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

DAVID HOOPER, JIAJIA LIN, JANA COMPTON

JILL BARON, CHRIS CLARK, DONNA SCHWEDE, SHABTAI BITTMAN, BARB CAREY, PETER HOMANN, HANNA WINTER, PETER KIFFNEY, NICHOLE EMBERTSON, HEATHER MACKAY, ROBERT BLACK, GARY BAHR

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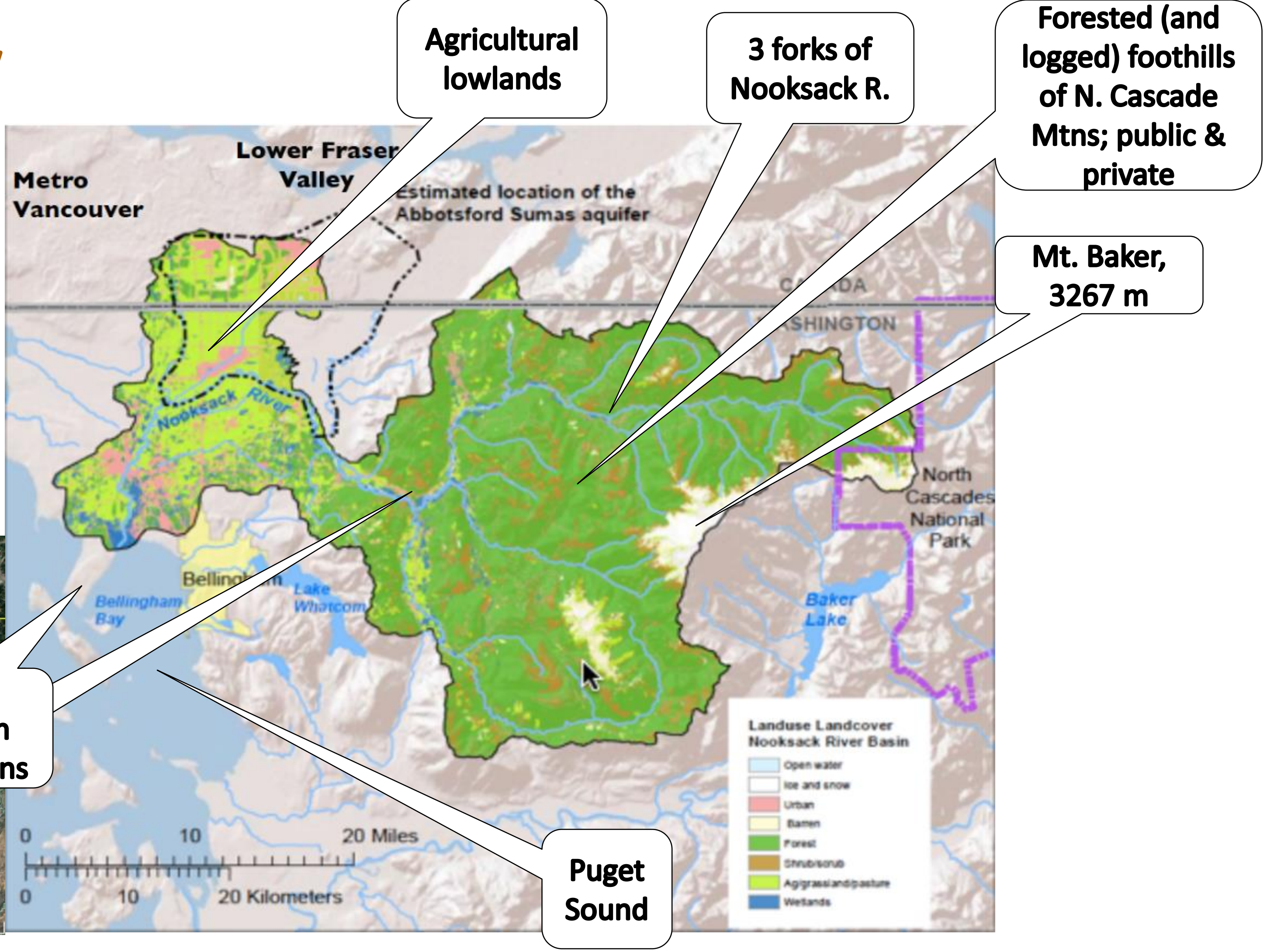
Outline

