Ottawa Research and Development Centre

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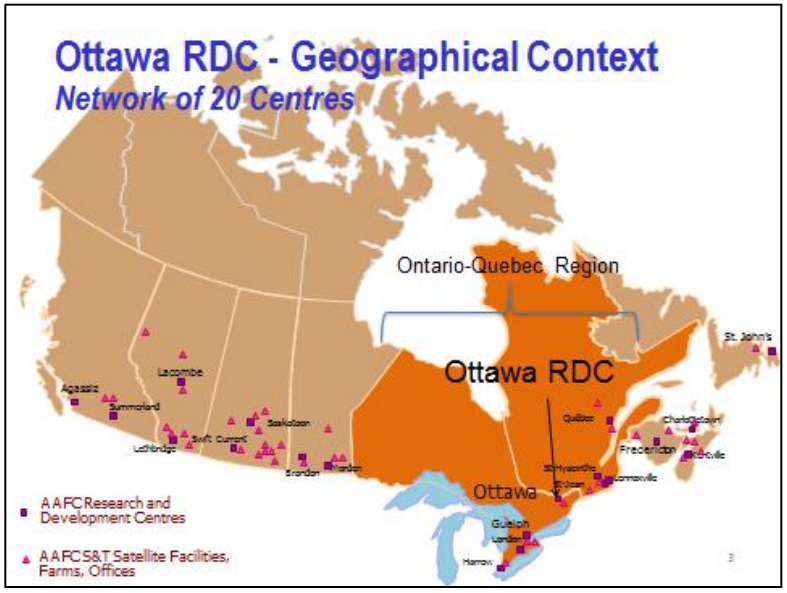
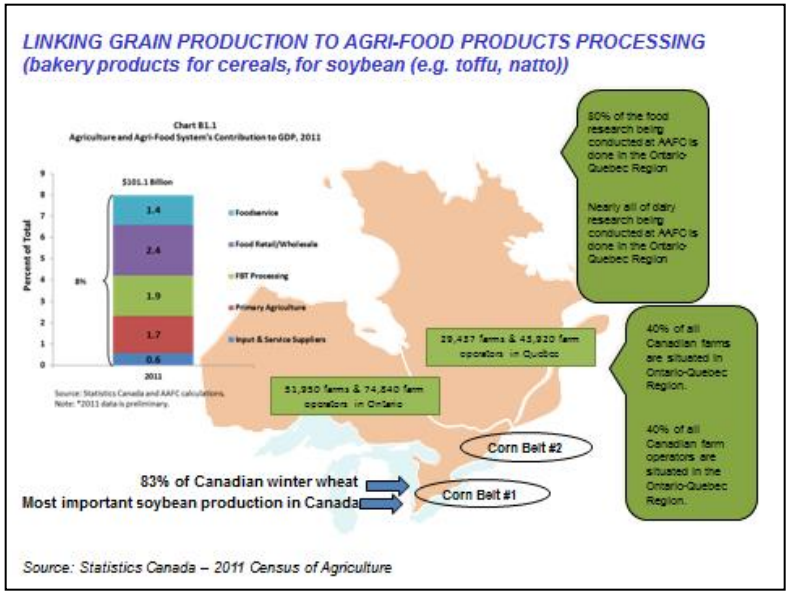
Ottawa RDC–Sep. 14, 2018

Geographical Context

- Only largest agricultural research centre – a farm in the city
- Proximity to a major population centre (Windsor-Quebec City Corridor), still embedded a large rural agricultural area
- In 1995, Ottawa RDC was mandated to provide crop genetics and genomics for Cereals and Oilseed in Eastern Canada
- Humid Climate and multiple eco-zones for testing- FHB is the most important disease
- 80% of the food processing industries located in Ontario and Quebec (e.g. bakery industry)
- Ottawa RDC provides leadership to facilitate interactions with industries along the food value chain of grains



