



A Valley Confinement Algorithm for Aquatic, Riparian, and Geomorphic Applications

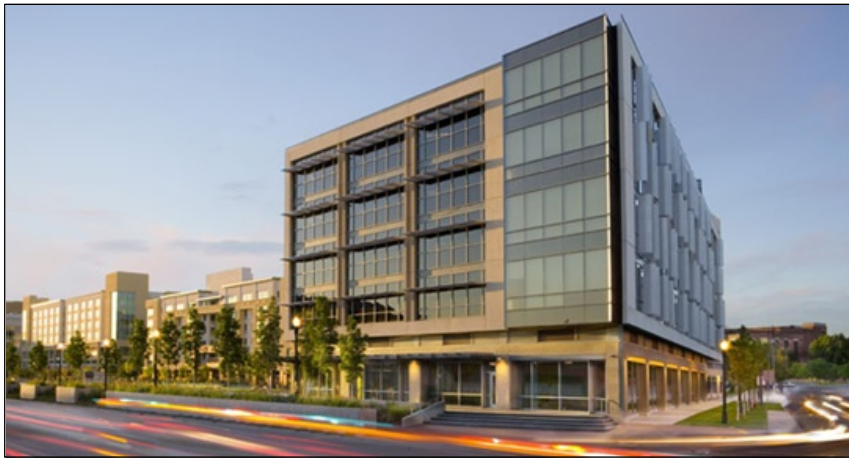
David E. Nagel and John M. Buffington

**U.S. Forest Service, Rocky Mountain Research
Station, Boise Aquatic Sciences Lab**

Nagel, D. E. and J. M. Buffington. 2013. A Valley Confinement Algorithm for Aquatic, Riparian, and Geomorphic Applications. Esri Southwest User Conference, Salt Lake City, UT, November 13-15.



Boise Aquatic Sciences Lab



Idaho Water Center

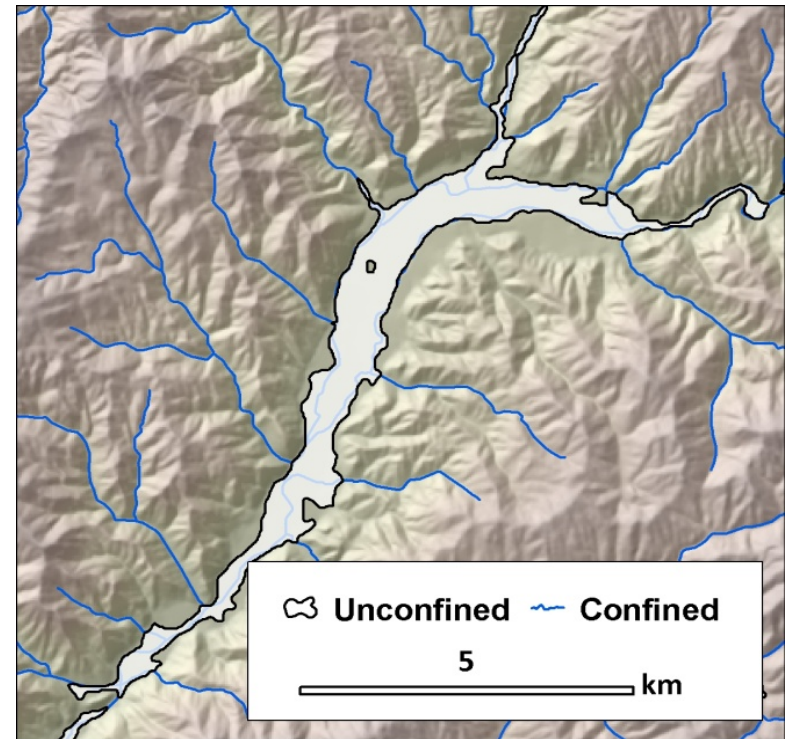


Fish and watershed research

Valley Confinement Algorithm (VCA)

