CLIMATE SCENARIO
NEEDS FOR ECOSYSTEM IMPACTS ASSESSMENTS

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OUTLINE

1. What Ecosystem Modelers have done with climate change scenarios in the past

2. Limitations of existing scenarios

3. What scenarios we wish for

1990 historical climate vs GCM-generated
What Ecosystem Modelers have done with Climate Change Scenarios in the Past

1. EQUILIBRIUM (STEADY –STATE) SIMULATIONS:

   METHOD: spin-up to steady state conditions using one year of average historical or future climate repetitively

2. TRANSIENT SIMULATIONS (CO\textsubscript{2} +1\% y\textsuperscript{-1})

   METHOD: spin-up to historical climate using detrended climate followed by historical climate and future scenario
**SIMULATION MODELS**

* Biogeography models (potential vegetation)

* Biogeochemistry models

* Dynamic Global Vegetation Models (ex. MC1, LPJ, HYBRID, SDGVM)

* DGVMs linked with atmospheric models (ex. IBIS, TRIFFID, VECODE)

* SVATs (ex. BATS, SiB) (fixed vegetation)
CLIMATE CHANGE IMPACTS ON THE UNITED STATES

**Ecosystem Models**
Maps of current and projected potential vegetation distribution for the conterminous US. Potential vegetation means the vegetation that would be there in the absence of human activity. Changes in vegetation distribution by the end of the 21st century are in response to two climate scenarios, the Canadian and the Hadley. Output is from MAPSS (Mapped Atmosphere-Plant-Soil System).

**Legend**
- Tundra
- Taiga / Tundra
- Conifer Forest
- Northeast Mixed Forest
- Temperate Deciduous Forest
- Southeast Mixed Forest
- Tropical Broadleaf Forest
- Savanna / Woodland
- Shrub / Woodland
- Grassland
- Arid Lands

**CREDIT:** NATIONAL ASSESSMENT SYNTHESIS TEAM, 2001, MAPSS Results
REGIONAL ASSESSMENT

CREDIT: in prep., BACHELET et al. 2002 and the VEMAP Data Group at NCAR
CHANGE in BIOMASS BURNED BETWEEN the 20th and 21st CENTURY

CREDIT: BACHELET et al. 2001, MC1 simulation
MODEL/SCENARIO COMPARISONS

HADCM2SUL with INCREASING CO2

CGCM1 with INCREASING CO2

CHANGE IN TOTAL C (Pg)

CREDIT: BACHELET et al., in press 2002
LIMITATIONS WITH EXISTING SCENARIOS

. Few Available Transient Climate-Change Scenarios (no daily transient scenarios)

. Low Spatial Resolution (uncertainty in regional assessments)

. Short Scenarios (missing long-term climate variability)

. Climate Variability Problems: Inaccurate Interannual and Inter-decadal accuracy

. Average Conditions are not enough, need Range and Modes of Variance

. Lack of Bio-Feedbacks

. Lack of Uncertainty Measure
VARIANCE in CLIMATE VARIABLES AFFECTS OUTCOME

REDMOND, OREGON

PREcipitation variance x 2

PREcipitation variance / 2

CREDIT: BACHELET, FERGUSON, MEARNS, MC1 results, unpublished
INTER-DECADAL VARIABILITY
BIOLOGICALLY RELEVANT INDICES

Southern Oscillation Index

Pacific Decadal Oscillation
SOME YEARS ARE BETTER THAN OTHERS ....
EL NINO and LA NINA YEARS AND ANNUAL AREA BURNED IN ARIZONA AND NEW MEXICO

A greater area burns during La Niña years (dry winters) than during El Niño years (wet winters). Wet El Niño years create a build-up of fine fuels (grasses and shrubs), which then dry out and ignite more effectively during the dry, warm La Niña years.

Year-to-year fluctuations and long-term trends in the North Atlantic Oscillation index (NAO), West Wind Stress (WWS) in m²/s², Sea Surface Temperature (SST) in °C, and abundance of Calanus finmarchicus and C. helgolandicus (log-transformed) from 1962 to 1992 over the northeast Atlantic and the North Sea.

CREDIT: FROMENTIN and PLANQUE
DEFINITIONS

PDSI = Palmer Drought Severity Index
Meteorological drought index based on PPT and T data as well as available water content. It varies between –6 and +6.

DAI = Drought Area Index based on PDSI. Area of land with a PDSI < 0.

SAI = Stress Area Index or fractional area of the U.S. land that underwent a decline in vegetation density (less than its long term mean) as simulated by the model.
FOURIER TRANSFORM

HISTORICAL

Number of years

0 5 10 15 20 25 30 35 40 45 50

0.2

0.4

0 50 1000

0.5

1

DAI TIME SERIES

HADCM2SUL

Number of years

0 5 10 15 20 25 30 35 40 45 50

0.2

0.4

0 50 1000

0.5

1

CGCM1

Number of years

0 5 10 15 20 25 30 35 40 45 50

0.2

0.4

0 50 1000

0.5

1

CREDIT: NEILSON, Unpub.; MC1 RESULTS from BACHELET et al, 2001
ANNUAL CHANGE IN TOTAL ECOSYSTEM C RELATIVE TO THE 1895 LEVEL
COUNTRY AVERAGE - MC1 DGVM SIMULATION RESULTS

HADCM2SUL

CGCM1

(10 year running average)

CREDIT: in prep., BACHELET et al. 2002 and the VEMAP Data Group at NCAR
SIMULATED CHANGE IN DROUGHT AREA NEAR THE END OF THE 21ST CENTURY OVER THE CONTERMINOUS U.S. UNDER SEVEN FUTURE CLIMATE SCENARIOS

\[ y = 0.114x - 0.1412 \]

\[ R^2 = 0.6214 \]
One of the most important aspect of land-atmosphere interactions is the feedback associated with disturbance but also with seasonal and interannual vegetation cycles.
EXAMPLE OF INTERACTIONS BETWEEN BIOSPHERE AND CLIMATE

Enhancement of inter-decadal climate variability in the Sahel by vegetation interaction
WHAT WE NEED

. Better Representation of Past Climate
   * GCM hydrologic cycle in particular (snowfall, runoff)
   * inter-annual and inter-decadal variability
   * min daily temperature

. Higher Spatial Resolution
   * for regional analysis
   * for direct use of scenarios (as opposed to deltas)

. Greater Range in Transient Scenarios

. Longer Temporal Extent (ex. 200 rather than 100 years), Daily Resolution

. Upper Atmosphere Information to better simulate Fire Ignition Conditions

. Index of Uncertainty

1990 historical climate vs GCM-generated