

CONTRIBUTED PAPER

Assessing the use of climate change information in State Wildlife Action Plans

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Abstract

Assessing how climate change information is used in conservation planning is an important part of meeting long-term conservation and climate adaptation goals. In the United States, state agencies responsible for fish and wildlife management create State Wildlife Action Plans (SWAPs) to identify conservation goals, prioritize actions, and establish plans for managing and monitoring target species and habitats. We created a rubric to assess and compare the use of climate change information in SWAPs for 10 states in the Intermountain West and Great Plains. Interviews with SWAP authors identified institutional factors influencing applications of climate change information. Access to professional networks and climate scientists, funding support for climate change vulnerability analysis, Congressional mandates to include climate change, and supportive agency leadership facilitate using climate change information. Political climate could either support or limit options for using this information. Together, the rubric and the interview results can be used to identify opportunities to improve the use of climate information, and to identify entry points to support conservation planning and natural resource managers in successful adaptation to climate change. This research is directly relevant to future SWAP revisions, which most states will complete by 2025, and more broadly to other conservation planning processes.

KEYWORDS

adaptation planning, Central United States, climate change, climate change vulnerability, conservation planning, Northern Great Plains, resilience, wildlife planning

1 | INTRODUCTION

Comprehensive planning to adapt and manage fish, wildlife, and habitats to climate change requires assessing species and ecosystem vulnerability to climate-related risks (Heller & Zavaleta, 2009; Mawdsley et al., 2009; West et al., 2009; Glick et al., 2011; Association of Fish and Wildlife Agencies, 2012¹; Stein et al., 2014). The imperatives for incorporating climate change information

into conservation planning are robust (c.f., Heller & Zavaleta, 2009). For example, key strategies to achieving conservation targets include using climate change information to identify risks to diverse habitats, map climate refugia, and increase habitat connectivity (Game et al., 2011; Groves et al., 2012; Lacher & Wilkerson, 2014; Michalak et al., 2018). However, there are gaps between managers' understanding of the importance of climate change, the use of climate information in planning

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efforts, and implementation of adaptation actions (Cross et al., 2013; Dilling et al., 2019; Donatti et al., 2019; Peterson St-Laurent et al., 2021). Although natural resource managers increasingly recognize the importance of using climate change information to inform conservation, this information is currently underutilized (Archie et al., 2014; Delach et al., 2019; Ellenwood et al., 2012; Lemieux et al., 2013). To close these gaps, there is a need for better guidance on how to use climate change to inform conservation planning (c.f., Archie et al., 2014; Yocum & Ray, 2019).

Understanding how climate change is being used in conservation planning is key to both improving those planning processes and to understanding the linkage between plans and actions. A review of 185 Comprehensive Conservation Plans for the US National Wildlife Refuge System found that plans varied in the extent to which they addressed climate change but also identified excellent examples within the plans that, if compiled and shared across planning entities, could improve planning efforts (Meretsky & Fischman, 2014). However, reviews of other conservation planning documents have found disconnects between managers' understanding of climate change-related risks to conservation and the inclusion of potential adaptation strategies or actions in plans (Fontaine, 2011; Delach et al., 2019; Hoepfner & Hughes, 2019). These gaps may result in conservation efforts that fall short of conservation goals (c.f., Delach et al., 2019).

Systematic comparison of strategic conservation planning across multiple, comparable land units can identify best practices to support the use of climate change information in conservation planning. In the United States, state fish and wildlife agencies are required to write State Wildlife Action Plans (SWAPs) to outline conservation goals, identify priority species and habitats, and describe plans for monitoring and observation (Department of the Interior, 2001). The first SWAPs were published in 2005, and must be revised every 10 years (AFWA, 2009). In 2005, 35 SWAPs mentioned climate change as a potential threat (Lerner et al., 2006); however, only four dealt substantively with climate change (Lacher & Wilkerson, 2014) and only one-quarter explicitly discussed using adaptive management to address climate change (Fontaine, 2011). For the most recent revision of the SWAPs, guidance from the President and the Department of the Interior (DOI)—which is responsible for national policy on fish, wildlife, and public land—strongly encouraged states to include climate change in the 2015 SWAP revisions (Executive Order 13514, 2009²; DOI Secretarial Order 3289, 2009). However, the best practices guidance on how to include climate change information was non-prescriptive in order to accommodate the specific ecological, environmental, and social differences between the states (AFWA, 2009, 2012;

Glick et al., 2011; National Fish, Wildlife and Plants Climate Adaptation Partnership, 2012).

SWAPs vary widely in approaches to conservation and criteria for selecting and classifying priority species and habitats (Lackstrom et al., 2018; Lerner et al., 2006; Paskus et al., 2016). Concurrently with our study, comparisons of SWAPs in the mid-west (Paskus et al., 2016) and the southern United States. (Lackstrom et al., 2018) suggest that enhancing regional collaboration and using shared classification and terminology could improve the use of climate change information in future SWAP revisions. This in turn could improve planning for climate adaptation, especially with regard to vulnerability analysis and identifying regional target species and habitats in common.

This study contributes to this literature by creating a method to analyze the use of climate change information in plans and understand the circumstances that facilitate its use. Our results are directly relevant to future SWAP revisions, and more broadly to other conservation planning processes. We created a novel rubric and conducted follow up interviews to evaluate and compare the use of climate change information in SWAPs in the north central United States. Similar rubrics have been used to compare other types of conservation plans (Meretsky & Fischman, 2014) and to understand how the use of climate change information in adaptation planning improves over time (Adler & Gosliner, 2019); however, no such rubric existed for SWAPs. We developed a novel rubric based on best practices and guidelines. Our rubric allows researchers and SWAP authors to assess the use of climate information, to compare it to available guidance, and to learn from examples from other states in order to improve future revisions. This article describes the development of the rubric and its application to the SWAPs of 10 states in the Intermountain West and Great Plains. Based on interviews, we describe reasons why states performed differently. We use these results to recommend steps to improving the use of climate change in these plans—and other conservation planning processes more broadly.

