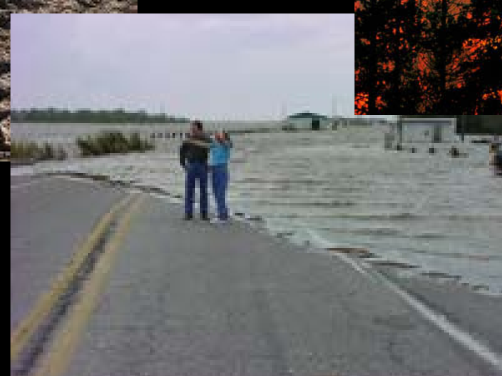
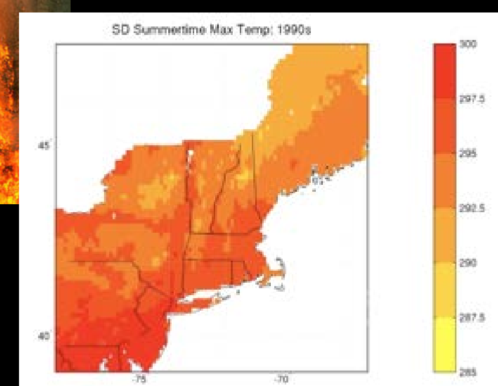
Unit 2: Elements of a Vulnerability Assessment: Exposure



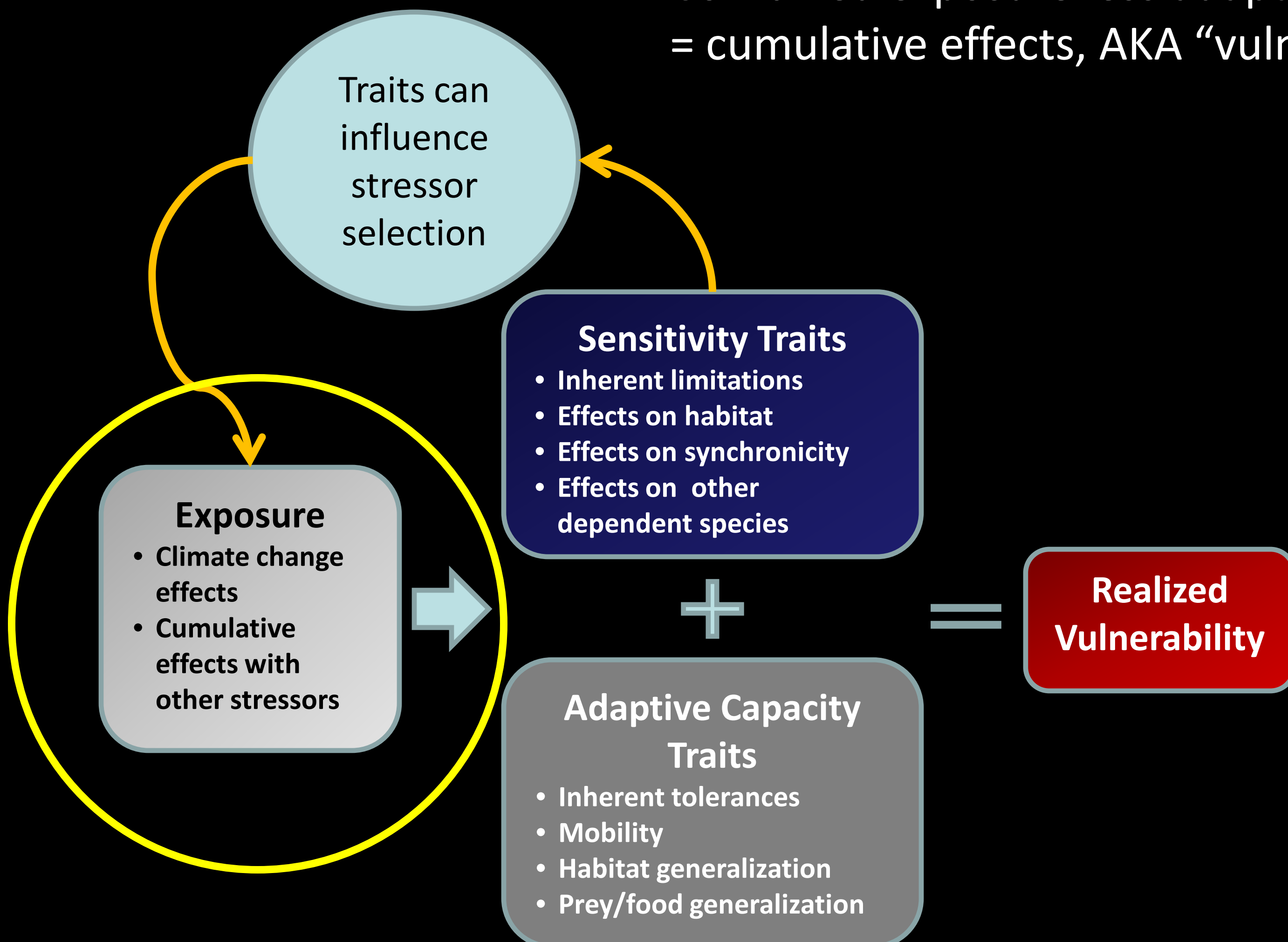


Exposure to What?

- Climate change direct and indirect effects
- Other current, planned, forecast stressors

Vulnerability Model

Combined exposure less adaptive capacity = cumulative effects, AKA “vulnerability”

