Southeast Wetland Monitoring and Assessment Intensification Study with North Carolina, South Carolina, Alabama, and Georgia

Rick Savage, Kristie Gianopulos, and James Graham
North Carolina Department of Environment and Natural Resources
Division of Water Resources

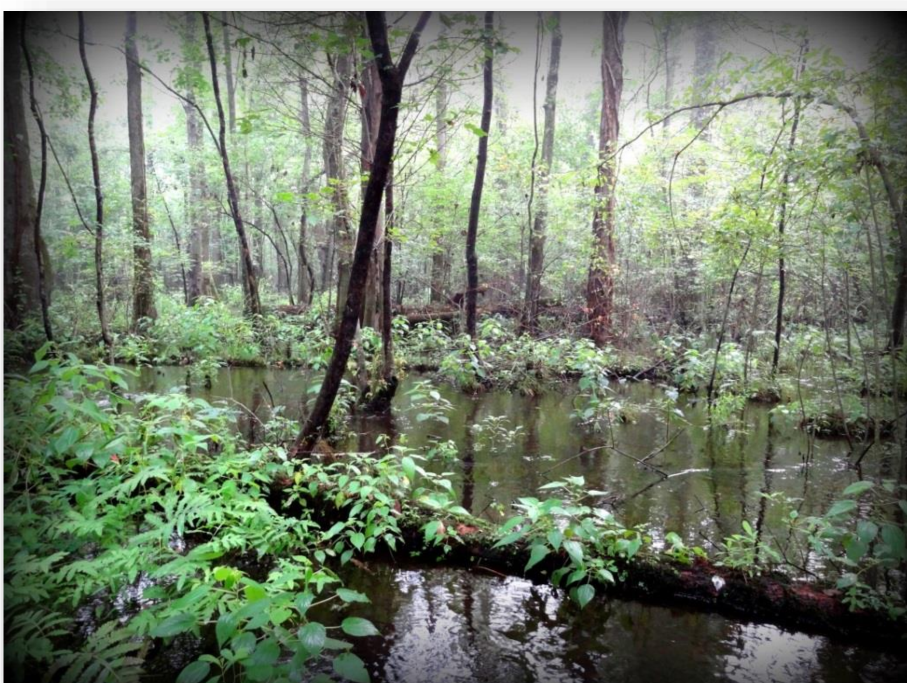
Breda Munoz
RTI International

Rusty Wenerick
South Carolina Department Health and Environmental Control
Bureau of Water

Gina Curvin
Alabama Department of Environmental Management
Field Operations Division, Aquatic Assessment Unit

Brandon Moody
Georgia Department of Natural Resources
Environmental Protection Division

Report Submitted to EPA Region IV -- July 2015



Acknowledgements

The project team would like to acknowledge EPA Region 4, EPA Headquarters, and EPA Corvallis for their support of this grant. Specifically, from the EPA, Mike Scozzafava, Gregg Serenbetz, Diana Woods, Rhonda Evans, Rich Sumner, Mary Kentula, Teresa Magee, Dave Melgaard, and Regina Poeske were all extremely helpful during the phases of this project with their advice, guidance, support and excitement about what this project could accomplish.

From NC, the team would like to thank John Dorney and Lori Montgomery for their support and leadership though the various stages of this project. Also thanks go to Larry Eaton who helped with the macroinvertebrate ID's and with the development of some of the metrics used. It should be noted that James Graham, who lead the NC sampling effort, also lead the botany team, and Anthony Scarbraugh lead the soils/buffer team. Their very hard work and dedication resulted in the success of this project for NC. Michael Coleman was part of the soils/buffer team, helping in a general way and playing multiple roles during this project, also contributing to the success of this project. We would also like to thank the teams from AL, SC, and GA, and especially the team leaders, Rusty Wenerick (SC), Gina Curvin (AL), and Brandon Moody (GA). Without them this project would not have been possible.

From AL, Special thanks to:

Lisa Huff, Chief of Environmental Indicators Section
Fred Leslie, Branch Chief of Montgomery Field Operations
Steve Jenkins, Division Chief of ADEM Field Operations
Lance LeFleur, ADEM Director.

In addition to the team members listed below, SC would like to acknowledge the following individuals: Nydia Burdick for help writing the SC QAPP; Chris Cole, Christine Mills, Stacey Munn, and Justin Souther for assistance with analyzing water samples; and Dr. John Nelson from the USC Herbarium for assistance curating plant specimens and identifying unknowns.

Finally, Rick would like to acknowledge Ginny Baker and Kristie Gianopulos. Ginny and I have been involved in the wetlands monitoring in NC for over ten years and Ginny's contribution has always been critical to all of our wetland projects. As far as I am concerned, this program probably would not be here if it were not for Ginny. Kristie has saved the day for me and others several times. Her talents in the office and in the field have been critical at just the right time. It is not uncommon for us to say "Kristie found that problem and is correcting it now". Also, Rusty Wenerick did an amazingly through review of this document – thanks so much Rusty! HOWEVER, any errors in this report are mine and mine alone!

Project Lead

Rick Savage

North Carolina Team

James Graham, lead
Anthony Scarbraugh
Michael Coleman
Gregory Rubino
Kristie Gianopulos
Virginia Baker
Amanda Johnson
Joe Gryzb
Rick Savage

South Carolina Team

Rusty Wenerick, lead
Scott Castleberry
Will Dillman
David Eargle
Emily Hollingsworth
Justin Lewandowski
Erin Owen
Jeff Schrag

Alabama Team

Gina Curvin, lead
Bonnie Coleman
Hugh Cox
Ashley Lockwood
Preston Roberts
Rebekah Moore
Ruth Perez
Ron Sparks
Brien Diggs
Aaron Goar

Georgia Team

Brandon Moody, lead
Danielle Floyd
Mike Weaver
Mark Ibbetson
Ryan Dent

Table of Contents

Acknowledgements …… 2

List of Figures …… 7

List of Tables …… 11

Executive Summary …… 16

Introduction and Grant Objectives …… 17

Riverine Swamp Forest and Bottomland Hardwood Forests: Introduction and Background .18

Wetland Site Selection and Assessment Area …… 23

Site Descriptions …… 24

Site Descriptions: North Carolina …… 24

Site Descriptions: South Carolina …… 29

Site Descriptions: Alabama …… 37

Site Descriptions: Georgia …… 41

NWCA 2011 sites …… 56

Sampling and Analysis Methodology …… 56

Level I: GIS Assessment …… 56

Level II: Rapid Assessment …… 57

North Carolina Wetland Assessment Method (NCWAM) …… 57

Ohio Rapid Assessment Method (ORAM) …… 58

USA-Rapid Assessment Method (USA-RAM) …… 59

Level III: Intensive Survey Methodology …… 59

Vegetation Data Collection …… 61

Amphibian Field Monitoring …… 62

Macroinvertebrate Field Monitoring …… 64

Soil Sampling …… 65

Monitoring Hydrology Wells and Transductors …… 66

Water Quality Sampling …… 67

Data Analysis Methods and Procedures …… 70

USA-RAM Scoring Procedure …… 70

Vegetation Data Analysis 72
Plant Metrics 74
Amphibian Data Analysis 79
Aquatic Macroinvertebrate Data Analysis and IBI Development 80
Data Analysis with Biotic and Abiotic Parameters 82
Results and Discussion 83
LDI – Landscape Development Intensity Index Results and Discussion 83
Rapid Assessment Results and Discussion 88
Hydrology Results 98
North Carolina hydrology results 98
South Carolina hydrology results 98
Alabama hydrology results 99
Georgia hydrology results 99
Soil Analysis Results 100
Water Quality Results 111
Vegetation Results 118
Vegetation Index of Biological Integrity 118
Vegetation Results 134
Floristic Quality Analysis 134
Nativity Analysis 143
Cover and Count Analysis 147
Amphibian Survey Results 155
Macroinvertebrate Results 170
Correlational Analysis 183
Exploratory Regression Analysis 192
Extent of Stressors on Wetlands and Extent of Wetland Condition 199
The Relative Risk of Stressors on Wetland Condition 219
Regional Wetland Condition 230
Conclusion 249

Literature cited and other relevant literature …………………………………………………………… 250

Appendix A: Hydrography ………………………………………………………………………………………………. 262

A1: Hydrographs for NC BLH sites ………………………………………………………………………. 263

A2: Hydrographs for NC RSF sites ………………………………………………………………………. 273

A3: Hydrographs for SC RSF sties ………………………………………………………………………. 283

A4: Hydrographs for AL RSF sites ………………………………………………………………………. 293

A5: Hydrographs for GA BLH sites ………………………………………………………………………. 303

A6: Hydrographs for GA RSF sties ………………………………………………………………………. 317

Appendix B: Site Maps ……………………………………………………………………………………………… zipped files

B1: Site Maps for Alabama ……………………………………………………………………………… AL Site Maps

B2: Watershed Maps for Alabama ……………………………………………………………….. AL Watershed Maps

B3: Site Maps for Georgia ……………………………………………………………………………… GA Site Maps

B4: Site Maps for North Carolina ……………………………………………………………………… NC Site Maps

B5: Watershed Maps for North Carolina ……………………………………………………….. NC Watershed Maps

B6: Site Maps for South Carolina ……………………………………………………………………….. SC Site Maps

B7: Watershed Maps for South Carolina ……………………………………………………….. SC Watershed Maps

List of Figures

Figure 1: Wetland site locations for Southeast region intensification project ………………………………… 24

Figure 2: Diagram of Standard plot set up with soil pit and water quality sampling stations .. 69

Figure 3: Results showing USA-RAM scoring method discriminating between most and least disturbed condition by wetland type …………………………………………………………………………………………………… 72

Figure 4: Percent area impacted by human activities vs. natural land for 300m buffer and for wetland watersheds (up to 20 sq. miles upstream from AA) ………………………………………………………………… 84

Figure 5: Mean 300-m Landscape Development Intensity Index values by state and wetland type …. 86

Figure 6: Mean 300-m Landscape Development Intensity Index values by wetland type for the Southeast region …… 86

Figure 7: Mean watershed Landscape Development Intensity Index values by state and wetland type 87

Figure 8: Mean watershed Landscape Development Intensity Index values by wetland type for the Southeast region …… 88

Figure 9: ORAM scores by state and wetland type ………………………………………………………………… 89

Figure 10: ORAM scores by wetland type for the four-state region ……………………………………………… 90

Figure 11: NCWAM scores for each state by wetland type (BLH ratings are on the left and RSF ratings are on the right) ……… 91

Figure 12: NCWAM scores for the four-state region by wetland type ……………………………………………… 92

Figure 13: USA-RAM scores by wetland type and by state ………………………………………………………… 93

Figure 14: USA-RAM scores for the four-state region by wetland type …………………………………………… 93

Figure 15: Total number of stressors present in AA buffer plots (mean of plots by site) ………………… 94

Figure 16: Total mean number of stressors in AA buffer – four-state region ………………………………… 94

Figure 17: Buffer strata by state for BLH wetlands, with 0 = Absent, 1 = Sparse (<10%), 2 = Moderate (10-40%), 3 = Heavy (40-75%), 4 = Very Heavy (>75%) …………………………………………………………… 95

Figure 18: Buffer strata by state for RSF wetlands, with 0 = Absent, 1 = Sparse (<10%), 2 = Moderate (10-40%), 3 = Heavy (40-75%), 4 = Very Heavy (>75%) ……………………………………………………………… 96

Figure 19: Cumulative soil metal levels (total mean mg/kg) for BLH and RSF wetlands …………………. 102

Figure 20: Box plots of mean magnesium and manganese soil levels in BLH and RSF wetlands ………. 103

Figure 21: Cumulative soil levels for selected nutrients (total mean mg/kg) in BLH and RSF wetlands. 104

Figure 22: Box plot of calcium soil levels in BLH and RSF wetlands in the Southeast. Calcium was not included in the previous graph because of scale 105

Figure 23: Percent of BLH sites with soil pits that had surface water, saturated soil, and/or groundwater in soil pits 106

Figure 24: Percent of RSF sites with soil pits that had surface water, saturated soil, and/or groundwater in soil pits 107

Figure 25: Surface water depth at soil pits on BLH and RSF wetland sites in the southeast region, where surface water was present 108

Figure 26: Depth to saturated soil and depth to groundwater in soil pits on BLH and RSF wetland sites, where saturated soil and/or groundwater were present. Note the y-axis is inverted 108

Figure 27: Percent of BLH sites (42) with soil pits that indicated the presence or absence of sandy soil, loamy/clayey soil, mucky mineral and mucky peat 109

Figure 28: Percent of RSF sites (68) with soil pits that indicated the presence or absences of sandy soil, loamy/clayey soil, mucky mineral and mucky peat 110

Figure 29: Percent change in mean of various biological water quality parameters from upstream water sampling points to downstream water sampling points in RSF wetlands 113

Figure 30: Percent change in mean of various chemical and physical water quality parameters from upstream water sampling points to downstream water sampling points in RSF wetlands 114

Figure 31: Comparison of mean water quality nutrients levels in BLH wetlands (NC and GA) 115

Figure 32: Comparison of mean water quality nutrients levels in RSF wetland sites 116

Figure 33: Occurrence of metals (copper, lead, magnesium, and zinc) in water samples from BLH and RSF wetland sites 109

Figure 34: Discrimination between least and most impaired BLH sites by the FQAI Cover metric (ANOVA p = 0.017) 123

Figure 35: Discrimination between least and most impaired BLH sites by the FQAI Cover metric when scored on a 1,3,5 point scale (ANOVA p = 0.0089) 124

Figure 36: Discrimination between least and most impaired RSF sites by the RSF Veg IBI (ANOVA p = 0.0002) 124

Figure 37: Distribution of BLH FQAI Cover values by state 125

Figure 38: Box plot summary of BLH FQAI Cover metric values and FQAI Cover scores by state 126

Figure 39: Metric Breakdown of North Carolina RSF VegIBI Results 129

Figure 40: Metric Breakdown of South Carolina RSF VegIBI Results …… 129

Figure 41: Metric Breakdown of Alabama RSF VegIBI Results …… 130

Figure 42: Metric Breakdown of Georgia RSF Veg IBI Results …… 130

Figure 43: Box plot summary of RSF Veg IBI values by state …… 131

Figure 44: Distribution of the frequency of C values (in percentage of total occurrences) for plant species for all BLH wetlands combined …… 136

Figure 45: Distribution of the frequency of C values (in percentage of total occurrences) for plant species for all RSF wetlands combined …… 137

Figure 46: Box plot of mean C (all species) values for BLH wetlands by state …… 138

Figure 47: Box plot of mean C (all species) values for RSF wetlands by state …… 139

Figure 48: Boxplots for FQAI Count (standard FQAI formula) and FQAI Cover (incorporates cover data) for BLH wetlands by state …… 140

Figure 49: Boxplots for FQAI Count (standard FQAI formula) and FQAI Cover (incorporates cover data) for RSF wetlands by state …… 141

Figure 50: Relative percent cover of tolerant plant species (C value < 4) and sensitive plant species (C value ≥ 7) in BLH wetlands by state. Sample size for SC is 3 sites …… 142

Figure 51: Relative percent cover of tolerant plant species (C value < 4) and sensitive plant species (C value ≥ 7) in RSF wetlands by state …… 142

Figure 52: Percentage of BLH wetland sites in each category of the Nonnative Plant Stressor Indicator for North Carolina and Georgia …… 144

Figure 53: Percentage of RSF wetland sites in each category of the Nonnative Plant Stressor Indicator by state …… 145

Figure 54: Relative importance of nonnatives in BLH wetlands. SC was excluded because sample size was too small (3 NWCA sites) …… 145

Figure 55: Relative importance of nonnatives in RSF wetlands …… 146

Figure 56: Relative percent cover by growth form for all BLH wetlands combined …… 150

Figure 57: Relative percent cover by growth form for all RSF wetlands combined …… 150

Figure 58: Relative percent cover by growth form for BLH wetlands in NC, SC, and GA …… 151

Figure 59: Relative percent cover by growth form for RSF wetlands in NC, SC, and GA …… 151

Figure 60: Simpson's Diversity index for native plant species on BLH wetlands ……………………………… 152

Figure 61: Simpson's Diversity index for native plant species on RSF wetlands ……………………………….. 152

Figure 62: Dominance index for plant species on BLH wetlands ……………………………………………………… 153

Figure 63: Dominance index for plant species on RSF wetlands …………………………………………………….. 153

Figure 64: Mean counts of trees of various sizes per BLH site across the region ……………………………. 154

Figure 65: Mean counts of trees of various sizes per RSF site across the region …………………………… 155

Figure 66: Box plot of Amphibian Quality Assessment Index (AQAI) values for all sites surveyed by state and wetland type …… 156

Figure 67: Box plot of Amphibian Quality Assessment Index (AQAI) values by wetland type for the four-state region ……… 157

Figure 68: Box plots of percentage of amphibian species within each site that were considered sensitive, facultative, or tolerant species for each state ………………………………………………………………………. 158

Figure 69: Box plot of relative abundance of tolerant, facultative, and sensitive amphibian species across the southeast region ……….. 160

Figure 70: Box plot of number of adult (and adult equivalent) amphibians observed in BLH and RSF wetlands by state …… 161

Figure 71: Percent Urodele (salamander) species and relative abundance of salamanders on BLH and RSF wetlands across the southeast ……………………………………………………………………………………… 161

Figure 72: Distribution of number of adults (and adult equivalent) individuals observed in BLH wetlands in the southeast region …………………………………………………………………………………………………… 162

Figure 73: Distribution of number of individuals (or adult equivalents) observed by species in RSF wetlands across the southeast region …………………………………………………………………………………… 165

Figure 74: Macroinvertebrate species richness in BLH and RSF wetlands for the southeast region and by state ……….. 170

Figure 75: Number of macroinvertebrate individuals observed in BLH and RSF wetlands for the southeast region and by state ……………………………………………………………………………………………… 171

Figure 76: Macroinvertebrate Biotic Index (MBI) by wetland type for the southeast region ……………. 172

Figure 77: Simpson's Diversity Index values for macroinvertebrates in BLH and RSF wetlands in the southeast region ……… 173

Figure 78: Percent of macroinvertebrate species which were sensitive, facultative, and tolerant on BLH and RSF wetlands in the southeast region …… 174

Figure 79: Relative abundance of sensitive, facultative, and tolerant species on BLH and RSF wetlands in the southeast region and by state …… 175

Figure 80: Estimated extent of stressors in North Carolina …… 201

Figure 81: Estimated extent of stressors for South Carolina …… 202

Figure 82: Estimated extent of stressors for Alabama …… 203

Figure 83: Estimated extent of stressors for Georgia …… 204

Figure 84: Estimated extent of condition for North Carolina …… 207

Figure 85: Estimated extent of condition for South Carolina …… 208

Figure 86: Estimated extent of condition for Alabama …… 209

Figure 87: Estimated extent of condition for Georgia …… 210

Figure 88: Estimated extent of the stressors for BLH wetlands in the SE region …… 212

Figure 89: Estimated extent of the stressors for RSF wetlands in the SE region …… 213

Figure 90: Estimated extent of the condition for BLH wetlands in the SE region …… 214

Figure 91: Estimated extent of the condition for RSF wetlands in the SE region …… 215

Figure 92: Estimated extent of stressors on wetlands in the SE region …… 217

Figure 93: Estimated extent of condition on wetlands in the SE region …… 218

Figure 94: Relative Risk of Poor Amphibian Quality Index for each Stressor ……221

Figure 95: Relative Risk of Poor Macroinvertebrate Biotic Index for each Stressor ……222

Figure 96: Relative Risk of Poor Macroinvertebrate Dominance for each Stressor …… 223

Figure 97: Relative Risk of Poor Macroinvertebrate Percent Sensitive for each Stressor …… 224

Figure 98: Relative Risk of Poor Macroinvertebrate Species Richness for each Stressor …… 225

Figure 99: Relative Risk of Poor Vegetation FQAI for each Stressor …… 227

Figure 100: Relative Risk of Poor Vegetation Mean C for all Species for each Stressor …… 228

Figure 101: Relative Risk of Poor Vegetation of Native Vascular Species Richness for each Strssor .. 229

Figure 102: Wetland condition based on LDI scores using 300 meters as the buffer ……………………… 232

Figure 103: Wetland condition based on LDI scores using the wetlands' watersheds ……………………. 233

Figure 104: Wetland condition based on ORAM scores ………………………………………………………………… 234

Figure 105: Wetland condition (functional value) based on NCWAM scores …………………………………. 235

Figure 106: Wetland condition based on USA-RAM scores …………………………………………………………. 236

Figure 107: Wetland condition based on the vegetation index of biological integrity ……………………. 237

Figure 108: Wetland condition based on Amphibian AQAI scores ………………………………………………... 238

Figure 109: Wetland condition base on Macroinvertebrate diversity …………………………………………… 239

Figure 110: Wetland Condition based on Macroinvertebrate Biotic Index (MBI)……………………………. 240

Figure 111: Composite rank map for the Southeast region …………………………………………………………… 242

Figure 112: Composite rank map for wetland sites in North Carolina …………………………………………… 243

Figure 113: Composite rank map for wetland sites in South Carolina ……………………………………………..244

Figure 114: Composite rank map for wetland sites in Alabama ………………………………………………………..245

Figure 115: Composite rank map for wetland sites in Georgia ………………………………………………… 246

Figure 116: Composite rank of sites by state and wetland type …………………………………………………… 247

List of Tables

Table 1: Wetland Land Cover Type and Index Values 57

Table 1: Field measurement methods: vegetation 62

Table 2: Field measurement methods: soils 66

Table 4: Scoring method for each metric of USA-RAM 70

Table 5: Correlations with Disturbance measures with USA-RAM scoring method 71

Table 6: Floristic Quality Assessment Index Coefficient of Conservation Value Assignments 73

Table 7: List of candidate metrics used to calculate the vegetation IBI 78

Table 8: Candidate macroinvertebrate metrics with expected response to disturbance measures ... 80

Table 9: Total square miles of land use/cover analyzed and percent natural vs. impacted by human activities 84

Table 10: Type of land use/cover in 300m buffer around AA and in watershed (up to 20 sq. miles upstream from AA) 85

Table 11: Chemical and physical characteristics of soil samples on BLH and RSF wetland sites in the Southeast region 101

Table 12: Mean upstream and downstream water quality parameters per site in BLH and RSF wetlands in the southeast region 112

Table 13: Mean of water quality parameters values per site in BLH and RSF wetlands in the southeast region 117

Table 14: Metric Selection Results for BLH Wetlands Veg IBI 120

Table 15: Metric Selection Results for RSF Wetlands Veg IBI 121

Table 16: Scores assigned to FQAI Cover values 122

Table 17: Scores assigned to metrics in the RSF Veg IBI 122

Table 18: BLH FQAI Cover metric values by site and state. Site prefix "SE" represents Intensification study sites, and "US" represents NWCA sites 127

Table 19: RSF Veg IBI component metric scores, total scores, and condition by site and state. Site prefix "SE" represents Intensification study sites, and "US" represents NWCA sites 132

Table 20: Highest C value (8-10) plant species found on BLH and RSF sites in the Southeast region . 135

Table 21: Number of BLH and RSF sites in the Low, Medium, High, and Very High category for the Nonnative Plant Stressor Indicator developed by the EPA 144

Table 22: Number of sites out of the 43 BLH sites on which given species was in the top 5 dominant species (by total percent cover) 148

Table 23: Number of sites out of the 71 RSF sites on which species was in the top 5 dominant species (by percent cover) 149

Table 24: Weighted mean AQAI values for BLH and RSF wetlands by state 156

Table 25: Total number of individuals within each genus observed in BLH wetlands in the southeast region 163

Table 26: Amphibian species utilization (count of occurrences) in BLH wetlands in the southeast region 163

Table 27: Total number of individuals within each genus observed in RSF wetlands in the southeast region 165

Table 28: Amphibian species utilization (count of occurrences) in RSF wetlands in the southeast region 166

Table 29: Amphibian Coefficient of Conservatism Ratings and Adult Conversion Table 167

Table 30: Macroinvertebrate species observed in BLH Wetlands in the Southeast 176

Table 31: Macroinvertebrate species observed in RSF wetlands in the southeast region 177

Table 32: Correlation coefficients of LDI, USARAM, ORAM, and NCWAM with selected variables or metrics for BLH wetlands 185

Table 33: Correlation coefficients of LDI, USARAM, ORAM, and NCWAM with selected variables or metrics for RSF wetlands 187

Table 34: Correlation coefficients of AQAI, MBI, and VegIBI with selected soil and water quality variables or metrics for BLH wetlands 189

Table 35: Correlation coefficients of AQAI, MBI, and VegIBI with selected soil and water quality variables or metrics for RSF wetlands 191

Table 36: Results of regression analysis used to discover which variables predicted various RAM scores 193

Table37: Regression results for LDI (300m) – list of variables that LDI successfully predicted, with at least one model 194

Table 38: Regression results for NCWAM – list of variables that NCWAM successfully predicted, using at least one model 195

Table 39: Regression results for USARAM – list of variables that USARAM successfully predicted based on the Generalized Linear Model 197

Table 40**:** Regression results for ORAM – list of variables that ORAM successfully predicted based on the Generalized Linear Model 198

Executive Summary

This project was an extension of the EPA's 2011 National Wetland Condition Assessment (NWCA), and was conducted in 2012. North Carolina, South Carolina, and Alabama were awarded an Intensification grant from the EPA to perform a regional wetland assessment that would add to the EPA's NWCA, but at a regional level, not just a state level. Georgia also participated in this project, but were funded by a different EPA grant.

The wetland assessment consisted of surveying 45 wetlands in ecoregion 45 (Peidmont, 15 for Georgia and 10 for the three states) and 45 wetlands in ecoregion 65 (Southeastern coastal plains, 15 for Georgia and 10 for the three states). The wetlands were of a specific type (forested wetlands), bottomland hardwood forest wetlands in ecoregion 45 and riverine swamp forest wetlands in ecoregion 65 in order to reduce some of the variance in the biotic measurements. The basis of this project was to use the same survey/sampling methods from the EPA's National Wetlands Condition Assessment effort with some additional methods that have been used in NC's wetlands monitoring programs for several years such as sampling for amphibians and macroinvertebrates, taking water quality samples over time, and monitoring the hydrology.

Measured indicators of wetland condition individually showed different resuts as some indicators can show good wetland condition while others can show poor wetland condition. This is not necessarily bad in that different stressors act on wetlands and will have different affect on wetlands. What is good for vegetation may be bad for amphibians and water quality or what is good for macroinvertebrates may be bad for hydrology and so forth. By looking a multiple indicators specific wetland problems can be indentified and therefore specific solutions can be addressed, or not. The best management decisions can be made on data and specifically data which indicate specific wetland conditions.

Results are presented at the landscape level (Land Development Index) and at the rapid assessment level (Ohio Rapid Assessment, NC Wetland Assessment, and USA-Rapid Assessment). Intensive survey results are presented for vegetation, amphibians, macroinvertebrates, as well as for hydrology and soil. Some of the results are presented in terms of Relative Risk and Relative Extent which shows how different stressors affect wetland condition and their probabilities of have these affects.

The results of this project show wetlands in the Southeast region to be in relatively good condition. Some trends are noted such as the bottomland hardwood forest wetlands in the Piedmond ecoregion tend to be more stressed/disturbed than the riverine swamp forest in the Southeast Coastal Plains ecoregion. If is felt that these differences are due to the recoregion differences rather thand the fact they are different types of forested wetlands. Furthermore, of the four states, NC's riverine swamp forest are dealing with more stressors, probably due to the hog, chicken, and turkey farms that near several of the sites, especially in Duplin County. A significant result was the improvement of water quality samples as water moved from upstream to downstream in riverine swamp forest wetlands.

INTRODUCTION AND GRANT OBJECTIVES

The Southeastern United States is rich in wetland acreage, especially in the Coastal Plain (Ecoregions 63 and 65; Omernik 1987) where about 80-90% of these wetlands occur. The Piedmont region (Ecoregion 45) has most of the rest of the region's wetlands acreage (with about 1% of the wetlands located in the Mountain region, Mitsch and Gosselink, 2000). While the value and ecosystem services provided by wetlands in the Coastal Plain are generally accepted, the value and ecosystem services of wetlands in the Piedmont region have often been overlooked or even ignored. This project provided an opportunity to not only extend the wetlands data collected by the National Wetland Condition Assessment (NWCA, coordinated by the US Environmental Protection Agency (EPA) in 2011), but provide critical data on the value of wetlands in the Piedmont region of the Southeast as well as surveying additional wetlands in the outer Coastal Plain (Ecoregion 65).

This project was the result of an "intensification" grant awarded by the EPA as part of the Wetlands Program Development grant program. Part of the funding came from the EPA headquarters, which coordinated the NWCA, and subsequently funded additional wetland data collection to augment the NWCA. The purpose of the intensification grants was to extend the national survey by allowing states to survey more wetlands from the same population of wetlands selected for the national survey and to use the same survey methodology. The data collected by the intensification grant could therefore be added to the national database of wetland condition and be included in future reports by the EPA.

This grant for this project was awarded to North Carolina Division of Water Resources (NCDWR, formerly the Division of Water Quality) to fund and work with South Carolina (SC) and Alabama (AL) so a regional analysis of wetland condition could be performed. Georgia (GA) joined the effort, but with separate funding. The basis of this project was to use the same survey/sampling methods from the NWCA effort with some additional methods that have been used in NC's wetlands monitoring programs for several years (see Baker et al. 2008 and Savage et al. 2010). These additional methods involved surveying amphibian and macroinvertebrate populations, monitoring wetland hydrology, and using the rapid assessment methods of NC (NC Wetland Assessment Method – NCWAM) and Ohio (Ohio Rapid Assessment Method - ORAM). Land Development Intensity Index (LDI, see Brown and Vivas, 2003) scores were also calculated. This analysis of wetland condition for the Southeast includes data from NC, SC, GA, and AL as well as data from the NWCA for the Southeast region, providing a unique opportunity to assess the condition of Southeast region wetlands.

The overall objectives of this project were to:

- Perform a comprehensive intensification survey/assessment of randomly selected wetlands in the Coastal Plain and Piedmont of NC, SC, AL, and GA,
- To provide data that will indicate wetland condition by state,

- Perform a regional analysis of the data to make statements on the condition of forested wetlands in the Southeast region,
- Look at stressor data in terms of their relative risk,
- Provide additional wetland data for the NWCA effort,
- Expand the NWCA methods with additional survey/monitoring methods used in NC such as monitoring hydrology and surveying amphibians and macroinvertebrates, and

The study area for this grant was in ecoregions 45 (Piedmont) and 65 (Southeasten (Coastal) Plains) of NC, SC, AL, and GA.

Riverine Swamp Forests and Bottomland Hardwood Forests: Introduction and Background

Bottomland Hardwood Forest (BLH) wetlands and Riverine Swamp Forest (RSF) wetlands occur in extensive mosaics along rivers and streams of the Southeast. While most of the following discussion about RSF and BLH wetlands applies across the Southeast, there are always exceptions. Riverine Swamp Forests are more common in the Coastal Plain, and occupy many positions in the landscape; stream headwaters, saturated areas along large rivers, floodplains, fresh- and brackish-water tidal forests, and large lakes where enough wind fetch occurs to produce wind tides that effectively function as overbank flooding (generally larger than 20 acres). Riverine Swamp Forests can also be created or augmented by beaver impoundments in the Coastal Plain and Piedmont ecoregions.

Both riverine and bottomland systems receive inputs from overbank flooding, groundwater, and surface runoff, but the frequency and amount of these inputs is higher in RSF wetlands, resulting in seasonal or semi-permanent inundation. Bottomland Hardwood Forest wetlands are common on the floodplains of second-order and larger streams and rivers throughout the Southeast and are usually intermittently to seasonally inundated (NCWAM User Manual 2010). It is possible to progress from a BLH downslope to a RSF, or to have only one type present. If both types are present, differences in topographic relief and hydrology can cause the borders of the two systems to undulate and intersperse.

In second or higher order streams, local hydrology and sedimentation are important factors in determining the presence of RSF or BLH wetlands in a given area. These factors influence plant community type and inundation period which in turn define wetland type. Flow regime plays an important part in nutrient and sediment inputs, which also in turn affect plant community type (Hodges 1997). Soils in RSFs are both organic and mineral, while BLH soils tend to be mineral only. Riverine Swamp Forests in the Piedmont and Blue Ridge regions are characterized by a canopy of overcup oak (*Quercus lyrata*), ashes (*Fraxinus* spp.), and American Elm (*Ulmus americana*) while the Coastal Plain canopy is dominated by bald-cypress (*Taxodium ascendens*) and/or pond-cypress (*Taxodium distichum*), and water tupelo (*Nyssa biflora*). The herbaceous layer ranges from nearly absent to moderate but is almost always obligate (Schafale and

Weakley 1990). In BLH wetlands, canopy tree species consist of hardwoods such as oaks (*Quercus* spp.), red maple (*Acer rubrum*), ashes (*Fraxinus* spp.), and other hardwoods (NC Wetland Assessment Method User Manual 2010). The herbaceous layer in RSFs is composed of sparse to moderately dispersed native herbs such as false-nettle (*Boehmeria cylindrica*), sedges of the genus *Carex*, river oats (*Chasmanthium latifolium*). The herbaceous layer in RSF wetlands are often suppressed by exotic invasive plant species such as Japanese stiltgrass (*Microstegium vimineum*) and Japanese honeysuckle (*Lonicera japonica*), particularly in the Piedmont and mountains (Schafale and Weakley 1990). The role of sediment and organic debris inputs and deposition on species distribution will be discussed in more detail below.

Though patterns of flooding and inundation differ between BLHs and RSFs, their formation is due to many of the same processes. Common landscape features found in southeastern floodplains include meandering river channels, oxbow lakes created when river meanders change course, natural levees, and areas of ponded water inside meanders called sloughs. Oxbows and sloughs, because of their increased water retention, are likely sites for the formation of bald cypress-tupelo RSFs in the Coastal Plain (Mitsch and Gosselink 2000). The levees and drier areas would be more likely to support BLHs or non-wetland vegetation. Sediment deposition during overbank flooding is greater on levees and swales, while the semi-permanently flooded RSFs receive less nutrient input. The same inundation pattern also leads to an accumulation of organic material in RSFs due to reduced decomposition and increased residence time. Bottomland Hardwood Forests on blackwater streams also receive less sediment and nutrients than their brownwater counterparts (NCWAM User Manual 2010). Brownwater streams that arise in uplands are high energy systems that often carry large sediment loads (Hupp 2000). Streams associated with these communities may be quite old, but the sediments deposited in these floodplains are of recent geologic origin, and consist of soil material derived from the Piedmont and mountains (Hodges 1997). Blackwater streams are generally low gradient and lack the energy for significant sediment transport (Hupp 2000).

Forested wetlands act as natural basins during heavy precipitation events. Excess rainwater from upland areas backs up into backwaters such as sloughs and oxbows and adjacent bottomlands, lessening the severity of downstream flooding as this water is slowly released downstream. In addition, this backwater flooding is often laden with pollution and nutrient-rich sediments, which are deposited in these bottomland and riverine basins far from stream and river channels, thus improving downstream water quality (Kellison and Young 1997). The pollution removing function (ecosystem service) of BLHs was quantified as a monetary value in a 1990 study of a BLH at present day Congaree National Park in central South Carolina. Researchers found that the pollutants removed by these wetlands were equivalent to the function of a $5 million wastewater treatment plant (USEPA 1995).

Wetland processes play an important role in transforming nutrients and releasing them into the atmosphere. In particular, BLHs and RSFs have high productivity and decomposition rates because of their flowing water and pulsing hydrological regimes, allowing for the rapid exchange of nutrients. Wetland inputs of nutrients derive from precipitation and river flooding;

outflows distribute nutrients and organic matter to downstream habitats (Mitsch and Gosselink 2000).

As mentioned above, hydrology and sedimentation are key differences between BLHs and RSFs. They are both highly productive and diverse systems as a result of episodic flooding which provides inputs of organic and mineral suspended materials. Disturbances play a large role in the successional pattern in a wetland, with intermediate magnitude and frequency of disturbances favoring the presence of fast-growing pioneer species. Reduced connectivity to rivers and streams will decrease the disturbance regime, allowing less competitive species to thrive. It should be noted that extreme isolation can increase diversity by preserving past vegetation patterns that are now atypical in a region (e.g. upland plants from the mountains in now-isolated floodplains)(Bornette 1998). Unlike upland sites, bottomland succession is very dependent on both internal (plant-mediated) and external processes such as soil deposition and floods (Hodges 1997). Another major factor in the succession of forested wetlands in the Southeast is the frequency of hurricanes. Windthrow due to these storms opens the canopy and allows increased sunlight into the forest floor, allowing sun-tolerant trees such as sweetgum (*Liquidambar styraciflua*), red oak (*Quercus rubra*), and pines (*Pinus* spp.) to flourish (Batzer and Sharitz 2006).

The cypress-tupelo swamps of the Coastal Plain (RSFs) experience a naturally longer successional cycle because of the longevity of the trees. With stands able to reach 200-300 years of age, succession can become arrested on these sites, barring significant disturbances (Hodges 1997). Schafale and Weakley (1990) have identified six ecosystem types that are considered to be Riverine Swamp Forests wetland by the NCWAM method. Those six types are: 1. Cypress-Gum Swamp (Blackwater subtype), 2. Cypress-Gum Swamp (Brownwater subtype), 3. Coastal Plain Stream Small Stream Swamp (part), 4. Piedmont/Mountain Swamp Forest, 5. Tidal Cypress-Gum Swamp, and 6. Natural Lake Shoreline (Schafale and Weakley, 1990, NCWAM User Manual 2010). Several of the RSF sites surveyed in this study were Cypress-Gum Swamp (Blackwater subtype). The understory of blackwater RSF ("Cypress-gum swamp [blackwater subtype]" from Schafale and Weakley (1990)) is characterized by Carolina ash (*Fraxinus caroliniana*), swamp tupelo, and red maple (*Acer rubrum*), while ti-ti (*Cyrilla racemiflora*), sweet pepperbush (*Clethra alnifolia*) and fetterbush (*Lyonia lucida*) often make up the shrub layer. Though generally sparse, the understory may be quite dense in areas. "The herb layer ranges from nearly absent to moderate cover" (Hodges 1997). Common herbaceous species include lizard's-tail (*Saururus cernuus*), giant sedge (*Carex gigantea*), dotted smartweed (*Persicaria punctatum*), spadeleaf (*Centella asiatica*), marshpennywort (*Hydrocotyle* sp.), threeway sedge (*Dulichium arundinaceum*), and netted chain fern (*Woodwardia areolata*).

Within the Riverine Swamp Forests in this study, cypress trees were more rare. Ash (*Fraxinus* spp.), red maple, sweet bay (*Magnolia virginiana*), swamp bay (*Persia palustris*), and sweetgum were also present in the canopy with ti-ti, wax myrtle (*Morella cerifera*), and tag alder (*Alnus serrulata*) in the shrub layer. Lizard's tail, royal fern (*Osmunda regalis*), and various sedges and rushes were present in the herb layer.

Bottomland hardwood succession and species distribution varies greatly depending on the rate and type of sediment deposition, as well as ecoregion. Schafale and Weakley (1990) list eight types of plant communities that are considered to be BLH wetlands with the NC WAM method (NC Wetland Assessment Method User Manual, 2010). The eight community types identified by Schafale and Weakley (1990) are: 1. Coastal Plain Bottomland Hardwoods (Blackwater subtype), 2. Coastal Plain Bottomland Hardwoods (Blackwater subtype), 3. Coastal Plain Levee Forest (Blackwater subtype), 4. Coastal Plain Levee Forest (Brownwater subtype), 5. Piedmont/Mountain Levee Forest, 6. Piedmont/Mountain Bottomland Forest, 7. Montane Alluvial Forest, 8. Piedmont/Low Mountain Alluvial Forest (Part). There are BLH communities throughout the state, however, the BLH communities surveyed in this study would be considered to be “Piedmont/Mountain Bottomland Forest” or “Piedmont/Mountain Levee Forest” according to Schafale and Weakley (1990).

The portions of a BLH situated lowest in the floodplain, such as oxbow lakes, are almost always flooded, except during times of extreme drought. Small RSFs often occur in these situations. In the Coastal Plain, these pockets of standing water support a canopy of bald cypress and water tupelo (*Nyssa aquatica*), species adapted to life in standing water and anoxic soil conditions. On river levees receiving inputs of fine sediment, a community of trees less adapted to inundation and soil anoxia can prevail, such as black willow (*Salix nigra*). Slow accumulations in areas with soils which are only semi-permanently saturated or inundated allow species such as overcup oak (*Quercus lyrata*), water hickory (*Carya aquatica*), and sweetgum to predominate (Batzer and Sharitz 2006, Hodges 1997). More rapid accumulation of these fine sediments will support an elm-ash-sugarberry (*Celtis laevigata*) community. Deposition of sandy and loamy materials will favor boxelder (*Acer negundo*) and sugarberry (Hodges 1997). Sweetgum, sycamore (*Platanus occidentalis*), swamp chestnut oak (*Quercus michauxii*), and cherry bark oak (*Quercus pagoda*) are also common on these sites (Schafale and Weakley 1990). Highly disturbed areas will be pioneered by river birch (*Betula nigra*) and as these short-lived trees die back and the canopy opens, a transitory sweetgum/tulip poplar (*Liriodendron tulipifera*) community can be found on the more well-drained flats and ridges. Old floodplains,or terraces, will exhibit the regional oak-hickory climax about 200 years after flooding and sedimentation cease (Hodges 1997). Herbaceous BLH species on levees are often dense and tall because of the higher elevation and fertile deposits left behind by flooding. In North Carolina, river oats (*Chasmanthium latifolium*), bottlebrush grass (*Elymus hystrix*), violets (*Viola* spp.), sedges (particularly *Carex* spp.), and false nettle (*Boehmeria cylindrica*) are most common (Schafale and Weakley 1990; Weakley 2008). Other herbs found on these sites include Christmas fern (*Polystichum acrostichoides*) jack-in-the-pulpit (*Arisaema triphyllum*), and axillary goldenrod (*Solidago caesia*). These sites often have a prominent vine community including poison ivy, Virginia creeper (*Parthenocissus quinquefolia*), cross-vine and *Smilax* spp. These areas are prone to invasion by Japanese stiltgrass and Japanese honeysuckle which can suppress the native herb layer (Schafale and Weakley 1990).
The BLHs sites that were surveyed in this study tended to have a canopy and sub-canopy dominated with American elm (*Ulmus americana*), sweetgum, red maple, American hornbeam (*Carpinus caroliniana*), and tulip poplar. Similar to the Schafale and Weakley’s (1990) description, non-natives such as Japanese stiltgrass and Japanese honeysuckle along with

Chinese privet (*Ligustrum sinense*) were very common, even the sites that did not have obvious human impacts. Poison ivy (*Toxicodendron radicans*) was also prevalent especially at the more disturbed sites.

Mature southern bottomland and swamp riverine communities have a flora and fauna as diverse as any in the continental United States. Especially diverse are the species of birds (water birds in particular) that use these areas for wintering and breeding habitat and as stopovers during migration. Diversity of trees in these bottomland and riverine communities rival those of the tropics, and mammals such as whitetail deer, beavers, black bears, bobcats, and river otters use forested wetlands as their primary habitat. Amphibians and reptiles are plentiful and diverse, especially amphibians such as frogs, toads, and salamanders who require ponded water of varying durations to complete their life cycle (Kellison and Young 1997).

National wetland loss in the continental United States has been well documented, with over 116,000,000 acres - over half of all wetlands - lost since the early seventeenth century (Dahl and Johnson 1991). Regionally, from the mid-1970 to the mid-1980, 89 percent of national wetland loss in the conterminous U.S. occurred in the Southeast. Of that percentage, 3.1 million acres of southeastern forested wetlands were lost, with 887,000 of those acres lost occurring in North Carolina alone. In total, North Carolina lost a total of 1.2 million acres of wetlands of all types over that time span, primarily for conversion due to silvicultural and agricultural uses (Hefner et al. 1994). According to The Nature Conservancy (1992), from 1883-1991, the South lost 77 percent (over 16,000,000) acres of southern BLHs. A NC collaborative study by the NC Department of Transportation, NC DENR, and Duke University (Cashin et al. 1992) found that 51% of the NC Coastal Plain wetlands had been impacted to such an extent that the original wetland function and value no longer existed. Palustrine wetlands experienced the greatest loss during this time due primarily to conversion to forestry and agricultural land use (Cashin et al. 1992). Similar losses have occurred throughout the Southeast.

Historically, the major reason for the loss of many forested wetlands throughout the Southeast has been draining and cutting for agriculture and timber. By the late 19^{th}-century, virtually all land suitable for cultivation along the South's larger rivers (which could include RSFs and BLHs) had been converted to cropland. This practice held until landowners and forestry managers came to understand that conversion to cropland was not the most valuable use of these riverine areas. The newfound efficiencies of RSFs include pollution removal, flood control, sediment retention, nutrient cycling, and wildlife habitat provided by these sponge-like riverine wetlands (Kellison and Young 1997).

A more recent survey of wetland status and trends (Dahl 2011) points out that wetland loss in the Southeast has been significant among freshwater wetlands (during 2004-2009). While the reasons are complex, a recent pilot study of causes by Sheehan, (pers. comm., 2014), continues to point to agriculture, but with an increased presence of development pressures from retirement communities. Current and future threats to forested wetlands throughout the Southeast are draining and clearing for agriculture, development, roads, silviculture operations, timber harvesting, and mining of phosphate and other mineral products.

WETLAND SITE SELECTION AND ASSESSMENT AREA

Wetlands were chosen by the GRTS method (see Generalized Random Tessellation Stratified (GRTS) Spatially-Balanced Survey Designs for Aquatic Resources, by A.R. Olsen, 2005 approx.) which is a spatial probabilistic random sampling design. The population of wetlands selected from was the same as that used to select from for the National Wetlands Condition Assessment (NWCA).

Three restrictions were placed on sample selection: (1) wetlands must be forested wetlands (Cowardian classification), (2) one-half of the wetlands must be in Ecoregion 65 (Coastal Plain) and one-half in Ecoregion 45 (Piedmont), and (3) wetlands must be Bottomland Hardwood Forest (BLH) wetlands in the Piedmont and Riverine Swamp Forests (RSF) in the Coastal Plain. Wetland type was restricted to limit variability due to wetland type, given the smaller numbers of wetlands that could be sampled. The definition of these wetland types were provided by the NC Wetland Assessment Method User Manual (NCWAM)(NCWAM User Manual, 2010). In NC, SC, and AL, 10 wetlands were selected in each ecoregion in each state, for a total of 20 wetland surveyed in each of these states. In Georgia, 15 wetlands were chosen in each ecoregion, for a total of 30. Data were collected in a total of 90 Southeast region wetlands for this project, 45 in each ecoregion (Figure 1).

GPS points for wetlands to be sampled were supplied by the EPA. The points were initially reconnaissanced to be sure they were accessible and that they met the definition of either a RSF in the Coastal Plain or a BLH in the Piedmont. If the site did not meet the definition or was not accessible, then the next site on the list from the EPA was selected. The Assessment Area (AA) was the same as that used by the NWCA methodology (see the Field Operations Manual, 2010). Generally, the GPS point defined the center of the AA and a 40 meter circle was delineated around the point. Vegetation plots and soil pits were all located within the AA based on cardinal directions.

One change to the original project proposal was that AL and SC underestimated the funds needed for the staffing required to fully monitor 20 wetlands. This was due to the lack of details that were presented in the original grant proposal and needed by SC and AL. It was therefore decided that SC and AL would perform full data collection on the RSFs and only do the rapid assessments for the BLH wetlands.

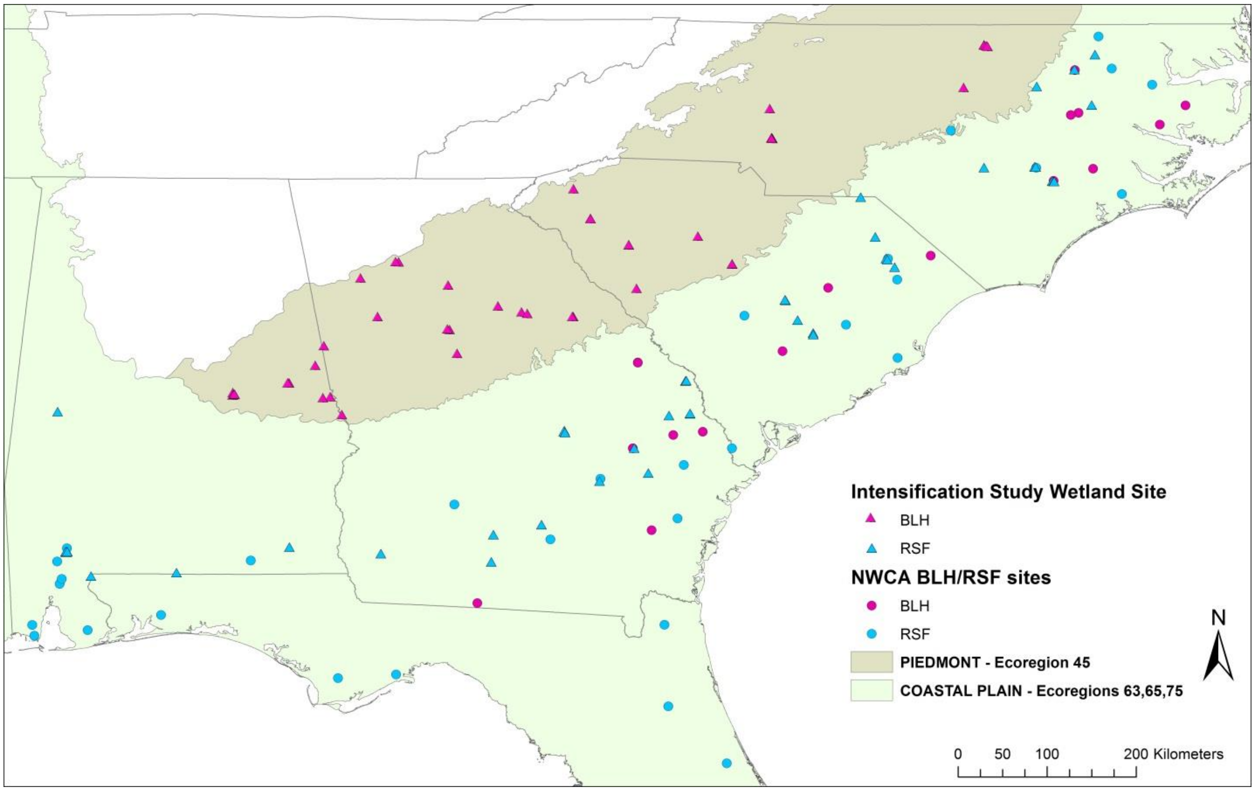


Figure 3: Wetland site locations for Southeast region intensification project.

Site Descriptions

Descriptions of the sites for each state follow for BLHs and RSFs. Maps of each site are included in Appendix B.

Site Descriptions: North Carolina

NC Riverine Swamp Forests

NC 1014 - This RSF wetland site is located along the northeast Cape Fear River basin in Duplin County, NC. Agricultural farms exist to the south and west. This site is a flooded RSF and has a more open canopy with emergent vegetation. There was abundant duck habitat with mallards and wood ducks seen on almost every site visit. Some plots were open enough to be considered marsh or scrub shrub. The canopy is moderately dense and becoming more open in areas as these canopy trees die off probably due to beaver flooding. The tallest live trees are red maple, ash, American elm (*Ulmus americana*), willow (*Salix* sp.), and bald-cypress (*Taxodium distichum*). The herb layer was dense wartremoving herb (*Murdannia keisak*). Frog species observed included the green frog (*Lithobates clamitans*), Southern leopard frog (*Lithobates* *sphenocephala*), Cope's gray tree frog (*Hyla chrysoscelis*), and the squirrel tree frog (*Hyla squirella*). Soil texture was a loamy/clayey mix. The dominant soil matrix color was 10yr 3/1. Redoxomorphic features were absent. This site had deep water and lots of suitable water habitat, not much upland or dry areas with logs and heavy emergent vegetation.

NC 1016 - This site is a RSF in Halifax County, NC. Overstory was dominated by red maple, green ash (*Fraxinus pennslyvanica*), and various oaks (*Quercus* sp.). The center was dry during the vegetation survey and through the last three quarters of 2012. Water quality samples were collected in the AA throughout the study. Water was present during the macroinvertebrate survey and during the last sampling and breakdown. A few of the plots were randomly placed on areas of a dried up cane brake, therefore herbaceous vegetation was sparse. When wet, the AA was mostly flooded. Macroinvertebrates included midges, beetles, amphipods, and isopods typical of semi-permanent waters. Soil texture was Mucky Mineral and mucky peat organic material. Soil matrix color was 10yr 2/1 in upper 15 cm and below that to 60+cm the color was G1 2.5 n. Redoximorphic features were absent.

NC 1018 - The Riverine Swamp Forest in Duplin County, NC was known as the Muck site, because "muck pits" existed throughout the site when one could sink more than a couple feet.. The vegetation was dominated by red maple and sweetgum, American holly (*Ilex opaca*), cinnamon fern (*Osmunda cinnamomea*), greenbrier (*Smilax laurifolia*) and various sedges (*Carex* sp.). Water was able to be collected from upstream and downstream locations five times. The hydric soil indicator was F1 Loamy mucky mineral. Soil texture to 15cm was a Mucky mineral. Soil matrix color down to 15 cm with 5% roots was 10yr 2/1. From 15-60cm; the soil texture was a mucky peat. The soil matrix color with 1 % roots was G1 2.5/n.

NC 1144 - This site is a RSF in Sampson County, NC. The wetland is impacted by beaver and marshy, but dominated by Chinese privet as well. It has some large standing trees, and is adjacent to agriculture. This RSF is part of the drainage out of Dismal Bay along a wetland and stream complex labeled as "Big Swamp" on the US Geological Survey (USGS) quadrangle map. Wartremoving herb was a dominant herbaceous plant in the area. The Buffer was interrupted by agriculture southeast of center and was dominated by small trees and emergent vegetation. The dominant soil texture was loamy/clayey mix. The soil matrix color was 10yr 2/1 with redoximorphic features absent.

NC 1149 - This RSF is in Edgecombe County, NC. This was a wet site with flow channels throughout. The site canopy was dominated by red maple and water oak (*Quercus niger*). The herbaceous layer was dominated by lizard's tail and sedges. This swamp forest was in a stream corridor but was adjacent to agricultural fields. Soils were loamy clays around a 10yr 3/1 to 10yr 3/4 (Munsell). Macroinvertebrates were typical of temporary to semipermanent waters.

NC 1150 - This site is a RSF along the northeast Cape Fear River in Duplin County, NC. This site is part of a large area of swamp forest with scattered dry areas on higher ground mostly adjacent to channels. Some orchid (*Platanthera* sp.) species were cataloged and collected, but could not be speciated. Laurel oaks (*Quercus laurifolia*), sweetgum, American hornbeam (*Carpinus* *caroliniana*), tupelo (*Nyssa* sp.), red maple, American elm, and some cypress (*Taxodium* sp.) dominated the canopy. There was abundant standing water for amphibian habitat. Amphibians collected included the Northern dusky complex salamander (*Desmognathus fuscus*), pickerel frog (*Lithobates palustris*), and Southern leopard frog. The soil texture was loamy/clayey. Soil matrix color was 10yr 2/1 within the upper 8cm. Soil matrix color was 10yr 4/1 with Iron (Fe) composition and soft masses below 37cm. The color of the most evident feature was 10yr 5/8.

NC **1154** - This site is a RSF located along Pate Pond Road in Duplin County, NC. The site is adjacent to hog farms and an old mill pond. The mill pond drains into the wetland. The buffer was covered moderately with small trees, woody shrubs, and standing water. The wetland site is located along at the intersection of Marsh Branch and Goshen Swamp in the Cape Fear Basin. The site was dominated by vines and mid-sized trees, red maple, and American hornbeam, some green ash, and American elm. The hydric soil indicators were A11 (depleted below dark surface) and F1 (Loamy mucky mineral). The soil texture was generally a mucky mineral. The soil matrix color was 10yr 2/1 with redoximorphic features absent.

NC 1157 - This site is a RSF in Pitt County, NC. It was dominated in the overstory by water tupelo (*Nyssa aquatic*), red maple, and sweetgum. The herbaceous layer was dominated by lizard's tail and sedges. This swamp forest was adjacent to agricultural fields. The surface hydrology included small channels and sheet flow through the wetland. The AA dried up during the growing season of 2012; however, water quality samples were obtained multiple times at upstream and downstream stations. Soils were loamy clays around a 10yr 3/1 to 10yr 3/4 (Munsell). Macroinvertebrates were typical of temporary to semipermanent waters.

NC 1159 - This site is RSF along the Northeast Cape Fear River in Duplin County, NC. This site is part of a large area of swamp forest with scattered dry areas on higher ground mostly adjacent to channels. Orchid species (*Platanthera* sp.) were cataloged and collected. Laurel oak, sweet gum, hornbeam, tupelo, red maple, American elm, and some cypress made up the overstory. The site had abundant standing water and a flowing channel adjacent to the Northeast Cape Fear River. The marbled salamander (*Ambystoma opacum*) was the only amphibian found during our survey. F3 Depleted matrix was the Hydric soil indicator. Soil texture was loamy/clayey 10yr 3/1 to 5/1 with redoximorphic features. Compositions of Iron (Fe) and soft masses occurred below 38 cm and the color most evident of the feature was 10yr 5/8.

NC 1161 - This site is located along the Tar Pamlico River basin in Nash County, NC. It is a flooded RSF and has a mostly closed canopy with some emergent vegetation. One plot was open enough to be considered Palustrine Emergent (Cowardin Classification). The canopy is moderately dense and becoming more open in areas impacted by beaver flooding. The live trees consisted of red maple, green ash, persimmon (*Diospyros virginiana*), black willow, laurel oak. and swamp chestnut oak. The herb layer was dense lizard's tail. The surrounding buffer is a mix of upland areas approximately 15% and wetland areas southwest of center and forested wetland over about 85 percent of the buffer area. The soil texture was a loamy clayey. Soil matrix color was 10yr 6/1 with redoximorphic features. Compositions of Iron with soft masses were present at 30-40%. The color most evident of the features was 7.5yr 5/6. Northern cricket frog (*Acris crepitans*), Southern leopard frog, green frog, and a marbled salamander egg mass were cataloged during the amphibian survey. Macroinvertebrates were typical of low flow to stagnant waters.

<u>NC Bottomland Hardwood Forests</u>

NC 1001 – This site is a BLH wetland in east-central Granville County about one mile east of Oxford, NC. A busy two-lane paved road, Williamsboro Street (SR158), abuts about 200 feet along its southern edge. The eastern edge is bordered by a wide sewer-line right-of-way which impedes natural flow to and from Coon Creek located just to the east of the sewer-line. On the southeast side about 20 percent of the wetland has been filled. Most likely this is old fill that was installed for residential yard reasons. To the west of the site, there is a residential home and to the north is a shrubby section dominated with Chinese privet. Natural habitat associated with the Coon Creek riparian corridor continues to the north. The existence of the sewer right-of-way seems to have raised the water table in this area. The canopy is extensive and consists of green ash, sweet gum, American elm, and red maple. The herb layer is dense but scattered and is mostly common woodreed (*Cinna arundinacea*) and sedges of the genus *Carex* spp. Due to the wetland's proximity to the sewerline right-of-way and the disturbance it receives through frequent maintenance efforts, invasive non-native species are creeping into the wetland from the sewerline's edge. Present non-native invasive species are Chinese privet, creeping-charlie (*Lysimachia nummularia*), ground-ivy (*Glechoma hederacea*), Japanese stiltgrass, Japanese honeysuckle, common water-purslane (*Ludwigia palustris*), and multiflora rose (*Rosa multiflora*). The "Third Approximation" (Schafale and Weakley, 1990) would define the Hancock site as Piedmont / Mountain Bottomland Forest. Soil texture was loamy clay. Soil matrix color was 10yr 5/4 with redoximorphic features. Iron composition, soft masses and pore linings make up 15% in the upper 26 cm. The color most evident of features was 5yr 4/6. Bullfrogs (*Lithobates catesbeiana*) and the northern cricket frog were catalogued on site.

NC 1002 - This site is a BLH along Sycamore Creek floodplain in the Neuse River basin in Wake County, NC. Dense Japanese stiltgrass dominates the herbaceous layer. There is a full canopy of river birch (*Betula nigra*), sweetgum, and loblolly pine (*Pinus taeda*). Shrubs and midstory are absent. There are some large standing dead trees. This site had some excellent ephemeral pools and ditches as habitat for amphibians. The southern leopard frog, green frog, Southern cricket frog (*Acris gryllus*), Northern cricket frog, and spring peeper (*Pseudacris crucifer*) were observed on this site. Floods of June and May 2013 deposited over a foot of sediment in the study area. The PVC constructed well casing was physically bent due to the force of the flood waters. Soils were typical piedmont floodplain soils -F19. Soil texture was a loamy/clayey mix. Dominant soil matrix color was 10yr 6/3 with redoximorphic features. Iron composition and nodules were the distinct features at about 45%.

NC 1004 - This BLH is within the floodplain matrix of Rocky River in Cabarrus County, NC. This site is a BLH wetland with green ash, box elder (*Acer negundo*), sugarberry, American elm, and bamboo. Japanese stiltgrass dominated the groundcover. The American Toad (*Bufo* *americanus*) and the Northern cricket frog were recorded. The wetland has been subjected to high sedimentation due to overwash and surrounding upstream development. Soil texture was loamy/clayey. Soil matrix color was 7.5yr 4/3 with redoximorphic and organic features. Iron Composition and soft masses were present and the color of most evident feature was 7.5yr 3/3 at 44 cm depth.

NC 1006 - This site is a BLH located adjacent to I-85 and Concord Regional Airport in Cabarrus County, NC. The overstory vegetation was dominated by typical BLH vegetation: box elder, sugarberry, sweetgum, American sycamore (*Platanus occidentalis*), and black walnut (*Juglans nigra*). The groundcover herbaceous was dominated by invasive Japanese stiltgrass. The site is within the floodplain of an incised channel. The Northern Cricket Frog was the only amphibian species documented during our survey. Macroinvertebrate populations are indicative of temporary waters as also indicated by hydrology data.

NC 1091 - This BLH site is located in the floodplain of Tabbs Creek in the Tar Pamlico Basin in Granville County, NC. This site is part of a corridor of BLH wetland and a floodplain matrix of soil types along Tabbs Creek. There is some disturbance of the ground surface by ATVs and the herbaceous vegetation layer is dominated by invasive Japanese stiltgrass. However, there is a variety of downed woody debris that creates excellent habitat for breeding amphibians. Small trees under the canopy are dominated by box elder. The canopy is dominated by American elm and American sycamore. The macroinvertebrate populations are indicative of temporary waters as our hydrology monitoring data confirmed. We do not believe that Tabbs Creek exited its banks during this study up to the beginning of June 2013, before Tropical Storm Andrea. We collected water once in 2013, but were unable to in 2012. The water quality sample contained high fecal coliform as compared to other sites. Amphibians documented during a 3 hour survey of the site included the marbled salamander, white-spotted slimy salamander (*Plethodon cylindraceus*), spotted salamander (*Ambystoma maculatum*), Eastern American toad (*Bufo americanus*), Northern cricket frog, and Cope's gray tree frog (*Hyla chrysoscelis*).

NC 1092 - This site is a BLH in Granville County, NC in the Tar Pamlico Basin. The canopy was dominated by red maple and sweetgum, and the groundcover was dominated by invasive Japanese stiltgrass. The site is surrounded by small residential developments. During the amphibian survey of 2012, upland chorus frogs (*Pseudacris feriarum*) and slimy salamanders (*Plethodon* sp.) were found using the wetland/intermittent stream complex as suitable habitat. Soil texture was a Loamy /clayey mix. Soil matrix color was 10yr 5/6 with iron (Fe) composition of 30%; color 7.5 4/6.

NC 1095 - This BLH in Granville County, NC is along the floodplain of Coon Creek adjacent to a sewer line and is in the Tar Pamlico Basin. Coon Creek is deeply incised. The vegetation is typical of a disturbed BLH in the piedmont and is dominated by tulip poplar, Chinese privet, Japanese stiltgrass, beech (*Fagus grandifolia*), and spicebush (*Lindera benzoin*). The soils were typical of disturbed BLH especially along sewerlines. Soils were keyed to be 10yr 3/3 to 10yr 3/6 with some redoximorphic features (Munsell). The soil texture was loamy/clayey. Hydrology analysis indicated a very dry BLH cut off from water by an incised channel, relic ditch, and sewerline. Macroinvertebrate populations are indicative of temporary waters as also indicated by the hydrology data. Green frogs were present on the site.

NC 1097 - This site is a BLH in Cabarrus County, NC along the Rocky River in the Yadkin Basin adjacent to I-85 northbound lane near Strayer University in Concord Mills. The site is impacted by development and road construction. The overstory consisted of sugarberry and ash and the herbaceous layer was dominated by invasive Japanese stiltgrass. The site was relatively dry with marginal hydric soil indicators with more floodplain type soils. Macroinvertebrates dominated by amphipods and small mollusks. Mosquitofish (*Gambusia* sp.) were present. Many of the overstory trees were logged due to road construction near the end of our monitoring window (June 2013). Soil texture in the upper 10cm was sandy. The soil matrix color was 10yr 3/1 in upper 10cm. Redoximorphic features were absent. Amphibians cataloged were spotted salamander, Northern cricket frog, and American toad.

NC 1098 - This BLH falls along the Withrow Creek floodplain in Rowan County, NC. The canopy and subcanopy include dense pawpaw (*Asimina* sp.), and scattered green ash, black walnut, American sycamore, tulip poplar, and various oaks. Chinese privet and Japanese stiltgrass were dominant invasive species. This was one of our driest sites in this study. The site never had any standing water to sample during site visits. The hydric soil indicators were F19 - Piedmont Floodplain Soils. Hydrology was fed mostly by precipitation and groundwater. Withrow Creek is deeply incised and thus has essentially cut off the site from overbank flooding.

NC 1101 - This site is in Cabarrus County, NC along the Rocky River in the Yadkin Basin adjacent to I-85 northbound lane behind Strayer University in Concord Mills. The site is impacted by development and road construction. The BLH hydrology is constricted with high sedimentation. The site is becoming marshy and the few remaining trees representing BLH canopy have been displaced due to road construction and the associated run off. Marshy areas provide a refuge for amphibian breeding and habitat. The hydric soil indicator was F19 (Piedmont Floodplain Soils). Soil texture was loamy/clayey. Soil matrix color was 10yr 5/2 with redoximorphic features. Iron composition and soft masses were present at 20-45%. Color most evident of feature was 10yr 6/6.

Site Descriptions: South Carolina

SC Southeastern Plains Riverine Swamp Forest Sites

SC 1034 - Site 1034 is in the Southeastern Plains in Clarendon County, SC within Lake Marion in the Santee Basin. The original Assessment Area point was on the edge of deep open water and was relocated less than 60 meters to within fringe RSF. The relocated point met the definition of a RSF, being located on the shoreline of a small island contiguous with the open water of Lake Marion that is 20 acres or more. The island is part of a large patchwork of islands, including uplands and wetlands, and open water and is located near the northeastern shore of the lake adjacent to the confluence with Jack's Creek, a major tributary. Lands on the opposite shore of Jack's Creek, more than 1,200 feet distant, are within the Santee National Wildlife

Refuge. Lands within the buffer are forested and undeveloped. Water depths in the assessment area ranged from 15 centimeters to a meter. The site was dominated by a closed canopy of mature water tupelo with a lesser amount of bald cypress, with planer trees (*Planer aquatic*) in higher elevation areas. The other dominant plant at the site was duckweed (*Lemna* sp.); the South Carolina-designated invasive aquatic plant pest, common water hyacinth (*Eichhornia crassipes* sp.), was also present. The soil map indicated water and the site is permanently inundated due to being within a managed impoundment. Soils exhibited strong hydric characteristics. Lake Marion is part of a FERC-licensed hydroelectric project operated by the SC Public Service Authority. Amphibians were only found during the late survey and included one Southern leopard frog, one pickerel frog, and two squirrel tree frogs. Benthic macroinvertebrate samples were dominated by midges. There were no notable disturbances or stressors at the site other than trace amounts of water hyacinth, and the site was generally of high quality.

SC 1036 - Site 1036 is in the Southeastern Plains in Sumter County, SC in the floodplain of the Wateree River just above its confluence with the Congaree River in the Santee Basin, not far from Poinsett State Park and Manchester State Forest. The original point was in an area of BLH and was relocated less than 60 meters to a local low area of RSF associated with backwater sloughs within Wateree Swamp, which lies at the headwaters of Lake Marion. The site is within the Santee Cooper Reservation Boundary for Lake Marion. Lands within the buffer are forested and undeveloped, lie completely within the river floodplain and are a mosaic of uplands and wetlands consisting of BLH and RSF. Because of this habitat diversity and heterogeneity, we recorded over 40 species of plants at this site. The vegetation plots were dry during every visit; however, there was strong evidence of periodic overland flow. Water and benthic macroinvertebrate samples were collected in a slough that was permanently inundated. The slough had slack water at times that didn't appear to flow. Vegetation in the assessment area was dominated by green ash, red maple, sweetgum, sugarberry, possumhaw (*Ilex decidua*), and sedges. No non-native invasive species were observed. Soil is mapped as TaA, listed as hydric, and seemed to match the description for a typical Tawcaw profile. Good numbers of amphibians were found during both surveys. Marbeled salamanders were the most common amphibian; other species found included: Southeren two-lined salamander (*Eurycea cirrigera*), Cope's gray tree frog, Southern toad (*Bufo terrestris*), and green frog. Benthic macroinvertebrate samples were dominated by Oligochaetes and Isopods. The most notable disturbance at the site, which was otherwise in good condition, was heavy rooting of the ground surface by feral pigs.

SC 1037 - Site 1037 is in the Southeastern Plains in Marlboro County, SC in the floodplain of the Great Pee Dee River in the Pee Dee Basin. The original point was sampled, as it was RSF. The site is on the opposite side of the river and about 2,500 feet from the SC Department of Natural Resources' Great Pee Dee Heritage Preserve. Lands within the buffer are forested and undeveloped, lie completely within the river floodplain and are a mosaic of uplands and wetlands consisting of BLH and RSF. Because of this habitat diversity and heterogeneity, we recorded over 50 species of plants at this site. The assessment area had surface water during several visits that was as deep as 2.5 meters. Vegetation in the assessment area was dominated by red maple, green ash, black willow, American hornbeam, sedges, and Virginia creeper (*Parthenocissus quinquefolia*). No non-native invasive species were observed. Soil is mapped as Ce, listed as hydric, and seemed to match the description for a typical Chastain profile. Large numbers of amphibians were found during both surveys. Marbled salamander larvae were common in the first survey and squirrel tree frog (probably) larvae were very abundant on the second survey. Other species recorded included green tree frog (*Hyla cinerea*), Southern cricket frog, and green frog. Benthic macroinvertebrate samples were dominated by crayfish, midges and isopods. The most notable disturbance at the site, which was otherwise in good condition, was heavy rooting of the ground surface by feral pigs.

SC 1039 - Site 1039 is in the Southeastern Plains in Marion County, SC in the floodplain of the Great Pee Dee River in the Pee Dee Basin. The original point was in an area of BLH and was relocated less than 60 meters to a local low area of RSF associated with a backwater slough. Lands within the buffer are forested and undeveloped, lie completely within the river floodplain and are a mosaic of uplands and wetlands consisting of BLH and RSF. Because of this habitat diversity and heterogeneity, we recorded over 35 species of plants at this site. Two of the vegetation plots had surface water as deep as 60 centimeters when sampled; however, water samples were only collected twice at this site and then only at the upstream station. A very large ditch, large enough to be seen in the 2006 color infrared aerial for the site, is located about 75 meters to the south of the relocated point. It contained water on nearly every visit. Vegetation in the assessment area was dominated by red maple, bald cypress, water tupelo, slippery elm (*Ulmus fulva*), box elder, and sedges. No non-native invasive species were observed. Soil is mapped as TC, which is listed on the Web Soil Survey as partially hydric for this site, and seemed to match the description for a typical Tawcaw profile. A small number of amphibians were found during both surveys including marbled salamander, Southern cricket frog, and Southern toad. Benthic macroinvertebrates were not sampled due to lack of water at the site during the sampling visit. The most notable disturbance at the site, which was otherwise in good condition, was the large ditch to the south described previously.

SC 1040 - Site 1040 is in the Southeastern Plains in Orangeburg County, SC on the shore of a small peninsula in Lake Marion in the Santee Basin, near the city of Eutawville. The original point was sampled as the assessment area was mostly RSF. Lands within the buffer are forested and undeveloped and are a mosaic of uplands and wetlands consisting of BLH and RSF. Because of this habitat diversity and heterogeneity, we recorded over 30 species of plants at this site. Three of the vegetation plots had surface water ranging from 6 to 25 centimeters when sampled; however, the point where the well was installed was a local high spot and remained dry on all visits. Water samples were collected on all visits from this site, with one station or another not sampled due to being dry on only two visits. Vegetation in the assessment area was dominated by bald cypress, water tupelo, overcup oak (*Quercus lyrata*), Shumard's oak (*Q. shumardii*), water oak (*Q. nigra*), red maple, sweetgum, Bitternut hickory (*Carya cordiformis*), wax myrtle (*Myrica cerifera*), sedges, and duckweed. No non-native invasive species were observed. Soil is mapped as RA, listed as hydric; however, it did not match the description for a typical Rains profile, nor did it seem to match profiles for any of the soils in common association with Rains. A good number of amphibians were found during both surveys including marbled salamander, Southern cricket frog, Southern toad, dwarf salamander (*Eurycea quadradigitatta*), Eastern narrow-mouthed toad (*Gastrophryne carolinensis*), green tree frog, barking tree frog (*Hyla gratiosa*), Atlantic Coast slimy salamander (*Plethodon chlorobryonis*), American bullfrog, pickerel frog, green frog, pig frog (*Lithobates grylio*), and Southern leopard frog. Over 40 different taxa of benthic macroinvertebrates were collected, dominated by several different midges. There were no notable disturbances or stressors at the site.

SC 1246 - Site 1246 is in the Southeastern Plains in Marion County, SC in Pitch Pot Swamp in the Pee Dee Basin near Dickerson Island. Pitch Pot Swamp is a tributary to Catfish Creek, a major tributary to the Great Pee Dee River. The original point was on the edge of a small island of uplands within the swamp and was relocated less than 60 meters to RSF typical of the entire swamp. Lands within the buffer are forested and undeveloped, lie completely within the floodplain and mostly RSF with some uplands. Over 20 species of plants were recorded at this site. All of the vegetation plots had surface water ranging from a low of 20 centimeters to a little over a meter when sampled and the relocated point, where the well was installed, was permanently inundated throughout all visits. Vegetation in the assessment area was dominated by water tupelo, red maple, black willow, and various genera and species of small floating aquatics such as duckweed. No non-native invasive species were observed. Soil is mapped as TC and listed as hydric; however, it more closely matched the description for a typical Chastain profile, which is commonly associated with Tawcaw. Amphibians were very abundant during both surveys and dominated by Southern cricket frog. Other species observed included dwarf salamander, green tree frog, American bullfrog, and green frog. Almost 30 different taxa of benthic macroinvertebrates were collected, dominated by fingernail clams and pea clams, followed by midges and isopods. There were no notable disturbances within the buffer. The only stressor observed at the site was evidence of beaver. A dirt road approximately 1,700 feet to the northwest of the site that was used for access was ponding water on the upstream side, indicating that it was at least partially obstructing hydrologic connectivity, particularly during low flows.

SC 1248 - Site 1248 is in the Southeastern Plains in Orangeburg County, SC on the shore of Lake Marion in the Santee Basin approximately one mile south of SC Site 1040, closer to the city of Eutawville. The original point was sampled as the assessment area was RSF with uplands to the north and water deeper than one meter to the south. Lands within the buffer are forested and undeveloped and are a mosaic of uplands, wetlands consisting of BLH and RSF, and open water deeper than one meter. Because of this habitat diversity and heterogeneity, we recorded over 35 species of plants at this site. All five of the vegetation plots had surface water ranging from a maximum depth of 5 to 105 centimeters when sampled and the point where the well was installed remained inundated throughout all the visits, with a surface water depth ranging from 27 to 93 centimeters. Water samples were collected from both stations on all visits from this site. Vegetation in the assessment area was dominated by bald cypress, sweethgum, black willow, common buttonbush (*Cephalanthus occidentalis*), alligatorweed (*Alternanthera philoxeroides*), and American white waterlily (*Nymphaea odorata*). The South Carolina-designated invasive aquatic plant pest, common water hyacinth was present in trace amounts in one plot. The soil map indicated water and the site is permanently inundated due to being within a managed impoundment. As described previously, Lake Marion is part of a FERC-licensed hydroelectric project operated by the SC Public Service Authority. Soil in the representative pit exhibited one hydric indicator. A good number of amphibians were found during both surveys dominated by larvae of Eastern narrow-mouthed toad, Southern leopard frog and marbled salamander. Other species found included: green tree frog, Atlantic Coast slimy salamander, and pig frog. Over 40 different taxa of benthic macroinvertebrates were collected, dominated by several different midges and a couple of snail species. There were no notable disturbances at the site and the only stressor noted was a trace amount of trash\litter.

SC 1249 - Site 1249 is in a wetlands system located in the Southeastern Plains ecoregion in Marlboro County, SC associated with a tributary to Marks Creek in the Pee Dee Basin, and approximately 600 feet south of the border with North Carolina. The original point was located in a Headwater Forest-type wetland and was relocated less than 60 meters downstream to the north where the wetlands were inundated during the reconnaissance visit and were primarily RSF with buttressed tree trunks. Lands within the buffer are forested and undeveloped, and consist of the wetlands\stream system that contains the assessment area and adjacent uplands planted in nearly mature pine. We recorded 40 species of plants at this site. None of the five vegetation plots had surface when sampled and the point where the well was installed remained without surface water throughout all the visits. Water samples were only collected from the downstream station on two visits from this site. Vegetation in the assessment area was dominated by sweetgum, tulip poplar, sweetbay (*Magnolia virginiana*), red maple, Virginia creeper, Greenbrier, and sensitive fern (*Onoclea sensibilis*). Nonnative Chinese Privet was noted in trace amounts during the rapid assessment. The web soil survey indicated Johnston mucky loam, frequently flooded with a hydric rating of 97 was present in the AA and the soil in most of the soil pits seemed to match the description for a typical Johnston Series profile well. Soil in the representative pit exhibited one hydric indicator. No amphibians were observed at this site on either of the two surveys. No benthic macroinvertebrates were collected at this site due to lack of surface water. There were no notable disturbances at the site and the only stressor noted was the adjacent pine plantation.

SC 1256 - Site 1256 is in the Southeastern Plains in Sumter County, SC in the floodplain of the Wateree River just above its confluence with the Congaree River in the Santee Basin, not far from Poinsett State Park and Manchester State Forest. It's also about 3,000 feet northwest of SC 1036, closer to the Little River and the Wateree River. The original point was in an area of BLH and was relocated less than 60 meters to an area of RSF associated with a backwater slough within Wateree Swamp. Lands within the buffer are forested and undeveloped, lie completely within the river floodplain and are a mosaic of uplands and wetlands consisting of BLH and RSF. Because of this habitat diversity and heterogeneity, we recorded over 40 species of plants at this site. Two of the vegetation plots had surface water during sampling, with one being mostly inundated with a maximum depth of 35 centimeters and the other only having one per cent coverage by water. The point where the well was installed remained dry throughout all the visits; however, there was strong evidence of periodic overland flow. Water and benthic macroinvertebrate samples were collected in a slough that was permanently inundated. The slough had slack water at times that didn't appear to flow. Vegetation in the assessment area was dominated by water tupelo, bald cypress, green ash and giant cane (*Arundinaria gigantean*). No non-native invasive species were noted. The Web Soil Survey maps the site as Tawcaw-Duckbottom-Mullers complex, 0 to 2 percent slopes, frequently flooded with a hydric rating of 28, meaning it's predominantly non-hydric. The soils in the AA seemed to best match the description for a typical Mullers profile. About three times as many amphibians were found during the second survey. Marbled salamander, Cope's gray tree frog, and Southern leopard frog were the most common amphibians; other species found included one Southern toad. Benthic macroinvertebrate samples were dominated by crustaceans including isopods, amphipods and decapods, followed by oligochaetes. No disturbances were noted at the site, which was in good condition.

SC 1257 - Site 1257 is in the Southeastern Plains in Marion County, SC in the floodplain of the Great Pee Dee River in the Pee Dee Basin. The original point was on a slight rise in an area of BLH and was relocated less than 60 meters to a large area of RSF. The relocated point lies about half a mile from the river bank and about a mile southeast of SC 1039. Lands within the buffer are forested and undeveloped, lie completely within the river floodplain and are a mosaic of uplands and wetlands consisting of BLH and RSF. The AA itself was very homogeneous and only 15 species of plants were recorded at this site, dominated by water tupelo, bald cypress, and planer tree/water elm. No non-native invasive species were observed. All five of the vegetation plots had surface water with maximum depths ranging from 20 to as deep as 50 centimeters when sampled. The area around the well was either saturated or had shallow surface water most of the time. Water samples were collected on six different dates at this site with the downstream station not being sampled on the two amphibian survey visits and one other date when there was no water. Soil is mapped as TC, which is listed on the Web Soil Survey as partially hydric for this site, and seemed to match the description for a typical Tawcaw profile. A small number of amphibians were found during both surveys dominated by marbled salamander. Other species observed included two green tree frogs and one Cope's gray tree frog. Benthic macroinvertebrate samples were dominated by crustaceans including isopods, amphipods and decapods, followed by dipterans. The entire AA was clear cut between the second amphibian survey in June and the next visit to the site in August. The well was pulled out of the ground but was still lying nearby with the pressure transducer still inside and working. The well was reinstalled in December.

<u>SC Bottomland Hardwood Forest Sites</u>

SC 1022 - This site is in the Southern Outer Piedmont in Anderson County, SC about 200 meters north of **SC 1205**. The original point was sampled and was BLH wetland type within the floodplain of Watermelon Creek in the Savannah Basin. The area in general is rural with mostly agricultural and some silviculture landuse, and generally forested riparian areas. The entire floodplain in the vicinity of the site is forested and the site was well-buffered. Japanese stiltgrass and Chinese privet were prevalent in the understory, with some pokeweed (*Phytolacca americana*) and poison ivy (*Toxicodendron radicans*). Trees were dominated by river birch, red maple, and sweetgum. Soil at the site is mapped as Cartecay-Chewacla complex with a hydric rating of 5.

SC 1027 - This site is in the Southern Inner Piedmont in Pickens County, SC. The original point was moved < 60 meters to the west side of Mauldin Lake Road, State Road S-39-122. The original point was borderline wetland and was not forested. The relocated point is forested bottomland hardwood in the floodplain of Wolf Creek in the Savannah Basin. The site is a little over a mile south of the center of downtown Pickens just outside the edge of town with a mixture of landuses ranging from residential, to agricultural to forested. The two-lane State road crosses the southeast edge of the assessment area, which is forested. The surrounding buffer area could probably be described as highly disturbed, with a powerline, areas of open water, cleared areas, forested areas, residential development and what's marked on the topo map as a sewage disposal pond. However, the pond was dry and appeared to be no longer in use. Chinese privet was prevalent in the understory, with some poison ivy. Trees were dominated by American sycamore, river birch, red maple, tulip poplar, and box elder. Soil at the site is mapped as Chewacla, frequently flooded, with a hydric rating of 10.

SC 1028 - Site 1028 is in the Southern Outer Piedmont in Greenwood County, SC. The original point was sampled and was in forested bottomland hardwood in the floodplain of Camp Branch in the Saluda Basin. The site is about 270 meters west of **SC 1192**, about one kilometer west of Vulcan Construction Materials LP granite quarry and about half a kilometer west of backwaters associated with an impoundment created by the quarry. Camp Branch flows to the east, past the quarry and then into Lake Greenwood, an impoundment of the Saluda River. The surrounding buffer area is forested with some pine plantation. Japanese stiltgrass was prevalent in the understory. Trees were dominated by red maple and sweetgum. Soil at the site is mapped as Cartecay and Toccoa with a hydric rating of 5.

SC 1029 - This site is in the Carolina Slate Belt in Richland County, SC. The original point was suitable BLH in the floodplain of the Broad River in the Broad Basin; however, it was relocated less than 60 meters to the southeast to avoid buffer overlap with SC 1204. There is a railroad bed embankment within the buffer on the northeast side of the assessment area with culverts at low spots (natural drainage ways), and a small shallow ditch on the southwest side of the assessment area. Aside from these disturbances and a small wildlife food plot to the southeast, the buffer area is forested. Martin Marietta Materials, Inc. granite quarry has an industrial NPDES discharge into the head of a tributary to the Broad River 700 meters north of the site; however, the tributary flows directly to the river and based on the topo map doesn't appear to have any hydrological interaction with the site. Giant cane was prevalent in the understory. Trees were dominated by green ash, red maple, swamp chestnut oak, and sweetgum. No non-natives were observed. Soil at the site is mapped as Congaree Loam with a hydric rating of 2.

SC 1192 - This site is in the Southern Outer Piedmont in Greenwood County, SC. The original point was sampled and was forested bottomland hardwood in the floodplain of Camp Branch in the Saluda Basin. The site is about 270 meters east of **SC 1028**, less than one kilometer west of Vulcan Construction Materials LP granite quarry and only about 100 meters west of some open backwaters associated with an impoundment created by the quarry. Camp Branch flows to the east, past the quarry and then into Lake Greenwood, an impoundment of the Saluda River. The surrounding buffer area is forested with some pine plantation. Japanese stiltgrass was dominant in the herbaceous understory along with an unidentified smartweed species (*Polygonum* sp.). Hazel alder (*Alnus serrulata*) dominated the woody understory. Trees were dominated by black willow, red maple and American hornbeam. Soil at the site is mapped as Cartecay and Toccoa with a hydric rating of 5.

SC 1204 - Site 1204 is in the Carolina Slate Belt in Richland County, SC. The original point was sampled and was BLH in the floodplain of the Broad River in the Broad Basin. There is a railroad bed embankment within the buffer on the northeast side of the assessment area with culverts at low spots (natural drainage ways), and a small shallow ditch on the southwest side of assessment area outside of the buffer. Aside from these disturbances, the buffer area is forested. Martin Marietta Materials, Inc. granite quarry has an industrial NPDES discharge into the head of a tributary to the Broad River 500 meters north of the site; however, the tributary flows directly to the river and based on the topo map doesn't appear to have any hydrological interaction with the site. Giant cane, unidentified sedge, non-native Chinese privet and American hornbeam were prevalent in the understory. Trees were dominated by red maple, green ash and swamp chestnut oak. Soil at the site is mapped as Congaree Loam with a hydric rating of 2.

SC 1205 - This site is in the Southern Outer Piedmont in Anderson County, SC about 200 meters south of **SC 1022**. The original point was sampled and was BLH wetland type within the floodplain of Watermelon Creek in the Savannah Basin. The area in general is rural with mostly agricultural and some silviculture landuse, and generally forested riparian areas. The entire floodplain in the vicinity of the site is forested and the site was well-buffered. Non-native Japanese stiltgrass, an unidentified grass, non-native Chinese privet and sweetgum were prevalent in the understory. Trees were dominated by red maple and tulip poplar. Soil at the site is mapped as Cartecay-Chewacla complex with a hydric rating of 5.

SC 1210 - Site 1210 is within Sumter National Forest in the Southern Outer Piedmont in Newberry County, SC. The original point was sampled and was in BLH in the floodplain of Hellers Creek in the Broad Basin. The area in general is rural with mostly forested land, with silviculture landuse and some agricultural landuse, and generally forested riparian areas. The entire floodplain in the vicinity of the site is forested and the site was well-buffered. Giant cane and non-native Japanese stiltgrass dominated the understory. Trees were dominated by red maple and sweetgum. Soil at the site is mapped as Chenneby silt loam, 0 to 2 percent slopes, frequently flooded with a hydric rating of 5.

SC 1220 - This site is in the Carolina Slate Belt in Edgefield County, SC. The original point was sampled and was in BLH in the floodplain of Stevens Creek in the Savannah Basin. Stevens Creek had very tall steep banks and seemed to be disconnected from its floodplain; however, the point was in an area where Rocky Creek joined it, maintaining moist soil and maintaining the area as wetland. The area in general is rural with mostly forested land, with silviculture landuse and some agricultural landuse, and generally forested riparian areas. The entire floodplain in the vicinity of the site is forested and the site was well-buffered. Giant cane, American hornbeam and pawpaw dominated the understory. Trees were dominated by swamp chestnut oak, pignut hickory (*Carya glabra*), red maple and tulip poplar. Soil at the site is mapped as Toccoa sandy loam with a hydric rating of 0.

SC 1229 - Site 1229 is in the Carolina Slate Belt in Richland County, SC. The original point was moved less than 60 meters to the northwest to avoid overlap between buffers with **SC Site 1204**. The relocated original and point were BLH in the floodplain of the Broad River in the Broad Basin. There is a railroad bed embankment within the buffer on the northeast side of the assessment area with culverts at low spots (natural drainage ways), and a small shallow ditch on the southwest side of assessment area outside of the buffer. A portion of Martin Marietta Materials, Inc. granite quarry is also within the buffer. The quarry has an industrial NPDES discharge into the head of a tributary to the Broad River 300 meters north of the site; however, the tributary flows directly to the river and based on the topo map doesn't appear to have any hydrological interaction with the site. Aside from these disturbances, the buffer area is forested. Giant Cane was prevalent in the understory. Trees were dominated by red maple, green ash and swamp chestnut oak and overcup oak. Soil at the site is mapped as Congaree Loam with a hydric rating of 2.

<u>Site Descriptions: Alabama</u>

<u>AL Riverine Swamp Forest sites</u>

AL 1084 - This site is a Riverine Swamp located in Baldwin County, AL. The site is within the Alabama River Basin. The site has a closed canopy, a moderately dense mid-story, a sparse shrub layer, and a moderately dense herb layer. There are also numerous large logs present. Dominant species observed during the vegetation survey included possumhaw holly, laurel oak, Nuttall oak (*Quercus nuttallii*), sugarberry, and Japanese climbing fern (*Lygodium japonicum*). Amphibians observed at the site included several juvenile Fowler's toads (*Bufo fowleri*), an adult Southern toad, two adult unidentified *Lithobates* sp., and several green frog larva. One Cope's gray tree frog was heard calling. The soil was a loamy/clayey texture, and the dominant matrix color was 7.5 YR 4/3. The most common redoximorphic feature was depletions, and the dominant feature color was 10 YR 6/2.

AL 1087 - This site is a Riverine Swamp located in Greene County, AL. The site is within the Tombigbee River Basin. The site has a moderately open canopy, a dense midstory, a dense shrub layer, and a dense herb layer. Dominant vegetation included American hornbeam, sawtooth blackberry (*Rubus argutus*), muscadine (*Vitis rotundifolia*), and Eastern poison ivy. Amphibians observed at the site included abundant adult Southern cricket frogs, one juvenile Southern cricket frog, and one *m*arbled salamander larva. One Cope's gray treefrog, one bird-voiced treefrog (*Hyla avivoca*), and three green tree frog were heard calling. The soil was a loamy/clayey texture, and the dominant matrix color was 10 YR 4/3. The most common redoximorphic feature was soft masses, and the dominant feature color was 10 YR 3/3.

AL 1491 - This site is a Riverine Swamp located in Escambia County, AL. The site is within the Perdido-Escambia River Basin. The site has an open canopy, a sparse mid-story, a dense shrub layer, and a moderately dense herb layer. There are also numerous large logs present. Dominant vegetation included inkberry (*Ilex glabra*) and downy sweet pepperbush (*Clethra tomentosa*). Amphibians observed at the site included several dwarf salamander larvae, two juvenile dwarf salamanders, three adult dwarf salamanders, and two juvenile unidentified toad species (*Bufo* sp.). Three Southern cricket frogs were heard calling. The soil was a loamy/clayey texture, and the dominant matrix color was 10 YR 5/8. The most common redoximorphic feature was soft masses, and the dominant feature color was 5 YR 4/6.

AL 1498 - This site is a Riverine Swamp located in Baldwin County, AL. The site is within the Alabama River Basin. The site has a closed canopy, a dense mid-story, a moderately dense shrub layer, and a moderately dense herb layer. Dominant vegetation included possumhaw holly, sugarberry, and *Carex* spp*.* One adult Fowler's toad was found during the amphibian survey. Also, one Cope's gray tree frog and one green tree frog were heard calling. The soil was a loamy/clayey texture, and the dominant matrix color was 10 YR 4/3. The most common redoximorphic feature was depletions.

AL 1508 - This site is a Riverine Swamp located in Baldwin County, AL. The site is within the Alabama River Basin. The site has a closed canopy, a dense mid-story, a sparse shrub layer, and a sparse herb layer. Dominant vegetation included sugarberry, muscadine, and Nuttall oak. Thirty-six juvenile unidentified toads (*Bufo* sp.) were found during the amphibian survey. Also, two Cope's gray tree frogs and one *g*reen tree frog were heard calling. The soil was a loamy/clayey texture, and the dominant matrix color was 7.5 YR 4/3. The most common redoximorphic feature was depletions, and the dominant feature color was 10 YR 5/2.

AL 1510 - This is a Riverine Swamp located in Baldwin County, AL. The site is within the Alabama River Basin. The site has a moderately open canopy, a dense mid-story, a moderately dense shrub layer, and a moderately dense herb layer. There are also numerous large logs present. Dominant vegetation included sugarberry, Nuttall oak, muscadine, and poison ivy. Amphibians observed at the site included three juvenile Fowler's toads and two adult unidentified *Lithobates* sp. Also, one Cope's gray tree frog and one green tree frog were heard calling. The soil was a loamy/clayey texture, and the dominant matrix color was 7.5 YR 4/4. The most common redoximorphic feature was soft masses, and the dominant feature color was 5 YR 4/6.

AL 1519 - This is a Riverine Swamp located in Dale County, AL. The site is within the Choctawhatchee River Basin. The site has a closed canopy, a dense mid-story, a moderately dense shrub layer, and a sparse herb layer. There are also numerous large logs present. Dominant vegetation included Southern magnolia (*Magnolia grandiflora*), Chinese privet, American hornbeam, and muscadine. Amphibians observed at the site included one adult American bullfrog, one adult Fowler's toad, one adult unidentified *Lithobates* sp., two juvenile unidentified *Lithobates* sp*.,* three green frog larvae, two adult Southern cricket frogs, one adult dwarf salamander, one adult three-lined salamander (*Eurycea longicauda*), and one adult

Eastern newt (*Notopthalmus viridescens*). One Cope's gray tree frog and one bird-voiced tree frog were heard calling. The soil was a loamy/clayey texture, and the dominant matrix color was 10 YR 5/2. The most common redoximorphic feature was depletions, and the dominant feature color was 10 YR 3/4.

AL 1522 - This site is a Riverine Swamp located in Baldwin County, AL. The site is within the Alabama River Basin. The site has a closed canopy, a dense mid-story, a sparse shrub layer, and a sparse herb layer. There are also numerous large logs present. Dominant vegetation included overcup oak, pecan (*Carya illinoinensis*), and green ash. Amphibians observed at the site included two adult American bullfrog, two juvenile American bullfrog, seven green frog larvae, and one adult Fowler's toad. Numerous Northern cricket frogs, one Cope's gray tree frog, one American bullfrog, and one green tree frog were heard calling. The soil was a loamy/clayey texture, and the dominant matrix color was 7.5 YR 4/4. The most common redoximorphic feature was depletions, and the dominant feature color was 10 YR 5/2.

AL 1526 - This is a Riverine Swamp located in Baldwin County, AL. The site is within the Alabama River Basin. The site has a closed canopy, a moderately dense mid-story, a moderately dense shrub layer, and a moderately dense herb layer. There are also numerous large logs present. Dominant vegetation included sugarberry, possumhaw holly, water oak, poison ivy, and muscadine. Amphibians observed at the site included several juvenile Fowler's toad, two adult unidentified *Lithobates* sp., and several green frog larva. One Cope's gray tree frog was heard calling. The soil was a loamy/clayey texture, and the dominant matrix color was 10 YR 4/3. The most common redoximorphic feature was depletions, and the dominant feature color was 10 YR 5/2.

AL 1536 - This site is a Riverine Swamp located in Baldwin County, AL. The site is within the Perdido River Basin. The site has a closed canopy, a dense mid-story, a sparse shrub layer, and a sparse herb layer. There are also numerous large logs present. Dominant vegetation included *s*weetbay and swamp tupelo (*Nyssa biflora*). Amphibians observed at the site included three adult green frog, one adult dwarf salamander, and one subadult Two-toed Amphiuma (*Amphiuma means*). Five squirrel tree frogs, one green tree frog, one spring peeper, and ten green frogs were heard calling. The soil texture was organic muck, and the only matrix color present was 10 YR 2/1. Redoximorphic features were absent.

<u>AL Bottomland Hardwood sites</u>

AL 1076 - This site is a Bottomland Hardwood Swamp located in Coosa County, AL. The site is within the Coosa River Basin. Only qualitative rapid assessment methodologies were utilized to assess this site. The site has a closed canopy, a dense mid-story, a sparse shrub layer, and a sparse herb layer and has been disturbed by clearcutting and shrub/sapling removal. The wetland's water source appears to primarily be precipitation. Amphibian breeding pools were noted.

AL 1078 - This is a Bottomland Hardwood Swamp located in Chambers County, AL. The site is within the Tallapoosa River Basin. Only qualitative rapid assessment methodologies were utilized to assess this site. The site has a mostly closed canopy, a moderately dense mid-story, a dense shrub layer, and a sparse herb layer. The wetland's water source appears to primarily be precipitation and seasonal, intermittent surface water. Amphibian breeding pools were noted.

AL 1080 - This is a Bottomland Hardwood Swamp located in Coosa County, AL. The site is within the Coosa River Basin. Only qualitative rapid assessment methodologies were utilized to assess this site. The site has a closed canopy, a dense mid-story, a moderately dense shrub layer, and a sparse herb layer. The wetland's water source appears to primarily be precipitation.

AL 1441 - This site is a Bottomland Hardwood Swamp located in Chambers County, AL. The site is within the Tallapoosa River Basin. Only qualitative rapid assessment methodologies were utilized to assess this site. The site has a closed canopy, a dense mid-story, a moderately dense shrub layer, and a moderately dense herb layer. The wetland's water source appears to primarily be groundwater sources & precipitation. Amphibian breeding pools were noted.

AL 1443 - This site is a Bottomland Hardwood Swamp located in Chambers County, AL. The site is within the Tallapoosa River Basin. Only qualitative rapid assessment methodologies were utilized to assess this site. The site has a closed canopy, a dense mid-story, a sparse shrub layer, and a sparse herb layer and has been disturbed by selective cutting. The wetland's water source appears to primarily be precipitation.

AL 1445 - This is a Bottomland Hardwood Swamp located in Tallapoosa County, AL. The site is within the Tallapoosa River Basin. Only qualitative rapid assessment methodologies were utilized to assess this site. The site has a closed canopy, a moderately dense mid-story, a sparse shrub layer, and a sparse herb layer and has been disturbed by selective cutting and shrub/sapling removal. The wetland's water source appears to primarily be precipitation.

AL 1452 - This site is a Bottomland Hardwood Swamp located in Coosa County, AL. The site is within the Coosa River Basin. Only qualitative rapid assessment methodologies were utilized to assess this site. The site has a closed canopy, a dense mid-story, a sparse shrub layer, and a sparse herb layer and has been disturbed by shrub/sapling removal. The wetland's water source appears to primarily be precipitation.

AL 1454 - This is a Bottomland Hardwood Swamp located in Chambers County, AL. The site is within the Chattahoochee River Basin. Only qualitative rapid assessment methodologies were utilized to assess this site. The site has an open canopy, a sparse mid-story, a moderately dense shrub layer, and a dense herb layer and has been disturbed by clearcutting. The wetland's water source appears to primarily be precipitation.

AL 1463 - This site is a Bottomland Hardwood Swamp located in Chambers County, AL. The site is within the Chattahoochee River Basin. Only qualitative rapid assessment methodologies were utilized to assess this site. The site has a closed canopy, a moderately dense mid-story, a moderately dense shrub layer, and a dense herb layer and has been disturbed by mowing. The wetland's water source appears to primarily be precipitation. Amphibian breeding pools were noted.

AL 1464 - This is a Bottomland Hardwood Swamp located in Coosa County, AL. The site is within the Coosa River Basin. Only qualitative rapid assessment methodologies were utilized to assess this site. The site has a closed canopy, a moderately dense mid-story, a sparse shrub layer, and a sparse herb layer and has been disturbed by selective cutting and shrub/sapling removal. The wetland's water source appears to primarily be precipitation.

Site Descriptions: Georgia

GA Riverine Swamp Forest sites

GA 1369 - Site 1369 is located in the Southeastern Plains in Jeff Davis County, GA in the floodplain of Bullard Creek within the Altamaha River basin. The site is located within a silviculture management area; the stand itself appeared mature (15-30 m tall, on average), with little understory vegetative coverage, and as such showed few signs of recent disturbance. Several trails, ditching activity, and other signs of semi-active management were found within the 100 meter buffer region surrounding the wetland. Hydrology data showed extended periods of surface water present throughout the majority of the monitoring period from February 2013 through June 2014. Soils were typically in the 10YR 2/1- 4/1 range with a peat layer of varying thicknesses at the surface. Vegetation was dominated by Acer rubrum, Quercus nigra, Liquidambar Styraciflua, Pinus elliotti, and Nyssa biflora. No invasives were found within the AA. While macroinvertebrate and amphibian data were collected in 2014, analysis has not been completed at the time of this writing.

GA 1377- Located in the floodplain of the Oconee River, this area is characterized by a patchwork mosaic of upland systems bisected by 20-30 meter wide slough-like wetlands. The floodplain itself exhibits little evidence of management save for the dirt rtv roads that bisect the land; this particular wetland polygon was located directly adjacent to one such road. It appears that hunting is the principle anthropogenic use of the area. Evidence of damage due to hog activity was evident throughout the assessment area. Hydrologic monitoring data showed that, once the unusually dry conditions exhibited throughout the region abated in early 2013, the assessment area was routinely flooded to a depth of close to 2 feet for much of that year through July of 2014. The SSURGO maps classify soils in the area as a Tawcaw-Chastain-Congaree association. Soil profiles were generally found to be in the 10YR 4/1-7/1 range, with numerous redoximorphic features spotted throughout the profile. Thirty-four species of vegetation were found in the assessment area, primarily dominated by Ostrya virginiana, Fraxinus pennsylvanica, and Quercus lyrata. Very few invasive species (<5% coverage) were spotted within the assessment area. While macroinvertebrate and amphibian data were collected in 2014, analysis has not been completed at the time of this writing.

GA 1062 - Located in the floodplain of the Oconee River, this area is characterized by a patchwork mosaic of upland systems bisected by 40-60 meter wide slough-like wetlands. The floodplain itself exhibits little evidence of management save for the dirt rtv roads that bisect the land; this particular wetland polygon was located directly adjacent to one such road. It appears that hunting is the principle anthropogenic use of the area. Evidence of damage due to hog activity was evident throughout the assessment area. This particular location differs from 1377 and 1430 in that the upland portion of the area exhibited signs that it might also experience periodic overland flow, and as such may meet the hydrologic characteristics of a wetland. Therefore, two monitoring wells were installed; one within the assessment area itself (termed the "lower" well), and one in the upland region near the assessment area ("upper" well). Hydrologic monitoring data showed that, once the unusually dry conditions exhibited throughout the region abated in early 2013, the assessment area was periodically flooded to a depth of close to 1 ½ feet in the upland region for much of that year through July of 2014. The lower well exhibited saturated conditions to just below the surface for most of the monitoring period, while water levels in the upper well were typically deeper than 15 inches below the surface. The SSURGO maps classify soils in the area as a Tawcaw-Chastain-Congaree association. Soil profiles were generally found to be in the 10YR 5/1-7/1 range, with numerous redoximorphic features spotted throughout the profile. However, some erosional deposition seems to be present in the assessment area, as most of the soil profiles exhibited a 10-15 cm thick surficial layer of 5YR 4/4 to 4/6 clayey soil. Fifty-two species of vegetation were found in the assessment area, primarily dominated by Chasmanthium sessiliflorum, Chasmanthium latifolium, Taxodium distichum, and Carpinus caroliniana. Very few invasive species (<5% coverage) were spotted within the assessment area. While macroinvertebrate and amphibian data were collected in 2014, analysis has not been completed at the time of this writing.

GA 1430 - Located in the floodplain of the Oconee River, this area is characterized by a patchwork mosaic of upland systems bisected by 20-30 meter wide slough-like wetlands. The floodplain itself exhibits little evidence of management save for the dirt rtv roads that bisect the land; this particular wetland polygon was located within 50 meters of one such road. It appears that hunting is the principle anthropogenic use of the area. No hydrologic data is available, as access to the site was rescinded by the property owner shortly after the conclusion of the initial survey. The SSURGO maps classify soils in the area as a Tawcaw-Chastain-Congaree association. Soil profiles were generally found to be in the 10YR 5/1-7/1 range, with numerous redoximorphic features spotted throughout the profile. Most of the soil profiles exhibited a thin (3-4 cm) layer of mucky peat at the surface. Thirty-four species of vegetation were found in the assessment area, primarily dominated by Ostrya virginiana, Quercus michauxii, and Carpinus caroliniana. A moderate coverage (5-25%) of invasive species was found within the assessment area. No macroinvertebrate or amphibian data was collected at this site, due to access restrictions noted above.

GA 1380 - Site 1380 is located in the Southeastern Plains in Bulloch County, GA in the floodplain of the Ogeechee River. The assessment area is located near a silviculture management area, though the site itself showed few signs of recent anthropogenic disturbance. atv trails, ditching activity, and an actively managed field (perhaps for hunting purposes) were located within the

100 meter buffer region surrounding the wetland. Hydrology data showed water levels routinely within 10 inches of the surface, with brief periods of inundation (2-3 days) present, most likely due to overland flooding from the river. The SSURGO maps classify soils in the area as Bladen and Rains soils and swamp (typic fluvaquents). Soils were typically in the 10YR 6/1 range with a muck or peat layer of varying thicknesses at the surface. Thirty four vegetative species were identified within the assessment area, including Ulmus rubrum, Carpinus Caroliniana, Acer rubrum, and Quercus laurifolia. No invasives were found within the AA. While macroinvertebrate and amphibian data were collected in 2014, analysis has not been completed at the time of this writing.

GA 1065 - Site 1065 is located in the Southeastern Plains in Screven County, GA in the floodplain of McDaniels Creek within the Savannah River basin. The assessment area is located within the stream buffer zone, surrounded by thin (70-100 meters wide) silviculture stands to the north and south. Just beyond the stand to the north are managed agricultural fields; at the time of assessment, they appeared to have been used for row crops. Few disturbances were spotted within the assessment area. Hydrology data showed water levels routinely within 10 inches of the surface, with brief periods of inundation (2-3 days) present. Surface depths during the inundation periods ranged from 2-16 inches. The SSURGO maps classify soils in the area as Surrency mucky sand (Arenic Umbric Paleaquults). Soil was generally found to be sandy, with colors in the 10YR 3/1-6/1 range. The upper 5-7 inches of each soil profile were typically of a peat or mucky peat consistency. Thirty seven vegetative species were identified within the assessment area, including Liquidambar styraciflua, Magnolia virginiana, Acer rubrum, Boehmeria cylindrica, and Ampelopsis arborea. A moderate coverage (5-25%) of invasive species was found within the assessment area. While macroinvertebrate and amphibian data were collected in 2014, analysis has not been completed at the time of this writing.

GA 1434 - Site 1434 is located in the Southeastern Plains in Screven County, GA in the floodplain of McDaniels Creek within the Savannah River basin. The assessment area is located within the stream buffer zone, surrounded by thin (50-200 meters wide) silviculture stands to the north and south. Just beyond the stand to the north are managed agricultural fields; at the time of assessment, they appeared to have been used for row crops. Few disturbances were spotted within the assessment area. Hydrology data showed water levels routinely within 1 inch of the surface, with brief periods of inundation (2-3 days) present. Surface depths during the inundation periods ranged from 2-16 inches. The SSURGO maps classify soils in the area as Surrency mucky sand (Arenic Umbric Paleaquults). Soil was generally found to be sandy, with colors in the 10YR 6/1-7/2 range. The upper 4-10 inches of each soil profile were typically of a peat or mucky peat consistency. Forty vegetative species were identified within the assessment area, including Microstegium vimineum, Liquidambar styraciflua, Magnolia virginiana, Acer rubrum, Morella cerifera, and Ligustrum sinense. An extensive coverage 26-75%) of invasive species was found within the assessment area. While macroinvertebrate and amphibian data were collected in 2014, analysis has not been completed at the time of this writing.

GA 1376 - Site 1376 is located in the Southeastern Plains in Tattnall County, GA in the floodplain of Cedar Creek within the Ogeechee River basin. The assessment area lies within an approximately 200 meter wide section of relatively undisturbed floodplain, surrounded by silviculture and other various agricultural activities (primarily row crops). No major disturbances were found within the assessment area. Hydrology data show water levels routinely within 1-2 inches of the surface, with brief periods of inundation. At the time of initial assessment, pockets of surface water 8-10 cm deep were found throughout the assessment area. The SSURGO maps classify soils in the area as Osier (Typic Psammaquents). Soil was generally found to be sandy, with colors in the 10YR 2/1-4/1 range and redoximorphic features found throughout. The upper 5-15 cm of each soil profile were typically of a peat or mucky peat consistency. Forty vegetative species were identified within the assessment area, including Woodwardia areolata, Magnolia virginiana, Acer rubrum, Morella cerifera, and Nyssa Ogeche. A moderate coverage (5-25%) of invasive species was found within the assessment area. While macroinvertebrate and amphibian data were collected in 2014, analysis has not been completed at the time of this writing.

GA 1435 - Site 1435 is located in the Southeastern Plains of Screven County, GA in the floodplain of Ogeechee Creek within the Ogeechee River basin. The assessment area lies within a large (approximately 420 km^2), relatively undisturbed stand of forest. The stand is mostly surrounded by silviculture and various other agricultural activities; a small racetrack abuts the northeastern portion of the stand. Hydrology data show water levels within the upper 12 inches of the surface, with brief periods of inundation (1-7 days) occurring throughout the year. The SSURGO maps classify soils in the area as Kinston and Bibb (Typic Fluvaquents). Soil was generally found to be sandy in the upper 12 inches, with a color of 10YR 2/1 and redoximorphic features found throughout. The upper 2-5 in of each soil profile were typically of a peat consistency. Forty vegetative species were identified within the assessment area, including Lyonia lucida, Ilex opaca, Liquidambar styraciflua, Pinus taeda, Acer rubrum, and Vitis rotundifolia. Invasives were nearly absent (<5% coverage) within the assessment area. While macroinvertebrate and amphibian data were collected in 2014, analysis has not been completed at the time of this writing.

GA 1371 - Site 1371 is located in the Southeastern Plains of Miller County, GA in the floodplain of Big Drain Creek within the Flint River basin. The assessment area lies within a small tract of forest (.8 km^2) surrounded by intensive agricultural activity, consisting primarily of row crops with some silviculture to the southeast. Hydrology data shows long periods of inundation (3-6 months) at an average of 2-4 inches above the surface, with depths intermittently reaching as high as 15 inches for 1-2 days.   The SSURGO maps classify soils in the area as Grady (Typic Paleaquults). Soil was generally found to be of a very fine clayey consistency in the upper 12 inches, with a color of 10YR 2/1-3/1 and redoximorphic features found throughout. The upper 14-22 cm of each soil profile were typically of a mucky mineral consistency. Twenty-four vegetative species were identified within the assessment area, including Symphyotrichum pilosum, Nyssa sylvatica, Quercus virginiana, and Quercus Nigra. A moderate coverage (5-25%) of invasive species was found within the assessment area. While macroinvertebrate and amphibian data were collected in 2014, analysis has not been completed at the time of this writing.

GA 1378 - Site 1378 is located in the Southeastern Plains of Cook County, GA in the floodplain of the Little River within the Suwannee River basin. The floodplain consists of a mosaic of upland features containing numerous oxbow-like wetland sloughs, typically around 30 meters wide. Much of the upland portion of the area is being utilized for silviculture. In addition, atv trails are plentiful around the assessment area in order to facilitate hunting efforts. Hydrology data shows long periods of inundation, with a median surface depth of 4-5 inches throughout the year, and occasionally reaching depths of 16 inches. The surface water tends to recede during the fall, and returns in early winter. The SSURGO maps classify soils in the area as Osier and Pelham (Typic Psammaquents and Arenic Paleaquults). Soil was generally found to be of a sandy consistency, with a color of 10YR 2/1-6/2 and redoximorphic features found throughout. The upper 4-10 cm of soil were typically of a mucky peat texture. Thirty-six vegetative species were identified within the assessment area, including Acer Rubrum, Nyssa ogeche, Taxodium distichum, and Boehmeria cylindrica. A moderate coverage (5-25%) of invasive species was found within the assessment area. While macroinvertebrate and amphibian data were collected in 2014, analysis has not been completed at the time of this writing.

GA 1374 - Site 1374 is located in the Southeastern Plains of Tift County, GA in the floodplain of a 3rd order trib to Little River within the Suwannee River basin. The assessment area is located adjacent to an auto salvage yard. Debris, both automotive and residential in nature (i.e. tires, fast food containers, etc) were found throughout the area. Employees of the auto yard noted that the assessment area frequently floods due to overbank flow from the adjacent stream, so the residential debris may be deposited in the area during those flooding events. Invasive coverage, consisting mostly of Ligustrum sinense, was extensive throughout the assessment area. Hydrology data showed water levels generally at the ground surface throughout much of the year, with inundation events of 1-2 inches of surface water occurring regularly. The SSURGO maps classify soils in the area as Osier and Kinston (Typic Psammaquents and Typic Fluvaquents). Soil was generally found to be sandy with a color of 10YR 2/1 and redoximorphic features found throughout. The upper 3-6 inches of soil were typically of a mucky peat texture. Twenty-four vegetative species were identified within the assessment area, including Liriodendron tulipifera, Acer rubrum, Vitis rotundifolia, and Smilax smalii. While macroinvertebrate and amphibian data were collected in 2014, analysis has not been completed at the time of this writing.

GA 1414 - Site 1414 is located in the Southeastern Plains of Coffee County, GA in the floodplain of Little Creek within the Satilla River basin. The floodplain and stream is relatively narrow- on average 50-60 meters wide, total- and is surrounded by silviculture and an open field that appears to have recently been used for row crops. Some atv trails were found outside of the assessment area, as the land immediately north is utilized for hunting throughout the year. Hydrology data showed water levels within 2 inches of the surface on average throughout the growing season, with occasional periods of inundation as great as 15 inches recorded above the surface. SSURGO maps classify soils in the area as Pelham (Arenic Paleaquults). Soil was generally found to be sandy with a color of 10YR 4/1 and redoximorphic features found throughout. The upper 4-6 inches of soil were typically of a muck-mucky mineral texture. Fourty-one vegetative species were identified within the assessment area, including Ligustrum sinense, Cyrilla racemiflora, Nyssa biflora, and Quercus nigra. An extensive coverage 26-75%) of invasive species was found within the assessment area. While macroinvertebrate and amphibian data were collected in 2014, analysis has not been completed at the time of this writing.

GA 1059 - Site 1059 is located in the Southeastern Plains of Screven County, GA in the floodplain of Long Branch within the Ogeechee River basin. The wetland is surrounded by silviculture and land that has been cleared, but at the time of sampling did not appear to be utilized for any particular purpose. A dirt road borders the north end of the wetland area assessed, and likely contributes stormwater and sediment runoff into the wetland during rain events. Hydrology data showed water levels to be within 12 inches of the surface throughout the year, with brief periods of inundation measured to be as deep as 10 inches above the surface. It should also be noted that this is one of the few wetland sites in which water was observed within the soil pit while conducting soil profile measurements (13 -25 inches below the surface). Soil was generally found to be mucky or sandy, with a color of 10YR 2/1. Fourty-two vegetative species were identified within the assessment area, including Woodwardia areolata, Ligustrum sinense, Persea palustris, Acer rubrum, and Nyssa sylvatica. An extensive coverage 26-75%) of invasive species was found within the assessment area. While macroinvertebrate and amphibian data were collected in 2014, analysis has not been completed at the time of this writing.

GA 1372 - Site 1372 is located in the Southeastern Plains of Tattnall County, GA within the floodplain of Beard Creek of the Altamaha River basin. The stream and its associated wetland are surrounded by active row crops. In addition, dirt roads run parallel to the stream/wetland complex, and bisect it in several locations both upstream and downstream of the assessment area. As a result, some evidence of sedimentation was present within the system, but not enough to provide overwhelming evidence that the wetland was significantly impacted. Hydrology data showed water levels consistently within 12 inches of the surface, often within 2 inches from the winter to around the middle portion of the growing season. Brief periods of inundation as deep as 10 inches above the surface were recorded throughout the year. It should also be noted that this is one of the few wetland sites in which water was observed within the soil pit while conducting soil profile measurements (3 -11 inches below the surface). Soil was generally found to be of a mucky peat or sandy consistency, with colors commonly 10YR 2/1 or 7.5YR 4/1. Fourty-six vegetative species were identified within the assessment area, including Murdannia keisak, Boehmeria cylindrica, Cyrilla racemiflora, and Fraxinus pennsylvanica. A moderate coverage 5-25%) of invasive species was found within the assessment area. While macroinvertebrate and amphibian data were collected in 2014, analysis has not been completed at the time of this writing.

GA Bottomland Hardwood sites

GA 1347 - Site 1347 is located in the Piedmont of Fulton County, GA within the floodplain of Bear Creek of the Chattahoochee River basin. The wetland is mostly surrounded by forest, save for a large area (~30km^2) of recently clear-cut land at the time of sampling. Several relic ditches were spotted along the periphery of the assessment area, though there's no indication that they continue to have a significant impact on the wetland itself. Alluvial sediment deposits were extensive throughout the assessment area, represented as thick layers of sand within the soil profiles. Hydrology data showed water levels within the upper 12 inches of the surface throughout the year, with inundation of 1-1.5 inches above the surface occurring throughout the winter months. Occasional periods of flooding up to 19 inches above the surface were observed throughout the year, though these lasted for only 2-9 days at a time. The site is located within the mapped 100-year floodplain, and SSURGO maps classify soils in the area as a Cartecay-Toccoa complex, with an even ratio of Typic and Aquic Udifluvents dispersed throughout along with a small percentage of Wehadkee Fluvaquentic Endoaquepts. Soil profiles near the stream contained thick (30-50 cm) upper layers of sand mixed with humic matter such as leaves and twigs. The soil below the sandy layers were typically loamy/clay with a color of 10YR 6/1 – 4/2, with redoximorphic features found throughout. This site was also one of the few in the Piedmont in which water was visible within the soil pit, at an average depth of 20-50 cm. Forty-nine vegetative species were found within the assessment area, dominated by species with a wetland indicator status of FAC and FACW, such as Microstegium vimineum, Acer rubrum, Liquidambar styraciflua, and Fraxinus pennsylvanica. A moderate coverage (5-25%) of invasive species was found within the assessment area. During the winter amphibian survey, Marble, Slimy, Spotted, and Mole Salamanders were found in limited quantities, along with colonies of unidentified tadpoles within several of the ponded areas throughout the wetland. No species were found during the spring survey. Macroinvertebrates were not sampled due to the lack of sufficient aquatic habitat during sample visits.

GA 1338 - Site 1338 is located in the Piedmont of Muscogee County, GA within the floodplain of the Chattahoochee River. The wetland is located within the Standing Boy Creek State Park, which is open to limited hunting activities. Some trails and dirt roads were present around the assessment area, but no other evidence of recreation was present at the time of assessment. Silviculture activity was present within 150 meters east and west of the assessment area. Hydrology data showed periods of inundation to depths of 1-5 inches above the surface throughout the winter and into early May, with brief periods (10-15 days) of inundation to depths of 1-4 inches above the surface occurring during the summer months. The site is located within the mapped 100-year floodplain, and SSURGO maps classify soils in the area as a Chewacla-Wehadkee complex, with a majority of the soils classified as fluvaquentic Dystrudeps, with a small percentage of Fluvaquentic Endoaquepts present. Soil profiles within the assessment area generally consisted of soil that was clayey with high sand content, though not enough to prevent the formation of a clay ribbon. Much of the soil color found within these profiles were around 10YR 2/2, 4/2, or 3/2 with various redoximorphic features, although one profile's primary layer was closer to 10YR 4/3 than 4/2. Forty vegetative species were found within the assessment area, dominated by species with a wetland indicator status of FAC and FACW, such as Carpinus caroliniana, Betula nigra, Quercus nigra, and Vitis rotundifolia. A few obligates were found in not insignificant quantities, such as Smilax laurifolia. It should also be noted that ligustrum sinense, currently considered a FACU in the Piedmont, was present within the assessment area, and contributed to an extensive coverage (26-75%) of invasive species throughout. In addition, it is believed that the extended severe drought which occurred during the vegetation assessment allowed for small quantities of Callicarpa Americana and Asplenium platyneuron, both FACU emergents, to take root within the AA. The only amphibians spotted during either survey occurred during the winter, with colonies of unidentified tadpoles found within a couple of puddles within the wetland. Macroinvertebrates were not sampled due to the lack of sufficient aquatic habitat during sample visits.

GA 1316 - Site 1316 is located in the Piedmont of Cherokee County, within the floodplain of Mill Creek within the Coosa River basin. The assessment area is located in an low-lying region that is potentially more saturated than should be expected due to a sewer easement that runs parallel to the stream. It appears that the land was raised slightly when installing the pipeline, thus acting as a slight impediment to surface water drainage towards the stream. The wetland is surrounded by a relatively significant buffer of forest land (200-275 meters radius from the AA) given its location within suburban Atlanta. Hydrology data showed inundation present almost entirely throughout the year after the drought ended in 2013; during the winter, water levels reached as high as 13 inches above the ground surface, while the summer months saw depths from 5 inches below the soil surface to as high as 5 inches above. It should also be noted that this was one of the few sites in which subsurface water was observed during soil profile activities conducted in 2011, with water spotted 38-60 cm below the surface. The site is located within the mapped 100-year floodplain, and SSURGO maps classify soils in the area as a Chewacla-Cartecay complex, with the majority considered Aquic Udifluvents and Fluvaquentic Dystrochrepts, along with a small percentage classified as Wehadkee Typic Fluvaquents. Soil profiles presented clayey soils with colors typically at 10YR 4/2 with redoximorphic features present. Thirty-three species of vegetation were found within the assessment area, dominated by FACW species such as Platanus occidentalis, Cornus foemina, and Betula nigra. A moderate coverage (5-25%) of invasive species was found within the assessment area. Marbled Salamanders, Slimy Salamanders, and Leopard Frogs were found during the winter amphibian survey, while Red Spotted Newts, American Toads, and a suite of unknown tadpoles were found during the spring survey. Macroinvertebrates were not sampled due to the lack of sufficient aquatic habitat during sample visits.

GA 1296 - Site 1296 is located in the Piedmont of Morgan County, within the floodplain of Big Sandy Creek in the Oconee River basin. It is surrounded by several large tracts of land used for silviculture and hunting. Some evidence of active hunting, such as tree stands, was located within sighting distance of the assessment area. Also, there appeared to be evidence of what may have been relic ditches, though the property owner was unaware of any such activity on that portion of land. The nearest silviculture activity is about 80-100 meters east of the assessment area, though any effects from that activity are likely mitigated by the stream that bisects the land between the tree plantation and the assessment area. Unfortunately, due to restricted access from the property owner, no hydrology data is currently available. The assessment area is located within the 100 year floodplain, and SSURGO maps classify soils in the area as a frequently flooded Wehadkee loam (Fluvaquentic Endoaquepts). Soil was generally found to be clayey with heavy sand content, though not enough to prevent the formation of a ribbon greater than 1 in. Soil colorization was problematic, with most pits being close to meeting the indicator for red parent material (none were contained within the upper 30 cm of the surface). Twenty-eight species of vegetation were found in the area, with the majority classified as FAC for the Piedmont, such as Microstegium vimineum and Acer negundo. It should also be noted that, among the dominant species present, there was a relatively even distribution of FACU and FACW species, such as Fraxinus pennsylvanica and Chasmanthium latifolium. In addition, approximately 15% of the herbaceous coverage consisted of Polygonum hydropiperoides, an OBL in the Piedmont. This assessment occurred during a period of extreme drought; the adjacent stream at the time of assessment was nearly completely dry. Perhaps alternative access arrangements can be made in the future such that we may be able to collect further information on this assessment area during a year with more typical precipitation patterns. Cricket Frogs, unknown tadpoles, and an unknown Salamander larva was observed during the winter amphibian survey, while a Three-Lined Salamander, Cricket Frog, and Fowler's Toad were found during the spring survey. Macroinvertebrates were not sampled due to the lack of sufficient aquatic habitat during sample visits.

GA 1310 - Site 1310 is located within the Piedmont of Taliaferro County within the floodplain of Williams Creek in the Savannah River Basin. The wetland is located within a large tract of private property used primarily for hunting. Several dirt roads are disbursed throughout the region, one of which is approximately 60 meters east of the assessment area. In addition, beaver activity had created a large ponded area immediately to the south of the assessment area, but the property owners noted that the drought had resulted in it becoming completely dry by the time we conducted our assessment. Additionally, the dam supposedly had been abandoned not long before our arrival. Hydrology data showed water levels fluctuating between 6- 0.5 inches below the surface throughout the winter and into early May, along with occurrences of very brief flashes of inundation of approximately an inch. In addition, brief periods (7-14 days) of saturation to within 2 inches of the surface occurred during the mid-summer months of July and August. The assessment area is located within the 100 year floodplain, and SSURGO maps classify soils in the area as a frequently flooded Chewacla silt loam (Fluvaquentic Dystrudepts), with some Wehadkee soils (Fluventic Endoaquepts) found within the area. Soil profiles found clayey soils with a color of 10YR 2/1 to 6/1-6/2 and redoximorphic features found throughout. Forty-nine botanical species were found within the assessment area. The more dominant species were classified as FAC and FACW, including Quercus laurifolia and Liquidambar styraciflua. In addition, several OBL species were spotted, including Smilax laurifolia, Lycopus rubellus, and Murdannia keisak. It should also be noted that one FACU species, Ulmus alata, was found to cover approximately 10% of both the short and tall woody strata within the assessment area. A moderate coverage (50-25%) of invasives was found within the assessment area. Cricket Frogs and tadpoles of an unknown species were found during the winter amphibian survey, while Leopard Frogs were found during the spring survey. Macroinvertebrates were not sampled due to the lack of sufficient aquatic habitat during sample visits.

