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A COMPARISON of INVERTEBRATE and FISH MULTI-STRESSOR MODELS ACROSS URBAN DISTURBANCE GRADIENTS

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Regional Stream Quality Assessment (RSQA)

U.S. Department of Interior
U.S. Geological Survey

Linking Landscape, Stressors, and Biology

Landscape
- URBANIZATION
- AGRICULTURE
- GEOLOGY, SOILS

Stressors
- HABITAT ALTERATION
- NUTRIENTS
- CONTAMINANTS

Biology
- ALGAE
- INVERTEBTATES
- FISH

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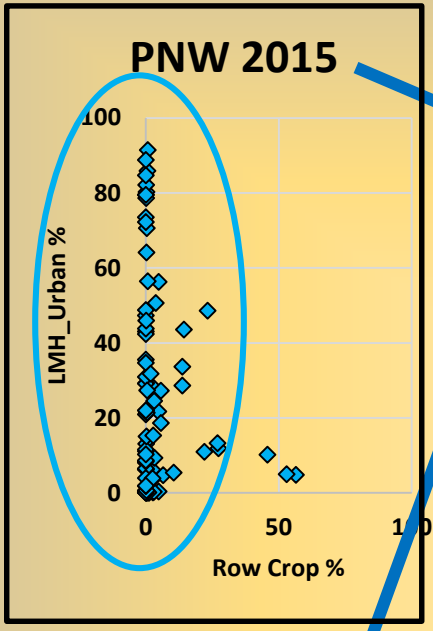
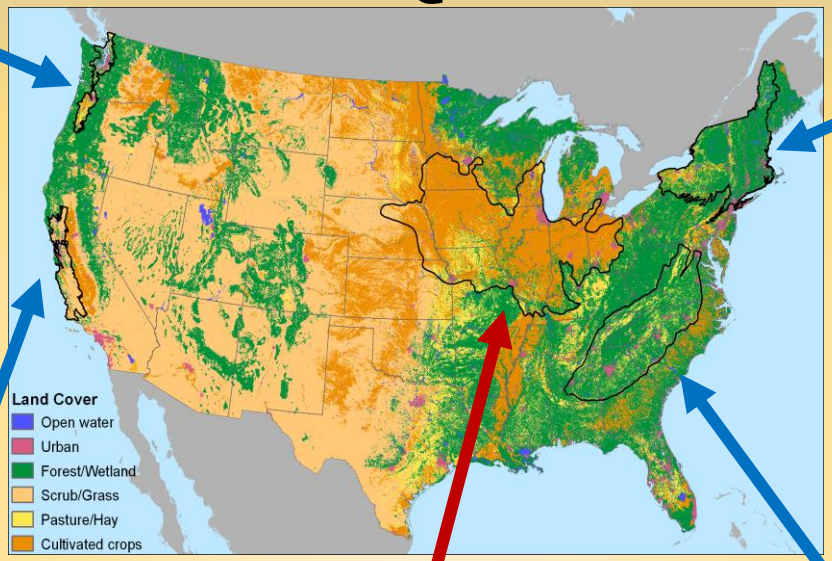
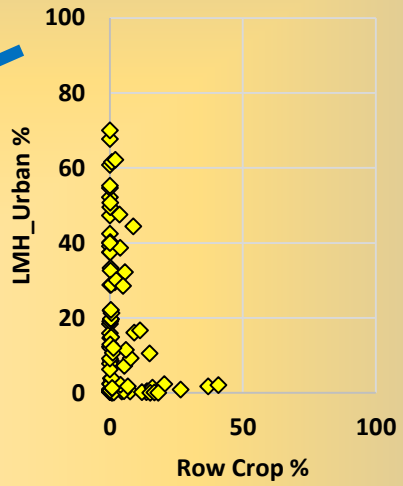
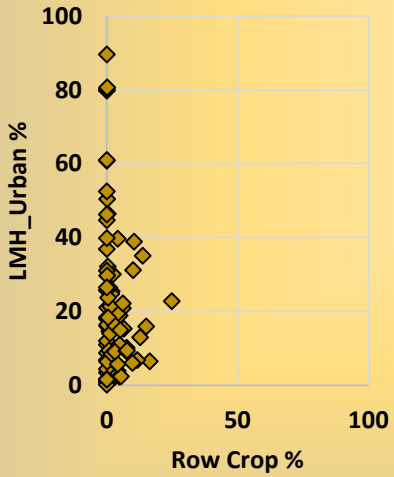
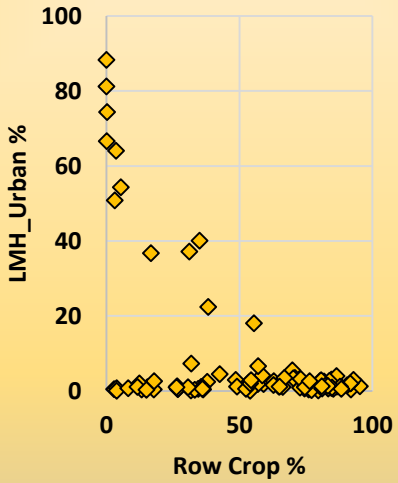
RSQA 1-5

