Development of Biological Indicators and a BCG Model Framework for the MBNEP Study Area

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The MBNEP is developing a monitoring program to assess the status and trends of estuarine condition.

Habitat based bioassessments are focused on streams and rivers (and riparian buffers), freshwater wetlands, and intertidal marshes and flats.

The management goal is to maintain and enhance habitat quality and the provision of important ecosystem services.

How does a stressor gradient of land use change and human disturbance relate to the biological condition of wetlands and coastal waters?

<u>Major Stressors</u>

- Land use change
- Dredging and filling
- Fragmentation
- Sedimentation

Monitoring Framework

Extent of wetland and water resources and their biological condition

↓

Relationship between biological condition and stressors

↑

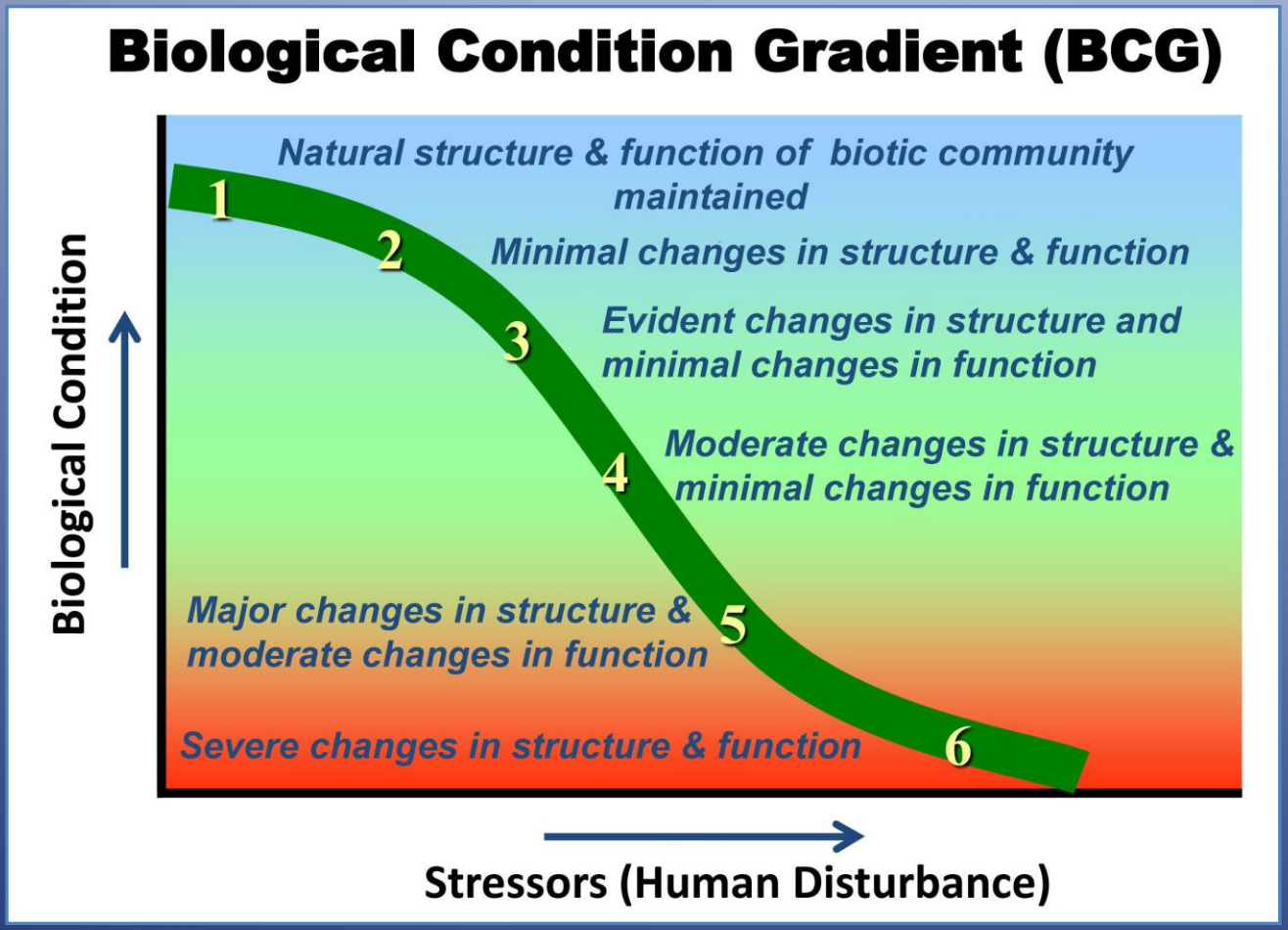
Extent of the stressors

DATABASE

→ Maintain/improve existing level of coastal monitoring

→ Manage system for multiple ecosystem services

→ Build a Biological Condition Gradient Framework for coastal Alabama



Report ecosystem status and trends

Identify restoration and conservation priorities

Track the effectiveness of ecosystem management

Habitats with high levels of ecosystem function are assumed to have the potential to provide the full range of ecosystem services we expect from those habitats in their natural condition.

Multi-scale Assessment

A tiered framework divides bioassessment procedures into three levels which vary in the degree of effort and the scale of application.

Level 1 – Landscape assessment
Level 2 – Rapid assessment
Level 3 – Intensive assessment

There is an increase in resolution and diagnostic reliability as data collection shifts from remote sensing to intensive sampling on the ground.

