Wetland Research in Oklahoma: Challenges, Successes, and Lessons Learned

Craig A. Davis
Department of Natural Resource Ecology and Management
Oklahoma State University

Funding, Cooperators, and Collaborators

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

OKLAHOMA DEPARTMENT OF WILDLIFE CONSERVATION

SOVEREIGN NATION OF THE KAW KANZA

OKLAHOMA STATE UNIVERSITY
DEPARTMENT OF Natural Resource Ecology & Management

USDA NRCS
U.S. Department of Agriculture
Natural Resources Conservation Service

IOWA TRIBE of OKLAHOMA

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

OKLAHOMA CONSERVATION COMMISSION

State of Oklahoma
OWRB
WATER RESOURCES BOARD
the water agency

Oklahoma Office of the Secretary of Energy and Environment

Acknowledgments

- Joe Bidwell
- Dan Dvorett
- Andy Dzialowski
- Mona Papes
- Sarah Gallaway
- Jeff Tibbits
- Matt Walters
- Jason Bried
- Dena Hartzell
- Naomi Cooper
- Anthony Thornton
- Micah Meyer
- Gene Albanese
- Suneeti Jog
- Numerous technicians
- Hundreds of landowners
- Brian Carter
- Kate Golden
- Ele Nugent
- Matt Hough
- Steve Barner
- Dennis Fowler
- Brooks Tramell
- Chris DuBois
- Bonnie Crissman
- Jody Cason
- Paul Koenig
- Richard Prather
- Eric Stein
- Roseanne Kuzmic

Oklahoma Wetlands





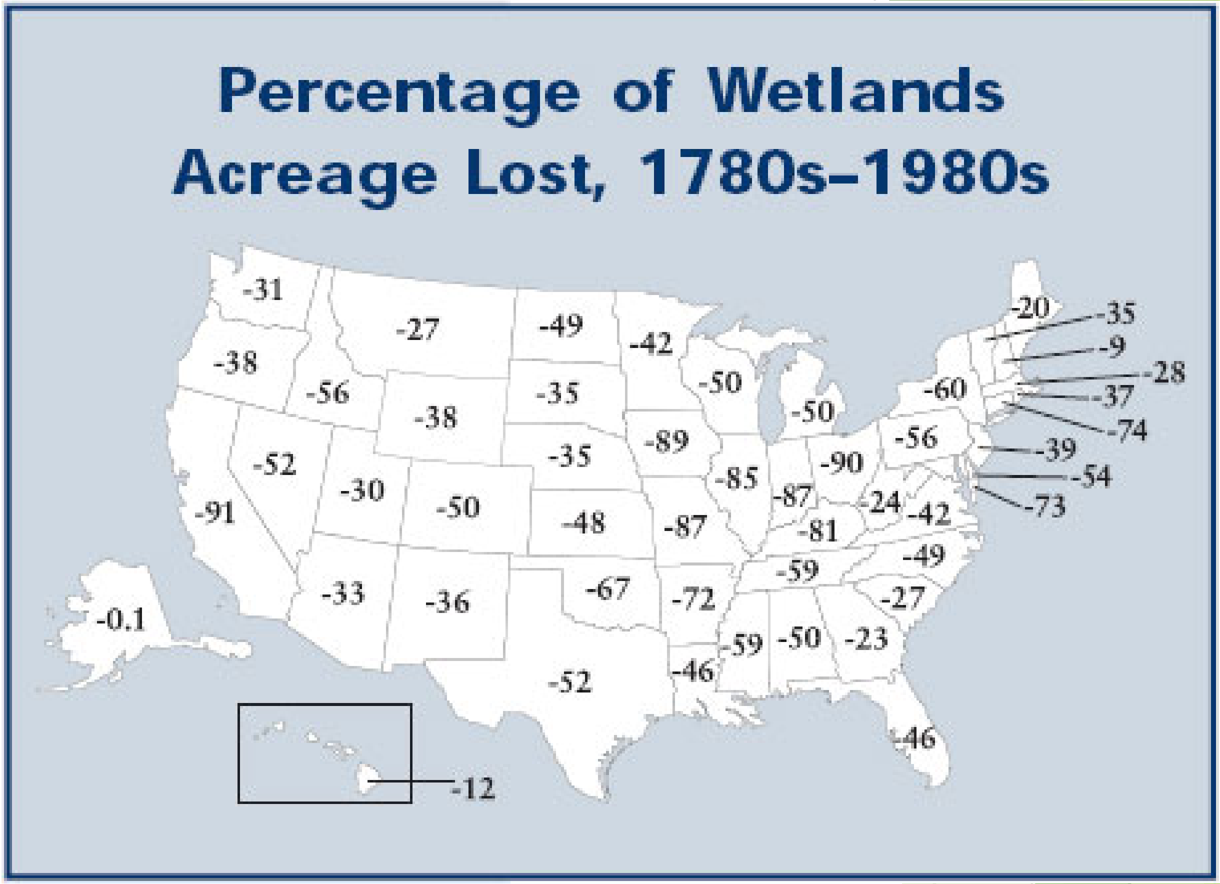




Ecosystem Services
Habitat & Biodiversity
Recreation
Nutrient Regulation
Soil & Sediment Regulation
Disturbance & Natural Hazard Regulation
Cultural & Aesthetic Values
Water Supply
Food Production

Historic Wetland Loss (1780’s – 1980’s)

- 53% decrease in wetland acreage across the U.S.
- 67 % decrease in wetland acreage in Oklahoma



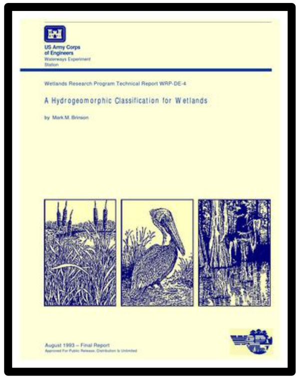
Dahl TE (1990) Wetlands-losses in the United States, 1780's to 1980's. Washington, D.C., U.S. Fish and Wildlife Service Report to Congress.

Wetland monitoring and assessment is critical to the State's Wetlands Program.

- Appraise health and condition of wetlands
- Determine effects of impairment on functions and services provided by wetlands
- Determine status and trends of wetlands
- Identify high quality wetlands for protection and low quality wetlands for restoration and enhancement
- Monitor compensatory mitigation
- Provide guidance on where to focus restoration efforts
- Assist with development and support of water quality standards

Evolution of Wetland Assessment Research at OSU

Indices of Biotic Integrity



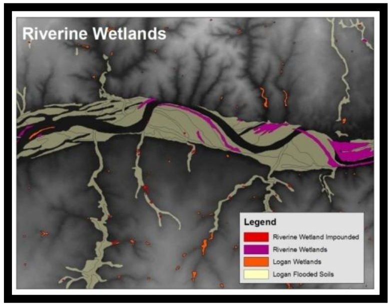
HGM Classification & Subclass Development

Developing Monitoring Strategy for Oxbows

Developing Water Quality Monitoring Protocols for Wetlands

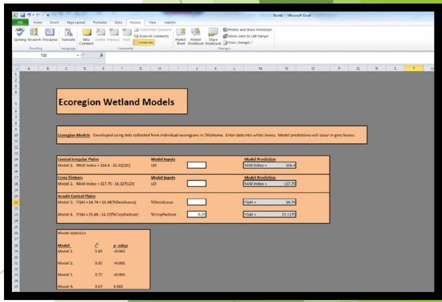
Evaluation of Floristic Quality Assessment

HGM Functional Assessment



Reclassification of NWI Polygons

Developing Landscape GIS Models for Predicting Wetland Condition



Oklahoma Rapid Assessment Method (OKRAM)

1. Hydrologic condition

a. Hydroperiod

Instructions:
1. On an aerial photograph in the field outline all areas within the AA where hydroperiod has been altered and severity of alteration. For calculations, sketches on aerial photographs can be converted to GIS or estimated from aerial photos.
2. Severity of alteration is based on indicator severity on the following worksheet.
3. Fill in the area as a percent of the AA and severity for each indicator of altered hydroperiod. Overlapping areas of indicators are only counted once and for the highest level of severity. Describe the indicator and circle all indicators on the indicator worksheet.

4. The metric is calculated by applying severity weights to the impacted area. For example a severity weight of 0.25 is applied to minor sources of impacted hydroperiod. If 50% of the AA is affected by a minor source of altered hydroperiod, the metric score would be 0.875 (1-[0.50*0.25] = 0.875).

