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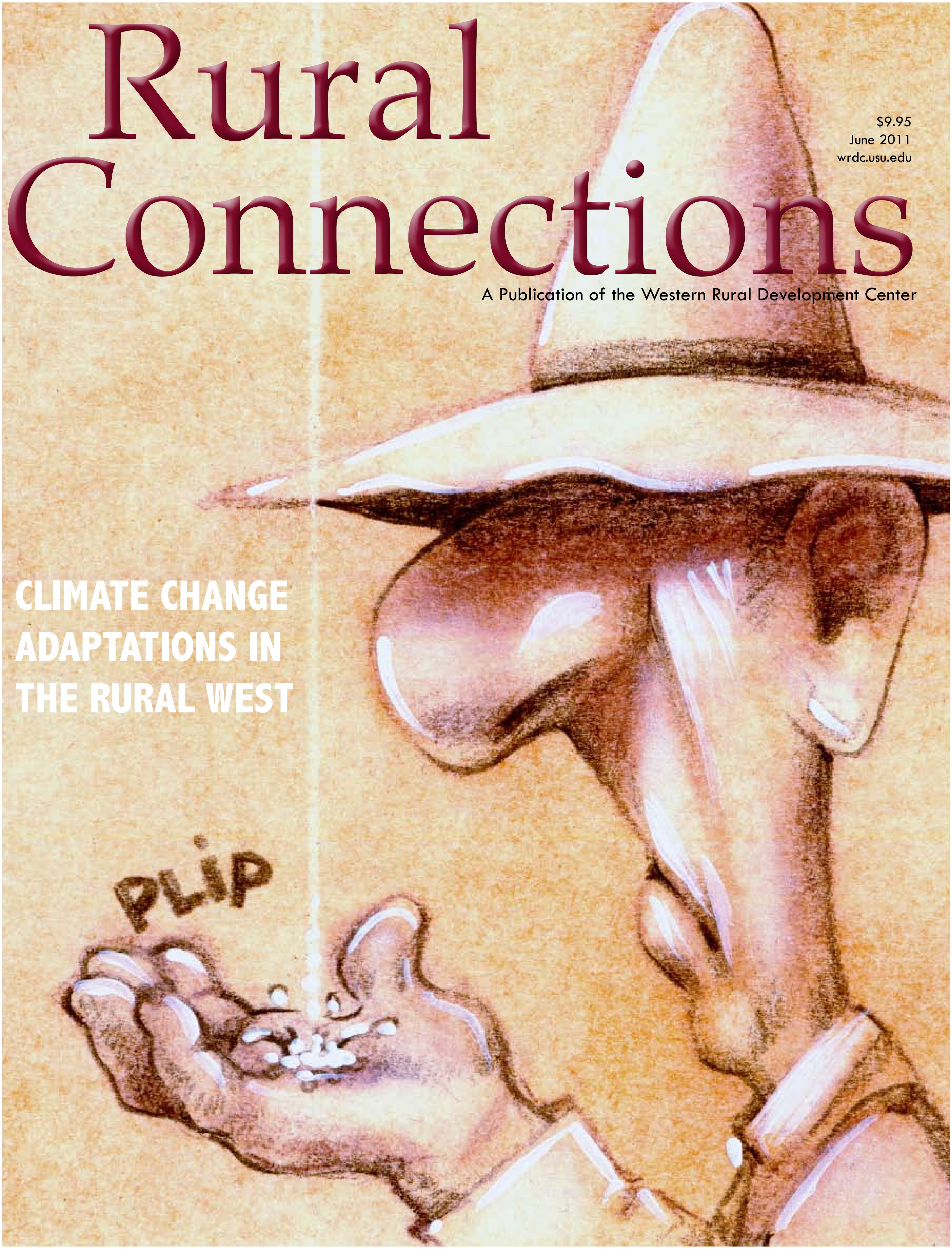

CLIMATE CHANGE ADAPTATIONS IN THE RURAL WEST

Rural Connections

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USDA National Institute of Food and Agriculture

WESTERN RURAL DEVELOPMENT CENTER
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FROM *the* Director

Climate Change Effects in the West

Are we ready to adapt?

BY DON E. ALBRECHT

Don E. Albrecht is the director of the Western Rural Development Center.

Climate changes resulting from human activities are among the most significant challenges confronting human societies. Climate change is primarily a consequence of the burning of fossil fuels such as coal, natural gas and petroleum. As fossil fuels are burned, carbon dioxide and other greenhouse gasses are released into the atmosphere. As greenhouse gases accumulate in the atmosphere, they allow light from the sun to enter, but then trap a portion of the outward-bound infrared radiation, which makes the air increasingly warmer.

In the 19th century and before, carbon dioxide levels in the atmosphere were about 284 ppm. Since then, carbon dioxide levels have increased by more than 36 percent to 387 ppm in 2009. The rate of increase has become greater as progressively larger amounts of fossil fuels are burned each year.

To provide some indication of fossil fuel usage, the United States consumes about 21 percent of the energy utilized worldwide. About 84 percent of the energy used in the U.S. is derived from fossil fuels. Less than one-half (44.5 percent) of the fossil fuel energy consumed in the United States is from petroleum, of which 71 percent is used in the transportation sector. Thus about one-fourth of the energy consumed in the U.S. is for transportation and this energy keeps approximately 250 million vehicles on the road. According to the Energy Information Administration, about 378 million gallons of gasoline are consumed by these vehicles each day in the U.S.

Evidences of climate change proliferate. On average the Earth's temperature has increased by 1.2 degrees Fahrenheit in the past century with 1998 and 2005 the warmest years on record. From 2003 to 2007, the 11 western states averaged 1.7 degrees Fahrenheit warmer than the region's 20th century average.

In the 19th century, there were 150 named glaciers in Glacier National Park in Montana. Today this number is down to 26, and several of these are mere remnants of their former selves. Estimates are that all of the glaciers in the park will soon be gone. The temperature of the oceans is increasing leading to more frequent and more severe storms. Further, temperature changes shift vegetation community boundaries, the centers of distribution for various species have changed, and globally the area affected by drought has increased. These changes make some habitats and some species extremely vulnerable.

Consequences are even more dramatic in the Arctic regions where average temperatures have increased almost twice the rate of the rest of the world. As a result, there is widespread melting of glaciers and sea ice.

Overall, the geographic extent of arctic sea ice has declined steadily since the late 1970s and has now decreased by 15 to 20 percent. The Columbia Glacier in Alaska, which discharges into Prince William Sound, has shrunk by nine miles since 1980 and is discharging nearly two cubic miles of ice annually. Decreasing sea ice, associated with melting of glaciers, especially in Greenland and Antarctica, are resulting in rising sea levels. Further, the extent of arctic snow cover has declined and river flows have increased, the permafrost is melting and the permafrost's southern limit has moved north by a significant amount. As a result, vegetation zones are shifting northward, the frequency and intensity of forest fires and insect disturbances have increased, and a number of marine species that are dependent on sea ice, including polar bears, seals and walruses are declining and some may face extinction.

Unless major changes are implemented, the amount of greenhouse gases in the atmosphere will continue to grow, and the consequences could be disastrous. If CO_2 levels can be sustained at 450 ppm, projections indicate that the eventual temperature rise will be between 1 and 3.75 degrees Celsius. Under these circumstances, deserts are likely to spread, crops fail, the number of people affected by hunger will grow, the melting of the Greenland ice sheet will be irreversible, cities such as Tokyo, New York and London will be threatened by rising seas, and there will be a substantial increase in hurricane damage in the United States. Should CO_2 levels increase beyond this level, consequences could be progressively more catastrophic.

While everyone on earth will deal with the impacts of climate change, the West may be especially susceptible to adverse consequences. This is primarily because the region already faces severe water shortage concerns and climate change is expected to increase the frequency and severity of droughts and reduce mountain snowpack. Fortunately, western researchers and Extension Specialists are deeply involved in work to address climate change issues. This issue of *Rural Connections* includes articles written by some of these individuals. Our hope is that these articles will stimulate the sharing of ideas across state lines and trigger others to become involved in this important work.

Finding a place for Climate Science in the Rural West

BY JULIE BRUGGER, MICHAEL A. CRIMMINS, AND GIGI OWENS

Challenges

Many rural Westerners are intimately attuned to weather and climate variability through livelihoods tied to production agriculture and resource management. One of the main challenges facing them as they relate to climate change science and policy is how to integrate new information about the risks of climate change into livelihood strategies already challenged by variability and uncertainty from a myriad of other sources, including economic, environmental, regulatory, and social, among others.

In addition, their livelihood strategies are shaped, not only by economic goals, but also by ties to place and identity (Coles and Scott 2009). Since extreme climate variability driven by topography and strong connections to large-scale patterns like the El Nino-Southern Oscillation is the norm across the Western U.S., recent climatic shifts related to climate change (e.g. warming temperatures) haven't necessarily stood out as unusual and caused concern for many Westerners. Their own depth of experience with weather and climate variability may actually contribute to skepticism of climate change as it has been framed by mainstream discourse, which focuses on human causation, apocalyptic future scenarios, and the reduction of greenhouse gas emissions as the primary means to address it (Brugger, 2010).

Meanwhile, the approach of the federal agencies charged with addressing climate change domestically has been to conduct and fund research on fundamental climate science with limited and under-resourced strategies on communicating research findings to the public or even assessing applied research needs in the first place (Kloprogge and Van der Sluijs, 2006: McNie, 2007). Underlying this approach is the assumption that, given sufficient information about the potential impacts of climate change, people will take action to mitigate or prepare for it. This has been referred to as the "loading dock" approach to linking science and society (Cash et al., 2006), because scientists decide what information is needed, produce it, and leave it on the loading dock for decision makers to pick up and use, without any interaction between them.

Even when this approach is modified so that scientists do some translation of the science for the public, the relationship is still one-way. Under this approach, the fact that little progress has been made in the U.S. in addressing climate change is interpreted to indicate a need for even more scientific research on climate change and more and better-communicated information about it (McNie, 2007).

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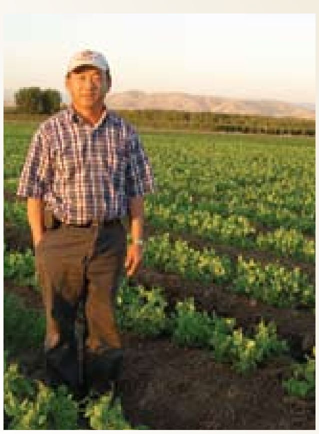
In this paper we suggest a different interpretation: that the lack of progress is a result of shortcomings of the "loading dock" approach itself. We begin by pointing out some of these shortcomings and how they make it challenging for rural Westerners to integrate new information about the risks of climate change into their livelihood strategies. Then we consider how Cooperative Extension provides an example of a "boundary organization" (Guston, 2001) that can overcome these shortcomings to find a place for climate science in the rural West.

Finally, we describe a case study in Arizona that will work through Cooperative Extension to draw on the understanding of weather and climate and the implicit adaptation strategies that rural Westerners already have to inform federal climate change research and policy.

To begin with, more than three decades of research in psychology on risk perception and decision making challenges a major assumption of the "loading dock" approach to linking climate science and rural residents: the assumption that the latter will find information about climate change useful and act on it. This research has established that people have two distinct systems for processing information used to make judgments or decisions: the feeling-based affective system and the reasoning-based analytical system (Weber, 2006).

The two systems typically operate in parallel and interact with each other, but the affective system, which is engaged by real world experience, has much more influence on decisions under risk and uncertainty than the analytical processing system, which is engaged by descriptions of risk. The former is hardwired, automatic, and fast, while the latter uses analytic algorithms and rules that must be learned and practiced and requires processing time and conscious effort. This leads to significant differences between experience-based and description-based perceptions of the long-term risk that climate change represents. As a result, people are more likely to be concerned about it if they have personally experienced its effects, if they believe it will affect them personally in the near future, or if they associate it with real victims. They are also more likely to be concerned if, by virtue of their education and training, they place greater reliance on descriptions of risk than the general public.



Rural agricultural producers, in particular, rely heavily on past experience to assess current conditions and make management decisions for the future. They seldom plan very far in advance because they know from experience how quickly conditions can change. If they are still in business, this strategy has worked for them so far. They are not likely to change behaviors and risk livelihoods that generate, not just economic income, but personal identity and the ability to remain rooted in place, based solely on descriptions of the potential risk of climate change (Coles and Scott, 2009).

Behavioral decision research has also shown that as worry about one type of risk increases, concerns about other risks goes down (Weber, 2006). This suggests that people have a limited capacity for worrying about issues, which researchers refer to as "a finite pool of worry," and that the effects of worry can lead to emotional numbing. Since rural producers already face uncertainty and immediate risk from a variety of sources, the risk of climate change may be too far down on the list for them to respond to information about it. This research suggests that, in order for rural producers to find information about climate change useful, it would need to resonate with their own experience and integrate into, not add on to, the ways they already manage for risk. In order to be able to produce this kind of information, scientists would need to have some understanding of their perspectives and concerns.

A second shortcoming of the "loading dock" approach to linking climate science and rural Westerners derives from the nature of climate science. Climate science exemplifies what Ravetz (1999) calls "post-normal science": "issue-driven science relating to environmental debates," in which "facts are uncertain, values in dispute, stakes high, and decisions urgent (199: 649). The "loading dock" approach is based on the dominance in traditional science of "hard" facts over "soft" values; whereas in post-normal science, "hard" value commitments may have to be made based on "soft" facts (Kloprogge and Van der Sluijs, 2006).

Its proponents argue that the approach to linking post-normal science and society must be participatory, inclusive, and deliberative. This is not only more democratic, it also improves the quality, creativity, and effectiveness of decisions because it draws on a broader representation of knowledge and values to coproduce a body of knowledge that "reflects the pluralistic and pragmatic context of its use" and "builds common ground among competing beliefs and values for the environment" (Robertson and Hull 2003: 399). Participatory processes of environmental decision making are more effective because they help prevent situations where scientists working alone produce information not considered relevant and useful by decision makers (McNie, 2007). They are also more effective because participants are more likely to accept information if they are involved in defining problems and solutions (Jacobs et al., 2010; McNie, 2007). The concept of post-normal science suggests that in order for rural Westerners to find information about climate change useful, they must be involved in coproducing it.

However, a critical issue in participatory processes of environmental decision making is the additional time, effort, and resources required to carry them out, including the processes of identifying stakeholders and establishing trust and effective communication among them before actual deliberation can even begin (e.g. McNie, 2007; Salter et al ., 2010). Another problem that has been identified is the difficulty of evaluating the outcomes of these processes since they include process outcomes, such as group learning, in addition to more concrete products (Salter et al., 2010).

A third shortcoming of the "loading dock" approach to linking climate science and rural producers is that it fails to recognize the major insight of science and technology studies: that science is not completely independent of the context in which it was produced, but is inescapably politically, culturally and economically inflected (McNie, 2007). As a result, people may associate scientific information with the context in which it is produced. Since people are more likely to accept information from those they trust (McNie, 2007), if they perceive that it is produced in a context that differs from their own, they may consider the information illegitimate and not be willing to accept it.

This recognition is basic to understanding why climate change is such a highly charged political issue in the U.S. Surveys show that a large percentage of the U.S. population is skeptical of climate science (Leiserowitz, 2010), and skepticism is especially prevalent among those with conservative political views (Maibach et al., 2009). The dominant framing of climate change focuses on the reduction of greenhouse gas emissions as the primary approach to addressing it, which implies massive government intervention. It also focuses on the imminent global peril that climate change represents, which leaves little room for political disagreement with this approach. For conservatives who are typically apprehensive of government intervention, skepticism of climate science may be the only way to express political disagreement (Brugger, 2010). Rural residents are more likely than the U.S. population at large to hold conservative views. They prize the independence and self-reliance necessary to make do in a rural setting that lacks many of the amenities found in urban areas, adding to their mistrust of government intervention.

We suggest that Cooperative Extension is uniquely positioned to serve as a boundary organization for linking climate science, policy, and rural society.

In addition, they may associate climate science with the cultural background of those disseminating it. The latter are predominantly urban, educated, and hold values that differ from those of rural residents, who often find their perspectives and concerns looked down on by the former (Brugger, 2011). These insights of science and technology studies suggests that in order to link climate science and rural Westerners, it will be necessary to increase mutual trust and respect between scientists, policymakers and stakeholders who are the intended consumers of applied research and will ultimately be impacted by policy responses.

Opportunities

One approach to linking science and society that has been suggested by critics of the "loading dock" approach is the use of boundary organizations (e.g. Cash, 2001; NRC, 2009; McNie, 2007). They are called boundary organizations because they manage the "boundary" between science and society: a boundary which is necessary to prevent the politicization of science and scientization of politics (Guston, 2001), but across which information must flow in both directions in order to avoid the shortcomings of the "loading dock" approach. Boundary organizations perform three boundary-managing functions: translating information; mediating actively across both sides of the boundary; and communicating effectively to all groups of stakeholders (McNie, 2007).

These functions address the first shortcoming of the "loading dock" approach to linking climate science and rural producers because two-way communication enhances the likelihood that scientists will produce information that responds to rural producers' needs. They address the second shortcoming because involving stakeholders in two-way communication will increase the quality and effectiveness of decisions. As standing organizations, boundary organizations can also help to reduce the time and effort needed to establish a participatory environmental decision making process for each specific issue. However, it will still require time for members of the boundary organization to build up enough mutual trust and respect to be accepted on both sides of the boundary as legitimate mediators and also for the knowledge coproduced in this way to be accepted on both sides.

Cooperative Extension has been cited as an example of a boundary organization that has successfully linked agricultural science, policy, and producers (e.g. Cash, 2001; Lynch et al., 2008). There has been much debate about the future of Cooperative Extension and the role it should play in the 21st century. We suggest that Cooperative Extension is uniquely positioned to serve as a boundary organization for linking climate science, policy, and rural society.

For nearly a century, Cooperative Extension has built up institutional knowledge and programs that facilitate two-way communication across the science-society boundary. In the process, it has also built up the social capital – the trust, respect, and cooperation between its members and stakeholders on both sides of the boundary – that is essential for coproduction of climate knowledge that rural residents will find legitimate and useful. It already maintains the network of relationships between university scientists, federal, state, and county agencies, and rural residents that a boundary organization needs to function, eliminating the time, effort, and expense needed to establish a new boundary organization or participatory decision-making process to address climate change.

Having agents and specialists who are "in place," gives Cooperative Extension a singular advantage for finding a place for climate science in the rural West.

This organizational and personal social capital is indispensable for assuring that climate scientists, policymakers, and rural residents will accept Extension personnel as legitimate mediators between them and will accept their coproduced knowledge and information. Cooperative Extension accomplishes these functions in a way unique to it: by having scientific specialists at the state land-grant university who focus on placed-based science, and by having agents who live in each county statewide and are able to develop experiential knowledge of local conditions, ongoing relationships with rural residents, and a deep understanding of local issues and concerns. Having agents and specialists who are "in place," gives Cooperative Extension a singular advantage for finding a place for climate science in the rural West.

Climate programs could be integrated into already existing programs aimed at agricultural production, resource management, youth development, consumer, family, and health sciences, and community and economic development. However, new investments and increased funding will be needed in order for Cooperative Extension to be able to live up to this potential and meet the challenges of this emerging and pressing issue.

Conclusion

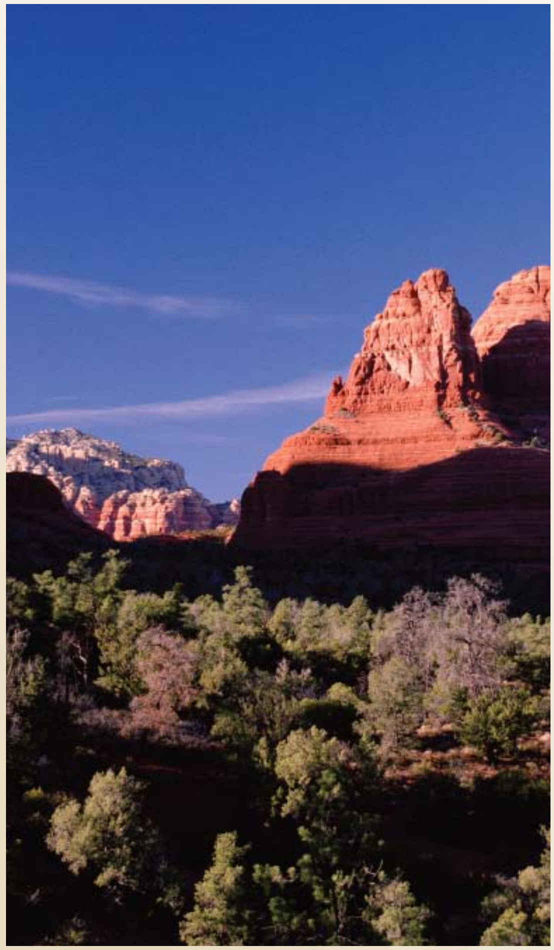
These challenges and opportunities inform a study we are carrying out as part of the 2010-2013 National Climate Assessment, a report to national leaders on the status of the federal research program on global change, required every four years by law, which is used to inform federal climate policy.

Our study has two goals:

1. To learn how federal agencies could provide climate-related information and programs that would better meet the needs of rural Arizonans.
2. To assess the role that Cooperative Extension can play in this process.

In pursuit of the first goal, we will use qualitative research methods to investigate how people in rural Arizona understand, respond to, and plan for weather and climate in their daily lives. This will provide insight into the understanding of weather and climate and the implicit adaptation strategies that rural Westerners already have that can be transferred across the climate science-rural producer boundary to indicate research directions and types of information that rural producers would find useful.

In pursuit of the second goal, we will work with Cooperative Extension to coordinate the research in each of Arizona's fifteen counties and include both Extension personnel and their clients in the research. This will allow us to explore the potential of Cooperative Extension to play a key role in linking climate science and rural society by examining how Arizona Cooperative Extension currently functions and drawing on the results of the qualitative research to identify specific ways it is positioned to mediate the challenges and opportunities that the issue of climate change presents for rural Westerners.



References

Brugger, Julie. 2010. Why Americans Don't Believe in Climate Change. Presented at Annual Meeting of American Anthropological Association, New Orleans.

_____. 2011. Perceptions of Glacier Retreat in the North Cascades. Presented at Meeting of the Society for Applied Anthropology.

Cash. 2001. "In Order to Aid in Diffusing Useful and Practical Information." Science, Technology, & Human Values, 26(4): 431-453.

Cash, et al. 2006. Countering the Loading-Dock Approach. Science, Technology, & Human Values, 31(4): 465-495.

Coles et al. 2009. Vulnerability and adaptation to climate change in southwestern Arizona, USA. Natural Resources Forum, 33: 297-309.

Guston. 2001. Boundary Organizations in Environmental Science and Policy. Science, Technology, & Human Values, 26(4): 399-408.

Jacobs, et al. 2010. Linking knowledge with action. Proceedings of the National Academy of Sciences, doi: 10.1073/pnas.0813125107

Kloprogge, et al. 2006. The Inclusion of Stakeholder Knowledge. Climatic Change, 75(3): 359-389.

Leiserowitz, et al. 2010. Climate change in the American Mind. Yale Project on Climate Change Communication.

Lynch, et al. 2008. Working at the Boundary. Bulletin of the American Meteorological Society, 89(2): 169-179.

Maibach, et al. 2009. Global Warming's Six Americas 2009: An Audience Segmentation Analysis.

McNie. 2007. Reconciling the supply of scientific information with user demands. Environmental Science & Policy, 10(1): 17-38.

National Research Council (NRC). 2009. Decision Support and Learning. Informing Decisions in a Changing Climate, Chapter 3.

Ravetz, et al. 1999. What is Post-Normal Science. Futures, 31(7): 647-653.

Robertson, et al. 2003. Public ecology. Environmental Science and Policy, 6: 399-410.

Salter, et al. 2010. Participatory methods of integrated assessment. Climate Change, 1(5): 697-717.

Weber. 2006. Experience-based and description-based perceptions of long-term risk. Climatic Change, 77(1-2): 103-120.

RECOMMENDED READING

Arizona Cooperative Extension
extension.arizona.edu

National Research Council
americasclimatechoices.org
Read their publication, "America's Climate Choices"

The National Climate Assessment
globalchange.gov/what-we-do/assessment

Classical and Jazz: Two Approaches to Supporting Rural Community Preparation for Climate Change

BY JOSEPH CONE, JENNA BORBERG, AND MIRIAH RUSSO

Joseph Cone is the assistant director and communications leader of Oregon Sea Grant at Oregon State University.

Jenna Borberg is the marine program specialist with Oregon Sea Grant at Oregon State University.

Miriah Russo is a graduate scholar with Oregon Sea Grant at Oregon State University.

Introduction

The changing climate is having and will continue to have varying local effects on physical features, habitats, and human communities everywhere on our planet. All those who need to make decisions, at individual or societal levels, need to better understand the effects of climate change in order to lessen its risks and make themselves and their communities more resilient. Taking up the recognized challenges within its own purview (Weber, 2009), since 2008 the Oregon Sea Grant program at Oregon State University has engaged and assisted small, rural coastal communities in addressing the climate-related risks that community members have been concerned about.

The work of our multidisciplinary university team[1] has had multiple phases, all grounded in empirical research on coastal residents and oriented to communicating in a collaborative and "nonpersuasive" way (Fischhoff, 2007). We have assessed the needs and constraints of target populations (Borberg, et. al., 2009); developed a specific communication and decision-support strategy based on identified needs and constraints; created and adapted research-based informational materials relating to climate change in print, online, and video formats (seagrant.oregonstate.edu/themes/climate); and distributed and evaluated these informational materials. Here, we focus on a portion of this overall effort: direct engagement with two rural communities.

