

25 April 2017

Precision Infrastructure for Climate Change mitigation and adaptation on the agricultural landscape

Hank Venema AIC 2017 Winnipeg



THE UNIVERSITY OF
WINNIPEG



Precision Agriculture versus Precision Infrastructure



Big data comes to farm

US farms generate **\$375 billion** from crops.

Almost all new farm equipment is equipped with sensors.

60% of farmers report using some sort of precision data.

80% of data now stays on tractors.

Farmers choose whether to use data themselves, share it locally or upload it to the cloud.

Farmers say data analytics have reduced input costs by **15%**; crop yields up by **13%**.

Source: American Farm Bureau Federation

Precision Infrastructure

Designing Advanced and Resilient Infrastructure: Big Spatial Data “CyberGIS”

GeoJournal (2016) 81:965–968
DOI 10.1007/s10708-016-9740-0



CyberGIS and spatial data science

Shaowen Wang

INTERNATIONAL JOURNAL OF GEOGRAPHICAL INFORMATION SCIENCE, 2016
VOL. 30, NO. 3, 427–431
<http://dx.doi.org/10.1080/13658816.2015.1112906>



EDITORIAL

Cyberinfrastructure, GIS, and spatial optimization: opportunities and challenges

INTERNATIONAL JOURNAL OF URBAN SCIENCES, 2016
<http://dx.doi.org/10.1080/12265934.2016.1233075>



Complexity in future cities: the rise of networked infrastructure

Sybil Derrible

Complex and Sustainable Urban Networks (CSUN) Laboratory, University of Illinois at Chicago, Chicago, IL, USA

Journal of Cleaner Production 117 (2016) 73–88

Contents lists available at ScienceDirect

Journal of Cleaner Production

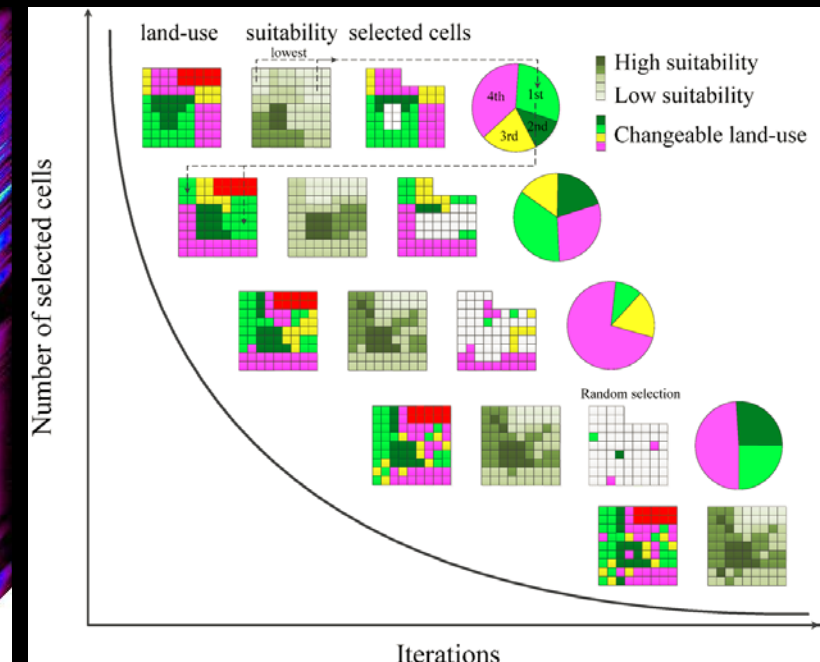
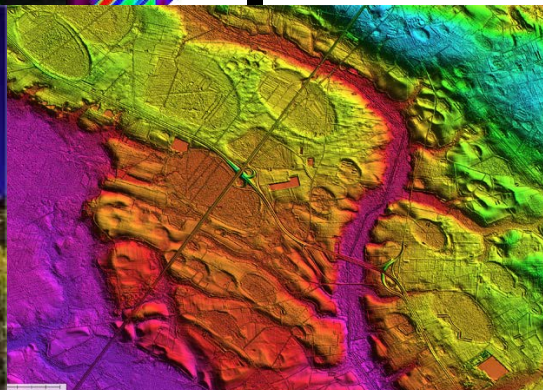
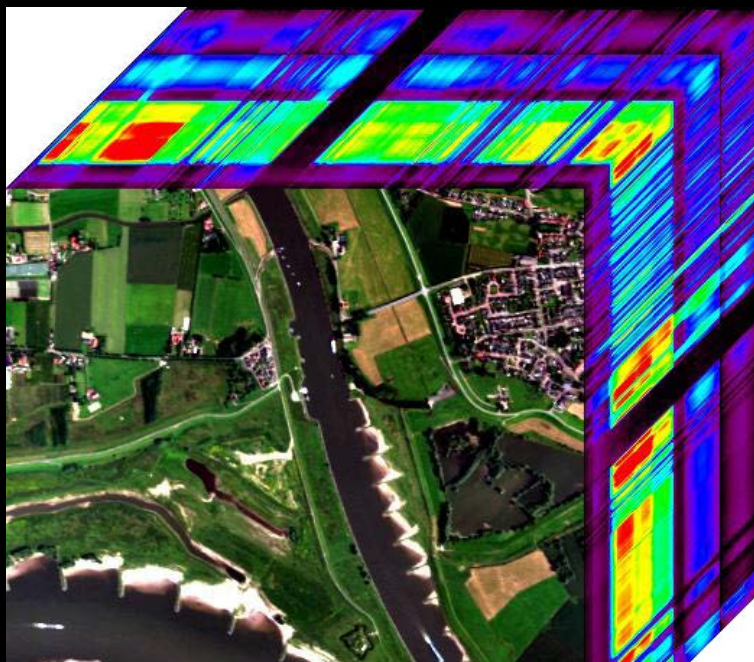
journal homepage: www.elsevier.com/locate/jclepro



The energy–water agriculture nexus: the past, present and future of holistic resource management via remote sensing technologies

Kelly T. Sanders*, Sami F. Masri

Sami Masri Department of Civil and Environmental Engineering, University of Southern California, 3620 S. Vermont Avenue, Los Angeles, CA 90089-2531, USA



PAN-CANADIAN FRAMEWORK



on Clean Growth and Climate Change

Canada's Plan to Address Climate
Change and Grow the Economy

Text analysis:

“resilience” 33x,

“resilient” 16x,

“agriculture” 18x

“water” 6x, and

“infrastructure”

83x!

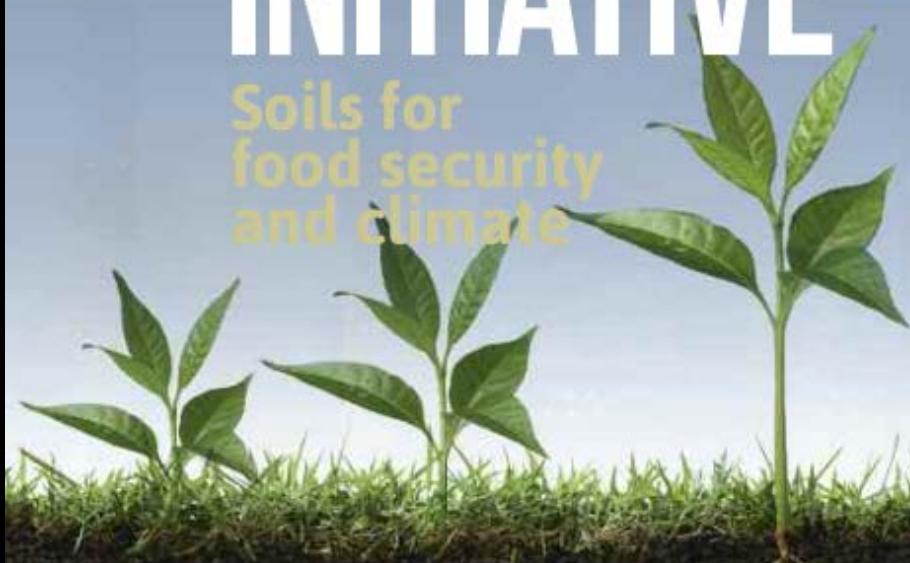
from foreword:

It means more resilient infrastructure and ecosystems that can better withstand climatic changes. It means land use and conservation measures that sequester carbon and foster adaptation to climate change. It means new jobs for Canadians...will allow us to become a leader in the global clean growth economy and will also help bring down the cost of low-emission technologies.

Global Motivation: Agriculture as crucial climate solution space

4 PER 1000 INITIATIVE

Soils for food security and climate

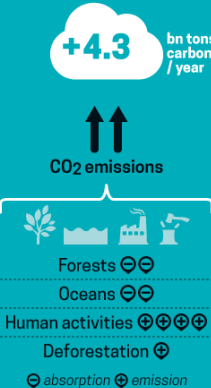


Building on solid, scientific documentation and concrete actions on the ground, the "4 per 1000 Initiative: soils for food security and climate" aims to show that **food security and combating climate change are mutually complementary** and to ensure that agriculture is a source of solutions. This initiative consists of a voluntary action plan under the **Global Climate Action Agenda (GCAA)**, backed by an ambitious research program

Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt

4 PER 1000 CARBON SEQUESTRATION IN SOILS FOR FOOD SECURITY AND THE CLIMATE

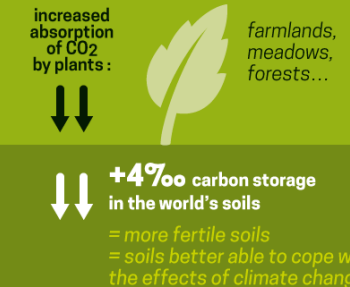
The quantity of carbon contained in the **atmosphere** increases by **4.3 billion tons** every year



The world's **soils** contain **1 500 billion tons** of carbon in the form of organic material



If we **increase by 4‰ (0.4%)** a year the quantity of carbon contained in soils, **we can halt the annual increase in CO2 in the atmosphere**, which is a major contributor to the greenhouse effect and climate change



HOW CAN SOILS STORE MORE CARBON?

The more soil is covered, the richer it will be in organic material and therefore in carbon. Until now, the combat against global warming has largely focused on the protection and restoration of forests. In addition to forests, we must encourage more plant cover in all its forms.

- Never leave soil bare and work it less, for example by using no-till methods
- Introduce more intermediate crops, more row intercropping and more grass strips
- Add to the hedges at field boundaries and develop agroforestry
- Optimize pasture management – with longer grazing periods, for example
- Restore land in poor condition e.g. the world's arid and semi-arid regions

"This international initiative can reconcile the aims of **food security** and the **combat against climate change**, and therefore engage every concerned country in COP21."

Stéphane Le Foll, French Minister of Agriculture, Agrifood and Forestry

Global Motivation “need to invest heavily in resilient infrastructure”



Carlo Koch-Weser
Chair
European Climate Foundation
EU Commissioner, New Climate Economy
Former Vice Chairman of Deutsche Bank
and German Deputy Minister of Finance



Michael Liebreich
Founder and Chairman of the Advisory
Board
Bloomberg New Energy Finance (BNEF)



Jouko Ahtvenainen
Chairman & Co-
Founder
Crowd Valley Inc.



Subhi Alsayed
Vice President,
Sustainable
Development
Mott MacDonald



Amal-Lee Amin
Deputy Chief
Sustainable
Development
Inter-American
Development Bank



Bruce Anderson
Managing Director,
Project Finance and
Infrastructure
Manulife Financial



**The Honourable
Navdeep Singh Bains**
Minister of Innovation,
Science and
Economic
Development
Government of
Canada



Sarah Baker
Head of North
American Strategic
Engagement
London Stock
Exchange Group



Renée Beaumont
Partner
Generation
Investment
Management



John M. Beck
President & CEO
Aecon Group Inc.



