Nitrogen balance and use efficiency in the Calapooia River Watershed, Oregon, United States

Jiajia Lin (US National Research Council-Environmental Protection Agency, lin.jiajia@epa.gov)
Jana Compton (US Environmental Protection Agency, compton.Jana@epa.gov)
George Mueller-Warrant (US Department of Agriculture, George.Mueller-Warrant@ars.usda.gov)
William Matthews (Oregon Department of Agriculture, wmatthews@oda.state.or.us)
Scott Leibowitz (US Environmental Protection Agency, leibowitz.Scott@epa.gov)

The Calapooia River

- Major tributary to the Willamette River in Oregon. Drainage area of 963 km^2
- Home to important habitat for threatened salmonids and other species
- Characterized by a mountainous forested uplands and flat agricultural lowlands Agricultural land accounts for 53% of the watershed area, and forest 43%.

Purpose of the study

- Quantify the impacts of natural processes and land uses on the N use efficiency of this watershed
- Help improve N management efficiency.

Hypothesis

- Agricultural input, mainly fertilizer is the dominant source of TN in the watershed
- Total N input, agricultural practices, as well as annual runoff control stream export and retention of nitrogen in the area

Methods

- Calculate annual and seasonal N budget
- Fractional stream yield and crop removal of N
- Correlation analysis: factors affect N export and retention in the watershed (land use; management)

- ***N Input***

GIS data of N sources

- ***N Export***

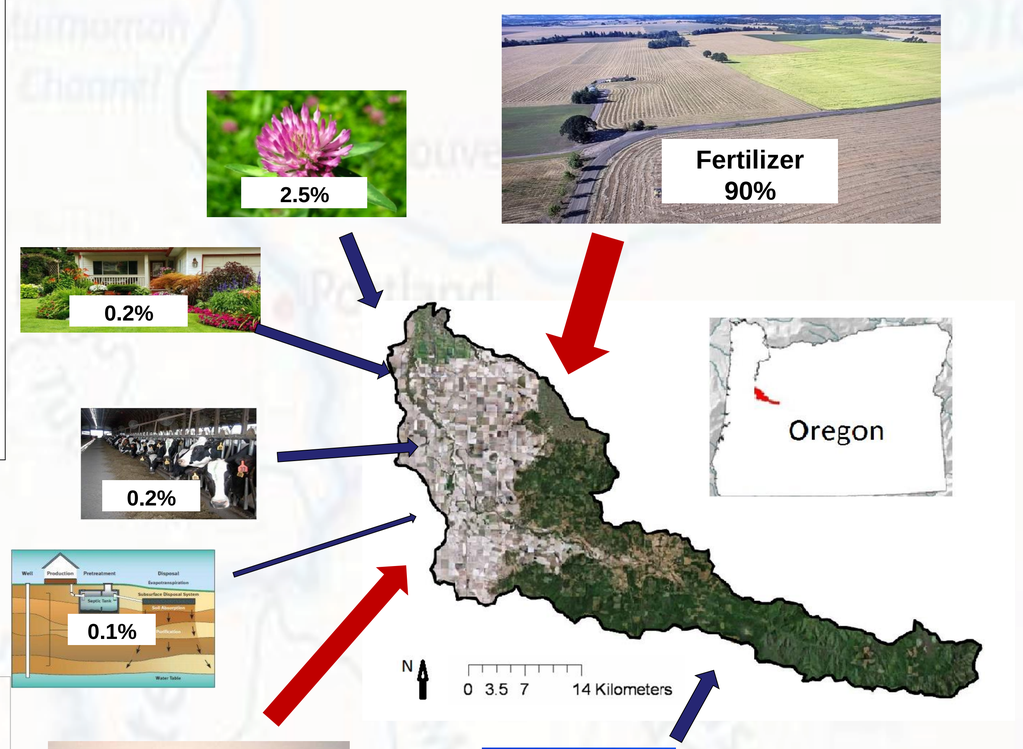
1. Geochemical measurements (73 sites) + LOADEST modeling (USGS) → Stream yield/export of N
2. Land use map + plant N content → Crop harvest removal of N

