

Adapting salmon habitat restoration for climate change

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Outline

- Literature review approach
- Examples of restoration actions
- Literature review summary
- Decision support framework

Literature review

- Actions grouped by processes and functions they attempt to restore
- 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

A group of about ten people, including children and adults, are walking away from the camera along a rocky path that runs parallel to a river. The path is lined with numerous young trees, each protected by a green mesh cage. The surrounding area is a mix of green grass and fallen autumn leaves. In the background, a dense forest of trees with yellow and orange foliage is visible under an overcast sky.

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

Restore riparian areas

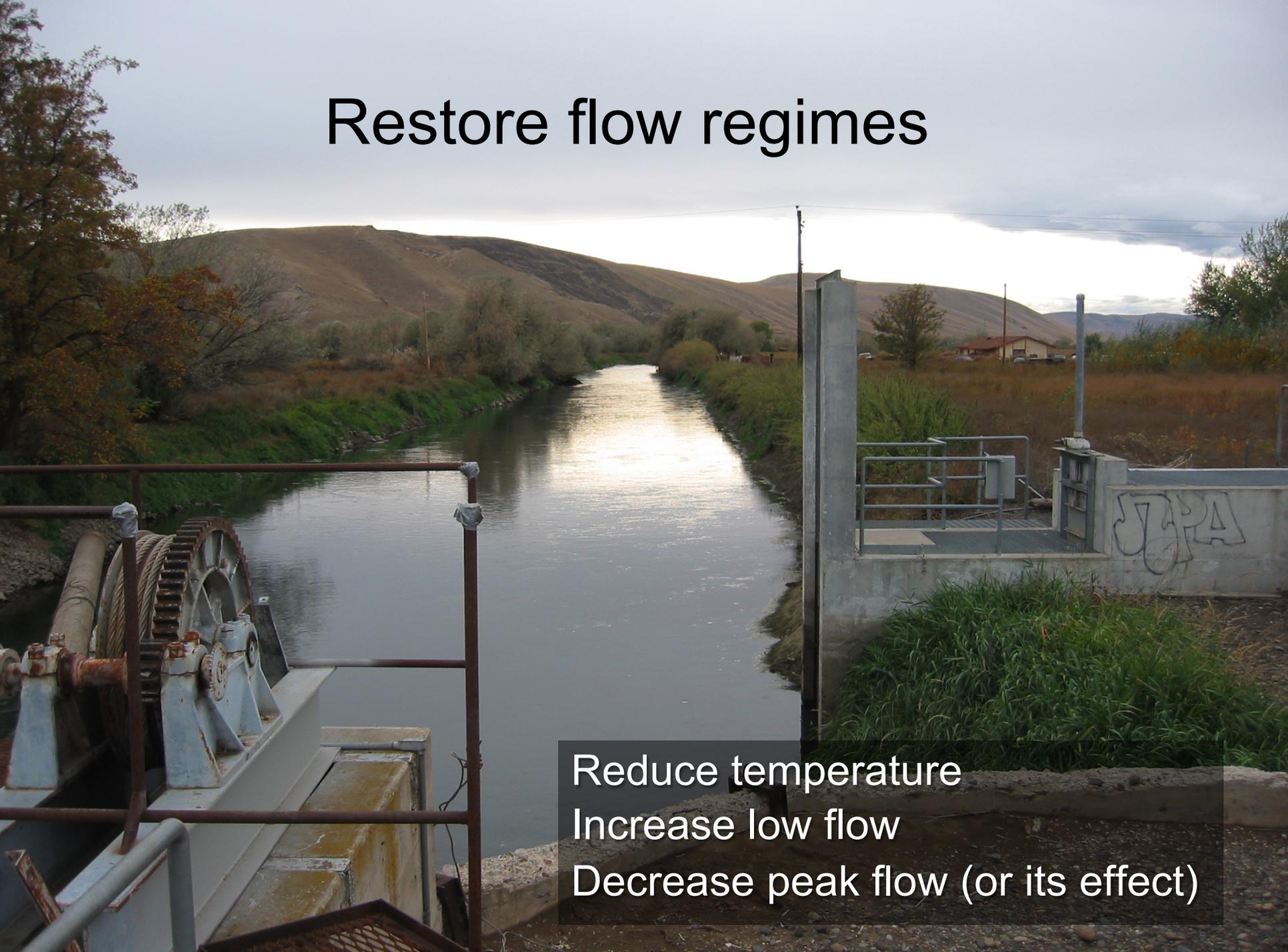
A group of about ten people, including children in bright yellow jackets, are walking away from the camera along a rocky path that runs parallel to a river. The path is lined with numerous young saplings, each protected by a green mesh cage. The surrounding forest has trees with yellow and green autumn foliage. The river is visible on the right side of the path.