2 | METHODS

Our analysis had three steps: documenting the use of climate change information in each plan; creating a rubric to compare and analyze the use of this information; and interviewing key informants. This research was part of a larger project seeking to generate actionable climate information to support wildlife managers and conservation in the north central United States. (c.f., Ballard et al., 2014; Abel et al., 2020; Yocum & Ray, 2019).

We reviewed the most recent SWAP from 10 states: Colorado (Colorado Parks and Wildlife, 2015); Iowa

(Iowa Department of Natural Resources, 2015); Kansas (Rohweder, 2015); Minnesota (Minnesota Department of Natural Resources, 2016); Montana (Montana Fish, Wildlife, and Parks, 2015); Nebraska (Schneider et al., 2011); North Dakota (Dyke et al., 2015); South Dakota (South Dakota Department of Game, Fish and Parks, 2014); Utah (Utah Division of Wildlife Resources, 2015); and Wyoming (Wyoming Game and Fish Department, 2017). These states were selected because they are served by boundary organizations which collaborate in the region (Averyt et al., 2018): the USGS North Central Climate Adaptation Science Center (NCCASC), the National Oceanic and Atmospheric Administration Western Water Assessment Regional Integrated Sciences and Assessments (NOAA RISA), and the US Department of Agriculture Northern Plains Climate Hub. Boundary organizations work to facilitate the flow of information between the research and management communities (Averyt et al., 2018; Crona & Parker, 2011; Gustafsson & Lidskog, 2018; McNie, 2007). Adjacent states of Iowa and Minnesota are included because they encompass the eastern portions of the Prairie Pothole Region and Northern Great Plains, ecosystems which are a focus of the NCCASC.

2.1 | Documenting the use of climate information

We read and annotated each SWAP to identify the climate information used. Often, specific information was absent, in separate reports, or had to be inferred based on available information.

2.2 | Creating and applying the rubric

We developed a rubric based on best practices and guidelines for revising the SWAPs in three guidance documents: the eight congressionally mandated elements (AFWA, 2002); Best Practices for State Wildlife Action Plans (AFWA, 2012); and Voluntary Guidance for States to Incorporate Climate Change into State Wildlife Action Plans and other Management Plans (AFWA, 2009). We identified guidance specific to the use of climate change information in these documents and then combined these guidelines to eliminate redundancy and create metrics for scoring. The rubric was not designed to evaluate the use of specific types of climate change information (e.g., specific downscaled climate projection tools) because the guidance documents did not make explicit recommendations about this.

Our rubric includes 20 metrics and criteria for five of the eight required elements: species, habitats, threats and

stressors, actions, and monitoring. three elements were not included because they were not closely related to climate information use nor easily scored based on SWAP content: timelines for revision; community and partner engagement; and public engagement. For example, while all SWAPs listed some partnerships, there were few details as to how these might specifically contribute to climate change adaptation.

For each metric, the score is based on criteria for the use of climate information. A score of 0 was given if a metric was not addressed in the SWAP, a score of 1 was given if the metric was addressed, and a score of 2 was given to exceptional examples. For some categories, the recommended criteria was either present or not in the plans, so the possible scores were limited to 0 or 1.

2.3 | Interviews

We used purposeful sampling (Bernard, 2005: 186–99) to identify key individuals involved in incorporating climate change information into the SWAPs. This process resulted in interviews with 16 individuals from state fish and wildlife management agencies, non-profit organizations, and universities. All interviewees were listed contributors to the SWAPs and gave permission for quotes to be used in this manuscript. Personnel from Iowa, Kansas, and Montana did not participate in the study because individuals either elected not to be interviewed or could not be reached after multiple attempts. The number of interviewees differs across states, reflecting the number of personnel involved in integrating climate change information into the SWAPs. Thirteen interview questions focused on the revision process and factors that influenced organizational capacity to identify, use, and integrate climate information into the SWAP. All interviews were conducted, transcribed, and analyzed by the lead author using a grounded theory approach (Corbin & Strauss, 2008; Saldaña, 2015). Interviews were analyzed using Atlas.ti, a qualitative data analysis program that facilitates the organization and analysis of textual data. Interview questions and thematic codes are available in Data S1. All interview questions and data collection procedures were approved by the University of Colorado Institutional Review Board (IRB) for research with human subjects.

3 | RESULTS

3.1 | Climate information used

The AFWA guidance did not make specific recommendations about which climate change information or models

TABLE 1 Climate change information used in SWAPs. For increased readability, please see Table 1 in Supporting Information.