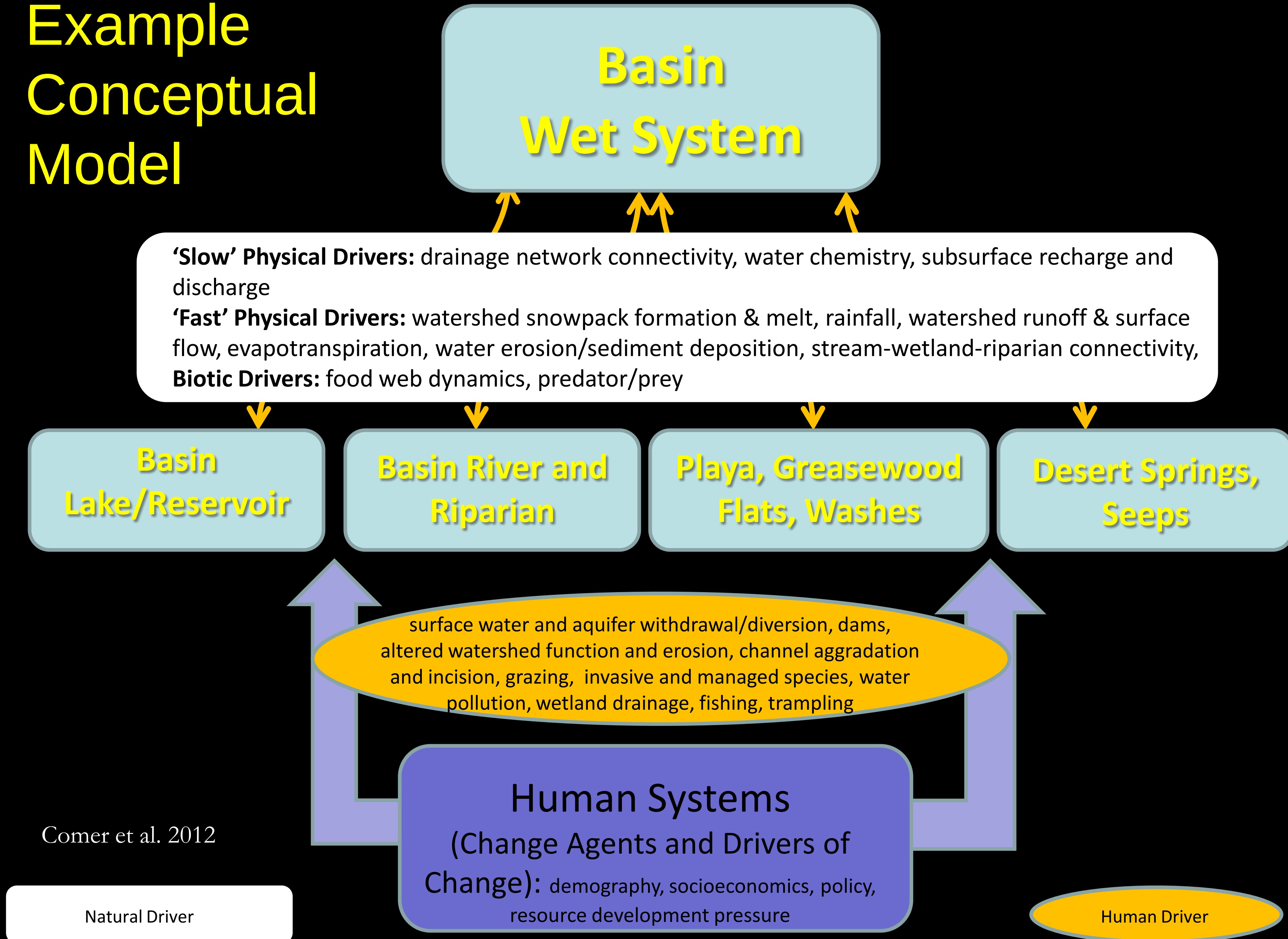


Crist et al. 2012

Where Do I Start?

- Useful to have a conceptual model to think through all stressors to be assessed and how they can affect resources
  - Precursor to “response models” covered in the assessment section
- Can also be greatly informed by scenario-based planning approaches to identify potential future stressors

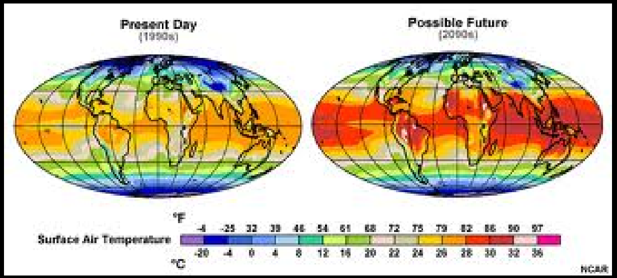
Example Conceptual Model



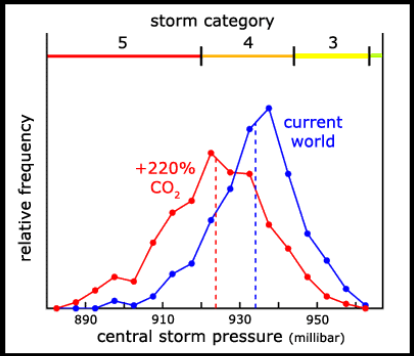
Comer et al. 2012

Climate Change Exposure

Measure of how much of a change in climate or other secondary factors a species or system is likely to experience



- Primary factors
  - Shifts in temperature, precipitation
  - Seasonality and extremes more important than averages
- Secondary factors, e.g.
  - Sea-level rise
  - Soil moisture
  - Hydrologic & chemical changes
  - Shifting sea ice dynamics

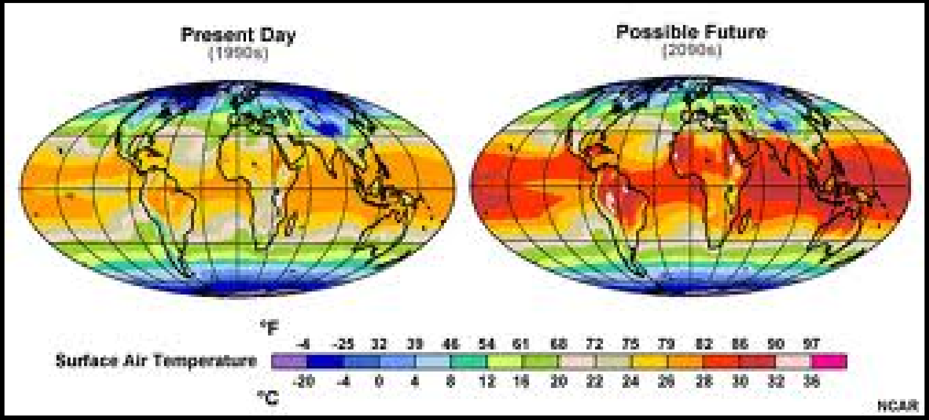


Sources & Differences in Climate Change Data

- All climate change data come from Global Climate Models (GCMs)
- Downscaled CC data are now ubiquitous but not standardized, use different methods and produce different variables
- Future forecasts don’t come with probabilities but uncertainty can be managed with backcasting results and use of “ensembles” by climate modelers

Global Climate Models (GCMs)

- Global climate models
  - Based on principles of thermodynamics and fluid dynamics
  - Describe complex interaction between atmosphere, cryosphere, oceans, land, and biosphere
  - Large-scale (~100 km^2 but constantly decreasing)



