Increasing Wildfire in Alaska's Boreal Forest: Pathways to Potential Solutions of a Wicked Problem

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Recent global environmental and social changes have created a set of "wicked problems" for which there are no optimal solutions. In this article, we illustrate the wicked nature of such problems by describing the effects of global warming on the wildfire regime and indigenous communities in Alaska, and we suggest an approach for minimizing negative impacts and maximizing positive outcomes. Warming has led to an increase in the areal extent of wildfire in Alaska, which increases fire risk to rural indigenous communities and reduces short-term subsistence opportunities. Continuing the current fire suppression policy would minimize these negative impacts, but it would also create secondary problems near communities associated with fuel buildup and contribute to a continuing decline in subsistence opportunities. Collaborations between communities and agencies to harvest flammable fuels for heating and electrical power generation near communities, and to use wildland fire for habitat enhancement in surrounding forests, could reduce community vulnerability to both the direct and the indirect effects of global climate change.

Keywords: Alaska, global change, scale, wildfire, wicked problem

Earth is undergoing profound changes in climate, ecology, culture, and technology (MEA 2005). Moreover, changes that occur in one place often have far-flung consequences because of biophysical connections (by oceans, atmosphere, and migratory animals) and human linkages (through high-speed communication, global markets, and human travel). These global changes challenge our capacity to sustain the desirable features of the local systems in which we live for at least three reasons (Chapin et al. 2006): (1) It is impossible to preserve a system in its current state when the factors that control its basic structure and function are changing directionally (i.e., show a persistent trend over time). (2) Many processes that concern policymakers at local or regional scales respond to changes occurring at other scales, over which they have little influence. (3) Diverse actors want to sustain different, sometimes conflicting, local and regional features in the face of directional change. For these reasons, global change has created "wicked problems" for society that are difficult or impossible to solve within current management and policy paradigms. If wicked problems cannot be solved without a shift in paradigm, incremental approaches to improving conditions may be insufficient to address major societal issues. What is a wicked problem, and why is it difficult to solve?

The concept of wicked problems was developed by community planners to describe social problems (e.g., poverty) that are so complex that people disagree about how to define and solve them; in addition, efforts to solve the focal problem

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generally create unanticipated secondary problems (e.g., dependence on transfer payments that are provided to alleviate poverty), so the problem can never be fully solved (Rittel and Webber 1973). When people disagree about the definition of a problem and its potential solutions, and no group has the power and authority to enforce a solution, conflicts are likely to persist until collaborative frameworks provide a new venue for collective solutions (Roberts 2000).

The concept of wicked problems has been extended to natural resource management, in which uncertainty about future environmental conditions and differences in social values make it impossible to define an optimal solution (Gunderson 1999, Shindler and Cramer 1999). In this article, we apply the wicked-problem framework to the effects of global change on ecosystems used by local communities. We discuss climate-mediated changes in wildfire regime with respect to rural hunting, fishing, and gathering opportunities in interior Alaska. The framework can also be extended to other situations for which a set of desired social-ecological conditions are controlled by biophysical systems at multiple scales (local, regional, and global), multiple jurisdictions, and different problem definitions among groups. By considering the impacts of global change on a wicked problem, we both demonstrate the importance of addressing multiple interconnected problems in combination rather than as isolated issues and provide an approach that may be applicable to wicked problems in general.

Our approach to wicked problems begins by formulating potential "simple" solutions at a scale (often local or regional) that directly addresses the central problem as defined by many of the actors. The second step is to explore the "wickedness" of the problem by determining the linkages among processes to identify potential future trajectories and intervention points that would reduce the magnitude or impact of the problem. We then approach secondary problems that emerge and the linkages among them. This involves beginning with a central problem and incorporating only those additional layers of complexity that enable one to address or more inclusively define the central problem. We illustrate this approach with respect to the issue of increasing wildfire extent in Alaska's boreal forest. Alaska is an excellent place to demonstrate wicked problems because it bridges decisionmaking within local native communities with policies set at state and federal levels, and climate changes at a global scale. Moreover, this same general approach is applicable everywhere. Our analysis suggests potential policy options that could enhance sustainability at multiple scales. By "sustainability," we mean the use of the environment and resources to meet the needs of the present without compromising the ability of future generations to meet their own needs (WCED 1987).

Research approach

Our project began as a basic research project on interactions between humans and fire. We sought to document the extent to which people modify the fire regime of interior Alaska through ignitions and suppression at the local scale and through anthropogenic climate warming at the global scale. We then asked how changes in fire regime affect people globally through climate feedbacks and locally through changes in fire risk and habitat for terrestrial subsistence resources (berries and game animals). We approached these issues as a multidisciplinary team of ecologists, anthropologists, political scientists, and economists. We divided initial research responsibilities largely along disciplinary lines, with ecologists, for example, focusing on the effects of fire on vegetation and social scientists on the determinants and impacts of increased fire extent on human communities. This enabled us to map out a basic framework of interactions (figure 1), but it provided little insight into the interdependencies governing the overall dynamics of this social-ecological system. The broader integration occurred as each person on the team became interested in the science of other team members and began asking questions, on the basis of his or her own conceptual framework, about processes that other group members were studying.