Team members chose two different approaches, partly on the premise that university-community interaction around climate change adaptation will be ongoing and developing a useful toolkit of tested methods would be a good way to start this long relationship.

One community approach followed a risk communication framework (Morgan, Fischhoff, Bostrom, & Atman, 2002). Although climate change poses unique challenges, responding to the risks posed by climate change is categorically a problem of risk analysis and decision-

[1]In addition to the three authors, Patrick Corcoran, Shawn Rowe, Michael Harte, Bridget Brown, faculty of Oregon State University, and OSU graduate students Kirsten Winters and Joy Irby.

making, for which a substantial body of pertinent research offers guidance. We think of this approach—rather structured and composed in advance—as akin to "classical" music.

In comparison to that "classical" design employed in one community, we contrast another design, used in a second coastal community, that was more like "jazz"—less structured and improvisational. Here, assistance was provided in response to emerging community requests, incrementally and without an overarching theoretical framework.

Engagement Principles

While much of the best-publicized guidance about climate adaptation (e.g., Climate Impacts Group, 2007) may be well suited for large cities with professional staffs that can be deployed to new tasks, such guidance may not be applicable to, or manageable by, small, resource-limited rural communities. Although some believe that such communities may be more susceptible to climate change due to their reliance on the natural resources that are being affected by the changing climate (Wall & Marzall, 2006), their ability to adapt to climate change—their adaptive capacity—can be improved through social networks, institution and governance, and human resources (Adger et al., 2007). With our two communities we therefore worked to address issues of importance to them while improving their adaptive capacity.

We were guided by four working principles. First, our approaches are all about engaging with communities rather than conducting more traditional outreach that focus on disseminating research. Interacting with a community to understand their needs and interests makes it more likely that they receive relevant and useful information for climate change decision making (Cash & Buzier, 2005; Tribbia & Moser, 2008). Further, this interactive process enables them to play an active role in the cogeneration of knowledge, leading the community to be more vested in the process and the outcomes.

Second, we concentrated on climate change adaptation (preparing for the effects) rather than mitigation (addressing the causes). This allowed us to avoid polarizing debates about causes and instead focus on the local effects of climate change and the risks these pose on coastal communities. Considering these practical issues is arguably easier for citizens of various persuasions to act and to believe their actions make an important difference. For example, most Oregon coastal residents have observed that severe storms and inundation cause the coastline to erode, so approaching them about preparing for and responding to the possibility of increased storminess can be a good common ground to initiate conversation.

Third, we drew upon the norms of university Extension[2] theory and practice, notably the "diffusion of innovations" theory. Diffusion, or how an innovation is communicated over time among the members of a social system (Rogers, 2003), relies on finding key members—innovators—within a community that are motivated to act on a particular emerging issue. In turn, according to the diffusion model, others in the community may adopt the practices of these early leaders. In theory, in time the whole community will be affected even though Extension personnel had only to engage a subset. So deeply ingrained in community assistance is this model and its appeal of leveraging resources that both our approaches make use of it, though not prescriptively. (We do note that the diffusion model may be less useful when the engagement is not about novel ideas. And we recognize that social networks are often more important than in-groups and much harder to identify and directly influence (Watts & Dodds, 2007).)

Fourth, we understood that climate change will continue to have effects for decades and longer, so adapting to it will be ongoing. In 2011, very few American communities have worked their way through a decision-making cycle (Figure 1) and are now monitoring the effects of those decisions. Many communities need help starting; and starting well means

[2] Just as diverse Extension programs connect academic research with various public interests and issues, Sea Grant Extension and Communication programs specialize in coastal issues.

helping the community analyze the decisions they want to make and evaluate potential solutions (Wilson & Arvai, 2011).

Contrasting Approaches

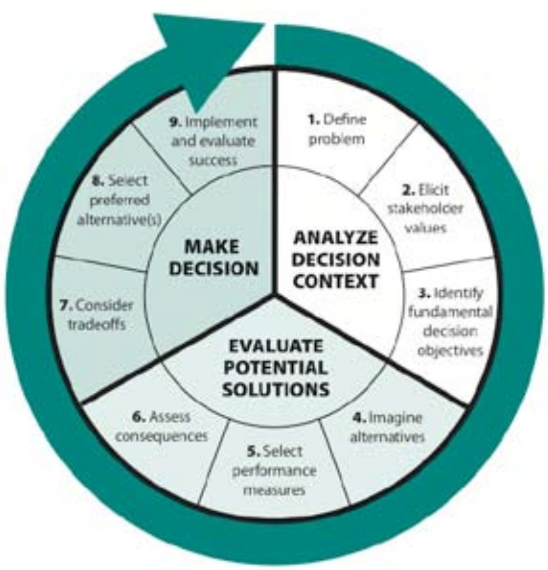
A. "Classical"

Climate adaptation planning requires communicating about risks, and thus is a particular instance of risk communication, a discipline that has evolved from an earlier orientation to the needs of the information provider to today, where the interests of the information user (or recipient) predominates (Fischhoff, 1995).

The research methodology Oregon Sea Grant has employed to understand communities is detailed in a standard reference for the field, Risk Communication (Morgan, Fischhoff, Bostrom, & Atman, 2002). The four key research elements relate to each other in providing increasingly detailed and specific understanding. In the first stage, a model of risks for the climate in the community of interest is obtained from climate scientists, either directly, or from published sources. In the next stage, mental model interviews reveal how members of the target community not only understand the climate risks but also how they feel about them—both of which are important, since they combine into an individual's assessments of risk (Marx et al., 2007). Often these exploratory interviews with 10 to 20 individuals will offer perspectives on the risks—particularly misunderstandings—that then become subject to further clarification via a discussion with a group drawn from the target community. Insights obtained from the interviews and group (often a "focus group") lead to a fourth step of discovery, a survey that seeks to confirm what the researchers believe they know about the community's view on risks. The survey of the community may also seek to understand information needs related to identified risks and the respondent's current involvement in any climate planning.

While ideally this preparatory research would employ a team of specialists in climate science, behavioral and decision research, and science communication (Pidgeon & Fischhoff, 2011), in our experience other professionals who understand and diligently apply the methods can still benefit from this user-centered approach (Figure 2). Our team has incorporated the above-named specialist expertise on an as-needed and temporary basis, while the core, continuing university team has been comprised of Extension and communication faculty aided by graduate students.

Conducting and analyzing the community research prepares our university team by understanding the knowledge, attitudes and current behaviors of community members. In workshops that follow, we bring together participants in real-time interaction to develop what are often referred to as "knowledge



The Decision Cycle

Analyze decision context

1. Identify group definition of the problem.
2. Elicit diverse stakeholder values in the form of problem-relevant objectives.
3. Separate the means from ends (fundamental) objectives.

Evaluate potential solutions

4. Create list of potential alternatives.
5. Select practical performance measures to evaluate the alternatives.
6. Use performance measures to assess the consequences of each alternative for each end objective.

Make decision

7. Identify and conduct tradeoffs to reach best-possible alternative.
8. Select preferred alternatives.
9. Implement, and evaluate success.

Figure 1. A Decision Cycle (from Wilson & Arvai, 2011).

We recognize that the actual preparation for climate change is likely to present numerous barriers for the community (Ekstrom, Moser, & Torn, 2010) so we offer a framework for decision-making to help empower the group. A key tenet of structured decision making (Wilson & Arvai, 2011) is that the group should define the problem that they want to make a decision about and the objectives that matter to them regarding that decision. Moreover, those objectives are best developed through an open process in which individual values are expressed, discussed, and inform the selection of objectives.

How do we do this? One technique that we used to make workshop participants' thinking visible to each other is concept-mapping (Cañas et al., 2005). The technique is quickly demonstrated and learned, and when asked to individually characterize the effects of climate change that they were concerned about, ten members of one working group readily produced, shared, and negotiated both the climate effects and their concerns that caused those effects to be important to them. From effects, the group was able to identify risks associated with those effects, potential actions that might be taken to address those risks, and who might be responsible for taking those actions—all in a first, four-hour workshop.

Only at this point, when the community members had begun to map the problem and decisions that they might make, did we introduce a preliminary model of climate risks as defined by climate scientists. That way, the understanding of the climate "experts" would be seen as helpful and clarifying, not prescriptive or preclusive. Through comparing their insights and understanding with those of the climate scientists, the community members both confirmed and amplified their knowledge, which grounded their continuing process of planning for the effects of climate change, arrayed in a community climate model (Figure 3).

B. "Jazz"

Although the classical and jazz approaches are similar in that they both seek community participation and maintain an organized structure, "jazz" is less structured, improvisational, and responsive to the directions taken by others. These characteristics really do describe a different style of interaction, one that reacts to the needs of the community, providing information on request and incrementally, and without a predetermined theoretical framework.

The planning group in our second coastal community invited Oregon Sea Grant to provide educational and facilitative resources as they planned their response to a rather urgent problem of shoreline erosion. The community effort is driven by a team of highly motivated

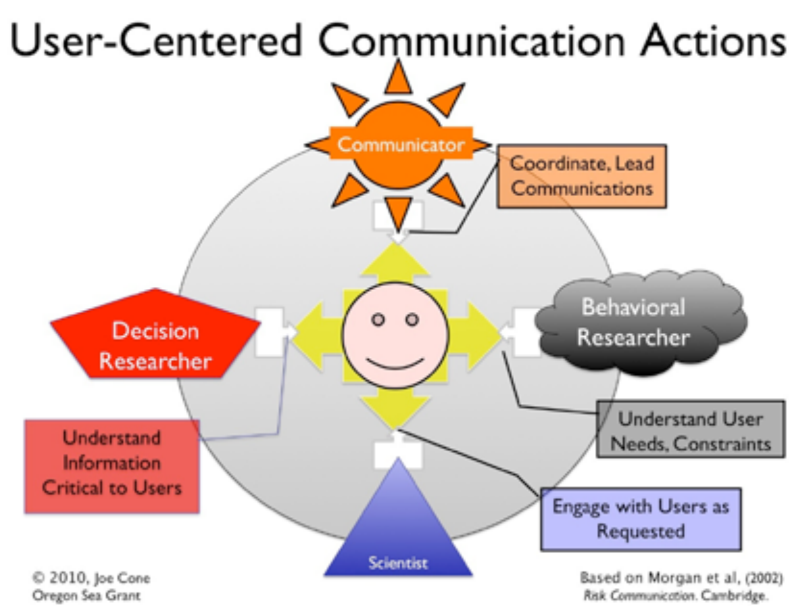


Figure 2. User-Centered Communication Actions and Actors.

RECOMMENDED READING

National Research Council Panel on Adapting to the Impacts of Climate Change, & National Research Council Board on Atmospheric Sciences. 2010. Adapting to the impacts of climate change: America's Climate Choices. Washington, D.C.: National Academies Press.

Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments. Chapter 8 is Conduct a climate change vulnerability assessment. cses.washington.edu/db/pdf/snoveretalgb574front.pdf

Morgan, et al. 2002. Risk communication: a mental models approach. New York: Cambridge University Press.

members, primarily local property owners, who have also requested participation from Oregon State University scientists, state agencies and county officials. In this case, rather than engaging a research-oriented team to implement strategies grounded in theory, we improvised. Policy changes, environmental impacts, and resource constraints demanded rapid and innovative project design. Strong relationships and consistent interaction with the community allowed us to tune in to the resource needs of the community, and respond with customized strategies.

For example, the group had a need to share documents, so Sea Grant established an online forum for sharing and posting relevant materials. The collaboration technology itself (Basecamp.com) was about as new to Sea Grant as it was to the community but is now an integral part of the communication processes of the group.

As another example, the community group asked for, and Sea Grant provided, assistance in preparing a document that described the group's history, goals, activities and progress, to better acquaint other members of the community. This document provides its readers with a transparent understanding of the community group's maturing identity.

Organizational structure provides a point of further differentiation between the classical and jazz approaches. Although this community group holds regular monthly meetings, other events, like workshops, are planned as necessary and have agendas developed by the community with input from our and other organizations. In this case the community group is empowered to create amorphous plans, redefine goals, and develop their own creative approaches. The group has taken this creative license and produced working subcommittees, letters to the community, and public outreach events.

The community group slowly evolved into existence and has no defined terminus. Classically, outreach projects establish an itinerary that sets the project to begin at a particular point and end at a future defined point. In this case Sea Grant involvement grew organically from relationships with community members and continues as needed with no prescribed end.

The continuously evolving nature of the jazz approach complicates the evaluation process. Although successes and failures can be reported regularly, it is difficult to make claims about the overall success of the program. The classical approach determines success based on predefined measures grounded in theory,

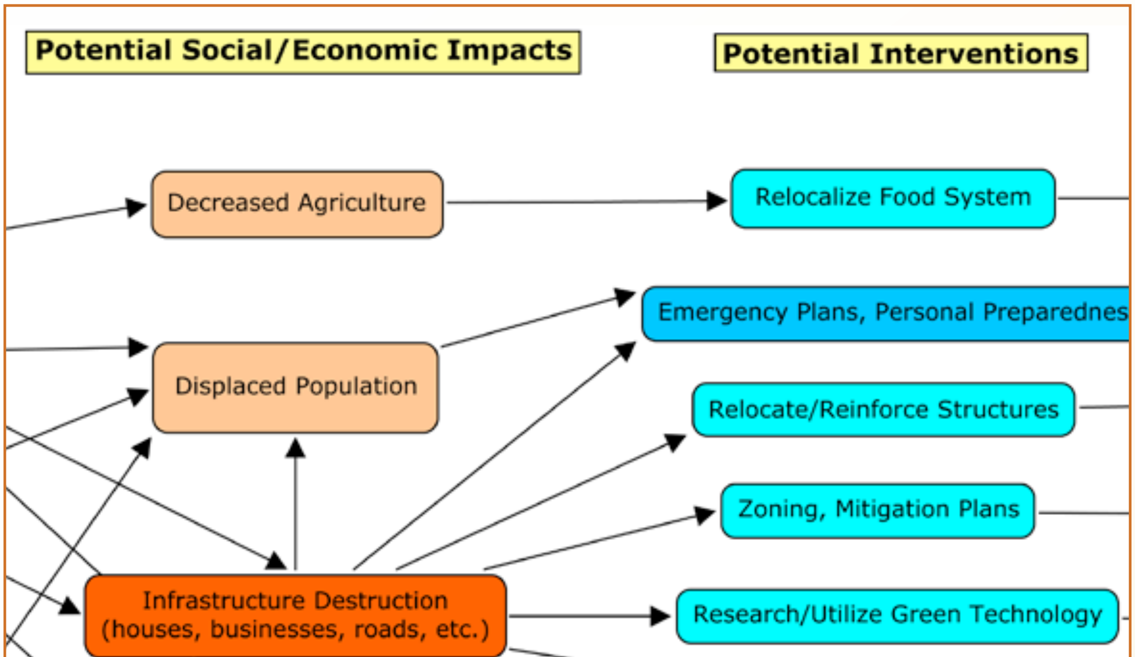


Figure 3. A small portion of one community concept map of climate risks.

whereas success in the jazz approach is determined by individual perception of effectiveness in reaching broad and changing goals.

The jazz approach may not be an appropriate model for all engagement professionals or for all communities. But as Extension programs face funding cuts which may make more highly structured programs difficult to sustain, and which put a higher premium on staff seizing opportunities organized by others, "jazz" professionals can slip in, contribute usefully, and bow out when no longer needed.

Conclusion

Adapting to climate change will likely require a variety of approaches, as every community will have different needs, priorities, and resources. Outreach and engagement professionals have a variety of methodologies that can be employed. Two have been highlighted here.

Do the differences between our "classical" and "jazz" styles correspond to other understandings of university and Extension faculty? It is well recognized that professional differences often exist between on-campus and "field" faculty and agents. One comparative study of these groups that used the Myers-Briggs Type Indicator (Saunders & Gallaher, 2003) found a significant difference in the "judging" function: 72% of on-campus specialists had a Thinking preference, while 60% of agents had a Feeling preference. Another study found that campus faculty view themselves as program providers while county staff view their jobs as the critical link between community needs and university resources (Franz, Peterson, & Dailey, 2002). Both from survey research and from substantial verbal and written endorsements from both communities, we know that our project communities appreciate and value our assistance. However, is either approach contributing to adaptation success?

The 2010 National Research Council report, America's Climate Choices, argued that adaptation "requires actions from many decision-makers . . . in governments, the private sector, non-governmental organizations, and community groups," but lamented that "current (adaptation) efforts are hampered by [among other factors] uncertainty about future climate impacts at a scale necessary for decision-making" (America's Climate Choices Panel, 2010, p.1). It seems to us that by convening a wide range of community decision-makers and by making decisions on the local scale, progress can be made, uncertainties can be resolved, and communities can be made more resilient to a changing climate. "Success" is still a ways off, surely, and adaptation, by nature, will likely never be completely finished. Those who are serious in helping communities will need to regularly update themselves on the state of adaptation social science and be willing to try new approaches. The future climate is very unlikely to look like today's climate; likely neither will our approaches look the same.

References

Adger, et al. 2007. Assessment of adaptation practices. Contribution of Working Group II to the Fourth Assessment Report of the IPCC, 717-743.

America's Climate Choices. 2010. Panel on Adapting to the Impacts of Climate Change. Adapting to the Impacts of Climate Change: Report in Brief. National Research Council.

Borberg, et al. 2009. An analysis of a survey of Oregon coast decision makers.

Cañas, et al. 2005. Concept Maps. *Knowledge and Information Visualization,* 3426: 205-219.

Cash. 2005. Knowledge-action systems. Report to the Roundtable of Science and Technology for Sustainability.

Climate Impacts Group, King County, & ICLEI. 2007. Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments.

Ekstrom. 2010. Barriers to Climate Change Adaptation. Public Interest Energy Research (PIER) Program.

Fischhoff. 1995. Risk Perception and Communication Unplugged. *Risk Analysis,* 15(2): 137-145.

_____. 2007. Nonpersuasive communication about matters of greatest urgency. *Environmental Science & Technology A-Page Magazine,* 41(21): 7204-7208.

Franz, et al. 2002. Leading Organizational Change. *Journal of Extension,* 40(3).

Kennel, et al. 2010. Knowledge Action Networks. Retrieved from escholarship.org/uc/item/8gd6j0k5.

Morgan, et al. 2002. Risk communication: a mental models approach.

Marx, et al. 2007. Communication and mental processes. *Global Environmental Change,* 17(1): 47-58.

Pidgeon, et al. 2011. The role of social and decision sciences in communicating uncertain climate risks. *Nature Climate Change,* 1(1): 35-41.

Rogers. 2003. Diffusion of Innovations.

Saunders, et al. 2003. Decision-Making Styles. *Journal of Extension,* 41(3).

Tribbia, et al. 2008. More than information. *Environmental Science & Policy,* 11(4): 315-328.

Wall, et al. 2006. Adaptive capacity for climate change. Local Environment, 11: 373-397.

Watts, et al. 2007. Influentials, Networks, and Public Opinion Formation. *Journal of Consumer Research,* 34(4): 441-458.

Weber. 2009. Climate Ready Communities. Oregon Coastal Management Program.

Wilson, et al. 2011. Structured Decision Making.

FOOD SECURITY adaptation plans

BY GARY AUSTIN

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Introduction

Availability, access and cost all contribute to food security. In every town some citizens are without food security and go hungry or turn to the support of federal, state or local programs to provide them with necessities. Just as natural catastrophes can plunge a community into circumstances where food is compromised or unavailable, the impacts of climate change will reduce food security unless we anticipate and adapt to the changes. In the United States the poor are most likely to suffer the greatest impact.

General Climate Change Impacts

Although uncertainties remain about the extent of climate change impacts especially at the local level, there is scientific consensus that CO_2 and other greenhouse gases are correlated to an average rise in the global temperature. The average global temperature from 1901 to 2000 was about 57.5°F. From 1880 to 1940 average annual temperatures were below 57.5°F but once CO_2 levels rose above 310 parts per million (ppm) then in many years the average temperature of 57.5°F was exceeded. Every year since 1980, when the CO_2 levels passed 330 ppm, the average global temperature of 57.5°F has been exceeded. The rate of CO_2 concentration increase and temperature gain steepened between 1980 and 2010. In the last decade the CO_2 concentration climbed to 385 ppm and the average annual temperature was about 58.5°F (Karl, 2009).

The effect of the higher temperature will vary across the globe. In the United States, regions that have ample precipitation are likely to receive more rain while regions that are arid will receive less that normal precipitation. Projections by the U.S. Department of the Interior indicate that annual water discharge will be reduced 8-14 percent in the Colorado, Rio Grande and San Joaquin rivers (Dept. of Interior, 2011). Since these watersheds provide drinking and irrigation water to large populations, negative impacts are expected. Climate change impacts have already occurred with impacts on agriculture including more frequent heat waves and higher-intensity rain and snow storms, and longer-lasting droughts (Karl, 2009).

Agriculture has been a significant contributor to green house emissions that lead to global warming. Agriculture produces as much as 30 percent of the U.S. greenhouse gas emissions through fuel, fertilizer and pesticide use (USDA, 2010). The raising of livestock contributes significantly to the emission of greenhouse gases. According to the United Nation Food and Agriculture program 18 percent of the world's total greenhouse gas emissions come from livestock operations, although some researchers conclude that it is much higher (Goodland, 2009).

Impacts on the Conventional Food System

Since global temperatures will continue to increase over the next 50 years, more disruption to production and availability of food is certain. In the parts of the world where the impact of climate change will be the greatest desertification and crop failure could place many people in jeopardy. Without significant adaptation and mitigation progress an additional 26 million people in Latin America and 132 million in Asia will suffer from malnutrition by 2050 (OECD, 2009). In addition to expected crop yield reductions, such as the predicted ten percent reduction of Maize in Latin America, the warming climate is projected to make flooding and drought events more frequent and extreme. Extreme weather events impact agricultural supplies and the cost of commodities. For example, droughts between 2006 and 2008 were responsible for a 217 percent rise in the cost for rice, a 136 percent increase for wheat, a 125 percent increase for corn, and an increase of 107 percent for soybeans (Mazhirov, 2011).

Crop yields at the lower latitudes in the U.S. are expected to decline and an additional 2°F rise in temperature above current levels will cause yields to decline in the upper latitudes as well (USDA, 2010). In addition to elevated temperature, changes in precipitation, snow pack and groundwater will stress natural ecosystems and require agriculture to adapt with different crops, methods and markets. Since solving the climate change problem is no longer possible except in the long term, adaptation and then mitigation of worsening impacts will consume our efforts in agriculture, energy, and land use (Orr, 2008).

During the last five years, there has been no success in reducing greenhouse gas levels. This lack of progress is likely to lead to more concerted future attempts to reduce fossil fuel use, perhaps through reduced production or rationing. Such a prospect is alarming for large-scale agriculture that is oriented toward high production of monoculture crops and export or sales requiring transportation to distant domestic markets. In addition, the price of agricultural products and farm profits are very sensitive to changes in fossil fuel prices. The prospect of climate mitigation measures leading to increased food cost increases the likelihood of food insecurity especially for the poor.

Adaptations of the conventional food system to climate change are researched and implemented at the federal and state levels. Federal agencies are in the beginning stages of framing research questions, policies, and support programs needed to implement a shift to new crop varieties, changes in pest management and irrigation techniques, as well as processing and distribution changes. At the global scale this agricultural challenge is so formidable that the hunger and starvation of millions of people weigh in the balance. In the United States the situation is not as dire and adaptation to moderate global warming is certainly possible.

Large-scale agriculture must be involved in climate change adaptation but also in the reduction in the global levels of greenhouse gas emissions in order to avoid serious consequences in the next century. Large-scale demonstration projects that reduce greenhouse gas emissions and promote carbon sequestration on private lands are underway (Vilsack, 2010). Since the change in land use in the last 150 years is responsible for about 30 percent of the human caused CO_2 emissions, changes in farm and forest management practices have the potential to provide a great deal of terrestrial carbon storage and mitigate climate change (USDA, 2010).

Impacts on the Local Food System

Of course, climate change impacts on rural towns will occur but they will be modified by the local topography, natural attributes, and microclimate. However, the impact of climate change on the food security of the town will be based primarily on the regional, national, and global reductions in agricultural products. Reduced supply will be aggravated by increased costs as energy prices rise or as fossil fuel use is reduced through regulatory or market mechanisms. Rural towns and even large cities have little influence on the practices of the conventional food system since it is based on economies of scale, and the sale and distribution of products at the global scale. Nevertheless, perturbations in this global network are felt regionally or locally. Perhaps the global, national and state efforts to adapt the conventional food system will be so successful that rural towns and citizens need do nothing to prepare for the new paradigm, but the prudent course is to make an effort to secure an available and affordable food system locally.

Rural towns in the western U.S. dependent on farm and forest products for a significant portion of their economic base may be dramatically impacted if climate changes makes these systems less profitable or less viable. A reduction of some magnitude in the economic base could threaten the well-being and quality of life of most of the residents. For these communities climate change adaptation is critical at the regional as well as the local scale. Immediate measures to implement reforestation or new agricultural crops or other products in consultation with federal, state and county government might be necessary to avoid long term problems.

