17 October 2017

Modern Agroclimatic Research and investment planning (high performance-high resolution adaptation)

Dr. Henry David (Hank) Venema, PEng

Prairie Climate Centre
From Risk to Resilience

The University of Winnipeg

IISD
International Institute for Sustainable Development

Key Ideas

Prairie Climate Centre

- Start-up Mode: need your wisdom and support
- Science -> Sustainability
- Climate risk and opportunity management
- Water
- Soil
- Biomass (Food++)
- Data -> High Performance Computation

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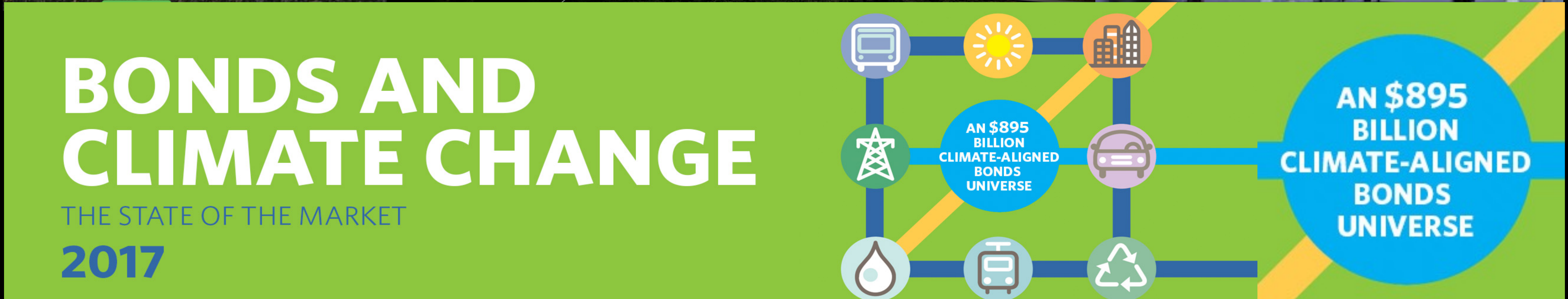
Global Motivation – the $64 trillion dollar question



2011 As a foreshadowing

56%

Feel the government should spend more on infrastructure

even if it means increasing the province's debt

Compared to **29%** who do not

Results based on weighted Vote Compass data

Climate and Agriculture: Three Views

Field

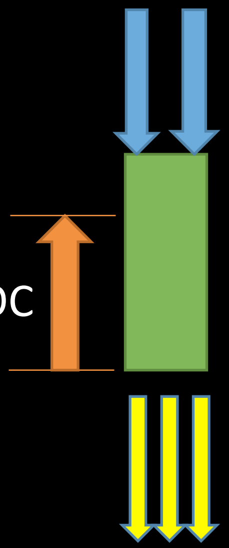
Landscape

Watershed

Precip
Temp

Management
(cultivar, N,P, tillage)

SOC



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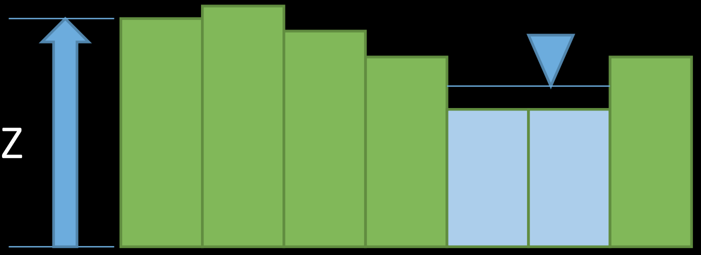

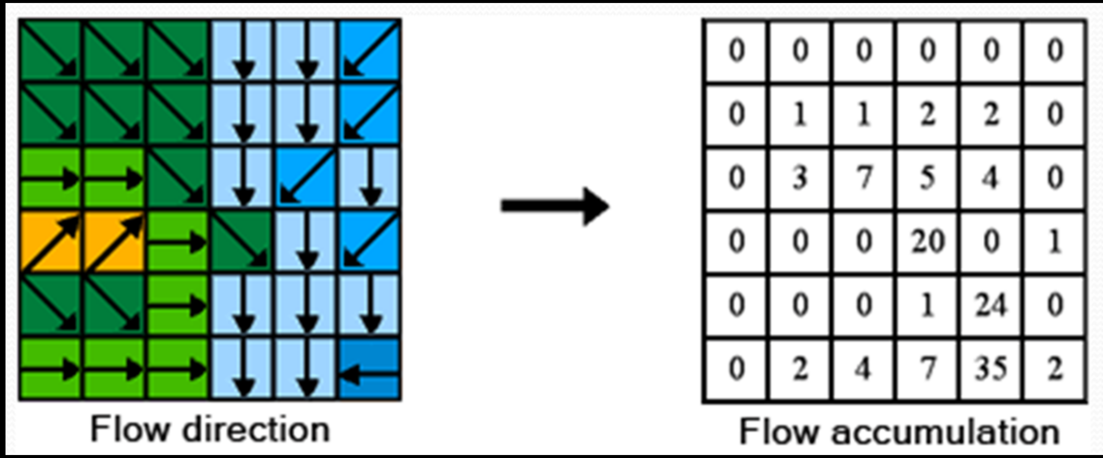

Biomass, $, Q

Max ($)
Max (SOC)
Min Var(Q)

$$

Key Domains

Prairie Climate Centre

- (traditional) Agro-climatic Risk Assessment
- (modern) Stochastic Crop, Biomass and Sink Analytics
- (modern) Natural Infrastructure System Design and System Resilience
- (modern) Finance and Investment

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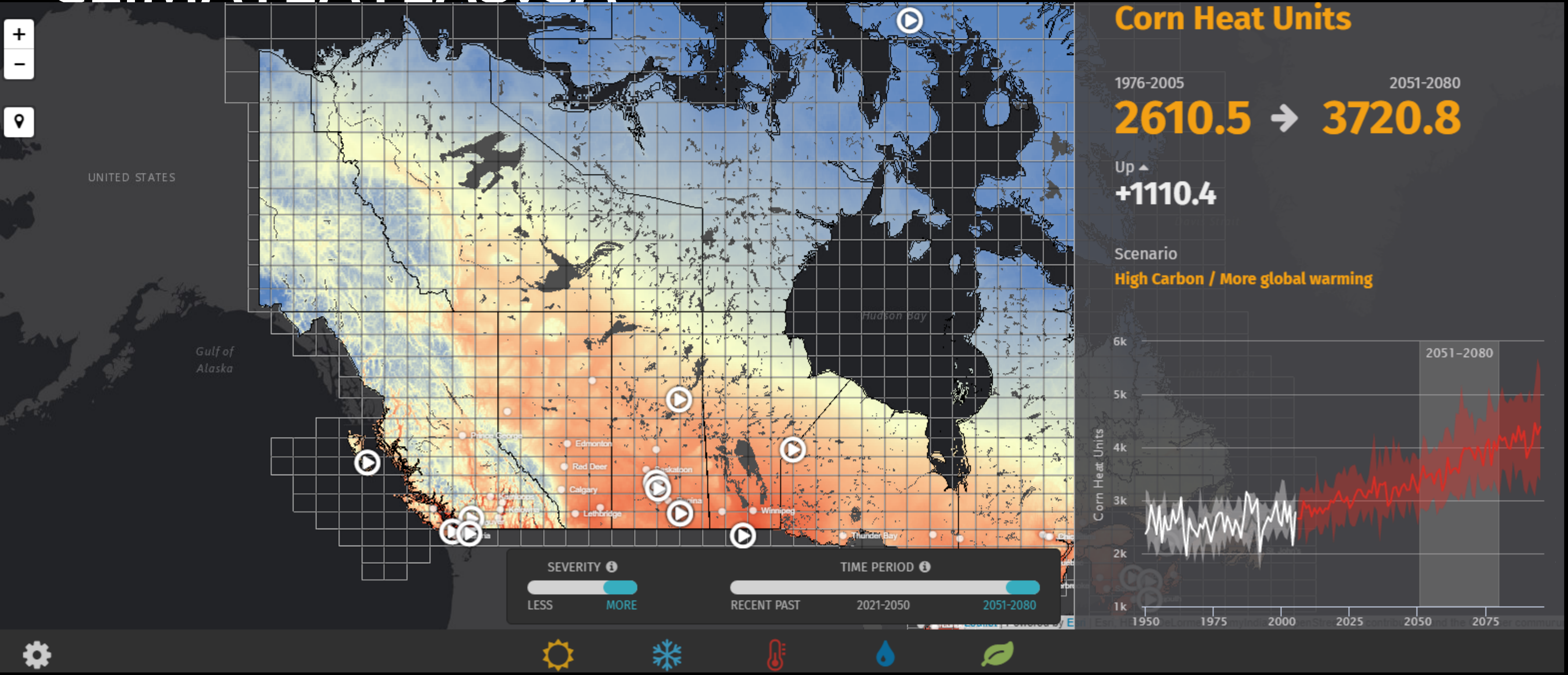
Agro-climatic Risk Assessment

Agro-climatic Risk Assessment: CLIMATEATLAS.CA



Agro-climatic Risk Assessment: Synthesis

2051-2080 Δ PPT: RCP8.5

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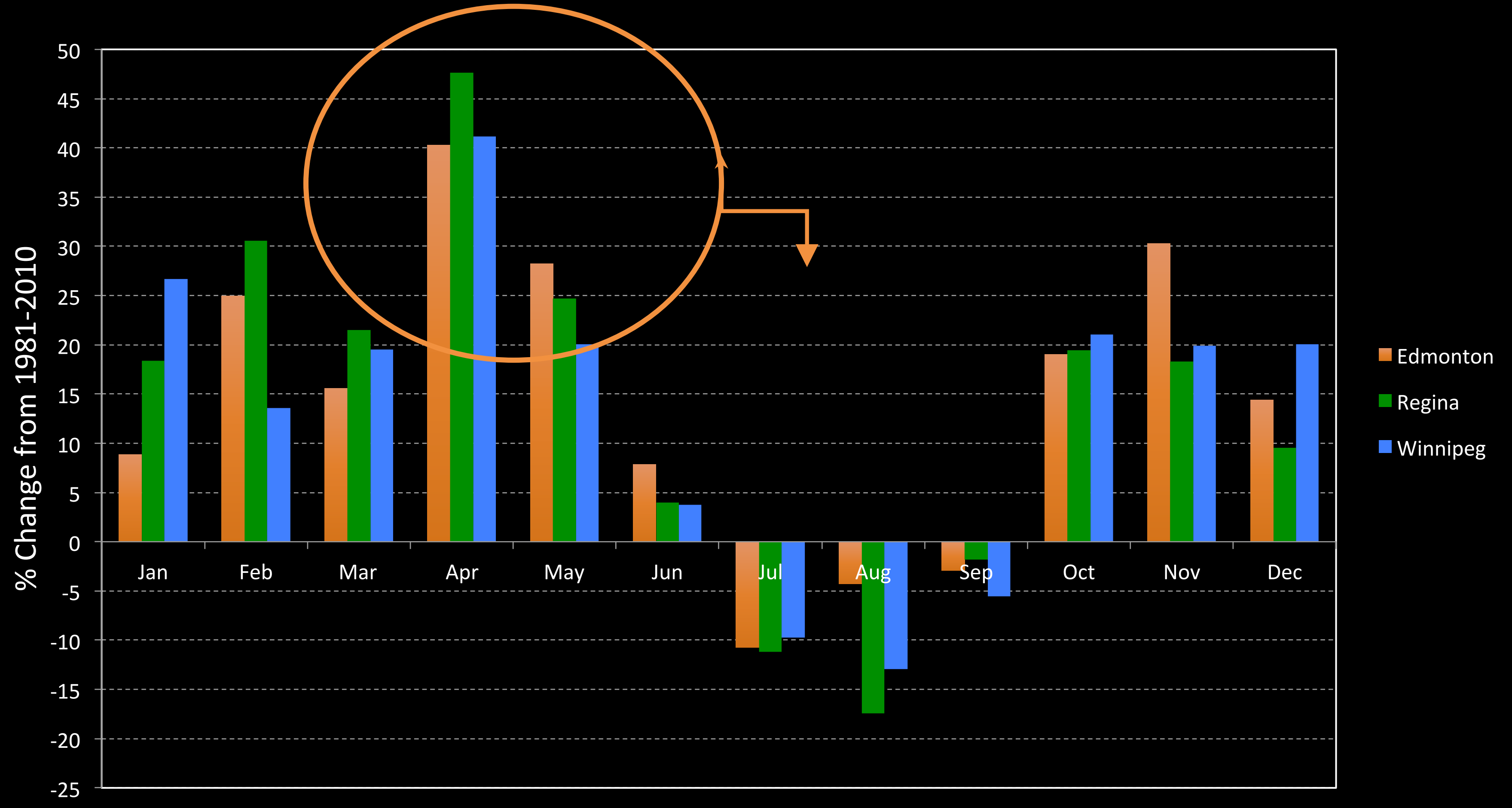

