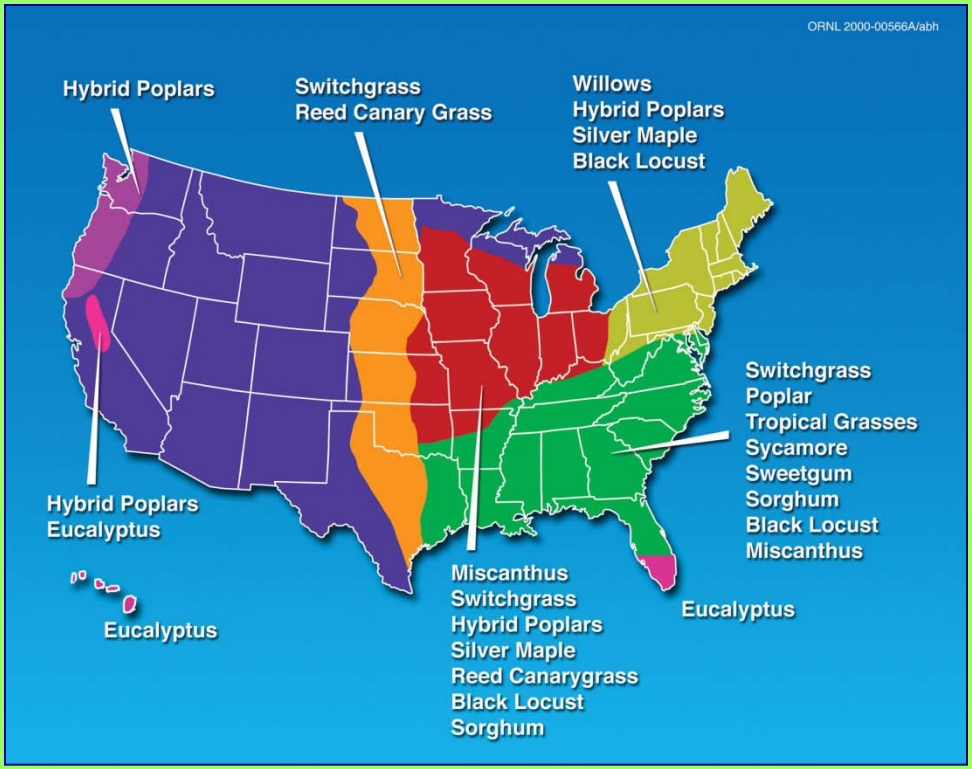
A Biophysical Model of Yields of Bioenergy Crops

Jim R. Kiniry
USDA-ARS, Temple, TX

Deliverables

- ALMANAC can simulate many plant types
- The model is functional across various soils, latitudes, and rainfall zones
- ALMANAC accurately simulates nutrient and water demands
- ALMANAC is free
- User-friendly interface