This process led to the application of social-science approaches to natural-science questions, and vice versa (figure 2). For example, a landscape model that was developed to simulate climate-induced changes in fire regime was modified to incorporate qualitative rules about human behavior that emerged from archival research, policy analysis, and interviews with agency personnel and community members. Similarly, regional GIS (geographic information system) databases of climate, fire history, and vegetation helped explain geographic variation in cultural traditions of indigenous burning. These data sets and perspectives had never before been assembled for Alaska.

Interdisciplinary discussions made us increasingly aware of the wickedness of the wildfire problem in Alaska, and they also identified key interdependencies that might be modified to reduce barriers to sustainability. The evolution from multidisciplinarity, in which we efficiently gathered information about the components of the social-ecological system, to transdisciplinarity, in which we focused on linkages and

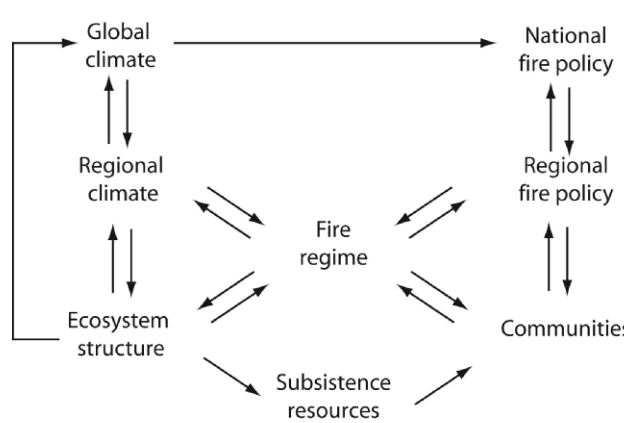

Figure 1. Conceptual model of the interactions among climate, ecosystems, fire, human communities, and fire policy in the Alaskan boreal forest. Modified from Chapin and colleagues (2003).

interdependencies, was crucial to developing our current understanding of the system. Equally important as we began considering potential solutions was the expansion of the research team from academic faculty and graduate students to include a high school teacher, residents of rural Alaska Native communities, and managers of state and federal agencies. Although we did not initially set out to address the practical consequences of increasing wildfire in Alaska, our collaboration with communities and agencies convinced us of the importance of seeking practical solutions, despite the complexity of the wicked problem. (The original data discussed in this article, collected by F. S. C., are archived and identified as human dimensions data at *www.lter.uaf.edu/data_b.cfm.*)

The local problem: Greater fire extent

Wildfires have dominated the disturbance regime of the boreal forest of interior Alaska for the last 6000 years (Lynch et al. 2002). The area burned in the North American boreal region tripled from the 1960s to the 1990s because of the increased frequency of large fire years (Kasischke and Turetsky 2006). For example, two of the three most extensive wildfire seasons in Alaska's 56-year record occurred in 2004 and 2005, and half of the largest fire years during this 56-year period have occurred since 1990. Recent fire in interior Alaska is probably more extensive than it has been at any other time in the last 150 years (Duffy 2006), although severe fire years have occurred periodically for thousands of years (Lynch et al. 2002). This leads to our initial problem statement: What caused the apparent recent increase in wildfire extent in Alaska, and what can be done to reduce its impacts on local communities?

Fires in interior Alaska burn most extensively during "unusually" dry years. However, these years now occur several times per decade rather than only once or twice, as was more typical when fire records were initiated in the 1950s (Kasischke and Turetsky 2006). The pronounced interannual variation in fire extent correlates closely with the strength and phase of the Pacific Decadal Oscillation (PDO), suggesting a connection with global-scale climatic patterns (Duffy et al. 2005, Marcias Fauria and Johnson 2006). Human-caused emissions of greenhouse gases are probably the largest cause of recent global warming trends (IPCC 2007), which are particularly pronounced at high latitudes (ACIA 2004).

Alaskan temperatures and fire extent have continued to increase in the last decade, despite the return of the PDO to its negative phase, suggesting that recent increases in wildfire reflect more than natural climate cycles; indeed, human activities dispersed across the globe appear to have contributed substantially to the increasing fire extent in Alaska. Recent increases in fire extent in the western United States also appear to be largely driven by climate variation rather than a history of fire suppression (Westerling et al. 2006). Alaska accounts for a miniscule proportion of global fossil fuel emissions, so Alaska by itself cannot reverse this climatic trend by reducing emissions. In addition, the multidecadal lag in the response of atmospheric carbon dioxide (CO_2) concentration (and therefore climate; IPCC 2007) to altered emissions makes it highly likely that recent warming and associated increases in wildfire extent will continue for several decades in Alaska, regardless of future changes in global emissions policies. Although large reductions in global emissions are important to stabilize Alaska's wildfire regime over the long term, this is not a sufficient short-term solution.