Spatial Stochastic Crop, Biomass and Sink Analytics

Crop Analytics

AgMIPS "the IPCC for food"

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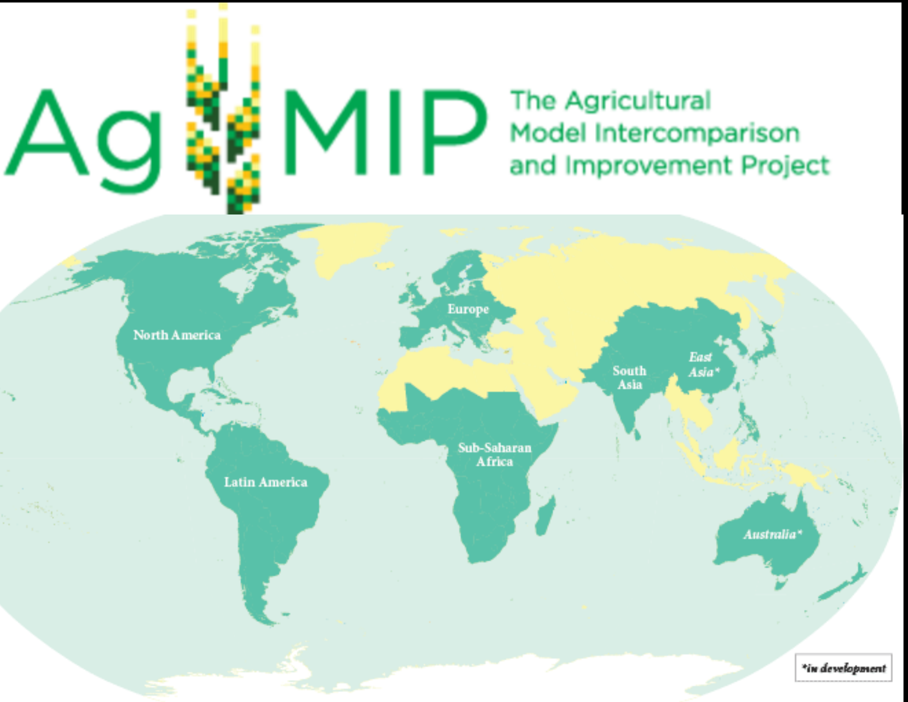

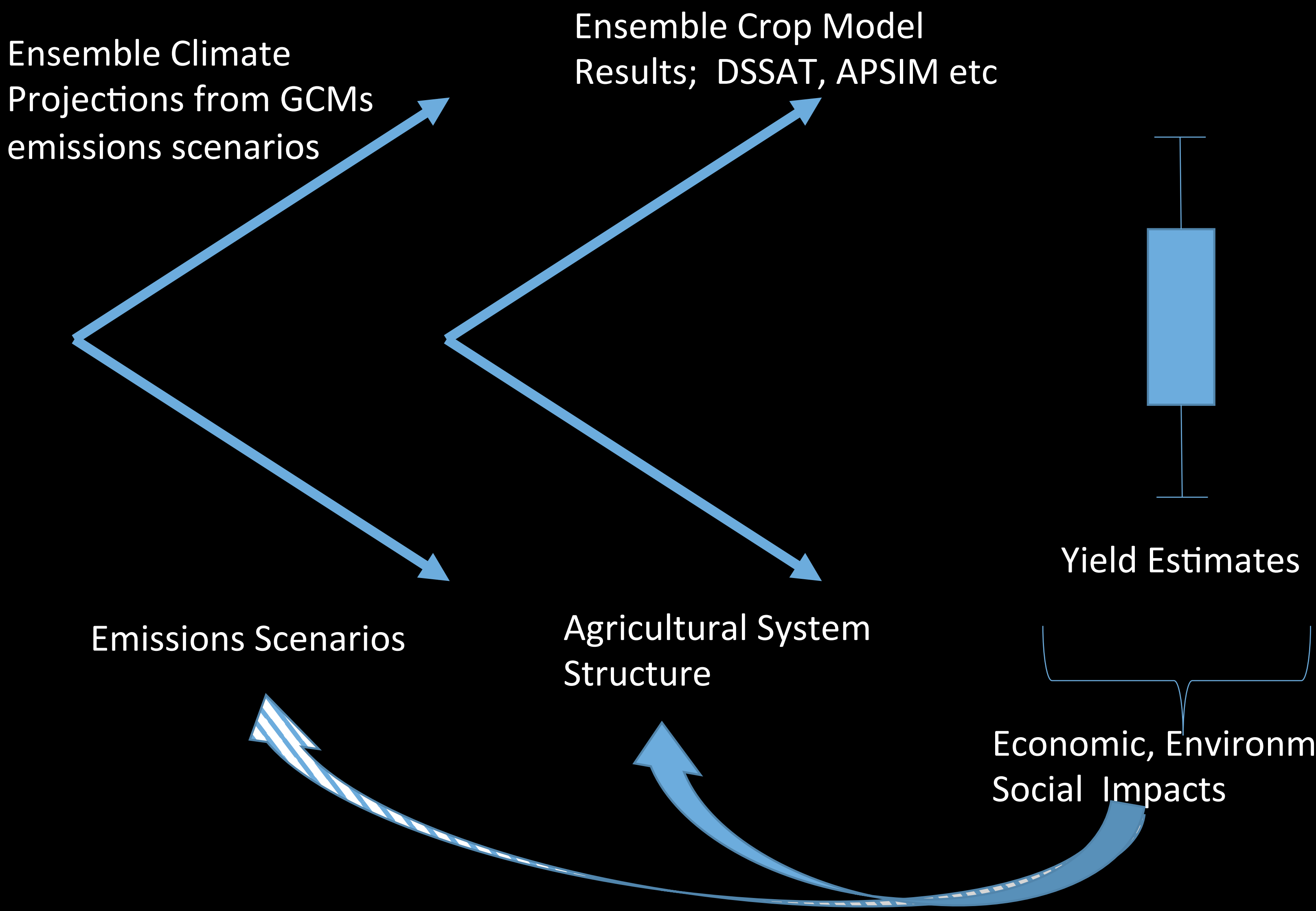

Atlas – Intermediate Products

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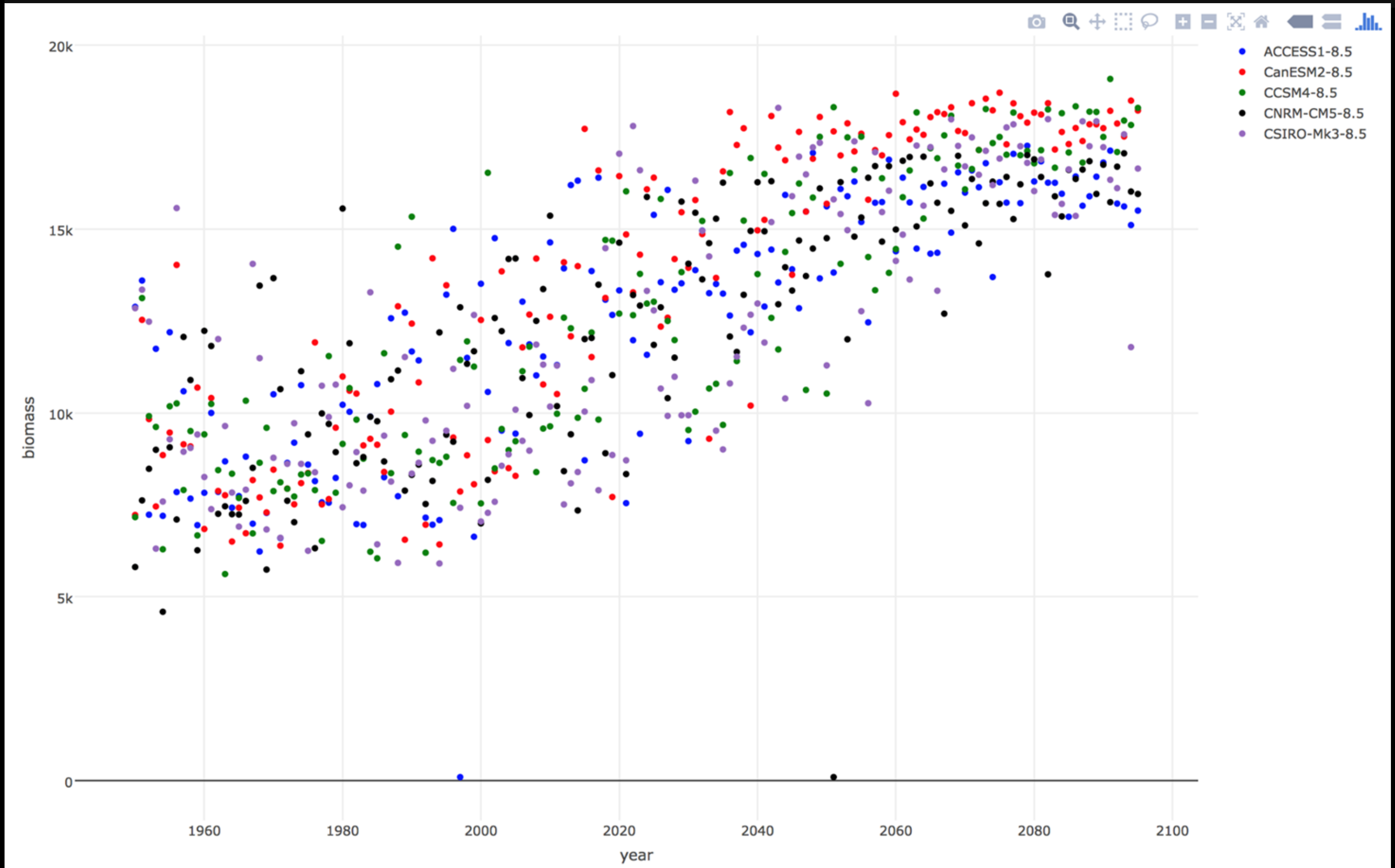
Location-Based crop modelling:

Example: Corn DSSAT cultivar P3573: Location Virden, MB   RCP8.5



Atlas – Advanced Products

spatial stochastic crop modeling and cultivar design

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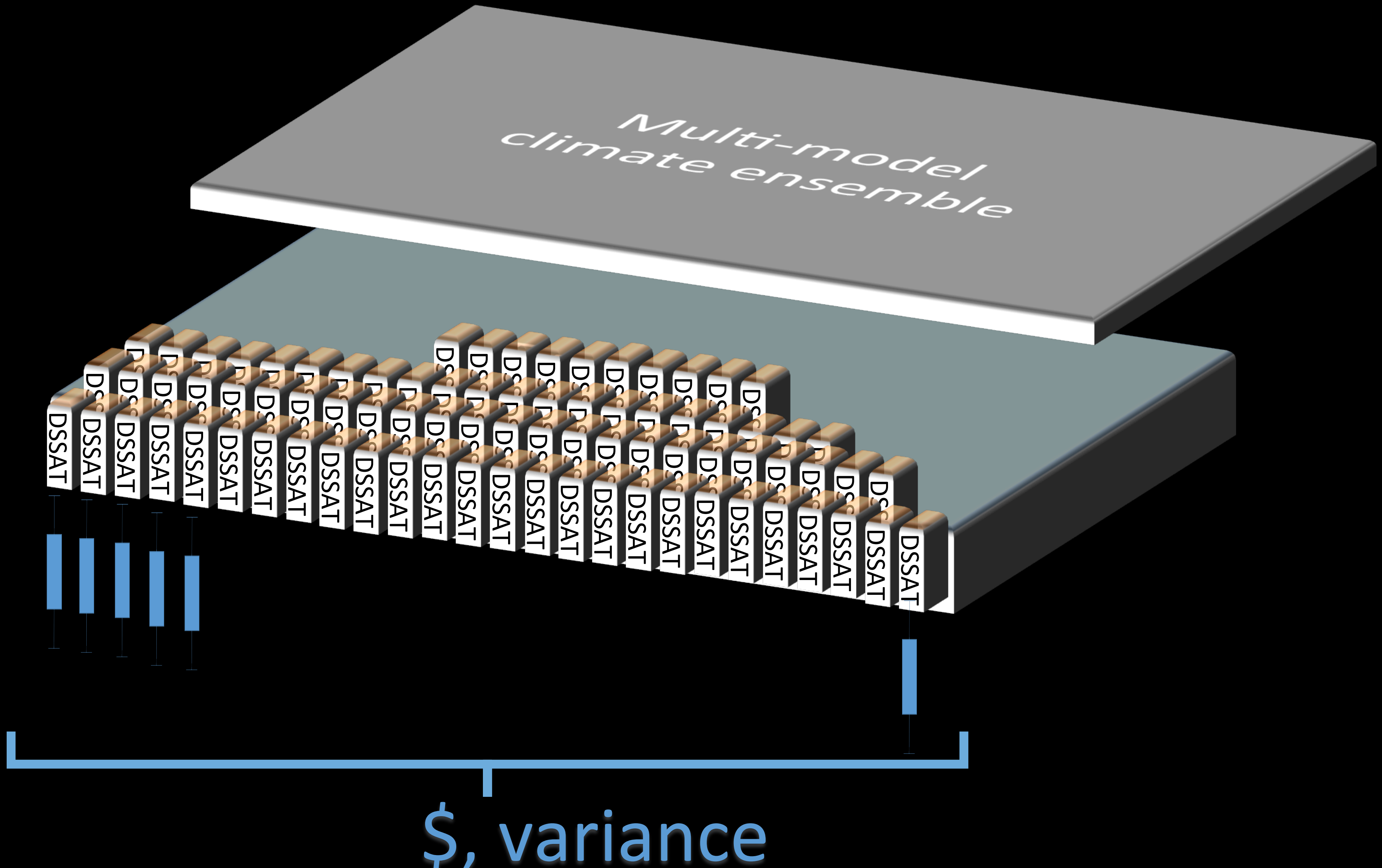