User-friendly front-end

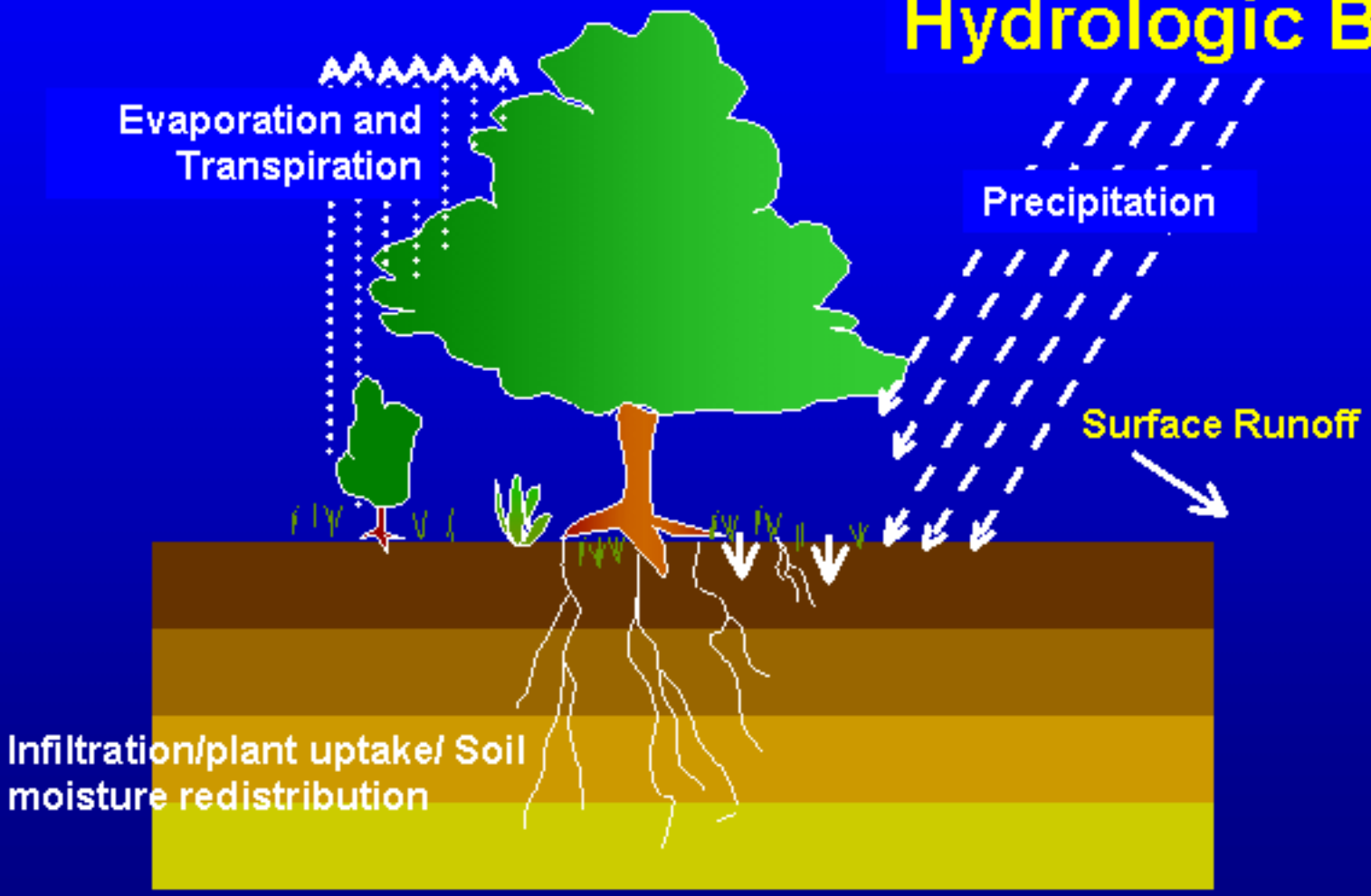
- Windows based
- Retrieves NRCS soils data easily
- Retrieves NOAA weather data easily
- Easy to choose output, run the model, and read the output

Needs

- ALMANAC requires field-based parameter development and field-validation of runs for each species of interest
- Cooperation is essential to:
  - 1. help develop and improve plant parameters
  - 2. validate the model at a wide range of sites, soils, and latitudes
  - 3. make large area yield simulation runs
- Continued ongoing collaboration and development of new collaborations is paramount

ALMANAC

Hydrologic Balance



ALMANAC Model

- Process-based model
- Processes are quantified such that they are general across locations
- The input variables for physical and biological processes in the model are measurable, and are not just fitted constants

ALMANAC Model

- Simulates plant growth through leaf area, light interception, biomass production, and nutrient availability and use
- Water balance, nutrient cycling, and temperature responses are part of the model
- Can simulate competition among species
- Can simulate changing management strategies

Measure fraction of Photosynthetic Active Radiation (PAR), Leaf Area Index, and Biomass

Radiation Use Efficiency is the slope of above ground dry biomass as a function of cumulative intercepted PAR

