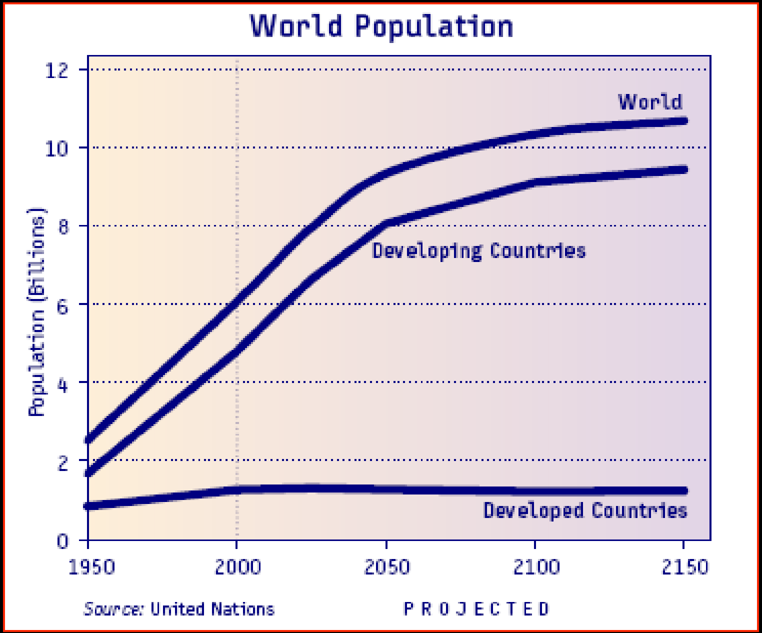
Global water cycles, Climate Change and Agriculture

Bruno Basso

Dept. Geological Sciences and W.K. Kellogg Biological Station

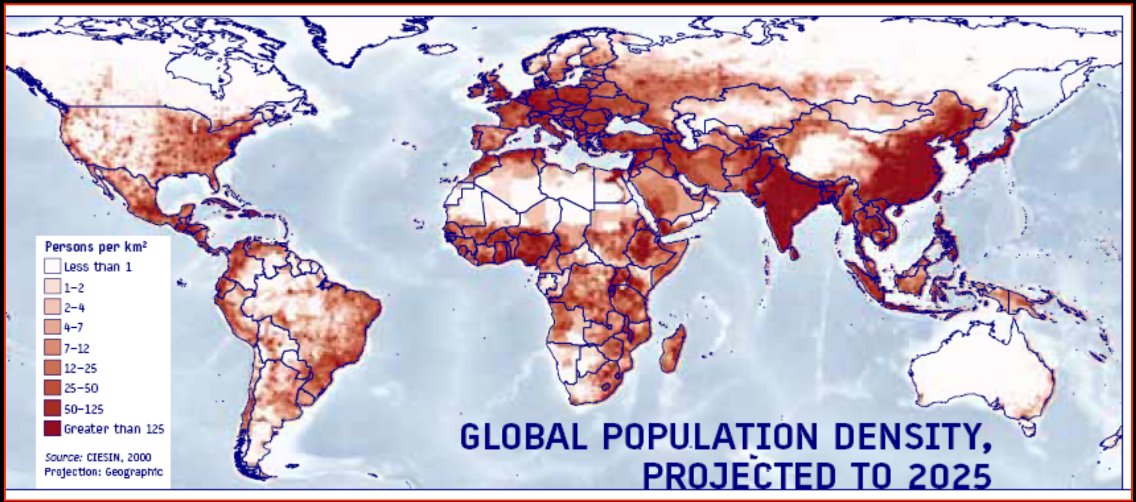
MICHIGAN STATE UNIVERSITY

The world will need to support five billion more people



World population is projected to grow to about 8 billion in 2025, to 9.3 billion in 2050, and eventually to stabilize between 10.5 and 11 billion. Almost all future population growth will occur in the developing world.

This increased population, combined with higher standards of living, particularly in the developing countries, will pose enormous strains on land, water, energy and other natural resources.



The Global Food and Water Paradox

Feeding more people with less water than we have now, in a changing climate

Some facts about water in agriculture

70% of global water withdrawals

18% of cultivated land
(280 million ha, 200 million in developing countries)

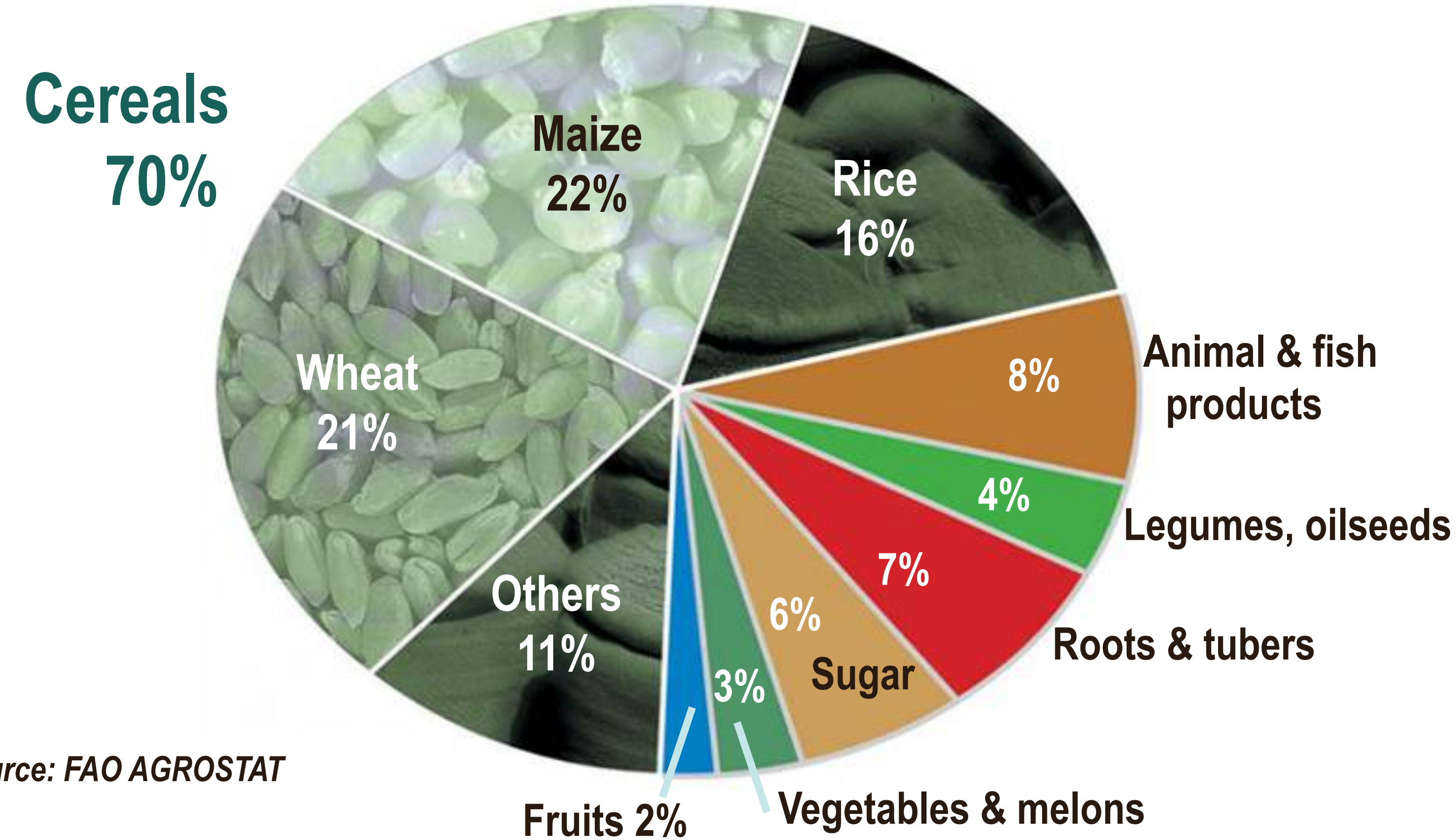
40% of world food harvest
(57% of cereal production)

By 2030, FAO expects world's irrigated area to increase by 50 million ha.

2013 World Food Supply

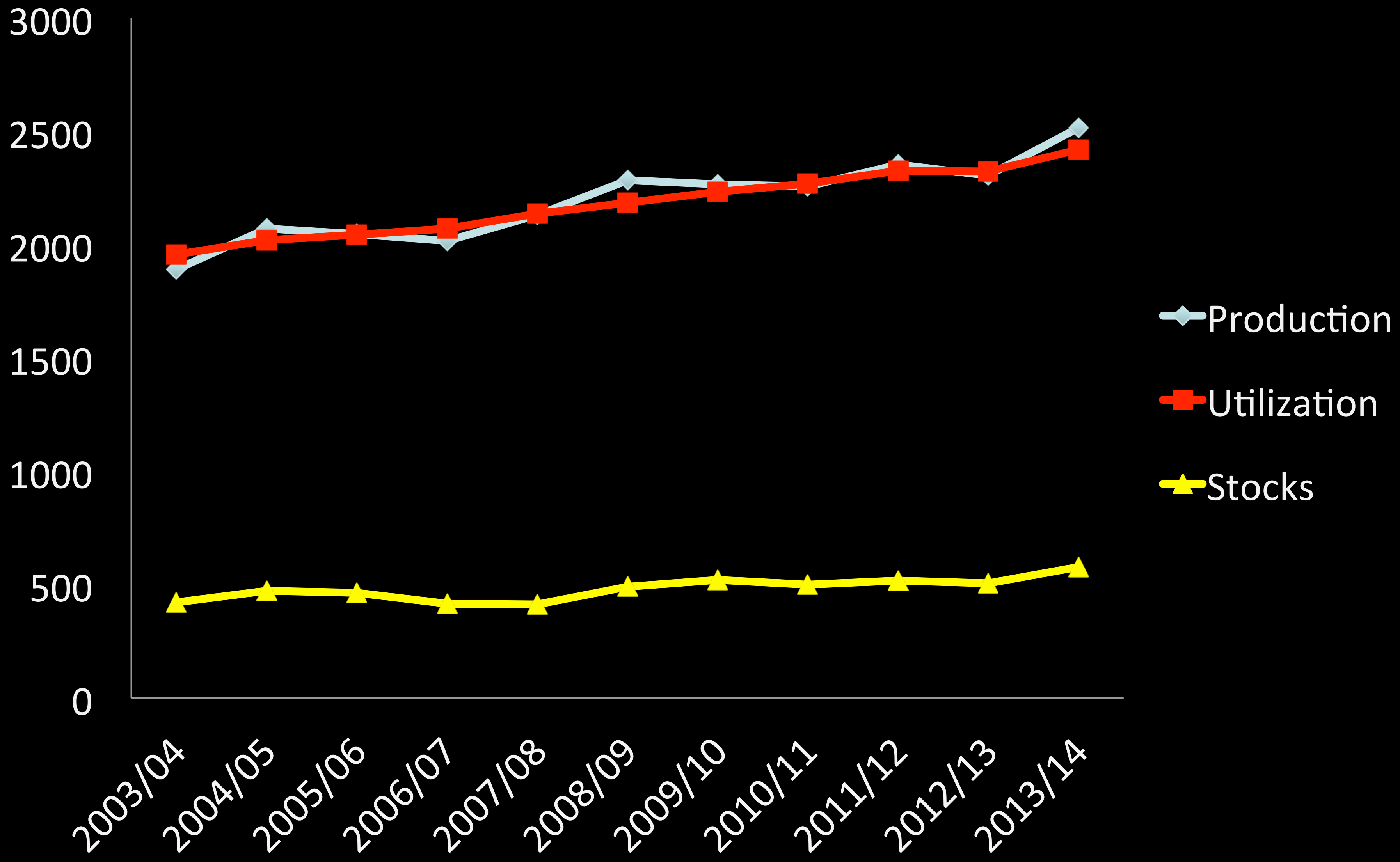
5.2 billion gross tonnes; 2.5 billion tonnes dry weight