Corn Yield Increase 2065 over present:

DSSAT cultivar P3573 – S. Manitoba RCP 8.5

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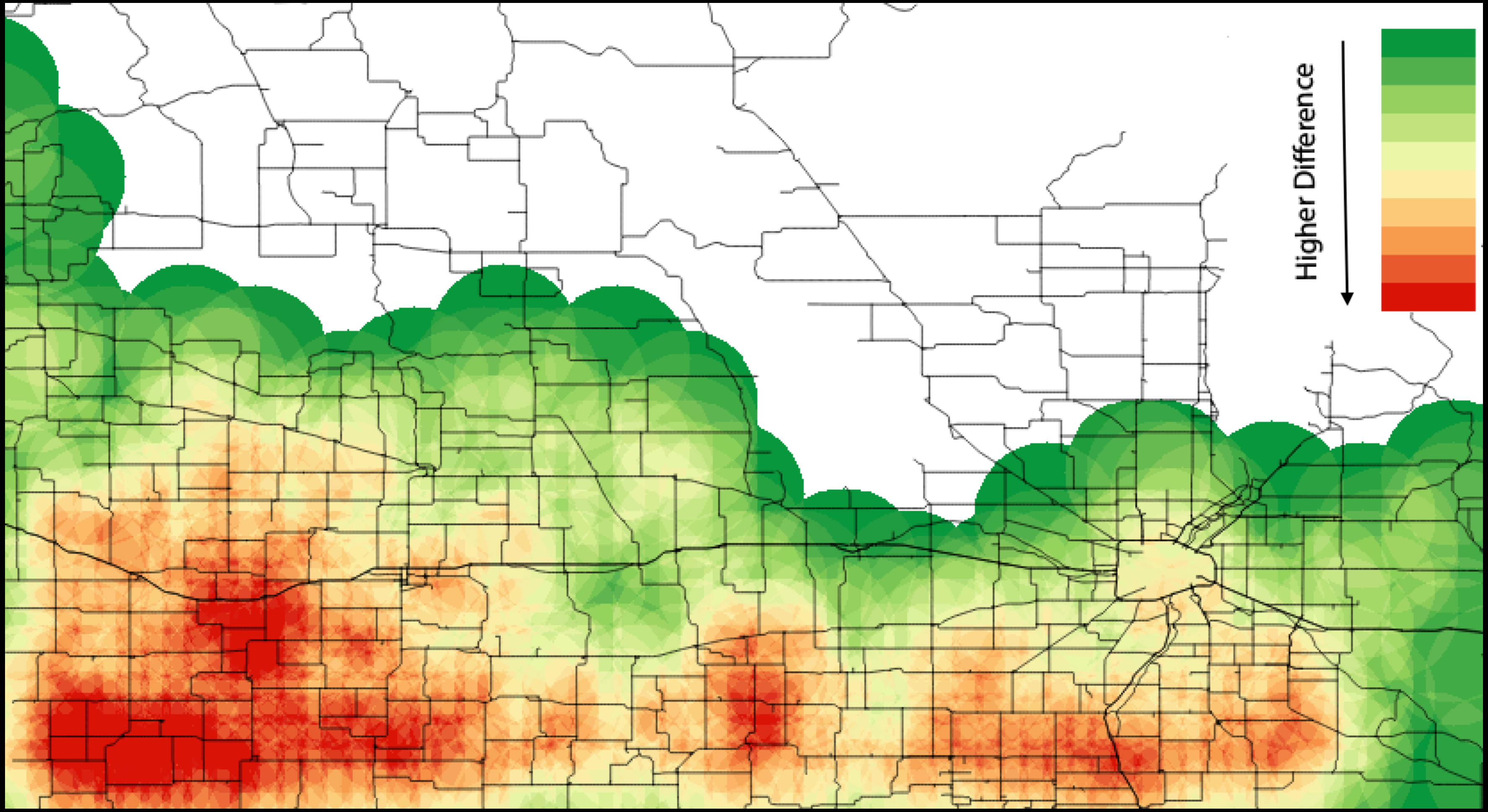

Biomass Analytics

Biomass for climate mitigation and adaptation

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REVIEW

BIOENERGY

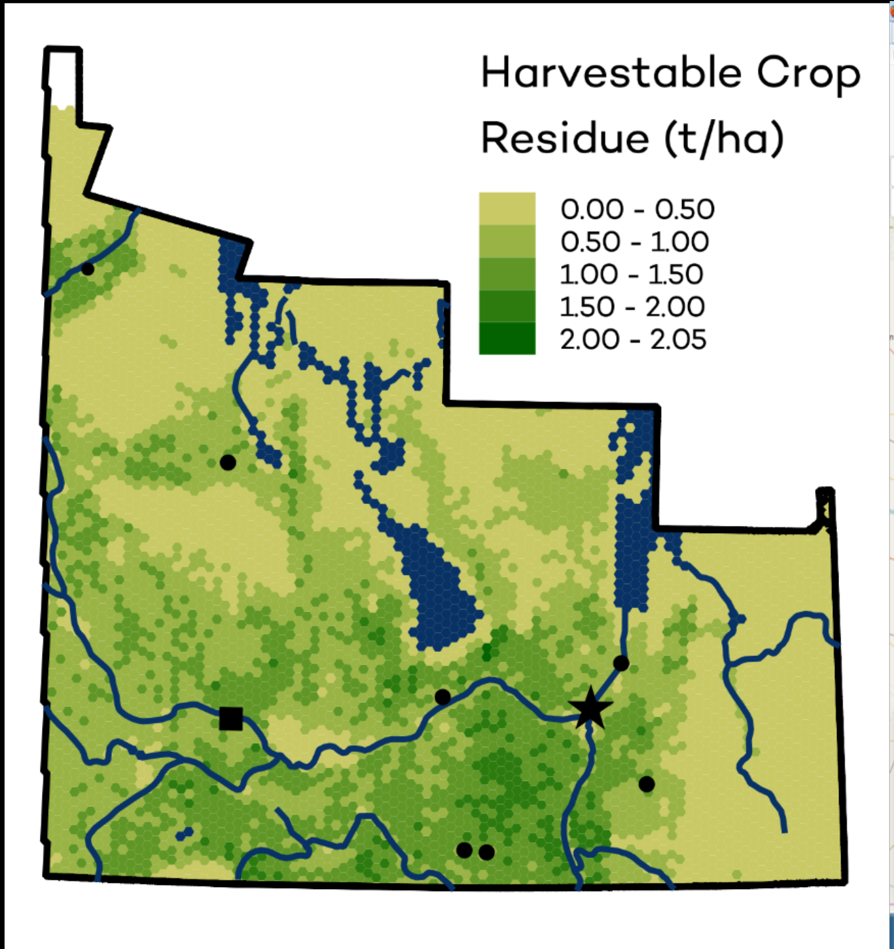
Cellulosic biofuel contributions to a sustainable energy future: Choices and outcomes

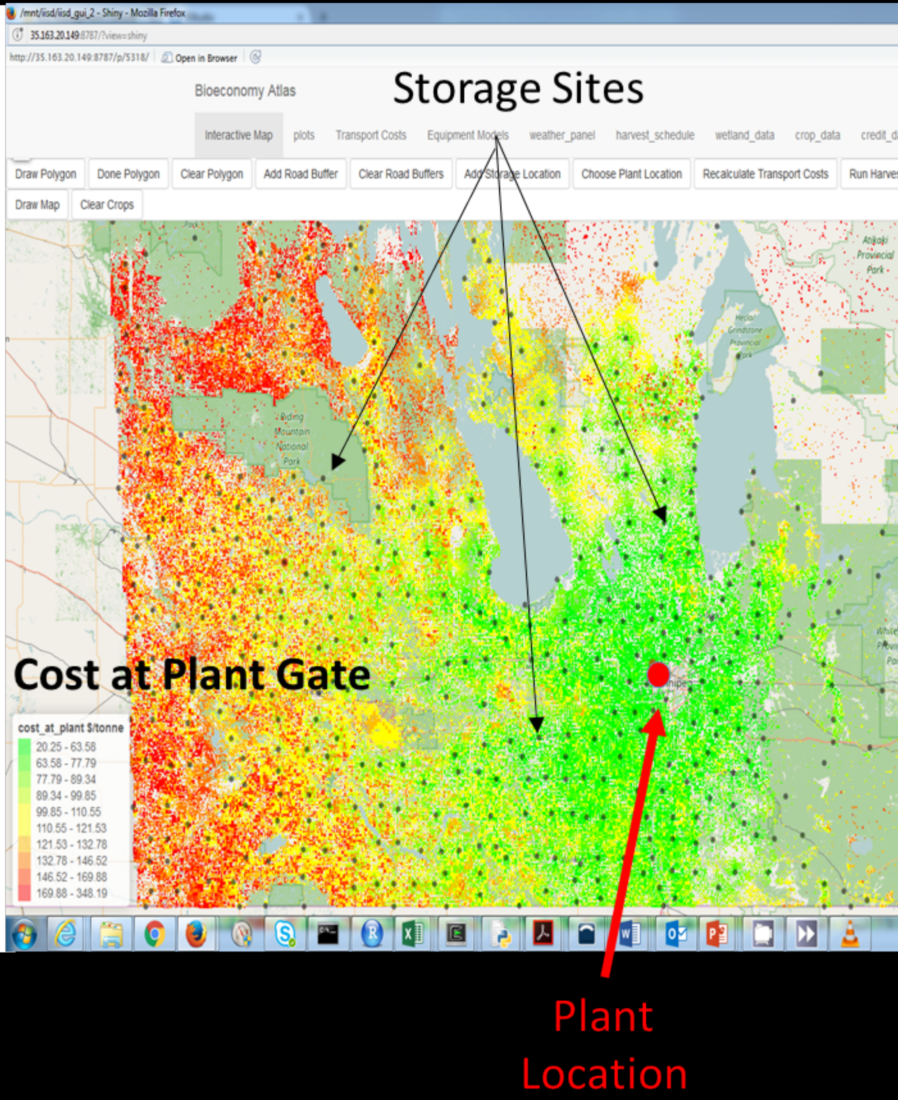
G. Philip Robertson,[1,2,3]* Stephen K. Hamilton,[1,3,4] Bradford L. Barham,[5,6] Bruce E. Dale,[3,7] R. Cesar Izaurralde,[3,8,9] Randall D. Jackson,[6,10] Douglas A. Landis,[3,11] Scott M. Swinton,[3,12] Kurt D. Thelen,[2,3] James M. Tiedje[2,3,13]

Cellulosic crops are projected to provide a large fraction of transportation energy needs by mid-century. However, the anticipated land requirements are substantial, which creates a potential for environmental harm if trade-offs are not sufficiently well understood to create appropriately prescriptive policy. Recent empirical findings show that cellulosic bioenergy concerns related to climate mitigation, biodiversity, reactive nitrogen loss, and crop water use can be addressed with appropriate crop, placement, and management choices. In particular, growing native perennial species on marginal lands not currently farmed provides substantial potential for climate mitigation and other benefits.

