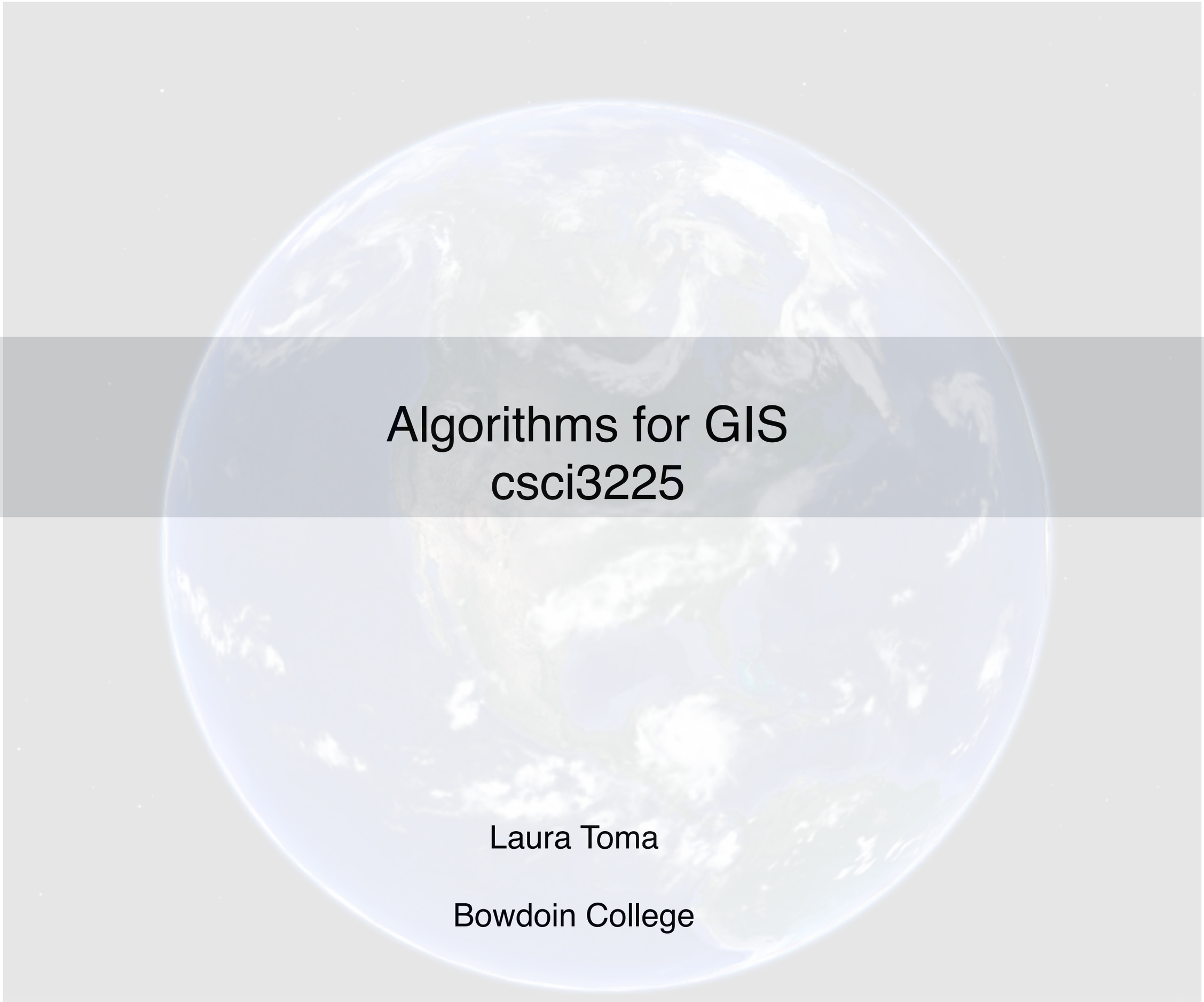


Algorithms for GIS
csci3225

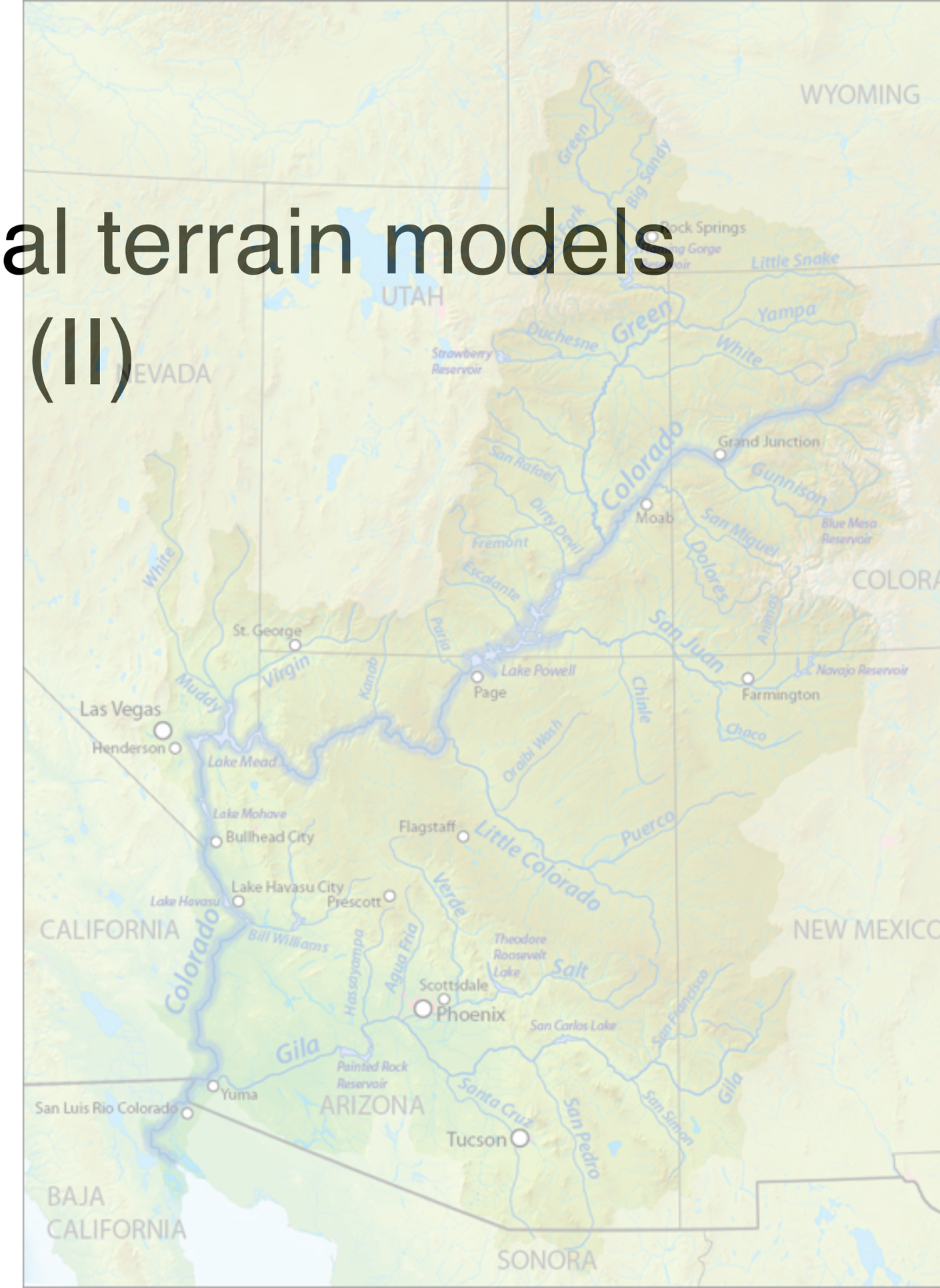
Laura Toma

Bowdoin College

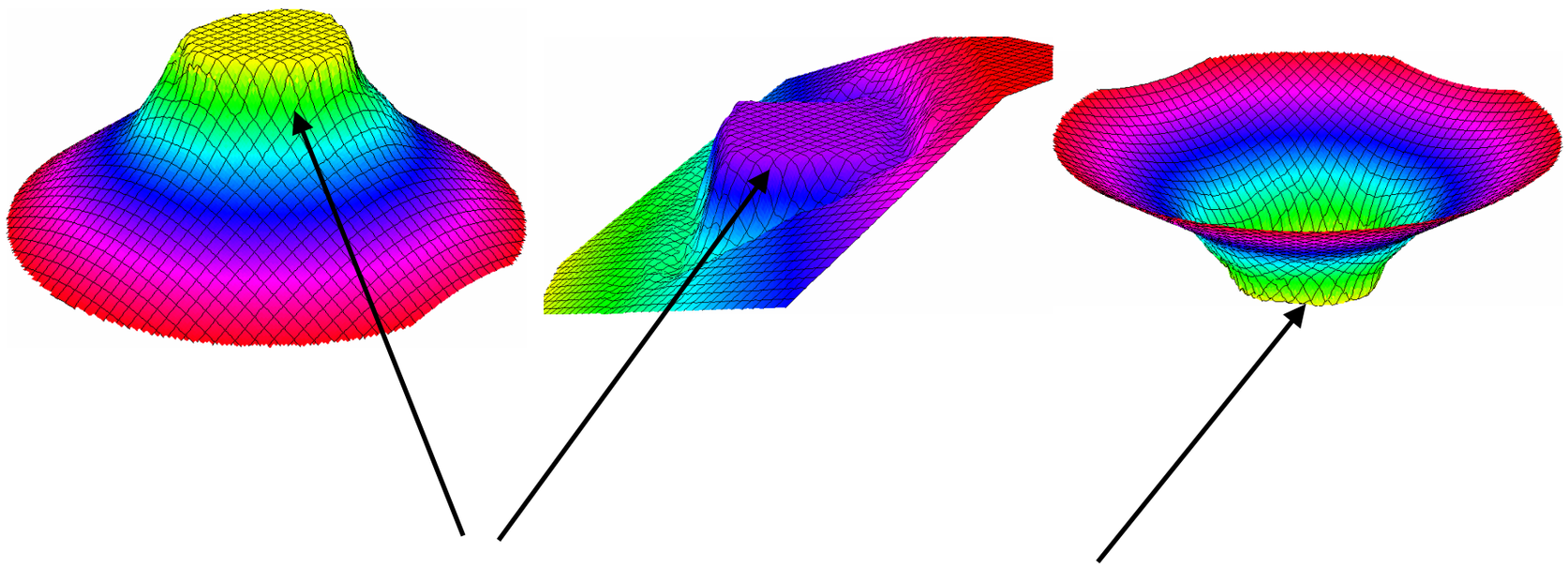
Flow on digital terrain models (II)

