Colorado Bureau of Land Management

MODELING FISH HABITAT RESPONSE TO SUPPORT CLIMATE ADAPTATION STRATEGIES

SUMMARY OF FINDINGS

Overview

In 2015, the Colorado Natural Heritage Program (CNHP) completed a statewide vulnerability assessment for Colorado BLM. In that assessment, we determined that, as a group, native fish are by far the most vulnerable of the animal species we assessed (CNHP 2015). Our next goal was to conduct additional analyses on the highest priority species to lay the groundwork for development of adaptation strategies.

In collaboration with BLM fisheries biologists, we identified two key information needs: a means of determining *where* fisheries projects would most likely be successful over the long term, and a way to evaluate potential fisheries projects through a climate lens. Though both cold-water and warm-water species are vulnerable to impacts from climate change, BLM fisheries managers highlighted the particular need for cold-water fisheries (including native and sport species) management decisions in the near term. Given this, we defined target species for additional assessment as:

- Cutthroat trout (*Oncorhynchus clarkii*)
- Rainbow trout (*Oncorhynchus mykiss*)
- Brook trout (*Salvelinus fontinalis*)
- Brown trout (*Salmo trutta*)
- Bluehead sucker (*Catostomus discobolus*)
- Mountain whitefish (*Prosopium williamsoni*)

Future Habitat Suitability Models

To address the first information need, we built upon existing methods originally developed by Isaak and others (e.g., Climate Shield, NorWeST) to model future habitat suitability in Colorado on a mid-Century (2040) timeframe for our target species.

We used existing data sources for stream flow, slope, and water temperature requirements of each species as basic criteria for habitat suitability inputs, following the generalized flow diagram depicted in Figure 1. Micro-scale habitat requirements (e.g., pools and riffles), other measures of water quality, and interactions among fish species could not be addressed with available input data, so these factors could not be represented in the models. Also, known limitations exist with input datasets, which are themselves models based on a limited number of gauges across the state. Though known errors exist, the models can be used to make general determinations on where habitat improvement projects may be most appropriate. Results of this modeling exercise are shown in Figures 2-8. See Fink et al. (2019) for details on data inputs and technical methods, available at www.cnhp.colostate.edu.

Evaluation Framework for Fisheries Projects

As management and conservation resources are limited and needs are great, it is crucial to leverage previous work whenever possible. In 2016, Nelson et al. developed a decision support framework specifically for purposes compatible with our second information need: a way to evaluate management goals and strategies for fisheries within the context of climate change. Their work, which focused on native salmonids (cold-water species) in the northern Rocky Mountains, resulted in a three-

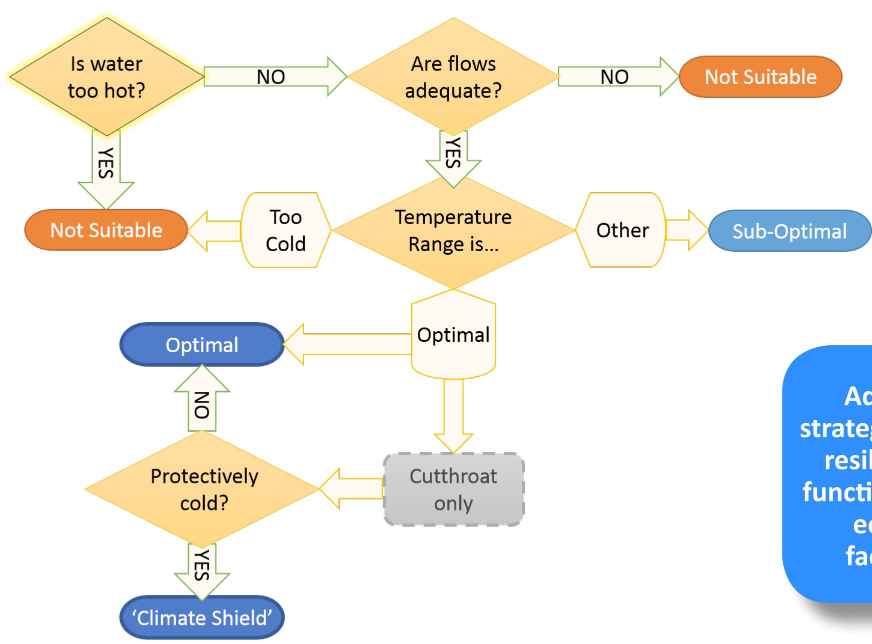


Figure 1. Decision tree (simplified) used to apply temperature and flows criteria.

Adaptation = management strategies that promote ecological resilience, maintain ecological function, and support sustainable ecosystem services in the face of a changing climate.