- ***N Retention***

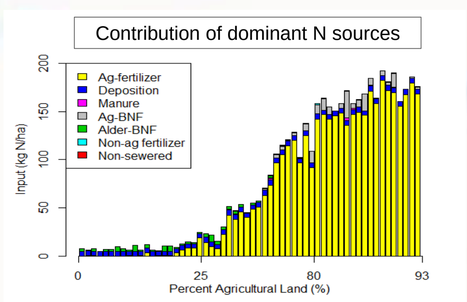
=Total input – stream yield – crop harvest

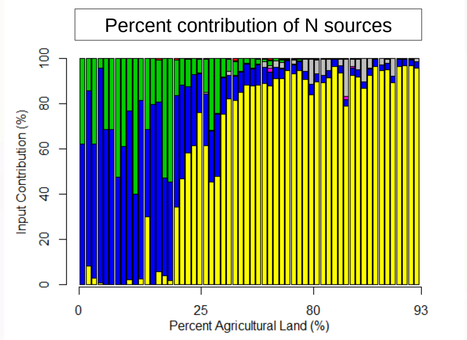
N source	GIS Data Source
Agricultural fertilizer input	USDA-ARS 2008; OSU extension suggestion on application rates
Non-farm fertilizer input	USGS SPARROW
CAFO (Concentrated Animal Feeding Operation) manure	ODA records (Oregon Department of Agriculture)
Agricultural BNF (Biological Nitrogen Fixation)	USDA-ARS 2008
Alder	LEMMA (Landscape Ecology, Modeling, Mapping & Analysis) data layer
Non-sewered	USGS SPARROW
Atmospheric deposition	CMAQ (Community Multiscale Air Quality) model data for 2008, new 4km grid