Overview

- Flow on grid terrains
  - FD: Dealing with flat areas
  - From FD and FA to watersheds
  - Pfafstetter watershed hierarchy



Computing FD on flat areas



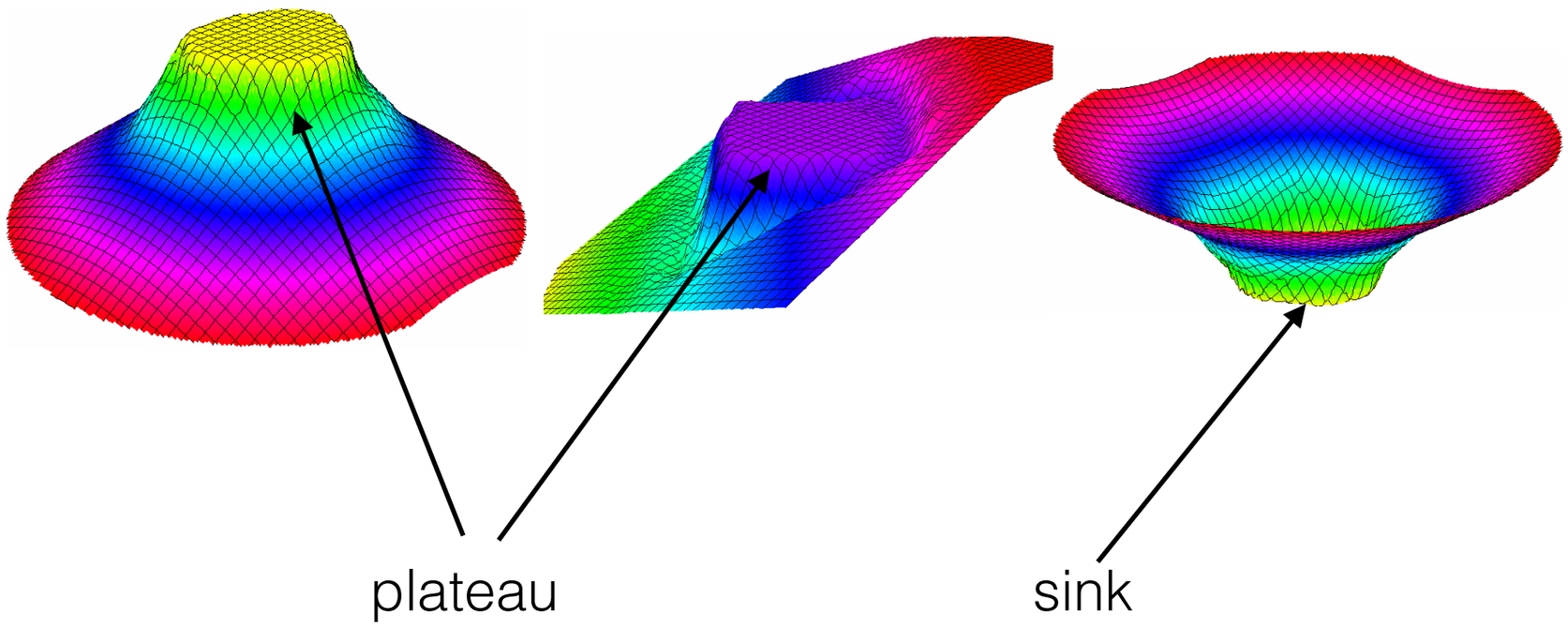
plateau

flat area has at least one spill point from which water flows downhill

sink

flat area surrounded by higher grounds

Computing FD on flat areas



plateau

flat area has at least one spill point
from which water flows downhill

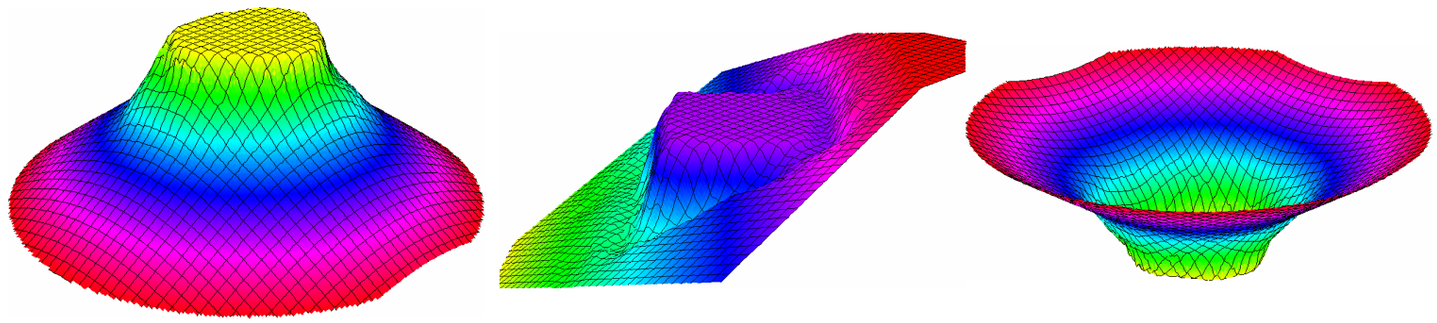
sink

flat area surrounded by higher grounds

- The computation of FD is **not local**, but needs **global** knowledge of the flat area

  => we need to identify the flat areas

Identifying flat areas

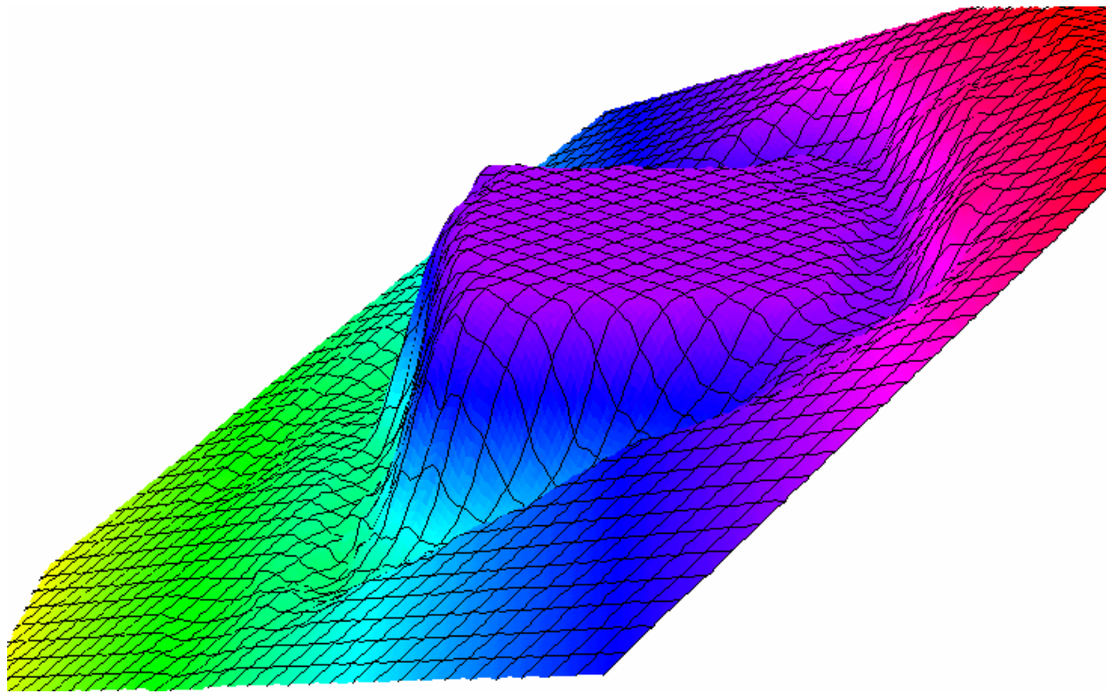


- Given an elevation grid, label each flat area with its own label, and distinguish between plateaus and sinks

How, and how fast?

FD on plateaus

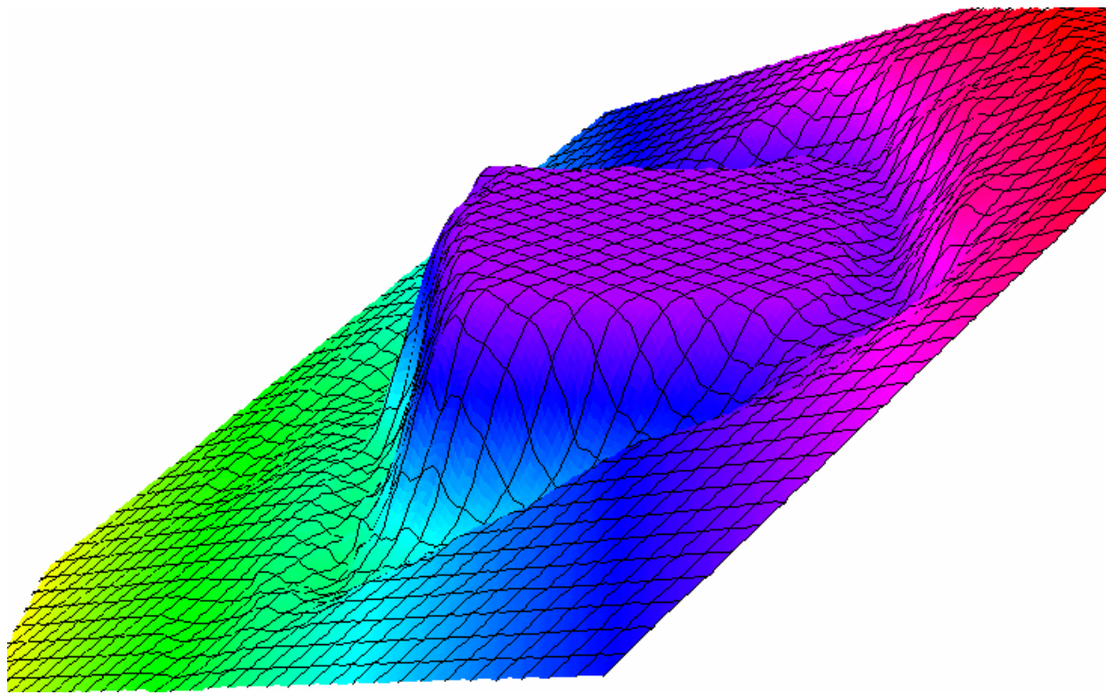
- Water leaves through the spill points —> direct FD towards the spill points