State	Climate futures used for climate change vulnerability analysis (CCVA)	Future period analyzed	Vulnerability assessment strategy	Notes
CO (2015)	12 IPCC5 models, ^a RCP6.0, 80% of the model spread represents range of futures; extensive discussion of how climate futures were chosen and used.	2035–2060	Loosely based on CCVI	Included spatially explicit information (GIS rasters and maps); represented uncertainty by bracketing a range of climate projections. USGS Fort Collins Science Center and the North Central Climate Science Center assisted with modeling and use of climate information.
IA (2015)	CCVI default ensemble inferred, because specific models not provided, ^b medium emissions scenario; narrative description of projected regional changes.	End of century	CCVI	Leverages Iowa Climate Change Impacts Committee Report ^c ; taxonomy of threats includes climate change and severe weather.
KS (2015)	CCVI default inferred because climate input choices not discussed; narrative description of projected regional changes.	End of century	CCVI	CCVI used to assess subset of 83 of 285 SGCN, representative of taxonomic groups; provides short bibliography on climate change impacts on species and ecosystems.
MN (2016)	Narrative descriptions of trends and impacts; drew from NCA report ^d ; qualitative scenarios of projected changes used for habitat vulnerability ^e ; did not directly use climate model output.	2041–2070, 2070–2099	Leveraged vulnerability analyses from other states ^f ; CCVI not used.	Technical Advisory Teams concluded that data was insufficient for a species CCVA; however, teams considered how changes in temperature, precipitation, and the frequency and severity of storms could interact with other criteria to reduce population long-term health and stability.
MT (2015)	Qualitative scenarios of projected changes used for habitat vulnerability; did not directly use climate model output.	Not specified	Used CCVAs from the literature; CCVI not used	Recommends continuing to evaluate current climate science models and recommended actions, but does not provide specifics on how to evaluate.
ND (2015)	CCVI default inferred because no discussion of climate inputs; Lit review drew from NCA ^g which uses B1/A2 and RCP 2.6/RCP 8.5 scenarios.	2021–2050, 2041–2070, 2070–2099	CCVI	An appendix to the main document describes projected climate change impacts based on the NCA, other literature and CCVI from other states.
NE (2011)	CCVI default inferred, no discussion of the climate inputs to CCVI; also used qualitative scenarios focused on the directionality of projected change, but these lack citations.	Not specified	CCVI	Describes how climate change is projected to impact fire regimes, hydrology, habitat fragmentation, pollution, and invasive species.

TABLE 1 (Continued)

State	Climate futures used for climate change vulnerability analysis (CCVA)	Future period analyzed	Vulnerability assessment strategy	Notes
SD (2014)	CCVI default inferred; separate analysis of 16 IPCC4 CMIP3 models ^h is used extensively in report.	2021–2050, 2070–2099	CCVI	Included spatially explicit information (GIS rasters and maps). Represented uncertainty through use of 16 GCM futures for temperature, precipitation, and growing degree days for each of the state's major land resource areas (MLRA).
UT (2015)	Qualitative assessment of threats including drought, increasing stream temperature, and increasing variability of temperature and precipitation. Did not directly use climate model output.	Not specified	Climate change as part of threats assessment ⁱ ; CCVI not used	Used threat assessment strategy; Qualitative assessment of threats being exacerbated by climate change (e.g., rising average temperatures increase the risk of fire frequency and intensity); describe specific data gaps for assessing threats.
WY (2017)	CCVI default; separate analysis of 16 CMIP3 models ^j and A2 scenario is used extensively.	2040–2069 ^k or “mid-century”	CCVI	Provides spatially explicit information (30-m GIS rasters and maps); considered microclimates based on topographic diversity and moisture availability; where temperature confidence was low, used only moisture deficit for climate exposure; represented uncertainty range of temperature and precipitation climate projections.

Note: All include narrative discussion of current climate, including maps and graphics, and literature review of climate impacts.

^aList of models in table 4 (Colorado Parks and Wildlife, 2015); see methods section for how CCVI was used and uncertainty represented.

^bThe CCVI provides a number of options or choices for climate inputs to generate their index (Young et al., 2010); if no options chosen, the tool calculates the index based on temperature and a moisture index (defined as potential evapotranspiration (PET) – precipitation (in mm)) from an ensemble average of 16 IPCC models (see Young et al., 2010), under three greenhouse-gas emissions scenarios, downscaled to 12-km (1/8°) resolution according to the method by Maurer et al. (2009). If the choices were not specified, we inferred that the default was used.

^cIowa Climate Change Impacts Committee (2011).

^dDescription in appendix D uses Staudinger et al. (2015); created maps from Climate Reanalyzer (<http://cci-reanalyzer.org>).

^eQualitative scenarios focus on directionality of projected change, for example, warmer temperatures, increased evapotranspiration, and more intense storm events.

^fWisconsin (LeDee & Ribic, 2015); and Iowa, Illinois, and Nebraska (Small-Lorenz et al., 2013).

^gMelillo et al. (2014), which provides the basis for our summary of potential climate changes in the Northern Plains, Kunkel et al. (2013).

^hSee Cochrane and Moran (2011) for models selected from Climate Wizard.

ⁱSalafsky et al. (2008).

^jCochrane and Moran (2011).

^kWyoming SWAP chose “mid-century” because, “2050 is far enough into the future for significant changes to have occurred, while projections from various climate models begin to diverge beyond 2050” (Wyoming Game and Fish Department, 2017: p. 14).

to use, allowing states discretion to decide which of the many available tools and downscaled climate models to use. While the rubric did not include criteria for the type or source of climate change information, we document this for each SWAP (Table 1). Rather than mandating

specific products, AFWA guidance (2009, 2012) suggested using tools that combined climate change information with projected impacts on species and habitats, such as NatureServes Climate Change Vulnerability Index (CCVI), a scoring system that incorporates a species'

predicted exposure to climate change with information about the species biology and potential climate change sensitivity (Young et al., 2010). Guidelines also suggest using qualitative scenarios focused on the directionality of projected change if resources were limited (e.g., warmer and drier climate without quantifying the amount of the change) (AFWA, 2009: 14).

Six states used the NatureServe CCVI version 2.1 (Young et al., 2010) to inform their vulnerability analysis of Species of Greatest Conservation Need (SGCN). The CCVI³ incorporates climate futures from a Nature Conservancy product, Climate Wizard (Girvetz et al., 2009), which is based on the Fourth Intergovernmental Panel on Climate Change (IPCC) generation of models (IPCC, 2007). Climate Wizard provides a default set of two variables (temperature and a moisture index) from 16 General Circulation Models (GCMs) under three greenhouse-gas emissions scenarios, downscaled to 12-km (1/8 degree) resolution (Maurer et al., 2009). Users can choose an ensemble average, select individual GCMs, or provide climate projections from other sources. Many SWAPs did not specify which option(s) authors chose, so this was inferred.