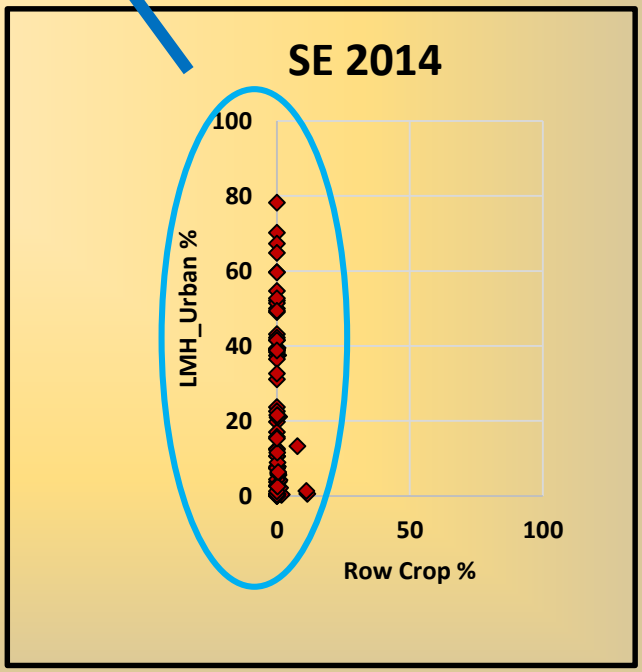

PNW 2015
LMH_Urban %
Row Crop %
0
20
40
60
80
100
0
50
100


Land Cover
Open water
Urban
Forest/Wetland
Scrub/Grass
Pasture/Hay
Cultivated crops


NE 2016
LMH_Urban %
Row Crop %
0
20
40
60
80
100
0
50
100


CAL 2017
LMH_Urban %
Row Crop %
0
20
40
60
80
100
0
50
100


Midwest 2013
LMH_Urban %
Row Crop %
0
20
40
60
80
100
0
50
100


SE 2014
LMH_Urban %
Row Crop %
0
20
40
60
80
100
0
50
100

PNW Sampling in 2015

- **Water**
  - **8 - 10 weekly samples at urban sites:** pesticides, glyphosate, nutrients, major ions, sediment, and organic carbon
  - **POCIS:** passive sampler - pesticides

- **Sediment**
  - **Chemistry:** metals, PAHs, organohalogens, hormones, pesticides