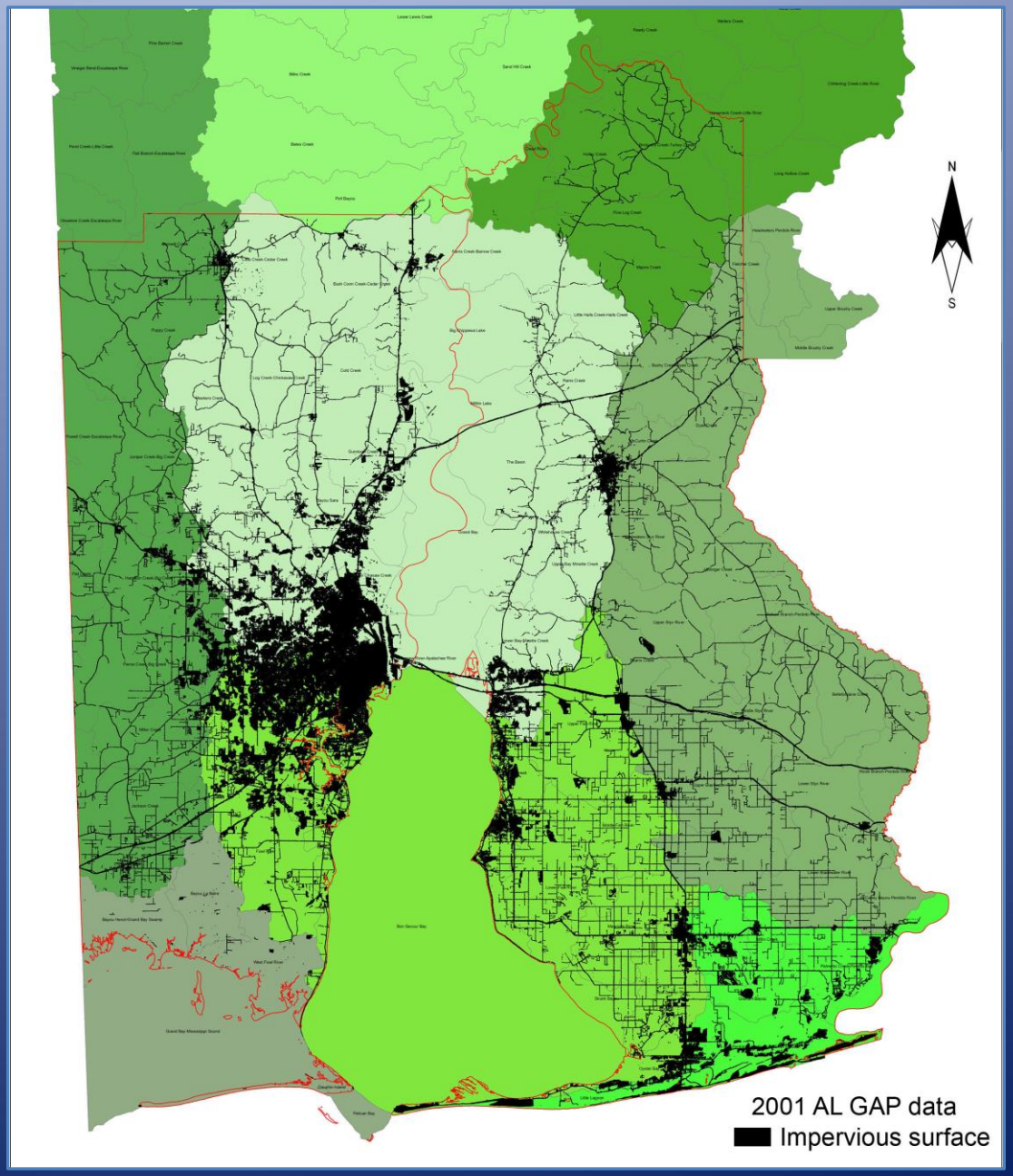
Landscape Assessment

Impervious surface

Road density

Development intensity

% Natural lands



Landscape Development Intensity Index

(Brown & Vivas, 2005)

The landscape development intensity (LDI) index is a land use based index of potential human disturbance calculated from land-use/land-cover (LULC) data.

Development intensity factors are a function of the non-renewable energy (electricity, fuels, fertilizers, pesticides, and water) use per unit area of land use.

LDI represents the cumulative anthropogenic impact in terms of nonrenewable energy to a landscape unit.

LANDSCAPE DEVELOPMENT INTENSITY INDEX

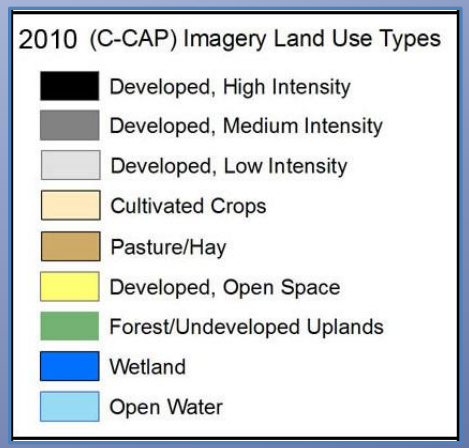
TABLE II

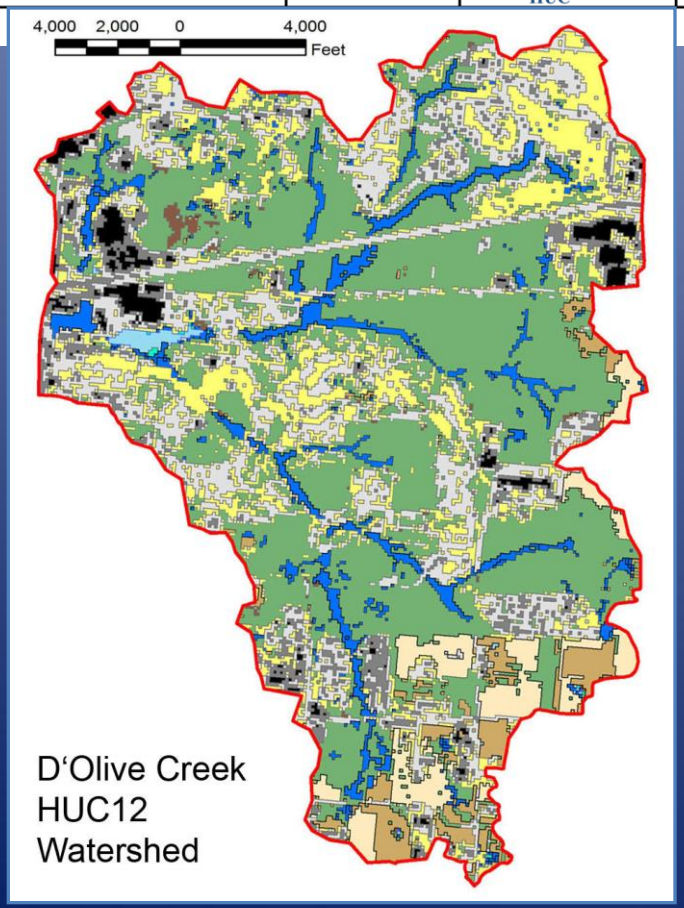
Land use classification, nonrenewable empower density, and resulting LDI coefficients

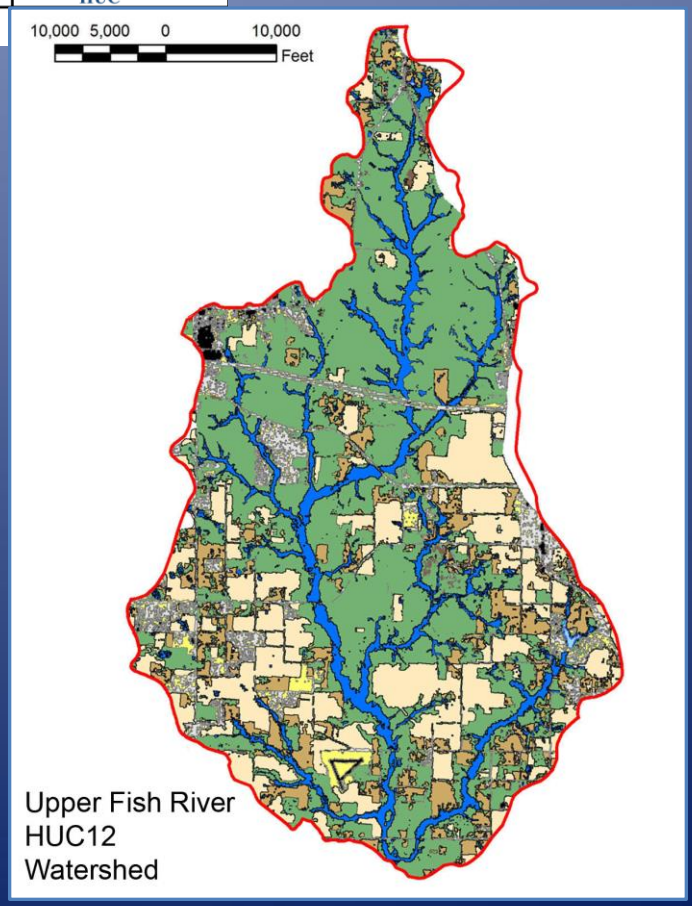
Land use	Nonrenewable empower density (E14 sej/ha/yr)	Ln Nonrenewable empower density	LDI coefficients[a]
Natural system	0.00		1.00
Natural open water	0.00		1.00
Pine plantation	5.10	1.63	1.58
Recreational / open space – low-intensity	6.55	1.88	1.83
Woodland pasture (with livestock)	8.00	2.08	2.02
Improved pasture (without livestock)	17.20	2.84	2.77
Improved pasture – low-intensity (with livestock)	33.31	3.51	3.41
Citrus	44.00	3.78	3.68
Improved pasture – high-intensity (with livestock)	46.74	3.84	3.74
Row crops	107.13	4.67	4.54
Single family residential – low-density	1077.00	6.98	6.9
Recreational / open space – high-intensity	1230.00	7.11	6.92
Agriculture – high intensity	1349.20	7.21	7.00
Single family residential – medium density)	2175.00	7.68	7.47
Single family residential – high density	2371.80	7.77	7.55
Mobile home (medium density)	2748.00	7.92	7.70
Highway (2 lane)	3080.00	8.03	7.81
Low-intensity commercial	3758.00	8.23	8.00
Institutional	4042.20	8.30	8.07
Highway (4 lane)	5020.00	8.52	8.28
Mobile home (high density)	5087.00	8.53	8.29
Industrial	5210.60	8.56	8.32
Multi-family residential (low rise)	7391.50	8.91	8.66
High-intensity commercial	12 661.00	9.45	9.18
Multi-family residential (high rise)	12 825.00	9.46	9.19
Central business district (average 2 stories)	16 150.30	9.69	9.42
Central business district (average 4 stories)	29 401.30	10.29	10.00