Projecting Global Climate Models

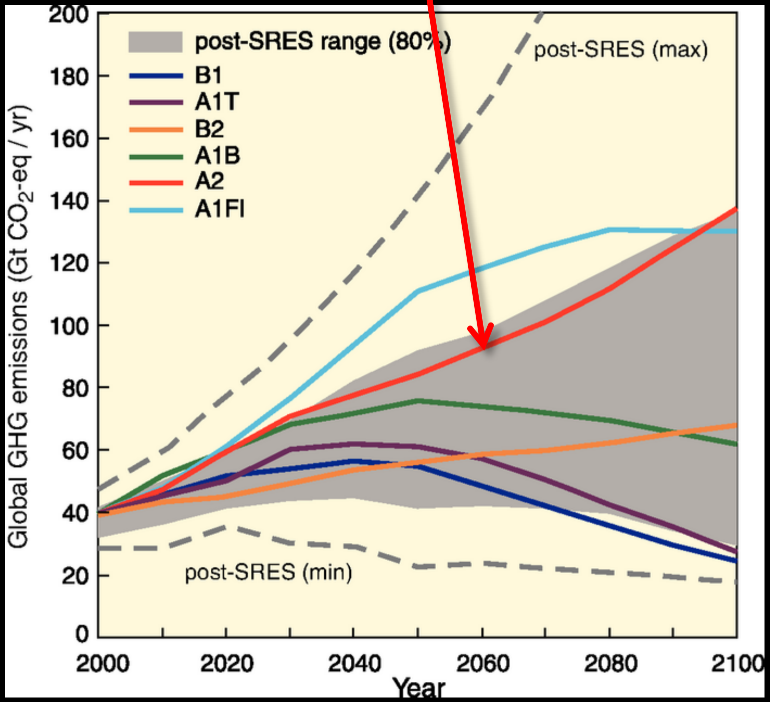
Projections for changes in climatic variables (e.g., average temperatures, precipitation) based on one or more scenarios for emissions of greenhouse gases, particulates, other factors

- Factors to consider in applying GCMs
  - Uncertainties in scenarios (depend on policy, economics, population, etc.)
  - Variation among output from different modeling teams
  - Confidence in results often higher in nearer term, also higher for temperatures than precipitation

Which Scenarios to Use?

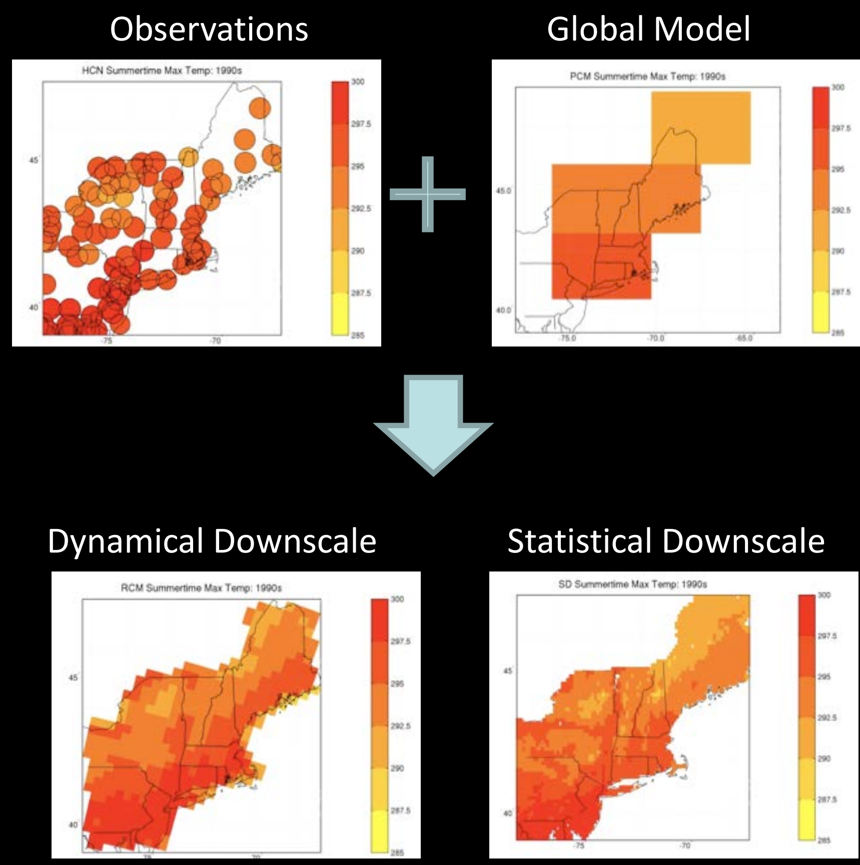
- Factors to consider
  - Length of your planning horizon
  - Sensitivity of key species or processes (helps ID variables to consider)
  - Relationship to current trends
  - Level of acceptable risk
- Level of detail
  - Specific numbers
  - A range of numbers
  - Directionality

Most planners now default to the A2 scenario as current trends support



Is Downscaled Information Necessary?

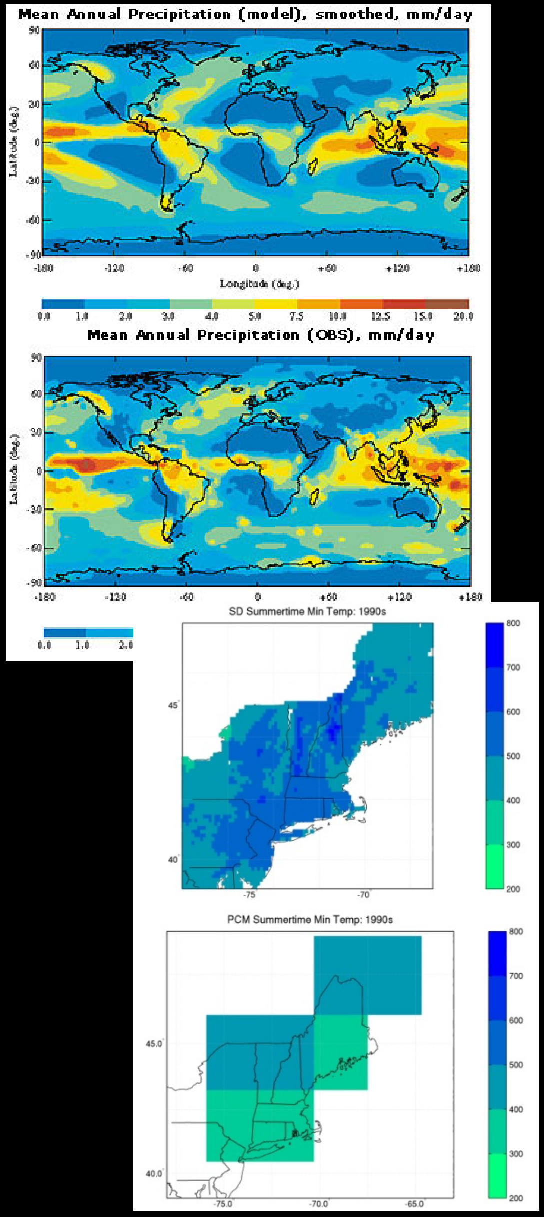
- Factors to consider
  - Scale of area being managed
  - Complexity of area being managed
- Benefits and limitations
  - Data often more relevant for management scale
  - Not necessarily more "accurate"
  - Better for modeling of secondary factors



