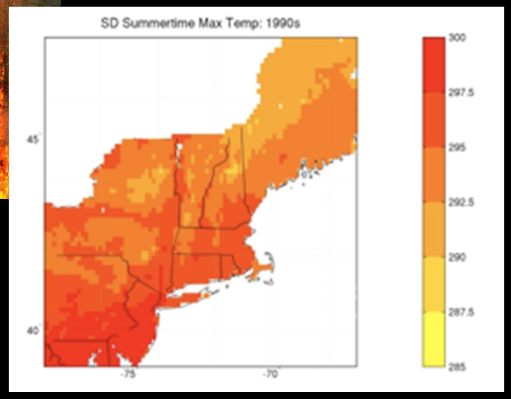
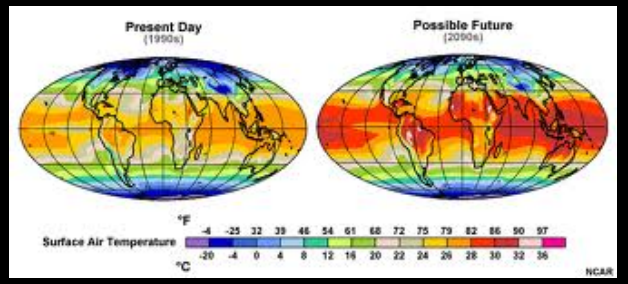
# Unit 2: Elements of a Vulnerability Assessment: Exposure

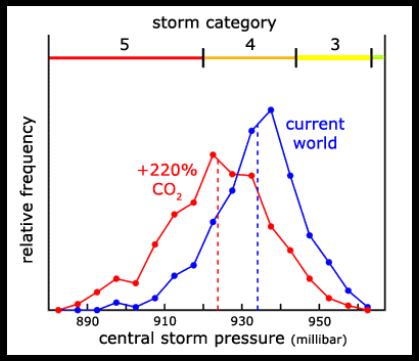


# Exposure

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

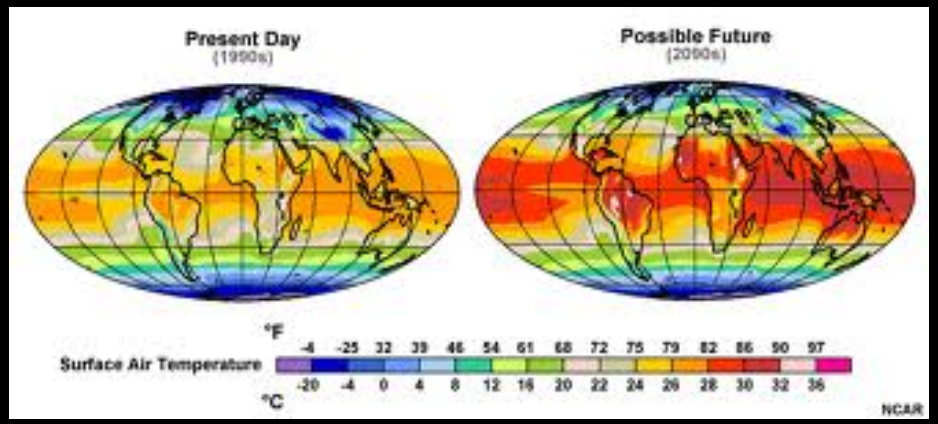



- Primary factors
  - Shifts in temperature, precipitation
- Secondary factors
  - Sea-level rise
  - Hydrologic changes
  - Shifting sea ice dynamics

