Assessing the Transferability of Ecosystem Service Production Estimates and Functions

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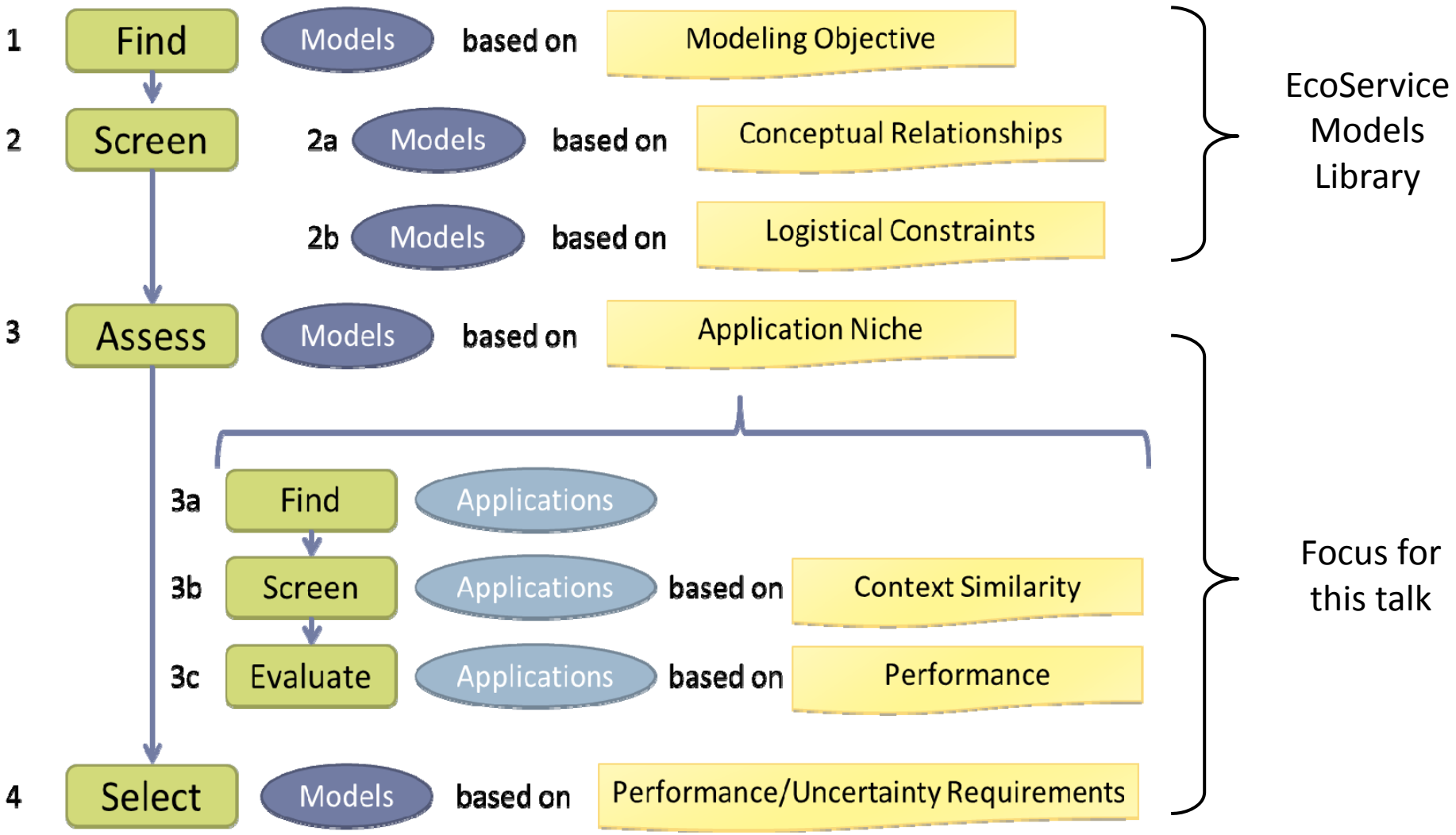
The Problem

- Estimate EGS stock or production at a location
  - Can't afford measurements
  - Also need to explore scenarios

- Transfer existing estimates or models?
  - Defensible rules, protocols lacking
  - Court challenges have been successful (EPA rules)

Ecological Model Transferability Framework



Ecological Context

Context Dimensions (CD's) form the setting for an ecological model in terms of which it can be fully understood and assessed

Identifying "Context Dimensions"

Intrinsic CD's

- Predictor variables directly affecting model endpoint(s)
- Require mechanistic understanding of causal processes
- Data often difficult to find

