UWF

Ecology Laboratory

PCB 4043L

"I readily believe that there are more invisible natures in the universe than visible ones. Yet who shall explain to us this numerous company, their grades, their relationships, their distinguishing features and the functions of each of them? What do they do? What places do they inhabit? The human intellect has always sought for knowledge of these matters, but has never attained it. Nevertheless, I do not deny that it is pleasing now and then to contemplate in the mind, as if in a picture, the image of a greater and better world, in order that our intelligence, grown accustomed to the trifles of modern life, may not shrink too drastically and become totally submerged in petty reflections. Nevertheless, we must pay heed to truth and keep a just measure, so that we can distinguish sure things from uncertain, day from night."

Burnet, T. 1692. *Archaelogiae Philosophicae*
From the Preface of: Coleridge, S.T. 1834. *The Rime of the Ancient Mariner*. Dover Edition (1970).

This is not a lab manual *per se*, but a set of outlines that will be used for the material covered in each lab session. The purpose of this laboratory is to explore natural processes and ecological concepts in local habitats. UWF is situated amid a variety of spectacular ecosystems, including the Gulf of Mexico, Barrier Islands, Salt Marshes, Seagrasses, Freshwater Marshes and Swamps, Hardwood Forests and Pine Sandhills. The Lab will take you to some of these places. You will be learning the names of dominant plants and animals and the processes that control their distribution and abundance. The species we will encounter may differ from the provided lists, especially for animal species, and the provided representatives are by no means complete listings. Further information on local habitats and species that will help you in the lab can be found in the Flora Fauna website:

http://www.uwf.edu/~rsnyder/ffnwf/page1.html

The Laboratory is designed to be fun as well as educational

we hope that you will find it an equal measure of both.

Cover Photo:

Migrating Monarch Butterflies (*Danaus plexippus*) rest on a salt-pruned sand live oak branch (*Quercus geminata*) in the secondary dunes of Santa Rosa Island before heading across the Gulf of Mexico (R.A. Snyder, Nov. 1997).

Charts, Maps, & Remote Sensing

1. Navigation: determining a position by triangulation
   Compass bearings of known points of land (2D)
   Celestial bearings from known paths/positions of Sun, Stars, Moon (3D)
   LORAN/ radio direction finders: frequency bearings from land stations (2D)
   GPS radio frequency bearings from satellites (3D)

2. Historical Maps as Information Records:
   Map maker's perspective: what information was critical: landmarks, safe harbors, fresh water
   Accuracy, Proportions/Scale, Reference points

3. Nautical Charts: NOAA: Navigation Purposes Latitude, Longitude

4. Topographic Maps: USGS: Land forms, land use/land cover. elevations, drainage basins

5. Aerial Photography: Soils Maps, Tax Assessors, Vegetation Analysis, Satellite Imagery

6. Geographic Information Systems (GIS)
   http://www.esri.com/base/data/catalog/type.html

7. Fine Scale Mapping: Mapping and Surveying Methods:
   Plane Table and Alidade or Compass and Measuring Tape
   Bearings and Distance, Reference points, Baseline, Triangulation, Elevation

<u>You should be capable of finding the following after this lab</u>:
Latitude and Longitude for a position on a chart
Distance and Scale
Depth or Elevation at a spot or along a transect
Vegetation type or extent
Soil type
Date, Source of a chart, map or photo (base map, updates)
Delineate watersheds and wetlands
Know how to create a map

<u>Internet charts and remote sensing sources:</u>
http://terraserver.microsoft.com/
http://maps.google.com/maps
http//wwwnmd.usgs.gov/esic/toorder.html
http//edcwww.cr.usgs.gov/glis/glis.html
http//edcwww.cr.usgs.gov/glis/hyper/guide/govtphotos
http//edcwww.cr.usgs.gov/glis/nsdi/digital2.htm
http//freenet3.scri.fsu.edu/MetaData/Landcover.html
http:/rst.gsfc.nasa.gov/start.html
http:/atlas.geo.cornell.edu

<u>Other sources:</u>
County Tax Assessor's websites, County Extension Services, engineering/consulting firms

Taxonomy

Introduction: **Taxonomy** is the science that deals with the naming and classification of organisms. Systematics invovles evolutionary relatedness and the development of higher groupings of organisms. Taxonomy is important to ecologists, because the first step in any ecological investigation is to correctly identify the organisms being studied. Systematics is important in tracing the pathways of evolutionary adaptations.

Carl Linnaeus, an eighteenth-century Swedish scientist, developed the system of naming organisms that we still use today: the binomial classification system. The first name of a two part species designation indicates the genus, and the second name the species. The genus is always capitalized; the species is not. When written, binomial names are underlined or italicized. In the hierarchical systematics of classification, species are grouped into genera, genera into families, families into orders, orders into classes, classes into phyla (divisions in plants),and phyla into kingdoms.

Kingdom
- Phylum
  - Class
    - Order
      - Family
        - Genus
          - Species

- Specialists often recognize sub- and super- taxonomic groups inattempts to better separate and categorize organisms. For example:subphylum Vertebrata.

- Today scientists consider a classification system to be an **evolutionary or phylogenetic system**, that is organisms are classified according to their patterns of evolutionary change and relatedness (common ancestry). These patterns are often complex, involving:

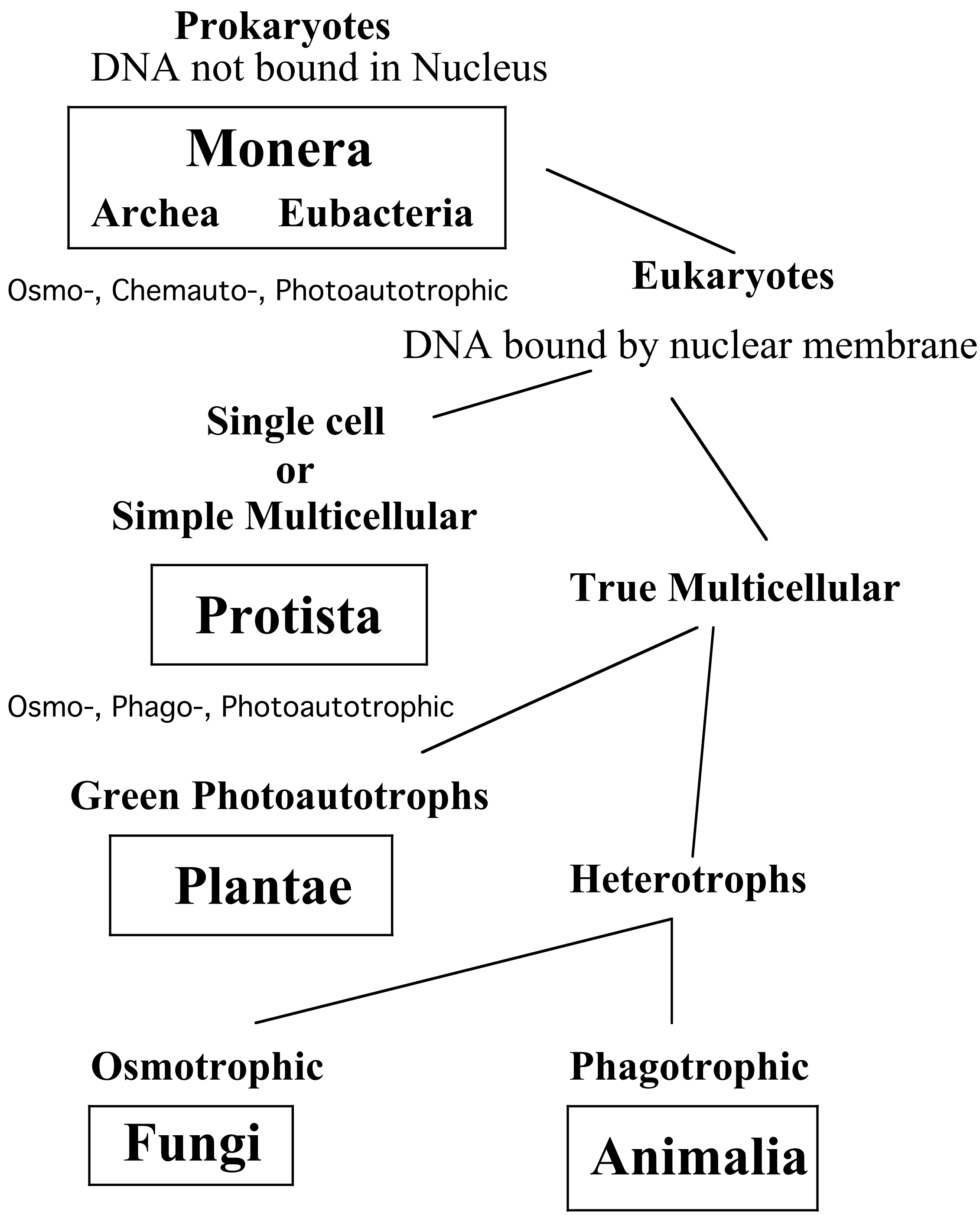
Divergence: one (or more) species becomming more different with time.
Convergence: two (or more) species becoming more similar with time.
Adaptive variation: explosive divergence of different groups over time

Living organisms are currently placed in one of five kingdoms:
Monera, Protista, Animalia, Plantae, or Fungi.

Lab Objectives:

A. Be familiar with the distinguishing characteristics of each kingdom and be able to name example organisms.
B. Identify organisms in lab to the taxonomic level indicated.
C. Using keys, identify unknown organisms to the taxonomic level indicated.

Five Kingdoms of Living Things



Kingdom Plantae

Division / Subdivision	Class	Order	Family
Hepaticophyta - liverworts			
Anthocerophyta - hornworts			
Bryophyta - mosses			
Polypodiophyta - Ferns			
	Polypodiopsida		
		Polypodiales	
			Osmundaceae - Cinnimon Ferns
Equisetophyta - Scoutring rushes, horsetails			
Psilotophyta - Whisk Ferns			
Lycopodiophyta - Spike & Club mosses			
Pinophyta (gymnosperms) = naked seeds within cones			
Cyadaceacea - Cycads			
Pinacae			
	Pinopsida		
		Ginkgoales - Ginko tree	
		Taxales - Yews	
		Pinales	
			Pinaceae - Pines
			Cupressaceae - Cypress
Magnoliophyta (angiosperms) = flowering plants & trees (seed in ovary or fruit)			
Magnoliopsida (Dicots)			
	Magnoliidae		
		Magnoliales - Magnolias	
		Laurales - Laurels	
		Nymphaealea - Waterlilies	
	Rosidae	Rosales	
			Rosaceae - rose, prunus, apple, hawthorn, blackberry,
		Fabales - Legumes, bean, pea	
		Euphorbales - spurge	
		Sapidales	
			Aceraceae - maples
			Anacardiaceae - sumac, poison ivy
	Asteridae - composites		
	Dilleniidae - mallows, violets, cucumber, willow,mustard, blueberry, primrose		
	Caryophyllidae		
	Hamamelidae - witch hazel, mulberry, fig		
		Fagales - beech, oak, chestnut, Birch	
Liliopsida (Monocots)			
	Alismatidae - water plantain		
	Arecidae		
		Arecales - palms	
		Arales - Arum	
	Liliidae		
		Liliales - lilies, onions, iris	
		Orhidales - orchids	
	Commelinidae		
		Commelinales- spiderwort	
		Juncales - rushes	
		Cyperales	
			Cyperaceae - sedges
			Poaceae - grasses

Kingdom Animalia

Phylum	Subphylum	Class	Order
Porifera - Sponges			
Cnidaria - Jellfish, Corals, Hydrozoans			
Ctenophora - Comb Jellies			
Rhyncocoela - Ribbon Worms			
Platyhelminthes - Flatworms			
Nemertina			
Nematoda - Nematodes, Roundworms			
Rotifera - Rotifers			
Bryozoa - Bryozoans			
Brachiopoda			
Chaetognatha - Arrow Worms			
Pogonophora			
Mollusca			
	Gastropoda - Snails, Slugs		
	Pelycypoda - Bivalves		
	Cephalopoda - Octopi, Squids		
	Amphineura		
	Scaphopoda		
	Monoplacophora		
Annelida			
	Polychaeta		
	Oligochaeta		
	Hirudinea		
	Archianelida		
Arthropoda - jointed appendages,exoskeleton of chitin, open circ. system			
	Crustacea - 2 pair antennae		
		Crustacea - crabs, shrimp, copepods, barnacles	
	Uniramia - 1 pair antennae		
		Insecta - 3 pair walking legs on thorax	
			Diptera - two winged, flies gnats, mosquitoes
			Lepidoptera - scale winged, moths, butterflies
			Hymenoptera - membrane wing, ant, wasp, bee
			Coleoptera - shielded wing, beetles
Echinodermata			
	Asteroidea - Starfishes		
	Ophiuroidea - Brittlestars, Basketstars		
	Echinoidea - Sea Urchins		
	Holothuroidea Sea Cucumbers		
	Crinoidea - Sea Lillies		
Chordata			
	Urochordata - Tunicates		
	Vertebrata		
		Agnatha - jawless fishes	
		Chondrichthyes - cartilaginous fishes	
		Osteichthyes -- bony fishes	
		Amphibia - frogs, toads, salamanders	
		Reptilia - lizards, snakes, turtles, alligators	
		Aves - birds	
		Mammalia - platypus (monotreme); opossum (marsupial); monkey, ape, humans (primates, placental mammals)	

Co-Actions Laboratory

<u>Symbiosis</u>: any case of an organism living on or in another
Mutualism: lichens, *Chlorella* in freshwater invertebrates
Commensalism: Spanish Moss, Remora
Parasitism: Mistletoe, Ticks

<u>Competition</u>
Balanus space competition
Trees competing for light (asymmetry of growth: open field tree vs. forest tree)

<u>Herbivory</u>
Types of leaf damage: miners, grazers, disease
Plant Defenses:
- Physical: bark, spines
- Chemical: allelochemicals: tannins, magnoline, etc.