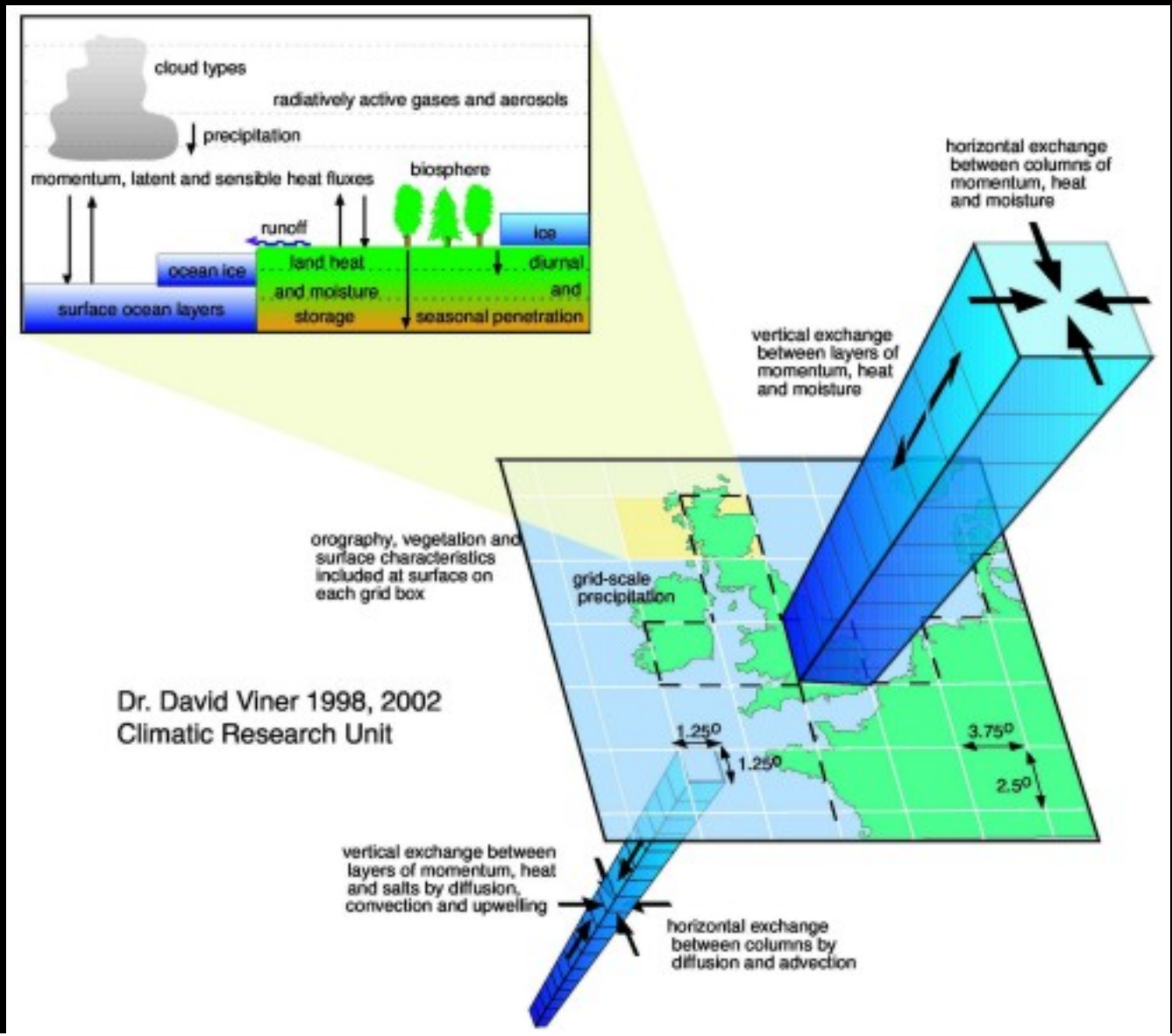


# Global Climate Models (GCMs)

- Based on principles of thermodynamics and fluid dynamics
- Describe complex interaction between atmosphere, cryosphere, oceans, land, and biosphere