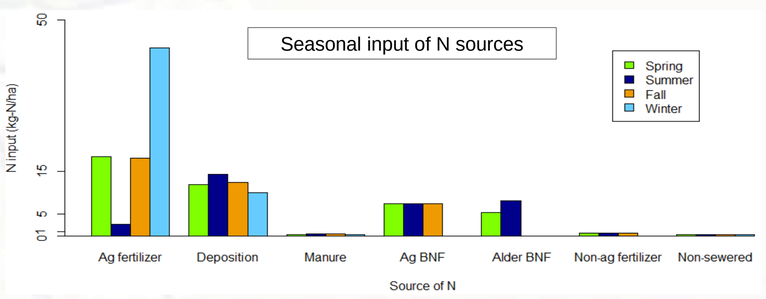
The Calapooia River Watershed

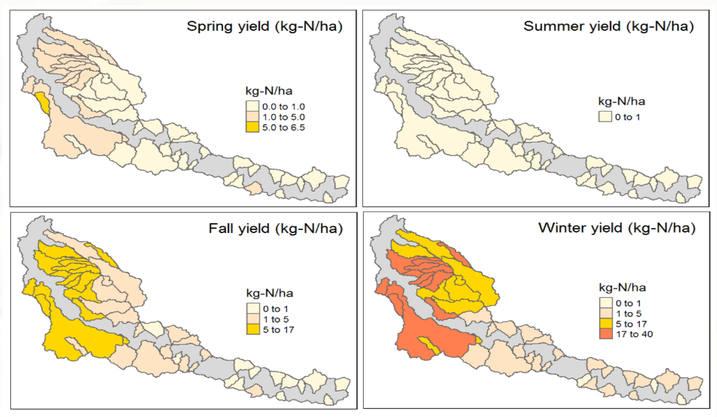


Nitrogen Sources in the Calapooia River Watershed



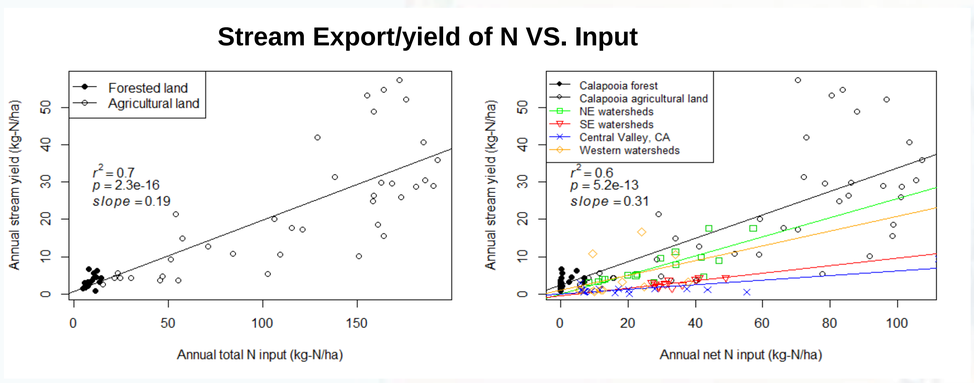


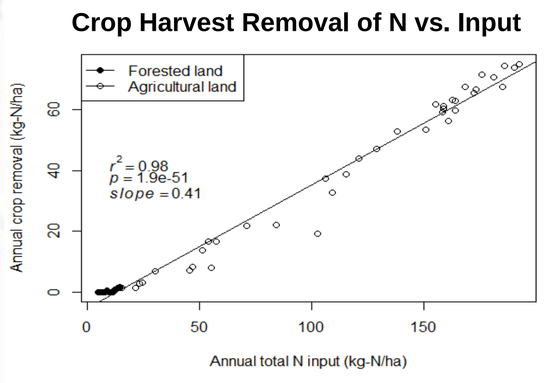


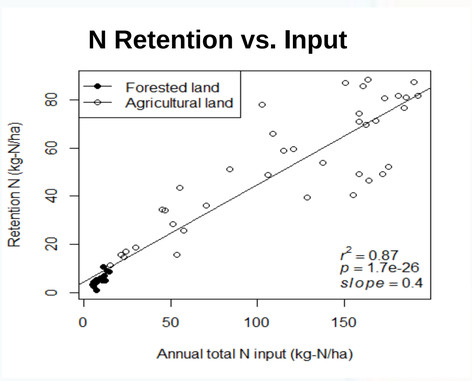


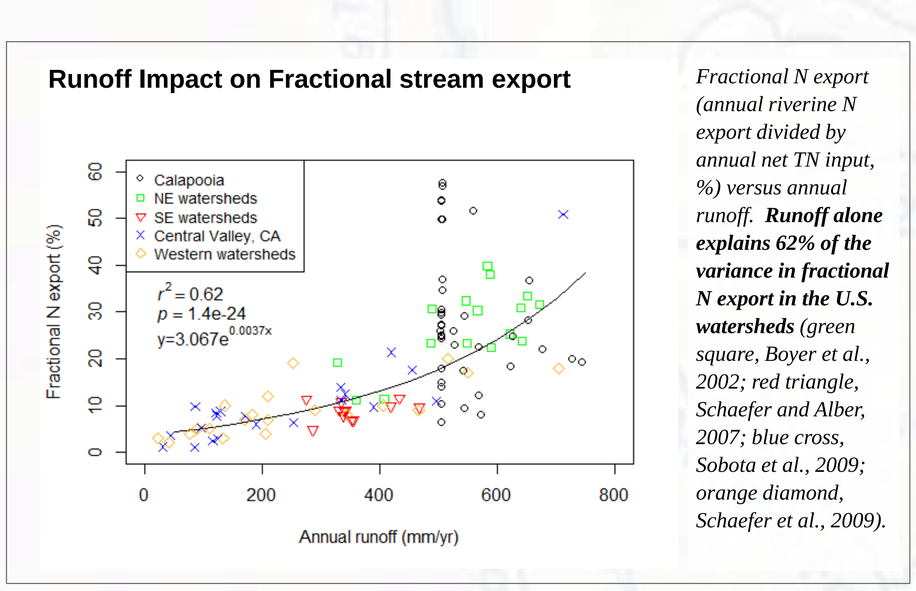
Seasonal riverine yield *of N* (kg N ha^{-1}) *in the Calapooia subwatersheds, 2008. Grey area: no data.* ***Winter yield accounts for over 60% of annual yield*** *on average.*

