Using Ecosystem Services to Design Multifunctional Landscapes

Elena Bennett

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Image credits: http://www.cpl.co.uk/

Image credit: Robert Bateman

Image credit: Firstpeoples.org

Canada's Demands on Ecosystems are Vast

Recreation

Iconic Wildlife and Habitat

Aesthetic Inspiration

Food

Water

Carbon Sequestration

Wildlife for Hunting

Air purification

Soil fertility

Increasing Pressure on Resources

Ecosystem Services:
The benefits people obtain from ecosystems

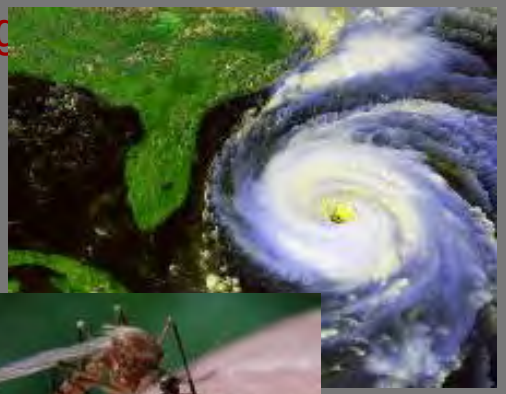
Types of Ecosystem Services

Provisioning

Goods produced or

Regulating

Benefits obtained from reg



Cultural

Non-material b

Credits (left to right, top to bottom): Purdue University, WomenAid.org, LSUP, NASA, unk, CEH Wallingford, unk, W. Reid, Staffan Widstrand

Provisioning Services

Goods produced or provided by ecosystems

Food

- Crops
- Livestock
- Capture Fisheries
- Aquaculture
- Wild Foods

Fiber

- Timber
- Cotton, hemp, silk
- Wood Fuel

Genetic resources

Biochemicals

Freshwater

Photo credit (top): Tran Thi Hoa (World Bank,

Regulating Services

Benefits obtained from regulation of ecosystem processes

- Air Quality Regulation
- Climate Regulation
  - Global (CO_2 sequestration)
  - Regional and local
- Erosion regulation
- Water purification
- Disease regulation
- Pest regulation
- Pollination
- Natural Hazard regulation

Cultural Services

Non-material benefits obtained from ecosystems

Spiritual and Religious Values
Knowledge Systems
Educational values
Inspiration
Aesthetic Values
Social Relations
Sense of Place
Recreation and Ecotourism

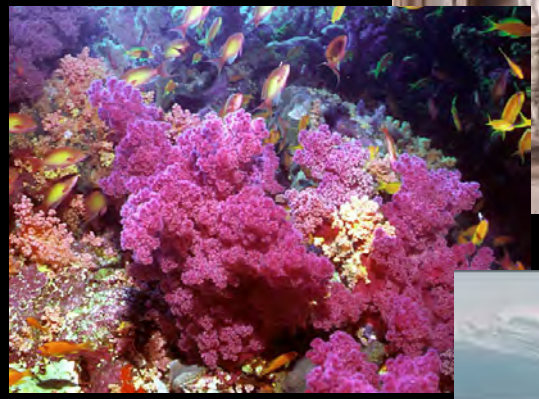
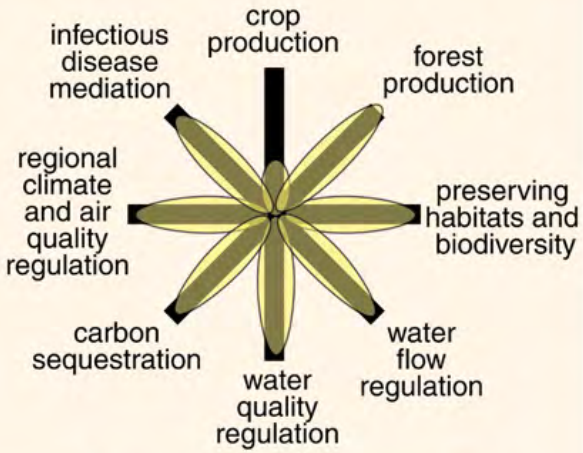
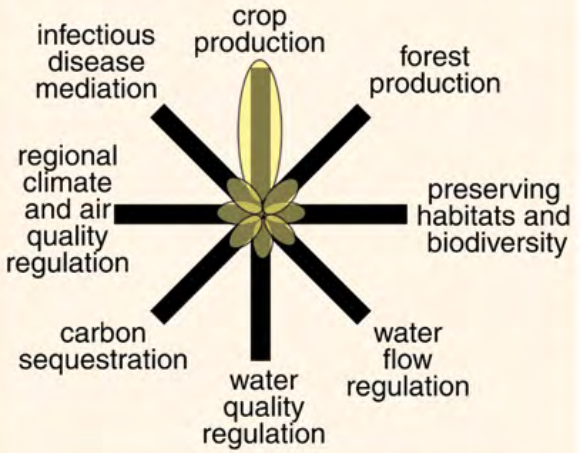


Photo credits (top to bottom): W. Reid, Mary Frost, Staffan Widstrand, unknown.

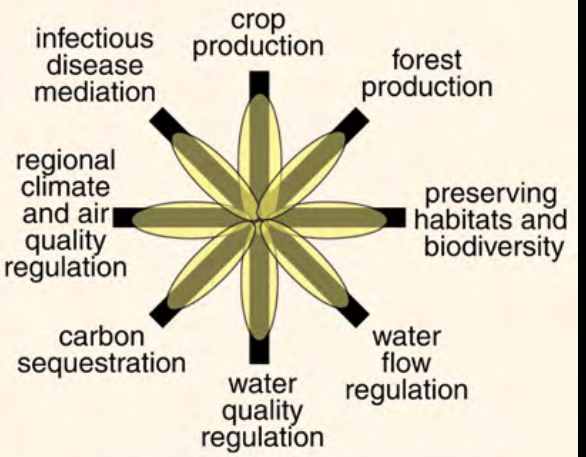
Ecosystems Provide Multiple Services



natural ecosystem



intensive cropland



cropland with restored ecosystem services

But we typically manage them as if they provide only one….

Millennium Ecosystem Assessment

Over the past 50 years,
humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history…

to meet growing demands
for food, fresh water,
fiber, and energy.