[a]The LDI coefficient is calculated as the normalized (on a scale of 1.0 to 10.0) natural log of the empower densities.

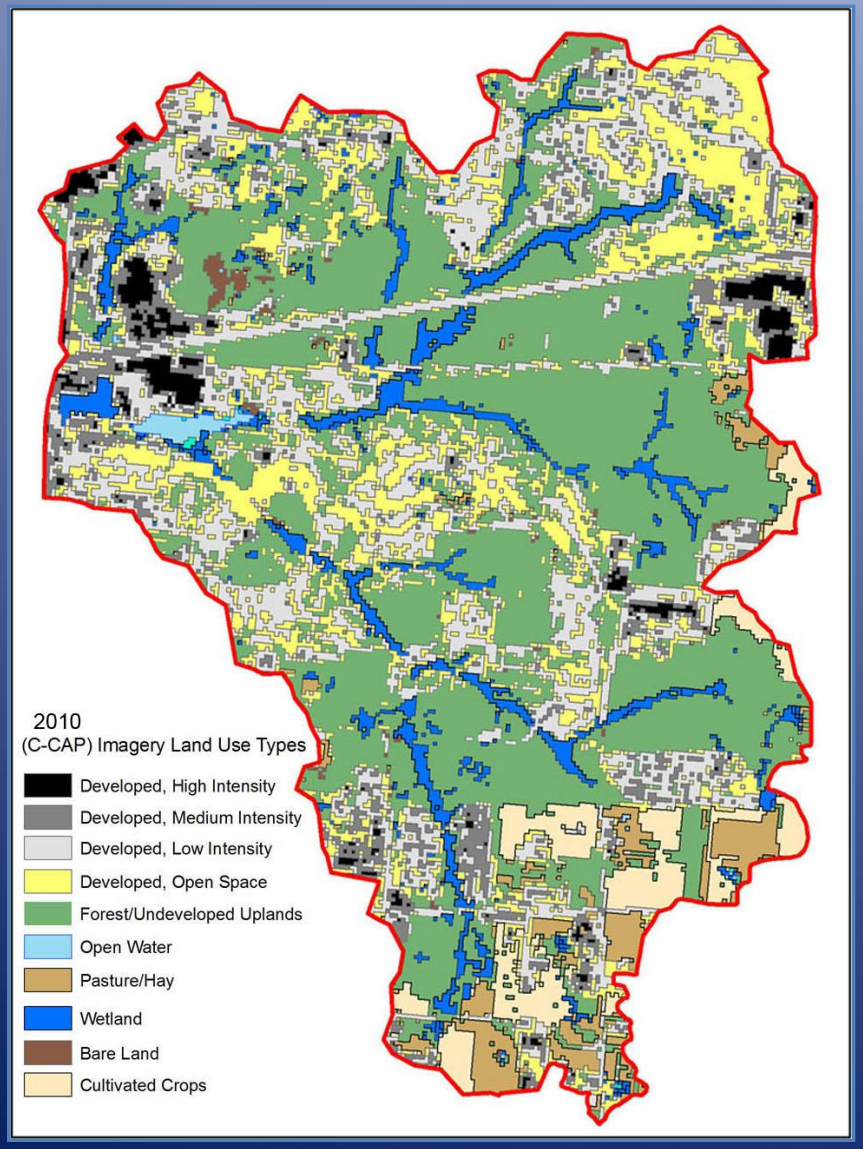
2010 CCAP LCLU	D'Olive HUC 12		Upper Fish River HUC 12	
Land Use Category (LDI Coefficient)	% Cover	%LU x LDI C	% Cover	%LU x LDI C
High intensity development (9.0)	2.4	21.6	0.5	4.5
Med intensity development (7.5)	5.7	42.8	1.4	10.5
Low intensity development (6.9)	21.3	147.0	6.7	46.2
Row crop (4.5)	4.2	18.9	19.5	87.8
Pasture (3.5)	3.6	12.6	11.8	41.3
Developed open space (1.8)	16.8	30.2	3.7	6.7
Forest/undeveloped (1.0)	38.4	38.4	44.5	44.5
Wetland (1.0)	6.6	6.6	10.6	10.6
Open water (1.0)	0.4	0.4	0.0	0.0
		LDI_{HUC}=318.5		**LDI_{HUC}=252.1**