- **Ecology** inverts, algae, fish, habitat, plus continuous temp and stage

Comparison of Flow: minimally impacted vs Johnson Creek for spring 2015

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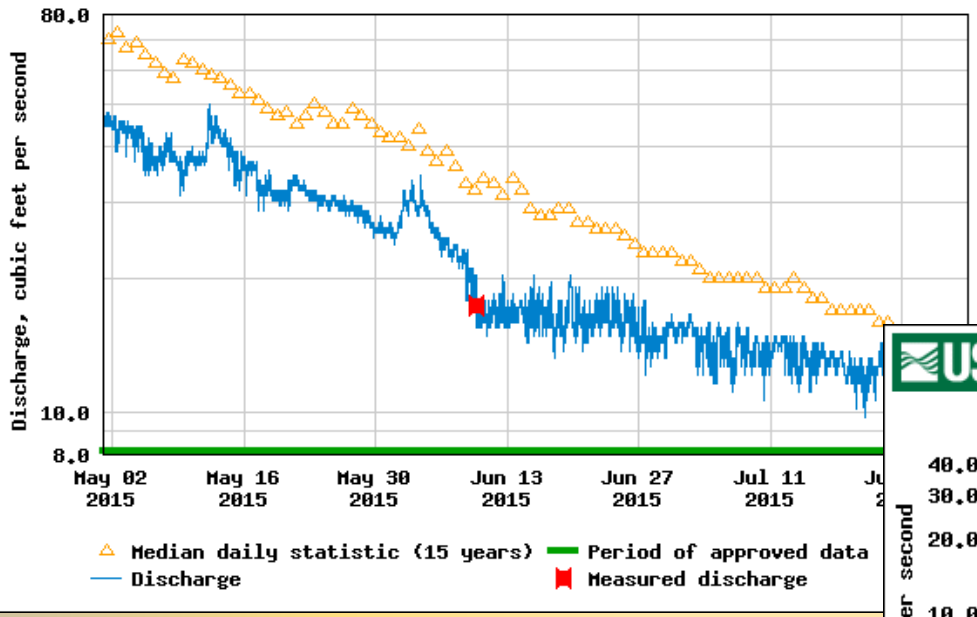
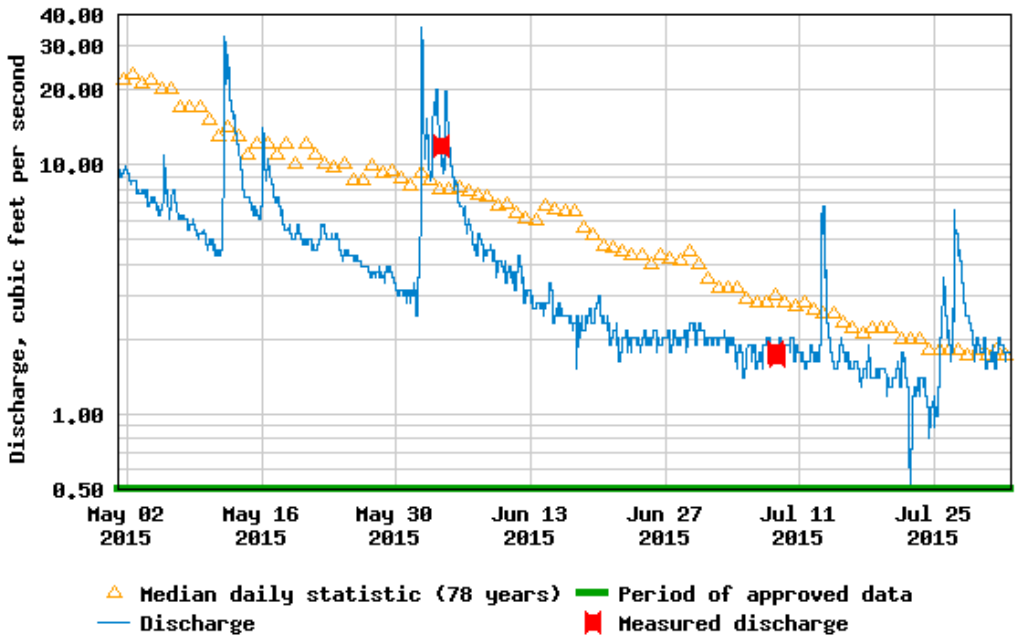
USGS 14205400 EAST FORK DAIRY CREEK NEAR MEACHAM CORNER, OR



USGS

USGS 14211500 JOHNSON CREEK AT SYCAMORE, OR



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PNW Regional Study 2015 Piedmont n = 87