Andrew Bowerbank
Global Director,
Sustainable Building
Services
EllieDon Corporation



Emma Howard Boyd
Chair & Vice-Chair
Environment Agency
North & Future Cities
Catapult



Jessica Butts
Director
Dalphi Group



Glenn Campbell
Executive Director,
Public Infrastructure
and Transportation
Infrastructure Canada

2017 Federal Budget - Green infrastructure Highlights

- **\$2.8 billion** directly on new green infrastructure over the next 11 years. Much more money for green infrastructure projects will be made available indirectly.
- **The federal government will transfer \$9.2 billion** over 11 years to the provinces for green infrastructure and a
- **further \$20.1 billion** over 11 years for public transit infrastructure.
- **The new Canada Infrastructure Bank will invest at least \$35 billion** of federal money over 11 years, of which \$5 billion is allocated to green infrastructure and an additional \$5 billion is allocated specifically to public transit infrastructure.

ers will
accelerate
sform our

ies will need to invest heavily
pside is huge: Necessary

s of investment necessary to
n and new pools of capital to
ent risk and enhancing

Hypothesis:

Agriculture is not at the table on Green

Infrastructure – dangerous omission as agriculture lies at the heart of a large class of climate solutions

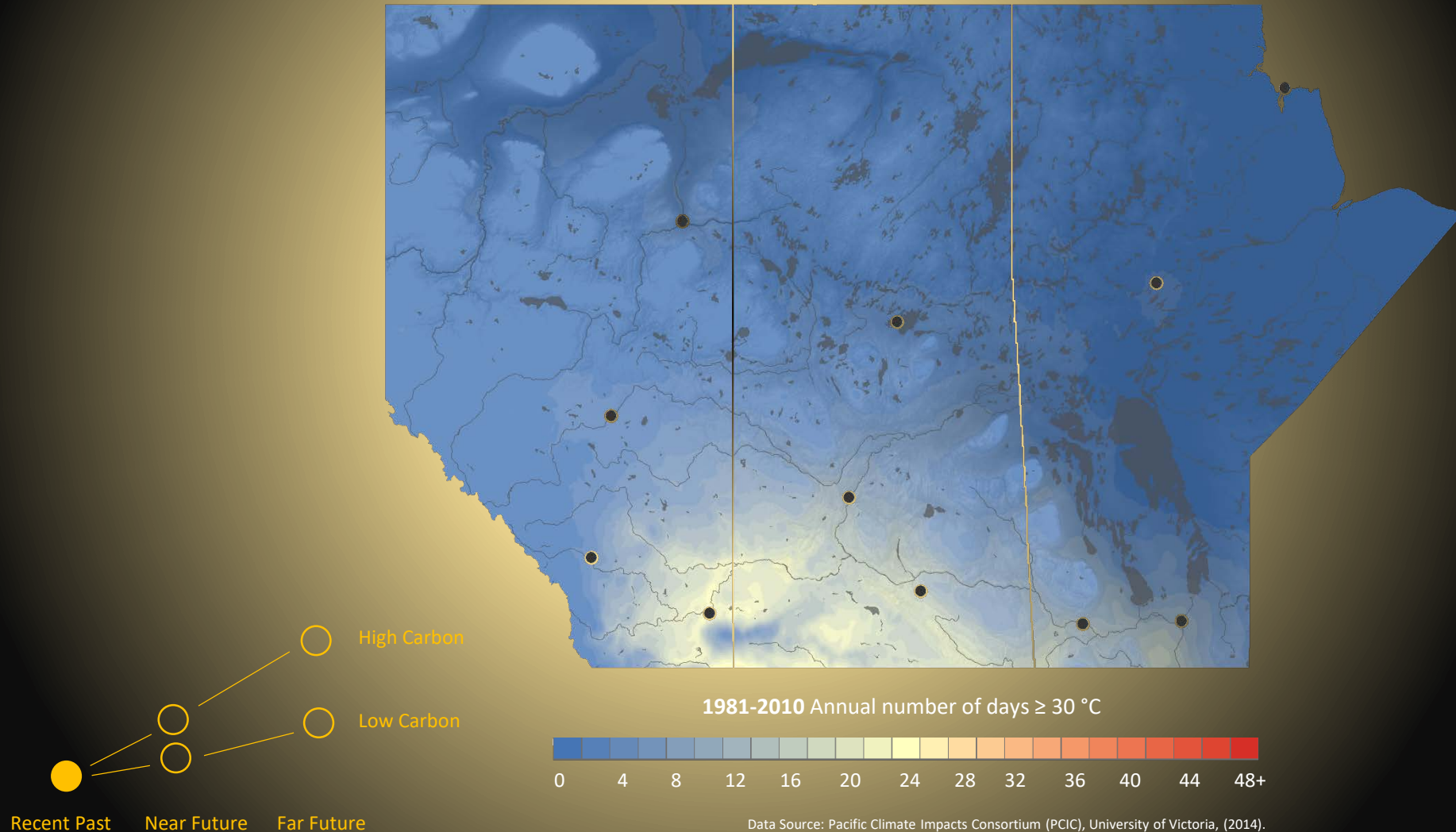


Regional Context:
Highlights from
[www.climateatlas.](http://www.climateatlas.ca)
[ca](http://www.climateatlas.ca)



