USDA United States Department of Agriculture
Forest Service

PNW Pacific Northwest Research Station

Science FINDINGS

issue one hundred eighty six / june 2016

INSIDE

"Science affects the way we think together."
Lewis Thomas

Big Changes in Cold Places: The Future of Wildlife Habitat in Northwest Alaska

Bruce Marcot

The effects of climate change in the Arctic are already evident: wildfires are becoming more frequent as forests become drier, leading to shifts in vegetation types, and thawing permafrost is causing lakes to drain as shown above. These changes affect the region's wildlife and the people who depend on them for subsistence.

IN SUMMARY

Higher global temperatures are changing ecosystems in the Arctic. They are becoming greener as the climate and land become more hospitable to taller vegetation. Scientists predict that woody vegetation in the Arctic will increase by more than 50 percent, and half of all vegetated areas will shift to types more suited to the higher temperatures and changing physical conditions. The implications for wildlife and people living in the Arctic are striking and hinge on rapid changes affecting ecosystems and habitats.

Bruce Marcot, a research wildlife biologist with the Pacific Northwest Research Station, is the lead scientist for the multi-agency Wildlife Potential Habitat Forecasting (WildCast) Project, which has projected climate change impacts on ecosystems and wildlife habitats in northwest Alaska. WildCast researchers anticipated that expansion of shrubs and trees will be driven by major disturbances including an increase in fire, vegetation succession, and thawing permafrost.

WildCast models projected that out of 201 bird and mammal species, 52 percent will experience habitat expansion, 45 percent will see habitat contractions, and 3 percent will have no change. They also found that declines in habitat will occur for half of the 50 bird and mammal species used for local subsistence hunting and trapping, and declines will occur in the habitat of small mammals that are the major prey base for many carnivores.

"Nothing is so painful to the human mind as a great and sudden change."
—Mary Shelley, *Frankenstein*

In May 2015, the small town of Eagle in interior Alaska broke a record that is both unsettling and portentous. Temperatures soared to 91 °F, the earliest 90-degree day ever recorded for the town. Later, state climate officials reported the month to be the warmest May on record for Alaska. After a warm and very dry spring, the state suffered one of its worst wildfire seasons. Flames burned through 5 million acres of forests, grasslands, and tundra.

Fires and record high temperatures are just a few of many signs of Alaska's transformation in a warming climate. And more changes are coming. The Arctic is warming at more than twice the global average. With most of the state within arctic and subarctic environments, the U.S. Forest Service is helping examine further changes to the land, wildlife, and communities that live there.

Bruce Marcot, a research wildlife biologist with the USDA Forest Service Pacific Northwest Research Station, is the lead scientist with the WILDlife Potential Habitat ForeCASTing Framework (WildCast), a collaboration between the Forest Service, the National Park Service (NPS), and the U.S. Geological Survey (USGS). Marcot and his colleagues set out to understand how these changes might play out in the country's largest and northernmost state. "We wanted to look ahead to the next century and forecast what could happen under climate change," Marcot says. "How would habitats change? How would wildlife and people be affected?"

Alaska is vast. It covers 663,000 square miles—more than twice the size of Texas—with a diverse range of landscapes. There are glaciers, snow-capped mountains, and great expanses of tundra, as well as long stretches of wilderness, volcanic landscapes, and sand dunes. "The National Park Service units and U.S. Fish and Wildlife refuges there are just astounding examples of vast, untouched areas," Marcot says. "You could fly for hours and hours and see absolutely no sign of people—no camps, trails, roads, or anything. It's just spectacular."

Yet the state's very breadth and isolation make it tough to explore and study. Tourists and backpackers are often caught unprepared for the large distances between towns, national parks, and other attractions, not to mention the high cost of transportation, food, and lodging. *Lonely Planet*, a travel guidebook, described some of the national parks here as so remote that the International Space Station gets more annual visitors. It's no surprise that Marcot and his colleagues had to refer to satellite images to assess the types of land cover, or ecotypes, in their vast study area.