Edible dry matter, expressed in Kcals

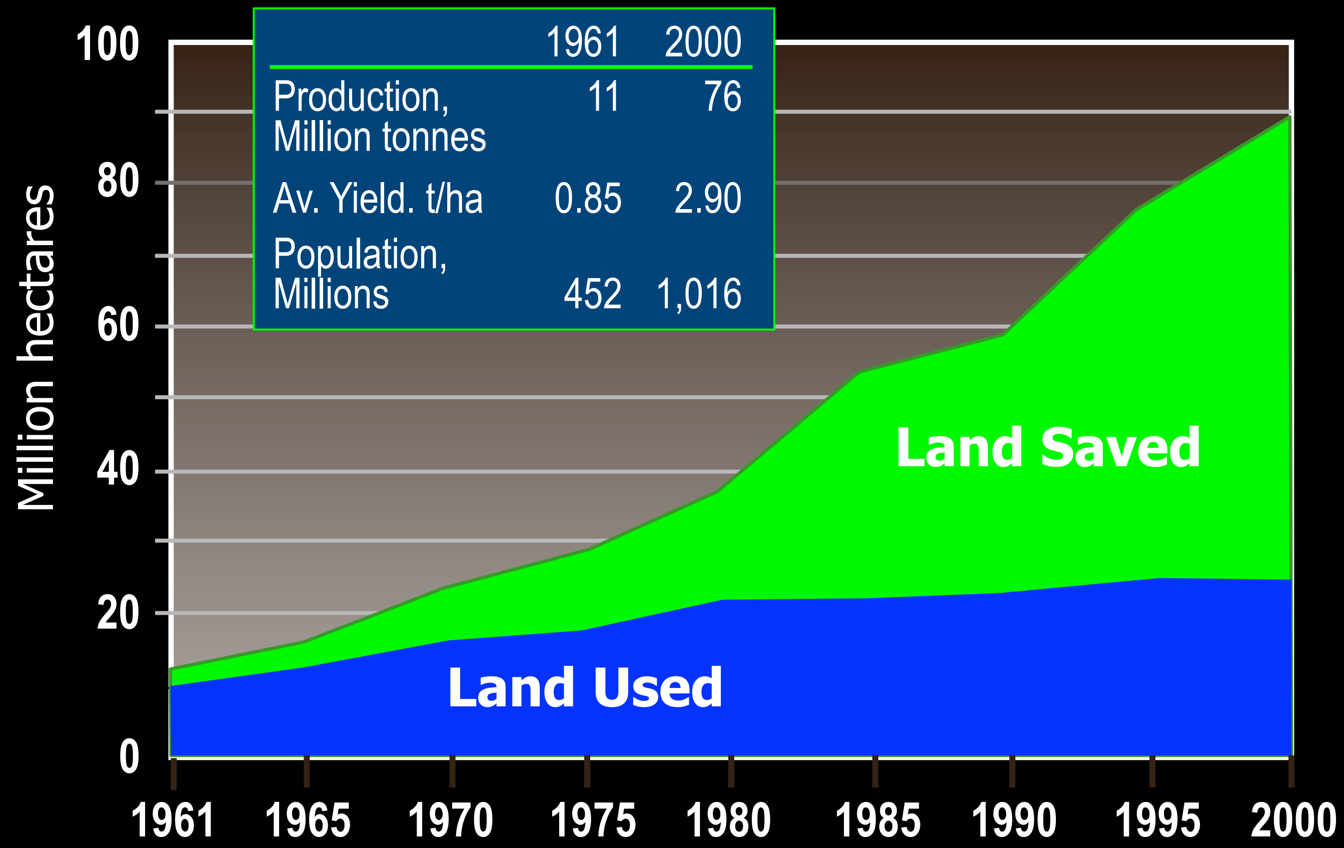


Source: FAO AGROSTAT

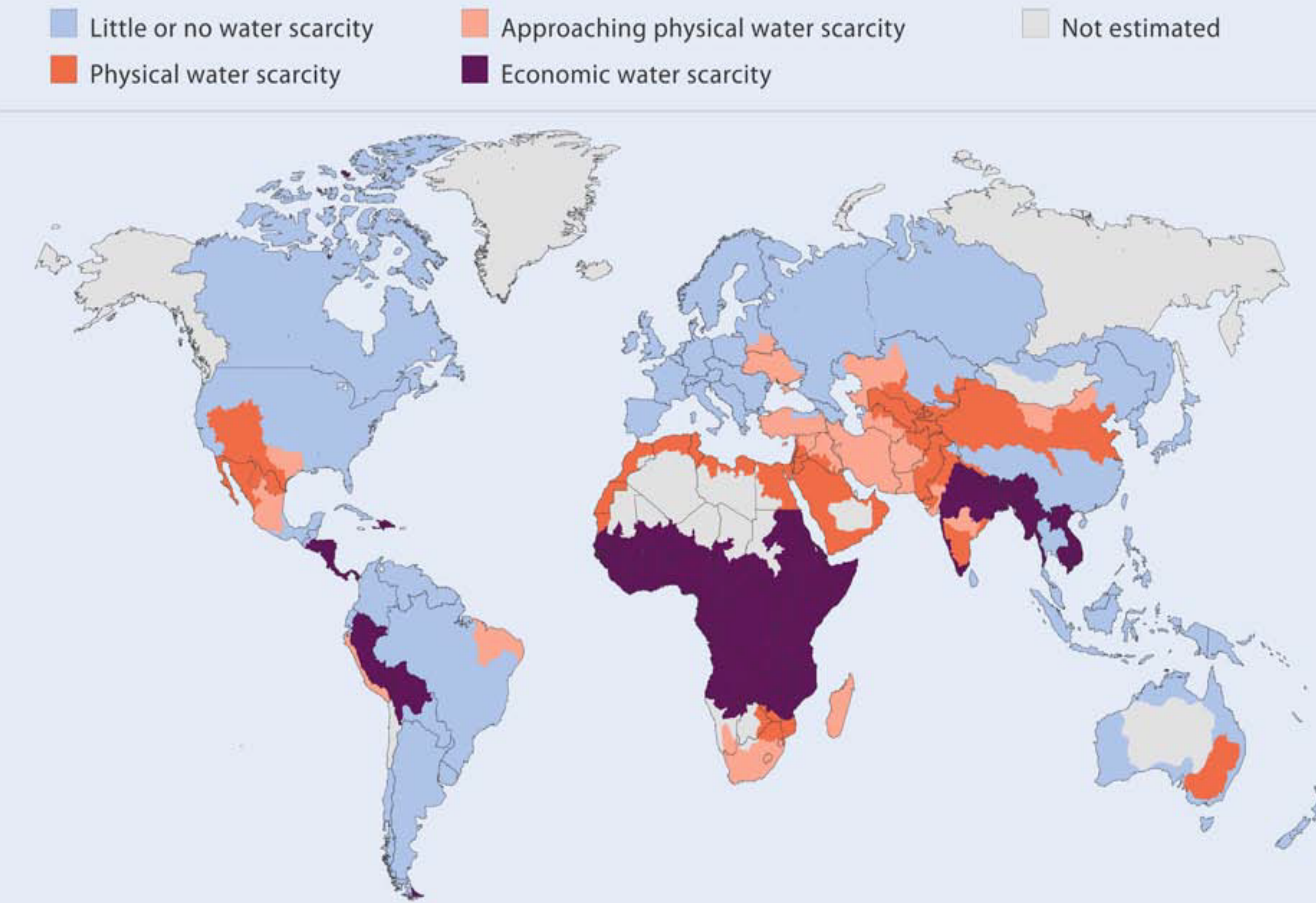
World Cereal Production, Utilization and Stocks
(Million tonnes)



Indian Wheat Production—Area Saved Through Adoption of High-Yield Technology



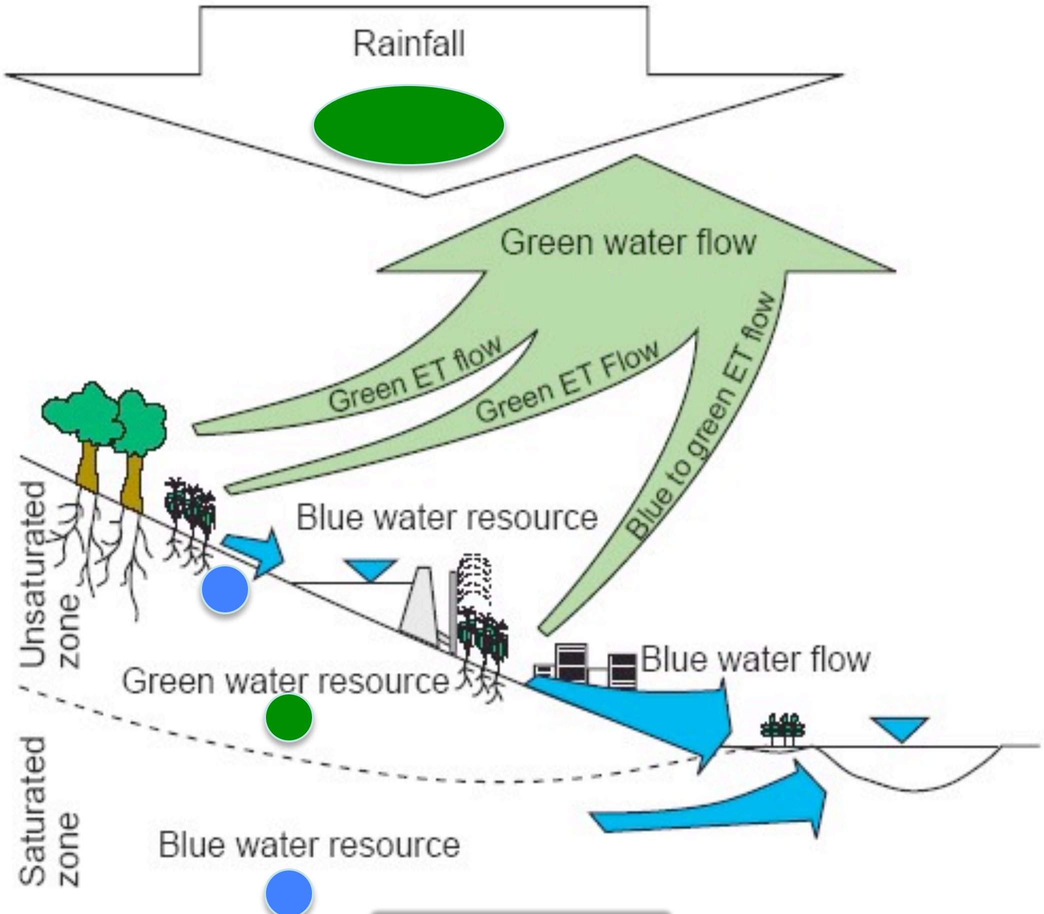
Source: FAOSTAT, 2002



Little or no water scarcity
Approaching physical water scarcity
Not estimated
Physical water scarcity
Economic water scarcity

Water footprint

Green Water



Blue Water

Grey Water

Water for food

1 pound (0.5 kilograms) of beef requires:

1,799

gallons (6,810 liters) of water

6.6 pounds (3 kilograms) of grain for feed, plus irrigation water

36.2 pounds (16.4 kilograms) of roughage or grasses for feed, plus irrigation water

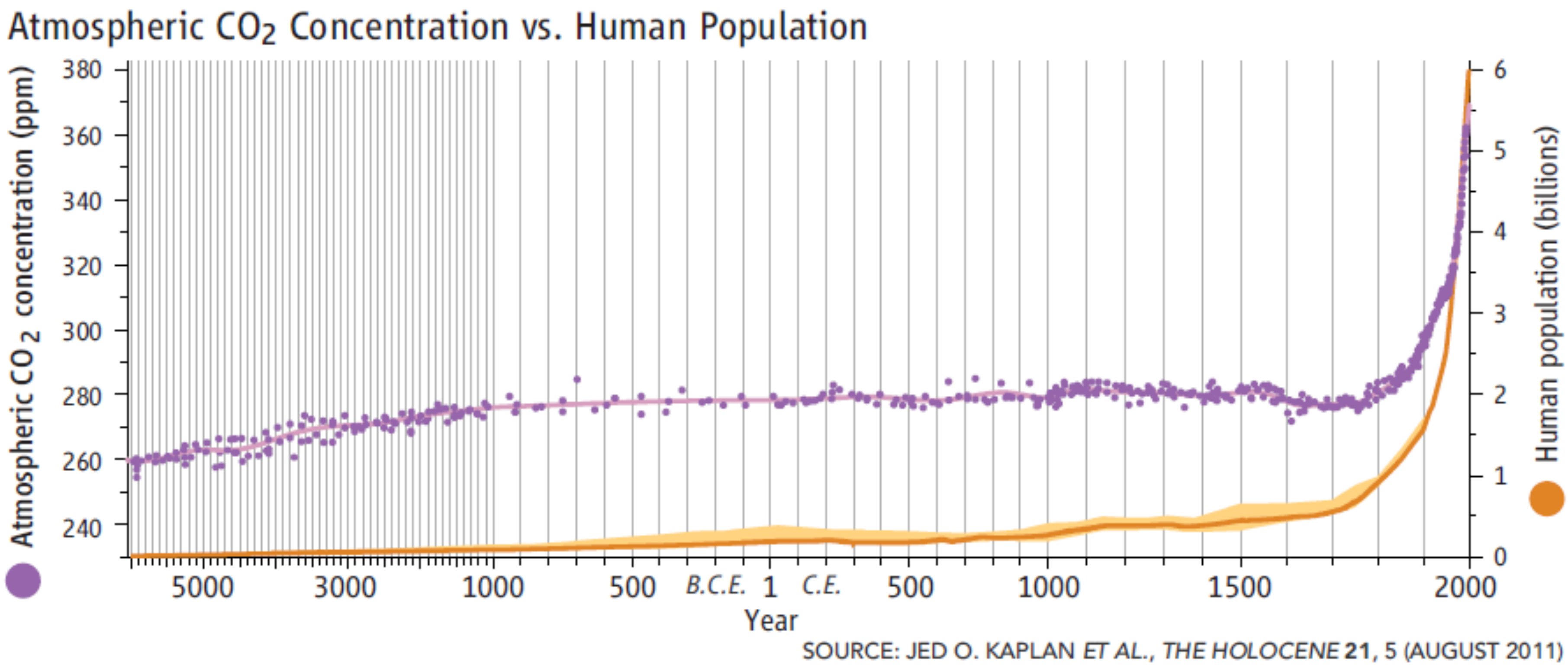
18.6 gallons (70.5 liters) of additional water for drinking and processing

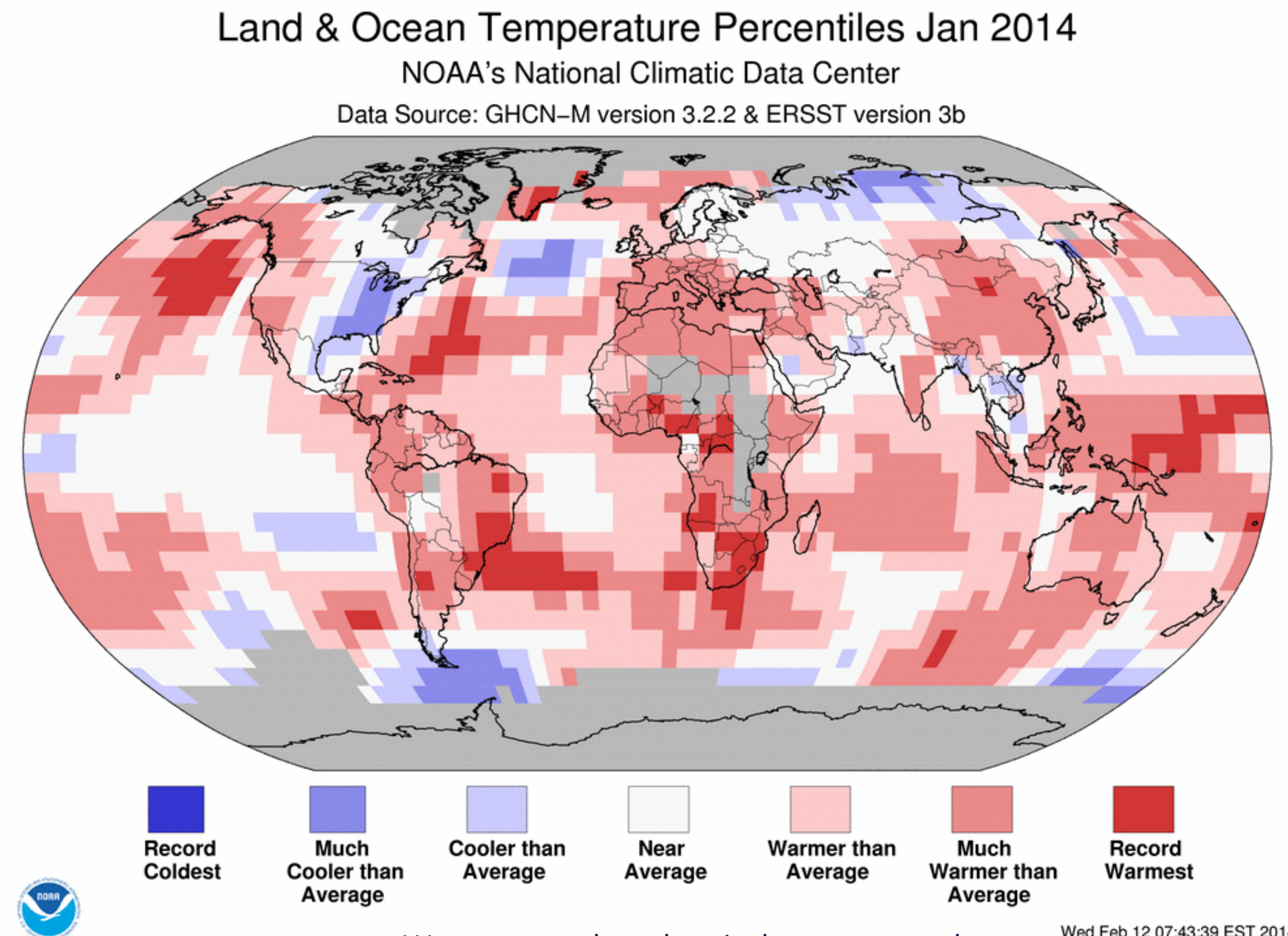
2500 liters of water (Green and Blue water)

70 liters of water (Green)

90 liters of water (mostly Green)

Current CO_2 Concentration = 398 ppm



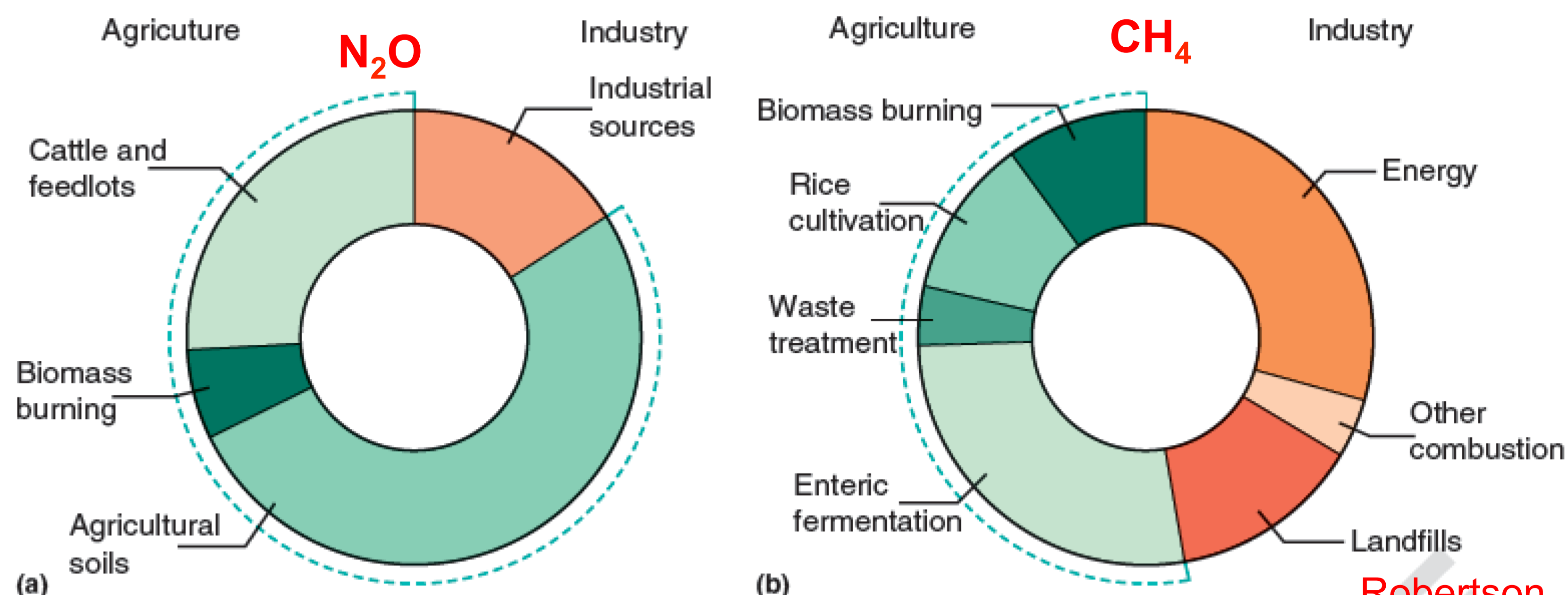


- Warmest southern hemisphere on record
- 4th warmest January northern hemisphere