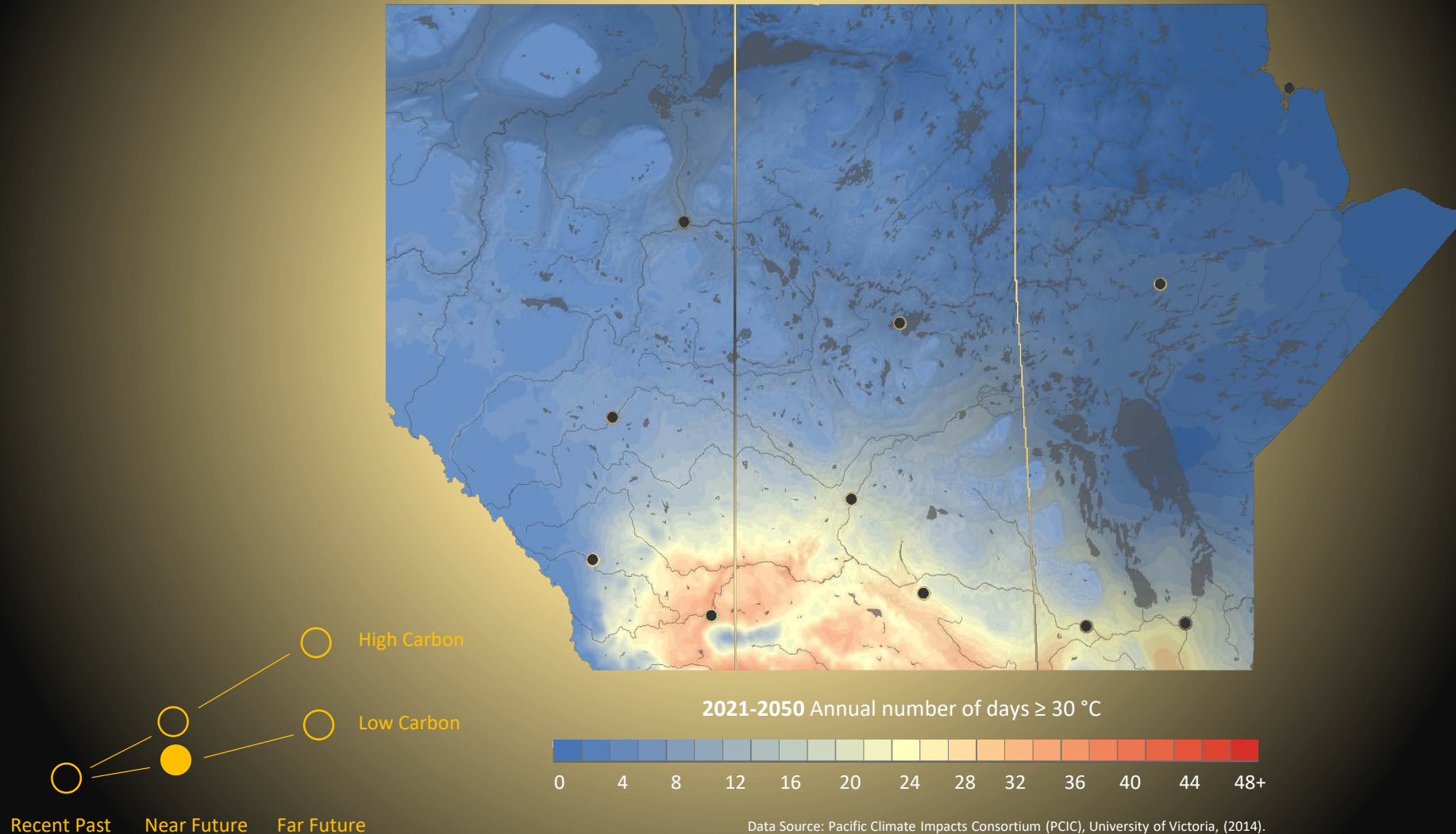
Shifting Extremes

Change in the Number of Very Hot Days



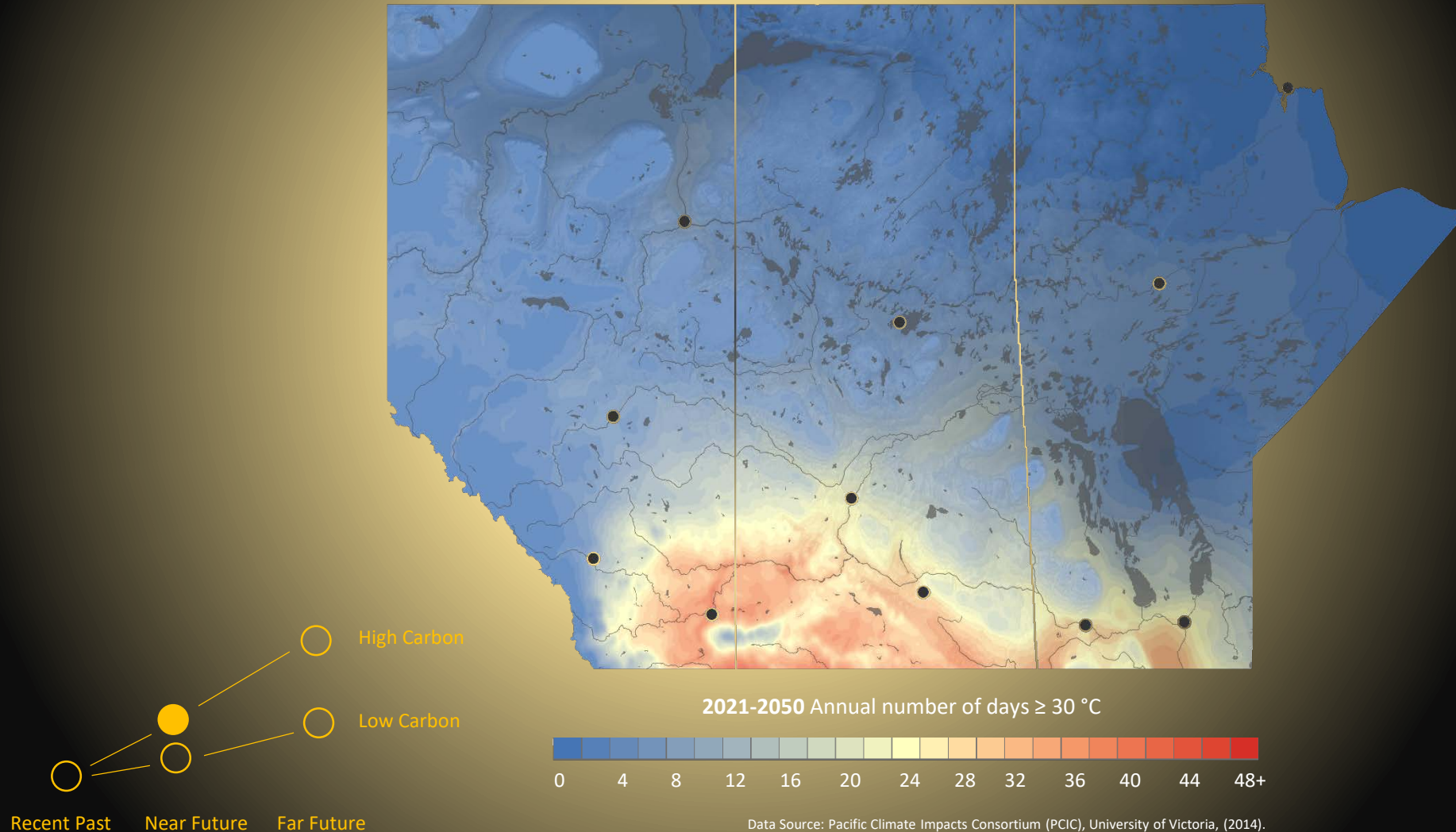
Shifting Extremes

Change in the Number of Very Hot Days



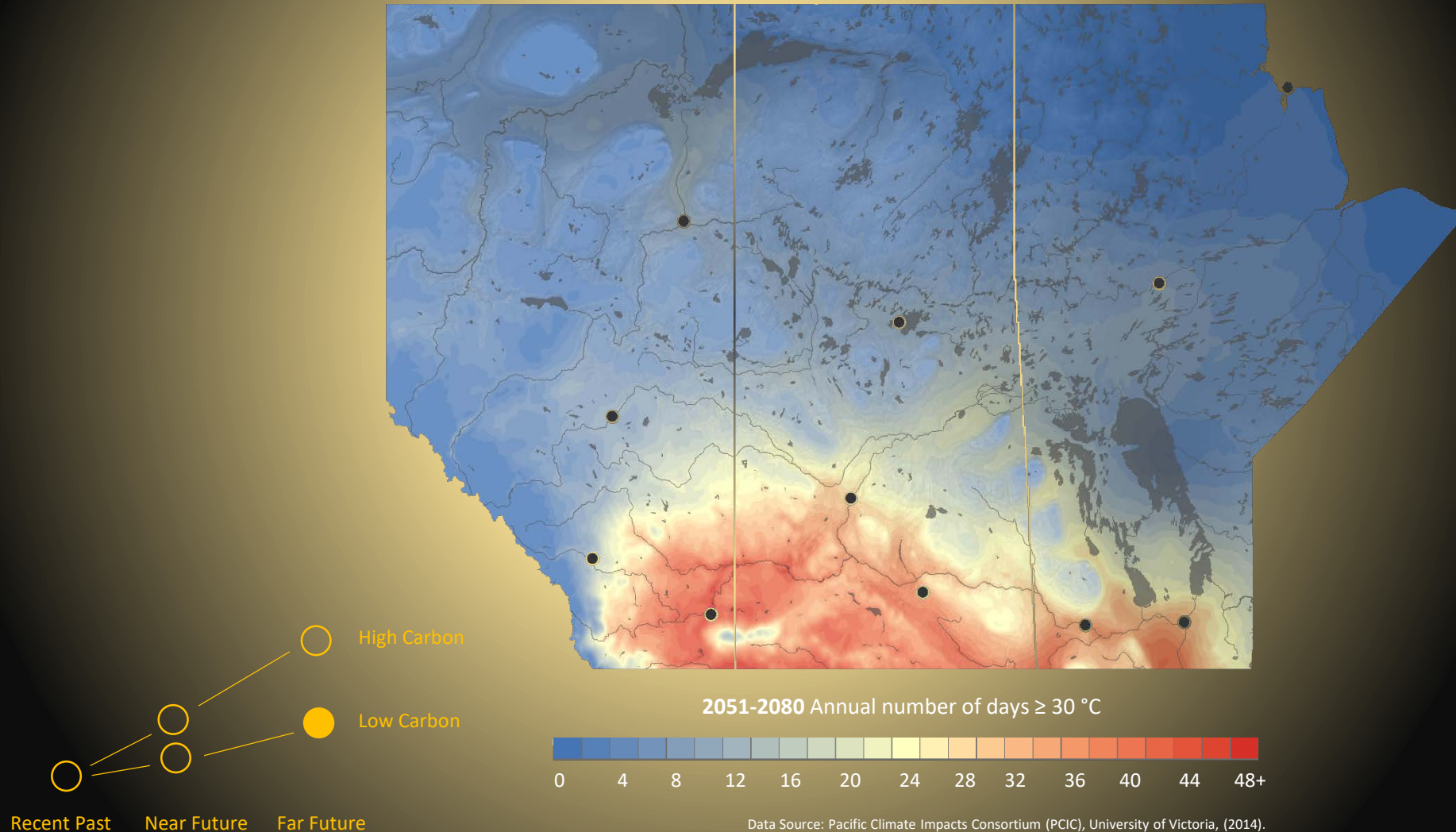
Shifting Extremes

Change in the Number of Very Hot Days



Shifting Extremes

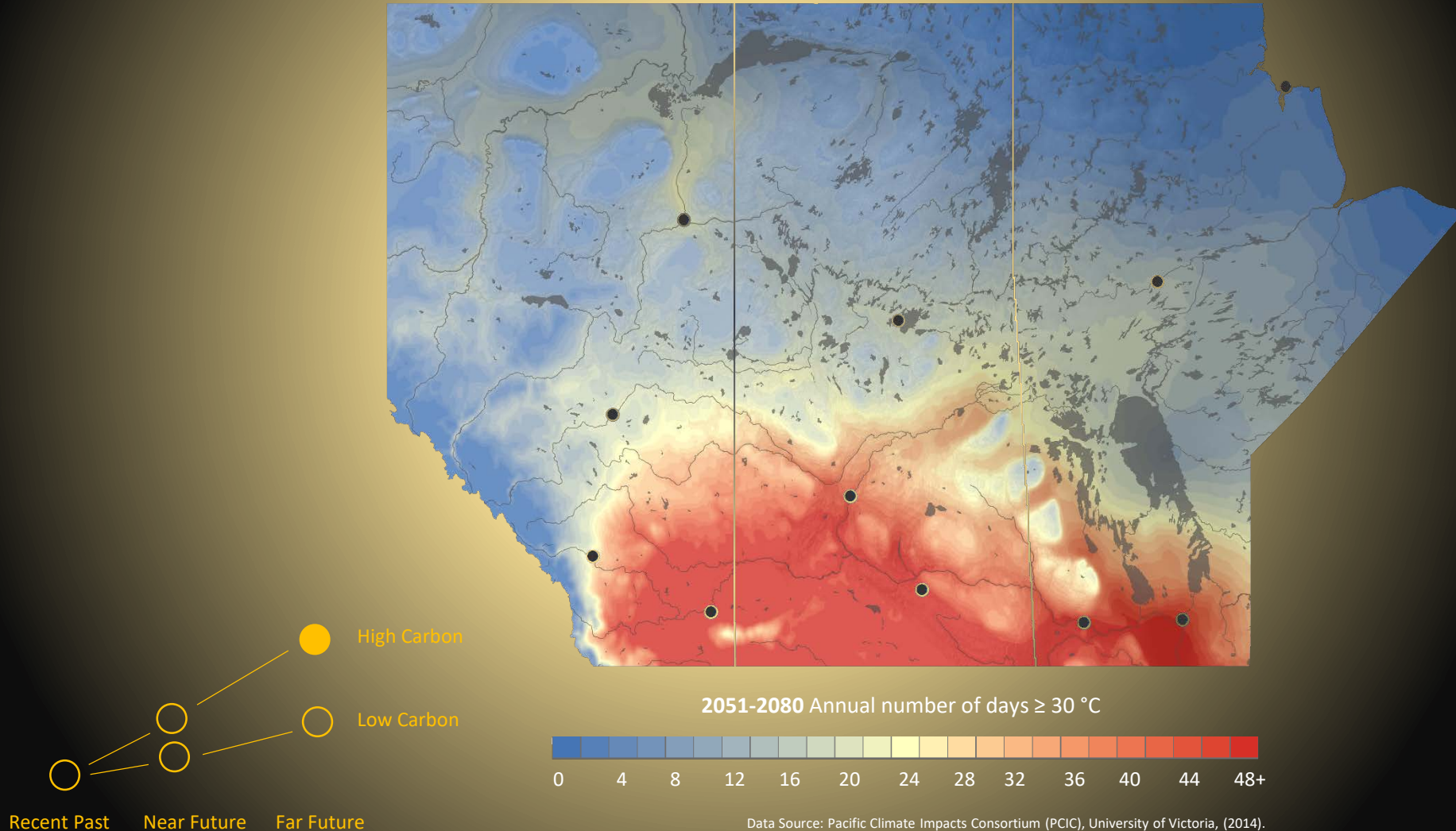
Change in the Number of Very Hot Days



Data Source: Pacific Climate Impacts Consortium (PCIC), University of Victoria, (2014).
Statistically Downscaled Climate Scenarios. Downloaded from pacificclimate.org.

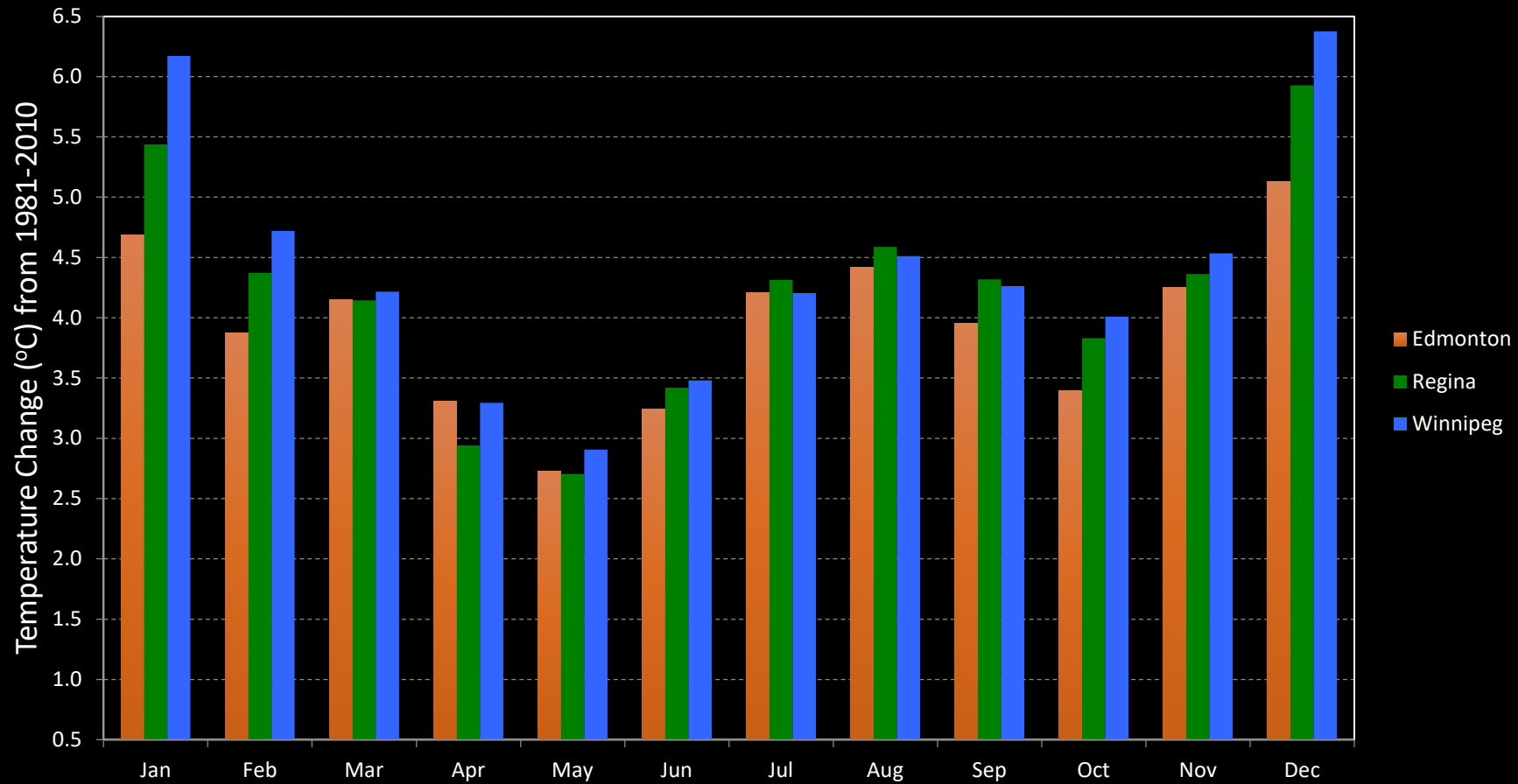
Shifting Extremes

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Statistically Downscaled Climate Scenarios. Downloaded from pacificclimate.org.

