Connecting Seasonal Riparian Buffer Metrics and Nitrogen Concentrations in a Pulse-Driven Agricultural System

Albany Democrat-Herald Mar 31st , 2012

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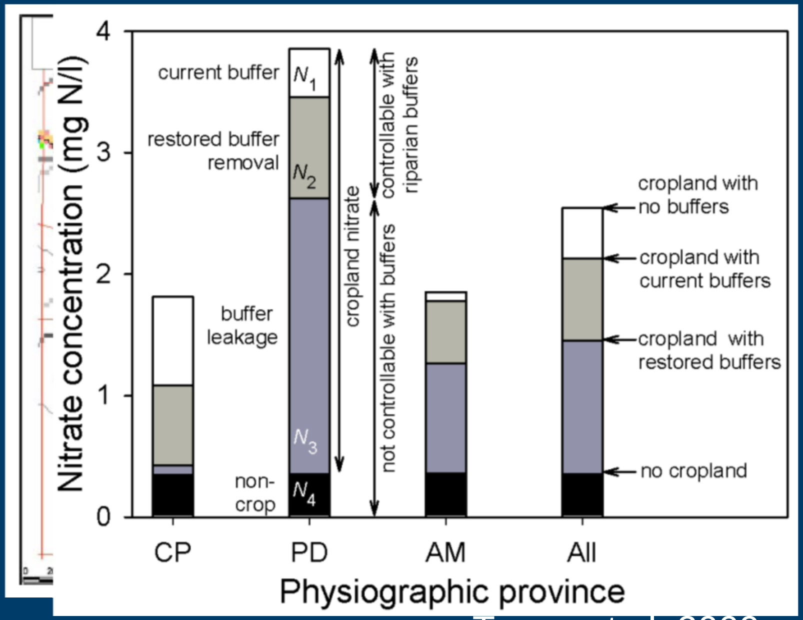
Riparian Watershed Assessment

- GIS metrics/tools developed to identify spatial "hot spots"
  - Baker et al. 2006
  - Tomer et al. 2009
  - Dosskey et al. 2011



Tomer et al. 2009
Weller et al. 2011

- Targeted placement of riparian buffers
- Improved nutrient prediction models that account for influence of buffers (Weller et al. 2011)

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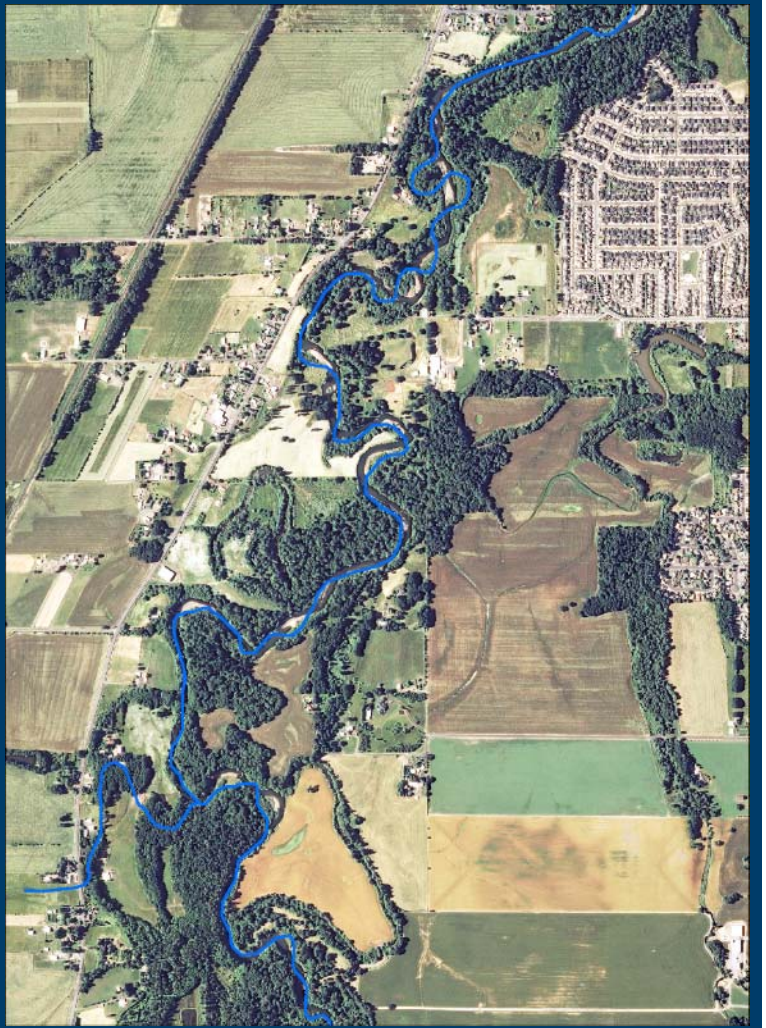
Static Riparian System

- Current GIS riparian metrics often address the spatial extent of a fixed stream with fixed buffers
- Regulations, conservation, and restoration efforts often focused on perennial USGS “blue lines”



Temporal Dynamics

- But convergent, concentrated and ephemeral flows occur
- Expand beyond “blue line” streams and reduce riparian buffer effectiveness

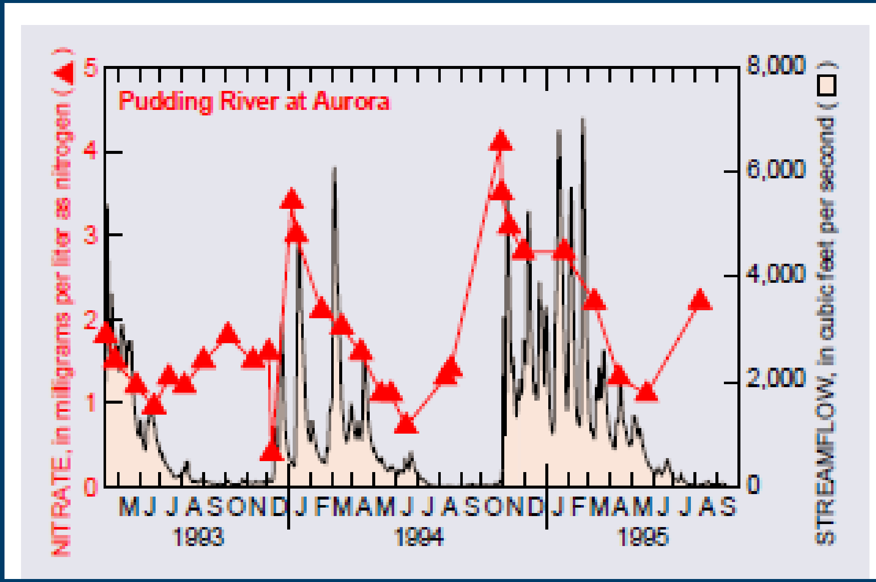
(Dosskey et al 2002, Wigington et al. 2003, Newbold et al. 2010, Pankau et al. 2012)

Temporal Dynamics

- More pollutants are transported in higher flows
- Seasonal pulses of nutrients

- Riparian buffers are potentially "bypassed" by flows

Wentz et al. 1998



Objectives

Incorporating temporal dynamics into GIS assessments of buffers and water quality

- Estimate seasonal flowpaths in agriculture
- Run riparian spatial metrics with seasonal flowpaths
- Statistically relate seasonal riparian metrics to seasonal water quality parameters
- Determine relative importance of buffers on seasonal water quality signal