FD on plateaus

- Water leaves through the spill points —> direct FD towards the spill points

- Idea: multi-source BFS
  - Initialize queue with all spill points.
  - While queue not empty
    - Remove cell p from queue
    - Look at all its neighbors
    - If any neighbor is still white, set its FD towards p; add it to the queue

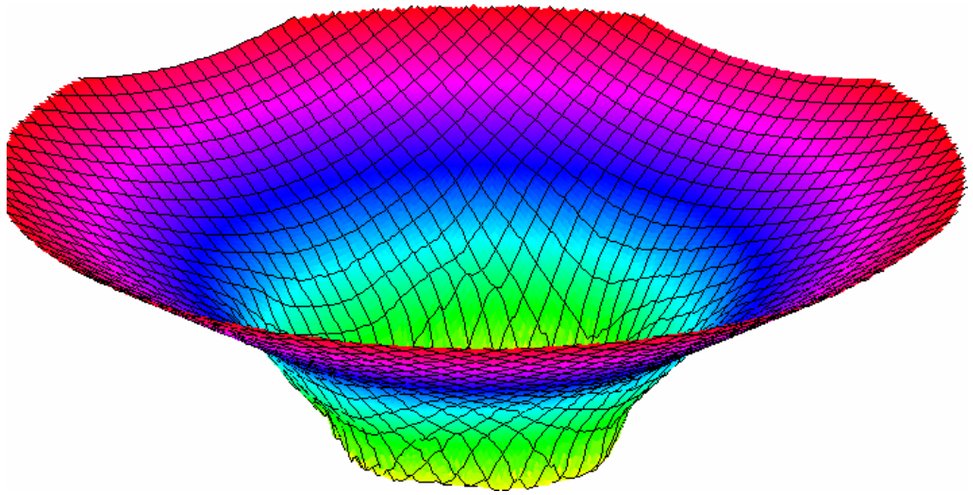


- BFS computes shortest paths —> water finds its shortest way to the spill point

FD in sinks

- **Downslope FD not possible**

NEXT TIME!



Water comes into the sink from the surrounding area and cannot go “out” following downslope paths

From FD and FA to rivers and watersheds

Terminology

- Mouth or end of a river
- Source of a river
- Streams
- Tributaries
- Junctions
- Watersheds
- Drainage basins
- Catchments
- Drainage divides

STAR GAZING YOGA SEA CREATURES GARDENING LEGENDS BIRDS MORE

Reference*

GEOGRAPHY BODIES OF WATER

Q: What is a mouth of a river?

A: QUICK ANSWER

The mouth of a river is another name for its terminus, where it meets an ocean, sea or lake. Because rivers generally carry abundant sediment and deposit it at the mouth, they often form deltas, or broad, shallow areas. The opposite enc
headwaters
same genera

Reference*

SCIENCE EARTH SCIENCE

Q: What is a river source?

A: QUICK ANSWER

A river source is the place from which a river begins to flow. Types of sources include lakes, bogs, springs, streams, collections of snow or rainwater, glaciers, swamps and other rivers. CONTINUE READING

KEEP LEARNING

Q: What is the difference between a rive and a stream?

A: QUICK ANSWER

The Minnesota Department of Natural Resources explains that there i official distinction between streams and rivers, but streams are comm held to be smaller bodies of water that feed into larger bodies, namel Both streams and rivers possess currents and are somewhat narrow, are at least constrained between two banks. CONTINUE READING

WYOMING
UTAH
NEVADA
COLORADO
CALIFORNIA
ARIZONA
NEW MEXICO
BAJA CALIFORNIA
SONORA
Green
Big Sandy
Blacks Fork
Rock Springs
Flaming Gorge Reservoir
Little Snake
Yampa
White
Duchesne
Strawberry Reservoir
Green
Colorado
Grand Junction
Gunnison
Blue Mesa Reservoir
San Rafael
Dirty Devil
Fremont
Escalante
Moab
San Miguel
Dolores
Animas
San Juan
Navajo Reservoir
Farmington
Chinle
Chaco
Paria
Lake Powell
Page
Kanab
Virgin
St. George
Muddy
Las Vegas
Henderson
Lake Mead
Lake Mohave
Bullhead City
Oraibi Wash
Flagstaff
Little Colorado
Puerco
Verde
Lake Havasu City
Prescott
Lake Havasu
Bill Williams
Colorado
Hassayampa
Agua Fria
Theodore Roosevelt Lake
Salt
Scottsdale
Phoenix
San Carlos Lake
San Francisco
Gila
Painted Rock Reservoir
Yuma
San Luis Rio Colorado
Santa Cruz
San Pedro
San Simon
Tucson
White

Watersheds, drainage basins, catchments

- Used interchangeably
- Area of land where where all the water that falls on the land flows to a common outlet.
- Every place on Earth is in some watershed
- Separated by ridges and hills (watershed divides)
- Scale: Watersheds are nested inside each other

Q: What is a watershed?

A:

QUICK ANSWER

A watershed is any area of land where water falls, flows and drains into a common lower outlet such as a river or lake. It can be as small as a puddle or as large as an area where all the water from the land goes to the same point.

CONTINUE READING ▼

KEEP LEARNING

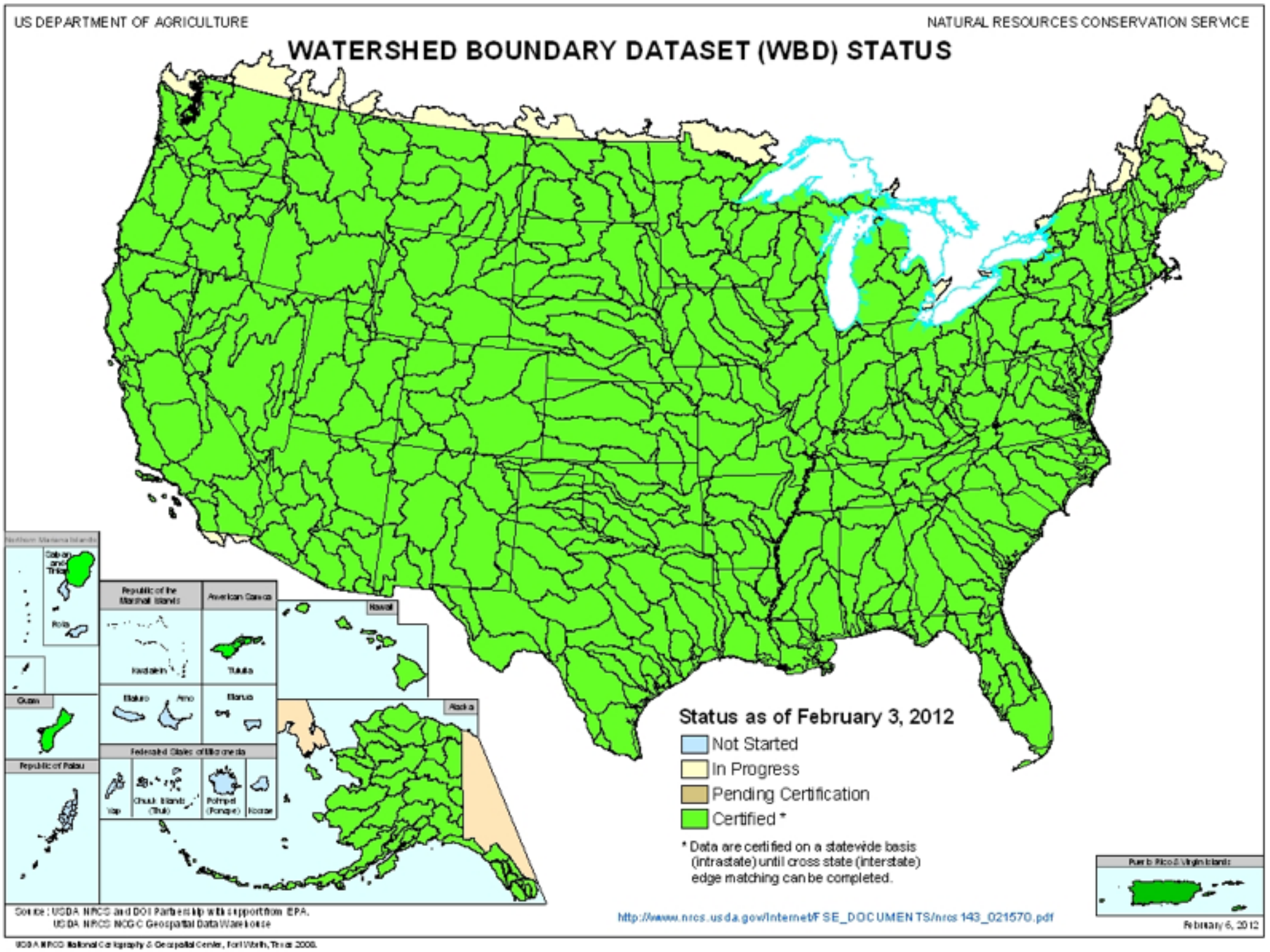
How does a watershed function?

What are some ways to protect a wildlife habitat?

What is the major river that flows through the Grand Canyon?

FULL ANSWER

A watershed is commonly known as a rainfall or precipitation collector. It collects water from the highest point, also called the headwater, and delivers the water through tributary streams to a larger water basin or a mouth, such as a river. One of the more well-known watersheds is the Sierra Nevada watershed, which supplies water not only to more than half of California and Northwestern Nevada's population, but also supports and provides premium habitat to the wildlife in the mountain area.



How do you think these maps are created?