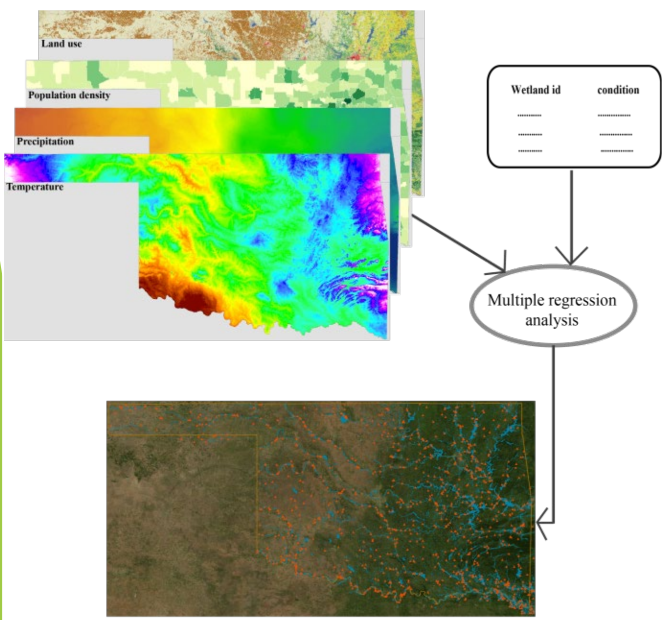
Indicators of Reduced hydroperiod	Minor	Moderate	Major	Complete Loss	Indicator Description
Upstream Dams					
Fill/sedimentation					
Water pumping out of the wetland					
Water control structures					
Culverts, discharges, ditches or tile drains out of the wetland					

EPA's 3-Tiered Framework

Level 1:
GIS-based landscape assessments

Level 2:
Rapid field-based assessment methods, qualitative data

Level 3:
Intensive sampling quantitative methods



State wide wetland condition prediction

Using Indices of Biotic Integrity (IBI) to Assess Wetland Condition

- IBIs originally developed for fish in streams, but had been developed for wetlands (e.g., Ohio and Minnesota)
- Most used macroinvertebrate and plant assemblages
- We used bird, plant, and macroinvertebrate assemblages to evaluate effectiveness of IBIs to assess wetland condition in depressional wetlands
- Examined relationship between IBI metrics and disturbance scores and between water chemistry parameters (e.g., nitrate, phosphate) and disturbance scores

Macroinvertebrate Metrics
Total number of taxa
Number of Chironomidae taxa
Number of Odonata taxa
Number of leech taxa
Percent dominant three taxa
ETSD
Proportion of Corixidae
Number of intolerant taxa
Proportion of Diptera
Number of Gastropoda species
Proportion of predators
Proportion of grazers
Proportion of omnivores
Shannon-Weiner diversity index
Proportion of gatherers
Proportion of shredders

Linear Regression Results

Assemblage	No. of Original Metrics	No. of Significant Metrics
Plant		
Fall '03	13	2
Summer '04	13	1
Macroinvertebrate		
Fall '03	16	4
Summer '04	16	3
Bird		
Fall '03	15	2
Spring '04	15	3
Summer '04	15	7
Fall '04	15	2



Conclusions from IBI Project

- Few of the metrics actually indicated a relationship with wetland condition, however, avian and macroinvertebrate assemblages seemed to track disturbance better than plant assemblages
- Considerable variation among wetlands (e.g., differences in wetland size, hydroperiod, type of wetland) and seasons limited the effectiveness of IBIs to track disturbance
- Timing of sampling is critical for all assemblages, but more so for macroinvertebrate and bird assemblages
- Time required for sorting and identification and level expertise is an important consideration (especially for macroinvertebrates!!!)

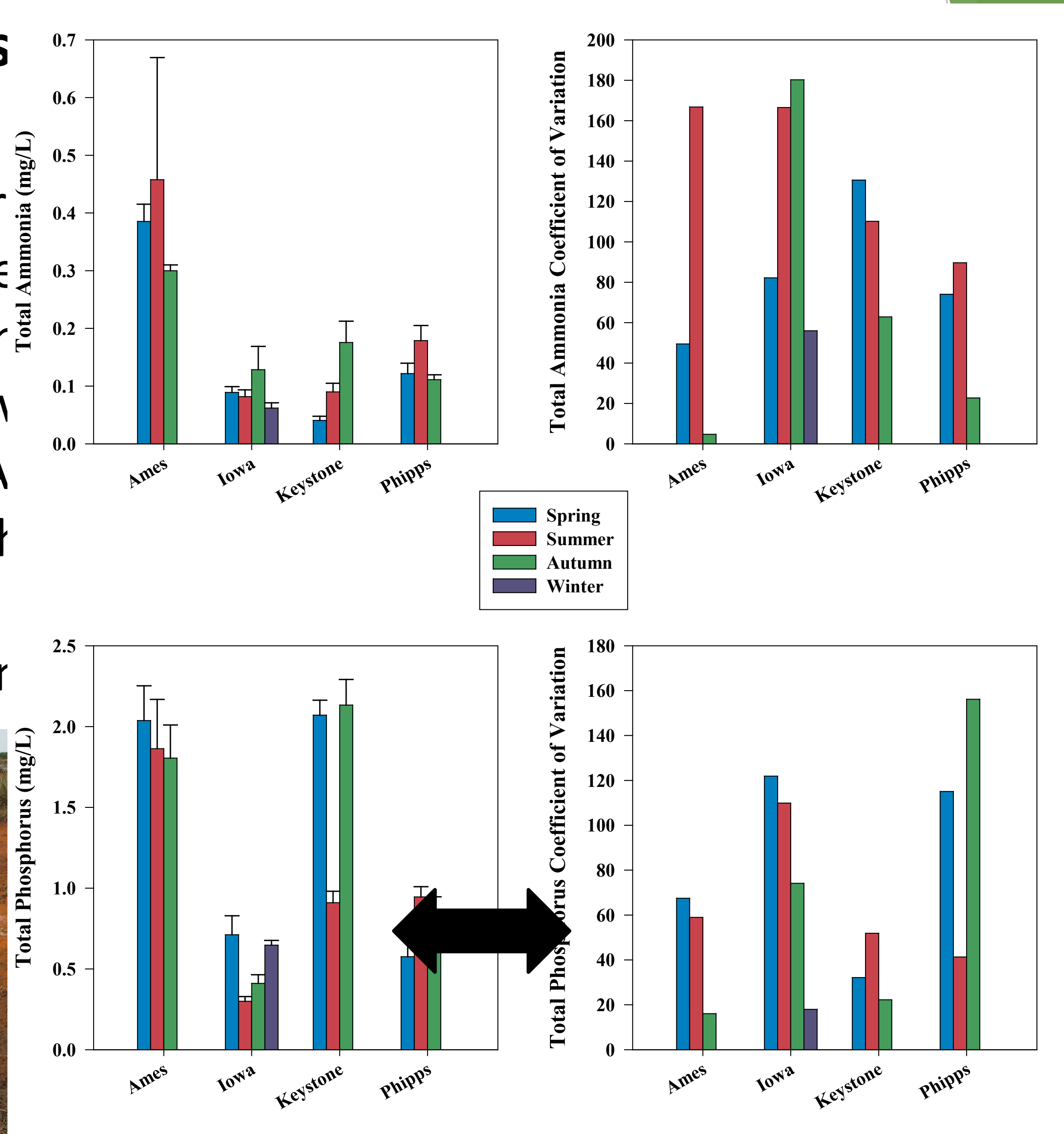
What we learned……

- A well-defined disturbance gradient is critical to developing assessment protocols
- Natural variation can and will mask relationships among metrics and disturbance scores and that variation must reduced for improve effectiveness of metrics
- IBI metrics have limited utility in determining impairment of wetland functions and services
- Effectiveness of IBI metrics are limited by the natural wet-dry cycle of wetland and inconsistency among seasons

