BULLETIN

Climate Change and Wildlife

PART II: SPECIES HIGHLIGHTS

MARCH 31, 2016 / BY JENNIFER HUSHAW, SI BALCH, & ERIC WALBERG

In Part I of this bulletin, we described how climate change may soon rival human influence as the biggest driver of biodiversity change, and in this piece we look more closely at the links between climate and the habitat requirements of some specific groups of wildlife and game species in North America.

We don't have much knowledge about exactly how climate will affect wildlife, even when compared to the uncertainties of forest response to climate change (as discussed previously). This is because wildlife species are higher up the trophic chain, with complicated interactions that determine their health and geographic limits (e.g. predator-prey relationships). In contrast, the distribution of vegetation communities is linked directly to climatic drivers and a short list of other factors, such as soils. The key to anticipating potential impacts is to understand the habitat characteristics that allow a species to survive in a particular place and determine how climate change might influence those conditions. The most robust predictions will be cases where a species has life history traits that are known to be particularly climate sensitive, such as the snowshoes hare's reliance on snow cover for camouflage.

Wildlife species are far more mobile than plants and will therefore be able to respond quickly to changing climate conditions—changes in the behavior, distribution, or population of wildlife species are early indicators of climate change in the field. Quick response times will also make it easier for managers to adjust their management strategies and adapt based on results that are observable within a decade or so, rather than the multiple decades, or longer, needed to observe shifts in vegetation.

The impacts of climate change are not always direct—climate can and will affect species in less obvious ways through shifting habitat suitability, changes in prey availability or abundance, altered patterns of herbivory, and others. These indirect impacts can pose a major risk to wildlife when they exacerbate existing stressors. Any effort on the part of forest owners or managers to maintain, improve, or increase habitat for climatically-vulnerable species will help buffer against shifts in desired wildlife.

Species Highlights

Studies examining the impacts of climate change on specific wildlife species are still a relatively new realm of science and, while there is an incredible amount of research being done, the information available varies greatly depending on the species—as shown in the relative length of the sections below. The management recommendations included here are also general in nature, reflecting the fact that many of the standard wildlife management techniques we already employ are suitable for responding to the impacts of climate change for number of species.

DEER, MOOSE, ELK

Climate change will affect the population dynamics, range limits, habitat selection, browsing/foraging behavior, and disease outbreaks of these ungulate species.

As conditions change, moose and deer may alter their **habitat selection**, shifting where and when they utilize certain types of habitat. For example, decreases in lake ice in Michigan have led to more lake effect snow that creates harsh winter conditions for deer and increases their reliance on shelter in conifer swamps (although this increased precipitation is expected to shift more toward rain over the next century) (Hoving & Notaro 2015). White-tailed deer are not expected to decline as a direct result of climate change, but these types of changes in migration patterns and seasonal habitat are likely (Hoving et al 2013). Similarly, it has been documented that moose will change their behavior to alleviate heat stress, by moving to areas of higher and denser forest canopy when they reach a daytime temperature threshold of around 68ºF (Melin et al 2014; Street et al 2015; NWF 2013a).

Range limits will also shift, and in some cases they already have, e.g. white-tailed deer have expanded into western boreal forests and climate has been shown to be an important factor determining their presence in that region (Dawe et al 2014). At the northern edge of their range, white-tailed deer are controlled by low winter temperatures and snow depth, so conifer stand deer yards are important for their survival because they provide thermal cover and reduced snow depth. As the climate changes, this cold/snow limiting line will move and two things are likely to result: (1) the more southerly deer yards will become less critical to survival and (2) deer populations will increase. Similarly, research on moose in China has revealed that climate is an important factor influencing population dynamics there; increases in late spring temperatures, in particular, have the potential to shift the southern limits of moose distribution northward (Dou et al 2013).

