Restoring salmon in a changing climate

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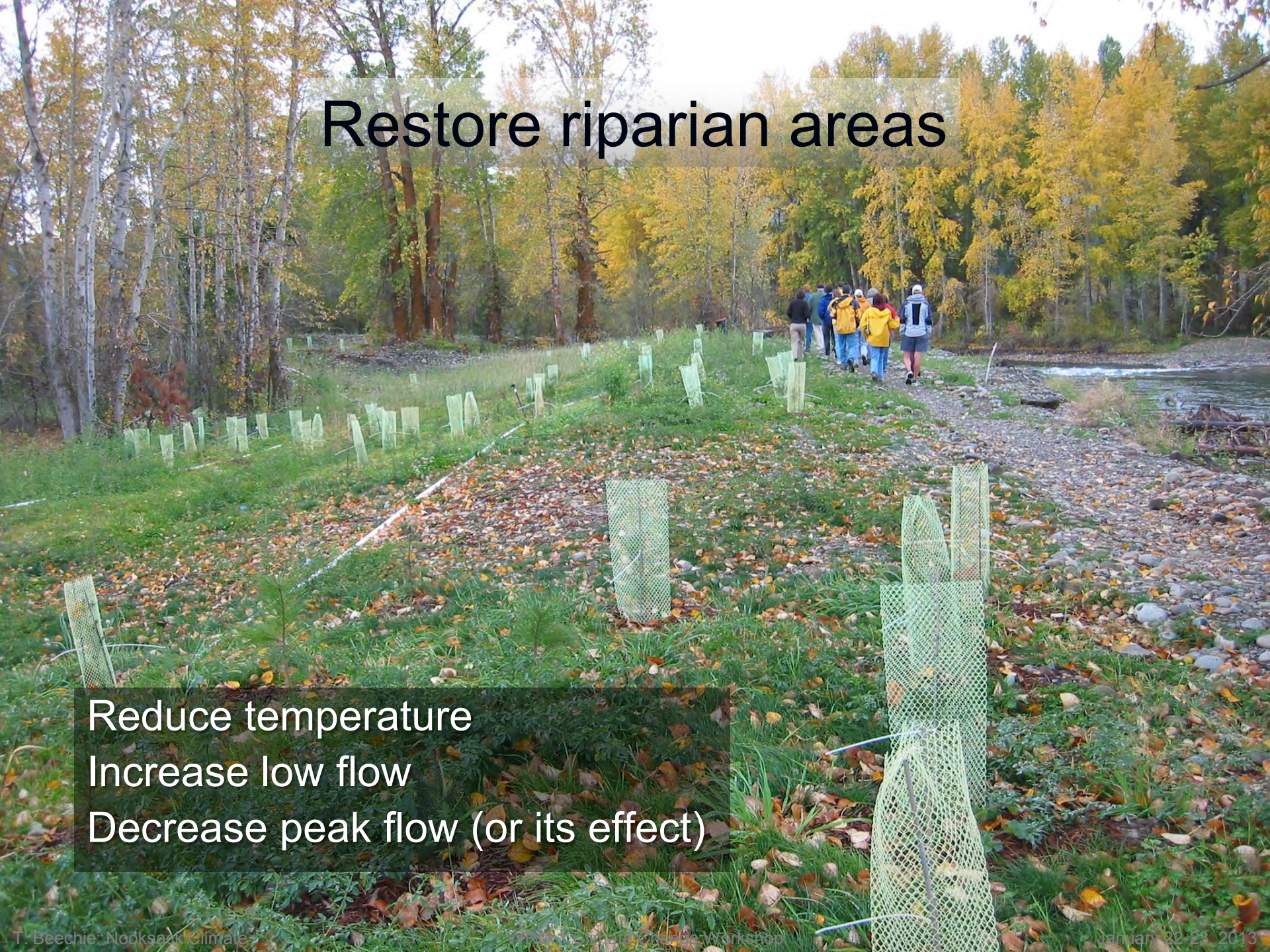
Literature review

- Does the action ameliorate a climate effect?
  - Increased peak flow
  - Decreased low flow
  - Increased stream temperature
- Does the action increase habitat diversity and population resilience?
  - Must increase habitat diversity enough to accommodate additional species or life-history types

Restore riparian areas



Reduce temperature
Increase low flow
Decrease peak flow (or its effect)