Python Script

**Objective: Identify
unconfined valleys at
a landscape scale
using nationally
available GIS data**





Valley Characteristics and Justification

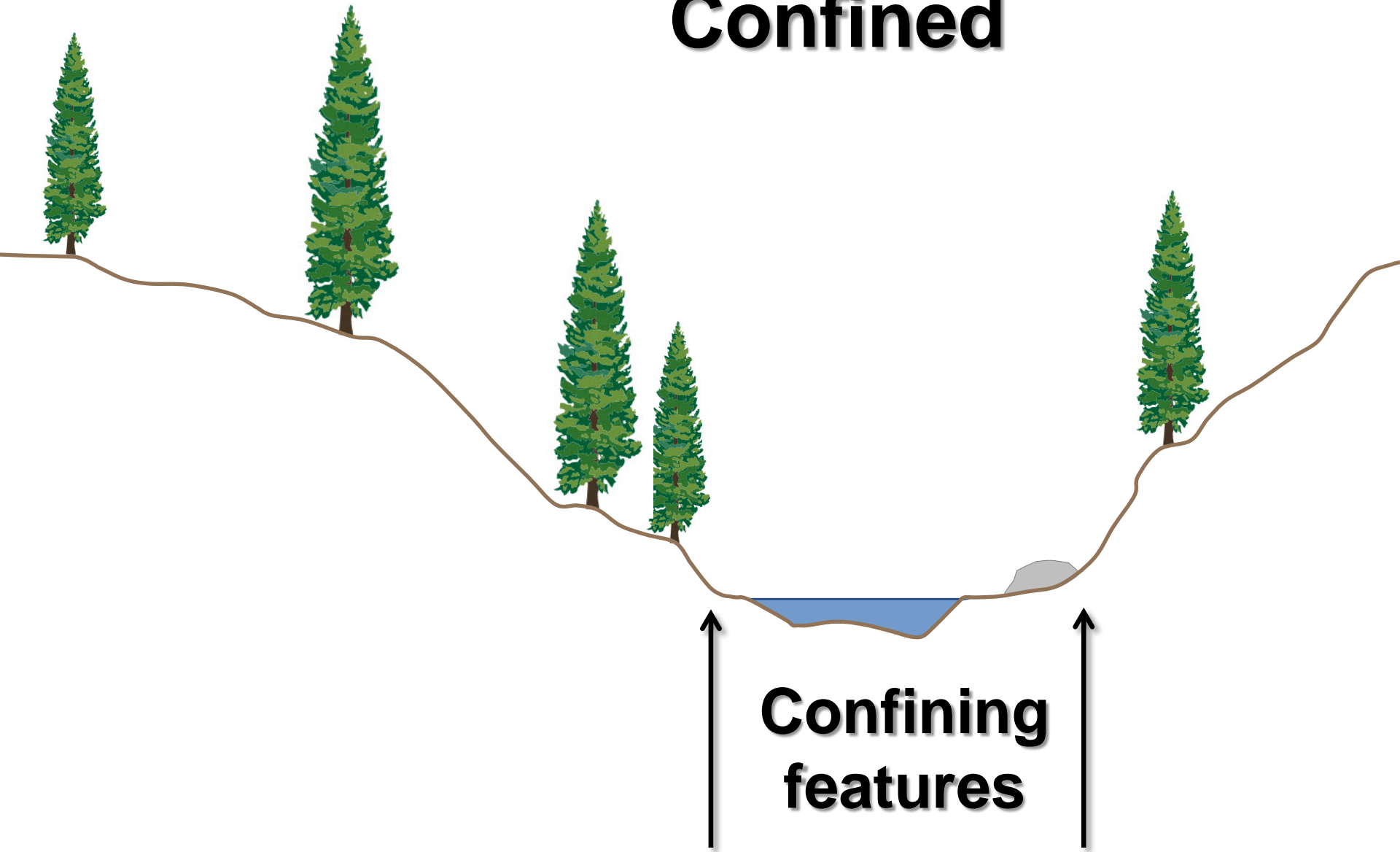
Valley Confinement

Degree of lateral confinement of a valley, constrained by topographic features





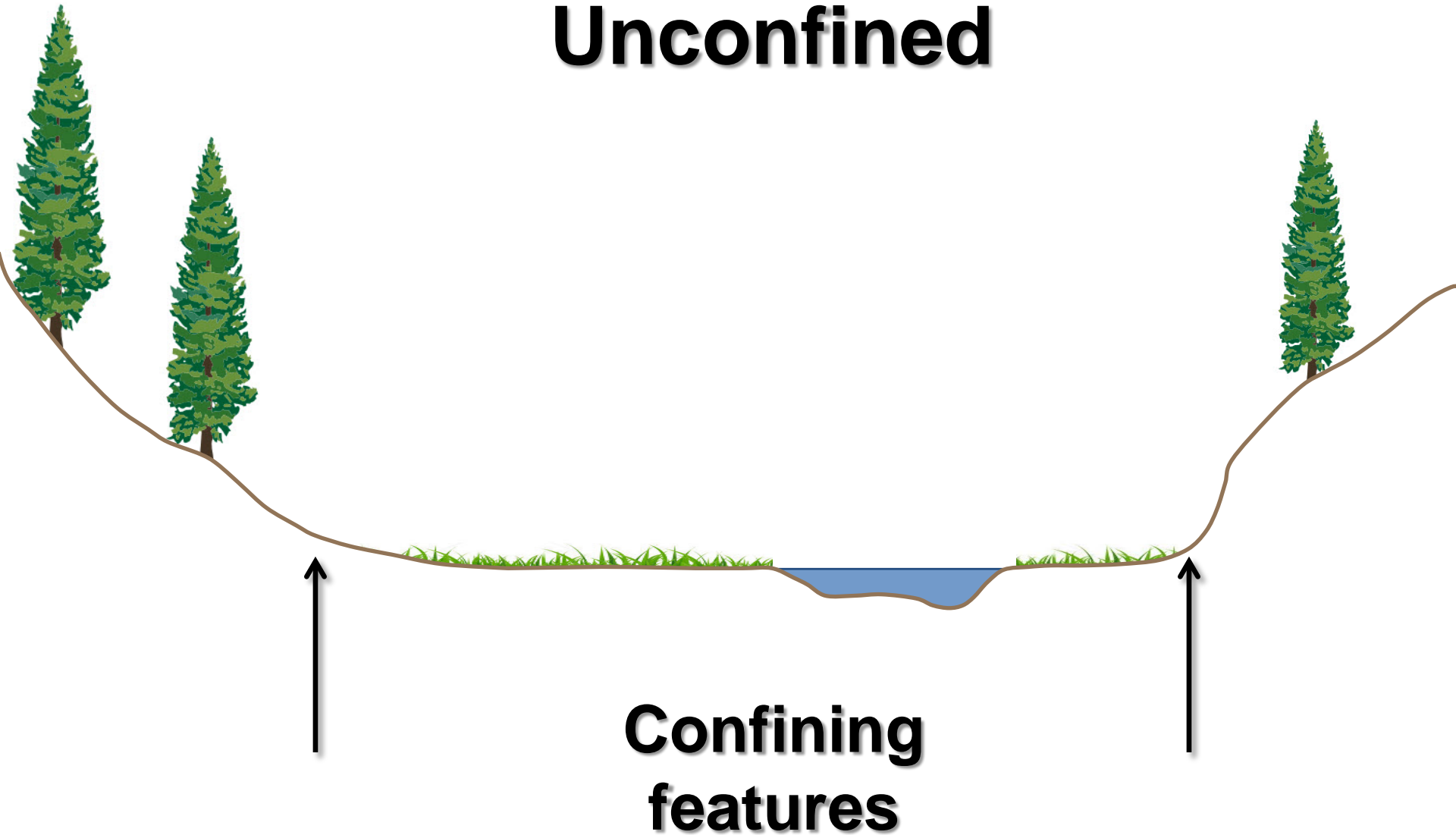
Confined



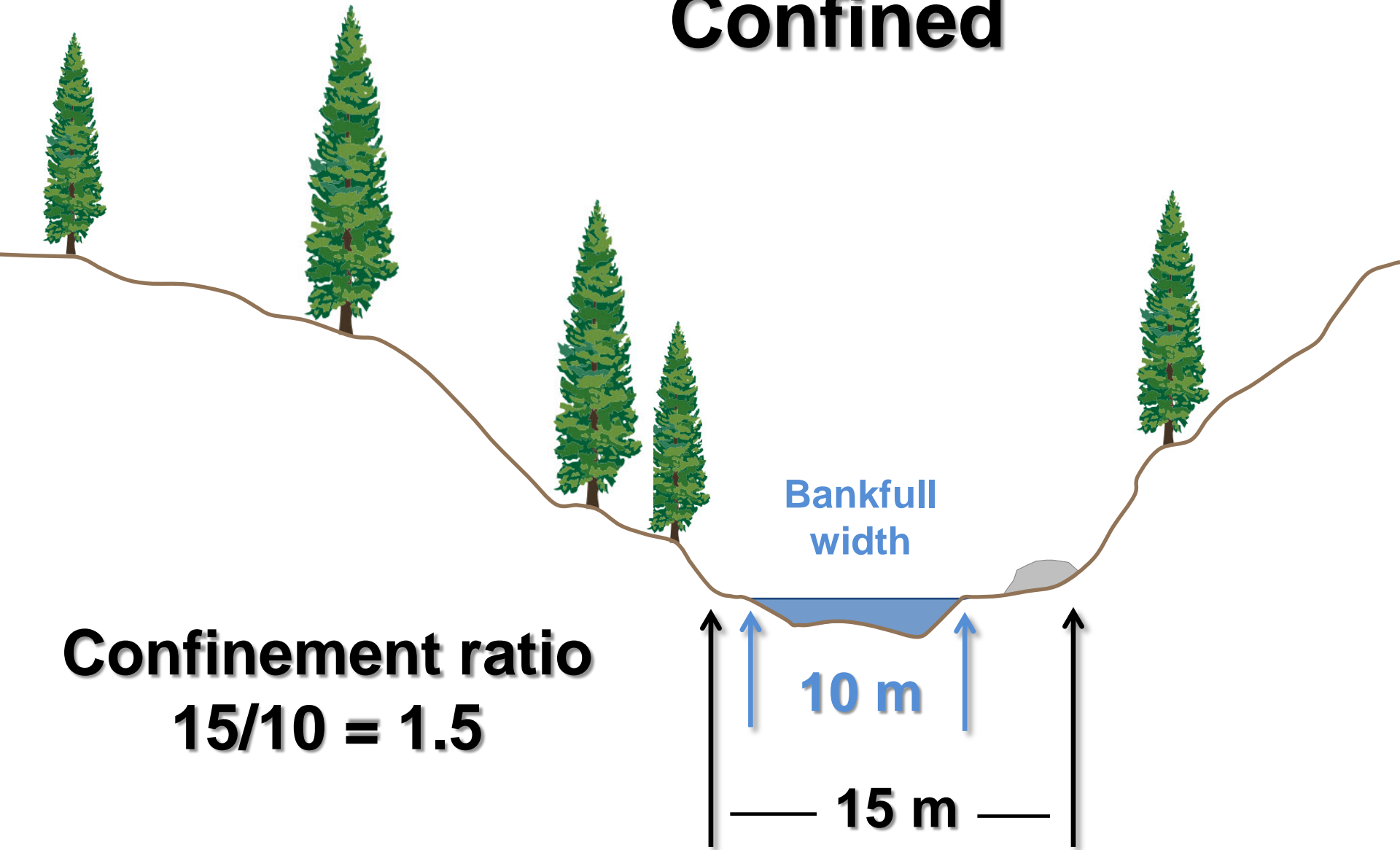
**Confining
features**



Unconfined



Confined

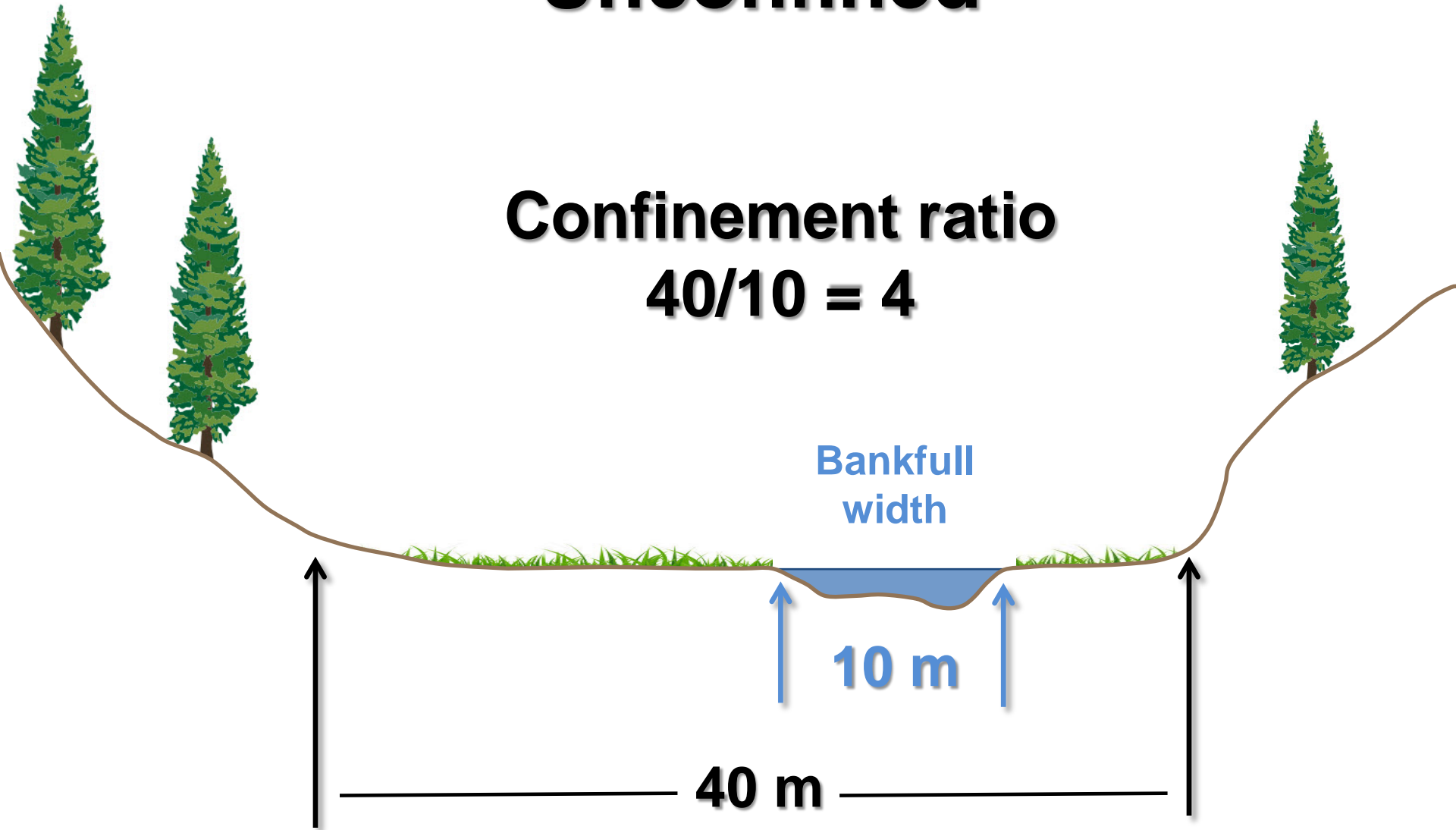


Confinement ratio
 $15/10 = 1.5$



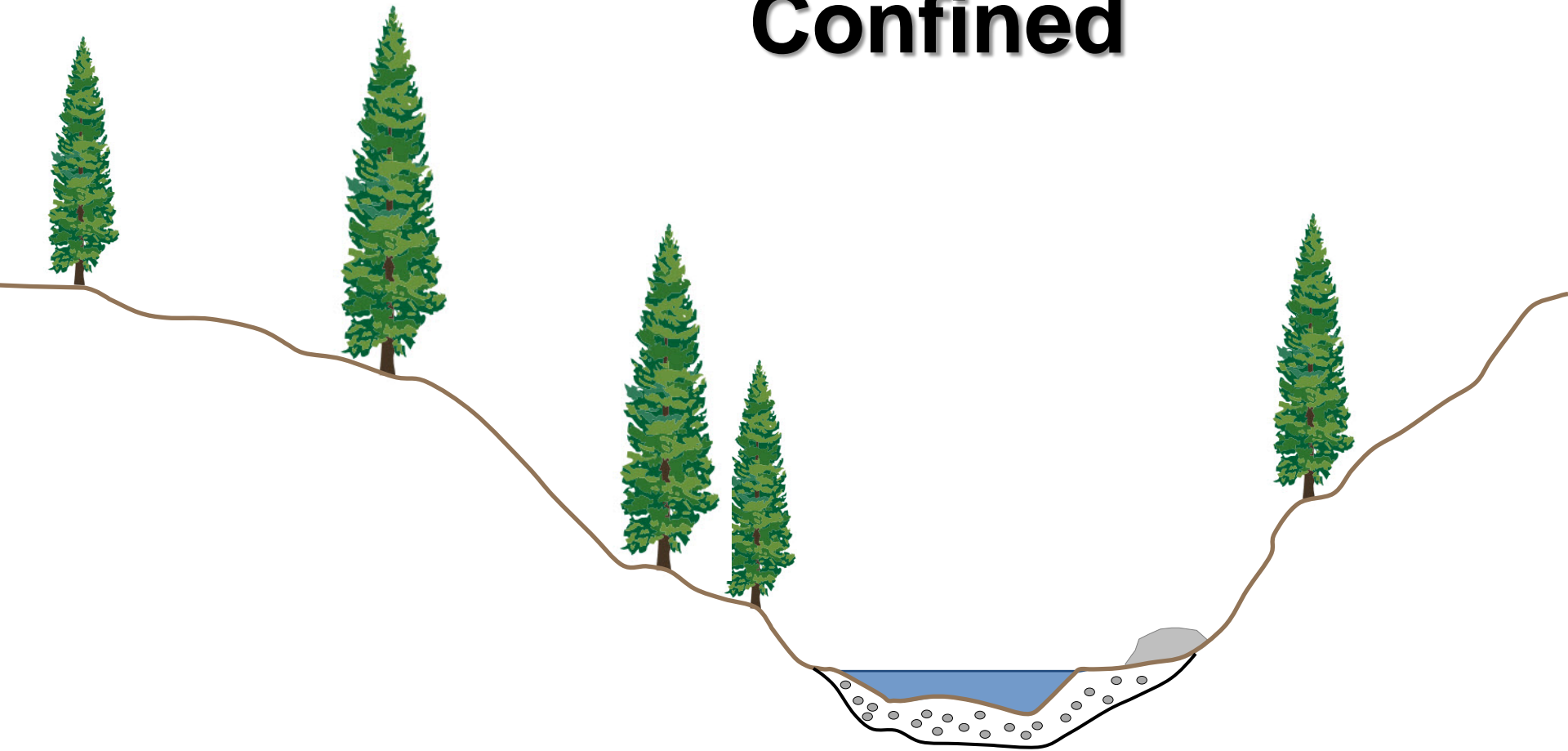
Unconfined

Confinement ratio