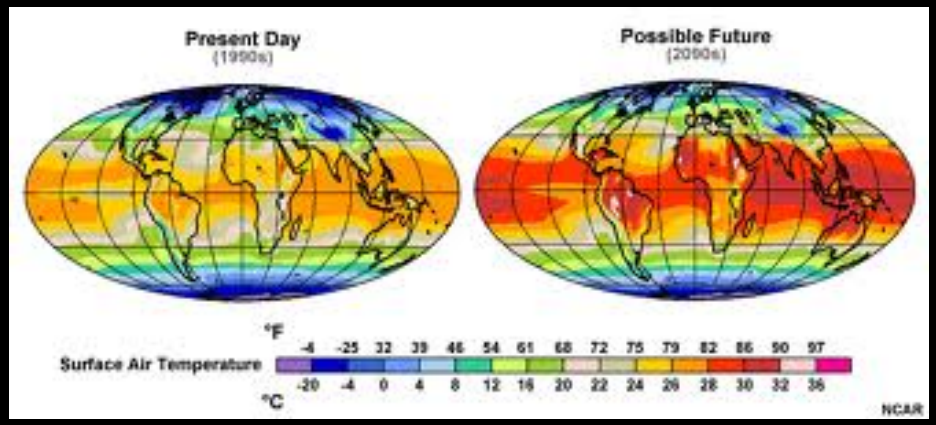


# Global Climate Models (GCMs)

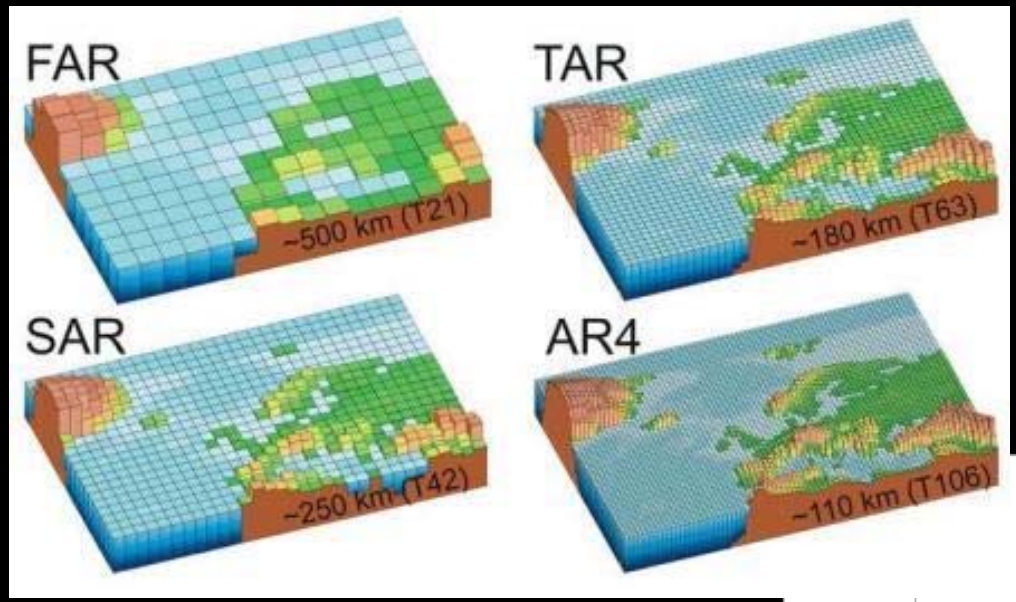


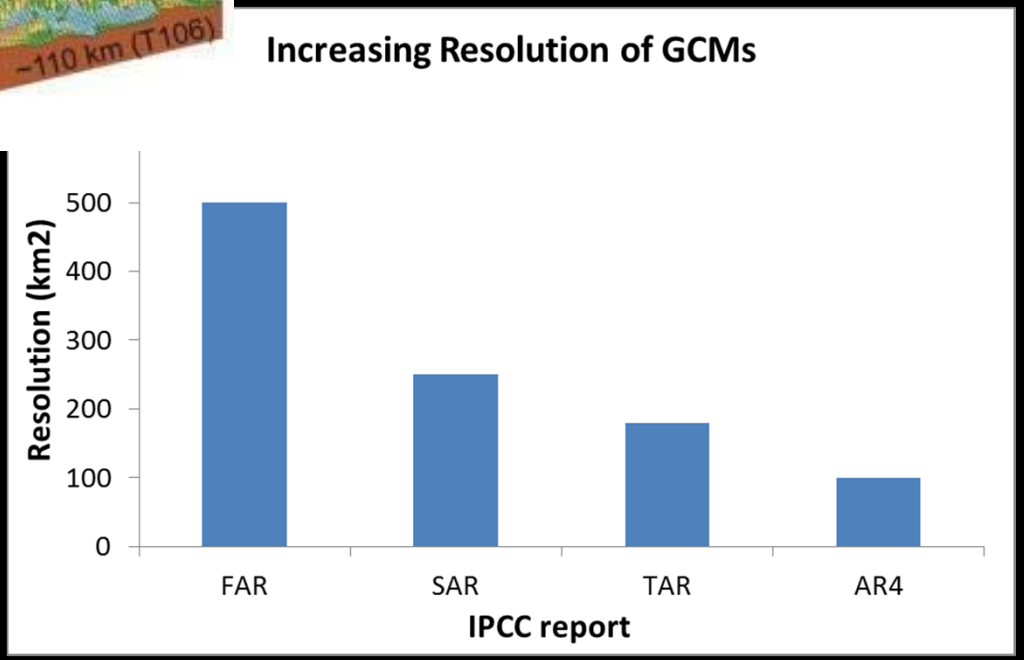
# Global Climate Models (GCMs)

- 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)