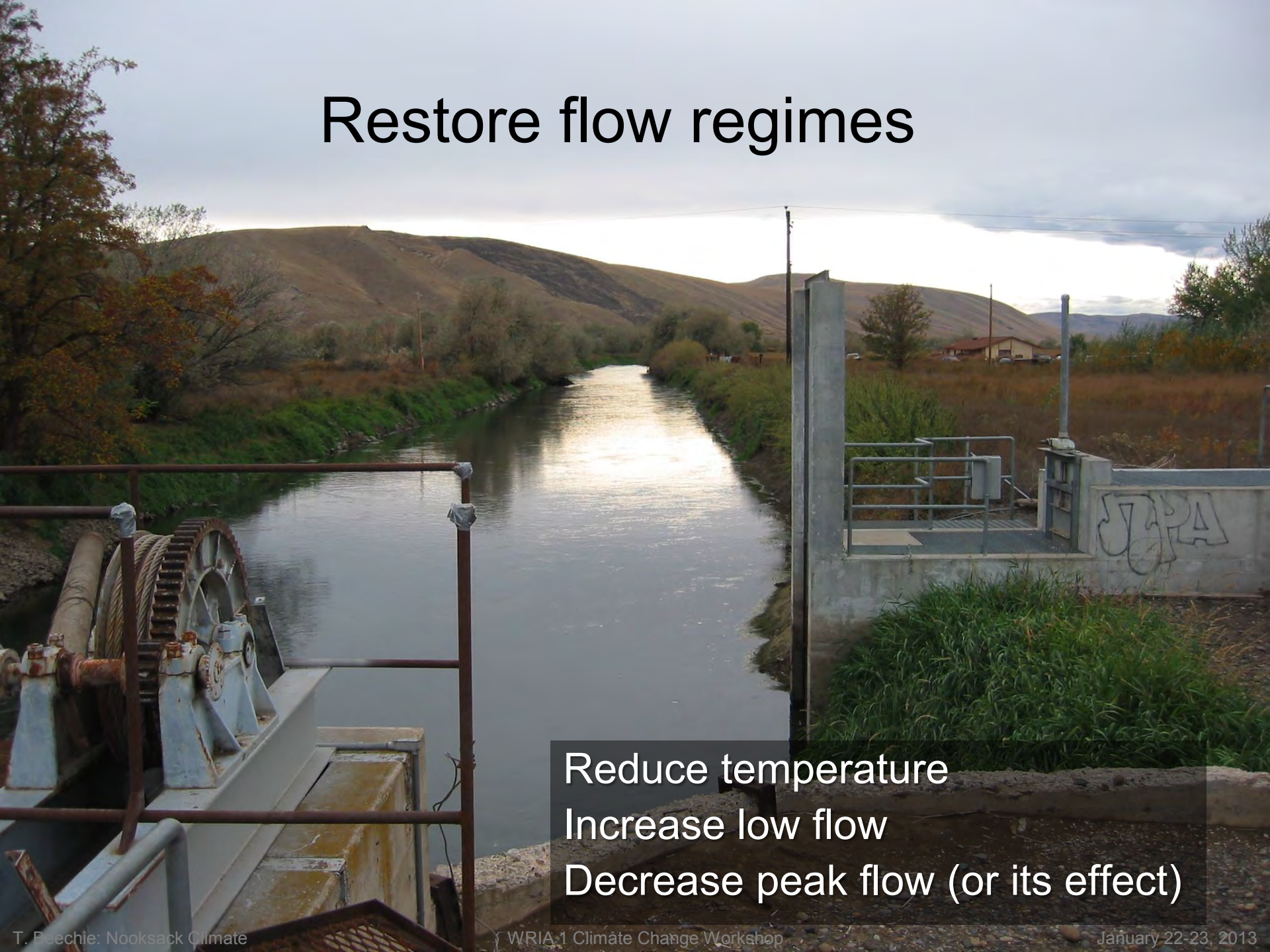
Restore riparian areas

Reduce temperature

Increase low flow

Decrease peak flow (or its effect)

