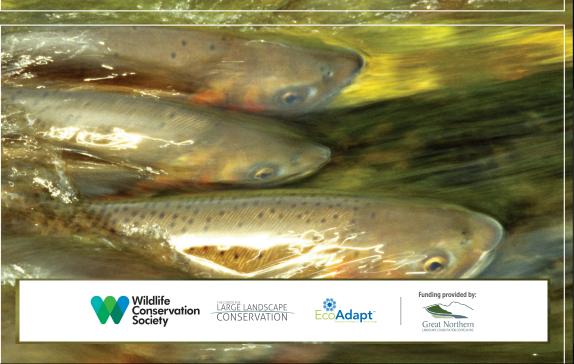


A THREE-STEP DECISION SUPPORT FRAMEWORK FOR CLIMATE ADAPTATION:

Selecting Climate-Informed Conservation Goals and Strategies for Native Salmonids in the Northern U.S. Rockies





Lara J. Hansen, PhD~ EcoAdaptMolly Cross, PhD ~ Wildlife Conservation SocietyRegan Nelson, PhD ~Gary Tabor, PhD/DVM ~ Center for Large Landscape Conservation



The State of Adaptation in the United States An Overview



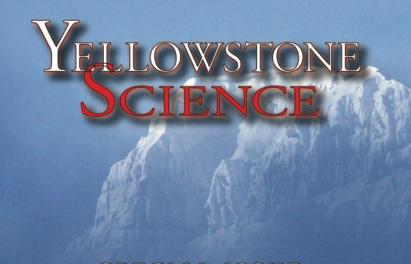
	Impacts	Vulnerability	Planning	Capacity	Implementation	Resources/	Monitoring/
	Assessment	Assessment		Building		Tools	Evaluation
Federal							
Tribal							
Region							
State							
Local							

Natural resource management sector



Lots of science & assessment





SPECIAL ISSUE

Ecological Implications of Climate Change on the Greater Yellowstone Ecosystem

Revisiting Climate Change Predictions from 1992

How Wetlands & Snowpack Help Us Understand a Changing Climate

Water in the Balance

- Past and future climate changes
- Snowpack
- Water balance
- Wetlands
- Forest composition and health
- Fisheries
- Wildlife interactions
- Non-forest vegetation changes
- Wildfire
- Pests, pathogens, diseases
- Paleo-climate-ecology relationships
- And much more...

Adaptation Planning & Capacity Building



Rocky Mountain Partner Forum Workshop on Climate Adaptation for Cold Water Ecosystems







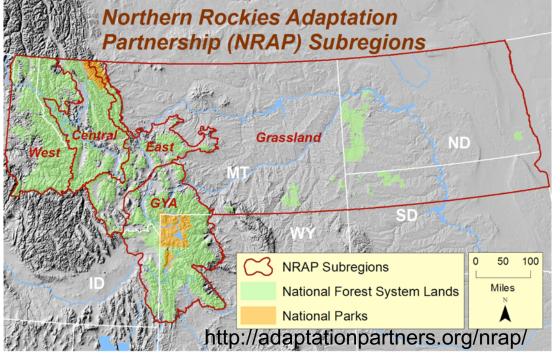
- Scientists, managers
- Agencies, tribes, NGOs
- Some presentations, mostly interactive planning and sharing



http://greatnorthernlcc.org/partner-forums/rocky-mountain

More Adaptation Planning & Capacity Building





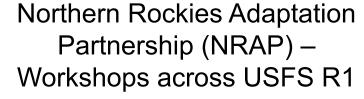
Crown Adaptation Partnership -Workshop on Adaptation for Native Salmonids



















Menu of adaptation "options"

STRATEGY	TACTIC
	Identify and restore "warm-adapted" populations of native trout
	Replicate and supplement native fish populations
	Connect current populations with streams that are currently too
	cold (and may warm to suitable levels in the future)
	Consider limiting angler pressure on native fish in streams that are
Increase resilience of native fish	at or near temperature thresholds
populations to warming stream	Establish large-scale reserves for long-term native cold-water fish
temperatures and flow changes	conservation
	Conduct field experiments of fish-temperature relationships for
	multiple species and regions
	Monitor changes in stream temperature for fish distributions
	Understand and map where groundwater inputs are providing cold water
	Replace or retrofit culverts that will not function well during future
Increase resilience of native fish	low base flows and flood periods
species by reducing barriers to	Identify, prioritize, and remove barriers to native fish movements
movement	Minimize water diversions; where they exist, ensure fish ladders
	avoid entrainment of native trout
Increase population resilience by	Increase public education to eliminate disease vectors Survey fish health conditions
increasing native fish health	Direct treatment or removal of infected fish
	Survey and map non-native species
	Combine non-native mapping with information on migration
	barriers
	Remove or control non-native fish species (electrofishing, chemical
	removal, genetic swamping, encouraging increased harvest of non-
	natives)
Prevent / remove invasive non-native	Strategically use physical or electrical barriers to prevent further
fish	spread of non-native fish
	Assess status of non-native fish more frequently to better detect
	changes in invasions (perhaps using citizen science)
	Model future changes in stream flow and habitat to anticipate
	future invasion hotspots
	Re-establish or replicate native fish populations in areas where non-natives have been removed or are effectively blocked by
	hon-hatives have been removed or are effectively blocked by barriers
	Damers

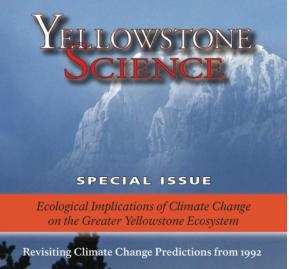
Continued on multiple pages...