2051-2080 ΔT : RCP8.5

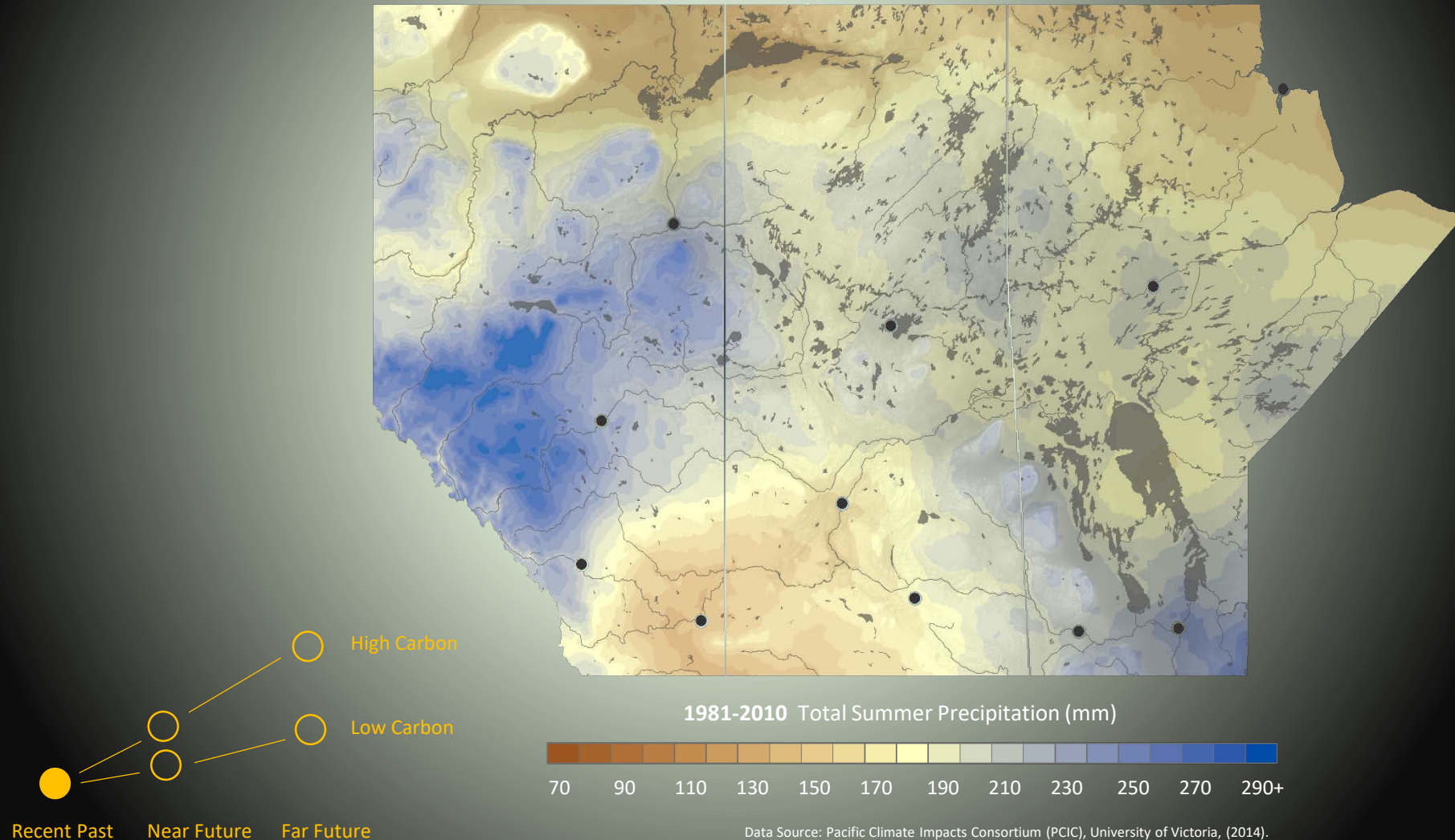


Summer Precipitation



Prairie Precipitation

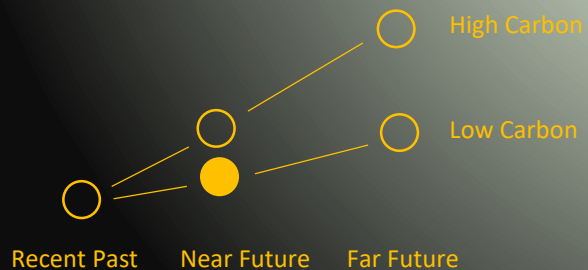
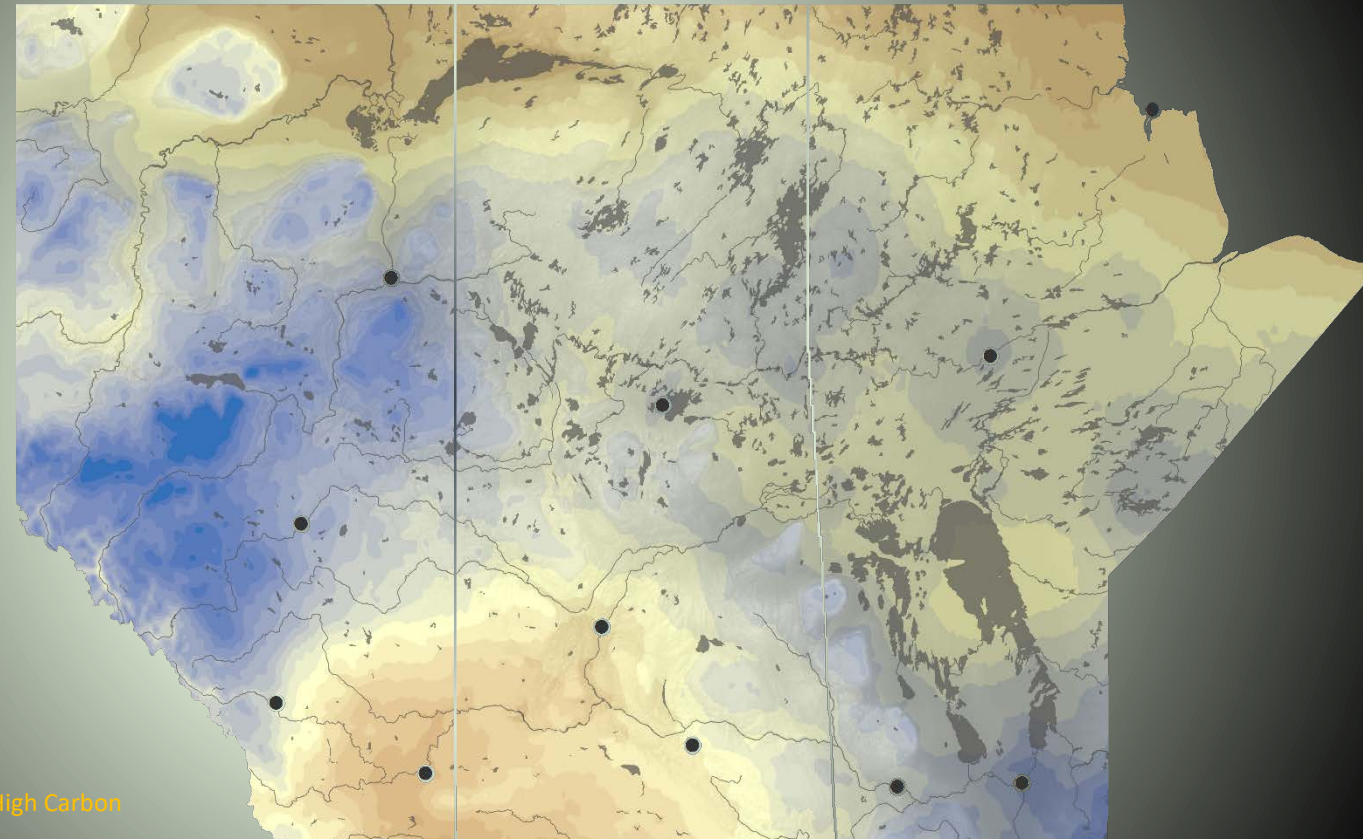
Projected Changes in Total Summer Precipitation



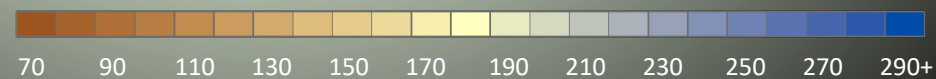
Data Source: Pacific Climate Impacts Consortium (PCIC), University of Victoria, (2014).
Statistically Downscaled Climate Scenarios. Downloaded from pacificclimate.org.

Prairie Precipitation

Projected Changes in Total Summer Precipitation



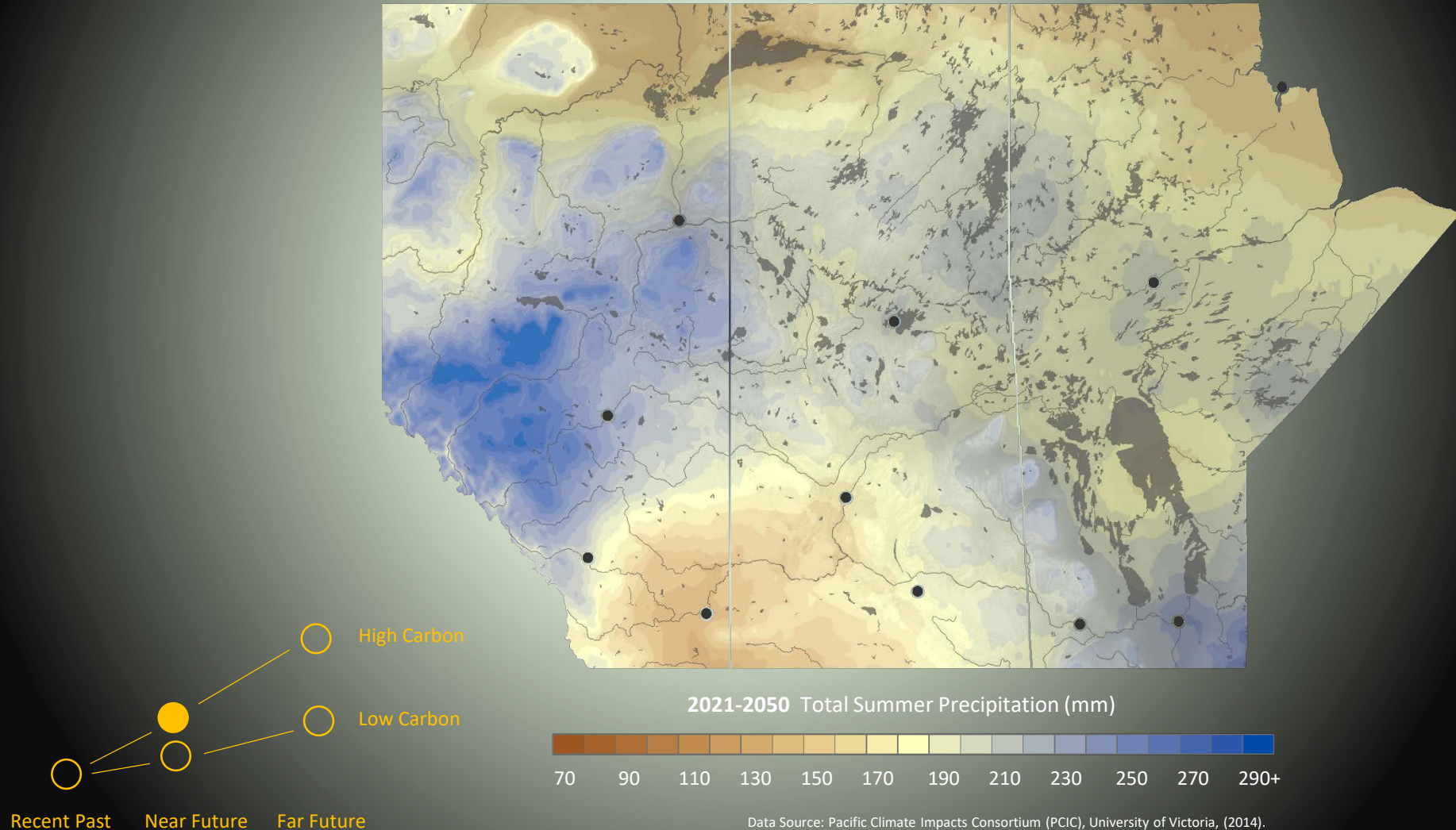
2021-2050 Total Summer Precipitation (mm)