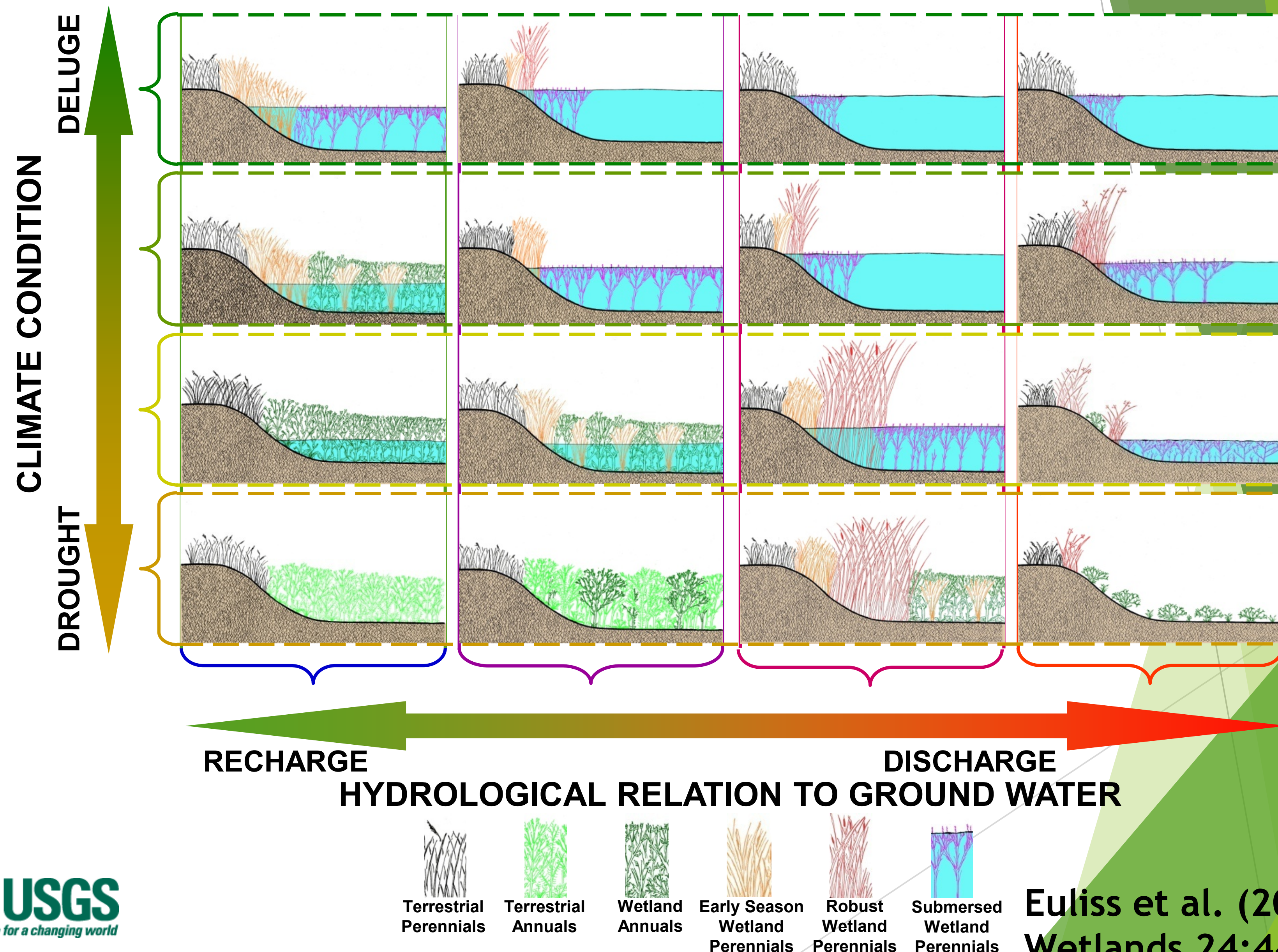


Developing Water Quality Monitoring Protocols for Wetlands

- Our results … tility in
  using water … ndition
- Unlike more …
  variability ir … among
  and within \ … pacts
  (BUT NOT A
- The "drough
  (especially, … nt role
  in influencir



THE WETLAND CONTINUUM



Euliss et al. (2004)
Wetlands 24:448-458.

USGS
science for a changing world

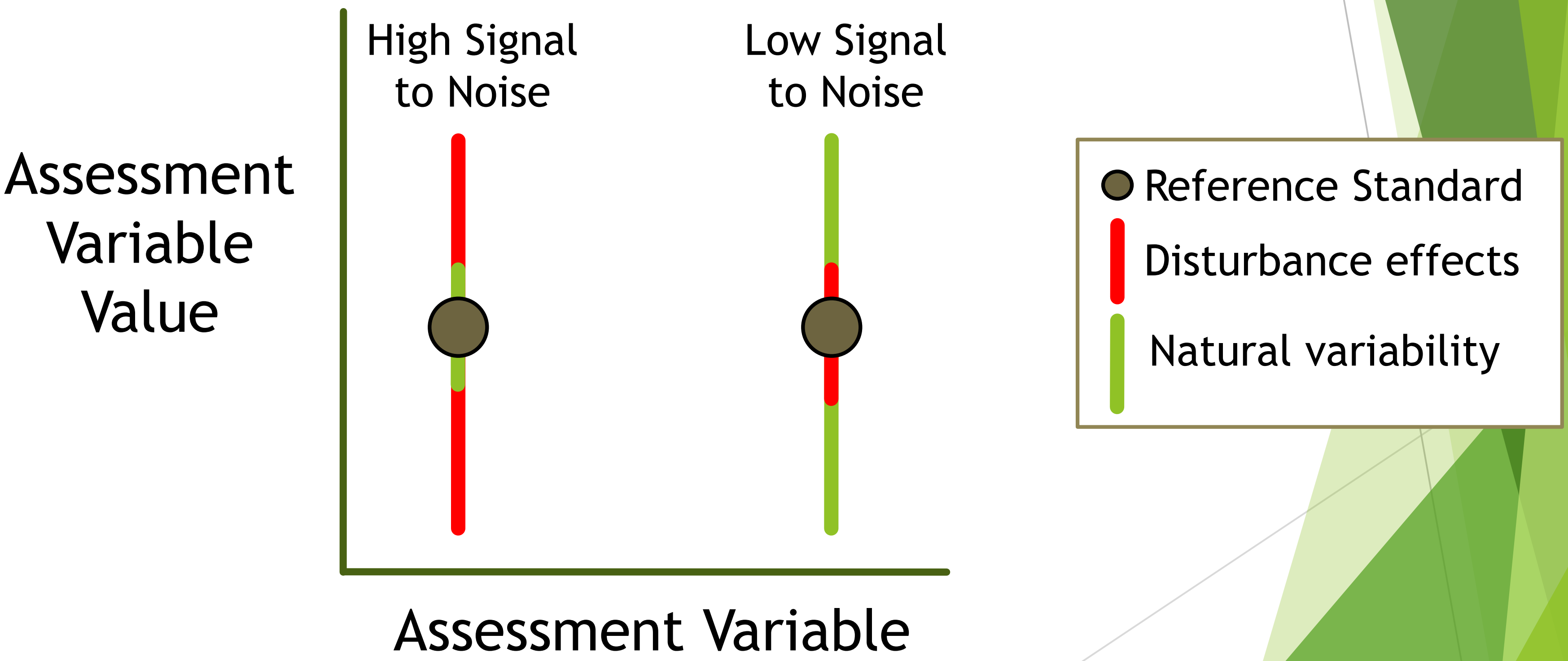
HGM Classification and Functional Assessment

- Natural variation in wetlands can make it difficult to discriminate anthropogenic-caused wetland condition
- Wide range variability among wetlands within wetland types (e.g., palustrine wetlands)
- To more easily and effectively identify anthropogenic impacts on wetlands, reducing the natural variation is critical

≠

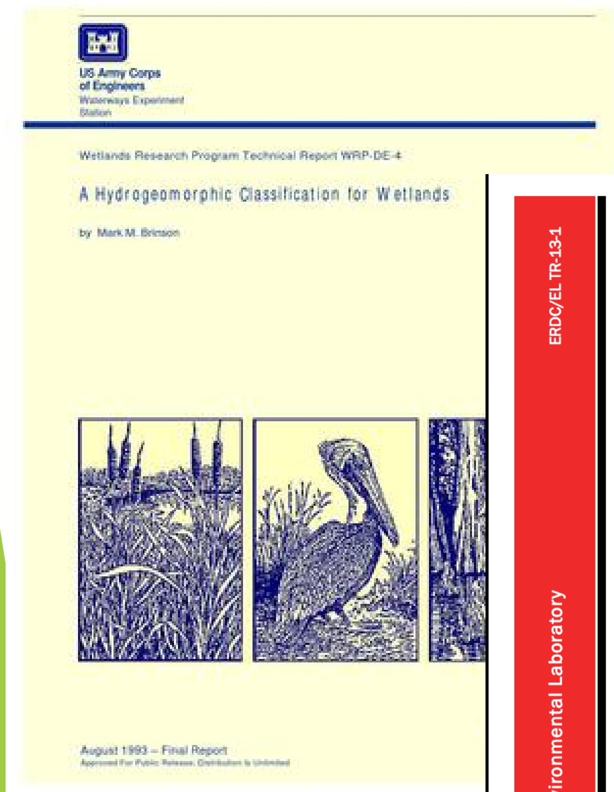
Natural Variability in Wetlands

- Natural variability can render assessment model output useless in identifying impairment



HGM Classification

- HGM includes functional classification based on three components:
  - Geomorphic setting
  - Water source and its transport
  - Hydrodynamics

