FERTILE GROUND: AGRONOMIC RESEARCH CAPACITY IN WESTERN CANADA

Executive Summary

Presented to:

Western Grains Research Foundation

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Definitions

AAFC- Agriculture and Agri-Food Canada

Agronomy- Agronomy is the study and practice of field crop production, and the management of land and water resources. It aims to meet the demands of producing food, feed, fuel and bioproducts while maintaining a sustainable environment.

Applied Research Associations (ARAs)- producer directed applied research associations in Alberta and Saskatchewan. . Manitoba uses a model of shared direction by the province and local producers.

Applied Research- adaptive research done for shorter term application (1 to 5 year), often into more specific geographic and farm industry directed needs.

Alberta Innovates Technology Futures- AITF, formerly Alberta Research Council

Capacity- It was taken to mean current internal capability (science and technical expertise, related skills, land, equipment, focus area) of an organization within the agronomy interest.

Capacity-building- the activity completed to raise the current capacity (eg. training, outside advisory services)

Co-location- is a practice of having people located in a common working space for the purpose of improving communication, relationships and the ability to transfer ideas to each other. Benefits include potentially sharing other resources and new opportunities.

Collaboration- a jointly delivered research project involving mutual interest and resources.

Core funds- funds which are known from year to year for basic operations. Are also expressed as A-based funds (government) or hard funds.

Clusters- a term describing a research funding program designed by AAFC and co-funded by AAFC and industry under the overall structure of Growing Forward 1 and 2 (funding programs).

Disciplines- the requisite education, skills and experience needed for agronomy projects including agronomy, crops and cropping systems, soils, entomology, physiology, pathology, weed sciences as defined for this review.

Extension- the practice of extending the new knowledge and new practices learned from basic and applied research findings to the end user (typically a farmer or business). It often involves practice change in learning a new or improved way of doing crop production related tasks. Also described as technology transfer.

Funders- are investors in research programs and projects.

Gap or bottleneck- the resource which is missing to improve or increase current capacity to the required or desired capacity as defined by the organization.

Multi-site – this is the practice of involving several geographic sites in a common experiment across regions to test for robustness/ effectiveness of the research concept and accelerates the research process. .

Network of Sites- an AAFC term meaning its research stations, sub-sites and farms which may be involved in completion of a research project or program.

Protocols- are accepted scientific procedures which are prescribed in a document to manage a research experiment with consistency, standards of good practice and to reduce the source of error. Companies will also use protocols to hire others to do contract research.

Project funds- Typically will be provided by any level of government, granting councils, commodity associations, non-profit funders, and others for the purpose of finding results for a time-limited research project, not usually involving core funds. These are also known as soft funds.

Basic Research- is highly varied in purpose but will involve peer reviewed projects, typically done at universities, public labs and provincial research departments for curiosity, understanding of structure, function, mechanisms of action, longer term effects and replicable experiments which provide broader additive foundational knowledge. This knowledge will add to the global knowledge pool and understanding.

Research Performers- are scientists, although others are typically involved including technicians, data analysts and other service providers. In ARAs, these may not be scientists but are otherwise qualified in the applied research they conduct.

Research and development system- all components (labs, people, programs and services) involved in moving an idea or concept from basic research (lab scale) through proof of concept, piloting, scale-up, developmental, adaptive and finally commercial applications. Roles and scope vary along the R&D continuum.

Sites- AAFC research stations, sub-sites and farms in Alberta, Saskatchewan and Manitoba

Executive Summary

Project Objectives

This project provides an inventory (capital and human resources) of agronomic research capacity in Western Canada, and projected capacity to 2020. It also included a review of the collaboration and capacity needs for producer funded research. The inventory itself was completed in 2014 with the specific purpose to inform the research capacity in the agronomy system (except for plant breeding- not included herein). This review of agronomy research capacity involved contacting all relevant organizations in the research (basic and applied) topics in BC, Alberta, Saskatchewan and Manitoba. A review of data, documents, survey and interview information were used to inform on the agronomy system.

Findings- Current Situation

Public Research Organizations- The combined Western Canadian University system, Agriculture and Agri-Food Canada and provincial governments have staff, resources and capacity which are focused on agronomy research and activities.