Changes in moose and deer **population dynamics** have been linked to large-scale climate patterns, particularly the North Atlantic Oscillation (NAO), which determines much of the snowfall and winter temperatures in northern latitudes (Post & Stenseth 1998). Likewise, recent research suggests that warmer temperatures and a shorter period of high quality forage in spring have led to nutritional deficiencies in maternal moose that decreased recruitment in the southern part of their range (Monteith et al 2015). As cold-adapted species, moose are generally considered to be highly vulnerable to climate change and decreases in abundance are likely by the middle of the century (Hoving et al 2013).

Climate change-induced decreases in snowpack have also led to shifts in **browsing or foraging behavior** in both moose and elk. In the case of moose, low snow conditions can increase browse on balsam fir compared to sugar maple or Viburnum (Christensen et al 2014). For elk, less snowpack means easier access to aspen shoots, which has caused substantial declines in aspen recruitment, particularly in the Rocky Mountains (Brodie et al 2012). In fact, climate change may actually provide some positive benefits for elk in the form of milder winters and better forage (NWF 2013a). Importantly, these kinds of climate-driven changes in plant-herbivore interactions can have wide reaching affects within the larger ecological community (Auer & Martin 2012).

Lastly, as discussed in Part I, climate change is altering **pest and disease** dynamics, including the transmission of wildlife diseases. White-tailed deer are vulnerable to hemorrhagic disease (HD), including epizootic hemorrhagic disease and bluetongue viruses, which are transmitted by biting midges. The first fall frost usually kills the insects, but longer summers will mean longer exposure times and hot, dry weather (which is likely to increase) has been strongly associated with past outbreaks, which suggests that the risk of widespread deer mortality from these diseases will increase (Hoving et al 2013; NWF 2013a). In recent years, warmer, shorter winters have also spelled trouble for moose populations, as winter ticks have proliferated enough to cause a significant increase in moose mortality (heavy infestations leave moose weak, vulnerable to disease, and at risk of cold exposure and death in cases where they rub off their insulating hair in an attempt to rid themselves of the ticks) (NWF 2013a).

Management Considerations:

- Monitor for changing browsing patterns.
- Provide areas of high, dense forest canopy for moose, particularly in southern parts of their range.
- Factor increased deer browsing into regeneration planning.

CANADA LYNX

Climate change will affect the population dynamics, distribution and abundance of prey species, hunting success, connectivity with peripheral populations, and range margins of lynx populations.

Canada Lynx is a charismatic animal that has drawn a great deal of conservation interest since its listing as a threatened species under the Endangered Species Act in March of 2000. It is considered highly vulnerable to climate change because it is a cold-adapted species that is particularly well-suited to hunting in deep snow, which gives it a competitive advantage over other predators (an advantage that will be lost with decreasing snow cover).

The decrease in snow cover will not only affect **hunting success**, but will also affect the **distribution and abundance of the primary prey species**, the snowshoe hare, whose populations are expected to shift northward due to climate change (Murray et al 2008). This is partly because hares in southern locations (with decreasing snow cover) often find themselves mismatched with their surroundings when they molt into their white winter coat in the absence of snow, which makes them far more visible to predators, with weekly survival decreases up to 7% (Zimova et al 2016). In contrast, the range of snowshoe hares has expanded in some northern locations, particularly Arctic Alaska, where warming temperatures and expanded shrub habitat have created more suitable conditions (Tape et al 2015).

Along with prey species abundance, climate itself is an important determinant of lynx **population dynamics**. Large-scale climate patterns, including the North Atlantic Oscillation index (NAO), the Southern Oscillation Index (SOI), and northern hemispheric temperature, play a role in producing and modifying the classic 10-year population cycles associated with lynx and snowshoe hare in the boreal parts of their range, by influencing rain and snowfall patterns (Yan et al 2013).

Climate change is also affecting **connectivity** between core and peripheral lynx populations, especially island populations that are sustained by immigration of individuals from other areas. Individuals from the core of the lynx range migrate over frozen rivers to reach island habitats, so warming conditions and less frequent formation of ice bridges will leave these populations even more isolated (Koen et al 2015; Licht et al 2015). As a result, **range margin shifts** are expected (and in some cases already observed) that include contraction of these smaller, peripheral groups, as well as northward contraction of the southern range boundary and the core population areas (Carroll 2007; Koen et al 2014).