<u>Predation</u>
Raptorial: pursuit: lions, sharks, hawks & owls, jumping spiders: adapted for pursuit, capture, dispatch
Ambush: sit and wait (toadfish, web spiders)

Predation as a selective pressure for evolution of prey traits:
Predator defense:
- **Physical defense**: shell damage, spines, hard parts
- **Spatial refuges**: burrows, thickets, benthic infauna, seagrasses
- **Speed**: rapid flight, quick bursts: deer, jumping insects
- **Motionlessness**: sometimes combined with above to confuse predator
  - most predators are visually (motion) oriented.
- **Repellents**, discharged or secreted: skunks, insects (stink bugs, etc.)
- **Startling**, **Confusing**: bob-white covey burst, schooling fish, flocks of birds
- **Misdirecting attack**: eyespots on fish, insects common, visual or audible display before
  - disappearing (alewives, squirrels)
- **Playing dead**: opossum, hog nosed snake
- **Crypsis**: mimicking objects or backgrounds (must remain immobile)
  - Sand colored Ghost crabs, transparent fish larvae, Counter coloration,
    - Saragassum Fish, Flounder (change to match background),
      - leaf mimic butterfly
  - Disruptive coloration: stripes, blotches
- **Aposematism**: warning coloration
- **Mimicry**: matching color and patterns of warning coloration:
  - Batesian: tasty mimic of distasteful species: Monarch and Viceroy.
    - Tasty mimic must be rare temporally or spatially for imprinting
  - Muellarian: poisonous species all look similar: imprinting effectiveness increased
- **Aggressive mimicry**: predator/parasite mimics that allow proximity for attack:
  - "Bee"-flies that lay eggs on bee larvae, angler fish uses "bait", lightning bugs

Evolution of coloration in peppered moths (*Biston betularia*): Industrial Melanism

Peppered moths are a European species that rests on tree trunks during the day. Until the 19th century, almost every individual of the species captured had light colored wings. From that point on, darker colorations increased in frequency in industrial areas, sometimes making up 100% of the population. Use of coal in the industrial revolution resulted in soot deposition and loss of lichens darkening trees in industrial areas. Non-industrial areas are still dominated by the lighter phase. H.B.D. Kettlewell described this phenomenon in 1973 and experimentally demonstrated the role of bird predation as a selective pressure resulting in evolution of darker coloration in the moths of the industrial areas, a process he called industrial melanism.

This exercise will mimic the selective pressure of predation in establishing these types of distribution patterns. In the lab, paper "moths" will be colored with various intensities of charcoal pencil. **AA** (homozygous dark) will be completely shaded. **AB** (heterozygotes) will be striped. **BB** (homozygous light) will be left unmarked. Part of the lab will distribute these moths in a wooded area outside the building. Designated "predators" will try and recover as many moths as possible. What is your prediction (hypothesis to be tested) of the outcome?

In populations not experiencing selection, gene frequencies tend to remain constant from one generation to the next. Selective pressures will change the gene frequencies by removing (or conversly, by favoring) one particular genetic combination (genotype). The evolutionary **Fitness** of different genotypes is defined as the representation of a genotype in the next generation. Fitness of the different moth types will be calculated from a table indicating the predation losses and transfer of alleles to the next generation. We will make three assumptions for the experiment: 1) all losses are due to predation only, 2) no immigration or emigration occurs, 3) all survivors will double in number for the next generation. A table can be generated to show these results, starting with 100 of each moth type:

	AA	**AB**	**BB**
Generation 1 l_x	100	100	100
Predation losses (m_x)			
G_1 Survivors (G1 l_x - m_x)			
$G_2 = (G_1\ l_x - m_x) * 2$			

Absolute Fitness is calculated by the proportional change from G_1l_x to G_2l_x: $G_2l_x / G_1l_x = AF$

Relative Fitness is calculated by dividing the absolute fitness of each genotype by the absolute fitness of the genotype with the highest absolute fitness, so that the genotype with the highest AF has a relative fitness (RF) of 1.

A **Coefficient of Selection** (s) indicates the "pressure" working against a particular genotype as a result of the observed change. The coefficient of selection is calculated as s = (1-RF).

The Blue Crab (*Calinectes sapidus*): anatomy of a marine epibenthic predator.

Blue crabs are estuarine species that are predators of fish and benthic invertebrates and scavengers of animal flesh. They are both raptorial and ambush predators, often hiding in the sand with antennae and eyes sticking out. They are among the “swimming crabs” having rear legs with oar-like paddles (backfins) for swimming. Two prominent and powerful claws are unequal in form and function. One is a “crusher” with heavy broad “teeth”. The other is a “shredder” with sharp, knife-like teeth. Blue crabs locate their prey by both visual and olfactory cues.

In addition to being versatile and efficient predators, blue crabs are under heavy predation pressure. Defense against attack is manifest as spines and a relatively light shell for mobility. Other crabs, like the stone crab, *Menippe mercenaria*, use a different strategy by having a heavily amored shell with few to no spines. These crabs are relatively sedentary, the weight of a heavy shell is not an energetic drain for mobility. These kinds of tradeoffs in energy allocation to defense relative to lifestyle are also apparent in the mollusks.

Predation Lab Exercise

Feeding rates (amount ingested over time) of predators change with prey density. This phenomenon is known as a **Functional Response**. Time factors in predation responses determine the functional response of different predators on different types of prey. **Search Time** limits prey ingestion at lower prey densities. **Handling Time,** how long it takes to subdue and ingest a prey item, affects prey ingestion rates at all densities, but has a greater effect at high prey densities where search time is negligible.

Each team will be responsible for following the predator. Using a timer or second hand on a watch, determine the search time for the predator in locating a prey, the handling time for at least three chunks of prey, and the total number of prey ingested over time. Back in the lab, the data will be plotted to show the predator’s function response.

Which is more variable, search time or handling time? What would happen to search time at higher prey densities?

Two features of functional response can be derived from this type of predation data:

1) Feeding rate is prey density dependent (changes with prey density) due to search time.

2) Feeding rate is a saturable function at higher prey densities due to handling time.

