Alteration of Riparian Plant Community Structure under Climate Change Scenarios: The Effects of Temperature and Hydroperiod

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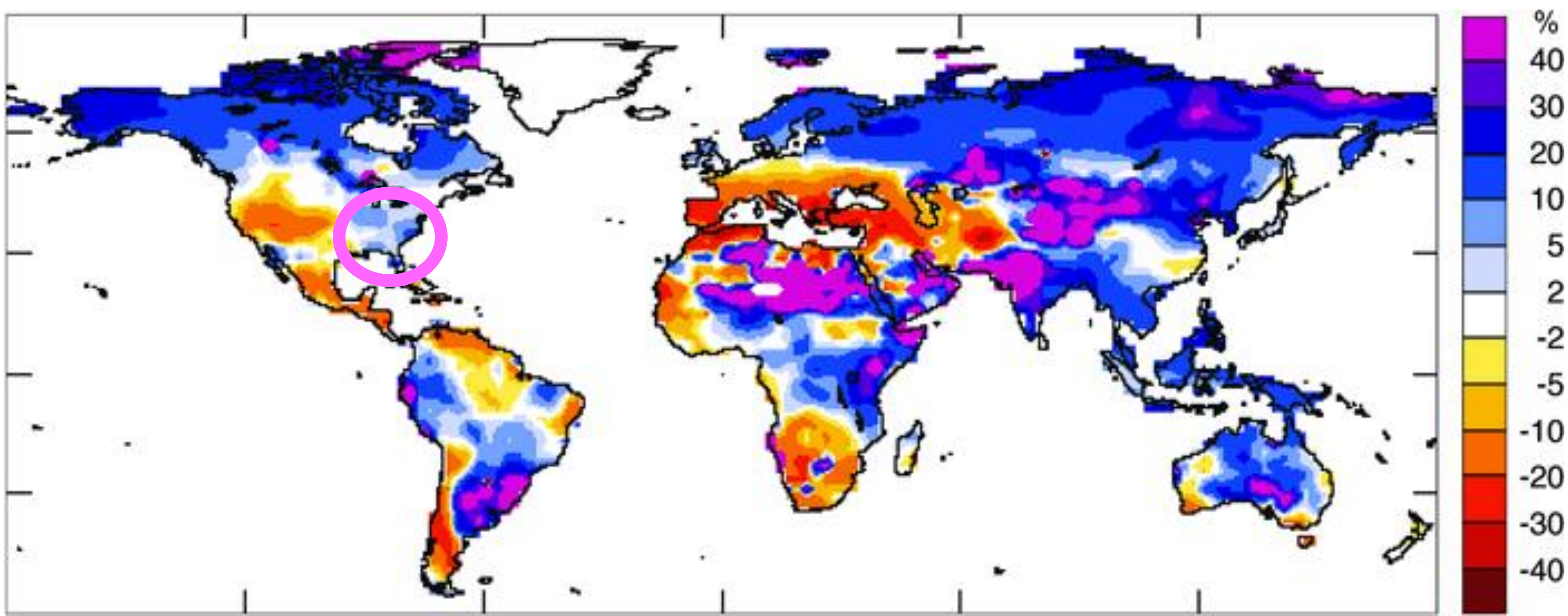
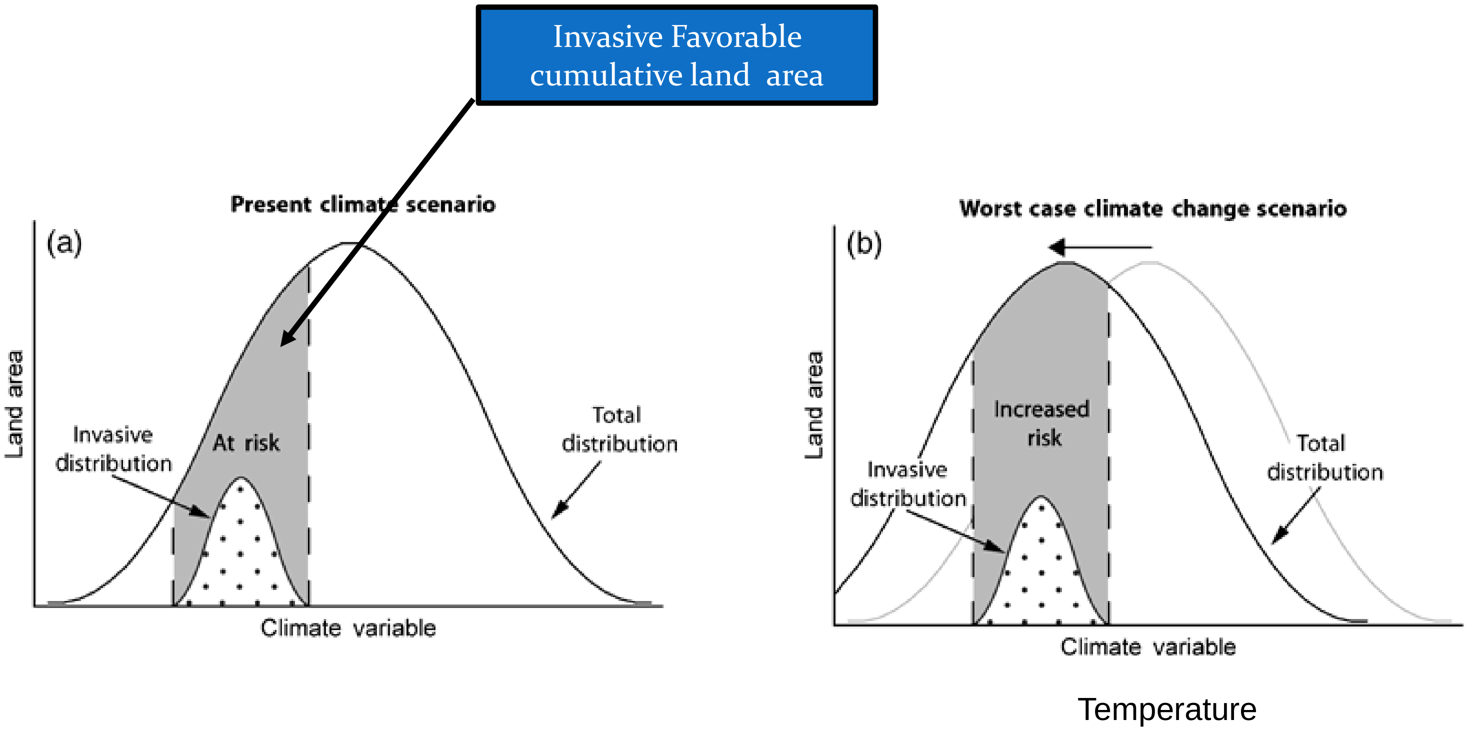
Future Climate Scenario

Global climate change and regional freshwater ecosystem models (IPCC) agree on three key findings;

1. water temperatures will increase 2 to 3°C and,
2. the frequency of high intensity rainfalls and large flood events will increase,
3. decreased duration of flooded/saturated conditions due to lower baseflow and higher ET



Climate change and plant invasions: envelope models



From Bradley and Oppenheimer, 2009

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Study Questions

1. How do species-richness, diversity, and "degree of invasion" differ under varying pulsed water and temperature regimes?
2. How have interactions between hydrology and temperature affected the current community composition/invasibility of southeastern floodplain ecosystems at the regional scale?