Food Security Adaptation Planning

Communities vary in their initial capacity to adapt to climate change or other challenges according to the social, human, institutional, natural, and economic resources available (Wall, 2006). Where a community resource is low in one or more of these areas, programs to improve the resource may be valuable. One approach is to build the resource as a function of creating the adaptation plan. For example, social resources or social capital is the ability of the citizens to work together to solve problems. Conflicting interests, lack of attachment to the community, or other factors might be reflected in a diminished capacity to devise and implement solutions to community problems. In this case, a facilitator might be necessary to guide a community through a democratic and deliberate decision-making process. The success and techniques learned add trust and capacity for future problem solving.

Abundant or limited natural resources such as fertile soils, water, manageable slope, etc. could affect the community's ability to implement an effective local food network. Often limited economic resources are viewed as prohibiting any progress toward solving pressing community problems, but social and human capital can often initiate a process or a solution that attracts economic support. If a foundation or other funding agency is presented with a well-conceived plan and the commitment of local government and civic groups, funding is much more likely.

1. Produce a series of events to increase public awareness of local food security and climate change impacts.

A series of community presentations given by local and/or regional experts that characterize the local situation in respect to climate change and the food security.

This first step might include a local, public process that assesses the vulnerability of the town to reductions in supply from the conventional food system or vulnerability to increases in the cost of food. This, of course, includes an assessment of the quantity and variety of locally-produced food. If, as in most rural towns, only a fraction of the food consumed comes from local sources then a plan to increase local production within the realities of the changing climate is merited.

2. Establish partnerships with non-profit organizations, other communities, county, state and federal agencies including land-grant universities and ag-

ricultural extension.

Some communities, such as Missoula, Montana, initiated their food security planning with an assessment of the needs of low-income residents and the capacity of the local service organizations to respond. This effort was not initially concerned with increasing local production of food but making sure that the most vulnerable citizens had access to adequate resources. The effort involved considerable research, economic study, and organizational systems to build a stable and ongoing community-wide program (Missoula County, 2007).

3. Prepare planning scenarios to study a range of food security possibilities and responses.

Citizen groups, city commissions, or partnerships with universities or other organizations can prepare plans for a number of food security scenarios from best to worst or for a number of approaches, such as high or low technology. Consideration of secondary benefits including open space, economic development, social opportunities, stormwater management, recreation, education, etc., will enrich the plans and make them more feasible.

4. Develop planning documents, policies, and investment decisions to support the development of a local food system with a diversity of technologies and approaches (i.e. community supported agriculture, community gardens, municipal farm).

Implementation of the adaptation plan begins with a mission statement and an action plan supported by policies, such as ordinances and zoning changes. Human, social, and political capital are required investments that can be promoted by citizen groups, non-profit organizations, and city government. Financing the plan elements will require municipal funding, tax incentives, a low-interest loan pool, grants, or private investment fostered by an economic development person within city or county government.

5. Build public or public/private facilities that implement local food production as public demonstrations, public services, or for-profit enterprises. Train staff and citizens in local food production techniques including marketing and distribution.

Physical implementation of the plan elements and continuing skill development will, over time, make the local food system increasingly robust.

6. Integrate other climate change adaptations, such as energy and water conservation into the local food system.

Food security is only one of the climate change adaptations that the community will face but it can be integrated into several other responses. The expertise gained by citizens and local farmers combined with the rural setting might lead to a community forest for production of biofuel as an alternative energy source for municipal buildings or homes. This might even generate grant funding as a climate mitigation measure since it sequesters carbon or is a carbon-neutral energy source (Stone, 2009).

Government Support for Adaptation Planning

Federal, state and county governments are preparing climate mitigation and adaptation plans (Climate Impacts Group, 2007). These efforts will provide models and eventually expertise and funding to assist communities in planning for food security. The federal Interagency Climate Change Adaptation Task Force established goals to address the many aspects of this problem including efforts to assist communities. Two of the task force goals related to communities are:

- Ensure that relevant Federal regulations, policies, and guidance demonstrate leadership on community adaptation
- Integrate adaptation considerations into Federal programs that affect communities (Interagency Climate Change Adaptation Task Force, 2010)

These goals will be achieved partly through research and outreach by land-grant universities and extension programs. These organizations are to provide expertise and information about climate change adaptation to communities and citizens, including the assessment of the impacts of climate change on regional food security (USDA, 2010).

References

Climate Impacts Group. 2007. Preparing for Climate Change: A Guidebook for Local Regional and State Governments. Seattle, WA.

Dept. of the Interior, Bureau of Reclamation. 2011. Reclamation Climate Change and Water: SECURE Water Act Section 9503(c).

Goodland, et al. 2009. "Livestock and Climate Change." World Watch, Nov./Dec. 2009.

Karl, et al. 2009. Global Climate Change Impacts in the U.S.

Mazhirov. 2011. "Climate Change to Exacerbate Rising Food Prices." Retrieved 3 March 2011 from http://blogs.ei.columbia.edu.

Missoula County. 2007. Food Insecurity in Missoula County: Barriers, Opportunities & Solutions.

Interagency Climate Change Adaptation Task Force. 2010. Recommended Actions in Support of a National Climate Change Adaptation Strategy.

OECD. 2009. Policy Guidance On Integrating Climate Change Adaptation Into Development Co-Operation.

Orr. 2008. "Land Use and Climate Change." Conservation Biology, 22: 6.

Stone. 2009. "Land Use as Climate Change Mitigation." Environmental Science and Technology, 43: 24.

Vilsack. 2010. "Release No. 0642.10." USDA Office of Comm. Speech in Cancun, Mexico, Dec. 9, 2010.

Wall. 2006. "Adaptive Capacity for Climate Change." Local Environment, 11: 4.

State Fiscal Implications of Climate Change Legislation to Energy-Dependent States

BY MILT GEIGER, ROGER COUPAL, AND DON MCLEOD

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Introduction

In the current political climate federal greenhouse gas legislation has become less likely. However, if scientists are correct the issue will not fade, so some regulatory policy will likely be implemented eventually. States like Wyoming that provide energy for the national economy are particularly concerned about impacts of such regulation. This analysis evaluates Wyoming's State Government Revenue stream if greenhouse gas (GHG) legislation is passed in Congress. Wyoming is among a small group of states whose economies are highly dependent upon supplying energy to the rest of the nation: Montana, Colorado, New Mexico, North Dakota, Kansas, Oklahoma, and Texas. Energy and GHG policy can have a significant impact on the regional economy and on the provision of state and local government services. This study seeks to explore how such legislation may affect Wyoming.

The drive for "energy independence" coupled with a growing demand for reduced GHG emissions has placed the significant energy resources of Wyoming at the forefront of domestic energy policy. Wyoming contains substantial reserves of fossil fuels, including oil, natural gas, and coal, as well as significant renewable energy resources, particularly wind. The state is the nation's leading coal producer, fifth in natural gas production, and seventh in oil production. Wyoming also ranks eighth in available wind energy resource and, as of the end of 2009, is ranked 13th in total wind energy production (DOE EIA, 2009b).

In 2009, Wyoming state and local governments received \$3.571 billion of direct tax revenue from the mining sector, which is comprised mostly of fossil fuel production, 98.2 percent of total mining related revenue (State of Wyoming DAI, 2009). These generate significant impacts in a state of just over 500,000 residents.

The economic benefits to Wyoming from fossil fuel extraction are not without environmental costs, including GHG's. Although Wyoming's individual contribution to global warming is small, the aggregate use of fossil fuels is a primary driver of climate change (UN IPCC, 2007a). The impacts to the environment serve as the impetus to act to stabilize Earth's climate. This requires the reduction of GHG emissions and eventual large-scale carbon sequestration schemes (IPCC, 2007c).

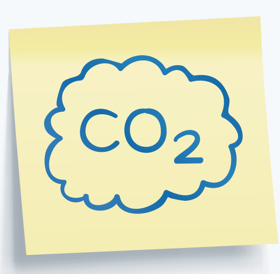
The federal government is engaged in an evolving consideration of limiting the emissions of GHGs. In 2007, the U.S. Supreme Court ruled that the Environmental Protection Agency had the statutory authority to regulate GHG emissions, as the court determined that emissions could lead to detrimental effects on health and welfare. The type and scale of federal regulation ultimately lies with Congress. Legislation considered by Congress, such as the Lieberman-Warner Climate Security Act of 2008 (S.2191) and the McCain-Lieberman Climate Stewardship Act of 2003 (S.139), provided restrictions on the emission of GHGs. Paltsev et. al. (2007) provides a detailed analysis of seven cap-and-trade plans proposed in the U.S. Congress as of early 2007 using a computable general equilibrium model of the world economy incorporating EPA data on GHG emissions. Economic welfare losses range from 0.06 to 0.55 percent by 2020 with CO_2 prices varying \$7-53/ton. By 2050, escalators in the proposed laws could increase carbon prices to \$39-210/ton. At ~\$27/ton CO_2 equivalent, the authors estimate that the added cost to coal will be 207 percent, natural gas will be 28 percent, and oil will be 30 percent based upon base price averages from 2002-2006. Coal prices are predicted to increase from 2030-2050 due to the rise of carbon capture and storage (CCS) technologies. Oil prices are predicted to increase nearly 50 percent, and gas prices double. Electricity prices are expected to increase over 50% in the face of GHG regulation, as consumers substitute lower carbon intensity electricity for fossil fuels. According to the author, energy consumption is reduced at all levels of GHG regulation as compared to the reference case through 2030. Coal consumption decreases markedly, with natural gas filling the majority of the void. The quantity of oil is not as sensitive to less stringent GHG regulations. Renewable energy grows in all scenarios, although growth is the fastest with a greater price of GHG emissions.

In a similar study the economic impacts of the proposed Lieberman-Warner Climate Security Act of 2007 (S.2191) (EIA, 2008a) were analyzed. The cap-and-trade proposal would commence in 2012 with a cap 7 percent below 2006 levels and progress to 39 percent below 2006 levels in 2030. The Reference case represents energy growth with no GHG emissions regulation. The "Core" Case "represents an environment where key low-emissions technologies, including nuclear, fossil with carbon capture and sequestration (CCS), and various renewables, are developed and deployed in a timeframe consistent with the emissions reduction requirements without encountering any major obstacles, even with rapidly growing use on a very large scale, and the use of offsets, both domestic and international, is not significantly limited by cost or regulation". The rate of growth of energy use is expected to decline under the Lieberman-Warner legislation, especially coal, as much as 4.6 quadrillion Btu. The escalating price of GHG emissions reduces coal further over time. Liquid fuel consumption is universally reduced, although the impact is limited. Natural gas is not impacted as significantly as coal because of the lower carbon intensity. Renewable energy benefits over the reference case in all GHG regulation cases.

The EIA forecasts strong growth in renewable energy, but also sees growth for the coal, oil, and natural gas industries through 2030. The manner in which fossil fuels are utilized is forecasted to change with carbon regulation, but overall consumption is predicted to increase. Demand for Powder River Basin Coal is expected to grow through 2030, as is demand for Western natural gas production. Overall, the EIA forecasts strong demand for Wyoming's energy production through 2030.

The existing literature contains little information regarding the ramifications of federal climate change legislation on energy-dependent states. The complex regulation-driven interaction between different fossil fuels and renewable energy, particularly wind energy, can have profound impacts on the fiscal well-being of energy producing states. Ford (2008) explored the impacts of an explicit price for GHG emissions in the western electricity system. The author simulates the impact of the adoption of Senate Bill 139 (McCain-Lieberman Bill) with a base price of \$22/ton of CO_2-e (CO_2 equivalent) in 2010 and escalating to \$60/ton in 2025. Using a simulation model, Ford determined that the source of electricity in the Western Electricity Co-ordination Council (WECC), which includes Wyoming, would move away from coal towards renewables, primar-

The EIA forecasts strong growth in renewable energy, but also sees growth for the coal, oil, and natural gas industries through 2030. The manner in which fossil fuels are utilized is forecasted to change with carbon regulation, but overall consumption is predicted to increase.



ily wind, and combined cycle gas turbines.

The model used in this study simulates market responses within a system dynamics state tax revenue framework (Geiger et al., 2010). Two scenarios are considered: The reference scenario where no Federal action occurs, and a scenario modeling the Lieberman-Warner (S.2191) bill. The Reference Scenario considers production, prices, and tax revenue at $0/ton CO_2-e. In the GHG Policy Scenario a carbon tax is applied to all fossil fuels based upon the fuels carbon intensity. Both production and real prices increase in the Reference Scenario through 2030, tax revenue is also predicted to increase to nearly $6 billion annually.

In the Reference Scenario both natural gas and oil revenues experience the greatest expansion (Figure 1). Coal revenues increase more gradually, and wind energy revenues remain small (undetectable at the scale of Figure 1). With no federal action regarding climate change, Wyoming's real energy derived tax revenues are expected to increase 78 percent from 2007-2030. Total tax revenue from energy over the time period is over $107 billion. Natural gas provides 53 percent of total revenue over the time period and wind provides 0.31 percent of revenue.

Following the steep decline through 2010 with the current recession, tax revenues are expected to grow steadily, which concurs with independent forecasts (CREG, 2009). If EIA forecasts of price and production are assumed, the only source of error is the proportion of national/regional production provided by Wyoming. As previously discussed, the proportion of production is held constant at 2007 levels; this may not accurately reflect future production in Wyoming. For example, with heightened interest in Wyoming's wind resource, limited current development, and new interstate transmission infrastructure, wind energy in Wyoming may experience more rapid growth than the country as a whole. Therefore, wind energy may be underreported in the model. Wyoming's oil industry has generally been in decline since the 1970's, although enhanced oil recovery has recently led to a slight increase. Therefore, oil production and revenues could be overstated.

GHG Policy Scenario

The GHG Policy scenario is based upon the Lieberman-Warner proposal in Congress, which was the leading proposed legislation. An explicit price for GHG emissions commences in 2012 at $10/ton CO_2-e. From 2012 to 2020, the price increases incrementally at a constant rate to $30/ton. From 2021 to 2030, prices increase evenly to $61/ton. This scenario receives the most analysis, due to the likelihood of GHG emissions regulation taking a form similar to this legislation.

The level of production, and total tax revenue are presented in Figures 2 and 3 and as expected,

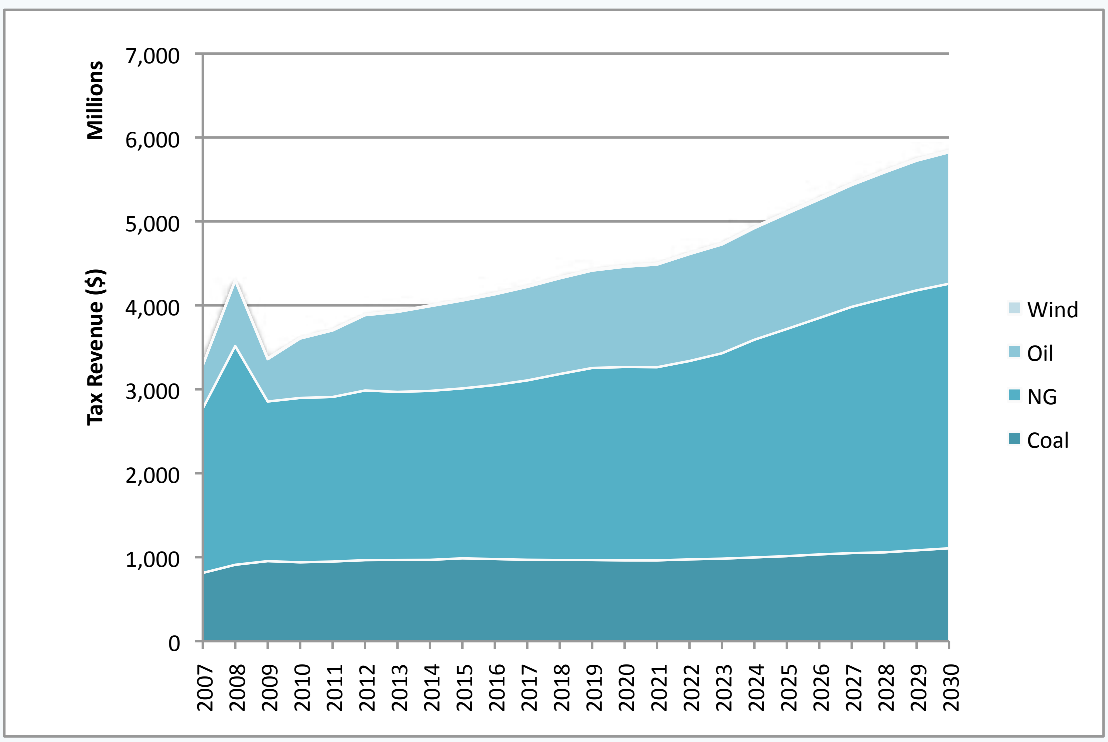


Figure 1. Tax Revenue in the Reference Scenario.

With no federal action regarding climate change, Wyoming's real energy derived tax revenues are expected to increase 78 percent from 2007-2030. Total tax revenue from energy over the time period is over $107 billion.

the imposition of a price for GHG emissions leads to a decline in high carbon intensity coal. The increased price overwhelms the relative inelasticity of coal and the EIA estimated increase in production. Due to coal providing such a large share of total energy production (78 percent of energy in 2007), overall energy production also declines markedly. Natural gas production, the second largest source of energy, increases, but the elevated level of production does not offset losses in coal. Oil is not drastically impacted due to its very low price elasticity and the general EIA trend for increased production. Wind remains a very small portion of primary energy production in Wyoming.

Prices change through the demand and supply relationships. Coal prices slowly decline until reaching zero in 2026. The model then predicts a negative price for coal, which is reflected as zero in calculations for tax revenue. (Tax revenue cannot be negative.) Natural gas price increases through 2030, reflecting EIA forecasted price increases and an increase in quantity demanded for the relatively low carbon intensity energy source (demand response). Oil prices increase drastically reflecting higher demand for the moderate carbon intensity fuel. The reference case also predicted a significant increase in oil prices. The price of wind energy also responds positively, as demand for wind increases with the large decline in coal production.

Overall tax revenue increases in the GHG Policy Scenario by 14.07 percent over the Reference Scenario. The increase comes despite the significant decline in coal revenues and is driven by growth in natural gas and oil tax revenues due to both increased production and prices. Wind energy tax revenue also grows drastically (418 percent) over the duration of the simulation, but the amount contributed is still very minor compared with fossil fuels.

Implications

These results have several important implications for Wyoming's energy dependent economy. The potential for climate change legislation to be beneficial is likely despite our coal dominance. Climate change legislation devalues this resource if utilized with existing technologies. The price of oil and natural gas will also increase with an explicit price for carbon, exerting downward pressure on demand. Loss of demand would theoretically depress prices received by producers. However, without considering market substitution responses, wind energy appears to be the only clear winner under federal action. However, this fails to consider the interrelationship between energy resources. The growth in demand for higher value natural gas overwhelms the loss of coal and growth in wind.

Regional and local impacts of a rapidly declining coal industry could be devastating to parts of this state. However, some coal producing areas are

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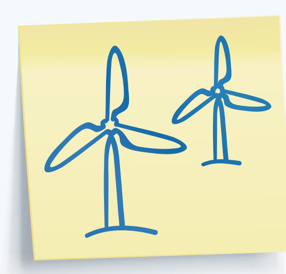

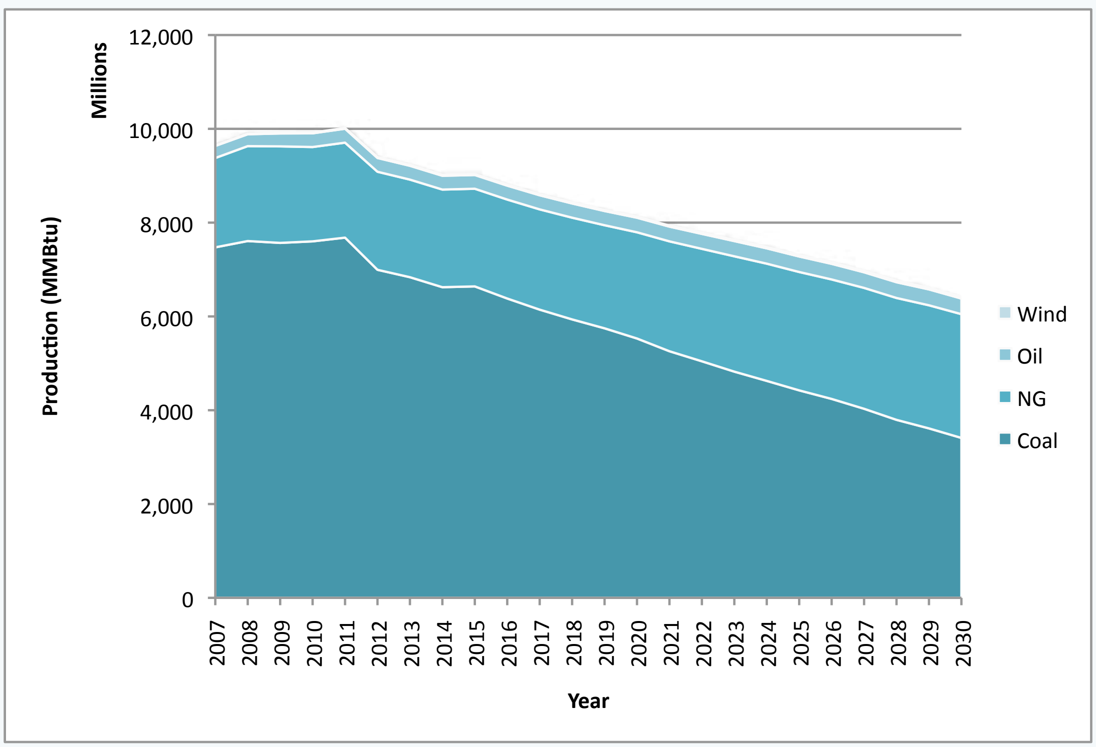

Figure 2. Energy Production in the GHG Policy Scenario.

also blessed with significant natural gas and oil resources, which could mitigate some of the declines in coal production. There would still be large-scale structural changes and unemployment with the loss of the coal industry.

The small contribution of the wind energy created tax revenue is also important. Under its existing tax structure, wind energy cannot readily replace revenues created by fossil fuels. This is not to diminish the potential for growth of revenue created by wind energy. The local taxes, landowner payments, and job creation could certainly be regionally important and also creates a sustainable revenue base that will not be depleted in the future.

References

DOE EIA, 2009a. Annual Energy Outlook 2009.

DOE EIA, 2009b. Annual Energy Outlook 2009.

DOE EIA, 2008. Annual Energy Outlook 2008.

Ford, A., 2008, Simulation scenarios for rapid reduction in carbon dioxide. Energy Policy 36: 443-455.

Geiger, et al. 2010. "Potential Impacts of Federal Regulation of Greenhouse Gas Emissions." Departmental Working Paper. University of Wyoming, Laramie, WY.

Intergovernmental Panel on Climate Change 2007a. The climate change basis Contribution of working group I to the fourth assessment of the intergovernmental panel on climate change. Solomon, et al., (eds.).

Intergovernmental Panel on Climate Change, 2007b. Impacts, adaptation, and vulnerability. Contribution of working group II to the fourth assessment of the intergovernmental panel on climate change. Parry, et al., (eds.).

Intergovernmental Panel on Climate Change, 2007c. Mitigation. Contribution of working group III to the fourth assessment of the intergovernmental panel on climate change. Metz, et al., (eds.).

Paltsev, et. al. 2007. Assessment of U.S. Cap-and-Trade proposals: Massachusetts Institute of Technology Center for Energy and Environmental Policy Research, 07-005.

State of Wyoming DAI, 2009.

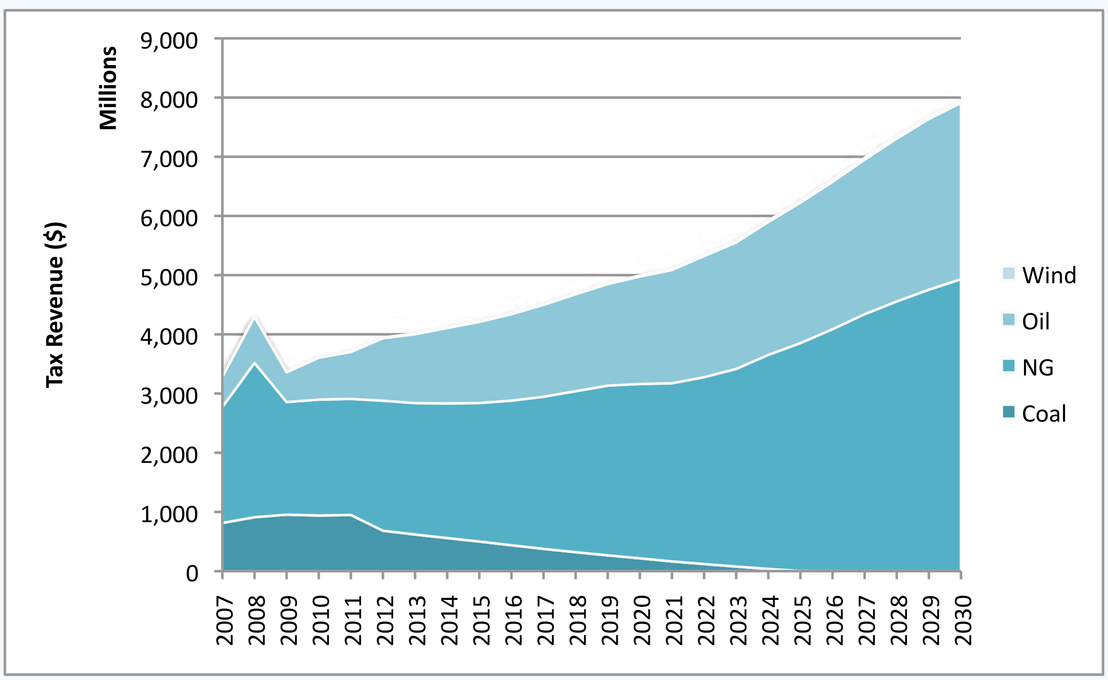

Figure 3. Tax Revenue in the GHG Policy Scenario.