 $40/10 = 4$





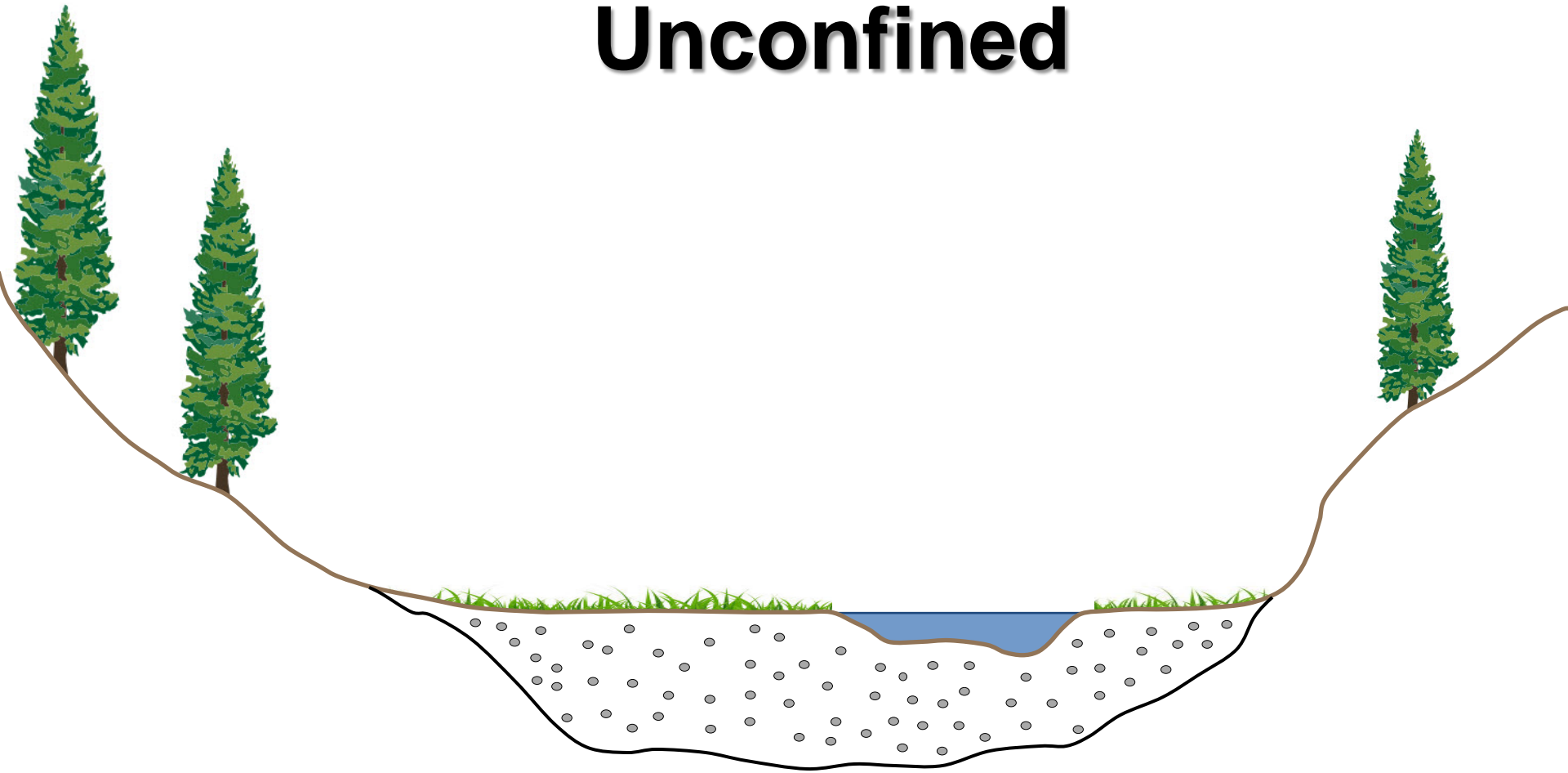
Confined



**Shallow alluvial
deposits**



Unconfined



**Deeper alluvial
deposits**



Confined





Unconfined

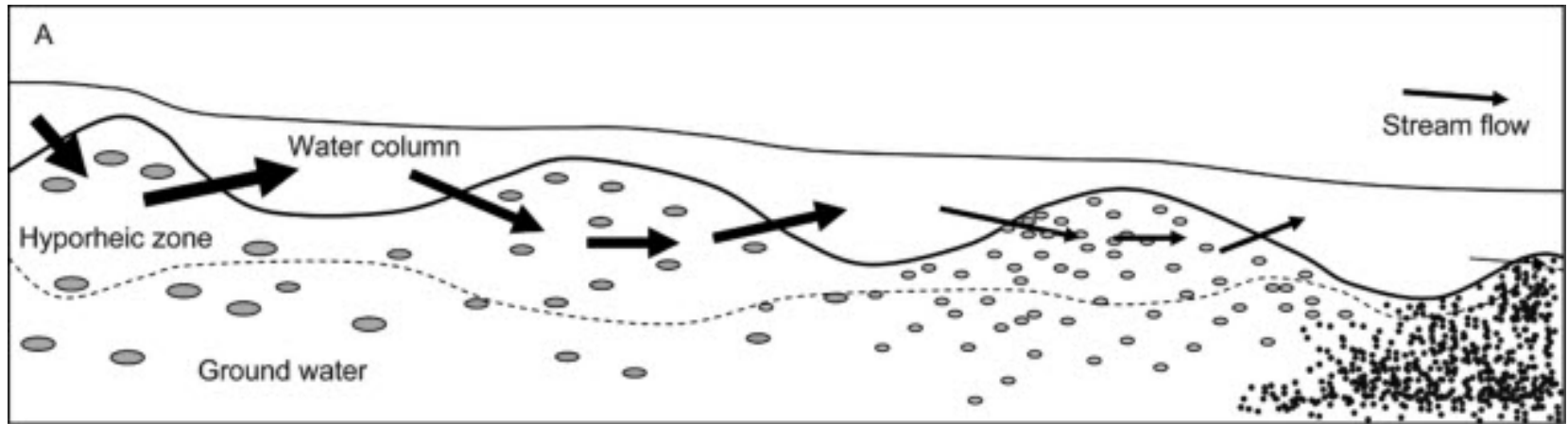


Characteristics of Unconfined Valleys

- **Hyporheic exchange**
- **Channel morphology**
- **Grain size**
- **Riparian habitat**



Hyporheic Exchange



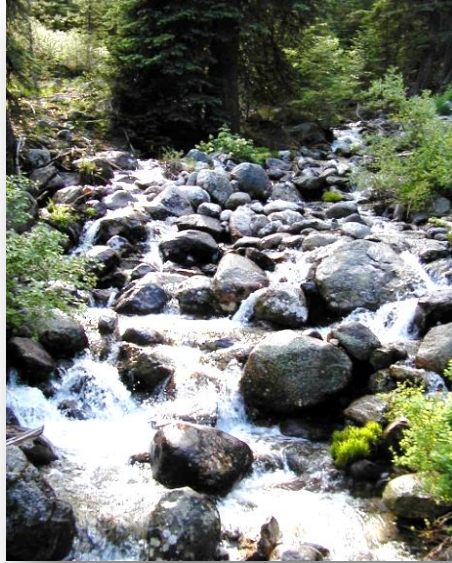
Baxter and Hauer 2000

Bull trout preferentially spawn at the downstream end of unconfined valleys where hyporheic upwelling may warm stream temperatures for overwintering embryos