Salt Marsh

Abiotic conditions:
Salt
Low wave and current energy: little relief, often with mud or sand flats seaward
Periodically Inundated (Spring, Neap Tides), saturated, anoxic sediments and sulfide
Sedimentation: mineral and organic particles, surface microlayer (organic)
High surface area aids sedimentation
Organic Accumulation in anaerobic sediments; Peat Formation: compacted root layers

Biological Functions
High plant productivity but low diversity
Aufwuchs (surface/fouling communities) productivity (surface area) and filtration
Detritus dominated systems: mineralizing deposited organic materials, microbial enrichment of particles
Tidal subsidy: edge (levee) areas greater plant growth and animal interactions (resident & transient)
Nursery area for many estuarine and marine species, export of detritus

Patterns of Distribution and Abundance

Plant distribution

Juncus roemarianus and *Spatina alterniflora* are restricted to "low' marsh areas that are regularly inundated by tides. Both tolerate salt, and have different mechnisms for handling excess salt. *J. roemarianus*, Black Needle Rush, gets its common name from its sharp, hard needle tips where it packs excess salt in dead cells (watch your eyes while walking through it). *S. alterniflora* has special salt glands that excrete salt out onto the surface of the leaves.

Animal distribution

Predation often has profound effects on the distribution of species. Identify trails used by marsh rabbits (*Sylvilagus aquaticus)* and raccoons (*Procyon lotor)* through the marsh vegetation. Fecal remains, or "scat", provide good indicators of the diet of these organisms. *S. aquaticus* is a herbivore, and the round, compact pellets (0.5-1.0 cm) from this organism are dominated by cellulose. Scat from *P. lotor* reflects its omnivorous diet, containing animal (usually unidentifiable) and vegetable remains. Note the seeds of *Seroena repens* that are passed after eating the fruits. This method of seed dispersal is called zoochory. *P. lotor* is also an avid consumer of mollusks, as are Blue and Gulf crabs (*Callinectes* spp.) that forage on the marsh at high tide. Note that the distribution of salt marsh mussels (*Guekensia demissa*) is largely restricted to the root mats between the stems of marsh vegetation (try to get one out with your fingers!), but empty shells and shell fragments are found on the marsh surface. What would you hypothesize to happen to the distribution of *G. demissa* if we put predator exclusion cages out on the marsh? Also note that *Littorina* is mostly restricted to the stems of marsh grasses. This species will climb the stems as the tide comes in to stay out of the water and avoid predators. Shell damage on these snails indicates their predation risk.

Salt Marsh Species

Plants

Black Needle Rush	*Juncus roemarianus*
Salt Marsh Cordgrass	*Spartina alterniflora*
Saltwort	*Salicornia perennis*
Salt Meadow Hay	*Spartina patens*
Saltgrass	*Distichylis spicata*
Cattail (brackish species)*	*Typha domingensis*
Sawgrass*	*Cladium jamaicense*
Saltbush**	*Baccharis halmifolia*
Seaside Elder**	*Iva imbricata*
Wax Myrtle**	*Myrica cerifera*
Yaupon Holly**	*Ilex vomitoria*
Palmetto**	*Serenoa repens*

* Found at upland edge where fresh ground water reduces salt, but sediment is still water saturated.
**Found at transition to or border of upland: low root tolerance for saturated sediment.

Animals

Molluscs	
Periwinkles	*Littorina irrorata*
Olive nerite	*Neritina reclivata*
Salt Marsh Mussel	*Guekensia demissa*
Oyster	*Crassostrea virginica*
Crustaceans	
Fiddler crabs (4 spp)	*Uca* spp
Square Back Crab	*Sesarma reticulatum*
Amphipods	*Gammarus* sp.
Green Striped Hermit Crab	*Clibanarius vittatus*
Blue Crab	*Calinectes sapidus*
Grass Shrimp	*Palaemonetes* sp
Fishes (limited listing)	
Long nosed Killifish	*Fundulus* majalis
Mummichog	*Fundulus heteroclitis*
Sheepshead minnow	*Cyprinodon variegatus*
Sailfin Molly	*Poecilia latipinna*
Mosquito fish	*Gambusia affinis*
Tidewater Silversides	*Menidia berylina*
Mullet	*Mugil cephalus*
Birds (limited listing)	
Rails	*Rallus* spp
Seaside Sparrow	*Ammospiza maritimus*
Redwing Blackbird	*Agelaius phoeniceus*
Great Blue Heron	*Ardea herodias*
Green Heron	*Butorides virescens*
Belted Kingfisher	*Ceryle alcyon*
Mammals	
Raccoon	*Procyon lotor*
Salt Marsh Rabbit	*Sylvilagus aquaticus*

Statistics and Data Analysis.

Introduction

Descriptive science in Ecology involves fitting mathematical models to patterns of distribution, abundance, and activity in nature. For experimental science, it is preferred that an experimental design, based on a defined statistical model, be established **BEFORE** running the experiment and collecting the data. Both methods have a similar goal: to define what is random versus what is real. Most statistics courses focus on the statistics used in experimental science; this exercise will consider the former. Often in descriptive science, one wishes to define or test the validity of a perceived relationship, where the precise type of relationship (mathematical model) is unknown.

Some Basics

All measurements are made with some degree of error. Whether it is the thickness of the graduations on a ruler, the ability to read a compass bearing, or the sensitivity of a piece of analytical equipment, measurements are only estimates of reality. In the surveying lab, the principles involved with defining a point in space were examined. Usually a minimum of three points are required to define a location or area of probability for a known point (triangulation), and the more points one has, the more confident one is of having **accurately** defined an area of probability for that location. The size of the area of probability so defined reflects the **precision** of our measurements.

Descriptive statistics has a similar goal, only now we are dealing with a more abstract "location" (size, abundance, concentration of a chemical, etc.). Here again, the more points one has, the more confident one is that what is being measured reflects reality. If one were to continually determine bearings of a tree from different reference points, the position estimates would begin to define a pattern within the area of probability. More points would fall closer to the actual position of the tree (hopefully), and progressively fewer would fall farther away from the actual spot. This distribution pattern of the frequency of the estimates can tell us more about our estimated location than merely that it is likely to be within a triangle of probability.

Data Distributions

One of the most common distribution patterns found from repeated measurements of a single "location" is the "normal" distribution or "bell curve". The actual "location" estimated by a normal distribution is represented by a peak at the top of the curve. Estimates closer to the true spot will occur at a higher frequency than those farther away, making the "bell" shape. The variability in the estimates (variance) determines the width of the distribution. With only a few data points, the shape of the distribution is difficult to see, and by chance, those few data points may suggest that the most frequent estimate is different than the true value determined from many data points where the shape of the bell is clearly defined.

In order to describe a distribution pattern, we use parameters that define the shape and extent of the distribution. For the normal distribution, these parameters are the **mean**, and some measure of **variance** (standard deviation, standard error). The mean provides an estimate of the location of the peak, and the variance provides an estimate of the width of the distribution. One standard deviation (std) on either side of the mean represents 66% of all estimates. Two std's represent 99% of all estimates made of our location.