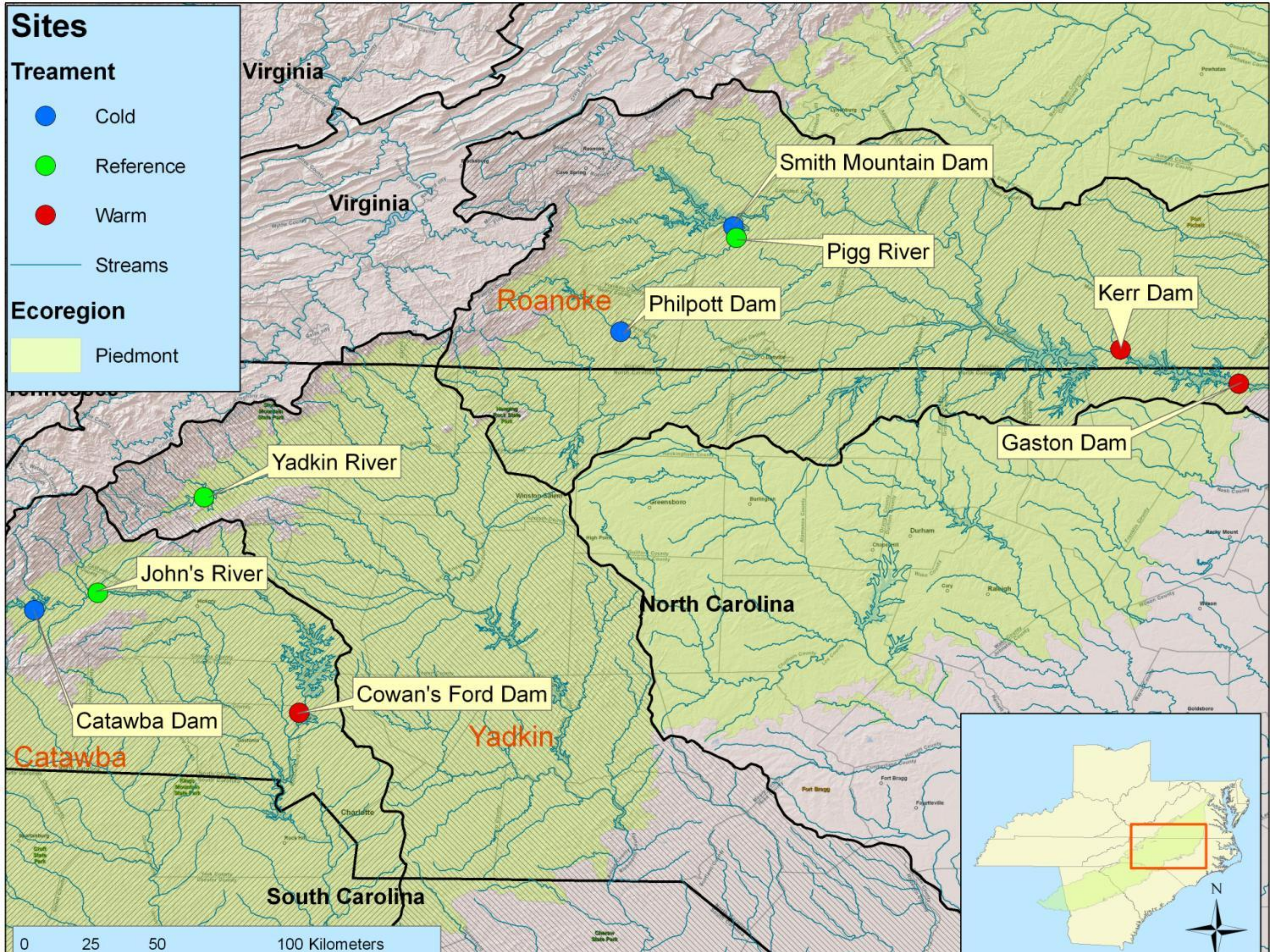
Methods

Site Layout

- Nine floodplains wetlands located on rivers throughout the North Carolina and southern Virginia.
- Downstream of:
  - 3 surface drawing dams (warm water)
  - 3 bottom-releasing dams (cool water)
  - 3 undammed reference watersheds

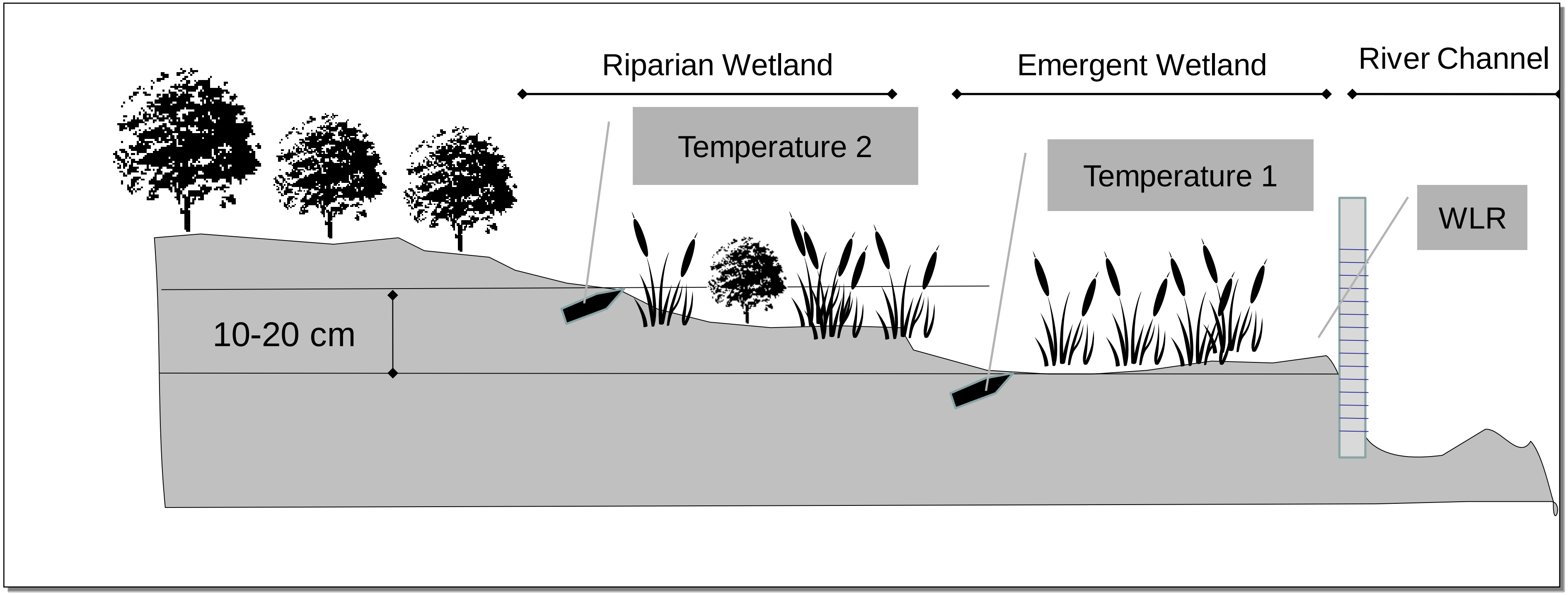
Site Selection Criteria

- Located within the Piedmont Ecoregion
- Headwaters in mountains
- Primarily rural (forest and agriculture)
- Similar soil/water nutrient regimes



Sites
Treament
Cold
Reference
Warm
Streams
Ecoregion
Piedmont
Virginia
Virginia
Roanoke
Smith Mountain Dam
Pigg River
Philpott Dam
Kerr Dam
Gaston Dam
Yadkin River
John's River
Catawba Dam
Cowan's Ford Dam
Catawba
Yadkin
North Carolina
South Carolina
0 25 50 100 Kilometers
N

