Point Blue

Integrating climate adaptation into land conservation: A climate-smart framework for land trusts

Cover photo: Childs Meadow Conservation Easement. Photo from B. R. Campos.

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Mountain Meadows. Photo from B. R. Campos.

Introduction

Land trusts across the U.S. are already experiencing and dealing with the effects of climate change to conserved lands, such as catastrophic flooding, increased wildfire risk, sea level rise, extreme heat waves, and prolonged periods of severe drought. Climate change is also threatening the persistence of conservation values and shifting the distribution of those values across the landscape (Owley 2010, 2011), with implications for where and how land trusts implement conservation.

To increase the likelihood that conservation investments persist and thrive in the face of climate change, land trusts need to proactively address and manage for climate impacts. Land trusts are well positioned to help species, ecosystems, and agricultural lands adapt to climate change through management and restoration of conserved lands and contribute to climate change mitigation and adaptation through pursuit of strategic, climate-smart land conservation projects.

The purpose of this handbook is to provide land trusts and other land conservation practitioners with a guide to integrating climate change projections and climate adaptation approaches into the process of private land conservation. This handbook focuses specifically on climate adaptation, which involves preparing for and responding to climate impacts to natural and human systems (Stein et al. 2014). Though the handbook is primarily focused on natural resources conservation and management, it does contain examples for both natural and agricultural resources; similarly, the approaches, principles, and strategies in the handbook can be directly applied to the management of both natural and working lands.

The handbook is organized into sections that reflect the steps in the private land conservation process and provides suggestions as to how climate change can be integrated into that particular step. The four topical sections include:

I. Gathering and analyzing climate projections
II. Climate-smart strategic conservation planning
III. Climate-smart acquisitions and conservation easements
IV. Climate-smart stewardship

Each section outlines a suggested climate-smart approach for that topic and discusses relevant climate adaptation principles and strategies pulled from multiple sources. The sections are designed to be standalone so that land trusts can focus on a single topic of interest if necessary, although we do recommend beginning with Section I on gathering and analyzing climate projections, which has background information relevant to future sections. The handbook also includes four appendices with additional relevant information and resources. Appendix A includes a glossary of key concepts and terms, Appendix B lists climate change resources for land trusts, and Appendix C includes a stewardship planning worksheet.

The suggested approaches, principles, strategies, and best management practices included in this handbook may help increase the resilience of conserved lands in the context of climate change and ensure land trusts fulfill their commitment to protect land in perpetuity.

Section I: Gathering and Analyzing Climate Projections

The single best way for your land trust to prepare for climate change is to become familiar with relevant climate projections for your region of focus, and understand how these projections are likely to impact the conservation values that you care about.

This section focuses on how to gather and analyze climate projections, which will inform application of the principles, processes, and strategies discussed in other sections. There are several things to consider when gathering and analyzing climate projections, including the form of the data, an understanding of the resolution and scale of the climate model under consideration, the emission scenario and model being considered, and associated uncertainties and likelihood of climate projections and vulnerabilities manifesting. This section reviews each of these considerations in turn.

Climate projections can take many forms, such as figures, raw data, species distribution models, and qualitative descriptions of expected change. A good place to start this process is with the State Climate Summaries and Regional Climate Summaries for the U.S. which both provide qualitative, written summaries of key climate projections on the state and regional level. Appendix B lists additional resources from which you can acquire climate projections.

Evaluating climate projections also requires consideration of the resolution and scale of the climate model being examined as well as the model's emissions scenario(s). Ideally, climate projections gathered should be at a resolution relevant to the scale of your project (Schmitz et al. 2015). Large-scale regional or state climate assessments can include information relevant to planning and serve as a good starting point for identifying relevant projections and vulnerabilities, although you should strive to acquire more region-specific projections when possible.

In some cases, available climate projections may be at a broader resolution than the scale of your planning process or region of focus, and may be made at longer time scales (e.g., mid- to late-century) than the temporal scope of your deliverable (e.g., stewardship plan, strategic conservation assessment). While it may be tempting to exclude climate projections and impacts as a means to cope with this uncertainty, climate projections at larger spatial and temporal scales nevertheless have important implications for finer-scale targets, such as species and ecosystems. Additionally, the large scale offered by some climate projections and species distribution models can provide a valuable perspective on how species and ecosystems may be shifting across the landscape and what new species may be coming into your region of focus.

You should also consider the climate model and representative concentration pathway (RCP) emissions scenario used to generate climate projections. Climate scientists use four RCPs for climate modeling and research, each of which describes a possible climate future based on assumptions about global socioeconomic conditions. Each RCP is considered a possible future, depending on how much greenhouse gas emissions are released in the years to come. The four RCPs (RCP2.6, RCP4.5, RCP6, and RCP8.5) are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values. Radiative forcing is the difference between the amount of sunlight absorbed by the atmosphere and

the amount of sunlight radiated back into space, with higher values indicating a stronger greenhouse effect.

Global temperature projection increases range from 1-2 degrees C by mid- century and 1-3.7 degrees C by late-century, with low projected temperature increases representing those modeled under the most moderate RCP (RCP2.6) and the high projected temperature increases representing those modeled under the "business as usual" scenario (RCP8.5). RCP4.5 is often referred to as the "mitigation" scenario, and has projections roughly equivalent to the goal set out in the Paris Climate Accords to keep warming to under 2 degrees C by late-century. However, the world is currently on track to experience the projections under the business as usual scenario (RCP8.5).

We recommend considering projections from both the business as usual scenario (RCP8.5) as well as the mitigation scenario (RCP4.5). We also recommend considering the projections from several different climate models in situations where the models differ in the projected direction of change. For example, some climate models for the state of California project increased precipitation, while others project decreased precipitation. It is important to consider multiple plausible futures in order to build strategies robust to uncertainty (Stein et al. 2014).

This leads to another important consideration, which is the need to understand the uncertainties associated with given climate projections as well as the likelihood of a climate projection and/or associated climate vulnerability manifesting. Some climate projections for your region may have more certainty associated with them (e.g., increased wildfire) than others (e.g., direction of precipitation). Rather than discounting these uncertainties by ignoring them entirely or choosing one possible future and its associated vulnerabilities on which to base decisions, managers should instead strive to select strategies that are robust across multiple plausible futures and focus on win-win, no regrets strategies that are highly likely to be beneficial regardless of whether the associated climate projection and/or vulnerability manifests (Watson et al. 2012; Stein et al. 2014; Galatowitsch 2019).

Text Box 1 provides an example of a template that can be used to quickly summarize climate projections for a project or plan. It demonstrates that gathering climate projections relevant for decision-making need not be overwhelming or complicated in order to be useful in framing and informing plans and projects.

Text Box 1: Climate Projections for Sardine Meadow

The Trust for Public Land's Sardine Meadow acquisition project in California is an excellent example of how a land trust acquisition catalyzed a climate-smart, multi-benefit restoration project. Project partners used climate projections to identify climate vulnerabilities and climate-smart actions to inform restoration planning and design. The following is a summary of the projections for this project.

Resources Consulted: USGS Basin Characterization Model (Flint et al. 2013), available on the California Climate Commons, and the Assessment of Climate Change in the Southwest U.S. (Garfin et al. 2013).

Climate Variable	Historical, 1981-2010	Projected , 2040-2069	Change
April 1 snow water equivalent	301,961 mm/year	65,029 mm/year – 262,359 mm/year	22 – 87% of historic April 1 SWE
Mean annual precipitation	592,642 mm/year	486,968 mm/year – 690,832 mm/year	82% - 117% of historic annual precipitation
Mean annual surface water runoff and groundwater recharge	337,494 mm/year	233,175 mm/year – 406,063 mm/year	69% - 120% of historic runoff and recharge
Summer maximum daily temperature (Jun, Jul, Aug)	76° F	78° F – 85° F	2° F - 9° F increase in summer maximum daily temperature
Winter minimum daily temperature (Dec, Jan, Feb)	18° F	20° F – 23° F	2° F – 5° F increase in winter minimum daily temperature
These projections are from the CSIRO-MK3-SA1B, MIROC5-RCP2.6, IPSL-CMSA-LR-RCP8.5, and MIROC-ESM-RCP8.5 climate models, which were selected because they capture a range of possible conditions that might be experienced in the meadow watershed across projected temperature and precipitation.			

Summary of Climate Projections:

- Increase in summer maximum daily temperature and winter minimum daily temperature
- Increase in extreme heat days and heat waves
- Decrease in April 1 snow water equivalent and winter snowpack
- Potential increase or decrease in annual precipitation
- Potential increase or decrease in surface water runoff and groundwater recharge
- More winter precipitation falling as rain than snow
- Increase in winter rain-on-snow (high flow) events and associated extreme winter floods
- Earlier peak snowmelt and runoff
- Shift in centroid timing to earlier in the year and reduction in late-season base flow
- Droughts will be hotter, more severe, and more frequent
- Increased probability of high-severity fire
- Increased climatic water deficit and less soil moisture

Section II: Strategic Conservation Planning

This section describes how climate change can be integrated into a strategic conservation planning process. The Land Trust Alliance recommends that land trusts develop a strategic conservation plan to identify the most valuable resources to protect and strategic priorities within the context of the broader landscape, your land trust's mission, and emerging threats such as climate change (Amundsen 2011). For the purposes of this section, we outline one possible approach to strategic conservation planning, which includes the following steps:

- Set the scope and define goals and conservation targets
- Assess and analyze the conservation situation
- Evaluate and select conservation priorities
- Develop an action plan and strategies to help achieve your goals

This section describes these steps (after Amundsen 2011; Conservation Measures Partnership 2013) and provides input as to how climate change can be incorporated throughout a strategic conservation planning process. These steps are not necessarily linear and may be happening simultaneously. This process and examples primarily center on the conservation of natural resources (e.g., species, ecosystems, and natural landscapes), though the concepts and strategies discussed are also applicable to other goals, such as conservation of agricultural and/or cultural resources.

Set the scope and define goals and conservation targets

An initial step in a strategic conservation planning process is to frame the project by clarifying the purpose and objectives, setting the appropriate scope and scale, determining the end-product, and defining your conservation targets and goals. The purpose of the process could be to identify new priority geographies or parcels for land protection. Specific objectives could be to identify conservation targets and threats in your region, identify landowners for outreach, and/or identify new partners.

The scope, scale, and end product of the planning process will generally flow from your purpose and objectives. This includes identifying the target geographic area and the time scale for decision-making. The geographic scale could range in size from a small watershed upwards to your entire region of focus, such as a county or state. End products could be a strategic conservation plan, a parcel analysis, a series of maps, and/or a list of priority parcels. You should also clarify the time-scale under which you will implement or apply the results of your planning process.

This step also involves establishing conservation targets and goals that flow from your land trust's mission (Amundsen 2011). Conservation targets include natural and cultural conservation values of interest, such as specific species, ecosystems, habitats, cultural resources, agricultural resources, and ecological processes (e.g., oak woodlands, acorn woodpecker, historic ranches, hydrological connectivity), while goals describe in more broad, qualitative terms the conditions and processes you would like to see on the ground as a result of plan implementation (e.g., network of conserved connected lands, viable agricultural lands that remain in production). Your team could also establish a shared vision of what you want to accomplish.

Climate change can be incorporated into this step by establishing goals informed by possible future conditions. Land conservation has been traditionally implemented under the assumption that the distribution of target species, habitats, ecosystems, and agriculturally viable lands will be static and unchanging over time and in space, and that permanent land protection is sufficient to conserve these targets in perpetuity (Stein et al. 2014). However, climate change is likely to impact the distribution of conservation targets across the landscape and lead to landscape-scale change (e.g., species range shifts, alterations to ecosystem processes, ecosystem transitions, unsuitable climatic conditions to support current agricultural crops; Figure 1). This requires understanding the long-term climate projections for your project area and associated climate impacts and vulnerabilities. This information can then be used to define forward-looking goals framed in the context of landscape-scale change, rather than defining goals under the assumption that historic conditions will persist into the future (Stein et al. 2014).