Management Considerations:

- Provide large, contiguous tracts of landscape, especially where there is connectivity with more stable Canadian populations of lynx.
- Maintain patches of young, dense conifers for hare habitat.

BATS

Climate change may affect bat population distributions, reproductive success, hibernation behavior, and access to food.

Climate is known to influence the biogeography of bats, as well as their access to food, timing of hibernation, development, and other factors, so it is likely that changing climate conditions may adversely impact some bat species—some specific life history characteristics that may put bats at risk from climate change include (Sherwin et al 2012):

- Small range size,
- high latitude or high altitude range,
- range that is likely to become water stressed,
- fruit-based diet,
- restricted to aerial hawking (prey pursued and caught in flight),
- and restricted dispersal behavior.

Throughout the globe, there have been a number of documented cases of shifting bat populations linked to climate change, including range expansion of at least one Mediterranean species (Ancillotto et al 2016) and mostly northward shifts in a number of species in China (Wu 2016). In the Czech Republic, evidence suggests that a temperate, insectivorous bat is benefiting from rising spring temperatures, but the effect may be buffered by excessive summer rain that decreases reproductive success (Lučan et al 2013)—an example of the complicated nature of predicting exactly how climate change will impact a given wildlife species.

Of course, climate change is not the most immediate concern in the United States, where the introduction of white-nose syndrome to the eastern U.S. in the early 2000's led to a massive decline in bat populations. However, changing climate conditions do have the potential to further stress these decimated populations, which is a cause for concern. This also highlights the need to protect the genetic diversity within refugial populations, especially on the leading edge for northward migration (Razgour et al 2013).

One particularly hard hit species, the Northern Long-eared Bat (NLB), was listed as threatened under the Endangered Species Act (ESA) and a final rule was released in January 2016 detailing the protections for this species under the ESA. Use these links to access a range map for the NLB and up-to-date maps of documented cases of white-nose syndrome, as well as details about the Final 4(d) Rule for the NLB under the ESA—there are some considerations for forest managers.

Management Considerations:

- Leave a ¼ mile buffer around known hibernaculum*.
- Leave a 150ft buffer around documented or potential maternal roosting trees*, especially during the pupping season in June & July.

* Contact your state agency or US Fish & Wildlife Service for more information about hibernaculum and maternal roost tree locations.

FOREST SONG BIRDS

Climate change will alter migration patterns, population dynamics, and the quality and availability of habitat for forest song birds.

Song bird species have exhibited a variety of responses to recent climate change. In particular, shifts in timing have been observed for some migratory species, including spring arrival shifted several days to more than a week early (depending on the species), such as Baltimore Oriole, Eastern Towhee, Red-eyed Vireo, Ruby-throated Hummingbird, and Mountain Bluebirds (NWF 2013b; Manomet). There is mixed evidence regarding changes in fall migration, with both early and late shifts observed in migrants passing through Massachusetts (Ellwood et al 2015).

Birds have the advantage of being able to respond rapidly to warming temperatures, but their ability to adapt depends on where they overwinter, how they receive their migration cues, and the level of mismatch between migration timing and the availability of associated food sources. In fact, evidence from 33 years of bird capture data collected by Manomet's land bird conservation program suggests that short-distance migrants respond to temperature changes, while some mid-distance migrants respond to temperature and/or changes in the Southern Oscillation Index, and long-distance migrants tend not to change over time (Miller-Rushing et al 2008).

