SUPPORTING INFORMATION

TABLES AND FIGURES

**Table 1.** *Reproduced here for improved readability compared to online version.* Climate change information used in SWAPs. All include narrative discussion of current climate, including maps and graphics, and literature review of climate impacts.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **State** | **Climate Futures****Used for Climate Change Vulnerability Analysis (CCVA)** | **Future Period****Analyzed** | **Vulnerability****Assessment Strategy** | **Notes** |
| CO(2015) | 12 IPCC5 models,[[1]](#footnote-1) 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[[2]](#footnote-2), medium emissions scenario; narrative description of projected regional changes.  | End of century | CCVI | Leverages Iowa Climate Change Impacts Committee Report[[3]](#footnote-3); 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[[4]](#footnote-4); qualitative scenarios of projected changes used for habitat vulnerability[[5]](#footnote-5); did not directly use climate model output. | 2041-2070, 2070-2099 | Leveraged vulnerability analyses from other states[[6]](#footnote-6); 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. |

**Table 1, continued.** *Reproduced here for improved readability compared to online version*. Climate change information used in SWAPs. All include narrative discussion of current climate, including maps and graphics, and literature review of climate impacts.

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| MT(2015) | Qualitative scenarios of projected changes used for habitat vulnerability; did not directly use climate model output. | Not specified | Used CCVA’s 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[[7]](#footnote-7) 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 |
| SD(2014) | CCVI default inferred; separate analysis of 16 IPCC4 CMIP3 models[[8]](#footnote-8) 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[[9]](#footnote-9); 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[[10]](#footnote-10) and A2 scenario is used extensively. | 2040-2069[[11]](#footnote-11) 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. |

**Table 2.** *Reproduced here for improved readability compared to online version.* Table listing the best practices for including climate change in the SWAPs from AFWA (2009; 2012). They have been summarized here and combined in order to create 20 metrics to evaluate and rank the states.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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** |
| **1. Species--** Information on the distribution and abundance of wildlife, including low and declining populations, that describes the diversity and health of the state’s wildlife, including Species of Greatest Conservation Need (SGCN). | 1.1. The SGCN list should consider climate change impacts on species including shifts in habitats and changes in distribution and abundance (2009).Include climate change impacts as one of the criteria for selecting and prioritizing SGCN (2012). | 0 = Not addressed1 = Considered impact of climate change on SGCN2 = Used climate change to select and/or prioritize SGCN | 1 | 1 | 1 | 1 | 1 | 0 | 2 | 2 | 1 | 2 |
| 1.2. Use vulnerability assessments to assess climate change impacts on species (2009). Conduct vulnerability assessments to inform the selection of SGCN and conservation actions using guidelines in Glick & al (2011) (2012). | 0 = Not addressed1 = Conducted vulnerability assessments for SGCN 2 = Used vulnerability assessments to ID SGCN | 1 | 1 | 0 | 0 | 1 | 1 | 2 | 2 | 1 | 1 |
| 1.3. Use models to forecast landscape-scale vegetation thru time, including future habitat changes under climate change projections (2009). | 0 = Not addressed1 = Used available models or vuln.assessments to project climate change impacts on species2 = Offered explicit examples (e.g., how projected changes in P and T will impact species) | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 0 | 2 |
| 1.4. Use species-based models to project climate change impacts. Information should be spatially explicit (2009). | 0 = Not addressed1 = Spatially explicit but not wrt to climate change2 = Spatially explicit wrt to climate change  | 2 | 0 | 1 | 1 | 1 | 0 | 1 | 2 | 1 | 1 |
| **2. Habitats--** Descriptions of locations and relative conditions of key habitats essential to SGCN. | 2.1. ID current location and condition of priority habitats. Use vulnerability assessments to assess climate change impacts on identified habitats (2009). | 0 = Not addressed1 = Used VA to assess CC impacts on habitats2 = Used VA to ID and/or prioritize habitats | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 2 | 1 |
| 2.2. Use scenarios to identify how habitats are likely to change (2009). Use existing models to project landscape-scale vegetation dynamics and how they might change in the future (2012). | 0 = Not addressed1 = Used scenarios or existing models to project potential climate change 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 | 0 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 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 addressed1= Used existing climate models to project general changes in habitat condition2 = Used climate models to project changes in habitat location, distribution, and extent (spatially explicit) | 2 | 1 | 1 | 1 | 0 | 1 | 0 | 2 | 0 | 2 |