While most SWAPs analyzed used the CCVI default options, some went further. South Dakota augmented the CCVI with a climate change study that used 16 GCM futures to represent a range of plausible futures for temperature, precipitation, and changes in Growing Degree Days, mapping these projected impacts on habitats (Cochrane & Moran, 2011). Wyoming's SWAP took advantage of a more detailed analysis that considered additional variables, including a topographic index to represent locations that accumulate moisture, and the Heat Load Index to represent the relative temperatures of locations based on solar radiation, aspect, and slope (Pocewicz et al., 2014). The 2014 Colorado SWAP Enhancement used downscaled model output (Bureau of Reclamation, 2013, an update of Maurer et al., 2009) based on the Fifth IPCC (IPCC, 2013) to select the five most influential climate variables for 17 habitat types (Decker & Fink, 2014: 19, table 5).

3.2 | Rubric analysis

We found that states used and incorporated climate change information in a variety of ways (Table 2; Figure 1). State scores ranged from 7 to 26 out of a possible maximum of 31. Points were given for each metric in the rubric: 0 if a metric was not addressed; 1 point if addressed satisfactorily; and 2 points for exceptional examples. The total score is less important than what the spread among scores reveals about the different ways that states are using climate change information in

conservation planning. Below we highlight examples from each required element.

3.2.1 | Species

All 10 states identified SGCN as required. Six states used the CCVI to determine the climate vulnerability of some or all of their SGCN species. Wyoming, South Dakota, and Nebraska—which all scored 2 for metric 1.1—went further and used the CCVI to prioritize and/or rank SGCN, consistent with prescribed best practices (AFWA, 2009, 2012; Glick et al., 2011). Wyoming combined its vulnerability analysis with threats from energy development and disease to identify and rank SGCN. South Dakota and Colorado SWAPs scored a 2 for metric 1.4 because they included spatially explicit maps and GIS rasters that depict projected climate change impacts to species distribution. North Dakota and Minnesota leveraged climate change vulnerability analyses from other states (LeDee & Ribic, 2015; Small-Lorenz et al., 2013), a practice that can save limited time and resources in conservation planning.

3.2.2 | Habitats

Eight of the 10 SWAPs included projected climate change impacts to habitat quality and/or distribution as recommended in the best practices. States scored a 2 on metrics 2.2 and 2.3 if they provided spatially explicit examples of projected climate impacts to habitats. For example: Wyoming included maps that depict habitat vulnerability, resilience, and exposure to climate change (Wyoming Game and Fish Department, 2017: figs. 1–3: II-4-9-II-4–10); Colorado's analysis included maps and projected changes for 17 habitat types in the state; and South Dakota produced an interactive website that provides information on current species and habitat distribution as well as projected changes in temperature and precipitation (South Dakota Department of Game, Fish and Parks, 2015).

3.2.3 | Threats and stressors

Most states used a standardized system (Salafsky et al., 2008) to identify threats and stressors on SGCN and habitats and how climate change could exacerbate them or pose new ones (e.g., habitat fragmentation, changes in disturbance regimens, water management and use). Nebraska scored exemplary on metric 3.1 because it considered how climate change is projected to

impact fire regimes, hydrology, habitat fragmentation, pollution, and invasive species. Colorado and Utah scored a 1 on most metrics in this category, but provide interesting approaches. Colorado considered compound threats, such as how increasing drought frequency may impact reservoir and dam management, which in turn may impact the availability and quality of aquatic habitats and breeding habitat for migratory waterfowl, potentially increasing disease prevalence among Sand Hill Cranes. Utah scored all the threats, including climate, relevant to conservation targets.

3.2.4 | Actions

All SWAPs identified potential actions to mitigate linked threats and stressors, as recommended. South Dakota ranked exemplary on metric 4.3 because it provided specific actions to address climate change impacts on species (e.g., planting native C4 species to replace declining C3 grasses) (South Dakota Department of Game, Fish and Parks, 2014: table 5-5: 121–127) and in some cases targets those actions and/or research and monitoring needs in particular habitats and areas. Utah scored a 2 on metric 4.3 because it listed threats, associated actions, and specific indicators for success with respect to managing species and habitats during drought and increased stream temperatures associated with climate change (Utah Division of Wildlife Resources, 2015: 154–162).

3.2.5 | Monitoring

All SWAPs reviewed scored 1s in this category because they did not provide detailed plans for monitoring climate change impacts on SGCN and habitats, only the general need to do so. While Utah included some climate-related variables among indicators of success for reducing threats of drought and stream temperature, none of the 10 SWAPs discussed specific monitoring needs for climate variables, for example, to assess if biological thresholds are being approached. Although monitoring changes in precipitation and temperature could be outside the scope of state wildlife agencies, describing key biological thresholds or indicators, or types of information needed to support management goals, could inform effective monitoring plans.

3.3 | Interview analysis

Interviews shed light on organizational differences in leadership, resources, and capacity that might explain the

differences in use of climate change information among states. Here we present the themes identified from these interviews.

