The 2017 BC Agricultural Climate Adaptation Research Workshop

Workshop Summary Report



Abbotsford, BC
Quality Hotel and Conference Centre
36035 North Parallel Rd
December 7th and 8th, 2017

Acknowledgements

Prepared by: Jason M. Lussier[1], Samantha Charlton[2], Sean M. Smukler[1] and Emily MacNair[2]

[1] BC Agricultural Climate Adaptation Research Network
[2] BC Agriculture & Food Climate Action Initiative

We would like to acknowledge the Workshop Planning Committee (Samantha Charlton, Serena Black, Garry Fehr, Sean Smukler and Emily MacNair) and Coordinator (Jason Lussier) for their hard work in organizing and delivering the 2017 BC Agricultural Climate Adaptation Research Workshop.

Special thanks go to the Natural Sciences and Engineering Research Council (NSERC) for funding the workshop through the NSERC Connect Grant and the BC Agricultural Climate Adaptation Research Network (ACARN) for providing additional funding to support participant travel and accommodations.

We would also like to thank the 57 participants that contributed to the workshop outcomes and Susanna Klassen, Sidd Paul, Serena Black and Nargiz Rahimova for documenting the workshop discussions included in this report.

Table of Contents

Workshop Overview and Executive Summary

The recently initiated BC Agricultural Climate Adaptation Research Network (ACARN) partnered with the BC Agriculture & Food Climate Action Initiative (CAI) to host a workshop on climate change adaptation research in the British Columbia agriculture sector.

The primary objectives for the workshop included:

- Enhance linkages between researchers and industry representatives.
- Share information on current climate change adaptation research in the BC agriculture industry.
- Establish strategies for climate change adaptation research extension.
- Discuss climate change adaptation priorities and establish strategies for developing applied research projects.
- Develop research teams and projects to address climate change adaptation priorities in the BC agriculture industry.

The first workshop day focused on knowledge transfer and included a variety of presentations and panel sessions focusing on climate adaptation research, extension and industry engagement. The second day was predominantly focused on the development of climate adaptation research projects.

Primary outcomes from the workshop included:

- New linkages between academic, government and industry groups involved with climate change adaptation research in BC.
- Knowledge transfer on current climate adaptation research projects in BC from a wide range of research disciplines.
- Preliminary discussions on methods to enhance climate adaptation research extension and mechanisms to better connect researchers to industry priorities.
- Information on potential funding opportunities to support network research projects.
- Early development of ACARN research projects and research teams.

In addition to these outcomes, the workshop discussions provided important information which will guide future steps to further establish ACARN.

The primary next steps for ACARN include:

- Update the ACARN Terms of Reference and clarify roles for research extension and industry engagement.
- Develop a clear ACARN strategic plan which outlines near-term network activities and long-term strategies.
- Establish an online ACARN platform which allows members to share research information and data.
- Expand ACARN membership and develop clear roles and responsibilities for members.
- Develop a research plan and proposals for upcoming funding opportunities.

Overall, participants at the workshop showed great interest for further establishing ACARN and for participating in future network activities. The organization looks to build from the discussions at this workshop to expand the network in 2018.

This document provides information on the 2017 BC Agricultural Climate Adaptation Research Workshop and the various discussions which took place during this event.

1 Workshop Participation

1.1 Participant Summary

A total of 57 participants from across the province attended the workshop. Attendance varied between the two workshop days with 56 people attending the first day and 40 people attending the second day.

Participants came from various regions of BC (Fig. 2). The workshop took place in the Lower Mainland and a large percentage of participants were from this region (60%). While there was good representation from the Okanagan, Thompson-Nicola and Vancouver Island region, fewer participants attended from the Peace, Omeneca, Kootenay and Cariboo regions.

Figure 1. Participants at the 2017 BC Agricultural Climate Adaptation Research Workshop on December 7th, 2017 (*Photo taken by Sidd Paul*)

Participants were affiliated with multiple agricultural institutions (Fig. 3). Approximately 26% were researchers affiliated with various Universities including: University of British Columbia (Vancouver & Okanagan), Thompson Rivers University, University of Northern British Columbia, University of the Fraser Valley, University of Victoria and Washington State University. A large proportion of participants were researchers and industry specialists affiliated with government

organizations (23%), while fewer participants were affiliated with private organizations/companies (16%) and producer associations (14%). Several graduate students from multiple universities were also in attendance (18%).

During the registration process, participants were asked to identify their primary climate adaptation research discipline of interest (Fig. 4). Of the options listed, Research Extension had the greatest interest (21%), while the broad grouping of Social Sciences was found to be underrepresented at this workshop (7%).

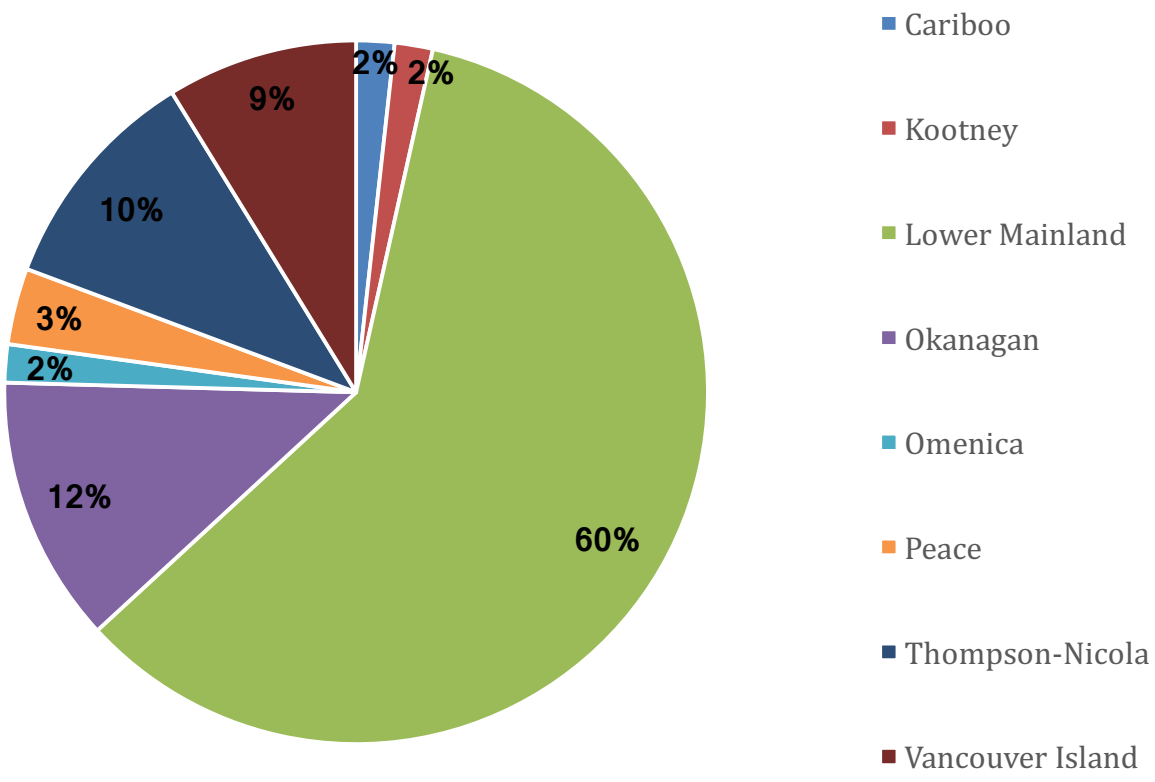

Figure 2. Regional representation of workshop participants.