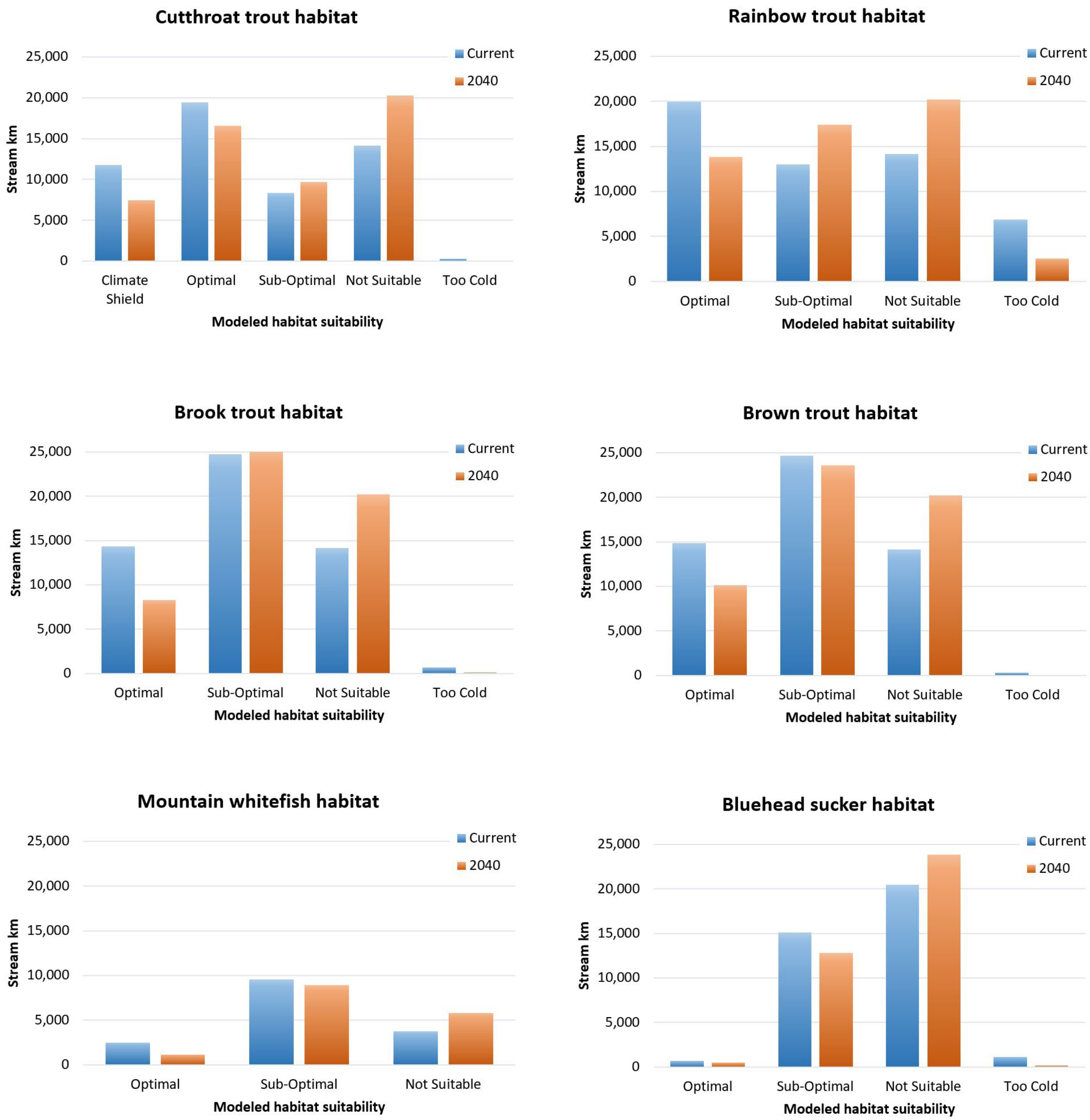
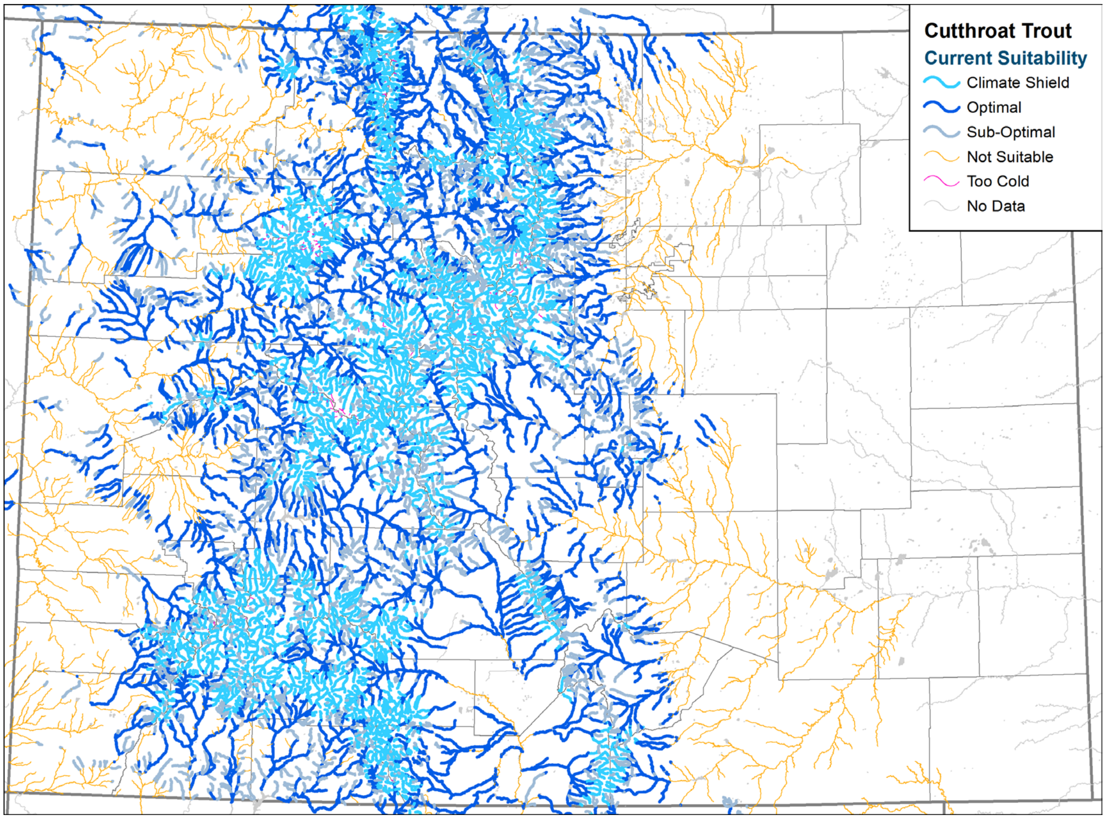