Boulton and others 2010

Channel morphology

Cascade



Step-pool



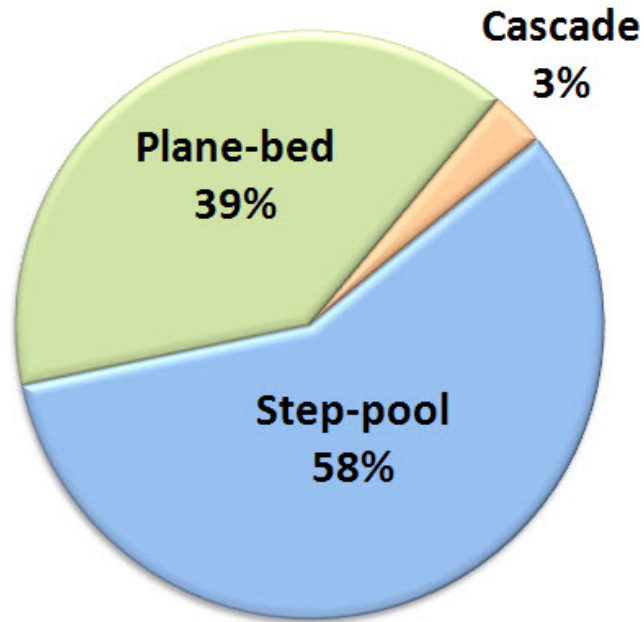
Plane-bed



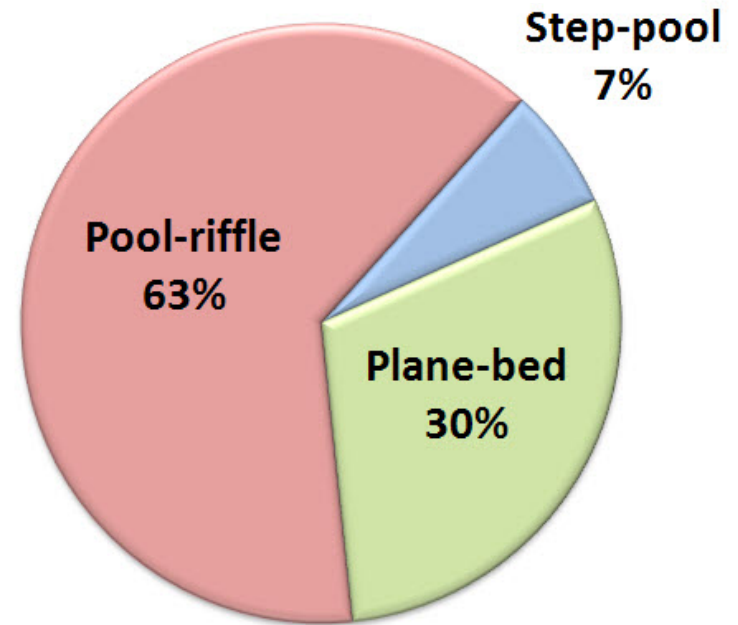
Pool-riffle

Channel morphology

Confined



Unconfined

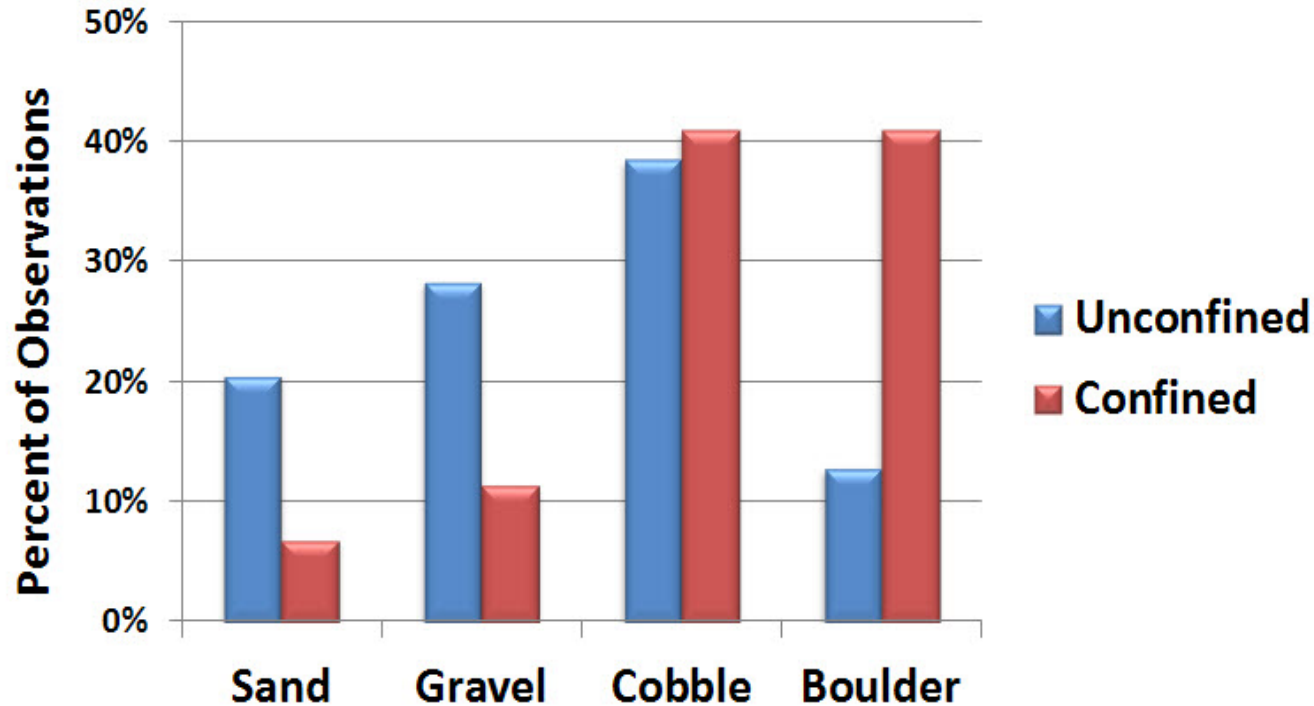


Pool-riffle morphology has 80% more pool area and 40% deeper pools, favored by juvenile salmon

McDowell 2001; Hall and others 2007



Grain Size



Spawning Chinook salmon prefer grain sizes that are often associated with unconfined valleys

Isaak and Thurow 2006



Riparian Areas

Riparian areas, often associated with unconfined valleys, provide disproportionately important ecosystem functions compared to confined valleys

Wissmar 2004





VCA

**Valley Confinement
Algorithm**

Python script with an interface that allows users to vary the results based on the needs of the application

Valley Confinement Algorithm (VCA)

Workspace location

Input DEM

Input streams

Use waterbody shapefile: Yes (1); No (0)
1

Input waterbodies (optional)

Valley form: Valley bottom only (1); Valley bottom and distance (2)
1

Use ground slope: Yes (1); No (0)
1

Maximum ground slope threshold (%) (optional)
9

Use flood option: Yes (1); No (0)
1

Flood factor (optional)
3

Average annual precipitation (cm)
250

Maximum valley width (m)
1000

Minimum drainage area (sq. km)
0

Minimum stream length per polygon (m)
100

Minimum valley bottom area (sq. m)
10000

Output shapfile name

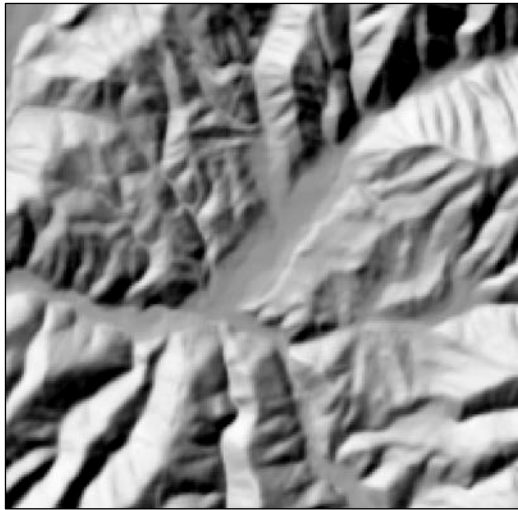
Valley Confinement Algorithm (VCA)

An algorithm that identifies unconfined valley bottoms.

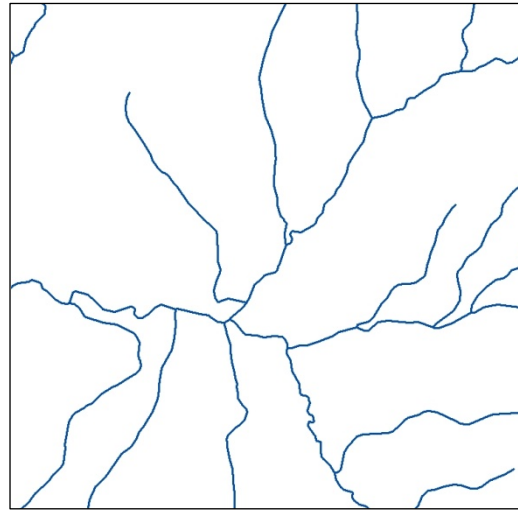
OK Cancel Environments... << Hide Help Tool Help