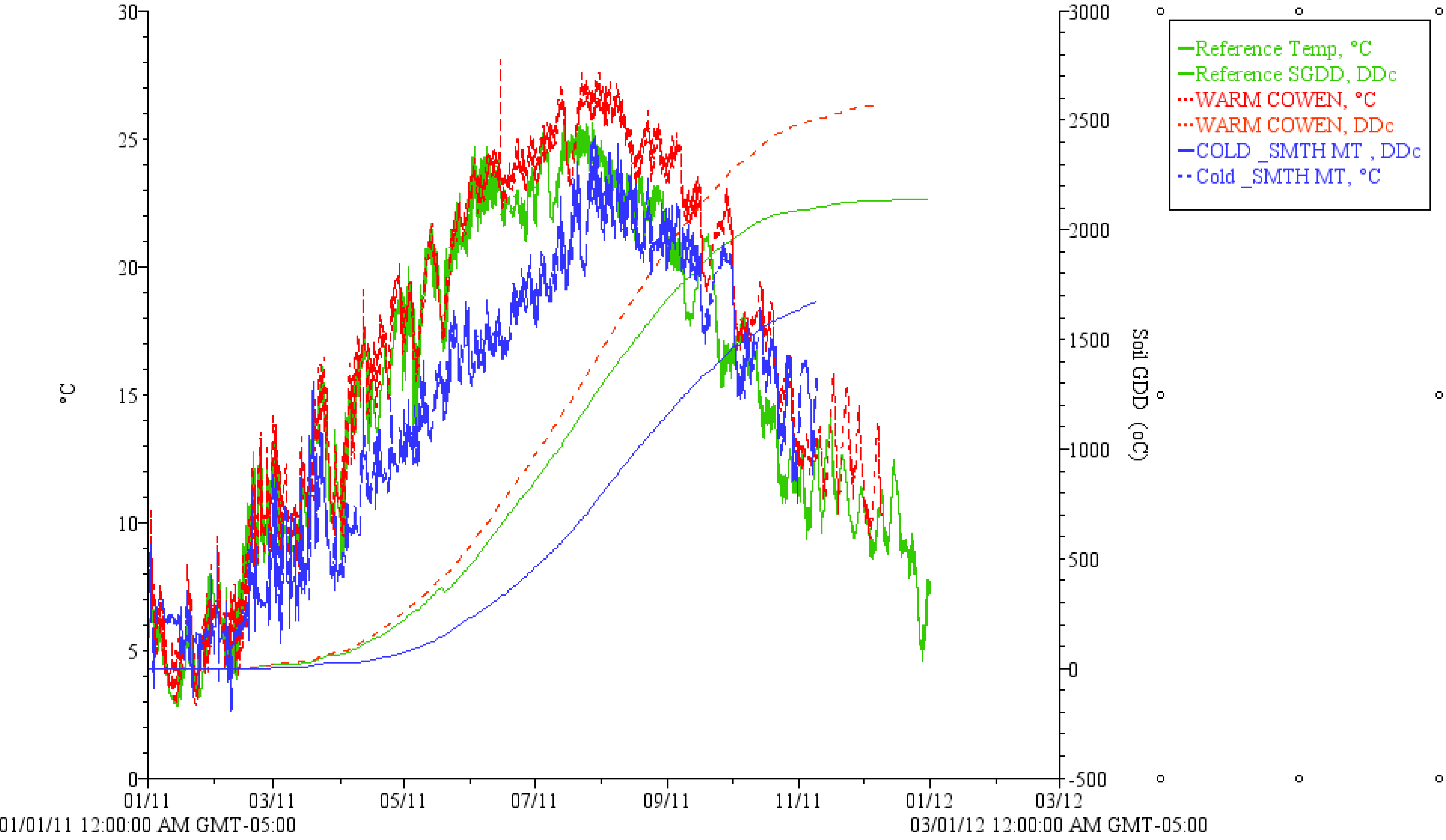
Site Layout



Riparian Wetland
Emergent Wetland
River Channel
Temperature 2
Temperature 1
WLR
10-20 cm

RESULTS

Representative SGDD Curves



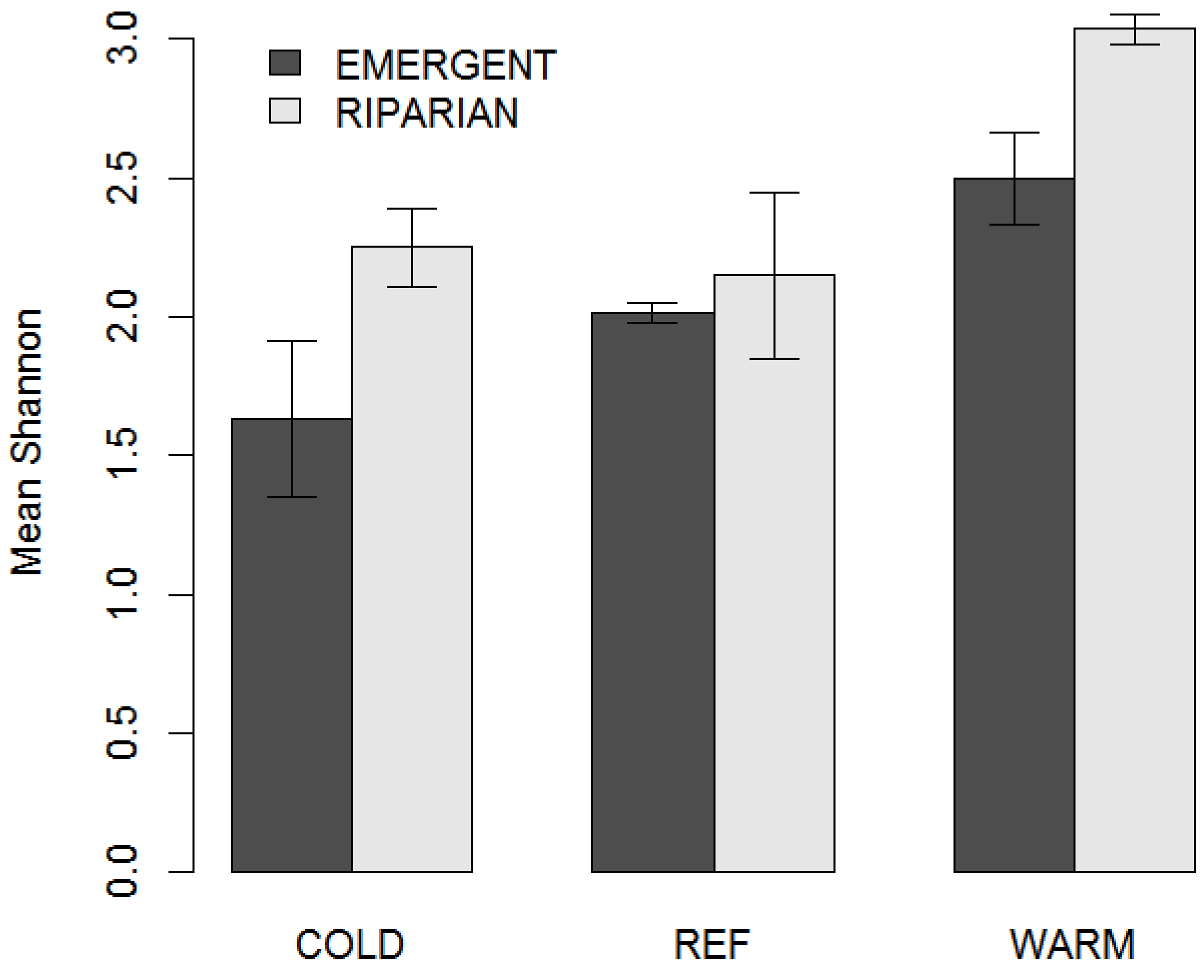
Hydrology Numerical Summary

Treatment	Flood Frequency	Average Flood Duration (hrs)	Total Inund. Duration (hrs)	Average Return Period (hrs)	MEAN Rate Rise “POWER “ (mm/hr)
Warm	432	4.26	1842	38.7	121
Reference	306	10.7	3291	90	84
Cold	485	4.3	2099	34.4	173