The three Universities have a total staff (PhD) FTE complement of 20 scientists (University of Alberta-3, University of Saskatchewan-10, University of Manitoba-7.5) in agronomy related disciplines.[a] Alberta is currently short two agronomy scientists and has recently lost an entomologist (deceased). Saskatchewan is in need of both entomology and cropping system scientists. It also needs access to larger scale equipment and some smaller scale seeding equipment. Core budgets are not typically available for these uses and funding is an ongoing challenge. The total University agronomy research capacity also includes about 38 support staff plus graduate students. Some retirements (about 4 positions) are expected in the next 3 to 5 years.

Table E1 – Summary of University PhD FTEs in Agronomy Research

Discipline	University of Alberta	University of Saskatchewan	University of Manitoba
Agronomy	Gap	2	2
Crops	-	1 Gap- cropping systems	1
Entomology	Gap	Gap	.5
Soils	1	3	3
Physiology	.5	0	0
Pathology	.5	2	0
Weeds	1	2	1
Total- FTEs Active	3	10	7.5
Comment	Lack 2 agronomy core positions, have others involved but part-time. Entomology unfilled.	Lack equip and core funds, need 2 positions	Lack core funds for graduate students, technicians and equipment

Source: Survey.

[a] FTE- full- time equivalent positions reflect how the organization is staffed. The approach helps to compare capacity across all organizations, but does not reflect quality of outputs or volume of outputs.

The agronomy graduate students total 167 in the three Universities in the related disciplines.[b] Graduate student counts are noted in the table below, (data sourced from University staff): the University of Alberta has 36 graduate students in the agronomy related areas; Saskatchewan has 66; and Manitoba has 65. (It is noted that other graduate students in related areas may also fill a need in agronomy research projects.) Only 37% (61 of 167) are PhD students which may be a limiting factor to a growing agriculture sector.

Table E 2 – Summary of Graduate Students in Agronomy Research

Discipline	Alberta- MSc	PhD	Saskatchewan- MSc	PhD	Manitoba- MSc	PhD	Totals-MSc	PhD
Agronomy*	5	0	9	1	6	2	20	3
Entomology	1	1	0	0	6	7	7	8
Soils	6	3	17	17	13	7	36	27
Physiology	4	1	1	6	6	3	11	10
Pathology	8	2	8	0	4	8	20	10
Weeds	5	0	6	1	1	2	12	3
Total- Agronomy Disciplines	29	7	41	25	36	29	106	61
Total- All	36 (22%)		66 (39%)		65 (39%)		167 (100%)	

Source: Survey. Classification titles differ by school. Alberta has 59 total graduate students in related breeding, range ecology and molecular areas. Saskatchewan has 137 total plant and soil science graduate students. Most (75%) of these students are in breeding/ genetics, horticulture or plant ecology. Plant breeding students are not included. * For MB includes 3 cropping systems students.

The table above illustrates fewer agronomy, entomology and weed science students than other disciplines and reflects the university scientist gap noted. (Other graduate students may also be involved in breeding/ agronomy, environment or other soils topics.) The agronomy science plans of these Universities are needed to help inform the broader sector on the desired future state.

In the public agronomic research area, AAFC is the strongest and most integrated organization although some concerns exist about its future plans. AAFC has 39 FTE PhDs and a number of support and other academic staff for other functions. The table below notes the FTE (full-time equivalent) positions.

Table E 3- AAFC Agronomy Research Positions

AAFC- Western Canada	Agronomy PhD FTEs	Comments
Alberta (3 sites)	17	Retirees expected
Saskatchewan (5 sites)	15	Retirees expected and unfilled position (1), farm uncertainty (eg. Melfort, Scott)
Manitoba (2 sites)	7	Retirees and unfilled positions
Total	39	Infrastructure $1.4 m; 16 retirees; 3 unfilled Entomology and weeds positions-key gaps

Source: Input to WGRF, 2014

[b] For the study, disciplines included: weeds, crops, soils, agronomy, pathology, physiology, entomology.