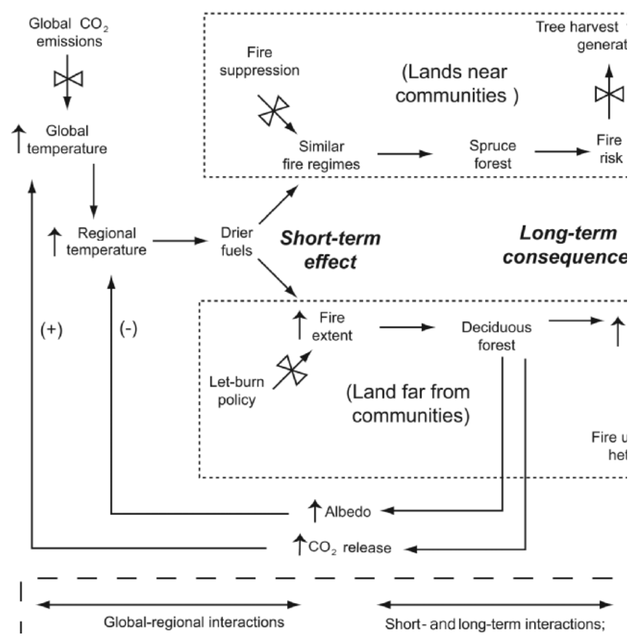

Figure 2. Social interactions with fire in Alaska's boreal forest, showing causal effects (arrows) and study methods (letters). Arrows indicate amplifying effects of one factor on another unless otherwise indicated (–). The order in which methods are listed indicates the relative effort applied. Methods are indicated as follows: A, archival research; G, GIS (geographic information system) analysis; I, interviews; L, literature reviews; M, modeling; R, records of management agencies; and W, workshops. Abbreviation: EFF, emergency fire-fighting crews.

In short, Alaska cannot solve its wildfire problem by simply eliminating the cause of the problem. Alaska's fire regime will probably continue to change, so options for adaptation must be explored. However, some adaptation options could create serious secondary problems, as described below. This places the changing wildfire regime in Alaska in the category of wicked problems requiring further exploration of linkages among social and ecological processes.

Fire suppression is the primary tactic used by public agencies to reduce the impacts of fire on communities throughout most of the United States, including Alaska (Pyne 1982). However, fire managers in interior Alaska have never had the resources necessary to fully implement the prevailing 20th-century US policy of suppressing all wildfires on all lands (Todd and Jewkes 2006). In the 1980s, managers therefore crafted an innovative policy of zoning Alaska into areas designated to receive different levels of suppression effort. The major features of this policy are (a) a largely natural regime for two-thirds of interior Alaska, where fires are monitored but generally allowed to burn; (b) active suppression of most fires on 17% of the lands, where the risk to life and property is greatest (generally lands near communities, roads, and private property—including lands owned by Alaska Native village corporations); and (c) an intermediate buffer zone, where fires are suppressed early in the season but are allowed to burn in the late season, when rains are expected (AIWFMP 1998). This policy spatially separates the problem (increasing wildfire) from the societal impacts (fire risk to communities) by focusing suppression actions on inhabited areas of the state (figure 3). For lands both with and without suppression, however, this attempt at a spatial solution generates a new suite of issues—that is, the linkages characteristic of wicked problems, as described in the next section.

The impacts of suppression

The greatest local human impact on fire regime occurs on the lands designated for suppression. This 17% of Alaska's land area accounts for 99% of the human-ignited fires and suppression effort (DeWilde and Chapin 2006). Human ignitions account for two-thirds of the fires in interior Alaska but only 10% of the area burned (DeWilde and Chapin 2006, Kasischke et al. 2006), because most human ignitions are in populated areas that have the highest suppression priority. In addition, people tend to light fires at times and places where fires are less likely to burn than are natural lightning-ignited fires. Arson accounts for a negligible (< 1%) proportion of the area burned in Alaska; most burned area results from land-clearing, construction, and abandoned campfires. The net human impact on fire regime is a 50% reduction in the proportion of the land area burned in suppression-designated areas compared with lands without suppression, because the extent of area burned is more strongly affected by suppression than by human ignitions (DeWilde and Chapin 2006, Calef et al. 2008). Thus, in the short term, fire suppression reduces the area burned near communities by about the same magnitude that climate warming and human ignitions have increased the area burned (figure 3).

Does this imply that this simple solution (fire suppression) has solved the wicked problem? Nearly half (44%) of interior Alaska is dominated by black spruce—often in extensive stands. After fire, the typical vegetation succession is herbs, deciduous shrubs, then back to highly flammable black spruce, within about 30 years (Johnstone et al. 2004). Early successional herb and deciduous-shrub stands have high leaf moisture content and less surface fuel than black spruce (Johnson 1992), creating fuel breaks between adjacent black spruce stands and reducing landscape fire probability (Rupp et al. 2002). A retrospective analysis based on observed stand-age distributions and landscape modeling suggests that forest stands of the current decade are older than other stands were at any time in the past century (Duffy 2006). This high proportion of flammable black spruce stands reflects at least three processes: (1) a half-century of fire suppression near communities and private lands (DeWilde and Chapin 2006); (2) a pulse of fire associated with the gold rush of the early 20th century, which has now succeeded to black spruce dominance (Duffy 2006); and (3) some longer-term dynamic that we do not yet understand—perhaps linked to a decline in indigenous burning in eastern Alaska (Natcher et al. 2007) when disease decimated human populations in the 19th century (Wolfe 1982). Thus a combination of factors has increased landscape flammability, particularly in areas close to communities, just when climate warming has increased the likelihood of large, uncontrollable wildfires (figure 3). Fire managers recognize this impending calamity and seek opportunities to prescribe fires or to let wildfires burn under conditions they deem to be safe. However, their capacity to reduce landscape flammability by burning black spruce under safe conditions is constrained by public pressure to *increase* fire suppression, as described later, and by regulatory changes that assign legal responsibility to fire managers for smoke impacts generated by prescribed fires. In addition, the success of the Alaska wildfire suppression policy has generated an expectation on the part of the public that any fire can be put out and that natural wildfires occurring near communities represent failures of fire management. In actuality, management contains the spread of wildfire, and weather puts out the fire. Short-term success in fire suppression has augmented the wickedness of warming-induced increases in wildfire risk near communities over the long term.