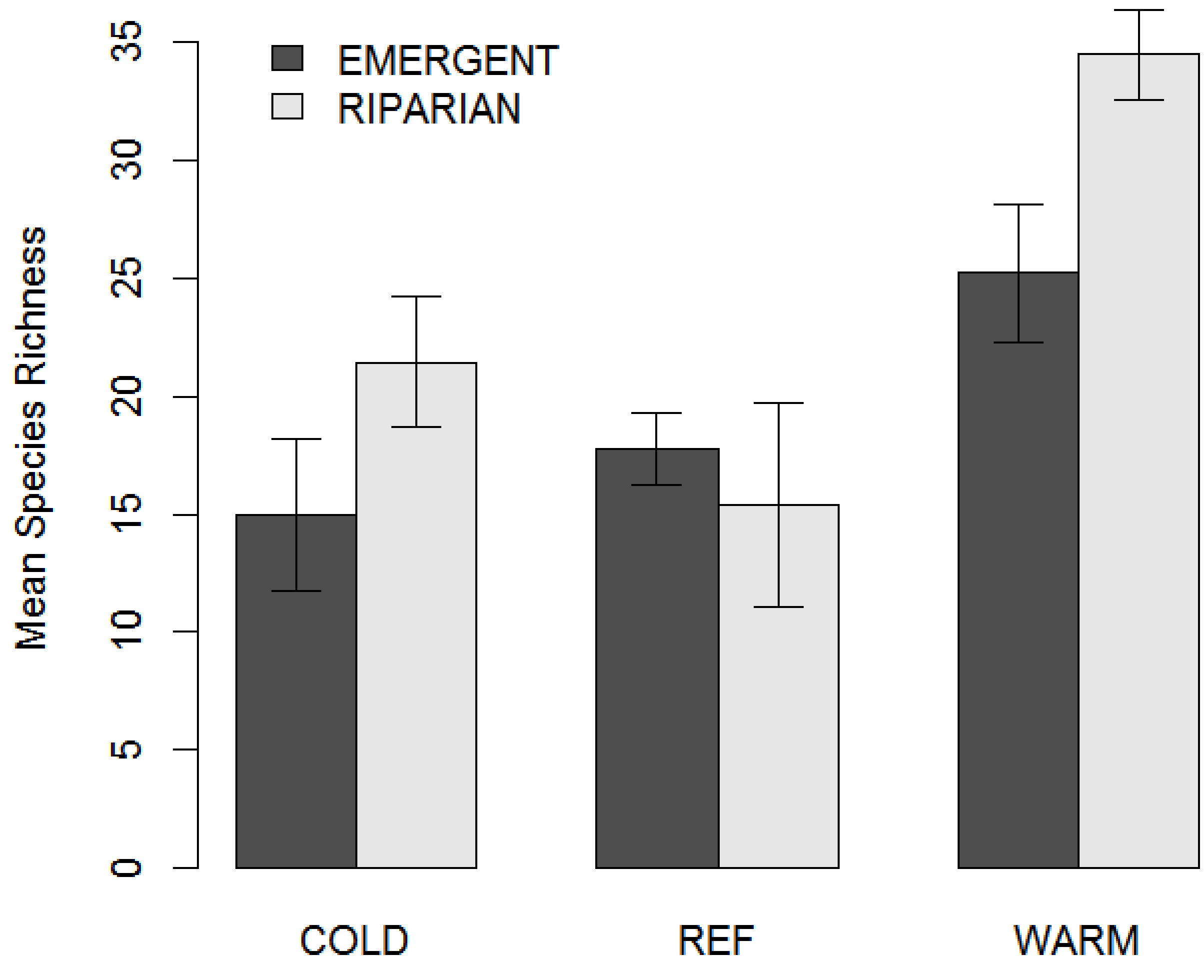
Analysis of Plant Community Indices

- Site specific indices of diversity, species richness, degree-of-invasion, dominance