Downscaling GCMs

- Using models (and sometimes observations) to convert GCM data to smaller grid sizes (50 – 1 km^2)

- Multiple techniques available
  - Dynamic (expensive, less common)
  - Statistical (more common)
  - Change-factor (Delta method)



Questions to Ask About Downscaled Data

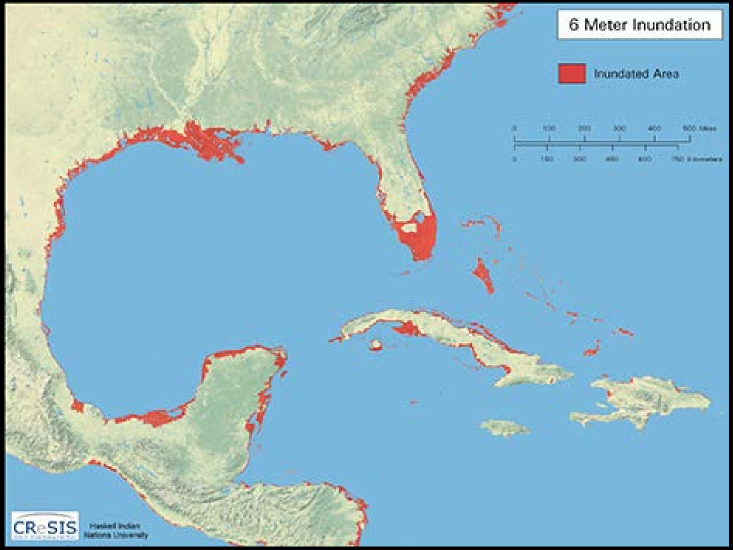
- What GCM(s) is it based on, and how well do they perform for this particular region?
- Downscaling method used and suitability for the purpose and region?
- Adequacy (density) of weather stations to calibrate the downscale model
- Is the grid cell size supportive of the relative uncertainty in the inputs? (4km currently fairly standard, any finer is questionable)

Secondary Factors

- All resources will be exposed to direct climate changes
- Not all resources will be exposed to all secondary climate change effects or may be irrelevant for any particular resource
- Conceptual model/expert involvement can assist in determining what effects are necessary to assess, based on e.g.,
  - Location, e.g., proximity to coast, landscape position
  - Dependence on regimes, e.g., hydro, precip, fire
  - Sensitivity to gradients, e.g., soil moisture, water temperature or salinity

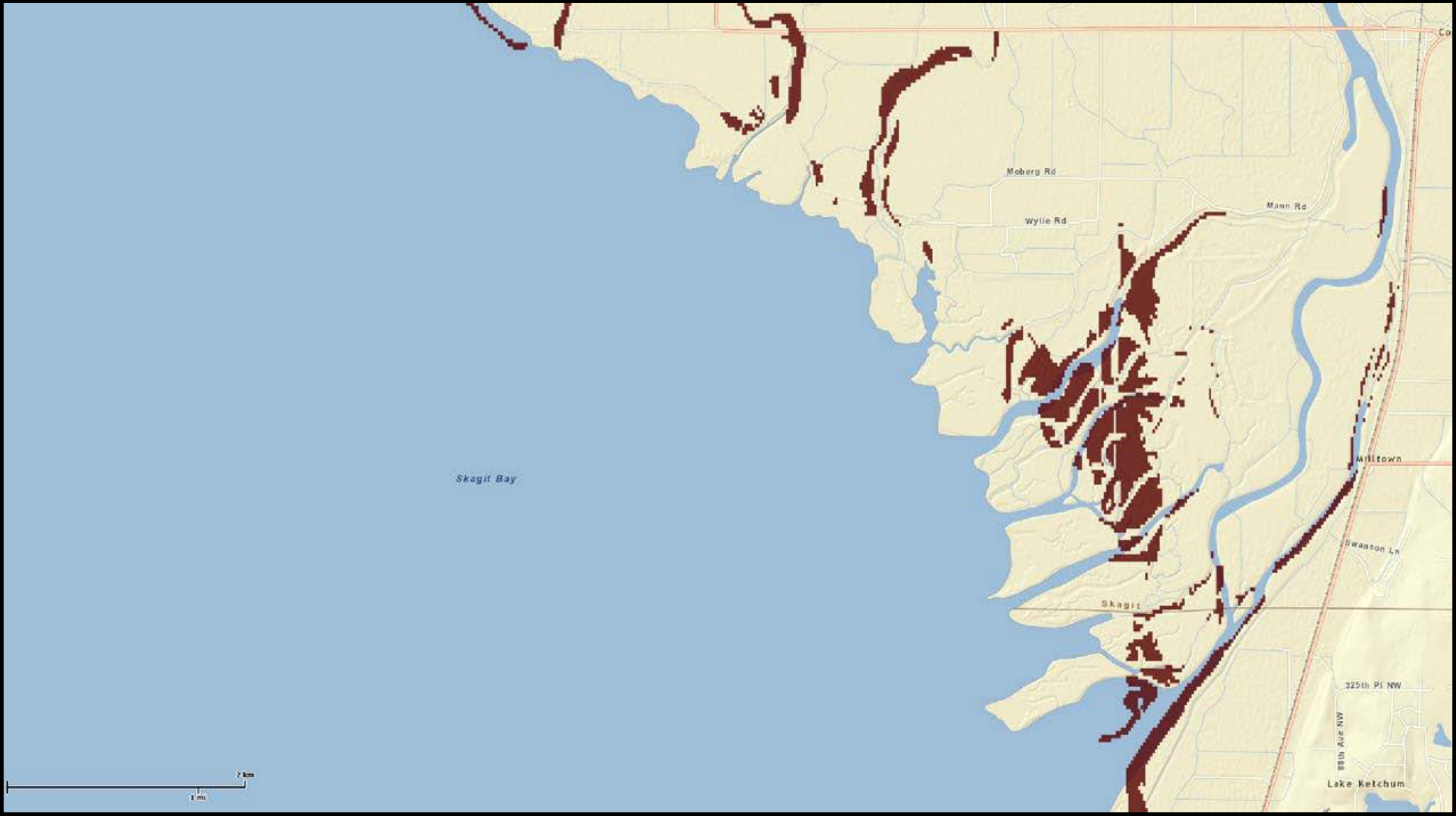
CC Exposure: secondary factors

- Examples of secondary factors
  - Sea level rise
  - Hydrologic regime
  - Soil moisture
  - Fire regime
  - Snow pack vs rainfall
  - Sea ice