Capacity Building

Science & Assessment



How Wetlands & Snowpack Help Us Understand a Changing Climate

Water in the Balance



Adaptation Plans & Options

A COMPILATION OF ADAPTATION STRATEGIES AND TACTICS FROM PREVIOUS PLANNING EFFORTS¹

STRATEGY	TACTIC
	Identify and restore "warm-adapted" populations of native trout
	Replicate and supplement native fish populations
	Connect current populations with streams that are currently too
	cold (and may warm to suitable levels in the future)
	Consider limiting angler pressure on native fish in streams that are
Increase resilience of native fish	at or near temperature thresholds
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	Conduct field experiments of fish-temperature relationships for
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	Understand and map where groundwater inputs are providing cold water
	Replace or retrofit culverts that will not function well during future
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Prevent / remove invasive non-native	Strategically use physical or electrical barriers to prevent further
fish	spread of non-native fish
1.31	Assess status of non-native fish more frequently to better detect
	changes in invasions (perhaps using citizen science)
	Model future changes in stream flow and habitat to anticipate
	future invasion hotspots
	Re-establish or replicate native fish populations in areas where
	non-natives have been removed or are effectively blocked by
	barriers
In second s	Restore stream and floodplain complexity, ensuring adequate
Increase spawning habitat resilience by restoring stream and floodplain	width-depth ratios and frequency of pools Provide alternative habitat for spawning
by restoring stream and floodplain structure and processes	Provide alternative habitat for spawning Increase use of engineered log jams where feasible
structure and processes	Prevent or remove aquatic invasive species
	Prevencior remove aquatic invasive species

What to do? Where to do it? Towards what goal?





A THREE-STEP DECISION SUPPORT FRAMEWORK FOR CLIMATE ADAPTATION: Selecting Climate-Informed Conservation

Goals and Strategies for Native Salmonids in the Northern U.S. Rockies



Using information on climate vulnerabilities to select goals and actions from a menu of adaptation options

Funding from:





Developed with input from:

Managers on the Custer Gallatin National Forest:

- Scott Barndt (ecosystems leader)
- Andy Efta (hydrologist)
- Dale White (hydrologist)
- Clint Sestrich (fisheries)
- Julie Shea (fire specialist)

Linh Hoang, USFS Region 1 climate coordinator



3-Step Decision Support Framework

Step 1

STEP 1: Assess Vulnerability of Selected Native Salmonid Population to Climate Chang

For all questions, document key assumptions (e.g., which species you are planning for, what stream temperature thresholds you are us which models or empirical analyses you are using, and what time frame you are considering!

Anteressing and	HABITAT SUITABLITY: To what extent will climat habitat saitability for the		THREATS FROM NOT To what extent will o increase the threat to present to the popul	limate change hat non-native fish	CONNECTIVITY: To what extent will climate change after the degree of correctivity of the population to a larger network of populations and suitable habitat?	
	 Are starts transactions Are starts the booms start Are starts the booms start Are starts the booms start Are starts and the booms start Are starts and when the booms start and the booms are of the bold starts and provide when the booms are start the bold starts and starts	abbit discos (o.g., faring, tr.) expected to abe as climate anges in writer a gaaring was naturally not far discussion of the devision, correction to al composition al com	of non-native fails of concern le.g., vi competition, predi- te invasion data fails the invasion data the invasion data	re currently present, tige alter the influence on native species a hybridization, zoorg? re currently absent, nge potentially increase (S.e., by alaring habitat rolance events that	 It is provide to any product or populations and values populations and values in convector to any provide one method, dry us operative convectors that makes a second provide the understatic to approximate the second understatic to approximate the second and convectors and the second and convectors and the second and convectors and the second and convectors and the second and the second any and the second any and any and the second any and any any any and any and any any any any any any any any any any any any any any any any any any	
	Considering your answers the most appropriate leve of the population to clima effects on habitot suitabil	it of valnerability ate change			Considering your answers above, choose the most appropriate level of vulnerability of the population to climate change effects on on connectivity:	
	A -Habitat likely to remain or become satable B - Habitat likely to become marginal. (i.e., at or near thresholds for local specied C - Habitat likely to become unsuitable		D - Threats from non-nutive flah likely to be low E - Threats from non-nutive flah likely to be high (because already present or likely to increase)		F - Population likely to be connected to a larger network G - Population likely to remain or become isolated	
	Areaner A		Answer E		ACOME G	
yau an		Пура атамет		If you answered:	Go to Bos:	
A D		B D F	5	CDF	9	
	F 3	BDG	6 7 8	CEG	30	
A D		8 E F			12	
AD	G 4	REG				