Their study area comprises five units of the National Park Service and one national wildlife refuge in northwest Alaska. Abutting the seasonally sea-ice-encrusted Chukchi and Bering Seas on the north and west are the wetlands and archeological sites of Cape Krusenstern National Monument and the hot springs and lava flows of the Bering Land Bridge National Preserve. Also on the west are the Noatak National Preserve and its mountain-ringed river basins; Kobuk Valley National Park and its shifting sand dunes; and the Selawik National Wildlife Refuge and its extensive wetlands. To the east lie the glacier-carved valleys of the Gates of the Arctic National Park and Preserve. In all, the study area covers 62,884 square miles. "That's larger than the state of Georgia and bigger than 64 percent of all countries on Earth," Marcot says.

Marcot worked with Torre Jorgenson, a research ecologist at Alaska Ecoscience who developed the satellite-derived ecotype map, to project changes for each of the 60 ecotypes

KEY FINDINGS

- Major disturbances, including the expansion of shrubs and trees, increasing wildfire, vegetation succession, and thawing permafrost will drive transitions of ecosystems and wildlife habitats in northwest Alaska over the 21st century.
- Of 201 bird and mammal species, models project that 52 percent will experience habitat expansion, 45 percent will see habitat contractions, and 3 percent will experience no change.
- A greater proportion of mammal species (62 percent) will experience habitat declines than will bird species (50 percent).
- Declines in habitat will occur for half of the 50 bird and mammal species used for local subsistence hunting and trapping, including large-bodied mammals like caribou and muskox.
- Declines will occur in the habitat of small mammals that are the major prey base for many carnivores, likely disrupting food webs.

Bruce Marcot

A continued decrease in aquatic and wetland habitats of lowland lakes in northwest Alaska is projected through 2100 as the lakes drain through thawed permafrost.

Purpose of PNW Science Findings

To provide scientific information to people who make and influence decisions about managing land.

PNW Science Findings is published monthly by:

Pacific Northwest Research Station
USDA Forest Service
P.O. Box 3890
Portland, Oregon 97208

Send new subscriptions and change of address information to:

pnw_pnwpubs@fs.fed.us

Rhonda Mazza, editor; rmazza@fs.fed.us

Cheryl Jennings, layout; cjennings@fs.fed.us

Science Findings is online at: http://www.fs.fed.us/pnw/publications/scifi.shtml

To receive this publication electronically, change your delivery preference here:

http://www.fs.fed.us/pnw/publications/subscription.shtml

USDA United States Department of Agriculture

Forest Service

in the study area. "We came up with a transition process in a spreadsheet-based model to ask what's going to happen to each of the ecotypes up there—those ponds, forests, tundra fields—over the 21st century," Marcot says.

Marcot and Jorgenson looked at historical trends in average annual air temperature from weather stations, then examined how fast or slow ecosystems responded to different factors, such as wildfire or high temperatures, during the last 30 to 50 years. They applied these trends and rates to statistical models that projected detailed changes for each of the 60 ecotypes for the rest of the century.

The researchers found that in the lowlands, the area occupied by dominant shrub will decline by 65 percent whereas tall shrubs and trees will steadily increase. Permafrost—frozen ground under the tundra—will likely continue to thaw deeper and earlier because of increasing temperatures. Forests, grasslands, and tundra will dry, leading to more wildfires. In turn, new vegetation will move into the burned areas, a process called vegetation succession. Thirty-three ecotypes would gain area, 23 would lose area, and four would stay the same.

"In general, there is going to be a shift from grassland tundra and low shrub to taller shrub and woodland and spruce forests," Marcot says. "A lot of the bogs, fens, wet grasslands, and tundra lakes will likely drain and dry out. Permafrost underneath these wetlands is going to start to thaw further through the ground, which is almost like punching a hole in the bottom of a bathtub. So there is going to be a fair loss of aquatic and wetland types too."

The forecasted shift from grasses and herbs to shrubs and trees is telling. "That's a big change, especially if you think of species like caribou which focus on, use, and migrate across a lot of the open grassland tundra."