Restore flow regimes



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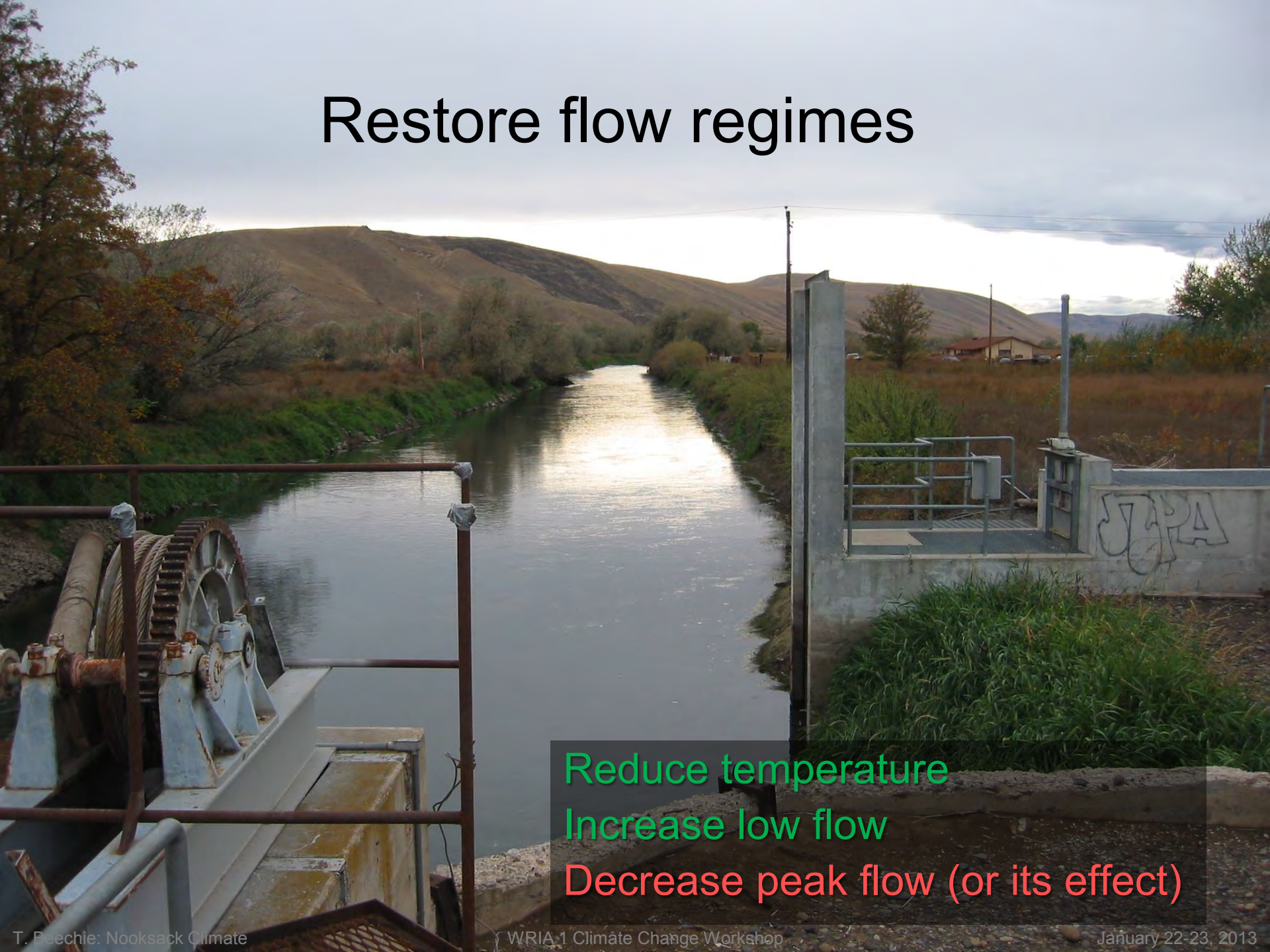