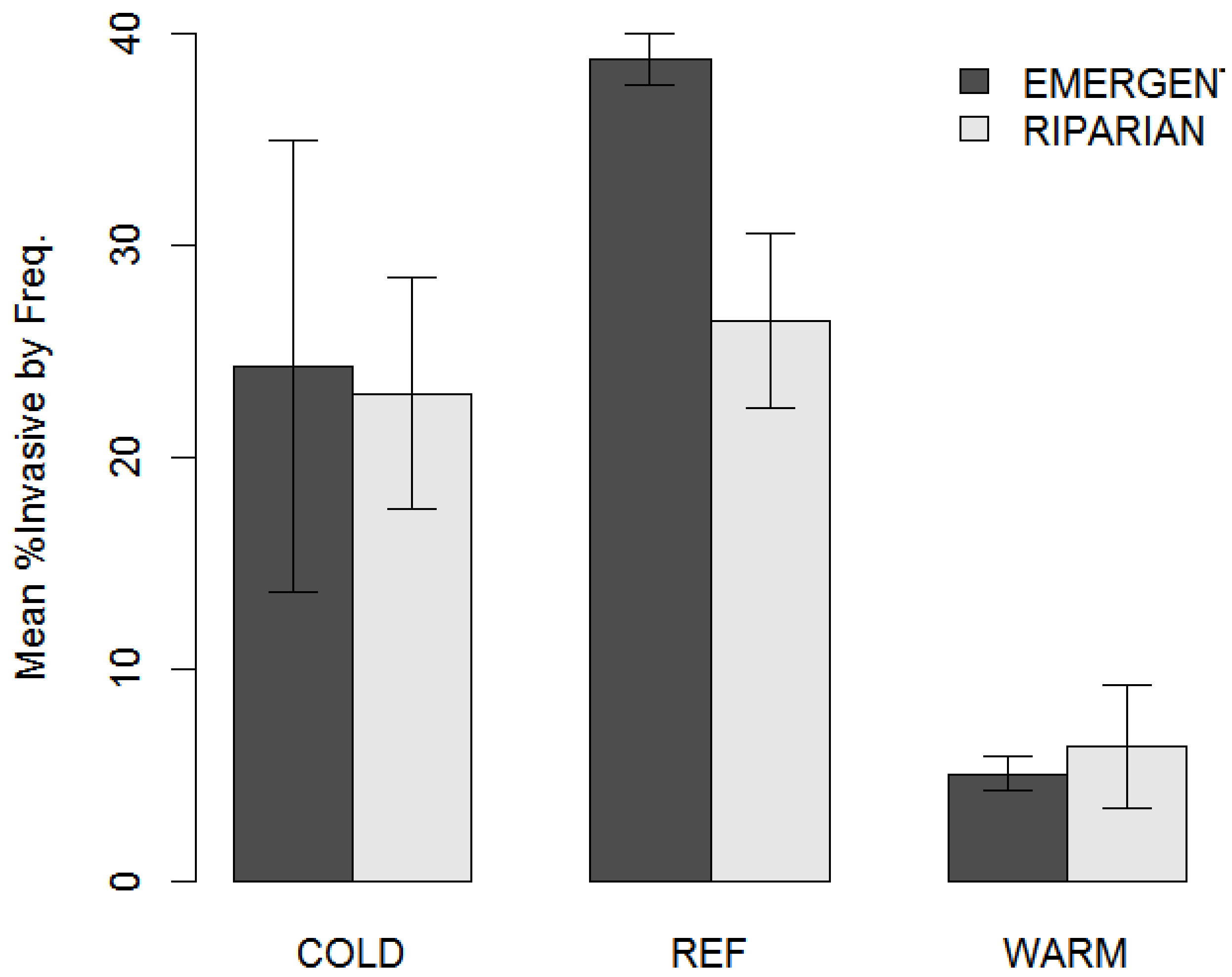
Shannon's Index



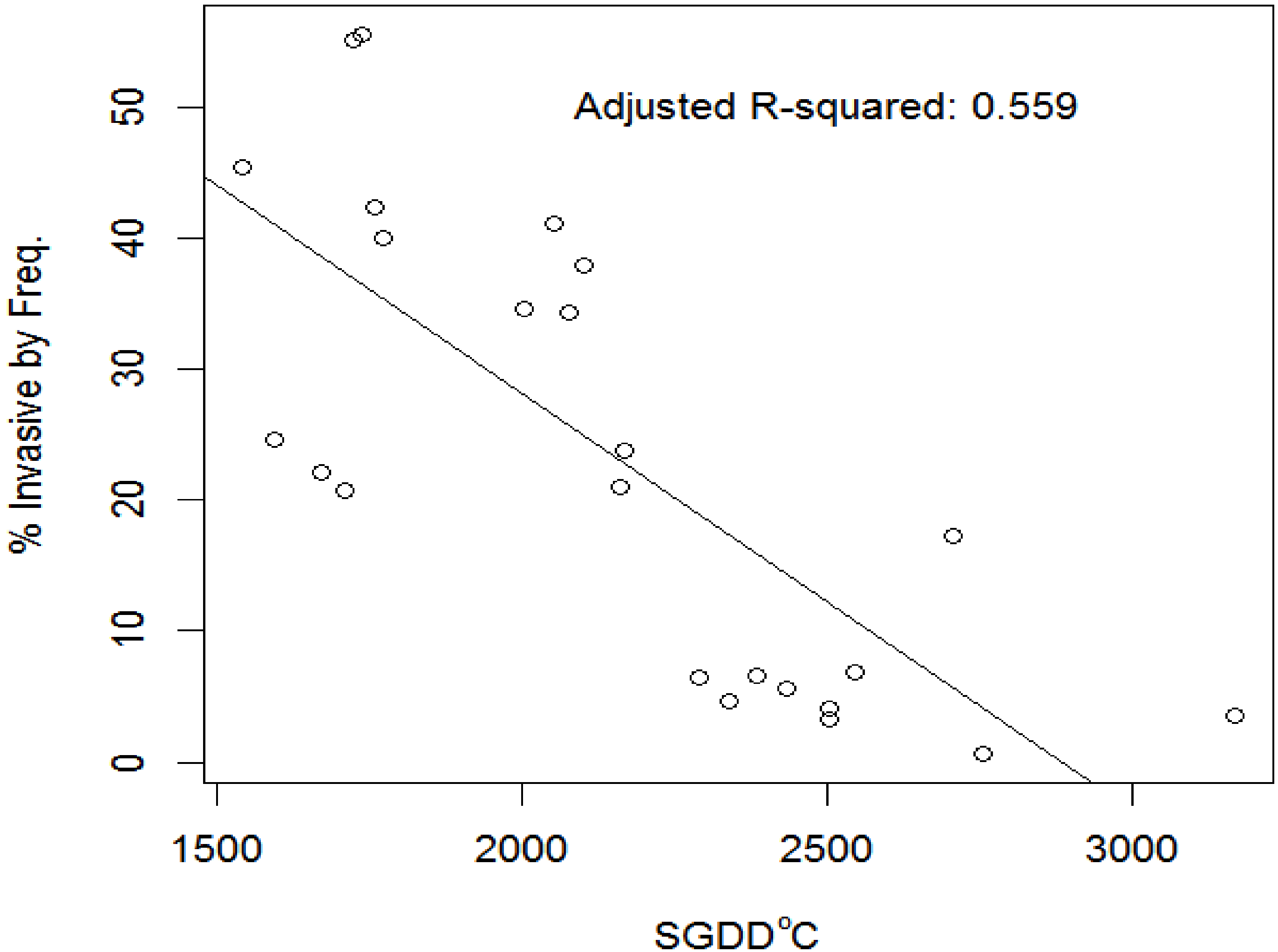
Species Richness



Percent Stems Non-Native



% Invasive Frequency v. SGDD All Sites



Correlation of Community Indices with Environmental Factors

Procedure: Random Forest

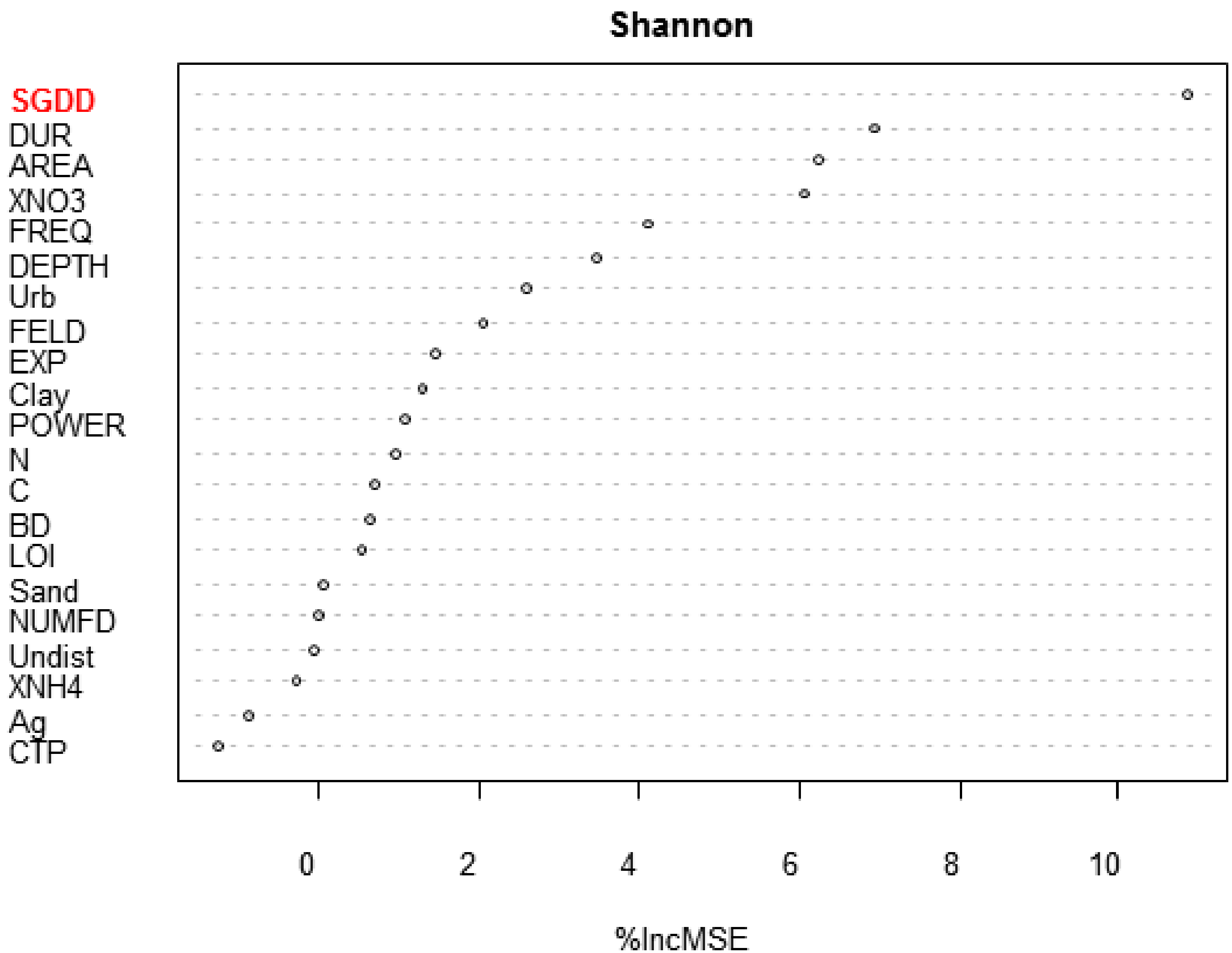
Index	Percent Variance Explained
Diversity	
Shannon	52.8
Species Richness (rarefy)	48.2
Degree of Invasion	
% Stems Non-Native	64.16

Analysis Variables

Watershed			**Soil**			**Hydrology**		
Urb	% Urban		Sand	% Sand		POWER	Flood Rate of Rise (m	
Ag	% Cultivated		Clay	% Clay		FREQ	Flood Freq.	
Undist	% Forested		BD	Bulk Density		DEPTH	Ave. Depth	
AREA	Sq Km		LOI	Loss on Ignit.		DUR	Ave Duration	
			C	Total C		NUMFD	Number of Floods	
			CTP	Total P				
			EXP	Extractable P				
Temperature			N	Total N				
SGDD	Soil Growing Degree Days		XNO3	Ext. NO3				
			XNH4	Ext. NH4				
			FELD	Sediment Depostion				
Postion								
POINT_X	Longitude							
POINT_Y	Latitude							