https://www.ncdc.noaa.gov/sotc/global/2014/1

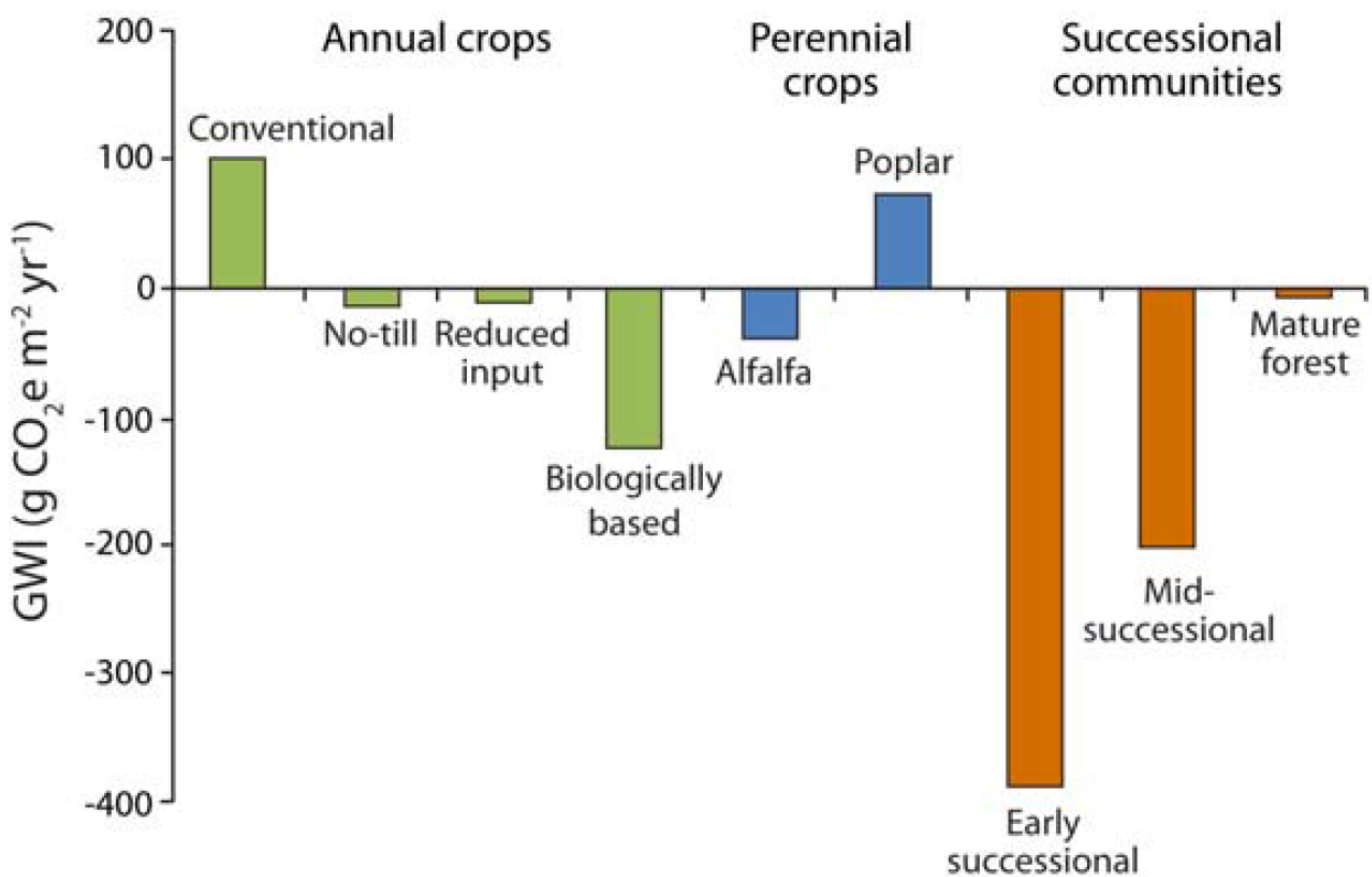
Primary Greenhouse Gases - Global Warming Potential

Agriculture is directly responsible for approximately 10%–14% of total annual global anthropogenic greenhouse gas emissions (Smith P et al. 2007)



Robertson, 2014

Net Global Warming Impact



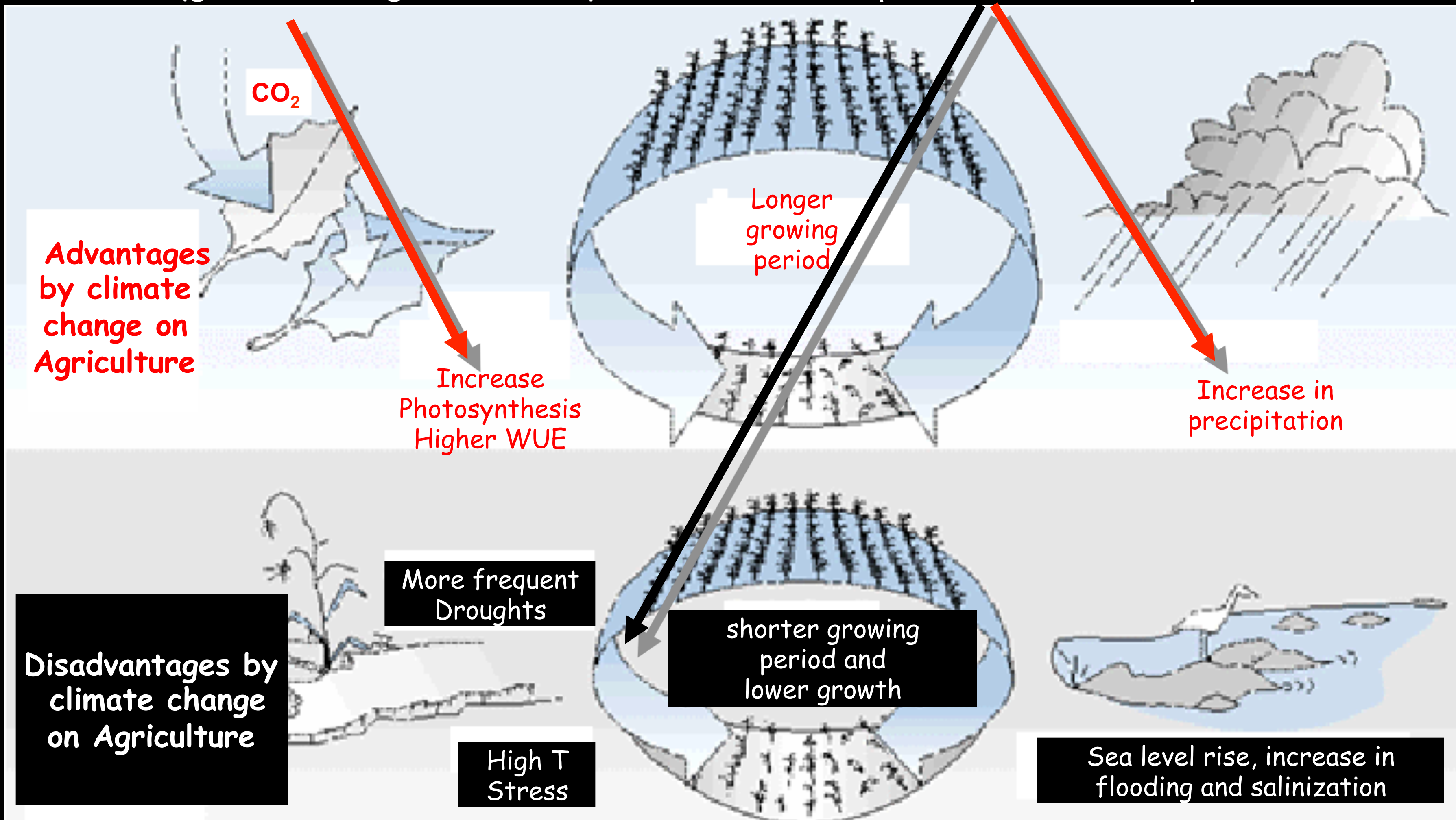
MSU, Kellogg Biological Station ecosystems.
The annual crops include corn–soybean–wheat rotations

Gelfand and Robertson, 2014

Climate change and Agriculture

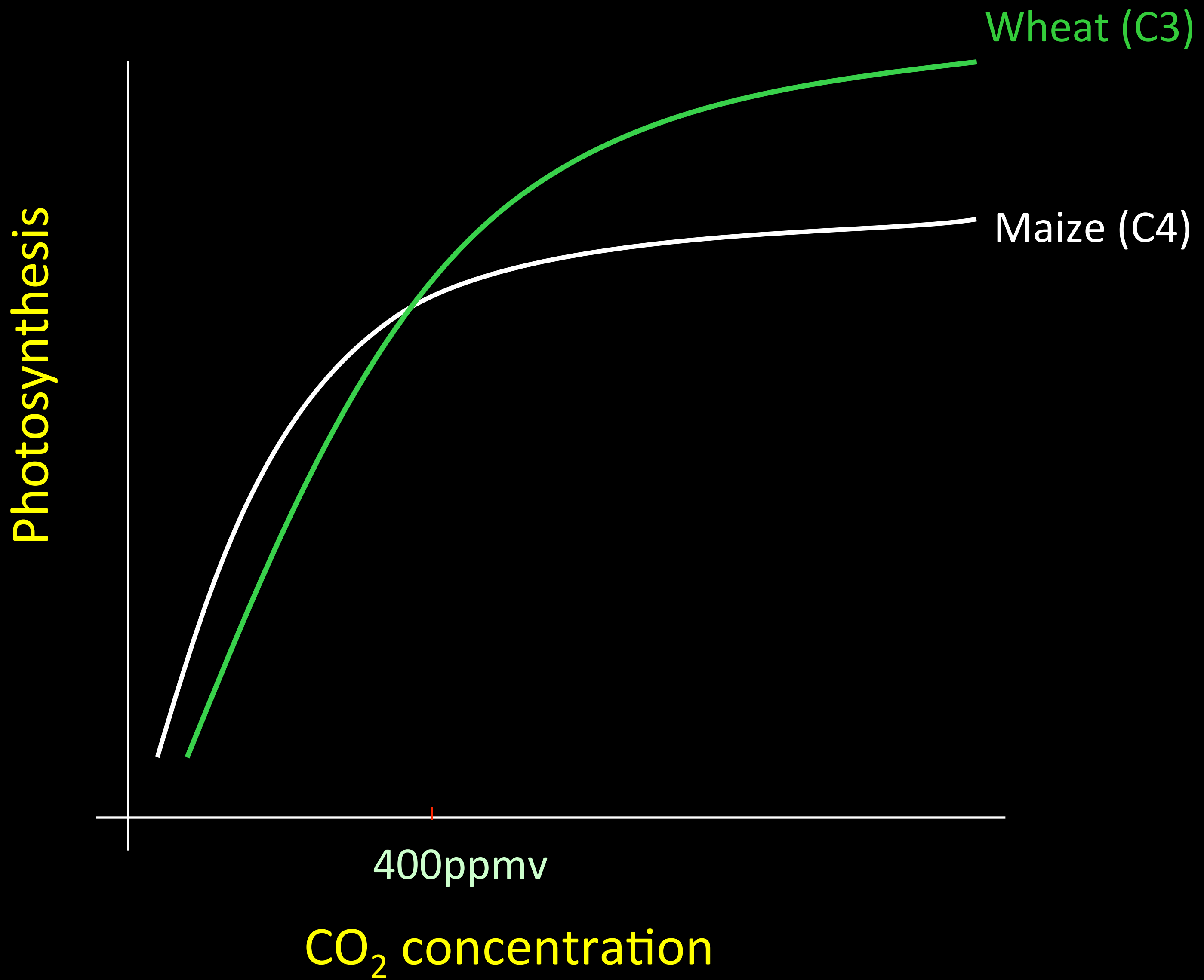
Direct Effect + Indirect

Direct Effect (greenhouse gas variation) | Indirect (climatic variation)



