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Comparing multiple scales of land use pressures and instream stressors on headwater stream macroinvertebrates

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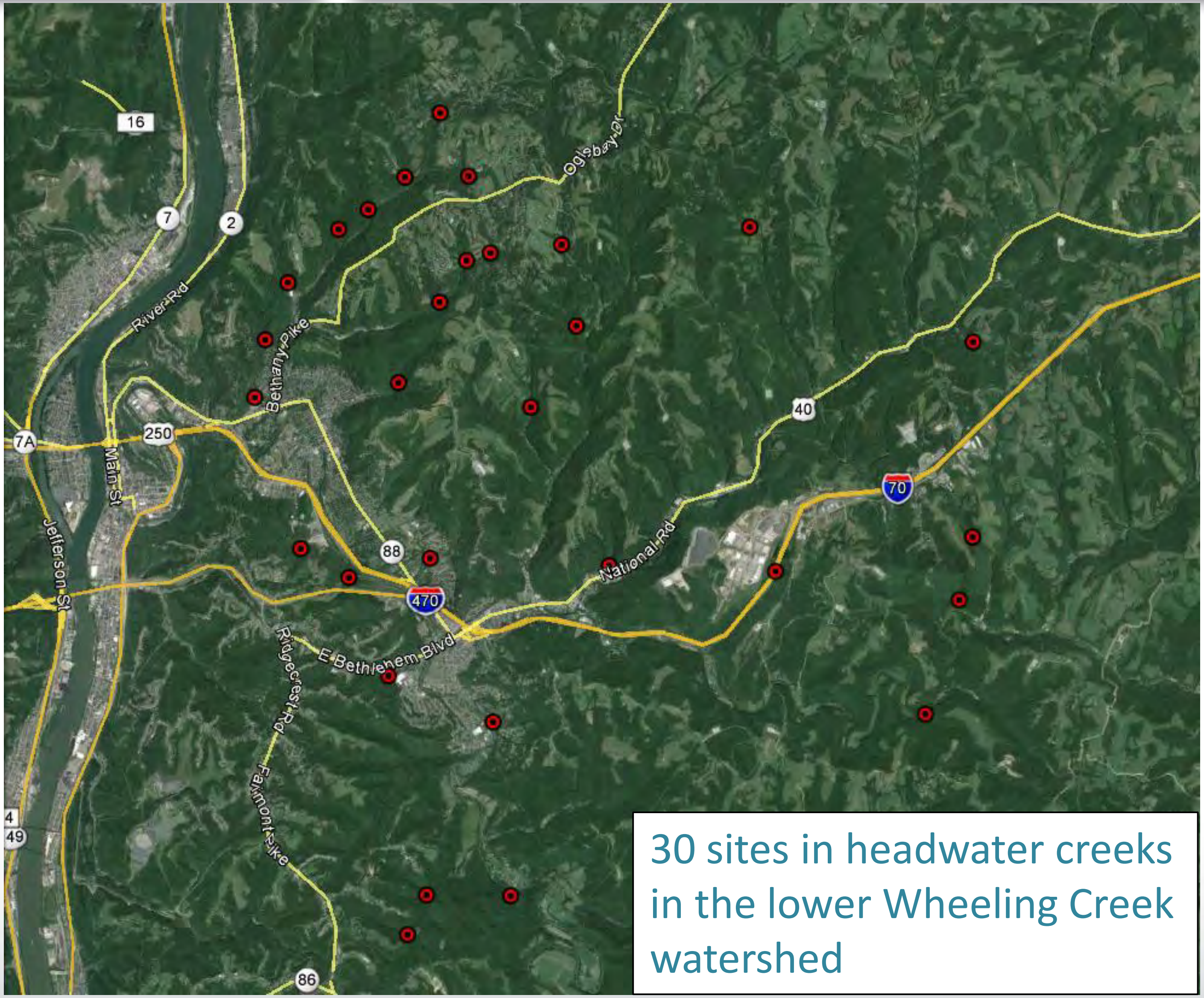
EPA

Overarching Theme

Shift happens in
macroinvertebrate assemblages along a gradient of
land uses and
instream measures

https://drmikelharry.files.wordpress.com/

Study Area



30 sites in headwater creeks in the lower Wheeling Creek watershed

Reach selection

Reaches selected by similar:

1. Stream Size/ Catchment Area
2. Full streambed shading
3. Elevation
4. General lithology
5. Dominant soil type
6. Stream channel morphology

Study Watershed and Land Use

Variables:
- Road density
- Structure density
- % Forest
- % Urban
- % Open
- % Developed
- % Agriculture