AAFC has strength in its integrated crop management approach and in the multi-site research projects. A key finding herein is the imminent number of expected retirees of the core and senior level PhD staff in Western Canada. AAFC expects about 16 positions of senior scientists (see appendix) to be vacated within three years. In some disciplines, such as weed sciences, nearly all positions will be vacated. In addition to these positions, another 3 agronomy positions have been unfilled for some time. The potential reduction of about 16 to 20 senior scientists is an important part of this total knowledge creating capacity.[c] This capacity is critical as it represents the "top of the knowledge pyramid", builds on global research and often helps to identify critical foresight topics.

These senior people are knowledgeable, experienced and are the current leaders or mentors in the agronomy sector. Research by this organization is often multi-site, multi-year and typically involves several disciplines/ scientists.. The AAFC system is viewed as significant with many scientists, sites (stations and farms), equipment and internal assets. No replacement plan for any of these positions is available. For a community and a region that is home to an AAFC (farm) site, the loss of access to the "system network knowledge", mentoring and information can be substantial. AAFC serves the west as a geographic whole region and strives to look at what is needed over any pressures of maintaining what currently exists. New models and partnerships are the way AAFC will likely proceed. However, a strategic plan from AAFC would help define a chosen path and help reduce the uncertainty for many people.

The most significant impacts of retraction within AAFC will be at Lacombe and Saskatoon (including Melfort and Scott), with entomology and weed research capacity expected to be hardest hit. As senior level researchers retire, both access to current agronomy knowledge and mentoring of new scientists will result in system gaps.[d] Discipline gaps will also appear. A listing of the current likely retirements by 2018 (agronomy system) are noted (for AAFC scientists) given comment/ expectations. The potential reductions include:

- Agronomy- 3 unfilled positions;
- Crops- 4 positions;
- Entomology- 5 positions;
- Soils- 1 position;
- Pathology- 2 positions;
- Weeds – 3 positions;
- Agrometerology -1 position;
- Total 16- reductions plus 3 currently unfilled positions;

Alberta (Agriculture & Rural Development and AITF) has a strong and recognized research capacity in the field of agronomy. In this regard, Alberta has new crop development efforts underway at Alberta Innovates Technology Futures (AITF) and the provincial department has research supports in three divisions: Lacombe Field Crop Development Centre, Food & BIo-Industrial Crops Branch and Pest Surveillance Branch. In total, Alberta has about 15 PhD

[c] This term is described on pg 17 below and relates to building the global pool of agronomy knowledge.
[d] These 16 staff are productive and produced about 34% of the agronomy research publications for the period reported- see pg 26.

FTEs and 5 MSc FTEs in agronomy. Manitoba completes applied research through 4 Crop Development Centres and operates with producer and community directed boards. Manitoba has 4 PhD/ MSc level staff to support agronomy. Saskatchewan does not have a similar internal research effort but supports agronomy research through the CDC and significant funding programs.

From the survey of these public sector organizations above, a total of 83 scientists are involved in agronomy research projects.[e] This total includes: 39 FTE PhD (full-time equivalent) Agriculture and Agri-Food Canada (AAFC) professionals, about 20 FTE PhD University staff and 24 PhD provincial government staff (Alberta and Manitoba) who are involved in peer reviewed research type projects. These total FTEs are complemented by staff that supports these research activities. In total the public research positions are in the order of 213 people (PhD plus staff).[f]

Table E 4- Summary of FTEs Involved in Public Agronomy Research

Region	Provincial Govt	AAFC	University	Total
BC	0	0	0	0
AB	20	17	3	40
SK	-	15	10	25
MB	4	7	7.5	18
FTE PhD/MSc	24	39	20	83
Staff*	62	42	26	130
Total	86	81	46	213

Source: Survey- 71.5 PhD and 12 MSc. Provincial staff include: AB- 32, SK- 20, MB- 10; total = 62.

Applied Research Associations, College and Industry Applied Research and Extension- In addition to the research positions noted above, there is another related industry research and extension aspect in the agronomy system. These important organizations include producer directed applied research associations (ARAs), colleges, private companies and agri-businesses.

Most of this work can be classified as adaptation and crop yield improvements and often only in a regional context. ARAs number 10 in Alberta, 8 in Saskatchewan and 4 in Manitoba. Three colleges are also involved in some areas of research and extension. In addition, several specialized companies work in agronomy. The positions include colleges (AB and SK) with 7 FTEs, ARAs- producer directed applied research associations (51 FTEs) and private industry (187 FTEs). Many of the latter positions are in crop advisory functions.