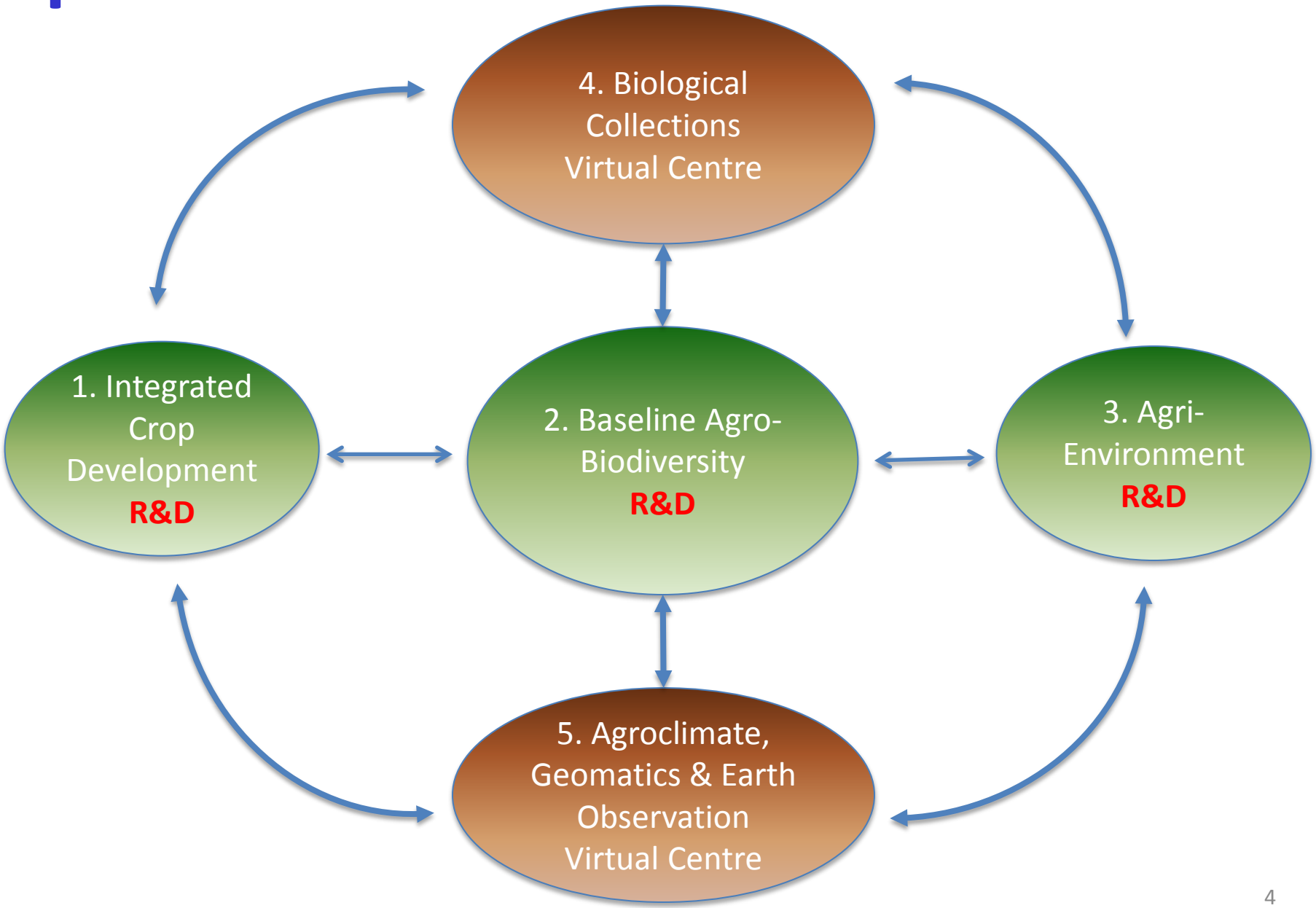


Ottawa RDC - Mission

National: for assessing and utilizing biodiversity and environmental resources for Canadian agriculture

Regional: for integrated crop development for Eastern Canadian producers located between Manitoba and PEI.
The focus is on Oats, Wheat, Barley, Corn and Soybean

Specifics of Ottawa RDC



1. Integrated crop development

Focus on:

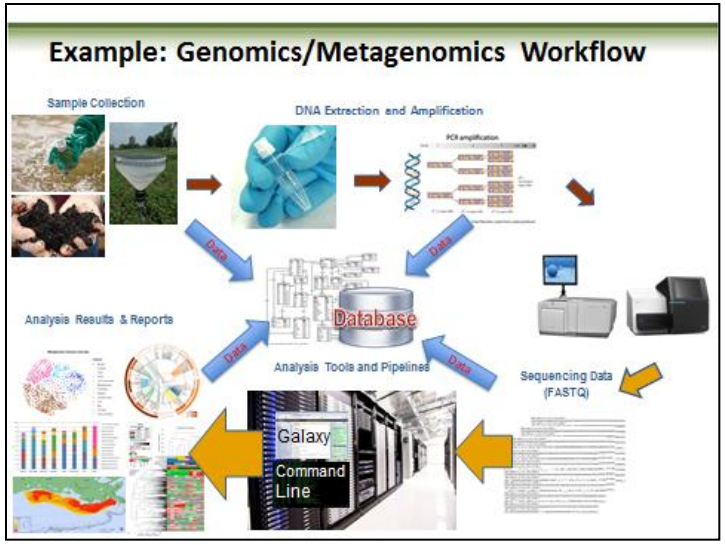
- ***Better Products for Stronger Markets***
  - Improving the genetic makeup of crops (e.g., corn, soybeans, wheat, oats, barley) that have been bred for desirable traits including, resistance to disease and insects, improved quality, early maturity, and tolerance to cold and drought
- ***Investing in Agro-Ecosystem Resilience***
  - Determining the best methods to produce crops, for example by less frequent tilling of the soil, and making better use of organic nitrogen sources
- ***Delivering Value through Science***
  - Isolating, characterizing and manipulating useful plant genes, and the elements that control or regulate them, to add product value, reduce environmental impact, and increase resistance to insects and diseases

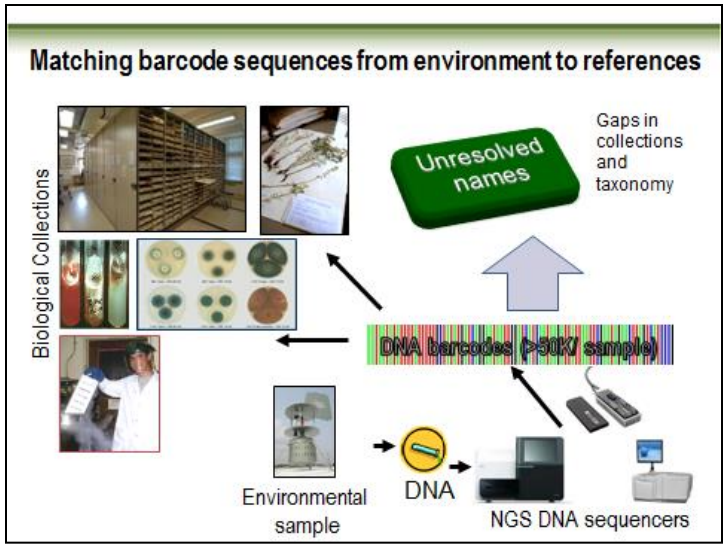
SOYBEAN RESEARCH – Breeding, Marker Assisted Selection, Agronomy, Physiology, Pathology, Food Attributes

2. Baseline agricultural biodiversity

Focus on:

- Identifying and characterizing Canada's flora and fauna to define economically important fungi, insects, weeds, and crops
- Studying ways to monitor and assess changes to support conservation and sustainable use of Canadian biological resources
- Developing identification tools to facilitate diagnostics of domestic and invasive pests of agricultural products for border protection
- Developing novel pest management strategies that exploit natural enemies that can be integrated with current agricultural practices

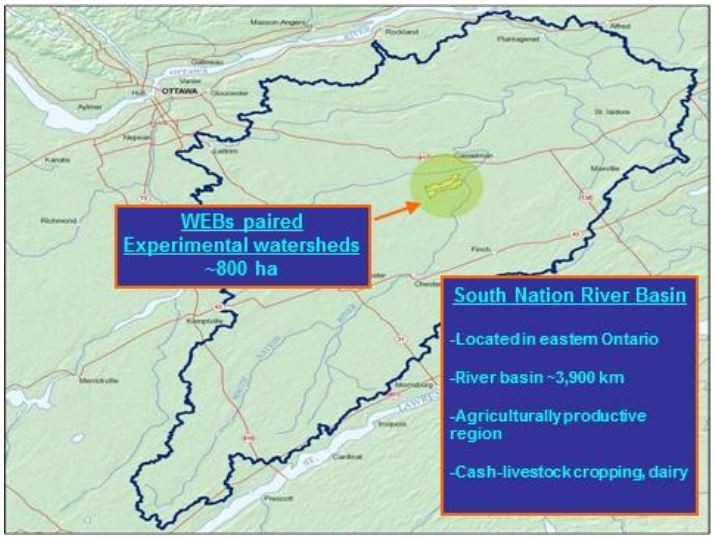




3. Enhanced environmental performance

Focus on:

- Establishing **environmentally sustainable ways** to develop and use land for field crop production in eastern Ontario and western Quebec
- Formulating methods and models to evaluate the **impact of agriculture on levels of carbon in the soil**, as well as greenhouse gas emissions
- Evaluating and modelling the dynamics of agriculture-based contaminants in soil and water, and studying **best management practices** to reduce movements of contaminants into the environment
- Creating resource **databases for land use and environmental assessments**

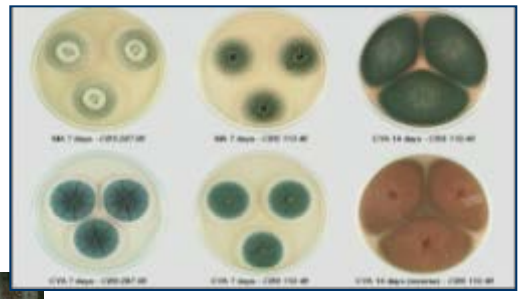


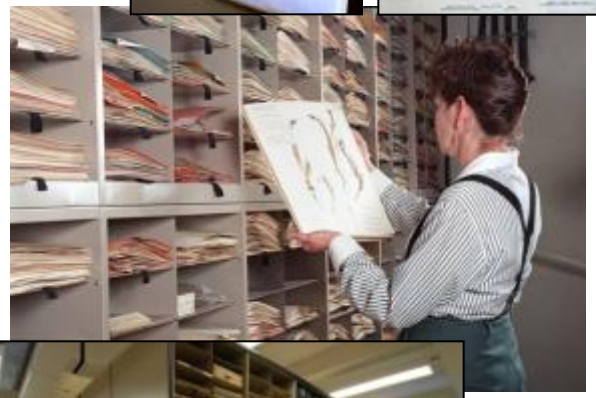
4. Ottawa Core Biological Resources

Biological Collections:

Fungi	– 18,000	maintained alive
Bacteria	– 2,000	
Insects	– 17 million	non-living specimens
Plants	– 1.7 million	
Nematodes	– 40,000	
Fungi (DAOM)	– 350,000	

Taxonomy library
Reference Collections

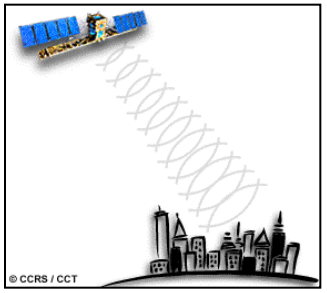


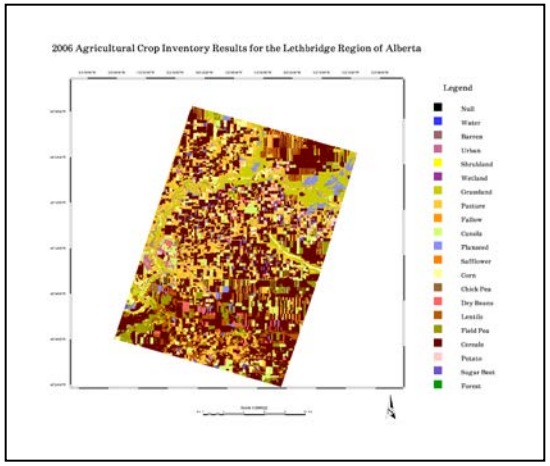


5. Agro-Climate, Geomatics and Earth Observation (ACGEO)

ACGEO provides:

- Official lead for drought monitoring for Government of Canada
- Leadership of international agricultural monitoring network, a contribution to the G20 global agricultural monitoring initiative
- Authoritative source for land use, land management, soils and agro-climate data, information and web applications
- Management, maintenance, and dissemination of AAFC geospatial data assets through the government of Canada's open data platform (data.gc.ca) and the Federal Geospatial Platform