Regional and local impacts of a rapidly declining coal industry could be devastating to parts of this state. However, some coal producing areas are also blessed with significant natural gas and oil resources, which could mitigate some of the declines in coal production.

Can Rangeland Carbon Sequestration Help Livestock Producers and Rural Economies Adapt to Climate Change?

BY JOHN P. RITTEN, BENJAMIN S. RASHFORD, AND CHRISTOPHER T. BASTIAN

Introduction

Despite its shrinking role as a contributor to income and employment (Bowers et al., 2000), agriculture remains the life-blood of many rural communities. This is especially true in the rangeland dominated Rocky Mountain West, where livestock production provides economic, political and social stability amidst the boom-and-bust cycles of energy development and tourism. The vital role livestock ranching plays in the rural West depends upon ranches remaining viable while facing the potential for climate change to alter the character and productivity of western rangelands.

From North Dakota to California, rangelands constitute over half of the land area in western states and are an irreplaceable input to livestock production. The latest scientific evidence suggests climate change has already negatively impacted western rangelands and the livestock industry that depends upon them (see CCSP, 2008). The increasing temperatures, higher frequency of prolonged drought, and heat waves predicted for the future are likely to further stress livestock production. The expected effects of climate change on livestock, however, are somewhat ambiguous, with some positive effects (e.g., increased forage production from elevated CO_2 levels) and some negative effects (e.g., lower livestock yields from heat stress). Given the complex relationship between climate, rangeland productivity, and livestock production, western producers need reliable income streams to buffer against the unpredictable effects of climate change. In this article we review the potential impacts of climate change on livestock production and consider

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whether markets for carbon sequestration could help livestock producers offset the economic impacts of climate change while simultaneously contributing to its solution.

Impacts of Climate Change on Livestock Production

Climate change is expected to impact livestock production through at least two mechanisms – impacts on forage quantity and quality, and direct impacts on livestock health. Higher atmospheric carbon dioxide (CO_2) concentrations and associated warmer temperatures will likely increase forage quantity (e.g., thru longer growing and grazing seasons). Forage quantity increases, however, could be partially or completely offset by reductions in forage quality due to lower plant nitrogen, protein and digestibility. Additionally, species composition on rangelands is likely to continue to shift (e.g., woody and invasive species encroachment) further reducing available high quality forage. The need for dietary supplements will likely rise as a result of these forage impacts, causing livestock production costs to rise (Karl et al., 2009).

Animal health will also be negatively impacted by climate change (Adams and Peck, 2008; Karl et al., 2009). Livestock will suffer from increased heat stress during the day, less effective nighttime relief, and increased vulnerability to new or simply more-abundant parasites and disease pathogens. Regions that do not directly experience losses to extreme heat might still be negatively affected by increased production costs in other regions. Cow-calf producers in the relatively cool Rocky Mountain West, for example, might experience reduced demand for feeder cattle due to increased production costs at feedlots, which tend to be located in warmer regions of the country.

It is difficult to predict how the varied and uncertain impacts of climate change will affect livestock production income. Research on the effects of extended droughts (the frequency of which may increase) and precipitation variability, however, likely provide a relevant projection of firm level impacts from climate change.

A survey of Wyoming livestock producers following the last period of severe drought (2000-2004) suggests that climate change could have significant negative economic impacts. Producers reported reductions in grazing capacity (from 16 to 31 percent below normal), irrigation water supplies (from 12 to 22 percent below normal), and winter feed production (from 18 to 35 percent below normal) [see Nagler et al., 2007 for full survey results]. Reduced feed availability coupled with other responses to drought also reduced sale weights and weaning percentages (each dropped from 4 to 6 percent below normal). Respondents also reported negative impacts to owner equity, which although small (7 percent reduction) suggest that longer term impacts from climate change could affect long-term ranch viability.

Ritten et al. (2010a) specifically examine the potential impacts of climate changed weather on stocking rates and profitability for stocker cattle operations in central Wyoming. The climate scenarios they analyzed included a 10.25 percent decrease and a five percent increase (5th and 95th percentile projections, respectively) in average growing season precipitation, each with more variability than historical conditions.

They conclude that increased variability in precipitation will have significant impacts on rangeland livestock production – decreasing profitability while requiring more adaptive management. Increased variability forces producers to reduce average stocking rates and to alter stocking rates more drastically. Their results suggest that even if mean precipitation increases, the increase in variability will result in a 19 percent decrease in annual profitability. In their worst case scenario (reduced precipitation with greater variability) revenues decline by over 23 percent.

Carbon Sequestration on Rangelands

The above discussion suggests that climate change may cause significant decreases in livestock production and associated incomes; therefore, livestock producers need new income streams to buffer the impacts of climate change. Emerging environmental markets could provide a possible solution. The 2008 Farm Bill contains programs to help quantify environmental and societal benefits from grazing land improvements, as well as programs which set the stage for improved sequestration of soil organic carbon (SOC), the recognition of possible greenhouse gas (GHG) emission offsets, and the ability of producers to participate in emerging environmental markets (Follett and Reed, 2010).

One recent environmental market development offering potential revenues for rangeland managers is the US-based Chicago Climate Exchange (CCX). The CCX, though now largely defunct, issued GHG emission offset contracts for SOC sequestration due to improved rangeland management practices. Approved practices included moderate stocking rates, rotational grazing, and seasonal use (CCX, 2009). Producers are able to sell carbon sequestered on western rangelands on the CCX based on fixed per acre sequestration rates. Rates varied from 0.12-0.27 metric tons of CO2-equivalent per acre per year. Prices reached a high of $7.40 per ton in 2008, but have fallen drastically in recent years.

Even during times of higher prices, the carbon markets did not offer especially attractive incentives to rangeland managers in the western U.S. A simulation based on actual prices from 2005-2009 revealed that, after all fees were paid, producers could expect to earn $0.15-$0.44 on average per acre per year depending on geographic location (Ritten et al., 2010b). Accounting for timing of payments, these contracts generated an average net present value (NPV) of $0.59-$1.79 per acre over the five-year life of a carbon contract. Returns, however, were highly variable with NPVs ranging from $0.17-$3.82 on lands with low sequestration rates, and from $0.18-$7.12 on lands with high sequestration rates.

These relatively modest returns to rangeland carbon sequestration are unlikely to cover the costs of required rangeland improvements let alone buffer against the impacts of climate change. Higher carbon prices projected with some cap and trade legislation scenarios, however, may make these sorts of contracts more appealing (Figure 1). Simulations consistent with proposed legislation produce annual payments exceeding $2.50 per acre per year (Ritten et al., 2010c).

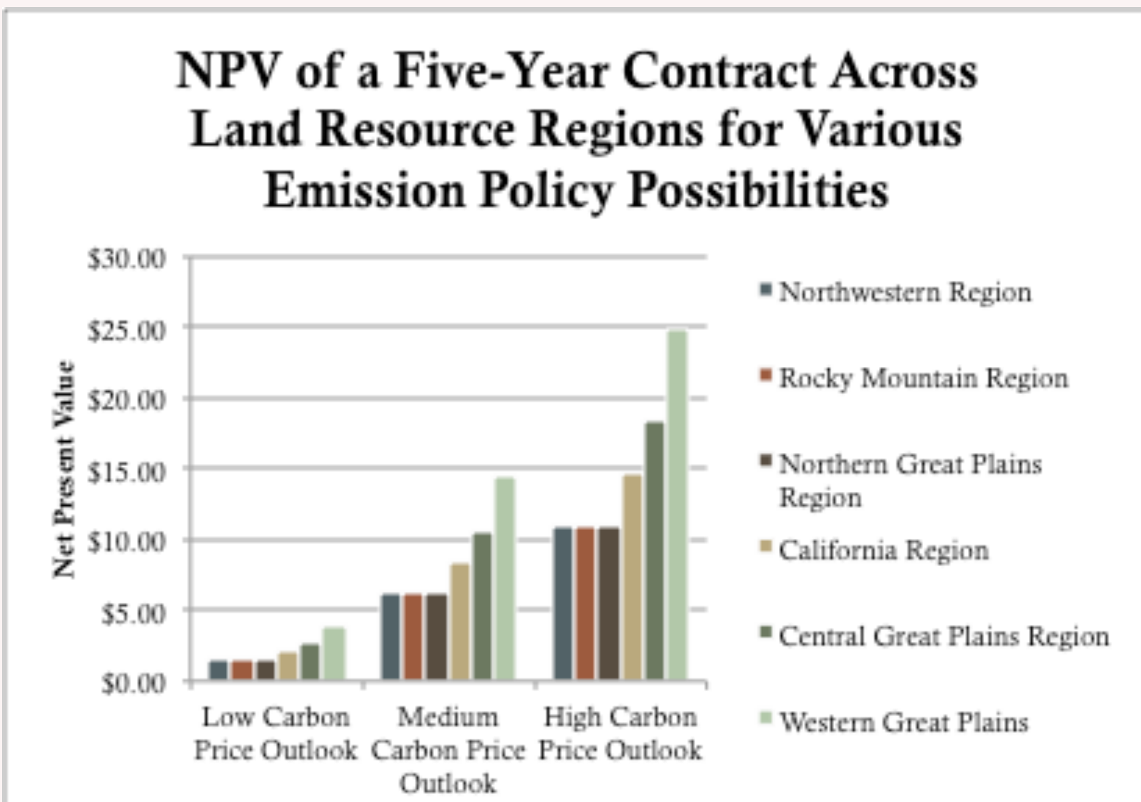

Figure 1. Comparison of Net Present Values Based on Estimated Carbon Prices for Various Emission Policies. (From Ritten et al., 2010c.)

We combine the predicted impacts of climate change on livestock returns (Ritten et al., 2010a) with the simulated returns from carbon sequestration contracts (Ritten et al., 2010b) to determine the potential for carbon markets to offset the impacts of climate change (Figure 2). Carbon sequestration contracts given historical prices realized on the CCX would do little to offset the predicted economic impacts of climate change. Even if climate change increases precipitation (Scenario 2), returns per acre decrease by significantly more than can be offset with a carbon sequestration contract given historical prices ($3.23 vs. $0.15). If cap and trade legislation is realized, however, carbon sequestration contracts have the potential to meaningfully buffer some of the impacts of climate change. With higher carbon prices, sequestration contracts could offset 70-85 percent of the predicted revenue losses from climate change.

Although our results suggest that markets for rangeland carbon sequestration could help livestock producers buffer the negative impacts of climate change, particularly if legislation induces the upper end of projected carbon prices, there is plenty of room for pessimism. The CCX's rangeland sequestration program has essentially gone belly-up, and there has been little progress in Washington towards the comprehensive climate legislation needed to renew carbon markets. Thus, unless the political climate changes faster than the actual climate, livestock producers and rural communities will likely face challenges and may need to rely on their standard tools – resourcefulness and ingenuity – to adjust to the changing climate.

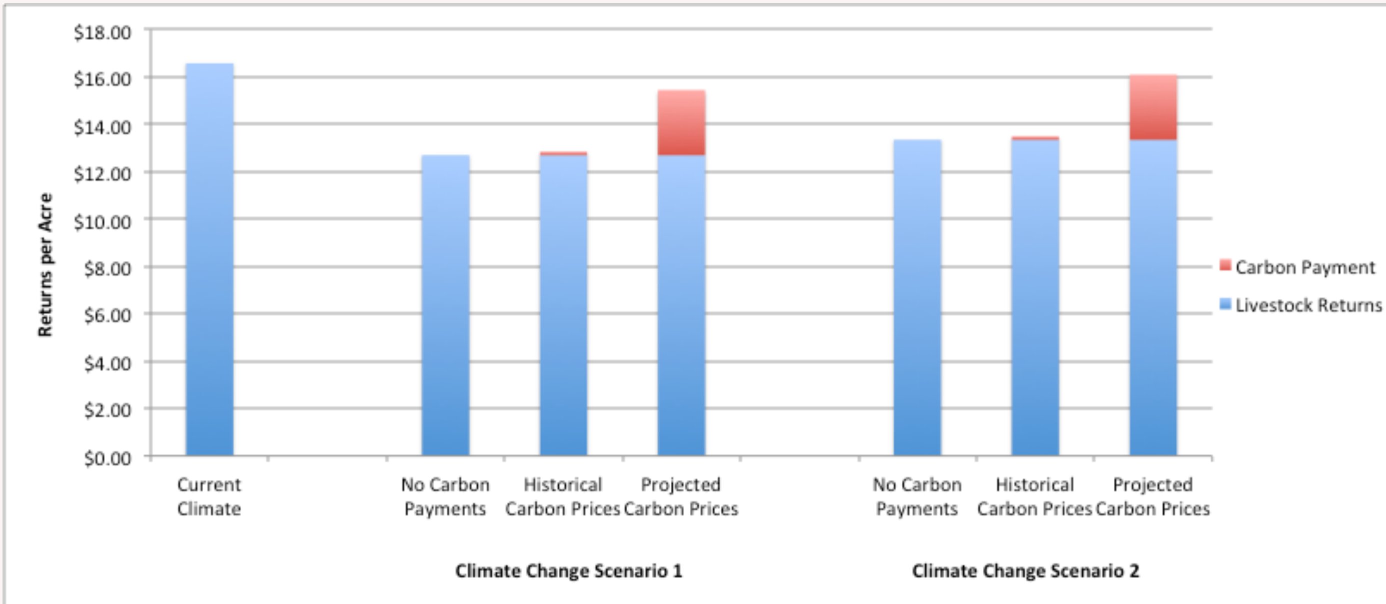

Figure 2. Impacts of alternative carbon sequestration payments to returns to rangelands in western Wyoming under two potential climate change scenarios. Scenario 1 represents a 10.25 percent reduction in mean growing season precipitation, while Scenario 2 represents a five percent increase in mean growing season precipitation. Both scenarios include wider variability in precipitation across years.

Recommended Reading

CCSP (Climate Change Science Program). 2008. The effects of climate change on agriculture, land resources, water resources, and biodiversity in the United States. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Backlund, et al. U.S. Department of Agriculture, Washington, D.C., USA, 362 pp.

Campbell, S. , S. Mooney, J. P. Hewlett, D. J. Menkhaus, and G. F. Vance. 2004. Can ranchers slow climate change? Rangelands, 26(40): 16-22.

Ribera, L. A., B. A. McCarl, and J. Zenteno. 2009. Carbon sequestration: a potential source of income for farmers. Journal of the American Society of Farm Managers and Rural Appraisers, 72: 70-77.

References

Adams, et al. 2008. Effect of climate change on drought frequency. Pp. 117-130.

Bowers, et al. (eds). 2000. Rural Connections and Trends, 10(2): 89.

CCX (Chicago Climate Exchange). 2009. Chicago Climate Exchange Sustainably Managed Rangeland Soil Carbon Sequestration Offset Project Protocol. Available at: http://www.chicagoclimatex.com.

Follett, et al. 2010. Soil carbon sequestration in grazing lands. Rangeland Ecology and Management, 63(1): 4-15.

IPCC, 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC. Solomon, et al. (eds.).

Karl, et al. (eds). 2009. Global climate change impacts in the U.S.

Nagler, et al. 2007. “Multiple impacts–multiple strategies.” CES, University of Wyoming, Laramie. Bulletin B-1178.

Ritten, et al. 2010a. Optimal stocking decisions. American Journal of Agricultural Economics, 92(4): 1242-1255.

_____. 2010b. Do Current Incentives Encourage Managers? Working Paper, Dept. of Agricultural and Applied Economics, University of Wyoming.

_____. 2010c. “Will Carbon Find a home on the Range?” Poster presentation at the Agricultural and Applied Economics Assoc. Annual Mtg. Denver, CO. July 26, 2010.

anaerobic DIGESTION in the Pacific Northwest

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Concerns about climate change have increased interest in anaerobic digestion (AD), a commercially available technology increasingly used to treat livestock manure on concentrated animal feeding operations (CAFOs). AD can provide climate benefits because it generates and captures methane, a powerful greenhouse gas[1], in a controlled environment. In the absence of AD, methane is generated from manure as organic materials decompose in oxygen-deprived conditions, and is released directly to the atmosphere (Mosier et al., 1998). By enhancing methane generation and capturing it, methane emissions are avoided. When burned, the methane-rich biogas can replace fossil-fuel generated energy, generating additional positive climate impacts. These two climate benefits can generate financial returns through the sale of carbon credits for manure management and renewable energy generation offsets.

AD technology creates an environment without oxygen (anaerobic) in which naturally-occurring microorganisms convert complex organic materials in manure and other wet organic wastes such as food processing wastes to biogas, a source of renewable energy (US-EPA, 2006), as well as fiber and a liquid effluent (Figure 1). Value-added products may also be produced if appropriate and economical technologies can be developed. In addition to reducing greenhouse gas (GHG) emissions, the process can reduce odors, stabilize waste, and decrease pathogen counts, greatly enhancing manure management efforts (Martin and Roos, 2007; US-EPA, 2004; US-EPA, 2005; US-EPA, 2008).

AD technologies are much more widely used in Europe than in the U.S., where concerns about high capital costs and poor return on investment have led to low adoption rates. In 2004, only two farms in the Pacific Northwest (PNW) had operational anaerobic digesters. Washington State University's Climate Friendly Farming (CFF) Team, in collaboration with industry, non-

[1]Methane has 25 times more global warming potential than carbon dioxide over 100 years (IPCC, 2007).

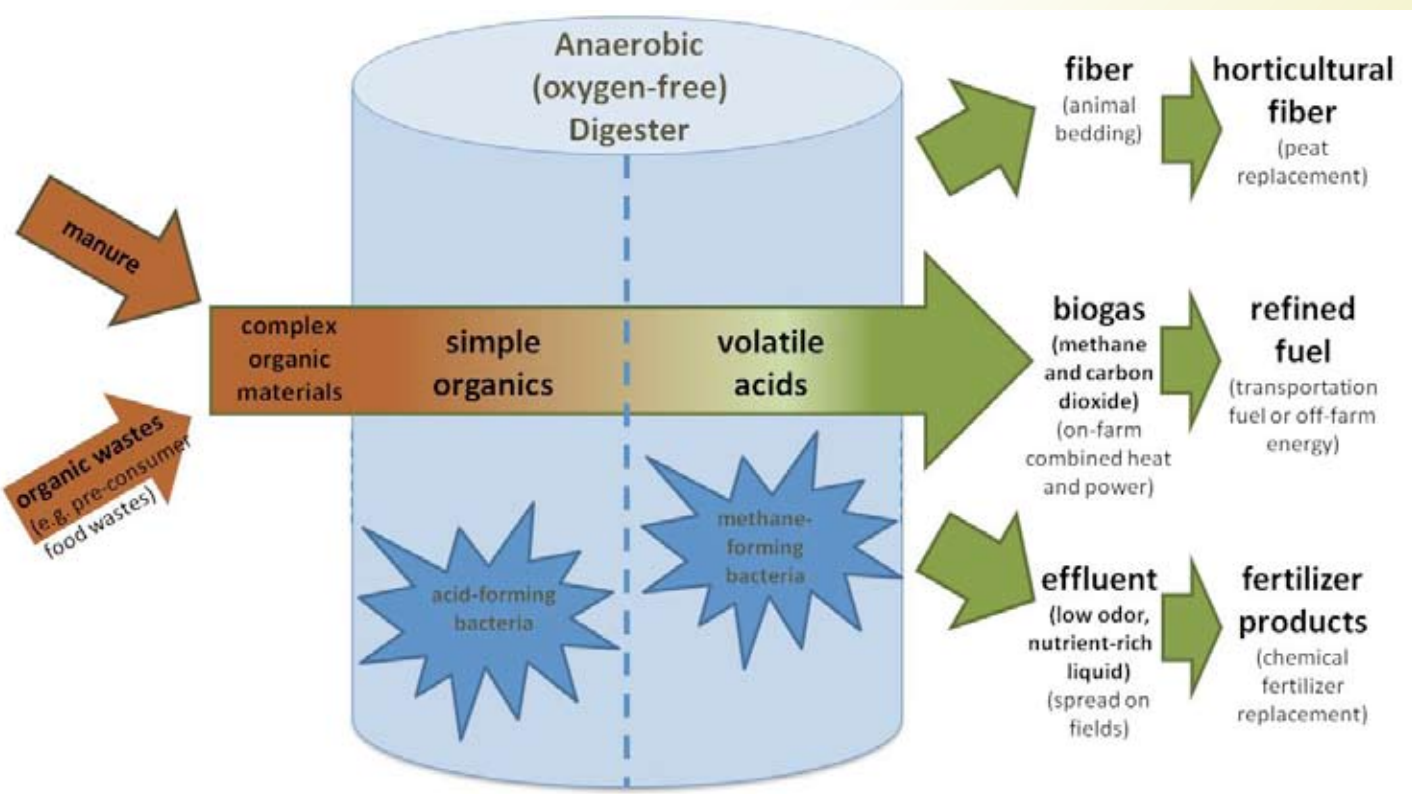

Figure 1. Overview of anaerobic digestion.

governmental organizations, and government agency partners, launched a comprehensive program to evaluate existing and develop new AD technology, support installation of a commercial digester on a PNW dairy farm, analyze the financial drivers for AD in our region, improve the management of AD systems (including improved understanding of the benefits of co-digesting manure and food processing wastes), research and develop co-product technologies to increase financial returns, and support the development of effective public policy to encourage deployment of AD technology.

This article focuses on two aspects of the research of particular interest to producers in the West: our financial assessment of a commercial scale digester with a special focus on co-digestion of food processing wastes, and ongoing research to develop technologies to recover nutrients from AD effluent.

Financial Assessment

To help prioritize technology development efforts, the economics of digester operation were analyzed using financial data from a commercial scale anaerobic digester installed with CFF support on a dairy farm in northwest Washington State.[2] The analysis considered a scenario based on actual construction costs (with grants covering a portion of these costs), manure from a 500-cow on-farm herd and 250 cow herd one mile away, and co-digestion of pre-consumer food processing wastes (16 percent by volume). Revenues were generated from electricity sales, tax credits for renewable energy generation, greenhouse gas offsets, tipping fees from food processing wastes, and fiber. The majority (85 percent) of fiber was used on farm as a bedding replacement, while 15 percent was upgraded for sale as a soil amendment after pretreatment by a patented process developed through the CFF Project (MacConnell, 2006; MacConnell et al., 2007; Liao et al., 2010).

Previously, the most documented and studied revenue stream from AD was electrical sales from power production. However, in the PNW, where received prices for produced electricity are well below the national average of $0.09/kWh (US-EIA, 2010), our analysis confirmed that other revenue streams are important to financial viability and stability. With only revenues from electricity produced from manure from 500 cows on farm, the project had a negative net present value -$644,556, and a modified internal rate of return of only 1.8 percent, lower than the discount rate (Bishop and Shumway, 2009).[3,4] This negative financial picture is partly attributable to the “oversizing” of the project (designed for 1,500 cows), resulting in high total construction costs of $1,136,364. Sizing was done to allow for possible future farm expansion, use of trucked-in manure from nearby farms, and utilization of other imported organic materials. A similar analysis carried out by the U.S. EPA (2004) noted that for digesters dependent on the sales of electricity, economic feasibility was dependent upon proper digester sizing and adequate electricity prices, both of which were more positive in their study.

When all additional revenue streams were considered, the economics of the project became quite positive. Operating revenues were significantly larger than operating expenses (Figure 2), and the entire project had a net present value of $1,375,371, and a modified internal rate of return of 9.9 percent (Bishop and Shumway, 2009). Surprisingly, further analysis indicated that trucking in manure from a neighboring farm had a negative impact on project economics in the case of the test digester, despite the relatively short travel distance of one mile (Bishop and Shumway, 2009). This finding may have important implications for projects that plan to transport liquid manure by truck, suggesting that economic feasibility should be carefully considered.