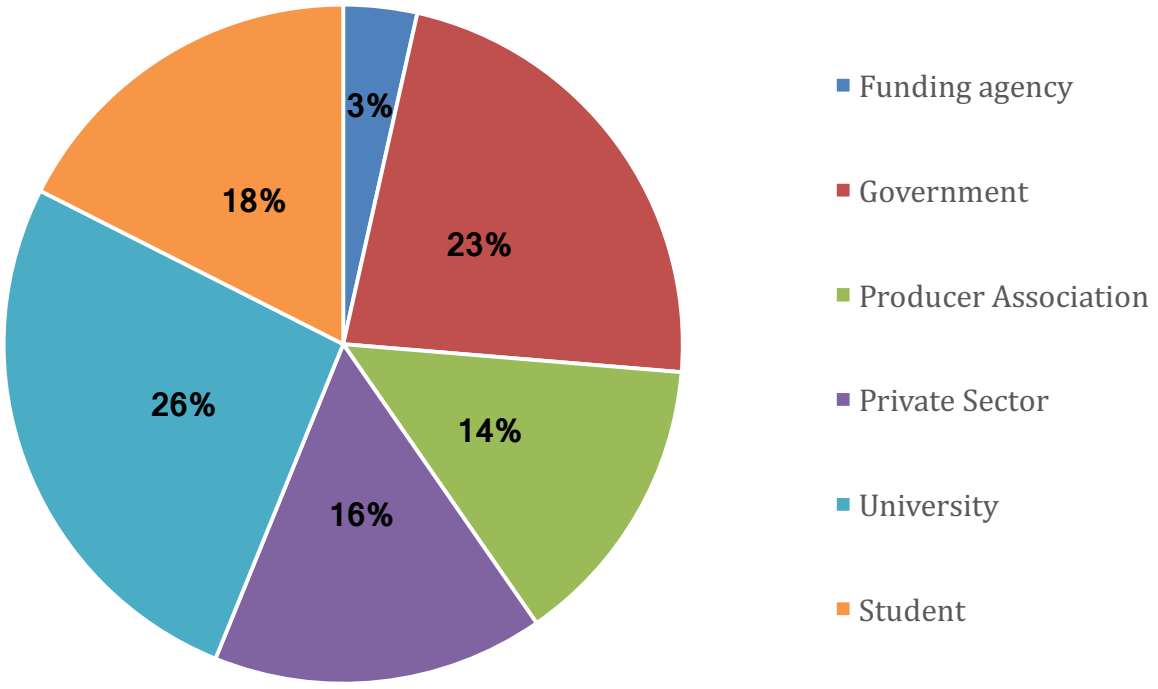

Figure 3. Sector/organization representation from workshop participants

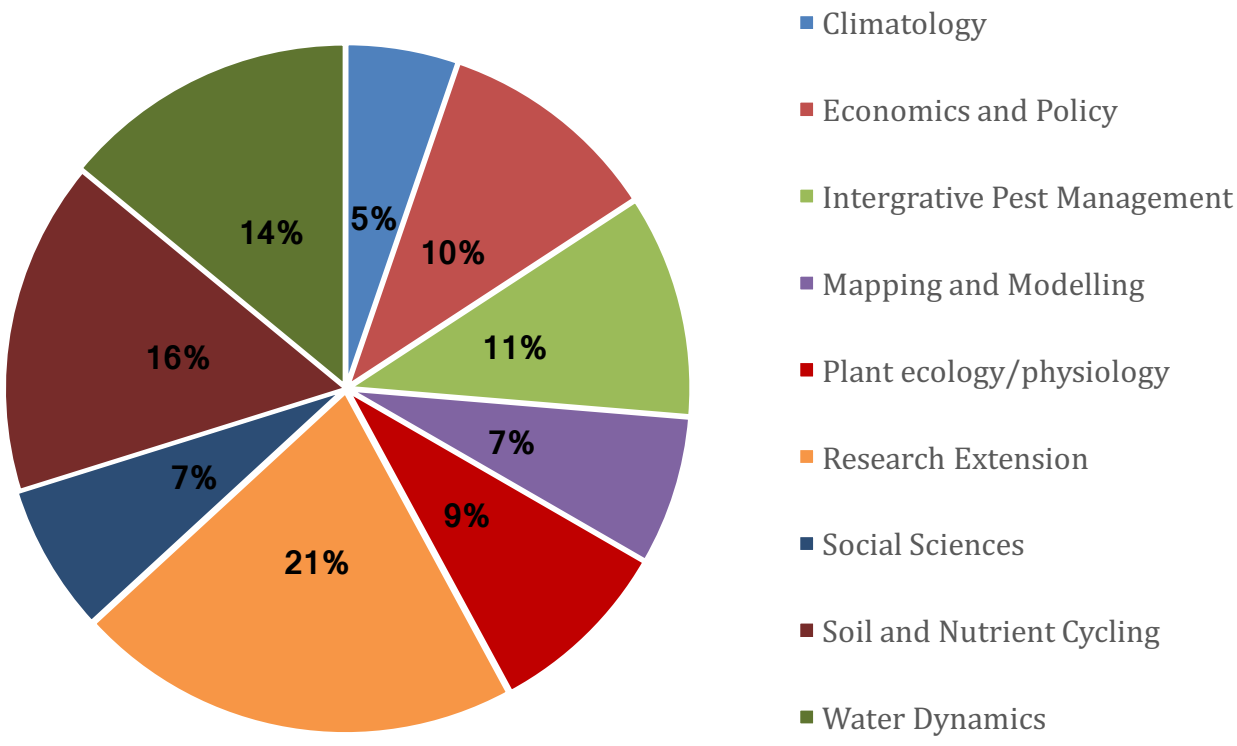

Figure 4. Primary climate change adaptation interest of workshop participants

2 Workshop Presentations

2.1 Research Presentations

A total of nine research presentations were included on the first day of the workshop (Fig 5). Presentations were organized within three sessions: Climate Change Adaptation for Forage and Rangeland; Pest Dynamics and Climate Change; and Management Strategies for Climate Change Adaptation. A list of research presentations (A.1.1) and abstracts (A.1.2) may be found in Appendix 1.

