Future of Farming in Washington: Climate Change

The purpose of this paper is to provide a framework that: (1) briefly summarizes the relationship between agriculture and climate, (2) provides a short update on the latest assessment of the potential impacts climate change may have on agricultural production in Washington State over the next 20 – 40 years; (3) provides some discussion on the potential opportunities and risks associated with the emergence of carbon market mechanisms / greenhouse gas emissions policy; (4) describes the existing assets and tools that the state has that can be utilized to improve agricultural management and decision-making in light of climate change; and (5) working group suggestions for areas of potential investment by the state.

Description of correlation between agriculture and climate

Climate is a critical determinant of the evolution of modern agricultural systems. Temperature, precipitation, humidity, solar radiation and many other climatic factors have direct impact on plant phenology, plant and animal health and productivity, incidence and severity of weed, disease and pest pressure, availability of moisture, soil development, and many other factors. Most agricultural systems generally develop / adapt to localized climate stimuli [as well as markets] – which often determines the predominate type or types of farming systems in any given region. Washington State's diverse agri-climatic conditions have led to the development of a wide variety of farming systems that are very well adapted to localized micro-climatic conditions. For instance, the arid regions of Central Washington, when irrigated, prove to be excellent regions for high-value horticultural production as the aridity tends to reduce pressure from pests and diseases. The "rainfed" or "dryland" production region of Eastern Washington has largely developed as a winter wheat dominated cereal grain cropping system – due to the adaptability of fall-planted wheat to a winter precipitation dominated regions.

Perhaps as important to the relationship between *localized* climate conditions and agricultural development is the fact that the climatic system has been *relatively stable* during the 100 year period in which modern commercial agriculture systems emerged, enabling the general climatic predictability necessary for risk management in the specialized animal and cropping systems that now dominate our landscape. Potential changes in our climate system – both in *averages* as well as *variability / extremes* – may require adaptation or changes in management strategies to ensure long-term sustainability of farming in Washington State. This is of particular importance as past climate history becomes less useful in predicting future climatic conditions in an industry where extreme weather events occurring at critical times, such as freezes, frosts, or heat waves, can be devastating to a highly specialized, capitalized, and integrated industry. Improving our understanding of new climate-associated vulnerabilities over the next 20 – 50 years is critical for reducing risk and improving the adaptive management capacity of agriculture in Washington State.

In addition to the impact that climate has on agriculture, agricultural systems directly affect the climate. The direct impacts include contributions to global carbon and nitrogen cycles (greenhouse gas emissions, carbon storage) as well as localized changes in climate (i.e.., evaporative cooling from irrigation). Agriculture contributes approximately 1/5th of the annual global greenhouse gas emissions (~7% of US emissions), primarily via carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). While these emissions are a by-product of necessary food and fiber production processes, the potential does exist that agriculture can reduce direct emissions and even restore carbon from the atmosphere to soils and vegetation. The agriculture industry may be well-placed to benefit from emerging carbon markets and public policy mechanisms for greenhouse gas mitigation. Efforts are under way in Washington State to assess the potential benefits to the Washington agriculture industry from these types of opportunities.

Potential impacts of climate change and variability on agricultural production in the Pacific Northwest

a. Water

Perhaps the most studied impact of climate change and variability on agriculture in the state of Washington relates to water resources. Extensive analysis of the potential impacts of climate change on Washington's water resources has been conducted by the University of Washington and the Pacific Northwest National Lab (PNNL) – specifically the relationship between expected snowpack and water levels in managed and unmanaged watersheds. Specifically related to agriculture, assessment of potential climate driven impacts on water levels in the Yakima River Basin – including assessment of potential economic impact associated with crop loss in low-water years – has been conducted by Mike Scott of PNNL. A low-water year in 1994, led to rationing of water for junior water rights holders in the Yakima Valley, resulting in crop losses estimated at $140 million dollars. Currently, water rationing for junior water rights holders happens 14% of the time. Predicted changes in climate by the 2040's indicate an average of 20-40% reduced annual water availability in the Yakima basin, and a likelihood of rationing for junior water right holders 50% of the time by the 2020's and 90% of the time by the 2040's. While the specialized conditions of the Yakima Basin (economic impact, low elevation watershed, limited storage) are not exactly duplicated in any other region of the state, it does provide an analogue relevant for estimating impact to other snow-pack dependent irrigated regions of the state (i.e.., Wenatchee, Methow, Okanogan, Walla Walla, etc.).