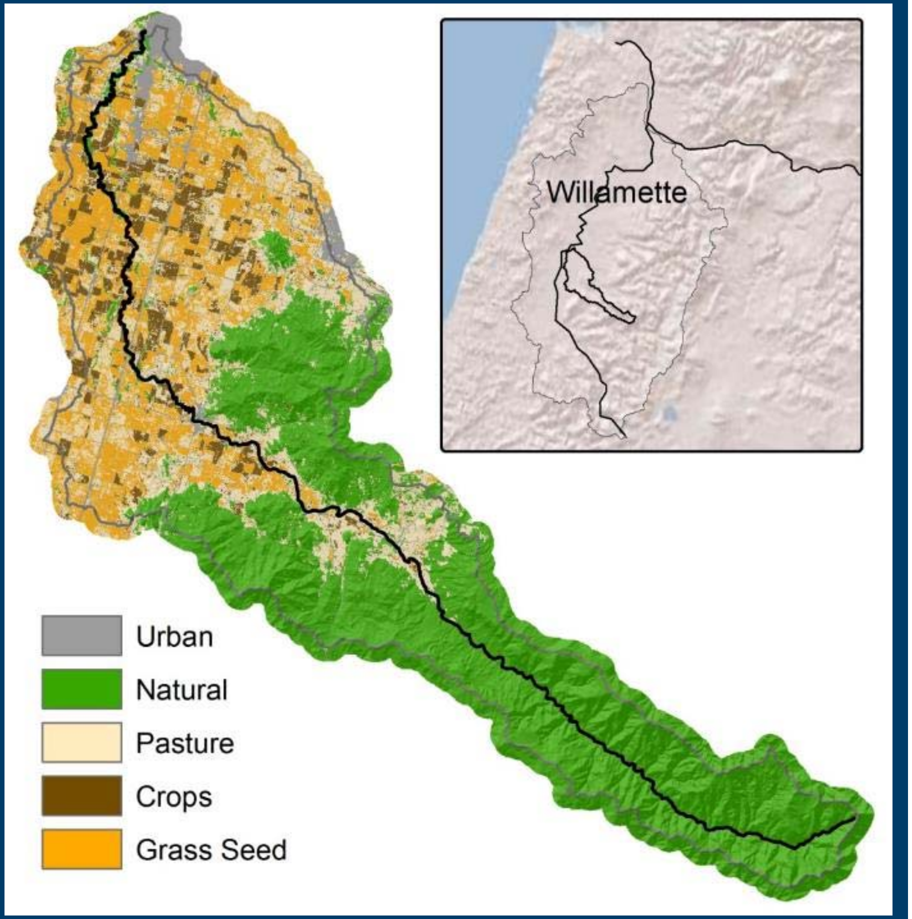
Calapooia River, OR

Watershed: 955 km^2

Flat valley with poorly drained soils

47% agriculture

- 39% pasture-grass seed mix
- 8 % row crops



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Calapooia River, OR

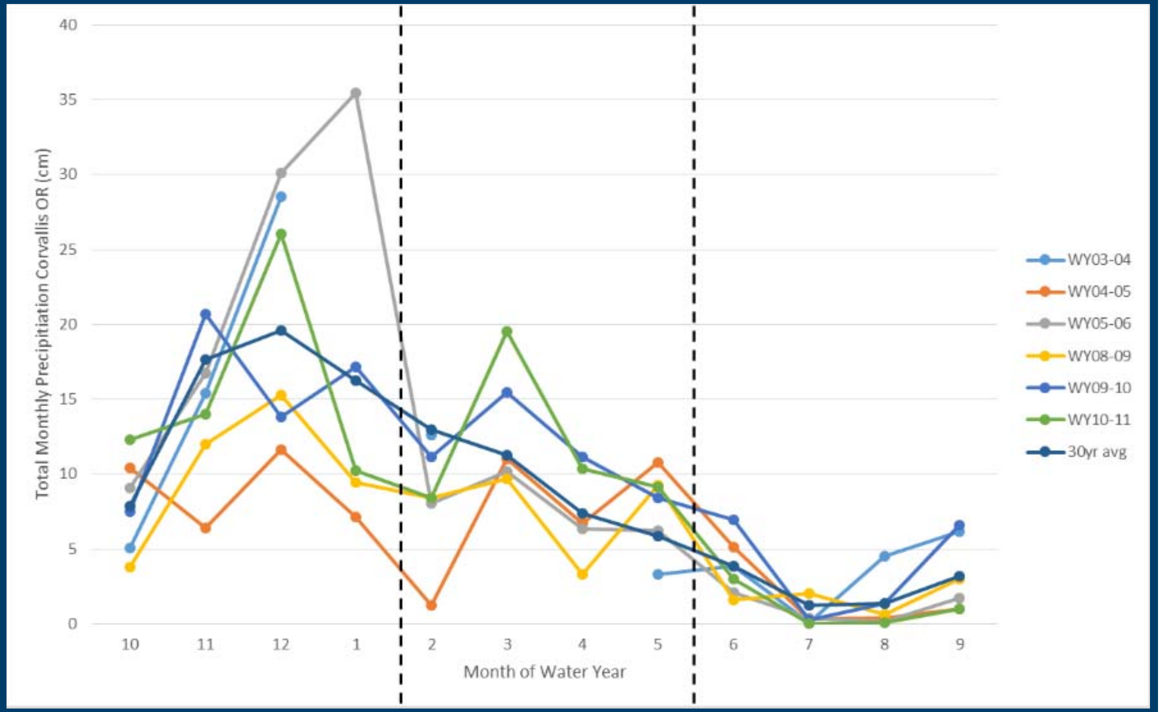
Strong Seasonality:

Precipitation totals

- Oct-Jan: 61 cm
- Feb-May: 38 cm
- June-Sep: 10 cm

Saturation – overflow on poorly drained soils during wet winter

Wet Transitional Dry

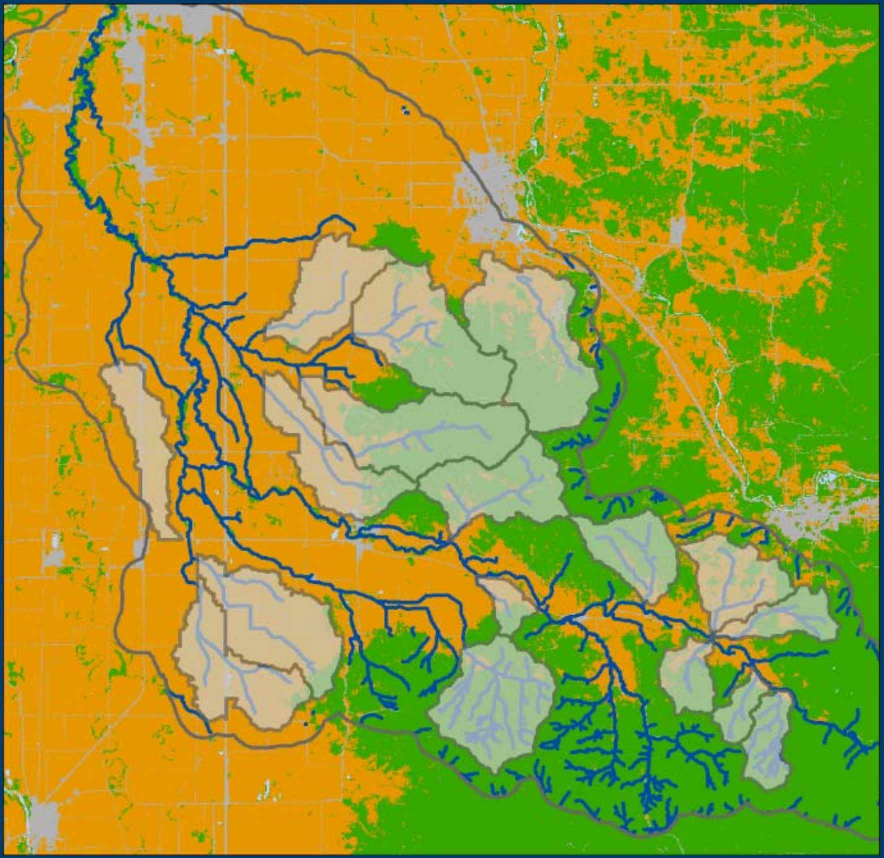


Ephemeral Intermittent Perennial

Calapooia River, OR

Seasonal water quality samples of Total Nitrogen:

- 2003-2006 and 2009-2011
- 17 catchments with perennial flows

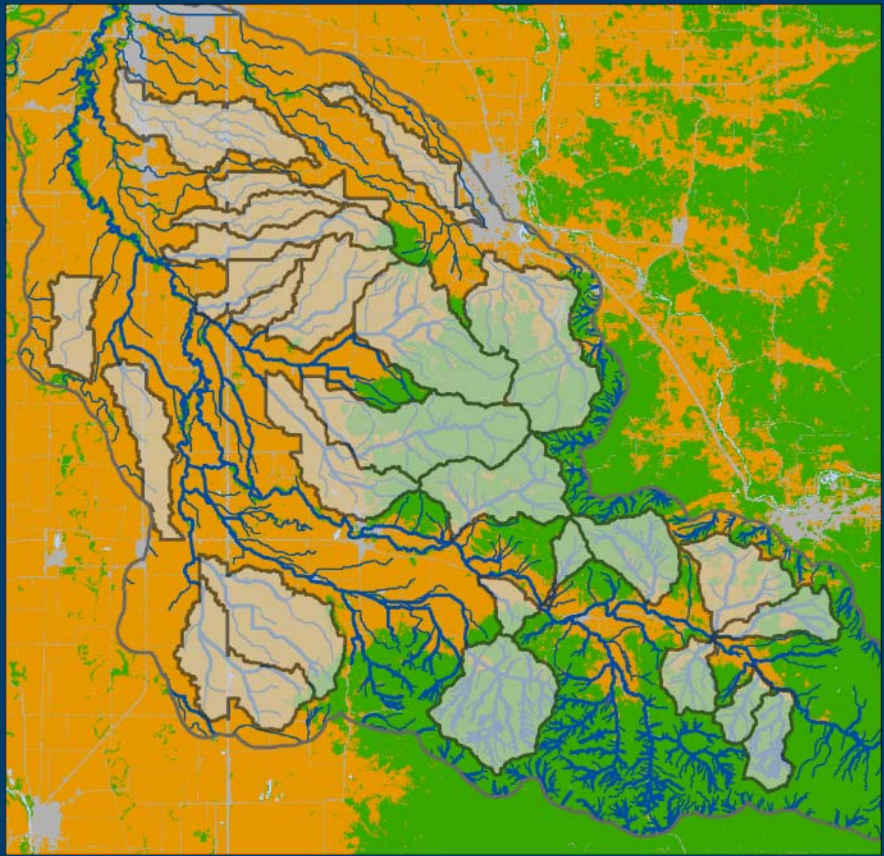


Perennial streams per NHD designation

Calapooia River, OR

Seasonal water quality samples of Total Nitrogen:

- 2003-2006 and 2009-2011
- 17 catchments with perennial flows
- 26 catchments with intermittent or ephemeral flows



Intermittent streams per NHD designation

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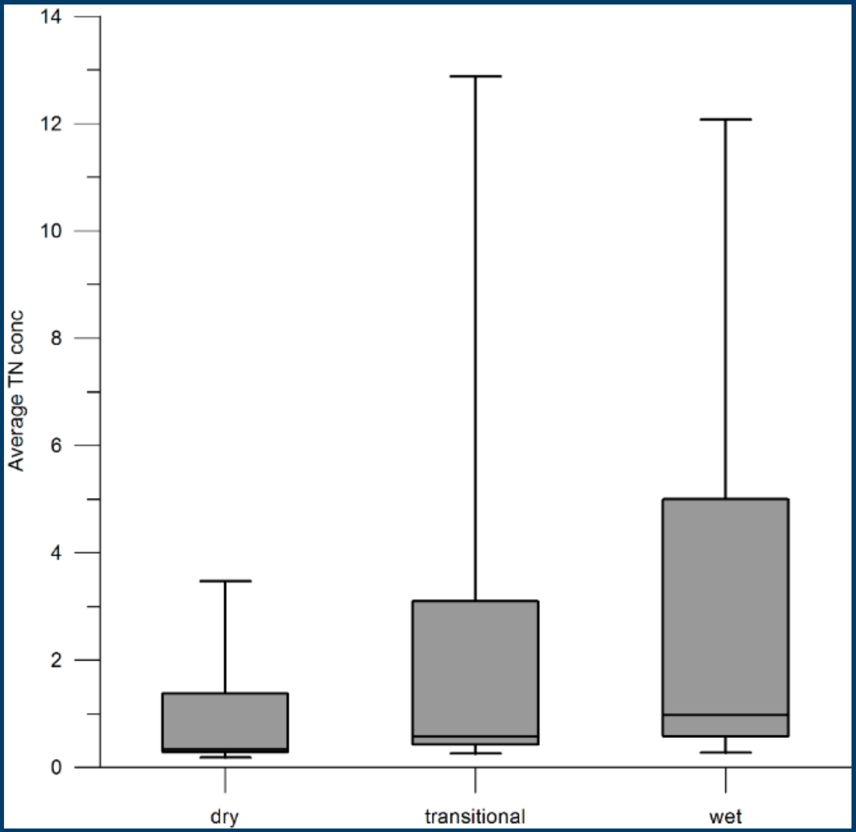
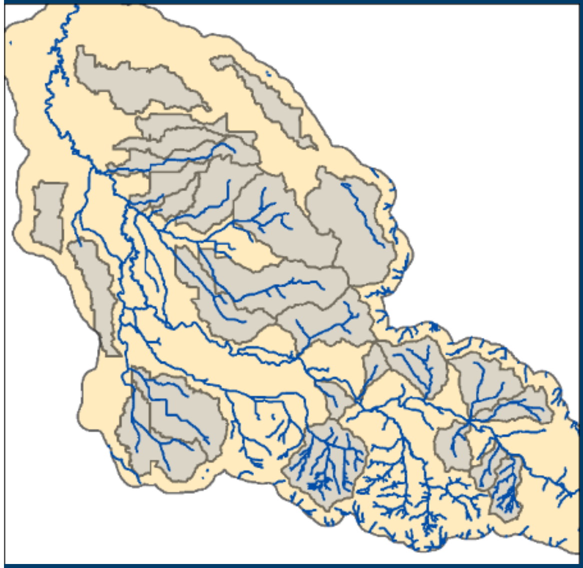
Calapooia River, OR

Seasonal water quality samples of Total Nitrogen:

- 2003-2006 and 2009-2011
- 17 catchments with perennial flows
- 26 catchments with intermittent or ephemeral flows
- Seasonal signal in TN concentrations

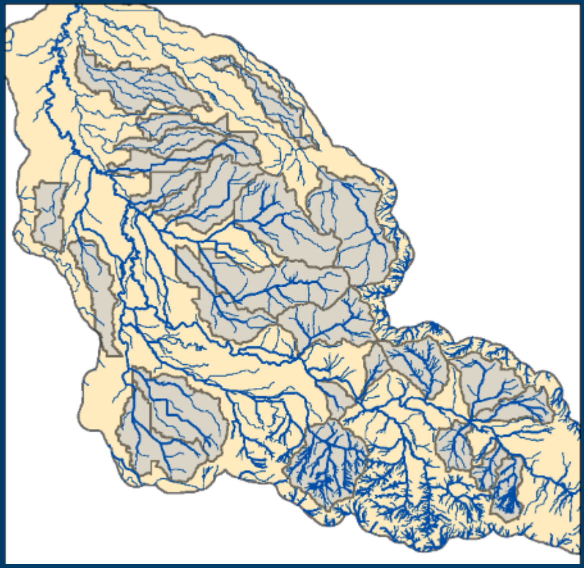


Estimating Stream Expansion – 3 stream extents



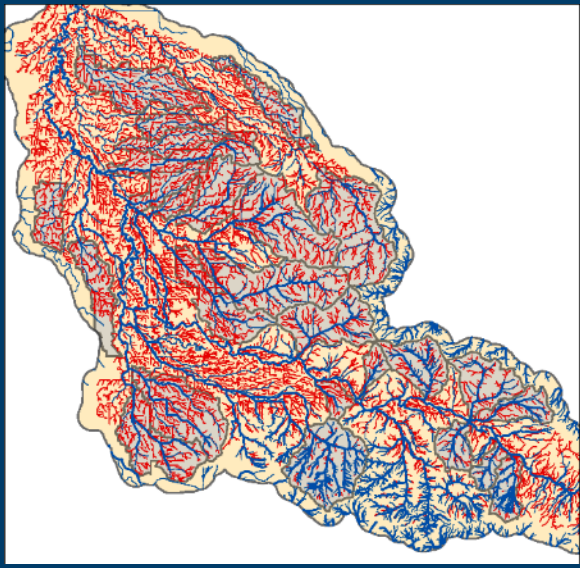
Perennial

NHD perennial



Intermittent

NHD intermittent



Ephemeral

Estimate from Wigington et al 2005 LiDAR, soils and landscape position

Riparian Metrics - Methods

Determine spatially-explicit riparian metrics for the three stream extents

GIS riparian tool (Baker et al. 2006)