Secondary factors: sea level rise bathtub model

Skagit Bay - areas at risk for inundation



Secondary factors: sea level rise
Complex responses modeled

Exposure analysis for assessing vulnerability of coastal wetlands to sea-level rise (wetlands are sensitive to tides/elevation)

- Initial Condition
- 11.2-inch SLR
- 27.3-inch SLR
- Diked areas

Secondary factors: hydrology

USGS generating hydrological models for large basins in US Coastal Plain

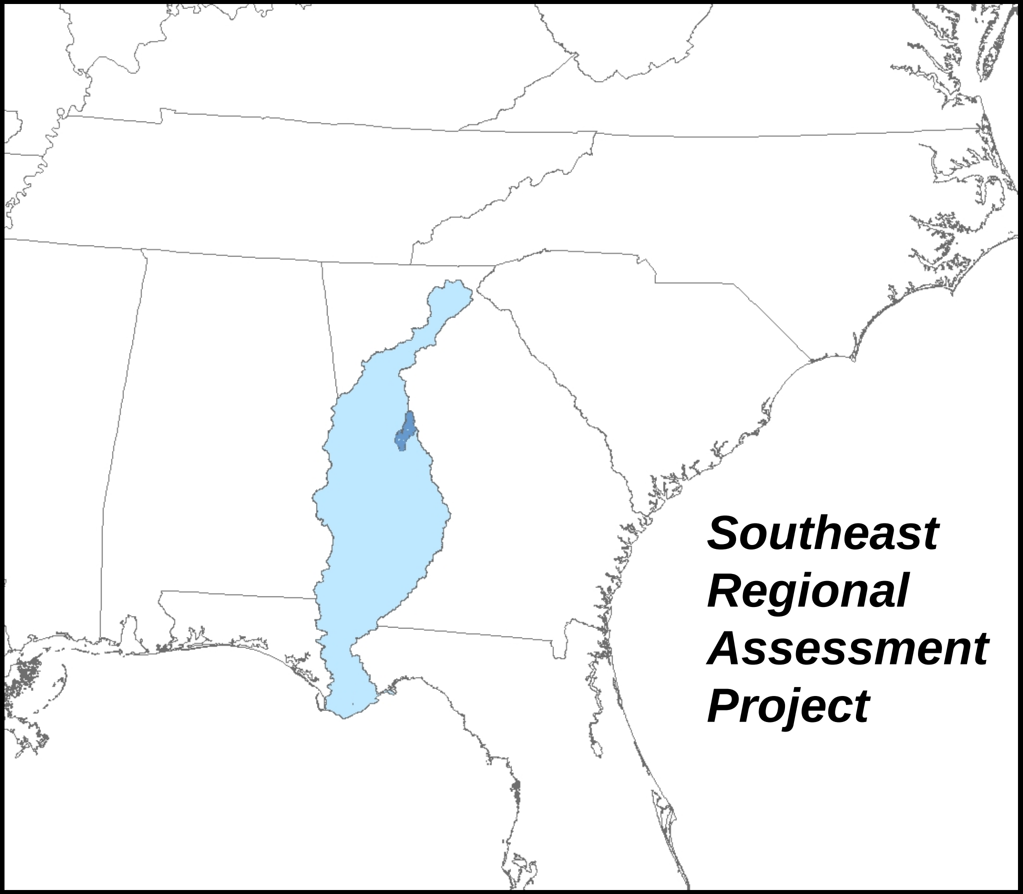
Climate change

↓

Hydrology &
Water temp

↓

Species and
locations most
affected?



Mary Freeman et al. (USGS)

Secondary factors: hydrology

- Examined climate and non-climate stressors
- Used downscaled projections to examine the potential hydrological shifts
- Parameterized model with expert opinion
- Expert elicitation methods used to populate & understand influence of climate change vs. non-climate stressors on resources