3.3.1 | Professional networks and boundary organizations

Professional networks facilitated the use of climate change information, including individuals with climate knowledge and boundary organizations. The Minnesota Fish and Wildlife Division is housed down the hall from the state climatologist offices within the Minnesota Department of Natural Resources, so SWAP authors reported that it was easy to walk down the hall to “bounce the idea off of them and see what they thought would be important to include or what resources they had to offer.” In Colorado, the NCCASC—a boundary organization—facilitated meetings between the Colorado Natural Heritage Program, which conducted the climate change vulnerability analysis, Colorado Parks and Wildlife, and NOAA climate scientists (Morissette et al., 2017). One interviewee commented that “[I]t was a really neat collaboration of the climate scientists that knew the models and how to do the computing and the ecologists from the National Heritage Program and the habitat specialists and wildlife biologists from the State Wildlife Agency to all sit around the table and talk.” Established professional relationships and previous working experience with researchers at universities or non-profit conservation organizations were also cited as helpful. Furthermore, interviewees wanted to know how other states navigated the revision process and expressed enthusiasm for increased interstate engagement and collaboration.

3.3.2 | Finding appropriate information

Interviewees reported that there was too much climate information, but not enough of the right kind. Most interviewees told us that they were limited not by the availability of information, but instead the lack of specific information on potential impacts on species and habitats in their region and “shovel-ready” data sets that could be used in conjunction with their existing planning or GIS tools. One reported, “I was astonished at how much data is available” but “half the time it’s not even explicitly clear what somebody did in order to produce it” and that it was necessary to “make some assumptions coupling what [ecological] research is out there with the [climate change] information.” Furthermore, many SWAP authors felt that their agencies did not have clear guidance on how climate change impacts or vulnerability analyses could be used to support management decisions,

TABLE 2 (Continued)

Required elements	Best practices from AFWA (2009, 2012) and metrics for using climate change info	Metrics and ranking scale for combined best practices	CO	IA	KS	MN	MT	ND	NE	SD	UT	WY
	dynamics and how they might change in the future (2012).	impacts on habitats (e.g., general, state-wide examples) 2 = Used scenarios or existing models to project potential climate change impacts on habitats (e.g., specific, spatially explicit examples)	2	1	1	1	0	1	0	2	0	2
	2.3. Identify projected impacts on quality and distribution of habitat across spatial and temporal scales. Information should be spatially explicit (2009). Include both present and future anticipated extent and condition of habitat (2012).	0 = Not addressed 1 = Used existing climate models to project general changes in habitat condition 2 = Used climate models to project changes in habitat location, distribution, and extent (spatially explicit)	2	1	1	1	0	1	0	2	0	2
3. Threats and stressors— Descriptions of problems that may adversely affect species or their habitats, and priority research and survey efforts to improve conservation of those species and habitats.	3.1. Consider climate change as a new threat to both species and habitats, and an exacerbating factor compounding known threats (2009).	0 = Not addressed 1 = Discuss climate change as a new and/or exacerbating threat to species and habitats 2 = Identify locations where climate change impacts may occur	1	1	0	1	1	1	2	1	1	2
	3.2. Use vulnerability assessments to ID and prioritize threats (2009) and to ID vulnerable SGCN and related conservation actions. Use existing information to identify specific aspects of climate change that produce the threat (2012).	0 = Not addressed 1 = Use vulnerability assessments to identify and prioritize threats to species and habitats	1	0	0	1	1	0	1	1	1	1
	3.3. Be specific, and “specify which impact will result in which threat, and which action will address that impact. Avoid unspecified generalities...” Consider both current and future trends (2012: 12).	0 = Not addressed 1 = Provided specific examples about which climate change impact(s) will result in which threat	1	0	0	1	1	1	1	1	1	1

(Continues)

TABLE 2 (Continued)

Required elements	Best practices from AFWA (2009, 2012) and metrics for using climate change info	Metrics and ranking scale for combined best practices										
		CO	IA	KS	MN	MT	ND	NE	SD	UT	WY	
5. Monitoring—Plans for monitoring species and habitats, and the effectiveness of conservation actions.	5.1. Monitoring methods should be scalable, affordable, streamlined, and broadly applicable (2009).	1	1	1	1	1	1	1	1	1	1	1
	5.2. Collaborate with other states, NGOs, and citizen scientists to improve monitoring efforts across region wrt climate change (2009).	1	1	1	1	1	1	1	1	1	1	1
	5.3. Use monitoring to inform adaptive management, and to evaluate and improve management decisions (2009).	1	1	1	1	1	1	1	1	1	1	1

Note: They have been summarized here and combined in order to create 20 metrics to evaluate and rank the states.

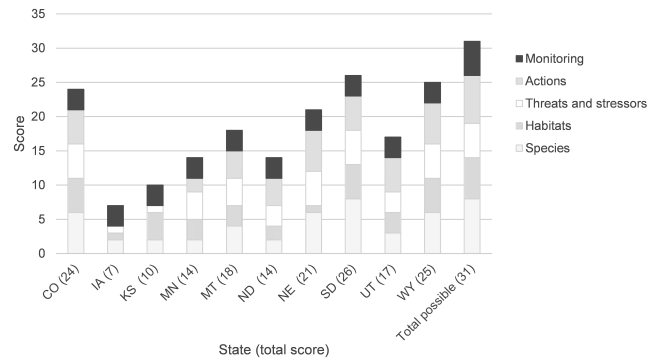


FIGURE 1 Comparison of state scores for ranked categories, including total score broken down by the scores for each required element

which made it difficult to select and apply climate information. Information overload, uncertainty, and the lack of clear explanations of the methods used to generate climate change information made it difficult to select, interpret, and use it to project impacts.

3.3.3 | Funding

Some states, like South Dakota, were able to secure additional funding to enhance climate change sections (e.g., SWAP Enhancement Grant from the USFWS or funding from the Landscape Conservation Cooperation networks). This allowed state agencies to bring in outside expertise when there was not enough in-house capacity or resources to conduct climate change vulnerability analyses or to interpret and apply climate change information and impact data. Some states leveraged information gaps identified in their SWAP to procure subsequent funding to address those needs. Conversely, lack of funding was a barrier to increase agency capacity to use climate change information or implement actions. One author reported that they “do a lot of this planning but...don’t have any resources to implement [the plans]...we’re talking big, big bucks for corridors, any other factors affected by climate change that’s not going to come at the state level.” Agency personnel interpreted a lack of funding to implement conservation actions identified in the plans to mean that including climate change in the SWAPs was more about checking a box than about encouraging substantive changes to long-term planning strategies or management actions.