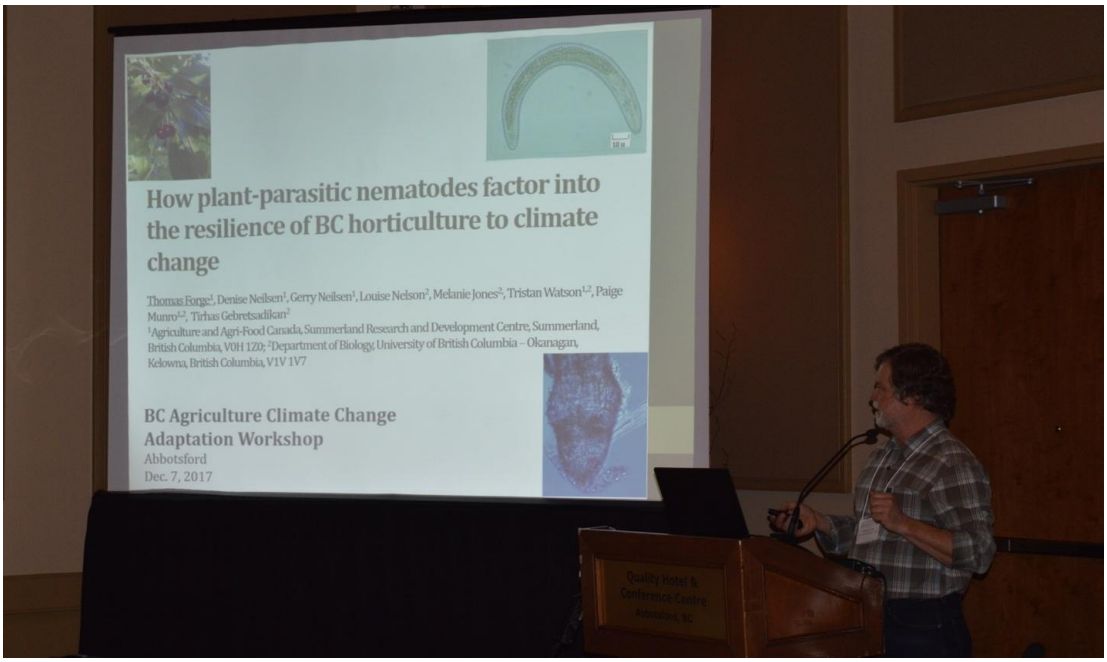

Figure 5. Presentation by Thomas Forge (Agriculture and Agri-food Canada) on *How plant-parasitic nematodes factor into the resilience of BC horticulture to climate change* (*photo taken by Sidd Paul*).

2.2 Poster Presentations

A total of nine posters were presented in the afternoon of the first workshop day. The posters covered a wide range of regions and climate adaptation topics (Fig. 6). The session began with each presenter providing a 2-3-minute summary of their posters to the group, which was followed by an open session where workshop participants could interact one on one with poster presenters. A list of posters and presenters may be found in Appendix 1 (A.1.3).

Figure 6. Group poster presentation by Georgine Yorgey (Washington State University) on climate change research conducted at the Center for Sustaining Agriculture and Natural Resources (*Photo taken by Sidd Paul*).

3 Workshop Panel Sessions

The afternoon of the first day consisted of two panel sessions focused on Climate Adaptation Research Extension and Industry Priority Setting Mechanisms. This section provides an overview of each session.

3.1 Climate Adaptation Research Extension Panel Session

The Climate Adaptation Research Extension Panel Session was facilitated by Garry Fehr and included a presentation, panel session and audience discussion. The panel included representatives from various agricultural institutions/organizations (Figure 7).

Figure 7. Climate adaptation research extension presenter and panel (From left to right: Jason Lussier (BC Agricultural Climate Adaptation Research Network), Lisa Powell (University of British Columbia/University of the Fraser Valley), Rachael Roussin (Kootenay & Boundary Farm Advisory Program), Samantha Charlton (BC Agriculture and Food Climate Action Initiative), Gary Telford (Agriculture and Agri-food Canada) and Mark Raymond (BC Ministry of Agriculture) (*Photo taken by Sidd Paul).*

3.1.1 Presentation

A provincial network approach to climate adaptation research extension in British Columbia
Jason Lussier, BC Agricultural Climate Adaptation Research Network

The panel session began with a brief presentation on current ACARN efforts to enhance the accessibility of research outcomes. Three near-term ACARN activities for extension were presented to the group and examples of current projects were provided.

1) **Develop extension tools and resources for researchers:** ACARN is working with CAI to develop Climate Adaptation Research Factsheets which will target a producer audience. A template has been established and several factsheet prototypes have been developed for recently completed FAIP projects.

2) **Provide researchers with the opportunity to exchange information with industry groups and producers**: ACARN is working with CAI and the Cariboo Agriculture Research Alliance (CARA) to host the Cariboo Agricultural Climate Adaptation Workshop. A primary aim of this workshop is to provide researchers, producers and policy-makers with the opportunity to share information on current and future climate adaptation research projects at a regional scale.

3) **Establish strategies to network research extension initiatives in British Columbia:** ACARN is planning to collaborate with the Centre for Sustainable Food Systems (UBC) on the addition of a climate adaptation section to an online extension tools which is being developed at the center (The BC Food Web).

ACARN is actively seeking other methods to enhance the accessibility of research outcomes for the agriculture industry. In order to achieve this objective, the network is looking to answer the following questions, which the panelists were asked to address from their perspectives:

- What are current and future climate adaptation extension initiatives in the BC agriculture sector?
- What are some of the challenges these initiatives are/will be facing?
- What forms of research extension are most effective?
- How can researchers, policy makers, and producers in BC work as provincial network to overcome barriers and deliver effective research extension?

3.1.2 Panel Session

The panel was asked to present information on current and future extension initiatives in relation to climate change adaptation. The extension initiatives presented in this discussion included:

- The developed of an online extension resource for diversified farmers in the province (BC Food Web) with the inclusion of a specific climate adaptation section.
- The establishment of an agriculture research and extension program for producers in the Kootenays (Kootenay & Boundary Farm Advisory Program).
- The development of a suite of climate adaptation research videos, factsheets, toolkits and reports by CAI.
- The future establishment of a pilot “living lab” at the AAFC Agassiz research station to enhance stakeholder engagement.
- The continued delivery of climate change adaptation related extension initiative through the provincial government via programs such as the Environmental Farm Plan Program and the Beneficial Management Practice Program.

