TACCIMO
Template for Assessing Climate Change Impacts and Management Options

TACCIMO Literature Report

Literature Report - Annotated Bibliography Format

Report Date: September 03, 2013

Content Selections

Animal Communities

Mammals

R1: Northern

R2 & R4: Mountain West

How to cite the information containted within this report

Each source found within the TACICMO literature report should be cited individually. APA 6th edition formatted citations are given for each source. The use of TACCIMO may be recognized using the following acknowledgement:

"We acknowledge the Template for Assessing Climate Change Impacts and Management Options (TACCIMO) for its role in making available their database of climate change science. Support of this database is provided by the Eastern Forest Environmental Threat Assessment Center, USDA Forest Service."

Best available scientific information justification

Content in this Literature report is based on peer reviewed literature available and reviewed as of the date of this report. The inclusion of information in TACCIMO is performed following documented methods and criteria designed to ensure scientific credibility. This information reflects a comprehensive literature review process concentrating on focal resources within the geographic areas of interest.

Suggested next steps

TACCIMO provides information to support the initial phase of a more comprehensive and rigorous evaluation of climate change within a broader science assessment and decision support framework. Possible next steps include:

1. Highlighting key sources and excerpts
2. Reviewing primary sources where needed
3. Consulting with local experts
4. Summarizing excerpts within a broader context

More information can be found in the user guide. The section entitled Content Guidance provides a detailed explanation of the purpose, strengths, limitations, and intended applications of the provided information.

Where this document goes

The TACCIMO literature report may be appropriate as an appendix to the main document or may simply be included in the administrative record.

Brief content methods

Content in the Literature Reports is the product of a rigorous literature review process focused on cataloguing sources describing the effects of climate change on natural resources and adaptive management options to use in the face of climate change. Excerpts are selected from the body of the source papers to capture key points, focusing on the results and discussions sections and those results that are most pertinent to land managers and natural resource planners. Both primary effects (e.g., increasing temperatures and changing precipitation patterns) and secondary effects (e.g., impacts of high temperatures on biological communities) are considered. Guidelines and other background information are documented in the user guide. The section entitled Content Production System fully explains methods and criteria for the inclusion of content in TACCIMO.

Resource Area (Factor): Animal Communities

Mammals

R1: Northern

Butler, D. R. (2012). The impact of climate change on patterns of zoogeomorphological influence: Examples from the Rocky Mountains of the Western U.S.A. Geomorphology, 157 – 158, 183 – 191. doi:10.1016/j.geomorph.2011.10.019

"Given that the beaver [Castor canadensis] ponds on several deltas (Red Eagle Creek, Elizabeth Lake, and Harrison Lake especially) [in Glacier National Park (GNP), Montana] are not fed by the main valley trunk stream but by minor distributaries and hyporheic flow (Butler, submitted for publication), the absence of the glacial contribution [due to climate warming] will inevitably lead to a reduction in overall as well as hyporheic flow, potentially to a point where insufficient flow would not maintain adequate water depths in beaver ponds for beaver survival during the harsh GNP winters. Beavers in these deltaic pond environments will need to find alternative living quarters, or they will die. In either event, their zoogeomorphic stamp [ie., entrapment of sediment] on the deltaic surfaces will be removed"

"Subalpine meadows are a major food source for grizzly bears [Ursus arctos horribilis]. In such meadows, grizzlies excavate plant tubers and bulbs (Fig. 5a) as well as seek to excavate burrowing animals such as marmots, ground squirrels, and gophers (Fig. 5b). These meadows, and, therefore, the food sources for bears found in them, are under increasing pressure because of climate change. Gielstra (2009) recently reviewed the literature on the invasion of subalpine meadows in the American West, and illustrated widespread invasions, i.e. tree seedlings are advancing into and infilling meadows. In the Preston Park area of GNP [Glacier National Park] (Fig. 6), Gielstra (2009, p. 128) specifically showed that invasion of Abies lasiocarpa seedlings is causing widespread infilling of meadow margins that is projected to cause meadows to "become more closed canopied in response to continuing climate change that is favorable for establishment". Gielstra attributed the tree seedling invasion of subalpine meadows to changes in autumn mean temperatures, with longer growing seasons extending into autumn allowing greater seedling establishment success. "