The Manitoba Bioeconomy Atlas

- Map sources of biomass in the province, whether♪
  - Extensive♪
  - Intensive♪
- Simulate harvests costs♪
  - Cutting♪
  - Densifying♪
  - Storage♪
- Simulate transport costs♪
  - Field to storage♪
  - Storage to plant♪
- Optimize production logistics♪
- Simulate economic scenarios♪
  - Carbon credits♪
  - Changing fuel costs♪





GPU Acceleration/Machine Learning

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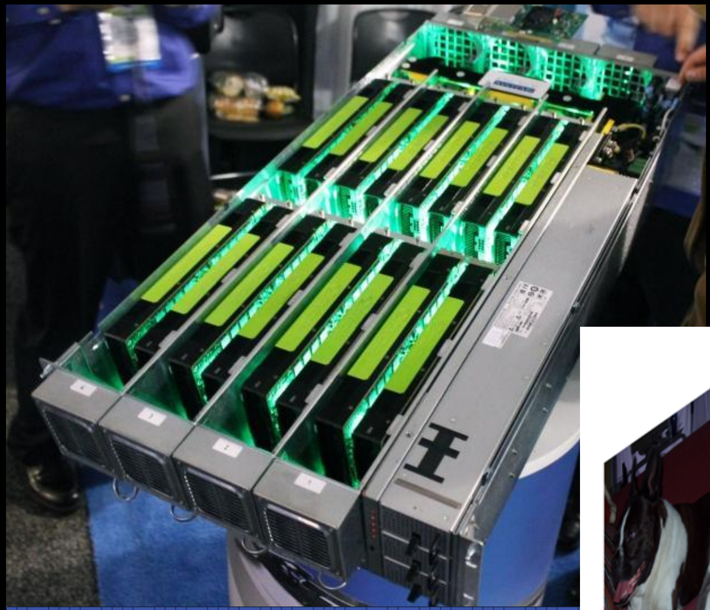
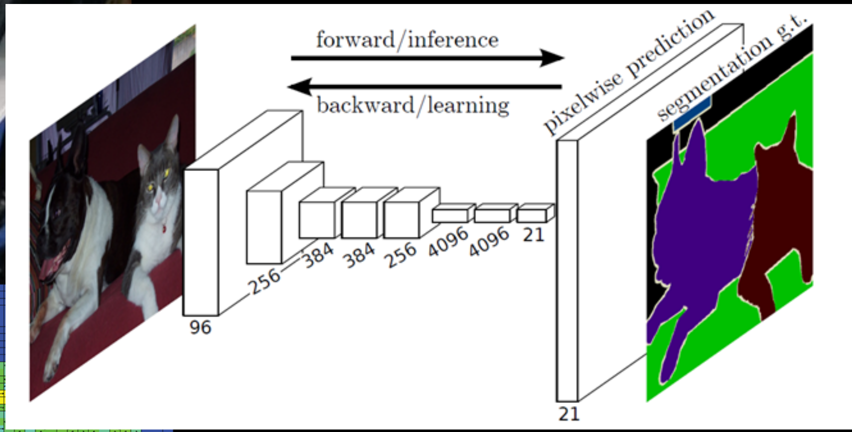
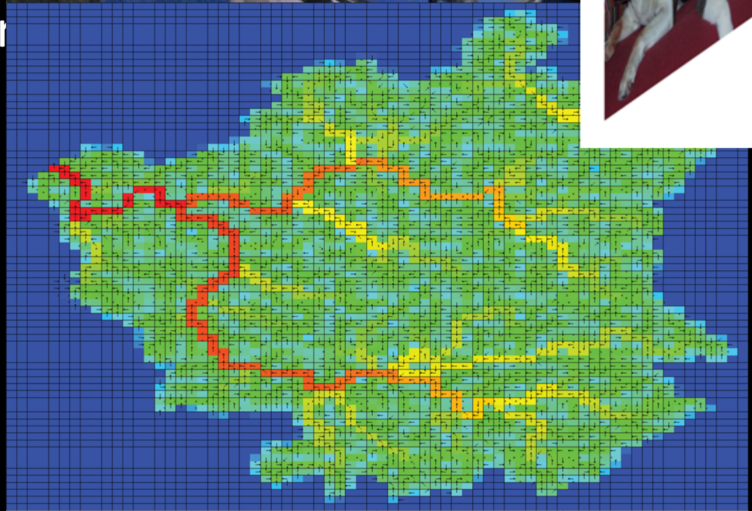
- GPU enables scaling to provincial scope
- So far
  - Harvest simulation accelerated
  - From 3 hours to 10 seconds
  - Using Python/Numba
- Future Work
  - Implement DSSAT crop growth models on GPU
  - Use GPU for running stochastic weather models, driven by climate models
  - Hydrology models on GPU







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Sink Analytics

McKinsey (2008) study – ghg abatement cost curve

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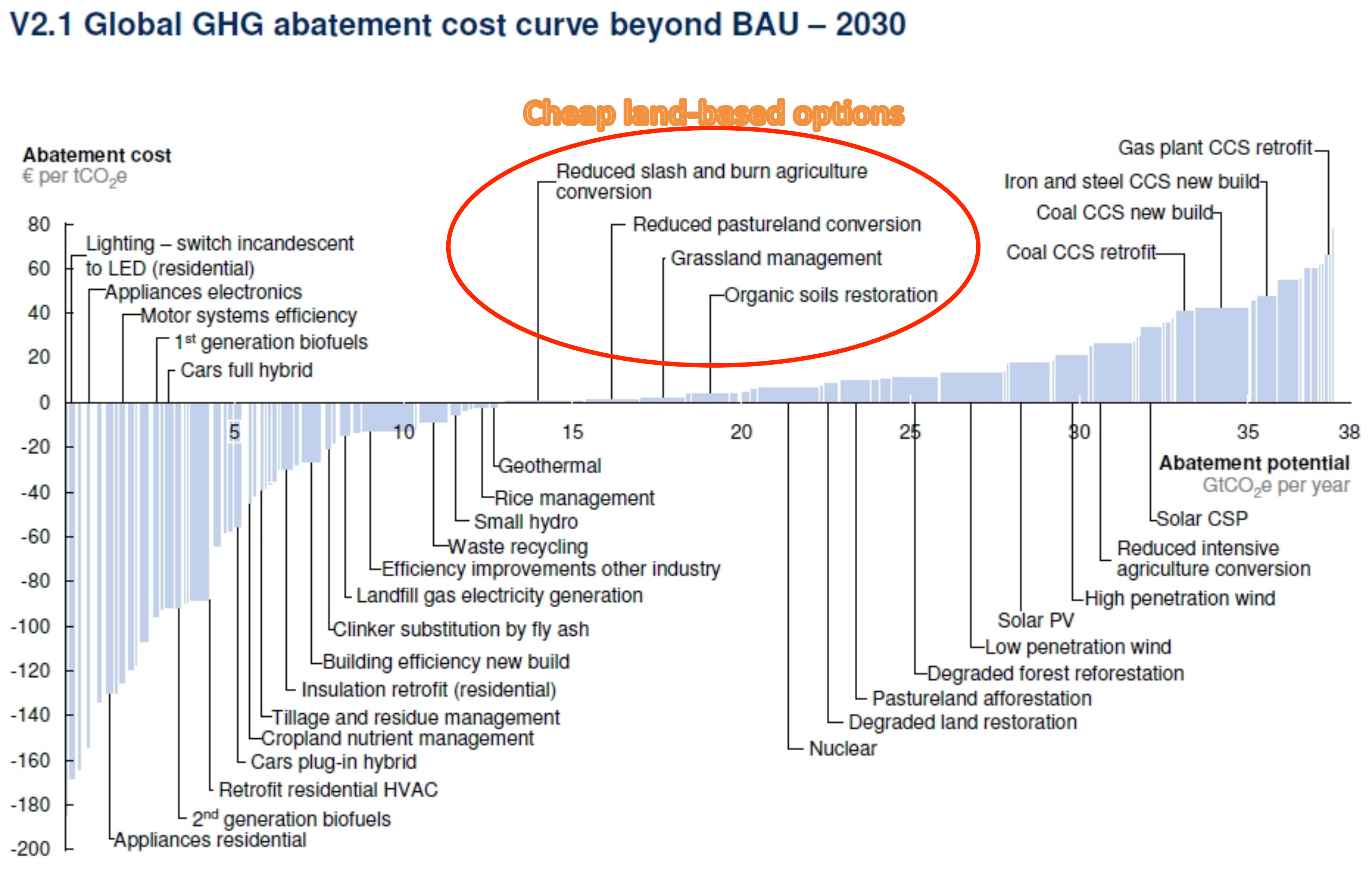
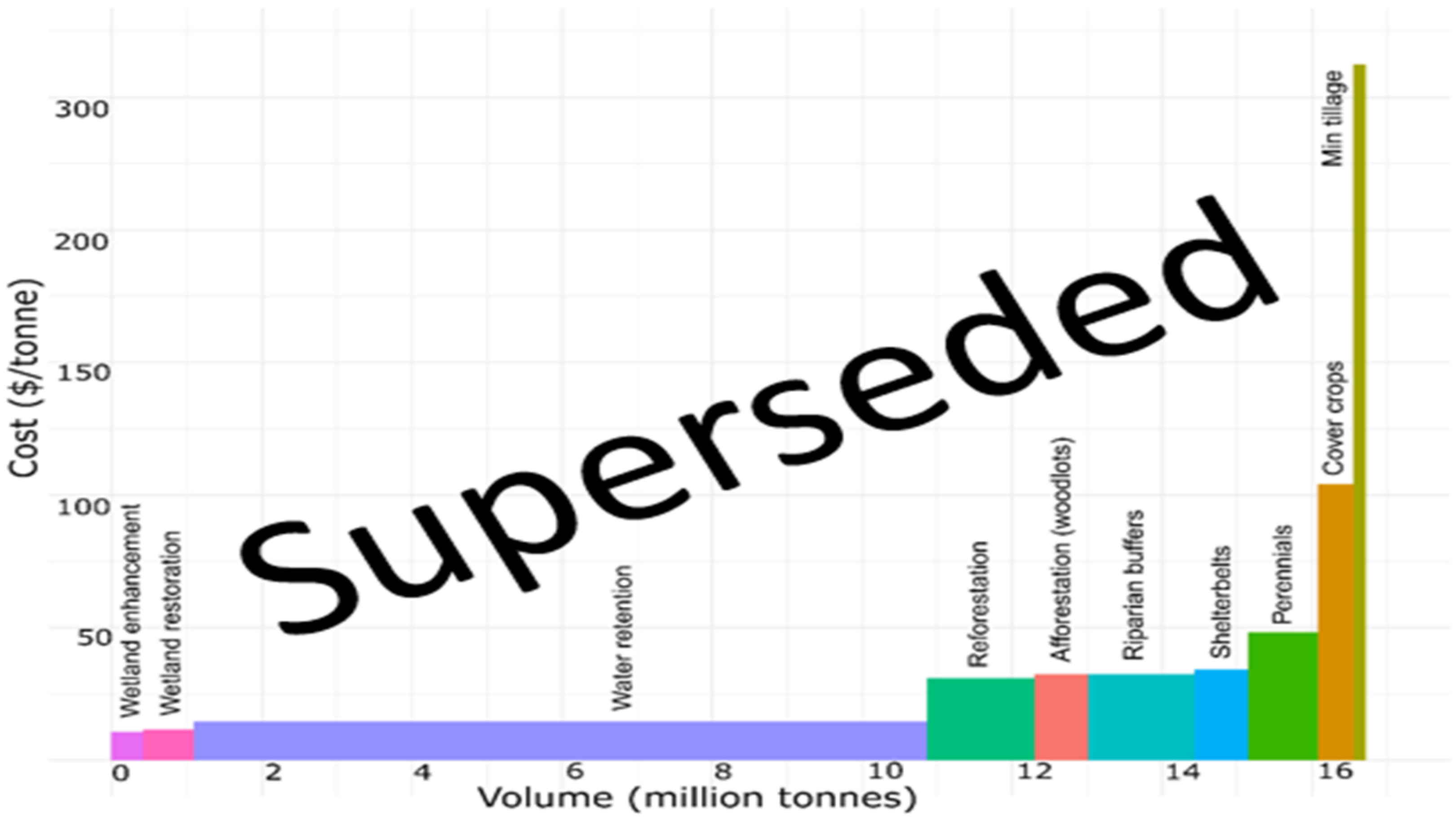
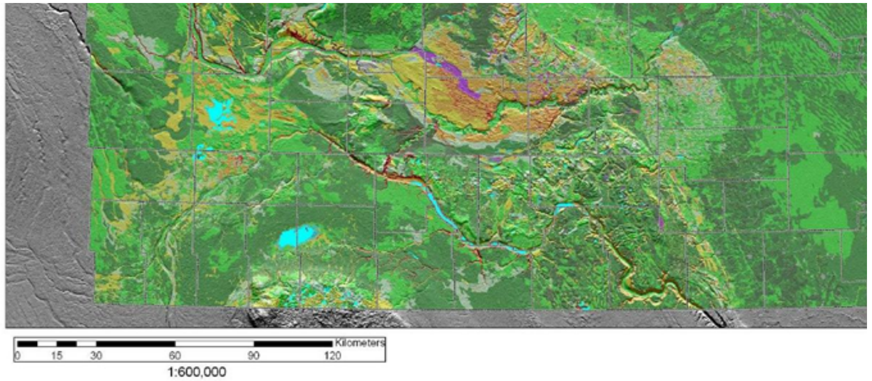


