Ecosystems and Species

Kaylee Carr[1] and Jeffrey A. Hicke[2]

[1]Undergraduate Researcher, College of Natural Resources, University of Idaho
[2]Professor, Department of Geology and Geological Sciences, College of Science, University of Idaho

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Overview

Ecosystems and species not covered in depth by other reports within the Idaho Climate-Economy Impacts Assessment were assessed for climate change impacts.

Idaho's ecosystems can be characterized in different ways, including a) resilience, a measure of human modification, diversity of microclimates, and ecological representativeness; b) connectivity and climate flow; and c) biodiversity value. Much of Idaho is considered resilient, with ecosystems that are connected, allow movement of species, and recognized for biodiversity value. Agricultural and urban areas in northern and southern Idaho are designated least resilient, less connected, and of less significance in terms of biodiversity value. Areas of biodiversity value within Idaho do not always overlap areas of climate resilience, which means adaptation options will help support and facilitate continued biodiversity.

Most ecosystems are addressed elsewhere in the assessment; here we cover alpine ecosystems (i.e., locations above treeline). Climate change is expected to facilitate upward movement of treeline, thereby reducing alpine area. Some evidence for this upslope movement exists, but in some areas, movement is slower than predicted.

Many Idaho species are covered in other assessment reports. This supplemental report focuses on significant species that may be impacted by climate change. Multiple plant and animal species, including those important to tribal communities, are expected to be impacted by climate change from warming, loss of snowpack, and shifting habitat. Some species will experience range shifts in response to climate change, either upward in elevation or northward in latitude.

1. Assessment of Idaho's ecosystems for climate-resilient locations

One way to evaluate species and ecosystem responses to climate change is to look at characteristics of ecosystems. The Nature Conservancy[1] evaluated locations across the US using three major characteristics: resilient sites, connectivity and climate flow, and recognized biodiversity value (Anderson et al., 2014; The Nature Conservancy, 2020).

[1] Including researchers from state and federal agencies, universities, nonprofits, and inter-governmental entities.

A resilient site is defined as an area that has experienced little human modification, has a diversity of linked (not fragmented) microclimates, and is an ecologically representative site (The Nature Conservancy, 2020). An area that is more resilient will be less affected by future climate change.

Idaho locations have different levels of resilience (Figure 1). The most resilient land is in mountainous regions, such as the Rocky Mountains and Owyhee Mountains. These areas have less human development and less human interaction compared to other locations in Idaho. The mountainous regions allow range shifts of species upslope, which can facilitate species adaptation to climate change. However, this does not apply to species already located at the top of mountainous regions; these species may be locally extirpated as conditions become too warm and if no upslope area exists for range shift.

Idaho's areas that are least resilient are also the areas that are the most developed by humans, either by urban development or by other human modifications, such as agriculture. These areas include parts of the Snake River Plain, other agriculture-intensive areas, and areas heavily influenced by human disturbances. Natural sagebrush ecosystems have been declining for many years due to human development (Aldridge et al., 2008).