Following this discussion, panelists were asked to share examples of successful research extension. The examples were primarily focused on initiatives that promote in-person extension, farmer to farmer knowledge transfer and the development of regional research

networks to engage with producers. The addition of a mandatory knowledge transfer component to funding programs was also suggested as an effective method to promote research extension.

During this session, panelists were also asked to share information on extension challenges/barriers and to share their thoughts on how a provincial network could help to overcome these barriers.

The primary extension challenges discussed, included:

- The existence of several segmented research extension initiatives across the province often leading to duplication and/or uncertainty on current extension gaps.
- Limited infrastructure and resources for extension.
- The diversity of extension preferences among producers, regions and commodities; determining how to best meet these needs, and finding resources to deliver multiple methods of extension.
- Limited incentives from universities to support researchers for undertaking extension activities.
- Limited government support for providing extension to agriculture producers in Canada.
- Challenges in getting producers to adopt online extension tools.
- Challenges for extension providers to know what forms of extension work best and how to best deliver effective research extension.

The use of a provincial network approach was generally viewed by the panel as an important method to enhance collaboration between current initiatives in the province, thereby, creating a more united and strategic infrastructure for enhancing the accessibility of research outcomes in the agriculture sector.

3.1.3 Audience Discussion

Following the panel session, the audience participated in a group discussion which covered a variety of topics including:

- The importance of referencing Ministry of Agriculture resources into new climate adaptation factsheets.
- The need for developing more effective extension initiatives to gain producer support.
- The need for extension efforts to occur earlier in the research process.
- The importance of developing regional “hubs” to strengthen linkages between researchers and producers.
- The use of decision aid tools as an extension resource and associated limitations.
- Challenges for professors to engage in extension due to minimal reward and infrastructure offered by universities; and increased graduate student’s engagement as a potential method to overcome this challenge.
- Collaboration between ACARN and regional research networks (i.e. CARA) as a method to enhance local extension (and define regional research priorities) in BC.

- The development of online forums to connect researchers to producers.

3.2 Industry Research Priority Setting Mechanisms Panel Session

The Industry Research Priority Setting Mechanisms Panel Session was facilitated by Samantha Charlton and included a presentation, panel session and audience discussion. The panel was composed of representatives from various agricultural commodity groups (Figure 8).

Figure 8. Industry research priority setting mechanisms presenter, facilitator and panel (from left to right: Emily MacNair (the BC Agriculture and Food Climate Action Initiative), Samantha Charlton (the BC Agriculture and Food Climate Action Initiative), Linda Delli Santi (BC Greenhouse Growers Association), Serena Black (BC Forage Council), Eric Gerbrandt (private consultant, on behalf of the BC berry sector), and David Zirnhelt (Cariboo Cattlemen's Association and the BC Cattlemen Association research committees) (*Photo taken by Sidd Paul*)

3.2.1 Presentation

Climate Adaptation Research Priorities in the BC Agriculture Industry
Emily MacNair, BC Agriculture and Food Climate Action Initiative

The presentation began by introducing some of the types of resources developed to date by CAI. Key resources developed since the inception of the initiative in 2008 are:

1. Risk and opportunities assessments: These are based on interviews and focus groups with the agriculture sector and assess how climate change will affect BC's agriculture sector at the regional level. This is one of the only pieces of CAI work that has a provincial scope.

2. Farm adaptation practices series: This is also a province-wide review. Visits to approximately 30 farms and detailed discussions with farmers informed this piece of work. This is a multi-criteria assessment of 6 specific farm practices. There are a number of recommendations about gaps and research needs.

3. Regional Adaptation Strategies: Strategies are completed in 6 regions to date and provide information on region-specific projections, risks, impacts and strategies & actions. CAI is currently updating these plans and re-prioritizing strategies and actions. Along with the strategies themselves, each regional project has produced final resources including: reports, toolkits, issue papers etc. A total of 41 projects are completed or are currently underway in 6 regions.

4. FAIP Deliverables: There are 15 projects either completed or underway as a part of the CAI FAIP program. Each project has produced various resources including: reports, factsheets and manuals/guides.

A recent scan was done by CAI on a number of the above resources and a document with identify research gaps and priorities was developed to guide future climate adaptation research in the province. The importance of grounding research in sector needs and leveraging existing and on-going work by CAI work was emphasized in this presentation.

While the research scan is a good starting point for identifying industry research needs, the document will need to be revisited and more in-depth information on commodity-specific issues will be added. There are opportunities to continue to define and refine research priorities through provincial and regional research hubs.

Major research gaps identified in the scan[1] are as follows:

1. Water resource and infrastructure vulnerability
2. Policy and adaptation interactions
3. Climate impacts to range ecology

[1] A copy of the full scan is available upon request to (jason@bcacarn.com)

4. Crop suitability thresholds and commodity-specific impact/management assessments
5. Pest biology
6. Plant-pollinator interactions

3.2.2 Panel Session

The panel was asked to present information on their respective association(s) or sector approaches for identifying and communicating research needs including: how their sector or association identifies research priorities? if and how priorities are shared back to their members? how priorities are communicated with researchers and other parties? and how often research priorities are revisited?

Some of the priority setting mechanisms and related topics presented by the panelists included:

Greenhouse:

- A well-organized industry makes it clearer/easier to identify what the key goals of the industry are.
- Linkages to other provinces and countries with advanced research programs has provided valuable information on research needs relevant to the BC Greenhouse sector.

Forage:

- Utilizing a network of director representatives from across the province for input on research needs/priorities.
- Directors and others bring issues from their respective regions to meetings (AGM and conference).
- The importance of connecting forage councils in the province and the methods they are using to support their work.

Berry (blueberry, raspberry and strawberry):

- These sectors are working in a joint breeding program with Agriculture and Agri-food Canada.
- Research priorities are identified through research committees designated for each berry commodity.
- Research results are communicated through field days.
- Research priorities are re-evaluated on an annual basis.
- The cross-commodity and cross-disciplinary nature of research needs within the three types of berries crops was emphasized.

Cattle:

- The provincial association is a network of regional and local associations.
- There is an over-arching document that indicates important research themes in the sector, however a challenge is making these themes relevant to research interests.
- It is challenging to identify the research needs. Efforts are made by the BC Cattlemen's' Association (BCCA) to define priorities with the use of local associations.

- Communication back to members is done through the Cattlemen Magazine (in print and digitally).
- The need to become a knowledge-based industry, that draws more heavily upon research.
- Best practices are most effectively shared through in-field demonstrations.
- Linking to the Applied Ranching Program at TRU has potential to create more knowledge mobilization within the industry.

Other commonalities that emerged from panelists:

- Commodity groups are interested in securing resources to drive their own research
- Producers priorities aren't necessarily on climate change overtly, but rather are often related to production needs and profitability of the business. However, these are both contributing factors to overall production and business resilience, which is a core part of resiliency to climate change.