- 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

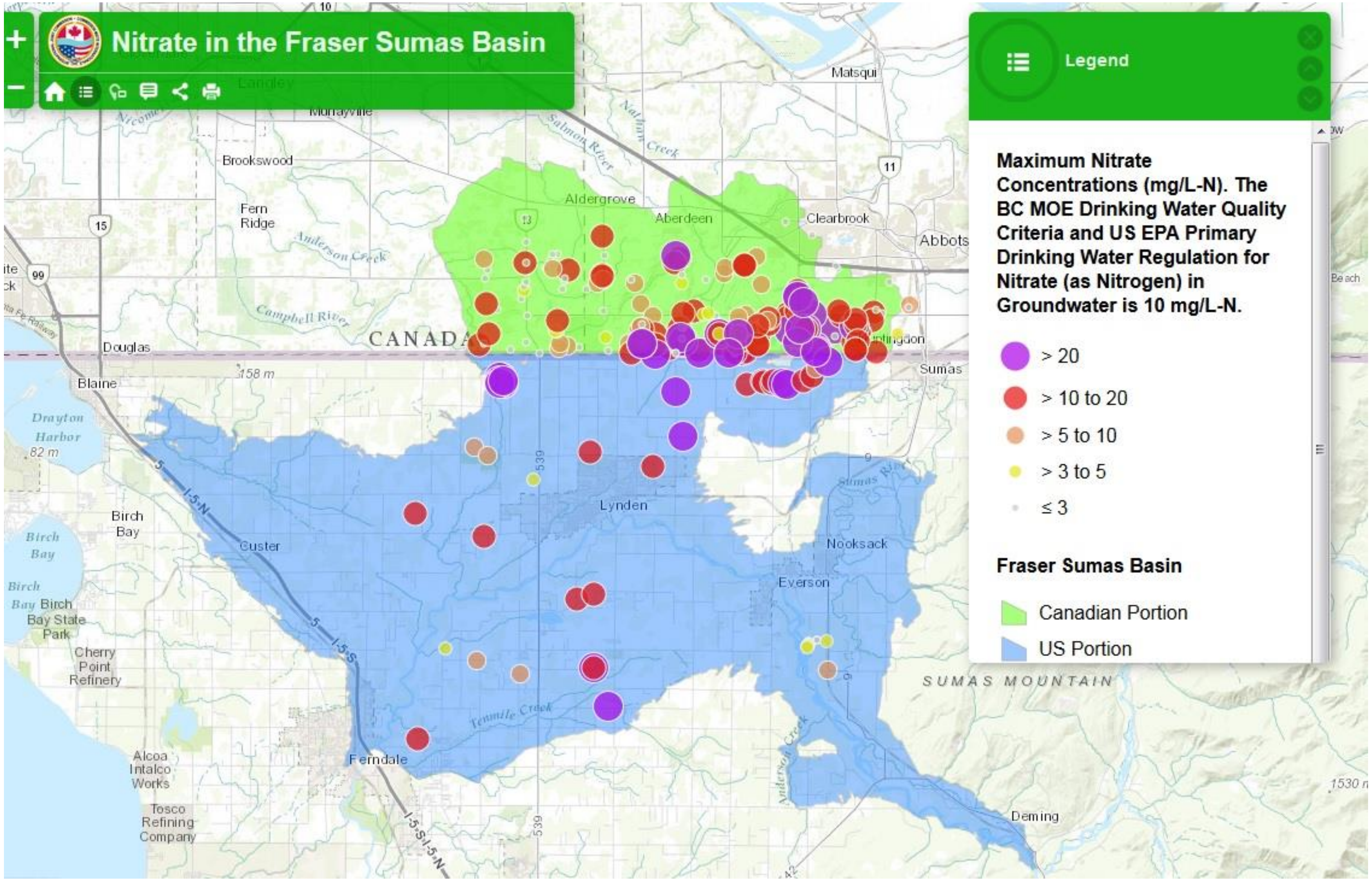


1. NFTN: WATERSHED FOCUS – LINKED N ISSUES
2. B'HAM BAY, PUGET SOUND AS END POINTS
3. COMPLEMENTARY FOCUS TO PSNSRP

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



IJC Cross-Border Characterization

Surface water quality issues

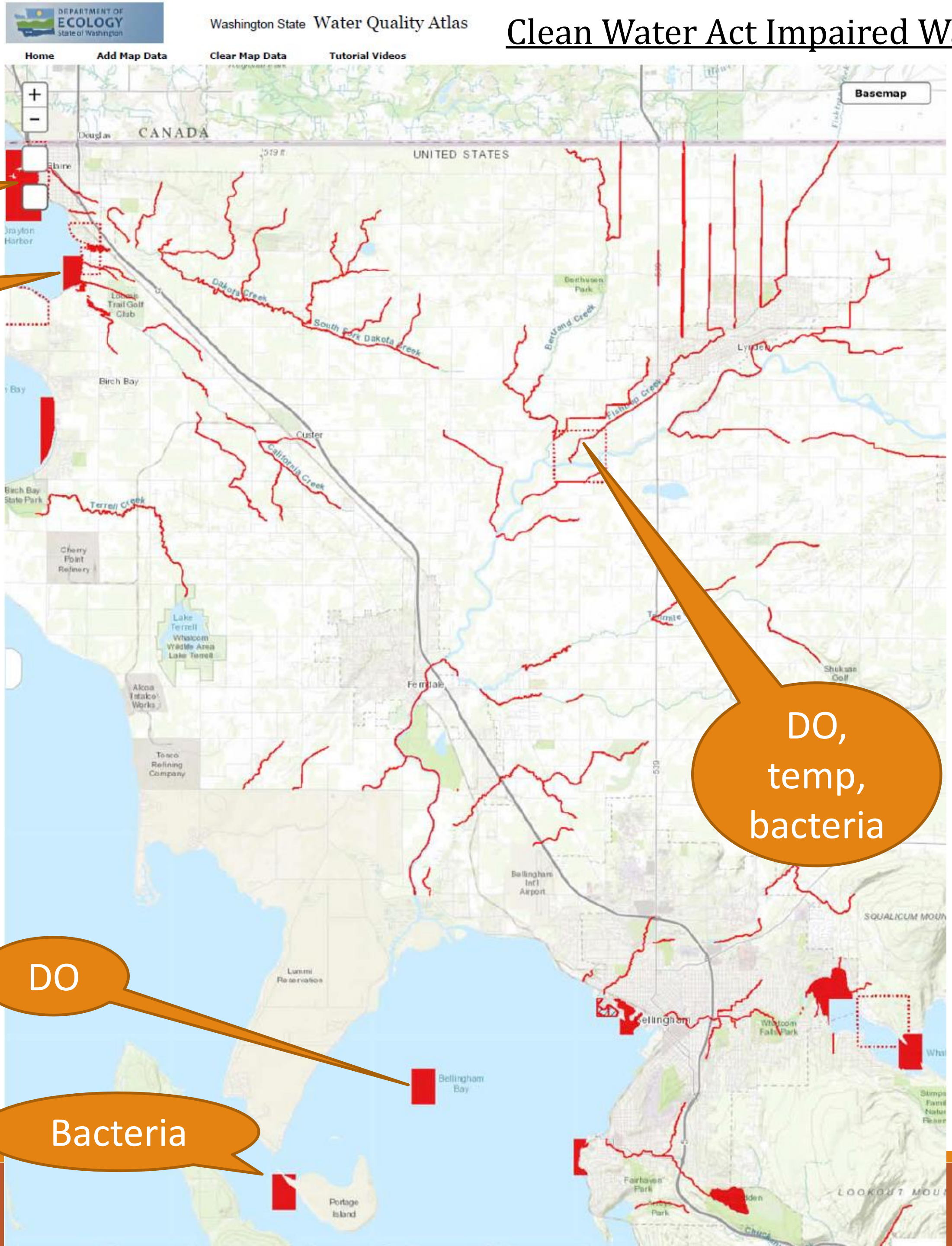
- Salmon habitat and restoration
- Cross-border policies and pollution
- Nooksack River flows to Bellingham Bay
  - Algal bloom; hypoxia
  - HABs, fecal coliform→shellfish closures

(Photo credit: City of Bellingham)

(Photo credit: U. Washington)

(Photo credit: EPA)

Clean Water Act Impaired Waters



Air quality issues

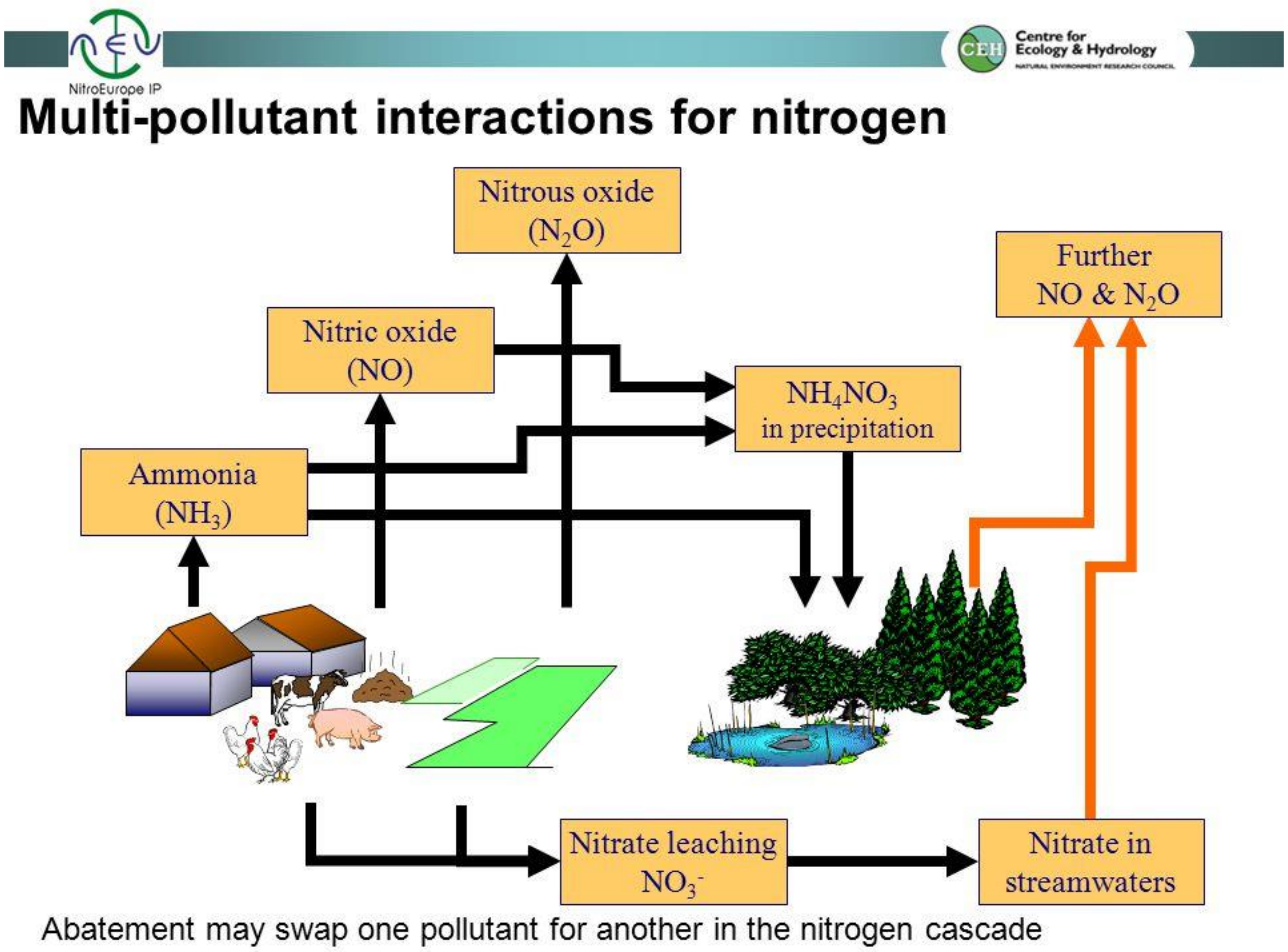
- Visibility
- Odor – ag lands
- N deposition - North Cascades NP, National Forests
- Human health effects of air pollution
- Requires attention to NO_x, NH_3, SO_2, ozone, organic carbon sources