Data Source: Pacific Climate Impacts Consortium (PCIC), University of Victoria, (2014).
Statistically Downscaled Climate Scenarios. Downloaded from pacificclimate.org.

Prairie Precipitation

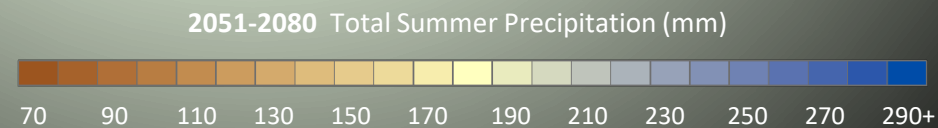
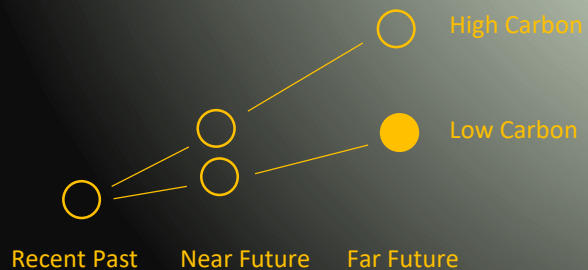
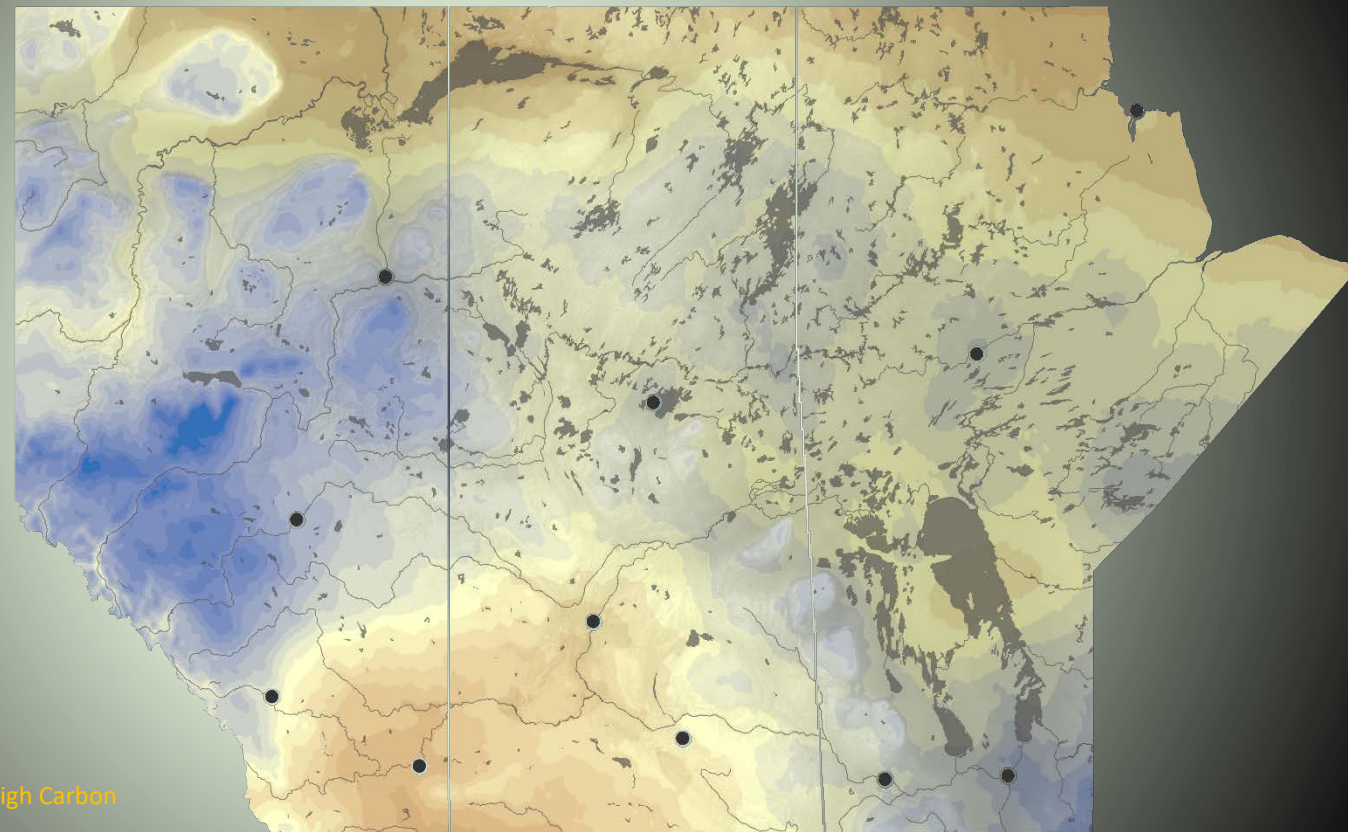
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Prairie Precipitation

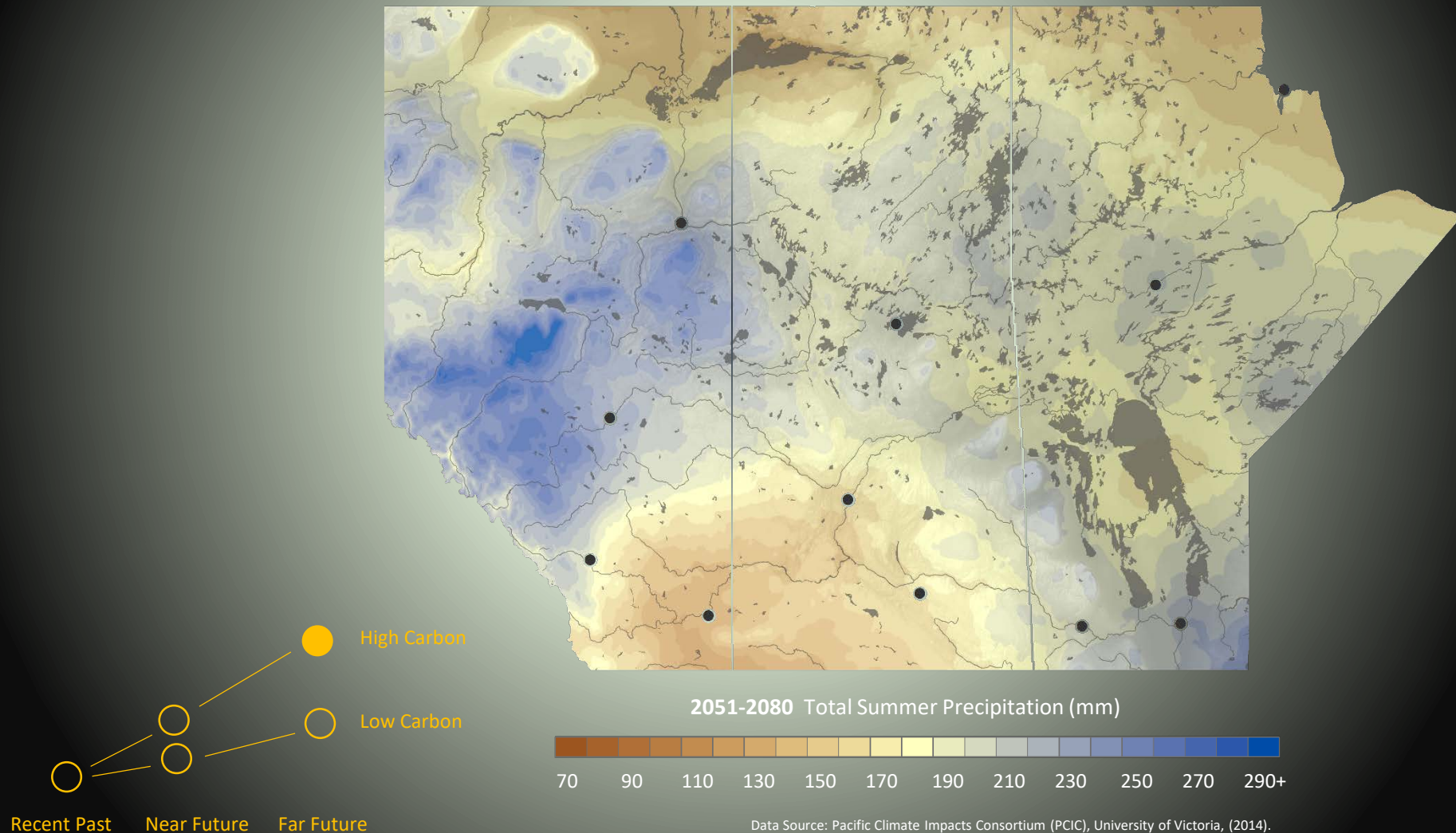
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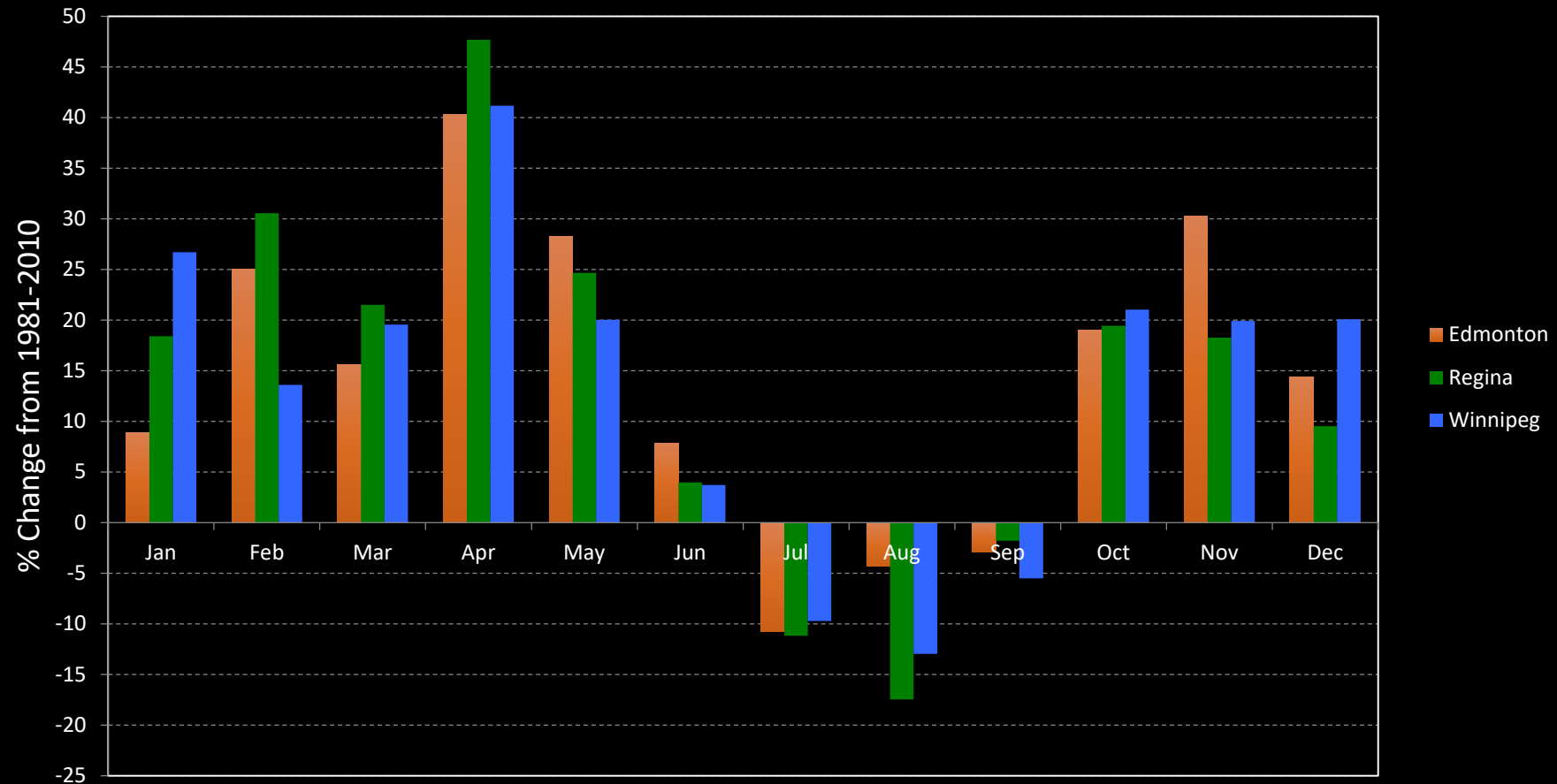
Prairie Precipitation