3.2.3 Audience Discussion

Following the panel session, the audience participated in a group discussion, which was intended to address the following questions:

- What mechanisms for identifying and sharing research needs are the most effective?
- How would association/commodity groups like to build on existing channels to communicate these needs back to ACARN and CAI?
- What is the best way for ACARN and CAI to communicate and share research results back to associations and their members?

The following themes emerged in the discussion:

- Having a separate industry advisory committee to ACARN would be useful, however, a wide-range of commodities in the province and limited resources for producers and producer association are potential barriers. This could be done possibly through BC Agriculture Council (BCAC) (Note: There is currently representation from BCAC on the ACARN Steering Committee). However, many associations do not have research capacity and research prioritization should also be inclusive of these commodities.
- Annual check-ins and reporting systems from commodity groups to relay priorities back to ACARN or CAI after AGMs or research committee meetings, were suggested. However, it was noted that the onus should be on ACARN/CAI to retrieve and synthesize this information since producers and groups are already so stretched in terms of capacity.
- There is limited capacity for engagement and outreach to some sectors, we need to tap into existing mechanisms (e.g. AGM's, The Pacific Agriculture show).
- It will be necessary to periodically reach beyond the existing association committees/boards and survey producers directly. Most sectors are diverse within the commodity itself and may have divergent interests (i.e. field vegetables).

- Research priorities are identified at the national level for some commodities.
- The new Research Manual developed through the BCFC FAIP project could be an innovative way to get a sense of priorities (if farmers begin using the manual and reporting back on experiments).
- Cross-over between industries is important to inform adaptation and inspire innovation (i.e. unused ranching land and new entrants interested in alternative crops).
- There is value in facilitating a cross-commodity conversation rather than ACARN and CAI individually retrieving priority lists from each commodity group.
- Developing a clear plan for linking ACARN to producers can build legitimacy and possibly catalyze industry support for climate change research.

4 A Research Network Approach and Funding

This session included a presentation on the use of a network approach for climate change adaptation research in BC and was followed by a presentation from NSERC and Mitacs on funding opportunities to support future network research projects.

4.1 Research Network Presentation

A network approach to climate change adaptation research in BC
Jason Lussier, BC Agricultural Climate Adaptation Research Network

This presentation provided a brief discussion on current climate adaptation research challenges, the benefits of a research network approach, and the future of ACARN.

Provincial climate adaptation challenges in BC mentioned in this presentation include:

- Missing research specializations in the province.
- Uneven distribution of researchers (i.e. some regions have very few researchers focusing on climate adaptation research).
- A large diversity of agriculture commodities and microclimates in the province.
- Limited communication between climate adaptation researchers in the province.
- Limited collaboration between various research institutions and research disciplines.
- Limited resources available to support climate adaptation research.
- Limited infrastructure for research extension and knowledge transfer in the province.

Potential advantages associated with the development of a research network included:

- Connecting researchers from around the province to increase research support in underserved agriculture regions of BC.
- Developing interdisciplinary research teams to address complex research questions.
- Sharing research information in order to establish a more strategic approach for climate adaptation research in the province.

- Sharing of equipment, data and, methodologies to enhance research efforts and the geographic scope of projects.
- Improving support for new students and professionals involved with climate adaptation research.
- Simplifying industry access to research expertise.
- Developing larger projects, which are greater than the sum of their parts.

The vision of ACARN is to be a provincial hub that fosters a collaborative approach for agricultural climate change adaptation research and extension strategies in British Columbia. However, the future of ACARN is uncertain and dependent on:

- The addition of dedicated ACARN members.
- Continued collaboration with CAI and other climate adaptation initiatives in the province.
- Support from the BC agriculture industry and government organizations.
- Future funding to support network management and research projects.

4.2 Research Funding Presentations and Discussion

Presentations were provided by both NSERC and Mitacs on relevant funding opportunities to support industry-academic research projects. The NSERC presentation outlined several industry partnership opportunities including the Engage grant, Engage Plus Grant, Experience Grant and the Collaborative Research and Development (CRD) Grant. The Mitacs presentation provided information on several industry co-funding models for the Accelerate Grant, Globalink Grant, Careerconnect Grant.

Following the presentations, questions regarding eligibility and cost-share requirements were asked by the group. The potential for a consortium of industry organizations was also discussed as a method to acquire funding resource to support CRD grants for network projects.

5 Project Brainstorm and Development Session

The afternoon of the second workshop day consisted of a project brainstorm, development and evaluation session. During the project brainstorm and development sessions, participants were placed into 4 groups related to varying climate adaptation themes, including: Climatology & water dynamics; Crop health and pests; Economics, policy and planning; and Soils and nutrient cycling. The session lasted 1.5 hours and groups were asked to first brainstorm general project ideas, then vote for 1-2 projects of interest. The projects with the most votes in each group were further developed.

Following this session, each Project Lead provided a short presentation to the group on their respective project idea and received feedback regarding associated strengths, challenges, and

opportunities. Participants were then free to join the project of their choice to further discuss research project ideas.

Below is an overview of 6 projects which were developed during this session– additional information can be found in Appendix 2 on other projects that were discussed during this session.

5.1 Water Resource Modelling and Projections in Semi-Arid Rangelands: Expanding on the Pond Risk Assessment Tool.

Summary: This project would follow-up on past research which assessed the depletion of livestock ponds in the Thompson-Nicola region. The proposed project would aim to expand an online pond risk assessment tool intended to help producers and decisions makers assess the impacts of climate change on BC rangeland ponds. Proposed stakeholders for this project included cattle producers, producer associations, and provincial government departments involved with rangeland management.

Figure 10. Group #1: Climatology and Hydrology brainstorming session (Left to right: Faron Anslow (Pacific Climate Impacts Consortium), Aaron Coelho (Urban Systems Ltd.), Brandi Newton (BC Ministry of Agriculture), Navin Ramankutty (The University of British Columbia), Andy Black (The University of British Columbia) and Mark Johnson (The University of British Columbia) (*Photo taken by Jason Lussier*).

5.2 Mapping Climate Change Induced Shifts in Crop Suitability Across BC

Summary: This proposed project would update crop suitability maps and identify potential changes under different climate change scenarios. The maps would be inclusive of several agriculture regions and commodities, and the project would require engagement from various producers and producer association groups, as well as the provincial government.

5.3 Enhancing Agricultural Adaptation to Climate Change Through Integrated Approaches to Soil Metrics

Summary: This proposed project would consist of 4 primary activities aimed at enhancing the collection of soil data and evaluating soil responses to climate change. The primary activities of this project include: 1) the development of a provincial soil map to generate a climate adaptation tool box, 2) the development of protocols to improve soil quality data, 3) the establishment of field experiments for parameterization and validation and 4) modelling carbon and nitrogen dynamics under climate change scenarios. Stakeholders would predominantly include government agencies and a broad range of producers and producer associations.