The vulnerability of individual species is also related to their specific habitat requirements and whether climate change may alter the availability of quality breeding or foraging areas. For example, a study of over 160 bird species in the Sierra Nevada mountains of California found that those associated with alpine/subalpine and aquatic habitats ranked as the most vulnerable, while those associated with drier habitats (i.e. foothill, sagebrush, and chaparral associated species) may experience range expansion in the future (Siegel et al 2014). Challenges may also arise for bird species that rely on temperature-sensitive prey species for food, such as aerial insectivores (e.g. Common Nighthawk, Chimney Swift, and Bank Swallow) that eat flying insects.

Lastly, as we have seen for other groups of species, rapid shifts in the distribution of wild birds will have implications for the spread and abundance of wildlife diseases (Van Hemert et al 2014).

Management Considerations:

- Use silvicultural techniques that promote the type of forest structure preferred by desired species, e.g.
    - See recommendations for a select number of important bird species that favor fully stocked stands in *Birds with Silviculture in Mind* (part of the Foresters for the Birds program by Audubon Vermont and the Vermont Department of Forests, Parks, and Recreation)
    - Use guidance and resources from your local NRCS field office to develop forest structure for bird species that prefer early successional habitat

Note: Visit the Climate Change Bird Atlas from the U.S. Forest Service for maps of projected change in species distribution for 147 birds in the eastern U.S.

GAME BIRDS (GROUSE, TURKEY, QUAIL)

> *Climate change may affect habitat suitability and availability for important game bird species, as well as their breeding success and population dynamics—positive and negative projections vary from species to species.*

Climate plays a role in the distribution of game bird species, as it does with many others. In fact, the population dynamics of several gamebirds seem to be influenced by large-scale climatic patterns (Kozma et al 2016; Williford et al 2016; Lusk et al 2001), but the effects of climate change are expected to vary significantly from one species to the next. For example, Black Grouse in Finland have experienced population declines for four decades related to seasonally asymmetric climate change. In particular, springs have warmed faster than the early summer period, so grouse lay their eggs earlier and then experience higher chick mortality when they hatch before temperatures are sufficiently warm (Ludwig et al 2006). Similarly, Spruce Grouse is considered moderately vulnerable because its montane spruce-fir habitat is rare (and likely to decline) in the southern edges of its boreal range. On the other hand, Ruffed Grouse is a resident species in the northeast U.S. whose range is projected to decrease and shift further north, even as overall populations remain relatively stable (Rodenhouse et al 2008; Hoving et al 2013).

In contrast, some gamebirds are likely to fare even better under climate change, including Wild Turkey (which has expanded northward (Niedzielski & Bowman 2015) and will benefit from less severe winters (Hoving et al 2013)), Northern bobwhite (which is likely to increase (Hoving et al 2013)), and Sage Grouse (which studies suggest may enjoy an increase in suitable habitat in some regions, such as southeastern Oregon, by the end of the century (Creutzburg et al 2015)).

Management Considerations:

- Follow habitat guidelines from the Ruffed Grouse Society, Wild Turkey Federation, Timberdoodle.org, the Wildlife Management Institute and others.

FISH

> *Climate change has already led to increased temperatures in freshwater systems, putting cold-water fish species at risk of physiological stress or extirpation in certain waterways, while some warm-water species may experience increased growth rates and northward expansion.*

Climate change has the potential for significant adverse impacts on cold-water fish species such as brook and rainbow trout. These species depend on access to cold water for reproduction and may also suffer from an increase in summer low flow stream conditions. As discussed in the August 2014 Bulletin, designing stream crossings to accommodate floods associated with the increase in heavy precipitation also has the benefit of minimizing fragmentation of aquatic habitat. Intact stream systems allow fish and other aquatic species to move in search of appropriate temperature and flow regimes.

For warm-water fish, evidence suggests that some species, such as small mouth bass, may experience increased growth rates as temperatures rise (although this growth effect may taper off if conditions become too warm later in the century) (Pease & Paukert n.d.). Some warm-water fishes have also moved northwards and are likely to continue expanding into freshwater systems traditionally dominated by cold-water species (Groffman et al 2014).

Management Considerations:

- Upsize culverts, transition to arched structures, or use removable crossings to provide the win/win of reduced infrastructure damage from floods and enhanced connectivity of aquatic habitat.