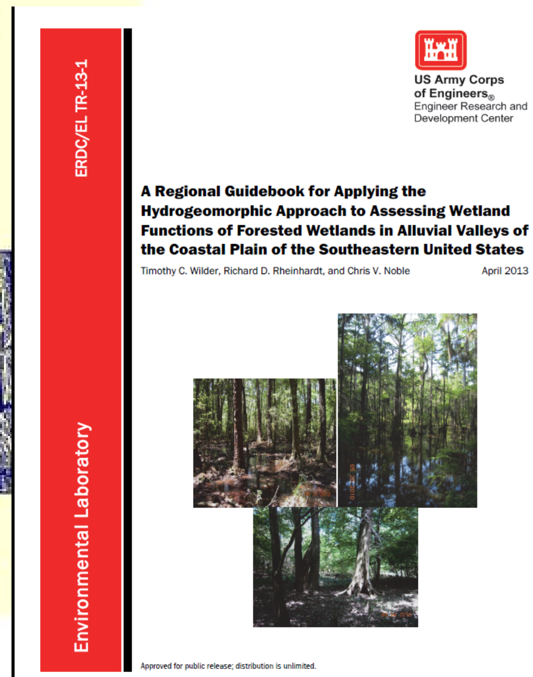

US Army Corps of Engineers
Waterways Experiment Station

Wetlands Research Program Technical Report WRP-DE-4

A Hydrogeomorphic Classification for Wetlands

by Mark M. Brinson

August 1993 – Final Report
Approved For Public Release; Distribution Is Unlimited


ERDC/EL TR-13-1

Environmental Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Wetlands in Alluvial Valleys of the Coastal Plain of the Southeastern United States

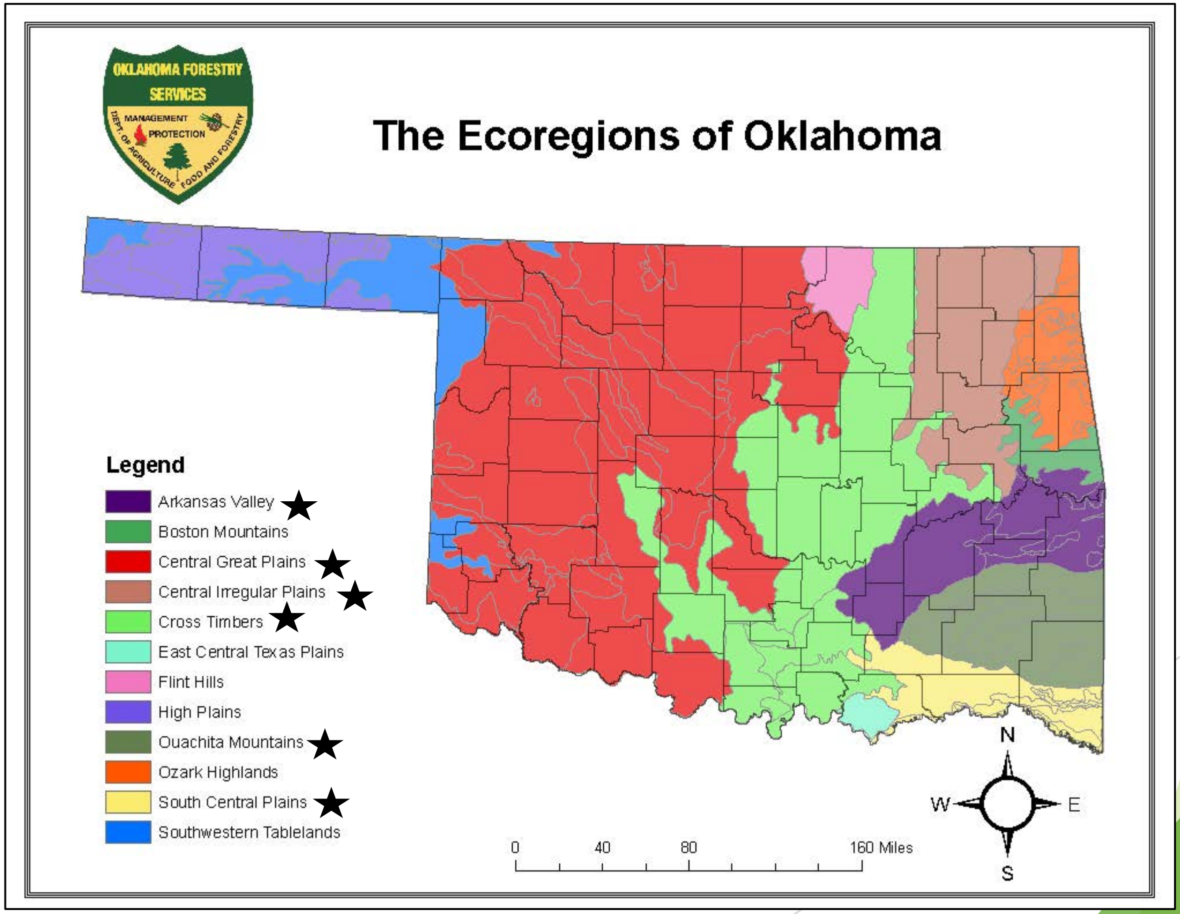
Timothy C. Wilder, Richard D. Rheinhardt, and Chris V. Noble — April 2013

Approved for public release; distribution is unlimited.

Additional HGM National Classes: Tidal Fringe, Mineral Salt Flats, and Organic Salt Flats

HGM Classification

- From 2007-2013, we surveyed nearly 350 wetlands in 6 major ecoregions of state (from a random pool of nearly 2,000 wetlands)
- Initial characterization of each wetland and assessed condition
- Determined HGM national class and further separated the wetlands into subclasses (developed 20 subclasses)



Riverine Dichotomous Key

The wetland is a remnant river channel that is periodically connected to a river or stream every 5 years or more frequently

Connected Oxbow

The hydrology of the wetland is impacted by beaver activity

Beaver Complex

The wetland occurs within the bankfull channel

In Channel

The wetland occurs within a depression on the floodplain

Floodplain Depression

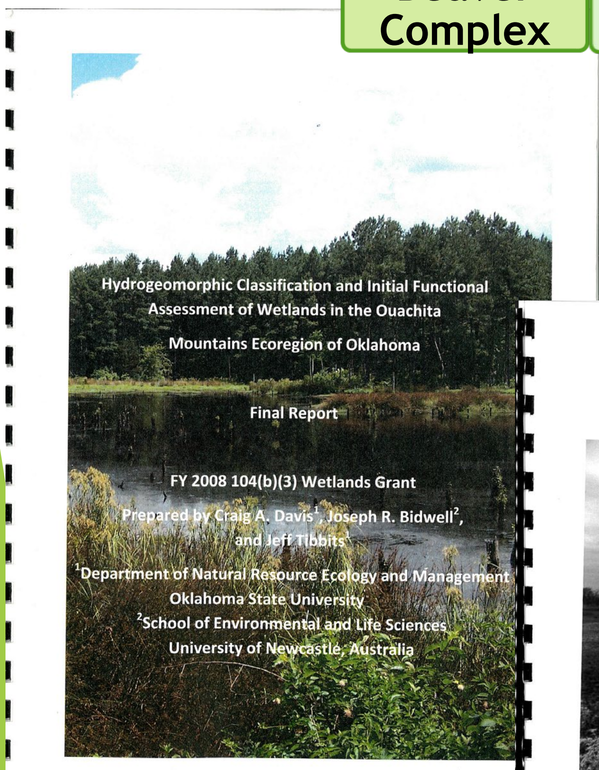
The wetland occurs on a flat area on the floodplain or is adjacent to the river channel.

Water source primarily from overbank flows that remain in the wetland due to impeded drainage

Water source overbank flow that recedes with floodwater

Floodplain

Riparian

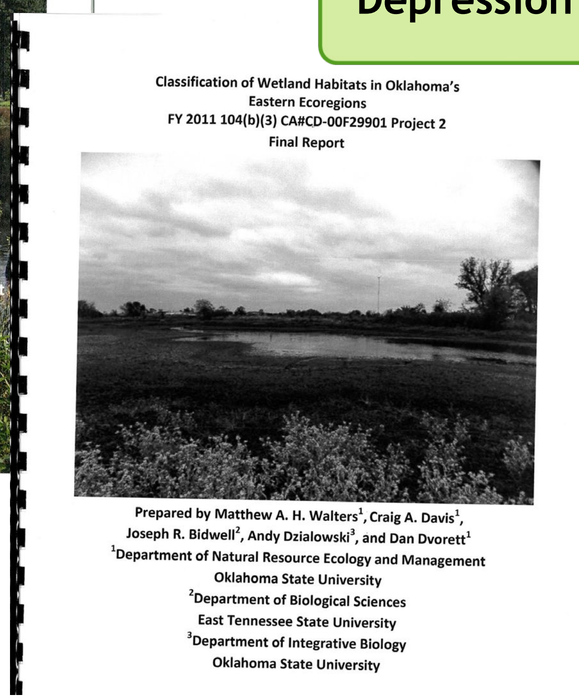

Hydrogeomorphic Classification and Initial Functional Assessment of Wetlands in the Ouachita Mountains Ecoregion of Oklahoma