"Elsewhere in GNP [Glacier National Park, MT], the invasion of tree seedlings from ribbon forests into snow glades is also occurring (Fig. 7), attributed to earlier spring melt-out of snow glades and corresponding longer snow-free growing seasons there (Butler et al., 2003). These widespread invasions of subalpine meadows and snow glades will lead to a decline in the geomorphic impact of grizzly bears [Ursus arctos horribilis] in these locations, and the loss of food sources derived from digging in meadows and glades will need to be somehow offset by increases/expansion in other food sources, or the grizzlies will inevitably decline in health and number."

"Another major food source for grizzly bears [Ursus arctos horribilis], snow-avalanche paths (Fig. 8), may be affected by climate change. If the maximum size of avalanches in a path should decline, succession along the path margins is initiated, reducing the overall size of path habitat in which bears search for food sources. This will shift potential geomorphic impacts to other Park [Glacier National Park, MT] habitats. Earlier melt-out of snow in avalanche paths would change the seasonality of bear utilization and geomorphic impacts. It is also conceivable that the sediment excavated on avalanche paths by bears would be more widely and quickly distributed downslope by accelerated spring runoff, amplifying the geomorphic contributions of the bears; or conversely, excavations may occur under conditions of reduced moisture on the paths, altering the amount of sediment movement occurring by post-bear excavation surface flow. Carrion availability in the margins of avalanche paths may also be affected in directions that can only be surmised at present. "

"Other geomorphic impacts created by grizzly bears [Ursus arctos horribilis] in search of food sources involve the movement of rocks and boulders on talus slopes in search of army cutworm moths [Euxoa auxiliaris] and ladybird beetles [Coccinellidae]. It is uncertain at this point what effects climate change may have on these food sources, but bears may become more dependent upon them in the event that other sources, such as those associated with subalpine meadows and avalanche paths, become negatively affected or have alterations in seasonal availability. It is also unclear what effects climate change may have on den excavations by grizzlies, another major annual source of zoogeomorphic displacement of sediments on hillslopes in GNP [Glacier National Park, MT] (Butler, 1992)."

"Climate warming in GNP [Glacier National Park] and across the American west where pika [Ohotona princeps] reside will have widespread negative impacts on the impacts of pikas on the landscape, as the animals are forced to shift upslope and to ice-rich habitats, such as rock glaciers, to survive (Beever et al., 2008; Millar and Westfall, 2010). The zoogeomorphic impacts of burrowing associated with pikas will also, therefore, shift locations and possibly intensities. Active rock glaciers, for example, would not allow for burrowing beneath the boulders because of the presence of an underlying ice core or interstitial ice. If climatic warming accelerates, it is possible that pikas in GNP and elsewhere will be “pinched off” the upper elevations where they reside, becoming at least locally extinct and removing their zoogeomorphological signature from such locations. Removal of the geomorphic influences of pika has implications for secondary geomorphic responses such as shifts in local rates of infiltration/runoff, deflation, and soil moisture retention associated with vegetation patterns influenced by pika grazing."

Garrott, R. A., Eberhardt, L. L., White, P. J. & Rotella, J. (2003). Climate-induced variation in vital rates of an unharvested large-herbivore population. Canadian Journal of Zoology, 81, 33 - 45. doi: 10.1139/Z02-218

"Variation in cold-season climate, specifically snowpack, was the primary driver of variation in vital rates, [for unharvested elk, Cervus elaphus, in Yellowstone National Park] with the data supporting modest effects on adult female survival and strong effects on recruitment. We detected pronounced survival senescence in older animals, with snowpack effects differing in severity and onset for prime-age and senescent animals. Snowpack had no effect on prime-age females except under the most severe conditions, while the depressing effects of snowpack on survival of senescent females was evident across the entire range of annual variation. "

"Snowpack conditions, however, can occasionally become so severe that a small proportion of prime-age animals succumb to starvation, perhaps because of other subtle physical anomalies. Elk [Cervus elaphus] in our study system [in Yellowstone National Park] experienced such extreme conditions during the winter of 1996–1997, when very deep snow pack, containing several ice layers, produced a formidable physical barrier to foraging and movement."