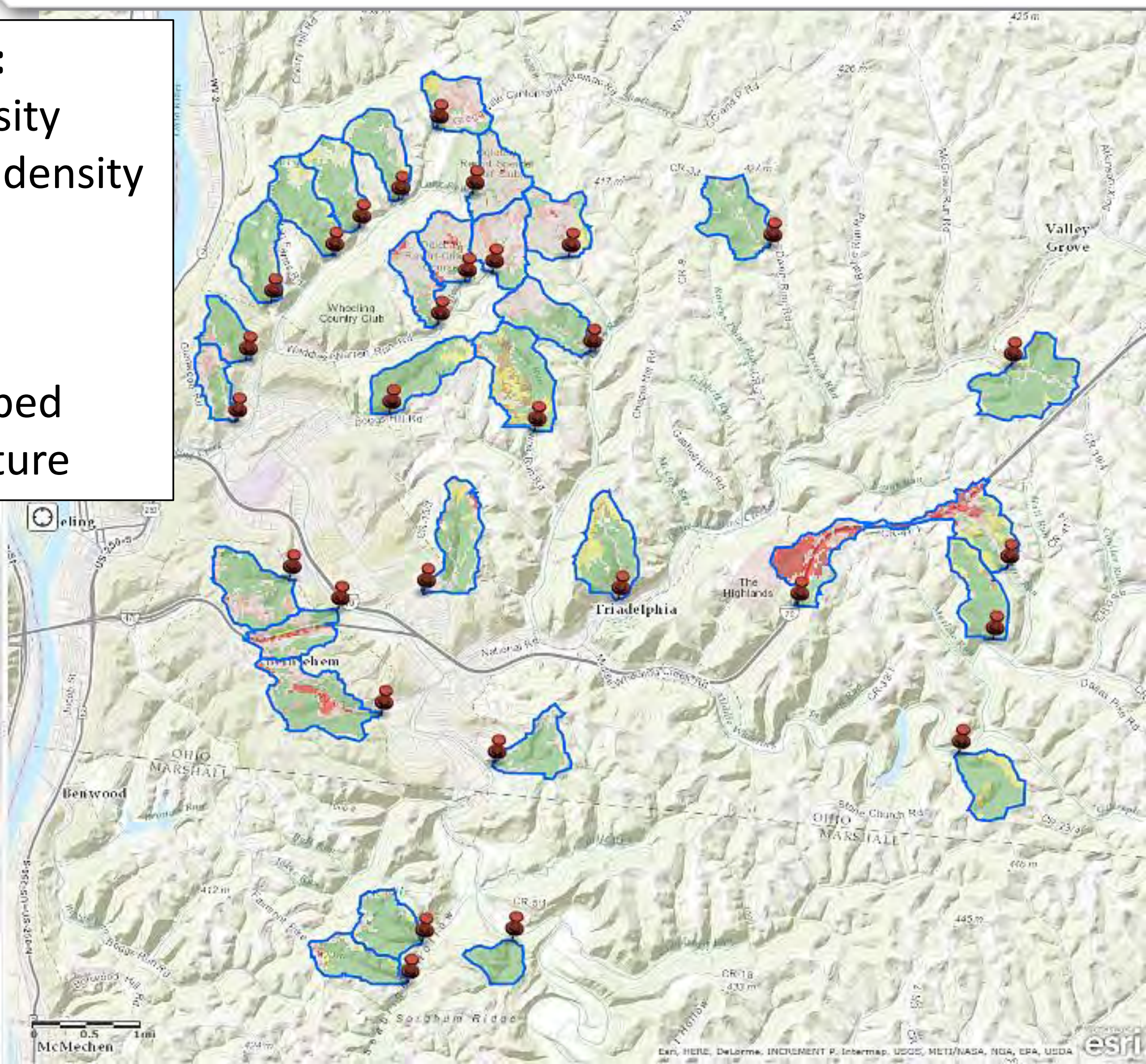
Legend

Benthic Site Locations

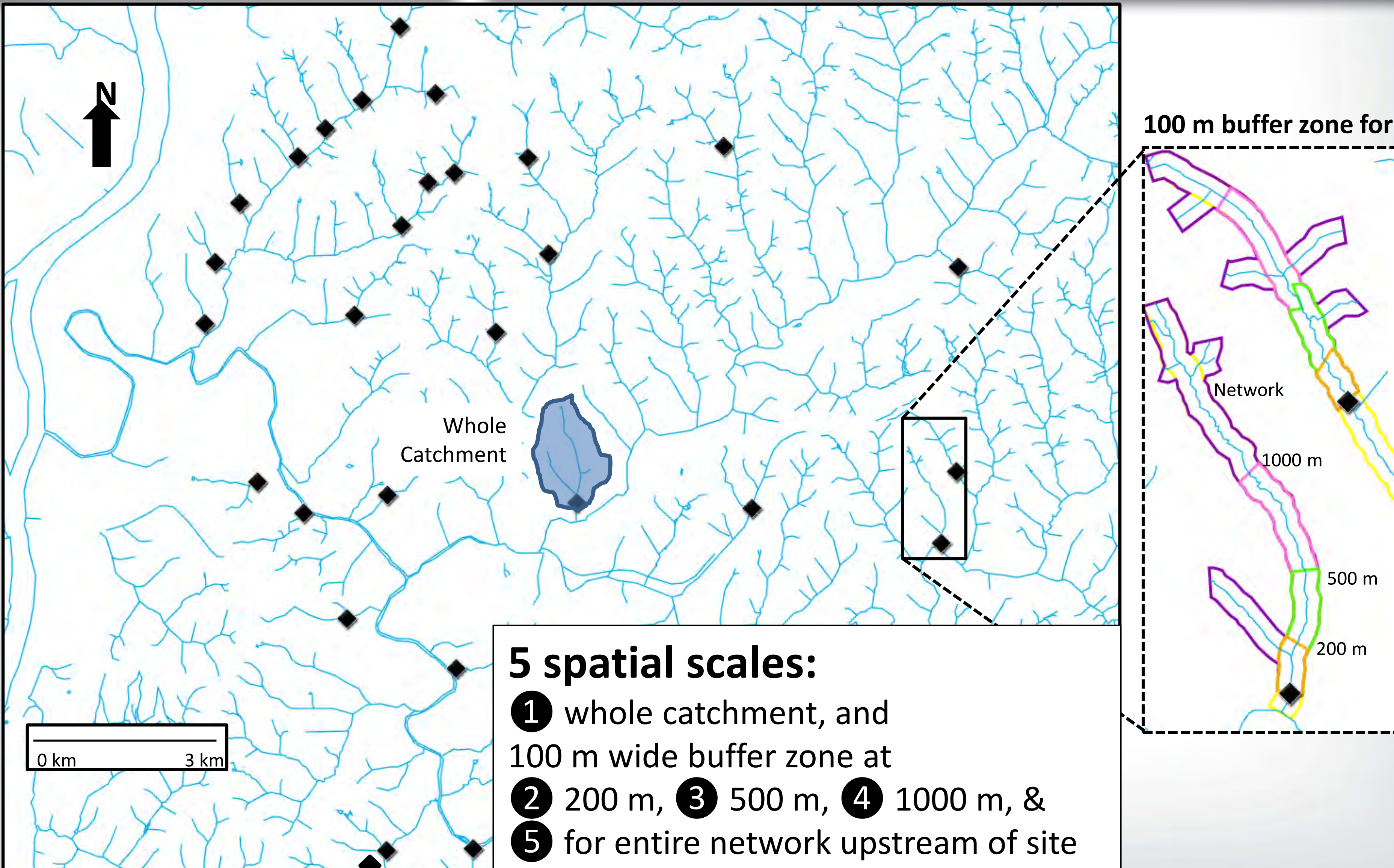
Subcatchment Areas

NLCD 2011

Subcatchment Areas
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Herbaceuous
- Hay/Pasture
- Cultivated Crops