5.4 Crop Productivity Under Climate Change: Evaluating Abiotic and Biotic Stress

Summary: This proposed project would establish multiple research field sites in a variety of crops (berries, grapes and forage) to generate experimental data on plant responses to CO_2, drought stress, heat stress, and crop-pest interactions. The data collected through these trials would be shared by researchers on an online platform and would provide valuable information required for the development of crop suitability/risk maps in the province. The findings from this study would also assist in the determination of climate-smart varieties/crops and generate genomic data for enhanced plant breeding. Several producers and producer association/councils would be primary stakeholders for this project.

5.5 Evaluating Climate Change Impacts and Options Across Commodities in BC Agriculture

Summary: The overarching objective of this project is to build on the Risk and Opportunity Assessments completed by CAI and conduct an in-depth assessment of cross-commodity impacts, risks and adaptation options & benefits. The sub-objectives of this project would include 1) a broad assessment of risk levels for various commodities, 2) understanding thresholds of production viability, 3) capturing interactions and synergies between industries and regions 4) and identifying strategic priorities for in-depth research by ACARN members. A preliminary pilot project would focus on 3-5 commodities in the province and stakeholders would include producers and producer associations, industry specialists, consultants, and research network alliances (i.e. CARA and ACARN).

5.6 Determining Future Labor Demand and Working Condition in the Face of Climate Change

Summary: This project would assess the influence of climate change on the agricultural labor force in BC. The specific objectives of this project include: 1) the identification of what makes a resilient ag labor force, 2) the investigation of ways in which the labor policy framework is currently restricting/constraining adaptive capacity of producers to climate change, 3) anticipating future stressors on the agricultural labor force based on projected changes (crops, management, climate), and 4) identifying opportunities to increase stability and quality of conditions for agricultural labor in BC. The primary stakeholders for this project would include producer and producer associations of labor-intensive commodities.

6 Workshop Evaluation

A total of 25 participants completed the workshop evaluation forms. The form provided participants with the opportunity to evaluate how well the workshop objectives were met and add any additional comments or suggestions.

6.1 Objectives Evaluation

A summary of responses to workshop evaluation questions may be found in Table 1. All respondents strongly agreed that the workshop increased their knowledge of the breadth of agriculture and climate change adaptation research occurring across BC. Most respondents agreed, or strongly agreed that it was valuable working in small groups to brainstorm ideas and that the workshop strengthened linkages between researchers and industry. Slightly fewer respondents found the workshop to produce effective strategies to strengthen knowledge transfer/extension, and establish mechanisms for defining and sharing industry priorities.

Table 1. Summary of responses to workshop evaluation questions (1= disagree, 2= agree, and 3= strongly agree) (n=25).

Questions	Ranking
This workshop strengthened linkages between researchers and industry representatives	2.37
This workshop produced effective strategies to strengthen knowledge transfer/extension	2.24
This workshop established mechanisms for defining and sharing industry priorities	2.24
It was valuable working in small groups to brainstorm and develop project ideas	2.70
Did the workshop increase your knowledge of the breadth of agriculture and climate change adaptation research occurring across BC?	All participants responded Yes

6.2 General Comments Included in Evaluations

Several respondents provide written or verbal feedback on the workshop.

A large proportion of respondents identified the need for:

- A greater social scientist and economist presence at the next workshop.
- Increased engagement from producers and/or producer associations, and additional discussions on industry needs and wants for climate adaptation research.
- More discussion on mechanisms for sharing research priorities between government, industry and academia.
- Increased opportunities for networking and discussions between participants.

Respondents also suggested:

- More government representation and discussion on climate adaptation related policies.
- More information on climate change itself, as well as the uncertainties of climate change and the challenge of making proactive adaptation decisions in the face of uncertainty.
- The inclusion of a training session on climate change extension or research.
- More interdisciplinary and cross-institutional engagement between participants.
- Improved structure and/or facilitation for the research project breakout sessions.

6.3 Recommendations for Future Events

The evaluation provided some useful feedback which will be used to inform future workshops.

Recommendations for future workshops include:

- Increased representation from participants outside the Lower Mainland, with a specific focus on underrepresented regions such as the Peace, Cariboo, Omeneca and Kootenays. This could be done by reducing overlap with other workshops/conferences which occur during this same time of the year and/or situating future workshops in a more central location.

- Increased representations from producers, producer organizations and companies affiliated with climate adaptation research.

- Increased representation from social scientists and economists who are involved or interested in climate adaptation based research in the agriculture sector.

- Additional time for networking and discussions between participants at the workshop.

- Increased opportunity for researchers to interact with other researchers from various regions, disciplines, institutions involved with climate adaptation research (i.e. World Café session).

- Hired professional facilitators to guide small and large group discussion sessions and the general workshop structure.

- Training session activities related to either climate adaptation extension or research.

7 Workshop Outcomes and Next Steps

7.1 Workshop Outcomes

The 2017 Agricultural Climate Adaptation Research Workshop provided a great opportunity for researchers and industry groups to share information on climate change adaptation research in the British Columbia agriculture sector.

The primary outcomes from this workshop include:

- New linkages between academic, government and industry groups involved with climate change adaptation research in BC.

- Knowledge transfer on current climate adaptation research projects in BC from a wide range of research disciplines.

- Preliminary discussions on methods to enhance climate adaptation research extension and mechanisms to better connect researchers to industry priorities.

- Information on potential funding opportunities to support network research projects which address climate adaptation research projects in the BC agriculture industry.

- Early development of ACARN research projects and research teams.

- Further establishment of ACARN and identification of future steps required to further develop the provincial research network.

7.2 Next steps

This workshop provided a good foundation for further establishing ACARN and future efforts will be undertaken in 2018 to expand the network. These next steps will include:

- Update the ACARN terms of reference and clarify specific roles for research extension and industry engagement.

- Develop a clear ACARN strategic plan which outlines near-term network activities and long-term strategies.

- Establish an online ACARN platform which allows members to share research information and data.

- Expand ACARN membership and develop clear roles and responsibilities for members.

- Develop a research plan and proposals for upcoming funding opportunities.