"While annual variation in snowpack conditions caused only modest changes in adult female [elk, Cervus elaphus] survival rates [in Yellowstone National Park], the effects on recruitment were pronounced. Annual recruitment was highly variable, with strong evidence that stochastic fluctuations in the severity of snowpack conditions directly influenced calf survival. With the exception of the mildest winter (1993– 1994), monthly mean calf–cow ratios declined steadily each winter. Because adult female survival rates were consistently very high, the over-winter reduction in calf–cow ratios is an unambiguous index of over-winter calf survival. All overwinter calf mortalities documented during this study were attributed to starvation, with the most severe winter conditions (in 1996–1997) resulting in the virtual elimination of the juvenile cohort. "

"We hypothesized [based on our study of variation in vital rates of an unharvested elk (Cervus elaphus) population using telemetry on the western edge of Yellowstone National Park, Wyoming] that precipitation during the warm season would have the most pronounced effects on reproduction, but found no support for this thesis, as reproductive rates remained essentially constant, near their biological maxima (0.85–0.96), throughout the 7-year study. Our assessment of variation in reproduction, however, was limited to mature animals (>1 year old). Variation in fecundity of large herbivores is generally driven by annual changes in age at maturity, which have been linked to climatic variables and, in some instances, animal density (Sæther 1997)."

Schwartz, M. K., Copeland, J. P., Anderson, N. J., Squires, J. R., Inman, R. M., … & Cushman, S. A. (2009). Wolverine gene flow across a narrow climatic niche. Ecology, 91 (11), 3222 – 3232.

"Overall, this research [testing whether a dispersal model in which wolverines (Gulo gulo) prefer to disperse through areas characterized by persistent spring snow cover produced least-cost paths among all individuals that correlated with genetic distance among individuals] suggests that areas characterized by persistent spring snow cover, which in previous studies have been shown to strongly correlate with wolverine denning locations and year-round movement, also is correlated with gene flow. This spring snow-cover niche has the biologically important elements of snow during the winter and spring, and acts as a surrogate for wolverine's within-home range movements and dispersals year-round. In addition, we identified potential movement corridors that may be critical for the persistence of wolverines. Unfortunately, spring snow cover, and the bioclimatic niche that it indicates, is likely to continue to be strongly impacted by global climate change (Mote et al. 2005), threatening wolverine throughout their geographic distribution."

Wasserman, T. N., Cushman, S. A., Littell, J. S., Shirk, A. J. & Landguth, E. L. (2012). Population connectivity and genetic diversity of American marten (Martes americana) in the United States northern Rocky Mountains in a climate change context. Conservation Genetics, DOI 10.1007/s10592-012-0336-z

"Climate change was predicted to dramatically reduce the extent and connectivity of dispersal habitat [for American marten, Martes americana, in the northern Rocky Mountains] across scenarios (Fig. 2b–e). The extent of dispersal habitat is reduced by over 40 % between the 1,500 and 2,000 m scenario, corresponding to a climatic warming of +3.3°C (Littell et al. 2011), to 42 % of the study area (Fig. 3). The largest patch of connected habitat decreases by 65 % (from 62 to 22 % of the study area) between the 1,500 and 2,000 m scenario (Fig. 3). Long distance dispersal is still predicted to maintain a level of gene flow among the core populations in the central and eastern parts of the study across all climate change scenarios (Fig. 4b–e), but many of the remnant core habitat patches in the northwestern part of the study area are predicted to become genetically isolated by the 1,900 m scenario (Fig. 5b–e)."