Reduce temperature

Increase low flow

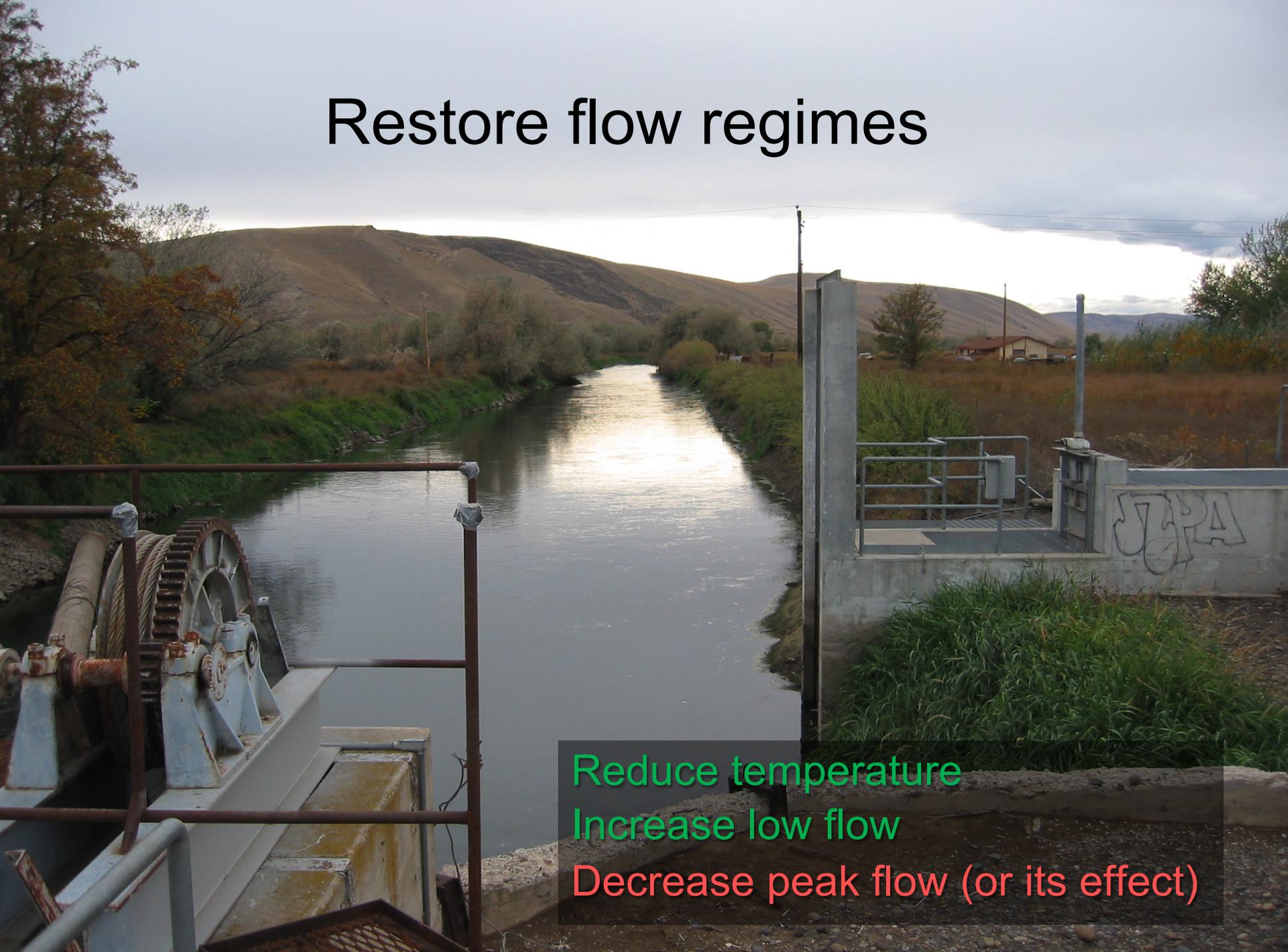
Decrease peak flow (or its effect)