Applied research associations are facing several challenges including the need to retain a

[e] Interestingly, the prior "normal" state would be about 87 FTEs, adding in the 4 unfilled positions.
[f] AAFC has another 98 high paid technical positions associated with their PhDs.

critical mass of workforce, funds for sustainability and in some cases, relevancy. Their bottlenecks include: core funds (low), equipment funding and in some cases, research management. Each should have a trained research manager (MSc level or even PhD) or access to that resource, if applied research is seen as the regional mission. Currently, not all of the associations have this staff capability (some are only part-time). Collaboration and joint projects can be enhanced among the associations and considerable opportunity exists to provide additional sites (for multi-site research and shared resources) among the public researchers.

These ARAs are highly varied in their geography, staffing, equipment resources and land base. Importantly they offer local networks, much opportunity for producer engagement, technical and technology support and an interest to leverage their knowledge. As producer-directed groups they also reflect regional interests for their crops, relative to market trends.

Private industry capacity includes such firms as Agritrend, Ag Quest, ICMS and Western Ag which are more fully described in the following chapters. Interestingly these organizations are increasing in people and projects over time in response to demand for their services. Much effort is involved in crop consulting (Agritrend) and the other two companies offer specialized crop research services. In contrast to the public sector research group which is facing an imminent decline in some retirees, it is interesting to note that the private industry segment's workforce is seen to be expanding.

Main System Capacity Issues

Currently the system has a number of capacity limiting issues or bottlenecks:

- **Workforce** development and more scientists are needed. Additional scientists (likely 4 to 5 in University) are needed in developing people for industry growth and building agronomic knowledge (given the gaps noted above). For a number of producer associations, staff retention is an issue and internal funds often limit their capacity to attract and retain people. An adequate workforce is an issue for all organizations and it is a core strategic investment for research projects. People make things happen (or not);[g]

- **AAFC** core capacity is important. Replacement scientists will be needed (16 to 20) in addition to the unfilled positions. A risk exists with the AAFC network of sites which has been the backbone for many research topics across Western Canada including agronomy. Research sites in the AAFC system (since before the 1900s) offer dedicated locations which can be accessed and experiments are conducted with standard protocols. Keeping these sites (stations and farms) is a strategic advantage for Western Canada. It appears that two operating Saskatchewan sites (research farms and also positions) may be at risk in the near term. Agronomy research positions within the AAFC system will also decline. AAFC indicates it also has an infrastructure and equipment shortfall of about $1.4 M plus $600 K annually for site upgrades (over 5 years will be $3 M);

[g] AAFC data indicates staff costs from $370,000 to $585,000 per FTE scientist. University research staff can be budgeted at about $300,000 each for salary, technician, equipment and a small research budget.

- An AAFC report indicates that science and innovation investments have declined and are planned to be reduced by 24% by 2015. One concern is the potential gap which may occur should long term agronomy research not be served by AAFC, as others in the system will not likely do this foundational research. The benefit of the network of sites provides accelerated research to gain answers to key questions or issues often within 3 to 5 years. Others may take substantially longer to provide an evidence- based answer to agronomic issues for current and potential crops. Why is the network model not used more among researchers and allied organizations?

- **Equipment** replacements and technology adequacy/ currency are a gap for some organizations. The "technology issue" faces all organizations (need for current/ adequate/ commercial scale and plot scale equipment). Equipment is of various ages, conditions and values, with some having newer equipment and others having older equipment which cannot really be useful on a similar data collection basis. Equipment is a capacity issue for many organizations (Producer directed research associations and Universities indicated some equipment/ replacement needs);

- **Agronomy research funds** appear to have been declining over time (researcher and industry comments). Longer term agronomy research (more than 2 to 3 years) is thought to be at risk by some people. Another view is that Growing Forward (I and II) programs have increased innovation funding since 2009 and agronomy is a beneficiary of this investment. No data has been obtained to describe this agronomy support;

- **Core operating funds** are low based on the survey comments. Applied research associations generally have low budgets (in the order of $200,000 to $500,000), although several (3) have larger budgets (of nearly $1 million). These funds cover all operations, staff, equipment R&M, management and research and extension projects. For the associations, the funding can be highly variable. Given this wide difference in funding levels and internal plans, some applied research associations perform at high levels and some do not. Core funds are low and are a critical success factor;