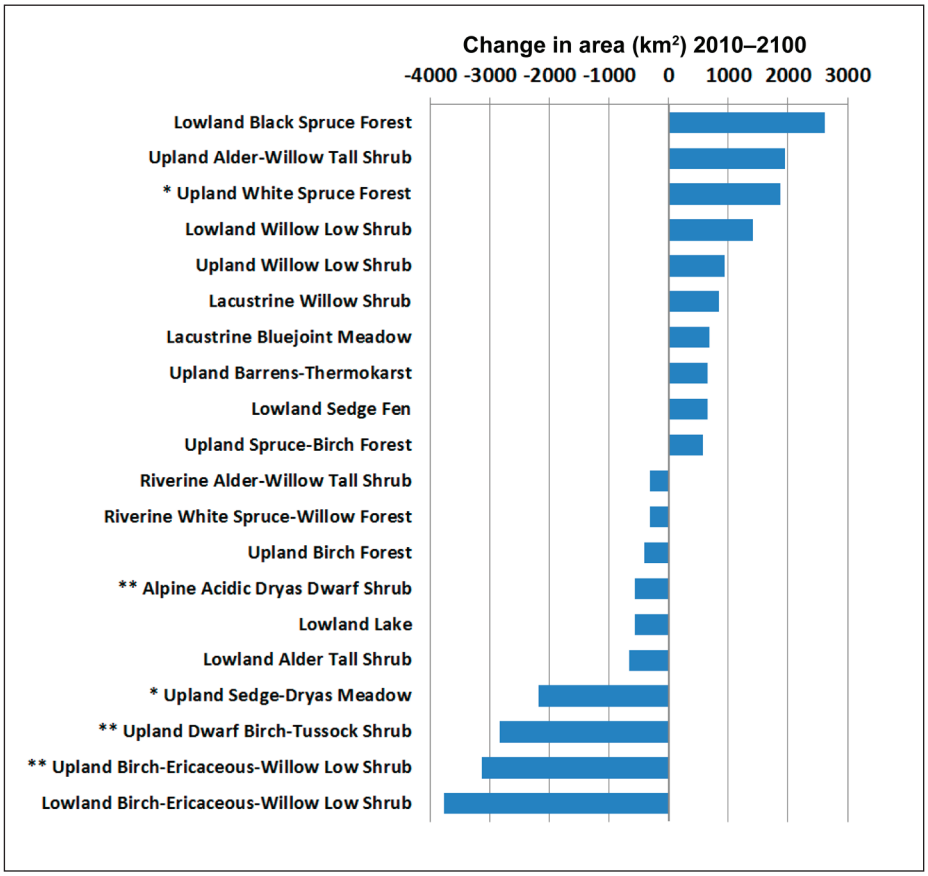
With these big changes happening to the land and the vegetation, what will happen to wildlife that depend on these habitats?

GAINERS AND LOSERS

The researchers now knew how ecotypes in the study area might change, but there was no readily available dataset on how wildlife species use these ecotypes. "So I worked with researchers in the NPS and USGS to build the first-ever wildlife-habitat relationships information base for this area," Marcot says.

To do this, the researchers listed all 162 species of birds and 39 species of mammals that lived within or near the study area, and plotted the value of each ecotype as habitat for each species, ranked as low, moderate, or high quality. Marcot and his colleagues also determined each species' total habitat area, how many ecotypes each species used, and the number of species each ecotype supported. Marcot says developing this wildlife-habitat relationships database was one of the most challenging parts of the study. To do so, the researchers relied on field studies, published literature, and consultations with numerous Forest Service, NPS, and USGS experts.

"Then we tied the projected changes for each of the 60 ecotypes to how each of the species of mammals and birds used those ecotypes," Marcot says. The researchers used statistical models to make projections under three scenarios: the first assumed that ecotype changes will continue at the same rate (time model); the second related past rates of ecotype changes to recent trends of increasing regional air temperatures (temperature model); and the third adjusted the temperature model to biophysical factors, such as the expansion of tall shrubs and trees, changes in water balance, river erosion, and the impact of wildfires (rate-adjusted temperature model). All three models led to similar outcomes and generally differed only in the degree of expected change, with the time model being the most conservative.