Restore flow regimes



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

Restore flow regimes



Reduce temperature

Increase low flow

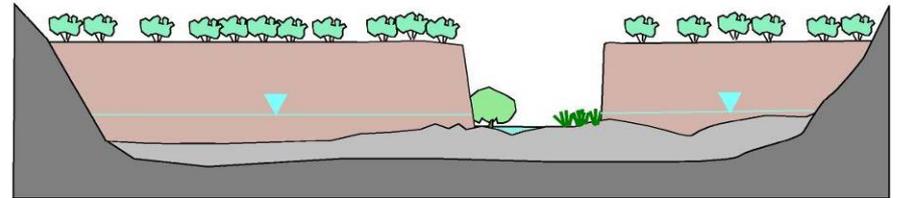
Decrease peak flow (or its effect)

Restoring incised channels



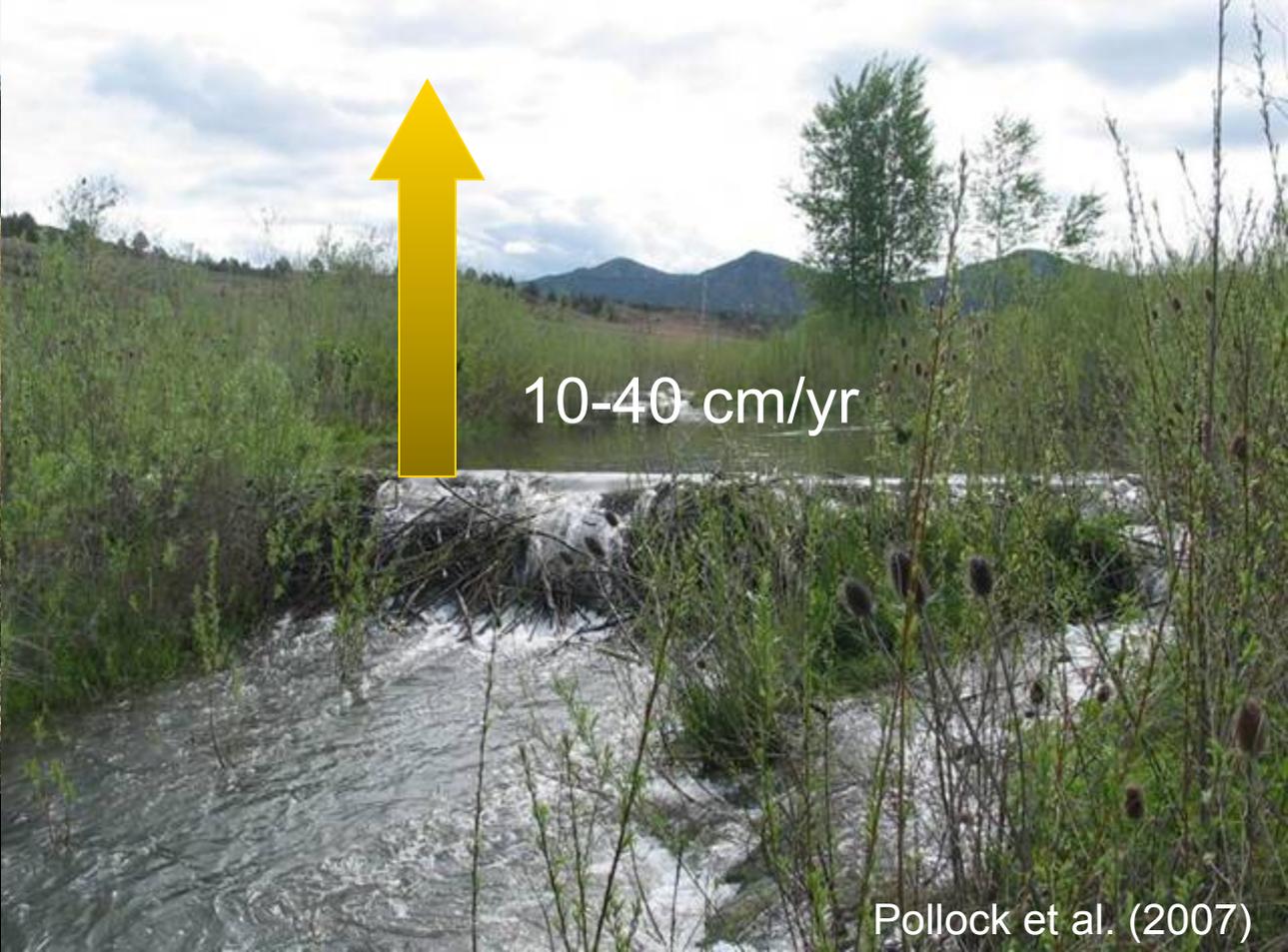
Incised channel:

- conversion to sagebrush
- lowered water table
- intermittent streamflow



Reduced flows in summer
Increased temperature
No refuge from peak flows

Restoring incised channels

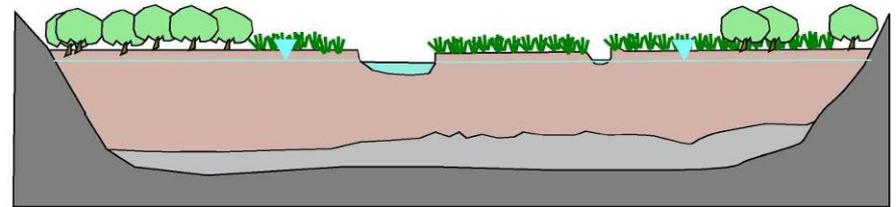


Restore incised channels



Wet floodplain system:

- sedge meadows
- deep accumulation of sediments
- elevated water table



Reduced flows in summer
Increased temperature
No refuge from peak flows



Restore incised channels

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



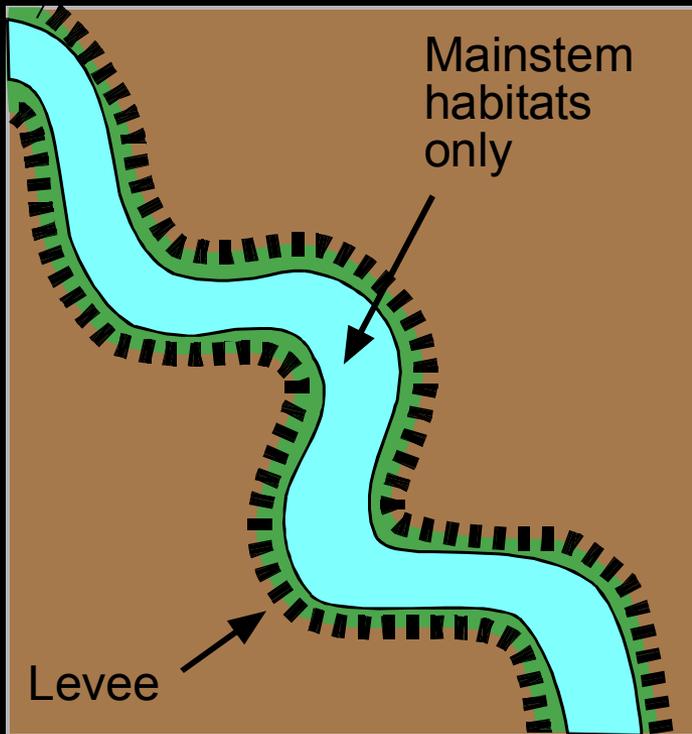
Restore incised channels

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

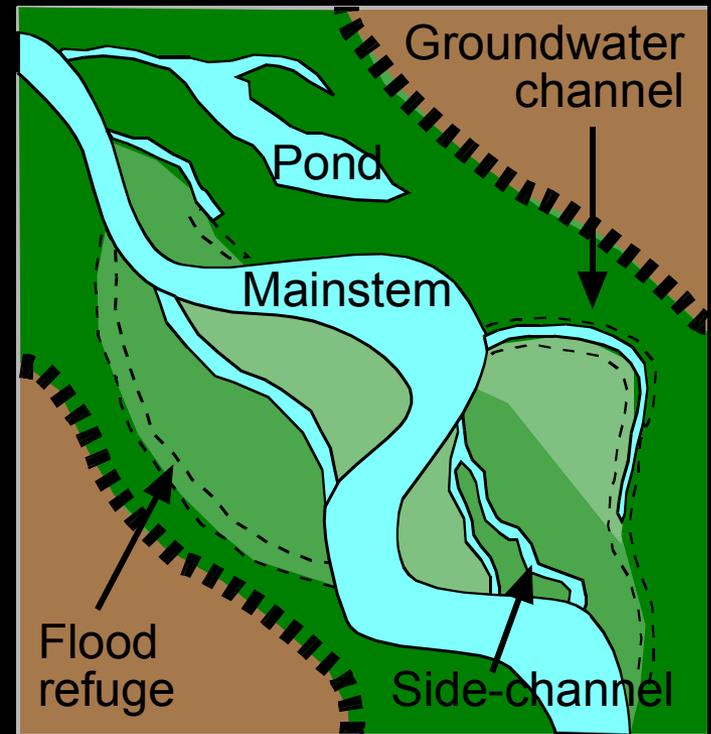
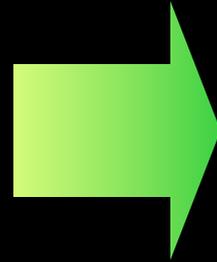
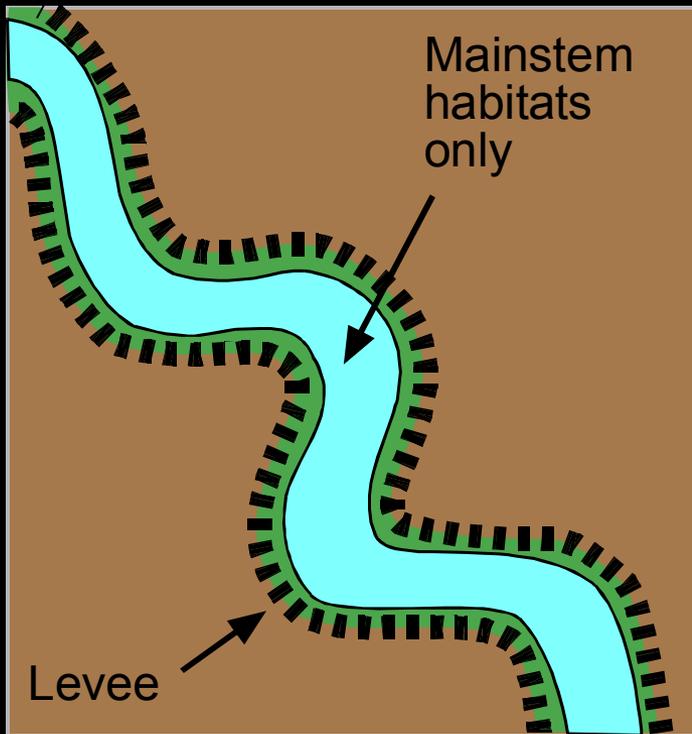
Strategies to increase resilience