Crop yield response to rate of senescence

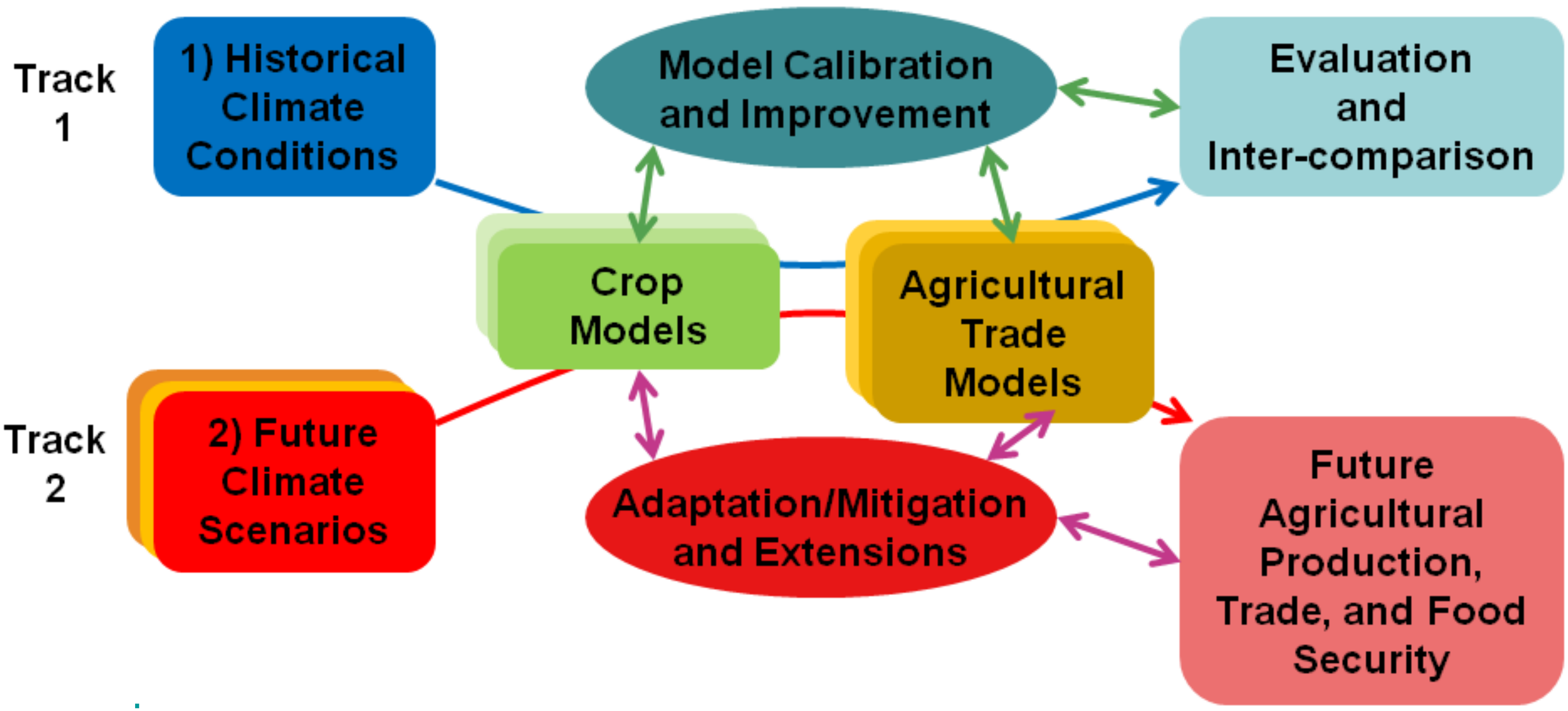
Photosynthesis response to CO_2 concentration



AGMIP

The Agricultural Model Intercomparison and Improvement Project

The goals of AgMIP are to improve substantially the characterization of risk of hunger and world food security due to climate change and to enhance adaptation capacity in both developing and developed countries.



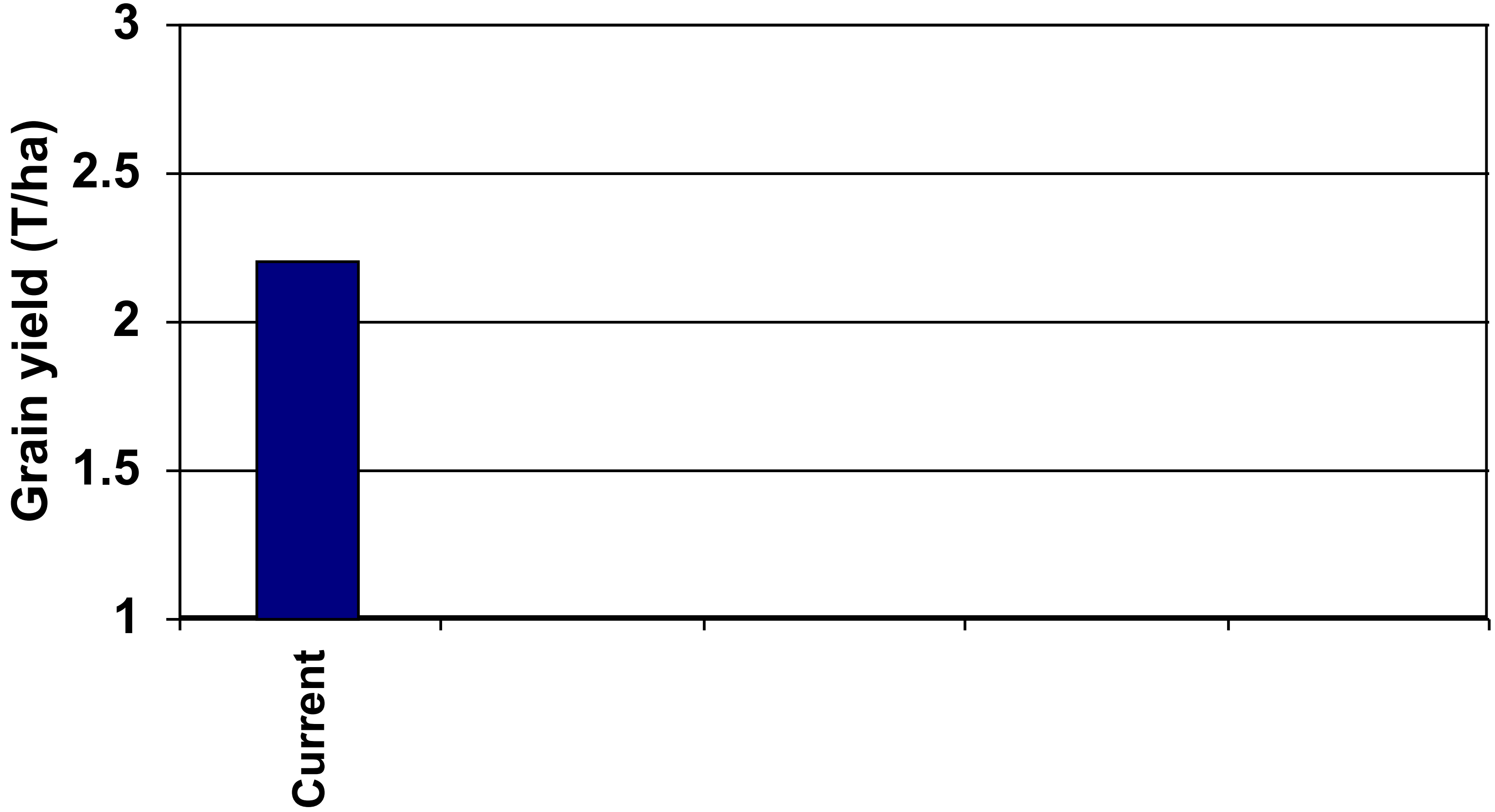
www.agmip.org

Rosenzweig et al, 2013 Agr. For Meteor., PNAS

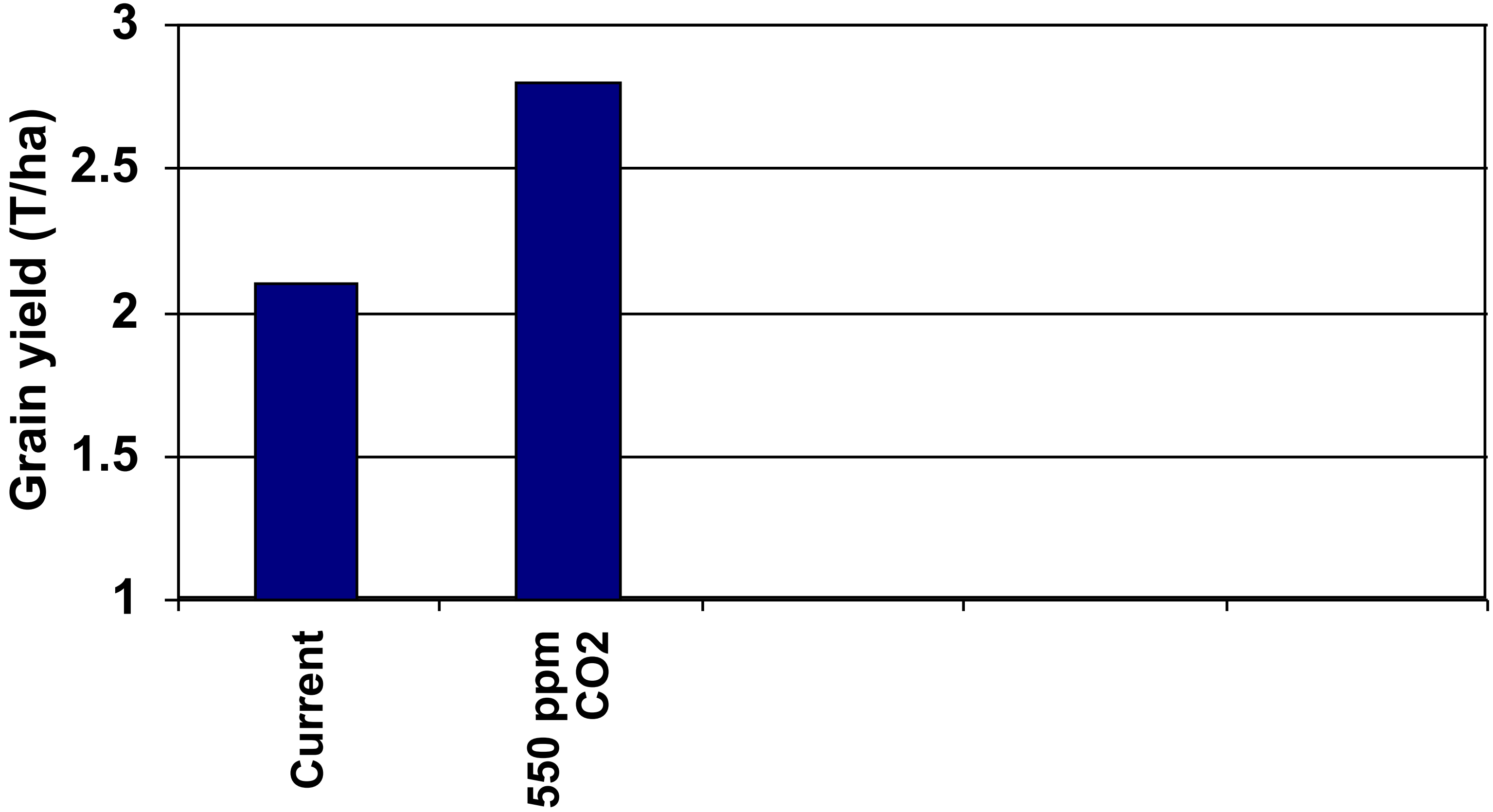
Asseng et al., 2013 Nature Climate Change