Vancouver, British Columbia, Canada

(Photo credit: http://www.ens-newswire.com/ens/oct2004/2004-10-01-04.html)

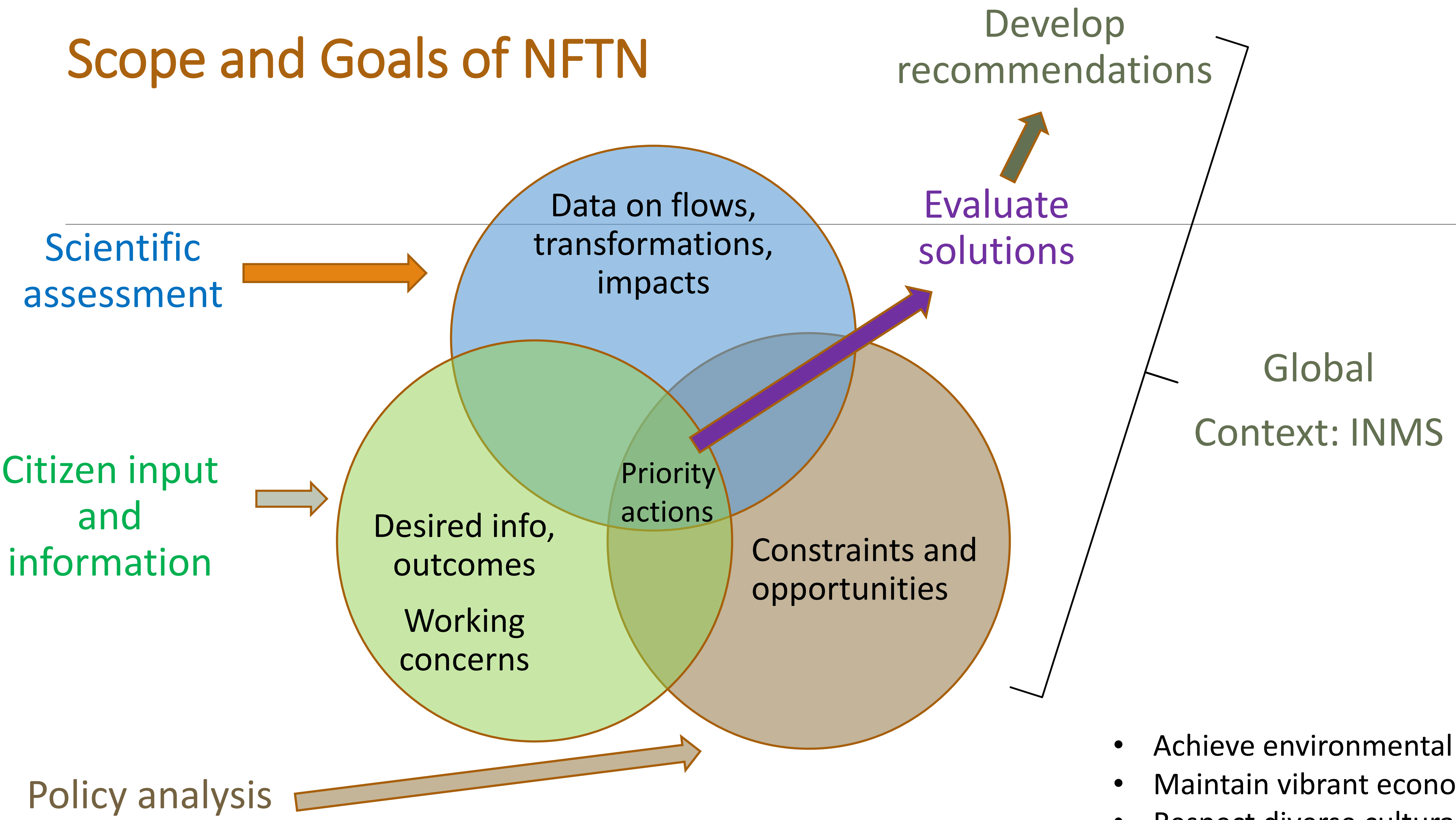
Nooksack-Fraser Transboundary Nitrogen Project

Integrated assessment of N benefits and threats (water, air, land)



Collaborative working group: >35 agencies, universities, tribes, and NGOs

Scope and Goals of NFTN

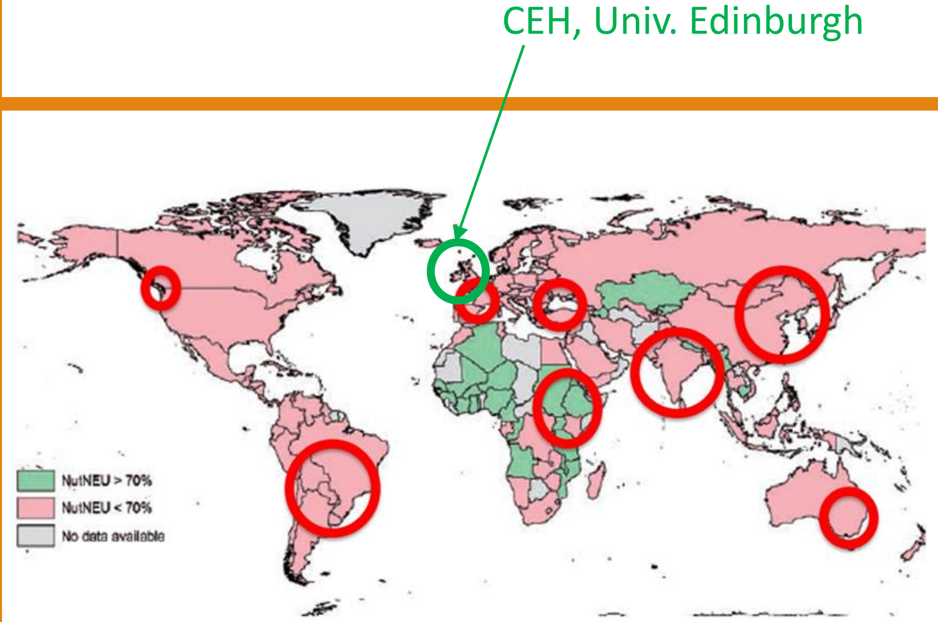


- Achieve environmental goals
- Maintain vibrant economies
- Respect diverse cultural values

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

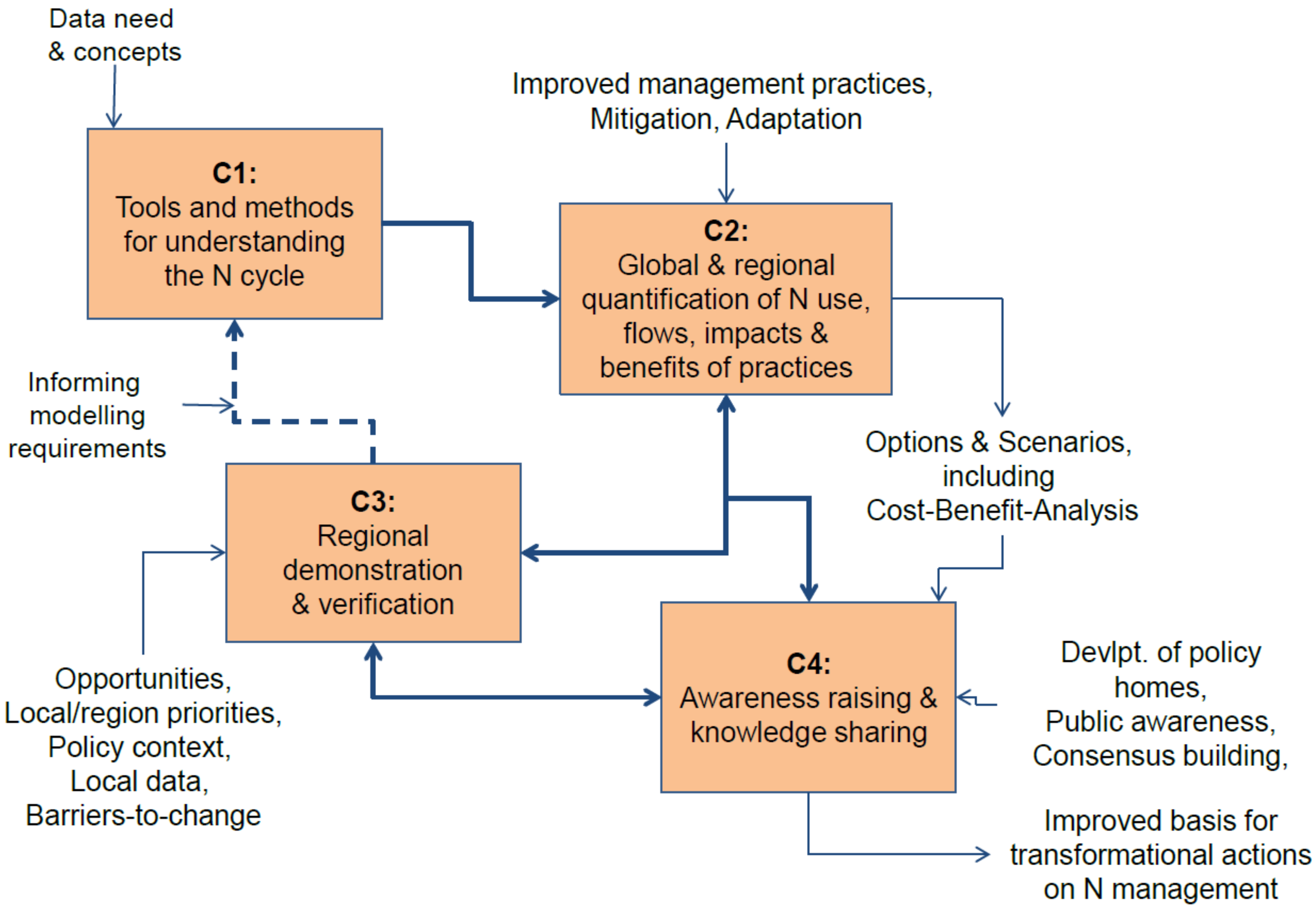
Towards the INMS
International Nitrogen Management System
www.inms.international