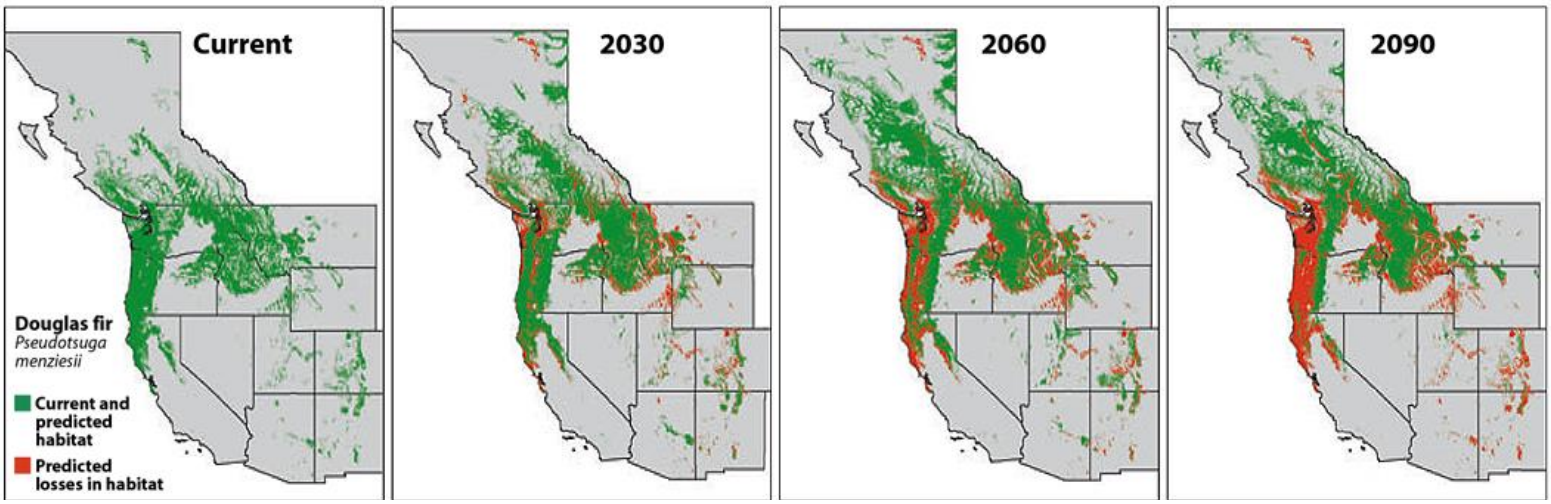

Figure 1: Projected current and future distribution of Douglas-fir potential habitat in western North America through late-century (Weiskittel et al. 2012). Climate change will alter the distribution of species and their habitats, thus goals should be framed in the context of landscape-scale change.

Climate change can also be integrated into this step by setting goals and targets at multiple scales in order to achieve multiple benefits across the landscape (Table 1). Goal setting can occur at the scales of species, ecosystems, and landscapes. This approach can help conserve species and their habitats while also ensuring that ecological and evolutionary processes can continue to operate across landscapes (Schmitz et al. 2015). Setting goals at multiple scales can also help account for some of the uncertainty surrounding climate change by identifying and prioritizing projects or a portfolio of projects that together result in multiple benefits. We define multiple benefit projects as efforts designed to meet societal and/or cultural needs and enhance ecological function and habitat quality for fish and wildlife. Considering multiple scales can help achieve benefits at the finer scales of species and habitats while also achieving benefits for landscape-scale patterns and processes, such as habitat connectivity, ecosystem functionality, and disturbance regimes (e.g., wildfire, floods).

Table 1: Examples of the multiple scales at which targets and goals can be set, from a species and habitat perspective (tidal marsh) and an ecosystem services perspective (water quality).		
Scale	Tidal Marsh Targets	Water Quality Targets
Species	At-risk tidal marsh-dependent species, such as Ridgway's rail and salt marsh harvest mouse	Water quality indicator species, such as macroinvertebrates, and target species, such as steelhead trout
Ecosystem	Mudflats, tidal marshes, and uplands	Wetlands, riparian areas, streams, rivers
Landscape	Lateral connectivity between tidal marshes and vertical connectivity from mudflats to tidal marshes and to adjacent uplands	Hydrological connectivity between streams and their floodplains, connectivity between groundwater and wetlands

Text Boxes 2 and 3 describe several climate-smart land conservation strategies that can be integrated into your goal setting process. These strategies will be further explored in the next step, which focuses on assessing and analyzing the conservation situation.

Text Box 2: Strengthening Best Practices

Protect current representative patterns of biodiversity. Practitioners should protect biodiversity "hotspots" and ecosystems that typically support high numbers of species because areas that currently support high biodiversity may continue to do so under climate change, though the exact species may change (Schmitz et al. 2015). This best practice can be made climate-smart by identifying and protecting several representative habitats that support high biodiversity. This "ecological redundancy" can help avert the risk associated with protecting only one representative habitat, which may be more vulnerable to climate impacts and other threats (Watson et al. 2012). This can involve identifying and protecting both small, locally important habitat patches (e.g., headwater spring that is likely to provide perennial cold water; Wintle et al. 2019) as well as large habitat patches and consider how ecological connectivity between these patches can be protected and restored to facilitate species' movements.

Protect large, intact natural landscapes. Protecting large, intact natural landscapes is a best practice that land trusts should continue to utilize and strengthen as part of climate adaptation efforts (Schmitz et al. 2015). This practice can help maintain viable populations of target species and maximize the adaptive capacity of such populations by protecting genetic diversity and evolutionary resilience. This practice can also be made climate-smart by explicitly identifying, protecting, and incorporating climate refugia into large protected area networks, although such networks are likely to encompass some refugia by nature of their size (Watson et al. 2012). Climate refugia are areas on the landscape least likely to undergo rapid climate-induced changes. Large, intact landscapes can also help conserve "nature's stage" –diverse geological features, topographical features, and soils that are correlated with biodiversity (Hjort et al. 2015; Lawler et al. 2015). Finally, this strategy can also be made climate-smart by modeling large-scale shifts in species distribution and vegetation change in response to climate projections to identify high priority areas on the landscape that may be important future habitat.

Protect, sustain, and enhance ecological connectivity. Protecting, sustaining, and enhancing ecological connectivity is one of the most commonly cited climate adaptation strategies for biodiversity conservation (Schmitz et al. 2015). This strategy increases adaptive capacity by allowing species and communities to respond to climate change through dispersal and colonization, which in turn can help increase evolutionary resiliency by potentially increasing gene flow. Connecting habitat patches across a larger landscape can also help extend the potential climate space for species (Gillson et al. 2013). Practitioners can identify, protect, and manage connectivity corridors between existing habitat patches and protected areas and inform the management of the intervening matrix and connectivity corridors for which total protection is unlikely to be practical (Groves et al. 2012). Practitioners should pay attention to both structural connectivity, related to the spatial arrangement of protected areas across the landscape, as well as functional connectivity, which refers to the behavioral response of target species to the physical landscape structure (Groves et al. 2012).

Text Box 3: Experimenting with Emerging Practices

Protect, sustain, and manage land for ecological processes and ecosystem functions. Practitioners should protect, sustain, and manage land for ecological processes and ecosystem functions, such as carbon and nutrient cycling, hydrology, and disturbance regimes like fire and floods (Groves et al. 2012; Glick et al. 2011; Schmitz et al. 2015). Practitioners can identify, protect, manage, and restore ecosystems that play important roles in such processes, such as wetlands and floodplains. This strategy can be enhanced through integration with other best practices, such as protecting biodiversity hotspots and connectivity corridors. Biodiversity is strongly correlated with ecosystem functioning, and landscape connectivity can facilitate large-scale ecological processes.

Protect habitat patches at edges of species' ranges and future habitat spaces. Climate change will likely lead to shifts in species' ranges upwards in elevation and northwards in latitude. Practitioners should protect habitat patches along the leading edges of target species' ranges, especially north edges and upslope edges (Schmitz et al. 2015). Practitioners can also use species distribution models and climate projections to identify and protect future climate space for target species. These identified areas can be incorporated into priority setting in conjunction with other strategies and goals. Monitoring species' responses to climate change will be essential in order to test the validity of models and assumptions about changes to species' ranges.

Identify and protect climate refugia. Practitioners can identify and protect climate refugia, which are areas on the landscape least likely to undergo rapid climate-induced changes (Glick et al. 2011; Groves et al. 2012; Gillson et al. 2013; Schmitz et al. 2015). Refugia can buffer species' exposure to climate change, allowing species to persist *in situ*. Climate refugia can be identified by drawing on past, current, and projected climate data, as well as by identifying areas where high topographic diversity creates a wide array of microclimates in close proximity and in consultation with local experts (Groves et al. 2012). Mountain valleys and meadows, drainages, and riparian areas (Seavy et al. 2009) are examples of areas on the landscape where temperature may be less than the surrounding landscape, providing species with a buffer against climatic exposure.

Protect the geophysical setting. There is a strong correlation between geophysical diversity, characterized by diverse geological features, topographical features, and soils within different land facets, and biodiversity (Hjort et al. 2015; Lawler et al. 2015). Protecting areas of high geodiversity may in turn protect biodiversity (Schmitz et al. 2015). This "conserving the stage" approach assumes that areas with high geodiversity will continue to support high levels of biodiversity in the future, even if the species themselves change over time. Species may disperse into such areas with high geodiversity (Groves et al. 2012). Practitioners should also ensure that geophysical settings currently under-represented in protected areas are also prioritized. For example, valleys and other low-lying areas that lack topographical diversity are often used for agricultural production and human development, and thus are under-represented in conservation portfolios.

Assess and analyze the conservation situation with a focus on future conditions

The next step is assessing and analyzing the conservation situation with a focus on future conditions. This involves gathering information relevant to the geographic scope of your process as well as to your conservation goals and targets; it may also involve identifying and mapping your conservation targets and assessing threats to those targets, such as development, fragmentation, and land use (Amundsen 2011). Information can be gathered from a variety of sources, such as interviews with partners and experts; a literature review of relevant reports, plans, and articles; discussions with key decision-makers in your community; review of available field data; and models of current and future distributions of target species.

Climate change can be integrated into this step by gathering information on relevant climate projections, evaluating how changing climatic conditions may impact your conservation targets and goals, and gathering data that can help you implement best practices (see Section I and Appendix B). Consider conducting a literature review to identify articles, reports, white papers, and existing climate models that discuss climate projections and impacts to target species and ecosystems. For example, there may be existing information about how a target species or ecosystem is projected to shift its distribution in response to climate change (Figure 2), how connectivity across the landscape might be best designed to support climate-driven range shifts, or which crops are likely to remain viable under future climatic conditions. Depending on the time and resources available to you, your team may want to consider engaging in scenario planning (see Moore et al. 2013) or conducting vulnerability assessments for your conservation targets (see Section IV).

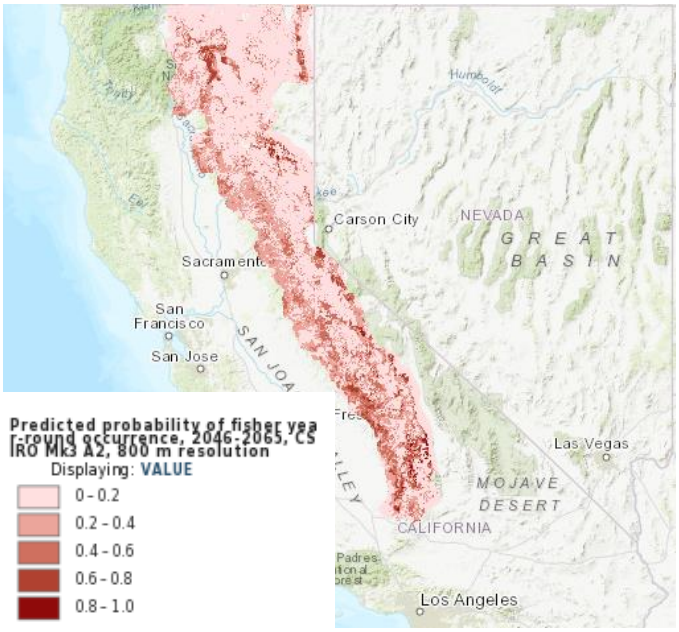

Figure 2: Predicted probability of fisher year-round occurrence in the Sierra Nevada, CA, in 2046-2065 under the CSIRO Mk3 A2 climate model. Maps such as these can be used to identify potential future habitat spaces for target species. Image from DataBasin and data from Spencer and Rustigian-Romsos (2012).

Throughout your planning process, your land trust should consider climate projections and impacts at multiple scales, including to target species, ecosystems, and the broader landscape. Avoiding consideration of climate projections may result in missed conservation opportunities as well as overlooked climate impacts to targets and goals, resulting in acquisitions that may not be able to support their current conservation values into the future. Examining climate projections at the broader landscape scale can help identify important areas to sustain large-scale ecological processes, such as connectivity corridors that allow species to shift their distributions in response to climate change. At finer scales, you can use climate projections and the likelihood of extreme events (such as droughts, floods, and fire) to identify potential vulnerabilities to conservation targets (Figure 3). You

can use this information to inform both land protection and management strategies to reduce vulnerabilities.