Reduce temperature
Increase low flow
Decrease peak flow (or its effect)


Restore floodplain ecosystems
Reduce temperature
Increase low flow
Decrease peak flow (or its effect)


Restore floodplain ecosystems
Reduce temperature
Increase low flow
Decrease peak flow (or its effect)

Restoration actions and climate change

Category	Common techniques	Ameliorates temperature increase	Ameliorates base flow decrease	Ameliorates peak flow increase	Increases salmon resilience
Longitudinal connectivity (barrier removal)					
	Removal or breaching of dam	●	●	○	●
	Barrier or culvert replacement/removal	○	○	○	●
Lateral connectivity (floodplain reconnection)					
	Levee removal	●	○	●	●
	Reconnection of floodplain features (e.g., channels, ponds)	●	○	●	●
	Creation of new floodplain habitats	●	○	●	●
Vertical connectivity (incised channel restoration)					
	Reintroduce beaver (dams increase sediment storage)	●	●	●	●
	Remove cattle (restored vegetation stores sediment)	●	●	●	○
	Install grade controls	●	●	●	○

Restoration actions and climate change

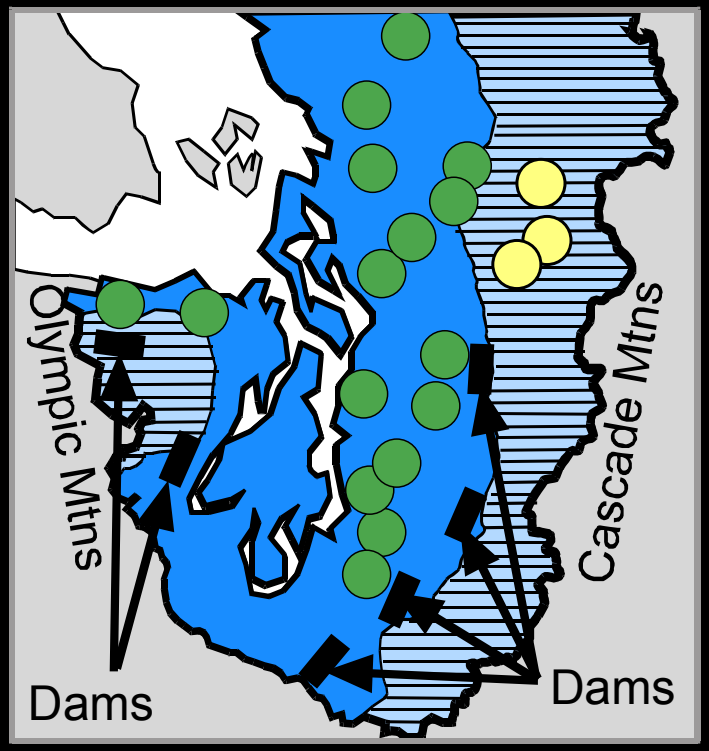
Category	Common techniques	Ameliorates temperature increase	Ameliorates base flow decrease	Ameliorates peak flow increase	Increases salmon resilience
Stream flow regimes					
	Restoration of natural flood regime	●	●	○	●
	Reduce water withdrawals	●	●	○	○
	Disconnect road drainage from streams	○	○	●	○
	Natural drainage systems, retention ponds, other urban stormwater techniques	○	○	●	○
Erosion and sediment delivery					
	Road resurfacing	○	○	○	○
	Landslide hazard reduction (sidecast removal, fill removal)	○	○	○	○
	Reduced cropland erosion (e.g., no till seeding)	○	○	○	○
	Reduced grazing (e.g., fencing livestock away from streams)	●	○	○	○