Step 2

	HABITAT REMAINS OR BECOMES SUITABLE	HABITAT BECOMES MARGINAL	HABITAT BECOMES UNSUITABLE
	Relative vulnerability to climate change: Low	Relative vulnerability to climate change: Medium	Relative valmentability to climate change: Medium-High
LOW PREDET REOM NON-NUT MUT HER INCU	Relative values for motion submotion conservation: Right sales in Jobs The Moral and/org term <i>Related Gast</i> manufactor in the submotion submotion manufactor for the submotion submotion Strutegies = Indext or dama relations = Indext or	Haldle values for mains suffmand conservation: Annexis abar core theology time, blue propose Particular Conservations of particular Particular Conservations of particular particular particular Particular Conservations of particular particular particular Particular Conservations of particular particula	Radia wata tai Marine submitta conversion: Narinet submitta conversion: Narinet submitta conversion: Narinet submitta conversion submitta Narinet submitta conversion submitta Narinet submitta conversion submitta Narinet submitta Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narin
HECH THREAT FROM NOW MUTHAT FISH	Relative selected by the drawter charges heat out of the selected conservation. The selected conservation of the selected conservation in the selected conservation. By the selected conservation of the selected conservat	Hadde undersähligt to citate charge: Hadde undersähligt Hadde undersähligt Hadde undersähligt och hadde undersähligt hadde undersähligt och hadde undersähligt hadde undersähligt hadde undersähligt och hadde undersähligt hadde undersähligt hadde undersähligt hadde undersähligt hadde undersähligt hadde undersähligt hadde undersähligt ha	Radie enterheitigt is cliente charge: Bradier wate the Ministrum of the second second second second methods are the short harm to be of methods are the short harm to be of methods are the short harm to be of methods are short to be of the short harm to an impair extend and the short harm to be methods and the short harm to be of the short harm to be of the short harm to be observed and the short harm to be observed and the short harm to harm to be observed and the short harm methods and the short hard the short hard methods and the short hard the short hard the short hard methods and the short hard the short hard the short hard method hard the short hard the short hard the short hard methods and the short hard the short hard the short hard method hard the short hard the short hard the short hard method hard the short hard the short hard the short hard method hard the short hard the

Step 3

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Nodeste stream (C) Nodeste stream (C) Strengenstern increases (D) Ba	stans stream linge regimes elementer on streek fooding element populations to cold-suiter rant networks	Stability optime registrice remote one settion registrice Alercover, thereases that care or advanced registry (Registrice departed hasks, edit) Alercover, that data and participant density Alercover in weblick definition of carbon Alercover in weblick and enders Alercover in the data and and enders Alercover to the set of the set of advance departed houses Alercover to the set of the set of advance departed houses Alercover to the set of the set of advance departed houses Alercover to the set of the set of advance departed houses
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Re Moderate stream (c) temperature increases (c) Ite	dure sim on-snow flooding enerct populations to cold-water nam networks	Homose or intendituumiercumi culturis «Nature instand damagin palvers, conder notes forsprands «Nature instand culturis, unitand culturi daginin vegetation coorer «Nature or culturis, fuit act act activities and fest finh uccess to cold-water streams
Moderate stream Co temperature increases the	remot populations to cold-water naminetworks	Maintainiestore lorest, welland and ripation respectice cover Formose dams or cultersh that act as barries and limit fish access to cold-water streams
Moderate stream Co temperature increases the	remot populations to cold-water naminetworks	Fernore dams or culters, that act as barries and limit fish access to cold-water streams.
temperature increases 137	ean networks	
	connect Enoded size	Fessive thermal tartiers
Re:		Reconnect Boodblain leatures le a side channels, sonshi
5e		Designate and restore natural flooriplain boundaries
5e		Remose infrastructure (e.g., roads, levees, rip rap, etc.) from floodplains
	stare inconfiscoured channels	Petitizatuce lieawer or build lieawer dam analogs to increase sediment storage Petitizature separation
		Remove devices that cause reparter damage (Regal or depraded trails, cattle, etc.)
1.0	stoe stean lows	Work to restore ratural flow regimes
		Reduce water withdrawait, restore sammer baseflow
		. On regulated streams, public flows during critical times, sourcing from lower in the thermoching
	aintuin (enhance riparium xegetatice to ade streams	 Reduce grazing pressare (e.g. reduce stocking roles, use red-volution rysters, ferce riparian areas, previde off stream-water sources, retire vacant abstreemb in priority/tish areas, increase monitoring in priority areas to resure good practices)
		Finstore ripadar-separation in degraded amax
		 Adjust riparian superation to favor species that are better suited for tuture climate conditions.
	event non-stative fight invasion	Strategically use physical or electrical barriers to present further spread of non-native Boh
native fish		Model future changes in stream flow and fubilities anticipate future invasion hotspets
	stare habitals that convey an kartage for native fish over non-native h	Restore spawning habitas for native figh Connect current native populations with streams that are too cold for non-native figh
	pand existing native fith populations to create character of resisting installor.	Expandinative fish populations in areas where trying to present invasion of non-native fish
	entity and protect areas likely to remain	Establishinge-scale reserves for long-term native-cold-water fish conservation
di	matically suitable over the long-term	 Connect current populations with streams that are currently too cold and may warm to suitable levels in the future)
		 Look for opportunities for wintroductions in habitats likely to remain suitable over the long- term
		Understand and map where groundwater inputs may buffer projected stream temperature increases
ha	ofect and restore critical or anique blats that buffer survival during	Protectilestore off-channel habitats, spring brooks, and seeps important as early reading environments
90 30	drwabie periods (se, wasonaby or at ricular life Notory stages)	Protectivatore Bood or thermal erlagia and steam segments that are important as connections