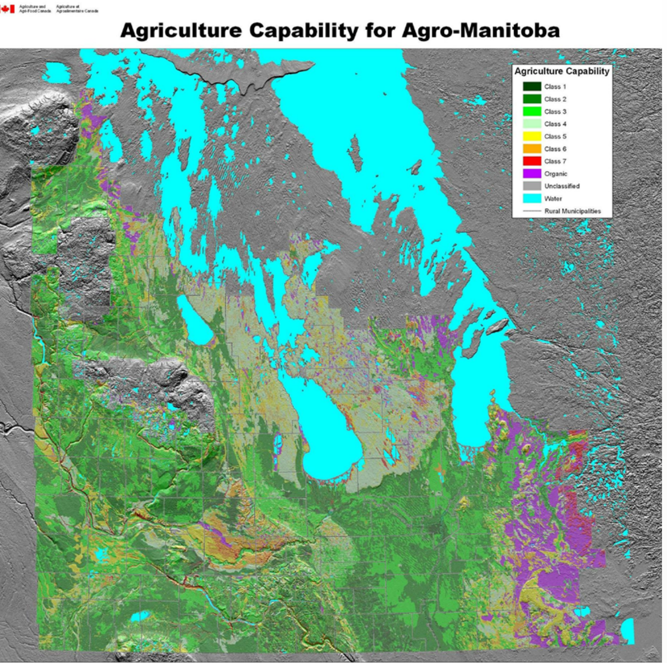


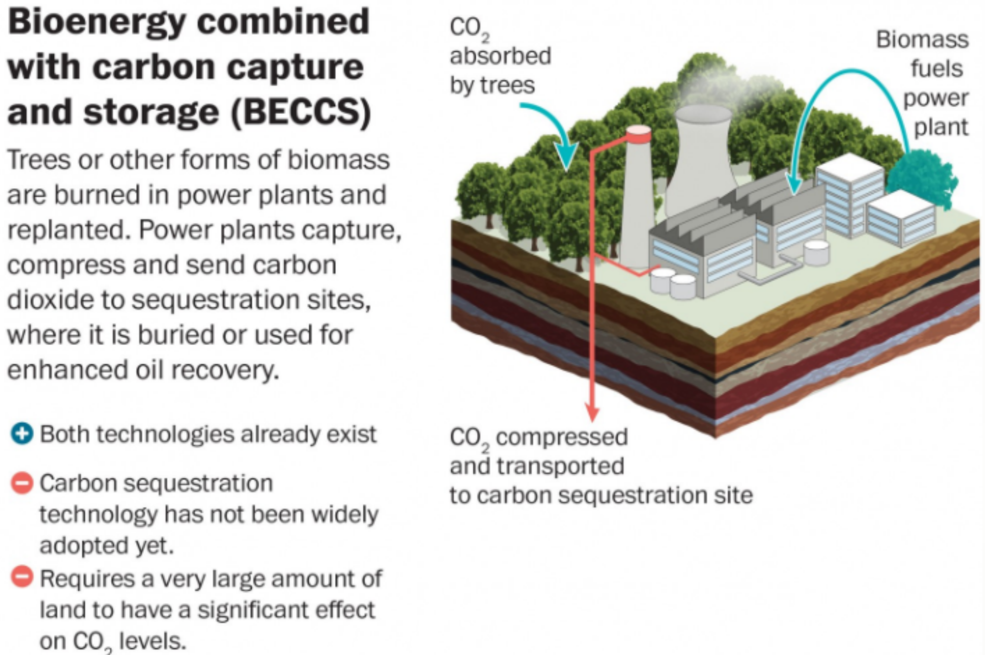
t in Manitoba – Phase 1 Scoping

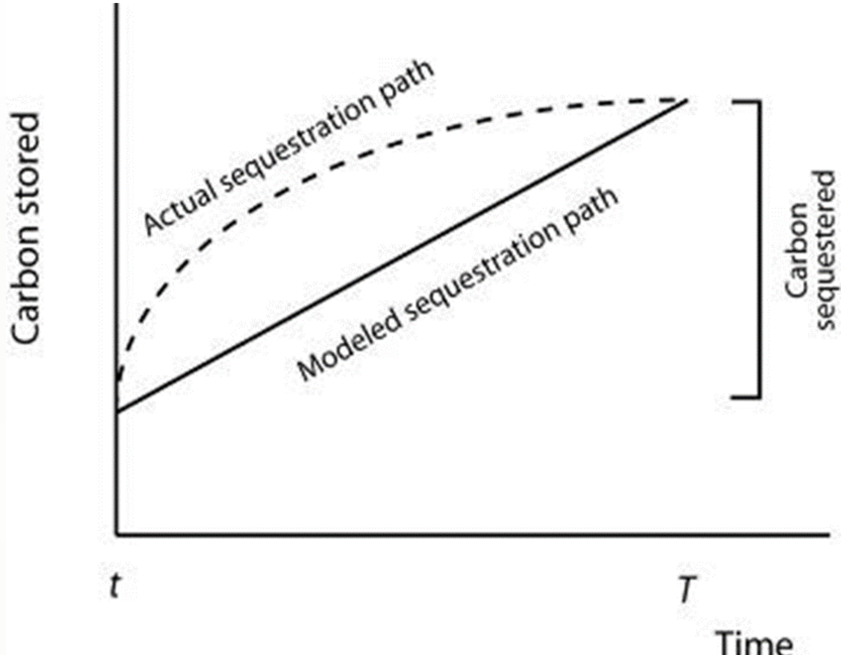
			…bon …ion … per …)	Carbon Cost ($ per tonne CO_2e)	Total Annual Reduction Potential (CO_2e)	Annual Cost Of Implementation ($ per hectare)	Total Annual Cost (millions $)
				$10.72	429.3 kt	$15.31	$1.3
				$11.47	668.4 kt	$51.02	$4.4
				$14.69	9,789.0 kt	$800.32	$137.6
				$32.48	1,425.0 kt	$204.08	$35.1
				$34.11	713.0 kt	$204.08	$17.5
				$15.52	930.0 kt	$33.61	$14.4
Cover crops	429,000	5%	1.1	$3.11	473.0 kt	$3.42	$1.5
Minimum tillage	214,673	2.5%	0.4	$0.37	83 kt		
Zero tillage	214,673	2.5%	1.6	$0.26	350 kt		
Afforestation (Woodlots)	86,000	1%	8.3	$32.48	713.0 kt	$204.08	$17.5
Reforestation	172,000	2%	8.3	$30.99	1,425.0 kt	$204.08	$35.1
Totals	**2,147,346.00**	**25%**			**16,998.7 kt**		



Modern Geospatial Decision Support for biomass, sinks, and negative emissions technology







Natural Infrastructure System Design and System Resilience

"With astute science, engineering, planning, and investment, we could develop of network of upstream water control structures—large and small, natural and constructed—together with properly designed channels, reservoirs, wetlands, and wooded areas to manage waterflows in a smarter, more effective way, countering the debilitating cycles of uncontrolled floods and droughts," said Goodale.

Minister Goodale's full statement is here.

Solutions: Re-mosaicking with multifunctional storage (MFS)

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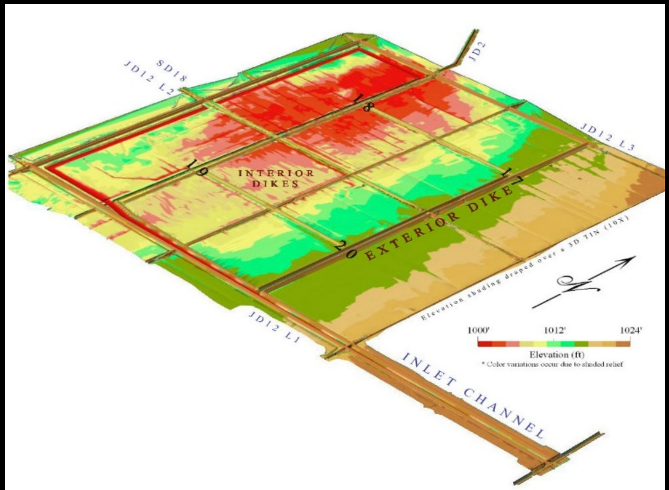
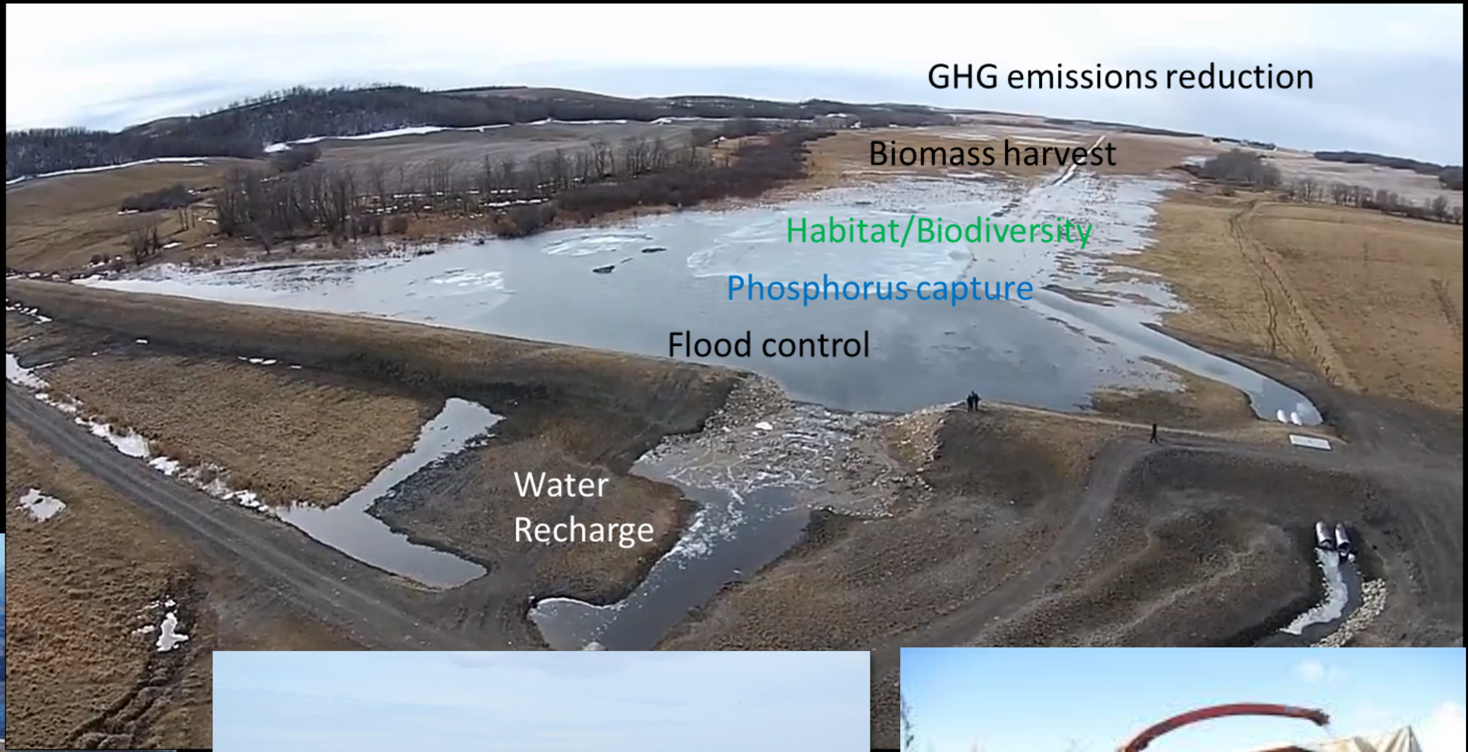
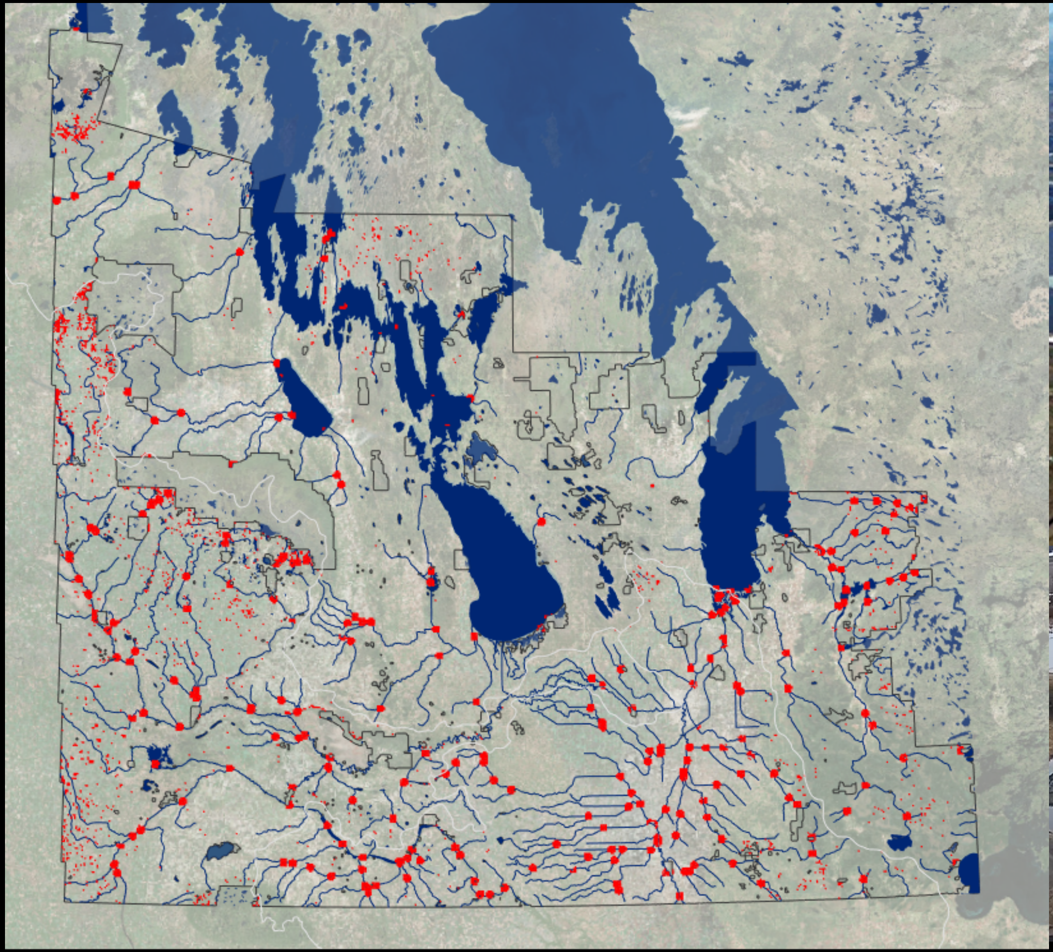
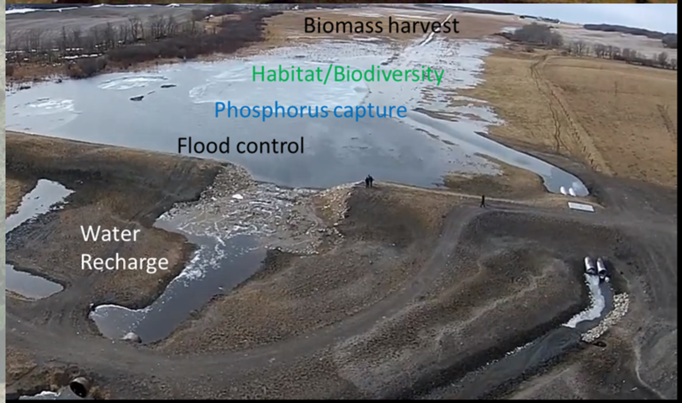