- In addition, ARAs often cannot pay comparable salaries to government/ industry and hence senior staff retention has been difficult. Some attention to adequate funds for these core operations is needed to overcome the continued bottleneck in people and strategic projects;

- **Land and buildings** are available, although access to some of this capacity may be limited due to prior project commitments.. Land is needed for projects and in some cases this means the organization can be "land rich and cash poor". Many of the private research companies also lease land. Some of the associations have buildings or access to government buildings for offices and storage. Given the land base available, it seems that more collaboration should occur with land but the trade-off will be the distance (and costs) in travelling to these locations for conducting projects (from the home base);

- **Leadership from Boards and Management** create the ARA vision for agronomy research. For some applied research associations, their capacity can be limited by the

internal leaders. Some associations are growing and others are not. This internal capacity can limit overall agronomy projects with potential partners. This is an important factor to agronomy research projects, outputs, budgets and collaborations. In our experience this is a critical capacity success factor (we did not examine/ audit organizations. However, not all organizations operate at the same level of quality, science and service delivery (however, these aspects can be addressed);

- **Networks and coordination** are needed. There appears to be a requirement to organize/ coordinate the agronomy research approach in Western Canada, and most likely with research associations. An umbrella group can help to consolidate and administer several funding sources to enable some longer term key research projects. It may also: evaluate, train, endorse research partners; address resource options; and help in the dissemination of findings.[h] Coordination (perhaps) through the use of a senior provincial science team on agronomy research would be useful. Within a province or region, access to a core team (can be virtual) of: soil, crop, weed, entomology, physiology and pathology sciences (and economics) for guidance can help;

- **Growing Forward** (I and II) are considered highly successful. Industry and producers can set their priorities and have succeeded with wheat, canola, pulse, barley, beef clusters that all have major agronomy components. There are several Agri-Science Projects (ASP) that address agronomy interests for producer groups. This model provides a "ready built" system for commodity groups and researchers to further their mutual activities;

- **Priority setting** of research is very important for all groups. Producer associations are often tasked with projects for specific end markets, and yield improvements, etc. Understanding the scope of public and producer/ industry agronomy projects is very useful. The use of crop clusters mainly involves AAFC and University service providers, (some applied research associations are now getting involved in clusters).[i] A key question arises: how can producer associations improve their sharing of best practices and research projects across the west?;

- **Communication** of research findings is important. Social media use and communication can be strengthened with more use of websites, mobile applications, data mining and other internet-based tools. These enhancements can appeal to all. It is noted that any new practice or technology needs to "pay to stay" at the farm level. The aspects of farm economics/ impacts/ adoption practices should be included in the research work;

- **Future state discussions are needed**. Comments were offered on clarifying the future state of agronomy research. Is there sufficient research capacity relative to roles to deal with any unforeseen crisis (disease, pests, climate, etc.)? What about the emerging areas

[h] In 2012-13, the GRDC (AU) invested $159 million into: markets- 12%, crop yield- 26%, protecting- 25%, farming systems- 19%, resource base- 8%, skills and capacity- 3%, foundational- 6% and management- 1%. (Note crop yield investments alone were about $41 million.)

[i] The use of crop clusters is used to link AAFC, University and other research organizations.

of climate change adaptation/ mitigation.[j] What will occur given the expected loss of existing Western Canadian capacity and further knowledge generation? There was a common interest in foresight planning for agronomy expressed by several people.

Summary of Possible Actions

The review of the current agronomy capacity situation shows four main action areas to address certain gaps so as to avoid imminent bottlenecks and to prepare for the change management process. Change management is used to describe the actions, goals and processes used to move from a current state of operations towards a preferred or desired future state (obviously thought to be better/ beneficial/ more impactful. Developing the future state requires a process and much stakeholder input toward a shared vision/ plan.) The action table below summarizes the main ideas which can be considered among a range of options.