Secondar

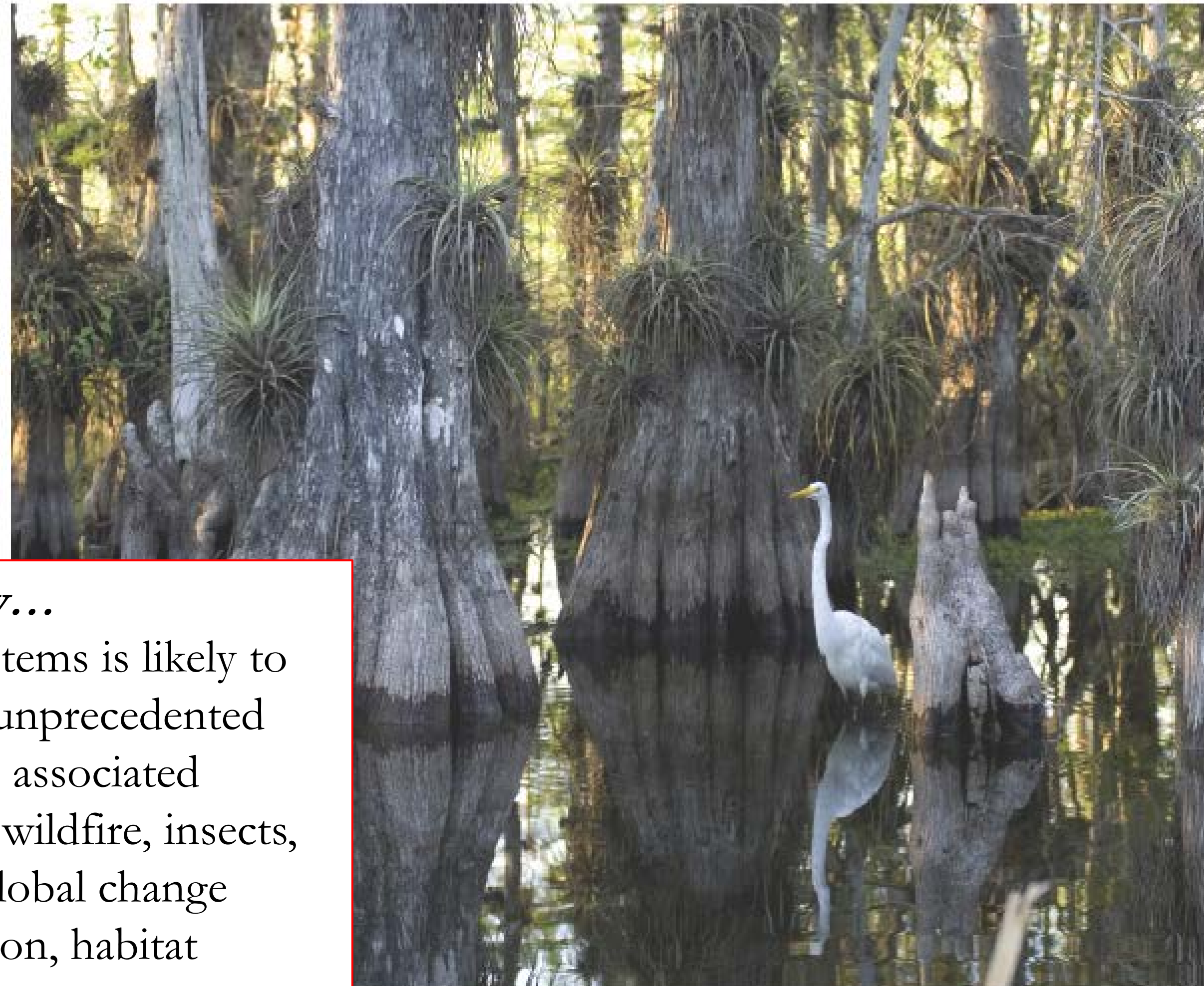
- Decreased soil
  precip) can lea

And/or

Understanding the Science of Climate Change

Talking Points – Impacts to the Gulf Coast

Natural Resource Report NPS/NRPC/NRR—2010/210



What scientists think is likely…

• The resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbance (flooding, drought, wildfire, insects, ocean acidification) and other global change drivers (land use change, pollution, habitat fragmentation, invasive species, resource over-exploitation) (Figure 6).

Non-climate Stressors Exposure

Important because they decrease integrity making resources less resilient to climate change (along with traditional conservation concerns)

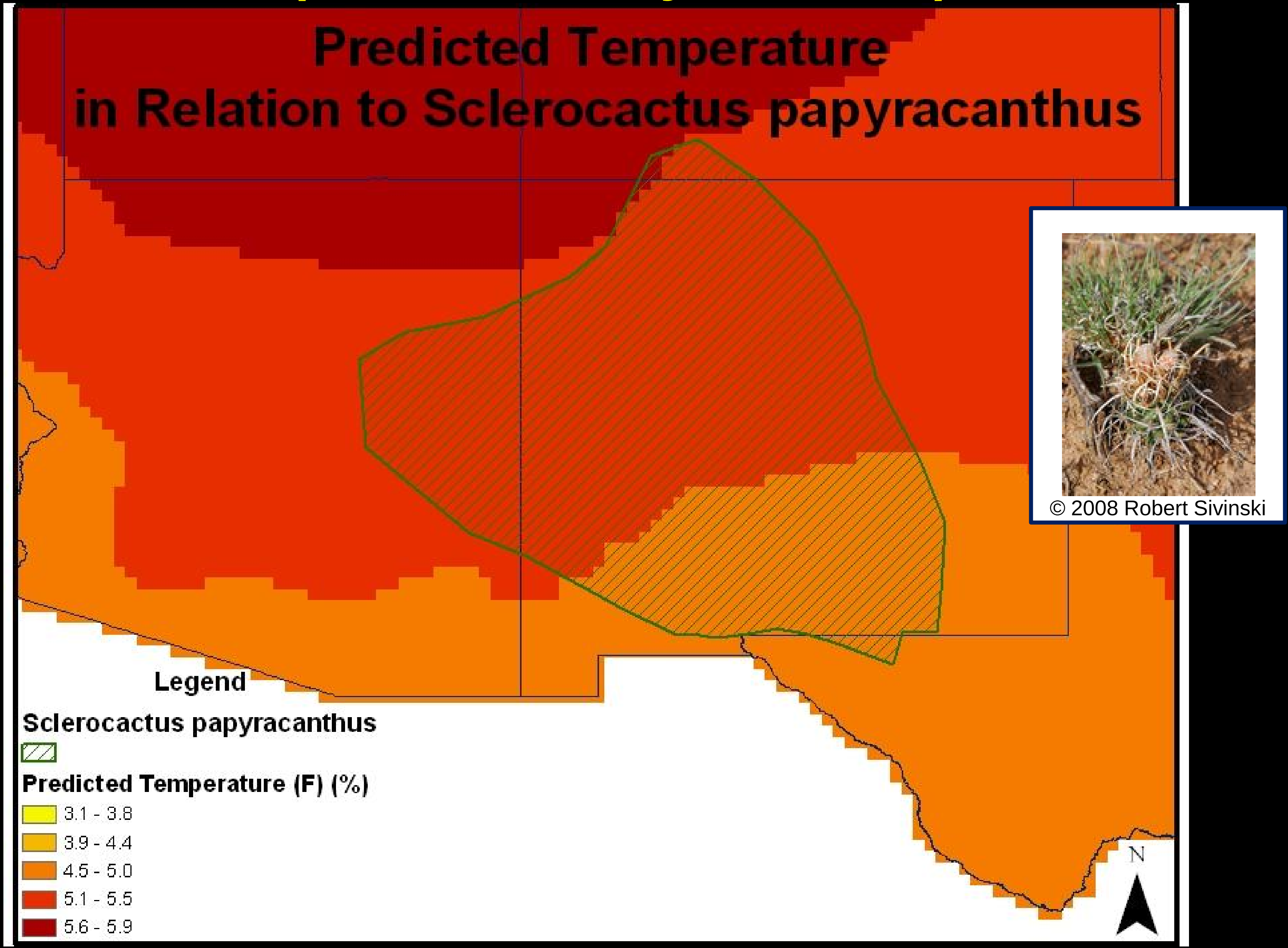
Examples

- All types of development (some resource dependent, e.g., power lines)
- Management practices (resource dependent)
- “Tertiary CC effects” e.g., invasive spp spread