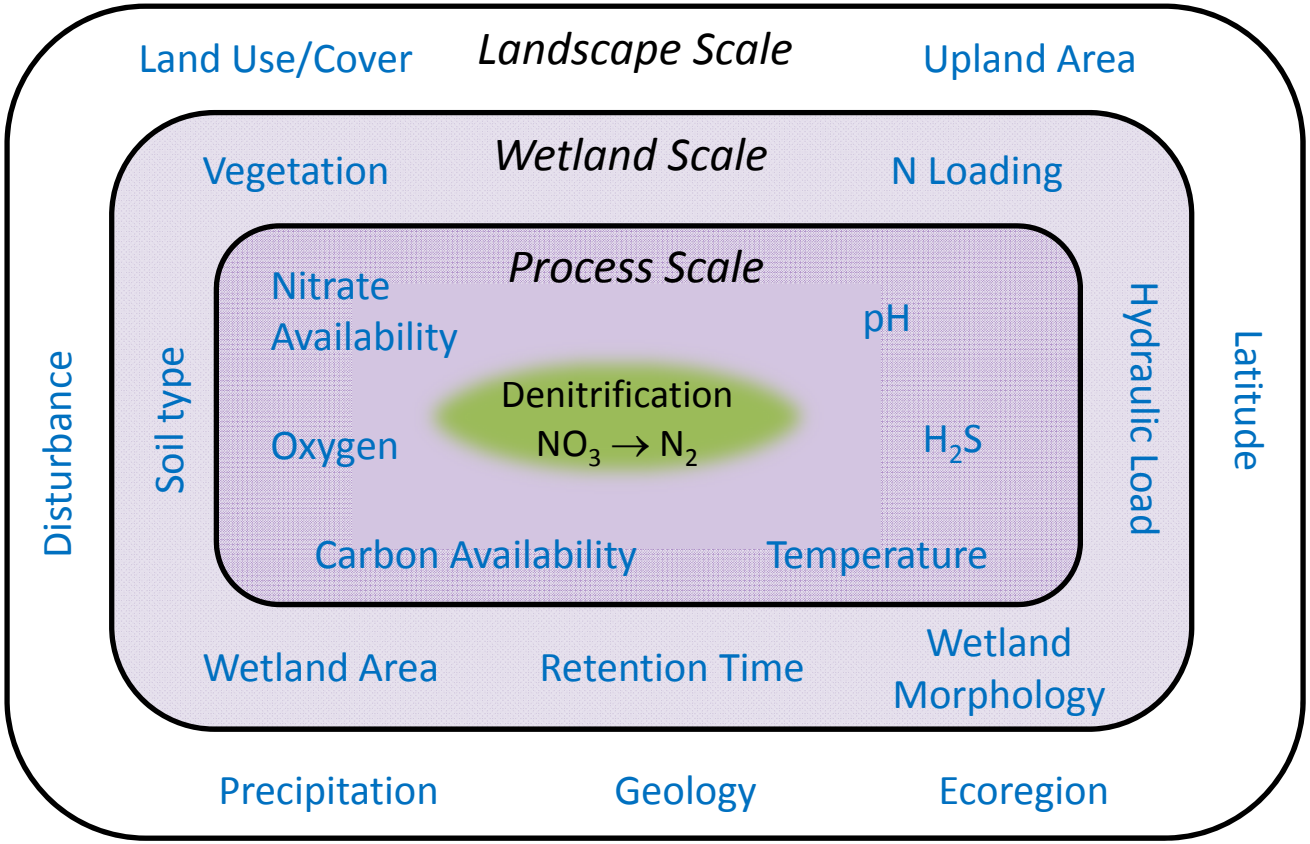
Extrinsic CD's

- Variables affecting a process but not included in model
- Relationship to process may be
  - causal (temperature affecting a microbially-driven denitrification)
  - correlated, but indirect (stream order affecting fish distributions)

Identifying Context Dimensions (CD's)

Context dimensions change with scale

- Intrinsic CD's operate at the spatial & temporal scale of the underlying process
- Extrinsic CD's can occur at various scales



after Trepel and Palmeri, 2002

Sources of Context Dimension Data

Climate, weather
NCAR Community Climate System Model
Climate.gov
PRISM

Geology, soils
USGS National Geologic Map Database
USDA Natural Resources Conservation Service

Elevation, topography
National Elevation Dataset
World Ocean Atlas

Hydrology
NHD, NHDPlus
HydroSHEDS
Hydrologic Unit Maps

Land & seafloor cover
MRLC National Land Cover Database (NLCD)
National GAP Land Cover Data Portal
Coastal & Marine Ecological Classification (CMECS)
National Wetland Inventory

Vegetation
Length of growing period
USDA Plant Hardiness GIS data
LANDFIRE

Fish & wildlife
USFW Threatened and Endangered Species Critical Habitat
NOAA marine critical habitat
NOAA essential fish habitat mapper
National GAP Species Data Portal
Wildfinder Database
BISON