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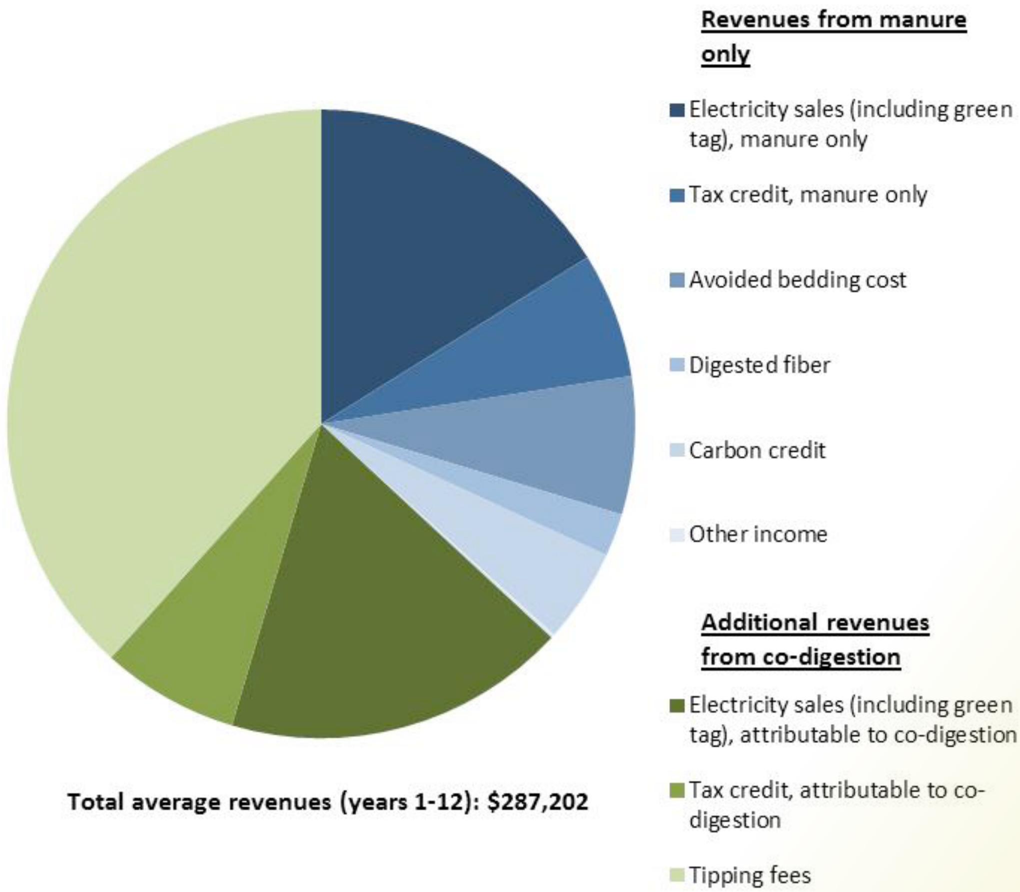
[2]The digester was a patented modified plug-flow digester with axial dispersion and sludge recycling.

[3]For investment in the digester to be considered feasible, the net present value (NPV) must be positive, meaning that the rate of return on the investment is greater than the cost of the capital (i.e., the interest rate). The modified internal rate of return (MIRR) is a modification of the internal rate of return (IRR) that corrects for the fact that internal rate of return (IRR) calculations assume that any potential revenue can be re-invested in the project and earn equal returns, an assumption that is often considered overly optimistic. For the project to be considered economically feasible, the MIRR must be greater than the minimum acceptable rate of return, normally the discount rate (Kay and Edwards, 1999).

[4]For their analysis, Bishop and Shumway set the discount rate to 4.0%, based on the average of the 4.3% rate of return to U.S. farm assets reported by Blank for the period 1960-2002 and the 3.4% rate or return to U.S. farm equity based on ARMS data (USDA) for the period 1996-2006.



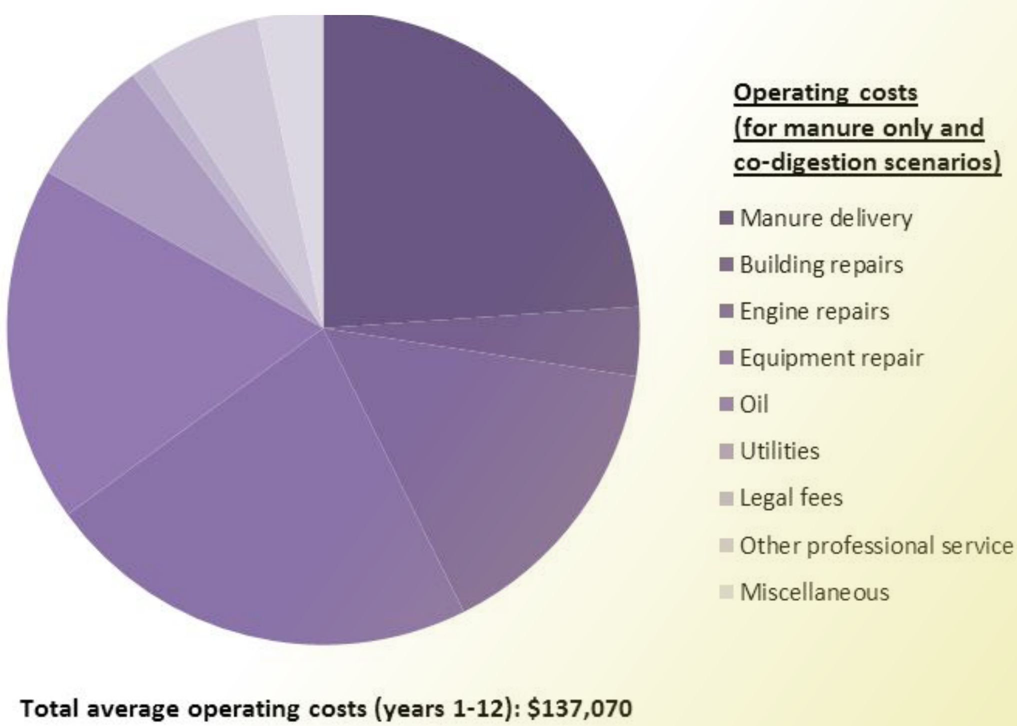


Figure 2. Breakdown of average projected annual operating revenues (top) and expenses (bottom) for anaerobic digester installed in northwest Washington, carrying out co-digestion of 16 percent pre-consumer food processing wastes with dairy manure. Financial data was collected from 2004-2007. For details of data collection and assumptions underlying financial analysis and digester performance, see Bishop and Shumway (2009) and Frear et al. (2010).

Co-digestion was by far the strongest contributor to financial performance, accounting for 63 percent of average annual project revenues (see green shaded portions of revenues chart in Figure 2). Food wastes roughly doubled methane production (and therefore electricity and tax credit revenues), because of the higher energy content of food processing wastes compared to manure. These results are consistent with other commercial and laboratory-scale studies indicating that biogas production can be enhanced by 25–400 percent, depending upon the type, concentration, and flow rate of the organic waste stream (Alatriste-Mondragon et al., 2006; Braun et al., 2003). Meanwhile, tipping fees received by accepting the wastes was the largest single project revenue source. Based on these results, locating digesters in areas where strong relationships can be formed with food processors may be important to project success.

The sale of carbon credits did contribute to overall project revenues, but made a relatively minor contribution. This may be important, because the prices of carbon credits through the Chicago Climate Exchange have been quite volatile over the past few years, and at times quite a bit lower than they were when the data underlying this analysis was gathered in 2004-2007. However, even without the consideration of carbon credits, the net present value of the project (considering all other revenue streams) was $1,185,416, and the modified internal rate of return was 9.3 percent (Bishop and Shumway, 2009).

Nutrient Management

While the financial analysis included many revenue streams, it did not incorporate analysis of the potential impact of refining biomethane into transportation fuel, or producing fertilizer-grade nutrients. Each of these technologies is still in development, with ongoing efforts by CFF Project researchers.

However, several considerations indicated that technology development for nutrient products was particularly important. First, farms that accept food processing wastes for co-digestion with manure import additional nutrients to the farm, exacerbating existing nutrient management concerns (Figure 3). Managing these additional nutrients has the potential to create additional costs (costs not captured in our financial analysis), as dairies need to manage the nutrients in compliance with applicable regulations.

Second, communication with dairy industry leaders in the PNW made it clear that nutrient management is a key concern for dairy farmers in our region. As one Washington dairy farmer stated, "We don't necessarily want to be energy producers. We want to milk cows. But...if an anaerobic digester can help us solve our manure

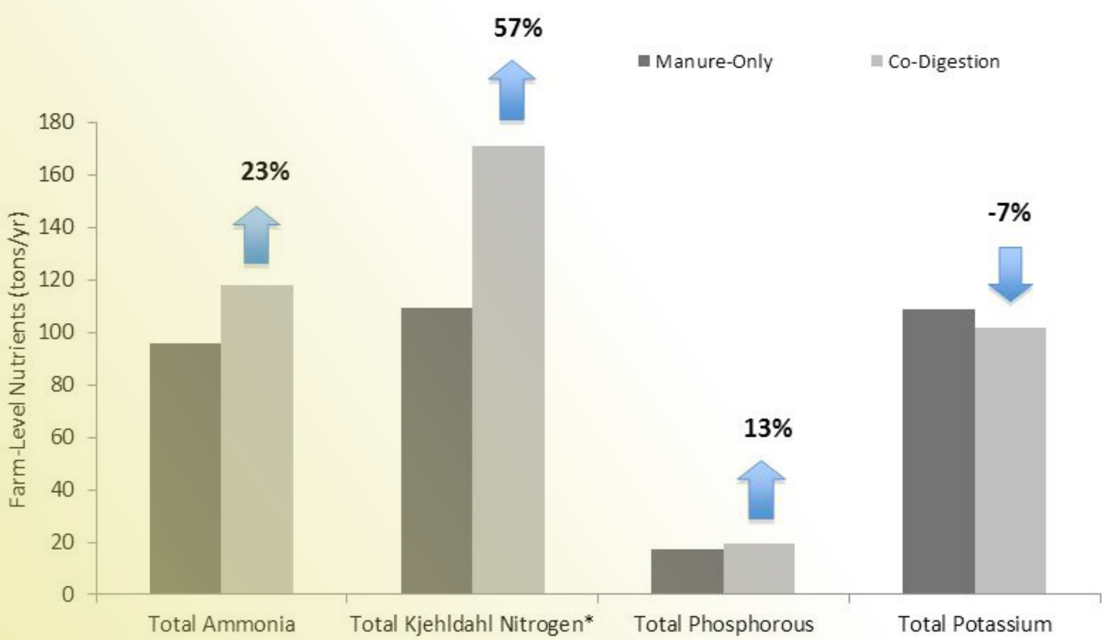


Figure 3. Modeled nutrient impacts of co-digestion with 16% organic wastes on test dairy in northwest Washington.

problems, help with nutrient management, and keep us in the business of producing milk, then…producing energy and mitigating GHG emissions will be welcome side benefits." Thus, a key focus of current research is the development of cost-effective methods for recovering marketable nitrogen and phosphorous from the AD effluent.

Our research has developed an integrated process for removing ammonia and phosphorous from the liquid effluent through the simple addition of heated air, forced into the pre-heated liquid effluent with blowers. After phosphorous and ammonia removal, the pH of the resulting low-nutrient effluent can be re-adjusted using the AD biogas, allowing for field application without additional chemical costs, though sulfuric acid is required to sequester the released ammonia in a stabilized ammonium sulfate solution. This process also removes some impurities from the biogas, improving biogas quality. A series of bench and pilot tests have confirmed that the integrated process is viable, with economics that could be cost-effective (Zhang et al., 2009; Zhang et al., 2010; Jiang et al., 2008; Jiang, 2009). The process generates two important bio-fertilizer products: an ammonium sulfate solution and a phosphorous rich organic solid.

Commercial-scale evaluation is ongoing with industry partners at two Washington dairies, and we are working with additional industry partners on product formulations that will meet fertilizer purchasers' needs. Future results will be available from WSU's Center for Sustaining Agriculture and Natural Resources. We plan to develop marketable fertilizer products that will further spur AD adoption and aid in nutrient management on dairy farms. Because the industrial processes currently used to manufacture fertilizers (particularly nitrogen fertilizers) may require large amounts of energy, these nutrient products also have the potential to create additional climate benefits if they are used in place of other fertilizer products (IFA, 2009; Zaher et al., 2010).

In addition, we hope that our research will help change the perception of AD technology, from a more limited view of AD as a manure management tool or an "energy technology", to a view that sees AD as a bio-refinery that can produce a number of different products from multiple organic feedstocks. Taken together, this variety of projects has the potential to provide financial stability and enhanced financial returns to dairies and other CAFOs, as well enhancing the beneficial impacts on the climate and rural communities.

RECOMMENDED READING

Climate Friendly Farming Information on the website of Washington State University's Center for Sustaining Agriculture and Natural Resources: csanr.wsu.edu/pages/Home

U.S. Environmental Protection Agency AgStar: epa.gov/agstar/

References

Alatriste-Mondragon, et al. 2006. Anaerobic codigestion. Water Environmental Resources, 78: 607-36.

Bishop, et al. 2009. The economics of dairy anaerobic digestion. Review of Agricultural Economics, 31(3): 394-410.

Braun, et al. 2003. Codigestion of proteinaceous industrial waste. Applied Biochemistry and Biotechnology, 109: 139-53.

Frear, et al. 2010. Baseline performance monitoring of commercial dairy anaerobic digester. CSANR Research Report, 2010-001.

IPCC. 2007. Climate change 2007: The fourth assessment report.

International Fertilizer Industry Association. 2009. Fertilizers, climate change…productivity sustainably. Paris, France: International Fertilizer Association.

Jiang. 2009). Ammonia recovery from digested dairy manure as nitrogen fertilizer. (Doctoral dissertation). Washington State University. Publication No. AAT 3401859.

Jiang, et al. 2008. U.S. Patent Number 12/132,016. Combined nutrient recovery and biogas scrubbing system. U.S. Patent and Trademark Office.

Kay, et al. 1999. Farm management.

MacConnell. 2006. U.S. Patent No. 20060150495. Anaerobically digested fiber for use as a container media substrate. U.S. Patent and Trademark Office.

MacConnell, et al. 2007. Utilization of re-processed anaerobically digested fiber. In Carlile, et al. (eds.). Proceedings of the International Symposium on Growing Media.

Liao, et al. 2010. Leaching-bed reactor for producing stabilized plant growing media. Biosystems Engineering, 106: 278-185.

Martin, et al. 2007. Comparison of the performance of conventional and modified plug-flow digester. Int'l Symposium on Air Quality and Waste Mgmt. for Agriculture.

Mosier, et al. 1998. Mitigating agricultural emissions of methane. Climatic Change, 40: 39-80.

US-EIA. 2010. Monthly electrical sales and revenue report. U.S. Energy Information Administration.

US-EPA. 2004. A comparison of dairy cattle manure management. U.S. Environmental Protection Agency.

US-EPA. 2005. An evaluation of a mesophilic, modified plug-flow. U.S. Environmental Protection Agency.

US-EPA. 2006. Market opportunities for biogas recovery systems. U.S. Environmental Protection Agency.

US-EPA. 2008. An evaluation of a covered anaerobic lagoon. U.S. Environmental Protection Agency.

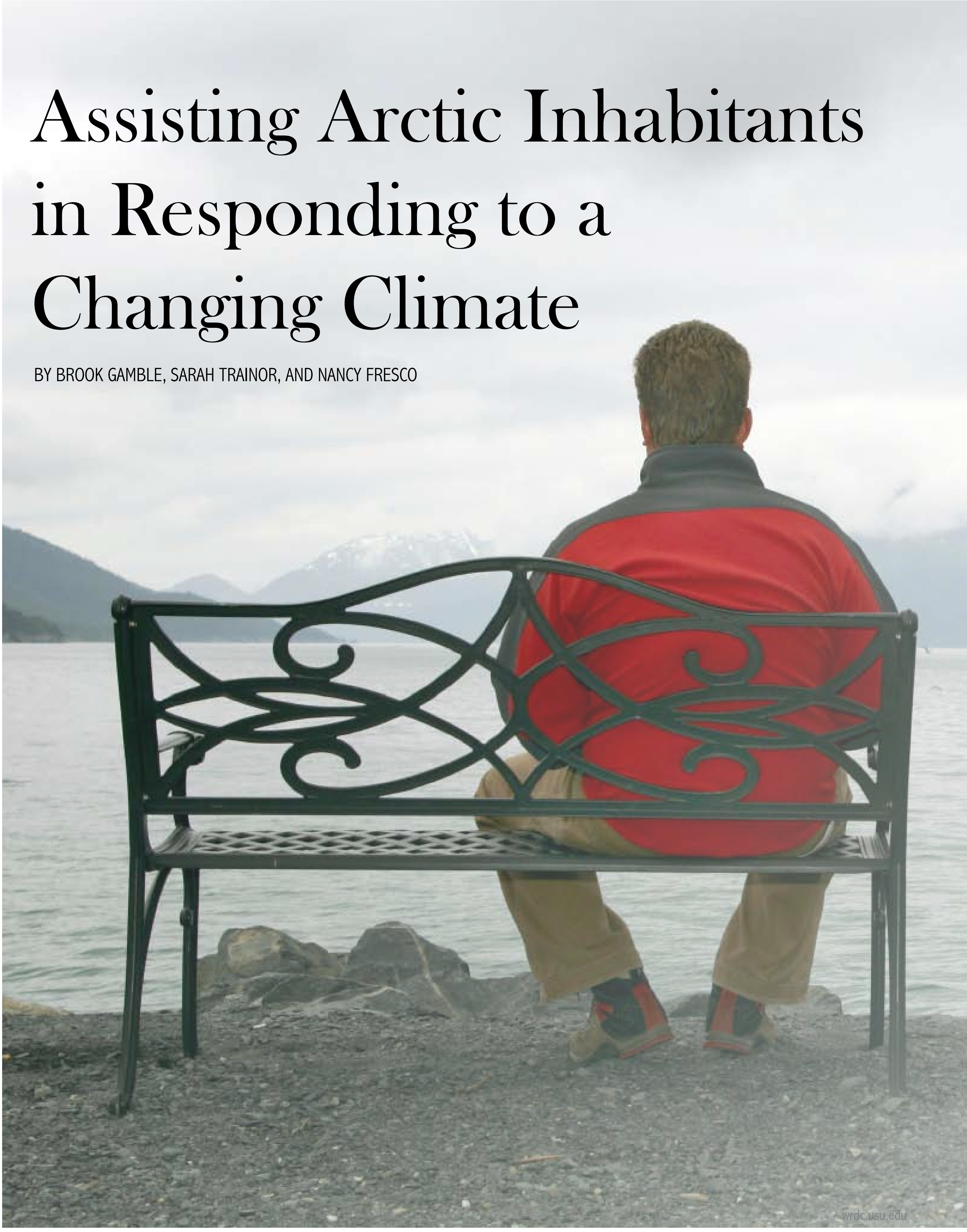
Zaher, et al. 2010. Life cycle assessment of the potential carbon credit. CSANR Research Report, (25): 2010-001.

Zhang, et al. 2010. Releasing phosphorus from calcium. Water Environment Research, 82: 34-42.

Zhang, et al. 2009. Compositions and methods for wastewater treatment. U.S. Patent and Trademark Office.

Assisting Arctic Inhabitants in Responding to a Changing Climate

BY BROOK GAMBLE, SARAH TRAINOR, AND NANCY FRESCO



wrdc.usu.edu

Climate Change in Alaska and the Arctic

Alaska and the Arctic are warming more rapidly than any other place on the planet. Alaska alone has warmed significantly, with a 1.9°C average increase in annual temperature since 1950 and as much as a 50% increase in the length of a frost-free season (Karl, Melillo and Peterson, 2009). The warming trend varies greatly among seasons, with the most warming occurring in winter. General circulation models (GCM) used to project future changes in temperature show that Alaska will experience continued warming and seasonal variability through this century (IPCC, 2007; Walsh et al., 2008).

A changing climate will profoundly affect the Arctic's people and ecosystems, infrastructure, transportation and development, fresh water access, energy production, coastal and living marine resources, agriculture, and traditional food systems. Challenges and opportunities to respond to climate change abound. Demand for information and assistance in adaptation planning is increasing state-wide and information needs are widespread and varied. Stakeholders throughout the state such as Alaska's state government, tribal governments, communities, private industry, as well as the state and federal agencies that manage transportation and natural resources are seeking assistance as they plan for and respond to climate change.

ACCAP and SNAP: Providing Resources to Respond to a Changing Climate

The Alaska Center for Climate Assessment and Policy (ACCAP) and the Scenarios Network for Alaska and Arctic Planning (SNAP), co-located programs at the University of Alaska Fairbanks, work collaboratively together and with regional stakeholders to fill increasing needs for the climate data and information required to effectively plan for the future and the inherent uncertainties of what lies ahead. This collaboration has yielded significant benefit and results for Alaskan stakeholders. A variety of services and approaches make information

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accessible to a wide spectrum of stakeholders with varying levels of technical expertise.

ACCAP is one of NOAA's Regional Integrated Sciences and Assessments Programs (RISA). The competitively funded RISA programs throughout the United States are designed to support research that addresses complex climate issues of concern to decision-makers and policy planners at a regional level. RISA programs focus on "use-inspired science", a process that engages scientists and end users in information needs assessment and collaborative research to inform decision-making (Stokes, 1997). Most RISA centers are strategically co-located with universities to facilitate the information exchange between scientists and end users.

SNAP is a collaborative network of the University of Alaska, state, federal, and local agencies, NGOs, and industry partners. The SNAP mission is to provide timely access to scenarios of future conditions in Alaska for more effective planning by land managers, communities, and industry. The primary products of the network are datasets and maps projecting future conditions for selected variables, and rules and models that develop these projections, based on historical conditions and trends. Models are based on five Global Circulation Models (GCMs) used by the Intergovernmental Panel on Climate Change (IPCC).

These models have been selected for their accuracy in the far north, validated with reference to historical data, and downscaled using the best available fine-scale gridded datasets. Detailed explanations of the assumptions, models, and methods, and uncertainties associated with projections are also provided. Currently most policy and management planning for Alaska and elsewhere assumes that future conditions will be similar to those of our recent past experience. However, there is reasonable consensus within the scientific community that future climatic, ecological, and economic conditions will likely be quite different from those of the past. We now know enough about current and likely future trajectories of climate and other variables to develop credible scenarios by which to plan. SNAP scenarios and the data used to produce them are openly available to all potential users. Stakeholders can access further SNAP network services and expertise by becoming a SNAP collaborator.

Collaboratively, ACCAP and SNAP have developed strong relationships with state and federal agencies, state, municipal and tribal governments, Native and conservation non-profit organizations, the private sector, and emerging regional federal initiatives such as the Department of Interior's Climate Science Center, the U.S. Fish and Wildlife Service Landscape Conservation Cooperatives and the NOAA Alaska Region Climate Services Director and Collaboration Team (ARCTic). We work closely with the University of Alaska Cooperative Extension Service in climate science outreach and engagement.

Data and Technical Capabilities

With a team of cutting edge spatial modelers, data technicians, climate scientists and communications specialists, SNAP can provide projections of temperature, precipitation and growing season length under a range of greenhouse gas emissions scenarios, downscaled to a two kilometer resolution throughout Alaska and western Canada. Data will be available at an even higher resolution of 800 meters soon. Projections include secondary parameters such as permafrost temperature, fire regime, and hydrology. SNAP assists stakeholders in interpreting the implications of these scenarios on ecosystems as well as built infrastructure, recreation, tourism and other commercial activities. SNAP offers data in several formats, including web-based maps, GIS formats, and Google Earth KML. SNAP also collaborates with outside researchers allowing them access to our data processing and modeling capabilities, currently including 44 processing cores, 132 gigabytes of memory, and over 47 terabytes of storage, supporting up to 20 virtual servers of various Linux, Windows, and Mac operating systems.

Examples of Innovative Decision Support Tools Available from ACCAP and SNAP

The remainder of this article highlights tools and resources that have been developed by SNAP and ACCAP and are available on our websites (please see Resources section).

Monthly Climate Webinars

ACCAP webinars are designed to promote dialogue between scientists, planners, state and local government, land and resource manag-

Pictured: Our scientists have partnered with the Alaska Sea Grant Marine Advisory Program to provide community workshops to assess climate change vulnerability and create adaptation strategies for coastal communities.

ers, industry, the news media, and others who need information specific to climate change in Alaska to make informed decisions. The ACCAP monthly webinar series creates a forum for feedback, discussion, and information exchange of current climate change science, policy and planning in Alaska. Webinars showcase cutting edge scientific research results and climate related decision support tools. They are accessible statewide and foster communication and collaboration across a vast geographic area. Archived videos, podcasts, and presentation slides from 2007-present are available on the ACCAP website. Recent webinar topics include National Ocean Policy & the Arctic region; changes and uncertainty in Alaska's water resources; permafrost degradation and monitoring; climate change and Alaska fisheries; implications of ocean acidification for Alaska; impacts of sea ice change on humans and marine mammals; and mapping tools for Alaska climate change projections.

Native Climate Impacts and Adaptation

In collaboration with RISA programs in the Southwest and Pacific Islands, ACCAP has hosted a series of video conferences linking Native leaders and resource managers in cross-regional dialog to document and share water-related impacts and adaptation strategies. Both SNAP and ACCAP have worked closely with the Alaska Native Tribal Health Consortium (ANTHC) Center for Climate and Health on a project assessing climate health impacts in Northwest Alaska. We are working closely with tribal communities along the length of the Yukon River documenting traditional knowledge and climate impacts specific to fisheries and changing seasonality. Additionally, we are developing a resource and action guide specifically targeted for rural indigenous communities in planning, preparing and responding to climate change.

Regional Climate Resilience Planning

Many communities in Alaska are faced with multiple threats to infrastructure and quality of life due, in part, to projected changes in precipitation, temperature, and related incidences of flooding and erosion. ACCAP and SNAP scientists work directly with stakeholders to inform community plans and climate adaptation strategies using the most scientifically accurate, reliable, and up to date information. They have participated on the adaptation and mitigation advisory groups and technical working groups for the Governor's Climate Change Sub-Cabinet. SNAP provides downscaled climate projections and analysis for these groups. Our scientists served as advisors for the Interior Issues Council Climate Change Task Force and have partnered with the Alaska Sea Grant Marine Advisory Program to develop climate change outreach materials and provide com-

The ACCAP monthly webinar series creates a forum for feedback, discussion, and information exchange of current climate change science, policy and planning in Alaska.

munity workshops to assess climate change vulnerability and create adaptation strategies for coastal communities.