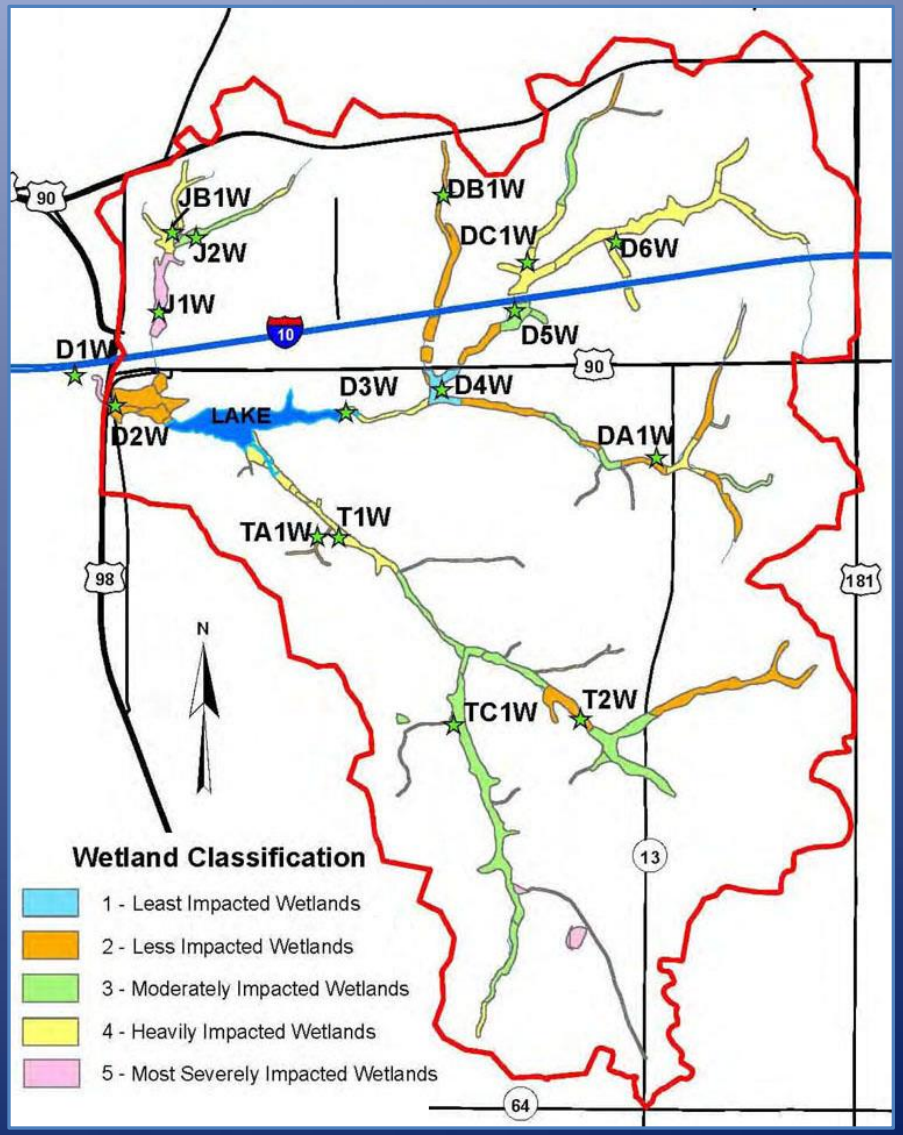






D'Olive Watershed
Land Use and Wetland Condition





Wetland Assessment Methods

Rapid assessment methods provide sound, quantitative information on the status of the wetland resource with a relatively small investment of time and effort.

The condition of wetland vegetation is a key metric in quality assessments.

Stressors are incorporated into assessments, including landscape variables.

Wetland rapid assessment procedure (WRAP) and the hydrogeomorphic (HGM) model are two methods used in coastal Alabama.

Mobile District Corps / ADEM Coastal use WRAP for wetland assessment, permitting and mitigation.

Six functional values:

- Wetland hydrology
- Water quality input and treatment
- Wetland vegetation ground cover
- Wetland overstory/shrub canopy
- Adjacent upland/wetland buffer
- Wildlife utilization

WRAP scores:

1.00-0.76 = high quality

0.75-0.51 = medium quality

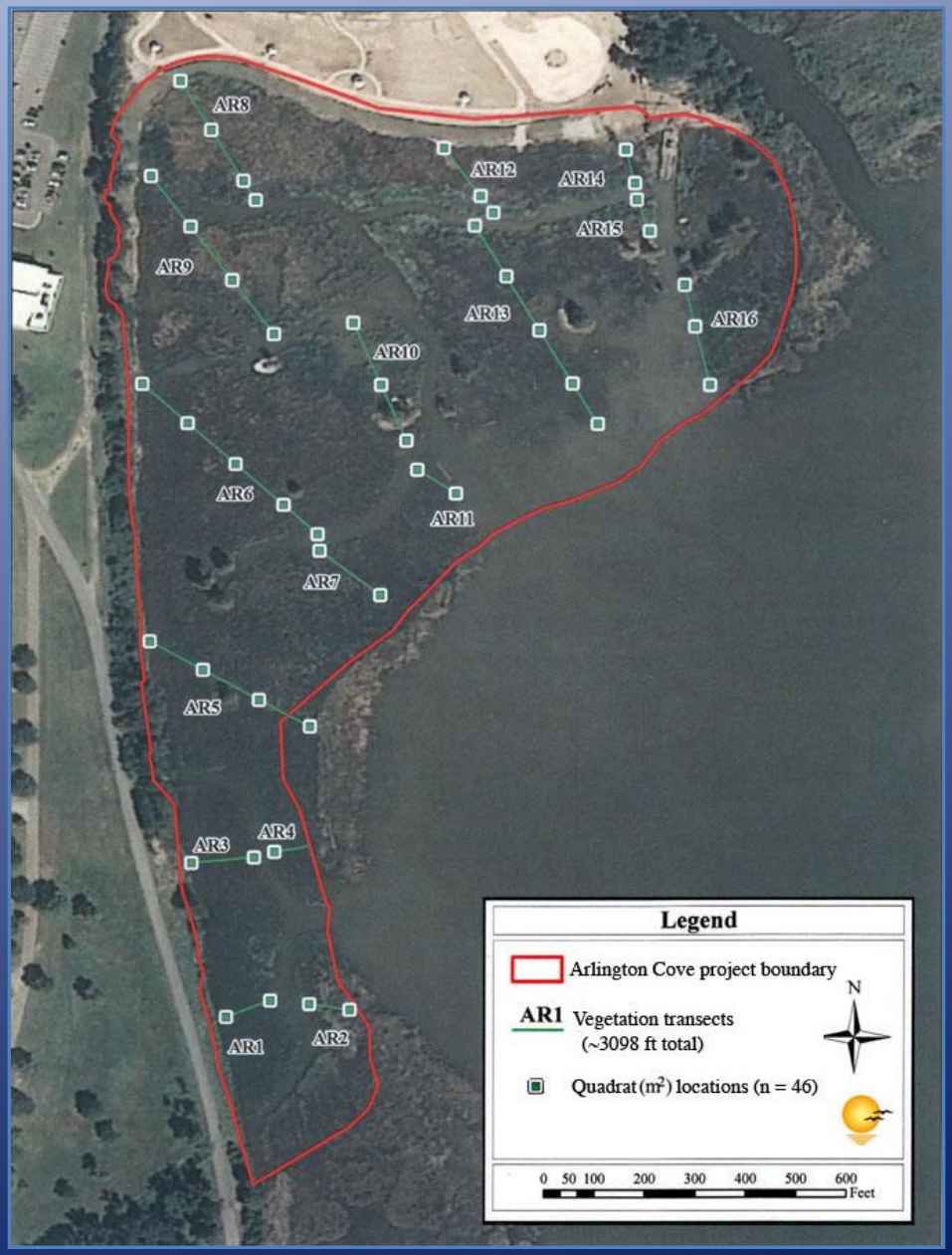
0.50-0 = low quality

Tidal Marsh HGM

Mathematically derived indices assess the capacity of Alabama fringing tidal marshes to perform specific ecosystem functions (Shafer et al 2007).

Landscape variables include patch size and width, amount of aquatic edge, surrounding land use, fetch exposure, and hydrologic regime alteration.

Field assessment variables include site-specific metrics for vegetation and habitat diversity.



Tidal Marsh HGM

Multiple variables are combined using mathematical expressions to estimate major ecosystem functions.

Functional Capacity Equations	
Wave Energy Attenuation	$FCI = [(3V_{WIDTH} + V_{COVER}) / 4 \times V_{EXPOSE}]^{1/2}$
Biogeochemical Cycling	$FCI = [V_{HYDRO} \times V_{COVER} \times V_{LANDUSE}]^{1/3}$
Nekton Utilization Potential	$FCI = (V_{EDGE} + V_{HYDRO} + V_{NHD}) / 3$
Provide Habitat for Tidal Marsh Dependent Wildlife Species	$FCI = \{V_{SIZE} \times \text{Minimum}(V_{HEIGHT} \text{ or } V_{COVER}) \times ((V_{EDGE} + V_{WHD}) / 2)\}^{1/3}$
Maintain Plant Community Composition and Structure	$FCI = (\text{Minimum}(V_{COVER} \text{ or } V_{EXOTIC} \text{ or } V_{WIS} \text{ or } V_{WOODY})$

As condition deviates from the reference standard, a variable sub-index is assigned based on the observed relationship between model variable condition and functional capacity (on a scale of 0.0 to 1.0).

