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.

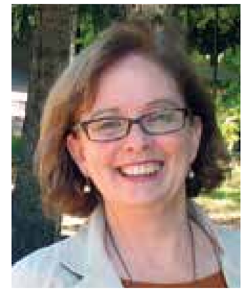
This list of attributes, no doubt, is still incomplete. Even so, it is already daunting, and we are only now taking the first faltering steps toward building a set of metrics that might satisfy these criteria. So what is the way forward? Maybe our quest can be guided by the following questions, asked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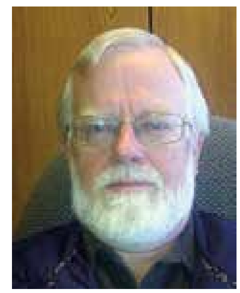

John Zylstra, P.Ag., Agriculture Land Management Specialist, Alberta Agriculture and Rural Development has many insights into agricultural adaptation to climate change in the Peace River Region of Alberta and contributed to the early development of regional land use plans in Alberta.

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

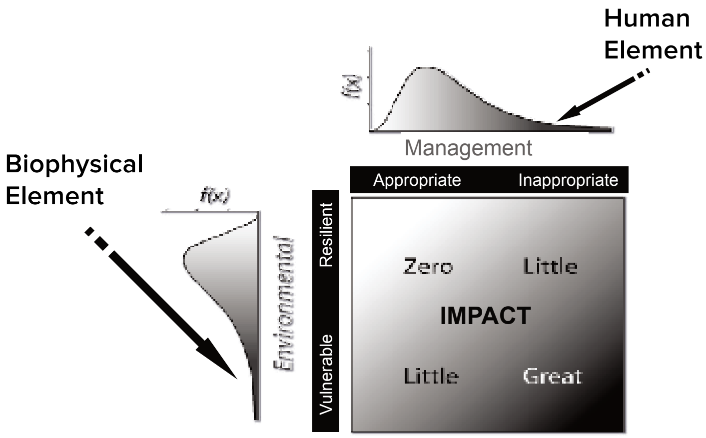

Figure 1: *Linking two forms of variance to focus efforts for greatest impact (P. Nowak, personal communication, February 12, 2014).*

adaptation include the need to diversify the economic base of the Canadian Prairies as well as external pressures, such as standards set in other countries and expectations arising from different cultural preferences.

Proactive government policy will anticipate change and balance long term goals of enhanced resource use with immediate term goals of competitiveness; proactive government policy will not simply respond to impacts. In view of the many uncertainties and influences on decision making, focus should be on enhancing resilience or 'adaptive capacity' that is the broader ability of agricultural producers, regions or sectors to cope with climate-related risks and opportunities[3].

Current status: Government policies that promote a vibrant, growing agricultural industry on the Canadian Prairies are already enhancing the resiliency of agricultural systems to a changing climate. Increasingly, regional land use planning initiatives are taking unique watershed and socio-economic characteristics into account when designing strategies in consultation with key stakeholders and the public. Evaluation of recent flood disasters is informing new planning efforts to minimize future impacts. Areas of high vulnerability within regions are being recognized for targeted actions, such as controlling cattle access to streams to address water quality. Public funding supports technologies that provide real-time data about field conditions that are being integrated into early warning systems. Government-backed crop insurance programs are providing a broadening range of options to mitigate risks of crop failures for farmers. Policies at provincial and national levels have supported a strong science and technology basis for progress towards continuous improvement of farm-scale management through research and extension programs. There are signals; however, that the social licence to operate will be challenged if the public concerns, valuations and expectations are not a part of the dialogue in future policy development.

Policies to heighten resiliency: In order to specifically increase resiliency to the highly variable and uncertain impacts of a changing climate, future government policy should develop a range of approaches to support outcomes that include: i) optimized management to ensure quality of biophysical resources, ii) sector and public preparedness for a range of possible climate change scenarios, and iii) diversification to broaden the basis for responding to change. A variety of simultaneous approaches can be used to support the development of innovations needed to address uncertainties and reduce risks, including incentives, market-based instruments, or tradable permits. Although regulation may be required in some cases, a range of approaches can be designed to meet specified outcomes, such as options to either change management or make payments into a fund to support future technological improvements. Outcomes that support resiliency will require innovation from a strong research base, the use of metrics to regularly gauge progress and fine tune policy approaches, as well as public and private sector involvement to apply existing momentum and increase the range of human and financial assets that are directed towards adaptation of the agricultural sector to a changing climate. Policies to increase the responsibility of Professional Agrologists to assess, assist with and document improved farm-scale management could also support outcomes of increased resiliency of agricultural systems.