Appendix 1: Research Presentations

A.1.1 List of presentations and presenters

Climate Change Adaptation for Forage and Rangeland

On-farm demonstration research
Catherine Tarasoff, Agrowest Consulting

Using aerial thermal imaging to measure differences in cattle surface temperature due to coat colour
John Church, Thompson River University

Expanding on the climate change risk assessment tool for ponds used as livestock water sources
Aaron Coelho, Urban Systems Ltd

Pest Dynamics and Climate Change

A multi-faceted approach to emerging pest threats in the Fraser Valley
Jen Scholefield, ES Cropconsult Ltd

How plant – parasitic nematodes factor into the resilience of BC horticulture to climate change
Tom Forge, Agriculture and Agri-Food Canada

Management Strategies for Climate Change Adaptation

Expanding cherry production in BC under climate change: Considering the biological quality of soils in new sites
Louise Nelson, the University of British Columbia Okanagan

Evaluating drainage management options to improve climate change adaptation n BC's Fraser River delta
Sean Smukler, University of British Columbia Vancouver

Radiative properties of plastic films and their use as soil mulches in low tunnels to modify crop microclimate and productivity
Hughie Jones, University of British Columbia Vancouver

Measuring multiple impacts of adaptation strategies: The case of Alderson Creek, North Okanagan
John Janmaat, University of British Columbia Okanagan

A.1.2 Presentations Abstracts

Using Aerial Thermal Imaging to Measure Differences in Cattle Surface Temperature due to Coat Colour

John Church, J. Mufford, M. Paetkau, P. Folkard, D. Hill

Heat stress in cattle is a growing welfare issue in North America as evidenced by observed cattle mortalities in 2017. Rising ambient air temperatures due to climate change will universally impact cattle thermoregulation, and may impact black-coated cattle more due to solar loading. We used aerial infrared thermography (IRT) from drone flights to assess the contribution of solar loading on cattle surface temperature to compare black versus white coat colour in a rangeland near Monte Creek, BC. A Black Angus/Speckle Park crossed cattle herd was used to provide colour diversity. Weather and sunlight were measured using a Kestrel portable weather station and a Newport 815 digital power meter, respectively. The mean ($\bar{x}$) and standard deviation (SD) for the following weather conditions were calculated: Ambient air temperature, 19.7 ± 1.4 °C; relative humidity, 37.5 ± 3.3 %; max wind speed, 12.1 ± 7.2 km/hr; intensity of sunlight, 758571 ± 37161 w/m2. A DJI Inspire 1 quadcopter equipped with an IRT camera was flown at 20 meters above the cattle to capture thermal temperature photos (radiometric JPEGs). Post-processing included using FLIR Tools+ to quantify cattle back (dorsal) temperatures using manually drawn polygons. The $\bar{x}$ surface temperature for the Black Angus type was significantly higher ($\bar{x}$ = 37.1°C ± 3.2 SD; n=10) than the $\bar{x}$ surface temperature for the "white" Speckle Park type ($\bar{x}$ = 30.1°C ± 4.5 SD; n=8), (P = 0.001). Future climate change research should consider coat colour when studying cattle performance and heat stress due to pronounced solar loading.

Expanding on the Climate Change Risk Assessment Tool for Ponds Used as Livestock Water Sources

Aaron Coelho and Tom Pypker

Recently, a prototype online tool for assessing the impacts of climate change on ponds used as livestock water sources was completed with funding from the Growing Forward 2 program under the BC Agriculture and Food Action Initiative. The intention of the tool is to provide risk assessment information for ponds in order to assist the ranching industry and resource managers with proactive adaptation to changes in water availability. The tool is applicable to BC's southern interior rangelands and uses climate models and site-specific pond assessment models to project future trends in pond water supply. As this project involved exploratory statistics and preliminary model development, the deliverable is considered a prototype. Throughout the process of developing the models, various limitations were encountered. The limitations are mainly statistical and can be overcome through the acquisition of more data. Other limitations include web page development and hosting. Future work is recommended to acquire more data and develop a more robust model. Additionally, the work completed in this project has the potential to act as a platform for other sources of climate change related data. Through a coordinated effort with a network of researchers, industry professionals and other

interested stakeholders, the online tool can be developed to provide a broader scope of information.

A multi-faceted approach to emerging pest threats in the Fraser Valley, BC
Jen Scholefield and Marjo Dessureault

As our climate changes, some pests will become more challenging to manage, and attention across the agricultural sector is needed to address these issues. Following surveys conducted with growers and specialists in 2016, an inventory was created that documented pest-related activities and perceived pest threats across 30 agricultural industries in the Fraser Valley. The activities included research, outreach, monitoring, and surveillance, and resulted in a list of over 300 projects that were conducted in the Fraser Valley over the past five years. Interested parties can use this to search for relevant projects, as well as avoid repetition of research by groups who are not aware of each other's projects. In a follow-up project, this inventory underwent further analysis and several pest priority lists were created. Existing projects were compared with producer concerns, enabling research and knowledge gaps to be identified. The project also includes the creation of outreach materials (pest fact sheets), strategic planning sessions each devoted to a specific pest, and a larger industry-wide workshop to encourage collaboration and connections across the diverse agricultural sectors in the Fraser Valley. The combined approach of analysis, outreach and collaboration provides a platform for a cohesive approach to shared pest threats, particularly in light of the changing climate.

How plant-parasitic nematodes factor into the resilience of BC horticulture to climate change
Tom Forge, Denise Neilsen, Gerry Neilsen, Tristan Watson, Paige Munro, Louise Nelson, Melanie Jones

For irrigation-dependent horticulture in the southern interior of BC, the development and adoption of water conserving irrigation and soil management practices will be critical for adapting to climate change, which is expected to bring greater inter-annual variation in evapotranspiration and the availability of water for irrigation. The resilience of these production systems is influenced by belowground interactions affecting the health and functioning of root systems, and water conserving management practices may potentially result in positive or negative feedback effects on these interactions. Plant parasitic nematodes (PPNs) affect the health and functioning of the root systems of most perennial fruit crops. Our research is aimed at improving knowledge of how the population dynamics and impacts of PPNs are affected by the adoption of water conserving orchard management practices and climate change. This presentation will review the known and potential impacts of PPNs on BC horticulture, and summarize the results of a series of recent field experiments elucidating the interactive influences of organic mulches, soil amendments and micro-irrigation techniques on PPN populations, indicators of root health and overall tree health

Expanding cherry production in British Columbia under climate Change: Considering the biological quality of soil in new sites

Louise Nelson, Paige Munro, Tirhas Gebretsadikan, Tanja Voegel, Tom Forage, Denis Neilsen and Melanie Jones

With climate change cherry production in the southern interior of British Columbia is expanding northward and to higher elevations than previously possible. Efficient use of limited water and maintenance of soil health while sustaining cherry quality and yield are important factors to consider in adaptation of cherry to these new sites. A greenhouse bioassay with soil from 18 new and established orchard sites in the Okanagan Valley was conducted to determine if native soil populations enhance or restrict cherry growth. It showed that new orchard soils were more 'biologically suitable' for planting sweet cherry, and management practices that had maintained soil organic carbon levels and high levels of microbial activity were positive predictors of plant growth. The effects of postharvest deficit irrigation (PDI) (25% reduction in water supply after harvest) and compost and mulch amendments on soil health and cherry production were assessed over two years in two new and one established orchard. PDI generally had no negative effects on cherry water relations growth or soil health after one year, but longer-term studies are needed to fully assess its effects. Compost amendment increased soil nutrients at all three sites and generally decreased the abundance of the root-lesion nematode, Pratylenchus penetrans, and the percent colonization of arbuscular mycorrhizal fungi in plant roots. Other influences on soil microbial communities are being explored via next generation sequencing. Organic amendments such as compost show potential to maintain soil health in newly planted orchards and to mitigate the biological effects of replant stress in established orchards.