GA 1326 - Site 1326 is located within the Piedmont of Taliaferro County within the floodplain of Williams Creek in the savannah River Basin. The wetland lies within a large tract of private property used primarily for hunting. Several dirt roads are located throughout the property, one of which is approximately 120 meters west of the assessment area. Some hunting activity is evident around the assessment area, including the presence of hunting stands and man-made structures whose exact purpose is unknown. Hydrology data showed inundation of the area throughout the winter and spring, with water levels fluctuating between 2 inches below the surface and 6 inches above. This trend continues through mid-May, with brief periods (6-20 days) of saturation and inundation of up to 6 inches above the surface occurring during the mid-summer months of July and August. The assessment area is located within the 100 year floodplain, and SSURGO maps classify soils in the area as a frequently flooded Chewacla silt loam (Fluvaquentic Dystrudepts), with some Wehadkee soils (Fluventic Endoaquepts) found within the area. Soils profiles found clayey soils with a color generally of 10YR 6/2 to 7/1, with redoximorphic features found throughout. The pit nearest the stream was likely located in the berm area, as the color was closer to 10YR 3/3 and 6/4. Forty-five botanical species were found within the assessment area, with the more dominant species classified as FAC and FACW in the Piedmont, including Microstegium vimineum, Ulumus Americana, Acer rubrum and Liquidambar styraciflua. In addition, a few OBL species were spotted, including Dulichium arundinaceum. It should also be noted that two FACU species, Polystichum acrostichoides and Allium canadense, was found to cover approximately 10% and 5%, respectively, of the short emergent stratum within the assessment area. A moderate coverage (50-25%) of invasives was found within the assessment area. Cricket Frogs and a juvenile red spotted newt were found during the winter amphibian survey, while nothing was found during the spring survey. Macroinvertebrates were not sampled due to the lack of sufficient aquatic habitat during sample visits.

GA 1341 - Site 1341 is located in the Piedmont of Henry County, GA in the floodplain of Mackey Creek within the North Ocmulgee River basin. Although the immediate assessment area has few signs of anthropogenic activity- one small untended foot trail is within the AA, but little else- clear cut low density residential development lay less than 120 meters west of the AA. Chinese privet has basically overrun the entire undeveloped area, choking out any emergents that may otherwise grow within. In addition, some evidence of sedimentation is present, though it’s unclear if the source is alluvial deposition, stormwater runoff, or a combination of the two. Hydrology data shows evidence of saturation and inundation throughout the winter to early spring (late April), with water levels fluctuating between 5 inches below the surface to 7 inches above. In addition, brief periods of saturation/inundation (3-17 days) occur throughout the summer months. The assessment area is located within the 100 year floodplain, and SSURGO maps classify soils in the area as flood plain Cartecay soils (Aquic Udifluvents), with some presence of Wehadkee (Fluvaquentic Endoaquepts) also noted. Soil recorded within field profiles were generally clayey with a color of 10YR 5/1 to 5/2, with redoximorphic features found throughout. One pit may have been located near a depositional area, as the soils within were closer to 10YR 5/3 than 5/2. Twenty-six botanical species were found within the assessment area, with the understory dominated by Ligustrum sinense. The only other understory species with any significant coverage was Alnus serrulata (OBL), occupying 10% of the understory. The canopy was dominated by FAC and FACW species, including Liquidamabar styraciflua, Betula nigra, and Acer rubrum. In addition, some vines were recorded within the assessment area, including Smilax rotundifolia (OBL), campsis radicans (FAC), and Vitis rotundifolia (FAC). Cricket Frogs were found during the winter and spring amphibian surveys, while Southern Two-Lined Salamanders, a Fowler's Toad, and clusters of unknown tadpoles were also spotted during the spring survey. Macroinvertebrates were not sampled due to the lack of sufficient aquatic habitat during sample visits.

GA 1042 - Site 1042 is located in the Piedmont of Greene County, within the floodplain of Town Creek in the Oconee River basin. The site is located within the Oconee National Forest. Upon initial recon and assessment, there appeared to be some evidence of trails and a campfire on the periphery of the wetland area, but nothing within the AA itself. Thus, the original anthropogenic impact assessment determined that there may be loss of potential faunal habitat due to the absence of snags and dead woody debris (collected for the observed campfire). However, subsequent visits revealed camping and campfire activities present within the AA itself. Furthermore, our groundwater monitors were twice stolen; as such, there is no hydrology data for this site. It should be noted that the initial assessment was conducted during a period of extreme drought; Town Creek was completely dry during the assessment, and the property owner initially believed that a dam had been constructed upstream of his property, as he had never seen the stream go dry in his 30+ years of ownership of the land. The assessment area is located within the 100 year floodplain, and SSURGO maps classify soils as frequently flooded Chewacla silt loam (Fluvaquentic Dystrudepts), with some Wehadkee soils (Fluventic Endoaquepts) found within the area. Soils were generally clayey, though some sandy horizons were present, as well. One pit contained soil with colors of 10YR 3/2 and redoximorphic features found throughout; the remaining pits contained soils that either met, or were close to meeting, the Piedmont Flood Plain and Red Parent Material indicators. Thirty-six botanical species were observed in the assessment area; the dominant species observed are categorized as FAC, such as microstegium vimineum, Ulmus rubra, and Carpinus caroliniana. An extensive coverage of invasives were catalogued in the area, mostly attributed to Microstegium, which accounted for approximately 60% of the emergent coverage in the AA. Cricket Frogs were observed during the winter and spring amphibian surveys, while tadpoles of an unknown species were found during the winter survey, as well. Macroinvertebrates were not sampled due to the lack of sufficient aquatic habitat during sample visits.

GA 1336 - Site 1336 is located in the Piedmont of Monroe County, GA within the floodplain of Rocky Creek in the Ocmulgee River basin. It is located on private property that once served as farmland approximately 80-100 years ago, but has since been reclaimed by forest. As such, relic ditching was spotted around the assessment area, but they are not suspected to contribute to any hydrological impairment of the area. Natural cover is extensive around the wetland, with the nearest active development nearly 1 kilometer southeast of the AA. A silviculture plantation is located approximately 600 meters northeast of the AA. Hydrology data shows periods of sustained inundation up to depths of approximately 5 inches above the surface lasting throughout the winter to early spring, with the water table eventually dropping to greater than 12 inches below the surface by late May. In addition, brief periods (5-22 days) of inundation/saturation occur throughout the summer months. SSURGO maps classify the area as a frequently flooded Chewacla loam (Fluvaquentic Dystrudepts), with some Wehadkee soils (Fluventic Endoaquepts) found within the area. Soil profiles were inconsistent in their colorization. One pit's primary horizon was 10YR 5/1 with redoximorphic features present. Another contained a horizon with 10YR 3/2 with multiple redoximorphic features. A third contained a large horizon with colors almost evenly distributed between 5YR 6/1 and 2.5YR 3/4; after much debate, it was decided that the 2.5YR 3/4 was maybe more prevalent, but only slightly so. The fourth pit contained a large layer colored to 7.5YR 4/3 with redoximorphic features present, meeting the Piedmont floodplain indicator but little else. Twenty-five botanical species were observed in the assessment area, and were dominated by FAC and FACW species such as Fraxinus pennsylvanica, Acer rubrum, and Liquidambar styraciflua. A moderate (5-25%) coverage of invasive species was found within the assessment area. During the winter amphibian survey, Cricket Frogs, Spotted Dusky Salamanders, Southern Two-Lined Salamanders, and a Fowler's Toad were found in and around the AA. Cricket Frogs and Dusky Salamanders were spotted during the spring survey. Macroinvertebrates were not sampled due to the lack of sufficient aquatic habitat during sample visits.

GA 1050 - Site 1050 is located in the Piedmont of Henry County, in the floodplain of Mackey Creek within the Ocmulgee River basin. It is located on private property near the base of a very steep slope, upon which sits a newly built residential community. The property owners complained of occasional sediment and stormwater runoff occurring during construction. The owners use the wetland area for hunting, and signs of tree stands and atv use throughout the area are evident. A significant maintained power line right-of-way is situated 80 meters west of the AA. Hydrology data shows that, save for a 12 day period in late-May-early June, the water table levels reside in the upper 12 inches of the soil surface throughout the year, residing 2-3 inches below the surface, on average. The assessment area is located within the 100 year floodplain, and SSURGO maps classify soils as floodplain Cartecay soils (Aquic Udifluvents) with some Wehadkee soils (Fluvaquentic Endoaquepts) found within the area. Soils were clayey with a general color of 10YR 5/1 to 6/2, with redoximorphic features present throughout. Of note was the westernmost pit, which contained an upper layer 27 cm thick of 10YR 3/4, below which lay an extended layer of 7.5YR 5/1. It's possible this area was subject to extensive sediment deposition that the property owners mentioned during the initial reconnaissance discussion. Fifty-one botanical species were observed within the AA, dominated by species classified as FAC and FACW, such as Betula nigra, Liquidambar styraciflua, and Lonicera japonica. A couple of FACU species, namely Ligustrum sinense and Ulmus alata, were found to occupy close to 15% of the assessment area within their respective strata levels. An extensive (26-75%) coverage of invasives were found within the AA. Cricket Frogs were the only species observed during the winter and spring amphibian surveys. Macroinvertebrates were not sampled due to the lack of sufficient aquatic habitat during sample visits.

GA 1363 - Site 1363 is located in the Piedmont of Cherokee County, GA in the floodplain of Little River within the Coosa River basin. The assessment area is located downhill of a recently completed baseball complex. Some ephemeral trails exist throughout the assessment area, though it appears that most of the public likely elects to stay on the periphery of the wetland as the trails around the system appear well-trodden in comparison. Based on the proliferation of standing dead and dying trees in and around the AA, it is believed that an increase in overland flow to the floodplain (likely do to stormwater runoff from the aforementioned complex) may be slowly converting the wetland from a seasonally saturated PFO1A to what may eventually be a frequently flooded emergent-dominated system. In an effort to try to characterize this transition, the assessment area was placed such that it partially encompassed both the heavily saturated area as well as the transitional (possibly berm) region between it and the receiving stream, which is reflected in the soil pit and vegetation surveys. Hydrology data shows sustained saturation/inundation throughout the year, with water levels at 1-5 inches below the surface. Flashes of inundation (1-7 days) were recorded throughout the year, as well, perhaps due to a deluge of stormwater runoff during rain events. The assessment area is located within the 100 year floodplain, and SSURGO maps classify soils as a floodplain Chewacla (Aquic Udifluvents)-Cartecay (Fluvaquentic Dystrochrepts) complex, with some Wehadkee soils (Fluvaquentic Endoaquepts) found within the area. Soils were somewhat confounding; one pit's dominant horizon was determined to be colored as 10YR 5/2, though that lay underneath close to 19cm of red material, implying active sedimentation occurring in the area. This was even more evident in the remaining pits, which typically met or came close to meeting the indicators for Piedmont flood plain or red parent material indicators. Of additional interest is that one pit with primary horizons of red parent colorization (10YR 5/3 and 7.5YR 4/3) was actually found to have water within 14 cm of the surface. Forty botanical species were found within the AA, dominated by Commelina communis (FAC), with higher-than average populations of Ligustrum sinense (FACU invasive), Platanus occidentalis (FACW), Quercus nigra (FAC), and Carya glabra (FACU) also noted. A moderate (5-25%) coverage of invasives were found within the AA. The winter amphibian survey yielded observations of Marbled Salamanders, Leopard Frogs, Bronze Frogs, Chattahoochee Slimy Salamanders, and egg masses of an undetermined species. Slimy Salamanders were found during the spring survey. Macroinvertebrates were not sampled due to the lack of sufficient aquatic habitat during sample visits.

GA 1348 - Site 1348 is located in the Piedmont of Paulding County, GA in the floodplain of Pumpkinvine Creek within the Coosa River basin. The assessment area is located near the base of steep slopes, upon which several developments are situated. A county park is located to the southeast, with a large gravel and asphalt parking lot situated near the crest of the hill. A medium-density residential area was under construction on the hill northeast of the AA. Most of the lots close to the edge of the hill's downslope had been cleared, but no construction had commenced at the time of assessment. Sediment input from the surrounding slopes is evident, as piles of what appear to be freshly lain sand/soil appear throughout the area. Hydrology data shows saturation to within 9-10 inches of the surface throughout the winter and spring through late May, with very brief (1-2 days) flashes of inundation occurring throughout. In addition, brief periods (14-16 days) of saturation to 10-11 inches below the surface occur throughout the summer. The assessment area is located within the 100 year floodplain, and SSURGO maps classify soils as a floodplain Cartecay sandy loam (Aquic Udifluvents), with some Wehadkee soils (Fluvaquentic Endoaquepts) found within the area. Soil profile characterization was somewhat problematic. Two pits readily met hydric indicators, containing large horizons with colors of

10YR 5/1 and 4/2, with multiple redoximorphic features found throughout. One pit met the indicator for Piedmont flood plain soils. The final pit contained a clay upper horizon of 10YR 3/2 to 3/3, though with some debate it was decided to lay more towards 3/3 than 3/2. This overlay a thick (42cm) horizon that was almost entirely sand. After some observation of the area, it was decided that this pit was located in an area of heavy overland deposition. Twenty-nine botanical species were found within the assessment area, dominated by stands of Ligustrum sinense, which has more or less taken over the entire understory. Some patches of Pilea pumila (FACW) occupied areas that the privet had yet to conquer, and accounted for approximately 20% of the understory coverage in the assessment area. The canopy consisted primarily of Platanus occidentalus (FACW), Fraxinus pennsylvanica (FACW), Acer negundo (FAC), and Betula nigra (FACW). Mole, Marbled, and Northern Slimy Salamanders were spotted during the winter amphibian survey, along with cricket Frogs. Only a single American Toad was found during the spring survey. Macroinvertebrates were not sampled due to the lack of sufficient aquatic habitat during sample visits.

GA 1323 - Site 1323 is located in the Piedmont of Heard County, in the floodplains of Town Creek within the Chattahoochee River basin. The system, located on private property, is surrounded by heavy anthropogenic activity. The southern edge is bordered by a recently thinned area (some of the canopy was left standing) designed to accommodate the property owner's RVs and horse trailers. It appears that the wetland under assessment perhaps occupied the majority of the area cleared. The assessment area is situated near the base of a steep hill; the top and sides of which are covered in pine silviculture. The pine trees have slowly crept down the slope and are beginning to encroach into portions of the wetland area. A two-lane asphalt road is located due east of the assessment area. Its effects on the wetland (in the form of sediment accumulation, most likely runoff occurring during construction/maintenance) are evident in the easternmost soil pit. Finally, recently dug ditches lined the southern end of the wetland, presumably to divert any water that would otherwise run down the hillsides, past the wetland area, and into the recently cleared area. Hydrology data shows saturation within 1-3 inches of the surface throughout the winter, spring and summer, with the water table dropping to greater than 15 inches below the surface in early-mid September. Numerous periods of inundation of approximately an inch above the surface were also observed throughout the year. SSURGO maps classify soils as a floodplain Riverview loam (Fluventic Dystrudepts). Most of the soil pits have a 1-9 cm thick layer of organic material at the surface, underlain by a layer of 10YR 4/2 clay with multiple redoximorphic features present. Two of the pits contained sandy horizons beneath the darkened clay and organic layers. One pit contained horizons that come close to meeting the depleted matrix (F3) indicator, but did not quite seem to be thick enough to qualify. Thirty-eight botanical species were present in the assessment area, dominated by Microstegium vimineum (FAC), Acer rubrum (FAC), Pinus elliotti (FACW), and Liquidambar styraciflua (FAC). In addition, 10% of the understory was occupied by Itea virginica (OBL). An extensive (26-75%) coverage of invasives were found within the assessment area. Massive quantities of tadpoles and egg masses were found in the drainage ditches around the wetland during the winter amphibian survey. Numerous Cricket Frogs were heard during the spring survey. Macroinvertebrates were not sampled due to the lack of sufficient aquatic habitat during sample visits.

GA 1333 - Site 1333 is located in the Piedmont of Greene County, in the floodplain of Richland Creek within the Oconee River Basin. This wetland sits on a parcel owned by a timber company; as such, most of the surrounding land not part of a stream buffer or considered wetland is occupied by planted pine. The closest stand is about 70 meters north of the assessment area, at the top of a steep slope. Other silviculture stands are located to the west and southwest. When surveying the area, there appeared to be a portion of the wetland that contained evidence of a higher frequency of saturation/inundation than other portions of the system. Therefore, two water table monitoring wells were installed, and the assessment area was placed in order to incorporate both potential hydrologic regimes. The hydrology in the more "wet" portion of the wetland in 2013 appears to encompass periods of saturation throughout the winter and spring months lasting anywhere from 10-28 days. During these periods, inundation of the area lasts anywhere from 3-13 days at a depth of up to 15 inches above the surface, though the average depth was closer to 5 inches above the surface. In addition, periods of saturation and inundation occurred for 5-17 days during July and August. 2014 showed hydrology in the winter to be a more constant level of saturation to within 2-3 inches of the surface with periods of inundation of 5-6 inches above the surface occurring for 1-2 days at a time. This trend continued through the well's retrieval on 3/31. The hydrology of the more "dry" well in the system showed fewer periods of saturation in 2013, with water levels within 12 inches of the surface occurring only 13-14 days at a time during the winter and spring months, and inundation up to 8 inches above the surface lasting only a day or so. 2014 saw a more sustained level of saturation during the winter, but the well was retrieved just prior to the onset of spring, so it is unknown how long this trend would have continued into the spring. The assessment area is located within the 100 year floodplain, and SSURGO maps classify the soils as frequently flooded Chewacla (Fluvaquentic Dystrudepts) and Congaree (Oxyaquic Udifluvents), with some Wehadkee soils (Fluvaquentic Endoaquepts) found within the area. Soils were generally 10YR 5/2 to 6/2, with redoximorphic features found throughout. Forty-five botanical species were found within the assessment area, dominated by FAC and FACW species such as Acer negundo, Fraxinus pennsylvanica, Boehmeria cylindrica, and Commelina communis. An extensive (26-75%) coverage of invasives were found within the assessment area. Cricket Frogs, a marbled Salamander, and a host of tadpoles of an unknown species were observed during the winter amphibian survey, while bronze Frogs were spotted during the spring survey. Macroinvertebrates were not sampled due to the lack of sufficient aquatic habitat during sample visits.

GA 1324 - Site 1324 is located in the Piedmont of Gwinnett County, GA in the floodplain of Big Haynes Creek within the North Oconee River basin. The site is surrounded by medium-density residential development such that it likely receives heavy volumes of stormwater runoff during rain events. The midpoint of the assessment area is a mere 50-60 meters from the nearest residential clearing. The receiving stream has been impounded in a couple of locations near the assessment area; one is most definitely the result of beaver activity, while the other, larger impoundment is a reservoir for purposes currently unknown. Hydrology data showed that, once drought conditions eased in early 2013, the assessment area was saturated throughout the winter in spring, with water levels fluctuating to 5-10 inches below the surface. This was punctuated by periods of inundation of up to 7 inches above the surface, typically lasting for 6-14 days. This trend continues until the well's retrieval in July of 2013. The assessment area is within the 100 year floodplain, and SSURGO maps classify the area as frequently flooded Chewacla silt loam (Fluvaquentic dystrudepts), with some Wehadkee soils (Fluvaquentic Endoaquepts) found within the area. Soils were generally 10YR 4/1 to 5/1, with redoximorphic features found throughout. A few of the soil surveys noted an organic layer at the surface, typically 10-14 cm thick. Fifty-six botanical species were found within the assessment area, though portions of the wetland were largely overrun with ligustrum sinense. Of the emergent species that were able to survive under the cover of the privet, the most common were FACW species Woodwardia areolata and Impatiens capensis. The most common canopy species were Acer rubrum (FAC) and Nyssa sylvatica (FAC). Obligate species were found in small quantities throughout the assessment area (3-10% coverage of the AA per species), such as Peltandra virginica, Lycopus virginicus, Viburnum nudum, and Smilax laurifolia. Due to the prevalence of privet, invasive coverage was extensive throughout the area. Southern Chorus Frogs and egg masses of an unknown species were noted during the winter amphibian survey, while Bronze Frogs, Three-Lined Salamanders, and an American Toad were found during the spring survey. Macroinvertebrates were not sampled due to the lack of sufficient aquatic habitat during sample visits.

NWCA 2011 sites

Since the national survey was performed by each of the four states that participated in this project just the year before, additional sites were chosen from the national survey to be included in the regional analysis. Sites that were classified as forested wetlands in the 2011 survey were screened using aerial photographs. From this preliminary screening, forested wetlands were selected that could be classified as bottomland hardwood forests in ecoregion 45 and as riverine swamp forests in ecoregion 65. A total of 40 sites were selected that included 22 riverine swamp forests and 18 bottomland hardwood forest in their respective ecoregions. Including these additional 40 sites increased the sample size for many of the parameters measured, yielding a stronger regional analysis.

SAMPLING AND ANALYSIS METHODOLOGY

Level I: GIS Assessment

A Land Development Intensity Index (LDI) value was calculated for each site's watershed using a method similar to that described in Brown and Vivas (2003). The LDI value estimates the potential impacts from anthropomorphic influences on land cover by evaluating land cover in a designated area. LDI values are essentially human-related disturbance scores that are associated with intensity of the land-use based on non-renewable energy flow. US Geographical Survey topographical quad maps were used to determine the watershed boundaries for each site. Watershed size differed radically from site to site. Therefore, when a site's watershed extended upstream from an AA by more than 20 square miles, the area for LDI analysis was limited to 20 square miles. However, when a site watershed was less than one square mile in area, the area for LDI analysis was expanded to encompass a circle (upstream) of one square mile. The result was LDI areas of analysis varied from one to 20 square miles.

Once the area for LDI watershed analysis was determined, land use information was obtained from the 2006 National Land Cover Database GIS layer. Aerial extent of each land cover type within the area of analysis was calculated using GIS, then visually verified against the most recent aerial images available, and assigned a land cover type value (see Table 3). The following equation was used to determine the Land Use Index value for the watershed of each site.

$$LDI_{Total} = \sum(\%\mathrm{Lu}_i * \mathrm{LDI}_i)$$

LDI_{Total} = LDI ranking for landscape unit
$\%Lu_i$ = percent of the total area of influence with land use i
LDI_i = LDI coefficient for land use i

Table 3: Wetland Land Cover Type and Index Values

Land Cover Types	LDI Coefficient
Natural Land	1
Natural Water Bodies	1
Unmanaged Herbaceous Land (grass; marshland; woodland pasture; regenerated cutovers)	2
Managed Herbaceous Land (pasture; recent cutovers/logged)	3
Pine Plantation	3
Agriculture/Cultivated Crops	5
Low Intensity Developed (single family residential; 2 lane roads, etc.)	6
High Intensity Developed (commercial; multifamily residential; highways; industrial)	8

Higher LDI Index values indicate land use for the given watershed was more heavily impacted by human usage.

Level II Rapid Assessment

North Carolina Wetland Assessment Method (NCWAM)

The newly developed North Carolina Wetlands Assessment Method (NCWAM) was performed on each wetland study site (http://portal.ncdenr.org/web/wq/swp/ws/pdu/ncwam-manual for a copy of the NCWAM form and NCWAM Dichotomous Key to General NC Wetland Types). NCWAM is a Level II, rapid assessment of wetlands based on functional value. The primary objective of NCWAM was to provide an accurate, rapid assessment of wetland function requiring no more than 15 minutes of on-site time. The development of NCWAM occurred over a six year period with participation from the NC Division of Water Quality, NC Department of Transportation, NC Natural Heritage Program, US Environmental Protection Agency, the US Army Corps of Engineers, the US Federal Highways Administration, US Fish and Wildlife Service, NC Wildlife Resource Commission, and the NC Ecosystem Enhancement Program which made up the Wetlands Functional Assessment Team (WFAT). NCWAM depends on wetland type to assess function. Therefore, 16 general wetland types were defined by WFAT and a dichotomous key was developed to help the assessor determine the correct wetland type.

Three functions are assessed by the method; hydrology, water quality, and habitat. The hydrology function is further broken down into surface and subsurface storage capacity and retention. The water quality function is assessed by the sub-functions of pathogen, particulate, soluble, physical, and pollution changes. Finally, the habitat function uses the sub-functions of physical structure, landscape patch structure, and vegetation composition. A single form is filled out by the assessor, which includes office time (GIS, map consultation for some of the metrics) and field time. Several scores are generated from the completed form which is entered into a Excel spreadsheet that calculates the results. Each score is assigned to a category of “high”, “medium”, or “low”. An overall score the rates the wetland area, and the three major functions are also rated. NCWAM also contains opportunity metrics, which are also scored high, medium, or low. Opportunity metrics are an assessment of the ability of the wetland to perform a function based on watershed condition. The opportunity metrics are not automatically used to calculate any of the function scores or overall score, but are provided as additional information for the assessor to use at his/her discretion as the underlying regulatory structure allows or requires.

Ohio Rapid Assessment Method (ORAM)

The Ohio Rapid Assessment Method v.5.0 (Mack, 2001, http://www.epa.state.oh.us/portals/35/401/oram50sf_s.pdf, for copy of ORAM form) was used for the Level II monitoring and to calculate a disturbance score for each of the wetland sites which is described further in Section XX. ORAM is an existing conditional evaluation tool that was suggested for use by the EPA since ORAM had been used in Ohio since 2001. ORAM contains six rapid assessment metrics: 1. wetland area, 2. upland buffers and surrounding land use, 3. hydrology, 4. habitat alteration and development, 5. special wetlands, 6. plant communities, interspersion, and microtopography. Metric 5, which was specific to Ohio wetlands, was not used in the assessment. The maximum score for a high quality wetland is 90 without the use of metric 5.

ORAM has not been specifically calibrated to any of the states in this study. However, the five metrics that were used (wetland area, upland buffer and surrounding land-use, hydrology, habitat, and plant communities) are believed to be important factors in determining the quality of Southeast wetlands.

USA-Rapid Assessment Method (USA-RAM)

USA-RAM is a wetland rapid assessment method developed by Collins and Fennessy (see EPA, National Wetland Condition Assessment, Field Operations Manual, 2011, http://water.epa.gov/type/wetlands/assessment/survey/upload/FOM-with-Errata.pdf) to be use with the National Wetland Condition Assessment (NWCA) in 2011. One of the objectives of developing USA-RAM was to serve as a national wetland rapid assessment method and as a starting point for states or regions that wanted to develop wetland rapid assessments. USA-RAM was used in this study as a third rapid assessment to attempt to validate some portions of the method and to understand its value as designating a disturbance gradient. In terms of our use of USA-RAM, we found that the stressor portion to be useful in our analysis whereas the condition portion was more problematic in its usefulness. We also developed our own scoring method for the stressors, partly because the official scoring method was not complete at the time of our analysis, and because we saw a way to utilize the stressor scores in our analysis.

Level III: Intensive Survey Methodology

Field data were collected on water quality, hydrology, soils, amphibians, aquatic macroinvertebrates, and plants. The following provides a brief description of the methods, which are described in detail in the following sections. Note that some of Georgia's sites were on a shifted time frame of approximately a year later from the times given below for NC, SC, and AL.

1. **Water Quality** – Water quality was monitored quarterly for 18 months from approximately January 2012 to mid-2013. The goal was to sample six times. The pH, dissolved oxygen, specific conductivity, and temperature were taken each quarter and water samples are collected for total suspended solids, fecal coliform (optional), nutrients (NO_2+NO_3, phosphorous, ammonia, and total Kjeldahl), metals (lead, copper, zinc, calcium, and magnesium), total organic carbon, and dissolved organic carbon. Water quality was typically collected from two stations at the riverine swamp sites ("upstream" and "downstream") and two stations in the bottomland hardwood sites ("upstream" and "downstream" stations) if that could be determined. Water samples were (filtered if needed) preserved with acids as required by the appropriate water chemistry lab. There were some differences in exactly what parameters were analyzed by the states, but there was overlap where the data was combined.

2. **Hydrology –** Hydrological data was collected at each site from one two-foot deep surface water monitoring wells for 18+ months from approximately January 2012 to mid-2013. Typically one automated well was installed at each RSF and BLH site.

Automated well were outfitted with Level Troll 500 vented pressure transducers (or similar device). Data from the pressure transducers were collected in the field and downloaded to a spreadsheet program every three months. Pressure transducer water level readings were always field proofed with measurements taken by hand every other download.

3. **Soils** – Four soil station/pit locations were dug within the wetland Assessment Area (AA, following the National Wetland Condition Assessment (NWCA) protocol) and additional station/pit locations were dug within the upland of the Buffer Area (BA) in the sites to a terminal depth of 60 cm. Each soil station/pit location were examined in the field for the number of horizons and color, texture, depth of each identified horizon, and presence or absence of hydric soils indicators. Soil samples were collected from sampleable horizon (defined as 8 cm or greater in depth) from one representative soil station/pit location or two soil station/pit locations if necessary to properly characterize the wetland site. A maximum of two soil station/pit locations were utilized to collect soil samples from the sampleable horizons within the wetland assessment area plus the upland of the BA for the sites. Soil samples were analyzed for nutrients (phosphorus, nitrate, nitrogen, potassium, calcium, magnesium, and sodium), metals (also called micronutrients- manganese, zinc, and copper), weight/volume, exchangeable acidity, sum of the cation, cation exchange capacity, base saturation, and humic matter. There were some differences in what was analyzed by GA and by AL, but there was overlap where the data could be combined.

4. **Amphibians** – A semi-qualitative amphibian survey of approximately three (3) man hours per site was performed in February/March and May/June of 2012. The survey started in the assessment area and expanded out into the wetland as time permitted. All visual and auditory observations of amphibians were recorded. Voucher specimens and / or photographs were taken for identification and record purposes for all captured amphibians adults and larvae that are not identifiable in the field. Dip-nets for standing water areas and potato rakes for moving logs were also used with the amphibian survey work.

5. **Aquatic macroinvertebrates** – Up to five (depending on the specific site conditions which may limit the number of sampling stations) macroinvertebrate sample stations were established at each site. Macroinvertebrate samples were collected with sweep nets and funnel traps (optional) in March of 2012 in conjunction with the amphibian survey.

6. **Plants** – A quantitative survey was conducted during the spring or summer of 2012 using methodology derived from the NWCA. This methodology included surveying the presence and coverage of all plant species and diameter at breast height of the woody species. In addition, habitat and microhabitat characteristics were evaluated in each plot.

7. **Monitoring Wells and Transducers** – PVC tubing was installed to a depth of two feet into the ground at the center point of the assessment area. The bottom 18 inches was slotted screening so water could flow through and the bottom was capped. The height of the PVC pipe above the ground varied depending on the water depth above the surface during the wet season. The transducer was hung from near the top of the PVC pipe (about 1.5 to 2 inches from the top, below the cap) so that the transducer was about one-half to one inch from the bottom. The transducer was set to measure "depth to water".

Vegetation Data Collection

The vegetation sampling, observations and associated protocols developed for the NWCA was based on the flexible-plot method of Peet et al. (1997), adapted to meet the objectives and data collection needs of the NWCA (NWCA Field Operations Manual (FOM), 2010). Vegetation sampling took place in five 100-m^2 plots arranged systematically across the Assessment Area (AA). The FOM Vegetation Chapter includes detailed instructions for establishing the vegetation plots in standard or alternate configurations. Vegetation composition, abundance and structure were assessed at the 100-m^2 scale. Each plot contained a series of nested quadrats established in two opposing corners to obtain estimates of species diversity, based on species presence at multiple spatial scales (1.0 m^2 and 10m^2).
To optimize vegetation characterization, field sampling for this project took place during the peak growing season when most vegetation was in flower or fruit. Sampling during this period minimized seasonal phenological variability and enhances plant species identification accuracy, particularly of difficult species such as grasses and sedges. Although some early ephemeral flowering forbs may have been missed by not sampling early in the season, most plant species were in mature reproductive stages and more readily detected during peak growing season.

Data sheets used were similar to those used for the NWCA data collection.

Sampling Activities

All measurements and observations were recorded on standardized forms.

Table 4 provides a brief summary of observations recorded by the Vegetation Team.

Table 4: Field measurement methods: vegetation

Variable or Measurement	Units	Summary of Method
Vascular strata coverage	%	Estimate total cover of emergent and non-aquatic vegetation by height class (< 0.5, 0.5-2, 2-5, 5-15, 15-30, >30 m, or liana, vines, and epiphytes), submerged aquatic vegetation and floating aquatic vegetation
Non-vascular coverage	%	Estimate percent cover for non-vascular taxonomic groups (bryophytes, ground lichens, arboreal epiphytic bryophytes and lichens, filamentous or mat-forming algae, and macro algae)
Individual vascular coverage	%	Estimate percent cover for each species and record the predominant height class in which it occurs
Ground surface attributes: coverage	%	Estimate cover of water, bare ground, vegetative litter, and dead woody debris
Ground surface attributes: depth	cm	Measurements for water (minimum, predominant, and maximum depth) and vegetative litter
Tree coverage	%	Estimate percent cover for each species by height class (< 0.5, 0.5-2, 2-5, 5-15, 15-30, >30 m)
Tree count	None	Count stems for individuals >5 cm diameter breast height (dbh) by diameter class (5-10, 11-25, 26-50, 51-75, 76-100, 101-200 and > 200 cm), by species
Standing dead trees and snags	None	Count total number of stems >5 cm dbh by diameter class (5-10, 11-25, 26-50, 51-75, 76-100, 101-200 and > 200 cm), by species
Species presence data	None	For each species present, record the smallest quadrat in which it occurs

Nomenclature:

The USDA PLANTS nomenclature was the authority used for standardizing plant scientific names (USDA, NRCS. 2013).

Collecting Plant Material for Specimens:

Throughout each sampling day, the Botanist/Ecologist and Botanist Assistant collected all unknown plant species and five known plant species (randomly selected from species identified in the 100-m^2 vegetation plots) from the site. Specimens were carefully labeled with tracking information and placed in a plant press to dry. Rare plants were not collected.

Amphibian Field Monitoring

Many amphibian species are sensitive to environmental disturbances and act as indicators of the quality of their surroundings (US EPA 2002b). The Southeast is home to a large number of amphibian species. North Carolina alone has 96 species of amphibians and is known for its diverse population of salamanders, boasting more than any other state in the Union with 54 salamander species (Braswell 2006). Deforestation and the increase of acidic conditions and pollutants such as nitrogen and heavy metals can affect these environmentally sensitive species (US EPA 2002a; Smith et al. 1994; Wilson et al. 2003). Most amphibians spend part of their life in water and part on land or even in subterranean habitats, which consequently makes surveying especially difficult except during the yearly breeding season. Some species of amphibians can reproduce in farm ponds, lakes, ditches, puddles, or rivers, while other species have more specialized requirements, needing mature forested wetland areas that have good water quality and lack predatory fish. These conditions can occur in these wetlands. Continued loss of these critical habitats in the Southeast has the potential to affect population diversity and survival of these unique and sensitive species.

A qualitative survey for amphibians was performed twice at each wetland site during March and again in June 2012. Typically, three man-hours of survey work were conducted at each site in Febuary/March and May/June. Seasonal weather patterns that encourage spring breeding (2-4 nights of >45^{o}C with rain) will be used to determine the exact timing of the February-March survey.

Sites were systematically searched for amphibians with the use of dip nets and potato rakes. Sweep nets were used to search for amphibians (frogs, tadpoles, egg masses, and larval salamanders) in areas with standing water. The potato rakes were used to turn over logs, woody debris, and leaves in the wetland and surrounding upland buffer area (no more than 200m from wetland). Leaf debris adjacent to wetlands was lightly scraped to search for salamanders. Moss hammocks overhanging water or within a few feet of water were searched by for cavities and peeled back on three sides and replaced to search for female salamanders guarding eggs. Crayfish holes were also searched for salamanders. All auditory frog calls were noted and recorded. The macroinvertebrate survey was generally performed on the same day in March as the amphibian survey. All amphibians collected at the macroinvertebrate stations either in a funnel-trap or a sweep net were also recorded on field sheets.

Amphibian Wetland Monitoring Field Sheets (field forms used by NC DWQ Wetlands Monitoring (Baker et al. 2008; Savage et al. 2010)) were completed for both the February/March and May/June amphibian sampling survey events. Information on the field data sheets included site name, county, observers, date, start and stop time, water quality parameters, current air temperature, wind speed, percent cloud cover, air temperature range and rain in last 48 hours, comments on the hydrology of the site, and a table with records for each separate observation. Each record included species, life-stage, the number observed, specimen number, photo number, and comments on microhabitat, behavior, malformations, auditory or visual observation, identification information. The previous 48-hour precipitation and temperature minimum and maximum levels were taken from the nearest weather stations and recorded on field sheets. Usually surveys were avoided when temperatures were below 4.4^{o}C (40^{o}F) the previous night or below 15.6^{o}C (60^{o}F) during the survey. Air temperature was taken on site and recorded during the survey. All amphibians were identified in the field if possible. All specimens collected for identification were donated to the NC State Museum of

Natural Sciences herpetology collection.

Macroinvertebrate Field Methods

Macroinvertebrates were sampled in conjunction with the amphibian survey in March of 2012. Each site was first scouted for appropriate sample station locations with the goal of finding variable microhabitats. Typically up to five macroinvertebrate stations were sampled at each site with a sweep net.

The Macroinvertebrate Sampling Field Sheet was completed for each site sampled. Basic site and sampling information was recorded. The physical water quality parameters of water temperature and pH were also recorded on the field sheet. Station description information was recorded on each macroinvertebrate field sheet. Station description information included the appropriate Sample ID Number, location (middle or edge of the wetland), flow rate, pool / stream, stream width, depth, percent vegetation cover, percent shade, and substrate texture. Flow Rate (No Flow, Slow, Med, Fast) at most sites was typically "No Flow" or "Slow". For pools, the width x length was estimated and for streams only the width was recorded (i.e. continuous water in stream bed). The "percent vegetation", "percent shade", and "substrate texture" solely referred to the microhabitat where the macroinvertebrate sample stations were located**.** GPS was used to record the location of the sampling stations. Photos were also taken of each sample station. Sample methods for funnel traps and sweep nets are described in the following sections.

SWEEP STATIONS

Sweep nets, or dip nets, are another semi-quantitative method that is quick and easy to use. They can collect a diverse array of representative taxa and are usable in very shallow water. Unlike funnel traps, sweep nets are not as useful for collecting motile and nocturnal species, require a longer processing time, and may result in user variability (US EPA 2002c). In order to ensure more semi-quantitative results, D-shaped nets (600-micron) were used to sweep a 1-meter area with 3-4 sweeps per station. Sweep net stations were conducted using sweeping or jabbing motions with the net to maximize the area of suitable microhabitat covered. The leaf and woody materials were then elutriated from the net, and a visual search of leaf packs and woody debris was made before discarding. The sample was then put in a labeled container. Sweep nets were rinsed thoroughly between wetland study sites.

Rose bengal dye was used when there was excessive sediment in the sample, which sometimes occur in some of the sweep-net samples and a very few funnel trap samples. For preservation, 70 percent non-denaturized ethanol alcohol was added to each sample bottle.

Macroinvertebrate Sample Processing Procedure

Macroinvertebrate samples were picked randomly under a light by using a picking tray with 12 grid cells (of equal size). Sample contents were stirred and then deposited evenly on a 14 x 17 inch tray. All macroinvertebrates that were >1 cm in length were picked from the sample first to ensure that predators and species higher on the food chain were included in the processed sample. Grid cells were randomly chosen for picking after the >1 cm long taxa were removed from the sample. Each grid cell was entirely picked prior to starting the next randomly chosen grid cell. A total of 200 individuals or the entire sample (if <200 individuals found) was picked for each sample.

Soil Sampling

Collecting Soil Samples:
Soil samples were collected from each sampleable horizon from the representative station/pit and in an upland representative station/pit to the terminal depth of the pit or boring of 60 cm. If needed, a maximum of two soil station/pit locations were excavated to properly characterize the wetland and one soil station/pit located in the upland areas located within the AA and Buffer Area, respectively.

Testing Soil Samples:
Soil samples for NC and SC were tested by the Soils Testing Section of the North Carolina Agronomic Division in Raleigh, North Carolina using methodologies described at http://www.ncagr.com/agronomistmethod.com. GA and AL used independent contractors for their soils analysis.

Soil samples were generally tested for the following:

- Levels of major plant nutrients, including phosphorus, potassium, calcium and magnesium
- Levels of plant micronutrients, including copper, manganese, sulfur and zinc
- Levels of sodium
- pH
- Exchangeable Acidity (Ac - ability of soil to absorb aluminum and hydrogen ions)
- Percent base saturation (soils with low base saturation are considered to be leached and are often acid, whereas neutral and alkaline soils tend to have high base saturation)
- Percent humic matter (percent of soil organic matter)
- Cation exchange capacity (CEC, storage capacity for plant nutrients)
- Weight-to-volume ratio (used to classify soil type, normally inversely related to CEC)

The parameters analyzed by GA and AL's contractors were not identical to NC and SC, but the overlap allowed analysis of like data for nutrients and a few other parameters. Results from the field survey were entered into an Excel database. Electronic results from the lab were received and copied into an Excel database for analysis.

Table 5: Field measurement methods: soils

Variable or Measurement	Units		Summary of Method	
Final Pit Depth	cm		Terminal depth of each soil station/pit location	
Impenetrable Layer Present	None		Clay pan, cemented layer, bedrock, large boulder or other.	
Hydrogen Sulfide Odor (rotten egg)	None		Present or absent	
Inundated/Saturated soil in station/pit, if present	None		If present initial color and what depth in cm and color after exposure to air	
Depth to Lower Boundary of Horizon (depth)	cm		Measurement of the depth of each soil horizon	
Soil Texture Classification	None		Type of soil particle present in each horizon whether sandy, loamy/clayey, mucky mineral, peat, muck, mucky peat or unspecified.	
Rock Fragments (>2 mm)	%		Estimate percent of rock fragments present in each horizon	
Soil Matrix Color	None		Record the color codes for the hue, value and chroma matching the soil matrix	
Feature Types	None		Presence or absence of redox features, mottles or organic bodies.	
Masked Sand Grains	%		Estimate percent of masked sand grains if present	
Percentage of Horizon with Prominent Features	%		Estimate of percent of horizon with prominent feature types	
Color of Most Evident Features	None		Record the color codes for the hue, value and chroma matching the most evident features in soil matrix	
Hydric Soil Indicators	None		Utilizing the collected field measurements to decide to particular hydric soil indicator (s) that each wetland soil station/pit location may include	
Soil Pit Water Depth	cm		Depth of surface water, groundwater and saturated soil (what may be applicable)	

Monitoring Hydrology Wells and Transducers

The methods outlined in the Army Corps of Engineers document entitled, "Wetlands Regulatory Assistance Program (WRAP) for Installing Monitoring Wells/piezometer in Wetlands" (http://el.erdc.usace.army.mil/elpubs/pdf/ tnwrap00-2.pdf) was used as a basis for installing the hydrology monitoring wells.

Prior to field installation, a sample of newly purchase transducers was checked for accuracy in a controlled indoor environment to be sure they were properly calibrated and measuring correctly. In-situ vented Level-Troll 500 (or similar make) transducers were installed in early 2012 at 10-20 wetland locations (10 in the Piedmont (GA and NC only) and 10 in the Coastal Plain (NC, SC, AL, and GA)) to record information on duration, frequency, and seasonal timing of wetland inundation. Transducers were hung with the sensors located about a half-inch from the bottom of the well. Data were collected for about 18 months until mid-2013 at all the sites (some of Georgia's hydrology data were collected on a later timeframe). In the field, transducers were set to record every 30 minutes in the RSF wetlands and every one (1) hour in the BLH wetlands. Hand measured water level readings were compared to automated-water levels to check for accuracy every other time well water level data were downloaded. Automated well water level data that was more than 0.08 feet different than water levels measured by hand in the field was considered for applying a correction factor, or recalibration, if so determined.

The wells had 0.01 inch slots along the lower 18 inches for water flow and vented caps to prevent a vacuum from forming and allow the water to flow freely. Wells were typically installed approximately 1.8 to 2 feet below the ground surface. Sand was used in the bottom of the installation hole and around the circumference of the well up to four to six inches from the ground surface where bentonite was used for a seal. Bentonite was piled around the well two to six inches above the ground surface and covered with wet soil. Wells were installed for at least 1 hour before the first water level readings were taken. The well locations were recorded with GPS and later imported into a GIS project/database.

Data were downloaded from the transducers every quarter when the water samples were collected. The last depth recording from the transducer was used to verify accuracy compared to the hand measurements.

Water Quality Sampling

Water quality was monitored quarterly for approximately 18 months from early January 2012 to 2013. Some of Georgia's sites were on a shifted time frame of approximately a year later. Measurements of pH, dissolved oxygen, specific conductivity, and temperature were taken each quarter and water samples were collected for total suspended solids, fecal coliform (optional), nutrients (NO_2+NO_3, phosphorous, ammonia, and total Kjeldahl), metals (lead, copper, zinc, calcium, and magnesium), total organic carbon, and dissolved organic carbon. Water samples were (filtered if needed, and) preserved with acids as required by the appropriate water chemistry lab.

Sample station locations were recorded with GPS and marked in the field with flagging. Additionally, station locations were photographed each time a station was sampled to make a visual record of the station's hydrology. The best sampling methodology was chosen according to the hydrological conditions on the sampling day; direct-grab or bail. The bailer and sample bottles (except for fecal coliform which had preservative in the bottle) were tripled rinsed with station water prior to use. Field data sheets were completed for each station as well as water quality lab sheets. Field data sheets included information on physical parameters, sample location, station number, 48-hour precipitation history from the nearest weather station, wetland site name, date, sampler's initials, air temperature, sample method, chlorine strip results, picture number, sample method, comments on hydrology, water quality, and details on the microhabitat of station location, sample time, preservation time, and which lab tests were to be performed. Water quality samples were analyzed by each state at relevant state labs and therefore the exact water quality parameters were not identical, but the overlap allowed data to be combined for summary and later analysis.

Figure 2 shows the setup with the assessment area and the vegetation plots and the soil pits at the southeast corner of each plot. Also shown are the water samples, one taken upstream and one downstream. If upland soil samples could be collected, then they were collected outside of the assessment area.

For measuring pH, Dissolved Oxygen, and Specific Conductivity, meters were calibrated at the beginning and end of each day and during the day if deemed necessary. Probes were rinsed with deionized water before and after each use. To avoid contamination of samples, gloves were worn for sampling, and a clean pair worn for filtering and for preservation. For DOC samples, 200 ml of water collected in the field was suction-filtered through 0.45-micron filters within 30 minutes of collection. DOC filtering equipment was triple-rinsed with deionized water before and after each sample was filtered and filters were changed between samples. Filtering blanks were prepared at the beginning and end of each sample day to test for DOC contamination. Additionally, one set of unlabeled duplicates was sent to the lab during each sample period to check for accuracy. DWQ Standard Operating Procedure and Laboratory Sample Submission Guidelines were followed to ensure that sample preservation, storage, labeling, and hold times were met. Details of these processes are explained in "The Quality Assurance Manual for the North Carolina DWQ Laboratory section" (NCDWQ 2003b).

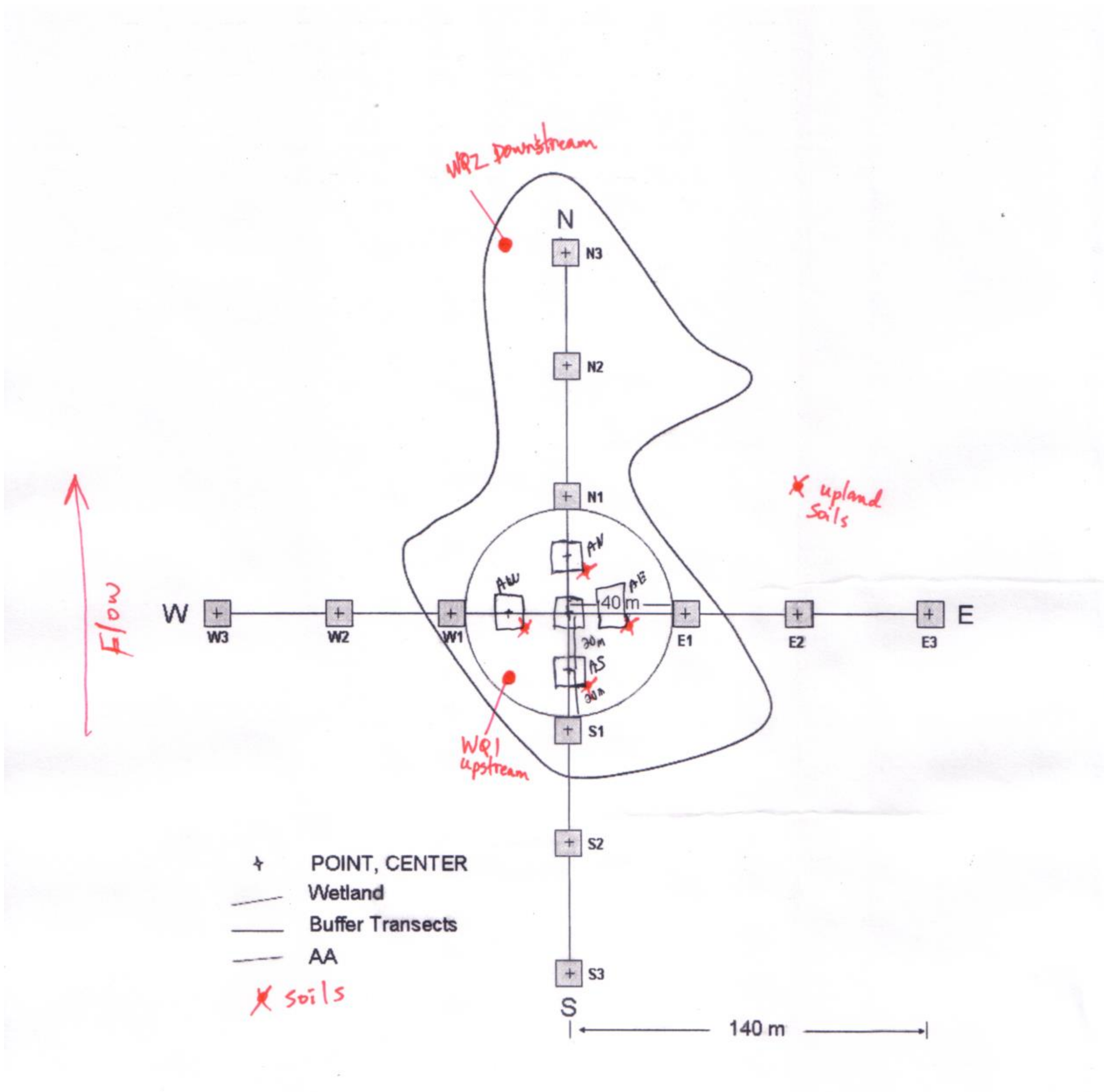


Figure 4: Diagram of Standard plot set up with soil pit and water quality sampling stations.

Data Analysis Methods and Procedures

USA-RAM Scoring Procedure

The USARAM is divided into a number of metrics, each with its own focus (see Table 4 below). Each metric was evaluated and, following the EPA's lead on summary scores, assigned a meaningful numeric value. This was with the intention of ultimately generating a single summary numeric value for the USARAM whereby sites could be ranked or rated. It also allowed the USARAM to be correlated with other disturbance measures to test its validity. The USARAM was treated as a measure of stressors in the wetland; therefore descriptive metrics such as buffer width were evaluated in terms of which situation would create stress in the forested wetland system (ie. small buffer width). For example, lack of topographical complexity (Metric 4) could be perceived as a stressor, so the number of complexity indicators was inverted to show the number of indicators not found.

Table 4: Scoring method for each metric of USA-RAM

Metric	Metric Name	Metric Description	Number Assigned for USARAM Scoring*	Total Possible Points	Multiplier
M1	Adjoining Buffer	% of AA adjoining buffer	<25% = 100 26-50% = 66 51-75% = 33 >75% = 0	0-100	n/a
M2	Average Width	average width of buffer (8 measurements)	100 – ave. width	0-100	n/a
M3	Buffer Stressor Score	field indicators of stressors in buffer	sum of individual severity ratings for all stressors	0-29	3.3
M4	Total Indicators	natural topographic complexity in AA	20 – (count of number of indicators)	0-20	5
M5	Diagram	patch mosaic complexity of AA	Row 1 = 100 Row 2 = 66 Row 3 = 33 Row 4 = 0	1-100	n/a
M6	Total Strata Cover	vertical complexity in AA	*not included in USARAM scoring*	-	-
M7	Plant Community Complexity	dominant species by stratum	*not included in USARAM scoring*	-	-
M8	Water Stressor Score	indicators of water quality stressors in AA	sum of individual severity ratings for all stressors	0-39	2.56
M9	Water Field Stressor Score	indicators of altered hydroperiod in AA	sum of individual severity ratings for all stressors	0-36	2.78
M10	Substrate Stressor Score	indicators of altered substrate in AA	sum of individual severity ratings for all stressors	0-36	2.78

M11	Total Invasive Cover	overall percent cover of invasive species	Absent (none) = 0 Trace (<5%) = 10 Moderate (5-25%) = 33 Extensive (26-75%) = 55 Dominant (>75%) = 100	0-100	n/a
M12	Vegetation Stressor Score	indicators of vegetation disturbance	sum of individual severity ratings for all stressors	0-39	2.56

*Multiplier is 100 divided by the total possible points.

Upon obtaining numbers for each individual metric, the second step was to ensure each metric was equally weighted. Simply summing the metrics was not advisable, because the possible points for each metric varied substantially depending on the possible number of stressor subcategories included in the metric. To achieve an equal weighting of the metrics in the final total, each metric was converted to a 100 point scale using a multiplier, where appropriate (some metrics were already on a 100 point scale). The multiplier was 100 divided by the total possible points.

The 10 metrics were scaled to 100 points and averaged to obtain a USARAM score, which could then be used in statistical analyses. In this study, when the USARAM scores were correlated with other measures of disturbance, the USARAM performed very well (see Table 5).

Table 5: Correlations with Disturbance measures with USA-RAM scoring method

Variable	# Sites	r	p
Amphibian AQAI	52	-0.37	0.007
Macroinvertebrate Diversity	32	-0.42	0.017
Relative Importance of Nonnative Plants	117	0.44	<0.0001
Vegetation Mean C	117	-0.35	0.0002
FQAI Count	117	-0.32	0.0009
FQAI Cover	117	-0.34	0.0004
LDI 300m	137	0.29	0.001
LDI Watershed	136	0.32	<0.0003
NCWAM	97	0.34	0.0005
ORAM	99	-0.36	0.0003
Soil Metals (Cu, Mg, Zn mg/dm^3)	113	-0.032	0.75
WQ Nutrients (P+TKN mg/L)	73	-0.22	0.068

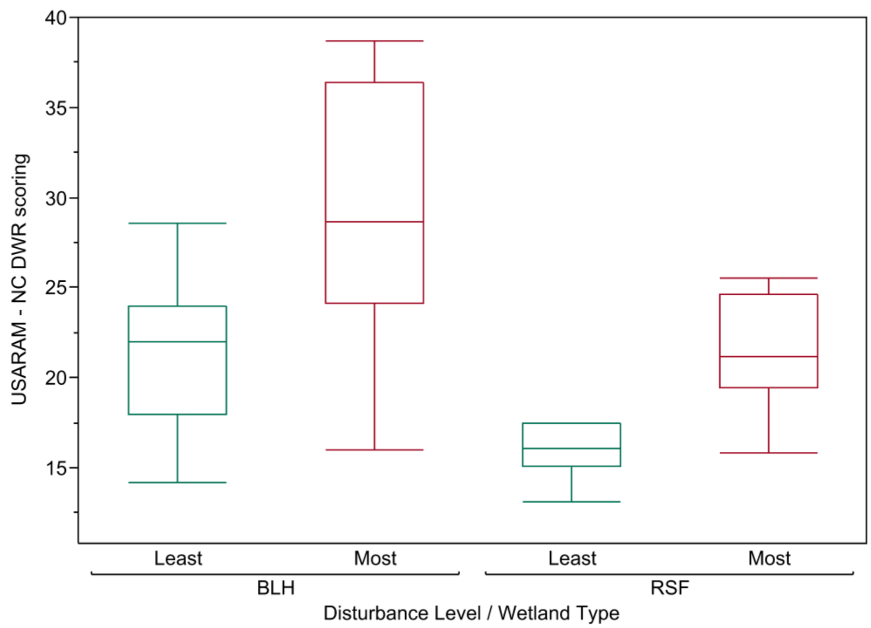
To test how well the USARAM was able to discriminate between least and most disturbed sites, a wetland disturbance index (WDI) was calculated using LDI, ORAM, and NCWAM. ORAM was inverted because a high ORAM score indicates a higher quality wetland. The index was calculated as follows:

$$WDI = \frac{\left[\left(\frac{LDI}{LDImax}\right) + \left(\frac{90-ORAM}{90-ORAMmin}\right) + (NCWAM\ stressor\ level^{*})\right]}{3}$$

*NCWAM stressor level: High = 0, Medium = 0.5, Low = 1.0

The top and bottom 25% percentiles of the WDI were considered the most and least disturbed sites. Based on this index, the USARAM was able to discriminate well between the least and most disturbed sites, for each wetland type as shown in Figure 3.

Figure 3: Results showing USA-RAM scoring method discriminating between most and least disturbed condition by wetland type



Based on these results, we were confident that our scoring method of the USARAM stressors would aid in our analysis of wetland condition.

Vegetation Data Analysis

Simultaneous to this intensification project, NC DWR has also been working, with the aid of a Wetland Program Development Grant, to develop a Coefficient of Conservatism database for wetland plants that occur within the Southeast. These Coefficient of Conservatism values had been developed for only small portions of the Southeast, and are essential for the calculation of a Floristic Quality Assessment Index (FQAI), which is the most widely used metric in floristic quality assessment. The FQAI employs a measure of conservatism (Coefficient of Conservatism) along with richness of a plan community to derive an estimate of habitat quality. The Coefficient of Conservatism is a number (C value) between 0 and 10 assigned to each species, indicating its fidelity to specific habitat types and degree of ecological tolerance (Taft et al.

1997; Swink & Wilhelm 1979). Plant species that are obligate to high quality natural areas are given high C values, whereas species typically found in a wide variety of habitats and that are tolerant of disturbance are assigned low C values (Table 6). Non-native species receive a C value of zero (0).

Table 6: Floristic Quality Assessment Index Coefficient of Conservation Value Assignments

C of C Value Assignment	Criteria used to define C of C assignment
0-1	Taxa adapted to severe anthropogenic habitat alteration, occurring so frequently that often only brief periods are available for growth and reproduction of the species. These species are also able to colonize areas with high degrees of anthropogenic alteration. Many also do well with severe natural disturbance, but most occurrences are in heavily altered areas. Non-native and adventive species are automatically assigned a C-value of zero.
2-3	Taxa associated with somewhat more stable, though degraded, environments.
4-6	Taxa that persist with moderate alteration, but which decline with more intense, long-lasting, or frequent anthropogenic alteration. Many are also present in natural areas, and may be dominant or matrix species with broad habitat tolerance.
7-8	Taxa associated mostly with well-established natural areas, but that can be found persisting where the habitat has been degraded somewhat.
9-10	Considered to be restricted to high-quality natural areas, including those which show high frequencies of natural disturbance such as flooding or fire. These species often exhibit a high degree of fidelity to a narrow range of habitat requirements, but may be tolerant of a broader range of high-quality natural habitats.

The Southeast Wetland Plant Coefficient of Conservatism Database was developed by a team of 15 expert botanists from around the Southeast, and released in the fall of 2013. This database became the major source of C values for plant species observed on BLH and RSF sites. C values for upland species observed were also found in a previous North Carolina C value database developed for previous grant projects by three recognized North Carolina botanists (Baker et al. 2013).

An overall species list database was developed for all wetland sites. The “Species list” database contained fields for the scientific name, common name, family, NWI Wetland Indicator Status (Resource Management Group, Inc. 1999), physiognomic form (fern, forb, grass, moss, sedge, shrub, small tree, tree, and vine), habit (annual, perennial, cryptogam, woody species), group (monocot or dicot), and Coefficient of Conservatism value (C value).

A variety of plant metrics were calculated for BLH and RSF wetlands. These metrics can be grouped into several categories, including community balance metrics, floristic quality metrics, wetness metrics, functional group metrics, and community structure metrics. These candidate metrics were for various analyses, including developing a Vegetation Index of Biological Integrity (VegIBI).

PLANT METRICS

Community Balance Candidate Metrics

Diversity Cover Simpson Metric – Simpson's Index (Simpson 1949) considers the number of species, the number of individuals, and the proportion of the total of each species. The first equation below is Simpson's diversity equation (D_s) subtracted from one (inverted) so that a higher value of D_s indicates higher diversity within the survey area. The index assumes a value from 0 to 1. Percent cover was substituted for abundance in this study.

$$D_s = 1 - \left(\frac{\sum n_i(n_i - 1)}{N(N-1)}\right)$$

D_s – Simpson's Diversity Index (inverted)
n_i - Total cover for species $_i$
N – Total cover for all species

Evenness Metric – Evenness is the distribution of individuals among species. If all species are equal in distribution, then evenness is high. *Native Evenness* was calculated with solely native species. Below is Pielou's Evenness (E_s) equation (Brower and Zar 1977). Evenness values assume a number between 0 and 1. Percent cover was substituted for abundance in this study.

$$E_s = D_s / D_{max}$$

$$D_{max} = \left(\frac{(s-1)}{s}\right)\left(\frac{total\ cover}{total\ cover - 1}\right)$$

s - total number of species
total cover = % cover of all species combined (>100%)
D_s – Simpson's Diversity Index
Dmax – Maximum value of Simpson's Diversity Index
N_{cov} – Total cover for all species

Dominance Metric and *Herb and Shrub Cover Dominance Metric* – These metrics incorporate the "distribution or concentration" of the three most dominant species cover class values for all individuals or herb and shrub species only.

$$D = (Cov_{a+b+c} / N_{cov})$$

Cov_{a+b+c} - Total percent cover of the most dominant species *a, b*, and *c*.
N_{cov} – Total cover for all species

Species Richness Metric and *Native Species Richness Metric* – Total number of vascular species and total number of native vascular species.
Vascular Plant Genera Richness Metric – Total number of native vascular genera.

Floristic Quality Candidate Metrics

FQAI Species Count Metric (all species) and FQAI Cover Metric (all species) - Floristic Quality Assessment Index (FQAI) is an evaluation of ecological integrity that incorporates the affinity of a species for natural pristine habitats (C value) and the total number of species in a sample (Taft et al. 1997). We include all species in calculations of floristic quality (Fennessy et al. 1998a, Lopez and Fennessy 2002, Andreas et al. 2004). The $FQAI_{cov}$ metric, which incorporates species percent cover into the equation, was also used in this study (as in Rocchio 2007). C values for wetland species were obtained from the Southeast Region Wetland Plant Coefficient of Conservatism Database (Gianopulos 2014 – in review) and for upland species from Baker et al. (2013) . Species which did not have a C value available were not included in the calculations; however, 87% of species in the BLH wetland analysis had a C value assigned.

$$\text{FQAI} = \frac{\sum C_i}{\sqrt{N}} \qquad \text{FQAI}_{cov} = \frac{\sum(C_i * Cov_i)}{\sqrt{(N * Cov_{tot})}}$$

C_i - Coefficient of Conservatism for species *i*
N - Number of species, including non-native species
Cov_i - Percent cover of species *i*
Cov_{tot} – Total percent coverage, including non-native species

Average C of C Metric – Average Coefficient of Conservatism value.

Percent Tolerant Metric – Total relative coverage of all species, including non-natives, with a C of C value ≤ 2.

Percent Sensitive Metric - Total relative coverage of all species, including non-natives, with a C of C value ≥ 6.

Invasive Coverage Metric – Total relative coverage of invasive species.

Invasive Shrub Coverage Metric – Total relative coverage of invasive shrub species.

Wetness Characteristic Metrics

FAQWet Equation 3 Metric and *FAQWet Cover Metric* - The Floristic Assessments for Wetland Plants index equation was devised by Ervin et al. (2006). This equation incorporates species wetness, number of species, number of native species, and cover of native species. The FAQWet metric equations are as follows:

$$\text{FAQWet Equation 3} = \left(\frac{\sum WC}{\sqrt{S}}\right)\left(\frac{N}{S}\right)$$

$$\text{FAQWet Cover} = \left(\frac{\sum WC}{\sqrt{S}}\right)\left(\frac{\sum Cov_{nat}}{\sum Cov_{tot}}\right)$$

WC = Wetness Coefficient (see below)
Cov_{nat} = Percent cover of native species

S = Number of species (all)
Cov_{tot} = Percent cover of all species
N = Number of native species

Wetland coefficient values in the above equations are calculated as follows:
OBL = + 5, FACW = + 3, FAC = 0, FACUP = -3, UPL = - 5.

Wetland Plant Species Richness Metric – Number of native herb species with a FACW or OBL wetland indicator status. Herbaceous species = all forbs, ferns, grasses, sedges, and rushes.

Wetland Plant Cover Metric – Relative (within the herb stratum) percent coverage of native herb species with a FACW or OBL wetland indicator status. Herbaceous species = all forbs, ferns, grasses, sedges, and rushes.

Wetland Shrub Species Richness Metric – Number of native wetland shrubs with a FACW or OBL wetland indicator status.

Wetland Shrub Cover Metric – Relative (within the shrub stratum) percent coverage of native wetland shrubs with a FACW or OBL wetland indicator status.

Function Guild Metrics

Cryptogam Richness Metric – Number of fern or fern ally species.

Cryptogam Cover Metric – Relative percent cover of fern and fern allies in the herb layer. Herbaceous species = all forbs, ferns, grasses, sedges, and rushes.

Annual : Perennial Metric – Annual + Biennial species / Perennial species.

Bryophyte Cover Metric – Total moss coverage relative to herb coverage (see Total Herb Cover Metric).

Carex Richness Metric – Total number of *Carex* species.

Carex Cover Metric – Relative percent cover (within the herb stratum) of *Carex* species in the herb stratum. Herbaceous species = all forbs, ferns, grasses, sedges, and rushes.

Cyperaceae, Poaceae, and Juncaceae Metric – Total number of native Cyperaceae, Poaceae, and Juncaceae species (sedge, grass, and reed species).

Cyperaceae, Poaceae, and Juncaceae Coverage Metric – Relative (within the herb stratum) percent cover of native Cyperaceae, Poaceae, and Juncaceae in the herb layer.

Dicot Richness Metric – Total number of native vascular dicot species (including woody species).

Native Herb Richness Metric –Total number of native vascular herbaceous species. Herbaceous species = all forbs, ferns, grasses, sedges, and rushes.

Native Herb Cover Metric – Total relative cover of native vascular herbaceous species. Herbaceous species = all forbs, ferns, grasses, sedges, and rushes.

Total Herb Richness Metric –Total number of herbaceous species. Herbaceous species = all forbs, ferns, grasses, sedges, and rushes.

Community Structure Metrics

Sapling Density Metric - Relative density of canopy and small tree sapling species and small tree species in any size class < 10 cm DBH. Relative density was calculated for each size class by dividing the total number of stems per size class for canopy and small tree species by all stems for canopy and small tree species. The relative density of the four size classes was then summed to equal the *Sapling Density Metric*.

Large Tree Density Metric – Relative density of native trees > 25 cm DBH. The relative density of trees > 25 cm was calculated by dividing the total number of > 25 cm DBH canopy species stems by the total number of all canopy species stems.

Pole Timber Density Metric – Relative density of trees in the 10-15, 15-20, and 20-25 cm DBH size class. Relative density of pole timber trees was calculated for each pole timber size class (10-15, 15-20, 20-25) by dividing the total number of stems per pole timber size class for canopy and small tree species by all stems for canopy and small tree species. The relative density of the three size classes (10-15, 15-20, and 20-25 cm) was then summed to equal the *Pole Timber Density Metric*.

Canopy Importance Metric - The *Canopy Metric* is the average relative importance value of native canopy species. The relative importance value is equal to the sum of relative density, relative dominance, and relative frequency. Relative density for each species was calculated by dividing the total number of canopy stems per species by the total number of canopy stems for all species. Species dominance per size class for size classes 0-1 cm to 30-35 cm DBH was calculated by multiplying the number of canopy stems in each species size class by the midpoint of the size class. The 0-1 cm to 30-35 cm dominance size class for each species was calculated by summing the dominance for size classes 0-1 cm to 30-35 cm. The species dominance for size classes >35 cm DBH was calculated by summing the total DBH for each canopy species >35 cm. Therefore, if two red maples each equal to 45 cm DBH and one red maple equal to 60 cm DBH were recorded during the woody vegetation survey the >35 dominance size class would be equal to 150 cm. The total dominance for each species was calculated by summing the 0-1 cm to 30-35 cm dominance and > 35 cm species dominance species size classes. Relative dominance was calculated by dividing total dominance of each canopy species by the total dominance of all canopy species. Relative frequency was calculated by dividing the number of size classes each canopy species occurred in by the total number of size classes, which were 10

(0-1, 1-2.5, 2.5-5, 5-10, 10-15, 15-20, 20-25, 25-30, 30-35, and ≥35). For example, if red maple occurred in the 0-1, 1-2.5, 2.5-5, 5-10, 20-25 and ≥35 size classes the frequency would be 6 / 10 or 0.60.

Snag Count – Total number of snag trees ≥ 5cm DBH.

Vegetation Index of Biological Integrity (IBI)

The vegetation data were used to calculate IBIs which were used in subsequent analyses. The development of the IBIs is discussed in the results section as a method to produce the IBI developed results.The candidate metrics are show in Table 7.

Table 7: List of candidate metrics used to calculate the vegetation IBI.

List of 51 Candidate Vegetation Metrics Tested	
All Species Dominance (Cover)	Native Wetland Shrub/ Subshrub Species Richness
Annual : Perennial Metric	Non-native Dominance (Cover)
Bryophyte Relative Cover	Nonnative Plant Stressor Indicator
Carex Relative Cover All Species	Nonnative Richness
Carex Richness	Non-native Shrub Relative Coverage
Cryptogam Cover %	Relative Cover All Natives
Cryptogam Richness	Relative Cover Ferns
Dicot Richness	Relative Cover Forbs
FACWet Cover	Relative Cover Graminoids
FACWet Equation 3	Relative Cover Native Monocots
FQAI Count	Relative Cover Nonnatives
FQAI Cover	Relative Cover Shrub & Subshrub
Herb and Shrub Cover Dominance	Relative Cover Trees
Mean C All Species	Relative Cover Vine
Native Evenness (Cover)	Relative Frequency Natives
Native Forb Relative Cover	Relative Frequency Nonnatives
Native Forb Richness	Relative Importance of Natives
Native Graminoid (Cyperaceae, Poaceae, Juncaceae) Relative Cover	Relative Importance of Nonnatives
Native Graminoid (Cyperaceae, Poaceae, Juncaceae) Richness	Relative Native Wetland Shrub/ Subshrub Coverage
Native Herb Relative Coverage	Relative Percent Cover Sensitive C>=7
Native Herb Richness	Relative Percent Cover Tolerant C<=4
Native Simpson's Diversity (Cover)	Tolerant Species Richness C<=4
Native Vascular Plant Genera Richness	Total Herb Richness
Native Vascular Species Richness	Total Vascular Plant Genera Richness
Native Wetland Herb Relative Cover	Total Vascular Species Richness
Native Wetland Herb Species Richness	

Amphibian Data Analysis

Amphibian C values (Coefficients of Conservatism) for each species were assigned from 1-10 with “1” being species that were considered to be generalists with the least specific habitat requirements and “10” being species with the most specific habitat requirements and sensitivity to stress plus a state protected species listing. An example of an amphibian with a C value of 1 is the American toad (*Bufo americanus*), and an amphibian with a rating of 10 is the four toed salamander (*Hemidactylium scutatum*).

These amphibian C values and adult equivalency conversions were assigned using best professional judgment by expert herpetologists Alvin Braswell (Lab Director and Curator for Herpetology at the N.C. State Museum of Natural Sciences) and Jeff Beane (Collections Manager for Herpetology at the NC State Museum of Natural Sciences) from 2005-2013 (**Error! Reference source not found.**). Species with a C value $\leq$ 3 were considered to be tolerant of a variety of conditions, while species with a C value $\geq$ 6 were considered sensitive. Species that require ephemeral wetlands, headwater wetlands, or seepage wetlands (i.e. the absence of predatory fish) are also denoted.

Field data observations were used to develop an amphibian survey database in Excel spreadsheets. To calculate statistics, each site’s larvae and egg stage tally for each species was converted to an adult-equivalent tally. Table 29 shows the conversion factors used to convert each egg and larval species observed during the survey to adult equivalent numbers. In most cases, 20% of the larvae were counted as one adult and every egg mass were counted as two adults.

An amphibian quality assessment index (AQAI) was calculated, similar to the floristic quality assessment index, to evaluate amphibian use at each site. The number of adults or adult equivalents for each site was determined and used to calculate the AQAI value, species richness, percent tolerant species, and percent sensitive species. The AQAI value for each site was determined using the following equation:

$$\text{AQAI} = \frac{\sum(S_i)(S_{icofc})}{\sqrt{N}}$$

S_i = Number of adults (plus adult equivalents) for species i
$S_{i\,c\,of\,c}$ = C value for species i
N = Total number of adults (plus adult equivalents)

Aquatic Macroinvertebrate Data Analysis and IBI Development

Approximately 36 biological attributes will potentially be tested as metrics for the NC Wetland Index of Biotic Integrity for RSF and BLH wetlands. The candidate metrics will be chosen by reviewing data with the assistance of NC DWQ aquatic macroinvertebrate biologists and a literature review of other stream and wetland IBI development studies by Rader et al. (2001), Ohio EPA (2004), U.S. EPA (2002c), Reiss and Brown (2005), Chirhart (2003), and Stribling et al. (1998). Wetland disturbance measures as determined by the Ohio Rapid Assessment Method (ORAM), Land Development Index (LDI) for the watershed and 100m buffer, water quality, soil pH, zinc, and copper will be used to test the 36 candidate metrics. Table 8 lists the potential candidate metrics according to metric type: Taxonomic Richness, Taxonomic Composition, Trophic Structure, and Tolerant/Sensitive and the expected response (positive or negative) with the various disturbance measures.

The original Macroinvertebrate Biotic Index (MBI) metric uses a method created by David Lenat of the NC DENR Division of Environmental Management for use in southeastern streams (Lenat 1993). The original equation was adjusted so that high index values indicate highly sensitive organisms are present (a desirable outcome), and low values denote the presence of stressors (tolerant organisms). The inverted Macroinvertebrate Biotic Index is calculated as follows:

$$\text{MBI} = 10 - \frac{\sum \text{TV}_i \text{N}_i}{\text{N}}$$

MBI = Macroinvertebrate Biotic Index
TV*i* = Tolerance Value of *i*th taxa
N*i* = Abundance of *i*th taxa
N = Total number of individuals in all taxa

The most recent tolerance values (TVs) developed for benthic macroinvertebrates were obtained primarily from biologists at the Biological Assessment Branch (NCDENR, Biological Assessment Branch 2013; Lenat 1993). In instances where TVs were unavailable in the NC DENR/Lenat database, the literature was searched for appropriate TVs, which were applied to complete the wetland macroinvertebrate TV database as much as possible (Bressler et al. 2006; Barbour et al. 1999).

Metrics using aquatic macroinvertebrate data were tested against disturbance measures using both Spearman's rho and Pearson's Correlation Coefficient with pairwise comparisons. Non-parametric data were transformed as needed for the Pearson's Correlation Coefficient test. Correlations were performed on each wetland type separately.

Table 8: Candidate macroinvertebrate metrics with expected response to disturbance measures

Metric Type	Candidate Metric	LDI, Water Quality, Soils Metals	ORAM, soil and water pH, DO
Taxonomic Richness	Species Richness	Negative	Positive
	Genera Richness	Negative	Positive
	Family Richness	Negative	Positive
	Chironomidae Richness	Negative	Positive
	EPT Richness	Negative	Positive
	OET Richness	Negative	Positive
	POET Richness	Negative	Positive
Taxonomic Composition	Percent Decapoda	Negative	Positive
	Percent Oligochaeta	Positive	Negative
	Percent Chironomidae	Positive	Negative
	Percent Coleoptera	Negative	Positive
	Percent Corixidae	Positive	Negative
	Percent Crustacea	Negative	Positive
	Percent Diptera	Positive	Negative
	Percent Dytiscidae	Negative	Positive
	Percent Hemiptera	Positive	Negative
	Percent Leech	Positive	Negative
	Percent Microcrustacea	Variable	Variable
	Percent Mollusk	Negative	Positive
	Percent Orthocladiinae	Positive	Negative
	Percent Terrestrial	Variable	Variable
	Percent Trichoptera	Negative	Positive
	Percent Trombidiformes	Negative	Positive
	Percent EPT*	Negative	Positive
	Percent OET**	Negative	Positive
	Percent POET***	Negative	Positive
	Percent of Top 3 Dominants	Positive	Negative
	Evenness	Negative	Positive
	Simpson's Index of Diversity	Negative	Positive
	Site Abundance	Negative	Positive
Trophic Structure	Percent Predators	Negative	Positive
	Predator Richness	Negative	Positive
Tolerance / Sensitive	Percent Sensitive	Negative	Positive
	Percent Tolerant	Positive	Negative
	Sensitive : Tolerant	Negative	Positive
	Macroinvertebrate Biotic Index Score	Positive	Negative

*EPT=Ephemeroptera, Plecoptera, Trichoptera
**OET=Odonata, Ephemeroptera, Trichoptera
***POET=Plecoptera, Odonata, Ephemeroptera, Trichoptera

DATA ANALYSIS WITH BIOTIC AND ABIOTIC PARAMETERS

A series of correlations were performed to evaluate the biotic metrics with the abiotic indicators of wetland condition. The abiotic measures indicate a wetland condition gradient. Water quality that has high amounts of nutrients or metals would be an indicator that the condition of the wetland is stressed. Likewise, high metal content in soils would also indicate that the wetland was stressed. Rapid assessment methods result in assessment of wetland condition such as ORAM where a higher score means a higher quality wetland (little or no stress) and a low score indicates wetland condition of lower quality, presumably due to stressors. NCWAM accesses functional value of wetlands, assigning a score of high, medium, or low and this can be used as a gradient of wetland condition. LDI scores indicate the type of land use around the wetland. Lower scores indicate little or no development whereas higher scores indicate more development, therefore more stressors on the wetland. The biotic indicators should also indicate wetland condition, but metrics calculated from the results needed to be validated with the abiotic measures. Therefore the vegetation IBI's were correlated with the abiotic measures of wetland condition. The amphibian AQAI and the macroinvertebrate MBI were used to correlate with the abiotic measures. High correlations indicate that the biotic metrics are also indicators of wetland condition. These relationships are discussed in the results and discussion section.

Site Weights

The randomly selected sites provided by the EPA were based on a probability sampling technique as discussed previously. The sites were therefore assigned weights based on their type, position in the landscape, and their selection rank. As sites are rejected as not being able to be sampled due to the owner denial of access or the site was not safe to sample, the weights shift, with the original sites selected becoming more heavily weighted and the oversample sites having much smaller weights.

In the NWCA survey design, the sampling weight represents the wetland area in the Target Population (e.g. state and wetland type) represented by the selected site. After the data were collected and quality checked, the sampling weights were adjusted to account for replacement sites (which were selected due to non-accessibility, denial of access or being non-target), missing values (e.g. not replacement site was selected to compensate for a site that was not accessible or not a wetland), and additional sites due to the intensification study. The adjustment process applied ensured that the sum of the final adjusted weights added to the expected total wetland area by state and wetland type.

Relative Risk and Attributable Risk

There is another major component to the analysis and that is calculating relative risk, risk extent and attributable risk of stressors to wetland condition. The EPA is using this analysis as their major analysis and is reporting these results from their national survey in 2011 (see Van Sickle, 2008 and

2013). Relative extent is the frequency of a stressor associated with a wetland condition and relative risk is the likelihood that if the stressor is present there is poor wetland condition. Finally, attributable risk is an estimate of how much the wetland condition would improve if the stressor were removed.

Adjusted sampling weights were used to calculate stressor condition by region, state and wetland type for several stressors. Each site was assigned a good, fair, or poor stressor condition based on its value and appropriate thresholds. Next, the site weights were added within a condition class to estimate the wetland area in good, fair, and poor condition. Confidence intervals were also calculated for each condition estimate. Complete wetland condition assessment results, including extent estimates (numbers of acres or percent of wetland area), relative risk and attributable risk for wetland condition classes were also calculated

RESULTS AND DISCUSSION

The results presented are by state and then across the four states. One major component of these results is to make some assessments of overall condition of forested wetlands in the Southeast Region. Therefore the results are presented by level of assessment starting with the landscape scale showing the LDI results, then the rapid assessments, and finally the intensive survey results for bitotic and abitotic parameters. Next comes the stressor and condition analysis that shows the extent of a stressor's probable impact and the extent of a wetland's condition based on a certain parameter in terms of percent area and actual acres. The final section shows maps of wetland condition based on varous indicators with the final map showing wetland condition based on a composit index which would be expected to be the more reliable indicator of wetland condition. The composit idex is shown across the four-state region (Southeast Region) and for each state indivicually.

LDI – Landscape Development Intensity Index Results and Discussion

The LDI analysis involves using GIS to classify land use and then assigning values weighted by area. Therefore, high LDI scores indicate more human development and hence disturbance. Table 9 shows the LDI using a 300-meter buffer around the assessment area and the watershed from the assessment area up to 20 square miles. In Table 9, the percent of the land area that has human impact versus largely natural is shown for each state, as well as the square miles for each. From this table, in terms of percent, Georgia had the largest human impact and North Carolina has the second largest in both the 300-meter buffer and the watershed. South Carolina had the least human impact in the 300-meter buffer whereas Alabama has the least human impact in the overall wetland watersheds. Georgia also had the largest area of human impact for the 300-meter buffer and North Carolina again had the second largest. However, for the watershed, South Carolina had the largest human impact and Georgia had the second most. The results in Table 9 are for both wetland types combined.

Table 9: Total square miles of land use/cover analyzed and percent natural vs. impacted by human activities

	State	Percent Impacted by Human Activities*	Percent Natural Land	Natural Land (sq mi)	Area Impacted by Human Activities* (sq mi)	Total Area Land Use Analyzed (sq mi)
300 m Buffer around AA	**NC**	38%	62%	2.2	1.4	3.6
	SC	28%	72%	2.3	0.9	3.2
	AL	32%	68%	2.1	1.0	3.1
	GA	48%	52%	2.4	2.3	4.7
Watershed	**NC**	63%	37%	86.2	148.5	234.6
	SC	56%	44%	173.1	219.6	392.7
	AL	36%	64%	182.9	102.9	285.8
	GA	67%	33%	100.8	202.1	303.0

* Relatively recent human activities (distinguishable through aerial photointerpretation)

Figure 4 shows the same results in graphical form where green represents largely natural land use and brown is human impacted land use. As the LDI analysis extends from the 300-meter buffer to the watershed of the wetland sites, a larger percentage of human disturbance is evident.

Figure 4: Percent area impacted by human activities vs. natural land for 300m buffer and for wetland watersheds (up to 20 sq. miles upstream from AA)

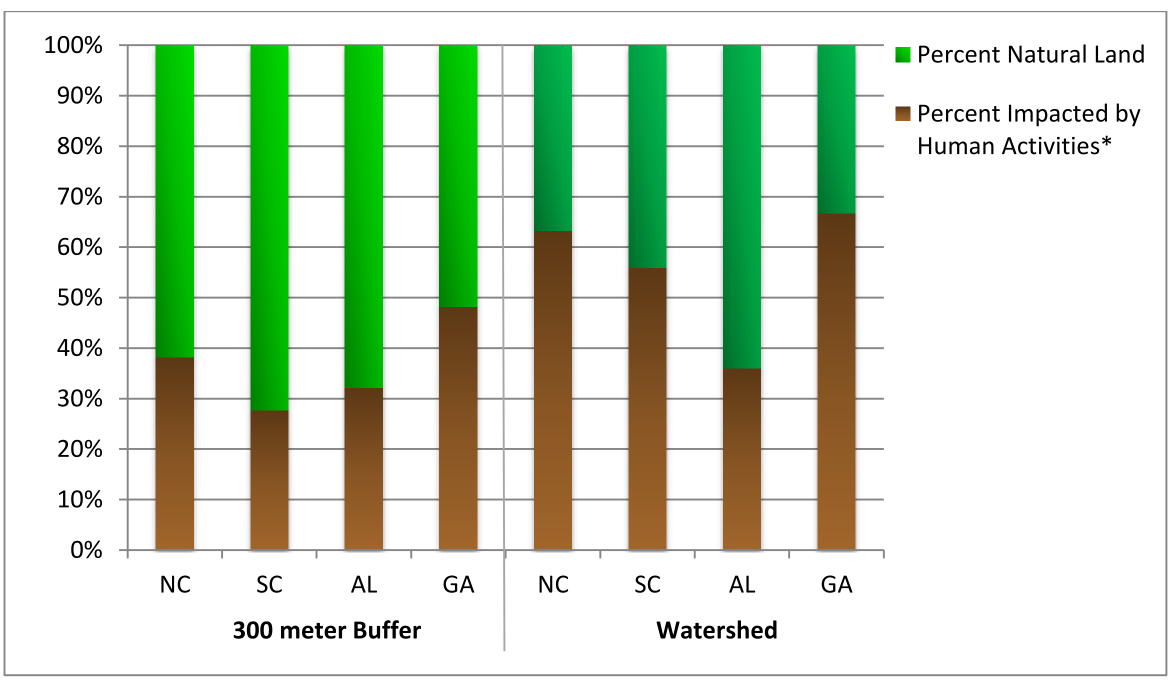


Table 10 shows the percent of land use by type in each LDI (300-meter and watershed). The largest percent of land use was natural for all states. In terms of human impact, for North Carolina, the most common land use was unmanaged herbaceous for the 300-meter and agricultural for the watershed LDI. South Carolina had pine plantation as its largest land use for the 300-meter and for the watershed. On the other hand, Alabama had unmanaged herbaceous as the largest land use for both the 300-meter LDI and the watershed LDI. Georgia had pine plantation as the largest land use for both of the LDIs. Clearly, unmanaged herbaceous, which is often farm pastures, and agricultural were the largest land use in the four state region.

Table 10: Type of land use/cover in 300m buffer around AA and in watershed (up to 20 sq. miles upstream from AA)

	State	% Natural	% Unmanaged Herbaceous	% Pine Plantation	% Managed Herbaceous or Cleared/ Logged	% Impounded	% Agricultural	% Low Density Development	% High Density Development
300 m Buffer around AA	NC	62%	10%	8%	3%	0%	9%	4%	5%
	SC	72%	3%	17%	2%	1%	1%	3%	1%
	AL	68%	13%	10%	6%	0%	1%	2%	0%
	GA	52%	6%	23%	2%	0%	9%	7%	1%
Water-shed	NC	37%	2%	10%	5%	0%	25%	17%	3%
	SC	44%	3%	32%	1%	0%	9%	11%	1%
	AL	64%	13%	10%	2%	0%	4%	7%	0%
	GA	33%	5%	31%	7%	1%	8%	14%	1%

Figure 5 shows box plots of the actual LDI 300-meter buffer mean scores for each state by wetland type. For bottomland hardwood forest (BLH) wetland type, North Carolina generally had higher LDI mean score whereas Alabama had the lowest (less mean human impact). For the riverine swamp forests (RSF), Georgia had the highest mean score and the other three states had about the same mean LDI score within the 300 meter buffers.

Figure 6 confirms what Figure 5 indicates about wetland type, that is, the BLH wetlands are more impacted than the RSF wetlands, with a higher mean LDI score within the 300-meter buffers. The BLH wetlands are in the piedmont region (ecoregion 45) which has generally more human impact due to agriculture and urban.

Figure 5: Mean 300-m Landscape Development Intensity Index values by state and wetland type

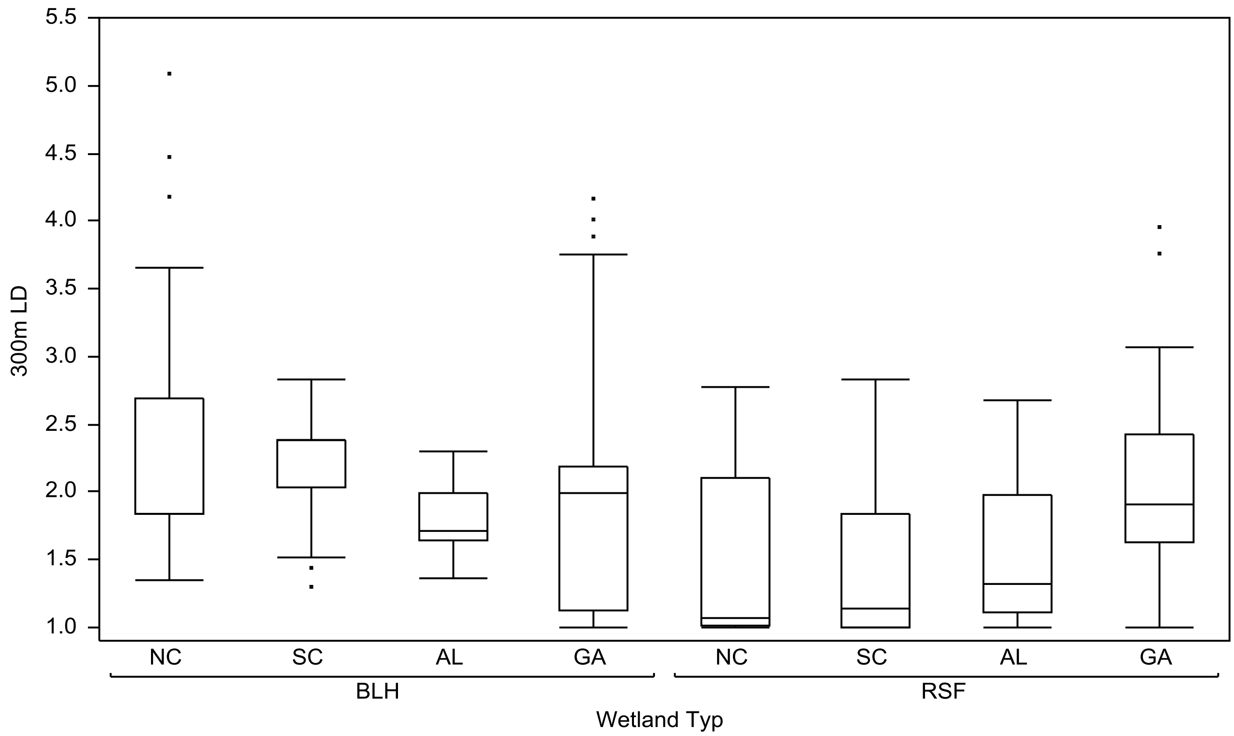


Figure 6: Mean 300-m Landscape Development Intensity Index values by wetland type for the Southeast region

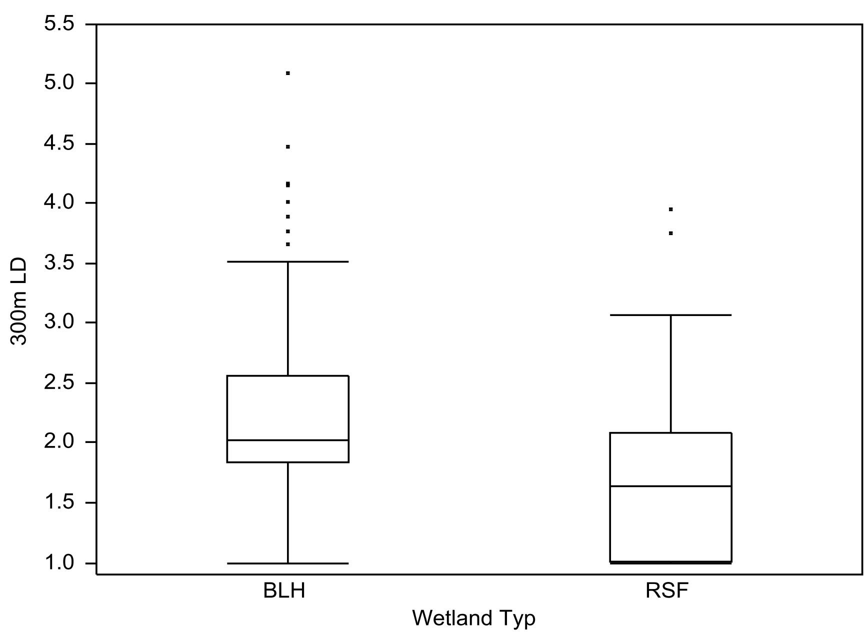


Figure 7 shows the mean LDI watershed scores for each state by wetland type. For the bottomland hardwood forests, North Carolina and Georgia had the highest (worst) LDI mean scores, with North Carolina having a large variance in mean scores. For riverine swamp forests, North Carolina and Georgia had the highest mean LDI score indicating more human disturbance. Alabama had the lowest mean LDI watershed scores for both wetland types indicating less human impact.

Figure 8 shows the mean LDI score using the watershed by wetland type. As with the previous LDI mean scores using the 300-meter buffer, bottomland hardwood forests have a higher mean LDI score. As pointed out previously, the Piedmont region (ecoregion 45) generally has a more significant human impact than does the Southeast Plains area (ecoregion 65) where the riverine swamp forests were studied.

Figure 7: Mean watershed Landscape Development Intensity Index values by state and wetland type

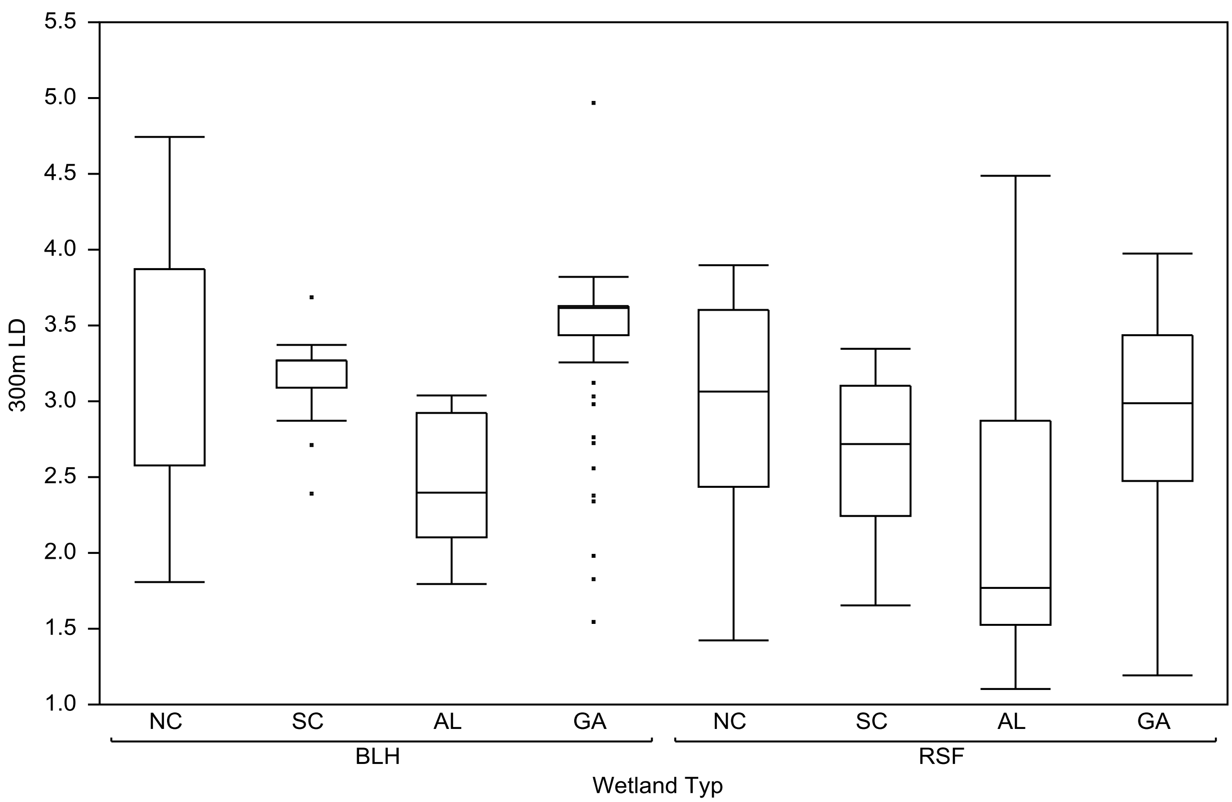
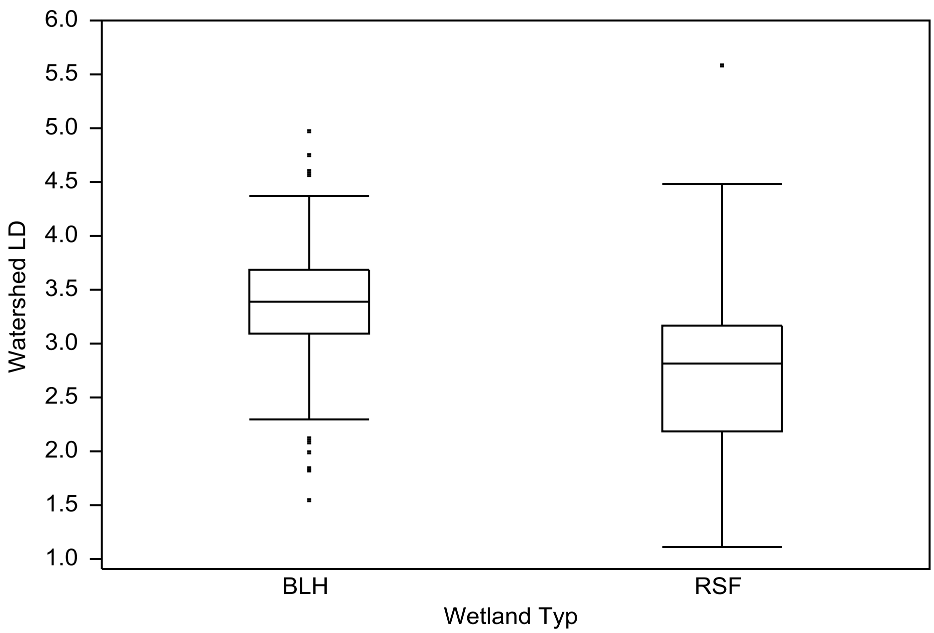


Figure 8: Mean watershed Landscape Development Intensity Index values by wetland type for the Southeast region



Generally the LDI scores show that with using larger buffers such as the entire watershed, the scores tend to get worse, however there is a point where the tend is to wash out any land use effects as the land use types just increase in all of the categories and no one land use becomes predominant. The LDI scores also show that bottomland hardwood forest wetlands in the Piedmont are more impacted in terms of increased development than are the riverine swamp forest wetlands in the Coastal Plain. For the 300-m LDI, Georgia tended to have wetlands that were more impacted whereas with the watershed LDI, Alabama tended to have wetlands that were less impacted by development.

Rapid Assessment Results and Discussion

This section presents the results of the three rapid assessment methods, ORAM, NCWAM, USA-RAM, and the buffer assessment. Rapid assessments are often used as gradients of wetland condition as in research; however they are often valuable tools in that if their validity is good, then they can be good estimates of wetland condition or function that does not normally require intensive surveys. The results are shown by state and wetland type as well as for the entire region. High ORAM scores indicate a good wetland condition whereas high USA-RAM scores indicate poor wetland condition. NCWAM scores wetlands as high, medium, or low based on wetland functional value.

Figure 9 shows the results for ORAM by state and wetland type. For bottomland hardwood forests, South Carolina had the highest scores indicating the wetlands were in pretty good condition compared to the other states. The bottomland hardwood forests in Alabama and Georgia scored much lower on ORAM indicating wetlands in poor condition. For riverine swamp forests, Georgia clearly had the lower ORAM scores relative to the other three states, again indicating wetlands in poorer condition.

Figure 10 shows the ORAM scores by wetland type across the four-state region. As with the LDI scores, the bottomland hardwood forest were in poorer condition relative to the riverine swamp forests as indicated by their lower ORAM scores.

Figure 9: ORAM scores by state and wetland type.

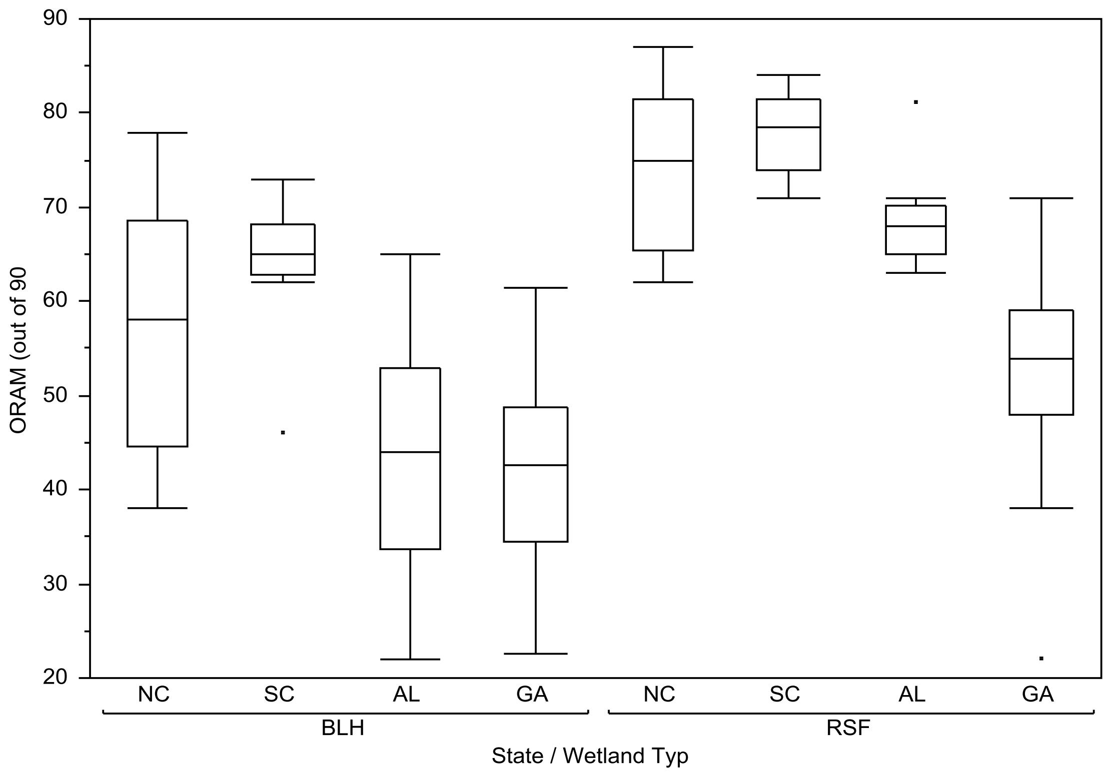
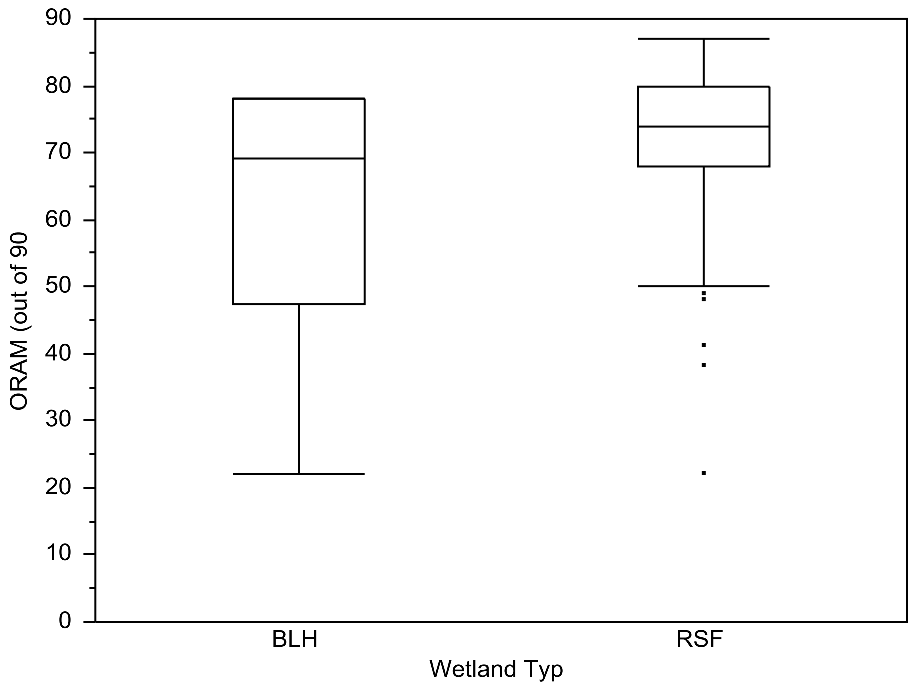


Figure 10: ORAM scores by wetland type for the four-state region.



While the overall ORAM scores for wetland type are consistent with the LDI scores (both 300-meter and watershed) showing that bottomland hardwood forests were generally in poorer condition than the riverine swamp forests, however there was wide variation in the state results between the two sets of scores.

Figure 11 shows the results for the NCWAM rapid assessment by wetland type (bottomland hardwood forests on the left and riverine swamp forests on the right) and by state. For the bottomland hardwood forests, Georgia clearly had the lowest NCWAM scores with most of the wetlands rated low. Alabama's bottomland hardwood forests received the highest scores for NCWAM. For the riverine swamp forests (right side of figure), the large majority scored high on NCWAM, however Georgia had a few that scored medium and low.

The NCWAM scores in Figure 12 show the results for the four-state region by wetland type. Bottomland hardwood forest scored lower on NCWAM than did riverine swamp forest which is consistent with ORAM and the LDI scores. Since ecoregion is confounded with wetland type, we believe it is the ecoregion that is causing the differences more so than the wetland type (see Savage and Baker, 2010).

Figure 11: NCWAM scores for each state by wetland type (BLH ratings are on the left and RSF ratings are on the right)

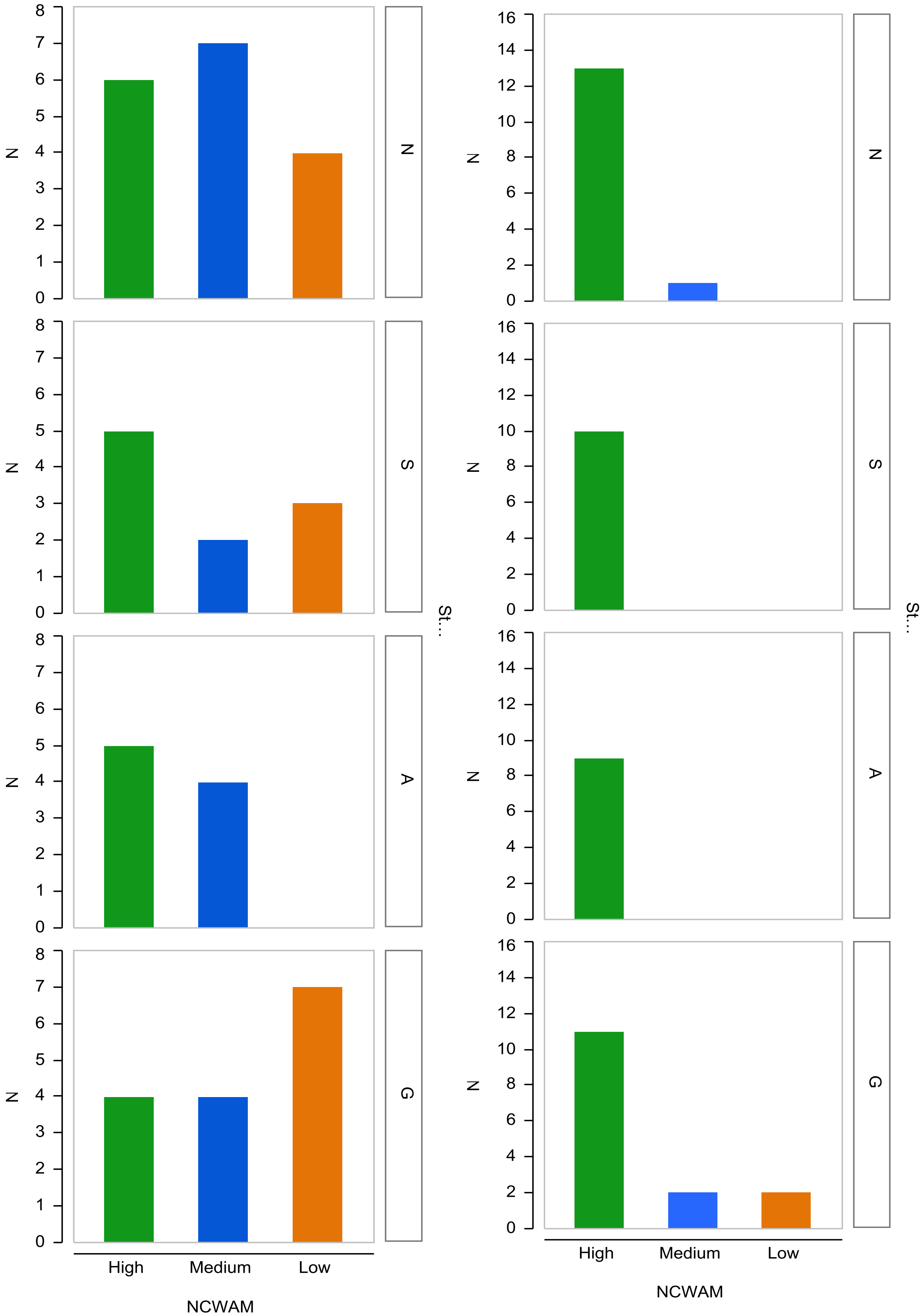
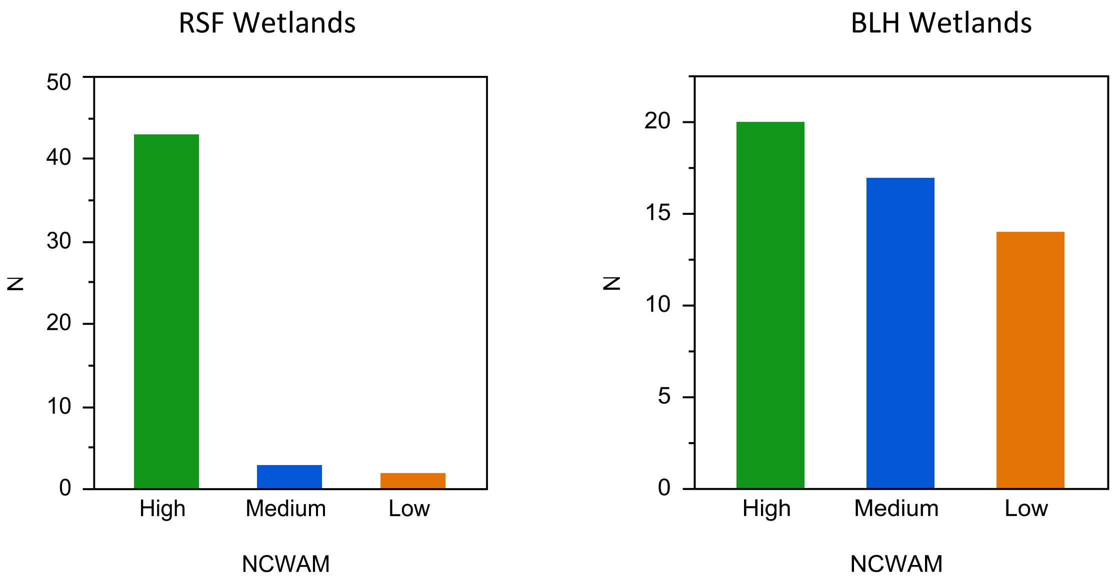


Figure 12: NCWAM scores for the four-state region by wetland type.



The USARAM scores are shown in Figure 13 by wetland type and by state. Based on these scores, Georgia again had scores indicating the bottomland hardwood forest wetlands were in poor condition, relative to the other states. For riverine swamp forest, Georgia again had wetlands in poorer condition than the other states; with Alabama having their riverine swamp forest in better condition that North and South Carolina.

Figure 14 shows the USA-RAM scores for wetland type across the four-state region. While the differences are small, bottomland hardwood forests were again scoring poorer than riverine swamp forests.

The buffer stressors are shown in the subsequent two figures. These are stressors indicated when the field crew ventured from the assessment area into the buffer areas (in each cardinal direction) and had stopping points (buffer plots) to assess the condition of the buffer. There were three plots in the buffer (beyond the assessment area) in each cardinal direction for a total of 12 plots, plus one plot in the very center of the assessment area, for a grand total of 13 buffer plots. The number of stressors were summed and averaged across the plots for each site. Figure 15 shows the number of stressors for each state by wetland type. Georgia had the largest number of stressors for both wetland types and South Carolina had the fewest for both wetland types. The differences between the states are more in terms of variance than the means. Figure 16 shows the number of buffer plot stressors across the four-state region. The bottomland hardwood forests had slightly more stressors on average than did riverine swamp forests, again being consistent with the previous measures.

Figure 13: USA-RAM scores by wetland type and by state.

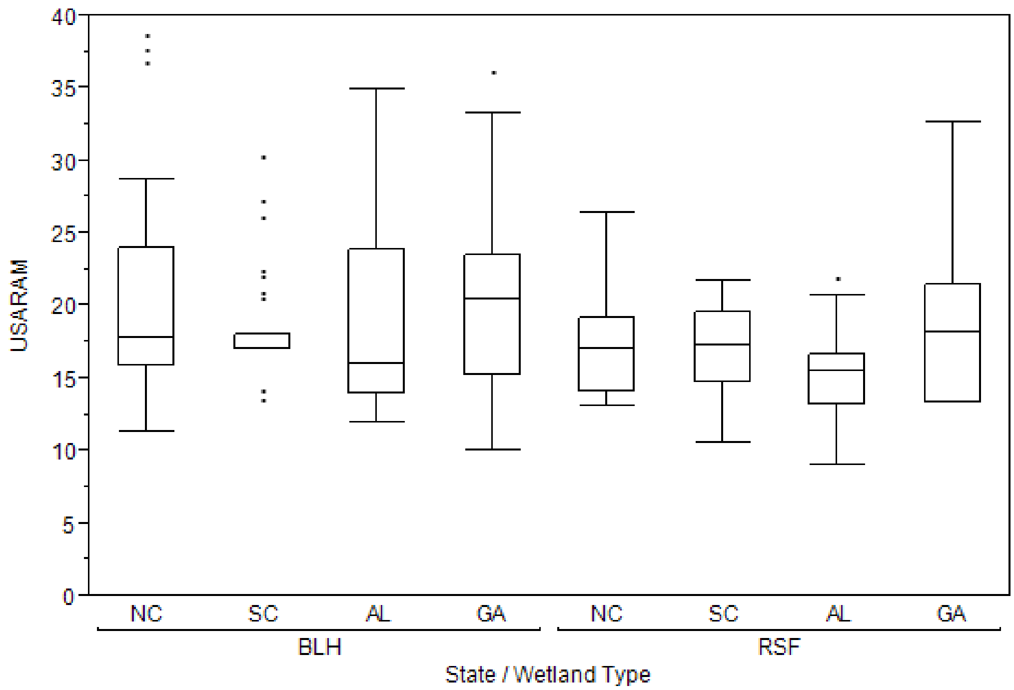


Figure 14: USA-RAM scores for the four-state region by wetland type.

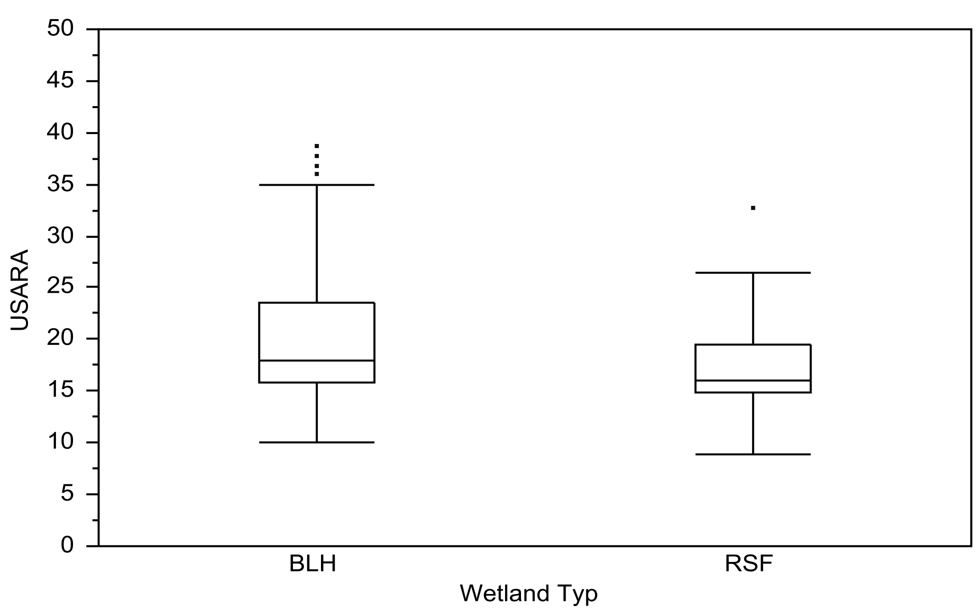


Figure 15: Total number of stressors present in AA buffer plots (mean of plots by site)

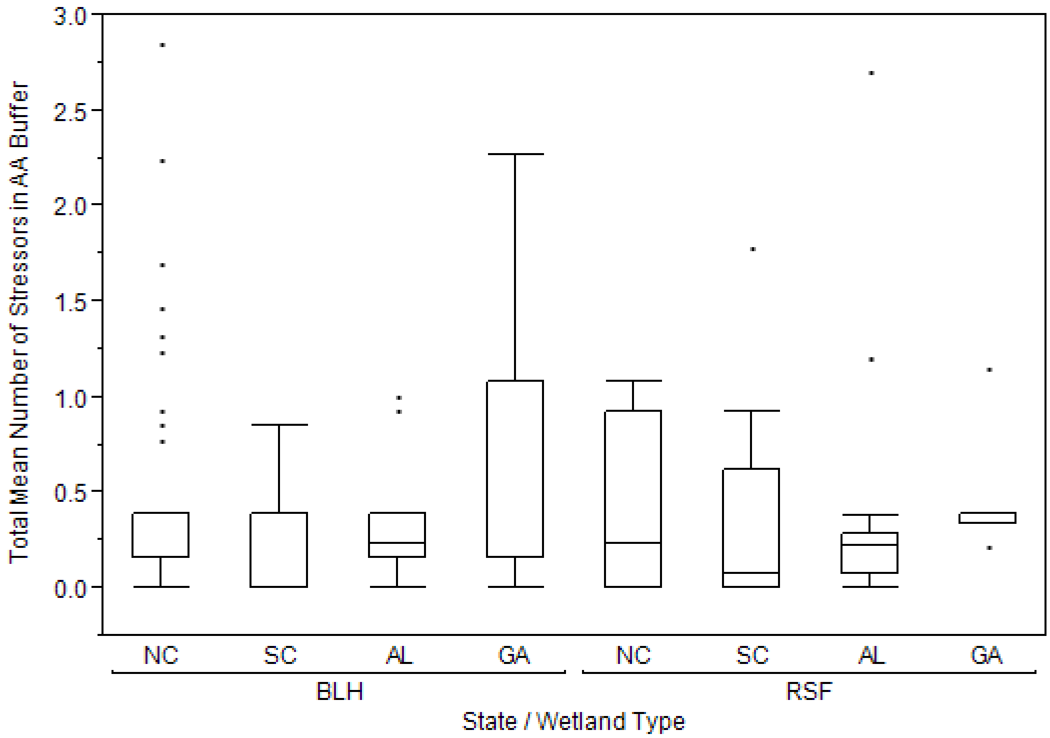


Figure 16: Total mean number of stressors in AA buffer – four-state region

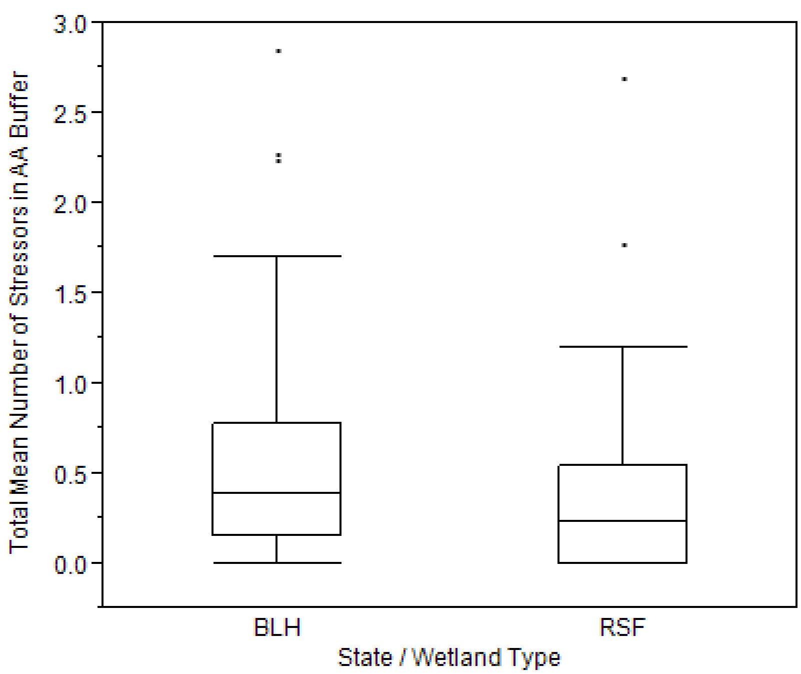


Figure 17: Buffer strata by state for BLH wetlands, with 0 = Absent, 1 = Sparse (<10%), 2 = Moderate (10-40%), 3 = Heavy (40-75%), 4 = Very Heavy (>75%)

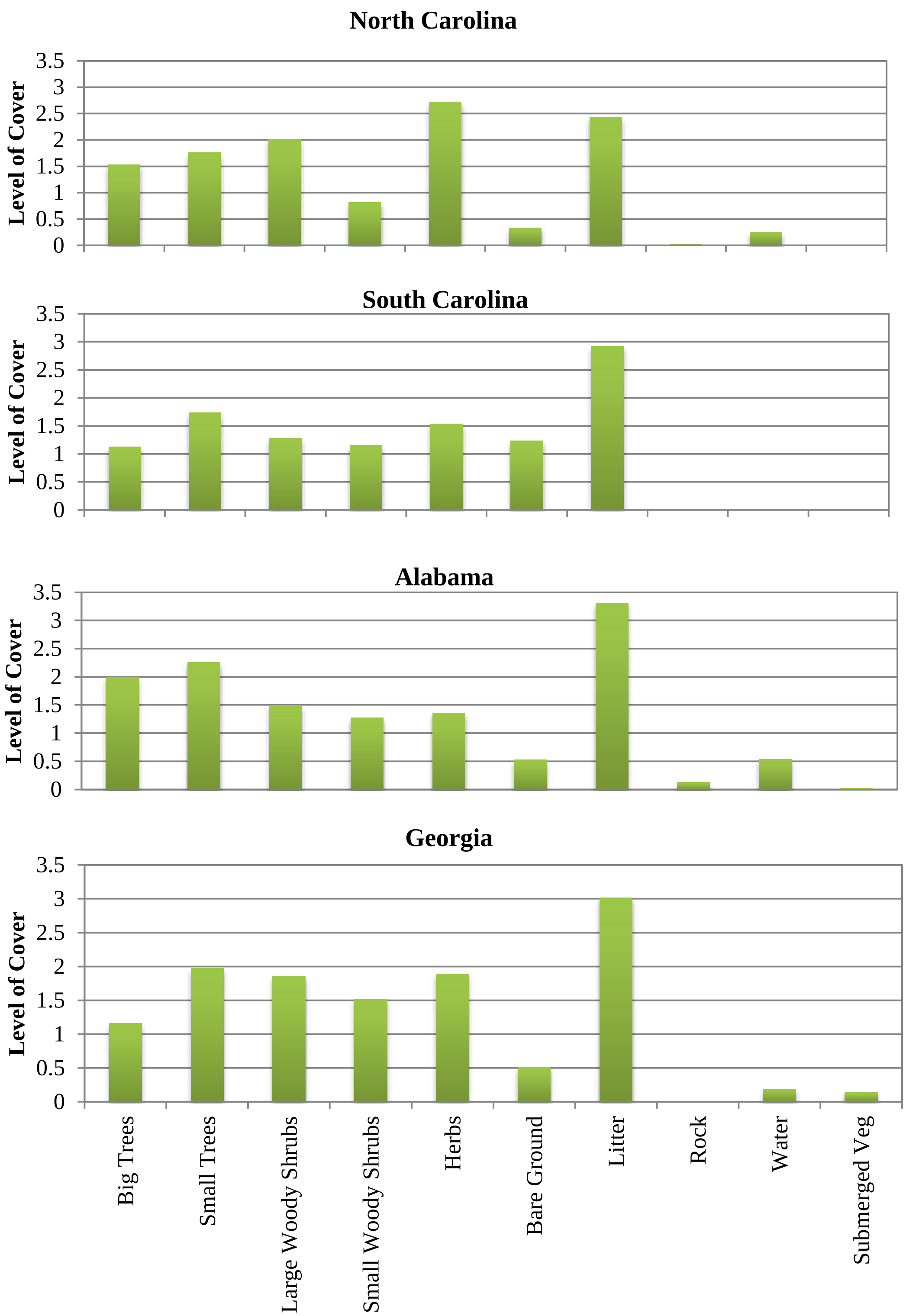
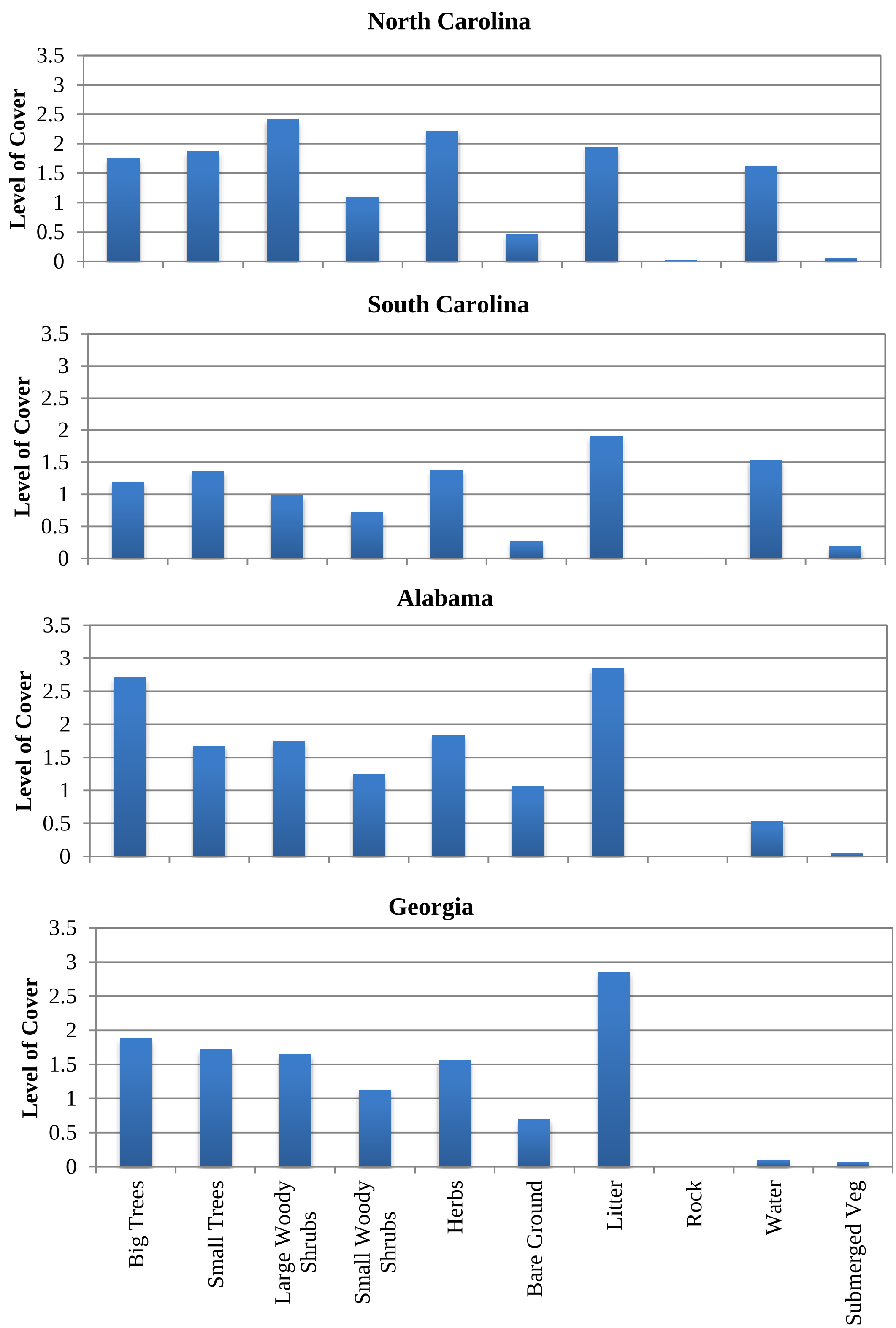


Figure 17 shows the composition of the buffer strata of the bottomland hardwood forest sites for each state. The vertical axis scale is defined in the figure titles, but the larger the number the more in the strata. Since these are forested wetlands, woody structures make up much of the composition. The small woody shrubs were much less in North Carolina than the other three states. The herb layer was also quite prominent in the bottomland hardwood forest wetland in all four states. Given the forested nature of these wetlands, the litter layer is also quite extensive.