Bassu et al., 2014 Global Change Biology

Climate change effects on wheat



Climate change effects on wheat



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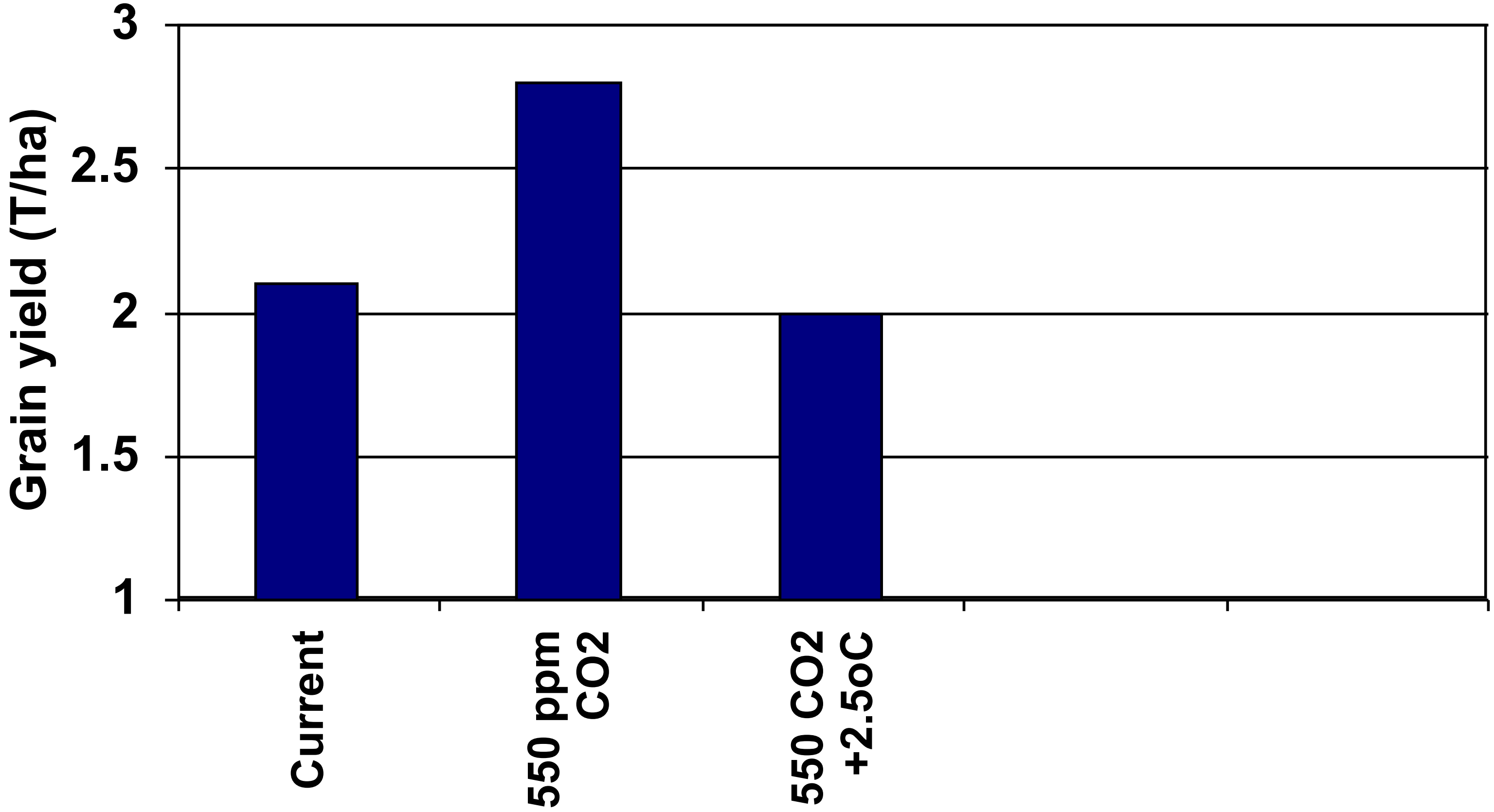

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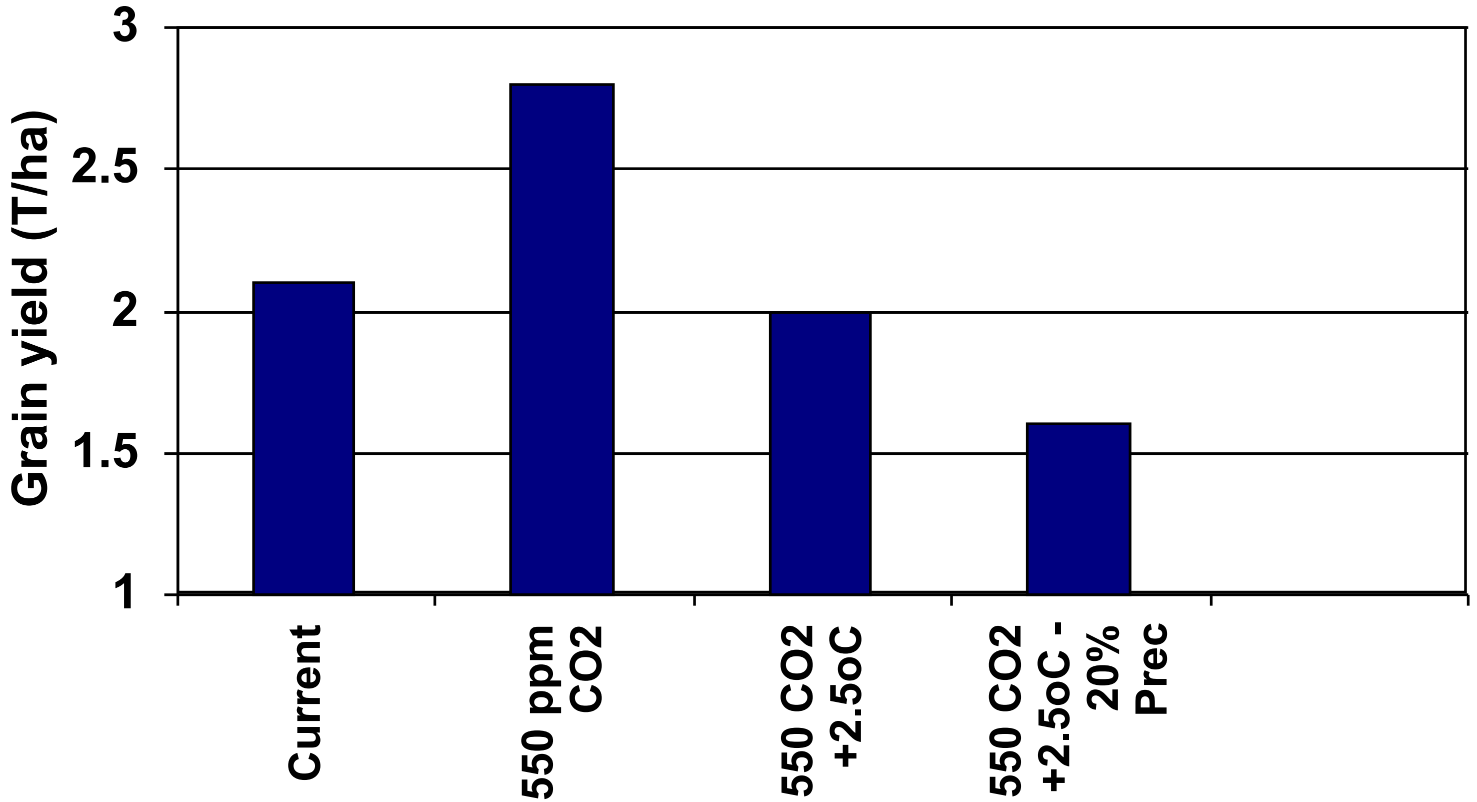
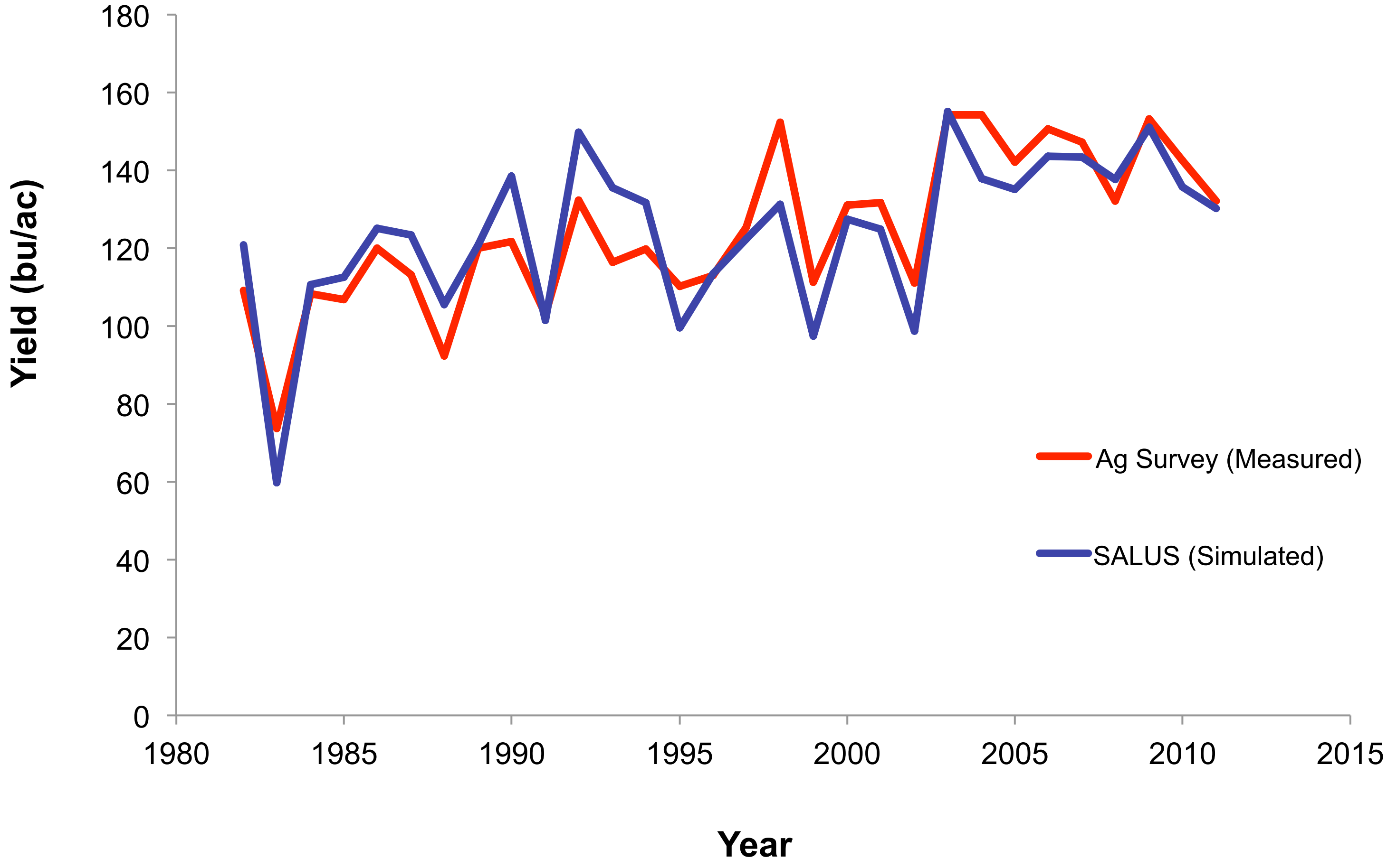
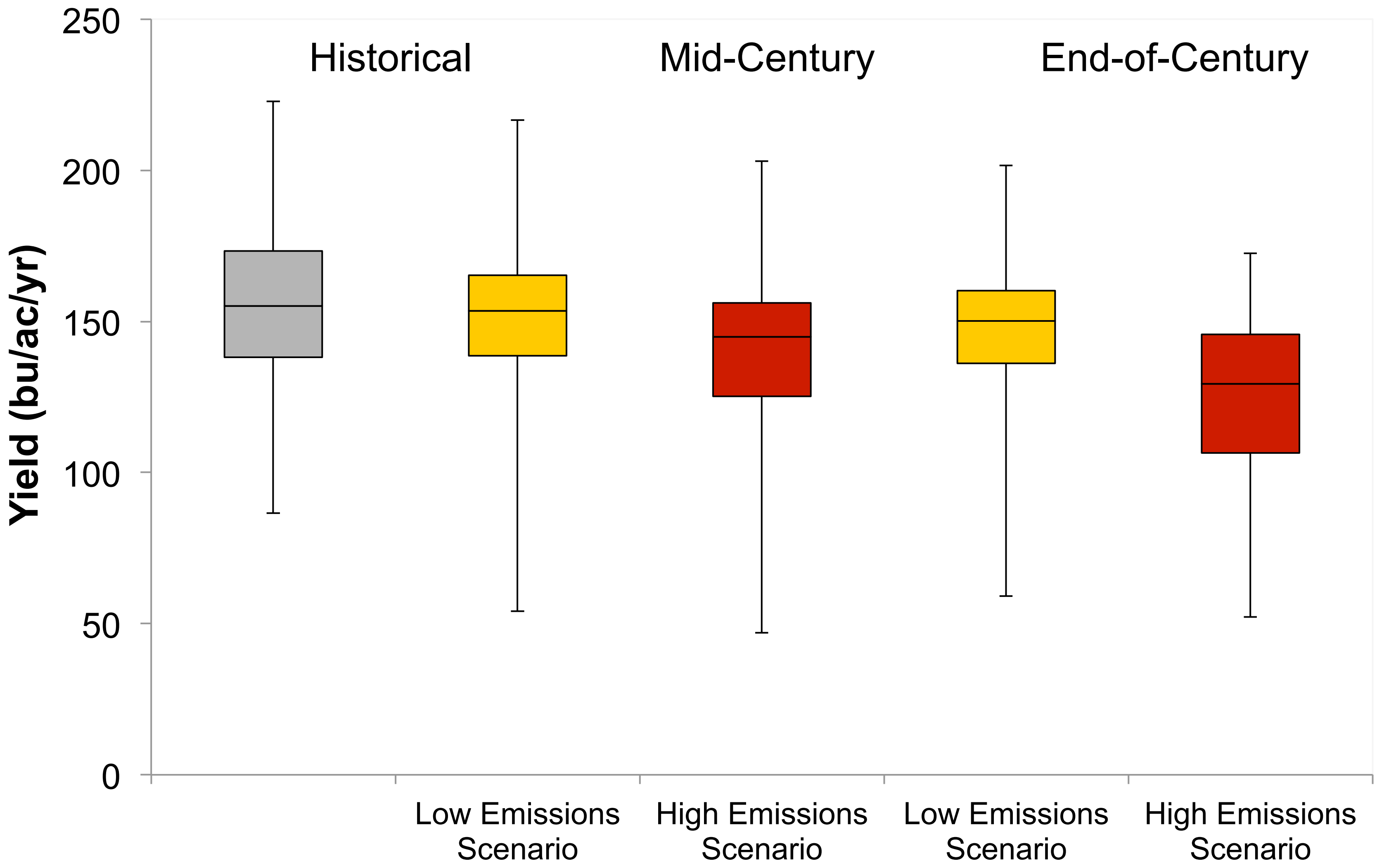