Countries that have a Crop NUE_N below 70% (2008, for details see Appendix).

Sutton et al. 2013

Overview of INMS Components



INMS Component 3

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

3.1 – Conduct regional N_r assessments (demo projects)

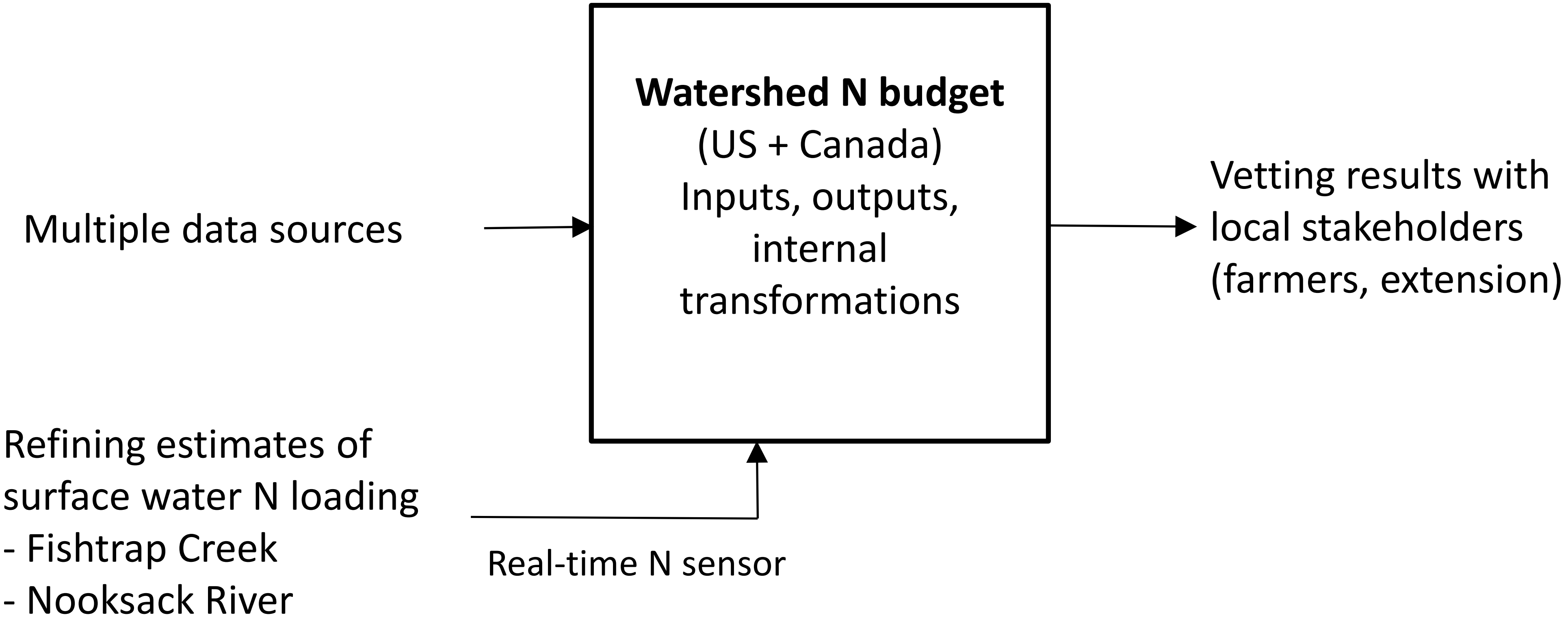
3.2 – Workshop to synthesize demo activities

3.3 – Benchmarking N indicators for different regions

3.4 – Demonstrating benefits of joined up N approach

Tasks 3.1.1-3.1.3 – Quantifying flows and uncertainties

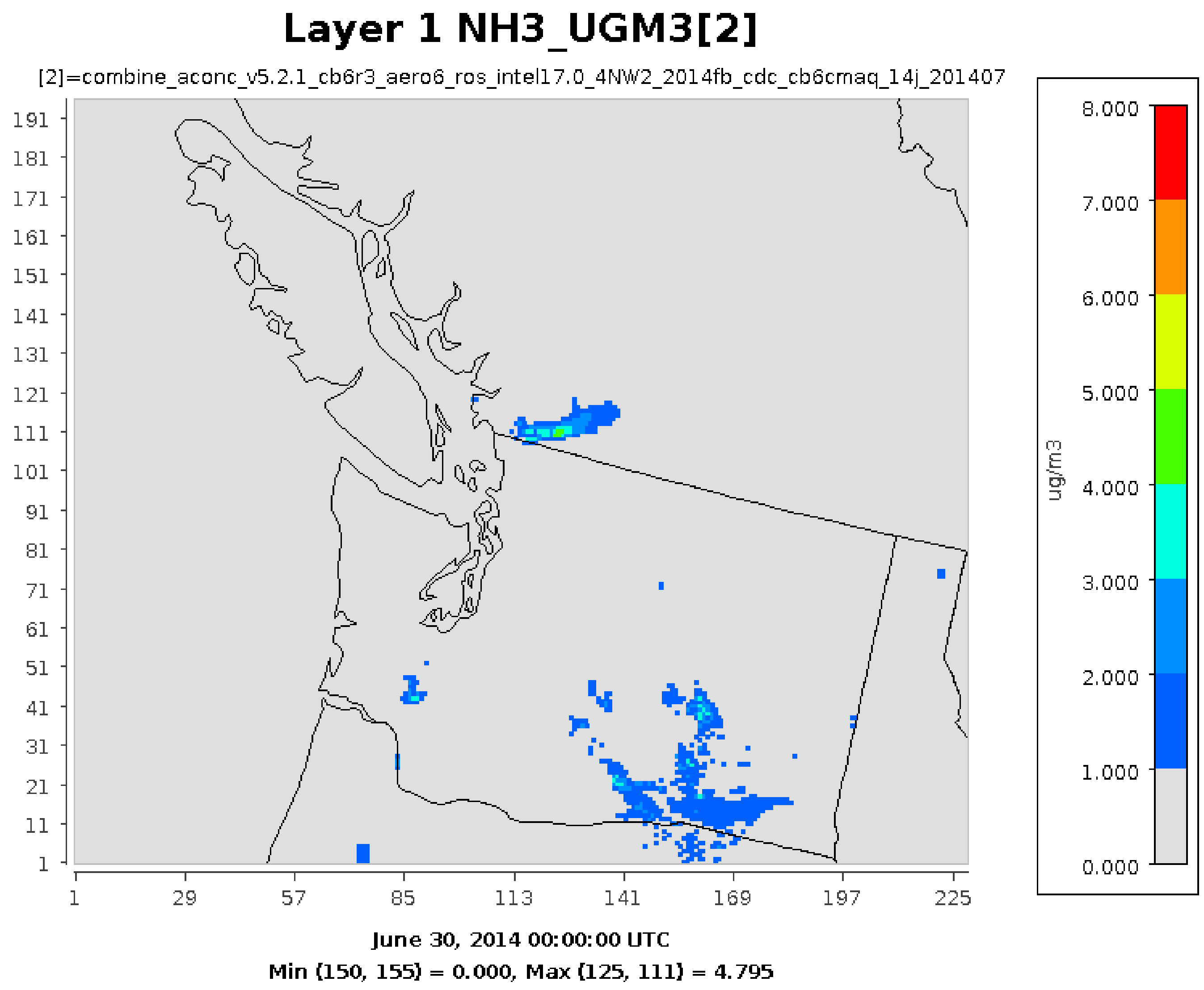
- Identified/perceived key N flows for the region
- Identified/perceived uncertainties for the region