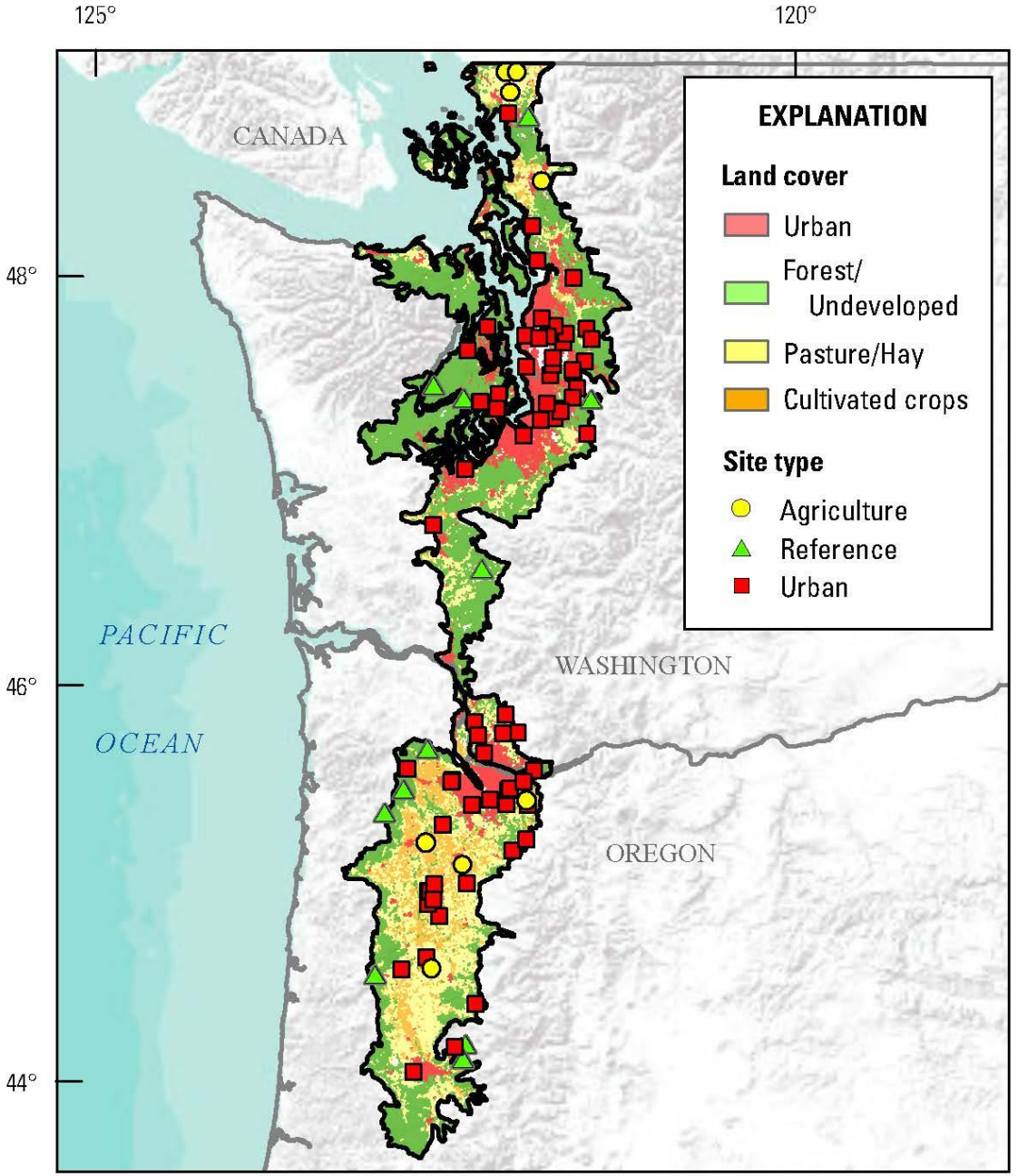

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Photo: Kurt Carpenter USGS

Lower 2 Photos: Alan Cressler USGS

USGS

Alternatives to Multiple Linear Regression models

- Classification and Regression Trees (CART)

Boosted Regression Trees

- Improvement of CART and Random Forest

- Completes 1000 – 10,000 independent Regression Trees and tests the prediction accuracy at the same time.

- Provides a list of variable importance

Boosted Regression Tree Models using R: Cross Validation R^2 -- Macroinvertebrates

SE Region	PNW
EPT Richness (EPTR-H) without Hydropsyche	EPT Richness
0.65 (6)	0.76 (6)
Observed/Expected Taxa (O/E)	Observed/Expected Taxa (O/E)
0.44 (6)	0.63 (5)
Total Richness	Avg Tolerant Taxa
0.62 (5)	0.79 (6)

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BRT Models using R: Macroinvertebrates