Ecological regions
Conservation GIS Data including Ecoregions
Ecoregions of North America
ESRI Global Ecological Land Units
Marine Ecoregions of the World (MEOW)
Freshwater Ecoregions of the World (FEOW)
The Ecological Site Information System (ESIS)

Human infrastructure
TIGER
National Transportation Atlas Databases 2014
NLCD 2011 Percent Developed Impervious
Homeland Infrastructure Foundation Level Data (HIFLD)
Facility Registry Service

Environmental data atlases
USEPA EnviroAtlas
ESRI Living Atlas

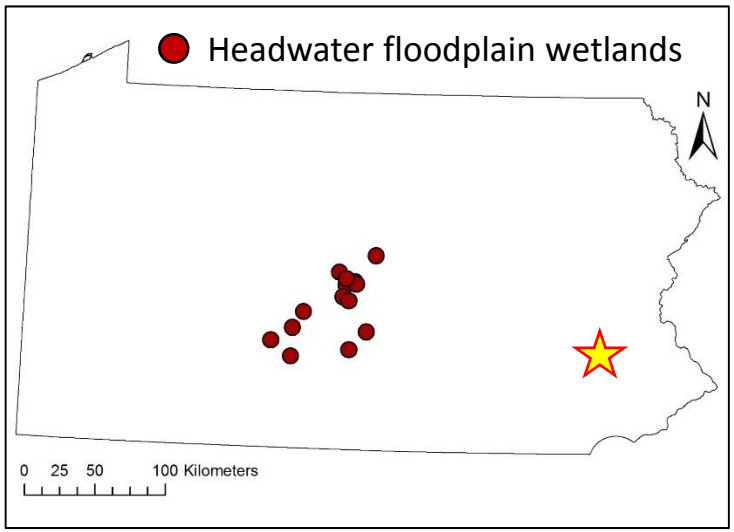
Example: Transferability of a statistical model for wetland condition

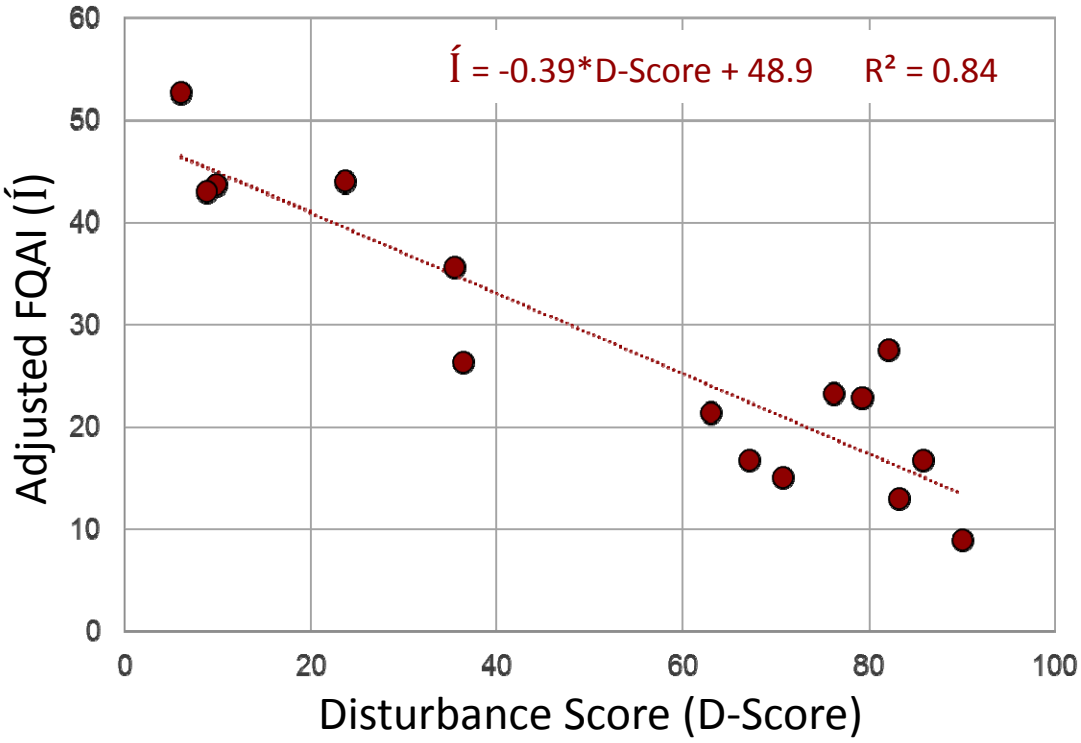
Q: How well might this model perform at my site (★)?