# Modeling climate: scale



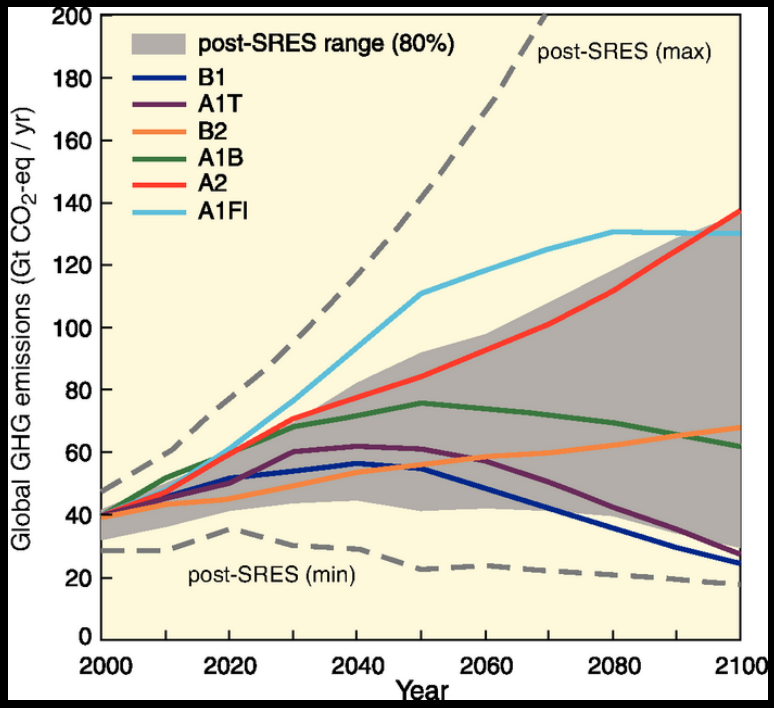
# Projecting Global Climate Models

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
  - 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?

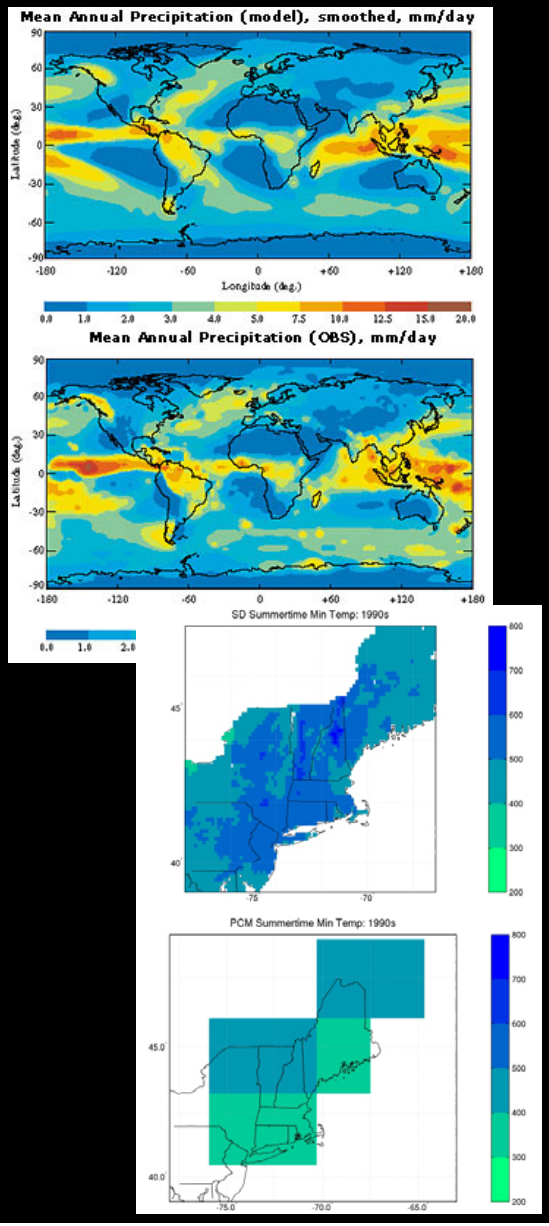
- Factors to consider
  - Length of your planning horizon
  - Sensitivity of key species or processes (helps ID variables to consider)
  - Relationship to current trends
  - Level of acceptable risk
- Level of detail
  - Specific numbers
  - A range of numbers
  - Directionality



# Downscaling GCMs

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

- Multiple techniques available
  - Dynamic
  - Statistical
  - Change-factor (Delta method)



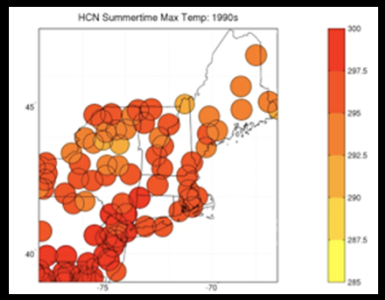
# Downscaling Projected GCMs: techniques

- Multiple techniques available
  - Dynamic: modeling embeds regional climate model w/in GCM (RCM can account for local surface-rainfall interactions, cloud formation, etc)
  - Statistical: statistical relationship identified between GCM and local variables (ex: GCM atmospheric pressure forecasts and local rainfall) – relationships used to downscale GCM for specific areas
  - Change-factor (Delta method): historical values from observations subtracted from GCM values – differences are used to correct modeled values at smaller scale

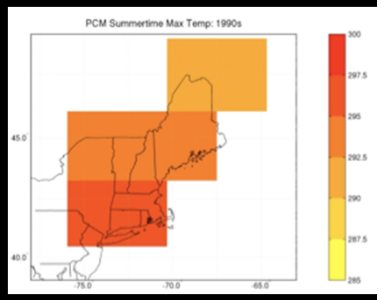
# Is Downscaled Information Necessary?