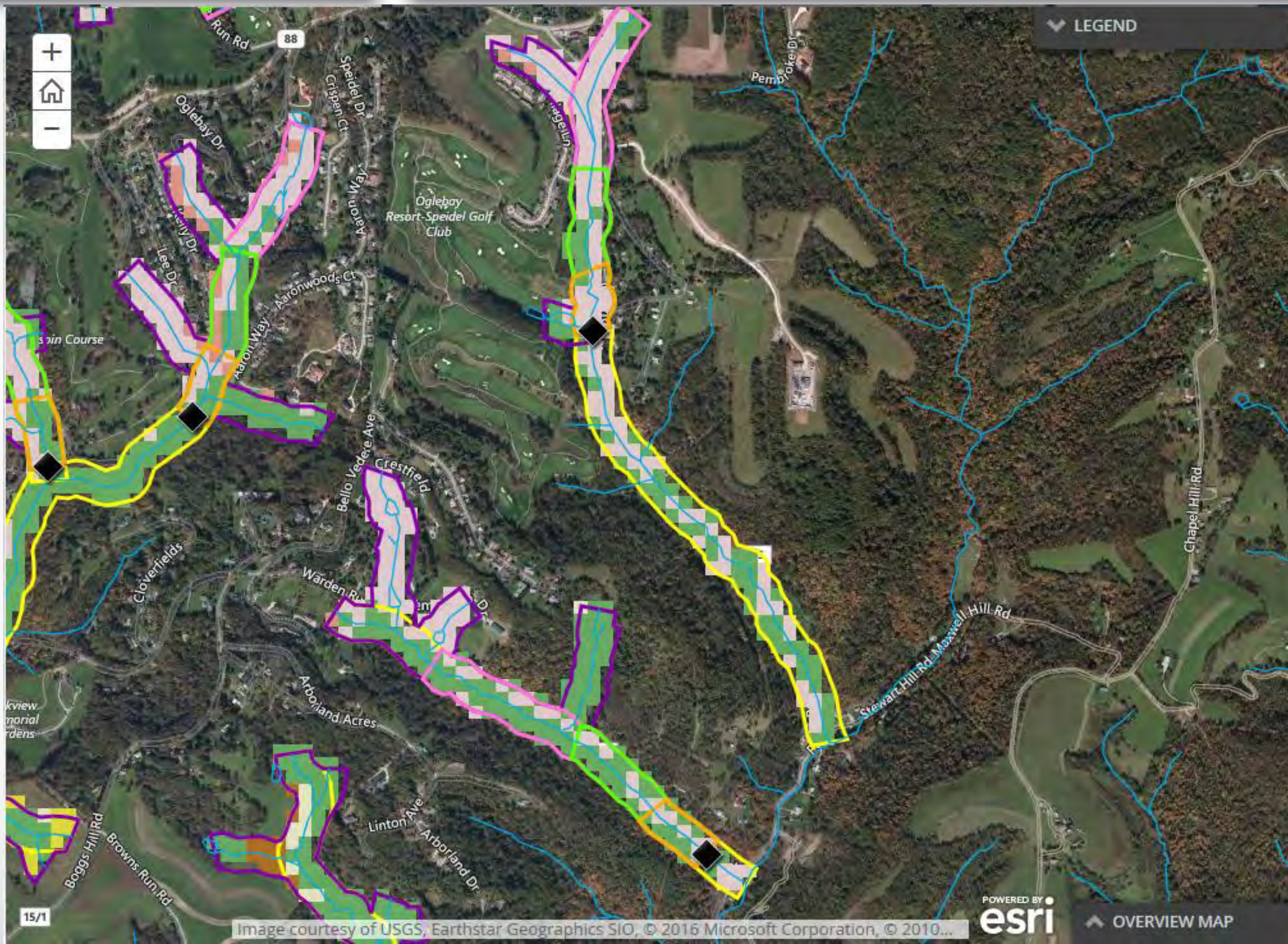
Land Use Quantification



5 spatial scales:

❶ whole catchment, and
100 m wide buffer zone at
❷ 200 m, ❸ 500 m, ❹ 1000 m, &
❺ for entire network upstream of site

Land Use Quantification



Varied Land Uses

Sampling Parameters

Macroinvertebrates-
Riffle kicknet method

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Habitat- RBP, channel slope, canopy cover, width

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Fecal Coliform Bacteria- Processed within 6 hours

Statistical Analyses

- Developed and compared simple and multiple linear regression models to explain and predict macroinvertebrate shifts along environmental gradients;
- Multivariate analysis (PCA, NMDS) to explore environmental and biological response patterns;
- Land use classes are spatially contagious and co-vary with instream measures, so…
  - partial correlation analysis to remove redundancy
  - stepwise-multiple regressions with low tolerance and low variance-inflation-factors
- Data were normalized by log, sqrt, or asn-sqrt transformations where necessary

Study Questions

1 Does near-stream (buffer zone) land use affect assemblages more than whole catchment-based land use?

Prediction: Near-site (200 m)-buffer zone > whole catchment

2 Does the best spatial arrangement of land use pressures better predict biological condition compared to instream measures (habitat and chemistry)?

Prediction: local instream factor > best land use indicator

3 Develop and compare strength of multivariable explanatory models based on combinations of instream and land use measures.

What level of effort (field, lab, land use, combinations) is appropriate?