VCA Inputs

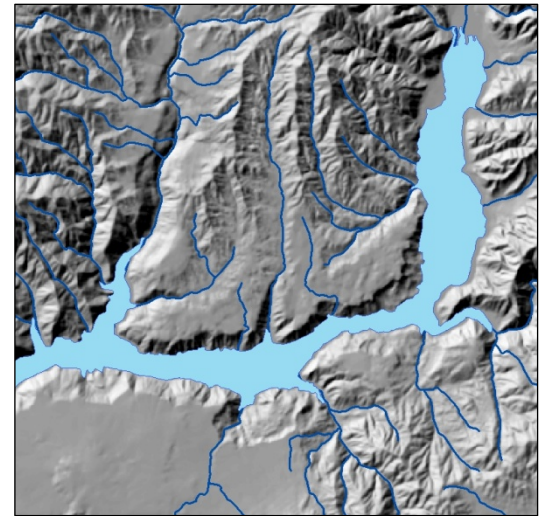
Uses nationally available NHDPlus data



DEM

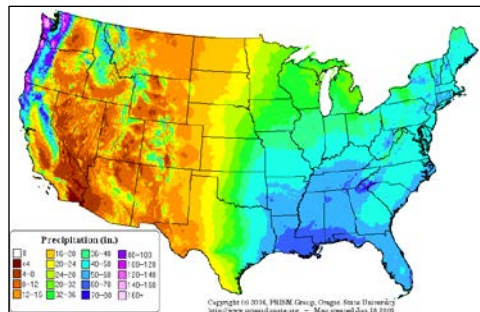


Flow lines



Water bodies

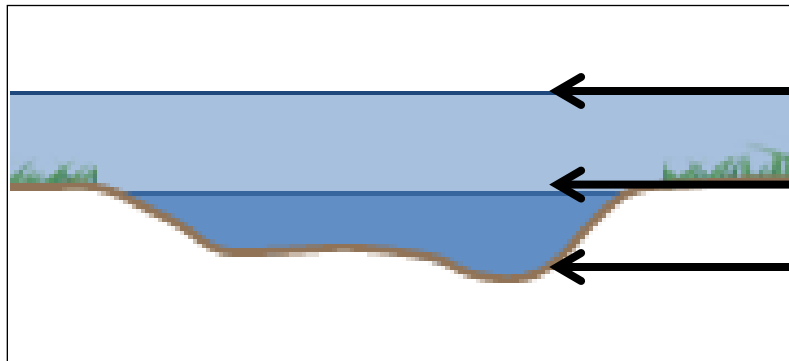
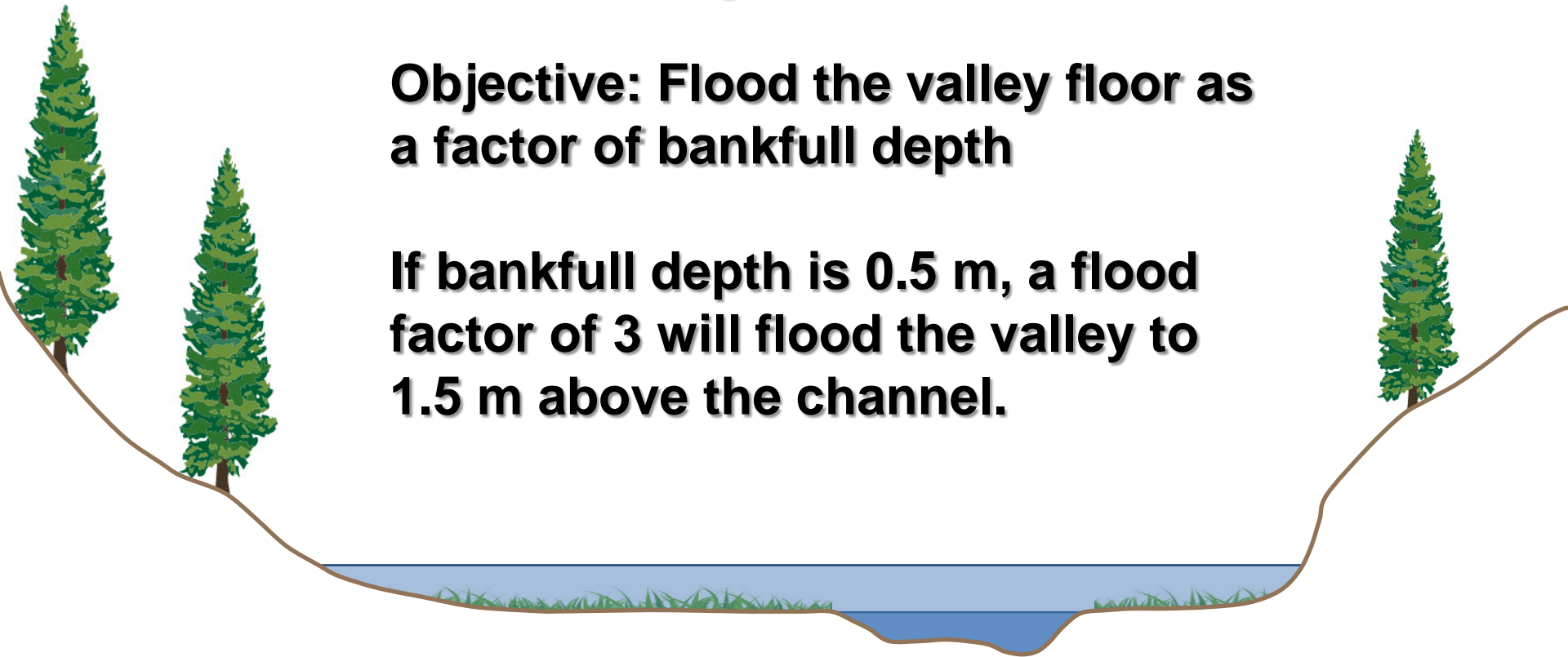
**Average annual
precipitation**



Valley Flood

Objective: Flood the valley floor as a factor of bankfull depth

If bankfull depth is 0.5 m, a flood factor of 3 will flood the valley to 1.5 m above the channel.



Flood depth

Bankfull depth



Computing Bankfull Depth

For channels in the Columbia River basin

$$h_{bf} = 0.054A^{0.170}P^{0.215}$$

h_{bf} is bankfull depth (m)

A is contributing area (km²)

P is average annual precipitation (cm)

Computing Bankfull Depth

$$0.054A^{0.170}p^{0.215} = h_{bf}$$

SequenceSlides.mxd - ArcMap - ArcInfo

File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help

1:77,544

ArcToolbox

- ArcToolbox
- 3D Analyst Tools
- Analysis Tools
- Cartography Tools
- Conversion Tools
- Data Interoperability Tools
- Data Management Tools
- Editing Tools
- Geocoding Tools
- Geostatistical Analyst Tools
- Linear Referencing Tools
- Multidimension Tools
- Network Analyst Tools
- Parcel Fabric Tools
- Schematics Tools
- Server Tools
- Spatial Analyst Tools
- Spatial Statistics Tools
- Tracking Analyst Tools
- ValleyConfinementAlgorithm
- XToolbox

Table of Contents

Layers

- ValleyBottom3
- a_Waterbody
- StreamsCAThresh_Edit
- a_NHDFlowline
- a_hill
 - Value
 - High : 254
 - Low : 0
- a_elev

-1513995.548 2446187.437 Meters

Table

StreamsCAThresh_Edit

CUMRAINAG	PRECIPX	BANKFW	BANKFD	FLOOD_DEP
0.498	7.1	1.14	0.16	0.48
2.668	7.1	1.85	0.21	0.63
3382.538	7.1	13.56	0.71	2.13
3382.477	7.1	13.56	0.71	2.13
3372.846	7.1	13.56	0.71	2.13
3369.574	7.1	13.56	0.71	2.13
3362.323	7.1	13.49	0.7	2.1
180.164	7.1	5.96	0.43	1.29
119.534	7.1	5.32	0.4	1.2
117.818	7.1	5.32	0.4	1.2
114.903	7.1	5.25	0.4	1.2
111.815	7.1	5.18	0.39	1.17
102.928	7.1	5.11	0.39	1.17

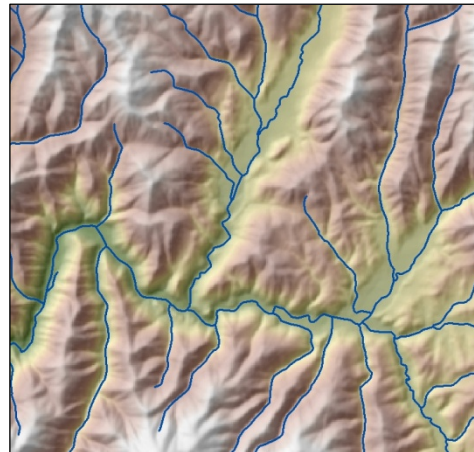
(0 out of 1851 Selected)

StreamsCAThresh_Edit

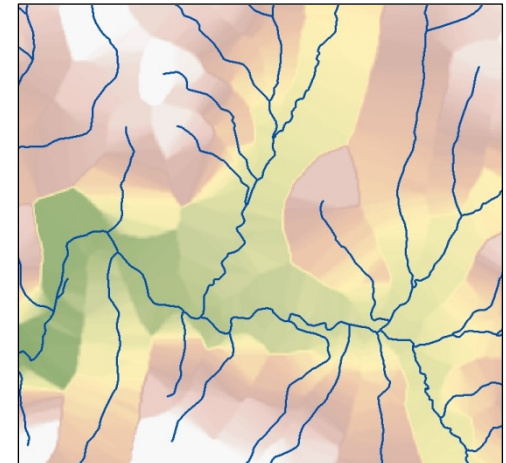
BANKFD * Flood factor = Flood depth
(3)

CUMDRAINAG	PRECIPX	BANKFW	BANKFD	FLOOD_DEP
0.498	7.1	1.14	0.16	0.48
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+



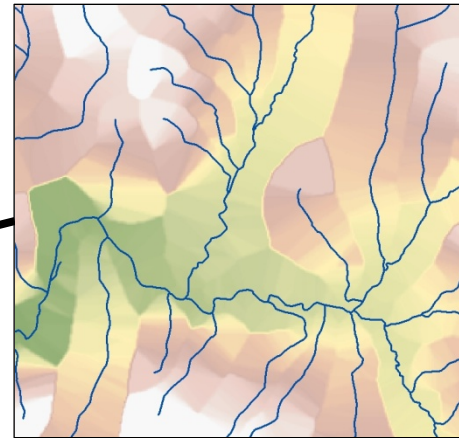
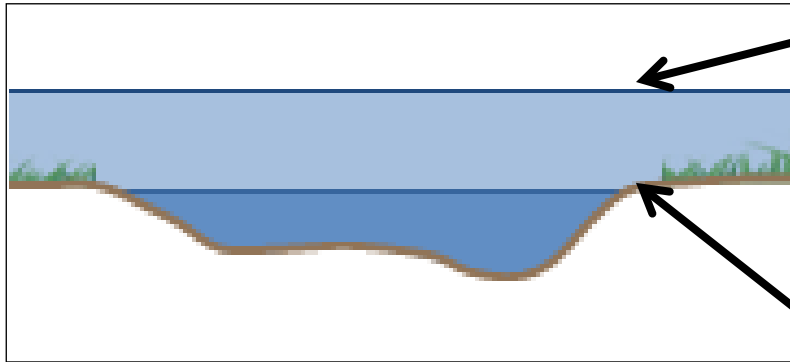
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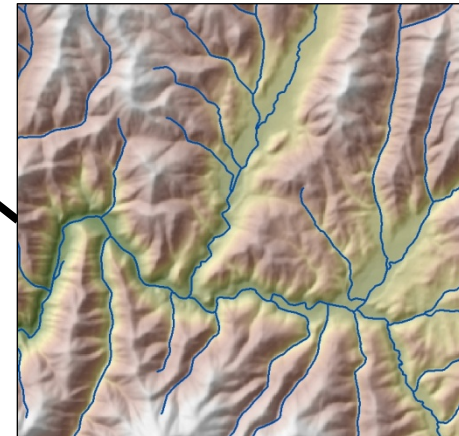
Elevation