"The isolation of remnant marten [Martes americana] populations in northwest Montana and the Idaho Panhandle predicted by 2080 may dramatically reduce genetic diversity, with most loci predicted to be fixed at a single allele. American marten populations in the western and northwestern portions of the study area may suffer severe demographic and genetic consequences. The dramatic reduction of habitat area will likely be accompanied by large decreases in local population size, increasing likelihood of local extinction due to demographic or environmental stochasticity (Stacey and Taper 1992) or Allee effects (Dennis 2002). We predict that many of the remnant habitat patches will be isolated thus cannot benefit from demographic rescue or experience recolonization after local extinction. "

"In contrast, the degree of climate change expected by 2080 we predict will not fragment the large population core areas [of American marten, Martes americana] in the central and eastern portions of the study area [in the northern Rocky Mountains]. These areas are characterized large extents of high elevation forest that are predicted to remain suitable as marten dispersal habitat across all climate change scenarios. As a result, gene flow is predicted to remain governed by isolation by distance with retention of high levels of genetic diversity."

Wilmers, C. C. & Post, E. (2006). Predicting the influence of wolf-provided carrion on scavenger community dynamics under climate change scenarios. Global Change Biology, 12, 401 – 409. doi: 10.1111/j.1365-2486.2005.01094.x

"Our model [an empirically driven stochastic model that estimates carrion abundance by month and species-specific consumption of carrion by year] reveals that continued warming will increase the frequency of the El Niño or warm phase of the ENSO [El Niño Southern Oscillation], further reducing late winter snow pack in YNP [Yellowstone National Park] and causing substantial reductions in late winter carrion availability to scavengers in scenarios without wolves [Canis lupus] under all warming scenarios (Fig. 2a–c). The results indicate that the greater the projected warming – and hence, the stronger the shift in the ENSO towards El Niño conditions – the more dramatic the effect of warming on carrion reduction. An increase in the La Niña or cold phase of the ENSO, conversely, leads to increased snow levels and a substantial increase in late winter carrion without wolves (Fig. 2d). The presence of wolves in both warming and cooling scenarios reduces the respective increase or decrease, in scavenge relative to scenarios without wolves (Fig. 2a– d). Climate influences on carrion availability with wolves are buffered relative to without wolves because wolf-pack size becomes the primary factor driving winter carrion availability to scavengers (Wilmers et al., 2003a). "

"Recent evidence suggests that the effect of ENSO [El Niño Southern Oscillation] on ecological dynamics is strengthening with increased global warming (Rodo et al., 2002). Our results [from using a combination of field observations, empirical data, and simulation modeling] indicate that the stronger the effect of ENSO on local climate variables (snow depth), the more pronounced are the effects of wolves [Canis lupus] on buffering carrion (Fig. 2e–h). Furthermore, the greater the increases in global temperatures in the future, the more important wolves become in buffering the effects of ENSO on carrion availability. In Yellowstone, the effects of warming induced changes in ENSO on the scavenger community are strongest when carrion is regulated by abiotic factors such as winter snow fall rather than biotic factors such as wolf predation."

"Regardless of the direction in which the ENSO [El Niño Southern Oscillation] pattern develops, the presence of wolves [Canis lupus] serves to buffer changes in the relative allocation of carrion to each scavenger species. The buffering is largest for species with the greatest expected change in carrion resources (Fig. 4, green bars). Many of the species that scavenge in the winter become important predators during the summer. Without wolves, climate-induced reductions in carrion will lead to lower reproduction and over-winter survival by scavengers, which could have community wide spillover effects as prey species are released from strong predation pressure."

R2 & R4: Mountain West

Beever, E. A., Ray, C., Mote, P. W. & Wilkening, J. L. (2010). Testing alternative models of climate-mediated extirpations. Ecological Applications, 20 (1), 164 – 178.

"Among our metrics of climate change, the one that differed most dramatically between extirpated and extant sites [for American pikas, Ochotona princeps, in the Great Basin] was estimated change in acute heat stress. Extirpated sites experienced a ~10% increase in estimated number of days above 28°C during 1976– 2006 (relative to 1945–1975), whereas the number slightly decreased at sites where pikas have persisted. In contrast, change in mean summer temperature was negligible and indeed counter to what one would predict, if an increase in this metric of stress were to predict extirpation. For numbers of days below freezing and below -5°C, extirpated sites lost fewer days from 1945– 1975 to 1976–2006 than did sites where pikas remained extant."