Photo: Dick Lathrop

Photo: Julia DeJoseph

Ecosystem Service Trade-offs

GLOBAL TRENDS

Provisioning services
e.g. crops, timber…

↗

Regulating services
e.g. flood, erosion control…

↘

Cultural services
e.g. education, tourism…

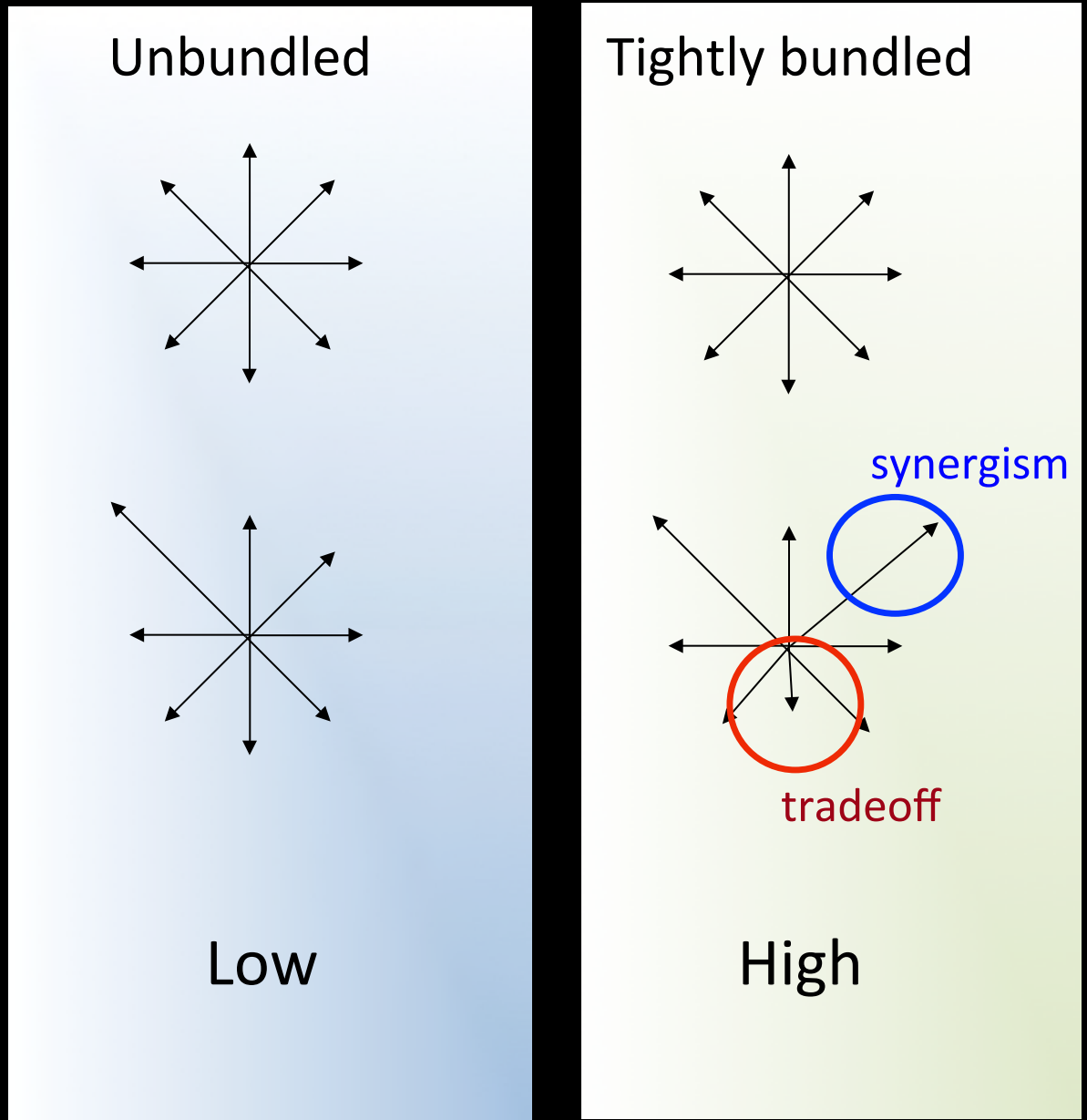
+/-

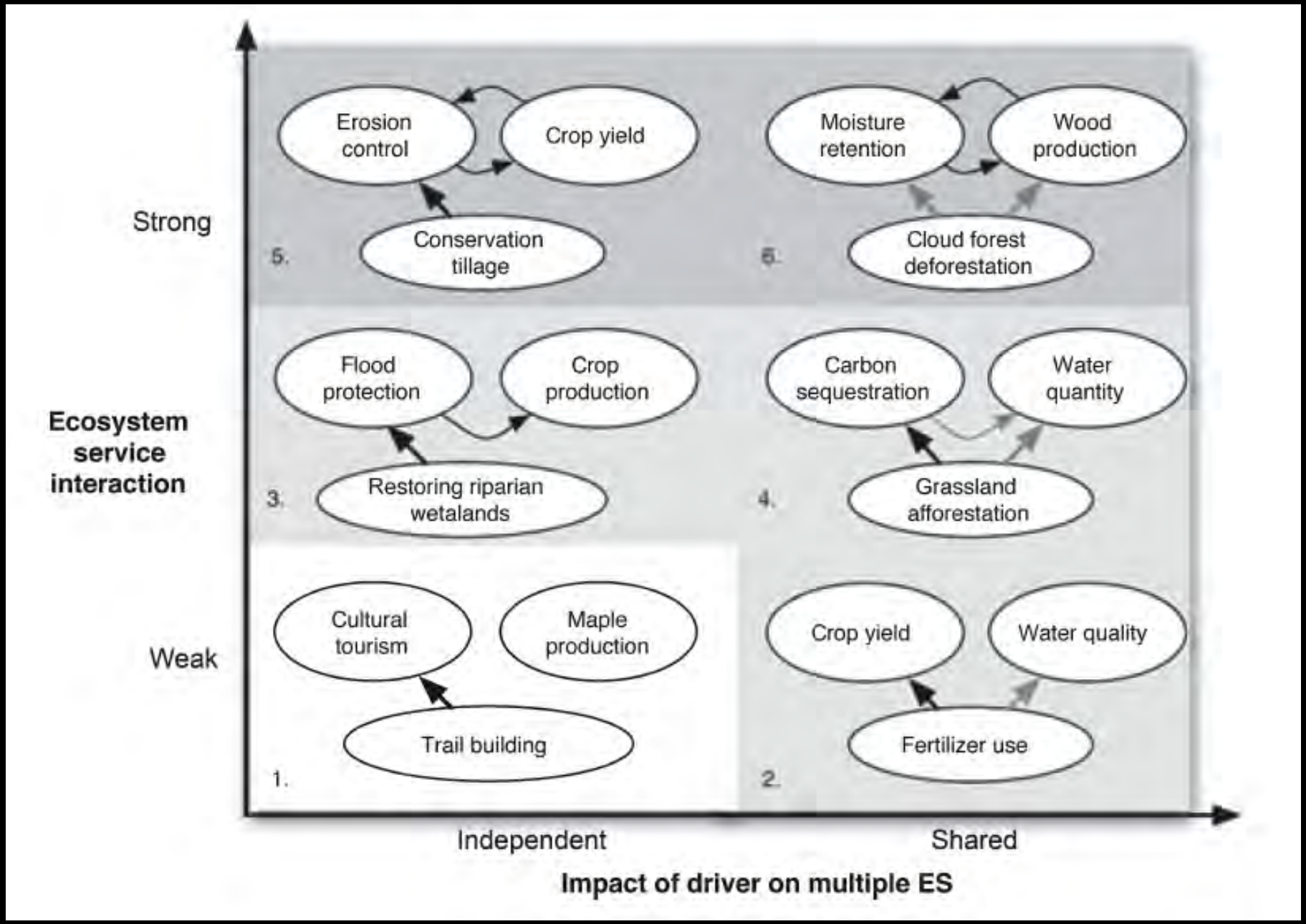
Millennium Ecosystem Assessment 2005

Managing ecosystem services

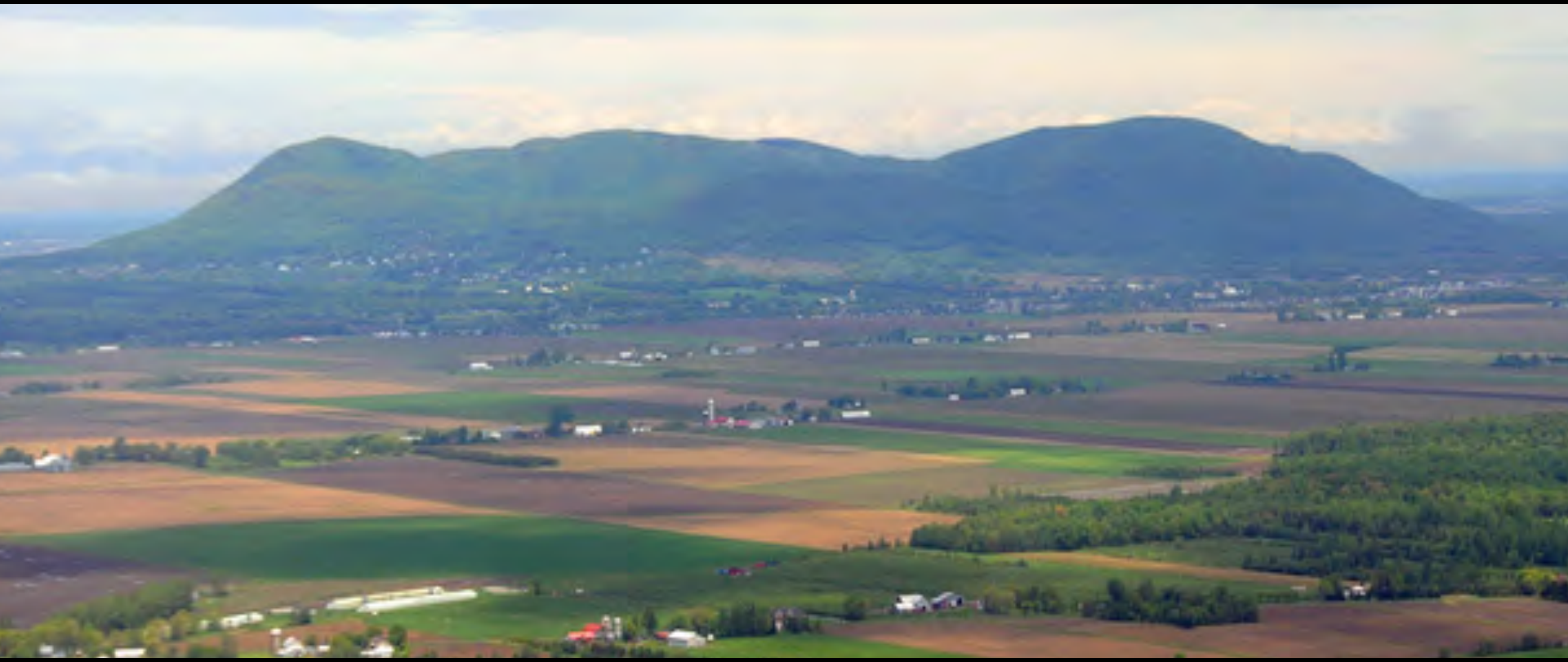
- Demand for all types of ecosystem services increasing
- Trade-offs are common between provisioning and other ecosystem services
- We may be able to alter trade-offs by focusing on the processes that link services
- Ignoring dynamics may increase the risk of regime shifts in which sudden, unexpected, and often unwanted changes in ecosystem services are experienced