Figure 2. Model results showing comparison of current and future habitat suitability in terms of stream kilometers. The "Climate Shield" category for cutthroat trout is water cold enough to minimize invasion of, and hybridization with, other trout species (Isaak et al. 2012). The "Too Cold" category refers to water that is too cold for reproduction, not necessarily survival of individuals. Amount of optimal habitat is reduced for all species by 2040.



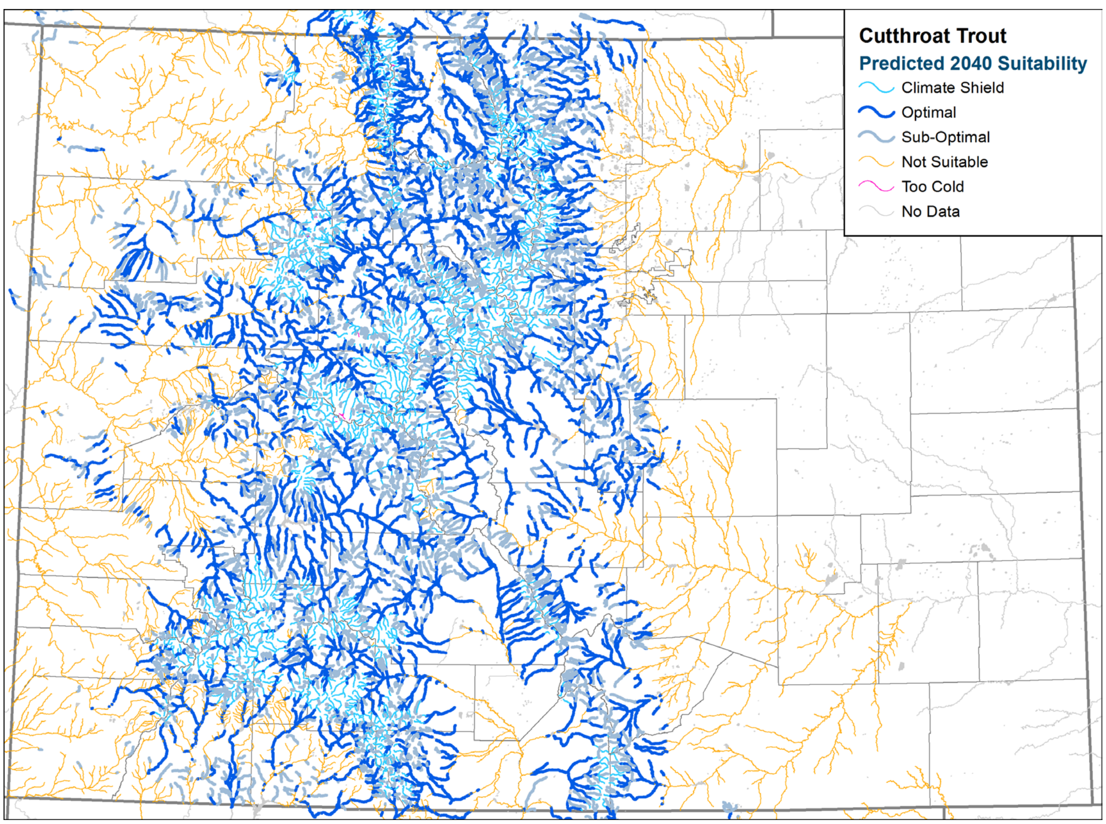
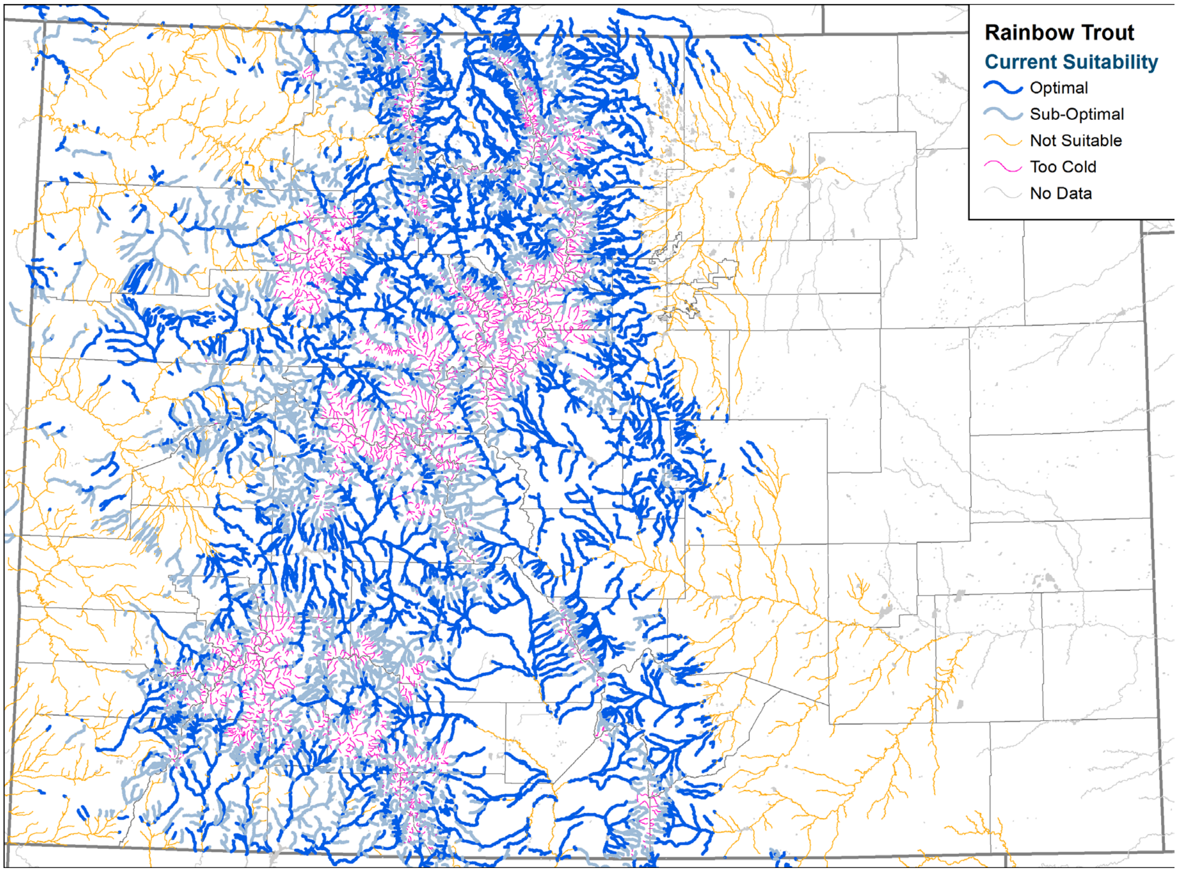