- 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”
  - Allows for modeling of secondary factors

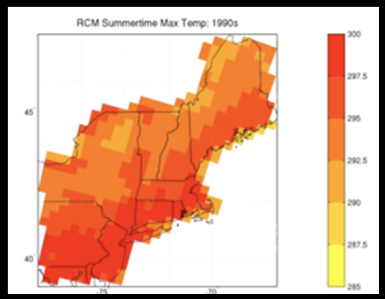
Observations



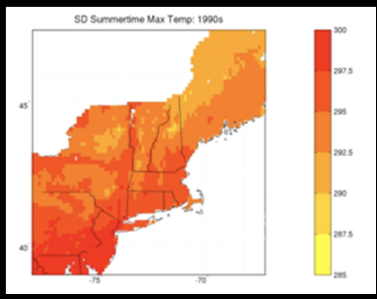

Global Model




Dynamical Downscale

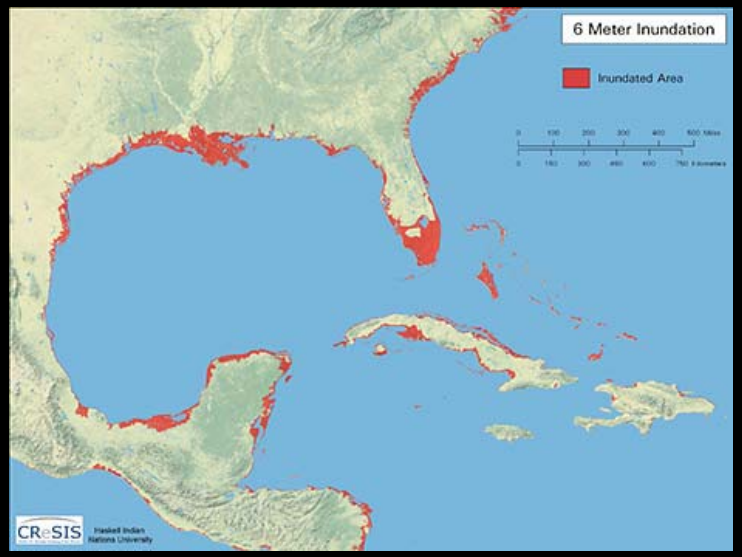



Statistical Downscale



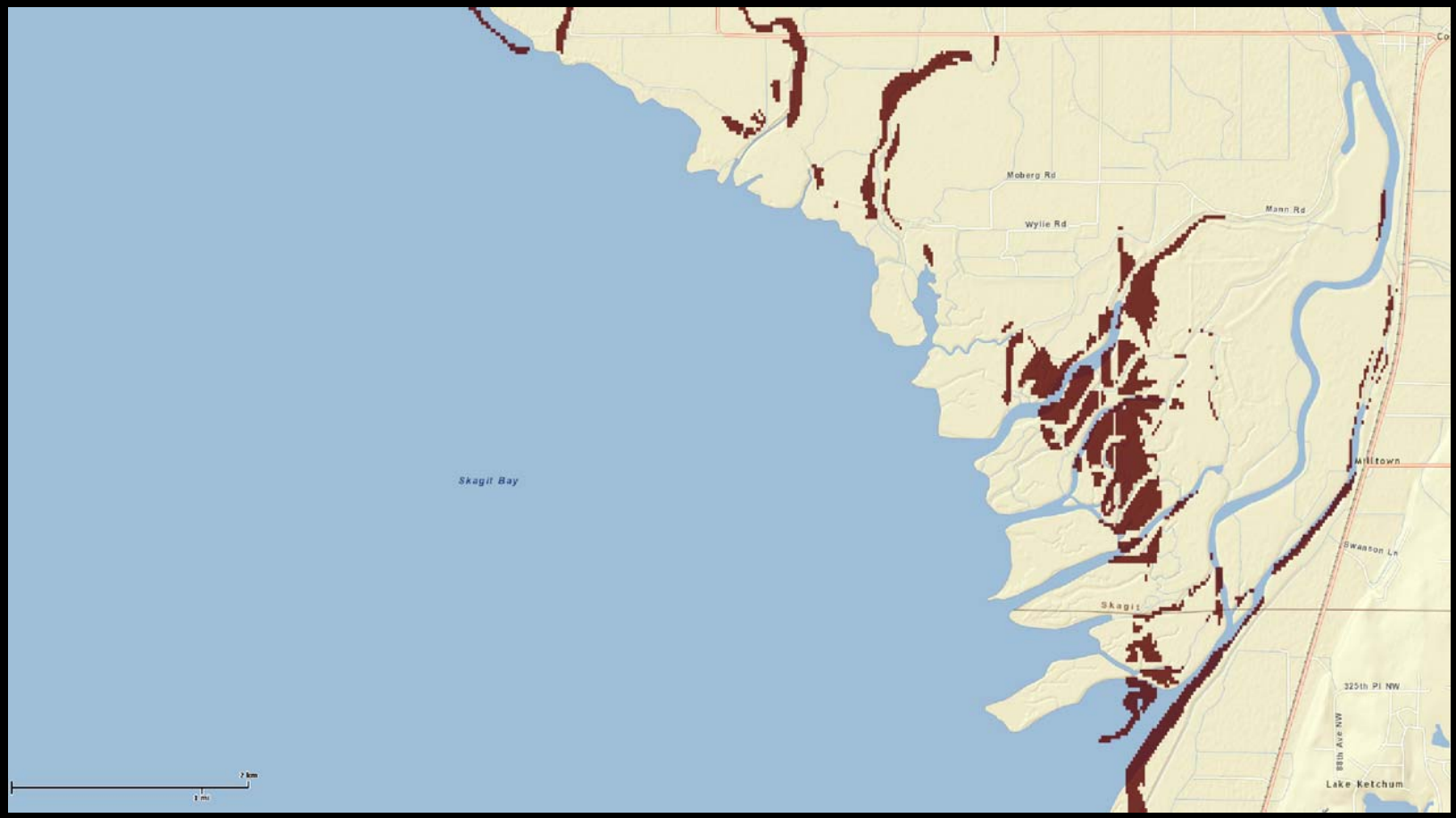
# Exposure: secondary factors

- Response Models
  - Conceptual (qualitative)
  - Qantitative (wide range of complexity)
- Examples of secondary factors
  - Sea level rise
  - Hydrology
  - Fire regime
  - Vegetation changes
  - Topography
  - Snow pack
  - 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 basin in US Coastal Plain