Since moisture is scarce or arrives at inopportune times in many parts of the Prairies, optimized management to ensure high quality of water resources will be fundamental to enhancing the resiliency of agricultural systems to a changing climate. Efforts to increase food production and economic activity must target improvements and innovation in water use efficiency. Schreier and Wood[4] outline various ways for government policy to support the development of a strategic approach to water use in Canadian agri-food production. In addition to creating incentives to promote innovations in water use efficiency, they note a need for research to develop methods to measure and analyse water footprints from a whole systems perspective. These measures may become a basis for identifying standards that can be used to encourage management that meets or exceeds specified criteria. Comprehensive assessment is needed to capture externalities and reflect full costs of production. Inventory and risk assessment tools are also needed to synthesize results and assess water use scenarios in different regions in order to target vulnerable areas for management that avoids or reduces adverse impacts. Support of on-farm pilot studies and farm level education are important components that support adoption of practice improvements to increase water use efficiency.

The Oldman River dam was constructed in 1992 in response to the many droughts experienced by Southern Alberta farmers.
(credit: D. Flaten)

Resiliency will be enhanced by policies that support the development of multiple approaches to encourage preparedness for a range of possible climate change scenarios. Area-specific contingency plans will help to operationalize a range of strategies and provide a basis from which to develop further innovations and improvements. Government initiatives to construct infrastructure to support increased resiliency will be needed, such as facilities that store water and increase irrigation capacity. Monitoring systems are also important components of preparedness strategies, allowing governments and industry to respond to risks in early stages, when issues are usually more manageable.

Policy instruments to target outcomes of increased diversification of agricultural production according to areas of strength will provide new opportunities from which to build success in uncertain futures. Incentives to leverage momentum and private investment through collaboration with other efforts to diversify the economic base on the Prairies will be an important means of bringing new ideas and assets from a broad range of industry, research, and stakeholder perspectives. Review of policies to support resiliency and adaptation to climate change in other areas than agricultural production, such as municipal development and health services, will identify new opportunities where momentum can be increased by collaboration and integration. A variety of policy approaches can be designed to reward progress towards attaining desired outcomes at multiple levels (e.g. farm, processor, distributors and general public). Policies to encourage integration of new knowledge and technology to optimize resource use and productivity will bring added benefits of increased competitiveness and reduced risk. These approaches will also require collaborative and transparent processes of assessment, planning and prioritization with regular evaluation of metrics to measure progress towards identified outcomes of increased resiliency.

Although the challenges of adaptation to a changing climate are considerable and fraught with high uncertainty, comprehensive, dynamic and outcome-based government policy approaches can draw on past and current successes to heighten the resiliency of agricultural systems to impacts of future conditions on the Canadian Prairies.

How Will Technical Innovation Help Us to Deal With Climate Change Risk?

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Technical development is widely recognized as a substantial contributor to the capacity of Canada's agri-food industry to adapt to climate change[3-7]. Climate change will spur the development of a variety of technical innovations to deal with the challenges of variable weather and climate change directly, or indirectly through consequences such high input prices, rising cost of transportation, or greenhouse gas emission penalties. New opportunities to earn carbon credits or grow new, higher-yielding crops in a warmer, longer growing season, will also encourage further innovation.

Continuous development and adoption will continue to be imperative: The agri-food sector is a highly competitive industry where, if we don't innovate as quickly or as well as

Red Queen Effect

"... Now, here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!"

Lewis Carroll

Through The Looking-Glass

"we will need to continue to invest in a combination of measures that enhance our capacity to be flexible"
(credit: W. Reimer)

our competitors, we will fall behind. As Julian Alston[8] states, it's similar to the classic "Red Queen Effect" in evolution, where our industry resembles the Red Queen's world from Lewis Carroll's *Through the Looking-Glass*, "it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!" Individually and collectively, we will need to continue to invest in a combination of measures that enhance our capacity to be flexible and adapt to new realities that will face the agri-food sector in the next decades.

Technical developments are difficult to predict: Historically, technical developments have been difficult to anticipate or predict. No one knows when another plateau in productivity may be reached or transcended; in large part because the fundamental nature of discovery is that it is a path that leads into unknown territory. In some cases the complexity of development from the basic through applied to commercialization stages will require both focused and comprehensive approaches to ensure acceptance by the user of the technology, the producer, as well as the general public. Situations in which industry and/or public confidence is challenged will increase development costs. At the 2014 annual meeting for the Weed Science Society of America in Vancouver, Damon Palmer, from Dow AgroSciences, estimated it now costs $250 million to research and develop a new crop protection product[9] and those costs are not likely to decrease. In other cases, especially where there is less perceived risk to human health or the environment, development of new techniques and technology may be faster than in the past because science and engineering tools for development have progressed substantially and because technology transfer is a global industry. Shifting drivers in the decision making process make predictions of future trends a subjective exercise, especially when one attempts to gauge the impact of future technologies applied collectively.