Quantifying em & dep: CMAQ Air Quality Modeling

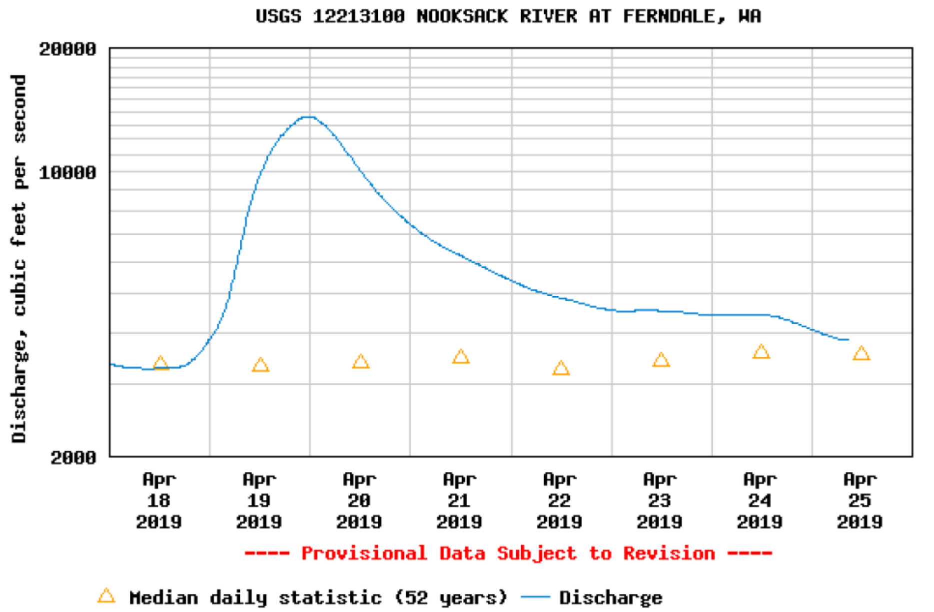
Donna Schwede (EPA)

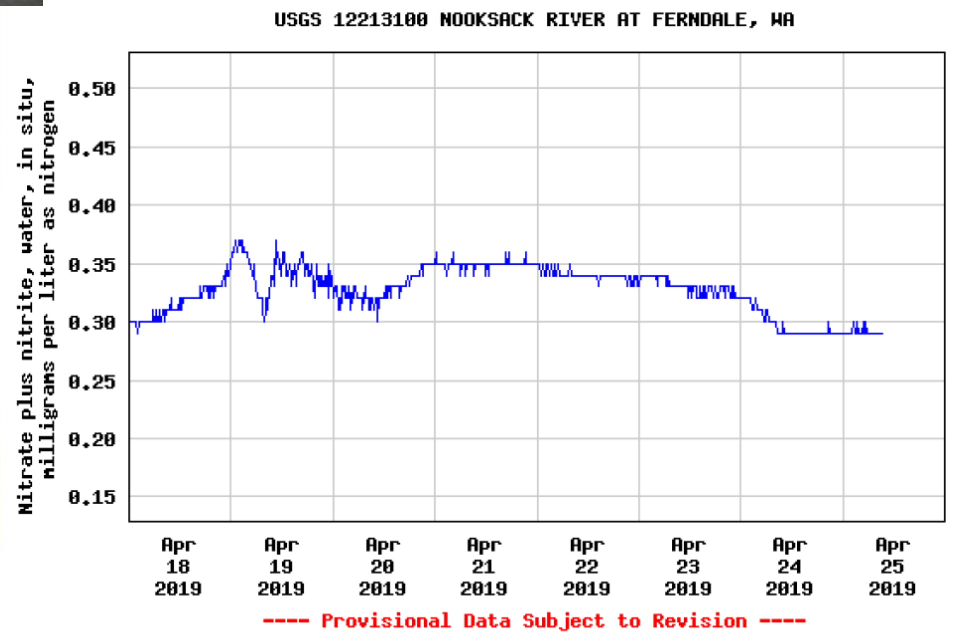
- Emissions – NO_x, NH_3
- Deposition
- Contribution to N budget within watershed



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_2O)
- Ecosystems (e.g., N deposition → biodiversity)
- Soils – (e.g., fertility, crop production)

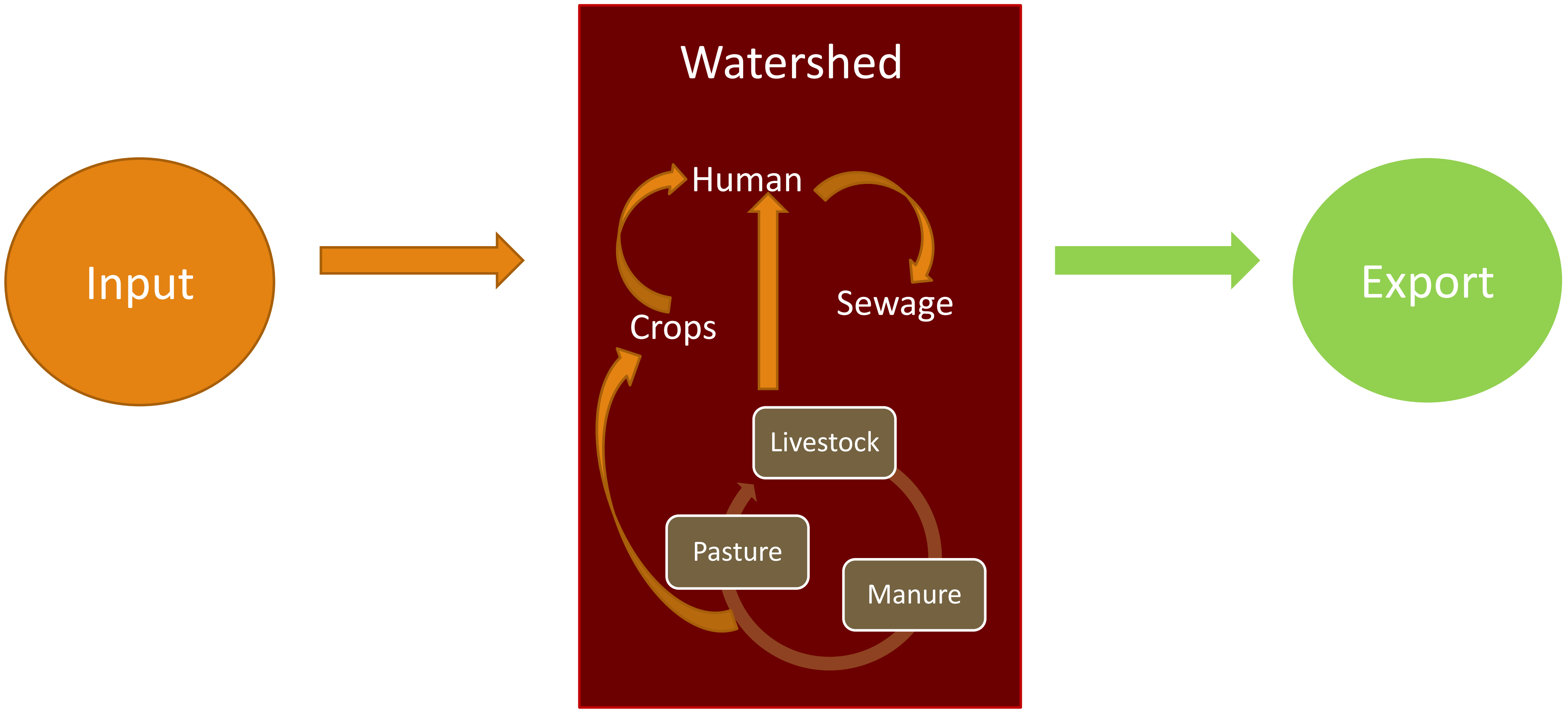
EPA United States Environmental Protection Agency