SE Region		PNW	
EPT Richness (EPTR-H) without Hydropsyche	**VI**	**EPT Richness**	**VI**
DO Minimum	34	Fungicides – P	47
Flow Peak Intervals	18	AvrOC.PEC.oc – S	24
Fungicides - P	18	Max. No. Fung Detect - W	10
Med. No. Pest Detect - W	15	Med. No. Pest Detect - W	9
TN Median	14	TN Median	6
Phenylpyrazole Insect - W	8	DO Minimum	5
Observed/Expected Taxa (O/E)		**Observed/Expected (O/E)**	
Flow Peak Intervals	28	Fungicides – W	27
Insecticides degrad – P	22	No. Pest Detected - S	27
Phenylpyrazole Insect – W	18	Max. No. Fung Detect – W	18
Four Sed. Contam PEC oc	17	Temp Median	14
TN Median	15	Substrate d50	14
Depth Bankfull Med.	12		
Total Richness		**Avg Tolerant Taxa**	
Insecticides degrad – P	29	Med. No. Pest Detect – W	30
Four Sed. Contam TEC oc	22	Fungicides – W	23
Med. No. Pest Detect - W	19	Insecticides – P	16
Insecticides – W	17	AvrOC.PEC.oc – S	13
Flow Peak Intervals	13	Depth Maximum	12
		Riffle percent	6

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Boosted Regression Tree Models: **Fish Metrics**

Photos: Alan Cressler USGS

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BRT Models using R: Fish

SE Region

Fluvial Specialists	VI
DO Minimum	35
Temperature Maximum	24
Triazine Herbicides - W	11
Percent Fine Substrate	10
Med. No. Pest Detected – W	8
TP Median	6
Flow Peak Intervals	6

Warmwater Taxa	
Flow Peak Intervals	26
Depth Minimum	20
DO Minimum	19
Percent Fine Substrate	17
Suspended Sediment Med.	10
Carbamate Insecticides – P	8

Benthic Invertivores	
Total PAH Sediment (TEC)	52
Insecticides – P	33
TP Median	15

PNW

Fluvial Specialists	VI
Temperature Median	45
Depth Maximum	19
Percent Fine Substrate	14
DO Minimum	11
Substrate d50	10

Fish IBI	
Temperature Min/Max	66
Depth Critical	15
Organophosphate – P	12
Run Percent	7

Coldwater Taxa	
Temperature Median	44
Med. No. Pest Detected – W	21
Run Percent	11
Depth Maximum	9
Flow: Time Since Last Peak	8
No. Pesticides Detected - S	8

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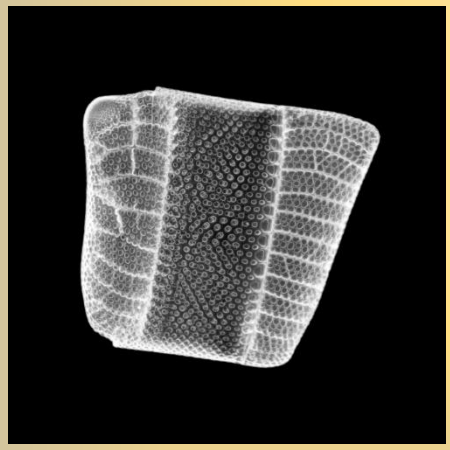
Ecological Models

Important to assess more than one assemblage

- Even though **It's Complicated**, similar responses across Regions and Disturbance Gradients
- Algae – TP, Herbicides, Flow and Sediment
- Inverts – DO, Temp, Pesticides and Habitat quality
- Fish – DO, Temp, Contaminants, Habitat quality
- Flow alteration important yet reduced in droughts



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Photos: Picturepest, Society for Freshwater Sciences, Alan Cressler USGS

Comparison of Johnson Creek to other OR sites

Stressors median values	Johnson Creek	Other Urban Sites n = 19	Reference Sites n = 12
Total Nitrogen mg/L	1.25	0.87	0.23
DO minimum mg/L	7.5	8.5	9.6
Temp max 42d °C	23.8	22.4	18.7
Substrate – % Fines	31	32	12
Fungicide ng/L	101	12	0
No. Pest. Detected - W	22	14	2
Total Pesticide – S ug/kg	822	437	12
Flow Peak Interval days	30	16	53

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Thank you

Insect Photos: Society for Freshwater Sciences

Boosted Regression Tree Models using R: Cross Validation R^2 – Fish

SE Region	PNW
Fluvial Specialists	Fluvial Specialists
0.42 (7)	0.63 (5)
Warmwater Taxa	Fish IBI
0.42 (6)	0.59 (4)
Benthic Invertivores	Coldwater Taxa
0.43 (3)	0.52 (6)

