Determinants of sustainability in socio-ecological systems: a natural experiment

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Complex interplay among multiple drivers underlies rapid changes in socio-ecological systems. An understanding of these dynamics is necessary to devise effective management strategies capable of keeping ecosystems productive and resilient and avoiding undesired ecosystem transitions. The science underlying this task is challenging, demanding multiple analytical techniques and methods in real situations. Research on the resilience, vulnerability, and adaptability of socio-ecological systems has largely used case studies and/or agent-based simulations. Comparatively few studies have used natural experiments, based on large N empirical research that allow for comparative analyses of drivers and system performance under varying circumstances. One way to address this challenge is to use current and historical differences in anthropogenic drivers to understand socio-ecological changes. In this paper, we present the TUNDRA project, a large scale effort that utilises natural experiments focusing on tundra systems. TUNDRA makes use of spatial contrasts in direct and indirect anthropogenic drivers as predictors of responses in ecosystem properties and services, while controlling for the influence of broader contextual factors (e.g. political and biophysical settings). Tundra systems feature: (i) comparable ecosystem properties including simplicity and low productivity, (ii) human communities heavily dependent on ecosystem services for subsistence and livelihood, and (iii) similar challenges based in nonrenewable resource extraction (e.g., fossil fuels) and climate change. At the same time, these systems exhibit large spatial contrasts in terms of socioeconomic conditions and governance between and within countries (Russia, Canada, Alaska and Norway). The natural experiment design allows investigation of the relative strength of different endogenous drivers influencing resource exploitation, such as habitat transformations and pollution, as well as exogenous drivers, such as globalization and climate change. We ask whether existing environmental and resource regimes (i.e.assemblages of rights, rules, and decision-making procedures) are effective in terms of maintaining or enhancing the resilience of tundra systems. We concentrate on ecosystem services important to the well-being of resource dependent communities and ecosystems. To link environmental and resource regimes with socio-ecological systems, we have developed a three-step research design. Step 1 features broad-scale analyses of policies and formal databases from national to community levels to explore interplay between indirect and direct drivers. In Step 2, results from step 1 lead to the selection of a set of socio-ecological systems that maximize contrasts in drivers within the same biophysical and political contexts. Finally, we integrate Steps 1 and 2 to allow for a third step that explores the effectiveness of regimes in achieving sustainable human-environment interactions in tundra systems.