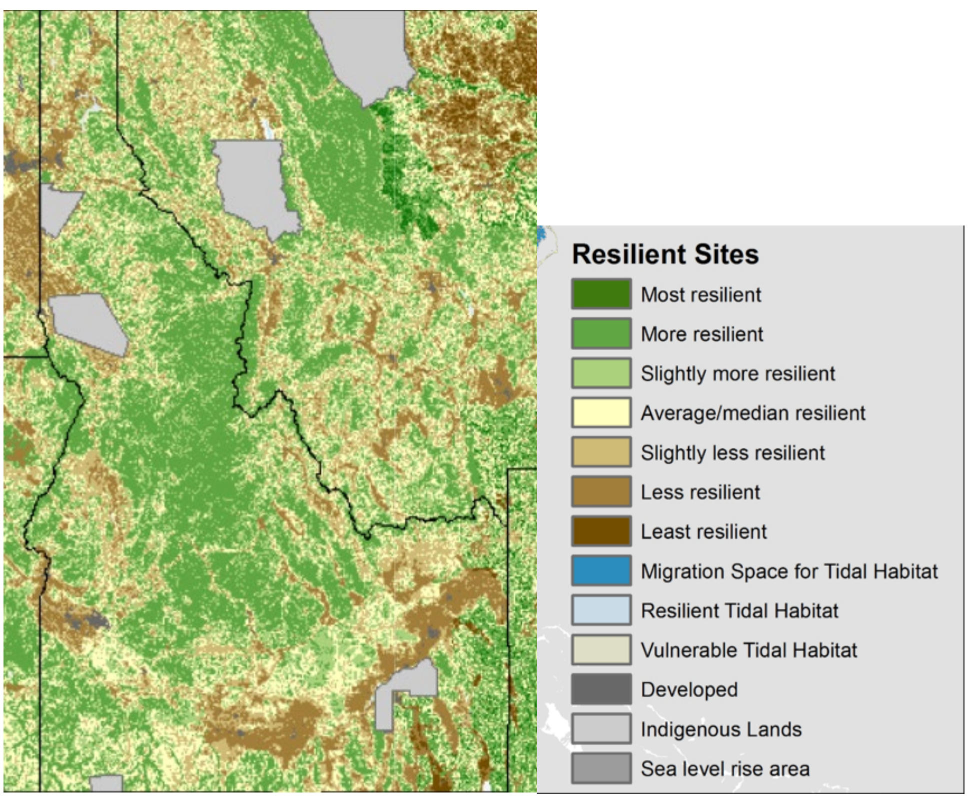

Figure 1. Climate resilient sites: ecologically representative sites with a diversity of connected microclimates and low human modification (The Nature Conservancy, 2020).

Connectivity and climate flow describes the potential for species movement across locations and climate gradients in response to climate change. This characteristic was determined using anthropogenic resistance (resistance to movement caused by human modification) and climatic gradients (upslope, northward, and riparian) (The Nature Conservancy, 2020). Locations were defined as either diffuse or concentrated. Diffuse flow refers to areas of land that have intact ecosystems and facilitate high levels of dispersed flow of species that allows for many different pathways (The Nature Conservancy, 2020). Keeping locations with diffuse flow intact will allow species to shift their ranges in response to climate change. Concentrated flow refers to locations where the flow of different species is limited through a narrow area that reduces connectivity. Because areas with concentrated flow are important to maintaining flow across a larger network, these locations are ideal places for land conservation strategies (The Nature Conservancy, 2020).

A majority of Idaho has high or climate-informed diffuse flow, thereby allowing species movement (Figure 2). Small areas, mainly in locations that are heavily developed by humans, have concentrated flow. Land conservation strategies in these locations would facilitate species movement in response to climate change.