Once a distribution pattern has been defined for a particular measurement, we can move from building a descriptive model to using it as a predictive model. For example, 66% of the time, measurements of the location of a tree will fall within one standard deviation of the mean of all previous estimates, provided we have made enough previous estimates to define the distribution. Thus, the validity of the model depends on how well the distribution pattern has been defined.

Types of Analysis

Visualization is a good first step with any dataset. This can be accomplished by plotting frequency histograms of the data to look for distribution patterns, or by plotting variables against each other as correlations or regressions to look for patterns of interactions. Visual patterns can be used to assess the need for and efficacy of various types of transformations to get the dataset to fit known distribution patterns so that parametric statistics can be used.

Parametric statistics (t-tests, ANOVA, Regression, etc.) uses the parameters of distributions (models) to make comparisons between measurements. The example of the bell shaped curve is for discontinuous data: where there is a single definable mean value for the data. This distribution is the basis of the **t-test** and **analysis of variance** (ANOVA), where we are trying to determine whether one bell shaped curve (or data distribution) is significantly different from another.

Regression and **correlation** analyses are also examples of parametric statistics. For continuously variable data, we define a slope of a line, the y intercept, and the variability around the line and intercept as the parameters of the linear model. In regression, we define the dependence of one variable on another. Correlation analysis is very similar, only in this case we don't know that one variable is dependent on the other, only that the two variables are related somehow and thus their data will define a linear model. Here are some examples of this distinction. If we apply increasing amounts of fertilizer to plants, we can measure the response as a linear model: more fertilizer, more plant growth. Plant growth is dependent on fertilizer (the independent variable). We can also define a linear model for hours of watching television and incidence of cancer. This does not mean that TV causes cancer (that would mean cancer is dependent on TV), only that the two are correlated, probably both the result of a sedentary lifestyle.

Sometimes our datasets do not fit to defined mathematical models. In this case we can use **Non-Parametric statistics**. Non-parametric in that they do not use the parameters of defined data distributions as a basis for analysis. Instead, the data are ranked (sorted) and the shape of the distributions are used in a comparison of differences at each rank. These differences will follow a normal distribution, allowing the use of parametric statistics on a derivative of the data where the data do not fit directly to a known distribution.

For the descriptive field data we collect this semester, the appropriate statistical analysis will be chosen based on our hypothesis statement and a trial and error process of finding mathematical models (distribution types) that best fit to the data.

How to Write a Technical Scientific Report

This report is as much, if not more, a writing exercise as it is a scientific one. The report will be graded accordingly: conformity to style and clarity are as important as the science you are reporting.

Sections of a Scientific Paper

Title
Abstract
Introduction
Materials and Methods
Results
Discussion
References Cited

Title: searchable key words, descriptive

Abstract: A summary of the paper.
Write this section last. Should include:
Principal Objective and Scope
Basic Methodology
Summarize Key Results
Principle Conclusions

Introduction: Define the problem.
Nature and Scope of the problem investigated
Review pertinent background literature that helps define the question
State the question being investigated: hypothesis testing

Materials and Methods: How was it studied/tested.
What were the exact procedures, equipment, controls, special reagents, etc. Used.
Experimental design, data collection, data analysis
Should be written so that someone can repeat your experiment

Results: What did you find.
Present and evaluate the quality of the data:
is it of sufficient quality to answer the question?

Discussion: What do the findings mean.
How does your answer to the question support or contradict what others working in the same area of research have found
Concluding paragraph

Sentence structure:
All sentences must have a subject and verb. Subordinate clauses, infinitives, gerunds, adverbs, adjectives, etc. must be used appropriately. Avoid flowery descriptions: "Just the facts, Ma'am".

Paragraph structure:
All paragraphs should have a topic sentence, one or more sentences explaining or expanding on the topic sentence, and a concluding sentence that may act as a transition phrase for the next paragraph.

Plankton and Water Quality Lab

Local conditions: http://www.dep.state.fl.us/northwest/Ecosys/waterquality/outlook.htm
Florida Water Quality Standards: http://www.dep.state.fl.us/northwest/62-302t.pdf
Florida Standard Operating Procedures: http://www.floridadep.org/labs/qa/sops.htm

Physical/Chemical Analyses
Temperature: thermometer, thermocouple
Salinity: refractometer, conductivity
pH: percent hydrogen
Dissolved Oxygen: Winkler assay, ionic methods
    BOD: biological oxygen demand - respiration potential
    COD: chemical oxygen demand - total oxidation potential
TOC: total organic carbon
Nutrient Analyses:
NH_4^+, NO_2 + NO_3, Kjeldahl Nitrogen (TKN), Orthophosphate, Total Phosphorous, Silica
    colorimetric wet chemistry,
    ion separation and detection methods
    AGP: algal growth potential - bioavailability of nutrients
Turbidity: Sechi depth, light absorbance, IR light backscatter
Particle Analysis: Chlorophyll by fluorescence, Organic content (ashed), Elemental analysis, microscopic analsyis

Biological Analyses: concentration and activity of biological populations
Viruses: fluorescent staining with DAPI, TEM
Bacteria: Culture on plates (CFU) or liquid medium, media can be selective or general, MPNs, Fluorescent Direct Count, Bacterial activity by radioisotope incorporation, BOD
Fecal indicators: Fecal Coliform and *Enterococcus* by filter method (EPA 1600)
Phytoplankton: Autofluorescence direct counts, counting chambers,
    $^{14}CO_2$ fixation, Production-Irradiance curves, Light-Dark bottles, O_2 evolution
Zooplankton: Fluorescent count, counting chambers, grazing rate tracers, O_2 consumption, lipid analysis, egg production

References for Methods

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Gerhardt, P., Murray, R.G.E., Wood, W.A., & Krieg, N.R. 1994. Methods for General and Molecular Bacteriology. American Society for Microbiology Press, Washington, D.C.

American Public Health Association, American Water Works Association, and the Water Pollution Control Federation. 1985. Standard Methods for the Examination of Water and Wastewater, 16th edition.:1268. Washington, D.C.: American Public Health Association.

Freshwater Marsh and Woodland Swamp

In the saltmarsh, there is a clear demarcation between the wetland and upland due to the effects of salt on plants. In freshwater wetlands, the transition or ecotone between wetland and upland is not as clear. Regulatory agencies use both physical properties (soil chemistry/appearance) and biological properties (plant species distributions) to "delineate" (determine the boundaries of) wetlands. This lab's approach to exploring Thompson Bayou will classify plants found there based on their value in delineating a wetland.

<u>Abiotic conditions</u>: Freshwater, saturated, anoxic sediment, flooding by tides and storm water runoff. Filtration and accumulation of organic material. Three main factors determine the type of freshwater wetlands: hydroperiod (frequency of inundation), fire, and nutrients.