Connects source cells (cropland) to streams via overland flowpaths

Land cover – DEM – 5m, CDL 2010, 3 stream layers

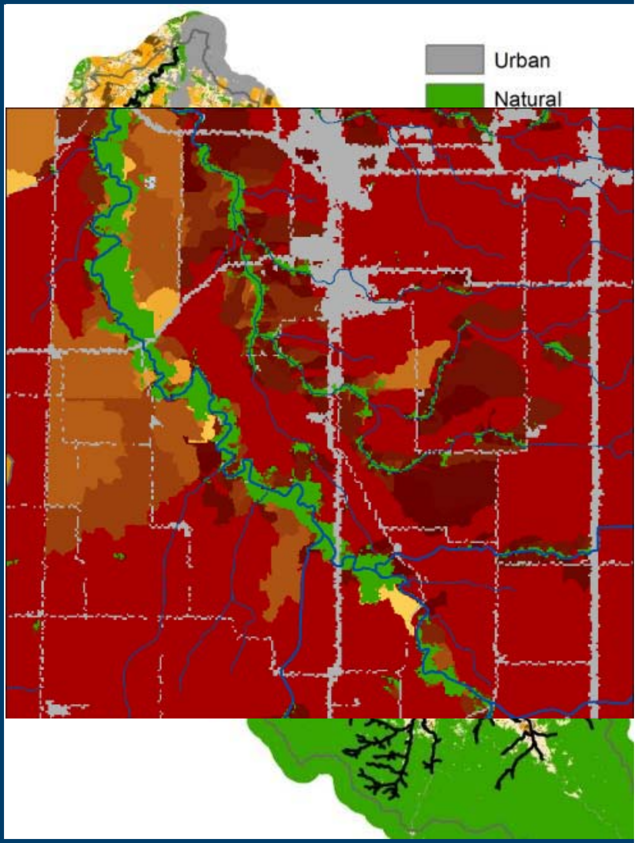
Output per catchment per season:

% agriculture

% of non-buffered agriculture

% of non-buffered agriculture on hydric

(Floyd et al 2009, Evans et al 2014)



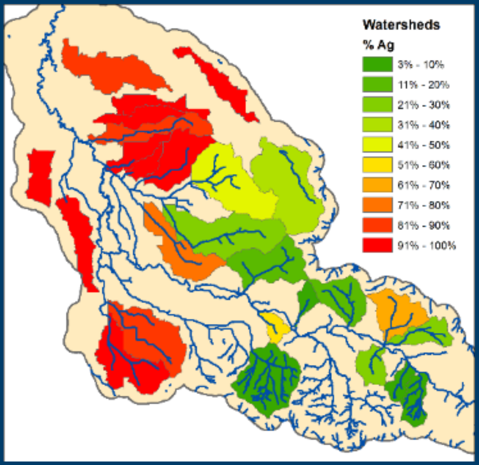
Statistical Structure (Weller et al Ecol App 2011)

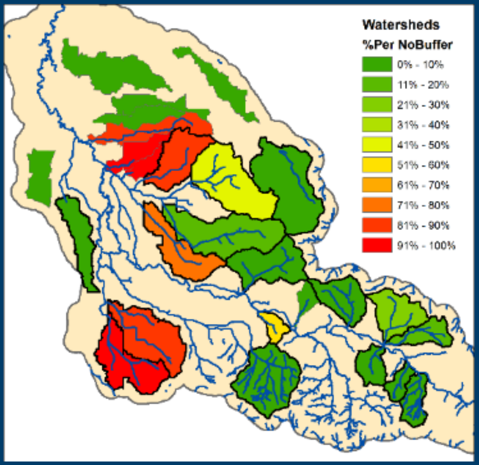
For each season:

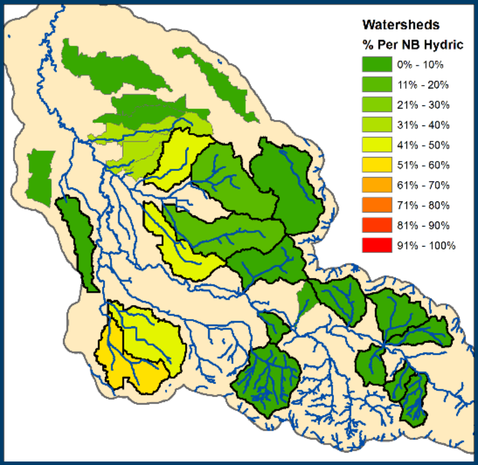
$LgTN_P = \beta_0 + \beta_{ag}\%Ag$ – background and all ag inputs

$LgTN_P = \beta_0 + \beta_{ag}\%Ag + \beta_{nb}\%NBAg_P$ – adds perennial non buffered ag inputs

$LgTN_P = \beta_0 + \beta_{ag}\%Ag + \beta_{nb}\%NBAg_P + \beta_{hy}\%NBHy_P$ – adds NB ag hydric soil inputs







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Statistical Structure (Weller et al Ecol App 2011)

- For each season:
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- AICc of regression analyses to determine acceptable models
- Variance Inflation Factor to remove highly collinear models
- Model Average

Model Results

Model/Season	independent variables			k	RMSE	Adj R^2	AICc	Delta	wt
Perennial (n=17)	%Ag	%PerNB	%PerNBHy						
	X			2	0.241	0.621	-25.711	1.059	0.315
	X	X		3	0.243	0.613	-23.070	3.700	0.084
	X	X	X	4	0.200	0.737	-26.770	0.00	**0.535**
	X		X	3	0.246	0.602	-22.600	4.170	0.066
Intermittent (n=26)	%Ag	%IntNB	%IntNBHy						
	X			2	0.259	0.785	-39.228	12.823	0.001
Corr=.98	X	X		3	0.235	0.824	-42.648	9.403	0.007
	X	X	X	4	0.200	0.873	-49.165	2.886	0.189
	X		X	3	0.196	0.877	-52.051	0.000	**0.802**
Ephemeral (n=26)	%Ag	%EphNB	%EphNBHy						
	X			2	0.264	0.763	-38.235	11.258	0.003
Corr=.99	X	X		3	0.252	0.784	-38.898	10.595	0.004
	X	X	X	4	0.214	0.844	-45.399	4.094	0.113
	X		X	3	0.210	0.850	-48.493	0.000	**0.879**

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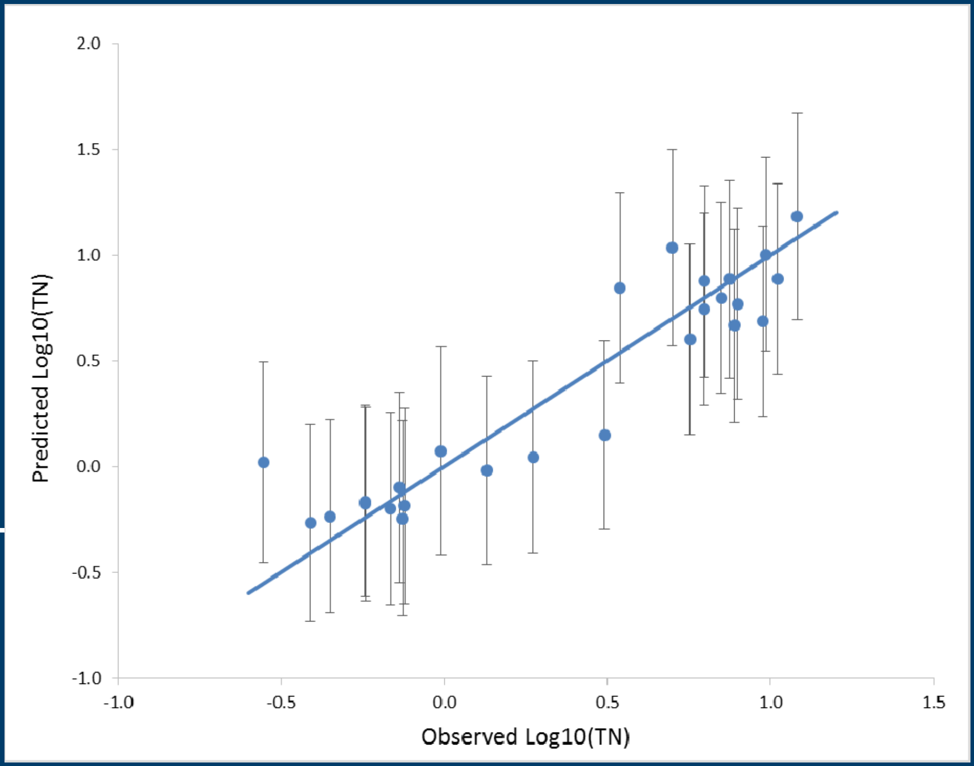
Model Averages



