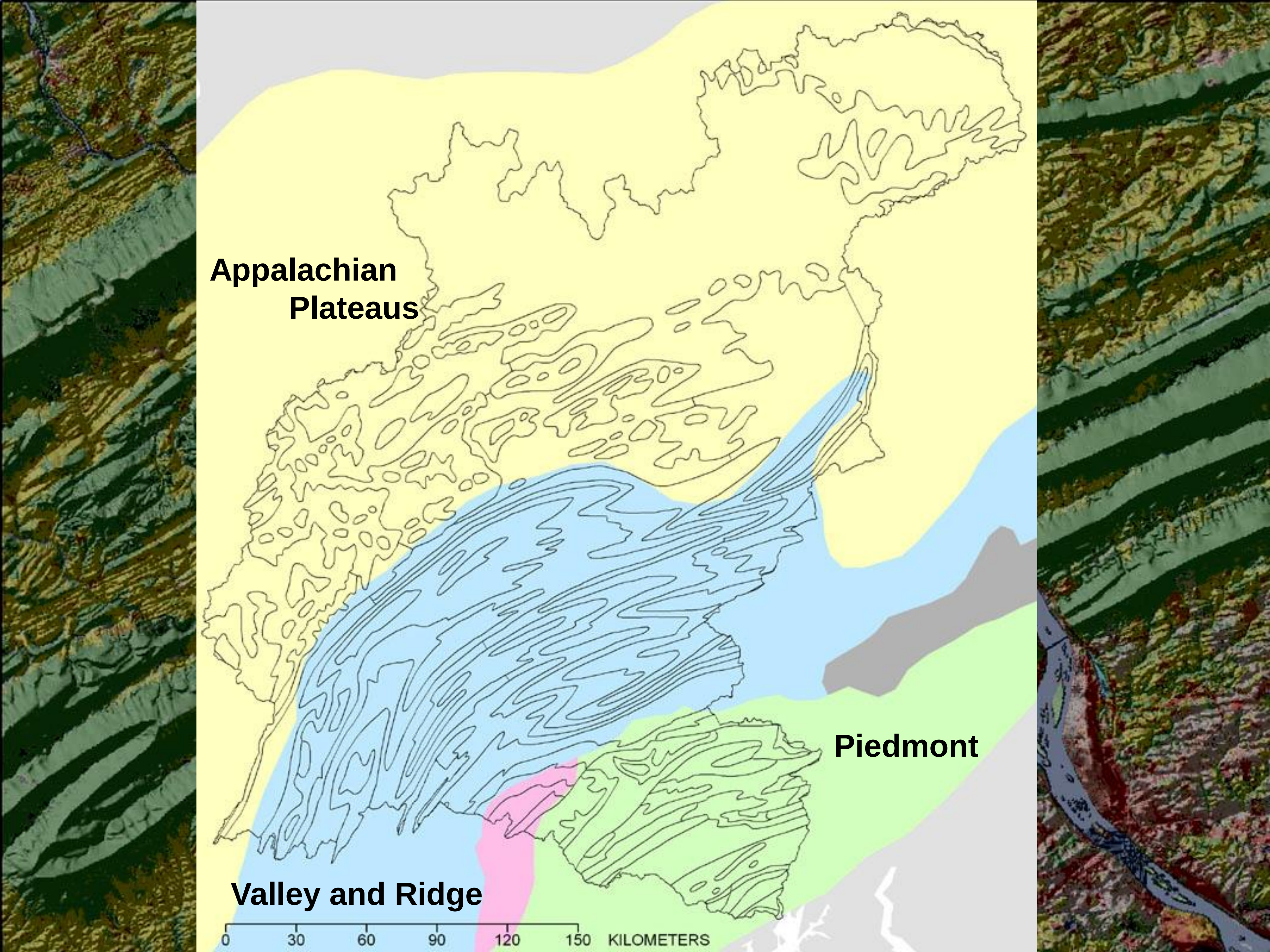
Framework of M.S. Research



The Susquehanna River Basin



- Basin size: >70,000 km^2
- North American passive margin
- Motivation: Chesapeake Bay
- Partly glaciated


Appalachian
Plateaus
Piedmont
Valley and Ridge
0
30
60
90
120
150
KILOMETERS

The Susquehanna River basin

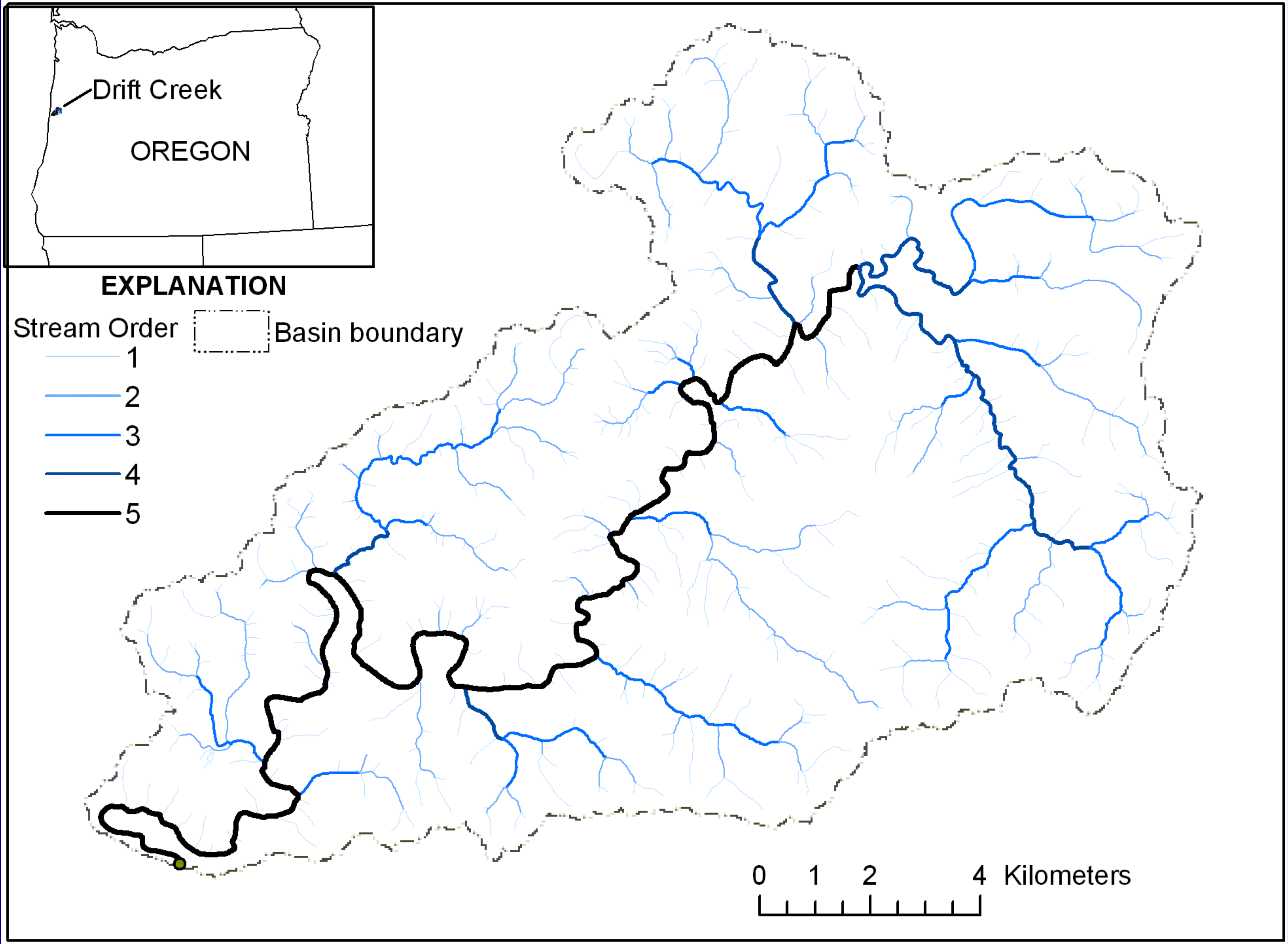
- 22 preliminary samples
  - Collected at USGS streamgages
- Challenges of data interpretation
  - Large basin
  - Glaciated basin
  - Sediment storage in terraces
- Sampling strategy
  - Utilize GIS to select sampling sites
  - Focus on small headwater basins
  - Focus on unglaciated parts of the basin