Figure 3. Modeled current (top) and future (bottom) habitat suitability for cutthroat trout in Colorado. See Isaak et al. (2012) for additional information on Climate Shield. Limitations in underlying flows data can be seen in the cutthroat models, where the Dolores River drainage modeled as Not Suitable though it is known to support this species.



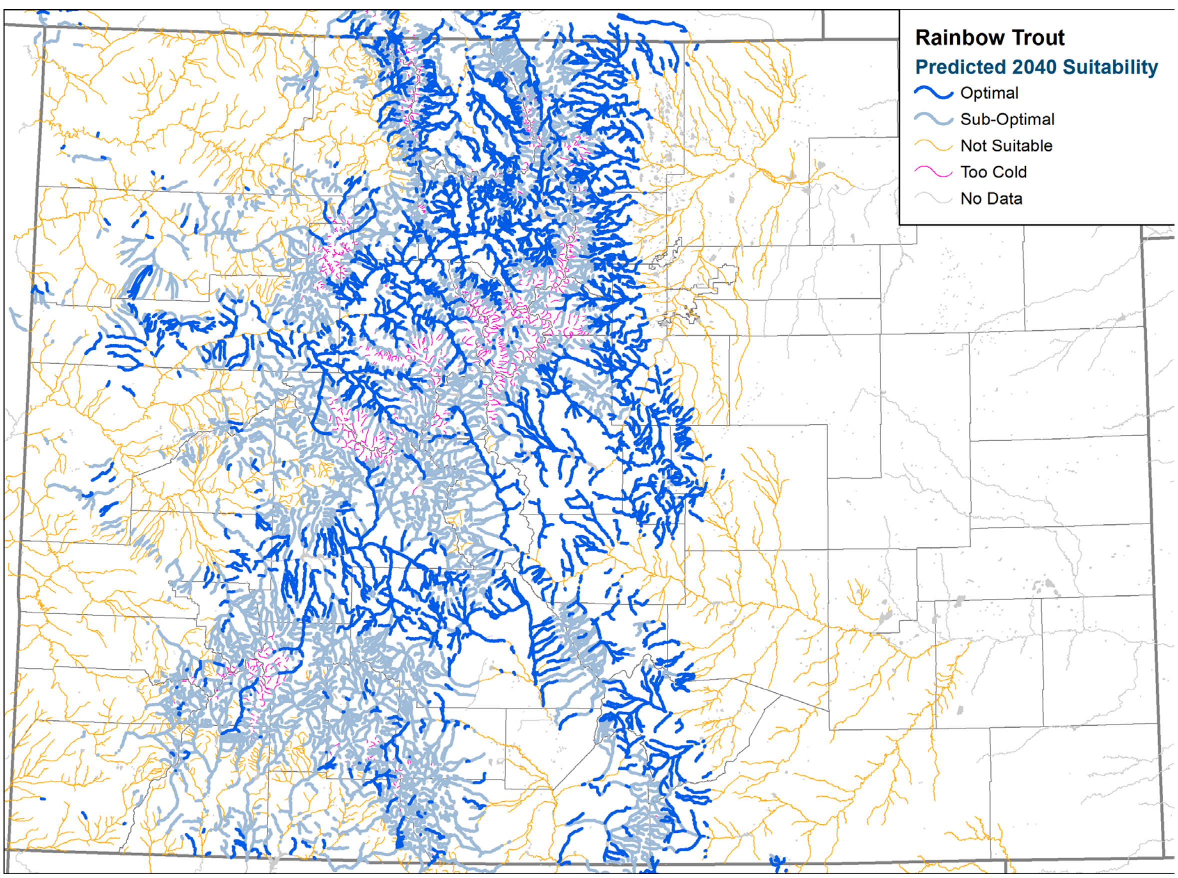


Figure 4. Modeled current (top) and future (bottom) habitat suitability for rainbow trout in Colorado.