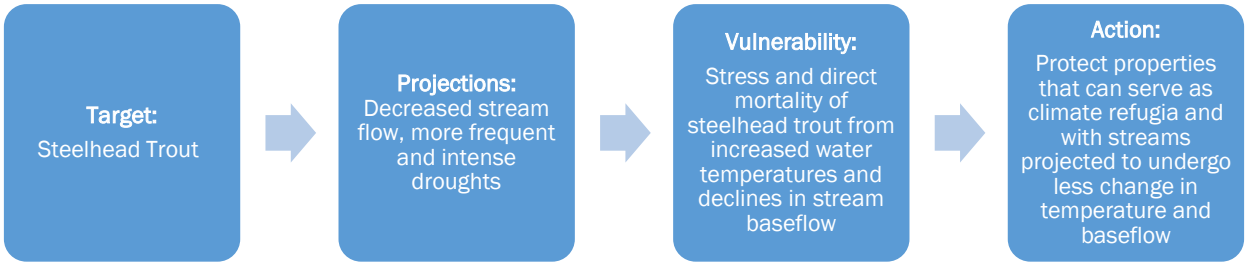

Figure 3: Example of how to use climate projections to identify potential vulnerabilities to a conservation target and design actions to address the vulnerability through climate-smart strategic conservation

Throughout this process, you may find that there is uncertainty associated with the climate projections for your region. You can respond to this uncertainty by focusing on climate-smart strategies such as protecting climate refugia, connectivity corridors, and the geophysical setting, all of which can facilitate adaptation without explicitly weighing one climate scenario over another.

Evaluate and select conservation priorities

The information gathered in the previous step should be used to evaluate and select conservation priorities. Depending on the purpose and deliverable(s) of your planning process, this might result in a list of individual parcels ranked based on established criteria, or a map of focus areas (Amundsen 2011).

Climate change can be integrated into this step by evaluating whether your previously established conservation goals and targets are relevant, feasible, and achievable in light of your analysis of the conservation situation and identified climate projections, impacts, and vulnerabilities. This can help you determine whether your goals and targets should be revised, or if others should be included. This may lead to difficult conversations about which conservation targets to prioritize given changing conditions as well as potential uncertainty about the likelihood of the identified climate vulnerabilities and projections. This requires understanding and evaluating tradeoffs and accounting for and adopting strategies robust to uncertainty, which in turn may actually lead to innovation and identification of new priorities that may not have been considered previously (see also Section IV).

Table 2: Example of a conventional goal versus a climate-smart goal.		
Goal Type	**Goal**	**Potential Long-Term Outcome**
Conventional	Protect existing tidal marshes from development.	Protection of a narrow band of existing tidal marshes along the coastline that are unable to migrate in response to sea level rise because of incompatible land uses in adjacent uplands, resulting in tidal marsh drowning.
Climate-Smart	Protect existing tidal marshes that are likely to recruit sufficient sediment to aggrade at a pace to match sea level rise and also protect associated uplands to allow for the natural process of marsh migration in response to sea level rise.	Prioritization of larger parcels or a series of connected parcels that will result in protection of existing tidal marsh as well as adjacent uplands, allowing for marsh migration and ecosystem adaptation to sea level rise.

Table 2 provides an example of how a conventional goal might be revised in light of climate projections. The original goal was made under the assumption that current conditions will persist into the future, while the climate-smart goal incorporates climate projections and assumes that the landscape will undergo climate-driven change in the distribution of conservation values. Your team should be prepared to discuss the benefits, tradeoffs, and uncertainty associated with different potential priorities in the context of your overarching goals, climate change, and other important considerations (e.g., feasibility, landowner preparedness, etc.).

You can also use the best practices in the previous text boxes to evaluate and select conservation priorities. Considering factors such as climate refugia, the geophysical setting, and connectivity corridors might result in identification of new priorities that might not have been considered previously (Figure 4).

Figure 4: Natural Landscape Blocks and Essential Connectivity Areas in California. Analyses such as these can help prioritize conservation of large areas important to maintaining ecological integrity (Spencer et al. 2010).

Develop an action plan and strategies to help achieve your goals

The final step is developing an action plan to help guide implementation and document how your team made decisions. This plan can outline different tiers of strategic priorities depending on factors such as risk of development, importance to regional conservation efforts, existing landowner relationships, and landowner willingness. It can also include your specific strategies, such as how you will conduct landowner outreach, raise acquisitions and stewardship funds, build strategic partnerships, how you will evaluate progress, and the process for updating and revising your plan.

This step can be made climate-smart by building and strengthening strategic partnerships and identifying strategic priorities that may include an active restoration or land management component. Land trusts can use strategic conservation planning to identify potential opportunities where acquisition can catalyze restoration, and build strategic partnerships with restoration practitioners, researchers, and landscape collaborations to assist with implementation. This could result in projects with a research and/or restoration component that can help identify and evaluate climate impacts, assess how species and ecosystems are responding to climate change, and/or identify and implement restoration projects.

Section III: Climate-Smart Acquisitions and Conservation Easements

Climate change can also be integrated into the process of evaluating and pursuing acquisition projects. Climate-smart approaches to acquisitions include re-evaluating, and, if necessary, revising project selection criteria, considering the role of stewardship and monitoring in maintaining and enhancing conservation values, selecting the appropriate acquisition tool, and integrating climate-smart principles into conservation easement terms.

Evaluating and selecting climate-smart projects

Climate change can be integrated into the acquisitions process by including climate-related factors in your land trust's project selection criteria. The Land Trust Alliance's Standards and Practices recommend (and, for accredited land trusts, require) that land trusts develop and apply written project-selection criteria that are consistent with the land trust's conservation priorities. These conservation priorities are likely articulated in your land trust's mission and/or strategic conservation plan. Table 3 describes some examples of climate-smart project selection criteria drawing on the best practices discussed in Section II.

When evaluating and selecting projects, consider how projected climate change might impact the conservation values of the land (Amundsen 2011) and steps necessary to ensure conservation values are protected in perpetuity. For example, if you are pursuing an easement to protect agricultural land, consider if the land is likely to remain viable for agricultural production in the future given climate projections and the contingency plans you may need to make to allow for adaptation in response to changing conditions. Other considerations include the quality of the conservation values to be protected, whether management or restoration actions are needed to maintain or enhance conservation values over the long term, and whether the landowner or land trust has capacity and funding to meet long-term stewardship requirements. In some cases, climate change impacts to conservation targets may require management actions to reduce vulnerabilities and increase the resilience of conservation targets (see Section IV). This will require exploring possible funding sources for long-term stewardship or, if that is not possible, actually consider turning down such projects.

Land trusts can also explicitly prioritize projects where acquisition can catalyze management, restoration, and/or research projects to enhance conservation values, increase resiliency, and achieve multiple benefits. For example, a land trust could acquire land at risk of inundation from sea level rise and implement tidal marsh restoration to provide habitat, help sequester carbon, and buffer coastal communities from rising waters. Such projects can also include a research and monitoring component to experiment with and evaluate the effectiveness of restoration and land management approaches in achieving desired outcomes.

Restoration is an important climate-smart strategy for land trusts to confer greater resiliency to conserved lands. In situations where there are opportunities for active management and restoration to maintain and enhance conservation values and respond to climate vulnerabilities, land trusts should consider whether the landowner is willing and able to implement land stewardship practices to address identified vulnerabilities and increase resiliency, or willing to permit such activities to occur on their land. This also has implications for crafting conservation easement agreements.

Table 3: Sample climate-smart project selection criteria.	
Sample Criteria	**Examples**
The property contributes to the protection of current representative patterns of biodiversity.	• Property falls in a biodiversity hotspot • Property features diverse habitats that support different species • Property features diverse geological features, topographical features, and/or soils that indicate geodiversity • Property features a geophysical setting currently under-represented in the existing network of protected areas • Property features rare, endemic, or at-risk species or habitats
The property contributes to important ecological processes and functions likely to be sustained in the long-term with or without management action.	• Property contributes to hydrological functioning through presence of riparian corridors, wetlands, or other important water features • Property features ecosystems important to nutrient and carbon cycling
The property falls within a large, intact natural landscape block.	• Property is adjacent to existing protected areas • Property is located in an area with limited development and/or high natural land cover
The property features climate refugia or is located in an area exhibiting refugial characteristics.	• Property features topographical diversity with different microclimates (e.g., mountain valleys, riparian corridors) • Property features cold water streams important to aquatic species • Property is located in a region projected to be buffered from climate impacts
The property contributes to landscape-scale connectivity.	• Property falls within identified connectivity corridor • Property provides a connection to existing protected areas, large landscape blocks, and/or important habitat patches • Property falls within connectivity "pinchpoint" • Property features streams that provide aquatic connectivity • Management actions on the property can enhance local connectivity (e.g., remove fences, riparian restoration)
The property is located in an area that may be important future habitat for a target species.	• Species distribution models based on climate projections suggest that the property may feature future climate conditions suitable for a target species • The property is located on the leading edge of a target species' current range.
The property is projected to provide value across a range of future climate change scenarios.	• The property has refugial features • The property is located in an area projected to be important for shifting distributions of species or ecosystems under multiple climate models
There is opportunity to enhance the property's conservation values through management and restoration actions.	• The property features conservation values or is located in an important area (e.g., corridor, large landscape block) that could be enhanced through management and restoration actions • The landowner is interested in and willing to implement or allow active management and restoration • There is the opportunity to develop and implement a climate-smart, multi-benefit adaptive management plan
The property adds ecological redundancy to your portfolio or to the region.	• The property contains additional populations of a species, an ecological community of interest, or both, which complements existing regional protected areas
The property is likely to remain viable for agricultural production.	• The property is projected to be buffered from climate impacts • The property could support new agricultural crops that are more suitable for projected climate impacts

Selecting the appropriate conservation tool

Because climate change is likely to impact the distribution and persistence of conservation values across the landscape, land trusts should consider the best acquisition tool to ensure that the conservation values are likely to remain protected in perpetuity. The decision of whether to use a conservation easement, fee title acquisition, or other tool should be informed by consideration of the long-term management needs required to protect conservation values in the context of climate-driven, landscape-scale change. This information can also inform whether to move forward with a given project in light of conservation values and the feasibility of implementing stewardship actions to address climate change and other stressors (Rissman et al. 2015). This question can be explored through vulnerability assessments for your conservation values or scenario planning exercises (Stein et al. 2014; Moore et al. 2013; Section IV).

When possible, land trusts should be strategic with the placement, use, and structure of conservation easement agreements in order to ensure that the conservation values to be protected remain viable under climate change. If the property and its conservation values (e.g., open space, scenic viewshed, geodiversity, agricultural production) are likely to persist under climate change in the absence of ongoing stewardship, a conventional conservation easement (e.g., one with negative restrictions) may be a viable option. However, it is likely that some degree of climate-driven, landscape-scale change can be expected, requiring consideration of the stewardship needs required to maintain and enhance conservation values. Pursuing fee title acquisition or acquisition and transfer for such projects could help ensure that the property is managed by a landowner with stewardship capacity.

In situations where a conservation easement is the only option, consider how to shape the agreement to allow for long-term stewardship and adaptive management in response to changing conditions; this may require partnering with the "right" landowner who is willing and/or able to allow such activities to occur. Given that conservation easements are the most widely used tool that land trusts have at their disposal, there is an emerging need for land trusts to shift towards an easement model that explicitly considers and promotes long-term, adaptive land management to ensure conservation values persist. There are four conservation easement agreement options available that can facilitate active and adaptive land management:

- CE with management plan
- CE with affirmative obligations on the landowner
- CE with affirmative rights of the land trust
- CE with affirmative obligations on the land trust

Table 4 describes each of these and the associated benefits and trade-offs. Regardless of the acquisition tool, we recommend conducting a climate vulnerability assessment and developing a comprehensive, multi-benefit management plan and associated monitoring strategy that discusses how conservation purposes and values will be protected and enhanced over time in response to changing conditions (Owley et al. 2017). We encourage land trusts to upgrade annual monitoring processes to include indicators and metrics that can be used to evaluate whether the property is fulfilling its conservation purpose, evaluate if management is meeting goals and objectives, and inform management management interventions to address emerging threats and climate impacts (see Section IV).

Table 4: Conservation easement agreements that support adaptive management and associated benefits and challenges (Larson et al. 2019).		
Type of CE agreement	**Description**	**Benefits and challenges**
CE with management plan	The CE refers to a management plan that exists as a separate document to guide management. There may be fewer management terms within the CE itself as a result. The CE contains reserved rights and negative restrictions based on conservation values, but the details are discussed in the management plan. May not have affirmative obligations associated with the plan, so it lists what the landowner "can do," rather than "must do."	The management plan can adapt to changes through regular updates and revisions and can be more in depth than management terms in an easement. Key questions include whether the plan is legally enforceable, what is required versus recommended, and who is responsible for implementation.
CE with affirmative obligations on landowner	The CE includes affirmative obligations on the landowner and requires the landowner to take certain actions, such as keep the land in agricultural production using organic farming methods. The CE contains reserved rights and negative restrictions based on conservation values as well as affirmative obligations on the landowner to act based on those values.	This could result in stronger public benefits as the landowner takes on burdens, not the land trust or the public. However, this may be outside the comfort zone of some landowners and enforcement may be difficult. What happens if the landowner no longer has the resources or ability to implement the management actions or keep the land in agriculture? What happens when the land switches hands? For affirmative agricultural easements, what happens if the land is no longer agriculturally viable, is no longer economically feasible to keep in production, or if certain years climatic conditions require it to lay fallow?
CE with affirmative rights of land trust	The CE gives the land trust the right to manage the land independently or if the landowner fails to do so, such as right to remove invasive species or the right to lease the land to an agricultural producer if the landowner is not actively keeping the land in agriculture. The CE contains reserved rights, negative restrictions based on conservation values, and affirmative rights, but not obligations, on the land trust.	This gives the land trust more control to implement land management activities. However, this may be outside the comfort zone of some landowners as it changes the perception of who "owns" the land. The landowner might also punt rights to the land trust. What happens if the land trust lacks capacity or resources to implement management actions or if actions are unsuccessful?
CE with affirmative obligations on land trust	The CE gives the land trust obligations to manage the land. The CE contains reserved rights, negative restrictions based on conservation values, and affirmative obligations on the land trust. Obligations could include maintaining certain habitats through management actions (e.g., removal of invasives, vegetation management, prescribed burning, grazing), keeping water rights attached to the land in support of conservation values, and/or conducting agricultural operations or securing an agricultural lessee.	This gives the land trust ultimate control to manage the land. However, this may be outside the comfort zone of some landowners as it changes the perception of who "owns" the land. The landowner might also punt obligations to the land trust. What happens if the land trust lacks capacity or resources to implement management actions or if actions are unsuccessful? Could the landowner or a third party enforce affirmative obligations against the land trust or challenge easement validity for failure of land trust's affirmative obligations?