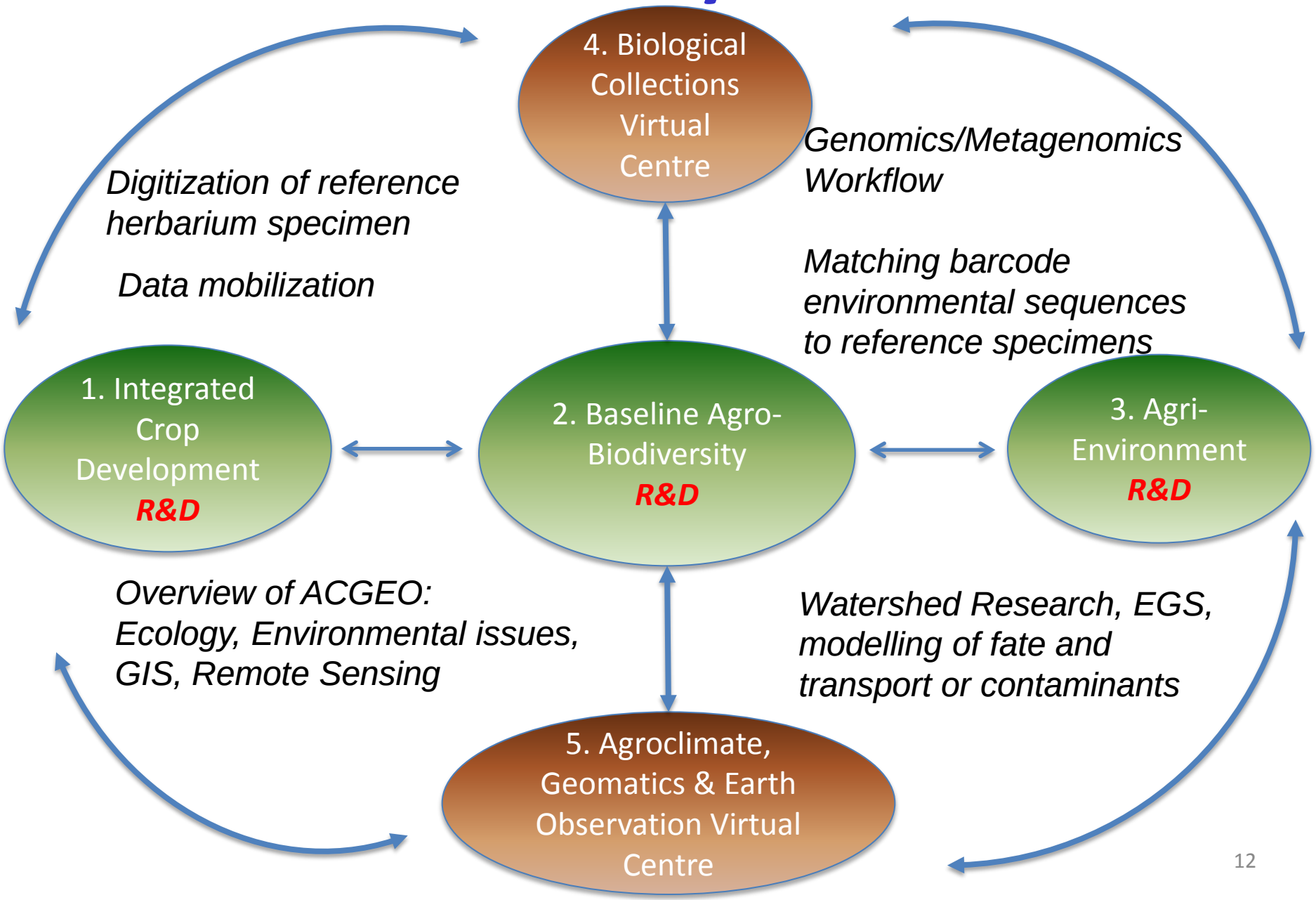
Ottawa RDC – Capacity (1)

- **1052 acres (425 hectares) in the Central Experimental Farm (CEF)**, **783 acres for Ottawa RDC, including 480 acres of research plots**
- ORDC occupies 34 of the AAFC buildings, 9 of which contain personnel. The rest are for machinery, maintenance and storage. The largest Ottawa RDC building is the K.W. Neatby Bldg with **26689 m^2 of Research Laboratories on 4 floors**
- **Integrated Growth Facility – Greenhouses** (2200 m^2) (bldg 21) built in 2008
- Research Laboratories mainly in the K.W. Neatby (bldg. 20, 120 laboratories). Others can be found in bldgs. 21 and 50
- **National Mycotoxin Analysis Laboratory** serving AAFC cereal breeders and *Fusarium* resistance research projects from across the country (30000 samples per year)
- **Electronic Microscopy** and **Nuclear Magnetic Resonance Center** as Research Support Units for AAFC Scientists
- **Central genomics facility (Molecular Technology Laboratory)** to sequence partial or full genomes of specimens and live microbial collections, to establish barcode reference sequence for regulated pests and their close relatives, to genotype material from gene banks (Plant and Animal) and to obtain global gene expression profiling for a variety of organisms

Ottawa RDC – Capacity (2)