In contrast, lands designated for minimal suppression (as well as the buffer lands, which have a similar fire regime—a total of 83% of interior Alaska [Calef et al. 2008]) are experiencing both more extensive and more severe burns. In Alaska, where most organic matter is in a surface layer of peat rather than in trees, burn severity is defined as the proportion of the soil organic mat combusted by the fire. As the climate warms, the increase in fire severity creates a moist mineral-soil seedbed that enables small-seeded deciduous trees to establish (Johnstone and Kasischke 2005). The addition of a deciduous forest stage reduces landscape flammability by adding about 50 years to the low-flammability phase of forest succession (Johnstone and Chapin 2006). This conversion acts as a negative (stabilizing) feedback that tends to reduce the magnitude of warming-induced increases in fire extent (figure 3).

An additional negative feedback to fire risk occurs through vegetation interactions with the climate system (figure 3). Fire has two counteracting effects on climate: (1) the release of CO_2 by combustion and by heightened decomposition in warmer, more deeply thawed postfire soils acts as a positive feedback to warming by contributing to rising atmospheric CO_2 concentrations; and (2) postfire deciduous stands absorb and transfer less heat to the atmosphere than do late-successional black spruce stands, so fire-induced increases in the proportion of deciduous stands act as a negative feedback to climate warming (McGuire et al. 2006). An important distinction between these two feedbacks is that the cooling effect of the altered energy budget occurs locally