The composition of the buffer area for riverine swamp forest is show in Figure 18. As was true for the bottomland hardwood forests, the woody structures make up most of the composition of the strata for riverine swamp forests. The herb layer is also quite extensive in these wetlands as is the liter layer. The major difference between the two wetland types is the standing water with riverine swamp forests has much more standing water than did the bottomland hardwood forests. The one exception to this was Georgia, where their riverine swamp forests did not have as much standing water as in the other states.

The results for the rapid assessments consistently showed that the bottomland hardwood forest wetlands were in poorer condition than the riverine swamp forest wetlands. Georgia also had both types of wetland in poorer condition than the other three states and Alabama tended to have wetlands in better condition based on NCWAM and USA-RAM. The buffer assessment also supported than bottomland hardwood forest wetlands were in poorer condition than riverine swamp forest wetlands. In the buffer results, South Carolina tended to have their wetlands in better condition.

Figure 18: Buffer strata by state for RSF wetlands, with 0 = Absent, 1 = Sparse (<10%), 2 = Moderate (10-40%), 3 = Heavy (40-75%), 4 = Very Heavy (>75%)



Hydrology Results

A results summary of the hydrology data is given below by state and then by wetland type. The actual hydrographs are presented in Appendix A. The graphs are not in a uniform style but can be easily compared with each other and with each state. Depth to water was measured in all sites. The BLH sites in the Piedmont (NC and GA only) had been in a drier period over the last couple years, so hydrology data for these sites reflect a drier than normal period for most of the BLH sites.

North Carolina hydrology results

Some equipment problems, and in some cases, difficulty obtaining permission to access a given site resulted in variation in recording periods. The BLH hydrographs are in Appendix A1. Therefore, ground level is specified for each site as the height of the wells varied from site to site. Generally, BLH systems in the Piedmont (Ecoregion 45) were drier than in the Coastal Plain and in particular, the last few years have been on the drier side. The hydrology results are fairly typical of BLH systems, showing seasonal effects when during the growing season, the water levels are underground, sometimes by more than a foot. The spikes that occurred during the growing season were rain events, when the water levels increased suddenly (e.g. hydrograph for site 1002). During the winter, the water levels are higher due to the lack of evapotranspiration.

The RSF hydrographs are presented in Appendix A2. As with the BLH wetland hydrology monitoring, the recording periods were not always consistent. Where the BLH hydrographs have flat levels over time, the RSF hydrographs do not. These systems in the Coastal Plain (Ecoregion 65) are very wet systems and many have water above the surface most of the year. Therefore, seasonal effects are less pronounced; however some of the spikes are rain events (e.g. hydrograph for site 1161).

South Carolina hydrology results

The hydrographs for the SC RSF sites are in Appendix A3. No hydrology data was collected for the BLH sites. The hydrographs for SC RSF sites indicate the location of the ground level and the probe depth. Also included is the temperature. As with the NC RSF sites, these RSF sites have water above the ground much of the year as they are very wet systems. There do seem to be some rain event spikes, but seasonal trends are not always obvious. Site 1257 is interesting in that the site was clear cut and the well was reinstalled afterwards. While the data is not enough to make any definite conclusions about what hydrology changes may have occurred, it does appear that the hydrology became flashier after the clear cutting as indicated by the much larger changes in water levels.

Alabama hydrology results

The hydrographs for AL RSF sites are in Appendix A4. As with SC, no hydrology data was collected for the BLH sites. AL did measure depth to water, but their wells were installed much deeper, up to 20 feet whereas the other states only installed wells to 2 feet. Ground level is at zero for the AL hydrographs. Half of AL RSF sites had water levels at ground level or above much of the year, which is consistent with RSF wetlands is the other states. However, four sites were uncharacteristically dry for RSF. These were sites 1084, 1491, 1510, and 1536. These four sites were marginal as wetlands and may have suffered some kind of disturbance. They did not have the normal hydrology of typical RSF wetlands in the Southeast. As with the other states, seasonal trends for RSF are not obvious.

Georgia hydrology results

The GA site hydrographs for their BLH sites are in Appendix A5. GA had 15 BLH sites, but only 13 hydrographs are presented because wells on two sites were vandalized. Several of the GA BLH sites showed signs of a seasonal trend (sometimes shifted). Many of their sites were on the dry side early in the measurement period but as rain came, they became wetter as the monitoring period progressed. Site 1333 has two hydrographs, an upper and lower, which correspond to upstream and downstream locations. Two wells were placed in this wetland because of observations of apparent differences in how wet the wetland was at various locations. The upstream well did show longer dry periods than the downstream section, consistent with observations. As with the NC BLH sites, the Piedmont region in particular had gone through drought conditions and therefore many of the BLH sites were in a recovery state.

The hydrographs in Appendix A6 show data form the RSF sites in Georgia. There were 15 RSF sites in the Coastal Plain for Georgia. Many of the sites showed the normal seasonal trends, with less water during the growing season, and as is typical with RSF wetlands, they were generally wet throughout the year. Most of the spikes are participation events. Several of the sites are somewhat uncharacteristic of RSF wetland in that the water was below the surface much of the time, probably due to drought conditions. The sites noted in particular were 1059, 1065, 1380, and 1435. Disturbance could also be a reason for some of the altered hydrology conditions.

Soil Analysis Results

The results for the soils are shown in Table 11 and Figures 19-28.

The chemical and physical parameters of the soil samples for bottomland hardwood forest wetlands and for riverine swamp forest wetlands are presented in Table 11. The mean for each parameter is shown averaged across all sites and across all states as well as the range and the actual number of sites. The riverine swamp forest wetlands had higher levels of all of the nutrients than the bottomland hardwood forest wetlands. This is probably due to their landscape position as the riverine swamp forest wetlands tend to be more downstream and to have more water flow in the system. However, the bottomland hardwood forest wetlands had higher levels of soil metals than the riverine swamp forest wetlands. This is probably due to greater development in the Piedmont region, where the vast majority of the bottomland hardwood forest wetlands were. The riverine swamp forests had a higher level of base saturation and humic matter as would be expected due to these systems being wetter. These sites also had lower bulk density. The pH levels in these riverine swamp forest wetlands soils were also higher.

Figure 19 shows the cumulative levels of the soil metals in both wetland types and by state. For the bottomland hardwood forest wetlands, Georgia had the higher levels of metals in the soils. All three states had mercury as being the highest; however, Georgia had a zinc level about as high. The metal that was the next highest tended to be lead. Alabama and South Carolina had the highest level of metals in the soil for riverine swamp forest wetlands with Georgia having the least. For all four states, mercury was the metal present in the highest levels in the soil samples for riverine swamp forest wetlands and zinc was present in the next highest levels.

Table 11: Chemical and physical characteristics of soil samples on BLH and RSF wetland sites in the Southeast region. Not every state analyzed the same parameters, and NWCA sites were included, hence the differences in number of sites for various parameters.

	BLH			RSF		
Nutrients	**Mean of Sites**	**Range**	**N of Sites**	**Mean of Sites**	**Range**	**N of Sites**
Total Carbon (%)	1.96	6.93	18	6.27	48.80	37
Total Nitrogen (%)	0.13	0.31	18	0.39	3.18	37
Total Sulfur (%)	0.02	0.06	18	0.09	1.09	37
Calcium (mg/kg)	619.09	2521.33	39	1301.25	6630.00	67
Phosphorus (mg/kg)	33.33	258.53	39	129.19	631.66	67
Potassium (mg/kg)	34.54	71.50	39	192.68	1662.81	67
Sodium (mg/kg)	11.36	74.21	39	63.11	639.40	67
Sulfur (mg/kg)	40.12	51.44	9	82.99	157.32	20
CEC (meq/100cm^3)	8.46	28.25	39	15.62	109.80	67
Metals						
Arsenic (ppm)	1.42	2.41	18	1.82	8.85	32
Cadmium (ppm)	0.02	0.06	18	0.08	0.39	32
Copper (ppm)	13.74	50.47	39	14.26	261.36	67
Lead (ppm)	12.96	21.87	18	12.22	33.81	32
Magnesium (ppm)	153.09	869.00	39	501.16	2965.77	67
Manganese (ppm)	452.37	2085.73	39	340.04	2086.67	67
Mercury (ppm)	33.23	66.83	18	83.18	207.67	22
Zinc (ppm)	33.94	148.40	39	35.58	133.93	67
Physical						
Base Saturation (%)	72.32	26.58	9	57.23	66.16	30
Bulk Density (g/cc)	1.06	1.45	24	0.95	1.70	45
Humic Matter (%)	0.27	0.34	9	3.55	33.47	30
pH	4.90	1.57	39	4.81	2.05	67

The box plots in Figure 20 show mean levels of magnesium and manganese in the soil for bottomland hardwood forests and riverine swamp forests. Georgia, followed by North Carolina, had the highest soil levels of manganese in the bottomland hardwood forest wetlands whereas for magnesium, North Carolina had the highest soil levels. For riverine swamp forest wetland, Alabama had the highest levels of both magnesium and manganese in the soil by a large margin. North Carolina had the next highest soil levels of magnesium and South Carolina had the next highest levels of manganese in soil sample from riverine swamp forest wetlands.

Figure 19: Cumulative soil metal levels (total mean mg/kg) for BLH and RSF wetlands.

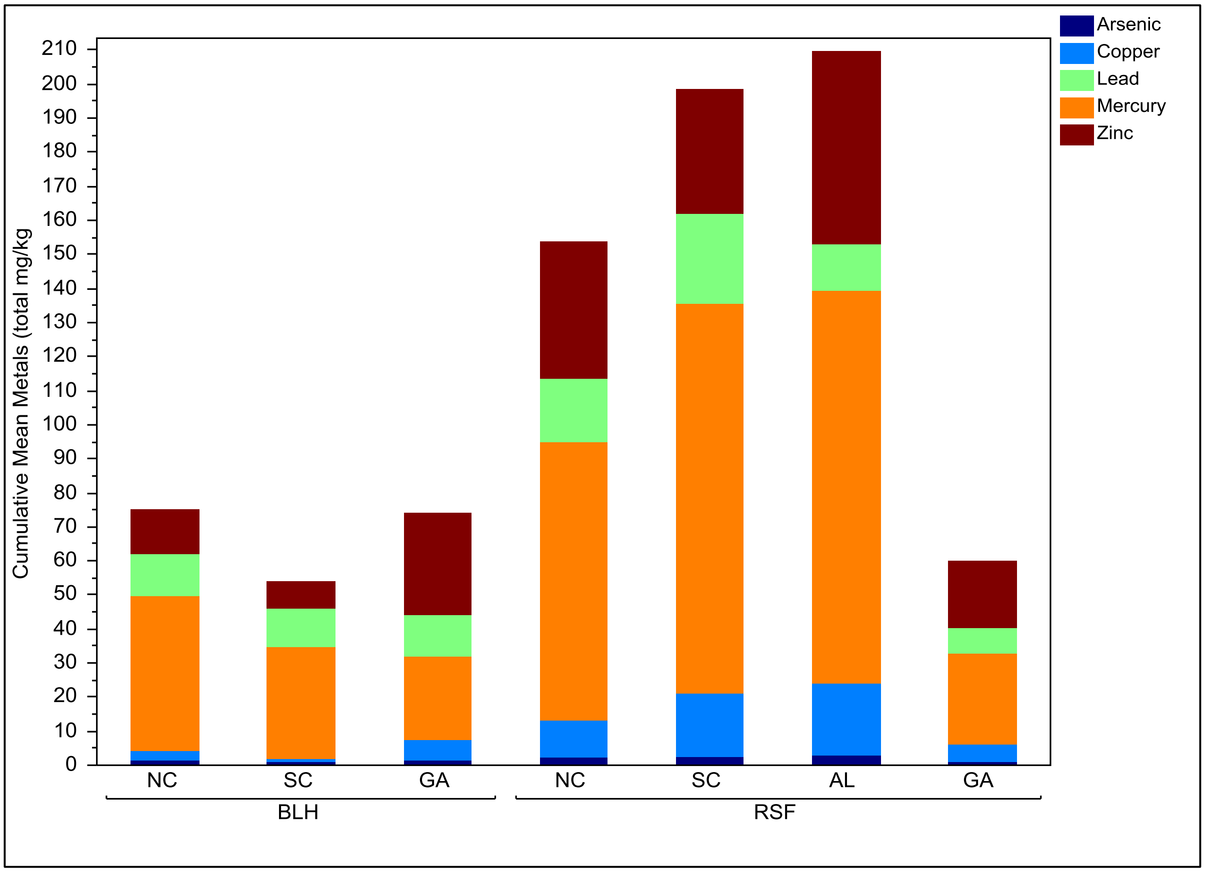


Figure 20: Box plots of mean magnesium and manganese soil levels in BLH and RSF wetlands. These were not included in the previous graph because of scale.

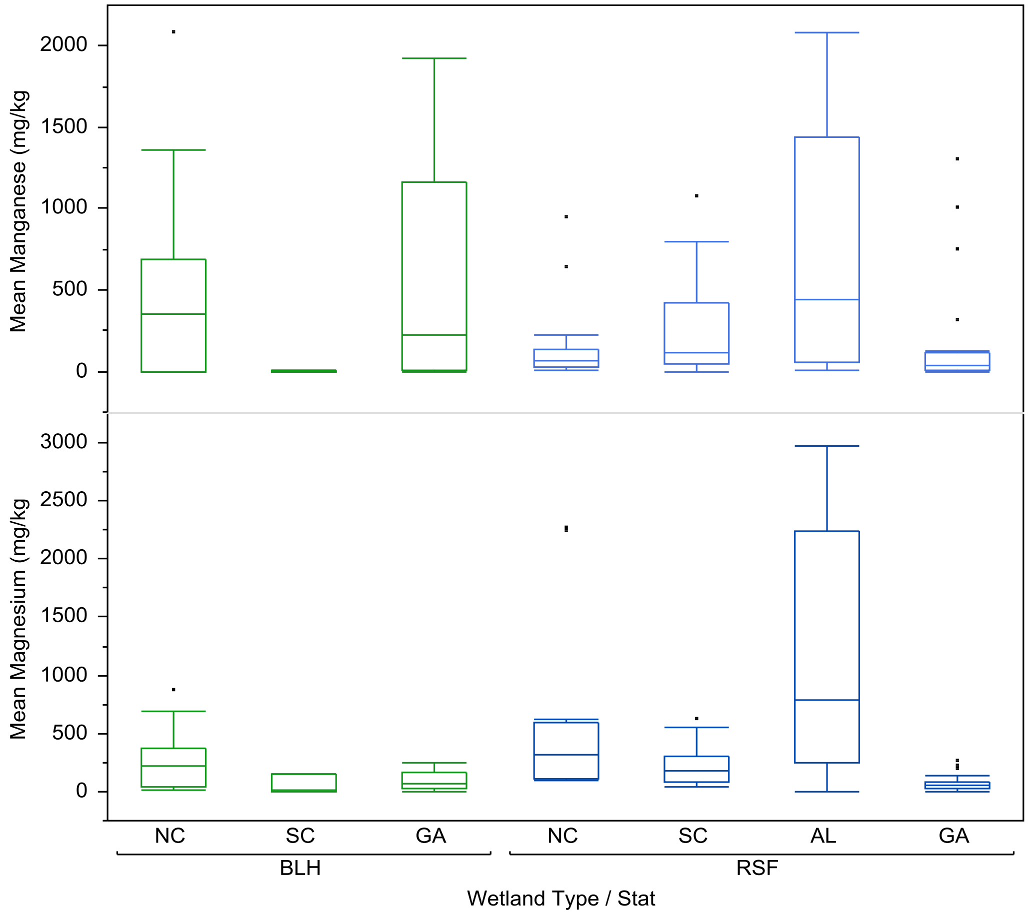


Figure 21: Cumulative soil levels for selected nutrients (total mean mg/kg) in BLH and RSF wetlands.

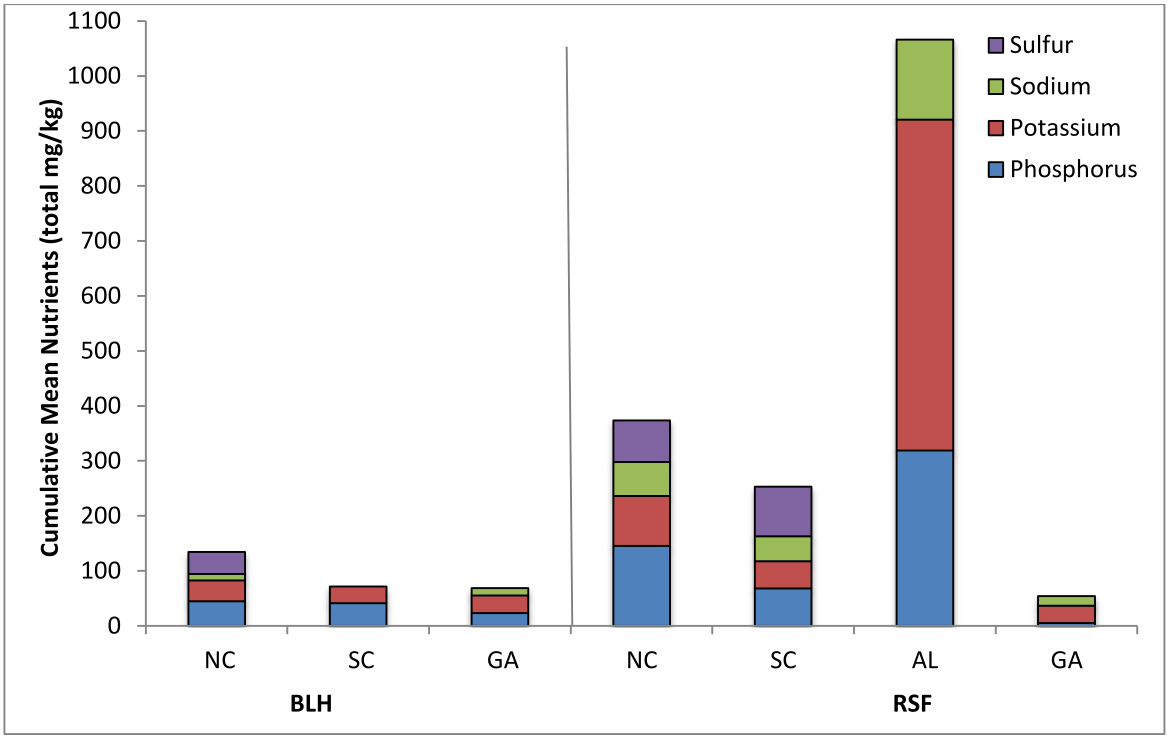
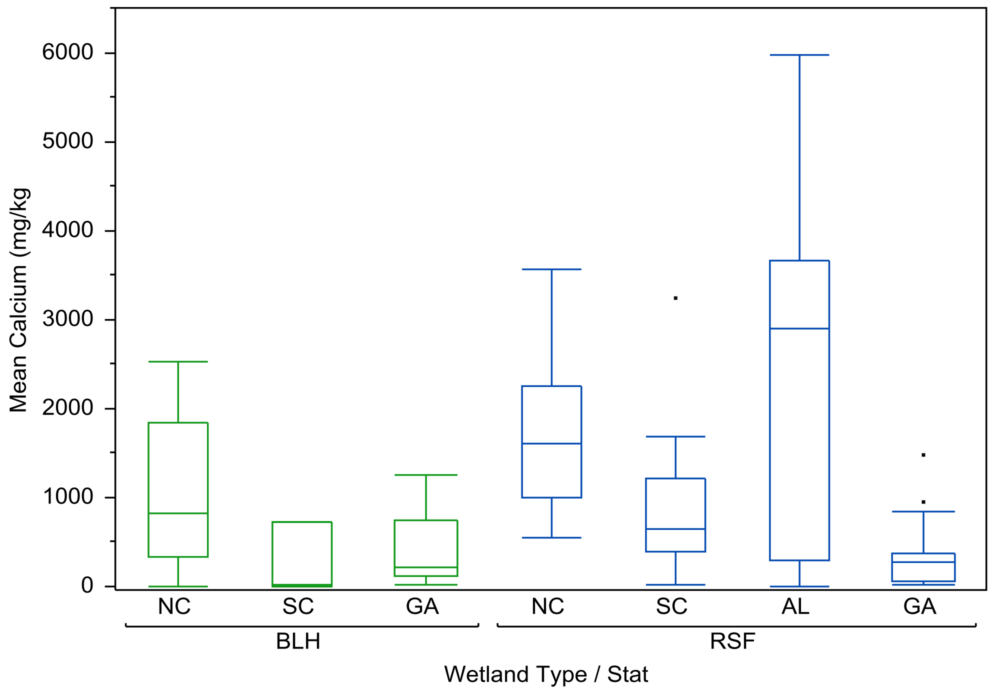


Figure 21 shows the cumulative levels of nutrients (sulfur, sodium, potassium, and phosphorus) in both wetland types by state. Generally, the bottomland hardwood forest wetlands had much lower nutrient levels than the riverine swamp forest wetlands. North Carolina had the highest levels of nutrients for bottomland hardwood forest wetlands. For all three states, the nutrient at the highest levels in the samples was phosphorus followed by potassium. For riverine swamp forest wetlands, Alabama had the highest levels of nutrients by a large margin, with Georgia having the lowest nutrient levels. Phosphorus and potassium tended to be the nutrients at the highest levels in the soil samples overall.

Figure 22 show the box plots of the calcium levels in both wetland types by state. For bottomland hardwood forest wetlands, North Carolina had the highest levels of calcium with Georgia probably having the next highest levels. Alabama had the highest levels of calcium in the riverine swamp forest wetlands soils with North Carolina having the next highest levels. Georgia had the lowest levels of calcium in the soil samples from riverine swamp forest wetlands.

Figure 22: Box plot of calcium soil levels in BLH and RSF wetlands in the Southeast. Calcium was not included in the previous graph because of scale.



The following sets of figures describe some of the data collected from the soil pits. Figure 23 shows the percent of bottomland hardwood forest wetlands that had surface water, saturated soil, or groundwater in the soil pits. The vast majority of sites lacked an impenetrable layer in the soil profile within the soil pits, which were generally excavated to 60 cm. On 4 sites, an impenetrable layer was present (2 RSF and 2 BLH), at around 50-60 cm below the surface. Very few of the bottomland hardwood forests sites had surface water, only about a third had saturated soil, and almost 39% had groundwater (Figure 23).

Figure 24 shows the same data but for riverine swamp forest wetlands. The data indicates that these wetlands have much more water, as expected. Just over 32% of the riverine swamp forest wetlands had surface water and about 70% or more had saturated soils and/or groundwater in the soil pits. Riverine swamp forest wetlands are generally much wetter systems than bottomland hardwood forest wetlands and the soil pit results confirm this (see hydrography in Appendix A).

Figure 23: Percent of BLH sites with soil pits that had surface water, saturated soil, and/or groundwater in soil pits.

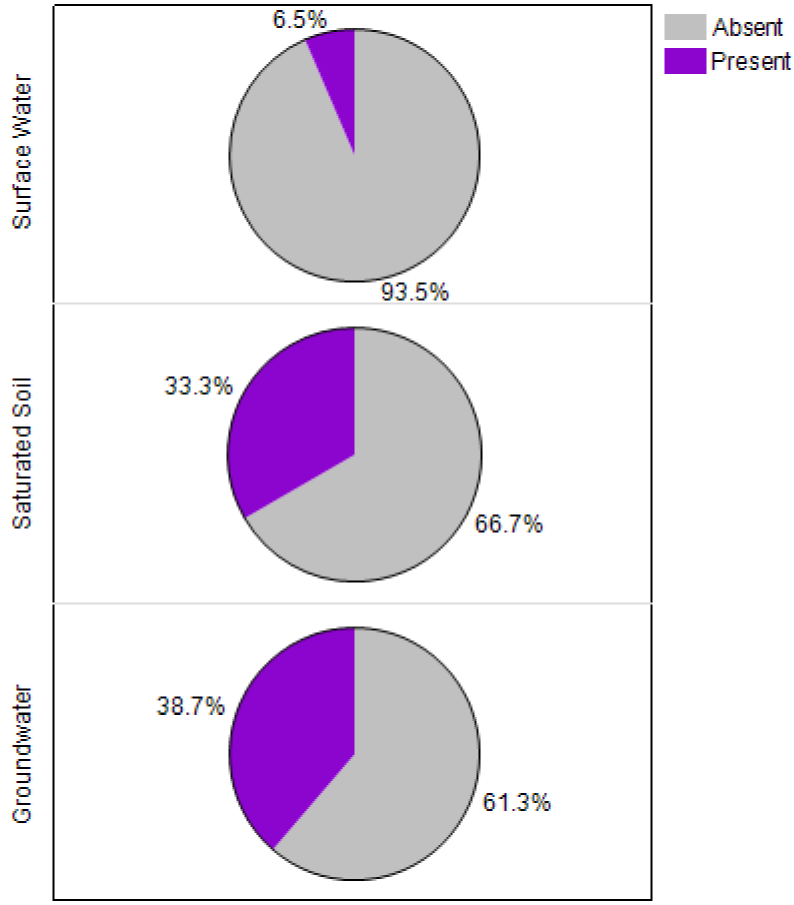


Figure 24: Percent of RSF sites with soil pits that had surface water, saturated soil, and/or groundwater in soil pits.

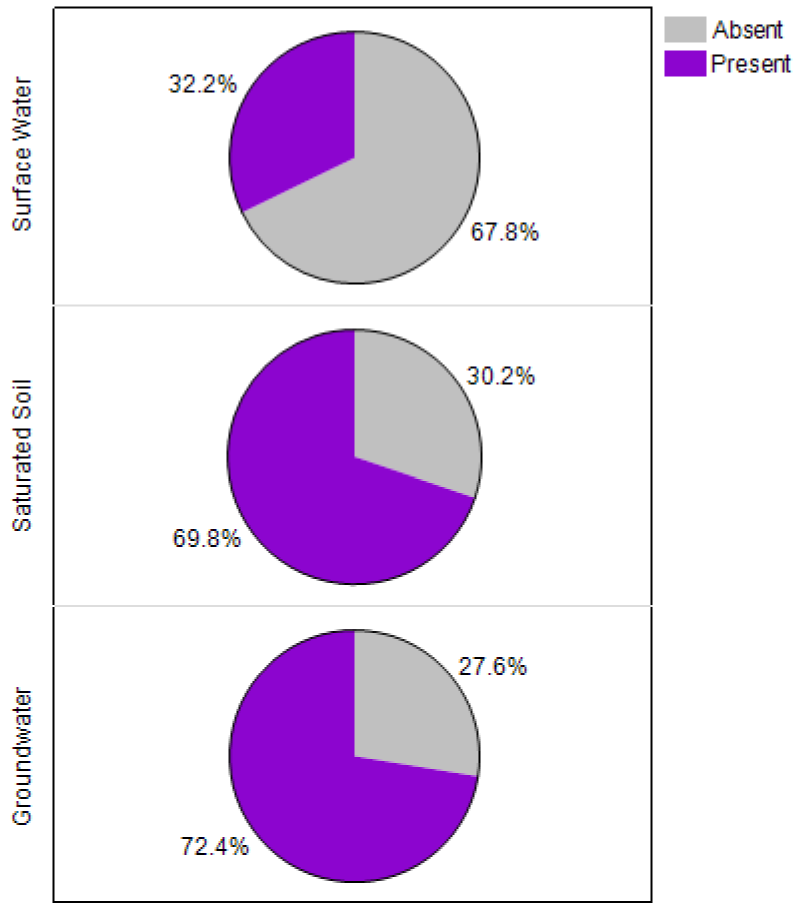


Figure 25 shows the depth of the surface water at the soil pits for both bottomland hardwood forest wetlands and riverine swamp forest wetlands. When surface water was present, the riverine swamp forest wetland had much deeper levels than the bottomland hardwood forest wetlands.

Figure 26 shows depth to saturated soil or to groundwater for both types of wetlands. Given that bottomland hardwood forest wetlands are relatively drier, depth to saturated soil or groundwater was much deeper than in riverine swamp forest wetlands as depicted in Figure 26.

Figure 25: Surface water depth at soil pits on BLH and RSF wetland sites in the southeast region, where surface water was present.

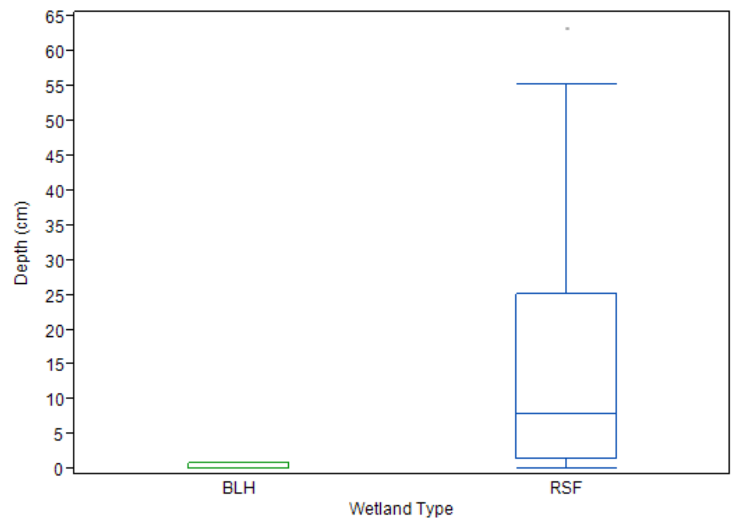


Figure 26: Depth to saturated soil and depth to groundwater in soil pits on BLH and RSF wetland sites, where saturated soil and/or groundwater were present. Note the y-axis is inverted.

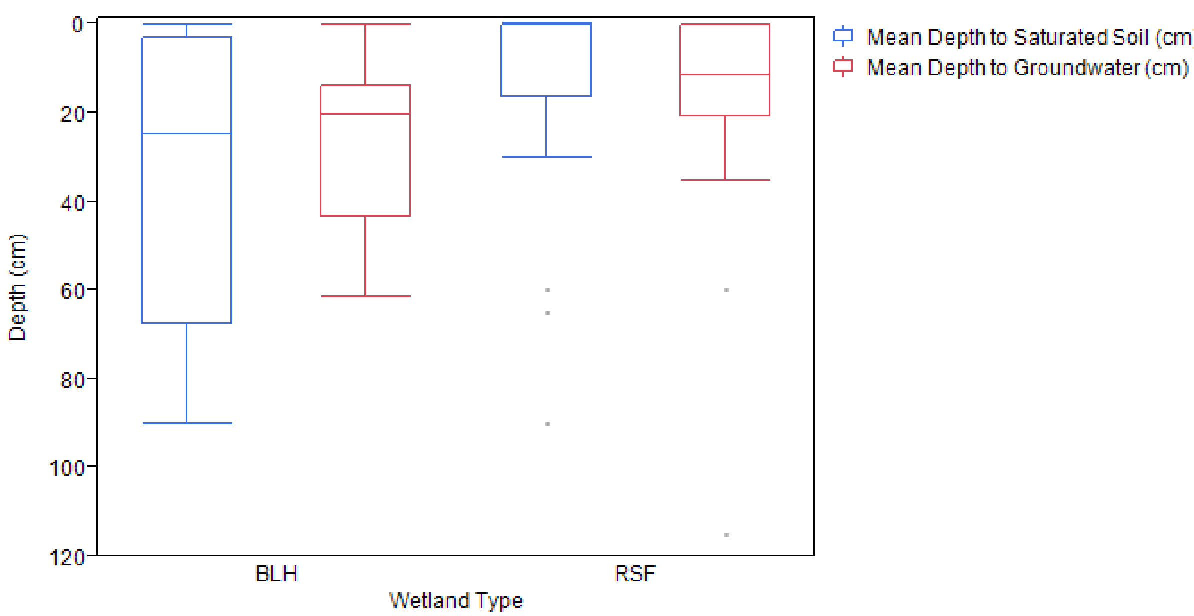


Figure 27: Percent of BLH sites (42) with soil pits that indicated the presence or absence of sandy soil, loamy/clayey soil, mucky mineral and mucky peat.

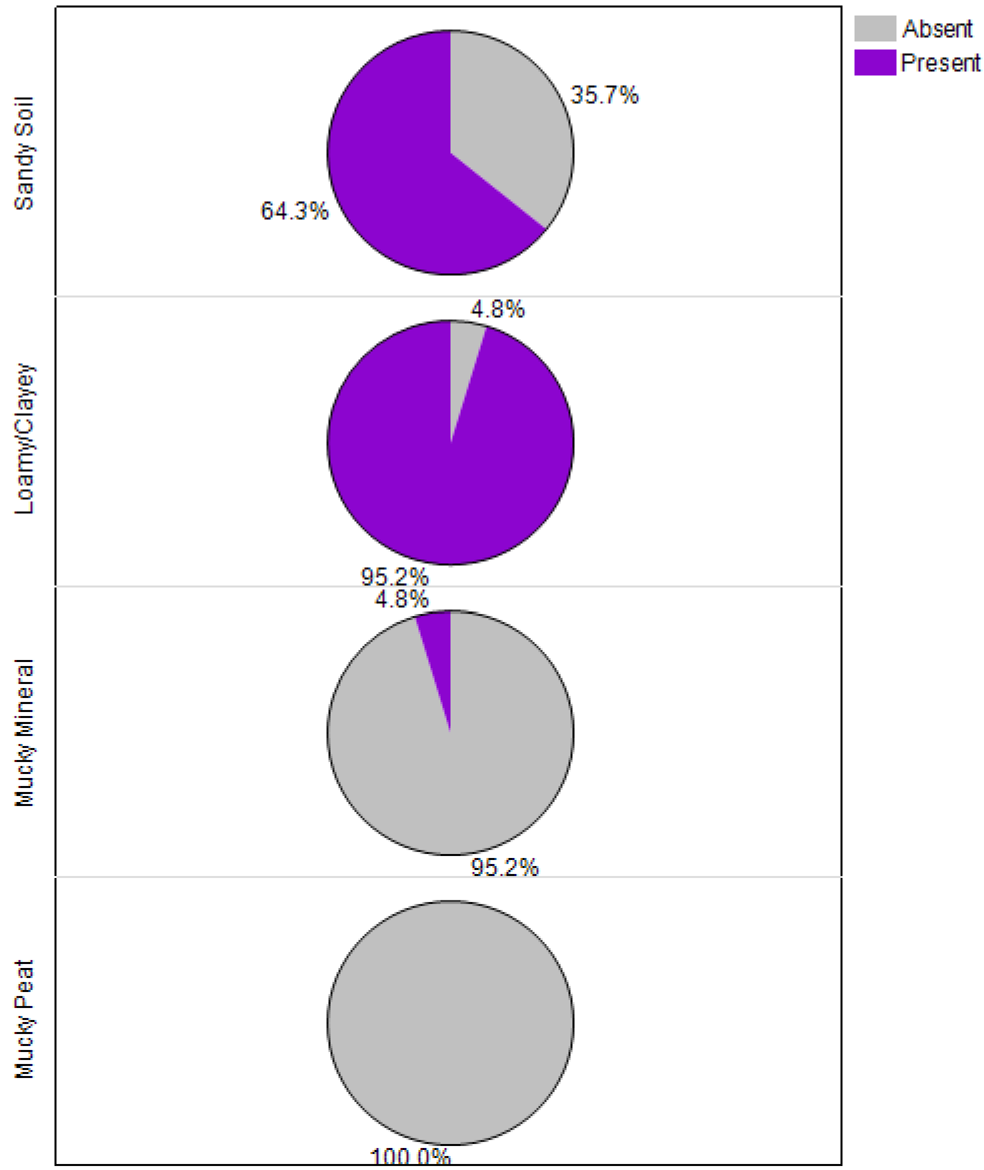
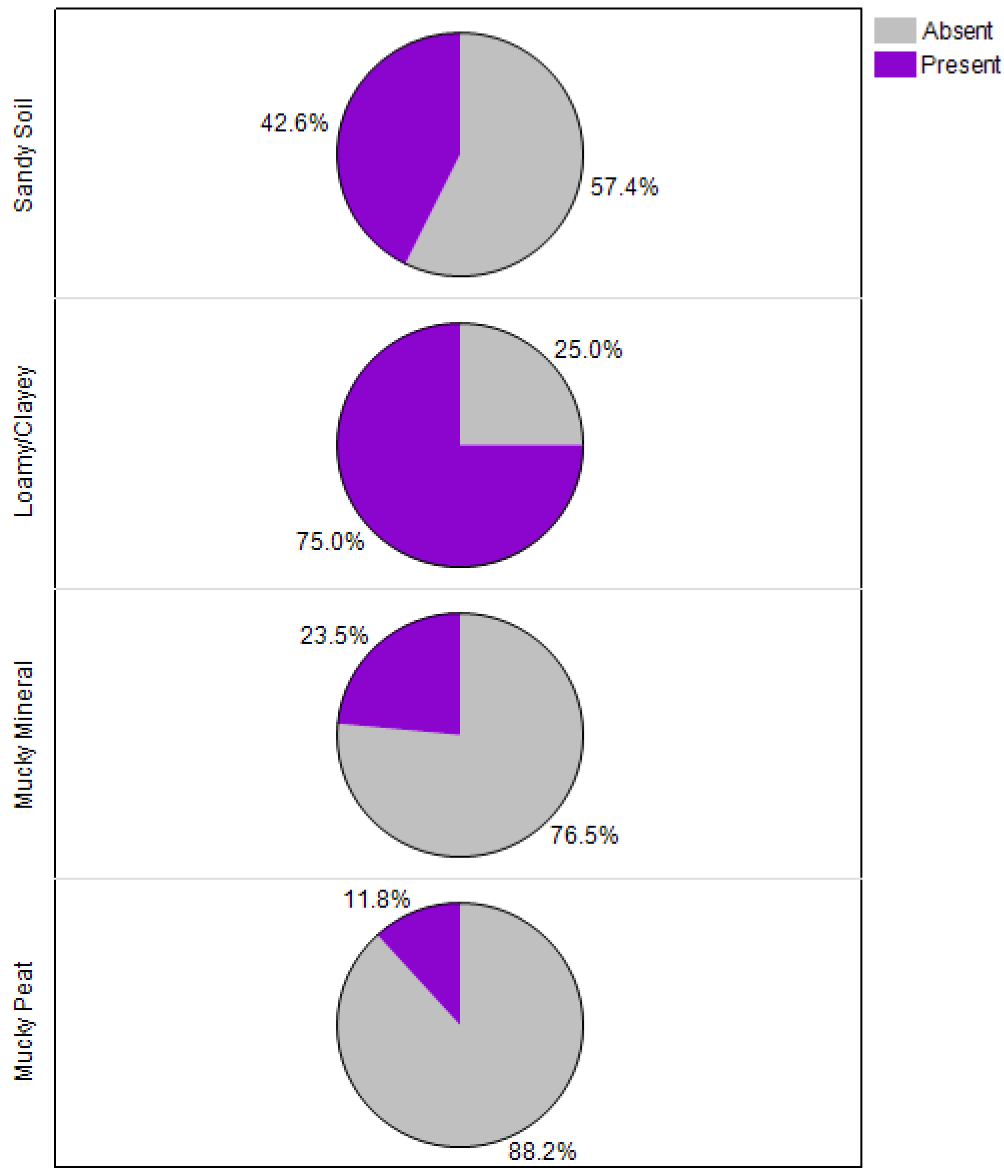


Figure 27 shows the percent of the bottomland hardwood forest wetland sites that had certain soil types present. Over 95% of these wetland sites had loamy/clayey soil and over 64% had sandy soil. Only about 5% of the bottomland hardwood forest wetland sites had any mucky soil and it was mucky mineral. Figure 28 shows the same soil type data for the riverine swamp forest wetland sites and, as depicted, less than 43% had sandy soil and 75% had loamy/clayey soil. Almost 24% of the riverine swamp forest wetland sites had mucky mineral soil and nearly 12% had mucky peat.

Figure 28: Percent of RSF sites (68) with soil pits that indicated the presence or absences of sandy soil, loamy/clayey soil, mucky mineral and mucky peat.



Generally the soil data indicates that riverine swamp forest wetlands are much wetter systems, have mucky soil, and contain much more nutrients than bottomland hardwood forest wetlands as would be expected.   Of particular interest however, is the fact that Alabama had a much higher level of nutrients (potassium primarily) than the other states for riverine swamp forest wetlands.

Water Quality Results

Wetland water quality data are presented in Figures 29-33 and Table 12-13. Water samples were taken in bottomland hardwood forest wetlands and in riverine swamp forest wetlands at upstream and downstream locations. The purpose of doing this was to trace potential pollutants through the wetlands to determine if the wetlands were functioning to reduce pollutant levels. If the levels of a potential pollutant remain the same (upstream to downstream), then it is possible that a wetland is not functioning properly for that particular pollutant or it is possible that the potential pollutant levels were originally so small that any filtering by the wetland would not be evident.

Table 12 shows the mean upstream and downstream water quality parameters at each site for both wetland types in the four-state region. If fewer than six samples were analyzed for a parameter, then it was excluded. Significant results (t-Test or nonparametric equivalent) are shown in blue. For bottomland hardwood forest wetland sites, the only statistically significant result was that total organic carbon was lower downstream; however specific conductivity was higher downstream. At riverine swamp forest wetland sites, dissolved oxygen was higher downstream (p=0.0002), which a positive result. All the other water quality parameters that were statistically significant were at lower levels downstream indicating that the wetlands may be filtering the water of potential pollutants. Ammonia, chlorophyll a, dissolved organic carbon, fecal coliform, phosphorus, TKN, total organic carbon, calcium, zinc, hardness, water temperature, and total suspended solids were all lower downstream and were statistically significant. Riverine swamp forest wetland sites have shown to be good filters of potential pollutants by water quality data analysis in other studies (Baker, et al, 2008 and Savage, et al, 2010) and these results from this study are very consistent with those findings.

Table 12: Mean upstream and downstream water quality parameters per site in BLH and RSF wetlands in the southeast region. BLH water quality parameters were excluded if fewer than 6 site samples were analyzed for that factor; results were considered significant if $p<0.10$ and are colored blue.

	BLH					RSF				
	Mean Upstream	Mean Downstream	N	p value	Direction of Change	Mean Upstream	Mean Downstream	N	p value	Direction of Change
Biological Parameters										
Ammonia (mg/L)	0.20	0.19	19	0.38		0.25	0.17	27	0.05	Lower Downstream
Biological Oxygen Demand (BOD)(mg/L)	1.92	2.05	13	0.24		3.15	2.82	9	0.18	
Chlorophyll a (mg/L)	3.74	5.49	13	0.54		11.35	4.31	10	0.02	Lower Downstream
Dissolved Oxygen (mg/L)	-	-	-	-		2.64	4.27	9	0.002	Higher Downstream
Dissolved Organic Carbon (mg/L)	9.03	8.54	6	0.50		20.01	17.73	11	0.04	Lower Downstream
Fecal Colliform (cfu/100mL)	1267.11	462.83	6	0.11		699.80	239.79	9	0.07	Lower Downstream
Nitrate (mg/L)	0.34	0.44	11	0.22		0.09	0.12	20	0.25	
NO2+NO3 (mg/L)	0.02	0.02	6	0.50		0.21	0.26	21	0.21	
Total Phosphorus (mg/L)	0.11	0.13	19	0.30		0.53	0.27	29	0.04	Lower Downstream
Total Kjeldhal Nitrogen (TKN) (mg/L)	0.65	0.65	19	0.27		3.18	1.86	29	0.02	Lower Downstream
Total Organic Carbon (TOC)(mg/L)	15.30	11.02	6	0.03	Lower Downstream	57.76	25.29	19	0.01	Lower Downstream
Chemical Parameters										
Cadmium (mg/L)	-	-	-	-		0.0001	0.0001	6	0.50	
Calcium (mg/L)	-	-	-	-		13.76	9.49	18	0.03	Lower Downstream
Copper (µg/L)	7.18	5.68	6	0.50		10.44	8.79	19	0.50	
Lead (µg/L)	3.18	2.92	6	0.37		5.16	4.06	19	0.48	
Magnesium (mg/L)	-	-	-	-		3.39	3.01	18	0.12	
Zinc (µg/L)	20.19	14.60	6	0.50		27.64	16.37	19	0.02	Lower Downstream
Physical Parameters										
Hardness (mg/L)	-	-	-	-		26.13	21.44	8	0.07	Lower Downstream
pH	6.85	6.77	16	0.31		6.4	6.2	17	0.19	
Specific Conductivity (µs/cm)	82.12	95.39	16	0.01	Higher Downstream	114.91	110.26	17	0.41	
Total Suspended Solids (TSS)(mg/L)	108.98	100.69	6	0.34		176.40	55.47	19	0.04	Lower Downstream
Water Temperature (°C)	-	-	-	-		16.7	14.3	9	0.01	Lower Downstream

The mean percent changes for biological water quality parameters from upstream to downstream for riverine swamp forest wetland sites are shown in Figure 29. All of the results are statistically significant with chlorophyll a, fecal coliform, and total organic carbon by being lower by 50% or more downstream. Dissolved organic carbon was only lower by 10% downstream, but still resulted in a statistically significant result. Dissolved oxygen increased by 60% and the difference was statistically significant, which is a positive result for organisms. These results indicate that riverine swamp forest wetlands may be reducing potential biological pollutants, while increasing dissolved oxygen.

Figure 30 shows statistically significant results for riverine swamp forest wetland sites showing their potential ability to reduce potential pollutants in terms of the percent of change for the chemical and physical parameters. Total suspended solids resulted in nearly 70% reduction downstream and zinc and calcium had over a 30% reduction downstream. The decrease in water temperature is also good for organisms along with the increase in dissolved oxygen.

Figure 29: Percent change in mean of various biological water quality parameters from upstream water sampling points to downstream water sampling points in RSF wetlands. Parameters shown are those for which there was a statistically significant difference ($p<0.10$) from upstream to downstream.

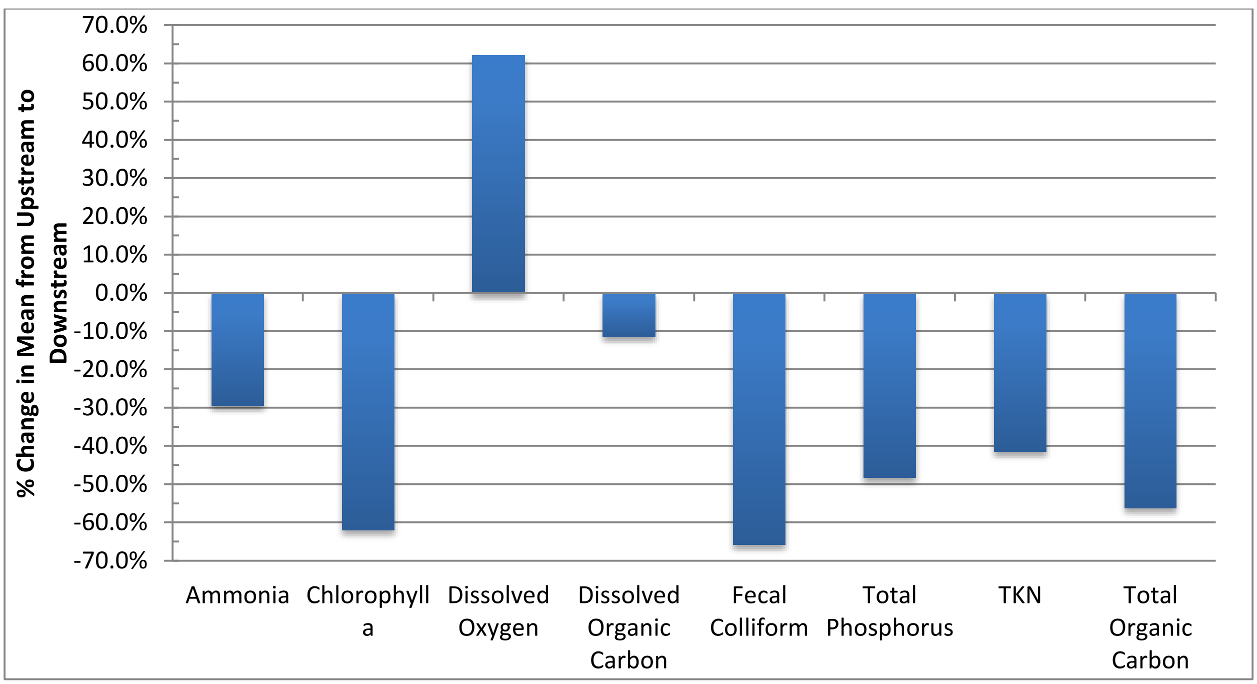


Figure 30: Percent change in mean of various chemical and physical water quality parameters from upstream water sampling points to downstream water sampling points in RSF wetlands. Parameters shown are those for which there was a statistically significant difference ($p<0.10$) from upstream to downstream.

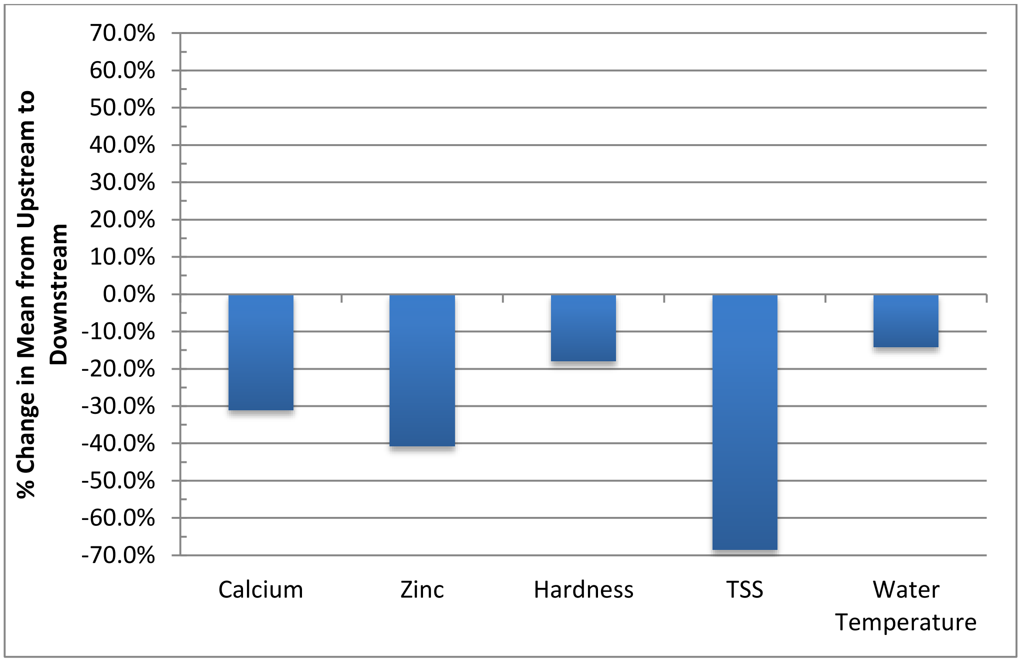


Figure 31 compares the mean nutrients levels from water quality data from bottomland hardwood forest wetland sites for Georgia and North Carolina (South Carolina and Alabama did not perform intensive surveys on this wetland type). North Carolina's water samples had higher levels of TKN and phosphorus than did Georgia's, however Georgia's had higher levels of nitrite-nitrate and ammonia. The variance in these parameters was also quite large.

The mean nutrients levels from water quality data from riverine swamp forest sites are shown in Figure 32 for each state. North Carolina had the highest levels of TKN and Georgia had the next highest levels. North Carolina's water samples also had the highest levels of phosphorus and South Carolina's were the next highest. Georgia's samples had the highest levels of ammonia and nitrite-nitrate with North Carolina's samples having the next highest.

Figure 31: Comparison of mean water quality nutrients levels in BLH wetlands (NC and GA). The parameters included are only those that were analyzed in both states (parameters that were commom to both states). Error bars show maximum and minimum values for each parameter.

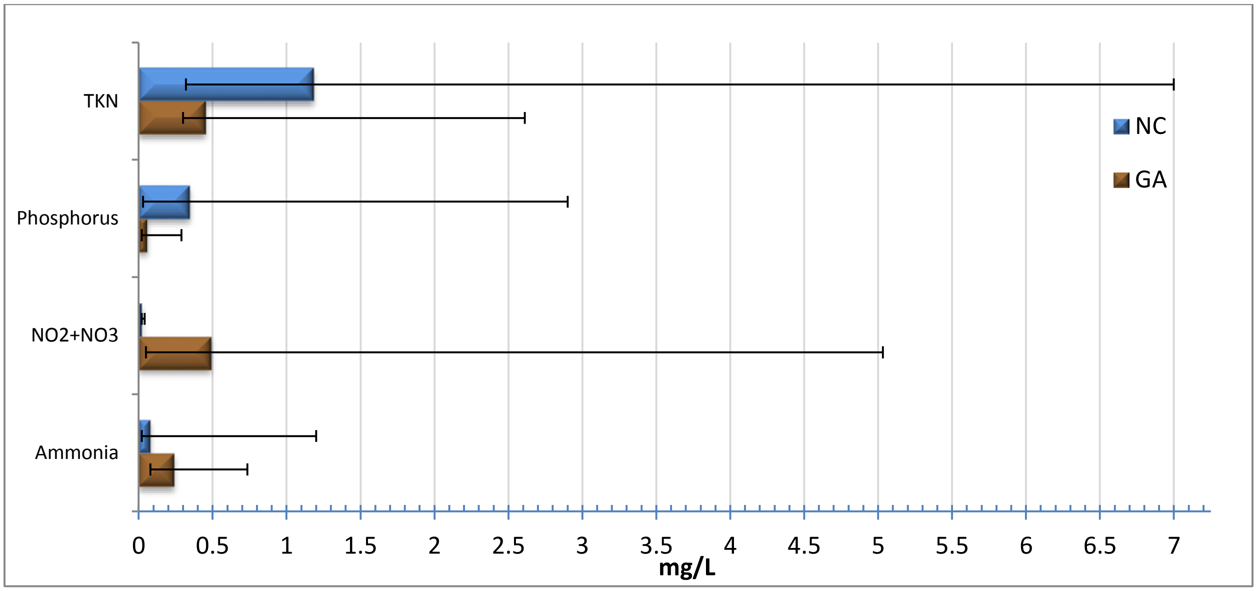


Figure 32: Comparison of mean water quality nutrients levels in RSF wetland sites. The parameters included are only those that were analyzed by all states and were common in all states. The maximum TKN value in NC was 13.0, which is too large to depict at the scale used in the graph below. Error bars show maximum and minimum values for each parameter.

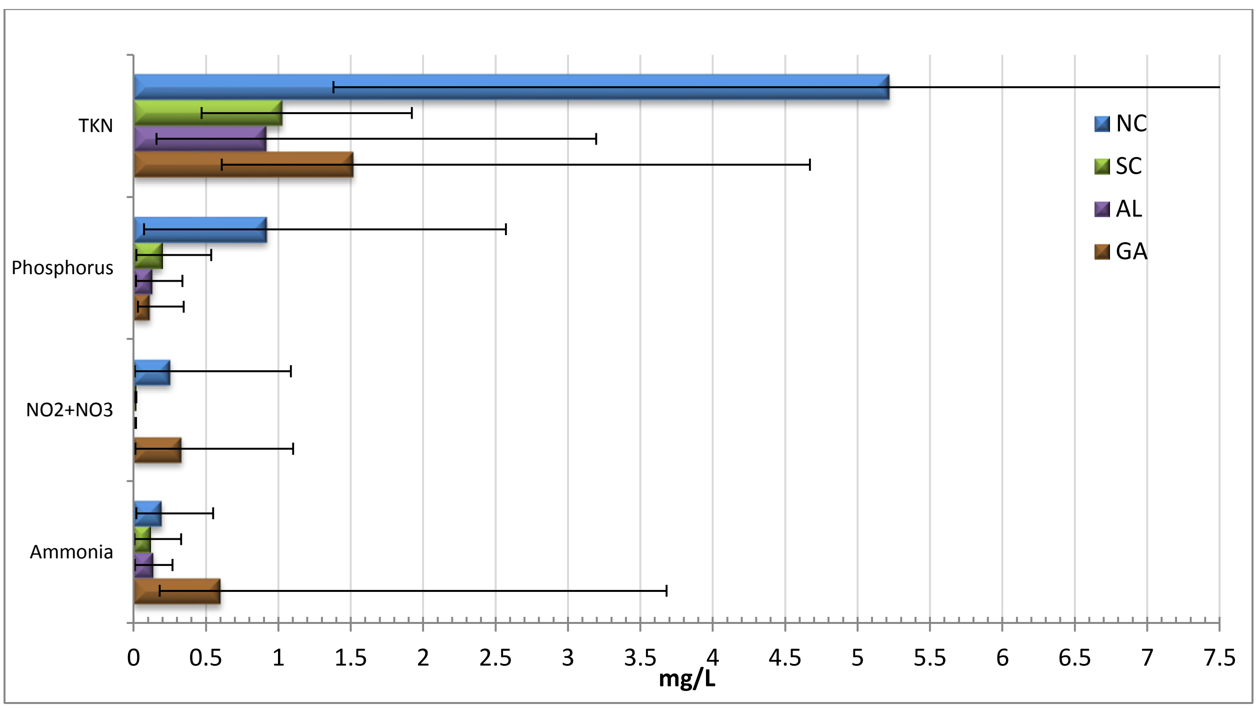


Figure 33: Occurrence of metals (copper, lead, magnesium, and zinc) in water samples from BLH and RSF wetland sites. AL and SC did not collect water samples in BLH wetlands, and GA did not analyze water samples for metals. SC was the only state that included Cadmium in its water sample analysis.

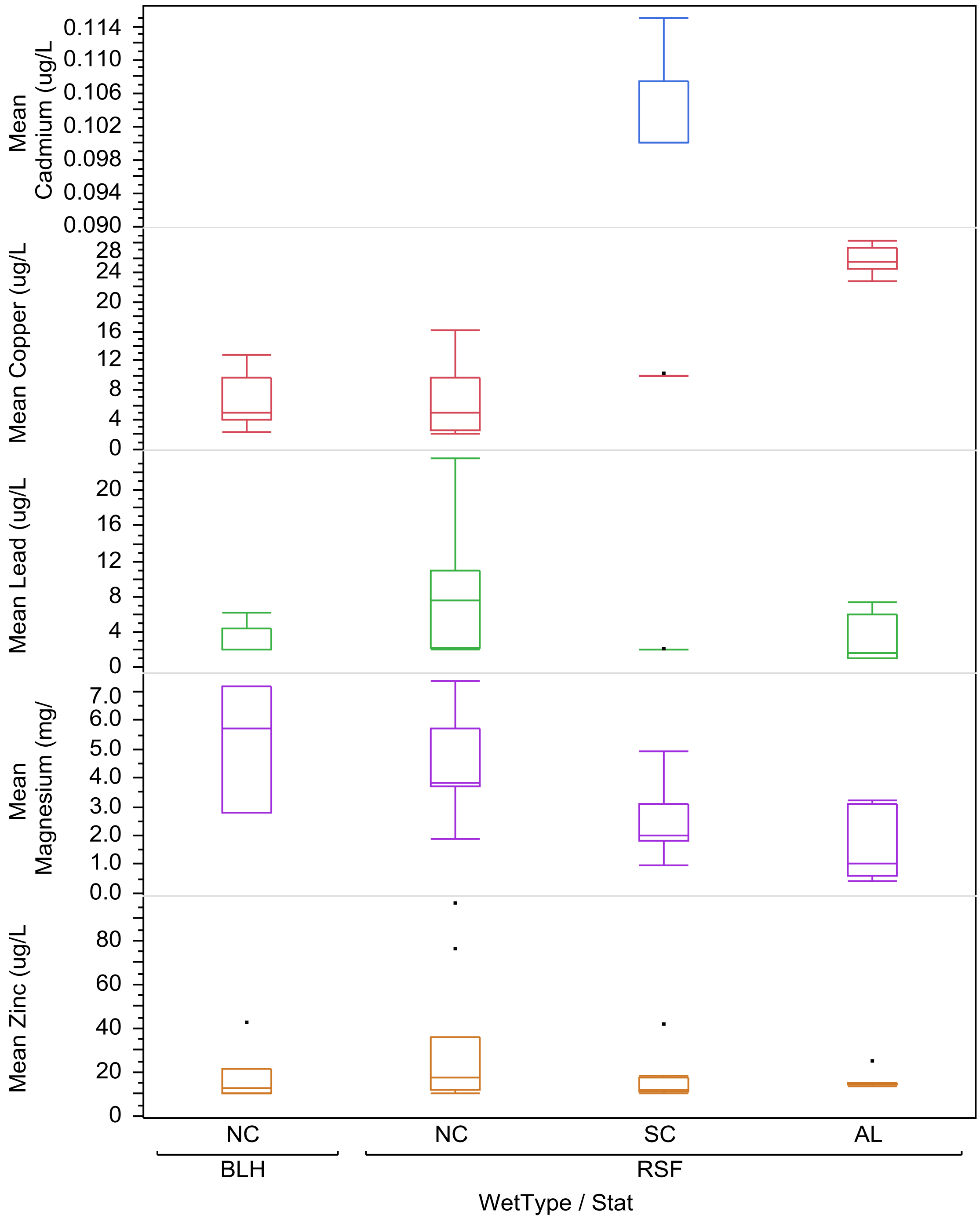


Figure 33 depicts the occurrence of metals in the water samples from both bottomland hardwood forest wetland sites and riverine swamp forest wetland sitess by state. For water samples from bottomland hardwood forest wetland sites, magnesium occurs at higher levels with copper and zinc at occurring at lower levels. Georgia had the highest levels of copper compared to sites of the same wetland type in other states. North Carolina had the highest levels of lead and magnesium compared to other sites of the same wetland type in other states. North Carolina had slightly higher levels of zinc in the riverine swamp forest wetlands sites compared to the other states. The means of the water quality parameters for all samples analyzed for in bottom land hardwood forest wetland sites and riverine swamp forest wetland sites across the four states are shown in Table 13. N is the number of samples used for calculating the average.

The results of the water quality analysis show that riverine swamp forest can reduce metals, nutrients and biological as potential pollutants as water flows through the wetland. Generally NC wetlands have higher levels of TKN and phosphorus than the other states, probably an indication of the hog, chicken, and turkey farms in central and eastern NC.

Table 13: Mean of water quality parameters values per site in BLH and RSF wetlands in the southeast region. BLH water quality parameters were excluded if fewer than 6 sites were analyzed for that factor. Means represent multiple water samples per site over time.

	BLH			RSF		
	Mean Value per Site	Range	N	Mean Value per Site	Range	N
Biological Parameters						
Ammonia (mg/L)	0.17	0.40	27	0.28	3.68	38
Biological Oxygen Demand (BOD)(mg/L)	1.97	1.58	14	3.04	1.39	9
Chlorophyll a (mg/L)	4.57	14.97	14	7.89	18.18	10
Dissolved Oxygen (mg/L)	-	-	3	3.16	4.84	12
Dissolved Oxygen (%)	-	-	3	28.75	51.4	12
Dissolved Organic Carbon (mg/L)	9.22	6.55	6	16.23	28.88	17
Fecal Colliform (cfu/100mL)	878.49	1784.1	6	462.23	2195.71	10
Nitrate (mg/L)	0.64	2.12	14	0.31	4.20	23
NO2+NO3 (mg/L)	0.02	0.06	13	0.18	1.10	31
Total Phosphorus (mg/L)	0.12	0.53	27	0.36	2.55	45
Total Kjeldhal Nitrogen (TKN) (mg/L)	0.89	2.73	27	2.24	12.90	45
Total Organic Carbon (TOC)(mg/L)	13.39	11.98	6	35.93	240.19	27
Chemical Parameters						
Cadmium (mg/L)	-	-	0	0.10	0.02	8
Calcium (mg/L)	-	-	4	12.04	31.66	26
Copper (μg/L)	6.43	10.52	6	12.72	26.33	27
Lead (μg/L)	3.10	4.12	6	4.34	22.57	27
Magnesium (mg/L)	-	-	4	2.94	6.95	26
Zinc (μg/L)	18.00	32.58	6	21.29	86.43	27
Physical Parameters						
Hardness (mg/L)	-	-	0	23.05	45.30	10
pH	6.51	3.33	24	6.37	2.64	28
Specific Conductivity (μs/cm)	89.12	248.94	24	112.57	246.05	28
Total Suspended Solids (TSS)(mg/L)	106.61	315.68	6	101.55	790.49	27
Water Temperature (^{o}C)	-	-	3	16.09	7.15	12

Vegetation Results

Vegetation Index of Biological Integrity

The development of the vegetation Index of Biological Integrity (IBI) is discussed and the resulting IBIs are presented below. First a wetland condition/impairment analysis was conducted pre-assign sites across a gradient of condition/impairment using the criteria described below. This classification was then used to test their ability of the IBI to discriminate wetland condition/impairment.

The wetland impairment analysis used the following steps:

1. *Determining general condition/impairment:* A system was developed to determine general impairment of wetland sites and to classify them accordingly. This allowed ranking of sites from worst to best, and facilitated the assessment of how well candidate vegetation metrics discriminated between the least and most impaired wetlands. USARAM, 300m LDI, NCWAM, and ORAM were all used as components of the scoring since they are attempting to evaluate wetland condition/function, therefore impairment. Each was converted to a percentage of the maximum (worst) within the wetland sample. For example, the highest (most disturbed site) USARAM score was 43, so the score for each site was divided by 43 to obtain a percentage relative to the worst site. The highest 300m LDI score was 5.1, so each LDI value was divided by 5.1. ORAM scores were inverted prior to conversion to a percentage, to make them consistent with the other measures in terms of direction. NCWAM results are in terms of general wetland quality, ie. high/medium/low. To convert NCWAM to a numeric impairment scale, a "Low" NCWAM was given a 100% rating, "Medium" a 50% rating, and "High" a 0% rating. A combined "impairment score" was developed by taking the average (percent impairment) of all disturbance measures available for each site.
2. *Defining least and most impaired:* Since each wetland type was being evaluated for its own VegIBI, the distributions of the "impairment scores" were analyzed separately. For the BLH wetlands, the lowest and highest 25th percentiles were labeled least and most impaired, respectively. This resulted in 11 sites for each extreme. For the RSF wetlands, most of which are higher quality, the lowest and highest 10th percentiles were used as least and most impaired. This resulted in eight sites for each extreme.

Development of the vegetation IBIs used the following steps:

1. We obtained weighted pairwise correlations of ORAM (scores) with the list of 50 candidate vegetation metrics (see Table 7 in Method section). Pearson's correlations were calculated for continuous metrics, and Spearman's rank correlations were calculated for discrete

metrics (eg. richness). Metrics which were not significantly correlated with ORAM (p>0.05) were discarded. This was done separately for each wetland type, as the list of significantly correlated metrics differed by wetland type (see Table 13 and 14).

2. From the remaining list, metrics were selected that discriminated well between the least and most impaired sites. Box plots were created and t tests were performed for each of the selected metrics to determine whether a metric was able to discriminate between the least and most impaired sites. Metrics were discarded if there was no significant separation between the extremes.
3. Weighted pairwise correlations of metrics from Step 2 were calculated and compaired with all other Step 2 metrics (Table 14 and 15), with the intent of eliminating any metrics that were highly correlated with each other or redundant (ie. cryptogam richness vs. cryptogam cover). Metrics were considered highly correlated with each other if they had a <u>correlation coefficient of 0.7 or greater, and a p value of less than 0.05</u>.
4. When two metrics were highly correlated with each other, correlations between the metric and LDI, USARAM, and NCWAM were examined. If significant correlations with these other disturbance measures were present, we retained the metric with more frequent or stronger correlations. If neither of the highly correlated metrics satisfied these two criteria, we chose the metric that correlated significantly with more of the other vegetation metrics.
5. The resulting list was comprised of variables that were all correlated with ORAM (and sometimes USARAM, NCWAM, and/or LDI), and that did not correlate strongly with each other (Table 14 and 15).
6. To generate the index value, we converted each metric to a 5,3,1 point scale by dividing the range of metric values into thirds. Depending on the direction of the relationship between the metric and disturbance, points (5, 3, or 1) were assigned to the upper, lower, and middle thirds based on Tables 16 for BLH and 17 for RSF. Points were summed for each site to arrive at a total Veg IBI score.
7. The Veg IBI was tested using ANOVA for its ability to distinguish between the least and most impaired sites based on the impairment analysis/preclassification of the previous set of steps.

Note that SC and AL did not survey BLH sites for this study; however; data from the NWCA indicated that some of the South Carolina sites surveyed in 2011 as part of that study were BLH sites while none were in Alabama. NWCA data from South Carolina BLH sites were used to supplement the data in this analysis. Note also that, the mean C (all species), native wetland herb relative cover, and relative frequency of natives were all positively correlated with condition (ORAM); whereas cryptogam richness and non-native shrub relative cover were negatively correlated with condition. Componet scores for generating the index values were assigned based on the direction of these correlations.

Table 14: Metric Selection Results for BLH Wetlands Veg IBI

Step 1 List. Metrics significantly correlated with ORAM (p<0.05)	------------> Step 2. Eliminate metrics that don't discriminate between least and most impaired	**Step 2 List. Metrics that discriminate between least and most impaired BLH sites**	------------> Step 3. When metrics are highly correlated with each other, reduce metrics in favor of ones that also correlate significantly with other disturbance measures	**Step 3 List. Metrics that are not significantly highly correlated with each other (r<0.70, p<0.05)**
Carex Richness	X	FQAI Cover		FQAI Cover
FACWet Equation 3	X	Relative Percent Cover Tolerant C<=4	X	
FQAI Cover				
Native Evenness (Cover)	X			
Native Graminoid (Cyperaceae, Poaceae, Juncaceae) Relative Cover	X			
Native Simpson's Diversity (Cover)	X			
Native Wetland Herb Relative Cover	X			
Relative Cover Forb	X			
Relative Cover Trees	X			
Relative Cover Vine	X			
Relative Percent Cover Sensitive C>=7	X			
Relative Percent Cover Tolerant C<=4				

Table 15: Metric Selection Results for RSF Wetlands Veg IBI

Step 1 List. Metrics significantly correlated with ORAM (p<0.05)	------------> Step 2. Eliminate metrics that don't discriminate between least and most impaired	**Step 2 List. Metrics that discriminate between least and most impaired BLH sites**	------------> Step 3. When metrics are highly correlated with each other, reduce metrics in favor of ones that also correlate significantly with other disturbance measures	**Step 3 List. Metrics that are not significantly highly correlated with each other (r<0.70, p<0.05)**
Carex Richness	X	Cryptogam Richness		Cryptogam Richness
Cryptogam Cover %	X	Mean C All Species		Mean C All Species
Cryptogam Richness		Native Wetland Herb Relative Cover		Native Wetland Herb Relative Cover
FACWet Equation 3	X	Nonnative Richness	X	Non-native Shrub Relative Coverage
Mean C All Species		Non-native Shrub Relative Coverage		Relative Frequency Natives
Native Wetland Herb Relative Cover		Relative Frequency Natives		
Native Wetland Herb Species Richness	X	Relative Frequency Nonnatives	X	
Nonnative Richness				
Non-native Shrub Relative Coverage				
Relative Cover Ferns	X			
Relative Cover Shrub & Subshrub	X			
Relative Cover Vine	X			
Relative Frequency Natives				
Relative Frequency Nonnatives				
Tolerant Species Richness C<=4	X			

Table 16: Scores assigned to FQAI Cover values.

Score Assigned	FQAI Cover
5	> 26.48
3	17.99 to 26.48
1	≤ 17.99

Table 17: Scores assigned to metrics in the RSF Veg IBI.

Score Assigned	Mean C All Species	Native Wetland Herb Relative Cover	Relative Frequency of Natives	Cryptogam Richness	Non-native Shrub Relative Coverage
5	> 5.15	> 0.67	> 0.94	< 2	< 0.24
3	> 4.39 to 5.15	> 0.33 to 0.67	0.88 to 0.94	2 to 5	0.24 to 0.47
1	≤ 4.39	≤ 0.33	≤ 0.88	≥ 5	≥ 0.47

Since the BLH VegIBI results resulted in one metric, converting that one score to an IBI score is hardly necessary; however, the single metric value was still converted to an IBI per step 6 above for purposes of comparison with other IBIs.

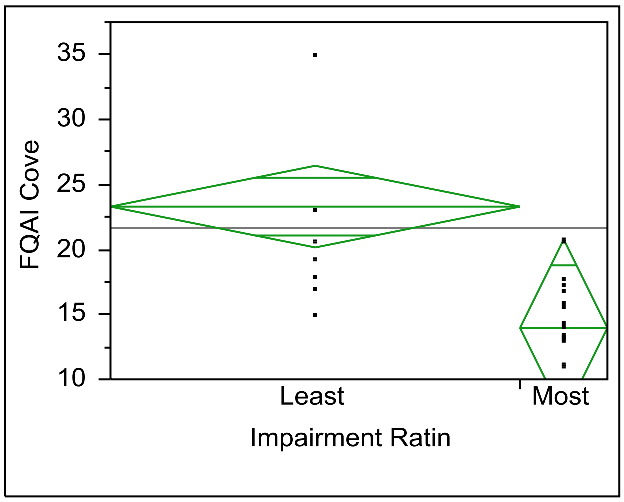
Figure 34 shows the discriminanation ability of the FQAI cover metric score prior to conversion to an IBI score. Clearly the FQAI cover metric successfully discriminates between least and most impaired BLH wetland sites. If the FQAI cover metric score is converted to an IBI score, then it also discriminates between least and most impaired BLH wetlands as depicted in Figure 35. This is of course an expected result; however it is interesting to note that the ANOCA p-value is stronger for the IBI score. Additionally, FQAI Cover is significantly correlated with impairment ($r = -0.37$, $p = 0.015$, $N = 43$).

Table 19 and Figure 36 show the results for the vegetation IBIs for the RSF wetland sites. Unlike the BLH sites, five metrics contributed to the IBI score for the RSF sites (see Table 7). The ANOVA indicated the RSF vegetation IBI successfully discriminated the least and most impaired sites as show in Figure 36 ($p < .0007$).

The RSF VegIBI had a maximum value of 25 points, with five metrics included. The highest values observed were in North Carolina, South Carolina, and Georgia, and the lowest observed were in Georgia. The RSF VegIBI also correlated with impairment ratings, $p = 0.003$, $r = -0.35$ $n = 67$.

Mean C for All Species, Native Wetland Herb Relative Cover, and Relative Frequency of Natives were all positively correlated with condition (ORAM), whereas All Species Dominance (based on cover), Cryptogam Richness, and Non-native Shrub Relative Cover were negatively correlated with condition.

Figure 34: Discrimination between least and most impaired BLH sites by the FQAI Cover metric (ANOVA p = 0.017)



Level	Mean FQAI Cover	Std Error	Lower 95% CI	Upper 95% CI
Least Impaired BLH	23.30	1.51	20.2	26.5
Most Impaired BLH	13.96	3.27	7.2	20.8

Figure 35: Discrimination between least and most impaired BLH sites by the FQAI Cover metric when scored on a 1,3,5 point scale (ANOVA p = 0.0089)

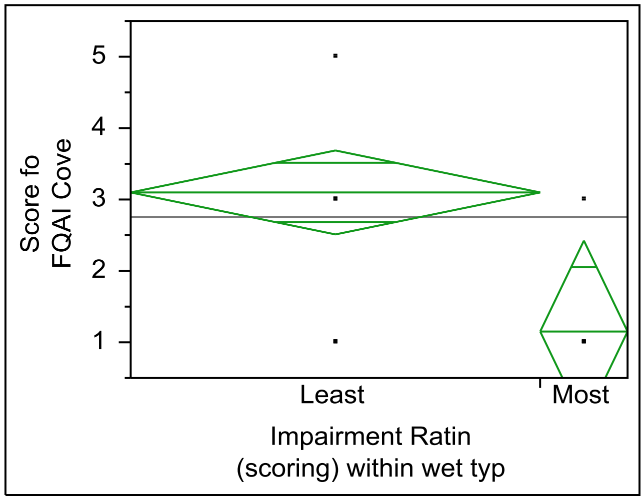
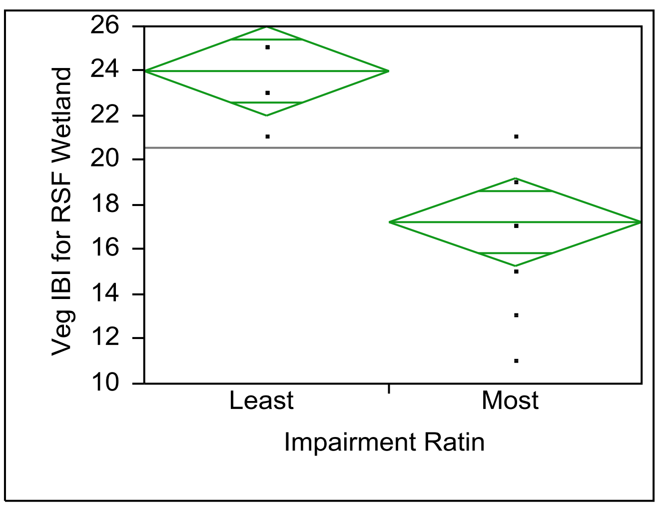


Figure 36: Discrimination between least and most impaired RSF sites by the RSF Veg IBI (ANOVA p = 0.0002)



Level	Mean RSF Veg IBI Score	Std Error	Lower 95%	Upper 95%
Least Impaired RSF	24.0	0.9	22.0	25.0
Most Impaired RSF	17.2	0.9	15.3	19.2

Figure 37 shows the distribution of the FQAI Cover values for the BLH sites by state. As can be seen, sites in Georgia generally scored higher than North Carolina sites based on this metric. The IBIs would show the same basic distribution, but the scale would be different. Figure 38 shows box plots of the FQAI metric cover scores and the IBI scores. Finally, Table 18 shows the actual vegetation IBI scores for each BLH wetland site and the corresponding condition category.

Figure 37: Distribution of BLH FQAI Cover values by state.

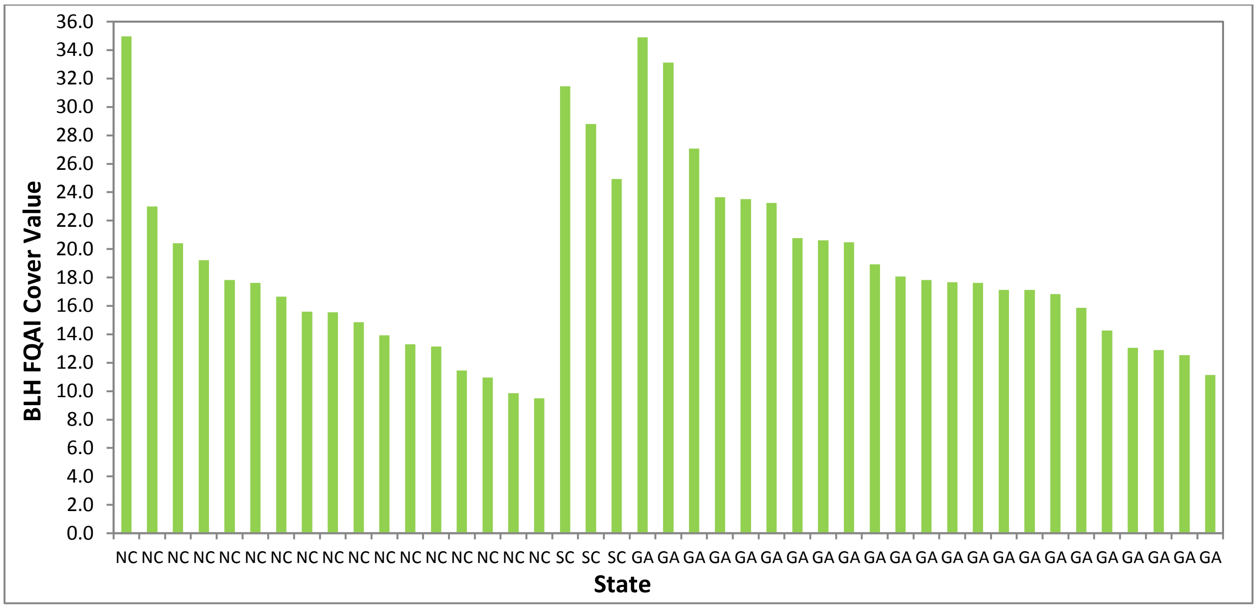


Figure 38: Box plot summary of BLH FQAI Cover metric values and FQAI Cover scores by state.

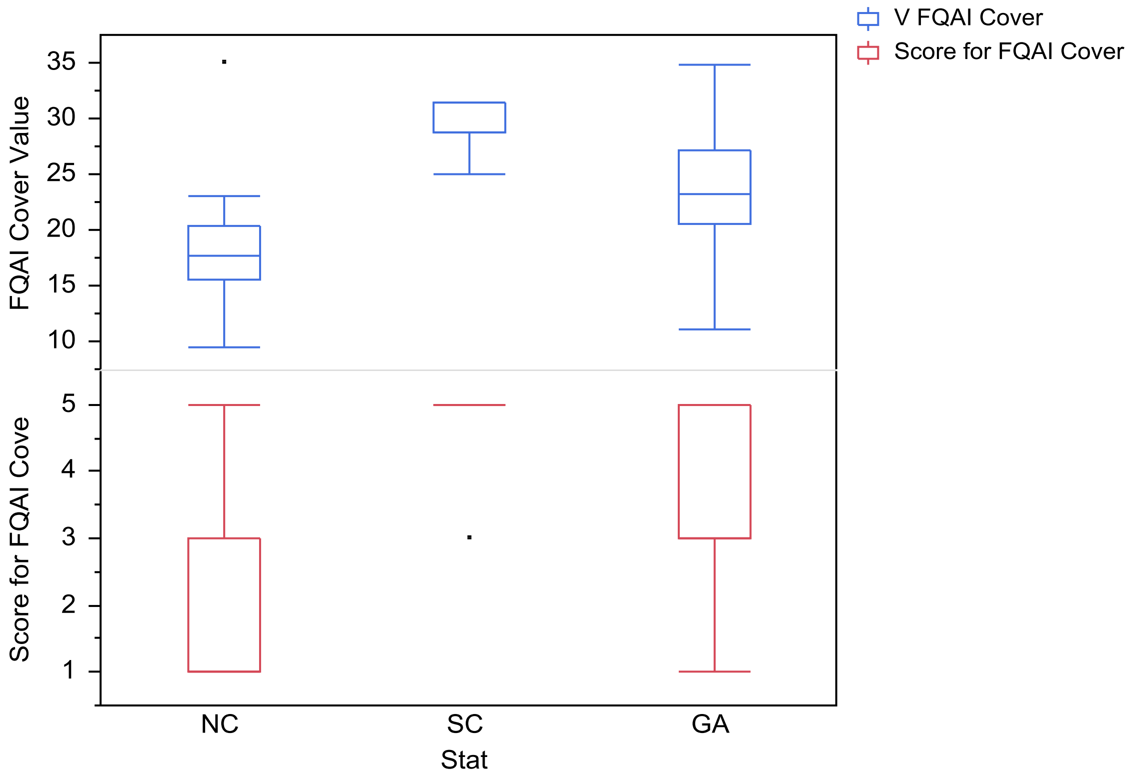


Table 18: BLH FQAI Cover metric values by site and state. Site prefix "SE" represents Intensification study sites, and "US" represents NWCA sites.

Site Number	State	FQAI Cover	BLH FQAI Cover IBI (5 possible)	Condition Based on IBI
US2042	NC	35.0	5	Excellent
US1394	GA	34.9	5	Excellent
US1410	GA	33.1	5	Excellent
US2448	SC	31.5	5	Excellent
US2417	SC	28.8	5	Excellent
US1415	GA	27.1	5	Excellent
US2445	SC	24.9	3	Moderate
US1414	GA	23.6	3	Moderate
US1398	GA	23.5	3	Moderate
US1386	GA	23.2	3	Moderate
US2035	NC	23.0	3	Moderate
US1382	GA	20.8	3	Moderate
SE1316	GA	20.6	3	Moderate
US1406	GA	20.5	3	Moderate
US2039	NC	20.4	3	Moderate
SE1091	NC	19.2	3	Moderate
SE1336	GA	18.9	3	Moderate
SE1050	GA	18.1	3	Moderate
SE1338	GA	17.8	1	Poor
SE1097	NC	17.8	1	Poor
SE1296	GA	17.7	1	Poor
US2023	NC	17.6	1	Poor
SE1042	GA	17.6	1	Poor
SE1324	GA	17.1	1	Poor
SE1326	GA	17.1	1	Poor
SE1310	GA	16.8	1	Poor
SE1098	NC	16.7	1	Poor
SE1323	GA	15.9	1	Poor
SE1004	NC	15.6	1	Poor
SE1101	NC	15.5	1	Poor
US2075	NC	14.9	1	Poor
SE1333	GA	14.3	1	Poor
SE1006	NC	13.9	1	Poor
SE1001	NC	13.3	1	Poor
SE1095	NC	13.1	1	Poor
SE1363	GA	13.1	1	Poor
SE1348	GA	12.9	1	Poor
SE1347	GA	12.5	1	Poor
SE1092	NC	11.5	1	Poor
SE1341	GA	11.1	1	Poor
US2055	NC	11.0	1	Poor
SE1002	NC	9.9	1	Poor
US2051	NC	9.5	1	Poor

The next set of figures (Figures 39 – 43) show the distribution of VegIBI scores by state for the RSF wetland sites and the relative contribution of each of the metrics that make up the VegIBI. The VegIBI scores are shown for North Carolina in Figure 39. The RSF wetlands in North Carolina generally had a high VegIBI score with only one site standing out as being lower than the others. Non-native shrub cover and cryptogam richness seem to account for much of the IBI scores, particularly among the sites with lower scores.

Figure 40 shows the VegIBI scores for South Carolina RSF wetlands. As with North Carolina, the RSF wetlands in South Carolina had high VegIBI scores. The contribution of mean C values and relative frequency of natives seem to fluctuate in their contribution more so than the other metrics making up the VegIBI. The South Carolina RSF wetlands overall had somewhat higher VegIBI scores than North Carolina. The higher scores for both states are roughly equal, however the sites with lower scroes are less equal and more variable.

Figure 41 shows the Alabama VegIBI scores for the RSF wetlands. The scores for Alabama for this wetland type seem somewhat lower than North Carolina scores and therefore also lower than South Carolina scores. The non-native shrub cover metric, cryptogram richness, and relative frequency of natives were the most consistent contributors to the IBI score.

Georgia's VegIBI scores for RSF wetland are shown in Figure 42. Their wetland VegIBI scores are lowest of all four states. Seven RSF wetlands scored below 17 for the VegIBI in Georgia, nine scored below 17 for Alabama, and North Carolina had one site below 17. South Carolina did not have any RSF wetland that scored belwo 17.

Figure 43 shows box plots of RSF VegIBI scores by state. It is clear in this figure, South Carolina RSF sites had the highest scores overall. Georgia, Alabama, and North Carolina VegIBI scores had a much greate variance.

Table19 shows VegIBI scores for all RSF wetland sites for all four states. The table also shows the scores for each of the individual metrics that make up the VegIBI. Finally, the condition class for each site is also shown in the table. Generally, the majority of the RSF wetland sites were in excellent or moderate condition.

Figure 39: Metric Breakdown of North Carolina RSF VegIBI Results.

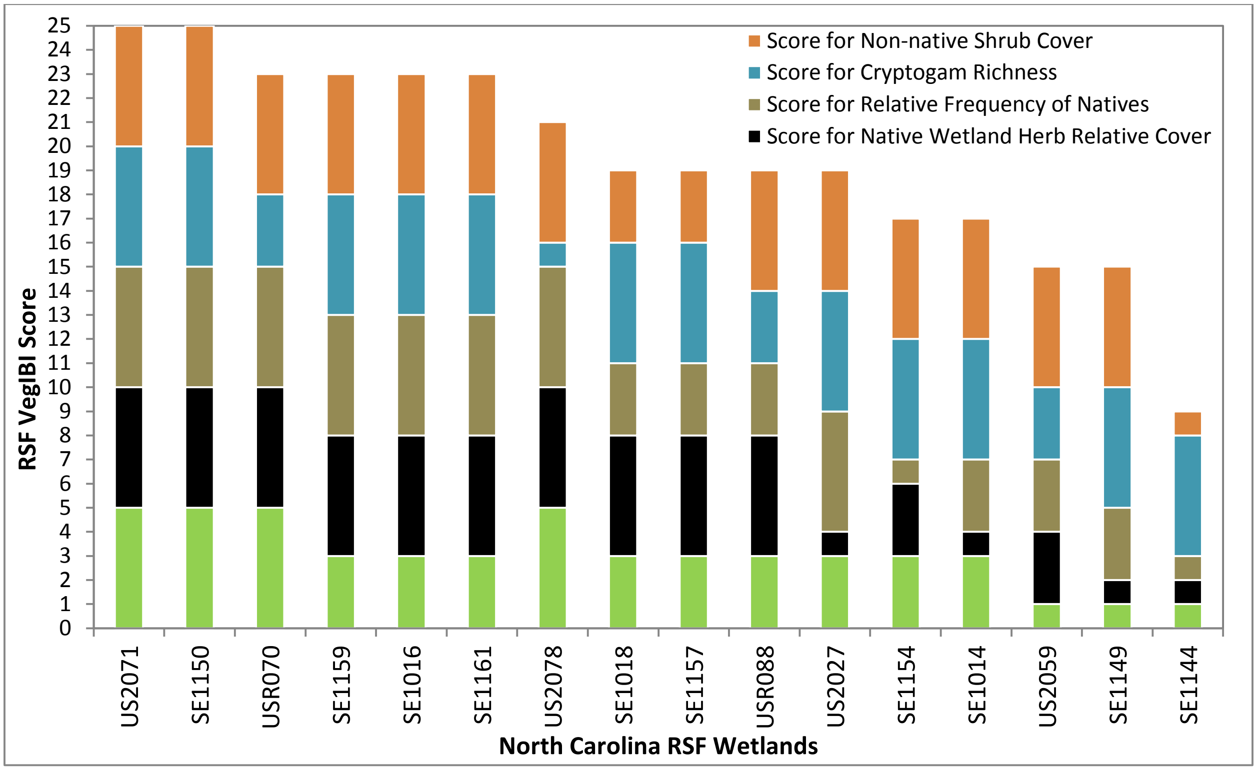


Figure 40: Metric Breakdown of South Carolina RSF VegIBI Results.

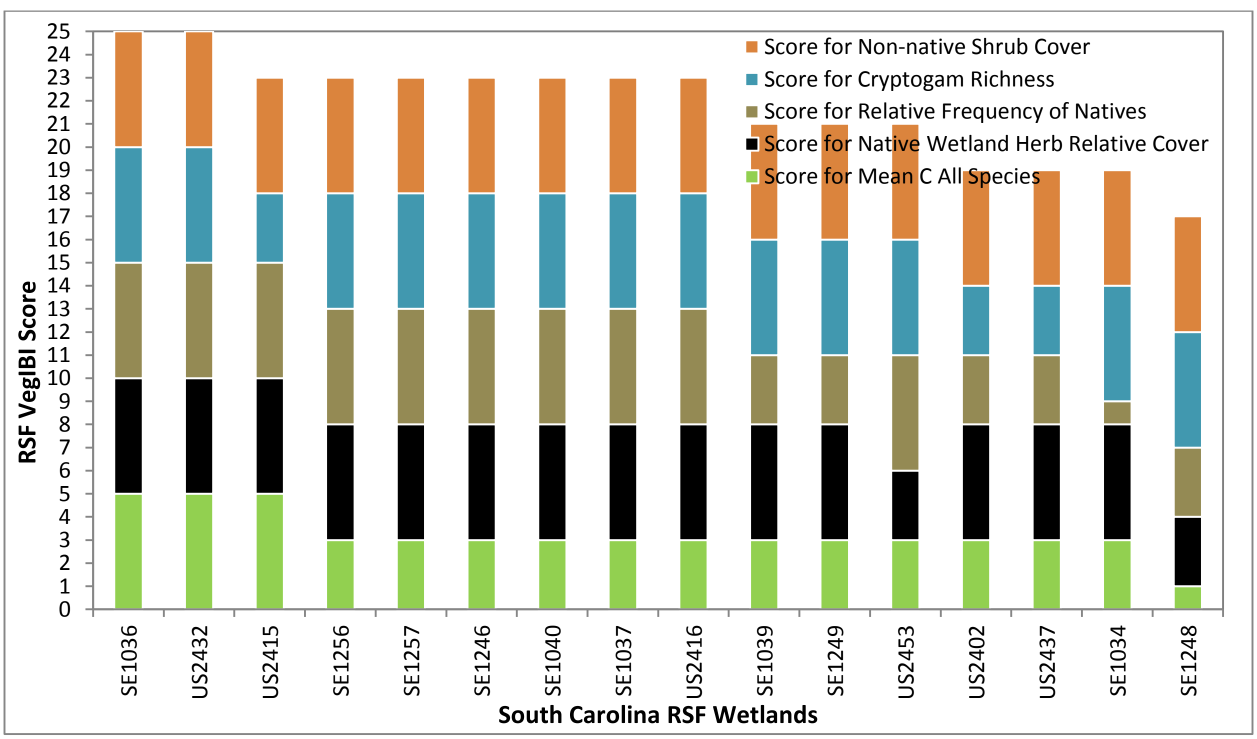


Figure 41: Metric Breakdown of Alabama RSF VegIBI Results.

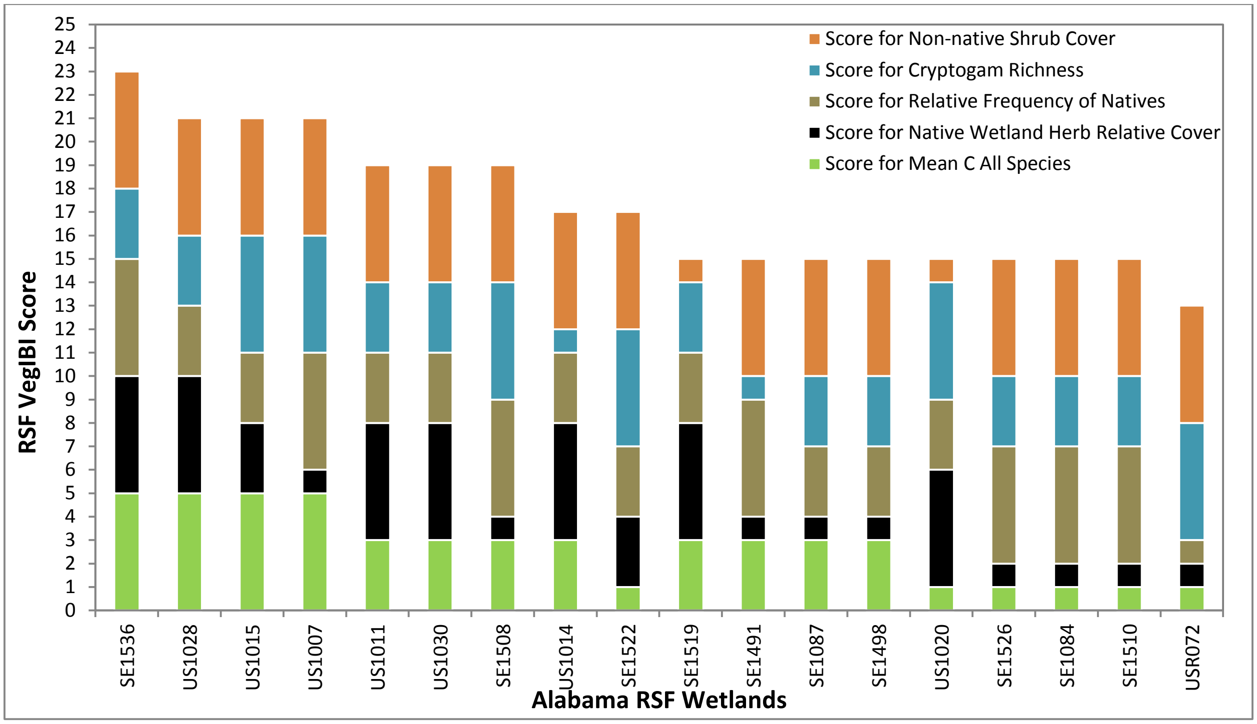


Figure 42: Metric Breakdown of Georgia RSF Veg IBI Results

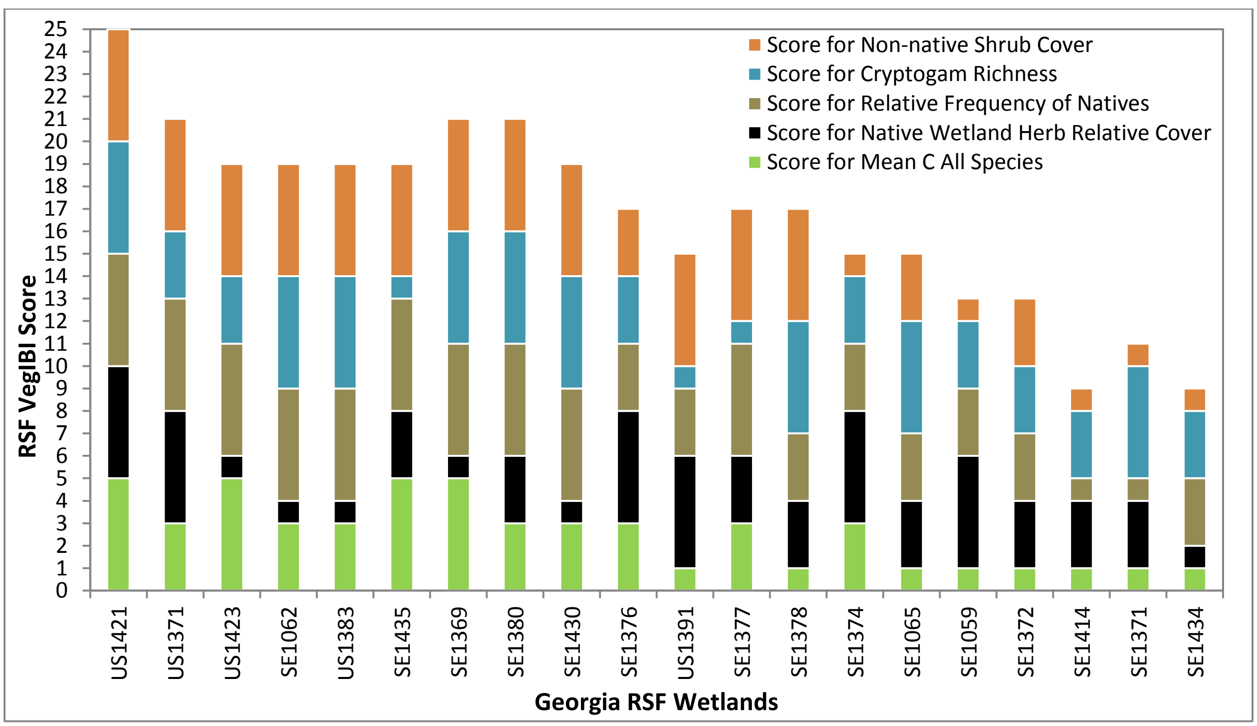


Figure 43: Box plot summary of RSF Veg IBI values by state.

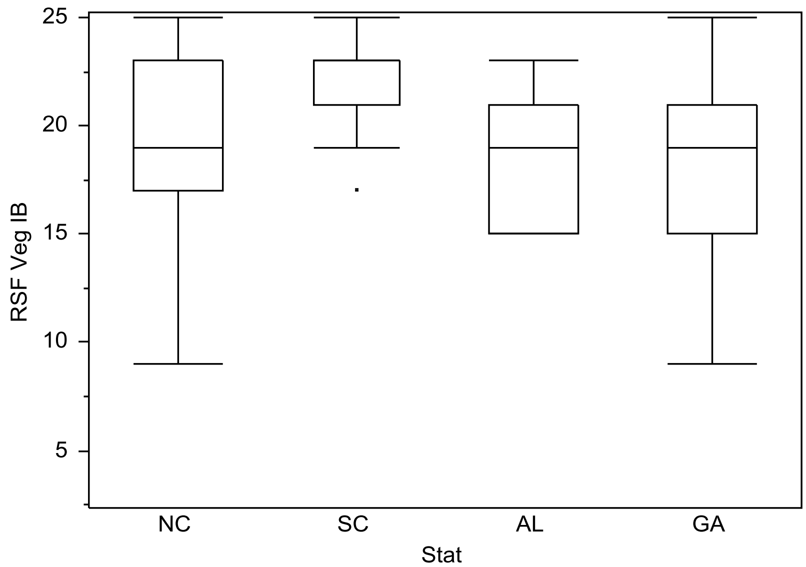


Table 19: RSF Veg IBI component metric scores, total scores, and condition by site and state. Site prefix "SE" represents Intensification study sites, and "US" represents NWCA sites.

Site Name	State	Score for Mean C All Species	Score for Native Wetland Herb Relative Cover	Score for Relative Frequency of Natives	Score for Cryptogam Richness	Score for Non-native Shrub Cover	RSF Veg IBI points (25 pts possible)	Condition (Based on Veg IBI)
US1421	GA	5	5	5	5	5	25	Excellent
US2071	NC	5	5	5	5	5	25	Excellent
SE1150	NC	5	5	5	5	5	25	Excellent
SE1036	SC	5	5	5	5	5	25	Excellent
US2432	SC	5	5	5	5	5	25	Excellent
SE1536	AL	5	5	5	3	5	23	Excellent
USR070	NC	5	5	5	3	5	23	Excellent
US2415	SC	5	5	5	3	5	23	Excellent
SE1159	NC	3	5	5	5	5	23	Excellent
SE1016	NC	3	5	5	5	5	23	Excellent
SE1161	NC	3	5	5	5	5	23	Excellent
SE1256	SC	3	5	5	5	5	23	Excellent
SE1257	SC	3	5	5	5	5	23	Excellent
SE1246	SC	3	5	5	5	5	23	Excellent
SE1040	SC	3	5	5	5	5	23	Excellent
SE1037	SC	3	5	5	5	5	23	Excellent
US2416	SC	3	5	5	5	5	23	Excellent
US2078	NC	5	5	5	1	5	21	Excellent
US1028	AL	5	5	3	3	5	21	Excellent
US1015	AL	5	3	3	5	5	21	Excellent
US1007	AL	5	1	5	5	5	21	Excellent
SE1369	GA	5	1	5	5	5	21	Excellent
US1371	GA	3	5	5	3	5	21	Excellent
SE1039	SC	3	5	3	5	5	21	Excellent
SE1249	SC	3	5	3	5	5	21	Excellent
US2453	SC	3	3	5	5	5	21	Excellent
SE1380	GA	3	3	5	5	5	21	Excellent
SE1435	GA	5	3	5	1	5	19	Moderate
US1423	GA	5	1	5	3	5	19	Moderate
SE1018	NC	3	5	3	5	3	19	Moderate
SE1157	NC	3	5	3	5	3	19	Moderate
US1011	AL	3	5	3	3	5	19	Moderate

Site Name	State	Score for Mean C All Species	Score for Native Wetland Herb Relative Cover	Score for Relative Frequency of Natives	Score for Cryptogam Richness	Score for Non-native Shrub Cover	RSF Veg IBI points (25 pts possible)	Condition (Based on Veg IBI)
US1030	AL	3	5	3	3	5	19	Moderate
USR088	NC	3	5	3	3	5	19	Moderate
US2402	SC	3	5	3	3	5	19	Moderate
US2437	SC	3	5	3	3	5	19	Moderate
SE1034	SC	3	5	1	5	5	19	Moderate
SE1508	AL	3	1	5	5	5	19	Moderate
SE1062	GA	3	1	5	5	5	19	Moderate
US1383	GA	3	1	5	5	5	19	Moderate
US2027	NC	3	1	5	5	5	19	Moderate
SE1430	GA	3	1	5	5	5	19	Moderate
US1014	AL	3	5	3	1	5	17	Moderate
SE1376	GA	3	5	3	3	3	17	Moderate
SE1377	GA	3	3	5	1	5	17	Moderate
SE1154	NC	3	3	1	5	5	17	Moderate
SE1014	NC	3	1	3	5	5	17	Moderate
SE1522	AL	1	3	3	5	5	17	Moderate
SE1248	SC	1	3	3	5	5	17	Moderate
SE1378	GA	1	3	3	5	5	17	Moderate
SE1519	AL	3	5	3	3	1	15	Moderate
SE1374	GA	3	5	3	3	1	15	Moderate
SE1491	AL	3	1	5	1	5	15	Moderate
SE1087	AL	3	1	3	3	5	15	Moderate
SE1498	AL	3	1	3	3	5	15	Moderate
US1020	AL	1	5	3	5	1	15	Moderate
US1391	GA	1	5	3	1	5	15	Moderate
US2059	NC	1	3	3	3	5	15	Moderate
SE1065	GA	1	3	3	5	3	15	Moderate
SE1526	AL	1	1	5	3	5	15	Moderate
SE1084	AL	1	1	5	3	5	15	Moderate
SE1510	AL	1	1	5	3	5	15	Moderate
SE1149	NC	1	1	3	5	5	15	Moderate
SE1059	GA	1	5	3	3	1	13	Poor
SE1372	GA	1	3	3	3	3	13	Poor
USR072	AL	1	1	1	5	5	13	Poor
SE1371	GA	1	3	1	5	1	11	Poor

Site Name	State	Score for Mean C All Species	Score for Native Wetland Herb Relative Cover	Score for Relative Frequency of Natives	Score for Cryptogam Richness	Score for Non-native Shrub Cover	RSF Veg IBI points (25 pts possible)	Condition (Based on Veg IBI)
SE1414	GA	1	3	1	3	1	9	Poor
SE1434	GA	1	1	3	3	1	9	Poor
SE1144	NC	1	1	1	5	1	9	Poor

Vegetation Results

Results from additional vegetationdata are presented in Figures 44-65 and Tables 20-23. The results are divided into three sections; floristic quality analysis, nativity analysis, and cover and count analysis. Most of the results are shown for the region as a whole as the differences between states were mostly minor; however, individual state results are shown where noteworthy.

Floristic Quality Analysis

The highest C value plant species are shown in Table 20 for bottomland hardwood forests wetlands and riverine swamp forest wetlands and the state(s) where the species occurred. The high C-value species tufted bulrush, American basswood, and chalk maple were found in wetlands of both types. Other species with high C values in RSF wetland were Tennessee pondweed and Nodding nixie. It is interesting to note that only two high C-values species occurred in South Carolina, namely - bristlystalked sedge and pumpkin ash.

Table 20: Highest C value (8-10) plant species found on BLH and RSF sites in the Southeast region.

BLH Wetlands			
Scientific Name	Common Name	C Value	State
Trichophorum cespitosum	Tufted bulrush	10	NC
Tilia americana	American basswood	8.5	NC
Acer leucoderme	Chalk maple	8	GA
Euphorbia purpurea	Darlington's glade spurge	8	NC
Hypericum brachyphyllum	Coastal Plain St. Johns wort	8	GA
Ilex myrtifolia	Myrtle dahoon	8	GA
Lycopus amplectens	Clasping water horehound	8	GA
Pinus serotine	Pond pine	8	NC
Sabatia campanulata	Slender rose gentian	8	GA
Sumplocarpus foetidus	Skunk cabbage	8	NC
RSF Wetlands			
Scientific Name	Common Name	C Value	State
Potamogeton tennesseensis	Tennessee pondweed	10	AL
Trichophorum cespitosum	Tufted bulrush	10	NC
Apteria aphylla	Nodding nixie	9	AL
Carex decomposita	Cypressknee sedge	9	AL
Rhapidophyllum hystrix	Needle palm	9	GA
Centrosema virginianum	Spurred butterfly pea	8.5	AL
Tilia americana	American basswood	8.5	AL
Acer leucoderme	Chalk maple	8	NC
Aristida stricta	Pineland threeawn	8	AL
Arundinaria gigantean ssp. *tecta*	Switchcane	8	AL, NC
Asclepias longifolia	Longleaf milkweed	8	AL
Carex abscondita	Thicket sedge	8	NC
Carex gigantean	Giant sedge	8	AL
Carex joorii	Cypress swamp sedge	8	NC
Carex leptalea	Bristlystalked sedge	8	AL, NC, SC
Carex lonchocarpa	Southern long sedge	8	AL, NC
Carex seorsa	Weak stellate sedge	8	NC
Dryopteris ludoviciana	Southern woodfern	8	GA
Fraxinus profunda	Pumpkin ash	8	SC
Gordonia lasianthus	Loblolly bay	8	NC, GA
Hymenocallis caroliniana	Carolina spiderlily	8	AL
Malaxis spicata	Florida adder's-mouth orchid	8	NC
Morella inodora	Scentless bayberry	8	AL
Oplismenus setarius	Erect pricklypear	8	AL
Pinus serotina	Pond pinePond pine	8	NC
Platanthera blephariglottis var. *conspicua*	White fringed orchid	8	NC
Platanthera clavellata	Small green wood orchid	8	NC
Rhynchospora careyana	Broadfruit horned beaksedge	8	NC
Taxodium ascendens	Pond cypress	8	NC, GA
Vallisneria americana	American eelgrass	8	AL

Figure 44 shows the frequency (in %) of C-values for plant species for all the bottomland hardwood forest wetlands. North Carolina and Georgia had the vast majority of bottomland hardwood forest wetlands in the sample for this analysis, with South Carolina having only three using the 2011 NWCA wetland type data. The most frequent C value was four, with five being the next most common value. The distribution of C-values for the bottomland hardwood forest wetlands appears relatively normal with the exception of the zero C-value frequency of 9%, which includes non-natives.

Figure 45 show the frequency of C-values for plant species for all the riverine swamp forest wetland across all four states. The most frequent C-values for this type of wetland were four and six with five, seven, and three being the next most frequent. With the exception of the center value of five, this distribution is also appears relatively normal. Again, the zero value frequency of 5% is an exception and indicates non-natives.

Figure 44: Distribution of the frequency of C values (in percentage of total occurrences) for plant species for all BLH wetlands combined. Distribution is for the 336 unique species (with C values assigned) observed on BLH sites in NC, SC, and GA. C values were available for 87% of the taxa (which were identified to species) observed in BLH wetlands.

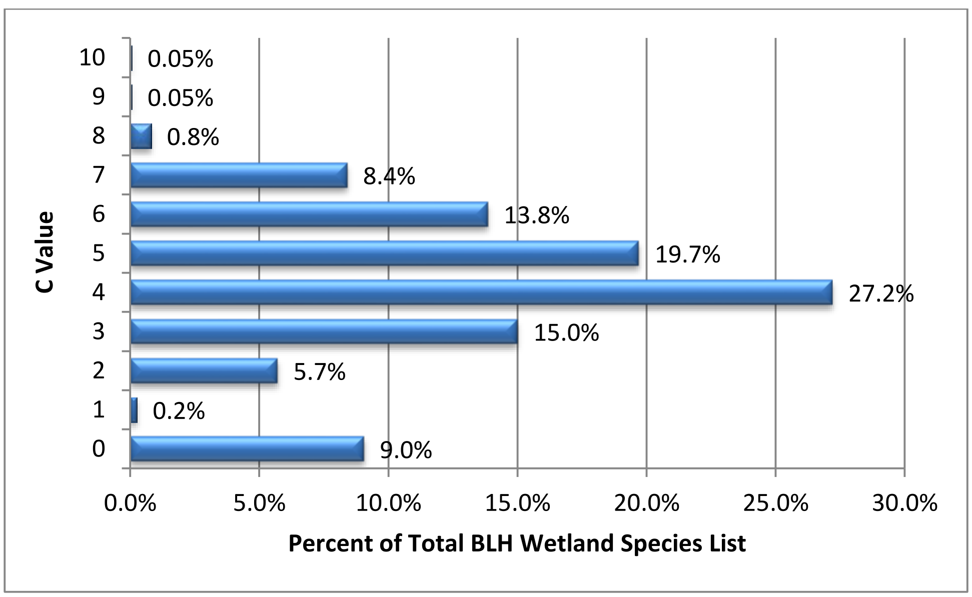


Figure 45: Distribution of the frequency of C values (in percentage of total occurrences) for plant species for all RSF wetlands combined. Distribution is for the 463 species (with C values assigned) observed on RSF sites in NC, SC, AL, and GA. C values were available for 91% of the taxa (which were identified to species) observed in RSF wetlands.

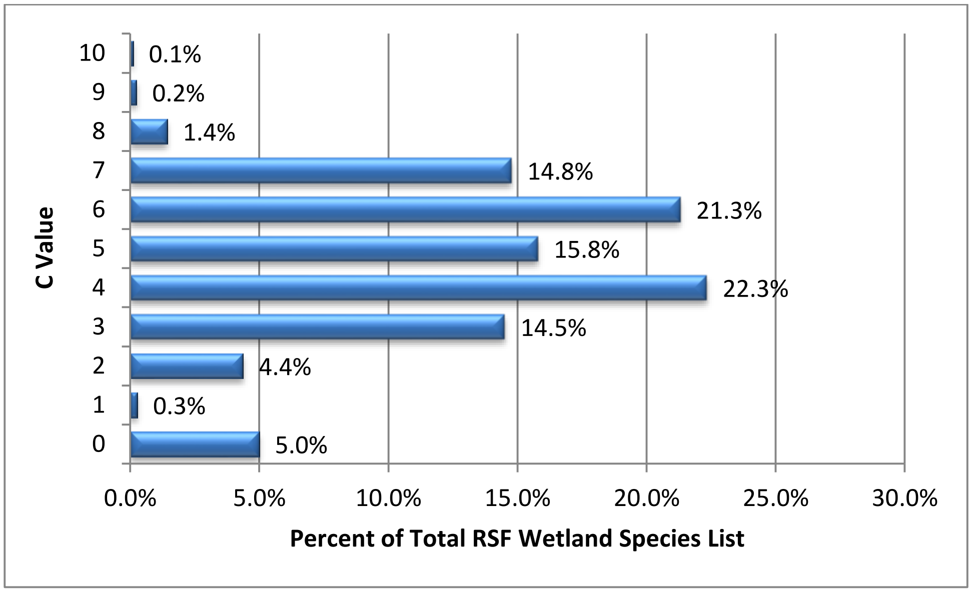
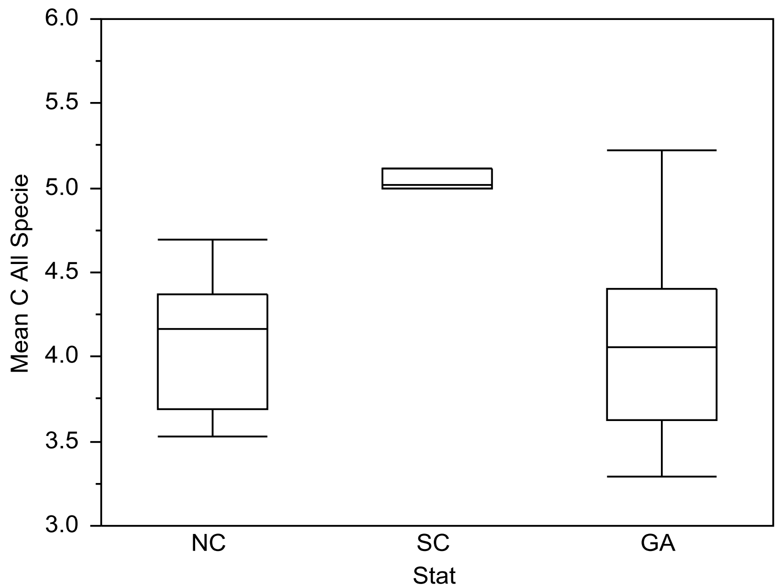


Figure 46 shows box plots of mean C-values by state for plant species in the bottomland hardwood forest wetlands. The mean C-values for North Carolina and Georgia are about the same (4.6 and 4.2 respectively), with the mean for South Carolina being higher around five (note however, that the sample size of the SC BLH sites is very small, n=3 as these were the data from sites surveyed during the 2011 NWCA).

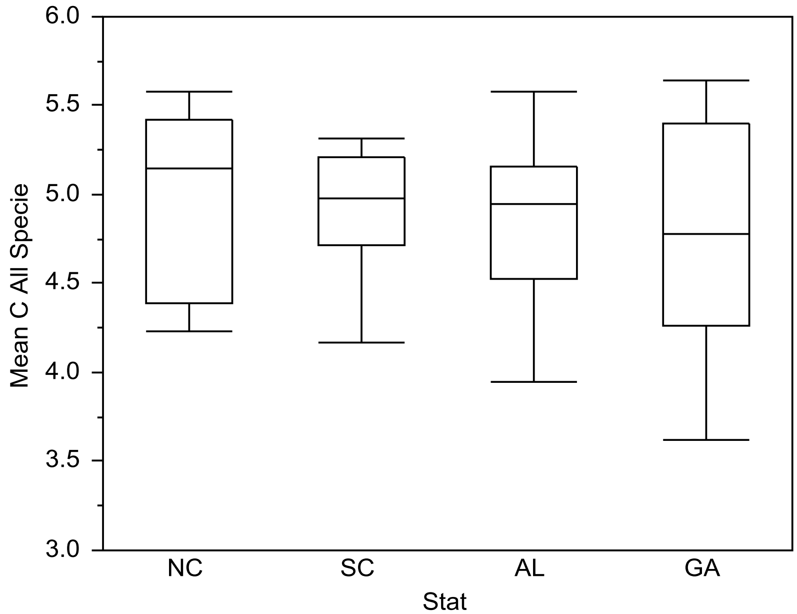
Figure 47 shows box plots of mean C-values by state for all plant species in the riverine swamp forest wetlands. The differences in the mean C values across the four states is minor, however the variance is largest in Georgia and smallest in South Carolina.

Figure 46: Box plot of mean C (all species) values for BLH wetlands by state. Sample size for SC BLH wetlands is 3 sites.



Variable	N	Weighted Mean	St. Dev.	Maximum	Minimum
North Carolina	17	4.2	0.4	4.7	3.5
South Carolina	3	5.0	0.1	5.1	5.0
Georgia	23	4.6	0.5	5.2	3.3

Figure 47: Box plot of mean C (all species) values for RSF wetlands by state.



Variable	N	Weighted Mean	St. Dev.	Maximum	Minimum
North Carolina	14	5.0	0.5	5.6	4.2
South Carolina	16	4.9	0.3	5.3	4.2
Alabama	17	4.9	0.5	5.6	3.9
Georgia	20	4.8	0.6	5.7	3.6

FQAI values were calculated using the standard FQAI formula (FQAI [Cover]) and also incorporating cover data (FQAI [Count]) as described in the Methods section. Figure 48 show the box plots for the FQAI [count] and the FQAI [cover] for the bottomland hardwood forest wetland by state. The figure shows the FQAI [count] values are higher in North Carolina and Georgia and South Carolina are somewhat lower (recall that the sample size for the South Carolina BLH wetlands is only three). For the FQAI [cover], Georgia and South Carolina had higher scores than did North Carolina, for the bottomland hardwood forest wetlands. While North Carolina had the highest FQAI [count] (slightly higher than Georgia's), the FQAI [cover] was lower.

Box plots for the FQAI [count] and FQAI [cover] for the riverine swamp forest wetlands are shown in Figure 49, by state. For FQAI [count], the higher values tend to be in North Carolina and Alabama for the riverine swamp forest wetland sites, with somewhat lower values in the other two states. For FQAI [cover], North Carolina stands out with generally lower values, whereas the other three states had sites with more similar values for these wetlands.

Figure 48: Boxplots for FQAI Count (standard FQAI formula) and FQAI Cover (incorporates cover data) for BLH wetlands by state. Sample size for SC is 3 sites.

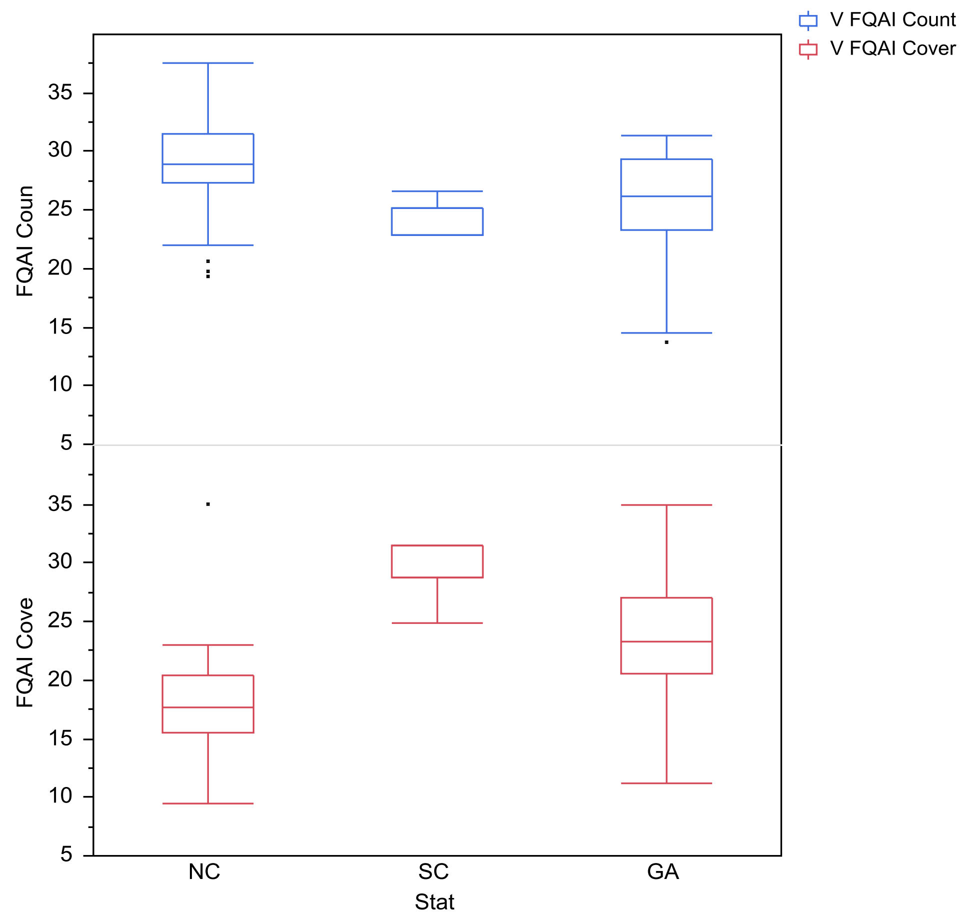


Figure 49: Boxplots for FQAI Count (standard FQAI formula) and FQAI Cover (incorporates cover data) for RSF wetlands by state.