"The best predictors [for pika, Ochotona princeps, persistence] were chronic heat stress (average summer temperature), acute cold stress (number of days below -5°C; also see Discussion: Importance of climatic extremes), and acute heat stress (Tables 2 and 3). The average of Akaike weights/model for the three metrics of chronic heat stress (wavg - 0.0394 per model) indicated that such chronic stress best predicts patterns of extirpation, across all timescales investigated. Following chronic heat stress, acute heat stress (wavg - 0.0277 per model) and cold stress based on days below -5°C (wavg - 0.0252) far surpassed the predictive value of number of days below freezing (wavg.-0.0171 per model; Table 3)."

"We used recent climate as a proxy for prevailing conditions [when examining the changing distribution of the American pika, Ochotona princeps, in the Great Basin], which should approximate the bioclimatic niche of the species either in the present (given recent climate change) or over the long term (given no climate change). The fact that stress metrics based on recent climate were the most explanatory, combined with the fact that these sites have experienced some climate change, suggests that climate change is having effects on the distribution of this species. The importance of recent climate conditions (Table 3) is consistent with not only the recency of many pika extirpations (five of the nine occurred within the past 15 years), but also with: (1) the fact that across the contiguous United States, all years since 1998 have had positive temperature anomalies relative to 1961–1990 (IPCC 2007); (2) strongly positive temperature anomalies in the Great Basin during 2002–2006; and (3) increased rate of upward shifts in alpine-plant distributions during 1985–2003 relative to 1905–1985 (Walther et al. 2005)."

Beever, E. A., Wilkening, J. L., McIvor, D. E., Weber, S. S. & Brussard, P. F. (2008). American pikas (Ochotona princeps) in northwestern Nevada: A newly discovered population at a low-elevation site. Western North American Naturalist, 68 (1), 8 – 14.

"Although several lines of evidence (e.g., variable weights from models tested by Beever et al. 2003) suggest that thermal influence may be the single strongest influence on persistence of pikas [Ochotona princeps] in the Great Basin, our results here [discovery of a low-elevation population of pikas in a mountain range from which they had not been reported previously] suggest that temperature is not a perfect predictor of persistence. Instead, temperature interacts with a variety of other factors to influence persistence. This is consistent with the conclusion of Thomas et al. (2006: 416), who stated that ". . . multi-factor causes of extinction are likely to be typical" in response to rapid climate change. As an illustration, temperatures at pika-occupied taluses at Hays Canyon [Washoe County, Nevada] averaged higher (rather than lower) than temperatures at several sites from which pikas have been extirpated, and higher than temperatures within tens of unoccupied taluses at pika-extant sites across the basin."

Inouye, D. W., Barr, B., Armitage, K. B. & Inouye, B. D. (2000). Climate change is affecting altitudinal migrants and hibernating species. Proceedings of the National Academy of Sciences, 97 (4), 1630 – 1633.

"At the other end of the hibernation period, [yellow-bellied] marmots [Marmota flaviventris] are emerging earlier than they did a few decades ago, and there is an increasing amount of snow on their emergence date (Fig. 6)."

Rodhouse, T. J., Beever, E. A., Garrett, L. K., Irvine, K. M., Jeffress, M. R., … & Ray, C. (2010). Distribution of American pikas in a low-elevation lava landscape: conservation implications from the range periphery. Journal of Mammalogy, 91 (5), 1287 – 1299.

"In some situations, such as occurs at Craters of the Moon [National Monument and Preserve in southern Idaho], substrate features could enable pikas [Ochotona princeps] to persist outside their typical bioclimatic envelope and might reduce the effects of accelerated climate change, which in our region is predicted to include a reduced snowpack and elevated summer temperatures (Karl et al. 2009). However, our results showed that elevation was associated with patterns of pika distribution, even after accounting for substrate. Elevation reflects the temperature and precipitation gradients across Craters of the Moon (Davey et al. 2006), and the physiological constraints of pika metabolism and thermoregulation might present the ultimate controls on pika distribution. If so, accelerated climate change could erode the area of lava habitable to pikas in Craters of the Moon and reduce their long-term probability of persistence, despite the mitigating effects of substrate."

