Preparedness -

Strengthening the Agri-Food Sector's Capacity to Adapt and Thrive

Has the Prairie agri-food sector adapted to the challenges and opportunities of climate, market and input cost changes over the past 40 years? Yes, remarkably well. For example, Prairie agriculture has developed a new crop (canola), a new level of conservation tillage for crop production, and has survived fusarium, wheat midge, as well as Bovine Spongiform Encephalopathy (BSE) outbreaks. Here we address the tools required to ensure that the agri-food industry has capacity to capture opportunities and successfully address challenges in the next 35 years.

There is general recognition that future policy will have to consider not only mitigation strategies but also adaptation and adaptive capacity. Barriers to adaptation are generally linked to uncertainty and lack of understanding causing lack of leadership or inaction by governments, or existing governance and institutional arrangements. Agriculture's capacity to either proactively or reactively respond to future change requires the support and trust of the Canadian public.

Background

There is tremendous potential for agricultural systems on the Canadian Prairies to expand agri-food exports in response to global demand for food by 2050. Globally, this demand is expected to require farmers to double their production of crops and/or livestock over the next four decades[1]. Achieving such increases in productivity will pose significant challenges since water, land and energy resources are increasingly in demand by other economic sectors and rapidly growing urban areas. As well, response to opportunities and challenges cut across a wide range of interdependent jurisdictions where decisions are made, from local farms to multi-national food processors.

Climate change will influence the conditions under which food is produced, stored and transported more in the future than has been experienced in the past. In addition to population growth and shrinking input resources, stakeholders along the food value chain will be expected to respond to shifts in consumer demand, environmental policy and global trade. While there is recognition that the economic, environmental and social health of Canadians is linked to the health of Canada's agriculture sector; Canadians have less opportunity to interact and, thereby, understand the short- and long-term impacts of current and future practices or technologies on their economic, environmental and social welfare.

Successful adaptation may occur through incremental improvements or may require much more radical change. The advent of the Haber-Bosch process for chemical fixation of nitrogen from air in the 1900s and of Mendelian genetics spurring the green revolution caused radical or system-level changes to food production around the globe. Most improvements to efficiency of resource and labor use, reliability of food delivery, food quality or safety in Canadian animal and crop production systems have been incremental; examples including precision agriculture, continued improvements in crop yield and disease resistance, and animal vaccines. As we look to 2050, we cannot predict the success of technologies such as in vitro meat production which could cause a radical shift in current food production systems. Nor can we predict the relative impacts of a broad range of technologies that will incrementally increase competitiveness, environmental stewardship or food quality in current food production systems across Canada's ecozones.

What Metrics Should We Use for Successful Adaptation?

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The essence of successful adaptation is coping creatively with unpredictable change; ideally it means not only *surviving* change, but discovering therein new opportunities. Adapting is more than merely conserving what once was; it seeks, rather, to manage our ecosystems – our lands – so that all the many benefits we derive from them are sustained *despite* inevitable changes. But how do we know if these benefits are being sustained? How do we know if our lands are building up or winding down? Clearly, we need some way of gauging the performance of our lands --- metrics to monitor how they are faring during the coming changes.

Establishing the need for metrics is easy enough; actually devising specific measures to use is another matter. Rather than prescribe a list of such metrics (likely a premature exercise, given the state of the science), we describe here what such metrics might look like. If we could develop an ideal set of metrics – of measurements – to monitor how

“Adapting is more than merely conserving what once was...so that the many benefits we derive (from them) are sustained despite inevitable changes.”
(credit: E. McGeough)

well ecosystems are adapting, what would it look like? The following attributes are proposed; the metric system should be:

Comprehensive: To be effective, an ideal set of metrics would consider all the functions expected of our ecosystems – not just conventional ones such as maximizing yield, sustaining economic return, mitigating greenhouse gas emissions, or avoiding nutrient loss (as important as these are), but also others not always immediately apparent: filtering water, fostering rural communities, preserving wildlife, ensuring aesthetic values, enriching human health, and promoting animal welfare, as a few examples. This perspective steers us toward looking at our lands not merely as ecosystems, but as social-ecological systems: humans embedded among the myriad biota, all interwoven and intertwined with each other and their physical habitat. To develop a set of metrics, then, we need first to enumerate the manifold functions derived from land, spanning the boundaries between traditional disciplines.

Unifying: None of the functions we ask of the land can be considered alone; all are interactive, creating some synergies but also inevitable trade-offs. For example, the system that best promotes economic return might also minimize nutrient loss, but deplete soil diversity; the system that best preserves aesthetic appeal may also sustain wildlife, but diminish income for rural populations. These interactions all need to be weighed together in arriving at a sound measure of adaptation. One way to move toward such holistic assessment might be to think in ratios of benefits and costs. As an example, consider the case of greenhouse gas mitigation. Reducing the emission of these gases is an urgent aim; but the system with the lowest emissions (e.g., abandoned land with minimal inputs) may not sustain other demands on the land (e.g., producing food). A useful metric, therefore, might be the ratio of services attained per unit of greenhouse gas emitted. In effect, this approach asks: if we ‘invest’ a tonne of CO_2 equivalent (a cost), what is the return in food yield, economic livelihood, biodiversity, and other benefits we deem important?