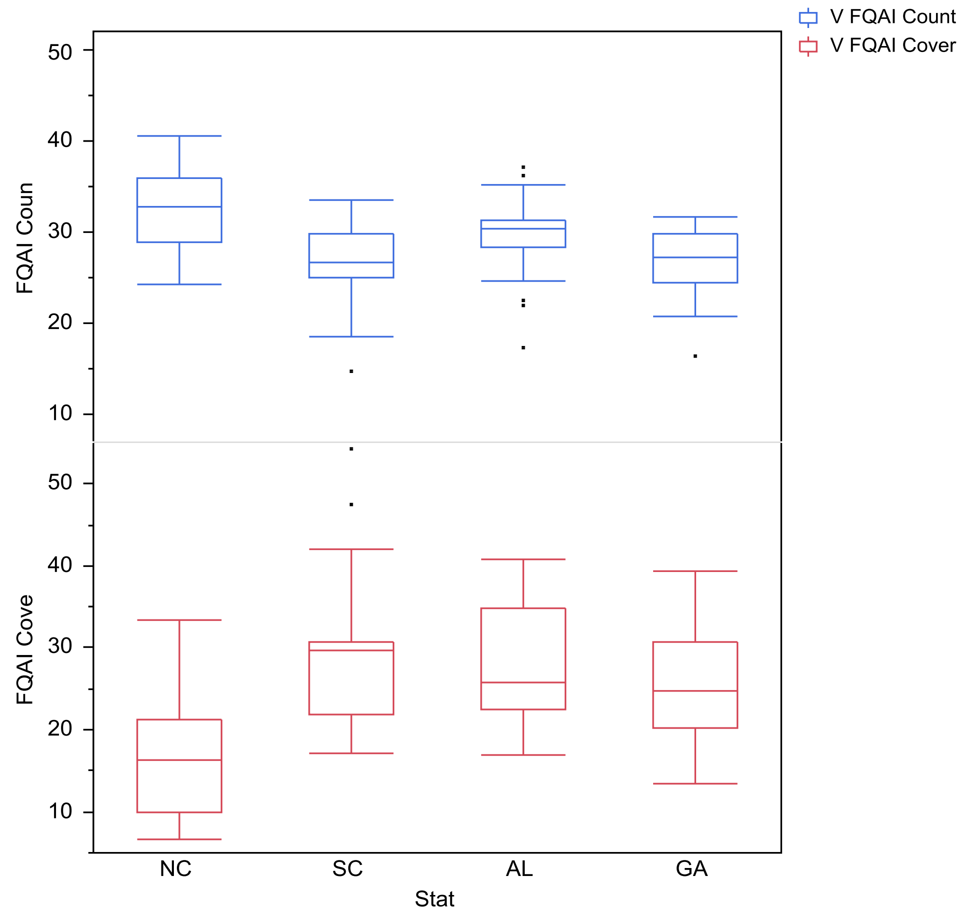


Figure 50 shows relative percent cover of plant species in bottomland hardwood forest wetland sites that are tolerant (tolerate many different wetland habitat conditions) and that are sensitive (sensitive plant species tend only to occur in higher quality wetlands). Georgia had a greater percentage of tolerant plant species relative to the other two states. North Carolina and Georgia had the lowest percentage of sensitive species with South Carolina having a larger percentage (again noting that the sample size for SC is only three) for this wetland type.

The relative percent covers of tolerant and sensitive plant species in riverine swamp forest wetland is shown in Figure 51. North Carolina had the highest percentage of tolerant species relative to the other three states, which were similar to one another in percentage of tolerant species. North Carolina also had the lowest percentage of sensitive species with Georgia having the next lowest percentage for these wetlands. Alabama and South Carolina had comparatively larger variance for sensitive species in riverine swamp forest wetlands.

Figure 50: Relative percent cover of tolerant plant species (C value < 4) and sensitive plant species (C value > 7) in BLH wetlands by state. Sample size for SC is 3 sites.

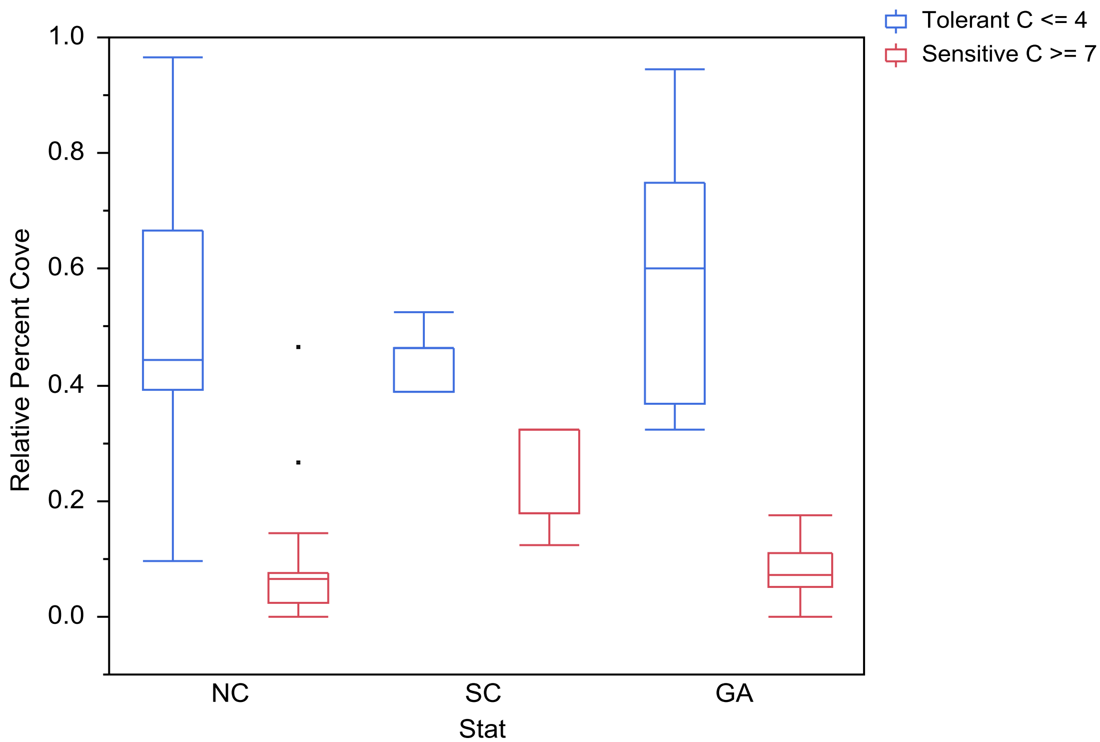
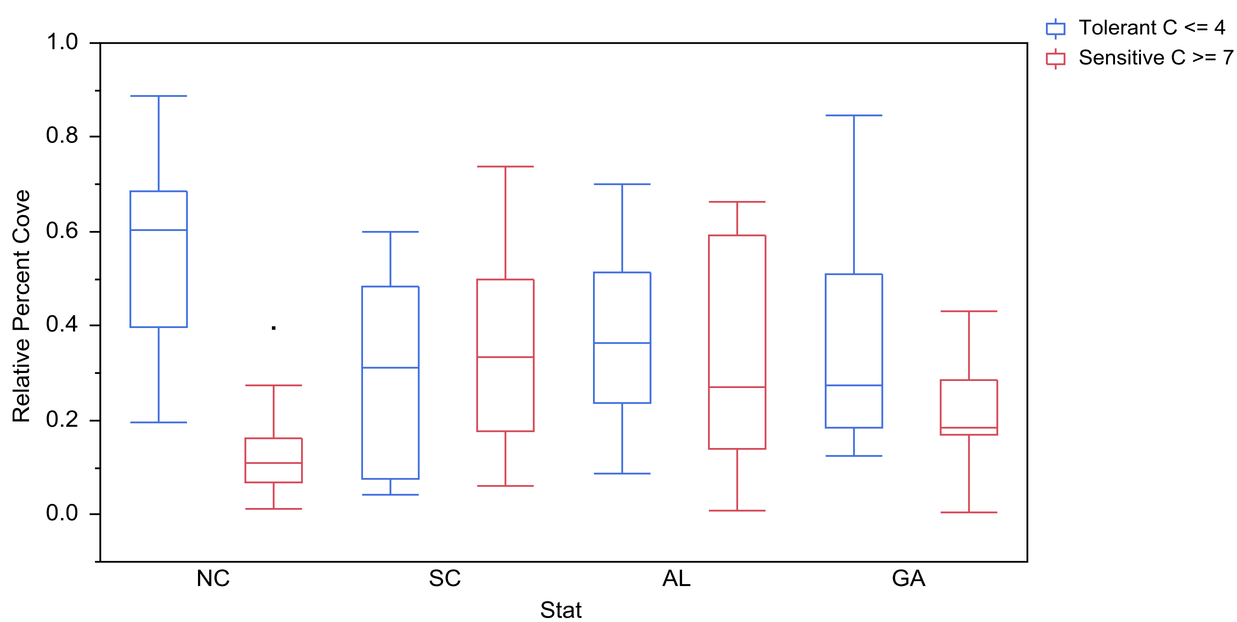


Figure 51: Relative percent cover of tolerant plant species (C value < 4) and sensitive plant species (C value > 7) in RSF wetlands by state.



Generally these results support that the bottomland hardwood forest wetlands in the Piedmont ecoregion are more disturbed than the riverine swamp forest wetlands in the Southeast Coastal Plains as indicated by the lower C values of the plant species and the larger number of tolerant plant species. NC's riverine swamp forest wetlands tened to have more tolerant plant species indicating some disturbance.

Nativity Analysis

The nativity analysis considered nonnative plants as stressors on wetland ecosystems. The Nonnative Plant Stressor Indicator was developed and used by the EPA for the National Wetland Condition Assessment (NWCA) conducted in 2011. This indicator classifys wetland sites into categories that represent different levels of stress associated with the presence of one or more nonnative plant species. Figure 52 shows results from bottomland hardwood forests in North Carolina and Georgia indicating the percentage of wetland sites in each stressor category (low, medium, high). North Carolina had about 35% in the low stressor category, but had over 50% in the high and very high stressor categories. Georgia had less than 40% in the high and very high stressor categories and about 30% in the low stressor category. About 50% of the bottomland hardwood forest wetland sitesin both states were in a stressed conditionbased on this indicator.

Figure 53 shows the percent of riverine swamp forest wetland sites in each of the four stressor categories for each of the four states. In general, when compared to bottomland hardwood forest wetlands, riverine swamp forest wetlands were much less stressed by nonnatives, in all four states. Alabama and South Carolina had riverine swamp forests with the least stressor based on this indicator while North Carolina had about 30% of their riverine swamp forest sites in the high/very high stress category. Table 21 shows the number of wetland sites in each stressor category for both types of wetlands. North Carolina and Georgia had the most in the two highest stressor categories.

Figure 54 shows the relative importance of nonnatives in bottomland hardwood forests which are about the same for North Carolina and Georgia, but with Georgia having a larger variance. Figure 55 shows the relative importance of nonnatives for riverine swamp forests for all four states. North Carolina had the largest variance in terms of relative importance for riverine swamp forests. The relative importance of nonnative plants was higher in North Carolina and Alabama than the other two states.

Figure 52: Percentage of BLH wetland sites in each category of the Nonnative Plant Stressor Indicator for North Carolina and Georgia. This indicator was developed by the EPA for the NWCA. (The three South Carolina NWCA BLH sites were all "Low".)

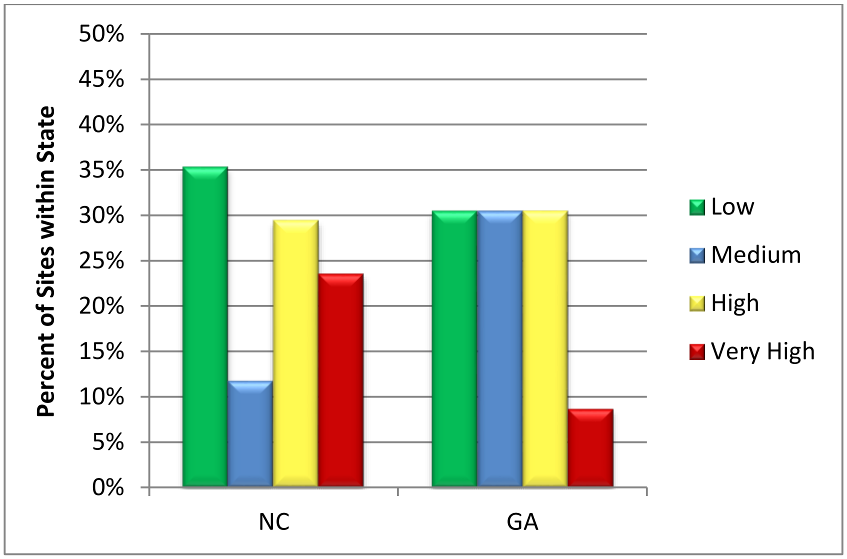


Table 21: Number of BLH and RSF sites in the Low, Medium, High, and Very High category for the Nonnative Plant Stressor Indicator developed by the EPA.

Wetland Type	State	Low	Medium	High	Very High
BLH	NC	6	2	5	4
	SC	3			
	GA	7	7	7	2
BLH Total		**16**	**9**	**12**	**6**
RSF	NC	7	4	2	3
	SC	10	6		
	AL	3	13	2	
	GA	9	7	4	
RSF Total		**29**	**30**	**8**	**3**

Figure 53: Percentage of RSF wetland sites in each category of the Nonnative Plant Stressor Indicator by state.

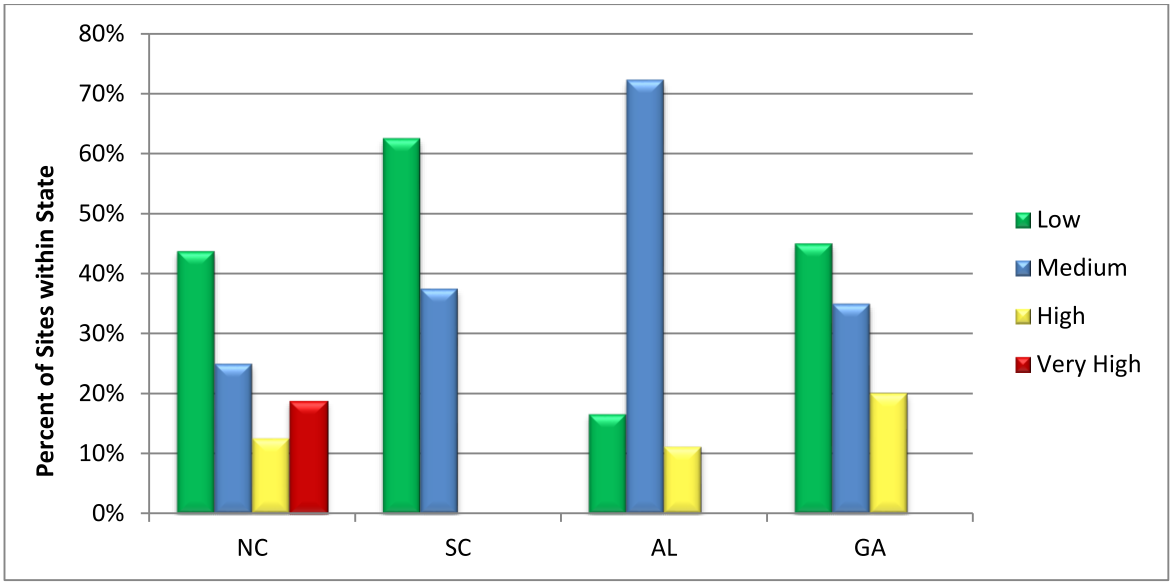


Figure 54: Relative importance of nonnatives in BLH wetlands. SC was excluded because sample size was too small (3 NWCA sites).

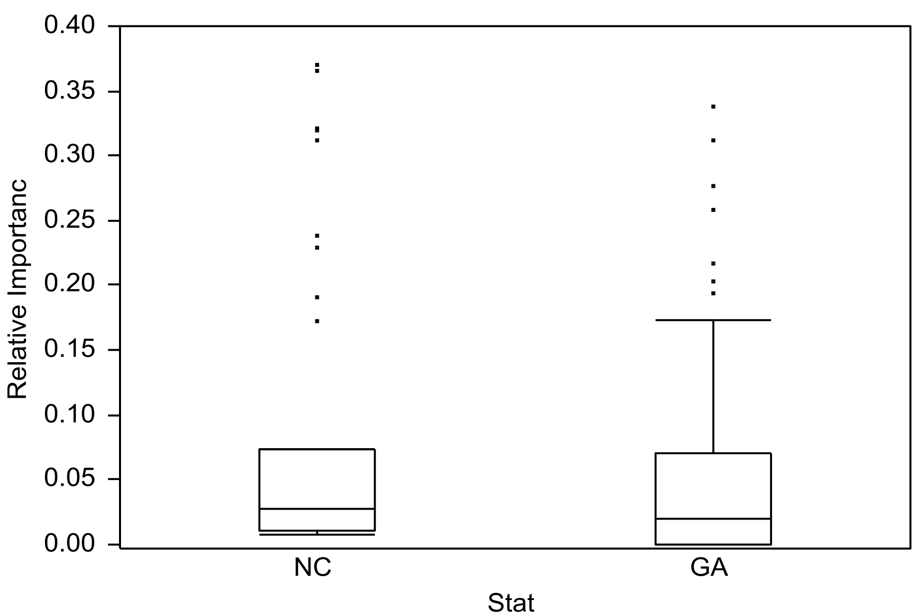
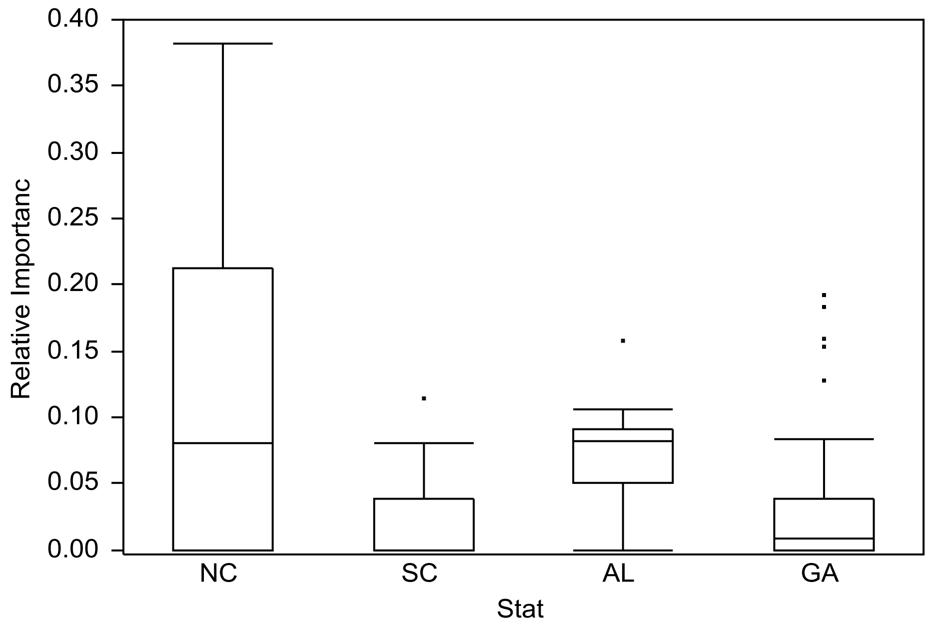


Figure 55: Relative importance of nonnatives in RSF wetlands.



Generally these results again support that bottomland hardwood forest in the Piedmont ecoregion are more disturbed than riverine swamp forest in the Southeast Coastal Plains as indicated by the non-native plant stressor indicator. Again, NC's riverine swamp forest wetlands tended to show more stress than the other three states.

Cover and Count Analysis

This section of the vegetation results deals with the plant species cover and frequency. Table 22 shows the number of bottomland hardwood forest sites out the total of the 43 BLH sites in which given species was in the top 5 list of dominant species (by total percent cover). The most frequently occurring dominant species in these wetland sites were red maple, sweetgum, and green ash. Japanese stiltgrass and Chinese privot were the most dominant nonnative plant species in bottomland hardwood forest wetlands. Generally, the most frequently occurring dominant plant species were those that tended to be associated with higher quality sites, higher C-values, higher sensitivity, lower tolerance, etc. which is consistent with other results reported here indicating bottomland hardwood forest wetland sites are more disturbed, probably due to the Piedmont ecoregion (45) having been so developed and farmed.

Table 23 lists (for riverine swamp forest wetland sites) the plant species that occurred most often in the list of top five dominant species for each site based on percent cover. The plant species that were found to be in the top five list at the most sites were red maple followed by sweetgum, swamp tupelo, water tupelo, green ash, bald cypress, and laurel oak. The most frequent nonnative for riverine swamp forest wetland sites was Chinese privet. While riverine swamp forest wetland sites had less typical/representative species as the top two most frequently occurring dominant species, there were plenty of numerous species occurring as dominants in sites of this wetland type that were very characteristic of typical riverine swamp forests.

Table 22: Number of sites out of the 43 BLH sites on which given species was in the top 5 dominant species (by total percent cover). Species that were found in the dominant top 5 on fewer than 4 of the sites were excluded from this table for simplicity.

Scientific Name	Common Name	Number of Sites Species was in the Top 5 for Percent Cover
Native Species		
Liquidambar styraciflua	Sweetgum	18
Acer rubrum	Red maple	17
Fraxinus pennsylvanica	Green ash	13
Acer negundo	Boxelder	9
Betula nigra	River birch	7
Campsis radicans	Trumpet creeper	6
Carpinus caroliniana	American hornbeam	5
Juncus effusus	Common rush	5
Ulmus americana	American elm	5
Cyrilla racemiflora	Swamp titi	4
Morella cerifera	Wax myrtle	4
Pinus taeda	Loblolly pine	4
Platanus occidentalis	American sycamore	4
Quercus nigra	Water oak	4
Non-native Species		
Microstegium vimineum	Japanese stiltgrass	13
Ligustrum sinense	Chinese privet	12
Lonicera japonica	Japanese honeysuckle	4

Table 23: Number of sites out of the 71 RSF sites on which species was in the top 5 dominant species (by percent cover). Species that were found in the dominant top 5 on less than 4 of the sites were excluded from this table for simplicity.

Scientific Name	Common Name	Number of Sites Species was in the Top 5 for Percent Cover
Native Species		
Acer rubrum	Red maple	39
Liquidambar styraciflua	Sweetgum	24
Nyssa biflora	Swamp tupelo	15
Fraxinus pennsylvanica	Green ash	15
Taxodium distichum	Bald cypress	14
Quercus laurifolia	Laurel oak	13
Nyssa aquatica	Water tupelo	12
Carpinus caroliniana	American hornbeam	12
Quercus nigra	Water oak	10
Vitis rotundifolia	Muscadine grape	10
Magnolia virginiana	Sweetbay magnolia	9
Liriodendron tulipifera	Tulip poplar	7
Quercus lyrata	Overcup oak	6
Salix nigra	Black willow	6
Toxicodendron radicans	Eastern poison ivy	5
Ilex decidua	Possumhaw	5
Planera aquatica	Planertree	5
Non-native Species		
Ligustrum sinense	Chinese privet	6

The relative cover by growth types in percent is shown in Figure 56 for bottomland hardwood forest wetlands in all four states. As would be expected, trees are dominant at 55% of the cover with shrubs the next dominant at 14%. Graminoids and forbs form most of the groundcover at 22%. Figure 57 shows the percent of the relative cover by growth types for riverine swamp forest wetlands. Trees dominate at 64% followed by shrubs at 11% with forbs forming most of the groundcover at 11%. It is interesting to note that vines play a significant role in the cover of both bottomland hardwood forest wetland sites and riverine swamp forest wetland sites at 7% and 6% cover respectively.

Figure 58 show box plots by state of the same plant cover by growth type for bottomland hardwood forest wetland with Figure 59 showing the same information for riverine swamp forest wetlands. North Carolina has the largest variance in percent tree cover and percent forb cover in comparison to the other three states for both types of wetland sites. For riverine swamp forest wetland sites , Alabama and South Carolina had a large variance in percent tree cover.

Figure 56: Relative percent cover by growth form for all BLH wetlands combined. (Relative % cover = total cover for growth form/total cover all growth forms combined)

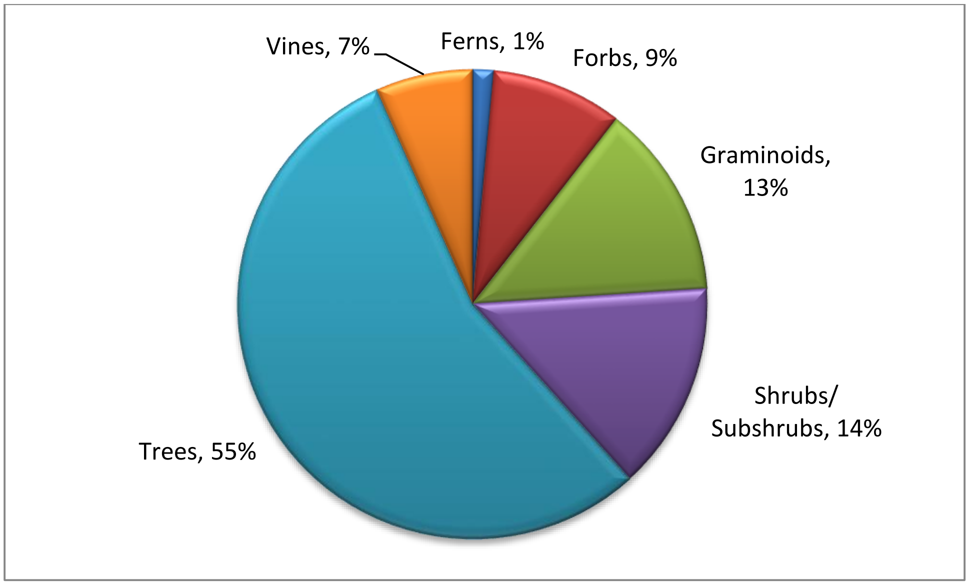


Figure 57: Relative percent cover by growth form for all RSF wetlands combined. (Relative % cover = total cover for growth form/total cover all growth forms combined)

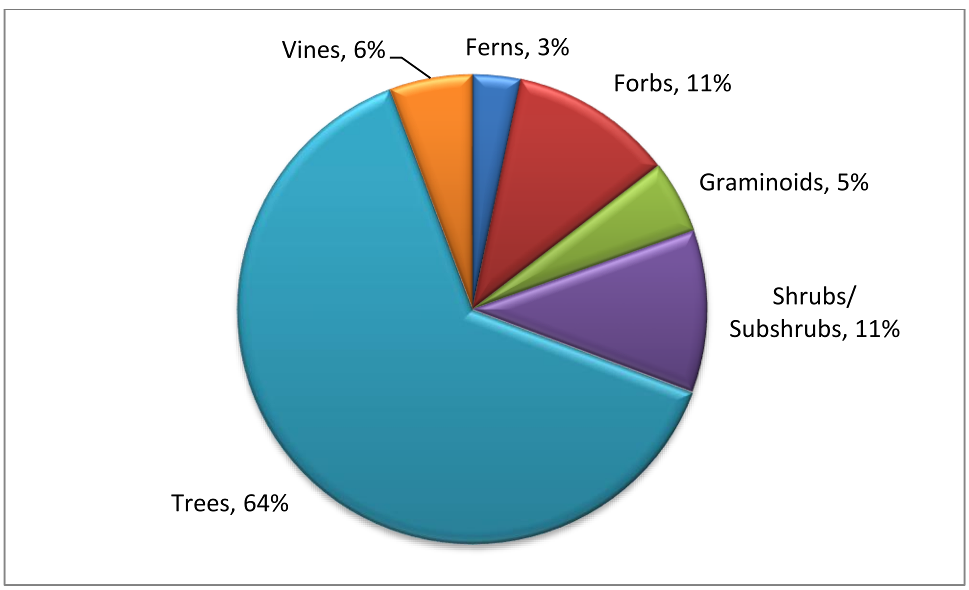


Figure 58: Relative percent cover by growth form for BLH wetlands in NC, SC, and GA.

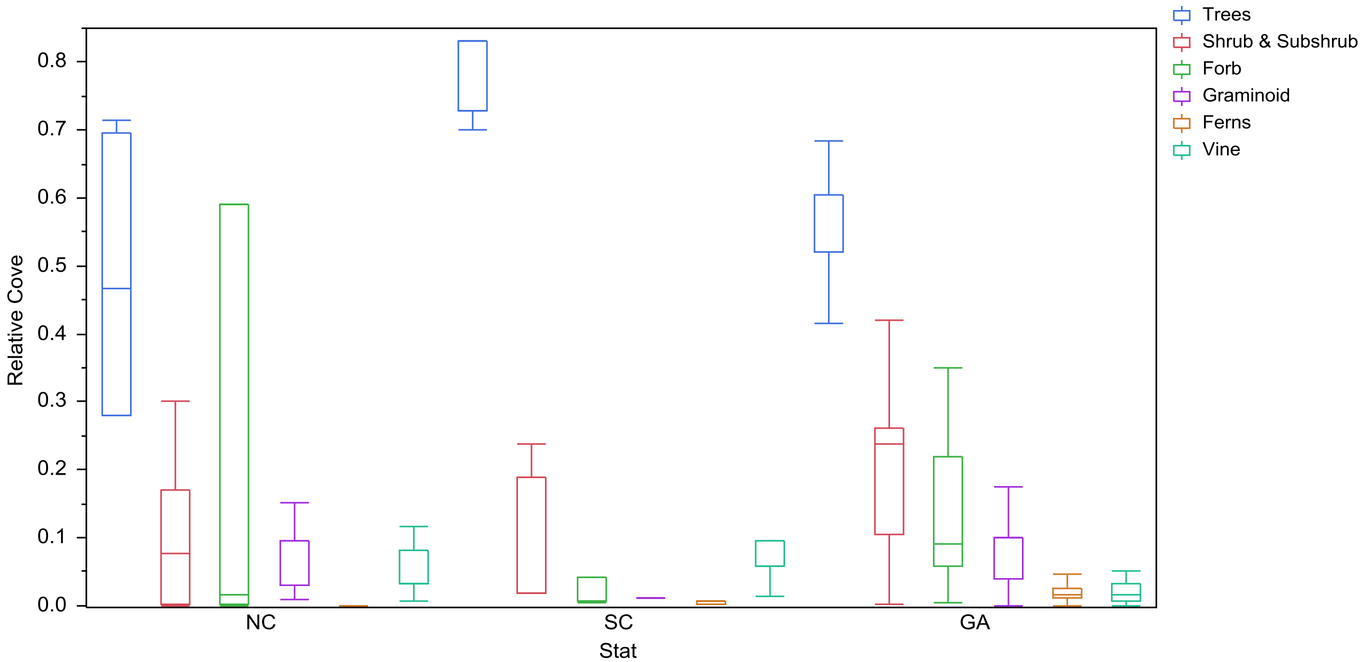


Figure 59: Relative percent cover by growth form for RSF wetlands in NC, SC, and GA.

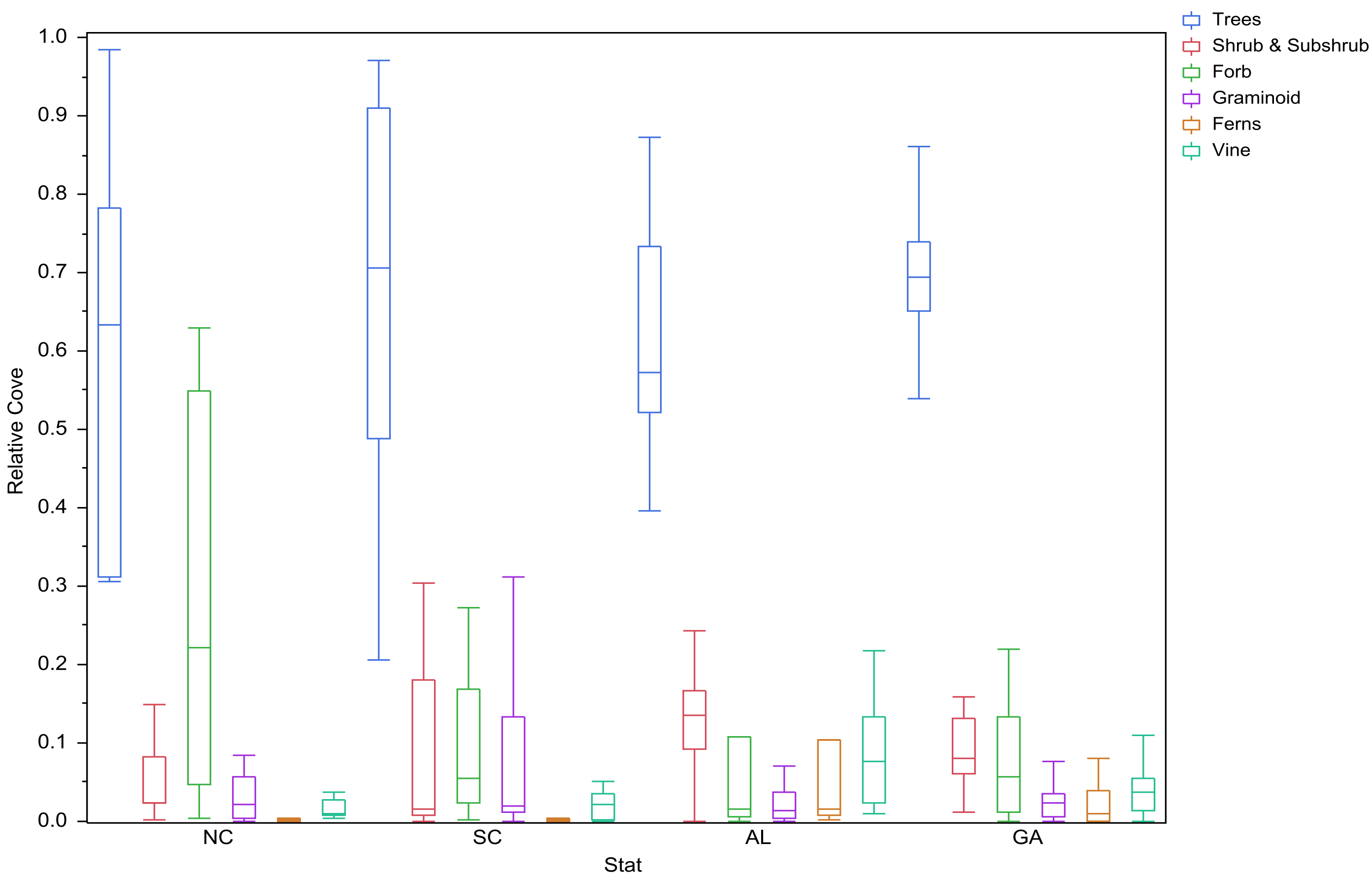


Figure 60 shows the Simpson’s diversity index of native plants in bottomland hardwood forest wetlands. All three states have a relatively high index value, with Georgia having slightly higher values. The Simpson’s diversity index of native plant species for riverine swamp forest wetland sites is presented in Figure 61. High values are characteristic of all four states, but Georgia had somewhat higher scores for riverine swamp forest wetlands.

Figure 60: Simpson’s Diversity index for native plant species on BLH wetlands.

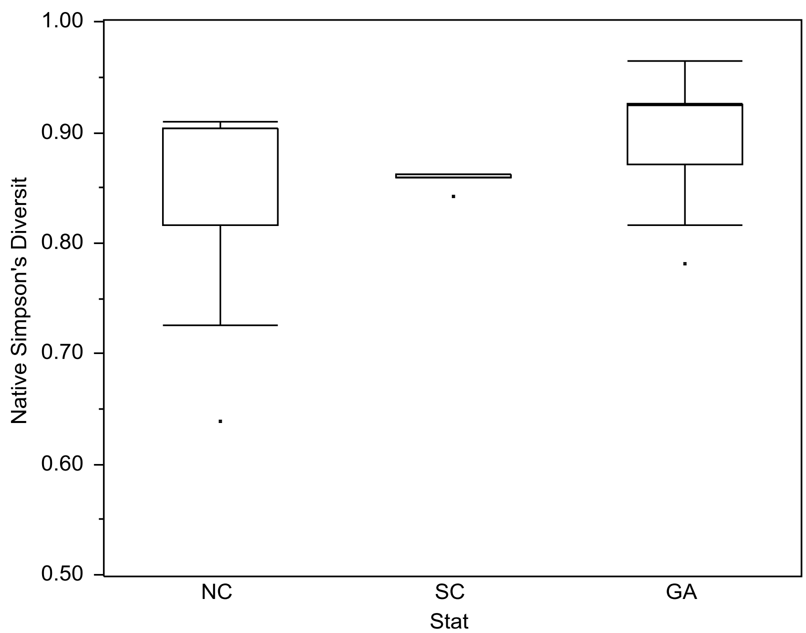
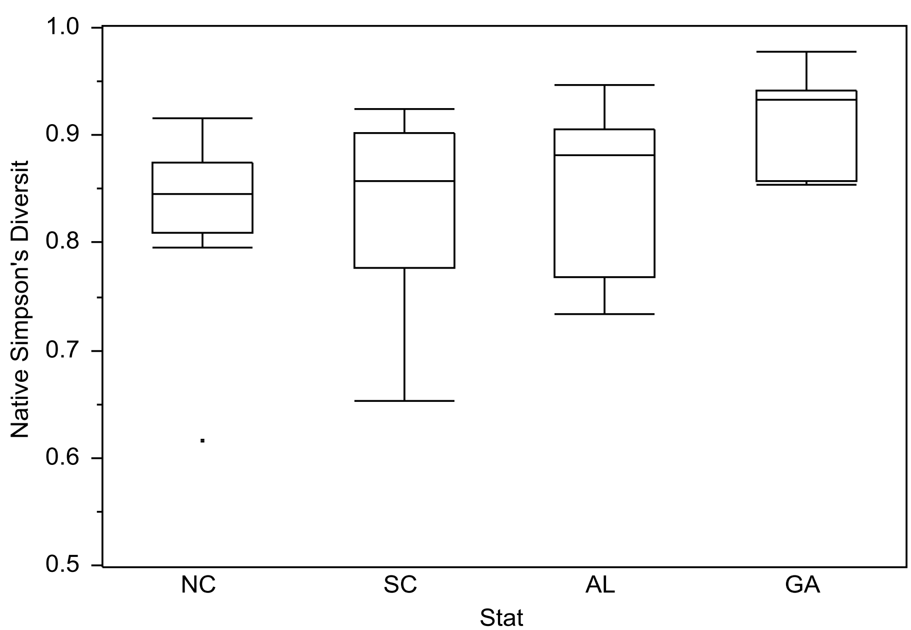


Figure 61: Simpson’s Diversity index for native plant species on RSF wetlands.



Dominance index values (indicative of total percent cover for the three species of vegetation with the highest percent cover at a site) are shown in Figure 62 for bottomland hardwood forests and in Figure 63 for riverine swamp forests. North Carolina had the higher scores relative to the other states for bottomland hardwood forest wetland sites. For riverine swamp forest wetland sites, North Carolina and South Carolina had the higher dominance index scores for plant species.

Figure 62: Dominance index for plant species on BLH wetlands. (ie. the percent cover of the top 3 highest coverage species, native and nonnative, out of the total coverage for all species)

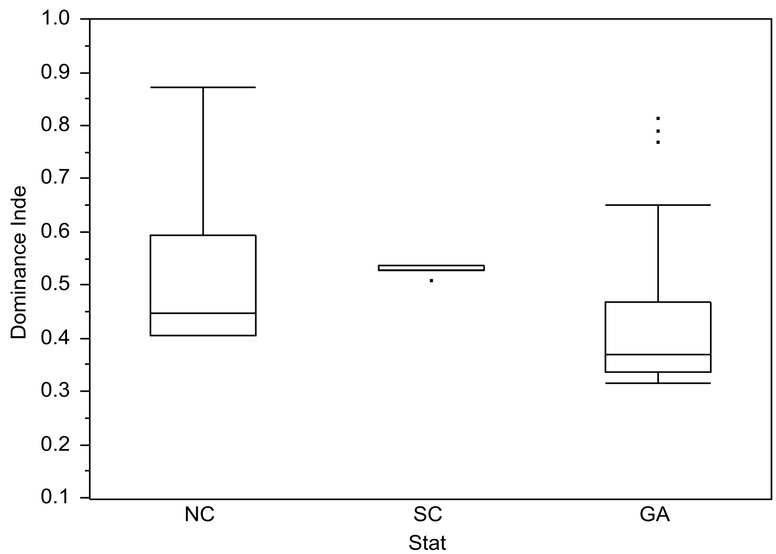
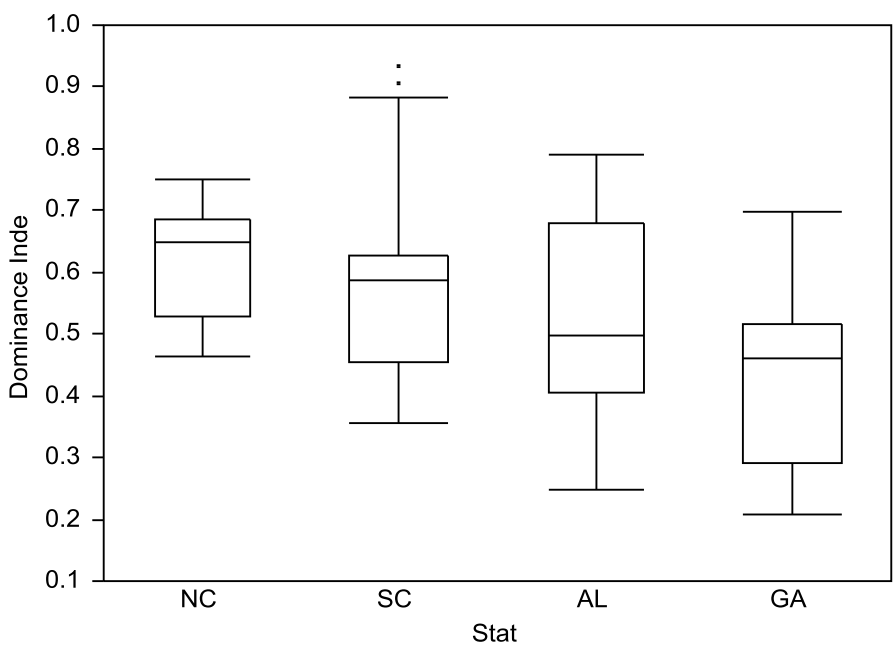


Figure 63: Dominance index for plant species on RSF wetlands. (ie. the percent cover of the top 3 highest coverage species, native and nonnative, out of the total coverage for all species)



The next two figures show the mean tree count by size class for bottomland hardwood forest wetland sites (Figure 64) and for riverine swamp forest wetland sites (Figure 65), across the region. Smaller trees dominated both wetland types, but riverine swamp forest wetland sites had more large trees than bottomland hardwood forest sites which are another indication that the Piedmont region is generally more disturbed than the Coastal region.

Again, bottomland hardwood forest in the Piedmont ecoregion tend to be somewhat more disturbed that riverine swampforest wetlands in the Southeast Coastal Plains.

Figure 64: Mean counts of trees of various sizes per BLH site across the region. N=43.

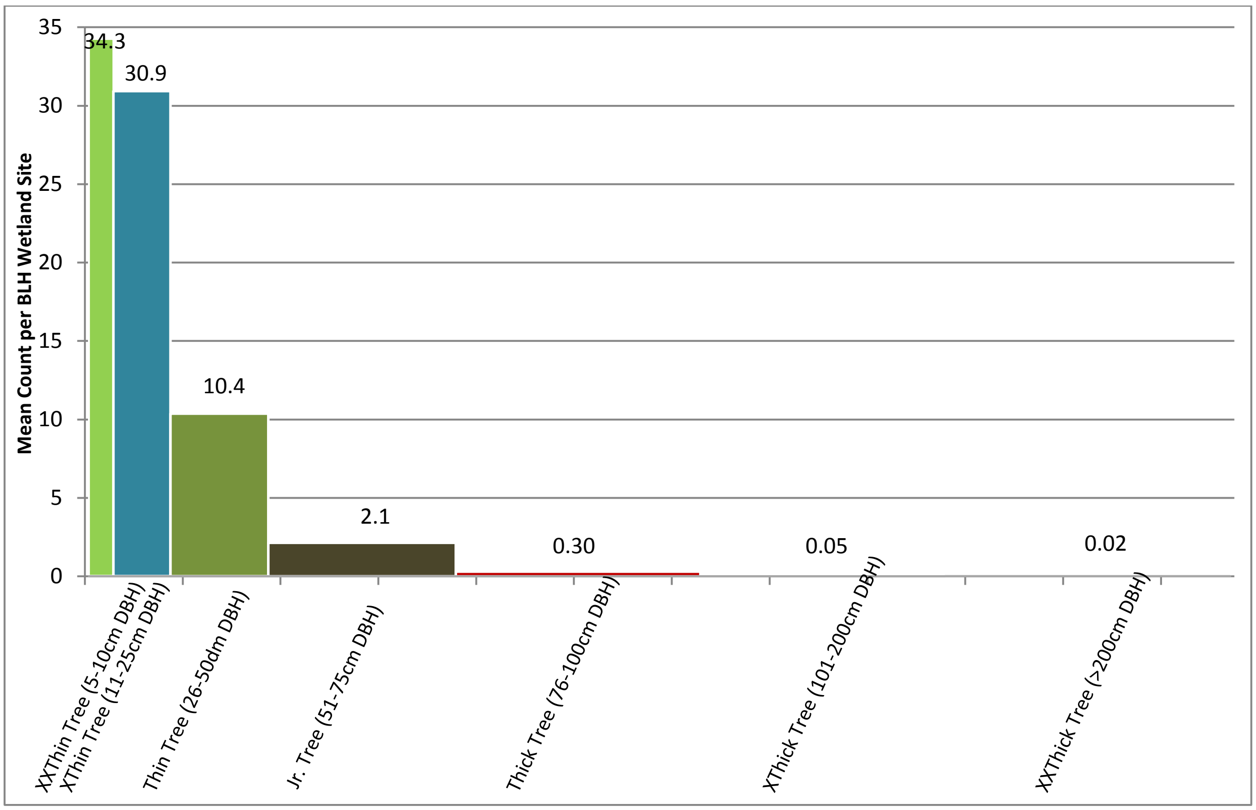
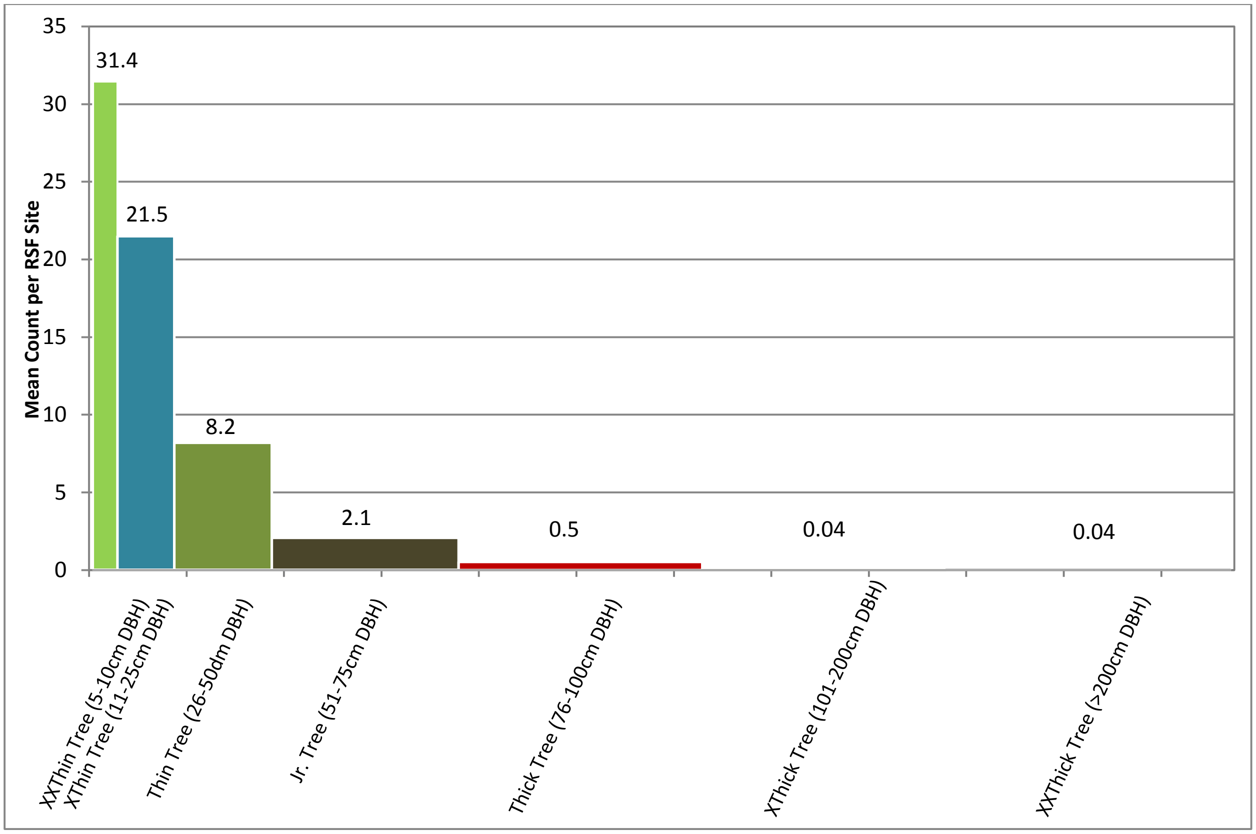


Figure 65: Mean counts of trees of various sizes per RSF site across the region. N=67.



Amphibian Survey Results

This section presents amphibian data collected from North Carolina and Georgia from bottomland hardwood forest wetlands (South Carolina and Alabama did not do intensive surveys of this wetland type) and for riverine swamp forest wetlands from all the states except Georgia (drought prevented surveying).

The amphibian quality assessment index (AQAI) values from all sites surveyed are shown in Figure 66 as box plots with data stratified by wetland type and by then state. Georgia had a larger range of AQAI scores, particularly at the top end of the range, and a higher mean AQAI scores for bottomland hardwood forest wetland sites than did North Carolina. For riverine swamp forest wetlands, South Carolina and North Carolina generally had higher AQAI scores than did Alabama, indicating a better habitat for amphibians. Table 24 lists values for mean AQAI scores for Bottomland hardwood forest wetlands; there was no significant difference between the states. However, AQAI means did significantly differ between North Carolina's wetland types (Wilcoxon Ranks test, $p<0.05$).

Figure 66: Box plot of Amphibian Quality Assessment Index (AQAI) values for all sites surveyed by state and wetland type. SC and AL did not do amphibian surveys for BLH wetlands, and GA did not do amphibian surveys for RSF wetlands.

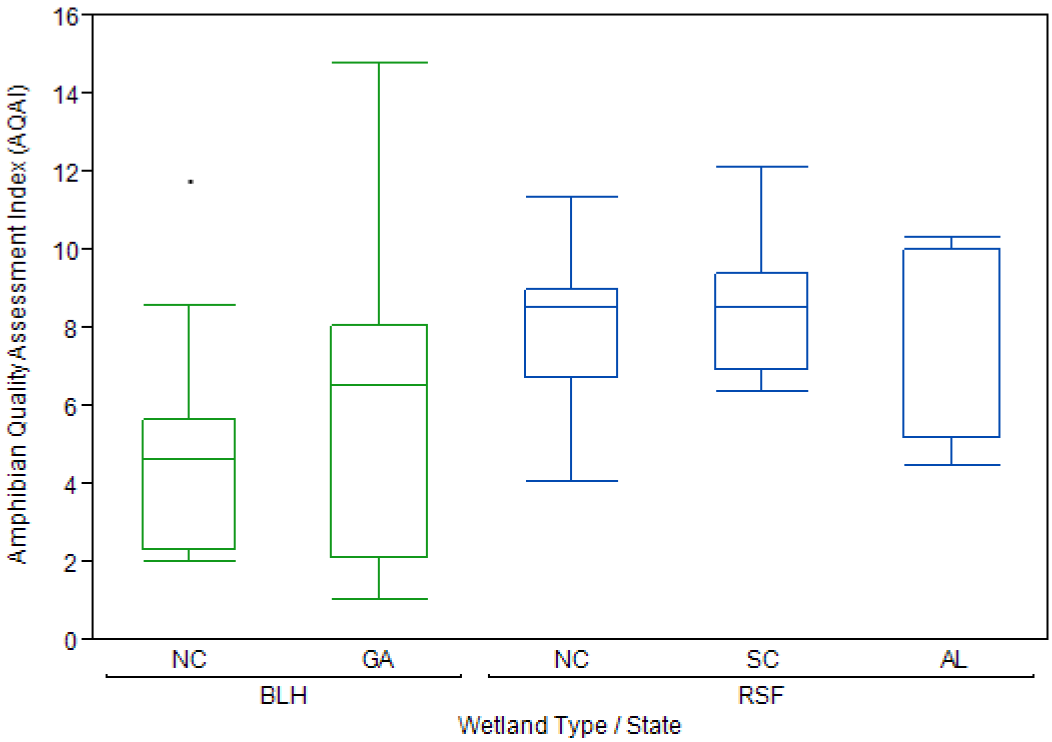


Table 24: Weighted mean AQAI values for BLH and RSF wetlands by state.

State	Weighted Mean AQAI	Maximum	Minimum	StDev	N
BLH					
NC	4.98	11.7	2.0	3.12	10
GA	6.33	14.8	1.0	4.05	15
RSF					
NC	7.69	11.3	4.0	2.13	10
SC	8.75	12.1	6.4	1.95	9
AL	6.76	10.3	4.5	0.76	10

Figure 67: Box plot of Amphibian Quality Assessment Index (AQAI) values by wetland type for the four-state region. SC and AL did not do amphibian surveys for BLH wetlands, and GA did not do amphibian surveys for RSF wetlands. Means are significantly different (p=.018, Wilcoxon Rank test).

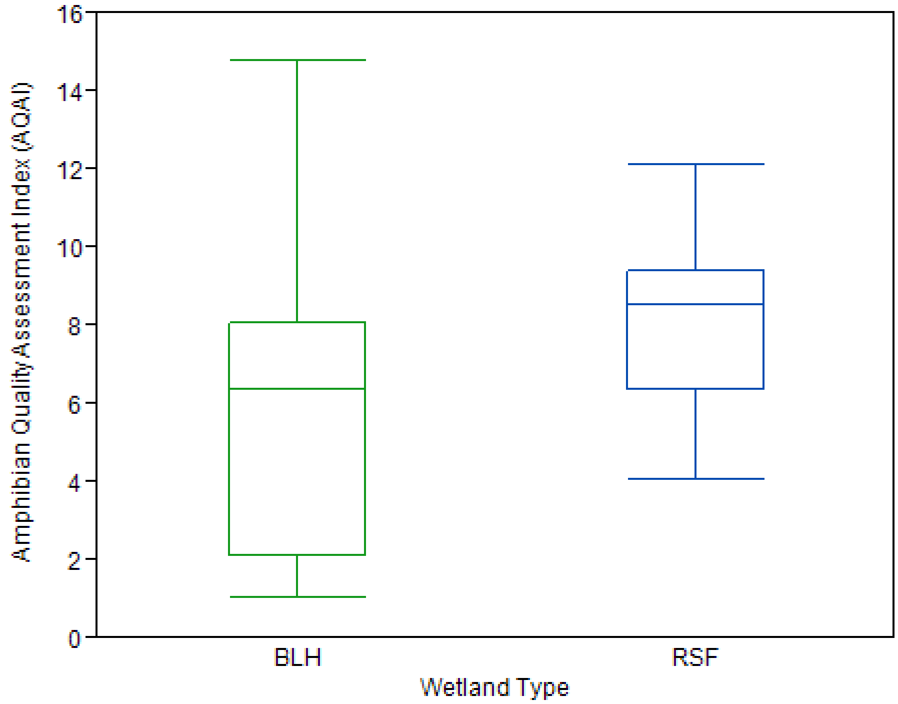
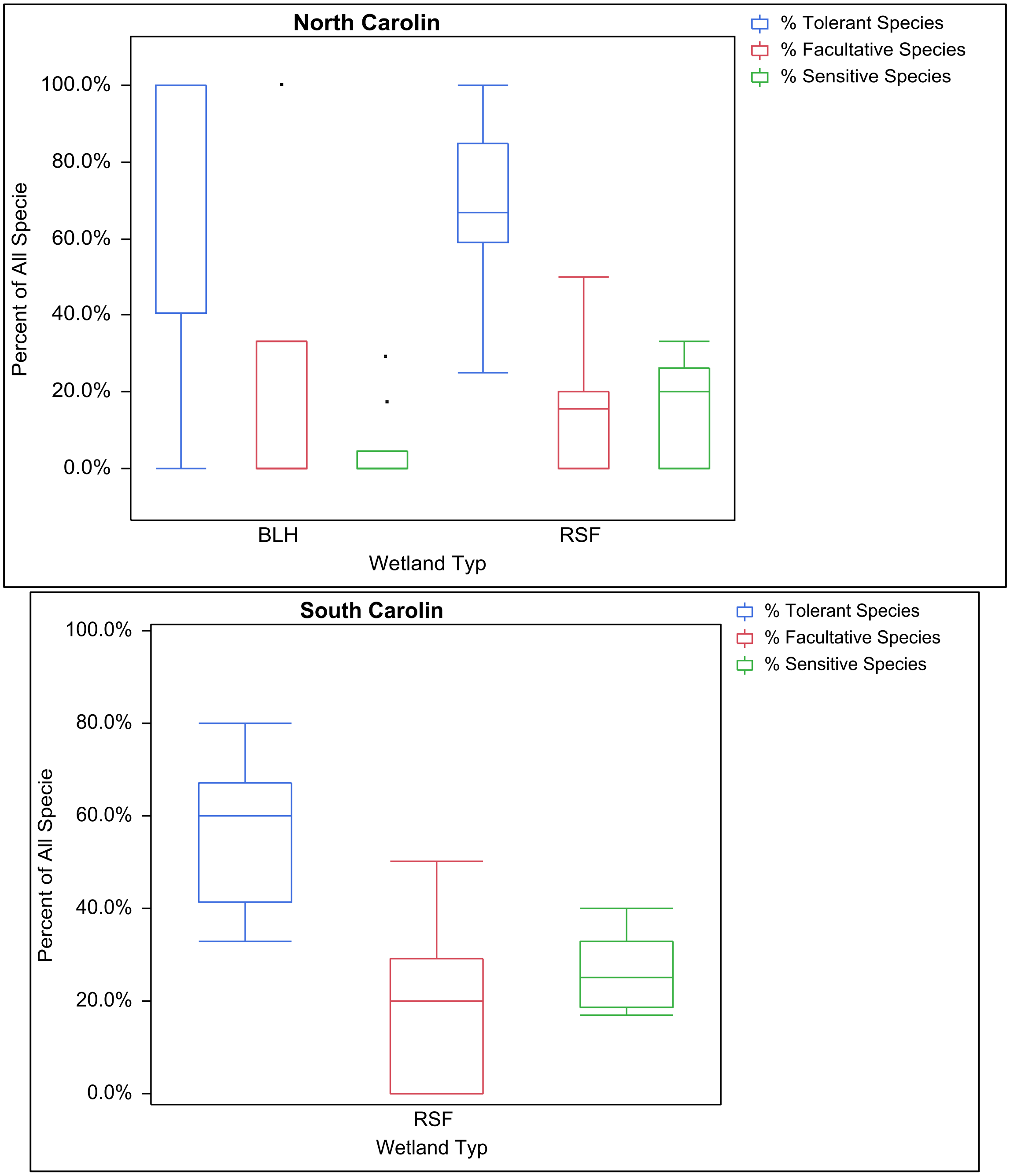
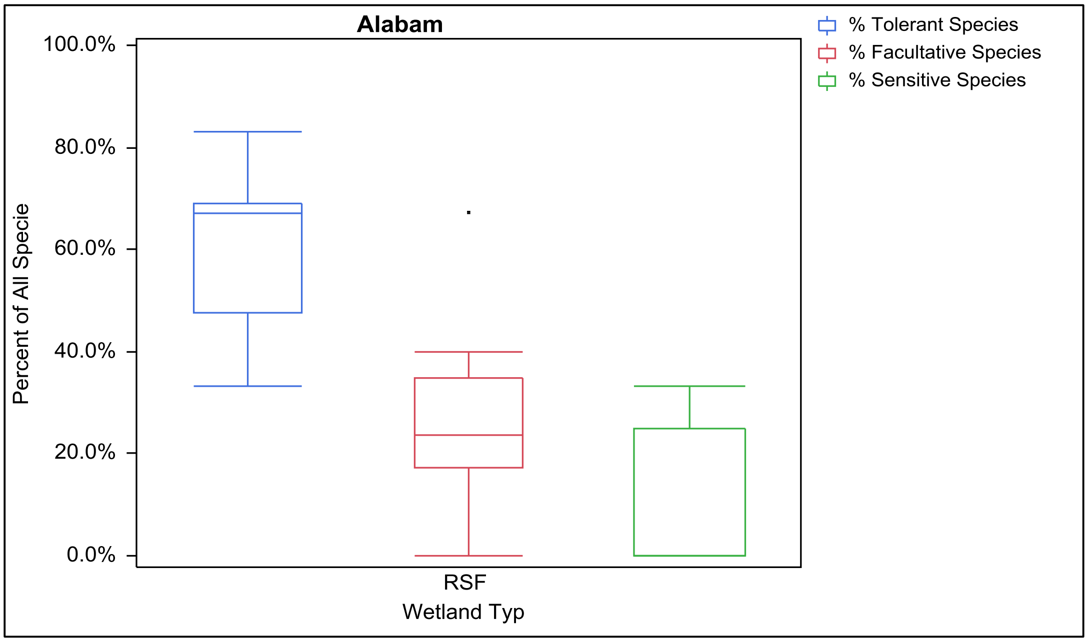


Figure 67 shows box plots of AQAI scores for amphibians by wetland type for the entire region. Riverine swamp forest wetland sites had significantly higher mean scores than the bottomland hardwood forest wetland sites (Wilcoxon two-sample test, p=0.018). From these results, the South Carolina riverine swamp forest had the best amphibian habitats based on the AQAI scores and Georgia had the best amphibian habitats for bottomland hardwood forest wetlands.

Amphibian species were put into categories based on their C values where a C value of less than or equal to three was considered tolerant and a C value greater than or equal to six was considered sensitive. C values of four and five were classified as facultative. Figure 68 show box plots of percent amphibians in each category, by state and by wetland type. For North Carolina, a large percentage of amphibians were tolerant in both bottomland hardwood forest wetland sites and riverine swamp forest wetland sites. Of the amphibians considered sensitive in North Carolina, the larger percentage occurred in the riverine swamp forests wetland sites. South Carolina and Alabama also had a larger percentage of tolerant amphibian species in their riverine swamp forest wetland sites. South Carolina had a larger percentage of amphibians in the sensitive category than did Alabama. For Georgia's bottomland hardwood forest wetland sites, tolerant species again had the largest percentage.

Figure 68: Box plots of percentage of amphibian species within each site that were considered sensitive, facultative, or tolerant species for each state. $C\leq3$ = Tolerant, C = 4 or 5 = Facultative, and $C\geq6$ = Sensitive. No significant difference existed between wetland types for each group of species within NC, which is the only state where both wetland types were sampled for amphibians.




Alabam
% Tolerant Species
% Facultative Species
% Sensitive Species
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
Percent of All Specie
RSF
Wetland Typ

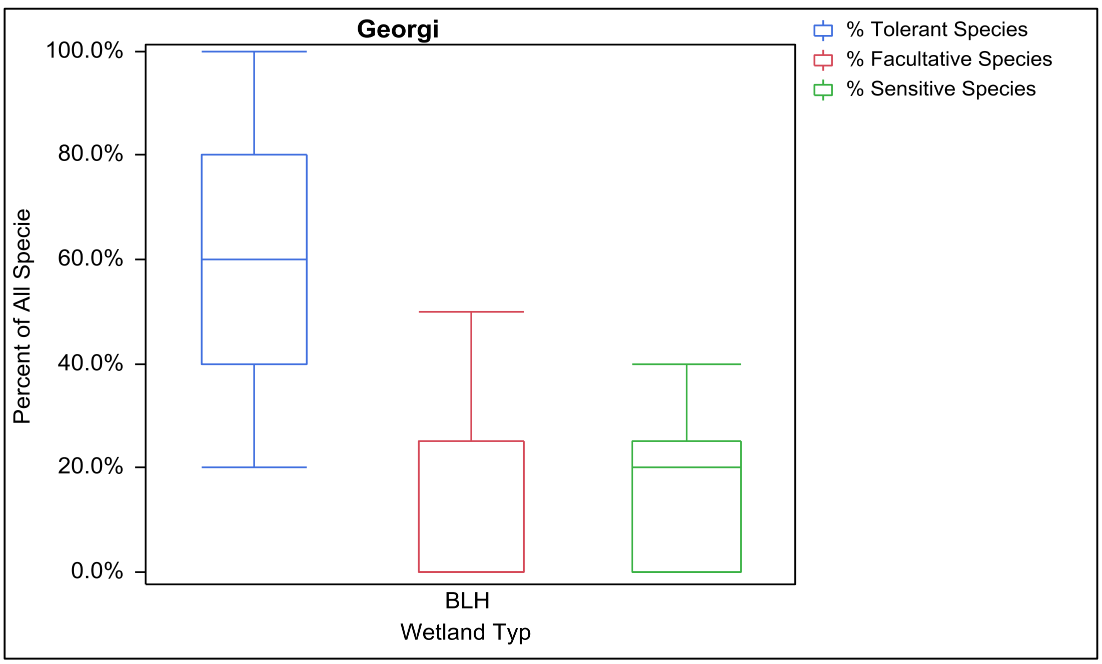

Georgi
% Tolerant Species
% Facultative Species
% Sensitive Species
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
Percent of All Specie
BLH
Wetland Typ

Figure 69: Box plot of relative abundance of tolerant, facultative, and sensitive amphibian species across the southeast region.

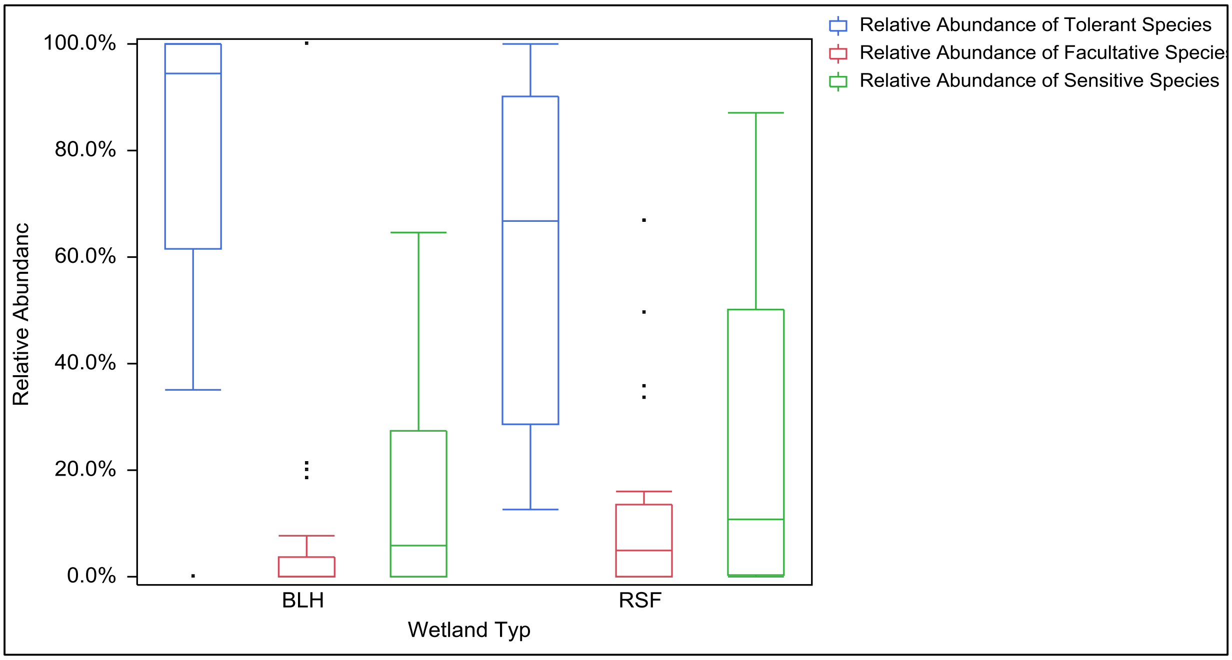


Figure 69 shows box plots of the relative abundance (percentage) of amphibian species in tolerant, facultative or sensitive categories for the four-state region. Tolerant species were again the largest percentage for both bottomland hardwood forest wetland sites and riverine swamp forest wetland sites. However in this case, a larger percentage of sensitive species occurred in both wetland types, especially for riverine swamp forest wetlands. No significant difference existed between wetland types in terms of relative abundance of any group. Within each wetland type, abundance of tolerant species was significantly greater than the abundance of either facultative or sensitive species ($p<0.0001$, Tukey test), but abundance of facultative and sensitive species did not differ.

Box plots showing the number of adult amphibians observed by wetland type and by state are presented in Figure 70. North Carolina had the largest number of adult amphibians in both bottomland hardwood forest wetland sites and riverine swamp forest wetland sites. South Carolina had the next largest number of adult amphibians in riverine swamp forest wetland sites.

Figure 71 shows theportion of the total number of amphibian species that were salamanders (as a percentage) and their relative abundance (percentage of all amphibian observations that were salamanders) by wetland type. At bottomland hardwood forest wetland sites, about 50% of the species were salamanders whereas at riverine swamp forest wetland sites, fewer amphibians were salamanders.

Figure 70: Box plot of number of adult (and adult equivalent) amphibians observed in BLH and RSF wetlands by state. One site with 885 individuals was excluded from the graph.

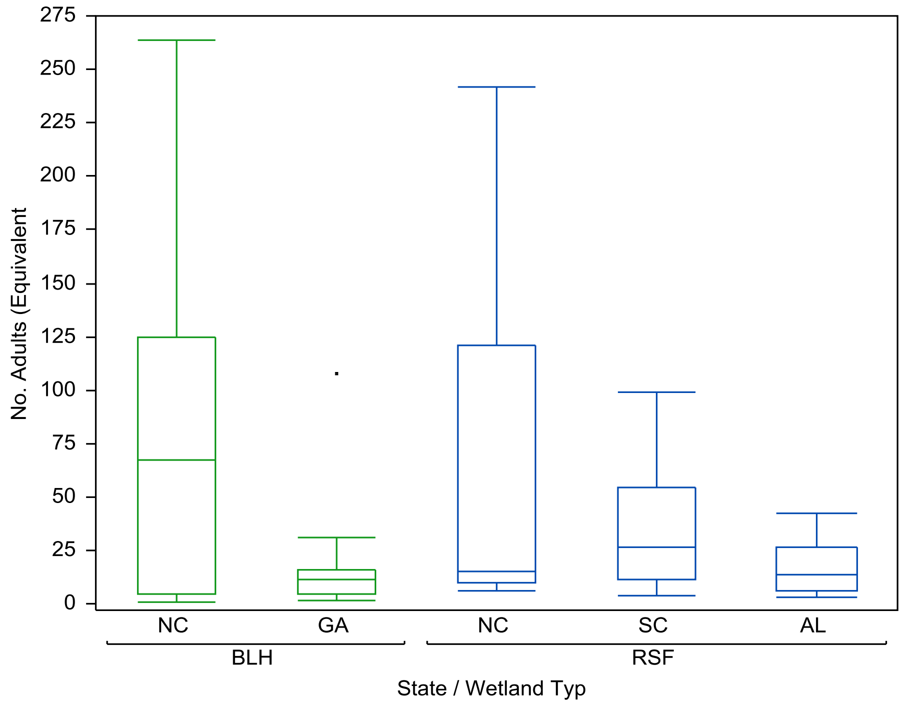
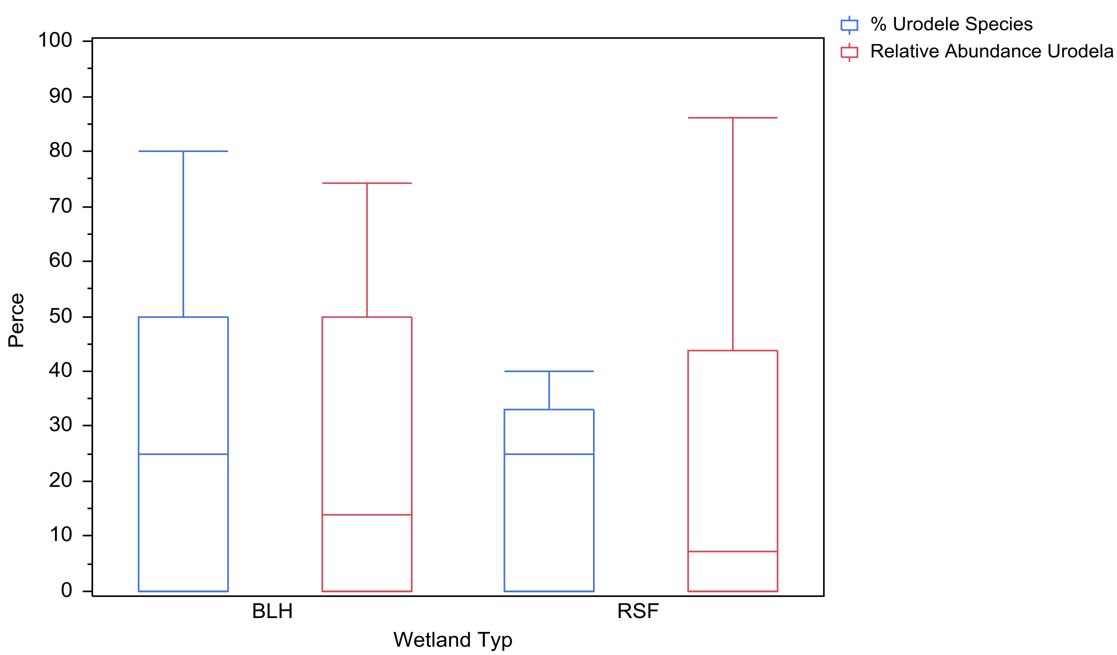


Figure 71: Percent Urodele (salamander) species and relative abundance of salamanders on BLH and RSF wetlands across the southeast.



The distribution of relative numbers (percentage) of adult individuals observed in bottomland hardwood forest wetland sites across the four states is shown in Figure 72, grouped by categories. Frogs and toads together comprised the group (indicated by dar blue categories in the figure) with the largest number of observations over 90% of the total. Table 25 shows the total number of individuals (within each genus) found in bottomland hardwood forest wetland sites across the four-state region. Acris, Bufo, Lithobates, and unidentified Anurans were the top four (dominant) genera of amphibians in these wetlands.

Finally, Table 26 shows the total number of individuals in each of each species observed by life stage (adult, tadpole/larva, egg mass) as well as showing the total number observed in each group, for bottomland hardwood forest wetlands throughout the four-state region (raw data for Figure 72). The Northern Cricket Frog both was the most common species overall and the most common species in the frog and toad group, whereas the Marbled and Spotted Salamanders were the most common species in the salamander and newt group in bottomland hardwood forest wetland sites.

Figure 72: Distribution of number of adults (and adult equivalent) individuals observed in BLH wetlands in the southeast region.

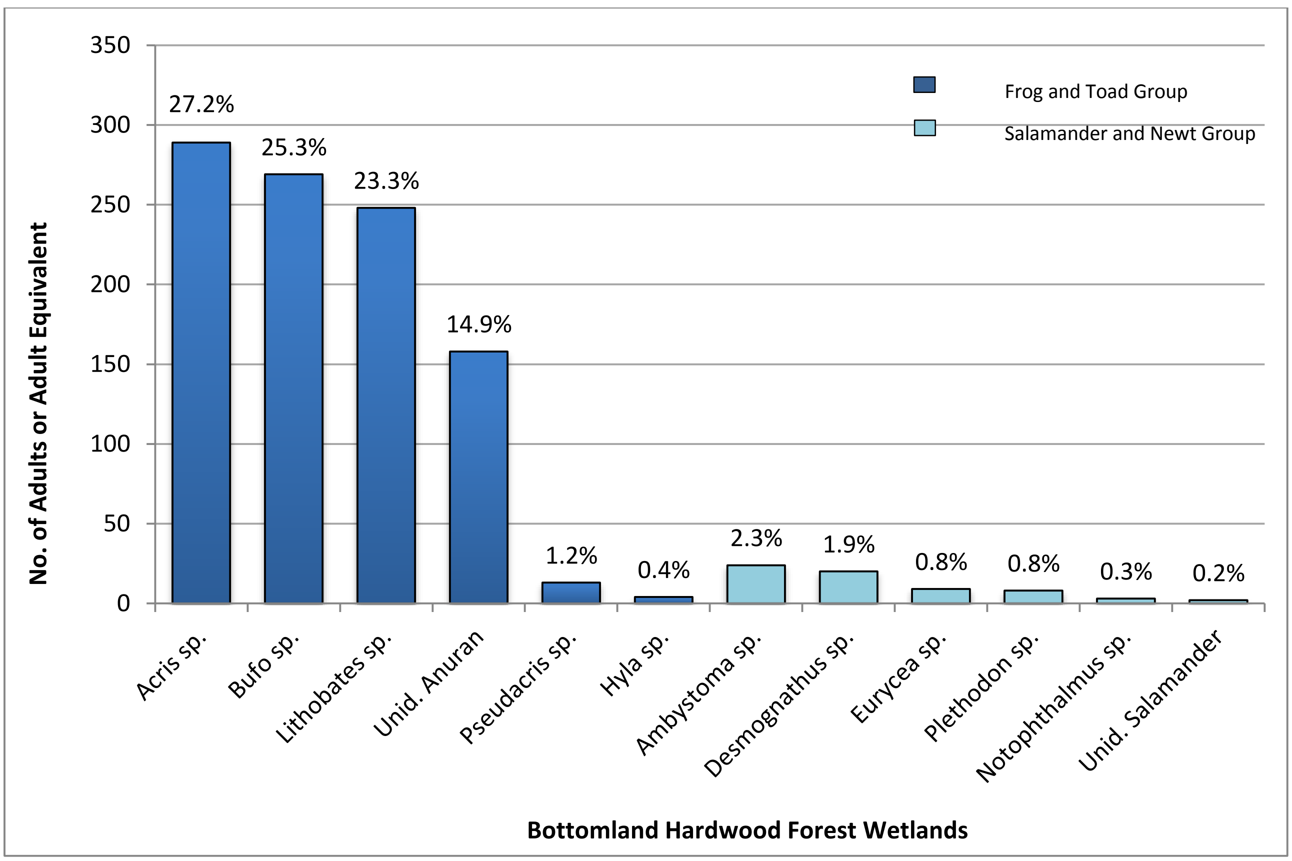


Table 25: Total number of individuals within each genus observed in BLH wetlands in the southeast region.

Genus	Total Individuals Observed (Adult Equivalent)
Acris sp.	289
Bufo sp.	269
Lithobates sp.	258
Unid. Anuran	157.6
Ambystoma sp.	29.5
Desmognathus sp.	20
Pseudacris sp.	13
Eurycea sp.	9
Plethodon sp.	8
Hyla sp.	4
Notophthalmus sp.	3
Urodela	2

Table 26: Amphibian species utilization (count of occurrences) in BLH wetlands in the southeast region

Scientific Name	Common Name	Adult and Juvenile	Tadpole/ Larva	Egg Mass	Total
Frogs and Toads					
Acris crepitans	Northern Cricket Frog	22			22
Acris gryllus	Southern Cricket Frog	1			1
Anura sp.	Unidentified Frog		10	1	11
Bufo americanus	Eastern American Toad	4	3		7
Bufo fowleri	Fowler's Toad	3			3
Bufo terrestris	Southern Toad	2			2
Hyla chrysoscelis	Cope's Gray Treefrog	3			3
Hyla cinerea	Green Treefrog	1			1
Lithobates catesbeiana	American Bullfrog	2			2
Lithobates clamitans	Bronze Frog	8			8
Lithobates palustris	Pickerel Frog	1			1
Lithobates sp.	Unidentified Ranid Frog	1	1	5	7
Lithobates sphenocephala	Southern Leopard Frog	7			7
Pseudacris crucifer	Northern Spring Peeper	1			1
Pseudacris feriarum	Upland Chorus Frog	2			2
Pseudacris nigrita	Southern Chorus Frog	1			1
Total Frog Species Occurrence		**61**	**14**	**6**	**79**
Salamanders and Newts					
Ambystoma maculatum	Spotted Salamander	2	1	4	7
Ambystoma opacum	Marbled Salamander	6			6
Ambystoma sp.	Mole Salamander	2			2

Desmognathus fuscus	Northern Dusky Salamander	2			2
Eurycea cirrigera	Southern Two-lined Salamander	2		1	3
Eurycea guttolineata	Three-lined Salamander	2			2
Notophthalmus viridescens	Red-spotted Newt	2			2
Plethodon chattahoochee	Chattahoochee Slimy Salamander	1			1
Plethodon cylindraceus	White-spotted Slimy Salamander	2			2
Plethodon glutinosus	Northern Slimy Salamander	4			4
Urodela	Unidentified Salamander		3		3
Total Salamander and Newt Species Occurrence		**21**	**1**	**5**	**29**
Unidentified Amphibian					
Unidentified Amphibian	Unidentified Egg Mass			1	1

Figure 73 shows the total numbers of observed and relative percentages of adult individuals (or equavalents) by species for riverine swamp forest wetland sites across the four-state region. As with the bottomland hardwood forest wetland sites, the frog and toad group was dominant with over 94% of the individuals. Table 27 shows the number of individuals in each genus in the four-state region. By far, the genus is Lithobates was observed in the largest numbers, followed by Acris. These two genera accounted for nearly 80% of the overall total number of individuals observed.

Table 28 lists the total number of individuals of each amphibian species observed at riverine swamp forest wetland sites, further providing subtotals for various life stage (adult, tadpole/larva, and egg mass). The most common frog/toad species were the Northern and Southern Cricket Frogs, Green Treefrog, Cope's Gray Treefrog, Bronze Frog, and the Southern Leopard Frog. The Marbled Salamander was by far the most common of the salamanders found in these wetlands.

Finally, Table 29 lists the amphibian coefficient of conservatism values for each amphibian species regardless of wetland type. Also shown is the adult conversion table for each amphibian species for both wetland types. This part of the table show how larvae and egg masses were converted into adults for purposes of analysis.

Most of the species found in both wetland types were tolerant species even though riverine swamp forest wetlands did have a large number of sensitive species. There were more salamander species found in the bottomland hardwood forest wetlands and NC had the largest number of amphibian species found of all the states.

Figure 73: Distribution of number of individuals (or adult equivalents) observed by species in RSF wetlands across the southeast region. An unidentified egg mass was excluded.

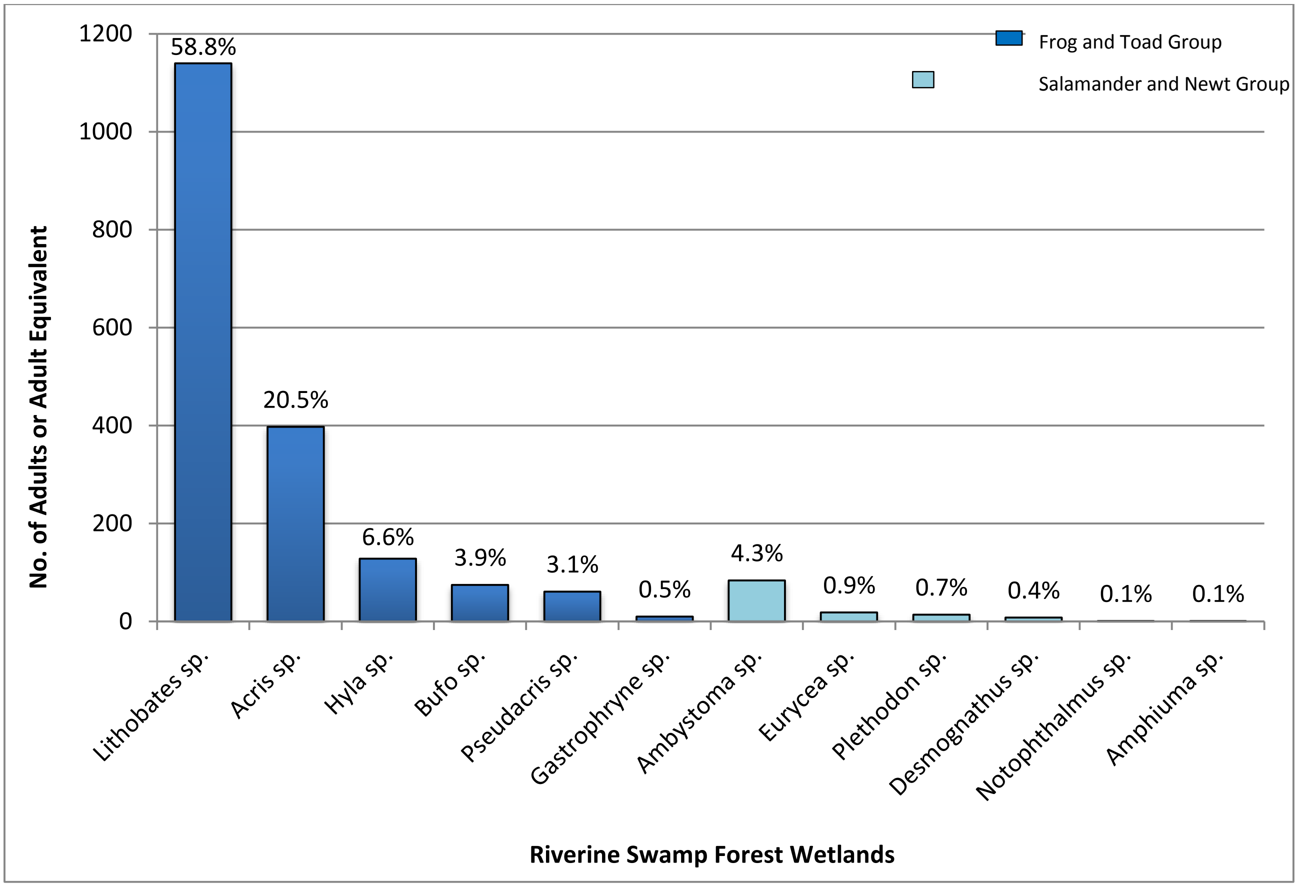


Table 27: Total number of individuals within each genus observed in RSF wetlands in the southeast region.

Genus	Number of Individuals Observed (Adult Equivalent)
Lithobates sp.	1140
Acris sp.	397
Hyla sp.	128
Ambystoma sp.	84
Bufo sp.	75
Pseudacris sp.	61
Eurycea sp.	18
Plethodon sp.	14
Gastrophryne sp.	10
Desmognathus sp.	8
Amphiuma sp.	1
Notophthalmus sp.	1
Unidentified (Egg mass)	0.5

Table 28: Amphibian species utilization (count of occurrences) in RSF wetlands in the southeast region.

Scientific Name	Common Name	Adult and Juvenile	Tadpole/ Larva	Egg Mass	Total
Frogs and Toads					
Acris crepitans	Northern Cricket Frog	24			24
Acris gryllus	Southern Cricket Frog	20	1		21
Anura sp.	Unidentified Frog species		10	1	11
Bufo americanus	Eastern American Toad	4	3		7
Bufo fowleri	Fowler's Toad	8			8
Bufo sp.	Unidentified toad species	2			2
Bufo terrestris	Southern Toad	8			8
Gastrophryne carolinensis	Eastern Narrow-mouthed Toad	1	1		2
Hyla avivoca	Bird-voiced Treefrog	3			3
Hyla chrysoscelis	Cope's Gray Treefrog	19			19
Hyla cinerea	Green Treefrog	20			20
Hyla gratiosa	Barking Treefrog	1			1
Hyla squirella	Squirrel Treefrog	5	1		6
Lithobates catesbeiana	American Bullfrog	6			6
Lithobates clamitans	Bronze Frog	20	6		26
Lithobates grylio	Pig Frog	2			2
Lithobates palustris	Pickerel Frog	9			9
Lithobates sp.	Unidentified Ranid Frog	5	2	3	10
Lithobates sphenocephala	Southern Leopard Frog	21	2		23
Pseudacris crucifer	Northern Spring Peeper	5			5
Pseudacris feriarum	Upland Chorus Frog	2			2
Pseudacris nigrita	Southern Chorus Frog	1			1
Total Frog Species Occurrence		**186**	**26**	**4**	**216**
Salamanders and Newts					
Ambystoma maculatum	Spotted Salamander	2	1	2	5
Ambystoma opacum	Marbled Salamander	23	4		27
Ambystoma sp.	Unidentified Mole Salamander	2	0		2
Amphiuma means	Two-toed Amphiuma	1	0		1
Desmognathus fuscus	Northern Dusky Salamander	3	0		3
Eurycea cirrigera	Southern Two-lined Salamander	4	0	1	5
Eurycea guttolineata	Three-lined Salamander	3	0		3
Eurycea quadradigitatta	Dwarf Salamander	6	1		7
Notophthalmus viridescens	Red-spotted Newt	3	0		3
Plethodon chattahoochee	Chattahoochee Slimy Salamander	1	0		1
Plethodon chlorobryonis	Atlantic Coast Slimy Salamander	3	0		3
Plethodon cylindraceus	White-spotted Slimy Salamander	8	0		8
Plethodon glutinosus	Northern Slimy Salamander	4	0		4
Urodela	Unidentified Salamander	0	3		3
Total Salamander and Newt Species Occurrence		**63**	**9**	**3**	**75**
Unidentified Amphibian					
Unidentified Amphibian	Unidentified Egg Mass			1	1

Table 29: Amphibian Coefficient of Conservatism Ratings and Adult Conversion Table

Species	Common Name	Amphibian C of C	Larvae -> Adult Conversion	Eggs or Egg Masses -> Adult Conversion	Tolerant Species (C<3)	Sensitive Species (CofC > 6)	Ephemeral Wetland or Headwater / Seepage Specific Species	Comments
Acris crepitans	Eastern Cricket Frog	2	20% = 1 Adult	1 egg mass = 2 adults	Y			Generalist- open grassy pond margins, ditches, marshy areas w/ shallow h2o
Acris gryllus	Coastal Plain Cricket Frog	2	20% = 1 Adult	1 egg mass = 2 adults	Y			Generalist-grassy margins of ponds, streams or ditches
Ambystoma maculatum	Spotted Salamander	8	20% = 1 Adult	250 eggs = 2 adults		Y	0.5*	Spotted salamanders tend to use isolated or deeper headwater site with semi permanent pools, will sometimes use other areas.
Ambystoma opacum	Marbled Salamander	8	20% = 1 Adult	1 egg mass = 2 adults		Y		
Ambystoma sp.		8	20% = 1 Adult	1 egg mass = 2 adults		Y	0.5*	
Ambystoma talpoideum	Mole Salamander	9	20% = 1 Adult	1 egg mass = 2 adults		Y		
Amphiuma means	Amphiuma	5	20% = 1 Adult					
Anura sp.	Frog or Toad Species	1	20% = 1 Adult	1 egg mass = 2 adults	Y			generalist for non-identified frog calls
Bufo americanus	Eastern American Toad	1	20% = 1 Adult	1 egg mass = 2 adults	Y			generalist for non-identified frog calls
Bufo americanusxfowleri	Eastern American Toad X Fowler's Toad	1	20% = 1 Adult	1 egg mass = 2 adults	Y			Generalist with short reproductive cycle and can tolerate disturbances eggs can develop fast can tolerate puddles, temperary pools, streams
Bufo fowleri	Fowler's Toad	1	20% = 1 Adult	1 egg mass = 2 adults	Y			Generalist with eggs develop fast and can tolerate disturbances. [pmds ;ales. Streams shallow water
Bufo quercicus	Oak Toad	4	20% = 1 Adult	1 egg mass = 2 adults				
Bufo sp.	Toad Species	1	20% = 1 Adult	1 egg mass = 2 adults	Y			Generalist, eggs develop fast and can tolerate disturbances
Bufo terrestris	Southern Toad	1	20% = 1 Adult	1 egg mass = 2 adults	Y			Generalist- eggs develop fast, and can tolerate disturbances, temporary pools, shallowy water, sandy areas, flooded meadows
Desmognanthus auriculatus	Southern Dusky Salamander	6	20% = 1 Adult	1 egg mass = 2 adults		Y	Y	Site specific to seepage areas, do not tolerate poor water quality as well as other species do, under leaf litter logs, eggs in moss cavities in summer, smal streams, eggs in cavities of rotton logs, under rock surfaces
Desmognanthus fuscus	Northern Dusky Salamander	6	20% = 1 Adult	1 egg mass = 2 adults		Y	Y	Site specific to seepage areas, do not tolerate poor water quality as well as other species do
Eurycea chamberlanii	Carolina Dwarf Salamander	6	20% = 1 Adult	1 egg mass = 2 adults		Y	Y	Site specific to seepage areas need better habitat
Eurycea cirrigea	Southern Two-lined Salamander	3	20% = 1 Adult	1 egg mass = 2 adults	Y			Can be found in perennial streams, seem to have hire tolerance to lower water quality conditions
Eurycea guttolineata	Three-lined Salamander	6	20% = 1 Adult			Y		

Eurycea quadridigitata	Dwarf Salamander	6	20% = 1 Adult			Y		
Gastrophryne carolinensis	Eastern Narrow-mouthed Toad	4						
Hemidactylium scutatum	Four-toed Salamander	10	20% = 1 Adult	If female w/ eggs do not count otherwise, each cluster found separately = 1 female		Y	Y	Seepage area specific habitat, need mature forest, developed moss cavities to lay eggs, found in bogs
Hyla avivoca	Bird-voiced Tree Frog	5	20% = 1 Adult					
Hyla chrysoscelis	Cope's Gray Tree Frog	5	20% = 1 Adult	1 egg mass = 2 adults			Y	Site specific to ephemeral ponds or deeper water headwater wetlands, adults rarely found -
Hyla cinerea	Green Tree Frog	3	20% = 1 Adult	1 egg mass = 2 adults	Y			
Hyla femoralis	Pine Woods Tree Frog	5	20% = 1 Adult	1 egg mass = 2 adults				
Hyla gratiosa	Barking Treefrog	7	20% = 1 Adult	1 egg mass = 2 adults		Y	Y	
Hyla sp.	Treefrog Species	3			Y			
Hyla squirella	Squirrel Treefrog	6	20% = 1 Adult	1 egg mass = 2 adults		Y		Will use ephemeral wetlands deeper water headwater wetlands can also use ditches and other areas, found in urban settings
Hyla versicolor	Common Gray Tree Frog	3	20% = 1 Adult	1 egg mass = 2 adults	Y		Y	
Lithobates catesbeiana	American Bullfrog	1	20% = 1 Adult	1 egg mass = 2 adults	Y			Generalist
Lithobates clamitans	Northern Green Frog	2	20% = 1 Adult	1 egg mass = 2 adults	Y			Generalist
Lithobates grylio	Pig Frog	5						
Lithobates palustris	Pickerel Frog	3	20% = 1 Adult	1 egg mass = 2 adults	Y			Generalist
Lithobates sp.	Frog species	1	20% = 1 Adult	1 egg mass = 2 adults	Y			Consider generalist if not identified to species
Rana sphenocephala	Southern Leopard Frog	3	20% = 1 Adult	1 egg mass = 2 adults	Y			Ephemeral pond or other areas, ponds, ditches and swamps, lake and stream margins
Necturus punctatus	Dwarf Mudpuppy	6	20% = 1 Adult	1 egg mass = 2 adults		Y		
Notophthalmus viridescens	Eastern Newt	1	20% = 1 Adult	1 egg mass = 2 adults	Y			
Notophthalmus viridescens dorsalis	Eastern Newt	1	20% = 1 Adult	1 egg mass = 2 adults	Y			
Plethodon chlorobryonis	Atlantic Coast Slimy Salamander	4						
Plethodon cinereus	Eastern Red-backed Salamander	4	20% = 1 Adult	1 egg mass = 2 adults				Not specific to needing headwater wetlands or ephemeral ponds, do need mature forested habitat I.e. quality buffer, under rocks and leaf litter/ logs in forested areas
Plethodon cylindraceus	White-spotted Slimy Salamandar	4	20% = 1 Adult	1 egg mass = 2 adults				
Plethodon glutinosus	Northern Slimy Salamander	4	20% = 1 Adult	1 egg mass = 2				Not specific to needing headwater wetlands or

				adults				ephemeral ponds, do need mature forested habitat I.e. quality buffer, wooded areas in burrows, under debris, ubiquitous, eggs hard to find in logs and among roots
Pseudacris brimleyi	Brimley's Chorus Frog	6	20% = 1 Adult	1 egg mass = 2 adults		Y		
Pseudacris crucifer	Northern Spring Peeper	3	20% = 1 Adult	1 egg mass = 2 adults	Y			Will use ephemeral wetlands deeper water headwater wetlands can also use ditches and other areas, woodland areas, forest litter, brush areas, swamps, ponds , and ditches
Pseudacris feriarum	Upland Chorus Frog	4	20% = 1 Adult	1 egg mass = 2 adults			Y	Site specific to ephemeral ponds or deeper water headwater wetlands, use semi perminant pools, Pseudocris feriarum synonym
Pseudacris nigrita	Southern Chorus Frog	6	20% = 1 Adult	1 egg mass = 2 adults				
Pseudacris ocularis	Little Grass Frog	6	20% = 1 Adult	1 egg mass = 2 adults		Y	Y	Site specific to ephemeral ponds or deeper water headwater wetlands, Limnaedus ocularis synonym
Pseudacris ornata	Ornate Chorus Frog	6	20% = 1 Adult	1 egg mass = 2 adults		Y		
Pseudacris sp.	Chorus Frog Species	4	20% = 1 Adult	1 egg mass = 2 adults		Y		If not identified to species then 4
Pseudotriton montanus	Eastern Mud Salamander	7	20% = 1 Adult	1 egg mass = 2 adults		Y	Y	Seepage area specific habitat, need mature forest, muck soil beneath logs and stones on banks of seepages, springs, brooks, or swamps
Pseudotriton ruber	Red Salamander	7	20% = 1 Adult	1 egg mass = 2 adults		Y		Need seepage area or small perennial stream with quality habitat to reproduce, leaf litter accumulation, brooks, near by crevices and burrows, under logs, stones and debris.
Scaphiopus holbrookii	Eastern Spadefoot	8	20% = 1 Adult	1 egg mass = 2 adults		Y	Y	Ephemeral pond quality habitat, sandy lowlands in burrows needs temperary pools to breed
Siren intermedia	Lesser Siren	6	20% = 1 Adult	1 egg mass = 2 adults		Y		
Stereochilus marginatus	Many-lined Salamander	7	20% = 1 Adult	1 egg mass = 2 adults				
Urodela sp.	Salamander or Newt Species	4	20% = 1 Adult	1 egg mass = 2 adults				If not identified to species consider to be a 4

**Ambystoma maculatum* requires ephemeral, headwater, or seepage specific wetlands half the time, but can also be found in less pristine environments such as roadside ditches or small retention areas.

Macroinvertebrate Results

The results for the macroinvertebrate data are show in Figures 74-79 and Tables 30-31. Recall that South Carolina and Alabama did not do intensive surveys of bottomland hardwood forests wetlands and Georgia was not able to collect macroinvertebrates due to drought conditions.

Figure 74 shows species richness of macroinvertebrate by wetland type and then by state. The species richness was much higher for riverine swamp forests wetland sites than for bottomland hardwood forest wetland sites. South Carolina had the largest spread of richness scores for macroinvertebrates in riverine swamp forest wetland sites and also had lower average score, whereas North Carolina and Alabama were about equal.

Figure 75 shows macroinvertebrate abundance for each wetland type and then by state. On average, riverine swamp forest wetland sites had about twice the number of individuals as did bottomland hardwood forest wetland sites; this may be due to these wetlands having a greater frequency and suration of inundation. Alabama had the largest number of individual macroinvertebrates found in riverine swamp forest wetland sites whereas North Carolina and South Carolina had about the same.

Figure 74: Macroinvertebrate species richness in BLH and RSF wetlands for the southeast region and by state.

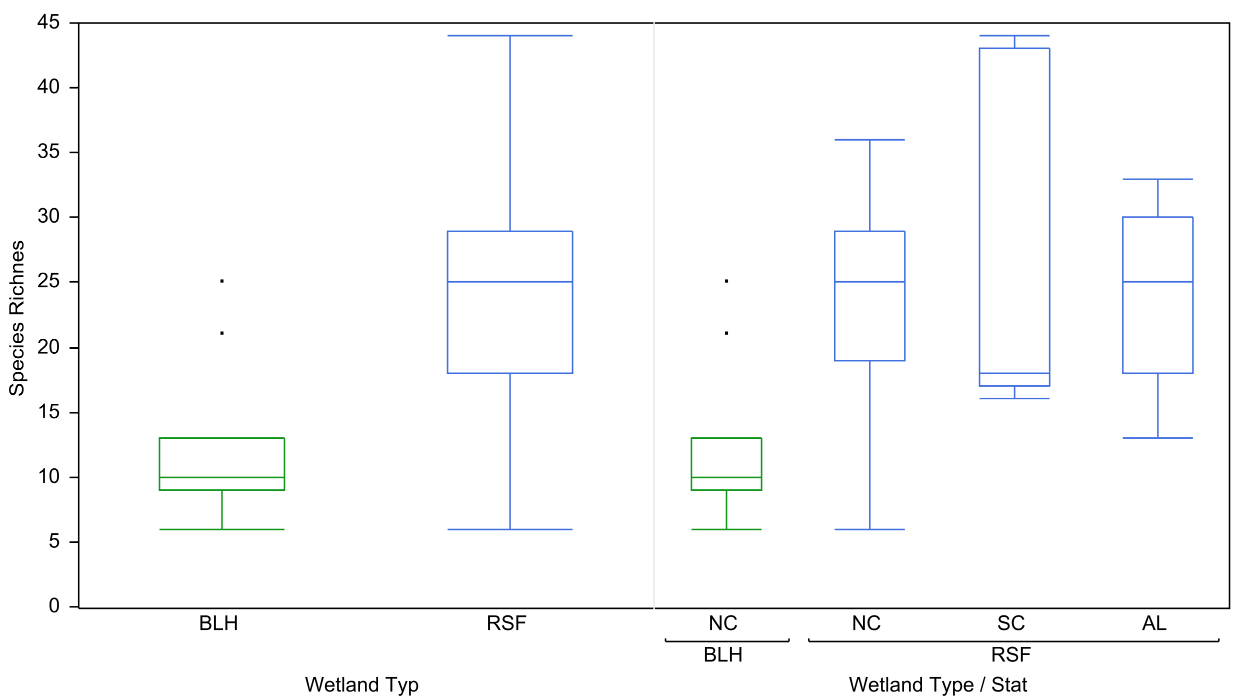


Figure 75: Number of macroinvertebrate individuals observed in BLH and RSF wetlands for the southeast region and by state.

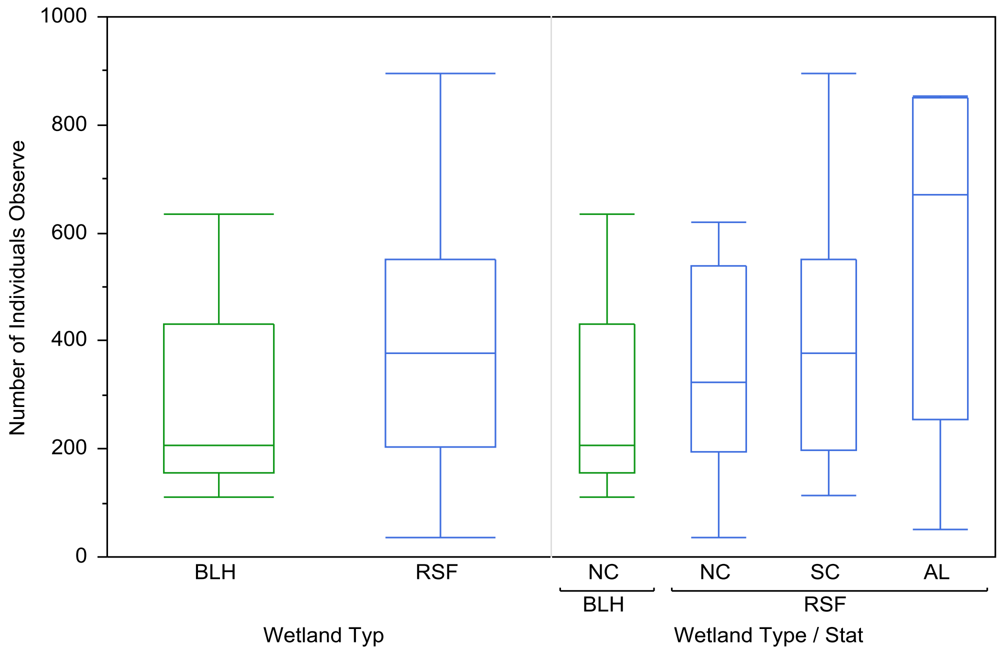


Figure 76 shows the macroinvertebrate biotic index (MBI) values by wetland type and by state. In general, riverine swamp forest wetland sitess had a slightly higher MBI than did bottomland hardwood forest wetland sites and the difference was statistically significant (Wilcoxon Signed Ranks test, p=0.05). For riverine swamp forest wetland sites, Alabama had a much higher MBI than did North or South Carolina and was also a statistically significant difference (Wilcoxon Signed Ranks test, p=0.001).

Simpson's Diversity Index values for macroinvertebrate data are shown in Figure 77 by wetland type and by state. Riverine swamp forest wetland sites had a statistically significant higher Simpson's Diversity Index value than bottomland hardwood forest wetland sites (Wilcoxon Signed Ranks test, p-0.002). Alabama had higher Simpson's Diversity Index value than North or South Carolina, but was not statistically significant.

Figure 76: Macroinvertebrate Biotic Index (MBI) by wetland type for the southeast region. MBI for each wetland type are significantly different (p=0.05, Wilcoxon Signed Ranks test). MBI for AL is significantly higher than NC and SC (p<0.001; Wilcoxon Signed Ranks test). NC and SC do not differ significantly.

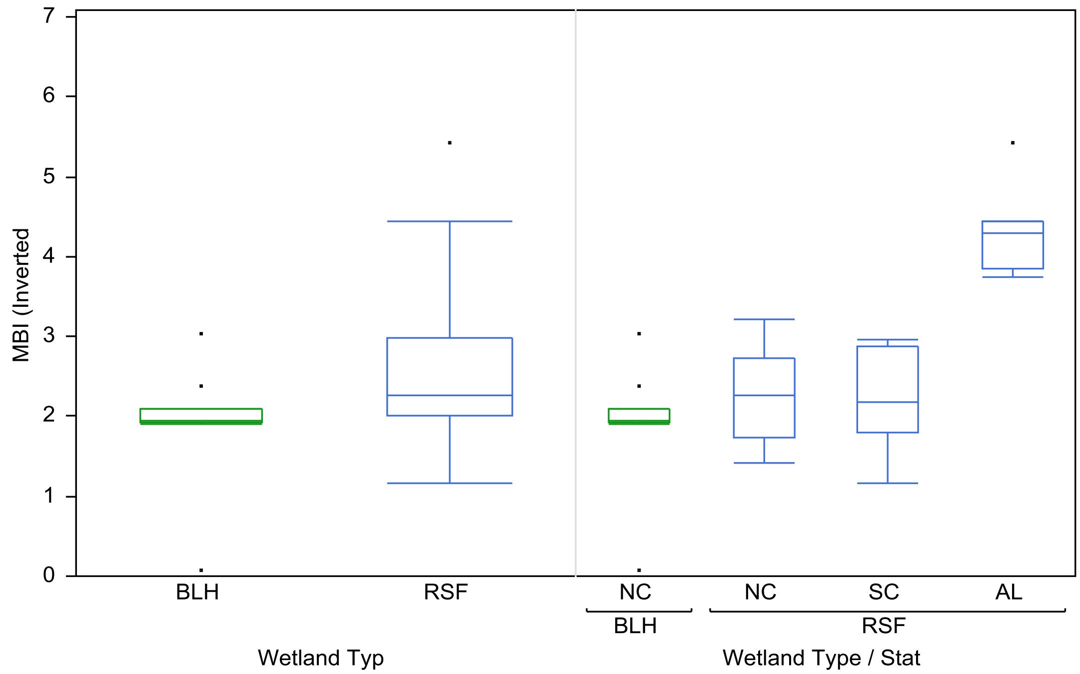


Figure 77: Simpson's Diversity Index values for macroinvertebrates in BLH and RSF wetlands in the southeast region. BLH - NC wetlands; RSF - AL, NC, and SC wetlands. Diversity was significantly higher in RSF than BLH wetlands (p=0.002, Wilcoxon Signed Ranks test). No state is significantly different from any of the others.

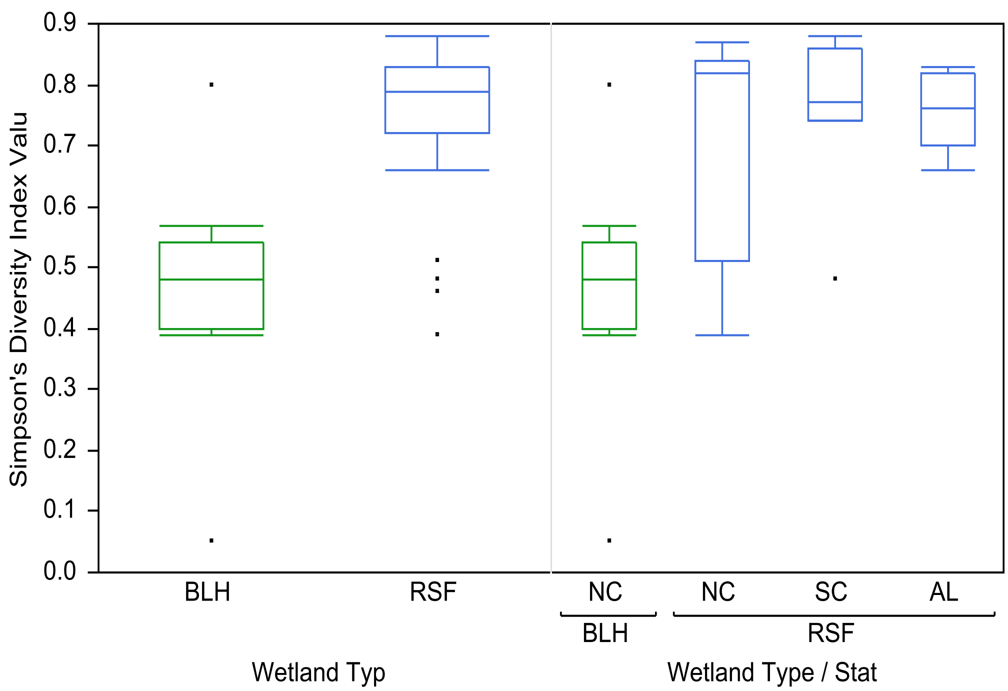


Figure 78: Percent of macroinvertebrate species which were sensitive, facultative, and tolerant on BLH and RSF wetlands in the southeast region. Sensitive = Tolerance Value = 0-4, Facultative= Tolerance Value ≥4 – 7, Tolerant = Tolerance Value >7-10. Tolerance Values were rounded to the nearest whole number for this categorization.

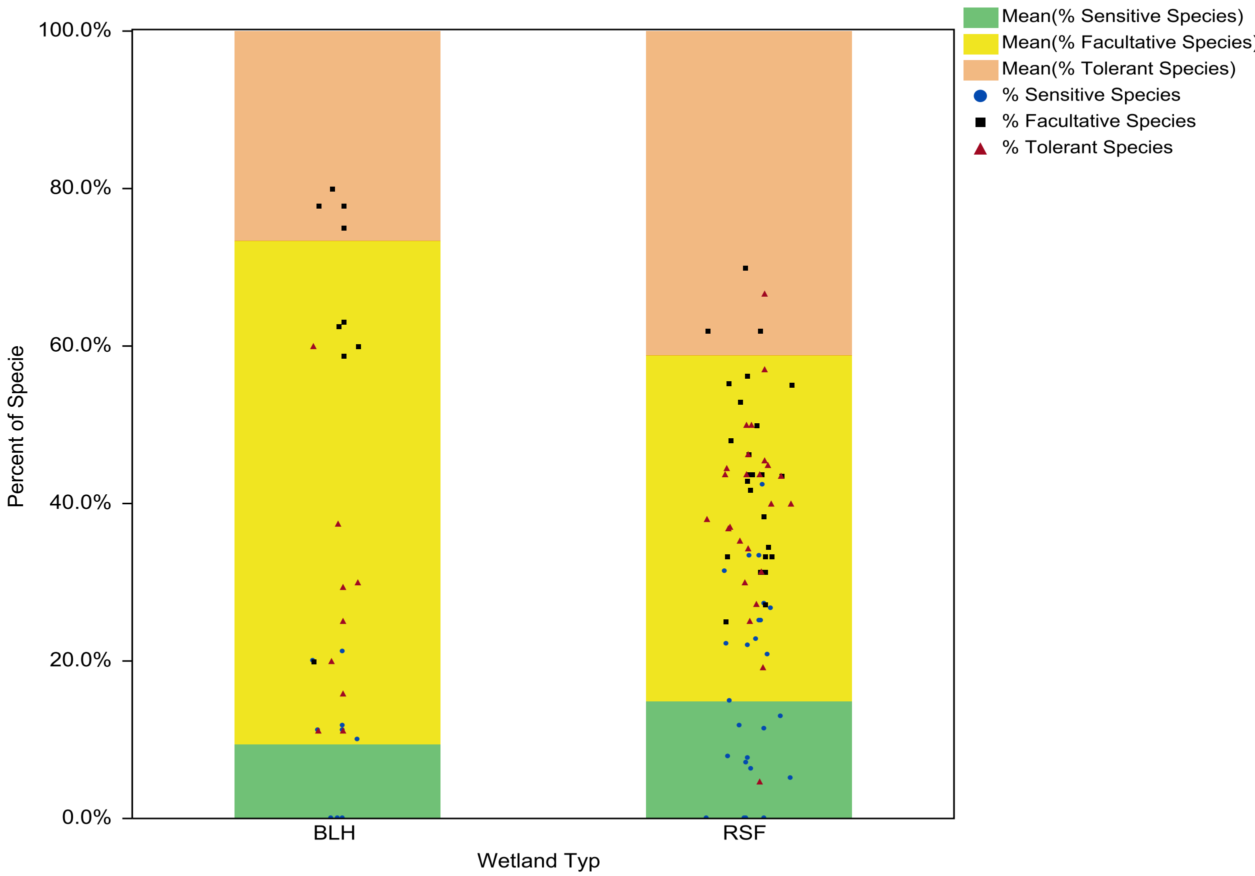


Figure 78 shows the overall mean percentage of macroinvertebrate species classified as sensitive, tolerant, or facultative for each wetland type as well as percentages for individual sites. Overall, species collected from bottomland hardwood forest wetland sites were classified facultative most often, with only a small percent classified as sensitive species, another indication that the bottomland hardwood forest wetlands in the Piedmont ecoregion were more impacted. However, species collected from riverine swamp forest wetland sites, were classified as facultative a smaller percentage of the time; meaning a larger percentage of species were classified as tolerant, indicating there wetlands did not necessarily provide the best habitat either.

The relative abundance (mean of sites in each wetland type and wetland type/state combination) of macroinvertebrate species that were classified as tolerant, sensitive or facultative are shown in Figure 79. Bottomland hardwood forest wetlands had about 70% of the macroinvertebrate species classified as tolerant, whereas riverine swamp forest wetland sites had about 50% being classified tolerant. Alabama had smallest number of tolerant macroinvertebrate species and thelargest number of sensitive species, whereas North and South Carolina had about the same percentage of macroinvertebrate species in each category.

Figure 79: Relative abundance of sensitive, facultative, and tolerant species on BLH and RSF wetlands in the southeast region and by state. Sensitive = Tolerance Value = 0-4, Facultative= Tolerance Value >4 – 7, Tolerant = Tolerance Value >7-10. Tolerance Values were rounded to the nearest whole number for this categorization.

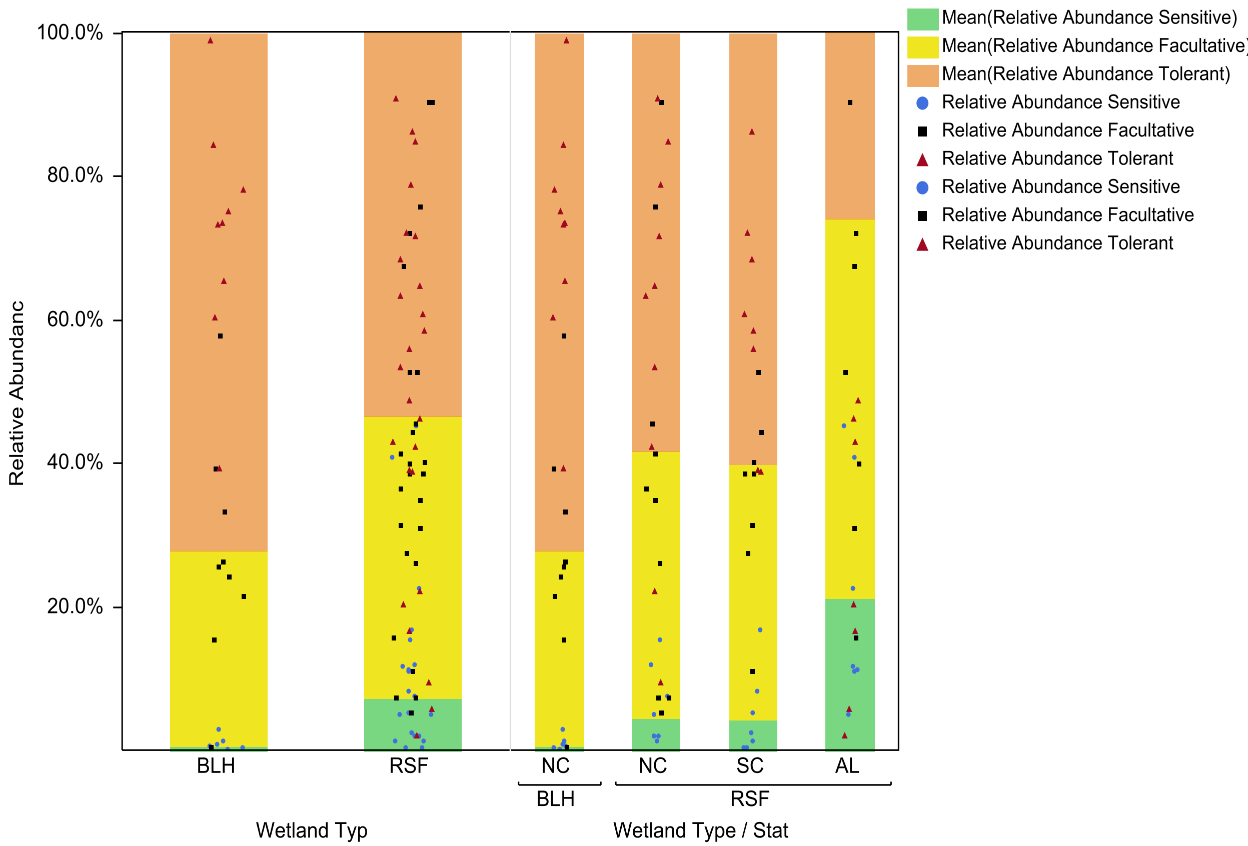


Table 30 shows the frequency (number of sites) and abundance (number of individuals) for macroinvertebrate species observed in bottomland hardwood forest wetland sites in the four-state region. The most abundant taxon was Isopoda by a large margin. The next most abundant taxa were Amphipoda, Diptera, and Veneroida.

The macroinvertebrate species observed in riverine swamp forest wetland sites are shown in Table 31. The most abundant taxa for these wetlands were Diptera and Isopoda. The next most abundant taxa were Amphipoda, Basommatophora, and Haplotaxida. Note also that many more species and individuals were found in riverine swamp forest wetland sites than in bottomland hardwood forest wetland sites.

Table 30: Macroinvertebrate species observed in BLH Wetlands in the Southeast.

Order – Family – Species	Frequency	Abundance
Amphipoda	**13**	**275**
Crangonyctidae	10	262
Crangonyx spp	8	254
Synurella spp	2	8
Gammaridae	3	13
Crangonyx serratus	3	13
Basommatophora	**3**	**8**
Physidae	1	3
Physella spp	1	3
Planorbidae	2	5
Helisoma anceps	1	4
Planorbella spp	1	1
Class Hirudinea	**1**	**1**
Undetermined Leech	1	1
Coleoptera	**10**	**18**
Dytiscidae	7	15
Acilius spp	1	1
Agabus spp	1	3
Copelatus spp	1	1
Dytiscus spp	2	2
Laccornis spp	1	3
Neoporus spp	1	5
Hydrophilidae	2	2
Hydrochara spp	1	1
Tropisternus spp	1	1
Scirtidae	1	1
Decapoda	**5**	**88**
Cambaridae	5	88
Undetermined Crayfish	5	88
Diptera	**28**	**336**
Ceratopogonidae	2	11
Dasyhelea spp	2	11
Chironomidae	15	34
Chironomus spp	1	2
Cricotopus annulator	1	1
Mesosmittia spp	3	9
Orthocladius nigritus	1	1
Phaenopsectra spp	2	3
Polypedilum tritum	2	6
Pseudosmittia spp	2	2
Psilometriocnemus triannulatus	1	1
Tanytarsus spp	1	2
Tribelos spp	1	7
Culicidae	2	207
Culex spp	2	207
Muscidae	2	3
Syrphidae	1	3
Eristalis spp	1	3
Tipulidae	4	9
Platytipula spp	2	6
Pseudolimnophila spp	2	3

Order – Family – Species	Frequency	Abundance
Undetermined Dipteran	2	69
Haplotaxida	**12**	**42**
Lumbriculidae	4	21
Tubificidae	8	21
Spirosperma nikolskyi	4	13
Tubificidae undetermined	4	8
Isopoda	**10**	**1466**
Asellidae	9	1465
Asellus spp	8	1060
Caecidotea spp	1	405
Undetermined Terrestrial Isopods	1	1
Odonata	**1**	**1**
Aeshnidae	1	1
Aeshna umbrosa	1	1
Oligochaeta	**4**	**8**
Undetermined Earthworm	4	8
Veneroida	**3**	**211**
Pisidiidae	3	211
Sphaerium spp	3	211

Table 31: Macroinvertebrate species observed in RSF wetlands in the southeast region.

Order – Family – Species	Frequency	Abundance
Amphipoda	**32**	**800**
Amphipoda undetermined	1	6
Crangonyctidae	22	729
Crangonyctidae undetermined	1	2
Crangonyx spp	17	697
Synurella chamberlaini	2	21
Synurella spp	2	9
Gammaridae	4	30
Crangonyx serratus	3	25
Gammarus spp	1	5
Talitridae	5	35
Hyalella spp	5	35
Architaenioglossa	**7**	**65**
Viviparidae	7	65
Campeloma decisum	2	29
Viviparus intertextus	3	16
Viviparus spp	2	20
Basommatophora	**39**	**770**
Ancylidae	2	14
Laevapex fuscus	2	14
Lymnaeidae	7	11
Fossaria spp	1	2
Lymnaea columella	5	6
Pseudosuccinea columella	1	3
Physidae	10	254
Aplexa spp	1	1
Physa acuta	3	115
Physa spp	2	6
Physella spp	4	132
Planorbidae	20	491
Gyraulus parvus	2	24
Helisoma anceps	3	125
Helisoma spp	2	2
Helisoma trivolvis	1	1
Menetus dilatatus	3	92
Micromenetus dilatatus	2	2
Micromenetus spp	2	171
Planorbella spp	2	10
Planorbella trivolvis	1	1
Planorbula armigera	1	50
Promenetus exacuous	1	13
Class Hirudinea	**1**	**1**
Undetermined Leech	1	1
Coleoptera	**97**	**234**
Dryopidae	2	2
Pelonomas spp	2	2
Dytiscidae	42	99
Acilius fraternus	2	2
Acilius spp	4	7
Agabetes acuductus	1	4
Agabus spp	7	17
Bidessonotus spp	1	1

Order – Family – Species	Frequency	Abundance
Celina spp	1	2
Copelatus spp	1	1
Coptotomus loticus	1	1
Coptotomus spp	1	1
Hydaticus spp	2	2
Hydroporus spp	9	38
Hygrotus spp	1	1
Laccophilus spp	1	1
Laccornis spp	1	1
Matus ovatus	2	3
Neoporus dilatus	1	7
Neoporus spp	4	6
Platambus spp	1	3
Thermonectus spp	1	1
Haliplidae	10	44
Peltodytes sexmaculatus	2	2
Peltodytes spp	8	42
Hydrophilidae	37	77
Berosus pantherinus	1	1
Berosus spp	3	5
Cybiodyta rotunda	1	3
Derallus spp	1	1
Enochrus spp	1	1
Helocombus spp	3	8
Hydrobius spp	2	2
Hydrocanthus iricolor	1	2
Hydrochara soror	5	9
Hydrochara spp	7	24
Hydrophilus triangularis	1	1
Tropisternus blatchleyi	2	3
Tropisternus quadristriatus	1	1
Tropisternus spp	8	16
Noteridae	2	2
Hydrocanthus atripennis	1	1
Hydrocanthus spp	1	1
Scirtidae	4	10
Cyphon spp	2	4
Ora spp	2	6
Decapoda	**20**	**209**
Astacidae	1	2
Cambaridae	15	199
Cambaridae undetermined	7	103
Procambarus clarkii	2	20
Procambarus spp	2	68
Undetermined Crayfish	4	8
Palaemonidae	4	8
Palaemonetes paludosus	3	7
Palaemonetes spp	1	1
Diptera	**218**	**3188**
Ceratopogonidae	7	18
Ceratopogonidae undetermined	1	1
Mallochohelea spp	1	1
Palpomyia complex	5	16
Chaoboridae	2	5
Chaoborus punctipennis	2	5

Order – Family – Species	Frequency	Abundance
Chironomidae	168	3000
Ablabesmyia peleensis	1	1
Ablabesmyia spp	6	53
Apsectrotanypus spp	1	11
Chaetocladius spp	2	14
Chironomidae undetermined	9	39
Chironomus spp	23	1535
Clinotanypus spp	1	3
Corynoneura spp	3	8
Cricotopus bicinctus	1	3
Cricotopus sylvestris gr	1	2
Dicrotendipes modestus	1	4
Dicrotendipes nervosus	1	5
Dicrotendipes spp	3	128
Endochironomus spp	2	2
Glyptotendipes spp	2	14
Goeldechironomus spp	1	1
Guttipelopia guttipennis	2	91
Gymnometriocnemus spp	3	4
Hydrobaenus spp	1	20
Kiefferulus dux	1	1
Kiefferulus spp	4	19
Larsia spp	7	15
Nanocladius spp	3	10
Natarsia spp	7	23
Omisus spp	1	17
Orthocladius annectans	1	1
Parachironomus chaetoalus complex	1	3
Parachironomus spp	6	8
Parametriocnemus spp	1	16
Paratanytarsus spp	2	38
Paratendipes spp	4	5
Polypedilum fallax/sp A	1	3
Polypedilum illinoense	8	57
Polypedilum spp	12	481
Polypedilum trigonum	2	3
Polypedilum tritum	10	134
Potthastia spp	1	8
Procladius spp	4	13
Rheocricotopus tuberculatus	1	1
Stenochironomus spp	1	3
Tanypodinae	2	7
Tanypus spp	1	1
Tanytarsus sp 3	1	1
Tanytarsus spp	10	101
Thienemannimyia gr	5	46
Tribelos spp	4	14
Zavrelimyia spp	3	33
Chironominae	2	15
Culicidae	9	40
Anopheles spp	5	14
Culex spp	4	26
Empididae	1	5
Ephydridae	5	7
Limoniidae	1	1

Order – Family – Species	Frequency	Abundance
Limonia spp	1	1
Muscidae	3	17
Simuliidae	1	1
Simulium spp	1	1
Tabanidae	5	5
Chrysops spp	2	2
Tabanidae undetermined	1	1
Tabanus spp	2	2
Tipulidae	7	8
Ormosia spp	2	3
Platytipula spp	1	1
Tipula spp	1	1
Tipulidae undetermined	3	3
Undetermined Dipteran	7	66
Ephemeroptera	**5**	**200**
Baetidae	2	2
Centroptilum spp	1	1
Paracloeodes spp	1	1
Caenidae	1	2
Caenis spp	1	2
Ephemerellidae	1	10
Eurylophella temporalis gr	1	10
Leptophlebiidae	1	186
Leptophlebia spp	1	186
Gastropoda	**1**	**2**
Undetermined Terrestrial snail	1	2
Haplotaxida	**30**	**536**
Enchytraeidae	5	11
Lumbriculidae	10	49
Naididae	8	437
Dero spp	1	7
Nais spp	1	2
Pristina spp	6	428
Tubificidae	7	39
Limnodrilus spp	2	13
Tubificidae undetermined	5	26
Hemiptera	**2**	**3**
Belostomatidae	2	3
Belostoma testaceum	1	1
Belostoma/Abedus spp	1	2
Heteroptera	**2**	**16**
Corixidae	2	16
Sigara spp	2	16
Isopoda	**24**	**2960**
Asellidae	24	2960
Asellus spp	10	1026
Caecidotea spp	13	1932
Lirceus spp	1	2
Megaloptera	**5**	**6**
Corydalidae	4	5
Chauliodes rastricornis	2	2
Chauliodes spp	1	2
Nigronia fasciatus	1	1
Sialidae	1	1
Sialis spp	1	1

Order – Family – Species	Frequency	Abundance
Neuroptera	**1**	**1**
Sisyridae	1	1
Climacia areolaris	1	1
Odonata	**18**	**35**
Aeshnidae	4	5
Aeshna umbrosa	3	4
Boyeria grafiana	1	1
Coenagrionidae	4	8
Coenagrionidae undetermined	2	2
Ischnura spp	2	6
Corduliidae	1	1
Somatochlora spp	1	1
Lestidae	1	1
Lestes spp	1	1
Libellulidae	8	20
Erythemis simplicicollis	1	1
Libellula spp	4	8
Pachydiplax longipennis	3	11
Oligochaeta	**8**	**54**
Haplotaxida	1	2
Earthworm	1	2
Lumbriculidae	6	42
Eclipidrilus spp	6	42
Undetermined Earthworm	1	10
Undetermined Earthworm	1	10
Trichoptera	**6**	**10**
Dipseudopsidae	1	1
Phylocentropus spp	1	1
Leptoceridae	1	1
Triaenodes spp	1	1
Limnephiloidae	2	6
Ironoquia spp	2	6
Phryganeidae	1	1
Ptilostomis spp	1	1
Polycentropodidae	1	1
Polycentropus spp	1	1
Veneroida	**13**	**218**
Pisidiidae	13	218
Pisidium spp	4	29
Sphaerium spp	9	189

Marcroinvertebrates tended to find better homes in riverine swamp forest and the quality of the species were also better in these wetlands. Alabama tended to have the best quality of macroinvertebrates when compared to the other states. Macroinvertebrate wetland habitat is area where more analysis is needed.