Available for download:

http://rmpf.weebly.com/cold-water-ecosystem-management-tool.html



Step 1: Assess vulnerability of selected native salmonid population to climate change

Suitability Threats from non-native fish likely to be low Threats from non-native fish likely to be high	Inerability Levels	
Suitability Habitat likely to remain or become suitable Habitat likely to become marginal Habitat likely to become unstable Threats from non-native fish Threats from non-native fish likely to be low Threats from non-native fish likely to be high	Vulnerability	Increasing Vulnerability to Climate Change
non-native fish		Habitat likely to remain or become suitable Habitat likely to become marginal Habitat likely to become unsuitable
Connectivity Population likely to be connected to a larger network Population likely to remain or become isolate		Threats from non-native fish likely to be low Threats from non-native fish likely to be high
	Connectivity	Population likely to be connected to a larger network Population likely to remain or become isolated

• Asks users "key questions" to assess climate vulnerabilities

Wes Decision Support Framework

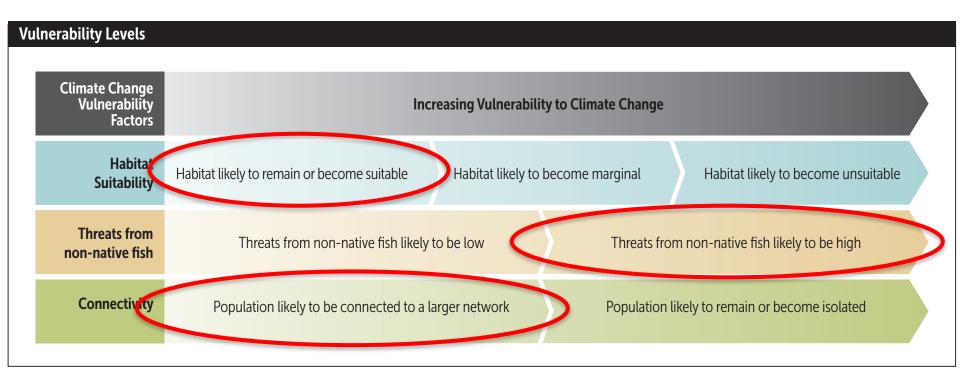


Step 1: Assess vulnerability of selected native salmonid population to climate change

Key Factor of Vulnerability	HABITAT SUITABILITY: To what extent will climate change alter habitat suitability for the population?	THREATS FROM NON-NATIVE FISH: To what extent will climate change increase the threat that non-native fish present to the population?	CONNECTIVITY: To what extent will climate change alter the degree of connectivity of the population to a larger network of populations and suitable habitat?
Climate-Related Questions to Consider	 Are stream temperatures expected to remain (or become) suitable? Are other key habitat conditions (e.g., streamflow quantity and timing, sediments, patch size, etc.) expected to remain or become suitable as climate changes? Are climate-driven changes likely to interfere with life-history requirements of focal species (e.g., changes in winter flooding might influence spawning success)? Is the population in an area naturally more resilient to changing climate conditions (i.e., because of the elevation, size of the habitat patch, connection to lakes that provide vertical temperature stratification, or the presence of features that could buffer warming such as groundwater upwelling or cold-air drainages)? Could climate-driven changes in human water use and management affect stream flow quantity, quality and timing? 	 Are non-native fish currently present? If non-native fish are currently present, might climate change alter the influence of non-native fish on native species of concern (e.g., via hybridization, competition, predation)? If non-native fish are currently absent, could climate change potentially increase the invasion threat (i.e., by altering habitat conditions or disturbance events that might facilitate invasion)? 	 Is the population currently isolated, or is it connected to a larger network of populations and habitat? If currently connected to a larger network, do you expect this connectivity to remain given changing climate conditions (e.g. is the existing habitat vulnerable to fragmentation by changing stream flows and temperatures)? Are features present (e.g. culverts, low water crossings) that could become barriers to fish movement under changing stream flows? If currently isolated, is the population like to persist given changing climate conditions and associated extreme events (e.g., wildfire, floods, erosion)?