3.3.4 | Congressional mandate

Many interviewees reported that the AFWA guidelines and the Congressional mandate to include climate change in the SWAPs provided the needed incentive to

do so. Although the latest revision of all SWAPs included climate change information, only four discussed climate change substantively in 2005 when it was not required (Lacher & Wilkerson, 2014). While some states reported that they would have done so regardless of the mandate in order to satisfy stakeholders or higher level leadership, most reported that the mandate provided motivation and justification for the additional personnel and financial resources needed to include climate change information, especially in politically conservative states where it might otherwise be considered politically risky. One SWAP author felt that, “Without the [mandate] and AFWA guidance...[climate change] would not have been given the attention that it was given...That sort of gave cover to a lot of states to be able to address it.”

3.3.5 | Leadership

Organizational leadership within the responsible state agency and existing relationships between agencies and partner organizations (e.g., universities and NGOs) could either facilitate or hinder the use of climate change information. Supportive agency leadership made it easier for SWAP authors to get time for agency personnel to work on the climate change portions of the plans or to find additional funding to do so. No one interviewed reported that leadership within their organizations was unsupportive or actively against including climate change in the SWAPs. One respondent shared that “supervisors are encouraging them to attend meetings, go to trainings, take on more information that’s related to the change in climate and so you have it both at the operational level and you also have it at the sort of personal...They’re trained as scientists. They understand that the environment is changing and they want to be part of what they view as the solution.”

3.3.6 | Political climate

Interviewees from several states noted that the local, state, or national political climate influenced the way that climate change information was used in the plans. AFWA guidance (2009) recognizes the politically charged nature of climate change and gives state agencies discretion in how to use climate change information. For example, individuals from politically moderate or progressive states felt that they had support from elected leaders and political appointees to use terms like “climate change,” and “adaptation” and did not feel that their jobs or their agency’s reputation would suffer. In conservative states, SWAP authors struggled to get clearance to discuss

“climate change” openly and might instead focus on drought, declining snowpack, or rising stream temperatures to avoid arousing negative feedback from the public or elected officials. One author reported that it took approximately “30 months to get a clear message back from my directorate that it was gonna be okay to even use the words climate change in” the SWAP. Another individual reported that although personnel in some states could discuss climate change more openly than those in others, it did not necessarily limit the actions that they could take if they were strategic: “[T]here’s a couple states that come to mind that are doing a lot of work and one of them, you know, they can say ‘climate change’ and the other they can’t, so they’re saying other things like saltwater intrusion...[B]ut they’re both...really leaders on adaptation efforts. And the main difference to me is that one state is blue [politically progressive] and the other state is red [politically conservative]. But like I said, they’re both doing really great work.” This observation is consistent with previous findings that political climate was a key factor shaping climate change information use by state and federal wildlife (Yocum & Ray, 2019) and water managers (Werner & Svedin, 2017).

4 | DISCUSSION

Our rubric and interview findings can be used to identify actions to improve the use of climate change information in SWAPs for the next revisions and beyond. This novel rubric provides a structure to compare the use of climate change information in SWAPs in three ways. First, in planning for the 2025 revisions, a state might view its score on any part of the rubric to assess how they used climate information compared to recommended best practices and identify areas for improvement. Second, it could be used to assess changes in the use of climate change information in subsequent SWAP revisions. Finally, states or researchers can consider how SWAPs with higher scores on any metric used climate information and identify examples of how to elevate the use of climate information moving forward. SWAP authors interviewed were eager to learn from the successes of other states; however, because plans are typically several hundred pages long, searching for examples is not a minor task. Opportunities for shared learning include state-to-state sharing of: climate change vulnerability analyses from neighboring states or regional conservation actors; case studies linking climate change impacts with management actions and evaluations of their effectiveness; and examples of successful engagement between state agencies, the climate science community, and boundary organizations. Some of this is already

happening, as states like Minnesota and North Dakota have leveraged available habitat and species data from neighboring states or regional conservation organizations to inform their plans, but opportunities remain.

Interview results contribute to understanding the differences between SWAPs and point to ways to support managers to improve the use of climate information in SWAPs by both boundary organizations and SWAP authors themselves. Several factors interviewees identified as informing the use of climate change information are not within the direct control of the state agencies or organizations seeking to support them (e.g., funding, Congressional mandates, and political climate). Two that are include finding appropriate climate change information and connecting with the climate science community and boundary organizations. SWAP authors were largely on their own to identify and apply climate change information, or to seek support from the climate science community. SWAP authors cited the disconnect between climate scientists, managers, and decision-makers as a hurdle to effectively identifying and applying climate change information to wildlife management decisions. This has been discussed in multiple studies (c.f., Barsugli et al., 2013; Dilling et al., 2015; Yocum & Ray, 2019), but our interviews highlight that this continues to be an issue.

Improved guidance is needed from the climate science community and boundary organizations regarding how to use climate information in conservation planning; however, we do not advocate for specific recommendations regarding the use of a particular climate change information product over another. Instead, our results show that allowing states to select which tools or information to use—as in the AFWA guidelines (2009, 2012)—allowed some to develop innovative approaches to address their particular management priorities and contexts (c.f., CO, SD, and WY). We also agree with AFWA's reasoning that non-prescriptive guidance accommodates the specific ecological and social differences between states. Furthermore, this discretion enabled states to work within their individual time, budget, and other constraints. However, we found that additional guidance and support in identifying, selecting, and applying this information could improve the use of climate information in SWAPs and other conservation plans, corroborating Yocum and Ray (2019).