County Average Reported Yield *vs* SALUS Simulation



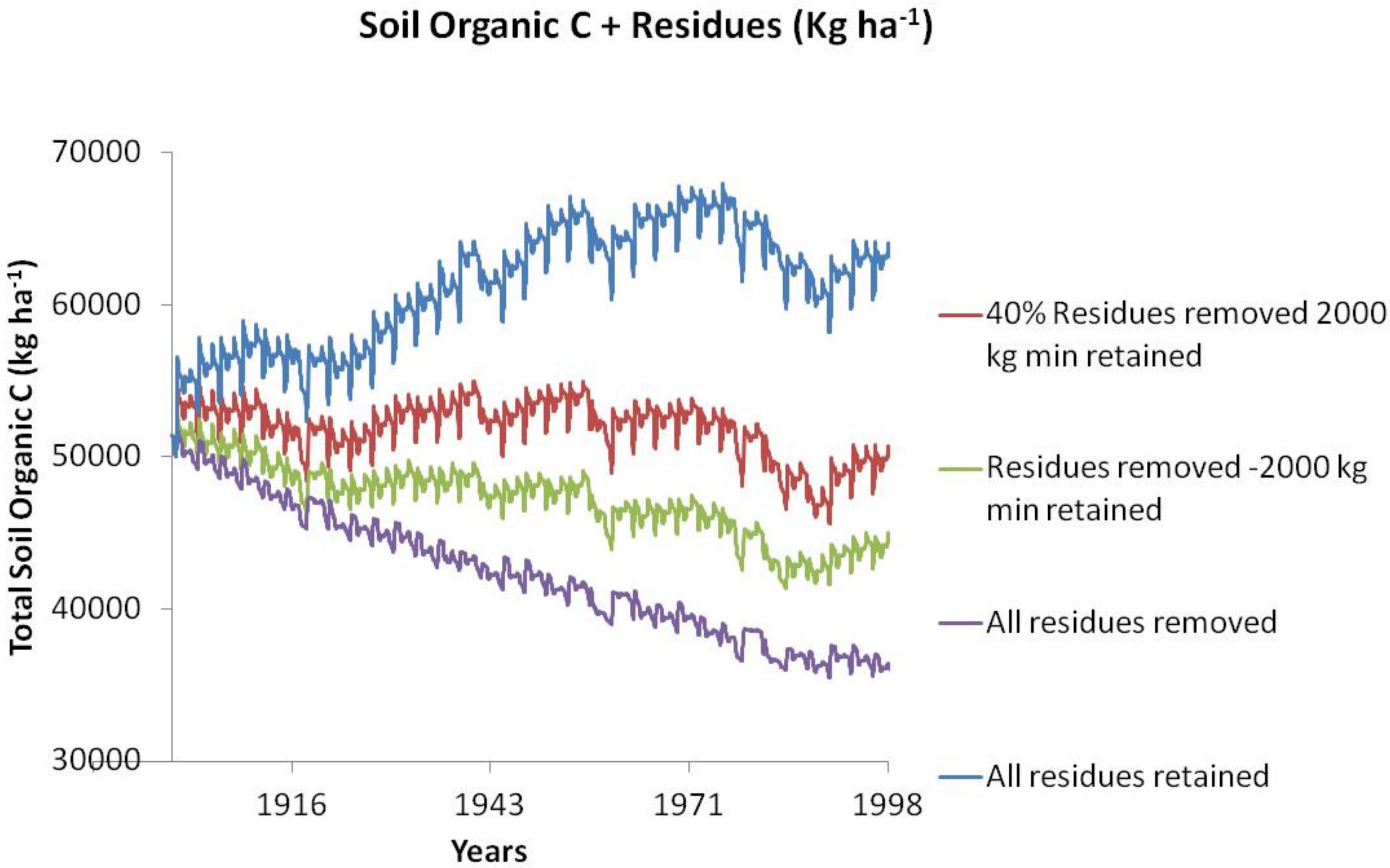
Nagelkirk et al. 2014

Climate change effects on maize

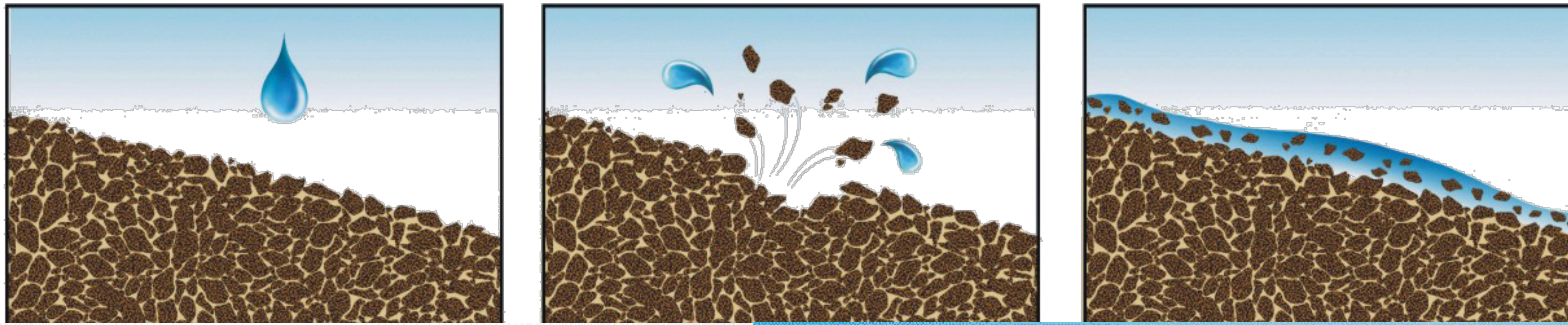


Nagelkirk et al. 2014

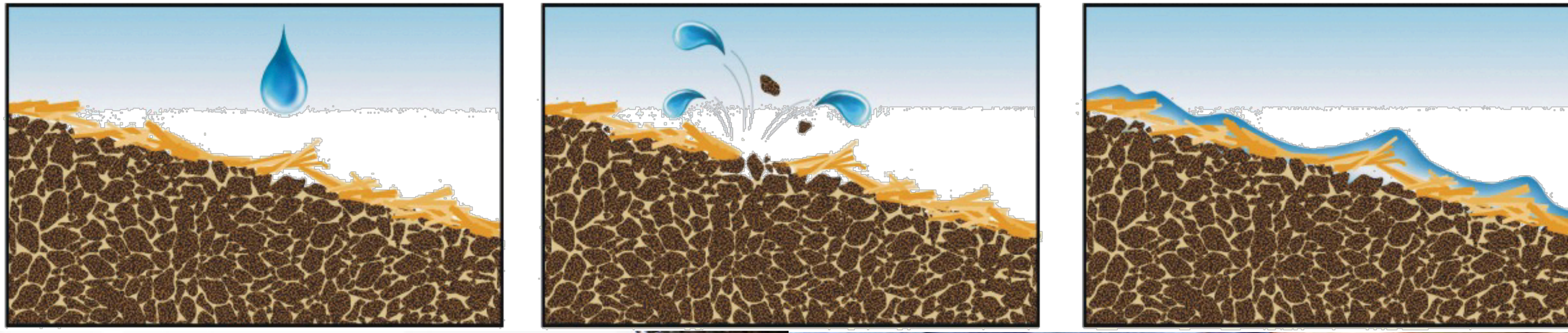
Assessing the impact of residues removal on soil carbon using soil-plant-atmosphere models. (Basso and Robertson 2014 in preparation)