Some Options for Determining Exposure

- Simple overlay model (what effects may this resource be subject to) – visual or quantitative
- Bioclimate envelope model (what parts of the resource's current distribution fall outside its known tolerances—and where might suitable climate exist in the future)
- Cumulative effects assessment (what parts of the resource's distribution will be subject to what combinations of stressors)

Simple Overlay Example



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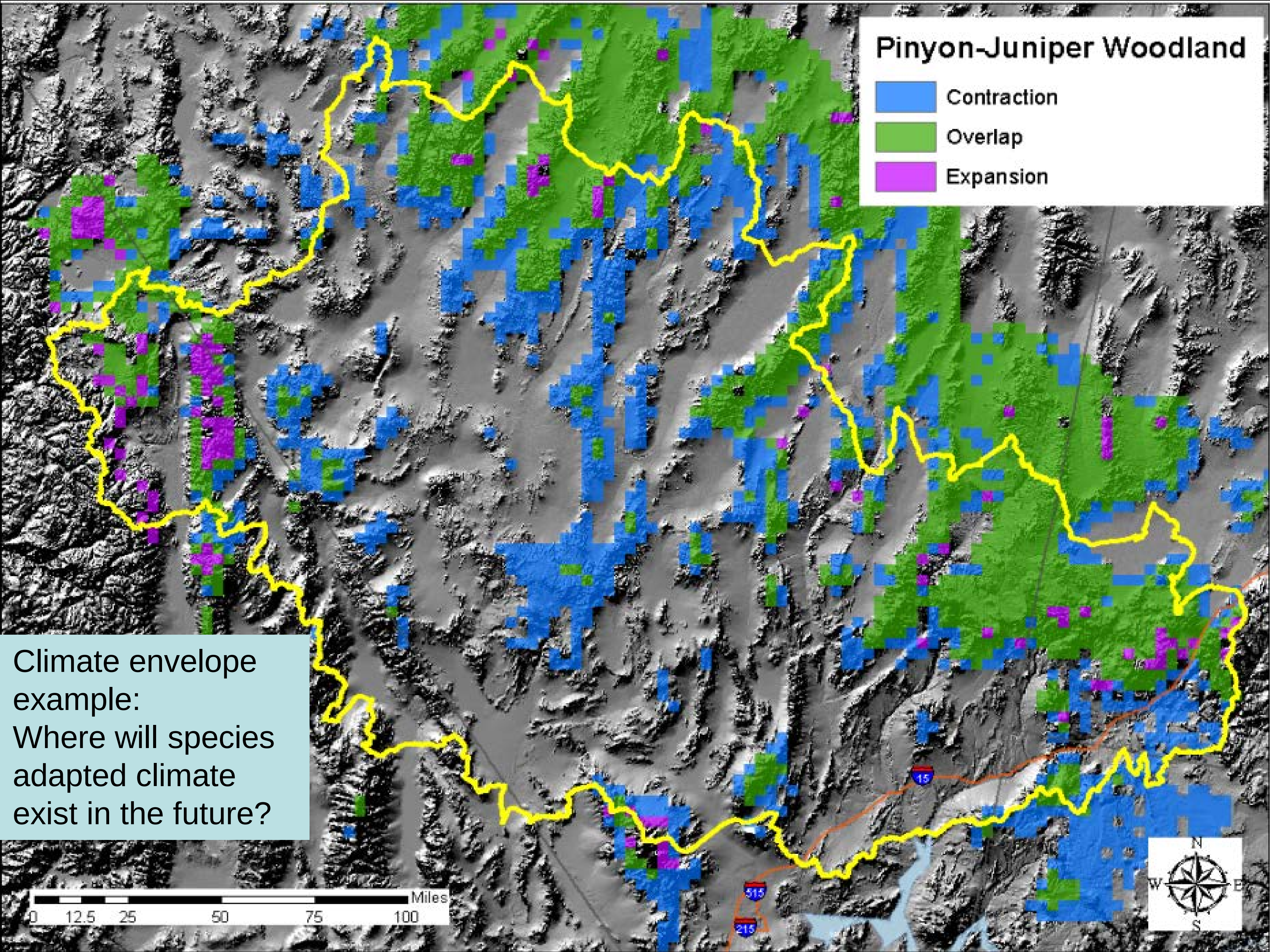
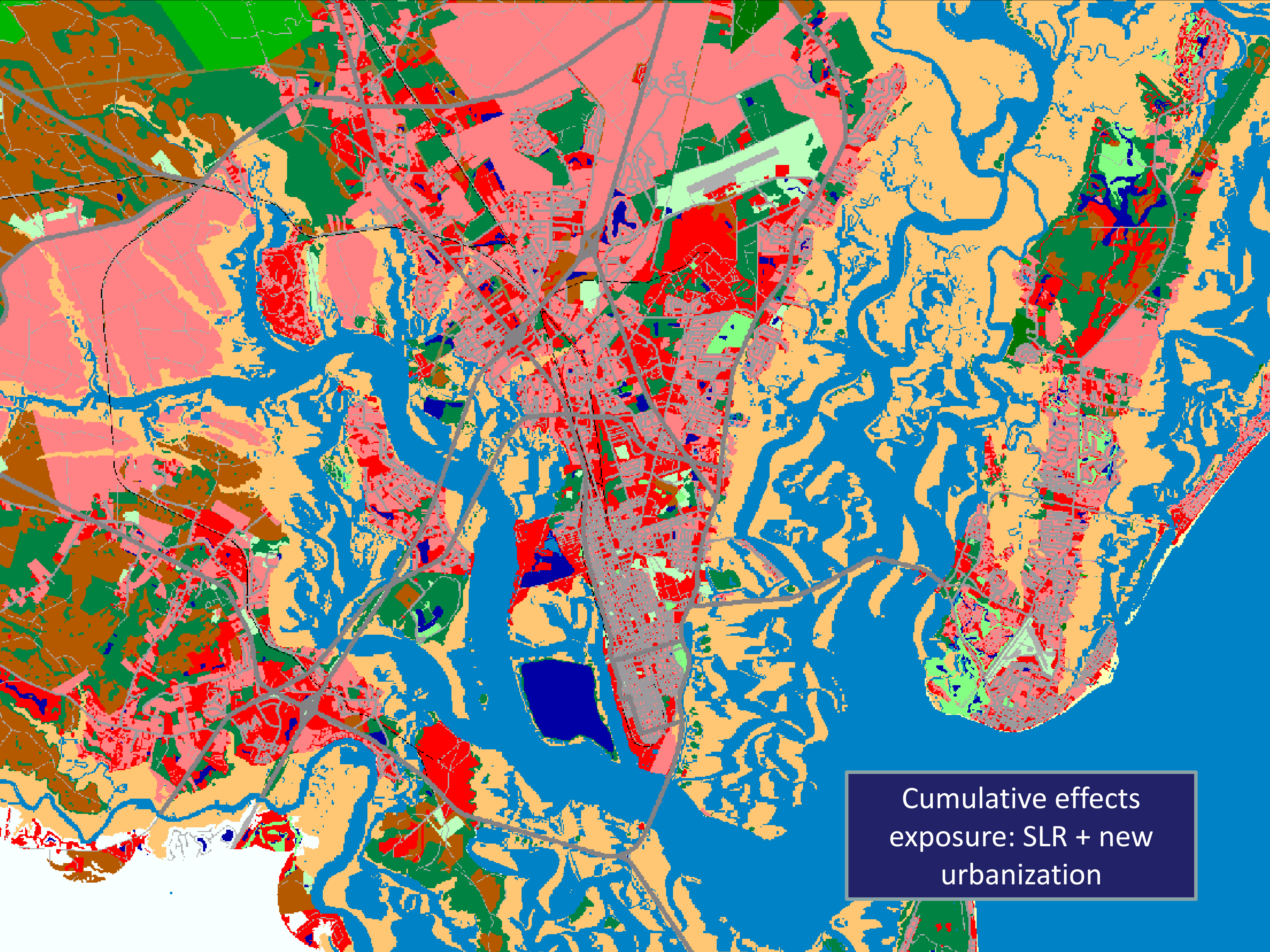