Correlational Analysis

EPA refers to a three-level wetlands monitoring and assessment framework (EPA, 2006), where the first step will involve classifying the wetland being assessed so that comparisons can be made to an appropriate reference. Level I assessments are the least time-intensive and generally consist of a desktop exercise that considers existing data, including geospatial data, to coarsely gauge wetland condition/function. Surrounding land use is often used to calculate a disturbance index, while other data such as digital elevation models can be used to estimate functional capacity such as flood storage for example. This study utilized a Land Disturbance Index or LDI based on the 2011 National Land Cover dataset. Level II assessments are generally rapid field-based assessments. These tools generally involve subjectively assessing observable aspects of the wetland in the field, and then processing this data through some algorithm that yields an overall score or rating to indicate the wetland's position on a gradient of ecological integrity. Some of these methods, such as NCWAM, are referred to as functional assessments. While they generally assess structural features, these features are chosen with consideration of their utility to act as surrogates for function based on some empirical framework. Other RAMs, such as USA-RAM, more or less inventory stressors, noting the presence or absence and severity of various stressors, with the score or rating indicating a site's position along a disturbance/impairment gradient. This study utilized the following rapid assessment methods or RAMs: NCWAM, ORAM, and USA-RAM. Level III assessments are time-intensive, detailed field surveys of various biotic and abiotic aspects of the wetland, such as vegetation, amphibians, macroinvertebrates, water quality, and soil chemistry for example. These assessments may involve such activities as directly surveying the structure and composition of the plant community in detail, collecting specimens to identify unknown species and for quality assurance/quality control; and, collecting and conducting laboratory analysis of water and soil samples, for example. Some ecological processes and rates could potentially be measured at this level of intensity in assessment effort; however, generally these types of measurements require longer periods of time. Consequently, most level III assessments conducted to date by regulators and managers of natural resources have focused on structural measures and have neglected this type of data, leaving it to academics to fill this gap. The direct and detailed level III measurements do, however, give the most thorough and rigorous measure of condition/function, and hence can serve as a benchmark for validating, calibrating and/or regionalizing Level I and II methods.

A series of correlational analyses were performed to determine how closely LDI measures (level I) and the rapid assessment measures (Level II - ORAM, NCWAM, and USARAM) related to intensive surveys data (Level III) and to determine closely the overall all biotic metrics were related to the abiotic metrics. These correlation analyses will yeild an understanding of the strenghtes of these approaches. For example, ORAM may be best RAM at evaluating habitats of wetlands whereas NCWAM may be best for evaluating water quality of wetlands and so forth. Analysis of biotic metrics (vegetation IBI, amphibian AQAI, and the macroinvertebrate MBI) and abiotic metrics can reveal the sensitivity of various biotic metircs, the importance of the various abiotic metrics, and the strenghtes of the various rapid assessment methods.

Table 32 shows the correlations of LDI, ORAM, NCWAM, and USARAM with abiotic and biotic level three parameters or metrics for bottomland hardwood forest wetlands. The table shows only the results that had statistically significant correlations ($p<0.10$) and that they were either significant for both North Carolina and Georgia, or for the region only, in cases where the parameter was not significantly correlated in any one state. LDI scores correlated well with several of the buffer stressors and with several of the macroinvertebrate metrics (such as crustaceae, percent sensitive species, and family and species richness). The one unexpected result is that soil nitrogen and carbon were related significantly to the LDI scores but in the opposite direction than would be expected. ORAM correlated well with several soil metals (copper, zinc, and manganese) and also with several macroinvertebrate metrics (such as percent mollusk and number of individuals) and vegetation metrics (such as Carex richness, native Simpson's diversity, and native wetland herb cover). NCWAM did not perform as well for bottomland hardwood forest wetlands, but did correlate well with two water quality parameters (TKN and nutrient combination), soil copper, and relative frequency of vegetation natives and nonnatives. USARAM correlated well with several metrics for bottomland hardwood forest wetland as did LDI and ORAM. For example, USARAM correlated well with several buffer stressors and several vegetation parameters, such as vegetation IBI, mean C for all species, relative cover of all natives, nonnatives, and trees, as well as the importance of natives/nonnatives.

NCWAM performed poorly with bottomland hardwood forests (correlated with eight parameters, three abiotic and five biotic) whereas USARAM performed the best and was correlated with 16 parameters (two abiotic and 14 biotic), ORAM with 13 parameters (four biotic and nine biotic), and LDI with 14 parameters (two abiotic and 12 biotic). All of these results were in the expected direction. It is interesting to note that all of these assessments correlated more strongly and more frequently for biotic parameters compared to abiotic parameters. In other words, all of these measures coorelated better with biotic measures than with abiotic measures.

Table 32: Correlation coefficients of LDI, USARAM, ORAM, and NCWAM with selected variables or metrics for BLH wetlands. All listed are significant (p<0.10) correlations in both states or the region. M = macroinvertebrates, V = vegetation, WQ = water quality, ns = not significant, pos = positive, neg = negative, x = no direction expected. Pos/neg label is bold if the direction of the data correlation was opposite what was expected. NCWAM was converted to indicate level of stress (high NCWAM = 0, medium NCWAM = 0.5, low NCWAM = 1.0).

LDI 300m (high is worse condition)					
Biotic or Abiotic	Variable	NC	GA	ALL BLH combined	Expected Direction of Correlation
A	Buffer Mean No. Stressors - Ag/Rural	ns	ns	0.35	pos
A	Buffer Mean No. Stressors - Hab/Veg	ns	ns	0.35	pos
A	Buffer Mean No. Stressors - Res/Urb	ns	ns	0.38	pos
A	Buffer Total Num. Stressors	ns	ns	0.59	pos
A	Soil Mean Total % Carbon	-0.71	-0.64	-0.58	pos
A	Soil Mean Total % Nitrogen	ns	ns	-0.45	pos
B	Buffer Canopy Absent	ns	ns	0.27	pos
B	Buffer Herb - Mean Cover Class	ns	ns	0.41	x
B	M % Crustaceae	0.65	n/a	0.65	pos
B	M % Diptera	-0.75	n/a	-0.75	x
B	M % Micro-crustaceae	0.63	n/a	0.63	pos
B	M % OET	0.80	n/a	0.80	x
B	M % POET	0.80	n/a	0.80	x
B	M % Sensitive	-0.64	n/a	-0.64	neg
B	M Family Richness	-0.64	n/a	-0.64	neg
B	M Species Richness	-0.66	n/a	-0.66	neg

ORAM (high is better condition)					
Biotic or Abiotic	Variable	NC	GA	ALL BLH combined	Expected Direction of Correlation
A	Soil Mean Cu mg/kg	ns	ns	-0.44	neg
A	Soil Mean Mn mg/kg	ns	ns	-0.43	neg
A	Soil Mean Zn mg/kg	ns	ns	-0.44	neg
A	WQ Mean pH	ns	ns	-0.42	x
B	Buffer - <0.5M Woody Shrubs Mean Cover Class	ns	ns	-0.35	x
B	Buffer - Broadleaf Canopy Mean Cover Class	ns	ns	0.43	pos
B	M % Mollusk	-0.70	n/a	-0.70	neg
B	M % Oligochaetes	0.60	n/a	0.60	x
B	M % Predator	0.74	n/a	0.74	x
B	M Evenness	0.71	n/a	0.71	x
B	M No. Individuals	-0.64	n/a	**-0.64**	**pos**
B	V Carex Richness	ns	ns	0.41	pos
B	V Native Evenness (Cover)	ns	ns	-0.33	x
B	V Native Simpson's Diversity (Cover)	ns	ns	**-0.33**	**pos**
B	V Native Wetland Herb Rel Cover	ns	ns	**-0.31**	**pos**
B	V Relative Cover of Forbs	ns	ns	-0.38	x

USARAM (high is worse condition)					
Biotic or Abiotic	Variable	NC	GA	ALL BLH combined	Expected Direction of Correlation
A	Buffer Mean No. Stressors - Hab/Veg	ns	ns	0.32	pos
A	Buffer Mean No. Stressors - Res/Urb	ns	ns	0.66	pos
B	Buffer Herb - Mean Cover Class	ns	ns	0.52	x
B	M % Oligochaetes	-0.68	n/a	-0.68	x
B	M % Predator	-0.85	n/a	-0.85	x
B	M Species Evenness	-0.72	n/a	-0.72	neg
B	V Mean C All Species	ns	ns	-0.27	neg
B	V Native Herb Rel Coverage	ns	ns	-0.62	neg
B	V Nonnative Richness	0.60	0.41	0.60	pos
B	V Non-native Shrub Relative Coverage	ns	ns	0.43	pos
B	V Relative Cover All Natives	-0.74	-0.36	-0.62	neg
B	V Relative Cover Nonnatives	0.74	0.36	0.62	pos
B	V Relative Cover Trees	ns	ns	-0.30	neg
B	V Relative Importance Natives	-0.80	-0.39	-0.64	neg
B	V Relative Importance Nonnatives	0.80	0.39	0.64	pos
B	V Veg IBI	ns	ns	-0.41	neg

NCWAM (high is worse condition)					
Biotic or Abiotic	Variable	NC	GA	ALL BLH combined	Expected Direction of Correlation
A	Soil Mean Cu mg/kg	ns	ns	0.33	pos
A	WQ Mean TKN mg/L	ns	ns	**-0.40**	**pos**
A	WQ Nutrient (P+TKN) mg/L	ns	ns	**-0.39**	**pos**
B	Buffer - <0.5M Woody Shrubs Mean Cover Class	ns	ns	-0.37	x
B	V Annual : Perennial Metric	0.52	0.50	0.54	x
B	V Relative Frequency of Natives	ns	ns	-0.33	neg
B	V Relative Frequency of Nonnatives	ns	ns	0.33	pos
B	V Native Graminoid (CypPoaJunc) Relative Cover	ns	ns	0.36	x

Table 33 shows that level III metrics for riverine swamp forest wetlands were correlated with LDI, USA-RAM, ORAM, and NCWAM. Again, only the significant results are presented ($p<0.10$) and the parameter had to be correlated with at least two states or with the entire region, in cases where the parameter was not significantly correlated in any one state. Generally many more level III metrics were correlated significantly with the level I and level II results for riverine swamp forest wetlands than were correlated with the bottomland hardwood forest wetlands. There were several significant correlations between abiotic variables and LDI scores, including several of the buffer stressors and many of the water quality parameters including ammonia, nitrite-nitrate, nitrate, and suspended solids. However, phosphorus was correlated in the opposite direction than expected for water quality and for soil. Soil nitrogen again correlated in an unexpected direction with LDI scores for riverine swamp forest wetlands as it did with the bottomland hardwood forest wetlands. LDI correlated well with a few buffer parameters and with many vegetation parameters such as large tree density, mean C, nonnative richness and shrub cover, relative cover of natives, native monocots, nonnatives, and shrub and subshrub cover, relative frequency and importance of natives and nonnatives, and cover of tolerant species. ORAM also correlated with many more riverine swamp forest wetland parameters; for example, several water quality parameters such as ammonia, nitrate, and zinc. Phosphorus in water samples was correlated in the opposite direction expected. Several soil metals, soil nitrogen, and soil phosphorus also correlated in a nonexpected direction. ORAM correlated well with biotic metrics including one buffer parameter, and with many vegetation parameters such as Carex cover and richness, relative importance and frequency of natives and nonnatives, vegetation IBI, mean C, FQAI cover, and relative cover of various categories of vegetation including natives, nonnatives, vines, and nonnative shrubs.

NCWAM and USA-RAM did not correlate with as many level III metrics as did LDI and ORAM as shown in Table 33. USA-RAM correlated in a nonexpected direction with soil phosphorus as did LDI and ORAM. While the direction is opposite what was expected, this result is consistent and warrants further investigation. Soil nitrogen was also consistently correlated in the direction opposite what was expected and also warrants further investigation. USA-RAM correlate well with soil sulfur and water quality results for ammonia, nitrite-nitrate, and specific conductivity. For the abiotic parameters, USA-RAM correlated well with several vegetation (biotic) metrics, for example, dominance by cover, relative cover of Carex, and relative frequency of native and nonnative species. NCWAM correlated with several soil (abiotic) metrics, such as combined soil metals, soil copper, and soil manganese, magnesium, and sodium but in the opposite direction than expected. Correlations with the results of analysis for the two nitrate-related water quality parameters were in the expected direction for NCWAM. The vegetation metrics generally correlated in the expected direction for NCWAM.

Overall, ORAM and LDI had the largest number of parameters that correlated, with ORAM correlated with 35 level III parameters (11 abiotic, 24 biotic), LDI correlated with 32 parameters (13 abiotic and 19 biotic), USA-RAM correlated with 11 parameters (six biotic and five abiotic) and NCWAM with 14 parameters (three abiotic and 11 biotic); all of these results are in the expected direction.

Table 33: Correlation coefficients of LDI, USARAM, ORAM, and NCWAM with selected variables or metrics for RSF wetlands. All listed are significant (p<0.10) correlations in at least two states or the region. M = macroinvertebrates, V = vegetation, WQ = water quality, ns = not significant, pos = positive, neg = negative, x = no direction expected. Pos/neg label is bold if the direction of the data correlation was opposite what was expected. NCWAM was converted to indicate level of stress (high = 0, medium = 0.5, low = 1.0).

LDI 300m (high is worse condition)									ORAM (high is better condition)							
Biotic or Abiotic	Variable	NC	SC	AL	GA	ALL RSF combined	Expected Direction of Correlation		Biotic or Abiotic	Variable	NC	SC	AL	GA	ALL RSF combined	Expected Direction of Correlation
A	Buffer Mean No. Stressors - Ag/Rural	0.61	ns	0.45	ns	0.39	pos		A	Buffer Mean No. Stressors - Hab/Veg	-0.57	ns	-0.64	ns	-0.49	neg
A	Buffer Mean No. Stressors - Hab/Veg	0.64	ns	ns	-0.90	0.32	pos		A	Soil Mean As mg/kg	ns	ns	ns	ns	**0.68**	**neg**
A	Buffer Total Num. Stressors	0.73	ns	0.63	ns	0.44	pos		A	Soil Mean Ca mg/kg	ns	ns	ns	ns	0.34	x
A	Soil Mean Cu mg/kg	ns	ns	ns	ns	**-0.39**	**pos**		A	Soil Mean Cd mg/kg	ns	ns	ns	ns	**0.64**	**neg**
A	Soil Mean Mn mg/kg	ns	-0.64	-0.40	ns	**-0.38**	**pos**		A	Soil Mean Na mg/kg	ns	ns	ns	ns	**0.28**	**neg**
A	Soil Mean Total % Nitrogen	ns	ns	ns	ns	**-0.36**	**pos**		A	Soil Mean P mg/kg	ns	ns	ns	ns	**0.40**	**neg**
A	WQ Ammonia - Downstream	ns	ns	ns	ns	0.32	pos		A	Soil Mean Pb mg/kg	ns	ns	ns	ns	**0.68**	**neg**
A	WQ Ammonia - Upstream	ns	ns	ns	ns	0.60	pos		A	Soil Mean Total % Nitrogen	ns	ns	ns	ns	-0.29	neg
A	WQ Mean Ammonia	ns	ns	ns	ns	0.31	pos		A	WQ Ammonia - Downstream	ns	ns	ns	ns	-0.48	neg
A	WQ Mean NO2+NO3	ns	ns	ns	ns	0.31	pos		A	WQ Mean Ammonia	ns	ns	ns	ns	-0.50	neg
A	WQ Mean Phosphorus mg/L	ns	ns	ns	ns	**-0.29**	**pos**		A	WQ Mean Nitrate	ns	ns	ns	ns	-0.59	neg
A	WQ Nitrate - Downstream	ns	ns	ns	ns	0.40	pos		A	WQ Mean pH	ns	ns	ns	ns	-0.58	x
A	WQ Nitrate - Upstream	ns	ns	ns	ns	0.46	pos		A	WQ Nitrate - Downstream	ns	ns	ns	ns	-0.61	neg
A	WQ pH - Downstream	ns	ns	ns	ns	0.44	x		A	WQ Nitrate - Upstream	ns	ns	ns	ns	-0.37	neg
A	WQ pH - Upstream	ns	ns	ns	ns	0.53	x		A	WQ pH - Upstream	ns	ns	ns	ns	-0.60	x
A	WQ Total Organic Carbon - Upstream	ns	ns	ns	ns	0.45	x		A	WQ Phosphorus - Upstream	ns	ns	ns	ns	**0.38**	**neg**
A	WQ Total Suspended Solids - Upstream	ns	ns	ns	ns	0.40	pos		A	WQ Zinc - Downstream	ns	ns	ns	ns	-0.56	neg
B	Buffer - 0.5M-5.0M Woody Shrubs Mean Cover Class	ns	0.44	0.58	ns	0.35	x		B	Buffer - <0.5M Woody Shrubs Mean Cover Class	ns	-0.63	-0.60	ns	-0.51	x
B	Buffer Big Trees Mean Cover Class	ns	-0.61	-0.41	ns	-0.26	neg		B	V All Species Dominance (Cover)	ns	ns	ns	ns	-0.56	x
B	Buffer Canopy Deciduous Mean Cover Class	-0.60	ns	-0.50	ns	-0.23	neg		B	V Carex Relative Cover	ns	ns	ns	ns	0.55	pos
B	M % EPT	ns	ns	ns	ns	-0.37	neg		B	V Carex Richness	ns	ns	ns	ns	0.61	pos
B	V Carex Richness	ns	ns	ns	ns	-0.28	neg		B	V Cryptogam Cover %	ns	ns	ns	ns	-0.37	x
B	V Large Tree Density Metric	ns	ns	ns	ns	-0.44	neg		B	V Cryptogam Richness	ns	ns	ns	ns	-0.40	x
B	V Mean C All Species	-0.52	ns	ns	-0.62	-0.23	neg		B	V FACWet Cover	ns	ns	ns	ns	0.39	pos
B	V Nonnative Richness	0.58	ns	ns	0.59	0.32	pos		B	V FACWet Equation 3	ns	ns	ns	ns	0.57	pos
B	V Non-native Shrub Rel Coverage	0.50	ns	ns	0.49	0.40	pos		B	V FQAI Cover	0.49	ns	0.56	ns	0.26	pos
B	V Relative Cover All Natives	-0.60	ns	ns	-0.58	-0.26	neg		B	V Herb and Shrub Cover Dominance	ns	ns	ns	ns	-0.58	x
B	V Relative Cover Native Monocots	ns	ns	ns	ns	-0.21	neg		B	V Mean C All Species	0.64	ns	ns	0.54	0.51	pos
B	V Relative Cover Nonnatives	0.60	ns	ns	0.58	0.26	pos		B	V Native Graminoid (CypPoaJunc) Rel	0.69	ns	ns	0.51	0.26	pos

B	V Relative Cover Shrub & Subshrub	ns	ns	ns	ns	0.25	x
B	V Relative Frequency of Natives	-0.55	ns	ns	-0.65	-0.31	neg
B	V Relative Frequency of Nonnatives	0.55	ns	ns	0.65	0.31	pos
B	V Relative Importance of Natives	-0.59	ns	ns	-0.62	-0.29	neg
B	V Relative Importance of Nonnatives	0.59	ns	ns	0.62	0.29	pos
B	V Relative Percent Cover Tolerant C<=4	0.52	ns	ns	0.65	0.34	pos
B	V Sapling Density Metric	ns	ns	ns	ns	0.38	x

	Cover						
B	V Native Wetland Herb Relative Cover	0.52	0.61	ns	ns	0.43	pos
B	V Native Wetland Herb Species Richness	ns	ns	ns	ns	0.31	pos
B	V Nonnative Richness	-0.80	-0.71	ns	-0.48	-0.49	neg
B	V Non-native Shrub Relative Cover	-0.63	-0.62	ns	ns	-0.54	neg
B	V Relative Cover Natives	0.72	0.75	ns	ns	0.47	pos
B	V Relative Cover Nonnatives	-0.72	-0.75	ns	ns	-0.47	neg
B	V Relative Cover Vine	ns	ns	ns	ns	-0.45	x
B	V Relative Frequency Natives	0.82	0.79	ns	0.60	0.55	pos
B	V Relative Frequency Nonnatives	-0.82	-0.79	ns	-0.60	-0.55	neg
B	V Relative Importance Natives	0.68	0.77	ns	0.44	0.47	pos
B	V Relative Importance Nonnatives	-0.68	-0.77	ns	-0.44	-0.47	neg
B	V Veg IBI	0.69	0.65	0.69	ns	0.27	pos

USARAM (high is worse condition)

Biotic or Abiotic	Variable	NC	SC	AL	GA	ALL RSF combined	Expected Direction of Correlation
A	Soil Mean P mg/kg	ns	ns	ns	ns	**-0.21**	**pos**
A	Soil Mean S mg/kg	ns	ns	ns	ns	0.43	pas
A	WQ Ammonia - Upstream	ns	ns	ns	ns	0.38	pos
A	WQ Mean NO2+NO3	ns	ns	ns	ns	0.34	pos
A	WQ pH - Downstream	ns	ns	ns	ns	0.60	x
A	WQ SpCond - Upstream	ns	ns	ns	ns	0.45	pos
B	Buffer Litter Mean Cover Class	ns	ns	ns	ns	-0.23	x
B	V All Species Dominance (Cover)	ns	ns	ns	ns	0.32	x
B	V Carex Relative Cover all spp	ns	ns	ns	ns	-0.22	neg
B	V Herb and Shrub Cover Dominance	-0.46	ns	ns	0.55	0.32	x
B	V Relative Frequency Natives	ns	-0.50	ns	-0.42	-0.25	neg
B	V Relative Frequency Nonnatives	ns	0.50	ns	0.42	0.25	pos

NCWAM (high is worse condition)

Biotic or Abiotic	Variable	NC	SC	AL	GA	ALL RSF combined	Expected Direction of Correlation
A	Soil Mean Cd mg/kg	ns	ns	ns	ns	0.57	pos
A	Soil Mean Cu mg/kg	ns	ns	ns	ns	**-0.24**	**pos**
A	Soil Mean Mg mg/kg	ns	ns	ns	ns	**-0.38**	**pos**
A	Soil Mean Mn mg/kg	ns	ns	ns	ns	**-0.25**	**pos**
A	Soil Mean Na mg/kg	ns	ns	ns	ns	**-0.36**	**pos**
A	Soil Combined Metals (Cu, Mg, Zn mg/kg)	ns	ns	ns	ns	**-0.34**	**pos**
A	WQ Mean Nitrate	ns	ns	ns	ns	0.50	pos
A	WQ Nitrate - Downstream	ns	ns	ns	ns	0.49	pos
B	Buffer Herbs Mean Cover Class	ns	ns	ns	ns	0.31	x
B	V All Species Dominance (Cover)	ns	ns	ns	ns	0.30	x
B	V Carex Relative Cover all spp	ns	ns	ns	ns	-0.26	x
B	V FQAI Count	ns	ns	ns	ns	-0.25	neg
B	V Herb and Shrub Cover Dominance	ns	ns	ns	ns	0.27	x
B	V Mean C All Species	ns	ns	ns	ns	-0.27	neg
B	V Relative Cover All Natives	ns	ns	ns	ns	-0.25	neg
B	V Relative Cover Ferns	ns	ns	ns	ns	0.28	x
B	V Relative Cover Nonnatives	ns	ns	ns	ns	0.25	pos
B	V Relative Importance Natives	ns	ns	ns	ns	-0.29	neg
B	V Relative Importance Nonnatives	ns	ns	ns	ns	0.29	pos

For bottomland hardwood forest wetlands, USA-RAM had the largest number of correlations but only slightly better than LDI and ORAM. With riverine swamp forest wetland, LDI and ORAM were clearly superior in the assessment.

The next set of correlations dealt with the overall biotic measures (vegetation IBI, amphibian AQAI, and the macroinvertebrate MBI) and is compared with various abiotic metrics in Tables 34 and 35. Table 34 shows correlations for the bottomland hardwood forest wetland sites between the biotic indices and abiotic level III metrics. The amphibian AQAI correlated with the most abiotic metrics including results from soil analysis for metals (combined), calcium, copper, magnesium, and manganese. The macroinvertebrate MBI correlated with soil phosphorus and humic matter. Results from the analysis of water quality samples were mixed in those correlations for copper and lead were in the opposite direction than expected, however dissolved organic carbon correlated in the expected direction. The vegetation IBI did not correlate well abiotic level III metrics for bottomland hardwood forest wetland sites for the abiotic metrics and the correlation with soil phosphorus was in a nonexpected direction.

Table 34: Correlation coefficients of AQAI, MBI, and VegIBI with selected soil and water quality variables or metrics for BLH wetlands. All listed are significant ($p<0.10$) correlations in both (when applicable) states or the region. WQ = water quality, ns = not significant, pos = positive, neg = negative, x = no direction expected. Pos/neg label is bold if the direction of the data correlation was opposite what was expected. For the VegIBI, some NWCA sites in SC and AL were included in the "All BLH combined", but samples sizes precluded detecting significant correlations by state.

AQAI (high is better quality)				
Variable	**NC**	**GA**	**ALL BLH combined**	**Expected Direction of Correlation**
Soil Mean Ca mg/kg	-0.55	ns	-0.42	x
Soil Combined Soil Metals (Cu, Mg, Zn mg/kg)	-0.68	ns	-0.39	neg
Soil Mean Cu mg/kg	ns	ns	-0.41	neg
Soil Mean Mg mg/kg	ns	ns	-0.37	neg
Soil Mean Mn mg/kg	-0.59	-0.55	-0.52	neg
WQ Mean pH	ns	ns	0.52	pos
WQ pH Downstream	ns	ns	0.42	pos
WQ pH Downstream	ns	0.47	0.59	pos
VegIBI (higher is better quality)				
Variable	**NC**	**GA**	**ALL BLH combined**	**Expected Direction of Correlation**
Soil Mean P mg/kg	0.52	0.53	0.41	neg
WQ pH Downstream	N/A	ns	0.47	x

MBI (higher is better quality)				
Variable	**NC**	**GA**	**ALL BLH combined**	**Expected Direction of Correlation**
Soil Mean Humic Matter %	-0.67	N/A	-0.67	x
Soil Mean P mg/kg	-0.58	N/A	-0.58	neg
WQ Cu Upstream	0.83	N/A	0.83	neg
WQ Dissolved Organic Carbon Upstream	0.83	N/A	0.83	pos
WQ Pb Upstream	0.78	N/A	0.78	neg
WQ Mean Dissolved Organic Carbon	0.83	N/A	0.83	pos

Tabel 35 shows the overall correlations for biotic metrics with various abiotic metrics for riverine swamp forest wetland sites. The vegetation IBI again did not correlate with abiotic parameters. The amphibian AQAI correlated well with soil calcium, humic matter and mean total carbon in the direction expected. Correlations with soil magnesium and manganese were in the opposite direction than expected. The AQAI was positively correlated with results from water quality parameters TKN and nutrients, and total suspended solids in the expected direction, but correlated in the nonexpected direction with nitrate. The macroinvertebrate MBI correlated well with the results from several soil parameters such as magnesium, manganese, and total carbon. The MBI also correlated well with the water quality samples analyzed for magnesium, nitrite-nitrate, and nutrients. However the correlatin for copper was negative and was in the nonexpected direction.

Recall that the biotic indices for the study sites were derived from level III intensive survey data. Level III assessments represent the most thorough and rigorus measures of ecological condition/function and can serve as a benchmark for the evaluation of less time-intensive level II rapid assessments methods (NCWAM, ORAM, and USA-RAM) and evne less time- intensive Level I desktop analysis protocols (LDI). Level I and II results did not correlate well with the VegIBI, whereas correlations were stronger with the macroinvertebrate MBI and amphibian AQAI for each site. It also appears that the macroinvertebrate and amphibian indices were sensitive to some of the water quality and soil parameters. The weaker correlations between abiotic metrics and the VegIBI could mean that vegetation at these study sites is less sensitive to conditions as represented by the abiotic metrics or there may be temporal lag in the response to vegetation to changes that result in a site have particular abiotic conditions at the time of the level III survey. These results also show that using multiple metrics are important to capture how these wetland systems function and what there condition is. These results also demonstrate the value of using multiple metrics to characterize wetland systems.

Table 35: Correlation coefficients of AQAI, MBI, and VegIBI with selected soil and water quality variables or metrics for RSF wetlands. All listed are significant ($p<0.10$) correlations in both (when applicable) states or the region. WQ = water quality, ns = not significant, pos = positive, neg = negative, x = no direction expected. Pos/neg label is bold if the direction of the data correlation was opposite what was expected. For the VegIBI, some NWCA sites in SC and AL were included in the "All BLH combined", but samples sizes precluded detecting significant correlations by state.

AQAI (high is better quality)					
Variable	**NC**	**SC**	**AL**	**ALL RSF combined**	**Expected Direction of Correlation**
Soil Mean Ca mg/kg	ns	ns	ns	0.45	x
Soil Mean Humic Matter %	ns	ns	ns	0.53	x
Soil Mean Mg mg/kg	ns	ns	ns	**0.33**	**neg**
Soil Mean Mn mg/kg	ns	ns	ns	**0.42**	**neg**
Soil Mean Total Carbon (%)	N/A*	N/A*	N/A*	-0.56	**neg**
WQ Mean TKN mg/L	-0.59		-0.76	-0.36	neg
WQ Nutrient (P+TKN) mg/L	-0.56	ns	-0.76	-0.35	neg
WQ Nitrate Upstream	N/A	ns	ns	**0.57**	**neg**
WQ TSS Downstream	ns	ns	ns	-0.46	neg

MBI (higher is better quality)					
Variable	**NC**	**SC**	**AL**	**ALL RSF combined**	**Expected Direction of Correlation**
Soil Ca mg/kg Mean	ns	ns	ns	-0.43	x
Soil Mean Surface Water Depth (cm)	ns	ns	ns	-0.53	x
Soil Mean Mg mg/kg	ns	ns	ns	-0.44	neg
Soil Mean Mn mg/kg	ns	ns	ns	-0.54	neg
Soil Mean Na mg/kg	ns	ns	ns	-0.55	neg
WQ DOC DN	ns	N/A	ns	**-0.64**	**x**
WQ Mean Copper	ns	ns	ns	**0.71**	**neg**
WQ Mean DOC	ns	N/A	ns	-0.69	x
WQ Mean Magnesium	ns	ns	ns	-0.35	neg
WQ Mean NO2+NO3	N/A	ns	ns	-0.78	neg
WQ NO2+NO3 Downstream	N/A	ns	ns	-0.51	neg
WQ NO2+NO3 Upstream	N/A	ns	ns	-0.55	neg
WQ Nutrient (P+TKN) mg/L	ns	ns	ns	-0.35	neg

VegIBI (higher is better quality)						
Variable	**NC**	**SC**	**AL**	**GA**	**ALL RSF combined**	**Expected Direction of Correlation**
Soil Mean Cd mg/kg	N/A*	N/A*	ns	N/A*	0.38	x

A final result from these correlations worth noting is the variables that correlated with both wetland types. From Table 32 for bottomland hardwood forest wetlands and Table 33 for riverine swamp forest wetlands, the variables that were common for the LDI 330-m correlation were; Buffer Mean No. Stressors (Ag/Rural and Hab/Veg), Buffer total Num. Stressors, and Soil Mean Total % Nitrogen. For the ORAM correlations, the common variables that correlated for both wetland types were; WQ Mean pH, Buffer <0.5M Woody Shrubs Mean Cover Class, V Carex Richness, and V Native Wetland Herb Rel Cover. NCWAM had on variable, Soil Mean Cu, that correlated significantly with both wetland types and USA-RAM has no variables that correlated significantly with both bottomland hardwood forest wetland and riverine swamp forest wetlands. There were seveal common variables that correlated significantly with both wetland types in Tables 33 and 34. For the Amphibian AQAI, the common variables were Soil Mean Ca, Soil Mean MG and Soil Mean Mn. There were no variables that correlated with both bottomland hardwood forest wetlands and riverine swamp forest wetlands for the macroinvertebrate MBI or the VegIBI. Noting the variables that correlated with both wetland types would indicate the possibility of developing a model for both wetland types rather than a model for each wetland type. This is an area for future exploration.

Exploratory Regression Analysis

Exploratory regression analyses were performed to see how the rapid assessment methods (ORAM, NCWAM, and USA-RAM) and LDI were able to be predicted or were able to predict to the level three variables. This is an extension of the correlational analysis and would be the first step to potential model building. These results are show in Tables 36-40.

Table 36 presents the results of the regression analysis with biotic and abiotic variables that were able to predict rapid assessment methods scores or LDI scores. USA-RAM scores were predicted by three abiotic variables (LDI Watershed, log mean TKN, and mean pH) and several biotic variables including as three macroinvertebrate parameters, three vegetation parameters and one amphibian parameter. The LDI 300m assessment was successfully predicted by four abiotic variables with two of them being water quality parameters and one being soil; all three were measures of metals. The biotic variables that successfully predicted LDI 300m were four vegetation parameters (two dealing with FQAI, cover and count) and two macroinvertebrate parameters. ORAM had five abiotic parameters successfully predict its scores, all being water quality measures and all being highly significant statistically (all p values less than 0.002). Seven biotic variables successfully predicted ORAM scores, with three being macroinvertebrate parameters (two dealing with richness) and two amphibian parameters. The biotic parameters were also hightly significant statistically, all with p values of less than 0.007. Finally, the NCWAM scores were successfully predicted by one abiotic variable (water quality log mean BOD) and two biotic variables, one macroinvertebrate and one buffer parameter. ORAM, USA-RAM, and LDI 300m all had 10-12 variables that were successful predictors whereas NCWAM only had three.

Table 37 presents the results of LDI 300m dealing with it being able to predict abiotic and biotic parameters; in other words the LDI 300m was the predictor in this regression analysis as opposed to being the predicted variable in the previous analysis. The variables highlighted in yellow were statistically significant (p <.05) on all three analyses (or two if one analysis involved an exponential distribution). The LDI 300m scores were categorized into an ordinal scale: Ordinal LDI rating was; Very Good = 1, Good = 1.1-2.4, Fair = 2.5-4.0, Poor = >4.0. A logistic regression and a GLM analysis were performed on the ordinal data. A GLM analysis was also performed on the raw LDI 300m scores. This analysis was redundant to some extent, but we want to make sure we captured the results with the right data. Of the biotic variables, ten were significant in every regression analysis showing that LDI 300m successfully predicted the variables; seven were macroinvertebrate parameters (three being richness variables) and three vegetation parameters. Seven abioitic variables were successfully predicted by LDI 300m. Three were soil parameters (combined metals, carbon, and nitrogen) and two were water depth measures. Interestingly LDI watershed was very predictable by LDI 300m scores.

Table 36: Results of regression analysis used to discover which variables predicted various RAM scores.

USARAM		**LDI 300m**	
	Significance		**Significance**
Biotic Variables		**Biotic Variables**	
Amphib. AQAI	<.0001	Macroinvert. Shannon_H Diversity Index	0.0638
Macroinvert. % Crustaceae	0.0357	Macroinvert. Species Richness	0.0012
Macroinvert. Family Richness	0.0472	Veg FQAI Count	0.0026
Macroinvert. MBI (Inverted)	0.0157	Veg FQAI Cover	0.0005
Buffer Herbs - Mean Cover Class	0.0854	Veg Relative Cover Trees	0.0014
Veg FQAI Count	0.0208	Veg Relative Perc Cover Tolerant C<=4	0.0041
Veg FQAI Cover	0.0382	**Abiotic Variables**	
Veg Pole Timber Density Metric	0.0006	LDI Watershed	0.0245
Abiotic Variables		log Soil Cu mg/kg Mean	0.0263
LDI Watershed	<.0001	log WQ Mean Phosphorus	0.0778
log WQ Mean TKN mg/L	0.0233	WQ Mean Magnesium	0.0179
pH Mean	0.0121		
ORAM		**NCWAM**	
Biotic Variables		**Biotic Variables**	
Mean Amphibian C	<.0001	Macroinvert. % Crustaceae	0.075
log Amphib No. Adults	0.0018	Buffer Herbs - Mean Cover Class	0.0035
Macroinvert. % Chironomidae	0.0055	**Abiotic Variable**	
Macroinvert. Genus Richness	<.0001	log WQ Mean BOD	0.0013
Macroinvert. Species Richness	<.0001		
Buffer <0.5M Woody Shrubs - Mean Cover Class	0.0067		
Veg Native Vascular Species Richness	0.0021		
Abiotic Variables			
log WQ Mean Ammonia	0.0017		
log WQ Mean DOC	<.0001		
log WQ Mean Phosphorus	0.0019		
log WQ Mean TKN mg/L	0.0004		
WQ Mean Magnesium	<.0001		

Generalized Linear Model Regression (normal distribution) was used for USARAM and ORAM, because they were normally distributed. An Ordinal Logistic Regression was used for the LDI and NCWAM analysis. LDI was converted to an ordinal scale for this regression because the distribution was skewed. The scale was: Very Good = 1, Good = 1.1-2.4, Fair = 2.5-4.0, Poor = >4.0.

Table37: Regression results for LDI (300m) – list of variables that LDI successfully predicted, with at least one model. Ordinal Logistic Regression and GLM were run. WQ = water quality. Ordinal LDI rating was: Very Good = 1, Good = 1.1-2.4, Fair = 2.5-4.0, Poor = >4.0. Exp. = variable had an exponential distribution, so logistic regression could not be performed.

Biotic/ Abiotic	Variable	# obs	Ordinal Logistic Regression	GLM - Ordinal LDI rating	GLM LDI raw data
B	Buffer <0.5M Woody Shrubs - Mean Cover Class	92	0.185	0.071	0.490
B	Buffer Big Trees - Mean Cover Class	92	0.009	0.073	0.003
B	Buffer Herbs - Mean Cover Class	92	0.063	0.087	0.011
B	Macroinvert. % Crustaceae	34	<.0001	<.0001	<.0001
B	Macroinvert. % Decapoda	34	0.001	0.002	0.000
B	Macroinvert. % Diptera	34	0.006	0.002	0.002
B	Macroinvert. Family Richness	34	0.001	0.008	0.000
B	Macroinvert. Genus Richness	34	<.0001	0.001	0.000
B	Macroinvert. MBI (Inverted)	34	0.238	0.008	0.112
B	Macroinvert. No. Individuals	34	0.170	0.400	0.028
B	Macroinvert. Shannon_H Diversity Index	34	<.0001	<.0001	0.000
B	Macroinvert. Species Richness	34	<.0001	0.001	0.000
B	Veg. All Species Dominance (Cover)	113	Exp.	<.0001	0.001
B	Veg. Canopy Importance Metric	40	0.157	0.018	0.055
B	Veg. FACWet Equation 3	113	0.050	0.113	0.079
B	Veg. FQAI Count	113	0.015	0.112	0.016
B	Veg. FQAI Cover	113	0.015	0.077	0.002
B	Veg. Mean C All Species	113	0.001	0.002	<.0001
B	Veg. Pole Timber Density Metric	40	0.604	0.072	0.132
B	Veg. Relative Cover Trees	113	0.033	0.175	0.073
B	Veg. Relative Percent Cover Tolerant C<=4	113	<.0001	<.0001	<.0001
B	Veg. Sapling Density Metric	40	0.290	0.038	0.032
B	Veg. Tolerant sp Richness C<=4	113	0.054	0.124	0.016
A	LDI Watershed	133	<.0001	<.0001	<.0001
A	log Soil CEC Mean	109	0.022	0.142	0.003
A	log Soil Combined Metals	108	0.000	0.001	0.001
A	log Soil Mean Copper	108	0.085	0.220	0.096
A	log Soil Mean Mercury	43	0.027	0.133	0.015
A	log Soil Mean Sulphur	29	0.066	0.130	0.091
A	log Soil Mean Zinc	109	0.111	0.380	0.055
A	Soil Humic Matter Mean	39	Exp.	0.003	0.674
A	log Soil Total Carbon (%) Mean	58	0.004	0.013	0.002
A	log Soil Total Nitrogen (%) Mean	58	0.004	0.027	0.002
A	Soil Mean pH	109	0.083	0.132	0.105
A	log WQ Mean DOC	23	0.067	0.192	0.252
A	log WQ Mean Phosphorus	73	0.085	0.080	0.076
A	log WQ Mean TSS	33	0.101	0.410	0.097
A	WQ Mean Copper	33	0.750	0.085	0.260
A	WQ Mean Magnesium	30	0.032	0.062	0.023
A	Mean Depth to Groundwater	54	Exp.	0.020	0.002
A	Mean Depth to Saturated Soil	46	Exp.	0.005	*0.339*
A	Mean Surface Water Depth	21	Exp.	0.002	*0.014*

Table 38: Regression results for NCWAM – list of variables that NCWAM successfully predicted, using at least one model. Ordinal Logistic Regression and GLM were run. WQ = water quality. Exp. = variable had an exponential distribution, so logistic regression could not be performed.

Biotic/ Abiotic	Variable	# obs	Ordinal Logistic Regression	GLM
B	Amphib. Amphibian Species Richness	53	0.059	0.199
B	Amphib. AQAI	53	0.017	0.047
B	Amphib. Mean Amphibian C	53	0.037	0.058
B	Buffer <0.5M Woody Shrubs - Mean Cover Class	58	0.059	0.182
B	Buffer Herbs - Mean Cover Class	58	0.006	0.019
B	Macroinvert. % Crustaceae	33	0.002	0.002
B	Macroinvert. % Decapoda	33	0.006	0.005
B	Macroinvert. Family Richness	33	0.059	0.129
B	Macroinvert. Genus Richness	33	0.023	0.076
B	Macroinvert. Shannon_H Diversity Index	33	0.003	0.005
B	Macroinvert. Species Richness	33	0.020	0.075
B	Veg. Dicot Richness	80	0.657	0.098
B	Veg. FACWet Equation 3	80	0.009	0.015
B	Veg. FQAI Count	80	0.000	0.000
B	Veg. FQAI Cover	80	0.002	0.016
B	Veg. Mean C All Species	80	<.0001	<.0001
B	Veg. Native Herb Richness	80	0.420	0.021
B	Veg. Native Vascular Plant Genera Richness	80	0.336	0.094
B	Veg. Native Vascular Species Richness	80	0.037	0.005
B	Veg. Pole Timber Density Metric	39	0.044	0.025
B	Veg. Rel Cover Trees	80	0.007	0.023
B	Veg. Relative Perc Cover Tolerant C<=4	80	0.000	0.001
B	Veg. Sapling Density Metric	39	0.025	0.014
B	Veg. Tolerant sp Richness C<=4	80	0.267	0.030
B	Veg. Total Vascular Plant Genera Richness	80	0.349	0.037
B	Veg. Total Vascular Species Richness	80	0.308	0.017
A	LDI Watershed	99	0.003	0.008
A	log Soil Combined Metals	76	0.115	0.073
A	log Soil Mean Copper	76	0.150	0.005
A	log Soil Mean Sulphur	29	0.046	0.084
A	log Soil Mean Zinc	76	0.005	0.172
A	Soil Humic Matter Mean	38	Exp.	<.0001
A	Soil Mean Base Saturation	38	0.013	0.111
A	Soil Mean Bulk Density	40	0.500	0.064
A	Soil Mean pH	76	0.042	0.106
A	log WQ Chlorophyll a	24	0.034	0.060
A	log WQ Mean TKN	63	0.001	0.005
A	log WQ nutrient (TKN + P)	63	0.000	0.004
A	logWQ Mean BOD	23	0.001	0.004
A	logWQ Mean Phosphorus	63	0.005	0.024
A	WQ Mean Dissolved Oxygen (mg/L)	15	0.010	0.154
A	WQ Mean Fecal Colliform	16	Exp.	0.050
A	WQ Mean Nitrate	36	Exp.	0.010

Biotic/ Abiotic	Variable	# obs	Ordinal Logistic Regression	GLM
A	Mean Depth to Groundwater	37	Exp.	0.005
A	Mean Depth to Saturated Soil	28	Exp.	0.036
A	Mean Surface Water Depth	17	Exp.	0.001

Table 38 presents the regression results of the NCWAM being able to predict biotic and abiotic variables. The yellow highlighted items are statistically significant on both regression analyses (unless one analysis dealt with an exponential distribution). NCWAM was able to successfully predict 15 biotic variables. Nine were vegetation parameters such as FQAI (count and cover), mean C for all species, and relevant cover of trees and tolerant species. NCWAM also successfully predicted three macroinvertebrate parameters and two amphibian parameters. Eleven abiotic variables were successfully predicted by NCWAM, with six being water quality parameters (such as TKN, phosphorus, nitrate, BOD, and fecal coliform). Three were water depth measures.

Table 39 presents the results of the ability of USA-RAM to predict biotic and abiotic variables. There were 20 biotic variables that USA-Ram was able to successfully predict. Eight were macroinvertebrate parameters (three being richness metrics) and eight were vegetation parameters (such as FQAI, count and cover, relative cover trees and tolerant species, and mean C). Three of the biotic variables USA-RAM was able to predict were amphibian parameters. For abiotic variables, USA-RAM successfully predicted 14 parameters, with six being water quality parameters (two metals and three nutrients) and five being soil parameters (such as copper and sulpher).

Finally Table 40 shows the results from the regression analysis of ORAM predicting biotic and abiotic variables. For biotic varibles, there were 22 that ORAM successfully predicted, with nine being macroinvertebrate parameters (three being richness metrics) and eight were vegetation parameters (such as FAQI cover and count, and relative cover trees and tolerant species). Four amphibian parameters were also successfully predicted. ORAM successfully predicted 19 abiotic variables with nine being water quality parameters (such as TKN, phosphorus, nitrate, and DOC) and six were soil parameters (such as combined metals, sulfer, nitrogen and carbon).

Table 39: Regression results for USARAM – list of variables that USARAM successfully predicted based on the Generalized Linear Model. WQ = water quality

Biotic/ Abiotic	Variable	# obs	GLM
B	Amphib. Amphibian Species Richness	52	0.021
B	Amphib. AQAI	52	0.017
B	Amphib. Mean Amphibian C	52	0.088
B	Buffer Herbs - Mean Cover Class	90	0.001
B	Macroinvert. % Crustaceae	32	0.002
B	Macroinvert. % Decapoda	32	<.0001
B	Macroinvert. Dominance_D	32	0.053
B	Macroinvert. Family Richness	32	0.003
B	Macroinvert. Genus Richness	32	0.001
B	Macroinvert. MBI (Inverted)	32	0.003
B	Macroinvert. Shannon_H Diversity Index	32	<.0001
B	Macroinvert. Species Richness	32	0.001
B	Veg. FACWet Equation 3	111	0.031
B	Veg. FQAI Count	111	0.010
B	Veg. FQAI Cover	111	0.001
B	Veg. Mean C All Species	111	0.000
B	Veg. Pole Timber Density Metric	38	0.034
B	Veg. Rel Cover Trees	111	0.021
B	Veg. Relative Perc Cover Tolerant C<=4	111	0.000
B	Veg. Sapling Density Metric	38	0.003
A	LDI Watershed	131	<.0001
A	log Soil Mean Copper	106	0.087
A	log Soil Mean Sulphur	27	0.049
A	Soil Humic Matter Mean	37	0.000
A	Soil Mean Base Saturation	37	0.012
A	Soil Mean pH	107	0.014
A	log WQ Mean TKN mg/L	71	0.062
A	log WQ nutrient	71	0.076
A	logWQ Mean DOC	23	0.069
A	WQ Mean Copper	31	0.022
A	WQ Mean Fecal Colliform	16	0.072
A	WQ Mean Magnesium	28	0.057
A	Mean Depth to Groundwater	52	0.002
A	Mean Depth to Saturated Soil	44	0.096

Table 40: Regression results for ORAM – list of variables that ORAM successfully predicted based on the Generalized Linear Model. WQ = water quality.

Biotic/ Abiotic	Variable	# obs	GLM
B	Amphib. Amphibian Species Richness	54	0.0128
B	log Amphib No. Adults	54	0.0424
B	Amphib. AQAI	54	0.0054
B	Amphib. Mean Amphibian C	54	0.0159
B	Buffer <0.5M Woody Shrubs - Mean Cover Class	60	0.0114
B	Macroinvert. % Chironomidae	34	0.0229
B	Macroinvert. % Crustaceae	34	0.0049
B	Macroinvert. % Decapoda	34	0.0018
B	Macroinvert. Dominance_D	34	0.0688
B	Macroinvert. Evenness_e^H/S	34	0.0667
B	Macroinvert. Family Richness	34	0.0237
B	Macroinvert. Genus Richness	34	0.0135
B	Macroinvert. Shannon_H	34	<.0001
B	Macroinvert. Species Richness	34	0.014
B	Veg. FACWet Equation 3	81	<.0001
B	Veg. FQAI Count	81	0.0002
B	Veg. FQAI Cover	81	0.0006
B	Veg. Mean C All Species	81	<.0001
B	Veg. Native Herb Richness	81	0.0092
B	Veg. Native Vascular Species Richness	81	0.0691
B	Veg. Relative Perc Cover Tolerant C<=4	81	<.0001
B	Veg. Tolerant sp Richness C<=4	81	0.0435
A	LDI 300m	101	0.0648
A	LDI Watershed	101	0.0151
A	Soil Mean Base Saturation	39	0.0936
A	log Soil Combined Metals	77	0.038
A	log Soil Mean Sulphur	29	0.0624
A	log Soil Mean Zinc	77	0.0247
A	log Soil Total Carbon (%) Mean	26	0.0108
A	log Soil Total Nitrogen (%) Mean	26	0.0074
A	log WQ Mean TKN mg/L	64	0.0039
A	log WQ nutrient (TKN + P)	64	0.0016
A	logWQ Mean Ammonia	57	0.0918
A	logWQ Mean DOC	23	0.0261
A	logWQ Mean Phosphorus	64	0.0006
A	WQ Mean Fecal Colliform	16	0.0099
A	WQ Mean Lead	33	0.0935
A	WQ Mean Magnesium	30	0.0356
A	WQ Mean Nitrate	37	0.056
A	Mean Depth to Groundwater	37	<.0001
A	Mean Surface Water Depth	17	0.0378

This preliminary regression analysis should open the door to using these metrics to build regression models. These results show that various biotic and abiotic variables can predict the rapid assessment methods and the rapid assessment method were even more successful predicting the biotic and abiotic parameters. In general, ORAM and USA-RAM were successfully predicted by biotic and abiotic variables and they were also successful in predicting several biotic and abiotic variables. LDI 300m was successfully predicted by biotic and abiotic variables; however, its predictive ability of biotic and biotic variables was the lowest of the rapid assessment methods. NCWAM was able to predict several biotic and abiotic variables; however only three variables were able to predict NCWAM scores.

Extent of Stressors on Wetlands and Extent of Wetland Condition

This section reports on the extent of wetlands that fall within discrete condition categories (poor, fari, and good) that reflect the degree to which selected "stressors" are present, and the extent of wetlands that fall within discrete condition categories (Poor, fair, and good) as determined by selected biotic indicators (various buffer, amphibian, and macroinvertebrate metrics). Results are extrapolated to report estimates of the overall percent of wetland area and acreage of wetland area that fall within each of the three condition categories for each indicator (selected stressors and biotic indicators). Results are presented as box plots for each indicator by state (including both wetland types), then by wetland type (bottomland hardwood forest and riverine swamp forest) for the four –state region, and then for the entire four-state region (including both wetland types). The effect of stressors is shown in terms of the percent of the wetland area affected and the acreage of wetland affected by each stressor. The condition of wetlands is expressed using various condition variables and the percent and area of wetlands in that condition. Therefore, for any stressor variable or condition variable, the wetlands that score high on that variable, then a certain percentage of the wetland area (in acres) will be in good condition, a certain percentage in fair condition and a certain percentage in poor condition.

The first set of figures (Figures 80-83) show estimated extent of wetlands (including both wetland types and extrapolated to overall percent area and acreage by state) that woul be classified as poor, fair or good based on the degree to which various stressors are present.

Figure 80 shows the results for North Carolina. LDI scores resulted in less wetland area classified as bing in good condition when the broader are of the wetland's watershed is considered rather than just the are of lan within a 300-meter buffer immediately surrounding a wetland, indicating an increased presence of stressors (developed land, ect.) in the broader watershed area compared to the wetland and buffer area. Overall the wetlands are largely classified as being in good condition based on the stressor analysis with better than 50% in good condition for all indicators and very little area falling within the poor category except for the following indicators: TKN, phosphorus, ammonia, and soil metals. However on all stressor variables, North Carolinas's wetlands were better than 50% in good condition in terms of wetland area.

Figure 81 shows the results for South Carolina. Even more wetland area in South Carolina (better than 75% for all indicators were classified as being in good condition based on this analysis with no stressor data causing wetland area in the state to be classified as being in poor condition. The wetlands in South Carolina were in good shape with no stressor resulting in poor wetlands. Condition classifications based on phosphorus in the water and specific conductivity of the water, soil metals, and the impairment rating included more wetland in the fair category. The results for LDI scores were opposite North Carolina, with more wetlands classified as being in poor condition when considering the landuse within an are area only including the 300-meter buffer surrounding the wetlands. South Carolina's wetlands were all better than 75% of the area is in good condition for all stressor variables.

Figure 82 shows results for Alabama. Alabama's wetlands were also generally classified as being in good condition; however specific conductivity (water quality parameter), soil phosphorus, soil potassium, and soil metals showed noticeable defferences with these being the only stressors other than LDI (considering the watershed) resulting in wetland area classified as being in poor condition. Wetland area classification based on LDI scores followed the same pattern when considering the wetland's watershed rather than just landue with the 300-meter buffer surrounding the wetlands. With the execption of the soil metals, Alabama's wetlands were at 50% or better in area on all the other stressor variables.

The results for Georgia are shown in Figure 83. As with the three states, Georgia's wetland areas were generally classified as being in good condition. The impairment rating and ammonia in the water had some noticeable effects resulting in the largest wetland area classified as being in poor condition. The LDI scores showed the same tend as in North Carolina, indicating more developed land, etc. (stressors) within the broader watershed when compared to the landuse only within the 300-meter buffer surrounding the wetland. With the exeception of the LDI watershed scores, all of Alabama's wetlands were at 60% or better in terms of area are in good condition.

Figure 80: Estimated extent of stressors in North Carolina.

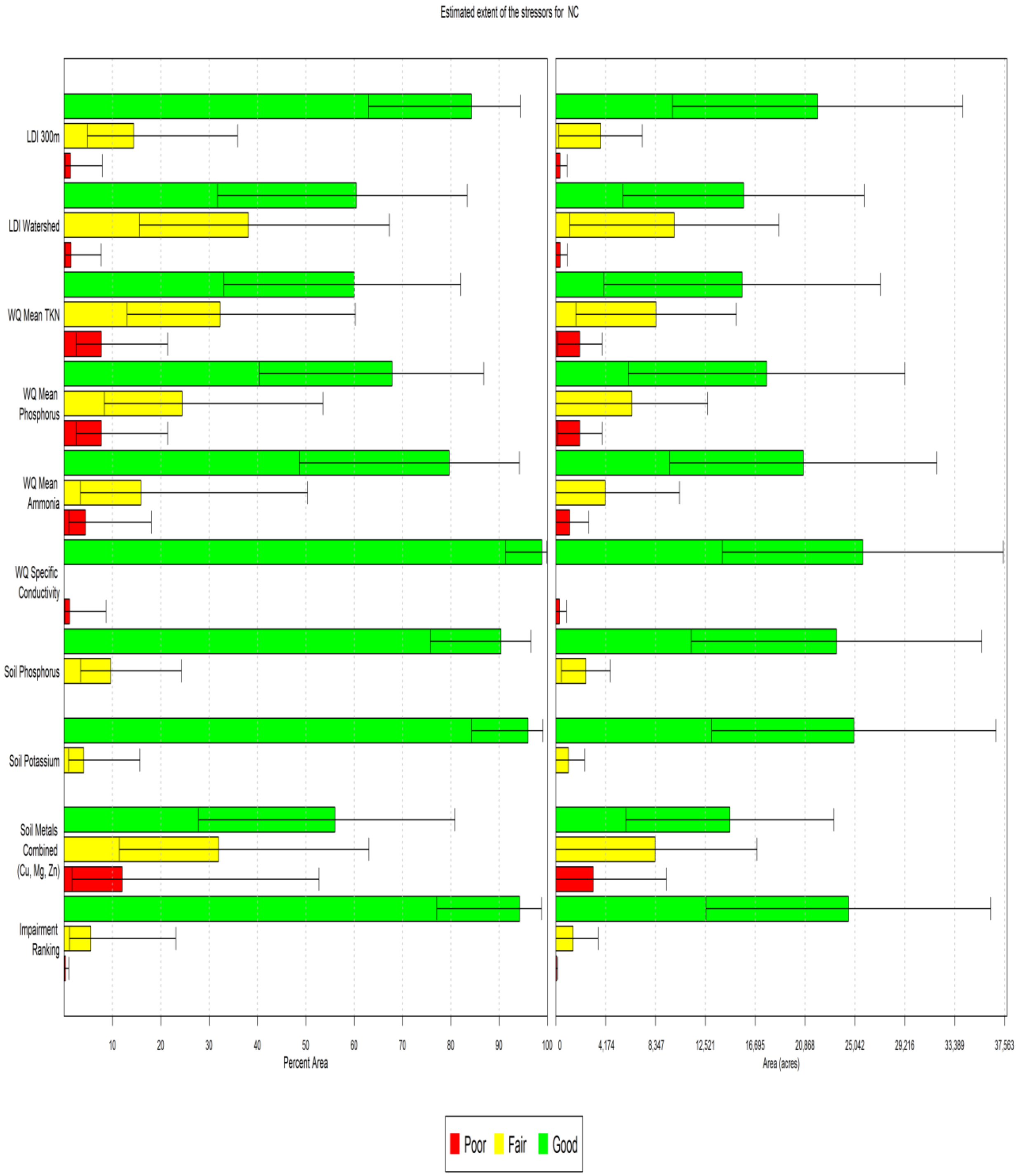


Figure 81: Estimated extent of stressors for South Carolina.

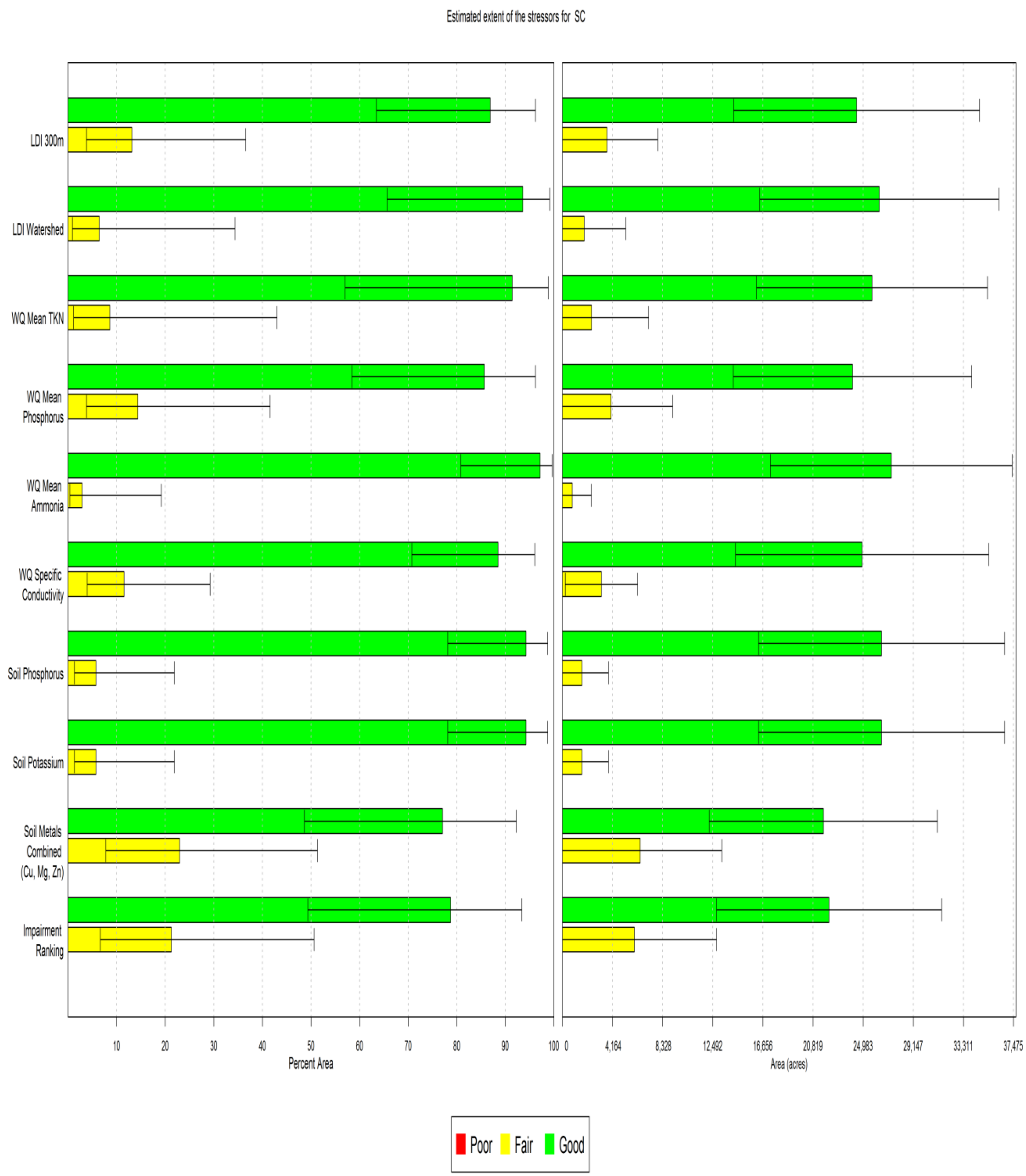


Figure 82: Estimated extent of stressors for Alabama.

Figure 83: Estimated extent of stressors for Georgia.

The next set of figures (Figures 84 – 87) shows the extent of wetland area in state (both as overall percentage and acreage) that was classified in discrete condition categories (poor, fair, and good) based on various biotic indicators.

Figure 84 shows wetland are condition classification results for North Carolina based on the selected biotic indicators. Note that macroinvertebrate and amphibian results are only reported in riverine swamp forest wetlands for three states, hence the smaller (or absent) acreages (and percentages) reported for these. Generally, the selected biotic indicators resulted in large wetland areas classified as being in good condition, and a smaller area classified as fair, and little or none classified as poor; with one notable exception. The mean cover of big tree class indicator resulted in the largest wetland area classified as being in fair condition, followed by good, and then poor. This may indicated the impact of forestry activities. Some of these results are clear and easy to interpret such as having a high amphibian AQAI score indicated a large area of wetlands good condition as does the macroinvertebrate biotic index or macroinvertebrate richness. More difficult to interpret is the percentage of tolerant macroinvertebrate species being associated with good wetland condition or large tree cover in the buffer is associated with poorer wetland condition. However, knowledge of how macroinvertebrate populations and species behave or thrive in wetlands is yet to be entirely understood. With the exception of the one buffer indicator, 50% or more of the wetland are in North Carolina was classified as being in good condition based on the selected indicators.

Figure 85 shows results for selected biotic indicators for South Carolina. Overall, the selected biotic indicators resulted in large wetland areas classified as being in good condition with lesser are in fair condition, with two noteable exceptions. The Amphibian Quality Index classified 100% of wetland area in the state in the good category, and one macroinvertebrate indicator (top three dominant species) classified a little more than 10% of the wetland area as poor. The mean cover of big tree class indicator, while it did not classify the largest area as being in fair condition following the pattern in North Carolina, did classify a larger area then most other indicators as being in fair condition. Two macroinvertebrate indicators, percent predator species and percent sensitive species, showed a similar pattern with very similar percentages. Wetlands with macroinvertebrate species richness scores clearly were wetlands in good condition in terms of area. Overall, 60% or more wetland area in South Carolina was classified as being in good condition.

Alabama's results are shown in Figure 86. The figure shows the same general pattern as in the previous two states with a number of noteable exceptions. Four of the selected biotic indicators (mean cover of big tree class in the buffer, macroinvertebrate index (MBI), macroinvertebrate species richness, and percent macroinvertebrate facultative species) classified 100% of wetland area in the state in the good category; one macroinvertebrate indicator, percent tolerant species, classified more area in the fair category than in the good category; and one indicator, mean cover for the small tree class in the buffer, resulted in a small are (just over 10%) classified in the poor category. With the excpetion of macroinvertebrate percent tolerant species, the other selected biotic indicators resulted in 70% or more of the wetland area classified as being in good condition.

Figure 87 shows the results for Georiga. Georgia lacked macroinvertebrate data which left only four biotic indicators for analysis. For Georgia, 60% or better of the wetland area was in good condition regardless of biotic indicaters. Three of the four condition variables (selected biotic indicators) resulted in small areas of wetland being classified in the poor category. The amphibian quality index (AQAI) followed the general pattern of the largest percentage area classified in the good category, second larest in fair, and the smallest in poor. However, of the four indicators, the AWAI resulted in the smallest percentage area classified in the good category, the largest classified in fair, and the smallest classified in the poor (of the three that had area classified poor).

Figure 84: Estimated extent of condition for North Carolina.

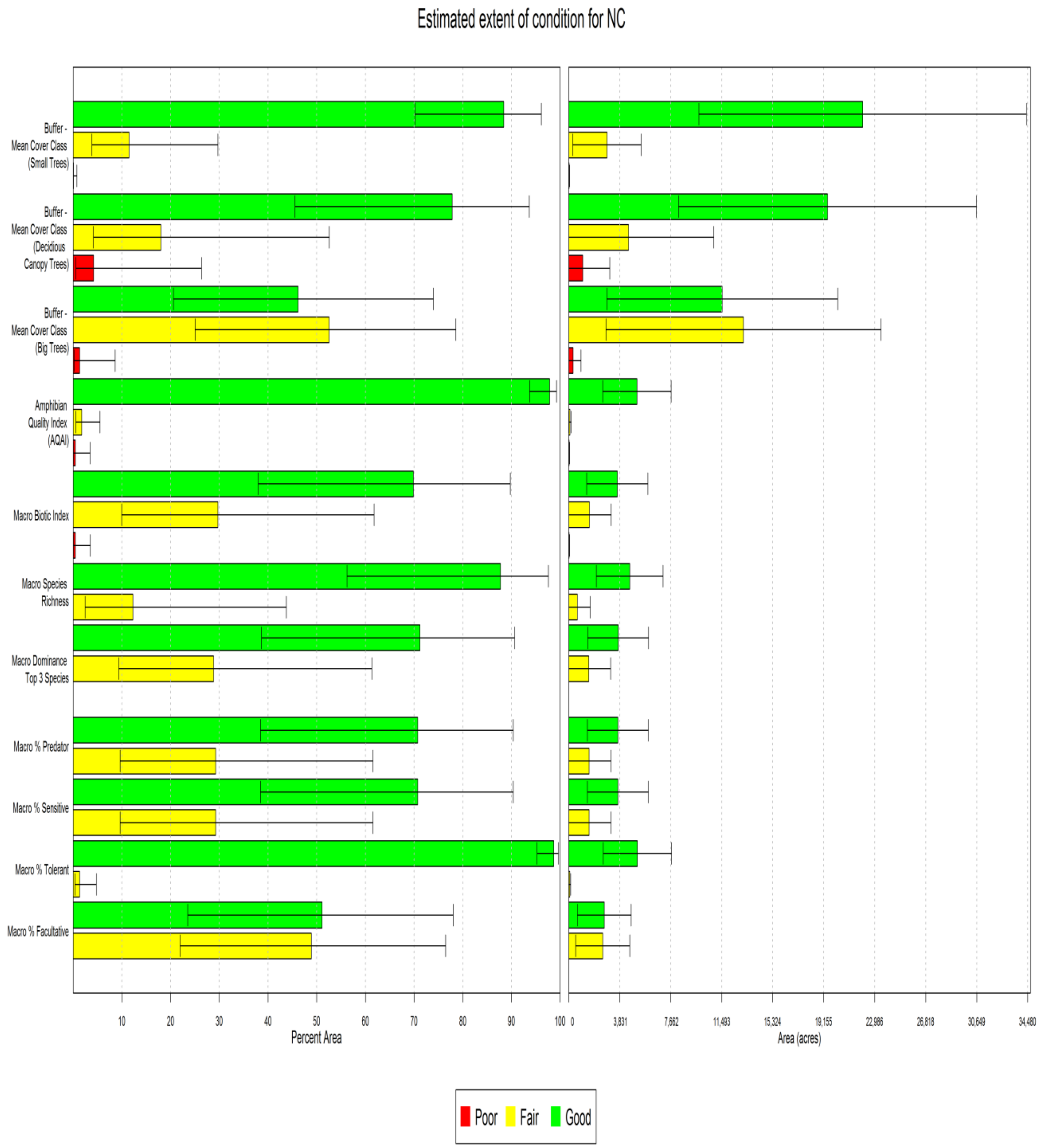


Figure 85: Estimated extent of condition for South Carolina

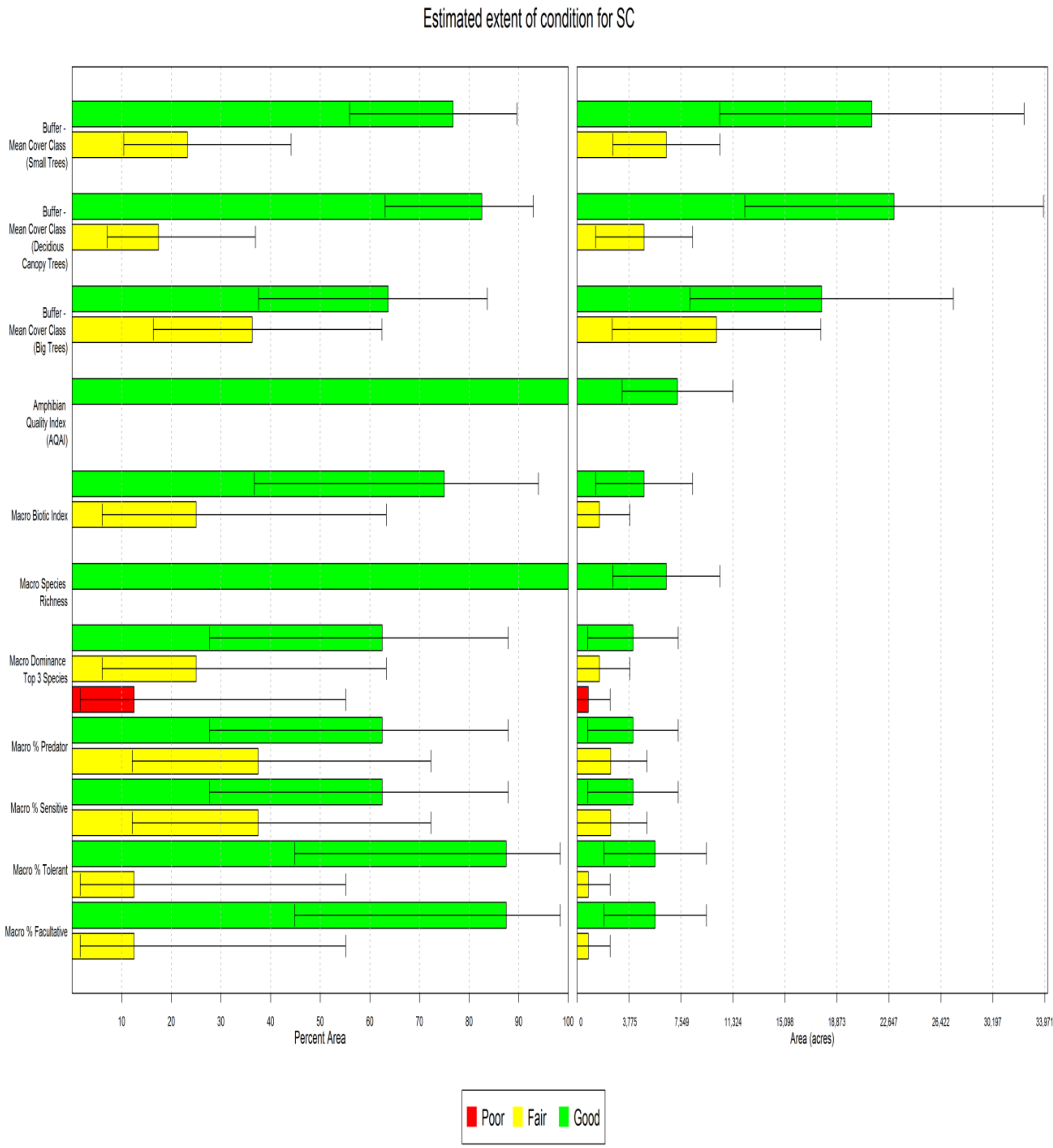


Figure 86: Estimated extent of condition for Alabama

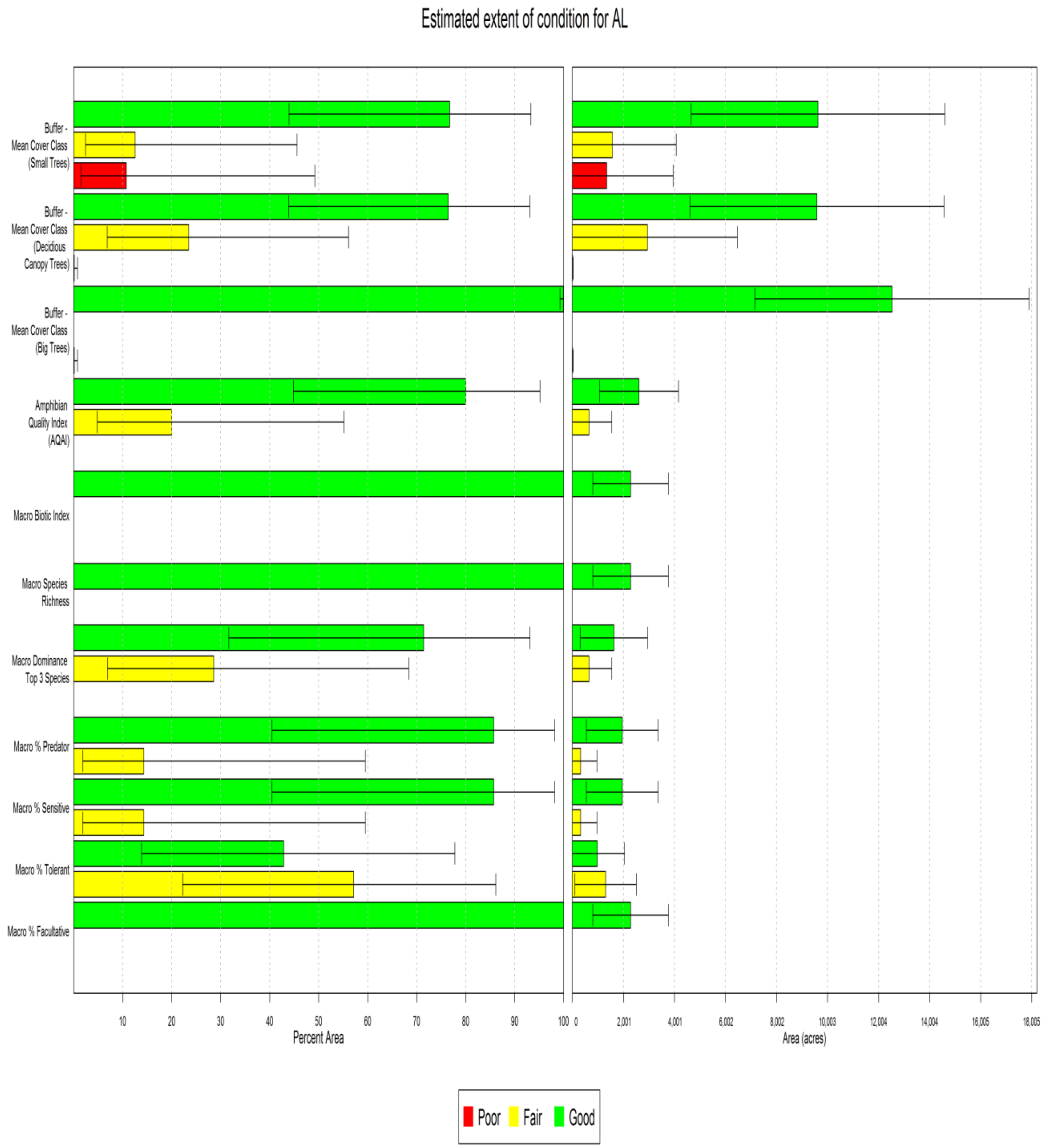
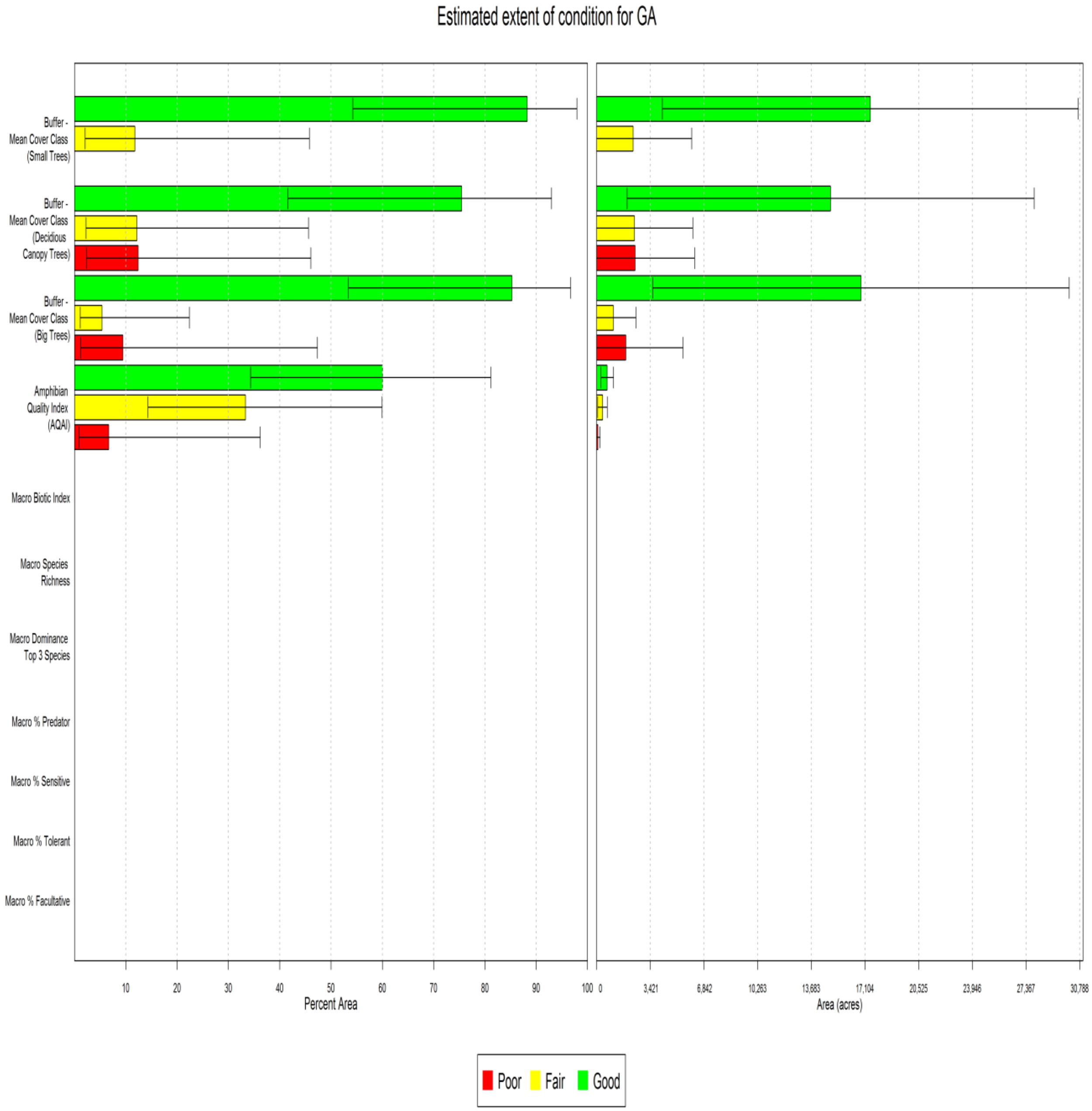


Figure 87: Estimated extent of condition for Georgia.



The next set of figures shows estimated extent (overall percentage area and acreage) of wetland in discrete categories of good, fari, and poor condition based on presence of “stressors” and also based on selected biotic condition indicators with data aggregated for analysis by wetland type (bottomland hardwood forest and riverine swamp forest) for the entire four-state region (Figures 88 – 91).

Figure 88 shows the results for stressor analysis for bottomland hardwood forest wetland areas throughout the entire four-state region. For the most part the stressors did not have any major impact to these wetlands in terms of area; however the LDI scores resulted in more wetland area being classified in the fair category than in the good category when considering landuse within the wetland’s watershed rather than only the 300-meter buffer surrounding the wetland. The more development in the watershed, more bottomland hardwood forest wetland area was in fair condition. With the exception of both LDI stressors, nearly 90% or more of the bottomland hardwood forest wetland area throughout the four-state region was classified as being in good condition.

Firgure 89 shows the results of analysis of stressors for riverine swamp forest wetland area throughout the entire four-state region. Soil metals were clearly having an impact with nearly 50% of the wetland area being classified in fair condition and about 15% as being in poor condition. Specific conductivity (a water quality parameter) also resulted in about 12% of the wetland area classified as being in poor condition. With the exception of soil metals, more than 80% of the riverine swamp forest wetland area throughout the entire four-state region was classified as being in good condition.

Results of analysis of selected biotic condition indicators are presented for bottomland hardwood forest wetland area throughout the entire four-state region is shown in Figure 90. Macroinvertebrate species richness estimates that more than 65% of the area of bottomland hardwood forests wetlands was classified as being only in fair condition. Otherwise over 65% of the bottomland hardwood forest wetland area in the entire region was classified as being in good condition based on all the other biotic condition indicator variables. Mean big tree buffer cover, mean cover of deciduous canopy in the buffer, macroinvertebrate (MBI) index, and amphibian (AQAI) quality index all result in around 10% of bottomland hardwood forest wetland area throughout the region classified as being in poor condition.

Figure 91 shows results of selected biotic condition indicators for riverine swamp forest wetland area throughout the entire four-state region. Overall, more than 65% of the riverine swamp forest wetland area throughout the region was classified as being in good condition. However, most of the selected macroinvertebrate biotic condition indicators classify 15% to 30% of the riverine swamp forest wetland area as being in fair condition.

Figure 88: Estimated extent of the stressors for BLH wetlands in the SE region.

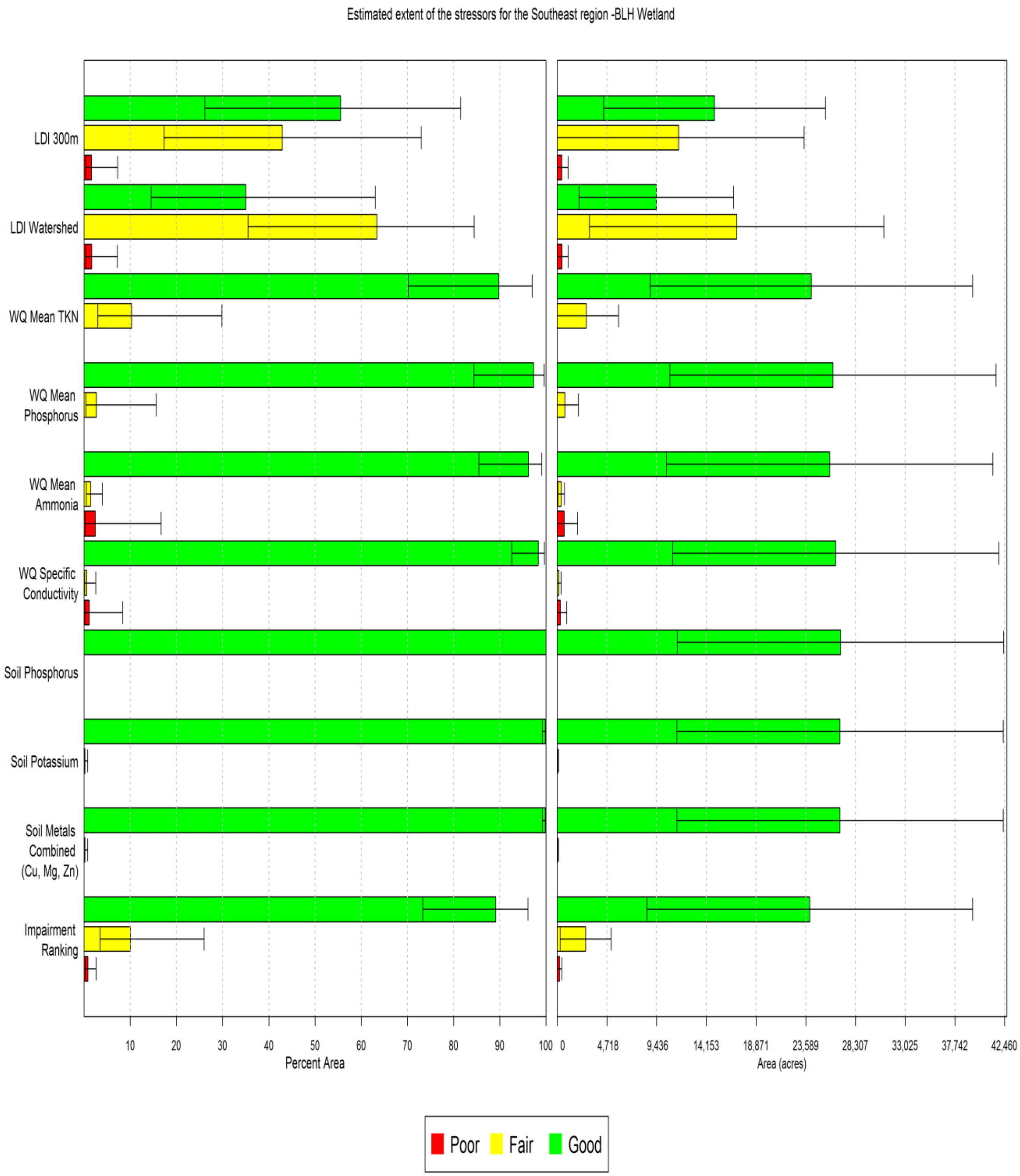


Figure 89: Estimated extent of the stressors for RSF wetlands in the SE region.

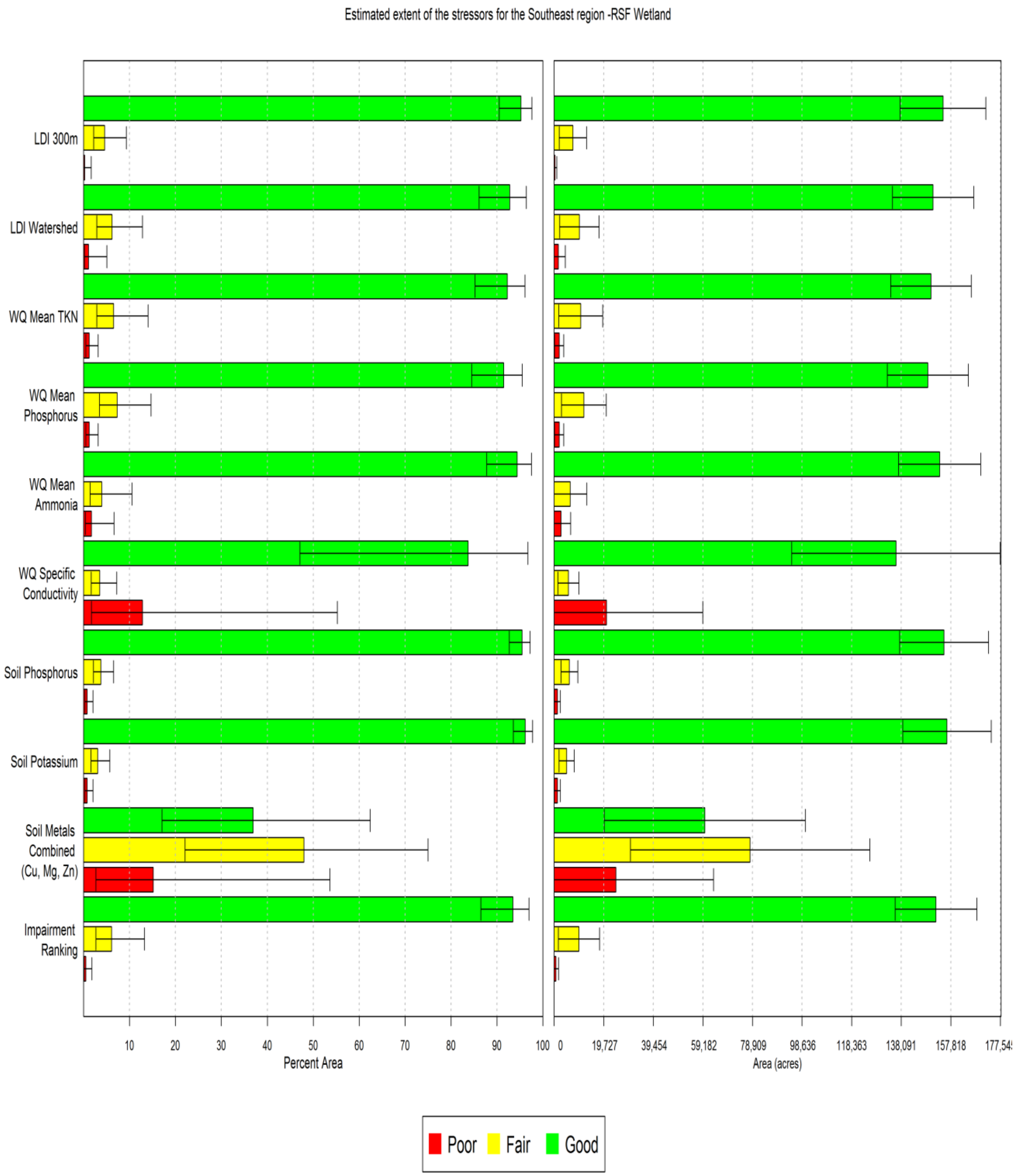


Figure 90: Estimated extent of the condition for BLH wetlands in the SE region.

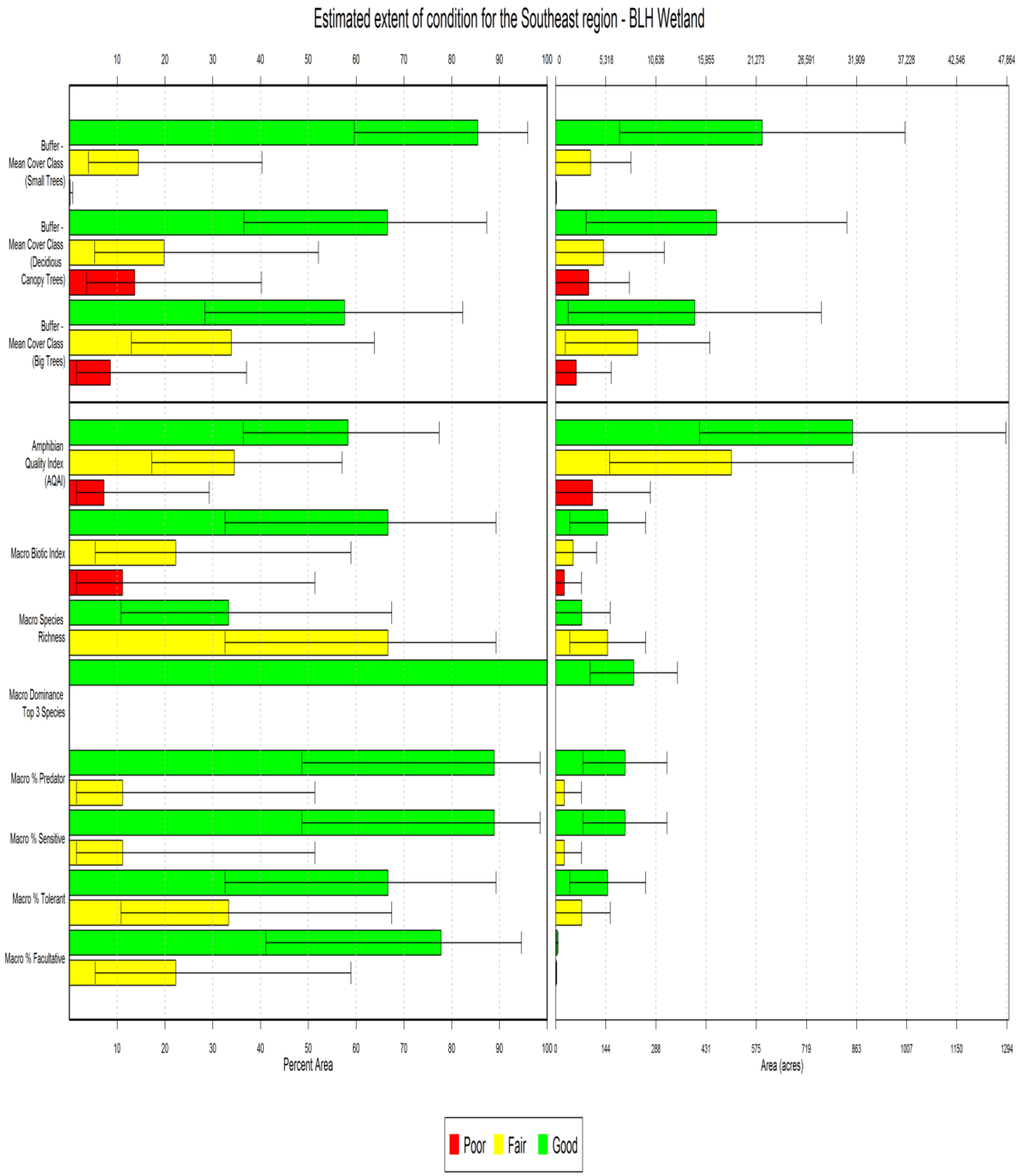
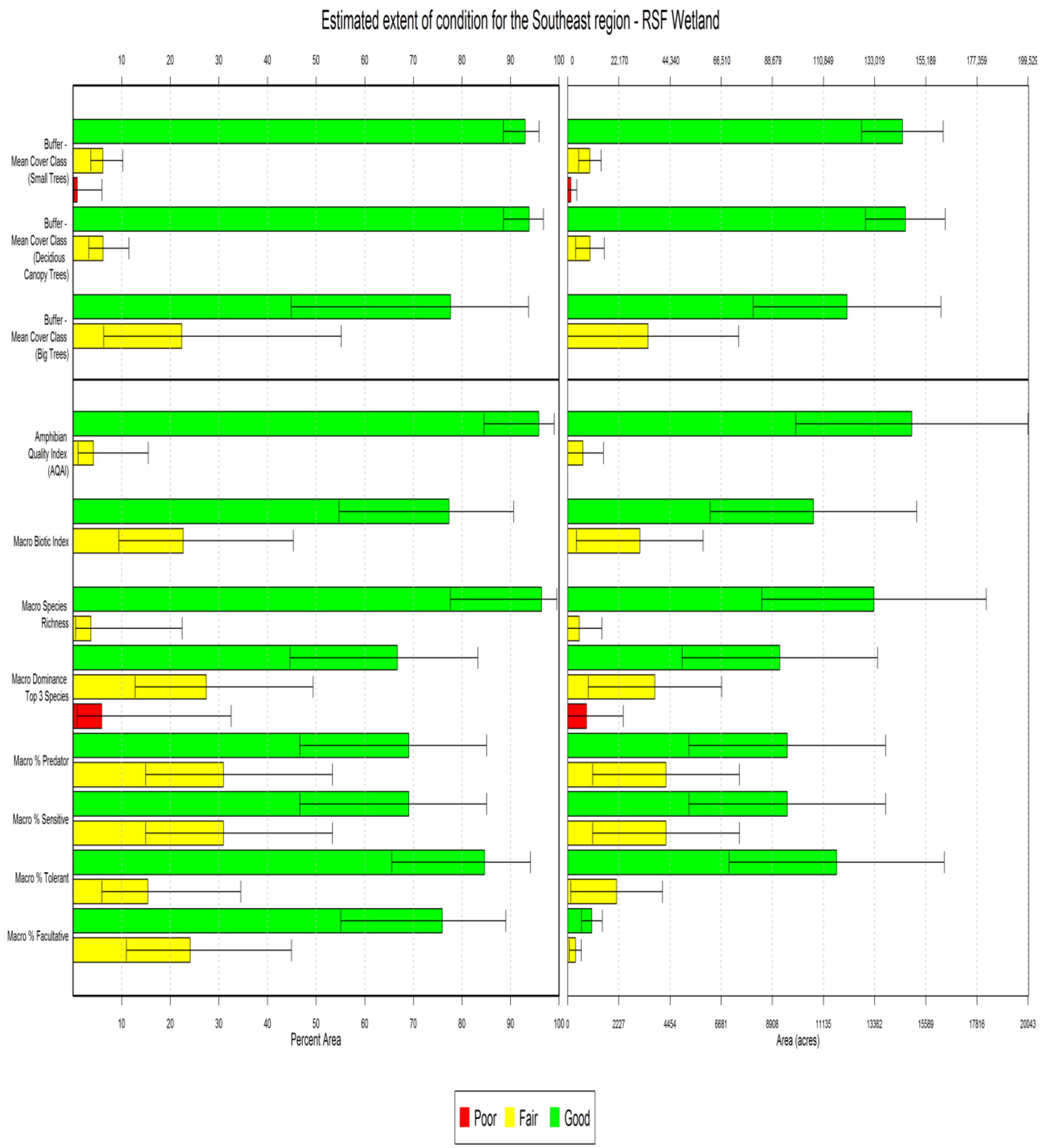


Figure 91: Estimated extent of the condition for RSF wetlands in the SE region.



The next set of figures (Figures 92 – 93) show the results of stressors analysis and analysis of selected biotic condition indicators for both wetland types combined throughout the entire four-state region.

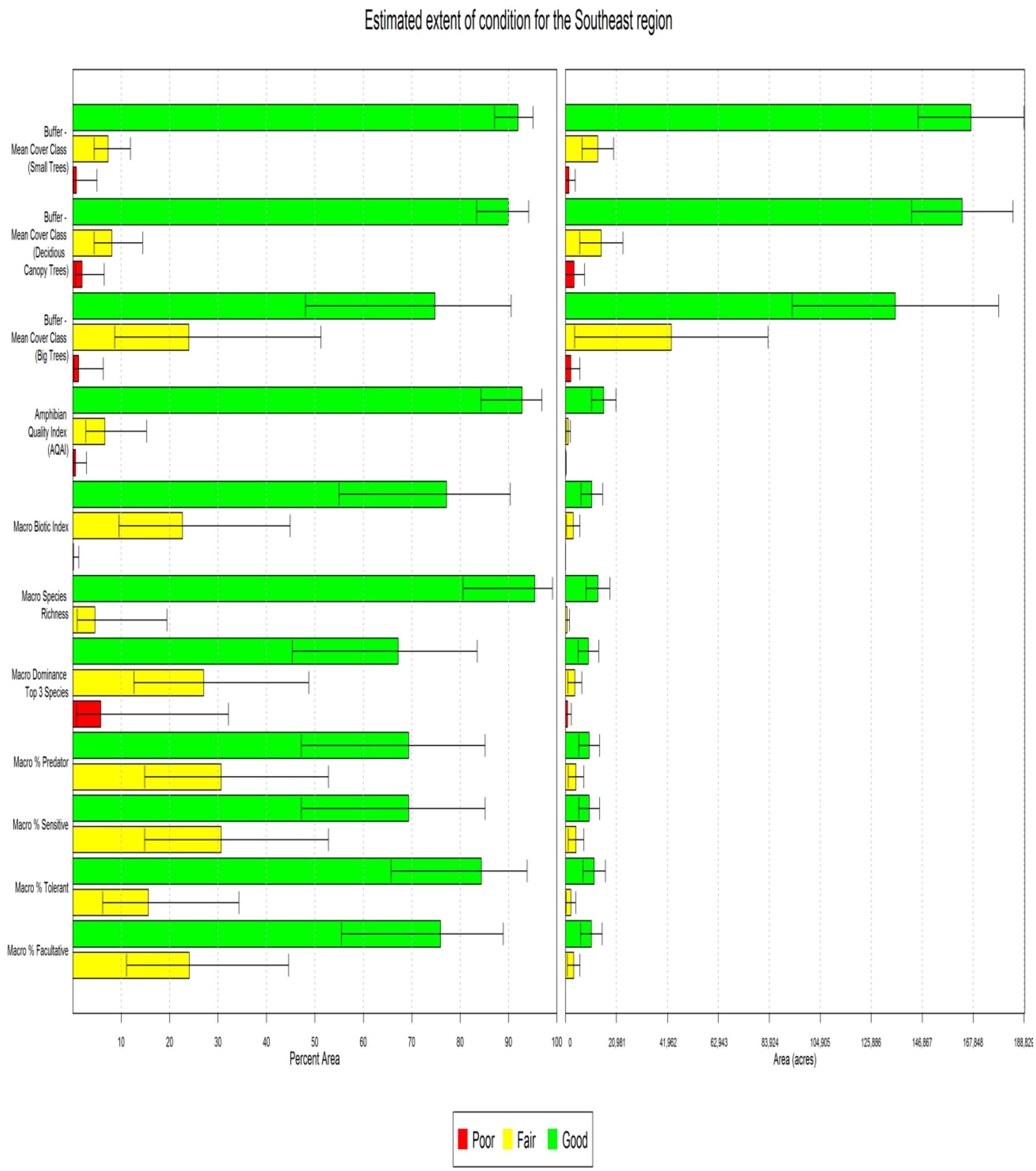
Figure 92 shows the results of stressor analysis for wetland areas throughout the entire four-state region for both wetland types combined. Over 50% of the wetland area was classified as being in fair or poor condition due to the soil metals stressor. The specific conductivity of water resulted in about 10% of the wetland area classified as being in poor condition. Other than the soil metals stressor, all other stressor condition variables resulted in estimates showing more than 80% of the wetland area throughout the entire region for both wetland types combined was classified in good condition.

Figure 93 shows the results of analysis of selected biotic condition indicators for wetland area throughout the entire four-state region. Regardless of indicator, more than 65% of the wetland area throughout the entire region was classified as being in good condition for both wetland types combined. However, most of the selectedmacroinvertebrate condition indicators resulted in about 15% - 30% of this wetland area classified as being in only fair condition.

Oveall, the results of the stressor analysis show the wetlands in the four-state region to be in realitively good shape with only small impactes due to various stressors.

Figure 92: Estimated extent of stressors on wetlands in the SE region.

Figure 93: Estimated extent of condition on wetlands in the SE region.



The Relative Risk of Stressors on Wetland Condition

This analysis aggregates the data in order to determine the relative risk or probability/likelihood, that a wetland will be in poor ecological condition, as indicated by a particular condition-indicator such as the amphibian quality index (AQAI), when a “stressor” is present to a greater degree (present at high level/value) compared to when the “stressor” is present to a lesser degree or not at all (present at a low level/value). In other words, this analysis tries to answer the question of how great a risk a particular “stressor” is for poor ecological condition. A value for relative risk can be any number greater than zero. A value of one would be neutral, meaning an equal likelihood of the outcome of the wetland area being in proo condition or not when the “stressor” is present (in other words, the presence of the “stressor” does not influence the outcome); a value between zero and one would mean the outcome is less likely when the “stressor” is present; and, a value grater than 1 would mean the outcome is more likely when the “stressor” is present. For example, having a particular stressor such as high levels of nutrients in the water would be X times more likely to have a poor condition wetland, on some condition variable.

Figure 94 shows the relative risk of having poor ecological condition as indicated by a wetlands area’s AQAI due to selected stressors. The figure shows that a high USA-RAM score which indicates either or both the presence of a greater number of stressors or the presence of stressors to a greater degree means the wetland area is more likely or at a greater risk to be in poor condition as indicated by the AQAI. The figure show that the same is true for higher levels of phosphorus in the water, however, neither relative risk factor is a great deal above one, which would mean an equal likelihood of the wetland area being in poor condition or not as indicated by the AQAI. These two stressors (or stress indicators) are not particularily strong for this wetland condition variable as neither reached the “2” times more likely, they were just over one.

Risk factors for poor condition for selected stressors are present in the next four figures, which use various indicators of wetland condition based on macroinvertebrate data.

Figure 95 uses the macroinvertebrate biotic index (MBI) to indicate wetland condition. Higher levels of phosphorus in the water result in poorer MBI, therefore poorer wetland condition for macroinvertebrates. The higher the scores on USA-RAM (indicating stressors on the wetland), the poorer were the MBI which reflected on the wetland condition.

Figure 96 looks at macroinvertebrate dominance to indicate wetland condition. Higher levels of nutrients in the water resulted in almost two times more likely to have poor macroinvertebrate dominance, reflecting on wetland condition. For the third time, higher USA-RAM scores, indicating multiple stressors on the wetland, resulted in poor wetland condition as indicated by macroinvertebrate dominance. Finally, higher scores of the LDI 300-m buffer surrounding the wetland area indicating less undeveloped forested land, were associated with a relative risk value greater than one, meaning greater likelihood of a wetland area being in poor condition as indicated by the macroinvertebrate dominance.

Figure 97 has the percent of sensitive macroinvertebrates species to indicate wetland condition. Higher LDI 300m score resulted in an approximately ten times greater likelihood that a wetland area would be in poor condition based on the percent sensitive macroinvertebrate species. Specific conductivity of water and TKN levels in the water had relative risk values greater than two, meaning wetland areas would be more than twice as likely to be in poor condition as indicated by percent sensitive species when these stressors are present at higher levels. With the higher levels of these two stressors, the wetland was more than twice as likely to be in poorer condition for sensitive macroinvertebrates.

Figure 98 uses macroinvertebrate species richness to indicate wetland condition. The only stressor acting on the condition variable was nutreints in the water (TKN and P). With higher levels of nutrients in the water, the wetland area was about six times more likely to be in poor condition as indicated by Macroinvertebrate species richness.

Figure 94: Relative Risk of Poor Amphibian Quality Index for each Stressor

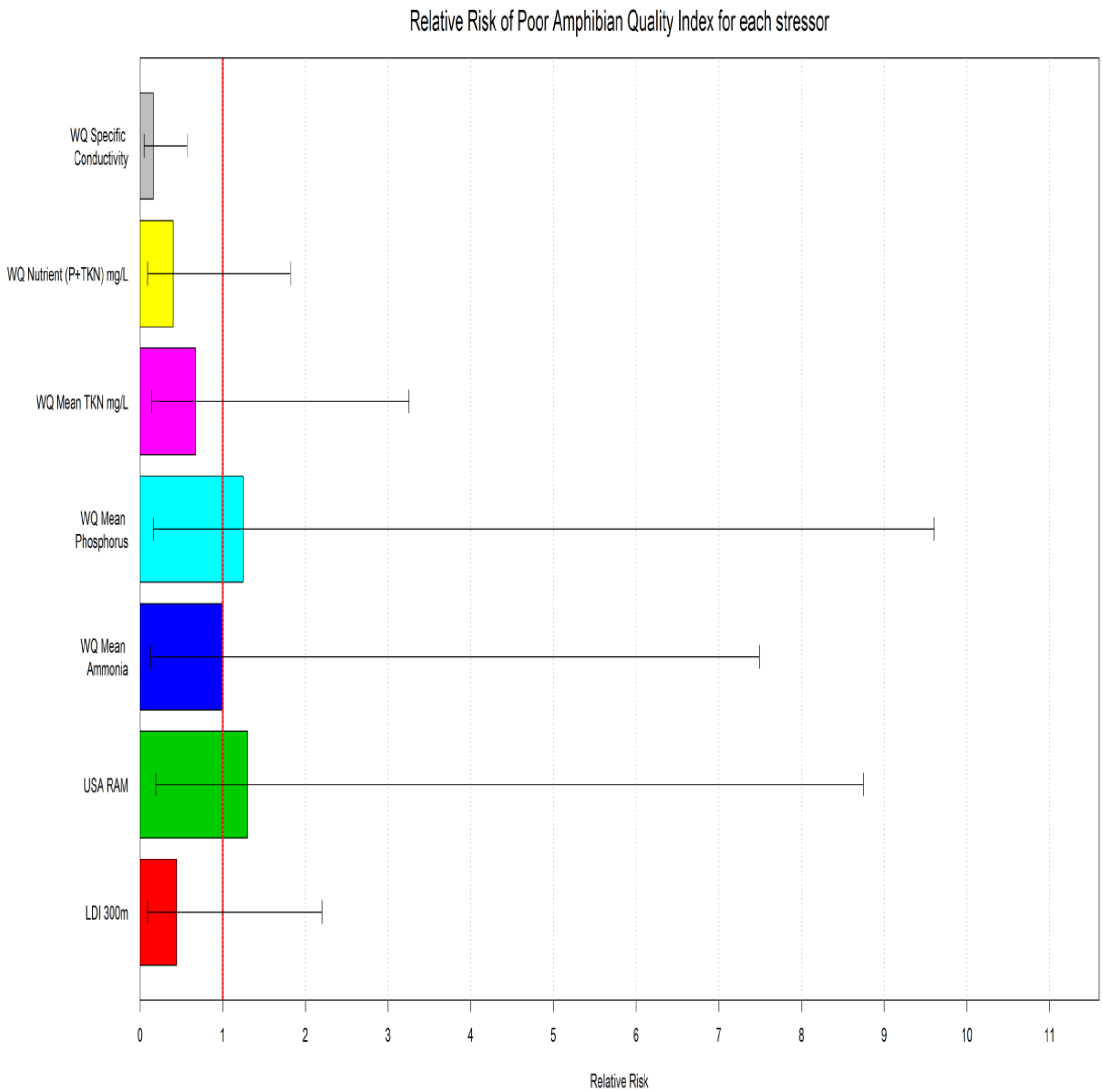


Figure 95: Relative Risk of Poor Macroinvertebrate Biotic Index for each Stressor

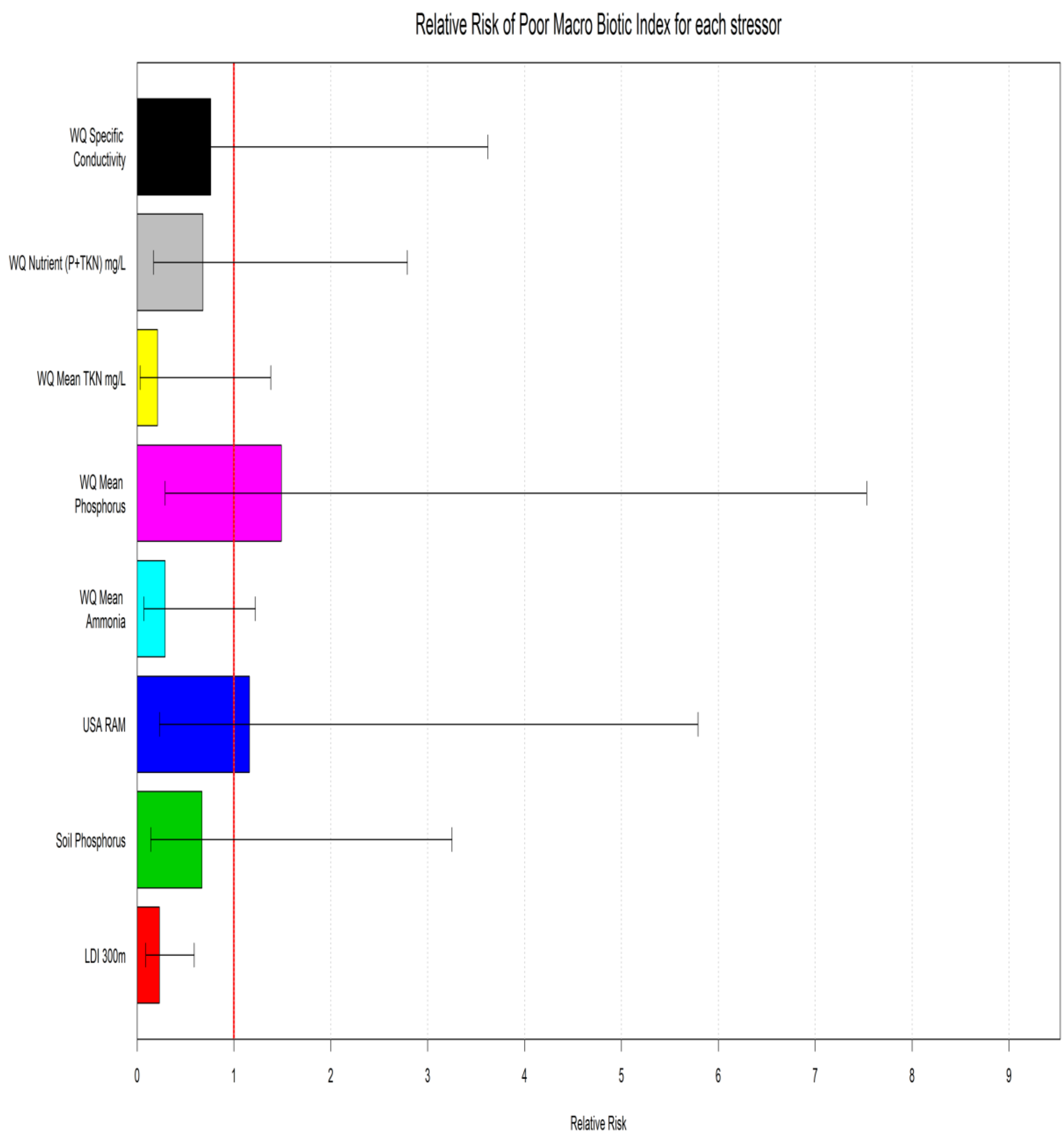


Figure 96: Relative Risk of Poor Macroinvertebrate Dominance for each Stressor

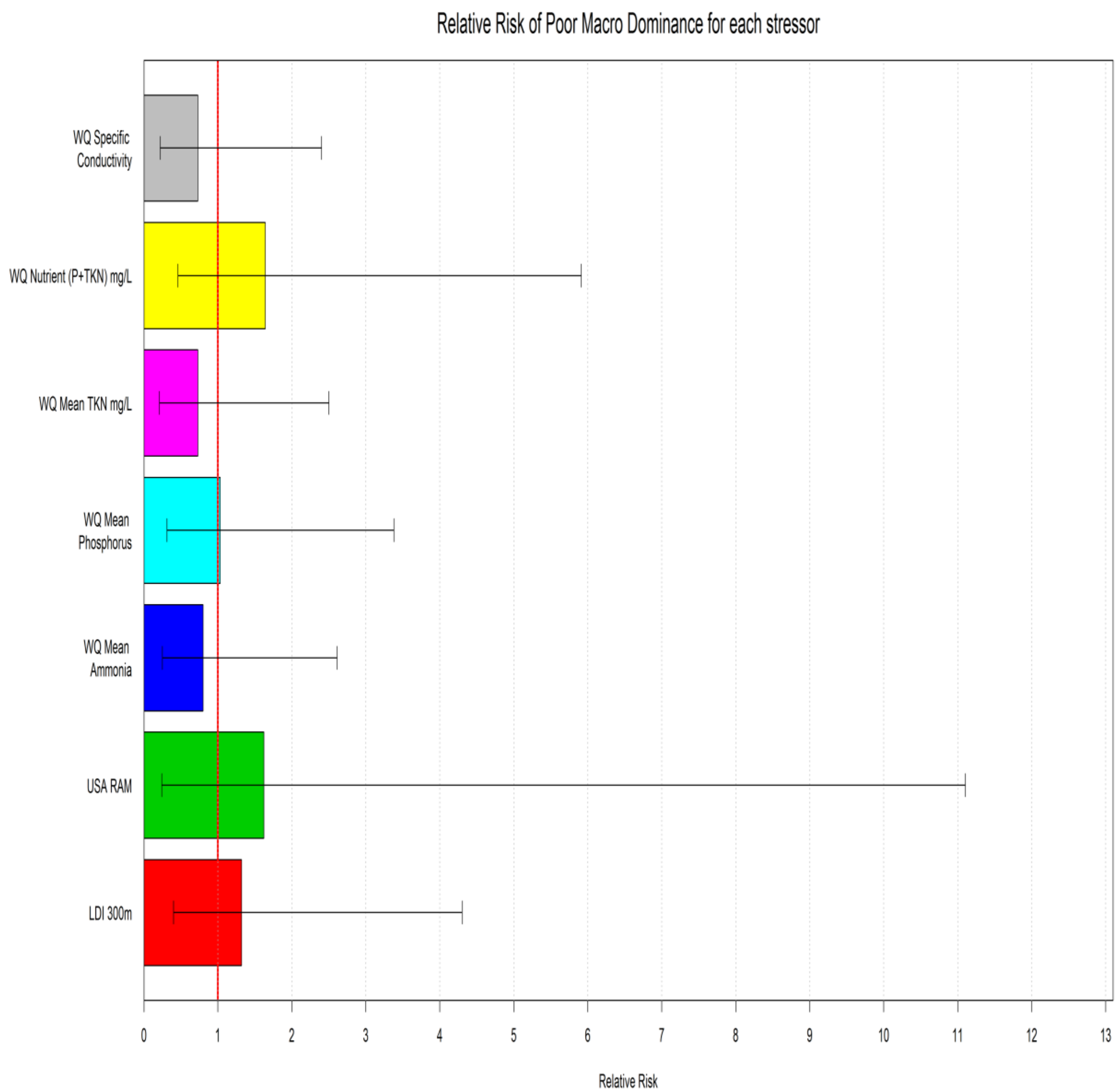


Figure 97: Relative Risk of Poor Macroinvertebrate Percent Sensitive for each Stressor

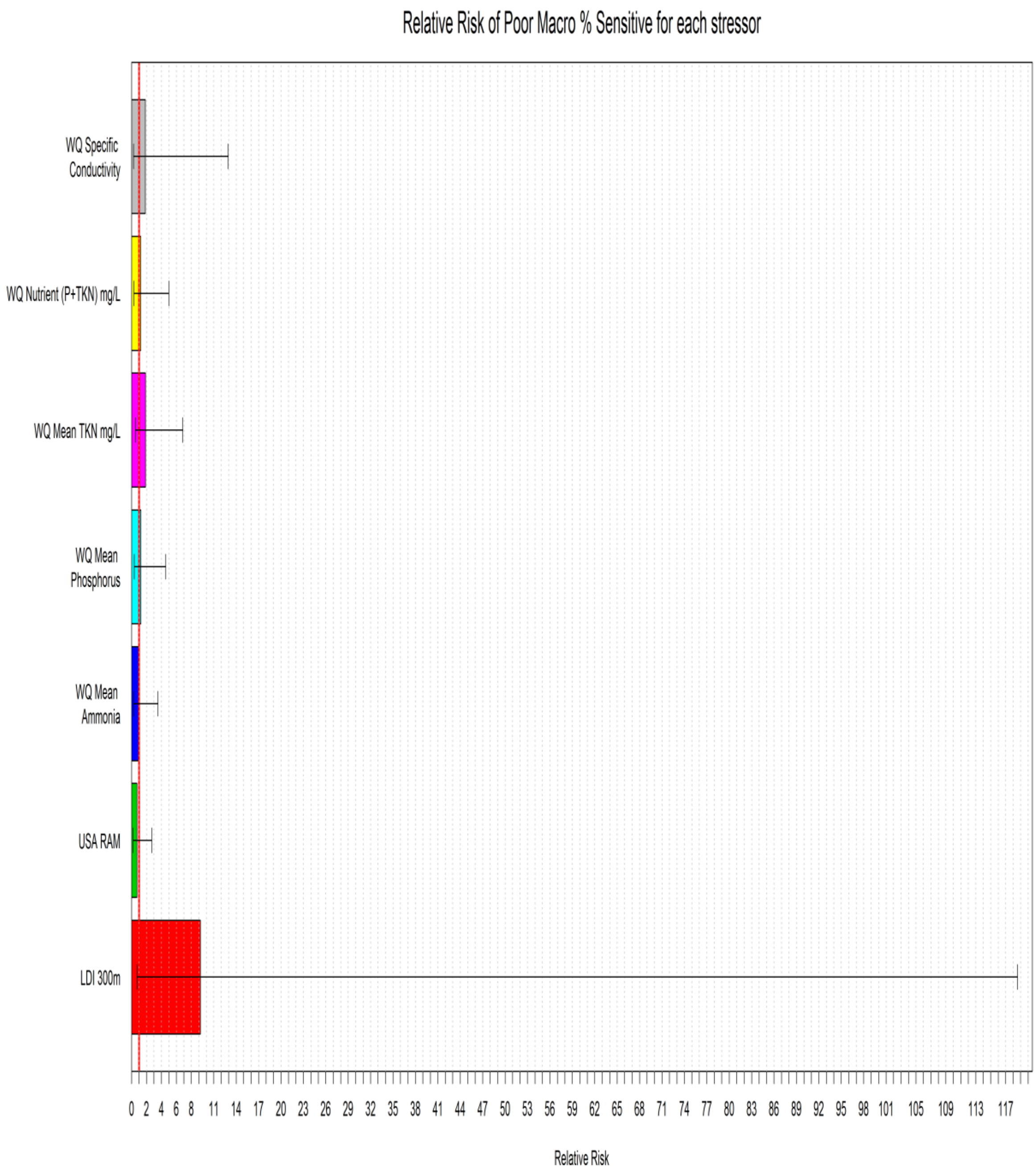
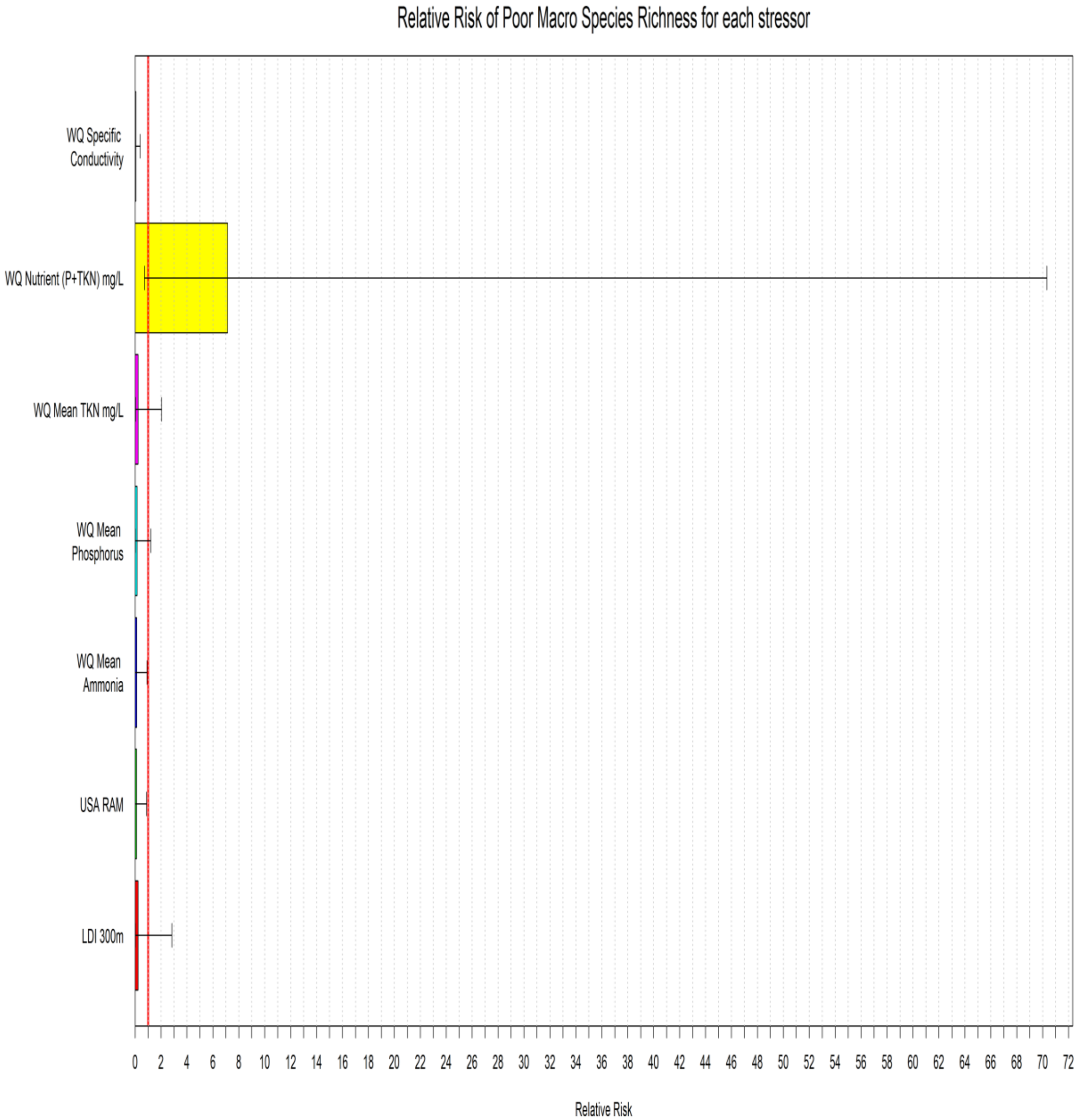


Figure 98: Relative Risk of Poor Macroinvertebrate Species Richness for each Stressor



The next three figures use various vegetation metrics as indicators of wetland condition.

