Nooksack-Fraser Transboundary Nitrogen Project: Goals, Results & Links to PSNSRP

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Outline

• Nooksack-Fraser Transboundary Nitrogen Project (NFTN) - Dave
  • Setting and goals
  • International context

• Nitrogen budget - Jiajia
  • Method and data sources
  • Preliminary results

• Future work - Jana
  • Potential links to PSNSRP
Nooksack watershed - overview

1. US & CANADA WATERSHED, AIR-SHED AND AQUIFER
2. VARIETY OF LAND USE WITHIN BASIN
3. POLICY DIFFERENCES BETWEEN CA AND US
4. TRIBAL/FIRST NATIONS TREATY RIGHTS
5. “DOWNSTREAM” EFFECTS ARE LOCAL

1. NFTN: WATERSHED FOCUS – LINKED N ISSUES
2. B’HAM BAY, PUGET SOUND AS END POINTS
3. COMPLEMENTARY FOCUS TO PSNSRP
Groundwater/drinking water issue

- 44% ≥ 5 mg/L
- 29% ≥ 10 mg/L
- 14% ≥ 20 mg/L
- 73 mg/L max nitrate-N in private well
Surface water quality issues

- Salmon habitat and restoration
- Cross-border policies and pollution
- Nooksack River flows to Bellingham Bay
  - Algal bloom; hypoxia
  - HABs, fecal coliform → shellfish closures
Air quality issues

- Visibility
- Odor – ag lands
- N deposition - North Cascades NP, National Forests
- Human health effects of air pollution
- Requires attention to NO$_x$, NH$_3$, SO$_2$, ozone, organic carbon sources
Nooksack-Fraser Transboundary Nitrogen Project
Integrated assessment of N benefits and threats (water, air, land)

Collaborative working group: >35 agencies, universities, tribes, and NGOs
Scope and Goals of NFTN

- Achieve environmental goals
- Maintain vibrant economies
- Respect diverse cultural values
International Nitrogen Management System (INMS)

- Science community, private sector & civil society
- Synthesize evidence to support integrated international policy development
- Implemented by the UN Environment Programme
- Funding through Global Environment Facility (GEF)
- Over 70 global project partners, with eight regional demonstrations
- NFTN is the N. American demo project
Overview of INMS Components

Data need & concepts

C1: Tools and methods for understanding the N cycle

Improved management practices, Mitigation, Adaptation

C2: Global & regional quantification of N use, flows, impacts & benefits of practices

Informing modelling requirements

C3: Regional demonstration & verification

Options & Scenarios, including Cost-Benefit-Analysis

Opportunities, Local/region priorities, Policy context, Local data, Barriers-to-change

C4: Awareness raising & knowledge sharing

Devlpt. of policy homes, Public awareness, Consensus building,

Improved basis for transformational actions on N management
INMS Component 3

NFTN work aligns with INMS Activities (3.1-3.4) and tasks

3.1 – Conduct regional $N_r$ assessments (demo projects)
3.2 – Workshop to synthesize demo activities
3.3 – Benchmarking N indicators for different regions
3.4 – Demonstrating benefits of joined up N approach

http://www.inms.international/our-project-0
Tasks 3.1.1-3.1.3 – Quantifying flows and uncertainties

- Identified/perceived key N flows for the region
- Identified/perceived uncertainties for the region

Watershed N budget (US + Canada)
Inputs, outputs, internal transformations

Multiple data sources

Refining estimates of surface water N loading
- Fishtrap Creek
- Nooksack River

Real-time N sensor

Vetting results with local stakeholders (farmers, extension)
Emissions – NO\textsubscript{x}, NH\textsubscript{3}
Deposition
Contribution to N budget within watershed
Quantifying surface water N loading: Real-time nitrate sensors

- Follow-up from Nutrient Sensor Action Challenge
- Nooksack River - OTT
- Fishtrap Creek - SUNA
- Kamm Creek - OTT

https://waterdata.usgs.gov/nwis/uv?site_no=12213100
To Do: Tasks 3.1.4, 3.1.5, 3.1.6 - Regional N Priorities

Description of watershed in relation to N performance indicators, with stakeholder input.

• **Water** (e.g., eutrophication, hypoxia, harmful algal blooms)
• **Air** (e.g., NO$_x$, smog, human health)
• **Greenhouse gases** (N$_2$O)
• **Ecosystems** (e.g., N deposition $\rightarrow$ biodiversity)
• **Soils** – (e.g., fertility, crop production)
Opportunities for collaboration

• **NFTN → PSNSRP**
  - Quantifying N flux
  - WA Sea Grant – Kodner, Hooper, & Curry: Effects of N loading on phytoplankton blooms in Bellingham Bay, WA;

• **PSNSRP → NFTN**
  - N loading and environmental thresholds for hypoxia
NFT-N
Nooksack-Fraser Transboundary Nitrogen budget
Why a nitrogen budget?