Data Analysis

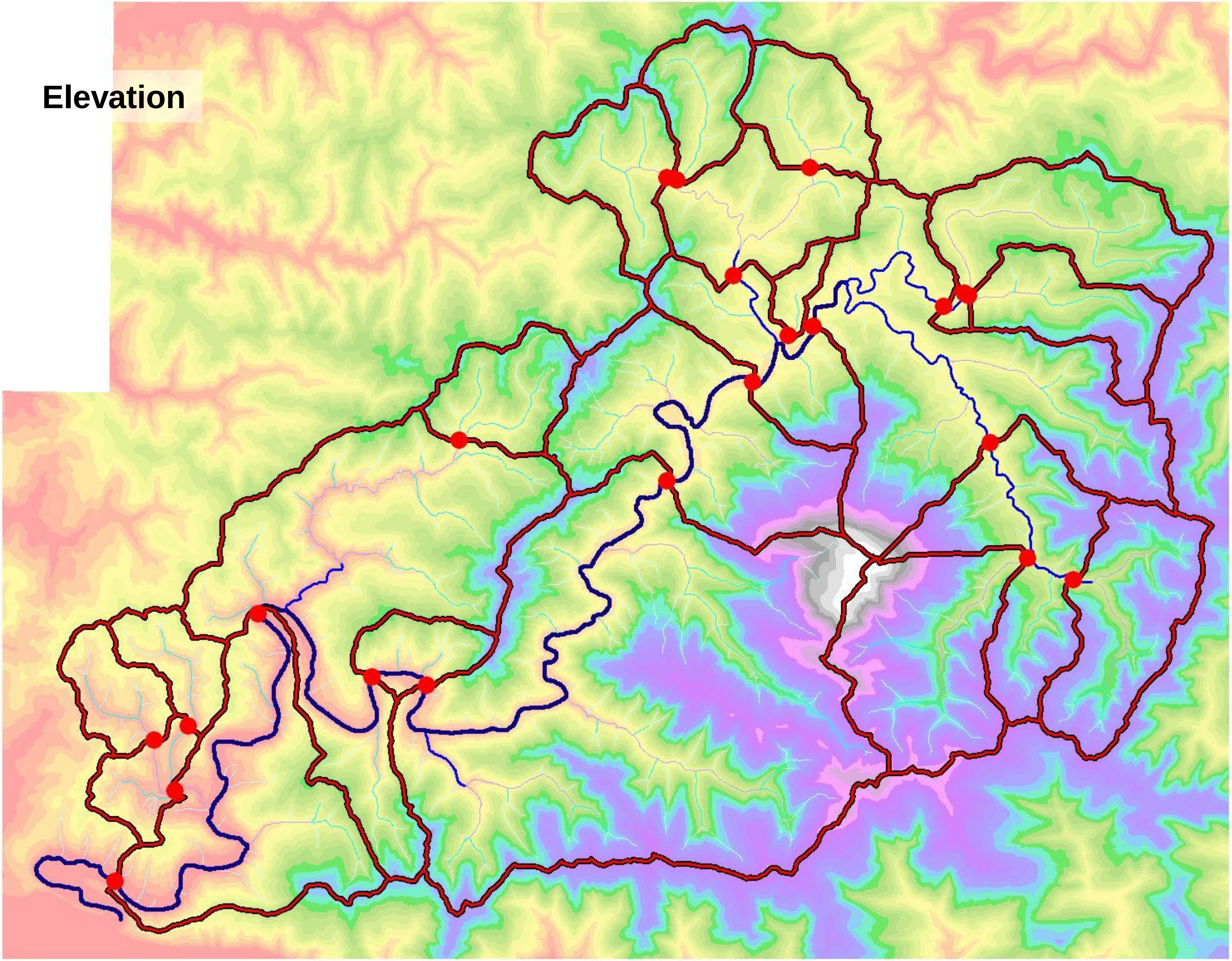
- Acquire GIS data
- Delineate drainage basin from digital elevation model
- Summarize data for each basin
- Explore data qualitatively—longitudinal profiles, etc.
- Explore data statistically
- Investigate whether sediment generation rates inferred from ^{10}Be activities correlate with basin-scale parameters