Rethinking conservation easements under a changing climate

Conservation easements (CEs) are an important and widely deployed tool for land conservation and are appealing because they can provide a variety of benefits to both land trusts and landowners (Owley 2010). However, conventional CEs have important limitations as a conservation tool under a changing climate. CEs are typically fixed, perpetual structures based on the underlying assumption that the conservation values present at the time of acquisition will remain present on the land in perpetuity (Owley 2010; Rissman 2011; Rissman et al. 2015; Owley et al. 2017). CEs generally achieve conservation goals by preventing development and locking in the land uses and preferences present at the time of acquisition (Owley et al. 2015, 2017). Because of this underlying structure, CEs are generally based on a static view of ecosystems that may not consider the dynamic, unpredictable ecosystem changes that occur naturally over time and which may be exacerbated by climate change (Owley 2010; Rissman 2011).

Indeed, climate change and other disturbances will likely result in landscape-scale changes that may conflict with CE terms and conservation values (Owley 2011), such as species range shifts, ecosystem transitions, loss of habitat for a target species, and/or changes in agricultural productivity and viability. Similarly, while the perpetual restrictions in a CE may be a good fit for the conditions present on the land at the time of acquisition, they may make it difficult to engage in the adaptive management practices needed to respond to environmental changes (Owley 2011; Rissman et al. 2015). Emerging stressors, such as climate change and associated disturbances, are likely to require more active management and adaptability on the part of the landowner to maintain and enhance certain conservation values, such as habitat for target species, a particular ecosystem of interest (Rissman et al. 2015), or viable agriculture.

Take the following example of how a conventional CE may make it difficult to respond to environmental change. Perhaps you have a CE agreement that includes restrictions around vegetation removal, including forestry activities. However, climate change might result in increased drought stress or invasion by non-native species, both of which may require vegetation removal to address these stressors and protect conservation values. In this case, the perpetual restrictions in the CE, while potentially adequate at the time of acquisition, may actually lead to maladaption and loss of conservation values under a changing climate as a result of limitations in the ability of the landowner or land trust to implement management actions.

Conservation easements have the potential to be structured in ways that may make them more viable as a tool to protect conservation values under a changing climate (Table 4). A climate-smart conservation easement is one that is flexible and adaptable while remaining effective, thus allowing for adaptive management to ensure conservation values are maintained and enhanced (Figure 5).

Some overarching recommendations for crafting climate-smart conservation easements include:

- Draft CE purpose and goals in a way that ensures they will remain viable in the face of climate change and other landscape-scale changes.
- Design provisions, restrictions, rights, and obligations that are flexible enough to allow adaptation in response to changing conditions and that avoid the possibility of maladaption.
- Develop a multi-benefit adaptive management plan and monitoring strategy with goals, objectives, and metrics explicitly linked to the CE purpose and conservation values that is updated and revised regularly.

Text Boxes 4 and 5 include some additional emerging best practices for crafting climate-smart, adaptive conservation easements in light of climate change and the reality of changing environmental conditions.

Figure 5: The Nature Conservancy holds a climate-smart conservation easement over Childs Meadow, located in northern California south of Lassen Volcanic National Park. The easement allows for restoration, research, and ecological monitoring by outside partners as well as community engagement. The easement has resulted in improvements to wildlife habitat, water storage, carbon sequestration, climate resiliency, and community benefits beyond which would have been achieved through conventional CE terms. Photo by B. R. Campos.

Text Box 4: Crafting Climate-Smart Easements

Identify conservation values that will endure. Identify conservation values that are likely to endure in the face of climate change, and link restrictions and obligations to the protection of those values. This may mean including a broad purpose and associated conservation values, such as protection of open space, a scenic viewshed, or working land. If you decide to list a more specific purpose and associated conservation values, consider what actions may need to be taken in the future to ensure that they remain viable under future environmental conditions and ensure that the provisions of the CE allow for such actions; this can be accomplished through reference to a management plan that is revised and updated regularly.

Decide whether to draft broad or specific purposes. There are tradeoffs when deciding whether to draft broad or specific purposes in a CE agreement. Broad purposes (e.g., scenic values, open space) are likely to remain effective regardless of landscape-scale change and may be preferable in instances where the CE landowner or land trust are unable to commit to long-term active land management practices. Specific purposes (e.g., protection of a particular species or ecosystem, keeping the land in a certain type of agriculture) may require more active management to ensure their persistence in the face of climate change (Owley 2011). Drafting more specific purposes can be preferable in cases where stewardship actions are likely to be undertaken. Specific purposes can help guide adaptation actions, resolve disputes in cases where tradeoffs among purposes need to be made, and may foster more active management by the landowner or CE holder (Rissman et al. 2013).

Include multiple clearly articulated purposes. Including multiple clearly articulated purposes in a CE may help ensure that the CE remains viable if landscape change hinders fulfillment of one or more purposes (Owley 2011). Care should be taken to ensure that inclusion of multiple purposes does not result in confusion for the landowner or land trust as to which purpose takes precedence, result in incompatibility among purposes, or lead to conflicting interpretations of CE terms (Owley and Rissman 2016). This can be addressed by specifying which purposes are most important and which will take precedence (Greene 2005; Owley 2011; Owley and Rissman 2016), including a tiered set of purposes in case climate change renders it impractical to achieve principal purposes (Owley et al. 2017), and/or including references to performance standards to address any conflict or tension between purposes (Greene 2005).

Include provisions that allow for stewardship and restoration. Fulfilling the purpose of your CE agreement may require stewardship actions to ensure that conservation values persist in the face of climate change impacts. Consider including affirmative rights or obligations on the land trust to conduct management designed to maintain and enhance the conservation values of the property when compatible with CE purposes. The landowner can also be given the right to do active management to enhance conservation values with written approval by the land trust (Stanford Institute for the Environment 2009; Rissman 2010; Rissman et al. 2013). Climate change can be explicitly referenced in this context, such as the intent to implement management actions that can facilitate adaptation and protection of conservation values over time (Owley et al. 2017).

Text Box 5: Crafting Climate-Smart Easements

Include a property management plan and allow for biophysical monitoring. Include a provision referencing a multi-benefit property management plan that links management goals to the CE purpose and conservation values and includes a biophysical monitoring strategy separate from compliance monitoring (Owley et al. 2017). Consider providing rights or obligations to the land trust or other organization or agency to assist in plan implementation. A long-term biophysical monitoring strategy linked to the management plan can help assess progress in meeting management goals and help adaptively manage the land in response to landscape-scale change. Modify the baseline documentation process to include a biophysical baseline and update the baseline report for the property and the management plan on a fixed increment to facilitate adaptive management.

Allow for adaptive management. Adaptive management is the process of incorporating information and research into conservation actions and adjusting as needed to meet stated goals. Adaptive management can be used to evaluate whether the CE is meeting its stated purpose and conservation values in the face of climate change and other landscape-scale change, and recommend and implement management actions in response to findings. CEs can encourage adaptive management through provisions allowing for stewardship and restoration actions, the inclusion of performance standards, requirement of a regularly updated management and monitoring plan, and regular updates to a biophysical baseline documentation report to measure progress towards goals (Greene 2005).

Consider inclusion of performance standards. Inclusion of performance standards can help encourage adaptive management and active stewardship of CEs. Such standards could either be listed explicitly in the CE or management plan, or the CE could reference external established standards (e.g., Forest Stewardship Council, Certified Organic). For example, the CE could include principles and best management practices that the landowner is required to follow when managing their land, such as those associated with regenerative ranching. Alternatively, the CE could explicitly reference regularly updated external performance standards tied to the easement's permitted and prohibited uses in accordance with a periodically updated management plan (Greene 2005). Examples of external performance standards include best management practices or certification standards such as those for organic agriculture or sustainable forestry.

Include an amendment clause. Including an amendment clause in your CEs can provide a mechanism for change in response to changing conditions in a way that enhances the conservation purposes of the easement (Rissman et al. 2015). Owley et al. (2017) recommend including an amendment clause that identifies narrow circumstances in which an amendment will be considered, preserves conservation purposes, limits the scope of permissible amendments in cases in which a tax deduction is sought, and gives holders the right to decline to agree to the amendment for any reason or no stated reason at all. Amendments should aim to protect conservation values and prohibit private benefit on the part of the landowner (e.g., providing more development rights to the landowner in detriment of conservation values of the property; Owley et al. 2017).

Section IV: Climate-Smart Stewardship

Stewardship is critical to address the threats and vulnerabilities to conserved lands posed by climate change. Building climate-smart stewardship into all land conservation projects can help ensure that your land trust is able to meet your commitments to protect each property's conservation values in perpetuity. We recommend creating climate-smart, multi-benefit land management plans for fee properties as well as for conservation easements in order to protect investments and ensure conservation values are protected and enhanced. This requires directing more resources towards stewardship, identifying and securing adequate stewardship funds, and building and strengthening relationships with CE landowners (Owley et al. 2017). Climate-smart stewardship differs from traditional stewardship by explicitly identifying climate vulnerabilities to conservation targets and goals as well as by emphasizing adaptive management and experimentation in land management efforts.

Stewardship can increase the resiliency of conservation targets through climate-smart actions designed to reduce climate vulnerabilities as well as through implementation of traditional stewardship actions that address non-climatic stressors (e.g., removing invasive species, repairing eroding roads). Land trusts are uniquely positioned to experiment with climate-smart stewardship actions on fee properties because of their inherent flexibility and autonomy over their land. Land trust preserves can be used as "living laboratories" to test innovative approaches to addressing climate vulnerabilities, and the results can be shared with the wider land trust and natural resource management communities. Stewardship actions on conservation easements is also essential (see Section III).

This section briefly describes a climate-smart stewardship process (adapted from Glick et al. 2011; Conservation Measures Partnership 2013; Stein et al. 2014; Swanston et al. 2016) that can be used to identify and implement climate-smart stewardship actions and adaptation approaches to help reach conservation goals and reduce climate vulnerabilities to both natural and agricultural lands. Deliverables of this process could include a climate-smart management plan, identification of actions and adaptation approaches that can complement an existing plan, and/or a plan for a specific project (e.g., riparian restoration, livestock grazing). The steps of this climate-smart stewardship process are as follows:

- Set the scope and define forward-looking targets, goals, and objectives
- Gather relevant data
- Assess climate vulnerabilities in the context of conservation targets and goals
- Review, evaluate, and revise stewardship goals and objectives
- Identify and implement climate-smart stewardship actions and adaptation approaches
- Monitor and evaluate effectiveness of implemented actions

This process can be used to inform stewardship of both fee properties and conservation easements, and can be applied either pre- or post-acquisition; one benefit of conducting a vulnerability assessment pre-acquisition is that it can help increase understanding of long-term management needs and inform the CE. Appendix C includes a stewardship project planning worksheet that can be used to help design your climate-smart stewardship plan or

project. Those interested in more in-depth information about climate vulnerability assessments should consult Stein et al. (2014) and Swanston et al. (2016).

Set the scope and define forward-looking goals, objectives, and targets

The first step in a climate-smart stewardship planning process is to set the scope and define your conservation targets, goals, and objectives for your property or project. Setting the scope requires defining the project area and management topic as well as the resulting deliverable. For example, you may be developing or revising a land management plan or developing the design plan for a specific project. The management topic might be for a specific land use (e.g., forestry, ranching, recreation), a target species or ecosystem (e.g., oak woodland, wetland, at-risk amphibian), or comprehensive management of all conservation values, infrastructure, land use, and activities for a property. Setting the scope also involves establishing the time frame under which the project or plan will be implemented Finally, you should also assess the activities and allowed uses of the property, which can inform goal setting as well as the overall scope of the process. For example, educational activities, recreation, and livestock grazing may all be allowed or anticipated uses of the property that have a bearing on the scope of your stewardship plan/project and your specific goals and objectives.