AMPHIBIANS

Climate change will drive changes in habitat availability and suitability for amphibian species, which are highly sensitive to changes in temperature and precipitation.

There is weak evidence that climate change is driving observed declines in amphibian populations in various locations worldwide (Li et al 2013), but a number of studies suggest that future climate change is likely to lead to declines and/or range contractions (Barrett et al 2014; Loyola et al 2014; Wright et al 2015). These changes will be driven by a reduction in climatically suitable habitat, reduced soil moisture (which will reduce prey abundance and lead to loss of habitat), reduced snowfall and increased summer evaporation (which will change the duration and occurrence of seasonal wetlands) (Corn 2005).

Amphibians are particularly vulnerable to changing climate because their ectothermic physiology makes them very sensitive to temperature and precipitation changes, they have low dispersal capability, and often have strong associations with temporary wetlands that are likely to be threatened by climate change (Tuberville et al 2015).

Management Considerations:

- Maintain appropriate buffer areas around water bodies, vernal pools, ephemeral and intermittent streams that act as amphibian habitat.

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References

Ancillotto, L., Santini, L., Ranc, N., Maiorano, L., Russo, D. 2016. Extraordinary range expansion in a common bat: the potential roles of climate change and urbanization. *The Science of Nature*. 103(15).

Auer, S.K. and Martin, T.E. 2012. Climate change has indirect effects on resource use and overlap among coexisting bird species with negative consequences for their reproductive success. *Global Change Biology*. 19(2): 411-419.

Barrett, K., Nibbelink, N.P., Maerz, J.C. 2014. Identifying Priority Species and Conservation Opportunities Under Future Climate Scenarios: Amphibians in a Biodiversity Hotspot. *Journal of Fish and Wildlife Management*. 5(2): 282-297.

Brodie, J., Post, E., Watson, F., Berger, J. 2012. Climate change intensification of herbivore impacts on tree recruitment. *Proc. R. Soc. B*. 279: 1366-1370.

Carroll, C. 2007. Interacting Effects of Climate Change, Landscape Conversion, and Harvest on Carnivore Populations at the Range Margin: Marten and Lynx in the Northern Appalachians. *Conservation Biology*. 21(4): 1092-1104.

Christenson, L.M., Mitchell, M.J., Groffman, P.M., Lovett, G.M. 2014. Cascading Effects of Climate

Change on Forest Ecosystems: Biogeochemical Links Between Trees and Moose in the Northeast USA. *Ecosystems*. 17: 442-457.

Corn, P.S. 2005. Climate change and amphibians. *Animal Biodiversity and Conservation*. 28.1:59-67.

Creutzburg, M.K., Henderson, E.B., Conklin, D.R. 2015. Climate change and land management impact rangeland condition and sage-grouse habitat in southeastern Oregon. *AIMS Environmental Science*. 2(2): 203-236.

Dawe, K.L., Bayne, E.M., Boutin, S. 2014. Influence of climate and human land use on the distribution of white-tailed deer (*Odocoileus virginianus*) in the western boreal forest. *Can. J. Zool*. 92: 353-363.

Dou, H., Jiang, G., Stott, P., Piao, R. 2013. Climate change impacts population dynamics and distribution shift of moose (*Alces alces*) in Heilongjiang Province of China. *Ecol. Res*. 28: 625-632.

Ellwood, E. R., A. Gallinat, R. B. Primack, and T. L. Lloyd-Evans. 2015. Autumn migration of North American landbirds. Pp. 193–205 *in* E. M. Wood and J. L. Kellermann (editors), Phenological synchrony and bird migration: changing climate and seasonal resources in North America. *Studies in Avian Biology* (no. 47), CRC Press, Boca Raton, FL.

Groffman, P. M., P. Kareiva, S. Carter, N. B. Grimm, J. Lawler, M. Mack, V. Matzek, and H. Tallis. 2014. Ch. 8: Ecosystems, Biodiversity, and Ecosystem Services. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program. DOI:10.7930/J0TD9V7H.