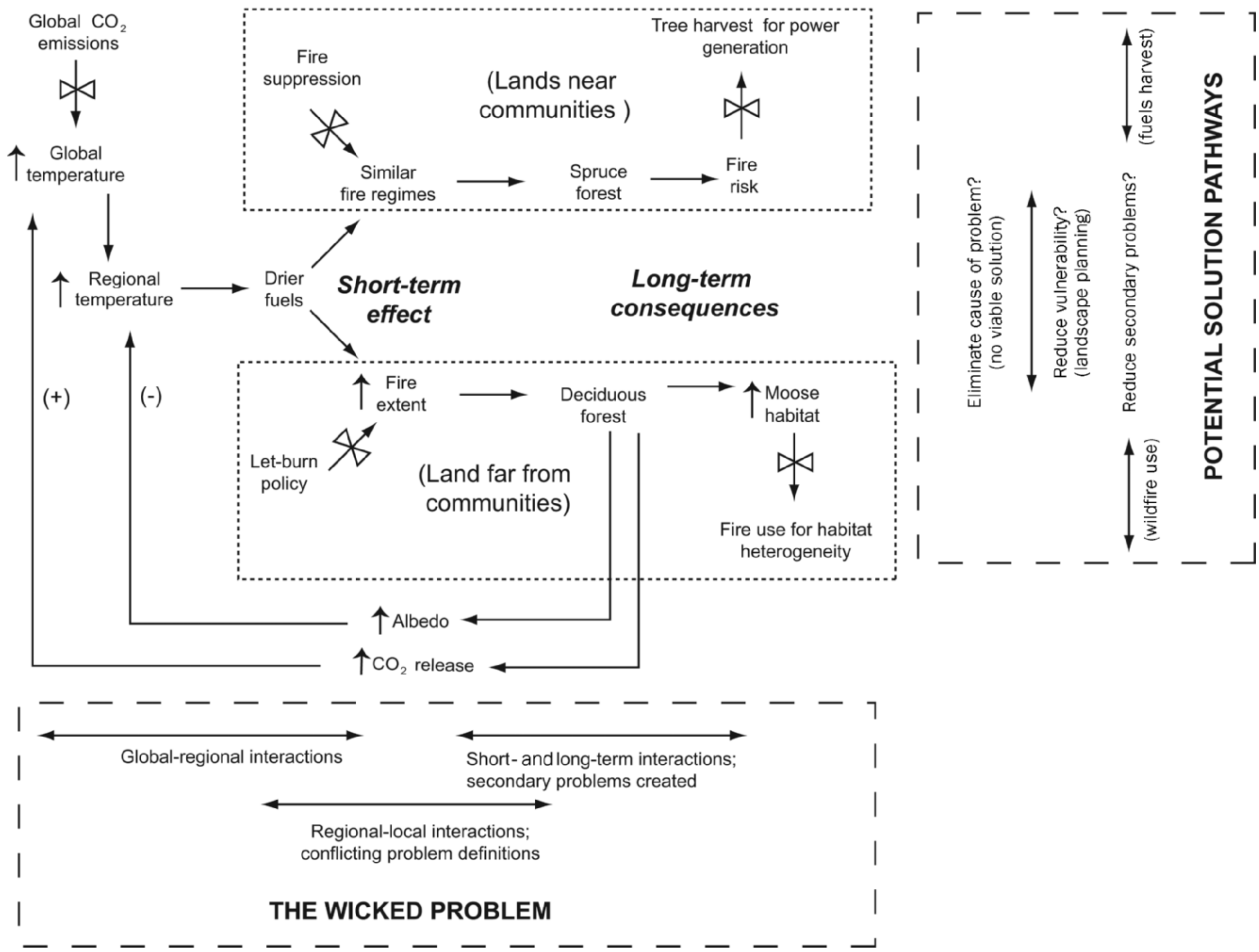

Figure 3. Model of the interactive effects of climate change and fire suppression on short- and long-term fire risk in interior Alaska, identifying the interactions that generate wicked problems (horizontal arrows at the bottom of the diagram) and selected pathways to potential solutions (vertical arrows at the right of the diagram). Bowties show points of potential policy intervention.

and immediately, whereas CO_2 released by fire is globally dispersed because CO_2 has a longer lifetime than heat does in the atmosphere, and therefore has negligible local consequences. Therefore, the regionally important effect of fire is local cooling of the climate—one of the few negative feedbacks to high-latitude warming that has been identified to date—which is partially offset at the global scale by higher CO_2 emissions (McGuire and Chapin 2006, Randerson et al. 2006). Allowing wildfires to burn in areas where the risk to local communities is minimal could provide global and regional benefits by reducing the high-latitude amplification of global warming. This reduction and the reduced landscape flammability in areas where fires burn extensively appear to be generally positive societal outcomes of the current fire policy, allowing the fire regime to adjust naturally to a warming climate in most (83%) of interior Alaska (figure 3). The secondary problems created by this aspect of Alaskan fire policy result from societal linkages to the changes, as discussed in the next section.

Societal trade-offs

There is seldom an optimal solution to wicked problems because these problems generally reflect societal trade-offs (Rittel and Webber 1973). Different actors, such as rural subsistence hunters and policymakers in federal and state agencies, focus on particular scales and concerns that might lead them to different understandings of both the problem and the criteria for acceptable solutions. This led us to explore more carefully the societal and cultural consequences of increased wildfire. With the exception of Fairbanks and a few other towns, most communities in interior Alaska have no road or power connections to the rest of the state, have predominantly indigenous (Athabascan) populations, and depend both culturally and nutritionally on the harvest of wild foods, especially salmon, moose, caribou, and berries. Some people in these communities also harvest pelts of furbearers, such as beavers, lynx, wolf, and marten, to make culturally important clothing and to earn supplemental income in the mixed cash-subsistence economy (Wolfe 1991). The optimal habitat of these different subsistence resources is strongly affected by wildfire, with increasing abundance of, for example, blueberries within a few years after fire, when light and nutrient availability is high; moose after 11 to 30 years, when resprouting deciduous shrubs reach a moderate density that provides adequate food and limits their visibility to potential predators; and caribou only after 80 to 100 years, because of the slow recovery of lichen, their primary winter food (figure 4; Maier et al. 2005, Rupp et al. 2006, Nelson et al. 2008).

Both local hunters and wildlife biologists report similar successional patterns of postfire recovery of subsistence resources (figure 4), but their conclusions about the implications for wildfire management are quite different (Nelson et al. 2008). Wildlife biologists recognize the importance of maintaining fire on the landscape to regenerate early successional habitat that supports animals such as moose (Maier et al. 2005), given the long fire intervals (80 to 200 years) reported for black spruce (Kasischke et al. 2006, Duffy et al. 2007). Looking at the same patterns, local hunters are concerned that opportunities to hunt for moose will not return for at least a generation—and for caribou, several generations (Huntington et al. 2006). These long time intervals are problematic because local economies are highly dependent on subsistence resources and because hunting has fundamental importance as a cultural practice, one that assimilation into Euro-American culture threatens. If hunters cannot teach their children how to hunt, or transmit the cultural values that are inherent in those activities, how can this subsistence-based culture survive? This intergenerational transmission of knowledge is further complicated by social, economic, and educational changes; technological changes in ways to access the land; and loss of seasonal mobility, which began as people settled into permanent villages in the mid-20th century (Nelson 1983, Natcher et al. 2007).

Perhaps the most serious conflict between communities and wildfire managers in Alaska is whether fires should be more actively suppressed or allowed to burn to maintain the historical dependence of the boreal forest on wildfire. Thus the apparently ecologically benign consequences of increasing wildfire extent described in the preceding section have some wicked implications for indigenous communities. Presentations by community members at workshops and responses in semistructured interviews consistently indicated greater community concern about loss of subsistence opportunities resulting from fire than about direct fire risk to communities. In other words, our initial conceptualization of the fire problem (figure 3) overlooked the issue of greatest concern to Athabascan residents.