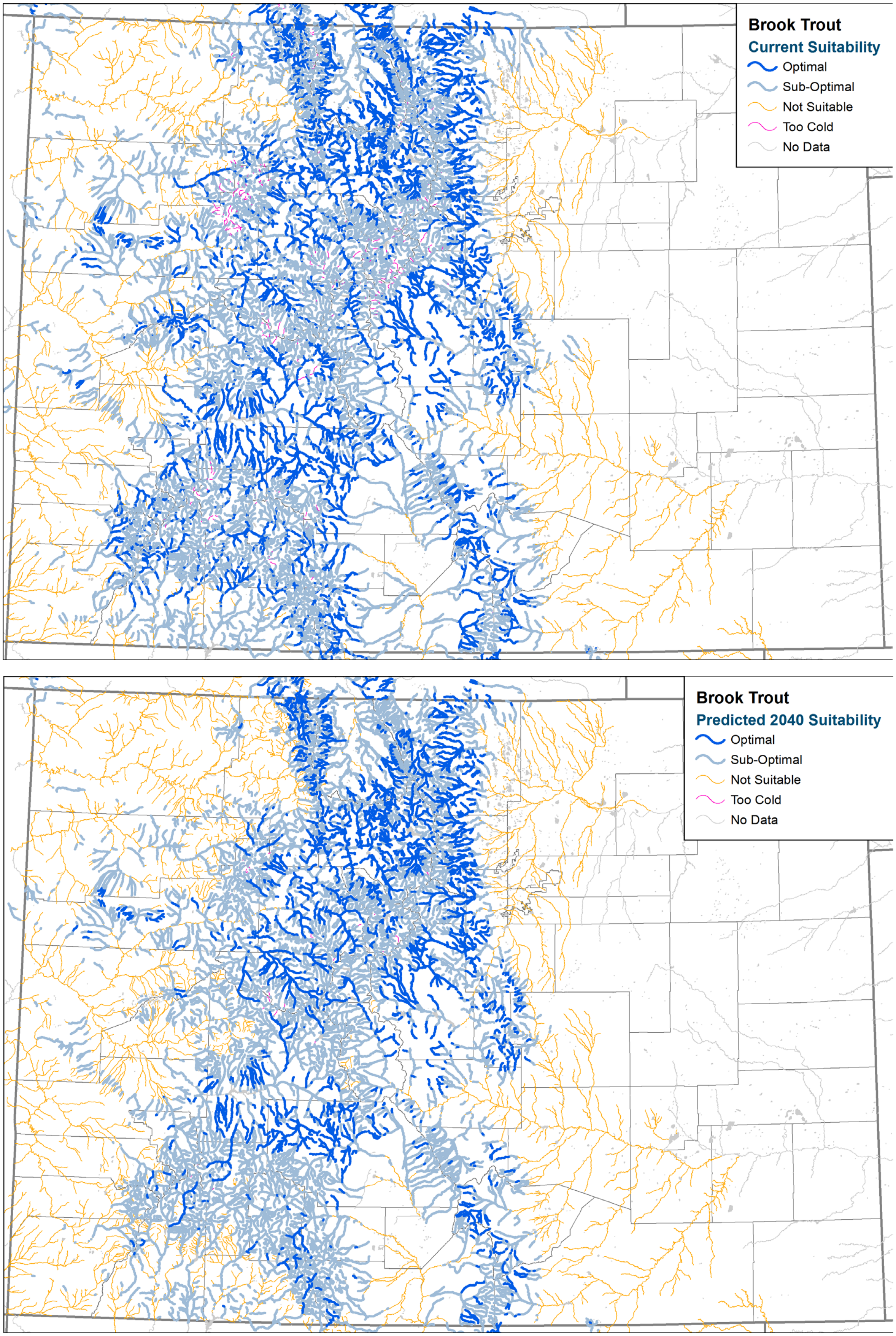
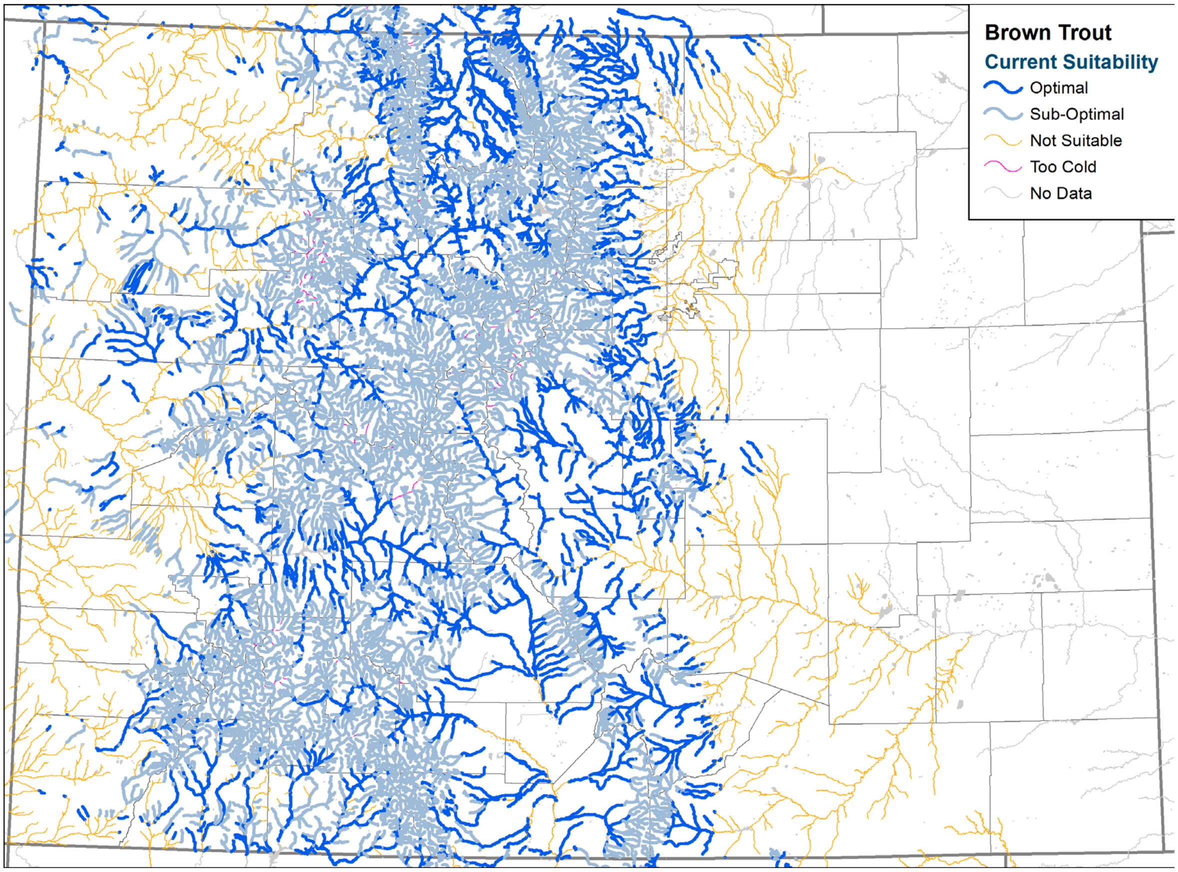