FCI and FCU Calculations for the Tidal Fringe HGM Regional Subclass in the North Central Gulf of Mexico (Version of 04/2007)

Project: ASPA 2013 Mitigation Assessment

WAA# Arlington Cove **Area (ha):** 11.53

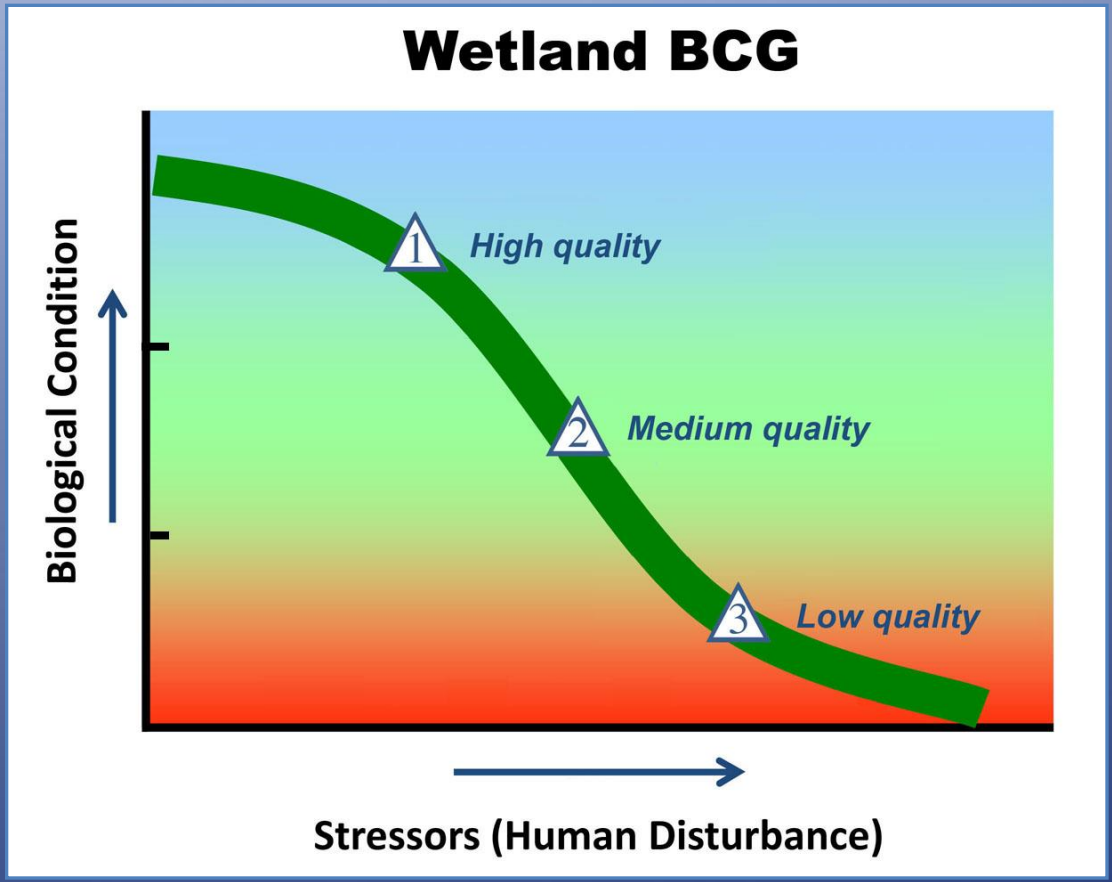
In the green shaded cells below delete any existing numeric values and

Variable	Metric Value	Units	Subindex
V_{COVER}	71	%	1.000
V_{EDGE}	245	m/ha	1.000
V_{EXPOSE}	High	NA	1.000
V_{EXOTIC}	6.2	%	0.800
V_{HEIGHT}	1 m+	cm	1.000
V_{HYDRO}	Open	NA	1.000
$V_{LANDUSE}$	56% developed	%	0.400
V_{NHD}	6	EA	1.000
V_{SIZE}	19	ha	1.000
V_{WIS}	0	%	1.000
V_{WOODY}	0	%	1.000
V_{WHD}	3	EA	0.700
V_{WIDTH}	142	m	1.000

Function	Functional Capacity Index (FCI)	Functional Capacity Units (FCU)
Wave Energy Attenuation	1.00	11.530
Biogeochemical Cycling	0.74	8.496
Nekton Utilization Potential	1.00	11.530
Provide Habitat for Tidal Marsh Dependent Wildlife Species	0.95	10.922
Maintain Plant Community Composition and Structure	0.80	9.224
Overall Average	0.897	51.702

Conceptual Wetland BCG

- Corps/ADEM wetland permitting/mitigation classifies wetlands as high, medium, or low quality.
- Highest quality represents reference standard wetlands and a minimally disturbed condition.



Can describe the entire study area, individual watersheds, HUC 12s, or other areas of interest

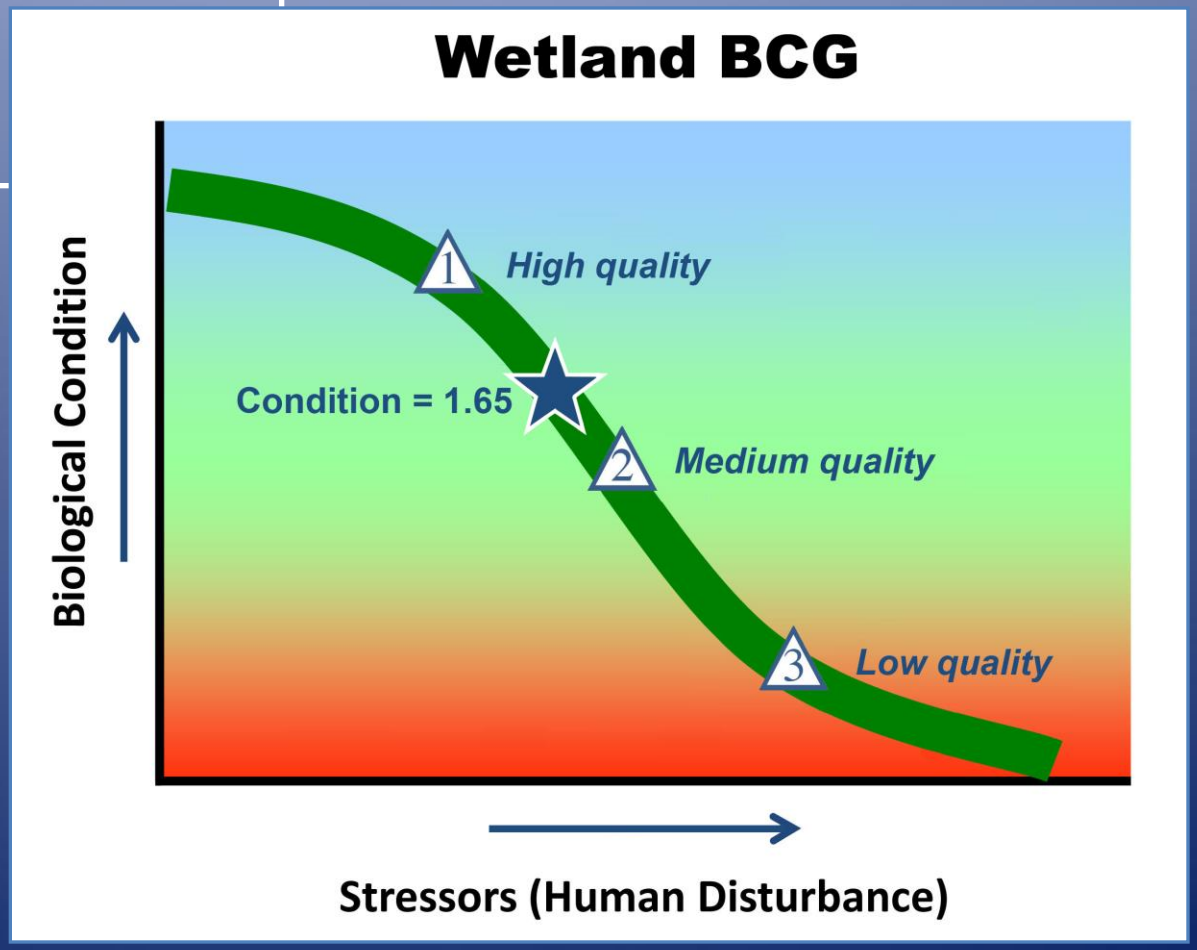
Can describe overall wetland condition or be broken down by wetland type