Projected Changes in Total Summer Precipitation



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2051-2080 Δ PPT: RCP8.5



Agricultural Water Management: Lessons from 2011

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Canada Manitoba Photo Galleries

Flood, drought, hits Manitoba

CBC News Posted: Aug 25, 2011 12:21 PM CT | Last Updated: Aug 25, 2011 12:21 PM CT

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Manitoba farmers are echoing this week's forecast which predicts a drop in annual grain production. Doug Chorney, president of Keystone Agriculture, said that 2011 and June were extremely wet in Manitoba, but the year has also been extremely dry.

He said while those who planted crops in 2011 have had a difficult time, it has not been an economic nightmare for producers because of flooded fields.

"There's weeds that are getting to be the real management issue for getting that crop in," Chorney said. "So, not having a crop production insurance because you don't have a crop production insurance is a tough season for those farmers."



THE GLOBE AND MAIL

Q Enter a term, stock symbol or company name

Investing Sports Life Arts Te

Manitoba Alberta Toronto World Video

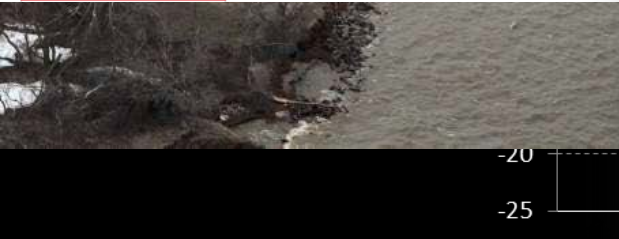
.../week for the first 4 weeks

...age for Manitoba farmers

in A A Print License article

...ring that Manitoba was confronted with one of the worst ...al history. A record one-third of cropland was too flooded

...ble reversal, some of the crops that were seeded are ...rts of the province have gone two months with almost no ...icane rains lashed the east coast, the centre reaches of ...ling against a drought, reflecting conditions in places such ...having a dry spell so bad it's earned comparisons to the



The solution: US example

North Ottawa project <http://www.bdswd.com/>



Prairie
Climate Centre



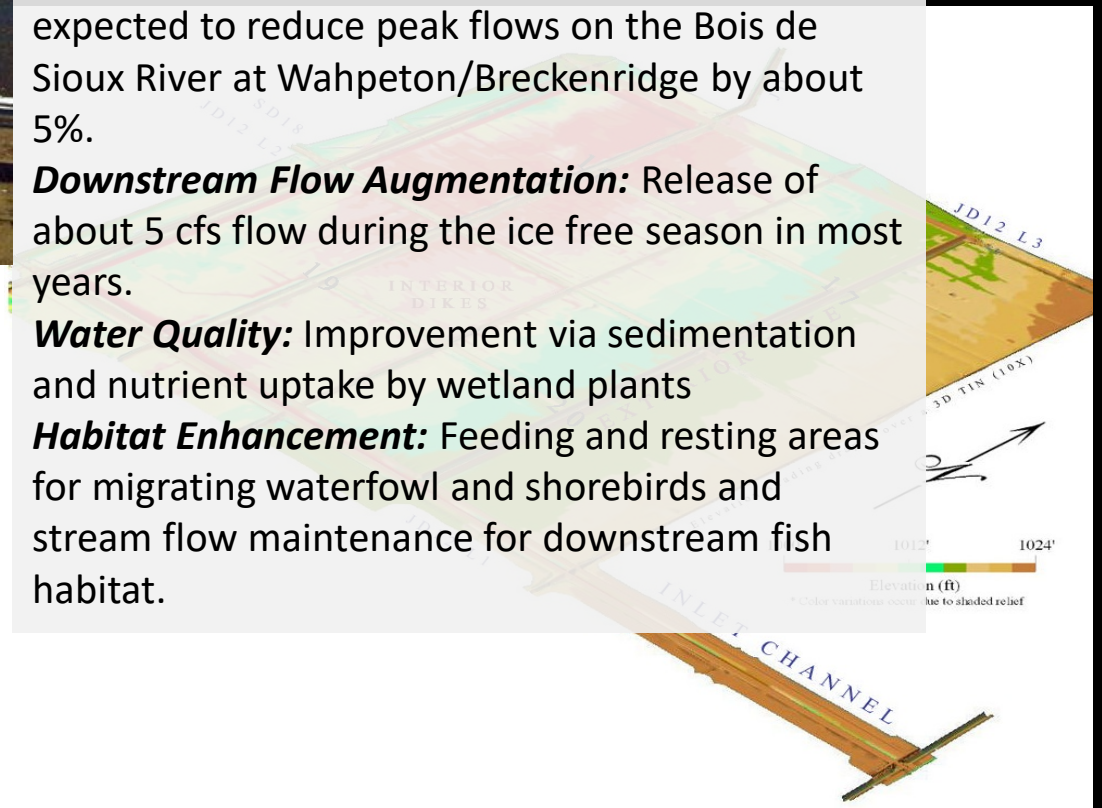
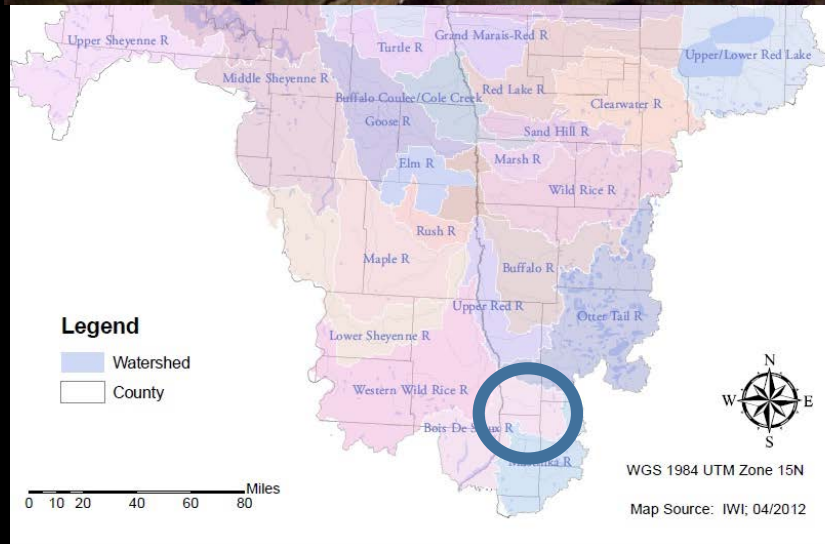
Project Benefits:

Flood Damage Reduction (Primary objective): Provides 16,000 acre feet of gate-controlled storage which is equivalent to 75% of the estimated 100 year spring runoff. This is expected to reduce peak flows on the Bois de Sioux River at Wahpeton/Breckenridge by about 5%.

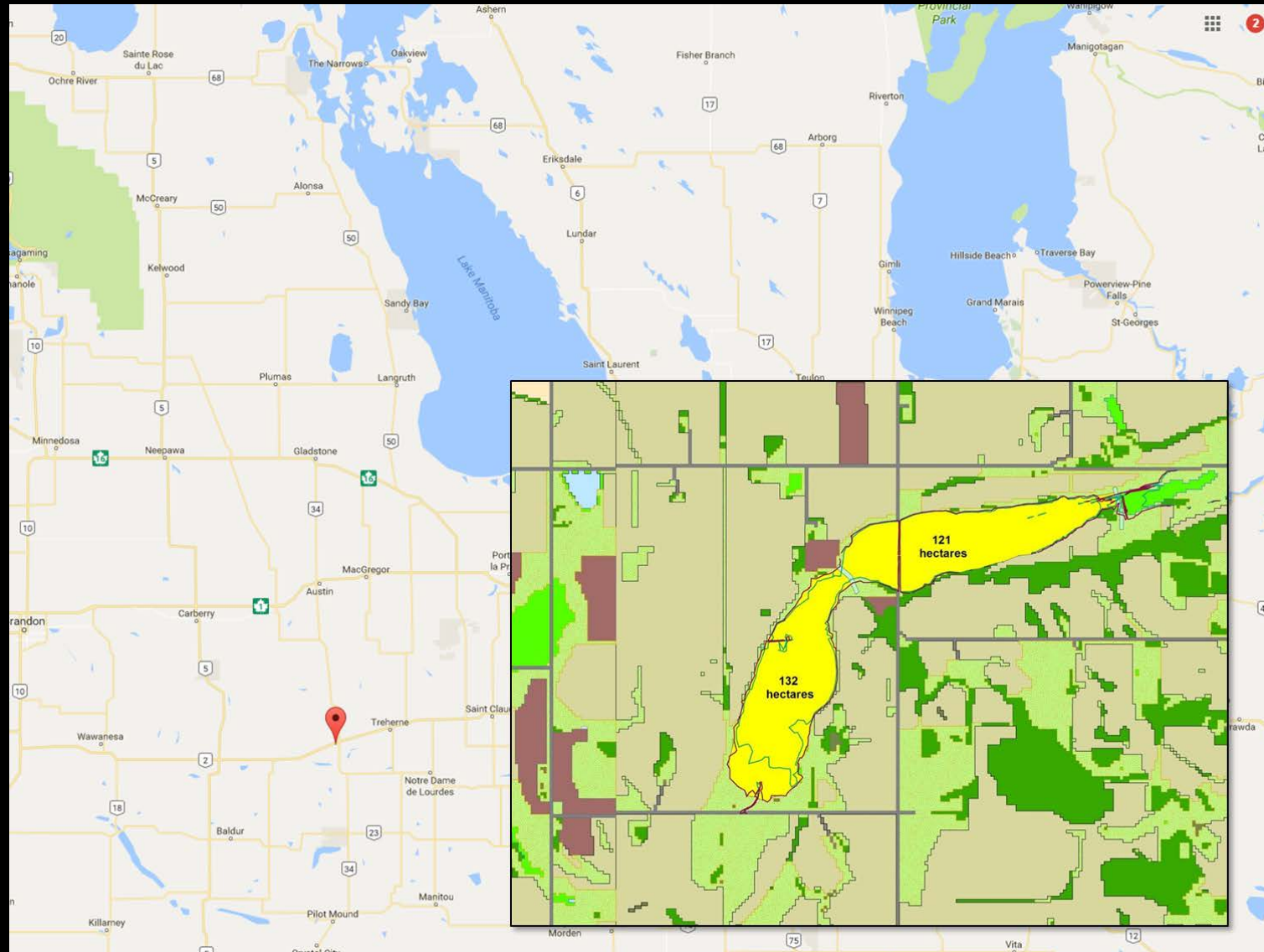
Downstream Flow Augmentation: Release of about 5 cfs flow during the ice free season in most years.