Figure 99 shows the relative risk of poor vegetation FQAI with potential stressors. From this figure, several stressors seem to be having a significant impact on the wetlands. The potential water quality stressors of ammonia and nutrients in the water show that as the levels of the stressor increase, the wetland was more that twice as likely to be in poorer condition for vegetation's FQAI. The specific conductivity of the water was also having an effect on wetland condition showing that the wetland is about four times more likely to be in poorer condition for the FQAI of vegetation. Higher scores on USA-RAM (indicating stressors on the wetland) shows that the wetland was also about four times more like to be in poorer condition for the vegetation FQAI. The 300m LDI also shows that as the area around the wetland becomes more developed (disturbed) the wetland was about three times more likely to have a poor FQAI vegetation score. Finally, two soil metrics used as potential stressors, also have an impact on the wetland. As the levels of potassium and phosphorus increase, the greater likelihood of the vegetation FQAI being poorer, reflecting the condition of the wetland.

Figure 100 uses the mean C of all vegetation species as an indicator of wetland condition. The potential stressors phosphorus and ammonia in the water are shown to be having an impact on the wetland condition. As their levels increase, the mean C becomes poorer, indicating that the wetland is in poorer condition for vegetation. These stressors are very strong, indicating that there was about 30 times more likely that the wetland will be in poorer condition. The USA-RAM scores show that stressore have a similarily stong impact on wetland condition. As the USA-RAM scores increase to indicate stressors on the wetland the vegetation mean C will be poorer and therefore the wetland being in poorer condition for vegetation.

Native vascular species richness is used as an indicator of wetland condition in Figure 101. This figure shows several stressors having an impact on wetland condition when using vascular species richness of native plant species. Four water quality parameters had significant impact on wetland condition indicating that as the stressors increase, the likelihood (relative risk) of the wetland being in poorer condition increases. In particular, the water quality parameters of TKN and specific conductivity strong impacts on wetland condition showing that they are more than four times likely to be in poor condition using vascular species richness for wetland condition. The 300m LDI score also had a strong impact, indicating that as more development/disturbance increase, the wetland was about six times more likely to be in poorer condition using species richenss of vascular native plants as the indicator of wetland condition. Also in Figure 101, the levels of phosphorus and ammonia in the water also had small impacts on wetland condition. Finally, the USA-RAM scores also indicated that stressors were having an impact of wetland condition by having poorer native vascular species richness.

Figure 99: Relative Risk of Poor Vegetation FQAI for each Stressor

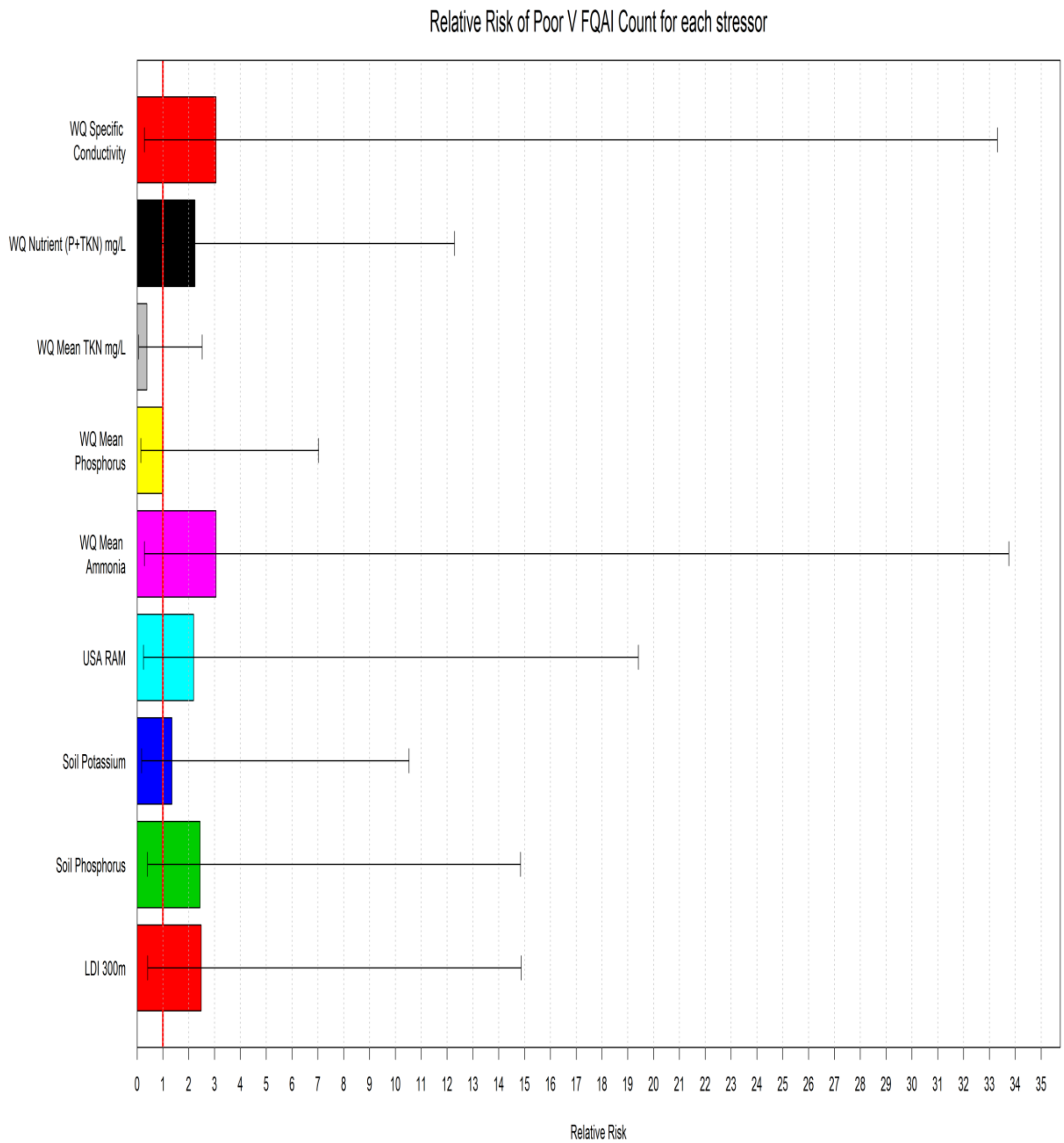


Figure 100: Relative Risk of Poor Vegetation Mean C for all Species for each Stressor

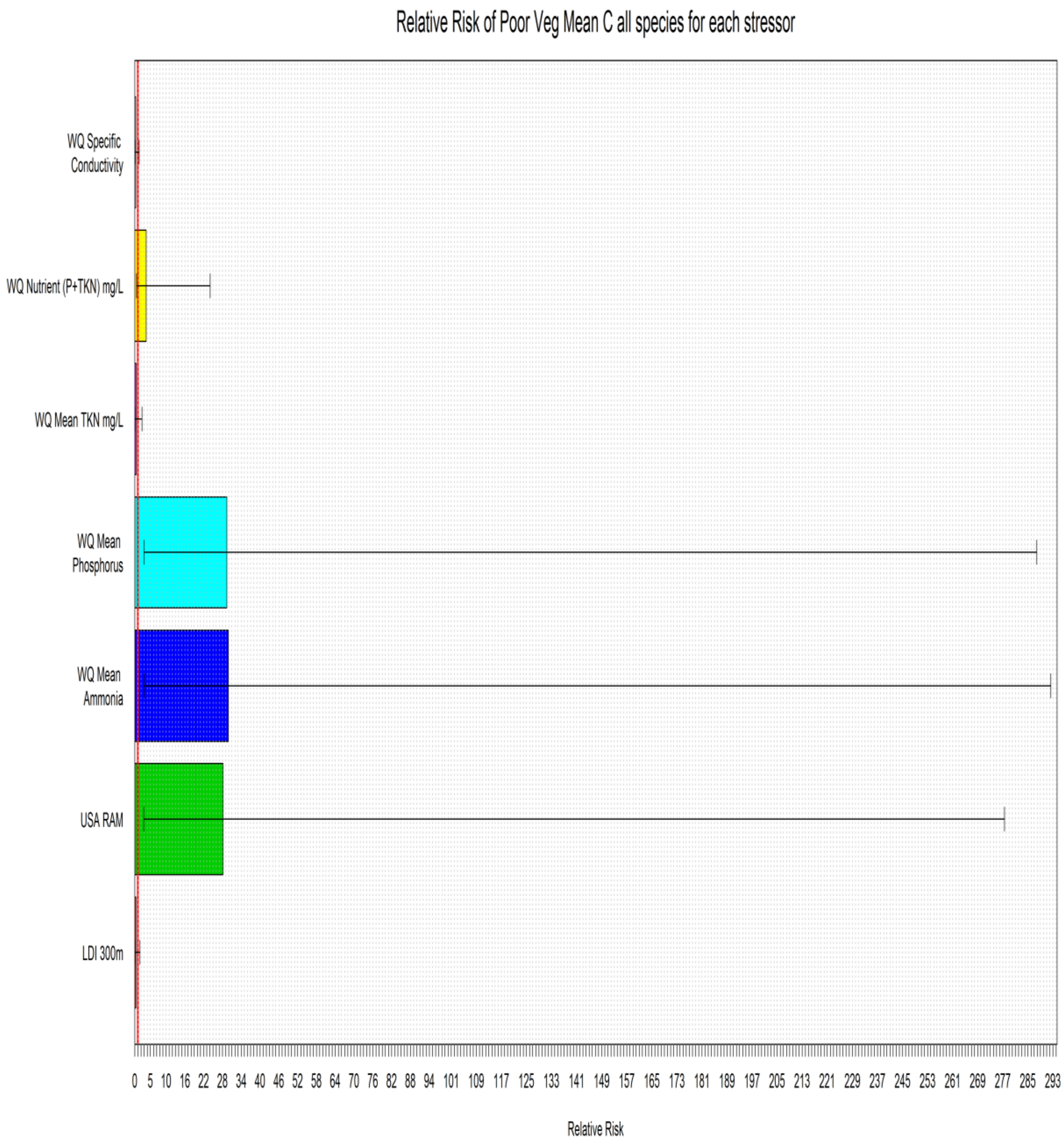
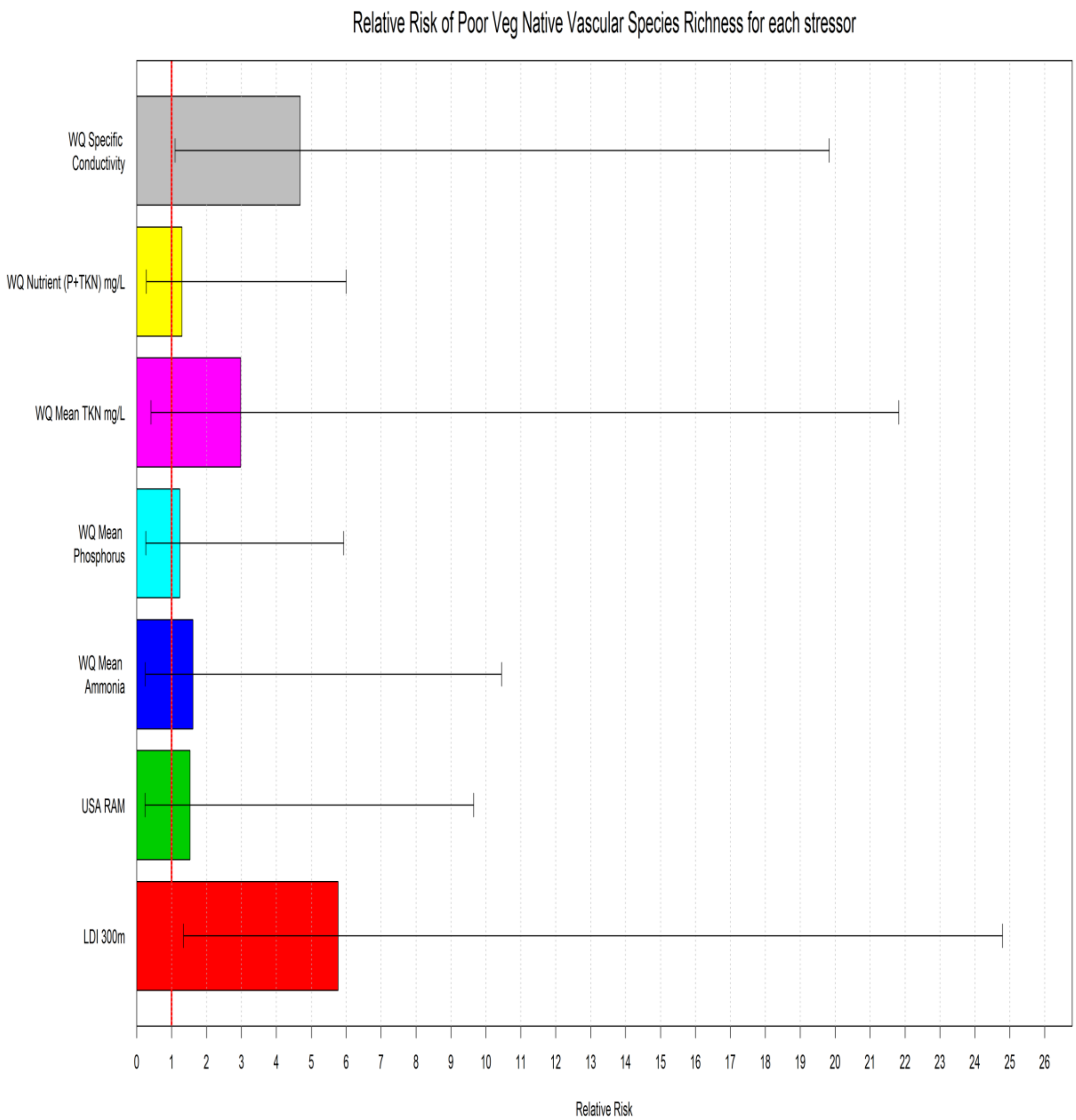


Figure 101: Relative Risk of Poor Vegetation of Native Vascular Species Richness for each Strssor



The relative risk analysis show the likelihood of poor wetland condition as indicated by various biotic varibles due to the presence of different stressors. This can can be very valuable when taking these measurements and know what the probablilities are that poor wetland condition may exits.

Regional Wetland Condition

One of the main objectives of this project was to look at wetland condition on a regional scale. Ecosystems do not recognize state boundaries, so looking at the data on a more regional level is beneficial. Wetland condition is a result of complex circumstances and processes, and different assessment methods can illuminate different aspects of this complexity. Additionally, regulators generally have a need for methods that support timely and scientifically valid decisions. This results in a need for different levels of assessment, as time-intensve methods give the most rigourus results, but generally require too much time for use in permitting decisions (with the exception of being appropriate for mitigation sites that are often monitored for a period of years). Therefore, wetland condition can be looked at in many ways using different measured parameters and they all give information about the wetland in terms of the parameter utilized and provide relevant information to practicitioners.

The first two figures present information on wetland condition based a Level 1 perspective, which uses a GIS analysis to assess wetland condition (LDI). This is the least time intensive level of assessment that also generally only uses existing information that is readily available, such as from GIS, to give a course indication of wetland condition by using a method such as the land development/density index. The next set of figures presents information on wetland condition based on a Level 2 perspective, which are field based assessments such as rapid assessments methods. These tools are used on site, but are subjectively assessed by answering questions about aspects of the observed wetland that are summed to give an overall condition rating through some algorithm. The rapid assessments were ORAM, NCWAM, and USA-RAM. NCWAM is a functional assessment whereas ORAM is more of a condition assessment. While they generally assess structural features, these features may serve as surrogates for function based on some empirical framework. Other RAMs, such as USA-RAM, more or less inventory stressors, noting the presence or absence and severity of various stressors, with the score or rating indicating a site’s position along a disturbance/impairment gradient. The final set of figures look at wetland condition based on level three measures (time intensive surveys) and these are measures that result from doing intensive surveys of various aspects of the wetland, such as vegetation, amphibians, macroinvertebrates, water quality, and soil chemistry for example. The final figures present wetland condition based on a composite ranking that integrate a wide range of data and more or less correspond to the “overall” wetland condition. The composite condition ranking is presented with maps showing all four states in the study region, both individually and forthe region.

Figure 102 shows wetland condition for the four-state region using LDI scores based on 300 meter buffer. Cutoffs for the condition categories were based on the actual LDI score (higher score means more intense development). Based on this parameter, wetlands in the four-state region are in good shape and there is little variation in ecoregion or wetland type (bottomland hardwood forests are in the Piedmont region and riverine swamp forests are in the Coastal Plain).

Figure 103 shows wetland condition in the region using LDI scores based on the site's watersheds (up to 20 square miles). Integrating landuse data from this area gave different results. Wetland condition was not quite as good, with more wetlands showing up as moderately impacted. This figure also shows a noticeable difference between bottomland hardwood foreste wetlands in the Piedmont region, which seem to be somewhat more impacted, compared to the Coastal Plain which has been consistent results. Based on the Level 1 scores (Figures 102 and 103, LDI scores), wetland condition in the region is generally just moderately impacted to somewhat impacted indicating wetland condition being better than average.

Figure 102: Wetland condition based on LDI scores using 300 meters as the buffer. *Cutoffs were not determined using percentiles, but by consulting the LDI scale and interpretation of the index values.*

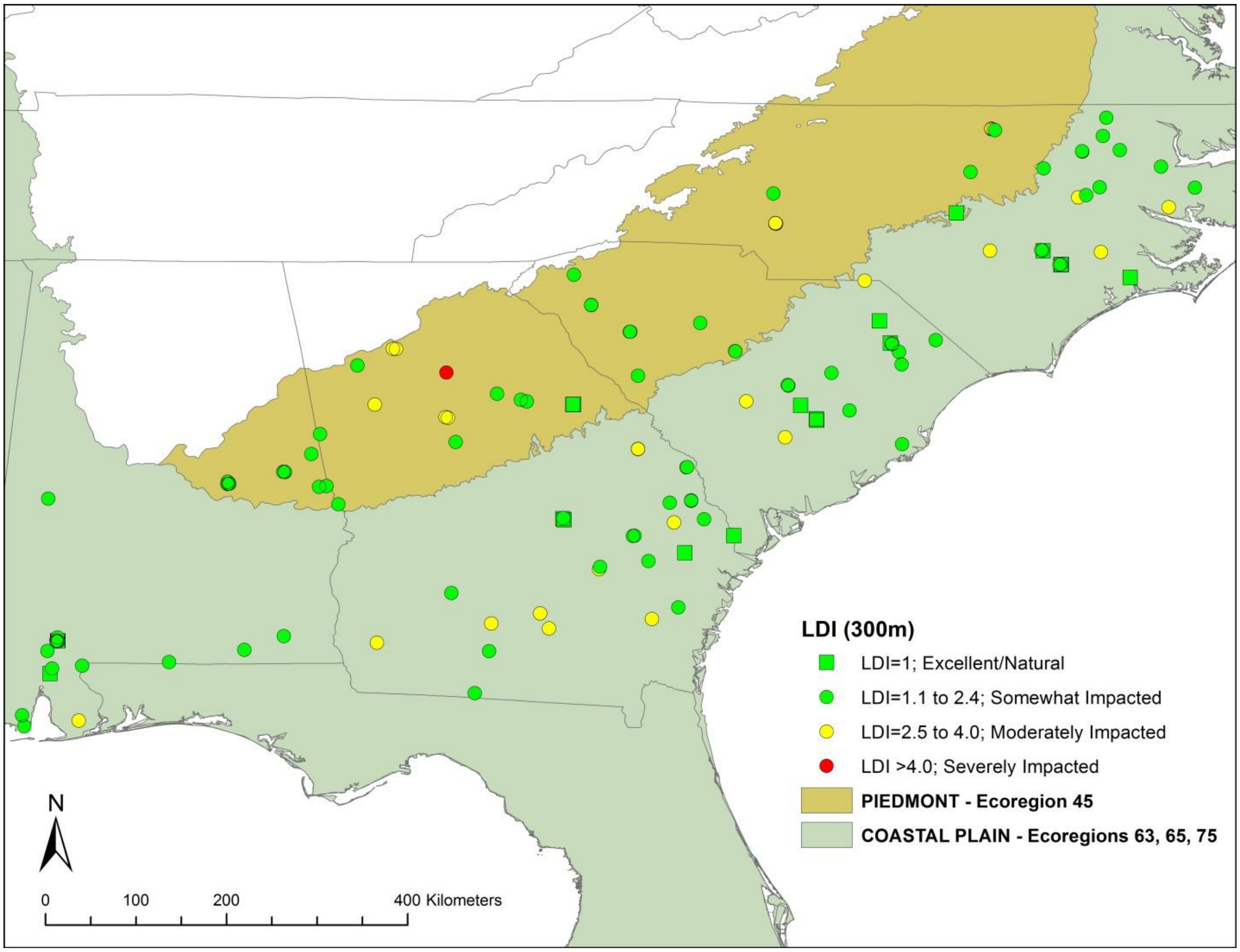


Figure 103: Wetland condition based on LDI scores using the wetlands' watersheds. *Cutoffs were not determined using percentiles, but by consulting the LDI scale and interpretation of the index values.*

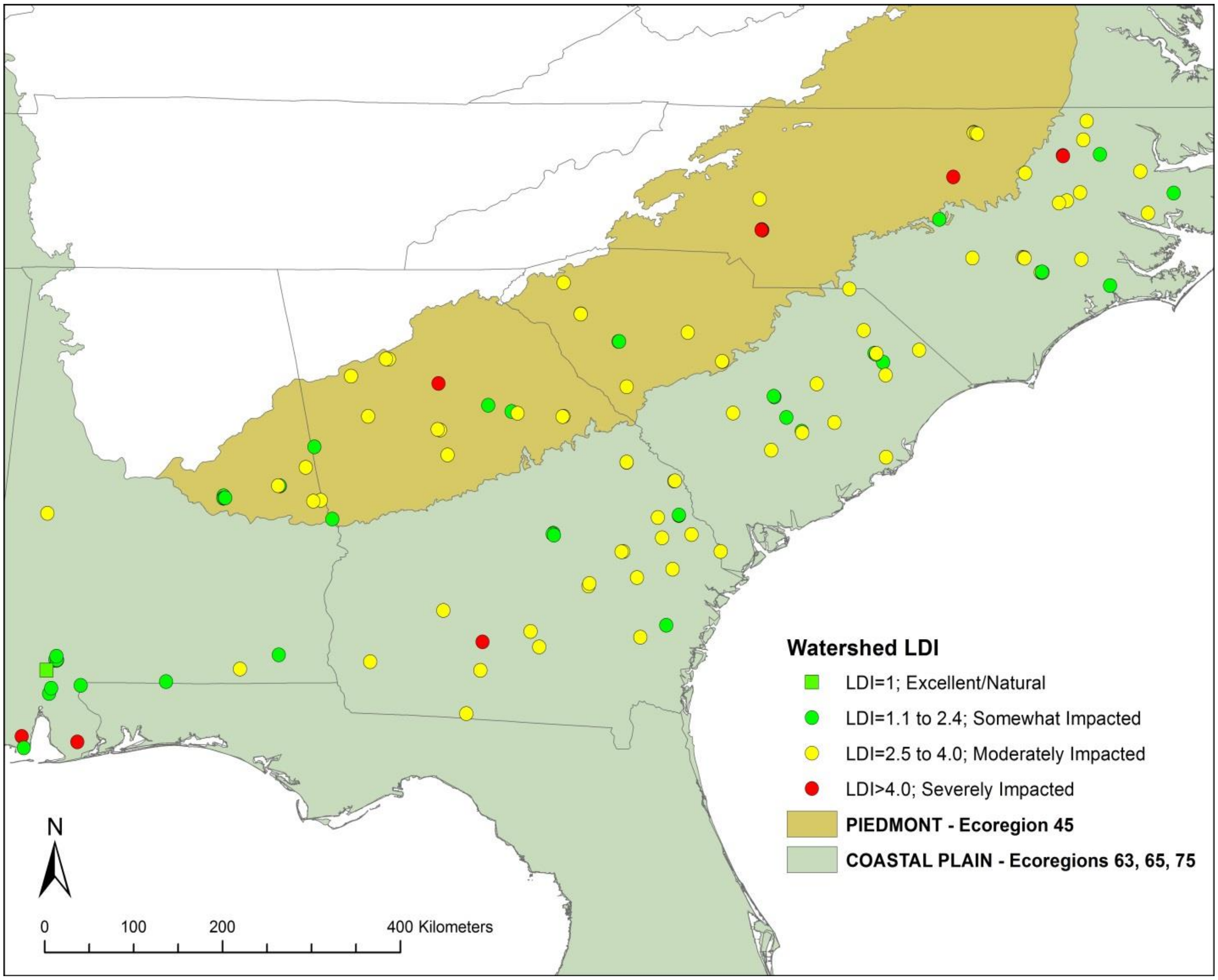


Figure 104 shows wetland condition in the four-state region based on ORAM scores, which is a Level 2 measurement (rapid assessment). ORAM has categories that take the numeric scores and assigns condition categories of superior, good, fair. From this figure, the Coastal Plain wetlands are in better condition than the wetlands in the Piedmont (bottomland hardwood forests) region with wetlands being more impacted. This is especially true for the Piedmont region of Georgia.

Figure 104: Wetland condition based on ORAM scores

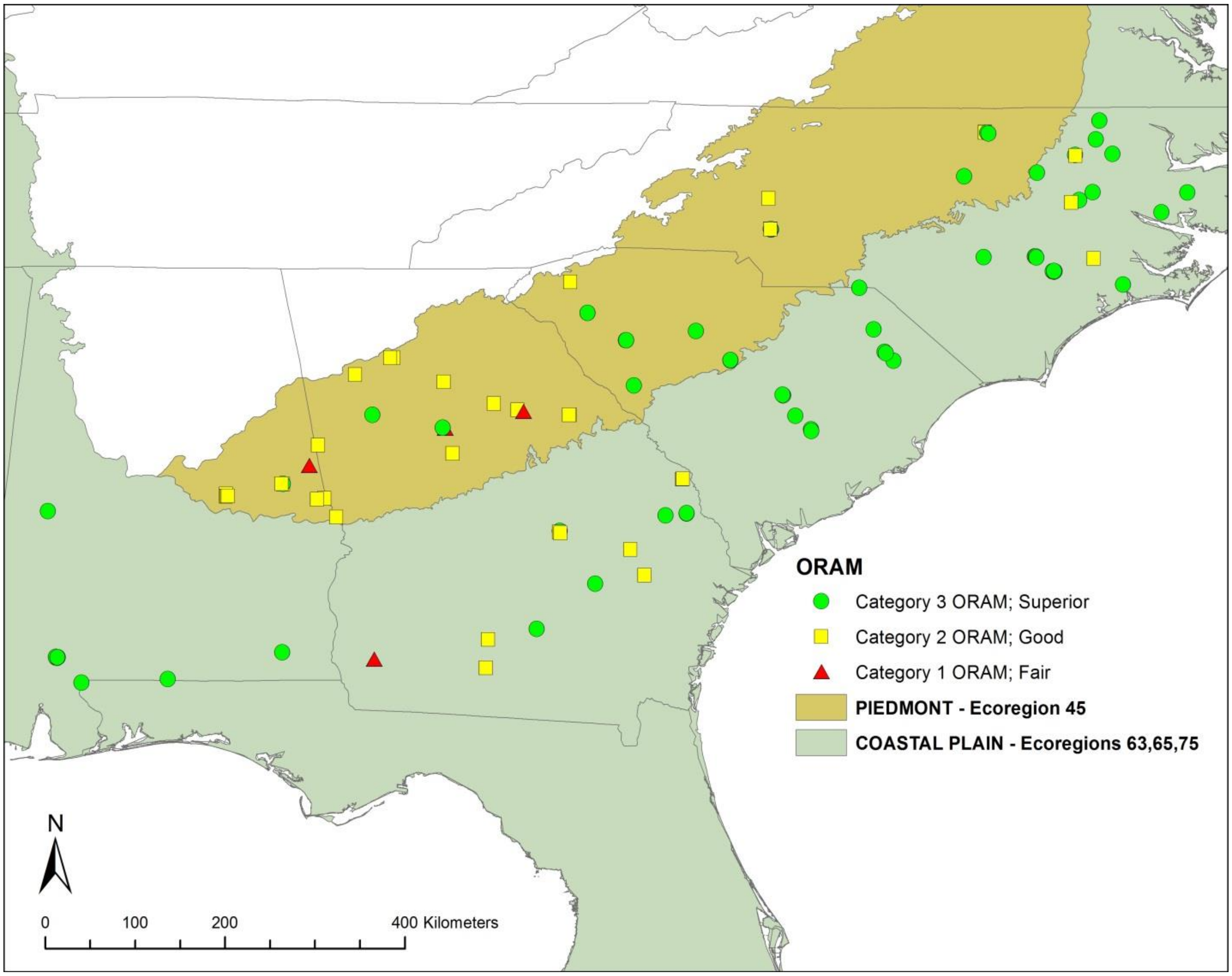
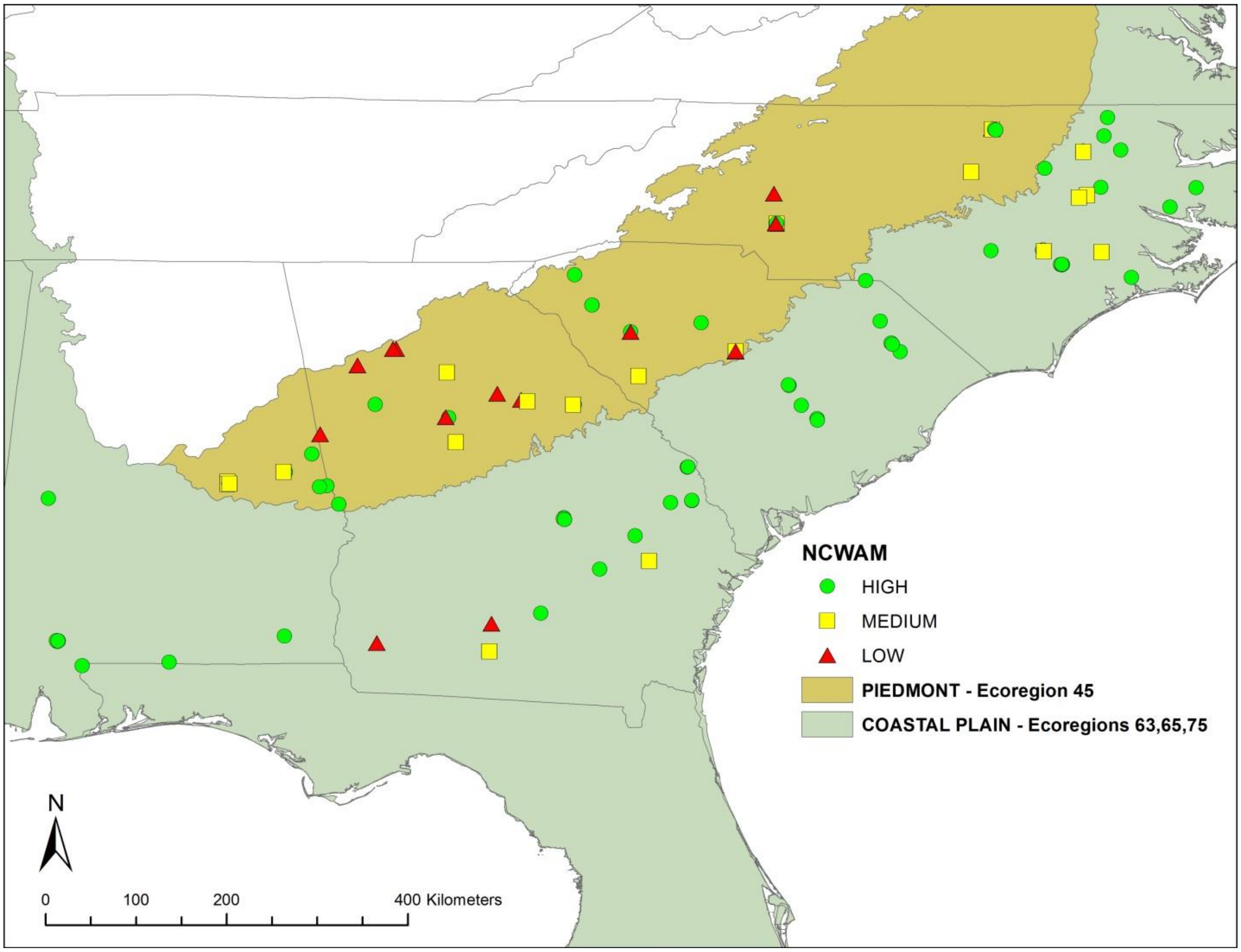


Figure 105 shows wetland condition based on functional value scores derived from NCWAM. Recall that NCWAM scores are categorical (high, medium, or low) which indicate their functional value which can be an indicator for wetland condition. Therefore, NCWAM is more or less a condition assessment that indicated functional capacity or lact thereof. Even more so than the ORAM scores indicated, the NCWAM scores show much poorer wetland condition in the Piedmont region than in the Coastal Plain. Results from Georgia stand out in this regard with even more wetlands in poor condition, but NCWAM data from North and South Carolina also indicate several bottomland hardwood forest wetlands in poor condition in the Piedmont.

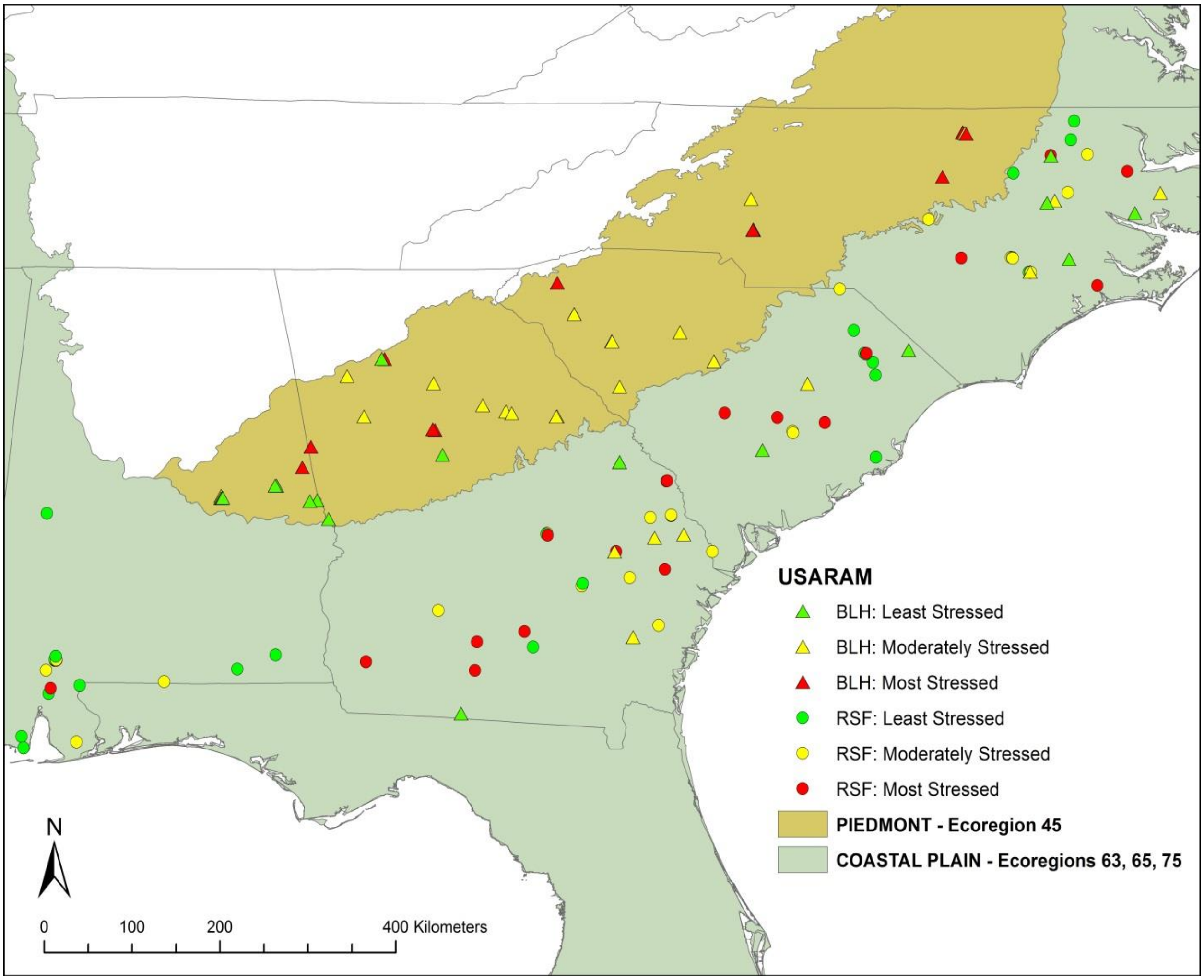
Figure 105: Wetland condition (functional value) based on NCWAM scores.



The final rapid assessment indicator of wetland conditon is shown in Figure 106 using the USA-RAM scores. Sites were assigned to condition categories based on percentiles, with sites in the bottom 25% of the weighted scores as being less stressed (therefore having fewer stressors, the least stressed category), the middle 50% had a moderate level of stressors (moderately stressed category) and the top 25% had the most stressors (most stressed category, more detail is given under the figure for each wetland type). These results indicate more wetland sites in poor conditon in the Coastal Plain than were indicated by any other parameter previously reported. While it is still largely true that the Piedmont had more wetland sites in poor condition, the USA-RAM shows that many of the Coastal Plains wetland do have stressors present, perphaps causing adverse effects to condition or function. Georgia again had the most wetland sites in poor condition in both ecoregions compared to the other three states.

The figures that present wetland condition based on the rapid assessment (Level 2) data show quite a bit of variation with the ORAM scores generally indicating wetland condition to be pretty good, whereas the USA-RAM indicate wetland condition to be poorer and more stressed present. NCWAM results were intermediate between the other two rapid assessments.

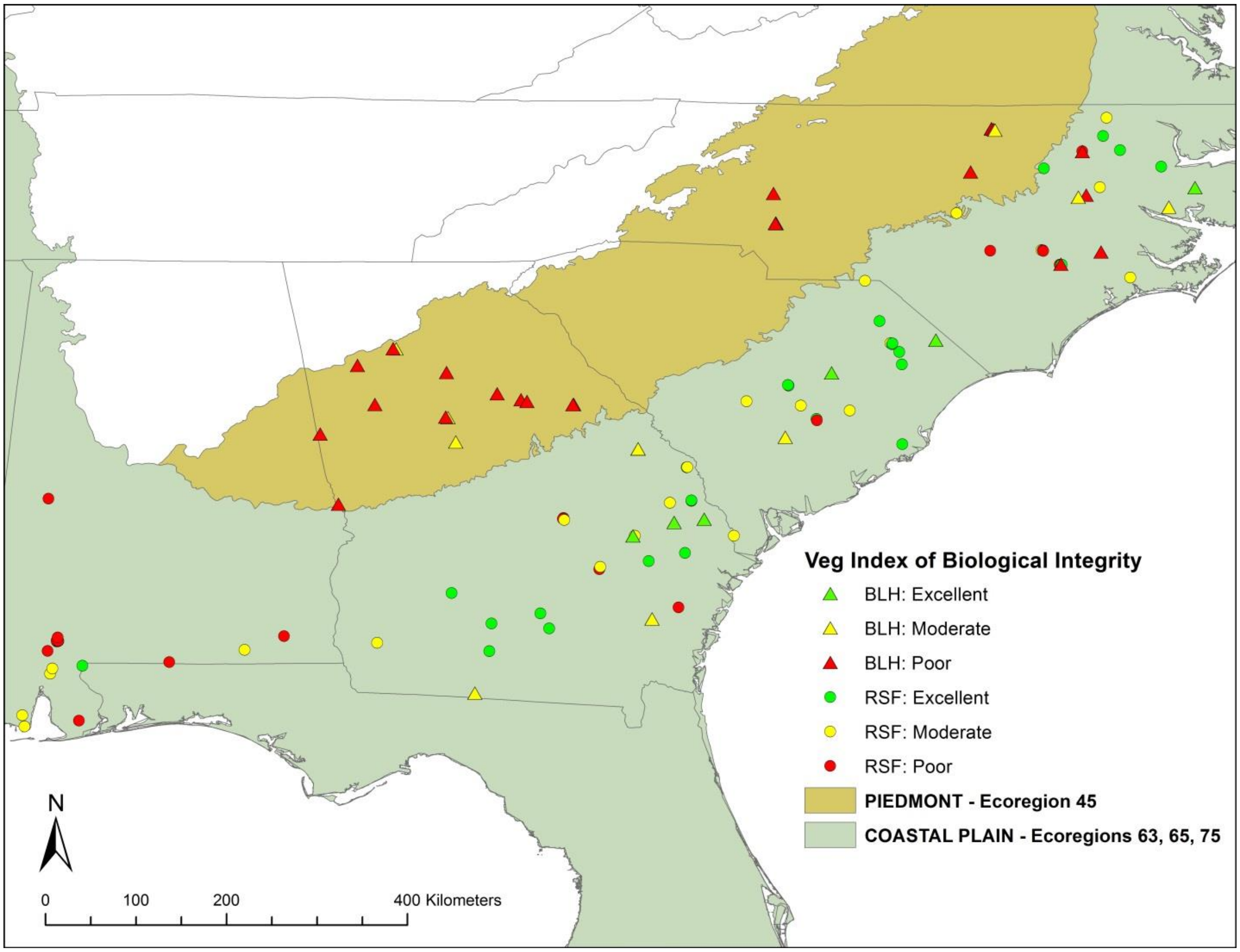
Figure 106: Wetland condition based on USA-RAM scores



USARAM stress level classification was based on weighted lower (least stressed) and upper (most stressed) 25th percentiles, with the middle 50% percentile considered moderately. Percentiles were calculated separately for BLH and RSF. BLH Least Stressed = 0 – 16.8, BLH Moderately Stressed = 16.9 – 26.7, BLH Most Stressed = above 26.7; RSF Least Stressed = 0 – 15.0, RSF Moderately Stressed = 15.1 – 20.7, and RSF Most Stressed = above 20.7.

Figure 107 shows wetland condition based on the vegetation index of biological integrity (VegIBI), which is a level three measurement. The classification of wetland condition using VegIBI values is explained under the figure for each wetland type. As with other measures, the Piedmont region had more wetland sites classified as poor than the Coastal Plain. However, Georgia and North Carolina also had a noteworthy number of wetland sites classified as poor wetlands in the Coastal Plain. Based on vegetation results, the wetland sites were generally not in very good condition in the Piedmont and even in the Coastal Plain, there were wetlands in poor condition based on the VegIBI results.

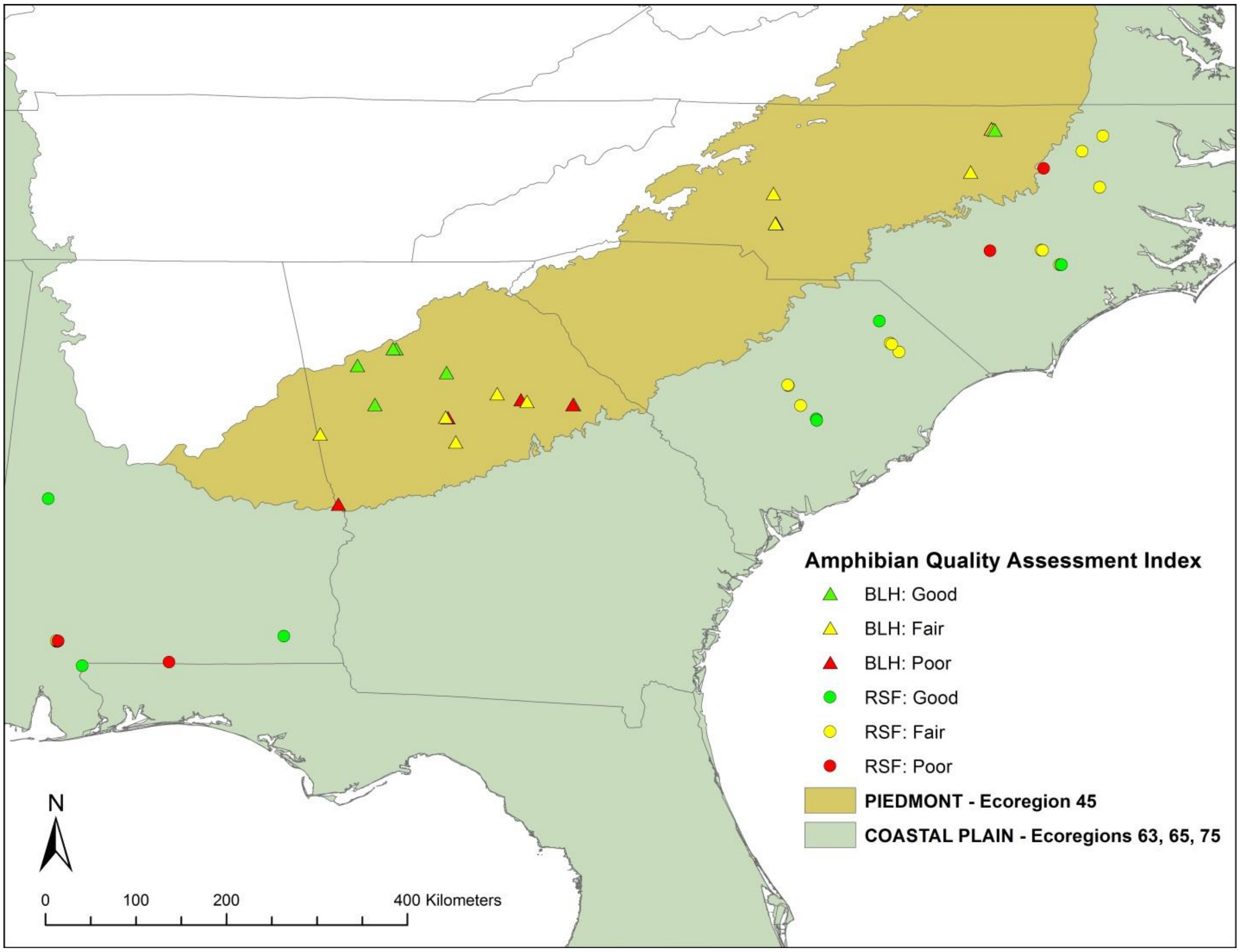
Figure 107: Wetland condition based on the vegetation index of biological integrity (VegIBI).



BLH condition classification – Veg IBI = 5 as Excellent, 3 as Moderate, and 1 as Poor; RSF condition classification – Veg IBI = 23-25 as Excellent, 18-22 as Moderate, and 5-17 as Poor.

Figure 108 shows wetland condition based on the amphibian quality assessment index (AQAI), another Level 3 measurement. The cutoffs used percentiles (upper 25% and lower 25% for good and poor respectively, see detail under the figure for each wetland type). Georgia did not have riverine swamp forest wetland amphibian data for this report. This figure shows that wetland condition as indicated by the AWAI was relatively poor in the Piedmont and somewhat better in the Coastal Plain. South Carolina's Coastal Plain had the best wetland condition based on amphibian data.

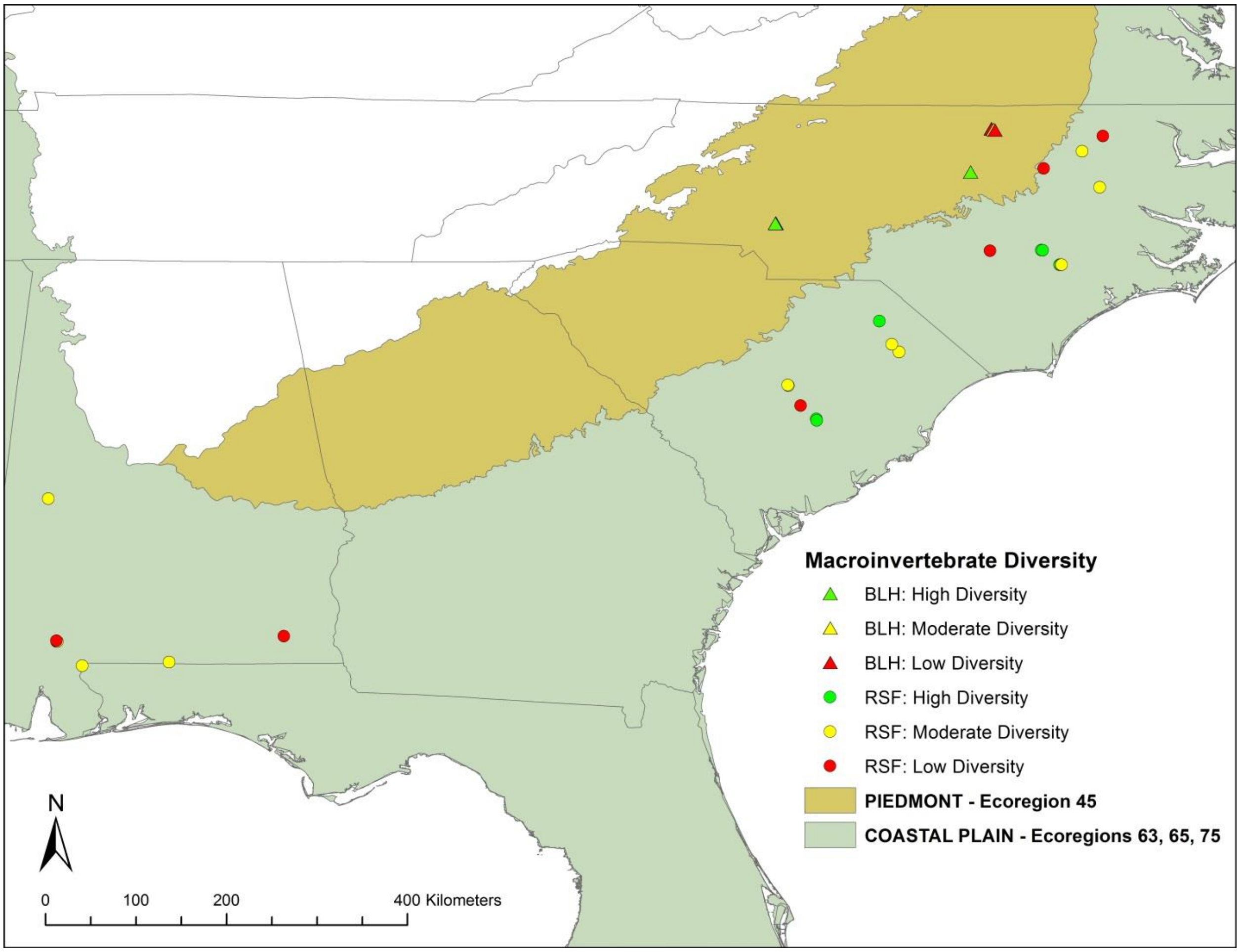
Figure 108: Wetland condition based on Amphibian AQAI scores.



AQAI condition classification was based on weighted lower (poor) and upper (good) 25th percentiles, with the middle 50% percentile considered fair. Percentiles were calculated separately for BLH and RSF. BLH Good AQAI = 8.0 and above, BLH Fair AQAI = 2.3 – 7.9, BLH Poor AQAI = 0-2.2, RSF Good AQAI = 9.3 and above, RSF Fair AQAI = 5.5 – 9.2, and RSF Poor AQAI = 0 – 5.4.

The next Level 3 measurement was macroinvertebrate diversity, show in Figure 109. Georgia was not able to collect macroinvertebrate samples due to the dryness of the wetlands at the time. Classification of wetland condition was again based on percentiles as explained at the bottom of the figure for both wetland types. Generally, Alabama did not have good wetland condition as indicated by macroinvertebrates data whereas South Carolina data indicated better wetland condition. North Carolina's Piedmont wetland sites were clustered in two counties and the wetlands in Granville County (NE Piedmont) were classified as poor wetland condition based on macroinvertebrate data whereas the wetland sites in Cabarrus County (SW Piedmont) were classified as wetland condition.

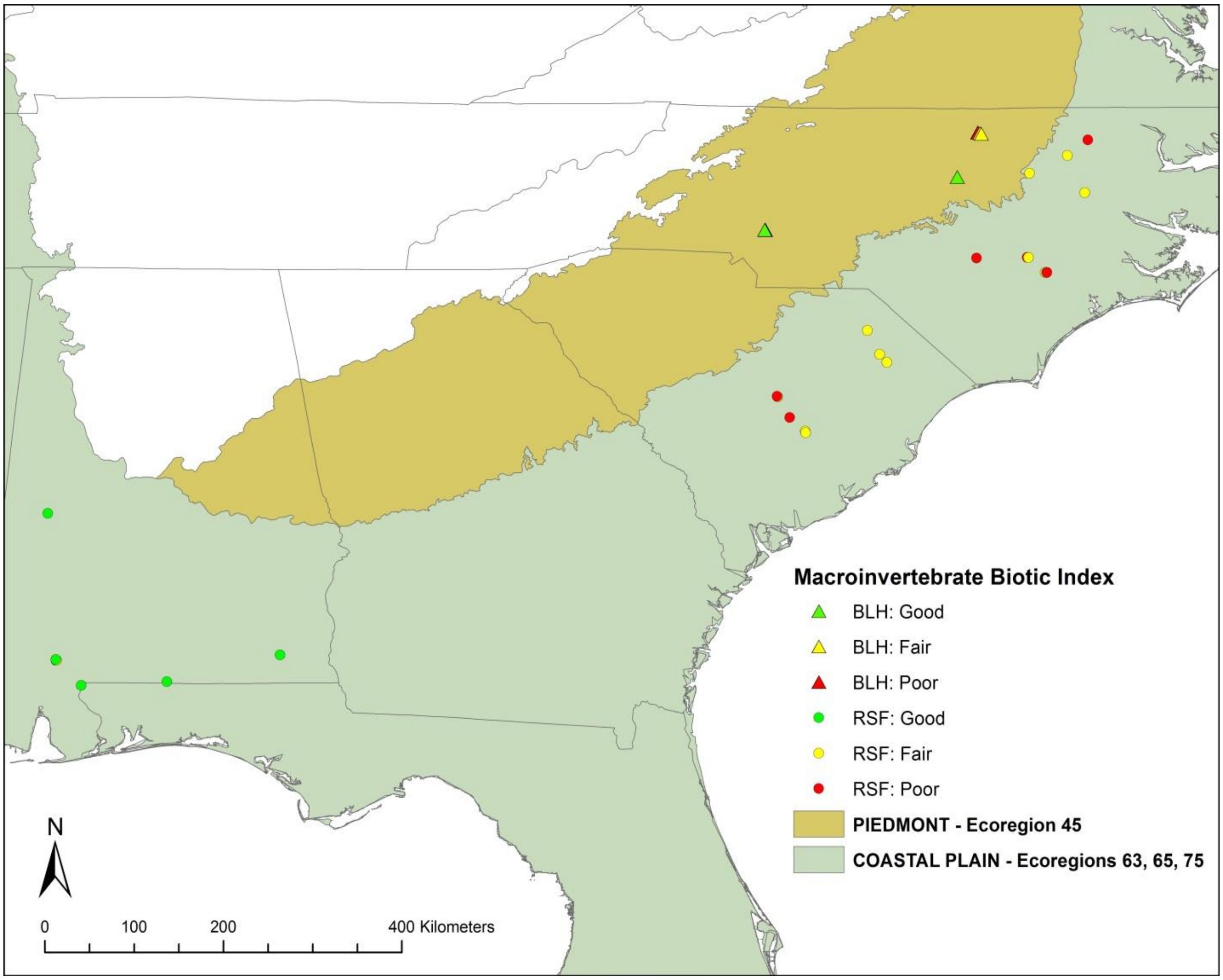
Figure 109: Wetland condition base on Macroinvertebrate diversity



Macroinvertebrate Diversity (MDiv) level classification was based on weighted lower (low) and upper (high) 25th percentiles, with the middle 50% percentile considered moderate. Percentiles were calculated separately for BLH and RSF. BLH High MDiv = 0.56 and above, BLH Moderate MDiv =0.40 – 0.55, BLH Low MDiv = 0-0.40, RSF High MDiv = 0.83 and above, RSF Moderate MDiv = 0.71 – 0.82, and RSF Low MDiv = 0 – 0.70.

Figure 110 shows wetland condition based on the macroinvertebrate biotic index (MBI), which takes into account number of individuals (abundance) as well as number of species (diversity). As stated previously there were no macroinvertebrate data available from Georgia due to drought conditions. Based on this data from other states, Alabama's wetland sites were generally classified in good condition whereas North and South Carolina had more wetland sites in moderate to poor condition based on the MBI. For North Carolina, Piedmont wetland sites were in better condition for macroinvertebrates based on the MBI.

Figure 110: Wetland Condition based on Macroinvertebrate Biotic Index (MBI).



Macroinvertebrate Biotic Index (MBI) level classification was based on weighted lower (low) and upper (high) 25th percentiles, with the middle 50% percentile considered moderate. Percentiles were calculated separately for BLH and RSF. BLH Good MBI = 2.23 and above, BLH Fair MBI =1.93 – 2.22, BLH Poor MBI = 0-1.92; RSF Good MBI = 3.80 and above, RSF Fair MBI =2.06 – 3.79, RSF Poor MBI = 0-2.05.

Level 3 intensive survey results gave a differed picture of wetland condition depending on the broad category of metrics. The wetland condition based on vegetation data/results indicate the poorest wetland condition whereas wetland condition based on macroinvertebrates results indicated a condition generally condition in general. The amphibian results indicate a condition generally intermediary between results indicated by the previous two categories, vegetation and macroinvertebrates.

Overall, there was a tendency for the Leve 1 assessment (LDI scores) to overestimate condition/underestimate impairments with Level 3 assessments (biotic measurements) indicating more wetlands in impaired/poor condition. The rapid assessment methods (Level 2) had ORAM indicating good wetland condition but USA-RAM showing poorer condition wetlands.

The next set of figures ranks sites on composite scores representing wetland condition. These scores were based on based on the following metrics:

- LDI 300m
- ORAM (out of 90)
- NCWAM
- USARAM
- AQAI
- MBI
- VegIBI
- Soil Combined Metals (Cu, Mg, Zn)
- Water Quality Nutrients (P+TKN)

The ranking was based on wetland type using 63 bottomland hardwood forest wetland sites in the Piedmont (ecoregion 45) and 70 riverine swamp forest wetland sites in the coastal plain (ecoregion 65). For each metric, each site was ranked from best to worst (a rank of 1 was the best); equal variable values were given the middle rank of those values. Because some variables (metric values) were not collected on every site, the ranks were adjusted to reflect what they would have been if all sites had that variable measured. This was done with this formula:

$$Adjusted\ rank = \left(\frac{rank}{number\ of\ sites\ with\ data}\right) * number\ of\ total\ sites$$

The adjusted ranks were then averaged for each site, to arrive at a composite rank. In principle composite scores give a more reliable and integrative measure of overall wetland condition and therefore more representative than any one single measure.

Figure 111 shows the results of the composite ranking for the four-state region by wetland type overlayed on a map showing ecoregion boundaries. These results clearly show that the bottomland hardwood forest sites in the Piedmont region were in poorer condition than the riverine swamp forest wetland sites in the Coastal Plain. As pointed out earlier, the Piedmont region in these states has been heavily farmed in the past and is where most of the cities are today, so the poorer condition of the wetands in the Piedmont is not a surprise. North Carolina generally had more wetlands in fair to poor condition in the Coastal Plain relative to the other states.

The next set of figures (112-115) show the same composite scores, but by state and showing more detail as there is one figure per state and the data is overlain top of airial photography. Figure 112 shows the North Carolina wetlands. None of the wetlands in the Piedmont were in good condition, whereas the wetlands in the Coastal Plain were in better condition. Figure 113 shows the condition of South Carolina's wetlands based on the composite scores. South Carolina did have a few bottomland hardwood forest wetlands in good condition in the

Piedmont but with the coastal plain wetlands in better contion. Figure 114 show Alabama's wetlands. Alabama also had a few wetlands in good condition in the Piedmont region, but their riverine swamp forest wetlands were in better condition in the Coastal Plain. Finally, figure 115 shows Georgia's wetlands based on the composite score. Georgia's Piedmont wetlands were in relatively poor condition with their Coastal Plain wetlands in better condiotion.

Figure 111: Composite rank map for the Southeast region. Good = best 25%, fair = middle 50%, poor = worst 25%

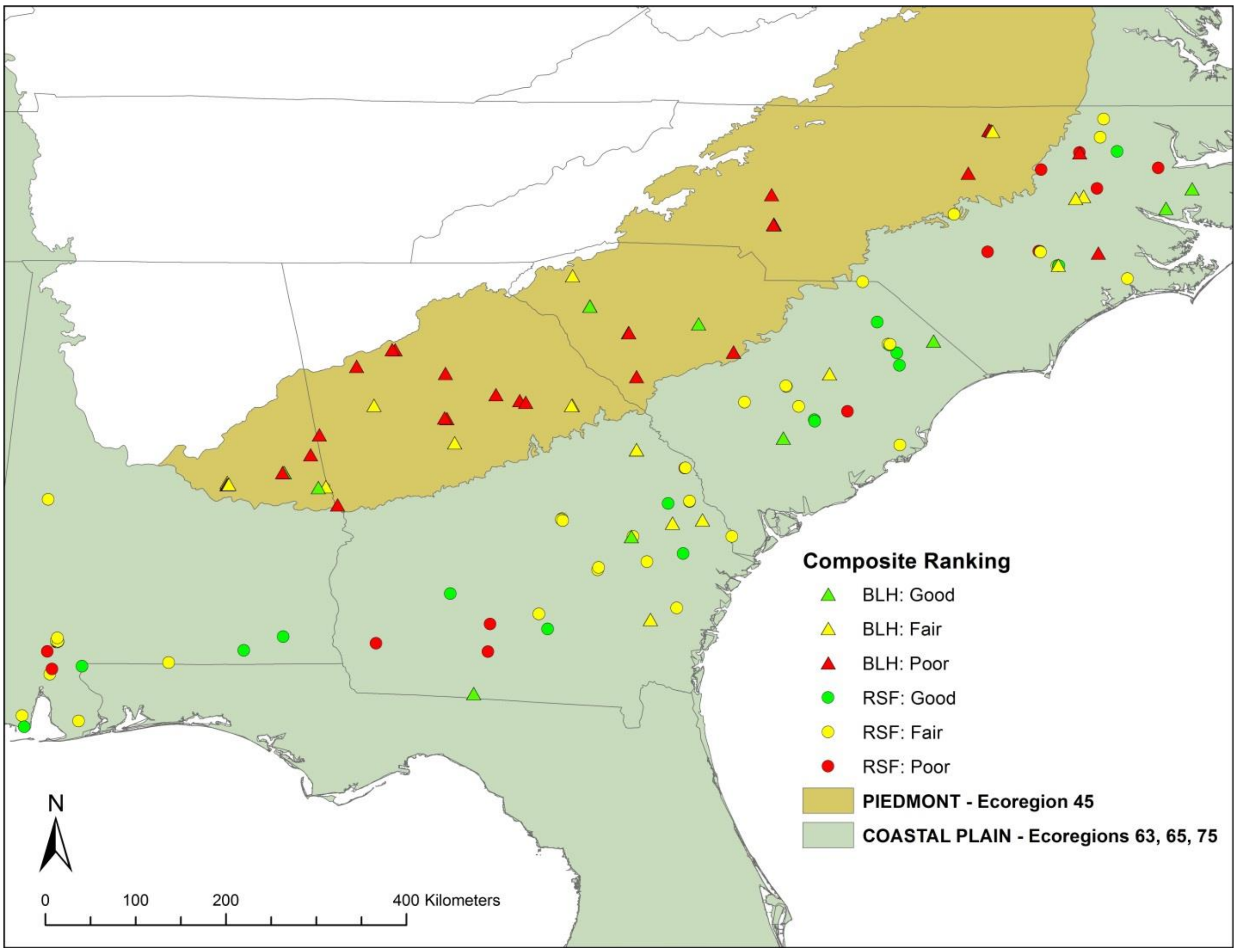


Figure 112: Composite rank map for wetland sites in North Carolina. Good = best 25%, fair = middle 50%, poor = worst 25%.

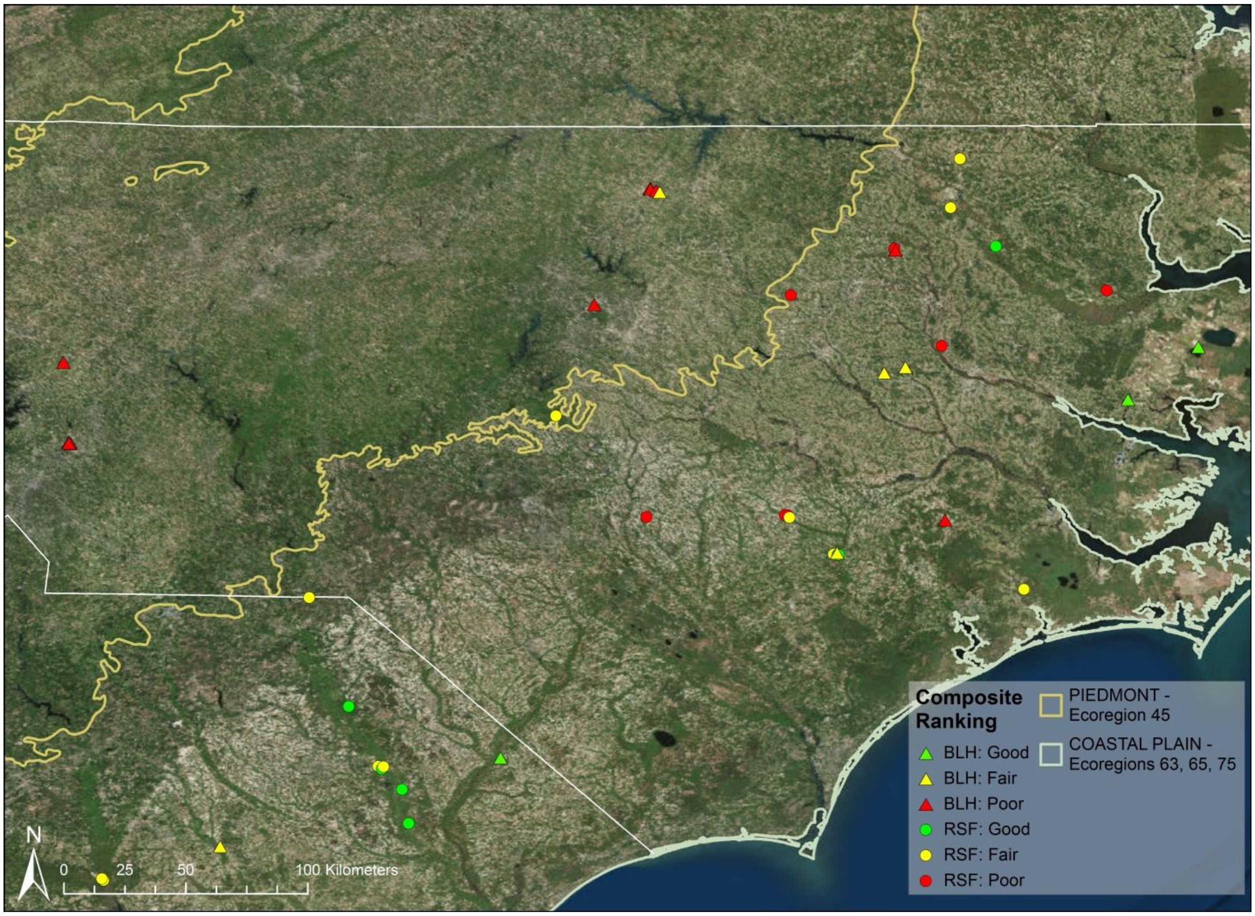


Figure 113: Composite rank map for wetland sites in South Carolina. Good = best 25%, fair = middle 50%, poor = worst 25%.

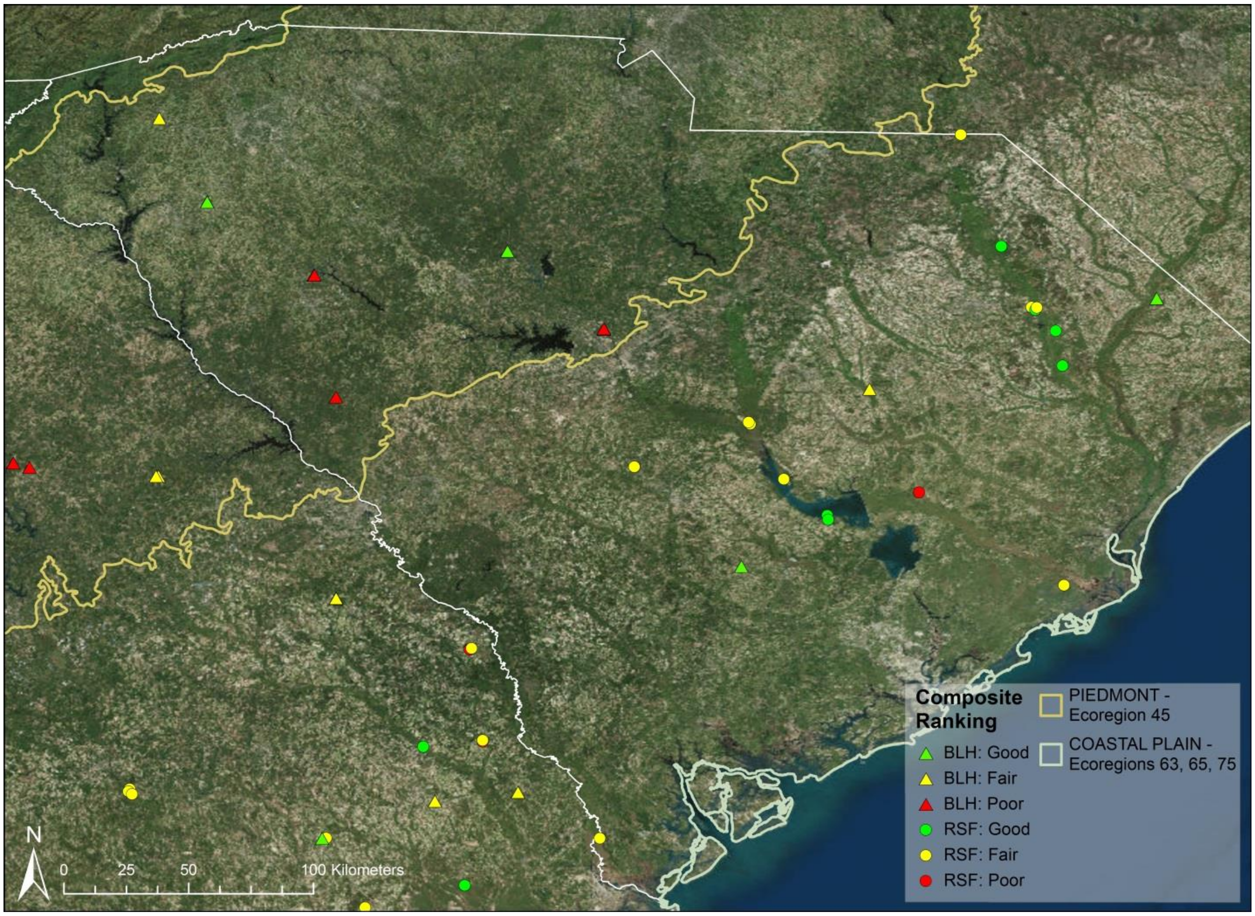


Figure 114: Composite rank map for wetland sites in Alabama. Good = best 25%, fair = middle 50%, poor = worst 25%.

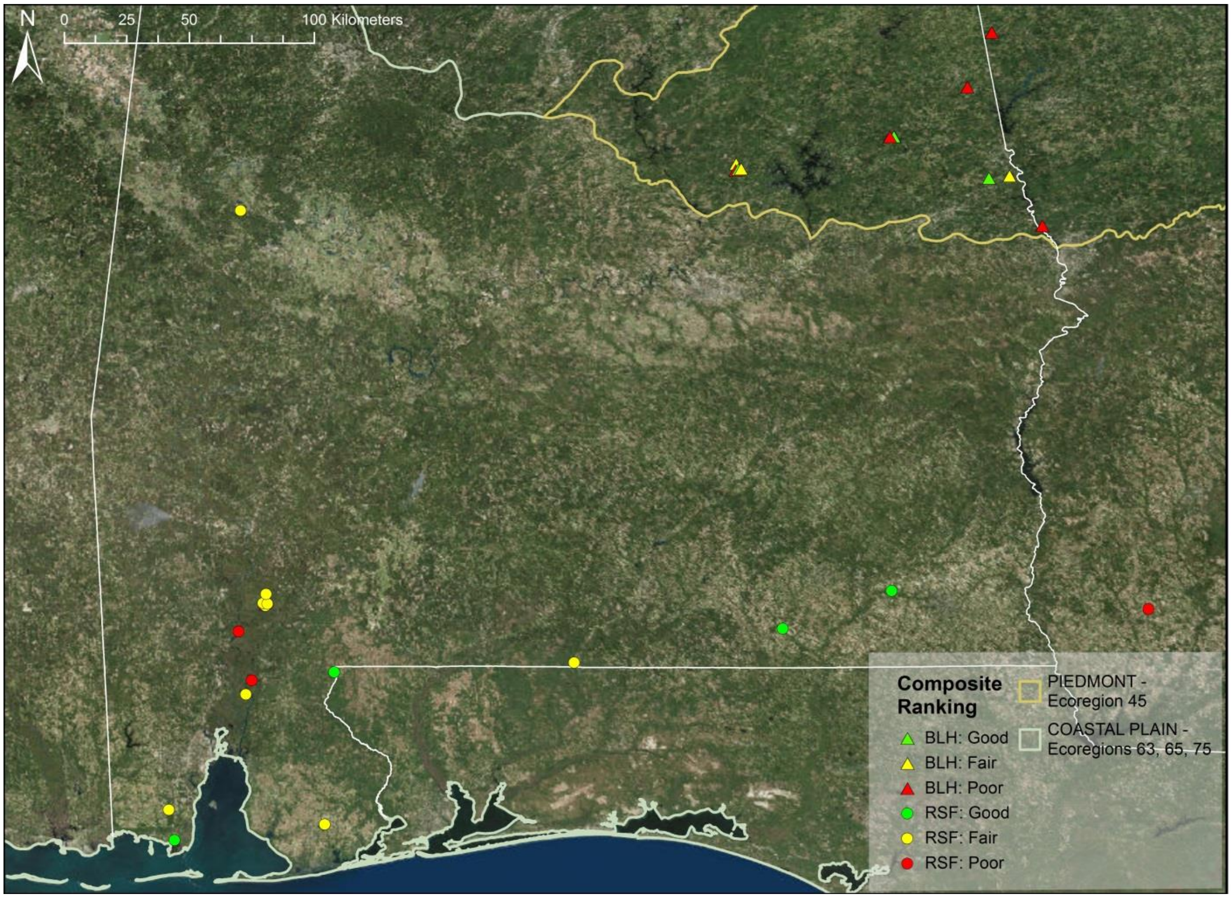


Figure 115: Composite rank map for wetland sites in Georgia. Good = best 25%, fair = middle 50%, poor = worst 25%.

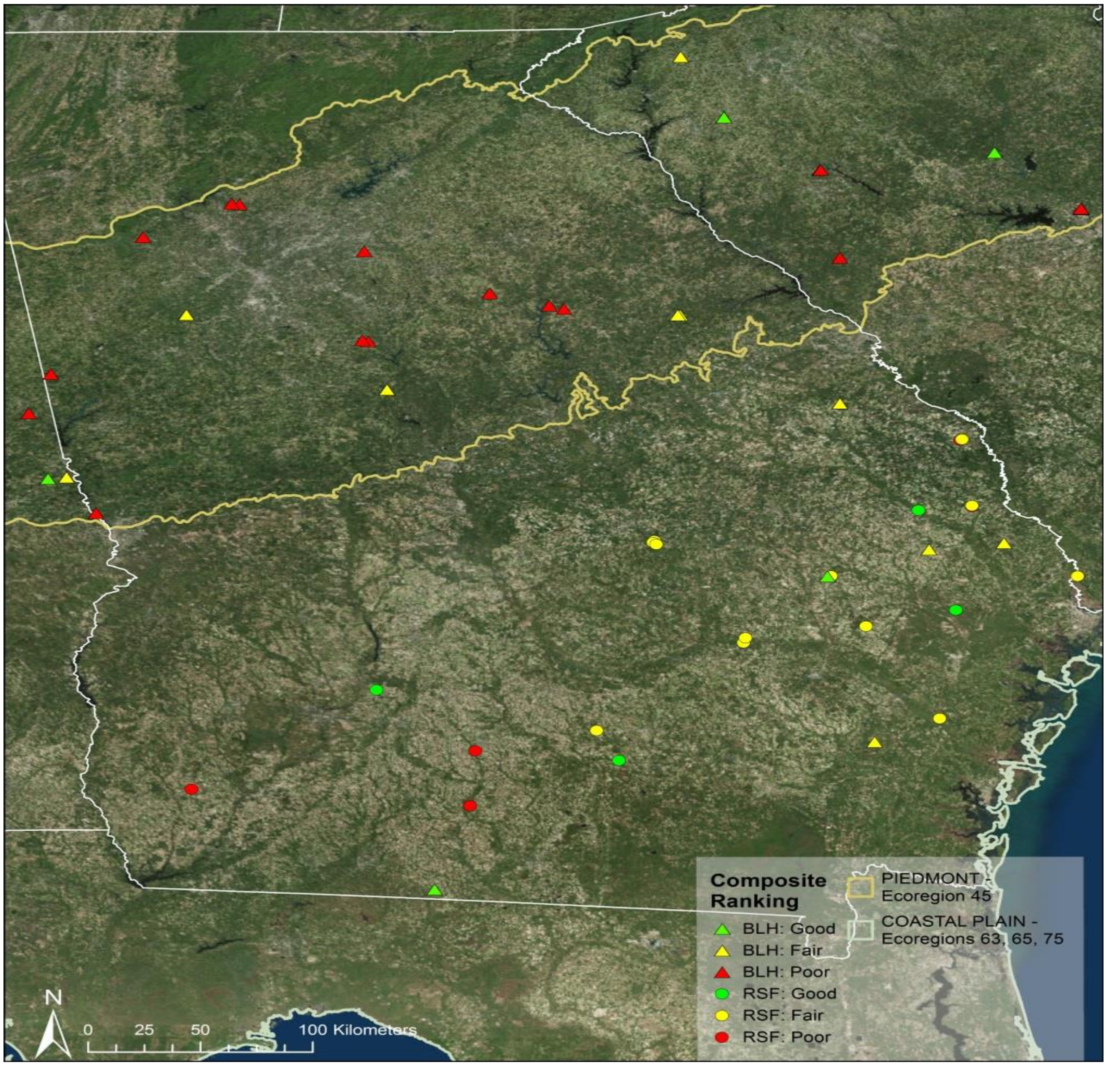
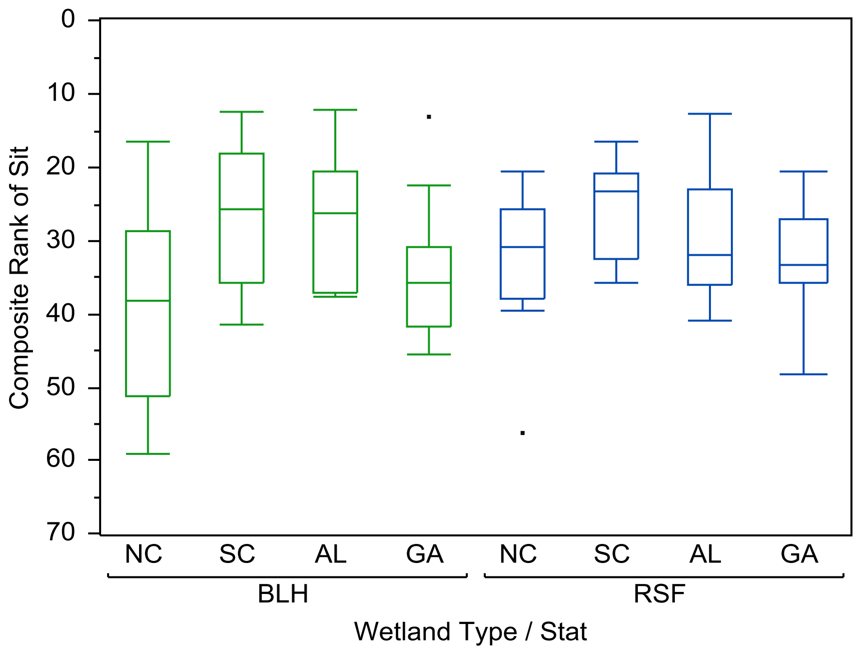


Figure 116 shows the overall comparision of wetland type by state. Bottomland hardwood forest wetland sites in North Carolina and Georgia were in relatively poorer conition (Piedmont region). For the riverine swamp forest wetland sites, South Carolina's wetland sites were in better condition relative to the other three states.

Figure 116: Composite rank of sites by state and wetland type.



CONCLUSIONS

This project was a coordinated effort of four states (NC, SC, AL, and GA) to combine their efforts such that a regional scale effort to monitor/survey forested wetlands in two ecoregions (45 and 65). By using the same methodology to collect wetland data, comparison could be made between states and data combined to perform a regional analysis of wetland condition. Wetlands were selected by the EPA from the sample used for the National Wetland Condition Assessment so that this data can contribute to a national wetland assessment.

It could be said that wetland condition is in the eye of the beholder or in this case the measured indicator as some indicators can show good wetland condition while others can show poor wetland condition. This is not necessarily bad in that different stressors act on wetlands and will have different affect on wetlands. What is good for vegetation may be bad for amphibians and water quality or what is good for macroinvertebrates may be bad for hydrology and so forth. By looking a multiple indicators specific wetland problems can be indentified and therefore specific solutions can be addressed, or not. The best management decisions can be made on data and specifically data which indicate specific wetland conditions.

The results of this project show wetlands in the Southeast (specifically the four-state) region to be in relatively good condition. Some trends are noted such as the bottomland hardwood forest wetlands in the Piedmond ecoregion tend to be more stressed/disturbed than the riverine swamp forest in the Southeast Coastal Plains ecoregion. If is felt that these differences are due to the recoregion differences rather thand the fact they are different types of forested wetlands. Furthermore, of the four states, NC's riverine swamp forest are dealing with more stressors, probably due to the hog, chicken, and turkey farms that near several of the sites, especially in Duplin County. A significant result was the improvement of water quality samples as water moved from upstream to downstream in riverine swamp forest wetlands. This result is an indication that riverine systems can filter potential pollutants as water flows through the wetland system.

This multi-state effort was a significant effort as it allowed for a regional scale type of analysis on many levels (landscape to intensive sureys) with much valuable data collected. Much more analysis can be done and this effort should just be the first of many more.

LITERATURE CITED AND OTHER RELEVANT LITERATURE

Andreas, B. K. and J. J. Mack, J. S. McCormac. 2004. Floristic Quality Assessment Index for Vascular Plants and Mosses for the State of Ohio. Wetland Ecology Group, Division of Surface Water, Ohio Environmental Protection Agency, Columbus, Ohio.

Axt, J. R. and M. R. Walbridge. 1999. Phosphate removal capacity of palustrine forested wetlands and adjacent uplands in Virginia. Soil Science Society of America Journal 63(4): 1019-1031.

Azous, A. L. and R.R. Horner, eds. 2001. Wetlands and Urbanization. Boca Raton, FL: Lewis Publishers.

Baker, V., R. Savage, C. Reddy, and M. Turner. 2008. Development of a wetland monitoring program for headwater wetlands in North Carolina. Final Report. EPA Grant CD 974260-01, North Carolina Department of Environment and Natural Resources (NC DENR), North Carolina Division of Water Quality (NC DWQ). Raleigh, NC.

Baker, V., A. Keyworth, D. Tufford, R. Vander Vorste, R. Bolich, C. Williams, W. Hankinson, R. Milosh, R. Savage, and A. Mueller, February 2013, “Hydrologic Connectivity, Water Quality Function, and Biocriteria of Coastal Plain Geographically Isolated Wetlands”, Final Report. EPA Grant CD 95415809. North Carolina Department of Environment and Natural Resources (NC DENR), North Carolina Division of Water Quality (NC DWQ). Raleigh, NC.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Batzer, D.P. and R.R. Sharitz, eds. 2006. Ecology of freshwater and estuarine wetlands. Berkeley, California University of California Press.

Bornette, G., C. Amoros, and N. Lamaroux. 1998. Aquatic plant diversity in riverine wetlands: the role of connectivity. Freshwater Biology. 39:267-283.

Boynton, A.C. 1994. Wildlife use of Southern Appalachian wetlands in North Carolina. Journal Water, Air, & Soil Pollution 77:3-4 pp. 349-358.

Braccia, A. and D.P. Batzer. 2001. Invertebrates associated with woody debris in a southeastern U.S. forested floodplain wetland. Wetlands 21:1 pp.18-31.

Braswell, A. 2006-2013. Personal Communication. Lab Director and Curator for Herpetology, NC State Museum of Natural Sciences Research Laboratory (NCDENR).

Bressler, D., J. Stribling, M. Paul, and M. Hicks. 2006. Stressor tolerance values for benthic macroinvertebrates in Mississippi. Hydrobiologia (2006) 573:155-172.

Brigham A. R., W. U. Brigham, and A. Gnilka. 1982. Aquatic Insects and Oligochaetes of North and South Carolina, a study sponsored by Duke Power Company. Midwest Aquatic Enterprises, Mahomet, IL.

Brower, J.E. and J.H. Zar. 1977. Field and laboratory methods for general ecology. Wm. Brown Company, Dubuque, Iowa.

Brown, M.T. and M.B. Vivas. 2003. A Landscape Development Intensity Index. Center for Environmental Policy, Department of Environmental Engineering Sciences, University of Florida. Technical Report Submitted to the Florida Department of Environmental Protection.

Cashin, G., J. Dorney, and C. Richardson. 1992. Wetland Alteration Trends in the North Carolina Coastal Plain, Wetlands 12(2): 63-71.

Chirhart, J. 2003. Development of a Macroinvertebrate Index of Biological Integrity (MIBI) for Rivers and Streams of the St. Croix River Basin in Minnesota. Minnesota Pollution Control Agency Biological Program. St. Paul, MN.

Collins, J. and M. S. Fennessey. 2009. USA-RAM draft manual, (http://www.epa.gov/oamhpod1/adm_placement/sapcbd/rapid.htm)

Crossett, K.M., T.J. Cullinton, P.C. Wiley, and T.R. Goodspeed. 2004. Population trends along the coastal United States: 1980-2008. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. National Ocean Service, Management and Budget Office, Special Prjects, Silver Springs, MD.

Darke, A. K. and M. R. Walbridge. 2000. Al and Fe biogeochemistry in a floodplain forest: Implications for P retention. Biogeochemistry 51(1):1-32.

Dahl, T. E., and Johnson, C. E. 1991. Wetlands—Status and trends in the conterminous United States, mid-1970's to mid-1980's: Washington, D.C., U.S. Fish and Wildlife Service.

Dahl, T.E. 2011. *Status and Trends of Wetlands in the Conterminous United States 2004 to 2009.* U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. http://www.fws.gov/wetlands/Status-And-Trends-2009/index.html.

Dorney J. D. 2009, Personal communication, North Carolina Division of Water Quality.

Downing, D.M., C. Winer, and L.D. Wood. 2003. Navigating through Clean Water Act jurisdiction: a legal review. Wetlands 23(3):475−493.

Eaton, L. and R. Vander Vorste. 2012. Final Report: Documenting Significant Nexus to Naviagable Waters in the Southeast. EPA Grant # CD 95415609-0.

Environmental Laboratory. 1987. US Army Corps of Engineers Wetlands Delineation Manual. U.S. Army Engineers Waterways Experiment Station, Vicksburg, MS.

Ervin, G.N., B.D. Herman, J.T. Bried, and D.C. Holly. 2006. Evaluating non-native species and wetland indicator status as components of wetlands floristic assessment. Wetlands 26:1114-1129.

Esheleman. K. N., J.S. Pollard, and A. Kuebler. 1992. "Interactions between Surface Water and Groundwater in a Virginia Coastal Plain Watershed." Virginia Water Resources Research Center.

Fennessy, M.S., R. Geho, B. Elifritz, and R.D. Lopez. 1998a. Testing the floristic quality assessment index as an indicator of riparian wetland quality. Final Report to U.S. EPA. Ohio Environmental Protection Agency, Division of SurfaceWater, Columbus, Ohio, USA.

Fisher, M. M., and K. R. Reddy. 2001. Phosphorus flux from wetland soils affected by long-term nutrient loading. Journal of Environmental Quality 30:261-271.

Garbarino, J., H. Hays, D. Rogh, R. Antweiler, T. Brinton, and H. Taylor. 1995. Contamination in the Mississippi River. *USGS Circular 113* (https://pubs.USGS.gov/circ/circ1133/heavy-metals.html).

Ghosh, M. and J. N. K. Rao. 1994. Small Area Estimation: An Appraisal. Statistical Science, Vol. 9, No. 1 (Feb., 1994), pp. 55-76

Gianopulos, K. 2014. Developing coefficients of conservatism to facilitate floristic quality assessment of wetlands in the Southeastern United States. Natural Areas Journal. *In review.*

Gibbons, J. W. and R. D. Semlitsch 1981. "Terrestrial drift fences with pitfall traps: an effective technique for quantitative sampling of animal populations" *Brimleyana* 7: 1-16

Gibbons, Whitfield J. 2003. "Terrestrial Habitat: A Vital Component for Herpetofauna of Isolated" *Wetlands*. 23: 630-635.

Gibbons, W., C. Winne, D. Scott, J. Willson, X. Glaudas, K. Andrews, B. Todd, L. Fedewa, L. Wilkinson, R. Tsaliagos, S. Harper, J. Greene, T. Tuberville, B. Metts, M. Dorcas, J. Nestor, C. Young, T. Akre, R. Reed, K. Buhlmann, J. Norman, D. Croshaw, C. Hagen, and B. Rothermal. 2005. "Remarkable Amphibian Biomass and Abundance in an Isolated Wetland:

Implications for Wetland Conservation”. *Conservation.* 20: 1457-1465.

Gilliam, F. S. 1988. Interactions of fire with nutrients in the herbaceous layer of a nutrient-poor Coastal Plain forest. Bulletin of the Torrey Botanical Club 115:265-271.

Godfrey, R.K., and J.W. Wooten. 1979. Aquatic and wetland plants of southeastern United States: monocotyledons. University of Georgia Press. Athens, USA.

Godfrey, R.K. and J.W. Wooten. 1981. Aquatic and wetland plants of the southeastern United States: dicotyledons. University of Georgia Press. Athens, USA.

Godfrey, R.K. 1988. Trees, shrubs, and woody vines of northern Florida and adjacent Georgia and Alabama. University of Georgia Press. Athens, USA.

Gore J.A., D.J. Crawford, D.S. Addison. 1998. An analysis of artificial riffles and enhancement of benthic community diversity by Physical Habitat Simulation (PHABSIM) and direct observation. Regulated Rivers: Research and Management. 14: 69–77.

Graubard BI and Korn EL. 1999. Predictive margins with Survey Data. Biometrics. 55:652-659.

Harper, E.B., T.A.G. Rittenhouse, and R.D. Semlitsch. 2008. Demographic consequences of terrestrial habitat loss for pool-breeding amphibians: Predicting extinction risks associated with inadequate size of buffer zones. Conservation Biology 22(5):1205-1215.

Hefner, J.M., B.O. Wilen, T.E. Dahl and WE. Frayer. 1994. Southeast Wetlands; Status and Trends, Mid-1970's to Mid-1980's. U .S. Department of the Interior, Fish and Wildlife Service, Atlanta, Georgia.

Hendricks, E.L., and M.H. Goodwin. 1952. Water-level fluctuations in limestone sinks in southwest Georgia. Pp. 157-245. In Contributions of hydrology of the United States, 1948-1952. U.S. Geological Survey Water Supply Paper 1110.

Herman, B. D., J. D. Madsen, G. N. Ervin. 2006. Development of Coefficients of Conservatism for Wetland Vascular Flora of North and Central Mississippi. Mississippi State, Department of Biological Sciences, GeoResources Institute Report.

Hill, T., E. Kulz, B. Munoz, and J. Dorney. 2011. Compensatory stream and wetland mitigation In North Carolina: an evaluation of regulatory success. North Carolina Department of Natural Resources, Division of Water Quality. Raleigh, NC.

Hobbs, H.H., Jr., and M. Whiteman. 1991. Notes on the burrows, behaviors, and color of the crayfish Fallicambarus (F.) devastator. *Southwestern Naturalist* 36:127–135.

Hodges, J.D. 1997. Development and ecology of bottomland hardwood sites. *Forest Ecology and Management*. 90: 117- 125.

Hupp, C.R. 2000. Hydrology, geomorphology and vegetation of Coastal Plain rivers in the south-eastern USA. *Hydrological Processes* 14: 2991-3010.

Karr, J. R. and E. W. Chu. 1999. Restoring life in running waters: better biological monitoring. Island Press, Washington D. C.

Kellison, R.C. and M.J. Young 1997. The Bottomland Hardwood Forest of the southern United States. *Forest Ecology & Management* 90: 101-115.

Kutka Franz, Marilyn Bachman. 1990. Acid sensitivity and water chemistry correlates in Northern WI, USA. *Hydrobiologia*. V 208. N3.

Leeper, D. A. and B. E. Taylor. 1998. "Insect emergence from South Carolina (USA) temporary pond, with emphasis on the Chironomidae (Diptera)". *Journal of the North American Benthological Society.* 17:54-72.

Legg, J. C. and W. A. Fuller. 2009. Two-Phase Sampling, Chapter 3 –C.R. Rao, Editor(s), Handbook of Statistics, Elsevier, Volume 29, Part A, Pages 55−70.

Lemly, J. and J. Rocchio. 2009.Vegetation Index of Biotic Integrity (VIBI) for Headwater Wetlands in the Southern Rocky Mountains, vs. 2.0 calibration of selected VIBI Models. Colorado Natural Heritage Program, CO State University, Fort Collins, CO.

Lefcort, H. RA Meguire, LH Wilson and W F Ettinger. 1998. Heavy metals alter the survival, growth, metamorphasis, and anti predatory behavior of Columbia Spotted Frog (*Rana luteivenstris*) tadpoles. *Archives of Environmental Contamination and Toxicology*. V. 35, N3. http.nap.edu/openbook.php?record_id=661&page=46.

Lenat, D. 1993. A biotic index for the southeastern United States: derivation and list of tolerance values, with criteria for assigning water-quality ratings. J. N. Am. Benthol. Soc. 12(3):279-290.

Lopez, R.D. and M.S. Fennessy 2002. Testing the Floristic Quality Assessment Index as an indicator of wetland condition. *Ecological Applications* 12:487-497.

Mack, J.J. 2001. Ohio EPA Rapid Assessment Method for Wetlands, Manual for Using Version 5.0. Ohio EPA Technical Bulletin Wetland/2001-1-1. Ohio Environmental Protection Agency, Division of Surface Water, 401 Wetland Ecology Unit, Columbus, Ohio.

Mack, John J. (2004). Integrated Wetland Assessment Program. Part 4: A Vegetation Index of Biotic Integrity (VIBI) and Tiered Aquatic Life Uses (TALUs) for Ohio wetlands. Ohio EPA Technical Report WET/2004-4. Ohio Environmental Protection Agency, Wetland Ecology

Group, Division of Surface Water, Columbus, Ohio.

Mack, J.J. (2004). Integrated wetland assessment program. Part 9: Field manual for the vegetation index of biotic integrity for wetlands v. 1.3. Ohio EPA Technical Report WET/2004-9. Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water, Columbus, Ohio.

Mahoney, D. S., M. A. Mort and B. E. Taylor. 1990. Species richness of calanoid copepods, cladocerans and other branchiopods in Carolina bay temporary ponds. *American Midland Naturalist.* 123:244-258.

Meade, R.H., T.R. Yuzyk, and T.J. Day 1990. Movement and storage of sediment in rivers of the United States and Canada. In Surface Water Hydrology, the Geology of North America, Wolman, M.G. and H.C. Riggs (Eds.). Geological Society of America: Boulder, Colorado; 225-280

Merritt, R.W., K. W. Cummins, and M. B. Berg. 1996. An Introduction to the Aquatic Insects of North America, fourth edition. Kendall/Hunt Publishing Company, Dubuque Iowa.

Messina, Michael G., and William H. Conner 1998. *Southern Forested Wetlands.* Boca Raton. CRC Press LLC.

Mitsch, W. J. and J. G. Gosselink. 1993. Wetlands. New York, Van Nostrand Reinhold.

Mitsch, W.J. and J.G. Gosselink 2000. Wetlands, Third Edition. John Wiley & Sons, Inc. New York, New York.

Munsell Color. 1998. Munsell Soil color Charts 1998. Revised Washable Edition. GretagMacbeth, New Windsor, NY

National Geodetic Survey (NGS) 2004. Federal Geodetic Control Subcommittee specifications and procedures to incorporate electronic digital/bar-code leveling systems. Ver. 4.1 5/27/2004. Federal Geodetic Control Subcommittee, National Geodetic Survey, National Oceanic and Atmospheric Administration, CITY, STATE, USA. Available at http://www.ngs.noaa.gov/FGCS/tech_pub/Fgcsvert.v41.specs.pdf.

National Wetland Condition Assessment, 2010. Field Operations Manual. US Environmental Protection Agency.

The Nature Conservancy 1992. The forested wetlands of the Mississippi River: An ecosystem in crisis. Nature Conservancy, Baton Rouge.

Nelson, J.B. 1986. The natural communities of South Carolina: initial classification and description. South Carolina Wildlife and Marine Resources Department, SC.

Newman, M. C. and J. F. Schalles 1995. "The Water Chemistry of Carolina Bays: a Regional Study." *Archive für Hydrobiologie* 118:147-168.

North Carolina Department of Environment and Natural Resources (NC DENR) 2004. North Carolina Division of Water Quality (NC DWQ), The Quality Assurance Manual for the NC DWQ Laboratory Section North Carolina Division of Water Quality (NC DWQ), North Carolina Division of Water Quality (NC DWQ), Laboratory Section, Raleigh, USA.

North Carolina Department of Environment and Natural Resources (NC DENR) 2005. North Carolina Division of Water Quality (NC DWQ), Laboratory Section. Laboratory Section Standard Operating Procedures, North Carolina Department of Environment and Natural Resources (NC DENR), North Carolina Division of Water Quality (NC DWQ), Raleigh, NC.

North Carolina Department of Environment and Natural Resources (NC DENR), North Carolina Division of Water Quality (NC DWQ) 2009. Laboratory Section Sample Submission Guidance Document North Carolina Department of Environment and Natural Resources, North Carolina Division of Water Quality, Raleigh, NC, USA. Available at http://portal.ncdenr.org/c/document_library/get_file?uuid=0f58d45f-35c4-48f8-84dc-a2d50f9820e5&groupId=38364.

NCDENR, Biological Assessment Branch 2013. Updated tolerance values for Southeastern benthic macroinvertebrates.

North Carolina Division of Water Quality (NC DWQ) 2012. Standard Operating Procedures for Benthic Macroinvertebrates. North Carolina Department of Environment and Natural Resources (NC DENR), Division of Water Quality, Raleigh, NC, USA.

North Carolina Natural Heritage Program (NC NHP) 2010. Natural Heritage Program list of the rare animal species of North Carolina. Raleigh, USA.

NC CREWS: North Carolina Coastal Region Evaluation of Wetland Significance. 1999. North Carolina Department of Environment and Natural Resources, Division of Coastal Mangement.

(NC DENR) N.C. Department of the Environment and Natural Resources. NC Natural Heritage Program. Natural Heritage Data. Accessed 3/4/2009. http://www.ncnhp.org

(NCDA&CS) N.C. Department of Agriculture and Consumer Services, Soil Testing Section. Soil Sample Information Lab Sheet (2007). http://www.ncagr.com/agronomi/pdffiles/issoil.pdf. Oct 2007.

(NCDA&CS) N.C. Department of Agriculture and Consumer Services, Soil Testing Section. 2006. http://www.ncagr.com/agronomistmethod.htm. July 2006.

(NC DENR) N.C. Department of the Environment and Natural Resources. 2003. NC Museum of Natural Sciences. Distribution of amphibians in North Carolina draft document. January 2003.

(NCDWQ) North Carolina Division of Water Quality. 2005. Laboratory Section: Sample Submission Guidance Document. North Carolina Division of Water Quality, Raleigh, NC. Available: http://h2o.enr.state.nc.us/lab/qa.htm.

(NCDWQ) North Carolina Division of Water Quality. 2003. Intensive Survey Unit Standard Operating Procedures. North Carolina Division of Water Quality, Raleigh, NC. Available: http://h2o.enr.state.nc.us/esb/isu.html.

(NCDWQ) North Carolina Division of Water Quality. 2003b. Quality Assurance Manual for the North Carolina Division of Water Quality Laboratory Section. Available: http://h2o.enr.state.nc.us/esb/qapp/labqam.pdf.

North Carolina and the Global Economy. 2004. Hog Farming. Accessed 4 March 2009. http://www.duke.edu/web/mms190/hogfarming/

North Carolina Wetland Assessment (NCWAM) User Manual .2010. v 4.1, http://portal.ncdenr.org/web/wq/swp/ws/pdu/ncwam-manual.

NC Wetland Functional Assessment Team. 2006. Committee to develop the N. C. Wetland Assessment Method.

NC Wetland Functional Assessment: Expansion and enhancement of the North Carolina Wetland Assessment Method, (NC WAM), grant WL 9643505-1.

Ohio EPA (Environmental Protection Agency) (2004). Integrated Wetland Assessment Program. Part 8: Initial Development of Wetland Invertebrate Community Index for Ohio. Ohio EPA Technical Report WET/2004-8. Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water, Columbus, Ohio.

Olsen, A. R. 2005, approx. Generalized Random Tessellation Stratified (GRTS) Spatially-Balanced Survey Designs for Aquatic Resources.

Omernik, J.M. 1987. Ecoregions of the conterminous United States. Map (scale 1:7,500,000). Annals of the Association of American Geographers 77(1):118-125.

Osmond, D.L., D.E. Line, J.A. Gale, R.W. Gannon, C.B. Knott, K.A. Bartenhagen, M.H. Turner, S.W. Coffey, J. Spooner, J. Wells, J.C. Walker, L.L. Hargrove, M.A. Foster, P.D. Robillard, and D.W. Lehning. 1995. Wetlands Loss and Degradation. WATERSHEDSS: Water, Soil and Hydro-Environmental Decision Support System,. Accessed 3 March, 2009. <http://www.water.ncsu.edu/watershedss/info/wetlands/wetloss.html#tree>

Peet R. K., T.R. Wentworth, R.P. Duncan, and P.S. White. 1997. The North Carolina vegetation survey protocol: A flexible, multipurpose method for recording vegetation composition and structure. Castanea 63:262−274.

Rader, R.B., D.P. Batzer, and S.A. Wissinger (eds.). 2001. Bioassessment and management of North American freshwater wetlands. John Wiley and Sons, New York, NY, USA.

Radford, A. E., H.E. Ahles, and C.R. Bell. 1968. Manual of the vascular flora of the Carolinas. University of North Carolina Press, Chapel Hill, USA.

Reddy, K.R., and R.D. DeLaune. 2008. Biogeochemistry of wetlands: science and applications. CRC Press, Boca Raton, FL.

Reiss, K.C. and M.T. Brown. 2005. The Florida Wetland Condition Index (FWCI): Developing biological indicators for isolated depressional forested wetlands. Final Report to the Florida Department of Environmental Protection, under contract #WM-683.

Resource Management Group, Inc. 1999. National list of plant species that occur in wetlands, Region 2, Southeast, B.J. Sabine (ed.), Dickinson Press, USA.

Rheinhardt, R. D., et al. 2002. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Wet Pine Flats on Mineral Soils in the Atlantic and Gulf Coastal Plains. ERDC/EL TR-02-9, US Army Corps of Engineers Engineer Research and Development Center Wetlands Reasearch Program: 97.

Rocchio, J. 2007. Floristic Quality Assessment Indices for Colorado plant communities. Colorado Natural Heritage Program: Colorado State University.

Savage, R., V. Baker, M. Turner, and S. Schwarzer. 2010. Field verification of wetland functional assessment methods within local watershed planning areas draft report. Report to the U.S. Environmental Protection Agency in fulfillment of EPA Wetlands Program Development Grant CD 96422105-0.

Schafale, M.P. and A.S. Weakley. 1990. Classification of the natural communities of North Carolina. Third approximation. North Carolina Department of Environment, Health, and Natural Resources, Division of Parks and Recreation, Natural Heritage Program, Raleigh, N.C.

Scott, D. E. 1994. The effect of larval density on adult demographic traits in *Ambystoma opacum. Ecology* 75:1383-1396.

Selley, R.C. 1988. Applied Sedimentology, Academic Press Limited.

Sharitz, Rebecca R. 2003. Carolina Bay Wetlands: Unique Habitats of the Southeastern United States *Wetlands*. 23: 550-562.

Sheehan, E. 2014. EPA, Personal Communication.

Simpson, E.H. 1949. Measurement of diversity. Nature 163:688.

Smith, S.D., and A.L. Braswell 1994. Preliminary investigation of acidity in ephemeral wetlands and the relationship to amphibian usage in North Carolina. Report submitted to NC Wildlife Resources Commission, Nongame and Endangered Wildlife Program, Raleigh, NC, USA.

Smock, L. A., and E. Gilinsky. 1992. Coastal Plain Blackwater Streams. Pages 271-313 *in* C. T. Hackney, S. M. Adams, and W. H. Martin, editors. Biodiversity of the Southeastern United States: Aquatic Communities. John Wiley & Sons, Inc., New York.

Sprecher, S.W. 2000. Installing Monitoring Wells/Piezometers in Wetlands. ERDC TN-WRAP-00-02, U.S. Army Research and Development Center, Vicksburg, MS.

Stribling J.B., J.S. White, B.J. Jessup, et al. 1998. Development of a benthic index of biotic integrity for Maryland streams. Report. Tetra Tech Incorporated, Owings, MD, USA

Stone, A. W., and A.J. Lindley Stone. 1994. Wetlands and Ground Water in the United States. The American Ground Water Trust, Dublin, OH, USA.

Taft, J.B., G.S. Wilhelm, D.M. Ladd, and L. A. Masters. 1997. Floristic Quality Assessment for Vegetation in Illinois, a method for assessing vegetation integrity. Erigenia 15:3-95.

Thien, S. J. 1979. A flow diagram for teaching texture by feel analysis. *Journal of Agronomy Education* 8:54-55.

U.S. Army Corps of Engineers (ACOE). 1987. Corps of Engineers Wetlands Delineation Manual. Final Report. U.S. Army Corps of Engineers, Waterways Experiment Station. Vicksburg, MD. 143pp.

U.S. Army Corps of Engineers. 2000. Installing Monitoring Wells/Piezometers in Wetlands. Wetland Regulatory Assistance Program, http://el.erdc.usace.army.mil/elpubs/pdf/tnwrap-2.pdf.

USDA, NRCS. 2012. The PLANTS Database (http://plants.usda.gov, 22 June 2012). National Plant Data Team, Greensboro, NC 27401−4901 USA.

U.S. Environmental Protection Agency (US EPA) 2002a. Methods for evaluating wetland condition: introduction to wetland biological assessment. Office of Water, U.S. Environmental Protection Agency, Washington, D.C., USA. EPA−822−R−02−014.

U.S. Environmental Protection Agency (US EPA) 2002b. Methods for evaluating wetland condition: study design for monitoring wetlands. Office of Water, U.S. Environmental Protection Agency, Washington, D.C., USA. EPA-822-R-02-015.

U.S. Environmental Protection Agency (US EPA) 2002d. Methods for evaluating wetland condition: developing an invertebrate index of biological integrity for wetlands. Office of Water, U.S. Environmental Protection Agency, Washington, D.C., USA. EPA-822-R-02-019.

U.S. EPA (U.S. Environmental Protection Agency) 1995. America's wetlands: Our vital link between land and water. Office of Water, Office of Wetlands, Oceans and Watersheds. EPA843-K-95-001.

U. S. EPA (2006). *Elements of a State Water Monitoring and Assessment Program for Wetlands.* Available here:
http://water.epa.gov/type/wetlands/upload/2006_04_19_wetlands_Wetland_Elements_Final.pdf (PDF) (12 pp, 90K)

U.S. EPA (U.S. Environmental Protection Agency) 2007. Invertebrates as Indicators of Prairie Wetland Integrity. U.S. Environmental Protection Agency. http://www.epa.gov/owow/wetlands/wqual/pph2_4.html#4.4.4.

U.S. EPA (U.S. Environmental Protection Agency) 2006, 2007. Polluted Runoff (Nonpoint Source Pollution). What is nonpoint source (NPS) pollution? http://www.epa.gov/owow/nps/qa.html.

U.S. EPA (U.S. Environmental Protection Agency) 2010. Field Operations Manual for the National Wetlands Condition Assessment.

Walbridge, M. R. and J. P. Struthers. 1993. Phosphorus Retention in Non-Tidal Palustrine Forested Wetlands of the Mid-Atlantic Region. Wetlands 13(2):84-94.

Van Sickle J. 2008. Assessing the attributable risks, relative risks, and regional extent of aquatic stressors. Journal of the North American Benthological Society. 27(4): 920-931.

Van Sickle J. 2013. Estimating the risks of multiple, covarying stressors in the National Lake Assessment. Freshwater Science. 32(1): 204-216.

Weakley, A. S. 2008. Flora of the Carolinas, Virginia, Georgia, Northern Florida, and Surrounding Areas. The University of North Carolina Herbarium. http://www.herbarium.unc.edu/flora.htm.

Wharton, C. H., W. M., Kitchens, E.C., Pendleton, and T. W. Sipe. 1982. The ecology of bottomland hardwood swamps of the southeast: a community profile. U. S. Fish and Wildlife Service, Office of Biological Services, Washington, DC, USA. FWS/OBS-81/37.

Weems, R.E., Lewis, W.C., Murray, J.H., Queen, D.B., Grey, J.B., and DeJong, B.D. 2011. Detailed sections from auger holes in the Elizabethtown 1:100,000-scale map sheet, North Carolina: U.S. Geological Survey Open-File Report 2011–1115.

Wilson, J.D., and M.E. Dorcas. 2003. Effects of habitat disturbance on stream salamanders: implications for buffer zones and watershed management. Conservation Biology 17:763−771.

Appendix A: Hydrographs

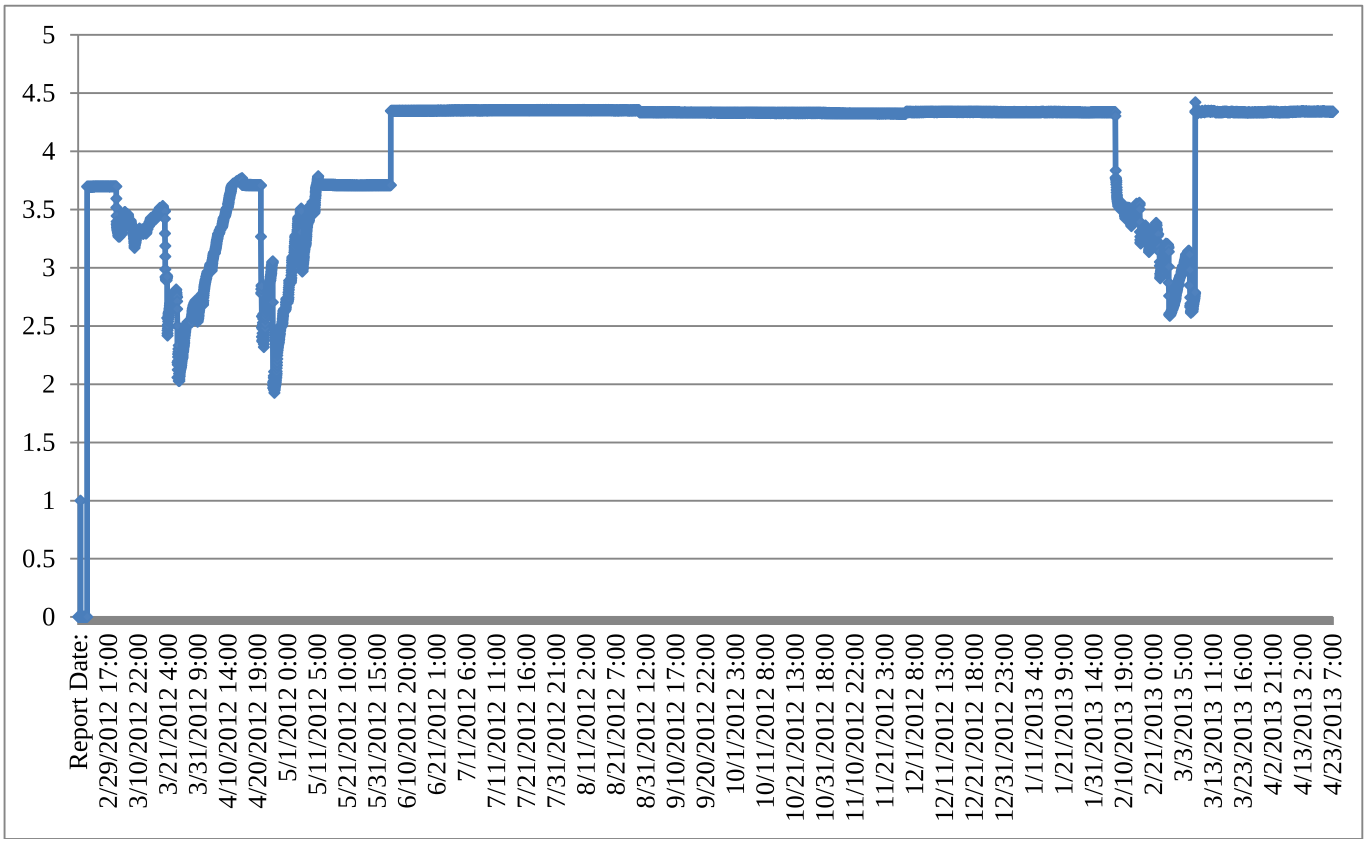
<u>Appendix A Table of Contents:</u>

A1: Hydrographs for NC BLH sites
A2: Hydrographs for NC RSF sites
A3: Hydrographs for SC RSF sties
A4: Hydrographs for AL RSF sites
A5: Hydrographs for GA BLH sites
A6: Hydrographs for GA RSF sties

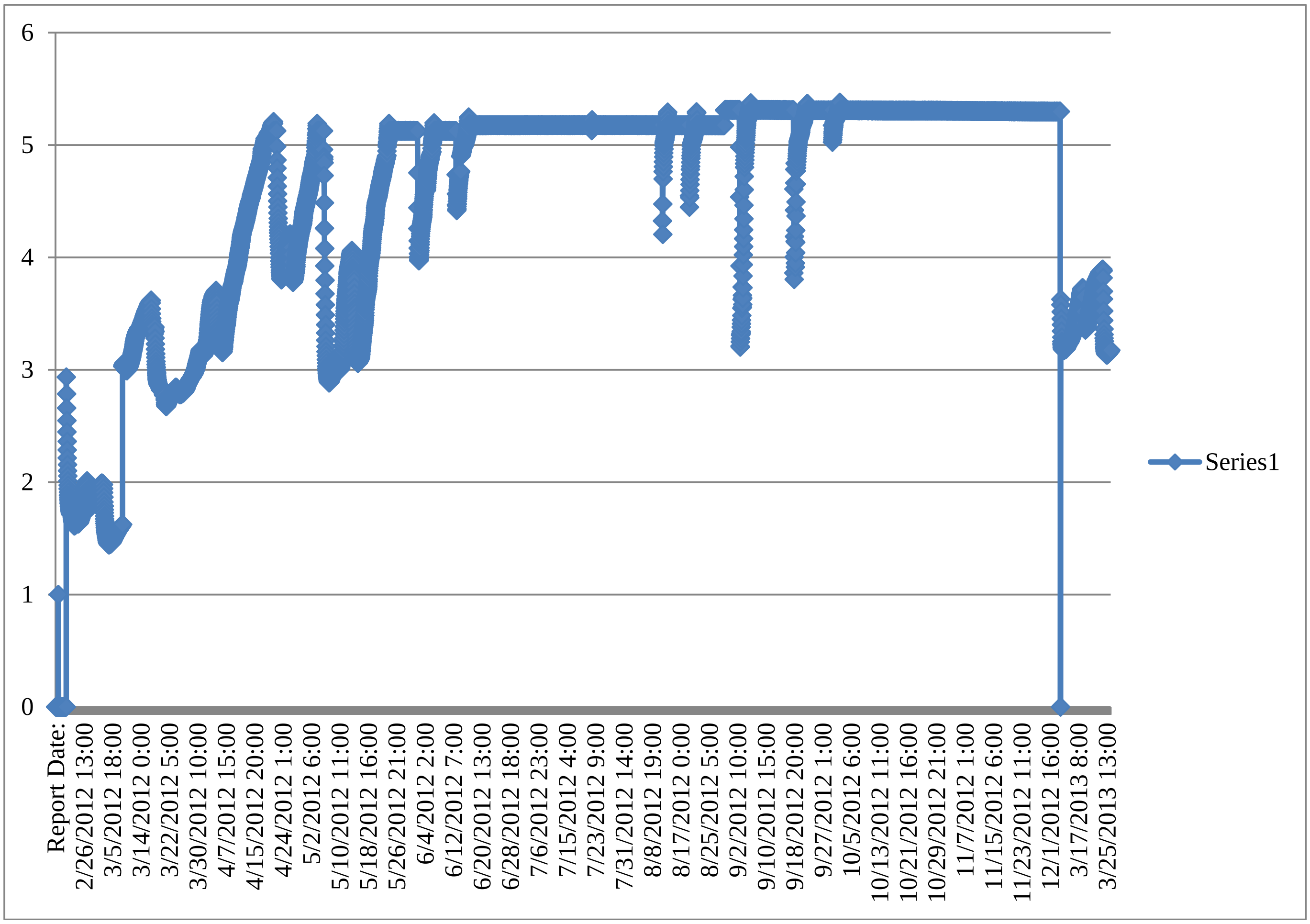
A1: Hydrographs for NC BLH sites

All hydrographs for NC are measured as depth to water. The zero value is the height of the well, and the deepest areas are where little or no water depth is being measured. As the graph lines move toward zero, the water levels are increasing toward the surface.