Predictor: Disturbance at Site
Disturbance Score[2] (D-Score); *function of forest cover, #stressors & buffer intactness*

Response: Wetland Condition metric
Adjusted Floristic Quality Assessment Index[1] (Í); *function of plant spp. rareness*

Wetland Data: Riparia, Penn St. Univ.[3]

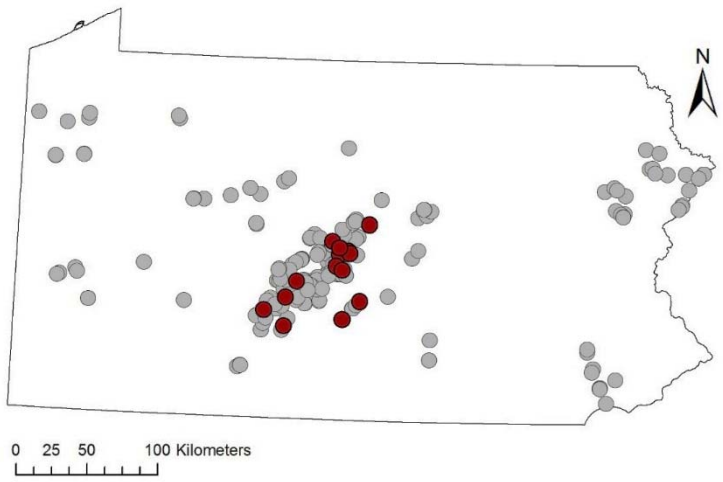




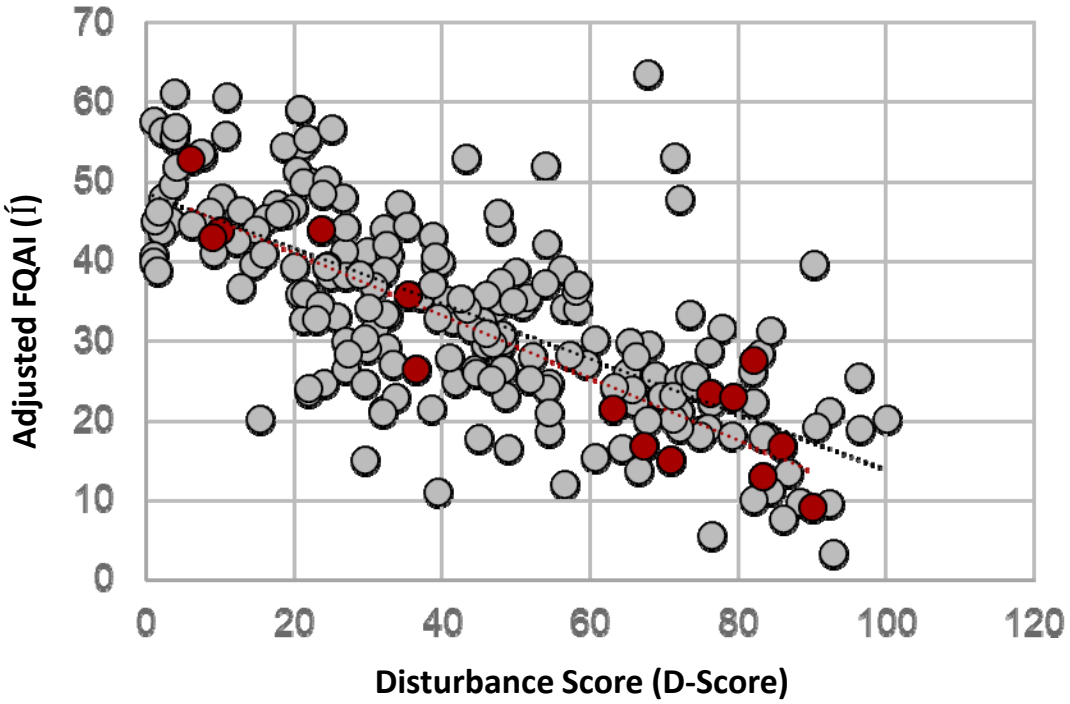
1. Miller and Wardrop 2006, *Ecol. Indicators*
2. http://apps.cei.psu.edu/fqacalc/
3. http://wa.cei.psu.edu/wetlands/

Locate “Applications” of the Model

222 reference wetland sites in Pennsylvania[1]



15 model sites
207 application sites



Í = -0.39*D-Score + 48.9 R^2 = 0.84 (model sites)

Í = -0.35*D-Score + 48.5 R^2 = 0.50 (application sites)

- Increased variability
- Decrease in model performance

1. Sarah Chamberlain, Riparia, Penn St. Univ.; http://wa.cei.psu.edu/wetlands/

Identify Context Dimensions of the Model

Wetland Condition Metric (Response) a function of:

N = number of native plant species

A = number of non-native plant species

Disturbance Score (Predictor) a function of:

FC (Forest Cover) = % forested land cover

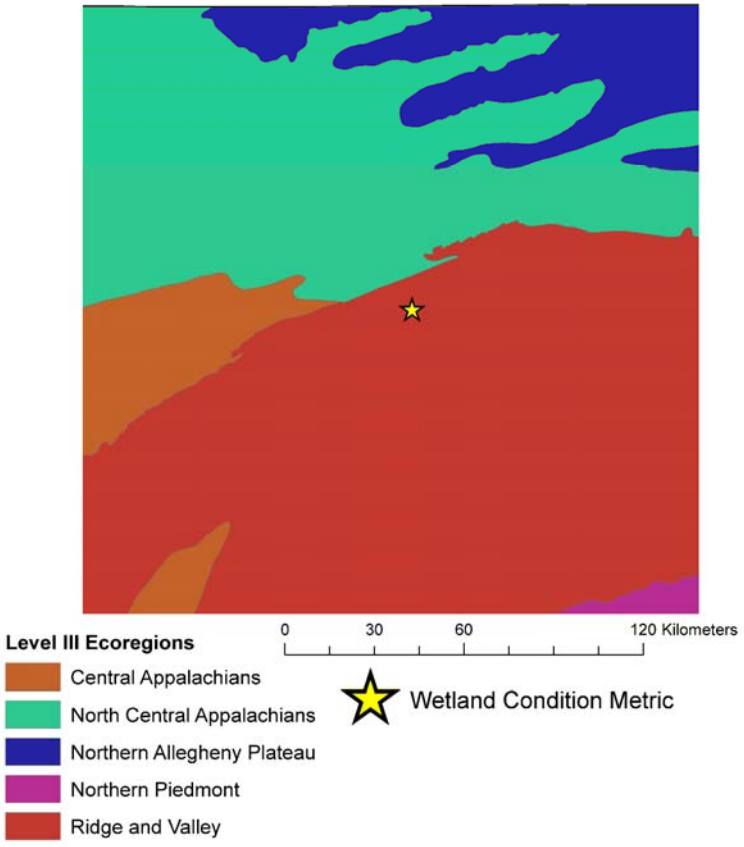
Stressors = # stressors present on site

Intrinsic CD'scome directly from the model

Plant species abundance, forest cover, stressor magnitude

Extrinsic CD's are inferred from the model

Wetland type (HGM, NWI), area, history; hydrology, stream order; geology, soil characteristics; climate (temperature, precipitation, etc.); landscape setting, Ecoregion; etc.