Perennial:

$LgTN_P = -0.69 + 1.07(\%Ag)$ -

Intermittent:

$LgTN_I = -0.48 + 0.49(\%Ag)$ $+ 1.73(\%NBHy_I)$

Ephemeral:

$LgTN_E = -0.28 + 0.45(\%Ag)$ $+ 1.66(\%NBHy_E)$

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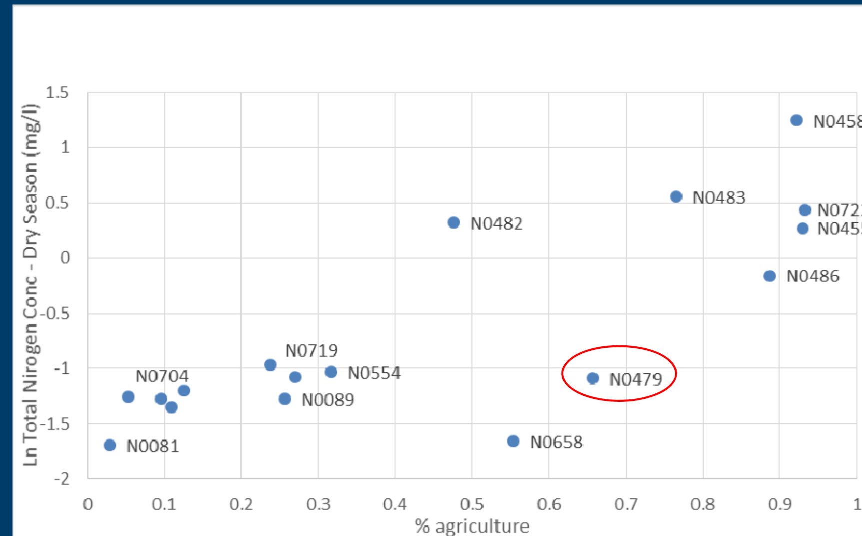
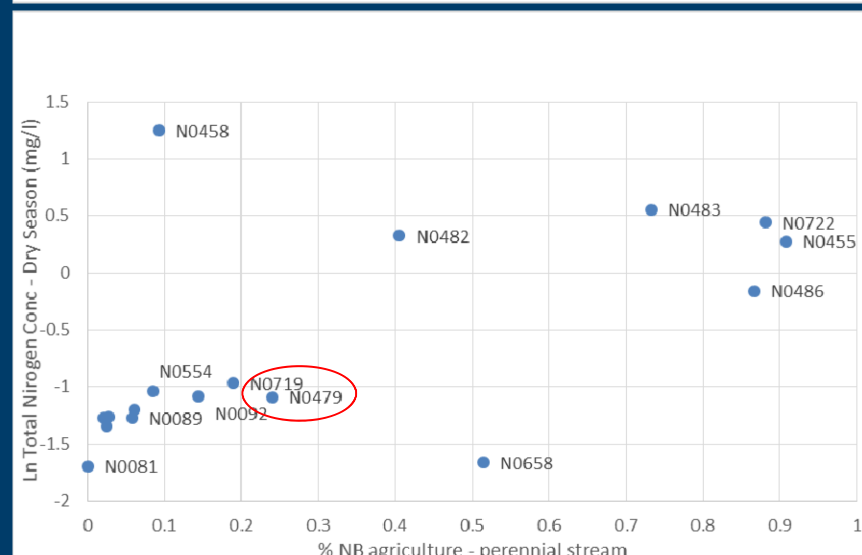
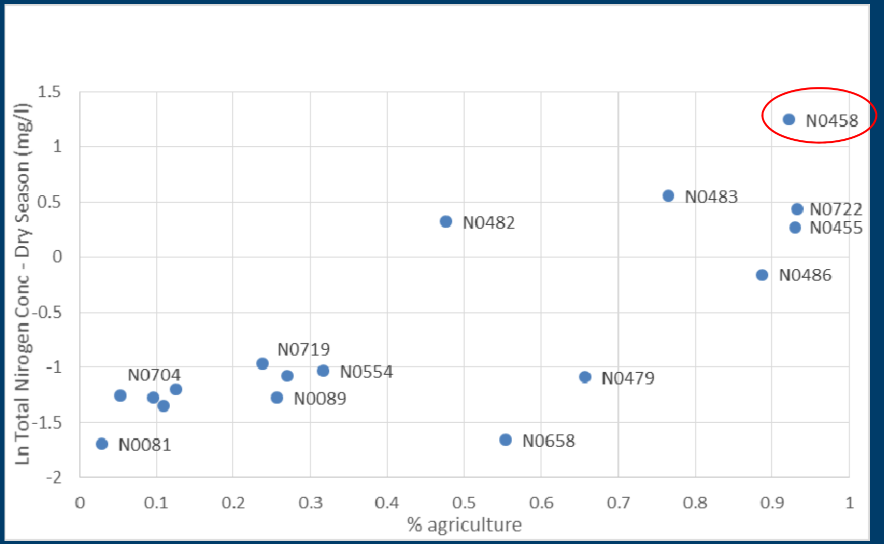
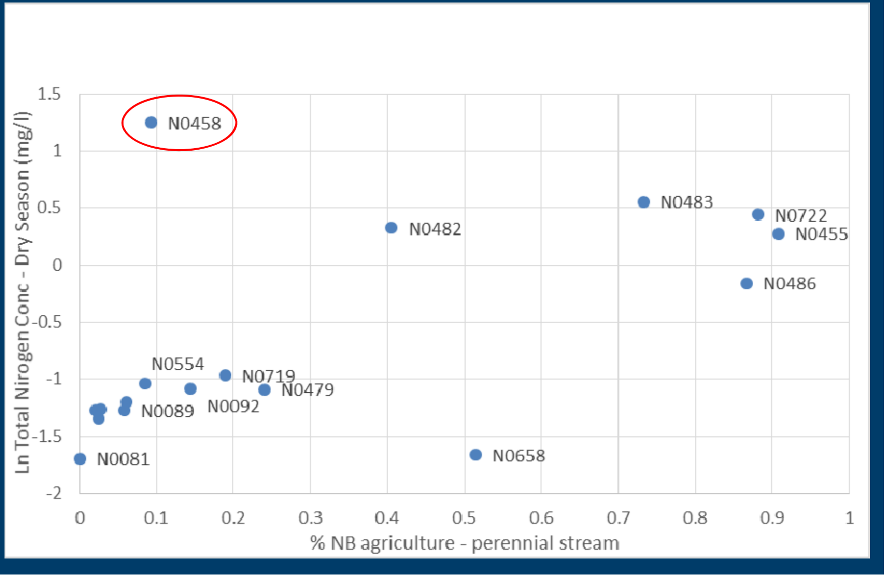
Positives of Buffer Metric