Hoving, C.L., Lee, Y.M., Badra, P.J., Klatt, B.J. 2013. Changing Climate, Changing Wildlife: A Vulnerability Assessment of 400 Species of Greatest Conservation Need and Game Species in Michigan. *Michigan Department of Natural Resources*, Wildlife Division Report No. 3564.

Hoving, C.L. and Notaro, M. 2015. Ice, Snow, and Swamp: Managing Deer in Michigan's Changing Climate. *Michigan Journal of Sustainability*. Volume 3, Spring: pp 101-110.

Koen, E.L., Bowman, J., Murray, D.L., Wilson, P.J. 2014. Climate change reduces genetic diversity of Canada lynx at the trailing range edge. *Ecography*. 37: 754-762.

Koen, E.L., Bowman, J., Wilson, P.J. 2015. Isolation of peripheral populations of Canada lynx (*Lynx canadensis*). Canadian Journal of Zoology. 93(7): 521-530.

Kozma, R., Melsted, P., Magnusson, K.P., Hoglund, J. 2016. Looking into the past – the reaction of three grouse species to climate change over the last million years using whole genome sequences. *Molecular Ecology*. 25(2): 570-580.

Li, Y., Cohen, J.M., Rohr, J.R. 2013. Review and synthesis of the effects of climate change on amphibians. *Integrative Zoology*. 8: 145-161.

Licht, D.S., Moen, R.A., Brown, D.P., Romanski, M.C., Gitzen, R.A. 2015. The Canada Lynx (*Lynx canadensis*) of Isle Royale: Over-harvest, Climate Change, and the Extirpation of an Island Population. *The Canadian Field-Naturalist*. 129: 139-151.

Loyola, R.D., Lemes, P., Brum, F.T., Provete, D.B., Duarte, L.D.S. 2014. Clade-specific consequences of climate change to amphibians in Atlantic Forest protected areas. *Ecography*. 37: 65-72.

Lučan, R.K., Weiser, M., Hanák, V. 2013. Contrasting effects of climate change on the timing of reproduction and reproductive success of a temperate insectivorous bat. *Journal of Zoology*. 290(2): 151-159.

Lusk, J.J., Guthery, F.S., DeMaso, S.J. 2001. Northern bobwhite (*Colinus virginianus*) abundance in relation to yearly weather and long-term climate patterns. *Ecological Modelling*. 146(1-3): 3-15.

Melin, M., Matala, J., Mehtatalo, L., Tiilikainen, R., Tikkanen, O., Maltamo, M., Pusenius, J., Packalen, P. 2014. Moose (*Alces alces*) reacts to high summer temperatures by utilizing thermal shelters in boreal forests – an analysis based on airborne laser scanning of the canopy structure at moose locations. *Global Change Biology* 20: 1115-1125.

Miller-Rushing, A.J., Lloyd-Evans, T.L., Primack, R.B., Satzinger, P. 2008. Bird migration times, climate change, and changing population sizes. *Global Change Biology*. 14: 1959-1972.

Monteith, K.L., Klaver, R.W., Herset, K.R., Holland, A.A., Thomas, T.P., Kauffman, M.J. 2015. Effects of climate and plant phenology on recruitment of moose at the southern extent of their range. *Oecologia*. 178: 1137-1148.

Murray, D.L., Steury, T.D., Roth, J.D. 2008. Assessment of Canada Lynx Research and Conservation Needs in the Southern Range: Another Kick at the Cat. *The Journal of Wildlife Management*. 72(7): 1463-1472.