In collaboration with scientists at the University of Alaska, Fairbanks, ACCAP has developed a guide with a matrix approach to communities at risk so that decision-makers are well informed on planning related to climate change and uncertainty, risk management, and relocation. Additionally, we produced an up-to-date, comprehensive, and practical guide to sea-ice and climate information resources that are relevant to Arctic Alaska coastal community leaders and local user groups for planning, subsistence activities, and search and rescue. Plans are in place to collaboratively create a sea ice atlas for Alaska using historical and current climatological data that will enable users to meet their site-specific and season-specific needs for information on sea ice in Alaskan waters.

Alaska Weather and Climate Highlights and Quarterly Climate Newsletters

Each month ACCAP summarizes notable statewide weather and climate information on our website, including key temperature, precipitation, storm, sea ice, and flooding events, in collaboration with the NOAA National Weather Service and the Alaska Climate Research Center. We disseminate a quarterly climate information newsletter, the Alaska Climate Dispatch. This publication is a partnership of the Alaska Climate Research Center, SEARCH Sea Ice Outlook, National Centers for Environmental Prediction, and the National Weather Service. Contents include seasonal weather and climate summaries and regional weather, wildfire, and sea ice outlooks. Guest columnists may provide information on related topics such as El Nino and La Nina, hydrology, and permafrost. Interpretive and clearly written text, full-color pictures, charts, and maps provide decision-makers with a timely snapshot of a wide range of Alaska's diverse weather and climate issues.

Web-based and Google Earth Mapping Tools

SNAP provides downscaled temperature, precipitation, and growing season projections for Alaska at a two kilometer resolution. Maps are offered in several formats, including web-based maps, GIS maps, and Google Earth maps. GIS maps (in ASCII format) are intended for advanced users who wish to manipulate data or do further modeling.

Community Charts

SNAP has created a web-based tool that charts projected monthly average temperature and precipitation through 2100 for more than 400 communities in Alaska. Users can select from low, medium and high future greenhouse gas levels, based on the B1, A1B, and A2 emission scenarios defined by the IPCC. The web-

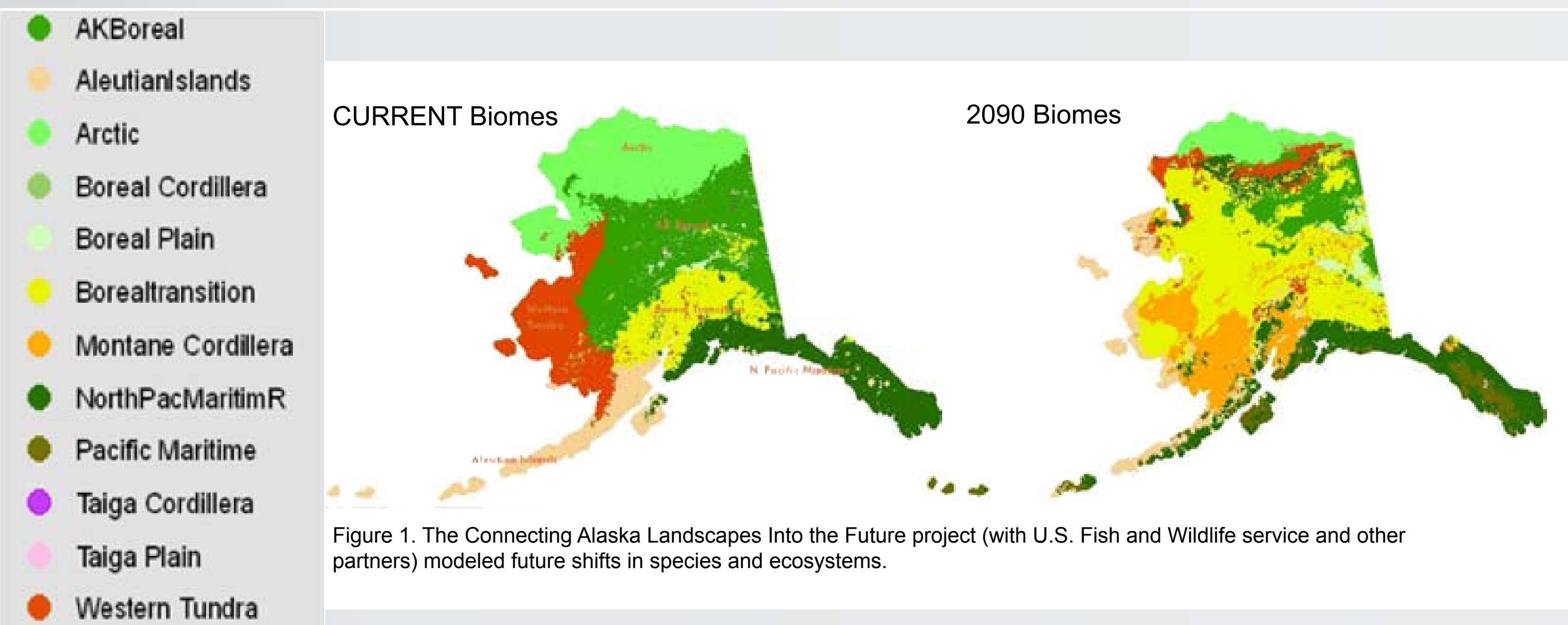

Figure 1. The Connecting Alaska Landscapes Into the Future project (with U.S. Fish and Wildlife service and other partners) modeled future shifts in species and ecosystems.

site allows users to compare communities and consider how climate change may affect activities such as gardening or hunting or public concerns like drought, forest fire or permafrost melt.

Applications of SNAP Projections

In collaboration with federal, state, and non-profit organizations SNAP has projections of shifting ecosystems and permafrost in Alaska under climate change, that aid in land, resource and wildlife management. The Connecting Alaska Landscapes Into the Future project (with U.S. Fish and Wildlife Service and other partners) modeled future shifts in species and ecosystems (Figure 1). It offers policymakers and the public a practical way to approach the question of climate change effects on Alaska ecosystems. Results suggest that during the twenty-first century approximately 60 percent of Alaska may shift to a climate that better matches a biome other than the current one. Another modeling project (with the UAF Geophysical Institute Permafrost Lab, GIPL) was developed to assess the effect of a changing climate on permafrost. The GIPL 1.0 model calculates the permafrost active layer thickness and average annual ground temperature. SNAP data were used for climate forcing. Results indicate that permafrost thaw may be widespread across Interior Alaska in coming decades. Collaboration with the Cook Inletkeeper's Stream Temperature Monitoring Network yielded future scenarios of air temperature and precipitation conditions in the Cook Inlet watershed that will guide fisheries management recommendations.

Social Media and Networking

ACCAP and SNAP have embraced social media with Facebook, Twitter, LinkedIn, iTunes U, and YouTube accounts. Through these outlets, we can highlight programs and events and showcase our growing library of audio, video, and animation products. Our websites are being updated to include custom data requests and increased search capabilities for resources.

Online Resources

University of Alaska Fairbanks
uaf.edu

Alaska Center for Climate Assessment and Policy (ACCAP):
ine.uaf.edu/accap

Alaska Climate Dispatch:
ine.uaf.edu/accap/dispatch.htm

Alaska Monthly Climate Webinar Series:
ine.uaf.edu/accap/teleconference.htm

Alaska Climate Research Center (ACRC):
climate.gi.alaska.edu

Alaska Native Tribal Health Consortium Center for Climate and Health:
anthc.org/chs/ces/climate/index.cfm

Alaska Sea Grant Climate Change Resources:
seagrant.uaf.edu/map/climate/index.php

NOAA's Alaska Regional Collaboration Team (ARCTic):
ppi.noaa.gov/NOAA_ARCTic/noaa_arctic.html

NOAA's Regional Integrated Sciences & Assessments Program (RISA):
climate.noaa.gov/cpo_pa/risa/

Scenarios Network for Alaska and Arctic Planning (SNAP):
snap.uaf.edu

SNAP Community Charts:
snap.uaf.edu/community-charts

SNAP Downloadable Data Sets:
snap.uaf.edu/gis-maps

References

IPCC. 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the IPCC. Pachauri et al., (eds).

Karl, et al. 2009. Global Climate Change Impacts in the U.S. NOAA/National Climatic Data Center.

Stokes. 1997. Paseur's Quantrant, Basic Science and Technological Innovation.

Walsh, et al. 2008. Global Climate Model Performance over Alaska and Greenland. Journal of Climate, 21: 6156-6174.

SNAP can provide projections of temperature, precipitation and growing season length under a range of greenhouse gas emissions scenarios, downscaled to a two kilometer resolution throughout Alaska and western Canada.

Climate Change and FAMILY FOREST LANDOWNERS

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in the Pacific Northwest: ATTITUDES & UNDERSTANDING

BY JANEAN H. CREIGHTON, CHRIS SCHNEPF, AMY GROTTA, SYLVIA KANTOR, AND CINDY MINER

Introduction

Family forest landowners control over 60 percent of the private forest land in the United States (Butler 2008). In the Pacific Northwest (PNW), family-owned forests make up more than 6,900,000 acres; it is estimated that more than 200,000 families each own between 5 and 10,000 acres in Oregon, Washington, Idaho and Alaska (USDA Forest Service, 2006). Global climate change (GCC) impacts on ecosystem functions such as stream flows, fire regimes, wildlife habitat, and vegetation types are of increasing concern for state and federal land managers and are the subject of much research. Private forest landowners in the PNW and elsewhere face the same challenges as public land managers with regard to changing forest conditions. However, little is known regarding the knowledge and understanding family forest landowners have about global climate change and the potential impacts on how they manage their forests. Consequently, the degree to which private landowners are prepared to respond effectively is unknown.

Family forest owners historically have looked to University Extension as a partner and a trusted source of information for forest management. As new knowledge about the potential impacts of GCC on western forests is being generated by the research community, Extension educators are now beginning to conceptualize education and technology transfer programs for family forests owners around GCC, its impacts and forest management implications. To inform these efforts, we conducted a needs assessment to: 1) determine the perceptions, understanding, and educational needs of private forest landowners in the Pacific and Inland Northwest regarding the impacts of GCC on western forests; 2) determine participant attitudes towards GCC as an issue directly affecting them; and 3) determine participant attitudes towards GCC as an issue directly affecting their property.

Methods

Family forest landowner needs were assessed through a series of focus group discussions throughout the PNW. A double-layer design allows for comparisons between regions (Layer 1) and sub-regions (Layer 2) based on general forest type among the four states within the Pacific Northwest (Table 1). Layer 1 consists of four regions: Pacific Coast, Inland Northwest, Northern Rockies, and Alaska boreal forests. Layer 2 is divided east to west and north to south. Three focus groups were conducted at three locations within each of the eight study areas for a total of 24 different groups (Figure 1).

Each focus group consisted of four to twelve family forest landowners solicited from the immediate area. Most participants were family forest landowners that had taken part in forestry education programs through Extension within one of the four states. Guiding questions were intended to reveal participant knowledge and attitudes regarding global climate change and the potential impacts to their forests. Questions were sequential and purposely open-ended (Table 2).

Each session was videotaped and audio recorded with participants' consent and recordings were transcribed verbatim. Analysis of transcripts is aided by the use of Computer Assisted Qualitative Data Analysis Software (CAQDAS), specifically Nvivo9.

Results

The analysis will be completed during summer 2011, so only initial findings are presented here. However, several themes are emerging from analysis to date. Other than the number of acres owned (5 to > 4,000; Table 3), and length of ownership (average = 40 years, not including the tribal communities), demographic information was not collected.

Common responses to a question about source(s) of climate change information included mass media such as newspapers, radio and television; periodicals from land management agencies (e.g. US Forest Service); the internet; and popular articles. In addition, specific individuals including local researchers, climatologists, and extension personnel were often named. Some participants actively sought out information on climate change, while others obtained information passively. In Alaska in particular, a number of participants cited personal observations as an information source:

> *Well all you have to do is fly around and look at what's happening with the glaciers. It's been a radical change in the last two years. – Interior Alaska*

> *I've just seen so many different things that are changing quickly, and loss of different types of plants, and plant life and stuff that aren't there at all anymore, they're just – they eventually, kind of like the lichen in western Alaska where they're, smaller and smaller and pretty soon they just are gone from areas. – Coastal Alaska*

Table 1. Double layer design comparing geographic regions.

Layer 1: Region	Layer 2: Sub-region	No./region	Focus Group Site
Pacific Coast	Western Washington	3	Chehalis, Issaquah, Mt. Vernon
	Western Oregon	3	Beaverton, Coquille, Salem
Inland Northwest	Eastern Washington	3	Spokane, Republic, Wenatchee
	Eastern Oregon	3	Baker City, Bend, La Grande
Northern Rockies	Central Idaho	3	Grangeville, Moscow, Orofino
	Northern Idaho	3	Coeur D'Alene, Sandpoint, St. Maries
Boreal	Interior Alaska	3	Copper Center, Fairbanks, Talkeetna
	Coastal Alaska	3	Anchor Point, Anchorage, Haines

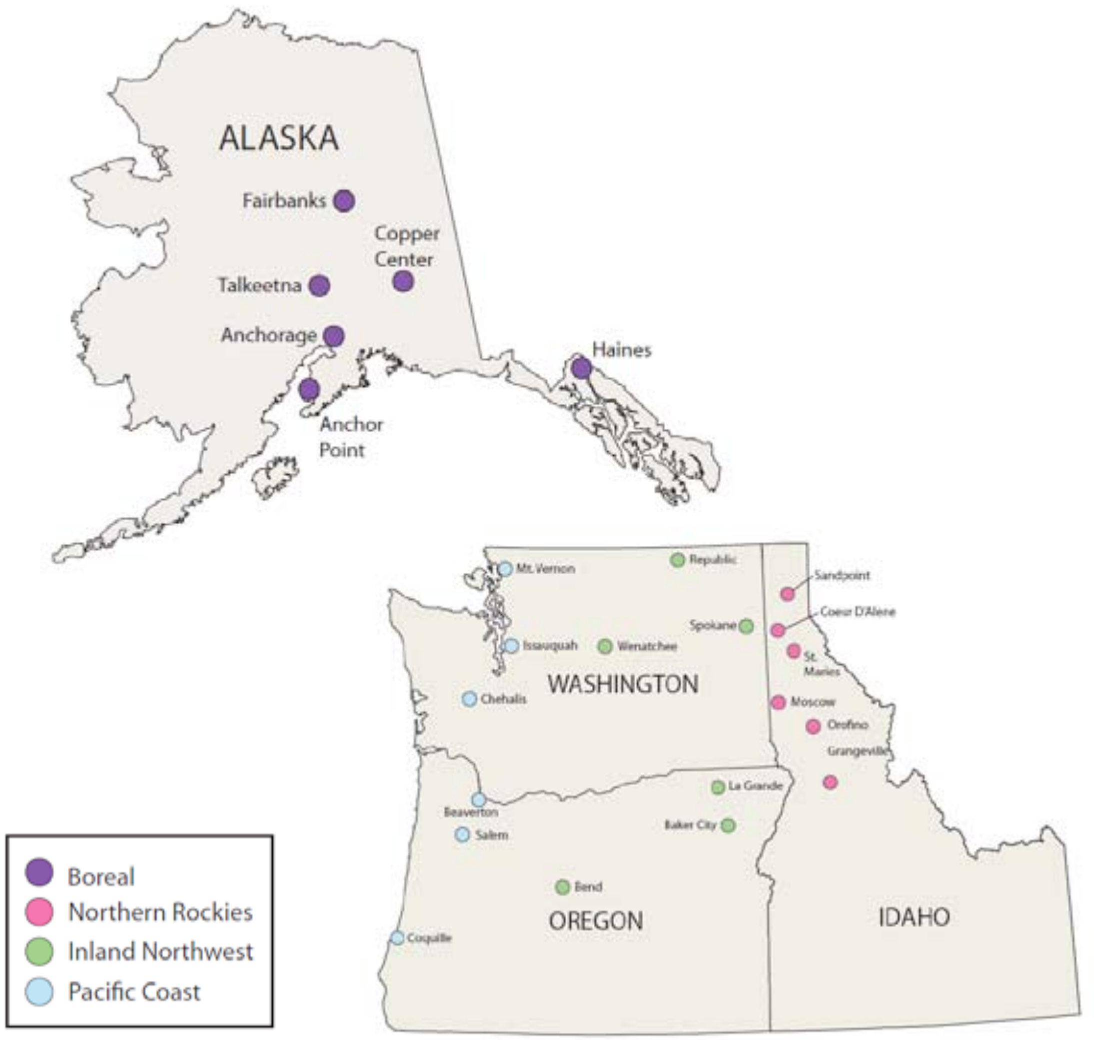

Figure 1. Location of the 24 focus groups in the Pacific Northwest study region.

Table 2. Questioning route and sequence.

Opening question	1. Tell us about your forest
Introductory questions	2. Where do you get information about climate change? 3. How do you assess the validity of the information you receive about climate change?
Transition questions	4. How do you think climate change may or may not impact your forest? 5. What are you doing differently on your forest (if anything) as a result of anticipated climate change?
Key questions	6. What are your major questions about climate change? 7. What form would you like to get information about climate change? 8. Do you have any further questions or comments?

Online Resources

Global Warming's Six Americas: June 2010: environment.yale.edu/climate/files/SixAmericasJune2010.pdf

Psychology & Global Climate Change: addressing a multifaceted phenomenon and set of challenges: apa.org/science/about/publications/climate-change.aspx

Western Forests Recommendations and Guidance for Addressing Climate Change Council of Western State Foresters: wflccenter.org/news_pdf/363_pdf.pdf

I've lived here all my life, I see the change. And again I'm not gonna argue about what's causing it, but it's changing, and one of the species that comes to my mind is frogs. And I say that because growing up here that used to be our summer pastime: you used to catch frogs and see how many you could get in a bathtub. I haven't seen a frog for years until this year. – Coastal Alaska

In discussions about validity of climate change information, many participants remarked on the amount of conflicting and confusing information on climate change. Most participants expressed frustration over deciphering what they considered "good science" from "bad science". Participants expressed bewilderment about the complexities of the issue and were uncertain how to determine the validity of the scientific information they received. They also expressed skepticism and concern regarding bias of information sources:

Most participants expressed frustration over deciphering what they considered "good science" from "bad science."

Follow the money! Even science gets grants to address what is popular, so I don't trust a lot of the literature that comes out. – Eastern Oregon

I consider myself a skeptic…the way I base my judgment on [global warming] is following the money. Everything is revolving around money, and if it DOES revolve around money, I discredit that immediately. – Northern Idaho

If you don't think that scientists aren't biased, then you're mistaken because, whether you're a doctor trying to have a certain medical procedure or whatever you think is the best thing since sliced bread, that person is biased, okay. So we all are human beings is the bottom line, and that's what I think makes this thing so difficult. – Eastern Oregon

How does the layman determine what is peer reviewed or not? – Eastern Oregon

I think an example of that is when you have a corporation that has an inherent goal, funds a study specifically to prove their point of view. And that's legitimate really – I mean maybe it's legitimate for their desires, but that's really not the scientific method per se. – Interior Alaska

While some uncertainty was recognized as being endemic to the sciences, many participants indicated that the degree of uncertainty surrounding climate change was unacceptable, especially given the perceived implications to forest policy and management:

I'm more worried about political decisions that may arise without solid scientific evidence; the fear that we might lose our place and leadership in the world. I'm more concerned about the threat of climate change than about climate change itself. – Eastern Oregon

My question is, will we be as affected by the climate change as we will by the regulations... regulations tied to climate change? We might not see any change on the ground but we'll have to change the way we do business. – Northern Idaho

Table 3. Forest land owned by families as represented by focus groups in four PNW states.

State	**Number of Acres**
Alaska*	14,012,485
Idaho	40,003
Oregon	21,738
Washington	59,350
Total acres represented	**14,133,576**

In general, participants were not managing their forests differently in anticipation of climate change, though some had experimented on a small scale with non-native trees (e.g. redwoods in Western Oregon). Participants commonly mentioned managing for a healthy and resilient forest as the best strategy regardless of changes, if any, that climate change might bring to their forests. Regarding participants' specific questions about climate change and explicit information interests, several topics were common: impacts on local conditions, climate change versus local historic climate trends, help deciphering available science and determining what is valid and credible, carbon credits, what to plant to prepare for the future, carbon sequestration, and ways to mitigate climate change on individual property:

> *How would few degrees temp change impact species locally? – Eastern Washington*
>
> *Should we be doing something different? We are managing for 20-500 years, but should we be doing anything with regards to long term? – Eastern Washington*
>
> *Assuming cap & trade, we will need education on what to do. – Eastern Oregon*
>
> *I'm wondering also if it's possible to [provide information] for specific regions because we do all have different kinds of forests, and cookie-cutter solutions don't usually work. – Coastal Alaska*

Discussion

Confirmation bias was exhibited by many of the participants in our discussions. In this case confirmation bias refers to the "unwitting selectivity in the acquisition and use of evidence" (Nickerson 1998). This is a commonly seen phenomenon when dealing with scientific communication (Nickerson 1998; Shome and Marx 2009). Confirmation bias is often a factor when significant uncertainties are associated with the science, such as with climate change (Marx et al., 2007). However, when the scientific information comes from competing interests or sources perceived as untrustworthy, individuals are often more receptive to information they feel is the most relevant, salient, and credible, and best supports their own viewpoints (Cash et al., 2002). Better understanding of scientific information often can be achieved when scientific uncertainties are addressed, especially with regard to how individuals process uncertainty, whether the process is analytical or experiential (Marx et al., 2007). Research suggests that discussions around climate change may be more effective if communications are designed to "create, recall and highlight relevant personal experience" (Marx et al., 2007). For example, the use of scenarios, narratives, and analogies may be more engaging than statistics and probabilities.

Conclusion

Since this project is currently in progress, the results presented here are preliminary. It is clear that for many participants climate change is an emotionally-charged and political issue. When designing educational programs on climate change, it may be necessary to view it first as a controversial issue. Strong feelings regarding climate change may significantly complicate some individuals' participation in educational programs. Preliminary results from these discussions suggest participants are interested in acquiring information regarding climate change and forest management; however, information sources, the way it is delivered, and to whom, must be considered carefully.

References

Butler. 2008. Family forest owners of the U.S., 2006.

Cash, et al. 2002. Salience, credibility, legitimacy and boundaries. Harvard University Faculty Research Working Paper. RWP02-046.

Marx, et. al. 2007. Communication and mental processes. Global Climate Change, 17: 47-58.

Nickerson. 1998. Confirmation bias. Review of General Psychology, 2(2): 175-220.

Shome, et al. 2009. The psychology of climate change communications.

USDA Forest Service. 2006. Forest Inventory and Analysis Program. National Woodland Owner Survey. Available at fia.fs.fed.us/nwos.

Participants commonly mentioned managing for a healthy and resilient forest as the best strategy regardless of changes, if any, that climate change might bring to their forests.

Climate Change and Agriculture in the Pacific Northwest

BY CHAD KRUGER, GEORGINE YORGEY, AND CLAUDIO STOCKLE

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Claudio Stockle is a professor and chair in the Department of Biological Systems Engineering at Washington State University.

Introduction

Public discourse surrounding agriculture and climate change in the U.S. has primarily focused on agriculture's role in carbon sequestration and greenhouse gas mitigation. However, concern over the potential impact of climate change on agricultural production is growing, particularly in the arid West where agricultural water security is already a concern. A February 2004 article in Science (Service 2004) entitled "As the West Goes Dry" painted a stark picture of a possible future of severely constrained water supplies that made many in the Pacific Northwest (PNW) take interest in the issue of climate change for the first time. This article and other earlier research into climate change impacts on agriculture have shown that changes in the climate represent a significant new source of risk and management challenges to the agricultural enterprises we depend on for food production and rural economic vitality.

Our regional agricultural systems have evolved within a variety of existing regional and local climatic patterns and the continued success of these systems depends on our capabilities to adapt to change. For instance, in addition to concerns regarding irrigation water supply, other climate-driven vulnerabilities include the need for adequate soil moisture at seeding time for rain-fed cereal grain production, plants' sensitivity to temperature extremes during critical life-stages (such as flowering), shift of seasonal patterns and production zones, and temperature-driven controls that limit the incidences of insect pests and diseases. Changes in any of these factors could dramatically impact the resiliency and viability of our PNW cropping systems. We can no longer afford to "ignore" the risks that climate change presents to the sustainability of future cropping systems in the Pacific Northwest.

In response to this concern, numerous research teams in the Pacific Northwest have initiated studies to assess the vulnerability of agriculture to climate change in order to improve decision-making, investment, and planning for adaptation. Completed studies include the projected impact of future climate change on wine grape production (Jones 2005; White et al., 2006; Jones 2007; Jones and Goodrich 2008), on pests and plant diseases (Sutherst et al., 2007; Scherm and Coakley 2003; Coakley et al., 1999), on Eastern Washington agriculture (Stockle et al., 2010), and on water supply for agriculture in the Yakima River Basin (Vano et al., 2010). Current work includes a forecast of future water supply and demand for the Columbia River Basin of Washington, funded by the Washington Department of Ecology, that will be completed in 2011 (Adam et al., 2009). Also, two new projects funded by USDA's National Institute for Food and Agriculture will address climate change impacts on PNW agriculture: a Coordinated Agricultural Project that will assess potential climate change induced production zone shifts, changes in beneficial organisms, and incidence of weed, disease and insect pests for wheat-based cropping systems of the Pacific Northwest (Eigenbrode et al., 2011) and a second project that will couple atmospheric, forest, crop, hydrological and economic models to assess the impact of changing climates on agricultural, forest and water resources and management (Adam et al., 2011).