Example Wetland BCG

Assessment Area Scenario – 100 acres

- 50 ac High quality
- 35 ac Med quality
- 15 ac Low quality

High	1 X 0.50 = 0.50
Med	2 X 0.35 = 0.70
Low	3 X 0.15 = 0.45
	1.65



D'Olive Watershed

Wetland Score Characteristics

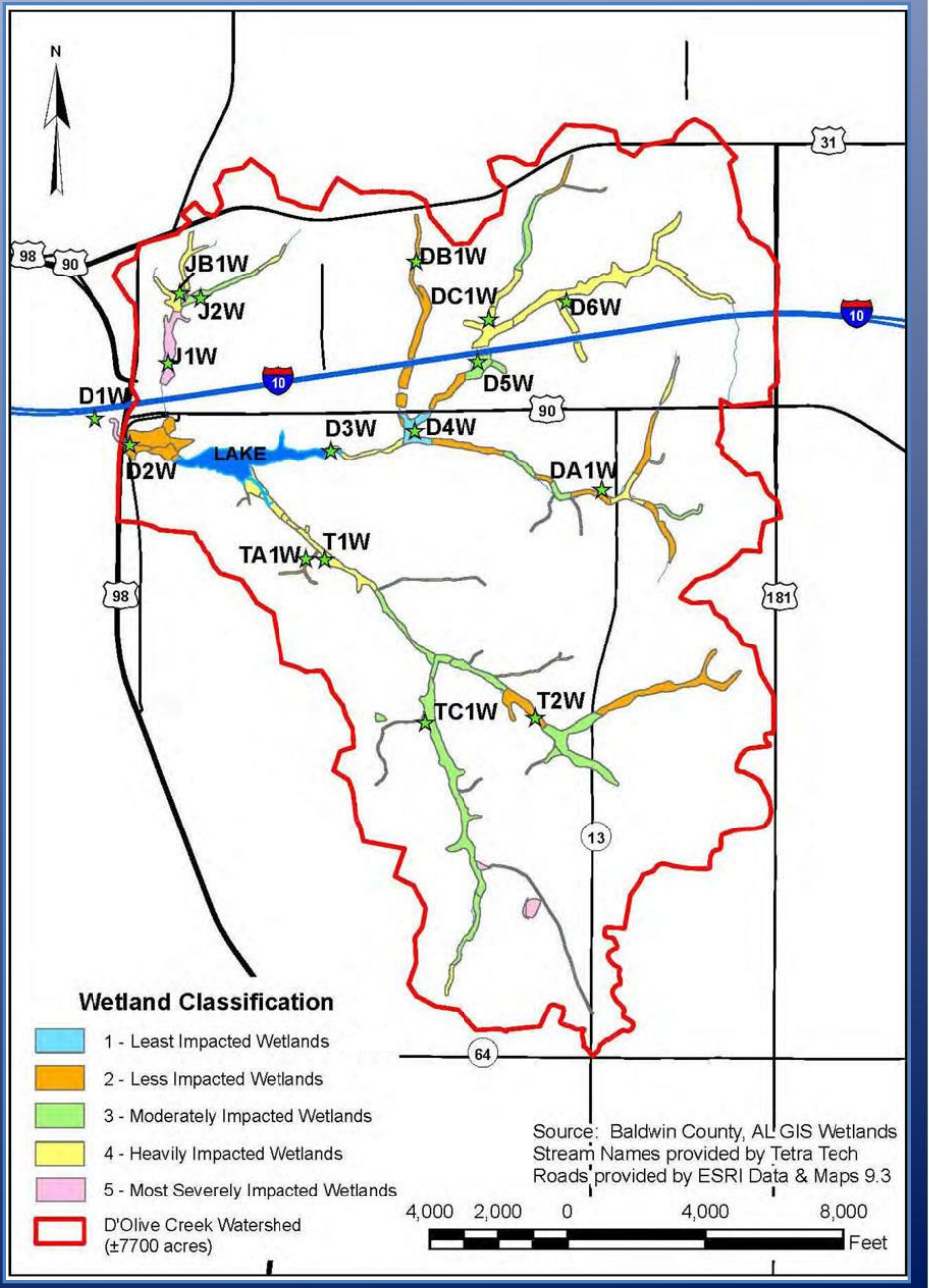
1 High-quality -- relatively undisturbed with healthy, native canopy trees; understory free of exotic species; minimal sedimentation; vegetated upland buffers > 100 ft wide and stable

2 Medium-high quality -- canopy trees >95% native; understory vegetation <5% exotics; minimal sedimentation; vegetated upland buffers 50-100 ft wide

3 Medium quality -- >75% native canopy trees; understory <25% exotic species; some sedimentation but mostly characteristic wetland vegetation; upland buffer altered but stable

4 Low-Medium quality -- canopy trees stressed; dead or dying vegetative strata contain 25-50% exotic species; drainage patterns altered by sedimentation; altered, unstable upland buffers

5 Low quality -- Severely impacted/impaired by sedimentation; native canopy trees dead or dying, and greater than 50% exotics; understory dominated by exotics; upland buffers unstable