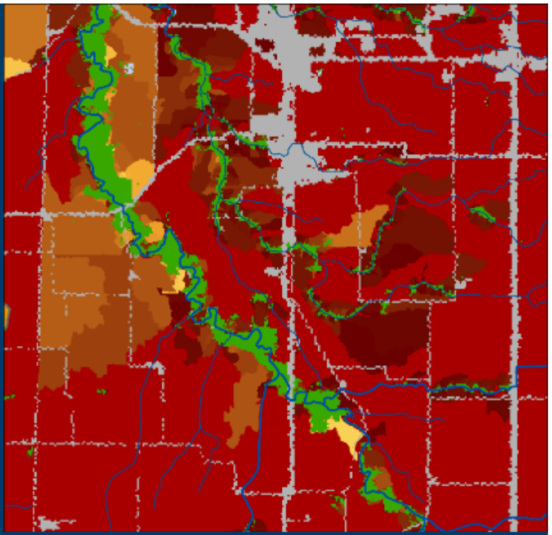


Limitations of Buffer Metric





Seasonal Riparian Metrics



- Perennial:
- Ag and NB included in the TN model but negative coefficient for NB likely due to collinearity and limitations of the riparian metric

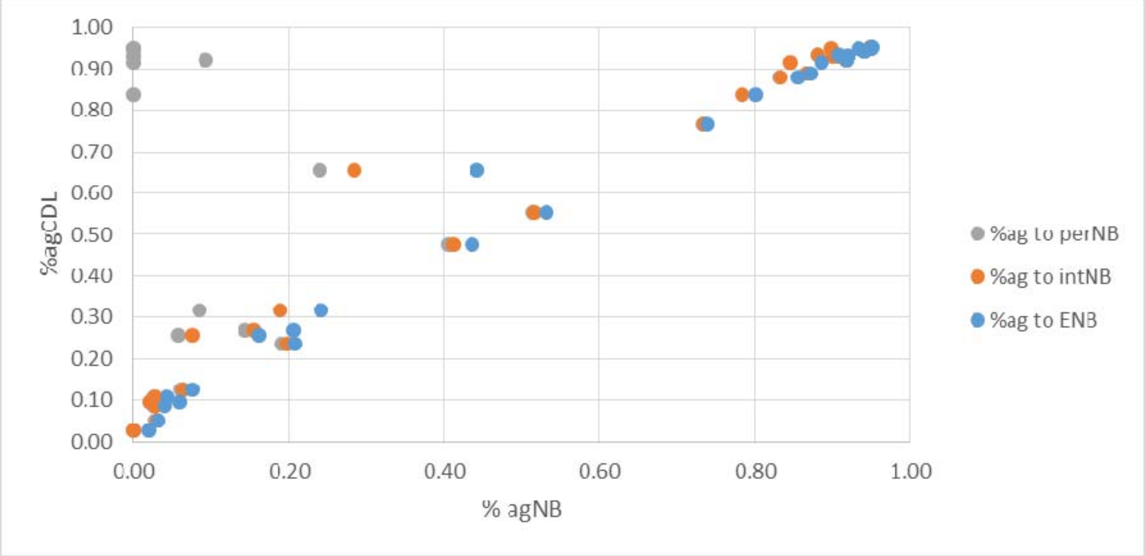
- Intermittent and Ephemeral:
- Ag and NB converge – 98 to 99% similar – there is no buffered cropland – higher spatial resolution of buffers may increase buffer presence for intermittent model
- Variation explained by NB hydric croplands

Implications

Calapooia valley USGS 1996

- Need to consider temporal dynamics in nutrient management and buffers
  - Perennial streams overlaid with CDL: 60% natural, 36% ag, 4% with urban – very little TN exported
  - Ephemeral streams overlaid with CDL: 25% natural, 67% ag

Temporal shift in streams alters the spatial analysis and areas of importance



Implications

Calapooia valley USGS 1996

- Need to consider temporal dynamics in nutrient management
  - Better techniques to map ephemeral flows in agriculture
  - Quantify ephemeral export of nutrients

- Incorporate GIS layers into management tools
  - Reasonable expectations of Riparian Buffers
  - Targeted placement – often impractical but highlights areas of hydric soils in the Calapooia
  - Look to rate and timing of fertilization
    - Holistic watershed approach needed

Implications

Calapooia valley USGS 1996

- Similarity to other agricultural regions?
  - Temporal dynamics very prevalent
  - Concentrated flows

Williard &Schoonover

Southern Illinois

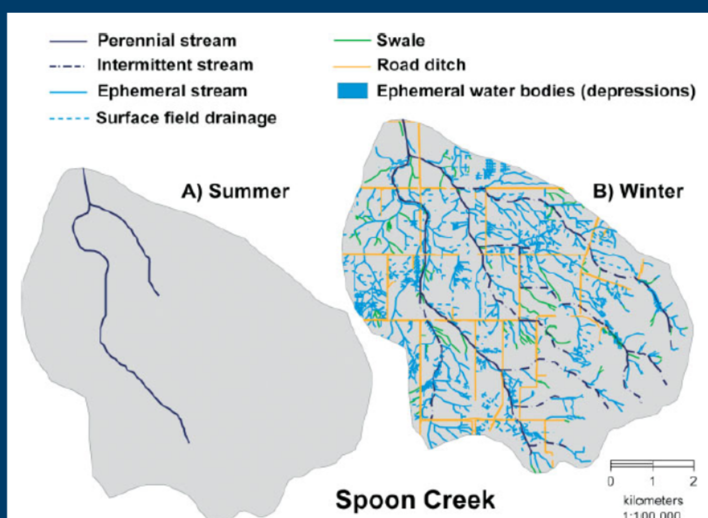
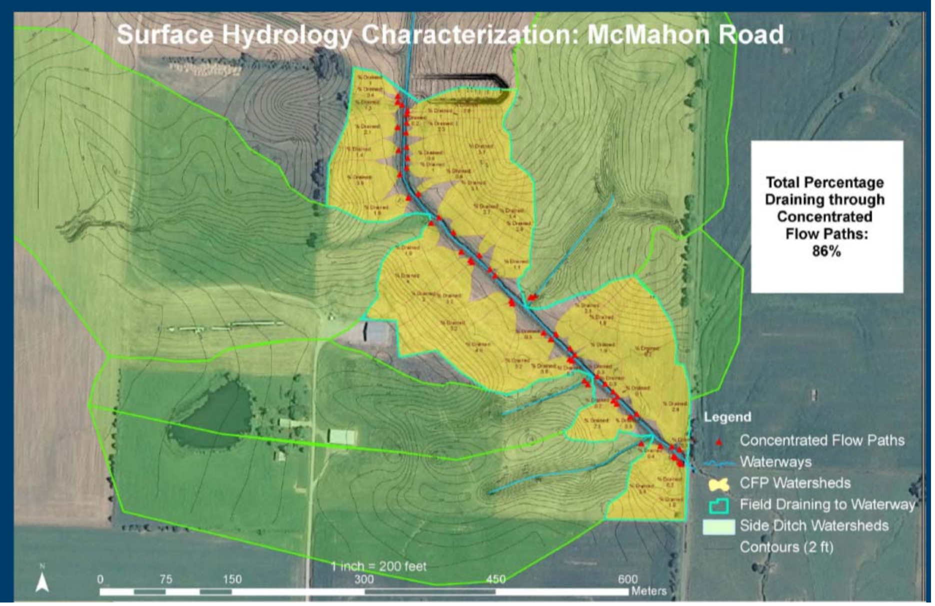


Figure 1. Spoon Creek stream network in summer 1997 and winter 1998–99



Implications

- Similarity to other agricultural regions?
  - Temporal dynamics very prevalent
  - Facilitated transport of water off of ag lands

  - Upper Midwest
  - Outer Coastal Plain

Acknowledgements:

Randy Comeleo – EPA Corvallis

Questions?