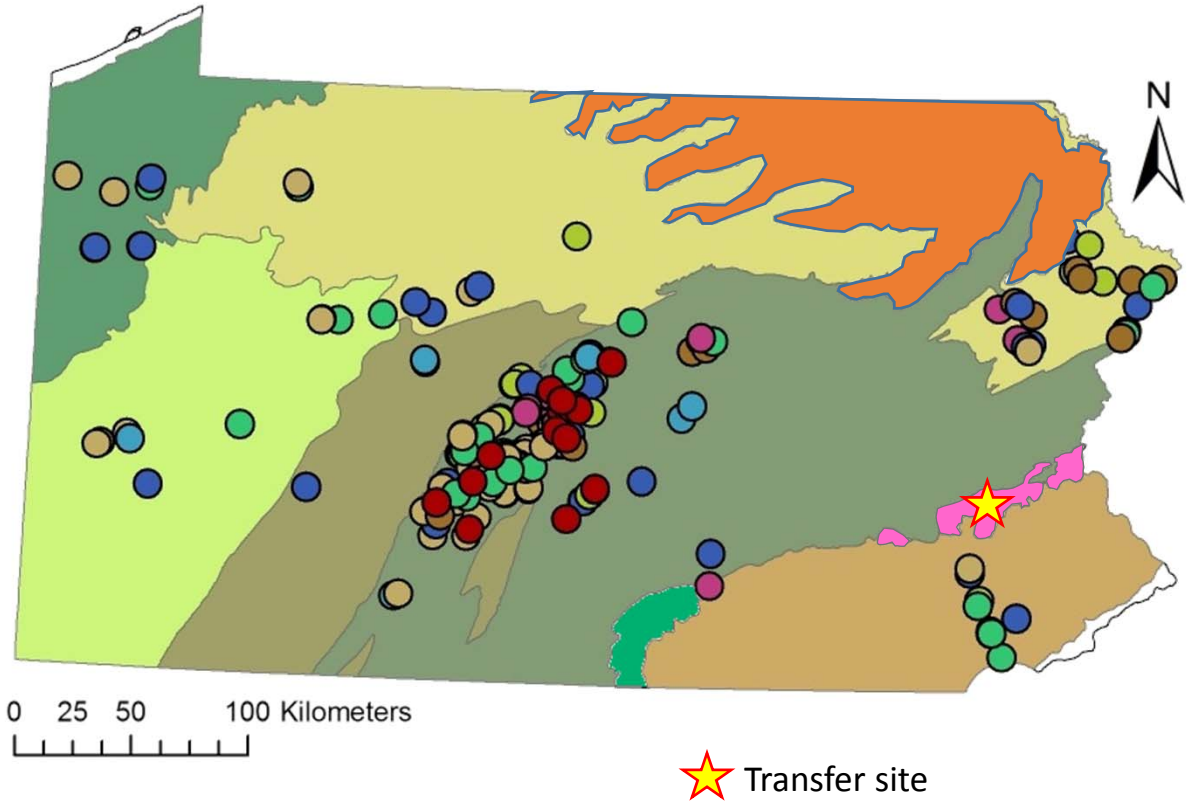


Determine the Context Dimension Domains

Use to assess context similarity

Site Type	% Forest	Wetland Type (HGM class)	Stream Order	Ecoregion Level 3 class
Model Sites (15)	**0 – 100%**	Headwater floodplain (**1 class**)	**1 - 3**	Ridge & Valley (**1 class**)
Application Sites (207)	**0 – 100%**	Headwater floodplain, Headwater impoundment, Mainstem floodplain, Slope, Fringing, Isolated depression, Riparian depression, Mainstem depression (**9 classes**)	**1 - 7**	Ridge & Valley, North Central Appalachians, Central Appalachians, Western Allegheny Plateau, Erie Drift Plain, North Piedmont, Northern Appalachian Plateau and Uplands (**7 classes**)
Transfer Site (1)	**65%**	Slope (**1 class**)	**1**	Northern Highlands (**1 class**)