In addition to the concern of adequate supplies of irrigation water, climate change and variability *may* increase the frequency and severity [and associated adaptation costs associated with] of extreme flooding events. At this time, most climate models are not sophisticated enough to adequately evaluate the location specific drivers for extreme weather event-driven conditions like flooding – so the degree of vulnerability for various agricultural regions of the state is unclear.

b. Weeds, diseases and pests (based on preliminary results from HB 1303 "generalized assessment" study, subcontracted to WSU by UW)

The potential for changes in the incidence and severity of weed, disease, and insect problems is likely the most important and yet least understood concern related to climate change and agriculture. It is important because these "pests" are extremely sensitive to climatic drivers and management of pests is one of the most significant production problems and costs for many of our agricultural systems. Potential for changes in weed, disease and insect problems is poorly understood because each pest type may react differently to highly localized changes in climatic conditions – (among numerous other factors), and few studies have been conducted that directly correlate climate change with changes in pest incidence and severity. Improving our understanding of vulnerabilities caused by likely changes in incidence and severity of existing pests as well as evaluating pest problems in other regions that currently have climatic conditions similar to what is expected in Washington is an essential investment that should be made. Initial efforts to provide a "triage" of likely changes in pest pressure are being conducted by WSU. Early results include:

- The increased temperatures in 2020 and 2040 on codling moth biology as predicted by a degree-day model would result in earlier emergence (5 to 10 days) of adults in the spring, an increase in the percent of third generation that growers would have to control, an increase in control costs of $50 to $100 per acre, and the potential that codling moth would develop resistance faster to newly registered, reduced-risk insecticides.
- Fire blight of pome fruits is projected to *increase* under all increased early-season temperature scenarios and *remain static* under all late season scenarios. The incidence and severity of powdery mildews on cherries and grapes would *increase* under the increased early-season temperature and increased precipitation scenario. The hop powdery mildew model indicated *no change* under the various early season temperature scenarios and a *decrease* in disease severity under increased late-season temperature scenarios.

c. Potential for "zone-shifting" and direct impacts on plant / animal productivity (based on preliminary results from HB 1303 "generalized assessment" study, subcontracted to WSU by UW)

One of the potential impacts of climate change and variability is the potential for "shifting" of production zones based on changes in temperature means and extremes, changes in the number of frost-free days, and changes in moisture availability (precipitation patterns / amounts, evapo-transpiration, etc.). Such changes could result in potentially increased or decreased productivity, the need for minor management changes, substitution of crops, or even the complete redesign of particular farming systems. The vulnerability of cropping and animal production systems in Washington is highest for crops that have very small windows for optimum performance (i.e.., small fruits, wine grapes), for perennial crops, for farming systems currently on the margin of climatic production zones (i.e.., low-rainfall dryland cropping zones), and for animal production systems that will face greater or sustained periods of extreme temperatures.

For instance, a 1ºC rise in temperature over the April-October growing season will add 214 heat units (GDD) to the season. Even such a modest increase will shift several of Washington's AVAs (American Viticulture Areas) into the next higher Winkler region, which will influence fruit composition and grape juice and wine quality. The projected increase in the frequency of hot (>35°C) summer days might compromise wine grape production in much of eastern Washington.

A modeling effort is currently underway at Washington State University that will assess the potential areas of vulnerability related to zone shifting. The results of this effort will identify areas where adaptation will be necessary, but adaptation strategies will still need to be determined on a case by case scenario.

Potential impacts of emerging carbon / greenhouse gas management policies and markets

Climate change has become the defining environmental policy issue of the day – globally, nationally, regionally, and in the State of Washington – and will likely become an even greater driver of state, national and global economies over the next 20 – 50 years as society looks for alternatives to a fossil fuel based economy. It is unclear, as of yet, what policy and market mechanisms will "win the day" in the race to effectively implement greenhouse gas mitigation practices through the economy –; though it is clear that the agricultural industry has had very little input to date in helping to define what these mechanisms might be (our state's agriculture industry is actually ahead of the curve at the state level relative to other states thanks to several "early adopters"). Increasing the engagement, understanding and participation of Washington producers at all levels of the climate change policy dialogue is essential for ensuring that our producers have the greatest opportunity for benefit.

d. Opportunities for Washington producers

Most discussions around emerging carbon markets and / or public policy mechanisms are relatively modest in scope when compared to the scale of the imbalance in global carbon emissions. For instance, goals set by Governor Gregoire and most of the Western States essentially "return us to 1990 levels by 2020" (i.e.., around 15% cuts) when most experts estimate that emissions cuts in excess of 80% will be needed to stabilize atmospheric concentrations of CO_2 at ~500ppm. This likely means that cuts in GHG technology are likely to be focused on relatively inexpensive technological options (in terms of net societal cost) –), and many of the agriculture technologies and practices that can mitigate emissions and store carbon are categorized as such. This also means that there will not likely be substantial compensation (in terms of price per ton of carbon) available in the next

10 – 20 years. Carbon prices on the European Climate Exchange have not sustained high trading prices –, likely because early mitigation goals were met through direct changes by emitters.