• Quantitative information on N fluxes (year: 2014)
• Examine N fates and transport
• Link sources to contamination: where and how to reduce N fluxes
• Ongoing project
• Cross boundary issues
Project Goals

• Develop a nitrogen inventory using local data

• Share among stakeholders
  o Anyone affected by nitrogen in some way is a stakeholder, who is welcome to participate, adding your information, knowledge, and perspective

• Identify and evaluate solutions that can be used by local stakeholders to meet community goals
  o Improve air quality and drinking water quality
  o Economic goals
### Inputs

<table>
<thead>
<tr>
<th>Component</th>
<th>Parameter</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric deposition</td>
<td>Total N deposition</td>
<td>EPA-CMAQ</td>
</tr>
<tr>
<td></td>
<td>Nutritional intake, per capita</td>
<td>USDA, 2012a; 2012b</td>
</tr>
<tr>
<td></td>
<td>Population: dog - 37% of watershed households; cat - 30% of watershed households. Assuming one pet per household.</td>
<td>U.S. Pet Ownership Statistics (AVMA, 2012)</td>
</tr>
<tr>
<td></td>
<td>Nutritional and energy needs</td>
<td>Veterinary online manual; Pet Basic Calorie Calculator (OSU)</td>
</tr>
<tr>
<td>Feed import</td>
<td>Animal populations (other than dairy cow)</td>
<td>NASS (2012)</td>
</tr>
<tr>
<td></td>
<td>Dairy cow population</td>
<td>WSDA (2014)</td>
</tr>
<tr>
<td>Fertilizer import</td>
<td>Crop land</td>
<td>WSDA land use map (2014)</td>
</tr>
<tr>
<td></td>
<td>Fertilization rates</td>
<td>Local agriculture experts (personal communication); Oregon and Washington Extension documentations</td>
</tr>
<tr>
<td>Biological N fixation</td>
<td>Alder density</td>
<td>OSU-LEMMA (2002)</td>
</tr>
<tr>
<td></td>
<td>Alder N fixation rate</td>
<td>Binkely et al., 1994</td>
</tr>
<tr>
<td>Adult fish return</td>
<td>Salmon population and size</td>
<td>Nooksack Stock Assessment (personal communication)</td>
</tr>
<tr>
<td></td>
<td>Adult fish body weight</td>
<td>Gresh et al., 2000</td>
</tr>
<tr>
<td></td>
<td>Adult fish body N content</td>
<td>Moore, 2011 AND MORE</td>
</tr>
</tbody>
</table>
NFT-N – complex land uses

Crop area
- Grass Hay high intensity
- Corn, Field (silage, high intensity)
- Caneberry
- Pasture
- Christmas Tree
- Barley
- Alfalfa Hay
- Apple
- Grass Hay low intensity
- Corn, Field (silage, low intensity)
- Blueberry
- Potato
- Strawberry
- Wheat
- Corn, Sweet

1% 0% 0% 0% 0%
### NFT-N: Data sources – Outputs

<table>
<thead>
<tr>
<th>Component</th>
<th>Parameter</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riverine nitrate export</td>
<td>Flow</td>
<td>Monitor: USGS site 12213100</td>
</tr>
<tr>
<td></td>
<td>Nitrate concentration</td>
<td>Monitor: WA Dept. of Ecology site 01A050</td>
</tr>
<tr>
<td>Riverine TKN export</td>
<td>Flow</td>
<td>Monitor: USGS site 12213100</td>
</tr>
<tr>
<td></td>
<td>TKN concentration</td>
<td>Monitor: Lummi Nation site SW118; USGS site 12213100</td>
</tr>
<tr>
<td>NH3 volatilization</td>
<td>Animal manure application rates</td>
<td>(See Table 1 Internal Section: Manure application)</td>
</tr>
<tr>
<td></td>
<td>Synthetic fertilizer application rates</td>
<td>(See Table 1 Input Section: Fertilizer import)</td>
</tr>
<tr>
<td></td>
<td>Fertilizer and manure volatilization rate/percentage</td>
<td>USDA-NRCS (1998); Local agriculture experts (personal communication)</td>
</tr>
<tr>
<td>Denitrification loss</td>
<td>Fertilizer and manure denitrification rate/percentage</td>
<td>USDA-NRCS (1998); Local agriculture experts (personal communication)</td>
</tr>
<tr>
<td>Animal product (milk)</td>
<td>Dairy cow population</td>
<td>WSDA (2014)</td>
</tr>
<tr>
<td>Animal product (other)</td>
<td>Animal populations (other than dairy cow)</td>
<td>NASS (2012)</td>
</tr>
<tr>
<td></td>
<td>Animal product N content</td>
<td>USDA National Nutrient Database (2015); Statistics Canada (2013); Goyette et al., 2016</td>
</tr>
<tr>
<td>Crop product</td>
<td>Crop land</td>
<td>WSDA land use map (2014)</td>
</tr>
<tr>
<td></td>
<td>Crop N content</td>
<td>USDA nutrient tool</td>
</tr>
<tr>
<td>Smolt export</td>
<td>Smolt population and size</td>
<td>Lummi Nation (personal communication)</td>
</tr>
<tr>
<td></td>
<td>Smolt body weight</td>
<td>Skagit River System Cooperative (personal communication)</td>
</tr>
<tr>
<td></td>
<td>Smolt body N content</td>
<td>Moore, 2011 AND MORE</td>
</tr>
</tbody>
</table>
Internal processes