Table 5: Definitions and examples for conservation targets, goals, and objectives in the context of stewardship.

Term	Definition	Example
Conservation Target	Specific species, ecosystems, habitats, cultural resources, agricultural resources, and ecological processes that are the target of management actions	• Wet meadow • Willow flycatcher • Terrestrial connectivity • Agricultural productivity • Livestock grazing
Goal	Broad, qualitative description of the desired conditions and processes to be achieved over the long-term	• The property's wet meadows support diverse native meadow-dependent terrestrial and aquatic wildlife, including birds, amphibians, and fish. • The property supports grasses and forbs that provide high quality forage for livestock.
Objective	Specific, measurable statements that indicate progress towards meeting stated goals	• Focal bird species richness will average at least 1 species per acre at 15 locations in 5 years. • Bare ground will be reduced to <10% as measured at 4 locations within 3 years.

After setting the scope, you should define the specific conservation targets, goals, and objectives that you want to achieve upon implementation of the plan or project (Table 5). Conservation targets are the basis for setting goals and objectives (Conservation Measures Partnership 2013), while goals are qualitative descriptions of the desired conditions and processes you would like to see on the ground as a result of implemented actions. Resources that can be used to help define goals include funding proposals, board memos, and property reports from the time of acquisition; the property's baseline documentation report; property maps; property photos; records of the property's history and past

management; and previous planning documents, management plans, or management records. You should also define one or more specific, measurable objectives for each goal that can be used to measure progress towards achieving your goals as part of the monitoring and evaluation step. Setting clear, specific, and easily interpretable goals is essential, as they are the basis for identifying climate vulnerabilities and actions.

This step can be made climate-smart by setting forward-looking goals informed by an understanding of the range of possible futures expected under climate change. Some climate impacts might not be realized within the time frame of your plan or project or may occur at a broader spatial scale than your individual property or project area. Nevertheless, goals and actions pursued today can help prepare for and address future impacts. For example, perhaps one of your conservation targets is a mixed conifer forest, and you know that you are located in an area with an increased risk of high severity wildfire. You could then set a forward-looking goal to promote a resilient forest that sustains ecological processes, including natural and climate-accelerated disturbances, and continues to support conservation values into the future (Figure 6). Consulting with natural resource and climate change experts in this step can help inform your thinking.

Figure 6: Tree mortality in Sierra National Forest, CA during the 2012-2016 California drought. Land conservation practitioners should set forward-looking goals framed in the context of landscape-scale change that consider future projections and climate-accelerated disturbances, such as drought, tree mortality, and wildfire. This can also help identify long-term stewardship needs to reach goals. Photo by U.S. Forest Service, Sierra National Forest.

Gather relevant data

After defining your initial conservation targets, goals, and objectives, you should gather relevant data on climate projections for your region (see Section I and Appendix B). These projections will be used to identify vulnerabilities to your targets and goals. Ideally, climate projections should be at a resolution relevant to the scale of your project (Schmitz et al. 2015). Large-scale regional or state climate assessments can include information relevant to planning and serve as a good starting point for identifying relevant projections and vulnerabilities, although you should strive to acquire more region-specific projections whenever possible.

Although there may be an apparent mismatch between the spatial and temporal scale of climate projections relative to your property or project, climate projections at a larger regional scale (e.g., increases in drought, wildfire, floods) have important implications for finer-scale conservation targets, such as species, ecosystems, or land uses like agricultural productivity. Proactive planning and stewardship actions now can help increase the adaptive capacity and resiliency of species and ecosystems that will allow them to persist if/when projected changes occur.

After relevant climate projections for your region have been identified, you should consider how these projections might make your conservation targets vulnerable. Consider conducting a literature review to identify articles, reports, or white papers that discuss climate projections and impacts to the species, ecosystems, and/or land uses relevant to your property. For example, there may be existing information about how a target species is projected to shift its distribution in response to climate change and how connectivity across the landscape might be best designed to support species-driven range shifts. There might also be information about which crops are likely to remain viable in a given region given shifting climatic conditions. Resources for climate projections and associated impacts include regional vulnerability assessments, local and/or regional conservation and climate adaptation plans, expert solicitation, local expertise, and historical information on past climate extremes for your region (Swanston et al. 2016).

Assess climate vulnerabilities in the context of conservation targets and goals

This step involves using climate projections to assess potential climate vulnerabilities to your goals and conservation targets. Conducting a climate vulnerability assessment can be as comprehensive as you like, depending on capacity. A single well-structured meeting in which vulnerabilities and actions are brainstormed in relation to stewardship goals is often sufficient for providing adequate guidance for future management activities. You can also take this a step further and develop a written climate vulnerability assessment for a specific plan or project, though it is not necessary.

A climate vulnerability is defined as the susceptibility or amount of risk of a conservation target (e.g., species, ecosystem, land use) to the negative impacts of climate change (Williams et al. 2008; Smit et al. 2000). Vulnerability is made up of three components: exposure, sensitivity, and adaptive capacity. Exposure includes extrinsic factors that influence a species or ecosystem. It focuses on the character, magnitude, and rate of change in climate variability that the species or system is likely to experience (Glick et al. 2011). Sensitivity includes intrinsic traits or characteristics of a species or ecosystem that

determine its tolerance and response to changes in climate variables, such as temperature or precipitation (Williams et al. 2008; Glick et al. 2011; Swanston et al. 2016). Adaptive capacity refers to the ability of a species or system to accommodate or cope with climate change impacts (Glick et al. 2011). It includes both evolutionary changes, such as pressures that favor certain genotypes and phenotypes over others, as well as plastic ecological responses, such as changes in a species' behavior or migration to more suitable habitat. Adaptive capacity can also be increased through management and restoration actions that minimize climate impacts to a species or system (Williams et al. 2000).

Throughout this process, consider the following questions:

- How do the climate change projections and the current site conditions make each conservation target and goal vulnerable?
- Is the current condition of the property or project site capable of achieving goals in the context of potential vulnerabilities?
- Are current or proposed management actions sufficient to achieve goals in the context of potential vulnerabilities?
- What are the priority vulnerabilities that should be addressed to ensure long-term project success?

We recommend listing climate projections and impacts for your region, and brainstorming a list of vulnerabilities associated with each conservation target and/or goal. If you have a large number of species targets and it feels overwhelming or too time-consuming to list vulnerabilities for each one, you can generate vulnerabilities for specific taxa (e.g., fish, amphibians) or their habitats (e.g., wetlands) (Clark et al. 2017; Table 6).

Once you have a list of vulnerabilities, you can conduct a prioritization process in order to identify priority vulnerabilities that you would like to address. This can be done by giving each vulnerability a qualitative rank (e.g., high, medium, or low priority). Higher priority can be given to vulnerabilities associated with targets or goals that have high exposure and sensitivity, low adaptive capacity, and/or high likelihood of the projection or impact occurring (Swanston et al. 2016). This prioritization can also be informed by the feasibility of addressing the vulnerability through stewardship actions, the likelihood of project success if the vulnerability manifests, and the risk associated with the vulnerability.

Finally, this step can be used to identify other existing or potential stressors that may impact your ability to achieve your goals. Stressors can include those that may be indirectly influenced by climate change, such as an increase in weeds or invasive species, as well as stressors that are non-climate related, such as road degradation, failing infrastructure, fish passage barriers, and/or old fencing. Additionally, consider if there are any existing or proposed land uses or activities that could impact your conservation targets and goals (either positively or negatively), such as livestock grazing, forestry, agriculture, and public recreation. You may determine that your planning process should also include recommendations and strategies for managing these land uses in ways that are compatible with other stewardship goals.

Table 6: Examples of exposure, sensitivity, adaptive capacity, and climate vulnerabilities for species, ecosystem, and agricultural conservation targets.				
Target	**Exposure**	**Sensitivity**	**Adaptive Capacity**	**Climate Vulnerability**
Steelhead trout/native fish	Rising stream temperatures	Fish unable to tolerate temperatures greater than 16 degrees C	Fish can migrate to cooler streams and temperature refugia if available	Increased fish stress and mortality in response to rising stream temperatures
Mountain meadow	Increase in high flows and flooding following rain-on-snow events and heavy summer rain events	Stream channels sensitive to erosion and incision from high-energy flood events	Meadows with complex channels, woody debris, and dense sedge mats may be better able to withstand high flow events	Increased likelihood of channel degradation and incision leading to erosion
Agricultural crops	Decrease in winter chill hours	Fruit and nut crops sensitive to cold temperatures to break dormancy and properly set fruit	Diversification of tree crop species may increase likelihood that some crops and/or individuals are tolerant to future conditions	Delayed pollination and foliation, decreased fruit yield and quality, novel temperature and precipitation regime favors crop pests, diseases, and weeds
Forage for livestock	Variability in precipitation, prolonged drought, shifting water availability, increase in heat events	Forage species sensitive to decreased precipitation and increased heat that may dry out soil	Alterations to livestock grazing may help reduce additional stressors	Decreased vigor and production of forage species, vegetation dries out earlier in the year

Review, evaluate, and revise stewardship goals and objectives

We recommend reviewing, evaluating, and, if necessary, revising your conservation targets, goals, and objectives in light of climate projections and the priority vulnerabilities identified. Consider the following questions in the context of climate vulnerabilities and landscape-scale change (Swanston et al. 2016):

- Are there any activities or uses of the property that may need to be modified?
- Should goals and objectives be revised in order to better reflect climate vulnerabilities and the potential for landscape-scale change?
- What management challenges or opportunities might emerge?
- What are other considerations that may impede or assist with your ability to meet goals and objectives (e.g., funding, capacity, obligations, etc.)?
- How will climate change impact the long-term viability of ranching or agricultural operations?

This step should also be used to consider how other activities and land uses on the property might be exacerbated by climate change, which may warrant revisions of goals and objectives. For example, consider a scenario where an overarching goal is to provide wildlife habitat while also allowing for livestock grazing. Perhaps target species and ecosystems on the property are slightly or moderately sensitive to livestock grazing at current levels. However, climate change may lead to increased drought frequency and intensity, which could decrease forage production and increase livestock grazing pressure on wetlands and riparian areas that may maintain greenness in drought years. In response, you could revise an objective such that grazing timing and intensity is adaptively managed based on assessments of climatic and site conditions throughout the year. You should strive to regularly review and, if necessary, revise your conservation goals and objectives as part of an adaptive management process.

Identify and implement climate-smart actions and adaptation approaches

The penultimate step is to identify and implement climate-smart management actions and adaptation approaches to address priority vulnerabilities and other stressors. Some questions to consider include:

- Are current or proposed management actions sufficient to address priority climate vulnerabilities and meet goals and objectives in the context of climate change?
- How might existing management actions be modified to more effectively address climate vulnerabilities?
- What other stressors, activities, and land uses should be addressed in concert with climate vulnerabilities to increase resiliency?
- What actions can address climate vulnerabilities and enhance the ability of conservation targets to adapt to anticipated changes and meet stewardship goals?

Text Boxes 6 and 7 summarize climate-smart stewardship and restoration strategies to guide actions.

Text Box 6: Strategies for Climate-Smart Stewardship

Reduce existing stressors. Climate change is likely to exacerbate the impacts of existing stressors on species and ecosystems (Glick et al. 2011; Watson et al. 2012). If a species is already negatively impacted by an existing stressor or stressors (e.g., pollution, agriculture, water diversions, invasive species), the species may in turn be more vulnerable to climate-related stressors and may have reduced adaptive capacity. For example, anadromous fish experiencing stress from stream sedimentation may have this stress compounded by increasing numbers of days where stream temperatures are at or above threshold levels. Reducing existing non-climatic stressors through stewardship and restoration actions can help increase the resilience of species and ecosystems to cope with climate-related impacts (Watson et al. 2012).

Engage in proactive management and restoration. While there remains uncertainty as to how the climate will change and the resulting impacts to species and ecosystems, proactive ecosystem management and restoration can help increase the ability of systems to recover from climate-related disturbances. Stewardship managers should focus efforts on proactive management and restoration of existing protected lands and, when possible, catalyze such stewardship efforts in new land protection projects, including for conservation easements. Like reducing existing stressors, proactive management and restoration can increase the resiliency of species and ecosystems, making it more likely that they can recover from climate-related disturbances such as drought, flood, or wildfire.

Sustain and enhance ecological connectivity. Protecting and managing land for connectivity is one of the most commonly cited climate adaptation strategies (Schmitz et al. 2015). This strategy increases adaptive capacity by allowing species and communities to respond to climate change through dispersal and colonization. Connecting habitat patches across a larger landscape can also help extend the potential climate space for species (Gillson et al. 2013). Stewardship managers can help sustain and enhance connectivity through management actions such as removing fences and other barriers to species' movement, revegetating movement corridors (e.g., riparian areas, valleys), and managing land uses in ways compatible with wildlife. Simple research and monitoring techniques, such as the installation of camera traps, can be useful in determining whether species are utilizing connectivity corridors between protected areas.