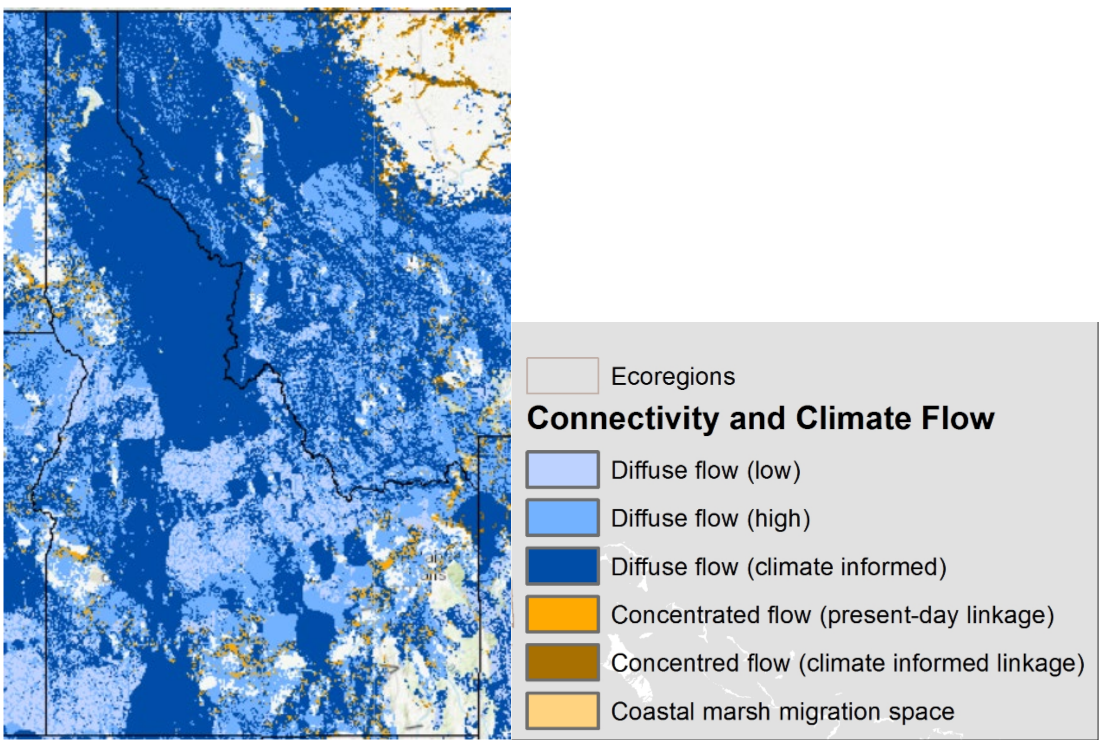

Figure 2. Connectivity and climate flow: linkages that allow species to move across sites and climate gradients (The Nature Conservancy, 2020).

The Nature Conservancy gathered data that pertained to biodiversity value based on rare species, intact habitat, and exemplary natural communities from different wildlife action plans, the Natural Heritage Network, and studies conducted over a ten-year period (The Nature Conservancy, 2020). Protecting locations with recognized biodiversity value can minimize future biodiversity loss from climate change.

As for the other characteristics, a majority of the locations that have recognized biodiversity value are within wilderness or other protected areas, such as the Rocky Mountains and Owyhee Mountains (Figure 3). These locations are less impacted by human modifications, such as urban or agriculture development; therefore, the habitat is more intact.

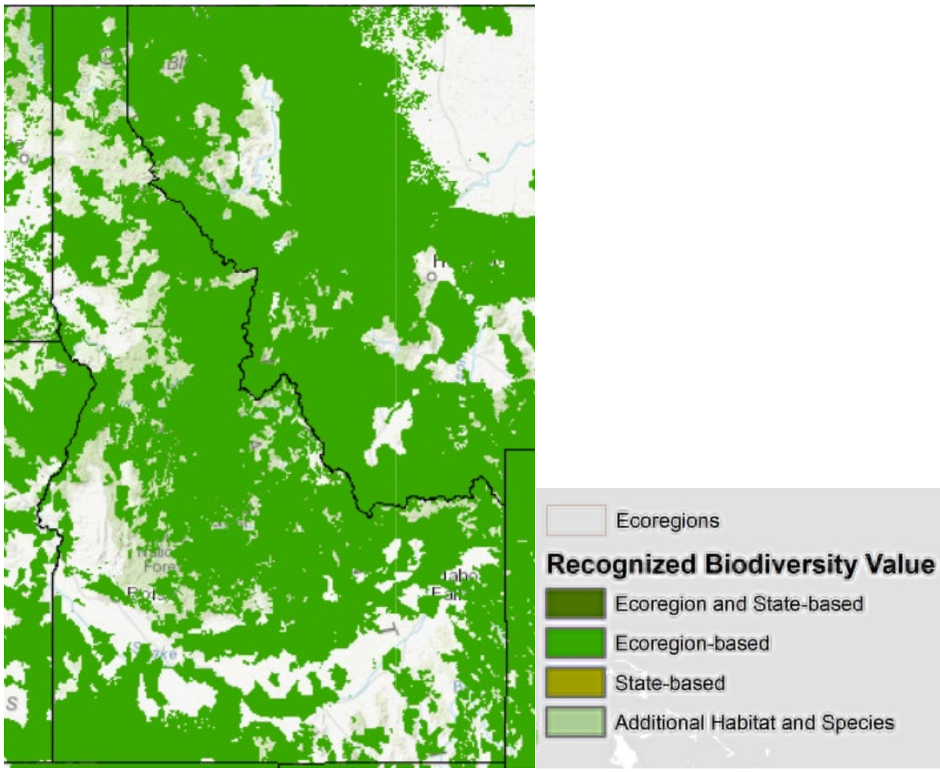

Figure 3. Recognized biodiversity value: places with intact habitats, rare species, or exemplary communities (The Nature Conservancy, 2020).

