Lakes, Wetlands, and Soil Moisture

Classification, Mapping, and Management of Wetlands in Alaskan Watersheds with Rapidly Growing Populations

Mike Gracz

Abstract

Teddy Roosevelt said that we are not so rich that we can afford to preserve everything, but neither are we so poor that we cannot afford to preserve anything. Senator Ted Stevens advocated for waiting until 2 percent of Alaska's wetlands were filled before having section 404 of the U.S. Clean Water Act, regulating placement of fill into wetlands, take effect in Alaska. Increasing development pressure on our aquatic resources might have led us to ask Ted the question: "Which two percent?" Wetland mapping and assessment efforts in the Matanuska-Susitna Valley and on the Kenai Peninsula, including a separate effort by the City of Homer, aim to answer the question we might have posed to Senator Stevens. When wetlands cover less than 1 percent of a State's area, as they do in Nevada or New Mexico, then "we can afford to preserve everything," but when they cover at least 40 percent, as they do in Alaska, some will be filled. Identifying which wetlands can be filled under what conditions is essential to maintain green infrastructure and avoid the costly mistakes made elsewhere. I report on a new wetland mapping classification and on wetland management plan efforts that aim to avoid and minimize disturbance to wetland functions in the face of continued land use change in populous watersheds. Some of the largest successes of these projects have come from unanticipated sources; we should learn from those successes, even though they may seem outside of the normal watershed planning paradigm.

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Will the Arctic Coastal Plain Wetlands Disappear?

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Abstract

Arctic Coastal Plain wetlands in Northern Alaska support a multitude of wildlife and natural resources that depend upon the abundance of water. Observations and climate model simulations show that surface air temperature over the Alaskan arctic coast has risen in recent history. Thus, a growing need exists to explore how the hydrology of these arctic wetlands will respond to the warming climate. In order to answer this question, we conducted a synthesis study combining the observational analysis of an extensive field campaign, which includes direct measurements of all components of the water balance, with a physically-based hydrological model forced by downscaled climate projections. Our studies show that unless the near-surface permafrost was to degrade, forming a more extensive drainage network of troughs, these arctic wetlands would remain temporarily inundated and wet throughout the snow-free period.

Currently, these wetlands exist despite a desert-like annual precipitation regime and a negative net summer water balance. At the primary study site within the Biocomplexity study area on the Barrow Environmental Observatory, shallow ponding of snowmelt water occurs for nearly a month at the vegetated drained thaw lake basin (DTLB). The length and depth of the ponding is only replicated by the hydrological model if the rims of low-centered polygons are represented. Simple model experiments suggest that the polygon type (low- or high-centered) controls runoff, evapotranspiration, and near-surface soil moisture. High-centered polygons increase runoff while reducing near-surface soil moisture and evapotranspiration.

A change in polygon type, from low- to high-centered polygons, has a larger effect on the near-surface soil moisture under the current meteorological forcing than the projected hydrological response to the altered climate regime alone. In the latter, the projected increase in summer precipitation offset the simulated increase in evapotranspiration. The length of the ponding period remained, while its start date became more variable. Nonetheless, the fall water tables for the end of the 21st century were similar to model simulations and field measurements for the present (1999–2009).

The model experiments show that microtopography plays an important role on the hydrologic fluxes and stocks of arctic wetlands. Although no soil drying was projected by the end of the 21st century, differential ground subsidence could potentially dominate the direct effects of climate warming resulting in a drying of the Arctic Coastal Plain wetlands. It is therefore crucial to merge hydrology, permafrost, and geomorphology models and observations at the appropriate spatial scales to elucidate the response of the Arctic Coastal Plain wetlands to a warmer climate.

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Lake Districts of the Koyukuk National Wildlife Refuge

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Abstract

The potential for broad scale habitat changes caused by global climate change has increased interest in the hydrology and dynamics of subarctic lakes and wetlands in recent years. The U.S. Fish and Wildlife Service and other Interior Alaskan land managers charged with the protection of wildlife species, habitat, and water resources seek a better understanding of boreal lake and wetland dynamics in order to anticipate potential changes to important natural resources. Using a geographic information system (GIS) we identified and delineated lake districts within the Koyukuk National Wildlife Refuge, Alaska, as a framework for future inventory and monitoring of Refuge lakes, wetlands and wildlife. We used the U.S. Geological Survey National Hydrography Dataset to identify and map lakes larger than 1 ha occurring within the Refuge. We then used a grid scaled to the geographic area and the number of lakes in the Refuge to identify lake rich areas, defined by (1) a lake surface area (limnetic ratio, in percent) greater than the mean for the Refuge, and (or) (2) a lake density (number of lakes per geographic cell) greater than the mean for the Refuge. The distribution of cells meeting these criteria, as well as information on surficial geology, watershed boundaries, lake shape and type, and field observations, were used as visual guides for manual delineation of lake districts. We identified and delineated 14 lake districts and 4 subdistricts. Combined, the lake districts encompass 11,940 km^2, representing 66 percent of the total land area of the Koyukuk Refuge. The lake districts contain 98 percent of Refuge lakes over 1 ha and 99 percent of lake-cover on the Refuge. Lake abundance on the Refuge was calculated to be 0.54 lakes/km^2 overall and 0.80 lakes/km^2 for the lake districts combined. Limnetic ratio for the entire Refuge was 3.9 percent and the limnetic ratio for the lake districts combined was 5.9 percent. We explored the following qualities of each lake district to identify similarities and differences in the regions: lake characteristics (lake density and limnetic ratio, lake size, shape, type, connectivity and flood potential), elevation (land elevation, hypsometric index, and lake elevation), surficial geology, vegetative cover, and wildlife populations (based on data collected through the Refuge Inventory and Monitoring Plan). We intend to use the lake district analysis for the Koyukuk Refuge as a framework for future field-based studies, habitat analyses, long-term monitoring and wildlife management. We will combine this information with data collected in the field to characterize the important hydrological processes at work within each lake district, to study relations between distinct lake and wetland systems and wildlife populations, and to forecast the potential effects of climate change.

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