Text Box 7: Strategies for Climate-Smart Stewardship

Manage land for ecological processes and ecosystem functions. Climate change may lead to shifts in species' ranges and changes in ecological communities. As a result, stewardship managers should begin focusing on managing land for ecological processes and ecosystem functions, rather than specific species (Groves et al. 2012; Glick et al. 2011; Schmitz et al. 2015). Examples of such processes and functions include habitat and hydrological connectivity, carbon and nutrient cycling, and disturbance regimes, such as wildfires and floods. Stewardship managers can work to manage and restore the ecosystems that play important roles in such processes, such as wetlands (nutrient cycling), floodplains (hydrological connectivity, floods), and forests (carbon storage). For example, in areas prone to increased wildfire risk, stewardship managers can implement ecological forestry practices and prescribed burns to manage risk and improve ecological functioning.

Build in ecological insurance. In cases where land trusts design and implement restoration projects, incorporating redundancies in restoration designs that are robust to a range of future scenarios may act to provide insurance against uncertain future conditions. Increasing redundancy in restoration means replicating and diversifying critical components (such as species) and functions. For example, in a riparian restoration project, practitioners could plant the full complement of native willow species intermixed in high densities and build beaver dam analogs in the floodplain in addition to adding coarse woody debris to help slow water and activate the floodplain. High ecological diversity is a form of ecological insurance that could reduce the probability of ecosystem collapse if it buffers change in functional composition of the community; there is relatively little risk in increasing it in restoration projects. This applies to agricultural landscapes, as well. Promoting diversity of both crops and native vegetation is an excellent climate adaptation strategy that can help increase resiliency (see for example Anderegg et al. 2018; Guo et al. 2018).

Build evolutionary resilience. It is increasingly recognized that micro-evolutionary change can occur at relatively short timescales relevant to natural resource management decisions, and may therefore be a critical pathway by which species escape extinction under climate change. Consequently, actions that build evolutionary resilience by managing microevolution are climate- smart. Evolutionary resilience can be accomplished by projects that increase the size and connectedness of populations to allow for the maintenance of genetic variation and ongoing evolution in order to keep pace with climate change and may increase the probability that an ecosystem can recover after climatic extremes. It may also include assisted migration, which is the human-assisted movement of plants or animals to more climatically suitable habitats. In ecosystem restoration, assisted migration can take the form of preferentially using genotypes best suited to the future predicted climate of the restoration site (Grady et al. 2011). For agricultural land managers, consider shifting to crops best suited to the future predicted climate of the property.

Stewardship managers should deliberately consider the uncertainties and trade-offs associated with various actions and strive to select strategies that are robust across multiple plausible futures (Watson et al. 2012; Stein et al. 2014; Figure 7). Dealing with uncertainty and trade-offs can also help avoid maladaption and ensure that actions taken to address climate vulnerabilities do not undermine other conservation goals and ecosystem health (Watson et al. 2012; Stein et al. 2014). For example, addressing increased wildfire risk may lead to identification of mastication in coastal scrub as a climate adaptation strategy; however, this may lead to negative impacts to other conservation targets, such as scrub-dependent birds. In such situations, managers should understand and evaluate tradeoffs to determine if the climate adaptation strategy is the best approach, given potential consequences and impacts to targets associated with implementing the strategy or doing nothing.

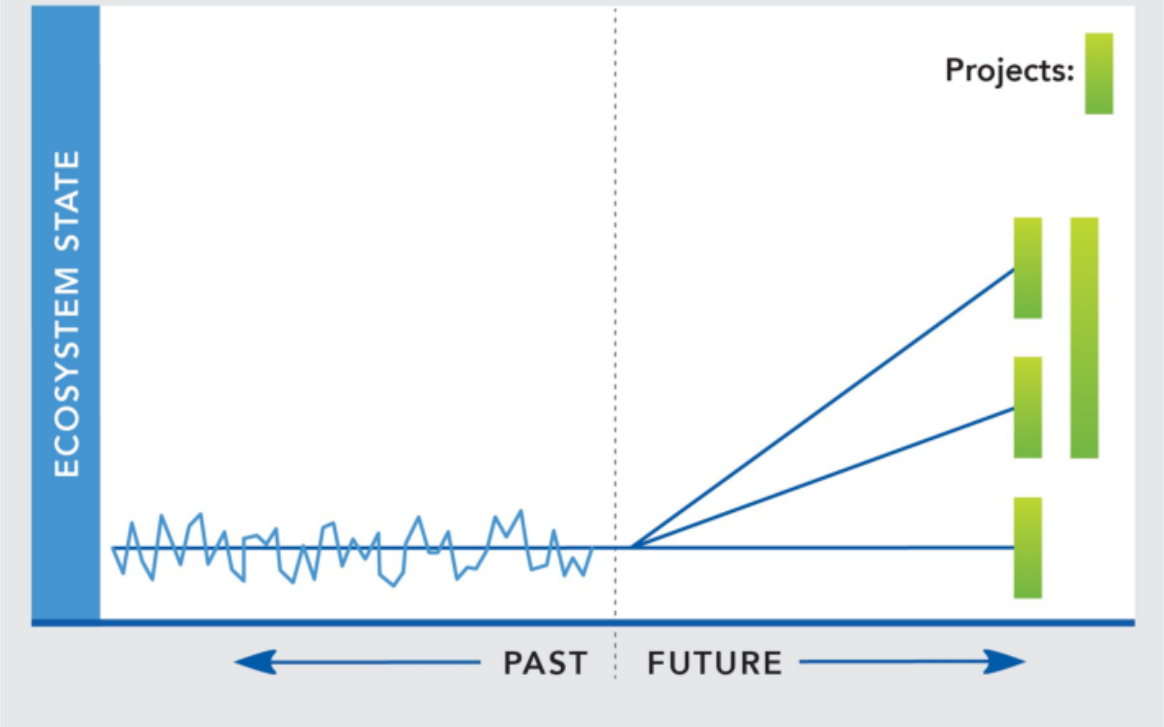

Figure 7: There may be uncertainty about how ecosystems will respond to climate change. Rather than assuming that the future ecosystem state will be the same as the past, or selecting just one possible ecosystem trajectory, design projects that are likely to succeed under multiple future ecosystem states.

Stewardship managers can address uncertainty and trade-offs by striving to identify and implement win-win, no-regrets strategies that are highly likely to be beneficial regardless of whether the associated climate vulnerability manifests itself (Galatowitsch 2019). Proactive stewardship and restoration today can help increase the resilience of species and ecosystems to cope with and recover from climate-related impacts (Watson et al. 2012). This can include restoring and enhancing ecosystems and key ecological processes, such as enhancing habitat connectivity, restoring species, and increasing hydrological connectivity. For example, restoring a diverse suite of native species with different ecological tolerances and functional roles can make the system more resilient to climate impacts, such as extreme drought or extended flood inundation. Stewardship should also focus on addressing

existing or potential non-climate stressors that may be exacerbated by climate change (Glick et al. 2011; Watson et al. 2012; Galatowitsch 2019).

Table 7: Example of how stewardship managers can explicitly link priority climate vulnerabilities to conservation targets and climate-smart actions.

Target	Priority Vulnerability	Possible Climate-Smart Action
Steelhead trout/native fish	Increased fish stress and mortality in response to rising stream temperatures	• Plant willows and other riparian shrubs/trees on stream banks to shade the stream • Address erosion and sedimentation from a nearby road contributing to decreasing stream water quality • Remove or modify culvert that may be preventing fish passage to cooler water upstream
Mountain meadow	Increased likelihood of stream channel degradation and incision leading to erosion	• Increase adaptive capacity by addressing outside stressors to the system (e.g., restricting livestock grazing in or near the channel to prevent further erosion) • Implement restoration actions to address existing degradation and increase resilience of the meadow (e.g., revegetate stream banks to increase stability)
Agricultural crops	Increased crop stress and mortality, novel temperature and precipitation regime favors crop pests, diseases, and weeds	• Diversify the varieties and types of crops planted to capture different climatic tolerances • Plant cover crops that attract beneficial insects and wildlife, including pollinators and pest predators • Implement soil health practices to increase soil water holding capacity • Implement water stewardship practices such as improvements to irrigation efficiency and increased groundwater recharge
Forage for livestock	Decreased vigor and production of forage species, vegetation dries out earlier in the year	• Work with landowner or rancher to develop contingency plan that specifies actions that will be taken to adjust grazing in response to environmental conditions • In years of prolonged drought or reduced forage, rancher could have plans in place to reduce herd size, provide supplemental feed, and/or graze on other lands • Adaptively manage livestock grazing in response to forage production and environmental conditions

Throughout this process, stewardship managers should “show their work” by documenting their rationale and logic to demonstrate how they arrived at identified climate adaptation actions and why actions were chosen (Table 7). Managers should clearly show how strategies and actions are linked to both near and long-term climate impacts in order to test

and evaluate those assumptions as part of an adaptive management cycle. Showing your work in this way can help clarify your thinking and serve as a record of decision-making.

Monitor and evaluate effectiveness of implemented actions

The final step is developing an adaptive management and monitoring plan for your property or project. Monitoring is a critical yet often overlooked component of robust stewardship. It is also an essential step in adaptive management, a decision-making process that recognizes uncertainties and allows for adjustments to strategies to be made through the process of iterative monitoring and evaluation. Climate projections and impacts are often uncertain, requiring managers to be explicit about assumptions, monitor the outcomes of strategies and actions, and adjust as needed based on the results of monitoring and new information.

Monitoring can be used to evaluate the results of management actions in meeting intended goals and objectives and reducing identified climate vulnerabilities, assess the overall success of a plan or project, and inform the revision of actions and strategies as needed. It can help identify emerging stressors to the system, such as new invasive species. Monitoring can also help catalyze innovation through greater risk-taking and experimentation with new stewardship approaches.

We recommend developing a monitoring plan that is integrated into your management plan or project design to help evaluate success and inform changes to management actions in response to data. Effective monitoring requires collecting baseline data for biophysical indicators before a stewardship action or plan is implemented; baseline monitoring can also occur at the start of a stewardship planning process in order to inform the stewardship plan itself as well as to assess resource values and potential stressors present on the property.

Table 8: Sample monitoring strategy for objectives associated with conservation targets, including the monitoring indicator/metric and frequency of collection.

Target	Goal	Objectives	Indicator/Metric	Frequency of Collection
Meadow focal bird species	The property's wet meadows support diverse native meadow-dependent terrestrial and aquatic wildlife, including birds, amphibians, and fish.	Increase willow cover to 30% of the riparian area to support birds	Willow cover	Every 4-5 years
		Increase meadow focal bird species richness to 1.03 meadow focal species per acre	Meadow focal species richness	Every 2 years
Livestock grazing	The property supports grasses and forbs that provide high quality forage for livestock.	Bare ground will be reduced to <10% as measured at 4 locations within 3 years	Bare ground	Every 3 years
		Stubble height of key forage plants at the end of the growing season is ≥6 inches measured at 15 locations annually	Stubble height	Annually

Monitoring can be incorporated into a stewardship plan by identifying metrics for each objective and an associated strategy that specifies the frequency and mode of data collection (Table 8). Modes of collection can range from more passive and/or qualitative (e.g., photo points, camera traps) to quantitative (e.g., bird counts, vegetation surveys, stream flow, stubble height), depending on resource availability and staff capacity. Frequency of collection should be determined based on a reasonable prediction of how long changes in the given metric might be expected; for example, bird species richness might change rapidly in response to stewardship, requiring annual or semi-annual monitoring, while changes in soil organic carbon might take several years to manifest.

Monitoring should be targeted and strategic in order to capture relevant information that can be used to evaluate the effectiveness of stewardship actions in meeting stated goals and objectives. Land trusts can partner and collaborate with scientists, researchers, and/or students to design and implement monitoring strategies (Robinson et al. 2018). The most important part of monitoring is arguably using the results to feed back into the adaptive management cycle and stewardship process. The results of monitoring may point to the need to tweak or adjust stewardship actions or even the need to rethink goals and objectives, and can thus help inform management plan revisions and updates.

Conclusion

Land trusts across the U.S. are already experiencing and dealing with the effects of climate change on their conserved lands, such as catastrophic flooding, increased wildfire risk, sea level rise, prolonged severe drought, and shifts in species distributions. It is likely that we will continue to experience profound changes throughout this century. Conventional land protection approaches that focus on preventing development are likely inadequate to ensure that conservation values persist on the landscape in the face of climate change. It is essential that land trusts and others involved in land conservation adapt and adjust their processes and strategies in order to respond to changing climatic and landscape-scale conditions.

This handbook has illustrated how climate change considerations and climate adaptation approaches can be integrated into all steps of the private land conservation process, including strategic conservation planning, acquisitions, conservation easements, and stewardship. The suggested approaches, principles, strategies, and best management practices included in this handbook may help increase the resilience of conserved lands in the context of climate change and ensure land trusts fulfill their commitment to protect land in perpetuity.