- Home of the National **Biological Informatics Centre of Excellence (BiCoE)**, Information Services Branch
- **National Arthropod Containment Facility (Bldg 136**) providing a single entry point for exotic insects with beneficial biocontrol potential
- Home of 4 of the 7 national biological collections
    - National Collection of Insects, Arachnids and Nematodes (CNC) housed in the Neatby Bldg.
    - AAFC Herbarium of vascular plants (DAO) – Saunders Bldg
    - AAFC herbarium of fungi (DAOM) – Saunders Bldg
    - Canadian Collection of Fungal Cultures (CCFC) & AAFC collection of arbuscular mycorrhizal fungi (GINCO) - Neatby Bldg
- Home of one of the demonstration sites for Evaluation of Beneficial Agricultural Management Practices – off-site location at the **South Nation Watershed, Prescott Russell**
- Home of the **National Soil Databases** containing soil, climate, land use, and crop yield
- ***Human Resources:*** 40 scientific staff for Agro-Ecosystem Resiliency (AER); 200 scientific staff for Ottawa RDC (Baseline Agrobiodiversity and Integrated Crop Development; 40 employees under ACGEO (50% in Ottawa); 40 employees under Biological Collections (50% in Ottawa)

Science Connectivity and Visit



GENOMICS RESEARCH AND DEVELOPMENT INITIATIVE

Quarantine and Invasive Species (QIS) Shared Priority Project

PATRICE BOUCHARD AND ANDRÉ LÉVESQU
Agriculture and Agri-Food Canada
June 20, 2016

Government of Canada | Gouvernement du Canada

Canada

Genomics R&D Initiative

2M$ for 5 year (2011-2016)

Need for collaborative approach

- **Agriculture and Agri-Food Canada:**
  - national collections, taxonomy, bioinformatics
- **Canadian Food Inspection Agency:**
  - plant quarantine pests, diagnostics, enforcement
- **Department of Fisheries and Oceans:**
  - aquatic ecosystems, invasive species, enforcement
- **Environment and Climat Change Canada:**
  - parasites, barcoding, end-users
- **National Research Council:**
  - sequencing, metagenomics, direct detection
- **Natural Ressources Canada:**
  - forest invasive species, databases, monitoring

Taxonomy, collections

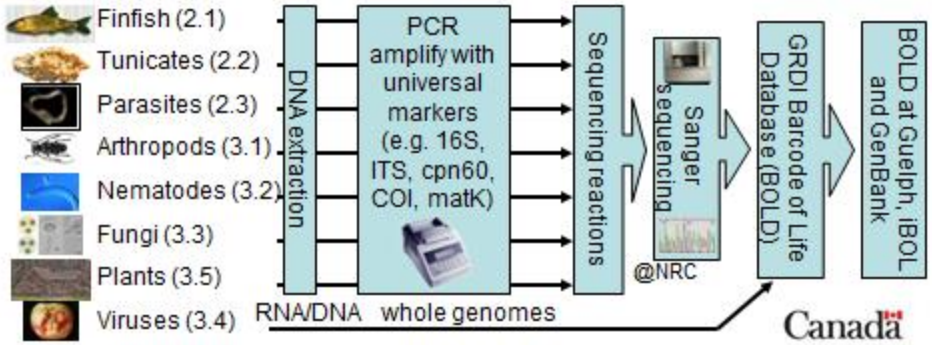
Enforcement

Canada

Genomics R&D Initiative

Scope

- Building targeted reference libraries of genetic data (Barcodes) to aquatic and terrestrial organisms of greatest concern to Canada
- Libraries will ultimately be made available to the national and international scientific community
- Develop focused metagenomic approaches for the direct detection of invasive species from complex environmental samples



Canada

Genomics R&D Initiative

Results and Impact

- Scientific collaborations demonstrated aligned with ministerial mandate letters. Complex problems require multi-disciplinary, multi-sectoral and multi-jurisdictional approaches;
- QIS-developed SeqDB used as a centralized database to store, analyze, and share raw and consensus sequences, linked to reference specimens and metadata in biological collections;
- More than 125000 sequences deposited during QIS project;
- Tool developed to efficiently share sequence date with public repositories (e.g. BOLD in Guelph and GenBank);
- New sequences allowed for review of species concepts and refinement of knowledge on species identity for specimens in collections;
- Focus on DNA extraction from a wide range of preserved specimens (e.g. plants, algae, all life stages) and environment samples (e.g. fungi in soil, fish in water);
- 27 Standard Operating Procedures (SOP) completed and made available to end-users;
- End-users included federal departments and agencies particularly regulators such as CFIA), provincial laboratories, university researchers, and the scientific community at large
- Some protocols actively used by diagnostics laboratories (e.g. CFIA);
- Extensive expertise used to evaluate available DNA extraction techniques and generate new protocols for EcoBioMics project.

