SOLUTIONSCAPES

Designing Nature-based Solutions for Sustainable Water and Food Transitions

Nandita Basu, University of Waterloo
July 7th, 2022

NbS CONFERENCE 2022
Water quality and its interlinkages with the Sustainable Development Goals

Joseph Alcamo

Synergies and tradeoffs among SDG target areas
Florida Fights Giant Algal Bloom in Lake Okeechobee
Governor declares state of emergency as algae covers about 90% of the 730-square-mile lake

Environmental agency: Nearly entire Gulf of Finland overrun with blue-green algae
The algal blooms have also invaded many inland lakes and researchers say the situation will only improve in August.

Southern California coast emerges as a toxic algae hot spot
New research shows domoic acid from ocean algae is a growing problem

Toxic algae in western Lake Erie makes early arrival because of heat
By Tom Henry | BLADE STAFF WRITER
Published on July 2, 2018 | Updated 1:20 a.m.

Urgent Water Warning
TOLEDO
- Do not drink the water.
- Do not shower in the water.
- Do not boil the water.
SOLUTIONSCAPES: Designing Nature-based Solutions for Sustainable Water and Food Transitions

- Wetland Protection and Restoration
- Manure to bioenergy
- Conservation Agriculture (Cover crops, tillage)
Natural climate solutions for Canada


Fig. 1. Potential annual mitigation in 2030 from 24 NCS for Canada. We indicate the mitigation potential at each price point, with lower-cost options in darker gray. Black lines indicate the 95% CI; the line with an arrow indicates where uncertainty extends beyond the graph pane (see table S2 for values). Co-benefits of each natural climate solution (table S1) are indicated by colored bars for air, biodiversity, soil, water, and social benefits. FWM, freshwater wetland.

<table>
<thead>
<tr>
<th>Agricultural lands</th>
<th>Wetlands</th>
<th>Grasslands</th>
<th>Forests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoided forest cover</td>
<td>Avoided wetland conversion</td>
<td>Avoided forest conversion</td>
<td>Improved forest management</td>
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<tr>
<td>Riparian forest cover</td>
<td>Wetland restoration</td>
<td>Riparian forest cover</td>
<td>Restoration of forest cover</td>
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<tr>
<td>Wetlands total</td>
<td>Grasslands total</td>
<td>Forests total</td>
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</tr>
</tbody>
</table>

Agricultural lands total

Co-benefits:
- Air
- Biodiversity
- Soil
- Water
- Social

*Fig. 1* Potential annual mitigation in 2030 from 24 NCS for Canada. We indicate the mitigation potential at each price point, with lower-cost options in darker gray. Black lines indicate the 95% CI; the line with an arrow indicates where uncertainty extends beyond the graph pane (see table S2 for values). Co-benefits of each natural climate solution (table S1) are indicated by colored bars for air, biodiversity, soil, water, and social benefits. FWM, freshwater wetland.
**Wetlands as large-scale nature-based solutions: Status and challenges for research, engineering and management**

Josefin Thorslund a,*, Jerker Jarsjö a, Fernando Jaramillo a, h, James W. Jawitz c, Stefano Manzoni i, Nandita B. Basu d, Sergey R. Chalov i, Matthew J. Cohen i, Irena F. Creed b, Romain Goldenberg a, Anna Hylin e, Zahra Kalantari a, Antonis D. Koussis h, Steve W. Lyon a, Katerina Mazi h, Johanna Mård i, Klas Persson g, Jan Pietroń a, Carmen Prieto a, Andrew Quin f, Kimberly Van Meter d, Georgia Destouni a, i

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### (a) Global change and wetland functions

<table>
<thead>
<tr>
<th>Function impact</th>
<th>Global change</th>
<th>Hydroclimatic change</th>
<th>Irrigation</th>
<th>Urban/Industrial pollution</th>
<th>Flow regulation</th>
<th>Drainage</th>
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<tbody>
<tr>
<td>Biodiversity support</td>
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<td>Pollutant retention</td>
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<td>Nutrient retention</td>
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<tr>
<td>Groundwater level and soil moisture regulation</td>
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<tr>
<td>Coastal protection</td>
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### (b) Consensus on judged global change impact