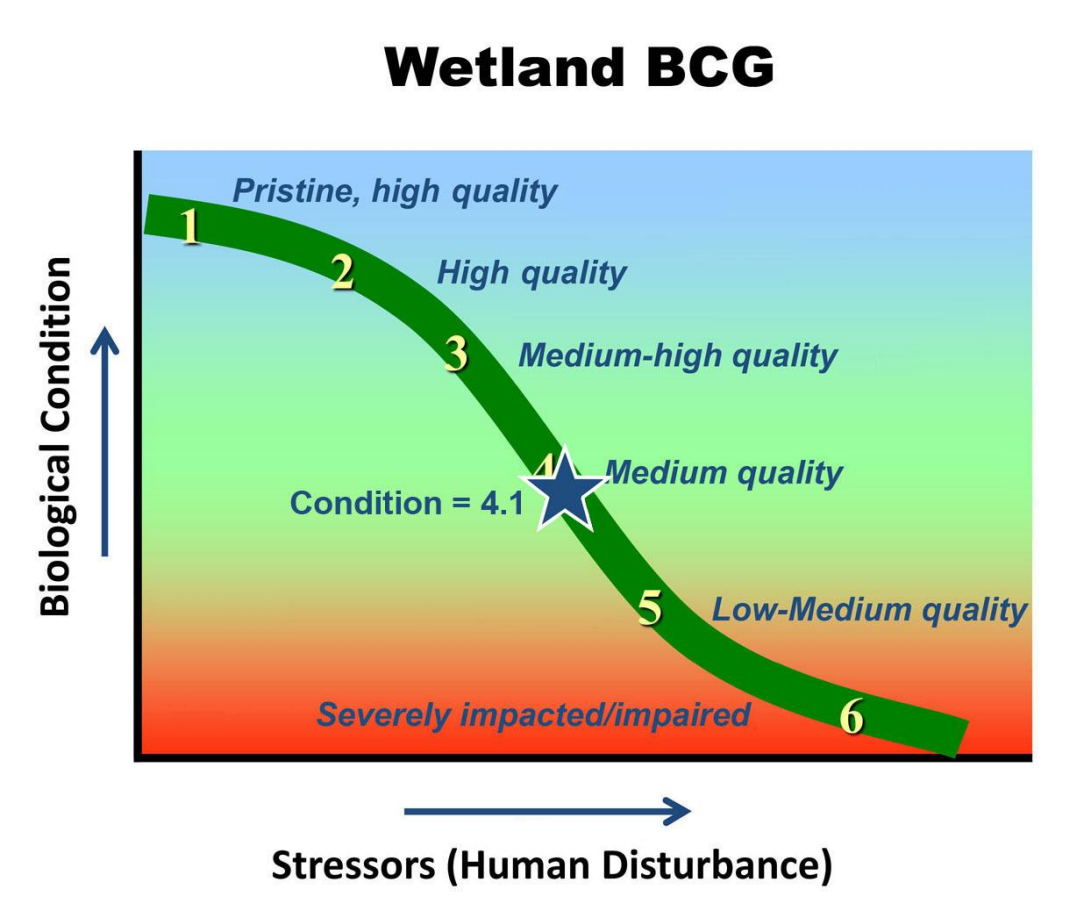


D'Olive Watershed

Assessment Scenario – 439 acres

- 10 ac High quality
- 126 ac Med-high quality
- 142 ac Med quality
- 130 ac Low-med quality
- 31 ac Low quality

High	2 X 0.02 = 0.04
Med-high	3 X 0.29 = 0.87
Med	4 X 0.32 = 1.28
Low-med	5 X 0.30 = 1.50
Low	6 X 0.07 = 0.42
	4.10



Stream Assessments

ADEM § 303(d) Program:

- Primarily uses existing biological, chemical, and physical data sources
- Classifies streams and rivers as Unimpaired or Impaired

Corps of Engineers Stream SOP:

- Categorizes streams according to Rosgen geomorphological parameters
- Classifies streams as Stable, Partially Unstable, or Unstable

Stream Bioassessment

Macroinvertebrates:

- Good indicators of localized conditions
- Abundant in most streams, including 1st and 2nd order streams
- Assemblages comprise a broad range of trophic levels and pollution tolerances

Fishes:

- Good indicators of long-term (several years) effects and broad habitat conditions
- Assemblages generally include a range of species representing a variety of trophic levels

Concurrent evaluation of habitat quality is an integral part of stream bioassessment:

- Adjacent land use
- Stream origin and type
- Stream width, depth, flow, substrate
- Water quality
- Riparian vegetation features

Mississippi stream macroinvertebrate IBI was calibrated according to statistically-based reference points representative of least-disturbed conditions.

Average discrimination efficiency (ability to detect impairment) was 92%.

Best performing metrics (East Bioregion Index):

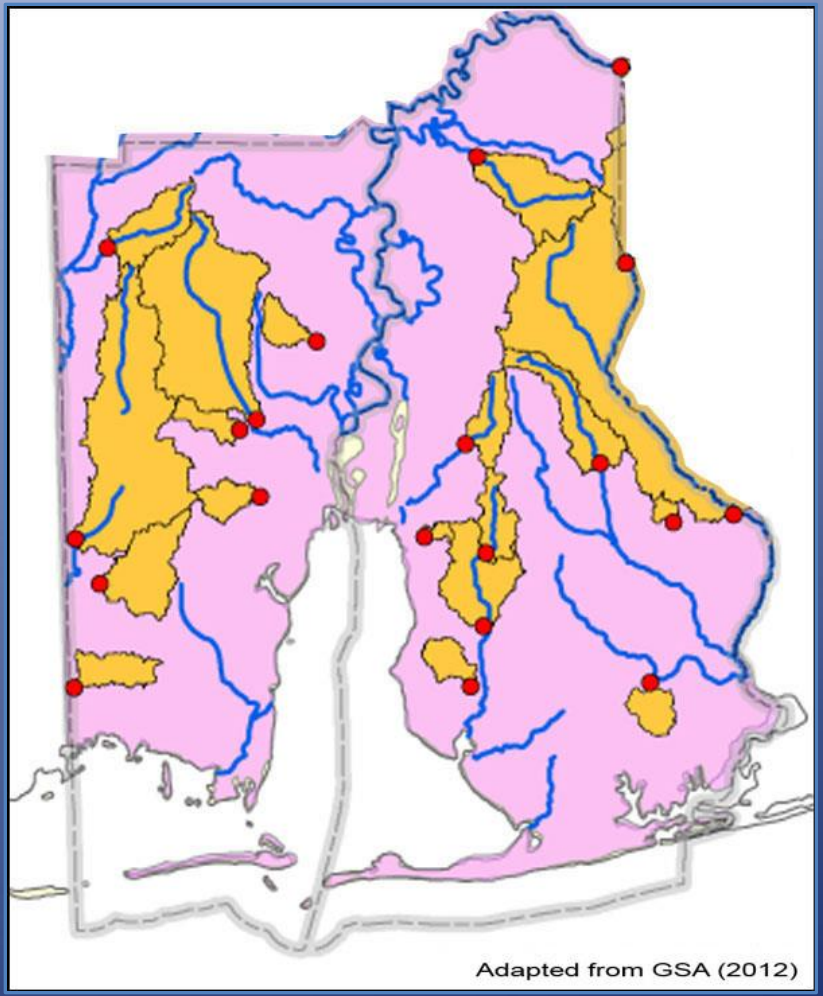
- % Caenidae
- No. Tanytarsini taxa
- % Filterers
- Beck's Biotic Index
- Hilsenhoff Biotic Index
- % EPT (no Caenidae)

Index scores are used for assessing the status of § 303(d)-listed streams, and for use in long-term stream and watershed monitoring.

GSA Southern Plains Fish Study (2012)

Created and calibrated a fish IBI:

- Sites selected to represent a range of watershed sizes and levels of human disturbance
- IBI metrics included measures of richness (e.g., No. native species), composition (e.g., % tolerant species), and trophic guild (e.g., % insectivorous cyprinids)
- Habitat measures were more effective than landscape measures in discriminating sites with good biological condition from sites with poor condition.