Step 1: Assess vulnerability of selected native salmonid population to climate change



• 12 combinations of vulnerability factors and levels



Decision Support Framework



Step 2: Use vulnerability matrix to clarify management goals and select climate adaptation strategies

HABITAT REMAINS OR BECOMES SUITABLE HABITAT BECOMES MARGINAL

Relative vulnerability to climate change: l ow

Relative value for native salmonid conservation:

High value in both the short and long term

Potential Goal:

Protect and maintain (or improve if 톬 warranted) this habitat network for long-term conservation of native salmonids

NATIVE Strategies:

- NON · Protect climate refugia; · Protect existing networks;
- FROM Expand/refound populations; Prevent invasion of non-native fish HREAT
- IT WO. ION IS CONNECTED TO A LARGER NETW

Relative vulnerability to climate change: Medium-Low Relative value for

native salmonid conservation: High value in both the short and long term, but may require investment to prevent/ remove/suppress non-native fish

Potential Goal:

HSF E Prevent invasion of non-native fish (or remove/suppress if already present). and protect and maintain (or improve if warranted) this habitat network for long-term Ś conservation of native salmonids

Strategies:

- ROM · Remove/suppress non-native fish;
- THREAT · Prevent invasion of non-native fish; Expand/refound populations;
- Protect existing networks;
- 튤 Protect climate refugia

Relative vulnerability to climate change: Medium

Relative value for native salmonid conservation:

Potential value over the long term, but will. likely require investment to moderate climate impacts

Potential Goal: Improve the suitability of this habitat network for long-term conservation of native salmonids

Strategies:

- · Moderate stream temperature increases; · Moderate base flow decreases:
- Moderate peak flow increases;
- Increase adaptive capacity of native fish; Minimize adverse impacts in the event. of potential increased wildland fire disturbance:
- · Protect existing networks; · Reduce uncertainty through research and
- monitoring: Prevent invasion of non-native fish

Relative vulnerability to climate change: Medium-High

Relative value for native salmonid conservation:

Potential value over the long term, but will. require a high-level of investment to both moderate climate impacts and prevent/ remove/suppress non-native fish

Potential Goal:

Prevent invasion of non-native fish (or remove/suppress if already present), and improve the suitability of this habitat network for long-term conservation of native salmonids

Strategies

- · Moderate stream temperature increases;
- · Moderate base flow decreases:
- · Moderate peak flow increases; Increase adaptive capacity of native fish;
- · Remove/suppress non-native fish;
- Prevent invasion of non-native fish:
- · Minimize adverse impacts in the event of potential increased wildland fire
- disturbance: Protect existing networks:
- Reduce uncertainty through research and monitoring

HABITAT BECOMES UNSUITABLE

Relative vulnerability to climate change: Medium-High

Relative value for native salmonid conservation:

Potential value in the short term to help with population recovery, maintenance of genetic diversity and/or local adaptations; Longerterm value is lower due to decreasing habitat suitability

Potential Goal:

Maintain population in the short-term; In the longer-term, consider facilitating the movement of current population to other locations with more suitable conditions, facilitating the transition of the location to a new state, and/or managing the location for other targets (e.g., game fish or non-fish targets)

Strategies:

· Reduce uncertainty through research and monitoring Increase adaptive capacity of native fish; · Relocate individuals to areas likely to remain or become suitable: · Facilitate transition to a new state

Relative vulnerability to climate change: High

Relative value for native salmonid conservation:

Potential value in the short term to help with population recovery, maintenance of genetic diversity and/or local adaptations, but will require investment to prevent/remove/ suppress non-native fish; Longer-term value is lower due to decreasing habitat suitability

Potential Goal:

Facilitate the movement of current population to other locations with more suitable conditions; Facilitate the transition of the location to a new state: Consider managing the location for other targets (e.g., game fish or non-fish targets)

Strategies:

· Reduce uncertainty through research and monitoring; Relocate individuals to areas likely to remain or become suitable;

- Facilitate transition to a new state: Determine additional strategies after clarifying management goal(s)

HABITAT REMAINS OR BECOMES SUITABLE HABITAT BECOMES MARGINAL

Relative vulnerability to climate change: Medium-Low

Relative value for native salmonid conservation:

HSE I

VITIVE

THREATFROM

NO

POPULATION REMAINS OR BECOMESISOLATED

Potential value for providing genetic diversity

and/or local adaptations in both the short and long term, but will likely require investment to address fragmentation Potential Goal: Evaluate representativeness of this population across the landscape, and determine what level of protection/reconnection to other habitats is warranted Strategies: Reconnect fragmented networks; Protect climate refugia; Minimize adverse impacts in the event of potential increased wildland fire

disturbance; Expand population; Prevent invasion of non-native fish

Relative vulnerability to climate change: Medium

Relative value for

native salmonid conservation: Potential value, but may will likely require

investment to prevent/remove/suppress non-

NATINE

No

HIGHTHREAT

native fish and address fragmentation Potential Goal: Evaluate representativeness of this population across the landscape, and determine what level of protection, reconnection to other habitats, and management on non-native fish is warranted