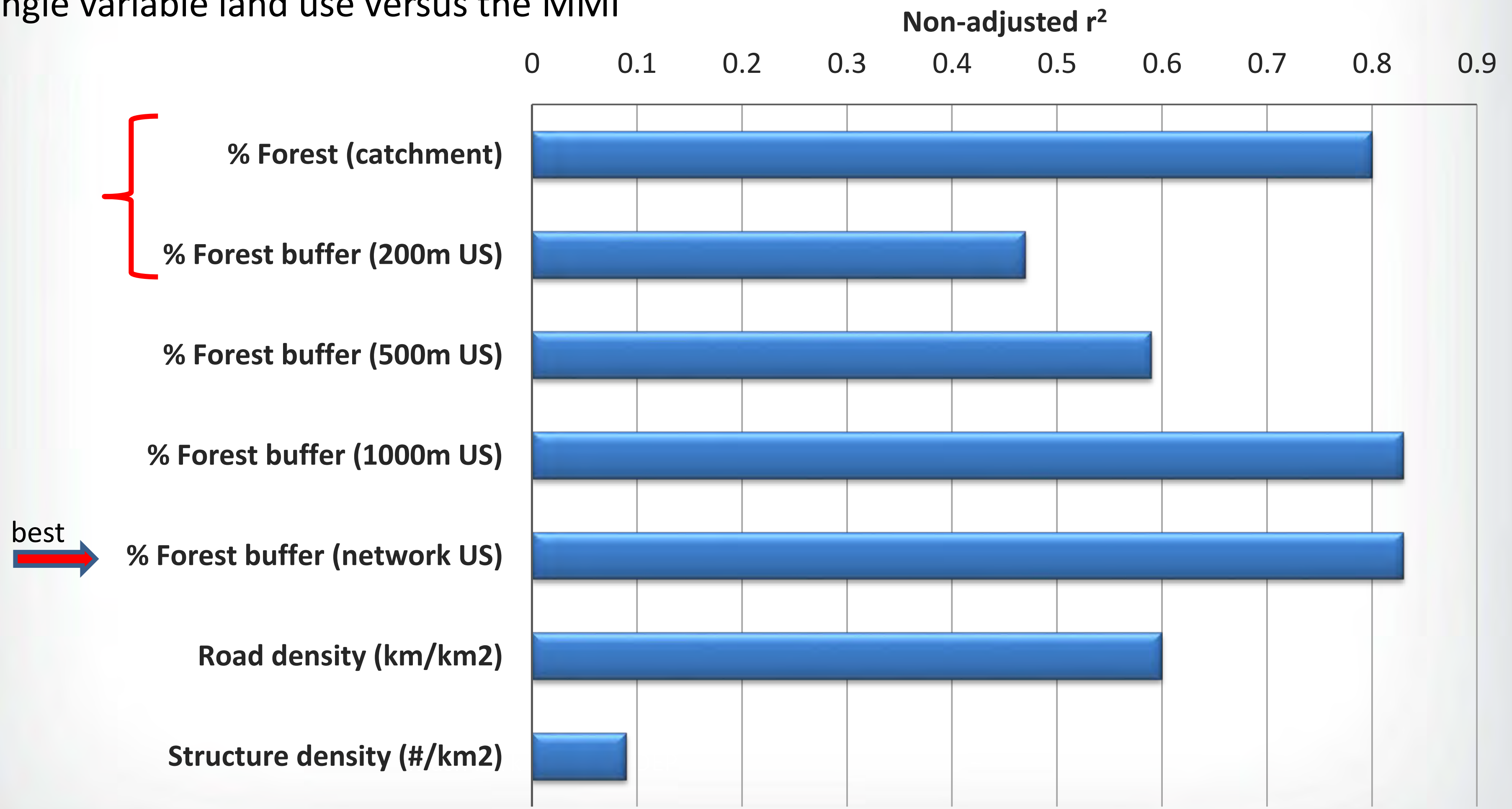
MMI

GLIMPSS (CF) scores

ranged from 12 (very degraded) to 89 (very good)

Question 1
Simple Linear Regression Models

Single variable land use versus the MMI



Question 1

Near-site (200 m) buffer zone land use explains less variation in macroinvertebrates than whole catchment.

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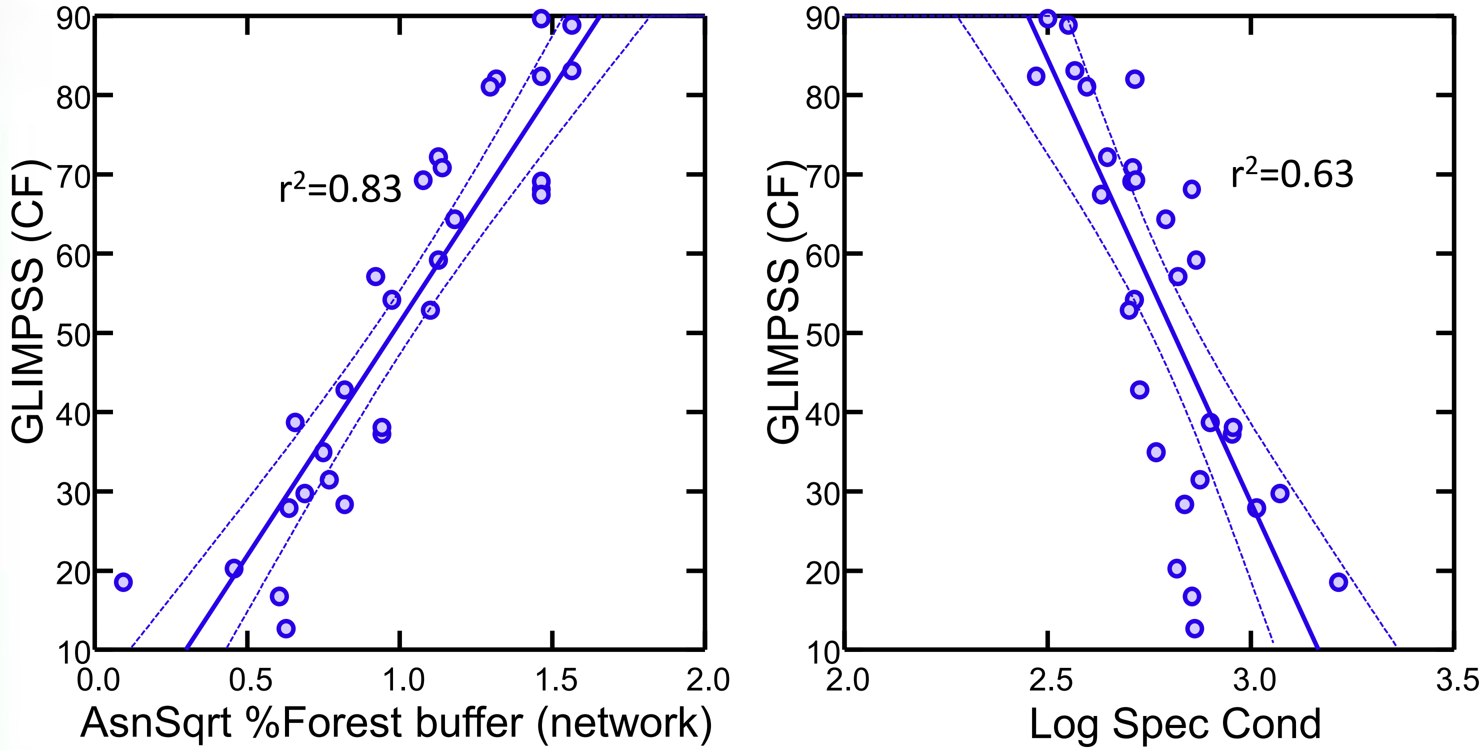
Question 2
Simple Linear Regression Models



Land Use vs. Biology

1. %forest buffer (network) (r^2=0.83)
2. % forest buffer (1000m) (r^2=0.83)
3. % forest catchment (r^2=0.80)
4. % developed catchment (r^2=0.80)

Instream vs. Biology

1. Spec. Cond. (r^2=0.63)
2. Hardness (r^2=0.58)
3. Chloride (r^2=0.48)
4. Total habitat score (r^2=0.46)

Question 2

Prediction 2 refuted since land use classes were stronger single predictors than any single instream variable.