Figure 5. Modeled current (top) and future (bottom) habitat suitability for brook trout in Colorado.



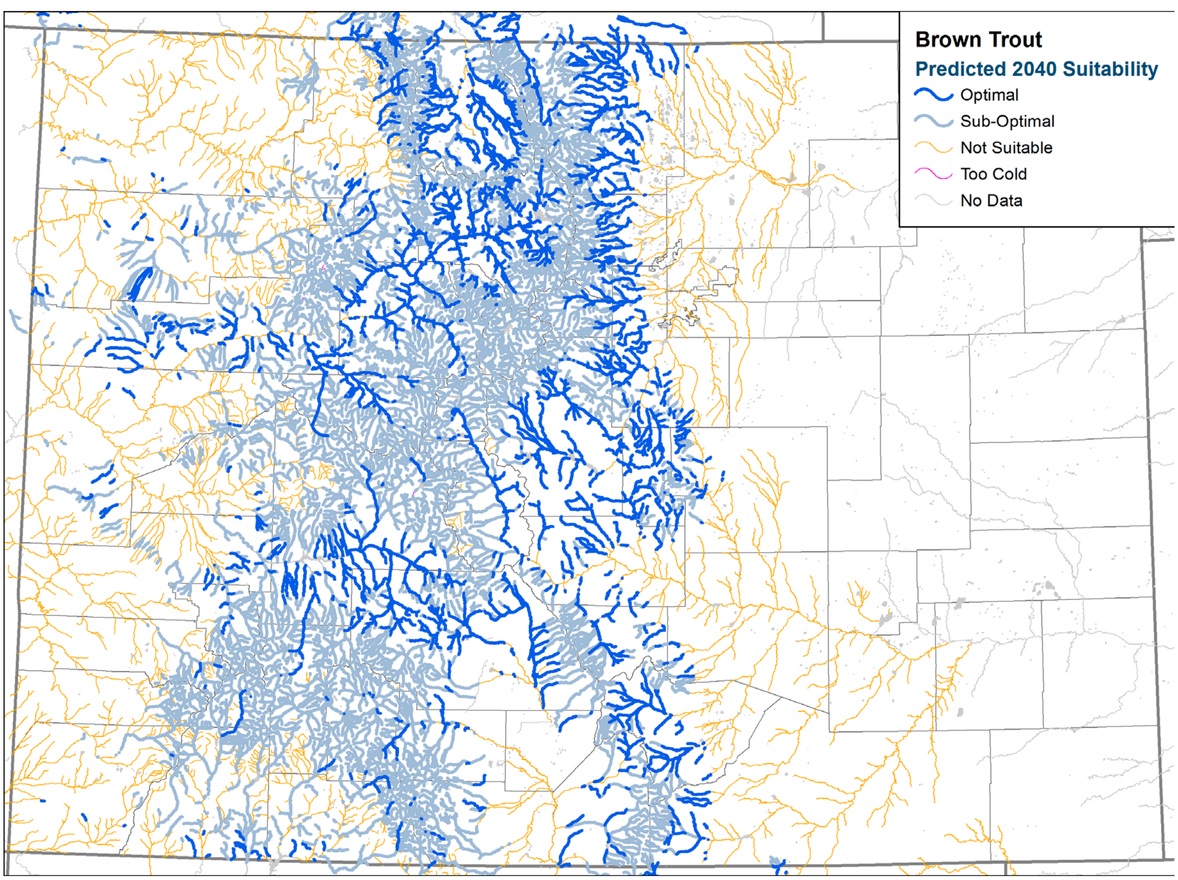


Figure 6. Modeled current (top) and future (bottom) habitat suitability for brown trout in Colorado.