Final Report

FY 2008 104(b)(3) Wetlands Grant

Prepared by Craig A. Davis[1], Joseph R. Bidwell[2], and Jeff Tibbits

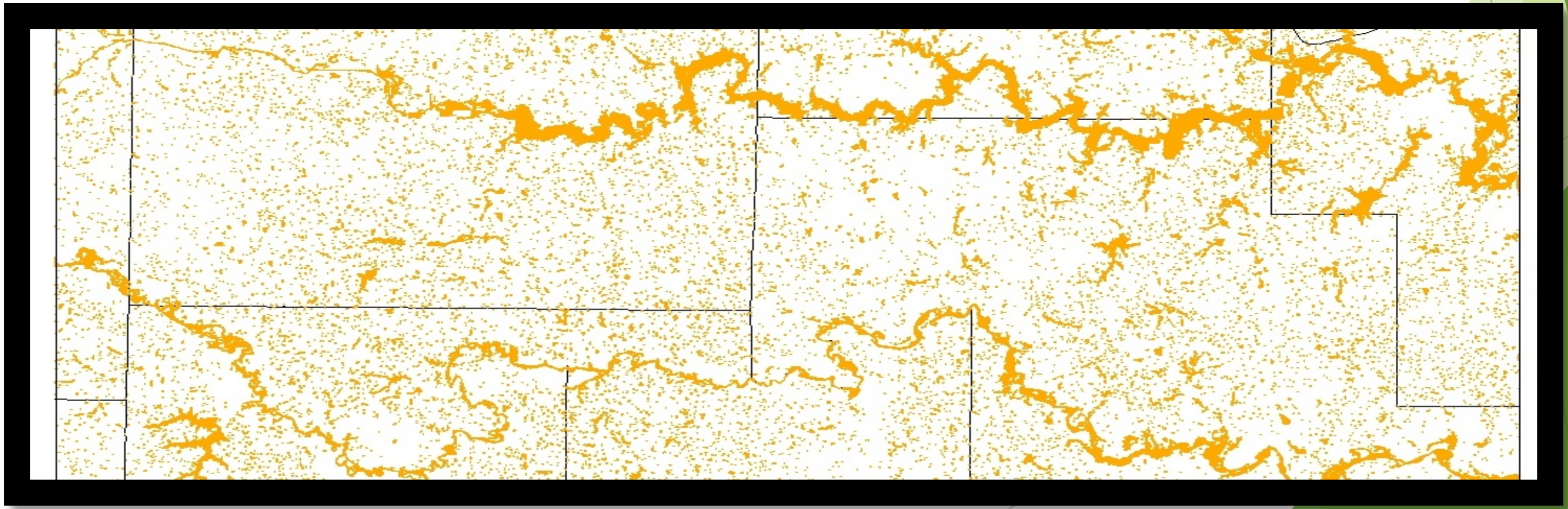
[1]Department of Natural Resource Ecology and Management
Oklahoma State University
[2]School of Environmental and Life Sciences
University of Newcastle, Australia


Classification of Wetland Habitats in Oklahoma's Eastern Ecoregions
FY 2011 104(b)(3) CA#CD-00F29901 Project 2
Final Report

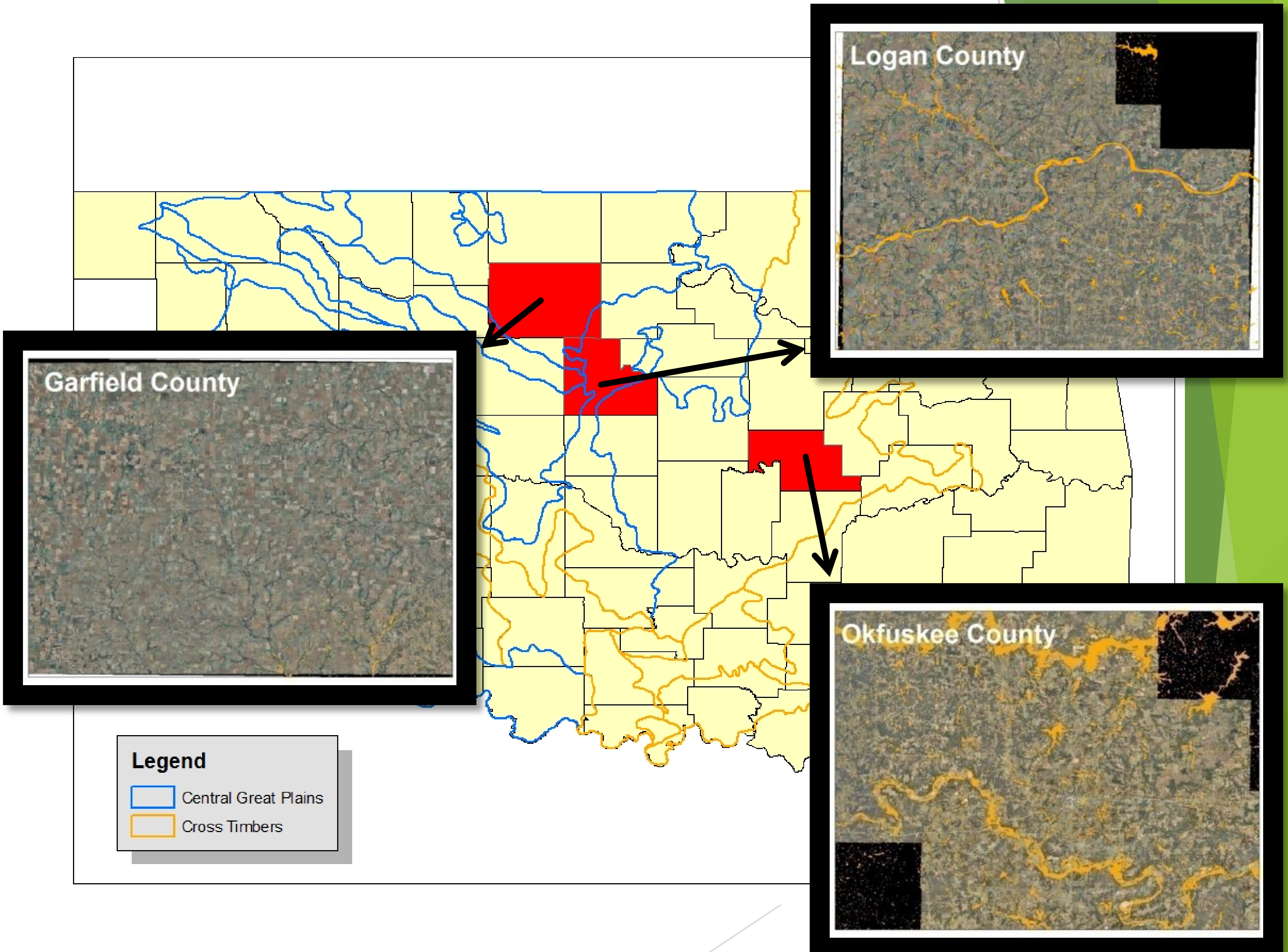
Prepared by Matthew A. H. Walters[1], Craig A. Davis[1], Joseph R. Bidwell[2], Andy Dzialowski[3], and Dan Dvorett[1]
[1]Department of Natural Resource Ecology and Management
Oklahoma State University
[2]Department of Biological Sciences
East Tennessee State University
[3]Department of Integrative Biology
Oklahoma State University

Improving the Utility of National Wetlands Inventory Maps for Assessment

- Most extensive inventory of wetlands in U.S.
- High altitude aerial photo interpretation
- Cowardin system of classification
- 20-30 years old in Oklahoma
- Limited utility in characterizing wetland functions

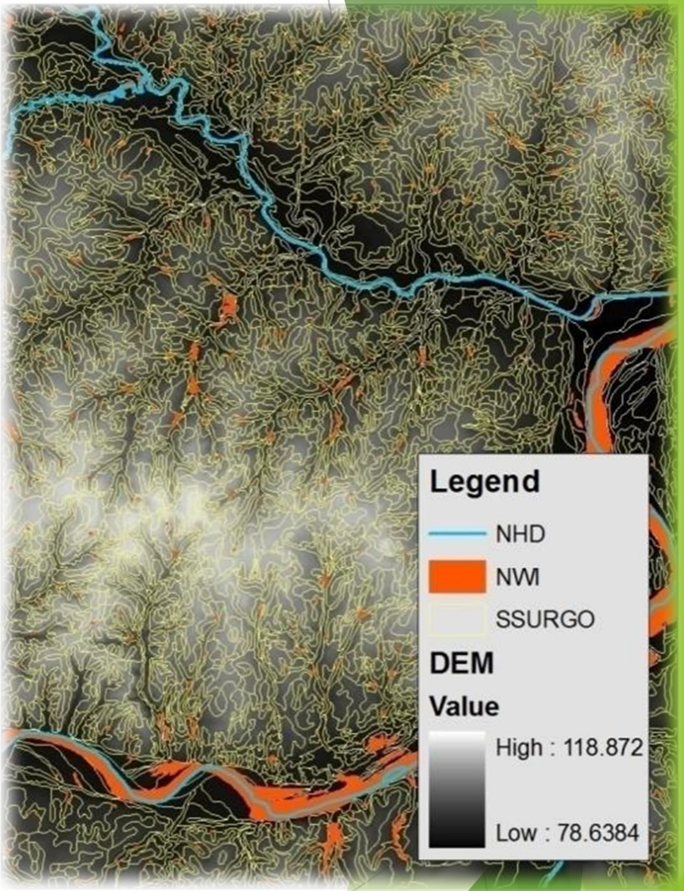


Study Area


Logan County
Garfield County
Okfuskee County
Legend
Central Great Plains
Cross Timbers