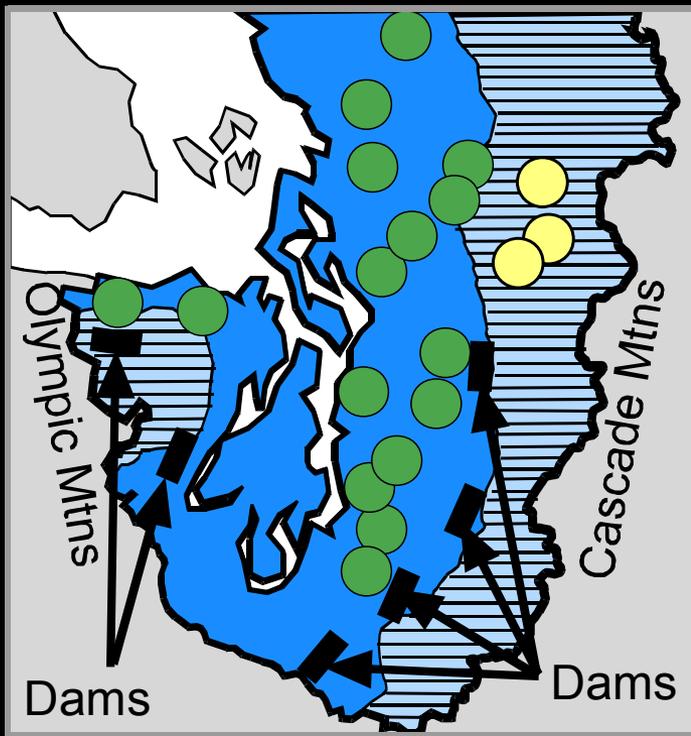
Increase habitat diversity



Increase habitat diversity



Restore access to diverse habitats



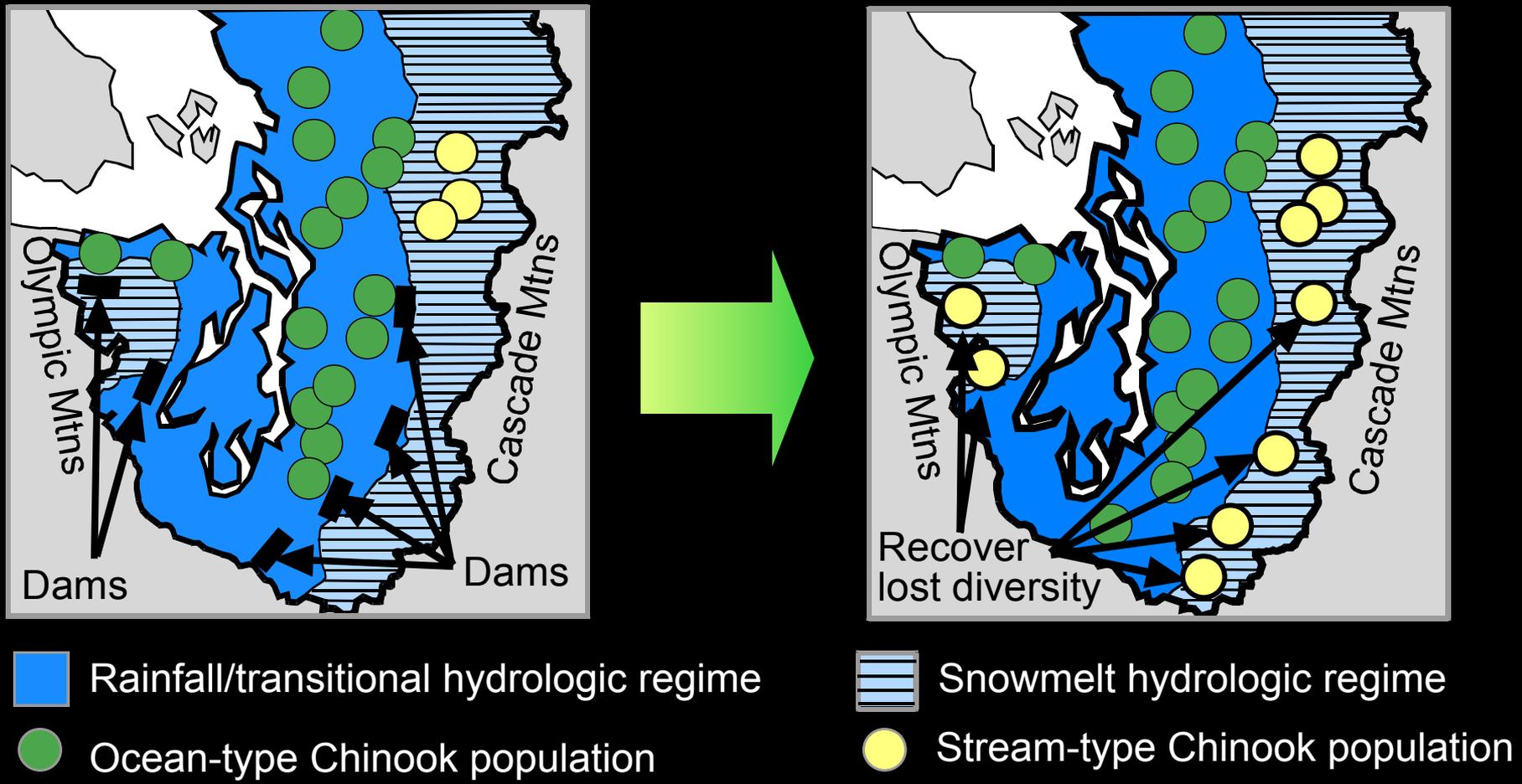
 Rainfall/transitional hydrologic regime

 Ocean-type Chinook population

 Snowmelt hydrologic regime

 Stream-type Chinook population

Restore access to diverse habitats



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 | <input checked="" type="radio"/> | <input checked="" type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| | Planting (trees or other vegetation) | <input checked="" type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| | Thinning to increase tree growth | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Instream rehabilitation | | | | | |
| | Remeandering, channel realignment | <input checked="" type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input checked="" type="radio"/> |
| | Adding log structures or jams | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| | Boulder weirs or boulders | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| | Brush bundles or other cover | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| | Gravel addition | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Nutrient enrichment | | | | | |
| | Addition of organic or inorganic nutrients | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Restoration actions and climate change

| Restoration action | Temperature increase | Low flow decrease | Peak flow increase | Increase resilience |
|---------------------------|----------------------|-------------------|--------------------|---------------------|
| Longitudinal connectivity | Y | Y | N | Y |
| Floodplain connectivity | Y | N | Y | Y |
| Restore incised channel | Y | Y | Y | Y |
| Restore in-stream flow | Y | Y | N | N/Y |
| Riparian rehabilitation | Y | N/Y | N | N |
| Sediment reduction | N | N | N | N |
| In-stream habitat | N | N | N | N |
| Nutrient enrichment | N | N | N | N |

Do climate change predictions alter restoration plans?