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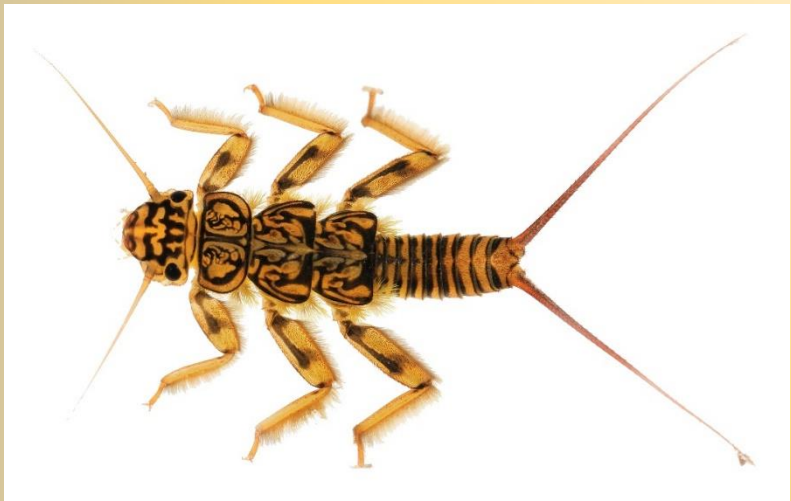
Responses by Individual Taxa

- **Individual taxa plots**
- **Ordinations w bubbles**
- **Gradient Forest Models – a new technique**



Photos: Alan Cressler USGS

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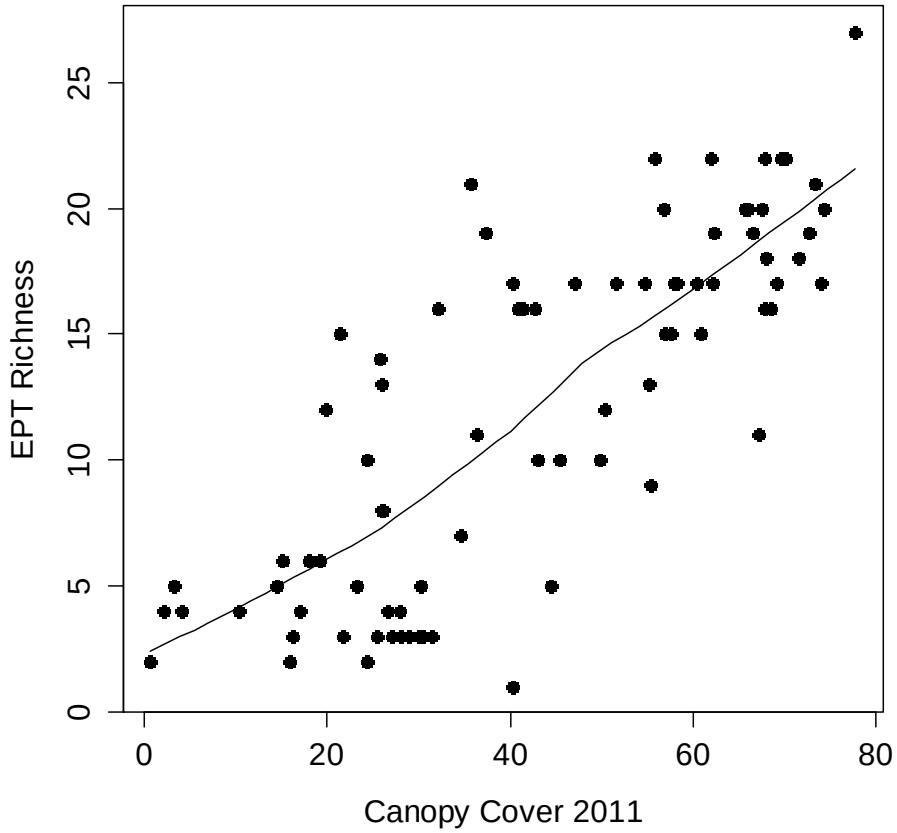
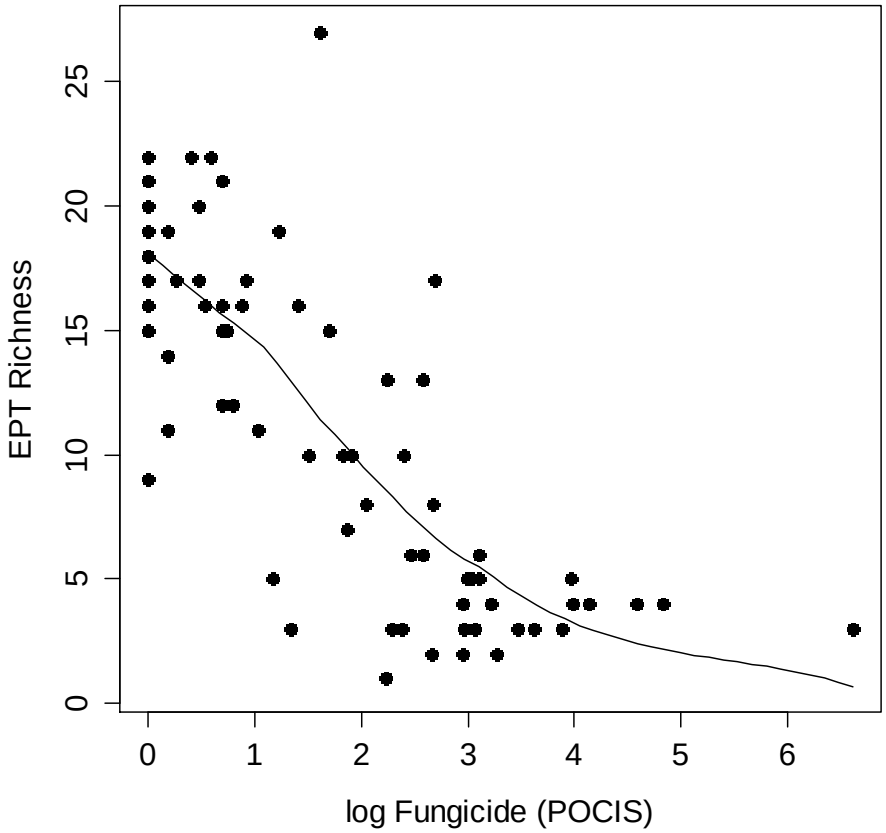
BRT Models using R: Macroinvertebrates