Ecosystem Service Interactions

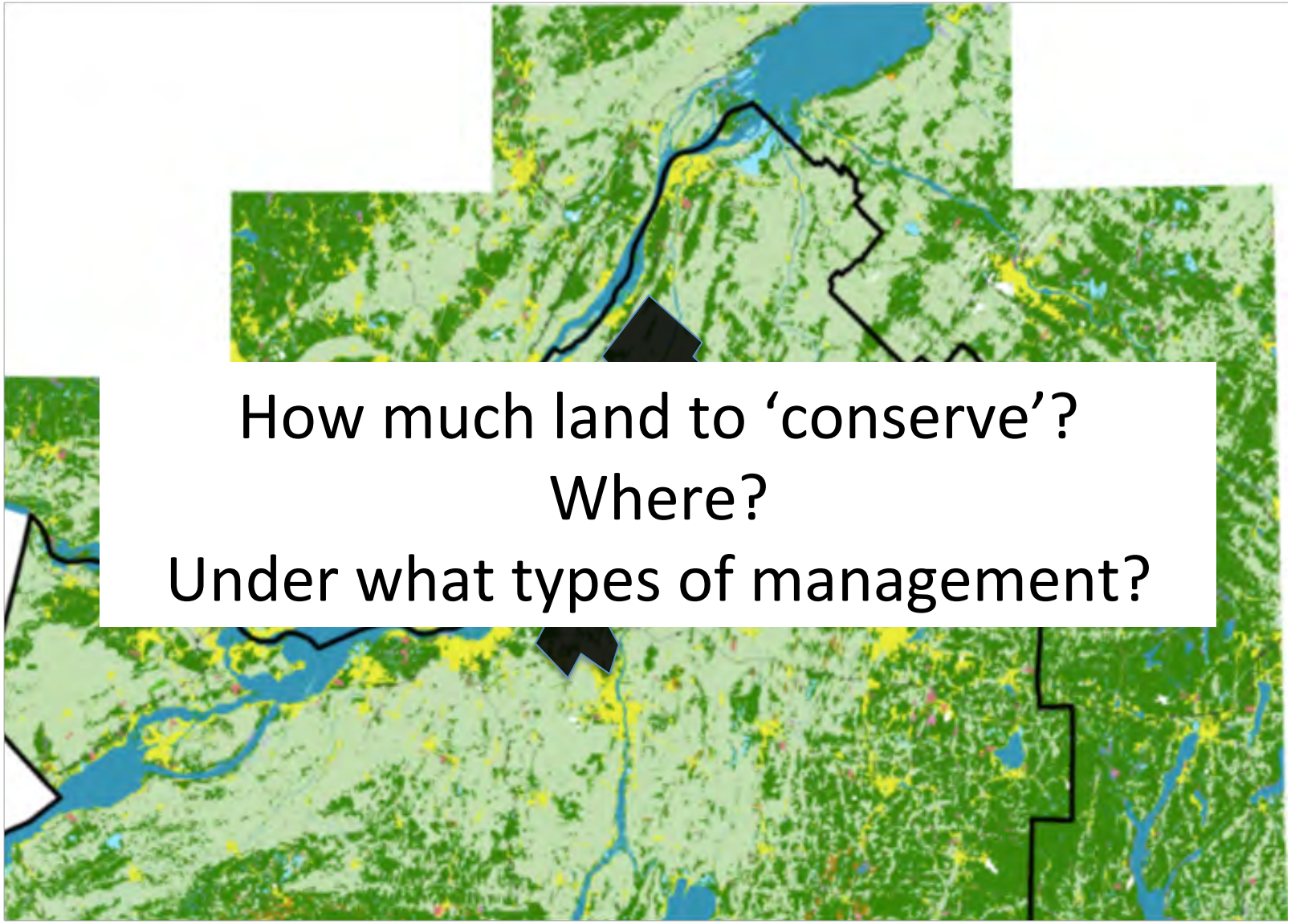




Bennett, Peterson, Gordon 2009. Ecology Letters



The Montérégie & The Vallée du Richelieu MRC



Biodiversity and conservation arguments alone are NOT answering the questions

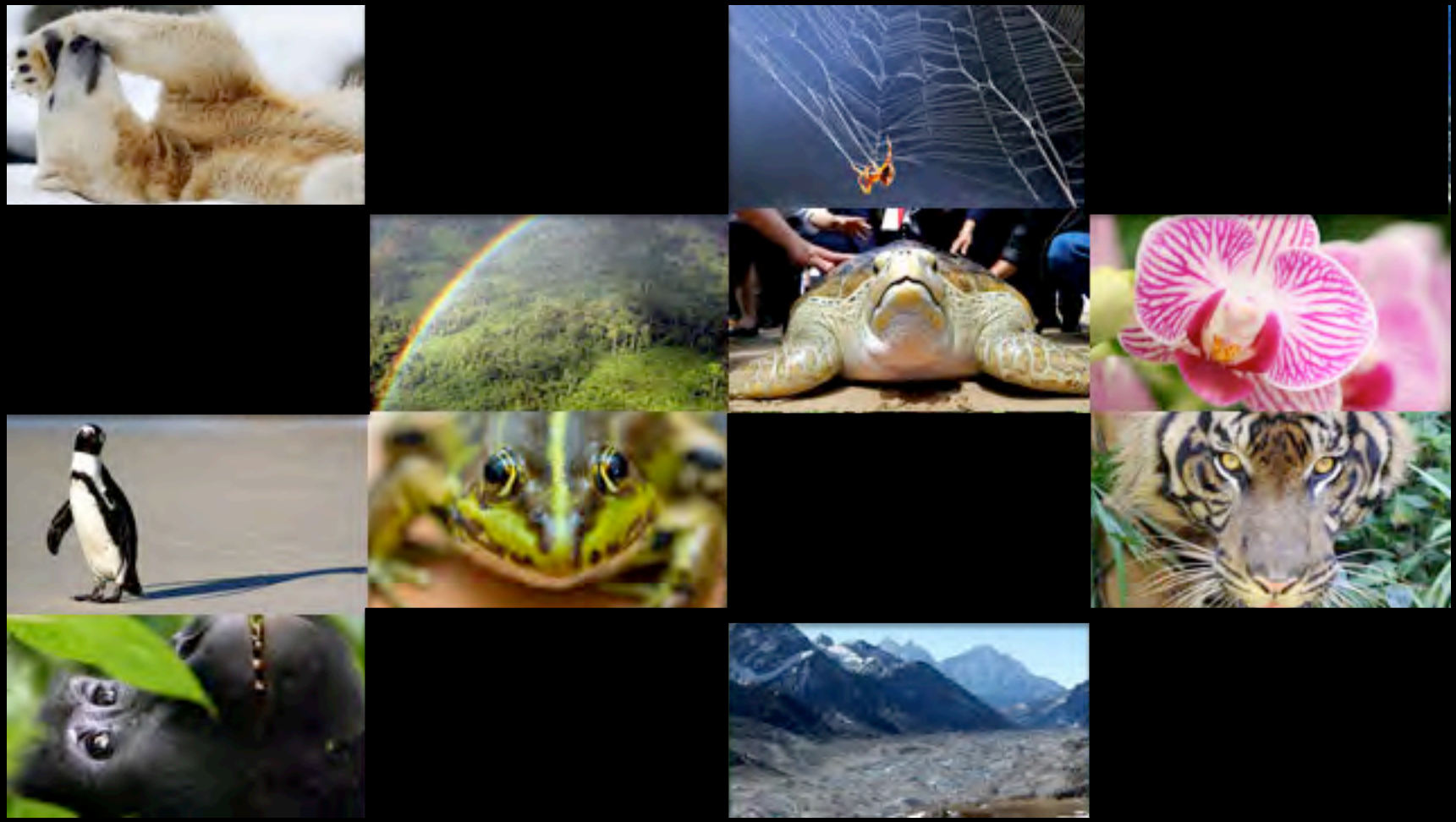
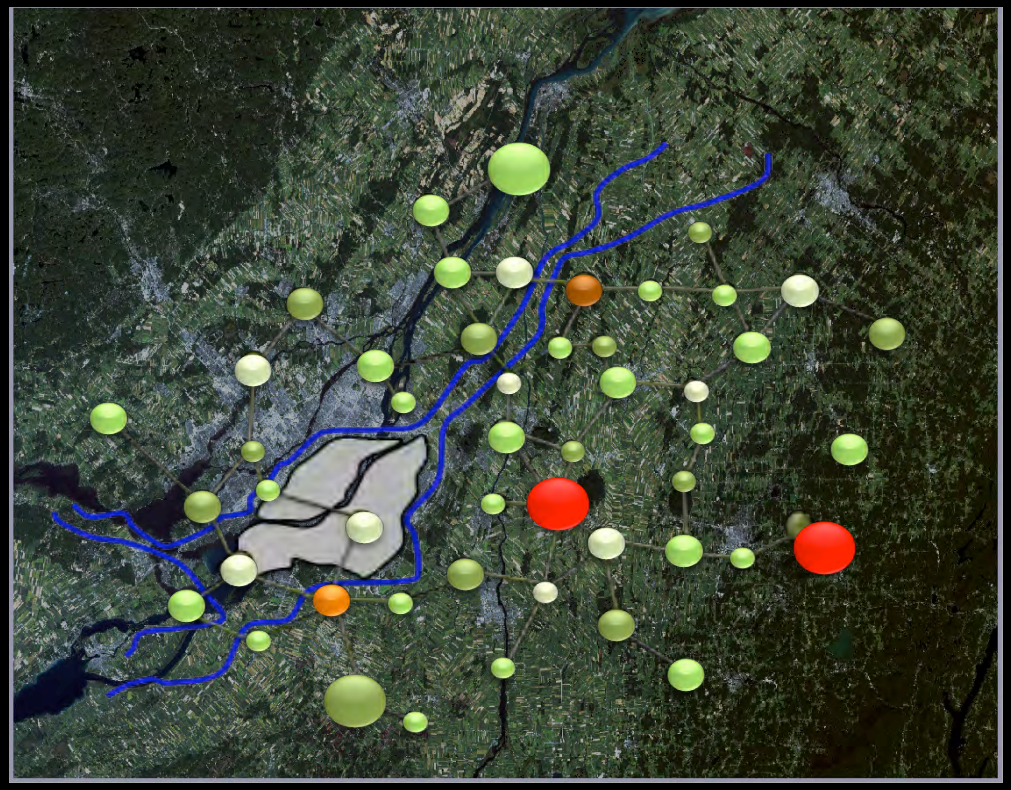
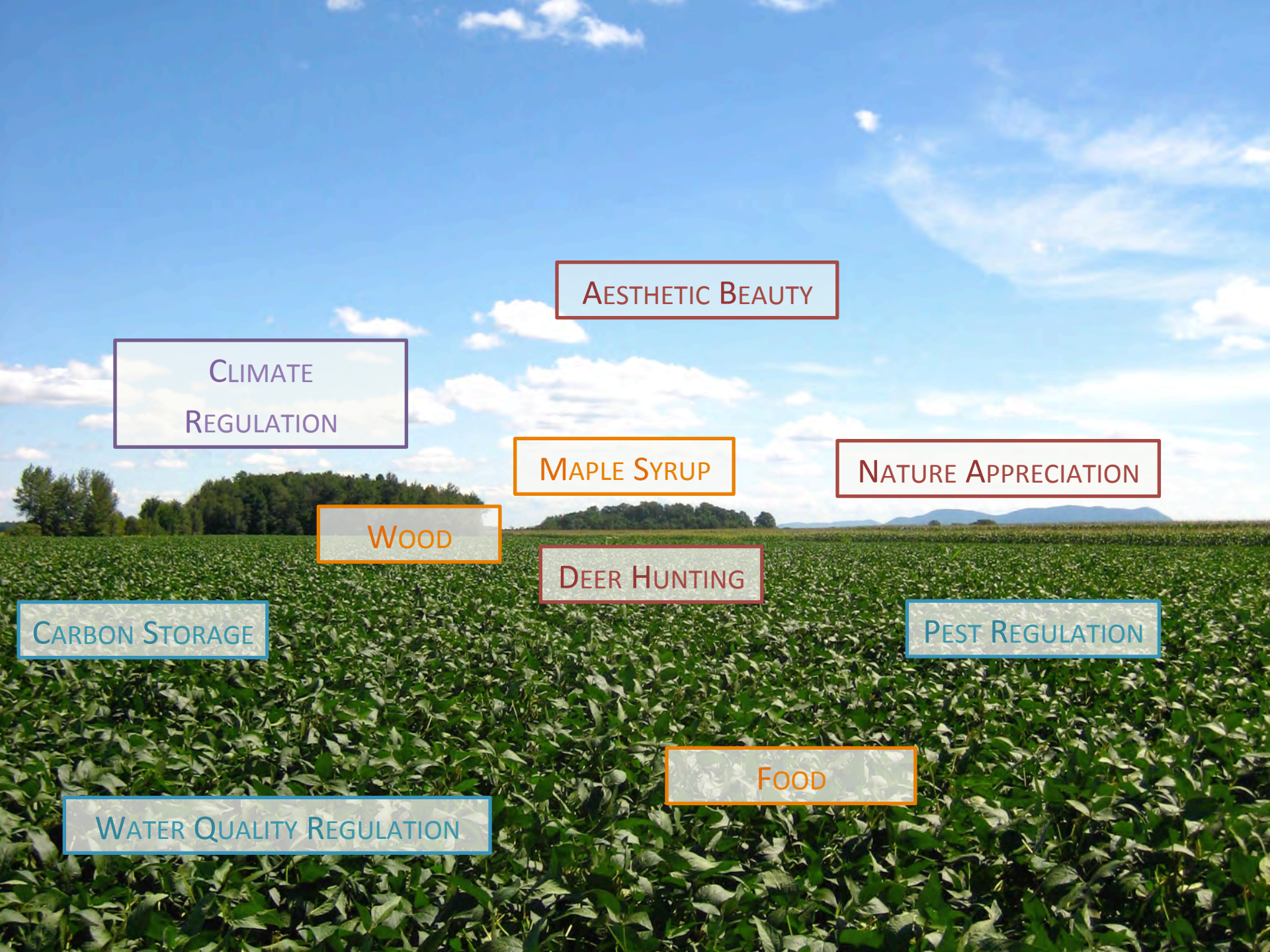


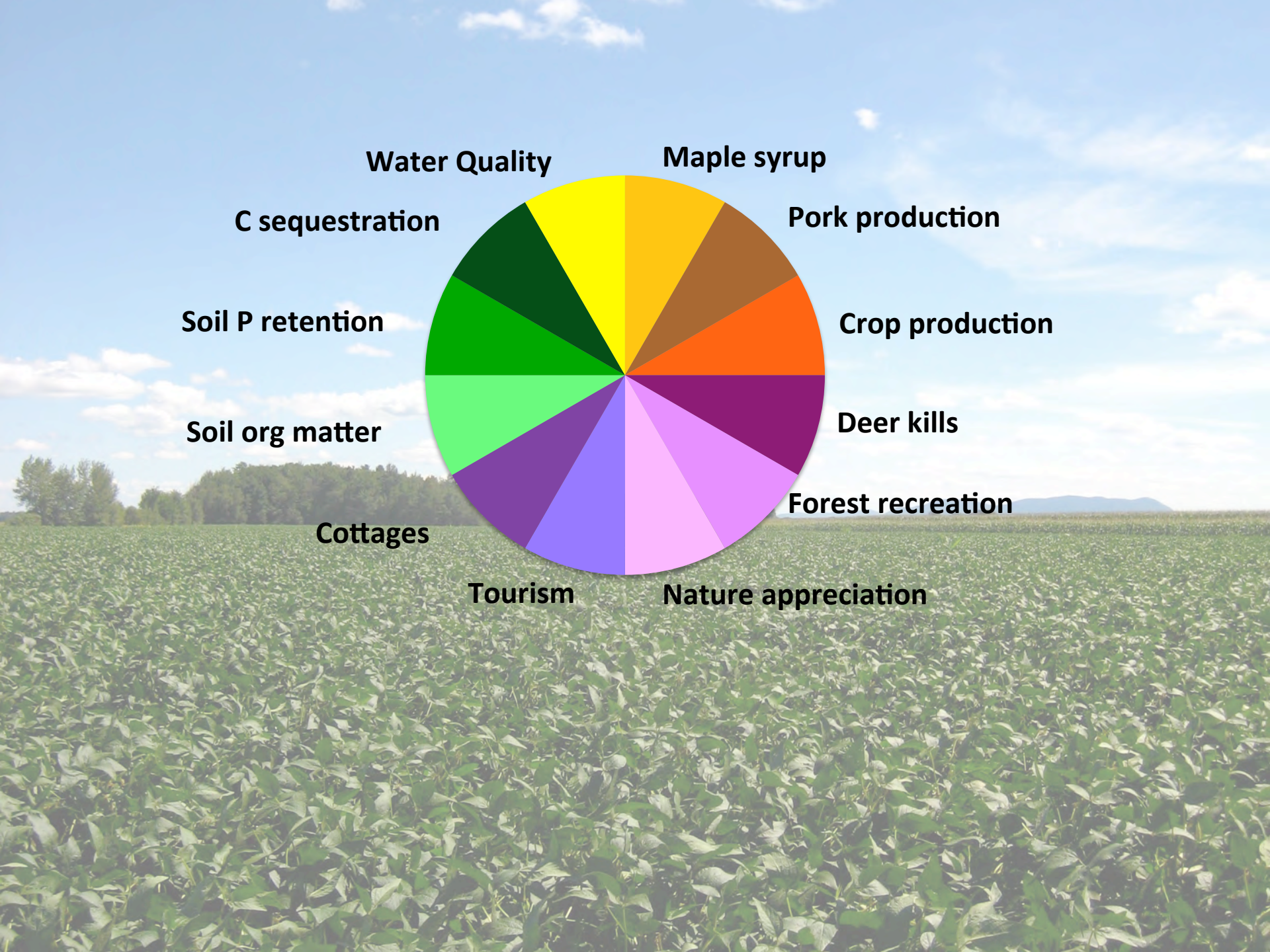
Image: Getty Images via CNN

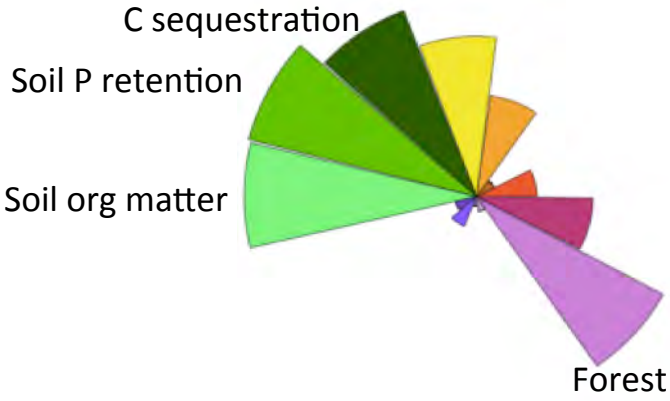
Goal: Communities making proactive decisions to design a resilient, multi-functional landscape

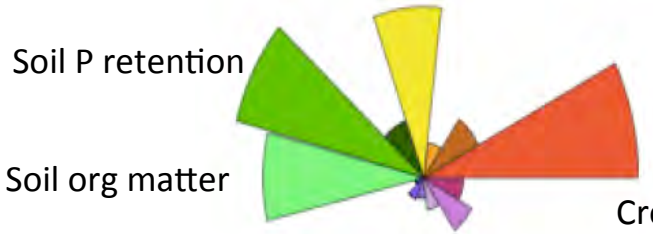
How: Understand ecosystem service interactions & how they are affected by landscape configuration and management

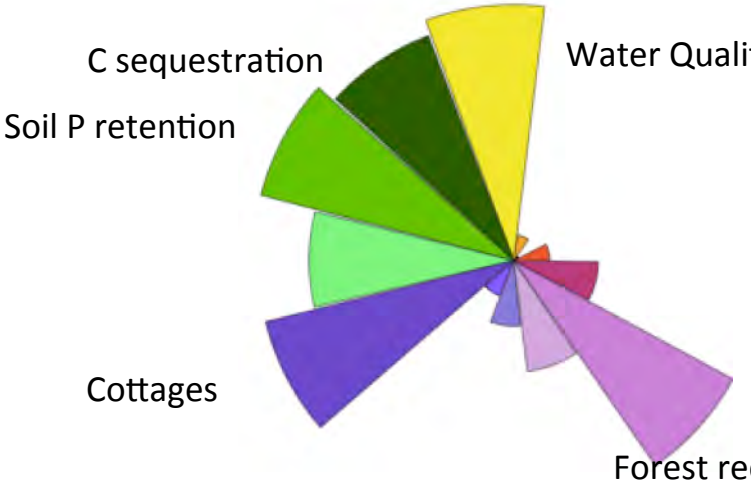



Aesthetic Beauty
Climate Regulation
Maple Syrup
Nature Appreciation
Wood
Deer Hunting
Carbon Storage
Pest Regulation
Food
Water Quality Regulation