In addition to the "value of carbon" considerations, it remains to be seen whether or under what conditions and constraints agricultural offset projects might be viable in carbon markets. Biological sequestration of carbon (i.e.., soils, vegetation), while very real, is also highly complex and subject to numerous variables that create uncertainty and difficulty in quantifying / measuring actual offsets. The uncertainty comes from variability in rates of soil carbon capture based on technology, cropping systems, soils, climate as well as questions of permanence of the offset due to the fact that the farmer can "undo" the storage through changing management, and potentially even considerations for trade-offs between soil carbon sequestration and nitrous oxide emissions. Even soil scientists are not in agreement over the degrees of certainty that are sufficient for "trading carbon". Several tools and methodologies at various stages of development exist to estimate, measure, and validate soil carbon changes, but the question remains whether these tools will meet the minimum standard criteria for a carbon market or be sufficiently simple and cost-effective to utilize. While some soil carbon offset projects have been sold, severe limitations and conditions have been agreed upon in the contracts. It remains to be determined whether soil carbon offset projects will result in sufficient compensation to farmers to compel a change in management practices. Similar to soil carbon, the application of many potential "organic inputs" (such as composts, biosolids, and biochar) will likely face similar scrutiny in carbon offset projects due to the variability inherent in biologically based sequestration.

Other agriculture greenhouse gas management technologies are more straightforward and may be much more conducive to market-based mechanisms. Methane reduction from the anaerobic digestion of manure and other wet organic wastes can be readily quantified and validated and does not have the uncertainty associated with permanence like soil carbon. Additionally, use of advanced fertilizer management technology (i.e.., precision nitrogen) results in definitive, quantifiable reductions in the use of Haber-Bosch synthesized nitrogen (reduction in carbon emissions associated with manufacture) as well as consequent nitrous oxide emissions. Reductions in fuel used in cultivation can readily be quantified and validated as well.

While carbon market mechanisms may be effective in spurring easily quantifiable changes (methane destruction, precision nitrogen, etc.), the real potential value to farmers in shifting to many of the "climate-friendly" technologies is in the actual agro-ecological benefits of the practices themselves. Increasing soil carbon (whether through no-till, organic, cover-cropping, changing residue management, managed grazing, etc.) improves soil quality and *generally* results in a number of substantive agronomic improvements such as improved water infiltration and storage, reduced erosion, increased microbial activity and carbon / nitrogen cycling. Some advanced agricultural systems that are based on soil building practices [(combined with other good agronomic management practices]) have demonstrated substantial changes to the productivity and quality of production –, usually as a result of improved soil microbial communities. Numerous anecdotal, and some documented, cases have demonstrated that investing in improving soil carbon can substantially improve the resiliency and profitability of a given farming system. Additional validation of the potential benefits of conservation-based agricultural systems is essential to provide quality decision-support for producers considering practice changes in an era of rapidly rising and volatile production costs.

e. Concerns for Washington producers

At this point, it appears that there are very few potential direct liabilities facing farmers due to climate change policy. Most farms fall well under the minimum size thresholds for proposed reporting, monitoring, or emissions management requirements and are therefore likely to be treated as an "uncapped" sector for a binding carbon market. In fact, most carbon market mechanisms currently under development separate farms from the managed "cap and trade" sector and treat potential agriculture [and forestry] contributions only as potential "offset" projects. Larger agricultural businesses (i.e.., processors, distributors, etc.) do likely have liabilities as similar players in other industries and will potentially fall under "capped" industrial sectors. There are likely to be additional "indirect" costs for farmers associated with doing business in a carbon constrained world –, but it is not clear yet what these costs will look like and whether they are significant [(in the next 20 years]) when compared to currently rising and volatile costs for energy inputs or the potential costs of adapting to changing climatic conditions. Additional assessment of these types of "indirect costs" is warranted.