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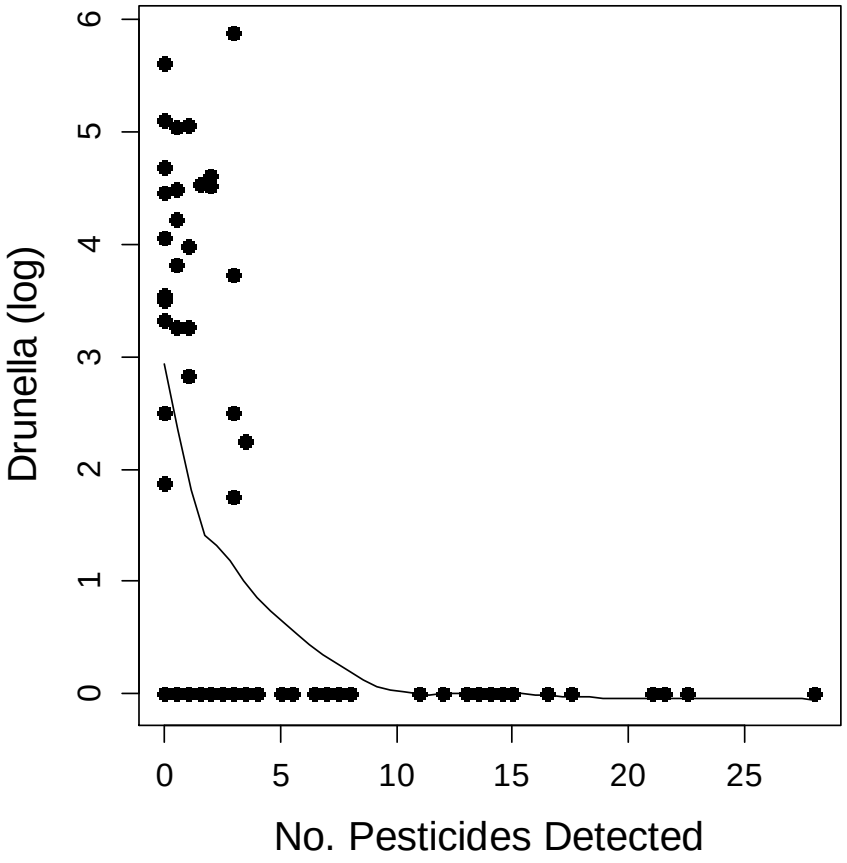
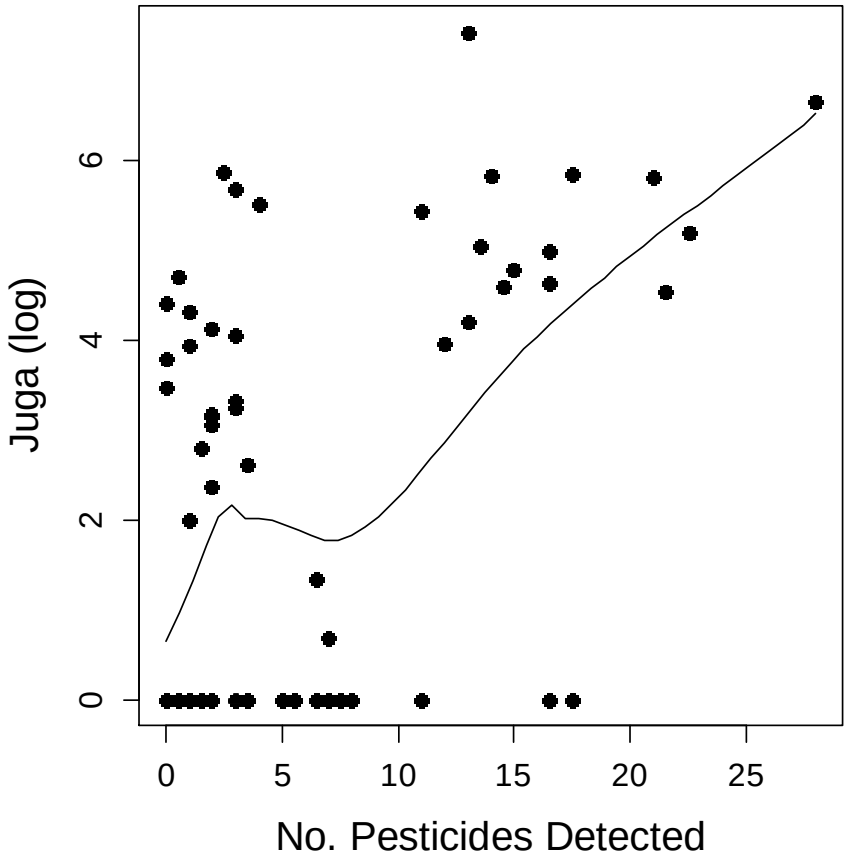
Individual Plots Inverts