FD and FA lead to elegant models of these concepts

A tree in FD graph represents a river and its tributaries.

Root of a river tree: river mouth

Pruning the tree: a river = all points with FA above a given threshold.

River backbone: walk from the mouth up along path with largest FA

Junctions: points in the river tree with >1 child

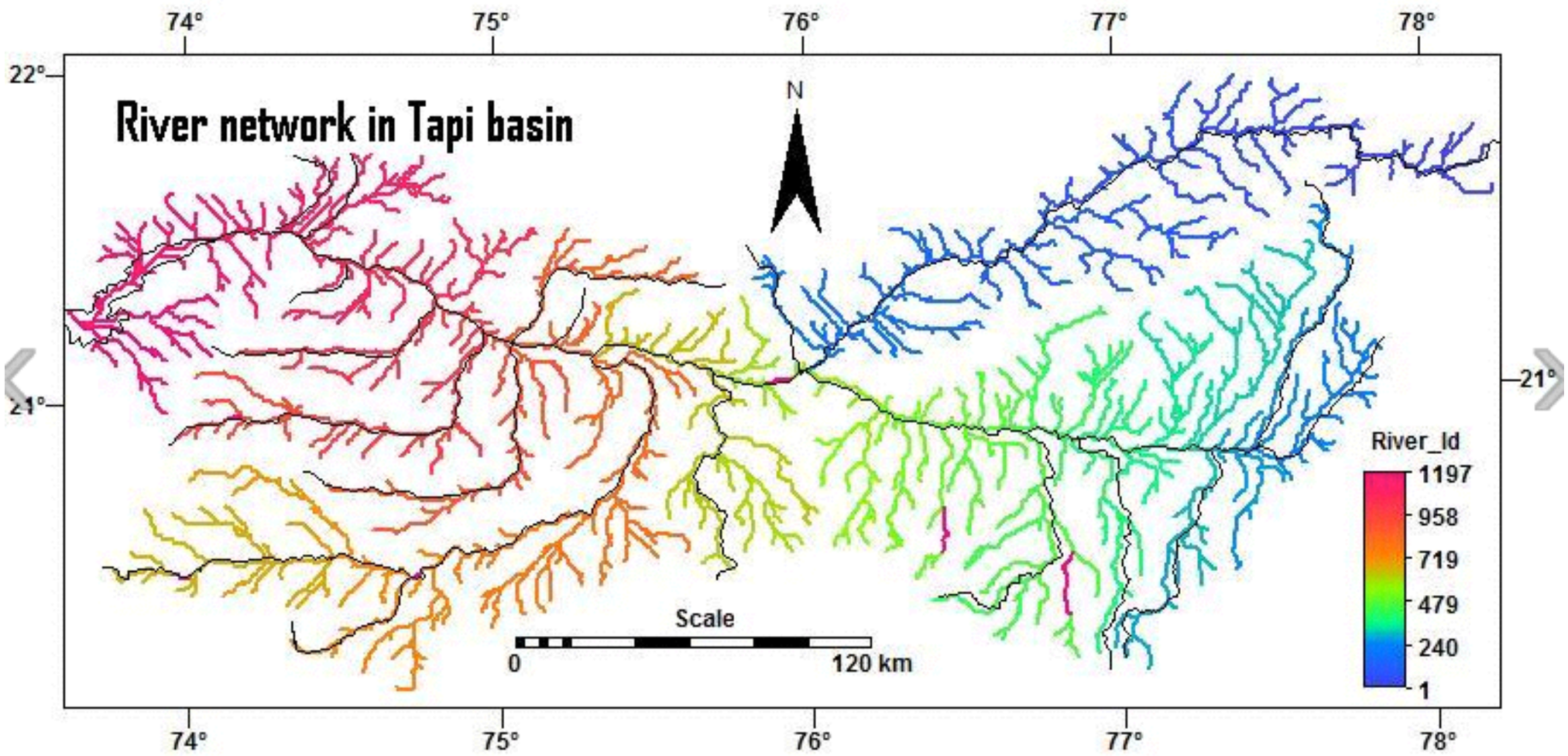
River tributaries: the connected components of the river tree minus the river backbone

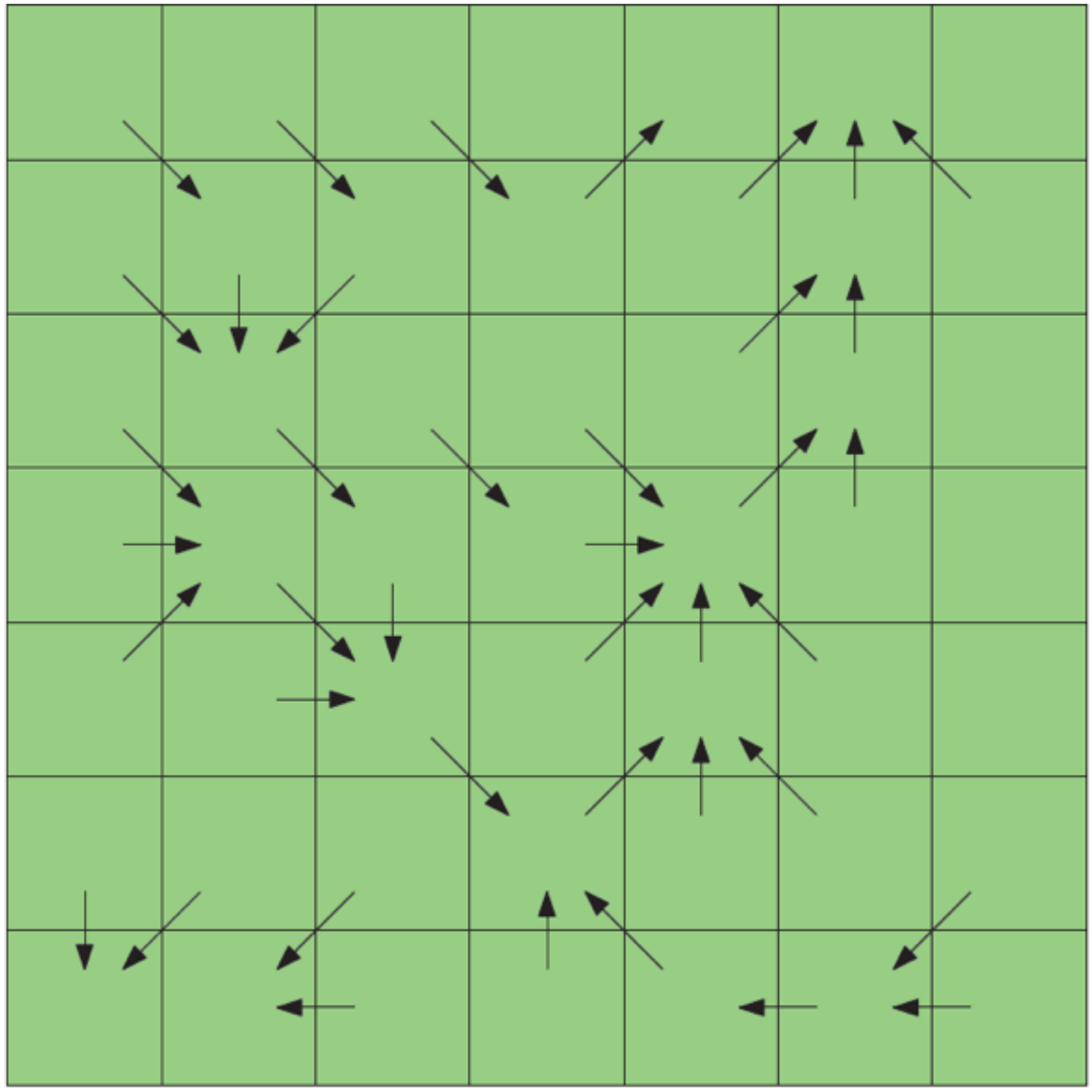
Watershed (s): all cells in the terrain that have a flow path into s.

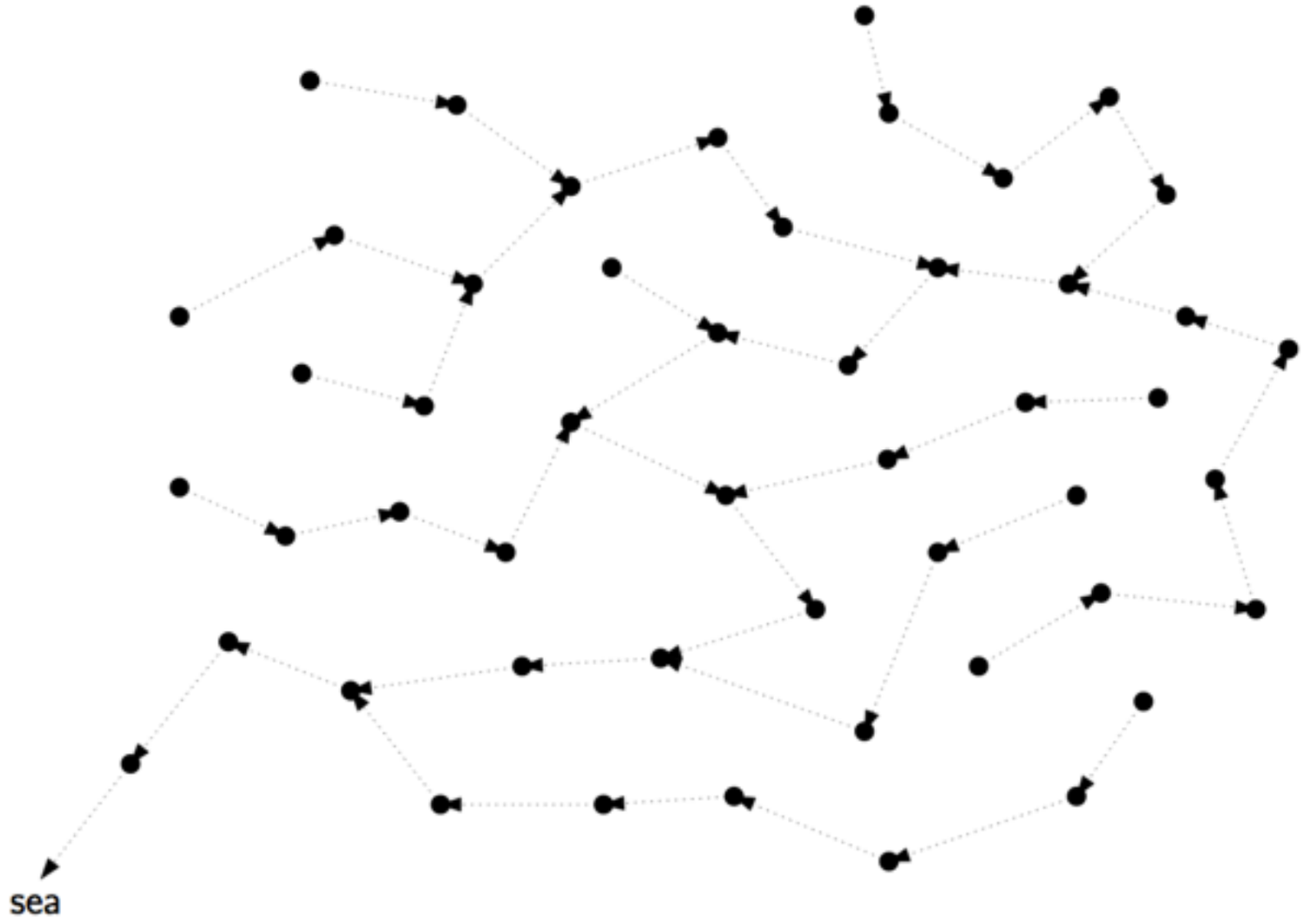
Watershed hierarchy:

- find river backbone
- find largest tributaries and their basins
- find inter-basins
- recurse in each basin

- Rivers = cells with FA > threshold



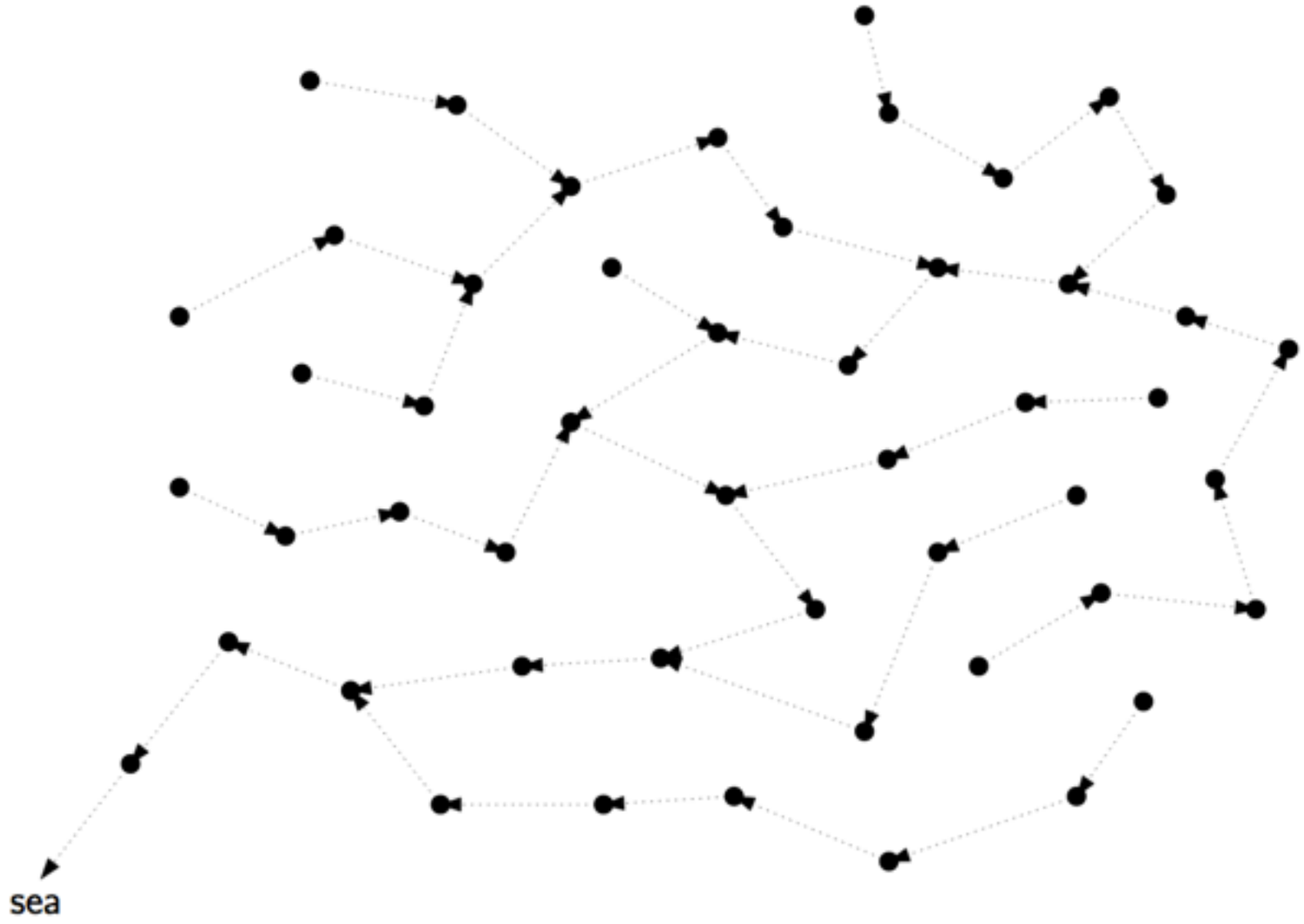



sea

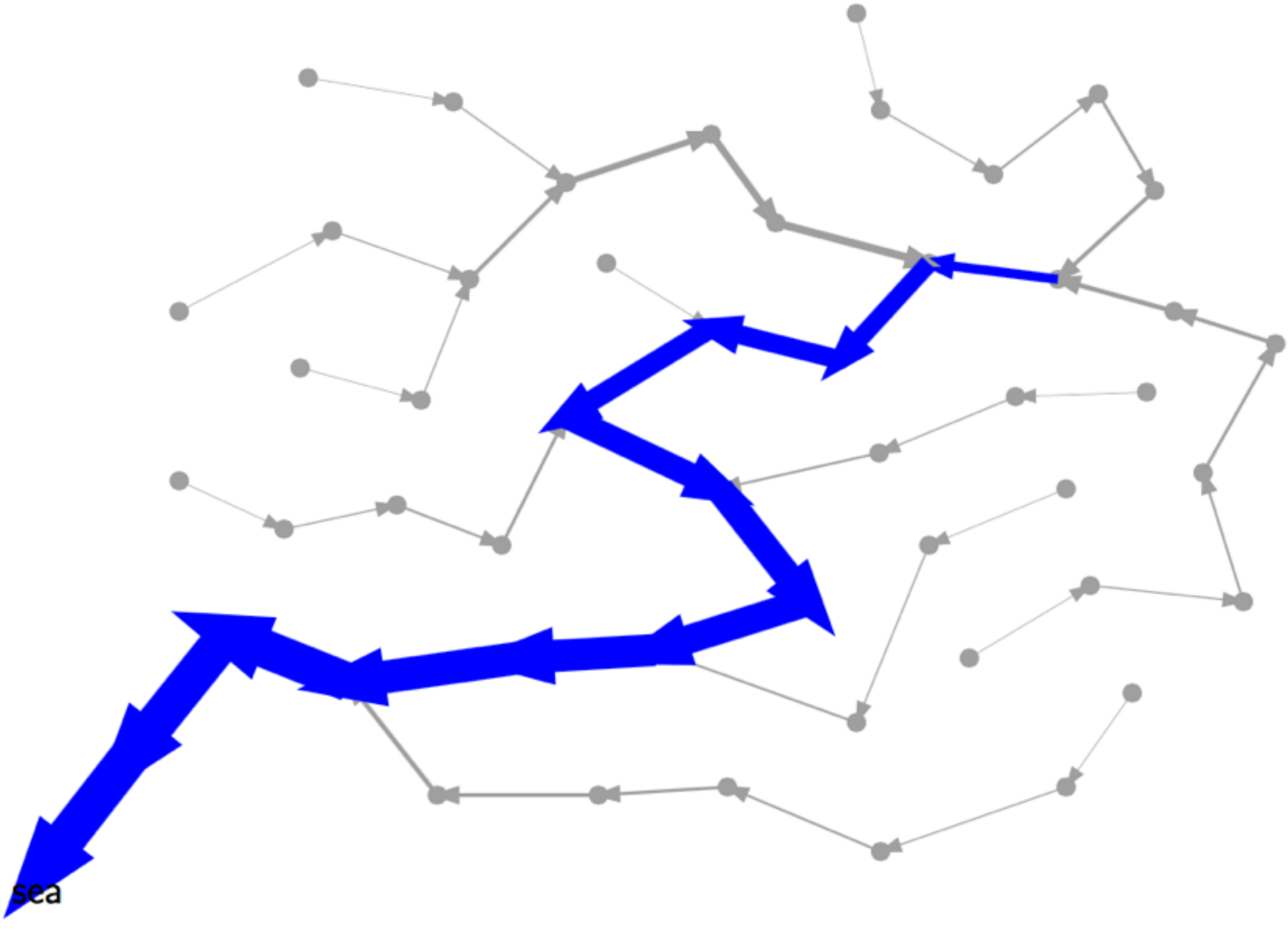
Below is a flow direction graph. It represents one river-tree.