Bruce Marcot

*Projected changes in total area of the ecotypes gaining or losing the most ground, under the rate-adjusted temperature model. ** = currently occupies more than 5 percent of the total area; * = currently occupies more than 2 percent of the total area.*

The time model projected that up to 52 percent of the 201 bird and mammal species currently occurring in the area will experience habitat expansion, 45 percent will see habitat contractions, and 3 percent will experience no habitat change. More species were projected to lose their habitats in the rate-adjusted model and even more so in the temperature model.

Overall, species such as grouse and black bear that occupy forest and tall-shrub ecotypes will see habitat expansion, while species like ptarmigan and caribou that occupy meadow and low-shrub ecotypes will have less habitat.

Bruce Marcot

A cross (red) fox: its habitat is projected to stay about the same, but the habitat of much of its prey (lemmings, shrews, voles) is projected to decline by 2100.

Bruce Marcot

The willow ptarmigan is valued by subsistence hunters; its meadow and low-shrub habitat is expected to decline by 2100.

Most of the small mammals, such as lemmings, voles, and shrews, which form the prey base for larger carnivores and raptors, will also lose some habitat. "I am hypothesizing that a trophic cascade effect is going to happen," Marcot says. "That's when you lose these key prey for carnivores and the food chain gets disrupted."

Compared to bird species, a greater proportion of mammal species are projected to experience habitat declines, the scientists found. Half of the 50 bird and mammal species used for subsistence hunting, including greater white-fronted goose, tundra swan, caribou, mink, and muskrat will experience habitat decline.

As habitats shift, subsistence hunters may have to travel to different areas, not necessarily close to their villages, to find food. And, as the climate changes, so will the windows of opportunity for getting out on the tundra to fish and hunt. Marcot explains, "With summer happening earlier and ending later, a lot of the frozen ground that people travel over by snowshoe or snowmobile becomes mush and marsh. This will impede their ability to hunt for food."

LIVING IN CHANGE, DOCUMENTING CHANGE

The WildCast project's findings will be valuable to land managers as they develop climate change adaptation policies for federal lands in the region. "Land managers for the Central Yukon and Seward Peninsula rapid ecosystem assessment teams are already using our findings in their planning discussions," Marcot says.

The NPS is using the findings in its State of the Parks assessment and Natural Resources Conditions Assessment for Cape Krusenstern National Monument, Bering Land Bridge National Preserve, Noatak National Preserve, Kobuk Valley National Park, and Gates of the Arctic National Park and Preserve, according to Jim Lawler, program manager for the Arctic Network Inventory and Monitoring Program of the NPS. "My hope is that this gets more managers engaged in using tools like this in their planning," Lawler says.

The project's findings also provide crucial information for Alaska Natives already experiencing the impact of climate change in their daily lives. About 30 villages are in the process of or considering relocation

Bruce Marcot

Thawing permafrost below the top layer of soil is causing erosion on the coast of the Bering Land Bridge National Preserve, Alaska. This photo is one of thousands in an aerial photo database developed as part of the WildCast project. The photos document current conditions and evidence of change, and are a resource for future researchers studying change rates.

because of thawing permafrost, sea level rise, and increased flooding.

Marcot and his colleagues also produced a photographic transect of the study area. Marcot strapped cameras to four-seater Cessna planes and documented current conditions and evidence of changes, such as drained lakes, thawing hills, forest fires, and expansions of tall shrubs and spruce forest. "I took a couple hundred thousand photos, all geotagged and orthorectified, along the 1,600 miles of flight transects, along with high-definition videos," Marcot said. "We built a high-resolution, low-altitude imagery dataset, a legacy of images that future studies could tie into that could run the same sites, and thereby compare the changes over time." Marcot also innovated a new photogrammetric method of doing the photo time-lapse transects.