**Flooded
elevation**

Flooded Elevation



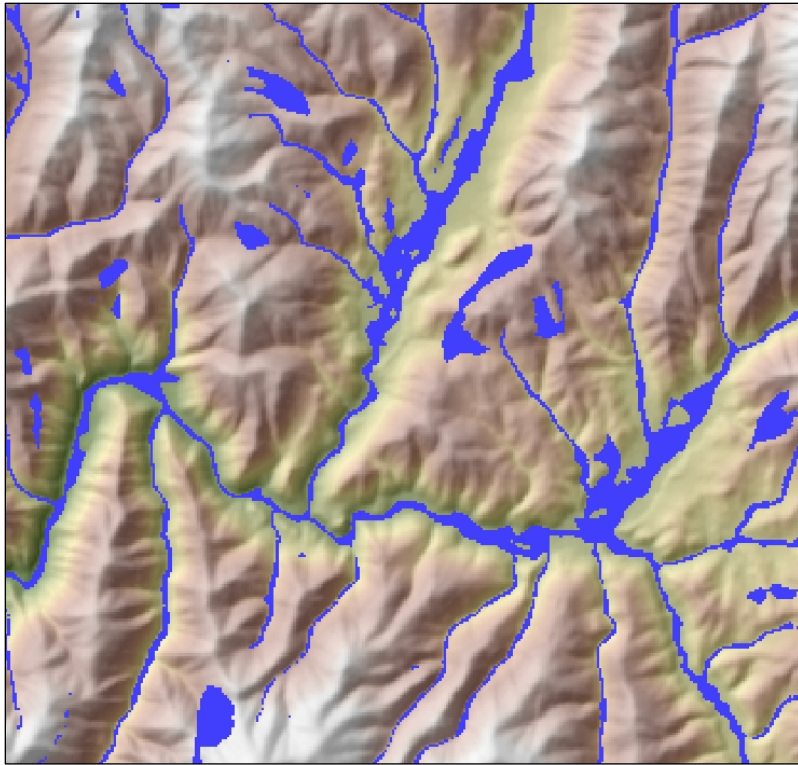
**Flooded
elevation**



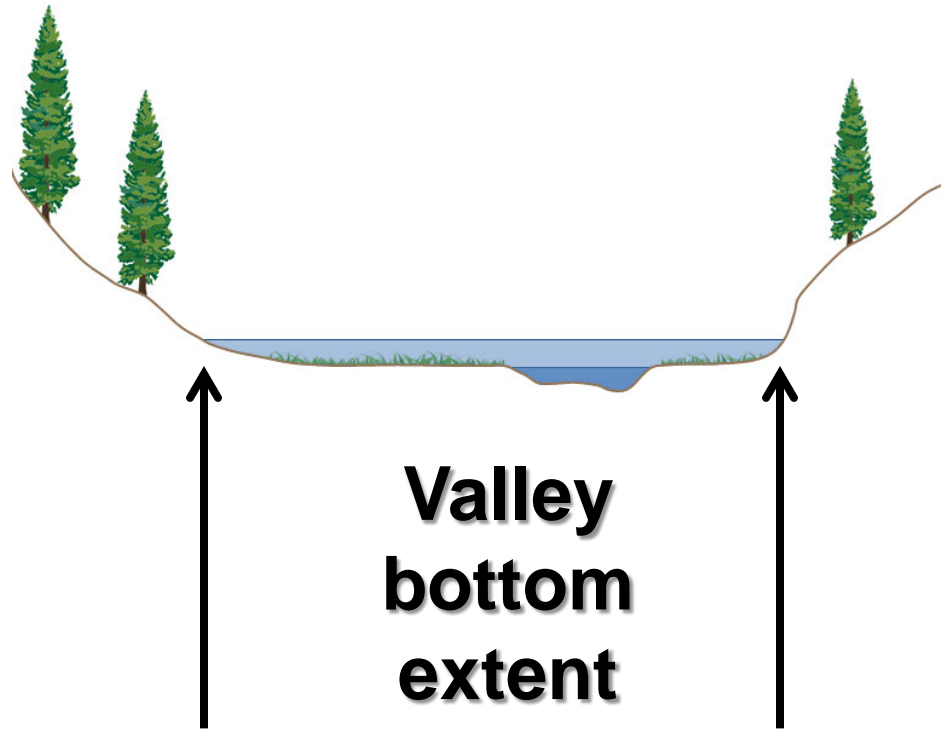
**Ground
elevation**

Initial Valley Bottom

Intersection of flooded elevation with ground elevation

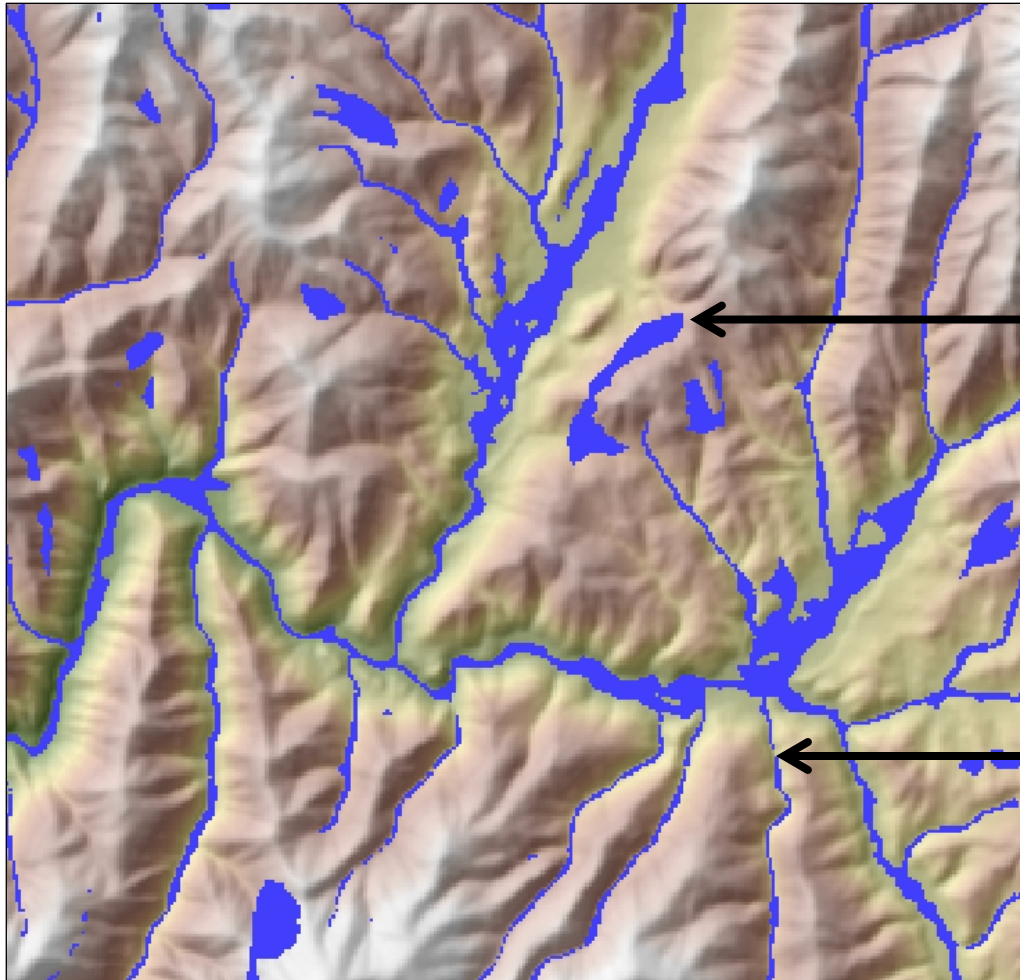


10 km





Clean Up

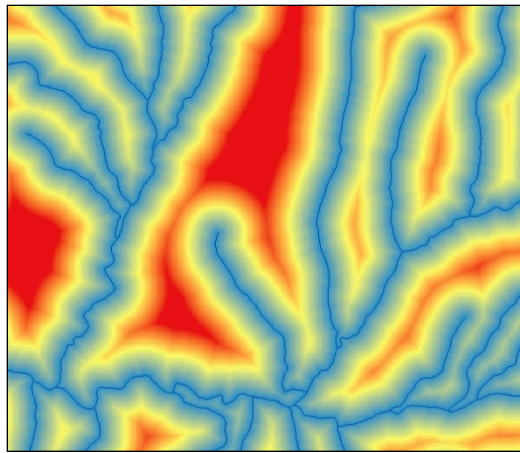


**Non-
channeled
valleys**

**Confined
valleys**

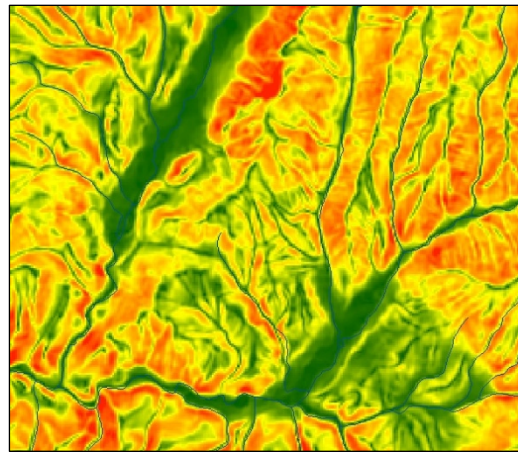