Technical developments require investment: One aspect of technical development is easy to predict: without any investment of time, effort and money, technical development is not going to occur. This important link between investment and return may be cause for some concern going forward to 2050. Traditionally, Canada's federal and provincial governments have been large investors in agricultural research, which has yielded large dividends to the regional and national economies. However, as noted by Veeman and Gray[10] in their review of agricultural production and productivity in Canada, real public agricultural research expenditures in Canada for crops and livestock has been declining. That total domestic research and development, a "knowledge stock" variable that is calculated as a 20-year stock of federal, provincial, and private sector research and development expenditures, has levelled off for crops and livestock in Prairie agriculture since 1990[10] is of even greater concern. This stagnant to declining investment in agriculture research has occurred even though return on investment in agricultural research and development is widely recognized as paying very large dividends for public, private, and producer group investors[7,10,11,12].

"Electronic communication technology enables farmers to access information directly"
(credit: C. Jorgenson)

New technology and techniques have no effect unless they are adopted: The rate of adoption of new technology is unpredictable[13]. Social factors such as education, attitudes and access to information are important; as are economic factors such as profitability, access to capital, and degree of risk or uncertainty. Electronic communication technology enables farmers to access information directly from public and private research organizations through a variety of channels, including web pages and Twitter. There is concern that the research community cannot meet the demand for information and lead research programs, and this has started to give rise to information brokers or consultants who are paid by industry. The economic incentives for farmers to integrate new knowledge or technology into their operations are linked to market opportunities and financial risk capacity. As major exporters of commodities and manufactured food and beverage, adoption of new technologies will be driven by international competitiveness, stability of trading partners and policy incentives or barriers to adaptation.

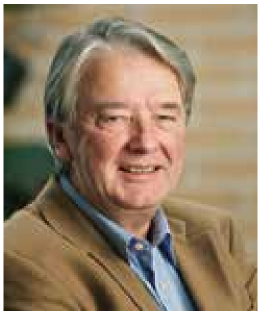
How much innovation can be imported, borrowed or adapted: Many people in the agri-food industry will continue to look elsewhere for technologies and techniques that might be new to them, but which are not really new. For example, soybean acreage in Manitoba has exploded over the last 10 years. Even though soybeans are a relatively new crop for most Manitoba farmers, they have been grown in the US and Central Canada for decades, so our farmers and agronomists are adopting and adapting techniques and technology for soybeans that are well proven in other regions. Nevertheless, the extent to which innovation can be imported or borrowed without any adaptation remains an important issue. The interactions between soil, crop, climate and market factors will result in unique challenges and rewards for agricultural production in the Prairies vs. the US and Central Canada.

Responding to the indirect side-effects of climate change challenges and opportunities: As the agri-food industry and society react to the challenges and opportunities associated with climate change, incentives for innovation will be created. For example, public demand for greenhouse gas mitigation may introduce substantial carbon credits, along with new regulations and penalties for greenhouse gas emissions. This regulatory environment could have a major impact on energy use in crop rotations and the need for new tools to enhance and validate carbon sequestration practices. As another example, warmer and longer growing seasons coupled with improved crop genetics may enable high yields of grain corn or other high yield crops to be grown across the Prairies. This could put a substantial strain on transportation capacity to provide sufficient amounts of fertilizer, as well as transportation access to move the higher grain volume to traditional export positions. Regionally this could translate into decisions that constrain the expansion or corn acres or promote more investment in livestock production to create local market for the energy and proteins crops grown.

Climate change adaptation will have to fit with other challenges and opportunities: Obviously, climate change is not the only challenge or opportunity that our agri-food industry will need to address. Some of the other major drivers that will shape the agri-food industry over the next 40 years will be complementary with efforts to adapt to or mitigate climate change and some will not. For example, carbon credits and concerns about agricultural sustainability, soil erosion and degradation may drive farmers towards innovations that improve soil quality (eg., water infiltration and water storage), which can improve farm profitability and sustainability, as well as the capacity of the land and cropping system to adapt to climate change. Conversely, if tight or negative margins force farmers towards short term exploitation strategies for management of land resources, their capacity to adapt to climate change may be reduced.

Innovation's capacity to help adapt to climate change is helpful but limited: Innovative technologies and practices can help to reduce the frequency of weather-based problems in our agricultural systems but extreme events will continue to periodically overwhelm our capacity to adapt. The probability and consequences of those periodic failures will likely vary among adaptation strategies. For example, the risk of flood damage to agricultural land from intensive rainfall or snowmelt events might be mitigated with levees, diversions, streambank stabilization measures, or reassignment of land use. Each of those strategies has a different risk in terms of the probability and consequences of failure. That type of risk is important to determine and then communicate to our professional colleagues, policy-makers and the general public.