National Wildlife Federation. 2013a. Nowhere to Run: Big Game Wildlife in a Warming World. Accessed online: http://www.nwf.org/~/media/PDFs/Global-Warming/Reports/NowheretoRun-BigGameWildlife-LowResFinal_110613.ashx

National Wildlife Federation. 2013b. Shifting Skies: Migratory Birds in a Warming World. Accessed online: https://www.nwf.org/pdf/Reports/NWF_Migratory_Birds_Report_web_Final.pdf

Niedzielski, B. and Bowman, J. 2015. Survival and cause-specific mortality of the female eastern wild turkey at its northern range edge. *Wildlife Research*. 41(7): 545-551.

Pease, A. and Paukert, C. n.d. Potential effects of climate change on smallmouth bass growth in streams of the central U.S. Accessed online: http://fishhabclimate.org/sites/default/files/documents/SMB%20growth%20fact%20sheet.pdf

Post, E. and Stenseth, N.C. 1998. Large-scale climatic fluctuation and population dynamics of moose and white-tailed deer. *Journal of Animal Ecology*. 67: 537-543.

Razgour, O., Juste, J., Ibanez, C., Kiefer, A., Rebelo, H., Puechmaille, S.J., Arlettaz, R., Burke, T., Dawson, D.A., Beaumont, M., Jones, G. 2013. The shaping of genetic variation in edge-of-range populations under past and future climate change. *Ecology Letters*. 16(10): 1258-1266.

Rodenhouse, N.L., Matthews, S.N., McFarland, K.P., Lambert, J.D., Iverson, L.R., Prasad, A., Sillett, T.S., Holmes, R.T. 2008. Potential effects of climate change on birds of the Northeast. *Mitig. Adapt. Strat. Glob. Change*. 13: 517-540.

Sherwin, H.A., Montgomery, W.I., Lundy, M.G. 2012. Review: The impact and implications of climate change for bats. *Mammal Review*. 43(3): 18pp.

Siegel, R.B., Pyle, P., Thorne, J.H., Holguin, A.J., Howell, C.A., Stock, S., Tingley, M.W. 2014. Vulnerability of birds to climate change in California's Sierra Nevada. Avian Conservation & Ecology. 9(1), No. 7.

Street, G.M., Rodgers, A.R., Fryxell, J.M. 2015. Mid-day temperature variation influences seasonal habitat selection by moose. *The Journal of Wildlife Management*. 79(3): 505-512.
Tape, K.D., Christie, K., Carroll, G., O'Donnell, J.A. 2015. Novel wildlife in the Arctic: the influence of changing riparian ecosystems and shrub habitat expansion on snowshoe hares. *Global Change Biology*. 22(1): 12pp.

Tuberville, T.D., Andrews, K.M., Sperry, J.H., Grosse, A.M. 2015. Use of the NatureServe Climate Change

Vulnerability Index as an Assessment Tool for Reptiles and Amphibians: Lessons Learned. *Environmental Management*. 56(4): 822-834.

Van Hemert, C., Pearce, J.M., Handel, C.M. 2014. Wildlife health in a rapidly changing North: focus on avian disease. *Frontiers in Ecology and the Environment*. 12(10): 548-556.

Williford, D., Deyoung, R.W., Honeycutt, R.L., Brennan, L.A., Hernandez, F. 2016. Phylogeography of the bobwhite (*Colinus*) quails. *Wildlife Monographs*. 193(1):1-49.

Wright, A.N., Schwartz, M.W., Hijmans, R.J., Shaffer, H.B. 2015. Advances in climate models from CMIP3 to CMIP5 do not change predictions of future habitat suitability for California reptiles and amphibians. *Climatic Change*. DOI 10.1007/s10584-015-1552-6

Wu, J. 2016. Detection and attribution of the effects of climate change on bat distributions over the last 50 years. *Climatic Change*. 134(4): 681-696.

Yan, C., Stenseth, N.C., Krebs, C.J., Zhang, Z. 2013. Linking climate change to population cycles of hares and lynx. *Global Change Biology*. 19: 3263-3271.

Zimova, M., Mills, L.S., Nowak, J.J. 2016. High fitness costs of climate change-induced camouflage mismatch. *Ecology Letters*. 19(3): 299-307.