Restoration actions and climate change

Category	Common techniques	Ameliorates temperature increase	Ameliorates base flow decrease	Ameliorates peak flow increase	Increases salmon resilience
Riparian functions					
	Grazing removal or control, fencing	●	●	○	○
	Planting (trees or other vegetation)	●	○	○	○
	Thinning to increase tree growth	○	○	○	○
Instream rehabilitation					
	Remeandering, channel realignment	●	○	○	●
	Adding log structures or jams	○	○	○	○
	Boulder weirs or boulders	○	○	○	○
	Brush bundles or other cover	○	○	○	○
	Gravel addition	○	○	○	○
Nutrient enrichment					
	Addition of organic or inorganic nutrients	○	○	○	○

Strategies to increase resilience

Restore access to diverse habitats



Rainfall/transitional hydrologic regime

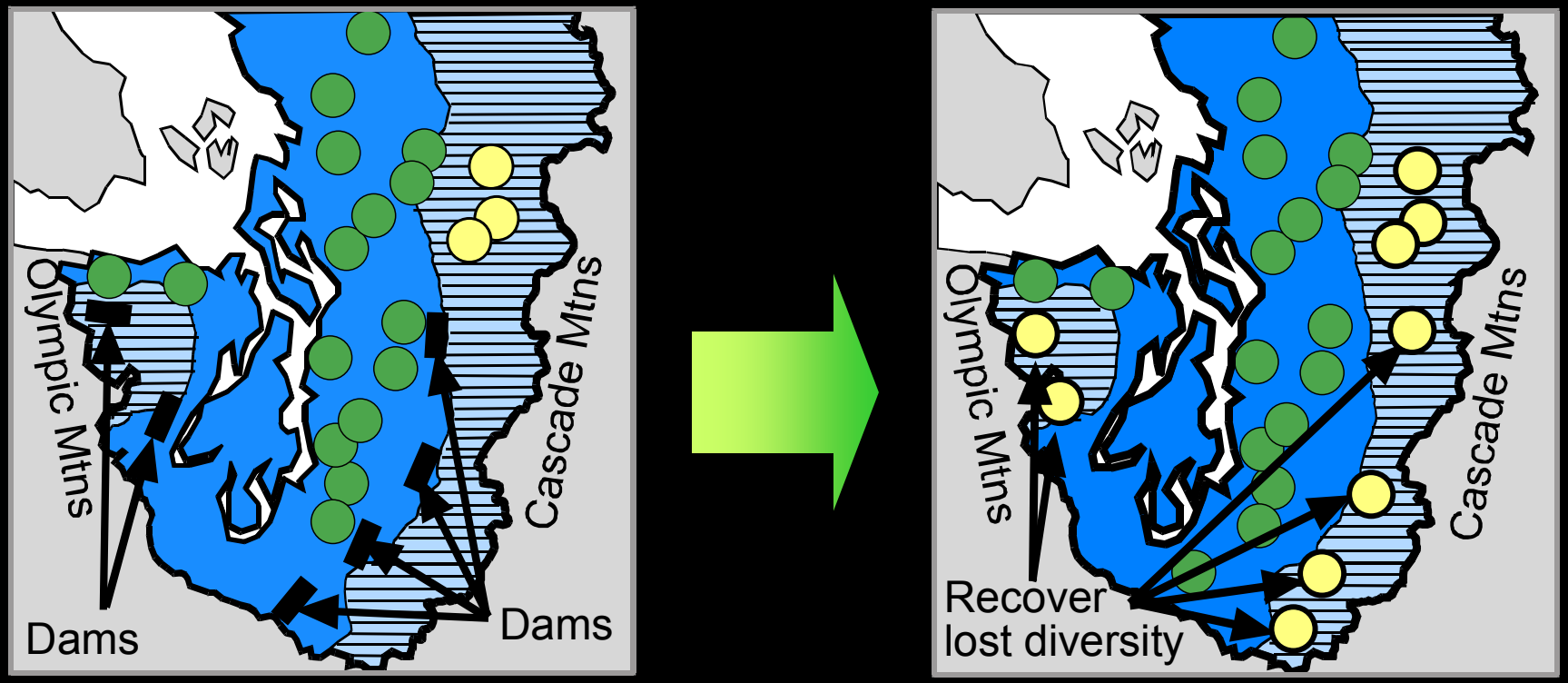