Slope Cost Distance

Restricts processing to near stream locations



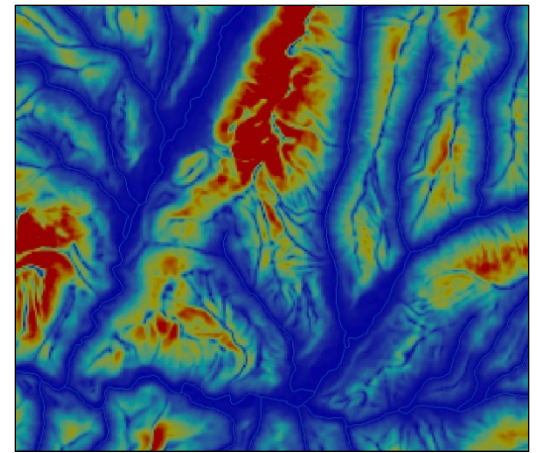
**Distance
from streams**

x



Slope

=



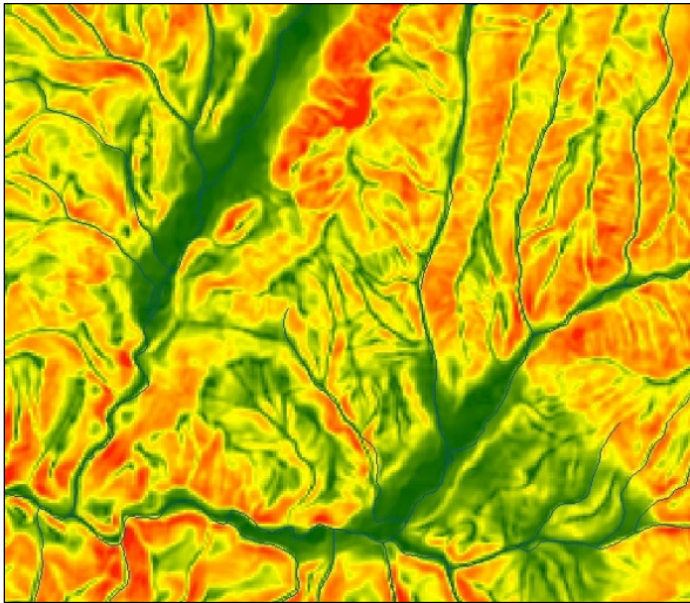
Slope cost

Slope cost distance threshold

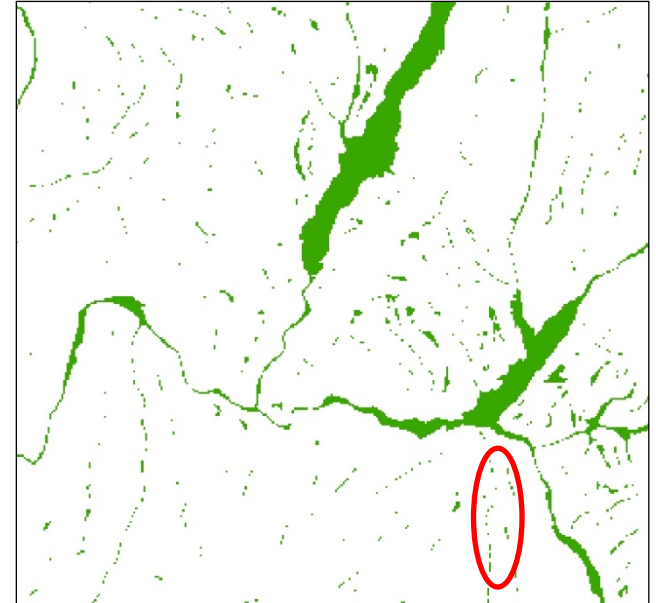
Eliminates non-channeled valleys



Ground Slope Threshold



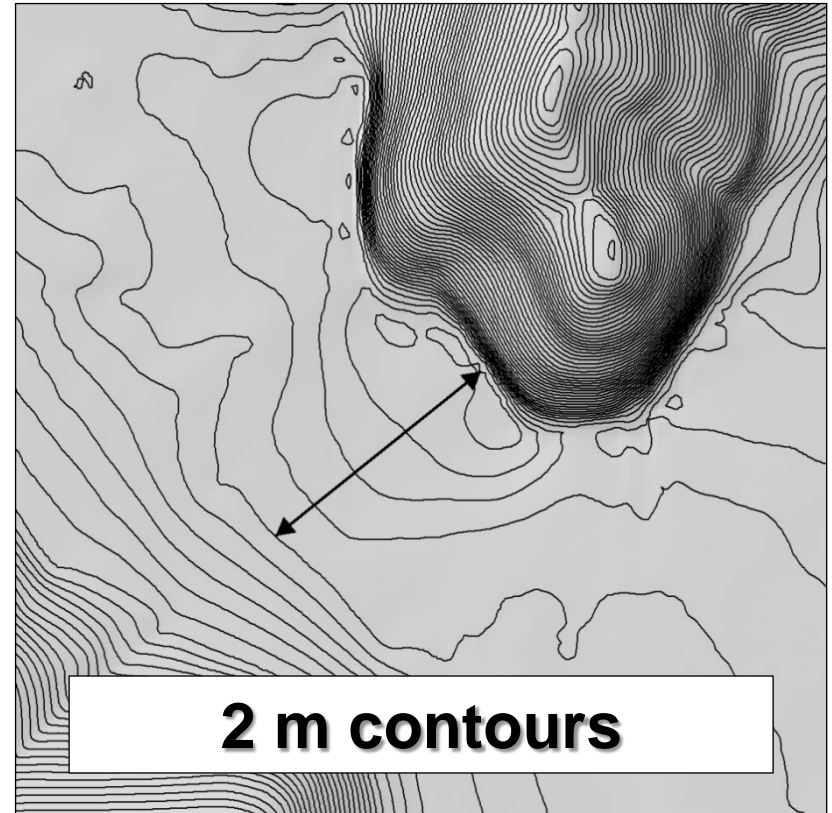
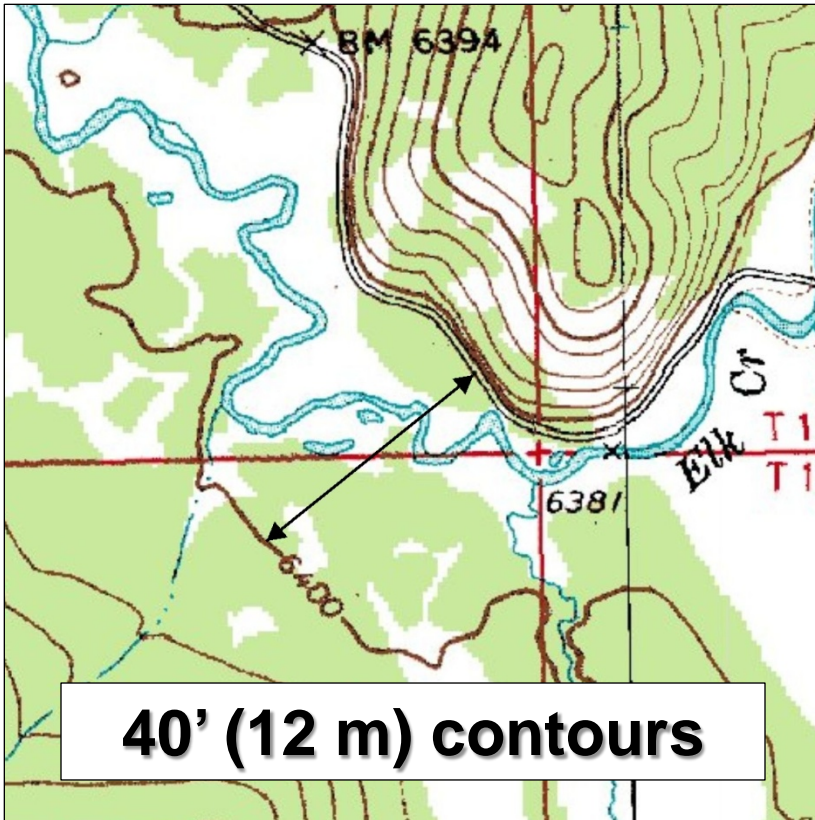
Slope