**Table 2, continued.** *Reproduced here for improved readability compared to online version*. Table listing the best practices for including climate change in the SWAPs from AFWA (2009; 2012). They have been summarized here and combined in order to create 20 metrics to evaluate and rank the states.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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** |
| **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 addressed1 = Discuss climate change as a new and/or exacerbating threat to species and habitats2 = ID locations where CC 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 addressed1 = Use vulnerability assessments to ID 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 addressed1 = Provided specific examples about which climate change impact(s) will result in which threat | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3.4. Use downscaled climate change information at an appropriate scale (2009). Should be spatially explicit (2012). | 0 = Not addressed1 = Spatially explicit, but not wrt to climate change2 = Spatially explicit wrt to climate change | 2 | 0 | 1 | 1 | 1 | 1 | 1 | 2 | 0 | 1 |
| **4. Actions--** Descriptions of conservation actions proposed to conserve the identified species and habitats and priorities for implementation. | 4.1. Develop “conservation actions to address direct and indirect climate change impacts on species and habitats” under a range of future conditions (2009). | 0 = Not addressed1 = ID’d conservation actions that address climate change impacts on species and habitats | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4.2. Identify and describe “how conservation actions will be prioritized” under multiple threats and increased uncertainty (2009). | 0 = Not addressed1 = Considered CC in prioritizing and listing conservation actions | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| 4.3. Identify which actions will minimize climate change impacts, which will promote wildlife adaptation, which improve resilience, and/or facilitate movement to suitable habitats (2009). | 0 = Not addressed1 = Provided examples wrt how actions will address threats or promote monitoring & adaptive mgmt2 = ID’d how actions will reduce climate change impacts and/or promote adaptation and resilience | 2 | 0 | 0 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| 4.4. Identify decision points or thresholds for actions to (1) recognize that some species will go extinct, and (2) minimize loss of habitats & species (2009). | 0 = Not addressed1 = ID’d thresholds or decision points related to impacts on species and habitats | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4.5. Identify and protect corridors to improve connectivity to facilitate wildlife movement and adaptation (2009). | 0 = Not addressed1 = Discussed establishing and maintaining wildlife corridors to promote adaptation | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 4.6. Prioritize conservation actions benefiting greatest number of SGCN, habitats, and/or economically valuable species (2009). | 0 = Not addressed1 = Considered actions that will benefit maximum # of SGCNs, habitats, and/or valuable species | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |

**Table 2,** **continued.** *Reproduced here for improved readability compared to online version.* Table listing the best practices for including climate change in the SWAPs from AFWA (2009; 2012). They have been summarized here and combined in order to create 20 metrics to evaluate and rank the states.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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). | 0 = Not addressed1 = Outlined monitoring methods 2 = Explicitly mentioned climate change | 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). | 0 = Not addressed1 = Work with other actors to improve monitoring2 = Explicitly address climate change | 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). | 0 = Did not do1 = Described mon. plans to inform adaptive mgmt2 = Explicitly monitoring for climate change impacts | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

**Interview Questions:**

1) Was working on the SWAP part of your regular job duties? Or were you brought on because of particular area of expertise?

2) Can you describe your role in the SWAP?

PROMPTS: At what point were you involved?

What did you do in particular?

What particular sections did you contribute to?

3) Can you describe the process?

PROMPTS: Were there meetings about the SWAPs with all the contributors?

Was it mostly just writing alone, passing the text back and forth for edits, regular team meetings?

4) At what point in the revision process did climate change become part of the conversation? When did you start thinking about the climate change component?

5) What climate information did you use, and why?

PROMPTS: Which climate models did you use? (e.g., CMIP3, etc.) Why?

Did you use impact models?

IF YES: Which impact models did you use, and how did you select those particular models?