1. Label each node with its flow accumulation (FA) value.

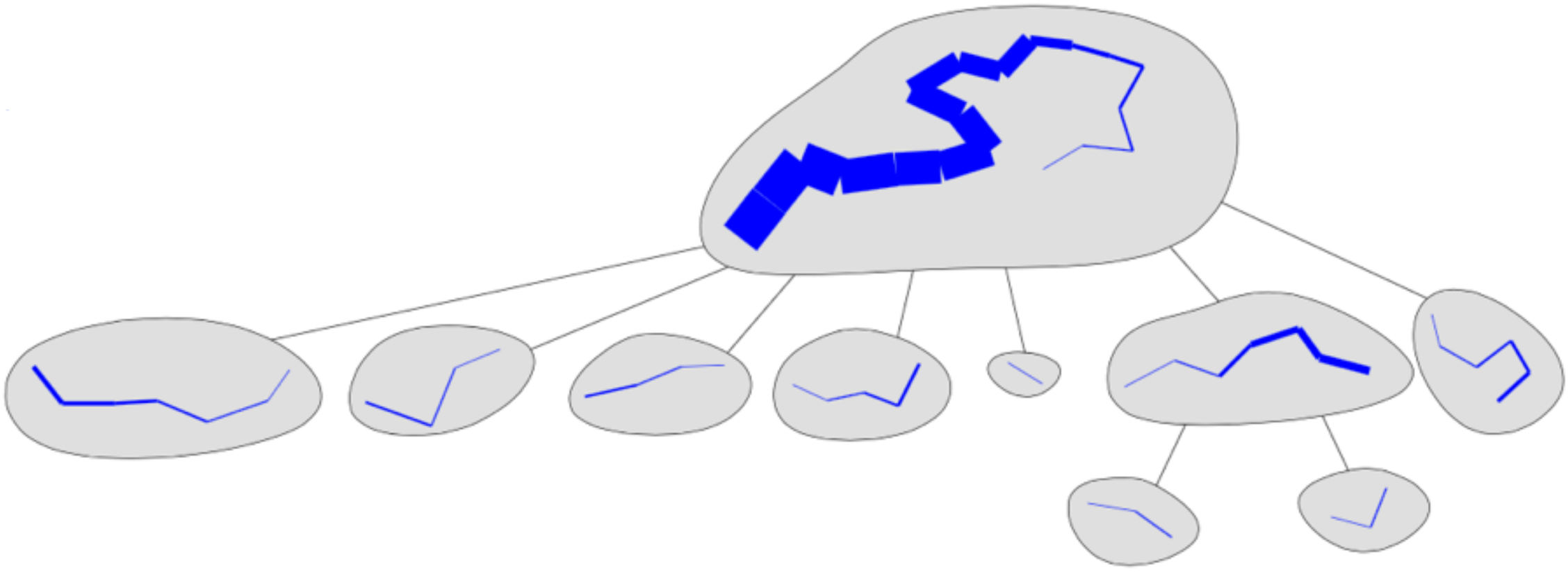
2. River backbone: start at the mouth, go upstream into the stream with largest FA value



River: start at mouth, keep going upstream into the stream with biggest drainage area.



tree of tributaries



Watersheds and watershed hierarchy

A watershed is an area of land where water drains to a common outlet. Because the whole watershed drains to the same point, it represents more or less a homogenous unit of landscape that can be studied on its own. Projects in the geo-sciences start by identifying the watershed they want to study.

Wait a minute: what scale? Clearly if we pick the “mouth” of a river, the entire river drains to it, so the whole river tree constitutes a watershed. What if we did not want to study the whole basin of the Amazon, but only a smaller portion of it? We would like to be able to partition the Amazon basin into sub-basins.

FD and FD give us an elegant way to model a watershed hierarchy. Idea is credited to Pfafstetter.

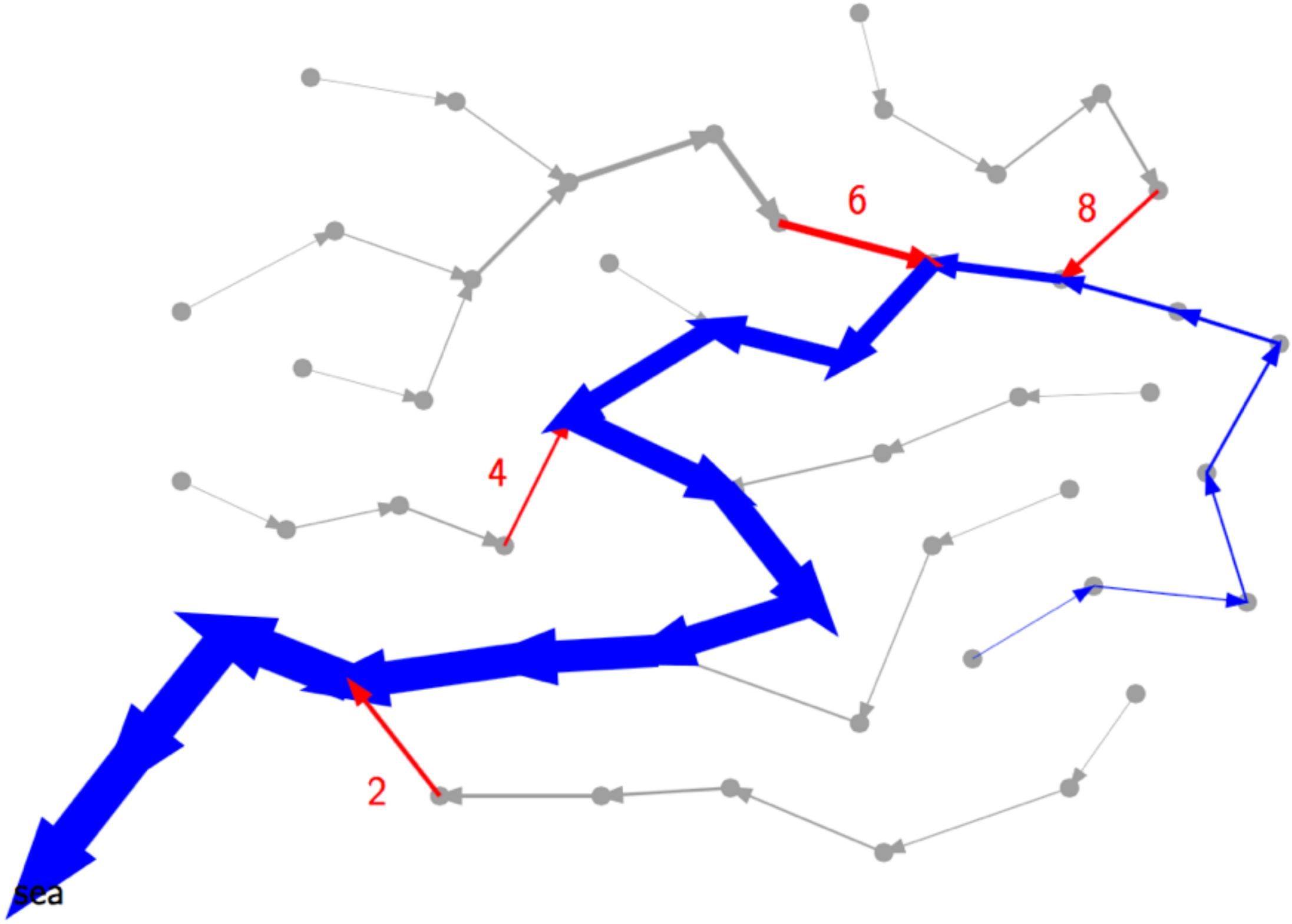
Pfafstetter watershed hierarchy:

- Find the backbone of the river.
- Find the largest 4 tributaries of the main river, and draw their basins; number these 2,4,6,8.
- Find the inter-basins between these four tributaries and number these 1,3,5,7,9.

TO DO:

- Show basins 1 through 9 on the FD graph on the other side. Every point in the terrain should be either in a basin or in an inter-basin. If it’s not, you did something wrong.
- Pick watershed 3 and recurse. Show its sub-watersheds 31,32,33…39

Subdivision: find four biggest tributaries, number them 2, 4, 6, 8;