Proposed Action Table

Capacity Gap	Action Needed	Comment
University- workforce Equipment/ infrastructure	• 4 to 5 new scientists to replace/ fill current gaps • Core funds for equip • Stronger interface with ARAs	Address Agronomy Entomology, Weeds scientist gap; 4 potential retirees, 1 unfilled
AAFC –impending	• Clarity from gap analysis on funds, staff needs, sites • Staff and infrastructure plan, strategic plan specific to agronomy	Address imminent –retirees-16, 3 unfilled positions, Sk sites, $1.4m infrastructure. Will reduce uncertainty and system “stress”.
Applied Research Associations	• Increase core operating funds • Training on research mngt, best practice, analytics, collaborations • Research & business plans • Develop a new TT network	Strengthen tech transfer (TT) and extension aspects. Improve quality in applied research. Tie funds more to research outputs. Each strives to have internal MSc staff (or access to.)
Western Canada Agronomy Knowledge/ Integration/ Collaboration	• Leadership & agronomy system strategy/ plan with clarity on priorities, roles & funds for enhanced western Canada approach (future state). • Total of 20 retirees imminent (with AAFC) plus 4 unfilled positions will challenge core knowledge capacity	AU system offers a model. Crop clusters do not integrate producer associations. Public system changes (expected) must better inform private sector/ producers. Improve communication.

Several actions should be considered to address the key bottlenecks (or capacity requirements):

- **Workforce**-the research indicates 4 to 5 new science positions are needed at a University level. Alberta is low relative to other Universities. In addition, industry requires students for a variety of agronomy related occupations. For producer research associations, the issue of staff attraction and retention will require adequate compensation relative to the industry;

[j] Some research stations are examining these climate aspects (Lethbridge for example) and a software program called Holos is available for farm level modelling on farm practices and GHG changes.

- **Disciplines**- The analysis indicates about 20 core PhD positions will be vacated in the next three years. Specific gaps will emerge specific to agronomy, weed science, entomology and crops. These real bottlenecks will appear soon in several organizations;

- **AAFC** core foundation role continues- This will become a deficiency as senior positions are vacated and internal consolidation continues. A Gap Analysis is to be done to understand the future role. As noted herein, other countries do have a science lead organization to ensure new ideas, innovations and technologies are being studied and developed;

- **Equipment** and infrastructure- AAFC indicates a need for new investment. Producer associations and university comments indicate several specific needs. There is a requirement to create a replacement fund for addressing these areas (which are case by case), although some organizations are addressing this issue already;

- **Strengthen Producer Directed Associations**- A segment which will expand is agronomic research projects provided by producer directed associations and by private companies. While this is useful to a specific target group or region, if the research is not repeatable or well designed, it can have minimal broad-based impact. However, some producer groups are working well in applied research projects and are recognized for their efforts. Co-location, collaboration and resource sharing with public institutions are some of the reasons for higher performance. Specific training and sharing of best practices can help associations;

- **Strategic plans**, boards and management practices- Some producer directed organizations perform better at certain tasks which relates to their plans and board/ management directions. Use of a strategic research plan, board and management training on research management and key performance indicators/ leveraging resources/ best management practices will help. Funders may need to increase their funding along with renewed expectations of outputs. Outside expert assistance may also help in these changes;

- **Collaborations/ partnerships**- Collaboration does occur with several producer groups and more can occur. Typically, collaboration requires like-minded people to focus on a common task. AAFC and University staff commonly will do this. Some producer associations also collaborate with other researchers. Funders can encourage these approaches to leverage resources. To assist producer associations/ industry, specific training and awareness will be needed to bring all participants to a common level of expectations;

- **Agronomy system coordination/ networks/ research focus**- Duplication of crop trials and some research projects is a symptom both of poor awareness and coordination. Creating a Western Canadian network or networks for sharing results of projects can help coordination and research results. The use of the crop clusters model supports AAFC and University collaboration, but are there opportunities to help support and integrate the

producer-directed associations and others' research efforts?[k] A strategic plan/ process is needed to help strengthen the overall system and to build new collaboration and stronger outcomes, given the many stakeholders, research providers and interests. The central question: what is the desired future state to build and leverage overall agronomic capacity?

[k] The original idea of clusters and networks derives from Dr. Porter's management research (Harvard) on how nations and sectors compete internationally and how the domestic players within the eco-system support each other for mutual benefit.