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

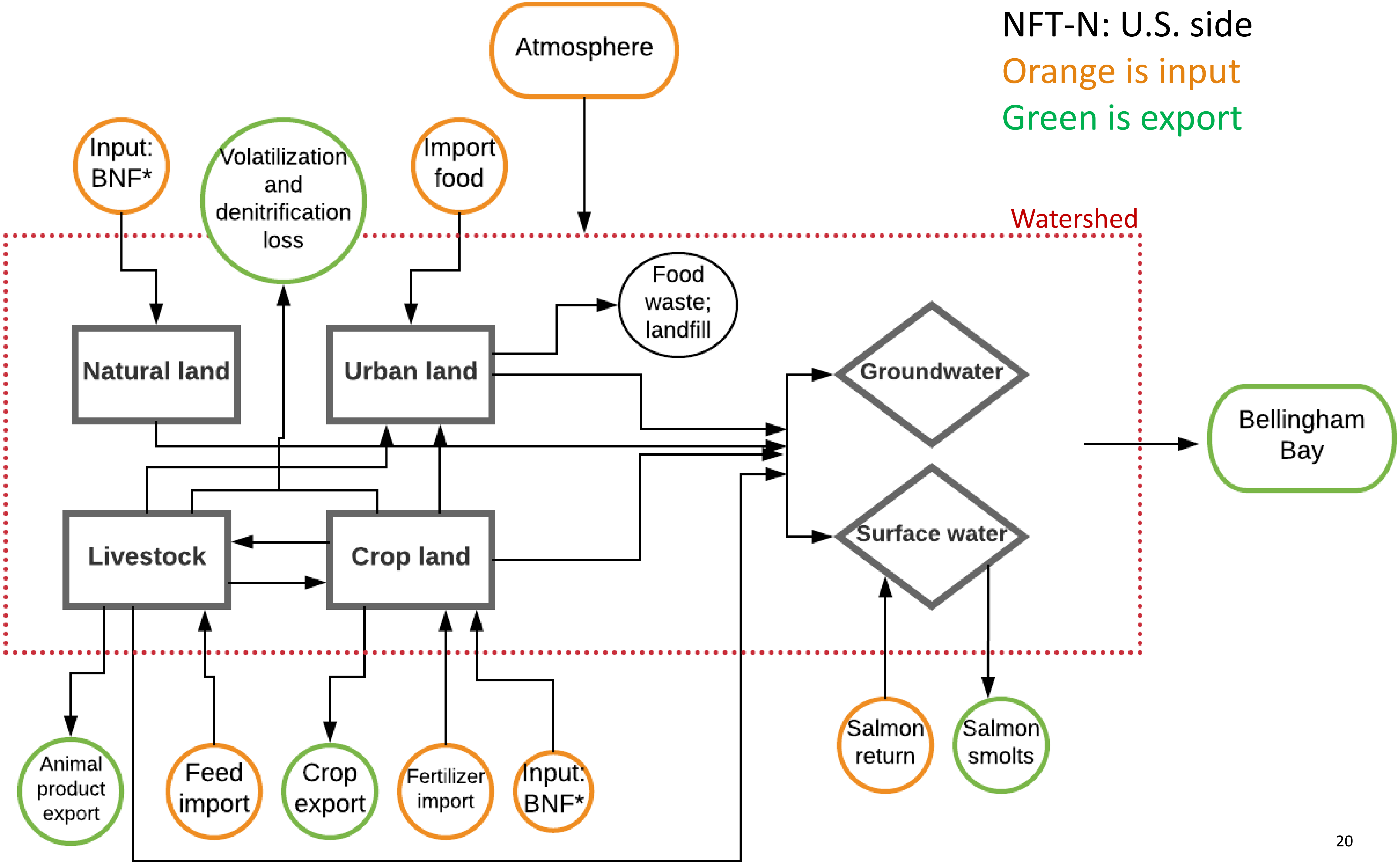
Project Goals

- Develop a nitrogen inventory using local data
- Share among stakeholders
  - 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
  - Improve air quality and drinking water quality
  - Economic goals

NFT-N: U.S. side

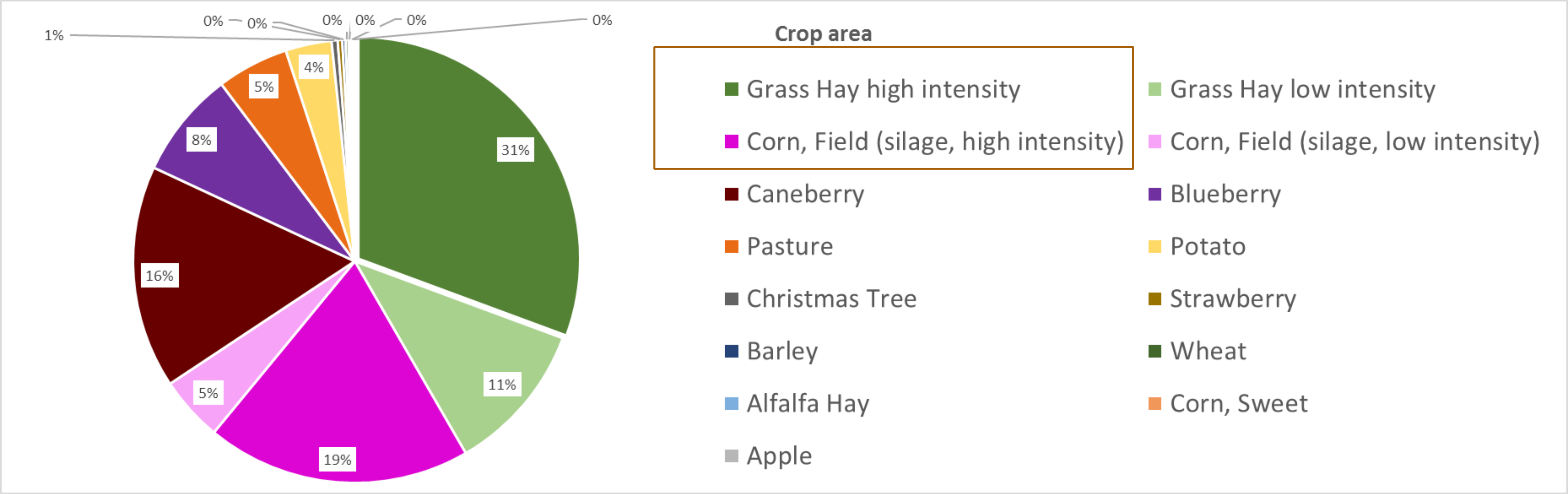
Orange is input

Green is export



NFT-N: Data sources—Inputs

	Component	Parameter	Data source
Input	**Atmospheric deposition**	Total N deposition	EPA-CMAQ
	Food import (human)	Population	U.S. Census (2015)
		Nutritional intake, per capita	USDA, 2012a; 2012b
	Food import (pet)	Watershed household	U.S. Census (2015)
		Population: dog - 37% of watershed households; cat - 30% of watersged households. Assuming one pet per household.	U.S. Pet Ownership Statistics (AVMA, 2012)
		Nutritional and energy needs	Veterinary online manual; Pet Basic Calorie Calculator (OSU)
	Feed import	Animal populations (other than dairy cow)	NASS (2012)
		Dairy cow population	WSDA (2014)
		Nutritional needs of farm animals	Boyer 2002; Hong 2012; NAS web; Gomez 2011; Altine et al 2016; Nennich 2005; Shabtai mode 2018?； Goyette 2016; Statistics Canada 2013
	Fertilizer import	Crop land	WSDA land use map (2014)
		Fertilization rates	Local agriculture experts (personal communication); Oregon and Washington Extension documentations
	Biological N fixation	Alder density	OSU-LEMMA (2002)
		Alder N fixation rate	Binkely et al., 1994
	Adult fish return	Salmon population and size	Nooksack Stock Assessment (personal communication)
		Adult fish body weight	Gresh et al., 2000
		Adult fish body N content	Moore, 2011 AND MORE