Results

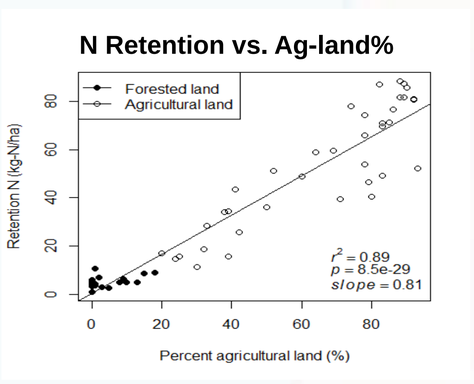


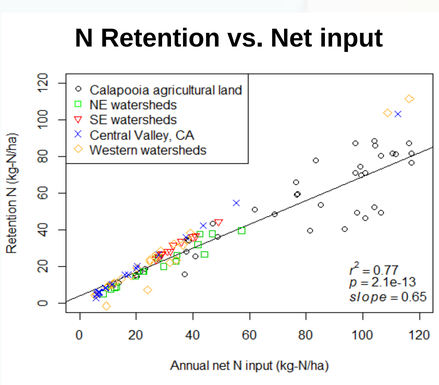






Fractional N export (annual riverine N export divided by annual net TN input, %) versus annual runoff. ***Runoff alone explains 62% of the variance in fractional N export in the U.S. watersheds*** *(green square, Boyer et al., 2002; red triangle, Schaefer and Alber, 2007; blue cross, Sobota et al., 2009; orange diamond, Schaefer et al., 2009).*





Retention versus net N input *in the Calapooia River Watershed, NE watersheds (slope = 0.74, green square, Boyer et al., 2002), SE watersheds (slope = 0.90, red triangle, Schaefer and Alber, 2007), California Central Valley (slope = 0.94, blue cross, Sobota et al., 2009), and western watersheds (slope = 0.97, orange diamond, Schaefer et al., 2009). The linear regression is based on data of Calapooia agricultural land.*

Correlation Analysis (n=58): seasonal yield vs. management

Winter yield ~ winter fertilization ($p<0.001, r^2=0.60$);
~ summer harvest ($p<0.001, r^2=0.58$, slope =0.32)

Fall yield ~ positively correlated to summer harvest removal ($p<0.001, r^2=0.67$) and negatively correlated to NET_{Summer} ($p<0.001, r^2=0.64$) and $NET_{Spring+Summer}$ ($p<0.001, r^2=0.56$)

Summer yield ~ summer runoff ($p<0.001, r^2=0.57$)

NET_{Summer} = Total input Summer – crop removal Summer
$NET_{Spring+Summer}$ = Total input (Spring+Summer) – Crop removal (Spring+Summer) – Stream yield Spring

Conclusions

- ❖ Fertilizer is the dominant source of watershed N in the agriculture dominated subwatersheds. Average N input rate of the agricultural area is about 130 kg ha^{-1} yr^{-1} (45-97%)
- ❖ In the forest subwatersheds, typical background N input is < 10 kg N ha^{-1} yr^{-1}; atmospheric deposition and alder BNF are the two main sources of N
- ❖ At the watershed level, 50% of nitrogen input occurs in the winter, nearly 24% in the spring, about 23% in the fall, and < 4% in the summer
- ❖ On average, annual stream export of N in Calapooia is 19% of total N input (r^2 = 0.7), and 31% of the net N input
- ❖ about 41% of total N input is removed via crop harvest annually among the 58 studied subwatershed
- ❖ The proportion of net N input that is "retained" in Calapooia is within the same range of estimates of NE watersheds, falling between 60-89%
- ❖ Runoff alone explains 62% of the variance in fractional N export in the U.S. watersheds
- ❖ Summer harvest is positively correlated with winter and fall yield, while NET_{Summer} and $NET_{Spring+Summer}$ are negatively correlated with winter and fall yield. These correlations indicate land use impact on stream N export.

Reference

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