6) How easy or difficult was it to find applicable climate change information? Did that impact the use of climate change information in the SWAP, and if so, how?

7) Were there people in-house who had the necessary expertise, or did you consult with others outside of your organization?

FOLLOW UP: If outside, how did you identify them? (e.g., professional network, already knew them, cold call, etc.)

8) How would you describe the attitude of the people producing the SWAP to the requirement to include climate change in the latest SWAP revision?

9) How would you describe the overall attitude of your organization/department to the use of climate information in conservation planning and management?

10) Were there particular things that *facilitated* the use of climate change in the SWAP?

11) Were there particular things that made it *more difficult or impeded* the use of climate change in the SWAP?

12) What do you think your organization could have done differently in this process? How would this impact the use of climate change in future SWAPs?

13) Do you have anything else you’d like to add, or any questions for me?

**Table S.1. Thematic codes used to analyze interview responses in Atlas.ti:**

|  |  |  |
| --- | --- | --- |
| **Primary Code:** | **Secondary Code (if applicable):** | **Description:** |
| Best Practices | NA | * References to established best practices in guidance documents
 |
| Budgetary or Financial Support | Before SWAP | * Funding to enhance SWAP revision process
 |
| Post-SWAP | * Funding secured based on recommendations or research needs noted in SWAP
 |
| Capacity (personnel) | NA | * Training and/or ability of SWAP authors or state agency personnel to include climate change information in the SWAPs
 |
| Climate Information  | NA | * References to sources of climate change information
 |
| Conservation Strategy and/or Actions | NA | * References to state agency or organizational approach to conservation
* References to specific conservation actions
 |
| Organizational Culture | Team | * Team or staff culture and attitudes
* Whether team was supportive of including climate change information
 |
| Leadership | * Culture and attitudes of organizational leaders
* Whether leadership was supportive of including climate change information
 |
| Mandates | NA | * Federal or Congressional mandates
* Other mandates (e.g., state-level)
 |
| Political Culture | NA | * References to conservative, moderate, or progressive politics
* Politics and climate change
* References to state or national political parties
 |
| Planning Process | NA | * Timelines for planning
* When climate change was considered in the process
 |
| Professional Network(s) | Boundary Organizations | * Professional networks which include boundary organizations
 |
| Climate Science Community | * Professional networks which climate scientists
 |
| Other State Agencies | * Professional networks which include other state agencies
 |
| Public Engagement | NA | * Efforts to engage public in SWAPs
 |
| Research and Information Needs | NA | * References to additional research or information needs to support SWAPs
 |
| Social Learning | NA | * Opportunities to collaborate with other state agencies or other conservation organizations
 |

1. List of models in Table 4 (Colorado Parks and Wildlife 2015); see methods section for how CCVI was used and uncertainty represented [↑](#footnote-ref-1)
2. The 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) minus 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 degree) resolution according to the method by Maurer et al. (2009). If the choices were not specified, we inferred that the default was used. [↑](#footnote-ref-2)
3. Iowa Climate Change Impacts Committee 2011. [↑](#footnote-ref-3)
4. Description in Appendix D uses Staudinger et al. (2012); created maps from Climate Reanalyzer (http://cci-reanalyzer.org) [↑](#footnote-ref-4)
5. Qualitative scenarios focus on directionality of projected change, e.g., warmer temperatures, increased evapotranspiration, and more intense storm events. [↑](#footnote-ref-5)
6. Wisconsin (LeDee & Ribic 2015); and Iowa, Illinois, and Nebraska (Small-Lorenz & al. 2013). [↑](#footnote-ref-6)
7. Melillo et al. (2014), which provides the basis for our summary of potential climate changes in the Northern Plains, Kunkel et al. 2013. [↑](#footnote-ref-7)
8. See Cochrane and Moran (2011) for models selected from Climate Wizard. [↑](#footnote-ref-8)
9. Salafsky et al. 2008. [↑](#footnote-ref-9)
10. Cochrane and Moran 2011. [↑](#footnote-ref-10)
11. Wyoming 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: 14). [↑](#footnote-ref-11)