Strategies:

 Reconnect fragmented networks; Protect climate refugia; Minimize adverse impacts in the event

of potential increased wildland fire disturbance:

Expand population:

Prevent invasion of non-native fish

Relative vulnerability to climate change:

Relative value for native salmonid conservation: Potential value for providing genetic diversity and/or local adaptations, but will likely require investment to moderate climate impacts and address fragmentation

Potential Goal:

Evaluate representativeness of this population across the landscape, and determine what level of protection/restoration/active management is warranted

Strategies:

Medium

- · Reconnect fragmented networks; Moderate stream temperature increases; · Moderate base flow decreases; · Moderate peak flow increases;
- · Increase adaptive capacity of native fish; · Minimize adverse impacts in the event of potential increased wildland fire
- disturbance: Reduce uncertainty through research and monitoring
- Prevent invasion of non-native species Relative vulnerability to climate change:

Medium-High

Relative value for native salmonid conservation:

Lower value, and will likely require a high-level of investment to moderate climate impacts, prevent/remove/suppress non-native fish, and address fragmentation

Potential Goal:

conditions: Facilitate the transition of the Facilitate the movement of current population location to a new state: Consider managing to other locations with more suitable the location for other targets (e.g., game fish conditions; Facilitate the transition of the or non-fish targets) location to a new state; Consider managing Strategies: the location for other targets le.g., game fish or non-fish targets)

Strategies:

- · Reduce uncertainty through research and monitorina
- Relocate individuals to areas likely to remain or become suitable;
- Facilitate transition to a new state: · Determine additional strategies after clarifying management goal(s)

HABITAT BECOMES UNSUITABLE

Relative vulnerability to climate change: Medium-High

Potential value in short-term for providing

genetic diversity and/or local adaptations,

but will likely require investment to address

Maintain population in the short-term; In

the longer-term, consider facilitating the

movement of current population to other

locations with more suitable conditions,

facilitating the transition of the location to

a new state, and/or managing the location

for other targets (e.g., game fish or non-fish

Reduce uncertainty through research and

Increase adaptive capacity of native fish;

Relative vulnerability to climate change:

Facilitate the movement of current population

· Reduce uncertainty through research and

Relocate individuals to areas likely to remain

to other locations with more suitable

Facilitate transition to a new state

native salmonid conservation:

Relocate individuals to areas likely to remain

fragmentation; Longer-term value is lower due

Relative value for native salmonid conservation:

to decreasing habitat suitability

Potential Goal:

targets)

High

Low value

Strategies:

monitoring:

or become suitable:

Relative value for

Potential Goal:

monitoring:

or become suitable:

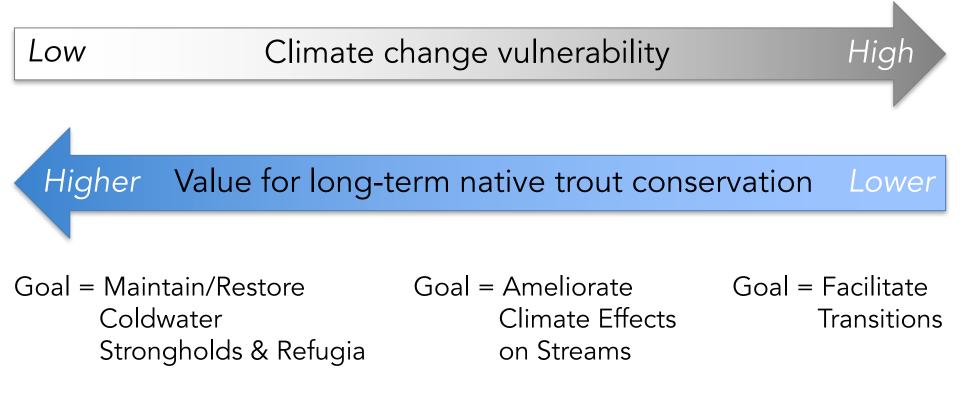
Facilitate transition to a new state;

clarifying management goalls)

Determine additional strategies after



Step 2: Use vulnerability matrix to clarify management goals and select climate adaptation strategies



Vulnerability Type + Goals → <u>Specific</u> Climate Adaptation Strategies



Step 3: Select actions to implement chosen climate adaptation strategies (from list of example actions)