Using Process Models to Project Future Impacts

Most climate change studies rely on the use of process models capable of integrating the complex set of factors (e.g. biophysical conditions and management and policy decisions) necessary to project climate change impacts in an uncertain future. While modeling is a well-accepted methodology in the scientific community, it can be a source of apprehension to stakeholders in the agricultural community who are more familiar with experimental research methodologies. To address this concern, we need to emphasize a few important principles of modeling:

1. Models are, by definition, a simplification of a particular process in the real world. As such, they are useful for understanding the relative impact of a change in conditions. They are not a "crystal ball" and do not "predict" the future, but rather they are useful for simulating the probability of a given future outcome.
2. Each sub-process within a model is based on existing experimental research and is, therefore, an integration of prior experimental science. Models are tested and evaluated against known values (e.g. the past) in order to determine confidence in projections where existing data are not yet available (e.g. the future).
3. Assumptions that are made in the context of applying models to real world cases should be evaluated along with model results when comparing with real world conditions and/or experimental data.
4. The ultimate value of modeling tools is to inform and aid in decision-making by providing projections of probable future conditions and helping to clarify what those conditions mean for management.

While the idea of using models to project future conditions can be controversial, it is important to understand that we regularly utilize models and model outputs as decision aids. For instance, farmers frequently use local weather reports (generated by models) to aid in a variety of farm management decisions (e.g. planting, harvesting, freeze/frost management, irrigation, etc.). In spite of the fact that these model outputs are not "perfectly accurate," we know they are quite useful. Similarly, using model projections for future climate change scenarios can be useful for assessing vulnerabilities and planning for change.

Findings to Date

To date, the most comprehensive assessment of potential climate change impacts on PNW agriculture was completed as part of the Washington Climate Change Impact Assessment[1] (WACCIA) project funded by the Washington Legislature (HB 1303) and led by the University of Washington Climate Impacts Group.

[1]The full WACCIA report is available at: http://cses.washington.edu/cig/res/ia/waccia.shtml.

University of Washington climate modelers provided regional climate scenarios "downscaled" from global climate models to teams of scientists who used these scenarios to evaluate potential impacts on various aspects of Washington's environment and economy, including agriculture (Stockle et al., 2010) and water supply (Vano et al., 2010). Potential impacts were assessed for three future time frames (2020's, 2040's, and 2080's). Stockle et al. (2010) used a cropping systems model (CropSyst) and a set of existing pest models to project climate impacts on yields of wheat (three locations), potatoes and apples; as well as project potential changes in the occurrence of codling moth and the incidence of powdery mildew on grapes and cherries. Vano et al. (2010) used a multi-model ensemble (hydrology, reservoir, cropping systems and water management models) to assess the impact of changes in water supply in the Yakima River Basin on water allocation for irrigation and consequent impacts on the agricultural economy. Detailed findings from these studies are available in a special issue of the journal Climatic Change (102:1-2) published in 2010. Several key conclusions can be drawn from the results:

- Assuming no change in available irrigation water:
    1. Projected increases in temperature would likely reduce yields of wheat, apples and potatoes moderately by the 2020's and severely by the 2080's, where irrigation is utilized.
    2. Increased CO_2 levels in the atmosphere, however, provide a "fertilization effect" that may offset much of the potential yield reduction caused by increased temperature.
    3. Reasonable adaptation strategies, including plant breeding and cultural practices, could further offset any potential losses in yields and may even lead to increased yields under future climates.
- The probability of reduced water supply in the Yakima Valley greatly increases under future climate scenarios, leading to more regular curtailment of irrigation water for junior water rights holders in the future. Regular curtailment without adaptation/intervention would likely lead to significant reductions in agricultural production and significant negative economic impact on the allied industry and communities.
- Insect pests are likely to have additional "generations" each season (insect lifecycles are driven by "degree days") leading to increased costs for control and the potential for reduced efficacy of control methods earlier than expected.
- Incidence and severity of plant disease outbreaks are more uncertain due to a more complex set of biophysical drivers than for insects, but more "high risk days" were projected for powdery mildews.

Conclusions and Future Directions

The agriculture-related vulnerabilities reported in the WACCIA study are actually far more modest than those reported for agriculture in other regions of the U.S. (Schlenker and Roberts, 2008). In general, higher latitudes are expected to fare better than lower latitudes, where the options for adaptation are more limited. While this appears to be good news for our region, it is critical that we do not underestimate the necessary planning and investment in adaptation that will be required even under relatively modest impact.

In general, higher latitudes are expected to fare better than lower latitudes, where the options for adaptation are more limited. While this appears to be good news for our region, it is critical that we do not underestimate the necessary planning and investment in adaptation that will be required even under relatively modest impact.

As noted above, modeling tools can be valuable tools for risk assessment, but they do have important limitations. While these models are sophisticated, they are still relatively simple representations of the real world. Even though they enable greater capability to evaluate the dynamics of complex systems than experimental approaches, the application of the models usually only considers a few factors (e.g. yield, temperature, and water use) and may not consider other factors that are critical to the success of a crop or agricultural enterprise (e.g. fruit quality and extreme weather events like floods and hail storms). While research into the development of more sophisticated modeling methodologies that will improve this capacity is increasing, we are a long way from being able to project these kinds of agricultural vulnerabilities and impacts with confidence.

Furthermore, even within the existing projections we can conclude that there are real and significant vulnerabilities that need to be addressed in order to secure a sustainable future for agriculture. For instance, we know from Vano et al. (2010) that we cannot assume a status quo of sufficient water supply for agricultural production. We just do not know yet the extent of this vulnerability for agriculture outside of the Yakima River Basin. Additional information will be provided by the initial effort to assess the vulnerability of Columbia Basin-wide water supply as it relates to agricultural, municipal and in-stream demands that is currently underway on behalf of the Washington Department of Ecology's Office of Columbia River (Adam et al., 2009). This project is using a multi-model ensemble approach to project water supply and demand out to 2030 under a variety of future scenarios, including economic as well as climate changes. These results (expected in December 2011 and available through the Washington State Department of Ecology web site) will be used by the Washington Department of Ecology to inform public decision-making processes on the investment of $200M for water supply development in Washington State.

Finally, the adaptation strategies assumed in Stockle et al. (2010) depend on continued and increased investment in plant breeding and agronomic and plant protection research at a time when regional investment in agricultural research is actually waning. USDA's agricultural research divisions (Agricultural Research Service – ARS and National Institutes for Food and Agriculture – NIFA) have recognized the need to increase federal research investment in agriculture and climate change and the Pacific Northwest universities have collaboratively capitalized in the first round of climate change funding solicitations (Eigenbrode et al., 2011; Adam et al., 2011). While this is an excellent start to better positioning our agricultural industries and rural communities, long-term success will depend on a renewed commitment to both public and private regional investment in research and implementation of that research by farmers to ensure successful adaptation to climate change.

References

Adam, et al. 2009. Columbia River Basin Water Supply Investment Plan.

Adam, et al. 2011. BioEarth: Biosphere Relevant Earth System Model for the Pacific Northwest.

Coakley, et al. 1999. Climate Change and Plant Disease. Annual Review of Phytopathology, 37: 399-426.

Eigenbrode, et al. 2011. Regional Approaches to Climate Change for Inland Pacific Northwest Agriculture.

Jones. 2005. Climate change in the western U.S. grape growing regions. Acta Horticulturae (ISHS), 689: 41-60.

Jones. 2007. Climate Change: Observations, Projections, and General Implications. Practical Winery and Vineyard, July/August 44-64.

Jones, et al. 2008. Influence of climate variability on wine region in the Western U.S. Climate Research, 35: 241-254.

Scherm, et al. 2003. Plant pathogens in a changing world. Australasian Plant Pathology, 32: 157-165.

Schlenker, et al. 2008. Estimating the Impact of Climate Change on Crop Yields. NBER Working Paper No. 13799.

Service. 2004. As the West Goes Dry. Science, 303: 1124-1127.

Stockle, et al. 2010. Assessment of Climate Change Impact on Eastern WA Agriculture. Climatic Change, 102 (1-2): 77-102.

Sutherst, et al. 2007. Pests under global change. Terrestrial Ecosystems in a Changing World, 211-225. Canadell, et al. (eds).

Vano, et al. 2010. Climate change impacts on water management and irrigated agriculture. Climatic Change, 102 (1-2): 287-317.

White, et al. 2006. Extreme heat reduces and shifts U.S. premium wine production. Proceedings of the National Academy of Sciences, 103(30): 11217–11222.

RECOMMENDED RESOURCES

Washington Climate Change Impact Assessment (WACCIA) project report:
cses.washington.edu/cig/res/ia/waccia.shtml.

Washington Department of Ecology Office of Columbia River:
ecy.wa.gov/programs/wr/cwp/crwmp.html

Regional Approaches to Climate Change for Pacific Northwest Agriculture (REACCH PNA):
reacchpna.uidaho.edu/reacchpna

BioEarth: Biosphere Relevant Earth System Model for the Pacific Northwest:
cereo.wsu.edu/bioearth

Better positioning our agricultural industries and rural communities for long-term success will depend on a renewed commitment to both public and private regional investment in research and implementation of that research by farmers to ensure successful adaptation to climate change.

MULTI-STATE WATER and CLIMATE COLLABORATION in the PACIFIC NORTHWEST

BY FRED SORENSEN AND LISA WEDIN

Since 1995 Cooperative Extension Services in the four-state Pacific Northwest region (Alaska, Idaho, Oregon, and Washington) have been collaborating with the Environmental Protection Agency on water programming with funding from USDA beginning in 2001. Despite the large geographic area, the states in this region face similar water issues and their regional collaboration has resulted in numerous ongoing research and outreach activities. In recent years, their work has expanded to include regional impacts of climate change.

Pacific Northwest Water Issues Survey

In 2002 the region conducted a survey on the Public Attitudes and Aptitudes Concerning Water Issues (Mahler et. al., 2004 and 2005) and a follow-up survey in 2007. According to Mahler et. al., 2010 one key finding was that over 90 percent of the region's citizens continue to list clean water as a priority issue. Another finding was the need for Extension to reassess its methods of disseminating information

Regional Programming and Publications

The Pacific Northwest (PNW) team provides numerous resources to the region. These include:

- Regional trainings for county Extension agents.
- Regional publications on watershed protection and drinking water.
- An award-winning series of satellite broadcasts on Watershed Group Management.
- Regional themed conferences on topics such as Total Maximum Daily Loads, Groundwater under the PNW, and Water Policy. The 2011 conference will focus on the Columbia River Basin.

The PNW team publishes monthly regional bulletins and distributes them to the region's state and national legislators, university administrators and faculty, and the county Extension offices in the region. The monthly bulletins are categorized into the following topics such as:

- Drinking Water
- Environmental Restoration
- Nutrient/Pesticide Management
- Water Policy, Economics, Surveys
- Watershed Management
- Urban Issues

A complete library of these publications and activities are located on the regional website (www.pnwwaterweb.com) under PNW Water Updates. From this website you may also access materials on Wells and Septics.

Regional Water and Climate Change Website

The Pacific Northwest Water and Climate website (https://sites.google.com/a/alaska.edu/pnwwater-and-climate-change/) is a portal to water and climate change related information that is relevant to the Pacific Northwest region. There are vast amounts of information available on the Internet regarding climate change, and the goal of this website is to make the information easily accessible from one Web portal.

Developed with a variety of uses in mind, the Pacific Northwest Water and Climate Change website can be used as a:

- Portal to the best climate change information on the Web.
- Flexible presentation device that can be reviewed later by people attending a presentation.
- Tool to explore climate impacts in the three ecoregions in the four states.
- Means to disseminate information on water and climate change to the PNWWATER partners.
- Place for the PNWWATER partners to engage the public on the topic of climate change.

The Web portal also includes state-specific information for the four-state region. The state Web pages include:

- Announcements.
- A map of the state showing a climate scenario from a variety of sources.
- General information about climate and impacts on water in the state.
- Links to state specific climate resources and reports.

Expanding the Water and Climate Portal

As the project evolves it is becoming apparent that an issue-based design may also be an effective way of conveying information. People may go looking for information on flooding, forest fires or erosion in addition to climate change. A web page on one of those topics could then make the connection between the impact and climate change. It could also be used as a social marketing tool to bring about behavior change guiding visitors to resources that would help them answer the question, "What can I do?" Adding that functionality would give an individual the tools to make personal decisions leading to a more climate-resilient region. This would empower the individual to make changes in their lives that would better prepare them for climate impacts. It would start with the individual and work out in a circle from the person to their home, yard, neighborhood, town/city, county, and ecoregion. It would break down the behavior changes into manageable actions, and would make the task of preparing for climate change less overwhelming.

Summary

Coordination and collaboration at the multi-state level in Water Quality and Climate Change programming has allowed the four PNW states to utilize resources that each state, especially the smaller states of Alaska and Idaho, cannot provide on their own. Since the start of this collaboration in 1995 the relationship built between the team members has increased the flow of communication and therefore the productivity of the four programs. In addition to the initial four state universities two others have become part of the group, Northwest Indian College and recently Heritage College, both in the state of Washington. With the reorganization of CSREES into the National Institute of Food and Agriculture (NIFA) continued funding for the regional coordination grants may change. Planning has already started to find alternative funding in order to continue this very successful multi-state collaboration.

References

Mahler, et al. 2010. Information sources, learning opportunities, and priority water issues in the PNW. Journal of Extension, 48(2): Article number 2RIB2.

_____, et al. 2005. Drinking Water Issues in the Pacific Northwest. Journal of Extension, 43(6).

_____, et al. 2004. Priority Water Issues in the Pacific Northwest. Journal of Extension, 42(5).

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Building Resiliency from Climate Impacts into Oregon Agricultural Systems: STRATEGIES and CHALLENGES

BY STEPHANIE PAGE AND KATHIE DELLO

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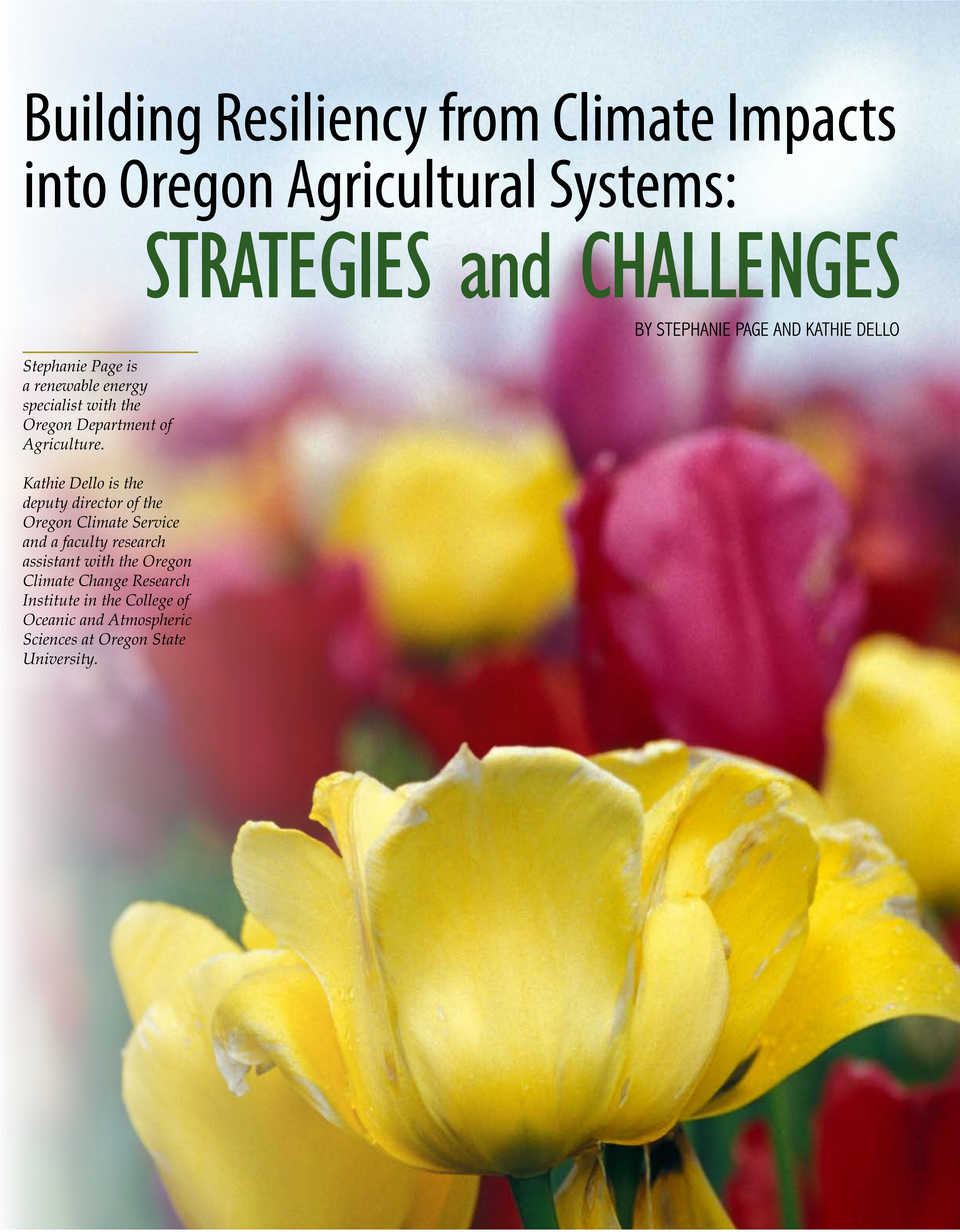
Kathie Dello is the deputy director of the Oregon Climate Service and a faculty research assistant with the Oregon Climate Change Research Institute in the College of Oceanic and Atmospheric Sciences at Oregon State University.



Oregon is a diverse, agriculturally rich state and much is at stake for agriculture in a changing climate. The agricultural sector in Oregon produces over 220 commodities and comprises 15 percent of the state's economy. Oregon is the top producer of 15 U.S. commodities, many of which are considered specialty crops. The potential impacts of a warming climate to Oregon's agricultural industry are equally diverse, with some potentially positive effects but largely negative effects, especially during the latter half of the century. Agriculture not only contributes substantially to our economy, but also to Oregonians' quality of life, making it an important sector to address in climate adaptation planning.

In addition to being impacted by a warming climate, agriculture contributes to the problem by adding greenhouse gases to the atmosphere. Oregon's agricultural systems make up about 8.2% of Oregon's total greenhouse gas emissions (Drumheller, 2011). However, there are many actions that agriculturalists and policymakers can take and are taking to reduce agriculture's greenhouse gas emissions and sequester carbon on agricultural lands.

Oregon released a trio of climate reports in 2010: the Oregon Climate Assessment Report (OCAR), the Oregon Climate Adaptation Framework and the Oregon Global Warming Commission's Roadmap to 2020. The OCAR details likely impacts to the state in a warming climate, and the framework builds on the OCAR report by offering a first cut of actions that state agencies in Oregon can take to reduce vulnerability and increase adaptive capacity. The Roadmap is a series of strategies to reduce greenhouse gas emissions in the state. In this article, we highlight some of the findings relating to the agricultural sector from all three reports, as well as additional strategies for adaptation and mitigation of greenhouse gases in agriculture.

As stated in the OCAR, in the Pacific Northwest, there is no plausible scenario where annual temperatures decrease in the next century. Regardless of future global greenhouse gas emissions, the region is projected to increase by a few degrees Fahrenheit. Additionally, climate models project warmer and drier summers for this region (Mote and Salathé, 2010).

Warming average annual temperatures and drier summers will affect agriculture both positively and negatively. A longer growing season, combined with increased temperatures, can boost crop productivity. In addition, warmer temperatures may allow for additional crops to be grown in some regions of Oregon. However, longer growing seasons can also promote increased voltinism (number of generations per season) of insect and other pests. Drier summers may make dryland crop and rangeland production even more challenging in certain regions of the state (Coakley et al., 2010).

Agriculture will be most significantly impacted by reduced summer irrigation water availability associated with climate change. Mountain snowpack acts as natural storage for much of our state's water resources and many Oregon irrigation systems are fed by snowmelt and stored in reservoirs. With warmer temperatures, mountain snowpack is projected to decline throughout the 21st century. Further impacting summer water availability is an anticipated decrease in summer precipitation, which provides a small, but not insignificant boost to rivers and streams. At the same time, warmer average temperatures could increase demands for summer irrigation water. These warmer average temperatures pose a host of challenges to crops – both irrigated and unirrigated, but may also present opportunities in the form of a longer growing season (Coakley et al., 2010; OCCRI, 2010).

Higher atmospheric carbon dioxide levels will have mixed impacts to agricultural production systems. Plants may use water more efficiently with higher atmospheric carbon dioxide concentrations, and may build more biomass. However, increased carbon dioxide concentrations may preferentially benefit invasive species over established crops and reduce crop quality (Coakley et al., 2010; OCCRI, 2010).

It is important to define the differences between adaptation and mitigation. The Fourth Assessment Report Intergovernmental Panel on Climate Change (IPCC) defines adaptation as the "adjustment in natural or human systems in response to actual or expected climatic stimuli on their effects, which moderates harm or exploits beneficial opportunities." This report also states that adaptation is necessary to address impacts resulting from warming which is already unavoidable due to past emissions (IPCC, 2007). Mitigation is an action that leads to the reduction of harmful greenhouse gases that warm the planet. Given the challenge of a world that has already bought into a few degrees (˚F) of warming through the mid-21st century due to the lifespan of greenhouse gases in the atmosphere, resilience needs to be built into human and natural systems to help protect from the impacts from climate change. However, mitigation actions are not without merit, as the magnitude of future warming will depend on total greenhouse gas emissions, and crop quality is directly affected by atmospheric CO_2.

As agriculture is an inherently climate sensitive sector, producers have long been practicing adaptation and building resiliency to climate related impacts. Oregon is prone to interannual variability in precipitation, largely dominated by the El Niño Southern Oscillation (ENSO). The agriculture sector has faced crippling drought as well as flooding impacts in the past. Lessons for adaptation can be drawn from these past impacts and adaptations to climate variability (NRC 2010).

In late 2009, Oregon state agencies were asked by then Governor Kulongoski to work together in developing a state climate adaptation plan. The Oregon Climate Change Adaptation Framework identifies several climate risks that will affect agriculture (DLCD, 2010) and associated risk management strategies and gaps in state capacity. Changes in hydrology have the potential to significantly affect agricultural productivity and reduced water availability can increase the cost to produce agriculture goods (DLCD, 2010). Oregon needs better capacity to predict water availability for irrigation and other uses in the short and long term. In addition, Oregon needs additional capacity to provide technical assistance and incentives to farmers and ranchers to increase water storage capacity and improve conservation, reuse, and water use efficiency (DLCD, 2010).

Critical strategies to help agriculture reduce its vulnerability to climate change include maximizing water use efficiency through irrigation water delivery systems and management practices, develop irrigation storage facilities that are protective of watershed health, managing non-irrigated cropping systems to build soil organic matter, identifying threats from invasive species and managing those threats; and developing crop varieties that will maintain product quality under greater atmospheric carbon dioxide concentrations. Additional research, as well as technical assistance and incentives to growers, will also be critical to ensure strategies are well suited to Oregon's various agricultural products and that growers have the resources to implement these strategies (OGWC, 2011).

In many cases, managing dryland and irrigated cropping systems to conserve water offers both adaptation and mitigation benefits. Practices such as scientific irrigation scheduling can conserve water and energy, and may reduce the saturated soil conditions that promote the release of greenhouse gases such as nitrous oxide (Coakley et al., 2010; OGWC, 2010). Dryland cropping practices such as cover cropping can increase soil water holding capacity and promote carbon sequestration in the soil. In other cases, however, trade-offs are involved. For example, switching from flood or furrow irrigation to more water-efficient methods such as sprinkler irrigation may create new electricity consumption and costs to the farmer (ODA, 2011).

Livestock producers also have a variety of strategies available to reduce greenhouse gas emissions and adapt to climate change. Strategies to reduce emissions include breeding to increase feed use efficiency, use of additives in diets to reduce methane emissions, managing rangelands to increase productivity and rangeland health, managing manure under aerobic conditions, installing lagoon covers to capture methane, and developing of anaerobic digesters that generate renewable energy from methane (US EPA, 2005). For rangeland managers, adaptation strategies include integrated weed and insect pest management; in addition, wildlife habitat restoration projects on pasturelands, rangelands and streamside areas help fish and wildlife adapt to climate change.

The Oregon Climate Change Adaptation Framework's short term priority actions to address hydrology changes also include maintaining the capacity to provide assistance to landowners to restore wetlands, uplands, and streamside areas. The State of Oregon, the federal government, and agricultural land managers have already invested significantly in watershed restoration activities. Much of this work has been accomplished with assistance from technical agencies. These activities are expected to help promote capture, storage and beneficial release of water from upland areas of watersheds, extending water availability further into the dry season. By maintaining capacity to support additional restoration work, Oregon will not only promote natural water storage, but may also help fish and wildlife species dependent on these ecosystems to cope with the impacts of climate change.