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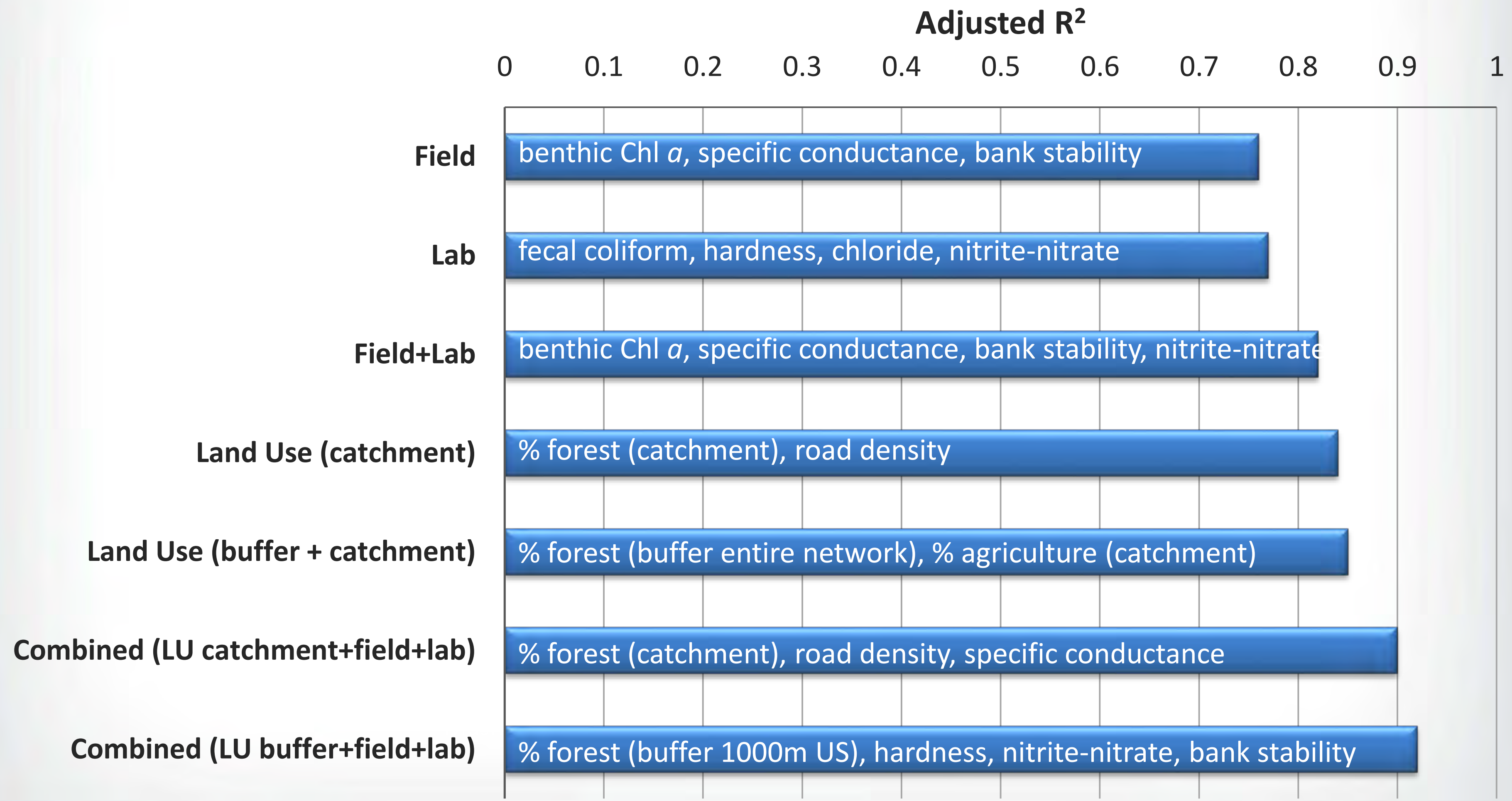
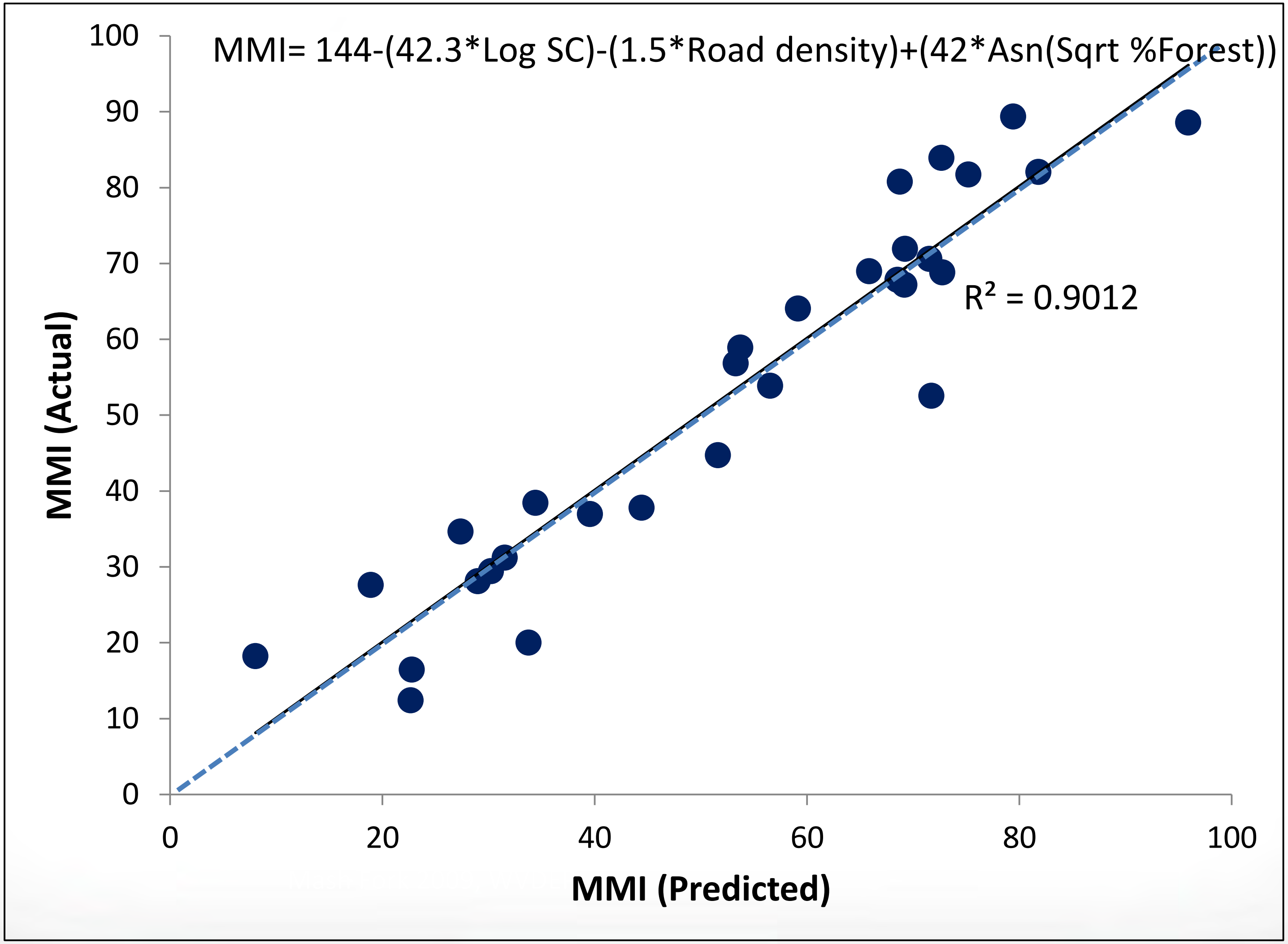
Question 3