References

Amundsen, O. 2011. Strategic Conservation Planning. Land Trust Alliance, 312 pp.

Anderegg, W. R., A. G. Konings, A. T. Trugman, K. Yu, D. R. Bowling, et al. 2018. Hydraulic diversity of forests regulates ecosystem resilience during drought. Nature 561, 538-541.

Conservation Measures Partnership. 2013. Open Standards for the Practice of Conservation. Version 3.0. Available online at http://cmp-openstandards.org/wp-content/uploads/2014/03/CMP-OS-V3-0-Final.pdf.

Chen, I., J. K. Hill, R. Ohlemuller, D. B. Roy, and C. D. Thomas. 2011. Rapid range shifts of species associated with high levels of climate warming. Science 333(6045): 1024-1026.

Clark, S., C. Kelly, and J. Morse. 2017. Habitat stewardship with climate change in mind. In *Land conservation in a changing climate: Stewardship science and financing.* Report of the 2016 Berkeley Workshop. Yale F&ES Publication Series. Report Number 33.

Cook, C. N., S. Inayatullah, M. A. Burgman, W. J. Sutherland, and B. A. Wintle. 2014. Strategic foresight: how planning for the unpredictable can improve environmental decision-making. Trends in Ecology and Evolution, 29(9), 531-541.

Flint, L.E., A.L. Flint, J.H. Thorne, R. Boynton. 2013. Fine-scale hydrologic modeling for regional landscape applications: the California Basin Characterization Model development and performance. Ecological Processes 2:25.

Galatowitsch, S. 2019. Wetlands in an era of rapid environmental change. Webinar 6: Dealing with changing weather patterns in restoration planning. May 6, 2019. Association of State Wetland Managers and Natural Resources Conservation Service.

Garfin, G., A. Jardine, R. Merideth, M. Black, and S. LeRoy, eds. 2013. *Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment*. A report by the Southwest Climate Alliance. Washington, DC. Island Press.

Gillson, L., T. P. Dawson, S. Jack, and M. A. McGeoch. 2013. Accommodating climate change contingencies in conservation strategy. Trends in Ecology & Evolution 28(3): 135-142.

Glick, P. B. A. Stein, and N. A. Edelson, editors. 2011. Scanning the conservation horizon: A guide to climate change vulnerability assessment. National Wildlife Federation, Washington, D. C.

Greene, D. M. 2005. Dynamic conservation easements: Facing the problem of perpetuity in land conservation. Seattle University Law Review, 28:467, 883-922.

Groves, C. R., E. T. Game, M. G. Anderson, M. Cross, C. Enquist, et al. 2012. Incorporating climate change into systematic conservation planning. Biodiversity and Conservation 21(7): 11651-1671.

Guo, Q., S. Fei, K. M. Potter, A. M. Liebhold, and J. Wen. 2019. Tree diversity regulates forest pest invasion. PNAS 116(15), 7382-7386.

Hansen, L., J. Hoffman, C. Drews, E. Mielbrecht. 2010. Designing climate-smart conservation: guidance and case studies. Conservation Biology 24:63–69.

Hjort, J., J. E. Gordon, M. Gray, and M. L. Hunter. 2015. Why geodiversity matters in valuing nature's stage. Conservation Biology 29(3): 630-639.

Larson, K., J. Jay, and E. Fred. 2019. Addressing ephemeral land management in a perpetual conservation easement. Presentation at Rally 2019: The National Land Conservation Conference, Raleigh, NC, October 18, 2019.

Lawler, J. L., D. D. Ackerly, C. M. Albano, M. G. Anderson, S. Z. Dobrowski, et al. 2015. The theory behind, and the challenges of, conserving nature's stage in a time of rapid change. Conservation Biology 29(3): 618-629.

Moore, S. S., N. E. Seavy, and M. Gerhart. Scenario planning for climate change adaptation: A guidance for resource managers. 2013. Point Blue Conservation Science and the California Coastal Conservancy.

Open Space Institute and the North Atlantic Landscape Conservation Cooperative. 2017. Conserving nature in a changing climate: A three-part guide for land trusts in the Northeast. Available online at https://s3.amazonaws.com/osi-craft/OSI-Climate-Guide-FINAL.pdf?mtime=20170213114541

Owley, J. 2010. Changing property in a changing world: A call for the end of perpetual conservation easements. Stanford Environmental Law Journal, 30, 121-170.

Owley, J. 2011. Conservation easements at the climate change crossroads. Law and Contemporary Problems 74: 199-228.

Owley, J. & A. R. Rissman. 2016. Trends in private land conservation: Increasing complexity, shifting conservation purposes and allowable private land uses. Land Use Policy 51, 76-84.

Owley, J., F. Cheever, A. R. Rissman, M. R. Shaw, B. H. J. Thompson, and W. W. Weeks. 2017. Climate change challenges for land conservation: Rethinking conservation easements, strategies, and tools. Denver Law Review 95, 727-780.

Rissman, A. R. 2010. Designing perpetual conservation agreements for land management. Rangeland Ecology & Management 63(2): 167-175.

Rissman, A. R. 2011. Evaluating conservation effectiveness and adaptation in dynamic landscapes. Law and Contemporary Problems 74: 145-173.

Rissman, A., M. Bihari, C. Hamilton, C. Locke, D. Lowenstein, M. Motew, J. Price, and R. Smail. 2013. Land management restrictions and options for change in perpetual conservation easements. Environmental Management 52: 277-288.

Rissman, A. R., J. Owley, M. R. Shaw, and B. Thompson. 2015. Adapting conservation easements to climate change. Conservation Letters 8(1), 68-76.

Robinson, N. M., B. C. Scheele, S. Legge, D. M. Southwell, O. Carter, et al. 2018. How to ensure threatened species monitoring leads to threatened species conservation. Ecological Management & Restoration 19(3): 222-229.

Schmitz, O. J., J. J. Lawler, P. Beier, C. Groves, G. Knight, et al. 2015. Conserving biodiversity: Practical guidance about climate change adaptation approaches in support of land-use planning. Natural Areas Journal 35(1): 190-203.

Seavy, N. E., T. Gardali, G. H. Golet, F. T. Griggs, C. A. Howell, et al. 2009. Why climate change makes riparian restoration more important than ever: Recommendations for practice and research. Ecological Restoration 27:3, 330-338.

Smit, B., I. Burton, R. J. T. Klein, and J. Wandel. 2000. An anatomy of adaptation to climate change and variability. Climate Change 45: 223-251.

Spencer, W. D., P. Beier, K. Penrod, K. Winters, C. Paulman, et al. 2010. California Essential Habitat Connectivity Project: A Strategy for Conserving a Connected California. Prepared for California Department of Transportation, California Department of Fish and Game, and Federal Highways Administration.

Spencer, W. and H. Rustigian-Romsos. 2012. Predicted probability of fisher year-round occurrence, 2076-2095, CSIRO Mk3 A2, 800 m resolution. Unpublished data

provided by Conservation Biology Institute. Available online at https://databasin.org/datasets/11cf16bf63344c869c185b2e3b3464b6.

Stanford Institute for the Environment. 2009. Climate change and conservation easement clause databank. Available online at https://woods.stanford.edu/sites/default/files/documents/Climate%20Change%20and%20Conservation%20Easement%20Clause%20Databank_0.pdf

Stein, B. A., P. Glick, N. A. Edelson, and A. Staudt, editors. 2014. Climate-smart conservation: Putting adaptation principles into practice. National Wildlife Federation, Washington, D. C.

Swanston, C. W., Janowiak, M. K., Brandt, L. A., Butler, P. R., Handler, S. D., et al. 2016. Forest Adaptation Resources: climate change tools and approaches for land managers, 2nd ed. Gen. Tech. Rep. NRS-GTR-87-2. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 161 p. http://dx.doi.org/10.2737/NRS-GTR-87-2

Watson, J. E. M., M. Rao, K. Ai-Li, and X. Lan. 2012. Climate change adaptation planning for biodiversity conservation: A review. Advances in Climate Change Research, 3(1), doi.10.3724/SP.J.1248.2012.00001.

Weiskittel, A. R., N. L. Crookston, and G. E. Rehfeldt. 2012. Projected future suitable habitat and productivity of Douglas-fir in western North America. Schweiz Z Forstwes 163(3): 70-78.

Wilkin, K. M., D. D. Ackerly, and S. L. Stephens. 2016. Climate change refugia, fire ecology and management. Forests 7(4): 77.

Williams, S. E., L. P. Shool, J. L. Isaac, A. A. Hoffmann, and G. Langham. 2008. Towards an integrated framework for assessing the vulnerability of species to climate change. PLoS Biology 6(12): 2621-2626.

Wintle, B. A., H. Kujala, A. Whitehead, A. Cameron, S. Veloz, et al. 2019. Global synthesis of conservation studies reveals the importance of small habitat patches for biodiversity. PNAS 116(3): 909-914.

Appendix A: Glossary of Key Concepts and Terms

Adaptive Capacity: One of the three components of climate vulnerability. Adaptive capacity is the ability of a species or system to accommodate or cope with climate change impacts. It includes both evolutionary changes, such as pressures that favor certain genotypes and phenotypes over others, as well as plastic ecological responses, such as changes in a species' behavior or migration to more suitable habitat. Adaptive capacity can also be increased through management and restoration actions.

Adaptive Management: A decision-making process that recognizes uncertainties and allows for adjustments to strategies to be made through the process of iterative monitoring and evaluation.

Climate Adaptation: Preparing for and responding to climate impacts to natural and human communities.

Climate Refugia: Areas on the landscape least likely to undergo rapid climate-induced changes.

Climate-Smart Conservation: The intentional and deliberate consideration of climate change in natural resource management, realized by adopting forward-looking goals and explicitly linking strategies to key climate impacts and vulnerabilities.

Climate Vulnerability: The susceptibility or amount of risk of a species or ecosystem to the negative impacts of climate change.

Connectivity: The degree of connectedness among habitat patches and/or protected areas that can allow for the movement of species as well as large-scale ecological processes.

Conservation Target: The natural and cultural conservation values of interest, such as specific species, ecosystems, habitats, natural/cultural resources, and ecological processes. Synonymous with conservation value.

Ecological Functions and Ecological Processes: The biological, geochemical, and physical processes and components that take place or occur within an ecosystem. How structural components of an ecosystem interact with each other. Ecological functions include, but are not limited to, nutrient cycling, hydrological processes, soil formation, and water purification.

Ecosystem Service: The benefits people obtain from the natural environment and properly functioning ecosystems, such as pollination, water purification, water storage, climate regulation, and natural hazard regulation.

Ecological Redundancy: The replication and diversification of critical components and functions in an ecosystem in order to increase resiliency in response to climate-driven disturbances. This could involve diversifying the species composition of a property through revegetation efforts.

Evolutionary Resiliency: The ability of populations to persist in their current state and to undergo evolutionary adaptation in response to changing environmental conditions.

Exposure: One of the three components of climate vulnerability. Exposure includes extrinsic factors that influence a species or ecosystem. It focuses on the character, magnitude, and rate of change in climate variability that the species or system is likely to experience.

Geodiversity: The diversity of geological features, topographical features, and soils within different land facets. High geodiversity is correlated with high biodiversity.

Goal: Broad, qualitative description of the desired conditions and processes to be achieved in the long-term.

Metric: Standards of measurement by which the effectiveness of an intervention can be assessed.

Multiple Benefits: Efforts designed to meet societal needs and enhance ecological function and habitat quality for fish and wildlife.

Objective: Specific, measurable statements that indicate progress towards meeting stated goals.

Representative Concentration Pathways (RCP): Emissions scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) that provide time-dependent projections of atmospheric greenhouse gas (GHG) concentrations based on assumptions about economic activity, energy sources, population growth, and other socio-economic factors. There are four scenarios used by the IPCC: RCP8.5, RCP6.0, RCP4.5, and RCP2.6. The numbers refer to the possible range of radiative forcing values in the year 2100.

Resilience: The ability of a system to return to desired conditions after disturbance, or maintain some level of functionality in an altered state.

Scenario Planning: A framework in which multiple plausible futures are used to evaluate the outcomes and consequences of different decisions or strategies that need to be made in the face of uncertainty.

Sensitivity: One of the three components of climate vulnerability. Sensitivity includes intrinsic traits or characteristics of a species or ecosystem that determine its tolerance and response to changes in climate variables, such as temperature or precipitation.

Vulnerability Assessment: See also Climate Vulnerability. A process to identify climate vulnerabilities to a species, ecosystem, or human community and design actions to reduce vulnerabilities.

Appendix B: Climate Change Resources for Land Trusts

This section lists some climate change resources, including sources of climate projections and climate summaries, structured adaptation approaches, libraries of climate adaptation case studies, and other tools. For land trusts just beginning to assess and understand overarching climate impacts to their region, I recommend beginning with the National Oceanic and Atmospheric Administration's State Climate Summaries 2019.