Existing assets and tools

a. Existing research capabilities and tools

Extensive resources exist in the state to enhance assessment, technology development and commercialization, education, and "service" to the agriculture industry regarding the interplay between agriculture and climate change. Extensive research measuring and evaluating soil carbon storage, greenhouse gas emissions, and the impact of climate change on agriculture has been completed and will continue. The development of sophisticated [(and simplified]) crop, livestock and pest models that enable estimation of carbon mitigation as well as impact assessment of climate change have been developed and used extensively in the region by WSU and USDA scientists as well as producers and industry. Emerging partnerships between University of Washington climate scientists and WSU agricultural scientists are laying the foundation for a state-wide partnership that can provide both assessment and farmer-friendly decision aids for climate driven challenges – similar to the efforts underway in the South East Climate Consortium.

b. Climate management tools: Ag Weather Net

The State of Washington and Washington State University have already made the most critical structural investment necessary for improving the potential of agricultural producers to practice technology-informed adaptive management to climate and weather-related concerns. The Ag Weather Net (AWN) includes 117 linked weather stations distributed throughout the agricultural production regions of the state. AWN provides rapid access to site and time specific information for producers that can be used for risk management, pest scouting and management, and strategic planning. In addition, numerous disease and insect pest degree day models are linked with AWN to provide excellent grower-based management decision-aids. Further investment in AWN and associated management tools will give the grower community continued information technology tools to reduce risks associated with climate change and variability. Similar efforts are currently underway in the South East Climate Consortium as well as the Oklahoma Mesonet.

Potential investments

The State of Washington is in a difficult place regarding agricultural investment related to climate change. The reality is that: there is limited potential for climate change -related financial investment and , immense political pressure to direct that investment toward transportation emission reductions rather than agriculture. The diversity of the agriculture industry makes it difficult to define a strategic investment that benefits the majority of farmers. Furthermore, the question of “mitigation” versus “adaptation” investment also complicates the issue. Two guiding principles that might be utilized to guide investment decisions are (1) investment in “mitigation” and “adaptation” technologies are frequently the same investment, and (2) use limited public resources to enhance market opportunities [(in the broadest sense of the word –, not just carbon credits]) that encourage the agriculture industry to adopt technologies and practices that generally improve farm profitability, sustainability and resiliency to a changing climate while also mitigating emissions or storing carbon.

c. Incentives for “no-regrets” voluntary action by producers for climate change preparation and carbon mitigation

The types of technologies and farming practices that are generally promoted for carbon storage or greenhouse gas mitigation are usually desirable for many other public and private justifications (i.e.., energy savings, improved profitability, environmental considerations, etc.). Climate change policy and / or carbon markets could be an effective mechanism or “funding source” to reduce risk and encourage innovation in the agriculture community. Innovation has been an historical underpinning for the success of Washington’s agriculture industry and public sector encouragement for innovation will likely be a critical factor in ensuring the continued competitiveness of Washington agriculture in considering both a carbon constrained economy and a changing climatic context. While certain technologies will have traditional economic drivers (i.e.., precision nitrogen) that are likely to happen regardless of public policy or carbon markets, public sector leadership and investment in the more complex arena of "soil management" is likely to be a necessary condition for change. In addition to the "public good" rationale (not an issue likely to be championed in the marketplace, because the benefits accrue more to society than individual enterprises) behind improving soil management, the state is actually well-positioned to provide relatively inexpensive, but effective investments that benefit the majority of agricultural producers – (as opposed to serving specific commodity interests). Furthermore, creative state investment could be used to leverage sources of substantial federal funding as well as private sector funding. The suite of soil improvement technologies and practices are as broad as the types of farming systems that exist in the state, and improving soil quality provides a critical "first line of defense" in a changing and increasingly variable and unpredictable climate.

d. Additional risk assessment in areas of concern

While initial efforts are underway to "triage" areas of vulnerability of Washington agriculture to changing climate conditions, additional investment will be necessary to further evaluate areas of concern and to develop and implement technology or practice changes that will enhance farmer preparation and adaptation. In addition to technology development and practice changes, many existing policies may need to be revisited and re-evaluated in light of new information.

e. Water investments

Perhaps the most controversial investment questions related to agriculture and climate change in Washington are investments in water availability and use. It is well beyond the scope of this document to tackle this issue – as both the history and perspectives on the issue merit their own processes (and have them!). That being said, it is clear that climate change could add significant additional pressures on water resources and agricultural uses of those resources in the future. It is entirely possible that the "value of water" (either through costs of pumping and using it, crop losses, competing uses) may actually be considerably higher than the value of carbon [or crops?] in agriculture with severe, localized impacts for irrigated production regions with insufficient water storage. Producers in the state have made numerous investments in water conservation and improving water use efficiency, and will need to continue these investments in the future. However, additional water storage capacity for certain regions will be essential to maintain the types of agricultural production systems that we currently depend on.