Canada

IAS threats to Canadian agriculture

- Invasive alien species (IAS) are estimated to cost Canadian agriculture $6.7 billion ($5.3–$13.9 billion) per annum (*Coulatti et al. 2006 Biological Invasions 8: 45–59*)
- The eastern Palaearctic region, mainly China and Japan, is the origin of 15% of invasive plants to Canada
- Two major agricultural pests arrived in Canada:
  Spotted Wing Drosophila in 2009
  Brown Marmorated Stink Bug in 2010
- High potential for more big pests to arrive in Canada –
  Peach Fruit Moth
  Carposina sasakii


Drosophila suzukii

Halomorpha halys

CABI's role in Canadian efforts targeting invasive insect pests and weeds

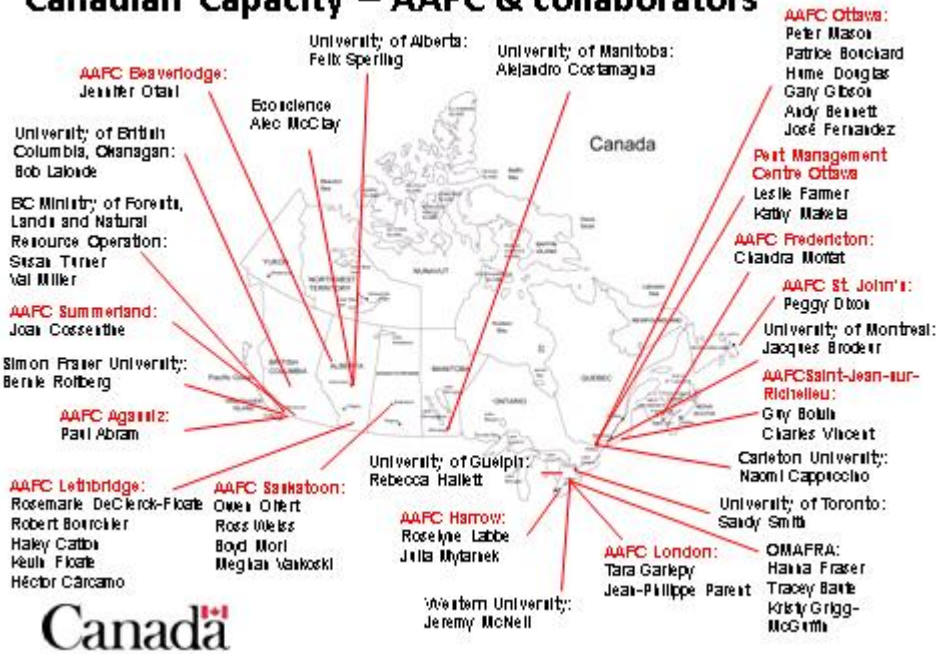
Assessing feasibility of biological control
- ➢ Field and literature surveys to look for possible biological control agents

Discovering potential biological control agents
- ➢ Field collections, setting up rearing colonies
- ➢ Determine the biology/life history of agents

Selecting and assessing suitable agents
- ➢ Host-specificity testing for safety
- ➢ Evaluate potential for damage

Canada

Canadian Capacity – AAFC & collaborators



Canada

Future directions (3-5 years)

Developing a 'Management Preparedness' strategy

Potential for biological control of high risk but not yet present IAS (e.g. peach fruit moth)

New biological control agents for important agricultural pests (existing and new IAS)

Diamondback moth, oriental fruit moth, brown marmorated stink bug, Japanese knotweed, toadflax, dog strangling vine

Innovations to improve risk assessment

Standardizing experimental designs, integrating molecular data into host range hypotheses, incorporating effects of changing climate into distribution models

Genomics Research and Development Initiative

Metagenomics Based Ecosystem Biomonitoring "EcoBiomics"

Tom Edge (ECCC) and James Macklin (AAFC)