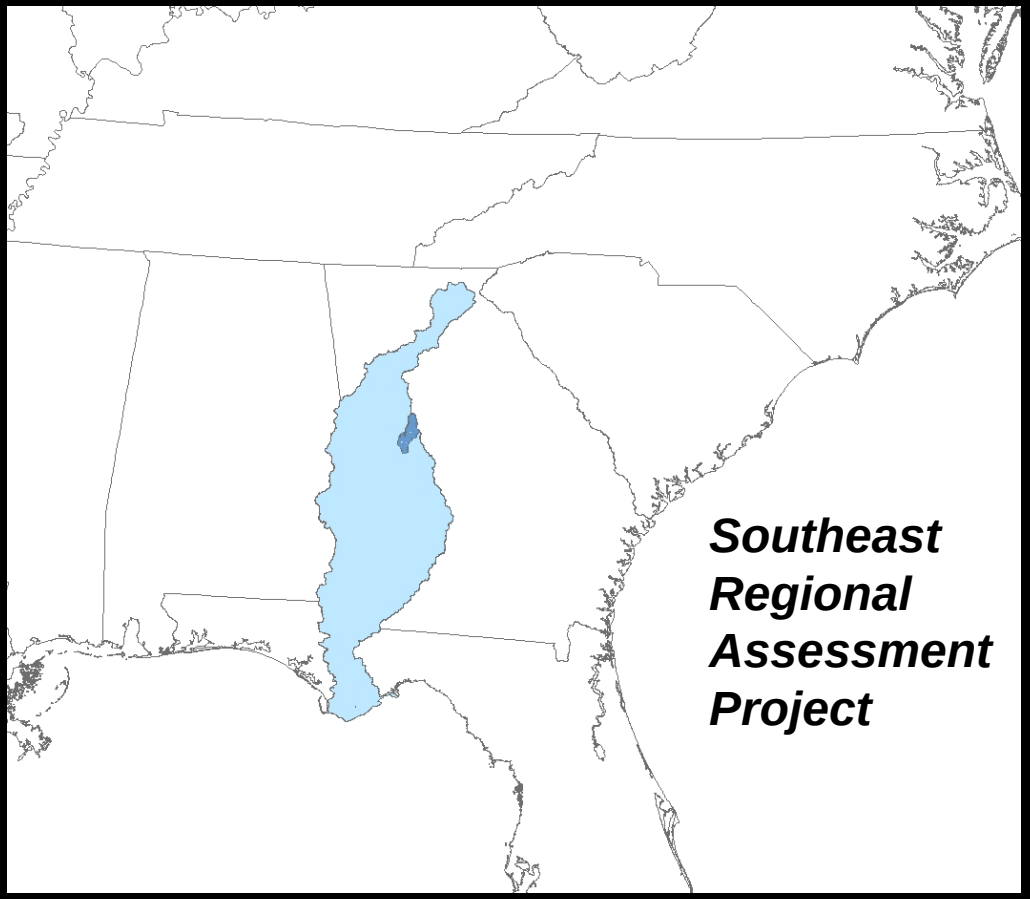
Climate change

↓

Hydrology & Water temp

↓

Species and locations most affected?

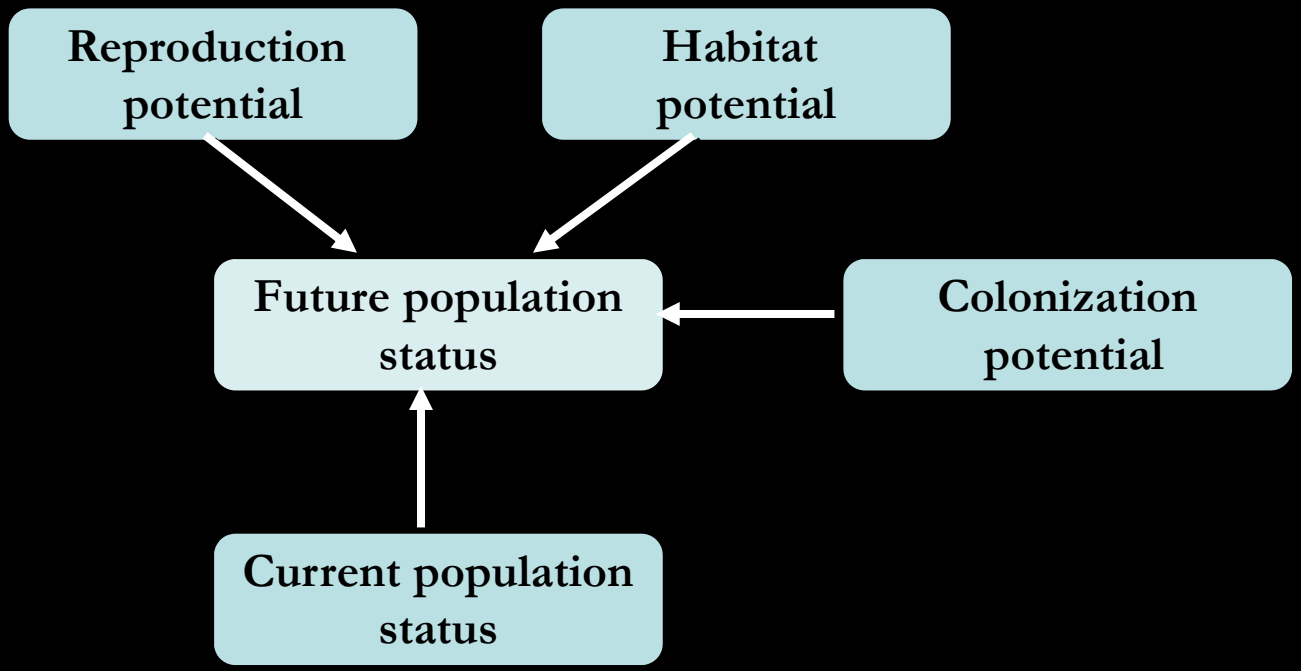



Mary Freeman et al. (USGS)