- 50% ≤ 75% ≤ 100% ≤ ?
- Enhanced function
- Impaired function
- Knowledge gap

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**Emerging impact relevance (%)**

- **Hydroclimatic change**
- **Irrigation**
- **Urban/Industrial pollution**
- **Human flow regulation**
- **Drainage**
- **Biodiversity support**
- **Retention**
- **Flood regulation**
- **Groundw. level and soil moisture reg.**
- **Coastal protection**

**Scale of wetland impacts**
- Scale of wetland impacts
- Scale of Individual wetlands

**Total number of published papers**
- 0
- 1000
- 2000
- 3000
- 4000
- 5000
- 6000
Wetlands retain excess nutrients and improve water quality.
How much N is removed by wetlands across the continental US?
Cheng and Basu (2017) Biogeochemical hotspots: Role of small water bodies in landscape nutrient processing. WRR

Spatial Data for each of the 30 million wetlands in the NWI

Parameters as a function of size
- $k$ (N removal rate constant)
- $\tau$ (hydraulic residence time)

Fractional N removal per wetland

$$R_i = 1 - \exp(-k\tau)$$
% N Removal (Potential) by wetlands in each watershed
Linking N Sinks with N Sources
Agricultural Nitrogen Surplus at County Scale

Synthesis of nearly 90 years of agricultural data to determine the N Surplus of every county in the conterminous US.
Mass Removed at HUC8 Scale

\[ \text{Mass Removed at HUC8 Scale} = \frac{\text{Fraction Wetland N Removal}}{\Gamma} \times \text{N Surplus} \]
How Much Nitrogen is Removed by Wetlands across the US?

Without existing wetlands, N loads in the Mississippi River B. would be \(~50\%\) higher than they are now.
How can wetland restoration contribute to improvements in water quality?
Restored wetland area (ha km$^{-2}$)

Random placement

Wetland Restoration Strategies (10% increase in area)

Cheng, Van Meter et al., Nature (2020)
Wetland Restoration Strategies (10% increase in area)

Wetland Restoration Strategies (10% increase in area)

Restored wetland area (ha km$^{-2}$)

Cheng, Van Meter et al., Nature (2020)
Targeted wetland restoration can reduce 40 times more N

Targeted wetland restoration can reduce 40 times more N and at double the cost of non-targeted restoration.
How can wetland restoration contribute to improvements in water quality?

A targeted 22% increase in wetland area in the Mississippi River Basin could result in an approximately 40% decrease in N loads—bringing us closer to policy goals for improving water quality in the Gulf of Mexico.

Co-benefits and Tradeoffs:
Wetlands also sequester carbon and increase biodiversity, but can potentially increase methane emissions.

Cheng, Van Meter, Byrnes and Basu, Nature (2020)
GTA’s workhorse wetlands are under threat

Driving through the Greater Toronto Area, you probably wouldn’t recognize the value of the wetlands you are passing. You might even consider them an eyesore. Sure, they have their warts. Invasive plants, scattered trash — urban development exerts stress on ecosystems.

But urban wetlands are valuable; they are our workhorses. Maybe they are not as awe-inspiring as wetlands in our provincial parks, but they are doing most of the heavy lifting when it comes to flood protection and water-quality improvement. They save us millions by retaining storm waters and removing nutrients that cause noxious algae blooms. They also serve as frontline workers against climate change, sucking carbon out of the air. Our urban wetlands work around the clock for us, performing what we scientists call “ecosystem services.”
• What are the key tradeoffs associated with wetland restoration in agricultural landscapes?

• What spatial patterns of restoration can lead to greater synergies in restoration for carbon and water?

• How can policies and incentives be designed to ensure greater farmer participation in wetland restoration?
No till agriculture can increase nitrate and dissolved phosphorus loss.

(1) What are the climate, water quality and productivity tradeoffs under different management scenarios (tillage, cover crops, fertilizer reduction)?

(2) What is the optimal placement of these practices across the landscape considering various economic and environmental tradeoffs?
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Identifying the Opportunities

Imagining the Possibilities

Designing for the Future

Key takeaways
1. Co-benefits and Tradeoffs need to be quantified
2. Spatially and temporally explicit quantification of services provided by NBS
3. Incentive mapping and coordination to facilitate widescale adoption

Thank you and Questions
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Email: nandita.basu@uwaterloo.ca