Locally applicable: In the end, lands are always managed locally, farm by farm, field by field; and the stresses of change will be exerted locally, uniquely to each place. A useful scale for applying metrics, therefore, might be the ecosystem: a single farm, perhaps, or a local assemblage of farms, encompassing most of the exchanges of energy, nutrients, and carbon. In a livestock system, for example, the ecosystem might include the land where animals are raised, as well as the surrounding lands that furnish the feed and recycle the manure. Any evaluation of adaptation must explicitly describe the boundaries within which the measurements apply. It is the boundaries, ideally local boundaries that distinguish between a concrete, relevant metric and an abstract, ethereal one.

Simple and transparent: To be widely adopted, a metric should be simple enough to be broadly applied and easily understood. An elementary measurement, decipherable by the uninitiated, is usually better than a sophisticated algorithm opaque to all but experts. For example, a measurement of soil carbon is preferred to a model output of carbon dynamics; an estimate of protein produced per unit of greenhouse gas emitted may be better than detailed spreadsheets of farm fluxes and yields. Elegant simplicity, of course, demands much more creativity than mere sophistication; so this attribute is better seen as alluring target than as immediate goal. Particularly challenging are those ecosystem functions that are not easily measured: aesthetic appeal, for example, or biodiversity. A possible approach for these might be a simple numerical index, produced by representative human panel. Better to include a simple index, with admitted flaws, than to ignore a function entirely.

Timeless: The underlying variable in adaptation is time; change, by definition, unfolds as each future moment is overtaken by the present, and then slips into the past. A metric to monitor adaptation to change, therefore, must stay true and consistent across time, into an uncertain future. This forces those who design the metrics to envision the range of unfolding possibilities for future lands, and to devise measures that will be robust across long time, even in the event of certain surprises. Ironically, some of the best insights toward this future perspective may be found in the past, by asking: Which metrics have survived the tumultuous changes of the past century or so? Some of these, such as soil carbon, ecosystem nutrient balances, diversity of farming systems (including livestock) might well be melded into future metric systems.

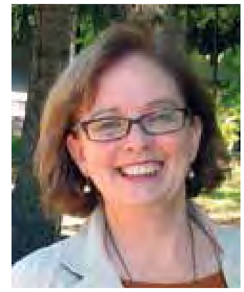
This list of attributes, no doubt, is still incomplete. Even so, it is already daunting, and we are only now taking the first faltering steps toward building a set of metrics that might satisfy these criteria. So what is the way forward? Maybe our quest can be guided by the following questions, asked sequentially:

1. What functions do we ask of the land? And what functions will our successors, some decades hence, ask of it? In pondering this question, of course, we think of the full spectrum of uses, from the biophysical to the social.
2. What stresses may be imposed on our lands? And which lands are most vulnerable? We cannot know exactly how the future unfolds, but many of the coming challenges seem already apparent: demand for food, shrinking land area per capita, energy constraints, dwindling freshwater, for example. Enumerating these coming stresses might steer us to those parameters and places of our systems most vulnerable to adaptive pressures.
3. What, then, do we measure to see how well our lands can continue to furnish into the future all we ask of them in the face of coming stresses?

These questions, of course, are not merely academic and conceptual. They are best asked in parallel to measurements already begun, or needing to be started. It is as we measure performance of our lands, even with our still feeble and fragmentary metrics that we answer the preceding questions, and stumble on new ways of resolving them with better measures. And always we think: “What measures should we start today for those who will be monitoring success of adaptation tomorrow?; just as we have learned so much from the measurements begun by our far-sighted forbearers.

A system of metrics for measuring adaption, as sketched above, may seem ideal, not soon fulfilled, if attainable at all. But the effort toward it still is warranted, for it will likely lead us to better science in understanding our ecosystems, and to more compelling visions about how we should live on our lands in a changing world.

What Kinds of Government Policies Will Help Us Adapt in 2050?



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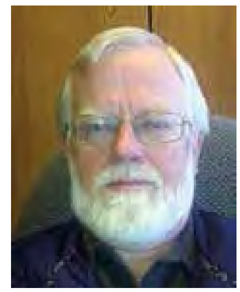

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A key role of government is to secure common goods and services that individuals cannot provide. This is done by developing a range of strategies, policies and plans to achieve outcomes that are implemented through legislation and regulations, through the use of instruments such as incentives or directives, or by using measures like standards or certificates. Although significant drivers are required for regulations, these may be set to trigger only at threshold changes in quality or supply of resources. Voluntary arrangements, education and outreach programs have also been successfully adopted to support strategic policies. Market-based instruments, such as taxes and tradable permits, have recently been used to alter price signals and create cost incentives. Although preference may be given to one approach, most jurisdictions rely on multiple policy approaches to achieve their goals.

Intensification of sustainable food production may be one of the better responses to climate change[2]. Increased efficiency of resource use for increased agricultural productivity will be a key policy driver in this context, including the need to enhance the quality and accessibility of the biophysical resource base. Figure 1 illustrates the challenge of linking variations in both biophysical and human elements, highlighting the need to target management to minimize adverse impacts in vulnerable areas. Another important policy driver related to a changing climate will be sector and public preparedness for a range of possible scenarios, such as strategies for stabilization of farm incomes. Although recovery from impacts that are gradual and widespread allows time to fine tune adaptation approaches, recovery from severe and highly uncertain climatic impacts can require many years. Broader drivers of policy to support