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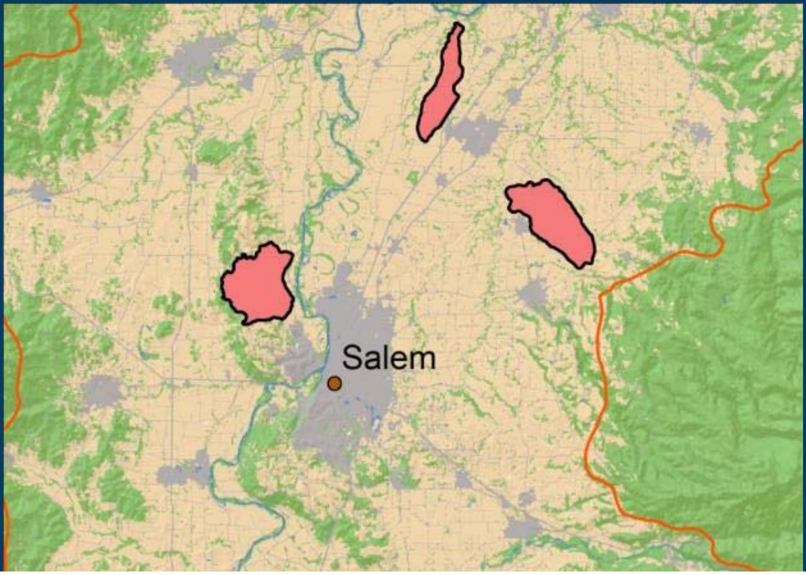
Estimating Stream Expansion - Methods

- Wigington et al. 2005
- Field study of 5 small agricultural catchments in the Willamette Valley
- Documented the summer and winter stream extent



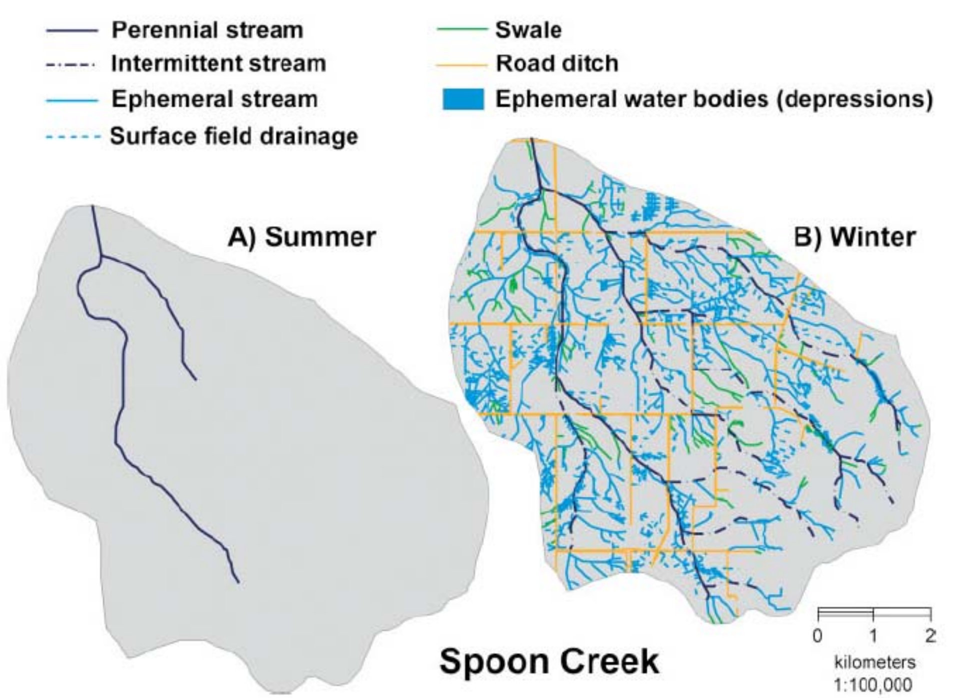
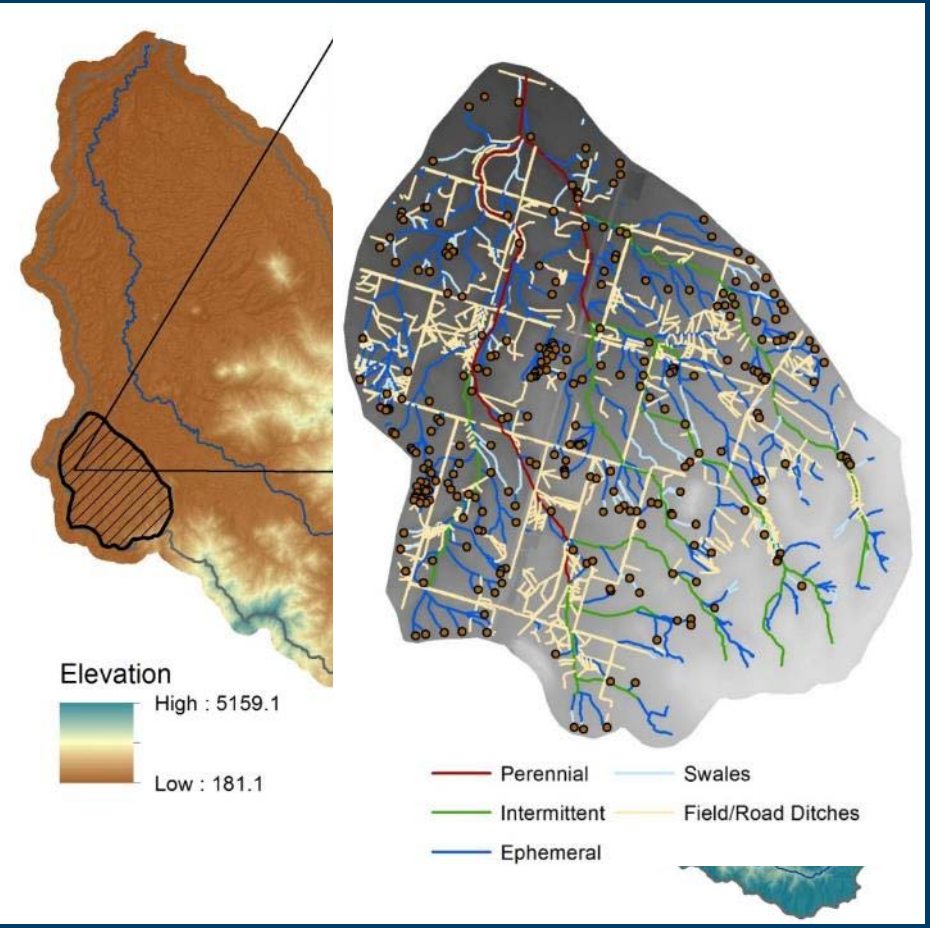


Figure 1. Spoon Creek stream network in summer 1997 and winter 1998–99

Estimating Stream Expansion - Methods

- 3m LiDAR 2010
- Flow Direction and Flow Accumulation
- Extracted Flow Accumulation at endpoints according to landscape position and soils