Educational Systems for 2050 – Lessons from History



Michael Trevan, Dean, Faculty of Agricultural and Food Sciences, University of Manitoba

"Education is what survives when what was learned has been forgotten"
(B.F. Skinner 1964, *New Scientist*, 21 May)

"[Education] has produced a vast population able to read but unable to distinguish what is worth reading, an easy prey to sensations and cheap appeals"
(G. M. Trevelyan 1942, in *English Social History*)

Taken together these quotes are pivotal to the type of educational systems we will need by 2050. Education is not school, especially when dealing with the so-called "wicked" problems of growing population, war and conflict, diminishing extractable resources, social and environmental activism, fluctuating demographics, economic boom and bust, internet generated experts and critics, and the vagaries of climate change and weather instability.

Learning how to be adaptable and adaptive comes from a variety of inputs and situations, only some of which are found in the traditional classroom. In the rapidly changing world of today and tomorrow access to "information" is instant and universal, the key question is how the validity of that information might be ascertained. Will we need teachers to stand in front of a class and attempt to fill their students' heads with presently known facts? Clearly this is not even necessary today, the student has multiple means of accessing "facts", but few means to validate their relevance or accuracy, or to understand possible connections between apparently incongruent fields.

A student is not just the registered attendee of an educational institution who aims to gain a qualification, but anyone who is motivated to learn for whatever reason.

When Wilhelm von Humboldt founded the University of Berlin in 1810, he set in train the beginnings of the type of university that we know today, one that links research to teaching, producing both innovations for industry and society, and knowledgeable people. Humboldt's fundamental belief was that a university education was not defined by a teacher-student relationship, but rather that learning was a student centred research activity guided by the professor.

A consequence of the interaction between the Humboldtian ideal and society over the last 200 years has been the continual creation of new research driven academic disciplines. This and the reductionism of parceling knowledge into ever narrower fields, has resulted in graduates from universities coming to know more and more about less and less, an almost inevitable consequence given the continual doubling of the total body of knowledge.

Another essential part of this 19th century model was the generation of new knowledge and its dissemination; if you needed to know you had to access knowledge within the university as part of that "community of scholars". But is this model still relevant to today's needs, let alone those of the mid 21st century?

For example, today's agriculture students may learn about the two separated entities: the fate of pesticides in the environment from a course in soil or environmental science; and about weed or pathogen control from a plant scientist or pathologist. Would it not be more useful to deliver that knowledge in one integrated course? Should not the teaching and learning offered by a university be relevant to the future needs of a student, rather than being based on the history of academic disciplines? And should it not provide the student with the analytical and synthesizing skills so that they can see connections and evaluate contradictions?

In their book *Academically Adrift: Limited Learning on College Campuses*, Richard Arum and Josipa Roksa[14] report the results of their surveys of US university and college students. Their study showed that 45% of college students do not gain in critical thinking, complex reasoning or writing skills during their 4 years as a student, less than 17% of their time is spent in class or studying, over 29% of graduates never or rarely read print or on-line news, and only 15% discuss politics or public affairs daily (another 46% on a weekly basis). Students may be socially engaged, but they are not academically engaged, nor is a significant proportion gaining an understanding of the process of discovery, that is learning how to learn.

In the 19th century change was dramatic and was viewed optimistically (at least by those whose voice was heard) as something that could have a positive effect on individuals and society. In the 21st century change has come to be viewed as a potentially detrimental challenge, one that threatens our comfortable preconceptions: that receiving teaching equals accomplishments that become qualifications that guarantee a life-long, well-paid job. Those days are gone: perhaps they never actually existed.

"development of the individual and society through academic programs or outreach activities, that help the individual to learn how to learn"

To meet the challenges of the future, today's young people need institutions and processes that help them develop into effective researchers, active and critical learners, and analytical thinkers something for which our present educational institutions with their emphasis, or obsession, of testing for information retention, seem ill-suited. Whether it is for the nurturing of the young or all citizens, should we not give up our focus on validating qualifications for the convenience of employers, and concentrate instead on delivering that 19th century vision of simultaneous development of the individual and society through academic programmes or outreach activities, that help the individual to learn how to learn: to populate society with analytical and critical researchers and thinkers, who can go on to become visionary leaders whose role will be to guide society successfully through the complex issues of the next 50 years? For without knowledgeable, adaptable citizens and educated, visionary and ethical leaders our future society must founder on the rocks of uncertain and rapid change.

Conclusion

Is the agri-food sector on the Canadian Prairies equipped for the known and unknown challenges both for the next 35 years? The answer to this important question lies in part with sector and public investment in dialogue, policy, innovation, and education.