	Strategy	Objective	Example Actions	
X	Expand/refound populations	Increase population size and number of populations to recover large, interconnected populations	 Expand populations at or below minimum viable population size Refound new populations in areas expected to be climatically suitable 	
	Facilitate transition to a new state	Allow colonization by new species that may be better suited to new environments and still provide some ecological function and value	Remove barriers to invasion Introduce new species	
X	Increase adaptive capacity of native fish	Increase resilience of native fish populations to warming stream temperatures and flow changes	 Identify and restore "warm-adapted" populations of native trout Consider limiting angler pressure on native fish in streams that are at or near temperature thresholds Replicate and supplement native fish populations Remove non-native fish 	
		Increase native fish health	Increase public education to eliminate disease vectors Treat or remove infected/diseased fish Eliminate or control pollutants or contaminants	
		Conserve genotypic/phenotypic diversity	 Conserve or restore a diverse representation of habitats across river basins Maintain large population sizes to minimize loss of genetic variability and adaptive potential. 	
	Minimize adverse impacts in the event of potential increased wildland fire disturbance	Identify and minimize negative effects to areas most vulnerable to fire impacts	 Develop a geospatial layer of debris flow potential for pre-fire planning Manage natural fuel conditions and unplanned wildfire effects through fuel management actions and/or use of unplanned wildfire ignitions to minimize negative effects (severity and extent) of fire. 	
		Restore areas adversely affected by fire	 Inventory disturbed areas for candidate sites for riparian and upland vegetation restoration Restore and re-vegetate burned areas to store sediment and maintain channel geomorphology 	Continued



3-Step Decision Support Framework

Step 1

STEP 1: Assess	Vulnerability	of Selected	Native Sa	ilmonid Po	pulation to 0	limate Cha	inge
-							

For all questions, document key assumptions (e.g., which species you are planning for, what stream temperature thresholds you are usi which models or empirical analyses you are using, and what time frame you are considering)

Villement (199	HABITAT SUITABLITY: To what extent will climat habitat suitability for the		THREATS FROM NO To what extent will increase the threat present to the popu	dimate change that non-native fish	CONNECTIVITY: To what extent will climate change after the degree of connectivity of the population to a larger metwork of populations and suitable habitat?	
	Are stream treppedares remain for become suits working the location suits second the log habitizes remain or become suits changed a fract characteristic and charged a fract characteristic and second and second suits charged a fract characteristic and second a fraction of the second and second second conditions is a fractional of the second and second second second and second second conditions is a fractional of the second and second second second and second second second second second second second second second second second second second second second second second second	abbit discos (o.g., fining, k.) expected to abe as clinate gas likely to magnimismits, innys in writer is gaaring of the denotion, connection to a longerature gas on a serve of instance in cold-air anges in human entraffect damas	might climate chi of non-native fait of concern le.g. v competition, prec • Erron-native fash could climate chi the invasion threa	are currently present, inge alter the influence on indive species is hybridization, alternity aboret, inge potentially increase Ellio, by altering habitat arbance events fluit.	 It is graphics control to black of populations and holds? It is creared to a support mode, of populations and holds? It is creared to an expective method, day to appet the control to the borneas go and appet graphics understable to approximation to graphic understable to approximation to graphic understable to approximation to graphic understable to approximation to graphic understable to approximation to a different and control part and and the control and control parts and and the control and control parts and appendix and and the population to a	
	Considering your answers the most appropriate leve of the population to clima effects on habitat suitabil	t of valnerability ite change			Considering your answers above, choose the most appropriate level of valuesability of the population to climate change effects on on connectivity:	
	A -Hubitat Takity to runnain or become suitable B - Habitat Hody to become marginal (i.e., it or near thresholds for local species) C - Hobitat Hody to become unsuitable			n-native fish likely n-native fish likely to already present or likely	 F - Population likely to be connected to a larger network G - Population likely to remain or become isolated 	
	Areaver A		hower E		ADSIME G	
you are A D		Epote attanee B D-F	ed: Go to Box:	Hyou answered: C.D.F	Go to Box: 9	
A D	G 2	BDG	6	CDG	30	
AE	F 3	8.6.5	7	CEF	13	
CAE	G 4)	BEG	8	CEG	12	
		Co in STER 2	to find compations	an extential and an	I strategies for your population of inter	

Step 2

	HABITAT REMAINS OR BECOMES SUITABLE	HABITAT BECOMES MARGINAL	HABITAT BECOMES UNSUITABLE
	Relative vulnerability to climate change: Low	Relative vulnerability to climate change: Medium	Relative valmentability to climate change: Medium-High
LOW PREDE REOM NON-NUETRE RESH	Relative values for motion submotion conservation: Right sales in Jobs The Moral and/org term <i>Related Gast</i> manufactor in the submotion submotion manufactor for the submotion submotion Strutegies = Indext or dama relations = Indext or	Haldle values for mains suffmand conservation: Annexis abar core theology time, blue propose Particular Conservations of particular Particular Conservations of particular particular particular Particular Conservations of particular particular particular Particular Conservations of particular particula	Radia wata tai Marine submitta conversion: Narinet submitta conversion: Narinet submitta conversion: Narinet submitta conversion submitta Narinet submitta conversion submitta Narinet submitta conversion submitta Narinet submitta Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narinet Narin
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Step 3