Drift Creek

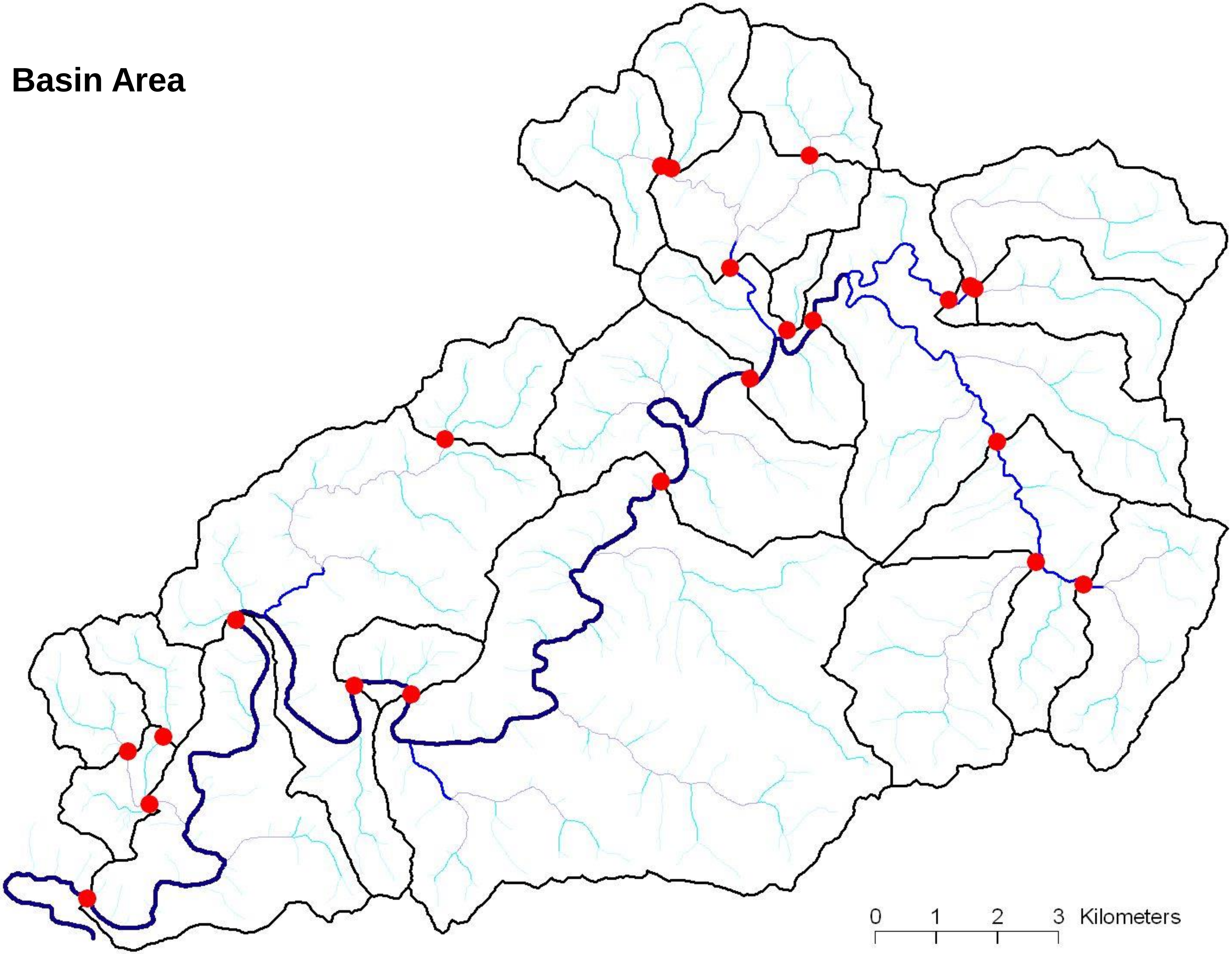
- 180 km^2 basin in the Oregon Coast Range
- Oregon Coast Range has received extensive geomorphic study
- Independent evidence suggests that the Oregon Coast Range approximates a topographic steady state


Drift Creek
OREGON
EXPLANATION
Stream Order
1
2
3
4
5
Basin boundary
0 1 2 4 Kilometers