At scale for flooding and water quality





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)

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

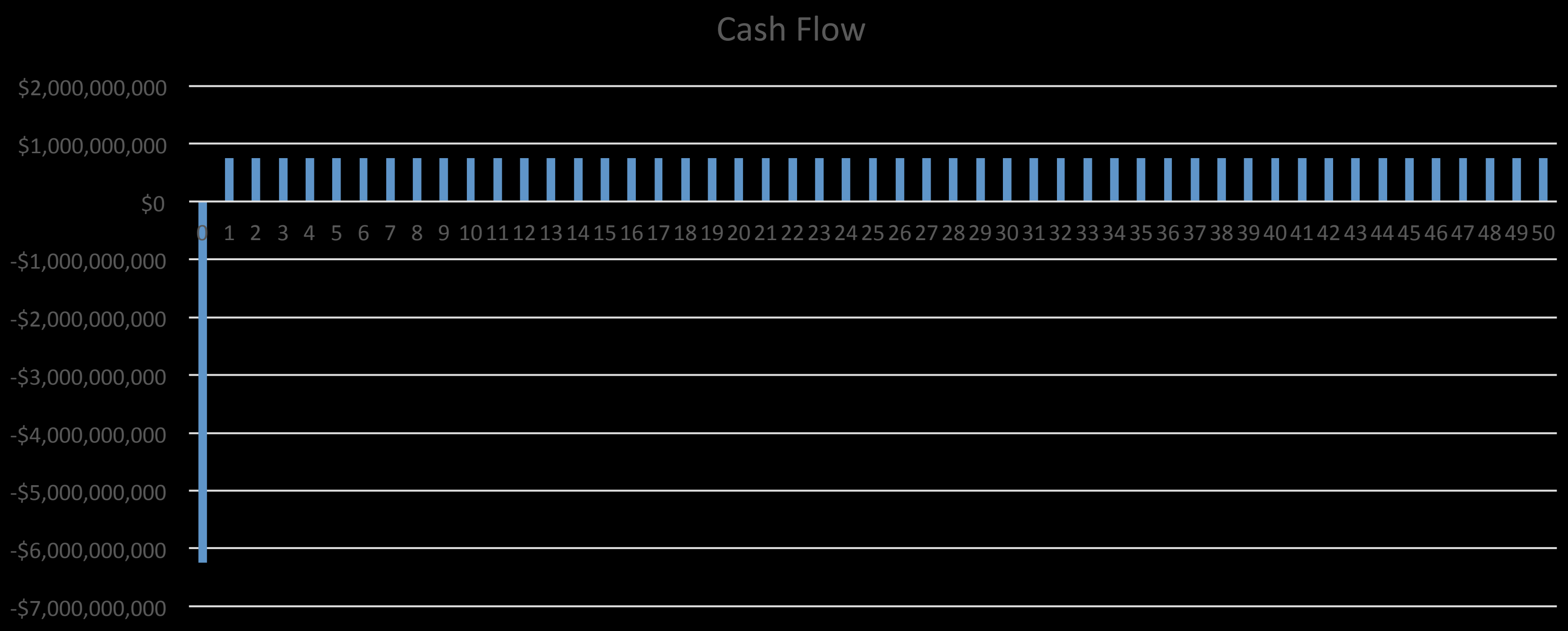
Flood Risk Reduction [omitted]

Drought Resiliency [omitted]

Habitat [omitted]

Co-Benefit Stack Total = $753 M/year

Blunt Force Investment Analysis – 50 years



IRR = 12.2%

NPV @ 3% = $12.75B

net Benefit-Cost Ratio = 2.04

The Manitoba Ecosystem Bank

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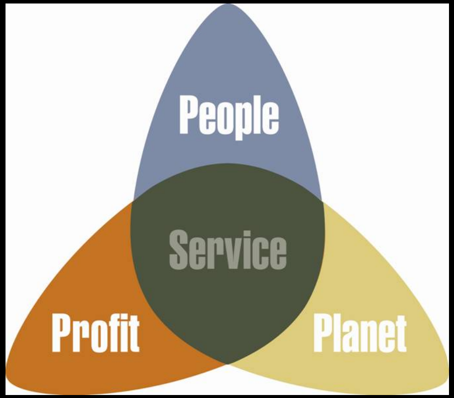
….will be a public-private partnership that develops MFS and sells the following services:



who	what	why
municipality	water supply	potable water demand
	infrastructure protection	flood risk reduction
	water quality credits	aquatic ecosystem protection
energy co	biomass	renewable heat and energy
farmer	water supply	irrigation
	biomass	renewable heat and energy
city	water quality credits	ecosystem protection
	water storage	flood risk reduction
province	habitat	terrestrial ecosystem protection
	water storage	flood risk reduction (crop insurance)
	water supply	drought risk reduction (crop insurance)
	co2 credits	climate mitigation
federal	water storage	disaster risk reduction
foundations	concept	profitable sustainable development
conservation orgs	habitat	biodiversity
		terrestrial ecosystem protection
research orgs	system design logic	valuable IP
	system management logic	valuable IP
bond markets	infrastructure package	systematic climate risk reduction
		economic development

Pilot Project and Investment Concept Validation

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Journal of Environmental Management 203 (2017) 500–509

Contents lists available at ScienceDirect

Journal of Environmental Management

ELSEVIER

Research article

Surface wat

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Appl Water Sci

DOI 10.1007/s13201-017-0592-7

CrossMark

ORIGINAL ARTICLE

An econo

water ret

Pamela Berry[1]

sustainability

Article

An Economic Assessme

Multi-Purpose Surface

Systems under Future C

Pamela Berry [1,*], Fuad Yassin [1], Kenneth B

sustainability

MDPI

Article

Financing High Performance Climate Adaptation in Agriculture: Climate Bonds for Multi-Functional Water Harvesting Infrastructure on the Canadian Prairies

Anita Lazurko [1] and Henry David Venema [2,*]

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Received: 3 May 2017; Accepted: 10 July 2017; Published: 14 July 2017

Modern Benefit-Cost Analysis

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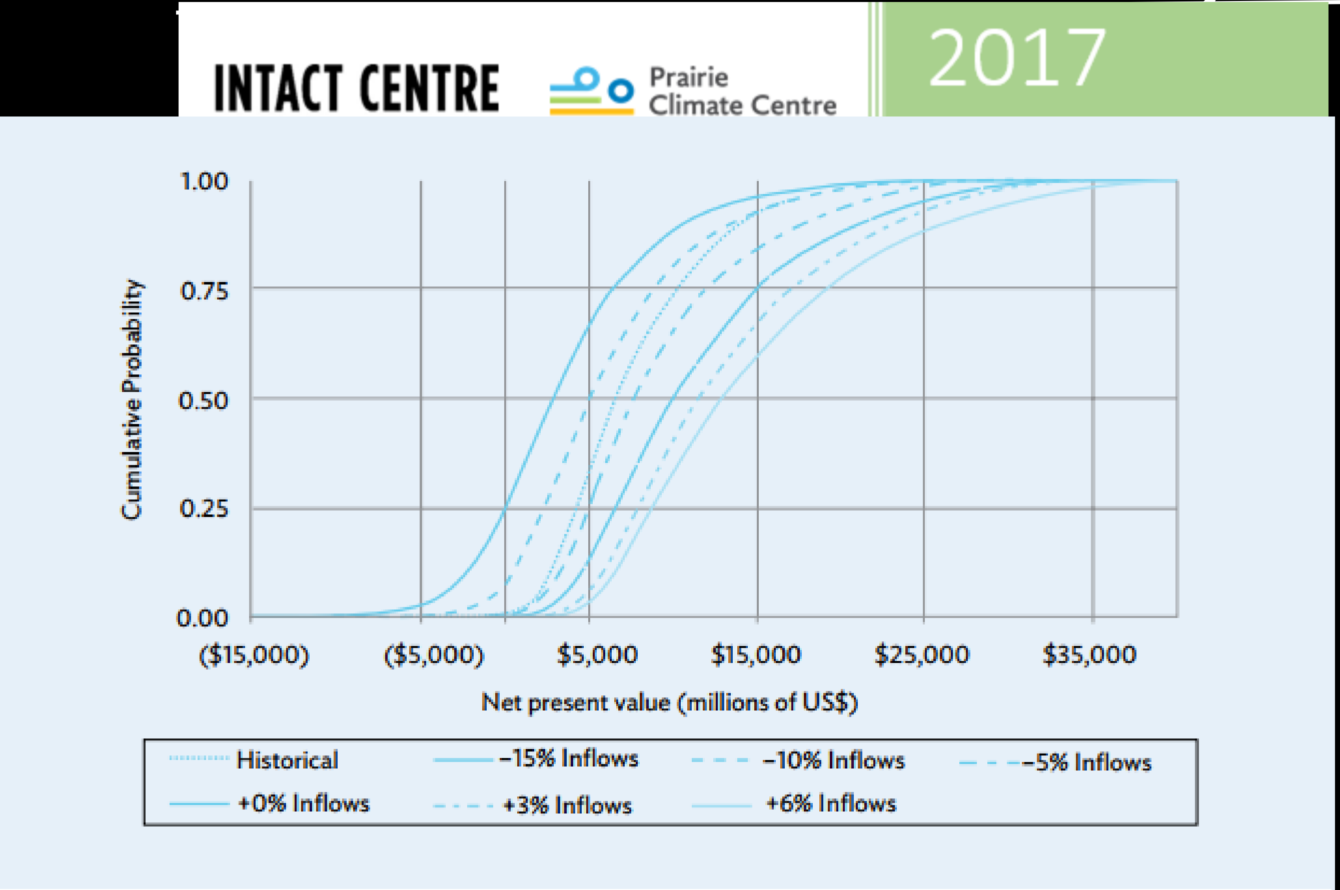