Snowmelt hydrologic regime

Ocean-type Chinook population

Stream-type Chinook population

Waples et al. 2008

Restore access to diverse habitats



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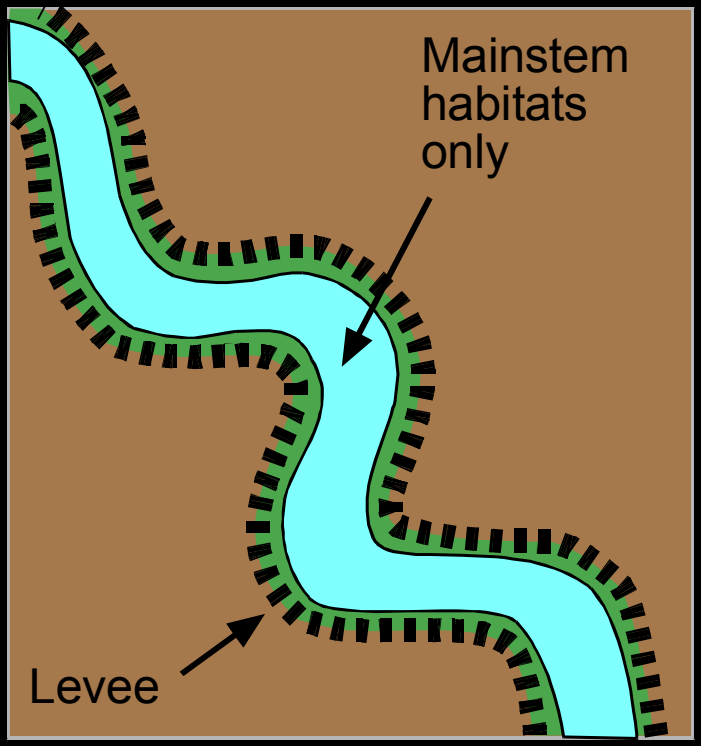
Increase habitat diversity



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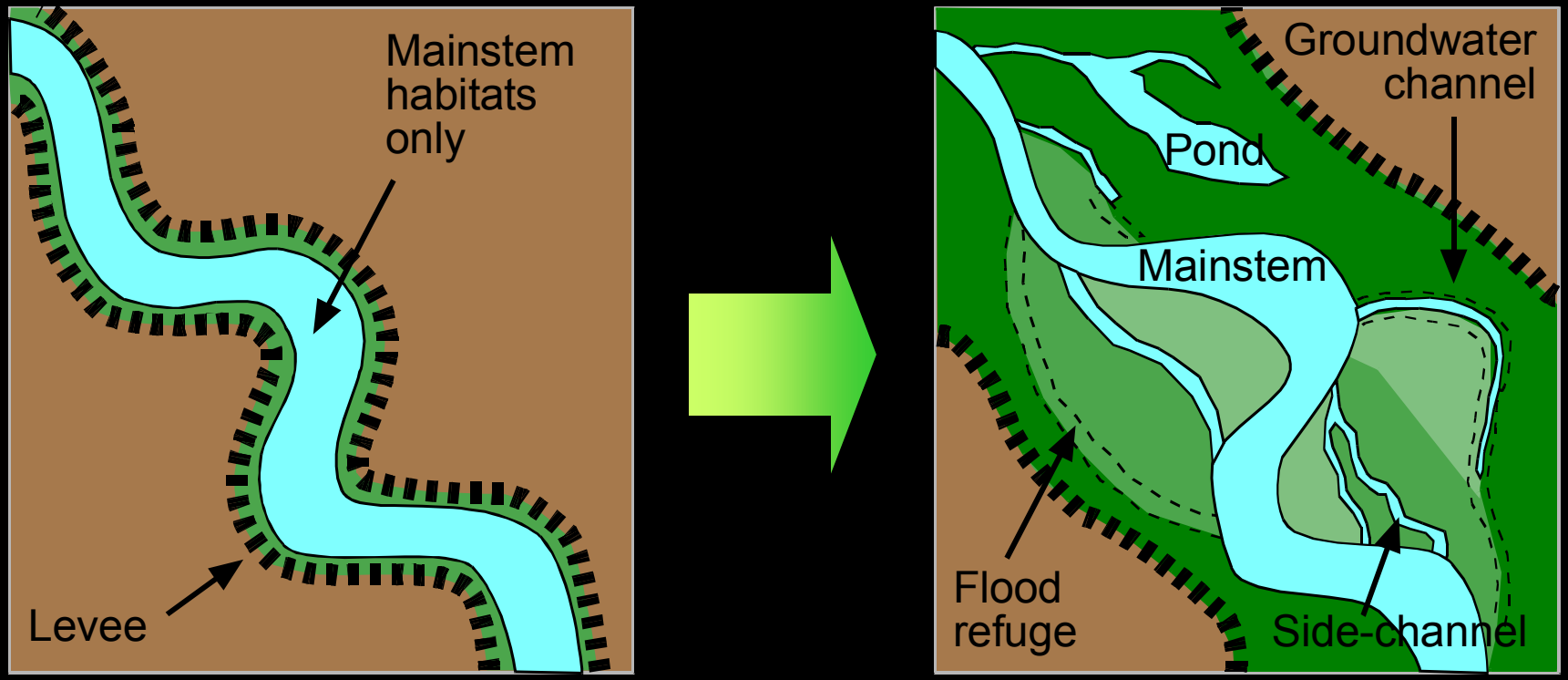

Waples et al. 2008

Reducing climate change effects through restoration

Expected climate change effect	Longitudinal connectivity	Floodplain connectivity	Restore incised channel	Restore stream flow	Restore riparian functions	Reduce sediment supply	Construct instream habitat
Increased temperature	Y	Y	Y	Y	Y	N	N
Decreased low flow	Y	N	Y	Y	Y/N	N	N
Increased peak flow	N	Y	Y	N	N	N	N
Reduced diversity	Y	Y	Y	Y/N	N	N	N