Considering these ecosystem characteristics, many locations in Idaho will facilitate species' and ecosystems' adaptive responses to climate change. The mountains of central and southwestern Idaho, in particular, have low amounts of human modification, include a diversity of microclimates, are connected with other regions with minimal human disturbance, and are recognized for their biodiversity value. Other locations, particularly along the Snake River Plain, are valued for their biodiversity or connectivity, but are less resilient because of human modifications.

2. Alpine ecosystems

An alpine ecosystem typically is defined as area above treeline in mountainous regions, such as the Rocky Mountains in Idaho. These ecosystems are naturally cold, windy, and snowy, as they typically reside at the highest elevations (Rundel and Millar, 2016). Plants that live in these environments are smaller and close to the ground. They are adapted to a short growing season, strong winds, and poor soil nutrients (Rundel and Millar, 2016). Animals that live in this region are adapted to the cold and are most often warm-blooded animals or insects. These ecosystems have unique biodiversity due to the isolated and harsh environment (Chardonnet et al., 2002).

Climate change will have many effects on the alpine ecosystem (Seastedt and Oldfather, 2021), including increased temperature, reduced snowpack from warming, changes in precipitation, and retreat of glaciers. Decreased snow cover and the retreat of glaciers will affect alpine soils through altered soil composition, processes, types, and erosion (Chersich et al., 2015). Increased atmospheric carbon dioxide may lead to an increase of net primary productivity in alpine ecosystems (Gao et al., 2016), although other studies suggest no benefit (Seastedt and Oldfather, 2021). The variety of microhabitats (slope, aspect, wind) within alpine ecosystems and myriad factors affecting alpine species besides warming (snowpack, moisture, human activities, such as livestock grazing) suggest variability in responses among species and locations (Seastedt and Oldfather, 2021).

A major effect of climate change on alpine ecosystems is a decrease in area from upslope encroachment of trees. The leading (highest elevation) edge of the treeline is expected to shift upward in response to warming as tree species strive to stay within their preferred temperature niche (Hansson et al., 2021). The movement thus far has been documented to be slower than was previously predicted (Davis et al., 2020); however, there is evidence that treelines are steadily moving upwards in elevation in some locations. In the nearby Canadian Rockies, repeat photographs have documented upslope movement over the past one hundred years (Figure 4), and this trend is expected to continue throughout the 21st century as temperatures and carbon dioxide levels increase (Trant et al., 2020). Some alpine areas may be in danger of extirpation with continued climate change; eventually, there will be no additional upslope to accommodate species shift, although there is uncertainty about the rate of change (Seastedt and Oldfather, 2021).