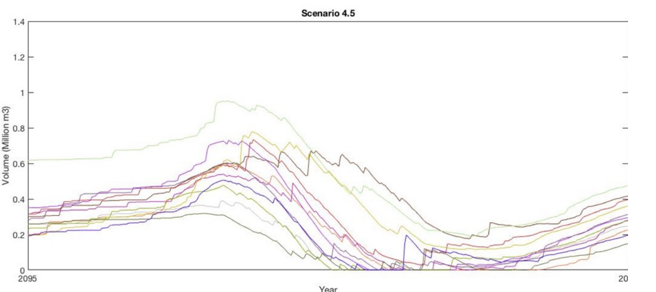

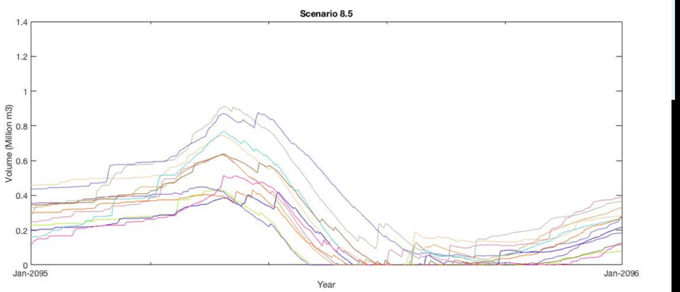

Key concepts

- *LiDAR for project identification*
- *Explicit use of Climate Change Projection Data to develop synthetic hydrology*
- *Explicit valuation of ecosystem service co-benefits*
- *Probabalistic interpretation of investment performance using ensemble climate data*

Finance and Investment

Design + Finance

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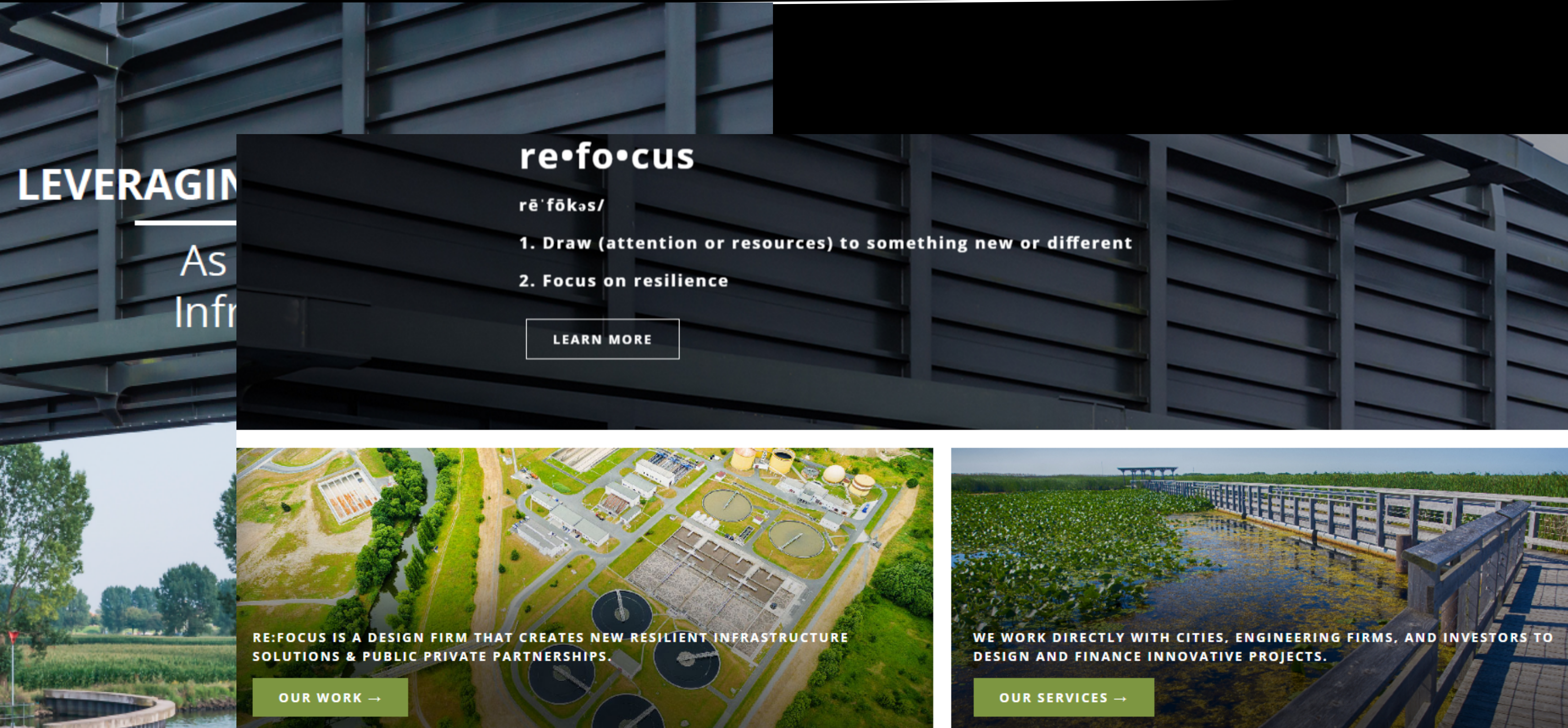

Climate resilient infrastructure

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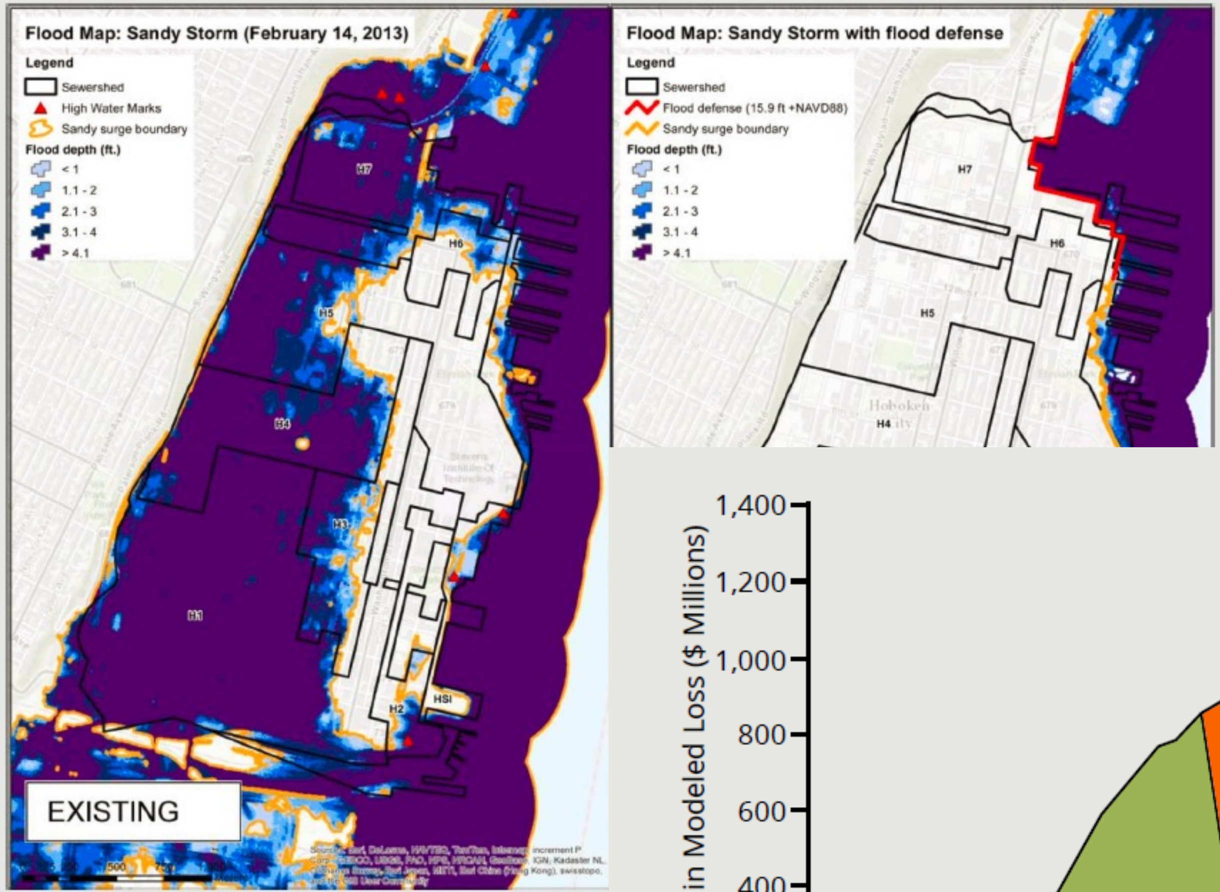