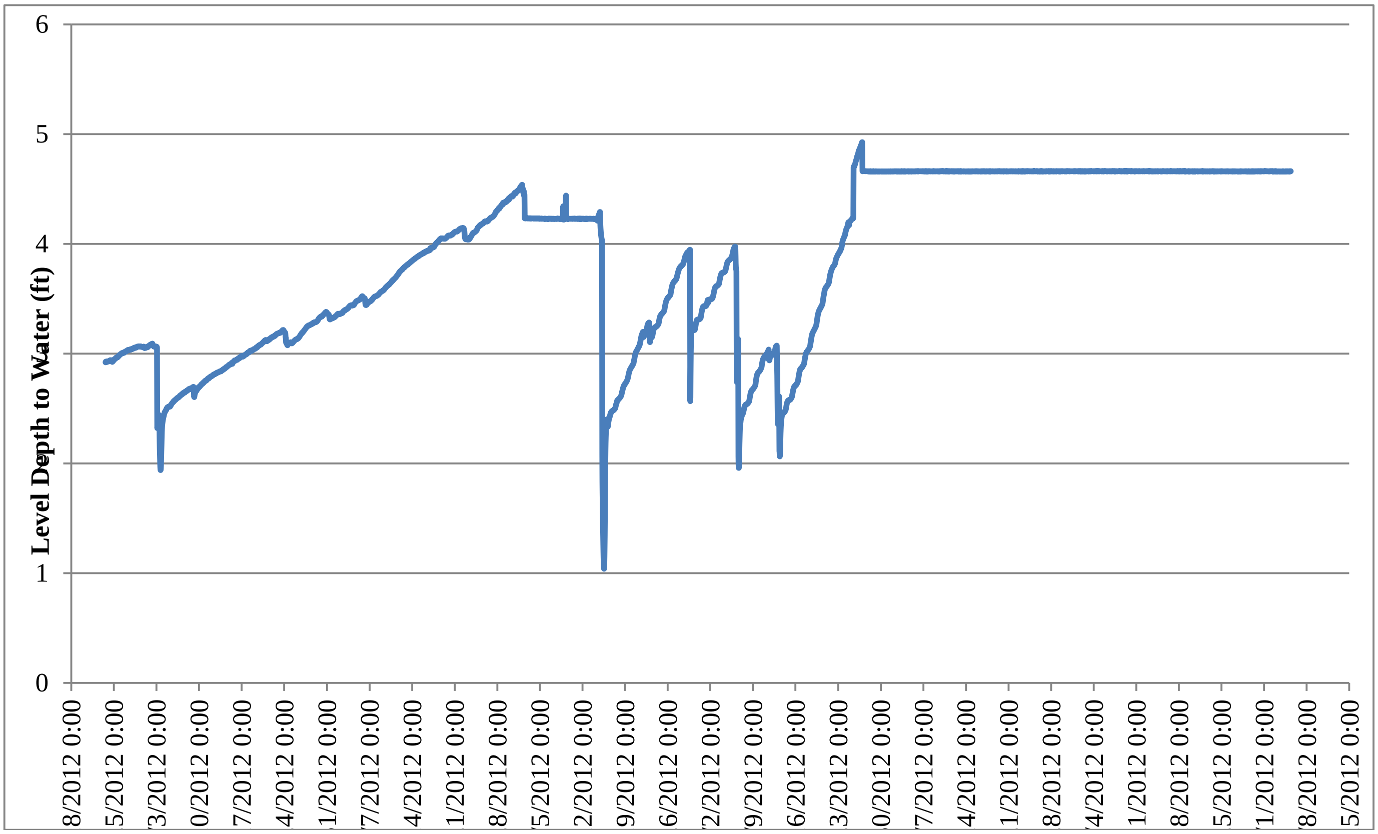
Hydrograph for site 1001 with ground level at approximately at 2 – 2.5 feet



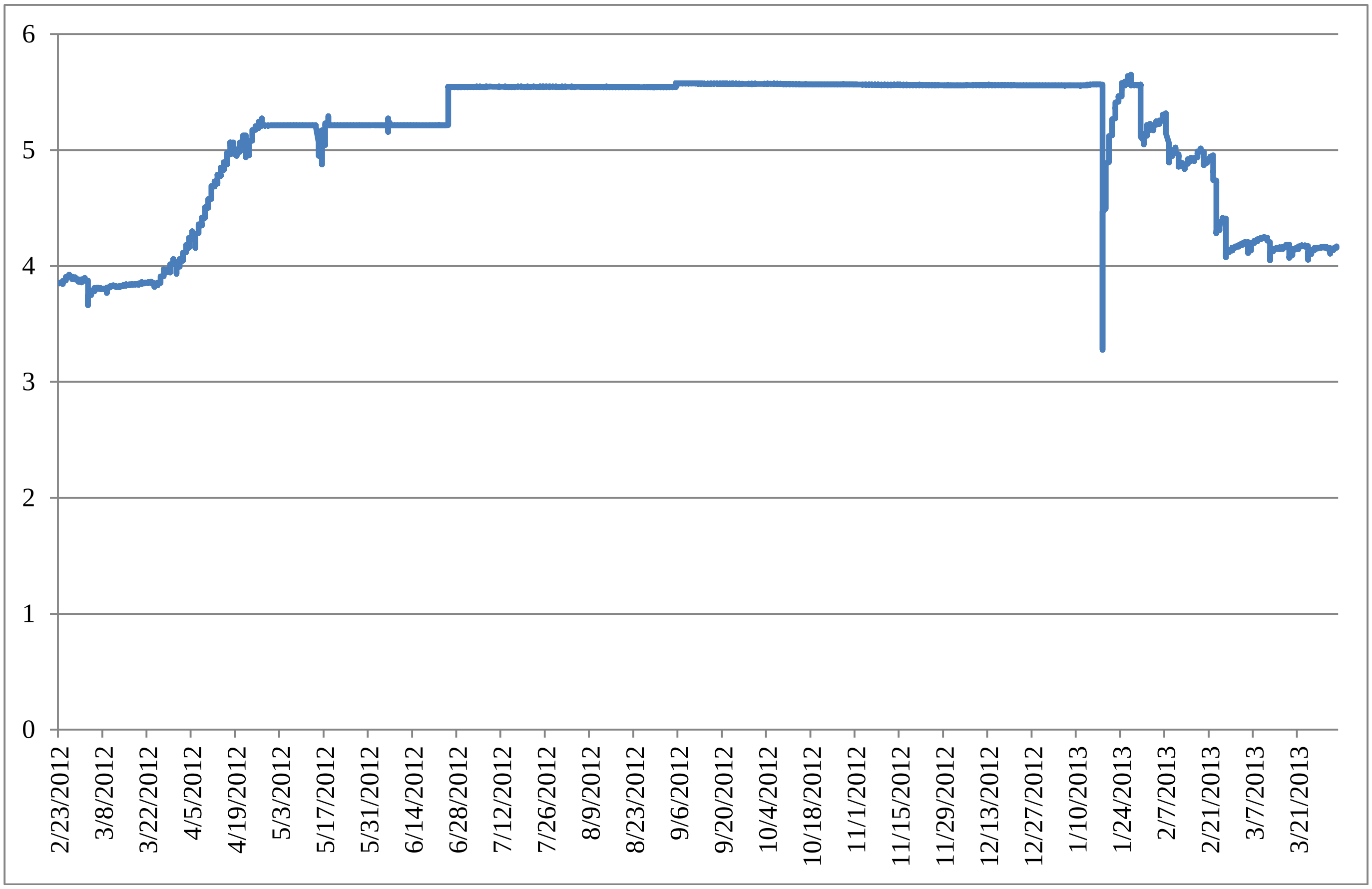
Hydrograph for site 1002 with ground level at approximately 2 -2.5 feet



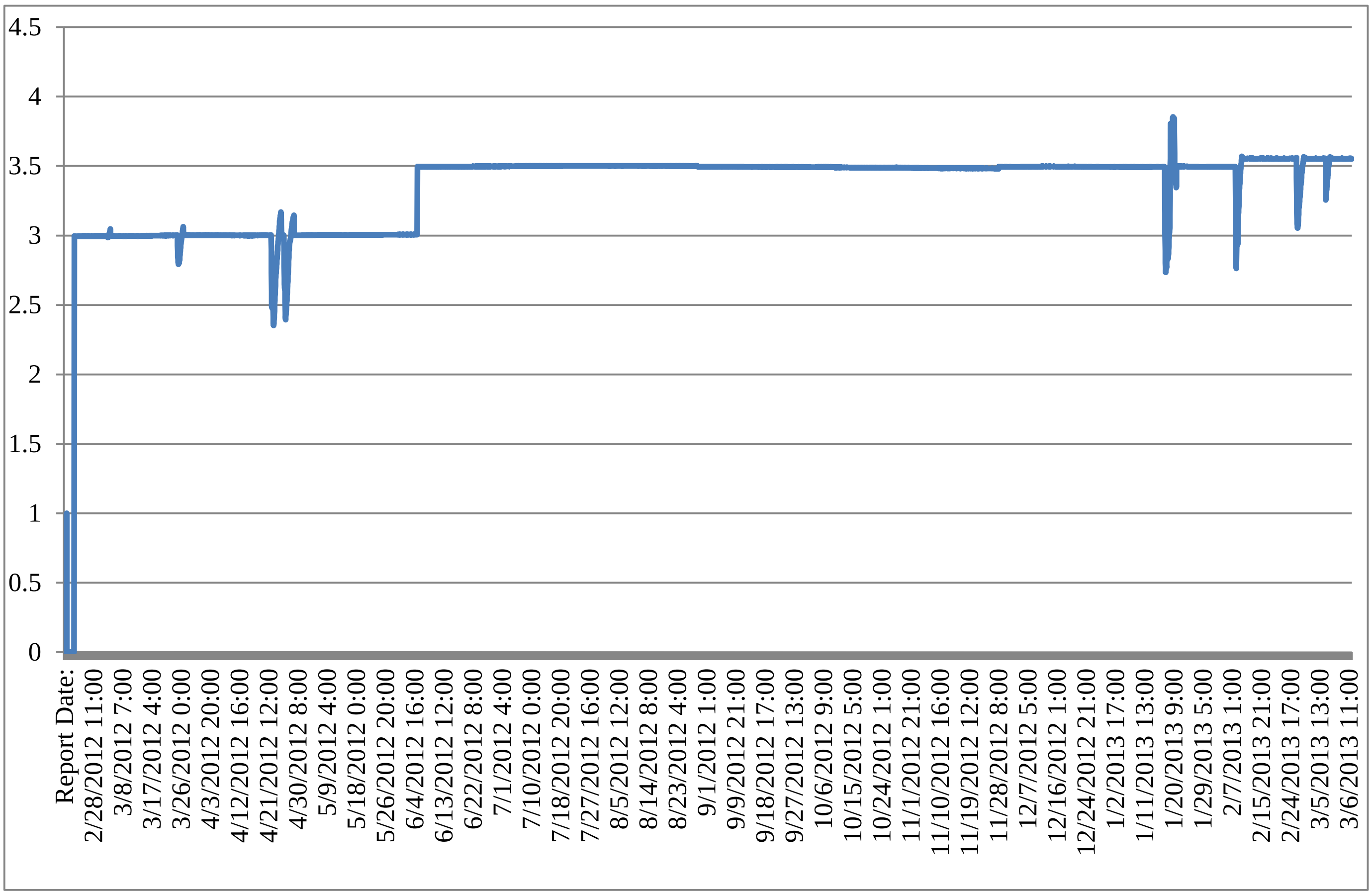
Hydrograph for site 1004 with ground level at approximately 2 – 2.5 feet



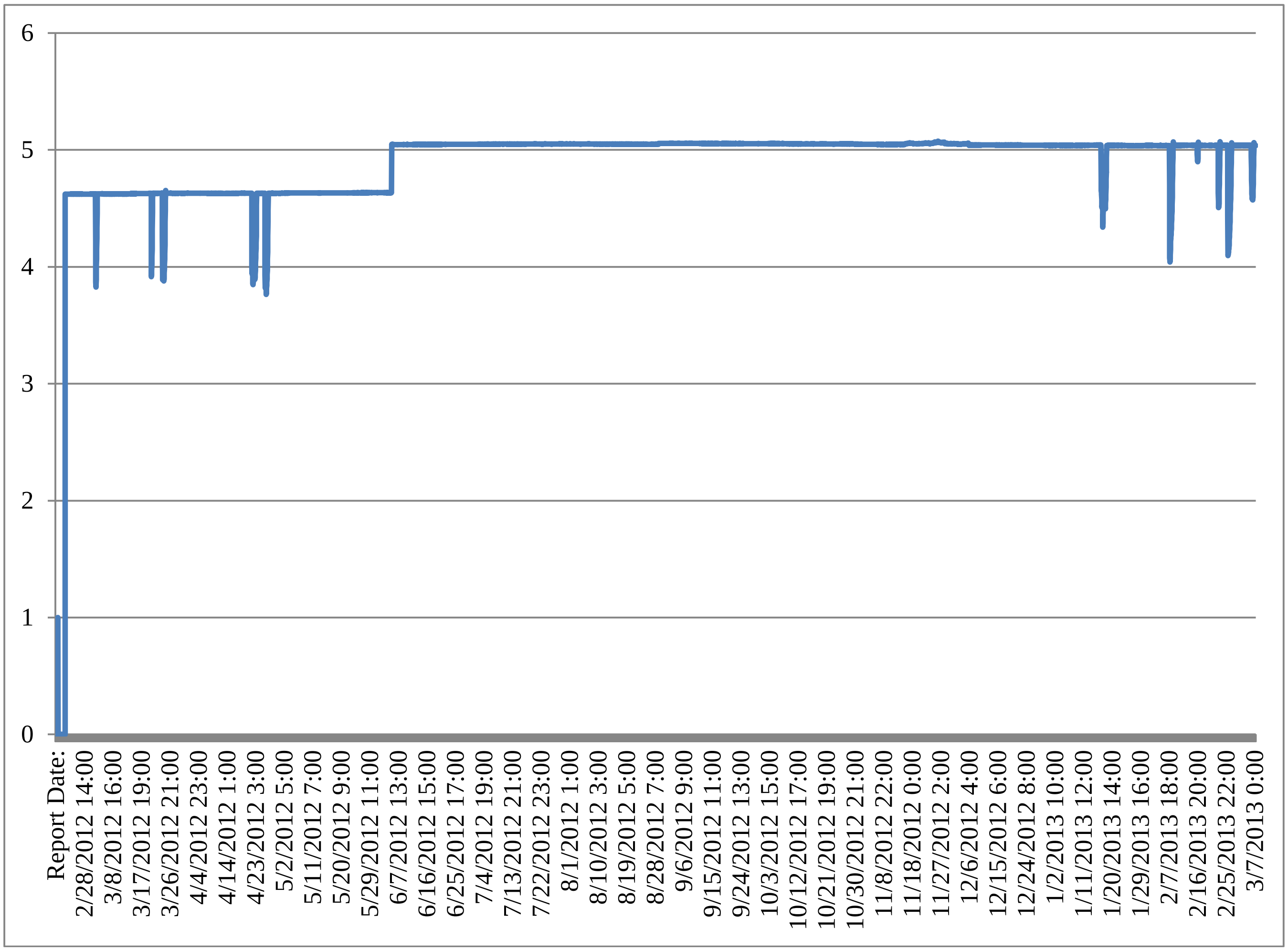
Hydrograph for site 1006 with ground level at approximately 2 – 2.5 feet



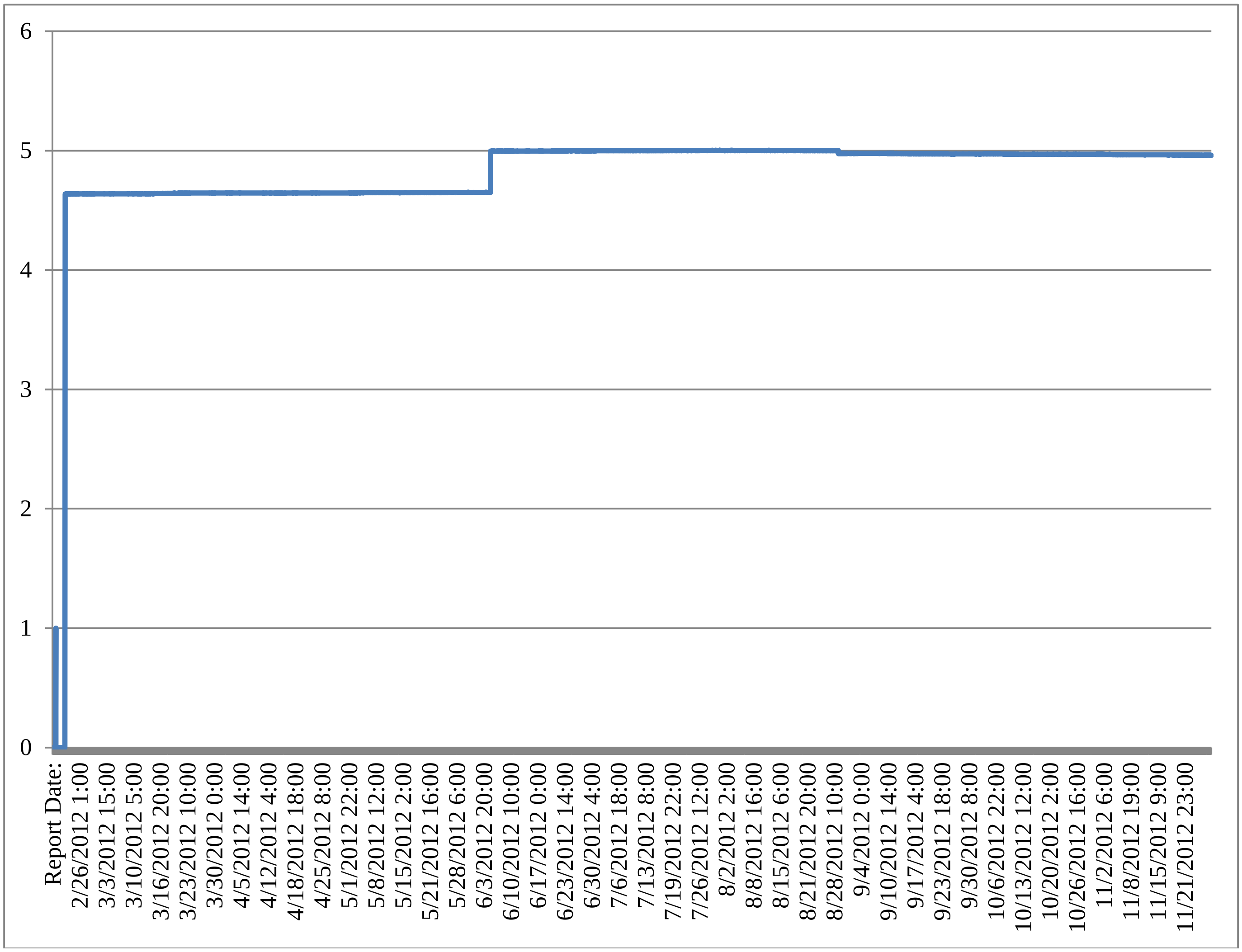
Hydrograph for site 1091 with ground level at approximately 2 – 2.5 feet



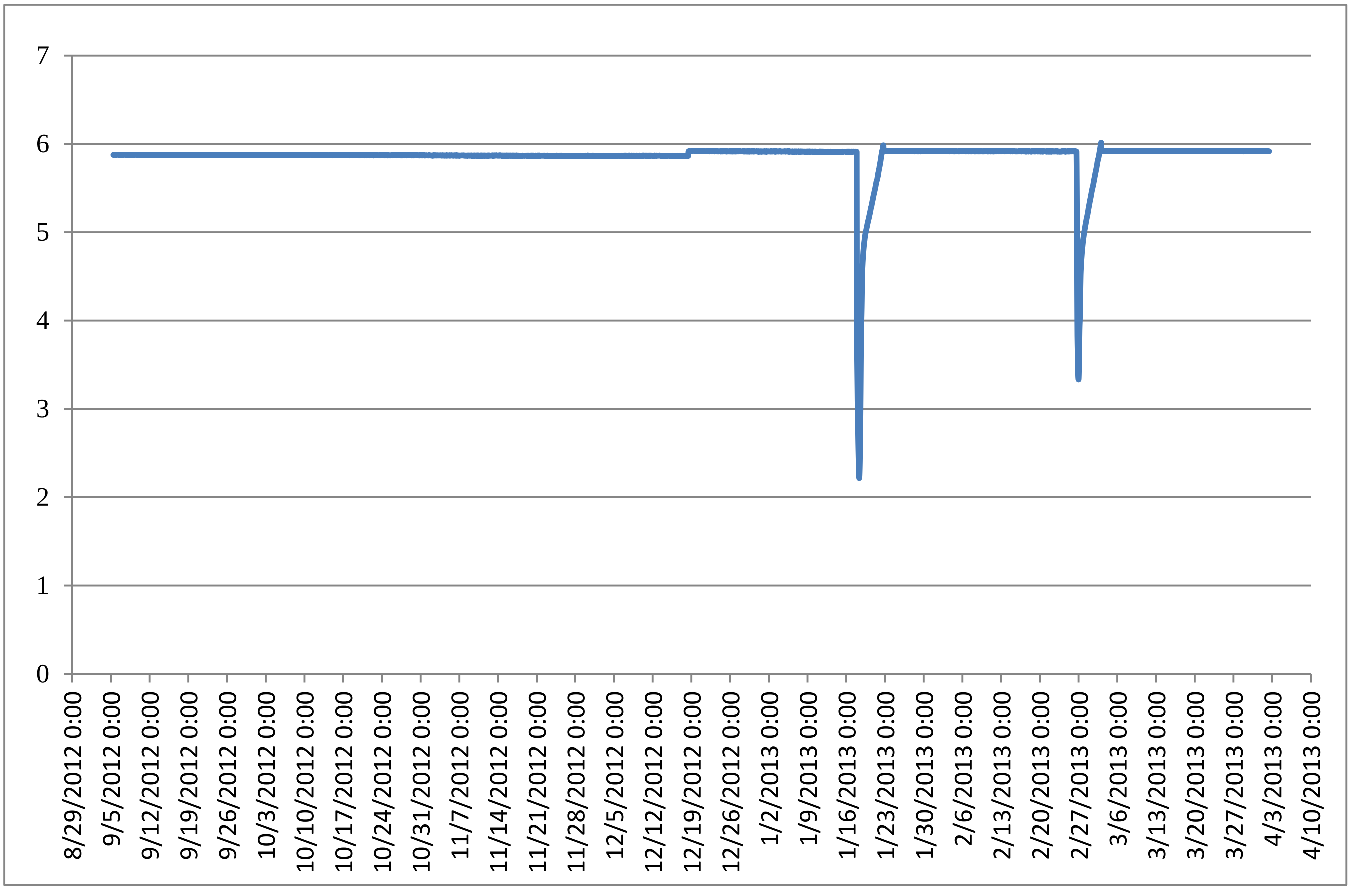
Hydrograph for site 1092 with ground level at approximately 2 – 2.5 feet



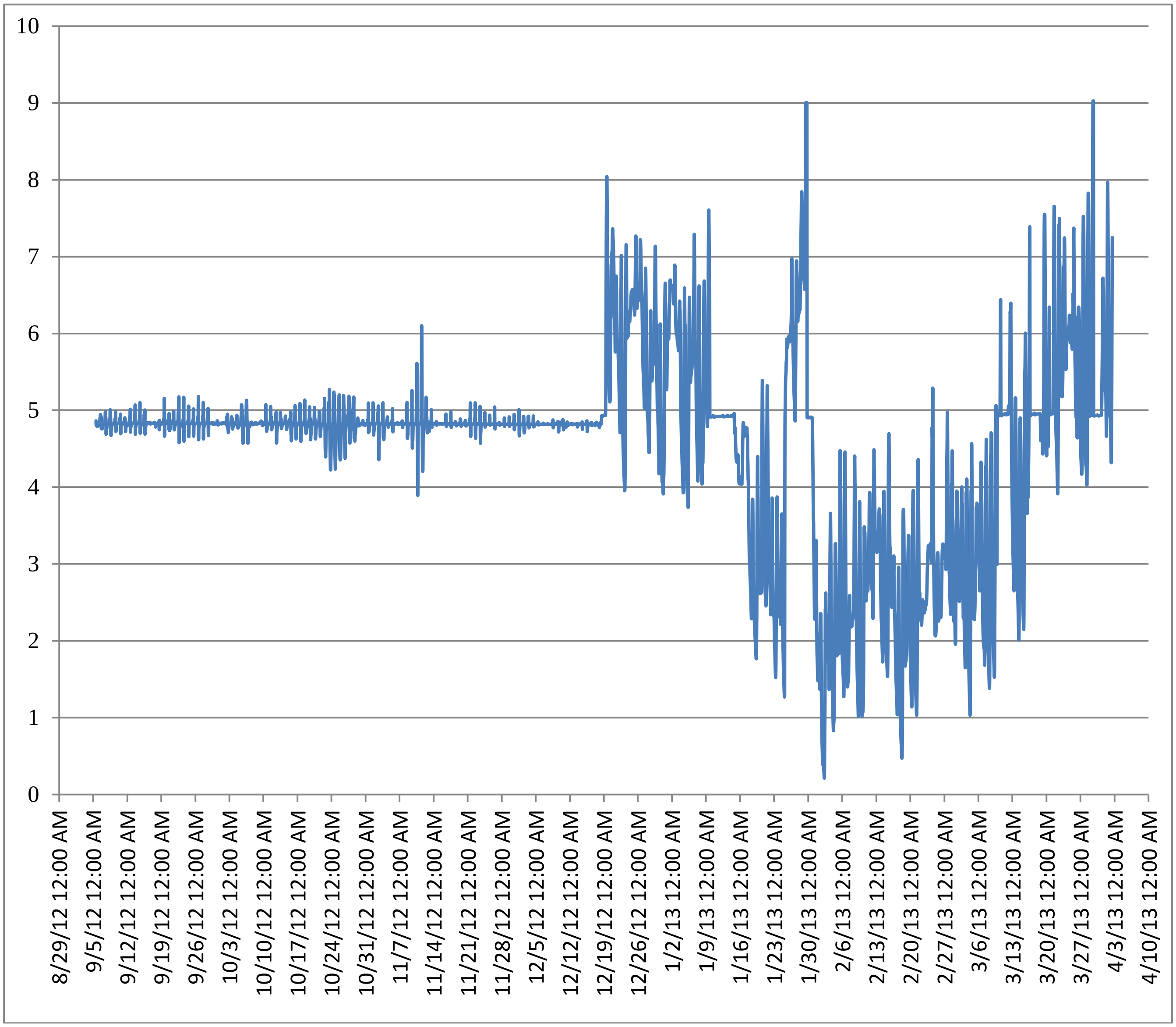
Hydrograph for site 1095 with ground level at approximately 2 – 2.5 feet



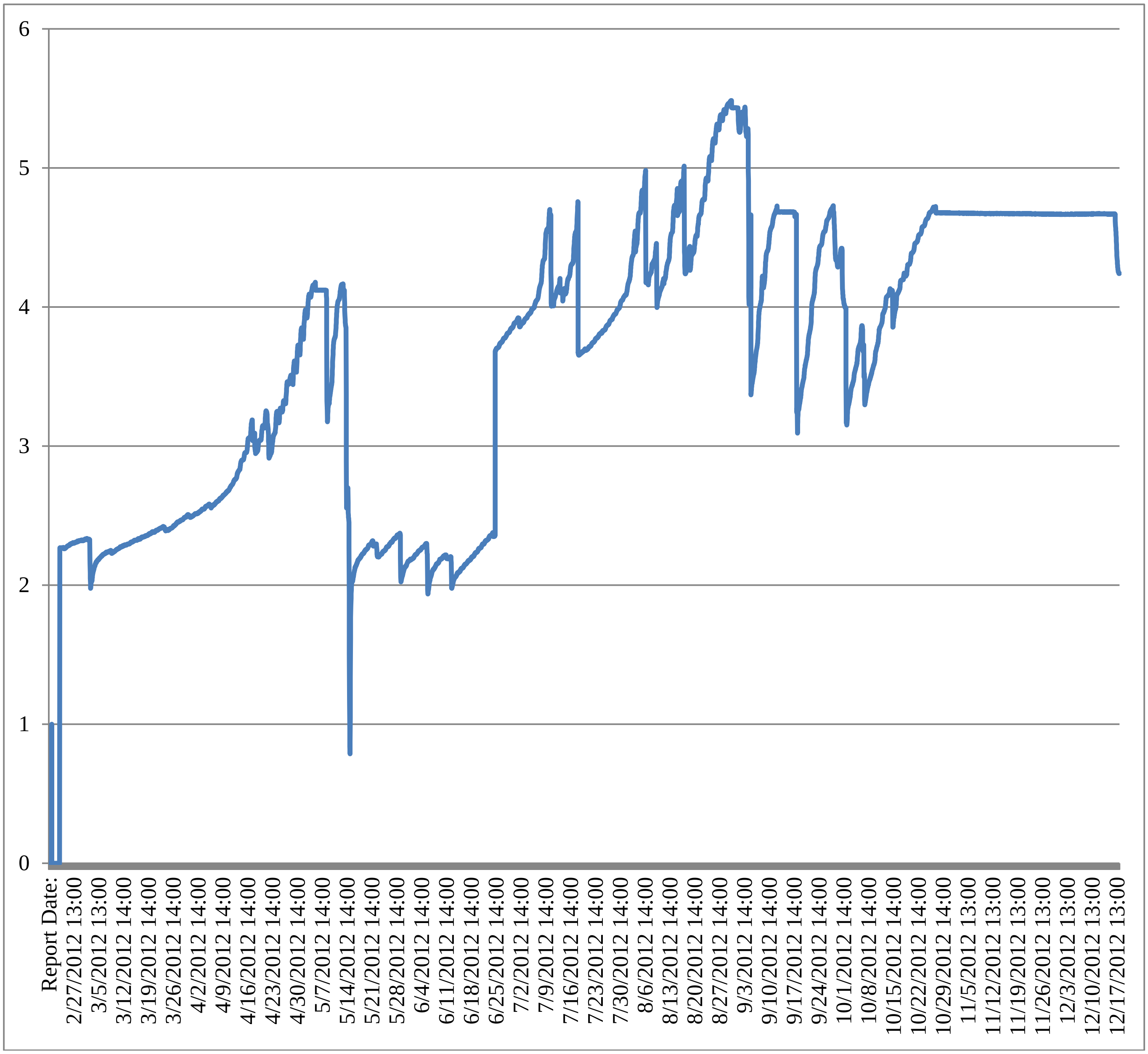
Hydrograph for site 1097 with ground level at approximately 2 – 2.5 feet



Hydrograph for site 1098 with ground level at approximately 2 – 2.5 feet

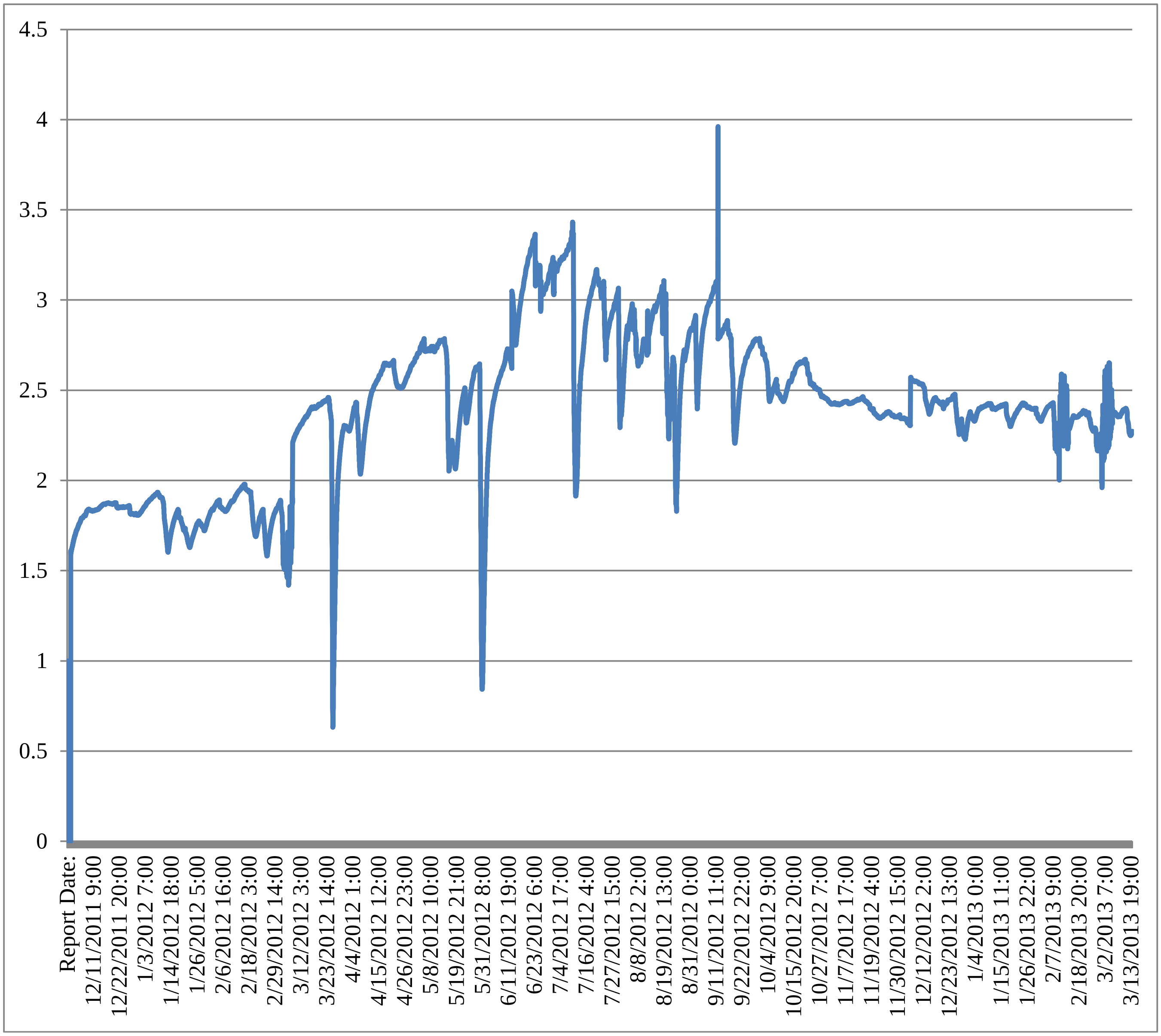


Hydrograph for site 1101 with ground level at approximately 2 – 2.5 feet

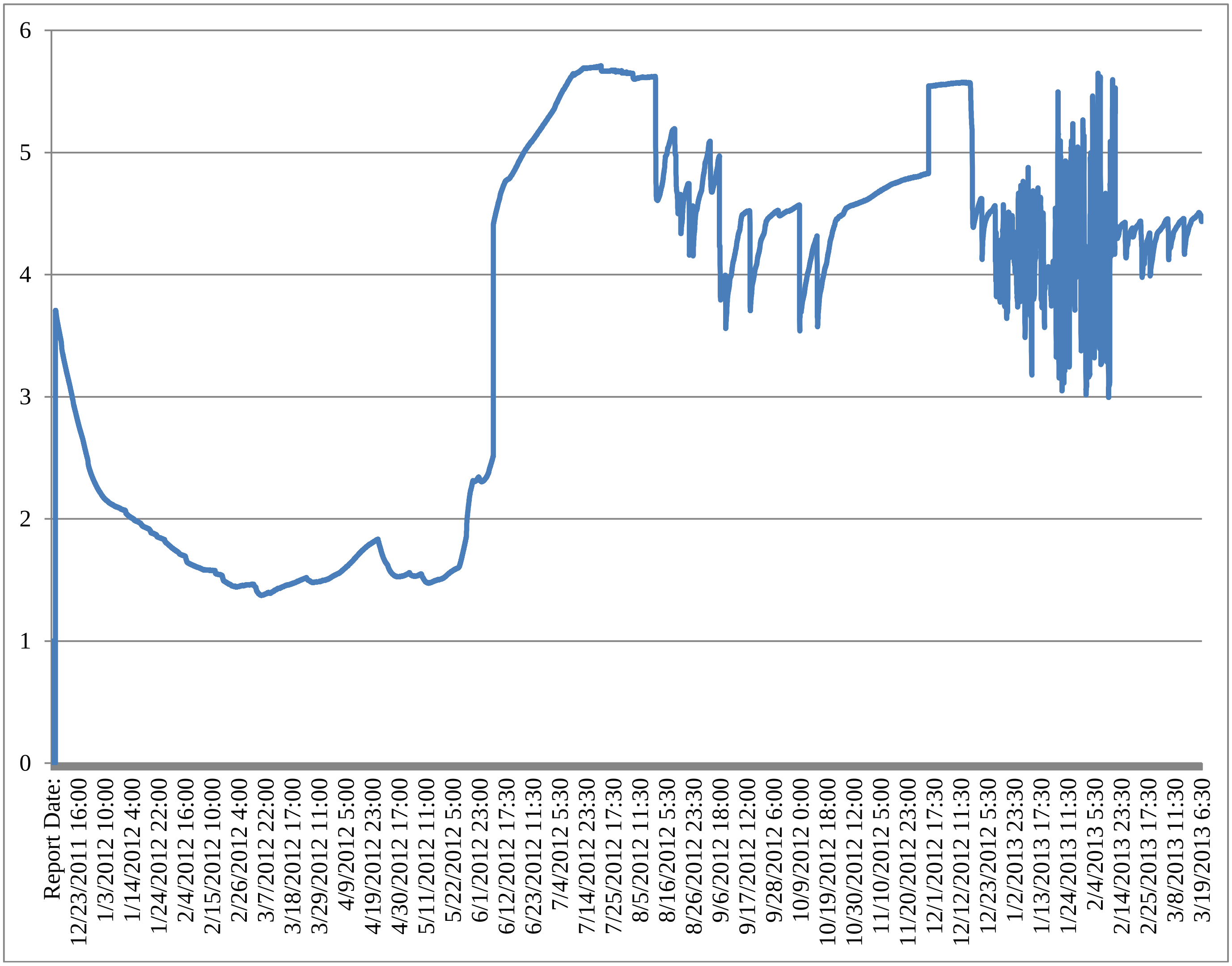


A2: Hydrographs for NC RSF sites

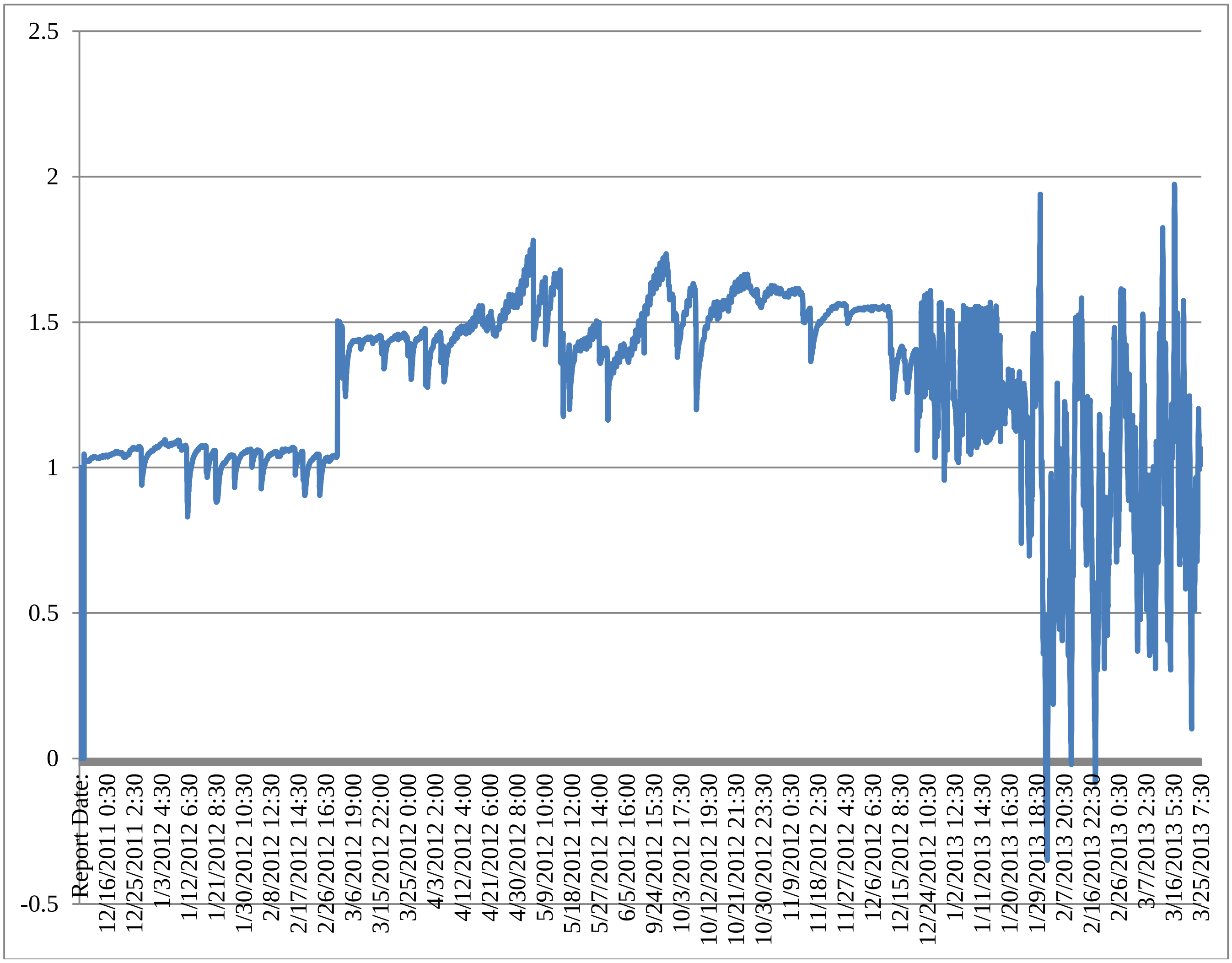
Hydrograph for site 1014 with ground level at approximately 2.5 – 3 feet



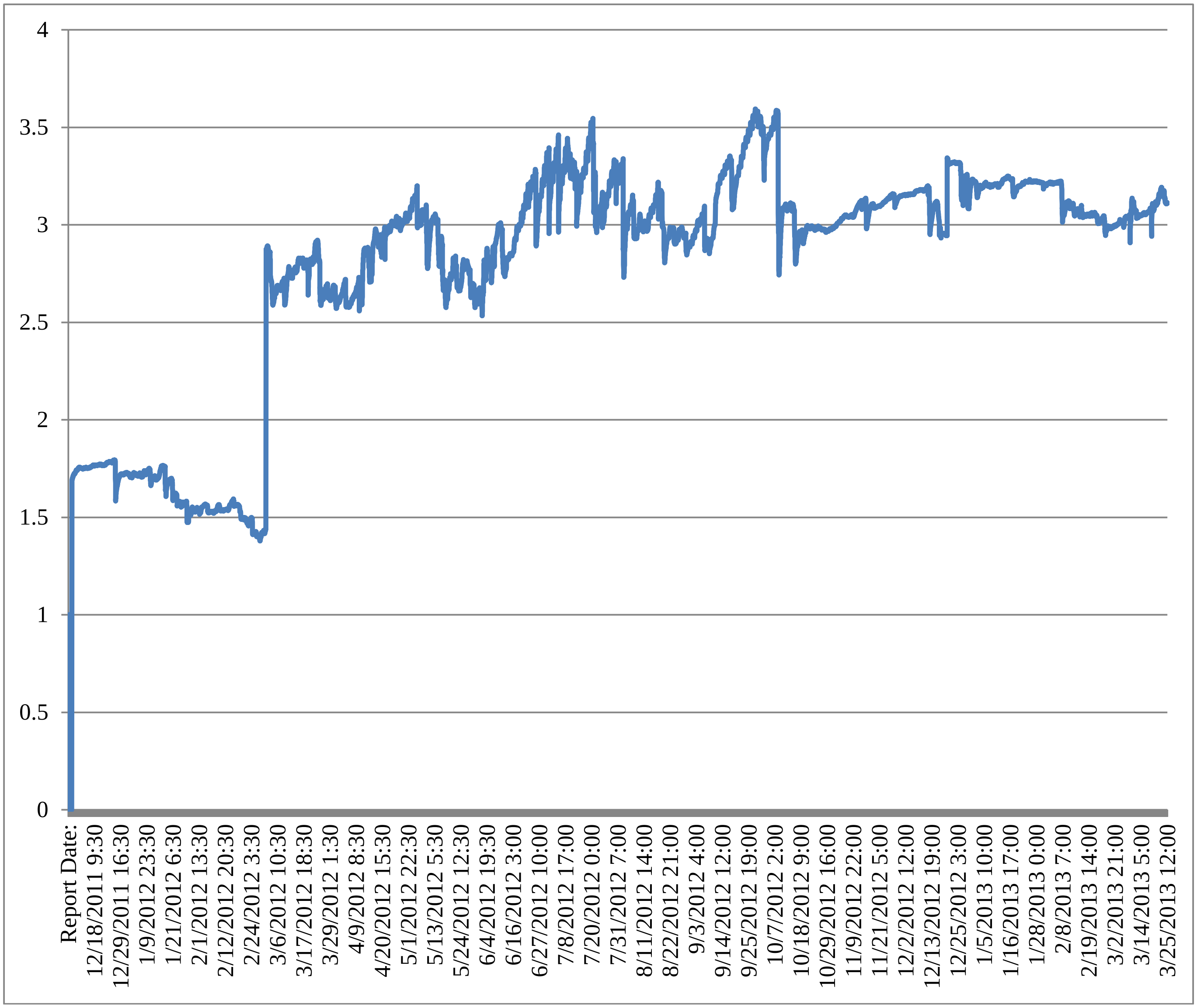
Hydrograph for site 1016 with ground level at approximately 2.5 – 3 feet



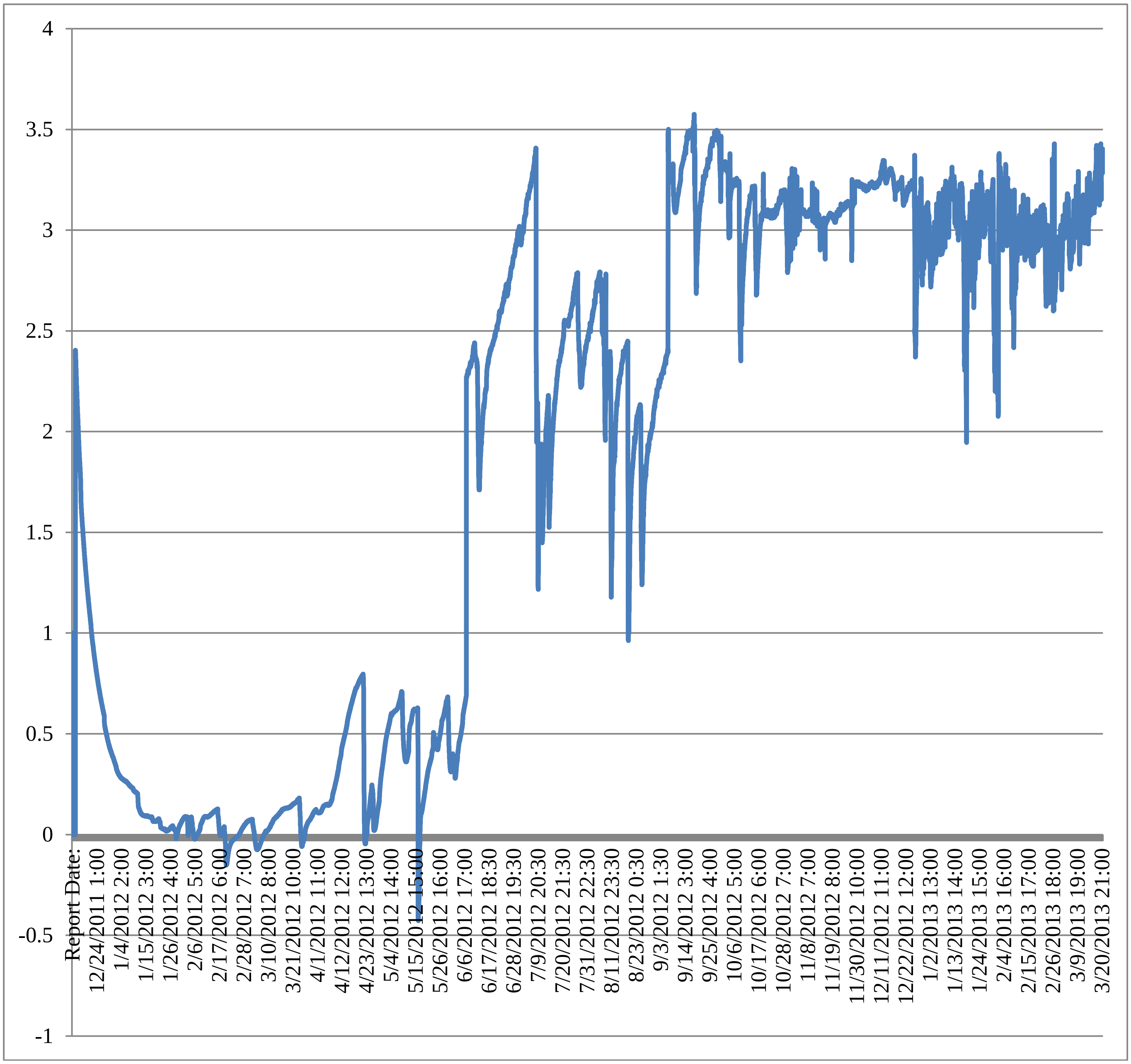
Hydrograph for site 1018 with ground level at approximately 1 – 1.5 feet



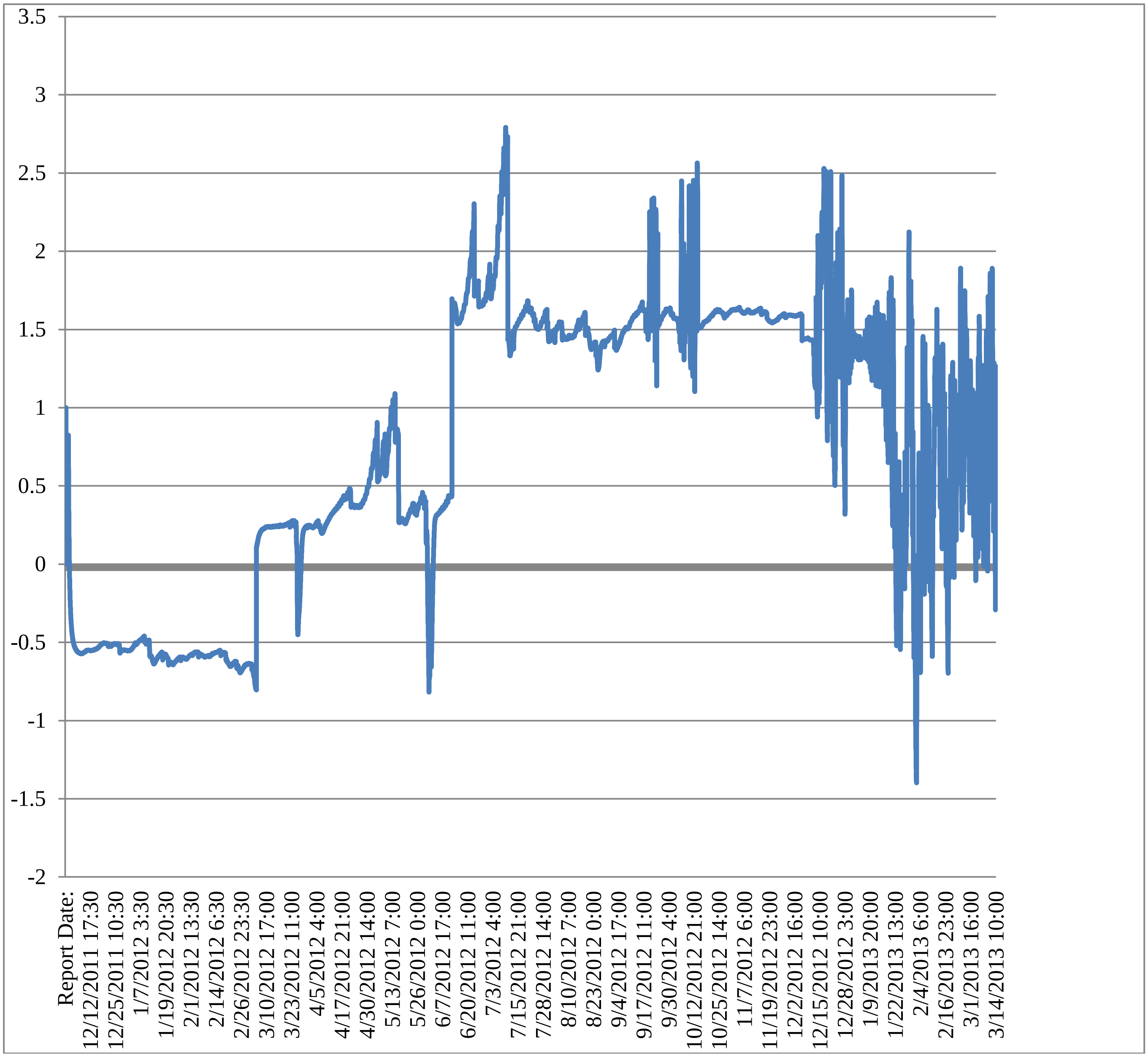
Hydrograph for site 1144 with ground level at approximately 2.5 – 3 feet



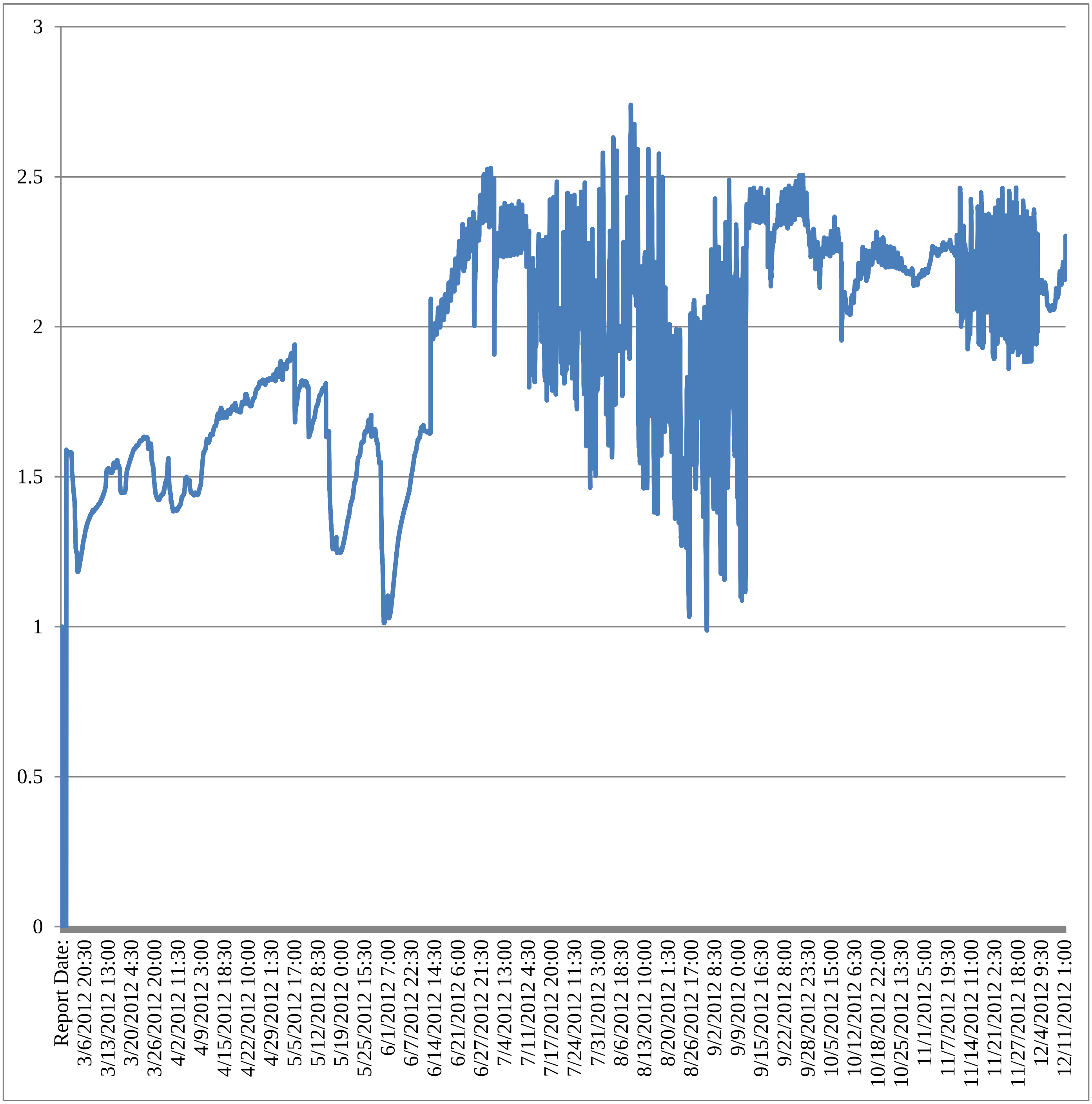
Hydrograph for site 1149 with ground level at approximately 2.5 – 3 feet



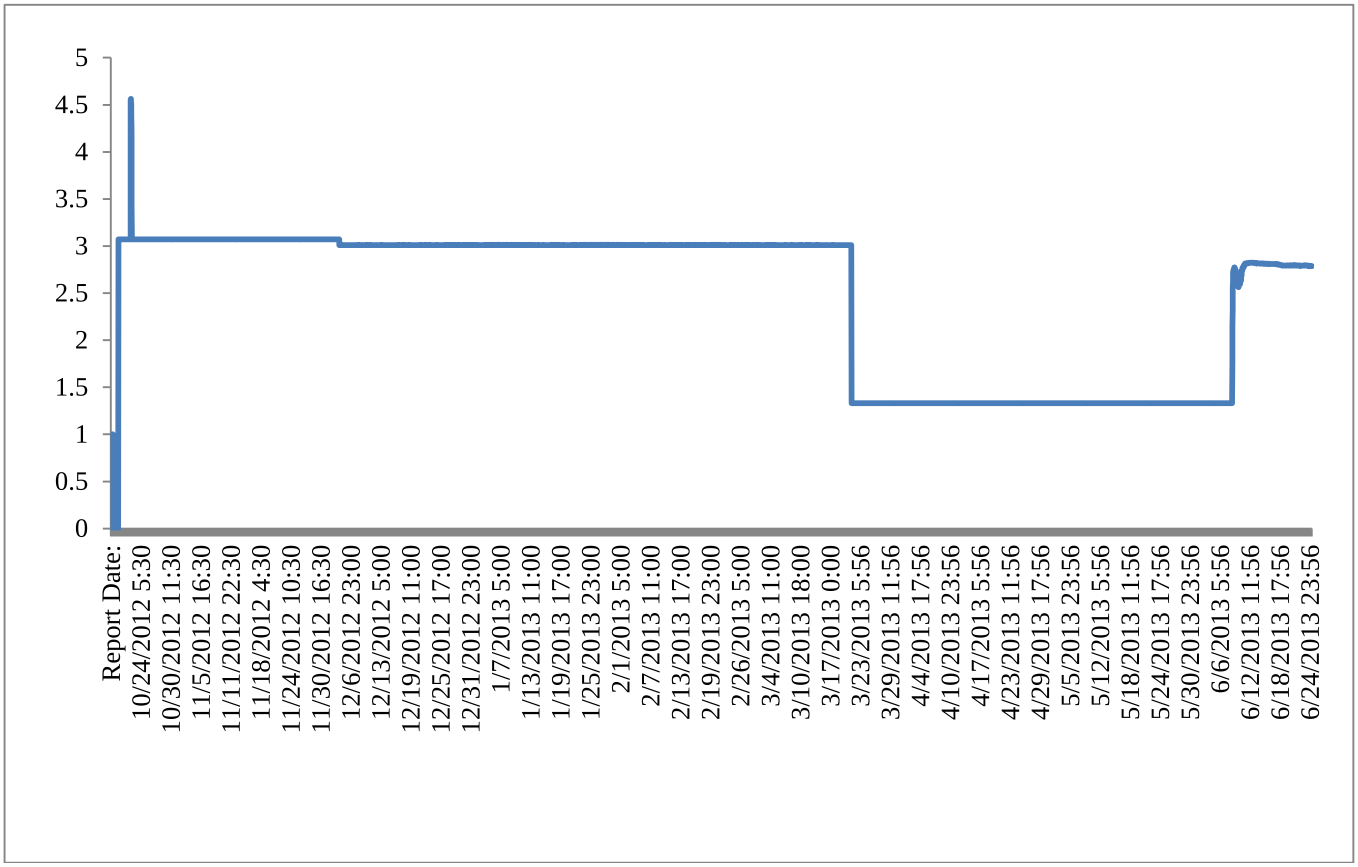
Hydrograph for site 1150 with ground level at approximately 2.5 – 3 feet



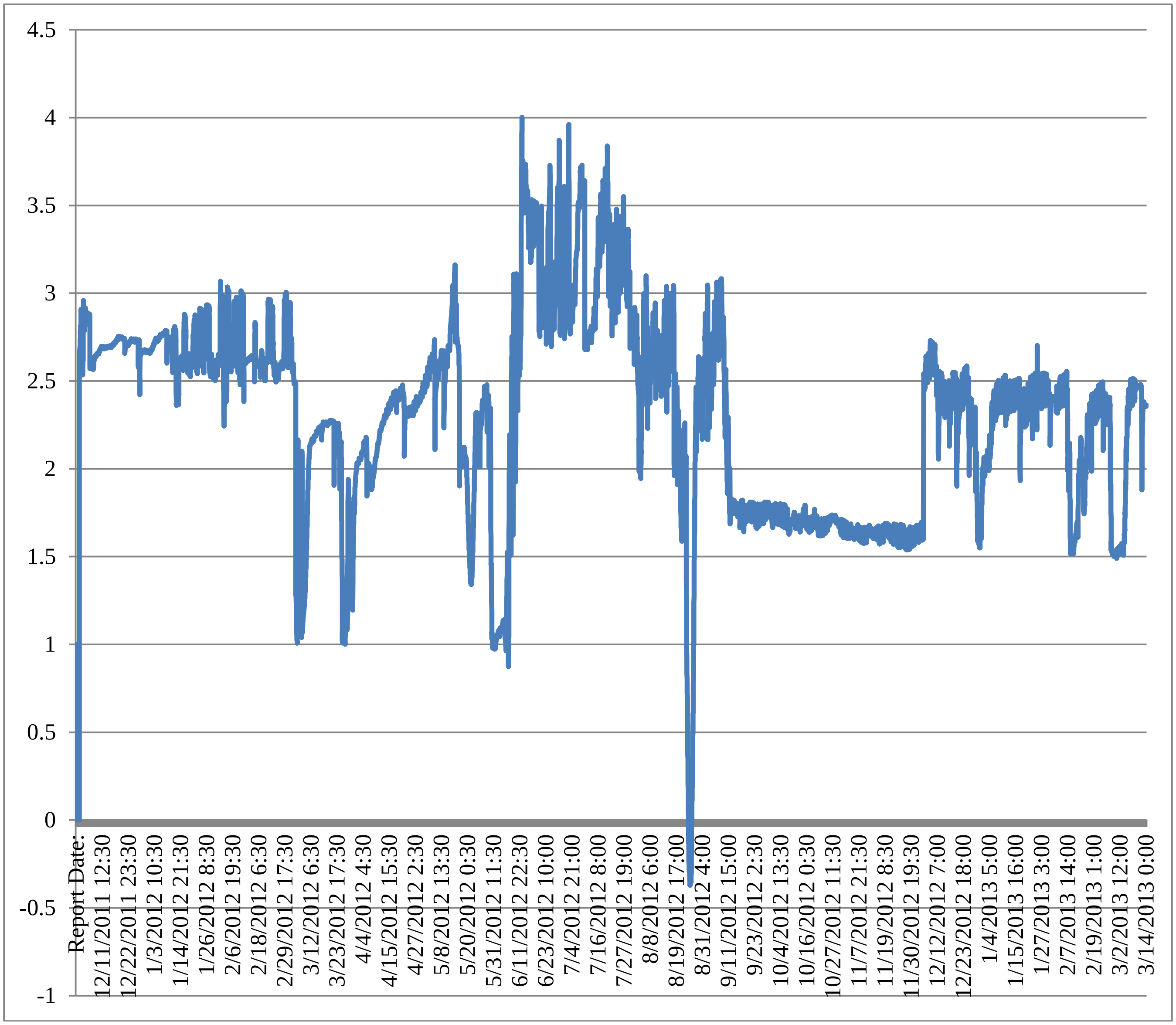
Hydrograph for site 1154 with ground level at approximately 2.5 – 3 feet



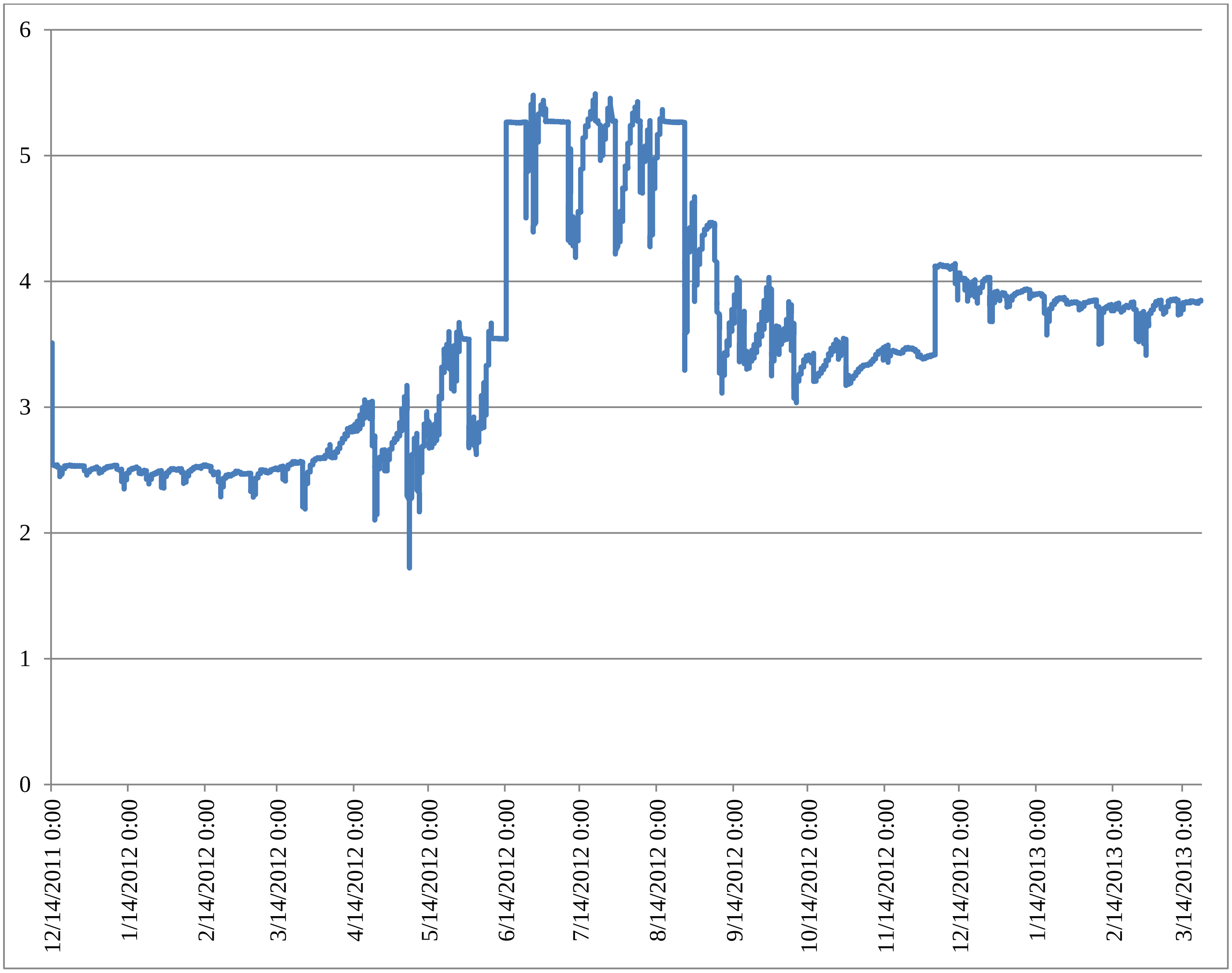
Hydrograph for site 1157 with ground level at approximately 2.5 – 3 feet



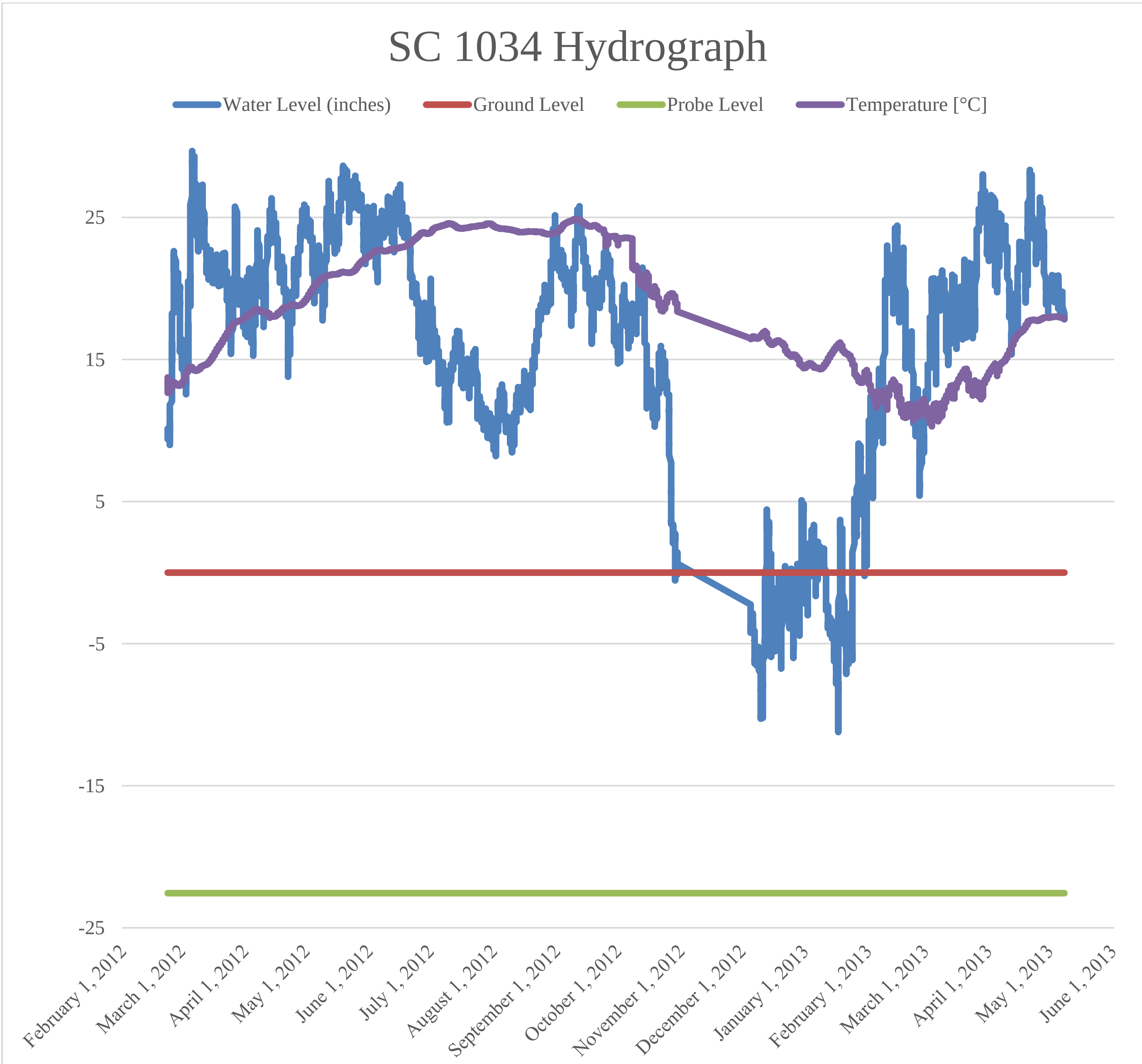
Hydrograph for site 1159 with ground level at approximately 2.5 – 3 feet

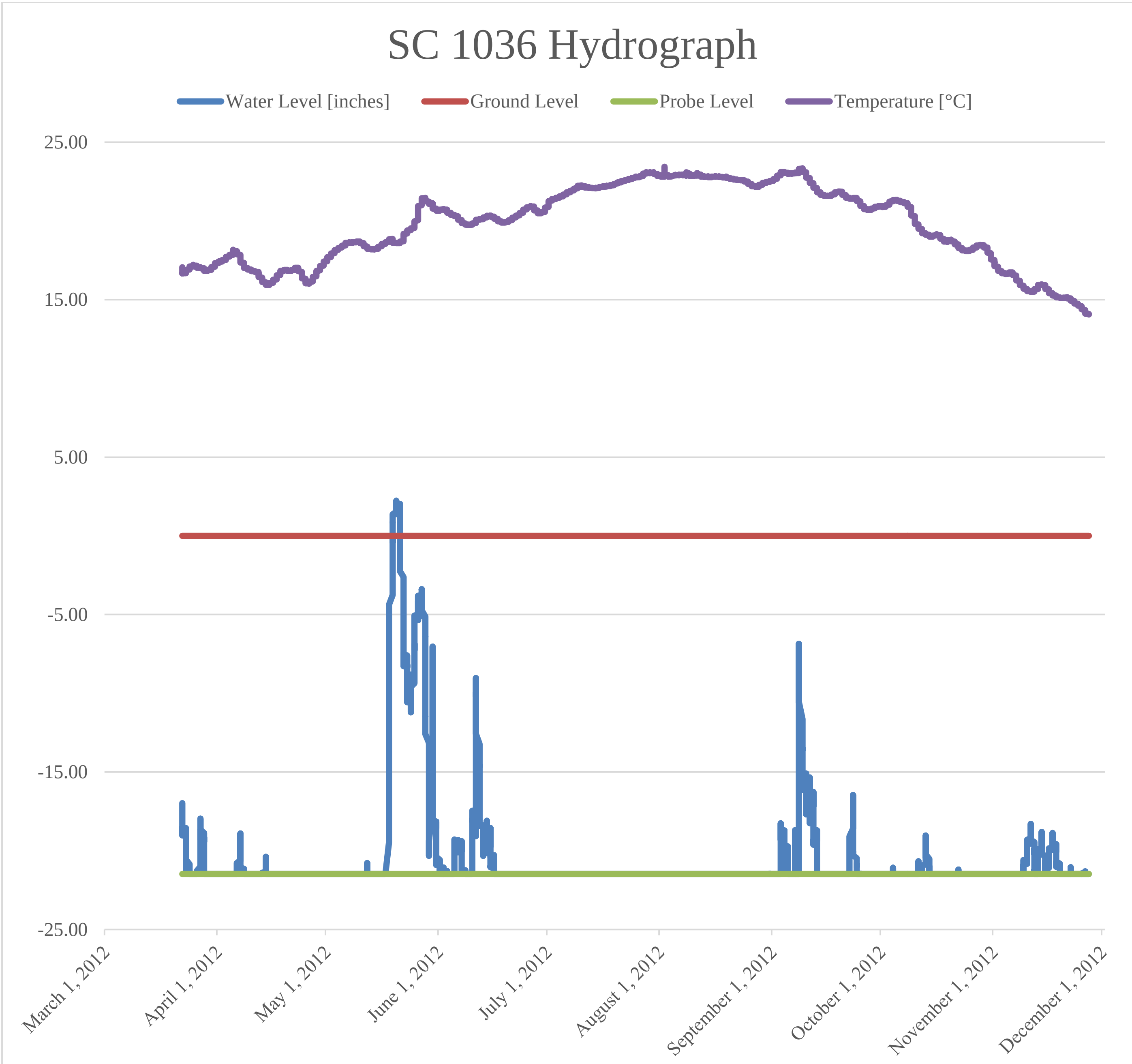


Hydrograph for site 1161 with ground level at approximately 2.5 – 3 feet

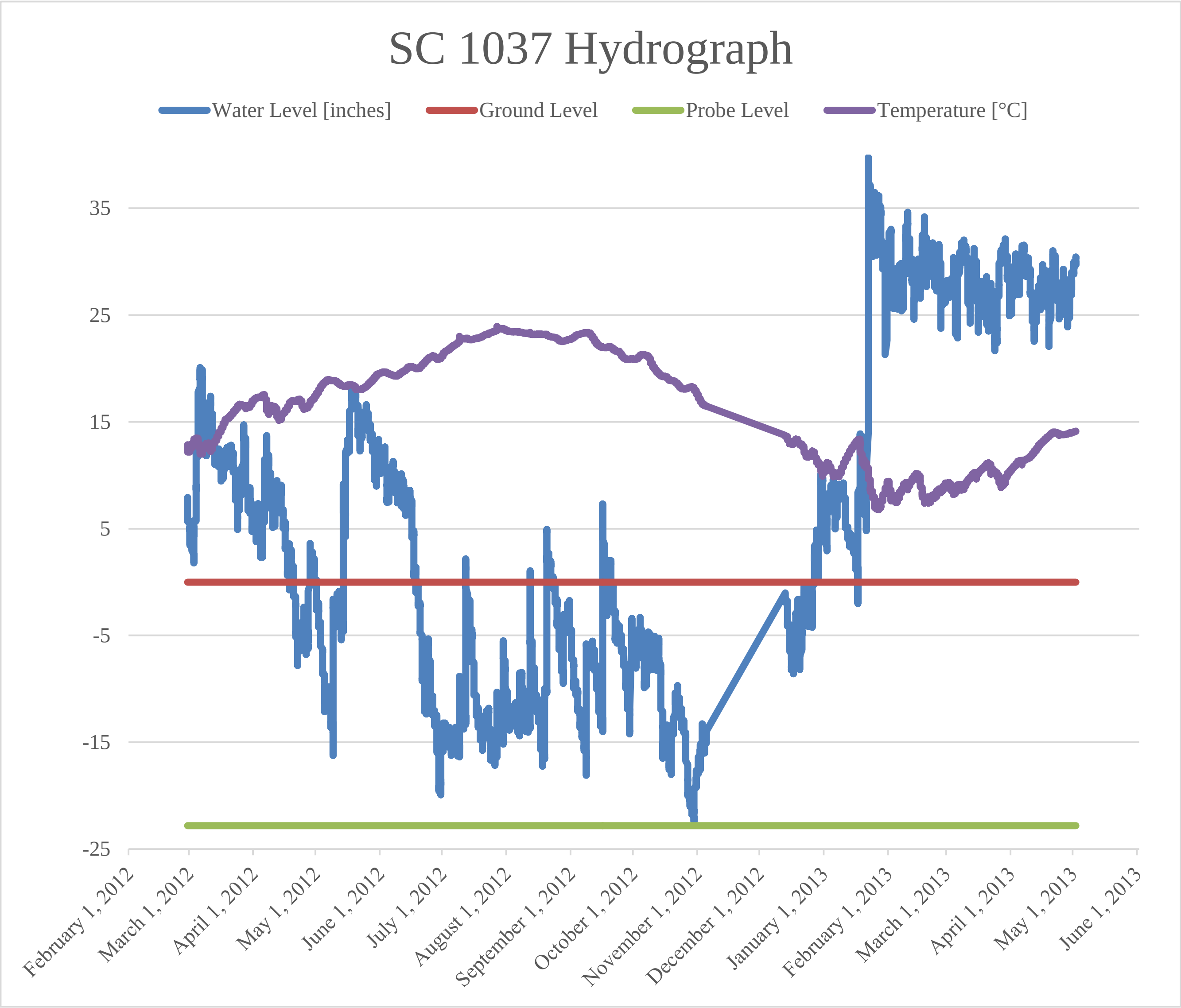


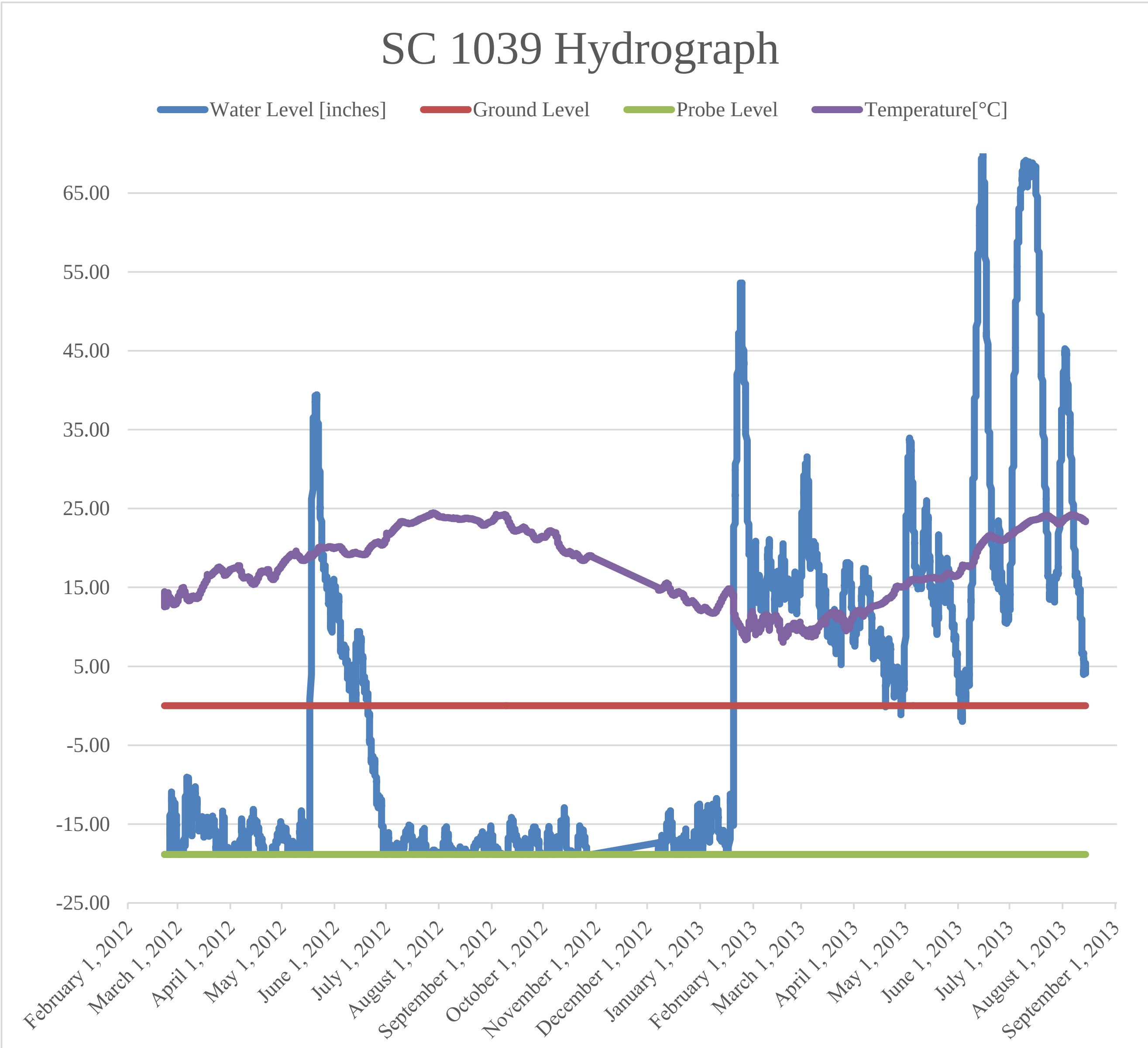
A3: Hydrographs for SC RSF sites



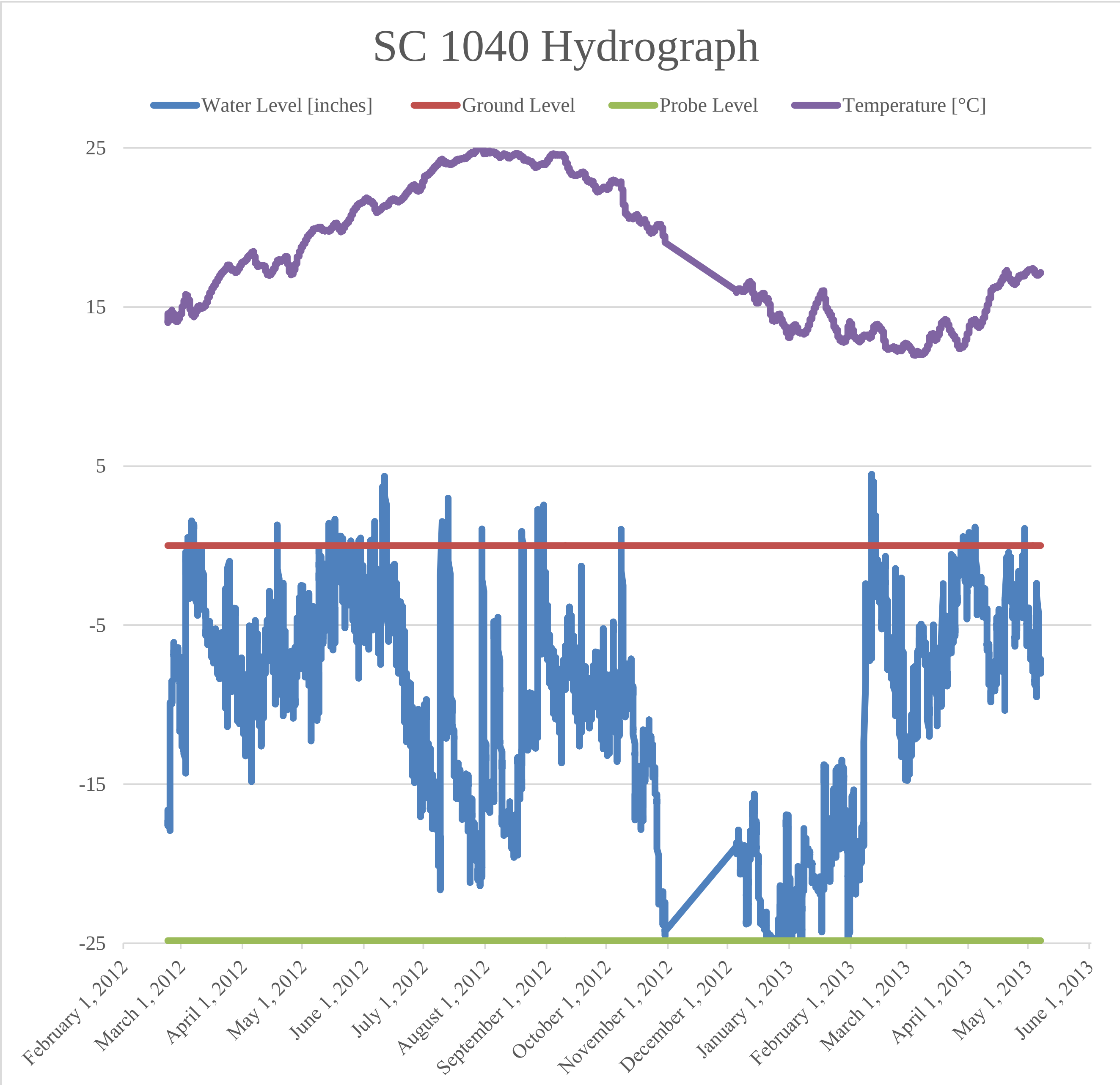


SC 1036 Hydrograph
Water Level [inches]
Ground Level
Probe Level
Temperature [°C]
25.00
15.00
5.00
-5.00
-15.00
-25.00
March 1, 2012
April 1, 2012
May 1, 2012
June 1, 2012
July 1, 2012
August 1, 2012
September 1, 2012
October 1, 2012
November 1, 2012
December 1, 2012

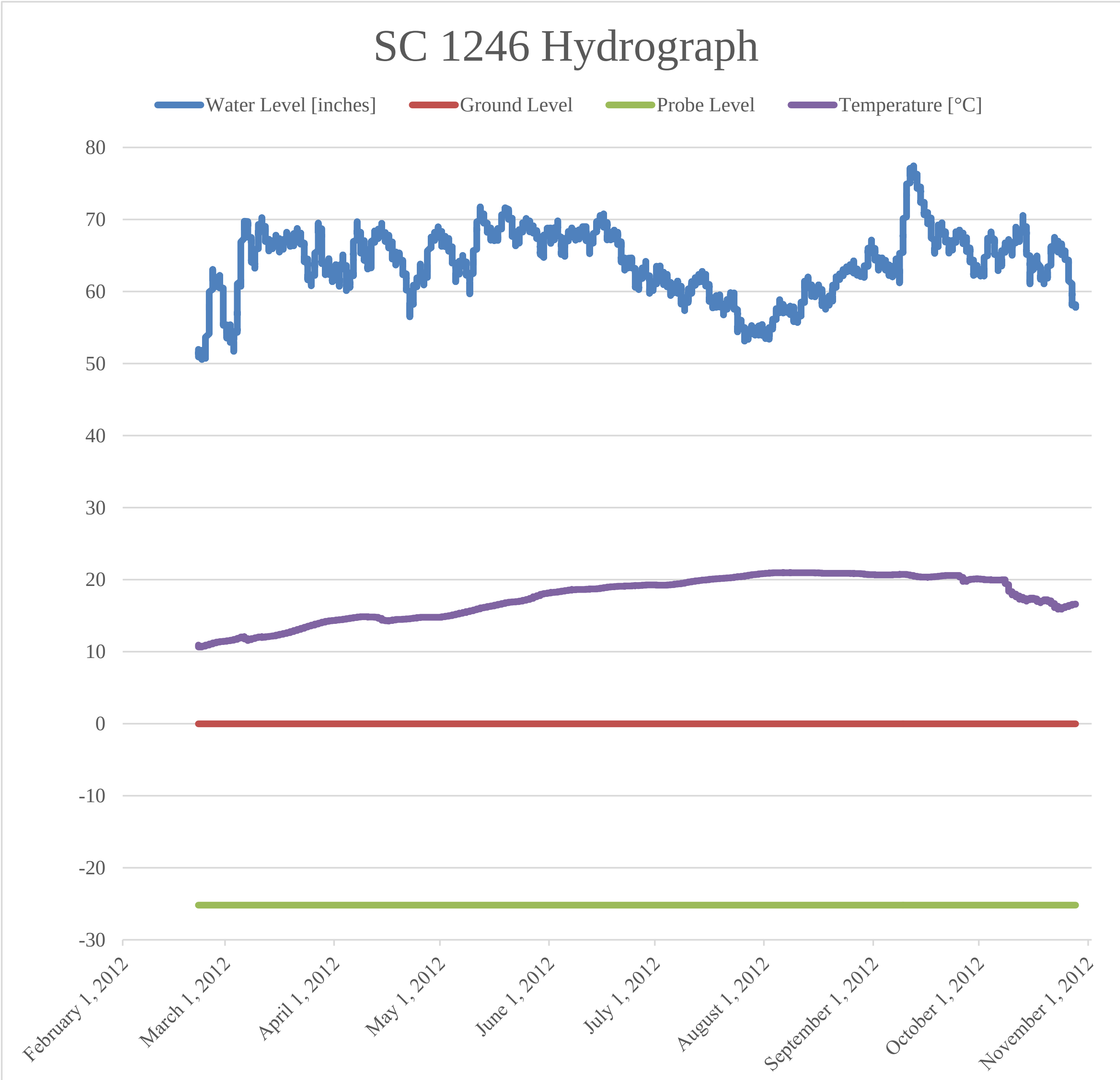

SC 1037 Hydrograph
Water Level [inches]
Ground Level
Probe Level
Temperature [°C]
35
25
15
5
-5
-15
-25
February 1, 2012
March 1, 2012
April 1, 2012
May 1, 2012
June 1, 2012
July 1, 2012
August 1, 2012
September 1, 2012
October 1, 2012
November 1, 2012
December 1, 2012
January 1, 2013
February 1, 2013
March 1, 2013
April 1, 2013
May 1, 2013
June 1, 2013

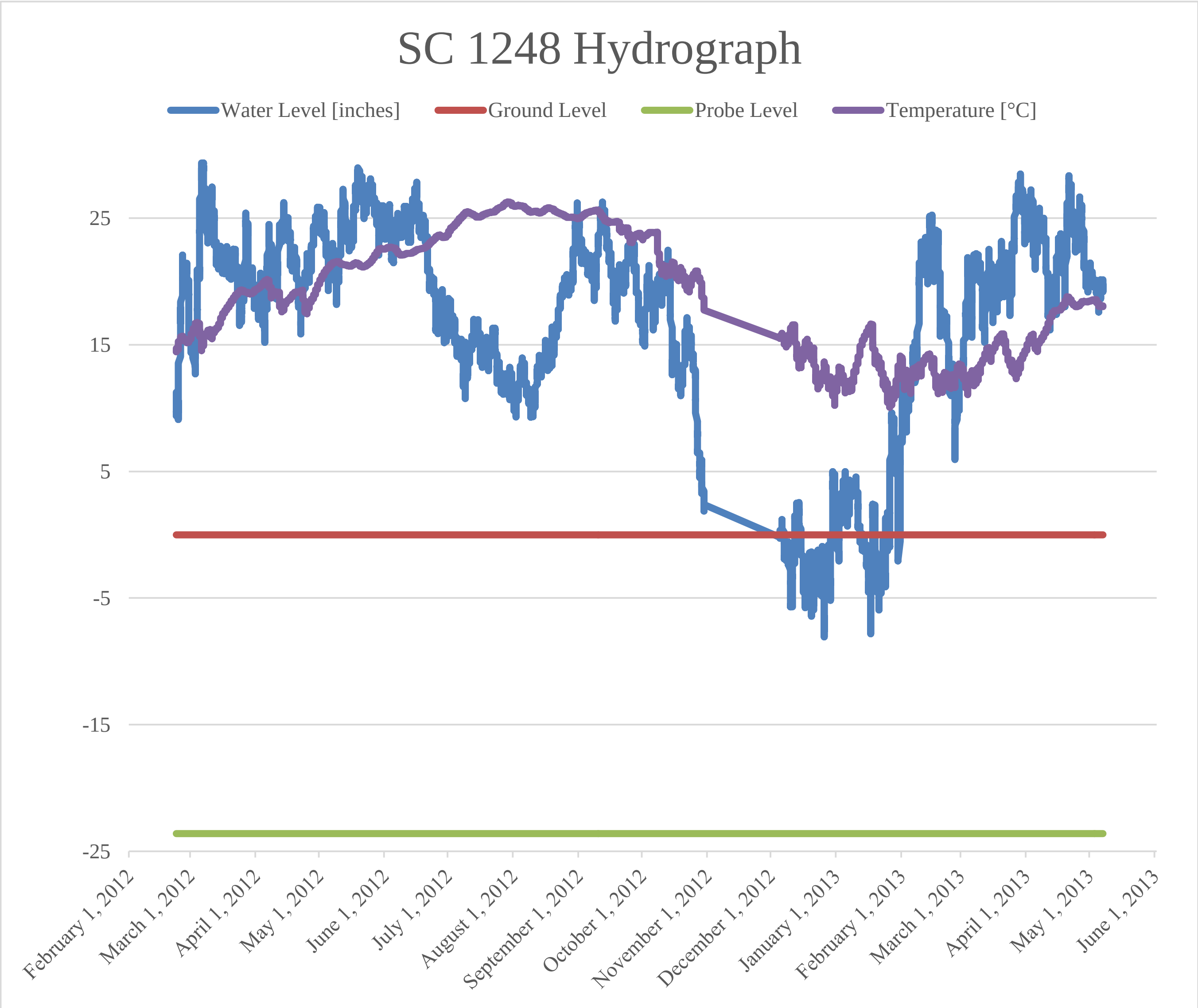


SC 1039 Hydrograph
Water Level [inches]
Ground Level
Probe Level
Temperature[°C]
65.00
55.00
45.00
35.00
25.00
15.00
5.00
-5.00
-15.00
-25.00
February 1, 2012
March 1, 2012
April 1, 2012
May 1, 2012
June 1, 2012
July 1, 2012
August 1, 2012
September 1, 2012
October 1, 2012
November 1, 2012
December 1, 2012
January 1, 2013
February 1, 2013
March 1, 2013
April 1, 2013
May 1, 2013
June 1, 2013
July 1, 2013
August 1, 2013
September 1, 2013

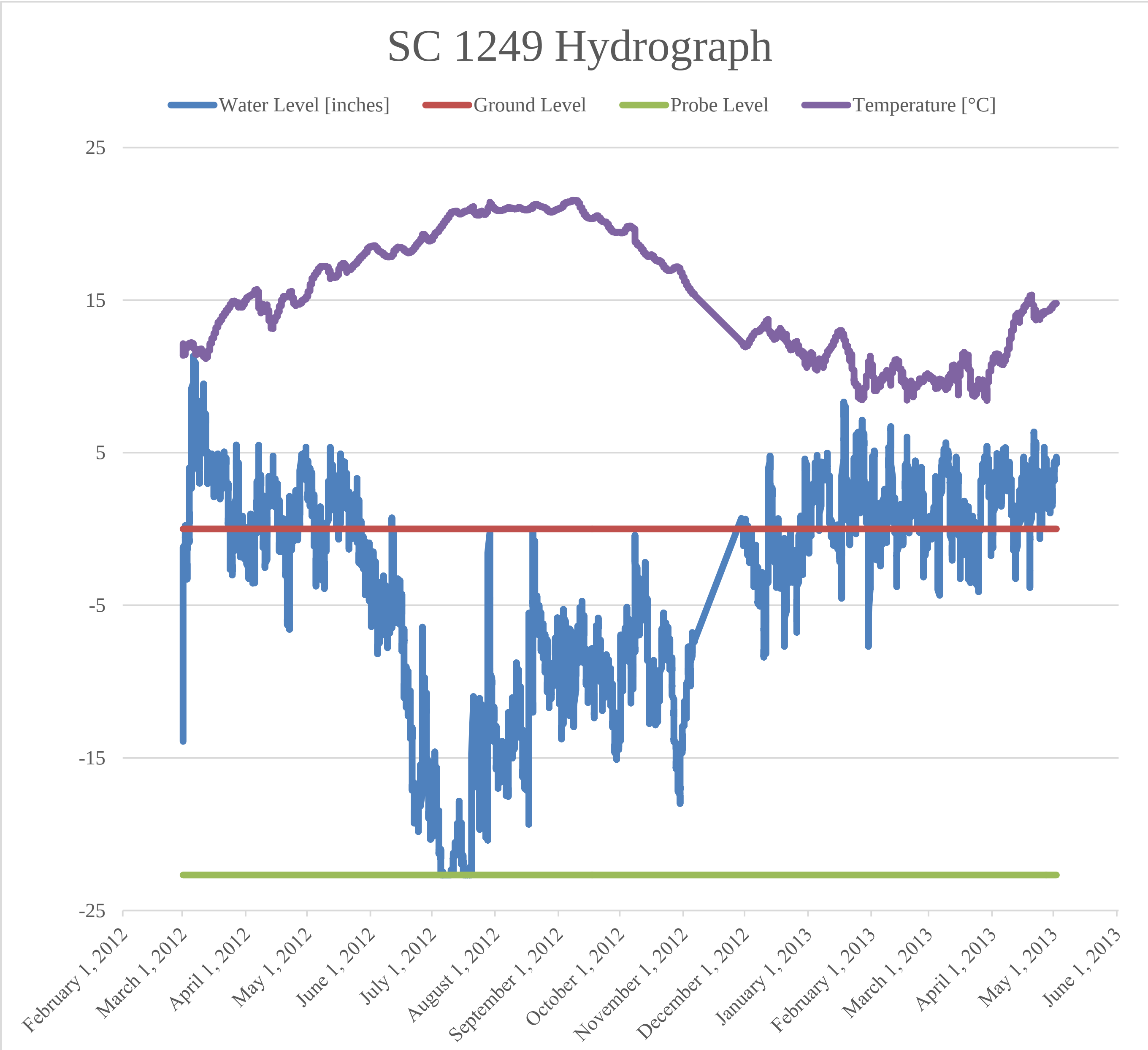


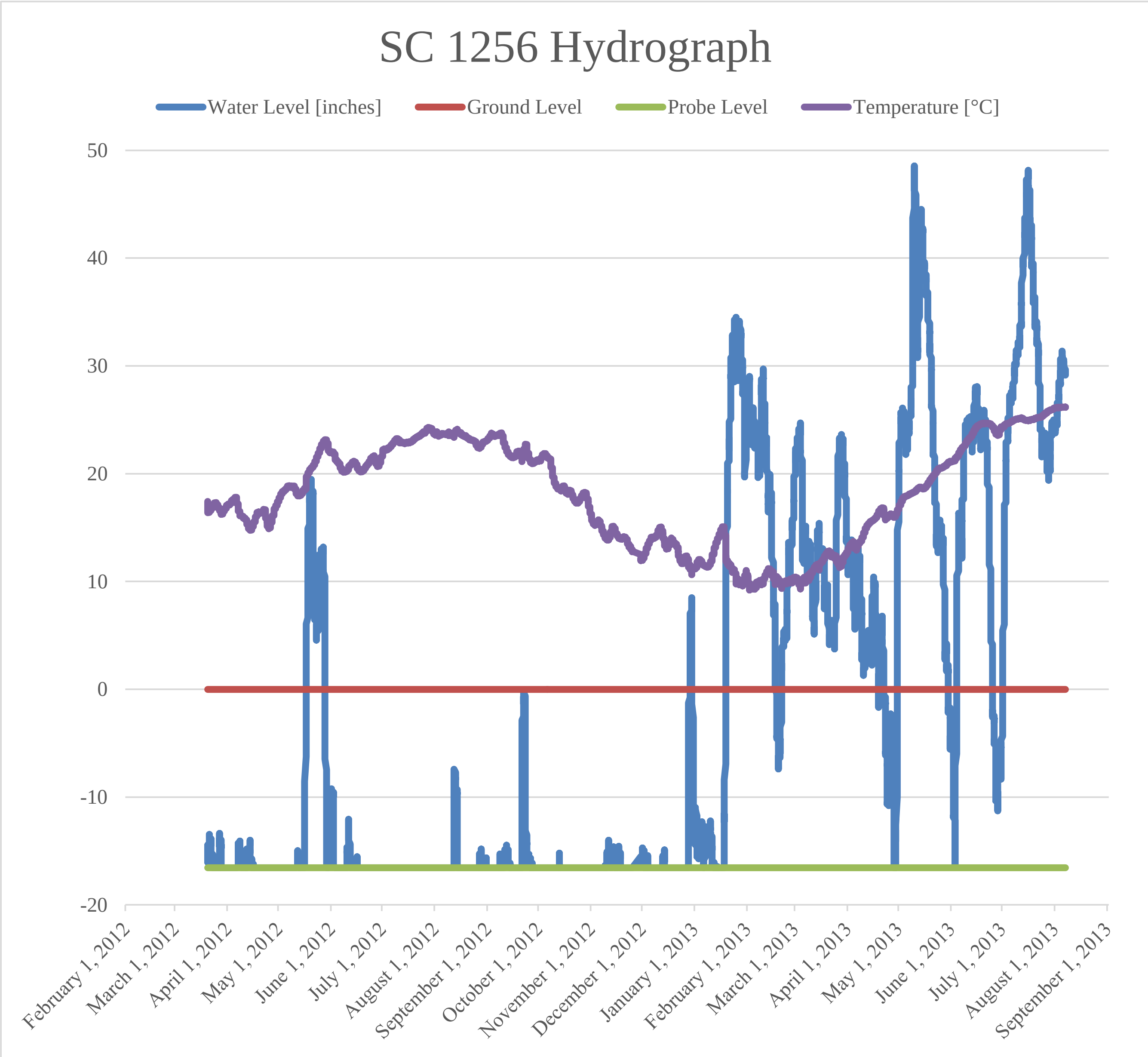
SC 1040 Hydrograph
Water Level [inches]
Ground Level
Probe Level
Temperature [°C]
25
15
5
-5
-15
-25
February 1, 2012
March 1, 2012
April 1, 2012
May 1, 2012
June 1, 2012
July 1, 2012
August 1, 2012
September 1, 2012
October 1, 2012
November 1, 2012
December 1, 2012
January 1, 2013
February 1, 2013
March 1, 2013
April 1, 2013
May 1, 2013
June 1, 2013

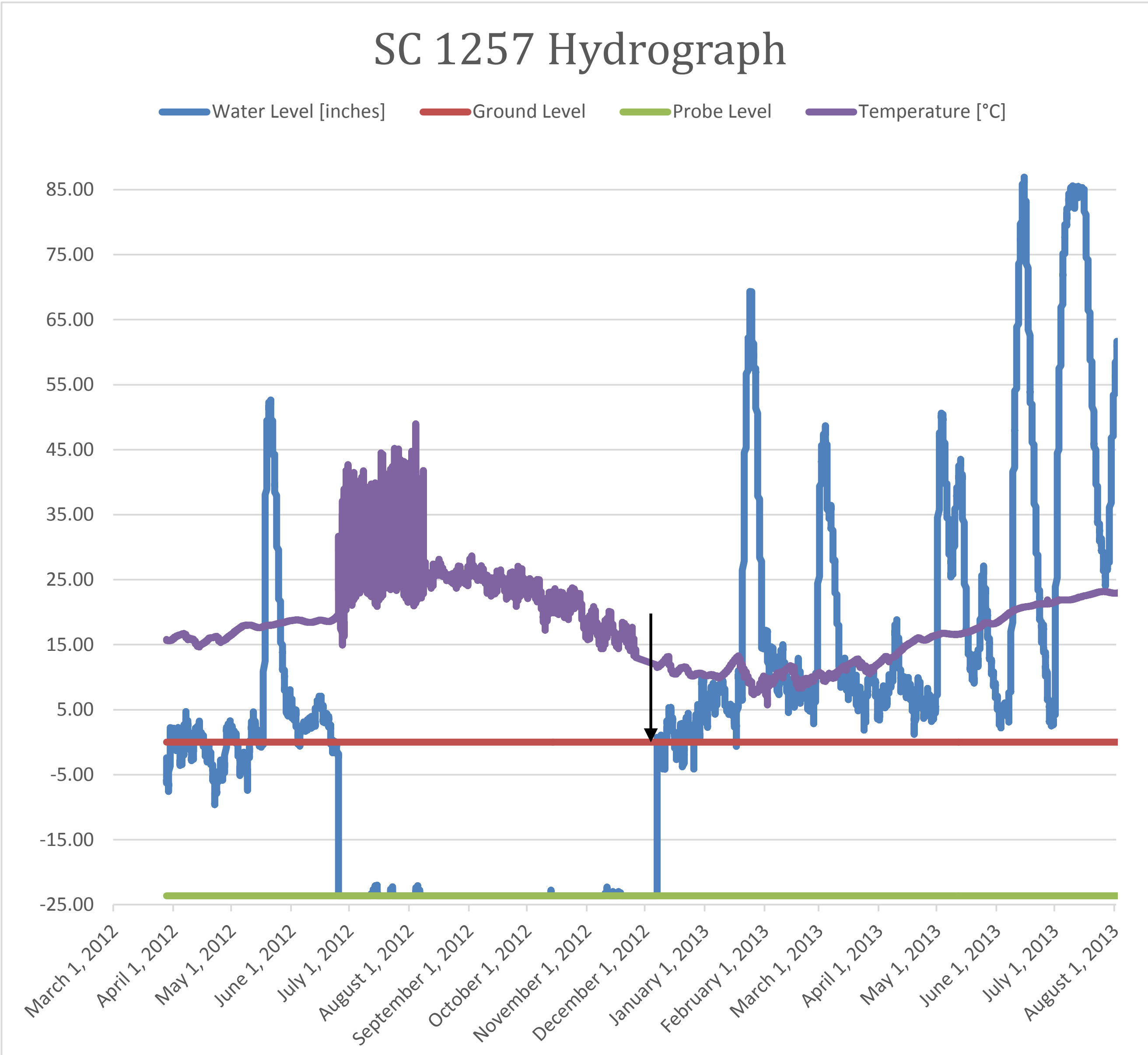

SC 1246 Hydrograph
Water Level [inches]
Ground Level
Probe Level
Temperature [°C]
80
70
60
50
40
30
20
10
0
-10
-20
-30
February 1, 2012
March 1, 2012
April 1, 2012
May 1, 2012
June 1, 2012
July 1, 2012
August 1, 2012
September 1, 2012
October 1, 2012
November 1, 2012



SC 1248 Hydrograph
Water Level [inches]
Ground Level
Probe Level
Temperature [°C]
25
15
5
-5
-15
-25
February 1, 2012
March 1, 2012
April 1, 2012
May 1, 2012
June 1, 2012
July 1, 2012
August 1, 2012
September 1, 2012
October 1, 2012
November 1, 2012
December 1, 2012
January 1, 2013
February 1, 2013
March 1, 2013
April 1, 2013
May 1, 2013
June 1, 2013

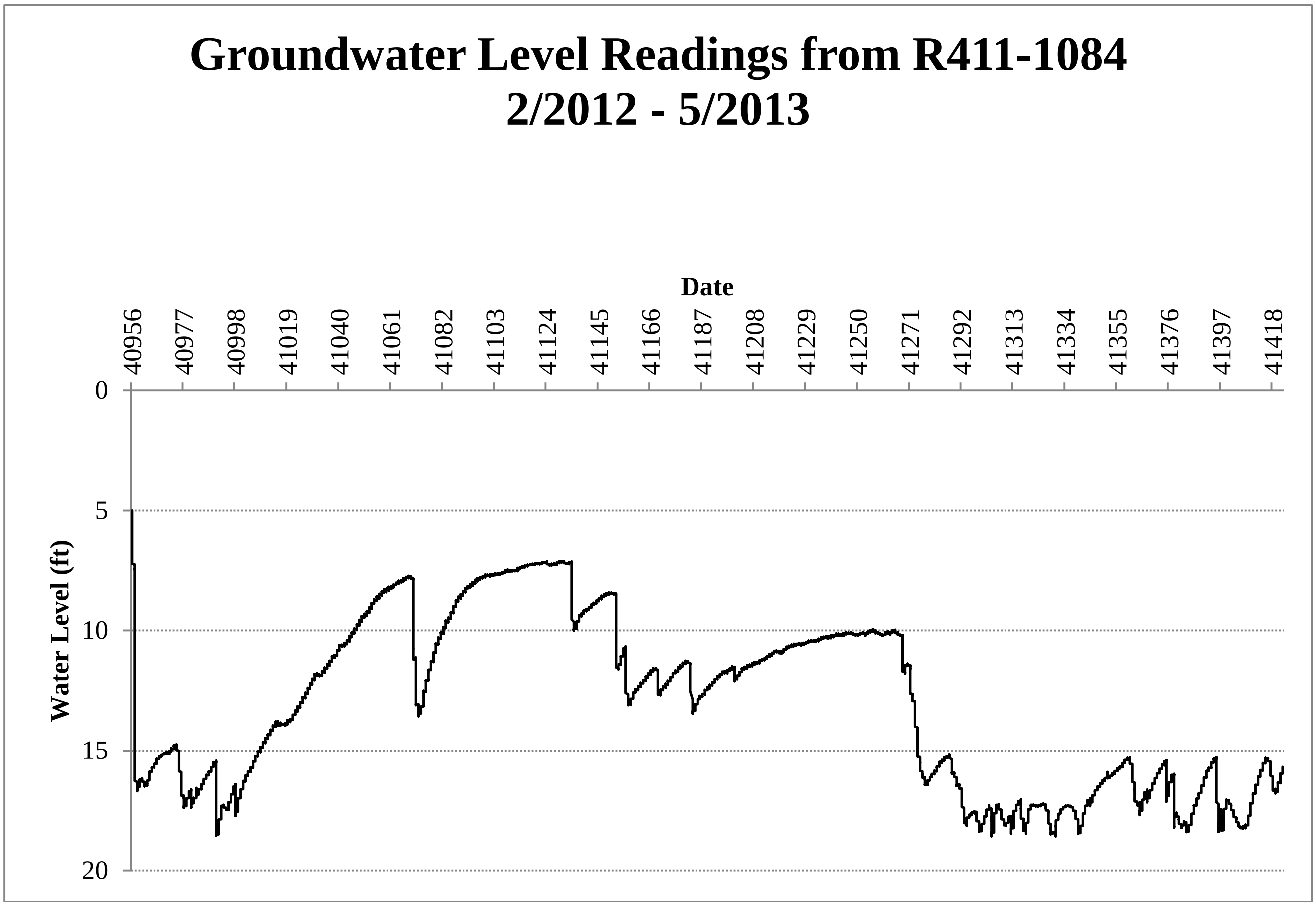

SC 1249 Hydrograph
Water Level [inches]
Ground Level
Probe Level
Temperature [°C]
25
15
5
-5
-15
-25
February 1, 2012
March 1, 2012
April 1, 2012
May 1, 2012
June 1, 2012
July 1, 2012
August 1, 2012
September 1, 2012
October 1, 2012
November 1, 2012
December 1, 2012
January 1, 2013
February 1, 2013
March 1, 2013
April 1, 2013
May 1, 2013
June 1, 2013

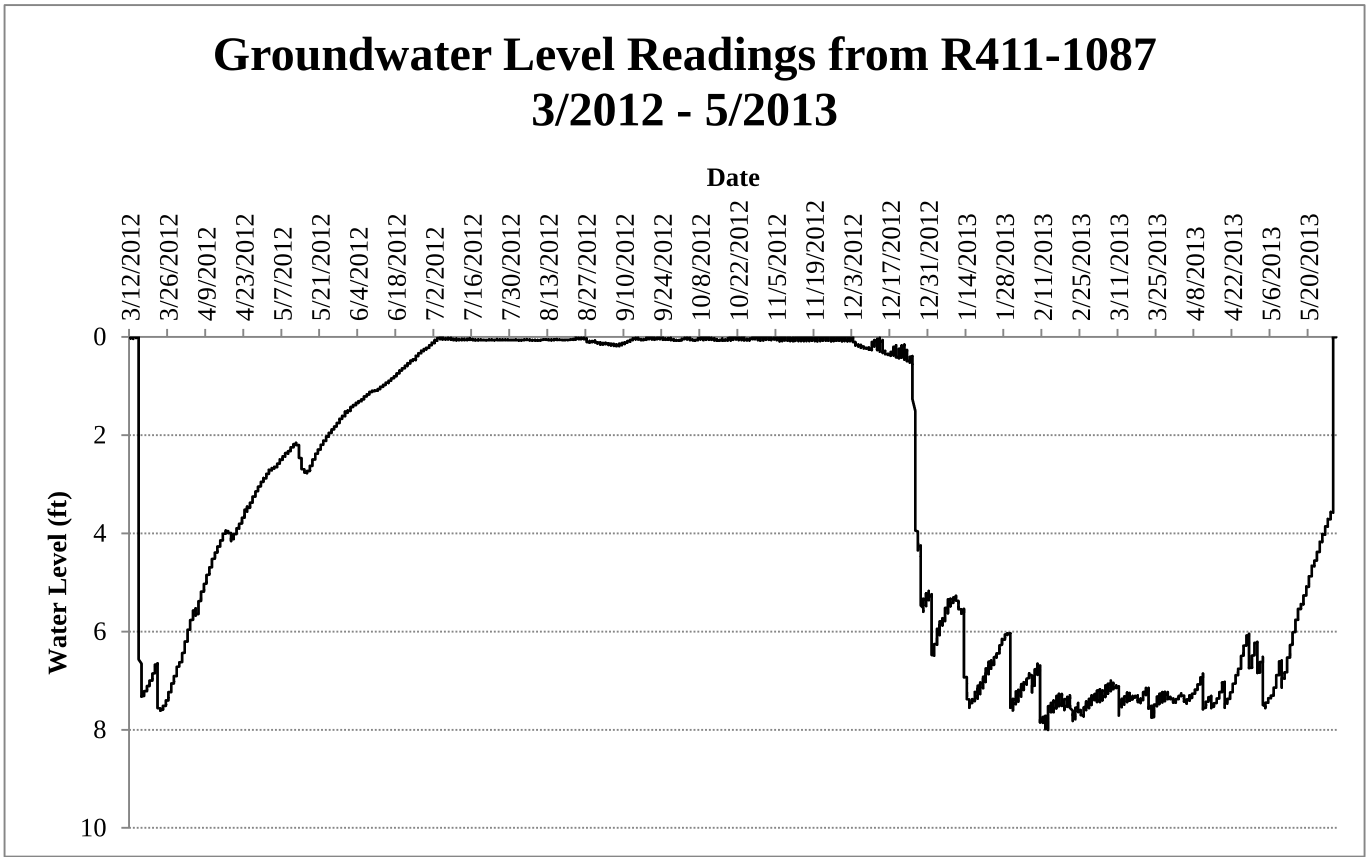

SC 1256 Hydrograph
Water Level [inches]
Ground Level
Probe Level
Temperature [°C]
50
40
30
20
10
0
-10
-20
February 1, 2012
March 1, 2012
April 1, 2012
May 1, 2012
June 1, 2012
July 1, 2012
August 1, 2012
September 1, 2012
October 1, 2012
November 1, 2012
December 1, 2012
January 1, 2013
February 1, 2013
March 1, 2013
April 1, 2013
May 1, 2013
June 1, 2013
July 1, 2013
August 1, 2013
September 1, 2013

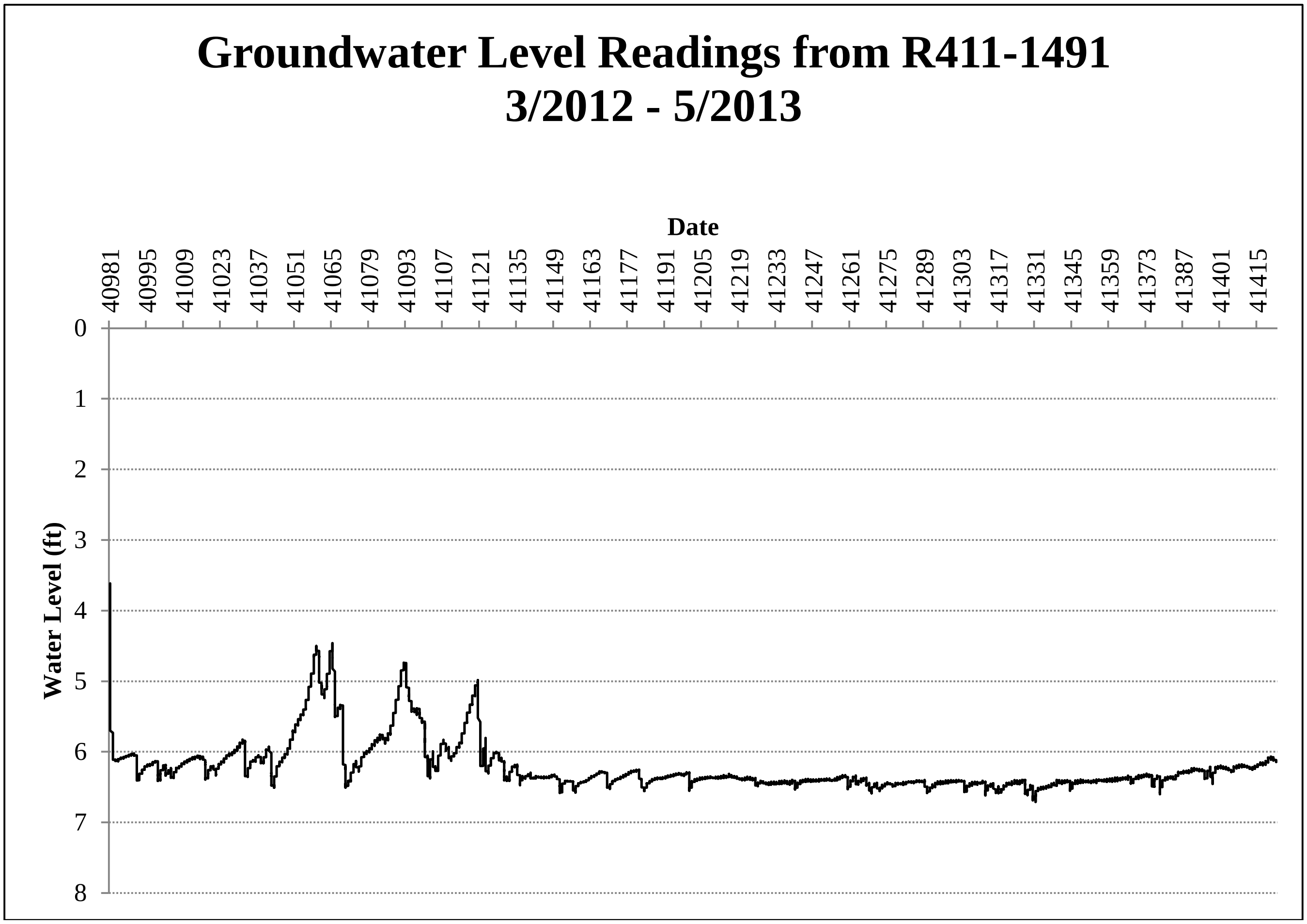

SC 1257 Hydrograph
Water Level [inches]
Ground Level
Probe Level
Temperature [°C]
85.00
75.00
65.00
55.00
45.00
35.00
25.00
15.00
5.00
-5.00
-15.00
-25.00
March 1, 2012
April 1, 2012
May 1, 2012
June 1, 2012
July 1, 2012
August 1, 2012
September 1, 2012
October 1, 2012
November 1, 2012
December 1, 2012
January 1, 2013
February 1, 2013
March 1, 2013
April 1, 2013
May 1, 2013
June 1, 2013
July 1, 2013
August 1, 2013

A4: Hydrographs for AL RSF sites

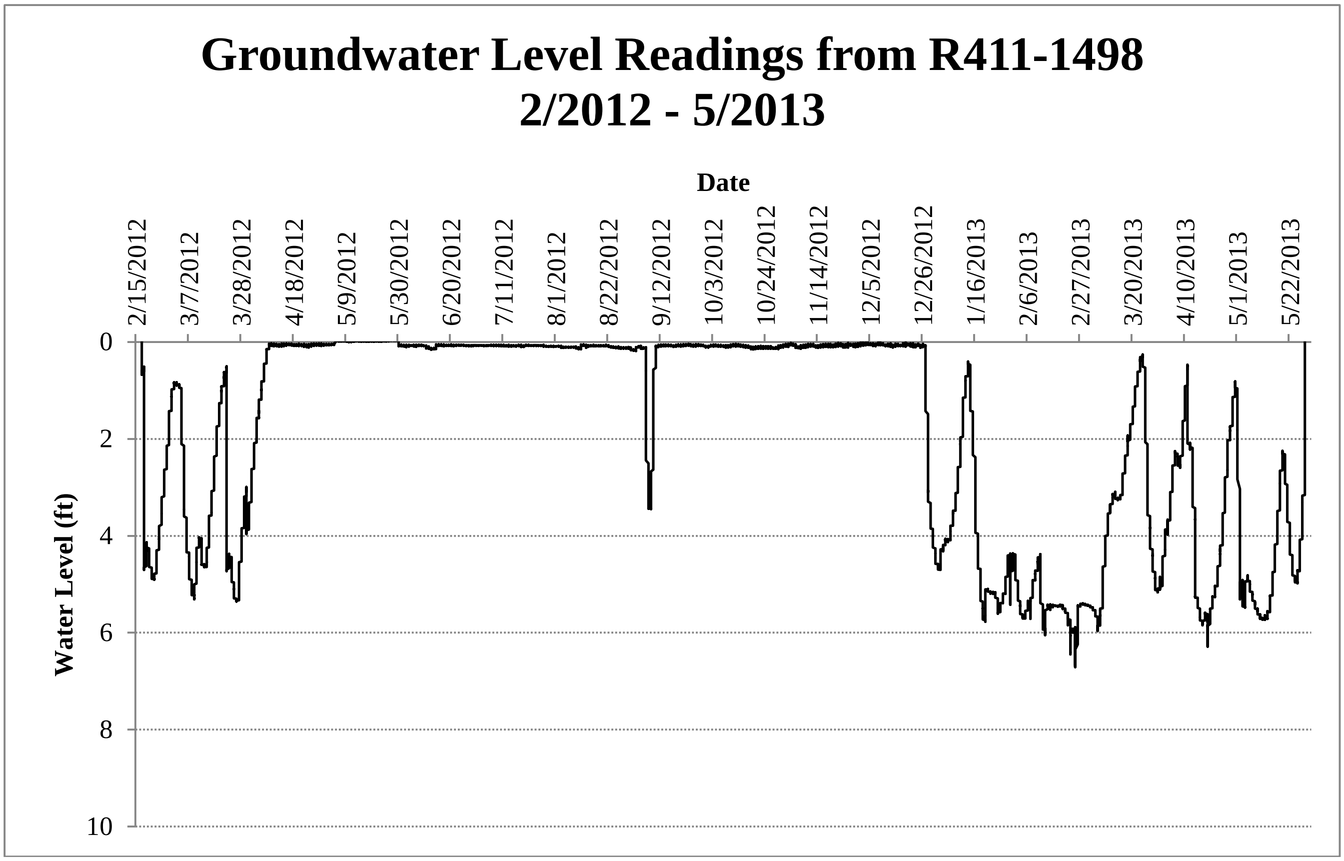
Note that AL did measure depth to water, but their wells were much deeper (up to 20 feet) whereas the other states only installed wells to 2 feet. Ground level is at zero.