Stepwise Multiple Regression Models



Question 3


MMI= 144-(42.3*Log SC)-(1.5*Road density)+(42*Asn(Sqrt %Forest))
R² = 0.9012
MMI (Actual)
MMI (Predicted)
0
10
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100

Question 3

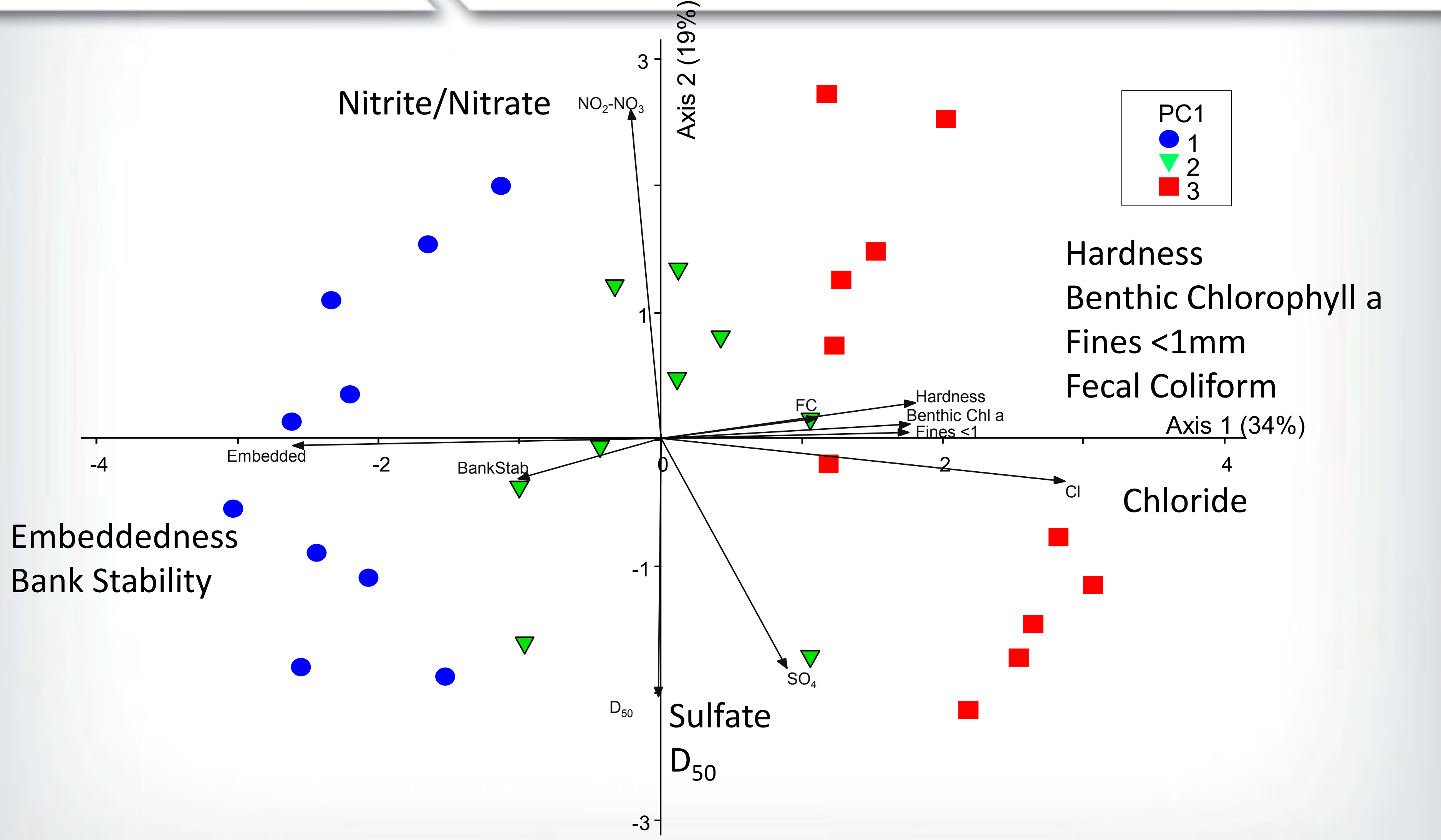
For the strongest model with the least effort, the recommended parameters are:

http://10-themes.com/373835.html

Digging Deeper: Exploratory Analyses

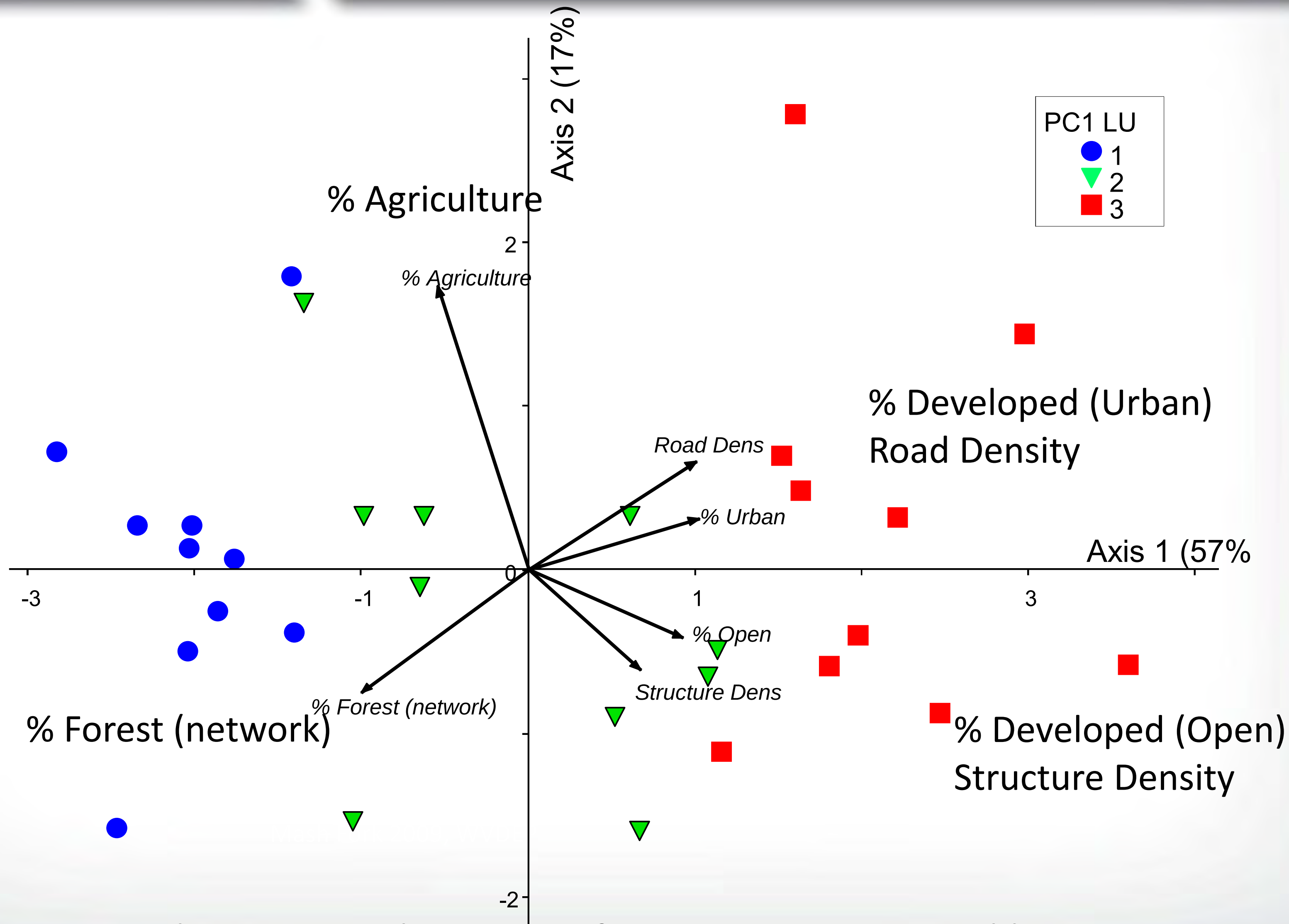
http://conservationmagazine.org

EXPLORATORY
Instream PCA



PC1 split into 3 equal categories for use as grouping variable

EXPLORATORY
Land Use PCA



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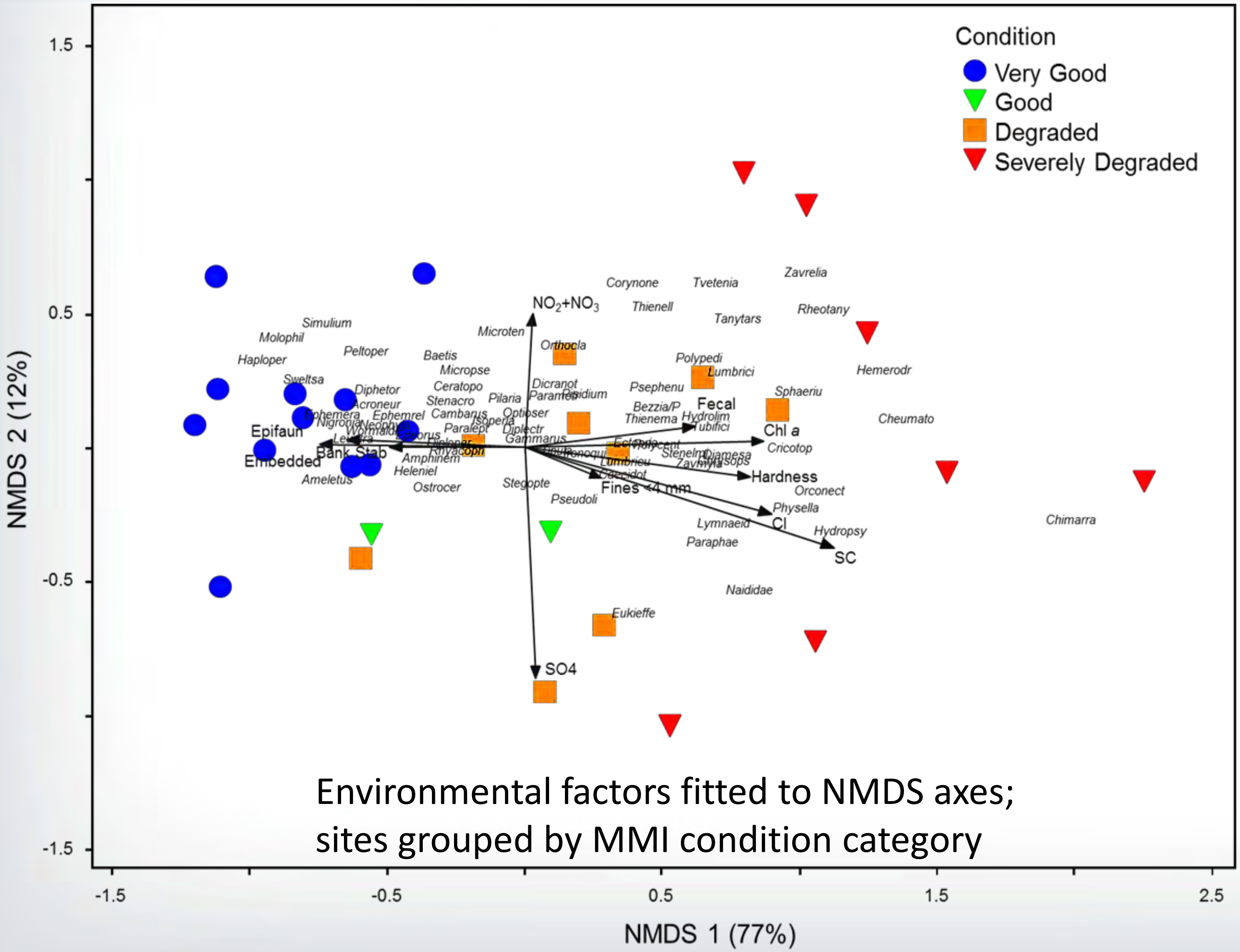
NMDS Ordination Community Structure