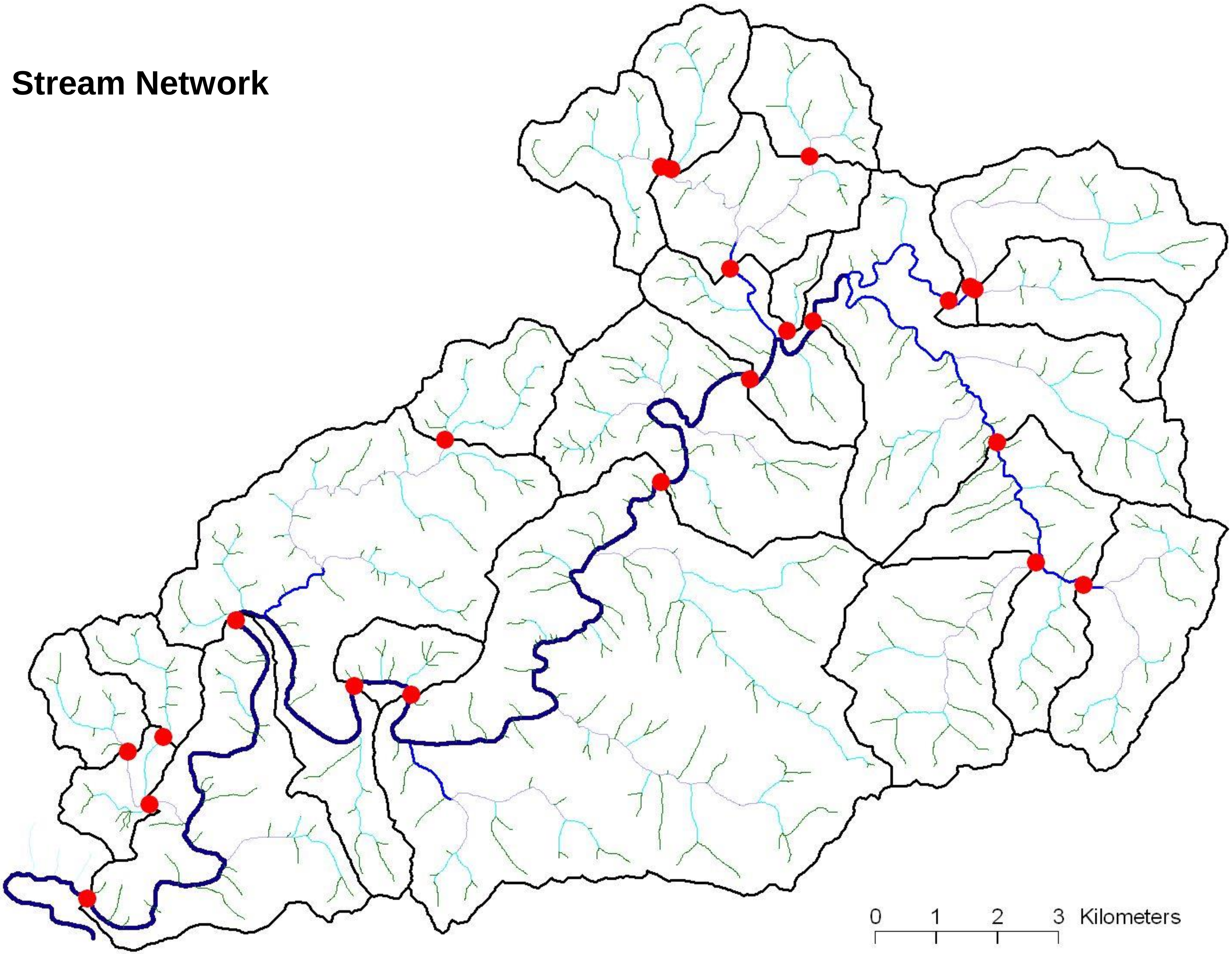
Elevation



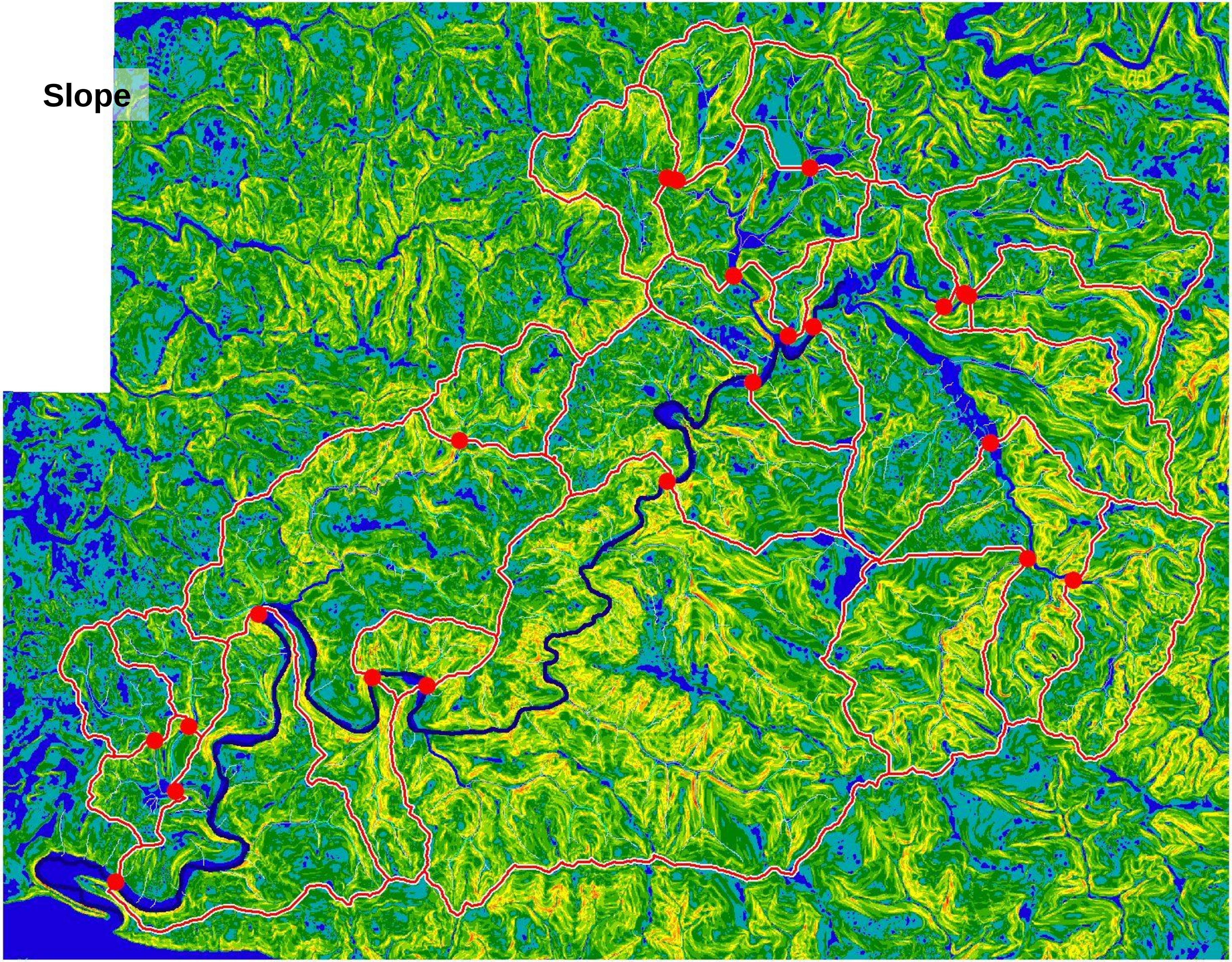
Basin Area



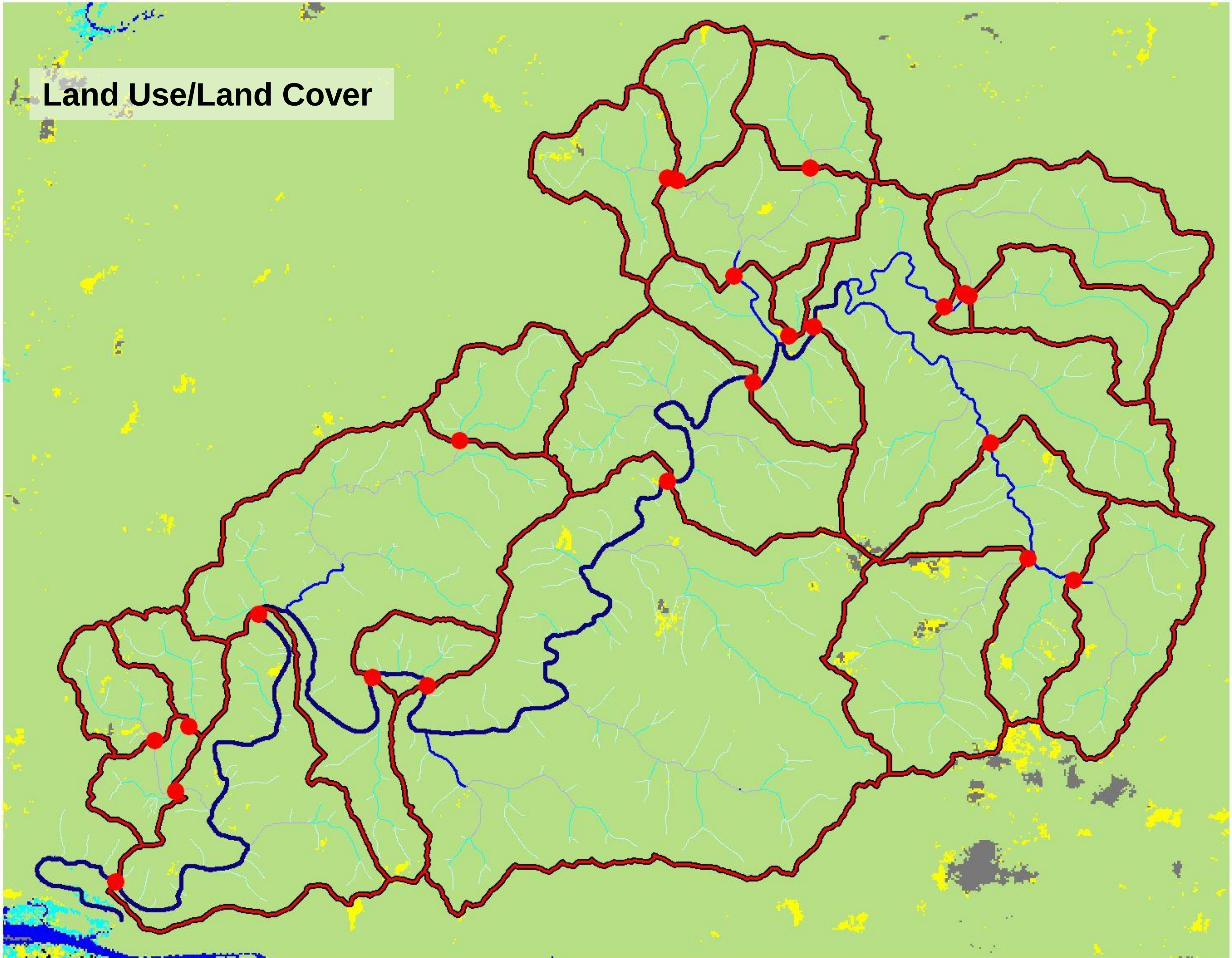
Stream Network



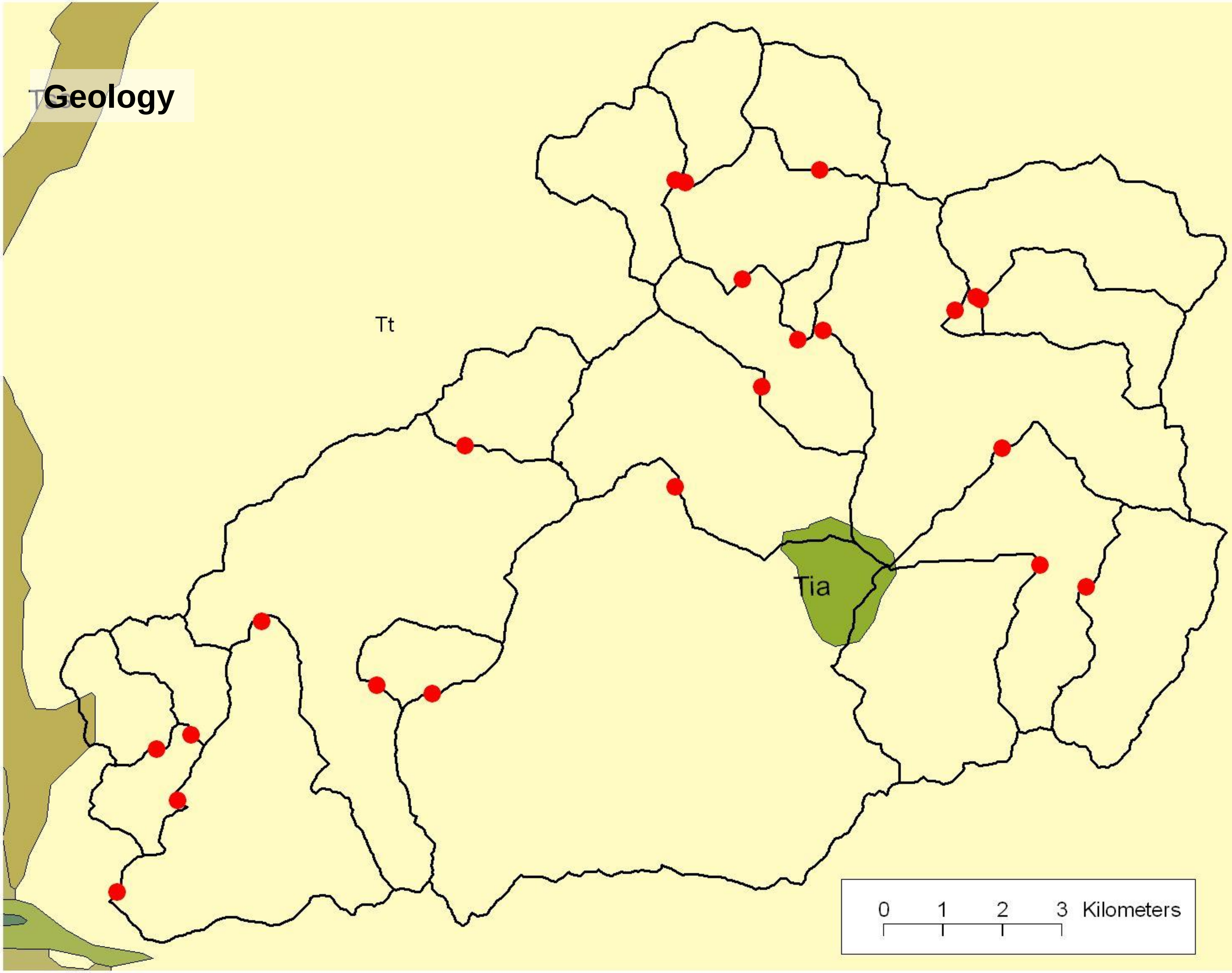
Slope



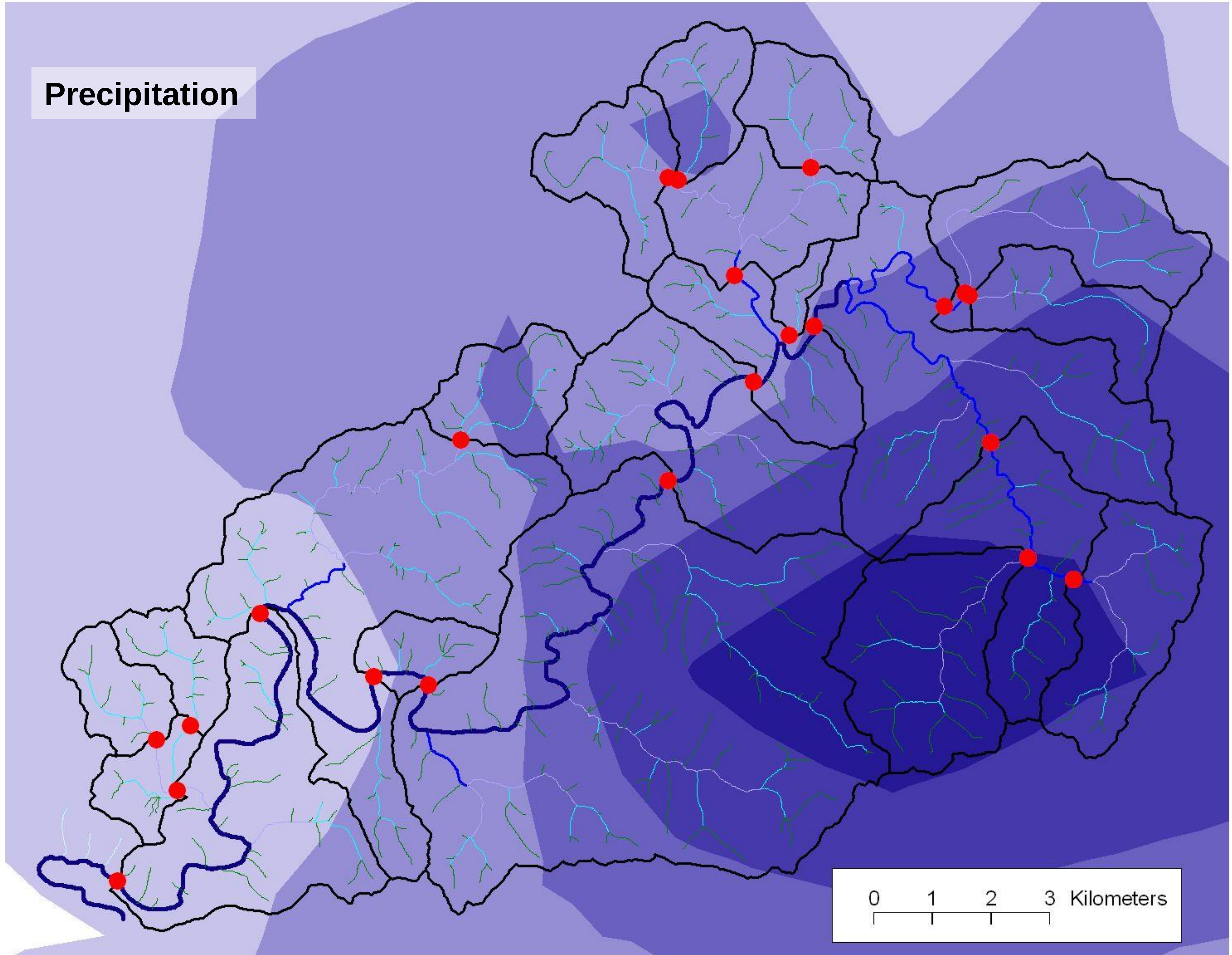
Land Use/Land Cover



Geology



Precipitation



Multivariate statistics

- Ascertain which variables have most explanatory value

- Principal components analysis
- Multiple linear regression
- Canonical correlation analysis

Anticipated Outcome