Water Quality: Improvement via sedimentation and nutrient uptake by wetland plants

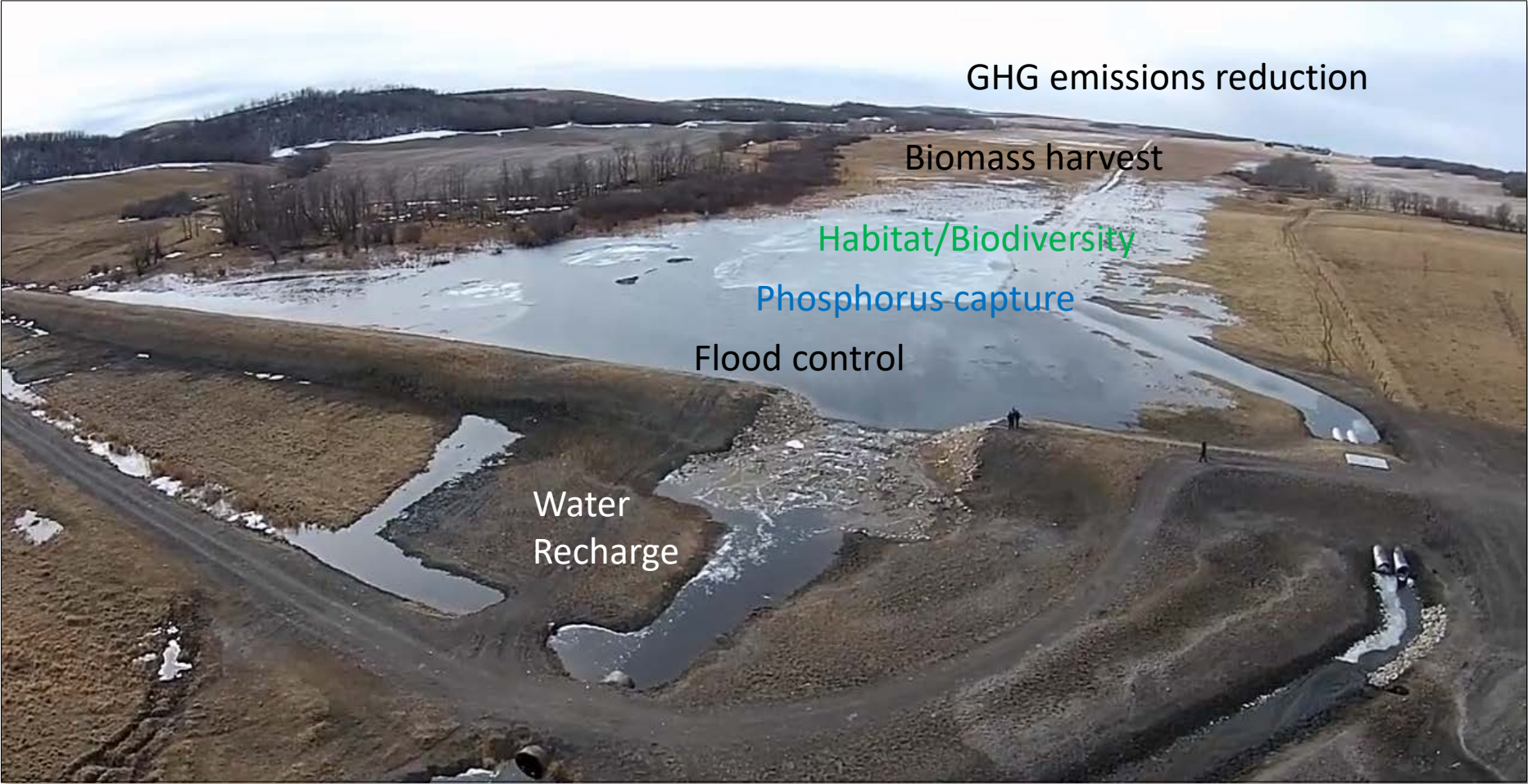
Habitat Enhancement: Feeding and resting areas for migrating waterfowl and shorebirds and stream flow maintenance for downstream fish habitat.



The solution: MB example Prairie Climate Centre



Stacked Benefits of Surface Water Retention: *Not just for flood management*



Pelly's Lake water retention site - near Holland, Manitoba

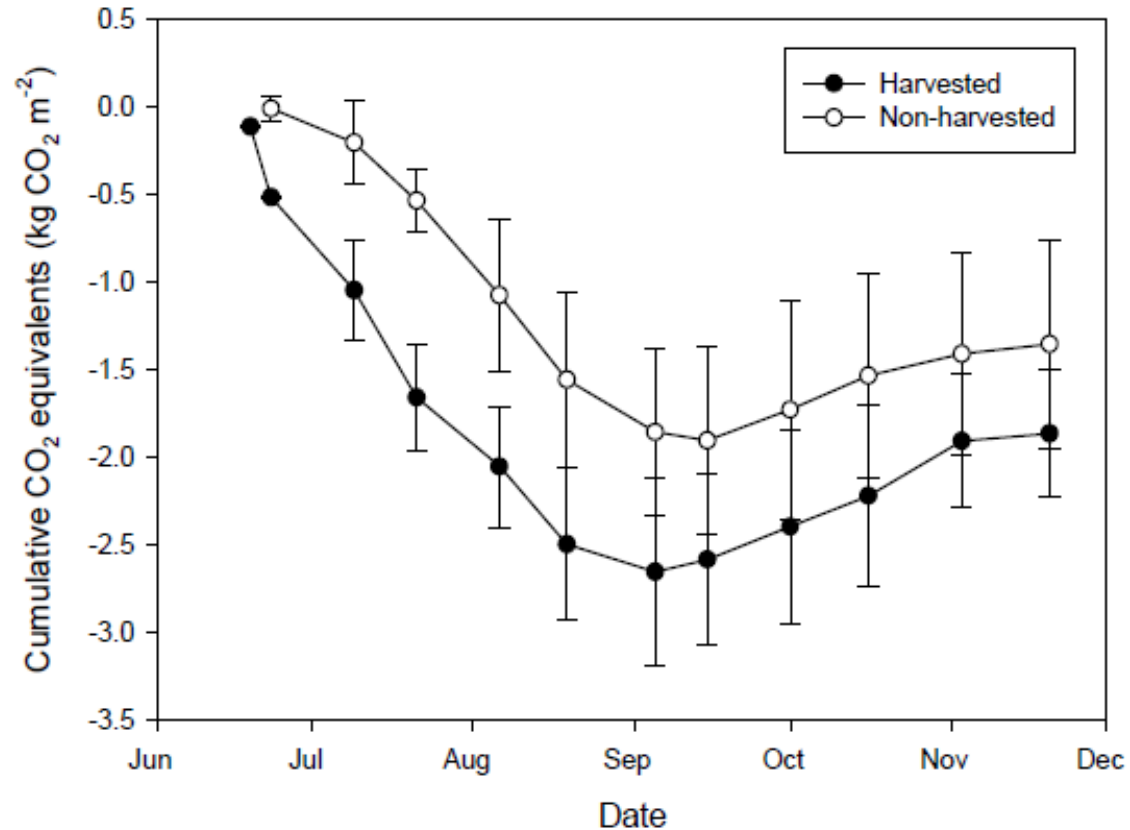
Pelly's Lake Fall 2015 Cattail Harvesting



Dries up in the fall (September) - suitable conditions for harvesting with conventional agricultural equipment



Reduction in GHG emissions

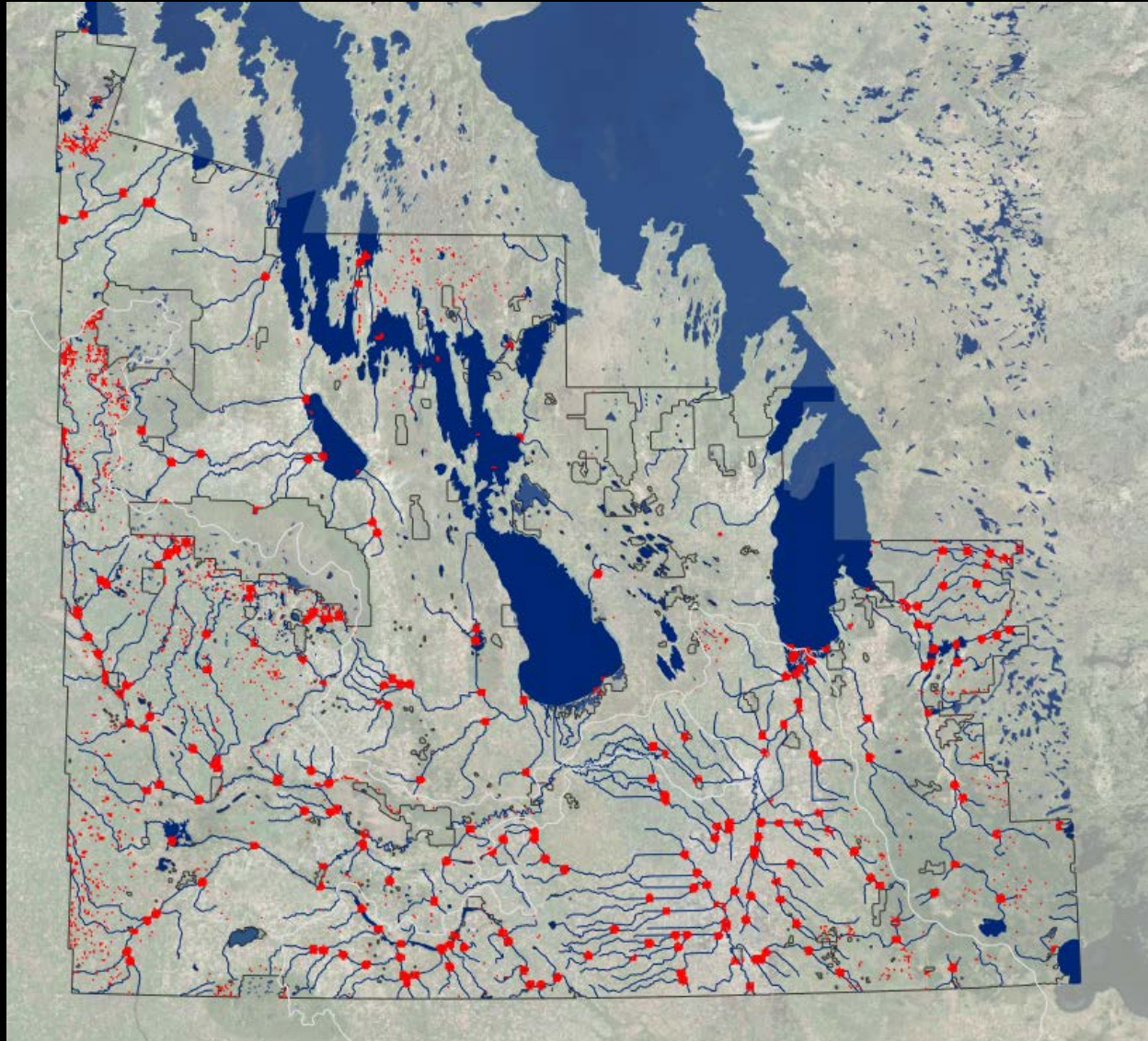


Cumulative greenhouse gas flux (CO₂ + CH₄ + N₂O, expressed as CO₂ equivalents; mean +/- SE) for harvested and non-harvested cattail plots in the Pelly's Lake retention area