<u>Biological adaptions</u>: butressed tree trunks, "knees", lenticels and hollow stems for breathing air

Wetlands delineation **By Soils**

<u>Hydric.</u>

Water saturated, anaerobic, reduced chemicals (sulfide), black color (FeS)

Mineral (<20-35% organic) gleys (greenish coloration) and mottles (red)

Organic (Histosols) peat and muck

Wetlands delineation **By Plants:**

Facultative. No clear distinction for growth in saturated soils

Facultative Wet. Under natural conditions have maximum cover in saturated soils

Obligate. Only found or achieve greatest abundance in saturated/inundated conditions.

Obligate Wet

<u>Hydrophytes (submerged or emergent)</u>

Coontail	*Ceratophyllum*
Yellow Water Lilly	*Nuphar luteum*
Pickerel Weed	*Pontederia cordata*
Bull Tongue	*Sagittaria lancifolia*
Arrow Arum	*Peltandra virginica*
Sawgrass	*Cladium jamaicensis*
Cattail	*Typha latifolia*
Sawgrass	*Cladium jamaicense*
Big cordgrass	*Spartina cynosuroides*
Phragmites	*Phragmites australis*

Faculatative Wet

Red Titi	*Cyrilla racemiflora*
Black Titi	*Cliftonia monophylla*
Azalea	*Azalea* spp.
Tulip Poplar	*Liriodendrom tulipifera*
Red Maple	*Acer rubrum*
Florida Anise	*Illicium floridanum*
Chain Fern	*Woodwardia virginica*
Cinnamon Fern	*Osmunda cinnamomea*

Obligate Wet

Bald Cypress	*Taxodium distichum*
White Cedar	*Chamaecyparis thyoides*
Water Tupelo	*Nyssa biflora*
Royal Fern	*Osmunda regalis*
Never-Wet	*Orontium aquaticum*
Sphagnum Moss	*Sphagnum* spp.
Bladderwort	*Utricularia* spp.
Pitcher plant	*Sarracenia purpurea*
Water Sundew	*Drosera intermeadia*
Butterwort	*Pinguicula lutea*
Centella	*Centella asiatica*
Sweet Bay Magnolia	*Magnolia virginiana*

Faculatative/Other:

Wax Myrtle	Myrica cerifera
Slash Pine	*Pinus elliotii*
Red Bay	*Persea borbonia*
Blueberry	*Vaccinium* spp.
Yaupon holly	*Ilex vomitoria*

Animal Species lists in the
Edward Ball Nature Walk Guide

Upland Hardwood Forest

Mixed mesophytic forest (mesophyte: between hydrophyte and xerophyte)
- Deciduous (Tulip Poplar, Beech, Hickory, Sparkleberry, Hawthorn)
- Evergreen (Spruce Pine, Live Oak, Laurel Oak, Magnolia)

Stratification:
- Canopy: mature trees, maximum light exposure (Oaks)
- Understory: shade tolerant, filtered light (Dogwood, Magnolia, Sparkleberry)
- Ground cover: herbaceous plants (Partridge Berry), lichen (Reindeer Moss), Ferns
- Vines/Epiphytes: mechanically dependent on host to reach canopy (Jasmine, Briar, Grape)

Nutrient availability dependent on mineralization of detritus:

Less than 5% of annual production consumed by herbivores

Forest Floor (thick organic layer over mineral soil):
- Litter to humus gradient:
  - Whole leaves on top
    - Leaf fall at cold weather/short photoperiod (deciduous trees)
    - or new spring growth (Laurel Oak)
  - Broken fragments of leaves
  - Mat of organic material/intermeshed roots/fungi (mycorrhizae and saprophytes)
    - (Exp. from text with ^{32}P: 18 different spp, 72% of trees within 2.5 m, 43% within 8 m)
  - Mineral soil (A Horizon)

Dead trees: massive detritus: may take years to break down, carbon storage
- Saprophytes: bacteria, fungi, protozoa: cellulose digestion
  - Insects require gut symbiants to digest cellulose (termites)

Species area curves:

One way to estimate diversity is to determine the shape of species vs. area or species vs. sampling effort curves. Each member of the class will draw a number from a hat indicating the time he/she will look for as many different plant species as she/he can. The lab instructor will call off the time on a stop watch; you are to continue until your time is called. You do not need to identify each species, only keep track of how many different species you can find. These data will be plotted back in the lab. Would you expect animal species curves to be different? How?

Dominant Plant Species:

Large Trees

Live Oak	*Quercus virginiana*
Laurel Oak	*Q. hemispherica*
White Oak	*Q. alba*
Southern Red Oak	*Q. falcata*
Turkey Oak	*Q. laevis*
Water Oak	*Q. nigra*
Spruce Pine	*Pinus glabra*
Magnolia	*Magnolia grandiflora*
Beech	*Fagus grandifolia*
Tulip Poplar	*Liriodendron tulipifera*
Pignut Hickory	*Carya glabra*
Mockernut Hickory	*C. tomentosa*

Understory

Sparkleberry	*Vaccinnium arboreum*
Wild Blueberry	*Vaccinnium elliotii*
Shadbush	*Amelanchier arborea*
Dogwood	*Cornus florida*
Yaupon	*Ilex vomitoria*
Redbay	*Persea borbonia*
Pensacola Hawthorn	*Crataegus lacrimata*.
Witch Hazel	*Hammelis virginiana*

Vines

Green Briar	*Smilax* spp.
Muscadine Grape	*Vitis rotundifolia*
Carolina Jasmine	*Gelsemium sempervirens*
Blackberry	*Rubus* spp.
Trumpet creeper	*Campsis radicans*
Crossvine	*Bignonia capreolata*
Poison Ivy	*Toxidendron radicans*

Forest floor

Saw Palmetto	*Seronoa repens*
Partridge Berry/ Twinberry	*Mitchella repens*
False Reindeer Lichen	*Cladonia* sp.
Mosses	
Bracken Fern	*Pteridium aquilinum*

Animal Species

Bird Distribution

Upper story

Warblers	Parulidae spp.
Vireos	

Trunks

Woodpeckers	spp.
Nuthatch	Sittidae spp.