- What habitat factors limit salmon recovery?
- What are local predicted climate change effects?
- Do proposed restoration actions reduce climate change effects?
- Do proposed restoration actions increase habitat diversity or ecosystem resilience?

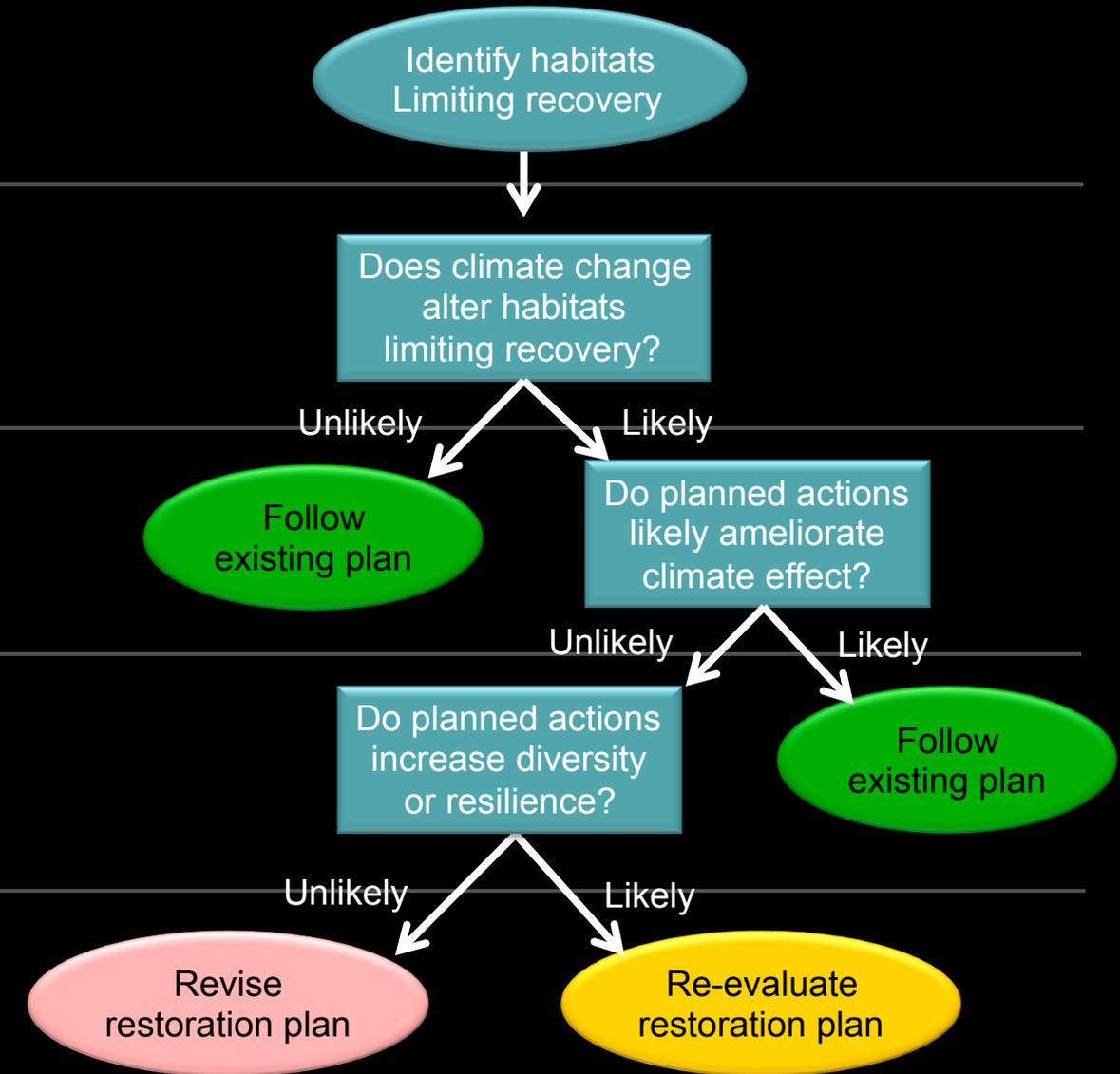
Evaluating a restoration plan

Question 1: What habitats limit salmon recovery?

Question 2: What are local predicted climate effects?

Question 3: Does the plan reduce the effect?