< 9% slope

Helps eliminate confined valleys

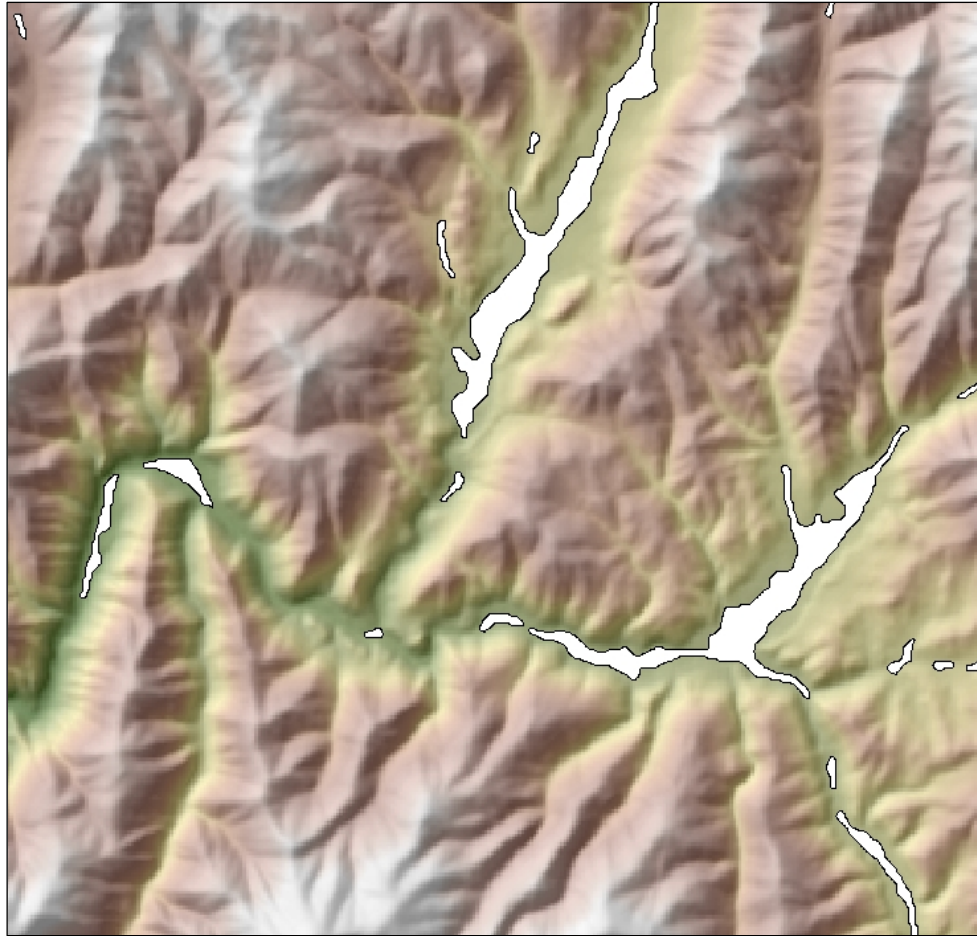
Quad Map and DEM Comparison



**DEMs may have higher ground slope
than indicated by quad maps**



Results

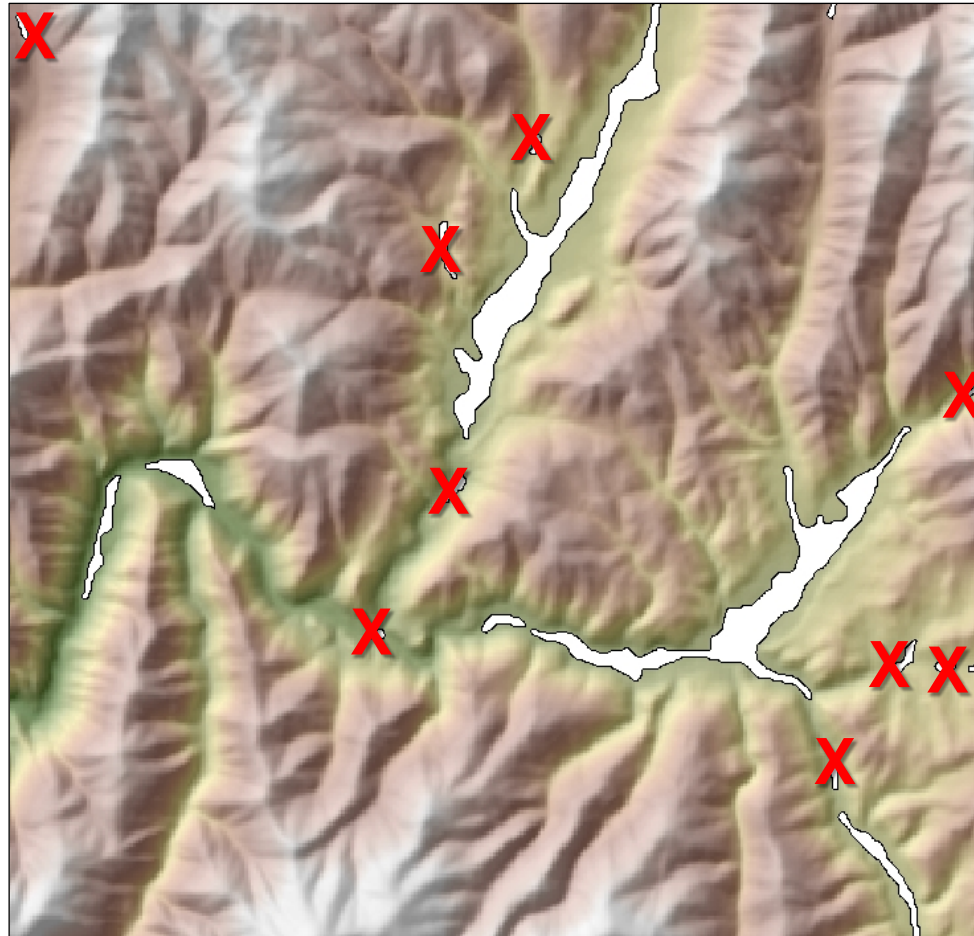


10 km



Filtering

Stream Length and Polygon Size Criteria

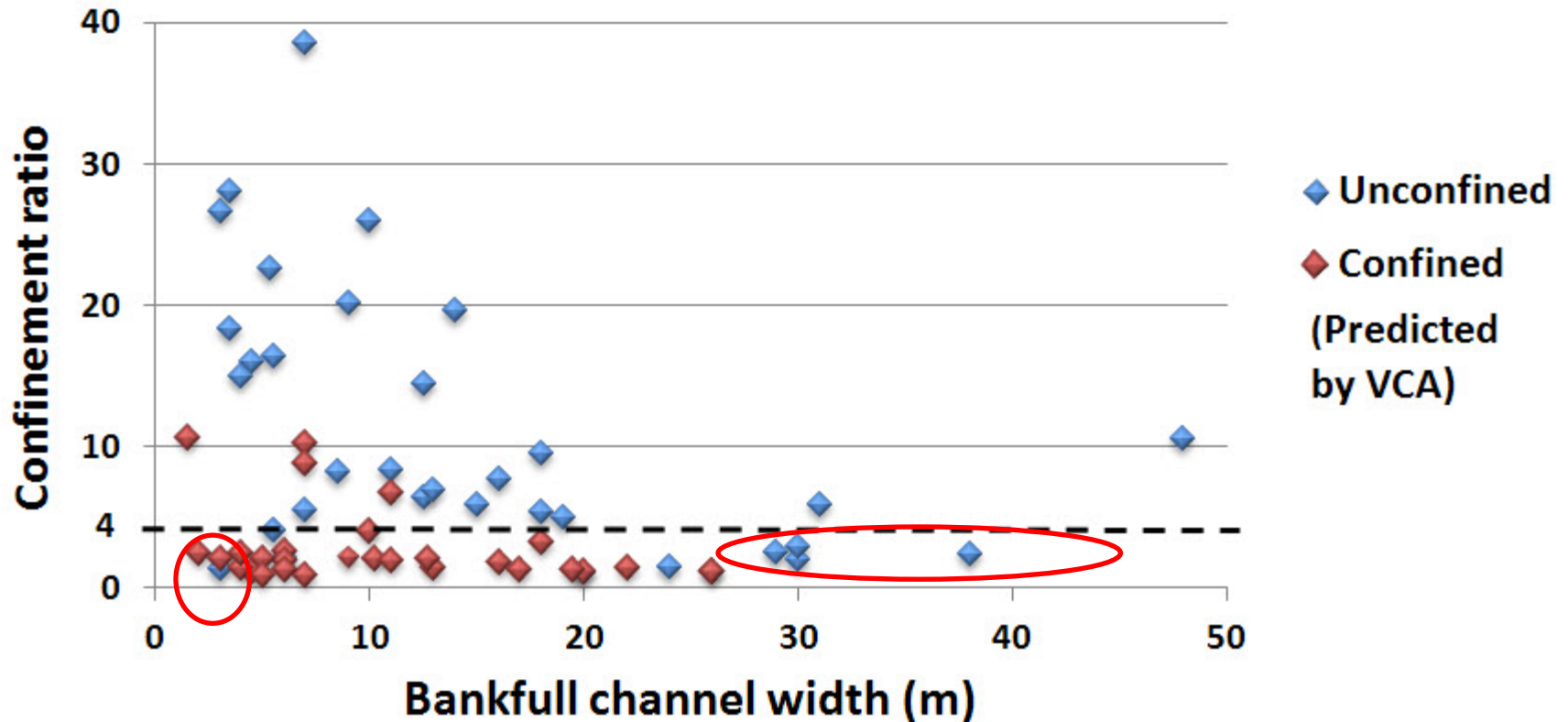


10 km



Validation and Results

Field Validation



78% of field sites identified as unconfined by the VCA had a confinement ratio greater than 4.



Office Validation

Quad Maps and Aerial Photography

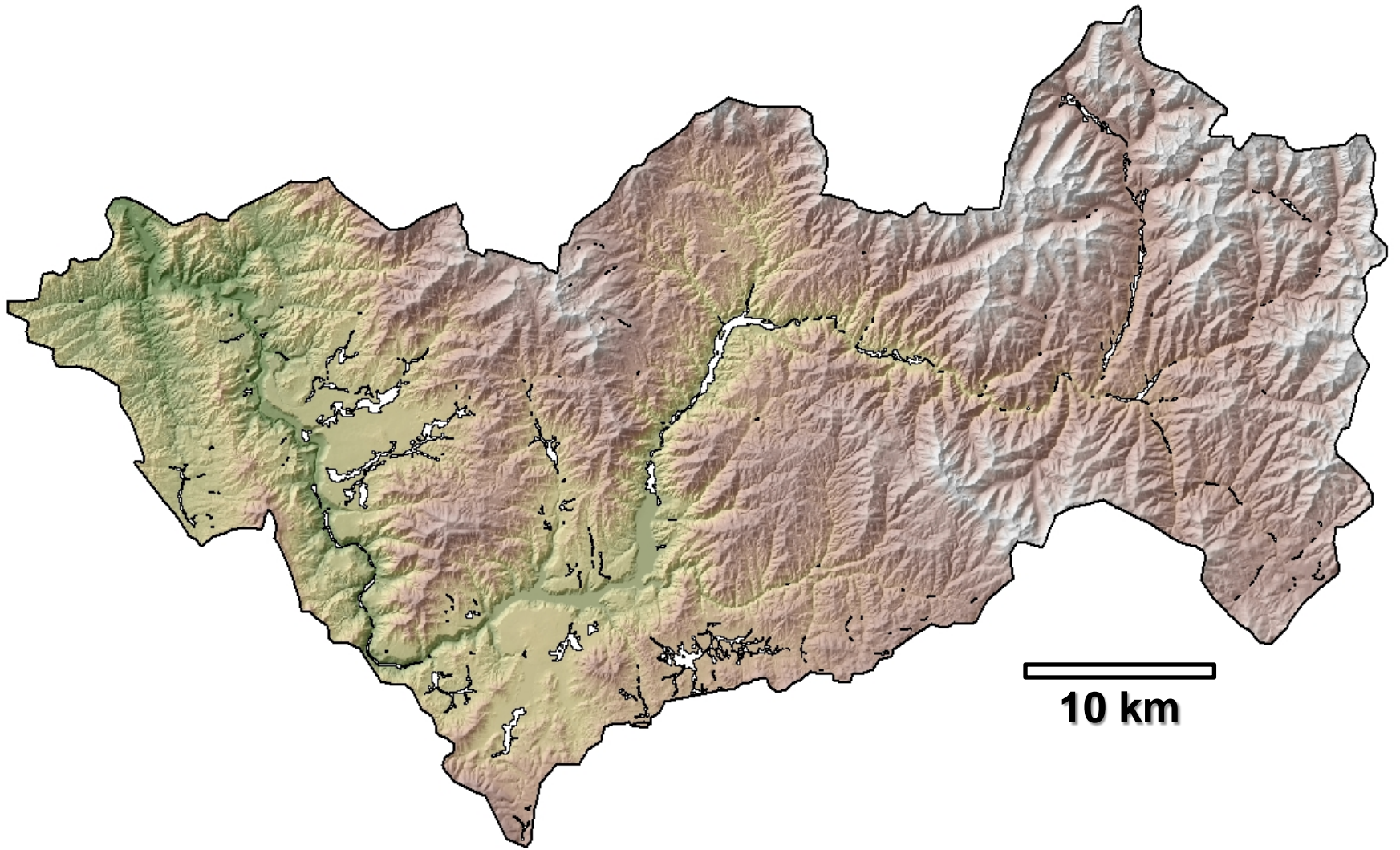
		Actual	
		Unconfined	Confined
Predicted	Unconfined	58	3
	Confined	3	56
Column count:		61	59

South Fork Boise River Basin
Accuracy = 94%

		Actual	
		Unconfined	Confined
Predicted	Unconfined	52	8
	Confined	8	52
Column count:		60	60

South Fork Salmon River Basin
Accuracy = 87%

Landscape Scale Results





THANK YOU

**Dave Nagel
dnagel [at] fs.fed.us**

**Acknowledgements: Sharon Parkes, Seth Wenger,
and Jaime Goode**



References

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