Climate envelope example:
Where will species adapted climate exist in the future?

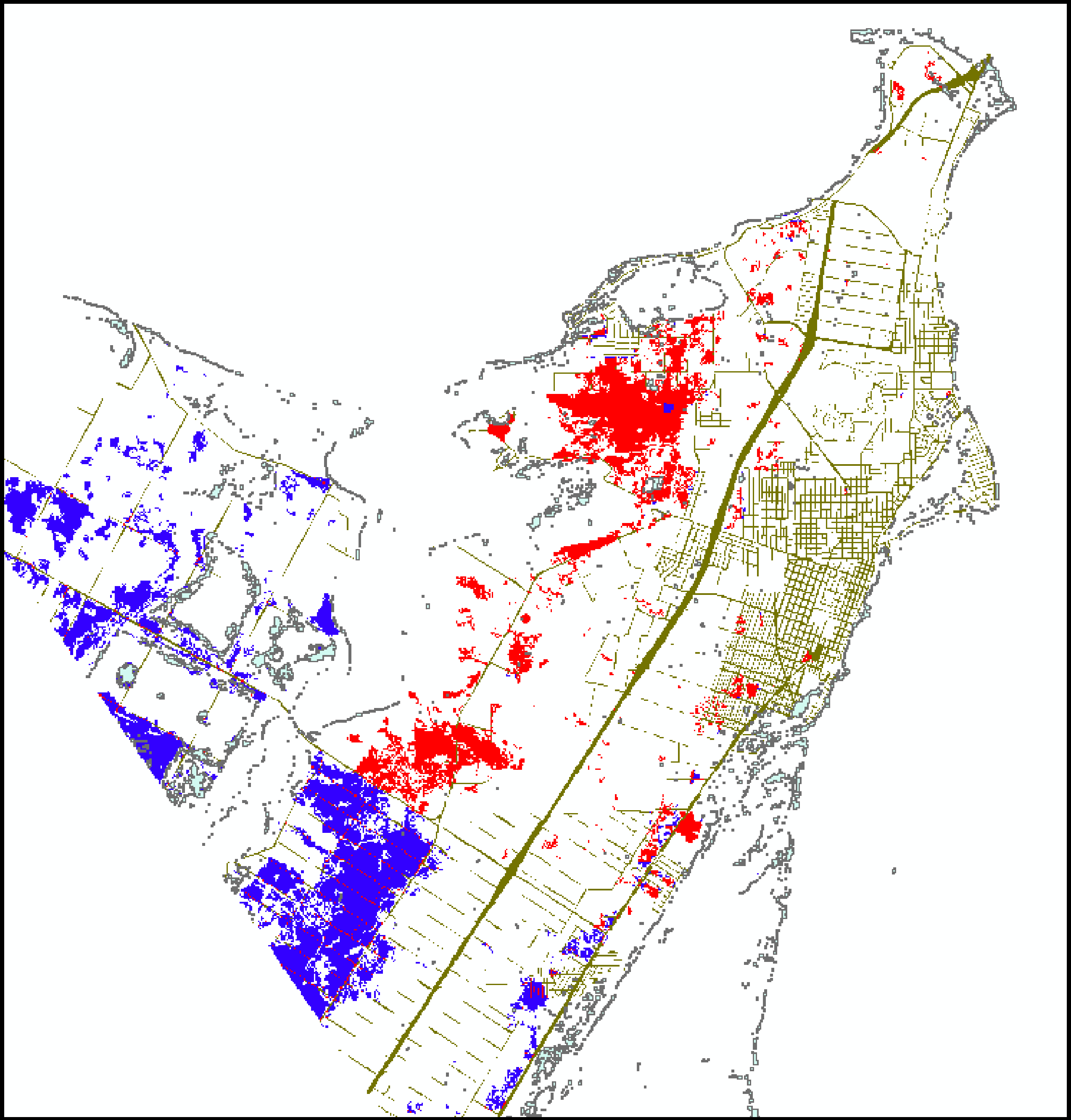

Cumulative effects exposure: SLR + new urbanization

Characterize Degree of Exposure

- Qualitative: Visual examination of overlay—typical when using online “viewers” where you can’t get quantification.
  - Tend to use “degree” or “relative proportion.”
- Quantification through GIS intersect, provides more, but maybe not necessary or true, precision

Map Exposure

Estuarine wetlands exposed to cumulative stressors in Aransas Bay, TX.



Tools/Resources for Relevant Information

- DOI Climate Science Centers (CSCs) and Landscape Conservation Cooperatives (LCCs)
  - CSCs will deliver basic climate impact science to LCCs
  - LCCs will link science with conservation delivery

- ClimateWizard (view & obtain data) http://www.climatewizard.org/
- Southern Regional Climate Center http://www.srcc.lsu.edu/
- Sea Level Rise Viewer http://www.csc.noaa.gov/slr/viewer/#
- RNCEP: R package to facilitate access and visualization to climate data

Break-out: Assessing Exposure