Methology

- Reclassified using NWI polygons + additional data (soil survey geographic [SSURGO] and national hydrography [NHD] datasets)
- Field verified GIS classification (149 wetlands)
- Measured accuracy of classification
- Inventory of HGM subclasses for 2 ecoregions



Sources of Error

- Errors within NWI
  - Inclusion of uplands
  - Misattributed polygons
  - Inaccurate polygon boundaries
  - Age of NWI + other dataset (NHD)

Accuracy of Classification

HGM Class	Visited	Correctly Classified	Percent Correctly Classified	Dominant Reason for Misclassification
Depressional	33	9	27%	Errors in NWI (misattributed)
Impounded Depressional	50	28	56%	Lack of Distinguishing Data
Lacustrine Fringe	58	48	83%	
Riverine	58	32	64%	Errors in NWI
Overall	199	117	59%	

Wetland Inventory Results for Cross Timbers and Central Great Plains Ecoregions

Class	Subclass	Total Low	Total High
Riverine	Beaver	2220	2880
	Riparian	6660	6734
	Floodplain	313	1124
	In Channel	313	325
	Riparian/In Channel	4128	5808
	Floodplain Dep	0	0
	Connected Oxbow	2360	3430
Total		16791	23751

Class	Subclass	Total Low	Total High
Depressional	SW/open	0	1447
	SW/closed	2341	4862
	GW/open	0	0
	GW/closed	863	1234
Total		3205	7543

Class	Subclass	Total Low	Total High
Lacustrine	Reservoir/Pond Fringe	37989	123367
	Disconnected Oxbow	635	637
Total		38624	124004

Class	Subclass	Total Low	Total High
Imp. Dep	SW/closed	108684	116865
	SW/open	7951	9956
Total		116635	126821

Conclusions

- Reclassification to HGM subclasses may be hampered by inherent problems with NWI (e.g., incorrect attribution of NWI polygons, upland sites included in NWI maps, and map age), but can still be a useful tool for inventorying wetlands and wetland functions/services as well as provide guidance on restoration and monitoring efforts

Functional Assessment

ERDC/EL TR-13-14

Environmental Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

ERDC
INNOVATIVE SOLUTIONS for a safer, better world

Wetlands Regulatory Assistance Program

A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Functions of Forested Wetlands in the Mississippi Alluvial Valley

Elizabeth O. Murray and Charles V. Klimas

July 2013

FHWA
U.S. Fish & Wildlife Service
USDA NRCS Natural Resources Conservation Service
NOAA

Approved for public release; distribution is unlimited.

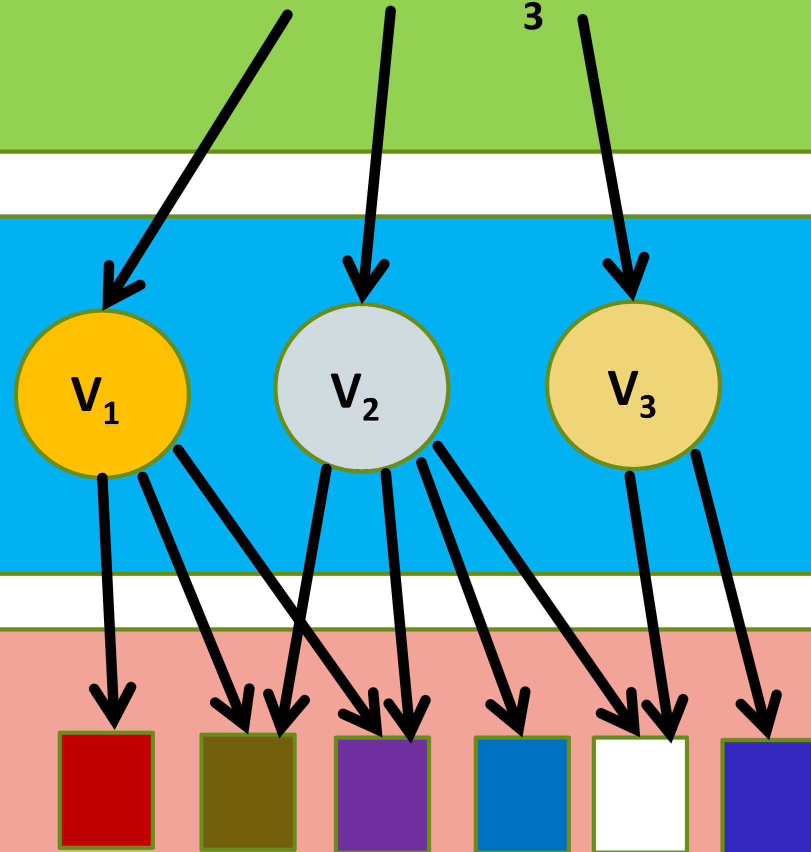
Structure of an HGM Functional Model

FUNCTIONS: Processes that are necessary for the maintenance of an ecosystem such as primary production, nutrient cycling, decomposition, etc.

Estimate of Function "X" (where "X" = $\frac{V_1 + V_2 + V_3}{3}$)

UNITS: Functional Capacity Index

VARIABLES: Attributes or characteristics of a wetland ecosystem or the surrounding landscape that influence the capacity of the wetland to perform a function



UNITS: Index scores (0.0-1.0 range)

INDICATORS: Observable characteristics of the wetlands that correspond to identifiable, variable conditions in the wetlands or the surrounding landscape

UNITS: As appropriate (#/unit area, acres, length, etc.)

HGM Functional Assessment

- Identify reference standard sites
  - Pristine or least altered
- Develop assessment models for functions
  - Algorithm of site variables presumed to impact function

Flood energy dissipation ={VFREQ × [(VMACRO + VMICRO + VDTREE + VCWD)/4]}1/2

- Compare study sites function to reference standard function
  - Functional Capacity Index

FCI= Site FC / Reference Standard FC

Subclasses

- Collected assessment variables from two HGM riverine subclasses

-**Oxbows**

-**Riparian**

Example of Assessment Variables-Vegetation

- Point Intercept
  - % Cover Herbaceous
  - % Cover Shrub/Sapling
  - % Canopy Cover
  - % Vine Cover
  - % Litter cover
- Line intercept
  - CWD volume
  - CWD stem count
- 10 meter belt transect
  - Tree Density
  - Tree Basal Area
  - Snag Density

Disturbance and Assessment Variables

- Results
  - No significant results from RDA for all assessment variables or suites of variables used in assessment models
  - Forward stepwise regressions:

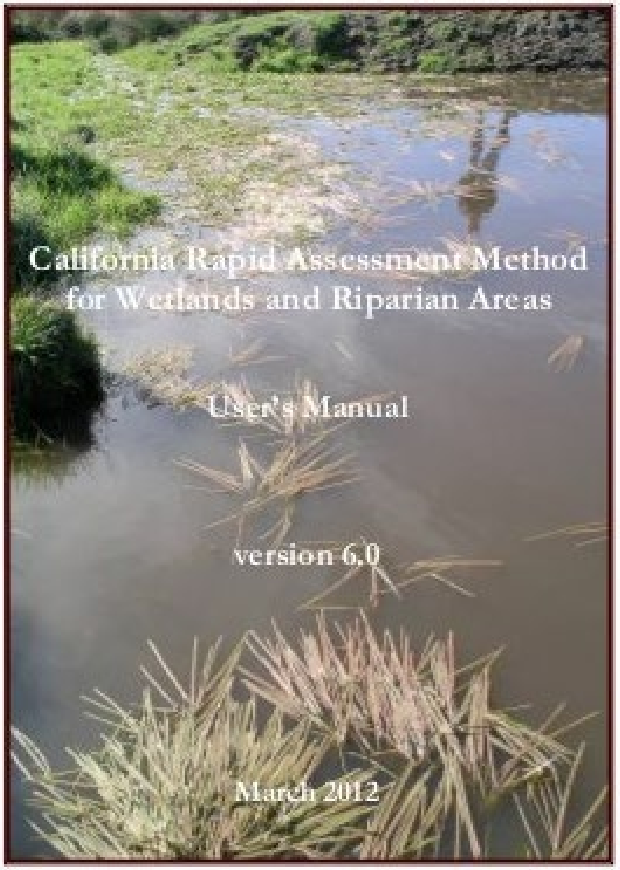
Subclass	**Assessment Variable**	**Disturbance Factor**	**R^2**	**Dir.**	***p***
Oxbow	% subsurface organic	hum. alt. 100m	0.282	+	0.016
Riparian	% subsurface sand	hum. alt. 100m	0.237	-	0.017
Riparian	% surface silt	hum. alt. 100m	0.258	+	0.016
Riparian	% subsurface silt	hum. alt. 100m	0.346	+	0.003