Conclusions and Recommendations

Investment strategies designed to support Washington agriculture for the next 20 – 40 years need to provide adequate consideration for climate change and global carbon / greenhouse gas mitigation. *Generally speaking*, Early evidence indicates that climate change will likely generate require additional management efforts / costs for *many* existing agricultural production systems in the state, and potentially could force substantial shifts for *some* of our agricultural production systems. More detailed assessment will be needed to understand the relative impact of these changes.

Agriculture can provide greenhouse gas emissions reductions and soil carbon sequestration opportunities that could help meet emission reduction goals. Legally binding carbon / greenhouse gas mitigation policies are likely to emerge in the next few years at both the regional and federal levels. While it appears at this time that none of these will directly "cap" emissions from agriculture, they will likely have indirect consequences for agricultural production. For instance, there may or may not be opportunities created for Washington producers to benefit from emerging carbon market mechanisms by providing "offsets" for capped carbon emitters, though protocols have not yet been widely adopted and may effectively prohibit farmers from receiving extensive benefits.

Three separate processes regarding climate change and agriculture moved forward in 2007 and 2008. They were:

- The 2007 Agriculture Preparation / Adaptation Working Group (Ag PAWG) – stakeholder process
- The 2007 HB 1303 Generalized Assessment of Climate Change Impacts on Agriculture study completed in partnership between the University of Washington, Washington State University, and Pacific Northwest National Laboratory.
- The 2008 HB 2815 Agriculture Sector Carbon Market Workgroup (ASCMW) – stakeholder process

The Ag PAWG and HB 1303 study focused on efforts related to the *impacts of climate change on agriculture* in Washington and potential options for adapting to or preparing for these changes. The ASCMW focused on providing guidance to the legislature on how the agricultural sector might participate in a regional carbon market by *voluntarily* providing 'offsets' or other greenhouse gas reduction credits.

Based on existing information, the Ag PAWG focused on two primary areas of potential investment by the state to ensure the continued viability of agriculture in the context of a changing climate: (1) *agricultural water availability* and (2) *monitoring and controlling pest and vector populations*. Detailed discussion of these strategies are found in the 2007 Preparation and Adaptation Draft Report (http://www.ecy.wa.gov/climatechange/CATdocs/122107_2_preparation.pdf). To summarize for water availability, the PAWG recommended that the state should continue investigations and investment in water storage and incentivizing knowledge and technology transfer associated with water conservation. To summarize for pest management, the PAWG recommended that the state's Invasive Species Council should establish statewide strategic plan and invasive species baseline to support future efforts to control problem pests, and to continue funding efforts to track plant and animal pathogens.

The HB 1303 study provides additional research-based analysis to assess the level of vulnerability for critical (keystone) crops, pests, and water issues affecting agricultural production in the state. The findings of this study will indicate where significant climate-driven vulnerabilities might be for the major cropping systems of the state and enable the state to prioritize efforts associated with adaptation planning and investment. The results are due December 2008.

The ASCMW provided a series of *consensus* recommendations related to the potential for the agricultural sector to provide high-quality "offset credits" into a regional carbon market mechanism. The final draft document can be found here: http://www.ecy.wa.gov/climatechange/2008FAdocs/Ag_Offset_Recc_Pkg_FINAL.pdf . The ASCMW recommended that agriculture be enabled to provide offset credits for soil carbon management on conservation and grazing lands, soil carbon management on working ag lands, methane avoidance and additional credits from the anaerobic digestion of manure and food wastes, and carbon dioxide and nitrous oxide avoidance credits associated with the use of precision agricultural management technologies. The ASCMW provided guidance for how market protocols should be developed that would enable farmers to voluntarily provide real, additional, verifiable and enforceable credits into the offset market that best position Washington farmers and ranchers to take advantage of our diverse agricultural system (rather than being penalized through "universal" protocols). The ASCMW believes that their recommendations represent an additional level of rigor above and beyond that which is currently being utilized in voluntary carbon markets – and therefore believes that the state should strongly support the opportunity to provide high-quality offsets from agriculture. The ASCMW recognized that there is potential that the Western Climate Initiative may not be ratified and therefore the recommendations could be universally applicable to any type of market-based mechanism.

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Drawing from work done by:

the Agriculture Preparation/Adaptation Working Group http://www.ecy.wa.gov/climatechange/2008FA_agr.htm

and by the Agricultural Sector Working Group http://www.ecy.wa.gov/climatechange/cat_pawg_ag.htm