<table>
<thead>
<tr>
<th>Component</th>
<th>Parameter</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human waste</td>
<td>Sewage Treatment Plants (STPs) monitored nitrogen in effluents</td>
<td>Everson STP; Lynden STP; Ferndale STP</td>
</tr>
<tr>
<td></td>
<td>Septic population: total population - service population on sewage</td>
<td>NASS (2015); Everson STP; Lynden STP; Ferndale STP</td>
</tr>
<tr>
<td></td>
<td>Septic leaching rate, per capita</td>
<td>Local agriculture experts (personal communication)</td>
</tr>
<tr>
<td>Food waste</td>
<td>40% of total available food</td>
<td>Hall et al., 2009</td>
</tr>
<tr>
<td>Manure application</td>
<td>Animal populations (other than dairy cow)</td>
<td>NASS (2012), WSDA (2014)</td>
</tr>
<tr>
<td></td>
<td>Animal excretion rates</td>
<td>NRCS (); Bittman et al. (); NANI ()</td>
</tr>
<tr>
<td>Crop to animal feed</td>
<td>Feed crop production rate</td>
<td>Local agriculture experts (personal communication); NASS (2012)</td>
</tr>
<tr>
<td></td>
<td>Crop nitrogen content</td>
<td>USDA nutrient tool; local agriculture experts (personal communication)</td>
</tr>
</tbody>
</table>
Results: N flows in the NFT Basin

- Feed: large proportion of inputs
- Fertilizer = human food
- Fates are nearly equal between NH$_3$ emission, animal product export and river export (25-30%)
- **Retention** and groundwater storage is large proportion (~20% of inputs)
U.S. & Canada: similarities and differences

1. U.S. mostly dairy, Canada mostly poultry

2. Sources:
   a. Feed and fertilizer dominate imports
   b. human proportions similar
U.S. & Canada: similarities and differences

1. U.S. mostly dairy, Canada mostly poultry

2. Sources:
   a. Feed and fertilizer dominate imports
   b. human proportions similar

3. Losses:
   a. U.S.—NH$_3$ and river nitrate
   b. Canada—groundwater/unknown
Future work

• Refine results and publish
• Continue to communicate and collaborate with local stakeholders
• Identify implications for management
• Develop a modeling structure and scenarios of N use in the future using stakeholder input – link to Salish Sea Model scenarios
Opportunities and connections to the PS Nutrient Source Reduction Project

Results from N sources to watershed and export to bay
  ◦ data and approach for other sites

Now that we have this N budget, how do stakeholders determine how to make reductions?
  ◦ Where?
  ◦ How?
  ◦ How much to reduce?
  ◦ Which sectors?