If Athabascan culture has coevolved with fire for at least 6000 years (Natcher et al. 2007), why do recent changes in fire regime represent such a serious cultural threat? Part of the answer reflects recent cultural changes. Athabascans traditionally moved seasonally as small family bands to exploit seasonal variation in the availability of wildlife resources. For example, people harvested salmon along rivers in summer during upriver spawning migration, whereas they hunted caribou in the fall and winter when animals migrated south from the Arctic into boreal wintering range (Nelson 1983, Natcher 2004). When fires periodically made habitat unsuitable for animals in one place, people adjusted their seasonal migrations to avoid recent burns and exploit areas where succession had enhanced the abundance of subsistence resources. This mobility enabled people to exploit a wide range of successional stages, although the specific locations changed over time. This pattern was most pronounced in eastern interior Alaska, where a combination of high fire frequency and resource dependence on moose and caribou made mobility critical to the survival of Gwich'in Athabascans. These people traditionally used fire for communication (signal fires); warfare; hunting (herding of animals and construction of caribou fences); habitat enhancement for wildlife, berries and medicinal herbs; insect relief; and fuel reduction (Natcher 2004, Natcher et al. 2007). In western interior Alaska, the more maritime climate of the tundra-taiga transition reduced the frequency of lightning-caused wildfires, and the Koyukon Athabascans living there today have no memories or stories to suggest active use or management of fire (Huntington et al. 2006, Natcher et al. 2007). Here, the more dependable availability of salmon made highly flexible seasonal movements less necessary, giving rise to a trilocal residence pattern (winter villages, spring camps, and summer fish camps) in which each family used the same lands for many generations, resulting in less interannual variation in residence patterns in response to fire-induced habitat change (Clark 1981, Langdon 1992). Thus even between adjacent Athabascan groups in interior Alaska, there were distinct differences in prevalence of fire on the landscape, traditional use of fire to manage landscapes, and therefore readiness to consider fire as a current management tool (Natcher et al. 2007).

The establishment in the mid-20th century of permanent villages with churches, stores, airports, schools, and heating and power systems, now integral to village life in rural Alaska, radically changed these traditional mobility patterns. Now fires occurring near communities have multigenerational detrimental consequences for resident hunters that did not occur when family bands were more mobile. In other words, it is the altered *configuration* of human-fire interactions that caused fire to change from an integral to a detrimental environmental influence. Snow machines and motorized boats partially compensate for this reduced cultural mobility but bring with them an increased dependence on a cash economy to provide the necessary equipment and fuel. Fire further constrains this mobility by toppling trees along traplines and burning shelter cabins that are essential to safe winter travel far from communities (figure 3). Finally, a warming climate decreases the thickness of river ice where people travel and creates less predictable weather patterns, further increasing travel hazards in autumn, winter, and spring. In summary, socioeconomic changes that have improved the well-being of rural residents now make it difficult for them to return to a highly mobile, fire-adapted lifestyle. In addition, a patchwork of state, federal, and tribal land ownership in Alaska has constructed legal and regulatory barriers to flexibility in land use that did not exist traditionally (Huntington 1992). In summary, innovation rather than a return to traditional movement patterns is the most likely pathway to potential solutions.

If village infrastructure and regulations now constrain human movement across a broad range of successional stages, would it be possible to enhance landscape diversity close to communities by small-scale burning, as may have occurred traditionally in eastern interior Alaska and the adjoining Yukon before contact with Europeans (Natcher et al. 2007, Nelson et al. 2008)? This would require planning at the scale of individual communities. Indeed, tribes in California are collaborating with public land management agencies to incorporate traditional burning practices to reduce fuel loads near communities and to enhance plant and wildlife habitat (Anderson 2005). In Alaska, however, this level of collaboration has not yet occurred, which may be traced to (a) continuing mistrust between local communities and state and federal land management agencies (Trainor 2006) and (b) cultural sensitivities related to fire management (Huntington et al. 2006). In traditional Athabascan legends of western Alaska, for example, people, animals, and spirits change from one form to another. People therefore feel a sense of kinship with and responsibility for the lives of ravens, hares, and other animals that is less evident in Judeo-Christian traditions. For some Athabascans, the act of deliberately burning a forest and its resident animals has moral implications that often go unrecognized by fire managers. Discussions of local fire planning in these communities therefore requires community engagement that recognizes and respects these and other cultural sensitivities (Huntington et al. 2006).

Most interior Alaskan communities nonetheless have firsthand experience with wildfire because many of their residents are members of emergency firefighting (EFF) crews. Since the 1940s, when fire suppression began in Alaska, EFF crews have been deployed on remote fires, both putting them out and altering their configuration on the landscape. Protection of remote trapping cabins, for example, often requires "fighting fire with fire" by creating "backburns" that are lit near the cabin and burn toward the oncoming wildfire. Firefighting has become an important part of village culture. EFF crew members are proud of their skills and self-sufficiency, and they fight fires throughout Alaska and the continental Unites States (Natcher 2004, Trainor 2006). Firefighting is one of few ways in which people can earn wages while being active on the land (Trainor 2006). In addition, it provides a venue for intergenerational mentorship and sharing of stories that is often absent in day-to-day village life. EFF crew members are often the same individuals who are most active in subsistence hunting, because they lack the time constraints of permanent jobs and are able to drop everything to fight fires or to respond opportunistically to hunting opportunities when weather conditions and animal migrations permit. In fact, firefighting wages are the only source of wage income for half of the members of EFF crews, and are essential for the purchase of the equipment, ammunition, and fuel required for modern subsistence hunting (Trainor 2006). In the Yukon Territory of western Canada, land-claim settlements have returned fire management to indigenous (Athabascan) residents, who have found ways to manage fires on their lands in the context of cultural traditions. Thus, it appears possible to carry out modern fire management in ways that are compatible with Athabascan cultural practices and values.