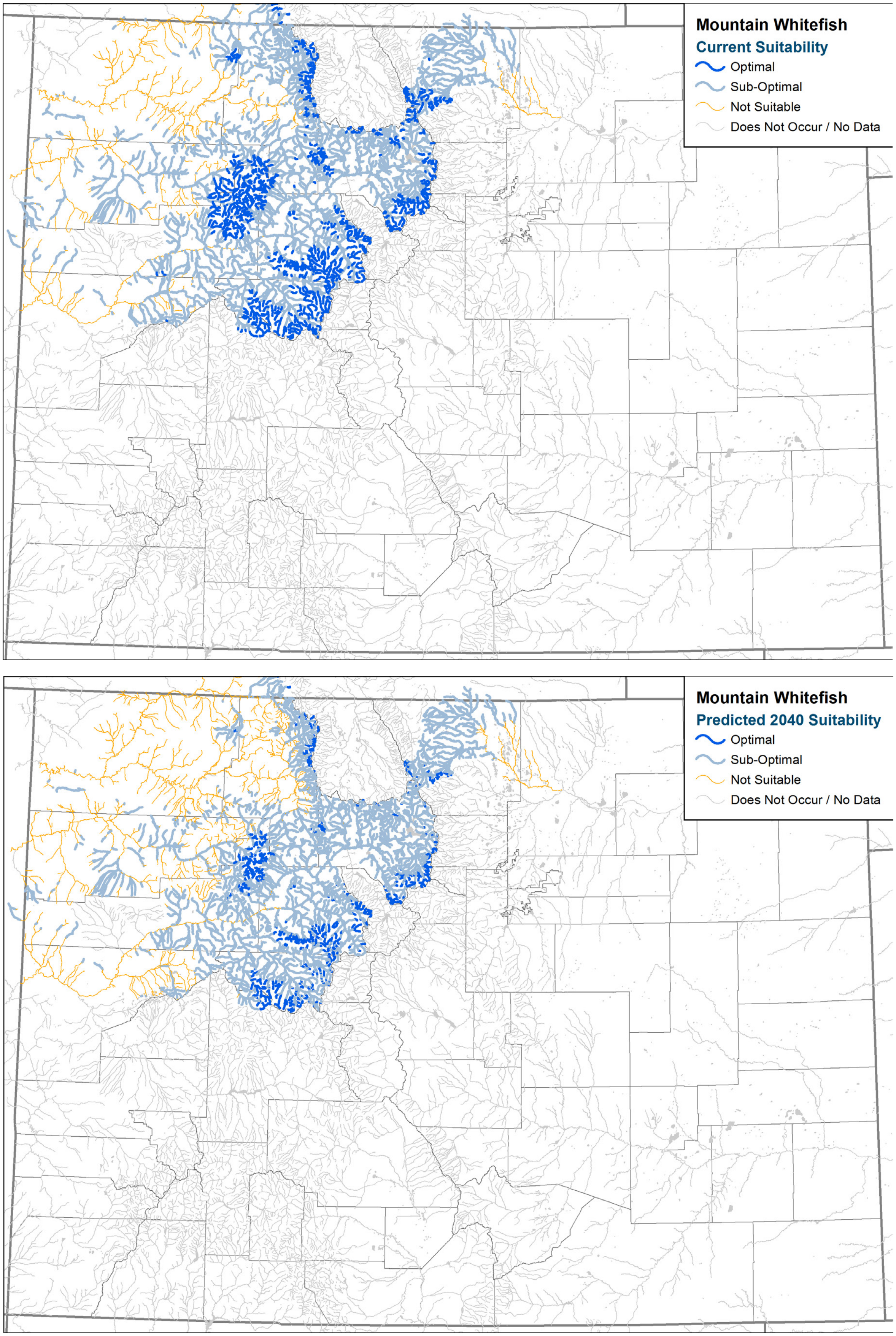


Figure 7. Modeled current (top) and future (bottom) habitat suitability for mountain whitefish in Colorado.