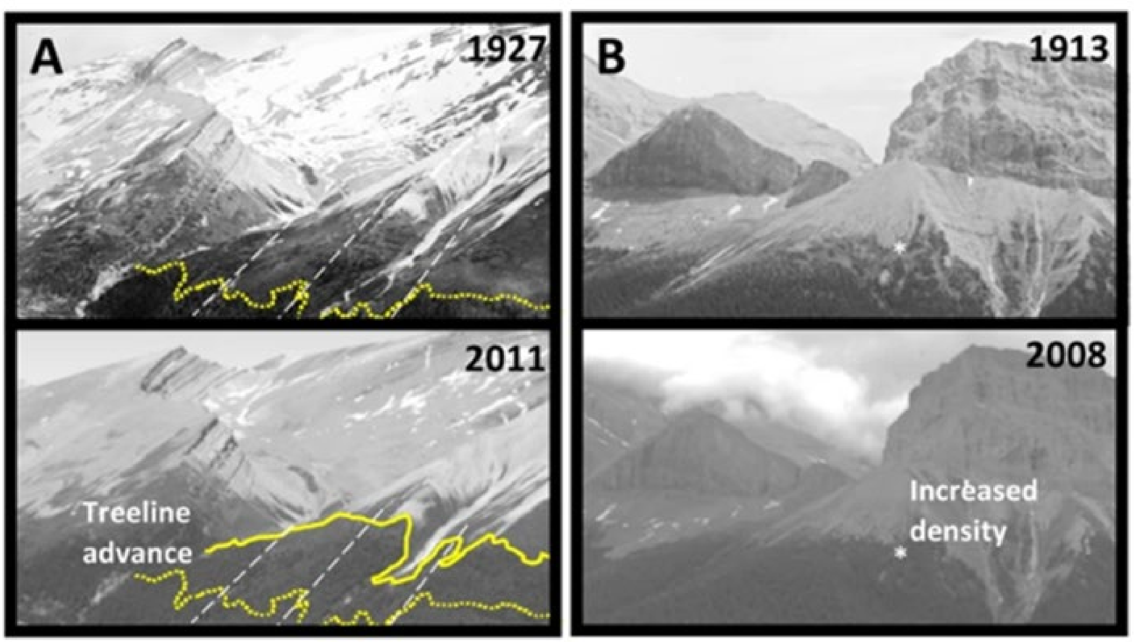

Figure 4. Repeat photographs from the Canadian Rocky Mountains showing upslope advance of the forest into the alpine ecosystem (Trant et al., 2020). They illustrate (A) treeline advance and (B) increased density of the forest at the leading edge of the forest.

3. Species' responses to climate change in Idaho

Here we discuss how climate change will affect plant and animal species of significance. The term significance is used to signify cultural, economic, aesthetic, and/or ecological importance. We describe climate change impacts on several animal species that are significant to Idaho by consulting with colleagues and by reading existing publications. We also discuss two plant species significant to local tribes.

Climate velocity is the speed and direction at which current climates will move across landscapes in response to future climate change. Globally, many species may be challenged to shift their ranges fast enough to keep up with climate velocity (tracking their current climates), potentially leading to declines in abundance or extirpation (IPCC, 2014). Mountainous regions have lower climate velocity than flat areas because of the additional cooling provided by upslope movement. Idaho and western North America have relatively low climate velocities because of the mountainous terrain (Loarie et al., 2009). Thus, species may have less difficulty shifting their ranges in Idaho in response to climate change compared with other locations.

3.1 Mammals

3.1.1 American Beaver

The American beaver (*Castor canadensis*) provides an important natural disturbance because of its capability to alter habitat dynamics by cutting down trees and building dams (Labrecque-Foy et al., 2020). The range of the American beaver extends throughout the majority of North America, and their preferred habitat includes woody wetlands with shrubland coverage (Francis et al., 2017). Their range is expected to shift modestly upward by the midcentury as climate change warms temperature, and their density in population is expected to increase at the center of their range (not the edges) (Jarema et al., 2008).

Recent studies of beavers and climate change have investigated the possibility of reintroducing more beavers as an adaptation measure for reducing the effects of climate change (Baldwin, 2017). With climate change expected to cause earlier snowmelt and reduce snowpack and summer precipitation, streamflows are expected decline in the dry season (Baldwin, 2017). Beavers are animals that typically increase water storage in ponds and flood plains, as well as restore meadows and riparian habitat through their dams and resulting ponds (Dittbrenner et al., 2018). Therefore, increasing beaver populations could help address habitat concerns and expand water availability within places where beavers reside.

3.1.2 American Pika

The American pika (*Ochotona princeps*) is a small and herbivorous lagomorph that is well adapted to alpine climates, and lives within rocky areas that exist throughout mountain ranges in North America (Millar et al., 2016). Pikas also live in low-elevation, hot environments that have cooler microhabitats, such as Craters of the Moon National Monument and Preserve in Idaho (Camp et al., 2020). Their physiology and metabolic system, which allow them to thrive in cold alpine weather, make pikas sensitive to high temperatures (Macarthur and Wang, 1973; Sheafor, 2003). For this reason, pikas may be highly susceptible to climate change.