Figure 2. Hoboken flood map with and withc

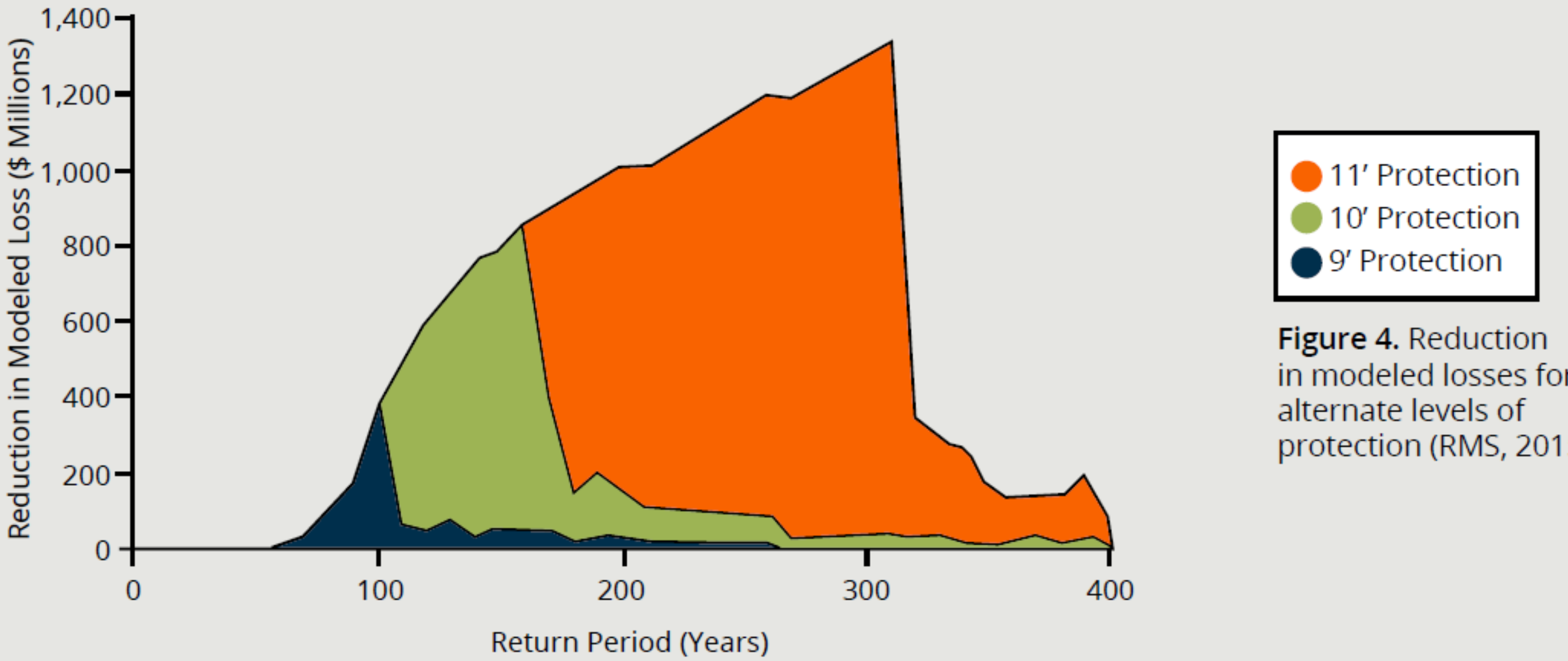
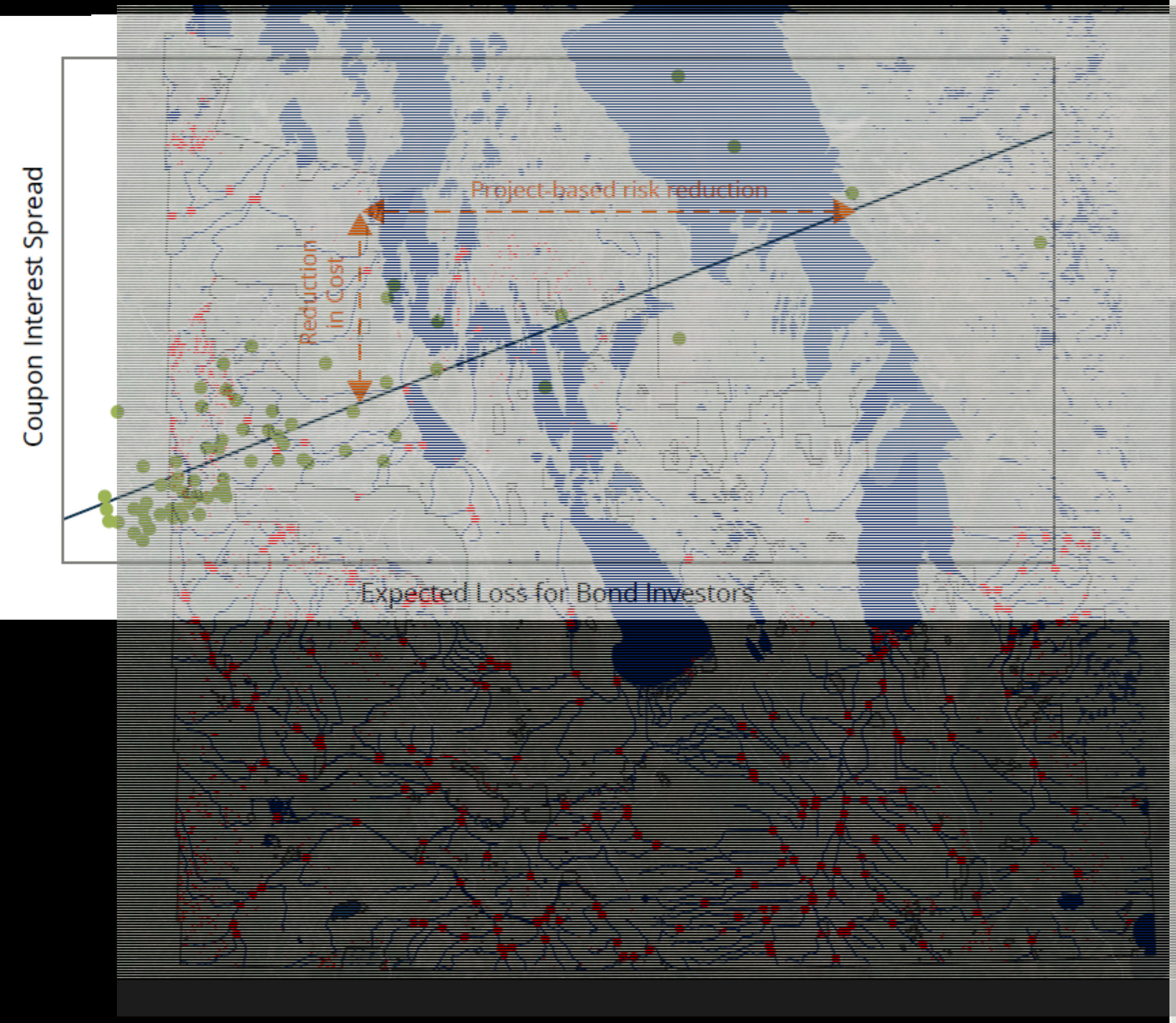
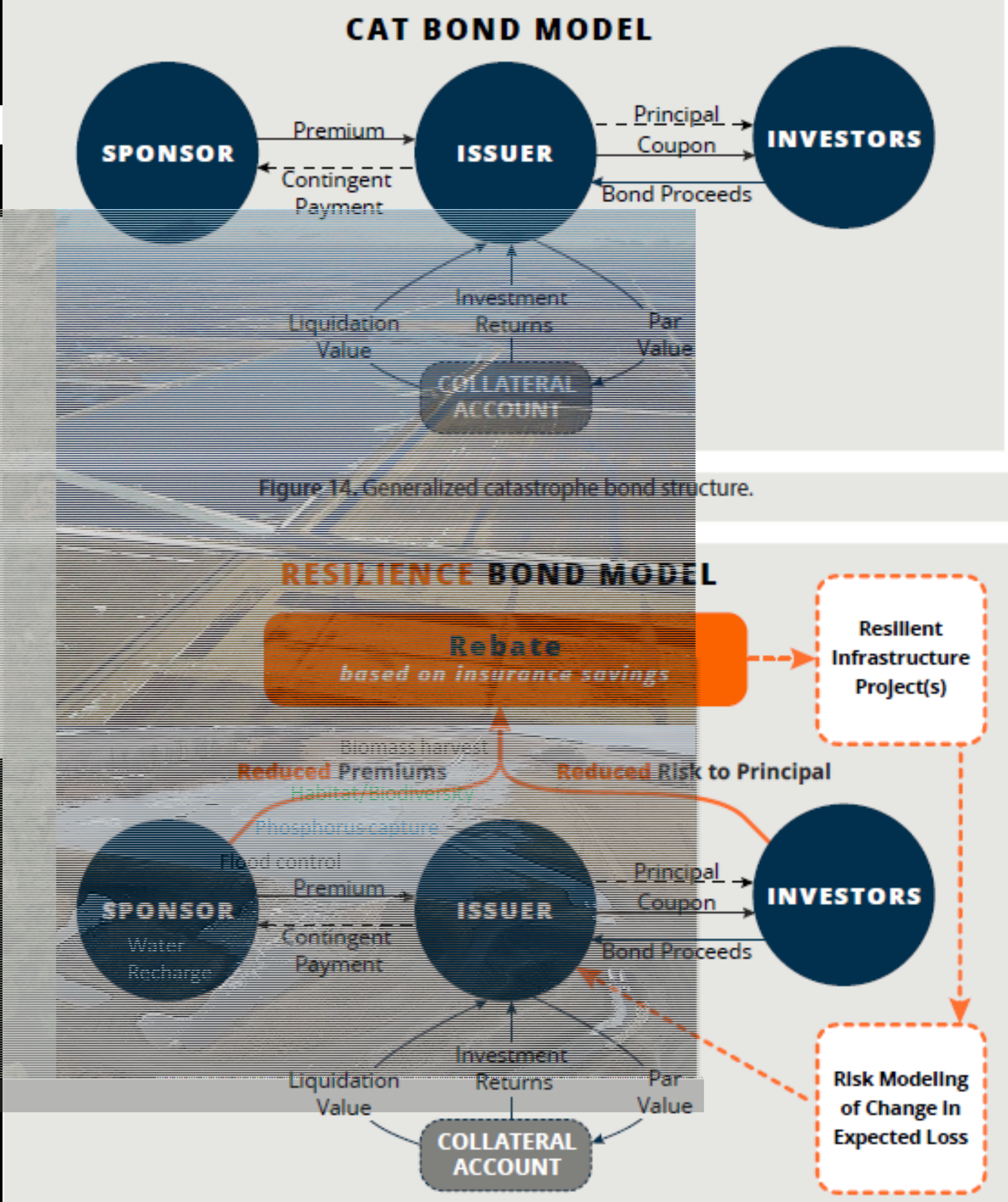


Figure 4. Reduction in modeled losses for alternate levels of protection (RMS, 2015).

Catastrophe Bond to Resilience Bo





Modern Agroclimate Research Centre (under construction)

Basic functions – beta version

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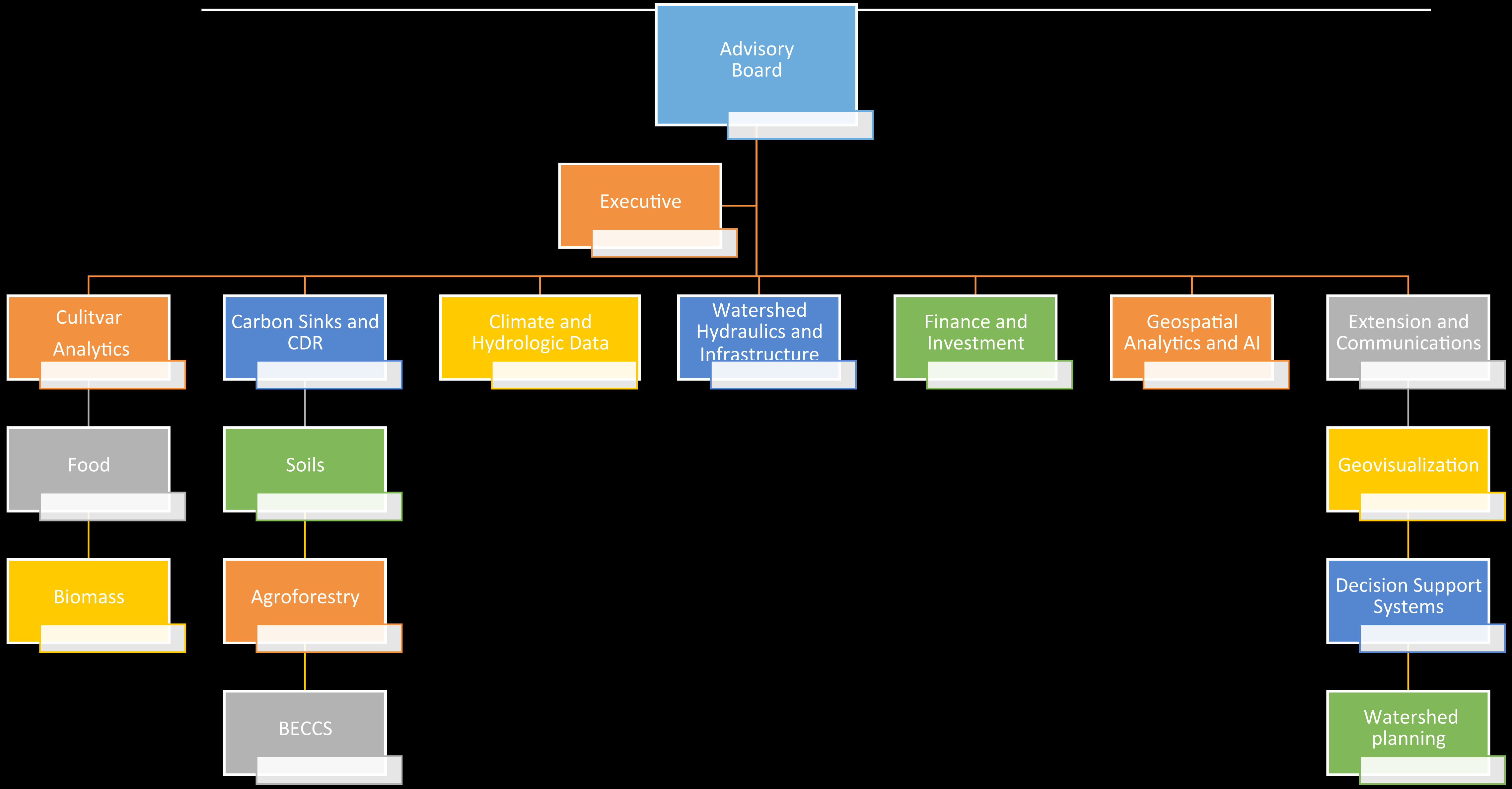

Thank you!

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