Water Quality
Maple syrup
C sequestration
Pork production
Soil P retention
Crop production
Soil org matter
Deer kills
Forest recreation
Cottages
Tourism
Nature appreciation


C sequestration
Soil P retention
Soil org matter
Forest recreation


Soil P retention
Soil org matter
Crop production


C sequestration
Water Quality
Soil P retention
Cottages
Forest recreation

THE WHAT IF MACHINE

$$f_x \approx \frac{f(x_0 + 1) - f(x_0 - 1)}{2}$$

$$f_y \approx \frac{f(y_0 + 1) - f(y_0 - 1)}{2}$$

$$f_{xx} \approx \frac{f(x_0 - 1) - 2f(x_0) + f(x_0 + 1)}{4}$$

Managing and planning agro-ecosystems to optimize the provision of multiple ecosystem services

Our Advisory Committee

Develop Future Scenarios

Work with local communities to develop scenarios and quantify ES outcomes of these scenarios

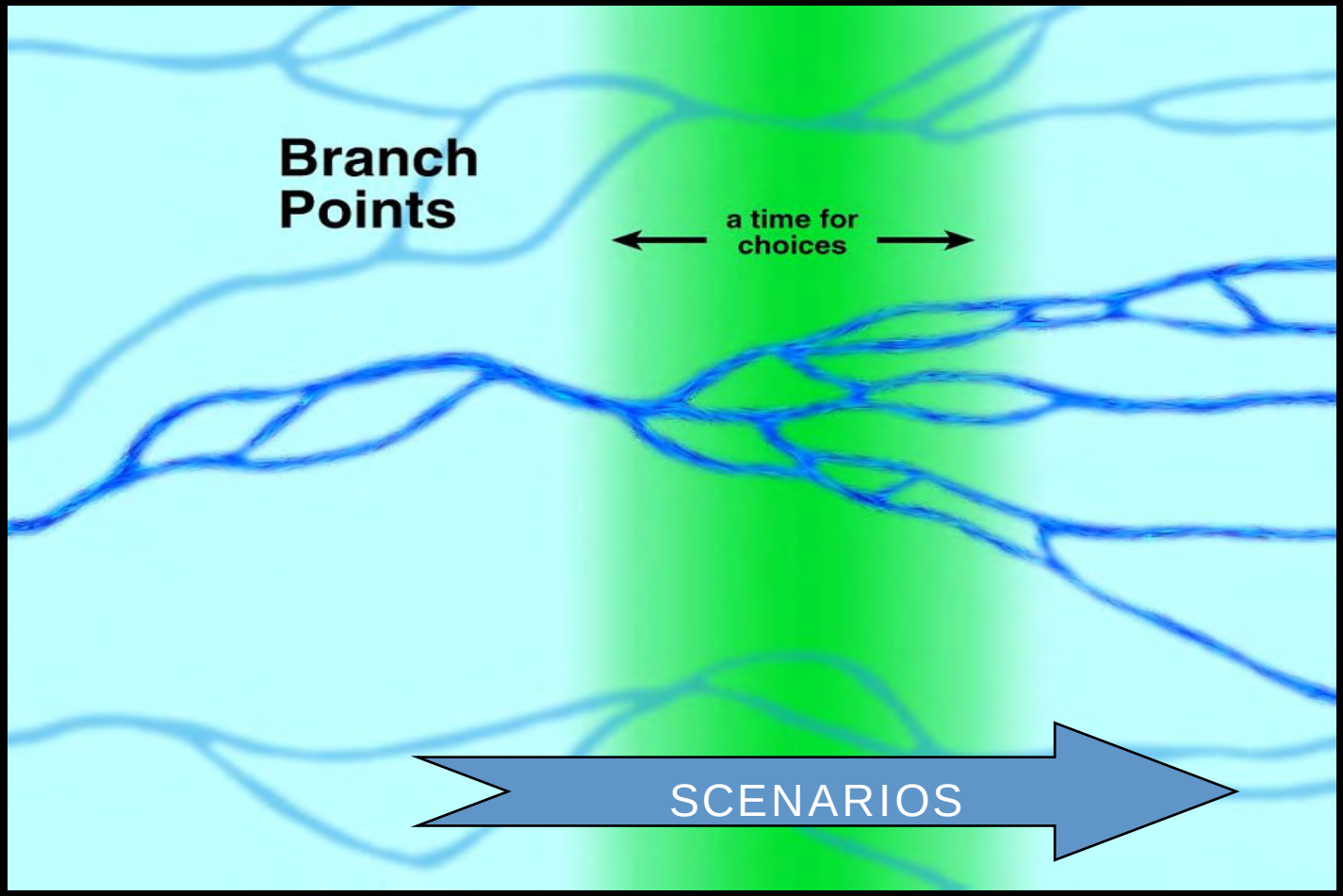
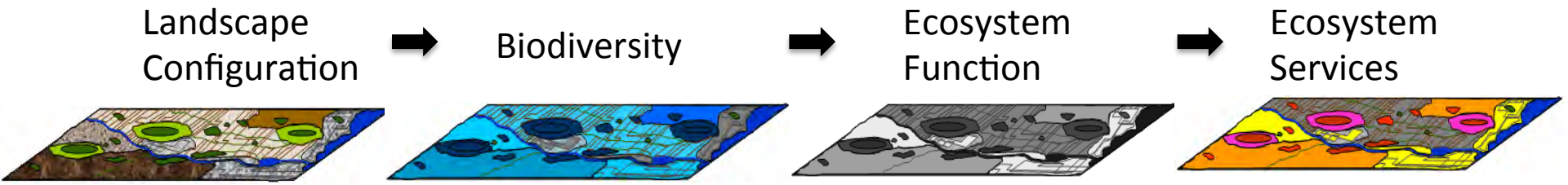


Image courtesy of Paul Raskin


PURIFICATION DE L'EAU
ACTIVITÉS DE CHASSE ET PÊCHE
POLLINISATION
PRODUCTION DE BOIS
BIODIVERSITÉ
PRODUCTION D'EAU POTABLE
Développement des filières locales et circuits courts
MAÏS ÉTHANOL
MAÏS ÉTHANOL
10-30
23
33
20
116
112

The role of landscape configuration in provision of ecosystem services



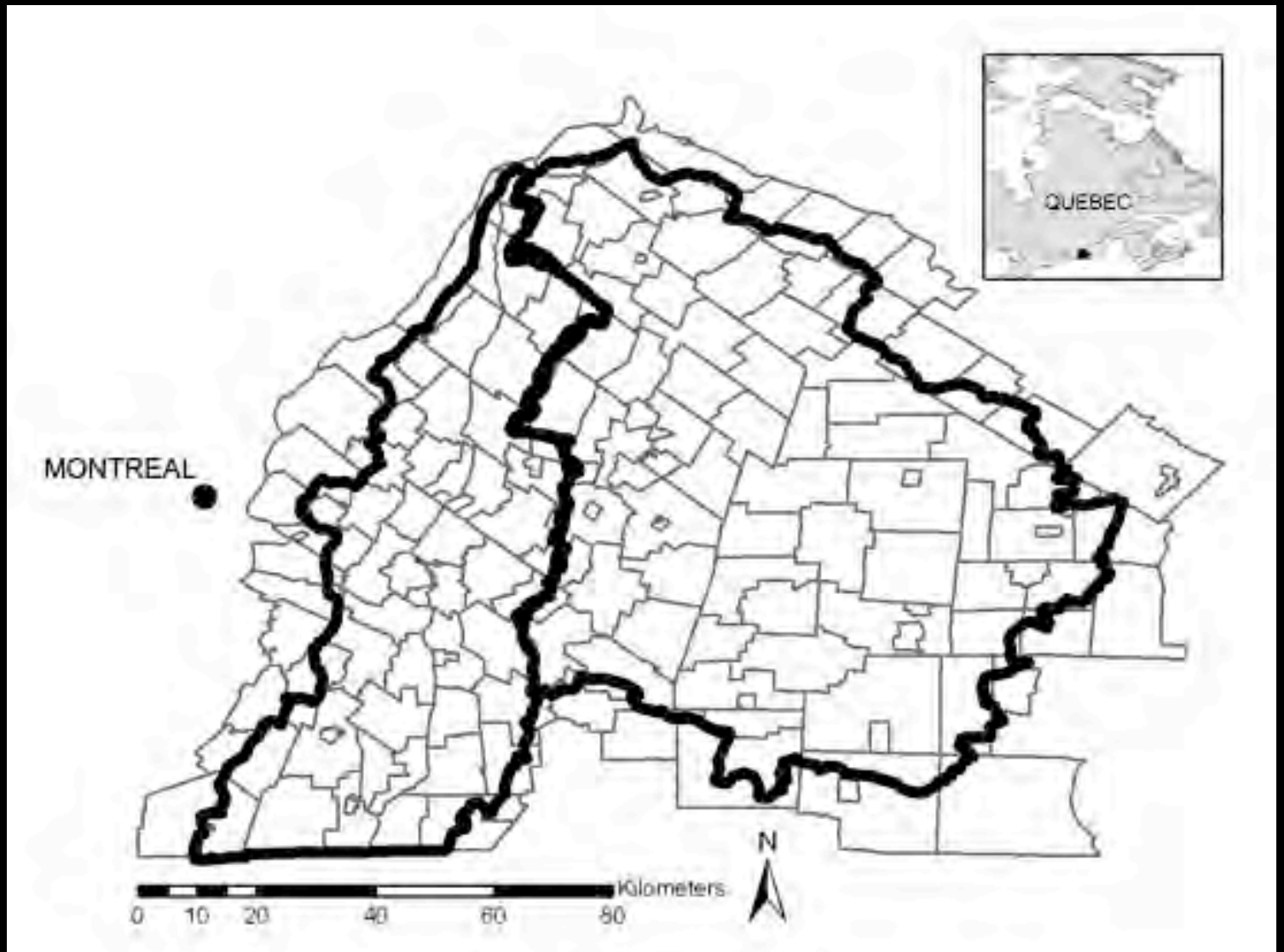
Could we use this to build
better multi-functional landscapes?

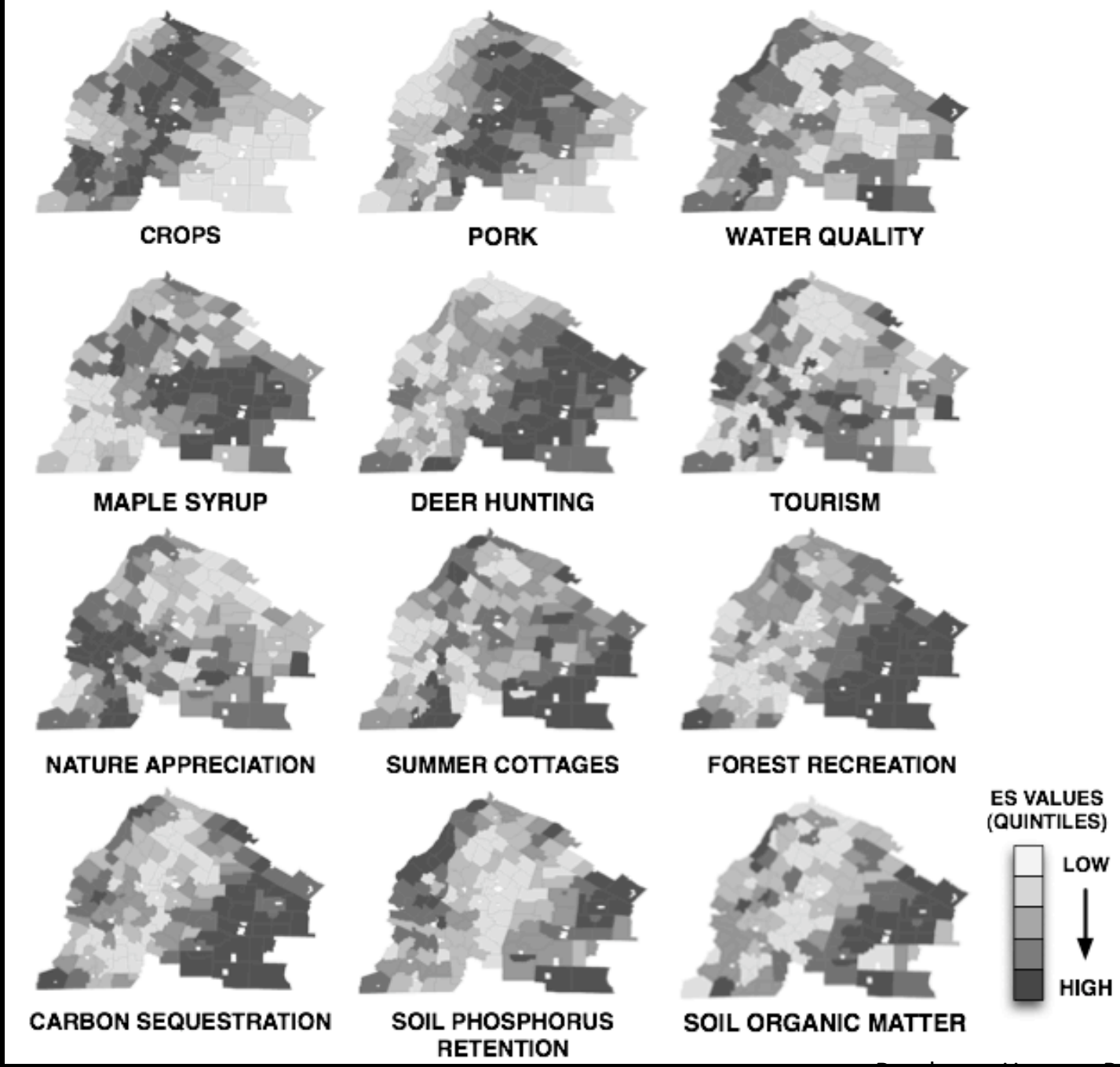
Richelieu

- 2 506 Km2
- 54 municipalities
- Pop: 349 500

Yamaska

- 4 782 Km2
- 90 municipalities
- Pop: 250 000




CROPS
PORK
WATER QUALITY
MAPLE SYRUP
DEER HUNTING
TOURISM
NATURE APPRECIATION
SUMMER COTTAGES
FOREST RECREATION
CARBON SEQUESTRATION
SOIL PHOSPHORUS RETENTION
SOIL ORGANIC MATTER
ES VALUES (QUINTILES)
LOW
HIGH