Like many other species, the pika's preferred habitat is moving further north and higher in elevation due to climate change. However, because it typically lives in alpine regions, the pika has more of a geographic constraint than lower-elevation species (Erb et al., 2011). Recently, there has been evidence of the role of climate in influencing pika populations and distribution (Erb et al., 2011; Beever et al., 2016). The influence of climate change on pikas is under debate, however (Smith, 2020), in part because of the pika's ability to alter its behavior and habitat characteristics (Millar et al., 2016).

3.1.3 Northern Bog Lemming

The northern bog lemming (*Synaptomys borealis*) typically resides in bogs, wet meadows, or fens with leafy overstory (DuBois, 2016). Its range extends across much of northern boreal America (DuBois, 2016). These animals rely on moist habitats to survive; therefore, future climate change and the resulting warming and drier conditions may pose challenges for these mammals (Layser and Burke, 1973). Further research is needed to fully understand the effects that climate change will have on northern bog lemmings.

3.1.4 Wolverine

The wolverine (*Gulo gulo*) is the largest terrestrial mustelid (Banci, 1994), with a range mainly within the northern forests and mountain ranges of North America and Eurasia. It has been found as far south as California and Colorado; however, within these locations, its abundance is much lower (Banci, 1994). In Idaho, wolverines have been spotted across almost the entire state with the exception of southwest Idaho, but mainly reside within high-elevation mountain ranges (Lukacs et al., 2020).

Wolverines are dependent on snowpack for their habitat. They have a reproductive denning period that can last until May 15 in a typical year, and they rely on snowpack persisting throughout that time for increased survival (Barsugli et al., 2020). Snowpack is expected to decline in the coming century in the western US (McKelvey et al., 2011). Many snowpack areas will become smaller and less connected, which, in turn, will shrink the habitat for the wolverine. If climate change continues to raise temperatures and increase snowmelt, then the wolverine's habitat may shrink even further (Brodie and Post, 2010). As the climate continues to change, and temperatures increase, their range is expected to shift further north and higher in elevation (Lukacs et al., 2020).

3.2 Birds

3.2.1 American Dipper

The American dipper (*Cinclus mexicanus)* is a semi-aquatic bird that is found year-round in mountainous watersheds across the western US (Sullivan and Vierling, 2012). They eat aquatic macroinvertebrate larvae and small fish, and they play a role in the structure of the streams in which they reside (Sullivan and Vierling, 2012); the structure of riparian environments is a key place to monitor climate change effects (Sæther et al., 2000). Dippers thrive in warmer temperatures, especially milder winters, and studies suggest that warmer temperatures may lead to an increase in carrying capacity for these birds (Sæther et al., 2000).

3.2.2 Greater Sage-Grouse

The greater sage-grouse (*Centrocercus urophasianus*) is the largest of the grouse family, and resides naturally in a habitat that consists of mainly sagebrush (Knick et al., 2013). Its range once included much of western North America, but has been reduced by about one-half since American industrialization, mainly due to habitat loss and human disturbance (Aldridge et al., 2008).

Determining the impacts of climate change on the greater sage-grouse can be difficult because this species is affected by a wide variety of human disturbances (most notably habitat loss). Climate change (warming) is expected to the increase wildfires in the western US, and cause losses of sagebrush steppe (Creutzburg et al., 2015), resulting in negative effects on greater sage-grouse habitat and therefore on bird populations (Creutzburg et al., 2015).

Rising temperatures also increase the spread of viruses, such as the West Nile virus (Schrag et al., 2011), which poses a risk to the greater sage-grouse. The risk of West Nile virus transmission in states near Idaho (Wyoming and Montana) is expected to increase as a result of future climate change (Schrag et al., 2011).

3.3 Amphibians

3.3.1 Columbia Spotted Frog

The Columbia spotted frog (*Rana luteiventris*) is an amphibian that resides mainly in mountain ponds throughout the northwestern US, and prefers moist, mild climates (Welch and MacMahon, 2005). The effects of climate change on these spotted frogs are unclear, as some studies report a benefit with increased climate change and others report adverse effects. In Montana, milder winters have led to an increase in the vitality and reproduction of the spotted frog (McCaffery and Maxell, 2010). However, it has also been suggested that increased temperatures and drought will decrease the size of montane ponds, which will significantly decrease the size of suitable habitat, which is already small (Arkle and Pilliod, 2015). Another possible effect of climate change is the spread of diseases, such as amphibian chytridiomycosis (Lips et al., 2008), which is very harmful and possibly deadly to amphibians, including the Columbia spotted frog.