Scenarios & connections INMS modeling – RCPs and SDGs – 6 scenarios
<table>
<thead>
<tr>
<th>Scenario</th>
<th>Climate</th>
<th>Development</th>
<th>Land-use</th>
<th>Diet</th>
<th>N policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business-as-usual</td>
<td>No mitigation (RCP 8.5)</td>
<td>Fossil-fuel driven</td>
<td>Medium regulation; high productivity</td>
<td>Meat &amp; dairy-rich</td>
<td>Low ambition</td>
</tr>
<tr>
<td>Low N regulation</td>
<td>Moderate mitigation (RCP 4.5)</td>
<td>Historical trends</td>
<td>Medium regulation; medium productivity</td>
<td>Medium meat &amp; dairy</td>
<td>Low ambition</td>
</tr>
<tr>
<td>Medium N regulation</td>
<td>Moderate mitigation (RCP 4.5)</td>
<td>Historical trends</td>
<td>Medium regulation; medium productivity</td>
<td>Medium meat &amp; dairy</td>
<td>Moderate ambition</td>
</tr>
<tr>
<td>High N regulation</td>
<td>Moderate mitigation (RCP 4.5)</td>
<td>Historical trends</td>
<td>Medium regulation; medium productivity</td>
<td>Medium meat &amp; dairy</td>
<td>High ambition</td>
</tr>
<tr>
<td>Best-case</td>
<td>Moderate mitigation (RCP 4.5)</td>
<td>Sustainable development (SSP 1)</td>
<td>Strong regulation; high productivity</td>
<td>Low meat &amp; dairy</td>
<td>High ambition</td>
</tr>
<tr>
<td>Best-case +</td>
<td>Moderate mitigation (RCP 4.5)</td>
<td>Sustainable development (SSP 1)</td>
<td>Strong regulation; high productivity</td>
<td>Ambitious diet shift and food loss/waste reductions</td>
<td>High ambition</td>
</tr>
<tr>
<td>Bioenergy</td>
<td>High mitigation (RCP 2.6)</td>
<td>Sustainable development (SSP 1)</td>
<td>Strong regulation; high productivity</td>
<td>Low meat &amp; dairy</td>
<td>High ambition</td>
</tr>
</tbody>
</table>

From David Kanter, NYU
# N policy interventions

<table>
<thead>
<tr>
<th>Sector &amp; country group</th>
<th>N policy ambition levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td><strong>Crop</strong></td>
<td></td>
</tr>
<tr>
<td>OECD</td>
<td>Target NUE by 2030</td>
</tr>
<tr>
<td>Non-OECD/High N</td>
<td>Target NUE in 10 years after catch-up with OECD countries</td>
</tr>
<tr>
<td>Non-OECD/Low N</td>
<td>Target NUE in 30 years by avoiding historical trajectory</td>
</tr>
<tr>
<td><strong>Livestock manure excretion</strong></td>
<td></td>
</tr>
<tr>
<td>OECD</td>
<td>10% reduction by 2030, 30% reduction by 2050</td>
</tr>
<tr>
<td>Non-OECD/High N</td>
<td>N excretion rates same as OECD in 10 years after catch-up</td>
</tr>
<tr>
<td>Non-OECD/Low N</td>
<td>30% reduction for new livestock production after 2030</td>
</tr>
<tr>
<td><strong>Manure recycling</strong></td>
<td></td>
</tr>
<tr>
<td>OECD</td>
<td>90% recycling by 2030</td>
</tr>
<tr>
<td>Non-OECD/High N</td>
<td>50% increase in recycling by 2030; 100% increase by 2050</td>
</tr>
<tr>
<td>Non-OECD/Low N</td>
<td>90% recycling by 2030</td>
</tr>
<tr>
<td><strong>Air Pollution</strong></td>
<td></td>
</tr>
<tr>
<td>OECD</td>
<td>70% of technically feasible measures by 2030, all measures by 2050</td>
</tr>
<tr>
<td>Non-OECD/High-Med income</td>
<td>Same as OECD in 10 years after catch-up</td>
</tr>
<tr>
<td>Non-OECD/Low income</td>
<td>CLE by 2030, OECD CLE by 2050, gradual improvement towards 70% technical feasible measures</td>
</tr>
<tr>
<td><strong>Wastewater</strong></td>
<td></td>
</tr>
<tr>
<td>OECD</td>
<td>&gt;99% wastewater treated; 100% N and P recycling from new installations from 2020</td>
</tr>
<tr>
<td>Non-OECD/High N</td>
<td>&gt;80% wastewater treated; Recycling same as OECD in 10 years after catch-up</td>
</tr>
<tr>
<td>Non-OECD/Low N</td>
<td>&gt;70% wastewater treated</td>
</tr>
</tbody>
</table>

Opportunities and connections to the PS Nutrient Source Reduction Project

Salish Sea Model → NFTN
◦ What does the Salish Sea Model recommend to improve DO in Bellingham Bay and Puget Sound?
◦ How much N reduction would this require?
◦ How might this differ across areas of Puget Sound and why?

NFTN → PSNSRP
◦ How could communities achieve these reductions?
◦ What reductions are realistic for the Nooksack Watershed and Bellingham Bay?
Thank you!

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Jana Compton <Compton.Jana@epa.gov>