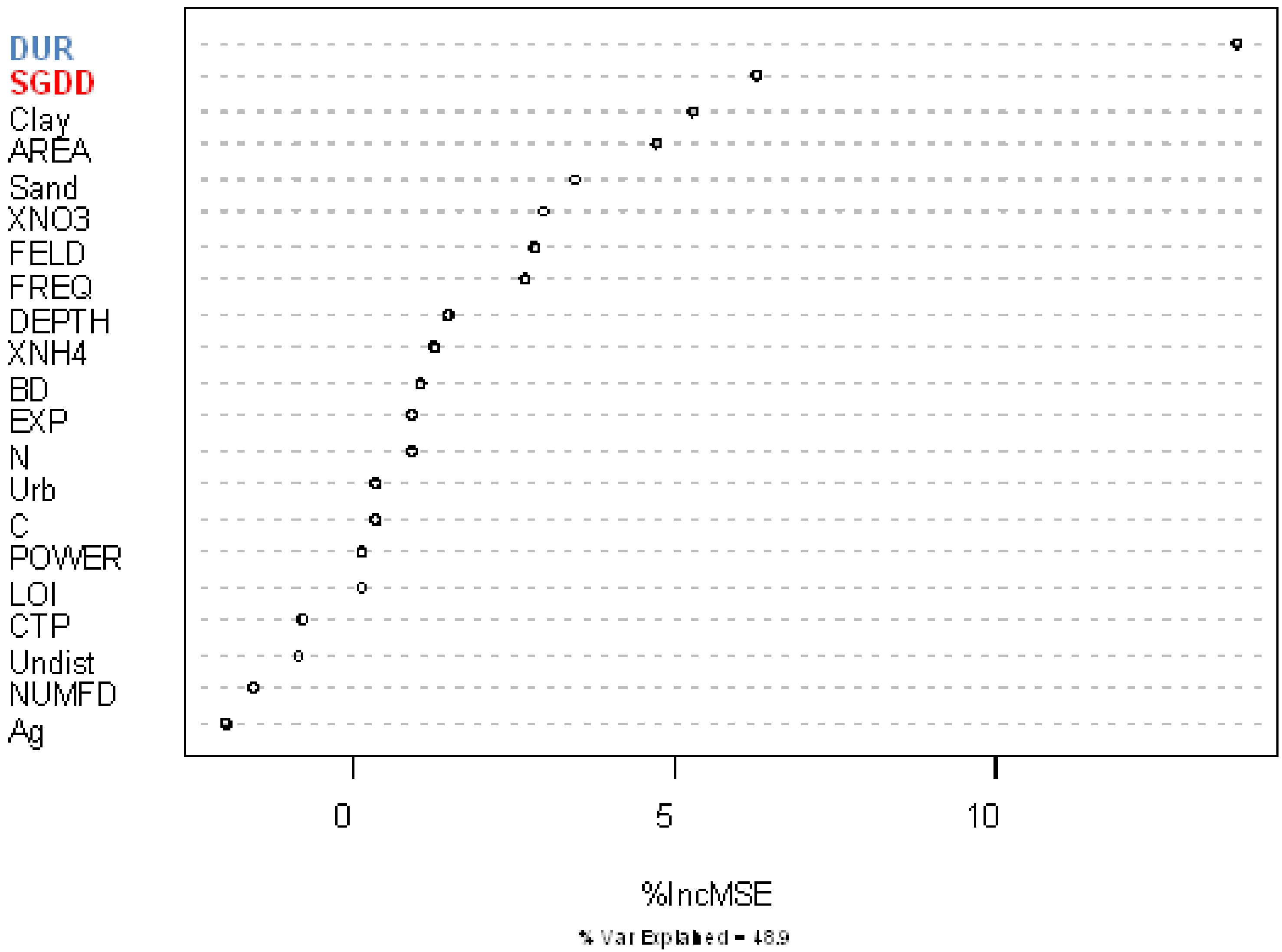
Random Forest Variable Importance

Diversity Index (Shannon)