Environmental factors fitted to NMDS axes; sites grouped by MMI condition category

Top 10 Taxa

Sensitive

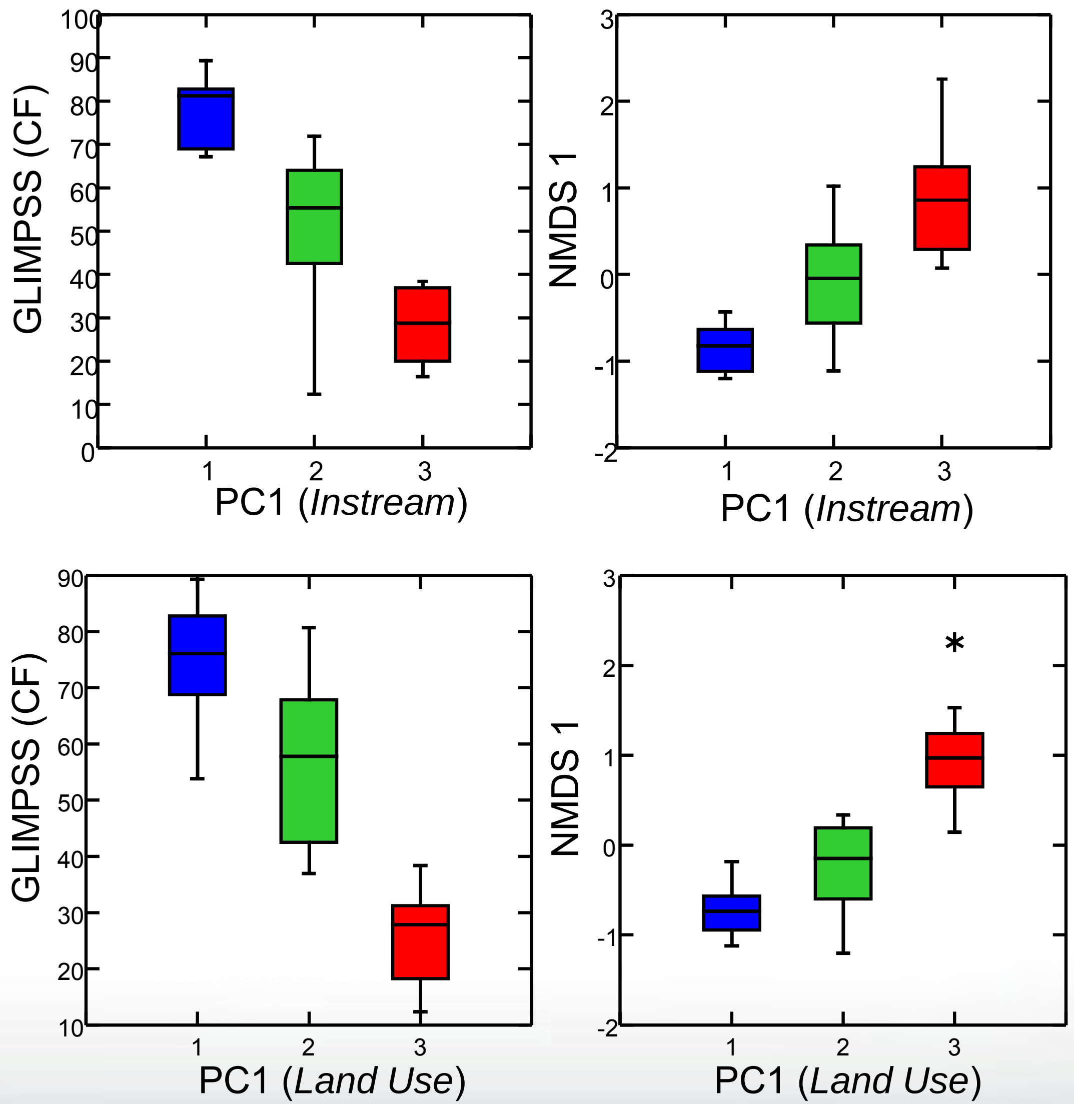
1. *Epeorus*
2. *Amphinemura*
3. *Ephemerella*
4. *Diphetor*
5. *Sweltsa*

Tolerant

1. *Cricotopus*
2. *Cheumatopsyche*
3. *Diamesa*
4. *Thienemannimyia*
5. *Hydropsyche*

Biological Response

Macroinvertebrate MMI and NMDS 1 were similarly responsive to both *Instream* and *Land Use* stressor gradients (PCA) in the multivariate world



Conclusion

Landscape models can be used for prediction or simple explanation, but resources managers are often tempted to use without biological data.

Local models should never replace biological assessments.

GIS-based models can provide managers with decision tools but are deficient without accompanying instream data.

Our models could help target areas for more intensive monitoring, prioritization of conservation areas, and/or selection of reference sites.

QUESTIONS???

Thank you to EPA R3 employees Frank Borsuk and Don Evans, interns Trevor Dunn and Lyndsey Burton, and the EPA R3 Laboratory