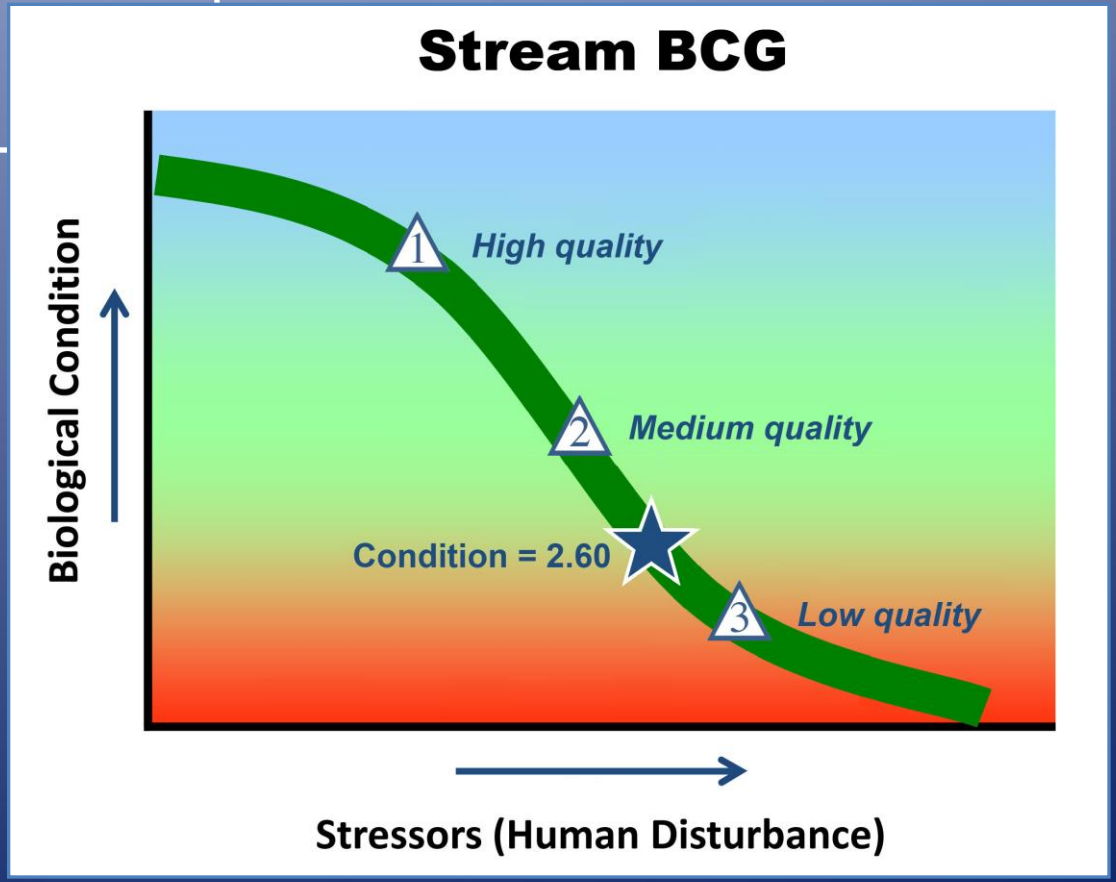
Mobile and Baldwin County streams had IBI scores ranging from good to very poor.

Conceptual Stream BCG

Assessment Scenario – 1000 stream feet

- 100 stream ft High quality
- 200 stream ft Med quality
- 700 stream ft Low quality

High	1 X 0.10 = 0.10
Med	2 X 0.20 = 0.40
Low	3 X 0.70 = 2.10
	2.60



Estuarine Subtidal Habitats

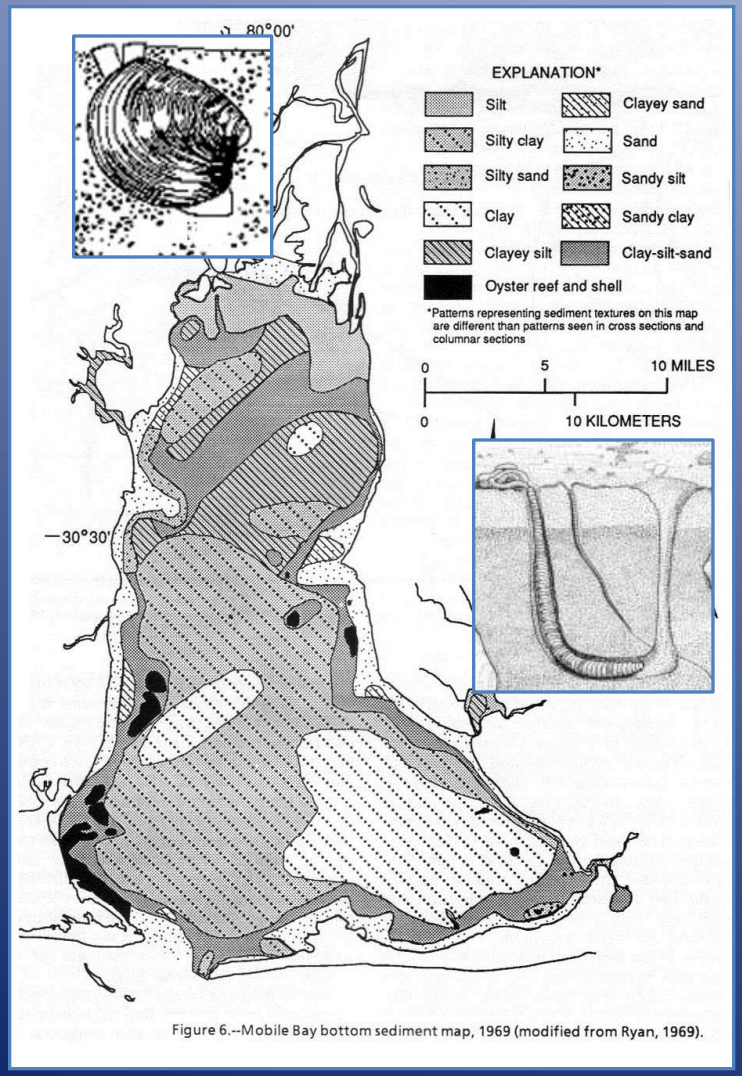
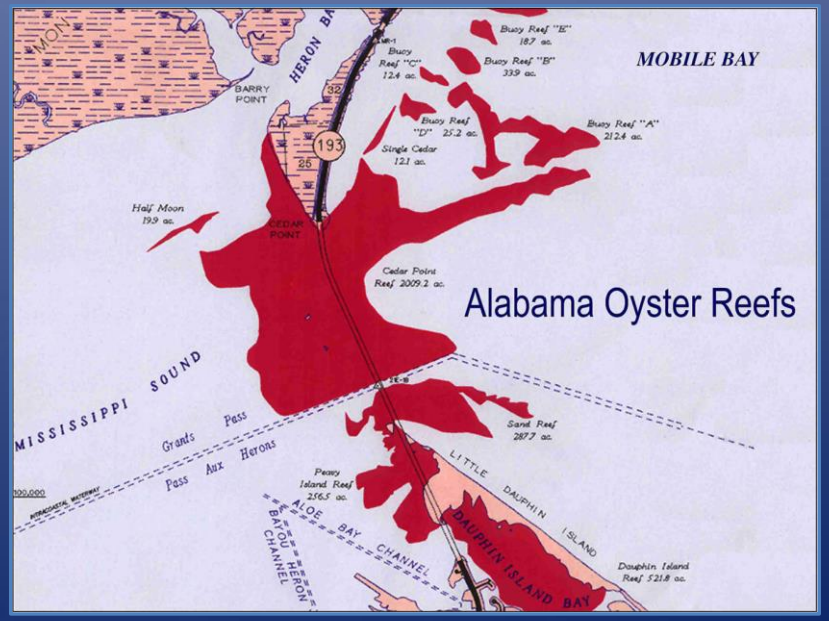


Figure 6.--Mobile Bay bottom sediment map, 1969 (modified from Ryan, 1969).



D'Olive Bay SAV

D'Olive Bay SAV

SAV extent has recently increased – why?

Initial Actions

- Build a database containing the spatial extent and ecological condition of wetlands, streams, rivers and riparian buffers, and the extent of major stressors.
- Use multi-scale assessment of habitat quality, consisting of landscape (Level 1) and ground-level assessments (Levels 2 and 3).
- Use wetland rapid bioassessment procedures (WRAP and HGM) currently in use on the Alabama coast.
- Use the ADEM § 303(d) listing or develop/adopt stream and river bioassessment methodologies.
- Use BCG framework based on the proportional extent of high, medium, and low quality wetlands and water resources.