Forest floor

Brown Thrasher	*Toxostoma rufum*
Carolina Wren	*Thryothorus ludovicianus*
Robin	*Turdus migratorius*

Anywhere

Mocking bird	*Mimus polyglottos*
Blue Jay	*Cyanocita cristata*

Reptiles

Pigmy Rattlesnake (Dusky and Carolina subspecies)	*Sistrurus miliarius*
Diamondback rattlesnake	*Crotalus adamanteus*
Canebrake Rattlesnake	*Crotalus horridus*
Broad headed Skink	*Eumeces laticeps*
Oak Toad	*Bufo quercicus*
Southern Toad	*Bufo terrestris*

Mammals

Gray Squirrel	*Scirius carolinensis*
Opossum	*Didelphis virginiana*
Raccoon	*Procyon lotor*
Striped Skunk	*Mephitis mephitis*
Whitetailed deer	*Odocoileus virginianus*
Grey Fox	*Urocyon cinereogenteus*
Coyote	*Canis latrans*

Pine Clay/Sand Hill

Longleaf Pine/Wiregrass Community
Once covered over 70 million acres in the south, now only about 3 million left.
    3,000 in old growth
Xerophytic, little organic humus accumulation, bare mineral soil exposed
Open/diffuse canopy allows sunlight to forest floor:
    more than 200 species of herbaceous plants and grasses on forest floor.
    Using a light meter, compare the light penetration in a Hardwood forest and in the pine forest
Periodic fire required: Spring/summer lightning, prescribed burning
    Older trees with heart rot/resin catch fire.

Longleaf pine
Lives 350-400 years.
Seeds require bare mineral soil for germination, no seed bank
"Grass" stage: can persist for 3-15 years, dense needles protect apical bud from fire
Develops deep taproot for water and food storage,
Shoots up rapidly without branches to above ground fire height,
Sub canopy trees may remain in a suppressed state for long periods

Wiregrass
Long-lived: bunches can be older than pines
Can indicate where former longleaf pine stands existed
For seed production: 2-4 week window for spring fire,
    otherwise about 1% seed viability, seed dispersal poor.

Scrub Oaks
More productive after fire: acorn production for wildlife.
Fire may kill above ground parts, new shoots from roots
Single individuals (root systems with many shoots/trees) may cover an acre

Gopher tortoise *Gopherus polyphemus*
Federal Listing: Threatened
Keystone species
Nearly 40 species are known commensals, some obligate, using tortoise burrows

Red-Cockaded Woodpecker (RCW), *Picoides borealis*
Federal Listing: Endangered; October 13, 1970
Status: Declining
Requires old living pine trees for nest cavities.
RCW calls:
http://rcwrecovery.fws.gov/rcw.htm

Longleaf Pine Forest Species

<u>Plants</u>

Long Leaf Pine	*Pinus palustris*
Turkey Oak	*Quercus laevis*
Runner Oaks	*Quercus pumila, Q. minima*
Blackjack oak	*Q. marilandica*
Bluejack oak	*Q. incana*
Gopher apple	*Licania michauxii*
Wiregrass	*Aristida stricta*
Yaupon	*Ilex vomitoria*
Saw palmetto	*Serona repens*
Gallberry	*Ilex glabra*
Broomsedge	*Andropogon* spp.
Bracken fern	*Pteridium aquilinum*
Ground huckleberries	*Gaylussacia* spp.
Blueberry	*Vaccinium* spp.
Blackberry	*Rubus cuneifolius*

<u>Birds</u>

Red cockaded woodpecker	*Picoides borealis*
Red tailed hawk	*Buteo jamaicensis*
Great horned owl	*Bubo virginianus*
Bobwhite	*Colinus virgnianus*
Bachman's sparrow	*Aimophila aestivalis*

<u>Amhibians/Reptiles</u>

Gopher frog	*Rana areolata*
Eastern tiger salamander	*Ambyostoma tigrinum*
Eastern spade foot toad	*Scaphiopus holbrookii*
Gopher tortoise	*Gopherus polyphemus*
Pygmy rattlesnake	*Sistrurus militarius*
Diamondback rattlesnake	*Crotalus adamanteus*
Florida pine snake	*Pituophis melanoleucus mugitus*
Indigo snake	*Drymarchon corais*
Redtailed skink	*Eumeces egregius*
Six-lined racerunner	*Cnemidophorus sexlineatus*
Southern fence lizard	*Sceloporus undulatus*

<u>Mammals</u>

Fox squirrel	*Sciurus niger*
Pocket gopher	*Geomys pinetus*
Old field mouse	*Peromyscus polionotus*
Cotton mouse	*P. gossypinus*
Short-tailed shrew	*Blarina brevicauda*
Mole	*Scalopus aquaticus*
Least shrew	*Cryptodus parva*
Cotton rat	*Sigmodon hispidus*
Cottontail rabbit	*Sylvilagus floridanus*
Florida black bear	*Ursus americanus floridanus*

Seagrasses

1) among the most productive aquatic ecosystems
2) contribute to autotrophic (epiphytes) and detrital (seagrass leaves) food webs
3) provide complex physical habitat: refuge and forage area for juvenile and adults
4) traps for suspended organic and inorganic particulate material:
high surface area base for filter feeding organisms, physical trapping.
5) shoreline protection: dissipation of wave energy

Mixed beds in Santa Rosa Sound comprised of

Halodule wrightii (Cuban Shoal Grass) thin blades from rhizome nodes
tolerates winter air exposure at extreme low tides and is found in shallower water than turtle grass, occurs down to 6-8 ft. Depth, limited by PAR penetration.

Thalassia testudinum (Turtle Grass) flat blades about 1/4 inch wide
at approximate northern limit in Santa Rosa Sound (deciduous here)
will not tolerate winter air exposure,
found to a depth of about 6-8 ft, limited by PAR penetration

Ruppia maritima (Widgeon Grass): Branched stems, tolerates salinity and temperature
prolific but does not form dense rhizome mats

Decline of seagrasses a world wide problem:

I. Increased Turbidity biggest problem.

Turbidity from construction, storm water, and nutrients from upland activity

Nutrient effects: 1) increased turbidity (light attenuation)
2) increased growth of microalgae on grass blades
3) increased growth of macroalgae (*Gracilaria & Chondria*) in grass beds

Nutrients from "point" sources":
Sewage treatment effluent: Pensacola Beach and Navarre sewage treatment plants
Boats pumping out raw sewage
and "non-point" sources (carried by Storm Water runoff):
Septic tanks in low areas that overflow
Homeowners and Commercial fertilization/herbicide application

Most toxin effects swamped by nutrient effects, but as with most stressors, effects are cumulative and often synergistic (sum of separate effects less than combined effect)

II. Physical Damage.

Dredge and Fill
Prop scars from boat traffic in shallow areas: 3-5 years to heal, cumulative damage.
Anchoring/Mooring
Shading from piers
Bio-perturbation: skates dig pits looking for food, crabs dig up roots in burrowing.

Seagrass Organisms

Epiphytes: Diatoms, filamentous algae
Epifauna: Protozoa, Rotifers, Copepods, Hydroids, Molluscs.