Distribution of Wetlands Relative to Two Extrinsic Context Dimensions



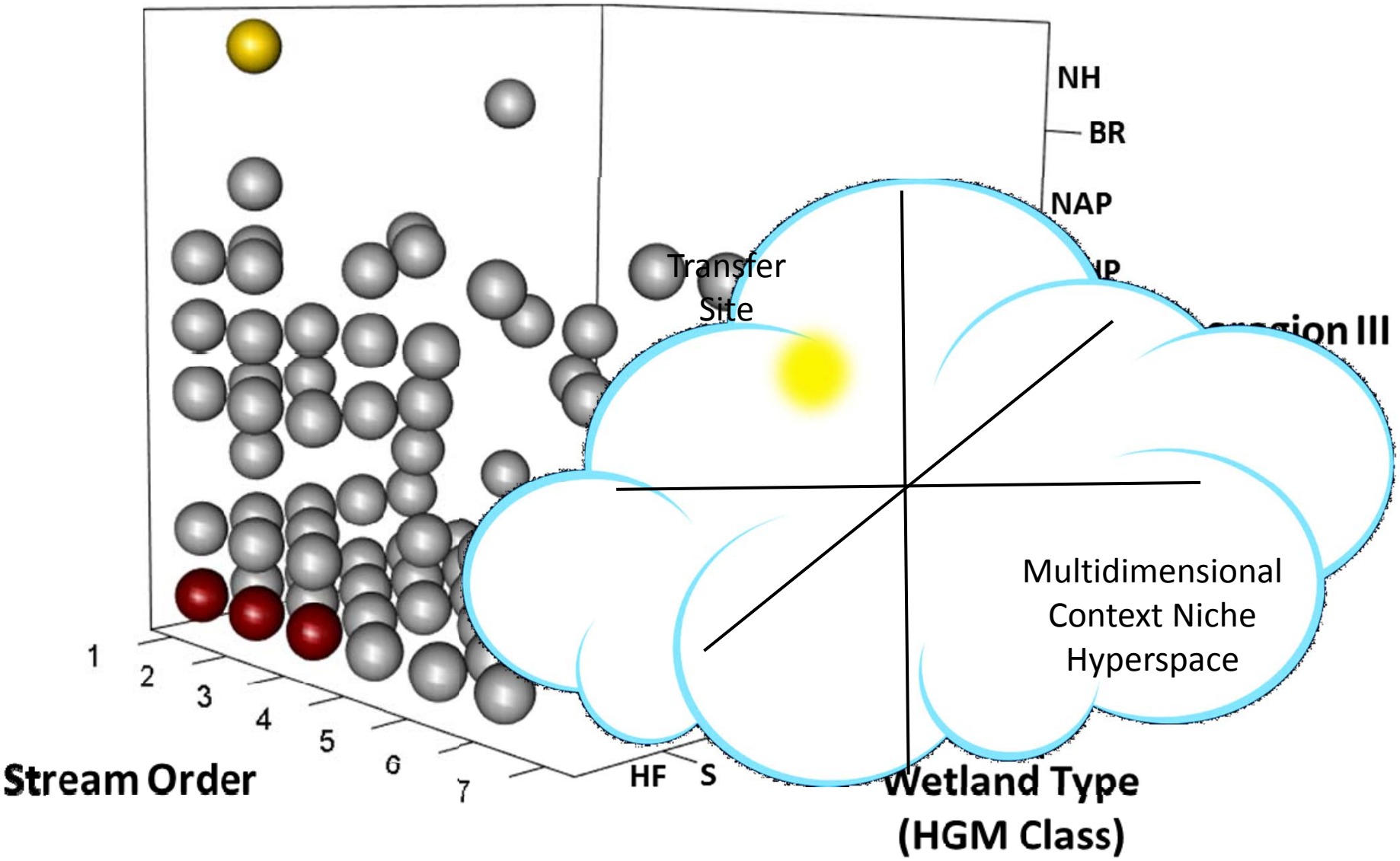
HGM Classification

- Headwater Floodplain - Model
- Headwater Floodplain
- Headwater Impoundment
- Mainstem Floodplain
- Slope
- Fringing
- Isolated Depression
- Riparian Depression

Ecoregions - Level 3

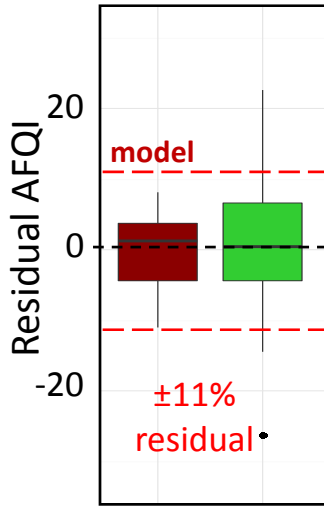
- Ridge and Valley
- Central Appalachians
- Erie Drift Plain
- North Central Appalachians
- Northern Piedmont
- Western Allegheny Plateau
- Northern Appalachian Plateau
- Blue Ridge
- Northern Highlands

Multidimensionality of Context



Model Performance Within Context Dimension Domains

– – – - Acceptability criterion: application residual does not exceed the largest model residual



Performance Metric:

Residual AFQI

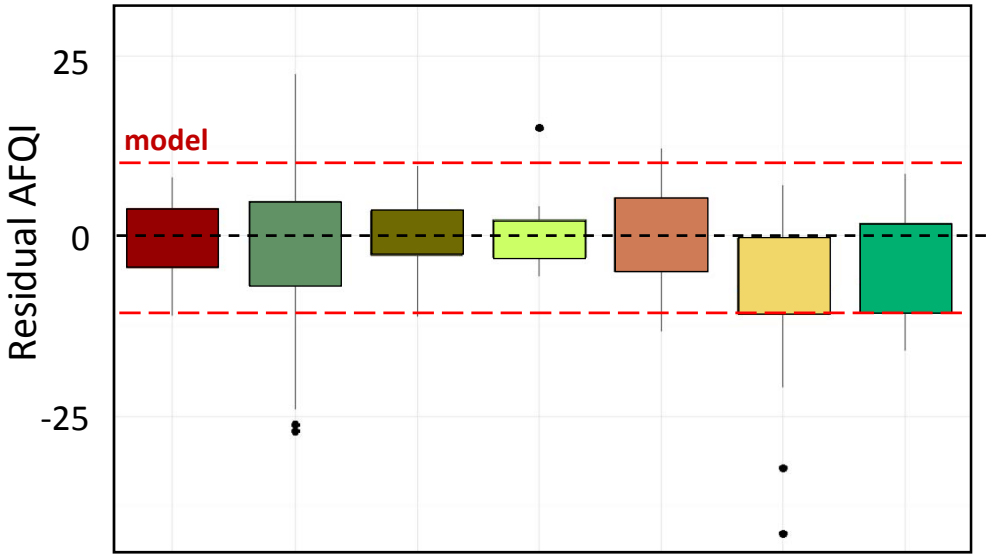
= Predicted AFQI – Measured AFQI

Overestimating

Underestimating

Wetland Type (HGM Class)

- Headwater Floodplain (model)
- Headwater Floodplain
- Headwater Impoundment
- Mainstem Floodplain
- Slope
- Fringing
- Isolated Depression
- Riparian Depression