3.4 Plants

3.4.1 Huckleberry

The huckleberry (*Vaccinium membranaceum*) is a critical food source for many species in North America, such as the grizzly bear (*Ursus arctos*), and also plays an important cultural role, especially in Indigenous cultures (Shores et al., 2019). These plants grow on subalpine slopes and in forests, bogs, and lake basins. They are an understory species, and rely on taller trees to shade them from the hot afternoon sun (Holden et al., 2012). Plant productivity is highest during cooler springs that are coupled with higher July temperatures (Holden et al., 2012). Climate change is expected to affect both the growing season and range for the huckleberry (Prevéy et al. 2020). Major impacts include habitat reduction along the drier and lower elevation parts of the present range, flowering and fruiting times advancing almost a month by 2100, and changing trophic relationships with other species (Prevéy et al., 2020).

3.4.2 Camas

Camas (*Camassia quamash*) is a perennial herb native to the northwestern US. It is predominately known for its importance to Indigenous tribes as a food source (Tomimatsu et al., 2009). It was once very widespread, but human development and agriculture have encroached on natural camas fields in recent years (Davis, 2018). The effects of climate change on the camas plants are largely unknown. Camas requires a significant amount water to grow, which means decreased summer precipitation (as projected in Idaho) could lead to decreases in population (Davis, 2018).

4. Impacts of species and ecosystems on Idaho's economy and adaptation opportunities

4.1 Impacts on Idaho's Economy

The species and ecosystems discussed in this report have impacts on Idaho's economy. These species and ecosystems provide opportunities for recreation through multiple activities that include recreation broadly, wildlife viewing, hiking, and camping (Hand and Lawson, 2018). They also provide various ecosystem services, including food products, cultural significance, and aesthetic values from scenery (Hand and Lawson, 2018; Warziniack et al., 2018).

4.2 Adaptation

Adaptation efforts are important for species, as they will have to contend with at least some degree of climate change and warming temperatures in the coming century (Moritz and Agudo, 2013). However, many different adaptation strategies can be implemented. These typically fall into the categories of land and water protection and management, direct species management, monitoring and planning, and policy (Mawdsley et al., 2009).

Most adaptation options come in the form of land and water management and protection. One strategy that falls under this umbrella is expanding the extent of protected areas. This strategy increases terrestrial and aquatic areas that are protected from anthropogenic threats other than climate change (Bruner, 2001). However, with a growing human population, expanding these protected areas to allow for more species movement might be difficult (Bruner, 2001). As the climate changes and species are expected to shift northward, they will need access to do so. To assist with species movement, another adaptation strategy is to expand the use of safe wildlife crossings across major roads, since roads can divide habitat into smaller segments and prevent movement or make movement significantly more dangerous (Lister et al., 2015). Other strategies include improving management within current protected wildlife areas and restoring ecosystem function, rather than focusing on singular species (Mawdsley et al., 2009).

Direct species management strategies are meant to help individual species adapt to climate change, rather than focusing on whole ecosystems. One of the main actions that falls under this umbrella is relocating species that are at risk of extinction (Mawdsley et al., 2009). Assisted migration can help at-risk species successfully find more suitable habitat (Adger et al., 2003); however, for many species, it is difficult to predict which locations would result in successful assisted migration (Adger et al., 2003). Other adaptation strategies include reducing pressure on species from non-climate driven sources and establishing captive populations for species that are at risk of going extinct (Mawdsley et al., 2009).

Monitoring species populations, ensuring that climate change and its effects are part of future management and adaptation plans, and reforming and enhancing public policies regarding wildlife are additional strategies (Mawdsley et al., 2009). Most legislation was written with the assumption that species and ecosystems would be more "static," with ranges that would not have to shift (Lemieux and Scott, 2005). However, as discussed, many species are expected to experience some range shift.

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