To Marcot, these all represent a simple step to further understand Alaska's transformation and anticipate changes that might happen in other circumpolar regions. "We hope this opens the door to lots of follow-up studies," he says. "I view our work as producing testable working hypotheses that can be validated and refined over time through further studies and monitoring. It's a first approximation and not a definitive prediction of changes in wildlife- population sizes to come, so continued studies will help refine our predictions and likely provide some surprises as the region continues to change."

LAND MANAGEMENT IMPLICATIONS

- Because climate change affects terrestrial and aquatic ecosystems and associated wildlife habitats in the Arctic more rapidly than anywhere else, these findings serve as an early warning signal for federal land planners in more temperate ecosystems further south.
- These findings can be used to develop climate change adaptation policies on federal lands in the region, particularly the National Park Service's Arctic Network and the Fish and Wildlife Service's Selawik National Wildlife Refuge.
- Findings on the impending declines in habitat for half of the subsistence wildlife species in the region can inform survival and adaptation strategies of local communities.
- The ecosystem maps, models of ecosystem change, wildlife-habitat relationships databases, and photographic databases developed during this study will spur and improve future research on climate change rates and effects.

Bruce Marcot

The snowy owl is the largest bird species in the Arctic. Its habitat, and habitat of its prey, is projected to decline by 2100 in northwest Alaska as the climate changes.

"The trouble with our times is that the future is not what it used to be."
—Paul Valéry

FOR FURTHER READING

DeGange, A.R.; Marcot, B.G.; Lawler, J., et al. 2013. Predicting the effects of climate change on ecosystems and wildlife habitat in northwest Alaska: results of the WildCast project. Alaska Park Science. 12(2): 66–73. http://www.treesearch.fs.fed.us/pubs/46195.

Jorgenson, M.T.; Marcot, B.G.; Swanson, D.K., et al. 2015. Projected changes in diverse ecosystems from climate warming and biophysical drivers in northwest Alaska. Climatic Change. 128(1–2). http://www.treesearch.fs.fed.us/pubs/48758.

Marcot, B.G.; Jorgenson, M.T.; DeGange, A.R. 2014. Low-altitude photographic transects of the Arctic Network of national park units and Selawik National Wildlife Refuge, Alaska, July 2013. USGS Data Series 846. doi:10.3133/ds846. http://www.treesearch.fs.fed.us/pubs/46166.

Marcot, B.G.; Jorgenson, M.T.; Lawler, J., et al. 2015. Projected changes in wildlife habitats in Arctic natural areas of northwest Alaska. Climatic Change. 130: 145–154. http://www.treesearch.fs.fed.us/pubs/49626.

WRITER'S PROFILE

Natasha Vizcarra is a science writer based in Boulder, Colorado. She can be reached through her website at www.natashavizcarra.com.

Science
FINDINGS

U.S. Department of Agriculture
Pacific Northwest Research Station
1220 SW Third Avenue
P.O. Box 3890
Portland, OR 97208-3890

Official Business
Penalty for Private Use, $300

PRSRT STD
US POSTAGE
PAID
PORTLAND OR
PERMIT N0 G-40

SCIENTIST PROFILE

BRUCE G. MARCOT is a research wildlife biologist at the Pacific Northwest Research Station. He earned his Ph.D. in wildlife science from Oregon State University. His research focuses on applied science research and technology development and application projects dealing with old-forest ecology, modeling of rare and little-known species, biodiversity assessment, ecologically sustainable forest management, and the development of a research framework on key ecological functions of plants and animals.

Marcot can be reached at:

USDA Forest Service
Pacific Northwest Research Station
Forestry Sciences Laboratory
620 SW Main St., Suite 400
Portland, Oregon 97205

Phone: (503) 347-2277

E-mail: bmarcot@fs.fed.us

COLLABORATORS

Anthony R. DeGange and Colleen M. Handel, Alaska Science Center, U.S. Geological Survey

M. Torre Jorgenson, Alaska Ecoscience

Janet C. Jorgenson, Arctic National Wildlife Refuge, U.S. Fish and Wildlife Service

James P. Lawler and David K. Swanson, Arctic Network, National Park Service