Terry, R. C., Cheng, L., & Hadly, E. A. (2011). Predicting small-mammal responses to climatic warming: autecology, geographic range, and the Holocene fossil record. Global Change Biology, 17, 3019-3034.

"Our results show that while we can expect to see some southern species moving northward, the bulk of future community responses to climatic warming will manifest as an increase in the dominance of species with a southern affinity that are already present. However, not all southern species will show this response because it is mediated by species autecology – specifically, a granivorous life history. Based on fossil evidence and species biology, we would expect granivorous species to thrive under a future of warmer and drier conditions in the Great Basin, independent of their geographic affinity. At the same time, we also expect species with a northern geographic affinity or an herbivorous diet to decline or show minimal response to climatic warming."

"Under projections of increased temperature and decreased precipitation [in the Great Basin]over the next 50 years, our results indicate that granivores should thrive as communities become more dominated by individuals with a southern geographic affinity. Granivores, however, are negatively impacted by the invasion of cheatgrass. The last century of anthropogenic impacts has thus placed granivores at a greater risk of extinction than predicted under climate-only scenarios."

Wang, G., Hobbs, N. T., Singer, F. J., Ojima, D. S. & Lubow, B. C. (2002). Impacts of climate changes on elk population dynamic in Rocky Mountain National Park, Colorado, USA. Climatic Change, 54, 205 – 223.

"The matrix model [projecting the potential impact of future climate on the elk population (Cervus elaphus) using logistic and non-linear matrix population models using 35 years of historic weather and elk population data in Rocky Mountain National Park (RMNP)] projections indicated that the equilibrium population sizes could reach 1,600 animals under the CCC scenario, and 2,000 animals under the Hadley scenario. The no-change scenario (based on historic, unadjusted weather) projected a steady state of 1,000 animals (Figure 4), which is close to current population estimates. Our projection, based on future climate scenarios, indicated that the increase in winter mean minimum temperature exerted effects on population dynamics that were more pronounced than effects of increased summer temperatures (Figure 5)."

"Our [logistic and non-linear matrix population] models portrayed the response of the elk [Cervus elaphus] population in RMNP [Rocky Mountain National Park] to historic [35 year] variation in weather. Coupling this portrayal with projections of a future climate suggests that the elk in RMNP could increase markedly as a result of enhanced survival and recruitment of juvenile animals. However, we emphasize that there are profound uncertainties in applying scenarios based on global models to ecological models operating at local scales. Thus, we do not offer these results as quantitative forecasts of what is likely to happen to elk numbers. Rather, we interpret our results as qualitative evidence that ecosystems that are stressed by overabundance of ungulates may be vulnerable to future climate changes."

"Under the CCC [Canadian Climate Center] and Hadley scenarios, coniferous forests would expand substantially and move upward to elevations currently dominated by tundra. In high elevations (>3450 m) of RMNP [Rocky Mountain National Park] area, the proportion of tundra in total area could be expected to decline from current 80% to 2% under the CCC scenario, and 13% under the Hadley scenario at climax stage (Hobbs et al., unpublished data). These vegetation changes would alter the summer and winter habitats [for elk, Cervus elaphus] enormously in RMNP. "

"The elk [Cervus elaphus] used a high proportion of grassland and open pine habitats (Larkins et al., 1995). The limitation of foods in winter is often believed as the mechanism for the density dependent effects in ungulate populations (Houston, 1982). Future warming winters could expand elk winter ranges to high elevation areas and lift or reduce the limitation of winter ranges on the population sizes of elk in RMNP [Rocky Mountain National Park] in a relative short term. However, in the long run, substantial decreases in the areas of tundra and grasslands, as suggested by the above climax stage, would deteriorate the food quality in both summer and winter ranges of elk and force elk to use more low-quality shrubs or trees. Therefore, climate change could affect the populations of elk not only directly, but also indirectly through altering the relative proportion of grassland to forest vegetation."