Current Research

- Simulating western range species for Rangeland CEAP

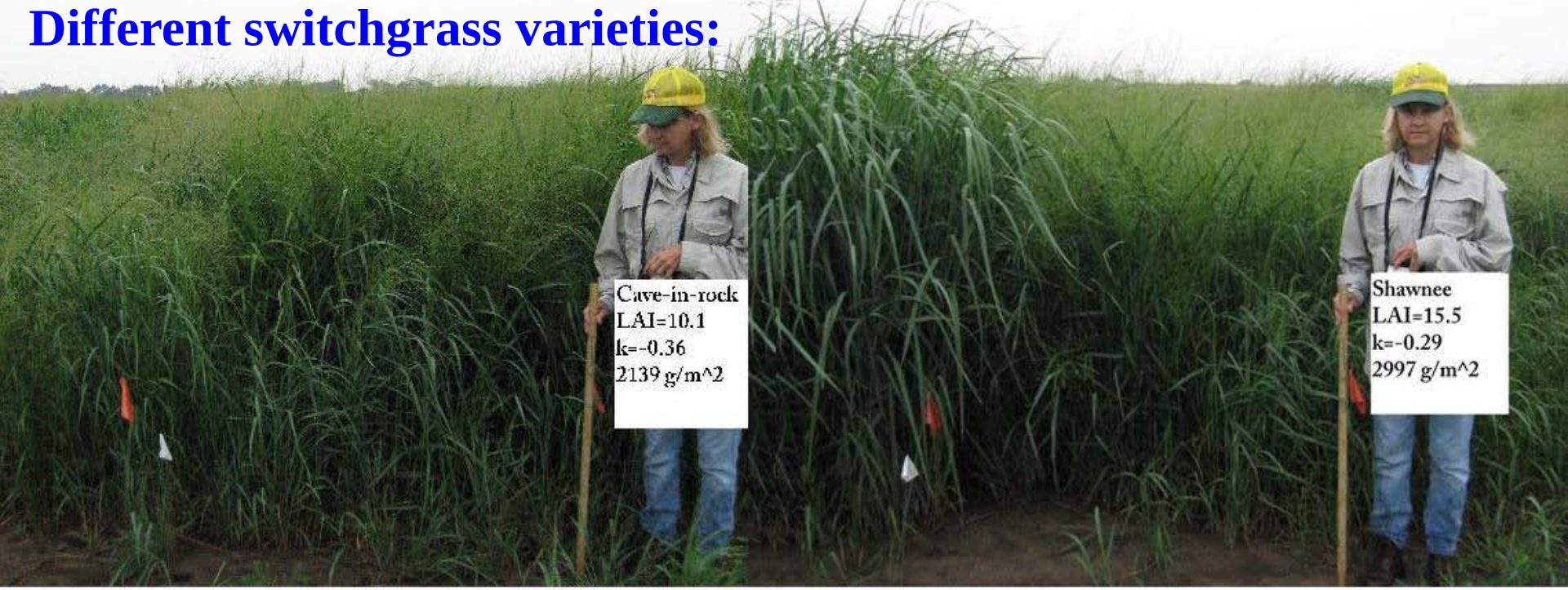
- Working in Hawaii on simulating biofuel plant species

Ongoing Applications of ALMANAC:

Simulating nutrient cycling and water use of switchgrass and Miscanthus

Biofuel candidate species production simulation in TX, LA, AR, and the northern Great Plains

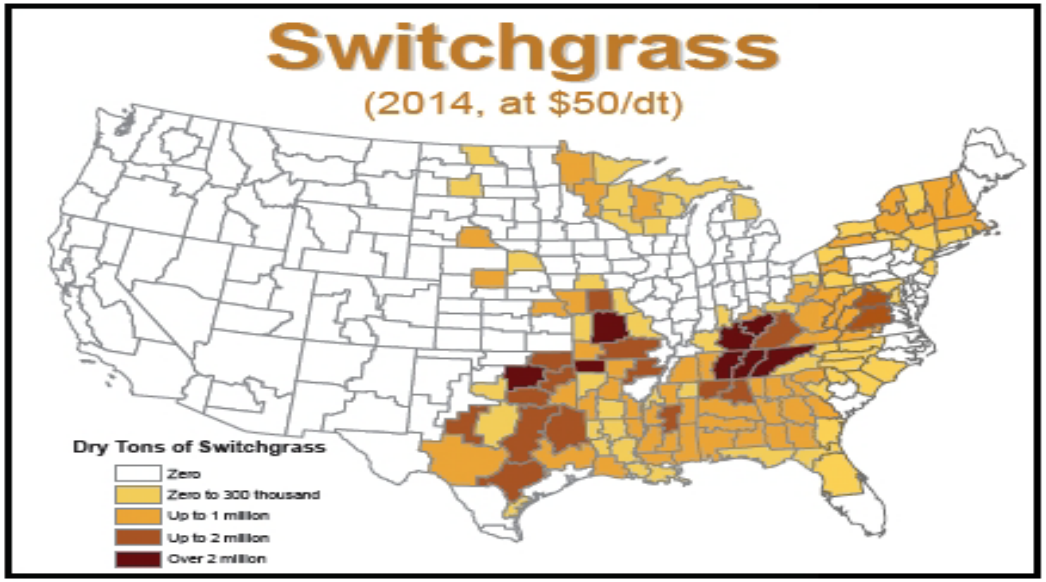
Different switchgrass varieties:



Miscanthus × giganteus and Alamo switchgrass in Central Texas


Miscanthus × giganteus in Missouri

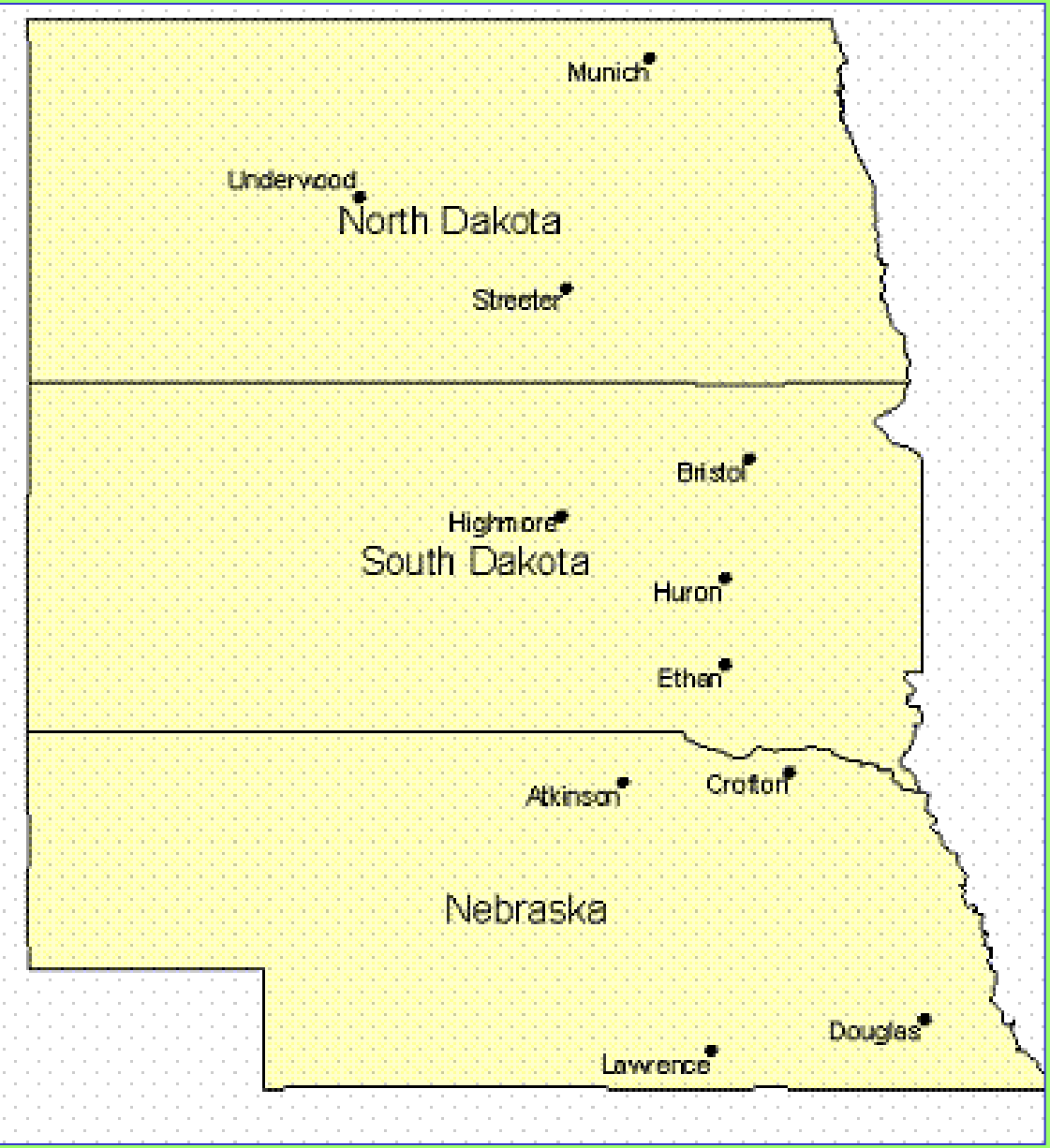
Two Case Studies Using ALMANAC



Ugarte, et al. 2006 (forthcoming). Economic Implications to the Agricultural Sector of Increasing the Production of Biomass Feedstocks to Meet Biopower, Biofuels and Bioproduct Demands.