Pigs and Crops

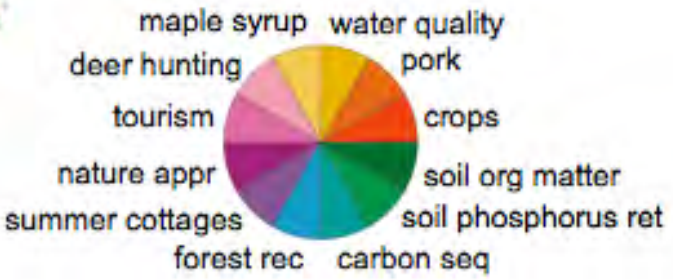
Cropland

Exurban

Cottages

Villages

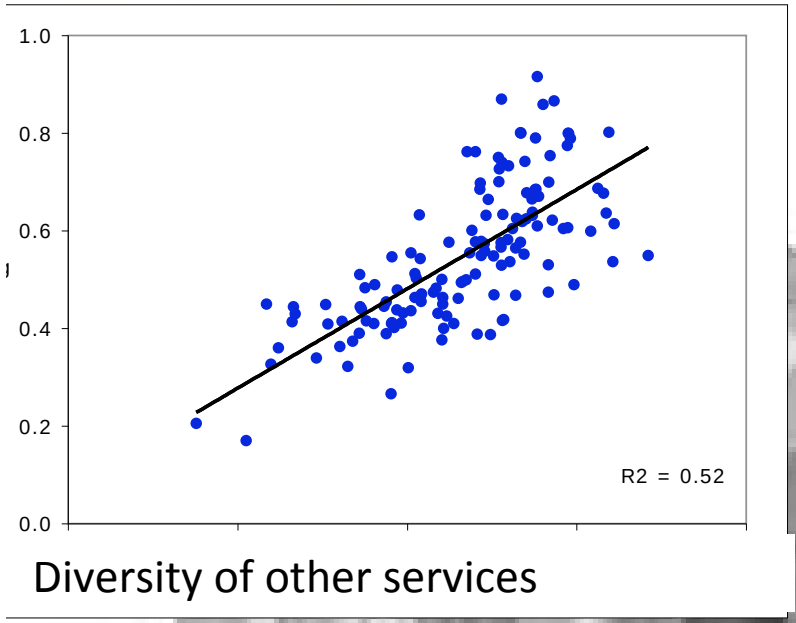
Tourism

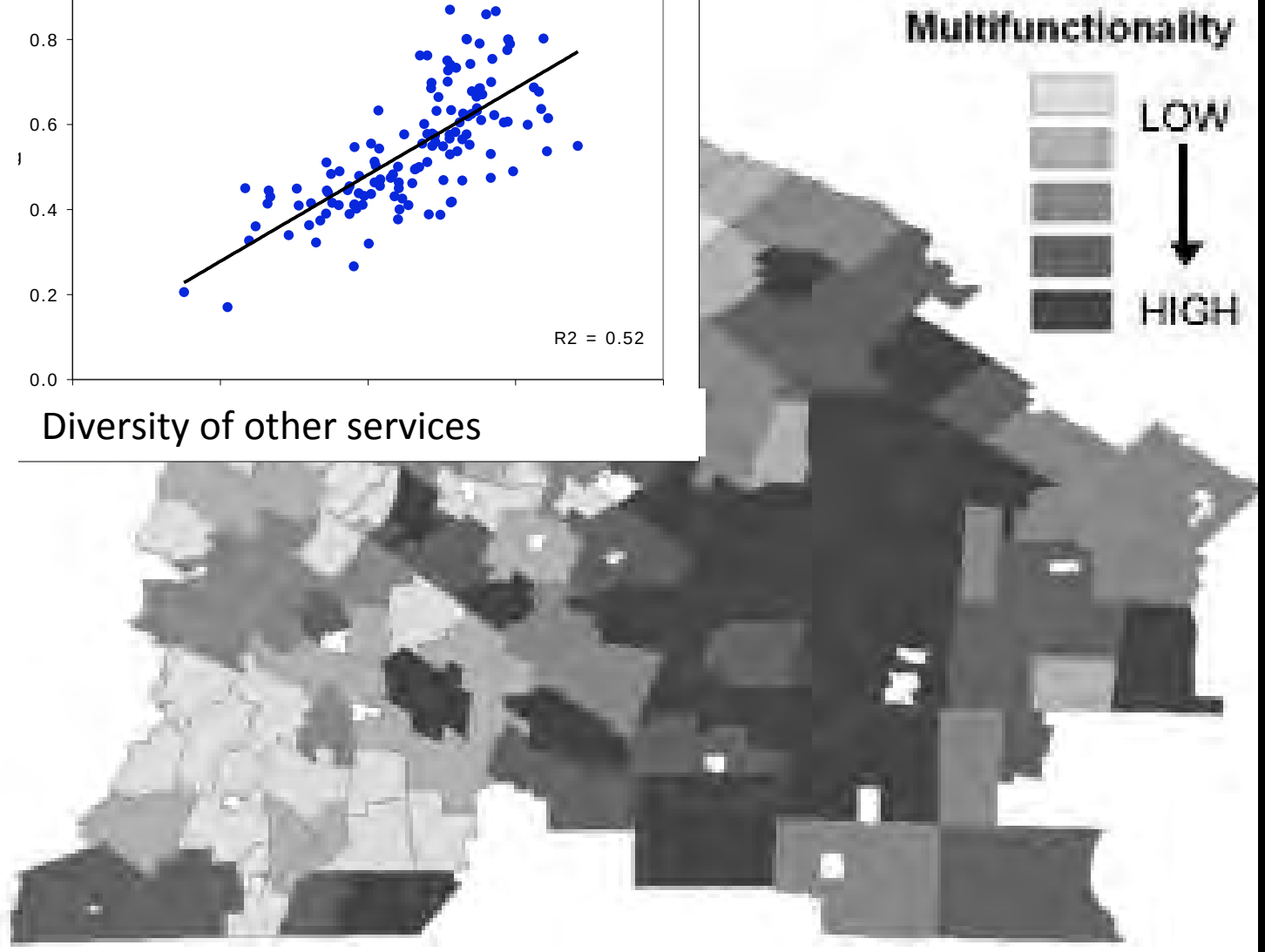


Raudsepp-Hearne, Peterson, Bennett 2010 PNAS

Multi-functional landscapes associated with supply of regulating services

Average regulating service provided





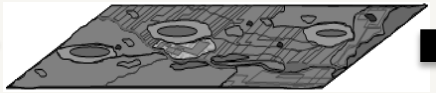
Land use and land cover

Forest
Agriculture
Rivers
Riparian buffers

Biodiversity

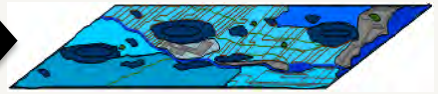
Herbivorous insects
Microorganisms
Trees
Bees

Ecosystem Function



Herbivory
Decomposition
Microbial activity

Ecosystem Services



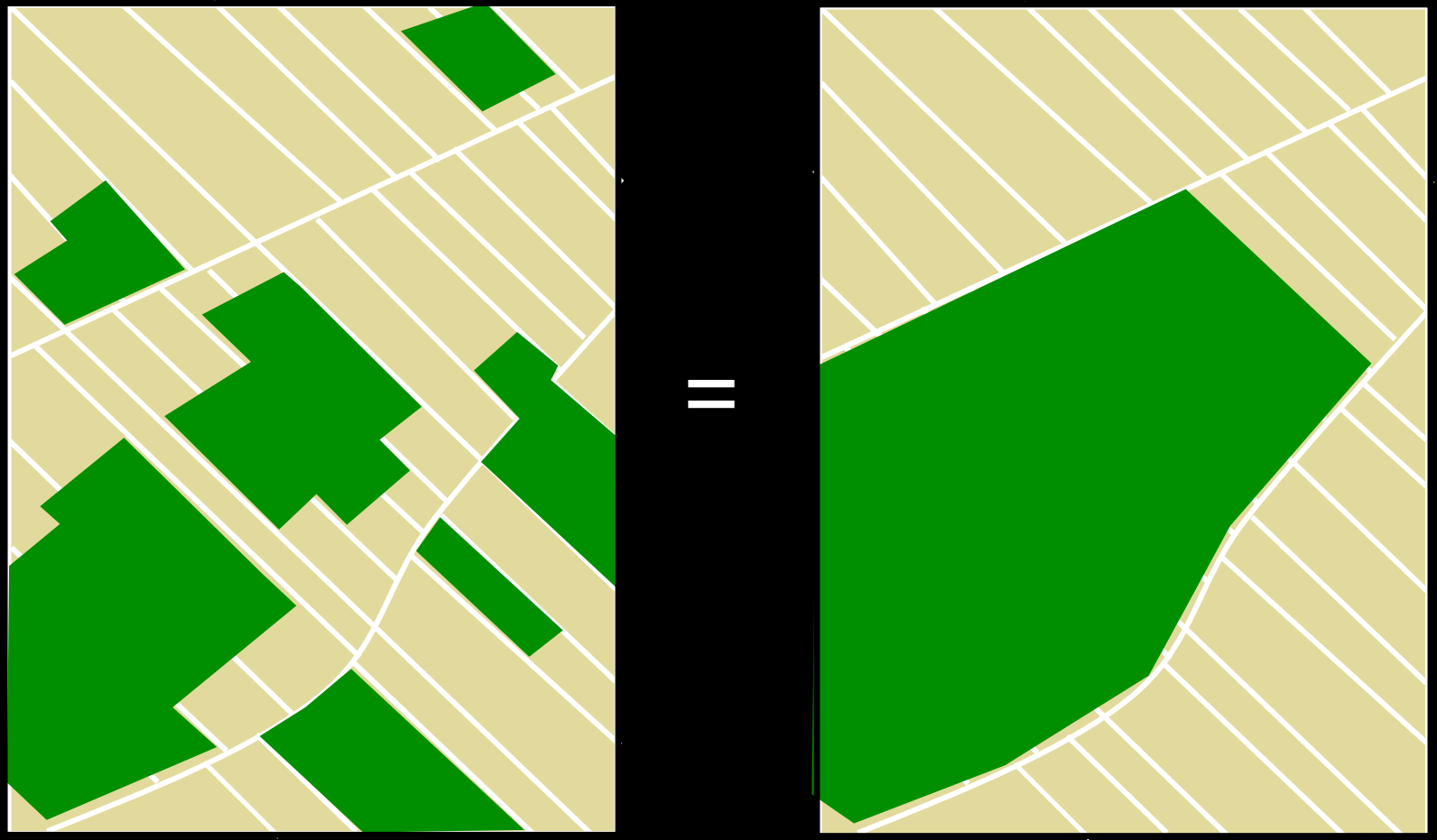
Food
C storage
Pollination
High quality water