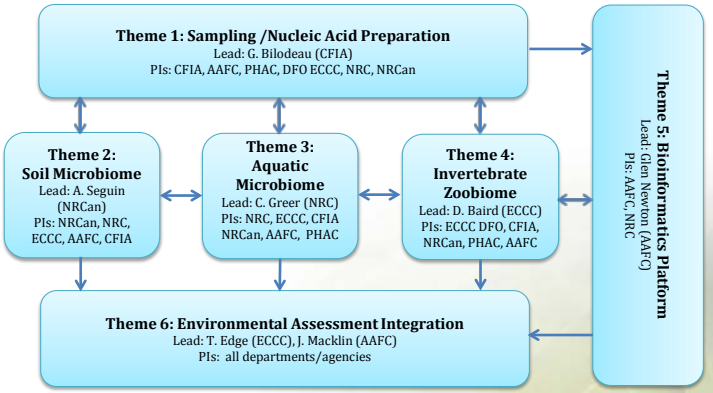
2 M$/year (2016-2019…2021)

EcoBiomics Project Objectives

- Develop standard soil and water methods and a federal Bioinformatics Platform to harmonize analyses of metabarcoding, metagenomics and metatranscriptomics data across federal departments/agencies, and communicate results to Canadians
- Establish genomics observatories and comprehensive biodiversity baselines for assessing future changes to water and soil biodiversity at long-term environmental monitoring sites in Canada
- Develop new knowledge to improve water quality and soil health by comprehensively characterizing aquatic microbiomes, soil microbiomes, and invertebrate zoobiomes, and testing hypotheses to enhance environmental assessment, monitoring, and remediation activities

EcoBiomics Project Structure

Project Co-Leads: T. Edge (ECCC) and J. Macklin (AAFC) / Manager: M-A. Hamel (AAFC)



Example Disturbance - Nutrients / Eutrophication

- Widespread agreement that action must be taken to address growing problem of algae in ecosystems across Canada:
  - Great Lakes, St. Lawrence, Lake Winnipeg, Lake Simcoe, Lake of the Woods
- Nutrients from fertilizers, sewage, fecal wastes, and land uses – multiple sources in aquatic and terrestrial ecosystems
- Canada-wide socio-economic impacts
- Impaired water and terrestrial resources
- Cumulative effects with other stressors
- Application of new genomics perspective and tools to enduring problem/questions


Algae's lake effect reveals putrid, pea green disaster

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Canada

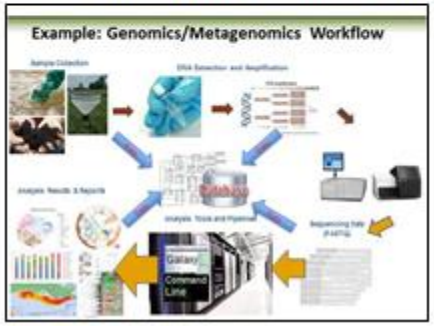
Data Mobilization of AAFC Biological Collections (BioMob)

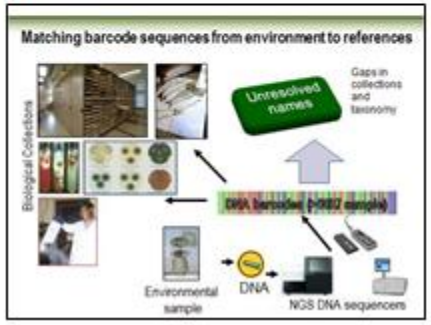
Collection Data Capture and Imaging

- **Mass data capture and imaging for the two large AAFC collections**
- **Imaging and data capture of other AAFC collections**
- **Survey collections**

Collection Molecular Characterization

- **DNA Barcoding:** Barcode reference sequences for regulated pests and their close relatives and other agriculturally significant targets;
- **Development of Next Generation Sequencing (NGS) techniques**: further develop and test protocols to sequence partial or full genomes from specimen and live collections.
- **Complete and partial genomes**: Use high throughput NGS to sequence partial and complete genomes from specimen and live microbial collections respectively.
- **Genotyping of Plant and Animal Genetic Resources**: genetic characterization of material from gene banks and specimens in collections.





Data Integration and Information Sharing

- **Data Capture:** specialized software development to communicate between digitization equipment and the collection management system(s);
- **Laboratory Information Management System:** improve current system to have full traceability of samples through DNA barcoding, NGS protocols and DNA sequence/genotyping data;
- **Collection Management System:** developing a new centralized collection management system and support migration into the new system, including the integration of PGRC and CAGR genetic data;
- **Data Quality:** clean and standardize for potential open release externally (Open Data and Open Science).
- **Geo-referencing legacy information** so that it can be mapped and used in modeling applications.
- **Data Publishing:** all captured data to be made openly available via appropriate outlets and an expanded collection portal;
- **Knowledge Products:** integrate data into knowledge products including interactive keys, models and e-resources (eg. Brassicaceae of Canada)