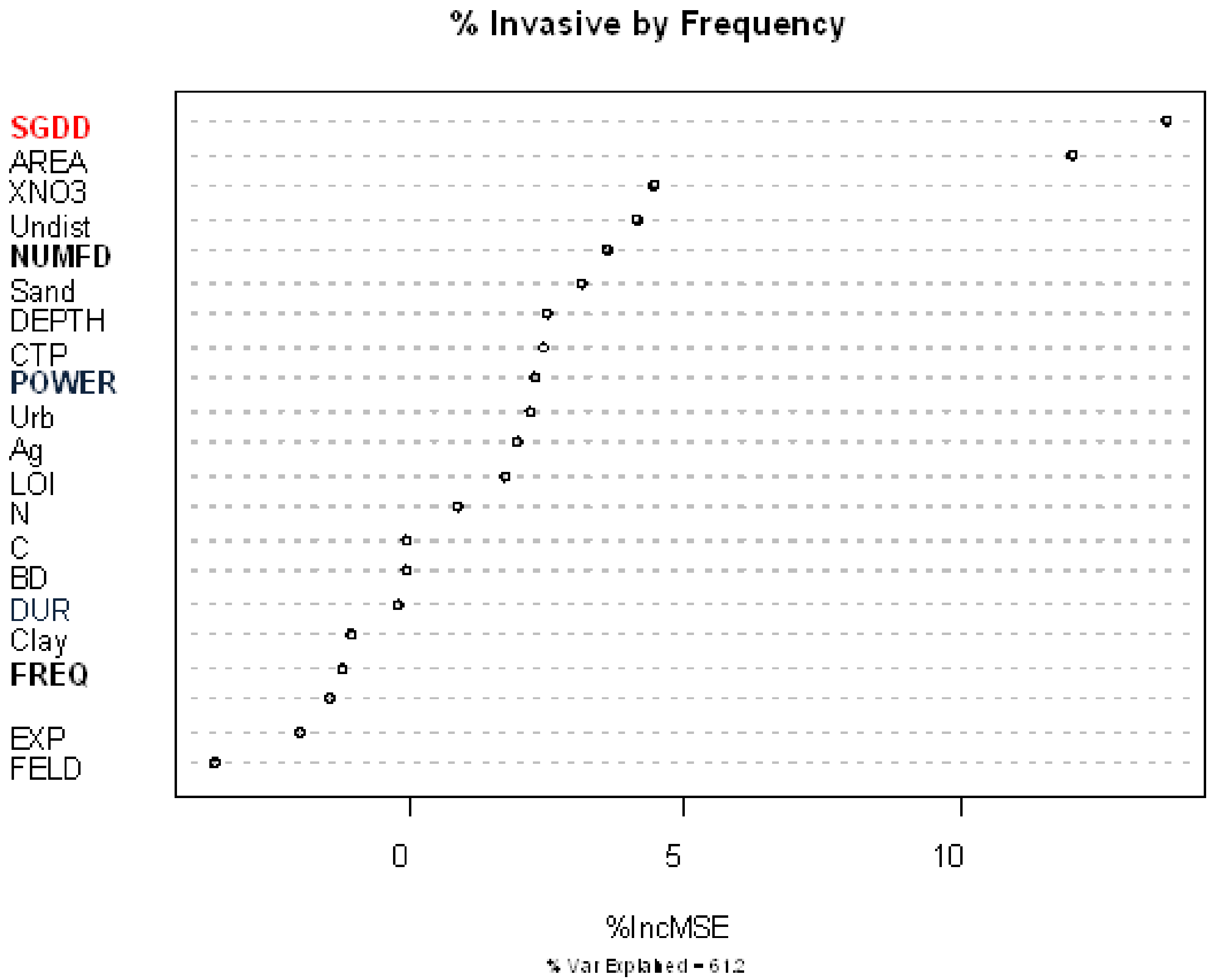
Random Forest Variable Importance

Species Richness

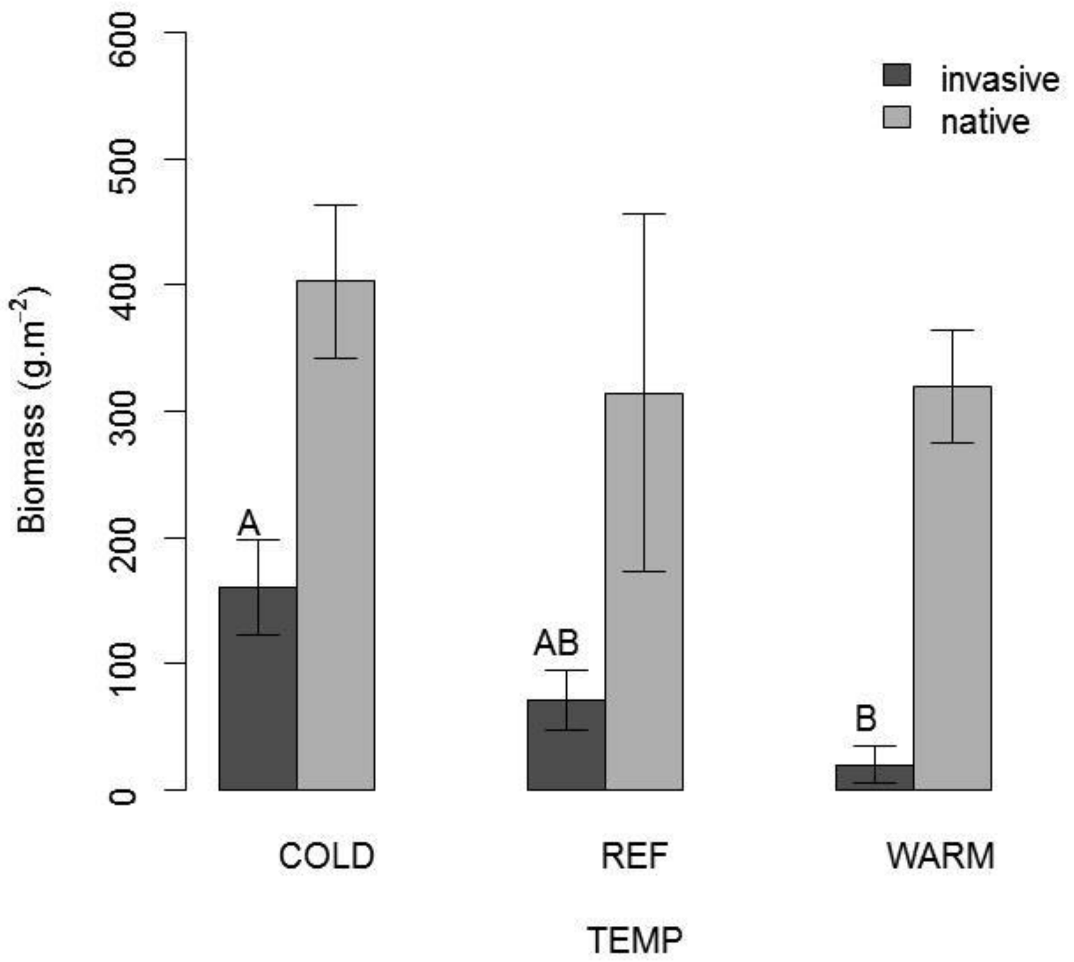


Random Forest Variable Importance

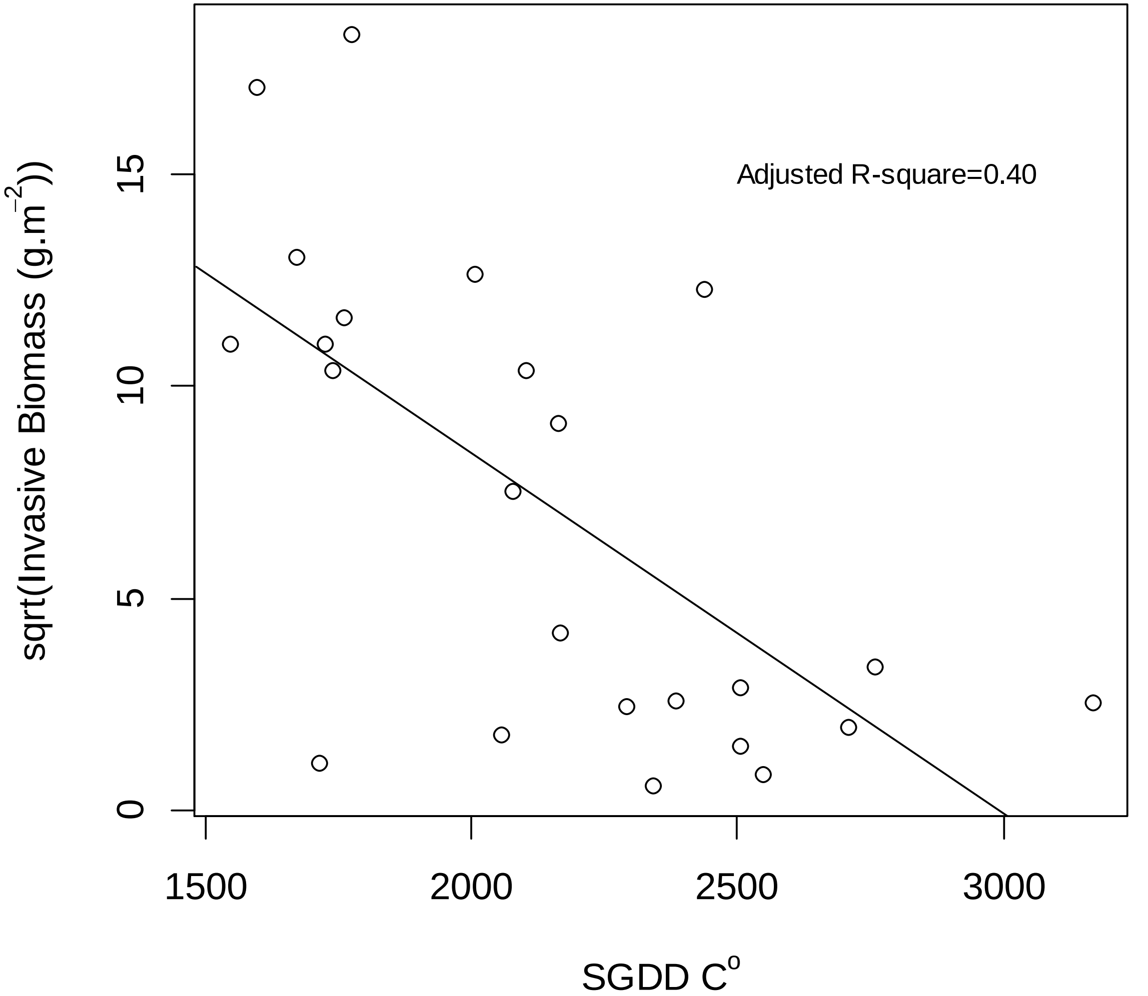
Degree of Invasion (% Non-Native Stems)