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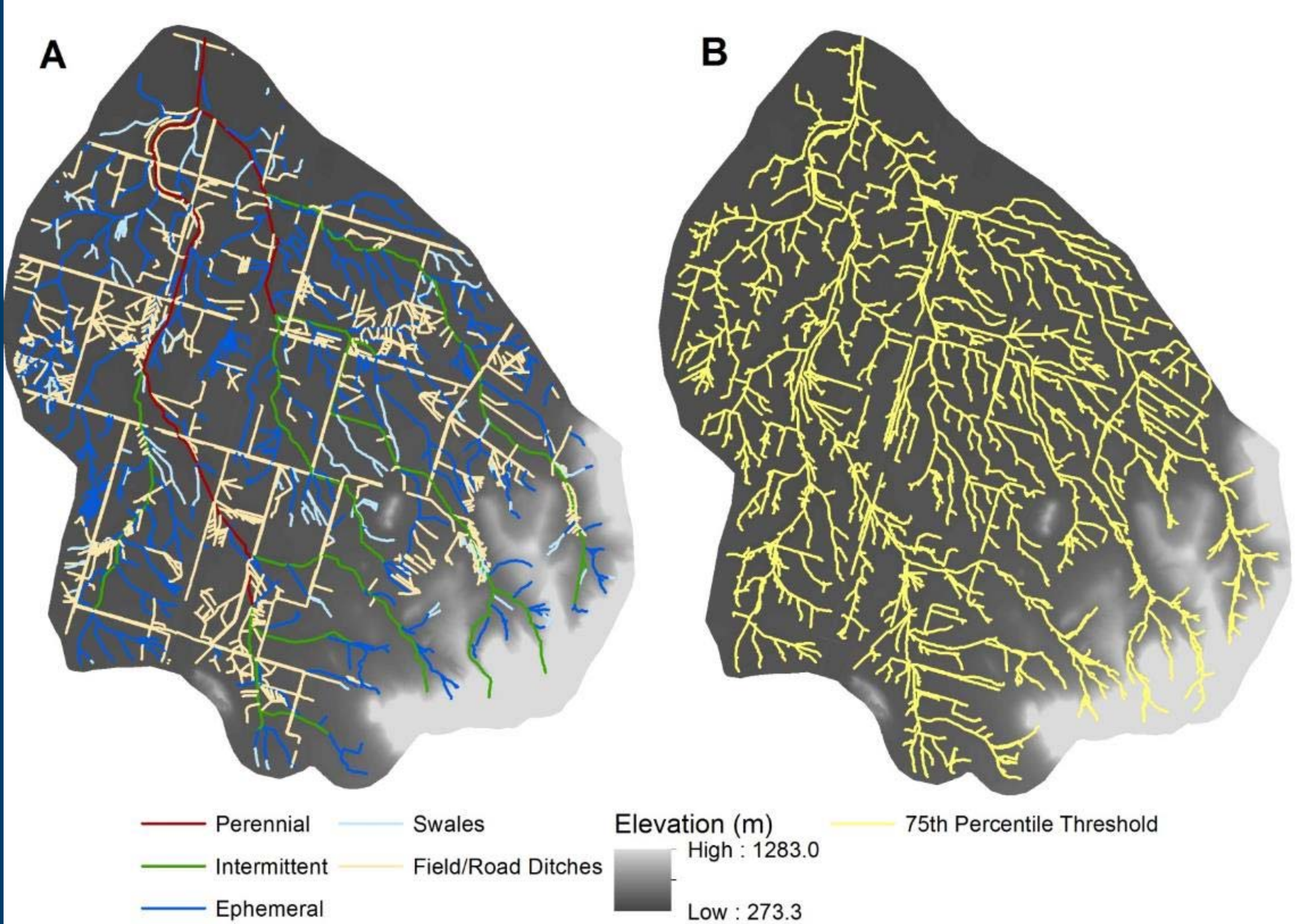
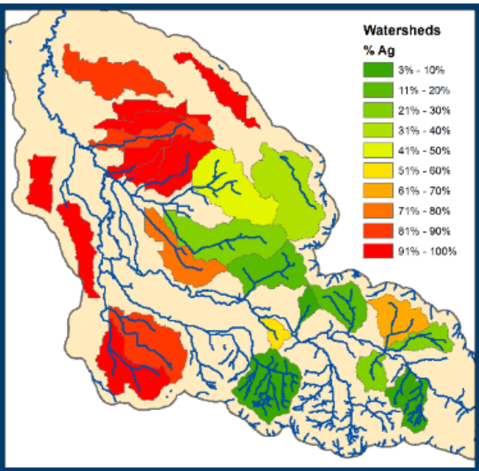
Estimating Stream Expansion




Watersheds
% Ag
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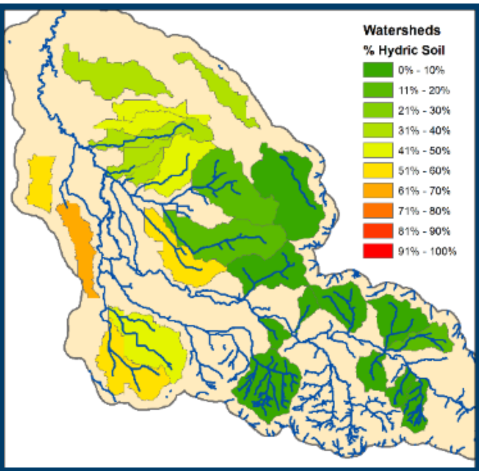
91% - 100%


Watersheds
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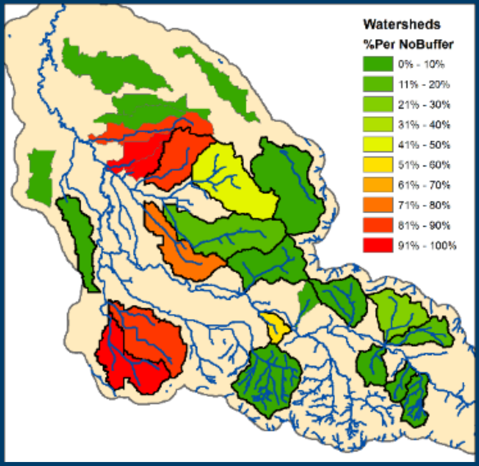
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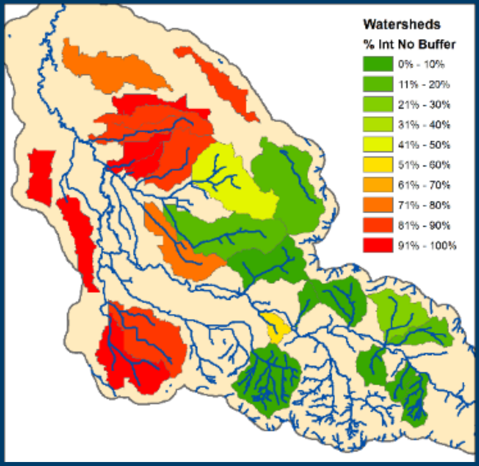
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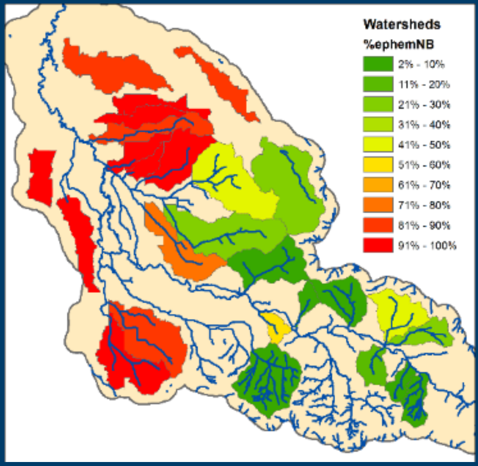
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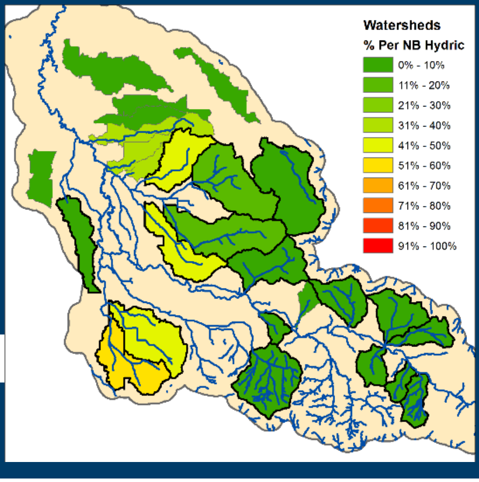
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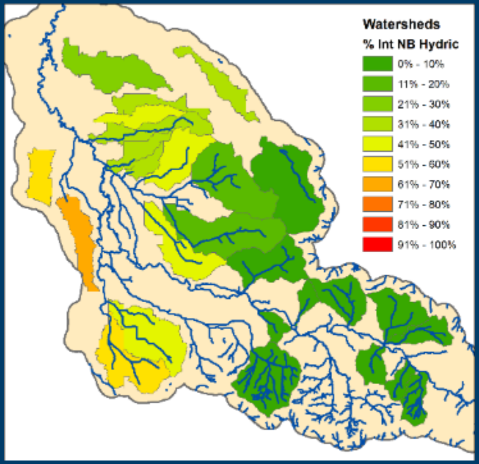
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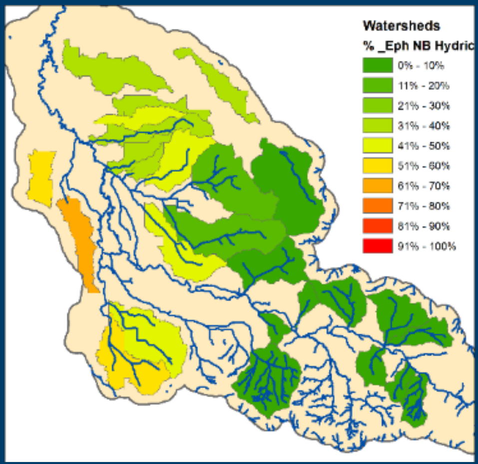
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Intermittent

Ephemeral