Insight regarding relative importance of:

- Climate
- Tectonics
- Topography
- Biota
- Local geology

Erosion

Motivation and Applications

- Assess human impacts on sediment yield
- Chesapeake Bay sedimentation
- Development of EPA Total Maximum Daily Load (TMDL) regulations

Funding

- USGS
- NSF Graduate Research Fellowship
- Graduate College Summer Research Fellowship
- Graduate Teaching Fellowship

Timeline

Spring 2003 (Graduate Teaching Fellowship)

- Preliminary Susquehanna samples: from quarts of sample to samples of quartz; data before summer field work
- GIS data acquisition (focus on US basins) and preliminary analysis

Summer 2003 (Graduate College Summer Research Fellowship)

- Susquehanna field work, purify quartz from new samples
- GIS work continued

Fall 2003 (NSF Graduate Research Fellowship)

- Continue intensive GIS analysis, analyze summer field data
- Present at GSA

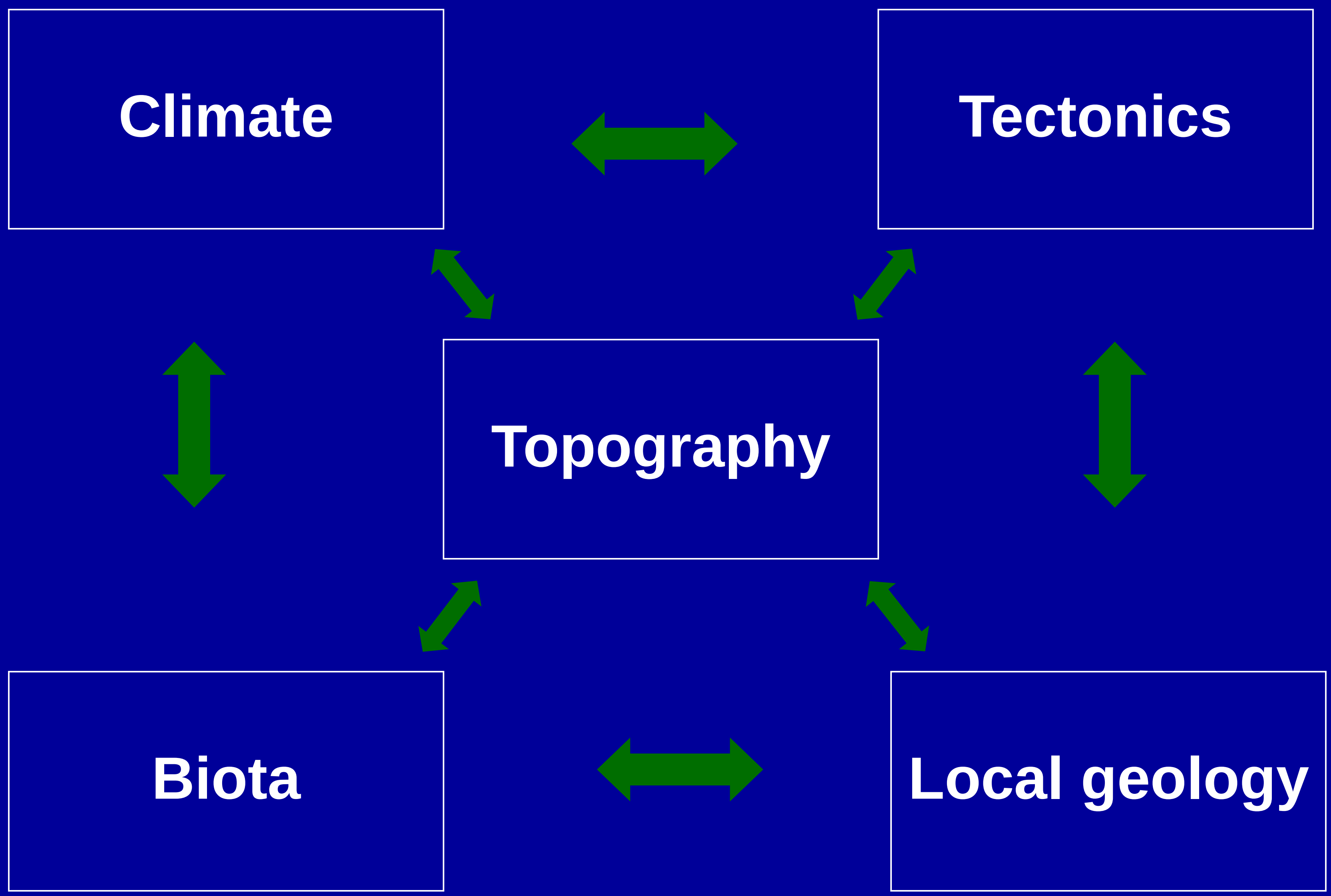
Spring & Summer 2004 (NSF Graduate Research Fellowship)