In 2008, agricultural emissions represented 8.2% of the greenhouse gas emissions in Oregon (Drumheller, 2011). There are many opportunities for agriculture to reduce greenhouse gas emissions. Fortunately, many of these strategies have a variety of other natural resource and economic benefits. Strategies include maximizing nutrient use efficiency to minimize nitrous oxide emissions; reducing consumption of fuel and electricity through efficiency and renewable energy measures; managing manure to minimize methane emissions; and promoting carbon storage in the soil through cover cropping and other practices (OCCRI, 2010).

Oregon's Global Warming Commission published a Roadmap (OGWC, 2010) to achieve Oregon's 2020 and 2050 greenhouse gas emissions reduction goals that includes priority actions to help agriculture contribute to those goals. For agriculture, these priorities include research, outreach, and technical assistance to promote nutrient use efficiency and quantify the greenhouse gas reduction benefits; research on Oregon's soil carbon sequestration rates; increase outreach and incentives to restore native vegetation along agricultural lands; and develop low-cost technology, incentives, and technical assistance to increase methane capture and digester technologies for all sizes of livestock operations (OGWC, 2010).

Oregon is poised to address the challenges associated with a warming climate, both through adaptation measures and mitigation strategies. The next step includes implementation of these strategies, revisiting the climate adaptation framework at a regional/local scale and continuing to learn more about the likely risks that agricultural sector faces in a warming world.

Recommended Resources

Oregon Climate Change Research Institute
occri.net

Oregon Department of Agriculture
oregon.gov/ODA

Oregon Climate Change Adaptation Framework
oregon.gov/ENERGY/GBLWRM/docs/Framework_Final_DLCD.pdf

References

Coakley, et al. 2010. Climate Change and Agriculture in Oregon. Dello, et al. (eds). Available at occri.net/OCAR.

Drumheller. 2011. Oregon greenhouse gas emissions from 1990 through 2008. Available at orclimatechange.gov.

IPCC, 2007. Summary for Policymakers. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Parry, et al. (eds).

Mote, et al. 2010. Future climate in the Pacific Northwest. Climatic Change, 201: 29-50.

OCCRI, 2010. The Oregon Climate Assessment Report. Dello, et al. (eds). Available at: occri.net/OCAR.

ODA, 2011. Agriculture and energy in Oregon.

OGWC, 2010. Interim roadmap to 2020. Available at: keeporegoncool.org.

ODLCD, 2010. Oregon Climate Change Adaptation Framework. Available at oregon.gov/ENERGY/GBLWRM/docs/Framework_Final_DLCD.pdf

NRC, 2010. Adapting to the impacts of climate change.

U.S. EPA Office of Atmospheric Programs, 2005. Greenhouse gas mitigation potential in U.S. Forestry and Agriculture.

PLANNING Agricultural Responses to Climate Change IN CALIFORNIA

BY RYAN HADEN AND LOUISE JACKSON

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Introduction

Agriculture is vital to the economy of California's Central Valley. California leads the nation in the production of fruits, nuts, vegetables and dairy products. The state is also at the forefront of legislation to protect air and water quality and most recently, in policies to mitigate climate change. Concerted efforts to plan for and adapt to higher temperatures, less snowpack, and potential drought are also being initiated. As California farmers balance these objectives, they also face numerous uncertainties. Will climate change dramatically influence water availability or alter which crops can be profitably grown? How will new government policies influence their day-to-day operations? How can they protect agricultural lands from rapid urbanization? How will changes in global commodity markets affect their bottom line? Anticipating and adapting to these uncertainties will be crucial for the future viability of California agriculture (Figure 1).

Yolo County as a Case Study for Climate Change Mitigation and Adaptation

In this article we discuss how one rural community in California's Central Valley, Yolo County, is already preparing for the future. We focus on Yolo County for several reasons. First, as a county it has many attributes typical of the Central Valley: small towns and cities with a changing mixture of urban, suburban, and farming-based livelihoods. Its agricultural landscape includes a mix of irrigated row crops and orchards grown on alluvial plains; and grazed rangelands in the

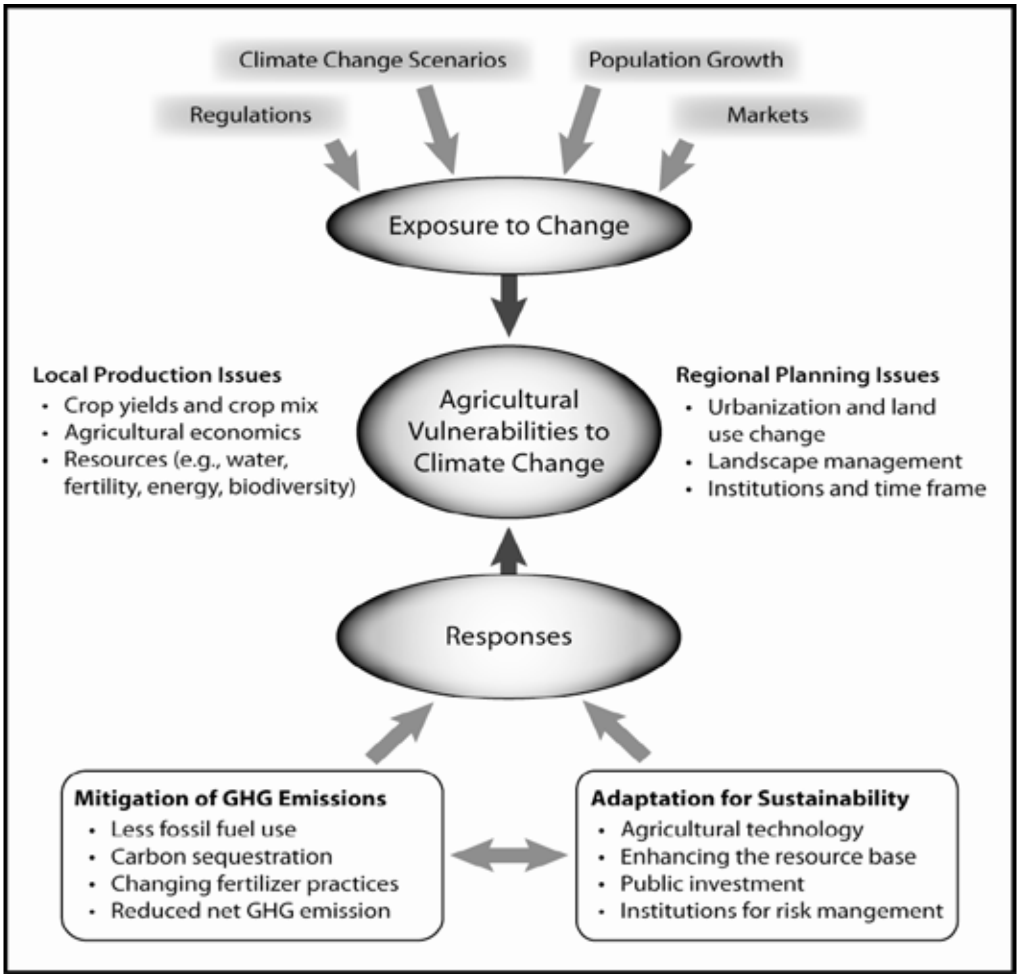


Figure 1. A diagram of potential agricultural vulnerabilities and responses to various change factors including climate change, population growth, markets and regulations. Adapted from Jackson et al., 2011.

uplands along the eastern edge of California's Coastal Range. The second reason is that Yolo is among the first rural counties in California to specifically address climate change mitigation and adaptation in their recently passed "climate action plan". Not surprisingly, concern about the impact of both climate change as well as the new state and local policies have brought a diverse range of stakeholders into the discussion. We also focus on Yolo County because of the relative wealth of research on climate change and agriculture that has been conducted at the nearby land-grant university (University of California, Davis), through partnerships with local farmers, cooperative extension, non-profit organizations and local officials.

An essential element of the adaptation process is an understanding that the capacity of a rural community to cope with climate change and other uncertainties will be largely dependent on its collective ability to assemble and process relevant information and then act accordingly (Adger, 2003). Since the impacts of climate change on agriculture will include agronomic, ecological, and socioeconomic dimensions, useful data and knowledge will come from many sources including scientists, Cooperative Extension, public officials, NGOs as well as innovative farmers and local businesses. Here we highlight how involvement and insights from these stakeholders in Yolo County have helped to spur planning and action in response to climate change.

Government Initiatives at the State and Local Level

Much of the recent impetus for both research and action on climate change stems from the passing of California's Global Warming Solutions Act in 2006 (Assembly Bill 32; AB32). For example, AB32 now requires local governments to address climate change mitigation in any update to their general plan or to submit a separate climate action plan that does so in detail (CAGO, 2009). The climate action plan recently completed by Yolo County's local government is an early example of what other counties and municipalities will carry out in the not so distant future (Yolo CAP, 2010). Yolo County's climate action plan consists of three main components; 1) an inventory of greenhouse gas emissions (GHG) for 1990 and the current period; 2) a set of local policies to mitigate future emissions; and 3) a section examining possible adaptation strategies to help county stakeholders cope with the local impacts of climate change.

Since the jurisdiction of Yolo County's government is limited to the mostly rural "unincorporated" parts of the county, insights and feedback from the agricultural community were crucial to the planning process. To facilitate this dialog, Yolo's Planning Department held a series of rural stakeholder meetings where available data on agricultural emissions sources and mitigation strategies were discussed with local farmers, the county's agricultural commissioner, cooperative extension, university scientists and others. Table 1 shows the range of GHG mitigation strategies addressed during these meetings and highlights some of the tradeoffs and co-benefits articulated by the participants.

While examining the county's data on GHG emissions, perhaps the most important observation made by local stakeholders was that electricity use and transportation in neighboring urban areas leads to emissions rates that are roughly 100 times higher per acre than agricultural land uses (Yolo CAP, 2010). The intent here was not to shift the emphasis away from the mitigation opportunities within agriculture, but rather to highlight how local policies to promote "smart growth" and protect prime farmland from urbanization may actually help stabilize and reduce future emissions from other sectors. This is particularly relevant in regions of the Central Valley which face mounting pressure to convert farmland to urban land uses. More importantly the concept seemed to

Pictured: Almonds orchard in full bloom in Yolo County, CA. Available from a public website.

Table 1. Stakeholder generated trade-offs and co-benefits of various agricultural GHG mitigation strategies in Yolo County.

Emissions Category	Strategy	Trade-offs	Co-benefits
Direct and Indirect Nitrous Oxide from Agricultural Soil (N_2O)	N fertilizer rate reduction	-yield loss for some crops -already optimized for some crops	-lower input costs -water quality
	organic farming methods	-organic fertilizer costs -labor costs -limited pest control options -yield loss for some crops	-price premium -local or direct marketing -environmental quality -agrobiodiversity
	cover cropping	-cost of crop establishment -additional fuel use -not compatible with all crop rotations -spring incorporation constraints	-erosion and runoff control -better soil water quality -agrobiodiversity
Mobile Farm Equipment (CO_2, N_2O, CH_4)	equipment maintenance	-maintenance cost -generally done already	-lower fuel costs
	optimize draw-bar load	-generally done already	-lower fuel costs
	conservation tillage	-not compatible will all crop rotations	-lower fuel costs and less labor -less wear on tractors -soil carbon sequestration -water conservation
	engine upgrades or retrofits	-cost of new equipment	-lower fuel costs
Irrigation Pumping (CO_2, N_2O, CH_4)	Maintain pump bowl assembly	-maintenance cost -generally done already	-lower fuel or electricity costs
	solar-powered pumps	-cost of photovoltaic cell -limited to low horsepower engines -limited to daytime use	-lower fuel or electricity costs
Livestock (CH_4)	biogas control systems	-cost of building the system -engines subject to air quality rules.	-energy generation (gas or electricity) -sale of carbon credits
Rice Cultivation (CH_4)	baling and removal of straw	-baling costs -limited market for rice straw -impacts quality of waterfowl habitat	-sale of rice straw -feed and bedding for livestock -feedstock for biomass power generation
	reduce winter flooding	-poor decomposition of straw -impacts quality of waterfowl habitat	-lower pumping costs, fuel savings
	mid-season drainage	-crop water stress -yield loss	-control of aquatic weeds -water conservation
Residue Burning (CO_2, N_2O, CH_4)	minimize burning	-low overall mitigation potential -already regulated	-air quality
Carbon Sequestration (CO_2)	reforest rangelands, riparian zones and hedgerows	-cost of establishment -require irrigation in early years	-water quality -erosion control -biodiversity

establish valuable common ground with those in the agricultural community. Unlike California's industrial sector, AB32 does not require agricultural producers to report their emissions or to implement mandatory mitigation measures (CARB, 2008). The state is however encouraging farmers to institute voluntary mitigation strategies through various public and private incentive programs (Niemeier and Rowan, 2009). That said, some in the agricultural community are still concerned that the policy for agriculture could shift from voluntary to mandatory mitigation at some point in the future, which could make it more difficult for farmers to stay in business. Given that this hypothetical shift in climate policy might inadvertently accelerate farmland conversion and further boost urban emissions, there appears to be a sound case for maintaining and protecting agriculture's voluntary mitigation status.

Tapping into Farmers' Ideas on Mitigation and Adaptation

Protecting farmland from conversion is an important first step, because it expands the opportunities to mitigate future emissions, and perhaps more importantly helps to maintain our economic and ecological resilience to the impacts of climate change. But for these goals to be fully realized local farmers and land managers must be part of the process. Farmers have a key role to play since they have vast practical knowledge on how to optimize farm management to reduce agricultural emissions, conserve water or store carbon in the agricultural landscape. Almond orchards in Yolo County are a prime example; reports from some local growers indicate that innovations in drip irrigation have allowed some to reduce N fertilizer applications by up to 30%, while also boosting yield and water use efficiency. Since

N_2O emissions from fertilizer use are the single largest source of emissions from agriculture, efforts by growers and commodity boards (e.g. California Almond Board) to expand the use of these technologies have already begun to yield mitigation benefits.

Given that local (and global) temperatures are expected to rise even if the state's mitigation targets are met, it is equally important for rural communities to consider ways to adapt local agricultural systems to the possible impacts. With this in mind, understanding how farmers have adapted to past extreme events (e.g. heat-waves, droughts, floods) can often give insight about what strategies might be effective in the future. For example, during previous droughts Yolo farmers reduced rice and alfalfa acreage (both of which require a lot of water) but increased the cultivation of rain-fed winter wheat. Another planning strategy is to simply look at what farmers are growing just a few hundred miles to the south. By the end of the century the climate in Yolo County is expected to resemble the current climate in Merced County (Jackson et al., 2011). Consequently, Yolo may become better suited for the more heat-tolerant crops commonly found there like olives, citrus and melons.

Bridging the Gap Through Research and Extension

To support these local efforts, an interdisciplinary group of researchers from UC Davis is working on a case study for the California Energy Commission to explore planning scenarios that support the sustainability of agriculture and its adaptation to climate change in Yolo County. The purpose of the project is to create a planning template for other California counties where knowledge on agricultural impacts and solutions are assembled and then made widely available to the public through an interactive website. A key component of this has been the development of three planning tools that will help local land managers and decision makers consider what land-use and adaptation strategies might be useful. The first is a water evaluation and planning (WEAP) model, which assesses how future climatic and economic projections will impact the local water supply and also test the efficacy of various mitigation and water conservation strategies. The second is an urban growth model called UPLAN, which will allow decision-makers to see how future urbanization scenarios might impact the county's farmland and greenhouse gas emissions. The final element has been the development of a survey, which solicits farmers' ideas and perspectives on proposed mitigation and adaptation strategies.

Conclusion

In addition to assembling the information and tools necessary for decision-making one of the main roles of this UC Davis research project has been to serve as a bridge between the various stakeholders. Uncertainty is an inherent part of climate change planning. However, by helping people to express their views and concerns about these uncertainties important social linkages within the community are also strengthened. Better communication in turn increases the ability to come to a consensus on the uncertainties, risks and opportunities posed by the various factors that drive change. Ultimately, communities with strong linkages among those in the social network are bound to have better adaptive capacity in response to change. While this planning process remains in its early stages, there appear to be many good reasons for optimism in Yolo County. Not the least of which is a recognition that the stakeholders mentioned above are committed to strengthening the resilience of Yolo's agricultural landscape to the many changes that lie ahead, be they climate-driven or otherwise.

References

Adger. 2003. "Social Capital, Collective Action, and Adaptation to Climate Change." Economic Geography, 79(4): 387-404.

CAGO, 2009. Climate Change, CEQA and General Plan Updates. California Attorney General's Office. September, 2009.

CARB. 2008. Climate Change Proposed Scoping Plan: A framework for change. California Air Resources Board. October, 2008.

Jackson, et al. 2011. Adaptation to climate change in agricultural landscape. In press, Climatic Change.

Niemeier, et al. 2009. From kiosks to megastores. California Agriculture, 63(2): 96-103.

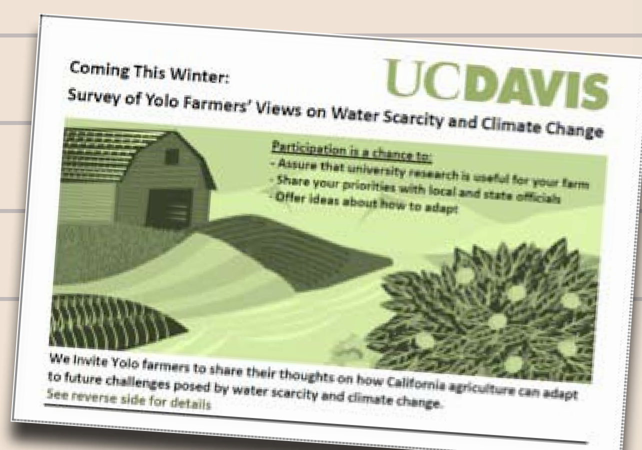
Yolo County, 2010. Final Yolo County Historic Greenhouse Gas Emissions Inventory Results.

Bridging the Gap in Yolo County

Researchers and Extension Specialists interacting with local growers in the field.

Researchers and local growers discussing perspectives on sustainable agriculture.

A field of newly transplanted tomatoes irrigated using traditional furrow irrigation.



SPLIT ESTATE

BY STEPHANIE MALIN

Benefits and consequences of drilling in the Rocky Mountain West. Health, land, and homes are impacted as gas companies erect fracking machinery.

Split Estate, a film produced by Red Rock Pictures and distributed by Bullfrog Films, explores the social and environmental consequences of natural gas drilling in the Rocky Mountain West. Showcasing sweeping landscapes and thorough interviews of colorful residents, the film's directors examine the rural, community-level impacts of hydraulic fracturing (fracking) in the Western United States. The film expertly intertwines these personal and community-level observations with more macro-level concerns, unpacking various regulations and policies that contribute to fracking's controversial environmental health outcomes.

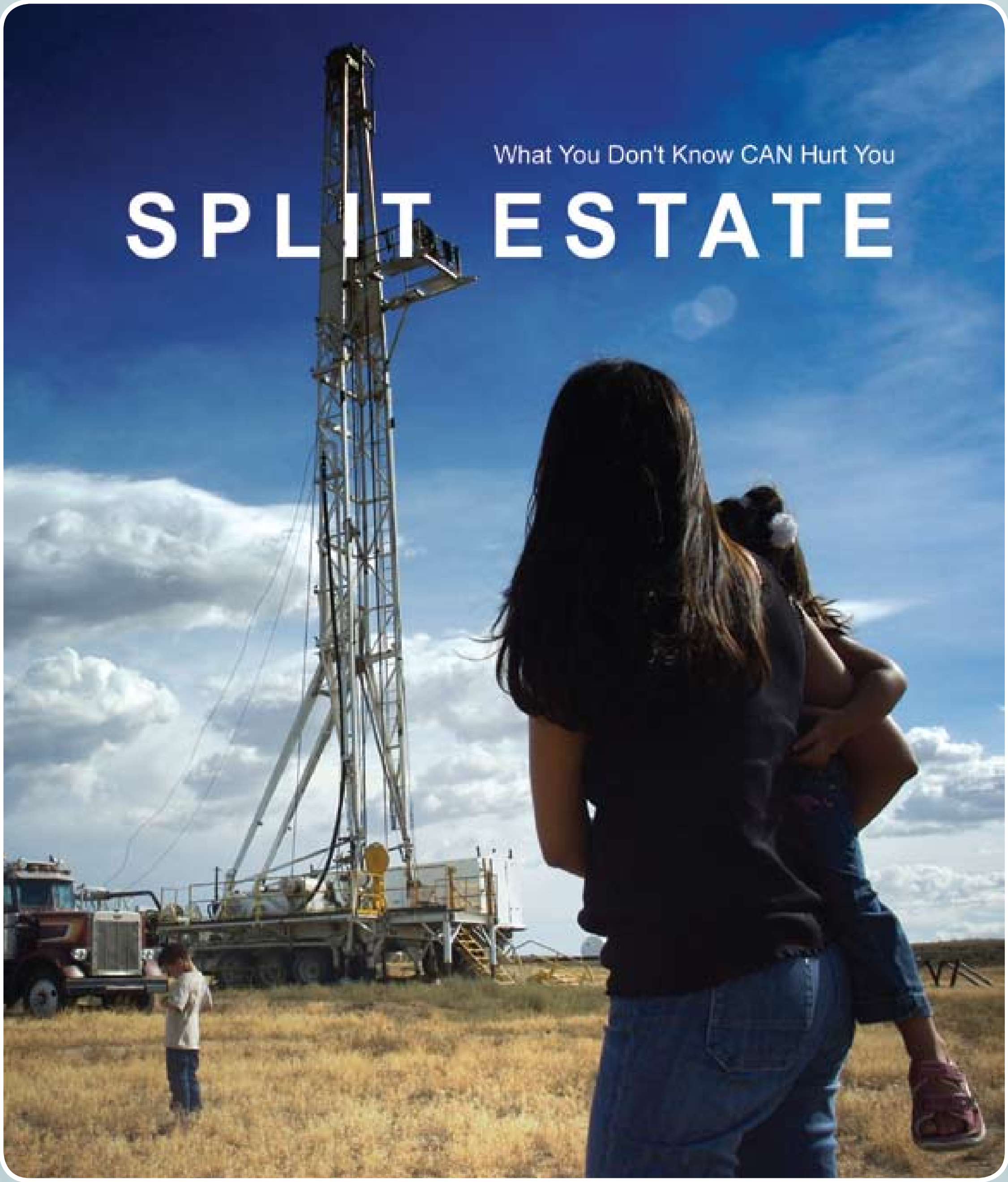
The filmmakers analyze these issues to expose the concept of the split estate, a fairly common land ownership and use arrangement in the public land-rich western US. In a split estate scenario, residents own the surface of their land but not the natural resources – such as oil and gas or minerals – under it. Thus, despite having deep roots on their land, long-term histories in their communities, and sometimes ranching or other agricultural enterprises, landowners in communities such as Rifle, Colorado, witness gas extraction wells erected in their yards to extract the natural gas far below its surface. The film highlights residents' indignation and powerlessness as gas companies erect fracking machinery on their land, sometimes right next to their homes and children's play areas. As viewers, we stand next to them and feel their indignation as their homes, land, and health are impacted.

Split Estate vividly captures quality of life impacts that affect residents proximate to hydraulic fracking sites, one of the film's strongest aspects. Moving in-depth interviews create an emotional connection between the viewer and documentary subjects, as we witness the heartbreak and powerlessness of living in the middle of a fracking field. The film presents compelling stories of fracking's health effects, taking us inside people's homes as families struggle with mysterious physical ailments they connect to exposure to chemicals used in the fracking process. We witness rural Colorado residents struggle with strange lesions on their brains, nervous system abnormalities, skin diseases and rashes, respiratory problems, and many serious afflictions showcased by the filmmakers but denied or undiagnosed by doctors. These glimpses into suffering and uncertainty brought about by the split estate give the film its unique character, putting a human face on policies like the Energy Act of 2005, which largely deregulated industries such as natural gas extraction.

The film's sweeping cinematography, which captures fracking's ecological footprint, and its mix of interviews and policy analysis further fortify its message that the split estate model may work well for gas firms and not so well for people living on affected tracts of land. Importantly, however, Split Estate is not a one-dimensional film. In particular, the film weighs economic development created by the fracking industry and the local economic stimulus this has created as compared to health and other negative quality of life consequences outlined above.

As with any film, there are weaknesses as well, though they certainly do not detract from the film's core message or strength in presenting the human side of hydraulic fracking.

Stephanie Malin just earned her PhD in Environmental and Development Sociology from Utah State University. She will begin a 2-year postdoctoral fellowship in Environmental Ethics at Brown University in August and will then be on the job hunt out west!



Courtesy Red Rock Pictures and Bullfrog Films.

While the topic matter is somber, the entire film is rather slow and quiet. The film would benefit from an injection of humor along the way, despite its serious and compelling subject matter. While humor scattered among fracking's serious repercussions might seem impossible to execute, other documentaries like Gas Lands create a balance in an exemplary manner, setting the bar high for films such as Split Estate. The film would move along more smoothly and a little less heavily with more levity.

Otherwise, Split Estate represents a thorough, engaging, and important peek into hydraulic fracturing and natural gas extraction. As we sit on the precipice of this type of energy development, the film offers a vital glimpse into policy's impacts on the ground, in rural western communities. Environmental health and social impacts are presented with vivid compassion for those living in the middle of a split estate. Recording their experiences creates a compelling case against hydraulic fracking in its current, deregulated form.

To learn more about the events discussed in SPLIT ESTATE, visit Bullfrog Films at: bullfrogfilms.com.

For information on other RRDC initiatives -- leadership development, regional collaboration, food security and local food systems, community-based disaster management education, youth development, and technology adoption -- visit each Center's website.

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