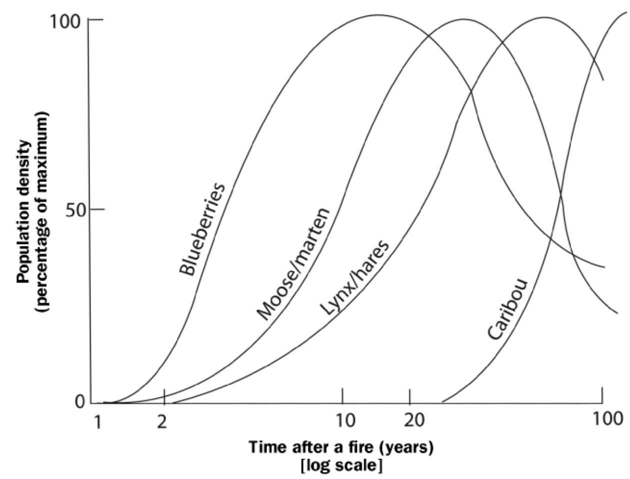

Figure 4. Temporal changes in subsistence resources after wildland fires in Alaska's boreal forest, based on observations of local hunters and corroborated by scientific studies.

Cross-scale policy interdependencies

Fire policy in Alaska is strongly governed by a national suite of policies to manage wildfires throughout the United States (figure 3). This policy clearly benefits Alaska by providing access to federal funds and firefighting resources that would otherwise be unavailable. Large fires in Alaska, for example, occur most frequently during June and July, after soils dry from snowmelt but before late-summer rains begin. In contrast, the greatest fire risk in the western United States typically occurs in May and June (Arizona and New Mexico) or August and September (northern Rocky Mountains). This allows fire crews and equipment to be shared among regions in many years. This resource sharing also creates interdependencies that constrain future options. For example, in recent years there has been a tendency for the Alaskan fire season to begin early as a result of early snowmelt or human ignitions (DeWilde and Chapin 2006), or to extend into late summer (Kasischke and Turetsky 2006). Under these circumstances, Alaska competes more strongly with other regions for firefighting personnel and equipment. As national firefighting budgets become increasingly constrained by federal budget shortfalls and the growing costs of fire suppression, managers must make difficult choices between fighting fires in forested subdivisions in the lower 48 states or fighting rural fires in Alaska. These emerging economic and resource constraints are one of the greatest concerns of Alaskan fire managers.

Other cross-scale interdependencies are more subtle but no less significant. Deaths of firefighters in catastrophic fires in the lower 48 states have led to increasingly rigorous federal health and fitness standards that increase the costs of training fire crews—particularly crews that must be transported from remote villages. Some of the older and more experienced village EFF crew members fail to meet the new standards, making it difficult for many villages to maintain full EFF crews (Trainor 2006). Although there are potential solutions to this problem (e.g., native-financed fire-training courses), there has generally been insufficient communication between fire management agencies and native communities to develop effective mechanisms to maintain active fire crews in many rural villages.

Temporal trade-offs create other interdependencies. Historical campaigns by governments and fire organizations have been largely successful in convincing people that all fire is bad and must be suppressed (Carle 2002, McCaffrey 2004). Even though some benefits of fire are now publicly recognized, people almost always prioritize local short-term benefits over global long-term consequences (Zinn et al. 1998, Shindler and Toman 2003). In 2004, for example, fires burned a record 2.7 million hectares (an area larger than the state of Massachusetts) in interior Alaska, costing a record $106 million in suppression costs. The city of Fairbanks had more than 42 smoke-filled days, including several days in a row in which particulates were four times the hazardous standard (ADAQ 2004). This fire season served as a focusing event, triggering public and agency reviews of fire management in interior Alaska. A three-month public review by the Wildland Fire Commission, appointed by the Fairbanks Borough Assembly, addressed smoke, predictive capability, fuels treatment, and the need for more equipment (e.g., aircraft), but there was virtually no contextual discussion of fire on the landscape, climate change, or implications for housing developments in the wildland-urban interface (WFCR 2004). A subsequent statewide review by state and federal fire managers (AWFCG 2005) focused its recommendations on public education related to fire seasons, suppression, fuel treatments, and personal responsibility for property. In short, both public reviews and reviews by fire professionals focused on ways to increase the short-term effectiveness of fire suppression, not on the long-term consequences of that policy. This failure to address temporal interdependencies contributes to the wicked nature of the wildfire problem in Alaska.