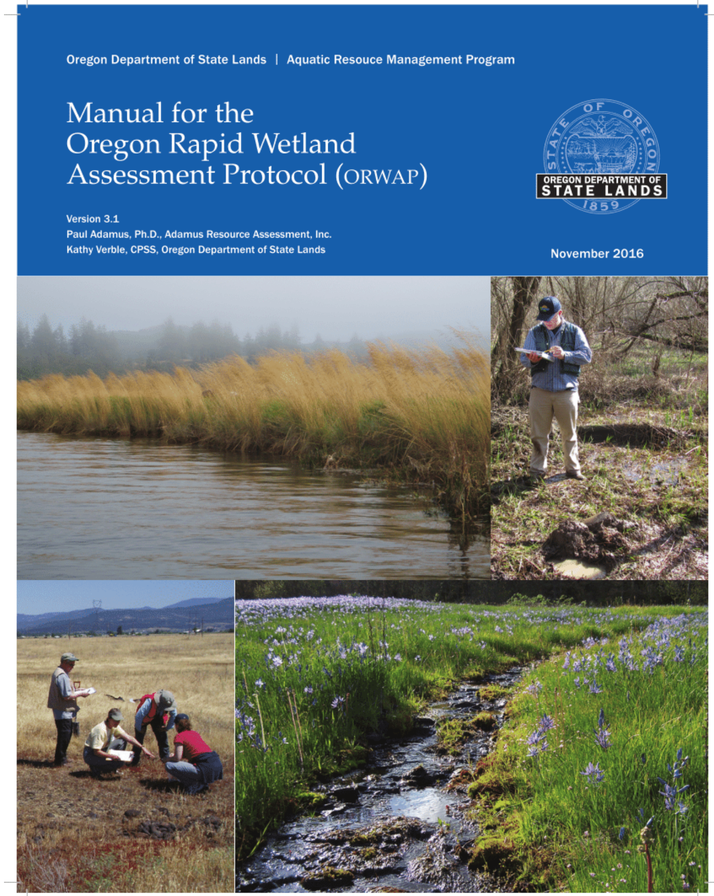
Conclusions

- The natural variability of assessment variables within subclasses may be masking landscape disturbance effects
- Assessment models may only be reliably able to identify severe landscape degradation or on-site disturbance.
- The inability to relate assessment variables with disturbance means that assessment model output may not be related to wetland impairment
- Data collection for HGM Functional Assessments can be very time-consuming which greatly limits the applicability of this approach to assessing condition

Development of Rapid Assessment Methods

- Focus on wetland monitoring has shifted more to RAMs than quantitative methods (e.g., IBIs and functional assessments)
- Less time-consuming, inexpensive, and have been shown to provide a meaningful and reliable tool for assessing wetland condition





OKRAM Attributes & Metrics

Hydrologic Condition	Hydroperiod, Water Source, Hydrologic Connectivity
Water Quality Condition	Nutrients, Sediments, Chemical Contaminants, Buffer
Biotic Condition	Vegetation, Habitat Connectivity

Example of Water Quality Condition Attribute and Metric

2. Water Quality Condition

a. Nutrients/Eutrophication

1. On an aerial photograph in the field outline all areas within the AA where nutrient cycling has been altered and severity of alteration. For calculations, sketches on aerial photographs can be converted to GIS or estimated from aerial photos.
2. Severity of alteration is based on indicator severity on the following worksheet.
3. Fill in the area as a percent of the AA and severity for each indicator of altered nutrient cycling. Overlapping areas of indicators are only counted once and for the highest level of severity. Describe the indicator and circle all indicators on the indicator worksheet.
4. The metric is calculated by applying severity weights to the impacted area. For example a severity weight of 0.25 is applied to minor sources of impacted nutrient cycling. If 50% of the AA is affected by a minor source of altered nutrient cycling, the metric score would be 0.875 (1-[0.50*0.25] = 0.875).

Indicators of Altered Nutrient Cycling	Minor	Moderate	Major	Indicator Description
Livestock/animal waste				
Septic/sewage discharge				
Excessive algae or Lemna sp. (Do not count this metric if algae or Lemna blooms are a result of evapoconcentration of nutrients as wetland is drying.)				
TOTAL IMPACTED AREA	**0**	**0**	**0**	
SEVERITY WEIGHT	**0.25**	**0.5**	**0.75**	
SEVERITY WEIGHTED AREA	**0**	**0**	**0**	
METRIC SCORE 2a				**1**

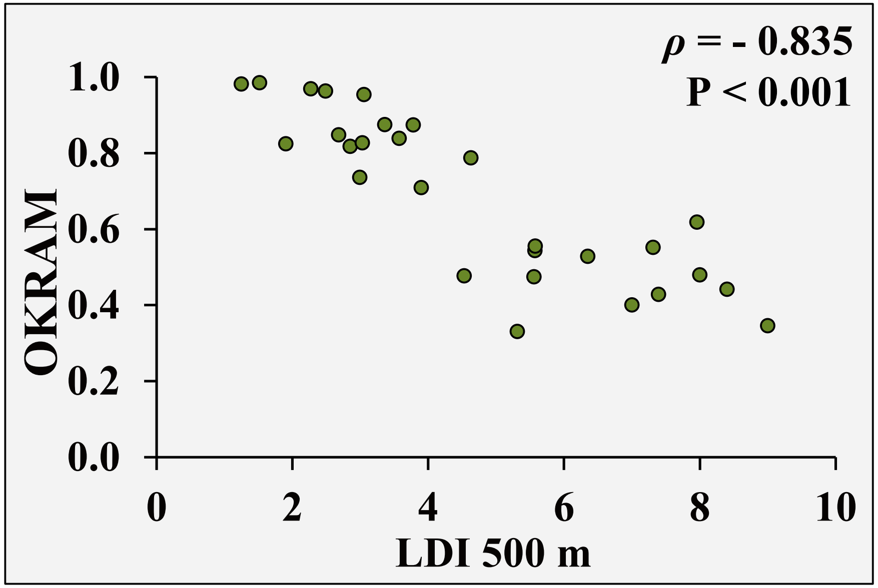
Calculating Overall OKRAM Condition Score

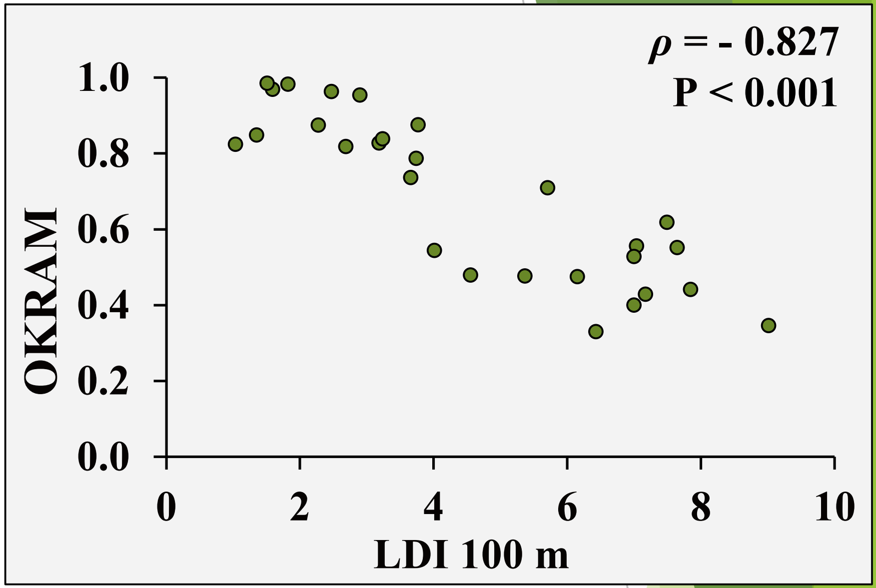
4. OKRAM Overall Condition Score				
	Metric	**Score**		
1	***Hydrology***			
1a.	Hydroperiod	1.00		
1b.	Water source	0.00		
1b.	Water source- Alt	0.00		
1c.	Hydrologic Connectivity	0.00		
1c.	Hydrologic Connectivity-Alt	1.00		
	Hydrology Attribute	**0.33**	**Hydrology Attribute Alternative**	**0.67**
	(metric 1a +metric 1b + metric 1c)/3			
2	***Water Quality***			
2a.	Nutrients	1.00		
2b.	Sediment	1.00		
2c.	Contaminants	1.00		
22	Buffer Filter	1.00		
2d.	Buffer Filter Alternate	1.00		
	Water Quality Attribute	**1.00**	**Water Quality Attribute Alternative**	1.00
	(metric 2a +metric 2b + metric 2c + metric 2d)/4			
3	***Biota***			
3a.	Vegetation	1.00		
3b.	Habitat Connectivity	1.00		
3b.	Habitat Connectivity-Alt	1.00		
	Biota Attribute	**1.00**	**Biota Attribute Alternative**	**1.00**
	(metric 3a + metric 3)/2			
Overall Condition Score		**0.78**	**Overall Condition Score (Alt)**	**0.89**