Regular planning processes such as the SWAP revisions are entry points to bring in the most recent climate change information to incorporate risks of climate change into conservation planning (Ray & Webb, 2016). Since the last revisions, there are a host of new tools and products, many of which are now more easily available in a variety of data formats for resource managers (c.f.,

USGS GeoData Portal).⁴ Model output from the Fifth IPCC assessment (IPCC, 2013) is available online as peer-reviewed downscaled products intended for natural resource management, such as: the Multivariate Adaptive Constructed Analogs projections (MACA)⁵ which now has online tools for visualizing the data and spread of the models (Abatzoglou & Brown, 2012); the localized constructed analogs product (LOCA)⁶ (Pierce et al., 2014, 2015; Vano et al., 2020); and products with hydrologic projections (Bureau of Reclamation, 2013). These products now power tools such as the Climate Toolbox (Williams et al., 2020) and the US Climate Resilience Toolkit's Climate Explorer⁷ (Lipschultz et al., 2020) and have been used in the US National Climate Assessment (US Global Change Research Program, USGCRP, 2017) and the 4th California Climate Assessment (Pierce et al., 2018). A third version of the NatureServe CCVI is available, but still uses GCMs from the third IPCC (2007). Products based on the sixth IPCC Assessment will be available over the next few years (IPCC, 2021; Tebaldi et al., 2021).

Each plan revision provides the opportunity to incorporate new information; however, the management community will not benefit from new products if it does not know about them or understand how to incorporate them into planning processes. Given the growing number of new and future climate information resources, improved and ongoing guidance on how to identify, select, and apply climate information is needed to support management and conservation planning. Such guidance could improve the use of climate change information in SWAPs and other conservation plans (c.f., Yocum & Ray, 2019) as well as support the ultimate goal of adapting to climate change.

Interview results stress the importance of connections to professional networks and boundary organizations to support finding and applying appropriate information. Boundary organizations facilitate regional cooperation among states and foster engagement between state agencies and the climate science community (c.f., McNie, 2007; Crona & Parker, 2011; Averyt et al., 2018). Further, as organizations that keep up with the latest advances in climate science and its application as part of their mission, they can provide translational information to help SWAP authors identify and apply appropriate climate information. Interviewees from Colorado credited the NCCASC with convening meetings with climate scientists, impact modelers, and agency personnel with helping them generate and use climate change information in the Colorado SWAP (c.f., Morissette et al., 2017). During interviews, SWAP planners in other states expressed interest in working more closely with the NCCASC during upcoming revisions, particularly in

moving towards scenario-based planning approaches used successfully in other state and federal agencies (c.f., Runyon et al., 2020). Our study highlights the key role that boundary organizations like the US Geological Survey Climate Adaptation Science Centers (USGS CASCs), the NOAA RISAs, or USDA Climate Hubs can play in facilitating engagement between managers, planners, and climate scientists and supports previous findings and recommendations to improve SWAPs (Lackstrom et al., 2018; Paskus et al., 2016). Although some of these organizations existed during previous SWAP revisions, they have a longer history now, and are more prepared to assist.

We see three ways in which SWAP authors themselves—in the 10 states in our study and in other states—could improve the use of climate information in planning efforts. First, the plans should include more specifics on monitoring information needed by state wildlife managers. Although several plans call for more monitoring of climate variables and developing long-term monitoring systems, they include few specifics that could inform state and federal monitoring activities (e.g., what to monitor for to detect trends towards thresholds or triggers for particular species or priority habitats). Second, SWAP authors should be explicit about what climate information was used in plans, providing the specific GCMs or downscaled products used, including time periods. This information was often lacking. For example, several SWAPs used CCVI with little or no discussion of the climate inputs selected and how these choices might influence the results. We recommend that SWAP authors specify whether they used the CCVI default options, selected particular GCMs, or used an ensemble, and if so, identify the GCMs in the ensemble. Furthermore, a number of the literature sections or discussions of qualitative scenarios are narratives with no citations. This information is needed to compare and leverage ecological and species studies with the SWAP climate change vulnerability analysis. For example, these details would be needed if SWAP authors and interested researchers wished to compare their vulnerability analysis with other analyses for particular habitats (e.g., Adhikari & Hansen, 2019; Steen et al., 2016), or with species and habitats in related assessments, for example, US Bureau of Land Management Rapid Ecoregional Assessments (e.g., Carr & Melcher, 2015; Ray et al., 2015; SAIC, 2012). Finally, the analysis of climate risks would be improved by assessing a range of plausible futures, as Colorado, South Dakota, and Wyoming did. This could be done by selecting two or more models representing challenging futures in the CCVI or another tool, or qualitative scenarios focused on the directionality of projected change (e.g., warmer and drier, cooler and wetter, etc.). Either strategy would support scenario planning, which seeks to

manage uncertainty, as described in a burgeoning literature on scenario planning in natural resource management (Lawrence et al., 2021; Runyon et al., 2020; Symstad et al., 2017).