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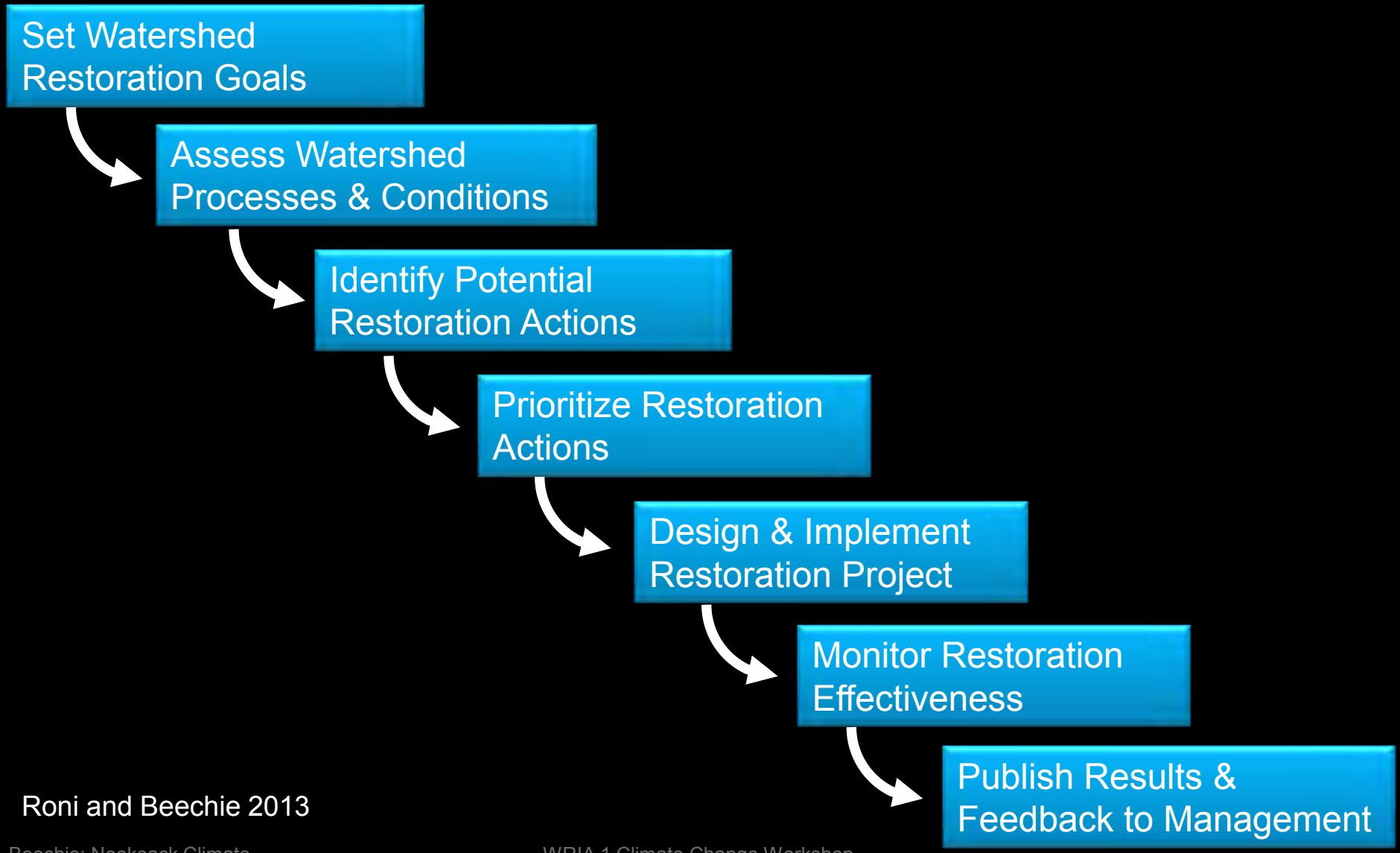
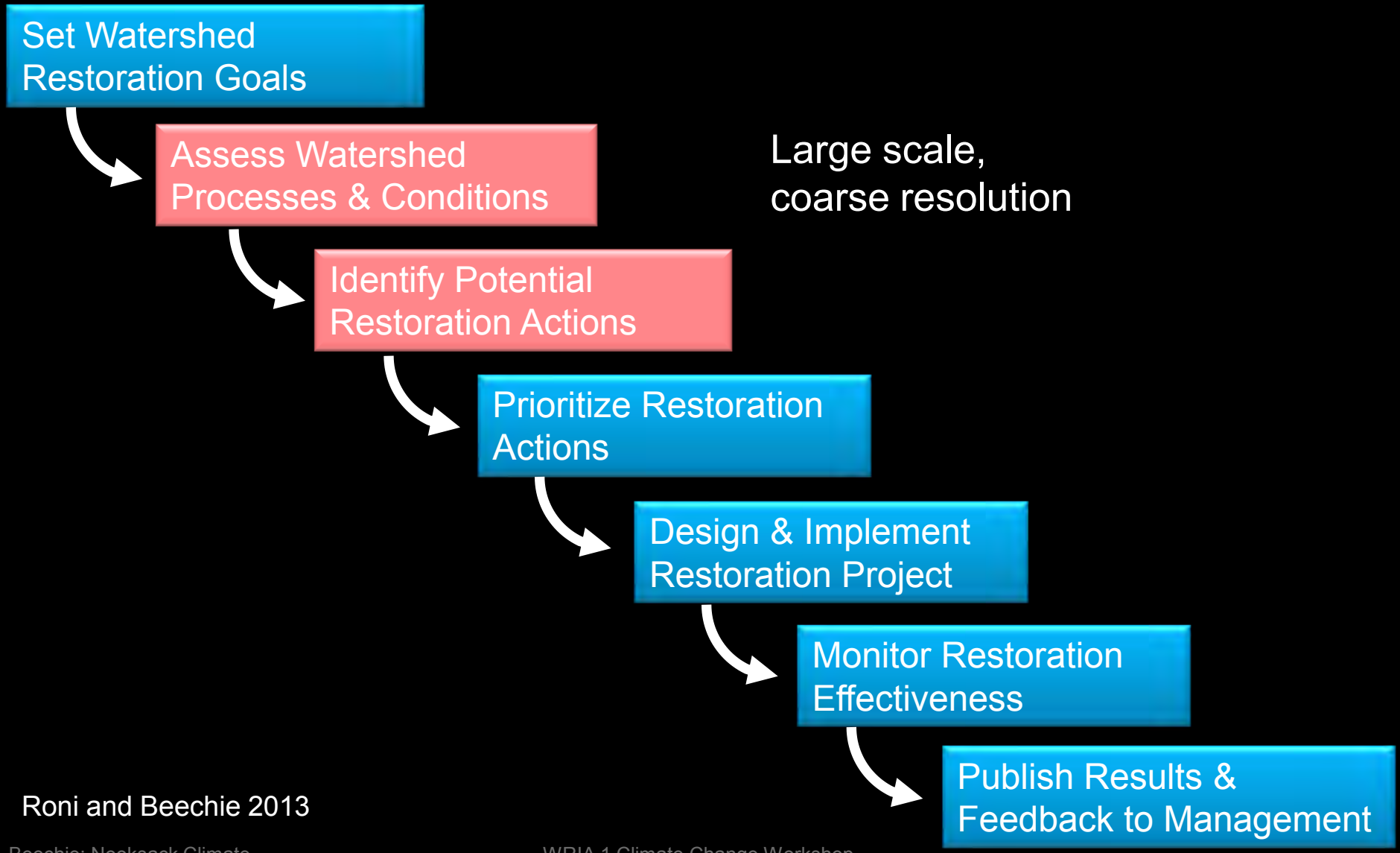
The Restoration Process