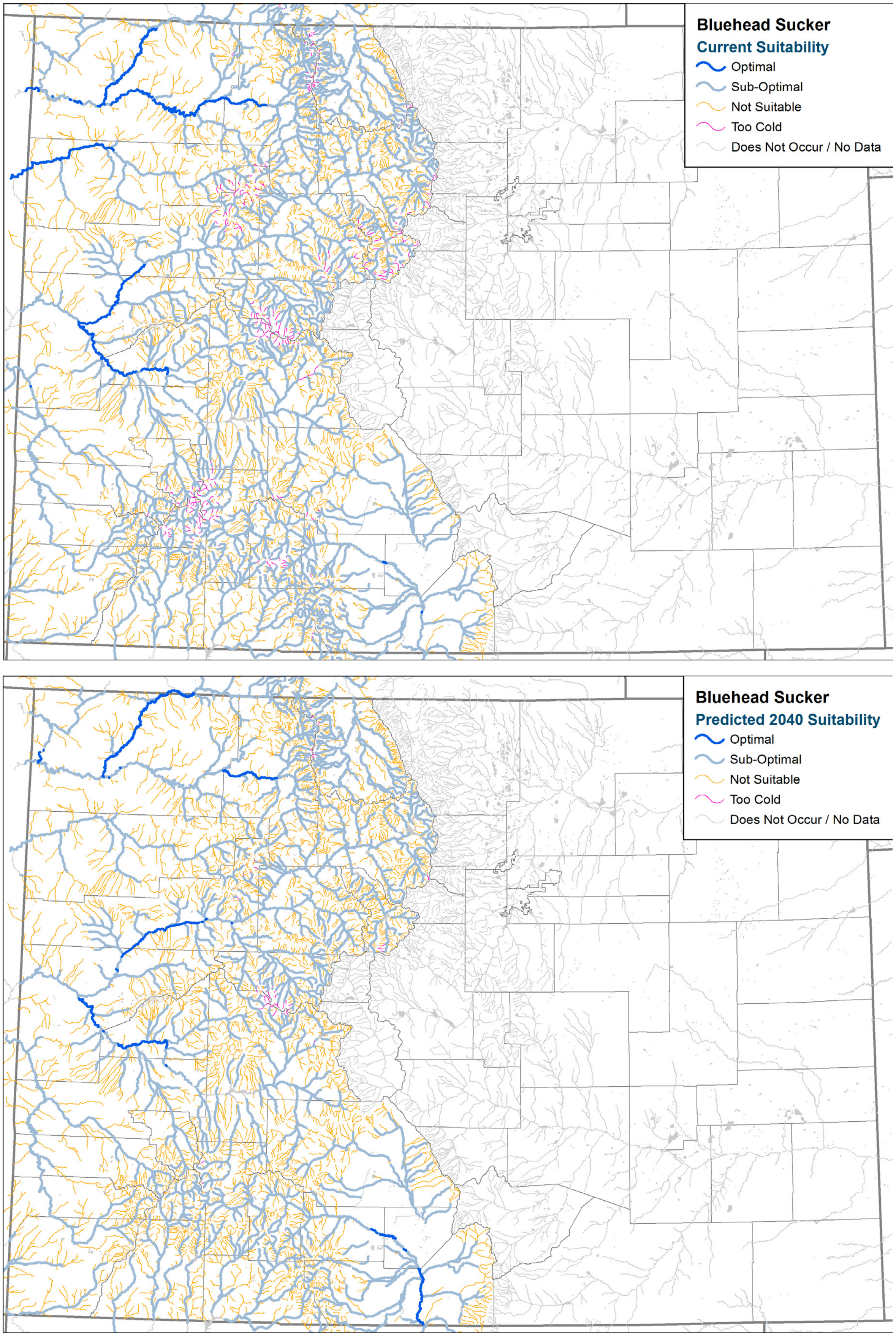


Figure 8. Modeled current (top) and future (bottom) habitat suitability for bluehead sucker in Colorado.

step matrix that considers key vulnerabilities (habitat suitability, threats from non-native fish, and connectivity) and aligns those with options for management goals and implementation strategies.

The BLM fisheries managers agreed that Nelson et al.'s framework offered an excellent tool for assessing vulnerability and documenting decision rationale, since the basic data and assumptions behind the framework are correct and relevant to Colorado cold-water fisheries. One key disconnect, however, is the treatment of non-native sport fish. In Nelson et al.'s framework, non-native species are (correctly) treated as one of the key vulnerabilities for native salmonids, based on the considerable potential for conflict related to hybridization and competition among the species. However, a reality of multiple-use resource management is the need to find balance between conservation needs of native species, and social / economic benefits of non-native sport fisheries. Thus, we adapted the language in Nelson et al.'s framework to reflect this multiple-use management need, but otherwise maintained the framework as originally developed. See Nelson et al. (2012) and Fink et al. (2019) for additional information.

STEP ONE in Climate Adaptation Decision Support Framework, modified from Nelson et al. 2016.

Key Factor of Vulnerability	**HABITAT SUITABILITY** To what extent will climate change alter habitat suitability for the population?	**THREATS FROM UNDESIRABLE FISH** To what extent will climate change increase the threat that undesirable 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 undesirable fish currently present? • If undesirable fish are currently present, might climate change alter the influence of undesirable fish on desirable fish (e.g., via hybridization, competition, predation)? • If undesirable 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)?
Assess Vulnerabilities	Considering your answers above, choose the most appropriate level of vulnerability of the population to climate change effects on habitat suitability: A -Habitat likely to remain or become suitable B - Habitat likely to become marginal (i.e., at or near thresholds for focal species) C - Habitat likely to become unsuitable	Considering your answers above, choose the most appropriate level of vulnerability of the population to climate change effects on undesirable fish: D - Threats from undesirable fish likely to be low E - Threats from undesirable fish likely to be high (because already present or likely to increase)	Considering your answers above, choose the most appropriate level of vulnerability of the population to climate change effects on connectivity: F - Population likely to be connected to a larger network G - Population likely to remain or become isolated

If you answered:	Go to Box:	If you answered:	Go to Box:	If you answered:	Go to Box:
A D F	1	B D F	2	C D F	3
A E F	4	B E F	5	C E F	6
A D G	7	B D G	8	C D G	9
A E G	10	B E G	11	C E G	12

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