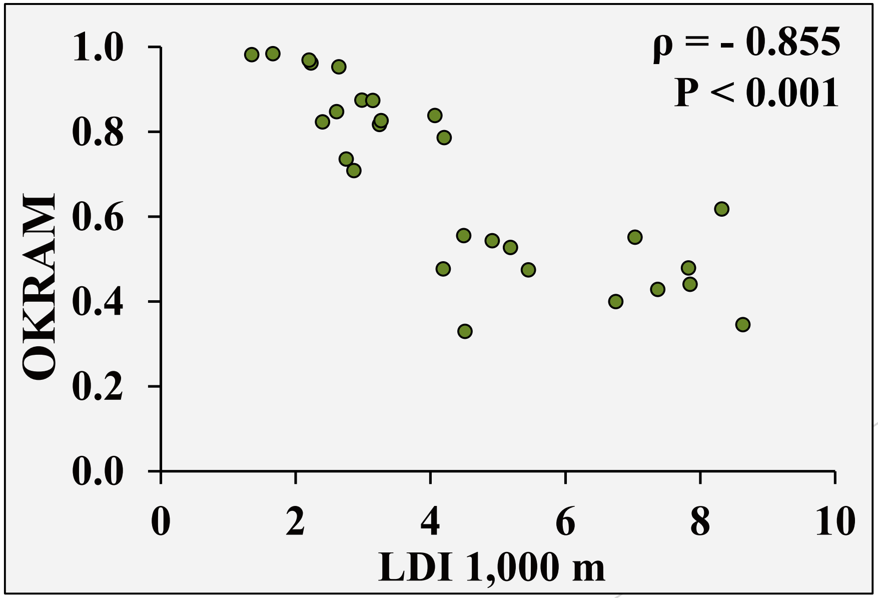
Calibration and Validation of OKRAM for Depressional, Lacustrine Fringe, Riverine, and Slope Wetlands

HGM Class	Initial Application	Calibration	Validation	Statewide Application
Depressional	YES	YES	YES	YES
Lacustrine Fringe	YES	YES		
Riverine	YES	YES	On-going	On-going
Slope				

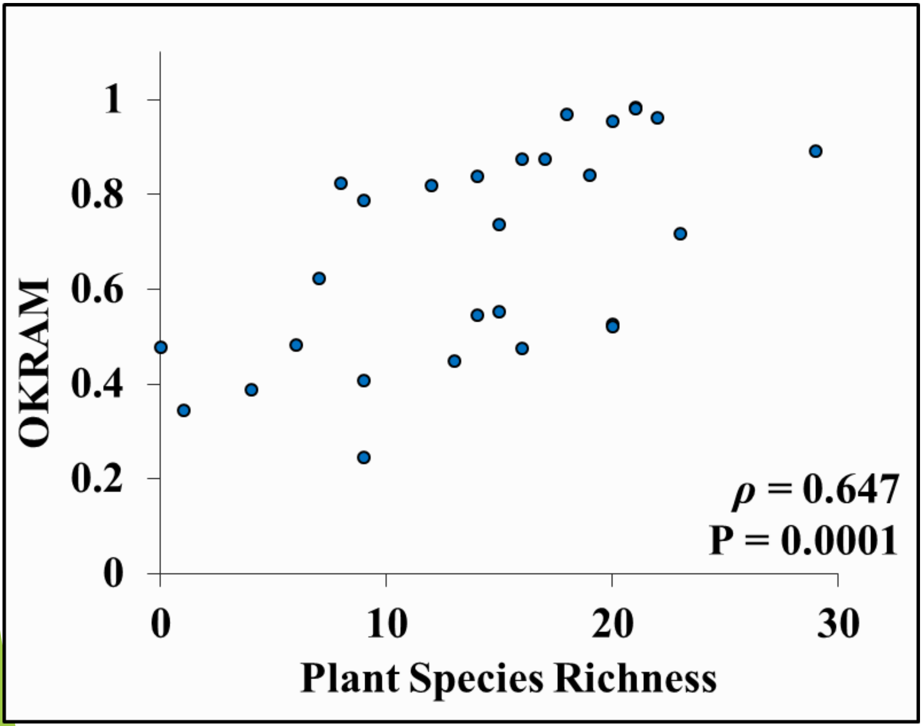
Validation of OKRAM for Depressional Wetlands Using Level 1 Data

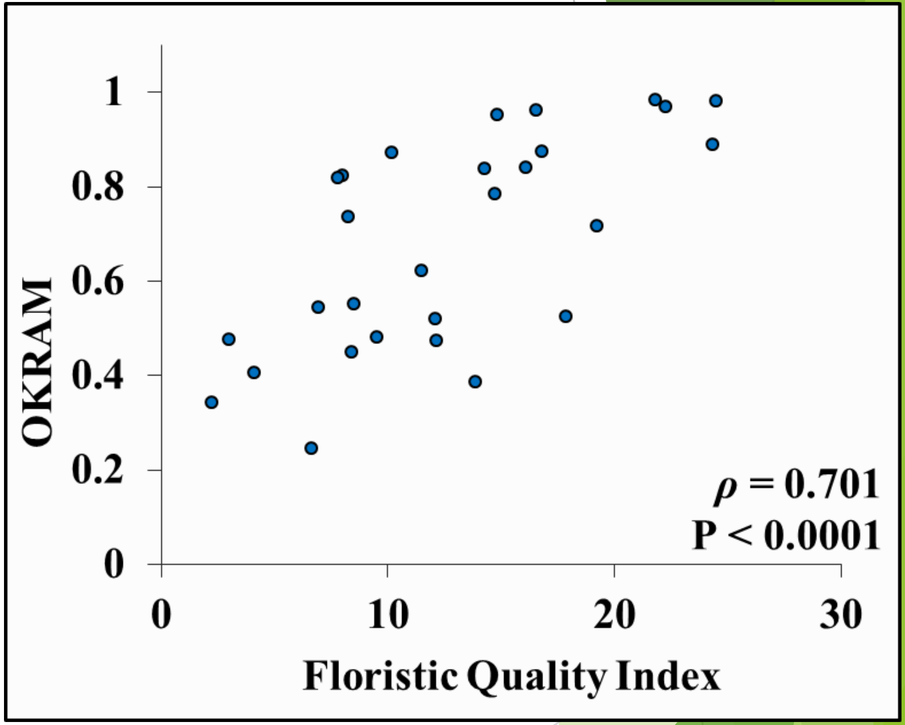






Validation of OKRAM for Depressional Wetlands Using Level 3 Data





Calibration of Lacustrine Fringe Wetlands

- **OKRAM and Level 1 data**
  - **Strong relationships between OKRAM and LDI**

- **OKRAM and Level 3 data**
  - **No relationships with vegetation, invertebrates, or water quality data**
  - **Few relationships with soil chemistry data**

- **CRAM and FACWet with Level 3 data**
  - **No consistent relationships**

OKRAM Conclusions

- OKRAM provides reliable, repeatable assessments of depressional wetlands
- OKRAM in its current model format cannot effectively capture wetland condition of lacustrine fringe wetlands
- For lacustrine fringe wetlands, highly regulated water levels (stable to extreme fluctuations) of reservoirs greatly affect Level 3 data (vegetation), narrow disturbance gradient, and possibly inappropriate abiotic/biotic data for calibration likely resulted in ineffectiveness of OKRAM assessment of condition
- For riverine, we are still in the early stages of calibration and validation

Lessons Learned from nearly 20 years of Wetland Assessment Research

- Because wetlands are unique ecosystems that are inherently spatially and temporally dynamic, development of applicable, repeatable, and responsive condition assessments can be difficult
- Spatial and temporal variation must be acknowledged (e.g., eastern-western precipitation gradient in Oklahoma)
- Applying assessment protocols at the appropriate scale and geographic region is critical to successful assessment
- Given the dynamic nature of wetlands, use of ambient water quality data can be problematic
- Stressor-based assessments such as RAMs may be more appropriate than quantitative assessments (HGM functional assessment and IBIs)
- Assessments must be linked to wetland functions and ecosystem services


Questions?