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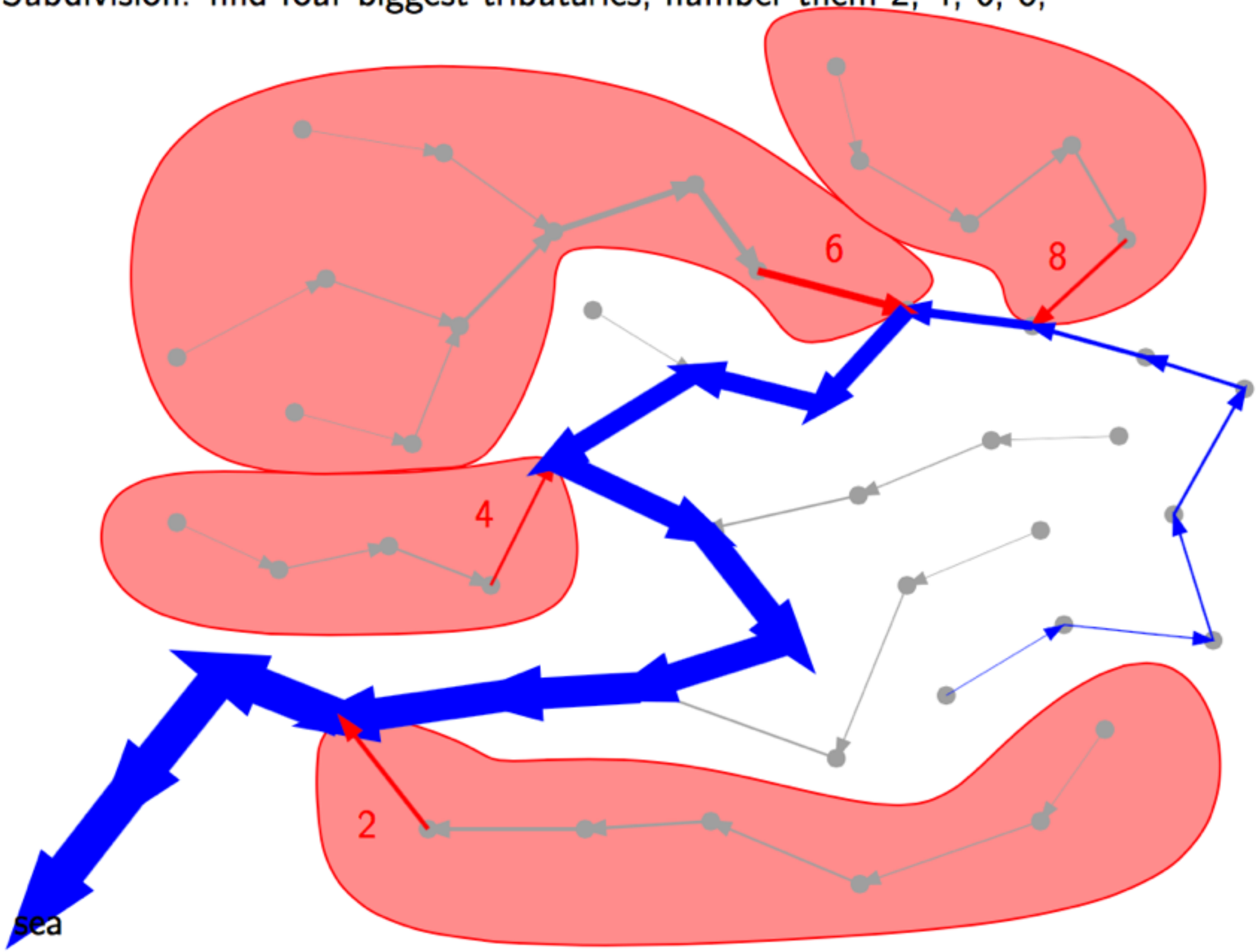
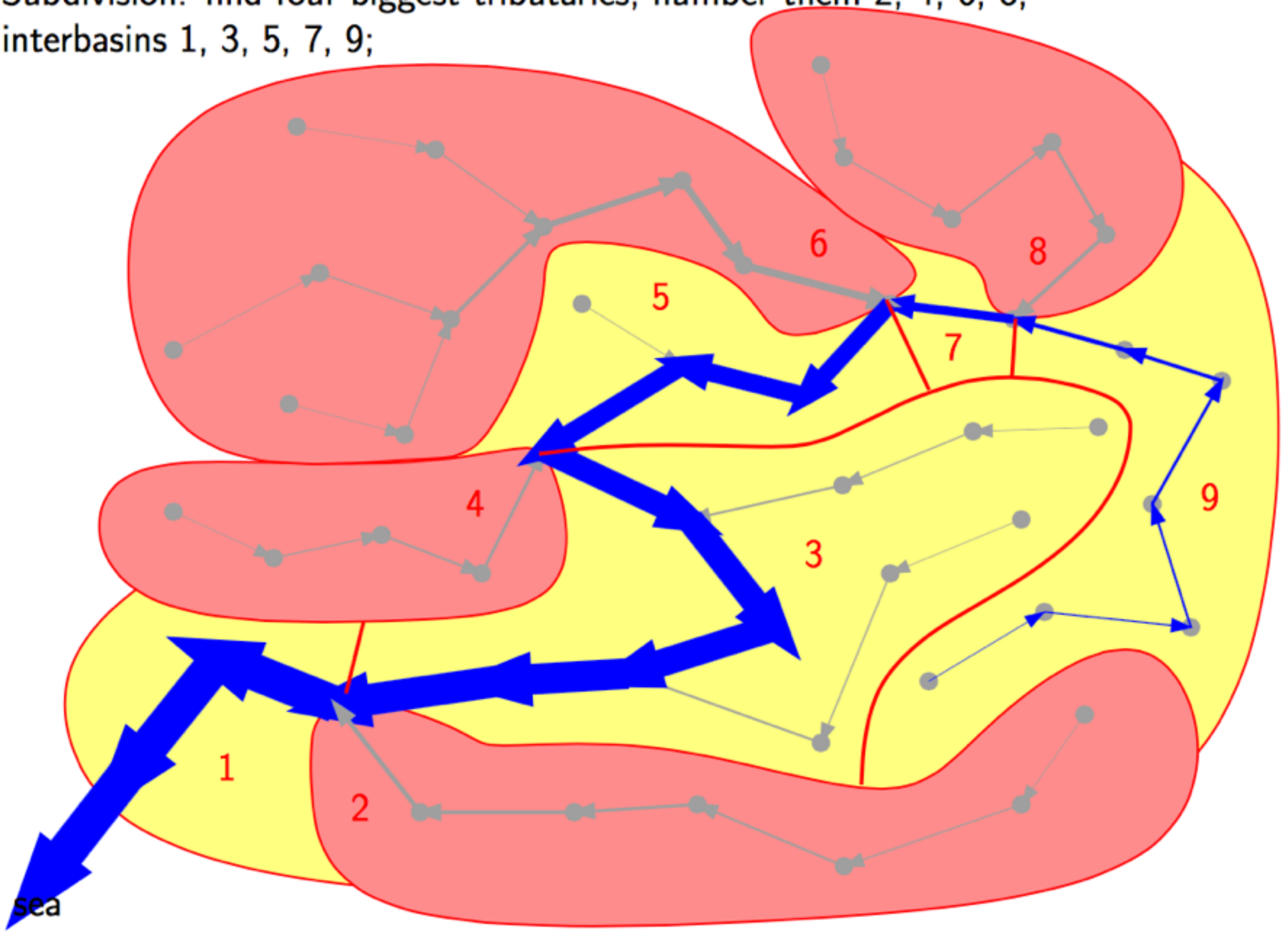
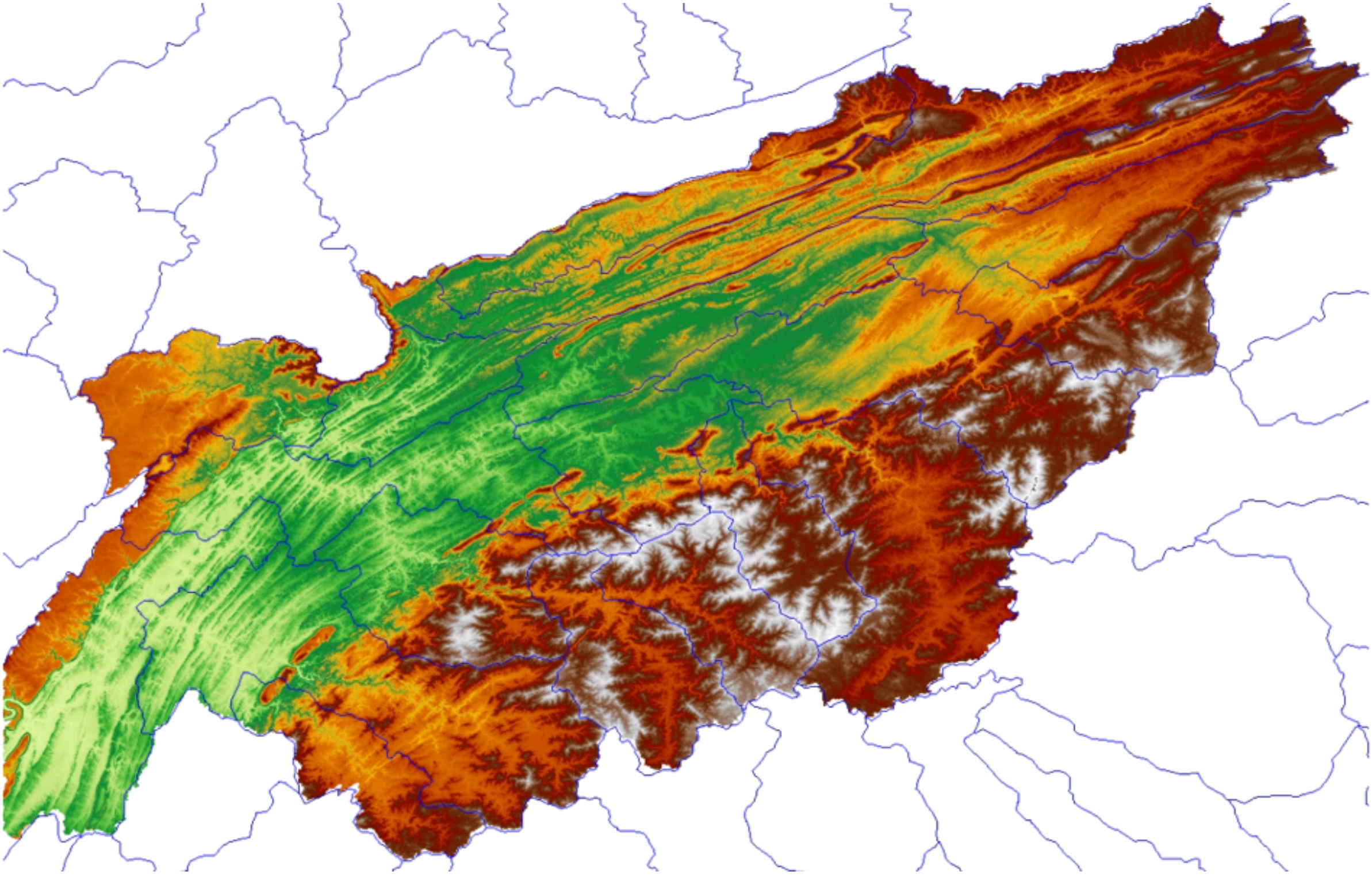


Subdivision: find four biggest tributaries, number them 2, 4, 6, 8;
interbasins 1, 3, 5, 7, 9;