- Species: switchgrass is an important forage grass and potentially a valuable biomass energy crop.
- Previous simulations: Highly productive conditions, primarily in the Southern United States.
- Objectives: Develop, refine, and test ALMANAC for applicability in less productive conditions due to latitude and soil types.

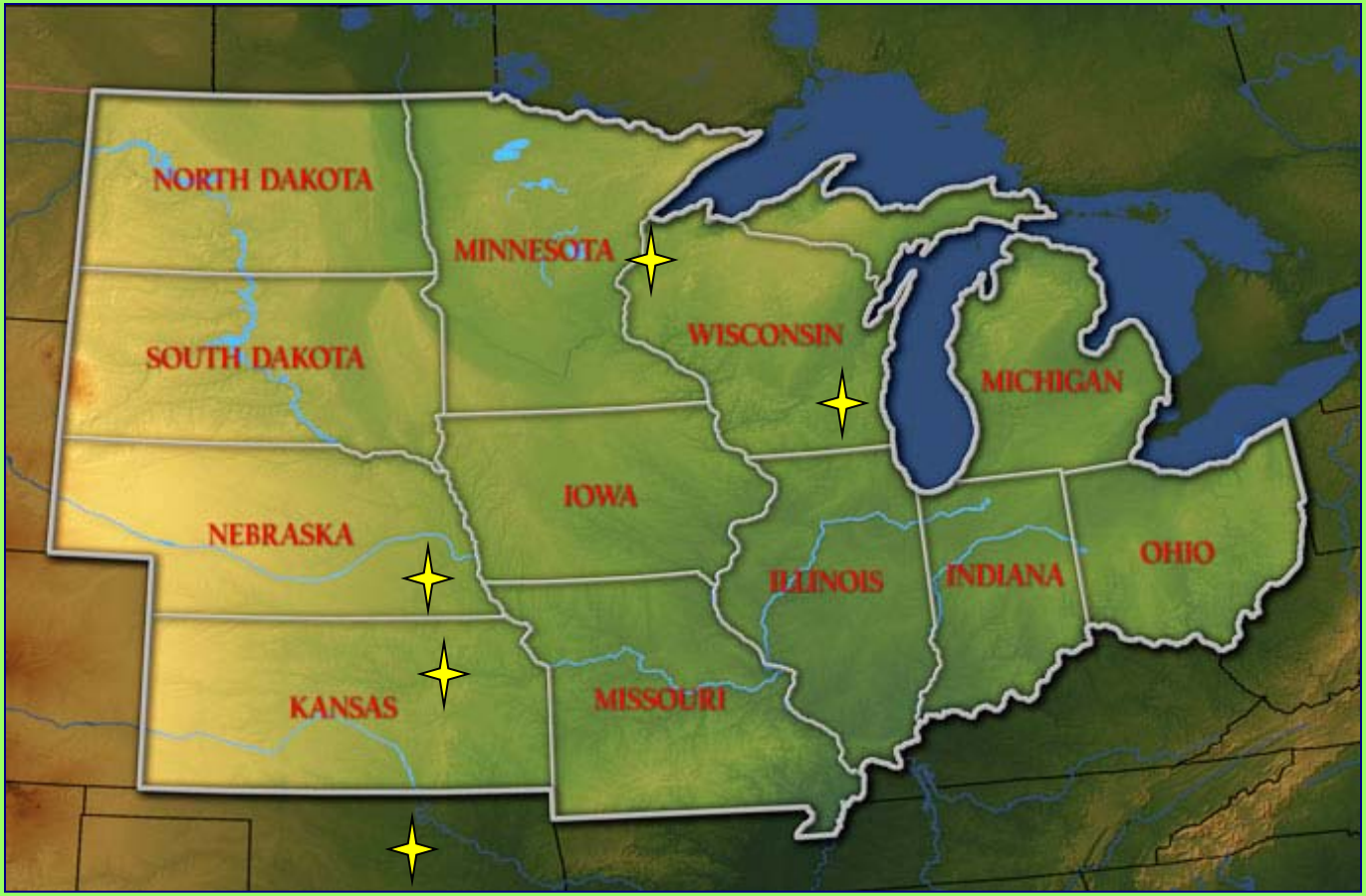
Case Study I



Model switchgrass yields in less productive areas of the country, with different degree days and in different soil types.