Strategy	Objective	Example Actions
Moderate peak flow increases	Restore Roodylain connections	Remove inhastructure (r.g., mach, levees, rip rap, etc.) from filoodiplains Reconnect filoodiplain hatavis (r.g. channels, pornh) Coulds new orrective deposited filoodiplain hatarian
	Restate incluef/scoured channels	Relationary beaver to encourage dam-duilding that increases sediment storage and deposition
	Restoe riparian vegetation	Establish-sparian regelation: remove non-sative regelation Pernore thespot that cause sparian damage literation descated trails, patie, esc)
	Bestave stream Rave regimes	Elscorrect toal distage from strarts Alernose or intelfit undersized calleds History sakad dislage splents, could indexfor ponds
	Reduce rain-co-snow flooding	Maintainitestore lovest, wetland and ripatian regetation cover
Nodente stroom	Connect populations to cold-sulter stream networks	Remove dams or collects that act as barries and limit fully access to cold-water streams Restancy/service in stream flows Restancy/service in stream flows
	Reconnect Roodplains	Facconnect Rocolpiain Isulaws (e.g. side channels, ponth) Evelopsite and retrieve natural (Rocifiain Isoundarin Fiernose infrastructure (e.g., roads, livees, rip rap, etc.) from (Boolpiains
	Restare incised scoured channels	 Reintroduce beaver or huld beaver dam analogs to increase sediment storage Risstore ripadian regulation Riverowe storagen that cause riparian starwage (Riegal or depraded toals, castia, etc)
	Restore stream Rows	Work to restore natural flow regimes Feduce water withdrawab, restore sammer baseflow On regulated streams, pulse flows daring critical times, sourcing from lower in the thermache
	Maintain/whence sparian regulation to shalls streams	 Reduce grazing pressaw (e.g. reduce stocking ratus, use not-rotation systems, ferror riparian areas, previde off stream-water sources, retire vacant adotments in priority faith areas, increase monitoring in priority areas to ensure good practices)
		Finitive spaniar separation in degraded amas Aduat spaniar separation to favor species that are better suited for future dimate conditions
Prevent Invasion of non- native fish	Prevent non-stative tuth invasion	Pepter spacer reported to aver protection and enter both of the speed of non-native fast • Strategically use physical or electrical barriers to prevent further speed of non-native fast
	Prevent normalise tax invation	House july de prystant decental partes de presentante speak anno house ten Andel Istare charges in stream Tex anti habitat te anticipale future invasion house ter
	Restate habitals that convey an advantage formative fish overnon-native fish	Restore spawning habitat for native fash Connect current native populations with dreams that are too cold for non-native fash
	Equal existing native feb populations to increase chances of resisting insulos	Expandinative fish populations in areas where trying to present invasion of non-native fish
Protect climate refugia	Mentily and pertect areas likely to remain climatically soliable over the lang-term	Establishinge-scale reserves for long-term native cold-water fish conservation Connect convent populations with streams that are curvently too cold land may warm to
		suitable levels in the future) + Look for opportunities for wintroductions in habitats likely to remain suitable over the long- term
		Understand and map where proundwater inputs may buffer projected stream temperature increases
	Protect and restore critical or anique habitits that buffer survival during vulnerable periods (ar., was analy or at	 Frotechiestore off-channel habitats, spring brooks, and seeps important as early reasing environments
	particular life fistory stages!	Protectivatore Road or thermal refugia and stream segments that are important as operations

What actions to take? Where to take those actions? Towards what goal?



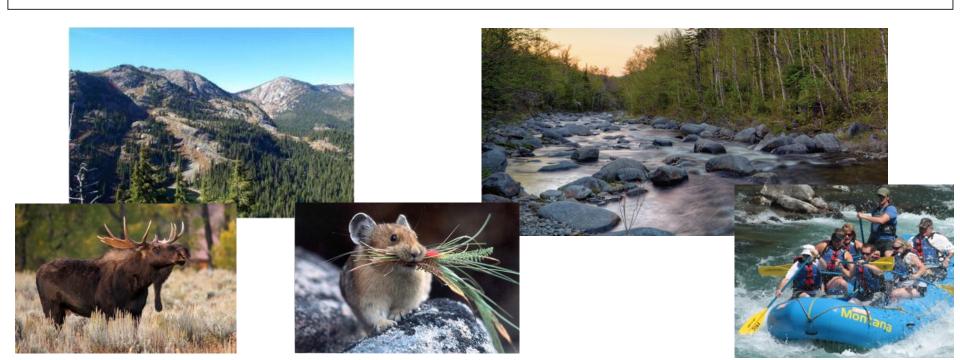
Tailor the Decision Framework



Decision Support Framework Development Process

Specify conservation target and unit of analysis Identify key climate change vulnerability factors Develop critical questions for assessing the relative vulnerability of the area or population to climate change

Create a 'vulnerability matrix' that aligns relative vulnerability with forward-looking goals and strategies Create a list of example actions to implement each climate adaptation strategy





Ask us questions. Ask us to replicate this tool for your work. Tell us how you've used it.

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Learn more: www.cakex.org/virtual-library/three-step-decision-supportframework-climate-adaptation-selecting-climate-informed