Question 4: Does the plan increase resilience?

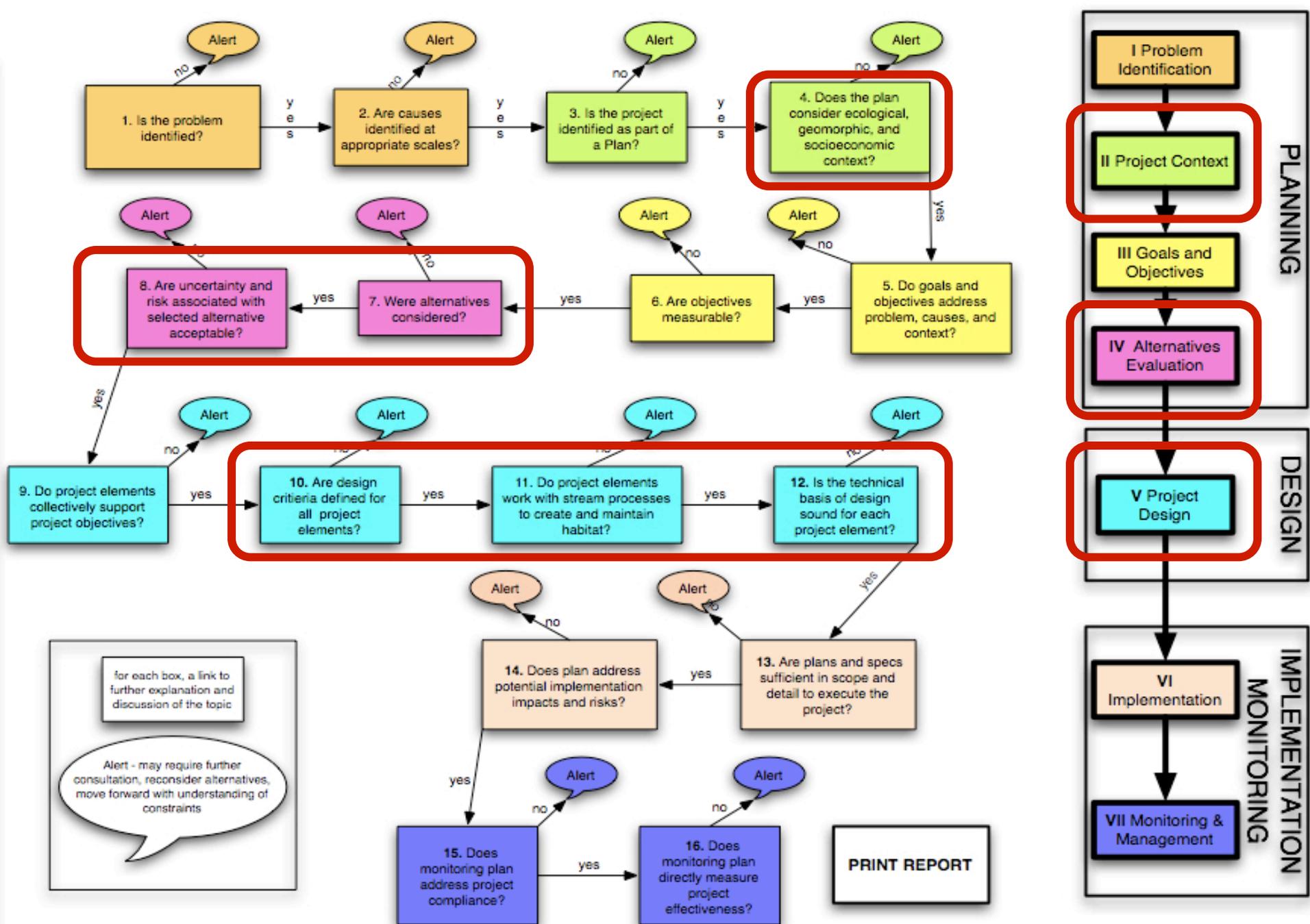


Identify actions that address long-term limiting habitats

Are there alternative actions that ameliorate climate effect?

Evaluating an individual project

- RiverRAT might be helpful
 - Intended for review of restoration projects
 - Follows the design process



Summary

- Restoration actions vary in their ability to ameliorate climate change effects
- Some restoration strategies can help increase salmon resilience
 - Restore connectivity
 - Increase habitat diversity (floodplains)
 - Restore flow regimes
- Decision support framework helps evaluate whether to adjust restoration plans or actions for climate change