Radiative properties of plastic films and their use as soil mulches in low tunnels to modify crop microclimate and productivity

Hughie Jones, Andy Black, Rachpal Jassal, Zoran Nesic

Plastic films used for soil mulches and low tunnels have the potential to suppress weeds, prevent erosion, alter the surface energy balance, conserve soil moisture (qs), and modulate soil (Ts) and air (Ta) temperature. Our goal is to characterize the spectral radiative properties (reflectivity (r), transmissivity (t) and absorptivity (a)) of various modern plastic films and determine their ability to alter net radiation, soil heat flux density (G), Ts and qs when used as soil mulches and in low tunnels to protect crops. Spectral radiative properties were measured using a spectroradiometer. Field trials were conducted at 3 organic farms: UBC Farm, Mackin Creek Farm (near Soda Creek, BC) and Cropthorne Farm (in Delta, BC). A soil mulch experiment at UBC Farm showed that plastic films with high t (i.e., transparent) achieved the highest daytime G and Ts compared to bare soil, whereas films with high r (e.g., white) resulted in lower G and Ts than the control. A vegetation free low-tunnel experiment at UBC Farm showed that August daily maximum Ta inside low tunnels with plastic films of high and low longwave radiation t was 16 and 20°C greater, respectively, than ambient Ta. Nighttime Ta inside the low tunnel covered with low longwave radiation t plastic film was 1-4°C greater than ambient Ta. We have found that zucchini, pepper and broccoli production increased by 10-25% when grown

in low tunnels. The results will assist BC farmers to adapt to climate change using readily available materials, techniques and models.

Evaluating drainage management options to improve climate change adaptation in British Columbia's Fraser River delta
Sean Smukler, Siddhartho Paul and Katie Neufeld

Downscaled climate models predict warmer temperatures and shifting precipitation patterns for the delta of British Columbia's Fraser River, one of the most productive agricultural regions in Canada. Shifting precipitation has already resulted in wetter soil conditions during spring and fall when mechanized operations are most critical for production. Many farmers in delta have installed drainage infrastructure but it is unclear if this has improved their adaptive capacity and farmers are hesitant to install additional tile given the substantial costs. The objective of this study was to better understand drainage management options in the context of increasing precipitation by: 1. Inventorying soil properties of farms with drainage tile, with drainage tile with pumps and undrained fields; 2. Monitoring water dynamics during key periods of the year to determine workable days or water table levels. From 2015 to 2017, we sampled and monitored 25 blueberry and vegetable fields across Delta for a number of different soil and water indicators. Our results show that drainage management performance is highly variable. The results for many of the performance indicators we monitored show that a pump system is essential for improving the capacity of farmers to adapt to wetter shoulder seasons and that tile cleaning is a simple cost-effective way to increase adaptive capacity.

Measuring multiple impacts of adaptation strategies: the case of Alderson Creek, North Okanagan
John Janmaat, Julien Picault and Alexander Cebry

As a society, we are gradually coming to recognize that 'natural' infrastructure, including ecologically healthy stream channels, can help moderate some impacts of climate change. In particular, such natural infrastructure can provide resilience to extreme weather. Infrastructure like this often provides a multitude of services in addition to moderating climate change impacts. Assessing the cost effectiveness of investing in restoring natural infrastructure requires accounting for the multiple services, and the uncertainty in estimating the value of these services. Using Alderson Creek, a small tributary creek in the North Okanagan, we examine the challenges in using benefit transfer to estimate the costs and benefits of small projects. We find that there are a very limited number of studies that present valuation estimates as "per household per unit area" that could reasonably be adapted to our example. We also find few studies that effectively deal with the question of standing, a question critical to small projects where effects may not significantly impact many people. We address this by combining distance based scaling with high resolution population density mapping to show that the economic justification for small projects may depend on nearby large communities caring 'enough' about the impacts.

A.1.3 List of Poster Presentations

Climate Change Adaptation for Small Scale Farmers
Olga Lansdorp, Society Promoting Environmental Conservation

Digital Mapping of Soil Workability to Improve Climate Adaptation in Delta, BC
Siddhartho Paul, University of British Columbia

The Effect of Post-Harvest Deficit Irrigation and Organic Amendments on the Expansion of Sweet Cherry Production Under Climate Change in the Okanagan Valley
Tirhas M. Gebretsadikan, University of British Columbia

Adapting to what? Climate Change and the Alderson Creek Group Environmental Farm Plan
Nargiz Rahimova, University of British Columbia

Optimizing Corn-cover Crop Systems for Production of Dairy Feed in a Changing Climate in BC, Canada
Derek Hunt, Agriculture and Agri-Food Canada

Developing Gridded Uncertainty Fields for PRISM Climate Data
Faron Anslow, Pacific Climate Impacts Consortium

Developing New Deficit Irrigation Strategies to Improve Grape and Wine Quality While Saving Irrigation Water
Eugene Kovalenko, University of British Columbia

Codling Moth Pest Pressures Under a Changing Climate
Georgine Yorgey, Washington State University

INFEWS/T1: Increasing Regional to Global-Scale Resilience in FEW Systems Through Coordinated Management of Storage in Concert with Innovations in Technology and Institutions
Georgine Yorgey, Washington State University

Appendix 2- Other Project Ideas from the Brainstorming Session

Climatology and Hydrology group

- The establishment of high resolution microclimate observations in high risk agricultural zones
- Weather station improvements to enhance climate data in BC agriculture regions

Crop health and pests group

- Expanding decision aid tools
    - Climate data/environmental monitoring
    - Crop/pest physiology
    - Modelling/mapping
    - Long-term trials for crop-disease epidemiology
- Update crop suitability models for BC
- Forage productivity
    - Drought impacts
    - Long-term monitoring of study sites
    - Grazing trials
    - Quality changes overtime
- Plant physiology in climate change
- Pest interaction and disease in climate change
- Range expansion and new/emerging pests (management and product registration)

Soils and Nutrient Cycling group

- Nutrient risk index based on fundamental soil properties (leaching risk indicator)
- Development of a spectral library of soil across the province
- Impact of extreme events (etc. fire, flooding, drought) on soils

Economics, policy planning group

- Links between policy and regulatory context and processing capacity and implications for adaptation
- How is business risk management being delivered and how does it relate to producer decision-making