NFT-N – complex land uses

NFT-N: Data sources – Outputs

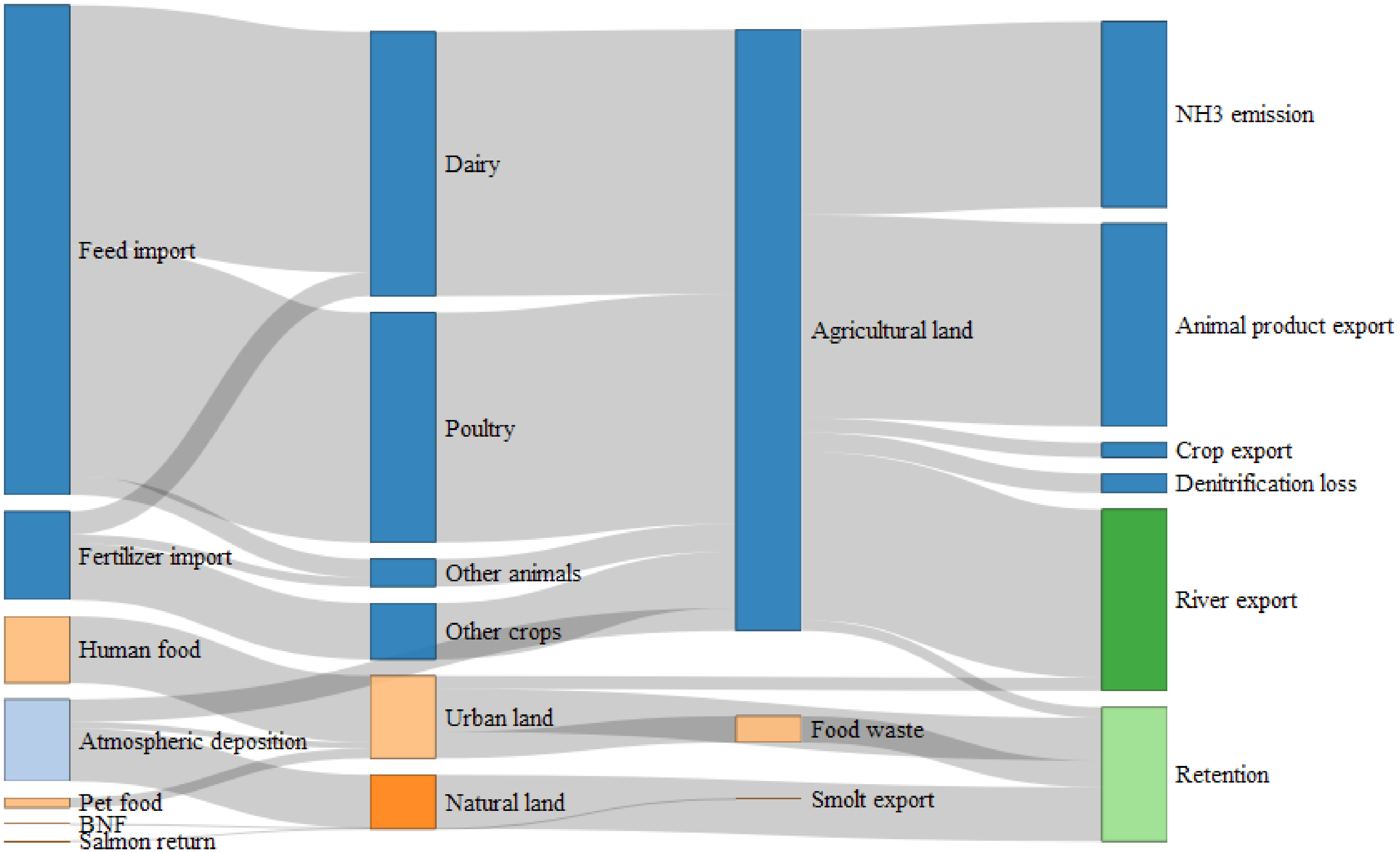
	Component	Parameter	Data source
Output	**Riverine nitrate export**	Flow	Monitor: USGS site 12213100
		Nitrate concentration	Monitor: WA Dept. of Ecology site 01A050
	Riverine TKN export	Flow	Monitor: USGS site 12213100
		TKN concentration	Monitor: Lummi Nation site SW118; USGS site 12213100
	NH3 volatilization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

NFT-N: Data sources—Internal processes

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

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)