In real life



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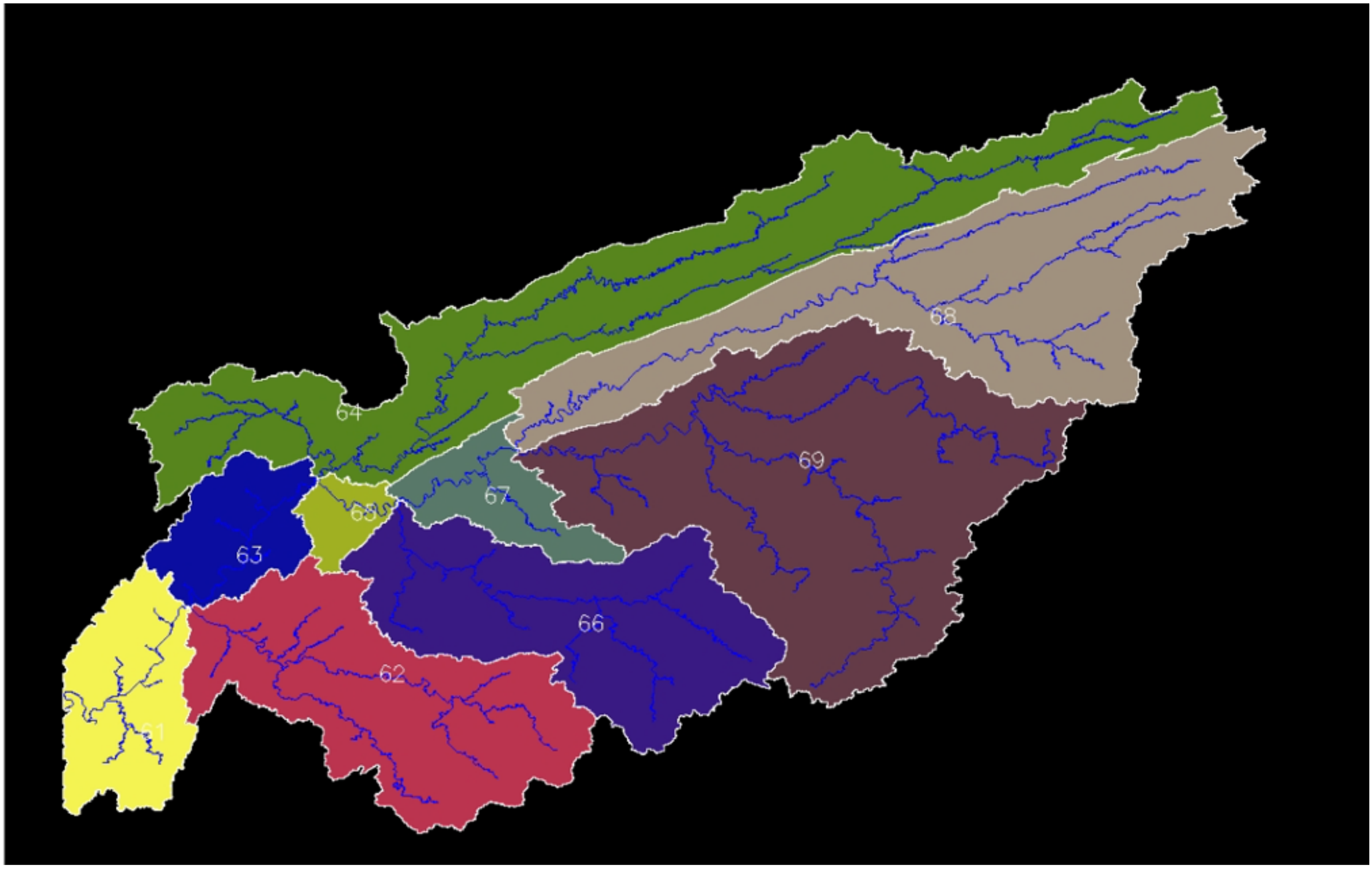

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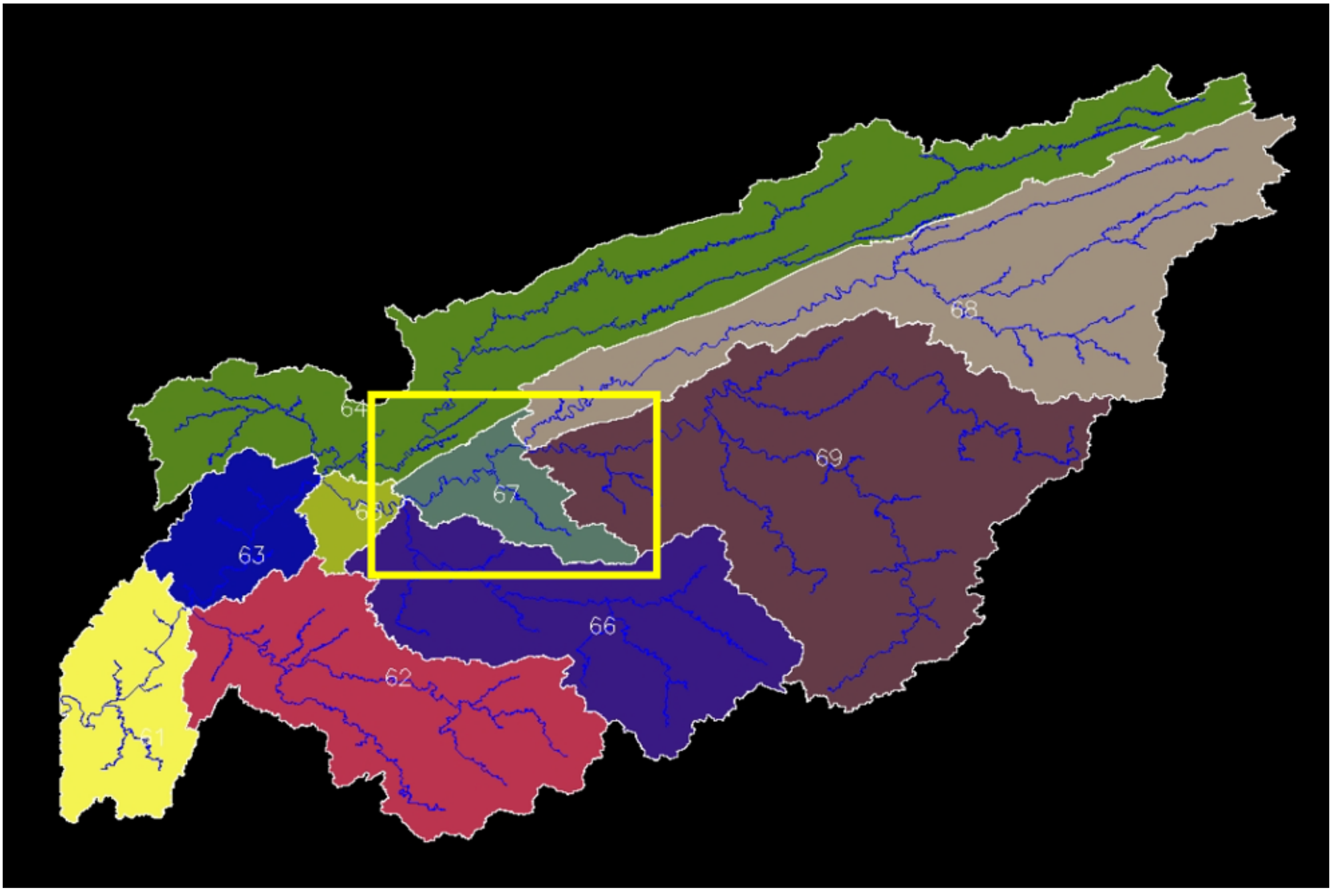

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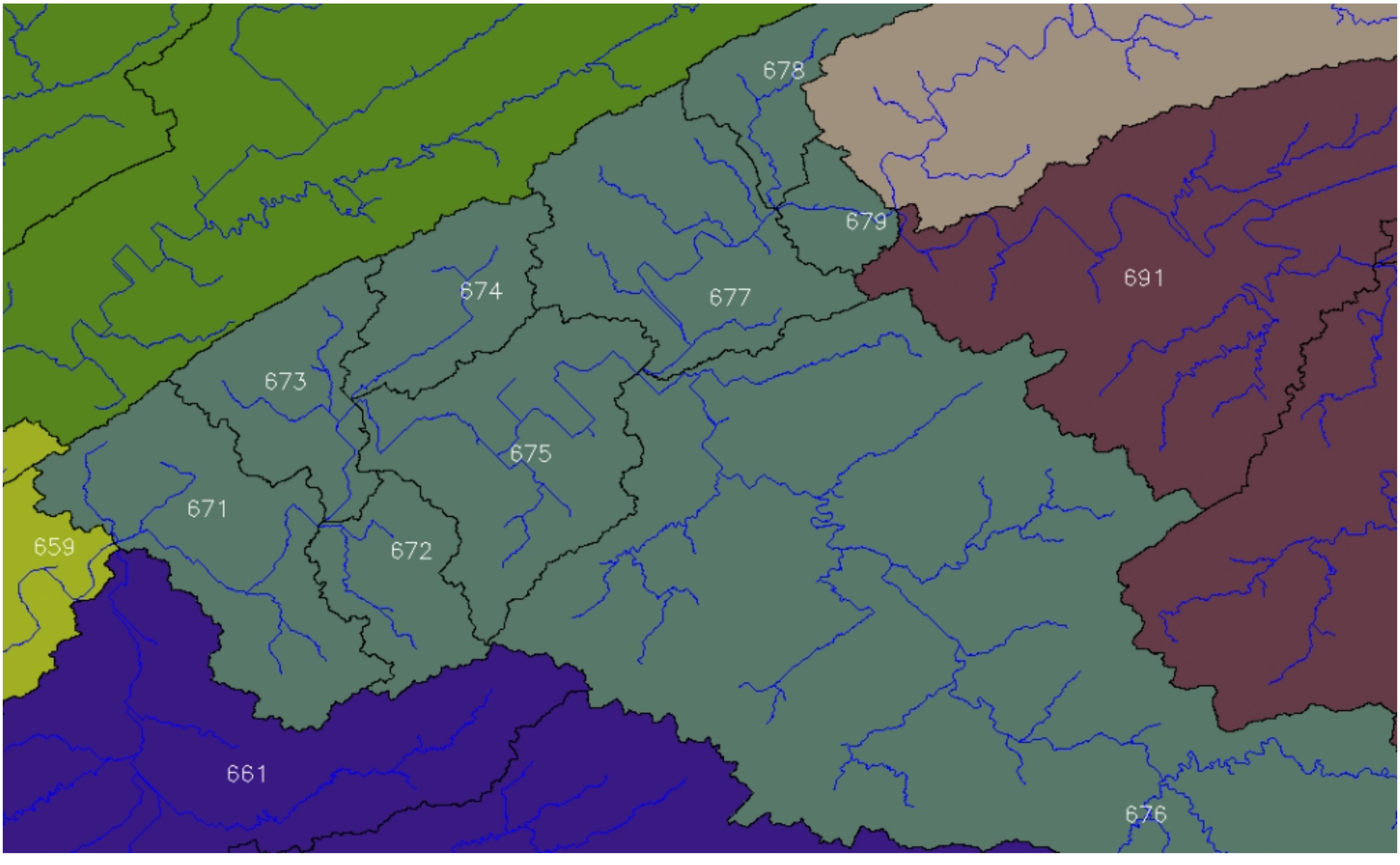

Full animation by

Herman Haverkort

University of Eindhoven

http://www.bowdoin.edu/~ltoma/teaching/cs350/fall14/Lectures/pfafstetter-short.pdf