- Complete data analysis
- Write and defend thesis
- Presentation of results at national meetings

JUNK

Cosmogenic nuclide analysis of sediment: key ideas

- Earth is continually bombarded by cosmic rays
- The interaction of cosmic rays with near-surface materials produces cosmogenic nuclides, including ^{10}Be and ^{26}Al in quartz
- Abundance of cosmogenic nuclides in stream sediments reflects the erosional history of the basin



Climate
Tectonics
Topography
Biota
Local geology

Data organization

Sediment sample properties			^{10}Be activity
			Interpreted sediment generation rate
			Grain size fraction used in analysis
Basin properties	Digital elevation model (DEM)		Basin area
			Slope
			Curvature
			Relief
		Stream network properties	Network length (by stream order)
			Sinuosity
		Longitudinal profile geometry	Concavity
	Geology		Area with quartz-bearing rocks
			Rock strength
	Physiography		Area of represented physiographic provinces
	Ecoregion		Area of represented ecoregions
	Land use/land cover		Area of land cover types
Region properties	Tectonics		Tectonic setting
	General climate		Rainfall
			Temperature

What's New & Different

Combination of:

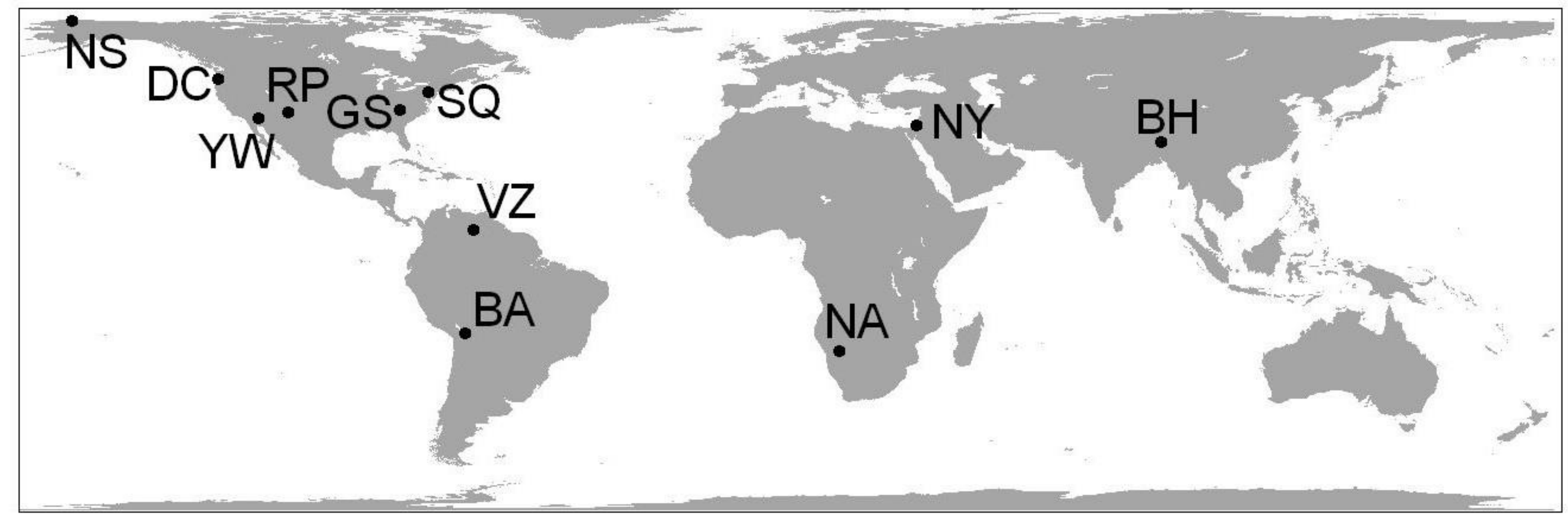
- **Temporal scale**
- **Spatial distribution**

Combination of analytical tools:

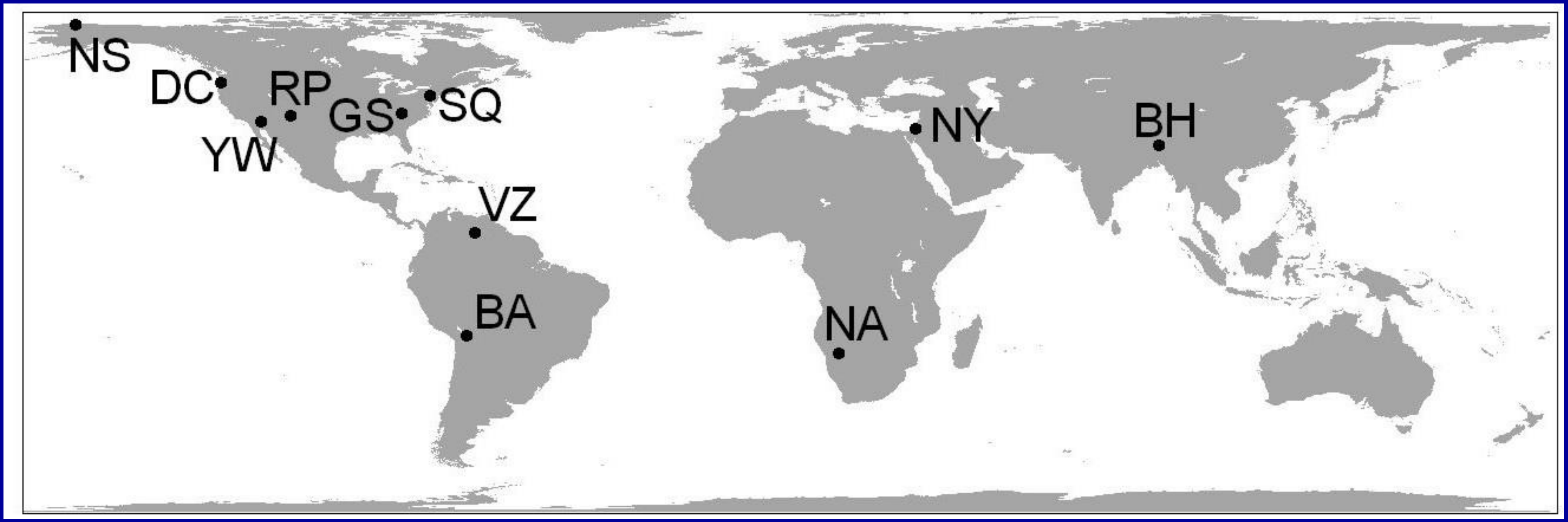
- **Cosmogenic nuclide analysis of sediment**
- **Geographic Information Systems (GIS)**
- **Multivariate statistics**