Crustaceans

Amphipods	*Gammarus* sp.
Green Striped Hermit Crab	*Clibanarius vittatus*
Blue Crab	*Calinectes sapidus*
Spider Crab	*Lubinia emarginata*
Mud Crab	*spp*
Grass Shrimp	*Palaemonetes sp*.
Broken Back Shrimp	*Hippolyte* sp.
Pink Shrimp	*Penaeus duorarum*
Brown Shrimp	*Penaeus aztecus*
Snapping Shrimp	*Alepheus heterochaelis*

Coelenterates
Hydroids

Molluscs

Crown Conch	*Melongena corona*
Oyster	*Crassostrea virginica*
Bay Scallop	*Argopecten irradians*
Lightning Whelk	*Busycon contrarium*
Mud Snail	*Ilyanassa obseleta*
Oyster Drill	*Urosalpinx cinerea*

Fishes

Goby	spp.
Pinfish (up to 90% of biomass)	*Lagodon rhomboids*
Pipefish	*Syngnathus spp*
Toadfish	*Opsanus beta*
Bay Anchovy	*Anchoa mitchelli*
Tidewater Silverside	*Menidia berylina*.
Spotted Seatrout	*Cynoscion nebulosus*
Red Fish (drum)	*Sciaenops ocellatus*
Croaker	*Micropogonias undulatus*
Needlefish	*Strongylura marina*
Ladyfish	*Elops sarus*
Striped Burrfish	*Chilomycterus schoepfi*

Barrier Islands

<u>Abiotic conditions</u>

nutrient poor sand: well sorted milky quartz originally from piedmont, worked by wind and waves
$CaCO_3$ in peninsular Florida away from continental drainages
xeric (low rainwater retention, hot sun)
salt (spray from surf, brackish groundwater, storm overwashes)
disturbance (surf zone, storm overwashes, blowing sand, winter/summer beach)
wrack line as a source of food/nutrients

Plant species

<u>Beach and Fore Dune</u>

Sea Oats	*Uniola paniculata*
Bitter Panicum	*Panicum amarum*
Sea Rocket	*Cakile constricta*

<u>Primary and Secondary Dunes</u>

Sea Oats	*Uniola paniculata*
Bitter Panicum	*Panicum amarum*
Woody Goldenrod	*Chrysoma pauciflosculosa*
Salt meadow hay	*Spartina patens*
Pennywort	*Hydrocotyle bonariensis*
Blue Stem	*Schizachyrium maritimum*

<u>Secondary Dunes and Maritime forest</u>

Beach Rosemary	*Ceratiola ericoides*
False Rosemary	*Conradina canescens*
St. John's wort	*Hypericum reductum*
Sand Live Oak	*Quercus geminata*
Myrtle Oak	*Quercus myrtifolia*
Magnolia	*Magnolia grandifolia*
Sweet Bay Magnolia	*Magnolia virginiana*
Yaupon	*Ilex vomitoria*
Slash pine	*Pinus elliottii*
Fetter Bush	*Lyonia lucida*
Saw Palmetto	*Serenoa repens*

<u>Swales (dune blowouts)</u>

Redroot	*Lachnanthes caroliniana*
Rushes and sedges	spp.
Pink Sundew	*Drosera capillaris*
Centella	*Centella asiatica*

<u>Fishes in Swale Pools</u>

Sheepshead minnow	*Cyprinodon variegatus*
Mosquitofish	*Gambusia affinis*

Animal Species

<u>Surf Zone</u>

Coquina Surf Clam	*Donax variabilis*
Augers	*Terebra* spp.
Moles crabs	*Emerita talpoida*
Shorebirds	several genera & species

<u>Wrack line and Beach</u>

Beach Flea	*Talorchestia* sp.
Ghost Crab	*Ocypode quadratus*
Least Tern (nesting)	*Sterna albifrons*
Shorebirds	several genera & species
Seagulls	several genera & species
Loggerhead Sea Turtle	*Caretta caretta caretta*

<u>Dunes, ponds, and Back Bay</u>

Raccoon	*Procyon lotor*
Fox	*Vulpes vulpes*
Skunk	*Mephitis mephitis*
Oppossum	*Didelphis virginiana*
Otter	*Lutra canadensis*
Santa Rosa Beach Mouse	*Peromyscus polionotus leucocephalis*
Ribbon Snake	*Thamnophis s. sauritus*
Diamondback rattlesnake	*Crotalus adamanteus*
Pygmy rattlesnake	*Sistrusrus miliarus*
Banded Water Snake	*Nerodia fasciata fasciata*
Cottonmouth	*Ancistrodon piscivorus*

Wet Prairies

Wet prairies (also called herb bogs, pitcher plant prairies or wet savannas) are unique wetlands typified by low organics, low nutrients, periodic hydroperiod, and frequent fire. Typically they are sandy soils underlain by a shallow clay layer holding ground water close to the surface resulting in saturated soils over broas flat terrain. Frequent fire removes and prevents the accumulation of organic matter and limits the growth of shrubs and trees, favoring herbaceous and grass species that are heliophytic. The wetland species found in these habitats can also be found in seepage slope communities, where a clay lens in a hilltop holds water that then seeps over the edge to saturate the soil on the hillside, creating a wetland on a slope. Once common along the Gulf Coast, development and fire suppression has reduced their coverage to the point where several plant species found only in these habitats are considered endangered (*Sarracenia leucophylla, Calamovilfa curtissii*).
Garcon Point Peninsula and West Pensacola contain extensive areas these wetlands. Smaller expanses of this habitat type are found scattered throughout our region. On Garcon Point, a prominent cypress dome, actually a pond, (*Taxodium ascendens*) is also found. Slash pines (*Pinus elliotii*) are common on wet prairies. The sea of herbaceous plants and grasses is dominated by wiregrass, *Aristida stricta*). Despite is monotypic appearance, a tremendous diversity of plant life occurs on the prairie, with as many as 11 species being recorded in a 10 x 10 cm square. Carnivorous plants are abundant, including pitcher plants (*Sarracenia* spp.) and sundews (*Drosera* spp.). These plants trap and dissolve insects to offset the low nutrient availability of the habitat.

Common and important Plant species include:

Andropogon virginicus
Aristida stricta
Aronia arbutifolia
Balduina uniflora
Calamovilfa curtissii
Carphephorus pseudoliatris
Chaptalia tomentosa
Ctenium aromaticum
Dichromena latifolia
Drosera capillaris
Drosera tracyi
Eriocaulon compressum
Eriocaulon decangulare
Hypericum crux-andreae
Ilex glabra
Lachnanthes caroliniana
Liatris spicata
Ludwigia virgata

Lycopodium alopecuroides
Marshallia graminifolia
Myrica cerifera
Pinus elliottii
Platanthera integra
Polygala cruciata
Rhexia alifanus
Rhexia lutea
Rhynchospora spp.
Sarracenia flava
Sarracenia leucophylla
Sarracenia psitticina
Smilax glauca
Smilax laurifolia
Toxicodendron radicans
Vaccinium spp.
Xyris spp.