Dominance Measure- Biomass



Invasive Biomass v. SGDD all sites

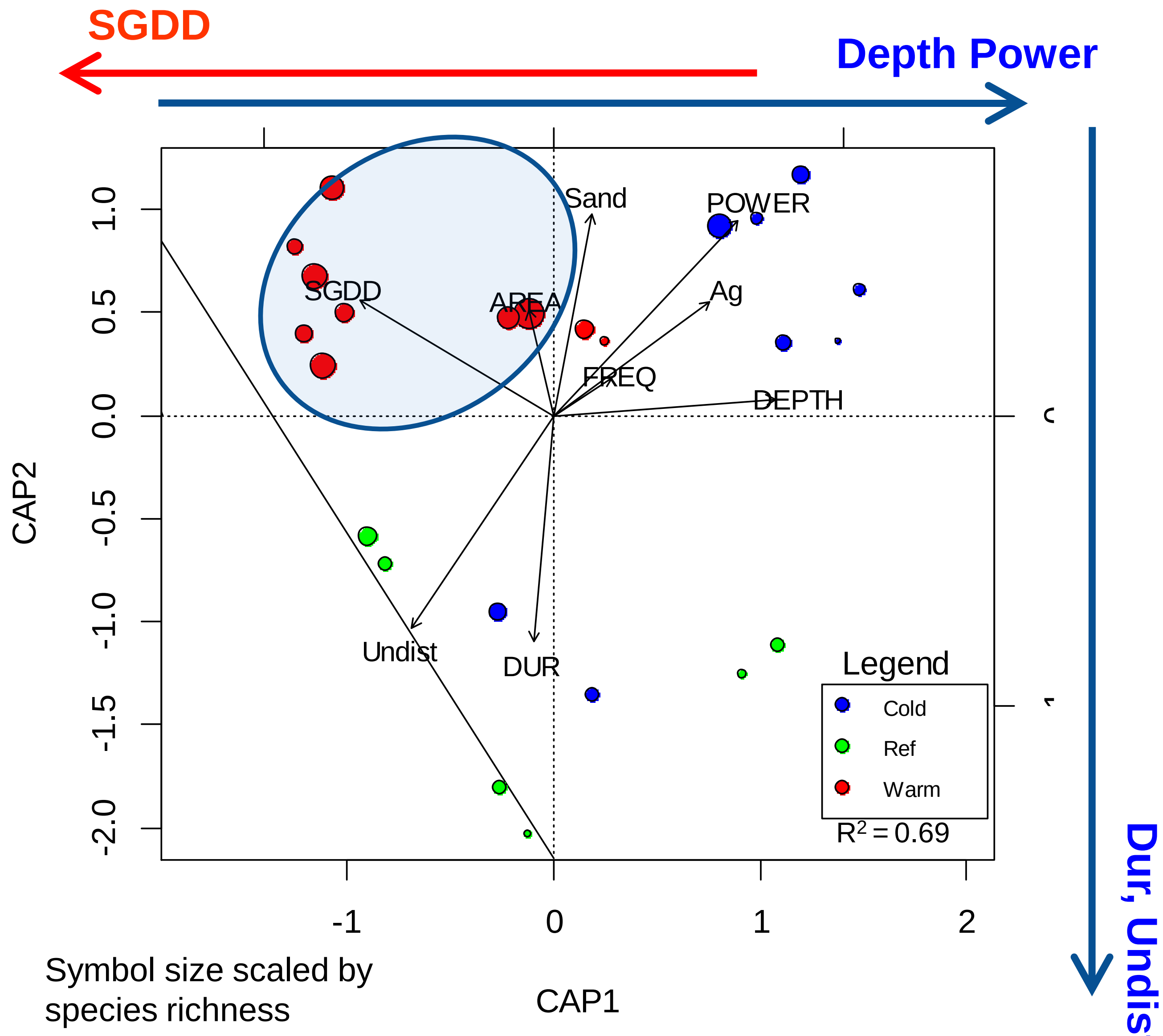


Ordination of Plant Community Data Beta Diversity

Permuted ANOVA of Fitted Distance Based RDA Model: -significant variables only

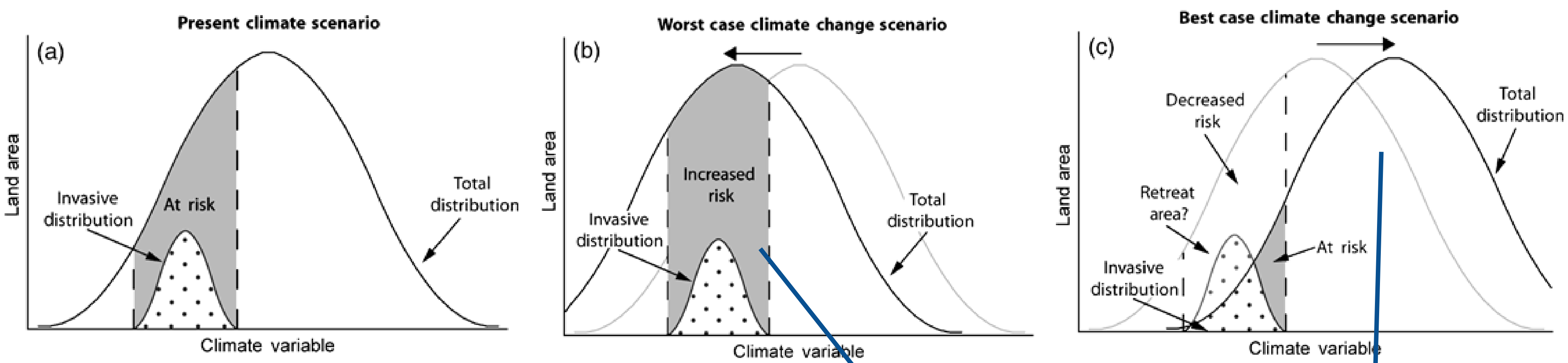
Variable	N	Var.	F	Pr>F	Signif.
POWER	1	2.353	6.400	0.001	***
SGDD	1	1.979	5.385	0.001	***
Ag	1	1.791	4.874	0.001	***
FREQ	1	1.106	3.010	0.001	***
AREA	1	1.002	2.727	0.001	***
Undist	1	0.936	2.547	0.002	**
DUR	1	0.907	2.466	0.001	***
DEPTH	1	0.721	1.963	0.008	**
Sand	1	0.589	1.602	0.049	*
Residual	14	5.146			

Distance Based RDA -CAPSCALE



Symbol size scaled by species richness

Climate change and plant invasions: envelope models



SGDD

Cold Sites

Warm Sites

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Summary

- ↑ Temperature scenario associated with;
  - ↑ diversity, species richness
  - ↓ degree of invasion
  - ↓ Invasive biomass
- ↑ Flooding associated with;
  - ↓ diversity (Power, Duration)
  - ↑ degree invasion (Number Floods)
- Outcome of climate change will depend on tradeoff of hydrology , temperature, and movement of invasive propagules

Conclusions

- Temperature and hydrology were significant predictors of invasive species
  - Cold sites- create bioclimatic envelopes that favor temperate invaders from cooler headwater (mountain) climates
  - Warm Sites-increased temperature could also create envelopes for warm climate invaders from coastal plains,
    - inhibited upstream invasive propagule movement may reduce envelope utilization
  - Increased flood power may disturb native communities making them more vulnerable to invasion, and aid in invasive propagule distribution

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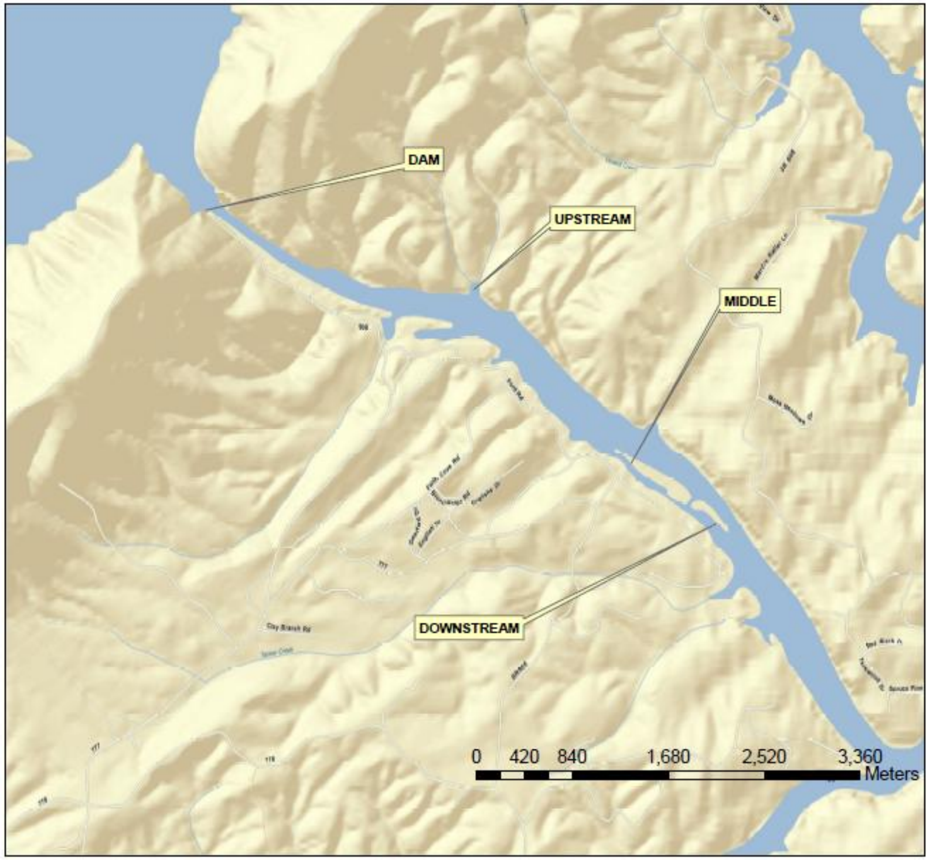
GRADIENT SITES



Three sites with similar

- Soils,
- Hydrology
- Propagule source
- Tempurature gradient toward ambient with movement away from dam

SGDD – Gradient Sites