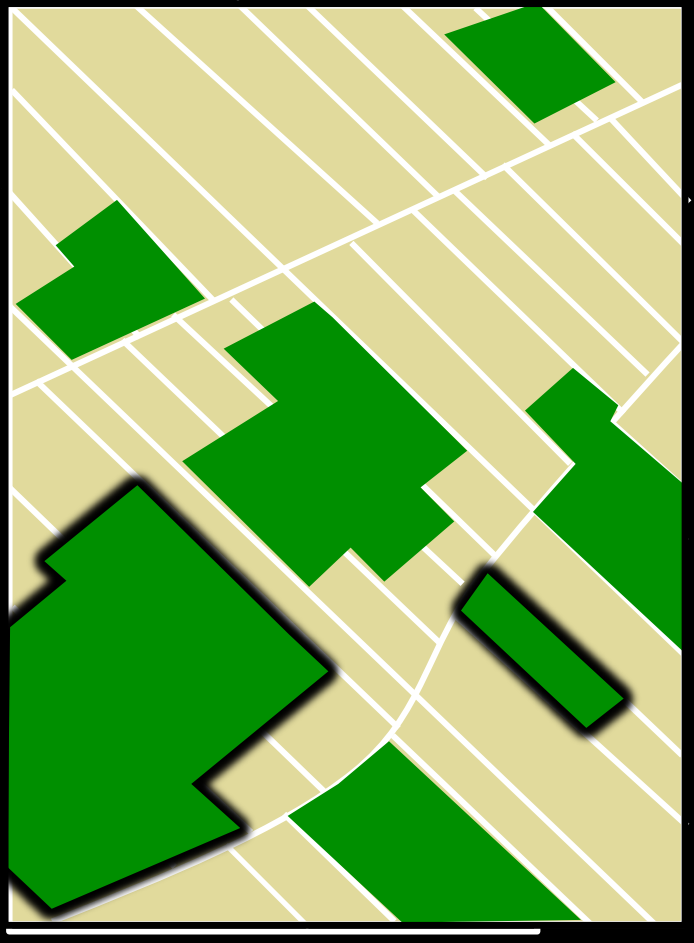



Biodiversity, Ecosystem Services, Connectivity

Tree Diversity, Carbon Storage, Forest Fragmentation

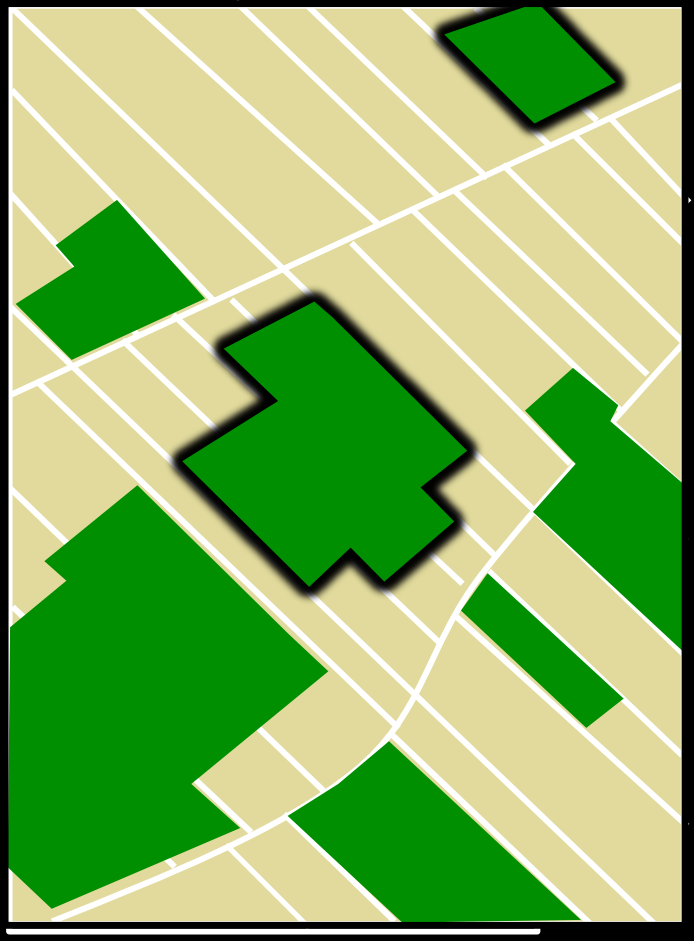


Tree Diversity, Carbon Storage, Forest Fragmentation



Area effects

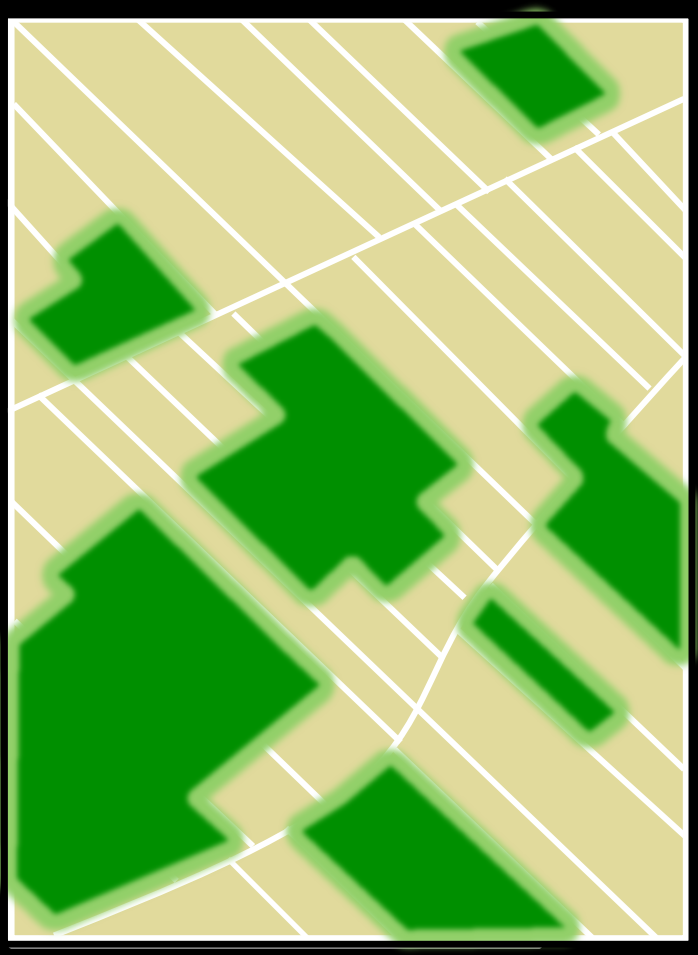
Tree Diversity, Carbon Storage, Forest Fragmentation



Area effects

Isolation effects

Tree Diversity, Carbon Storage, Forest Fragmentation

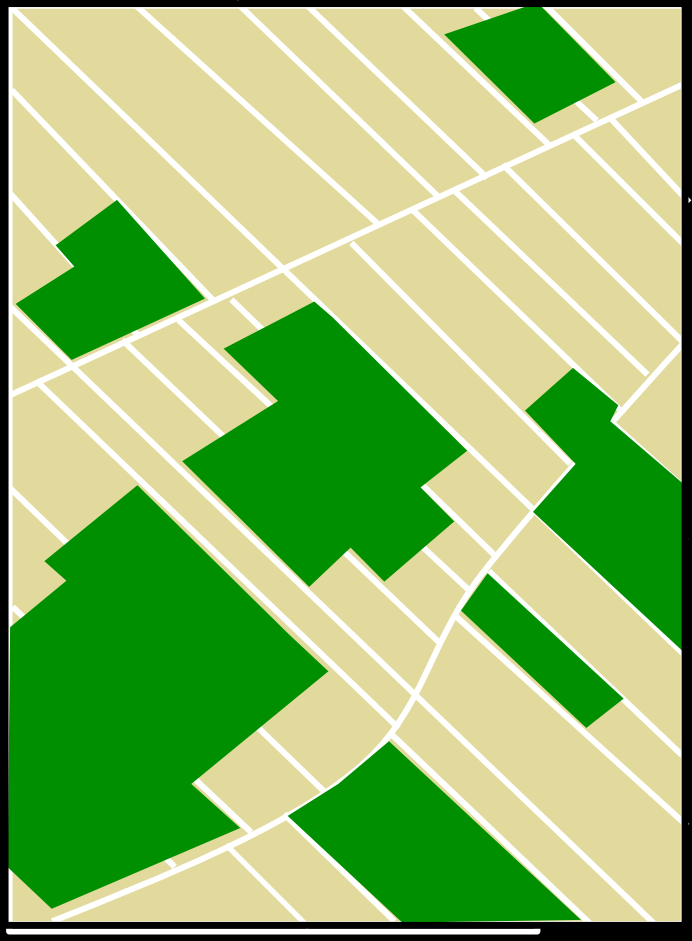


Area effects

Isolation effects

Edge effects

Tree Diversity, Carbon Storage, Forest Fragmentation



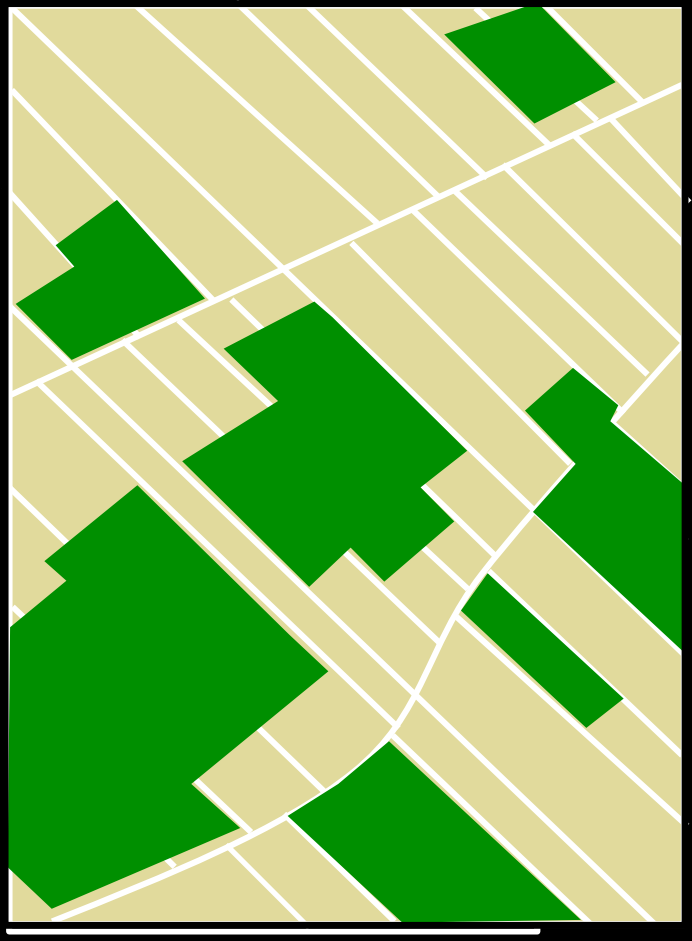
Area effects

Isolation effects

Edge effects

Management

By ignoring the potential effects of fragmentation, we risk over- or under-estimating landscape level carbon stocks