Framework of M.S. Research

- Obtain and interpret ^{10}Be data from Susquehanna River basin sediments
- Analyze worldwide basins from which Bierman and collaborators have obtained cosmogenic nuclide data from sediment
  - Consider relationship of ^{10}Be activities to basin-scale parameters using GIS



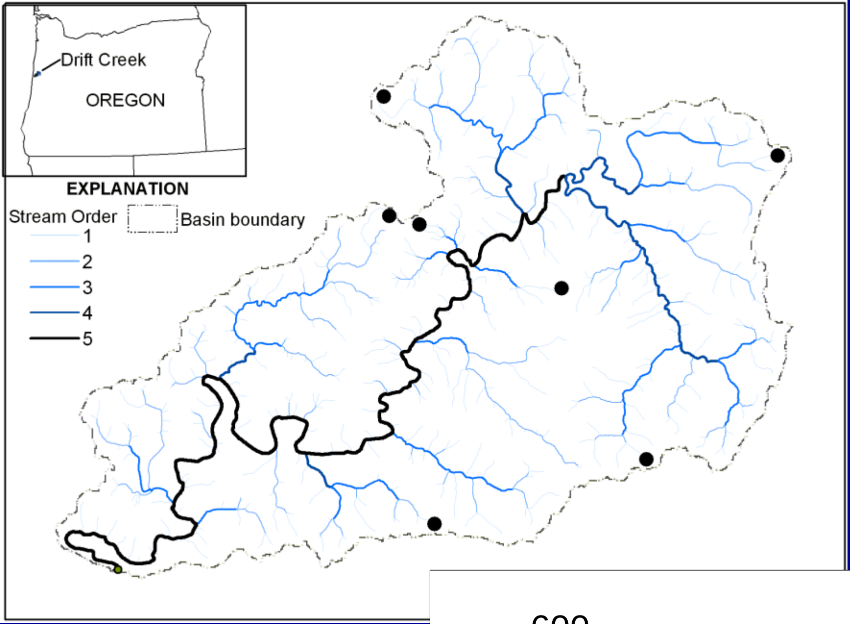
Spatial Distribution
Cosmogenic Data Sets

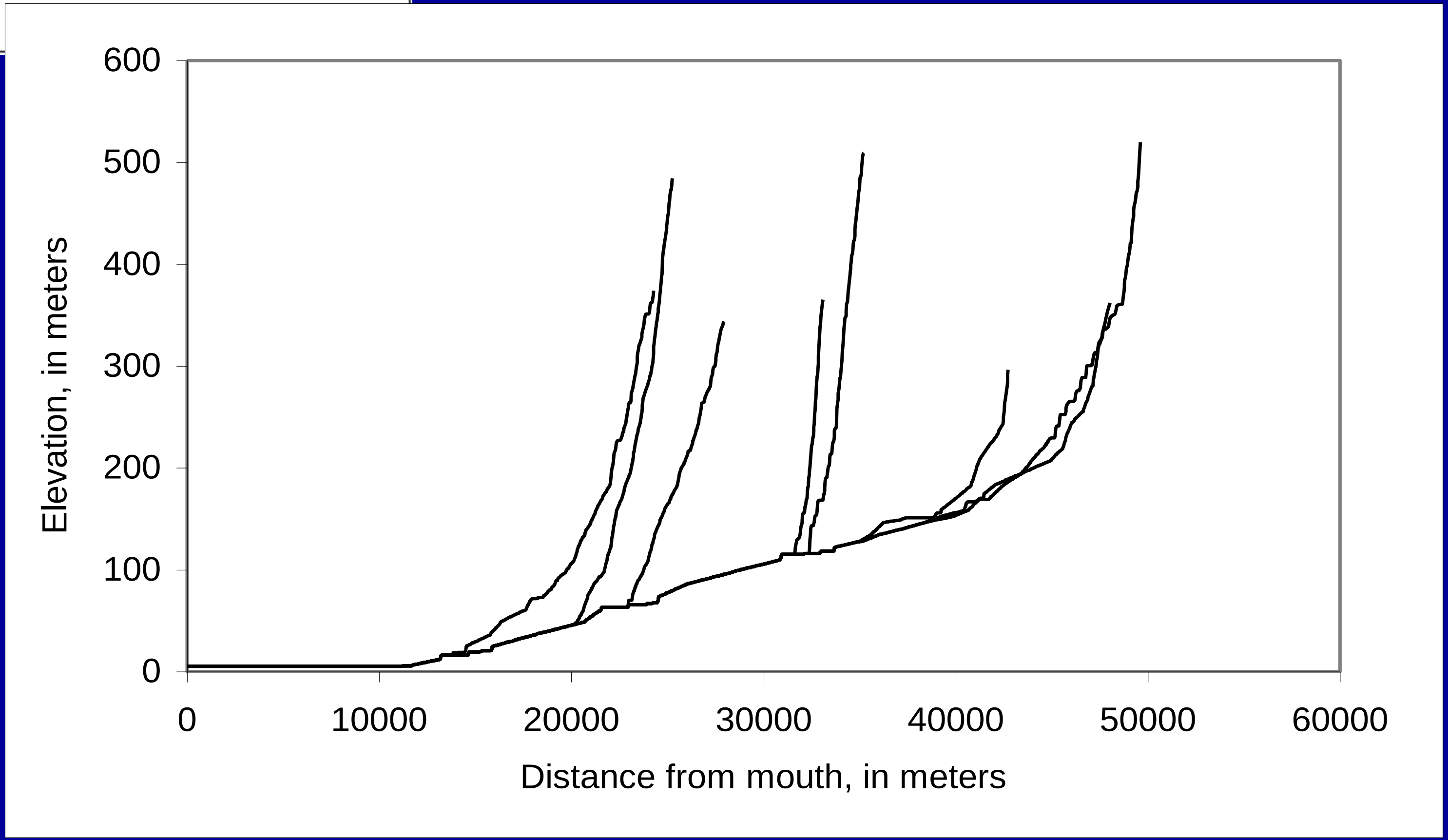


EXPLANATION

DC: Drift Creek, OR (Bierman et al., 2001)
YW: Yuma Wash, AZ (Bierman et al., 2001)
RP: Rio Puerco, NM (Clapp et al., 2001)
GS: Great Smoky Mtns. (Matmon et al., 2003)
NY: Nahal Yael, Israel (Clapp et al., 2000)
BA: Bolivian Andes

SQ: Susquehanna River
NS: North Slope, Alaska
VZ: Venezuela
NA: Namibia
BH: Bhutan


Drift Creek
OREGON
EXPLANATION
Stream Order
1
2
3
4
5
Basin boundary


600
500
400
300
200
100
0
Elevation, in meters
0
10000
20000
30000
40000
50000
60000
Distance from mouth, in meters

Anticipated Outcome

Results of the analysis of cosmogenic nuclide data and basin-scale parameters will provide insight regarding the relative importance of climate, tectonics, topography, biota, and lithology in determining sediment generation rates.