Roni and Beechie 2013

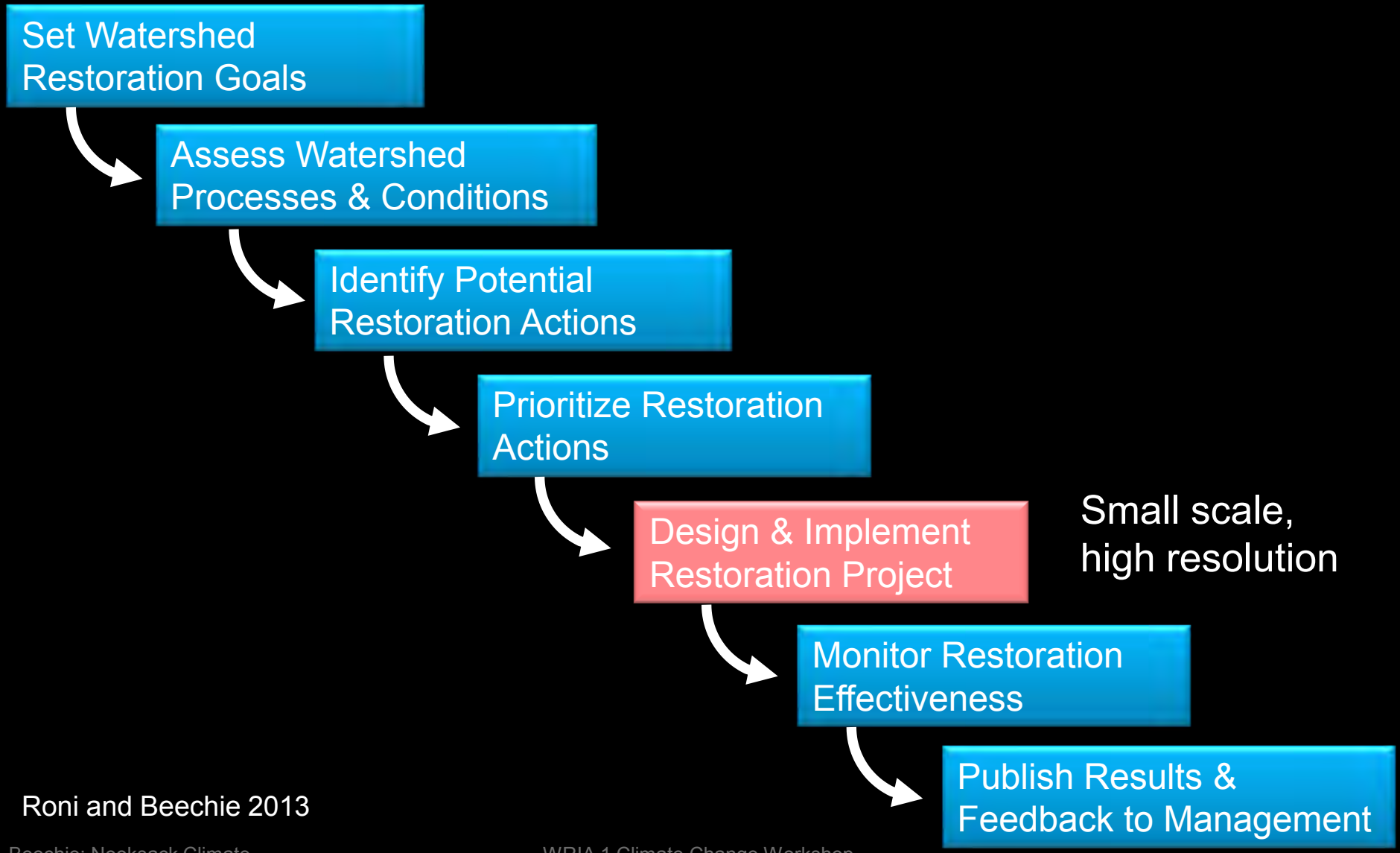
The Restoration Process



Large scale,
coarse resolution

Roni and Beechie 2013

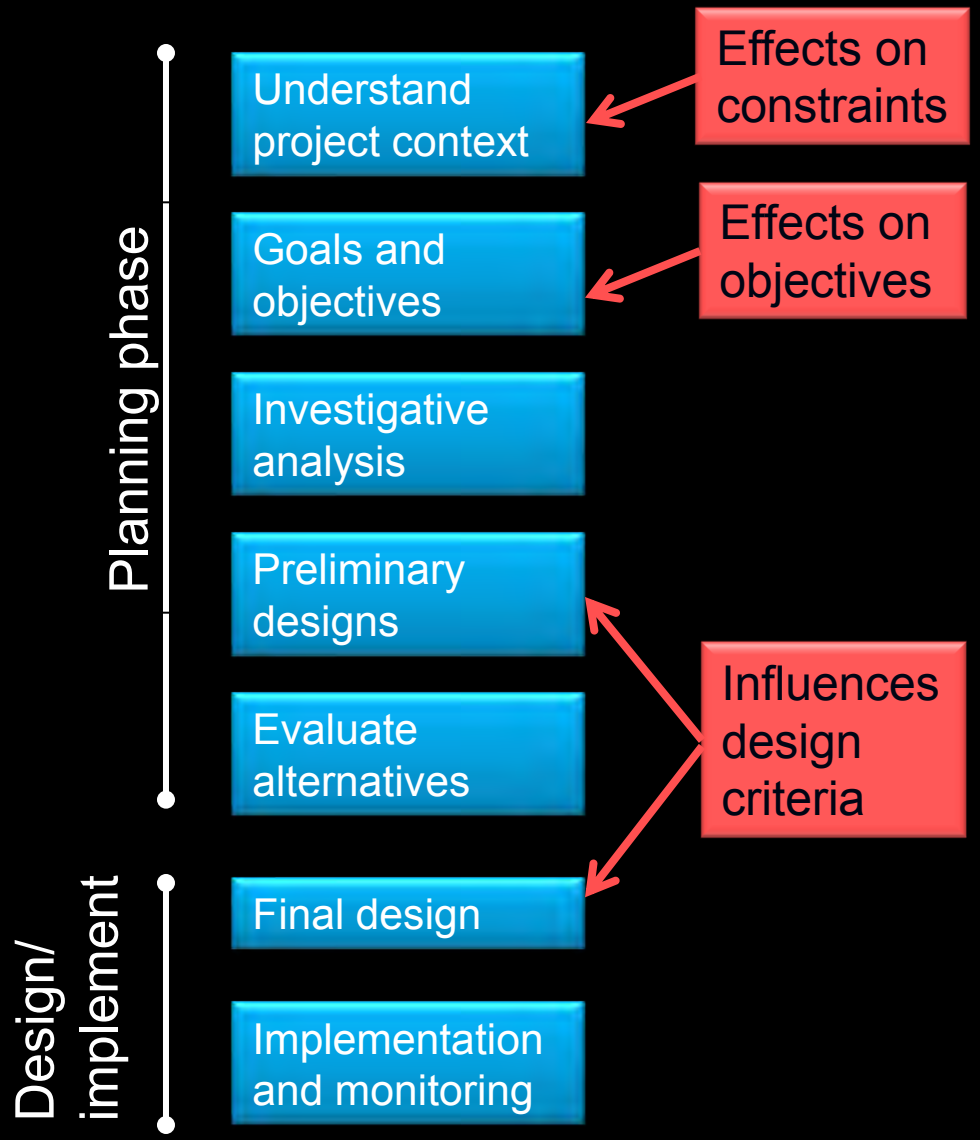
The Restoration Process



Roni and Beechie 2013

The project design process

- Anticipated effects
  - Increased peak flows
  - Decreased low flows
  - Increased stream temperature



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