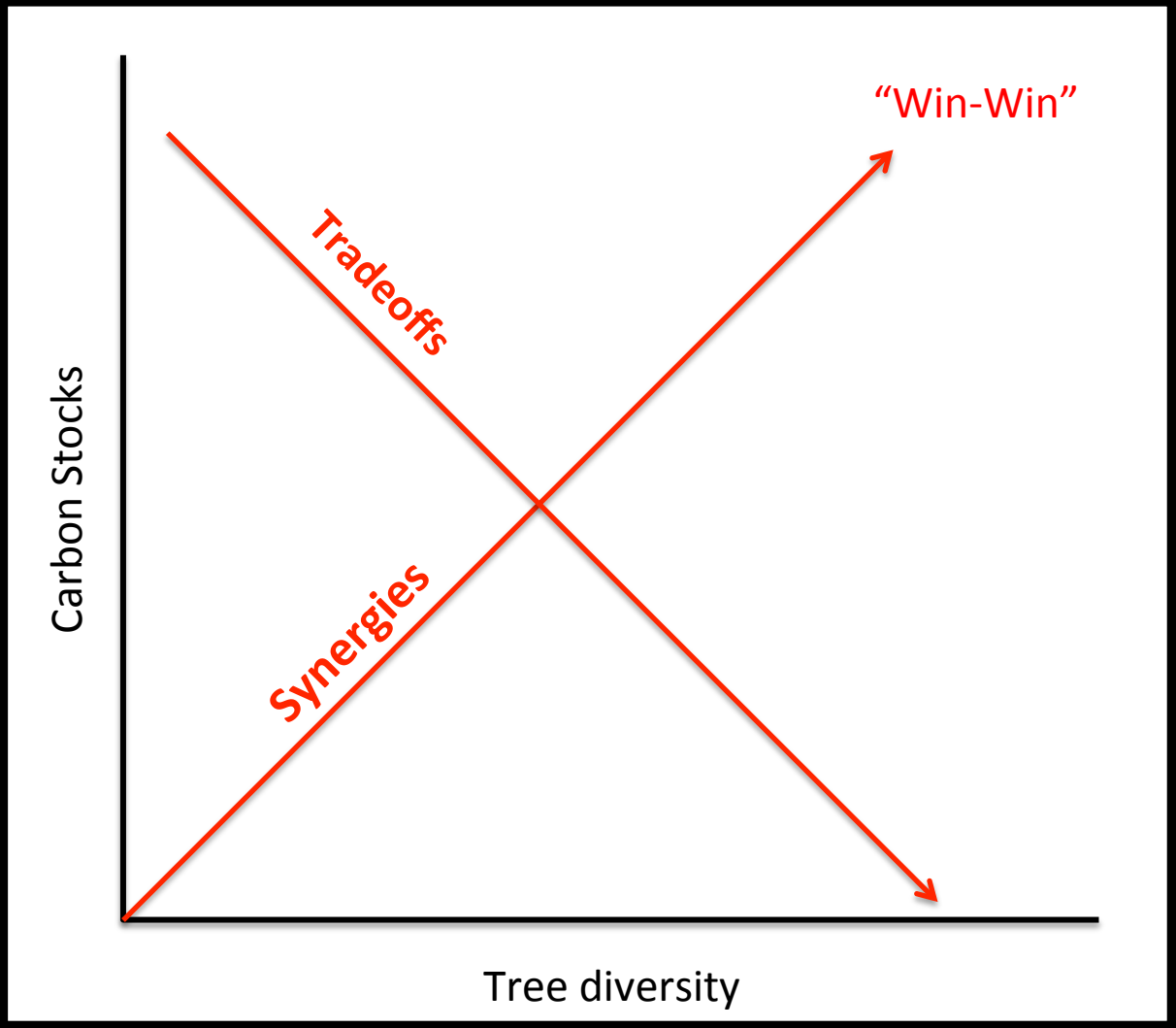
Area effects

Isolation effects

Edge effects

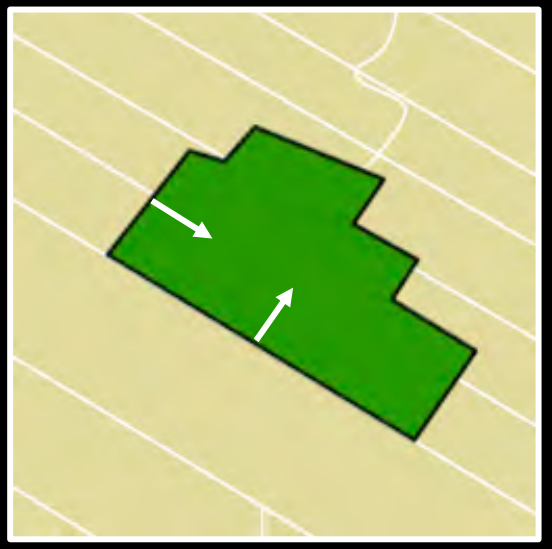
Management

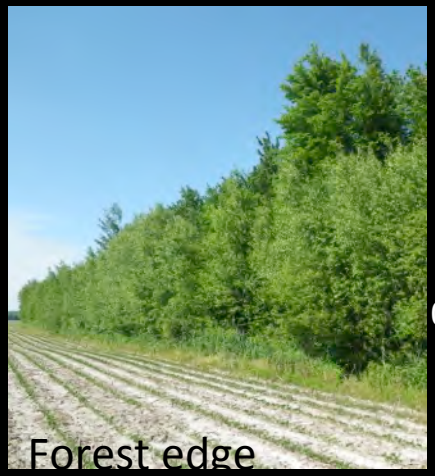
Are there synergies or tradeoffs, between biodiversity and carbon storage? What role does fragmentation play?

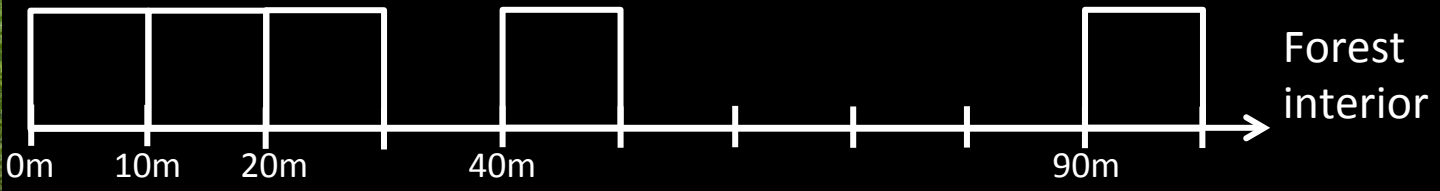


Two 100m transects were established within each fragment

x 24 fragments = 48 transects








Not managed

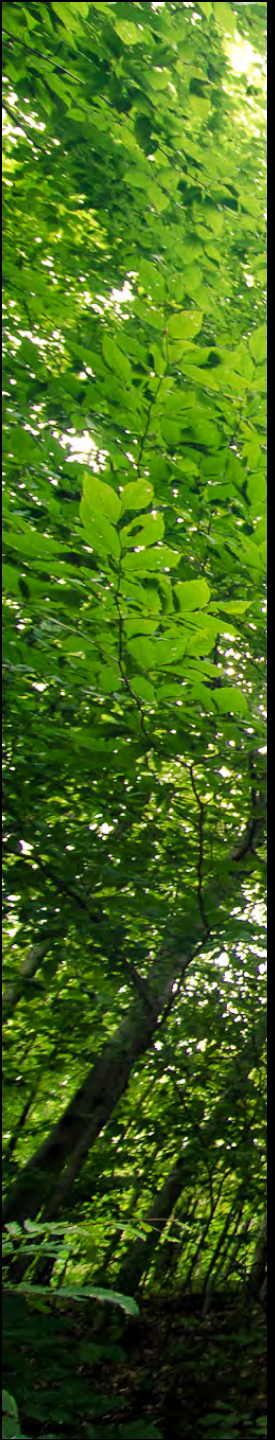

Managed

11 570 trees, 52 species, 5450 pieces of woody debris!

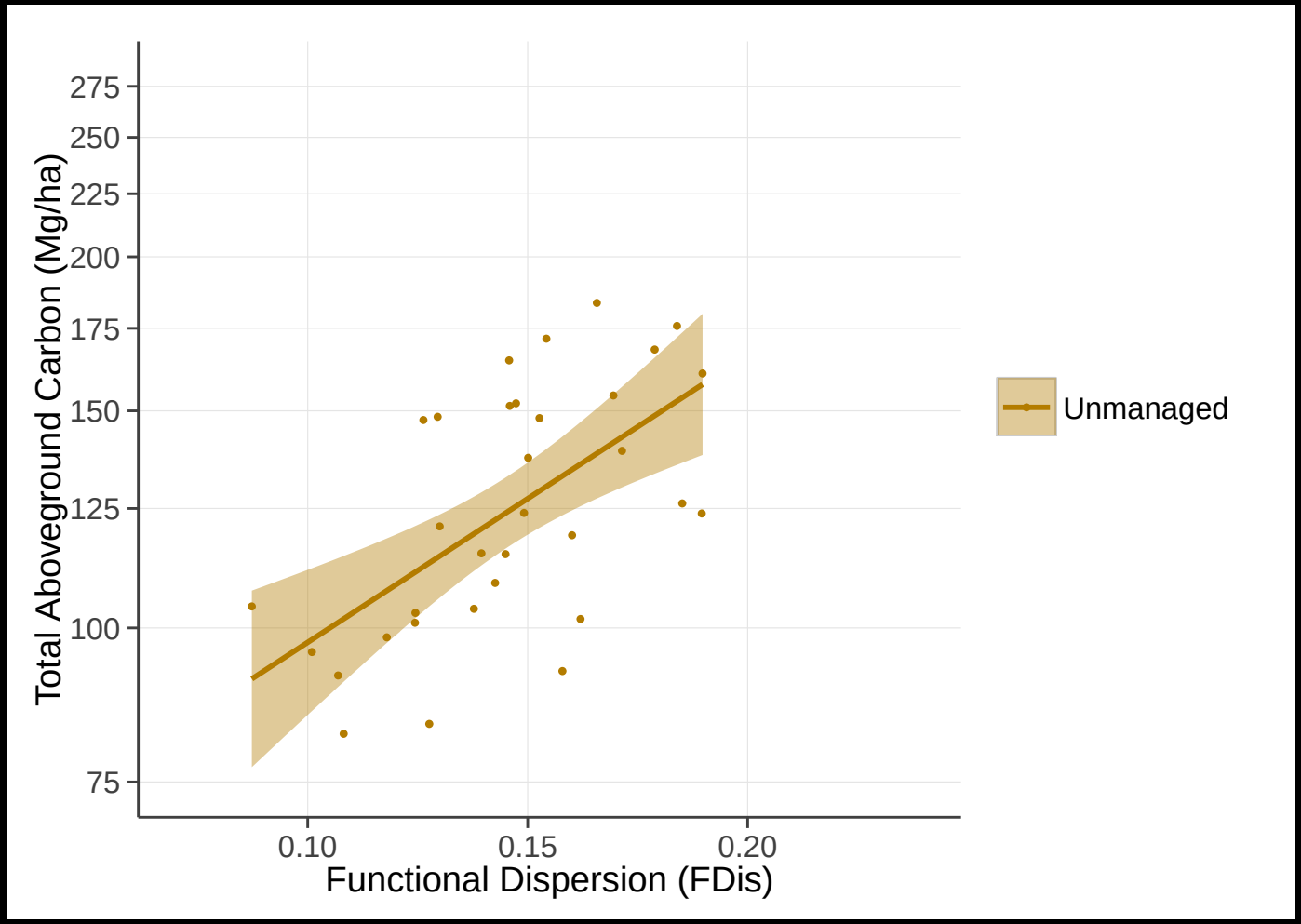
DBH

Species ID

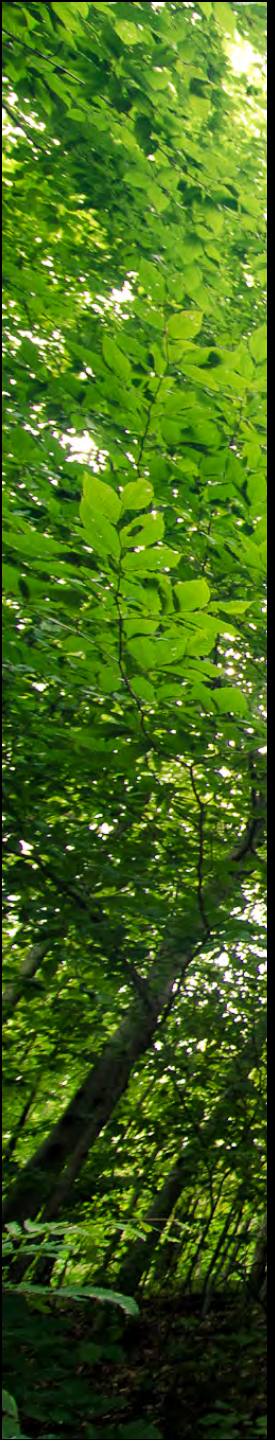
Woody Debris



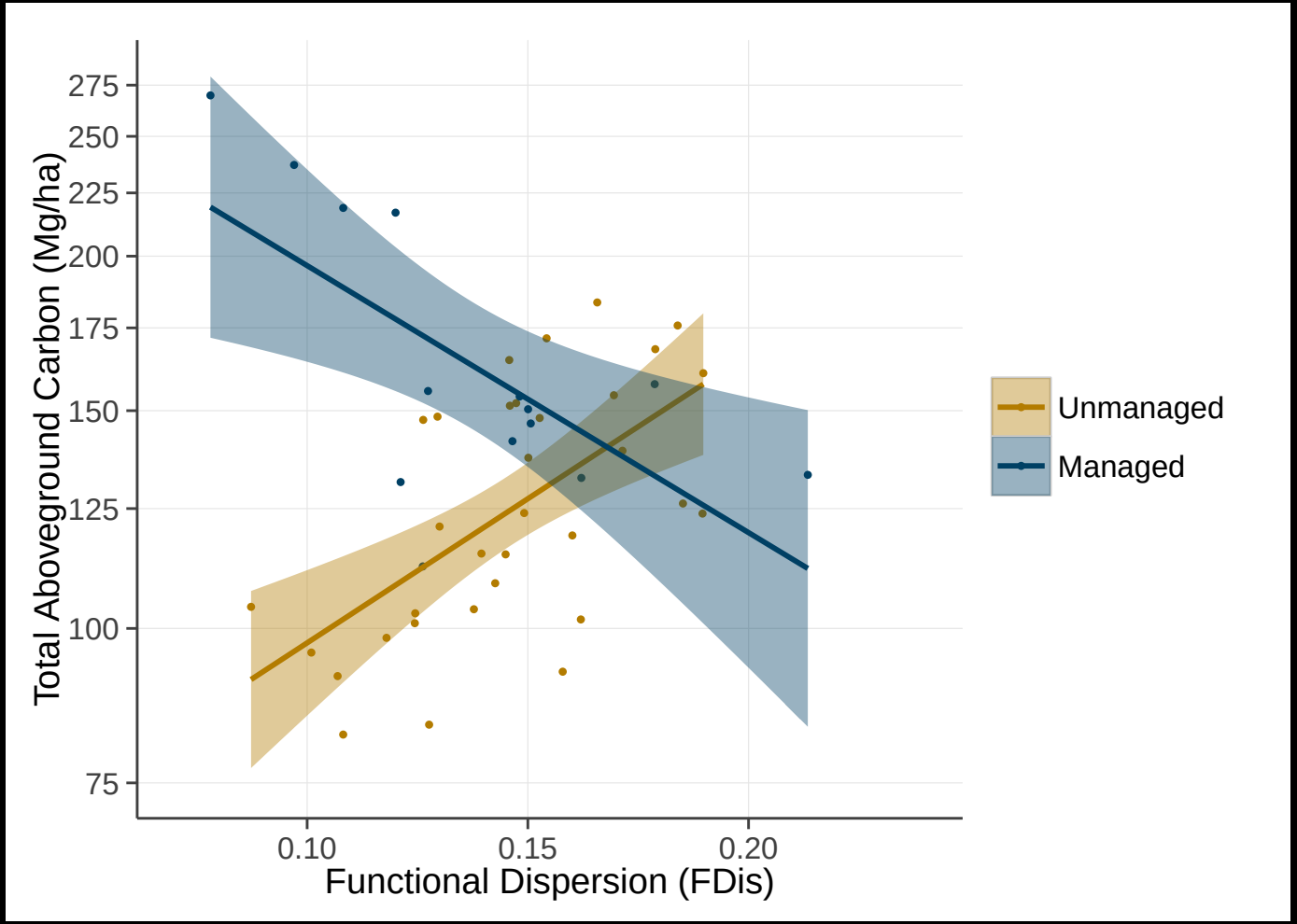
Aboveground carbon stocks are mediated by functional diversity