Adaptation Workbook: The Adaptation Workbook is a climate change tool for land management and conservation. It follows a structured process to consider the potential effects of climate change and design management actions. Its primary use is for planning stewardship projects. The website will also populate climate projections and impacts for your particular region and provide a list of suggested resources for further information. You can use the website's interactive features to develop a stewardship plan for a particular project or property.

Best used for: Stewardship

AdaptWest: AdaptWest is a spatial database designed to help land management agencies and other organizations implement strategies that promote resilience, protect biodiversity, and conserve and enhance the adaptation potential of natural systems in the face of a changing climate. It builds on the climate adaptation objectives of the Yale Framework (see below) by comparing and synthesizing methods and building mapped products that integrate priorities from the different methods. The resulting mapping products and prioritization approaches can be used to guide conservation planning in North America.

Best used for: Strategic Conservation Planning

Cal-Adapt: For land trusts operating in California, Cal-Adapt can be used to find tools, data, and resources to inform adaptation planning. The interactive functions of the website also allow the user to explore climate projections under various climate models and emission scenarios for specific locations in California and download figures.

Best used for: Strategic Conservation Planning, Stewardship

Climate Adaptation Knowledge Exchange: This website includes climate adaptation case studies and resources, including a digital library, directory, and tools. This is a useful site to explore case studies for a particular topic, location, or ecosystem of interest that can inform your projects.

Best used for: Stewardship

Climate Explorer: Explore graphs and maps of historical and projected climate variables for any county in the contiguous United States.

Best used for: Strategic Conservation Planning, Stewardship

LTA's Climate Change Program: The Land Trust Alliance's Conservation in a Changing Climate website includes a library of climate change resources tailored for land trusts, spanning all different aspects of the land protection process. Resources include climate change impacts and projections for each U.S. region along with tailored lists of resources for each state; how to integrated climate change into strategic conservation planning and stewardship; how to assess and address climate vulnerabilities; and how to communicate about climate change through community engagement. It also includes case studies, reports, and articles tailored to land trusts, with options to filter by region and other topics.

Best used for: Strategic Conservation Planning, Conservation Easements, Stewardship

National Climate Change Viewer: The U.S. Geological Survey (USGS) National Climate Change Viewer (NCCV) includes downscaled historical and future climate projections from the most recent IPCC assessment report, the Fifth Assessment Report. The data are from 30 of the downscaled models for two of the RCP emission scenarios, RCP4.5 and RCP8.5. The NCCV allows users to visualize projected changes in climate variables (temperature, precipitation) and the water balance (snow water equivalent, runoff, soil water storage and evaporative deficit) for any state, county and USGS Hydrologic Units (HUC). The viewer provides other tools for characterizing climate change (e.g., maps, plots, time series, summary statistics) and provides access to comprehensive, summary reports in PDF format and CSV files of the temperature and precipitation data for each geographic area.

Best used for: Strategic Conservation Planning, Stewardship

NorWest Stream Temperature Map: The NorWest webpage hosts stream temperature data and climate scenarios in a mapping application for streams and rivers across the western U.S. It can be used to explore historical and projected future stream temperature data, with implications for freshwater organisms.

Best used for: Strategic Conservation Planning, Stewardship

Our Coast, Our Future: This is a collaborative, user-driven project focused on providing coastal California resource managers and land use planners locally relevant, online maps and tools to help understand, visualize, and anticipate vulnerabilities to sea level rise and storms. It includes an interactive map with different coastal flooding and sea level rise scenarios for California.

Best used for: Strategic Conservation Planning, Stewardship

Rangeland Monitoring Network Handbook of Field Methods: This handbook provides the Rangeland Monitoring Network (RMN) protocols for sampling soil, vegetation, and wildlife on rangelands. Developed by Point Blue Conservation Science, the RMN provides tools, data, and people that assist ranchers, researchers, and conservation planners and partners in collecting data that expands our knowledge of rangelands and ranching practices.

Best used for: Stewardship, Monitoring

Resilient and Connected Landscapes Project: The Nature Conservancy's Resilient and Connected Landscapes project maps resilient lands and significant climate corridors in eastern North America. The project is expanding to other geographic regions in the U.S., for example, resilient lands data are also available for the Midwest and Great Plains. You can explore resilient landscapes and connected landscapes in separate online mapping applications.

Best used for: Strategic Conservation Planning

Sea Level Rise Viewer: This online mapping tool can be used to view sea level rise, potential coastal flooding impact areas and relative depth, areas susceptible to high tide flooding, impacts to vulnerable populations, and potential changes in marsh and other land cover types based on inundation levels.

Best used for: Strategic Conservation Planning, Stewardship

Sea Level Rise Adaptation Framework: This user guide can help planners and others include nature-based strategies to address sea level rise hazards. The framework helps planners determine which nature-based measures are suitable given specific site conditions, and offers an approach for evaluating which combination of measures are the most appropriate to achieve desired outcomes.

Best used for: Strategic Conservation Planning, Stewardship

State Climate Summaries 2019: These state climate summaries were released in 2017 by the National Oceanic and Atmospheric Administration and cover historical climate variations and trends, future climate model projections of climate conditions during the 21st century, and past and future conditions of sea level rise and coastal flooding. You can click on your state and view key messages, narrative, and view summary figures of climate data.

Best used for: Stewardship

U.S. Climate Resilience Toolkit: This website includes information and tools to help understand and address climate risks. It includes a structured process for building resiliency, case studies, and a Climate Explorer to access climate projections.

Best used for: Stewardship

U.S. Forest Service Climate Change Resource Center: This website includes multiple resources for climate change adaptation planning, including an interactive map to explore region-specific projections and information. You can also select topics (e.g., forests, grasslands, assessments, disturbances) to further refine the results. The website also includes information about climate change science and modeling, climate change impacts to forests and grasslands specifically, and how to respond to climate change. It includes a list of climate change and carbon tools, adaptation approaches and case studies, and a library of climate change resources that includes articles, reports, factsheets, and newsletters with relevant content.

Best used for: Strategic Conservation Planning, Stewardship

U.S. Forest Service Climate Gallery: This website includes numerous web mapping applications with galleries for a variety of topics and regions. Some examples of data resources include information on droughts, temperature/precipitation changes, wildfire, and refugial streams. Some examples of region and ecosystem-specific resources include adaptation resources for Mid-Atlantic forests, New England and Northern New York forests, and the Northern Rocky Mountains.

Best used for: Strategic Conservation Planning, Stewardship

Yale Framework for Climate Adaptation: This framework includes advice and tools to assist conservation planners in integrating climate adaptation into landscape conservation planning. It includes six climate adaptation objectives (which are listed as strategies in this handbook) at and advice to help practitioners select the assessment and modeling strategies that fit their needs. It includes a structured menu of options to assist resource managers in determining climate adaptation approaches, simple and flexible advice on models and data, and commonly used datasets that can be helpful to planners.

Best used for: Strategic Conservation Planning

Appendix C: Stewardship Planning Worksheet

This worksheet offers a structured process that you can use to identify climate vulnerabilities to your conservation targets, goals, and objectives, and design stewardship actions that can increase the resilience of your project to identified vulnerabilities. The steps in this worksheet are based on multiple sources (Glick et al. 2011; Conservation Measures Partnership 2013; Stein et al. 2014; Swanston et al. 2016).

Step 1: Set the scope and define conservation targets, goals, and objectives

The first step in a climate-smart stewardship planning process is to set the scope and define your goals and objectives for the property or project of interest. Conservation targets (also known as resource/conservation values) are the specific species, ecosystems, or habitats within the project area that are the focus of your plan or project and are the basis for setting goals and objectives. Goals are broad, qualitative descriptions of the conditions, processes, and conservation values you would like to see on the ground as a result of implemented actions. You may have several conservation targets that relate to a single goal, or several goals pertaining to one conservation target. Goals should be linked to one or more specific, measurable objectives that can be used to measure progress towards achieving your goals as part of the monitoring and evaluation step.

Conservation Target(s)	Goals	Objectives
(1) Wet meadow *(2) Willow flycatcher* *(3) Steelhead trout* *(4) Long-toed salamander*	*The property's wet meadows support diverse native meadow-dependent terrestrial and aquatic wildlife, including birds, amphibians, and fish.*	*Increase willow cover to 30% of the meadow area to support willow flycatchers.*

Step 2: Gather relevant data.

The next step is to gather relevant data on climate projections for your project area. These projections will be the basis for identifying vulnerabilities to your desired restoration outcomes in the next step. Some sources include Climate Explorer and National Climate Change Viewer. Appendix B also includes additional resources for acquiring projections. Use the text box below to record your findings.

Projections used:

Example: HadGEM2-ES, CNRM-CM5, CanESM2, and MIROC5, under RCP 8.5

Summary of climatic projections for the project area:

Example: The number of extreme heat days per year projected to increase on average from a historic baseline of 6 days/year in 1981-2010 to 33 days/year by mid-century (2041-2060).

Step 3: Assess climate impacts and vulnerabilities in the context of desired outcomes.

In this step, you will use the climate projections gathered previously to assess potential climate vulnerabilities to your goals and conservation targets. A climate vulnerability is defined as the susceptibility or amount of risk of a species or ecosystem to the negative impacts of climate change (Williams et al. 2008; Smit et al. 2000). The following are some questions to consider:

- How do the climate change projections and the current site conditions make each conservation target and stewardship goal vulnerable?
- Is the current condition of the property or project site capable of achieving goals in the context of potential vulnerabilities?
- Are current or proposed stewardship actions sufficient to achieve goals in the context of potential vulnerabilities?
- What are the priority vulnerabilities that should be addressed to ensure long-term project success?

Use the table below to list your priority vulnerabilities.

Conservation Targets	Goals	Priority Vulnerabilities
Steelhead Trout	*The property's wet meadows support diverse native meadow-dependent terrestrial and aquatic wildlife, including birds, amphibians, and fish.*	*Increased fish stress and mortality in response to rising stream temperatures.*

Step 4: Review, evaluate, and revise stewardship goals and objectives

Once you have identified priority vulnerabilities, we recommend reviewing, evaluating, and, if necessary, revising your conservation targets, goals, and objectives in light of climate projections and your vulnerability assessment. Consider and answer the following questions in the context of climate vulnerabilities and the potential for landscape-scale change (after Swanston et al. 2016).

Are there any activities or uses of the property that may need to be modified? *Example: We should consider changing livestock grazing management to reduce impacts to the riparian area and stream that may be contributing to loss of riparian shrubs that could help shade the stream for fish.*
Should goals and objectives be revised in order to better reflect climate vulnerabilities and the potential for landscape-scale change? *Example: Change the willow cover objective to: Increase willow cover to 30% of the meadow area to support willow flycatchers and 40% of the riparian area to shade the stream for fish.*
What stewardship challenges or opportunities might emerge? *Example: We should explore how to best balance other property uses (e.g., livestock grazing, recreation) with protection of conservation targets given potential for increased vulnerabilities.*
What are other considerations that may impede or assist with your ability to meet stewardship goals and objectives (e.g., funding, capacity, obligations, etc.)? *Example: We are required to provide public access to the site, so we should consider how to manage human recreation while protecting conservation targets.*

Step 5: Identify and implement climate-smart actions and adaptation approaches.

This step is to identify and implement climate-smart stewardship actions and adaptation approaches to address the priority vulnerabilities and other stressors identified in the previous step. Some key questions to consider include:

- Are current or proposed stewardship actions sufficient to address priority climate vulnerabilities and meet goals and objectives in the context of climate change?
- How might existing stewardship actions be modified to more effectively address climate vulnerabilities?
- What other stressors, activities, and land uses should be addressed in concert with climate vulnerabilities to increase resiliency?
- What actions can address climate vulnerabilities and enhance the ability of conservation targets to adapt to anticipated changes and meet stewardship goals?

List your identified actions for each priority vulnerability in the table below.

Priority Vulnerabilities	Climate-Smart Stewardship Actions
Increased fish stress and mortality in response to rising stream temperatures	*(1) Plant willows and other riparian shrubs/trees on stream banks to shade the stream* *(2) Fence the riparian area and/or install exclosures around newly planted shrubs/trees to prevent cattle grazing* *(3) Address erosion and sedimentation from a nearby road that may be contributing to decreased water quality* *(4) Remove or modify culvert that may be preventing fish passage*

Step 6: Monitor and evaluate effectiveness of implemented actions

The final step is developing an adaptive management and monitoring plan for your property or project to evaluate the effectiveness of your stewardship actions in reducing identified vulnerabilities and meeting goals and objectives. Monitoring can easily be incorporated into a stewardship plan by identifying metrics for each objective and an associated strategy for evaluating these metrics that specifies the frequency and mode of collection of these data. Use the table below to develop your monitoring strategy.

Conservation Targets	Goals	Objectives	Monitoring Indicator/Metric	Frequency of Collection
Meadow focal bird species	*The property's wet meadows support diverse native meadow-dependent terrestrial and aquatic wildlife, including birds, amphibians, and fish.*	*Increase meadow focal bird species richness to 1.03 meadow focal species per acre*	*Meadow focal species richness*	*Every 2 years*