Summary: Pathways to potential solutions

Recent and projected changes in climate and fire regime suggest that extreme fire years will become more frequent, and that the areas with greatest fire risk are those near communities, where past fire suppression makes the current fuel matrix particularly flammable. The human population of Alaska has, over the long term a 20- to 40-year doubling time, with a 50% increase in the last 25 years (ADLWD 2007), which has led to urban expansion into fire-prone areas surrounding major towns and cities. If this trend continues or is exacerbated by state initiatives to build roads and privatize land for homesites, we expect more human ignitions and greater public demand for fire suppression in an expanding wildland-urban interface, as projected for eastern Canada (Wotton et al. 2003). Such a scenario would present Alaska with problems similar to those that now confront broad areas of the western United States (Dombeck et al. 2004). These projections suggest that the "wildfire problem" in Alaska will not go away and will probably become worse: suppression actions increase forest age and landscape flammability, and climate warming heightens fire risk. Conceptualizing wildfire as a wicked problem leads to a logical sequence of steps that address incremental increases in complexity, as we discuss below.

1. Eliminate or reduce the causes of the problem, where possible, and promote global reductions in emissions (figure 3). Climate warming is the primary direct cause of recent increases in wildfire in Alaska. Global reductions in fossil-fuel emissions are essential to constrain the long-term increases in wildfire, but in coming decades this will be insufficient to prevent further increases in the extent of area burned annually—adaptation will also be essential. Secondary challenges associated with reduced fossil-fuel emissions include restructuring the economy and changing the focus of people in developed nations from continued economic growth to sustainability.

2. Implement adaptive solutions that diminish society's vulnerability to the problem. Maintain the current policy of suppressing fires close to communities, but allow distant fires to burn in a fashion dictated by climate and vegetation (figure 3). This would minimize fire risk to life and property in communities, at least in the short term, but provide benefits from fire over most of interior Alaska. These benefits include the cooling effects of postfire vegetation on regional climate (due to increased albedo), extensive areas of midsuccessional habitat suitable for moose, and reduced continuity of flammable fuels. The secondary problems (societal costs) that would be created by such policies include a smaller winter range for caribou, reduced hunting opportunities in areas that have recently burned, more smoke, greater risk to remote cabins, and curtailment of infrastructure development in remote areas.

3. Maximize opportunities and minimize secondary problems created by adaptive solutions. In areas near communities where fires are suppressed, prevent fuel buildup by harvesting black spruce for heat and power generation (figure 3). Some Alaskan rural communities are currently threatened with abandonment, in part because of the rapidly rising costs of diesel fuel for electrical power and heating. The abundant black spruce that now constitutes a fire risk around many communities could serve as an ecologically sustainable fuel supply for most interior Alaskan communities (Fresco 2006). Conversion from diesel to wood fuels would reduce fire risk, diminish the vulnerability associated with rising energy costs, generate local employment, and produce early successional habitat suitable for species that communities depend on for subsistence, such as moose. Potential tertiary problems with this approach include community dependence on the maintenance of a biomass-based power-generation facility and the challenge of developing a viable plan in the face of jurisdictional complexity involving, for example, multiple land ownerships and power-subsidy programs.

At greater distances from communities, landscape heterogeneity can be enhanced by implementing management policies that incorporate some of the successful aspects of past indigenous use of fire—specifically, using small-scale fire to break up large continuous areas of flammable vegetation into a more heterogeneous landscape with fire-induced fuel breaks that interconnect natural fuel breaks such as lakes and wetlands. Potential tertiary challenges with this approach concern the need to educate the public about long-term fire effects, the financial feasibility of hiring local EFF crews to implement the plan, and the willingness of local residents to participate in the planning process, which may depend on cultural acceptability of fire management (Huntington et al. 2006).

If the secondary problems can be resolved, potential tertiary problems can be explored, repeating step three as an ongoing process of social-ecological adaptive comanagement (Walters 1986, Armitage et al. 2007).

4. Foster cross-scale interactions that contribute to solutions. Provide policy flexibility that allows Alaskan fire managers and communities to design locally appropriate solutions such as adaptive comanagement arrangements for the planning and use of wildland fire (figure 3). Village lands are currently protected from fire, but communities have no input into decisionmaking about the planning or implementation of fire management for the nearby state and federal lands on which they depend for subsistence. A more collaborative comanagement system that considers both community and agency goals has a greater likelihood of adjusting successfully to expected and unexpected changes in social and ecological conditions. Similarly, educating the global public about the social costs of climate-change impacts in Alaska may promote willingness to reduce emissions. For example, the Inuit Circumpolar Conference, an indigenous nongovernmental organization, has brought global warming before the United Nations Human Rights Commission as an issue of "cultural genocide," a dramatic way of putting a human face on climate change.

Recent increases in the extent of wildfire in Alaska constitute a wicked problem that has no simple solution. This is symptomatic of social-ecological problems everywhere, especially during this era of rapid global changes in environmental and social conditions. Substantive attempts to solve wicked problems will inevitably create new problems because of process linkages and interactions across scales. In addition, every wicked problem is locally unique, so the specific lessons learned in one situation must be applied cautiously at other times or places. Nonetheless, ignoring the problem is unlikely to make it disappear. Even though wicked problems can never be solved, we suggest that there is a logical sequence of steps that maximizes the benefits and minimizes the risks of attempted solutions.

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