Tillage impact on runoff



Conventional tillage with no surface residues



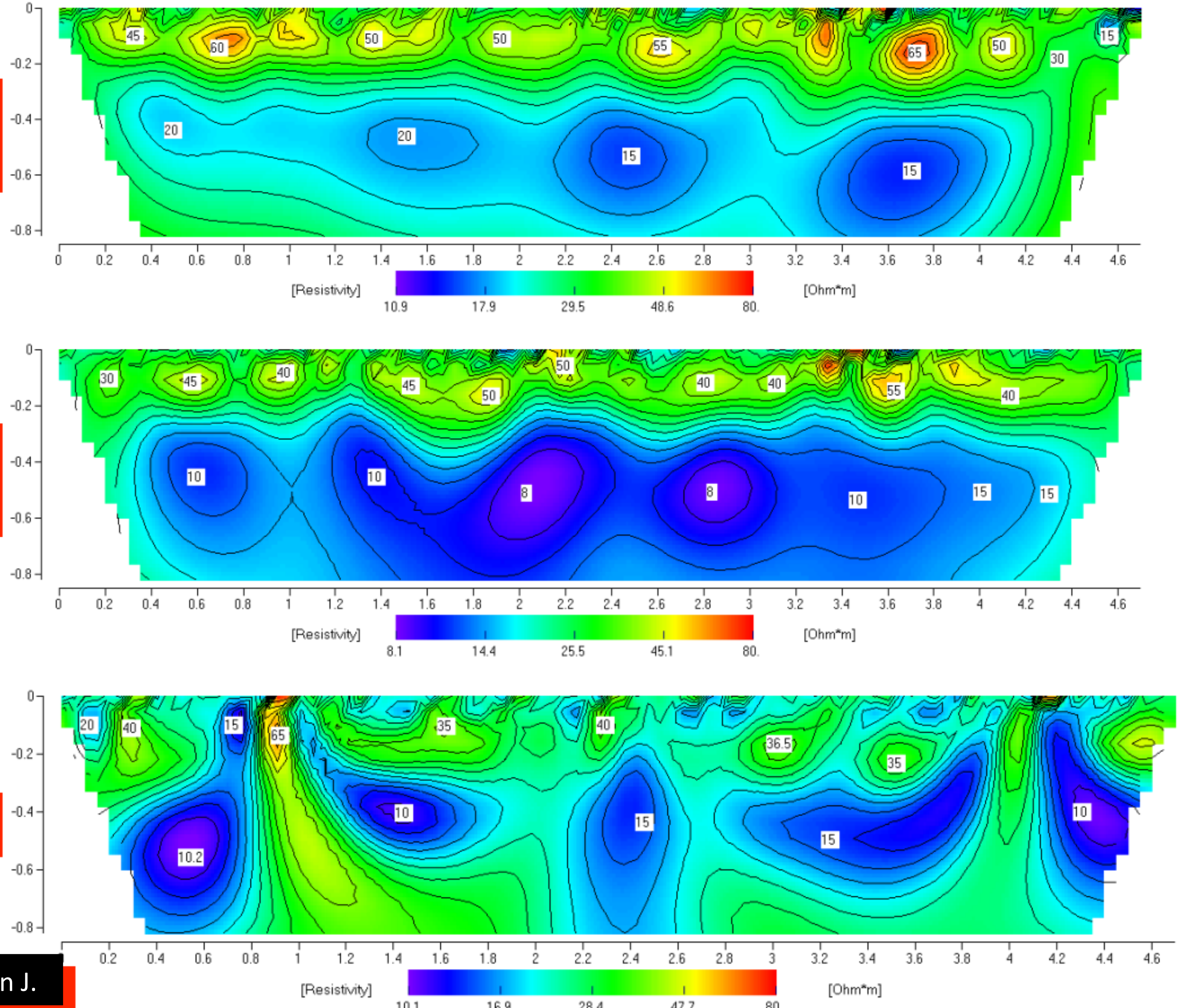
Conservation Tillage with crop residues retained on the soil surface significantly reduces runoff and soil erosion

High-resolution 2-D resistivity tomography

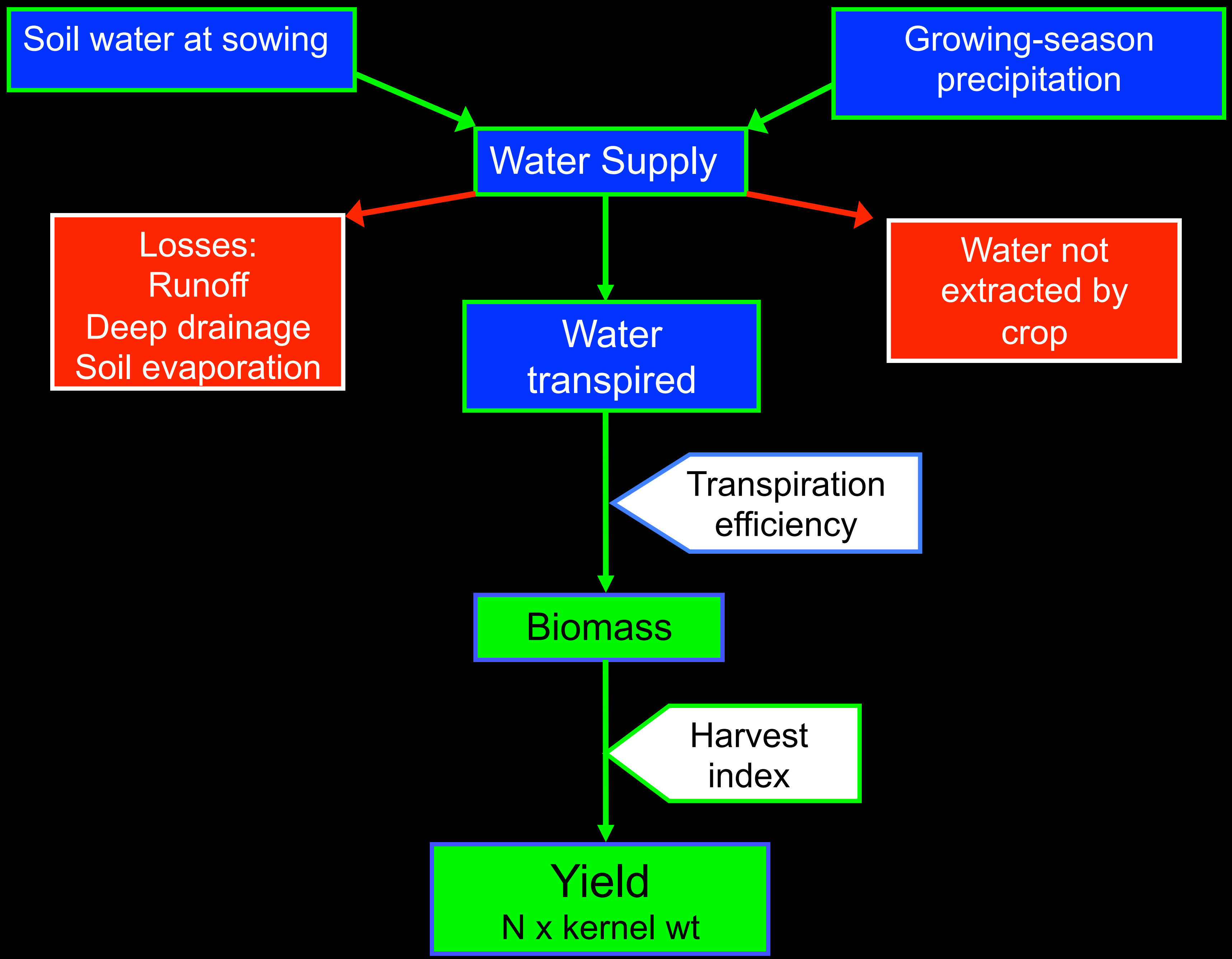
Conventional Tillage

Minimum Tillage

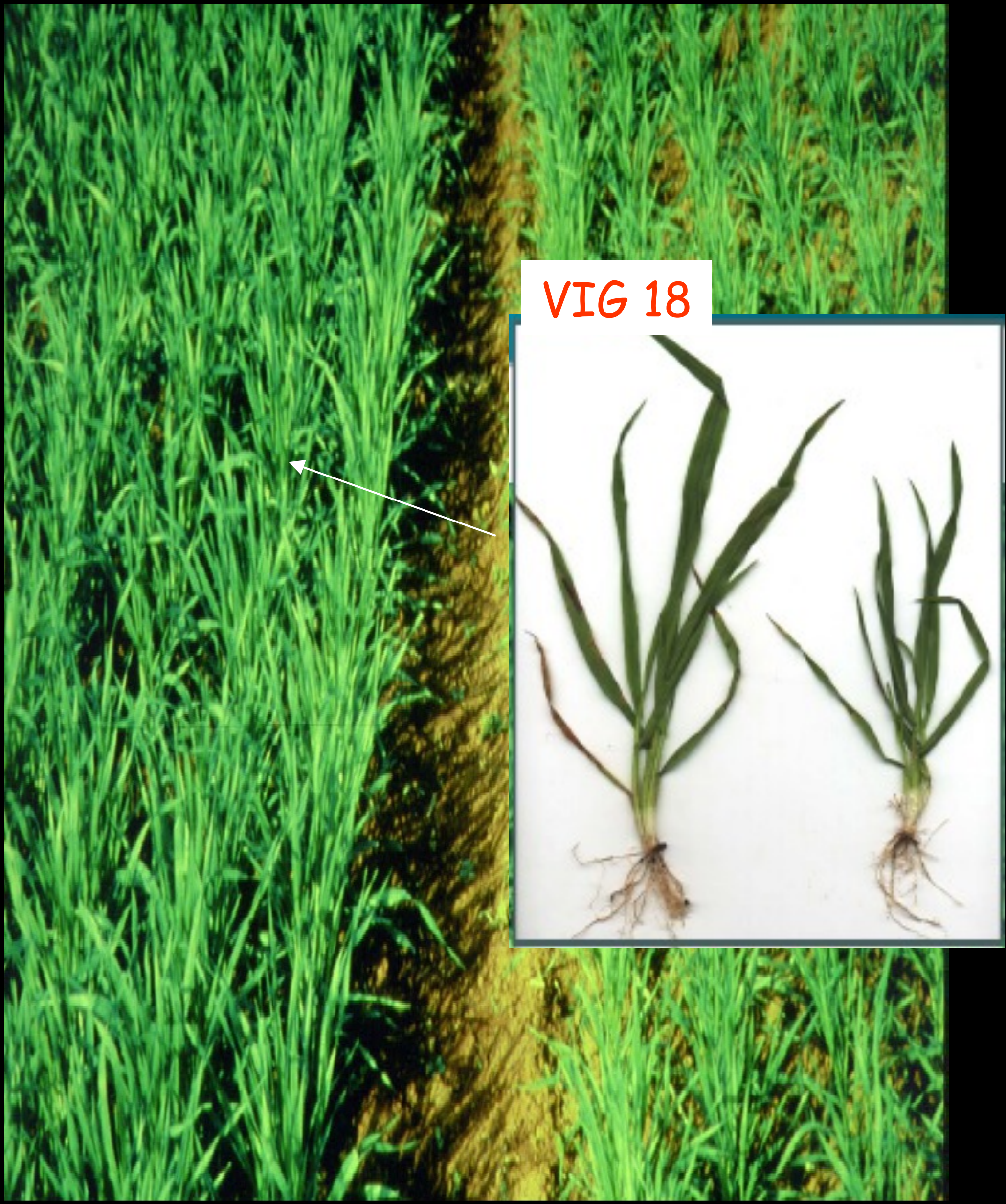
No Tillage



Basso et al., 2010 Agron J.


Soil water at sowing
Growing-season precipitation
Water Supply
Losses:
Runoff
Deep drainage
Soil evaporation
Water transpired
Water not extracted by crop
Transpiration efficiency
Biomass
Harvest index
Yield
N x kernel wt

Seedling Vigour



Soil evaporation decreases while transpiration increases

Improvements in drought-resistant corn