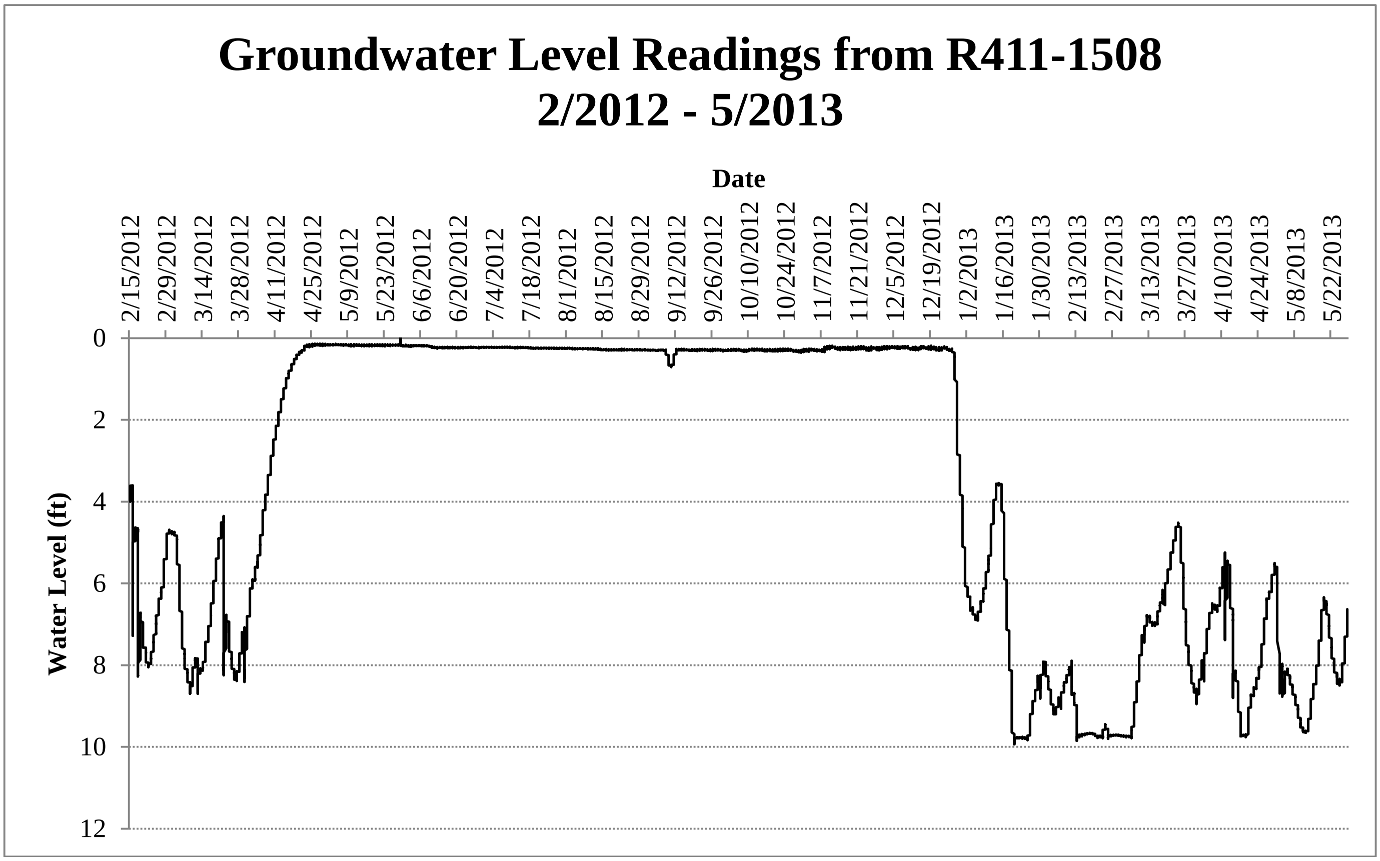



Groundwater Level Readings from R411-1087
3/2012 - 5/2013
Date
3/12/2012
3/26/2012
4/9/2012
4/23/2012
5/7/2012
5/21/2012
6/4/2012
6/18/2012
7/2/2012
7/16/2012
7/30/2012
8/13/2012
8/27/2012
9/10/2012
9/24/2012
10/8/2012
10/22/2012
11/5/2012
11/19/2012
12/3/2012
12/17/2012
12/31/2012
1/14/2013
1/28/2013
2/11/2013
2/25/2013
3/11/2013
3/25/2013
4/8/2013
4/22/2013
5/6/2013
5/20/2013
Water Level (ft)
0
2
4
6
8
10

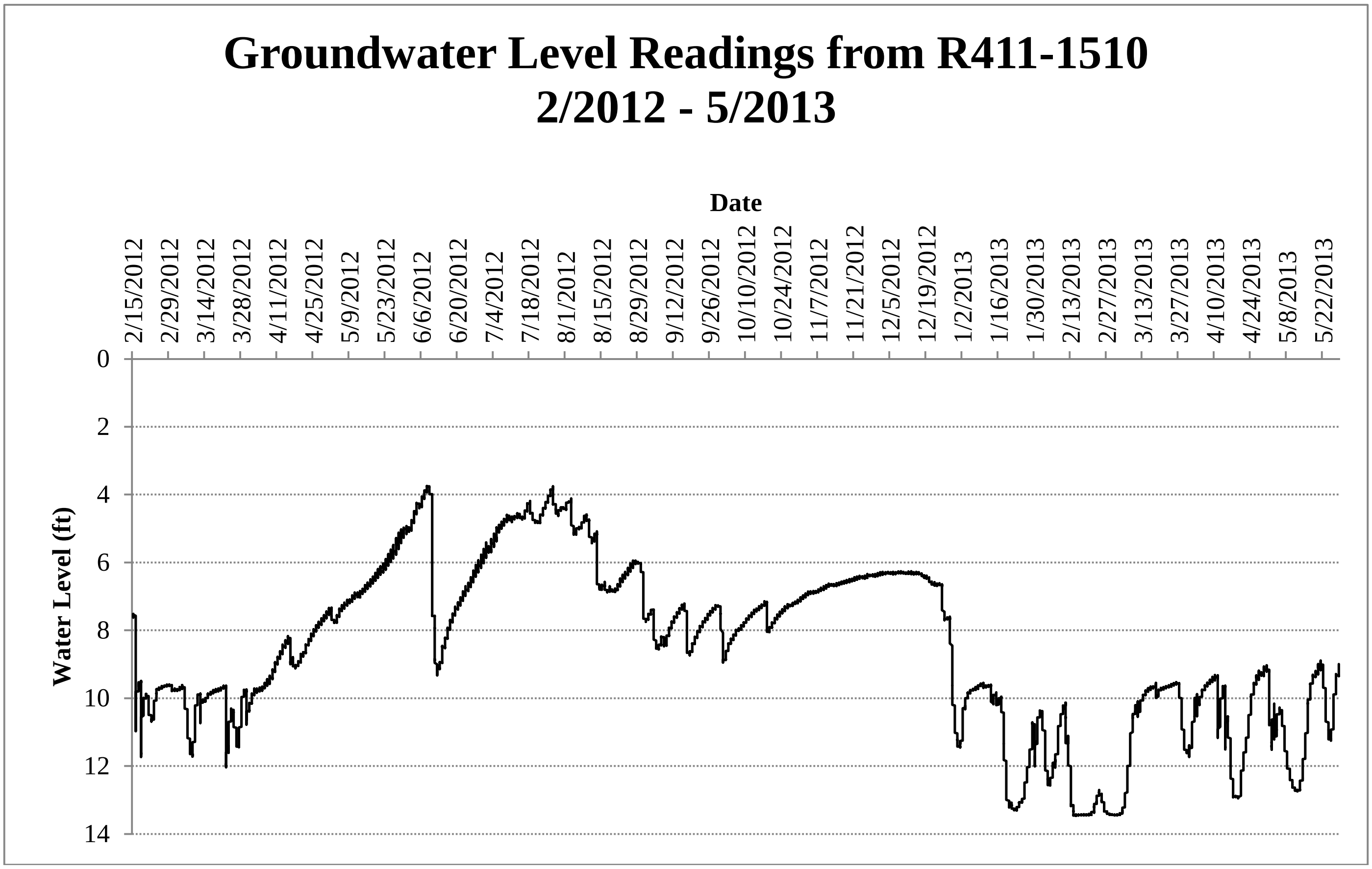


Groundwater Level Readings from R411-1491
3/2012 - 5/2013
Date
40981
40995
41009
41023
41037
41051
41065
41079
41093
41107
41121
41135
41149
41163
41177
41191
41205
41219
41233
41247
41261
41275
41289
41303
41317
41331
41345
41359
41373
41387
41401
41415
Water Level (ft)
0
1
2
3
4
5
6
7
8

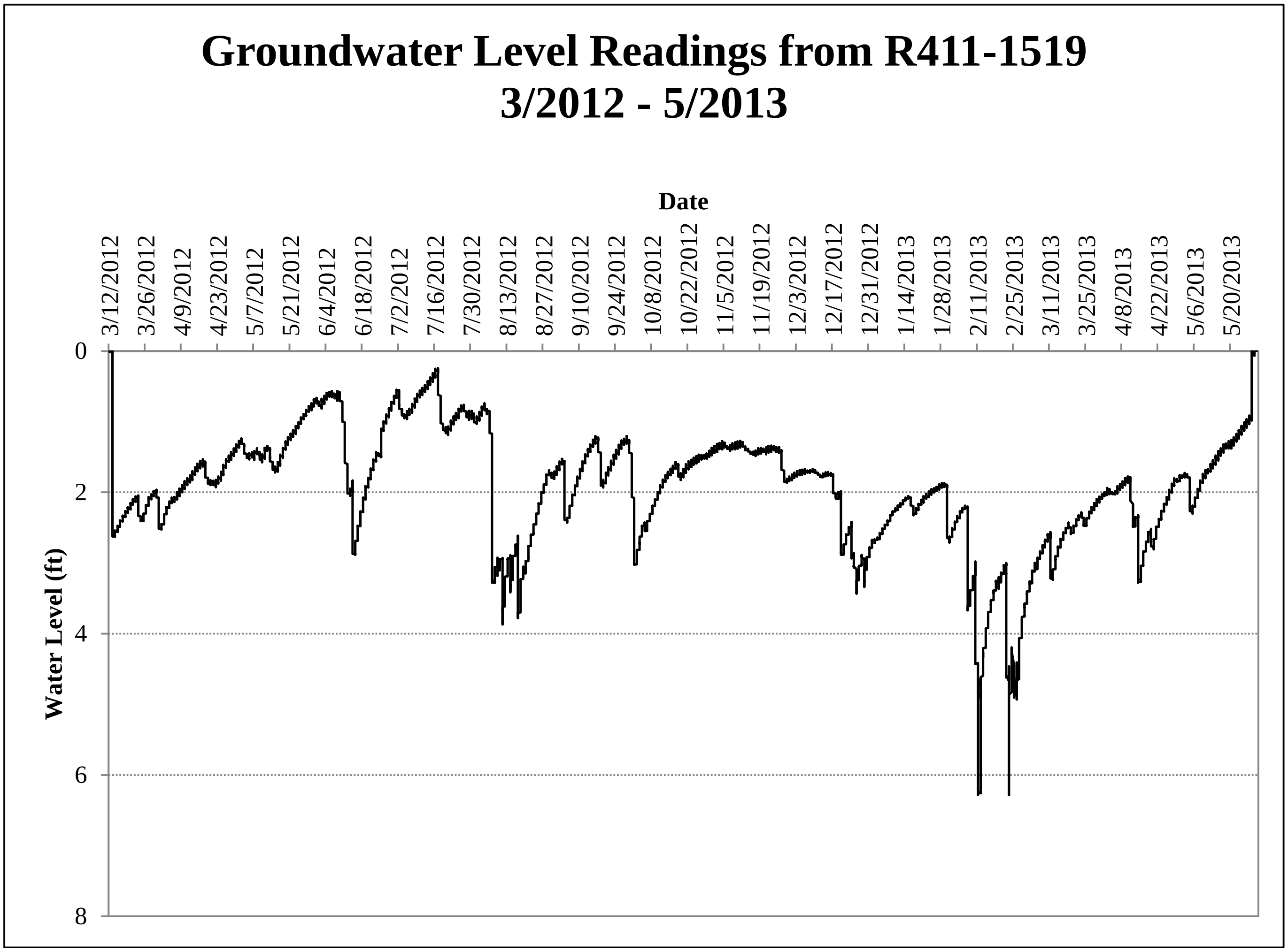

Groundwater Level Readings from R411-1498
2/2012 - 5/2013
Date
2/15/2012
3/7/2012
3/28/2012
4/18/2012
5/9/2012
5/30/2012
6/20/2012
7/11/2012
8/1/2012
8/22/2012
9/12/2012
10/3/2012
10/24/2012
11/14/2012
12/5/2012
12/26/2012
1/16/2013
2/6/2013
2/27/2013
3/20/2013
4/10/2013
5/1/2013
5/22/2013
Water Level (ft)
0
2
4
6
8
10

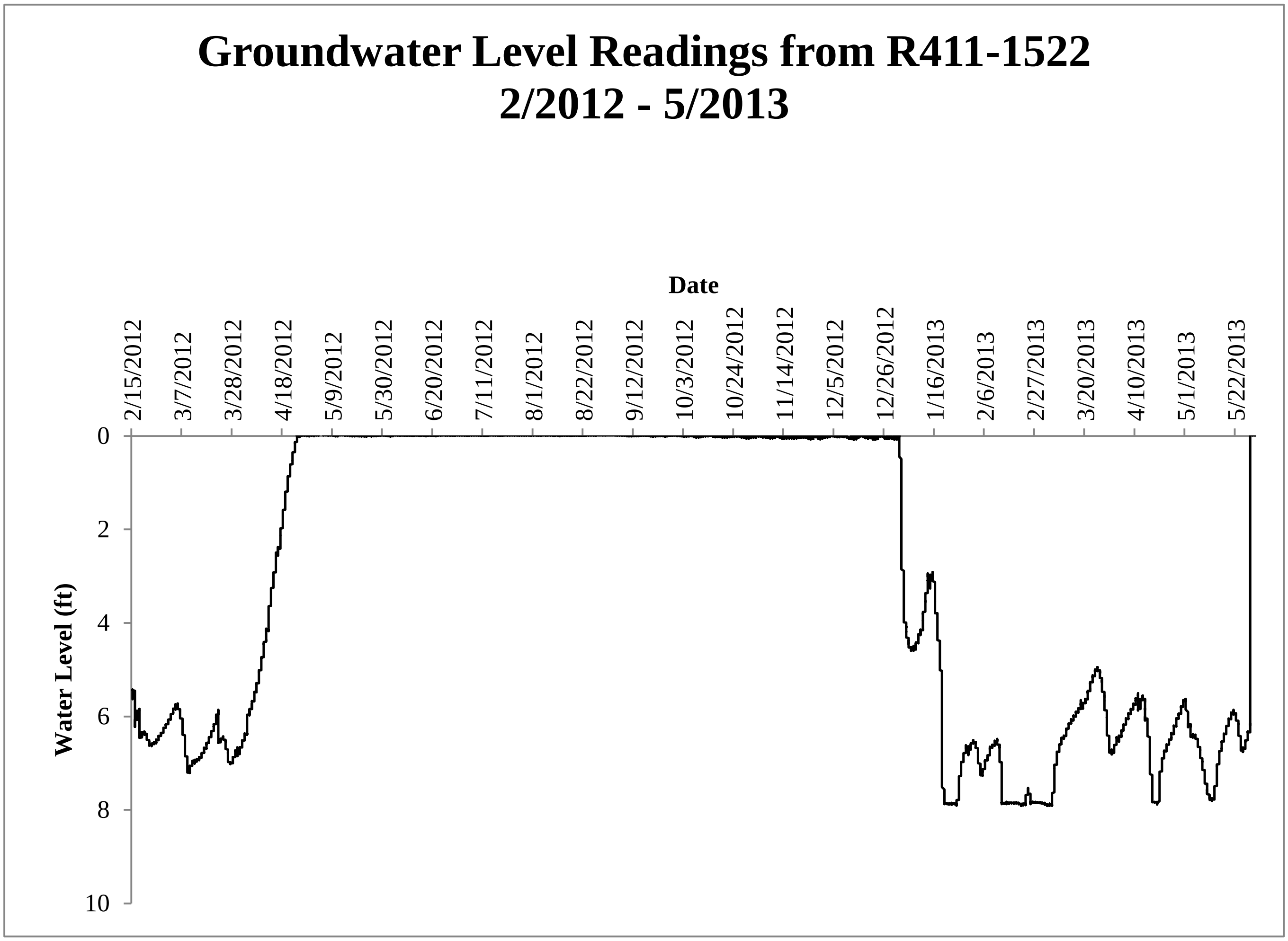


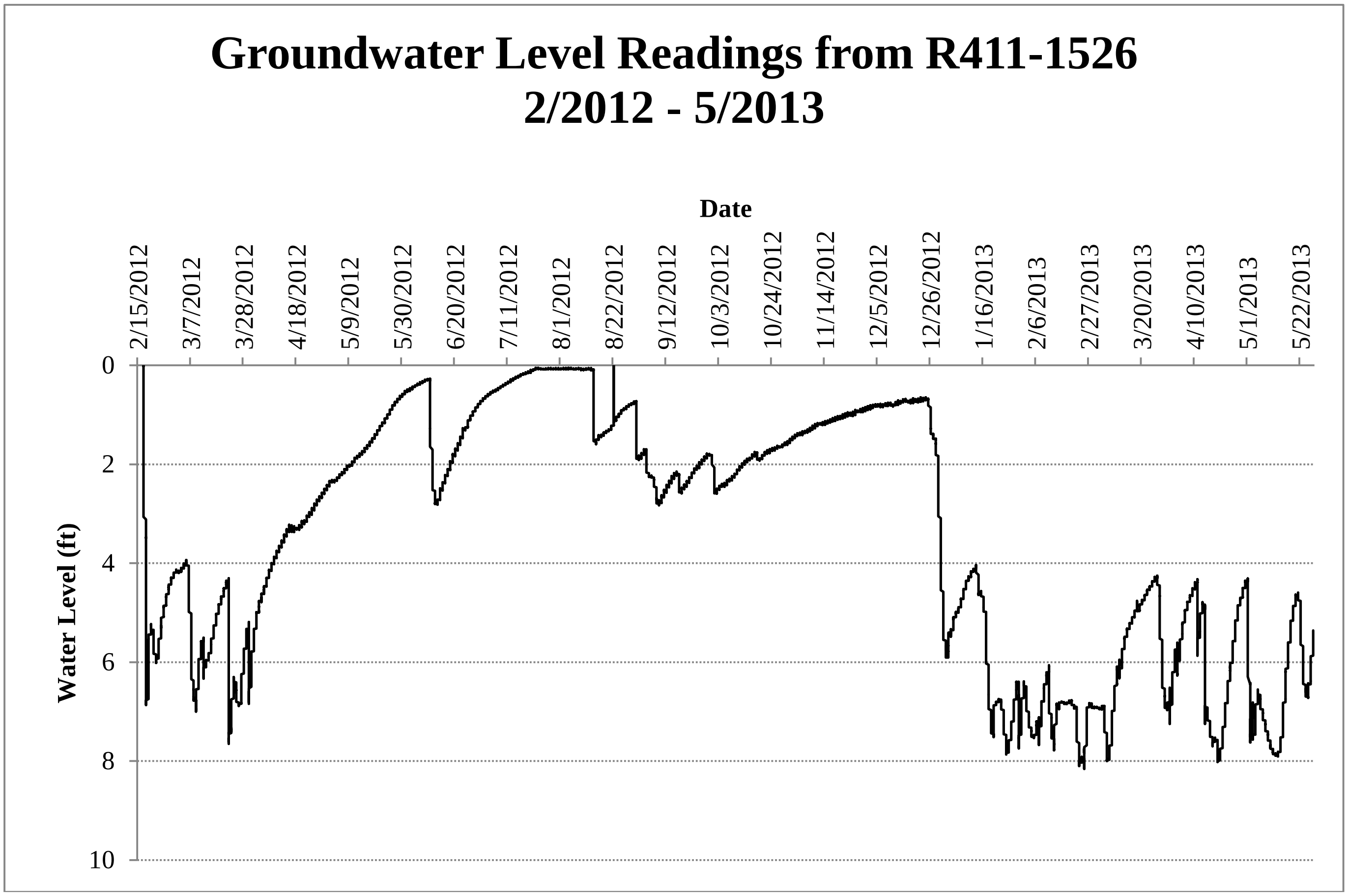
Groundwater Level Readings from R411-1508
2/2012 - 5/2013
Date
2/15/2012
2/29/2012
3/14/2012
3/28/2012
4/11/2012
4/25/2012
5/9/2012
5/23/2012
6/6/2012
6/20/2012
7/4/2012
7/18/2012
8/1/2012
8/15/2012
8/29/2012
9/12/2012
9/26/2012
10/10/2012
10/24/2012
11/7/2012
11/21/2012
12/5/2012
12/19/2012
1/2/2013
1/16/2013
1/30/2013
2/13/2013
2/27/2013
3/13/2013
3/27/2013
4/10/2013
4/24/2013
5/8/2013
5/22/2013
Water Level (ft)
0
2
4
6
8
10
12



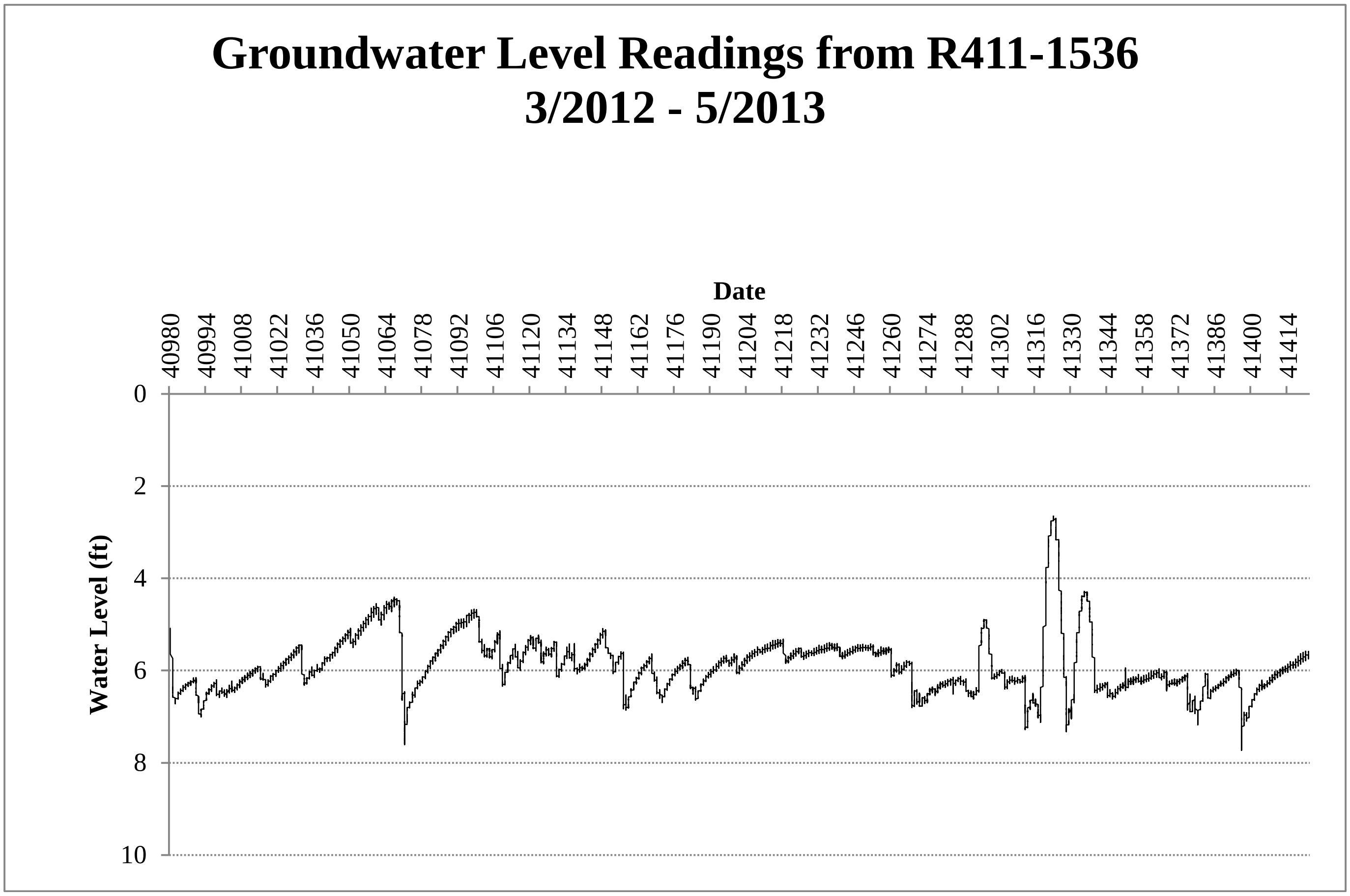
Groundwater Level Readings from R411-1510
2/2012 - 5/2013
Date
2/15/2012
2/29/2012
3/14/2012
3/28/2012
4/11/2012
4/25/2012
5/9/2012
5/23/2012
6/6/2012
6/20/2012
7/4/2012
7/18/2012
8/1/2012
8/15/2012
8/29/2012
9/12/2012
9/26/2012
10/10/2012
10/24/2012
11/7/2012
11/21/2012
12/5/2012
12/19/2012
1/2/2013
1/16/2013
1/30/2013
2/13/2013
2/27/2013
3/13/2013
3/27/2013
4/10/2013
4/24/2013
5/8/2013
5/22/2013
Water Level (ft)
0
2
4
6
8
10
12
14


Groundwater Level Readings from R411-1519
3/2012 - 5/2013
Date
3/12/2012
3/26/2012
4/9/2012
4/23/2012
5/7/2012
5/21/2012
6/4/2012
6/18/2012
7/2/2012
7/16/2012
7/30/2012
8/13/2012
8/27/2012
9/10/2012
9/24/2012
10/8/2012
10/22/2012
11/5/2012
11/19/2012
12/3/2012
12/17/2012
12/31/2012
1/14/2013
1/28/2013
2/11/2013
2/25/2013
3/11/2013
3/25/2013
4/8/2013
4/22/2013
5/6/2013
5/20/2013
Water Level (ft)
0
2
4
6
8


Groundwater Level Readings from R411-1522
2/2012 - 5/2013
Date
2/15/2012
3/7/2012
3/28/2012
4/18/2012
5/9/2012
5/30/2012
6/20/2012
7/11/2012
8/1/2012
8/22/2012
9/12/2012
10/3/2012
10/24/2012
11/14/2012
12/5/2012
12/26/2012
1/16/2013
2/6/2013
2/27/2013
3/20/2013
4/10/2013
5/1/2013
5/22/2013
Water Level (ft)
0
2
4
6
8
10



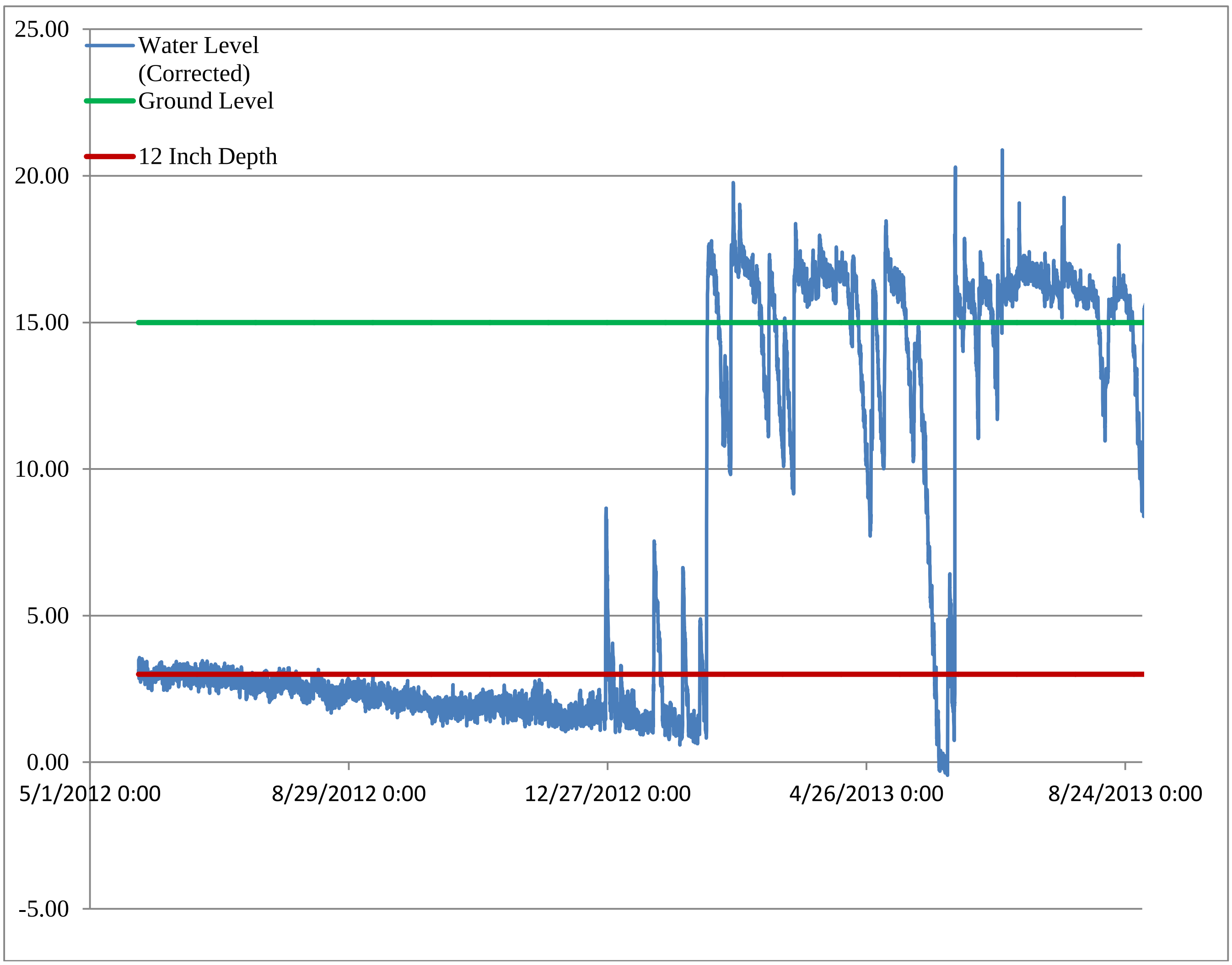
Groundwater Level Readings from R411-1526
2/2012 - 5/2013
Date
2/15/2012
3/7/2012
3/28/2012
4/18/2012
5/9/2012
5/30/2012
6/20/2012
7/11/2012
8/1/2012
8/22/2012
9/12/2012
10/3/2012
10/24/2012
11/14/2012
12/5/2012
12/26/2012
1/16/2013
2/6/2013
2/27/2013
3/20/2013
4/10/2013
5/1/2013
5/22/2013
Water Level (ft)
0
2
4
6
8
10


Groundwater Level Readings from R411-1536
3/2012 - 5/2013
Date
40980
40994
41008
41022
41036
41050
41064
41078
41092
41106
41120
41134
41148
41162
41176
41190
41204
41218
41232
41246
41260
41274
41288
41302
41316
41330
41344
41358
41372
41386
41400
41414
Water Level (ft)
0
2
4
6
8
10

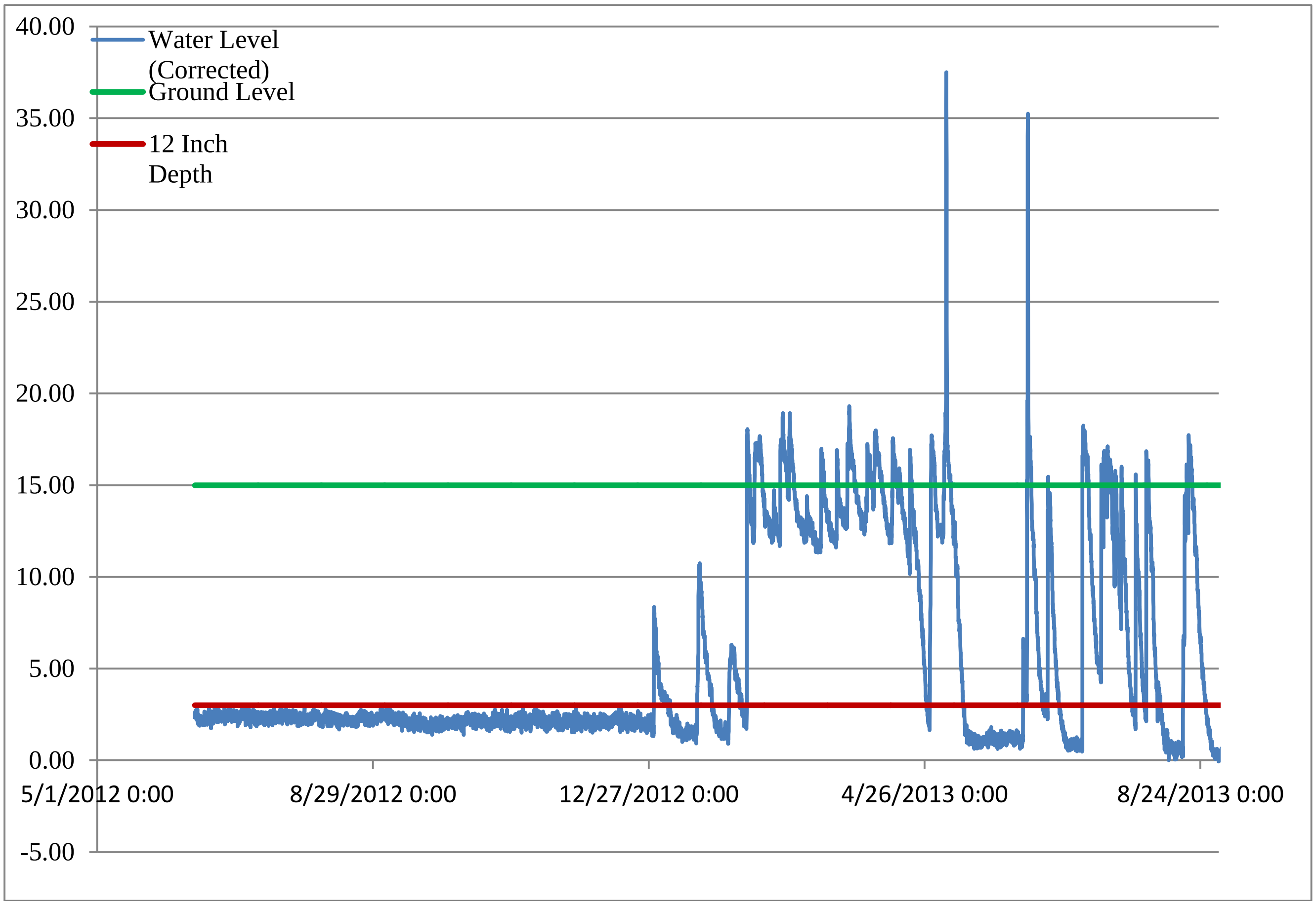
A5: Hydrographs for GA BLH sites

The hydrographs for GA show the water levels and the ground level. The red line shows the one foot level. Hydrographs for sites 1296 and 1342 are not included as the hydrology was not monitored due to vandalism or technical problems.

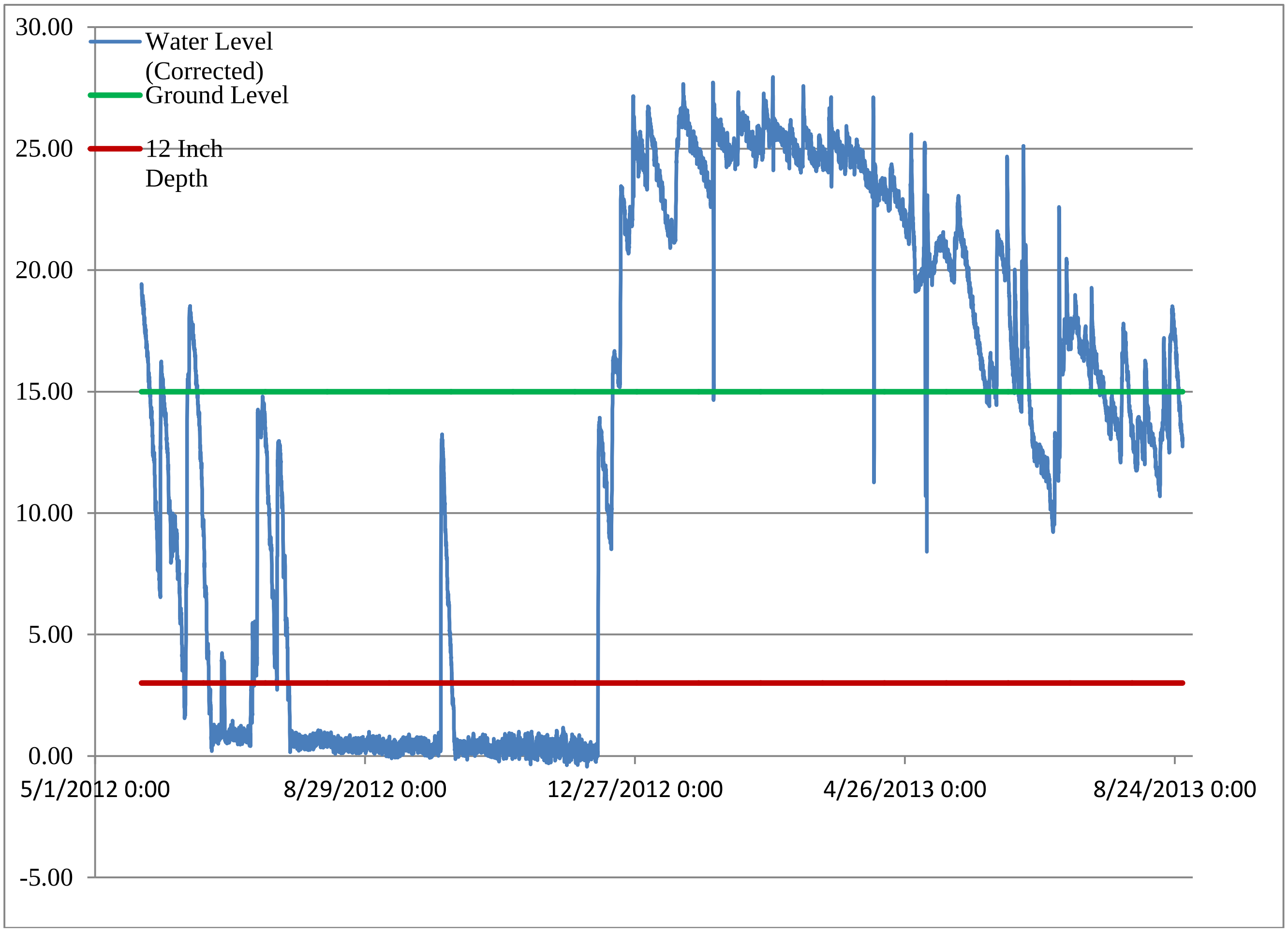
Hydrograph for site 1050



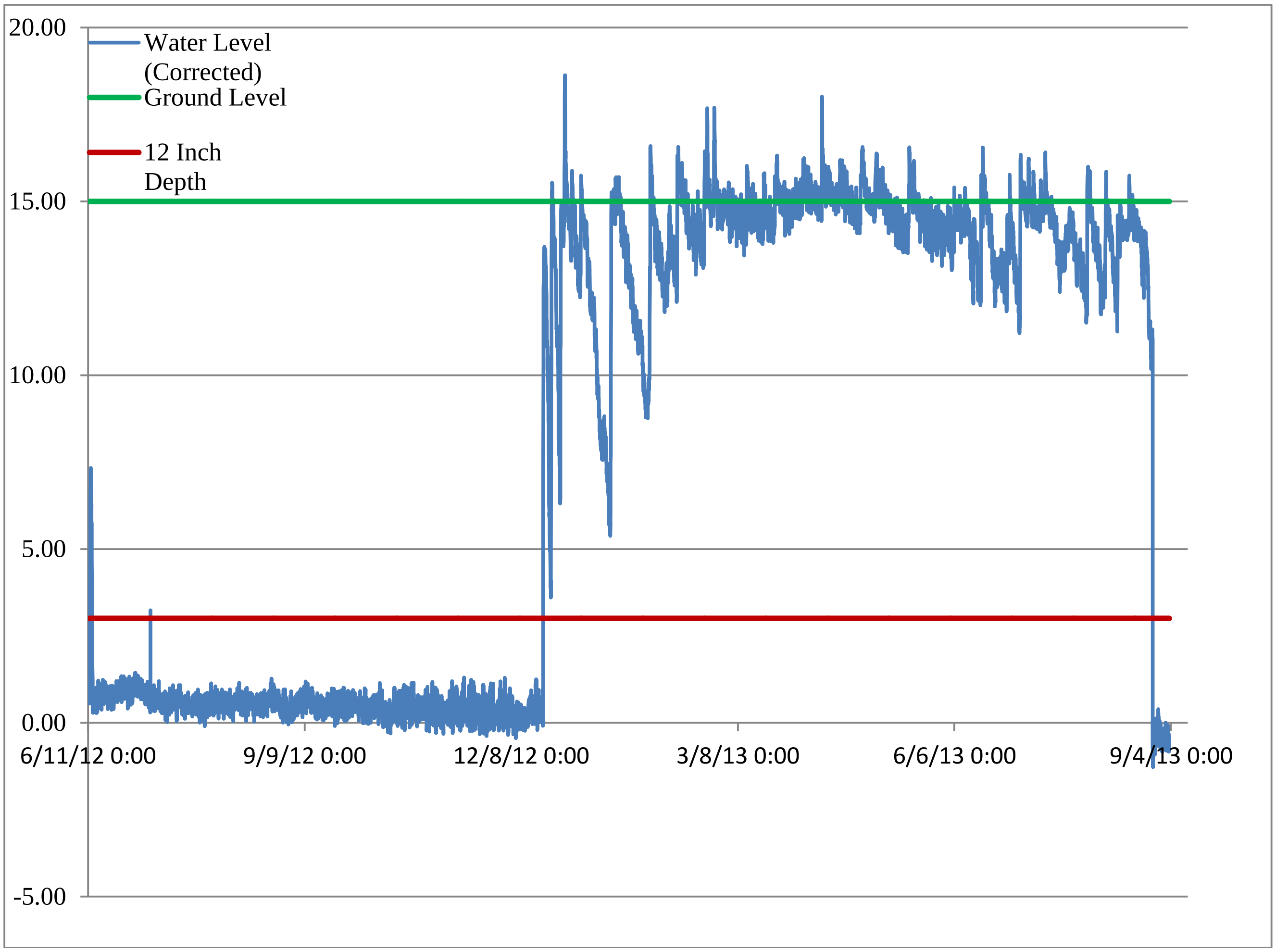
Hydrograph for site 1310



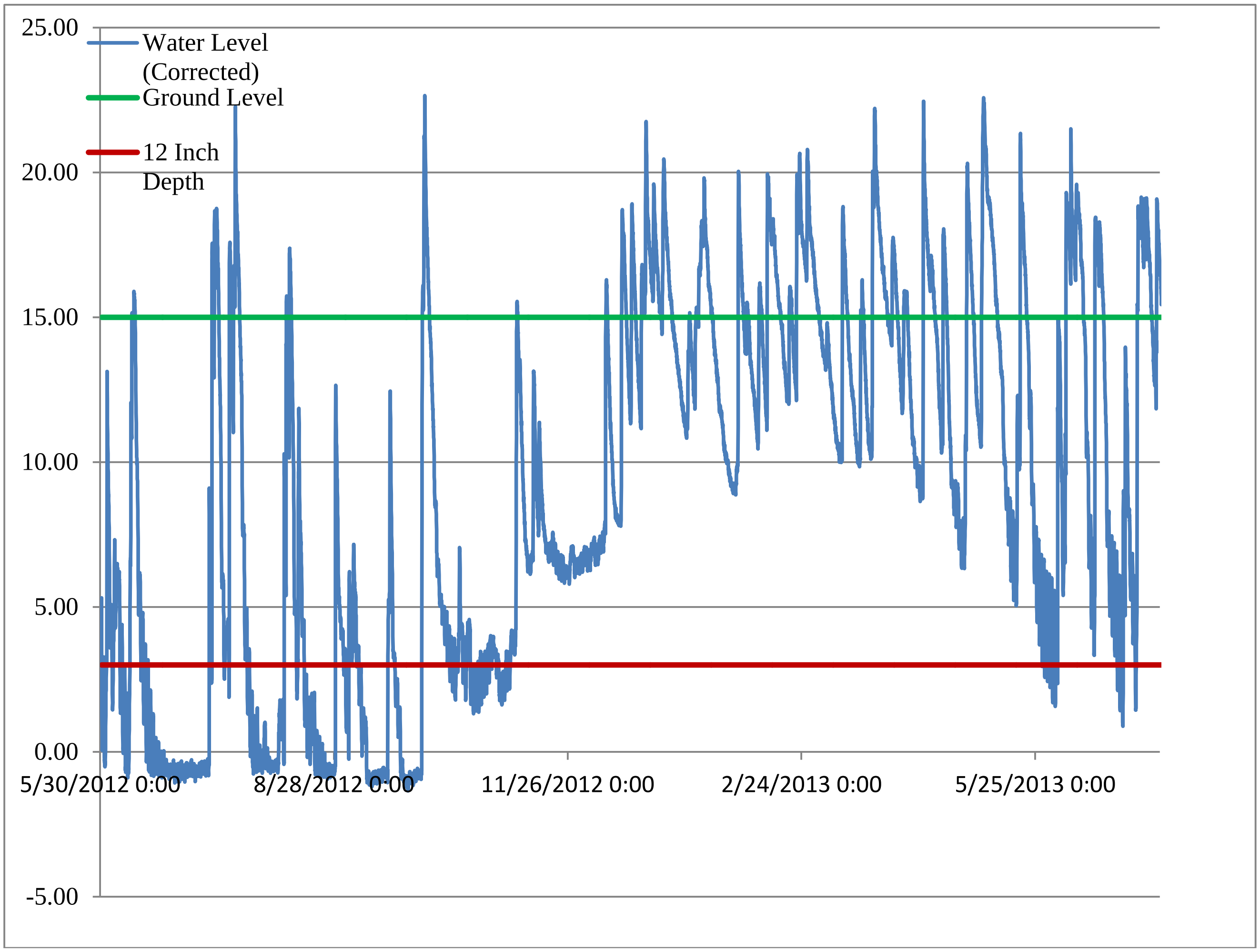
Hydrograph for site 1316



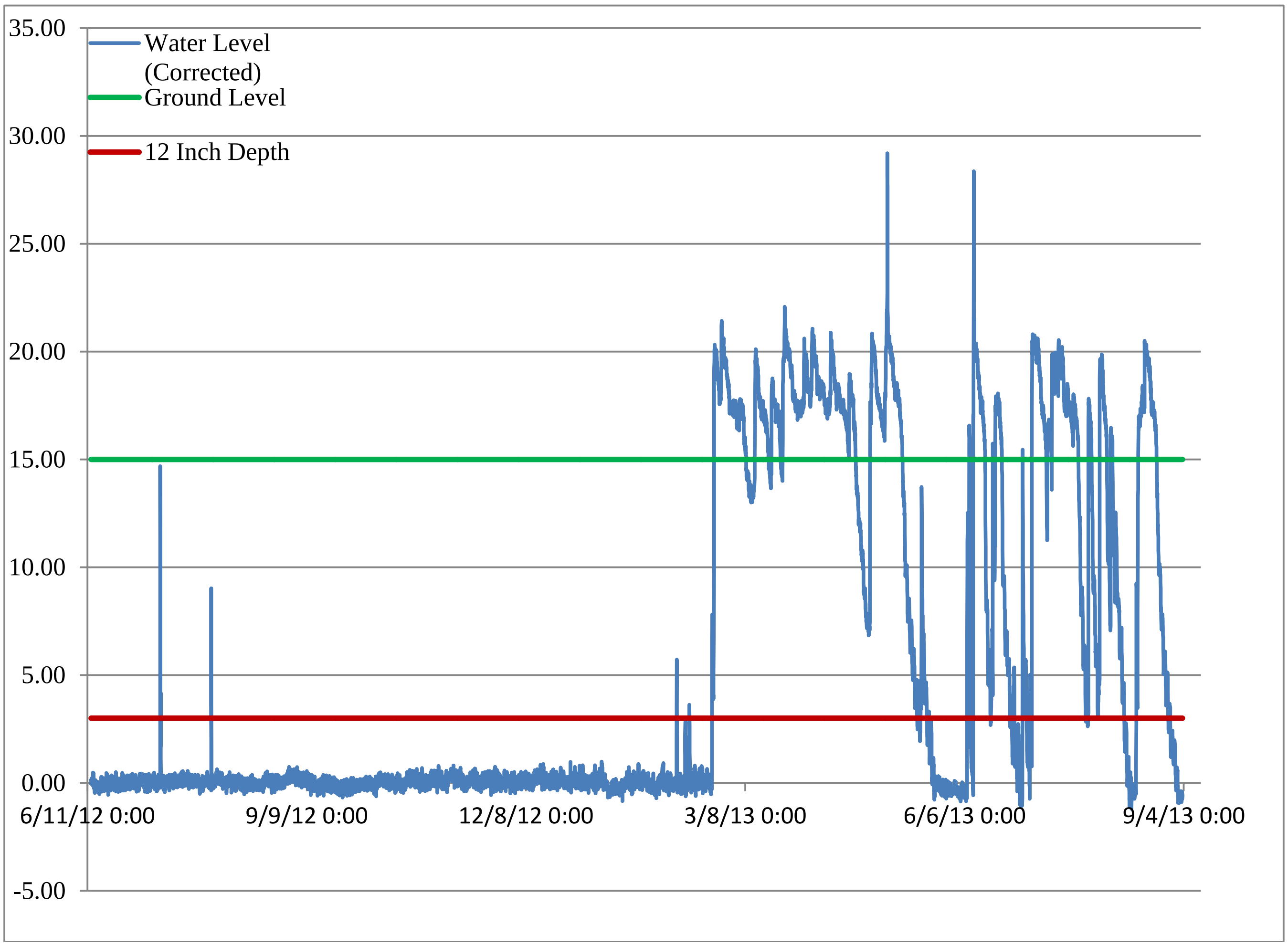
Hydrograph for site 1323



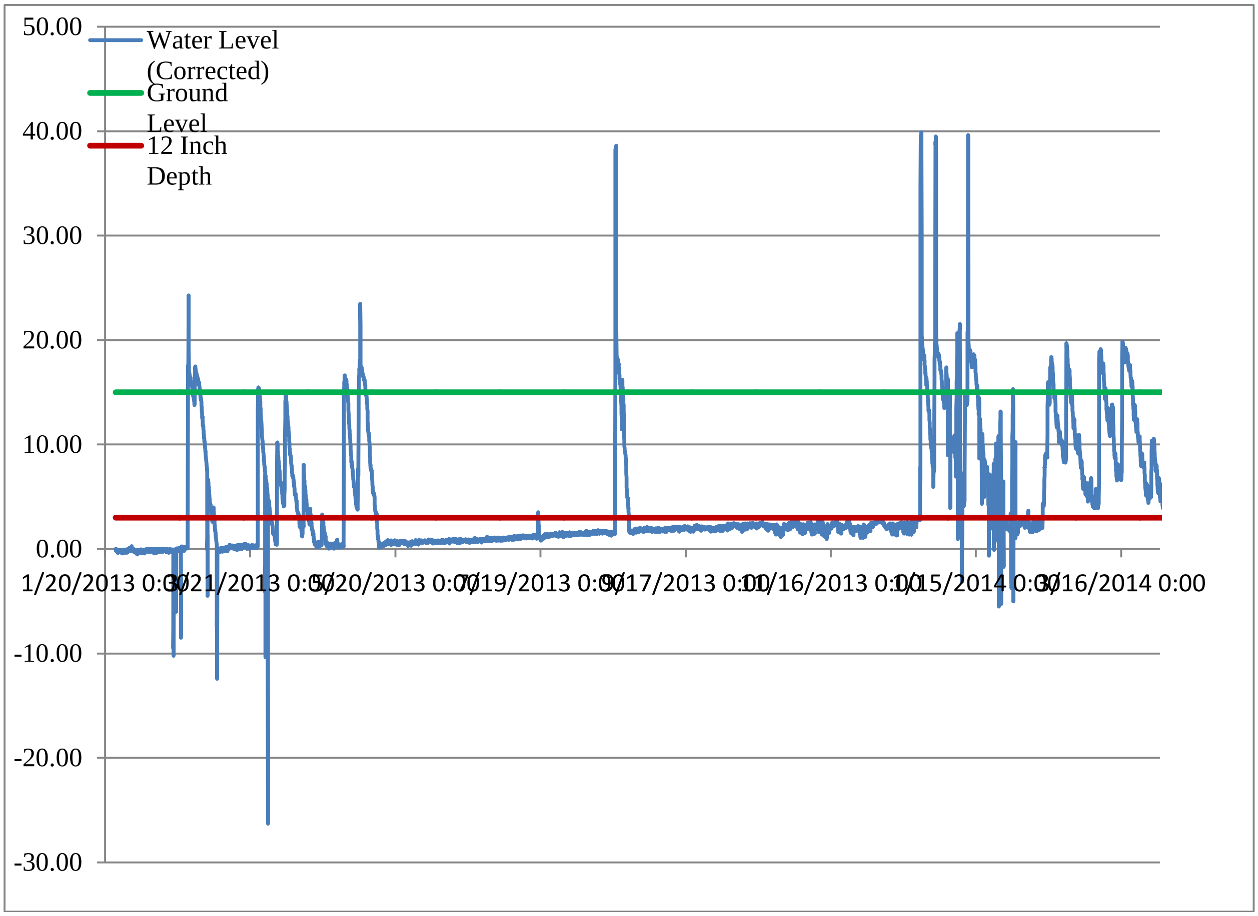
Hydrograph for site 1324



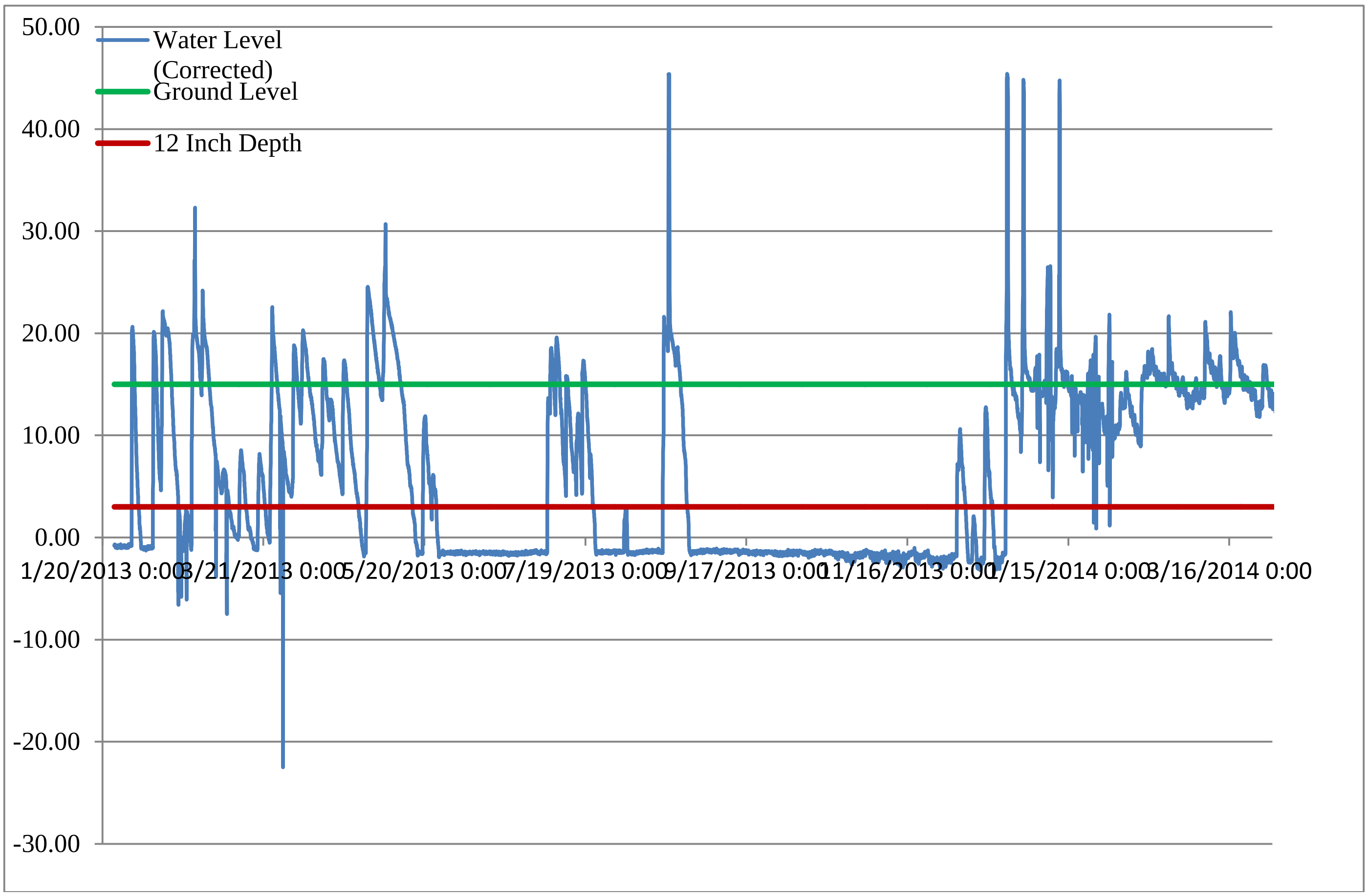
Hydrograph for site 1326



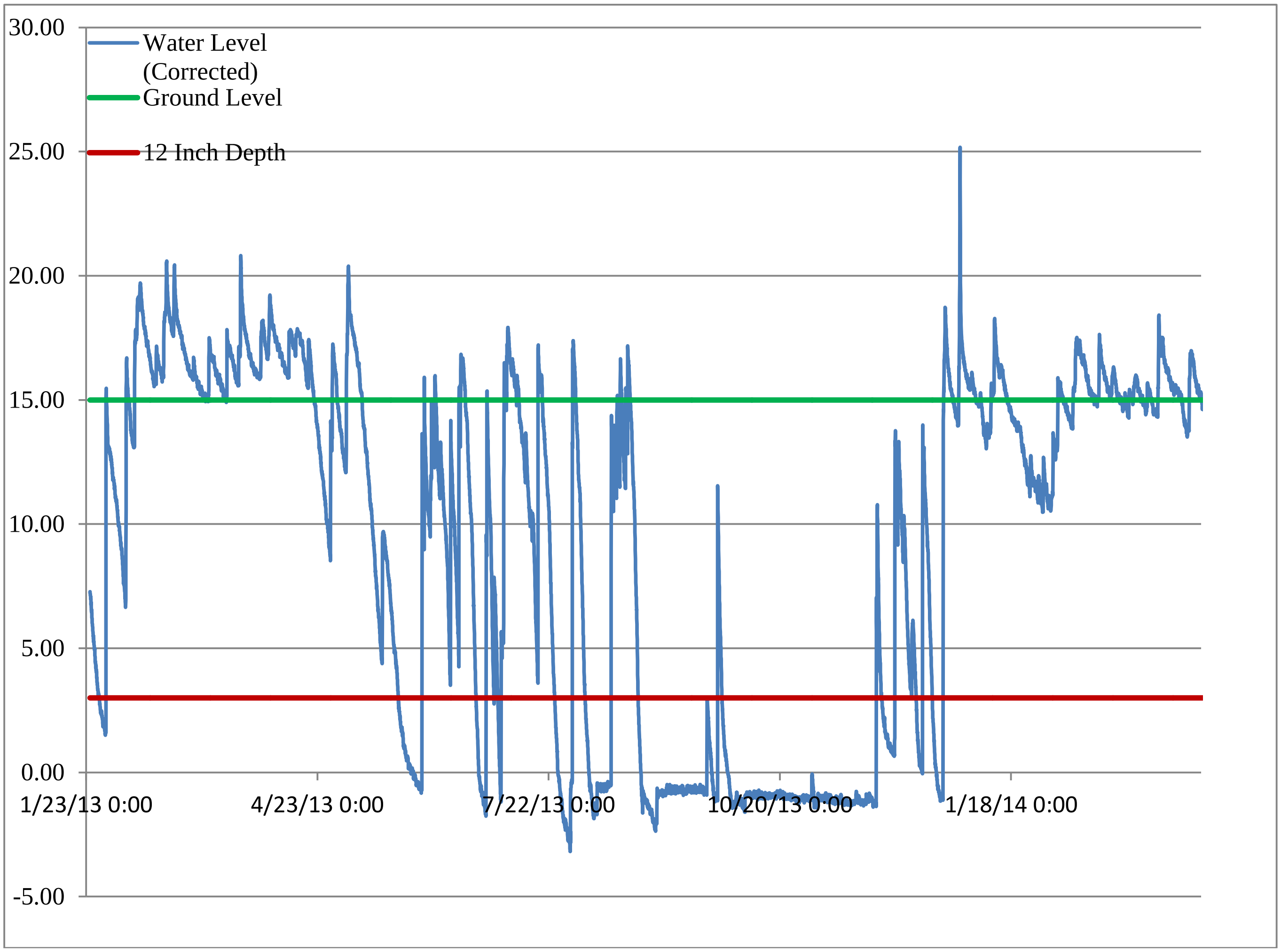
Hydrograph for site 1333: Upper



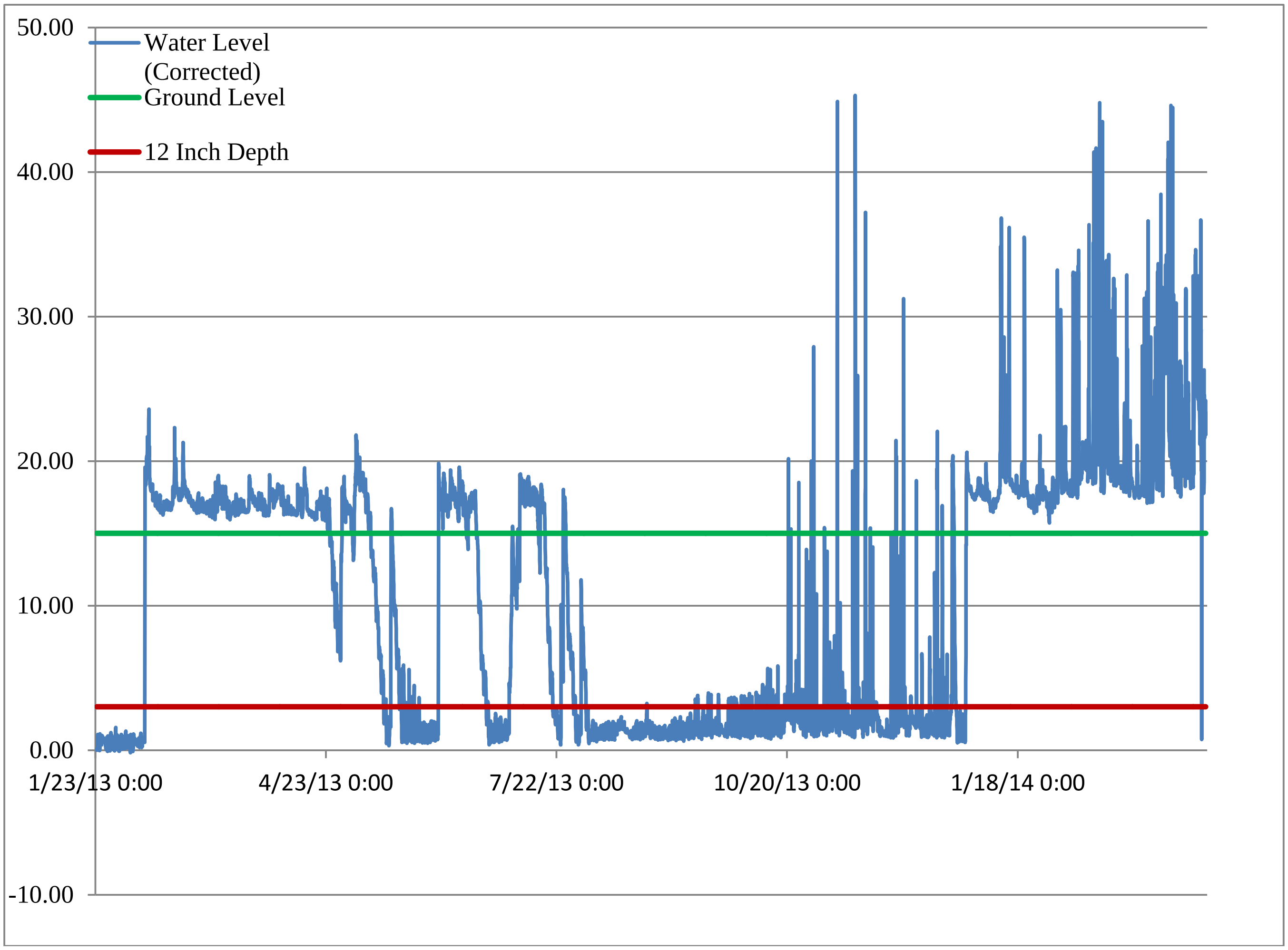
Hydrograph for site 1333: Lower



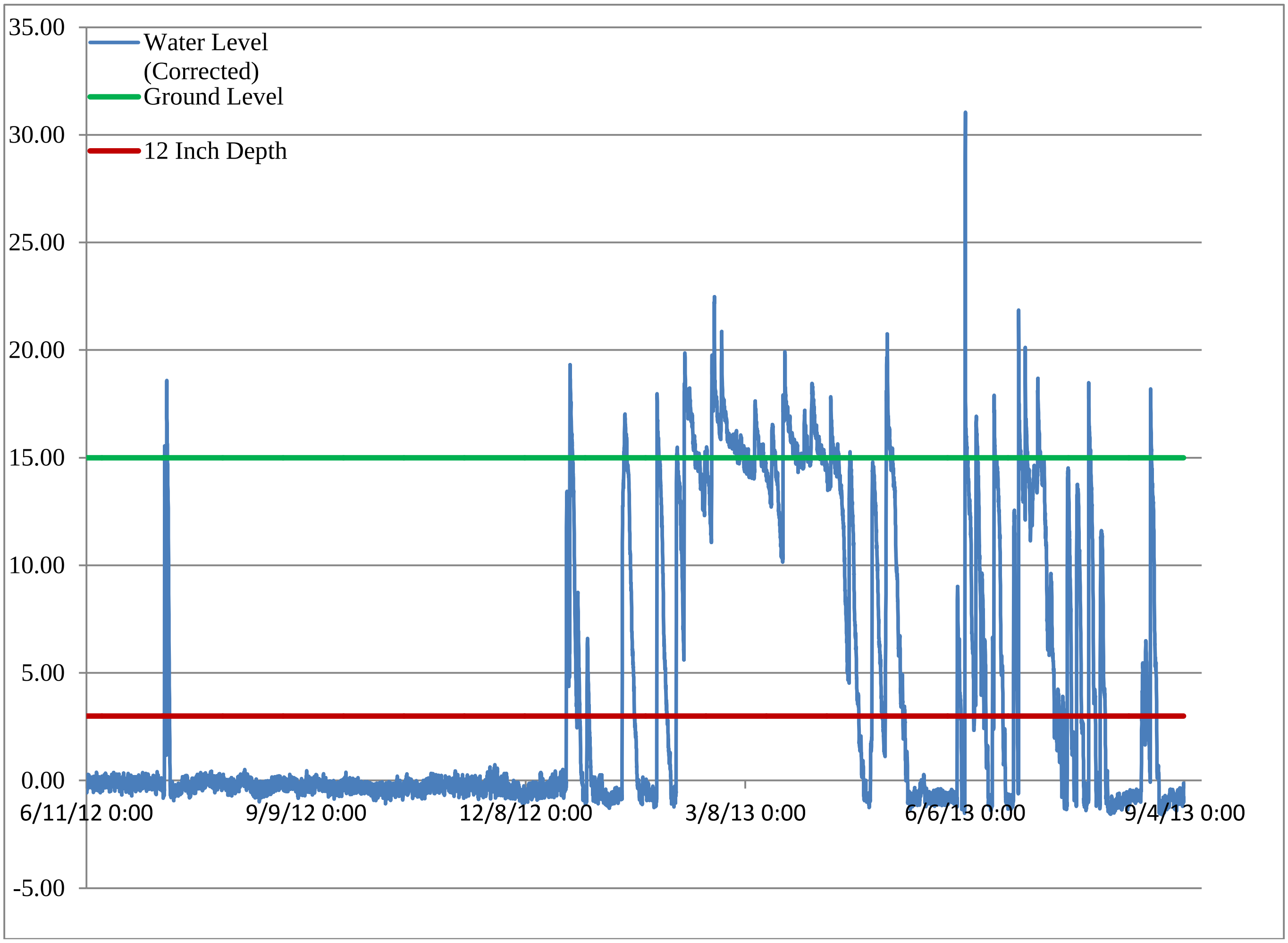
Hydrograph for site 1336



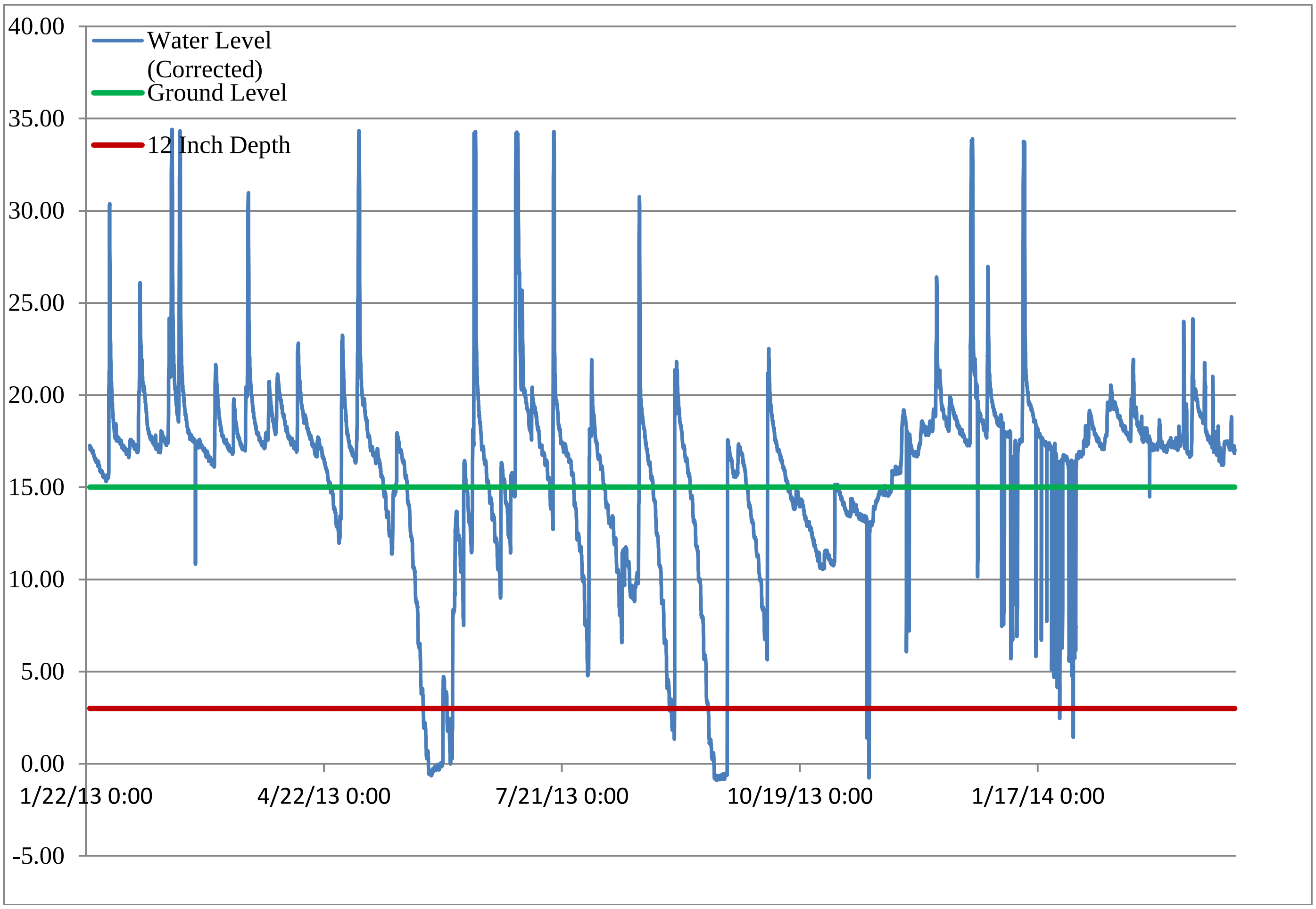
Hydrograph for site 1338



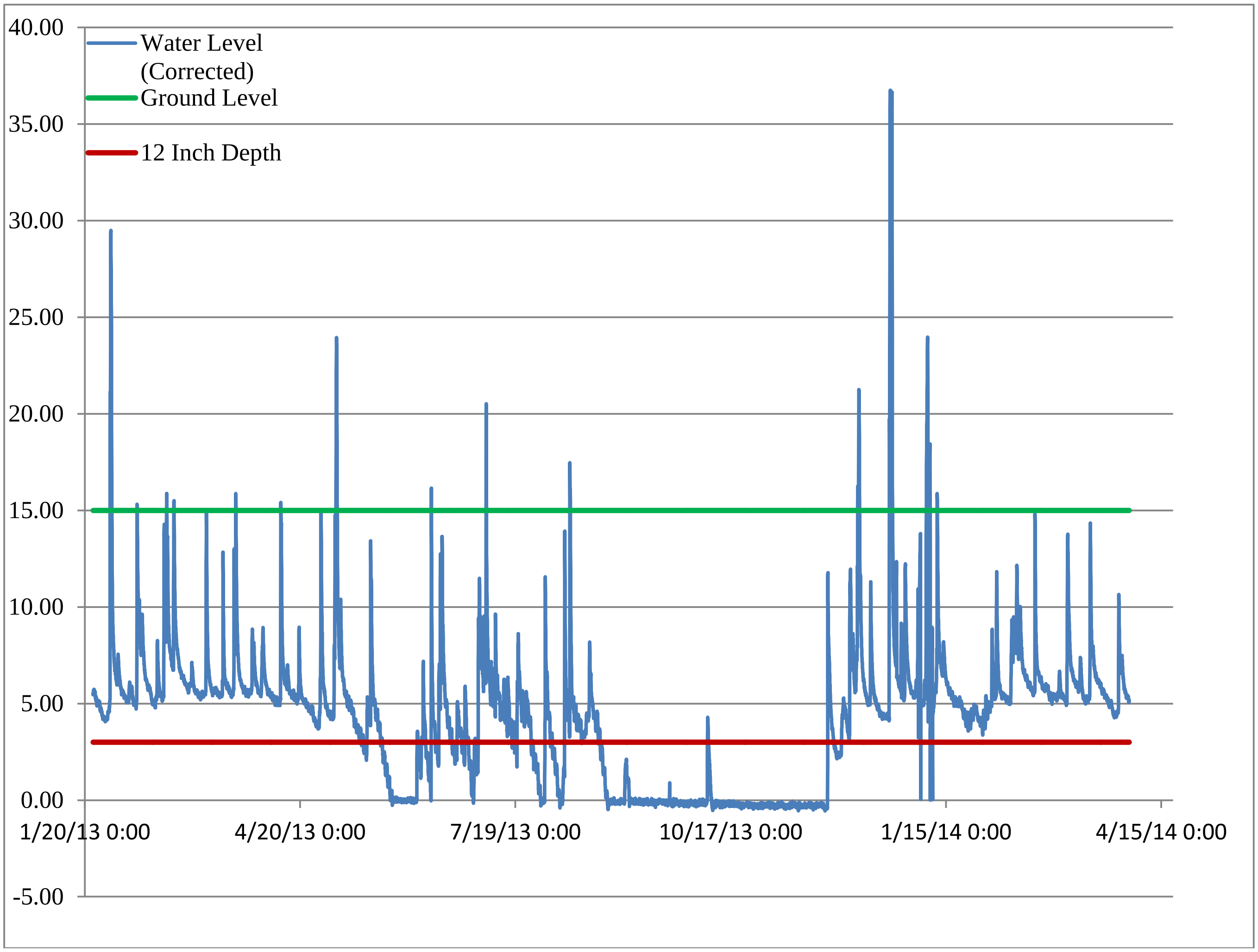
Hydrograph for site 1341



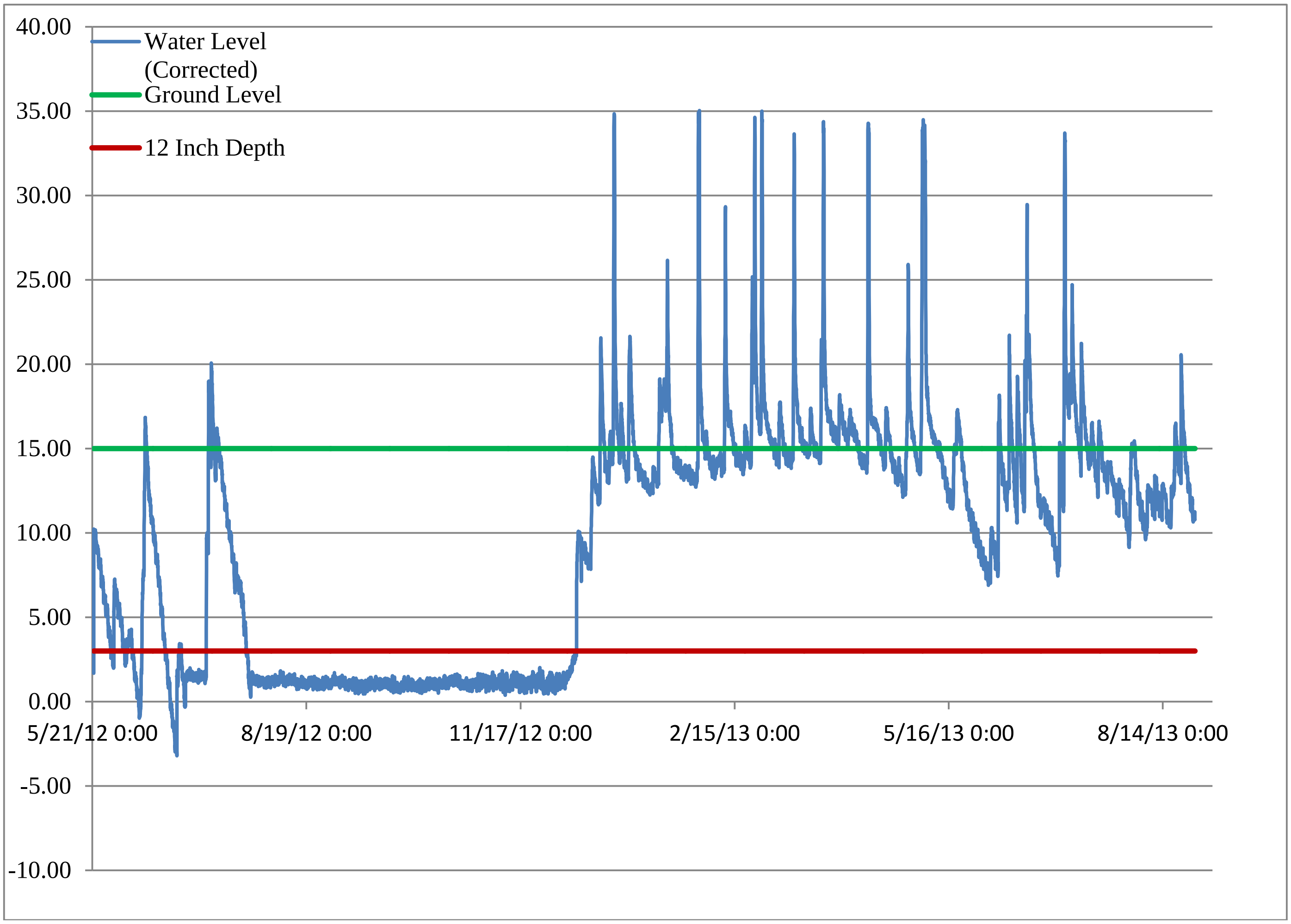
Hydrograph for site 1347



Hydrograph for site 1348



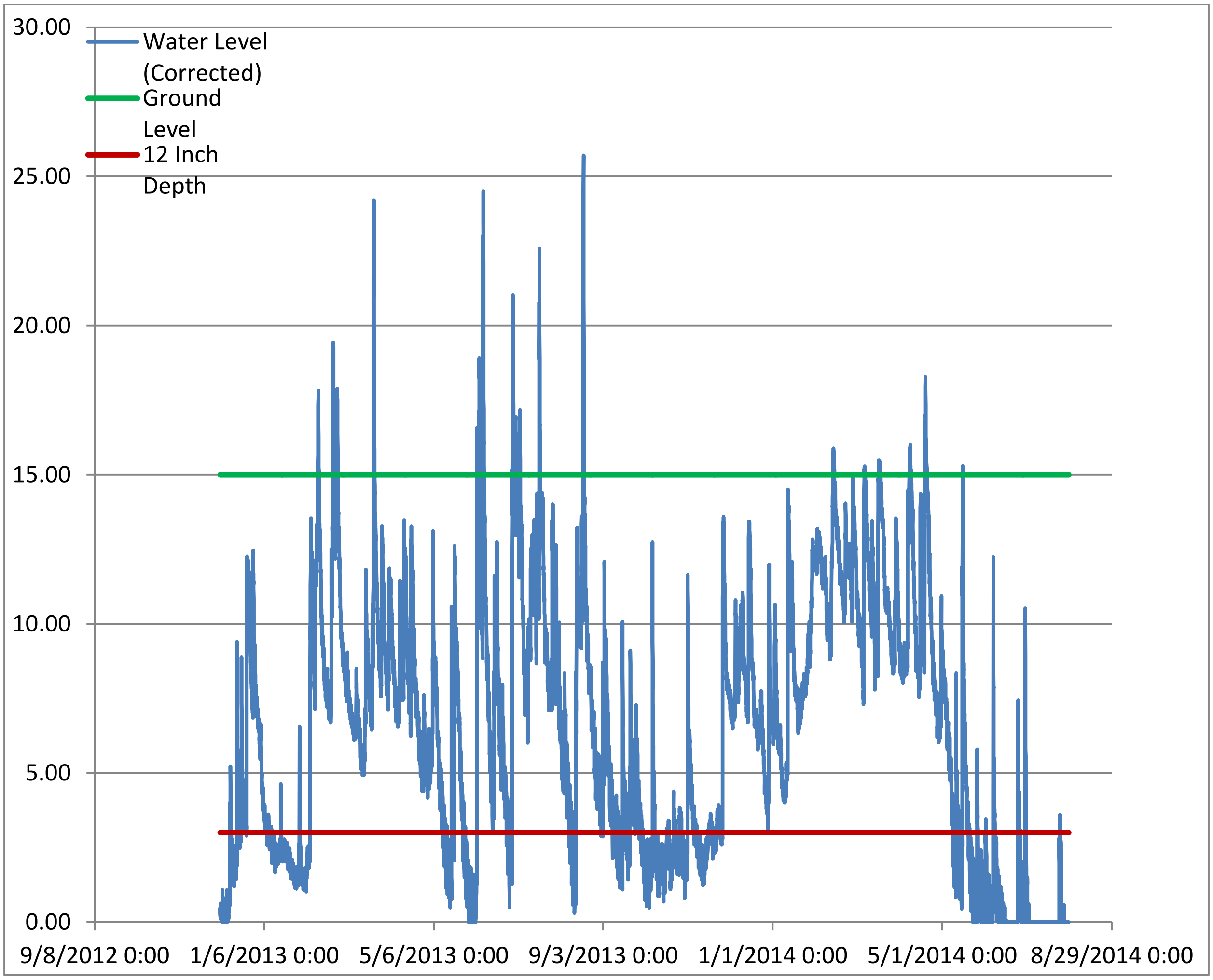
Hydrograph for site 1363



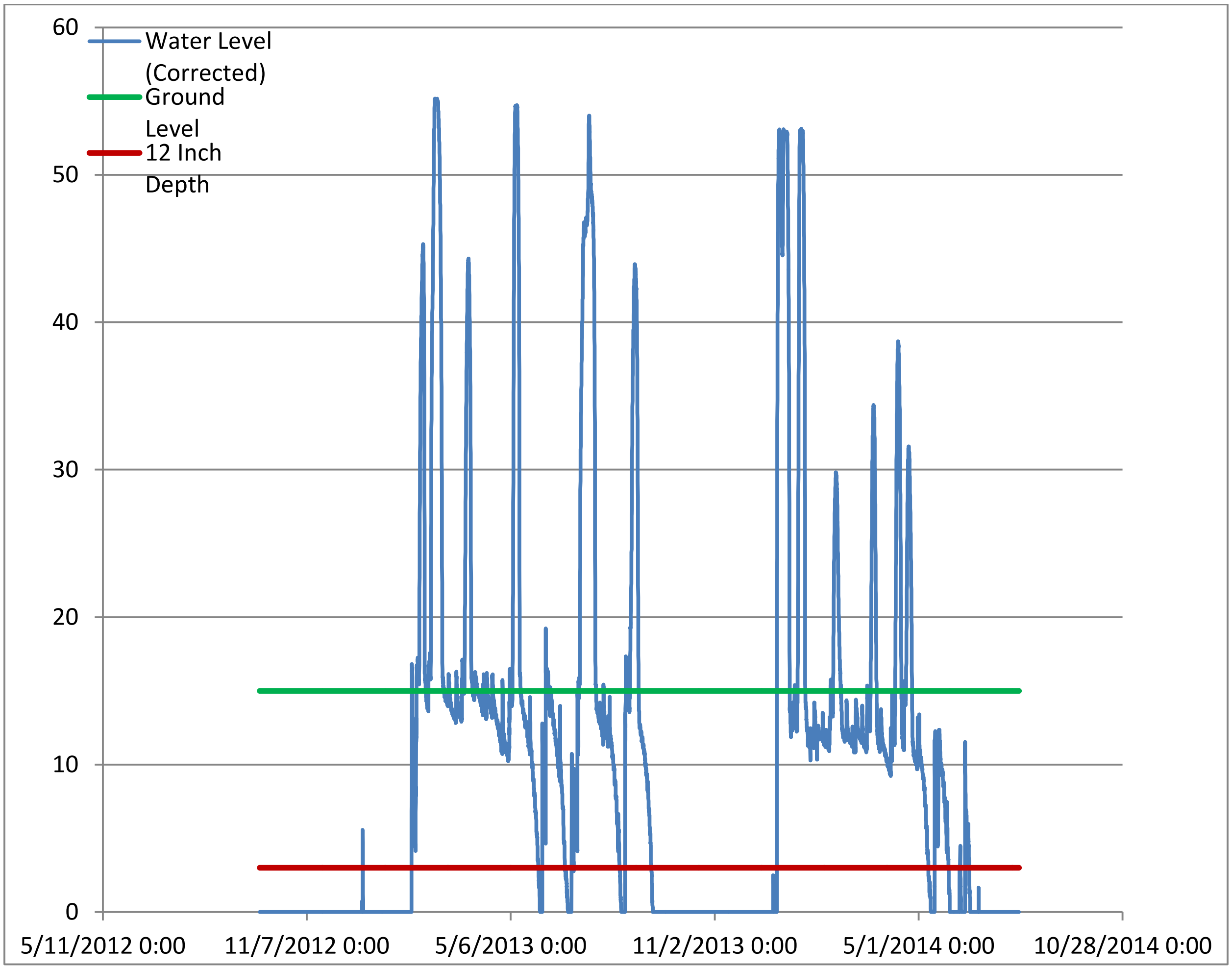
A6: Hydrographs for GA RSF sites

The following hydrographs of Georgia well data show groundwater levels above or below ground surface level (green line) and the one foot below ground surface depth (red line).

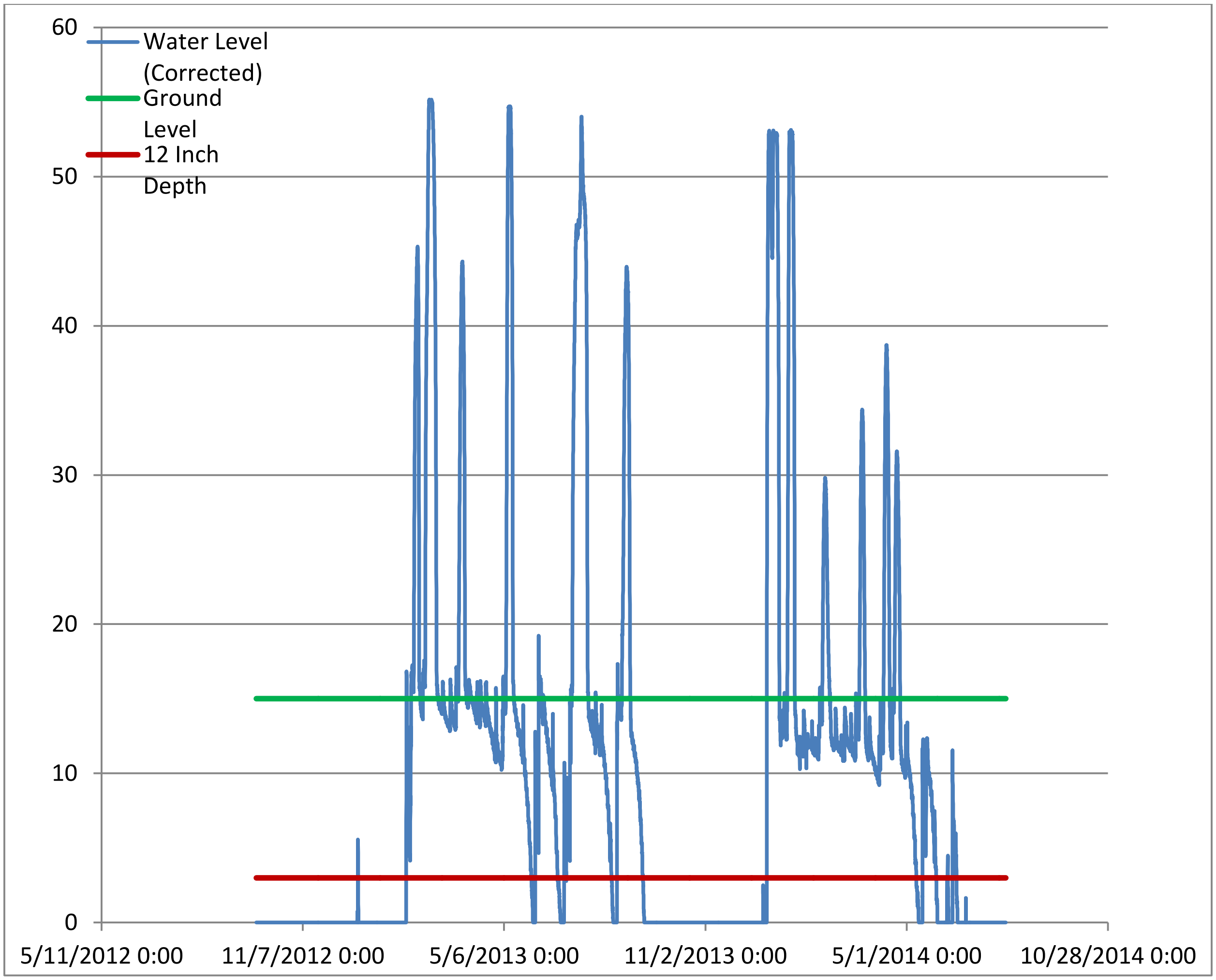
Hydrograph for site 1059



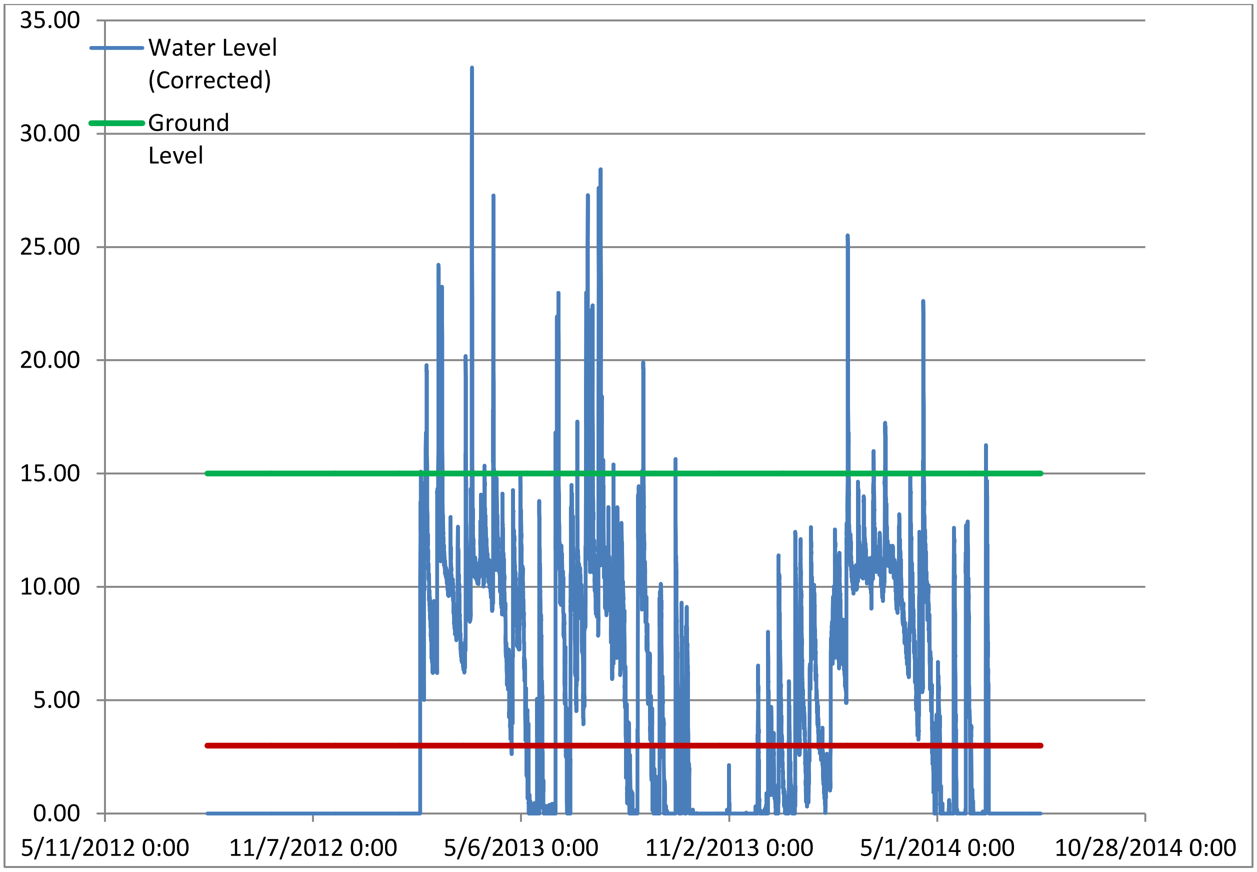
Hydrograph for site 1062 PF01C



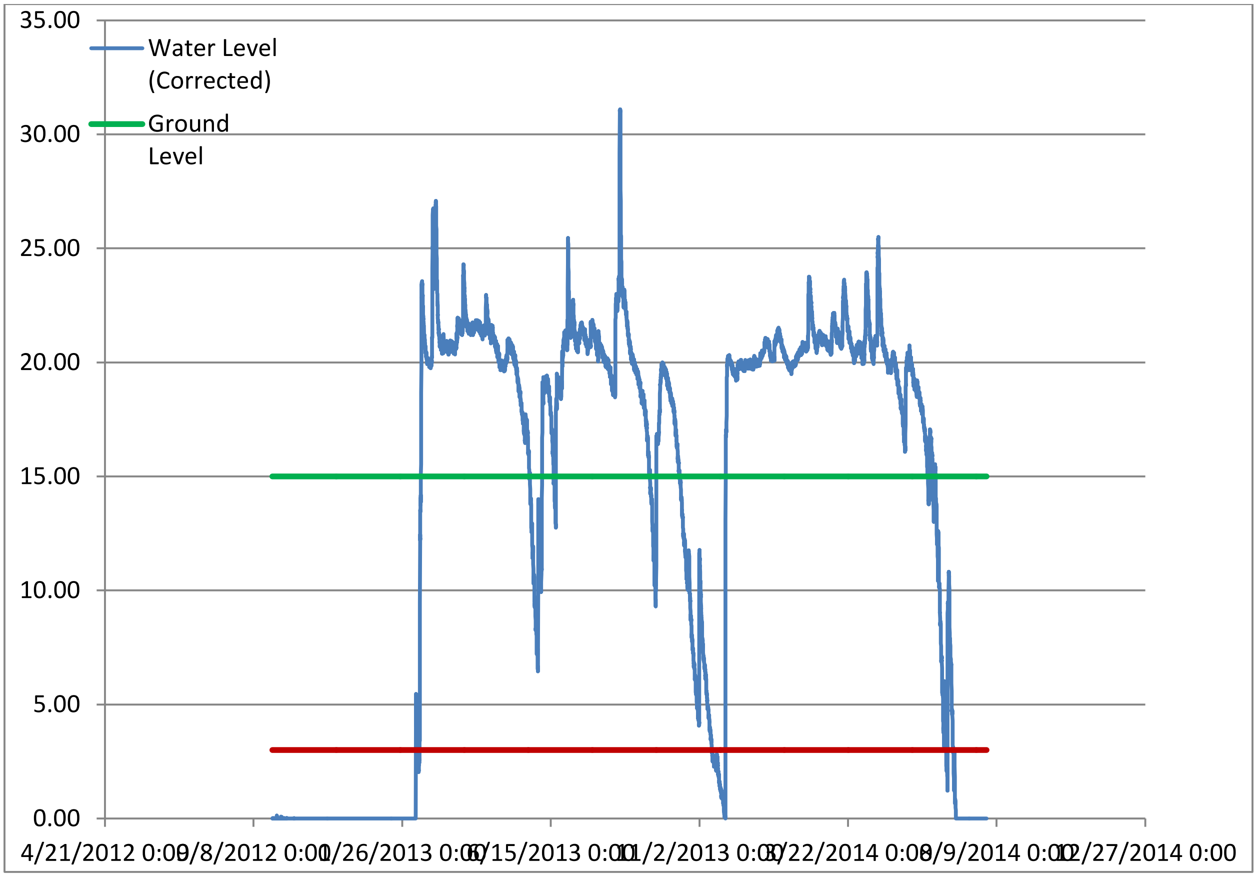
Hydrograph for site 1062 PF01A



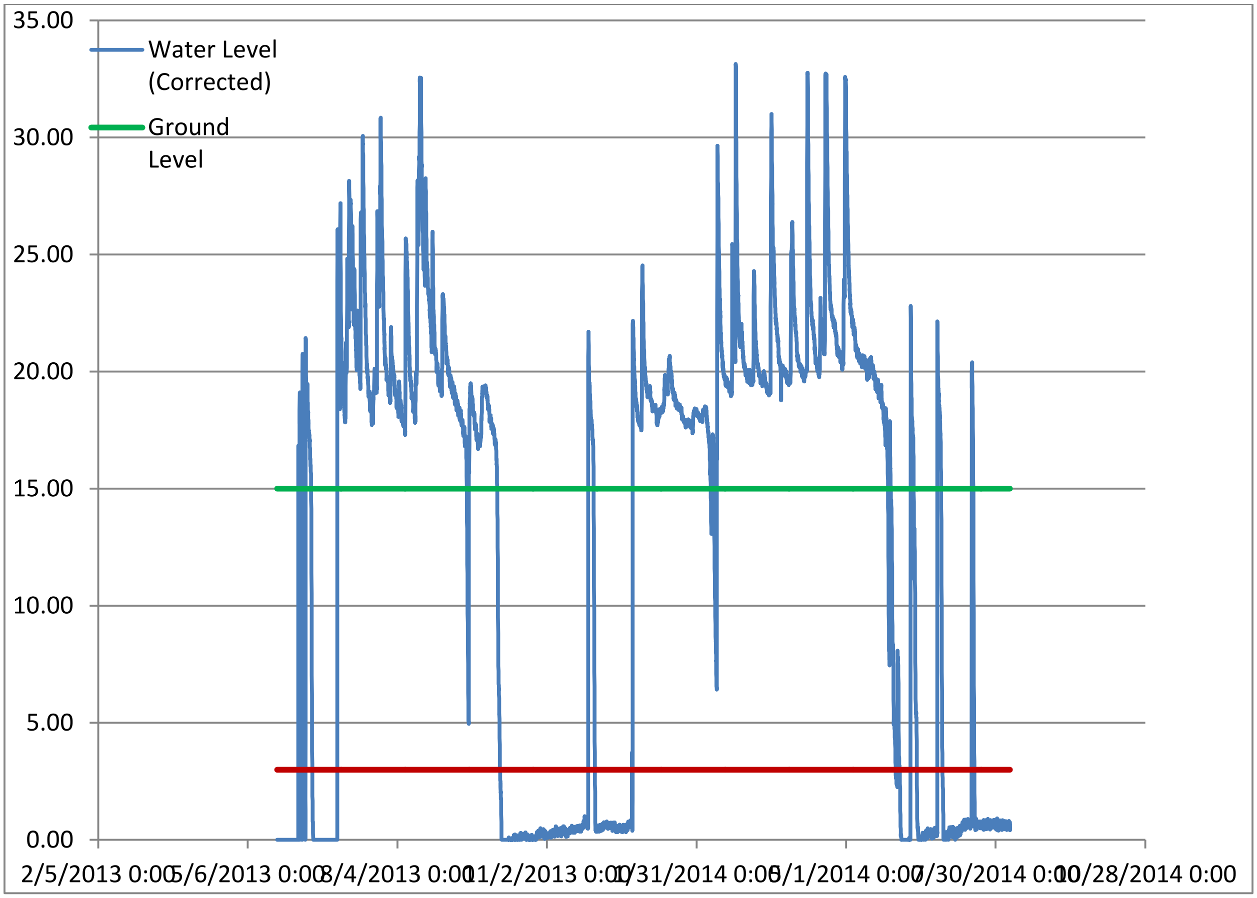
Hydrograph for site 1065



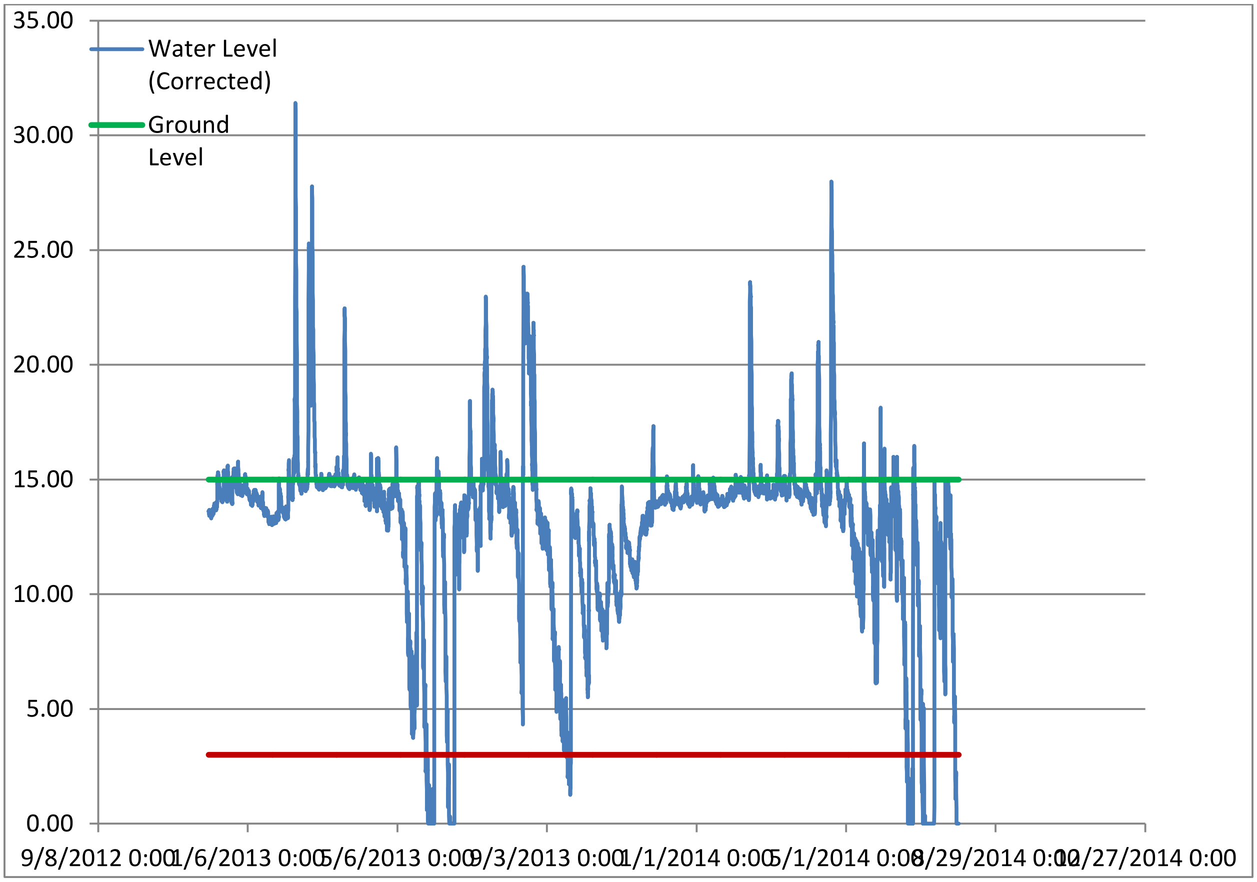
Hydrograph for site 1369



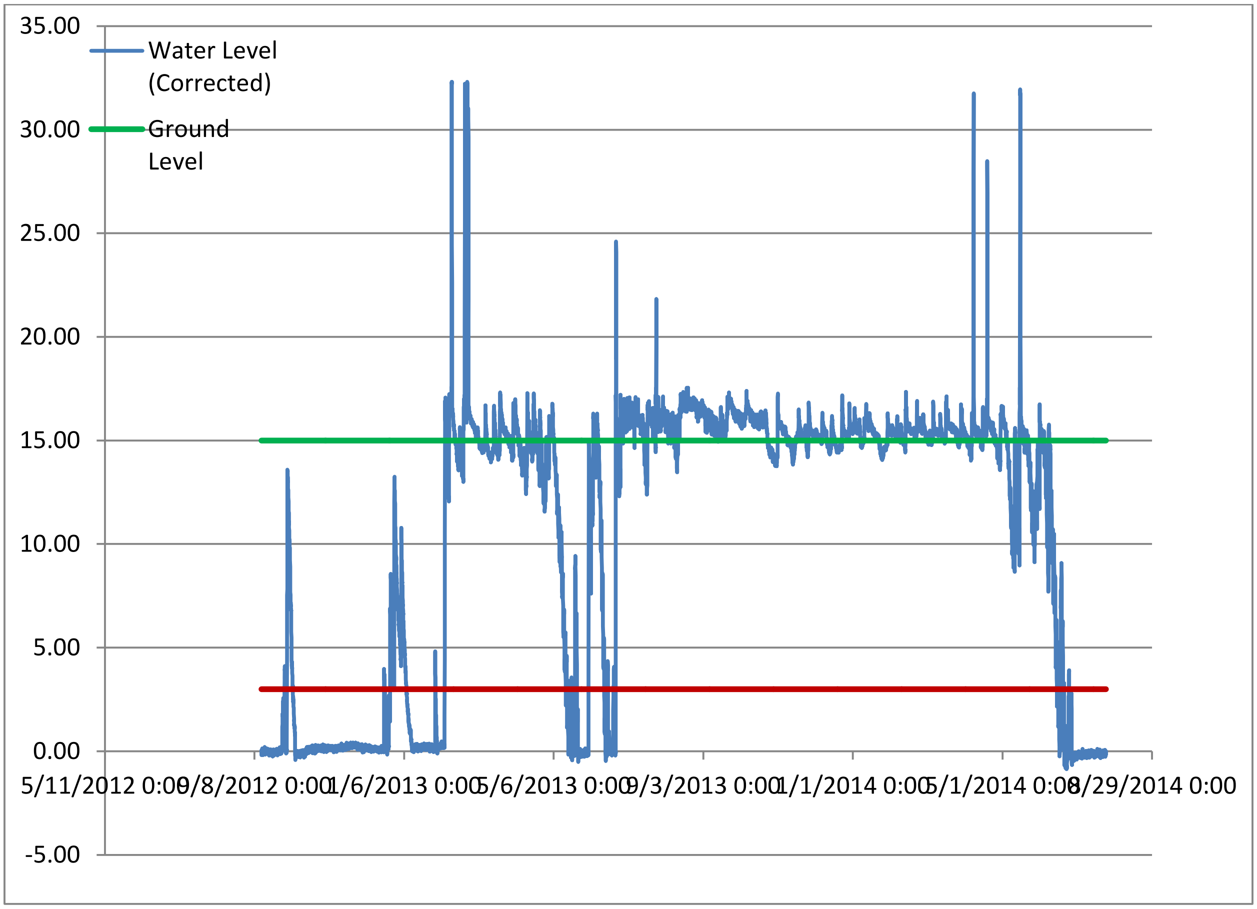
Hydrograph for site 1371



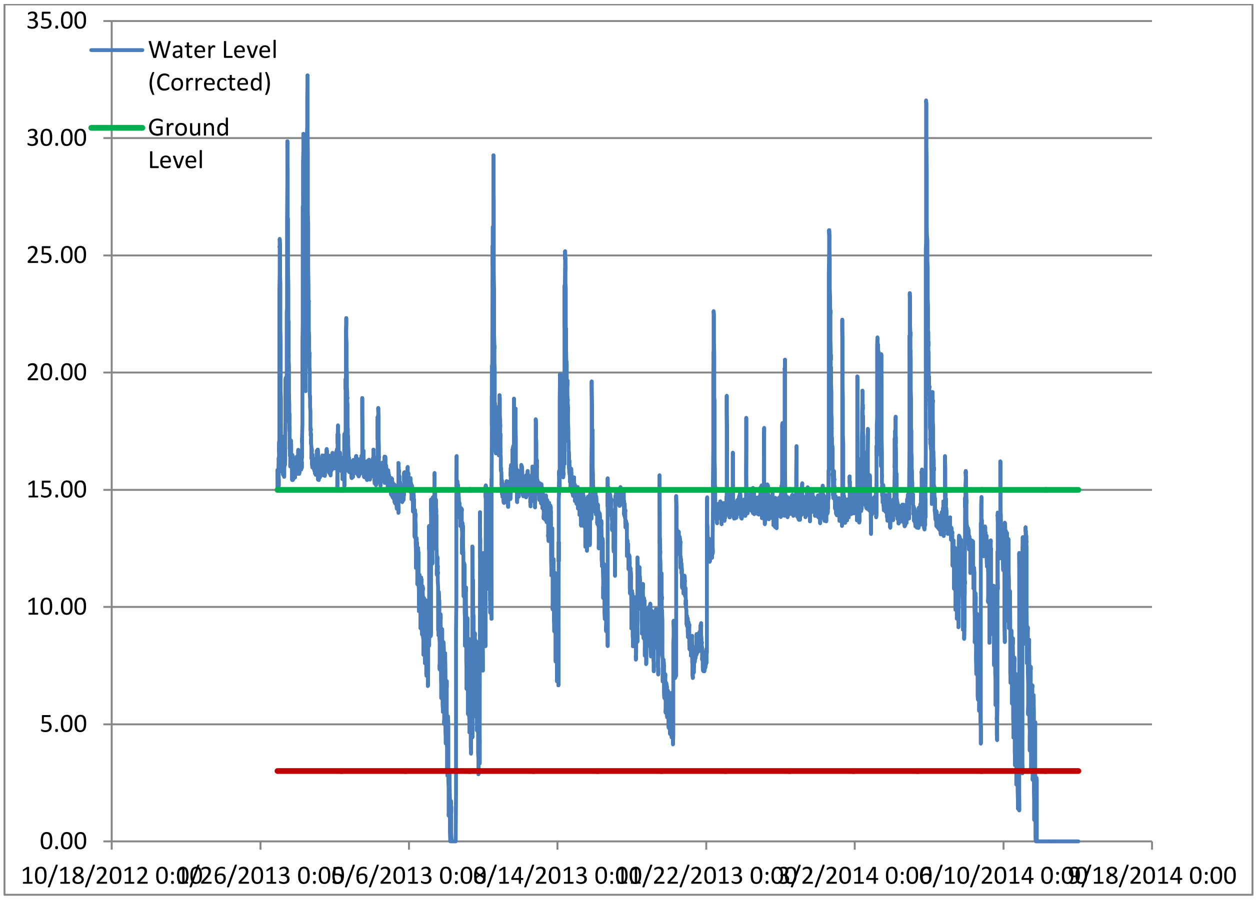
Hydrograph for site 1372



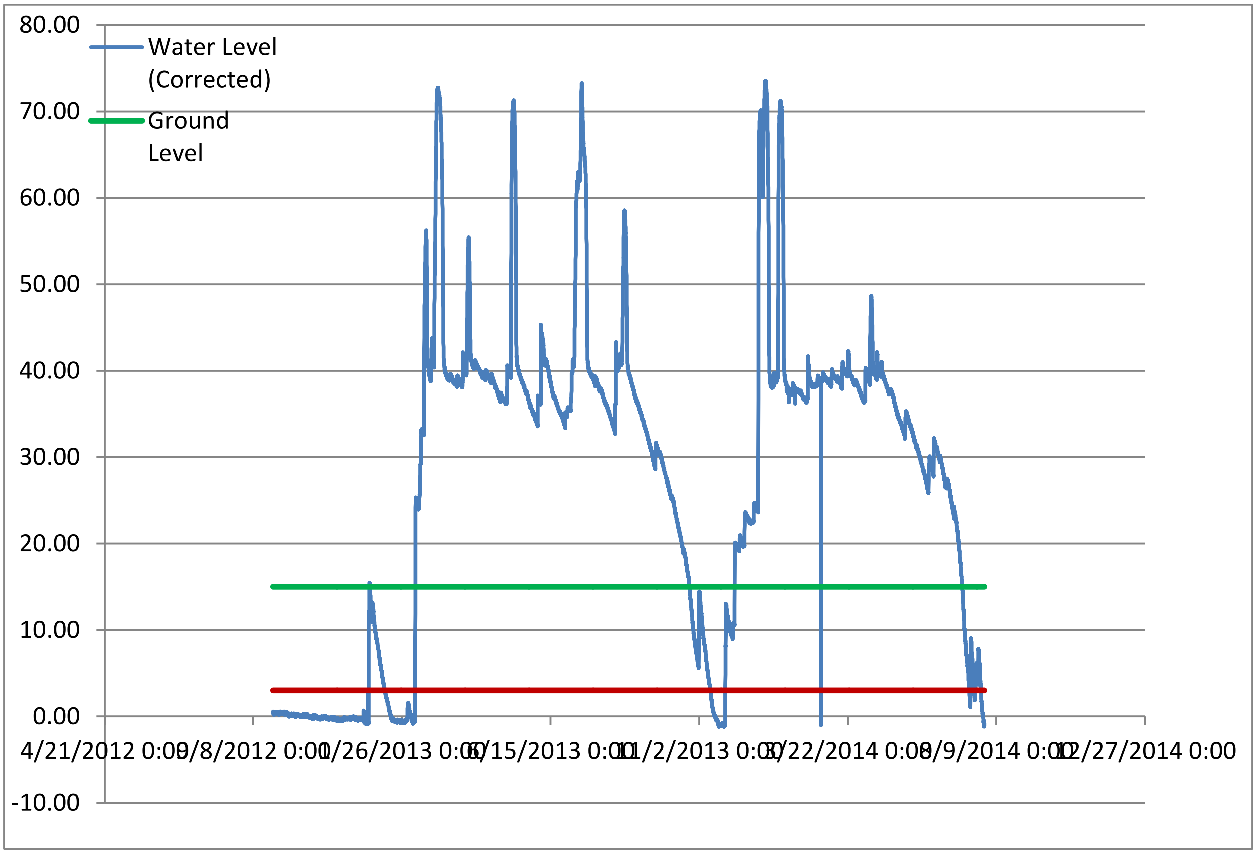
Hydrograph for site 1374



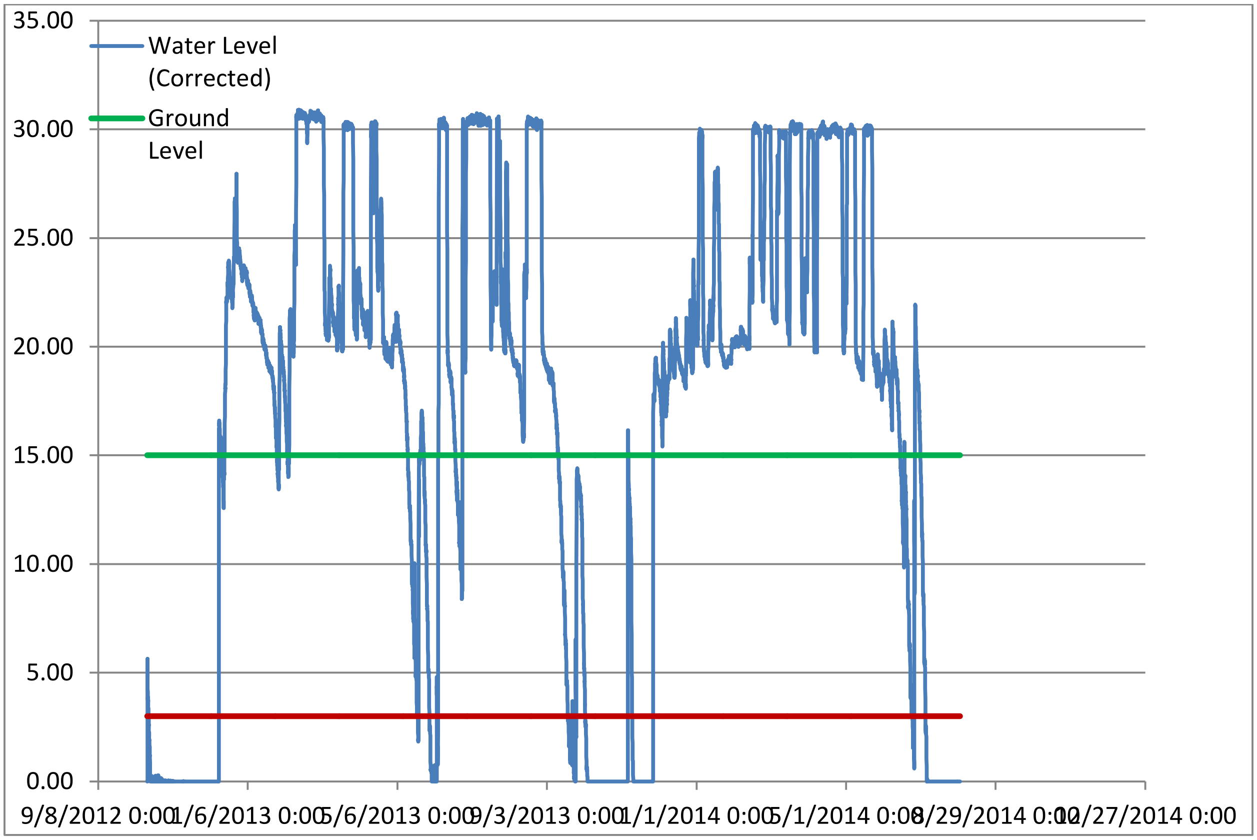
Hydrograph for site 1376



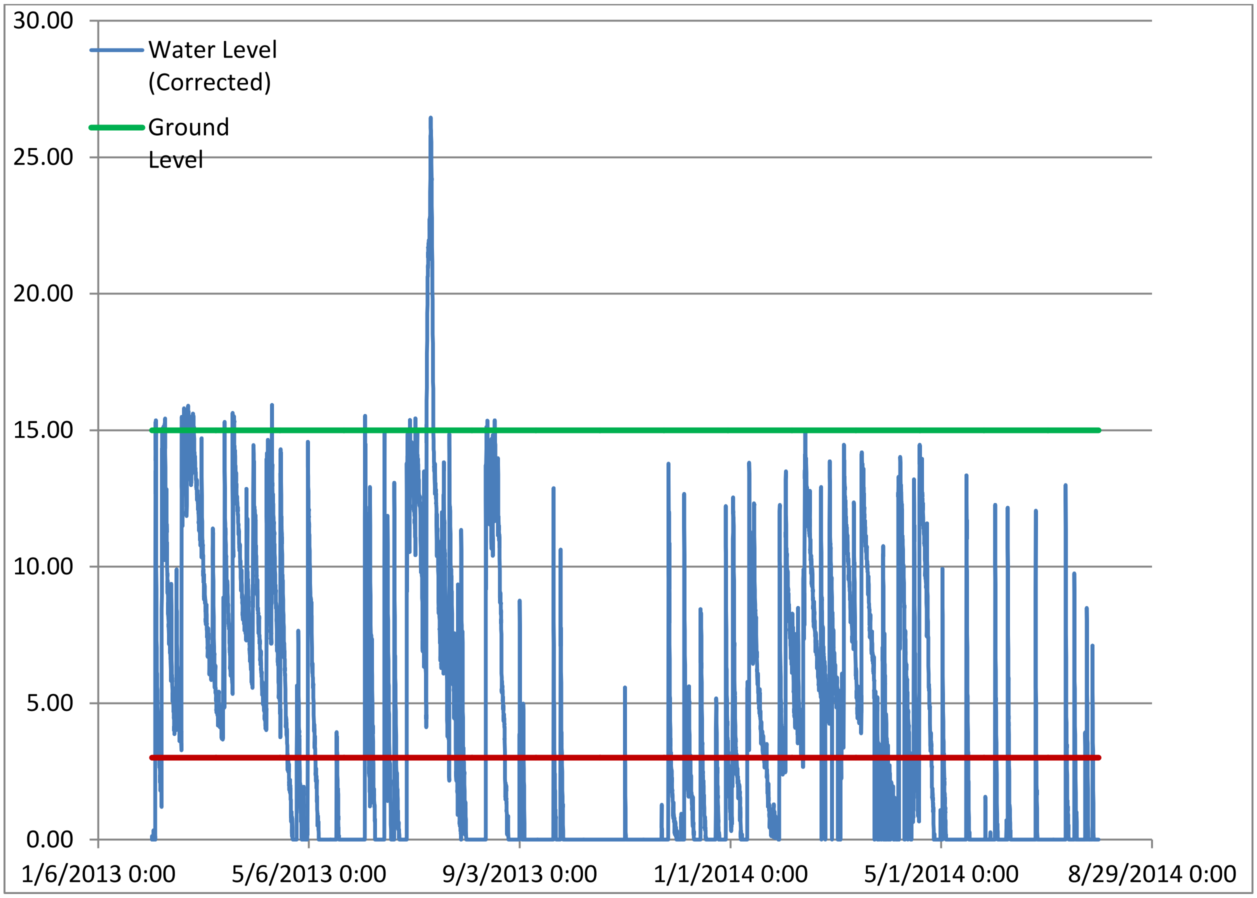
Hydrograph for site 1377



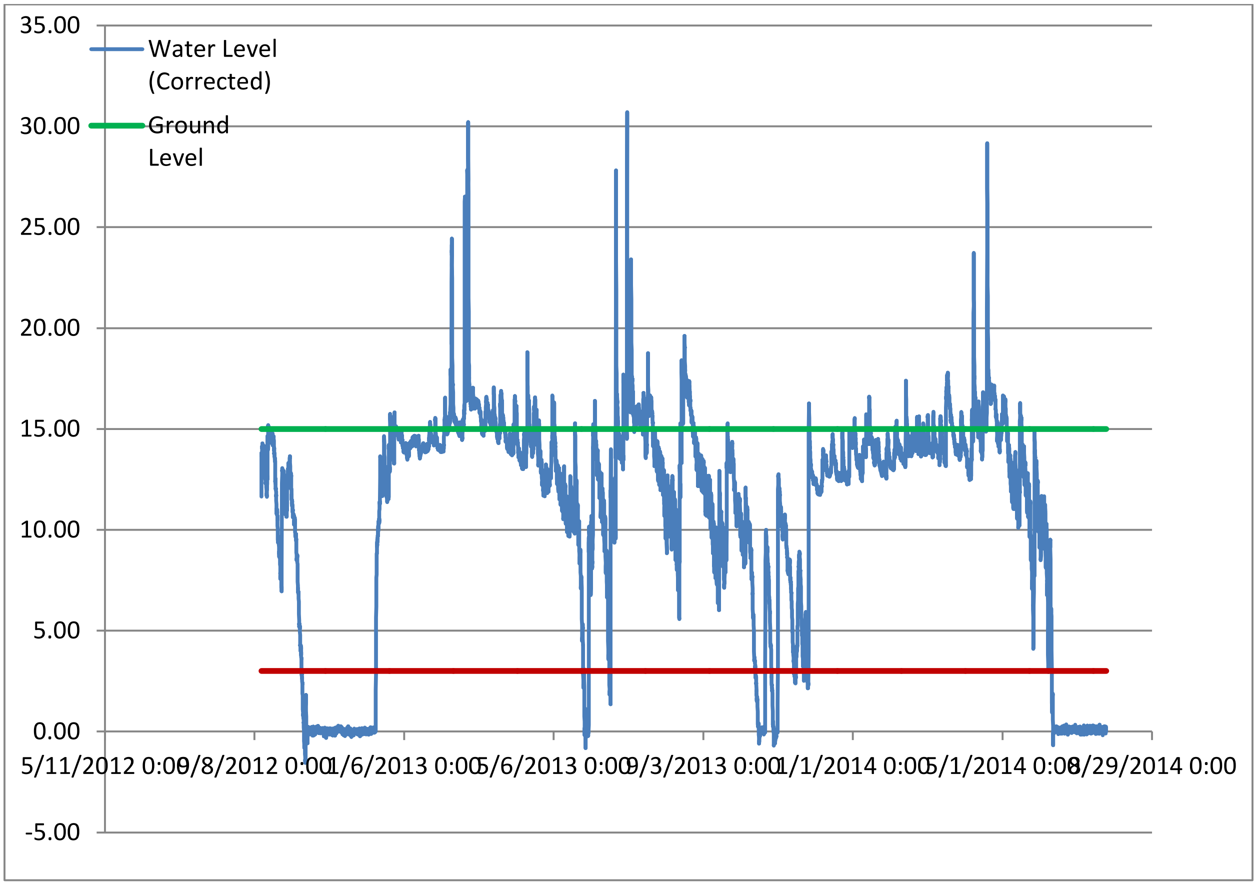
Hydrograph for site 1378



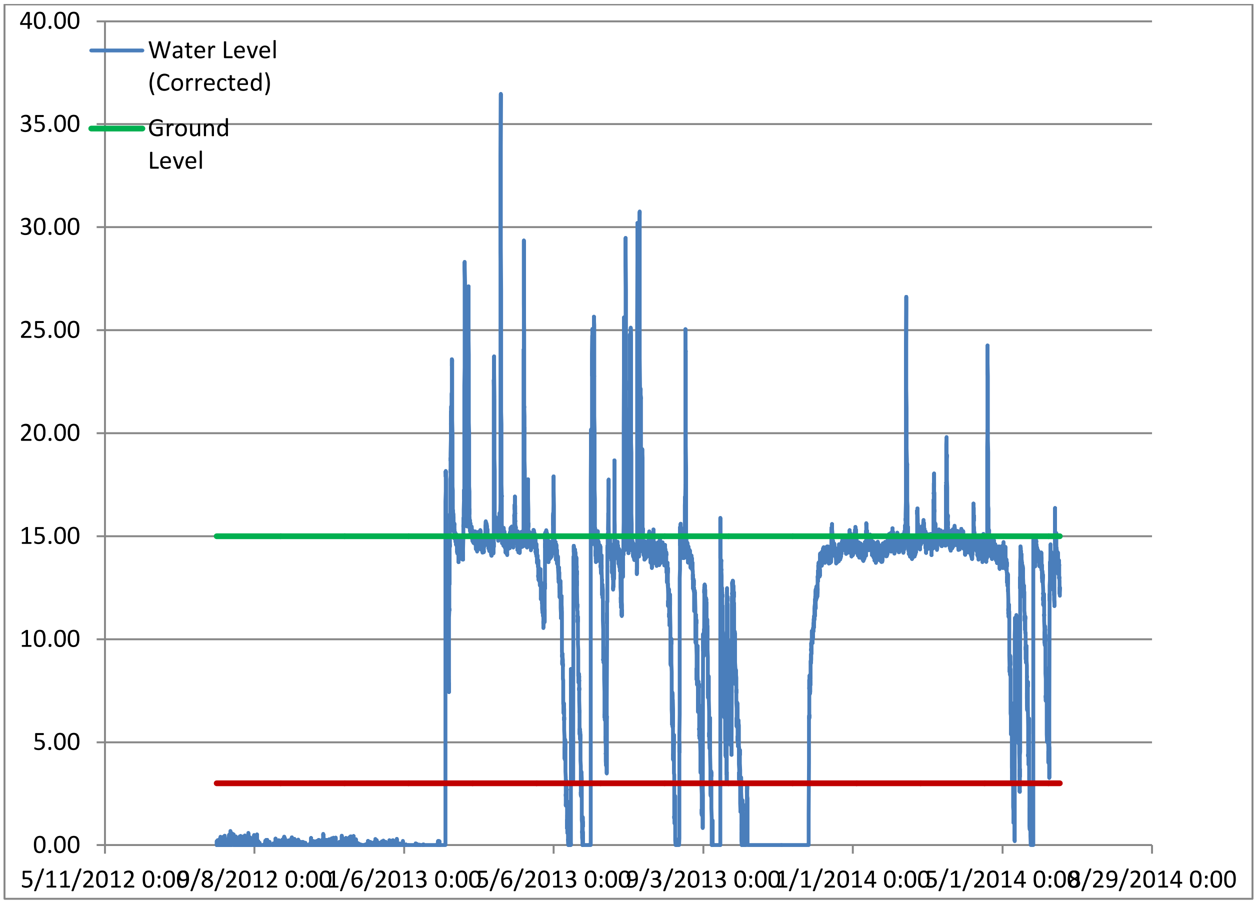
Hydrograph for site 1380



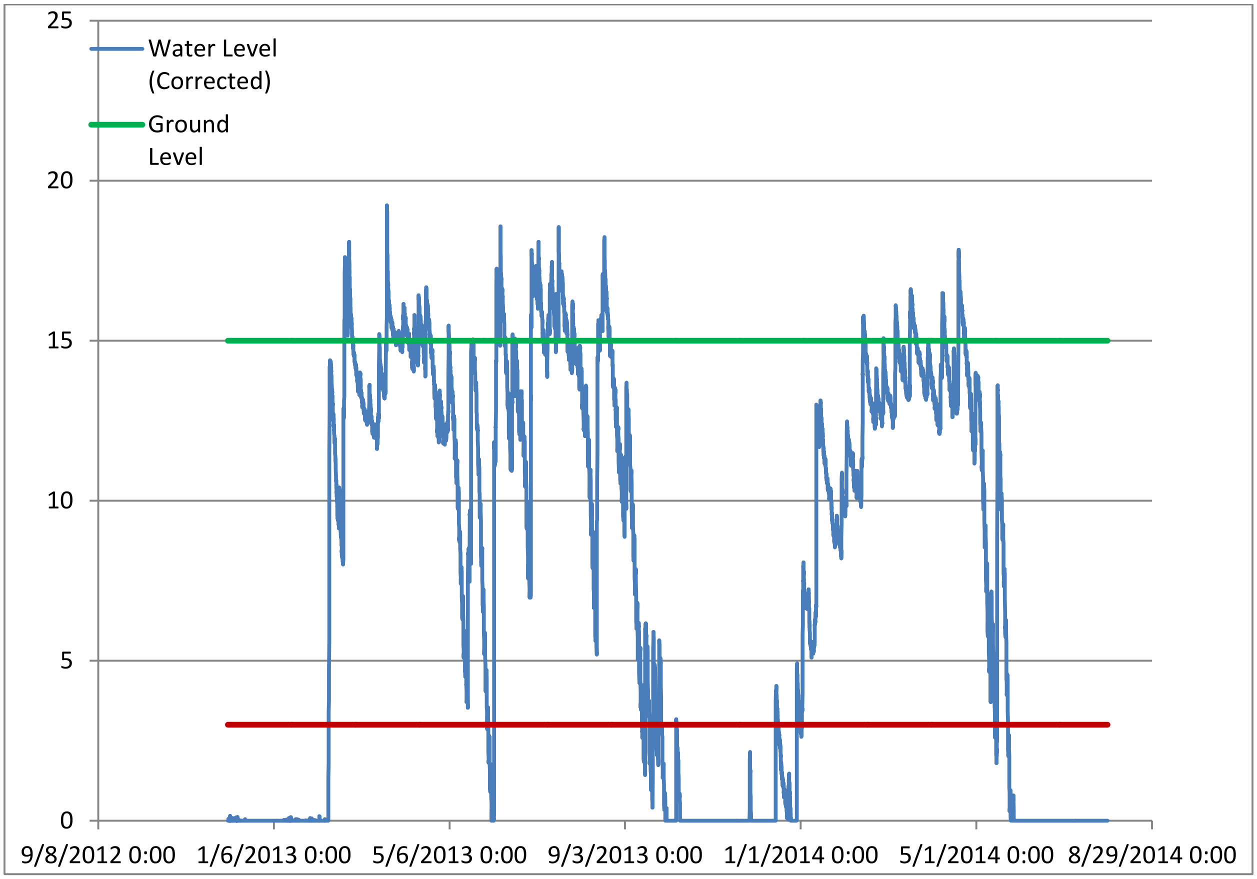
Hydrograph for site 1414



Hydrograph for site 1434



Hydrograph for site 1435



Appendix B: Site Maps

B1: Site Maps for Alabama

B2: Site Maps for Georgia

B3: Site Maps for North Carolina

B4: Site Maps for South Carolina

B1: Site Maps for Alabama (not enough document space)

B2: Site Maps for Georgia (Not enough document space)

B3: Site Maps for North Carolina