Ziter et al. Ecosphere 2013



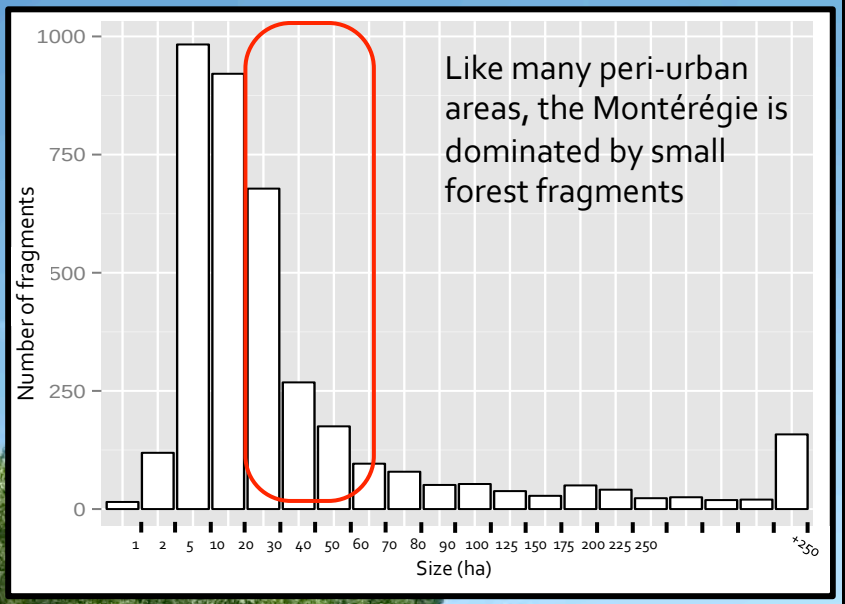
and by local forest management



Ziter et al. Ecosphere 2013

All forest fragments are not created equal!

Don’t sweat the small stuff?



The significant contributions of small forest fragments to regional diversity and service provision emphasizes the important role these fragments can play in conservation efforts

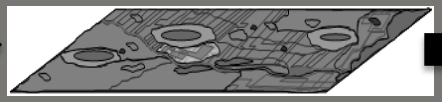
Land use and land cover

Forest
Agriculture
Rivers
Riparian buffers

Biodiversity

Herbivorous insects
Microorganisms
Trees
Bees

Ecosystem Function

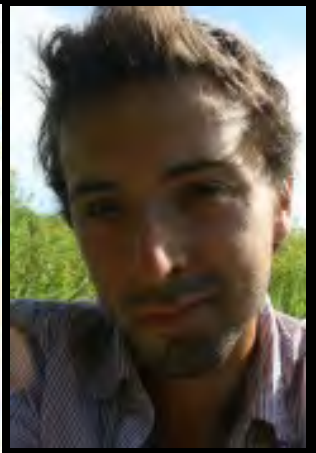


Herbivory
Decomposition
Microbial activity

Ecosystem Services

Food
C storage
Pollination
High quality water



http://monteregieconnection.com











2087 bees captured
11570 trees identified and measured
5450 DWD measured
3600 leaves analyzed
275986 insects counted
270 soil samples collected





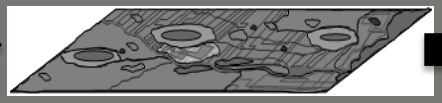
Land use and land cover

Forest
Agriculture
Rivers
Riparian buffers

Biodiversity

Herbivorous insects
Microorganisms
Trees
Bees

Ecosystem Function



Herbivory
Decomposition
Microbial activity

Ecosystem Services

Food
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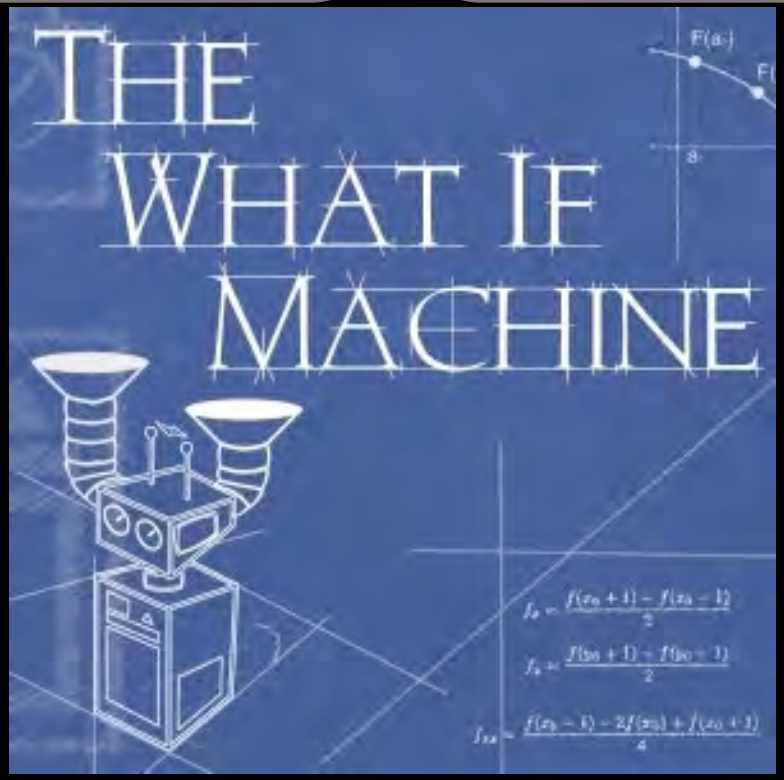
High quality water



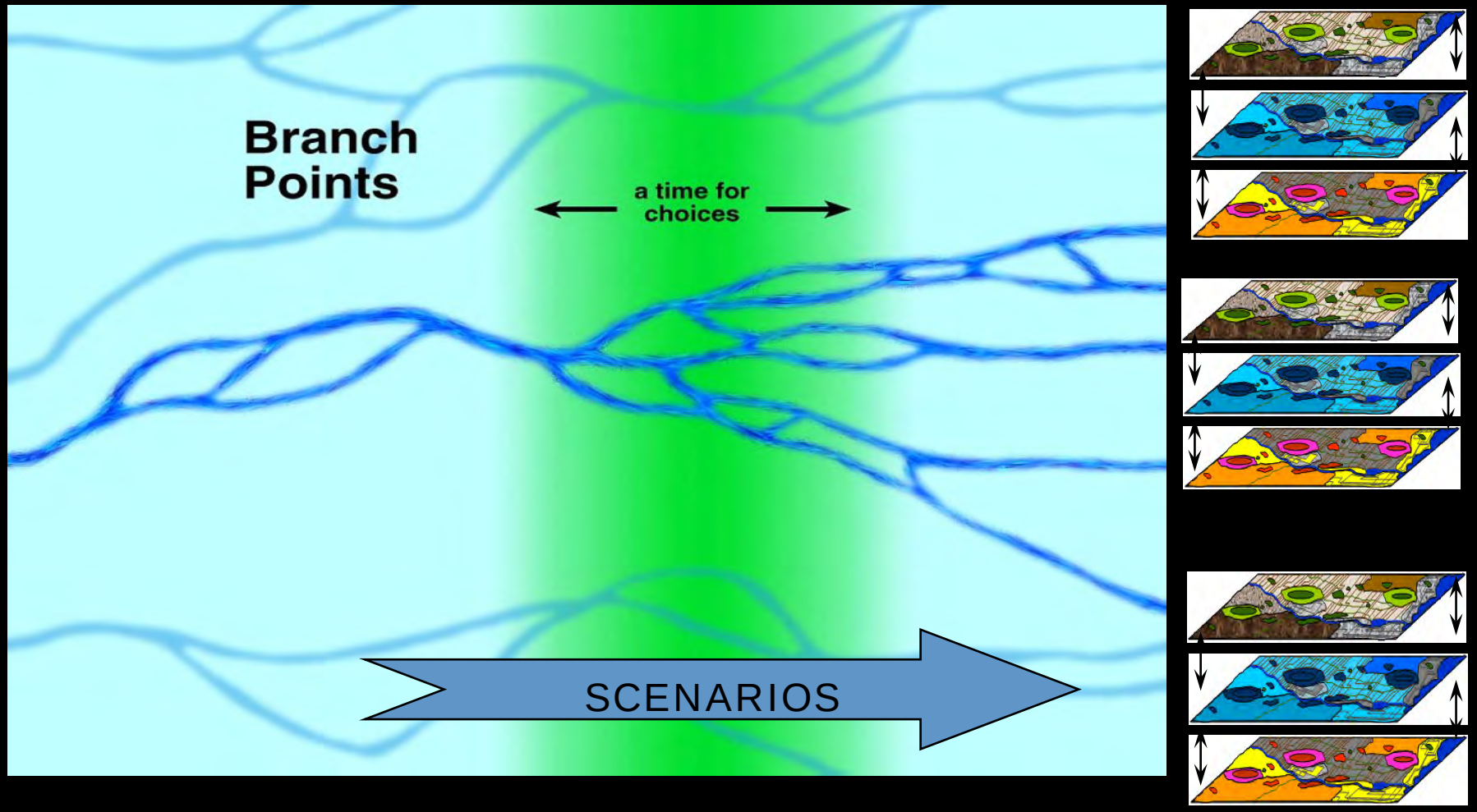


Image courtesy of Paul Raskin

Programme on
Ecosystem Change and Society

Photos: Andre MaslennikovSimon Edman/Azote

- Embrace the complexity of social-ecological systems; every system provides multiple services
- Recognize that nature and people together produce ecosystem services, but that there are limits to the role that technology can play without nature
- Engage local citizens in science (and action)

At the root of every good project is a great team

Ville de Mont-Saint-Hilaire

Centre de la Nature Mont Saint-Hilaire

Développement durable, Environnement et Parcs Québec

M.R.C. de La Vallée-du-Richelieu

ÉEM Sustainable Management Gestion Durable

CENTRE DE LA SCIENCE DE LA BIODIVERSITÉ DU QUÉBEC
QUEBEC CENTRE FOR BIODIVERSITY SCIENCE

Students:

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- Matt Mitchell
- Kate Liss
- Martine Larouche
- Carly Ziter
- Dorothy Maguire
- Kyle Teixeira-Martins
- Bronwyn Rayfield
- Cecile Albert
- Delphine Renard
- Sylvestre Delmotte

Collaborators:

- Jeff Cardille
- Andy Gonzalez
- Martin Lechowicz
- Jeanine Rhemtulla
- Chris Buddle

Montérégie Farmers et Vergers - Yvan Savaria, Francois Brodeur, Lamoureux Noel, Cyrille Beaudreault, Marcel Viens, Louis-Alexandre Gurtin, Claire Lavoie, Ghyslain Lamontagne, Daniel Lussier, Genevieve Blain, Yves Bessette, Andre Palardy, Rosaire Bernard, Andre Jelbert

Au Pavillon de la Pomme, Verger Barber, Verger Boucher et Fils, Verger Gauvin, Verger Gingras, Verger Kessler, Verger MacLean, Verger Messier, Verger Riquita, Verger St-Paul

- Embrace the complexity of social-ecological systems; every system provides multiple services
- Recognize that nature and people together produce ecosystem services, but that there are limits to the role that technology can play without nature
- Engage local citizens in science (and action)