Case Study II

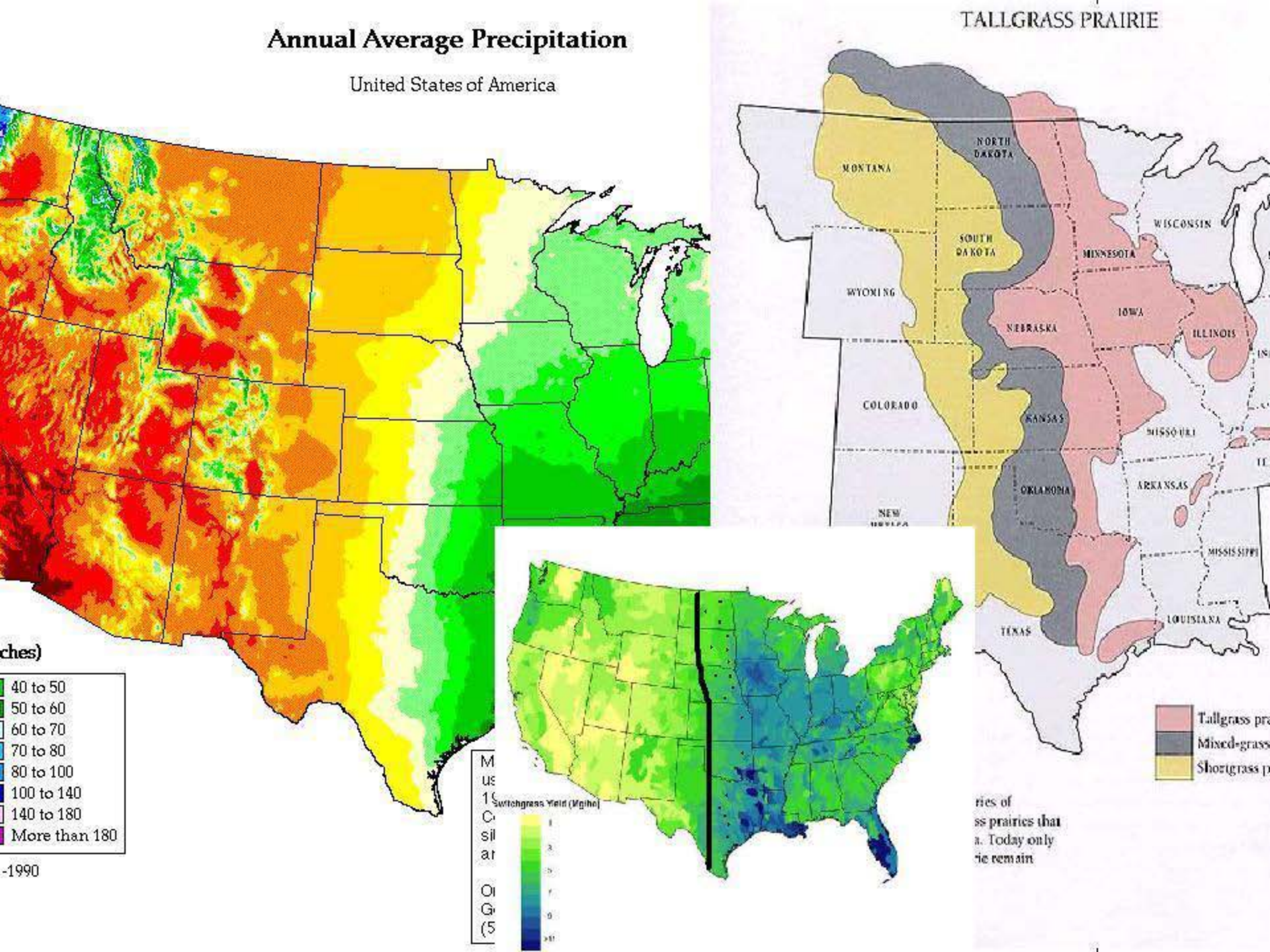
Model four varieties of switchgrass yields in less productive areas of the country, with different degree days and in different soil types.



Conclusions

- ALMANAC can realistically simulate biofuel crop management, production, and yields for different plant species on different soil types

- ALMANAC is an emerging, powerful decision making tool for biofuel crop expansion and ecosystem impact management


Annual Average Precipitation
United States of America
ches)
40 to 50
50 to 60
60 to 70
70 to 80
80 to 100
100 to 140
140 to 180
More than 180
-1990
TALLGRASS PRAIRIE
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
COLORADO
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MISSISSIPPI
Tallgrass pra
Mixed-grass
Shortgrass p
ries of
ss prairies that
. Today only
ie remain

ORNL 2000-00566