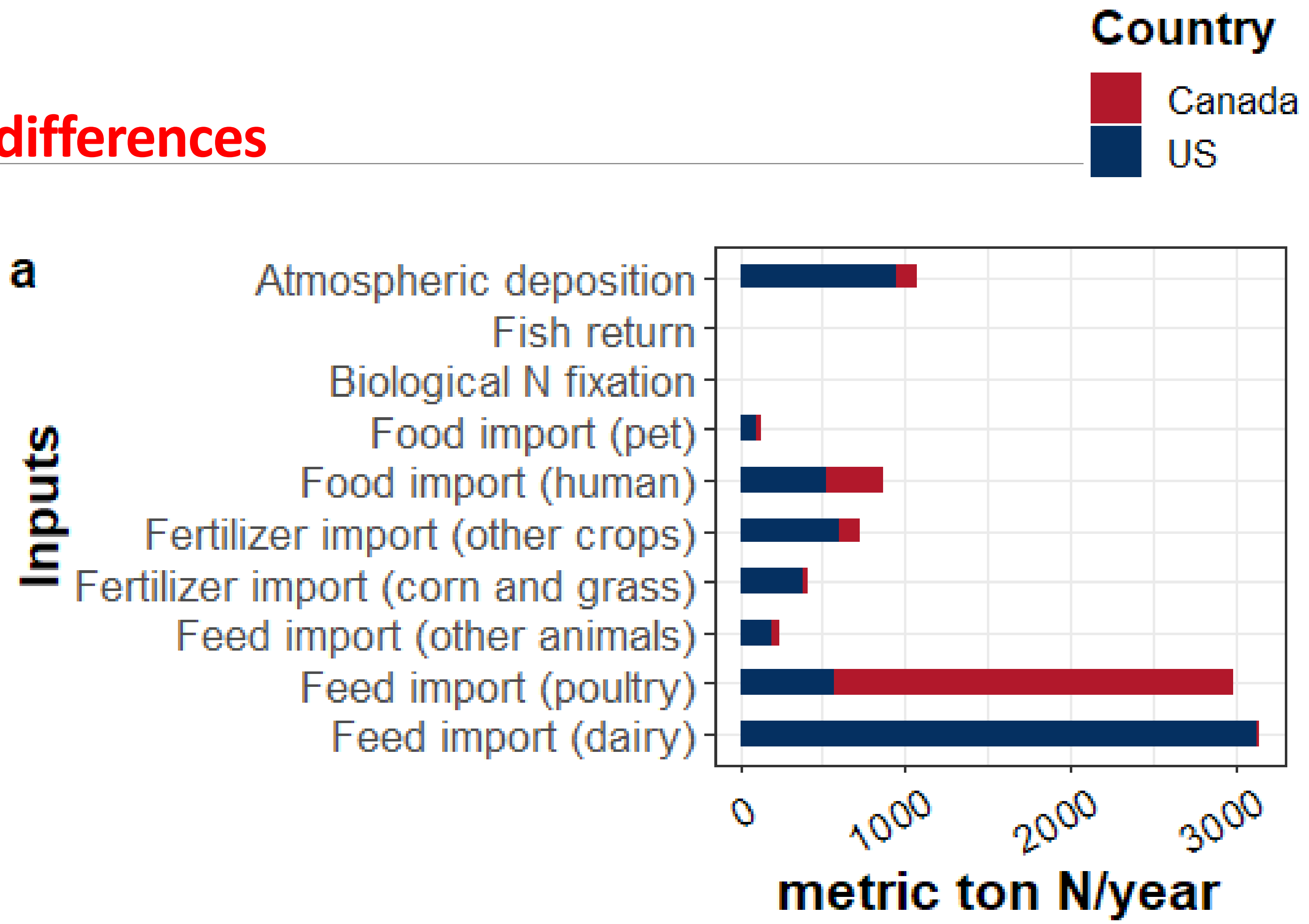


NFT Basin N input

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



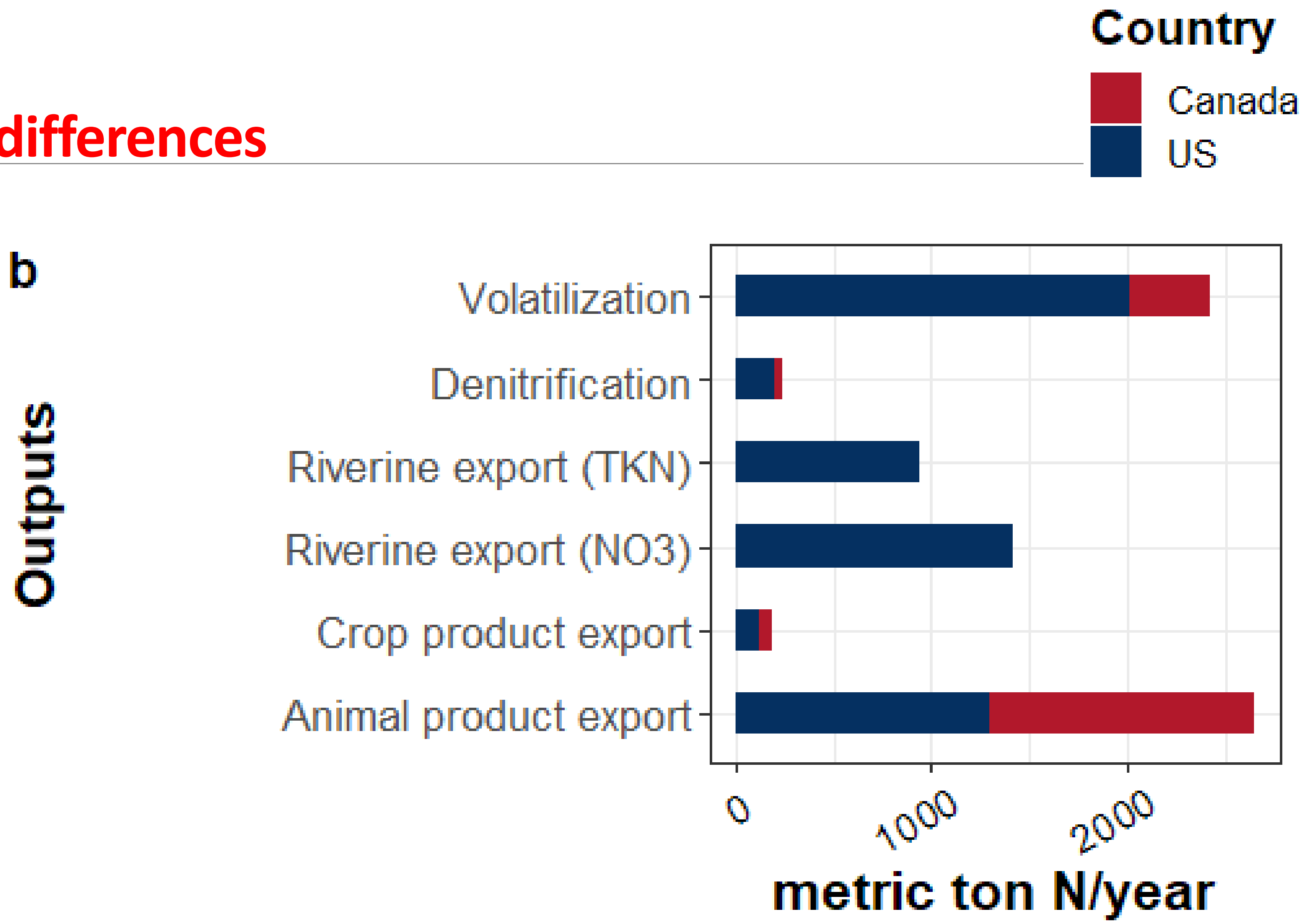
NFT Basin N export

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

Selected scenarios for modeling

Scenario	Climate	Development	Land-use	Diet	N policy
Business-as-usual	No mitigation (RCP 8.5)	Fossil-fuel driven (SSP 5)	Medium regulation; high productivity	Meat & dairy-rich	Low ambition
Low N regulation	Moderate mitigation (RCP 4.5)	Historical trends (SSP 2)	Medium regulation; medium productivity	Medium meat & dairy	Low ambition
Medium N regulation	Moderate mitigation (RCP 4.5)	Historical trends (SSP 2)	Medium regulation; medium productivity	Medium meat & dairy	Moderate ambition
High N regulation	Moderate mitigation (RCP 4.5)	Historical trends (SSP 2)	Medium regulation; medium productivity	Medium meat & dairy	High ambition
Best-case	Moderate mitigation (RCP 4.5)	Sustainable development (SSP 1)	Strong regulation; high productivity	Low meat & dairy	High ambition
Best-case +	Moderate mitigation (RCP 4.5)	Sustainable development (SSP 1)	Strong regulation; high productivity	Ambitious diet shift and food loss/waste reductions	High ambition
Bioenergy	High mitigation (RCP 2.6)	Sustainable development (SSP 1)	Strong regulation; high productivity	Low meat & dairy	High ambition

From David Kanter, NYU

N policy interventions

Sector & country group		N policy ambition levels: High	Medium	Low
Crops[1]	*OECD*	Target NUE by 2030	Target NUE by 2050	Current NUE remains constant
	Non-OECD/High N	Target NUE in 10 years after catch-up with OECD countries	Target NUE in 30 years after catch-up with OECD countries	NUE trends from past 10 years continue if positive, otherwise NUE remains constant
	Non-OECD/Low N	Target NUE in 30 years by avoiding historical trajectory	NUE follows historical trajectory towards high N/low NUE over 30 years, before improving	Current decreasing NUE trends continue akin to countries with similar socioeconomic status
Livestock manure excretion[2]	*OECD*	10% reduction by 2030, 30% reduction by 2050	10% reduction by 2050, 30% reduction by 2070	Current rates remain constant to 2050
	Non-OECD/High N	N excretion rates same as OECD in 10 years after catch-up	N excretion rates same as OECD in 30 years after catch-up	Current trends continue if positive, otherwise remain constant
	Non-OECD/Low N	30% reduction for new livestock production after 2030	30% reduction for new livestock production after 2050	Current trends continue or remains constant
Manure recycling[2]	*OECD*	90% recycling by 2030	90% recycling by 2050	Current rates remain constant to 2050
	Non-OECD/High N	50% increase in recycling by 2030; 100% increase by 2050	50% increase in recycling by 2050; 100% increase by 2070	Current trends continue if positive, otherwise remain constant
	Non-OECD/Low N	90% recycling by 2030	90% recycling by 2050	Current trends continue or remain constant
Air Pollution[3]	*OECD*	70% of technically feasible measures by 2030, all measures by 2050	Current legislation (CLE) by 2030, 70% of technically feasible in 2050 increasing to all measures by 2100	CLE reached by 2040, further improvements slow
	Non-OECD/High-Med income	Same as OECD in 10 years after catch-up	Delayed catch-up with OECD (CLE achieved by 2050), 70% of technical feasible reductions achieved by 2100	CLE reached by 2040, further improvements slow
	Non-OECD/Low income	CLE by 2030, OECD CLE by 2050, gradual improvement towards 70% technical feasible measures	OECD CLE achieved by 2100	CLE reached 2050, further improvements negligible
Wastewater[4]	*OECD*	>99% wastewater treated; 100% N and P recycling from new installations from 2020	>95% wastewater treated 100% N and P recycling from new installations from 2030	>90% wastewater treated
	Non-OECD/High N	>80% wastewater treated; Recycling same as OECD in 10 years after catch-up	>70% wastewater treated Recycling same as OECD in 30 years after catch-up	>60% wastewater treated
	Non-OECD/Low N	>70% wastewater treated	>50% wastewater treated	>30% wastewater treated

1. Zhang et al. 2015; 2. UNEP 2013; 3. Rao et al. 2017; 4. Van Puijenbroek et al. 2018

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!

David Hooper <hooper@wwu.edu>

Jiajia Lin <lin.jiajia@epa.gov>

Jana Compton <Compton.Jana@epa.gov>

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