The big picture

- *Boutique projects are necessary but insufficient*
- *Finance, Treasury, Feds can not deal with the granularity of high-performance adaptation projects*
- *Structural adaptation means aggregation and bundling for green bond issues.*
- *High performance computational platform for benefit aggregation, economic performance, visualization (and institutional gap analysis)*

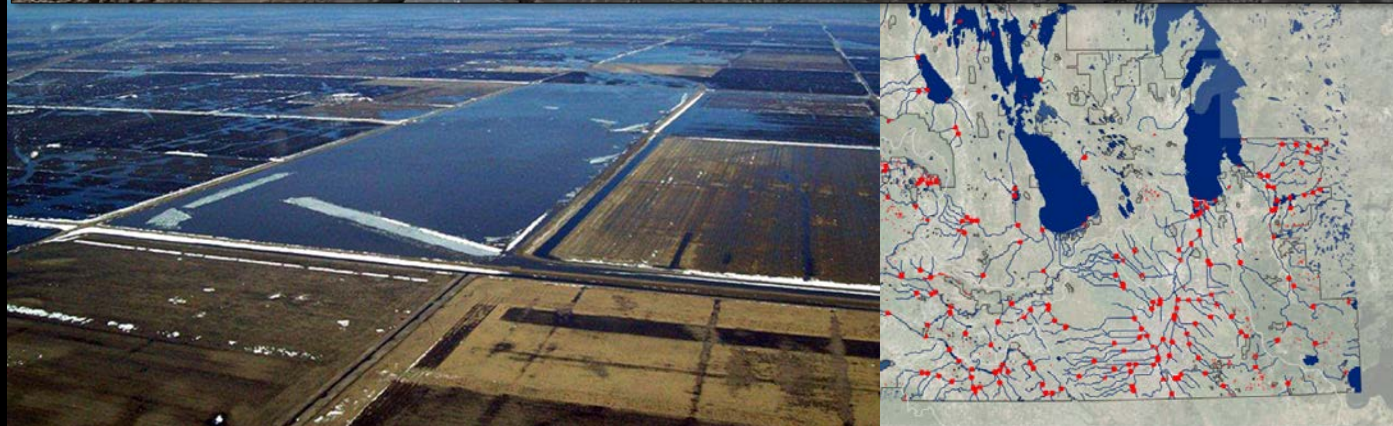
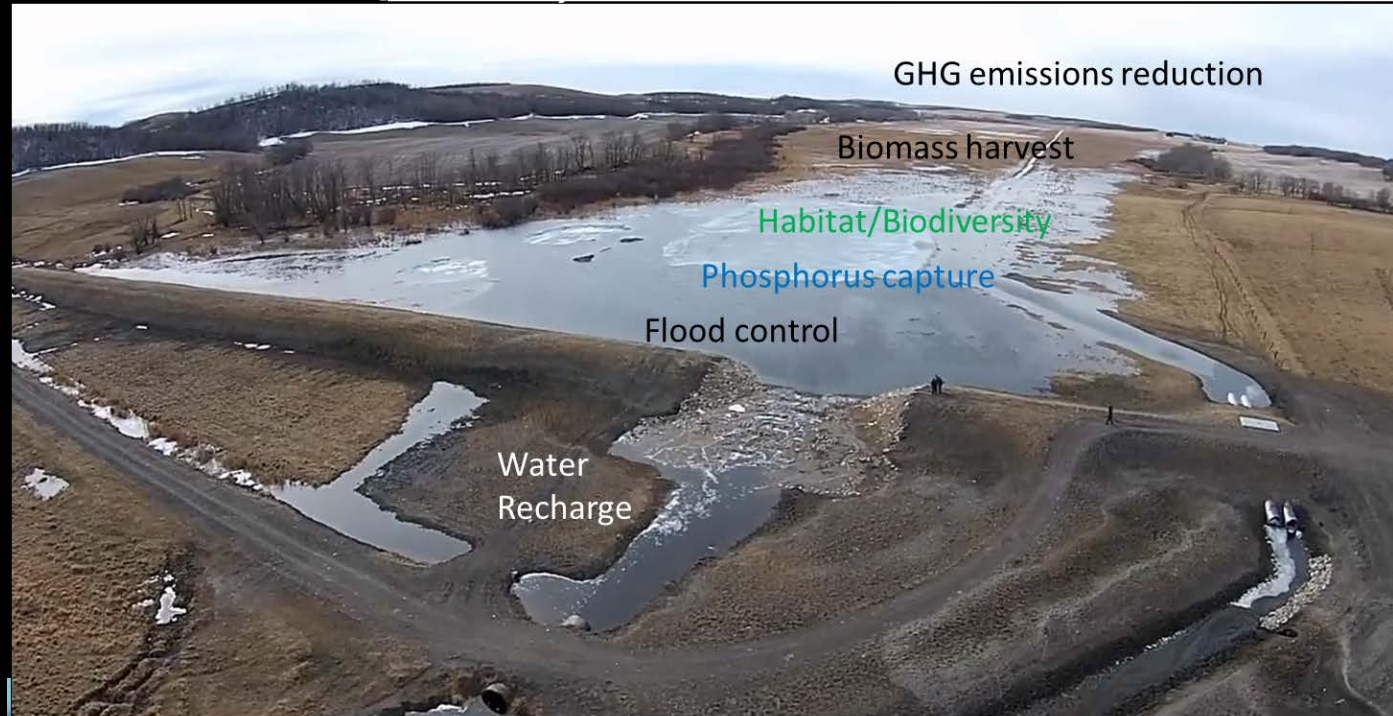
Aggregation and Systems Design Re-mosaicking the landscape



Key parameters:

- *Retention area*
 - = 4750 km²
 - = 1840 sections
 - = 3.4% of ag land base
- *Storage Volume @ 1m depth*
 - = 4.75 Gm³
 - = 3.85 M ac-ft
 - = 80.6% of 2011 flood
- *Biomass / Phosphorus @ 8t/ha*
 - = 3.8 Mt biomass
 - = 3.8 kt phosphorus
 - (100% of Lk Winnipeg policy target)

Aggregating Costs and Benefits (direct monetization and engineering substitution costs)



Cost

@ \$1000/acre-foot + \$400/acre + 50% contingency
= \$6.3 Billion

Co-Benefit Stack

Irrigation @ 10% of storage @ \$500 acre-ft
= \$192 Million/year

Biomass Production @ \$30/t
= \$114 M/year

GHG emissions reduction
Fuel Switch @ \$30/t CO₂e
= \$114 M/year

Sequestration @ \$30/t CO₂e @ 10t/ha
= \$142 M/year

Water Quality @ \$50/kg P
= \$190 Million/year

Flood Risk Reduction [omitted]

Drought Resiliency [omitted]

Habitat [omitted]

Co-Benefit Stack Total = \$753 M/year

Motivation – the \$64 trillion dollar question (actually \$90T)

nature
climate change

PERSPECTIVE

PUBLISHED ONLINE: 14 NOVEMBER 2016 | DOI: 10.1038/NCLIMATE3142

Nested barriers to low-carbon infrastructure investment

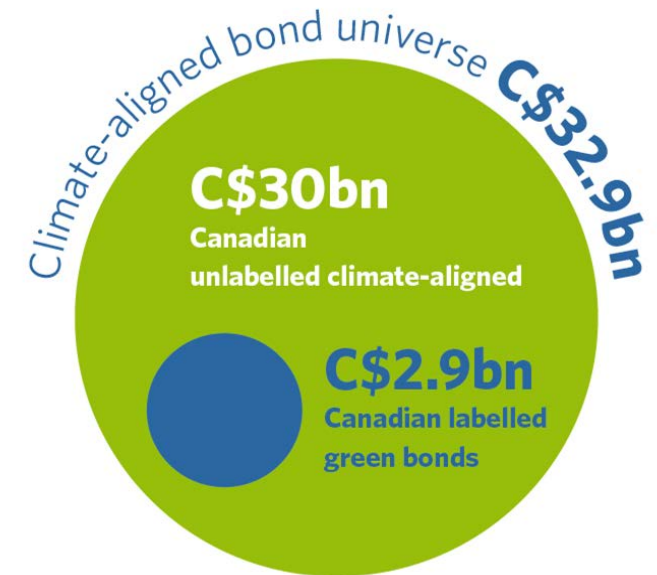
Ilmi Granoff^{1,2*}, J. Ryan Hogarth^{1,3*} and Alan Miller¹

Low-carbon, 'green' economic growth is necessary to simultaneously improve human welfare and avoid the worst impacts of climate change and environmental degradation. Infrastructure choices underpin both the growth and the carbon intensity of the economy. This Perspective explores the barriers to investing in low-carbon infrastructure and some of the policy levers available to overcome them. The barriers to decarbonizing infrastructure 'nest' within a set of barriers to infrastructure development more generally that cause spending on infrastructure—low-carbon or not—to fall more than 70% short of optimal levels. Developing countries face additional barriers such as currency and political risks that increase the investment gap. Low-carbon alternatives face further barriers, such as commercialization risk and financial and public institutions designed for different investment needs. While the broader barriers to infrastructure investment are discussed in other streams of literature, they are often disregarded in literature on renewable energy diffusion or climate finance, which tends to focus narrowly on the project costs of low- versus high-carbon options. We discuss how to overcome the barriers specific to low-carbon infrastructure within the context of the broader infrastructure gap.

Climate Bonds INITIATIVE



Climate
Bond
Certified



Recent climate-aligned bonds in Canada

DATE	ISSUER	SIZE	THEME	LABEL
October 2015	Dufferin Wind Power	C\$200m	Energy	Unlabelled project bond
December 2015	EDC	US\$300m	Multi-sector	Green Bond
January 2016	Ontario	C\$750m	Multi-sector	Green Bond
February 2016	CoPower	C\$300,000	Energy	Green Bond
February 2016	Canadian National Railway	US\$500m	Transport	Unlabelled corporate bond
March 2016	Hydro Quebec	C\$16.9m	Energy	Unlabelled corporate bond

The enablers

- (technical) LiDAR for proper geospatial and hydrodynamic modelling
- (technical) Hydro-climatic modelling (ECCC-MESH model)
- (technical) High performance computational platform for benefit aggregation, economic performance, watershed visualization
- (policy) hard commitment to climate leadership/green economy/cleantech and green value chain development
- (policy) institutional flexibility on carbon/water quality/biodiversity offsetting
- (policy) investment aggregation/leveraging: green infrastructure/P3
- (policy) institutional and governance innovation

The Prize: Deep Innovation

- Deep Driver for Economic Development and Growth
- Climate Resilience
- International Leadership in Precision Infrastructure design, implementation and management
- A new class of cyberinfrastructure technology crucial to climate resilience, water and food security:
 - Biorefining
 - Biomaterials
 - Systems Design and Logistics
 - Geospatial Analytics
 - Smart Hydrology and Hydraulics
 - Ecosystem Modeling and Visualization
 - Low-impact Agricultural Harvesting