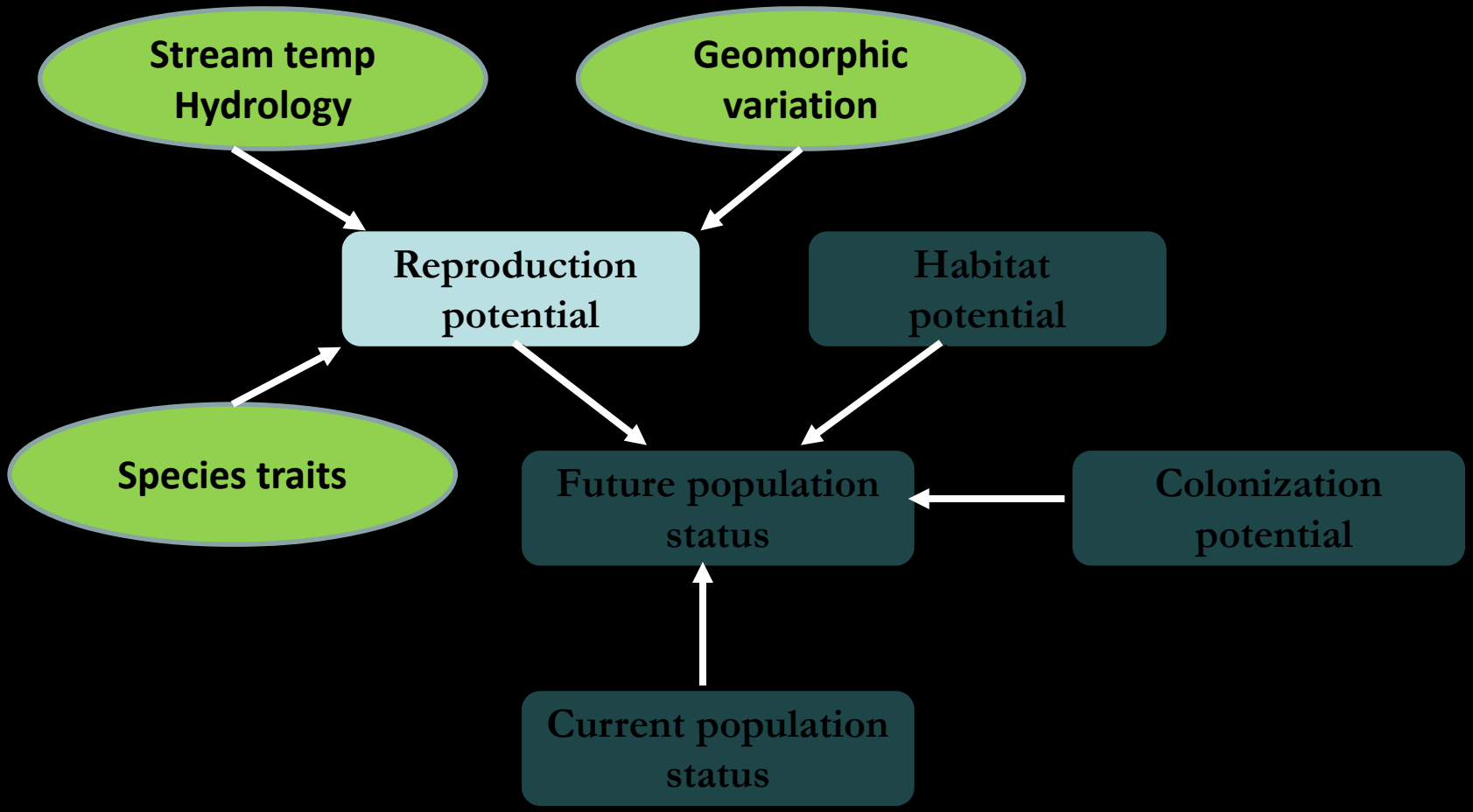
# Secondary factors: hydrology

- Examined climate and non-climate stressor
- Used downscaled projections to examine the potential hydrological shifts
- Parameterized model with expert opinion
- Bayesian belief networks populated to understand influence of climate change vs. non-climate stressors

# Secondary factors: hydrology



# Secondary factors: hydrology



# Secondary factors: fire regime

- Reduced snow pack and earlier snow melt can produce bigger, more frequent fires

And/or

- Fuel production may decline and drive down fire frequency

CSIRO PUBLISHING

www.publish.csiro.au/journals/ijwf *International Journal of Wildland Fire* **2010**, *19*, 903–913

**Future climate affects management strategies for maintaining forest restoration treatments**

*Corinne Diggins*[A], *Peter Z. Fulé*[A,C], *Jason P. Kaye*[B] *and W. Wallace Covington*[A]

# Secondary: dynamic veg models

- Niche-based modeling to understand vegetation response to changing climate
  - Uses empirical physiological characteristics to model
  - Can link to GCMs (but with caution)
  - Excludes some ecosystem types (e.g., wetlands)
- Exposure or sensitivity?

# 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
- SLAMM
- SNAP (Scenarios Network for Alaska Planning)

# Considerations for Ecological Response Models

- Choice of models
  - Depends on the species, habitats, ecosystems of concern (including scale)
  - Depends on the types of questions being asked
  - Depends on end-user's needs
- Limitations of response models
  - Overly-simplified (e.g., may ignore factors such as interactions between species; nonlinear, complex responses; other factors)
  - Data availability varies
  - Transferability across regions and scales

# Break-out: Assessing Exposure