These findings have implications for other conservation planning efforts beyond the SWAPs. There is a need to develop approaches to compare and evaluate the use of climate change information in conservation planning. Similar rubrics can be developed and used to evaluate conservation and adaptation plans in three ways: (1) compared to best practices and guidelines; (2) compared to similar plans; or (3) to track changes in planning efforts over time (c.f., Adler & Gosliner, 2019). Our work and similar efforts would contribute to growing research on the linkage between conservation and adaptation planning with actions, supporting evidence-based planning (c.f., Dilling et al., 2019; Donatti et al., 2019; Peterson St-Laurent et al., 2021). Coupling rubric analysis with interviews moves beyond identifying barriers towards understanding the use of climate information in natural resource planning (e.g., Archie et al., 2014; Ellenwood et al., 2012; Lemieux et al., 2013; Yocum & Ray, 2019). This combined method allowed us to identify specific opportunities to improve planning and information use across any agency or plan while describing the key social and institutional context that influences how climate change information is used. More broadly, linking conservation planners with boundary organizations and providing examples of conservation plans that include best practices can facilitate integration of additional new science information, not just climate change information, into conservation planning efforts.

Our study has several limitations that should be considered. First, this work was intended as a regional study to support efforts of the regional adaptation planners and boundary organizations with which the authors work. Findings from our targeted sample of SWAPs and interviews with SWAP authors may not be generalizable to all states. However, our results are consistent with findings from other regional studies of SWAPs (Lackstrom et al., 2018; Paskus et al., 2016) and studies supporting public land managers to use climate change information in planning (e.g., Archie et al., 2014; Ellenwood et al., 2012; Lemieux et al., 2013). Second, our analysis is limited to the information provided in SWAPs analyzed and does not include internal planning processes or additional information (e.g., vulnerability assessments or additional climate studies) which were not in the SWAPs themselves. We cannot conclude that a state agency is not taking action on or considering climate change in conservation planning simply because it is not included in the specific planning documents we reviewed.

Additional research is needed to understand how and to what extent the use of climate change information in

SWAPs and other planning documents leads to changes in conservation targets and strategies, and ultimately to adaptation. Previous studies have identified a gap between conservation planning in the SWAPs and conservation actions, particularly as it relates to addressing habitat fragmentation and connectivity (Lacher & Wilkerson, 2014) and implementing adaptive management practices (Fontaine, 2011). Efforts to support planners could be improved through further research on how the use of climate change information in planning documents influences day-to-day and longer-term operations. Such research could also refine the types of climate change information needed. Further interdisciplinary work is needed to understand how human adaptation and socioeconomic processes will interact with climate change to impact species and habitats and related conservation efforts (Ahlering et al., 2020; Heller & Zavaleta, 2009). Making climate change information useful to managers will require increased understanding of the complex interactions between social, ecological, and climatological systems (Sutherland et al., 2021; USGCRP, 2021). Understanding these interactions is crucial to support SWAPs and similar conservation planning efforts by leading to better understanding and prioritization of the full range of threats and stressors across multiple time-scales (Ahlering et al., 2020).

5 | CONCLUSION

This study seeks to understand how climate change information has been used in conservation planning—and what circumstances facilitate use of this information—in order to support long-term conservation goals. We developed a novel rubric to compare SWAPs and improve plan revisions, which most states will complete by 2025. States can draw from experiences of other states to find approaches that meet the demands of their own social and ecological context. Combining the rubric with interviews with SWAP authors allows identifying factors that account for differences in rubric scores. Factors that facilitated the use of climate change information included access to additional funding, professional networks that included boundary organizations or climate information providers, and supportive leadership within the organization. Factors that hindered its use in plans included challenges in finding and applying appropriate climate information, budget and capacity limitations, and conservative state political climates. Boundary organizations can foster engagement between states and between management and climate science communities in addition to providing climate information and technical support.

Our research has broad implications for other conservation planning processes, including: the value of rubrics

as a tool to evaluate and compare the use of climate change information in plans; using interviews to understand the planning process and context; and the importance of linking conservation planners with boundary organizations to facilitate integration of climate change information into conservation planning efforts. Additional research to understand how human adaptation responses to climate change may mitigate or exacerbate existing stressors and threats to key habitats and species could help managers prioritize actions to achieve wildlife conservation targets. This research supports natural resource managers as they work to conserve species and habitats under a changing climate.

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CONFLICT OF INTEREST

Heather M. Yocum is currently supported by the NCCASC although she was not during the period when this research was conducted.

AUTHOR CONTRIBUTIONS

Heather M. Yocum: conducted the initial document analysis and created the final rubric, conducted and analyzed all interviews, wrote the initial manuscript; **Andrea J. Ray:** provided substantial edits and additions to the original manuscript and subsequent revisions; **Deanna Metivier Sassorossi:** conducted the initial document analysis and created an initial version of the rubric. All authors contributed to the revision of the manuscript and agreed to submission.


ETHICS STATEMENT

All ethical guidelines were followed in the conduct of this research. The interview questions and protocols were approved by the University of Colorado Internal Review Board (IRB) for research with human subjects. All documents analyzed are in the public domain.

DATA AVAILABILITY STATEMENT

The interview questions and thematic codes used for qualitative analysis are available in Data S1.

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ENDNOTES

¹ Hereafter, AFWA.

² Although the Trump administration reversed President Obama's Executive Order in 2018 (Executive Order 13834, 2018), the SWG from the US Congress (DOI, 2001) and DOI Secretarial Order 3289 (DOI, 2009) were not changed. The Biden administration has renewed efforts to consider climate change in managing public lands and species in the United States (c.f., DOI et al., 2021).

³ The climate variables used in the CCVI analysis are temperature and a moisture index which reflects conditions for plants and animals better than simple changes in precipitation. For a chosen geographical area, the CCVI Microsoft Excel-based tool allows downloading downscaled climate projection data in GIS rasters for spatially explicit vulnerability assessments (Young et al., 2010).

⁴ <https://cida.usgs.gov/gdp/>.

⁵ <https://climate.northwestknowledge.net/MACA/>.

⁶ loca.ucsd.edu; <https://climate.northwestknowledge.net/MACA/>.

⁷ <https://toolkit.climate.gov>.

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