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Now Algae Models

Boosted Regression Tree Models using R: Cross Validation R^2 – Algae

SE Region	PNW
Moderately & Highly Motile Taxa	Moderately & Highly Motile Taxa
0.41 (4)	0.40 (5)
Biological Condition 4-5 Taxa (Tolerant)	Biological Condition 4-5 Taxa
0.50 (4)	0.35 (4)
High TN Taxa	Taxa Richness
0.44 (4)	0.26 (6)

Unpublished; subject to revision

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BRT Models using R: Algae

SE Region		PNW	
Moderate & Highly Motile	**VI**	**Moderate & Highly Motile**	**VI**
TP Median	48	TP Median	40
Acetanilide Herbicides – W	19	Fungicides – P	19
Flow: Time Since Last Peak	17	PEC.LEB4.oc – S	16
Soft Sediment Depth	17	Depth Median	15
		Arsenic PEC oc – S	11
BC 4-5 Tolerant Taxa		**BC 4-5 Tolerant Taxa**	
TP Median	43	TN Median	38
Acetanilide Herbicides – W	22	TP Median	29
Soft Sediment Depth	19	AvrOC.PEC.oc – S	18
Flow: Time Since Last Peak	16	PEC.LEB4.oc - S	15
High TN Taxa		**Taxa Richness**	
TP Median	51	Channel Bar Area	28
DO Minimum	19	TN Median	21
Acetanilide Herbicides – W	19	TP Median	15
Flow: Time Since Last Peak	11	Triazine Herbicides – W	14
		Riffle Percent	12
		Copper PEC oc - S	11

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