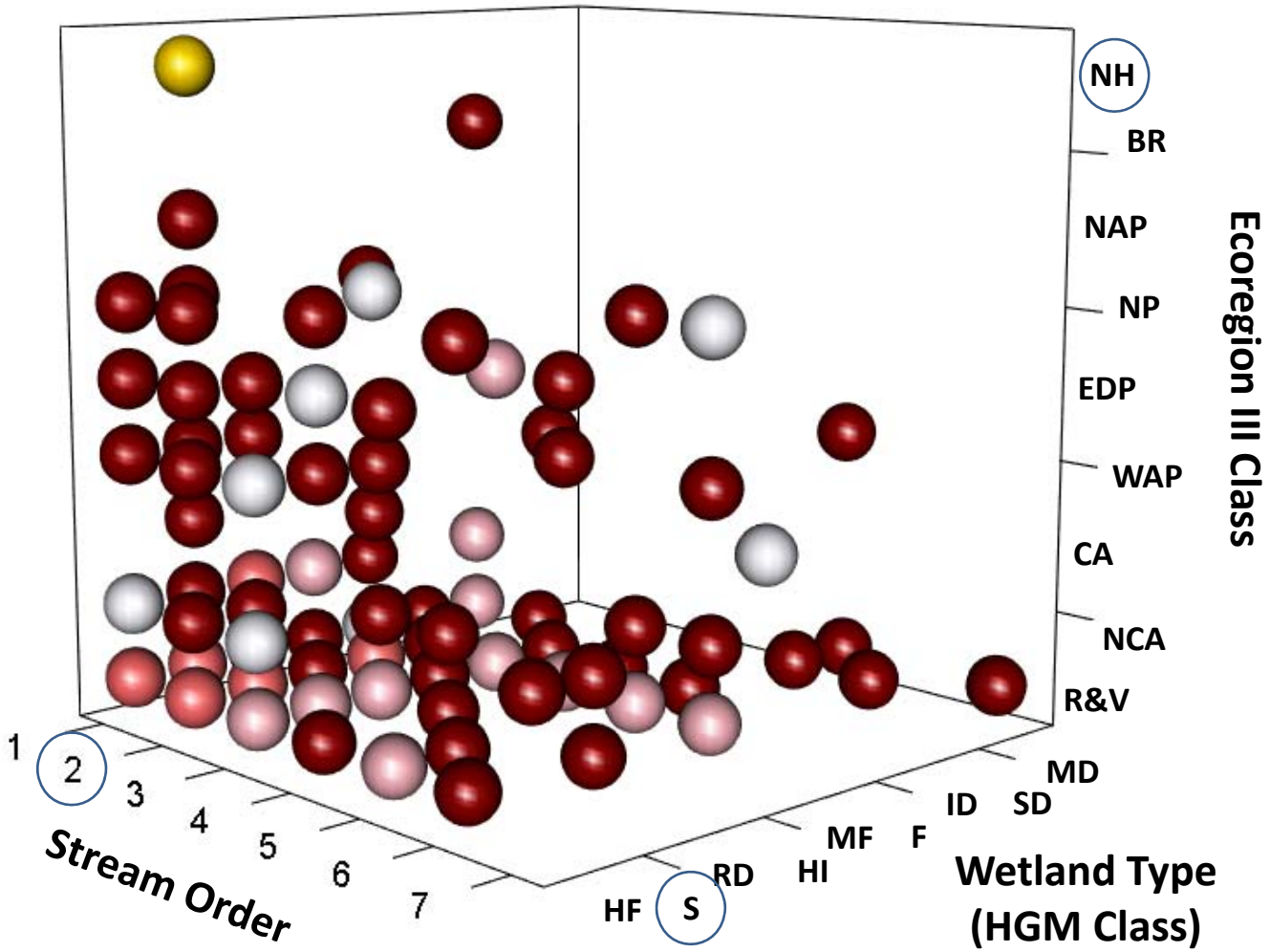
Overestimating

Underestimating

Ecoregion – Level 3

- Ridge & Valley (model)
- Ridge & Valley
- Central Appalachians
- Western Allegheny Plateau
- North Piedmont
- North Central Appalachians
- Erie Drift Plain

Model Performance at Context Dimension Intersections



± 11.0 Residual (largest residual in the model)

Applications
Percent Accepted

- 100%
- 75-99%
- 50-74%
- 25-49%
- 1-24%
- 0%
- Transfer Context

Summary

- General need to transfer models & estimates to unstudied locations
- Inappropriate transfers can lead to poor decisions
- Developing a methodology to assess the risk associated with transfers
  - A process for how to think about & then quantify
    - Context similarity
    - Performance across context dimensions

Next Steps and Challenges

- Statistical methodology – multivariate comparisons of context niches
- Linkage to other tools
  - EcoService Models Library
    - candidate model identification
    - intrinsic context dimensions
    - locations of model & application sites
  - GIS databases & tools (EnviroAtlas, ESRI Living Atlas, Bison, etc.)
    - data for intrinsic & extrinsic context dimensions
    - locations where model has good, poor, or uncertain applicability